30V 1.2A Step-Down Dimmable LED Driver

Features

- Wide 6V to 30V Operating Input Range
- 1.2A Continuous Output Current
- Maximum 1MHz Switching Frequency
- Over Temperature Protection
- Inherent Open-Circuit LED Protection
- High-side Current Sense
- Hysteretic Control: No Compensation
- 400mΩ Low $R_{DS(ON)}$ Internal Power MOSFETs
- High efficiency (up to 98%)
- Adjustable Constant LED current
- PWM and Analog Dimming
- Typical 5% Output Current Accuracy
- Available in SOT89-5 Package
- -40°C to +85°C Temperature Range

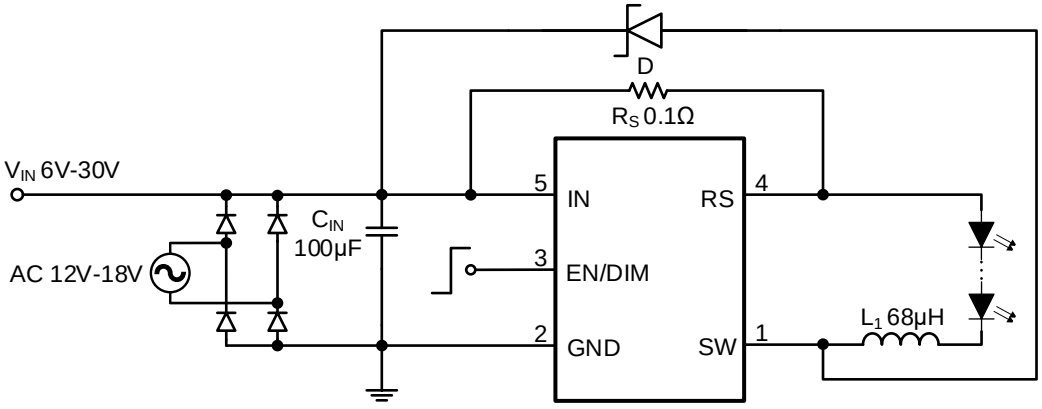
Applications

- Low voltage halogen replacement LEDs
- Automotive/Decorative LED Lighting
- Low-Voltage Halogen Replacement
- Signs/Emergency Lighting
- LED Backlighting
- SELV Lighting

General Description

The RY7312 is step-down regulator for dimmable LED driver, which is designed in continuous current mode for driving the high-brightness LEDs from a wide input voltage of 6V to 30V. The RY7312 employs a hysteretic control scheme to regulate LED current. Moreover, the control scheme provides optimal loop stabilization and a very quick response time. The RY7312 implements PWM and analog dimming together on the EN/DIM pin. The RY7312 includes under-voltage lockout and thermal overload protection to prevent damage in the event of an output overload. The RY7312 requires a minimal number of readily available, external components and is available in a space saving SOT89-5 package.

Typical Application Circuit



Basic Application Circuit

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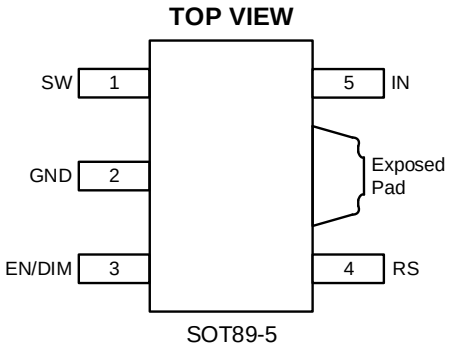
Pin Description

Pin Configuration



Top Marking: JBYLL (device code: JB, Y=year code, LL= lot number code)

Pin Description

Pin	Name	Function
1	SW	Drain of Internal MOSFET. Connect the inductor common terminal and Schottky anode to this pin.
2	GND	Ground.
3	EN/DIM	Enable/Dimming Command Input. For PWM dimming, apply a square wave signal to this pin. For analog dimming, apply a 0.3V-to-2.5V DC voltage to linearly control the LED current range from 25% to 100%. Turn off the output current when pulling this pin below 0.3V.
4	RS	LED Current Sense Input. Connect a current-sense resistor to program the LED average current to IN pin.
5	IN	Input Supply Pin. Connect an appropriate decoupling capacitor from the IN pin to GND.

