MP3308

Step-up White LED Driver with Dual PWM Dimming Input Control

The Future of Analog IC Technology

DESCRIPTION

The MP3308 is a monolithic step-up converter designed to drive arrays of white LEDs from a 3.3V input or a single-cell lithium-ion battery. The MP3308 uses fixed-frequency current-mode architecture to regulate the LED current, which is measured through an external current sense resistor. Its low 200mV feedback voltage reduces power loss and improves efficiency.

The MP3308 features dual PWM-dimming input control and true PWM dimming—this control allows for a wide luminescent range that makes the display readable under a variety of ambient light conditions with minimal PWM dimming noise.

The MP3308 includes over-voltage protection, short-circuit protection, under-voltage lockout, current limiting, and thermal overload protection.

The MP3308 is available in small 3mmx4mm 14-pin QFN package.

FEATURES

- Internal Power MOSFET
- Drives Up to 10 White LEDs in Series
- 2.2MHz Fixed Switching Frequency
- Up to 88% Efficiency
- Dual PWM-Dimming Input Control
- Internal 1.3A Current Limit
- ±3% True PWM Dimming Duty Accuracy
- Adjustable Over-Voltage Protection Threshold
- Low 200mV Feedback Voltage
- Under-Voltage Lockout, Short-Circuit Protection, Thermal Shutdown
- Available in 3mmx4mm QFN14 Package

APPLICATIONS

- Small LCD Panels
- Digital Picture Frames
- Smartphones
- Portable Media Players
- Digital Cameras

All MPS parts are lead-free and adhere to the RoHS directive. For MPS green status, please visit MPS website under Products, Quality Assurance page.

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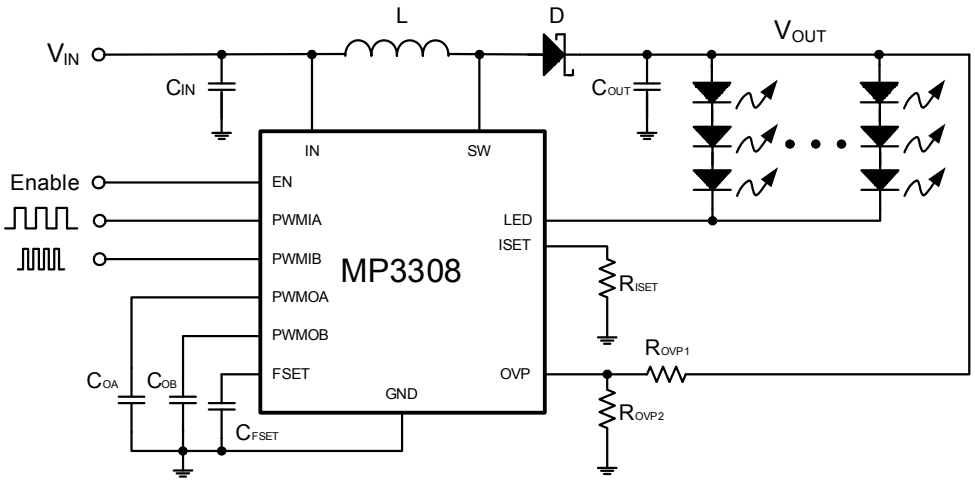
TYPICAL APPLICATION



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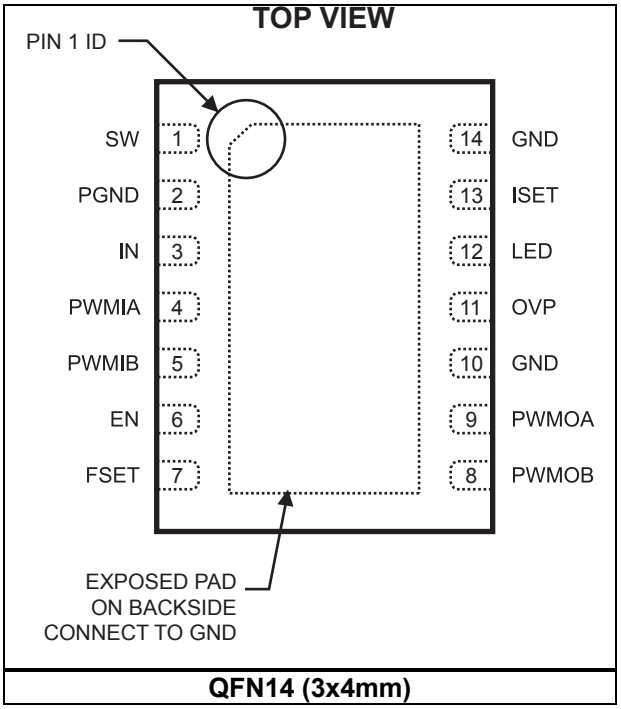
ORDERING INFORMATION

Part Number*	Package	Top Marking
MP3308DL	QFN14 (3x4mm)	3308

For Tape & Reel, add suffix –Z (e.g. MP3308DL-Z).
For RoHS, compliant packaging, add suffix –LF (e.g. MP3308DL–LF–Z).

