

Power MOS FET • IGBT

Attention of Handling Semiconductor Devices

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Contents

1.	Selection of Semiconductor Devices	2
1.1	Maximum Ratings	2
1.2	Consideration about Derating	2
1.3	Selection of Package Type	3
2.	Precautions for Physical Handling	4
2.1	Forming and Cutting Leads	4
2.2	Mounting on the Circuit Board	5
2.3	Soldering	6
2.4	Removing Residual Flux	7
2.5	About Heat Sink Mounting	8
2.6	Positioning of Component Parts	12
3.	Mounting Precautions	13
3.1	General Precautions	13
3.2	Noise and Surge Countermeasures	13
3.3	Relation between Characteristic Parameters and Reliability	14
4.	Precautions on Storage, Transport and ESD Damage	15
4.1	Storage	15
4.2	Transport	16
4.3	Electrostatic breakdown prevention	16
5.	Reliability test methods and failure determination criteria for semiconductor devices	16
5.1	Reliability test methods	17

1. Selection of Semiconductor Devices

Semiconductor devices reliability is remarkably affected by using conditions such as electronic circuits, mounting, environments, etc. In order to keep high reliability of our semiconductor devices for customer's use important hints on selecting the maximum rating, derating, and device package are explained in this chapter.

1.1 Maximum Ratings

The maximum ratings of a semiconductor device are usually defined by the "absolute maximum ratings" and can not be exceeded in any circumstances, even momentarily.

If a device operates in excess of the absolute maximum ratings, even momentarily, the device may immediately be degraded or broken. Even if it goes on operating, its lifetime should be considerably reduced. Therefore, in designing an electronic circuit using semiconductor devices, it is necessary to consider that the maximum ratings of devices shouldn't be exceeded under any changes of external conditions. Furthermore, it should be noted that most of ratings are closely related to each other and ratings are not always allowed at the same time. For example, even if a current and a voltage applied to a transistor are individually within their maximum ratings, the collector dissipation should also be kept within the maximum rating at the same time, because power consumption is the product of current and voltage. In addition to maximum D.C. ratings, it is necessary to consider ratings of SOA, peak voltage, and peak current when devices are used in pulse condition.

1.2 Consideration about Derating

It is a very important matter for high reliable design to decide the degree of derating from the maximum ratings. Derating of RENESAS semiconductor devices are already mentioned. Here it is noted that the derating items during system design, depending on the semiconductor device are electrical stress (voltage, current, power, load) environmental stress (temperature, humidity) and mechanical stress (vibration, shock).

Table 1 shows some examples of derating standards to be used for reliability designs.

Items for junction temperature are assumed that the overnight continuous operation. Furthermore, the values in "()" is the value of assuming the intermittent operation for about three hours a day.

It should be considered these derating standards from the design phase of the equipment for ensure reliability. When it is difficult to setting the rated value within the derating standards, it is necessary to another means such as selecting a device of larger absolute maximum rating.

Table 1 Example of derating standard*1 for Power MOSFET • IGBT

Derating factors*2		Example of derating standard
Temperature	Junction temperature	$T_j = 60\text{ }^{\circ}\text{C}$ or less ($T_j = 110\text{ }^{\circ}\text{C}$ or less)
	Device ambient temperature	$T_a = 0$ to $45\text{ }^{\circ}\text{C}$
	Others	Consumption power, ambient temperature, heat radiation conditions $T_j = P_D \times \theta_{ja} + T_a$
Humidity	Relative humidity	$RH = 45$ to $75\%RH$
	Others	Semiconductor devices and printed circuit boards are coated in case of condensation by rapid change of temperature
Voltage	Tolerance voltage	Max rating $\times 0.8$ or less
Current	Mean current	$I_C \times 0.5$ or less
Power	Mean power	Max rating $\times 0.5$ or less
Pulse*3	SOA	SOA curve $\times 0.8$ or less
	Overload voltage	Make the proper preventive way for overvoltage, including breakdowns by static electricity

Notes: 1. Exclude special applications.

2. Fill the requirements as many of these derating items as possible at the same time.

3. As for SOA, it is recommended to design the voltage, current, power, and junction temperature including surge etc. in consideration of the above derating design standard example in order to ensure reliability.

Even if the device is being used within Absolute maximum rating (Operating temperature/Rated current/Rated voltage etc.), be used continuously at high load (High temperature and high current/High voltage applying/Large temperature change etc.) will reduce the reliability of the devices. Please refer to the appropriate reliability design with confirming of the Renesas Semiconductor Reliability Handbook (Recommendation for Handling and Usage of Semiconductor Devices/Derating) and the individual reliability information (Reliability test report/Estimated failure rate, etc.)

1.3 Selection of Package Type

Package types are generally classified to two, one is the hermetic sealed type using metal or glass and the other is the plastic molded type. Selection of package types should be done with considering the purpose of system, environment, reliability, cost etc.

The reliability of plastic molded-type semiconductor devices has been greatly improved. Recently, their applications have also been expanded to automobiles, measuring and control systems, and computer terminal equipment operated under relatively severe conditions. Actually, field application data has revealed that their trouble factors under favorable indoor environmental conditions are equivalent to those of the hermetically sealed type.

Recently, the miniaturization of electronic devices has progressed, packaging of semiconductor devices is also strongly demanded for miniaturization and thinning. In order to respond to these demands, devices of packages that can be surface-mounted like the chip parts of capacitors and resistors have been developed.

Surface-mount package has the following features compared to the insertion type package.

- (1) Since it is small, the mounting area can be reduced.
- (2) Since it is thin, the mounting height can be lowered.
- (3) Since it is not necessary a through-hole in the circuit board, the substrate density can be increased.
- (4) It is possible to double-sided mounting on the circuit board.

It has been developed various types of surface mount package. And mountability, ease of use, heat resistance etc. are different for each package. When using these package, it is necessary to use with an understanding of the features of the package.

For details of the surface mount package, refer to RENESAS Semiconductor Package Mount Manual.

2. Precautions for Physical Handling

There are considerable precautions when semiconductor devices are attached to circuits. In order not to impair the reliability of the semiconductor devices during installation, care should be taken in forming and cutting leads, mounting on the circuit boards, soldering, removing residual flux, mounting to the heat sink, positioning of component parts, circuit board coating, etc. In order to ensure the reliability, it is necessary to pay attention to these attachments mounting methods.

2.1 Forming and Cutting Leads

When forming and cutting the leads of semiconductor devices, be careful of the following points:

- (1) When bending the lead, fix between the lead bending point and the package body so that relative stress is not applied between the package body and the lead. Then, do not bend the lead while holding the package body (see figure 1). And, when forming outer leads using a metal mold, use a mechanism that fixes the outer leads. And, the mechanism to secure the lead also please be careful to not put stress on the semiconductor device body (See figure 2).

