[6] Handling Guide

1. Using Toshiba Semiconductors Safely

TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing TOSHIBA products, to comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such TOSHIBA products could cause loss of human life, bodily injury or damage to property.
In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the “Handling Guide for Semiconductor Devices,” or “TOSHIBA Semiconductor Reliability Handbook” etc..

The TOSHIBA products listed in this document are intended for usage in general electronics applications (computer, personal equipment, office equipment, measuring equipment, industrial robotics, domestic appliances, etc.). These TOSHIBA products are neither intended nor warranted for usage in equipment that requires extraordinarily high quality and/or reliability or a malfunction or failure of which may cause loss of human life or bodily injury (“Unintended Usage”). Unintended Usage include atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, medical instruments, all types of safety devices, etc.. Unintended Usage of TOSHIBA products listed in this document shall be made at the customer’s own risk.

2. Safety Precautions

This section lists important precautions which users of semiconductor devices (and anyone else) should observe in order to avoid injury and damage to property, and to ensure safe and correct use of devices.

Please be sure that you understand the meanings of the labels and the graphic symbol described below before you move on to the detailed descriptions of the precautions.

[Explanation of labels]

⚠DANGER	Indicates an imminently hazardous situation which will result in death or serious injury if you do not follow instructions
⚠WARNING	Indicates a potentially hazardous situation which could result in death or serious injury if you do not follow instructions.
⚠CAUTION	Indicates a potentially hazardous situation which if not avoided, may result in minor injury or moderate injury.

[Explanation of graphic symbol]

Graphic symbol	Meaning
	Indicates that caution is required (laser beam is dangerous to eyes).

2.1 General Precautions regarding Semiconductor Devices

⚠CAUTION

Do not use devices under conditions exceeding their absolute maximum ratings (e.g. current, voltage, power dissipation or temperature).

This may cause the device to break down, degrade its performance, or cause it to catch fire or explode resulting in injury.

Do not insert devices in the wrong orientation.

Make sure that the positive and negative terminals of power supplies are connected correctly. Otherwise the rated maximum current or power dissipation may be exceeded and the device may break down or undergo performance degradation, causing it to catch fire or explode and resulting in injury.

When power to a device is on, do not touch the device’s heat sink.

Heat sinks become hot, so you may burn your hand.

Do not touch the tips of device leads.

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

When conducting any kind of evaluation, inspection or testing, be sure to connect the testing equipment’s electrodes or probes to the pins of the device under test before powering it on.

Otherwise, you may receive an electric shock causing injury.

Before grounding an item of measuring equipment or a soldering iron, check that there is no electrical leakage from it.

Electrical leakage may cause the device which you are testing or soldering to break down, or could give you an electric shock.

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.

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 which 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.”.

(1) Work environment

- 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.
- Be sure that all equipment, jigs and tools in the working area are grounded to earth.
- 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
- 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.
- 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 on 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 which come into contact with device lead terminals, use a material which dissipates static electricity

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

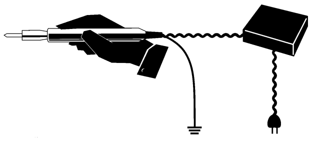
(e) Make sure that sections of the tape carrier which come into contact with installation devices or other electrical machinery are made of a low-resistance material.

(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.

- 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.
- Keep track of charged potential in the working area by taking periodic measurements.
- 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 $10^{12}\Omega$.)
- 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.)
- For transport and temporary storage of devices, use containers (boxes, jigs or bags) that are made of anti-static materials or materials which dissipate electrostatic charge.
- Make sure that cart surfaces which come into contact with device packaging are made of materials which will conduct static electricity, and verify that they are grounded to the floor surface via a grounding chain.
- 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.

