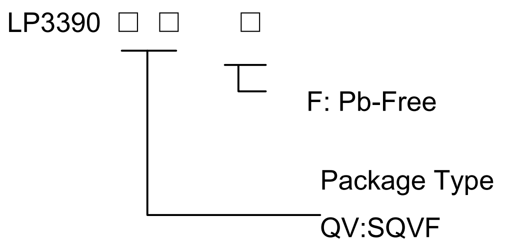
High Performance, Constant Current Switching for White LED and Boost Convertor

General Description

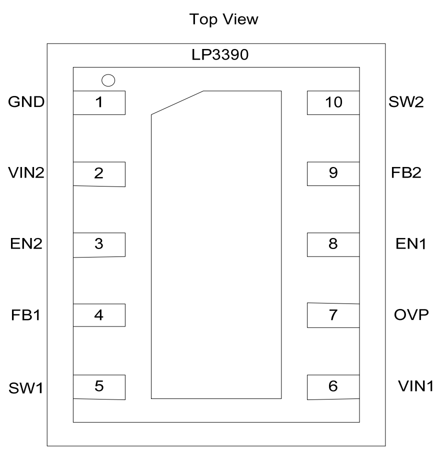
The LP3390 is designed for constant- current white LED driver applications. It can drive a string of up to 8 white LED from a 3.3V supply or 3S9P white LED from a 5V supply in series. To improve efficiency, the feedback voltage is set to 200mV, which reduces the power dissipation in the current setting resistor.

LP3390 also has constant-voltage boost applications and FB voltage is 1250mV. LP3390 implements a constant frequency 1.2MHz PWM control scheme. The high frequency PWM operation also saves board space by reducing external component sizes. Optimized operation frequency can meet the requirement of small LC filters value and low operation current with high efficiency.

Order Information



Pin Configurations



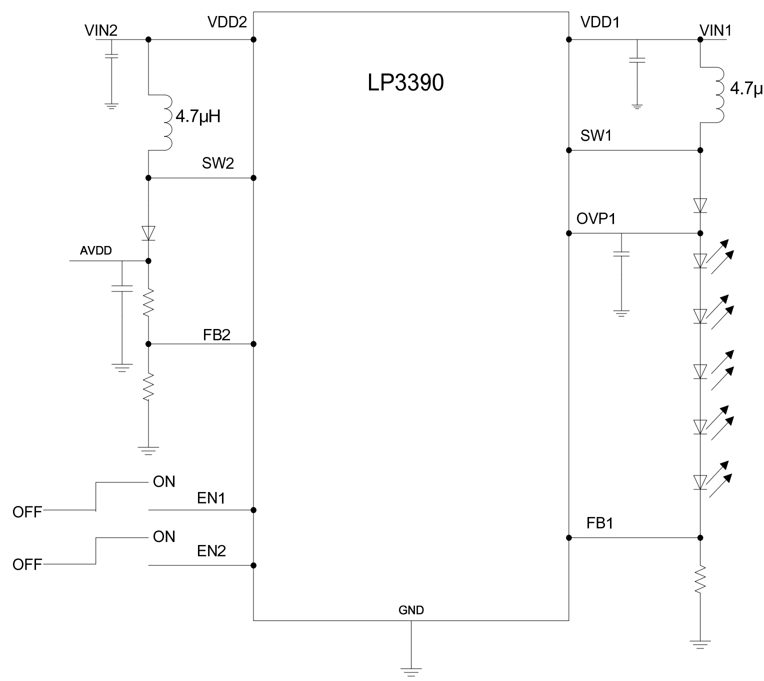
Features

- ●High Efficiency: 95%
- ●1.2MHzFixed-Frequency PWM Operation
- ●Maximum Output Voltage up to 30V
- ●Operating Range : 2.7V to 6V
- ●Shutdown Supply Current:<1uA
- ●Available in SOT23-6 Package
- ●Minimize the External Component.
- ●RoHS Compliant and 100% Lead (Pb)-Free

