Application Note

Super Hyposaturation type Series Regulator IC

SI-3010LLSL Series

August 2011 Rev.2.1

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1. General Information

The SI-3010LLSL is a series regulator IC using NPN bipolar transistors for a power section. The V_{IN} terminal is connected to the NPN bipolar transistor of a power section. The V_B terminal is connected to the power supply of the control section and also to the former stage transistor in Darlington connection with the NPN power transistor connected to the V_{IN} terminal. By performing 2 inputs, the SI-3010LLSL is operated in the ultra hyposaturation to the V_{IN} terminal. The ON/OFF terminal of "Active High" is provided to make the current consumption of circuits at OFF time zero. This is a regulator that uses low ESR capacitors like a ceramic capacitor for the output capacitor.

● 1-1 Features

- Output current 1.5A

  Output current is 1.5A at maximum with the outline of SOP8.

- Hyposaturation (V_{dif} = 0.3Vmax / Io = 1A)

  It can be designed with super low difference of input/output voltages.

- ON/OFF function

  The ON/OFF terminal which can be directly controlled by **TLL** logic signals is provided.

- Low current consumption

  Current consumption of circuits at OFF time is zero.

  Dark currents at no load are 500μA at maximum.

- Built-in Overcurrent protection / Thermal shutdown

  The current limiting type overcurrent protection and Thermal shutdown circuits are built-in.

  (Automatic restoration type)

