MP24183

1A, 55V, Programmable Frequency White LED Driver

END OF LIFE, REFER TO MP2483

DESCRIPTION

The MP24183 is a 55V, 1A, white LED driver suitable for either step-down or inverting step-up/down applications. It achieves 1A peak output current over a wide input supply range with excellent load and line regulation. Current mode operation provides fast transient response and eases loop stabilization. Fault condition protection includes thermal shutdown, cycle-by-cycle peak current limiting, input over voltage protection, open strings protection and output short circuit protection.

The MP24183 incorporates both DC and PWM dimming onto a single control pin. The separate input reference ground pin allows for direct enable and/or dimming control for a positive to negative power conversion.

The MP24183 requires a minimum number of readily available standard external components and is available in a 10-pin 3mm x 3mm QFN package.

FEATURES

- 1A Maximum Output Current
- Unique Step-up/down Operation (Buck-Boost Mode)
- Wide 4.5V to 55V Operating Input Range for Step-Down Applications (Buck Mode)
- 0.28Ω Internal Power MOSFET Switch
- Adjustable Switching Frequency
- Analog and PWM Dimming
- 0.198V Reference Voltage
- 5μA Shutdown Mode
- No minimum LED required
- Stable with Low ESR Output Ceramic Capacitors
- Cycle-by-Cycle Over Current Protection
- Thermal Shutdown Protection
- Open Strings Protection
- Input Over Voltage Protection
- Output Short Circuit Protection
- Available in 10-Pin 3x3 QFN Package

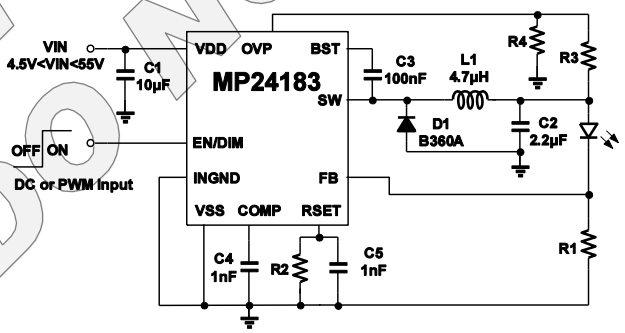
APPLICATIONS

- General LED Illuminations
- LCD Backlight Panels
- Handheld Computers
- Automotive Internal Lighting
- Portable Multimedia Players
- Portable GPS Devices

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TYPICAL APPLICATION



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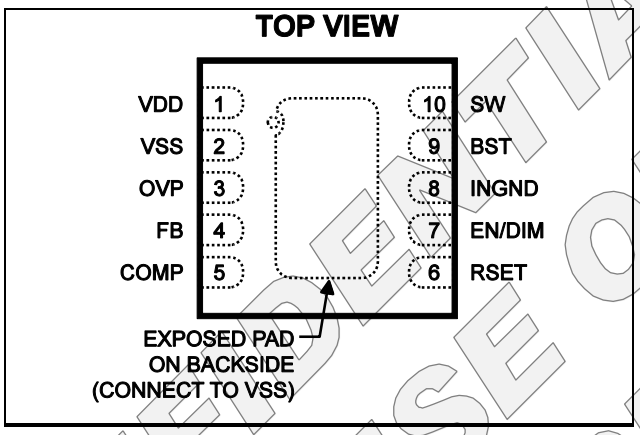
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ORDERING INFORMATION

Part Number*	Package	Top Marking	Free Air Temperature (T_A)
MP24183DQ	3x3 QFN10		-40°C to +85°C

* For Tape & Reel, add suffix –Z (e.g. MP24183DQ–Z).
For RoHS compliant packaging, add suffix –LF (e.g. MP24183DQ–LF–Z)

PACKAGE REFERENCE



ABSOLUTE MAXIMUM RATINGS (1)

Supply Voltage V_{DD} – V_{SS} 60V
V_{SW} – V_{SS} ..... -0.3V to V_{IN} + 0.3V
V_{BST} ..... V_{SW} + 6V
V_{OVP} – V_{SS} ..... -0.3V to +6V
V_{EN} – V_{INGND} ..... -0.3V to +6V
V_{DIM} – V_{INGND} ..... -0.3V to +6V
V_{INGND} – V_{SS} ..... -0.3V to 60V
Continuous Power Dissipation (T_A = +25°C) (2) 2.5W
Junction Temperature ..... 150°C
Lead Temperature ..... 260°C
Storage Temperature ..... -65°C to +150°C

Recommended Operating Conditions (3)

Supply Voltage V_{DD} – V_{SS} ..... 4.5V to 55V
Operating Junct. Temp (T_J) ..... -40°C to +125°C

Thermal Resistance (4)

	θ_{JA}	θ_{JC}
3x3 QFN10	50	12 ...°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 function is not guaranteed outside of the recommended operating conditions.
4) Measured on JESD51-7, 4-layer PCB.

