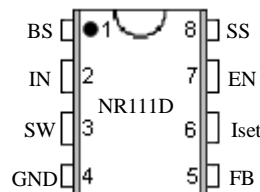


NR111D

General Descriptions

The NR111D is buck regulator ICs integrates High-side power MOSFETs. The feature increasing efficiency at light loads allows the device to be used in the energy-saving applications. With the current mode control, ultra low ESR capacitors such as ceramic capacitors can be used. The ICs have protection functions such as Over-Current Protection (OCP), Under-Voltage Lockout (UVLO) and Thermal Shutdown (TSD). An adjustable Soft-Start by an external capacitor prevents the excessive inrush current at turn-on. The ICs integrate phase compensation circuit which reduces the number of external components and simplifies the design of customer application. The ON/OFF pin (EN Pin) turns the regulator on or off and helps to achieve low power consumption requirements. The NR111D is available in an 8-pin DIP package.

● DIP8 Package



Features & Benefits

- Current mode PWM control
- Up to 94% Efficiency,
Up to 68% Efficiency at $I_O = 20\text{mA}$ Light Load
- Stable with low ESR ceramic output capacitors
- Built-in protection function
Over Current Protection (OCP)
Thermal Shutdown (TSD)
Under Voltage Lockout (UVLO)
- Built-in phase compensation
- Adjustable Soft-Start with an external capacitor
- Turn ON/OF the regulator function

Electrical Characteristics

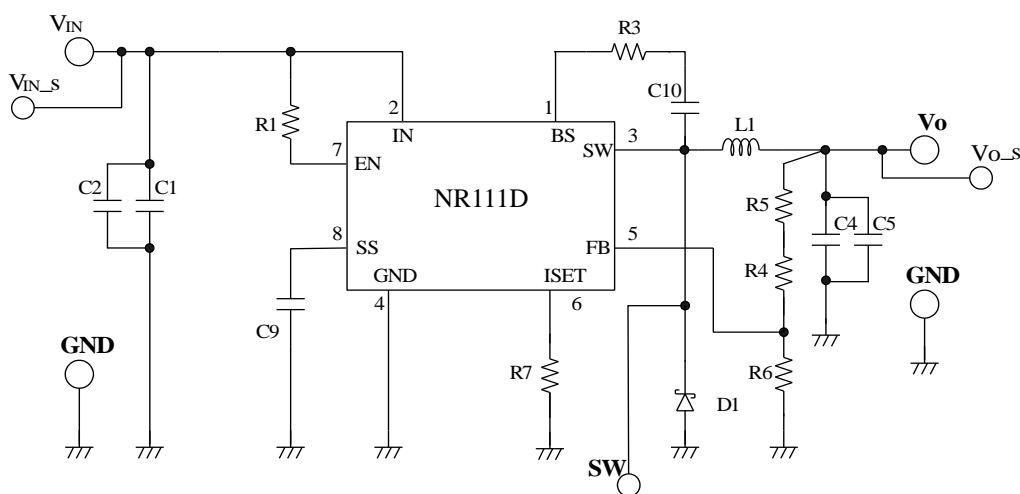
- 4A output current
- Operating input range $V_{IN} = 6.5\text{V} \sim 31\text{V}$
- Output adjustable $V_O = 0.8\text{V} \sim 24\text{V}$
- Fixed 350kHz frequency

Applications

- LCD TV / Blu-Ray / Set top box
- Home appliance
- Green Electronic products
- Other power supply

Package

Typical Application Circuit



C1, C2: 10 μF / 35V
C4, C5: 22 μF / 16V
C9: 0.1 μF
C10: 0.1 μF

R1: 510k Ω
R3: 22 Ω
R4: 18k Ω , R5: 2.7k Ω ($V_O = 5.0\text{V}$)
R6: 3.9k Ω
L1: 10 μH

NR111D

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Series Lineup

Product No.	f _{sw}	V _{IN}	V _O	I _O
NR111D	350kHz	8V to 31V ⁽¹⁾	0.8V to 24V ⁽²⁾	4A

⁽¹⁾The minimum input voltage shall be either of 6.5V or V_O+3V, whichever is higher.

⁽²⁾The I/O condition is limited by the Minimum on-time (T_{ON(MIN)}).

Absolute Maximum Ratings

項目	記号	規格値	単位	条件
DC input voltage	V _{IN}	35	V	
BS Pin voltage	V _{BS}	44	V	
BS-SW Pin voltage	V _{BS-SW}	8	V	
SW Pin voltage	V _{SW}	35	V	
FB Pin voltage	V _{FB}	5.5	V	
EN Pin voltage	V _{EN}	35	V	
SS Pin voltage	V _{SS}	5.5	V	
Power dissipation	⁽³⁾ P _D	1.47	W	Glass-epoxy board mounting in a 70×60mm. (copper area in a 1310mm ²) Max T _J =150°C
Junction temperature	⁽⁴⁾ T _J	-30 to 150	°C	
Storage temperature	T _S	-40 to 150	°C	
Thermal resistance (junction- Pin No. 7)	θ _{JP}	41	°C /W	
Thermal resistance (junction-ambient air)	θ _{JA}	85	°C /W	Glass-epoxy board mounting in a 70×60mm. (copper area in a 1310mm ²)

⁽³⁾Limited by thermal shutdown.