Applications

- ✧ WLED Backlight driver
- ✧ Panel Bias Voltage supply

Typical Application Circuit



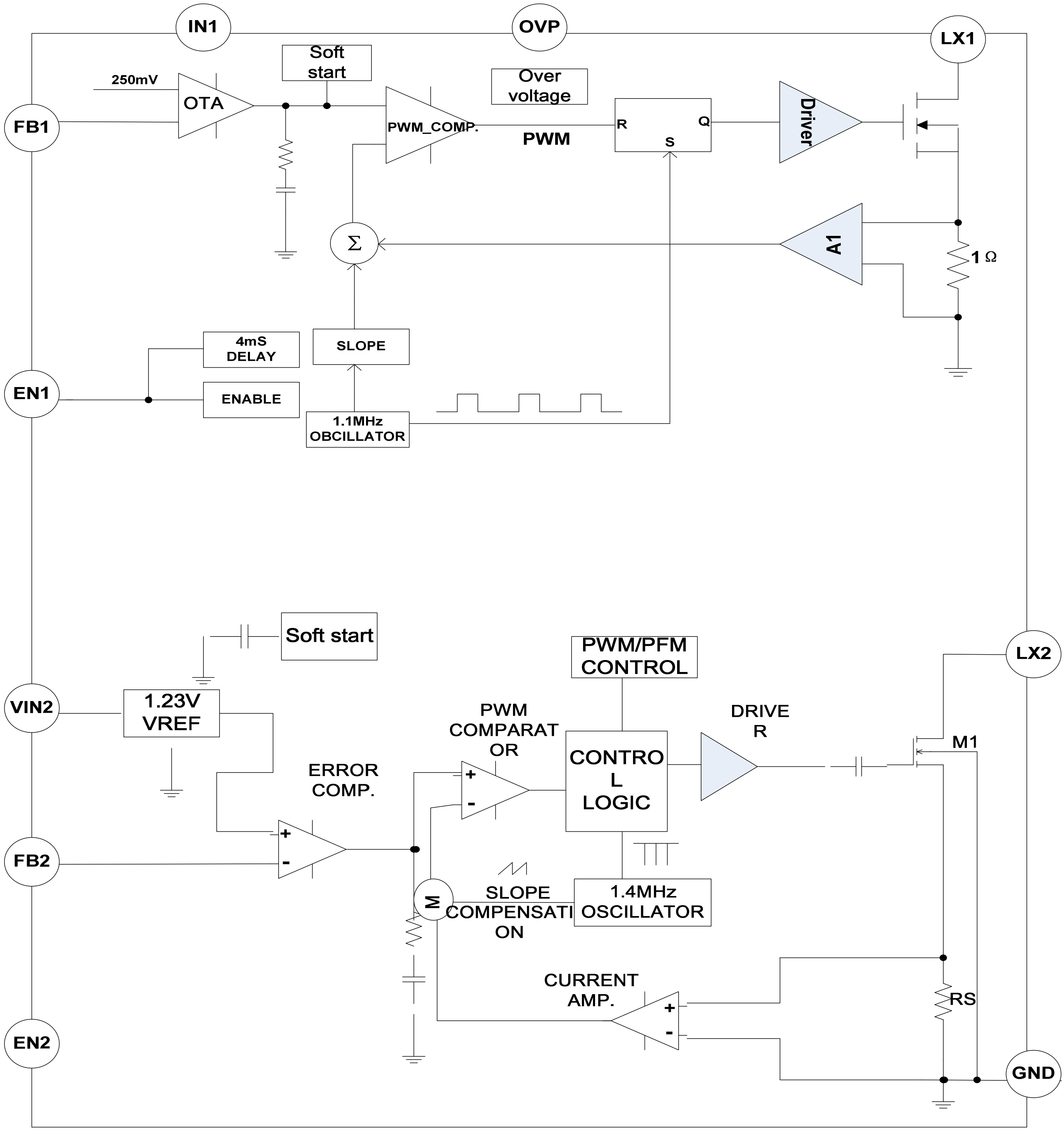
Marking Information

Device	Marking	Package	Shipping
LP3390QVF	LPS LP3390 XXXX	QV:SQVF	3K/reel

Functional Pin Description

Pin Number	Pin Name	Pin Function
1	GND	Ground Pin
2	VIN2	Supply Input Voltage Pin. Bypass 1uF capacitor to GND to reduce the input noise.
3	EN2	Chip Enable (Active High). Voltage sensing input to trigger the function of over voltage protection. Note that this pin is high impedance. There should be a pull low 100kΩ resistor connected to GND when the control signal is floating.
4	FB1	Feedback Reference Voltage Pin. Series connect a resistor between WLED and ground as a current sense. Sense the current feedback voltage to set the current rating. FB voltage is 200mV.
5	SW1	Switch Pin. Connect this Pin to inductor and catch diode. Minimize the track area to reduce EMI.
6	VIN1	Supply Input Voltage Pin. Bypass 1uF capacitor to GND to reduce the input noise.
7	OVP	OVP Pin. Overvoltage Sense. When VOUT is greater than 29V, the internal N-channel MOSFET turns off until VOUT drops below 29V, then the IC reenters start. Connect a 1uF capacitor from OUT to GND
8	EN1	Chip Enable (Active High). Voltage sensing input to trigger the function of over voltage protection. Note that this pin is high impedance. There should be a pull low 100kΩ resistor connected to GND when the control signal is floating.
