DC-to-DC Step-Down Converter

Features and Benefits

- 1.5 A output current supplied in a small power surface mount package
- High efficiency: 81% at V_{IN}=15 V, I_O=0.5 A,V_O=5 V
- Requires only six external components (optional soft start requires an additional capacitor)
- Oscillation circuit built-in (frequency 300 kHz typical
- Constant current type overcurrent protection circuit and an overheating protection circuit built in
- Soft start function built-in (can be implemented as an ON/OFF function, output OFF state at low level)
- Low consumption current during output OFF state

Package: TO252-5 (SC-63)

Not to scale

Description

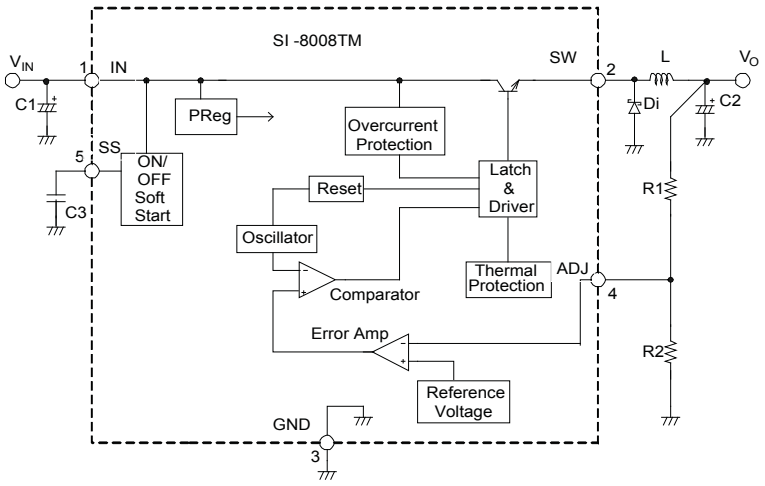
The SI-8008TM DC voltage regulator is a DC-to-DC buck convertor that attains an oscillation frequency of 300 kHz, and has an integrated miniaturized choke coil, allowing it to serve as a small, high efficiency power supply in a compact TO252-5 (SC-63) package.

The switching regulator function realizes a high efficiency switching regulator operation without adjustment, requiring only six external support components, and an optional capacitor for soft start operation and an optional transistor for on/off control. The SI-8008TM includes overcurrent and overheating protection circuits.

Applications include:

- DVD recorder
- FPD TV
- Telecommunications equipment
- Office automation equipment, such as printers
- On-board local power supply
- Output voltage regulator for second stage of SMPS (switched mode power supply)

Functional Block Diagram with Typical Application



Component	Rating
C1	220 µF
C2	470 µF
C3	1 µF (for soft start function)
Di	SJPB-H6 (Sanken)
L1	47 µH

Figure 1. Application implementing soft start, without implementation of on/off control.

SANKEN ELECTRIC CO., LTD.
http://www.sanken-ele.co.jp/en/

Selection Guide

Part Number	Output Voltage (V)	Efficiency (Typical) (%)	Input Voltage (V)	Output Current (A)	Packing
SI-8008TM-TL (Adjustable Type)	0.8 (V_{ADJ})	81 (5 V Set-up)	43	0 to 1.5	3000 pieces per reel

Absolute Maximum Ratings

Characteristic	Symbol	Remarks	Rating	Units
DC Input Voltage	V_{IN}		43	V
Power Dissipation 1	P_{D1}	Glass-epoxy board mounting in 900 mm², copper area 4.3%, Tj ≤ 125°C	1.06	W
Power Dissipation 2	P_{D2}	Glass-epoxy board mounting in 900 mm², copper area 50% Tj ≤ 125°C	1.65	W
Junction Temperature	T_J	The thermal protection circuit is built-in and may enable when junction temperature rises to 130°C or higher. Recommended maximum junction temperature during product operation is 125°C.	–30 to 150	°C
Storage Temperature	T_{stg}		–40 to 150	°C
Thermal Resistance (Junction-case)	$R_{\theta j\text{-}c}$		6	°C/W
Thermal Resistance (Junction-ambient air)	$R_{\theta j\text{-}a}$	Glass-epoxy board mounting in 900 mm², copper area 4.3%	95	°C/W