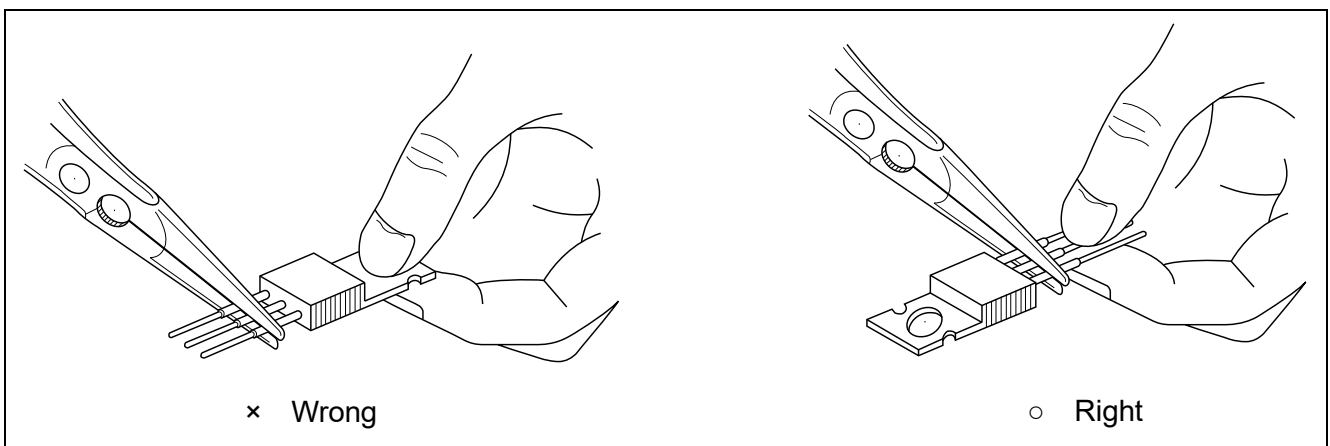


Figure 1 How to Bend Package Leads with Handling

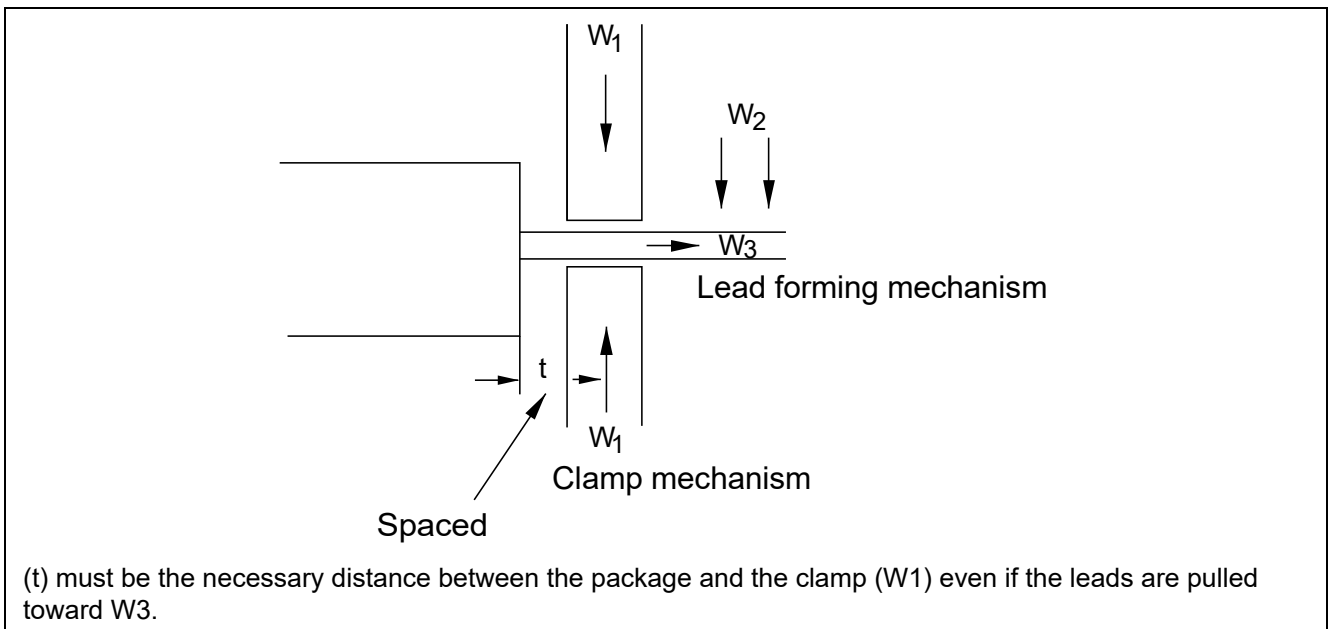


Figure 2 How to Bend the Lead by Using a Mold

- (2) When bending the leads at right angles, make the bend at least 3 mm away from the package end as illustrated in figure 3 (A). Do not bend them more than 90°. When they must be bent less than 90°, allow a space of more than 1.5 mm (See figure 3 (B)).
- (3) Do not repeatedly bend the leads.
- (4) Do not bend them sideways as shown in figure 3 (C).
- (5) A lead of a semiconductor device can be broken by excessive stress (such as tension) in the axial direction, so do not apply more than the prescribed force. The prescribed stress will vary depending on the cross-sectional area of a lead.
- (6) Depending on the shape of the bending jig or tool, the plated surface of an outer lead can be damaged, so exercise caution.

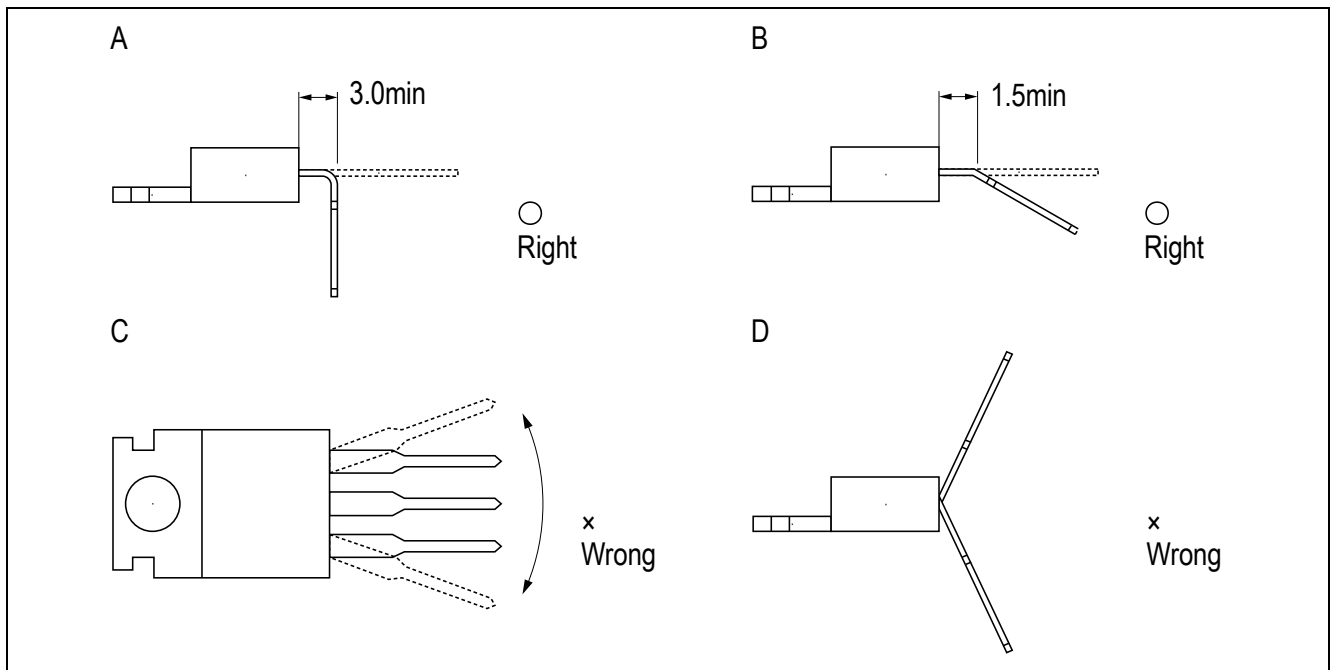


Figure 3 Places and Angles for Lead Bending

2.2 Mounting on the Circuit Board

Care must be taken not to apply excessive stress to the lead when attaching the semiconductor device to the circuit board.