9	FB2	Feedback Reference Voltage Pin. Series connect a resistor between WLED and ground as a current sense. Sense the current feedback voltage to set the current rating. FB voltage is 1250mV.
10	SW2	Switch Pin. Connect this Pin to inductor and catch diode. Minimize the track area to reduce EMI.

Function Block Diagram



Absolute Maximum Ratings

- ✧ Supply Input Voltage--−0.3V to 5.5V
- ✧ LX Input Voltage ---−0.3V to 36V
- ✧ OVP Voltage--−0.3V to 32V
- ✧ The Other Pins --−0.3V to 5.5V
- ✧ Power Dissipation, PD @ TA = 25°C SOT-23-6 ---0.455W
- ✧ Lead Temperature (Soldering, 10 sec.) --- 260°C
- ✧ Operation Temperature Range -- -−40°C to 80°C
- ✧ Storage Temperature Range ---−65°C to 150°C

Electrical Characteristics

Parameter	Symbol	Test Condition	Min	Typ.	Max	Units
System Supply Input						
Operation voltage Range	VDD		2.5		5.5	V
Under Voltage Lock Out	UVLO			2.3		V
Supply Current	IDD	FB=0V, Switching		0.8	1.3	mA
Shut Down Current	IDD	VEN < 0.4V		0.1	1	uA
Line Regulation		VIN : 3.0~4.3V		3		%
Oscillator						
Operation Frequency	FOSC			1.2		MHz
Maximum Duty Cycle			89	92	96	%
Dimming Frequency			100		1M	Hz
Feedback1 Voltage	LP3390		185	200	215	mV
Feedback2Voltage			1220	1250	1280	mV
MOSFET						
On Resistance of MOSFET	RDS(ON)			0.5		Ω
Protection						
OVP Threshold	VOVP			29		V
OVP Sink Current				5		μA
OCP				1250		mA
Shut Down Voltage	VEN				0.4	V
Enable Voltage	VEN		1.5			V

Application Information

LED Current Setting

The loop of Boost structure will keep the FB pin voltage equal to the reference voltage VREF.