PACKAGE REFERENCE



QFN14 (3x4mm)

ABSOLUTE MAXIMUM RATINGS (1)

SW Pin, LED Pin.....-0.5V to +40V
All Other Pins.....-0.3V to +6.5V
Storage Temperature..... -55°C to +150°C
Continuous Power Dissipation (T_A = 25°C) (2)
.....2.6W

Recommended Operating Conditions (3)

Supply Voltage (V_{IN}).....3V to 6V
SW Pin.....V_{IN} to 36V
Operating Junction Temp. (T_J). -40°C to +125°C

Thermal Resistance (4)

	θ_{JA}	θ_{JC}	
QFN14 (3x4mm)	48	10	°C/W

Notes:

1) Exceeding these ratings may damage the device.
2) The maximum allowable power dissipation is a function of the maximum junction temperature T_J (MAX), the junction-to-ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D (MAX) = (T_J (MAX)-T_A)/θ_{JA}. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
3) The device is not guaranteed to function outside of its operating conditions.
4) Measured on JESD51-7, 4-layer PCB.

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ELECTRICAL CHARACTERISTICS

V_{IN} = V_{EN} = 5V, T_A = 25°C, unless otherwise noted.

Parameters	Symbol	Condition	Min	Typ	Max	Units
Operating Input Voltage	V_{IN}		2.5		6	V
Supply Current (Shutdown)	I_{IN_SD}	V_{EN} = 0V		25	30	μA
Supply Current (Quiescent)	I_{IN_QS}	V_{ISET} = 0.3V		860		μA
Switching Frequency	f_{SW}		1.7	2.2	2.7	MHz
Maximum Duty Cycle	D_{MAX}	V_{ISET} = 0V	90			%
Under Voltage Lockout						
V_{IN} Under Voltage Lockout	V_{UVLO}	V_{IN} Rising		2.1	2.3	V
Under Voltage Lockout Hysteresis				30		mV
Over-Voltage Protection Threshold	V_{OVP}	V_{OUT} Rising		0.9		V
Enable and Dimming						
EN/PWMIX OFF Threshold	V_{LOGIC_LOW}	V_{EN} Falling	0.4			V
EN/PWMIX ON Threshold	V_{LOGIC_HIGH}	V_{EN} Rising			1.8	V
True PWM Dimming Duty Accuracy	ΔD_{DPWM}	D_PWMIA=D_PWMIB=70%		±3		%
Feedback						
ISET Voltage	V_{ISET}	V_{EN} > 2V	185	200	215	mV
ISET Input Bias Current		V_{ISET} = 0.2V	-600	-300		nA
Output Switch						
SW On-Resistance	R_{ON}			0.4		Ω
SW Current Limit		Duty Cycle = 60%		1.33		A
Thermal Shutdown				150		°C
LED Switch ON-Resistance (M2 in the functional block diagram)				0.8		Ω

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PIN FUNCTIONS

Pin #	Name	Description
1	SW	Power Switch Output. Drain of the internal MOSFET switch. Connect to the power inductor and the output rectifier. SW can swing between GND and 40V.
2	PGND, Exposed Pad	Power Ground. Connect exposed pad to GND plane for proper thermal performance.
3	IN	Input Supply Pin. Locally bypassed.
4	PWMIA	PWM Input A. Apply one PWM signal on this pin for brightness control. This signal is uniform and filtered at PWMOA pin.
5	PWMIB	PWM Input B. Apply the other PWM signal on this pin for brightness control. This signal is uniform and filtered at PWMOB pin.
6	EN	ON/OFF Control. Hold EN pin low to turn off part, high to turn of part.
7	FSET	PWM Dimming Frequency Programmer. Connect a capacitor from this pin to GND to set the PWM-dimming frequency as the formula, $F_{PWM}(Hz) = 16176 / C_{FSET}(nF)$
8	PWMOB	PWM Filtered Output B. Connect a capacitor from this pin to GND.
9	PWMOA	PWM Filtered Output A. Connect a capacitor from this pin to GND.
10,14	GND	Ground.
11	OVP	Over-Voltage Protection. Connect a resistor divider from output to this pin to adjust the OVP threshold. When this pin voltage reaches the shutdown threshold 0.9V, the switch turns off.
12	LED	LED Current Input. Open-drain output of an internal dimming control switch. Connect the LED cathode to this pin.
13	ISET	LED Current Set. This pin is the source output of an internal dimming control switch. The MP3308 regulates the voltage across the current setting resistor. Tie a current-setting resistor from this pin to ground. Regulates the voltage to 200mV.

