Application Note

Surface Molding Series Regulator IC

SI-3000ZD Series

Not Recommended for New Designs:
SI-3033ZD

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SANKEN ELECTRIC CO., LTD.

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Not Recommended for New Designs:
SI-3033ZD

1. General Information

The SI-3000ZD is a series regulator IC using a hyposaturation type PNP bipolar transistor in the power section; it can be used with the low difference of input/output voltages and rated 3A. It is provided with an ON/OFF terminal which operates in Active High mode and the current consumption of circuits at OFF time is zero.

Not Recommended for New Designs: SI-3033ZD

● 1-1 Features

- Output current 1A

  Output current is 3A at maximum with the outline of TO263-5.
- Hyposaturation (V_{dif} = 0.6Vmax / Io = 3A)

  It can be designed with low difference of input/output voltages.
- ON/OFF function

  The ON/OFF terminal which can be directly controlled by TTL logic signals is provided.
- Low current consumption

  Current consumption of circuits at OFF time is zero.

  Dark currents at no load are 1.5mA at maximum.
- High ripple attenuation ratio

  75dB (SI-3050KD): F = 100 - 120kHz)
- Built-in overcurrent protection

  The automatic restoration and foldback type overcurrent protection circuit is built in.

● 1-2 Application

For on-board local power supplies, power supplies for OA equipment, stabilization of secondary output voltage of regulator and power supply for communication equipment

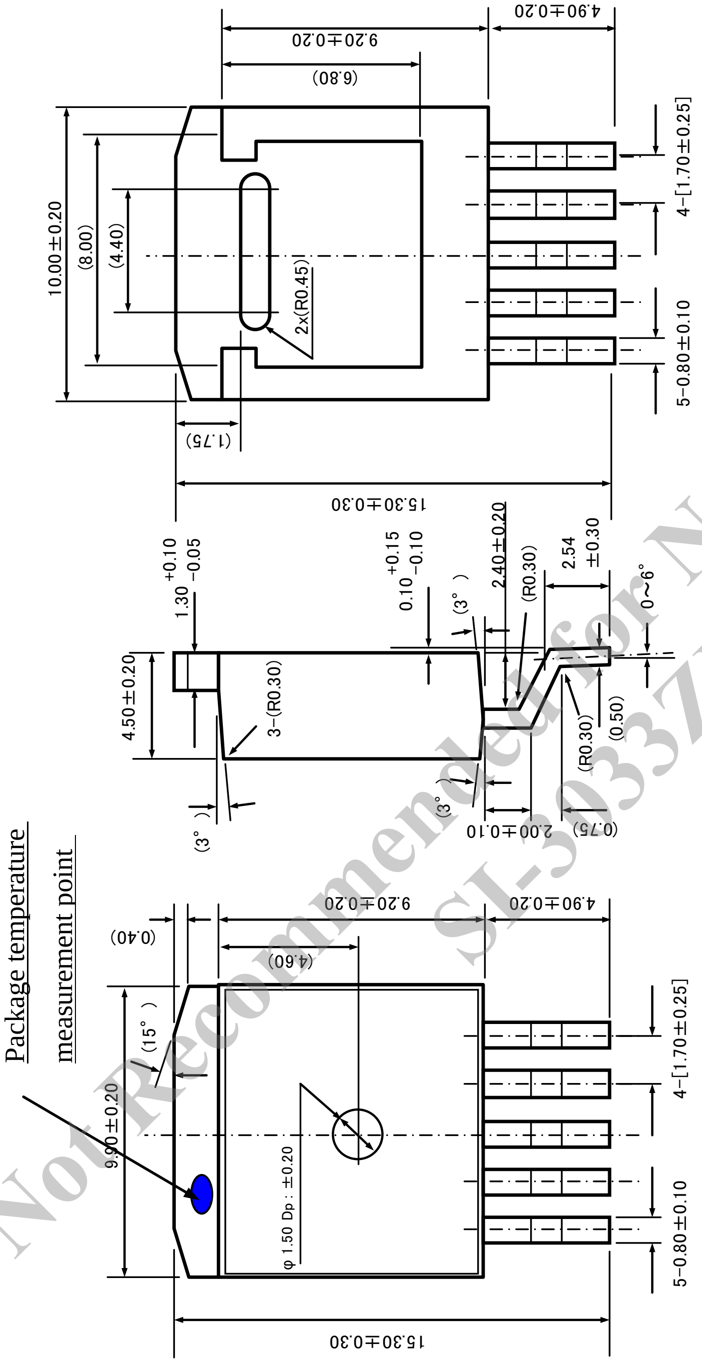
● 1-3 Type

- Type: Semiconductor integrated circuits (monolithic IC)
- Structure: Resin molding type (transfer molding)

