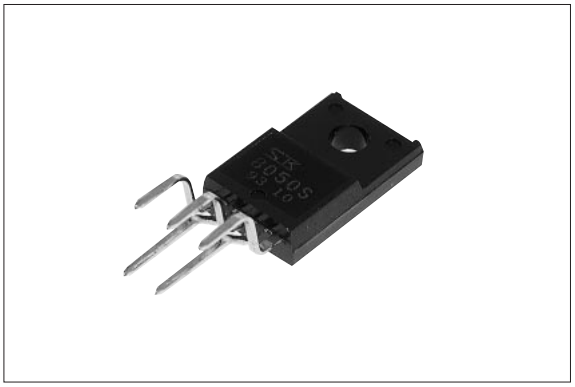
SI-8000S Series

Full-Mold, Separate Excitation Switching Type

■Features

- Compact full-mold package (equivalent to TO220)
- Output current: 3.0A
- High efficiency: 79 to 91%
- Requires only 4 external components
- Phase correction and output voltage adjustment performed internally
- Built-in reference oscillator (60kHz)
- Built-in overcurrent and thermal protection circuits
- Built-in soft start circuit (output ON/OFF control)



■Applications

- Power supplies for telecommunication equipment
- Onboard local power supplies

■Lineup

Part Number	SI-8033S	SI-8050S	SI-8090S	SI-8120S	SI-8150S
V_O(V)	3.3	5.0	9.0	12.0	15.0
I_O(A)	3.0				

■Absolute Maximum Ratings

Parameter	Symbol	Ratings	Unit
DC Input Voltage	V_{IN}	43*	V
Power Dissipation	P_{D1}	18(With infinite heatsink)	W
	P_{D2}	1.5(Without heatsink, stand-alone operation)	W
Junction Temperature	T_j	+125	°C
Storage Temperature	T_{stg}	–40 to +125	°C
SW Terminal Applied Reverse Voltage	V_{SW}	–1	V
Thermal Resistance(junction to case)	$R_{th(j-c)}$	5.5	°C/W

*SI-8033S: 35V

■Recommended Operating Conditions

Parameter	Symbol	Ratings					Unit
		SI-8033S	SI-8050S	SI-8090S	SI-8120S	SI-8150S	
DC Input Voltage Range	V_{IN}	5.5 to 28	7 to 40	12 to 40	15 to 40	18 to 40	V
Output Current Range	I_O	0 to 3.0					A
Operating Junction Temperature Range	T_{jop}	–30 to +125					°C

■Electrical Characteristics

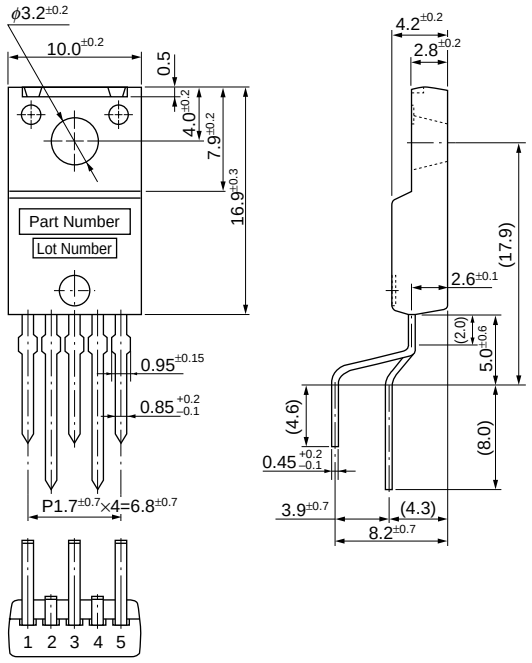
(Ta=25°C)