(2) Operating environment

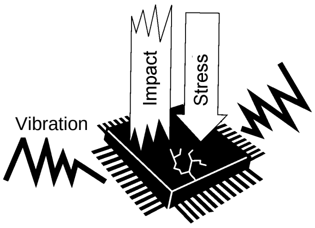


- Operators must wear anti-static clothing and conductive shoes (or a leg or heel strap).
- Operators must wear a wrist strap grounded to earth via a resistor of about 1 MΩ.
- Soldering irons must be grounded from iron tip to earth, and must be used only at low voltages (6 V to 24 V).
- If the tweezers 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).
- Do not place devices or their containers near sources of strong electrical fields (such as above a CRT).

- 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.
- 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.
- 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).
- Equipment safety covers installed near devices should have resistance ratings of 10^9 Ω or less.
- If a wrist strap cannot be used for some reason, and there is a possibility of imparting friction to devices, use an ionizer.

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 the 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 devices are incorporated into the design of equipment which will be subject to vibration, the structural design of the equipment must be thought out carefully.

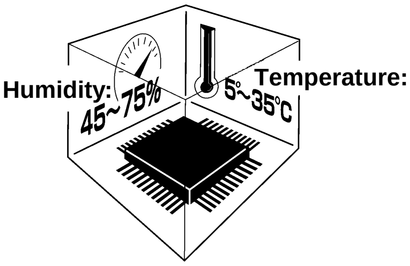
If a device is subjected to especially strong vibration, mechanical shock or stress, the package or the chip itself may crack. In products such as CCDs which incorporate window glass, this could cause surface flaws in the glass or cause the connection between the glass and the ceramic to separate.

Furthermore, it is 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

- Avoid storage locations where devices will be exposed to moisture or direct sunlight
- Follow the instructions printed on the device cartons regarding transportation and storage.
- 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%.
- Do not store devices in the presence of harmful (especially corrosive) gases, or in dusty conditions.
- 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.
- When repacking devices, use anti-static containers.
- Do not allow external forces or loads to be applied to devices while they are in storage.
- 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.



3.3 Design

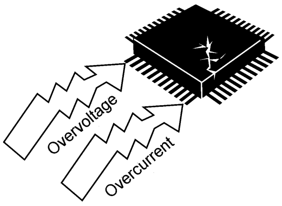
Care must be exercised in the design of electronic equipment to achieve the desired reliability. It is important not only to adhere to specifications concerning absolute maximum ratings and recommended operating conditions, it is also important to consider the overall environment in which equipment will be used, including factors such as the ambient temperature, transient noise and voltage and current surges, as well as mounting conditions which affect device reliability. This section describes some general precautions which 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 technical datasheets 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, power dissipation or temperature) 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 absolute 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 Input processing

Inputs to CMOS ICs have such a high impedance that the logic level becomes undefined under open input conditions. Should the floating input be neither High nor Low, both P-channel and N-channel transistors turn on, and unnecessary supply current flows.

Therefore, as shown in Figure 3.1, be sure to connect unused input lines to V_{CC}, GND or other inputs and the output to the logic level determined by the inputs.

In the case of CMOS, if a soldered part has poor contact, a malfunction of the system or an increase in supply current will occur. Therefore, care must be taken when soldering.

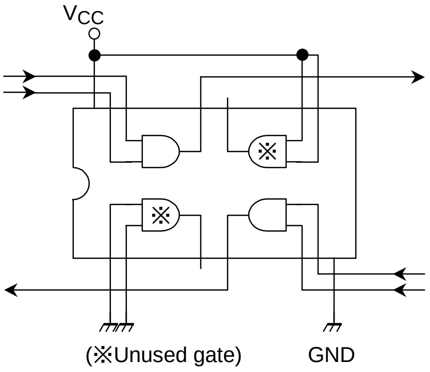


Figure 3.1 Treatment of Inputs

3.3.5 Inputs to a Printed Circuit Board

When the input pin of a printed circuit board is connected directly to a CMOS input, that input floats electrically. This condition is the same as a when a single IC is being transported or stored. It is advisable, therefore, to connect this input to V_{CC} or GND via a resistance on the printed circuit board, as shown in Figure 3.2.

