Single Channel LED Current Source Controller

General Description

The RT9052 is a low cost, single channel LED current source controller with a specific $\overline{\text{FAULT}}$ detector. The part can drive an external NPN-BJT for various applications. The RT9052 is operated with Vcc power ranging from 3.8V to 13.5V. With such a topology, it's very flexible and cost effective.

The RT9052 comes in a small SOT-23-6 package.

Ordering Information

RT9052□□
- Package Type
  E : SOT-23-6
- Operating Temperature Range
  G : Green (Halogen Free with Commercial Standard)

Note :

Richtek Green 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.

Marking Information

EU=DNN	EU= : Product Code DNN : Date Code

Features

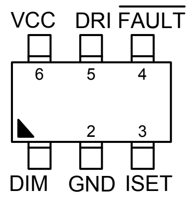
- **3.8V to 13.5V Operation Voltage**
- **Voltage Reference 0.8V with ±2% High Accuracy**
- **$\overline{\text{FAULT}}$ Indicator with Delay**
- **Dimming Control by PWM**
- **Small Footprint Package SOT-23-6**
- **RoHS Compliant and Halogen Free**

Applications

- LED Backlight applications
- Current Source
- Transistor Driver

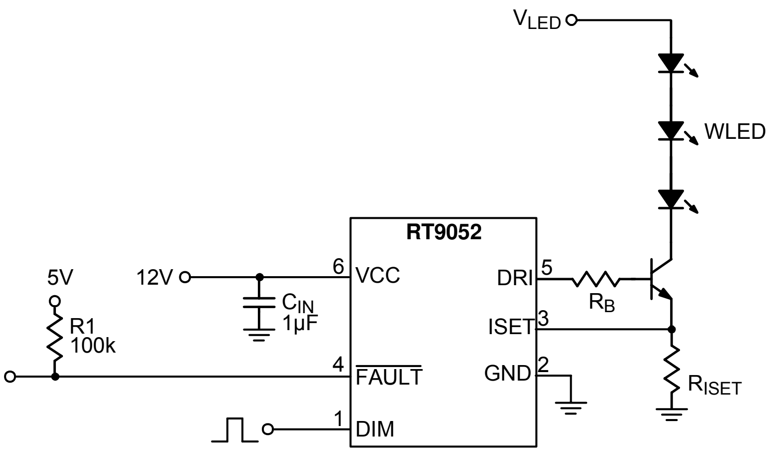
Pin Configurations

(TOP VIEW)



SOT-23-6

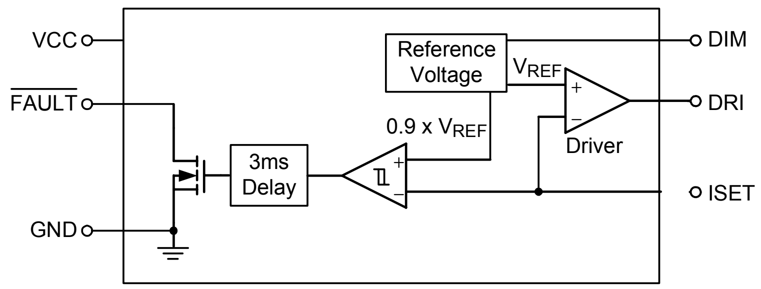
Typical Application Circuit



Functional Pin Description

Pin No.	Pin Name	Pin Function
1	DIM	PWM Dimming Control Input.
2	GND	Ground.
3	ISET	Current Setting Input.
4	$\overline{\text{FAULT}}$	$\overline{\text{FAULT}}$ Signal Open Drain Output.
5	DRI	Driver Output.
6	VCC	Power Supply Input.

