NR301E
Application Note Rev.1.3

SANKEN ELECTRIC CO., LTD.
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CONTENS

General Descriptions ---------- 3

1. Electrical Characteristics ---------- 4

1.1 Absolute Maximum Ratings ---------- 4

1.2 Recommended Operating Conditions ---------- 4

1.3 Electrical Characteristics ---------- 5

2. Block Diagram & Pin Functions ---------- 6

2.1 Functional Block Diagram ---------- 6

2.2 Pin Assignments & Functions ---------- 6

3. Example Application Circuit ---------- 7

4. Allowable package power dissipation ---------- 8

5. Pattern Design ---------- 8

6. Package Outline ---------- 9

7. Marking of NR301E ---------- 10

8. Operational Descriptions ---------- 11

8.1 Constant vboltage control ---------- 11

8.2 Over current protection ---------- 11

8.2 Thermal protection ---------- 11

9. A precaution in design ---------- 13

9.1 About the selection of the input and output capacitor (C_{IN} and C_{OUT}). --- 13

9.2 About handling of the ADJ-terminal ---------- 13

9.3 About handling of the Vc-terminal ---------- 13

9.4 About reverse bias protection diode ---------- 13

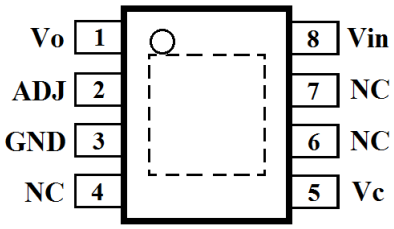
IMPORTANT NOTICE ---------- 14

General Descriptions

NR301E is the low saturation voltage type Io=1.0A linear regulator IC built in the exposed SOIC8 package.
The output voltage Vo is adjustable by the external resistor.
In this IC, start-up and shut-down are possible by the external signal input.
Over-current protection and thermal protection are built in as a protection function.
A low-ESR capacitor like a ceramics capacitor can be used for the output capacitor.

Package

- Package Name：Exposed SOIC 8
- Exposed pad is a radiator on back-side of package.
- Surface mount 8-pin package



Pin Assign

Features & Benefits

- The output voltage is adjustable by the external resistor.
- Start-up and shut-down are possible when a VC terminal is used.(External signal input)
- Ceramics capacitor is possible to use as the output capacitor .
- Protection Functions
  - －Over current protection(OCP)
  - －Thermal protection with temperature hysteresis . (TSD)

Electrical Characteristics

- Input voltage: *Vin*=2.7V to 27V（Recommeded）
- Reference voltage:V_{FB} = 1.0V ±1.5%
- Output current: I_o= 1.0A
- Difference in input and output:V_{DIF} = typ. 0.6V

Applications

- For local regulator circuit
- LCD-TV/STB/DVD/Blu-Ray
- Audio/PC
- USBoutput protection

Series Lineup

Product Name	Vin(max)	Io(max)	Vc(on/off)	V_{DIF}
NR301E	30V	1A	2V/0.6V	0.6V@1A,0.3V@0.5A

1. Electrical Characteristics

- Refer to a product specification sheet for contents of details.
- Based on the IC, each current value is prescribed: polarity"－" is the source current, "+" polarity is the sink current.

1.1 Absolute Maximum Ratings

Table1 Absolute Maximum Ratings（The condition when there is no special mention: Ta=25°C）

Parameter	terminal	Symbol	Ratings	Units	Conditions
DC input voltage	4−8	Vin	30	V	
Vc terminal voltage	4−5	V_C	30	V	Vc≦Vin
ADJ terminal voltage	4−3	V_{ADJ}	5.0	V	
Power Dissipation (1)	—	P_D	1.4	W	Glass-epoxy board mounting in a 30×30mm. (copper area in a 25×25mm)
Thermal Resistance(junction to ambient Air)	—	θj-a	71	°C/W	
Thermal Resistance（junction to Pin No.4）	—	θj-L	26	°C/W	
Junction temperature (2)	—	$T_{J(max)}$	−40～+125	°C	This product builds in an thermal protection circuit. When junction-temperature is more than 135℃,thermal protection often works.
Strage temperature	—	T_{stg}	−40～+125	°C	

(1) Limited by thermal shutdown.
(2) The temperature detection of thermal shutdown is about 155°C (Typical).

