VP3162

1A/40V/1.2MHz White LED Driver

General Description

The VP3162 is designed to drive up to 10 white LEDs in series with a 3.6V cell Li-Ion battery. It works as a boost converter using current mode, 1.2MHz PWM frequency with the measure of an external current sense resistor to regulate the LED current. In order to minimize the power loss and keep the efficiency, the feedback voltage is designed as low as 300mV. With the DC voltage dimming control, it is easily to adjust the brightness of LEDs in either analog method or PWM duty control.

The VP3162 features many protection schemes such as UVLO, open load protection, 1A current limit and over-temperature protection.

VP3162 is packaged with the popular SOT23-5 small package with RoHS 2.0 compliant, green package is optional.

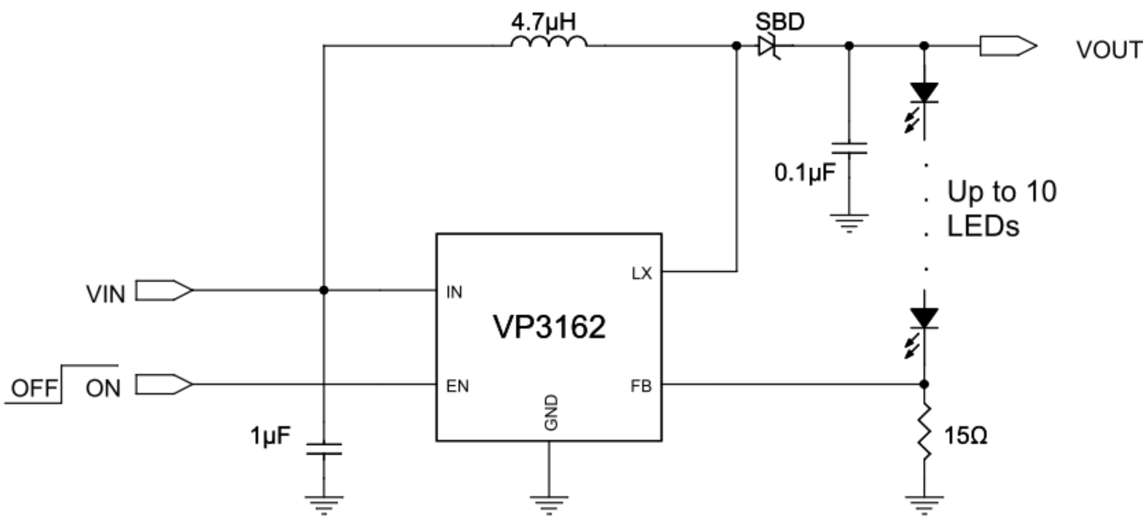
Features

- Wide Input Voltage from 2.75V to 6V
- 300mV Feed-Back Voltage
- 40V Open Load Protection
- DC Voltage/PWM Dimming Control
- 1A Maximum Input Current
- Integrated 400mΩ MOSFET Switch
- 1.2MHz Switching Frequency
- 2.75V UVLO Protection
- 1μA Low Shutdown Current
- Over Temperature Protection
- SOT23-5 Package with RoHS 2.0 Compliant