Function Block Diagram



Absolute Maximum Ratings (Note 1)

- Supply Input Voltage, V_{CC} ---------- 15V
- DIM Voltage ---------- 7V
- $\overline{FAULT}$ Output Voltage ---------- 7V
- Power Dissipation, P_D @ T_A = 25°C
  SOT-23-6 ---------- 0.4W
- Package Thermal Resistance (Note 2)
  SOT-23-6, θ_{JA} ---------- 250°C/W
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Junction Temperature ---------- 150°C
- Storage Temperature Range ---------- −65°C to 150°C
- ESD Susceptibility (Note 3)
  HBM (Human Body Mode) ---------- 2kV
  MM (Machine Mode) ---------- 200V

Recommended Operating Conditions (Note 4)

- Supply Input Voltage, V_{CC} ---------- 3.8V to 13.5V
- DIM Voltage ---------- 0V to 5.5V
- Junction Temperature Range ---------- −40°C to 125°C
- Ambient Temperature Range ---------- −40°C to 85°C

Electrical Characteristics

(V_{CC} = 5V/12V, T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
UVLO Threshold		V_{CC} Rising	3.15	3.4	3.65	V
UVLO Hysteresis			0.1	0.2	0.3	V
V_{CC} Supply Current	I_{CC}	V_{CC} = 12V	--	0.3	0.8	mA
Driver Source Current		V_{CC} = 12V, V_{DRI} = 6V	5	--	--	mA
Driver Sink Current		V_{CC} = 12V, V_{DRI} = 6V	5	--	--	mA
ISET Reference Voltage	V_{REF}	V_{CC} = 12V, V_{DRI} = 5V	0.784	0.8	0.816	V
ISET Line Regulation		V_{CC} = 4.5V to 13.5V	--	3	6	mV
Amplifier Voltage Gain		V_{CC} = 12V, No Load	--	70	--	dB
$\overline{FAULT}$ Rising Threshold		V_{CC} = 12V	85	90	95	$\%V_{REF}$
$\overline{FAULT}$ Hysteresis		V_{CC} = 12V	--	15	--	$\%V_{REF}$
Sink Capability		V_{CC} = 12V @ 1mA	--	0.2	0.4	V
Delay Time	t_{DELAY}	V_{CC} = 12V	1	3	10	ms
Falling Delay		V_{CC} = 12V	--	15	20	μs
DIM						
DIM Rising Threshold	DIM_{th}	V_{CC} = 12V	--	0.7	1	V
DIM Hysteresis		V_{CC} = 12V	--	30	--	mV
Standby Current	$I_{STANDBY}$	V_{CC} = 12V, V_{DIM} = 0V	--	--	5	μA

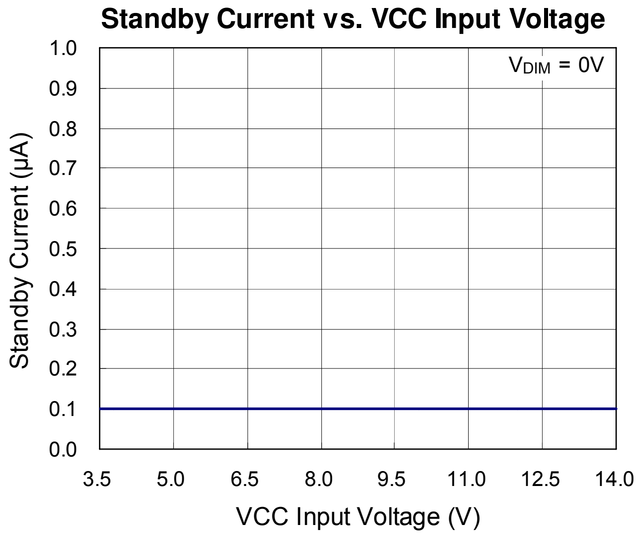
Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

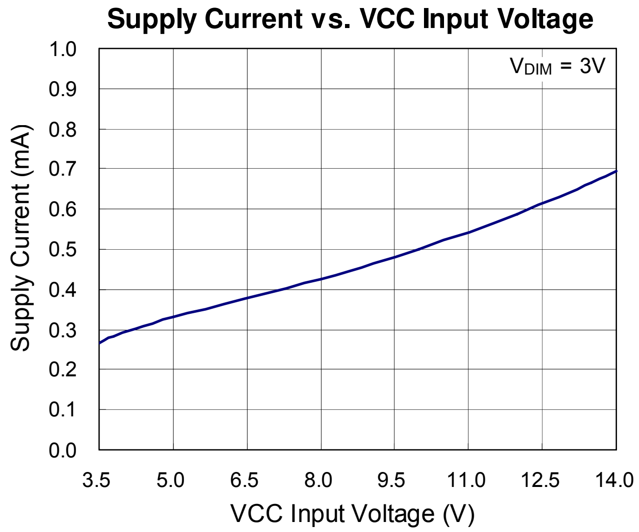
Note 2. θ_{JA} is measured in natural convection at T_A = 25°C on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