The main points to notice are as follows. (see figure 4)

- (1) Make installation holes on the circuit board at intervals corresponding to the distance between leads, so that no excessive stress is produced when mounting.
- (2) When a device is inserted into a circuit board, do not pull on the leads with excessive force from the backside, and do not put stress on between the leads and the case.
- (3) Leave proper space between the semiconductor device and the circuit board surface. Insertion of a spacer between them is recommended.
- (4) Do not apply any additional stress to the device already attached to the board. For example, if a semiconductor device is connected to a heat sink after the leads of the semiconductor device have been soldered to the circuit board, stresses produced by small differences in lead length and component distance will be concentrated on the leads. As the result, problems like detached leads, broken packages, or broken bonding wires may occur. In order to prevent these accurately position the semiconductor device first and solder the leads later.
- (5) Refer to paragraph 2.1 when automatic forming and soldering machines are used.

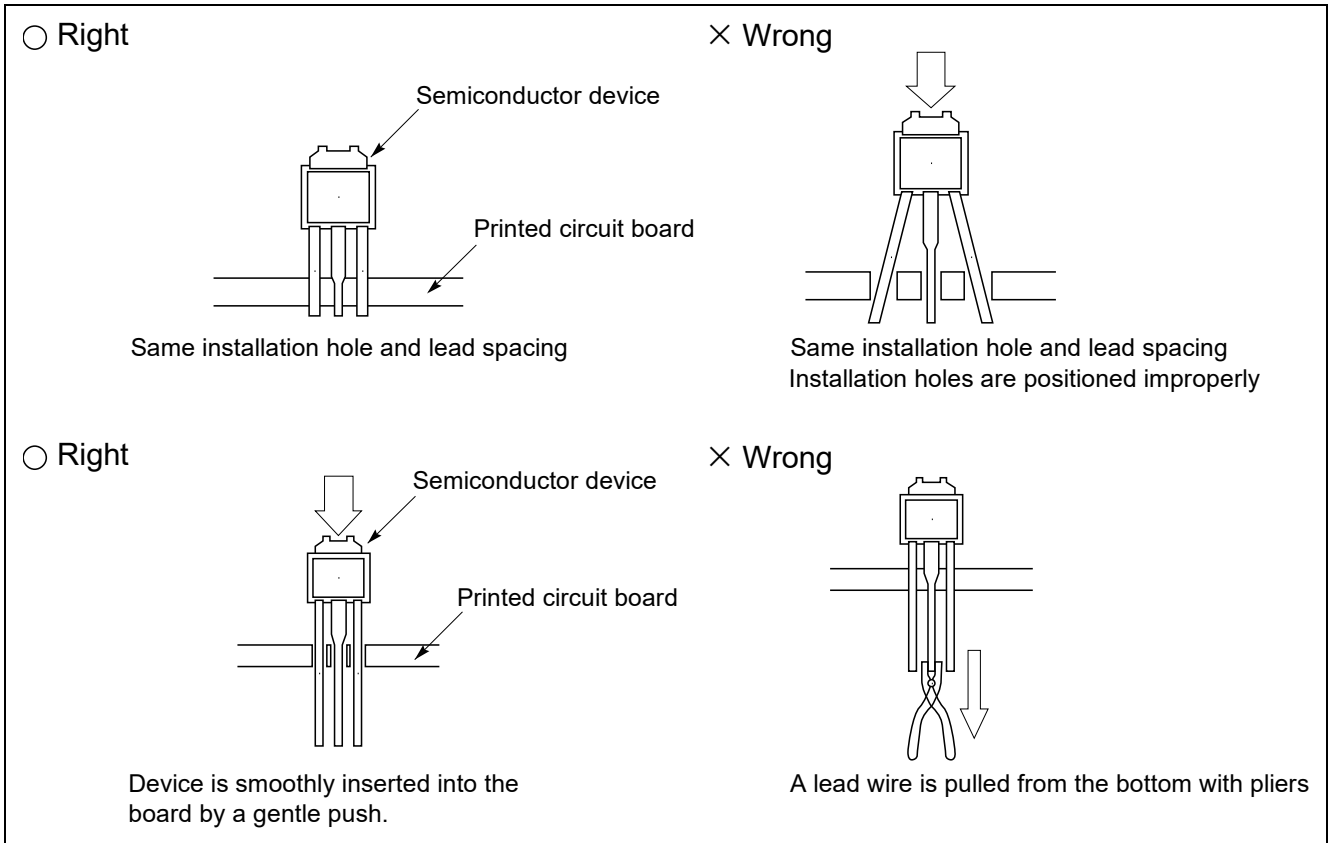


Figure 4 Mounting Method to Circuit Boards

2.3 Soldering

It is not good in general to leave semiconductor devices at high temperatures for a long term. Regardless of the soldering method, whether it may be a soldering iron or the flowing solder method, soldering must be done in the shorter time and at the lowest temperature possible. Your soldering work must meet test conditions of resistance of soldering heat, tolerability, namely, 260°C for 10 seconds and 350°C for 3 seconds at a point 1 to 1.5 mm away from the package body. Therefore, when the soldering work, be careful not to exceed these values. An example of junction temperature increasing curves during soldering obtained from a plastic package small power transistor is shown in figure 5. These data were measured after dipping the transistors into the soldering baths at 260°C or 350°C, respectively, for the prescribed periods. If transistors are soldered at temperatures or periods of time exceeding the ratings, their temperature rises and may be degraded or in the worst case broken.

Use of a strong alkali or acid flux may corrode the leads, deteriorating device characteristics. The use of rosin type flux is recommended. The recommended soldering iron is the type that is operated with a secondary voltage supplied by a transformer and grounded to prevent current leads. (see figure 6). Also, try to solder the leads at the farthest point from the package body.