Recommended Operating Conditions

Characteristic	Symbol	Remarks	Min.	Max.	Units
DC Input Voltage Range[1]	V_{IN}	I_O = 0 to 1.5 A	V_O + 3	40	V
DC Output Voltage Range	V_O		0.8	24	V
DC Output Current Range[2]	I_O	$V_{IN} \geq V_O + 3$ V	0	1.5	A
Operating Junction Temperature Range	T_{JOP}		–20	100	°C
Operating Temperature Range[2]	T_{OP}		–20	85	°C

[1]The minimum value of the input voltage, V_{IN}(min) is the larger of either 4.5 V or V_O+3 V. In the case in which V_{IN} is in the range V_O + 2 V to V_O + 3 V, V_{IN}(min) is set so that I_O = 1 A (maximum).
[2]To be used within the allowable package power dissipation characteristics (refer to Power Dissipation chart).

All performance characteristics given are typical values for circuit or system baseline design only and are at the nominal operating voltage and an ambient temperature, T_A, of 25°C, unless otherwise stated.

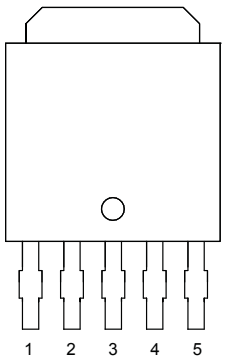
ELECTRICAL CHARACTERISTICS, valid at T_A = 25°C, V_O = 5 V (adjusted), R1 = 4.2 kΩ, R1 = 0.8 kΩ

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Reference Voltage	V_{ADJ}	V_{IN} = 15 V, I_O = 0.1 A	0.784	0.8	0.816	V
Reference Voltage Temperature Coefficient	$\Delta V_{REF}/\Delta T$	V_{IN} = 15 V, I_O = 0.1 A, T_{OP} = 0 to 100 °C	–	±0.1	–	mV/°C
Efficiency*	η	V_{IN} = 15 V, I_O = 0.5 A	–	81	–	%
Operating Frequency	f_O	V_{IN} = 15 V, I_O = 0.5 A	–	300	–	kHz
Line Regulation	V_{Line}	V_{IN} = 10 to 30 V, I_O = 0.5 A	–	60	80	mV
Load Regulation	V_{Load}	V_{IN} = 15 V, I_O = 0.2 to 1.5 A	–	10	40	mV
Overcurrent Protection Threshold Current	I_S	V_{IN} = 15 V	1.6	–	–	A
SS Terminal On/Off Operation Threshold Voltage	V_{SSL}		–	–	0.5	V
SS Terminal On/Off Operation Outflow Current	I_{SSL}	V_{SSL} = 0 V	–	10	40	µA
Quiescent Current 1	I_q	V_{IN} = 15 V, I_O = 0 A	–	6	–	mA
Quiescent Current 2	$I_{q(off)}$	V_{IN} = 15 V, V_{SS} = 0 V	–	200	400	µA

*Efficiency is calculated by the following equation.

$$\eta\,(\%) = \frac{V_O \times I_O}{V_{IN} \times I_{IN}} \times 100$$

Pin-out Diagram



Terminal List Table

Name	Number	Function
IN	1	Supply voltage
SW	2	Regulated supply output
GND	3	Ground terminal
ADJ	4	Terminal for resistor bridge feedback
SS	5	The SS terminal is used to enable soft start and to control on/off operation of the IC output, V_O (see figure 2). To enable soft start, connect a capacitor between SS and ground. To control on/off operation, connect an NPN bipolar transistor, in a TTL open collector output configuration, between the SS terminal and GND. Turn off is done by decreasing V_{SSL} below its rated level. When both soft start and V_O on/off are used, a protection measure such as current limiting is required because, if the capacitance of C3 large, the discharge current of C3 flows across the transistor for on/off operation. Because a pull-up type resistor is provided inside the IC, no external voltage can be applied.