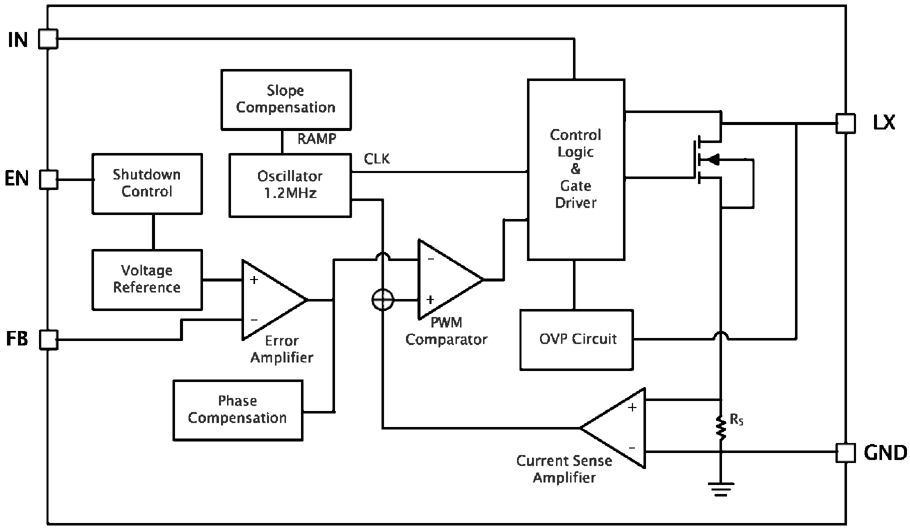
Applications

- LCD Panel
- MID/PND/GPS
- Digital Still Camera/Photo Frame
- Smart Phone

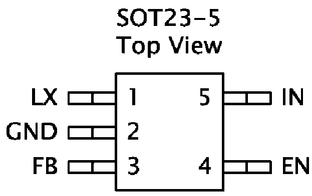
Typical Application



Functional Block Diagram



Pin Assignments And Descriptions



Pin No.	Pin	I/O/P	Function Description
1	LX	O	Switch Output. Connect this pin to the node between the inductor and the schottky diode.
2	GND	P	Power Ground.
3	FB	I	Feedback Input. FB monitors the feedback voltage to regulate the LED current. Connect a current sense resistor from the bottom of the LED string to ground to configure LED current.
4	EN	I	Chip Enable. Pull EN high to enable the regulator, pull it low to turn it off. Pull up with a 100kΩ resistor to start it up automatically.
5	IN	P	Power Input. Drive IN pin with a 2.75V to 6V power source to activate the LED driver.

Absolutely Maximum Ratings

Over operating free-air temperature range, unless otherwise specified (* 1)

Symbol	Parameter	Limit	Unit
V_{IN}	Supply voltage range	-0.3 to 6.5	V
V_{LX}	Switch voltage range	-0.3 to 42	V
V_{IN}(EN, FB)	Low voltage input range	-0.3 to 6.5	V
T_J	Operating junction temperature range	-40 to +160	ºC
T_{STG}	Storage temperature range	-65 to 150	ºC
Electrostatic discharge	Human body model	±2	kV
Electrostatic discharge	Machine model	±200	V
θ_{JC}	Thermal Resistance (Junction to Case)	110	ºC/W
θ_{JA}	Thermal Resistance (Junction to Air)	220	ºC/W

(*1): Stress beyond those listed at "absolute maximum rating" table may cause permanent damage to the device. These are stress rating ONLY. For functional operation are strongly recommend follow up "recommended operation conditions" table.

Recommended Operating Conditions

Symbol	Parameter	Specification		Unit
		Min	Max	
V_{IN}	Supply voltage	2.75	6	V
T_A	Operating free-air temperature range	-40	85	ºC
T_J	Operating Junction range	-40	125	ºC

Electrical Characteristics

T_A = 25℃, V_{IN} = 3.6V, unless otherwise noted

Symbol	Parameter	Test Condition	Specification			Unit
			Min	Typ	Max	
I_{SD}	Shutdown supply current	V_{EN}=0V		1	5	μA
I_Q	Quiescent current	V_{EN}=3.6V, V_{FB}=0.15V		0.9	2	mA
V_{UVLO}	Under voltage lockout			2.65		V
$V_{UVLOHYS}$	UVLO hystersis			100		mV
V_{FB}	Feedback voltage	V_{EN}=2V	270	300	330	mV
I_{FB}	Feedback bias current	V_{FB}=0.1V		0.05	1	μA
$R_{DS(ON)}$	Internal switch $R_{DS(ON)}$ (*1)			0.4		Ω
	Current limit			1		A
V_{OVP}	Load open protection threshold	V_{OVP} rising		42		V
f_{OSC}	Oscillation frequency		1	1.2	1.4	MHz
D_{MAX}	Maximum duty cycle	V_{FB}=0V		90		%
	Chip enable threshold	V_{EN} rising		1		V
	Chip shutdown threshold	V_{EN} falling		0.4		V
	Thermal shutdown threshold(*1)			160		oC
	Thermal shutdown hysteresis(*1)			20		oC

(*1) Design Center Value

Functional Descriptions

The VP3162 is a compact high-efficiency boost converter with integrated switch specifically designed to drive up to 10 WLEDs in series. Series connection of the LEDs provides identical LED current resulting in uniform brightness. Fixed 1.2MHz operation allows possible smallest output ripple and external component size. With high conversion efficiency and small package, the VP3162 is ideally suitable for portable devices where PCB area is especially concerned.