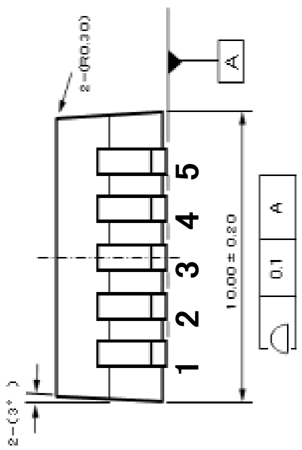
2. Specification

● 2-1 Package Information

Unit: mm



Note
1) Dimensions do not include molding burr.
2) Figures in parentheses ( ) are shown only for reference.
3) Figures in parentheses [ ] are dimensions after lead forming.
4) Backside bumps: 0.8 mm at maximum
5) Unit: mm



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Products Weight：Approx.1.48g

The stem part has same potential as No. 3 pin (GND).

Pin assignment
1. Vc (on/off)
2. VIN
3. GND
4. Vout
5. ADJ

● 2-2 Ratings

2-2-1 Absolute Maximum Ratings

Ta=25°C

Parameter	Symbol	Ratings	Unit
DC Input Voltage	V_{IN}*1	10	V
Output Control Terminal Voltage	V_C	6	V
DC Output Current	I_O*1	3.0	A
Power Dissipation	P_D*3	3	W
Junction Temperature	T_j	−30 to +125	°C
Operating Ambient Temperature	T_{op}	−30 to +85	°C
Storage Temperature	T_{stg}	−40 to +125	°C
Thermal Resistance (Junction to Ambient Air)	θ_{j-a}	33.3	°C/W
Thermal Resistance (Junction to Case)	θ_{j-c}	3	°C/W

2-2-2 Recommended Conditions

Parameter	Symbol	Ratings	Unit	Remarks
Input Voltage	V_{IN}	*2 to 6*1	V	
Output Current	I_O	0 to 3	A	
Operating Ambient Temperature	$T_{op(a)}$	−20 to +85	°C	
Operating Junction Temperature	$T_{op(j)}$	−20 to +100	°C	
Output Voltage Variable Range	$V_{O(ADJ)}$	1.2 to 5	V	Only for SI-3011ZD. Refer to the block diagram.

*1: V_{IN} (max) and I_O (max) are restricted by the relation $P_D = (V_{IN} - V_O) \times I_O$.

*2: Set the input voltage to 2.4V or higher when setting the output voltage to 2.0V or lower (SI-3011ZD).

*1: V_{IN} (max) and Io (max) are restricted by the relation $P_D = (V_{IN} – Vo) \times Io$.

*2: Set the input voltage to 2.4V or higher when setting the output voltage to 2.0V or lower (SI-3011ZD).

2-2-3 Electrical Characteristics (SI-3011ZD, SI-3033ZD)

Ta=25°C, Vc = 2V if without special instruction

Parameter	Symbol	Ratings						Unit
		SI-3011ZD (Variable type)			SI-3033ZD			
		min.	typ.	max.	min.	typ.	max.	
Output Voltage (Reference Voltage V_{ADJ} for SI-3011ZD)	V_O (V_{ADJ})	1.078	1.100	1.122	3.234	3.300	3.366	V
	Conditions	V_{IN}=V_O+1V, I_O=10mA			V_{IN}=5V, I_O=10mA			
Line Regulation	ΔV_{OLINE}			10			10	mV
	Conditions	V_{IN}=3.3 to 5V, I_O=10mA (V_O=2.5V)			V_{IN}=4.5 to 5.5V, I_O=10mA			
Load Regulation	ΔV_{OLOAD}			40			40	mV
	Conditions	V_{IN}=3.3V, I_O=0 to 3A (V_O=2.5V)			V_{IN}=5V, I_O=0 to 3A			
Dropout Voltage	V_{DIF}			0.6			0.6	V
	Conditions	I_O=3A (V_O=2.5V)			I_O=3A			
Quiescent Circuit Current	I_q		1	1.5		1	1.5	mA
	Conditions	V_{IN}=V_O+1V, I_O=0A, V_C=2V			V_{IN}=5V, I_O=0A, V_C=2V			
Circuit Current at Output OFF	I_q (OFF)			1			1	μA
	Conditions	V_{IN}=V_O+1V, V_C=0V			V_{IN}=5V, V_C=0V			
Temperature Coefficient of Output Voltage	$\Delta V_O/\Delta T_a$		±0.3			±0.3		mV/°C
	Conditions	T_j=0 to 100°C			T_j=0 to 100°C			
Ripple Rejection	R_{REJ}		60			60		dB
	Conditions	V_{IN}=V_O+1V, f=100 to 120Hz, I_O=0.1A			V_{IN}=5V, f=100 to 120Hz, I_O=0.1A			
Overcurrent Protection Starting Current*2 *4	I_{S1}	3.2			3.2			A
	Conditions	V_{IN}=V_O+1V			V_{IN}=5V			
Vc Terminal: Control Voltage (Output ON)*3	$V_{C, IH}$	2			2			V
Vc Terminal: Control Voltage (Output OFF)*3	$V_{C, IL}$			0.8			0.8	V
Vc Terminal: Control Current (Output ON)	$I_{C, IH}$			100			100	μA
	Conditions	V_C=2.7V			V_C=2.7V			
Vc Terminal: Control Current (Output OFF)	$I_{C, IL}$	−5	0		−5	0		μA
	Conditions	V_C=0V			V_C=0V			