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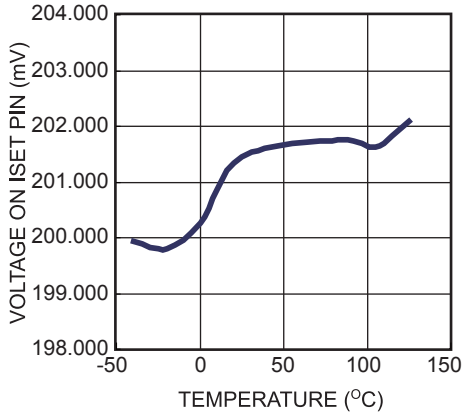
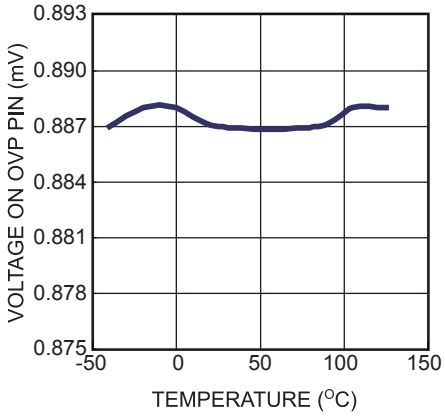
TYPICAL CHARACTERISTICS

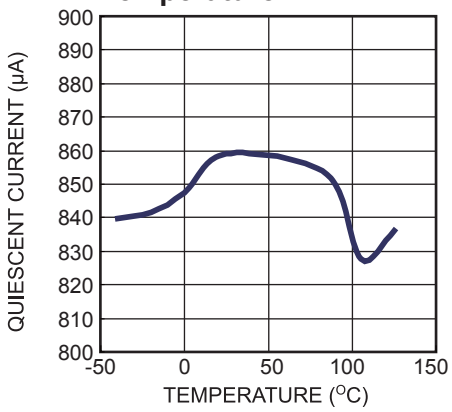
V(Iset) vs. Temperature



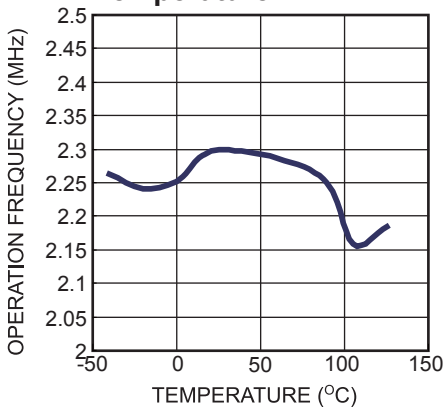
V(OVP) vs. Temperature



Quiescent Current vs. Temperature



Operation Frequency vs. Temperature



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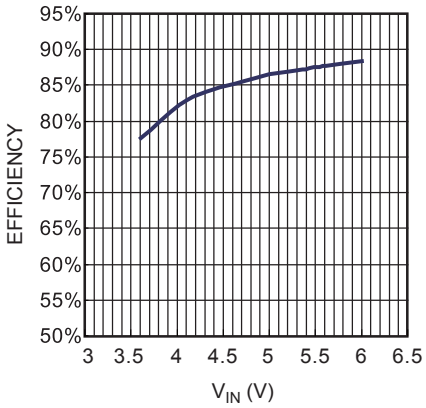
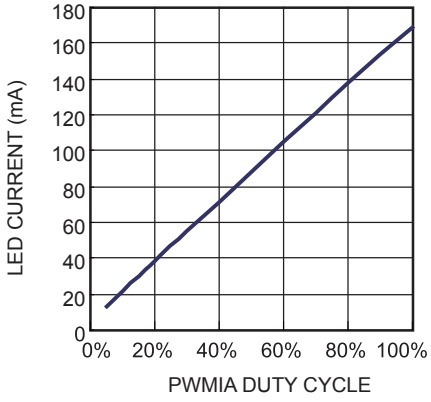
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} =5V, 3 LEDs in series, 9 strings parallel, 120mA/string, unless otherwise noted.