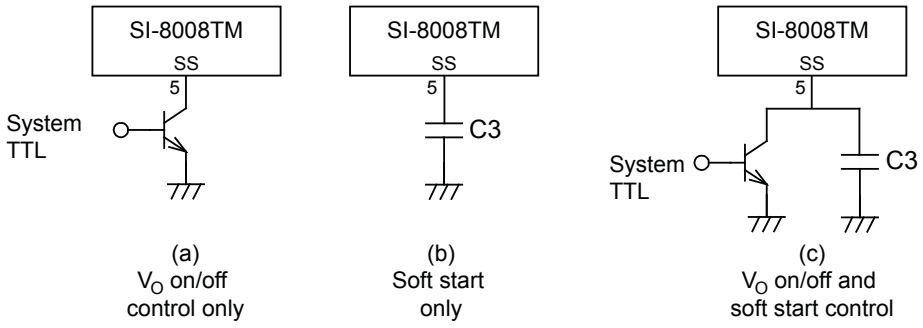
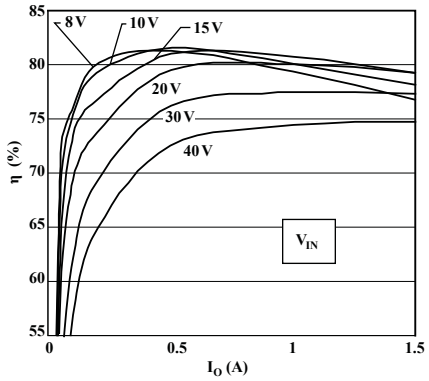


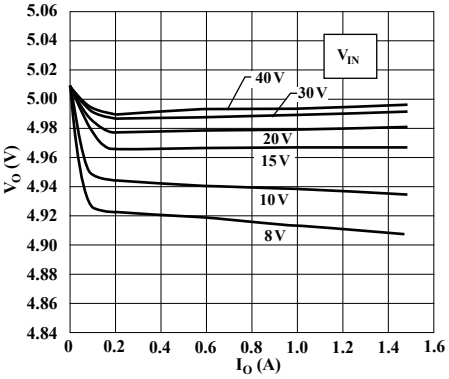
Figure 2. Alternative configurations for SS pin. If neither soft start nor V_O on/off is required, the SS pin is left open.

SI-8008TM Performance Characteristics at T_A = 25°C

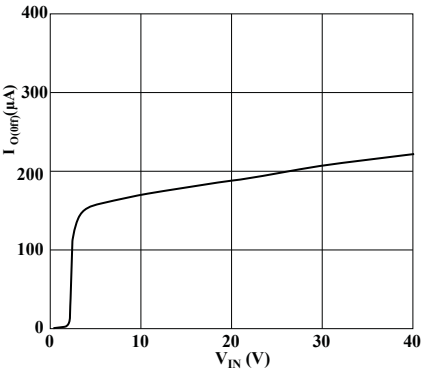
Efficiency versus Output Current
V_O= 5 V (Adjusted)
R_1 = 4.2 kΩ
R_2 = 0.8 kΩ



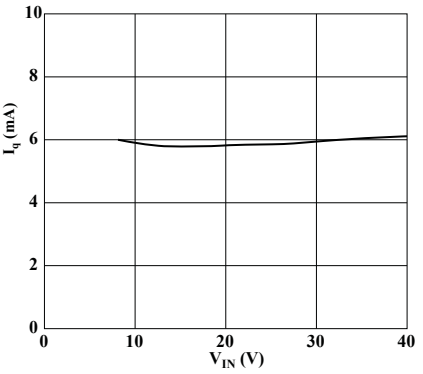
Load Regulation: Output Voltage versus Output Current



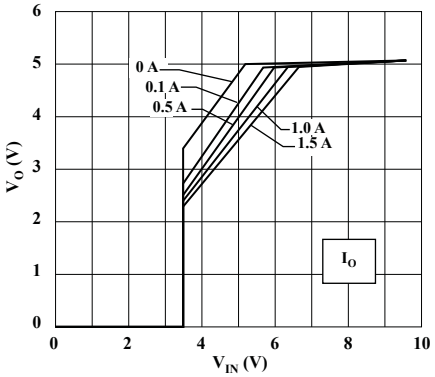
Circuit Current at Output Off versus Supply Voltage
V_{SS} = 0 V



Quiescent Current versus Supply Voltage
I_O = 0 A



Low Voltage Behavior Output Voltage versus Supply Voltage



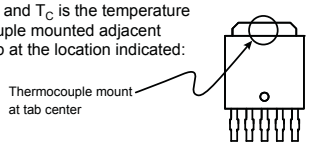
SI-8008TM Thermal Performance Characteristics