⁽⁴⁾The temperature detection of thermal shutdown is about 160°C

Recommended Operating Conditions

Parameter	Symbol	Ratings		Units	Conditions
		MIN	MAX		
DC input voltage	⁽⁵⁾ V _{IN}	V _O +3	31	V	
DC output current	⁽⁶⁾ ⁽⁷⁾ I _O	0	4.0	A	
Output voltage	V _O	0.8	24	V	
Ambient operating temperature	⁽⁷⁾ Top	-40	85	°C	

⁽⁵⁾The minimum value of input voltage is taken as the larger one of either 6.5V or V_O +3V.

⁽⁶⁾ Recommended circuit refer to Typical Application Circuit (P.7).

⁽⁷⁾To be used within the allowable package power dissipation characteristics (P.9)

Electrical Characteristics

Ta = 25°C

Parameter		Symbol	Ratings			Units	Test conditions
			MIN	TYP	MAX		
Reference voltage		V _{REF}	0.784	0.800	0.816	V	V _{IN} = 12V, I _O = 1.0A
Output voltage temperature coefficient		$\Delta V_{REF}/\Delta T$	—	±0.05	—	mV/°C	V _{IN} = 12V, I _O = 1.0A -40°C to +85°C
Switching frequency		f _{SW}	280	350	420	kHz	V _{IN} = 12V, V _O = 5.0V, I _O = 1A
Line regulation		⁽⁸⁾ V _{Line}	—	50	—	mV	V _{IN} = 8V ~ 31V, V _O = 5.0V, I _O = 1A
Load regulation		⁽⁸⁾ V _{Load}	—	50	—	mV	V _{IN} = 12V, V _O = 5.0V, I _O = 0.1A ~ 2.0A
Overcurrent protection threshold		I _{S1}	—	1.5	—	A	V _{IN} = 12V, V _O = 5.0V ISET = OPEN
		I _{S2}	—	5.5	—		V _{IN} = 12V, V _O = 5.0V ISET = SHORT
Supply Current		I _{IN}	—	1	—	mA	V _{IN} = 12V V _{EN} = 10kΩ pull up to V _{IN}
Shutdown Supply Current		I _{IN(off)}	0	1	—	μA	V _{IN} = 12V, I _O = 0A, V _{EN} = 0V
SS Pin	Source current at low level voltage	I _{EN/SS}	6	10	14	μA	V _{SS} = 0V, V _{IN} = 12V
EN Pin	Sink current	I _{EN}	—	20	50	μA	V _{EN} = 10V
	Threshold voltage	V _{CEH}	0.7	1.4	2.1	V	V _{IN} = 12V
ISET Pin	Open voltage	V _{ISET}	—	1.5	—	V	V _{IN} = 12V
Max on-duty		⁽⁸⁾ D _{MAX}	—	90	—	%	
Minimum on-time		⁽⁸⁾ T _{ON(MIN)}	—	150	—	nsec	
Thermal shutdown threshold temperature		⁽⁸⁾ TSD	151	165	—	°C	
Thermal shutdown restart hysteresis of temperature		⁽⁸⁾ TSD_hys	—	20	—	°C	

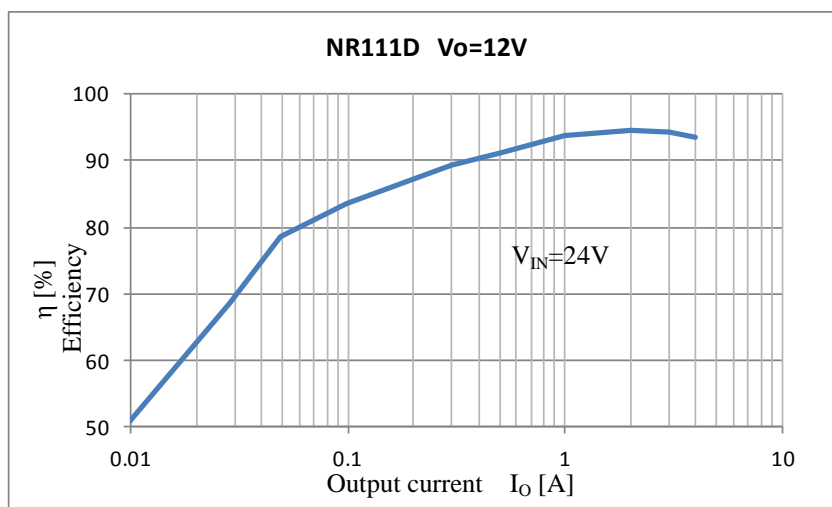
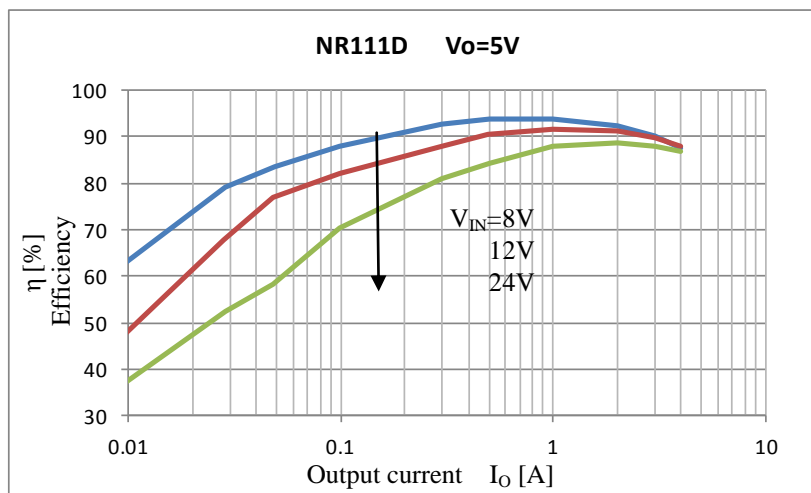
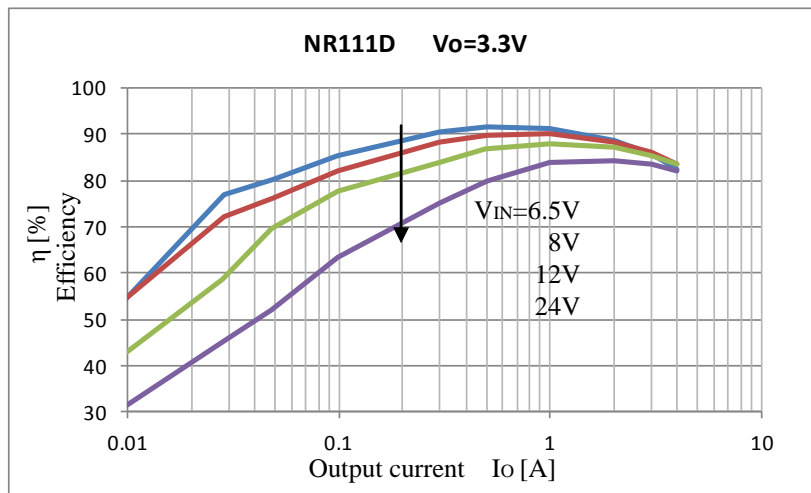
⁽⁸⁾ Guaranteed by design, not tested.