Parameter		Symbol	Ratings															Unit
			SI-8033S			SI-8050S			SI-8090S			SI-8120S			SI-8150S			
			min.	typ.	max.	min.	typ.	max.	min.	typ.	max.	min.	typ.	max.	min.	typ.	max.	
Output Voltage	SI-8000S *1	V_O	3.17	3.30	3.43	4.80	5.00	5.20	8.55	9.00	9.45	11.50	12.00	12.50	14.25	15.00	15.75	V
	SI-8000SS		3.234	3.30	3.366	4.90	5.00	5.10	8.73	9.00	9.27	———			———			
		Conditions	V_{IN}=15V, I_O=1.0A			V_{IN}=20V, I_O=1.0A			V_{IN}=21V, I_O=1.0A			V_{IN}=24V, I_O=1.0A			V_{IN}=25V, I_O=1.0A			
Efficiency		η		79			84			88			90			91		%
		Conditions	V_{IN}=15V, I_O=1.0A			V_{IN}=20V, I_O=1.0A			V_{IN}=21V, I_O=1.0A			V_{IN}=24V, I_O=1.0A			V_{IN}=25V, I_O=1.0A			
Switching Frequency		f		60			60			60			60			60		kHz
		Conditions	V_{IN}=15V, I_O=1.0A			V_{IN}=20V, I_O=1.0A			V_{IN}=21V, I_O=1.0A			V_{IN}=24V, I_O=1.0A			V_{IN}=25V, I_O=1.0A			
Line Regulation		ΔV_{OLINE}		25	80		40	100		50	120		60	130		60	130	mV
		Conditions	V_{IN}=8 to 28V, I_O=1.0A			V_{IN}=10 to 30V, I_O=1.0A			V_{IN}=15 to 30V, I_O=1.0A			V_{IN}=18 to 30V, I_O=1.0A			V_{IN}=21 to 30V, I_O=1.0A			
Load Regulation		ΔV_{OLOAD}		10	30		10	40		10	40		10	40		10	40	mV
		Conditions	V_{IN}=15V, I_O=0.5 to 1.5A			V_{IN}=20V, I_O=0.5 to 1.5A			V_{IN}=21V, I_O=0.5 to 1.5A			V_{IN}=24V, I_O=0.5 to 1.5A			V_{IN}=25V, I_O=0.5 to 1.5A			
Temperature Coefficient of Output Voltage		$\Delta V_O/\Delta T_a$		±0.5			±0.5			±1.0			±1.0			±1.0		mV/°C
Ripple Rejection		R_{REJ}		45			45			–45			45			45		dB
		Conditions	f=100 to 120Hz			f=100 to 120Hz			f=100 to 120Hz			f=100 to 120Hz			f=100 to 120Hz			
Overcurrent Protection Starting Current		I_{S1}	3.1			3.1			3.1			3.1			3.1			A
		Conditions	V_{IN}=15V			V_{IN}=20V			V_{IN}=21V			V_{IN}=24V			V_{IN}=25V			

*1: "S" may be indicated to the right of the Sanken logo.

■Outline Drawing

(unit: mm)

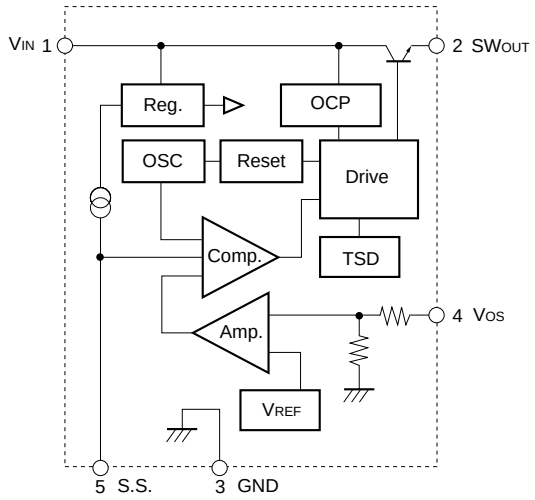


Forming No. 1101

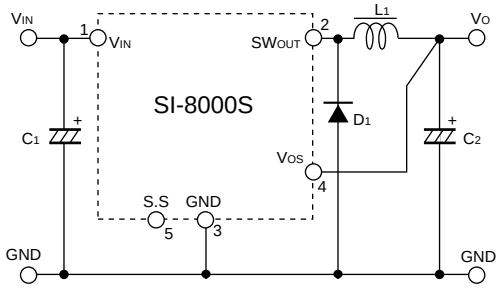
Plastic Mold Package Type
Flammability: UL94V-0
Weight: Approx. 2.3g