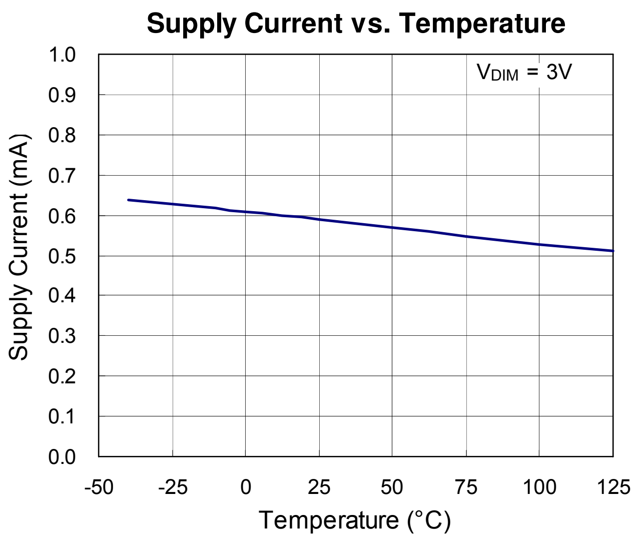
Note 3. Devices are ESD sensitive. Handling precaution is recommended.

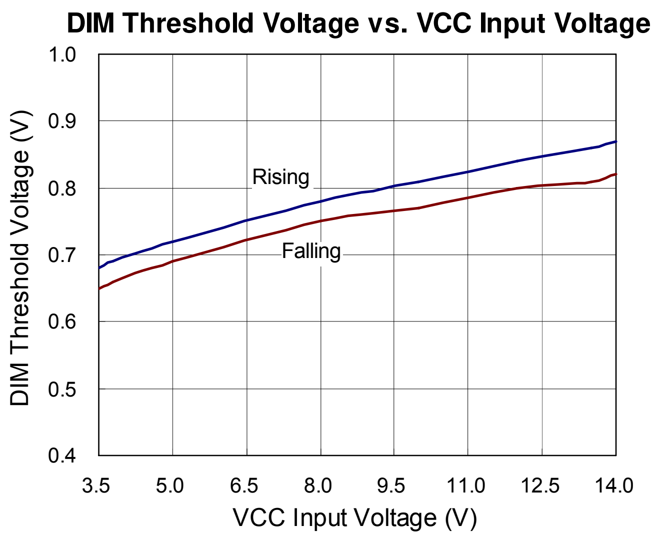
Note 4. The device is not guaranteed to function outside its operating conditions.