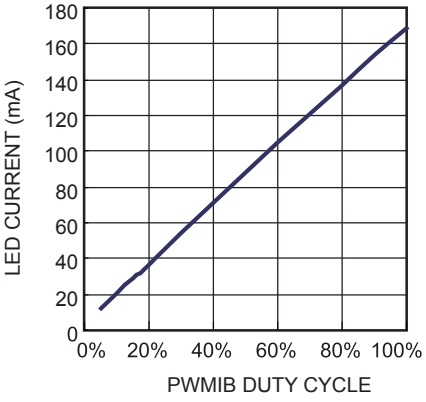
Efficiency vs. V_{IN}



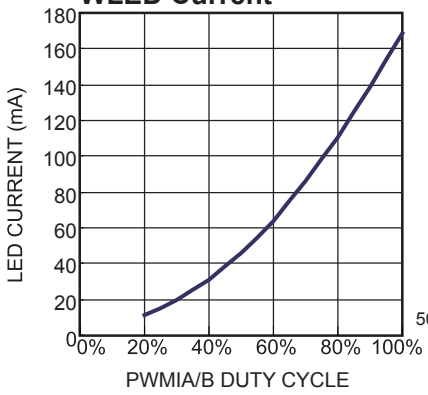
PWMIA Dimming Duty vs. WLED Current



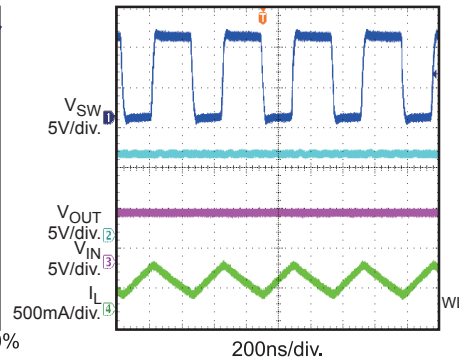
PWMIB Dimming Duty vs. WLED Current



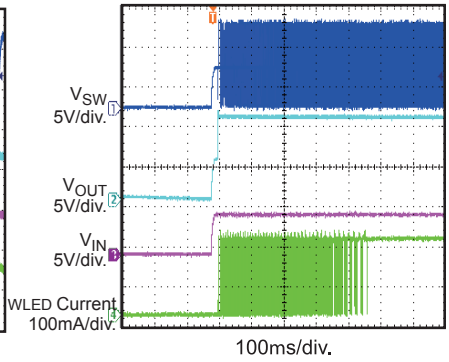
PWMIA*DPWMIB vs. WLED Current



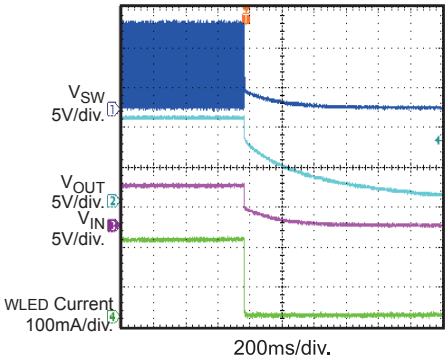
Steady State Operation



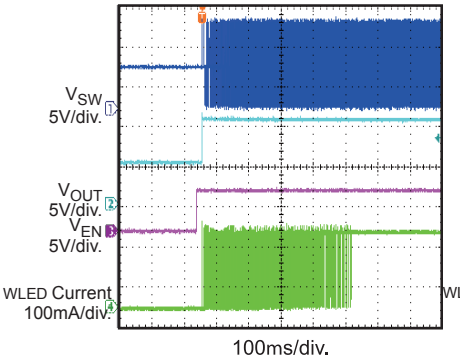
V_{IN} Power On



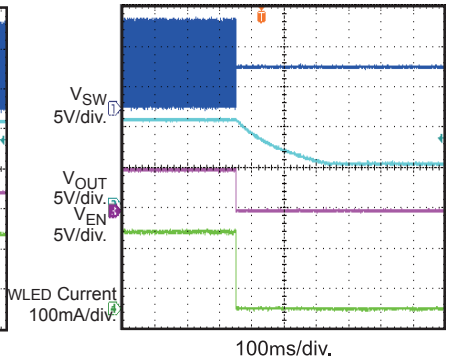
V_{IN} Shut Down



EN Power On



EN Shut Down



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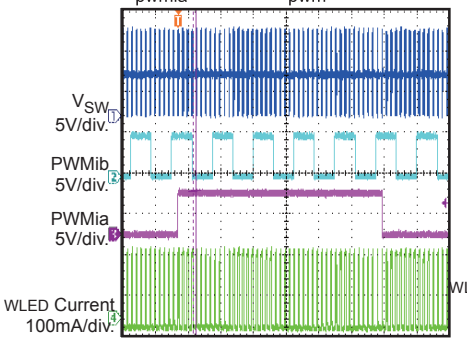
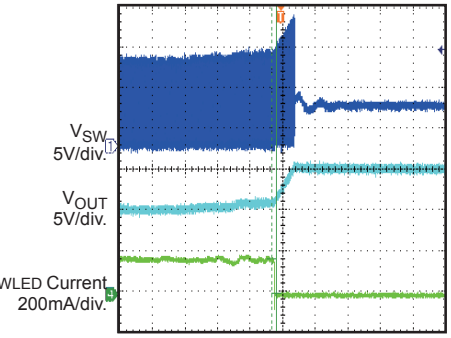
TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

PWM Dimming

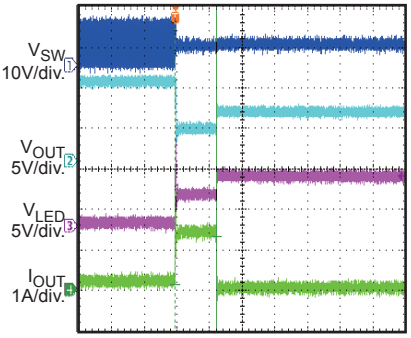
F_{pwmib} = 2kHz, Dpwmia = 50%,
F_{pwmia} = 200Hz, f_{pwm} = 17kHz



