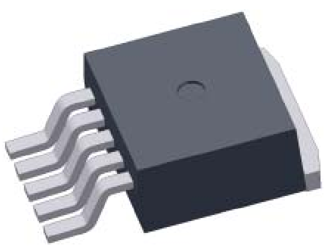
DC-to-DC Step-Down Converter

Features and Benefits

- 3.5 A output current supplied in a small, surface mount power package
- High efficiency: 83% at V_{IN} = 15 V, I_O = 2.0 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 mode overcurrent protection circuit and overtemperature protection circuit built-in
- Soft start function built-in (can be implemented as an on/off function; output-off state at low level)
- Low current consumption during output-off state

Package: TO263-5



Not to scale

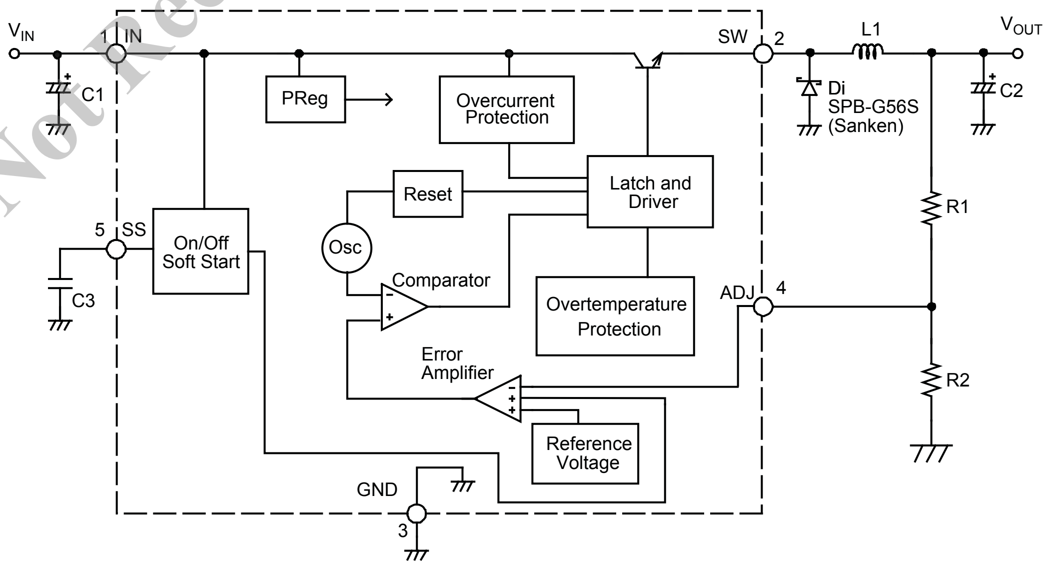
Description

The SI-8001FDE 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 TO263 package.

The internal switching regulator function provides high efficiency switching regulation without any need for adjustment. The device requires only six external support components. The optional soft start function requires an additional capacitor. Optional on/off control can be performed using a transistor. The SI-8001FDE includes overcurrent and overtemperature 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



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

Selection Guide

Part Number	Output Voltage Adjustable Range (V)	Efficiency, Typ. (%)	Input Voltage, Max. (V)	Output Current, Max. (A)	Packing
SI-8001FDE-TL	0.8 to 24	83	40	3.5	800 pieces per reel

Absolute Maximum Ratings

Characteristic	Symbol	Remarks	Rating	Units
DC Input Voltage	V_{IN}		43	V
Power Dissipation	P_D	Mounted on 40 mm × 40 mm exposed copper area on 40 mm × 40 mm glass-epoxy PCB; limited by internal overtemperature protection.	3	W
Junction Temperature	T_J	Internal overtemperature protection circuit may enable when $T_J \geq$ 130°C. During product operation, recommended $T_J \leq$ 125°C.	–40 to 150	°C
Storage Temperature	T_{stg}		–40 to 150	°C
Thermal Resistance (junction-to-case)	$R_{\theta JC}$	Mounted on 40 mm × 40 mm exposed copper area on 40 mm × 40 mm glass-epoxy PCB.	3	°C/W
Thermal Resistance (junction-to-ambient air)	$R_{\theta JA}$	Mounted on 40 mm × 40 mm exposed copper area on 40 mm × 40 mm glass-epoxy PCB.	33.3	°C/W