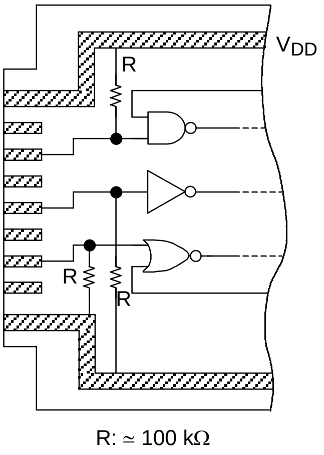


Figure 3.2 Input Processing by Printed Circuit Board

3.3.6 Power Source Design

In general, CMOS has a small current consumption in comparison with bipolar digital ICs, and therefore it only needs a low-capacity power supply. However, in practice CMOS consumes power during transition, and therefore, it is necessary to keep the high-frequency impedance of the power source at a low level.

It is advisable to make the wiring of the power source (V_{CC}) and GND lines thick and short, and insert, as a high-frequency filter, a capacitor of from 0.001 μF to 0.1 μF between V_{CC} and GND for each IC.

Also, it is recommended that a capacitor of from 10 μF to 100 μF be inserted between the power supply input and GND as a low-frequency filter. The mean supply current varies considerably depending upon the operating frequency of the system, the existence of capacitive load, the power supply voltage and the rise and fall of the input signal. When using a simple power supply consisting of a battery and a zener diode, if the mean supply current is high, please be careful with the power supply, as its power is low. When there is overshoot or undershoot during the power supply's transition time use a filter or similar device so that the absolute maximum rating is not exceeded.

3.3.7 Effect of Slow Rise and Fall Time on Input

When a waveform with a slow rise and fall time is applied to a CMOS input, the output will sometimes tend to oscillate around V_{th} (the circuit threshold voltage) of the input waveform. This is because the CMOS gate becomes an equivalent linear amplifier in the vicinity of V_{th}, and minute power source ripples and noise components are amplified and appear in the output.

When these power source ripples exceed the absolute maximum rating, it not only effects operation but may also cause the device to break down. In particular, care must be taken while the power is on if the input signal is slow to rise and fall.

Therefore, as mentioned in section 3.3.6, to stabilize the power supply, a filter capacitor should be inserted between V_{CC} and GND. In addition, the design should take into account of the input rise and fall times specified in the recommended operating conditions.

3.3.8 Output Short-Circuit

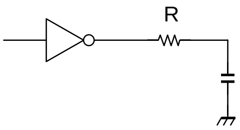
In the C^2MOS^{TM} ICs Series, a buffer is added to the output, and both flow-out (I_{OH}) and flow-in (I_{OL}) current drive is possible. For this reason, excessive current will flow in a C^2MOS^{TM} output when the high-level output line is shorted to the GND line or when the low-level output line is shorted to the V_{CC} line. In particular, when the supply voltage is high, IOH and IOL are excessive and may damage the device; care must be taken not to cause an output short circuit.

It is, of course, impossible to directly connect ordinary outputs together, but in the case of an IC with a three-state output, a wired OR connection is permitted, provided that no more than two outputs are enabled simultaneously.

3.3.9 Capacitors Connected to Signal Line or V_{CC}/GND

To reduce signal delay or to eliminate noise, a capacitor of up to 500 pF can be connected directly to the signal line. However, if a capacitor of over 500 pF is used, it must be connected via a resistor, as shown in Figure 3.3, and not connected directly .

This resistor limits the flow of the current to the CMOS output parasitic circuit when the power supply is turned on or off. The resistor also prevents prolonged shorting of the CMOS output.



R: Output current-limiting resistance

Figure 3.3 How to Insert a Capacitor

3.3.10 Wiring Precautions

(1) Output waveform distortion

Since the output impedances of the Mini-MOS Series are very low, distortion is sometimes caused in the output waveform by the L component of the wiring. This occurs when the wiring connected to the output pin is long or when capacitance is connected between the signal line and V_{CC} or GND. Therefore, when designing a printed circuit board, take care not to make the signal wiring too long. On the clock signal line, distortion of the waveform causes malfunctions.