① V_{IN}
② SW_{OUT}
③ GND
④ V_{OS}
⑤ S.S

■Block Diagram

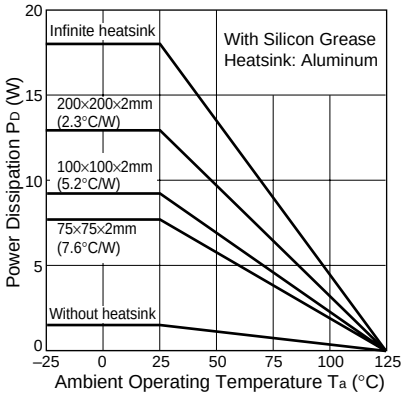


■Standard External Circuit



$C_{1,2}$: 1000µF
L_1 : 150µH
D_1 : RK46(Sanken)

■T_a-P_D Characteristics



$$P_D = V_O \bullet I_O \left(\frac{100}{\eta\chi} - 1 \right) - V_F \bullet I_O \left(1 - \frac{V_O}{V_{IN}} \right)$$

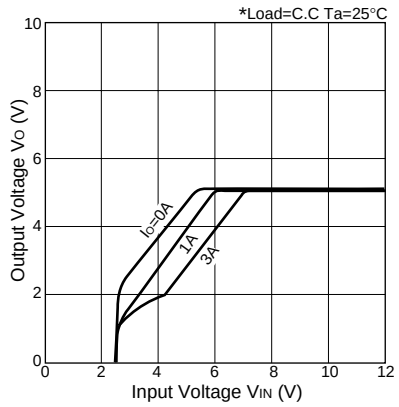
The efficiency depends on the input voltage and the output current. Thus, obtain the value from the efficiency graph on page 83 and substitute the percentage in the formula above.

V_O : Output voltage
V_{IN} : Input voltage
I_O : Output current
$\eta\chi$: Efficiency (%)
V_F : Diode forward voltage
0.5V(RK46)

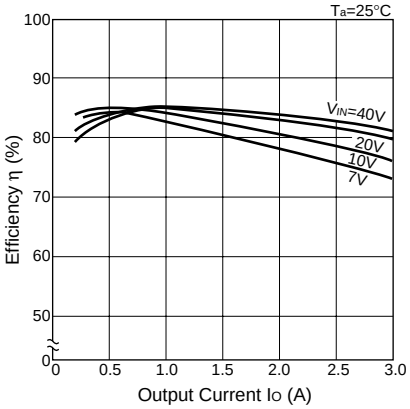
Thermal design for D_1 must be considered separately.

■Typical Characteristics

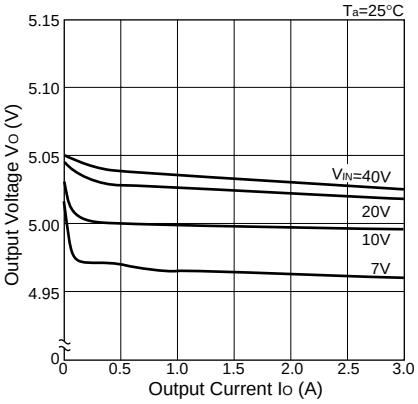
Rise Characteristics(SI-8050S)



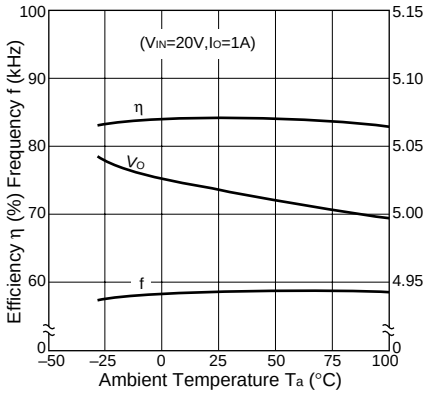
Efficiency Characteristics(SI-8050S)



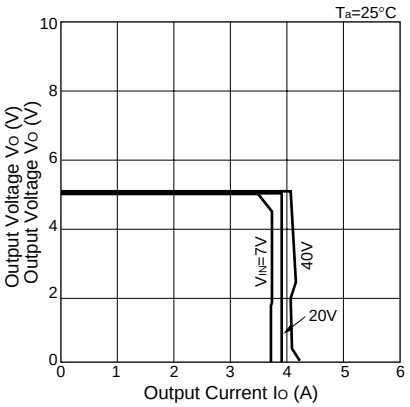
Load Regulation(SI-8050S)



