

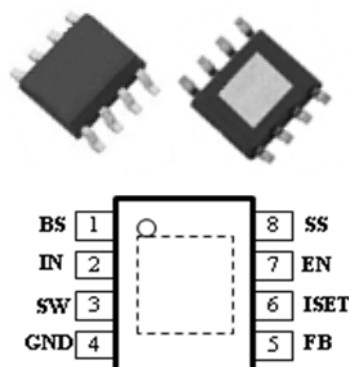
NR110E series

General Descriptions

The NR110E series is buck regulator ICs integrates High-side power MOSFET. 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 NR110E series is available in an 8-pin SOIC package with an exposed thermal pad on the back side.

Package

- Exposed SOIC 8
- Thermally enhanced 8-Pin package



Features & Benefits

- Current mode PWM control
- Up to 94% Efficiency,
Up to 68% Efficiency at $I_O = 20\text{mA}$ Light Load
- Adjustable "Over Current Protection (OCP)"
- Current mode PWM control
- 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

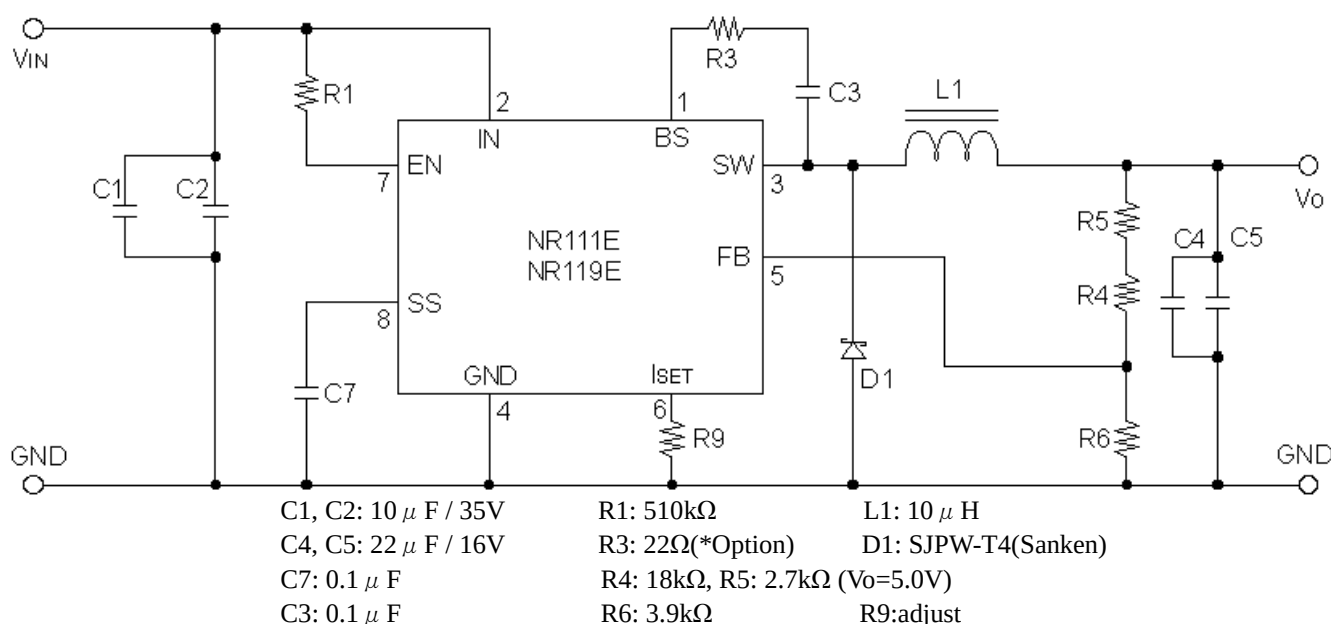
Electrical Characteristics

- Operating input range $V_{IN} = 6.5\text{V} \sim 31\text{V}$
- Output adjustable $V_O = 0.8\text{V} \sim 24\text{V}$
- 2A / 4A output current
- Fixed 350kHz frequency : NR111E
Fixed 364kHz frequency : NR119E