(2) Precautions for wiring arrangements

The outputs from the Mini-MOS Series have fast rise and fall times, and swing between V_{CC} and GND; therefore they become a noise source to other signals. It is preferable to locate the output away from components which are sensitive to noise from an analog circuit. Also, the number of loads and the wiring length should be minimized.

(3) Termination

Due to their physical and electrical characteristics, the Mini-MOS Series are apt to cause overshoot and undershoot; this leads to malfunction of the circuit or the breakdown of passive ICs. These problems can be prevented to some extent by terminating the signal line. Figure 3.4 shows examples of termination.

(a) Termination Using RC Components (b) Termination Using Diodes

Figure 3.4 Examples of Termination

(4) Fan-out

In the case of a mutual interface between CMOS ICs, the input impedance of CMOS is so large that there is little limitation on the number of fan-outs. However, there is a need to consider the increase in propagation time due to the effect of adding load capacitance and the increase in power consumption.

The input capacitance of CMOS is about 5 pF per input. If ten fan-outs are taken, for example, the load capacitance is 50 pF. Additionally, the line capacitance of the printed circuit board must be taken into account. This shows that the processing speed of the system is controlled not only by the circuit components but also by the fan-out.

When designing a system using CMOS ICs, carefully consider the fan-out.

3.3.11 Latch-up

CMOS devices are subject to latch-up, an undesirable condition in which a parasitic PNPN junction (thyristor) in the CMOS IC conducts. An abnormal current of several hundred mA can flow between V_{CC} and GND, destroying the IC.

Latch-up occurs when the voltage applied to the input or output pins exceeds the prescribed absolute maximum rating value, causing a large current to flow in the device, or when the V_{CC} pin voltage exceeds (even momentarily) the absolute maximum rating value causing internal components to break down. Latch-up results in a large, continuous current between V_{CC} and GND and can cause overheating and burn-out. To avoid this, observe the following precautions.

(1) Ensure that the voltage level on the input/output pins is no higher than V_{CC} and no lower than V_{SS}, taking into account the timing at power-on. (As the V_{CC} and V_{SS} levels vary from device to device, please refer to the datasheet for the device in question.)

(2) Do not subject the device to abnormal noise.

(3) Fix the potential of any unused input pins to V_{CC} or V_{SS}.

(4) Do not connect output pins directly to other output pins, or to V_{CC} or VSS.

Since ample margin against latch-up is provided, there is no problem if Min-CMOS devices are used within their specifications. However, since the interface component may receive excessive surges, it is recommended that protective circuits be added, as shown in Figure 3.5.

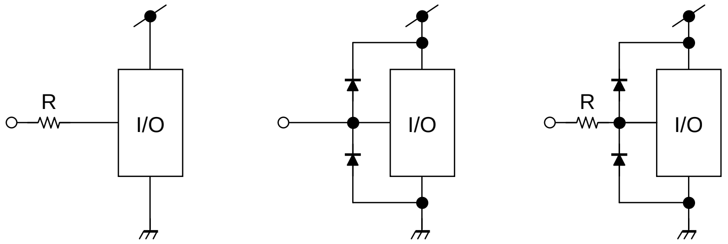
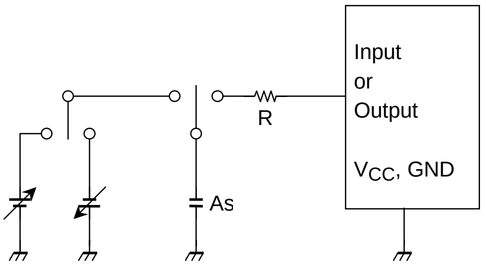


Figure 3.5 Example of Latch-up Prevention Methods

3.3.12 Electrical Discharge and Precautions against Noise

The Mini-MOS Series have ample margin for handling noise such as electrical discharge. Figure 3.6 show a circuit for ESD testing and Table 3.1 shows the results of ESD tests for various devices.