The input and output condition is limited by Minimum on-time.

NR111D

Typical characteristics

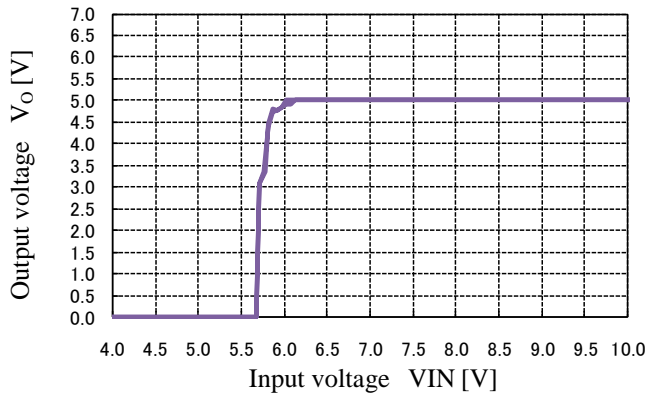
(1) Efficiency



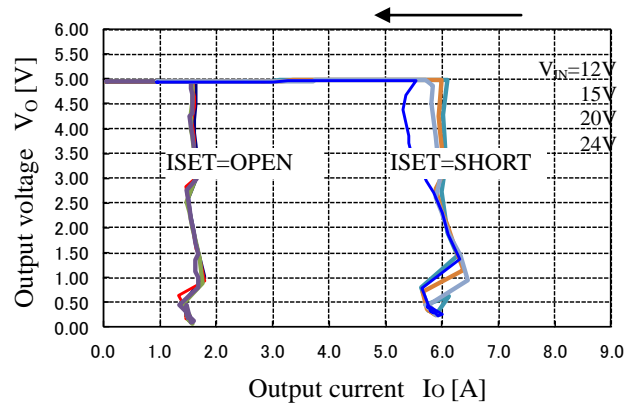
NR111D

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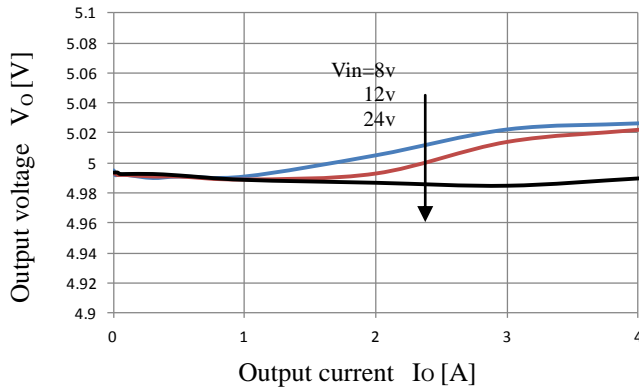
(2) Output start-up Load=CR



