

## 2A Bus Termination Regulator

### General Description

The RT9173B regulator is designed to convert voltage supplies ranging from 1.7V to 6V into a desired output voltage of which adjusted by two external voltage divider resistors. The regulator is capable of sourcing or sinking up to 2A of current while regulating an output voltage to within 40mV.

The RT9173B, used in conjunction with series termination resistors, provides an excellent voltage source for active termination schemes of high speed transmission lines as those seen in high speed memory buses and distributed backplane designs. The voltage output of the regulator can be used as a termination voltage for DDR SDRAM.

Current limits in both sourcing and sinking mode, plus on-chip thermal shutdown make the circuit tolerant of the output fault conditions.

The RT9173B are available in the popular 5-lead TO-252 and fused SOP-8 (the multiple  $V_{CNTL}$  pins on the SOP-8 package are internally connected but lowest thermal resistance) surface mount packages.

### Ordering Information

RT9173B □□

- Package Type
  - S : SOP-8
  - L5 : TO-252-5
- Lead Plating System
  - P : Pb Free
  - G : Green (Halogen Free and Pb Free)

Note :

Richtek products are :

- ▶ RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- ▶ Suitable for use in SnPb or Pb-free soldering processes.

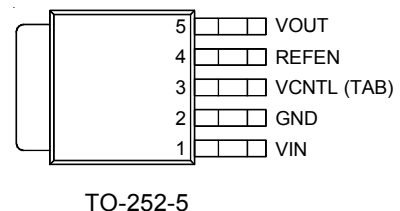
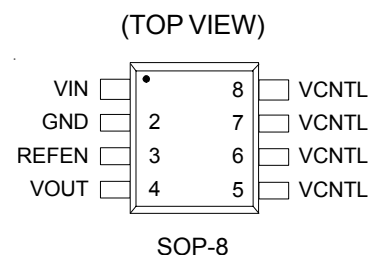
### Features

- Support Both DDR I (1.25V<sub>TT</sub>) and DDR II (0.9V<sub>TT</sub>) Requirements
- SOP-8 and TO-252-5 Packages
- Capable of Sourcing and Sinking Current
- Current-limiting Protection
- Thermal Protection
- Integrated Power MOSFETs
- Generates Termination Voltages for SSTL-2
- High Accuracy Output Voltage at Full-Load
- Adjustable V<sub>OUT</sub> by External Resistors
- Minimum External Components
- Shutdown for Standby or Suspend Mode Operation with High-impedance Output
- RoHS Compliant and 100% Lead (Pb)-Free

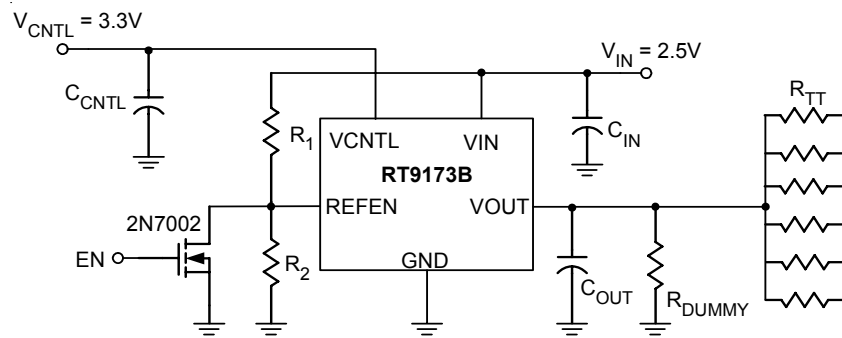
### Applications

- DDR Memory Termination Supply
- Active Termination Buses
- Desktop PC/AGP Graphics
- Set Top Box/IPC
- Supply Splitter

### Pin Configurations



Typical Application Circuit



$R_1 = R_2 = 100k\Omega$ ,  $R_{TT} = 50\Omega / 33\Omega / 25\Omega$

$C_{OUT(MIN)} = 10\mu F$  (Ceramic) +  $1000\mu F$  under the worst case testing condition

$R_{DUMMY} = 1k\Omega$  as for VOUT discharge when VIN is not present but VCNTL is present