*1: Set the input voltage to 2.4V or higher when setting the output voltage to 2.0V or lower.

*2: Is1 is specified at the -5% drop point of output voltage Vo under the condition of Output Voltage parameter.

*3: Output is OFF when the output control terminal (Vc terminal) is open. Each input level is equivalent to LS-TTL level. Therefore, the device can be driven directly by LS-TTLs.

*4: These products cannot be used for the following applications because the built-in foldback-type overcurrent protection may cause errors during start-up stage.

(1) Constant current load (2) Positive and negative power supply (3) Series-connected power supply (4) Vo adjustment by raising ground voltage

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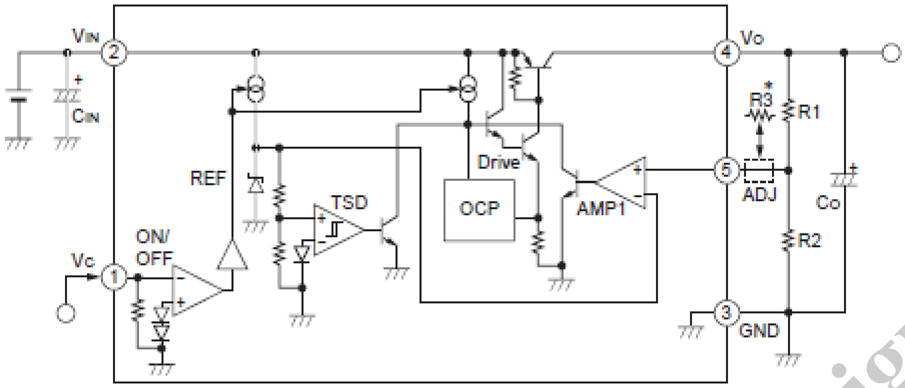
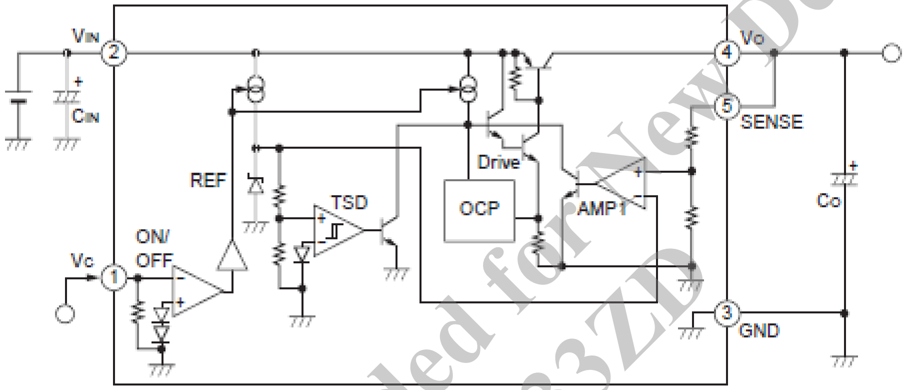
2-3 Circuit Diagram

SI-3011ZD



SI-3033ZD



C_{IN}: Input Capacitor (around 10µF)

C_O: Output Capacitor (over 47µF)

In the SI-3000ZD, if capacitors with low ESR such as ceramic capacitors are used, the output voltage may oscillate.

R1, R2: resistors for setting output voltages

Output voltages can be set by connecting R1 and R2 as shown in the above figure.

R2: 10kΩ or 11kΩ are recommended.

$$R1 = (V_O - V_{ADJ}) / (V_{ADJ} / R2)$$

In the case that Vo ≤ 1.8V is set, R3 should be inserted.

10 kΩ is recommended for R3.

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3. Operational Description

3-1 Voltage Control

In the SI-3000ZD series, the driving circuit is controlled by comparing the reference voltage with the ADJ terminal voltage (voltage divided by Vo detection resistor in fixed output products) to stabilize the output voltage by varying the voltage between the emitter and collector of a main PNP power transistor. The product of voltage between emitter and collector and the output current at this moment is consumed as heat.