Order Information

Marking	Part No.	Model	Description	Package	MOQ
JBYLL	70380010	RY7312	RY7312 dimmable LED driver IC, 30V, 1.2A, SOT89-5	SOT89-5	3000PCS

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Absolute Maximum Ratings (1)(2)

V_{IN} V_{SW} V_{RS} Voltage ……..…….... -0.3V to 50V
All Other Pins ...…..……..……..… -0.3 to 50V
Operating Temperature Range ….....-40°C to +85°C
Lead Temperature (Soldering, 10s) …..…..... +260°C
θ_{JA} ……..……..……..……..….....110°C/W
θ_{JC} ……..……..……..….....70°C/W
$V_{EN/DIM}$ Voltage ……....…..... -0.3V to 12V
Storage Temperature Range…….. -65°C to 150°C
Junction Temperature……..……..….....……+150°C
Power Dissipation (PD) @T_A=25°C SOT89-5…...…1.5W
ESD (Human Body Made) HMB……..……...……2KV
ESD (Machine Made) MM……..……....…...….... 200V

Note1: Exceeding these ratings may damage the device.
Note2: The device is not guaranteed to function outside of its operating conditions.

Recommended Operation Conditions

Supply Voltage V_{IN} ……...….... 6V to 40V
Operating Junction Temp. (T_J)……..... -40°C to +125°C

Electrical Characteristics

(V_{IN} = 24V, T_J =-40°C to 125°C (4), unless otherwise noted.)

Parameter	Symbol	Test Conditions	Min	Typ.	Max	Unit
Input Voltage Range	V_{IN}		6.0		30.0	V
IN UVLO Rising Threshold	V_{UVLO}	V_{IN} Rising		5.3	5.9	V
Under-Voltage Lockout Hysteresis	V_{UVLO_HYS}			500		mV
Shutdown Supply Current	I_{SD}			90	150	μA
Feedback Reference Voltage (with respect to V_{IN})	V_{IN-VCS}		94	100	106	mV
Feedback Min Reference Voltage	V_{FB_MIN}		92		108	mV
EN/DIM Input High Voltage	V_{EN_HIGH}		2.5			V
EN/DIM Input Low Voltage	V_{EN_LOW}				0.3	V
EN/DIM Pull-Up Resistor	R_{EN}			200		kΩ
EN/DIM internal supply voltage	V_{DIM}	EN/DIM floating		4		V
Switch On Resistance	$R_{DS\ ON}$			0.4		Ω
Continuous SW current	I_{SW}				1.2	A
SW leakage current	I_{LEAK}			0.5	5	μA
Thermal Shutdown (3)	T_{SD}			160		°C
Thermal Hysteresis (3)	T_{HYS}			20		°C

Note3: Guaranteed by design
Note4: Not test in production, guaranteed by characterization. Typical value represents the most likely parametric norm at +25°C