Applications

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

Typical Application Circuit



NR110E series

Series Lineup

Product No.	f_{SW}	V_{IN}	V_O	I_O
NR111E	350kHz	6.5V to 31V	0.8V to 24V	4A
NR119E	364kHz			2A

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

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

Absolute Maximum Ratings

Parameter	Symbol	Ratings	Units	Conditions
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	1.76	W	Glass-epoxy board mounting in a 30×30mm. (copper area in a 25×25mm) Max $T_J=150^{\circ}C$
Junction temperature	⁽⁴⁾ T_J	-40 to 150	$^{\circ}C$	
Storage temperature	T_S	-40 to 150	$^{\circ}C$	
Thermal resistance (junction- Pin No. 4)	θ_{JP}	26	$^{\circ}C/W$	
Thermal resistance (junction-ambient air)	θ_{JA}	71	$^{\circ}C/W$	Glass-epoxy board mounting in a 30×30mm. (copper area in a 25×25mm)

⁽³⁾ Limited by thermal shutdown.

⁽⁴⁾ The temperature detection of thermal shutdown is about 160 $^{\circ}C$

Recommended Operating Conditions

Parameter		Symbol	Ratings		Units	Conditions
			MIN	MAX		
DC input voltage	⁽⁵⁾	V_{IN}	6.5	31	V	
DC output current	NR111E	⁽⁶⁾ I_O	0	4.0	A	
	NR119E		0	2.0		
Output voltage		V_O	0.8	24	V	
Ambient operating temperature	⁽⁷⁾	T_{op}	-40	85	$^{\circ}C$	

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

⁽⁶⁾ Recommended circuit refers to Typical Application Circuit.

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

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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	NR111E	f_{SW}	280	350	420	kHz	$V_{IN}=12V, V_O=5.0V,$ $I_O=1A$
	NR119E		291	364	437		
Line regulation		⁽⁸⁾ V_{Line}	—	50	—	mV	$V_{IN}=8V\sim 31V, V_O =5.0V,$ $I_O=1A$
Load regulation		⁽⁸⁾ V_{Load}	—	50	—	mV	$V_{IN}=12V, V_O=5.0V,$ $I_O=0.1A\sim 2.0A$
Over current protection starting current	NR111E	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
	NR119E	I_{S1}	—	0.9	—		$V_{IN}=12V, V_O = 5.0V$ ISET=OPEN
		I_{S2}	—	2.8	—		$V_{IN} = 12V, V_O = 5.0V$ ISET=SHORT
Supply Current		I_{IN}	—	1	—	mA	$V_{IN} = 12V$ $V_{EN}=10k\Omega$ 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	$V_{C/EH}$	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	NR111E	⁽⁸⁾ $T_{ON(MIN)}$	—	150	—	nsec	
	NR119E		—	150	—		
Thermal shutdown threshold temperature		⁽⁸⁾ TSD	151	165	—	°C	
Thermal shutdown restart hysteresis of temperature		⁽⁸⁾ TSD_hys	—	20	—	°C	