EIAJ Method : C = 200 pF
R = 0 Ω
MIL-STD Method : C = 100 pF
C = 1.5 kΩ

Figure 3.6 Test Circuit

Table 3.1 Test Result

Name	EIAJ Method		MIL-STD Method	
	Input	Output	Input	Output
TC7MH244FK	>±200 V	>±200 V	>±2000 V	>±2000 V
TC7MET244AFK	>±200 V	>±200 V	>±2000 V	>±2000 V
TC7MZ244FK	>±200 V	>±200 V	>±2000 V	>±2000 V
TC7MA244FK	>±200 V	>±200 V	>±2000 V	>±2000 V

However, input and output signal lines are long in many cases and have distributed inductance or reactance.

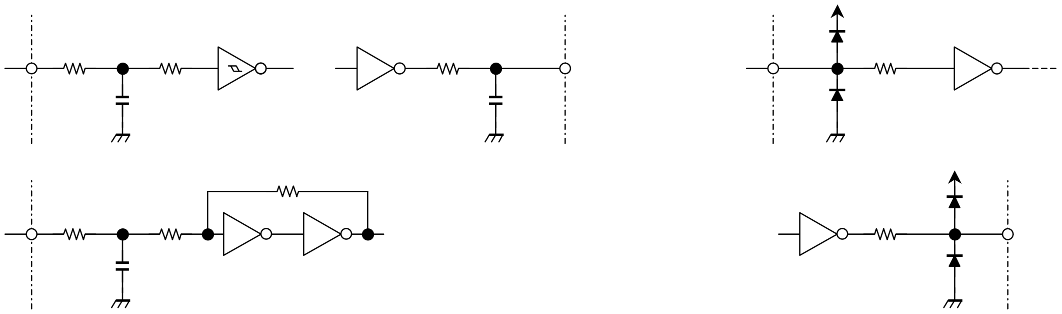
Therefore, if these lines are directly connected to CMOS, various problems can arise.

Possible problems are malfunction due to induced noise, or destruction of the input/output elements due to a surge. Reducing the signal line impedance (driving impedance) or inserting noise-eliminating circuits on the receiving side are two ways of dealing with the former problem; surge protection measures are taken to cope with the latter.

Figure 3.7 shows an example of noise and surge protection.

Alternatively, the PCB can be isolated using a photocoupler or a lead relay connection.

Note that it is not necessary to make design allowances for the overshoot and undershoot which can occur under light loads.

