4-CH LED Current Source Controller

General Description

The RT6030 is a current source controller, capable of driving up to 4-CH of LEDs . The part can also be used to drive an external BJT or N-MOSFET for various applications. With a wide operating voltage range from 3.8V to 13.5V, the RT6030 has the advantage of being flexible and cost-effective. The RT6030 is available in an SOP-16 package.

Features

- **3.8V to 13.5V Operating Voltage**
- **0.8V Voltage Reference with ±2% High Accuracy**
- **Independent Enable Control for Each Channel**
- **Quick Transient Response**
- **Over Temperature Protection**
- **RoHS Compliant and Halogen Free**

Ordering Information

RT6030 □ □

- Package Type
  S : SOP-16
- Lead Plating System
  G : Green (Halogen Free and Pb Free)

Note :

Richtek products are :

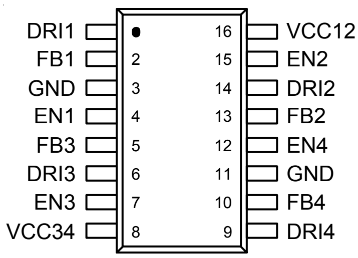
- RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- Suitable for use in SnPb or Pb-free soldering processes.

Applications

- LED TV Backlight
- Lighting
- Intelligent Instruments
- Industrial Display Backlight

Pin Configurations

(TOP VIEW)