● 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

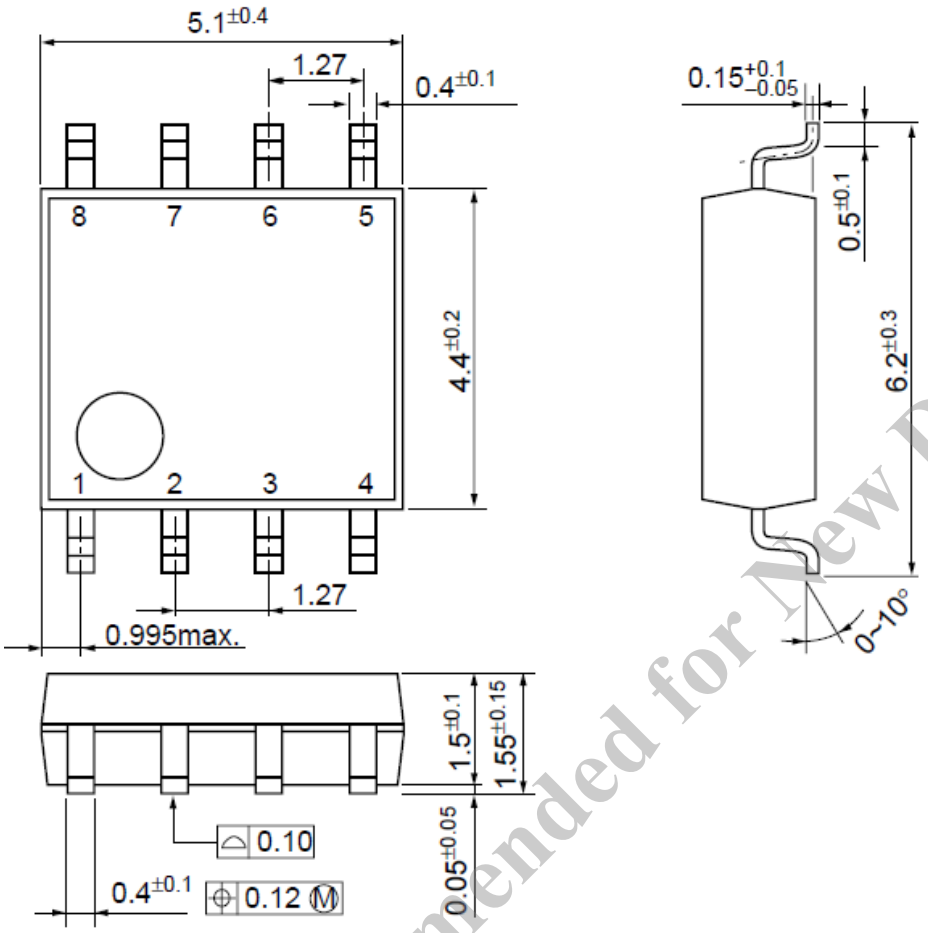
● 1-3 Type

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

2. Specification

Unit: mm

● 2-1 Package Information



Pin assignment

1. Vo
2. ADJ
3. V_B
4. Vc
5. GND
6. GND
7. V_{IN}
8. V_{IN}

● 2-2 Ratings

2-2-1 Absolute Maximum Ratings Ta = 25°C

Parameter	Symbol	Ratings	Unit
DC Input Voltage	V_{IN}	10	V
DC Bias Voltage	V_B	10	V
Output Control Terminal Voltage	V_C	V_{IN}	V
DC Output Current	I_O	1.5	A
Power Dissipation	P_D*1	1.1	W
Junction Temperature	T_j	−30 to +125	°C
Operating Ambient Temperature	T_{op}	−30 to +100	°C
Storage Temperature	T_{stg}	−30 to +125	°C
Thermal Resistance (Junction to Lead (Pin 8))	$\theta_{(j-L)}$	36	°C/W
Thermal Resistance (Junction to Ambient Air)	$\theta_{(j-a)}$*1	100	°C/W

*1: When mounted on glass-epoxy board of 40 × 40mm (copper laminate area 100%).

2-2-2 Recommended Conditions

Parameter	Symbol	Ratings	Unit
		SI-3010LLSL	
Input Voltage	V_{IN}	1.4 to 3.6*1	V
Bias Voltage	V_B	3.3 to 5.5	V
Output Current	I_O	0 to 1.5*1	A
Operating Ambient Temperature	T_{op}	−20 to +85*1	°C