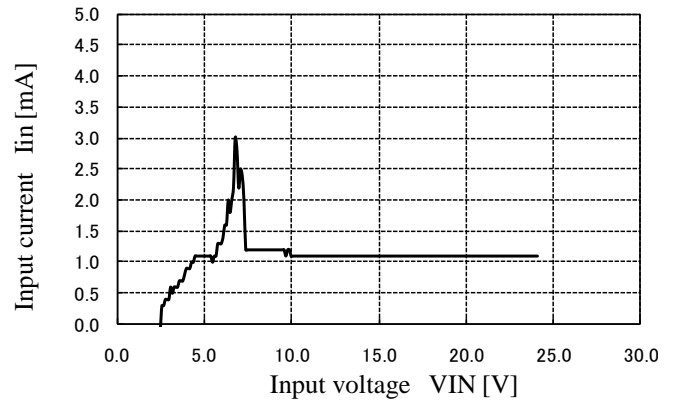
(5) Over current protection



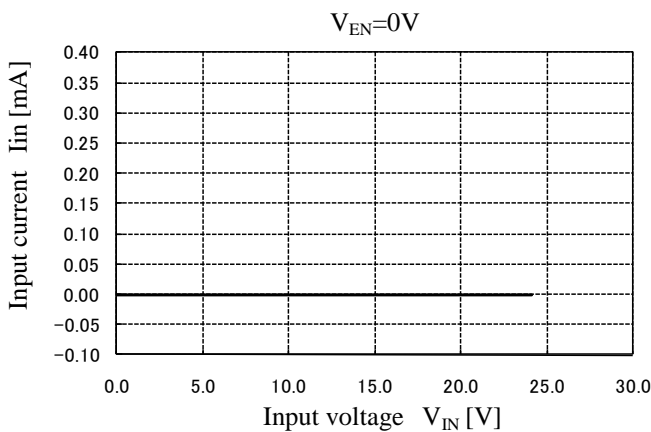
(3) Load Regulation : V_{Load}



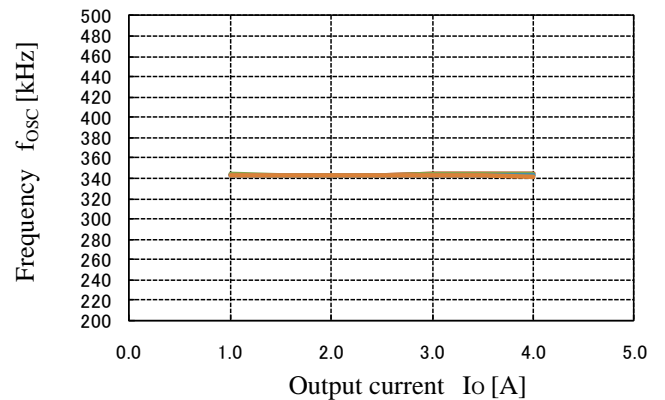
(6) Supply current : I_{IN}
At No-load $V_o=5.0V$



