3 General Safety Precautions and Usage Considerations

This section is designed to help you gain a better understanding of semiconductor devices, so as to ensure the safety, quality and reliability of the devices which you incorporate into your designs.

3.1 From Incoming to Shipping

3.1.1 Electrostatic Discharge (ESD)

When handling individual devices (which are not yet mounted on a printed circuit board), be sure that the environment is protected against electrostatic electricity. Operators should wear anti-static clothing, and containers and other objects that come into direct contact with devices should be made of anti-static materials and should be grounded to earth via an 0.5- to 1.0-MΩ protective resistor.
Please follow the precautions described below; this is particularly important for devices which are marked "Be careful of static.".

3.1.1.1 Work Environment

(1) When humidity in the working environment decreases, the human body and other insulators can easily become charged with static electricity due to friction. Maintain the recommended humidity of 40% to 60% in the work environment, while also taking into account the fact that moisture-proof-packed products may absorb moisture after unpacking.

(2) Be sure that all equipment, jigs and tools in the working area are grounded to earth.

(3) Place a conductive mat over the floor of the work area, or take other appropriate measures, so that the floor surface is protected against static electricity and is grounded to earth. The surface resistivity should be 10^4 to 10^8 Ω/sq and the resistance between surface and ground, 7.5×10^5 to 10^8 Ω.

(4) Cover the workbench surface also with a conductive mat (with a surface resistivity of 10^4 to 10^8 Ω/sq, for a resistance between surface and ground of 7.5×10^5 to 10^8 Ω). The purpose of this is to disperse static electricity on the surface (through resistive components) and ground it to earth. Workbench surfaces must not be constructed of low-resistance metallic materials that allow rapid static discharge when a charged device touches them directly.

(5) Pay attention to the following points when using automatic equipment in your workplace:

(a) When picking up ICs with a vacuum unit, use a conductive rubber fitting at the end of the pick-up wand to protect against electrostatic charge.

(b) Minimize friction on IC package surfaces. If some rubbing is unavoidable due to the device's mechanical structure, minimize the friction plane or use material with a small friction coefficient and low electrical resistance. Also consider the use of an ionizer.

(c) In sections that come into contact with device lead terminals, use a material that dissipates static electricity.

(d) Ensure that no statically charged bodies (such as work clothes or the human body) touch the devices.

(e) Make sure that sections of the tape carrier which come into contact with installation devices or other electrical machinery are made of a low-resistance material.

(f) Make sure that jigs and tools used in the assembly process do not touch devices.

(g) In processes in which packages may retain an electrostatic charge, use an ionizer to neutralize the ions.

(6) Make sure that CRT displays in the working area are protected against static charge, for

example by a VDT filter. As much as possible, avoid turning displays on and off. Doing so can cause electrostatic induction in devices.

(7) Keep track of charged potential in the working area by taking periodic measurements.

(8) Ensure that work chairs are protected by an anti-static textile cover and are grounded to the floor surface by a grounding chain. (Suggested resistance between the seat surface and grounding chain is 7.5×10^5 to 10^{12} Ω/sq.)

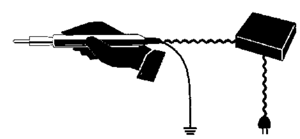
(9) Install anti-static mats on storage shelf surfaces. (Suggested surface resistivity is 10^4 to 10^8 Ω/sq; suggested resistance between surface and ground is 7.5×10^5 to 10^8 Ω/sq.)

(10) For transport and temporary storage of devices, use containers (boxes, jigs, bags) that are made of anti-static materials or of materials that dissipate electrostatic charge.

(11) Make sure that cart surfaces which come into contact with device packaging are made of materials that will conduct static electricity, and verify that they are grounded to the floor surface with a grounding chain. (The suggested resistance between the cart surface and grounding chain is 7.5×10^5 to 10^{10} Ω/sq.)

(12) In any location where the level of static electricity is to be closely controlled, the ground resistance level should be Class 3 or above. Use different ground wires for all items of equipment which may come into physical contact with devices.

3.1.1.2 Operating Environment



(1) Operators must wear anti-static clothing and conductive shoes (or a leg or heel strap).

(2) Operators must wear a wrist strap grounded to earth via a resistor of about 1 MΩ.

(3) Soldering irons must be grounded from iron tip to earth, and must be used only at low voltages (6 V to 24 V).

(4) If the tweezers you use are likely to touch the device terminals, use anti-static tweezers and in particular avoid metallic tweezers. If a charged device touches a low-resistance tool, rapid discharge can occur. When using vacuum tweezers, attach a conductive chucking pat to the tip, and connect it to a dedicated ground used especially for anti-static purposes (suggested resistance value: 10^4 to 10^8 Ω).

(5) Do not place devices or their containers near sources of strong electrical fields (such as above a CRT).

(6) When storing printed circuit boards which have devices mounted on them, use a board container or bag that is protected against static charge. To avoid the occurrence of static charge or discharge due to friction, keep the boards separate from one other and do not stack them directly on top of one another.

(7) Ensure, if possible, that any articles (such as clipboards) which are brought to any location where the level of static electricity must be closely controlled are constructed of anti-static materials.

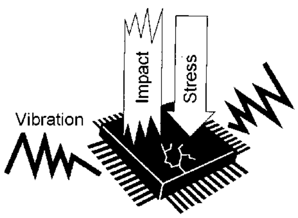
(8) In cases where the human body comes into direct contact with a device, be sure to wear anti-static finger covers or gloves (suggested resistance value: 10^8 Ω or less).

(9) Equipment safety covers installed near devices should have resistance ratings of 10^9 Ω or less.

(10) If a wrist strap cannot be used for some reason, and there is a possibility of imparting friction to devices, use an ionizer.