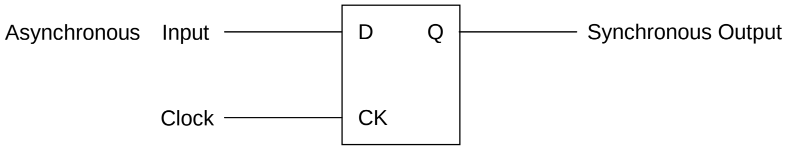


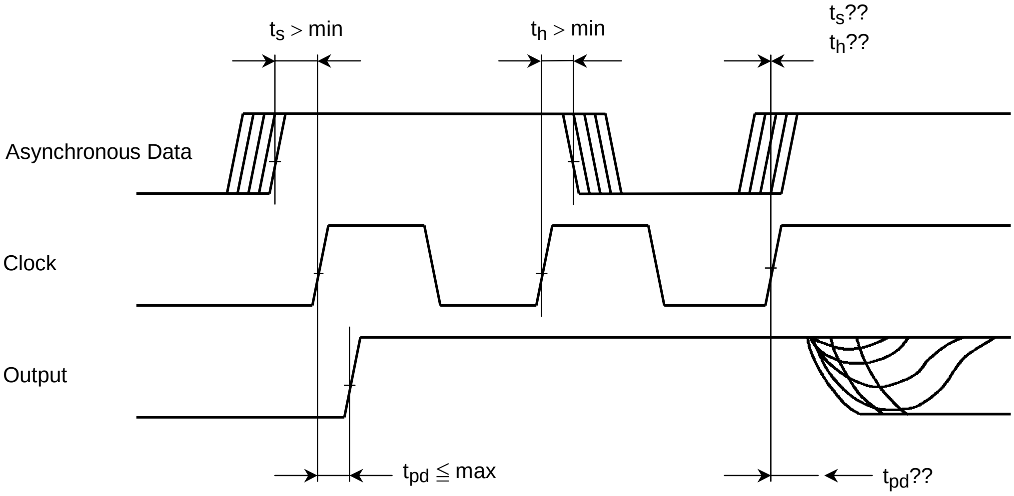
(a) Noise protection **(b) Surge protection**

Figure 3.7 Protection Circuits

3.3.13 Meta-Stable Characteristics

When the setup time or hold-time of a flip-flop is not adhered to the device's output response is uncertain. This phenomenon is called meta-stability.





The diagram shown above describes a meta-stable state which can generate a glitch or increase the propagation delay time. If the asynchronous signal is an input to a flip-flop which is clocked by the internal clock of a synchronous system, the meta-stable state is unavoidable.

Therefore, in order to avoid this problem, it is recommended that the timing requirements specified in the data sheet be observed. When a synchronous signal is used, care must be taken with the output signal.

Figure 3.8 shows an example of how to solve this problem. In this case, if the difference in phase between CK1 and CK2 is the same as the tpd (output clock) of the first stage flip-flop, care must be taken.

Note: If CK1 and CK2 cannot be used together, the synchronous clock signal used for CK1 should be phase-shitted and applied as the clock for Second stage flip-flop (CK2) (i.e. $\overline{CK2} = CK1$)

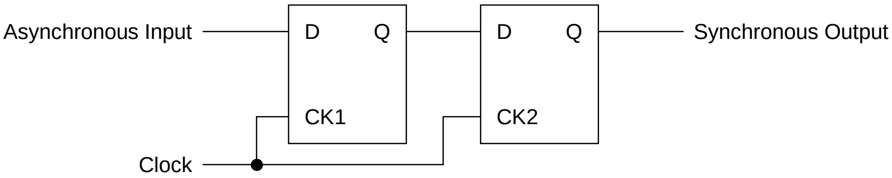


Figure 3.8 Solving the Meta-stable Problem

3.3.14 Thermal Design

The failure rate of semiconductor devices is greatly increased as operating temperatures increase. As shown in Figure 3.9, 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.

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

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

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

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

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)

P = power dissipation (W)

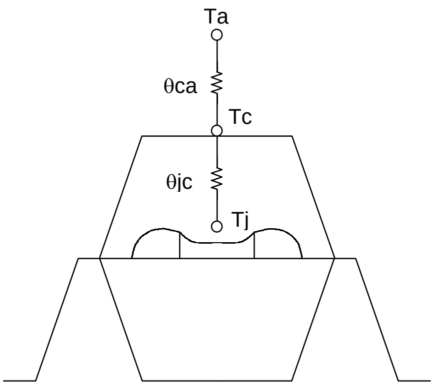
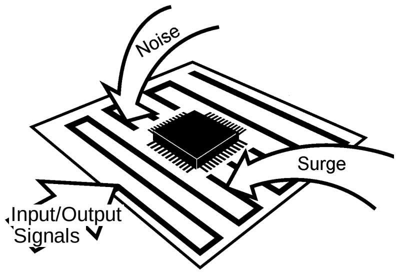


Figure 3.9 Thermal Resistance of Package

3.3.15 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.

3.3.16 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.

3.3.17 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.