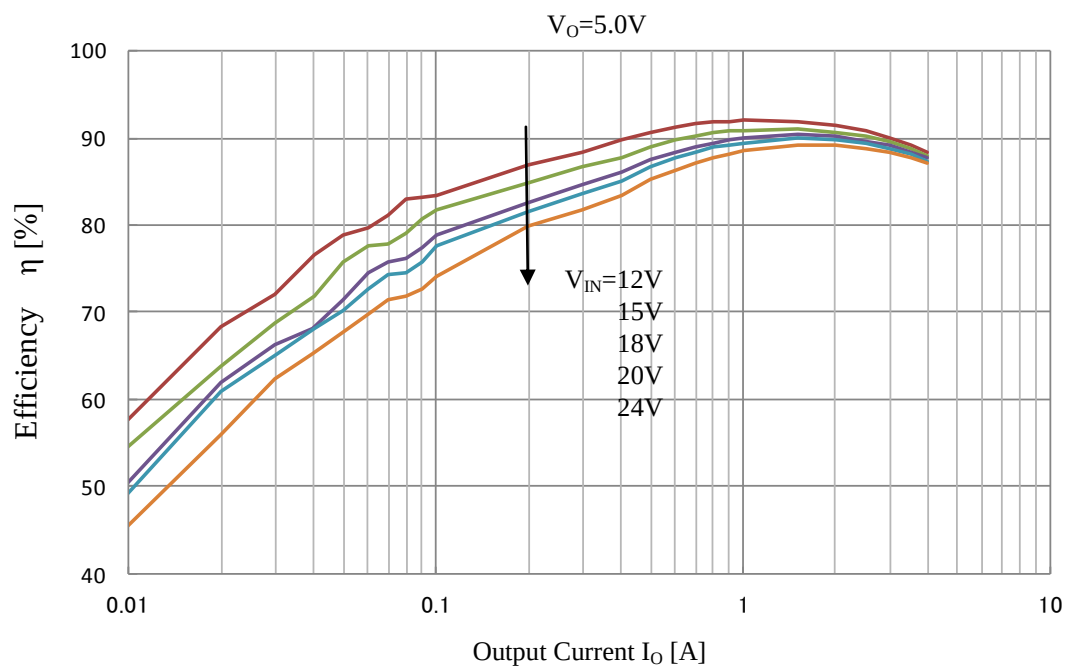
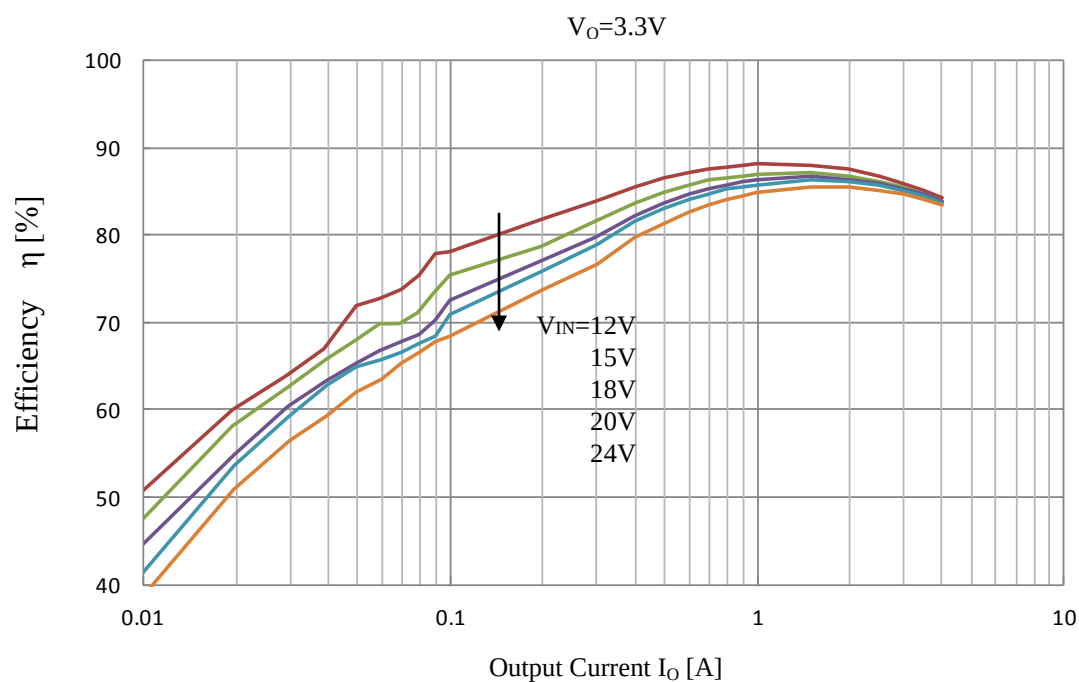
⁽⁸⁾ Guaranteed by design, not tested.

