# Low-Dropout Linear Regulator Controller with PGOOD Indication

## General Description

The RT9024 is a low-dropout voltage regulator controller with a specific PGOOD indicating scheme. The part could drive an external N-MOSFET for various applications. The part is operated with $V_{CC}$ power ranging from 3.8V to 13.5V. With such a topology, it's with advantages of flexible and cost-effective. The part comes to a small footprint package of SOT-23-6.

## Ordering Information

RT9024 □□

- Package Type
  E : SOT-23-6
- 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.

## Marking Information

For marking information, contact our sales representative directly or through a Richtek distributor located in your area.

## Features

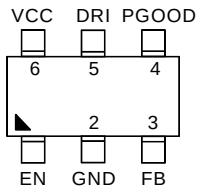
- **3.8V to 13.5V Operation Voltage**
- **0.8V ± 2% High Accuracy Voltage Reference**
- **Quick Transient Response**
- **Power Good Indicator with Delay**
- **Enable Control**
- **Small Footprint Package SOT-23-6**
- **RoHS Compliant and 100% Lead (Pb)-Free**

## Applications

- DSC
- DSLR

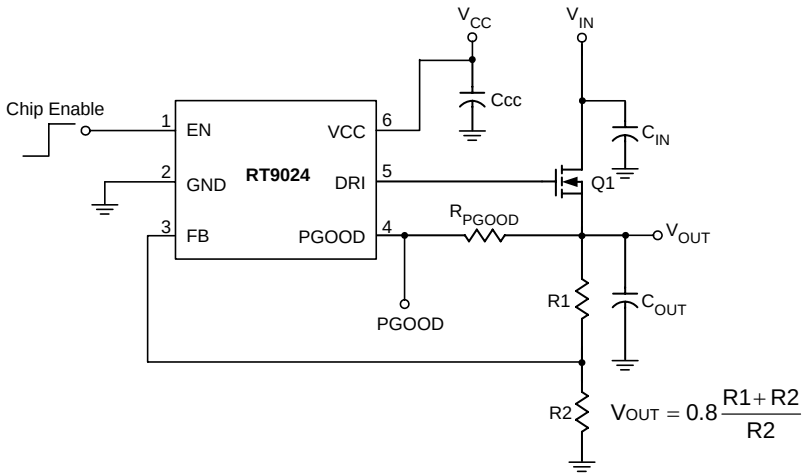
## Pin Configurations

(TOP VIEW)




