PR8910

Universal High Brightness LED Driver

Features

- Switch mode controller for single switch LED drivers
- Open loop peak current controller
- Internal 18.0 to 450V linear regulator
- Applications from a few mA to more than 1A output
- Constant frequency or constant off-time operation
- Linear and PWM dimming capability
- Requires few external components for operation

Applications

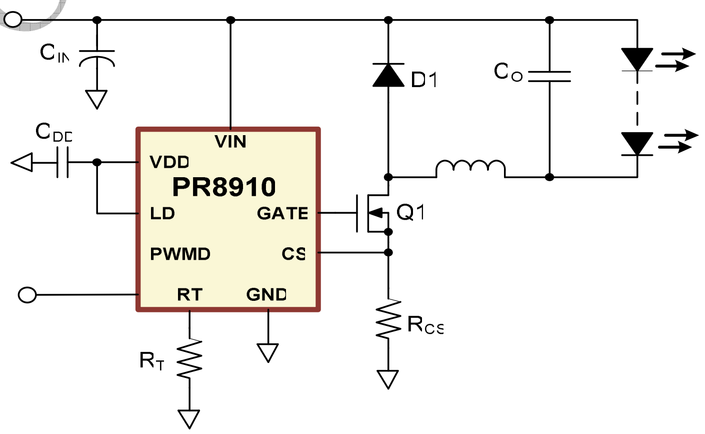
- DC/DC or AC/DC LED Driver applications
- RGB Backlighting LED Driver
- Back Lighting of Flat Panel Displays
- General purpose constant current source
- Signage and Decorative LED Lighting
- Automotive
- Chargers

General Description

The PR8910 is an open loop, current mode, control LED driver IC. The PR8910 can be programmed to operate in either a constant frequency or constant off-time mode. It includes an 18.0 - 450V linear regulator which allows it to work from a wide range of input voltages without the need for an external low voltage supply. The PR8910 includes a PWM dimming input that can accept an external control signal with a duty ratio of 0 - 100% and a frequency of up to a few kilohertz. It also includes a 0 - 250mV linear dimming input which can be used for linear dimming of the LED current.

The PR8910 is ideally suited for buck LED drivers. Since the PR8910 operates in open loop current mode control, the controller achieves good output current regulation without the need for any loop compensation. PWM dimming response is limited only by the rate of rise and fall of the inductor current, enabling very fast rise and fall times. The PR8910 requires only three external components (apart from the power stage) to produce a controlled LED current making it an ideal solution for low cost LED drivers.

Typical Application Circuit



ORDERING INFORMATION

DEVICE	PACKAGE-PIN	TEMP RANGE
PR8910S	SOP-8L	-40°C to 85°C
PR8910T	DIP-8L	-40°C to 85°C

Absolute Maximum Ratings

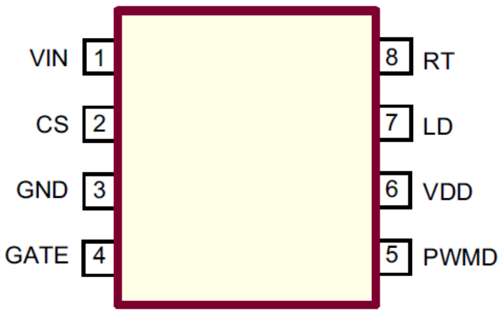
Parameter	Value
V_{IN} to GND	-0.5V to +700V
V_{DD} to GND	10V
CS, LD, PWMD, GATE, RT to GND	-0.3V to (V_{DD}+0.3V)
Junction temperature range	-40°C to +150°C
Storage temperature range	-65°C to +150°C

Stresses beyond those listed under "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 for extended periods may affect device reliability.