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ELECTRICAL CHARACTERISTICES

V_{IN} = 12V, T_A = +25°C, all voltages with respect to V_{SS}, unless otherwise noted.

Parameters	Symbol	Condition	Min	Typ	Max	Units
Feedback Voltage	V_{FB}	4.5V ≤ V_{IN} ≤ 55V	0.188	0.198	0.208	V
Feedback Current	I_{FB}	V_{FB} = 0.22V	-50		50	nA
Switch-On Resistance (5)	$R_{DS(ON)}$			280		mΩ
Switch Leakage		V_{EN} = 0V, V_{SW} = 0V			1	μA
Current Limit (5)				2.0		A
Oscillator Frequency	f_{SW}	V_{FB} = 0.19V, Rset=100kΩ		0.5		MHz
Default oscillator frequency	$f_{SW_default}$	V_{FB} = 0.19V, Rset open	1.05	1.35	1.65	MHz
Fold-back Frequency		V_{FB} = 0V, V_{OVP}=0V		250		kHz
Maximum Duty Cycle		V_{FB} = 0.19V		90		%
Minimum On-Time (5)	t_{ON}			100		ns
Under Voltage Lockout Threshold Rising			3	3.3	3.6	V
Under Voltage Lockout Threshold Hysteresis				100		mV
EN Input Current		V_{EN} = 2V		2.1		μA
EN OFF Threshold (w/Respect to INGND)		V_{EN} Falling	0.4			V
EN ON Threshold (w/Respect to INGND)		V_{EN} Rising			0.6	V
Minimum EN Dimming Threshold		V_{FB} = 0V	0.6	0.7	0.8	V
Maximum EN Dimming Threshold		V_{FB} = 0.2V	1.25	1.4	1.5	V
Supply Current (Quiescent)	I_Q	V_{EN} = 2V, V_{FB} = 1V		0.8	1.0	mA
Supply Current (Quiescent) at EN Off	I_{off}	V_{EN}=0V		3.4	15	μA
Thermal Shutdown (5)				150		°C
Open LED OV Threshold	V_{OVP_th}		1.1	1.2	1.3	V
Open LED OV Hysteresis	V_{OVP_hys}			60		mV

Notes:
5) Guaranteed by design.

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PIN FUNCTIONS

Pin #	Name	Description
1	VDD	Supply Voltage. The MP24183 operates from a +4.5V to +55V unregulated input (with respect to VSS). C1 is needed to prevent large voltage spikes from appearing at the input.
2	VSS	Power Return Pin. Connect to the lowest potential in the circuit, which is typically the anode of the Schottky rectifier. This pin is the voltage reference for the regulated output voltage. For this reason care must be taken in its layout. This node should be placed outside of the D1 to C1 ground path to prevent switching current spikes from inducing voltage noise into the part. The exposed pad is also connected to this pin.
3	OVP	Over Voltage Protection Pin. Use a voltage divider to program OVP threshold. When the OVP pin voltage reaches the shutdown threshold 1.2V, the switch will be turned off and will recover when OVP voltage decreases sufficiently. When the OVP pin voltage (with respect to VSS) is lower than 0.4V and FB pin voltage is lower than 0.1V, the chip reecognizes this as short circuit condition and the operating frequency will be folded back. Program the OVP pin voltage from 0.4V to 1.2V for normal operation.
4	FB	LED Current Feedback Input. MP24183 regulates the voltage across the current sensing resistor between FB and VSS. Connect the current sensing resistor from the bottom of the LED strings to VSS. The FB pin is connected to the bottom of the LED strings. The regulation voltage is 0.198V.
5	COMP	Output of error amplifier. Connect a 1nF or larger capacitor on COMP to improve the stability and to provide a soft on at start up and PWM dimming.
6	RSET	Frequency Set Pin. Connect a resistor to VSS to set the switching frequency and an 1nF capacitor to VSS to bypass the noise. Leaving this pin open gets a default operating frequency 1.35MHz.
7	EN/DIM	On/Off Control Input and Dimming Command Input. A voltage greater than 0.6V will turn on the chip. Both DC and PWM dimming are implemented on this pin. When the EN/DIM pin voltage (with respect to INGND) rises from 0.7V to 1.4V, the LED current will change from 0% to 100% of the maximum LED current. To use PWM dimming, apply a 100Hz to 2kHz square wave signal with amplitude greater than 1.4V to this pin.
8	INGND	Input Ground Reference. This pin is the reference for the EN/DIM signal.
9	BST	Bootstrap. A capacitor is connected between SW and BST pin to form a floating supply across the power switch driver. A 100nF or larger ceramic capacitor is recommended to provide sufficient energy to drive the power switch's gate above the supply voltage.
10	SW	Switch Output. SW is the source of the internal MOSFET switch. Connect this pin to the power inductor and the cathode of the Schottky rectifier.
		Exposed pad should be connected to VSS in step up/down mode.