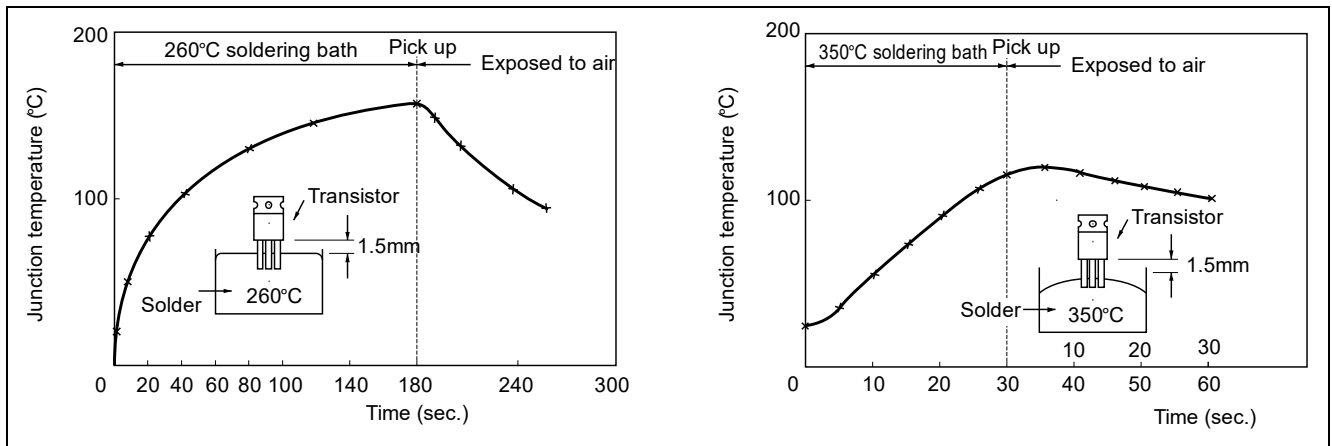


Figure 5 Junction Temperature Curves During Soldering

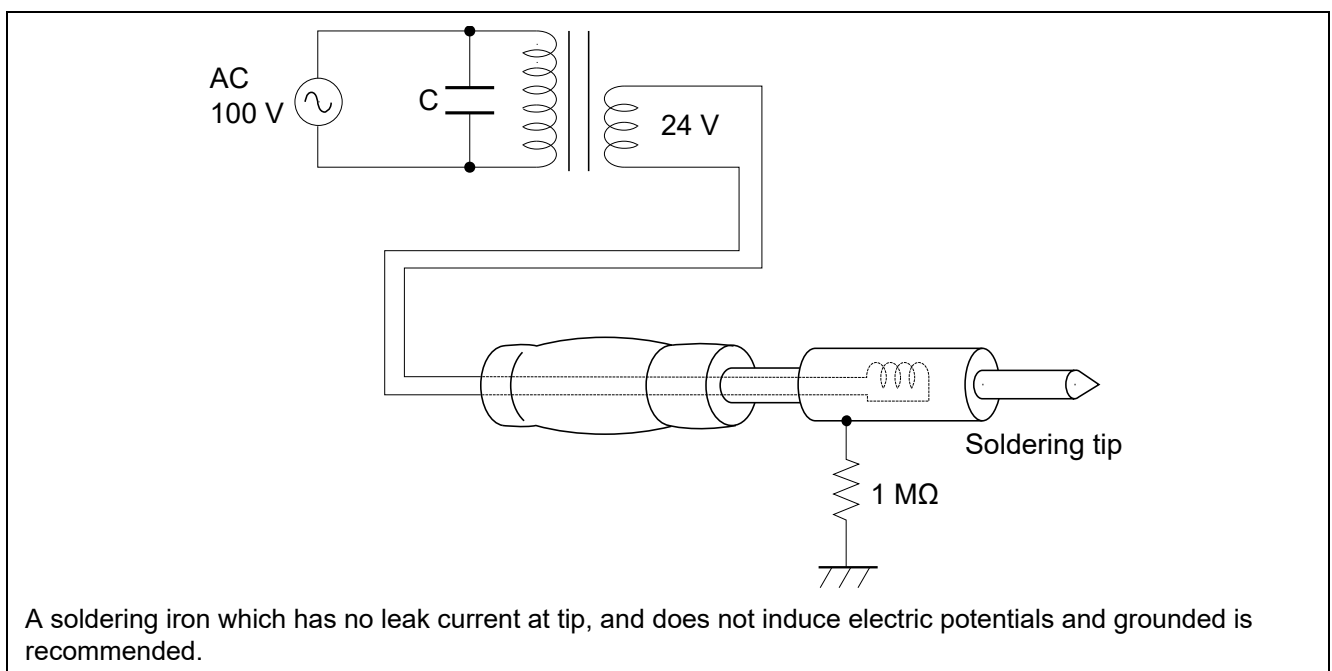


Figure 6 Recommended Soldering Iron

2.4 Removing Residual Flux

To ensure the reliability and lifetime of electronic systems, residual flux must be removed from circuit boards. If not removing flux, the reliability of the semiconductor device and board wiring may be affected. For washing, it is usual to use detergent or ultrasonic waves. For example, if chlorinated detergent is used for the plastic molded semiconductor devices, package corrosion may occur. Also, even with general removal agents, cleaning over extended periods or at high temperatures will cause swollen chip coating material to solvent permeation, so please consider sufficiently to these precautions prior to determining the type of detergent and cleaning condition. Do not use any trichloroethylene solvent.

The recommended conditions for ultrasonic washing are shown below :

- Frequency: 28 to 29 kHz (the semiconductor device must not resonate)
- Ultrasonic output: 15W/I (once)
- Do not allow the devices to contact the generator source directly.
- Washing time: Less than 30 seconds

2.5 About Heat Sink Mounting

The heat sink is normally used to radiate heat from the power device preventing a rise of the junction temperature. There is a heat radiation effect by attaching a heat sink to semiconductor devices, but the following handling precautions are necessary to ensure the reliability.

(1) Selection of silicon grease

In order to improve heat radiation efficiency by increasing the heat conductivity from the semiconductor device to the heat sink, generally, silicon grease is applied thinly and uniformly to the contact surface between the semiconductor device and the heat sink and then installed. However, some types of silicon grease, the semiconductor device absorbs grease oil and swells the internal chip coating agent. Therefore, when selecting a silicon grease, to prevent chip coat swelling, a special oil featuring outstanding oil separation and excellent permeation to the mold resin is employed.

(2) Selection of the insulator (insulating sheet)

When a non-insulated package whose metal is exposed on the back side is mounted on the heat sink, a high voltage is applied to the heat sink through the metal on the back side, so insulate it with insulator. Thermal resistance of the insulator is determined by material, thickness, area, thermal conductivity, etc. However, since it affects the junction temperature of the semiconductor device, so please select the semiconductor devices that can be used within the maximum ratings.

(3) Setting optimal tightening torque / hold down torque

If the tightening torque is too loose, thermal resistance will be increased. On the contrary, if it is too tight, the semiconductor device will be distorted and its pellet and leads may be broken.

Please apply optimum tightening torque/hold down torque range which has been listed in a table 2.

Table 2 Optimum Tightening Torque / Hold Down Torque for Typical Packages

Package type	Optimum tightening torque / Hold down torque
TO-220AB	0.39 to 0.59 [N · m]
TO-3P, TO-3PL, TO-3PSG, TO-247	0.59 to 0.78 [N · m]
TO-220FM, TO-220CFM, TO-220FN TO-220FL, TO-220FP	0.39 to 0.59 [N · m]
TO-3PFM, TO-3PF, TO-3PFP	0.39 to 0.59 [N · m]
TO-247plus	20 to 100 [N]

(4) Regarding flatness of heat sink

When the heat sink is attached to the semiconductor device, if the flatness of the heat sink is not appropriate, the heat dissipation effect will be hindered. When abnormal stress is applied, characteristic deterioration and resin crack will occur. When mounting the semiconductor device on a heat sink, observe the following precautions:

- (i) Check to ensure that aluminum, copper, or iron plate edges are smooth without burrs and that all screw holes have been chamfered.
- (ii) The surface of the heat sink in contact with semiconductor devices must be polished flat.
- (iii) Make sure that metallic chips or foreign matter is not left between the heat sink and semiconductor device. (Please be more careful about TO-220FM and TO-3PFM. It causes the dielectric breakdown.)

(5) Inhibition of direct soldering to the radiation fin of the semiconductor device

If the radiation fin of the semiconductor device is directly soldered, junction temperature will rise far above the rating and the semiconductor device may be broken or its lifetime is remarkably reduced.

(6) Don't apply mechanical stress to the package

If a screw driver or fastening jig hits the plastic package while tightening the heat sink, not only the package may be cracked but the mechanical stress may be transmitted to the inside of the device and wire fatigue may result in breakage or disconnection.

(7) Don't mount the semiconductor device to a heat sink after soldering them.

If a semiconductor device is mounted on a heat sink whose leads have already been soldered to the circuit board, excessive stress will be concentrated on the leads due differences in lead length and distance between the heat sink and the semiconductor device on the circuit board. This may cause the loosened leads, package damage, or disconnection of a bonding wire. Therefore, solder the leads of the semiconductor device after mounting it on a heat sink.

(8) Do not machining or deform a semiconductor device.

If a semiconductor device is machined or deformed, the thermal resistance will be increases or abnormal stress applied to the internal of a semiconductor device, it will be the cause of the failure.

