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High Voltage Programmable Constant-Current LED Driver

General Description

The RT7320 is a simple and robust constant-current regulator designed to provide a cost-effective solution for driving high-voltage LEDs in LED lamp applications. The wide input voltage range (up to 400V) allows flexible LED string design to operate with $110V_{RMS}$ or $220V_{RMS}$ AC input voltage.

The RT7320 allows users to set the regulated current level by connecting the pins from I1 to I5 for various LED lamps. Parallel LED strings operation is possible with right regulated current setting on the RT7320. In addition, the RT7320 also provides a thermal regulation protection, instead of traditional thermal shutdown, to suppress the rise of IC junction temperature and prevent LED lamps from flicker.

Ordering Information

RT7320□□

Package Type
SP : SOP-8 (Exposed Pad-Option 2)

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.

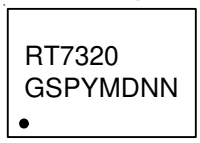
Features

- **Programmable Regulated Current : 2.8mA to 78.3mA**
- **AC Input Voltage : 90 to $130V_{RMS}$ or 200 to $240V_{RMS}$**
- **Thermal Regulation Protection**
- **Minimized Start-up Time (<10ms)**
- **Easy EMI Solution**
- **Minimized BOM Cost and Space Required**
- **Small SOP-8 (Exposed Pad) Package**
- **RoHS Compliant and Halogen Free**

Applications

- High-Voltage LED Lamps
- High-Voltage Sinking Current Regulator

Marking Information

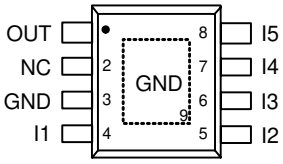


RT7320GSP : Product Number

YMDNN : Date Code

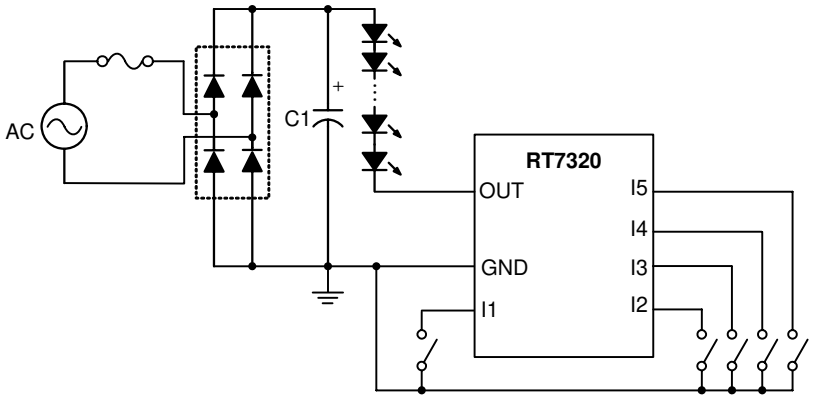
Pin Configurations

(TOP VIEW)



SOP-8 (Exposed Pad)