(11) The transport film used in TCP products is manufactured from materials in which static charges tend to build up. When using these products, install an ionizer to prevent the film from being charged with static electricity. Also, ensure that no static electricity will be applied to the product's copper foils by taking measures to prevent static occuring in the peripheral equipment.

3.1.2 Vibration, Impact and Stress



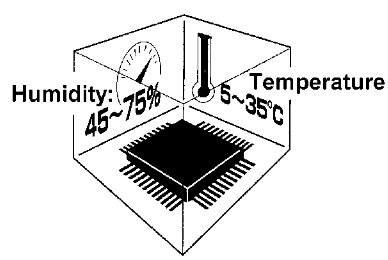
Handle devices and packaging materials with care. To avoid damage to devices, do not toss or drop packages. Ensure that devices are not subjected to mechanical vibration or shock during transportation. Ceramic package devices, and devices in canister-type packages which have empty space inside them, are subject to damage from vibration and shock because bonding wires are secured only at their ends. Plastic molded devices, on the other hand, have a relatively high level of resistance to vibration and mechanical shock because their bonding wires are enveloped and fixed in resin. However, when any device or package type is installed in target equipment, it is to some extent susceptible to wiring disconnections and other damage from vibration, shock and stressed solder junctions. Therefore when incorporating devices into the design of vibration-prone equipment, the structural design of the equipment must be thought out carefully.
If a device is subjected to especially strong vibration, mechanical shock or stress, the package or the chip itself may crack. In products such as CCDs which incorporate window glass, this could cause surface flaws in the glass or cause the glass connection to separate.
Furthermore, it is generally known that stress applied to a semiconductor device through the package changes the resistance characteristics of the chip because of piezoelectric effects. In analog circuit design, attention must be paid to the problem of package stress as well as to the dangers of vibration and shock as described above.

3.2 Storage

3.2.1 General Storage

(1) Avoid storage locations where devices will be exposed to moisture or direct sunlight. (Be especially careful during periods of rain or snow.)

(2) Do not place device cartons upside down. Stack cartons on top of one another in an upright position only; do not place cartons on their sides.



(3) The storage area temperature should be kept within a temperature range of 5°C to 35°C, and relative humidity should be maintained at between 45% and 75%.

(4) Do not store devices in the presence of harmful (especially corrosive) gases, or in dusty conditions.

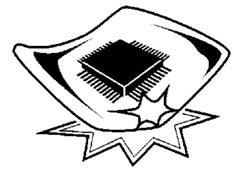
(5) Use storage areas where there is minimal temperature fluctuation. Rapid temperature changes can cause moisture to form on stored devices, resulting in lead oxidation or corrosion. As a result, the solderability of the leads will be degraded.

(6) When repacking devices, use anti-static containers.

(7) Do not allow external forces or loads to be applied to devices while they are in storage.

(8) If devices have been stored for more than two years, their electrical characteristics should be tested and their leads should be tested for ease of soldering before they are used.

3.2.2 Moisture-Proof Packing



(1) Do not drop or toss device packing. The laminated aluminum material in it can be rendered ineffective by rough handling.

(2) Ensure that packing materials are stored in a 30°C, 90% RH environment. Use devices within 12 months.

(3) If the 30% humidity indicator shown in Figure 3.2.1 is pink when the packing is opened, depending on the device and packing types, it may be advisable to bake the devices at high temperature to remove any moisture. See Section 3.2.2 (4) below. It may also be advisable to bake the devices if the effective usage period for the indicator has expired. After the pack is opened, use the devices in a 30°C, 60% RH environment, and within the effective usage period listed on the moisture-proof package.

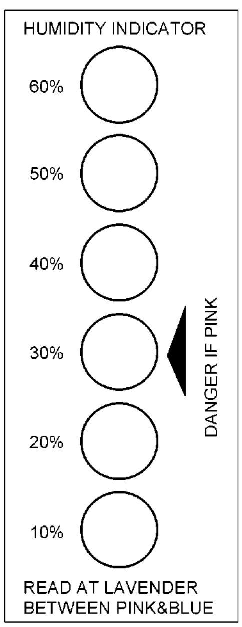
(4) The following describes high-temperature treatments for the various packing types. Contact Toshiba or a Toshiba distributor for more information.

(a) Tray: If the tray is heat-proof, bake at 125°C for 20 hours (heat-proof trays bear a "Heat-Proof" marking). Bake non-heat-proof trays at 70°C for 168 hours.

(b) Tube: Tubes are not heat-proof. Transfer devices to heat-proof trays or aluminum tubes before baking at 125°C for 20 hours.

(c) Tape: Packing that includes adhesive or embossed tape cannot be baked. Devices packed on tape must be used within the permitted time limit after unpacking, as specified on the packing.

For types (a) and (b), be careful not to bend device leads when baking.



The indicator shown on the left can detect the approximate humidity level at a standard temperature of 25°C. When the ambient humidity is below 10%, all the humidity indicators will be blue.

If the 30% humidity indicator is completely pink when the devices are unpacked, treat the devices at high temperature, as described in Section 3.2.2 (4) above, to remove moisture before use.

Figure 3.2.1 Humidity indicator

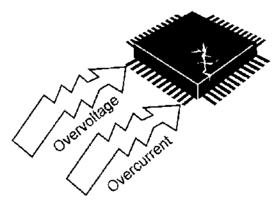
3.3 Design

Care must be exercised in the design of electronic equipment to achieve the desired reliability. It is important not only to adhere to specifications concerning absolute maximum ratings and recommended operating conditions, it is also important to consider the overall environment in which equipment will be used, including factors such as the ambient temperature, transient noise, voltage and current surges, as well as mounting conditions that affect device reliability. This section describes some general precautions that you should observe when designing circuits and when mounting devices on printed circuit boards.
For more detailed information about each product family, refer to the relevant individual databooks, available from Toshiba.