SOT-23-6

## Typical Application Circuit



## Test Circuit

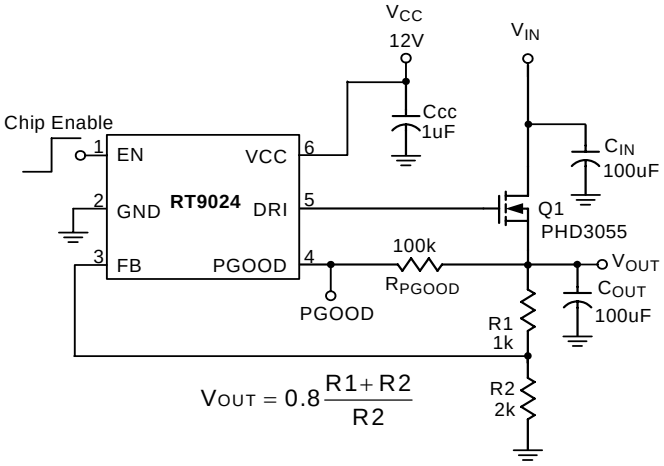



Figure 1. Typical Test Circuit

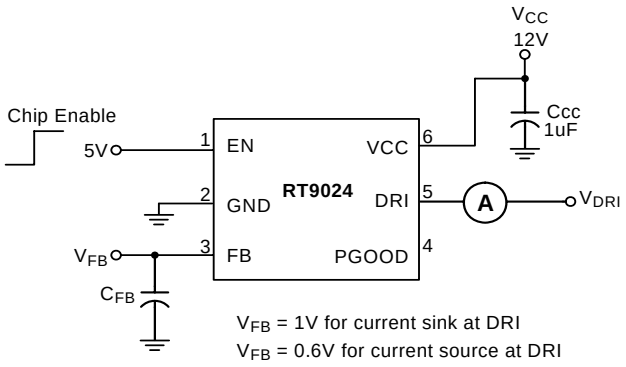
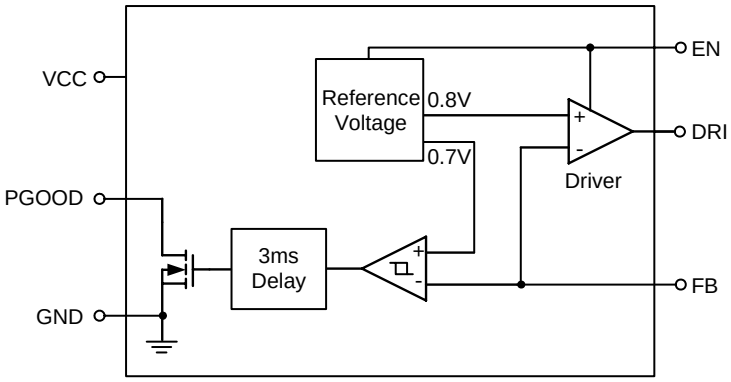



Figure 2. DRI Source/Sink Current Test Circuit

## Functional Pin Description

| Pin No. | Pin Name | Pin Function |
|---|---|---|
| 1 | EN | Chip Enable (Active High). |
| 2 | GND | Ground. |
| 3 | FB | Output Voltage Feedback. |
| 4 | PGOOD | Power Good 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
- Enable Voltage ---------- 7V
- Power Good Output Voltage ---------- 7V
- Power Dissipation, $P_D$ @ $T_A$ = 25°C
  SOT-23-6 ---------- 0.4W
- Package Thermal Resistance (Note 2)
  SOT-23-6, $\theta_{JA}$ ---------- 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
- Enable 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 |
|---|---|---|---|---|---|---|
| $V_{CC}$ Operation Voltage Range | | $V_{CC}$ Input Range | 3.8 | -- | 13.5 | V |
| POR Threshold | | $V_{CC}$ Rising | 3.15 | 3.4 | 3.65 | V |
| POR Hysteresis | | $V_{CC}$ Falling | 0.1 | 0.2 | 0.3 | V |
| $V_{CC}$ Supply Current | | $V_{CC}$ = 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 |
| Reference Voltage ($V_{FB}$) | | $V_{CC}$ = 12V, $V_{DRI}$ = 5V | 0.784 | 0.8 | 0.816 | V |
| Reference Line Regulation ($V_{FB}$) | | $V_{CC}$ = 4.5V to 15V | -- | 3 | 6 | mV |
| Amplifier Voltage Gain | | $V_{CC}$ = 12V, No Load | -- | 70 | -- | dB |
| PSRR at 100Hz, No Load | | $V_{CC}$ = 12V, No Load | 50 | -- | -- | dB |
| **Power Good** | | | | | | |
| Rising Threshold | | $V_{CC}$ = 12V | 85 | 90 | 95 | % |
| Hysteresis | | $V_{CC}$ = 12V | -- | 15 | -- | % |
| Sink Capability | | $V_{CC}$ = 12V @ 1mA | -- | 0.2 | 0.4 | V |
| Delay Time | | $V_{CC}$ = 12V | 1 | 3 | 10 | ms |
| Falling Delay | | $V_{CC}$ = 12V | -- | 15 | 20 | us |

*To be Continued*

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Chip Enable** | | | | | | |
| EN Rising Threshold | | $V_{CC}$ = 12V | -- | 0.7 | 1 | V |
| EN Hysteresis | | $V_{CC}$ = 12V | -- | 30 | -- | mV |
| Standby Current | | $V_{CC}$ = 12V, $V_{EN}$ = 0V | -- | -- | 5 | uA |