Thermal Resistance

Package	θja
SOP-8L	120℃/W

Pin Description



SOP-8L

Electrical Characteristics

(Over recommended operating conditions unless otherwise specified - T_A = 25° C)

Sym	Description	Min	Typ	Max	Units	Conditions
V_{INDC}	Input DC supply voltage range	18.0	-	450	V	DC input voltage
I_{INsd}	Shut-down mode supply current	-	0.3	1	mA	Pin PWMD to GND, V_{IN} = 8V
V_{DD}	Internally regulated voltage	7.0	7.5	8.0	V	V_{IN} = 18 – 450V, $I_{DD(ext)}$ = 0, pin GATE open
V_{DDmax}	Maximal pin V_{DD} voltage	-	-	10	V	When an external voltage applied to pin V_{DD}
$I_{DD(ext)}$	V_{DD} current available for external circuitry [1]	-	-	1.0	mA	V_{IN} = 18 – 100V
UVLO	V_{DD} undervoltage lockout threshold	6.45	6.7	6.95	V	V_{IN} rising
ΔUVLO	V_{DD} undervoltage lockout hysteresis	-	600	-	mV	V_{IN} falling
$V_{EN(lo)}$	Pin PWMD input low voltage	-	-	1.1	V	V_{IN} = 18 – 450V
$V_{EN(hi)}$	Pin PWMD input high voltage	1.5	-	-	V	V_{IN} = 18 – 450V
R_{EN}	Pin PWMD pull-down resistance	50	100	150	kΩ	V_{EN} = 5V
$V_{CS(hi)}$	Current sense pull-in threshold voltage	225	250	275	mV	@T_A = -40°C to +85°C
$V_{GATE(hi)}$	GATE high output voltage	V_{DD}-0.3	-	V_{DD}	V	I_{OUT} = 10mA

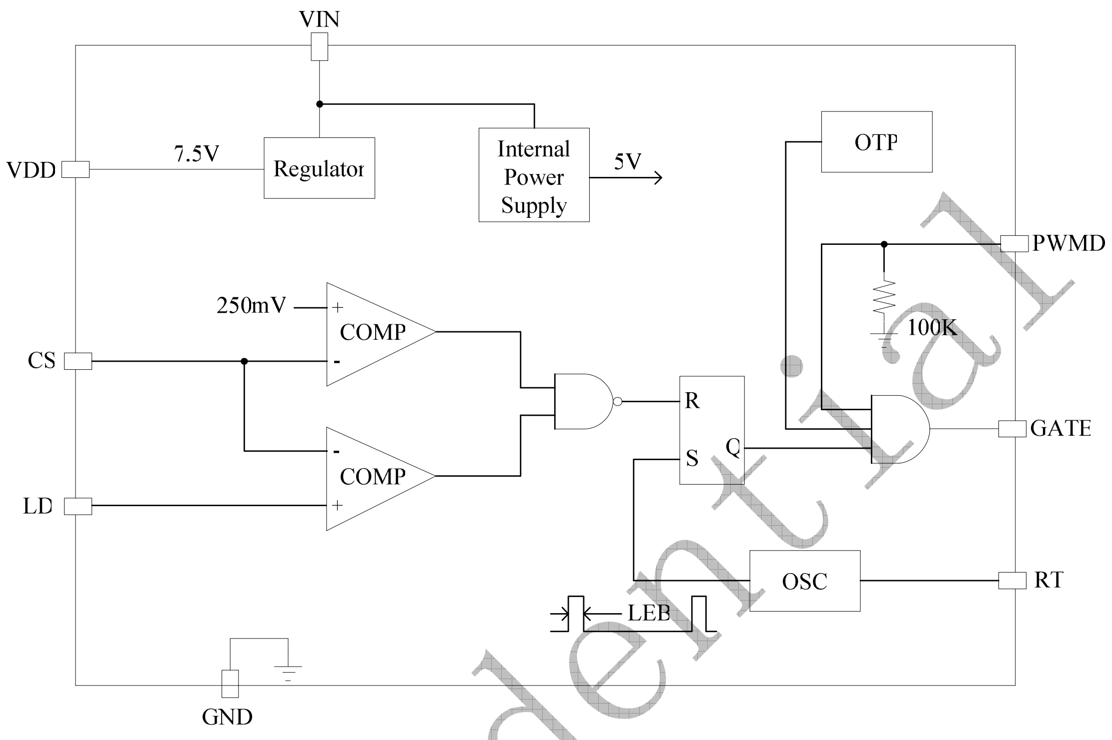
Sym	Description	Min	Typ	Max	Units	Conditions
$V_{GATE(lo)}$	GATE low output voltage	0	-	0.3	V	I_{OUT} = -10mA
f_{OSC}	Oscillator frequency	20 80	25 100	30 120	kHz kHz	R_T = 1.00MΩ R_T = 226kΩ
D_{MAXhf}	Maximum PWM duty cycle	-	-	100	%	F_{PWMhf} = 25kHz, at GATE, CS to GND.
V_{LD}	Linear dimming pin voltage range	0	-	250	mV	@T_A = <85°C, V_{IN} = 12V
T_{BLANK}	Current sense blanking interval	150	230	310	ns	V_{CS} = 0.55V_{LD}, V_{LD} = V_{DD}
t_{DELAY}	Delay from CS trip to GATE lo	-	-	300	ns	V_{IN} = 12V, V_{LD} = 0.15, V_{CS} = 0 to 0.22V after T_{BLANK}
t_{RISE}	GATE output rise time	-	30	50	ns	C_{GATE} = 500pF
t_{FALL}	GATE output fall time	-	30	50	ns	C_{GATE} = 500pF
Vth_{OTP}	Over temperature protection threshold		160		℃	
hys_{OTP}	OTP hysteresis		25		℃	