$C_{IN} = 470\mu F$  (Low ESR),  $C_{CNTL} = 47\mu F$

Test Circuit

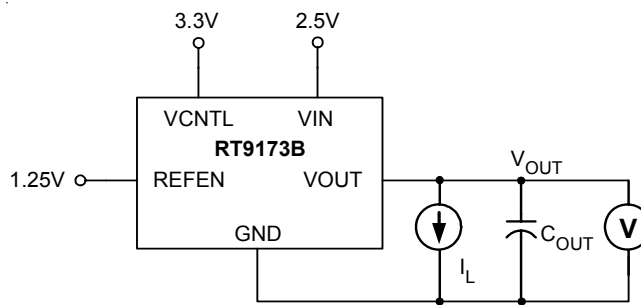


Figure 1. Output Voltage Tolerance,  $\Delta V_{OUT}$

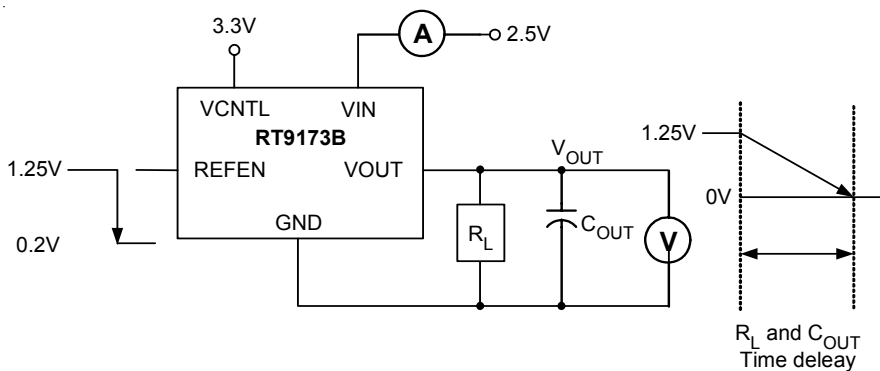


Figure 2. Current in Shutdown Mode,  $I_{SHDN}$

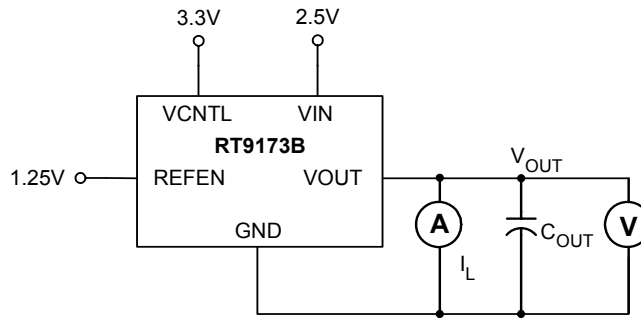


Figure 3. Current Limit for High Side,  $I_{CLHIGH}$

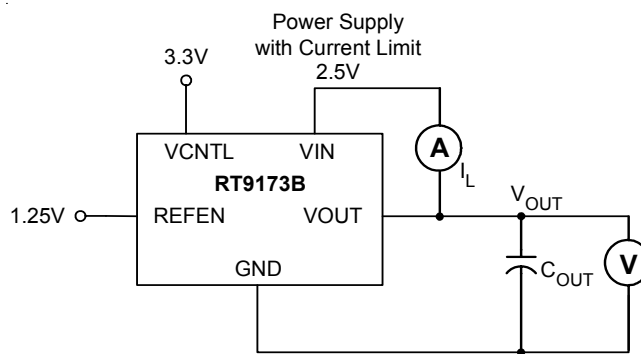


Figure 4. Current Limit for Low Side,  $I_{CLLOW}$

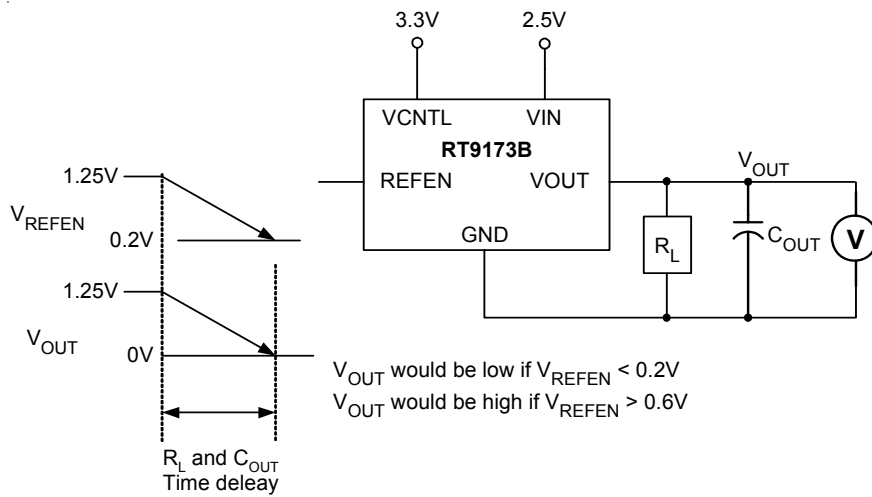
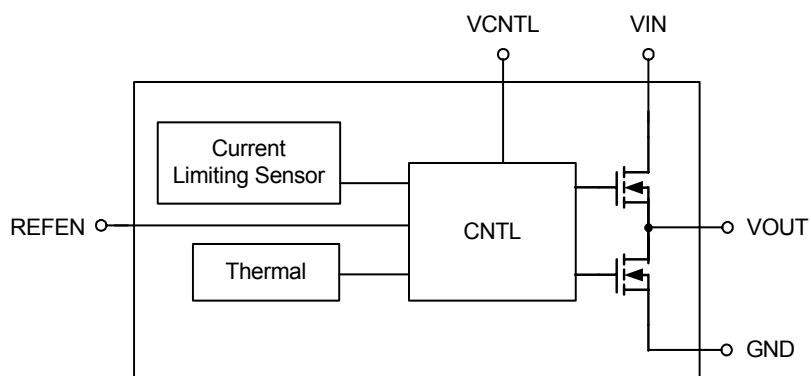


Figure 5. REFEN Pin Shutdown Threshold,  $V_{TRIGGER}$

## Functional Pin Description

| Pin Name | Pin Function                            |
|----------|-----------------------------------------|
| VIN      | Power Input                             |
| GND      | Ground                                  |
| VCNTL    | Gate Drive Voltage                      |
| REFEN    | Reference Voltage Input and Chip Enable |
| VOUT     | Output Voltage                          |

## Function Block Diagram



**Absolute Maximum Ratings** (Note 1)

- Input Voltage ----- 7V
- Power Dissipation,  $P_D$  @  $T_A = 25^\circ\text{C}$ 
  - SOP-8 ----- 0.625W
  - TO-252 ----- 1.471W
- Package Thermal Resistance (Note 2)
  - SOP-8,  $\theta_{JA}$  -----  $160^\circ\text{C/W}$
  - SOP-8,  $\theta_{JC}$  -----  $23^\circ\text{C/W}$
  - TO-252,  $\theta_{JA}$  -----  $68^\circ\text{C/W}$
  - TO-252,  $\theta_{JC}$  -----  $8^\circ\text{C/W}$
- Lead Temperature (Soldering, 10 sec.) -----  $260^\circ\text{C}$
- Junction Temperature -----  $150^\circ\text{C}$
- Storage Temperature Range -----  $-65^\circ\text{C}$  to  $150^\circ\text{C}$
- ESD Susceptibility (Note 3)
  - HBM (Human Body Mode) ----- 2kV
  - MM (Machine Mode) ----- 200V