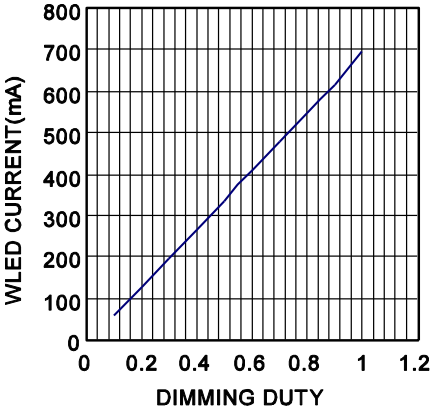
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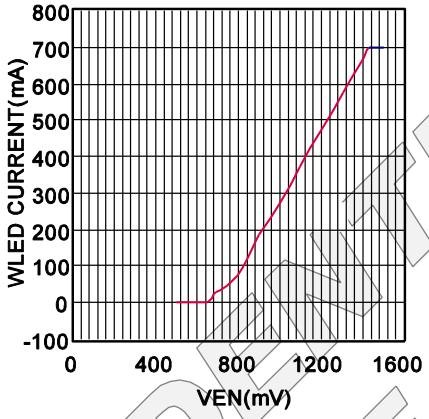
TYPICAL PERFORMANCE CHARACTERISTICS

VIN=20V, ILED=0.7A, two 3W LED in series, step down application, unless otherwise noted.

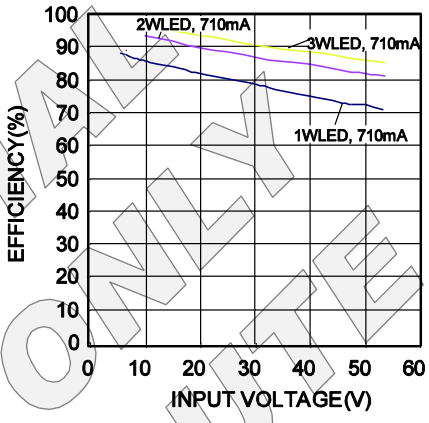
WLED current vs Dimming Duty



WLED Current vs VEN



Efficiency



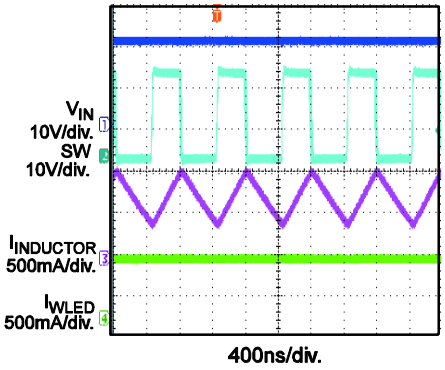
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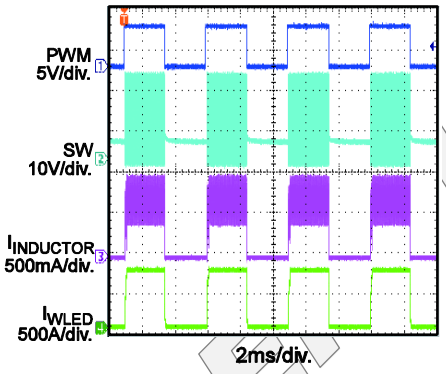
TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

VIN=20V, ILED=0.7A, two 3W LED in series, step down application, unless otherwise noted.