Open Load Protection



Short Protection



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FUNCTIONAL BLOCK DIAGRAM

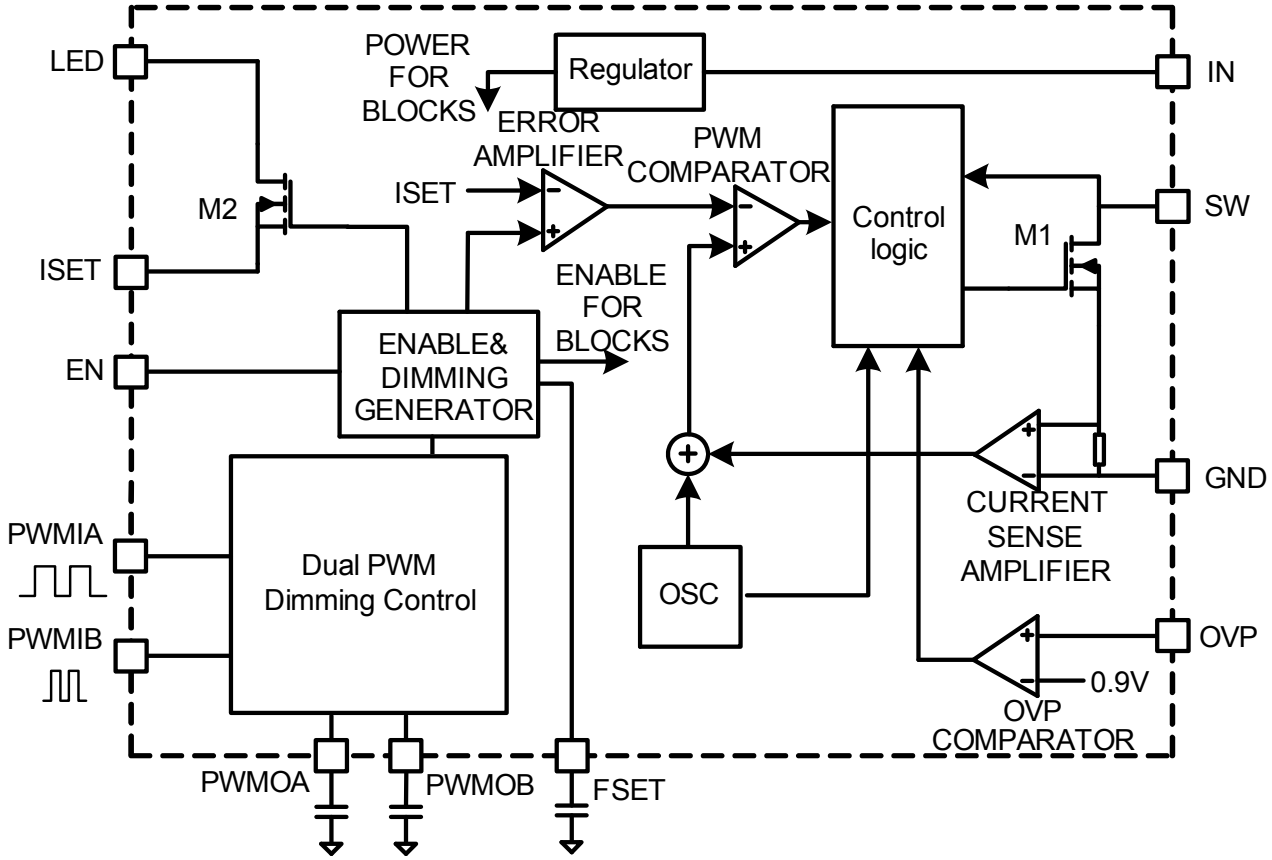

Figure 1—Functional Block Diagram

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OPERATION

The MP3308 uses a constant-frequency peak-current–mode boost-regulator architecture to regulate multiple strings of white LEDs connected in series.

At the start of each oscillator cycle, the control circuitry turns on the MOSFET. A stabilizing ramp at the output of the current sense amplifier prevents sub-harmonic oscillations at duty cycles greater than 50 percent—this output feeds into the positive input of the PWM comparator. When this voltage equals the output voltage of the error amplifier the power MOSFET turns off.

The error amplifier compares the difference between the 200mV reference voltage and the feedback voltage. If the feedback voltage drops, the output of the error amplifier increases, resulting in more current flowing through the power MOSFET and increasing the power delivered to the output, thus regulating the output.

Dual PWM dimming can adjust LED brightness. True PWM dimming allows for flexible control of the backlighting luminance to improve visibility for a wide range of ambient brightness. A capacitor on the FSET pin sets the PWM dimming frequency with a duty cycle of:

$$D_{PWMIA} \times D_{PWMIB}$$

Where D_{PWMIA} is the duty cycle on the PWMIA pin, and D_{PWMIB} is the duty cycle on the PWMIB pin.