1.2 Recommended Operating Conditions

Operating IC in recommended operating conditions is required for normal operating of circuit functions shown in Table 3 Electrical characteristics of NR301E.

Table2 Recommended operating conditions of NR301E.(The condition when there is no special mention: Ta=25°C）

Parameter	terminal	Symbol	Ratings		Units	Conditions
			MIN	MAX		
Input voltage range (1)	4−8	Vin	2.7	27	V	
Output current range (1)	4−8	I_O	0	1.0	A	
Output voltage range	—	V_O	1.1	16	V	Refer to Page7-fig4.
Ambient operating temperature	—	$T_{OP(a)}$	-30	85	°C	
Junction operating temperature	—	$T_{OP(j)}$	-30	100	°C	

(1) Vin and Io are restricted by the use condition because there are relations of PD= (Vin-Vo) ×Io.

1.3 Electrical Characteristics

Electrical characteristics indicate specific limits, which are guaranteed when IC is operated under the measurement conditions shown in the circuit diagram (fig. 1)

Table3 NR301E Electrical Characterristics (The condition when there is no special mention: Vin＝V_O+1V, V_O＝5V(typ)：R1=10kΩ, R2=39k+1k、Ta= 25°C)

Parameter		Symbol	Ratings			Units	Conditions
			MIN	TYP	MAX		
Reference voltage		V_{ADJ}	0.985	1.00	1.015	V	Io=10mA
Line regulation		ΔV_{LINE}	—	25	50	mV	Vin=6~15V, Io=10mA
Load regulation		ΔV_{LOAD}	—	30	60	mV	Io=0～1A
Difference in input and output		ΔV_{DIF}	—	0.3	0.4	V	Io=0.5A
			—	0.6	0.8	V	Io=1A
Supply Current(Non-operating)		Iq	0.5	0.9	1.6	mA	Io=0mA, V_C=2V
Shutdown Supply Current		$Iq_{(OFF)}$	—	0	1	uA	V_C=0V
Output voltage temperature coefficient		ΔVo/ΔTa	—	±0.5	—	mV/°C	Tj=0～100°C
Power supply rejection ratio		R.REJ	—	55	—	dB	Vo=5V, Io=0.1A, f=100～120Hz
Output voltage control terminal voltage *2	Vo :ON	$V_{C(H)}$	2.0	—	—	V	Io=10mA
	Vo:OFF	$V_{C(L)}$	—	—	0.6	V	Io=10mA
Output voltage control terminal current *2	Vo:ON	$V_{C(IH)}$	—	4	40	uA	V_C=2.0V
	Vo:OFF	$V_{C(IL)}$	-2	0	0.1	uA	V_C=0V
Over current protection threshold *3		I_{S1}	1.1	—	—	A	Vin=7V
Thermal shutdown threshold temperature		TSD	135	155	—	°C	—
Thermal shutdown restart hysteresis of temperature		$TSD_{(HYS)}$	—	50	—	°C	—

*2 The internal circuit of the Vc-terminal is high impedance, To avoid a un-stable condition, the Vc-terminal must surely pull-up or pull-down.
Because Vc-terminal input level is equal to the LS-TTL, therefore direct-drive is possible.

*3 Is1 is prescribed that the output voltage Vo descend to -5%.