*1: Because of the relation of Pd = (Vin - Vo) × Io, Vin (max.) and Io (max.) may be restricted subject to conditions of use. For each value, refer to the data of copper foil area - permissible loss for calculation.

2-2-3 Electrical Characteristics

Ta = 25° C, Vc = 2V, V_{IN} = 1.8V, V_B = 3.3V and V_O = 1.5V without special instruction

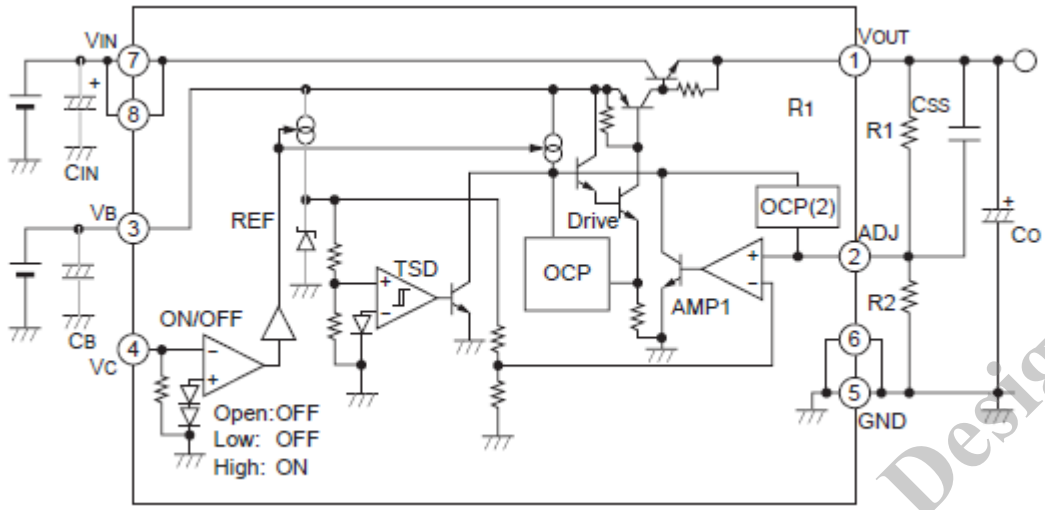
Parameter		Symbol	Ratings SI-3010LLSL min.	typ.	max.	Unit
Reference Voltage		V_{ADJ}	0.980	1.000	1.020	V
		Conditions		I_O=10mA		
Line Regulation		ΔV_{OLINE}			10	mV
		Conditions		V_{IN}=1.7 to 2.5V, I_O=10mA		
Load Regulation		ΔV_{OLOAD}			30	mV
		Conditions		V_{IN}=1.8V, I_O=0 to 1.5A		
Dropout Voltage		V_{DIF}			0.3	V
		Conditions		I_O=1.0A		
Quiescent Circuit Current		I_q		500	800	μA
		Conditions		I_O=0A, R_2=10kΩ		
Circuit Current at Output OFF		$I_{q(OFF)}$			1	μA
		Conditions		V_C=0V		
Temperature Coefficient of Output Voltage		$\Delta V_O/\Delta T_a$		±0.2		mV/°C
		Conditions		T_j=0 to 100°C		
Overcurrent Protection Starting Current*1		I_{S1}	1.6			A
		Conditions		V_{IN}=1.8V, V_B=3.3V		
Vc Terminal	Control Voltage (Output ON)*2	V_C, IH	2			V
	Control Voltage (Output OFF)	V_C, IL			0.8	V
	Control Current (Output ON)	I_C, IH			50	μA
		Conditions		V_C=2.7V		
	Control Current (Output OFF)	I_C, IL			10	μA
		Conditions		V_C=0.4V		