Recommended Operating Conditions*

Characteristic	Symbol	Remarks	Min.	Max.	Units
DC Input Voltage Range	V_{IN}	V_{IN} (min) is the greater of 4.5 V or V_O+3 V.	See remarks	40	V
DC Output Voltage Range	V_O		0.8	24	V
DC Output Current Range	I_O	$V_{IN} \geq V_O$ + 3 V; to be used within the allowable package power dissipation characteristics (refer to Power Dissipation chart).	0	3.5	A
Operating Junction Temperature Range	T_{JOP}		–30	100	°C
Operating Temperature Range	T_{OP}	To be used within the allowable package power dissipation characteristics (refer to Power Dissipation chart).	–30	85	°C

*Required for normal device functioning according to Electrical Characteristics table.

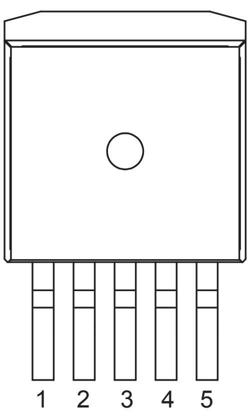
All performance characteristics given are typical values for circuit or system baseline design only and are at the nominal operating voltage and an ambient temperature, T_A, of 25°C, unless otherwise stated.

ELECTRICAL CHARACTERISTICS[1], valid at T_A = 25°C, V_O = 5 V (adjusted), R1 = 4.2 kΩ, R1 = 0.8 kΩ

Characteristic	Symbol	Test Conditions[1]	Min.	Typ.	Max.	Units
Reference Voltage	V_{ADJ}	V_{IN} = 15 V, I_O = 0.2 A	0.784	0.800	0.816	V
Reference Voltage Temperature Coefficient	$\Delta V_{ADJ}/\Delta T$	V_{IN} = 15 V, I_O = 0.2 A, T_C = 0 to 100 °C	–	±0.1	–	mV/°C
Efficiency[2]	η	V_{IN} = 15 V, I_O = 2 A	–	83	–	%
Operating Frequency	f_O	V_{IN} = 15 V, I_O = 2 A	270	300	330	kHz
Line Regulation	V_{Line}	V_{IN} = 10 to 30 V, I_O = 2 A	–	–	80	mV
Load Regulation	V_{Load}	V_{IN} = 15 V, I_O = 0.2 to 3.5 A	–	–	50	mV
Overcurrent Protection Threshold Current	I_S	V_{IN} = 15 V	3.6	–	–	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	–	6	30	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	600	μA

[1]Using circuit shown in Typical Application Circuit diagram.
[2]Efficiency is calculated as: η(%) = ([V_O × I_O] × [V_{IN} × I_{IN}]) × 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). If neither soft start nor on/off control is used, leave pin open. 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.

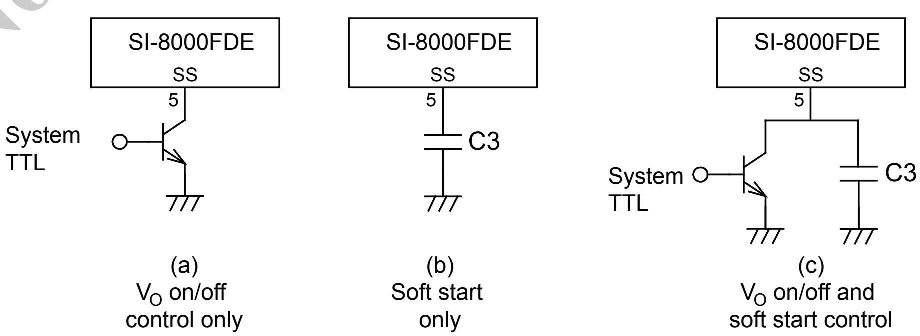
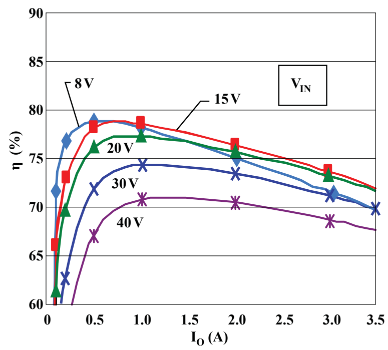