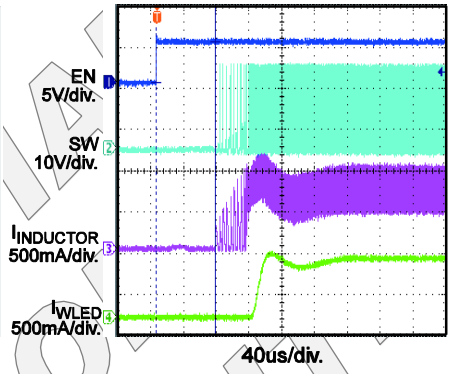
Steady State



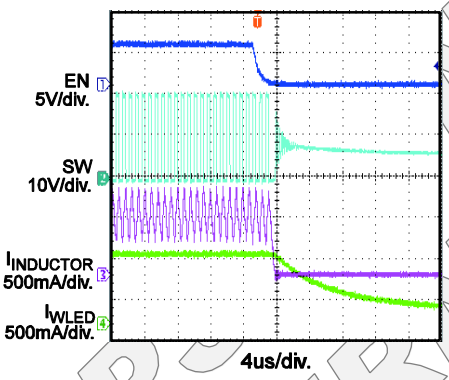
PWM Dimming



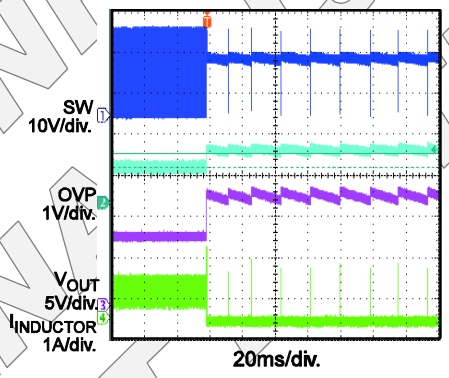
EN on



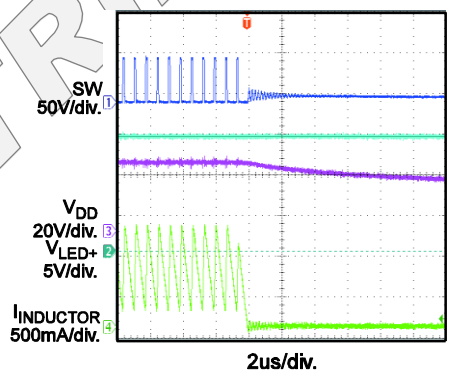
EN off



Open LED Protection



VDD-VSS OVP Protection



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FUNCTIONAL BLOCK DIAGRAM

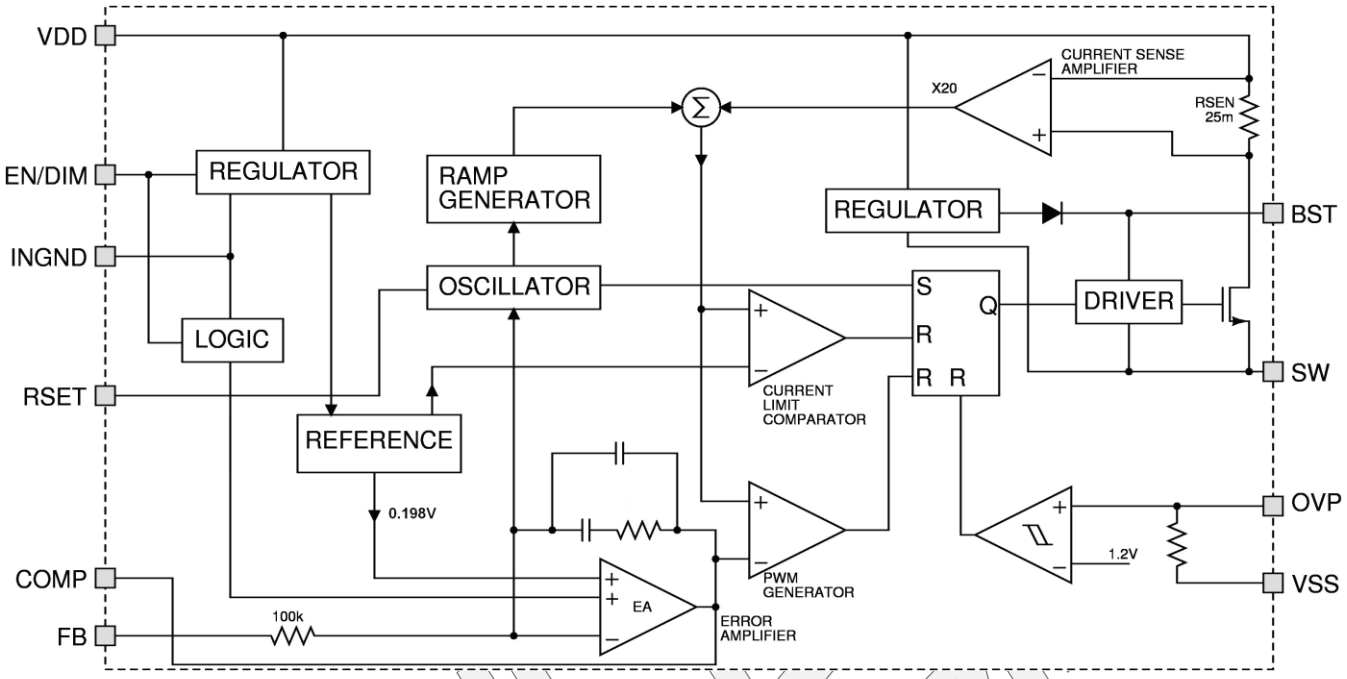


Figure 1—Functional Block Diagram

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OPERATION

The MP24183 is a current mode regulator. The EA output voltage is proportional to the peak inductor current.

At the beginning of a cycle, M1 is off. The EA output voltage is higher than the current sense amplifier output, and the current comparator's output is low. The rising edge of the 1.35MHz CLK signal sets the RS Flip-Flop. Its output turns on M1 thus connecting the SW pin and inductor to the input supply.

The increasing inductor current is sensed and amplified by the Current Sense Amplifier. Ramp compensation is summed to the Current Sense Amplifier output and compared to the Error Amplifier output by the PWM Comparator. When the sum of the Current Sense Amplifier output and the Slope Compensation signal exceeds the EA output voltage, the RS Flip-Flop is reset and M1 is turned off. The external Schottky rectifier diode (D1) conducts the inductor current.

If the sum of the Current Sense Amplifier output and the Slope Compensation signal does not exceed the EA output for a whole cycle, then the falling edge of the CLK resets the Flip-Flop.

The output of the Error Amplifier integrates the voltage difference between the feedback and the 0.198V reference. The polarity is a FB pin voltage lower than 0.198V increases the EA output voltage. Since the EA output voltage is proportional to the peak inductor current, an increase in its voltage also increases the current delivered to the output.

Open LED Protection