3.3.18 Peripheral Circuits

In most cases semiconductor devices are used with peripheral circuits and components. The input and output signal voltages and currents in 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 or pull-down resistors. When designing your system, remember to take the effect of this on the 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.

3.3.19 Safety Standards

Each country has safety standards which must be observed. These safety standards include requirements for quality assurance systems and design of device insulation. Such requirements must be fully taken into account to ensure that your design conforms to the applicable safety standards.

3.3.20 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 42.4 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) Apply voltage to the test jig only after inserting the device securely into it. When applying or removing power, observe the relevant precautions, if any.

(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. With surface-mount devices in particular, 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 relevant technical datasheet and databook.

3.5.1 Lead Forming

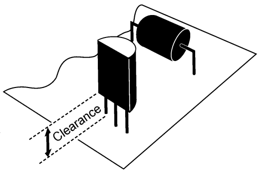
⚠CAUTION

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. Do not touch the tips of device leads. 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 and 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) Observe the following precautions when forming the leads of a device prior to mounting.
- Use a tool or jig to secure the lead at its base (where the lead meets the device package) while bending so as to avoid mechanical stress to the device. Also avoid bending or stretching device leads repeatedly.
- Be careful not to damage the lead during lead forming.
- 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.

(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 of up to 350°C.

(2) Using medium infrared ray reflow

- Heating top and bottom with long or medium infrared rays is recommended(see Figure3.10).

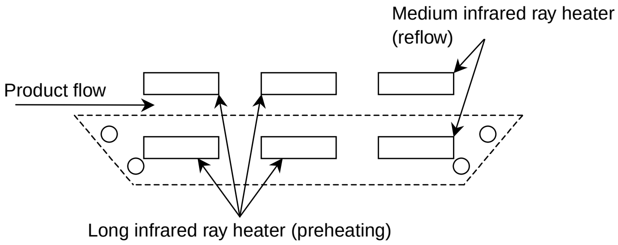


Figure 3.10 Heating Top and Bottom with Long or Medium Infrared Rays

- Complete the infrared ray reflow process within 30 seconds at a package surface temperature of between 210°C and 240°C.
- Refer to Figure 3.11 for an example of a good temperature profile for infrared or hot air reflow.

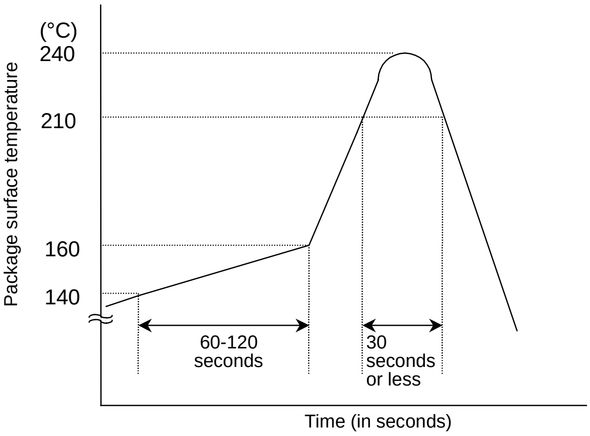


Figure 3.11 Sample Temperature Profile for Infrared or Hot Air Reflow

(3) Using hot air reflow

- Complete hot air reflow within 30 seconds at a package surface temperature of between 210°C and 240°C
- For an example of a recommended temperature profile, refer to Figure 3.11 above.

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 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 a residue. 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 should not be used with hermetically-sealed ceramic packages such as a leadless chip carrier (LCC), pin grid array (PGA) or charge-coupled device (CCD), because the bonding wires can become disconnected due to resonance during the cleaning process. Even if a device package allows ultrasonic cleaning, 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 kHz ~ 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.

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 W% or less), the devices may be used without cleaning without any problems.

3.5.6 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 then choose the coating resin which results in the minimum level of stress to the device.

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

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 which 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 taken, use devices only in environments with appropriate ambient moisture levels (i.e. within a relative humidity range of 40% to 60%).

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 their 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 that 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 are 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.

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