(4) Shut down supply current : $I_{IN(off)}$

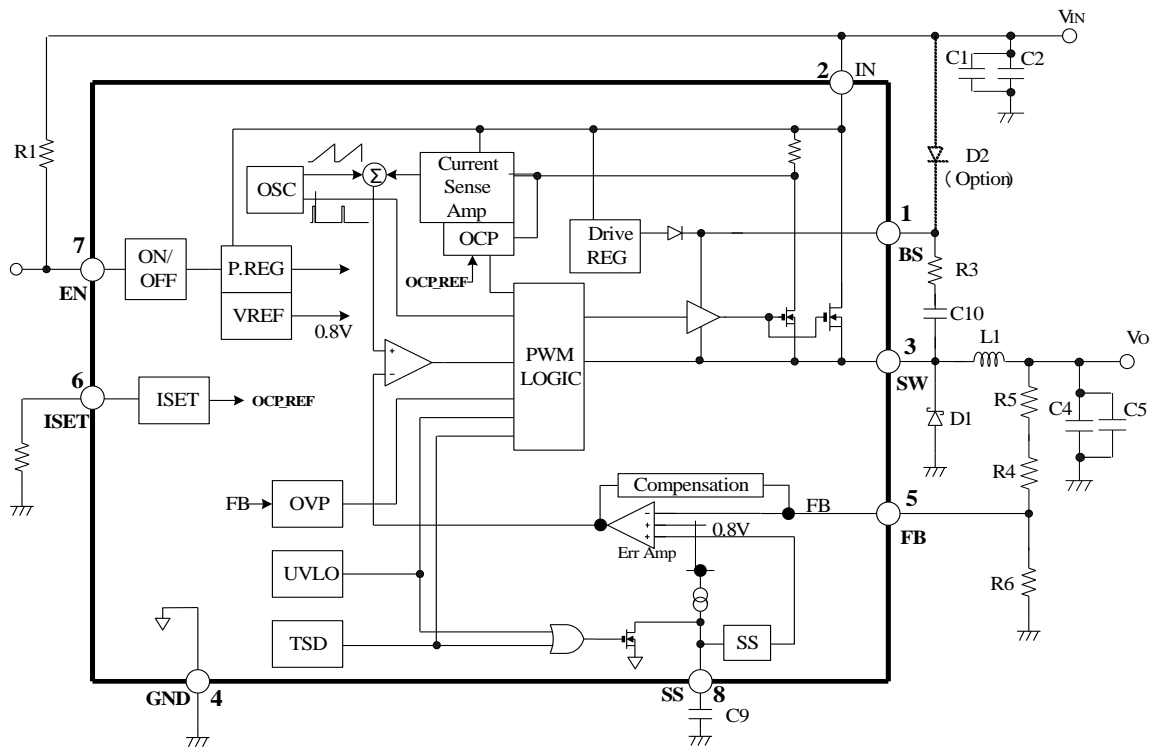


(7) Switching Frequency : fsw

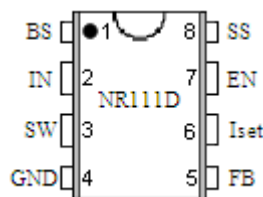


NR111D

Functional Block Diagram



Pin Assignment & Functions

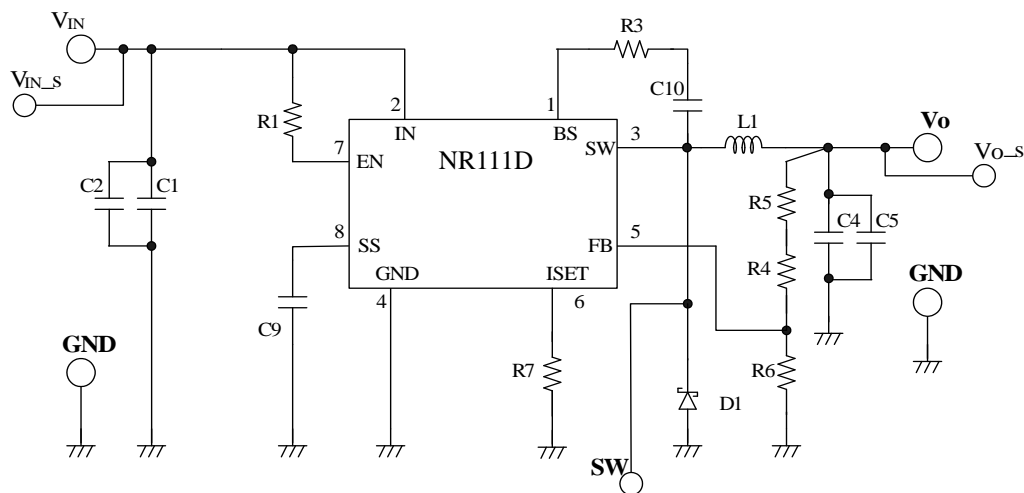


Pin Assign

Pin Assign & Functions

Pin No.	Symbol	Description
1	BS	High-side Boost input. BS supplies the drive for High-side Nch-MOSFET switch. Connect a capacitor and a resistor between SW to BS.
2	IN	Power input. IN supplies the power to the IC as well as the regulator switches
3	SW	Power switching output. SW supplies power to the output. Connect the LC filter from SW to the output. Note that a capacitor is required from SW to BS to supply the power the High-side switch
4	GND	Ground. Connect the exposed pad to Pin No.4
5	FB	Feedback input Pin to compare Reference Voltage. The feedback threshold is 0.8V. To set the output voltage, FB Pin is required to connect between resistive voltage divider R4 and R6.
6	Iset	Adjust Pin of OCP starting current. OCP starting current can be adjusted by connecting a resistor to ISET Pin. In the case of using at Maximum Io, ISET Pin is required to connect to GND.
7	EN	Enable input. Drive EN Pin high to turn on the regulator, low to turn it off.
8	SS	Soft-Start control input. To set the soft-start period, connect to a capacitor between GND.

Example Application Circuit

C1, C2: 10 μ F / 35VR1: 510k Ω L1: 10 μ HC4, C5: 22 μ F / 16VR3: 22 Ω C9: 0.1 μ FR4: 18k Ω , R5: 2.7k Ω ($V_o=5.0V$)C10: 0.1 μ FR6: 3.9k Ω

A design guide of External Components

(1)Diode D1

• The schottky-barrier diode must be used for D1. If other diodes like fast recovery diodes are used, IC may be destroyed because of the reverse voltage applied by the recovery voltage or ON voltage.

(2)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.
 • As the start current of the over current protection is approximately 4A, attention must be paid to the heating of the choke coil by the magnetic saturation due to overload or short-circulated load.

(3)Capacitor C1(C2), C4(C5), C9

• As large ripple currents across C1 (C2) and C4 (C5), capacitors with high frequency and low impedance for SMPS must be used. Especially when the impedance of C4 (C5) is high, the switching waveform may not be normal at low temperature.
 • C9 is a capacitor for soft start. In case soft start function is not used, please keep Pin No.2 open.

(4)Resistor R4, R5,R6

• R4, R5, R6 are resistor to the Output Voltage. IADJ is required to set to 0.2mA.
 R4, R5, R6 are calculated by the equation (1).

$$R4 + R5 = \frac{(V_o - V_{FB})}{I_{FB}} = \frac{(V_o - 0.8)}{0.2 \times 10^{-3}} (\Omega), \quad R6 = \frac{V_{FB}}{I_{FB}} = \frac{0.8}{0.2 \times 10^{-3}} \doteq 4.0k(\Omega) \quad \text{----- (1)}$$

I_{FB} :The electric current which flows to R6

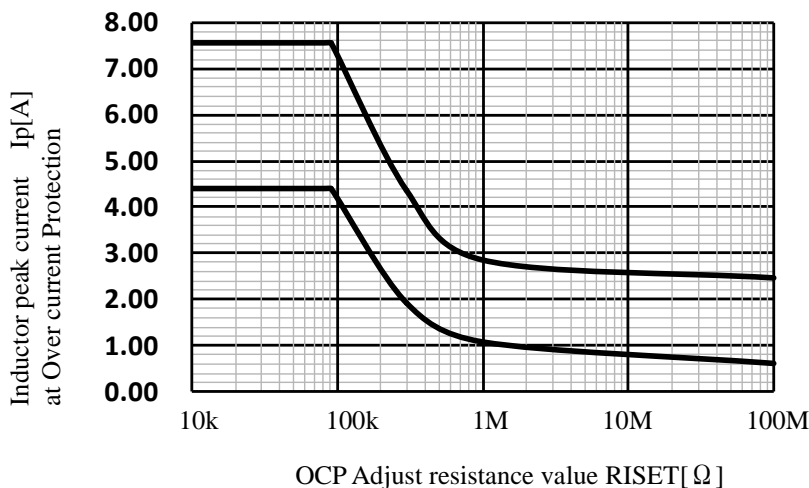
NR111D

(5) Resistor R7

• R7 is resistor to adjust OCP starting current .