External capacitors on the PWMOA and the PWMOB pins smooth the PWM signals to provide DC signals by selecting the proper time constant.

MP3308 provides over-voltage protection, which will shut off the MP3308 if the output voltage goes too high. OVP pin senses the output voltage through the tap of a resistor divider between V_{OUT} and GND. In the case of an LED failure, the feedback voltage goes to zero and the part will run at maximum duty cycle. The output voltage then rises and triggers OVP if the OVP pin exceeds 1.23V.

MP3308 also provides short-circuit protection in cases where individual LEDs on a string or a whole LED string shorts: This condition causes the ISET pin to pull high. If the voltage exceeds 0.4V for more than 240μs, MP3308 will shutdown.

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APPLICATION INFORMATION

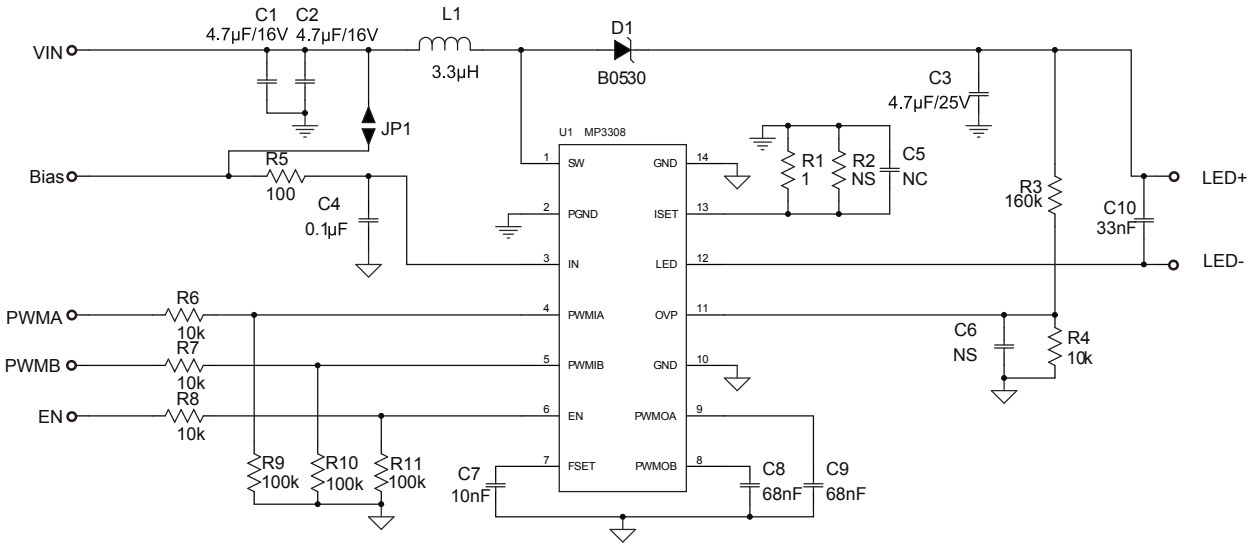

Figure 2—Typical Application Driving 9 Strings of 3 WLEDs

Figure 2 shows a typical application circuit that can drive up to nine strings of three white LEDs with an output of 9V/180mA. A 4.7µF output capacitor is sufficient for most applications. A 3.3µH inductor with low DC inductor resistance (DCR) will improve efficiency. Two 4.7µF ceramic capacitors provide sufficient input decoupling. Use Schottky diodes with fast recovery for high frequencies, and rated for a 500mA peak inductor current. An internal soft-start limits I_{IN} at startup and I_{OUT} overshoot.

The ramped voltage added to the current sense amplifier reduces the maximum output current as the duty cycle increases. As more LEDs are added, the output voltage rises but the maximum current delivered to the load falls as well.

Setting the LED Current

The resistor R1 sets the LED current, where the current value is given by:

$$I_{LED} = \frac{200mV}{R1}$$

Table 1 pairs resistor values with an LED current.

Table 1—I_{LED} vs. R1

I_{LED} (mA)	R1 (Ω)
1	200
5	40
10	20
20	10
60	3.33
180	1.11
200	1

PWM Dimming

PWM dimming requires the application of square waves to both the PWMIA and the PWMIB pins. A capacitor on the FSET pin sets the PWM dimming frequency according to the equation:

$$F_{PWM}(Hz) = 16176 / C_{FSET}(nF),$$

For C_{FSET}=10nF, the F_{PWM} is set to 1.6kHz.

The recommended F_{PWM} range is 50Hz to 50kHz.

The minimum recommended amplitude of the PWM signal is 2V.