If the LED is open, there is no voltage on the FB pin. The duty cycle will increase until V(VDD)-V(VSS) reaches 55V or OVP-VSS reaches the shutdown threshold set by the external resistor divider. The top switch will turn off till the voltage V(VDD)-V(VSS) and OVP-VSS decreases sufficiently.

Dimming Control

The MP24183 allows both DC and PWM dimming. When the voltage on EN is less than 0.6V, the chip is turned off. For analog dimming, when the voltage on EN is from 0.7V to 1.4V, the LED current will change from 0% to 100% of the maximum LED current. If the voltage on EN pin is higher than 1.4V, maximum LED current will be generated. For PWM dimming, its amplitude (VDIM – VINGND) must exceed 1.4V. The PWM frequency is recommended in range of 100Hz to 2kHz to get a good dimming linearity.

Output Short Circuit Protection

The MP24183 integrates output short circuit protection. When the output is shorted to VSS, the voltage on OVP pin which detects the output voltage gets smaller than 0.4V, and FB pin senses no voltage (<0.1V) as no current goes through the WLED. At this condition, the operating frequency is folded back to decrease the power consumption.

In Buck-boost application, when there is possibility that the LED+ short circuit to VSS, it is recommended to add a diode from VSS to INGND to protect the IC, as shown in below Figure 2 .

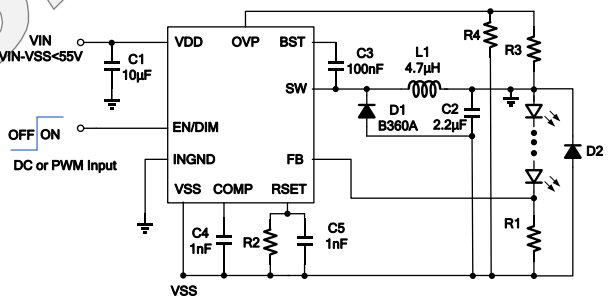


Figure 2—Buck-boost Application When LED+ Possibly Short to VSS

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APPLICATION INFORMATION

Setting the LED Current

The external resistor is used to set the maximum LED current (see the schematic on front page) through the use of the equation:

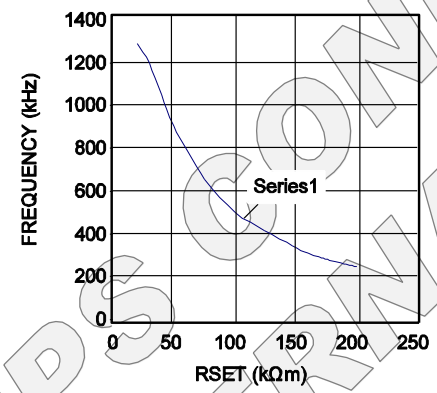
$$R_{SENSE} = \frac{0.198V}{I_{LED}}$$

Setting the Operating Frequency

The resistor on Rset pin is used to set the operating frequency. A 1nF capacitor is recommended to bypass this pin to GND.