(9) Use the recommended parts (spacer, washer, lug terminal, screw, nut, etc.) for the semiconductor device installation (see figure 7).

(10) Use only suitable screws

Machine screws and tapping screws are used to mount the heat sink on the semiconductor device. Observe the following precautions:

- (i) Use binding-head screws and truss-head screws specified by JIS-*B1101 standard or screws with equivalent heads.

* Japanese Industrial Standards

- (ii) Don't use flat head screws which cause abnormal stress in the semiconductor device (see figure 8).
- (iii) Also, when using tapping screws, be sure to apply the tightening torque in table 2.
- (iv) When using tapping screws, do not use thicker than the hole diameter of the mounting part of the semiconductor device. If a thicker screw than the installation hole of the semiconductor device is used, it will tap not only on the heat sink but also the installation hole of the semiconductor device, which will cause malfunction. (Especially, in the case of the TO-220FM package and TO-3PFM package, when a tap injury occurs in the installation hole, dielectric breakdown will occur in that portion.)

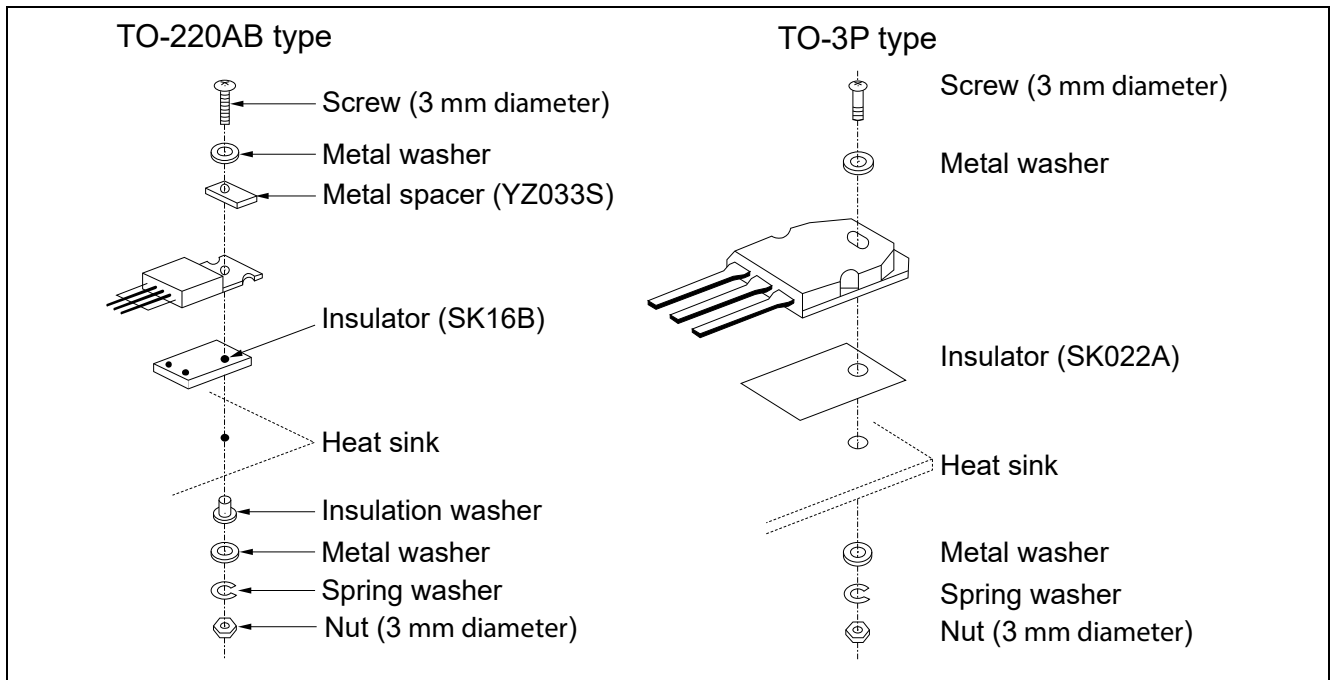


Figure 7 Examples of Power Device Installations

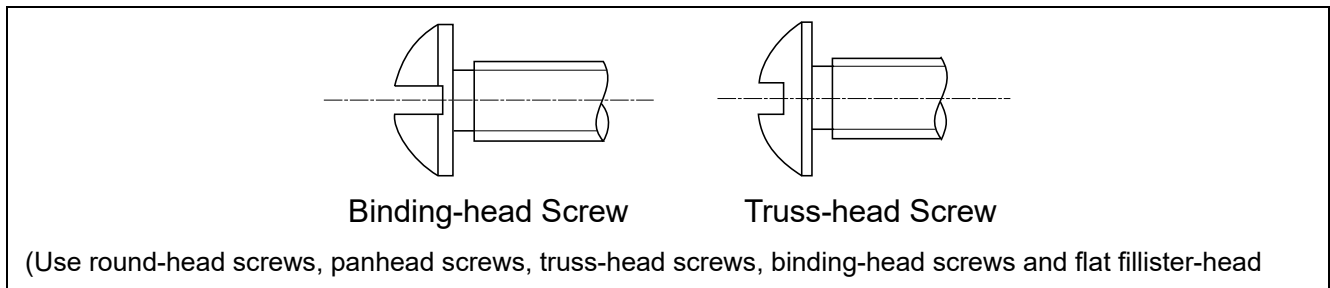


Figure 8 Recommended screws and prohibited screws

(11) Screw hole diameter of the heat sink

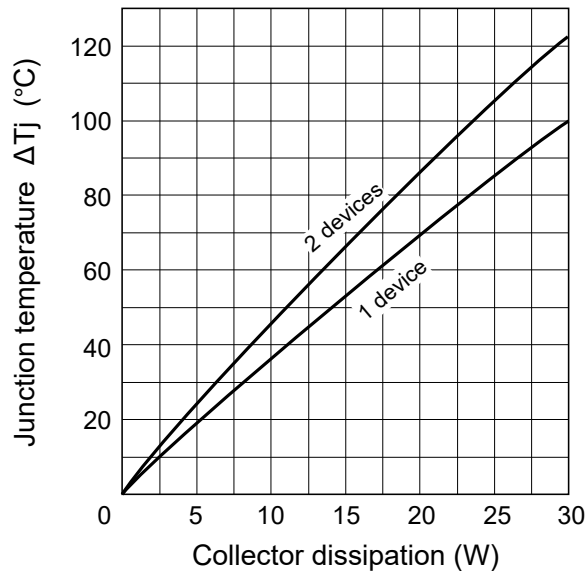
- (i) If diameter is too large: Do not make the heat sink hole diameter or chamfering larger than the head diameter of the screw to be used. Especially, take care when mounting the semiconductor devices (TO-220AB, TO-3P, etc.)

using copper frame on the heat sink, because the copper frame and plastic package are easily deformed by the tightening torque.

- (ii) If diameter is too small: Especially, when tapping screws are used, the tightening torque increases, exceeds the recommended tightening torque value, or the desired contact resistance may not be obtained.

(12) Other precautions and recommendations for heat sink installation

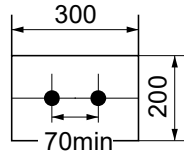
- (i) When two or more semiconductor devices are attached to same heat sink, the thermal resistance of each semiconductor device is increased (see figure 9).
- (ii) Heat sink must have a suitable shape and dimensions for efficient radiation. Also, forcibly cool down the semiconductor devices etc., if necessary. (figure 10 and figure 11).



Notes: (1) Heat sink, aluminium plate (mm) 300 x 200 x 1.5

(2) Method of installation:

(a) Position: As illustrated (unit: mm)



(b) Tightening torque: 9 kg·cm.