Figure 2. Alternative configurations for SS pin. If neither soft start nor V_O on/off is required, the SS pin is left open.

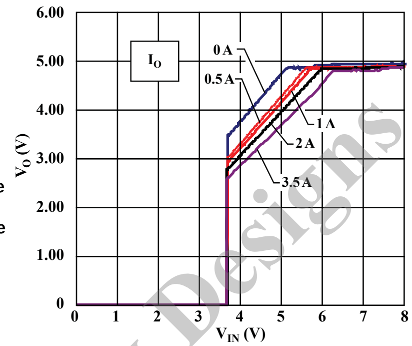
Performance Characteristics

At T_A = 25°C, V_O = 5 V Adjusted, R1 = 4.2 kΩ, R2 = 0.8 kΩ

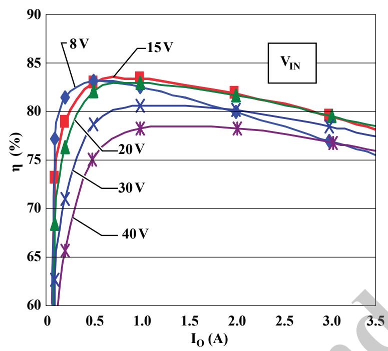
Efficiency versus Output Current
V_O= 3.3 V



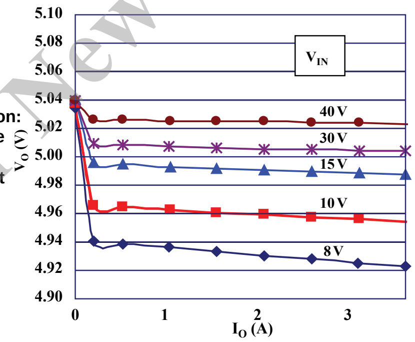
Low Voltage Behavior: Output Voltage versus Supply Voltage



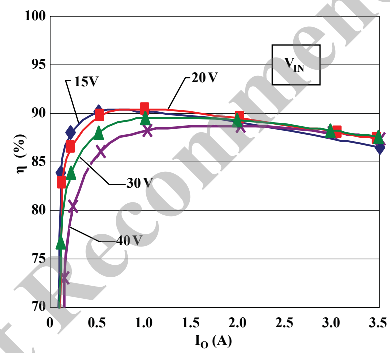
Efficiency versus Output Current
V_O= 5.0 V



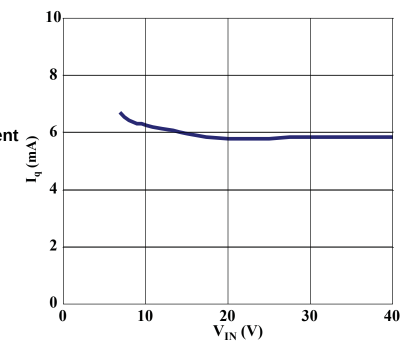
Load Regulation: Output Voltage versus Output Current