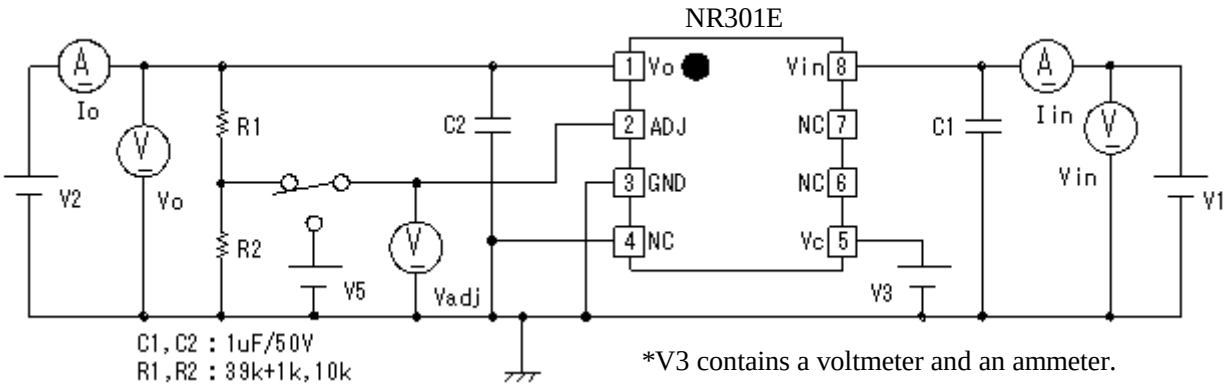


fig.1 NR301E Measurement circuit diagram

2. Block Diagram & Pin Functions

2.1 Functional Block Diagram

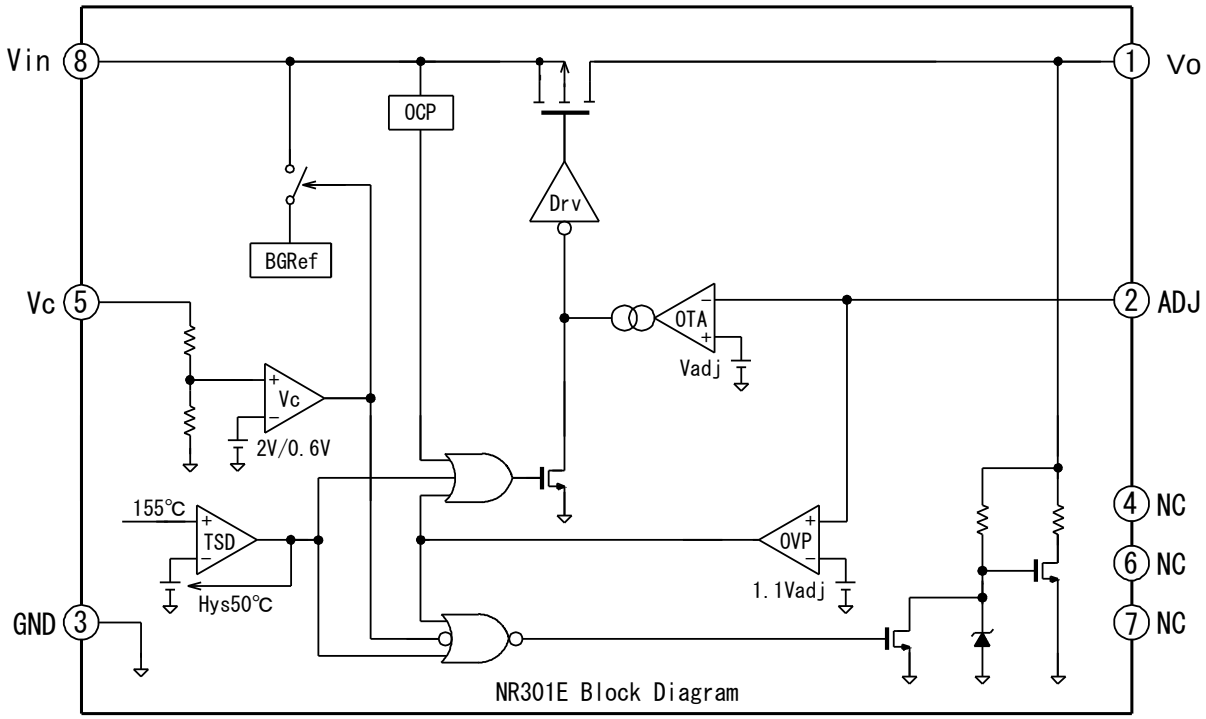


Fig.2 NR301E Function Block Diagram

2.2 Pin Assignments & Functions

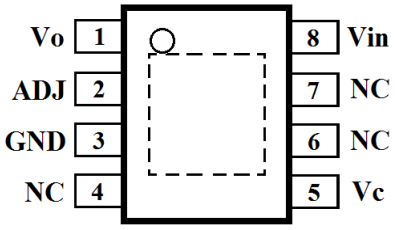


fig.3 NR301E Pin assignments

Table4 NR301E Pin assign & function

Pin No.	Symbol	Description
1	V_O	Output voltage
2	ADJ	Output voltage adjustment
3	GND	Ground
4	NC	No connection
5	V_C	Output ON/OFF control
6	NC	No connection
7	NC	No connection
8	Vin	Input voltage
Back side	FIN	Sub- straight (Ground) *Exposed thermal pad