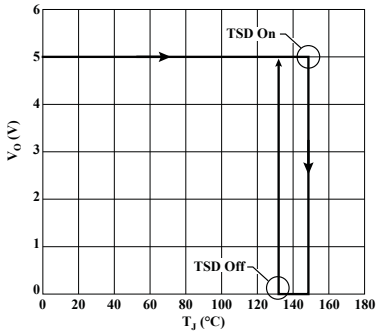
Thermal Protection: Output Voltage versus Junction Temperature
V_{IN} = 8 V, I_O = 0.01 A

Junction temperature, T_J, can be calculated as:

$$T_J = P_D \times R_{\theta JC} + T_C$$

where $R_{\theta JC}$ = 6°C/W, and T_C is the temperature taken by a thermocouple mounted adjacent to the case on the tab at the location indicated:

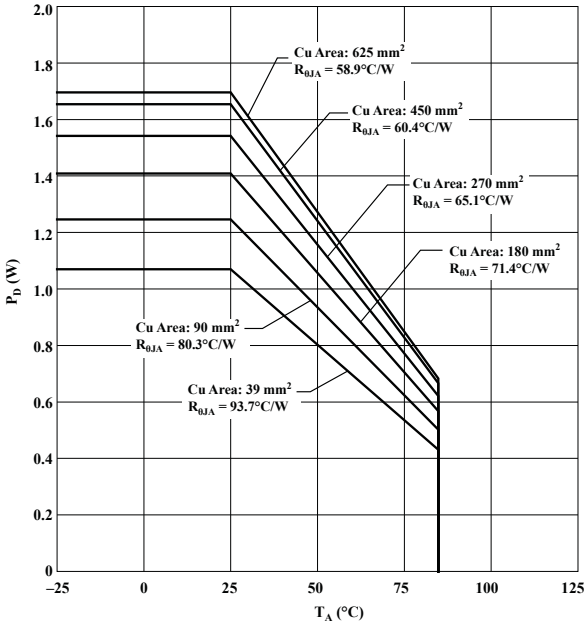




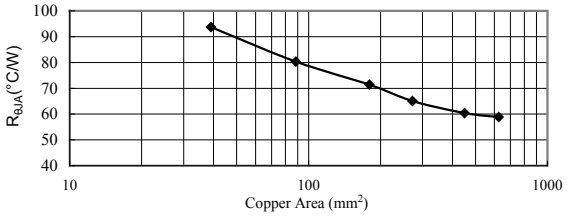
Power Dissipation versus Ambient Temperature
T_J(max) = 125°C
Mounted on glass-epoxy PCB (30 mm × 30 mm), with varying exposed copper areas

$$P_D = V_O \cdot I_O \left(\frac{100}{\eta_x} - 1 \right) - V_F \cdot I_O \left(1 - \frac{V_O}{V_{IN}} \right)$$

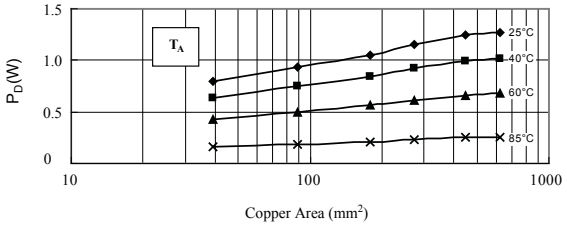
where:
V_O is output voltage in V,
V_{IN} is input supply voltage in V,
I_O is output current in A,
η_X is IC efficiency in percent (varies with V_{IN} and I_O; refer to efficiency curve for value), and
V_F is forward voltage for the input diode, D_i. In these tests, the Sanken SJPB-H6 was used, at 0.5 V and I_O = 1.5 A. For application design, obtain thermal data from the datasheet for the diode.



Device Thermal Resistance versus Exposed Copper Area on PCB
Glass-epoxy PCB, 30 mm²



Device Power Dissipation versus Exposed Copper Area on PCB
Glass-epoxy PCB, 30 mm²



Component Selection

Diode Di

A Schottky-barrier diode must be used for Di. If other diode types are used, such as fast recovery diodes, the IC may be destroyed because of the reverse voltage applied by the recovery voltage or ON voltage.