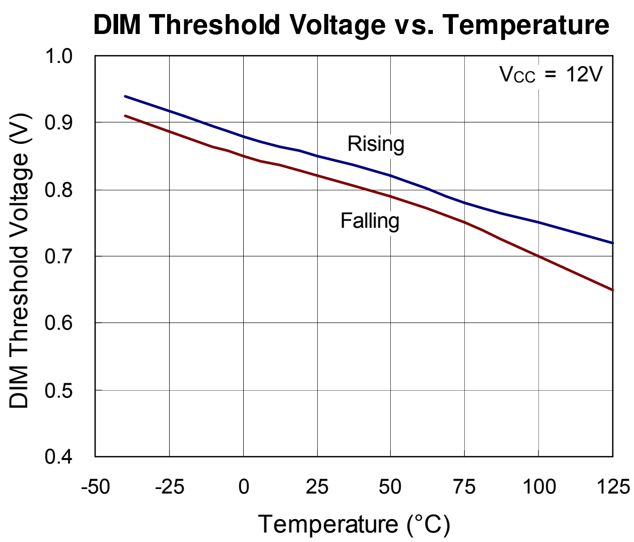
Typical Operating Characteristics

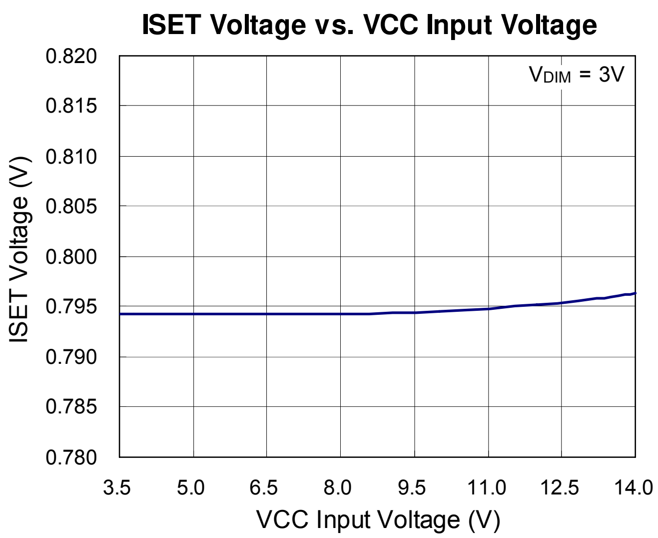


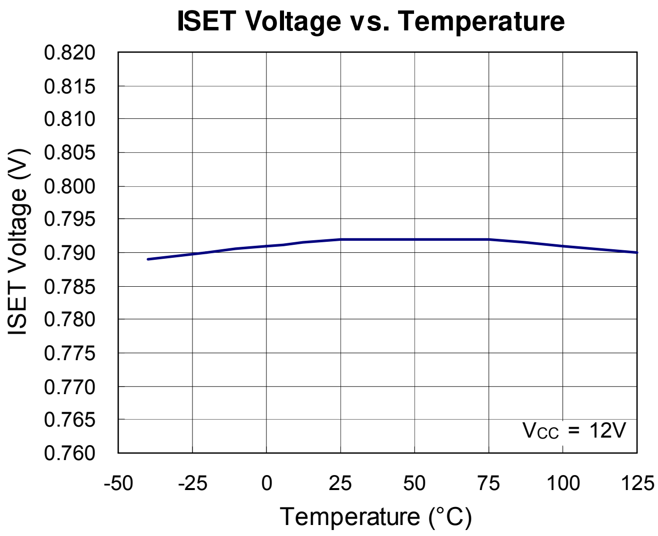


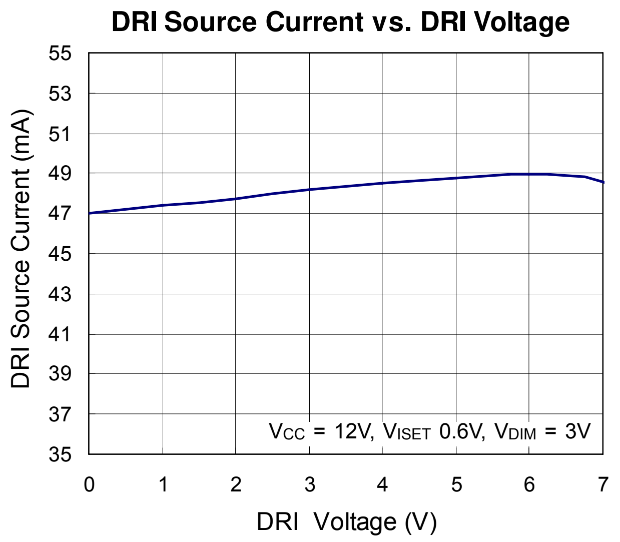


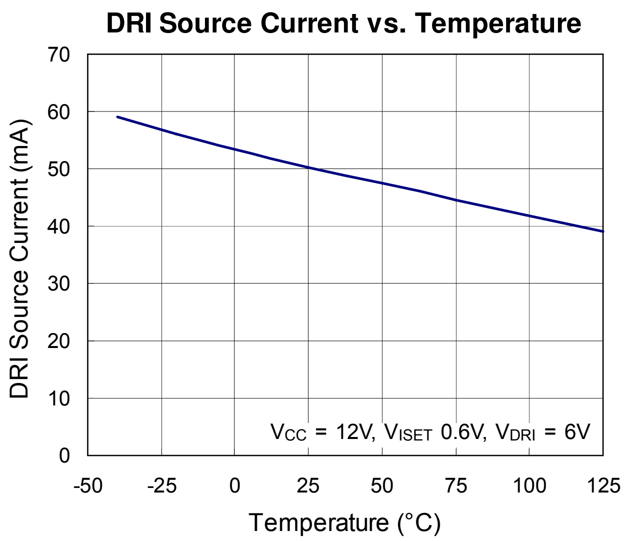


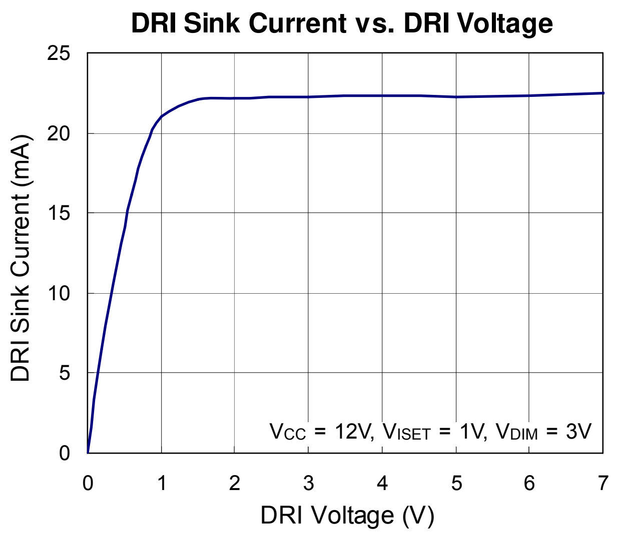