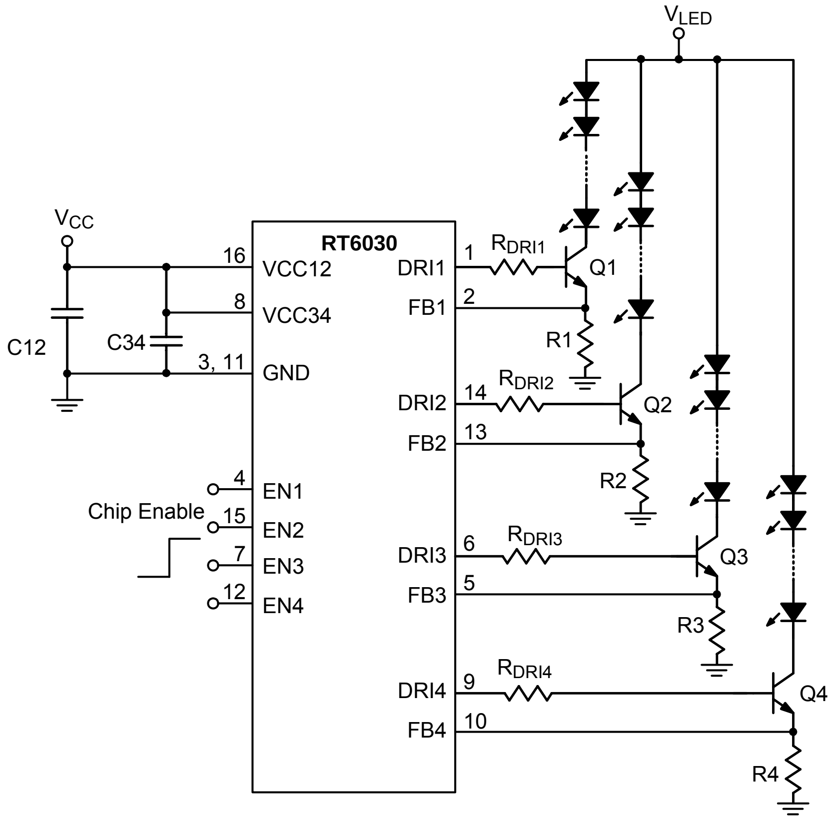


SOP-16

Marking Information

RT6030 GSYMDNN	RT6030GS : Product Number YMDNN : Date Code

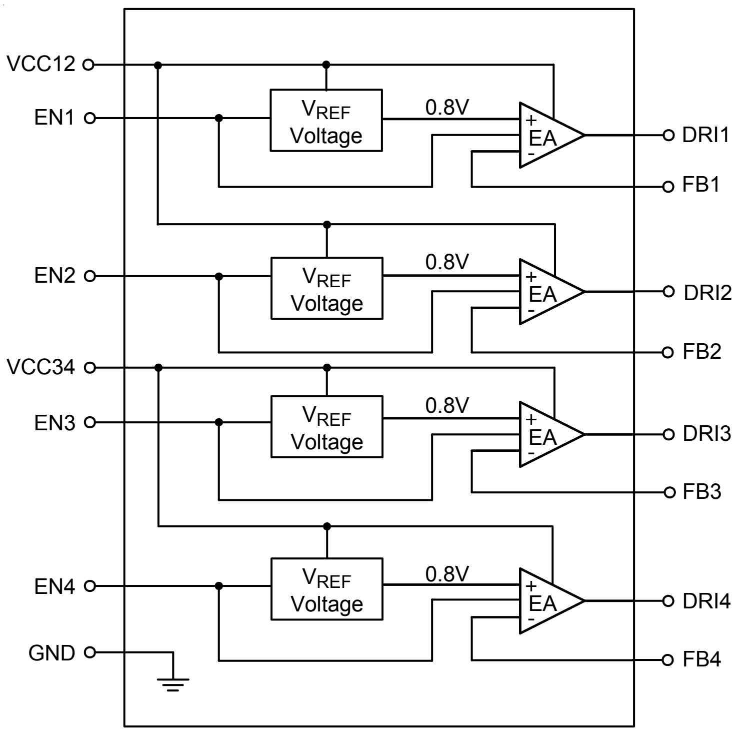
Typical Application Circuit



Functional Pin Description

Pin No.	Pin Name	Pin Function
1	DRI1	1st CH Driver Output.
2	FB1	1st CH Current Sense Voltage Feedback.
3, 11	GND	Ground.
4	EN1	1st CH Chip Enable (Active High).
5	FB3	3rd CH Current Sense Voltage Feedback.
6	DRI3	3rd CH Driver Output.
7	EN3	3rd CH Chip Enable (Active High).
8	VCC34	CH3 and CH4 Power Supply Input.
9	DRI4	4th CH Driver Output.
10	FB4	4th CH Current Sense Voltage Feedback.
12	EN4	4th CH Chip Enable (Active High).
13	FB2	2nd CH Current Sense Voltage Feedback.
14	DRI2	2nd CH Driver Output.
15	EN2	2nd CH Chip Enable (Active High).
16	VCC12	CH1 and CH2 Power Supply Input.

Function Block Diagram



Absolute Maximum Ratings (Note 1)

- VCC12, VCC34 ---------- 15V
- All Other Inputs ---------- 7V
- Power Dissipation, P_D @ T_A = 25°C
  SOP-16 ---------- 1.053W
- Package Thermal Resistance (Note 2)
  SOP-16, θ_{JA} ---------- 95°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 ---------- 1.5kV
  MM ---------- 150V

Recommended Operating Conditions (Note 4)

- Supply Input Voltage, V_{CC12} , V_{CC34} ---------- 3.8V to 13.5V
- Chip Enable Voltage, EN1, EN2, EN3, EN4 ---------- 0V to 5.5V
- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

Electrical Characteristics

(V_{CC12} = 5V/12V, V_{CC34} = 5V/12V, T_A = 25°C, unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Under Voltage Lockout Threshold	V_{UVLO}	V_{CC12} and V_{CC34} Rising	3.15	3.4	3.65	V
Under Voltage Lockout Hysteresis	ΔV_{UVLO}	V_{CC12} and V_{CC34} Falling	0.1	0.2	0.3	V
V_{CC12} and V_{CC34} Supply Current		V_{CC12} and V_{CC34} = 12V	--	0.6	1.6	mA
Driver Source Current	I_{SR}	V_{CC12} and V_{CC34} = 12V V_{DRI1} to V_{DRI4} = 6V	5	--	--	mA
Driver Sink Current	I_{SK}	V_{CC12} and V_{CC34} = 12V V_{DRI1} to V_{DRI4} = 6V	5	--	--	mA
Reference Voltage (V_{FB1} to V_{FB4})		V_{CC12} and V_{CC34} = 12V V_{DRI1} to V_{DRI4} = 5V	0.784	0.8	0.816	V
Reference Line Regulation (V_{FB1} to V_{FB4})		V_{CC12} and V_{CC34} = 4.5V to 13.5V	--	3	6	mV
Amplifier Voltage Gain		V_{CC12} and V_{CC34} = 12V, No Load	--	70	--	dB
Chip Enable						
EN Rising Threshold	V_{EN}	V_{CC12} and V_{CC34} = 12V	--	0.7	--	V
EN Hysteresis	ΔV_{EN}	V_{CC12} and V_{CC34} = 12V	--	30	--	mV
Standby Current		V_{CC12} and V_{CC34} = 12V V_{EN1} to V_{EN4} = 0V	--	--	10	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.