Soft Start

The VP3162 limits the inrush current at start-up by increasing the current limit. This prevents unwanted shutdown otherwise may be triggered by voltage drop due to large inrush current.

Under Voltage Lock-Out Protection

Once the V_{IN} becomes too low, the internal gate driver may not work well. The VP3162 internal circuit will remain disabled until V_{IN} exceeds the input UVLO threshold voltage. This function assures the boost converter works properly and protects the internal gate driver away from entering any unexpected state.

Open LED Protection

During each switching cycle, the VP3162 monitors the voltage at the LX pin. Once the LX voltage exceeds the OVP threshold voltage, the converter will turn off the switch and enter shutdown mode. Toggling EN pin from logic low to logic high will resume the fault state.

LED Current Setting

The LED current is constant and can be adjusted by setting the external current sense resistor in series with the LED string. It can be calculated by the following formula:

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

where I_{LED} is the output current of LEDs, V_{FB} is the feedback reference voltage, R_{ISET} is the current sense resistor. Hence the offset of LED output current depends on the accuracy of V_{REF} and R_{ISET}.

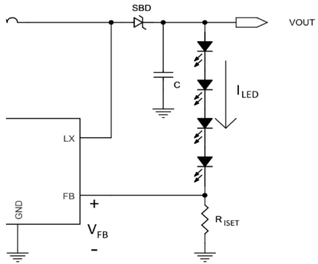


Figure 1. Setting LED current

Chip Enable

Pull the EN pin higher than 1V to enable the device and initiate its soft start cycle. Pulling the EN pin lower than 0.4V disables the device and reduces it shutdown current to less than 1μA typically. Never let the EN pin floating as it will result the driver in unknown state.

Dimming Control

1. **PWM Dimming:**

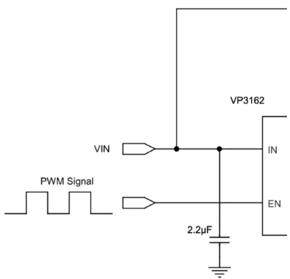


Figure 2. PWM dimming control

The simplest way to perform LED brightness control is to connect an external PWM waveform

Functional Descriptions (cont.)

at EN pin. During 0% duty of PWM waveform the VP3162 will be turned off and it will be turned on when the duty of PWM waveform is back to 100%. Since the brightness of LED is proportionally to its driving current and the average LED current is proportionally with the PWM duty cycle, the LED brightness can be controlled easily.

Figure 2 shows the circuit of PWM dimming to control the brightness of LEDs. The appropriate PWM frequency range is about 100Hz~50kHz.

2. **Analog Dimming:**

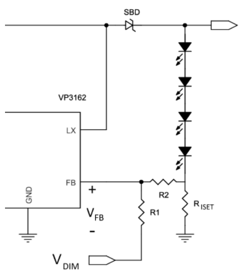


Figure 3. Dimming with a DC voltage

Figure 3 shows the circuit of analog dimming control with a external DC voltage. As the V_{DIM} increases, the voltage drop on R_2 increases and the LED current decreases. One thing very important is the dimming current must be much larger than the FB bias current and much smaller than the LED current. In this configuration, the LED current can be calculated as:

$$I_{LED} = \frac{V_{FB} \times (R_1 + R_2) - V_{DIM} \times R_2}{R_1 \times R_{ISET}}$$

The V_{DIM} shall be larger than V_{FB}, or the inverse case will happen and the brightness of LEDs will increase.

The analog dimming circuit network can be described by different resistor value by the following equation:

$$R_1 = \frac{(V_{DIM\_MAX} - V_{FB}) \times R_2}{V_{FB} \times \left(1 - \frac{I_{LED\_DIMMED\_MIN}}{I_{LED\_UNDIMMED}}\right)}$$

$$V_{DIM} = V_{FB} \times \frac{R_1}{R_2} \times \left(1 + \frac{R_2}{R_1} - \frac{I_{LED\_DIMMED\_MIN}}{I_{LED\_UNDIMMED}}\right)$$

where V_{DIM_MAX} is the upper bound of V_{DIM}, $I_{LED\_DIMMED\_MIN}$ is the minimal value of LED current when V_{DIM} is equal to V_{DIM_MAX}, $I_{LED\_UNDIMMED}$ is the maximum I_{LED} current when V_{DIM} is equal to V_{FB}.