The relationship between the operating frequency and the Rest resistor is as the following curve. A 20kΩ to 200kΩ Rset resistor is recommended, which sets the operating frequency from around 1.3MHz to 250kHz. Leaving the RSET pin open will set the operating frequency to the default operating frequency 1.35MHz.

Frequency vs. RSET



Selecting the Inductor (Step-Down Applications, see Figure 3)

A 1μH to 47μH inductor with a DC current rating of at least 25% percent higher than the maximum load current is recommended for most applications. For high efficiency, the inductor's DC resistance should be less than 200mΩ. Refer to Table 2 for suggested surface mount inductors. For most designs, the required inductance value can be derived from the following equation.

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{SW}}$$

Where ΔI_L is the inductor ripple current.

Choose the inductor ripple current to be 30% of the maximum load current. The maximum inductor peak current is calculated from:

$$I_{L(MAX)} = I_{LOAD} + \frac{\Delta I_L}{2}$$

Under light load conditions below 100mA, a larger inductance is recommended for improved efficiency.

Also note that the maximum recommended load current is 2A if the duty cycle exceeds 35%.

Selecting the Input Capacitor

The input capacitor reduces the surge current drawn from the input supply and the switching noise from the device. The input capacitor impedance at the switching frequency should be less than the input source impedance to prevent high frequency switching current from passing through the input. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. For most applications, a 4.7μF capacitor is sufficient.

Selecting the Output Capacitor

The output capacitor keeps the output voltage ripple small and ensures feedback loop stable. The output capacitor impedance should be low at the switching frequency. Ceramic capacitors with X5R or X7R dielectrics are recommended for their low ESR characteristics. For most applications, a 2.2μF ceramic capacitor will be sufficient.

PC Board Layout

The high current paths (VSS, VDD and SW) should be placed very close to the device with short, direct and wide traces. The input capacitor needs to be as close as possible to the VDD and VSS pins. The external feedback resistors should be placed next to the FB pin. Keep the switch node traces short and away from the feedback network.

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Table 2—Suggested Surface Mount Inductors

Manufacturer	Part Number	Inductance(µH)	Max DCR(Ω)	Current Rating (A)	Dimensions L x W x H (mm3)
Toko	A921CY-4R7M	4.7	0.027	1.66	6 x 6.3 x 3
Sumida	CDRH4D28C/LD	4.7	0.036	1.5	5.1 x 5.1 x 3
Wurth Electronics	7440530047	4.7	0.038	2.0	5.8 x 5.8 x 2.8