The graph shows the relationship between R7 and OCP .

The OCP output current is calculated in terms of the equation (2),(3),(4) .



VIN: Input voltage
 Vo: Output voltage
 Io: Output current
 L: Inductance
 f: Switching Frequency
 ΔIL : Inductor ripple current
 Ip: Inductor peak current at Over current protection

*Ip becomes the peak value of inductor ripple current. Calculate it in accordance with the following equation.

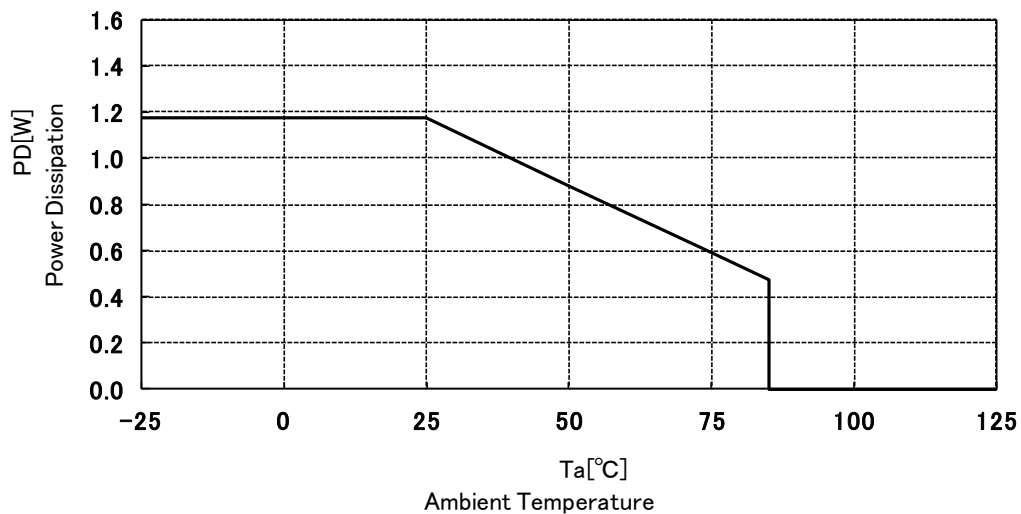
$$\text{In case of continuous inductor current} \dots \Delta IL = Ip - \frac{\Delta IL}{2} \dots (2)$$

$$\text{In case of discontinuous inductor current} \dots Io = \frac{(VIN \times L \times f)}{\{2 \times Vo \times (VIN - Vo)\}} \times Ip^2 = \frac{1}{(2 \times \Delta IL)} \times Ip^2 \dots (3)$$

$$\text{*Inductor ripple current} \dots \Delta IL = \frac{Vo}{L \times f} \times (1 - \frac{Vo}{VIN}) \dots (4)$$

In order to have optimum operating condition, each component must be connected with the minimum distance.

Allowable package power dissipation



NOTES:

- 1) Glass-epoxy board mounting in a 30×30mm
- 2) copper area : 25×25mm
- 3) The power dissipation is calculated at the junction temperature 125 °C
- 4) Losses can be calculated by the following equation.
As the efficiency is subject to the input voltage and output current, it shall be obtained from the efficiency curve and substituted in percent
- 5) Thermal design for D1 shall be made separately.

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

V_O : Output voltage

V_{IN} : Input voltage

I_O : Output current

η_x : Efficiency(%)

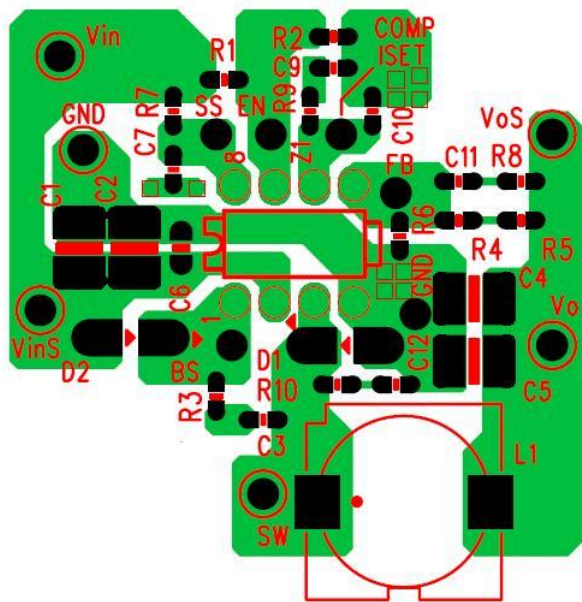
V_F : Diode forward voltage

SJPB-L4...0.55V($I_O=3A$)

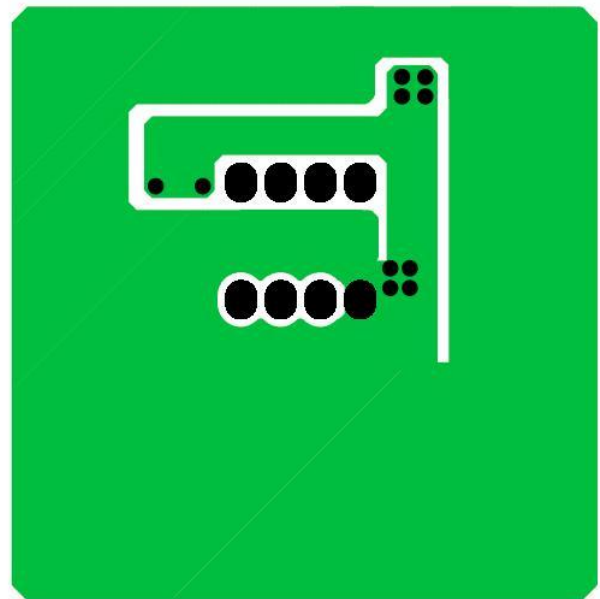
NR111D

PCB layout recommendation

*The demonstration Printed circuit board. It can mount a part for the experiment ,except for the Example Application Circuit.