3-2 Overcurrent Protection

3-2-1 Overcurrent Protection Characterization for SI-3011ZD and SI-3033ZD

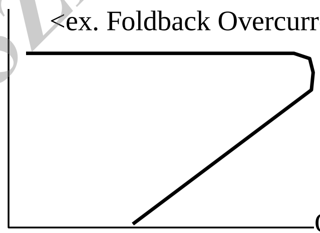
The foldback type overcurrent protection function is provided in the SI-3011ZD and SI-3033ZD. After operation of the overcurrent protection function, if the load resistance decreases and the output voltage drops, the output current of products is squeezed to reduce the increase of loss. However, in the case of the foldback type overcurrent protection function, since current limiting is also made at start-up, the function may not be used for the following applications, as it may cause a start-up error.

(1) Constant current loads

(2) Plus/minus power supply

(3) DC power supply

(4) Output voltage adjustment by grounding-up



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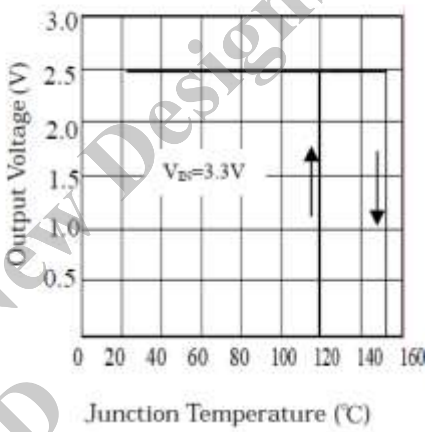
SI-3033ZD

● 3-3 Thermal Shutdown

This IC is provided with the overheat protection circuit which detects the semiconductor junction temperature of the IC to limit the driving current, when the junction temperature exceeds the set value (around 150°C). Since the minimum operating temperature of the overheat protection circuit is 130°C, the thermal design of Tj <125°C is required. Since the hysteresis of around 30°C is provided for the overheat protection, when the junction temperature falls below the set temperature, the operation is automatically restored.

<ex. Thermal Shutdown>



*Note for thermal shutdown characteristic

This circuit protects the IC against overheat resulting from the instantaneous short circuit, but it should be noted that this function does not assure the operation including reliability in the state that overheat continues due to long time short circuit.

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SI-3033ZD

4. Cautions

● 4-1 External Components

4-1-1 Input Capacitor C_{IN}

The input capacitor is required to eliminate noise and stabilize the operation and values of 0.47µF - 22µF are recommended. Any of ceramic capacitors or electrolytic ones may be used for the input capacitor.

4-1-2 Output Capacitor Co

In the output capacitor Co, larger capacitance than the recommended value is required for phase compensation. Equivalent series resistance values (ESR) of capacitors are limited, and depending on products, therefore the type of recommended capacitors is limited.

- Recommended values: 2Ω > ESR > 0.2Ω

It is recommended to use electrolytic capacitors. When capacitors with extremely high ESR such as ceramic capacitors, functional polymer capacitors etc., are used, phase margin is decreased, possibly causing the oscillation of output voltage.

4-1-3 Reverse bias protection diode D1

In the case of falling-down of the input voltage, it is recommended to insert a protection diode D1 against the reverse bias between input and output. However, in the case of setting the Vout < 3.3V or lower, D1 is not required including the case of reverse bias. In order to select a suitable D1, it should be taken into consideration that the diode has adequate forward current withstand voltage against the instantaneous discharge of energy stored in Cout.

The permissible value of the forward current per unit time of diode is specified in I_{FSM} (A) and in the case of our diode, it is specified at 50Hz half wave (10ms), but it should be noted that different companies may specify different times. The selection of diode should be made by converting the specified time into the actual discharging time so as to meet the required I_{FSM} (A). The discharging time of Co is normally shorter than 1ms, but it is recommended to do the conversion with 1ms in consideration of margin.

For conversion into I_{FSM}, calculation should be made by using the equations (1) and (2).

$$\left(\frac{I_{FSM}}{\sqrt{2}}\right)^2 * t1 = X \qquad \text{--- (1)}$$

As for I_{FSM}, please refer to the catalog of each company.

t1 = specified time in catalog of each company

$$\text{Converted IFSM} = \sqrt{\frac{2 * X}{t2}} \qquad \text{--- (2)}$$

t2: converted time (discharging time of Co)