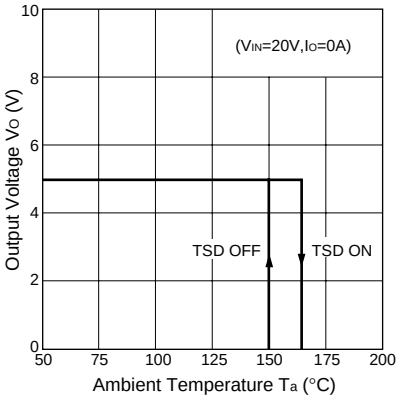
Temperature Characteristics(SI-8050S)



Overcurrent Protection Characteristics(SI-8050S)



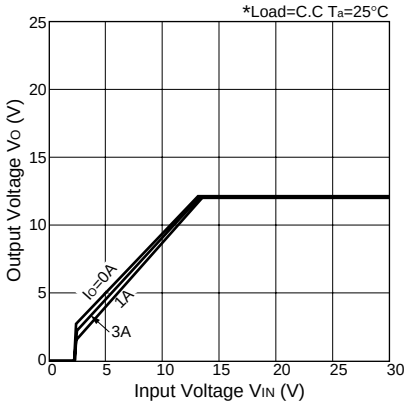
Thermal Protection Characteristics(SI-8050S)



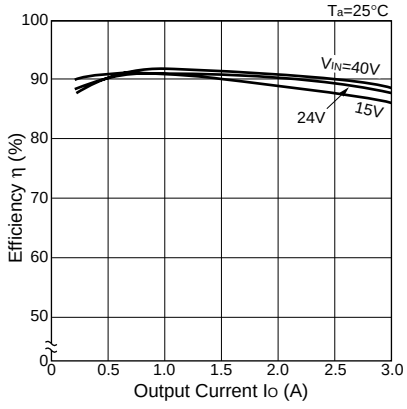
Note on Thermal Protection:

The thermal protection circuit is intended for protection against heat during instantaneous short-circuiting. Its operation is not guaranteed for short-circuiting over extended periods of time.

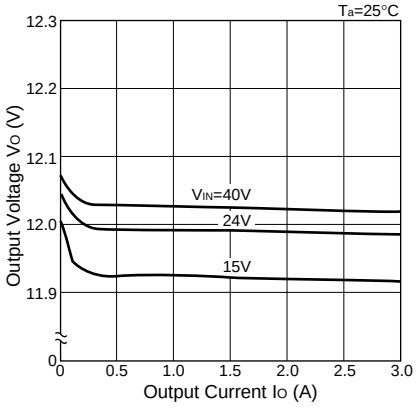
Rise Characteristics(SI-8120S)



Efficiency Characteristics(SI-8120S)



Load Regulation(SI-8120S)



Caution

1. Selecting External Components

(1) Choke coil L_1

To maintain the stable operation of the regulator, choke coil L_1 should be selected appropriately.

When selecting choke coil L_1, consider the following:

a) Suitable for a switching regulator

Do not use a coil as a noise filter because it generates excess heat.

b) Appropriate inductance

The greater the inductance of the choke coil, the smaller the output ripple voltage. However, the size of the coil increases large as the inductance increases. If the inductance is low, a greater peak current flows to the IC and loss increases. This is not favorable for stable operation.

The standard external circuit shows reference inductance values suitable for stable operation. However, the appropriate inductance may also be calculated as follows:

$$L=\frac{(V_{IN}-V_O)\bullet V_O}{\Delta IL\bullet V_{IN}\bullet f}$$

Where, deltaIL indicates the ripple current of the choke coil that is roughly set as follows:

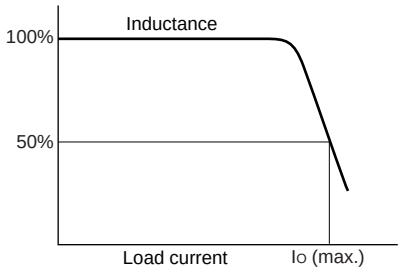
- If the working output current is close to the maximum rating (3 A) of SI-8000S
  Ripple current = output current × 0.2 to 0.3
- If the working output current is about 1.0A or less
  Ripple current = output current × 0.3 to 0.4

c) Satisfying the rated current

The rated current of a choke coil must be greater than the maximum load current. Note that the inductance decreases drastically and an excess current flows if the load current exceeds the rated current of the coil.

d) Good DC current superposition characteristics

The current flowing through a choke coil is a triangular waveform current superimposed on a DC current equal to the load current. The coil inductance decreases as the load current increases. In general, the coil can be used until the inductance drops to 50% of the rated value. Use this as the reference value for selection.



e) Less noise

A drum-type open magnetic core coil can affect peripheral circuits with noise because the flux passes outside the coil. To avoid this problem, use a toroidal, EI, or EE type open magnetic core coil.