**Recommended Operating Conditions** (Note 4)

- Junction Temperature Range -----  $-40^\circ\text{C}$  to  $125^\circ\text{C}$

**Electrical Characteristics**

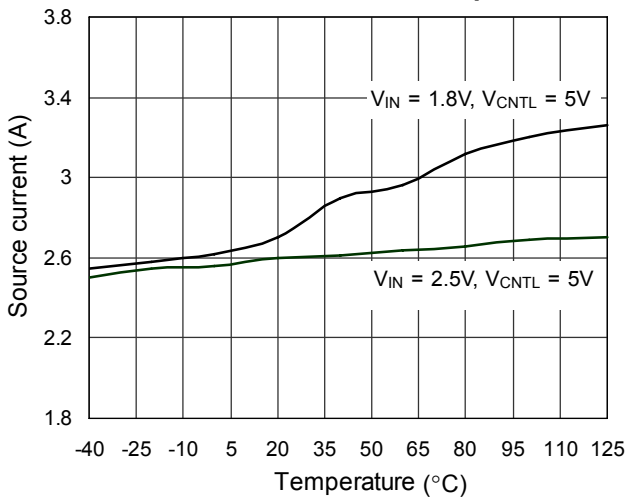
( $V_{IN} = 2.5\text{V}$ ,  $V_{CNTL} = 3.3\text{V}$ ,  $V_{REFEN} = 1.25\text{V}$ ,  $C_{OUT} = 10\mu\text{F}$  (Ceramic),  $T_A = 25^\circ\text{C}$  unless otherwise specified)

| Parameter                          | Symbol            | Test Conditions                                                           | Min | Typ     | Max | Unit             |
|------------------------------------|-------------------|---------------------------------------------------------------------------|-----|---------|-----|------------------|
| Output Offset Voltage              | $V_{OS}$          | $I_{OUT} = 0\text{A}$ , Figure 1 (Note 5)                                 | -20 | 0       | 20  | mV               |
| Load Regulation                    | $\Delta V_{LOAD}$ | $I_L : 0\text{A} \rightarrow 2\text{A}$ , Figure 1                        | -20 | 0       | 20  | mV               |
|                                    |                   | $I_L : 0\text{A} \rightarrow -2\text{A}$                                  |     |         |     |                  |
| Input Voltage Range (DDR I/II)     | $V_{IN}$          | Keep $V_{CNTL} \geq V_{IN}$ on operation power on and power off sequences | 1.7 | 2.5/1.8 | --  | V                |
|                                    | $V_{CNTL}$        |                                                                           | 3   | 3.3/5   | 6   |                  |
| Operating Current of $V_{CNTL}$    | $I_{CNTL}$        | No Load                                                                   | --  | 1       | 2.5 | mA               |
| Current In Shutdown Mode           | $I_{SHDN}$        | $V_{REFEN} < 0.2\text{V}$ , $R_L = 180\Omega$ , Figure 2                  | --  | 50      | 90  | $\mu\text{A}$    |
| <b>Short Circuit Protection</b>    |                   |                                                                           |     |         |     |                  |
| Current limit                      | $I_{LIM}$         | Figure 3,4                                                                | 2.2 | 2.6     | --  | A                |
| <b>Over Temperature Protection</b> |                   |                                                                           |     |         |     |                  |
| Thermal Shutdown Temperature       | $T_{SD}$          | $3.3\text{V} \leq V_{CNTL} \leq 5\text{V}$                                | 125 | 170     | --  | $^\circ\text{C}$ |
| Thermal Shutdown Hysteresis        | $\Delta T_{SD}$   | $3.3\text{V} \leq V_{CNTL} \leq 5\text{V}$                                | --  | 35      | --  | $^\circ\text{C}$ |
| <b>Shutdown Function</b>           |                   |                                                                           |     |         |     |                  |
| Shutdown Threshold Trigger         |                   | Output = High, Figure 5                                                   | 0.6 | --      | --  | V                |
|                                    |                   | Output = Low, Figure 5                                                    | --  | --      | 0.2 |                  |

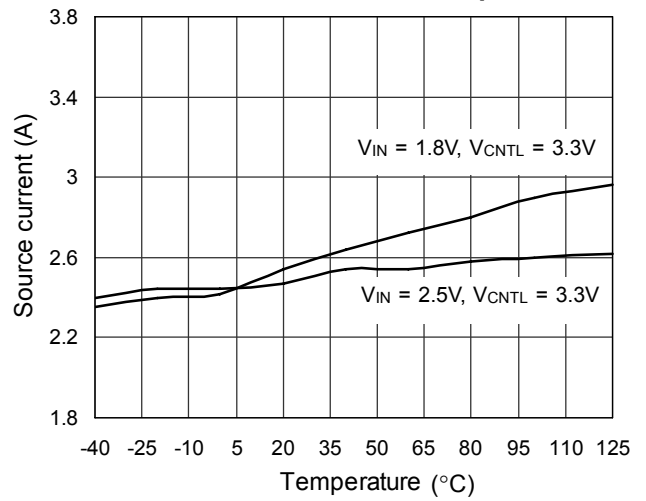
- Note 1.** Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
- Note 2.**  $\theta_{JA}$  is measured in the natural convection at  $T_A = 25^\circ\text{C}$  on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard. The case point of  $\theta_{JC}$  is on the center of  $V_{CTRL}$  pins (Lead 6 & 7) for SOP-8 packages.
- Note 3.** Devices are ESD sensitive. Handling precaution recommended. The human body model is a 100pF capacitor discharged through a 1.5k $\Omega$  resistor into each pin.
- Note 4.** The device is not guaranteed to function outside its operating conditions.
- Note 5.**  $V_{OS}$  offset is the voltage measurement defined as  $V_{OUT}$  subtracted from  $V_{REFEN}$ .