Choke Coil L1

If the winding resistance of the choke coil is too high, the efficiency may go down to the extent that it is out of the rating. Because the overcurrent protection start current is approximately 2.5 A, attention must be paid to the heating of the choke coil by the magnetic saturation due to overload or short-circulated load.

Capacitor C1,C2, and C3

As large ripple currents flow across C1 and C2, capacitors with high frequency and low impedance for SMPS must be used. Especially when the impedance of C2 is high, the switching waveform may not be normal at low temperature. Please use neither OS capacitors nor tantalum capacitors which cause an abnormal oscillation for C2.

C3 is a capacitor for soft start. In case soft start function is not used, please keep the SS terminal open. A pull-up resistor is provided inside the IC.

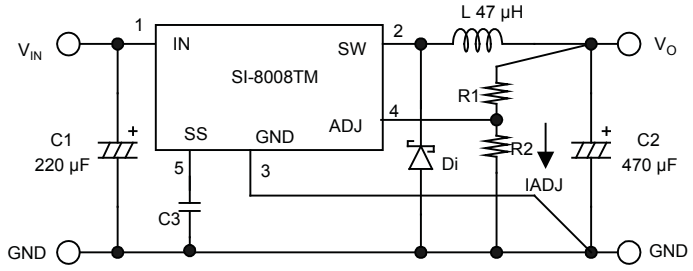
Resistor R1 and R2

R1, R2 is a resistor bridge to the output voltage. I_{ADJ} should be set to 1 mA. To do so, calculate R1, R2 by the following expressions:

$$R1 = \frac{(V_O - V_{ADJ})}{I_{ADJ}} = \frac{(V_O - 0.8)}{1\times10^{-3}}(\Omega),\ R2 = \frac{V_{ADJ}}{I_{ADJ}} = \frac{0.8}{1\times10^{-3}} = 0.8k(\Omega)$$

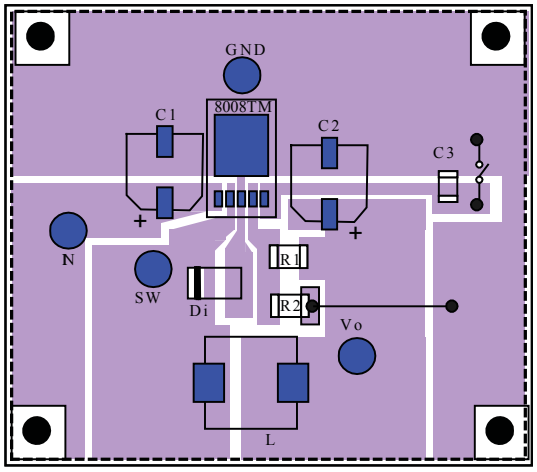
R2 should always be connected for stable operation, even if output voltage, V_O, is set to 0.8 V. It is recommended that V_O be set at V_{IN}+ 8% or greater.

Typical Application Circuit



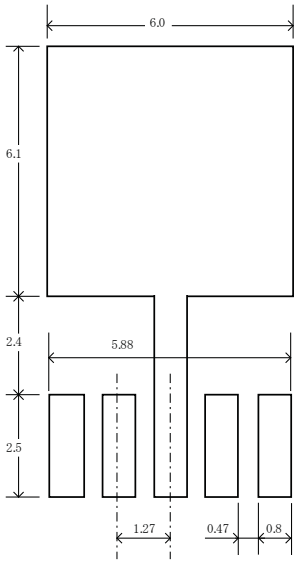
Component	Rating
C1	220 µF
C2	470 µF
C3	1 µF (for soft start function)
Di	SJPB-H6 (Sanken)
L1	47 µH

