# NR120E series

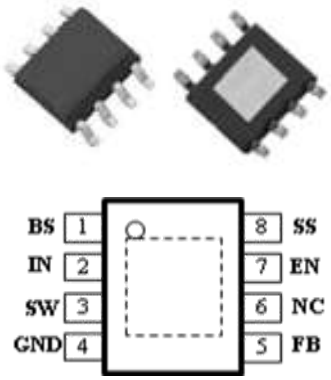
May/16/2012

## eneral Descriptions

The NR120E series is buck regulator ICs integrates High-side power MOSFET. 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 NR120E 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
- 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

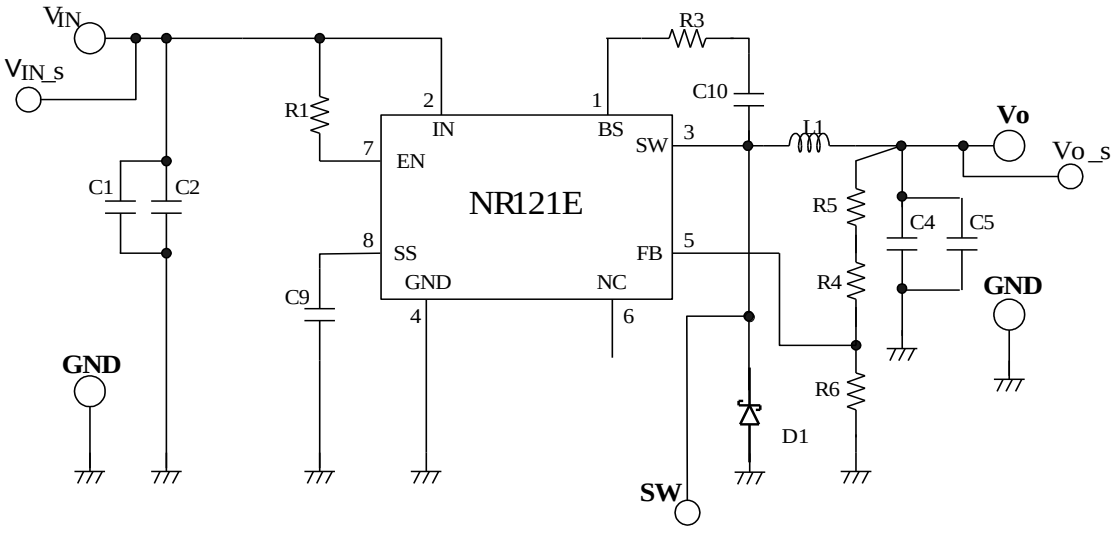
## Electrical Characteristics

- 3A output current
- Operating input range $V_{IN}$ = 4.5V～18V
- Output adjustable $V_O$ = 0.8V～14V
- Fixed 350kHz frequency

## Applications

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

## Typical Application Circuit




C1, C2: 10µF / 25V
C4, C5: 22µF / 16V
C9: 0.1µF
C10: 0.1µF

R1: 100kΩ
R3: 22Ω
R4: 8.2 kΩ, R5: 4.3kΩ ($V_O$=3.3V)
R6: 3.9kΩ

D1: SJPB-L4
L1: 10µH

## Series Lineup

| Product No. | $f_{SW}$ | $V_{IN}$ | | $V_O$ | | $I_O$ |
|---|---|---|---|---|---|---|
| NR121E | 350kHz | 4.5V to 18V | (1) | 0.8V to 14V | (2) | 3A |

(1) The minimum input voltage shall be either of 4.5V 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 | | $V_{IN}$ | 20 | 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°C |
| Junction temperature | (4) | $T_J$ | –40 to 150 | °C | |
| Storage temperature | | $T_S$ | –40 to 150 | °C | |
| Thermal resistance (junction- Pin No. 4) | | $\theta_{JP}$ | 26 | °C /W | |
| Thermal resistance (junction-ambient air) | | $\theta_{JA}$ | 71 | °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°C

## Recommended Operating Conditions

| Parameter | | Symbol | Ratings | | Units | Conditions |
|---|---|---|---|---|---|---|
| | | | MIN | MAX | | |
| DC input voltage | (5) | $V_{IN}$ | Vo+3 | 18 | V | |
| DC output current | (6) (7) | Io | 0 | 3.0 | A | |
| Output voltage | | Vo | 0.8 | 14 | V | |
| Ambient operating temperature | (7) | Top | –40 | 85 | °C | |