(c) Silicone oil was applied to the contact surface and mylar was not used.

(d) Natural ventilation, horizontal position

Figure 9 Thermal Resistance with 2 Semiconductor Devices on a Heat Sink

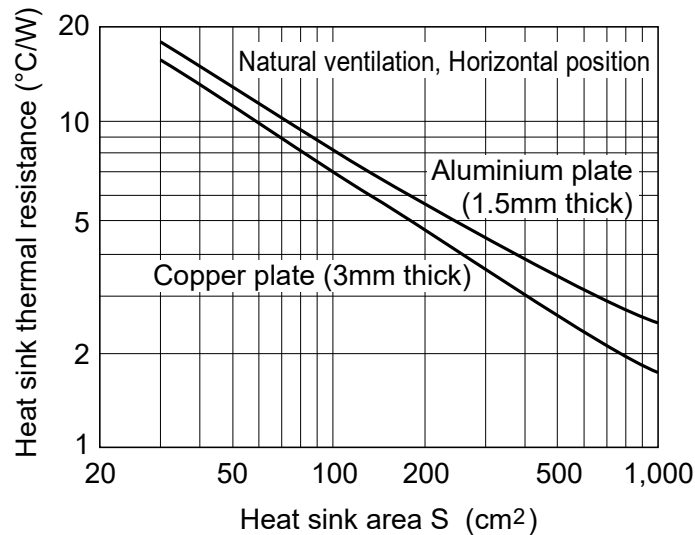
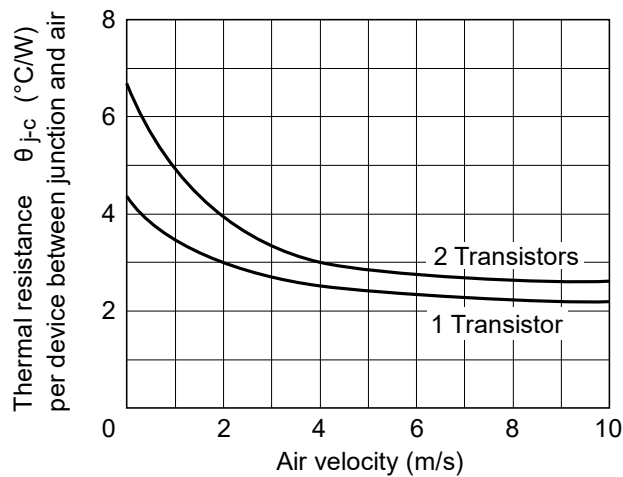


Figure 10 Relation between Heat Sink Area and Thermal Resistance



Notes: 1. Insulator was not used and silicone oil was applied to the contact surface.
2. Ventilation: As illustrated

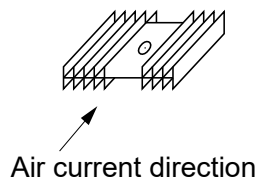


Figure 11 Thermal Resistance with Forced Air cooling

2.6 Positioning of Component Parts

Reliability and characteristics of semiconductor devices are remarkably affected by operating environments. Therefore, it is not only important to examine operating temperatures and the heat radiation methods, but also the positioning of each semiconductor device in the system, to obtain high reliability.

Improper example of positioning of component parts are as follows:

- (1) When there is a heat source such as a large resistor near the semiconductor device and the heat sink for the semiconductor device is heated or the semiconductor device is directly heated, the reliability is lowered by abnormal heating. Therefore, in this case, placement considering ventilation is necessary.
- (2) In the equipment, dust collects easily in the vicinity of the high voltage circuit and the corner of the lower part of the equipment. The semiconductor devices in such an environment may be insulation degrade and malfunction by adhesion of dust. As a countermeasure method, there are methods such as coating the printed board and the semiconductor device with a water-proof resin.
For example, there are troubles, such as the following.
 - (i) It will malfunction because of a short circuit by the conductive foreign matter (Solder waste, Plated scrap, etc.) between the circuit board wiring and the terminal of the semiconductor device.
 - (ii) Dust accumulation and moisture absorption cause noise.
 - (iii) Trouble due to large leakage current.
 - (iv) Trouble due to metallic migration (Ag migration) occurring in exposure environment.
 In a harsh environments with high humidity, exposure and dusty deposition, in systems that are used for a long-term maintenance-free operation, substrate coating is an important means for ensuring reliability.
- (3) In the case of equipment used for high voltage or high frequency applications, surge voltage may be induced to semiconductors depending on the method of wires bundling and path of connecting wires.
Take care not to expose the semiconductors to such conditions. Refer to paragraph 3.2.
- (4) A test terminal for operation confirmation may be provided on the printed board. Wiring should be performed in the place where the abnormal voltage is not erroneously applied during maintenance and service.

3. Mounting Precautions

To make reliable circuits, it is necessary to consider the applications of derating and safety allowances for possible fluctuations of characteristics during operation, in addition to the satisfaction of initial device ratings incorporated. The problems to be taken up, for making reliable circuits, are methods of wiring, external surge, reactive load, noise margin, safe operation area (SOA), reverse bias, fly-back pulse, static charge, pulse stress, and others.

3.1 General Precautions

The important things to assure the reliability of system are: Use them within the maximum ratings specified in the brochure and pay special attention to the operating environments detailed below.

- (1) Keep to lower ambient temperatures of the semiconductor devices.
- (2) Operate the semiconductor devices within the prescribed ratings for power voltage, input voltage, and power consumption. Also, apply deratings.
- (3) Take care not to allow any induction voltage or overvoltage, accompanied by noise, to the input, output, or power source terminals. Also, care must be used not to let strong electromagnetic waves affect semiconductor devices.
- (4) Prevent static electricity etc. during operation.
- (5) Since the semiconductor devices for high-speed operation has a fine structure, add a protection circuit etc. to the input part or do not apply electrostatic pulse.
- (6) When the power supply turns ON/OFF, do not imbalance the voltage application.
For example, if voltage is applied to the input or power terminal whose grounding terminal is floating, excessive stress will be put on the semiconductor device.

3.2 Noise and Surge Countermeasures

The problems of surge voltage, static charge, and noise are common to all semiconductor devices and the necessary countermeasures should be taken to eliminate the causes of these problems.

In general, electronic equipment is designed considering about a 10% voltage fluctuation from commercial electric power-sources. However, if any equipment which produces surge voltage is operated in the near area, it may cause failures and malfunctions in other electronic equipment through line voltage. The similar type of noise in the form of pulse is also produced in the power supply lines by thunderbolt. To reduce the influence of line surges, it is useful to connect a filter to the A.C. input line as shown in figure 12. If there is a possibility that the component parts or semiconductor devices in the circuit will directly be exposed to a surge or static charge, a shielding system must be provided. When installing a shielding circuit, make sure that the ground impedance is low enough.

If there is a possibility that a static charge or surge pulse will be applied to the semiconductor devices in the form of noise, a protective circuit shown in figure 13 may be connected, in special cases. In this circuit, a suitable value of $R_i \times C_i$ Time Constant must be determined to absorb surge noise without affecting circuit operation.