(2) Input capacitor C_1

Input capacitor C_1 operates as a bypass capacitor in the input circuit.

When selecting input capacitor C_1, consider the following:

a) The breakdown voltage is higher than the maximum input voltage.

b) Satisfies the allowable ripple current

Exceeding the ratings of this capacitor or using it without derating may reduce its service life and also cause the regulator to malfunction. Therefore, an input capacitor with a sufficient margin should be selected. With the SI-8000S Series, the effective ripple current Irms flowing to the input capacitor can be calculated approximately as follows:

$$I_{rms}\fallingdotseq 1.2\times\frac{V_O}{V_{IN}}\times I_O$$

(3) Output capacitor C_2

Output capacitor C_2 operates as a smoothing capacitor for switching output. The output ripple voltage from the regulator is determined by the product of the pulsating current part ΔIL (=C_2 charge-discharge current) of the choke coil current and the equivalent series resistance ESR of the output capacitor C_2.

$$V_{rip}=\Delta IL\bullet C2ESR$$

Therefore, a capacitor of low equivalent series resistance ESR should be selected to reduce the output ripple voltage. It is recommended to select a low-impedance capacitor intended for use with switching regulators as C_2.

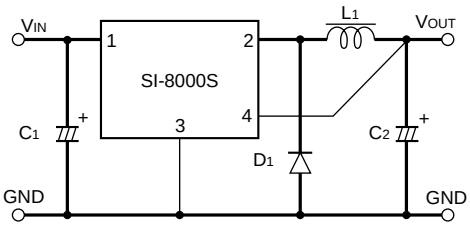
(4) Diode D_1

Use a Schottky barrier diode for D_1. If you use a general rectifier diode or fast recovery diode, the IC may be damaged. (Sanken RK46 recommended)

2. Notes on Pattern Design

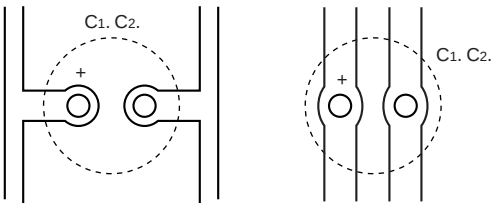
(1) Large current line

Since a large current flows through the bold lines in the standard external circuit make the pattern as wide and as short as possible.



(2) Input capacitor

Place the input capacitor C_1 and output capacitor C_2 as close to the IC as possible. Since a large current flows through the lead wires of the input and output capacitors to charge and discharge them quickly, minimize the lead wire length. The pattern around the capacitors should also be minimized.

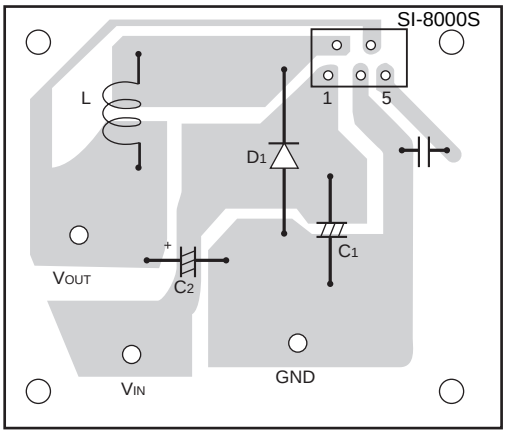


Example of bad pattern　　Example of good pattern

(3) Sensing terminal

Output voltage sensing terminal V_{OS} should be connected as close to output capacitor C_2 as possible. If the terminal is far from the capacitor, the decreasing regulation and increasing switching ripple may result in abnormal oscillation.