(5) The minimum value of input voltage is taken as the larger one of either 4.5V or $V_O$ + 3V.
In the case of $V_{IN}$=$V_O$ +1～$V_O$ +3V , it is set to $I_O$ = Max. 2A
(6) Recommended circuit refers to Typical Application Circuit.
(7) To be used within the allowable package power dissipation characteristics

## 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 | | | $\triangle V_{REF}/\triangle T$ | — | ±0.05 | — | mV/°C | $V_{IN}$ = 12V, $I_O$ = 1.0A<br>–40°C to +85°C |
| Switching frequency | NR121E | | $f_{SW}$ | 280 | 350 | 420 | kHz | $V_{IN}$ =12V, $V_O$=3.3V,<br>$I_O$ =1A |
| Line regulation | | (8) | $V_{Line}$ | — | 50 | — | mV | $V_{IN}$ = 6.3V～18V,<br>$V_O$ = 3.3V, $I_O$ = 1A |
| Load regulation | | (8) | $V_{Load}$ | — | 50 | — | mV | $V_{IN}$ = 12V, $V_O$ = 3.3V,<br>$I_O$ = 0.1A～3.0A |
| Over current protection threshold | | | $I_S$ | 3.1 | — | 6.0 | A | $V_{IN}$ = 12V, $V_o$ = 3.3V |
| Supply Current | | | $I_{IN}$ | — | 6 | — | mA | $V_{IN}$= 12V<br>$V_{EN}$=10kΩ pull up to $V_{IN}$ |
| Shutdown Supply Current | | | $I_{IN(off)}$ | 0 | — | 10 | μA | $V_{IN}$ =12V, $I_O$ =0A,<br>$V_{EN}$=0V |
| SS Pin | Source current at low level voltage | | $I_{EN/SS}$ | 6 | 10 | 14 | μA | $V_{SS}$=0V, $V_{IN}$=12V |
| | High level voltage | | $V_{SSH}$ | — | 3.0 | — | V | $V_{IN}$ =12V |
| EN Pin | Sink current | | $I_{EN}$ | | 50 | 100 | μA | $V_{EN}$= 10V |
| | Threshold voltage | | $V_{C/EH}$ | 0.7 | 1.4 | 2.1 | V | $V_{IN}$ =12V |
| Max on-duty | | (8) | $D_{MAX}$ | — | 90 | — | % | |
| Minimum on-time | NR121E | (8)<br>(9) | $T_{ON(MIN)}$ | — | 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.

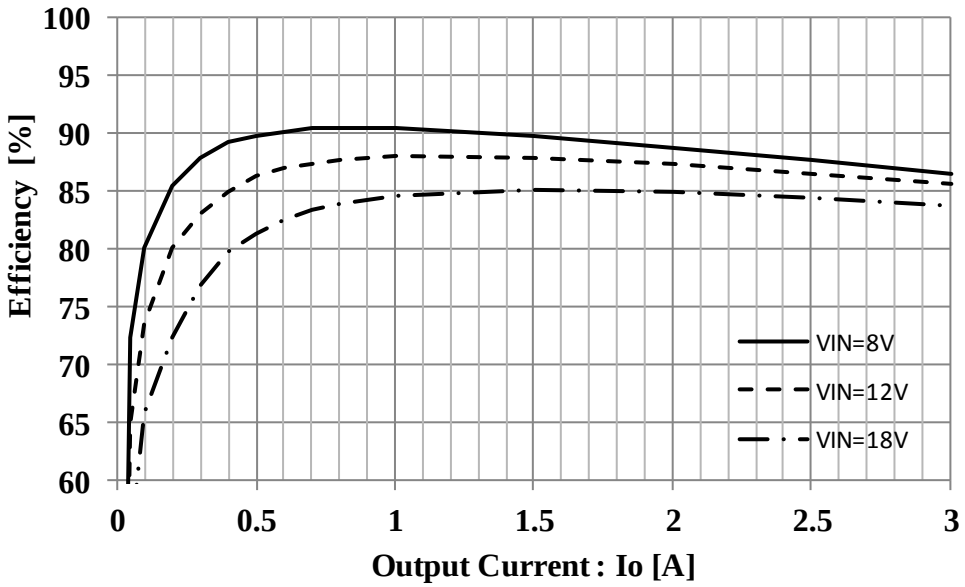
(9) The I/O characteristic are limited by the $T_{ON(MIN)}$.