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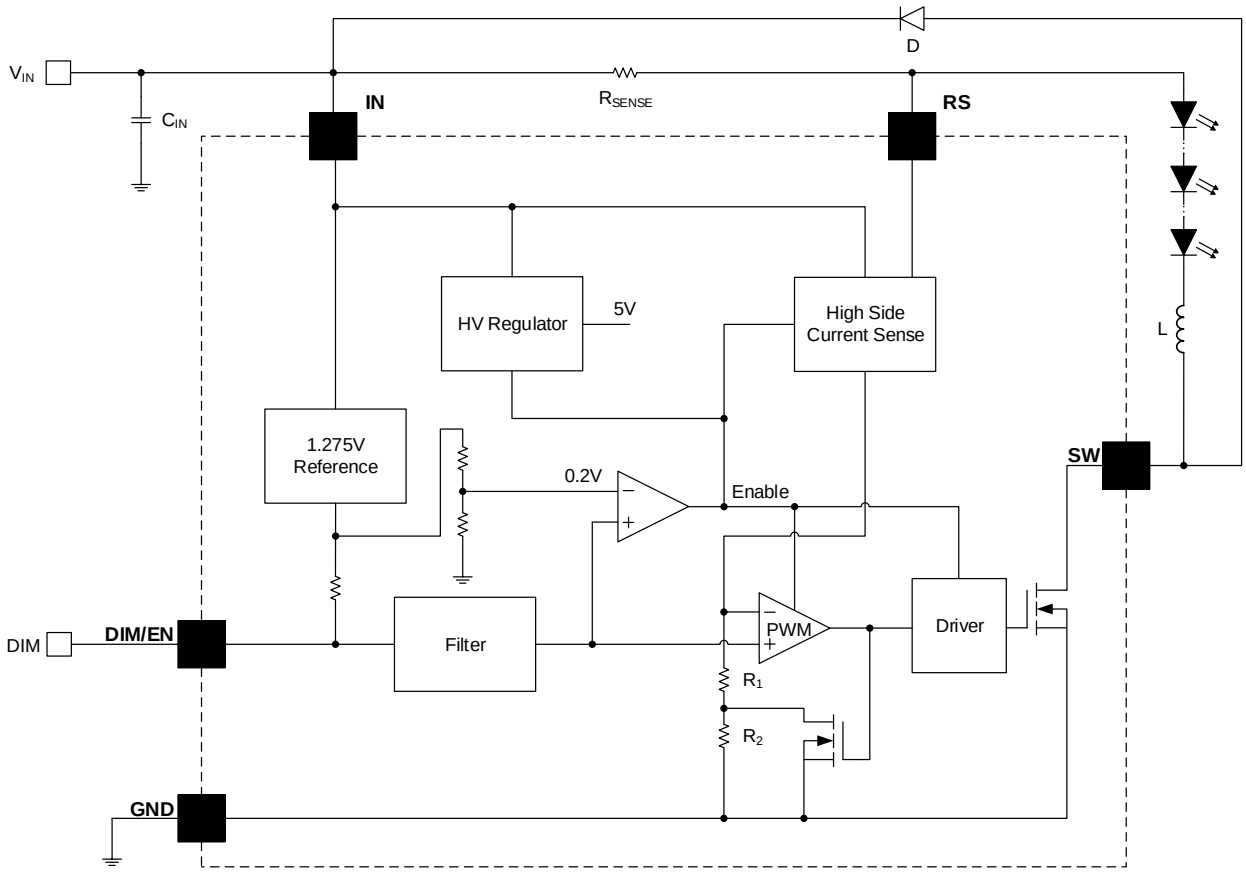
Functional Block Diagram



RY7312 Block Diagram

Operation

Steady State

The RY7312 is a hysteretic-controlled, step down LED driver that is easily configured for various applications with an input range from 6V to 30V. The converter employs a high-side current-sense resistor to detect and regulate the LED current. The voltage across the current sense resistor is measured and regulated to within 100mV±20mV.

When V_{EN}>0.3V, the output of the comparator goes high and the other blocks are enabled. A high-side resistor, R_{SENSE}, senses the output current. When the switch is on, R2 is shorted and R1 sets the output current upper-threshold. When the switch is off, R1 and R2 set the output current lower-threshold, and the ratio of R1 and R2 determines the current hysteresis.

Enable Control

Once Input voltage is applied, the internal reference is connected to EN/DIM pin through pull up resistor. If the EN/DIM pin is left open, the IC automatically starts up to the maximum brightness. Adding a capacitor to this pin can hereby program a soft-start time.

Applying an external voltage range from 0.3V to 2.5V to the EN/DIM pin linearly controls the current-sense voltage reference from 0mV to 100mV for analog dimming.

Applying an external PWM voltage with an amplitude of 2.5V to the EN/DIM pin achieves PWM dimming. For

additional information on the flexible external PWM dimming method, please refer to the "Selecting Dimming Control Mode" section.

System Soft Start

The voltage on the EN/DIM pin is the inductor current reference. An external capacitor from the EN/DIM pin to ground provides a soft-start delay.

Dimming Control

RY7312 provides two dimming methods: PWM dimming and DC analog dimming.
To use PWM dimming, apply a square wave to the EN/DIM pin. To use analog dimming, apply a 0.3V-to-2.5V DC voltage to this pin.