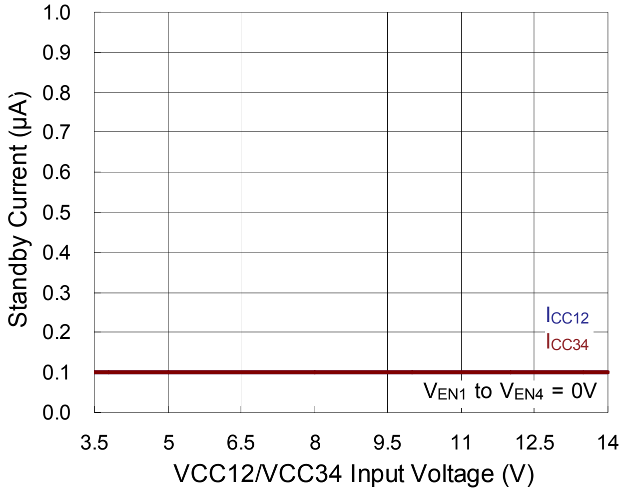
Note 2. θ_{JA} is measured in natural convection at T_A = 25°C on a low-effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

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

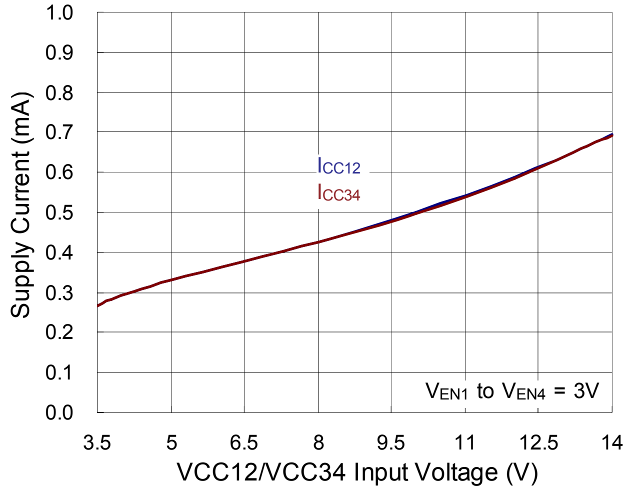
Note 4. The device is not guaranteed to function outside its operating conditions.

Typical Operating Characteristics

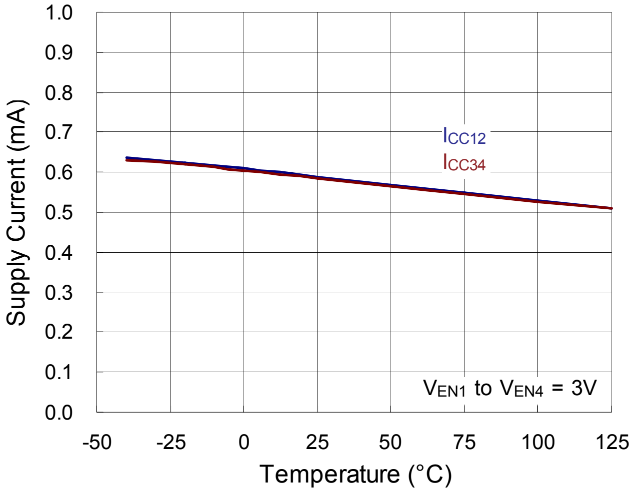
Standby Current vs. VCC12/VCC34 Input Voltage