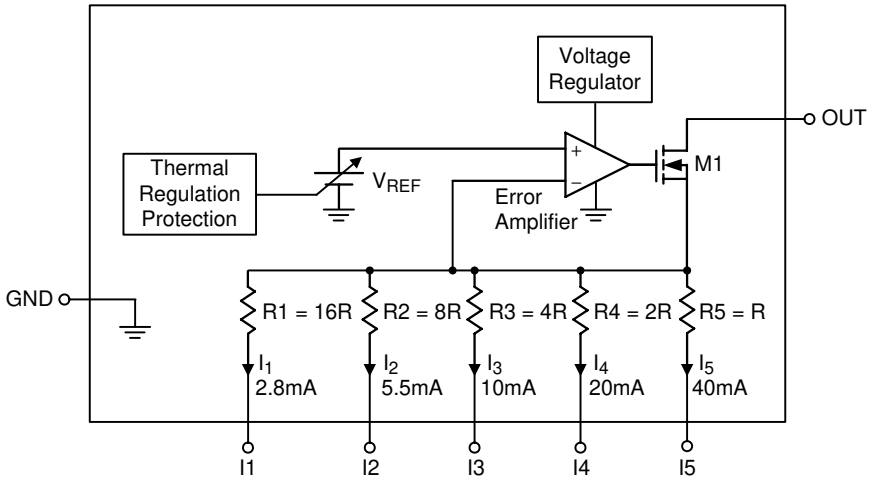
Simplified Application Circuit



Functional Pin Description

Pin No.	Pin Name	Pin Function
1	OUT	Output of the Constant-Current Regulator. A programmable regulated current, flowing into this pin, drives high-voltage LEDs connected between this pin and the rectified voltage.
2	NC	No Internal Connection.
3, 9 (Exposed Pad)	GND	Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.
4	I1	Current Setting Input. If this pin is directly connected to GND, the regulated current increases 2.8mA (typical).
5	I2	Current Setting Input. If this pin is directly connected to GND, the regulated current increases 5.5mA (typical).
6	I3	Current Setting Input. If this pin is directly connected to GND, the regulated current increases 10mA (typical).
7	I4	Current Setting Input. If this pin is directly connected to GND, the regulated current increases 20mA (typical).
8	I5	Current Setting Input. If this pin is directly connected to GND, the regulated current increases 40mA (typical).

Function Block Diagram



Operation

Constant-Current Regulator

The constant-current regulator in the RT7320 consists of an output high-voltage MOSFET (M1), programmable current-sense resistors (R1 to R5), an error amplifier and a reference voltage (V_{REF}). The error amplifier, designed with high DC gain, compares the current signal (V_{CS}) on the current-sense resistors and the V_{REF} to generate an amplified error signal. The error signal regulates the output MOSFET to control the sinking current on the OUT pin at the programmed current level. In addition, the operating OUT voltage (V_{OUT}) must be higher than the minimum OUT voltage (V_{OUT_MIN}). Otherwise, the output current might not be regulated at the programmed level (I_{OUT_SET}). The V_{OUT_MIN} is approximately calculated by the following equation :

$$V_{OUT\_MIN} = 3000 \times I_{OUT\_SET}^2 + 4 \quad (V)$$

Thermal Regulation Protection

When a LED lamp operates in high ambient temperature conditions, it needs a thermal protection to limit the temperatures for protecting LED lamps and ensuring system reliability. The RT7320 provides a thermal regulation protection, instead of traditional thermal shutdown, to suppress the rise of temperatures. When the IC junction temperature rises above 125°C (typ.), this function starts to gradually reduce the regulated LED current, depending on the rise of the junction temperature. Meanwhile, the system power dissipation is also reduced. Finally, the temperatures in the system will be well controlled and enter their steady-state. The function can achieve both of the two targets : to protect LED lamps and to prevent them from flicker.

Absolute Maximum Ratings (Note 1)

- OUT to GND ---------- –0.3V to 250V
- I1, I2, I3, I4, I5 to GND ---------- –0.3V to 5V
- Power Dissipation, P_D @ T_A = 25°C
  SOP-8 (Exposed Pad) ---------- 3.44W
- Package Thermal Resistance (Note 2)
  SOP-8 (Exposed Pad), θ_{JA} ---------- 29°C/W
  SOP-8 (Exposed Pad), θ_{JC} ---------- 2°C/W
- Junction Temperature ---------- 150°C
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Storage Temperature Range ---------- –65°C to 150°C
- ESD Susceptibility (Note 3)
  HBM (Human Body Model) ---------- 2kV
  MM (Machine Model) ---------- 200V

Recommended Operating Conditions (Note 4)

- Input DC Voltage, V_{OUT} ---------- 0V to 100V
- Input Current, I_{OUT} ---------- 2.8mA to 78.3mA
- Ambient Temperature Range ---------- –40°C to 85°C
- Junction Temperature Range ---------- –40°C to 125°C

Electrical Characteristics

(T_A = 25°C, unless otherwise specification)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
OUT Section						
OUT Regulated Current Level-1	I_1	V_{OUT} = 30V, I1 = GND	2.66	2.8	2.94	mA
OUT Regulated Current Level-2	I_2	V_{OUT} = 30V, I2 = GND	5.225	5.5	5.775	mA
OUT Regulated Current Level-3	I_3	V_{OUT} = 30V, I3 = GND	9.5	10	10.5	mA
OUT Regulated Current Level-4	I_4	V_{OUT} = 30V, I4 = GND	19	20	21	mA
OUT Regulated Current Level-34	I_{34}	V_{OUT} = 30V, I3 = I4 = GND	28.5	30	31.5	mA
OUT Regulated Current Level-5	I_5	V_{OUT} = 30V, I5 = GND	38	40	42	mA