## Typical Performance Characteristics

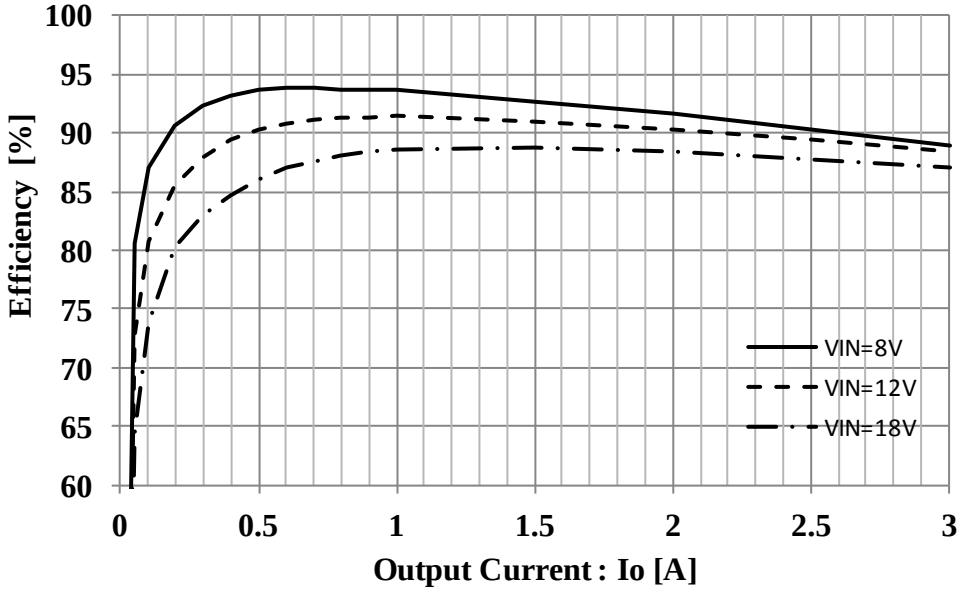
### NR121E Typical Performance Characteristics