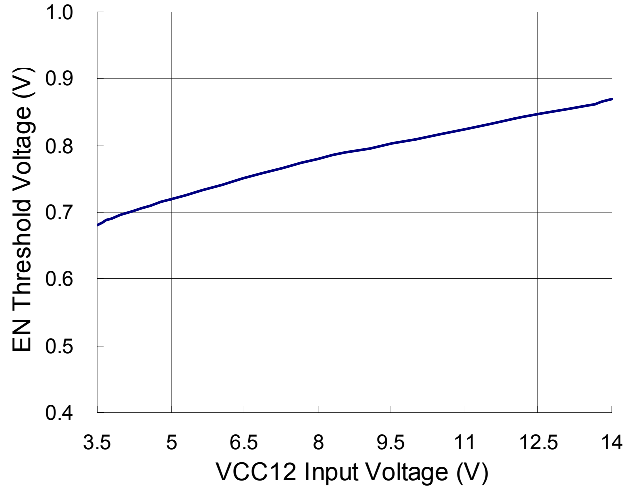
Supply Current vs. VCC12/VCC34 Input Voltage



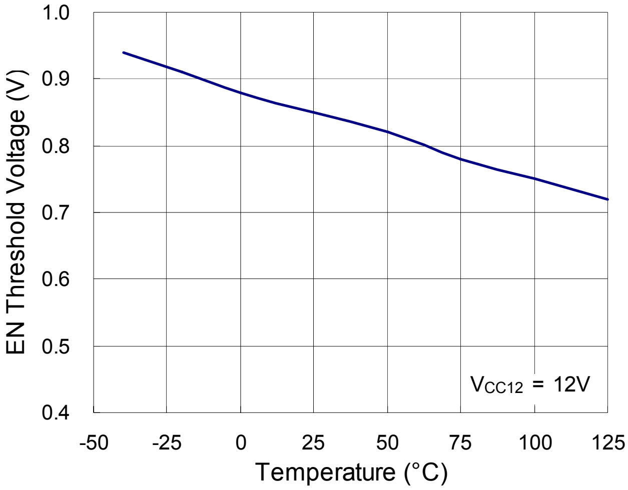
Supply Current vs. Temperature



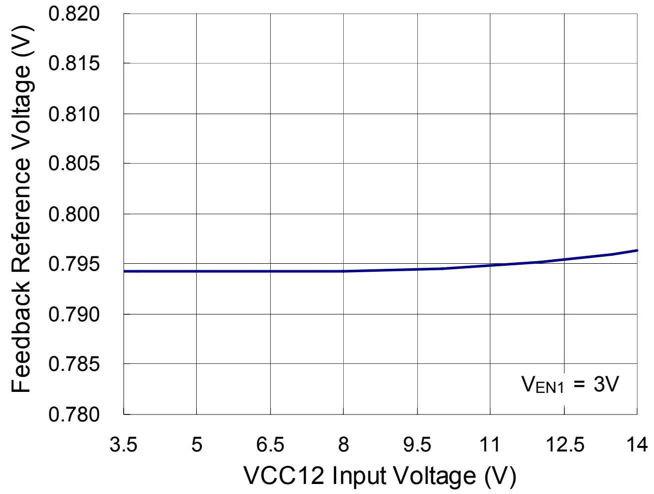
EN Threshold Voltage vs. VCC12 Input Voltage