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Typical Performance Characteristics

NR111E Typical Performance Characteristics

Efficiency

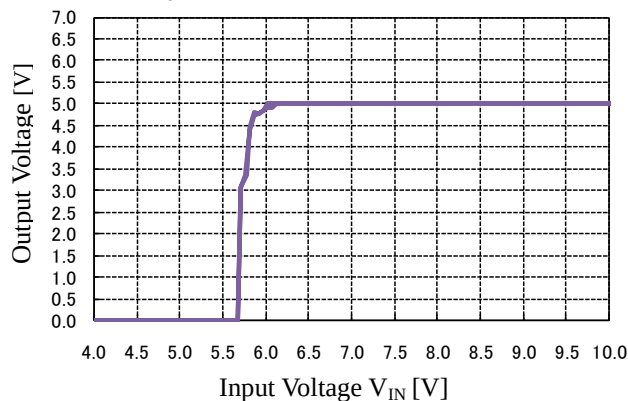


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NR111E Typical Performance Characteristics

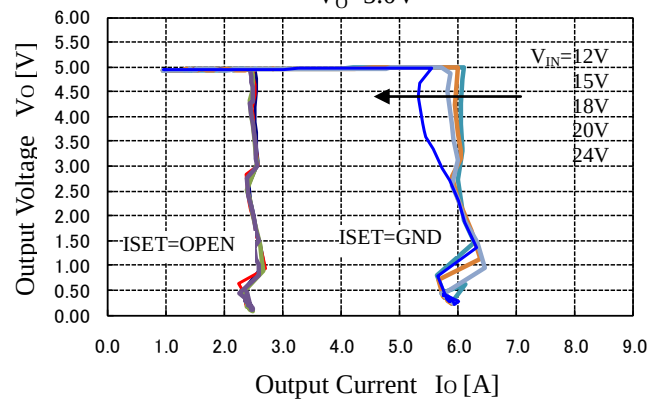
Output startup

$V_O=5.0V$, Load = Constant Resistance



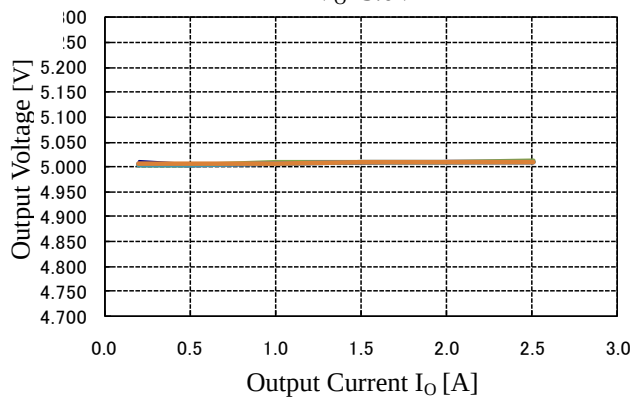
Over Current Protection

$V_O=5.0V$



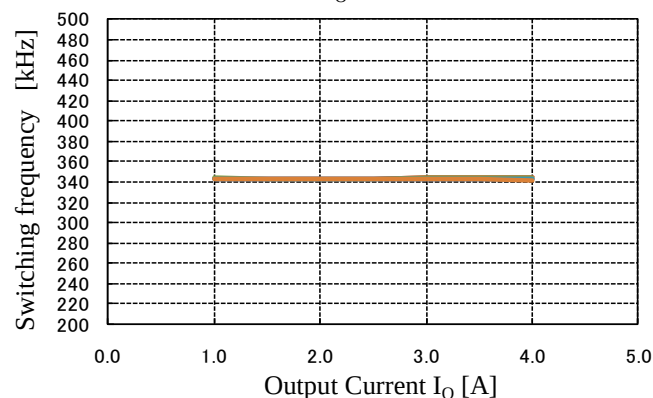
Load Regulation: V_{Load}

$V_O=5.0V$



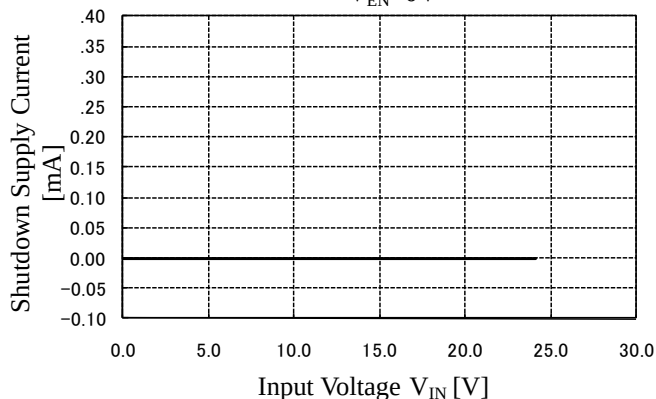
Switching Frequency: f_{SW}

$V_O=5.0V$



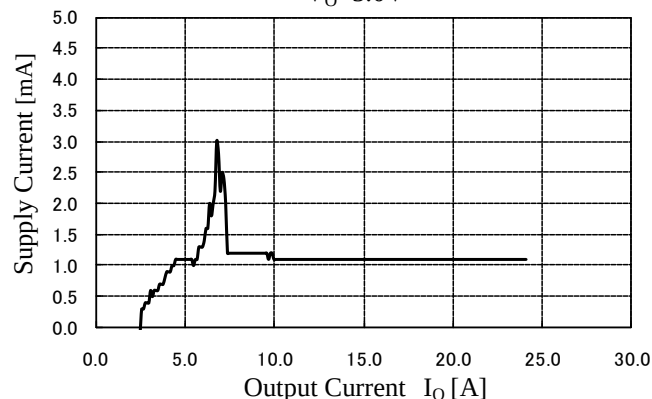
Shutdown Supply Current : $I_{IN(off)}$

$V_{EN}=0V$