3.3.1 Absolute Maximum Ratings

⚠CAUTION

Do not use devices under conditions in which their absolute maximum ratings (e.g. current, voltage or power dissipation) will be exceeded. A device may break down or its performance may be degraded, causing it to catch fire or explode resulting in injury to the user.



The absolute maximum ratings are rated values which must not be exceeded during operation, even for an instant. Although absolute maximum ratings differ from product to product, they essentially concern the voltage and current at each pin, the allowable power dissipation, and the junction and storage temperatures.
If the voltage or current on any pin exceeds the absolute maximum rating, the device's internal circuitry can become degraded. In the worst case, heat generated in internal circuitry can fuse wiring or cause the semiconductor chip to break down.
If storage or operating temperatures exceed rated values, the package seal can deteriorate or the wires can become disconnected due to the differences between the thermal expansion coefficients of the materials from which the device is constructed.

3.3.2 Recommended Operating Conditions

The recommended operating conditions for each device are those necessary to guarantee that the device will operate as specified in the datasheet.
If greater reliability is required, derate the device's absolute maximum ratings for voltage, current, power and temperature before using it.

3.3.3 Derating

When incorporating a device into your design, reduce its rated maximum voltage, current, power dissipation and operating temperature in order to ensure high reliability.
Since derating differs from application to application, refer to the technical datasheets available for the various devices used in your design.

3.3.4 Unused Pins

Some devices can exhibit input instability problems if unused pins are left open. Similarly, care must be taken not to connect the output pins of a device to the power supply (Vcc or Vdd) pin or to other output pins. For details concerning the handling of unused pins, follow the procedures described in the relevant technical datasheet or databook for the device being used. CMOS logic IC inputs, for example, have extremely high impedance. If an input pin is left open, it can easily pick up extraneous noise and become unstable. In this case, if the input voltage level reaches an intermediate level, both the P-channel and N-channel transistors may be turned on, allowing unwanted supply current to flow. Therefore, ensure that the unused input pins of a device are connected to the power supply (Vcc) pin or ground (GND) pin of the same device. For details of what to do with the pins of heat sinks, refer to the relevant technical datasheet or databook.

3.3.5 Latch-up

Latch-up is an abnormal condition inherent in CMOS devices, in which Vcc gets shorted to ground. This happens when a parasitic PN-PN junction (thyristor structure) internal to the CMOS chip is turned on, causing a large current of the order of several hundred mA or more to flow between Vcc and GND, eventually causing the device to break down.
Latch-up occurs when the input/output voltage exceeds the rated value, causing a large current to flow in the internal chip, or when the voltage on the Vcc (Vdd) pin exceeds its rated value, forcing the internal chip into a breakdown condition. Once the chip falls into the latch-up state, even though the excess voltage may have been applied only for an instant, the large current continues to flow between Vcc (Vdd) and GND (Vss). This causes the device to heat up and, in extreme cases, to emit gas fumes as well. To avoid this problem, observe the following precautions:

(1) Do not allow voltage levels on the input/output pins either to rise above Vcc (Vdd) or to fall below GND (Vss). Also, follow any prescribed power-on sequence, so that power is applied gradually or in steps rather than abruptly.

(2) Allow no abnormal noise signals to be applied to the device.

(3) Set the voltage levels of unused input pins to Vcc (Vdd) or (GND) Vss.

(4) Do not connect outputs to one another.

3.3.6 Input/Output Protection

Wired-AND configurations, in which outputs are connected together, cannot be used, since this short-circuits the outputs. Outputs should, of course, never be connected to Vcc (Vdd) or GND (Vss).
Furthermore, ICs with tri-state outputs can undergo performance degradation if a shorted output current is allowed to flow for an extended period of time. Therefore, when designing circuits, make sure that tri-state outputs will not be enabled simultaneously.

3.3.7 Load Capacitance

Some devices display increased delay times if the load capacitance is large. Also, large charging and discharging currents will flow in the device, causing noise. Furthermore, since outputs are shorted for a relatively long time, wiring can become fused.
Consult the technical information for the device being used to determine the recommended load capacitance.

3.3.8 Thermal Design

The failure rate of semiconductor devices is greatly increased as operating temperatures increase. As shown in Figure 3.3.1, the internal thermal stress on a device is the sum of the ambient temperature and the temperature rise due to power dissipation in the device. Therefore, to achieve optimum reliability, observe the following precautions concerning thermal design:

(1) Keep the ambient temperature (Ta) as low as possible.

(2) If the device's dynamic power dissipation is relatively large, select the most appropriate circuit board material, and consider the use of heat sinks or of forced air cooling. Such measures will help lower the thermal resistance of the package.

(3) Derate the device's absolute maximum ratings to minimize thermal stress from power dissipation.

$\theta ja = \theta jc + \theta ca$

$\theta ja = (Tj - Ta)/W$

$\theta jc = (Tj - Tc)/W$

$\theta ca = (Tc - Ta)/W$

in which θja = thermal resistance between junction and surrounding air (°C/W)

θjc = thermal resistance between junction and package surface, or internal thermal resistance (°C/W)

θca = thermal resistance between package surface and surrounding air, or external thermal resistance (°C/W)

Tj = junction temperature or chip temperature (°C)

Tc = package surface temperature or case temperature (°C)

Ta = ambient temperature (°C)

W = power dissipation (W)

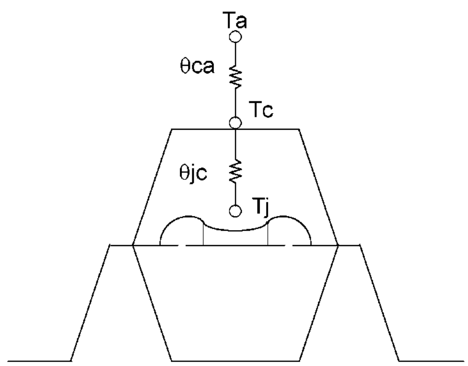


Figure 3.3.1 Thermal resistance of package

3.3.9 Interfacing

When connecting inputs and outputs between devices, make sure input voltage (V_{IL}/V_{IH}) and output voltage (V_{OL}/V_{OH}) levels are matched. Otherwise, the devices may malfunction. When connecting devices operating at different supply voltages, such as in a dual-power-supply system, be aware that erroneous power-on and power-off sequences can result in device breakdown. For details of how to interface particular devices, consult the relevant technical datasheets and databooks. If you have any questions or doubts about interfacing, contact your nearest Toshiba office or distributor.