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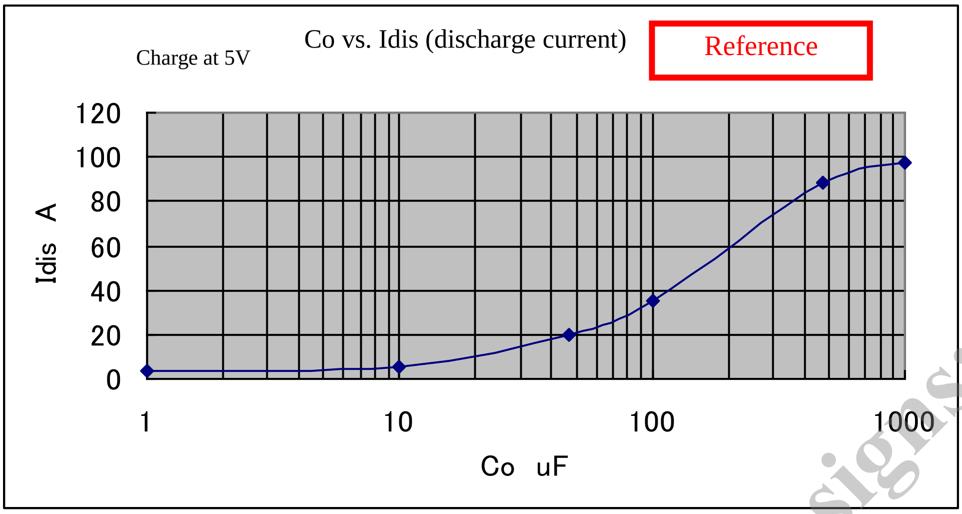
<Graph 1>



On the assumption of Cout = 470µF, I_{FSM} of around 90A or more (in 1ms time period) is required and according to our specifications of diode, I_{FSM} is specified for 10ms, therefore the diode of 30A has the tolerated dose of 94.8A (in 1ms) to prove that it is usable.

● 4-2 Pattern Design Notes

4-2-1 Input / Output Capacitor

The input capacitor C1 and the output capacitor C2 should be connected to the IC as close as possible. If the rectifying capacitor for AC rectifier circuit is on the input side, it can be used as an input capacitor. However, if it is no close to the IC, the input capacitor should be connected in addition to the rectifying capacitor.

4-2-2 ADJ Terminal (Output Voltage Set-up for SI-3011ZD)

The SI – 3011ZD is a variable regulator and the output voltage can be arbitrarily set by using the feedback detection terminal (ADJ terminal) for controlling the output voltage.

The output voltage set-up is achieved by connecting R1 and R2.

SI-3011ZD: it should be set in a manner that I_{ADJ} is around 100µA.

R1, R2 and output voltage can be obtained by the following equations:

$I_{ADJ}=V_{ADJ}/R2$ ($*V_{ADJ}$ = 1.1V ± 2% (SI-3011ZD), R2 = 10kΩ or 11kΩ recommended)

$R1 = (Vo-V_{ADJ}) / I_{ADJ}$ $R2 = V_{ADJ} / I_{ADJ}$

$Vout = R1 \times (V_{ADJ} / R2) + V_{ADJ}$

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5. Applications

● 5-1 Output ON/OFF Control

The ON/OFF control of output can be made by directly applying voltage to No. 1 Vc terminal. When the Vc terminal is open, the operation is in OFF. The Vc terminal is in OFF below 0.8V and in ON at above 2V.

● 5-2 Thermal Design

Calculation of heat dissipation

Heat generation of the surface mounting IC is generally dependent on size, material and copper foil area of the mounted printed circuit board. Full attention should be paid to heat dissipation and adequate margin be taken into consideration at thermal design. In order to enhance the heat dissipation effect, it is recommended to enlarge the copper foil area connected to the stem part on the back side of the product. The copper foil area of the printed circuit board significantly affects the heat dissipation effect.

As the junction temperature Tj (MAX) is a product-specific value, it must be observed strictly. For this purpose, heat sink design (thermal resistance of board) which is appropriate for Pd (MAX) and Ta MAX is required. This is graphically shown in the heat derating curve for easy understanding. The heat dissipation design is done in the following procedure.

1) The highest ambient temperature in the set Ta MAX is obtained.
2) The maximum loss PdMAX which varies the input/output conditions is obtained.

   $Pd = (V_{IN} - Vout) \times Iout$

3) The area of copper foil is determined from the intersection point in the heat derating curve below shown.