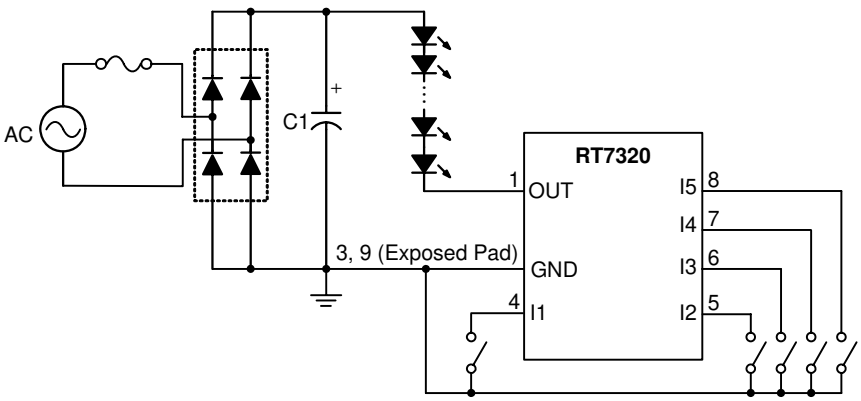
Note 1. Stresses beyond those listed "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Note 2. θ_{JA} is measured at T_A = 25°C on a high effective thermal conductivity four-layer test board per JEDEC 51-7. θ_{JC} is measured at the exposed pad of the package.

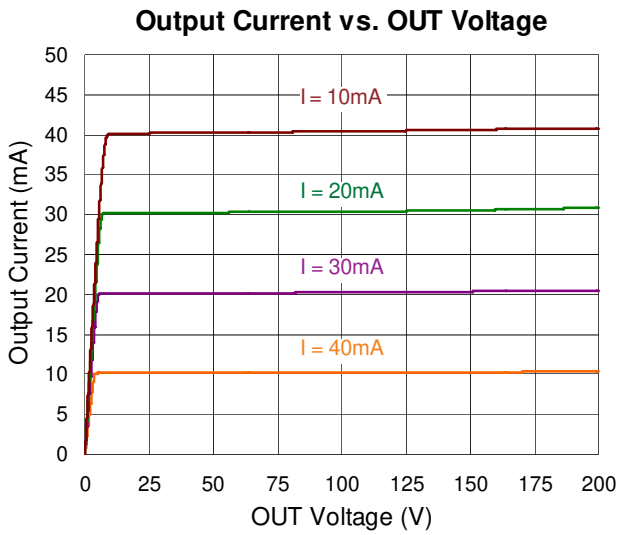
Note 3. Devices are ESD sensitive. Handling precaution is recommended.

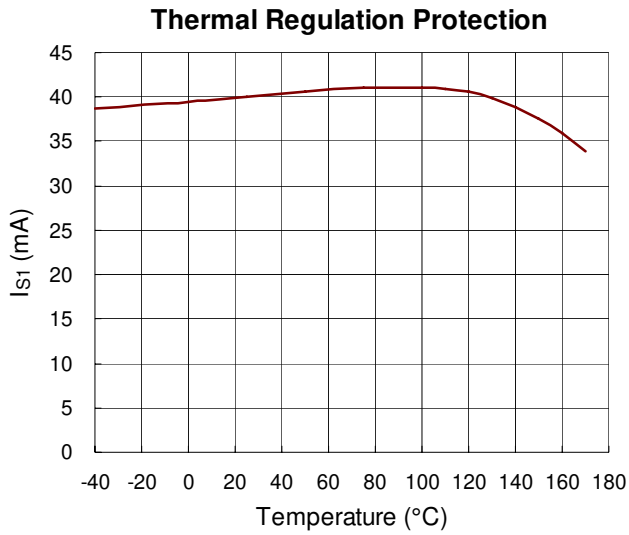
Note 4. The device is not guaranteed to function outside its operating conditions.

Typical Application Circuit



Typical Operating Characteristics





Application Information

Input Capacitor

Input capacitor (C1) determines the resulted minimum DC voltage and hold-up time.

Definition of the parameters :

Vi_{min} : Minimum line input (Vrms)

f_{line} : line frequency (Hz)

Vdc_{valley} : minimum DC voltage for the system

DC voltage at minimum line voltage Vdc_{min_pk} is given as

$$Vdc_{min\_pk} = \sqrt{2} \times Vi_{min} \quad (V)$$

Calculation of charging duty D_{ch} each half-line cycle

$$Dch = \frac{1}{2} - \frac{1}{\pi} \times \text{asin}\left[\frac{Vdc_{valley}}{Vdc_{min\_pk}}\right]$$

After the selected minimum DC voltage, the minimum input capacitance is obtained by the following equation :

$$C1\_min = \frac{Pin \times (1 - Dch)}{(Vdc_{min\_pk}^{2} - Vdc_{valley}^{2}) \times f_{line}} \quad (F)$$