FB voltage is 200mV,Therefore, when RSET connects FB pin and GND, the current flows from VOUT through LED and RSET to GND will be decided by the current on RSET, which is equal to following equation:

$$I_{LED} = \frac{V_{REF}}{R_{SET}}$$

Dimming Control

a. Using a PWM Signal to EN Pin

For the brightness dimming control of the LP3390, the IC provides typically 200mV feedback voltage when the EN pin is pulled constantly high. However, EN pin allows a PWM signal to reduce this regulation voltage by changing the PWM duty cycle to achieve LED brightness dimming control. The relationship between the duty cycle and FB voltage can be calculated as following equation:

V_{FB} = Duty x 200mV

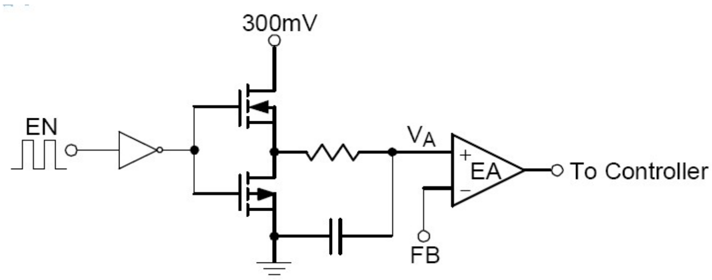
Where

Duty = duty cycle of the PWM signal
200mV = internal reference voltage

The duty cycle of the PWM signal is used to cut the internal 200mV reference voltage. An internal low pass filter is used to filter the pulse signal. And then the reference voltage can be made by connecting the output of the filter to the error amplifier for the FB pin voltage regulation.

However, the internal low pass filter 3db frequency is 500Hz. When the dimming frequency is lower then 500Hz, VA is also a PWM signal and the LED current is controlled directly by this signal. When the frequency is higher than 500Hz, PWM is filtered by the internal low pass filter and the VA approach a DC signal. And the LED current is a DC current which elimate the audio noise. Two figures of PWM Dimming from EN are shown in Typical Operating Characteristics section and the PWM dimming frequency is 100Hz and 1MHz respectively.

But there is an offset in error amplifier which will cause the VA variation. In low PWM duty signal situation, the filtered reference voltage is low and the offset can cause bigger variation of the output current. So the LP3390 is not recommend to be dimming by the EN pin. For the LP3390, the minimum duty vs frequency is listed in following table:



b. Using a DC Voltage

Using a variable DC voltage to adjust the brightness is a popular method in some applications. The dimming control using a DC voltage circuit. The output voltage can be calculated by the following Equations.

$$V_{OUT} = V_{REF} \times \frac{R1+R2}{R2} \text{ ; } R2 > 10k$$

c. Using a Filtered PWM signal

Another common application is using a filtered PWM signal as an adjustable DC voltage for LED dimming control. A filtered PWM signal acts as the DC voltage to regulate the output current. In this circuit, the output ripple depends on the frequency of PWM signal. For smaller output voltage ripple (<100mV), the recommended frequency of 2.8V PWM signal should be above 2kHz. To fix the frequency of PWM signal and change the duty cycle of PWM signal can get different output current. The LED current can be calculated by the following equation.

$$I_{LED} = \frac{V_{REF} - \dfrac{R3 \times (V_{PWM} \times Duty - V_{REF})}{R4 + R_{DC}}}{R_{SET}}$$

Constant Output Voltage Control

The output voltage of the LP3390 can be adjusted by the divider circuit on the FB pin. The output voltage can be calculated by the following Equations.

$$V_{OUT} = V_{REF} \times \frac{R1+R2}{R2} \text{ ; } R2 > 10k$$

Power Sequence

In order to assure the normal soft start function for suppressing the inrush current the input voltage should be ready before EN pulls high.

Soft-Start

The function of soft-start is made for suppressing the inrush current to an acceptable value at the beginning of power on. The LP3390 provides a built-in soft-start function by clamping the output voltage of error amplifier so that the duty cycle of the PWM will be increased gradually in the soft-start period.

Current Limiting

The current flow through inductor as charging period is detected by a current sensing circuit. As the value comes across the current limiting threshold, the N-MOSFET will be turned off so that the inductor will be forced to leave charging stage and enter discharging stage. Therefore, the inductor current will not increase over the current limiting threshold.