*1: Is1 is specified at the 5% drop point of output voltage Vo on the condition that VIN = overcurrent protection starting current, Io = 10mA.

*2: 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.

● 2-3 Circuit Diagram

2-3-1 Block Diagram



C_{IN}, C_B: Input Capacitor and Biased Capacitor (0.1μF - 10μF)

It is required in the case of that input line includes inductance or it has long line.

Co: Output capacitors (47μF or more)

The SI-3010LLS is designed on the assumption that low ESR type capacitors such as ceramic capacitors are used for the output capacitor. It is recommended to use capacitors with the ESR of 500mΩ or less (at room temperature) for the output capacitor.

R1, R2: resistors for setting output voltages

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

R2: 10kΩ is recommended.

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

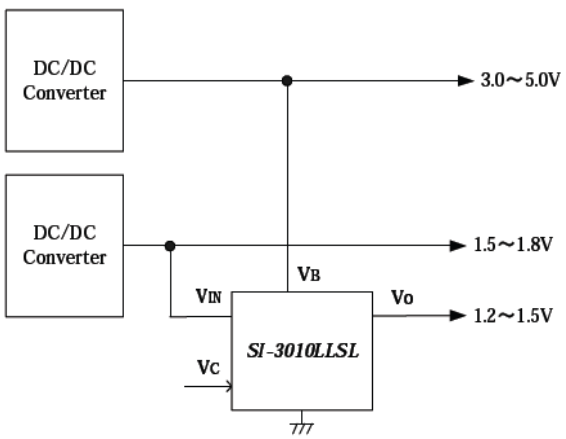
C_{SS} = Capacitors for soft start setting

It is possible to set the rise time of output voltage by connecting C_{SS} between V_{OUT} and ADJ.

***Around 0. 3A is required for the current capacity of VB power supply.**

2-3-2 Application circuit

Example application circuit



3. Operational Description

● 3-1 Voltage Control

In the SI-3010LLSL 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 NPN power transistor.

The product of voltage between collector and emitter and the output current at this moment is consumed as heat.

In the SI-3010LLSL, a NPN transistor connected to the V_{IN} terminal and a PNP transistor connected to the V_B terminal are in Darlington connection and are operated at hyposaturation to the V_{IN} terminal.

Although the V_{IN} terminal input voltage is 1.3V at minimum (MIN), it is required to apply 3.0V or higher to the V_B terminal for the stable operation of control section.

In order to operate the main power transistor for Darlington operation, it is required for V_B terminal to apply the V_B voltage which is higher by 1.2V or more than V_{IN} voltage.