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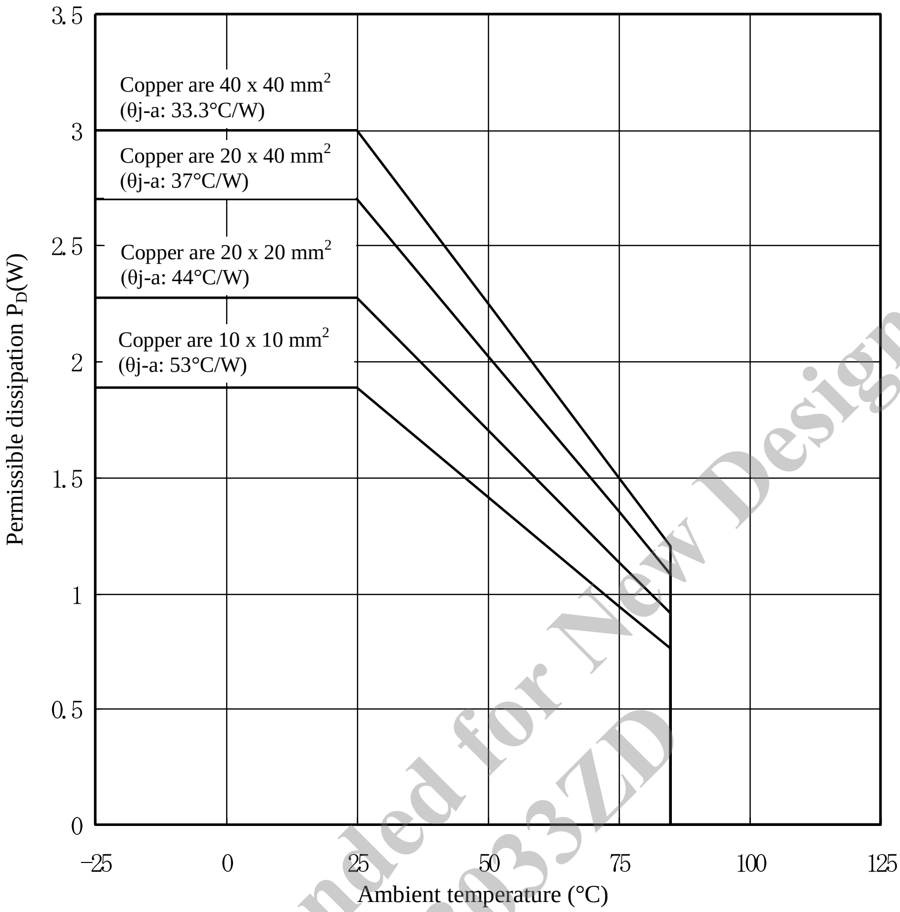
- SI – 3000KD derating curve



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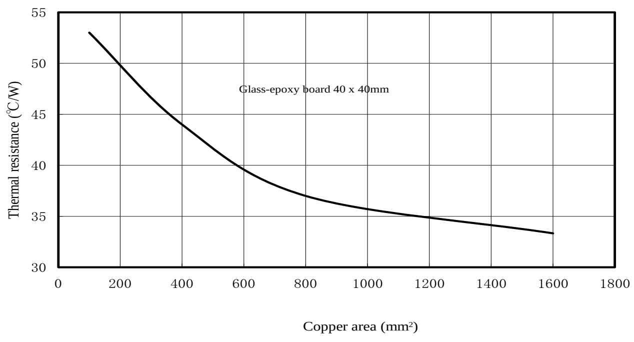
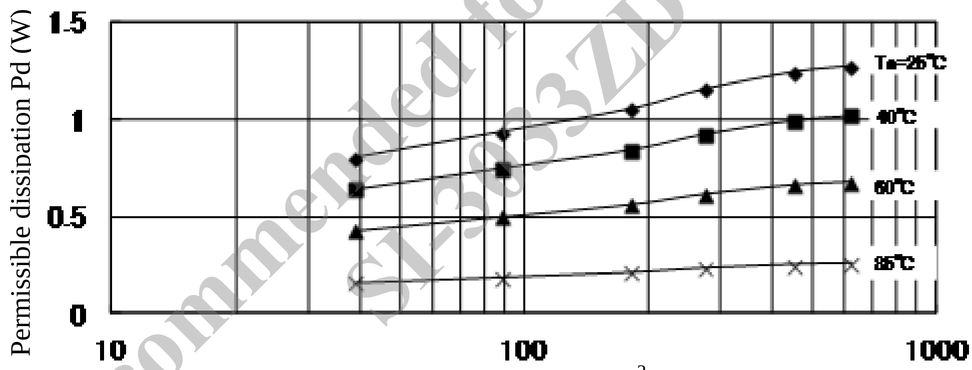
For reference information, the graph of copper foil area vs. thermal resistance between junction temperature and ambient temperature θj-a and the graph of copper foil area vs. permissible dissipation that both are in the single side copper foil board FR - 4 are shown below.