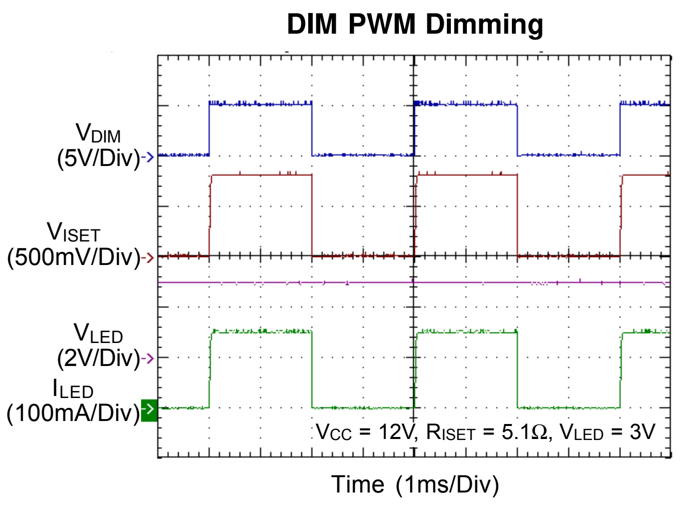


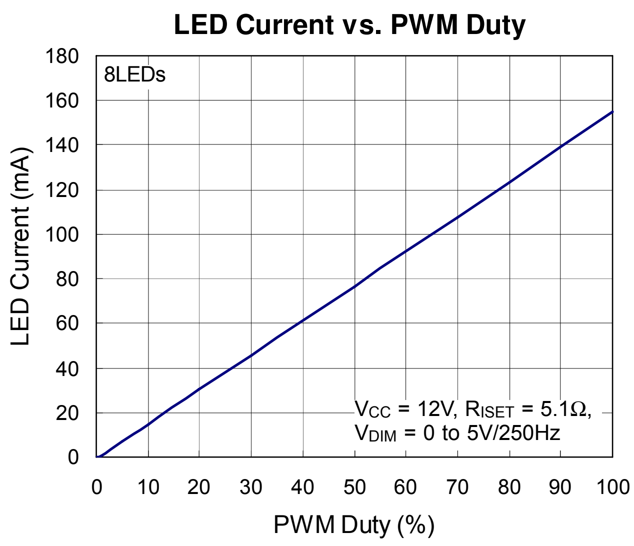

ISET Voltage vs. Temperature
ISET Voltage (V)
0.820
0.815
0.810
0.805
0.800
0.795
0.790
0.785
0.780
0.775
0.770
0.765
0.760
VCC = 12V
-50
-25
0
25
50
75
100
125
Temperature (°C)