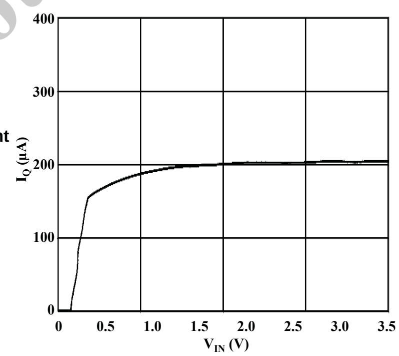
Efficiency versus Output Current
V_O= 12.0 V



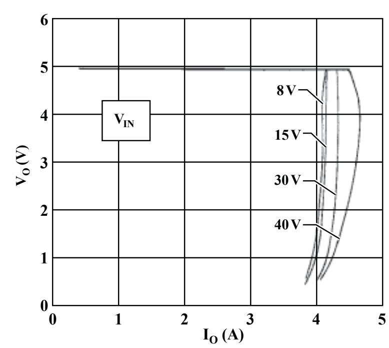
Quiescent Current versus Supply Voltage
I_O = 0 A
SS pin open



Behavior at Turn-Off: Quiescent Current versus Input Voltage
I_O = 0 A
V_{SS} = 0 V



Overcurrent Protection: Output Voltage versus Output Current



Thermal Performance Characteristics

The application must be designed to ensure that the T_J(max) of the device is not exceeded during operation. To do so, it is necessary to determine values for maximum power dissipation, P_D(max), and ambient temperature, T_A(max).

The relationships of T_J, P_D, T_A, and case temperature, T_C, are as shown in the following formulas:

$$P_D = \frac{T_J - T_C}{R_{\theta JC}} \quad \text{and} \quad P_D = \frac{T_J - T_A}{R_{\theta JA}} \quad .$$

P_D can be calculated from input values:

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

where:

V_O is output voltage in V,

V_{IN} is input supply voltage in V,

I_O is output current in A,

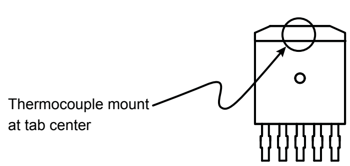
η_x is IC efficiency in percent (varies with V_{IN} and I_O; refer to efficiency performance curves for value), and

V_F is forward voltage for the input diode, Di. In these tests, the Sanken SPB-G56S was used, at 0.4 V. For application design, obtain thermal data from the datasheet for the diode.

P_D is substantially affected by the heat conductance properties of the application, in particular any exposed copper area on the PCB where the device is mounted. The relationships of P_D, T_A, and copper area is represented in the Power Dissipation chart.

$R_{\theta JA}$ for a given copper area can be determined form the Device Thermal Resistance chart. This can be substituted into the formula above to determine the T_J (max) allowable in the application. Generally, more than 10% to 20% derating is required.

Because the heat dissipation capacity of the copper area depends substantively on how it is used in the actual application, thermal characteristics of the application must be confirmed by testing. T_C is determined by connecting a thermocouple to the device as shown here:

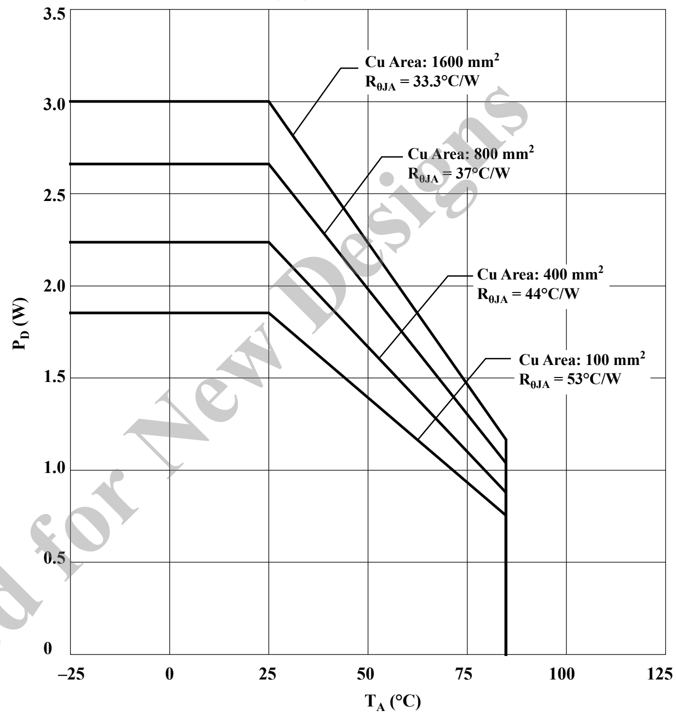


And analyzing the results using the following formula:

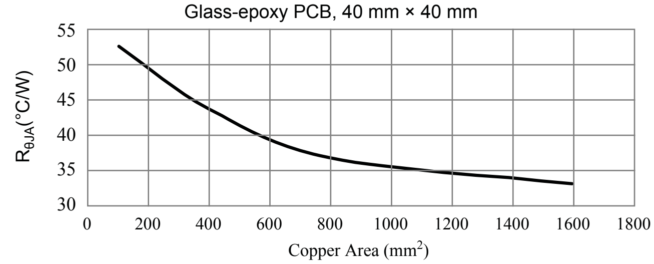
$$T_J = P_D \times R_{\theta JC} + T_C \quad ,$$

for this device, $R_{\theta JC}$ is 3 °C/W.

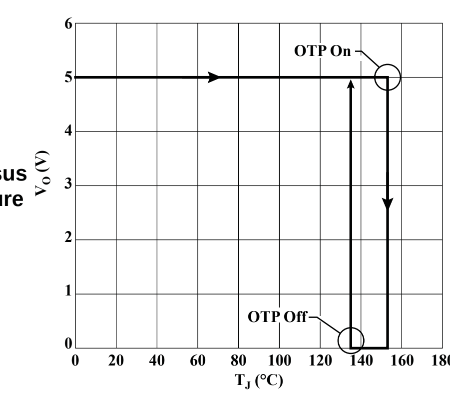
Power Dissipation versus Ambient Temperature
T_J(max) = 125°C; Mounted on glass-epoxy PCB (40 mm × 40 mm), with varying exposed copper areas



Device Thermal Resistance versus Exposed Copper Area on PCB
Glass-epoxy PCB, 40 mm × 40 mm



Overtemperature Protection: Output Voltage versus Junction Temperature
V_{IN} = 15 V, I_O = 10 mA



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 be reduced below rating. Because the overcurrent protection start current is approximately 4.2 A, attention must be paid to the heating of the choke coil by magnetic saturation due to overload or short-circuited load.

Capacitors C1, C2, and C3 Because for SMPS, large ripple currents flow across C1 and C2, capacitors with high frequency and low impedance must be used. If the impedance of C2 is too high, the switching waveform may not be normal at low temperatures. Do not use either OS or tantalum types of capacitors for C2 or C3, because the extremely low ESR causes an abnormal oscillation.

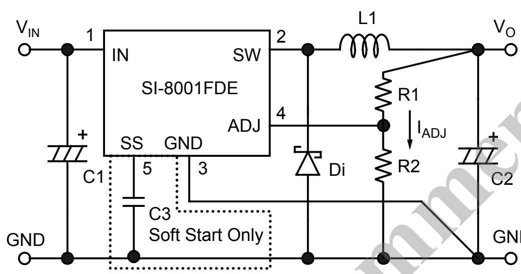
The device is stabilized, and for proper operation, C1 must be located close to the device (see layout diagram, below). C3 is required only if the soft start function is used. If not using soft-start, leave the SS terminal open. A pull-up resistor is provided inside the IC.