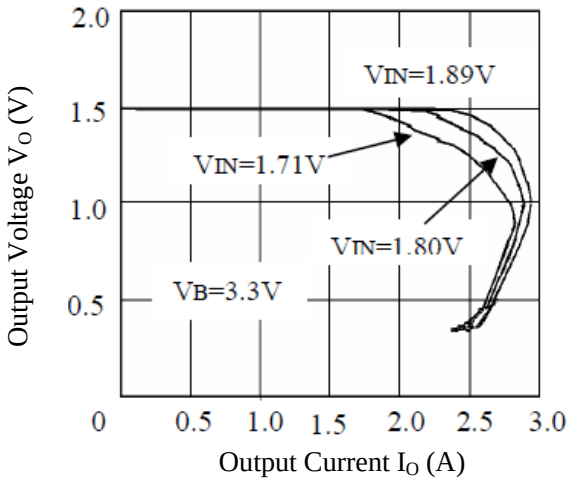
● 3-2 Overcurrent Protection

The current limiting type overcurrent protection function is provided in the SI-3010LLSL.

In the case of the series regulator, as the output voltage drops subject to the overcurrent protection, the difference of input/output voltages increases to cause significant heating.

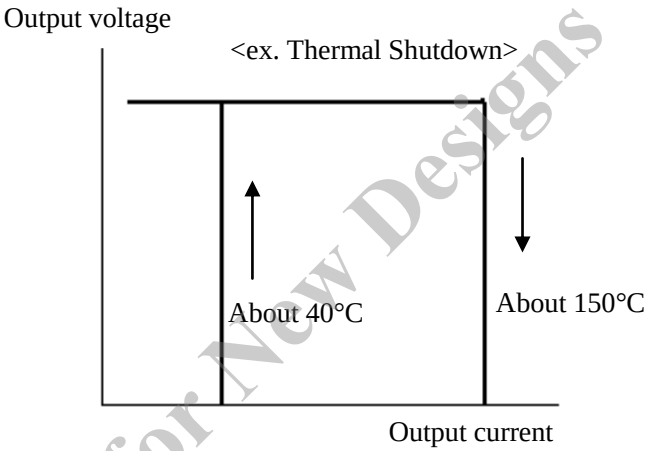
Special care should be taken for the current limiting type overcurrent protection, since large current flows continuously.

<Example of foldback type overcurrent protection characteristic>



● 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. Hysteresis is provided for overheat protection, therefore when the junction temperature falls down to around 40℃, automatic restoration takes place. Restoration also takes place, when the input voltage is interrupted or operation is restarted at V_C terminal.



*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.

4. Cautions

● 4-1 External Components

4-1-1 Input Capacitor CIN

The input capacitor is required to eliminate noise and stabilize the operation and values of 0.1μF - 10μF 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.

- Recommendation: ESR < 500mΩ

It is recommended to use ceramic capacitors or functional polymer capacitors. If electrolytic capacitors having large ESR are used, the phase margin is decreased to cause the possible oscillation of output voltage. Even if oscillation does not occur at low temperature, ESR is increased to cause oscillation, therefore the use of electrolytic capacitors is not recommendable.

● 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-3010LLSL)

The ADJ terminal is a feedback detection terminal for controlling the output voltage.

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

SI-3010LLSL: 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} = 1.00V ± 2% (SI-3010LLSL, R2 = 10kΩ recommended)

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

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

5. Applications

● 5-1 Output ON/OFF Control

The ON/OFF control of output can be made by directly applying voltage to No.4 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.

The inner frame stage on which the power transistor is mounted is connected to the V_{IN} terminal (7, 8 pins). Therefore, the heat dissipation effect is increased by enlarging the copper foil area connected to the V_{IN} terminal.

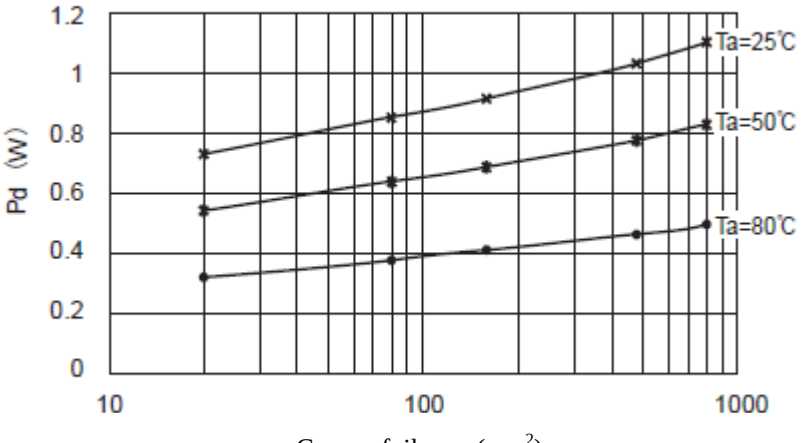
As the junction temperature Tj (MAX) is a product-specific value, it must be observed strictly. For this purpose, heat sink design (thermal resistance of board) which is appropriate for Pd (MAX) and Ta MAX is required. This is graphically shown in the heat derating curve for easy understanding. The heat 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 graph of copper foil area (round shape to connect to 7, 8 pins) vs. permissible dissipation below shown.