3. Example Application Circuit

- **Input capacitor C1 & output capacitor C2**
  For stable movement,You must connect a capacitor C1 in the shortest distance between Vin-terminal and GND-terminal. In the same way, Connect a capacitor C2 between Vo-terminal and GND-terminal. Do decoupling with a low ESR capacitor such as a ceramics capacitor. A capacitor has the dispersion of the capacitance and has a temperature character. Especially, as for the ceramics capacitor , Capacity decreases by the input voltage. Especially, as for the ceramics capacitor , In that character, Capacitance decreases by the input voltage value. Please select the capacitor which has good DC-bias character,and use it on the condition of enough voltage margin.

- **About the heat-radiation design.**
  NR301E adopts an exposed SOIC 8 package because of the heat-radiation effect improvement. Because heat-slag on the back side of the IC becomes radiator, soldering with copper foil pattern of PCB becomes a premise. Refer to the temperature derating curve of page10 for the details.

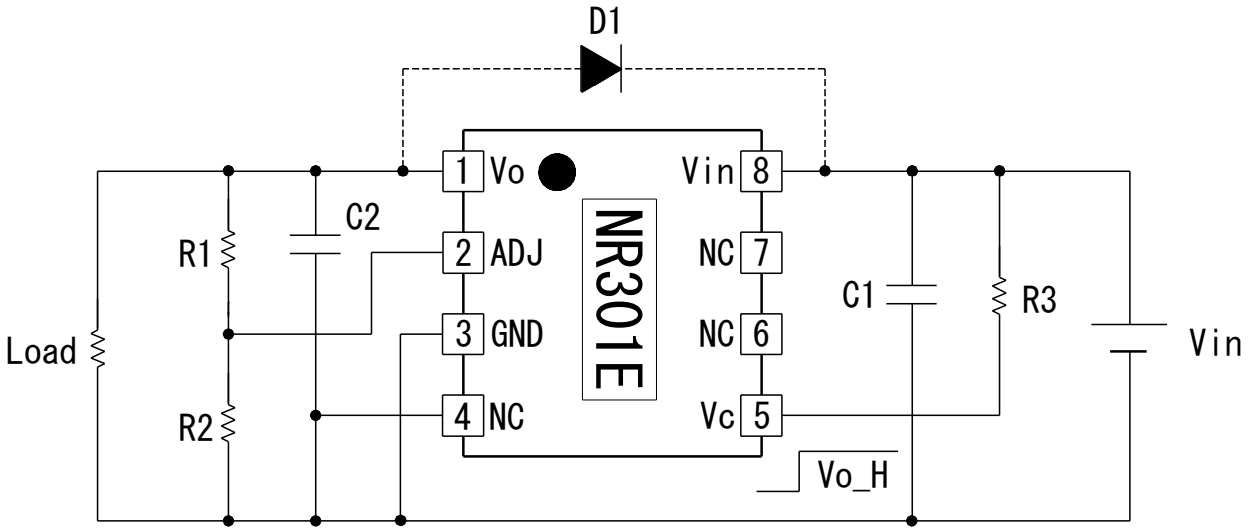


fig.4 NR301E example application circuit

In case of the Vo=5V and Vin=6V.