[1] *Also limited by package power dissipation limit, whichever is lower.*

Pinout

Pin	SOP-8L	Description
V_{IN}	1	Input voltage 18V to 450V DC
CS	2	Senses LED string current
GND	3	Device ground
GATE	4	Drives the gate of the external MOSFET
PWMD	5	Low Frequency PWM Dimming pin, also Enable input. Internal 100kΩ pull-down to GND
V_{DD}	6	Internally regulated supply voltage (7.5V nominal). Can supply up to 1mA for external circuitry. A sufficient storage capacitor is used to provide storage when the rectified AC input is near the zero crossings.
LD	7	Linear dimming by changing the current limit threshold at current sense comparator
R_T	8	Oscillator control. When a resistor is connected between RT and GND, the PR8910 operates in constant frequency mode. When the resistor is connected between RT and GATE, the IC operates in constant off-time mode.

Block Diagram



Application Information

AC/DC Off-Line Applications

The PR8910 is a low-cost off-line buck or boost converter control IC specifically designed for driving multi-LED stings or arrays. It can be operated from either universal AC line or any DC voltage between 18-450V. Optionally, a passive power factor correction circuit can be used in order to pass the AC harmonic limits set by EN 61000-3-2 Class C for lighting equipment having input power less than 25W. The PR8910 can drive up to hundreds of High-Brightness (HB) LEDs or multiple strings of HB LEDs. The LED arrays can be configured as a series or series/parallel connection. The PR8910 regulates constant current that ensures controlled brightness and spectrum of the LEDs, and extends their lifetime. The PR8910 features an enable pin (PWMD) that allows PWM control of brightness.

The PR8910 can also control brightness of LEDs by programming continuous output current of the LED driver (so-called linear dimming) when a control voltage is applied to the LD pin.

The PR8910 is offered in a standard SOP8 package.

The PR8910 includes an internal high-voltage linear regulator that powers all internal circuits and can also serve as a bias supply for low voltage external circuitry.

LED Driver Operation

The PR8910 can control all basic types of converters, isolated or non-isolated, operating in continuous or discontinuous conduction mode. When the gate signal enhances the external power MOSFET, the LED driver stores the input energy in an inductor or in the primary inductance of a transformer and depending on the converter type, may partially deliver the energy directly to LEDs The energy stored in the magnetic component is further delivered to the output during the off cycle of the power MOSFET producing current through the string of LEDs (Flyback mode of operation).

When the voltage at the V_{DD} pin exceeds the UVLO threshold the gate drive is enabled. The output current is controlled by means of limiting peak current in the external power MOSFET. A current sense resistor is connected in series with the source terminal of the MOSFET. The voltage from the sense resistor is applied to the CS pin of the PR8910. When the voltage at CS pin exceeds a peak current sense voltage threshold, the gate drive signal terminates, and the power MOSFET turns off. The threshold is internally set to 250mV, or it can be programmed externally by applying voltage to the LD pin. When soft start is required, a capacitor can be connected to the LD pin to allow this voltage to ramp at a desired rate, therefore, assuring that output current of the LED ramps gradually.

Optionally, a simple passive power factor correction circuit, consisting of 3 diodes and 2 capacitors, can be added to the typical application circuit.

Supply Current

A current of 1mA is needed to start the PR8910. As shown in the block diagram on page 7, this current is internally generated in the PR8910 without using bulky startup resistors typically required in the offline applications. Moreover, in many applications the PR8910 can be continuously powered using its internal linear regulator that provides a regulated voltage of 7.5V for all internal circuits.