OVP/UVLO/OTP

The Over Voltage Protection is detected by a junction breakdown detecting circuit. Once VOUT goes over the detecting voltage, LX pin stops switching and the power N-MOSFET will be turned off. Then, the VOUT will be clamped to be near VOVP. As the output voltage is higher than a specified value or input voltage is lower than a specified value, the chip will enter protection mode to prevent abnormal function. As the die temperature is higher then 160°C, the chip also will enter protection mode. The power MOSFET will be turned off during protection mode to prevent abnormal operation.

Thermal Considerations

For continuous operation, do not exceed absolute maximum operation junction temperature. The maximum power dissipation depends on the thermal resistance of IC package, PCB layout, the rate of surroundings airflow and temperature difference between junction to ambient. The maximum power dissipation can be calculated by following formula :

$$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$$

Where TJ(MAX) is the maximum operation junction temperature, TA is the ambient temperature and the qJA is the junction to ambient thermal resistance.

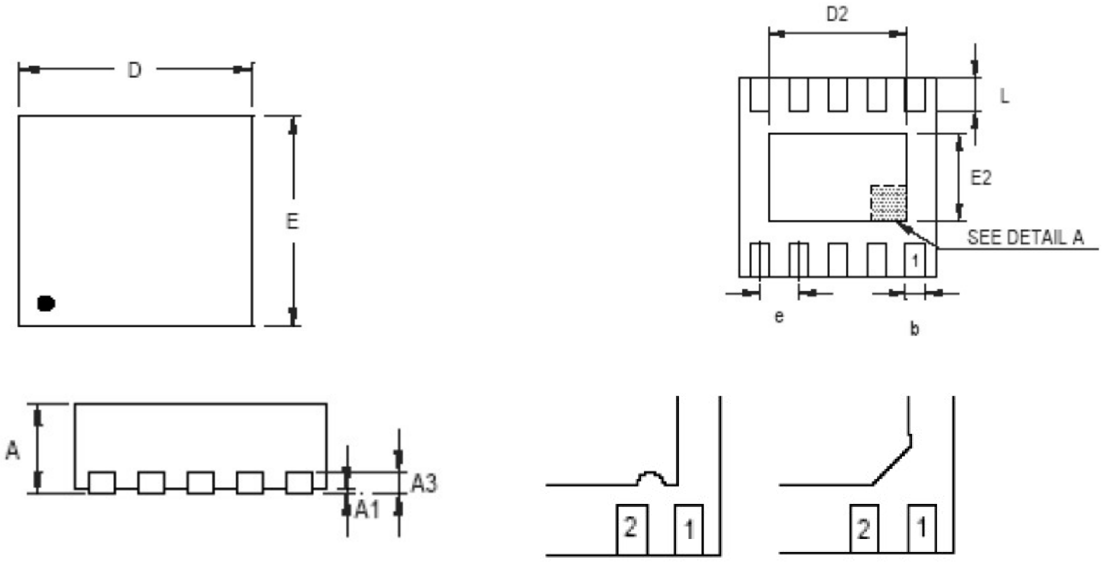
For the recommended operating conditions specification of LP3390, the maximum junction temperature of the die is 125°C. The junction to ambient thermal resistance Qja is layout dependent.

Layout Consideration

For best performance of the LP3390, the following guidelines must be strictly followed.

- Input and Output capacitors should be placed close to the IC and connected to ground plane to reduce noise coupling.
- The GND and Exposed Pad should be connected to a strong ground plane for heat sinking and noise protection.
- Keep the main current traces as possible as short and wide.
- LX node of DC-DC converter is with high frequency voltage swing. It should be kept at a small area.
- Place the feedback components as close as possible to the IC and keep away from the noisy devices.

Packaging Information



DETAIL A

Pin#1 ID and TIE Bar Mark Options

Note: The configuration of Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.175	0.250	0.007	0.010
b	0.180	0.300	0.007	0.012
D	2.950	3.050	0.116	0.120
D2	2.300	2.650	0.091	0.104
E	2.950	3.050	0.116	0.120
E2	1.500	1.750	0.059	0.069
e	0.500		0.020	
L	0.350	0.450	0.014	0.018