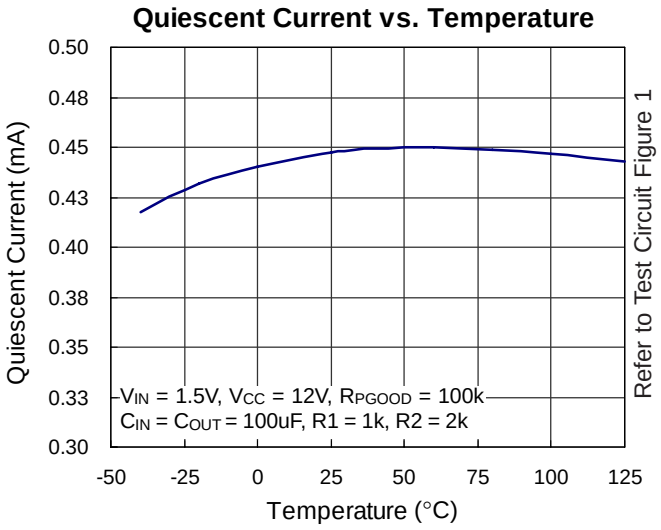
**Note 1.** Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure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

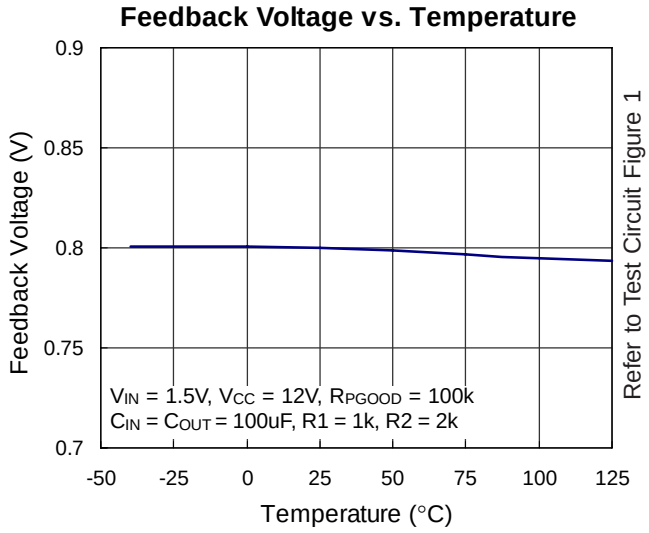
**Note 2.** $\theta_{JA}$ is measured in the natural convection at $T_A$ = 25°C on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

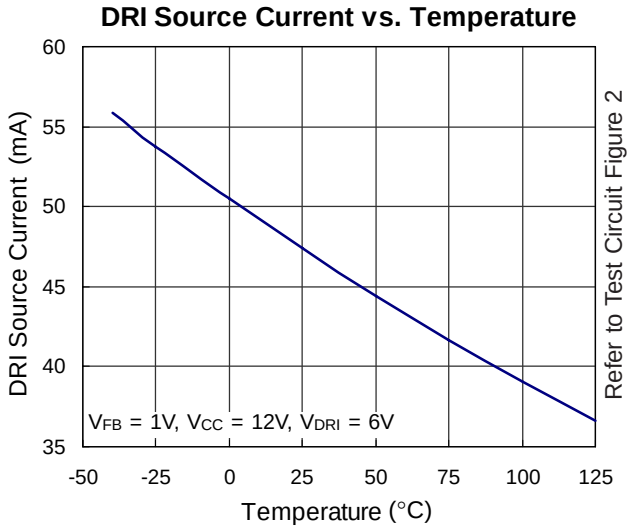
**Note 3.** Devices are ESD sensitive. Handling precaution is recommended.

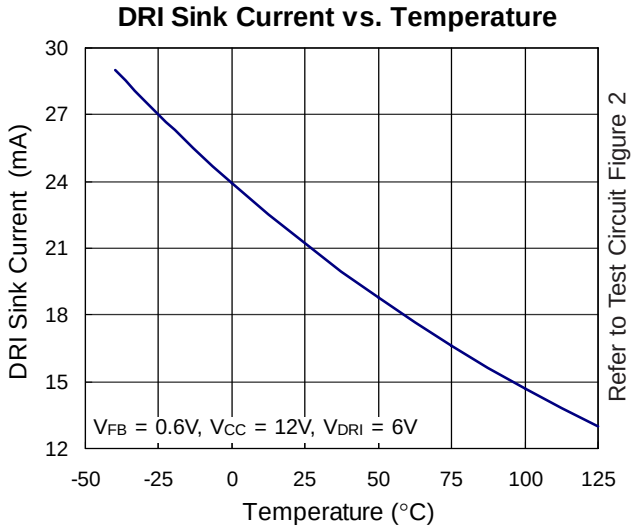
**Note 4.** The device is not guaranteed to function outside its operating conditions.