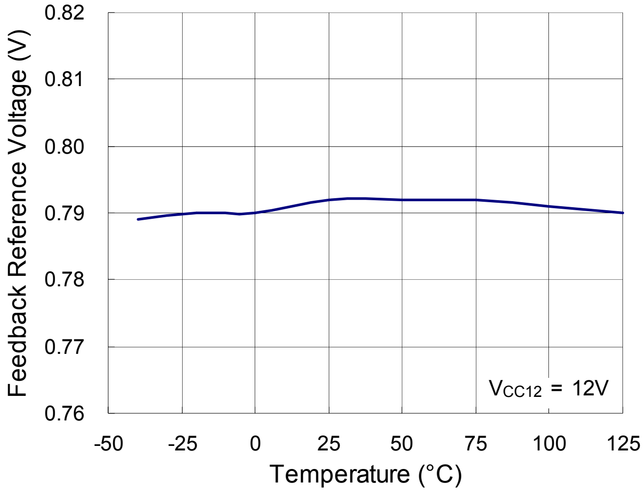
EN Threshold Voltage vs. Temperature



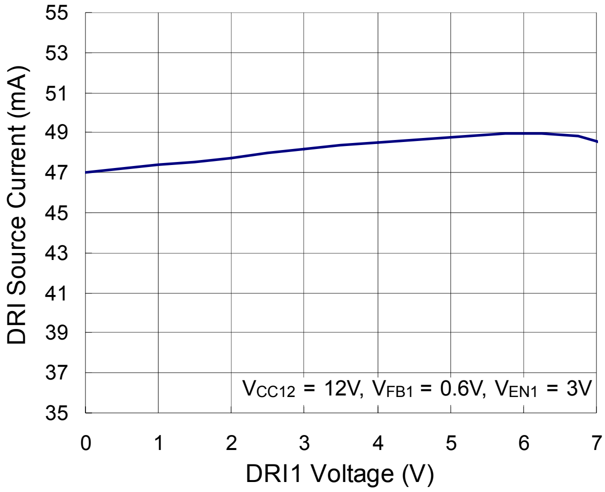
Feedback Reference Voltage vs. VCC12 Input Voltage



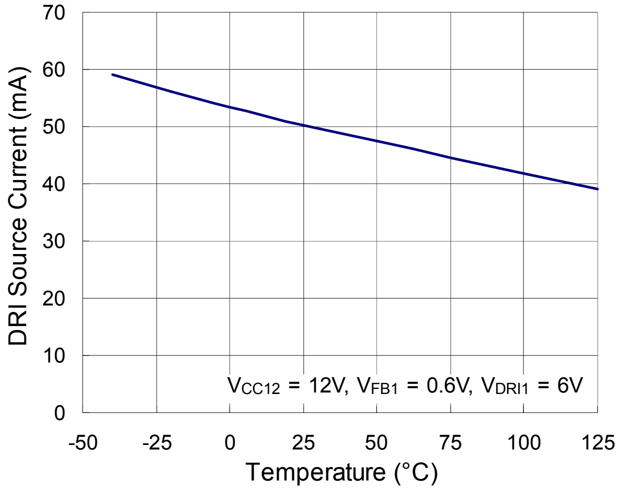
Feedback Reference Voltage vs. Temperature