Resistor Bridge R1 and R2 comprise the resistor bridge for the output voltage, V_O, and are calculated as follows:

$$R1 = \frac{(V_O - V_{ADJ})}{I_{ADJ}} = \frac{(V_O - 0.8)}{1 \times 10^{-3}} \,(\Omega)\text{, and } R2 = \frac{V_{ADJ}}{I_{ADJ}} = \frac{0.8}{1 \times 10^{-3}} = 0.8\,(\mathrm{k}\Omega)$$

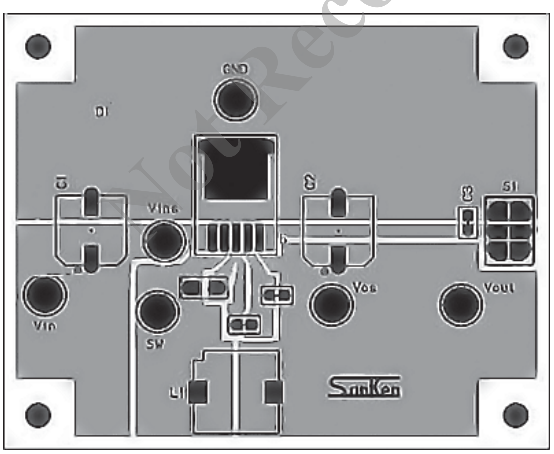
I_{ADJ} should always be set to 1 mA. Note that R2 should always be present to ensure stable operation, even if V_O, is set to 0.8 V (that is, even if there is no R1). V_O should be at least V_{IN} + 8%.

Typical Application Diagram



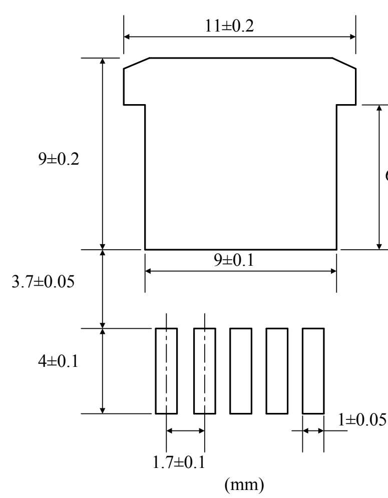
Component	Rating
C1	470 µF
C2	680 µF
C3	0.1 µF (For soft start function)
Di	SPB-G56S (Sanken)
L1	47 µH