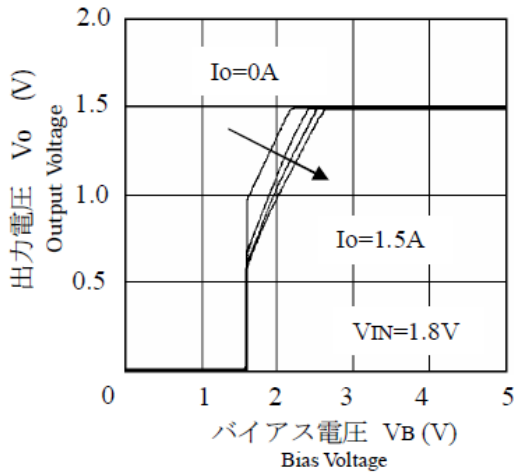
Copper foil area vs. Permissible dissipation



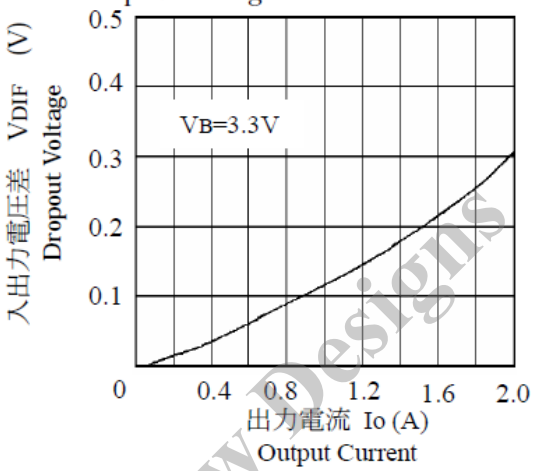
6. Typical Characteristics

- SI-3010LLSL *Set Vout = 1.5V

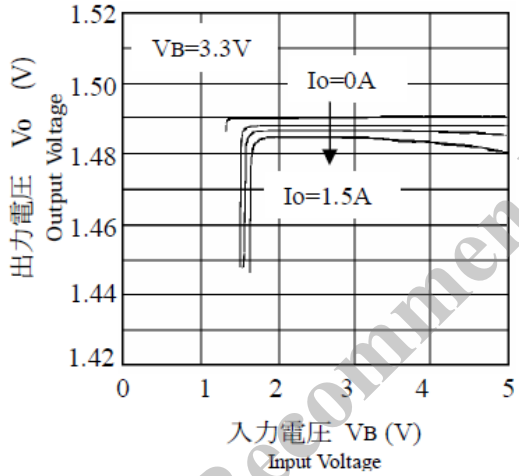
1) 立上り特性
Low Voltage Behavior



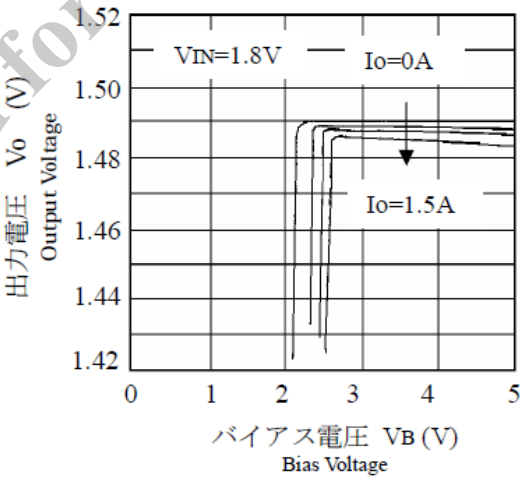
2) 入出力電圧差
Dropout Voltage



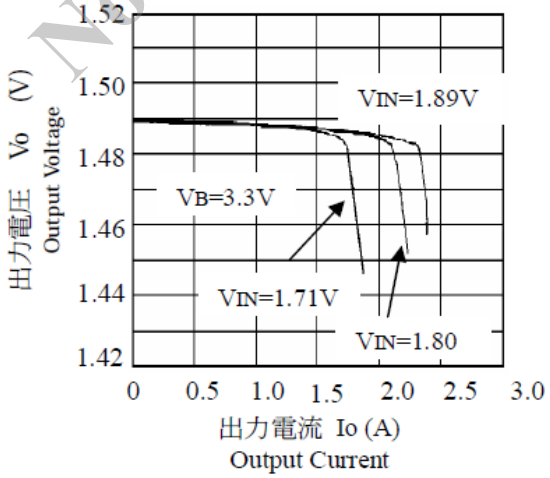
3) ﾗｲﾝﾚｷﾞｭﾚｰｼｮﾝ(対入力電圧)
Line Regulation (vs. Input voltage)



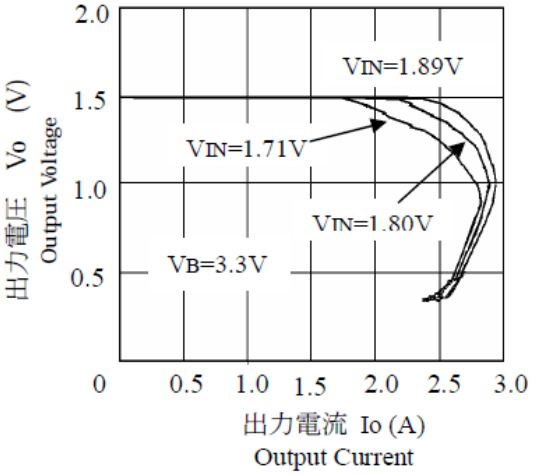
4) ﾗｲﾝﾚｷﾞｭﾚｰｼｮﾝ(対バイアス電圧)
Line Regulation (vs. Bias voltage)



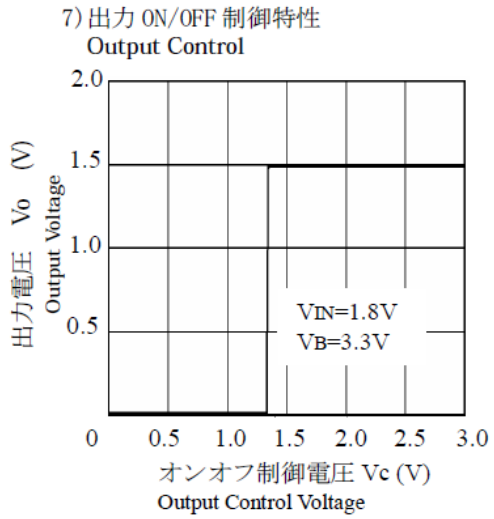
5) ﾛｰﾄﾞﾚｷﾞｭﾚｰｼｮﾝ
Load Regulation



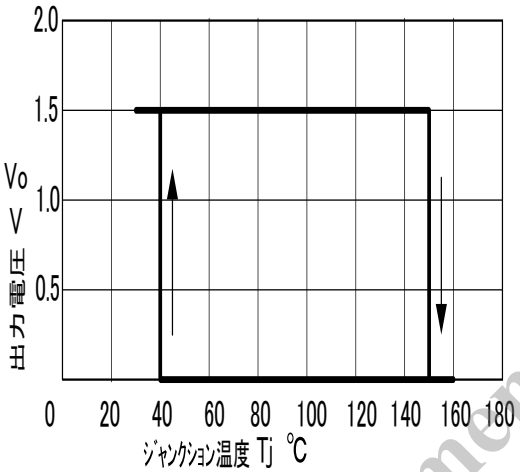
6) 過電流保護特性
Over Current Protection



- SI-3010LLSL *Set Vout = 1.5V



8) Thermal Shutdown Circuit



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