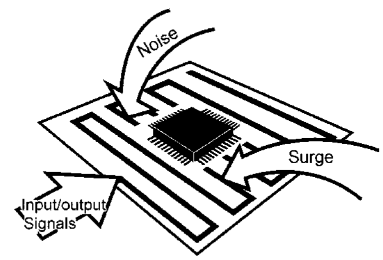
3.3.10 Decoupling

Spike currents generated during switching can cause Vcc (Vdd) and GND (Vss) voltage levels to fluctuate, causing ringing in the output waveform or a delay in response speed. (The power supply and GND wiring impedance is normally 50 Ω to 100 Ω.) For this reason, the impedance of power supply lines with respect to high frequencies must be kept low. This can be accomplished by using thick and short wiring for the Vcc (Vdd) and GND (Vss) lines and by installing decoupling capacitors (of approximately 0.01 to 1 μF capacitance) as high-frequency filters between Vcc (Vdd) and GND (Vss) at strategic locations on the printed circuit board.
For low-frequency filtering, it is a good idea to install a 10- to 100-μF capacitor on the printed circuit board (one capacitor will suffice). If the capacitance is excessively large, however, (e.g. several thousand μF) latch-up can be a problem. Be sure to choose an appropriate capacitance value.
An important point about wiring is that, in the case of high-speed logic ICs, noise is caused

mainly by reflection and crosstalk, or by the power supply impedance. Reflections cause increased signal delay, ringing, overshoot and undershoot, thereby reducing the device's safety margins with respect to noise. To prevent reflections, reduce the wiring length by increasing the device mounting density so as to lower the inductance (L) and capacitance (C) in the wiring. Extreme care must be taken, however, when taking this corrective measure, since it tends to cause crosstalk between the wires. In practice, there must be a trade-off between these two factors.

3.3.11 External Noise

Printed circuit boards with long I/O or signal pattern lines are vulnerable to induced noise or surges from outside sources. Consequently, malfunctions or breakdowns can result from overcurrent or overvoltage, depending on the types of device used. To protect against noise, lower the impedance of the pattern line or insert a noise-canceling circuit. Protective measures must also be taken against surges.



For details of the appropriate protective measures for a particular device, consult the relevant databook.

3.3.12 Electromagnetic Interference

Widespread use of electrical and electronic equipment in recent years has brought with it radio and TV reception problems due to electromagnetic interference. To use the radio spectrum effectively and to maintain radio communications quality, each country has formulated regulations limiting the amount of electromagnetic interference which can be generated by individual products.
Electromagnetic interference includes conduction noise propagated through power supply and telephone lines, and noise from direct electromagnetic waves radiated by equipment. Different measurement methods and corrective measures are used to assess and counteract each specific type of noise.
Difficulties in controlling electromagnetic interference derive from the fact that there is no method available which allows designers to calculate, at the design stage, the strength of the electromagnetic waves which will emanate from each component in a piece of equipment. For this reason, it is only after the prototype equipment has been completed that the designer can take measurements using a dedicated instrument to determine the strength of electromagnetic interference waves.
Yet it is possible during system design to incorporate some measures for the prevention of electromagnetic interference, which can facilitate taking corrective measures once the design has been completed. These include installing shields and noise filters, and increasing the thickness of the power supply wiring patterns on the printed circuit board. One effective method, for example, is to devise several shielding options during design, and then select the most suitable shielding method based on the results of measurements taken after the prototype has been completed.

3.3.13 Peripheral Circuits

In most cases semiconductor devices are used with peripheral circuits and components. The input/output signal voltages and currents of these circuits must be chosen to match the semiconductor device's specifications. The following factors must be taken into account.

(1) Inappropriate voltages or currents applied to a device's input pins may cause it to operate erratically. Some devices contain pull-up/pull-down resistors. When designing your system, remember to take the effect of this on the required voltage and current levels into account.

(2) The output pins on a device have a predetermined external circuit drive capability. If this drive capability is greater than that required, either incorporate a compensating circuit into your design or carefully select suitable components for use in external circuits.

3.3.14 Safety Standards

Each country has safety standards which must be observed. For example, for devices that handle high voltages, it is often required that an appropriate insulation distance be maintained between the device proper and the conductor pattern on the printed circuit board. Such requirements must be fully taken into account to ensure that your design conforms to the applicable safety standards.

3.3.15 Other Precautions

(1) When designing a system, be sure to incorporate fail-safe and other appropriate measures according to the intended purpose of your system. Also, be sure to debug your system under actual board-mounted conditions.

(2) If a plastic-package device is placed in a strong electric field, surface leakage may occur due to the charge-up phenomenon, resulting in device malfunction. In such cases, take appropriate measures to prevent this problem, for example by protecting the package surface with a conductive shield.

(3) With some microcomputers and MOS memory devices, caution is required when powering on or resetting the device. To ensure that your design does not violate device specifications, consult the relevant databook for each constituent device.