C1、C2 : 1uF/16V

R1、R2 : It is controlled so that ADJ-GND voltage may be 1V (typ).
R1 : 39k+1k(A resistor for the fine tuning),
R2 : 10k

R3 : About handling of the Vc terminal function .
case1) If you don't use Vc function (Vo normally ON), Vc must connect to Vin directly with R3= 0Ω.
case2) If you use Vc function (Vo ON/OFF) by TTL-Logic signal, R3 is unnecessary. Input a TTL-Logic signal to Vc directly.
case3) If you use Vc function (Vo ON/OFF) by the condition of open-collector or open-drain, You must connect pull-up resistor R3 between Vin and Vc.
* How to calculate R3 in case3
In the condition of $Vc > V_{C(H)}$, the output turns on. And, calculate R3 in accordance with the following equation because internal-impedance between Vc and GND is R_{VC}=50kΩ (Min).

$$R3 < R_{VC} \times (V_{IN} - V_{C(H)}) / V_{C(H)}$$

And, $V_{C(H)}$ =2V (Min). When the V_{IN} is supposed to be 12V , it become the relations of "R3<250kΩ" by "R3<50kΩ× (12V-2V) /2V". $V_{C(IH)}$, the maximum sink current of the Vc terminal is 40μA. In the condition of Vc=2V, the current which can be supplied from R3 is should be larger than "40μA". Therefore, if the R3 is 200kΩ, it becomes 50μA by "$V_{C(IH)}$=(12V－2V)／200kΩ".

D1 : Diode for the reverse bias protection. When relations between the input voltage and the output voltage are reversed (Vin<Vo),this diode is necessary.

4. Allowable package power dissipation

Temperature derating curve

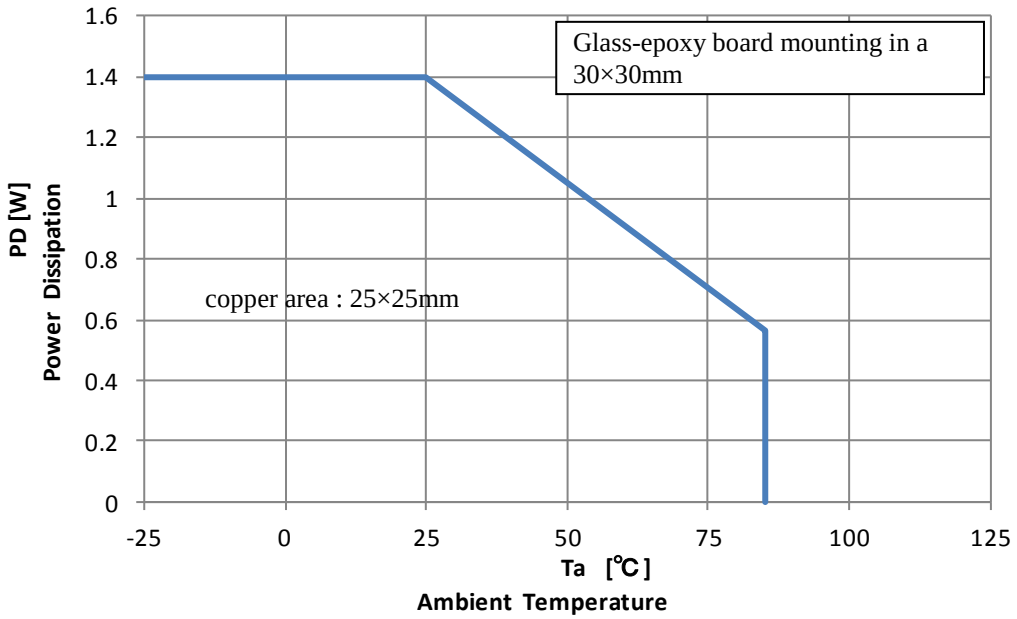
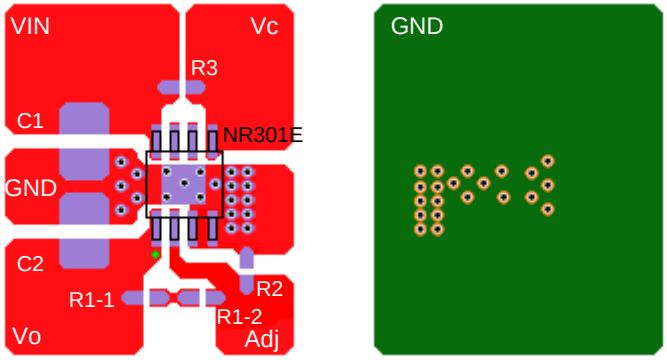