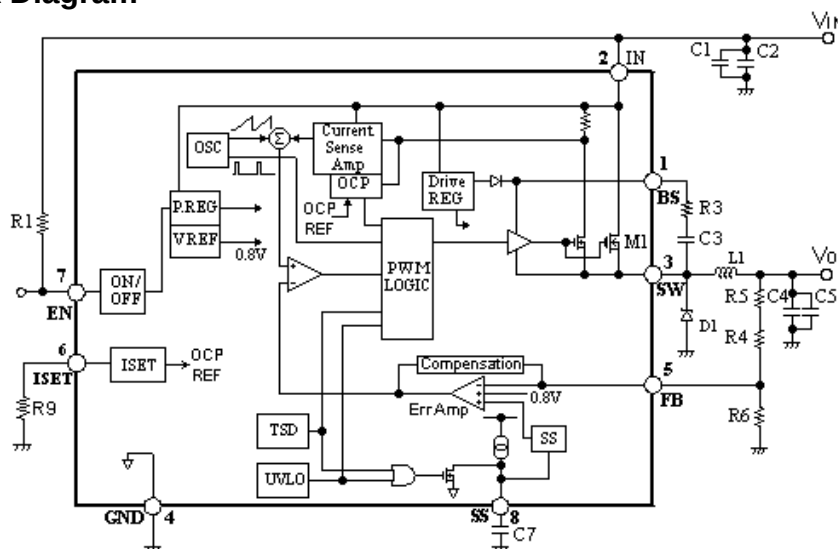


Supply Current : I_{IN}

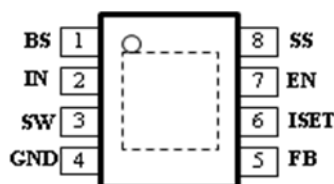
$V_O=5.0V$



Functional Block Diagram



Pin Assignments & Functions



Pin Assignments

Pin 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.

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External Components Design Guide

(1)Diode D1

- The schottky-barrier diode must be used for D1. If other diodes like fast recovery diodes are used, IC may be damaged 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), C7

- As large ripple current 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.
- C7 is a capacitor for soft start. A soft-start controls the over-shoot of the output voltage rising and rush current.