(4) Ensure that no conductive material or object (such as a metal pin) can drop onto and short the leads of a device mounted on a printed circuit board.

3.4 Inspection, Testing and Evaluation

3.4.1 Grounding

⚠CAUTION Ground all measuring instruments, jigs, tools and soldering irons to earth. Electrical leakage may cause a device to break down or may result in electric shock.

3.4.2 Inspection Sequence

⚠CAUTION

① Do not insert devices in the wrong orientation. Make sure that the positive and negative electrodes of the power supply are correctly connected. Otherwise, the rated maximum current or maximum power dissipation may be exceeded and the device may break down or undergo performance degradation, causing it to catch fire or explode, resulting in injury to the user.

② When conducting any kind of evaluation, inspection or testing using AC power with a peak voltage of approximately 45 V or DC power exceeding 60 V, be sure to connect the electrodes or probes of the testing equipment to the device under test before powering it on. Connecting the electrodes or probes of testing equipment to a device while it is powered on may result in electric shock, causing injury.

(1) Before beginning device inspection, make a final check to ensure that all associated equipment is properly grounded to earth and that there is no electrical leakage as described above. Apply voltage to the test jig only after inserting the device securely into it. (Do not power the test jig up or down abruptly; always apply or remove power gradually or in steps.)

(2) Make sure that the voltage applied to the device is off before removing the device from the test jig. Otherwise, the device may undergo performance degradation or be destroyed.

(3) Make sure that no surge voltages from the measuring equipment are applied to the device.

(4) The chips housed in tape carrier packages (TCPs) are bare chips and are therefore exposed. During inspection take care not to crack the chip or cause any flaws in it.
Electrical contact may also cause a chip to become faulty. Therefore make sure that nothing comes into electrical contact with the chip.

3.5 Mounting

There are essentially two main types of semiconductor device package: lead insertion and surface mount. During mounting on printed circuit boards, devices can become contaminated by flux or damaged by thermal stress from the soldering process. Particularly with surface mount devices, the most significant problem is thermal stress from solder reflow, when the entire package is subjected to heat. This section describes a recommended temperature profile for each mounting method, as well as general precautions which you should take when mounting devices on printed circuit boards. Note, however, that even for devices with the same package type, the appropriate mounting method varies according to the size of the chip and the size and shape of the lead frame. Therefore, please consult the appropriate technical datasheet or databook.

3.5.1 Lead Forming

⚠CAUTION

① Always wear protective glasses when cutting the leads of a device with clippers or a similar tool. If you do not, small bits of metal flying off the cut ends may damage your eyes.

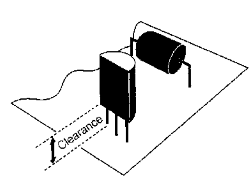
② Because some types of device have leads with pointed tips, you may prick your finger.

Semiconductor devices must undergo a process in which the leads are cut and formed before the devices can be mounted on a printed circuit board. If undue stress is applied to the interior of a device during this process, mechanical breakdown or performance degradation can result. This is attributable primarily to differences between the stress on the device's external leads and the stress on the internal leads. If the relative difference is great enough, the device's internal leads, adhesive properties or sealant can be damaged. Observe these precautions during the lead forming process (this does not apply to surface mount devices):

(1) Lead insertion hole intervals on the printed circuit board should match the lead pitch of the device precisely.

(2) If lead insertion hole intervals on the printed circuit board do not precisely match the lead pitch of the device, do not attempt to forcibly insert devices by pressing on them or by pulling on their leads.

(3) For the minimum clearance specification between a device and a printed circuit board, refer to the relevant device's datasheet or databook. If necessary, achieve the required clearance by forming the device's leads appropriately. Do not use the spacers which are used to raise devices above the surface of the printed circuit board during soldering to achieve clearance. These spacers normally continue to expand due to heat, even after the solder has begun to solidify; this applies severe stress to the device.



(4) Do not repeatedly bend or stretch device leads.

(5) Observe the following precautions when forming the leads of a device prior to mounting.

(a) Use a tool or jig to secure the lead at its base (where the lead meets the device package) while bending.

(b) Maintain a certain distance between the device package and the tool or jig.

(c) When forming a lead by bending it over a jig surface, be careful not to damage the lead on the edge of the jig surface.

(d) Follow any other precautions described in the individual datasheets and databooks for each device and package type.

3.5.2 Socket Mounting

(1) When socket mounting devices on a printed circuit board, use sockets which match the inserted device's package.

(2) Use sockets whose contacts have the appropriate contact pressure. If the contact pressure is insufficient, the socket may not make a perfect contact when the device is repeatedly inserted and removed; if the pressure is excessively high, the device leads may be bent or damaged when they are inserted into or removed from the socket.

(3) When soldering sockets to the printed circuit board, use sockets whose construction prevents flux from penetrating into the contacts or which allows flux to be completely cleaned off.

(4) Make sure the coating agent applied to the printed circuit board for moisture-proofing purposes does not stick to the socket contacts.

(5) If the device leads are severely bent by a socket as it is inserted or removed and you wish to repair the leads so as to continue using the device, make sure that this lead correction is only performed once. Do not use devices whose leads have been corrected more than once.

(6) If the printed circuit board with the devices mounted on it will be subjected to vibration from external sources, use sockets which have a strong contact pressure so as to prevent the sockets and devices from vibrating relative to one another.

3.5.3 Soldering Temperature Profile

The soldering temperature and heating time vary from device to device. Therefore, when specifying the mounting conditions, refer to the individual datasheets and databooks for the devices used.

3.5.3.1 Using a Soldering Iron

Complete soldering within ten seconds for lead temperatures of up to 260°C, or within three seconds for lead temperatures up to 350°C.

3.5.3.2 Using Medium Infrared Ray Reflow

(a) Heating top and bottom with long or medium infrared rays is recommended (see Figure 3.5.2).