Output Current Setting

The typical regulated currents are calculated

by the following equation :

IOUT = I1 (if I1 = GND) + I2 (if I2 = GND) + I3 (if I3 = GND) + I4 (if I4 = GND) + I5 (if I5 = GND)

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, the maximum junction temperature is 125°C. The junction to ambient thermal resistance, θ_{JA}, is layout dependent. For SOP-8 (Exposed Pad) package, the thermal resistance, θ_{JA}, is 29°C/W on a standard JEDEC 51-7 four-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) / (29°C/W) = 3.44W for SOP-8 (Exposed Pad) package

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

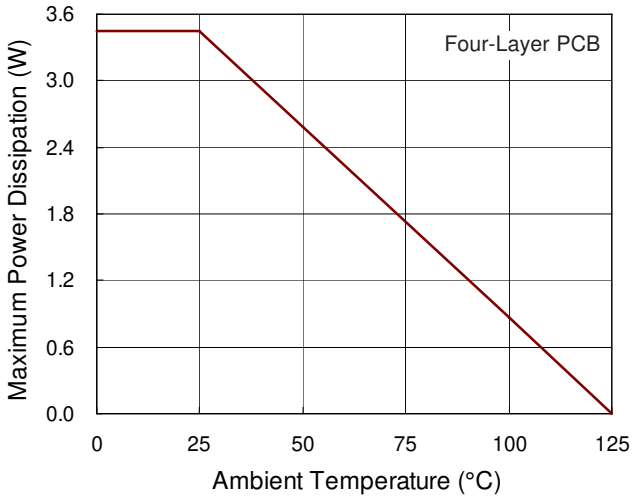
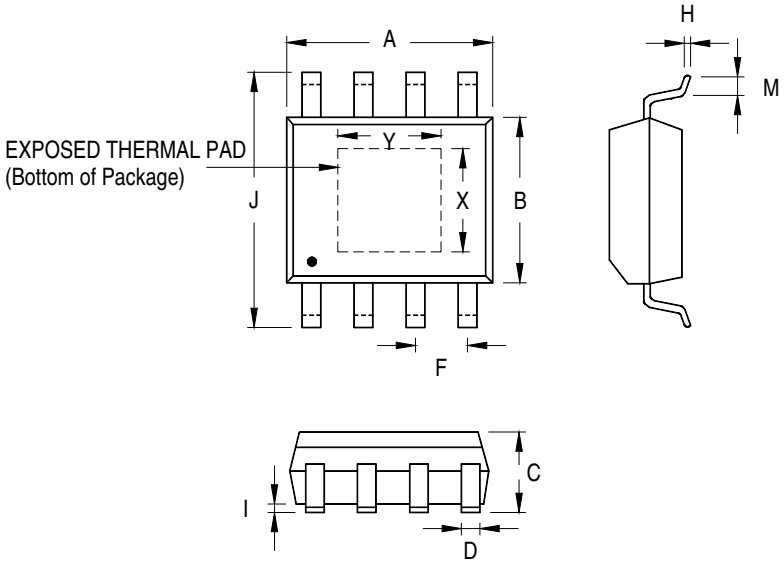


Figure 6. Derating Curve of Maximum Power Dissipation

Layout Considerations

- The thermal resistance θ_{JA} of SOP-8 (Exposed Pad) is determined by the package design and the PCB design. However, the package design had been designed. If possible, it's useful to increase thermal performance by the PCB design. The thermal resistance θ_{JA} can be decreased by adding a copper under the exposed pad of SOP-8 (Exposed Pad) package. The Exposed Pad can be connected the ground or an isolated plane on the PCB.
- The used current setting pins (I1 to I5) must be directly connect to the GND pin with shortest copper paths. Not-used current setting pins (I1 to I5) must be kept open.

Outline Dimension



Symbol		Dimensions In Millimeters		Dimensions In Inches	
		Min	Max	Min	Max
A		4.801	5.004	0.189	0.197
B		3.810	4.000	0.150	0.157
C		1.346	1.753	0.053	0.069
D		0.330	0.510	0.013	0.020
F		1.194	1.346	0.047	0.053
H		0.170	0.254	0.007	0.010
I		0.000	0.152	0.000	0.006
J		5.791	6.200	0.228	0.244
M		0.406	1.270	0.016	0.050
Option 1	X	2.000	2.300	0.079	0.091
	Y	2.000	2.300	0.079	0.091
Option 2	X	2.100	2.500	0.083	0.098
	Y	3.000	3.500	0.118	0.138

8-Lead SOP (Exposed Pad) Plastic Package

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