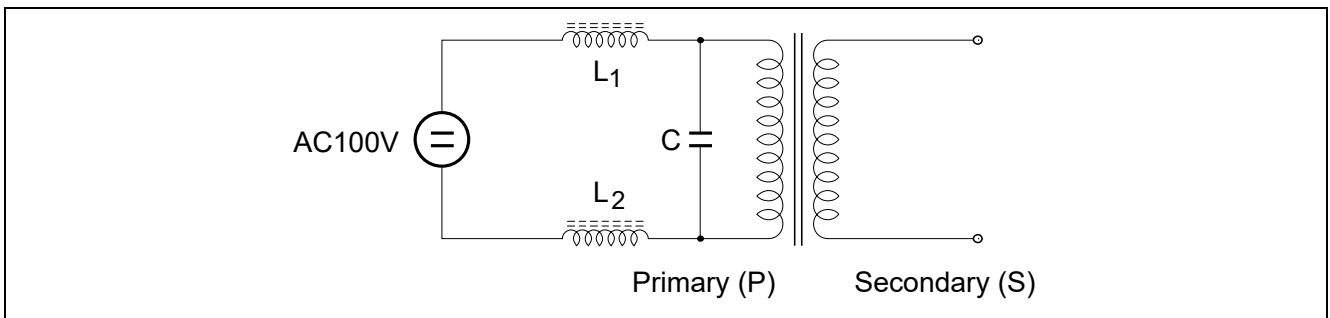


Figure 12 An Example of a Surge Absorption Circuit

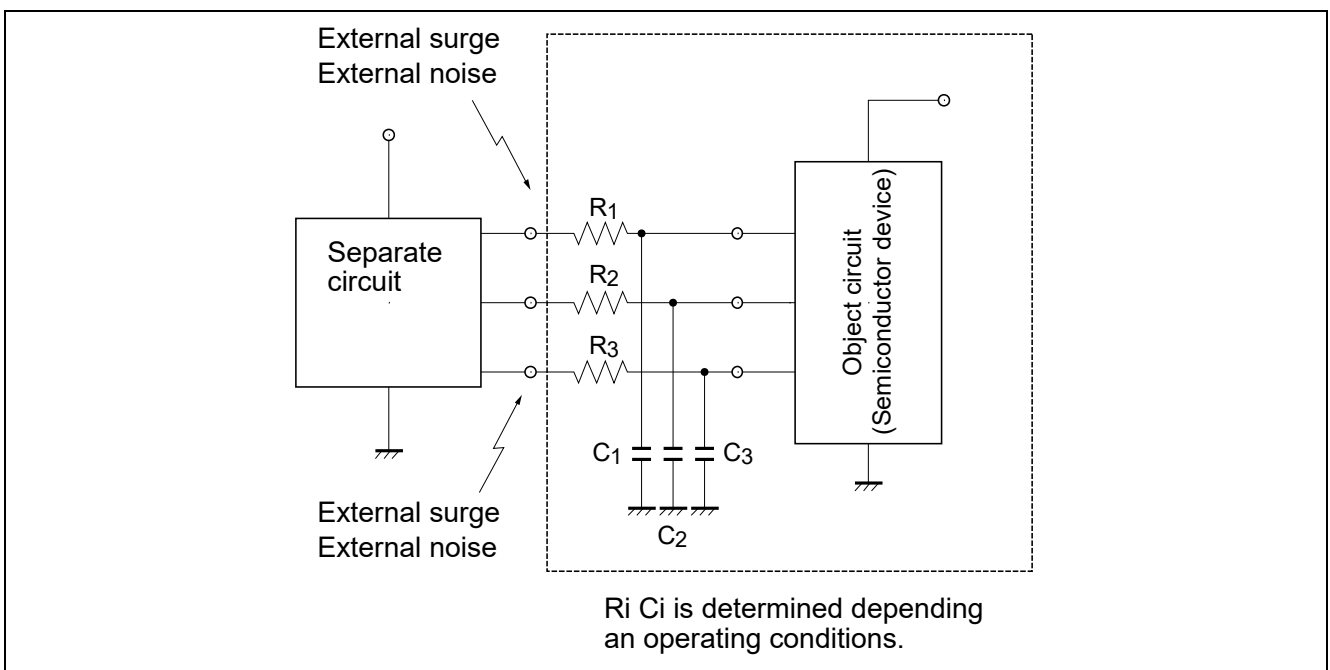


Figure 13 An Example of a Protection Circuit for Surge

3.3 Relation between Characteristic Parameters and Reliability

Characteristic parameters and their required ranges for each semiconductor device are fixed according to function and application. The importance of these parameters are sometimes different in designing systems. Cares must be needed for important parameters, for instance taking a margin of initial characteristic or considering a derating.

With regard to take a margin, it is important to choose a semiconductor device with considering the operating limit of system or to apply the statistical designing method, or to design with considering the value of failure judgement already mentioned in chapter 1.2. Regarding the fluctuation parameters, for items with no system margin or important items, design them with consideration of the failure judgement standard values.

The following points are essential for parameter assessment:

- (1) Is the parameter important? Does it cause the system failure?
- (2) Consider the initial value margin of the parameter.
- (3) Does it vary with time or not? If yes, does it fluctuate in an allowable direction?
- (4) Is the fluctuation allowable or not in relation to other devices being used?
- (5) Is their redundancy in the design?
- (6) Is it possible to employ a statistical designing method for the parameters?

4. Precautions on Storage, Transport and ESD Damage

4.1 Storage

When storing semiconductor devices, environmental control is necessary for temperature, humidity, ultraviolet rays, harmful gases such as hydrogen sulfide, radiation such as X-rays, static electricity and strong electromagnetic fields.

(1) Storage Environment

(a) Ambient temperature and Humidity

The temperature and humidity of the storage location of the semiconductor device are preferably in normal temperature and normal humidity. Avoid temperature and humidity that are too far from these. As a condition of normal temperature and normal humidity, it is desirable that $T_a = 15$ to $35\text{ }^{\circ}\text{C}$ and $RH = 45$ to $75\text{ \%RH}$. (For some products there are restriction in the storage conditions. In such cases, observe the prescribed storage conditions.). When it is very dry, such as during winter, it is necessary to use a humidifier. If tap water is used in the humidifier the chlorine in it can corrode leads of the semiconductor devices, so purified or distilled water should be used.

(b) Clean location

Avoid places that are dusty or where corrosive gases are generated.

(c) Stable temperature

Avoid environments where there are sudden temperature changes, since moisture condensation can occur in semiconductor devices. Choose darker places with no direct sunlight or strong lighting.

(d) Other

Choose a location free from radiation, static electricity, and strong electromagnetic fields.

(2) Storage form

- (a) Care is required so that weight is not applied to semiconductor devices in storage. Especially, in the stacked state, excessive weight is applied to the semiconductor device. Avoid placing heavy objects on semiconductor devices. (see figure 14)