External capacitors on both PWMOA and PWMOB, together with internal 100kΩ resistors filter the square waveform to provide a DC value. The time constant should be ten times greater than a PWM waveform cycle:

$$RC > 10 \cdot T_{PWM}$$

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Selecting the Inductor

The inductor forces a higher output voltage driven from a lower input voltage. A larger inductor value results in less ripple current, a lower peak inductor current, and reduces stress on the internal N-Channel MOSFET. However, larger-value inductor has a larger physical footprint, higher series resistance, and lower saturation current.

Choose an inductor that does not saturate under the worst-case load conditions. Calculate the required inductance value using the following equations:

$$L \geq \frac{\eta \times V_{OUT} \times D \times (1-D)^2}{2 \times f_{SW} \times I_{LOAD}}$$

$$D = 1 - \frac{V_{IN}}{V_{OUT}}$$

Where V_{IN} and V_{OUT} are the input and output voltages, f_{SW} is the switching frequency, I_{LOAD} is the LED load current, and η is the efficiency.

Over-Voltage Protection

Open Load protection will shut off the MP3308 if the output voltage reaches over-voltage protection (OVP) threshold. LED failures will result in the feedback voltage falling to zero, which will cause the part to run at maximum duty cycle and boost the output voltage. If the output voltage exceeds the adjusted OVP threshold:

$$V_{OV} = 0.9V(1 + \frac{R2}{R3}),$$

The MP3308 will shut down and will not remain off until the power cycles.

Layout Considerations

Layout requires special consideration to avoid electromagnetic interference from the high-frequency switching path. The high-frequency ripper current in the loop from the SW pin, through the output diode, and output capacitor to GND requires a connection loop that is as short as possible.

The IN pin must be locally bypassed, with a highly-recommended RC filter to eliminate noise. See Figure 3 for an example of this circuit.

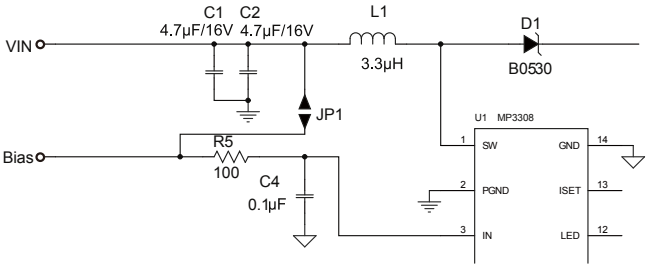

Figure 3—Input Bias Filtering

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TYPICAL APPLICATION CIRCUITS

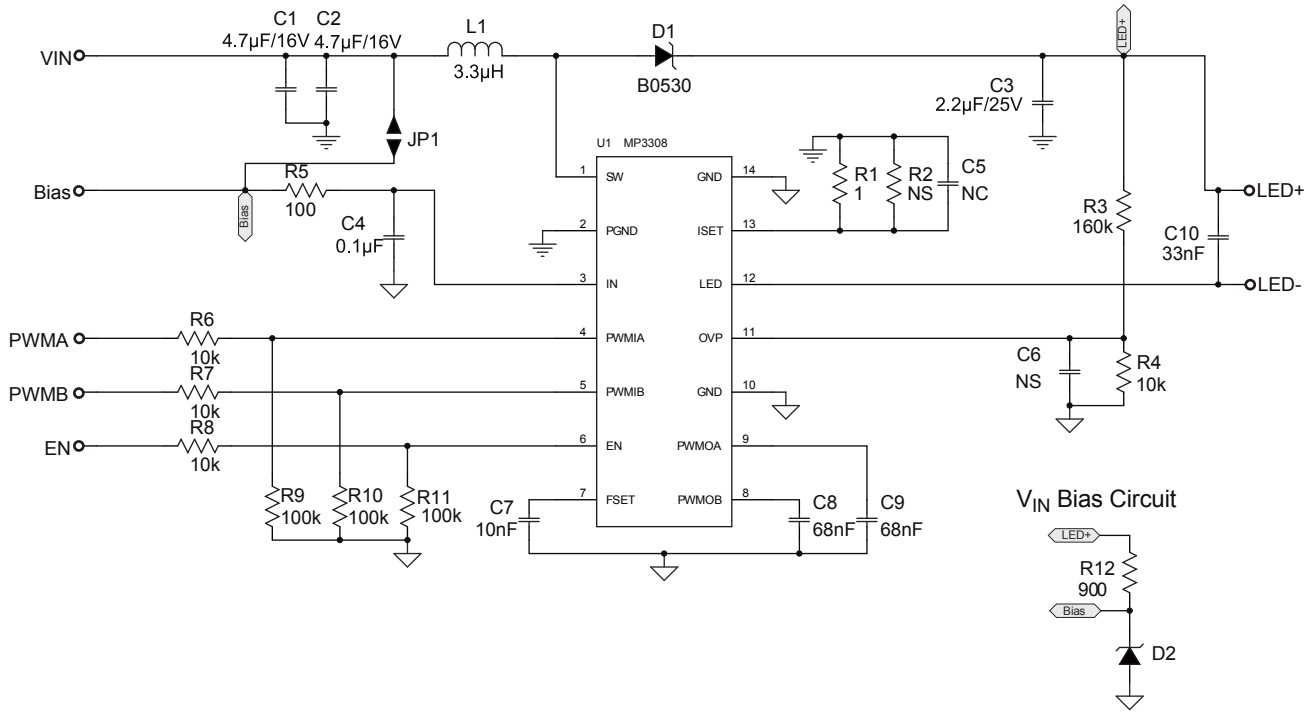

Figure 4— Driving 27 WLEDs (9 WLEDs in Series and 3 Strings Paralleled) with 3V-3.3V Input Voltage[1]

(1) Use additional bias circuit for low input voltage compatibility.