**Typical Operating Characteristics**

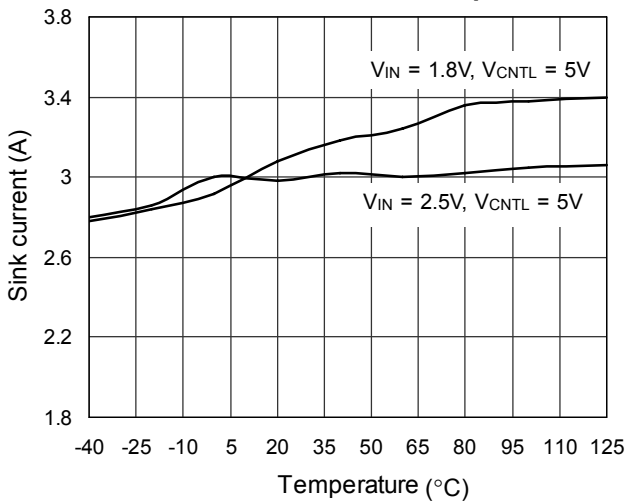
**Source Current Limit vs. Temperature**



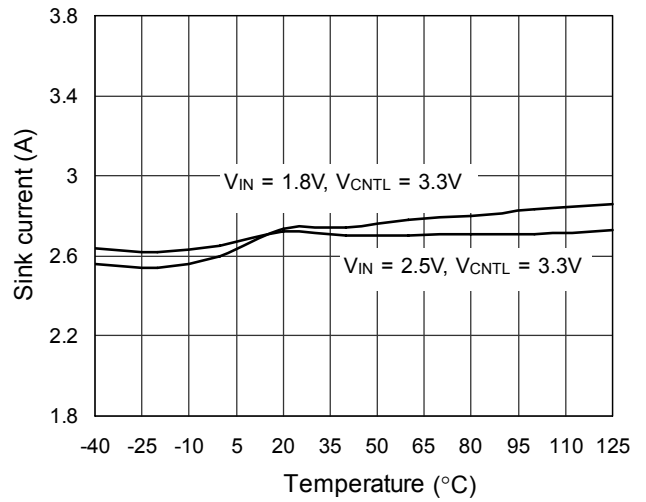
**Source Current Limit vs. Temperature**