Copper foil area vs. permissible dissipation (Tjmax = 100°C)



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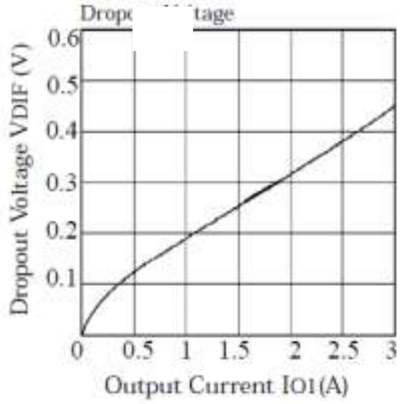
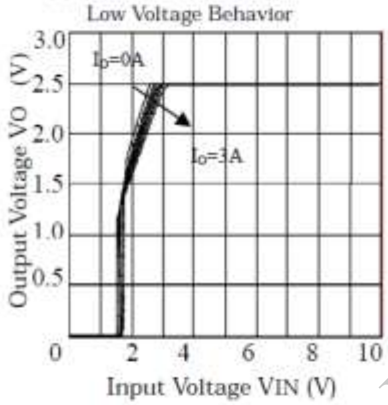
6. Typical Characteristics

- SI-3012KD (Ta = 25°C) *Set Vout = 2.5V

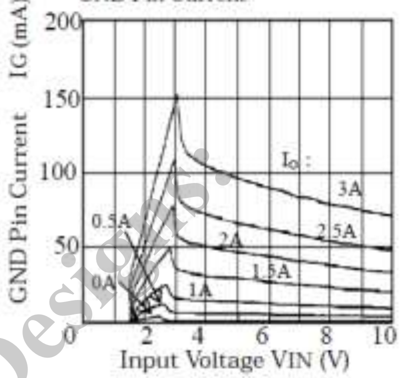
(1) 入出力電圧差
Drop tage



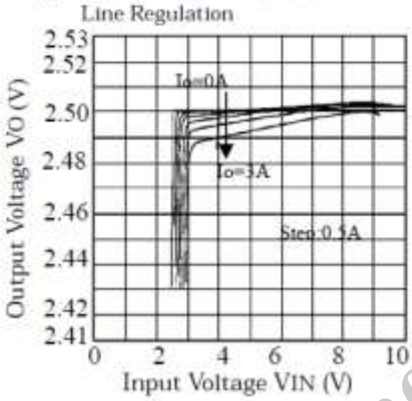
(2) 出力立上り特性
Low Voltage Behavior



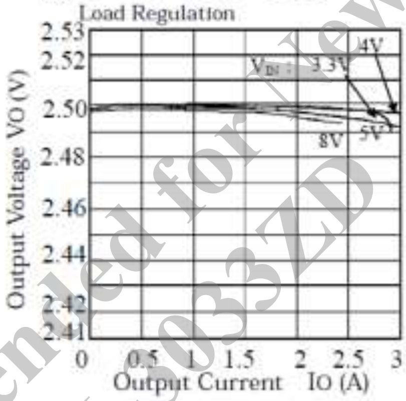
(3) グランド端子電流
GND Pin Current



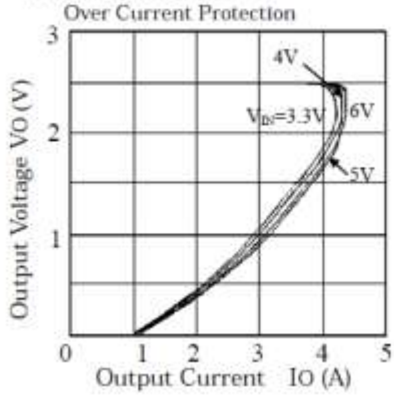
(4) ラインレギュレーション
Line Regulation



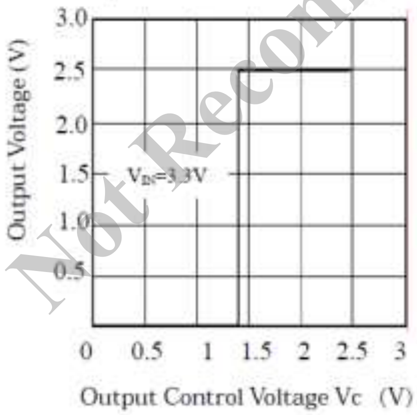
(5) ロードレギュレーション
Load Regulation



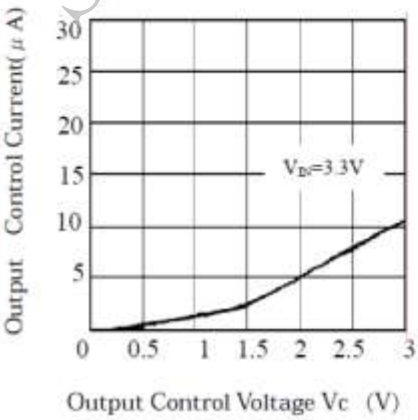
(6) 過電流保護特性
Over Current Protection



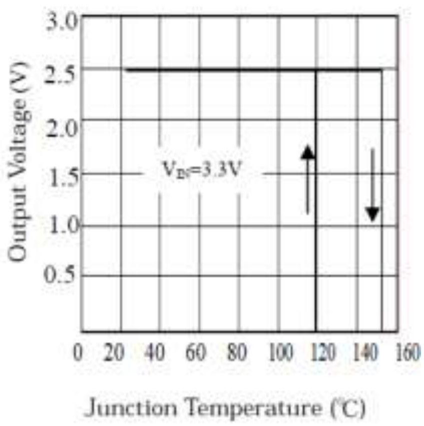
(7) 出力オンオフ制御電圧
Output ON/OFF Control Voltage