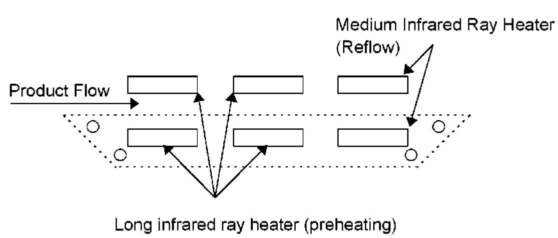


Figure 3.5.2 Heating top and bottom with long or medium infrared rays

(b) Complete the infrared ray reflow process within 30 seconds at a package surface temperature of between 210°C and 240°C.

(c) Refer to Figure 3.5.3 for an example of a good temperature profile for infrared or hot air reflow.

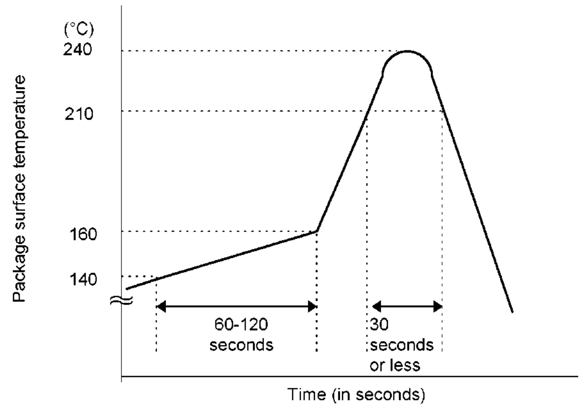


Figure 3.5.3 Sample temperature profile for infrared or hot air reflow

3.5.3.3 Using Hot Air Reflow

(a) Complete hot air reflow within 30 seconds at a package surface temperature of between 210°C and 240°C.

(b) For an example of a recommended temperature profile, refer to Figure 5.3.4 above.

3.5.3.4 Using Vapor Phase Reflow Soldering (VPS)

(a) The recommended solvent is Fluorinate FC-70 or equivalent.

(b) Complete hot air reflow within 30 seconds at an ambient atmospheric temperature of 215°C, or within 60 seconds at an ambient atmospheric temperature of 200°C.

(c) Refer to Figure 3.5.4 for an example of a good temperature profile for vapor phase reflow soldering.

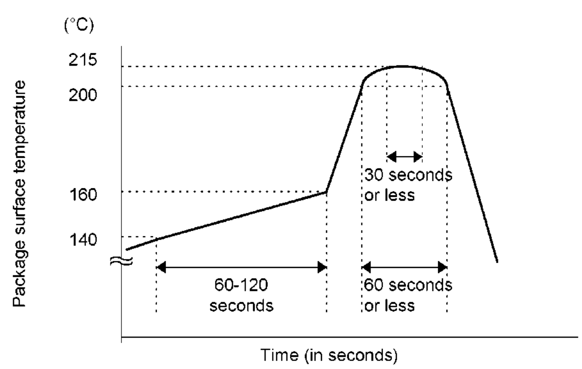


Figure 3.5.4 Example temperature profile for vapor phase reflow

3.5.3.5 Using Solder Flow

(1) Apply preheating for 60 to 120 seconds at a temperature of 150°C.

(2) For insertion-type packages, complete solder flow within 10 seconds with the temperature at the stopper, or at a location more than 1.5 mm from the body if there is no stopper, which does not exceed 260 °C.

(3) For surface mount packages, complete soldering within 5 seconds at a temperature of 250 °C. or less in order to prevent thermal stress in the device.

(4) Figure 3.5.5 shows an example of a recommended temperature profile for surface mount packages using solder flow.

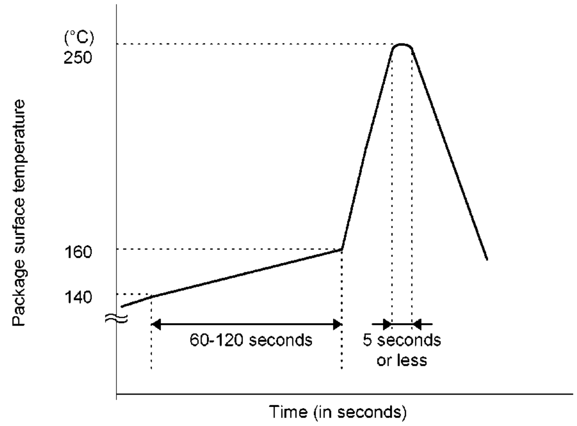


Figure 3.5.5 Sample temperature profile for solder flow

Table 3.5.1 lists the recommended methods for mounting for various surface mount discrete semiconductor packages.

Table 3.5.1 Recommended methods for mounting for each discrete semiconductor packages

Classification	Package Name	Code No.	Mounting Method: Solder Flow	Near Infrared Reflow	Far Infrared Reflow	VPS & HOT Air Reflow	Soldering Iron
Small-signal devices	ESC	1-1G1A	C	B	A	A	B
	ESM		C	B	A	A	B
	SSC	1-1F1A	C	B	A	A	B
	SSM	2-2H1A	C	B	A	A	B
	USM	2-2E1A	B	A	A	A	B
	USC	1-1E1A	B	A	A	A	B
	USV		B	A	A	A	B
	USQ		B	A	A	A	B
	US6	2-2J1A	B	A	A	A	B
	SM	2-3F1A	B	A	A	A	B
	SMC	1-2J1A	B	A	A	A	B
	SMV	SSOP5-P	B	A	A	A	B
	SMQ	10-3C1A	B	A	A	A	B
	SM6	SSOP6-P	B	A	A	A	B
	SM8		B	A	A	A	B
	FM8	SOP6-P	B	A	A	A	B
	PW-Mini	2-5K1A	C	B	A	A	B
Power devices	PW-Mold		C	B	A	A	B
	NPM	2-7F1A	C	B	A	A	B
	TO-220SM		C	B	A	A	B
Rectifier devices	PW-Mini		C	B	A	A	B
	I-Flat		B	A	A	A	B
	PW-Mold	12-7B1A	C	B	A	A	B
	H-Flat		B	A	A	A	B
	H-FlatL		B	A	A	A	B
	TO-220SM	12-10D2A	C	B	A	A	B
Couplers	MFC		C	B	B	B	B

A: Suitable

B: Suitable once only

C: Not suitable; other methods are recommended.