#### Efficiency

$V_O$ = 3.3V, L=10uH



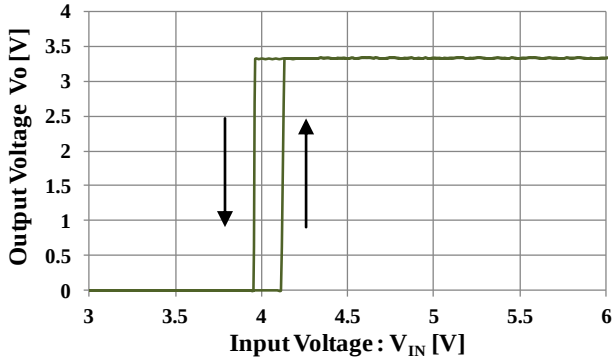

$V_O$ = 5V, L=10uH



## NR121E Typical Performance Characteristics

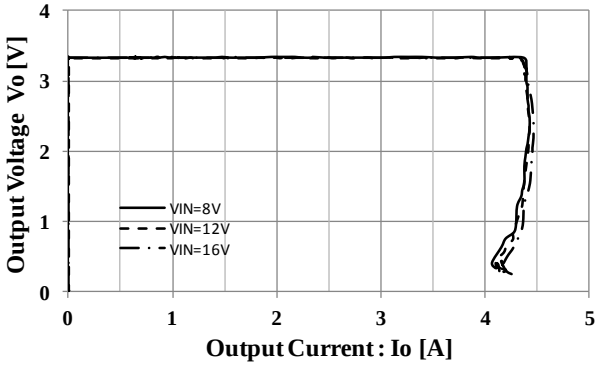
### Output startup

$V_O$=3.3V, Load = Constant Resistance, $I_O$=0.5A



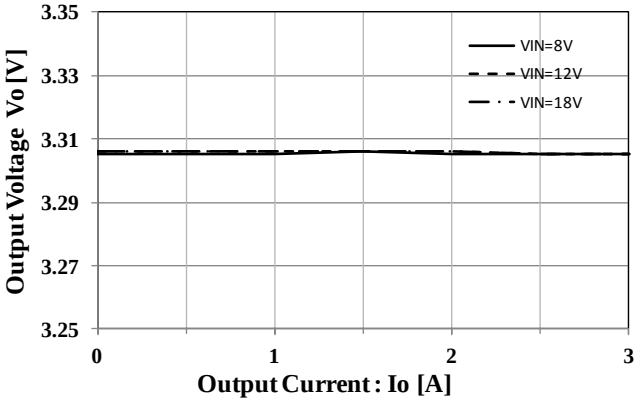

### Over Current Protection

$V_O$=3.3V



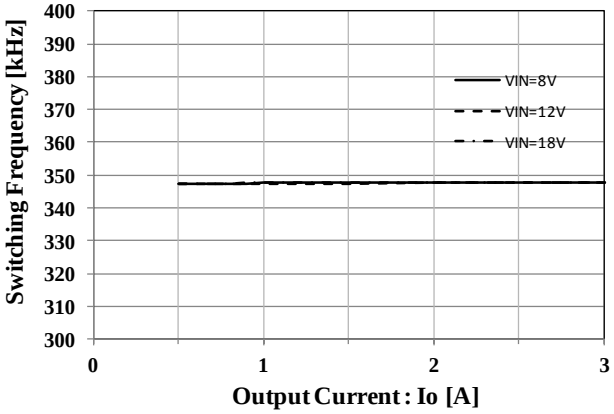

### Load Regulation

$V_O$=3.3V



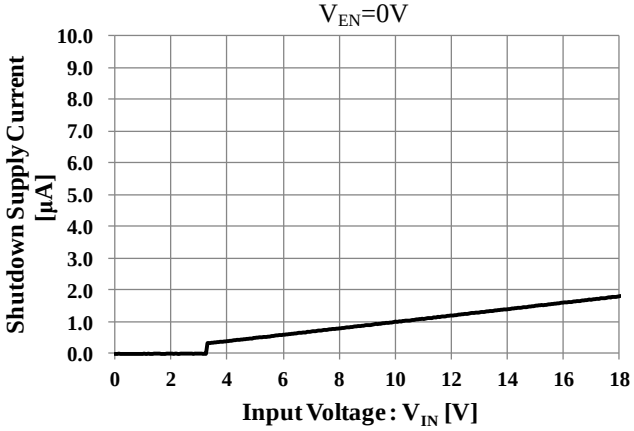

### Switching Frequency

$V_O$=3.3V



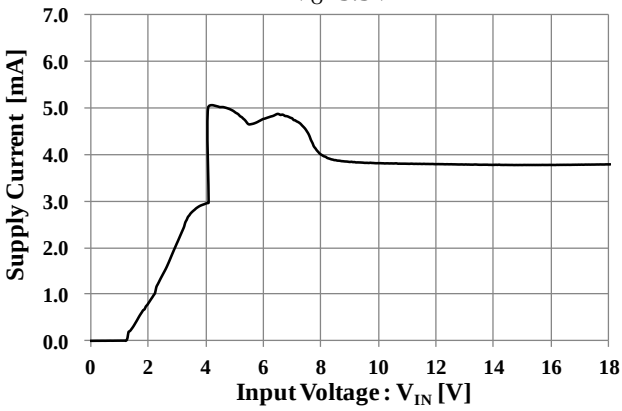

### Shutdown Supply Current

$V_{EN}$=0V

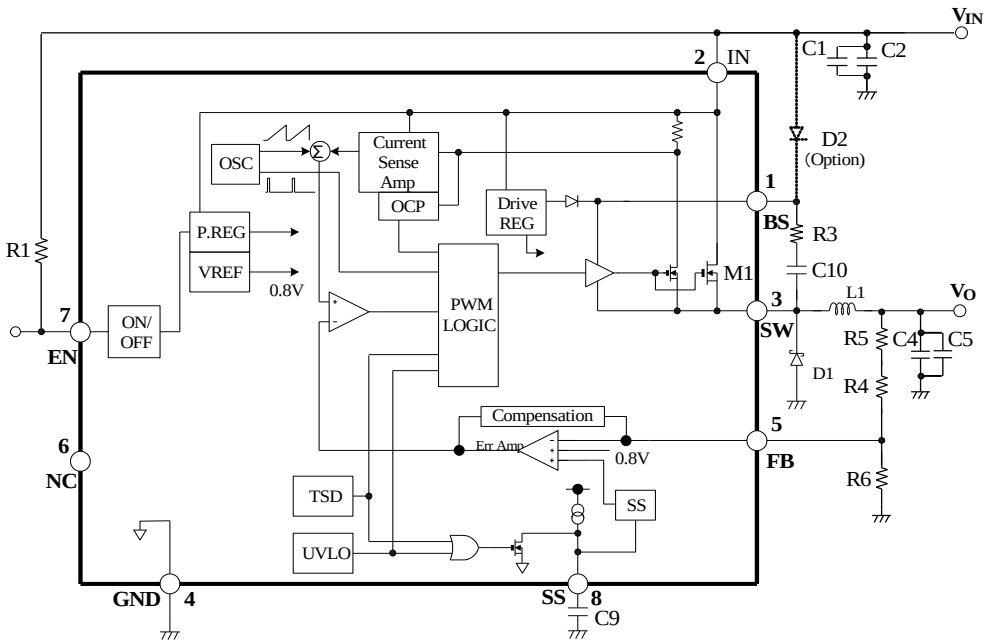



### Supply Current

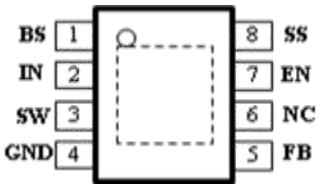
$V_O$=3.3V



## Functional Block Diagram




## Pin Assignments & Functions

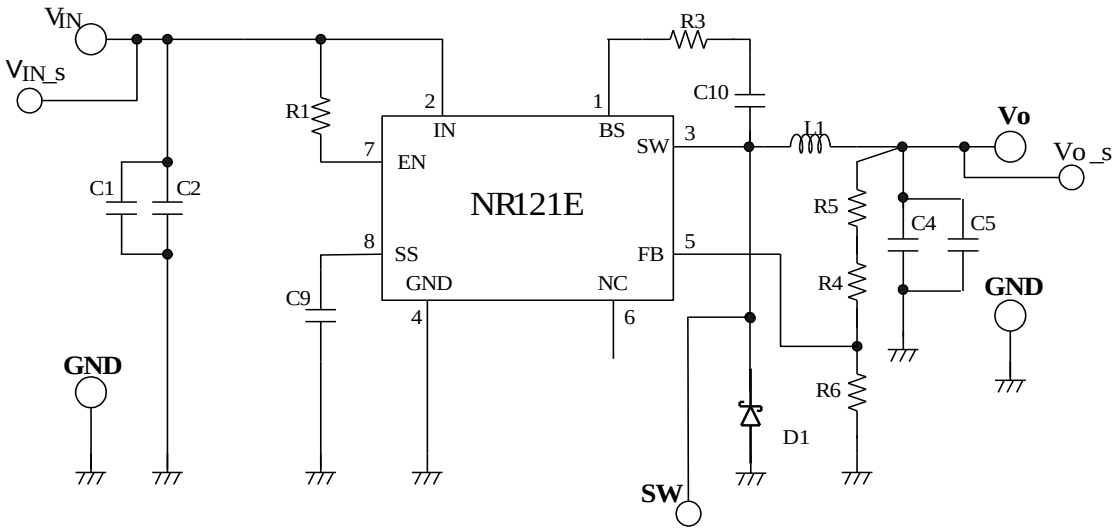



**Pin Assignments**

### Pin Functions

| Pin No. | Symbol | Description |
|---|---|---|
| 1 | BS | High-side Boost input.<br>BS supplies the drive for High-side Nch-MOSFET switch.<br>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.<br>SW supplies power to the output.<br>Connect the LC filter from SW to the output.<br>Note that a capacitor is required from SW to BS to supply the power the High-side switch |
| 4 | GND | Ground<br>Connect the exposed pad to Pin No.4 |
| 5 | FB | Feedback input Pin to compare Reference Voltage. The feedback threshold is 0.8V.<br>To set the output voltage, FB Pin is required to connect between resistive voltage divider R1 and R2. |
| 6 | NC | No Connection. |
| 7 | EN | Enable input.<br>Drive EN Pin high to turn on the regulator, low to turn it off. |
| 8 | SS | Soft-Start control input.<br>To set the soft-start period, connect to a capacitor between GND. |

## Typical Application Circuit




C1, C2: 10µF / 25V
C4, C5: 22µF / 16V
C9: 0.1µF
C10: 0.1µF

R1: 100kΩ
R3: 22Ω
R4: 8.2 kΩ, R5: 4.3kΩ ($V_O$=3.3V)
R6: 3.9kΩ

D1: SJPB-L4
L1: 10µH

## 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), 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 No.2 Pin open.