Recommended PCB Layout

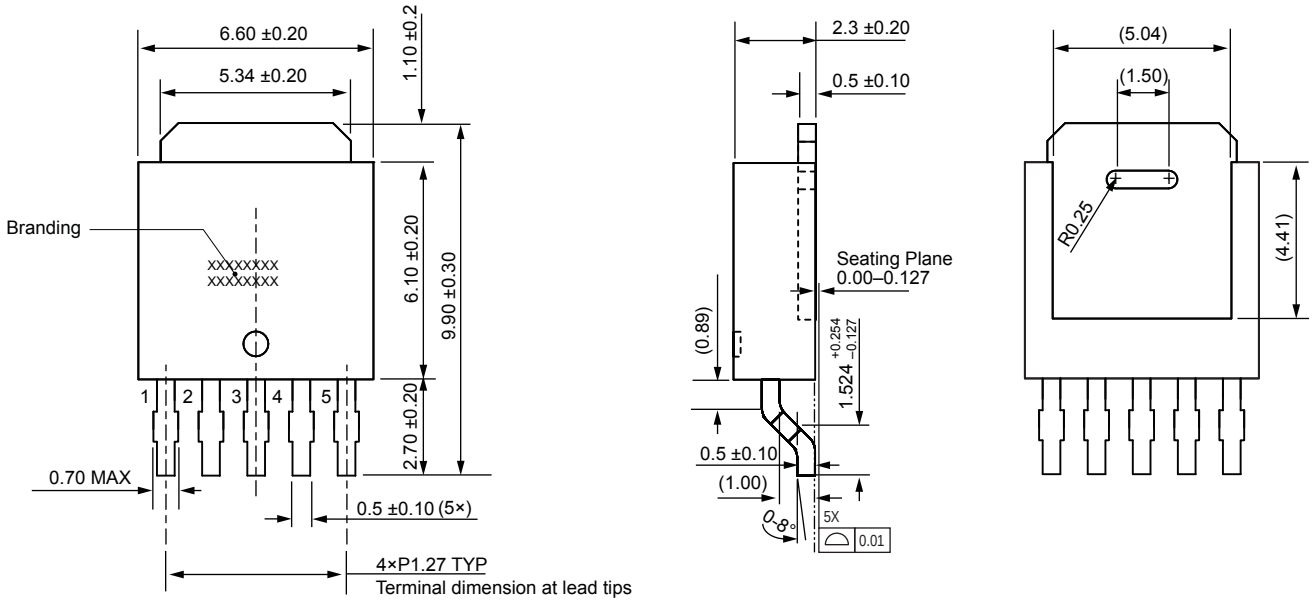


All external components should be mounted as close as possible to the SI-8008TM. The ground of all components should be connected at one point.

Recommended Solder Pad Layout



PACKAGE OUTLINE DRAWING, TO252-5



Terminal core material: Cu
Terminal treatment: Ni plating and solder dip
Heat sink core material: Cu
Heat sink treatment: Ni plating
Approximate weight: 0.33 g

Dimensions in millimeters

Branding codes (exact appearance at manufacturer discretion):
1st line, type: 8008TM

2nd line, lot: *YM W*
Where: Y is the last digit of the year of manufacture
M is the month (*1* to *9*, *O*, *N*, *D*)
W is the week
3rd line, Tracking number (four digits)

Device is lead (Pb) free.

Because reliability can be affected adversely by improper storage environments and handling methods, please observe the following cautions.

Cautions for Storage

- Ensure that storage conditions comply with the standard temperature (5°C to 35°C) and the standard relative humidity (around 40% to 75%); avoid storage locations that experience extreme changes in temperature or humidity.
- Avoid locations where dust or harmful gases are present and avoid direct sunlight.
- Reinspect for rust on leads and solderability of the products that have been stored for a long time.

Cautions for Testing and Handling

When tests are carried out during inspection testing and other standard test periods, protect the products from power surges from the testing device, shorts between the product pins, and wrong connections. Ensure all test parameters are within the ratings specified by Sanken for the products.

Remarks About Using Silicone Grease with a Heatsink

- When silicone grease is used in mounting the products on a heatsink, it shall be applied evenly and thinly. If more silicone grease than required is applied, it may produce excess stress.
- Volatile-type silicone greases may crack after long periods of time, resulting in reduced heat radiation effect. Silicone greases with low consistency (hard grease) may cause cracks in the mold resin when screwing the products to a heatsink.

  Our recommended silicone greases for heat radiation purposes, which will not cause any adverse effect on the product life, are indicated below:

Type	Suppliers
G746	Shin-Etsu Chemical Co., Ltd.
YG6260	Momentive Performance Materials Inc.
SC102	Dow Corning Toray Co., Ltd.