(8) 出力オンオフ端子制御電流
Output ON/OFF Control Current



(9) 過熱保護特性
Thermal Protection



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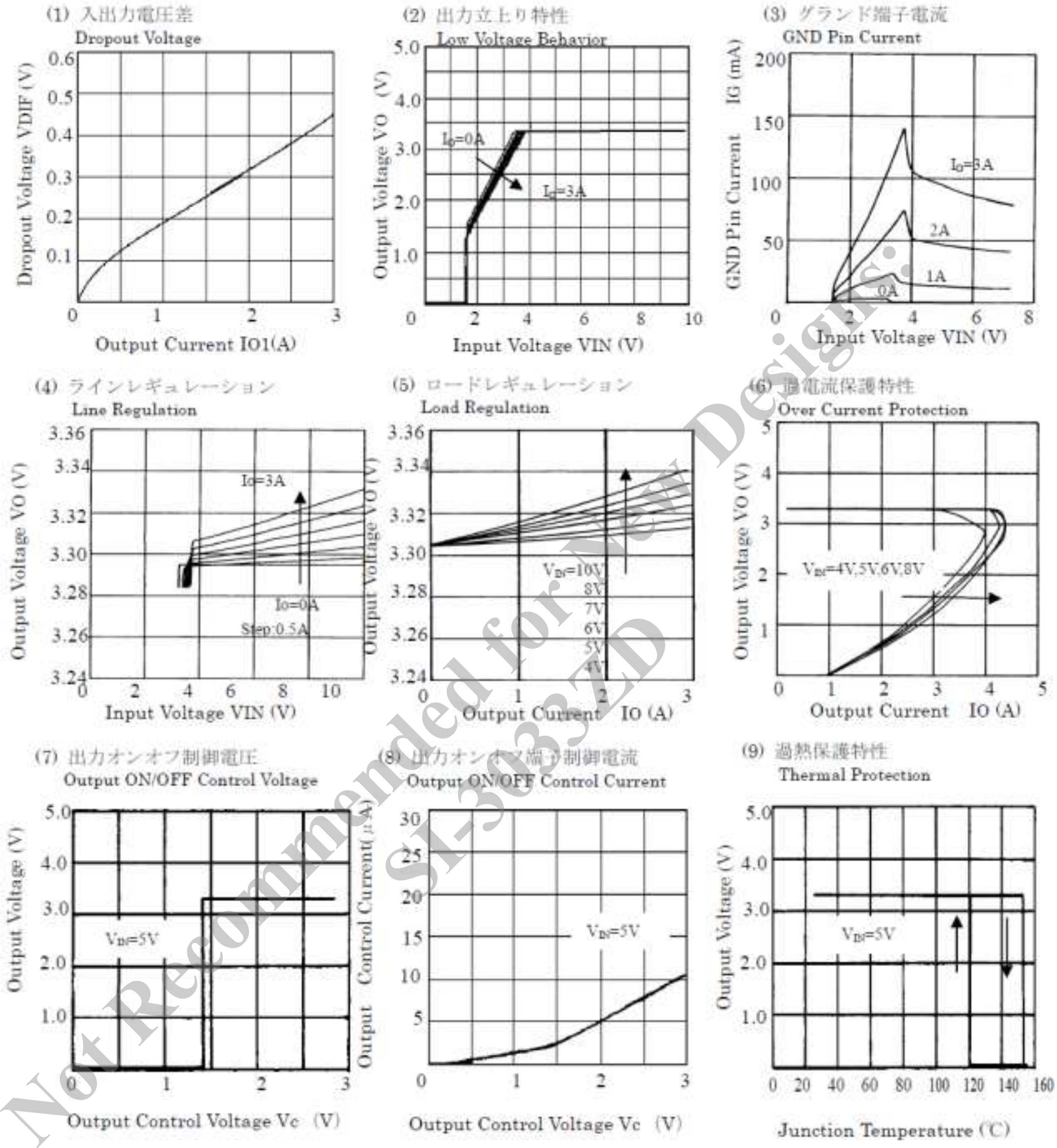
- SI-3033ZD (Ta = 25°C)



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