Setting Light Output

When the buck converter topology of Figure 2 is selected, the peak CS voltage is a good representation of the average current in the LED. However, there is a certain error associated with this current sensing method that needs to be accounted for. This error is introduced by the difference between the peak and the average current in the inductor. For example if the peak-to-peak ripple current in the inductor is 150mA, to get a 500mA LED current, the sense resistor should be 250mV/(500mA+ 0.5*150mA) = 0.43Ω.

Dimming

Dimming can be accomplished in two ways, separately or combined, depending on the application. Light output of the LED can be controlled either by linear change of its current, or by switching the current on and off while maintaining it constant. The second dimming method (so-called PWM dimming) controls the LED brightness by varying the duty ratio of the output current.

The linear dimming can be implemented by applying a control voltage from 0 to 250mV to the LD pin. This control voltage overrides the internally set 250mV threshold level of the CS pin and programs the output current accordingly. For example, a potentiometer connected between V_{DD} and ground can program the control voltage at the CS pin. Applying a control voltage higher than 250mV will not change the output current setting. When higher current is desired, select a smaller sense resistor.

The PWM dimming scheme can be implemented by applying an external PWM signal to the PWMD pin. The PWM signal can be generated by a microcontroller or a pulse generator with a duty cycle proportional to the amount of desired light output. This signal enables and disables the converter modulating the LED current in the PWM fashion. In this mode, LED current can be in one of the two states: zero or the nominal current set by the current sense resistor. It is not possible to use this method to achieve average brightness levels higher than the one set by the current sense threshold level of the PR8910. By using the PWM control method of the PR8910, the light output can be adjusted between zero and 100%. The accuracy of the PWM dimming method is limited only by the minimum gate pulse width, which is a fraction of a percent of the low frequency duty cycle.

Oscillator

The oscillator in the PR8910 is controlled by a single resistor connected at the RT pin. The equation governing the oscillator time period t_{OSC} is given by:

$$t_{OSC(us)} = \frac{R_{T(K\Omega)} + 22}{25}$$

If the resistor is connected between RT and GND, PR8910 operates in a constant frequency mode and the above equation determines the time-period. If the resistor is connected between RT and GATE, the PR8910 operates in a constant off-time mode and the above equation determines the off time.

Power Factor Correction

When the input power to the LED driver does not exceed 25W, a simple passive power factor correction circuit can be added to the PR8910 typical application circuit in order to pass the AC line harmonic limits of the EN61000-3-2 standard for Class C equipment. A simple circuit consisting of 3 diodes and 2 capacitors can be added across the rectified AC line input to improve the line current harmonic distortion and to achieve a power factor greater than 0.85.

Inductor Design

Referring to the typical application circuit on page 7 the value can be calculated from the desired peak-to-peak LED ripple current in the inductor. Typically, such ripple current is selected to be 30% of the nominal LED current. In the example given here, the nominal current I_{LED} is 350mA.

The next step is determining the total voltage drop across the LED string. For example, when the string consists of 10 High-Brightness LEDs and each diode has a forward voltage drop of 3.0V at its nominal current; the total LED voltage V_{LEDS} is 30V.

Knowing the nominal rectifi ed input voltage V_{IN} = 120V*1.41 = 169V, the switching duty ratio can be determined, as:

$D = V_{LEDs}/V_{IN} = 30/169 = 0.177$

Then, given the switching frequency, in this example f_{OSC} = 50KHz, the required on-time of the MOSFET transistor can be calculated:

$T_{ON} = D/f_{OSC}$ = 3.5 microsecond

The required value of the inductor is given by:

$L = (V_{IN} - V_{LEDs}) * T_{ON}/(0.3 * I_{LED})$ = 4.6mH

Input Bulk Capacitor

An input filter capacitor should be designed to hold the rectified AC voltage above twice the LED string voltage throughout the AC line cycle. Assuming 15% relative voltage ripple across the capacitor, a simplified formula for the minimum value of the bulk input capacitor is given by:

$C_{MIN} = I_{LED} * V_{LEDs} * 0.06 / V_{IN}$^2
C_{MIN} = 22 μF, a value 22μF/250V can be used.

A passive PFC circuit at the input requires using two series connected capacitors at the place of calculated C_{MIN}. Each of these identical capacitors should be rated for 1/2 of the input voltage and have twice as much capacitance.