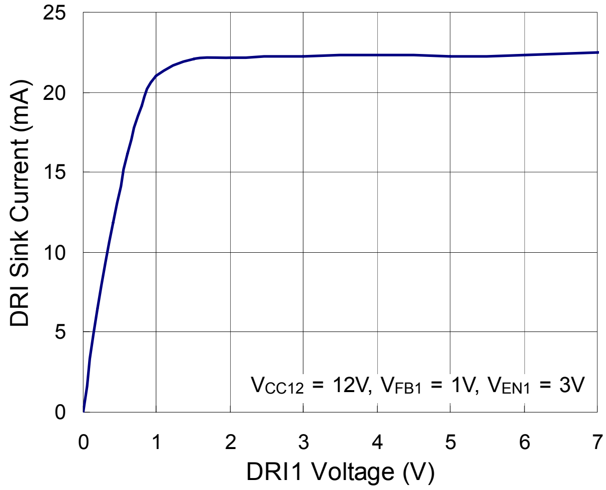
DRI Source Current vs. DRI1 Voltage



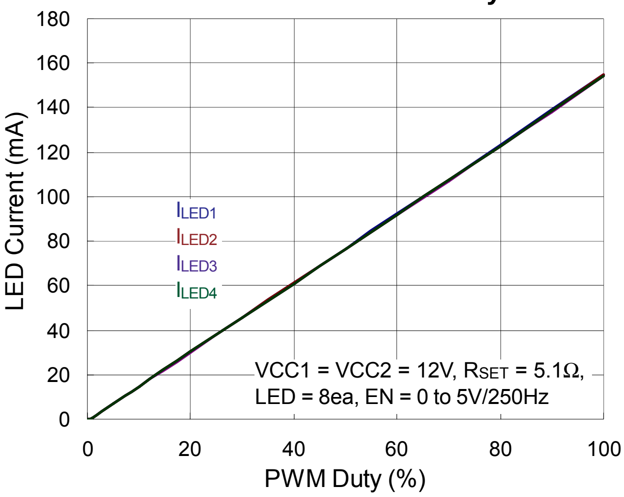
DRI Source Current vs. Temperature



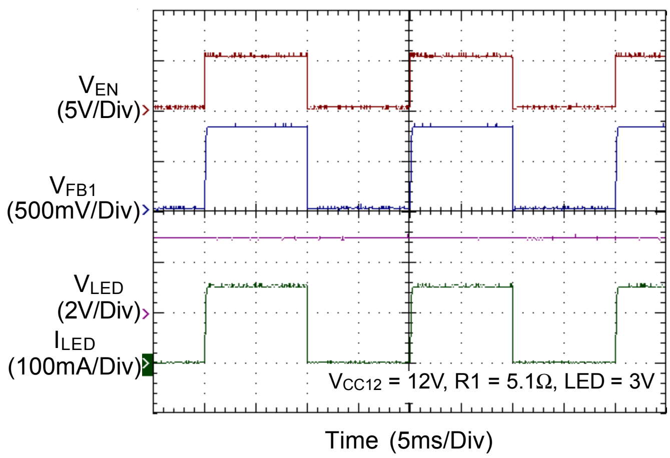
DRI Sink Current vs. DRI1 Voltage



LED Current vs. PWM Duty



PWM Dimming From EN



Applications Information

The RT6030 is a 4-CH LED current source controller. This device can also drive an external BJT or N-MOSFET for various applications. Refer to topology in Typical Application Circuit for more details.

Capacitors Selection

Careful selection of the external capacitors for the RT6030 is highly recommended in order to maintain high stability and performance. An input capacitor with minimum 1μF must be connected between VCC and ground. The capacitor improves the supply voltage stability for proper operation.

Chip Enable Operation

Pull the EN pin low to drive the device into shutdown mode. During shutdown mode, the standby current drops to 10mA(MAX). Drive the EN pin high to turn on the device again. To control LED brightness, the RT6030 can perform dimming function by applying a PWM signal to the EN pin. The average LED current is proportional to the PWM signal duty cycle. To obtain correct dimming, the magnitude of the PWM signal should be higher than the threshold voltage of the EN pin.

MOSFET Selection

The RT6030 is designed to drive external N-MOSFET pass element. MOSFET selection criteria include threshold voltage, V_{GS} (V_{TH}), maximum continuous drain current, I_D, on resistance, $R_{DS(ON)}$,maximum drain-to-source voltage, V_{DS}, and package thermal resistance, θ_{JA}. The most critical specification is the MOSFET $R_{DS(ON)}$. $R_{DS(ON)}$ can be calculated from the following formula :

$$R_{DS(ON)} = \frac{(V_{IN} - V_{OUT})}{I_O}$$

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

The power dissipation is calculated as :

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

The thermal resistance from junction to ambient 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 θ_{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.

LED Current Setting

The RT6030 maintains an internal reference voltage of 0.8V. As shown in Typical Application Circuit, the LED current can be set accordingly via the Rx (x = 1, 2, 3, 4) resistor.

$$I_{LEDx} = \frac{0.8}{R_x} \text{ (A)}$$

NPN Transistor Selection

The RT6030 drives the external NPN transistor via the DRIx pin (source Base current I_B). NPN transistor selection criteria include DC current gain, h_{FE}, threshold voltage, V_{BE}, collector emitter voltage, V_{CE}, maximum continuous collector current, I_C, and package thermal resistance, θ_{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 θ_{JA} is the junction to ambient thermal resistance.

For recommended operating condition specifications of the RT6030, 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 SOP-16 packages, the thermal resistance, θ_{JA}, is 95°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) / (95°C/W) = 1.053W for SOP-16 package

The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance, θ_{JA}. For the RT6030 package, the derating curve in Figure 1 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

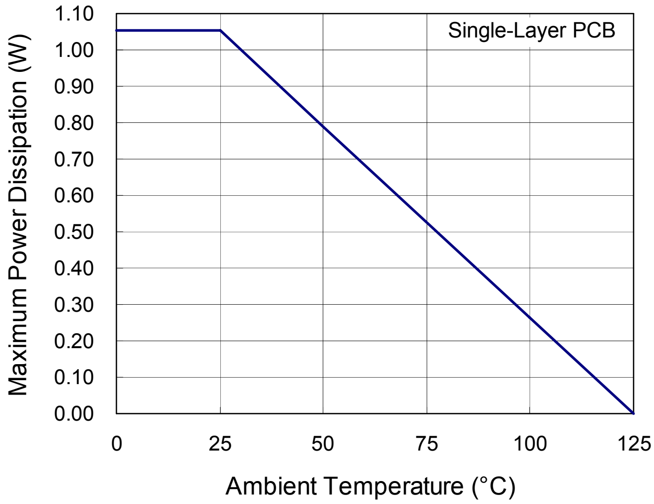


Figure 1. Derating Curve for RT6030 Package

Layout Considerations

There are three critical layout considerations.