Note 1: For each mounting method, the table above shows whether or not it is suitable under Toshiba's recommended mounting conditions.

Note 2: When mounting is to be performed a number of times only those methods marked A can be used. In this case, mounting can be performed up to three times, with the interval between the first and third mountings being less than 24 hours.

3.5.4 Flux Cleaning and Ultrasonic Cleaning

(1) When cleaning circuit boards to remove flux, make sure that no residual reactive ions such as Na or Cl ions remain. Note that organic solvents react with water to generate hydrogen chloride and other corrosive gases which can degrade device performance.

(2) Washing devices with water will not cause any problems. However, make sure that no reactive ions such as sodium and chlorine are left as residues. Also, be sure to dry devices sufficiently after washing.

(3) Do not rub device markings with a brush or with your hand during cleaning or while the devices are still wet from the cleaning agent. Doing so can rub off the markings.

(4) The dip cleaning, shower cleaning and steam cleaning processes all involve the chemical action of a solvent. Use only recommended solvents for these cleaning methods. When immersing devices in a solvent or steam bath, make sure that the temperature of the liquid is 50°C or below, and that the circuit board is removed from the bath within one minute.

(5) Ultrasonic cleaning can clean circuit boards efficiently in a short period of time. However, it should not be used with hermetically-sealed ceramic packages such as a leadless chip carrier (LCC), charge-coupled device (CCD) or pin grid array (PGA), because the bonding wires can become disconnected due to resonance during the cleaning process. Plastic packages do not have this problem. However, limit the duration of ultrasonic cleaning to as short a time as possible, since long hours of ultrasonic cleaning degrade the adhesion between the mold resin and the frame material. The following ultrasonic cleaning conditions are recommended:

Frequency:	27 to 29 kHz
Ultrasonic output power:	300 W or less (0.25 W/cm^2 or less)
Cleaning time:	30 seconds or less

Suspend the circuit board in the solvent bath during ultrasonic cleaning in such a way that the ultrasonic vibrator does not come into direct contact with the circuit board or the device.

Conventional cleaning solvents that contain freon are not recommended due to the danger that they pose to the earth's ozone layer. Alternative products listed below are available on the market. Some alternative cleaning agents that do not contain freon include:

- FRW-1, 17; FRV-100 from Toshiba Corporation
- AK-225AES from Asahi Glass Co., Ltd.
- 750H from Kao Co., Ltd.
- ST-100 from Arakawa Chemical Co., Ltd.

Contact Toshiba or a Toshiba distributor regarding cleaning conditions and other relevant information for each product type.

3.5.5 No Cleaning

If analog devices or high-speed devices are used without being cleaned, flux residues may cause minute amounts of leakage between pins. Similarly, dew condensation, which occurs in environments containing residual chlorine when power to the device is on, may cause between-lead leakage or migration. Therefore, Toshiba recommends that these devices be cleaned.

However, if the flux used contains only a small amount of halogen (0.05% or less), the devices may be used without cleaning without any problems.

For details of individual devices' cleaning conditions, please contact Toshiba or a Toshiba distributor.

3.5.6 Mounting Tape Carrier Packages (TCPs)

(1) When tape carrier packages (TCPs) are mounted, measures must be taken to prevent electrostatic breakdown of the devices.

(2) If devices are being picked up from tape, or outer lead bonding (OLB) mounting is being carried out, consult the manufacturer of the insertion machine which is being used, in order to establish the optimum mounting conditions in advance and to avoid any possible hazards.

(3) The base film, which is made of polyimide, is hard and thin. Be careful not to cut or scratch your hands or any objects while handling the tape.

(4) When punching tape, try not to scatter broken pieces of tape too much.

(5) Treat the extra film, reels and spacers left after punching as industrial waste, taking care not to destroy or pollute the environment.

(6) Chips housed in tape carrier packages (TCPs) are bare chips and therefore have their reverse side exposed. To ensure that the chip will not be cracked during mounting, ensure that no mechanical shock is applied to the reverse side of the chip. Electrical contact may also cause a chip to fail. Therefore, when mounting devices, make sure that nothing comes into electrical contact with the reverse side of the chip.
If your design requires connecting the reverse side of the chip to the circuit board, please consult Toshiba or a Toshiba distributor beforehand.

3.5.7 Mounting Chips

Devices delivered in chip form tend to degrade or break under external forces much more easily than plastic-packaged devices. Therefore, caution is required when handling this type of device.

(1) Mount devices in a well-prepared environment so that chip surfaces will not be exposed to polluted ambient air or other polluted substances.

(2) When handling chips, be careful not to expose them to static electricity.
In particular, measures must be taken to prevent static damage during the mounting of chips. With this in mind, Toshiba recommends mounting all peripheral parts first and then mounting chips last (after all other components have been mounted).

(3) Make sure that circuit boards (e.g. PCBs) on which chips are being mounted do not have any chemical residues on them (such as the chemicals which were used for etching the boards).

(4) When mounting chips on a board, use the method of assembly that is most suitable for maintaining the appropriate electrical, thermal and mechanical properties of semiconductor devices.