Enable

The PR8910 can be turned off by pulling the PWMD pin to ground. When disabled, the PR8910 draws quiescent current of less than 1mA.

Output Open Circuit Protection

When the buck topology is used, and the LED is connected in series with the inductor, there is no need for any protection against an open circuit condition in the LED string. Open LED connection means no switching and can be continuous.

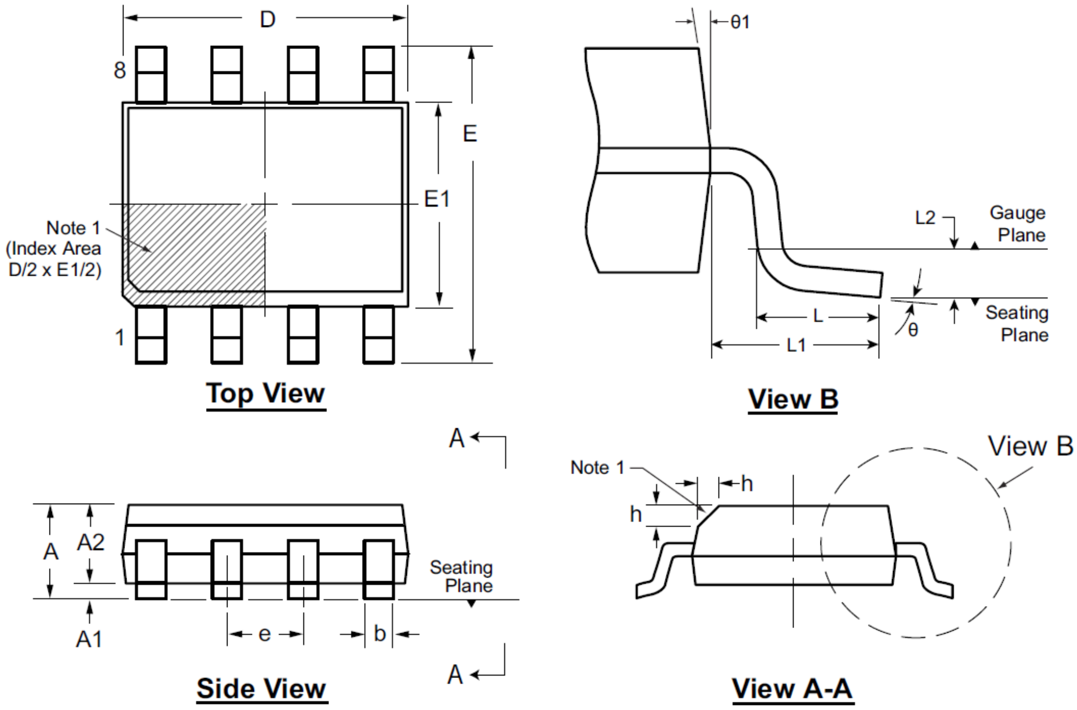
DC/DC Low Voltage Applications

Buck Converter Operation

The buck power conversion topology can be used when the LED string voltage is needed to be lower than the input supply voltage. The design procedure for a buck LED driver outlined in the previous chapters can be applied to the low voltage LED drivers as well. However, the designer must keep in mind that the input voltage must be maintained higher than 2 times the forward voltage drop across the LEDs. This limitation is related to the output current instability that may develop when the PR8910 buck converter operates at a duty cycle greater than 0.5. This instability reveals itself as an oscillation of the output current at a sub-harmonic of the switching frequency.

SOP-8L Package Outline

4.90x3.90mm body, 1.75mm height (max), 1.27mm pitch



Note:
This chamfer feature is optional. A Pin 1 identifier must be located in the index area indicated. The Pin 1 identifier can be: a molded mark/identifier; an embedded metal marker; or a printed indicator.

Symbol		A	A1	A2	b	D	E	E1	e	h	L	L1	L2	θ	θ1
Dimension (mm)	MIN	1.35	0.10	1.25	0.31	4.80	5.80	3.80	1.27 BSC	0.25	0.40	1.04 REF	0.25 BSC	0°	5°
	NOM	-	-	-	-	4.90	6.00	3.90		-	-			-	-
	MAX	1.75	0.25	1.65*	0.51	5.00	6.20	4.00		0.50	1.27			8°	15°