Application Information

Setting the LED Current

The LED current is set by the current-setting resistor between the IN and RS pins, where:

$$R_{SET} = \frac{100mV}{I_{LED}}$$

For R_{SET}=0.2Ω, the LED current is set to 500mA

Selecting the Inductor

Lower value of the inductor results in higher switching frequencies, leading to larger switch loss. For most applications, select a switching frequency between 200kHz and 600kHz. Estimate the inductor value based on the desired switching frequency, where:

$$L = \frac{V_{OUT} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)}{0.4 \times I_{LED} \times f_{SW}}$$

For higher efficiency, use inductors with low DC resistance.

Selecting the Diode

The output diode supplies current flowing path to the inductor when the internal MOSFET is off. To reduce losses due to the diode forward voltage and recovery time, use a Schottky diode. Select a diode rated with a reverse voltage greater than the input voltage. The average current rating must exceed the maximum expected load current, and the peak current rating must exceed the peak inductor current.

Selecting Soft-Start Capacitor

The delay time with the soft-start capacitor can be estimated by 0.2ms/nF. In PWM dimming, select a C<2.2nF to eliminate its effect on the average LED current.

Selecting Dimming Control Mode

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RY7312 provides two dimming methods: DC analog dimming and PWM dimming.

1. DC analog dimming mode

Apply a 0.3V-to-2.5V DC voltage to the EN/DIM pin. The voltage from 0.3V to 2.5V changes the inductor current reference directly and linearly controls the inductor current range from 25% to 100% (see Figure 2).

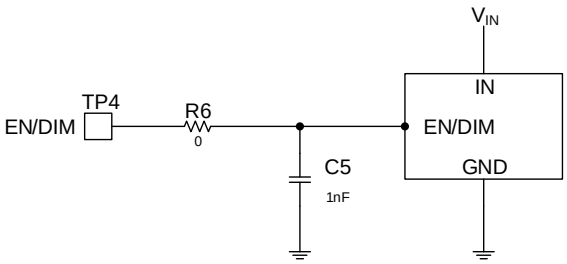


Figure 2: Analog Dimming External Circuit

The average output current is given by:

$$I_{OUT} = \frac{0.1 \times V_{DIM}}{2.5 \times R_S}$$

$0.5V<V_{DIM}<2.5V$

2. PWM dimming mode

Apply a 100Hz-to-2kHz square waveform to the EN/DIM pin. The average LED current is proportional to the PWM duty cycle. Add an NPN transistor on/off circuit to separate the PWM signal from the current reference (see Figure 3) because this pin is pulled up by the 1.25V internal source as the inductor current reference. The minimum PWM amplitude is 1.5V.

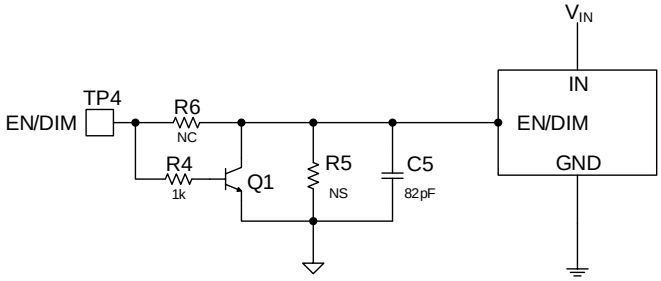
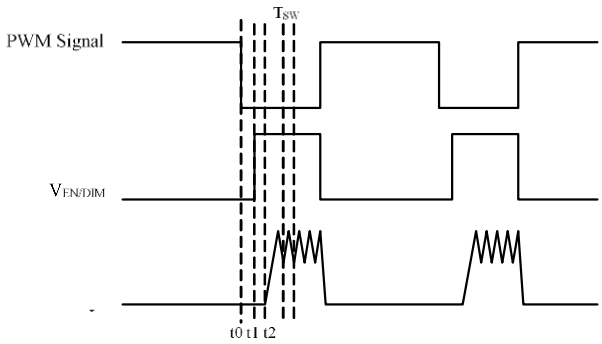


Figure 3: PWM Dimming External Circuit



t0-t1: Delay time caused by transistor turning-off. t1 is about 1us-2us t1-t2: Delay time caused by signal transmission (less than 1us).