DRI Source Current vs. DRI Voltage
DRI Source Current (mA)
55
53
51
49
47
45
43
41
39
37
35
VCC = 12V, VISET 0.6V, VDIM = 3V
0
1
2
3
4
5
6
7
DRI Voltage (V)


DRI Source Current vs. Temperature
DRI Source Current (mA)
70
60
50
40
30
20
10
0
VCC = 12V, VISET 0.6V, VDRI = 6V
-50
-25
0
25
50
75
100
125
Temperature (°C)


DRI Sink Current vs. DRI Voltage
DRI Sink Current (mA)
25
20
15
10
5
0
VCC = 12V, VISET = 1V, VDIM = 3V
0
1
2
3
4
5
6
7
DRI Voltage (V)


DIM PWM Dimming
VDIM
(5V/Div)
VISET
(500mV/Div)
VLED
(2V/Div)
ILED
(100mA/Div)
VCC = 12V, RISET = 5.1Ω, VLED = 3V
Time (1ms/Div)


LED Current vs. PWM Duty
LED Current (mA)
180
160
140
120
100
80
60
40
20
0
8LEDs
VCC = 12V, RISET = 5.1Ω,
VDIM = 0 to 5V/250Hz
0
10
20
30
40
50
60
70
80
90
100
PWM Duty (%)

Application Information

The RT9052 is a low cost single channel LED current source controller with a specific $\overline{\text{FAULT}}$ indicating scheme. This device can drive an external NPN-BJT for various applications. The RT9052 is operated with VCC power ranging from 3.8V to 13.5V. With such a topology, it is very flexible and cost effective.

Capacitors Selection

Careful selection of the external capacitors for the RT9052 is necessary to maintain high stability and performance. A capacitor ≥ 1μF must be connected between VCC and ground to improve supply voltage stability for proper operation.

$\overline{\text{FAULT}}$ Function

The RT9052 has a $\overline{\text{FAULT}}$ function with delay. The $\overline{\text{FAULT}}$ output is an open drain output. Connect a 100kΩ pull up resistor to external 5V source to obtain an output voltage. When the ISET voltage reaches 90% of normal value, $\overline{\text{FAULT}}$ will become active and be pulled high by external circuits with a typical 3ms delay.

LED Current Setting

The RT9052 includes a 0.8V reference voltage for easy setting of the LED current source. As shown in application circuit, the LED current is easily set via an R_{ISET} resistor.

$$I_{LED} = \frac{0.8\ (V)}{R_{ISET}\ (\Omega)} \quad (A)$$

PWM Dimming Operation

For controlling the LED brightness, the RT9052 can perform dimming control by applying a PWM signal to the DIM pin. The average LED current is proportional to the PWM signal duty cycle. Note that the magnitude of the PWM signal needs to be higher than the maximum dimming voltage of the DIM pin, in order to have correct dimming control.

NPN Transistor Selection

The RT9052 drives the NPN transistor via the DRI pin (source Base current I_B). When making an NPN transistor selection, the following criteria Should be considered : DC current gain h_{FE} , threshold voltage V_{BE}, collector-emitter voltage V_{CE}, maximum collector current IC package thermal resistance $\theta_{(JA)}$.

Thermal Considerations

For continuous operation, do not exceed absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated by the following formula :

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

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

For recommended operating condition specifications of the RT9052, the maximum junction temperature is 125°C and T_A is the ambient temperature. The junction to ambient thermal resistance, θ_{JA}, is layout dependent. For SOT-23-6 packages, the thermal resistance, θ_{JA}, is 250°C/W on a standard JEDEC 51-3 single-layer thermal test board. The maximum power dissipation at T_A = 25°C can be calculated by the following formula :

$P_{D(MAX)}$ = (125°C − 25°C) / (250°C/W) = 0.400W for SOT-23-6 package

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, θ_{JA}. For the RT9052 package, the derating curve in Figure 1 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