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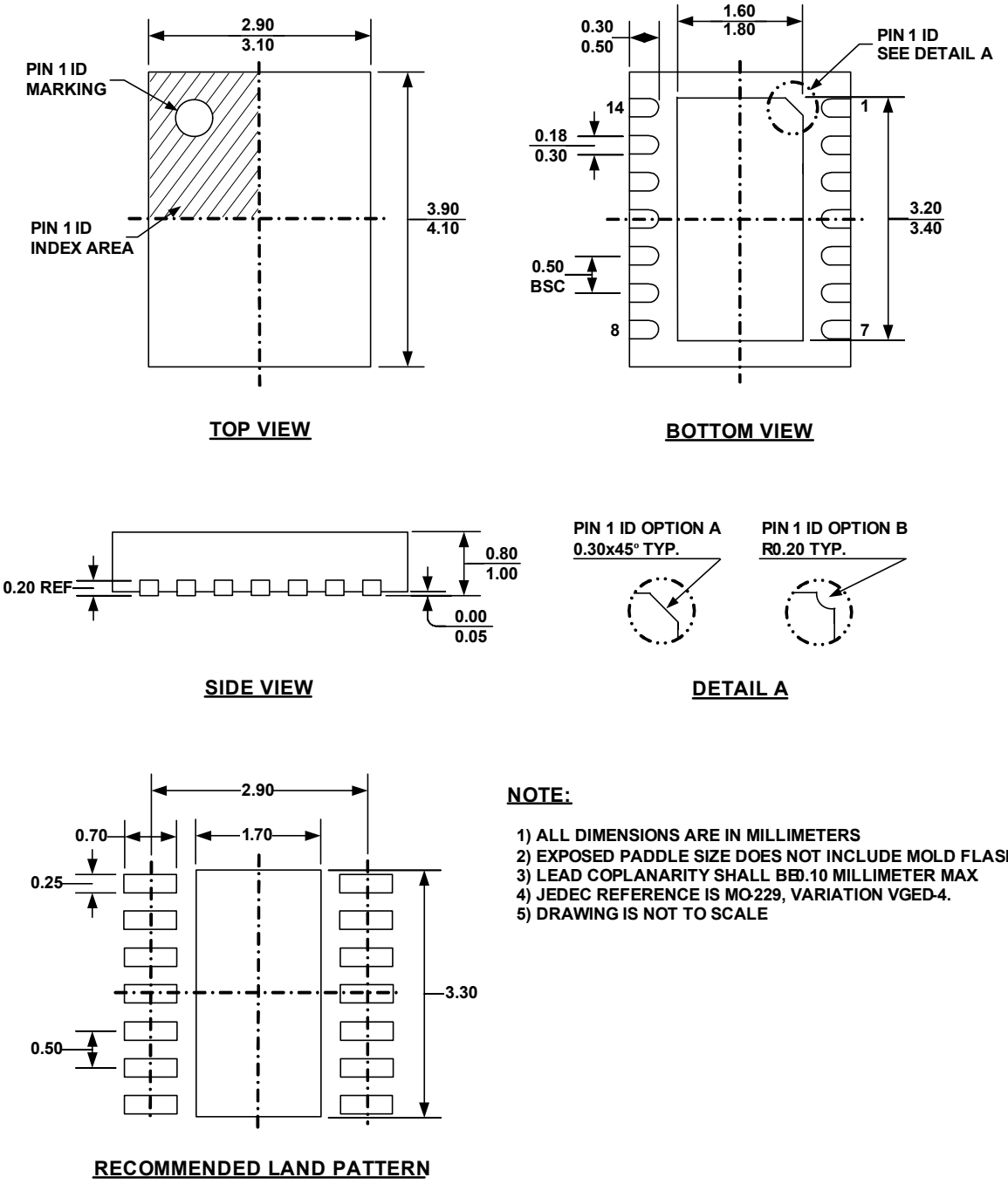
PACKAGE INFORMATION

QFN14 (3x4mm)



NOTE:

1) ALL DIMENSIONS ARE IN MILLIMETERS
2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH
3) LEAD COPLANARITY SHALL BE 0.10 MILLIMETER MAX
4) JEDEC REFERENCE IS MO-229, VARIATION VGED-4.
5) DRAWING IS NOT TO SCALE

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