(4)Resistor R1, R2

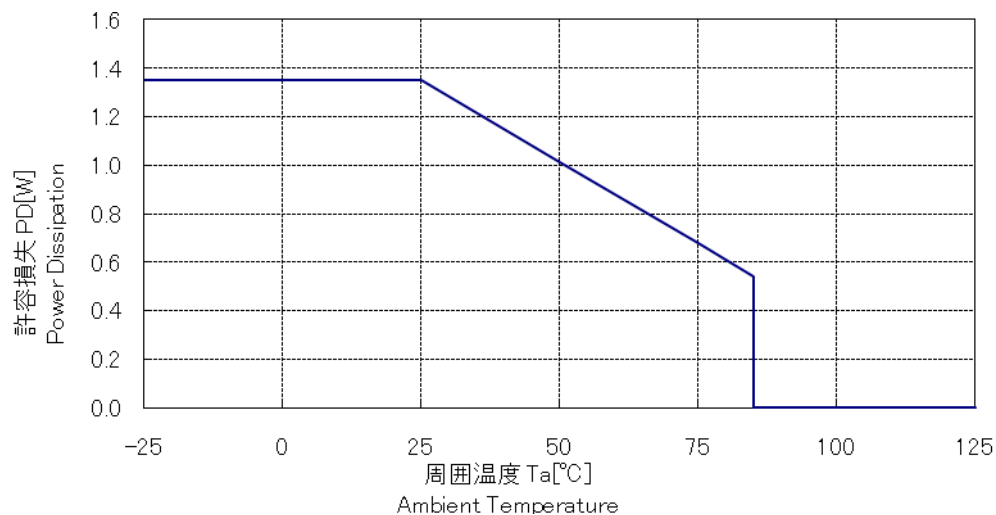
- R4, R5, R6 are resistor to the Output Voltage. I_{ADJ} is required to set to 0.2mA.
R4, R5, R6 are calculated by the equation (1).

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

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

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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

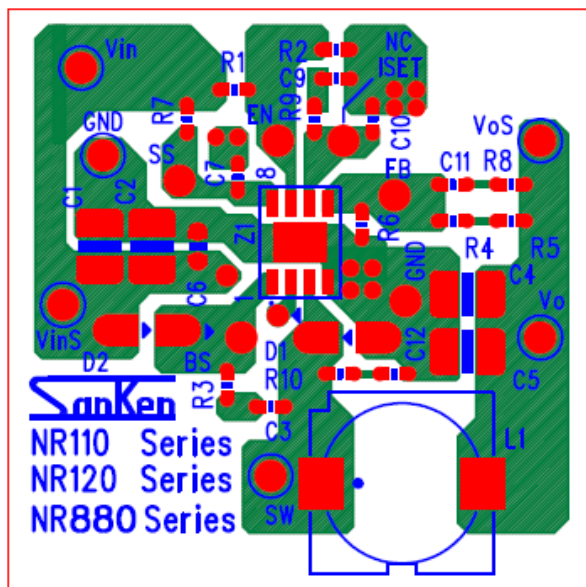
η_x : Efficiency(%)

V_F : Diode forward voltage
SJPB-L4...0.55V($I_O=3A$)

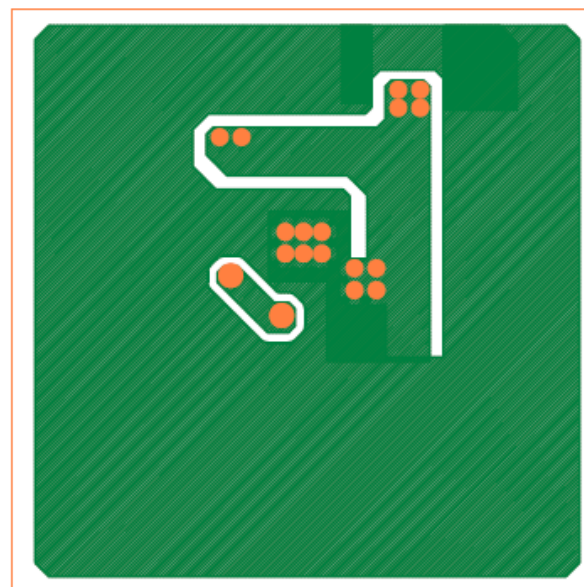
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PCB Layout Example & Recommended Land Pattern

- (1) Each ground of all components is connected as close as possible to the Pin No.1 at one point.
- (2) To help heat dissipation, connect a large copper plane to exposed pad on the back side of the package.
The copper plane is required for GND