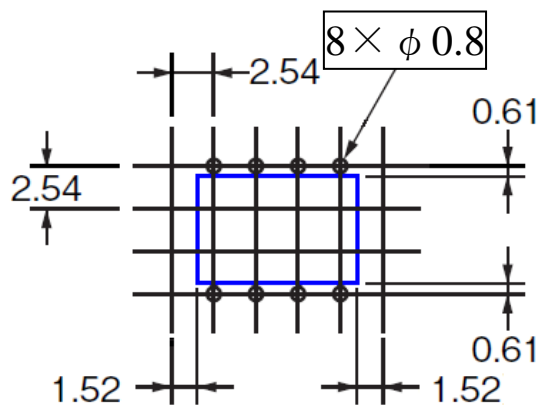
Front Side: Component Side (double sided board)



Back Side: GND Side (double sided board)

Note

- 1) Size of the PCB is about 40mm × 40mm
- 2) Dimension is in millimeters, dimension in bracket is in inches.
- 3) Drawing is not to scale.



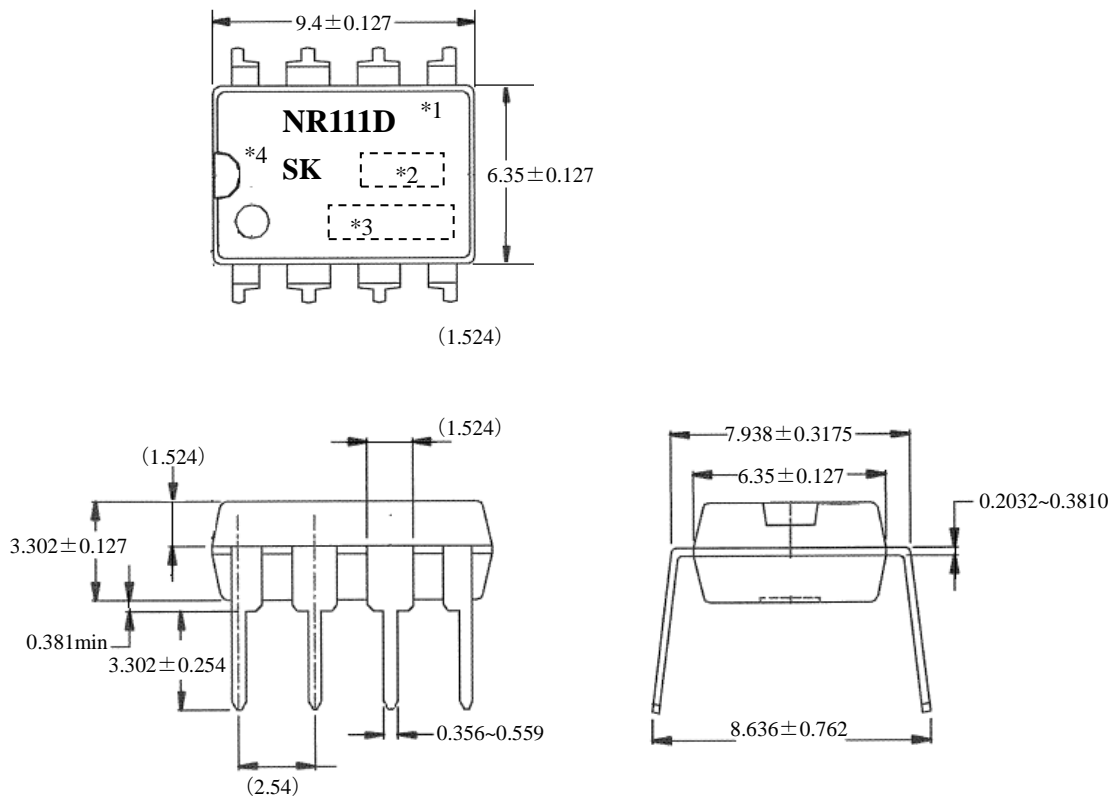
(Reference)
DIP8 package
About the position of the lead-insertion hole

NR111D

Package outline & Dimension

An outside size is supplied by either Package type A or Package type B.