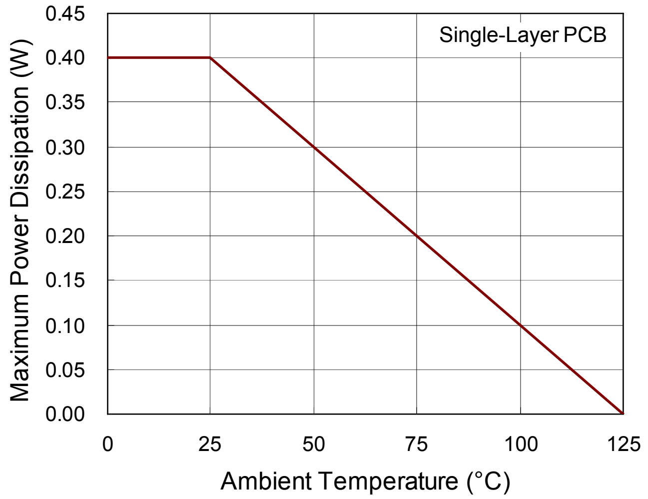


Figure 1. Derating Curve for RT9052 Package

Layout Consideration

There are three critical layout considerations.

- The current setting resistor should be located as close as possible to the RT9052 to avoid inducing any noise.
- The input capacitor have to put at near the IC for improved performance.
- The pass element operating under high power situation may raise the junction temperature above the package thermal resistance limit. (copper area can be added to improve power dissipation.)

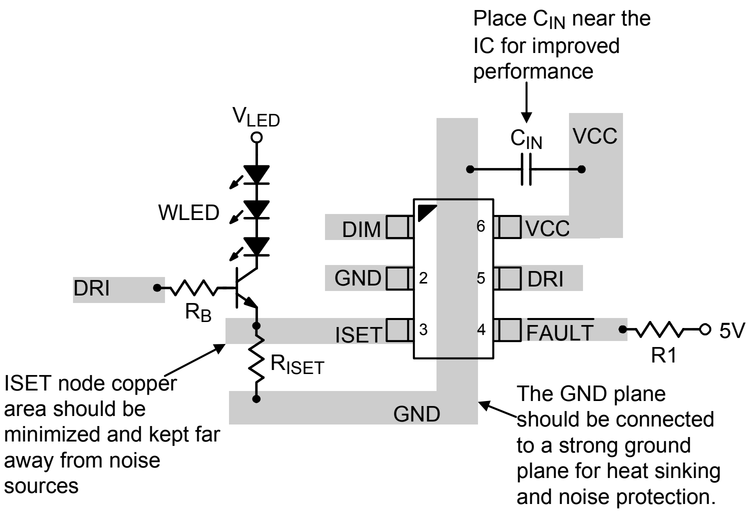
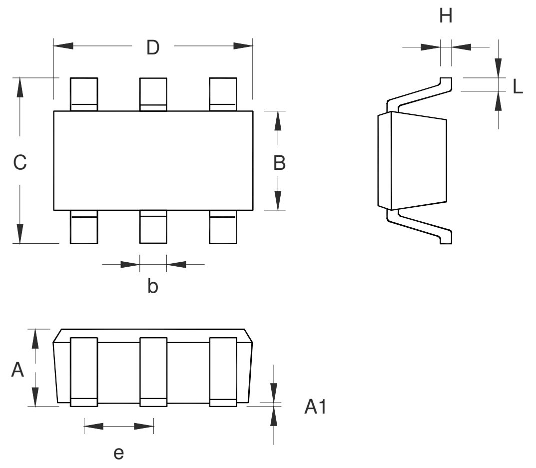


Figure 2. PCB Layout Guide

Outline Dimension



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.889	1.295	0.031	0.051
A1	0.000	0.152	0.000	0.006
B	1.397	1.803	0.055	0.071
b	0.250	0.560	0.010	0.022
C	2.591	2.997	0.102	0.118
D	2.692	3.099	0.106	0.122
e	0.838	1.041	0.033	0.041
H	0.080	0.254	0.003	0.010
L	0.300	0.610	0.012	0.024

SOT-23-6 Surface Mount 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)
8F, No. 137, Lane 235, Paochiao Road, Hsintien City
Taipei County, Taiwan, R.O.C.
Tel: (8862)89191466 Fax: (8862)89191465
Email: marketing@richtek.com