Front Side: Component Side (double sided board)

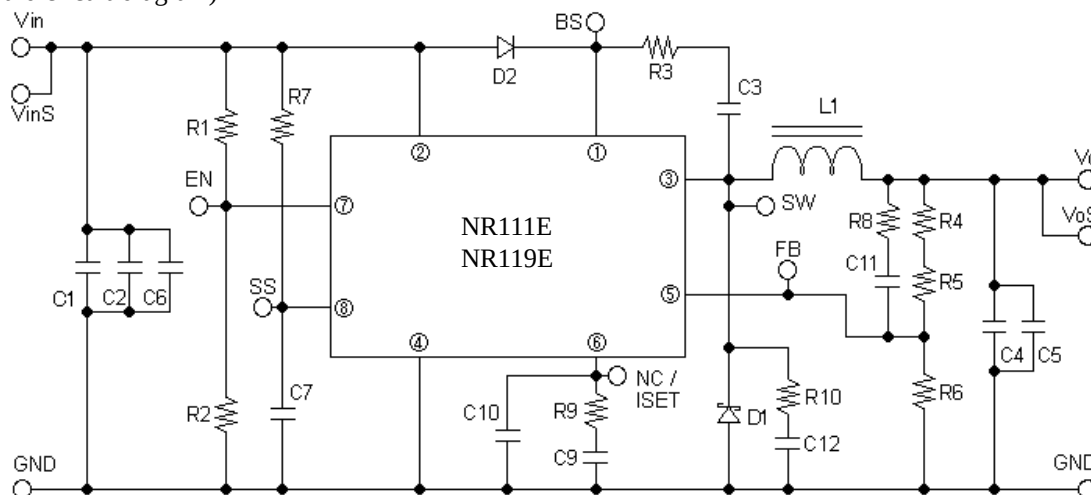


Back Side: GND Side (double sided board)

NOTES:

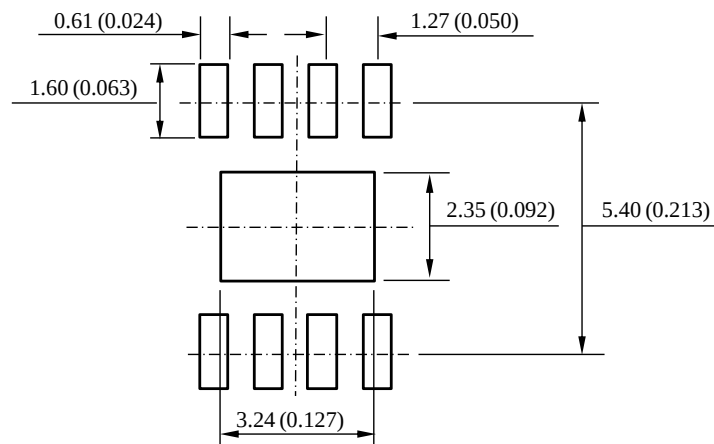
Real size of the PCB is 60mm×60mm

(Demo-board circuit-diagram)



As for the part number of the demonstration board "circuit-diagram", a circuit board concerned doesn't partly fit each other with the above application circuit example and so on for NR110, NR120 and the NR880 series common use. Approve it in advance. C9, R9 and C10 aren't used in the NR110 series. And, D2, R3, R8, R10, C11 and C12 are options.
*Mount I_{SET} setup resistor R9 on the position of C10.

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NOTES:

- 1) Dimension is in millimeters, dimension in bracket is in inches.
- 2) Drawing is not to scale.