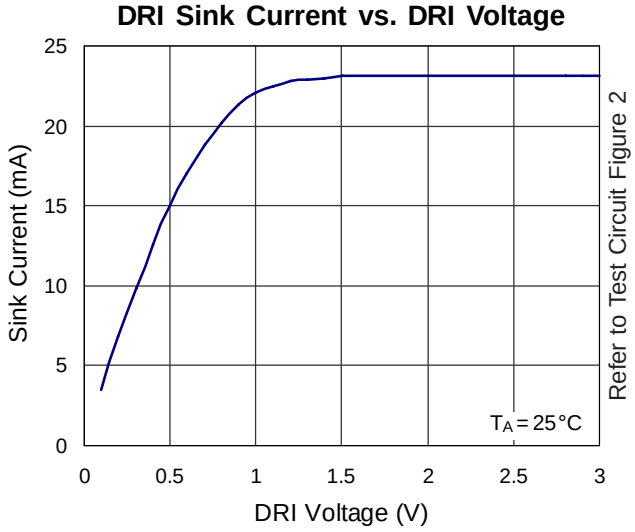
## Typical Operating Characteristics

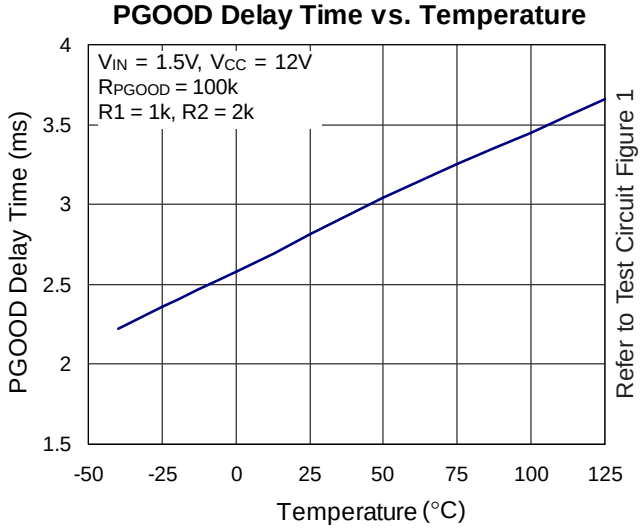


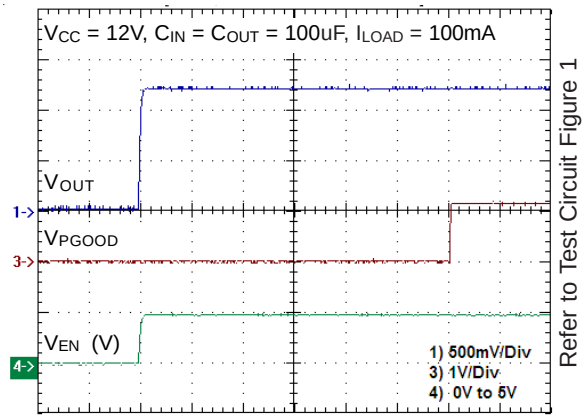



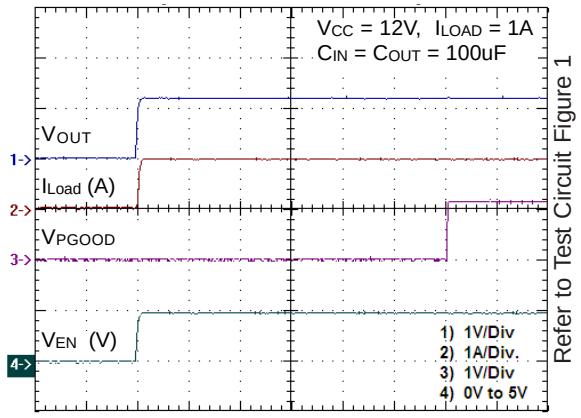



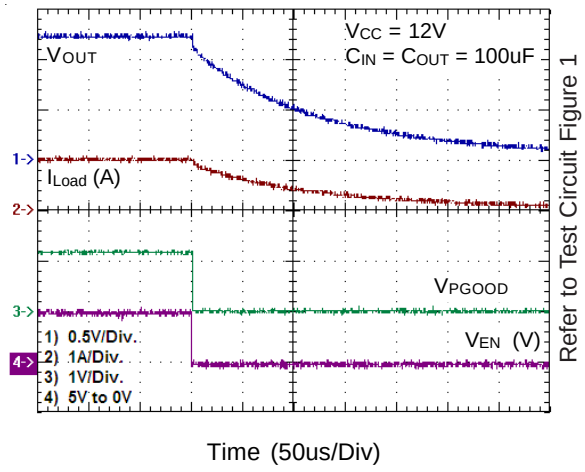
### PGOOD Delay Time



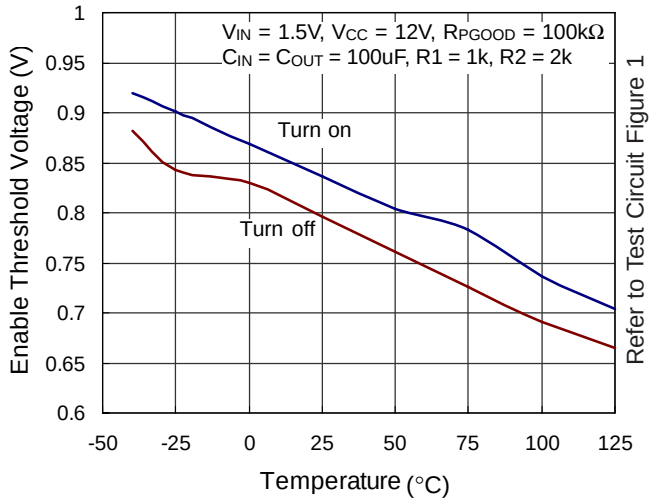

### PGOOD Delay Time



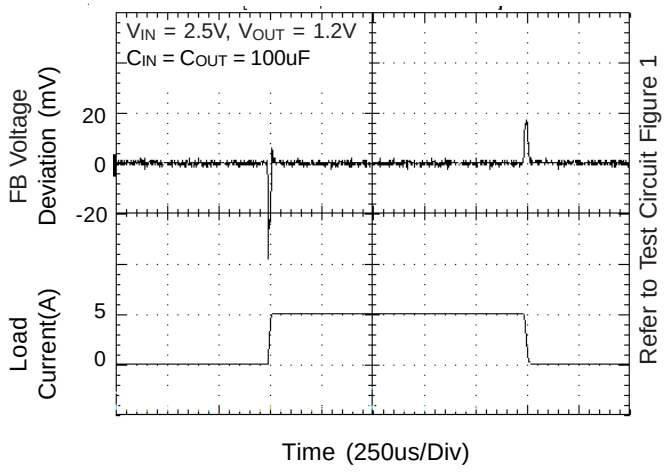

### PGOOD Off



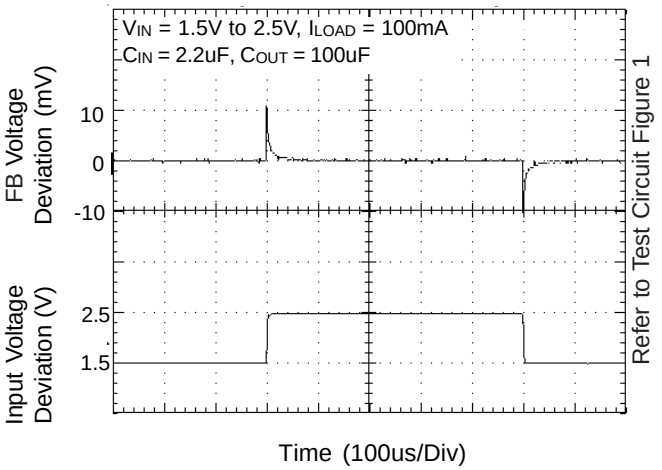

### Enable Threshold Voltage vs. Temperature




### Load Transient Response




### Line Transient Response



## Application Information

### Capacitors Selection

Careful selection of the external capacitors for RT9024 is highly recommended in order to remain high stability and performance.

Regarding the supply voltage capacitor, connecting a capacitor which is ≥ 1μF between $V_{CC}$ and ground is a must. The capacitor improves the supply voltage stability for proper operation.