T_{SW}: one switching period

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The average LED current is proportional to duty cycle of PWM signal. For good PWM dimming linearity, inductor current has to achieve the peak threshold during PWM on time. The minimum PWM duty cycle can be estimated as below：

$$\frac{D_{MIN}}{f_{PWM}} = t1 + t2 + 4 \times D \times T_{SW}$$

Circuit Layout Consideration

Pay careful attention to the PCB board layout and components placement. R_{SENSE} should be placed close to the IN pin and RS pin to minimize set current error. The input loop including the input capacitor, Schottky diode, and internal MOSFET should be as short as possible.

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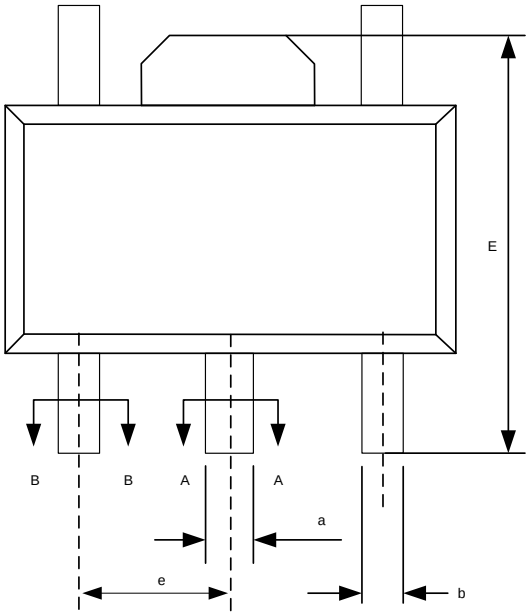
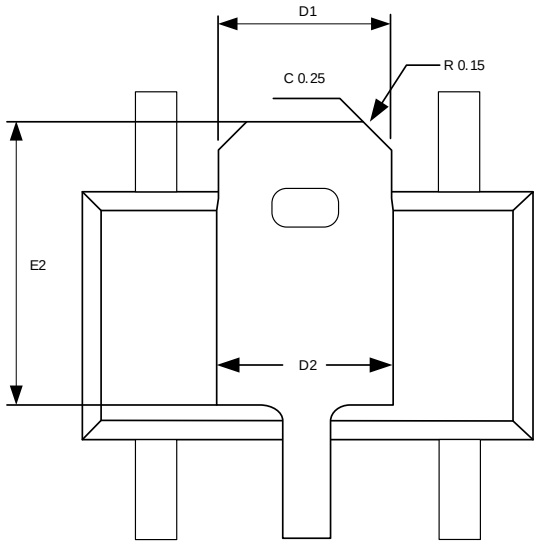
Package Description

SOT89-5

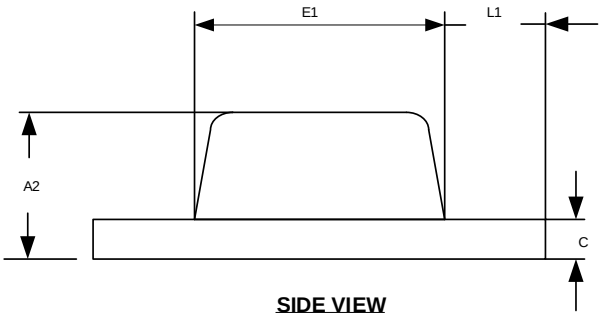


TOP VIEW



BOTTOM VIEW

FRONT VIEW



SIDE VIEW

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A2	1.40	1.50	1.60
b	0.38	-	0.46
a	0.46	-	0.56
D	4.40	4.50	4.60
E	4.00	4.20	4.40
E1	2.40	2.50	2.60
e	1.50BSC		
L1	0.80	1.00	1.20

Size(mm) / L/F Size(mil)	D1	D2	E2
85×70	1.70REF	1.75REF	2.84REF

NOTE:
1. CONTROL DIMENSION IS IN INCHES. DIMENSION IN BRACKET IS IN MILLIMETERS.
2. PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
3. PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
4. LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.004" INCHES MAX.
5. DRAWING CONFORMS TO JEDEC MS-012, VARIATION BA.
6. DRAWING IS NOT TO SCALE.