Recommended PCB Layout

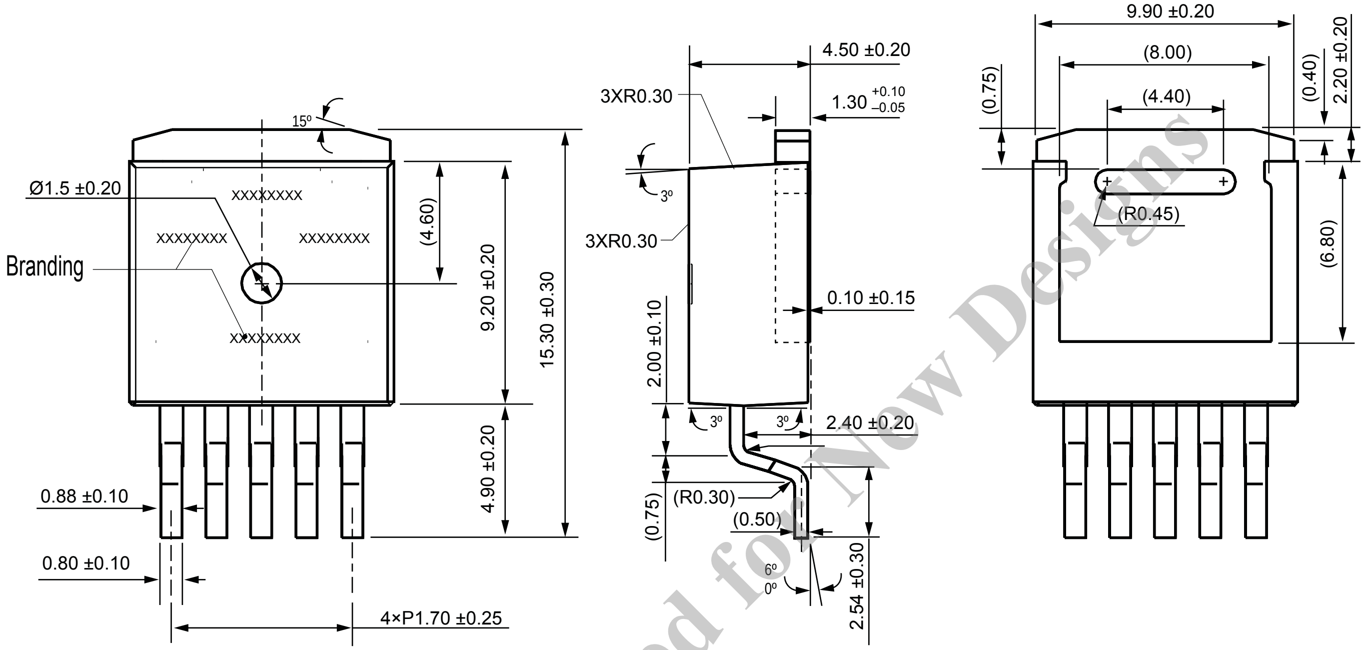


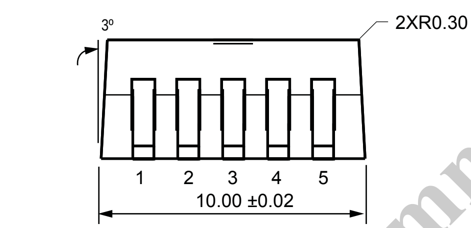
All external components should be mounted as close as possible to the SI-8001FDE. The ground of all components should be connected at one point near GND pin (pin 3).

Recommended Solder Pad Layout



PACKAGE OUTLINE DRAWING





Dimensions do not include mold protrusion
Heastsink side flash: 0.8 mm maximum

Dimensions in millimeters

Branding codes (exact appearance at manufacturer discretion):

1st line: SK
2nd line, lot: *YMW X*
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 of the month (*1* to *5*)
X is the device subtype suffix number
3rd line, type: 8001FDE

RoHS directive compliant
Device pins lead (Pb) free

Cautions for Use

- Operation of the product in parallel to increase current is not permitted.
- Although the product has an internal overtemperature protection circuit, that is intended only to protect the product from temporary excess heating due to overloads. Long-term reliability cannot be guaranteed when the product is operated under continuous overload conditions.

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 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 adjacent products, and shorts to the heatsink.

Electrostatic Discharge

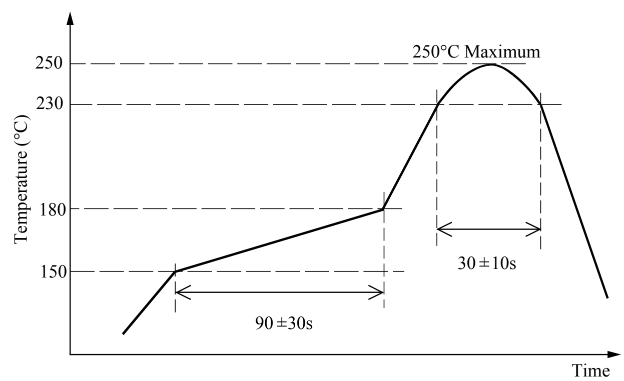
- When handling the products, operator must be grounded. Grounded wrist straps worn should have at least 1 MΩ of resistance to ground to prevent shock hazard.
- Workbenches where the products are handled should be grounded and be provided with conductive table and floor mats.
- When using measuring equipment 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 other to prevent leak voltages generated by them from being applied to the products.
- The products should always be stored and transported in our shipping containers or conductive containers, or be wrapped in aluminum foil.

Soldering

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

Soldering Iron Temperature (°C)	Time (s)
380±10	3 (once only)

- Reflow soldering can be performed a maximum of twice, using the following recommended profile:



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  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.
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