Regarding the input capacitor, connecting a capacitor which ≥ 100μF between $V_{IN}$ and ground is recommended to increase stability. With large value of capacitance could result in better performance for both PSRR and line transient response.

When driving external pass element, connecting a capacitor ≥ 100μF between $V_{OUT}$ and ground is recommended for stability. With larger capacitance can reduce noise and improve load transient response and PSRR.

### Output Voltage Setting

The RT9024 develops a 0.8V reference voltage; especially suitable for low voltage application. As shown in application circuit, the output voltage could easy set the output voltage by R1 & R2 divider resistor.

### Power Good Function

The RT9024 has the power good function with delay. The power good output is an open drain output. Connect a 100kΩ pull up resistor to $V_{OUT}$ to obtain an output voltage. When the output voltage arrives 90% of normal value. PGOOD will become active and be pulled high by external circuits with typically 3ms delay.

### Chip Enable Operation

Pull the EN pin low to drive the device into shutdown mode. During shutdown mode, the standby current drops to $5\mu A_{(MAX)}$. The external capacitor and load current determine the output voltage decay rate. Drive the EN pin high to turn on the device again.

### MOSFET Selection

The RT9024 are designed to driver external N-MOSFET pass element. MOSFET selection criteria include threshold voltage $V_{GS}$ ($V_{TH}$), maximum continuous drain current ID, on-resistance $R_{DS(ON)}$ ,maximum drain-to-source voltage $V_{DS}$ and package thermal resistance $\theta_{(JA)}$.

The most critical specification is the MOSFET $R_{DS(ON)}$. Calculate the required $R_{DS(ON)}$ from the following formula:

$$N-MOSFET\ R_{DS(ON)} = \frac{V_{IN} - V_{OUT}}{I_{LOAD}}$$

For example, the MOSFET operate up to 2A when the input voltage is 1.5V and set the output voltage is 1.2V, $R_{ON}$ = (1.5V-1.2V) / 2A = 150mΩ, the MOSFET's $R_{ON}$ must be lower than 150mΩ. Philip PHD3055E MOSFET with an $R_{DS(ON)}$ of 120mΩ(typ.) is a suitable solution.

The power dissipation is calculate as :

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

The thermal resistance from junction to ambient $\theta_{(JA)}$ is :

$$\theta_{(JA)} = \frac{(T_J - T_A)}{P_D}$$

In this example, $P_D$ = (1.5V – 1.2V) x 2A = 0.6W. The PHD3055E's $\theta_{(JA)}$ is 75°C/W for its D-PAK package, which translates to a 45°C temperature rise above ambient. The package provides exposed backsides that directly transfer heat to the PCB board.

### PNP Transistor Selection

The RT9024 could driver the PNP transistor to sink output current. PNP transistor selection criteria include DC current gain $h_{FE}$, threshold voltage $V_{EB}$, collector-emitter voltage $V_{EN}$, maximum continues collector current $I_C$, package thermal resistance $\theta_{(JA)}$.

For example, the PNP transistor operates sink current up to 0.5A when the input voltage is 1.5V and set the output voltage is 1.2V. As show in Figure 3. A KSB772 PNP transistor, the $V_{EN}$ = 1.2V, $V_{BE}$ = -1V, $I_C$ = 0.5A, $I_B$ = 0.5/160 ≥ 3.125mA, when the DRI pin voltage is 0.2V could sink $6.8mA_{(MAX)}$ is a close match.