TYPICAL APPLICATION CIRCUITS

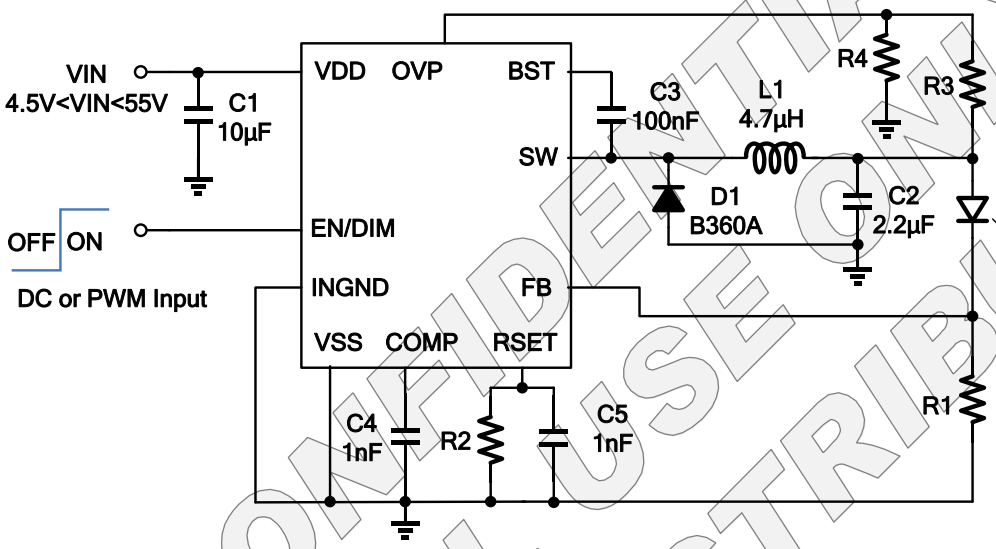


Figure 3—Step-Down White LED Driver Application

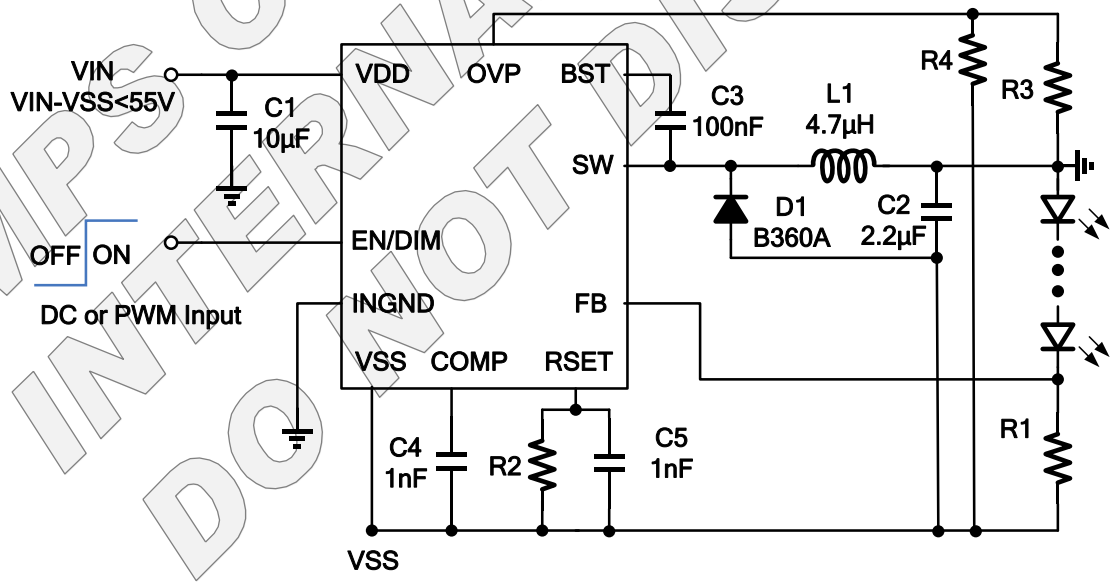


Figure 4— Step-up/down White LED Driver Application

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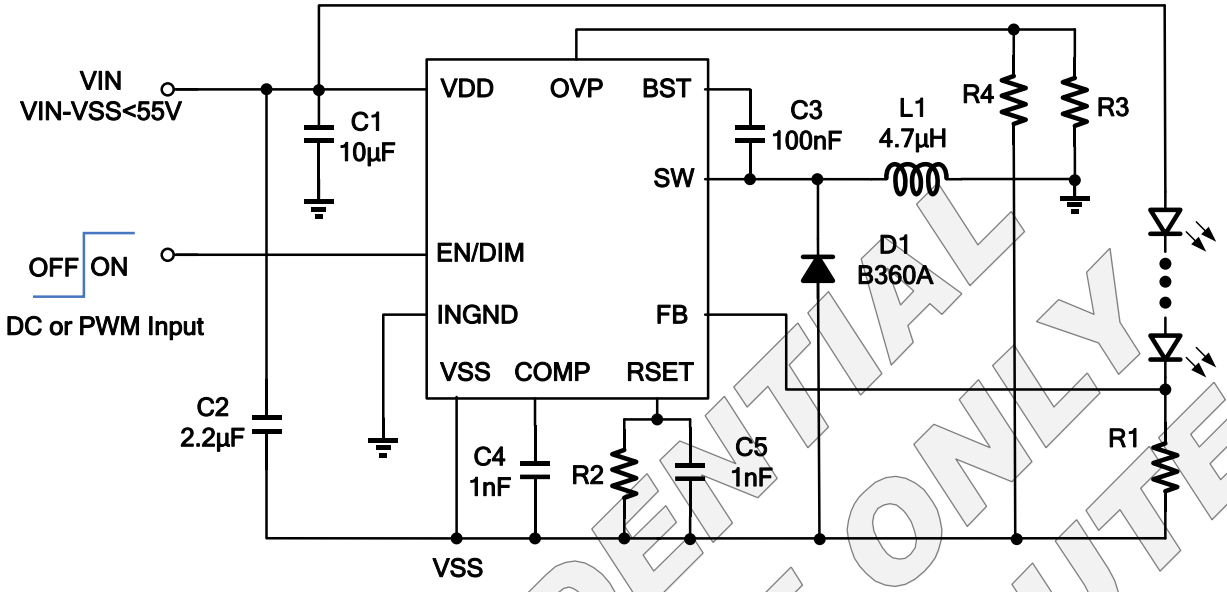