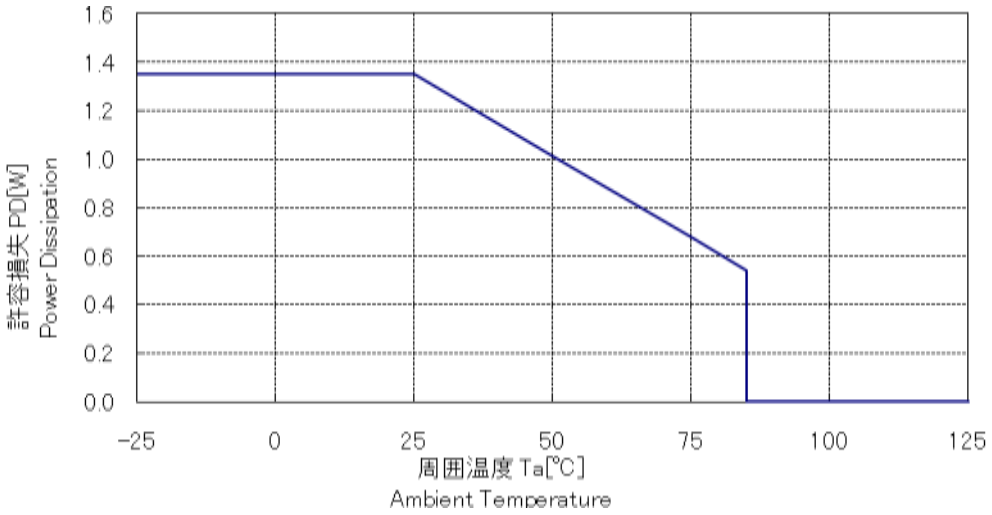
**(4)Resistor R4, R5, R6**

・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).

$$R4+R5=\frac{(V_O-V_{FB})}{I_{ADJ}}=\frac{(V_O-0.8)}{0.2\times10^{-3}}(\Omega),\quad R6=\frac{V_{FB}}{I_{ADJ}}=\frac{0.8}{0.2\times10^{-3}}\fallingdotseq4.0k(\Omega)\qquad\text{------- (1)}$$

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

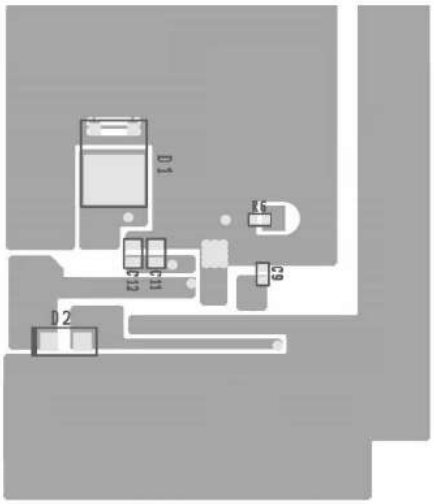
$\eta$ x: Efficiency(%)

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

## PCB Layout & Recommended Land Pattern

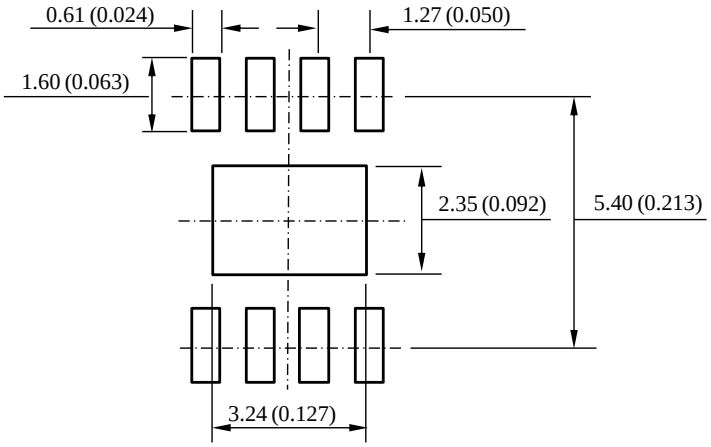
(1)Each ground of all components is connected as close as possible to the Pin No.4 at one point.
(2) To help heat dissipation, connect a large copper plane to exposed pad on the back side of the package.
The copper plane is required for GND