fig.5 NR301E temperature derating curve

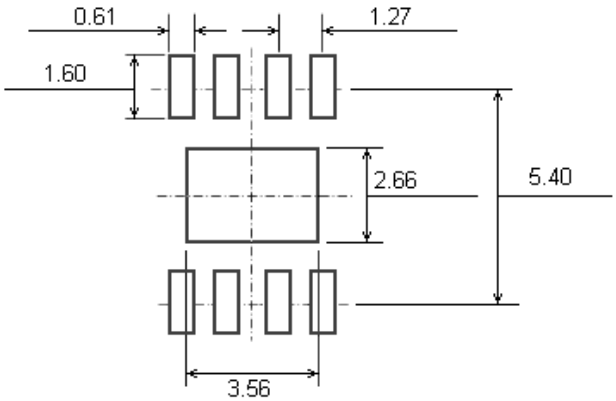
Note:
The power dissipation is calculated at the junction temperature 125 °C

5. Pattern Design



Note:
Size of the PCB is about
28mm×40mm t=1.6mm
(double sided board, copper foil thickness=35 μ m)

fig.6 Recommended pattern layout



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

fig.7 Recommended land pattern

6. Package Outline

- eSOIC 8 package

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

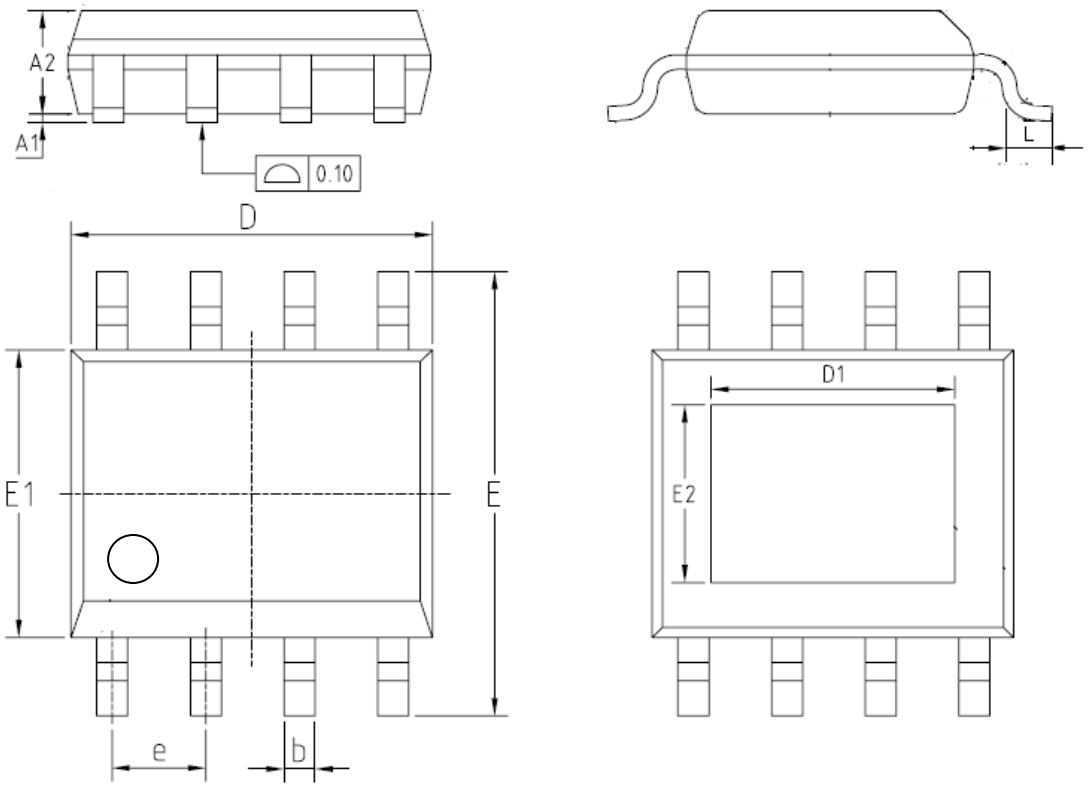


fig.8 Package outline

Outside size table.

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

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

7.Marking of NR301E

Laser marking, specifications are based on the following.