- First the current setting resistor should be placed as close as possible to the RT6030 to prevent any noise coupling.
- Second of all C_{IN} and C_{OUT} should be placed near the RT6030 for good performance.
- Last of all, proper copper area for the pass element should be acknowledged. Pass elements operating under high power situations can result in abnormally junction temperature. In addition to the package thermal resistance limit, the copper area should be increased accordingly to improve the power dissipation.

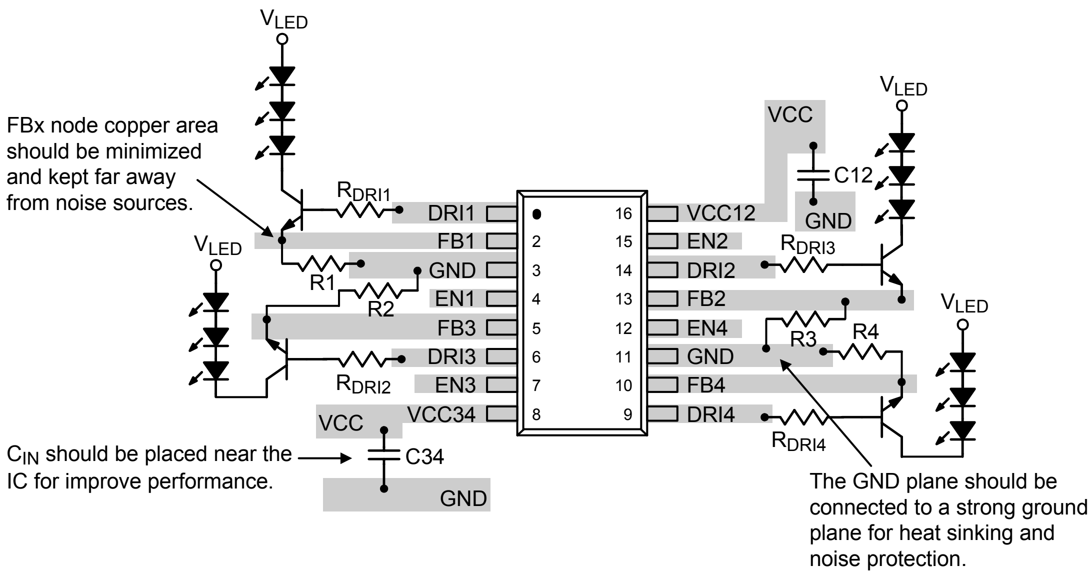
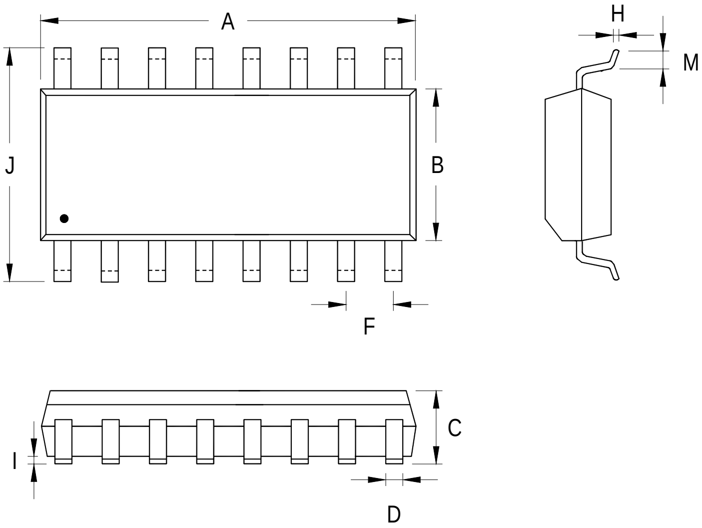


Figure 2. PCB Layout Guide

Outline Dimension



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	9.804	10.008	0.386	0.394
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	0.178	0.254	0.007	0.010
I	0.102	0.254	0.004	0.010
J	5.791	6.198	0.228	0.244
M	0.406	1.270	0.016	0.050

16–Lead SOP Plastic Package

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