Front Side: Component Side (double sided board)




Back Side: GND Side (double sided board)

NOTES:
Real size of the PCB is 60mm×60mm

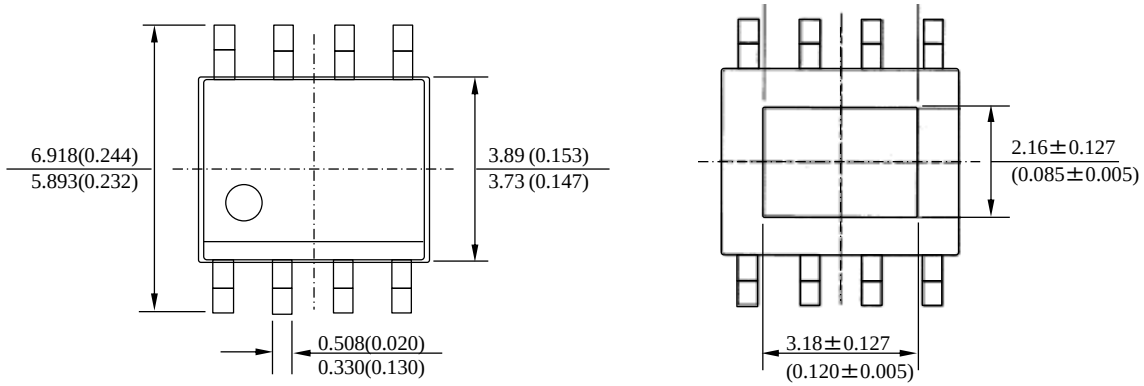



NOTES:
1) Dimension is in millimeters, dimension in bracket is in inches.
2) Drawing is not to scale.

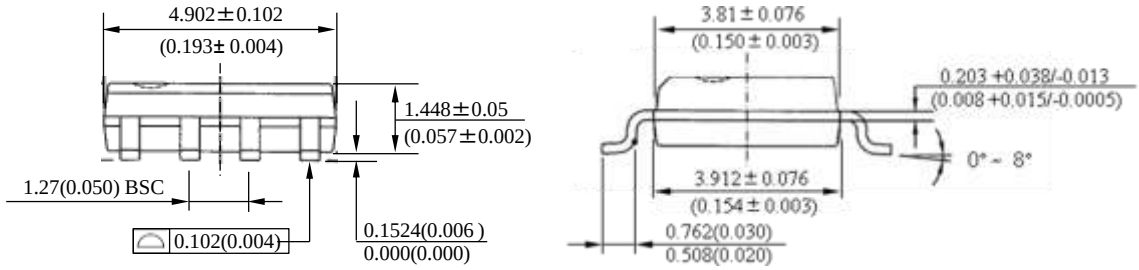
Recommended land pattern

## Package Outline

Exposed SOIC8 package



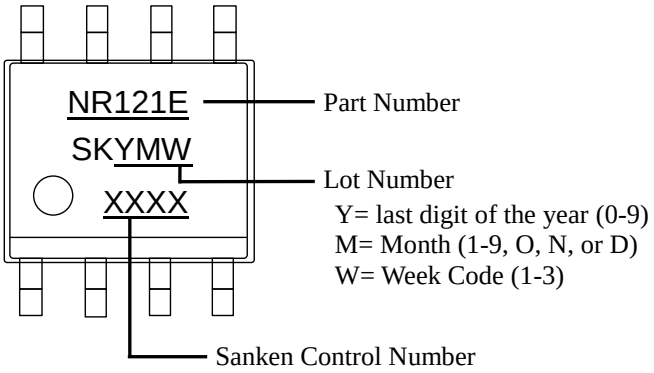

Top view　　Bottom view




Front view　　Side view

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.

## Package Marking



## OPERATING PRECAUTIONS

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

### 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 1MΩof 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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