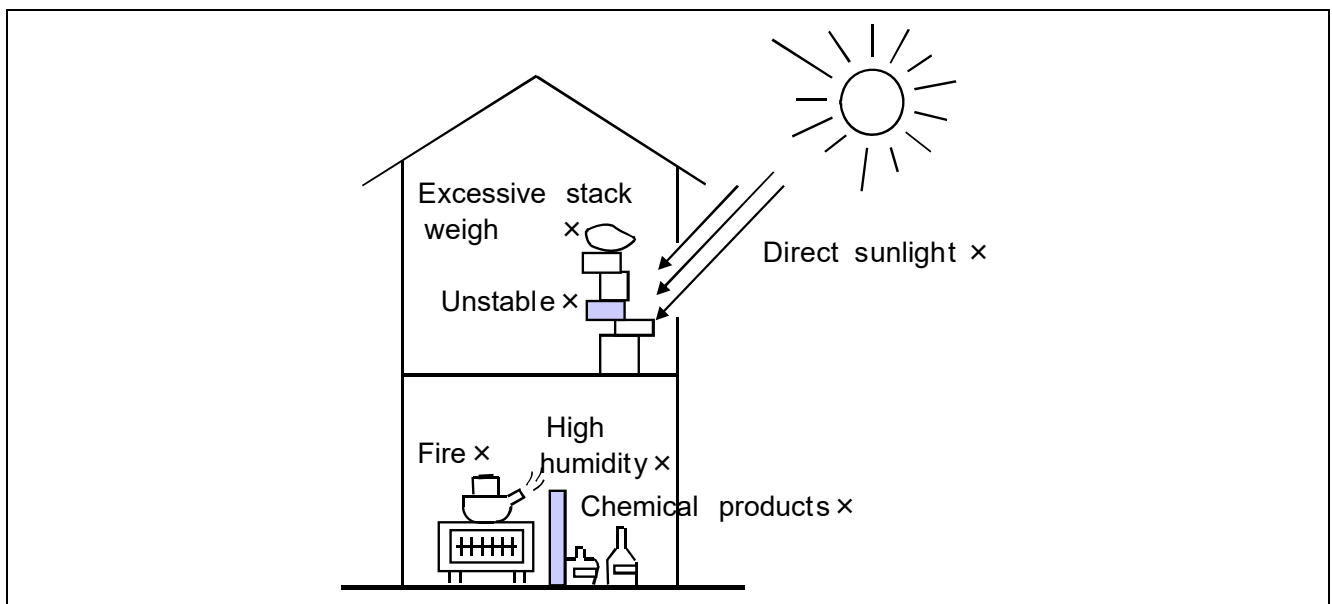


Figure 14 Bad Storage Locations

(b) Store semiconductor device external terminals in an unprocessed condition. This is to avoid solder-ability failure during mounting due to occurrence of rust etc.

(c) Choose containers that do not charge easily for storing semiconductor devices.

(3) Long Term Storage

When storing semiconductor devices for long periods, there is a chance of lead pin solder-ability decrease, rusting, or electrical characteristic faults. The following cautions are especially necessary.

(a) For the storage environment, please refer to the previous section (1).

(b) When long term storage is foreseen, use vacuum packing or put silica gel in a sealed container.

(c) If long term has passed under normal storage conditions, it is necessary to inspect solderability and lead rust before use.

(d) Devices that have been placed in poor environment also must be examined for solderability, and including of rusting of the leads, and electrical characteristics.

4.2 Transport

(1) During products transport, if the product is subjected to shock or falls, it will cause it to break.

(2) When the products get wet, it causes a failure. So as not to wet with rain and snow, please cover a sheet.

4.3 Electrostatic breakdown prevention

(1) Please be grounded when handling the semiconductor devices. An example of grounding is shown in figure 15.

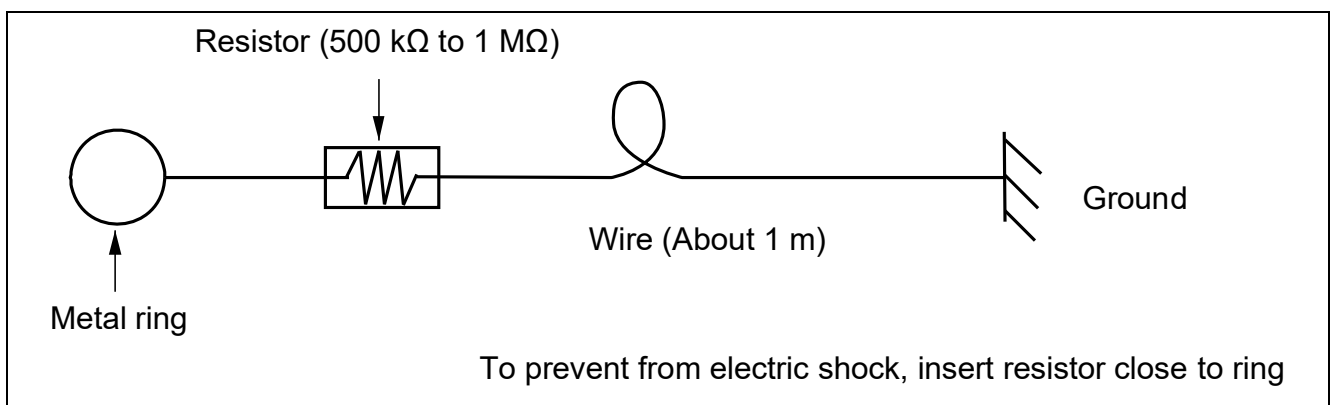


Figure 15 Example of body grounding

(2) Use a conductivity mat for the workbench which puts a semiconductor device. Be grounded through a resistor of 1 MΩ to the mat.

(3) When measuring a semiconductor device element, measuring instrument (curve tracer, etc.) should be grounded.

(4) To prevent the leakage voltage of the soldering iron from applying to the semiconductor device, ground the iron tip of the soldering iron through 1 MΩ. (It is recommended to use a soldering iron for low voltage.)

(5) When transporting in the circuit boards, it should be used packaging material made of conductive sheet. Unless the gate and the source are connected by resistor or inductors. (Therefore, it is recommended to first install the parts between to the gate and the source.)

(6) Do not put the semiconductor devices in a plastic case or plastic bag directly. Please use conductive container or aluminum foil etc.

5. Reliability test methods and failure determination criteria for semiconductor devices

The reliability test methods to check the reliability of semiconductor devices vary depending on the purposes of the tests. Moreover, when performing a reliability test, what need to be determined first should be the definitions of defects and failures (failure determination criteria).

Outlined below are the reliability test methods and the failure determination criteria for package.

5.1 Reliability test methods

- (1) When performing a reliability test, an appropriate test method should be chosen, proper test conditions should be selected and reliable determination criteria should be set out fitting to applications of the product or to the purposes of the test. For example, if a test is meant to find out the limits or if a test is meant to determine if a product conforms to the specifications would require different test plans, respectively. What to use as the failure detection mode should also be important and the environmental factors relevant to the structures, production processes and using conditions of respective devices, means "stress", should normally be used as the failure detection mode. Meanwhile, such stress can be singular or multiplex depending on the circumstances.

When applying multiplex stress, it is necessary to consider the actual using environments.

Upon the above prerequisites, objectives of implementing the reliability tests should be to make accurate presuppositions and to contribute to enhancement of the reliabilities of the object devices. For this purpose, it becomes necessary to accumulate the accomplishments of various reliability tests and to feed back the failure analysis results.

- (2) While, as the reliability tests, tests under the actual using conditions should be ideal but, in majority of the cases, it becomes extremely difficult to acquire accurate and sufficient data within the limited time and costs. Consequently, it is necessary to simulate them as far as feasible.

In such cases, although stress conditions not as far as causing breakage will usually be selected as the stress strength, depending on the circumstances, stress conditions causing breakage may sometimes be applied intentionally to cause failures in an earlier stage for the failure analysis purposes.

Meanwhile, from the viewpoint of reproducibility of the reliability tests, standardized test methods should also become necessary. The EIAJ Standard, JIS Standard, IEC Standard, MIL Standard, etc. prescribe these test methods. They are exemplified in Table 3 below, listing their typical reliability test standards.

Table 3 Typical reliability test standards

JEITA (Japan Electronics and Information Technology industries Association) Standards	
JEITA ED-4701:	Environmental and durability test methods for semiconductor devices
JIS (Japanese Industrial Standards) Standards	
JIS C60068:	Environmental test methods and durability test methods for individual semiconductor devices
IEC (International Electrotechnical Commission) Standards	
IEC-60068:	Environmental test methods
IEC-60749:	Mechanical test methods and environmental test methods for semiconductor devices
MIL (U.S. Military Standard) Standards	
MIL-STD-202F:	Test methods for electronic parts and electric parts
MIL-STD-750C:	Test methods for individual semiconductor devices
MIL-STD-883D:	Micro-Electronics test methods

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Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

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