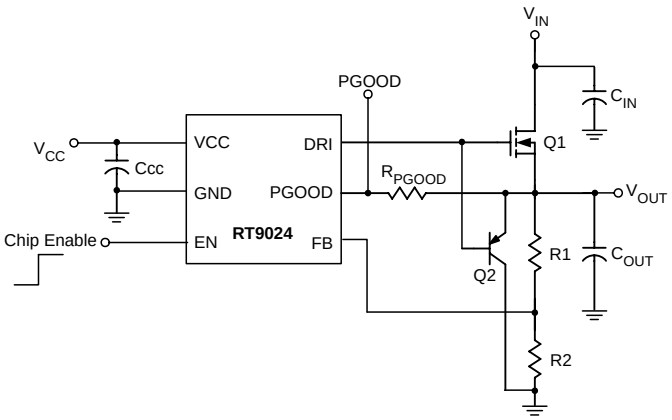



Figure 3

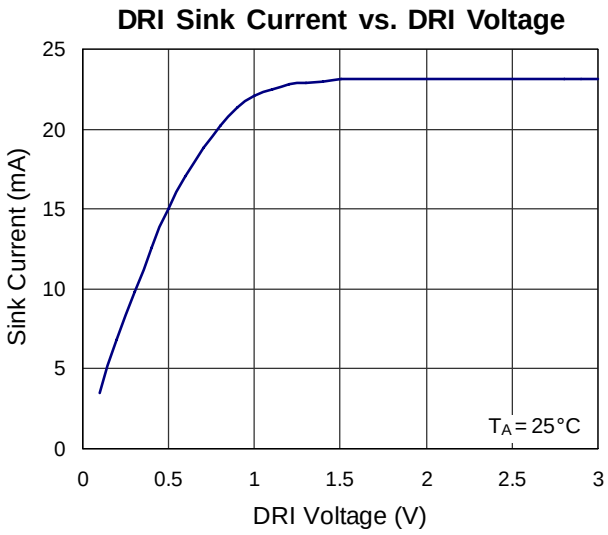



Figure 4

## Layout Considerations

There are three critical layout considerations. One is the divider resistors should be located to RT9024 as possible to avoid inducing any noise. The second is capacitors place. The $C_{IN}$ and $C_{OUT}$ have to put at near the N-MOSFET for improve performance. The third is the copper area for pass element. We have to consider when the pass element operating under high power situation that could rise the junction temperature. In addition to the package thermal resistance limit, we could add the copper area to improve the power dissipation. As show in Figure 5 and Figure 6.

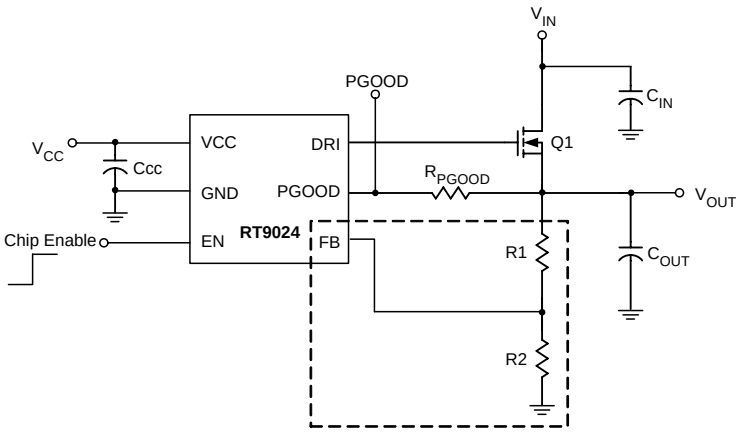



Figure 5

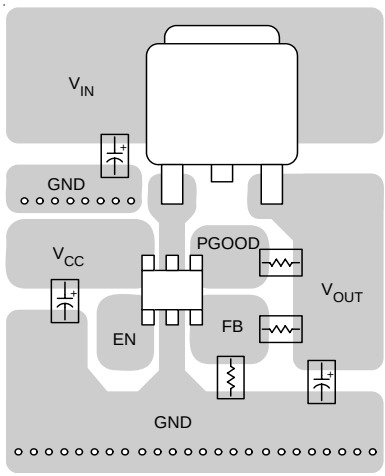
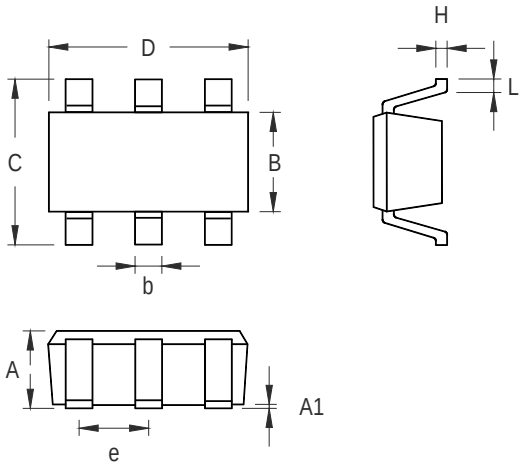



Figure 6

## 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**

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