Package A



PIN Assignment

- 1.NC
- 2.IN
- 3.SW
- 4.GND
- 5.FB
- 6.EN
- 7.SS
- 8.BS

Marking

- *1. Type number
- *2. Lot number (three digit)
 - 1st letter: The last digit of year
 - 2nd letter: Month
(1 to 9 for Jan. to Sept.,
O for Oct. N for Nov. D for Dec.)
 - 3rd letter week
 - 01~03 : Arabic Numerical
- *3. Control number (four digit)
- *4 .Logo: SK

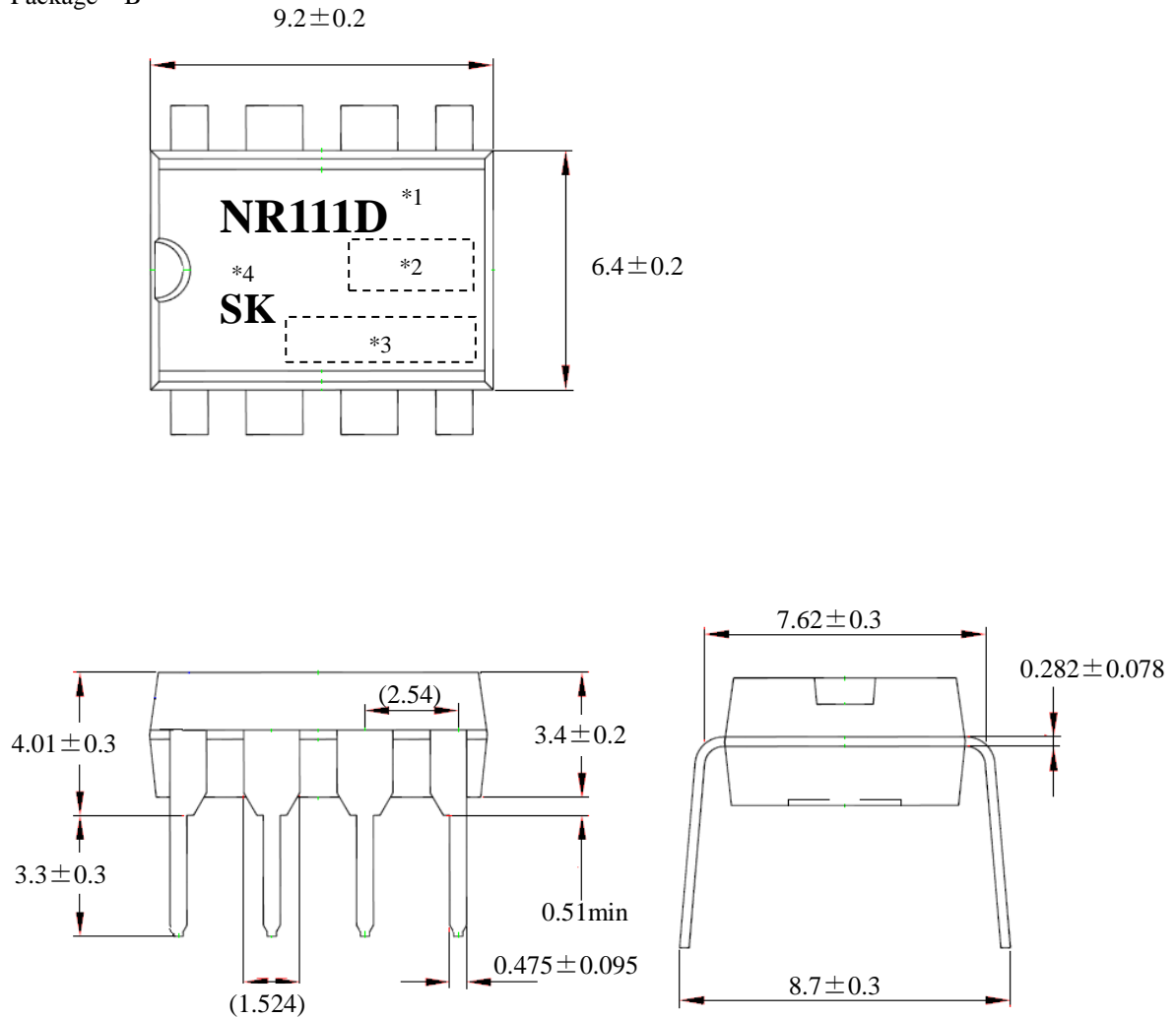
Note:

- 1) Dimension is in millimeters.
- 2) Drawing is not to scale.

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Package B



PIN Assignment

- 1.NC
- 2.IN
- 3.SW
- 4.GND
- 5.FB
- 6.EN
- 7.SS
- 8.BS

Note:

- 1) Dimension is in millimeters.
- 2) Drawing is not to scale.

Marking

- *1. Type number
- *2. Lot number (three digit)
 - 1st letter: The last digit of year
 - 2nd letter: Month
(1 to 9 for Jan. to Sept.,
O for Oct. N for Nov. D for Dec.)
 - 3rd letter week
01~03 : Arabic Numerical
- *3. Control number (four digit)
- *4 .Logo: SK

OPERATING PRECAUTIONS

Reliability can be affected adversely by improper storage environments and handling methods. Please observe the following cautions.

Heat dissipation and reliability

Thermal performance of the surface mount package IC depends on the material and area size of PCB and its copper plane. Design thermal condition with sufficient margin

Parallel operation

The parallel operation to increase the current is not available.

Thermal shut down

The NR111D has a thermal protection circuit.

This circuit protects the IC from the heat generation by the over load.

This circuit cannot guarantee the long-term reliability against the continuously over load status.

Cautions for Storage

- Ensure that storage conditions comply with the standard temperature (5 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 products, shorts between the product pins, and wrong connections. In addition, avoid tests exceeded ratings

Soldering

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

- Reflow Preheat ; 180°C / 90±30s
Heat ; 250°C / 10±1s (260°C peak ,2times)
- Soldering iron ; 380±10°C / 3.5±0.5s (1time)

Electrostatic Discharge

- When handling the products, the operator must be grounded. Grounded wrist straps worn should have at least 1MΩ 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 a 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.

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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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