Cautions for Mounting to a Heatsink

- When the flatness around the screw hole is insufficient, such as when mounting the products to a heatsink that has an extruded (burred) screw hole, the products can be damaged, even with a lower than recommended screw torque. For mounting the products, the mounting surface flatness should be 0.05 mm or less.
- Please select suitable screws for the product shape. Do not use a flat-head machine screw because of the stress to the products. Self-tapping screws are not recommended. When using self-tapping screws, the screw may enter the hole diagonally, not vertically, depending on the conditions of hole before threading or the work situation. That may stress the products and may cause failures.
- Recommended screw torque: 0.588 to 0.785 N●m (6 to 8 kgf●cm).
- For tightening screws, if a tightening tool (such as a driver) hits the products, the package may crack, and internal stress fractures may occur, which shorten the lifetime of the electrical elements and can cause catastrophic failure. Tightening with an air driver makes a substantial impact. In addition, a screw torque higher than the set torque can be applied and the package may be damaged. Therefore, an electric driver is recommended.

  When the package is tightened at two or more places, first pre-tighten with a lower torque at all places, then tighten with the specified torque. When using a power driver, torque control is mandatory.

Soldering

- When soldering the products, please be sure to minimize the working time, within the following limits:

  260±5°C 10±1 s (Flow, 2 times)

  380±10°C 3.5±0.5 s (Soldering iron, 1 time)
- Soldering should be at a distance of at least 2.0 mm from the body of the products.

Electrostatic Discharge

- When handling the products, the operator must be grounded. Grounded wrist straps worn should have at least 1 MΩ of resistance from the operator to ground to prevent shock hazard, and it should be placed near the operator.
- Workbenches where the products are handled should be grounded and be provided with conductive table and floor mats.
- When using measuring equipment such as a curve tracer, the equipment should be grounded.
- When soldering the products, the head of soldering irons or the solder bath must be grounded in order to prevent leak voltages generated by them from being applied to the products.
- The products should always be stored and transported in Sanken shipping containers or conductive containers, or be wrapped in aluminum foil.

- The contents in this document are subject to changes, for improvement and other purposes, without notice. Make sure that this is the latest revision of the document before use.
- Application and operation examples described in this document are quoted for the sole purpose of reference for the use of the products herein and Sanken can assume no responsibility for any infringement of industrial property rights, intellectual property rights or any other rights of Sanken or any third party which may result from its use.
- Although Sanken undertakes to enhance the quality and reliability of its products, the occurrence of failure and defect of semiconductor products at a certain rate is inevitable. Users of Sanken products are requested to take, at their own risk, preventative measures including safety design of the equipment or systems against any possible injury, death, fires or damages to the society due to device failure or malfunction.
- Sanken products listed in this document are designed and intended for the use as components in general purpose electronic equipment or apparatus (home appliances, office equipment, telecommunication equipment, measuring equipment, etc.).

  When considering the use of Sanken products in the applications where higher reliability is required (transportation equipment and its control systems, traffic signal control systems or equipment, fire/crime alarm systems, various safety devices, etc.), and whenever long life expectancy is required even in general purpose electronic equipment or apparatus, please contact your nearest Sanken sales representative to discuss, prior to the use of the products herein.

  The use of Sanken products without the written consent of Sanken in the applications where extremely high reliability is required (aerospace equipment, nuclear power control systems, life support systems, etc.) is strictly prohibited.
- In the case that you use Sanken products or design your products by using Sanken products, the reliability largely depends on the degree of derating to be made to the rated values. Derating may be interpreted as a case that an operation range is set by derating the load from each rated value or surge voltage or noise is considered for derating in order to assure or improve the reliability. In general, derating factors include electric stresses such as electric voltage, electric current, electric power etc., environmental stresses such as ambient temperature, humidity etc. and thermal stress caused due to self-heating of semiconductor products. For these stresses, instantaneous values, maximum values and minimum values must be taken into consideration.

  In addition, it should be noted that since power devices or IC's including power devices have large self-heating value, the degree of derating of junction temperature affects the reliability significantly.
- When using the products specified herein by either (i) combining other products or materials therewith or (ii) physically, chemically or otherwise processing or treating the products, please duly consider all possible risks that may result from all such uses in advance and proceed therewith at your own responsibility.
- Anti radioactive ray design is not considered for the products listed herein.
- Sanken assumes no responsibility for any troubles, such as dropping products caused during transportation out of Sanken's distribution network.
- The contents in this document must not be transcribed or copied without Sanken's written consent.