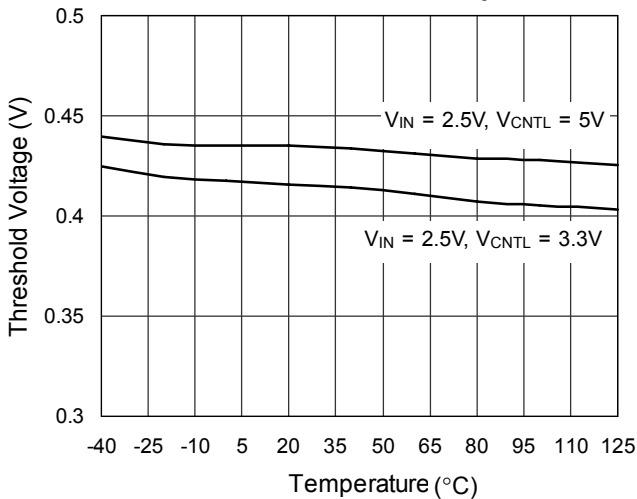
**Sink Current Limit vs. Temperature**



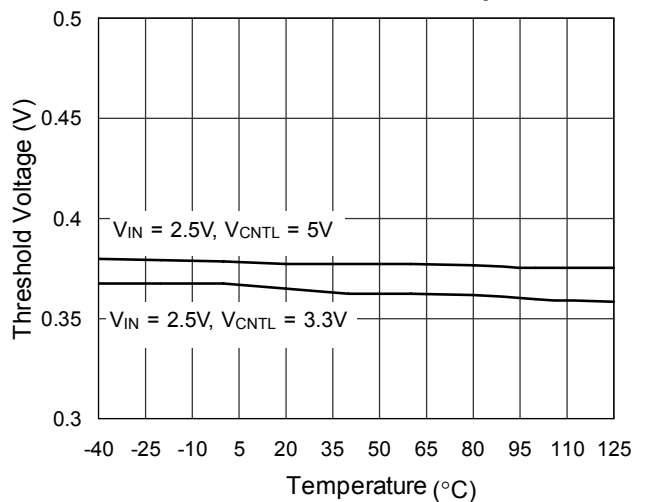
**Sink Current Limit vs. Temperature**



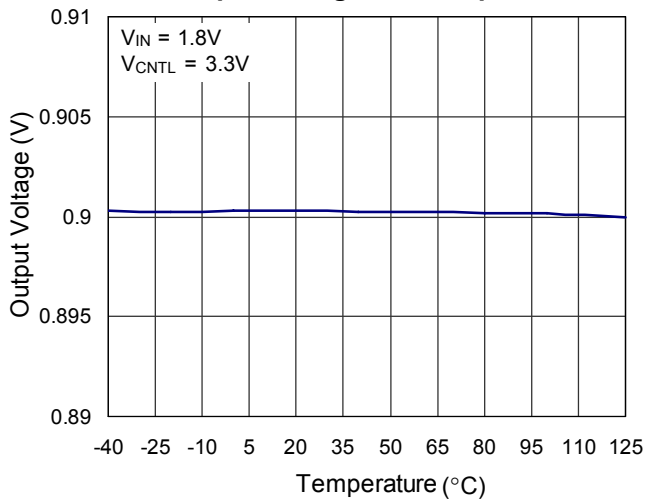
**Turn-On Threshold vs. Temperature**



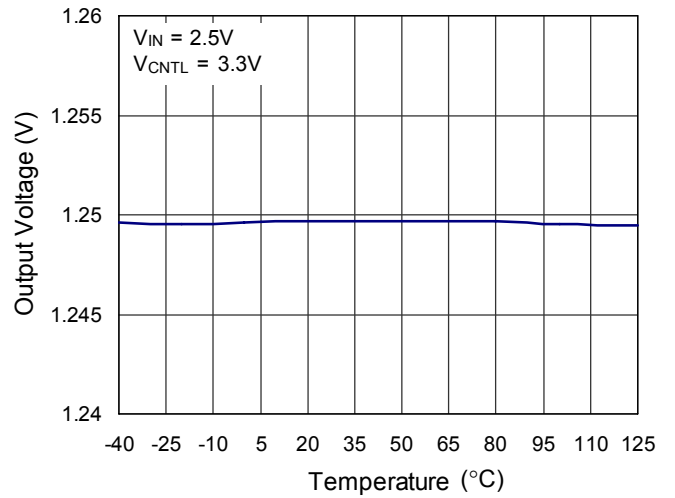
**Turn-Off Threshold vs. Temperature**



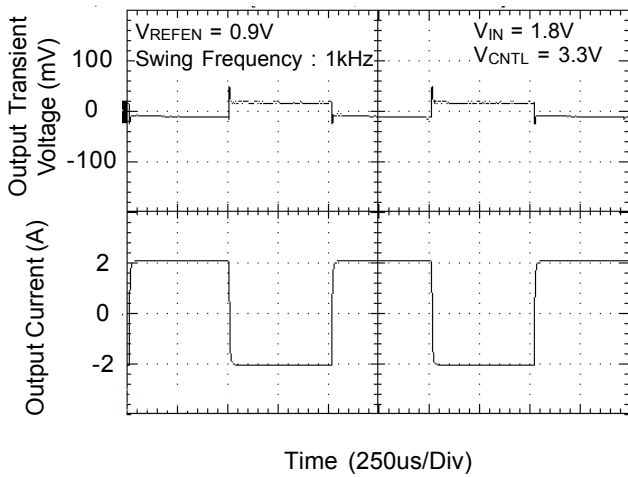
Output Voltage vs. Temperature



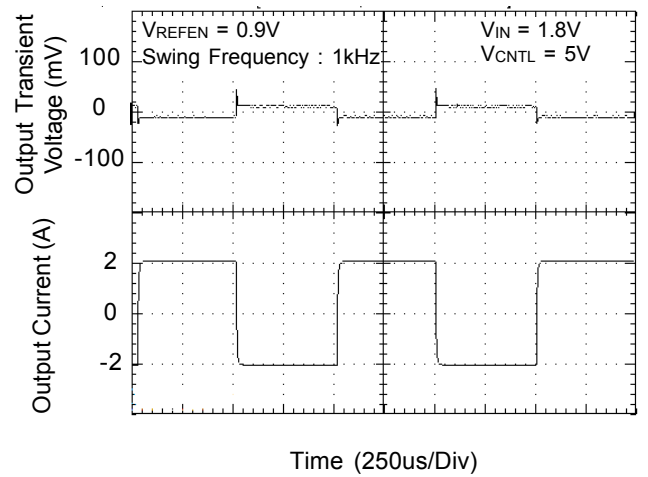
Output Voltage vs. Temperature



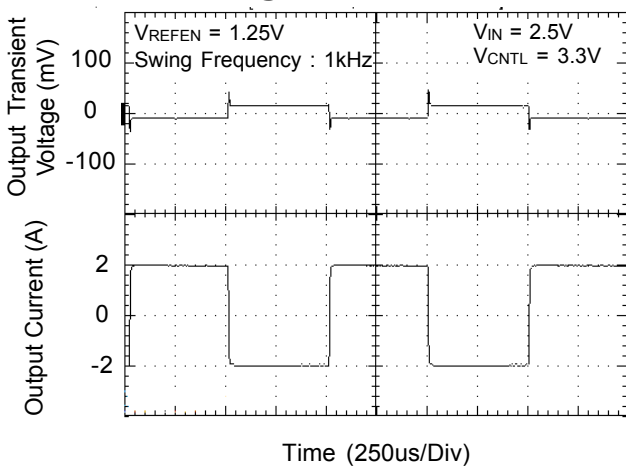
0.9V<sub>TT</sub> @ 2A Transient Response



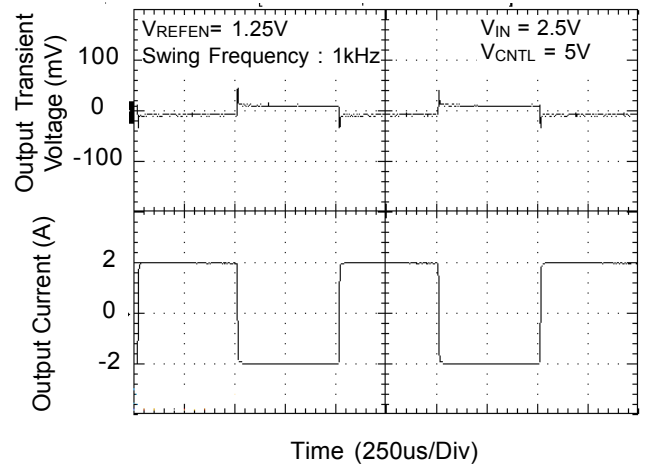
0.9V<sub>TT</sub> @ 2A Transient Response