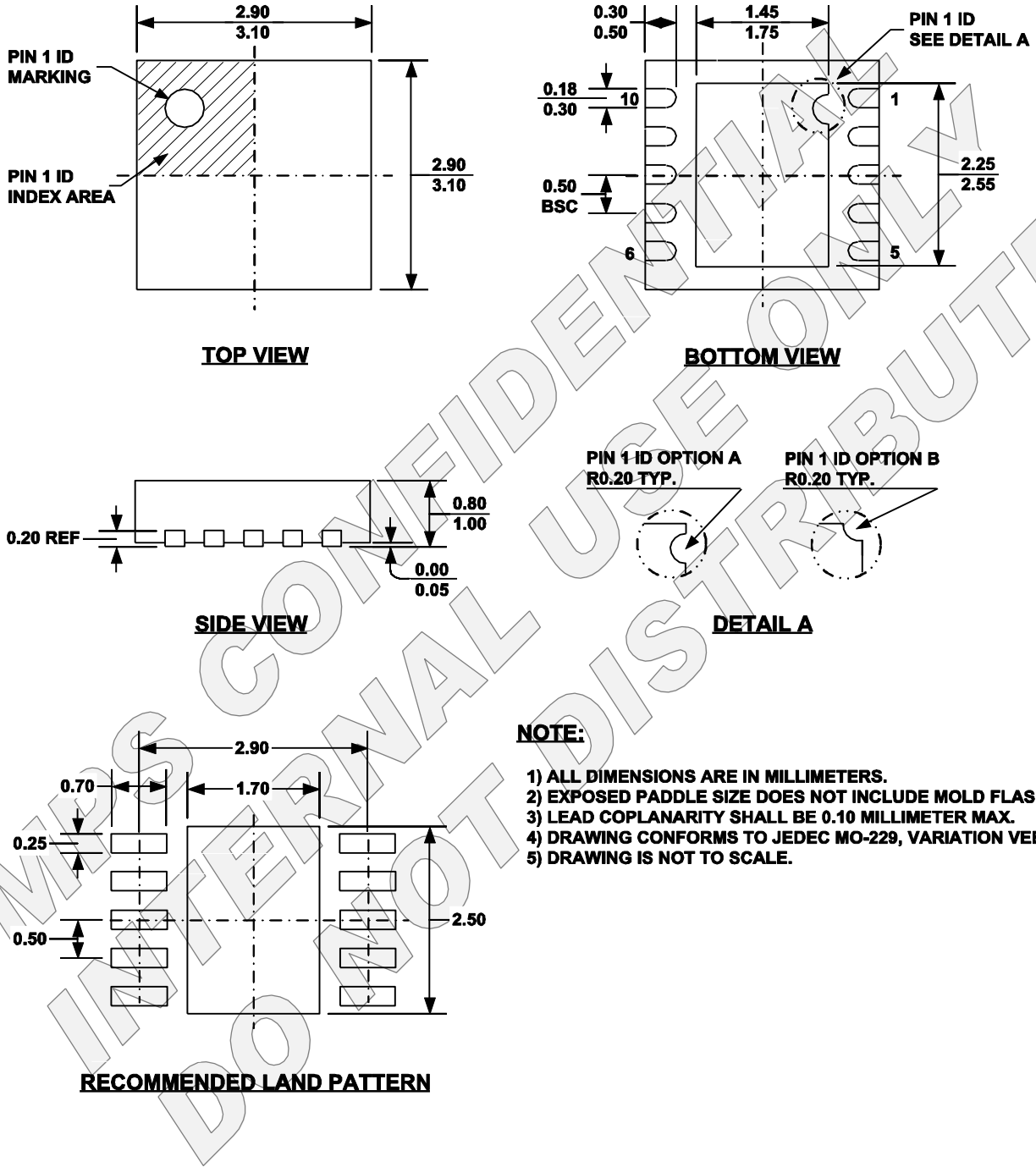
Figure 5— Step-up White LED Driver Application

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PACKAGE INFORMATION

3mm x 3mm QFN10



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) DRAWING CONFORMS TO JEDEC MO-229, VARIATION VEED-5.
5) DRAWING IS NOT TO SCALE.

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