Example of basic pattern



Top view (with part names)

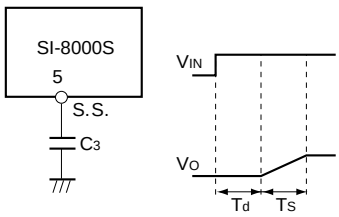
Applications

1. Soft Start

Connecting a capacitor to terminal no. 5 permits a soft start at power-on. Delay time T_d and rise time T_s can roughly be calculated as shown below. (However, the values may slightly vary in an actual application.) If the capacitance of C_3 is increased, it takes longer to discharge C_3 after V_{IN} is turned off. Therefore, it is recommended to set the value within 10µF. When not using the soft start function, keep terminal no. 5 open.

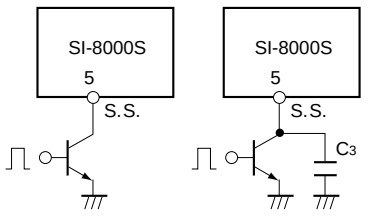
$$T_d = \frac{0.7 \times C_3}{20 \times 10^{-6}} \text{ (sec)}$$

$$T_s = \frac{4.845 \times C_3}{V_{IN} \times 20 \times 10^{-6}} \text{ (sec)}$$



2. Output ON/OFF control

Output can be turned on and off by using the soft start terminals. Set the soft start terminal voltage to V_{SSL} (0.2V typ.) or less to stop output. To switch the potential at the soft start terminals, drive the open collector of the transistor. Since the discharge current from C_3 flows to the ON/OFF control transistor, limit the current for protection. The SS terminal is pulled up to the power supply in the IC and no external voltage can be applied.

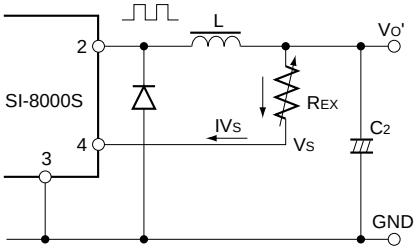


ON/OFF S.S + ON/OFF

3. Variable Output Voltage

The output voltage can be increased by connecting a resistor to V_{OS} terminal No. 4. (There is no way of decreasing the voltage)

(1) Variable output voltage with single external resistor



The output voltage adjustment resistance R_{EX} is calculated as follows:

$$R_{EX} = \frac{V_O' - V_S}{I_{VS}}$$

V_S : Set output voltage of product

V_O' : Adjusted output voltage

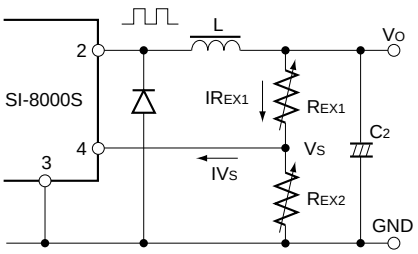
I_{VS} : Inflow current to Vs terminal

* The temperature characteristics of output voltage worsen because the value R_{EX} is not compensated for temperature. The Vs value fluctuates by up to ±20% depending on the IC product. Since the output voltage fluctuates more, a semi-fixed resistor is necessary for accurate output voltage adjustment. If Vs and R_{EX} are constant, the range of output voltage fluctuation can be expressed as follows:

$$\Delta V_O'(\%) = \pm 20 \bullet \frac{V_O' - V_S}{V_O'}$$

$\Delta V_O'$:Adjusted output voltage

(2) Variable output voltage with two external resistors



The output voltage adjustment resistances R_{EX1} and R_{EX2} are calculated as follows:

$$R_{EX1} = \frac{V_O' - V_S}{S \bullet I_{VS}}$$

$$R_{EX2} = \frac{V_S}{(S-1) \bullet I_{VS}}$$

S:Stability factor

Bypassing the current to R_{EX2} improves the temperature characteristics and voltage fluctuation ranges more than the method of (1). Stability factor S indicates the ratio of R_{EX1} to Vs terminal inflow current. Increasing the S value improves the fluctuations of the temperature characteristics and output voltage. (Usually 5 to 10)

If the Vs and R_{EX} values are constant, the output voltage fluctuation range can be calculated as follows:

$$\Delta V_O'(\%) = \frac{\pm 20}{S} \bullet \frac{V_O' - V_S}{V_O'}$$