*1. Product number

*2. Lot number (three digit)

1st letter : The last digit of the year
2nd letter : Month
January to September : 1 to 9
October : O
November : N
December : D
3rd letter : manufacturing week
First week to 5th week : 1 to 5

*3. Control number (four digit)

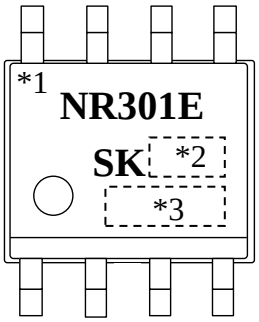


fig.9 marking specification

8. Operational Descriptions

The characteristic numerical value of the case without special mention writes typ value according to the specifications of NR311E. Based on the IC, each current value prescribes...

"Positive : +"= sink current.

"Negative : －"= source current.

8.1 Constant vboltage control

A regulator IC is composed of the reference voltage, the error amplifier, the series pass element, and so on. A series pass element is Linear-controlled by the error amplifier, the internal reference voltage correspond to the ADJ terminal voltage. NR301E does stabilize the output voltage by controlling the source-drain voltage of PchMOSFET which becomes a series pass element. Therefore, enough radiation design is necessary because the multiplication of the source-drain voltage and output current becomes internal loss.

And, the output-voltage is prescribed these items, the load-regulation, the line-regulation, the temperature coefficient.

8.2 Over current protection

NR301E builds in the over-current protection of Fold-back type.

Is1: The current when Over-current protection is started.

Is2: The current when the load is short-circuited .

Is2<<Is1 ⋯refer to fig.10.

By this characteristic, as for the loss of the IC under the condition when the load is short-circuited, (VIN×Io)loss becomes smaller than the constant-current type over-current protection.

When an IC starts, and when the voltage of the output capacitor is 0V, the output voltage rises from the over-electric current protection condition.

Fold-back type over-current protection is suitable for the constant-resistance load and high-impedance load. Therefore, be careful in case of the load type and the circuit composition (1)-(4), because the output voltage can't rise up normally.

(1) Constant-current load.
(2) Positive & negative dual output power supply.
(3) Constant-voltage & constant-current power supply Composition.
(4) A change of the GND-terminal voltage for the output voltage adjustment.

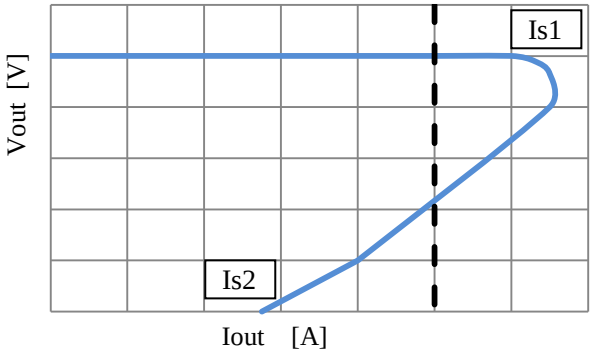


fig.10 Fold-back OCP characteristic

8.3 Thermal protection

NR301E builds in an thermal protection circuit with temperature hysteresis. When junction-temperature inside of the IC gets over at 155℃(typ), then the IC is shut down by turning off the output transistor. The thermal protection function has temperature hysteresis of about 50℃. After the IC shut down, the IC restarts when the junction-temperature descends at about 100℃.

And, because there is dispersion in the thermal protection circuit and the lower limit of protection start temperature is 135℃, the heat radiation design which doesn't usually begin thermal protection under the normal operation is necessary. Even a maximum condition, you must do the heat radiation design which goes into the one within Tj< 125℃.

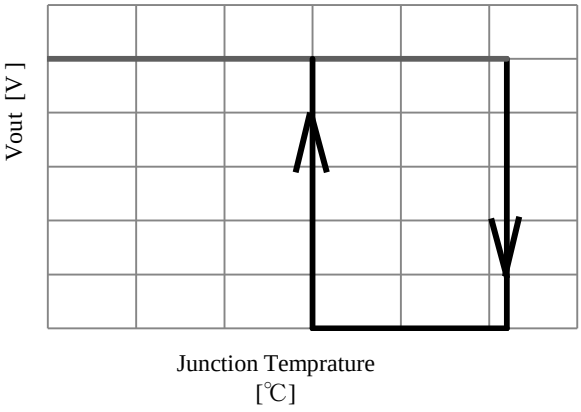


fig.11 Examlpe characteristic of thermal protection circuit

*precaution

So that an IC may avoid suffering big damage due to a fever which occurs when load is short-circuited in the moment, the thermal protection is a purpose to protect an IC from thermal runaway.