* For details of devices in chip form, refer to the relevant devices' individual datasheets.

3.5.8 Circuit Board Coating

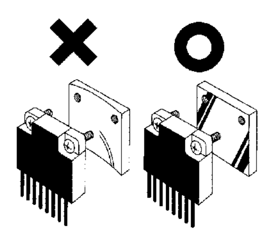
When devices are to be used in equipment requiring a high degree of reliability or in extreme environments (where moisture, corrosive gas or dust is present), circuit boards may be coated for protection. However, before doing so, you must carefully consider the possible stress and contamination effects that may result and choose the coating resin which applies the minimum level of stress to the device.

3.5.9 Heat Sinks

(1) When attaching a heat sink to a device, be careful not to apply excessive force to the device in the process.

(2) When attaching a device to a heat sink by fixing it at two or more locations, evenly tighten all the screws in stages (i.e. do not fully tighten one screw while the rest are still only loosely tightened). Finally, fully tighten all the screws up to the specified torque.

(3) Drill holes for screws in the heat sink exactly as specified. Smooth the surface by removing burrs and protrusions or indentations which might interfere with the installation of any part of the device.



(4) A coating of silicone compound can be applied between the heat sink and the device to improve heat conductivity. Be sure to apply the coating thinly and evenly; do not use too much. Also, be sure to use a nonvolatile compound, as volatile compounds can crack after a time, causing the heat radiation properties to deteriorate.

(5) If the device is housed in a plastic package, use caution when selecting the type of silicone compound to be applied between the heat sink and the device. With some types, the base oil separates and penetrates the plastic package, significantly reducing the useful life of the device. Two recommended silicone compounds in which base oil separation is not a problem are YG6260 from Toshiba Silicone and G746 from Shinetsu Chemical Industries.

(6) Heat-sink-equipped devices can become very hot during operation. Do not touch them, or you may sustain a burn.

3.5.10 Tightening Torque

(1) Make sure the screws are tightened with fastening torques not exceeding the torque values stipulated in individual datasheets and databooks for the devices used.

(2) Do not allow a power screwdriver (electrical or air-driven) to touch devices.

3.6 Protecting Devices in the Field

3.6.1 Temperature

Semiconductor devices are generally more sensitive to temperature than are other electronic components. The various electrical characteristics of a semiconductor device are dependent on the ambient temperature at which the device is used. It is therefore necessary to understand the temperature characteristics of a device and to incorporate device derating into circuit design. Note also that if a device is used above its maximum temperature rating, device deterioration is more rapid and it will reach the end of its usable life sooner than expected.

3.6.2 Humidity

(1) Resin-molded devices are sometimes improperly sealed. When these devices are used for an extended period of time in a high-humidity environment, moisture can penetrate into the device and cause chip degradation or malfunction. Furthermore, when devices are mounted on a regular printed circuit board, the impedance between wiring components can decrease under high-humidity conditions. In systems that require a high signal-source impedance, circuit board leakage or leakage between device lead pins can cause malfunctions. The application of a moisture-proof treatment to the device surface should be considered in this case. On the other hand, operation under low-humidity conditions can damage a device due to the occurrence of electrostatic discharge. Unless damp-proofing measures have been specifically carried out, use devices only in environments with appropriate ambient moisture levels (i.e. within a relative humidity range of 40% to 60%).

(2) When semiconductor devices are to be used in equipment requiring a high degree of reliability or in extreme environments (where humidity is high, or where corrosive gas or dust is present), devices may be coated in order to moisture-proof them. In such cases, choose the coating resin which applies the minimum level of stress to the device.

3.6.3 Corrosive Gases

Corrosive gases can cause chemical reactions in devices, degrading device characteristics. For example, sulphur-bearing corrosive gases emanating from rubber placed near a device (accompanied by condensation under high-humidity conditions) can corrode a device’s leads. The resulting chemical reaction between leads forms foreign particles which can cause electrical leakage.

3.6.4 Radioactive and Cosmic Rays

Most industrial and consumer semiconductor devices are not designed with protection against radioactive and cosmic rays. Devices used in aerospace equipment or in radioactive environments must therefore be shielded.

3.6.5 Strong Electrical and Magnetic Fields

Devices exposed to strong magnetic fields can undergo a polarization phenomenon in plastic material, or within the chip, which gives rise to abnormal symptoms such as impedance changes or increased leakage current. Failures have been reported in LSIs mounted near malfunctioning deflection yokes in TV sets. In such cases, the device's installation location must be changed or the device must be shielded against the electrical or magnetic field. Shielding against magnetism is especially necessary for devices used in an alternating magnetic field, because of the electromotive forces generated in this type of environment.

3.6.6 Interference from Light (ultraviolet rays, sunlight, fluorescent lamps and incandescent lamps)

Light striking a semiconductor device generates electromotive force due to photoelectric effects. In some cases the device can malfunction. This is especially true for devices in which the internal chip is exposed. When designing circuits, make sure devices are protected against incident light from external sources. This problem is not limited to optical semiconductors and EPROMs. All types of device can be affected by light.

3.6.7 Dust and Oil

Just like corrosive gases, dust and oil can cause chemical reactions in devices, which will adversely affect a device's electrical characteristics. To avoid this problem, do not use devices in dusty or oily environments. This is especially important for optical devices because dust and oil can affect a device's optical characteristics as well as its physical integrity and the electrical performance factors mentioned above.

3.6.8 Fire

Semiconductor devices may be combustible; they can emit smoke and catch fire if heated sufficiently. When this happens, some devices may generate poisonous gases. Devices should therefore never be used in close proximity to an open flame or a heat-generating body, or near flammable or combustible materials.

3.7 Disposal of Devices and Packing Materials

When discarding unused devices and packing materials, follow all procedures specified by local regulations in order to protect the environment against contamination.