1.25V<sub>TT</sub> @ 2A Transient Response

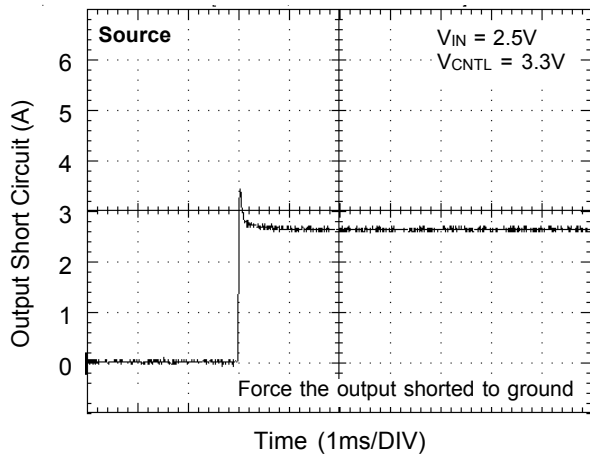


1.25V<sub>TT</sub> @ 2A Transient Response

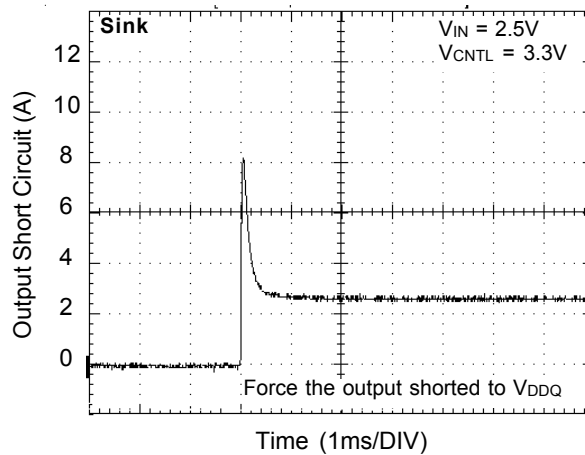




Output Short-Circuit Protection



Output Short-Circuit Protection



## Application Information

### Internal parasitic diode

Avoid forward-bias internal parasitic diode,  $V_{OUT}$  to  $V_{CNTL}$ , and  $V_{OUT}$  to  $V_{IN}$ , the  $V_{OUT}$  should not be forced some voltage respect to ground on this pin while the  $V_{CNTL}$  or  $V_{IN}$  is disappeared.

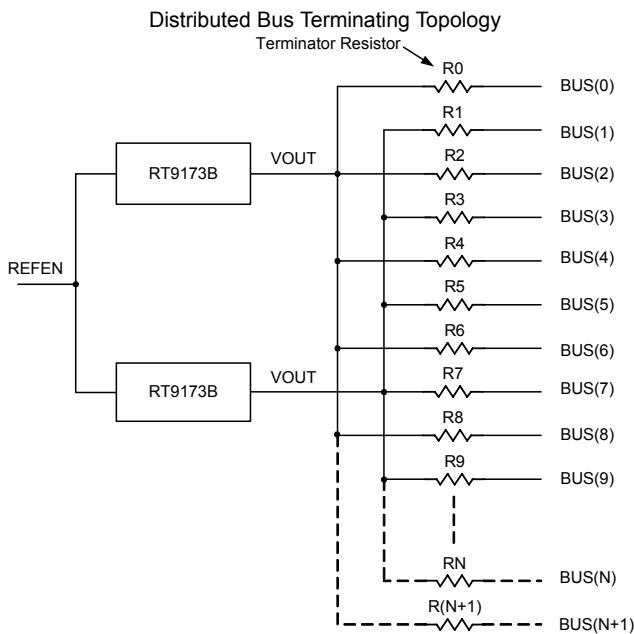
### Consideration while designs the resistance of voltage divider

Make sure the sinking current capability of pull-down NMOS if the lower resistance was chosen so that the voltage on  $V_{REFEN}$  is below 0.2V.

In addition, the capacitor and voltage divider form the low-pass filter. There are two reasons doing this design; one is for output voltage soft-start while another is for noise immunity.

### How to reduce power dissipation on Notebook PC or the dual channel DDR SDRAM application?

In notebook application, using RichTek's Patent "Distributed Bus Terminator Topology" with choosing RichTek's product is encouraged.



### General Regulator

The RT9173B could also serves as a general linear regulator. The RT9173B accepts an external reference voltage at REFEN pin and provides output voltage regulated to this reference voltage as shown in Figure 6, where

$$V_{OUT} = V_{REF} \times R1 / (R1 + R2)$$

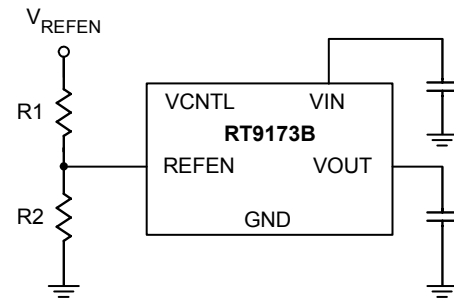
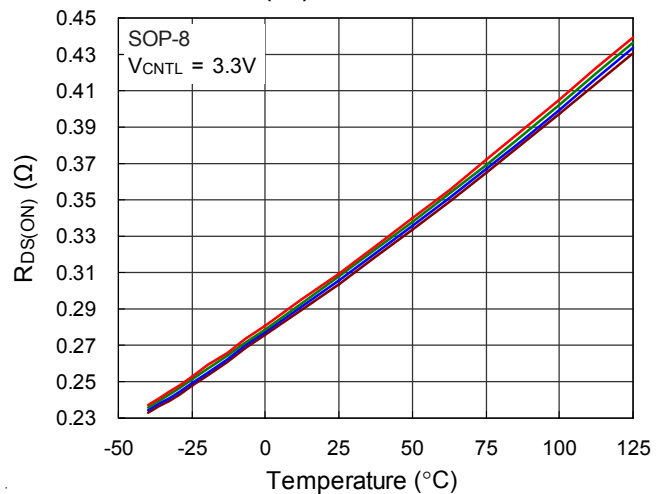