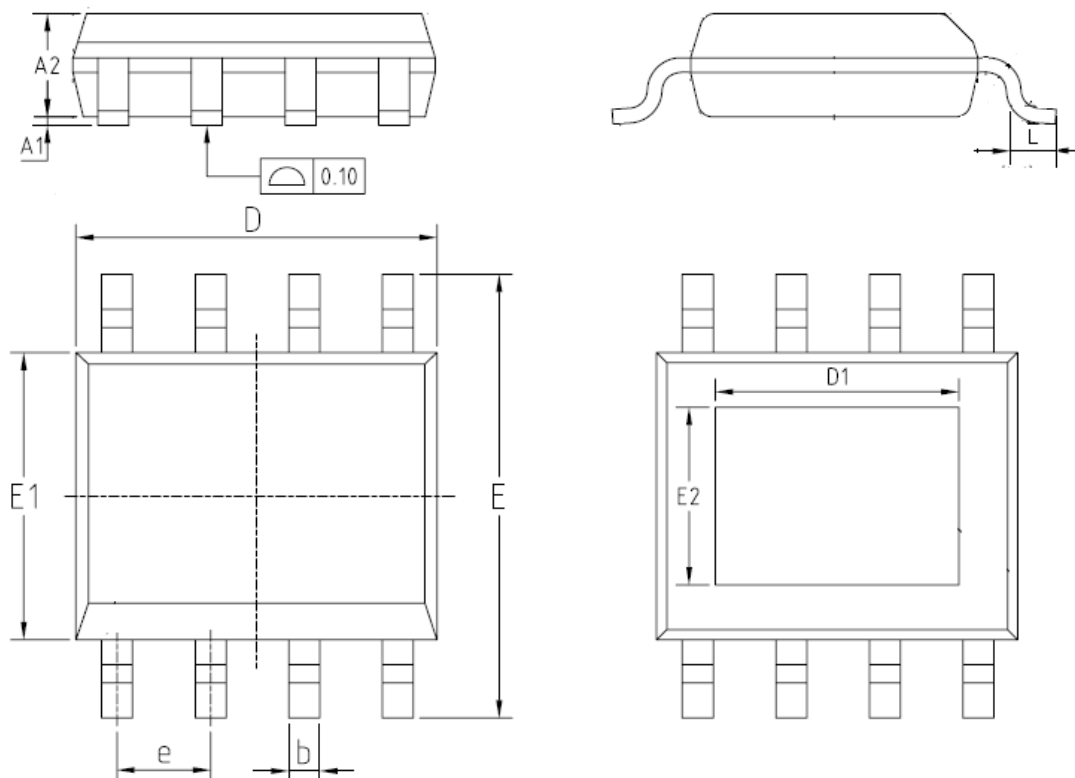
Recommended land pattern

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Package Outline

Exposed SOIC8 package

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



Package outline, dimensions

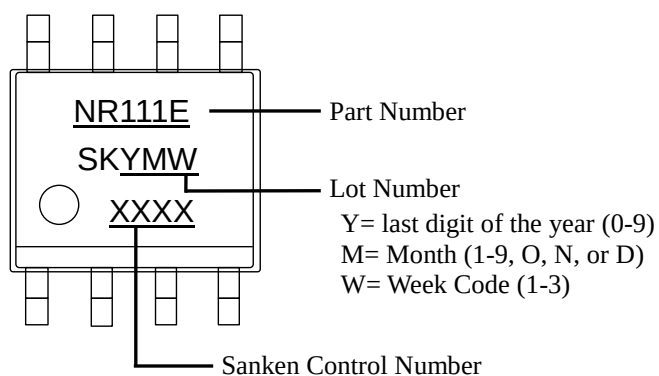
Symbol	Package A			Package B		
	MIN	TYP	MAX	MIN	TYP	MAX
A1	0	—	0.1524	0	0.10	0.15
A2	1.398	1.448	1.498	1.25	1.40	1.65
b	0.330	—	0.508	0.38	—	0.51
D	4.80	4.902	5.004	4.80	4.90	5.00
D1	3.053	3.18	3.307	3.10	3.30	3.50
E	5.893	—	6.918	5.80	6.00	6.20
E1	3.73	—	3.89	3.80	3.90	4.00
E2	2.033	2.16	2.287	2.20	2.40	2.60
e	—	1.27	—	—	1.27	—
L	0.508	—	0.762	0.45	0.60	0.80

NOTES:

- 1) Dimension is in millimeters, dimension in bracket is in inches.
- 2) Drawing is not to scale.
- 3) Pb-free: Device composition comply with the RoHS directive.

NR110E series

Package Marking



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 NR111E 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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