In the condition that is long imprudence and a continuous fever , a movement including that reliability isn't assured.

9. A precaution in design

9.1 About the selection of the input and output capacitor (CIN and COUT).

Power supply impedance is raised when long wiring from the input capacitor CIN to the input-terminal Vin of the IC. To plan the stable movement of the IC, it is recommended connecting an input capacitor CIN to the input-terminal Vin in shortest distance. Select the capacitor whose equivalent serial resistance (ESR) is low, because impedance of the capacitor must be lowered fully, too. For the confirmation of the movement stability, evaluation and examination are necessary with an actual circuit board. As a recommendation value of CIN, capacitance becomes the ceramics capacitor beyond 1uF or the electrolytic capacitor of about 22uF.

The internal phase compensation is influenced by the capacitance of the output capacitor Cout. Because of that, more than recommendation capacitance value (with a ceramics capacitor and so on, beyond 1uF) is necessary for Cout. You must use the good kind of the DC bias character in low ESR, and connect it in the shortest distance of the IC output terminal Vo. And, in case of the capacitor whose temperature character of ESR isn't good, though it becomes stable movement in the room-temperature, a unusual oscillation may occur at a low-temperature. Because of this, we can't recommend that use of an electrolytic capacitor only.

9.2 About handling of the ADJ-terminal

An ADJ terminal is the feedback signal input terminal to control the output voltage. R1 and R2 are connected between the output voltage terminal Vo and the GND terminal, and output voltage is set up. Though the current of R1 and R2 is feedback-current. Set up a feedback-current that becomes about 100 μ A. The ADJ terminal voltage of NR301E is 1.00V (typ). 1V/100 μ A=10kΩ becomes recommendation value of R2. As for the output voltage Vo, Calculate R1 by the next equation under the condition of R2=10kΩ and VADJ=1.00V (typ).

$$Vo = \frac{R1 + R2}{R2} Vadj \quad R1 = \frac{Vo - Vadj}{Vadj} R2$$

(Calculation example)

In case of a setup of Vo=5V : R1=10kΩ×(5V-1V)/1V=40kΩ ・・・If 40kΩ is used as R1, Vo becomes 5V.
When there is no result of a calculation of R1 in the Exx series, Divide resistance into two like 39kΩ + 1kΩ (for the fine tuning), and adjust resistance value.

And, a absolute maximum rating of ADJ-terminal is 5.5V. When the IC usually works, 1.00V (typ) is being inputted by the resistor divider of R1 and R2. Don't input voltage forcibly under such condition from the outside. If there is a condition which gets over a absolute maximum rating, Clamp the ADJ terminal voltage in less than 5.5V by use of zenner-diode.

9.3 About handling of the Vc-terminal

Pin-No.5 is an output control function in the NR301E
As a condition of Vc-terminal input voltage,
Vc＞2V : RUN (The IC is started.)
Vc＜0.6V : STOP(The IC is stopped.)
Because of the reduction of consumption-current, a Vc-terminal is being done PULL-DOWN by the high impedance.
Therefore a Vc-terminal must be terminated.
A connection is directly possible because withstand-voltage of the Vc-terminal is the same as the Vin terminal.
*Refer to CASE1-3 in the page 7 for the details.

9.4 About reverse bias protection diode

As for the NR301E, because a series pass transistor is Pch-MOSFET. Therefore the parasitic diode exists between Vo and Vin. When the IC usually works, it is the condition of Vin>Vo.When the input power supply voltage is lowered rapidly, it becomes the condition of Vin<Vo.

In such case, the surge-current flow to the parasitic diode. This product are not the specifications which parasitic diode is used for actively. When there is a reverse bias condition, Connect protection diode to between Vo and Vin. （Refer to fig.4-Page7:D1）.

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