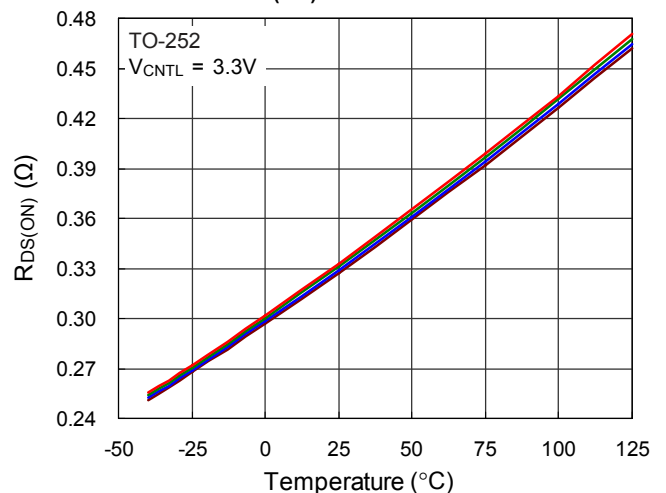
Figure 6

Make sure that  $V_{CNTL} \geq V_{IN}$  in all conditions including power on and off. As other linear regulator, dropout voltage and thermal issue should be specially considered. Figure 6 and 7 show the  $R_{DS(ON)}$  over temperature of RT9173B in SOP-8 and TO-252 packages respectively. The minimum dropout voltage could be obtained by the product of  $R_{DS(ON)}$  and output current. For thermal consideration, please refer to the relative sections.

### $R_{DS(ON)}$ vs. Temperature



### $R_{DS(ON)}$ vs. Temperature



**Input Capacitor and Layout Consideration**

Place the input bypass capacitor as close as possible to the RT9173B. A low ESR capacitor larger than 470uF is recommended for the input capacitor. Use short and wide traces to minimize parasitic resistance and inductance. Inappropriate layout may result in large parasitic inductance and cause undesired oscillation between RT9173B and the preceding power converter.

**Thermal Consideration**

An internal thermal limiting circuitry shuts down the RT9173B when junction temperature is over 170°C. This protects the device during overload conditions. It is noted that the thermal limiting circuitry is not intended for normal operation. For maximum reliability, the junction temperature should not exceed absolute maximum operation temperature 125°C during normal operation. The power dissipation should be well considered to keep the junction temperature within the specification.

The power dissipation in RT9173B is calculated as:

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} + V_{IN} \times I_Q$$

The maximum power dissipation can be calculated by following formula:

$$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$$

Where  $T_{J(MAX)}$  is the maximum operation junction temperature 125°C,  $T_A$  is the ambient temperature and the  $\theta_{JA}$  is the junction to ambient thermal resistance.

The junction to ambient thermal resistance  $\theta_{JA}$  highly depends on IC package, PCB layout, the rate of surroundings airflow.  $\theta_{JA}$  for SOP-8 package is 160°C/W and TO-252 package is 68°C/W on standard JEDEC 51-3 (single layer, 1S) thermal test board. The maximum power dissipation at  $T_A = 25^\circ\text{C}$  can be calculated by following formula:

$$P_{D(MAX)} = (125 - 25^\circ\text{C}) / 160 = 0.625\text{W (SOP-8)}$$

$$P_{D(MAX)} = (125 - 25^\circ\text{C}) / 68 = 1.471\text{W (TO-252)}$$

Since the multiple VCTRL pins of the SOP-8 package are internally shorted and connected to lead frame, it is efficient to dissipate the heat by adding copper area on VCTRL footprint. Figure 7 shows the relation about thermal resistance  $\theta_{JA}$  vs. copper area on a standard JEDEC 51-7 (4 layer, 2S2P) thermal test board at  $T_A = 25^\circ\text{C}$ . The corresponding maximum power dissipation is shown in Figure 8. For example, with 10mm x 10mm copper area, we can obtain the lower thermal resistance about 45°C/W. The power maximum dissipation can be calculated as:

$$P_{D(MAX)} = (125 - 25^\circ\text{C}) / 45 = 2.22\text{W (SOP-8)}$$

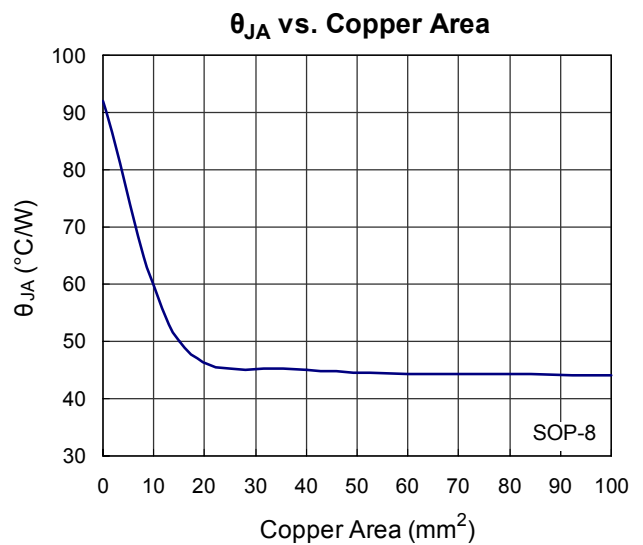


Figure 7

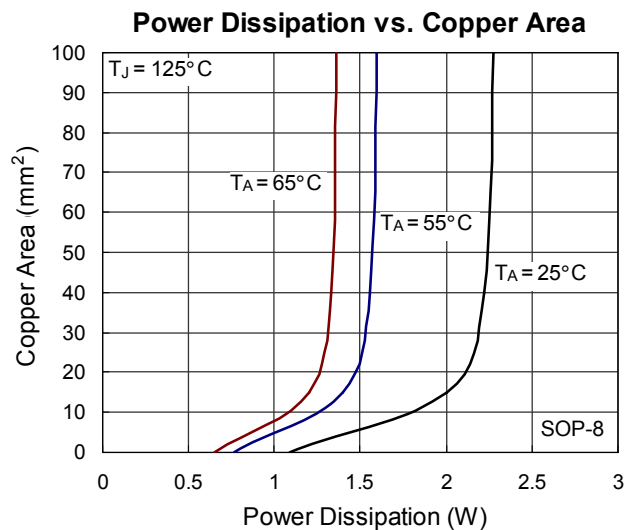
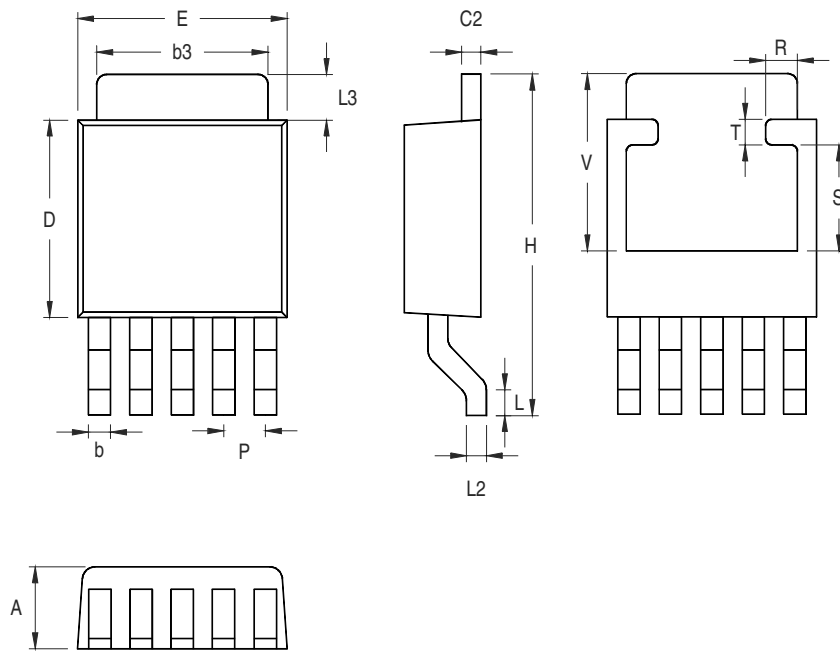


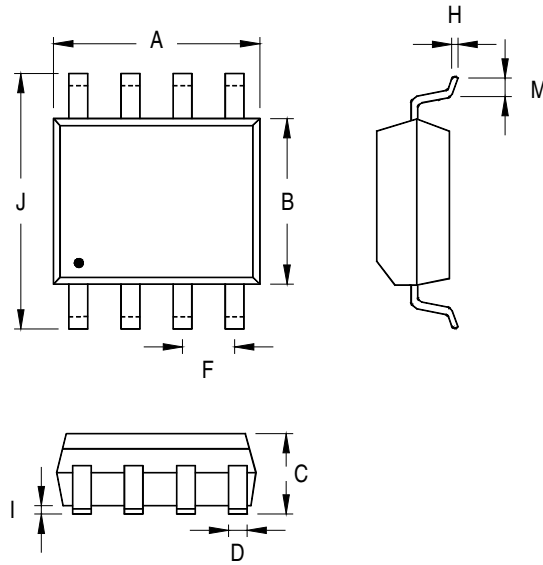
Figure 8

## Outline Information



| Symbol | Dimensions In Millimeters |        | Dimensions In Inches |       |
|--------|---------------------------|--------|----------------------|-------|
|        | Min                       | Max    | Min                  | Max   |
| A      | 2.184                     | 2.388  | 0.086                | 0.094 |
| b      | 0.381                     | 0.889  | 0.015                | 0.035 |
| b3     | 4.953                     | 5.461  | 0.195                | 0.215 |
| C2     | 0.457                     | 0.889  | 0.018                | 0.035 |
| D      | 5.334                     | 6.223  | 0.210                | 0.245 |
| E      | 6.350                     | 6.731  | 0.250                | 0.265 |
| H      | 9.000                     | 10.414 | 0.354                | 0.410 |
| L      | 0.508                     | 1.780  | 0.020                | 0.070 |
| L2     | 0.508 Ref.                |        | 0.020 Ref.           |       |
| L3     | 0.889                     | 2.032  | 0.035                | 0.080 |
| P      | 1.270 Ref.                |        | 0.050 Ref.           |       |
| V      | 5.200 Ref.                |        | 0.205 Ref.           |       |
| R      | 0.200                     | 1.500  | 0.008                | 0.059 |
| S      | 2.500                     | 3.400  | 0.098                | 0.134 |
| T      | 0.500                     | 0.850  | 0.020                | 0.033 |

**5-Lead TO-252 Surface Mount Package**



| Symbol | Dimensions In Millimeters |       | Dimensions In Inches |       |
|--------|---------------------------|-------|----------------------|-------|
|        | Min                       | Max   | Min                  | Max   |
| A      | 4.801                     | 5.004 | 0.189                | 0.197 |
| B      | 3.810                     | 3.988 | 0.150                | 0.157 |
| C      | 1.346                     | 1.753 | 0.053                | 0.069 |
| D      | 0.330                     | 0.508 | 0.013                | 0.020 |
| F      | 1.194                     | 1.346 | 0.047                | 0.053 |
| H      | 0.170                     | 0.254 | 0.007                | 0.010 |
| I      | 0.050                     | 0.254 | 0.002                | 0.010 |
| J      | 5.791                     | 6.200 | 0.228                | 0.244 |
| M      | 0.400                     | 1.270 | 0.016                | 0.050 |

**8-Lead SOP Plastic Package**

**Richtek Technology Corporation**

Headquarter  
 5F, No. 20, Taiyuen Street, Chupei City  
 Hsinchu, Taiwan, R.O.C.  
 Tel: (8863)5526789 Fax: (8863)5526611

**Richtek Technology Corporation**

Taipei Office (Marketing)  
 5F, No. 95, Minchiuan Road, Hsintien City  
 Taipei County, Taiwan, R.O.C.  
 Tel: (8862)86672399 Fax: (8862)86672377  
 Email: marketing@richtek.com

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