3. **Filtered PWM Dimming from FB pin:**

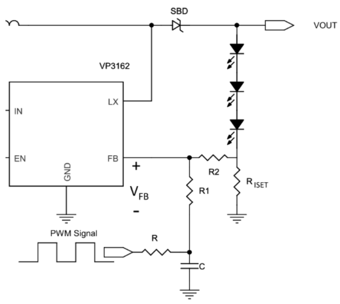


Figure 4. Dimming with filtered PWM waveform

Figure 4 shows the other way to control the LED brightness by varying PWM duty. The calaculation of LED current is:

$$I_{LED} = \frac{V_{REF} - \frac{R_2 \times (V_{PWM} \times Duty - V_{FB})}{R + R1}}{R_{ISET}}$$

where Duty is the duty of the PWM waveform.

This configuration is recommended if the frequency of PWM controlling waveform is larger then 100kHz.

Over Temperature Protection

The excessive internal dissipation of thermal protection will damage VP3162. The junction over-temperature threshold is 160ºC. The output voltage resumes automatically when the temperature reduces more than the temperature hysteresis 20ºC.

Application Information

Components Selection

External component selection begins with inductor value selection based on the considerations of the output voltage, output current, and the maximum/minimum input voltages. Catch diode and input/output capacitors can be selected according to the inductor value L.

Inductor Selection

Inductor selection should consider the inductor value, rated current, DC resistance, size, core material and cost. The inductor value is selected based on the consideration of inductor ripple current. The recommended value of inductor for 10 WLEDs applications is from 3.3μH to 4.7μH. The inductor should have low core loss at 1.2MHz and lower DC resistance for better efficiency. The inductor saturation current rating should be considered to cover the inductor peak current.

Diode Selection

The catch diode should be capable of handling the output voltage and the peak switch current. Make sure that the diode peak current rating is at least $I_{LX(PEAK)}$ and that its breakdown voltage exceeds V_{OUT}. Schottky diodes are recommended due to its low forward voltage and low reverse recovery current. The capability for handling power dissipation should be considered.

Layout Consideration

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

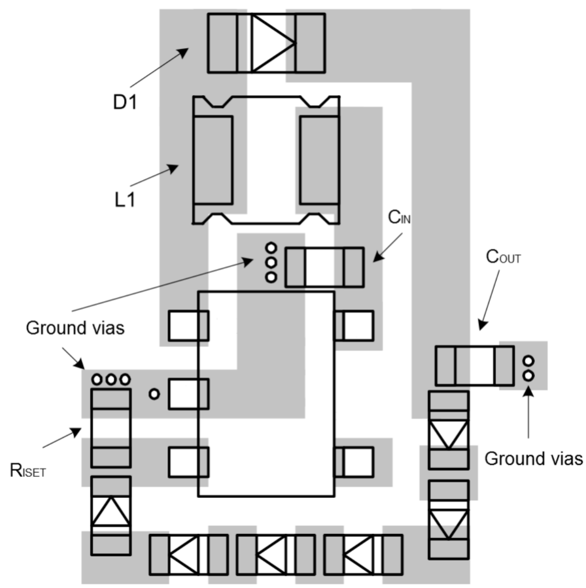


Figure 5. VP3162 layout recommendation

Typical Characteristics

T_A = 25℃, V_{IN} = 3.6V, unless otherwise noted

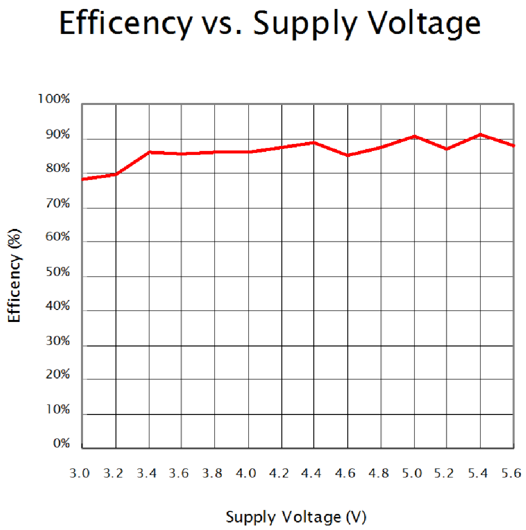


Figure 6. Efficient vs. Supply Voltage

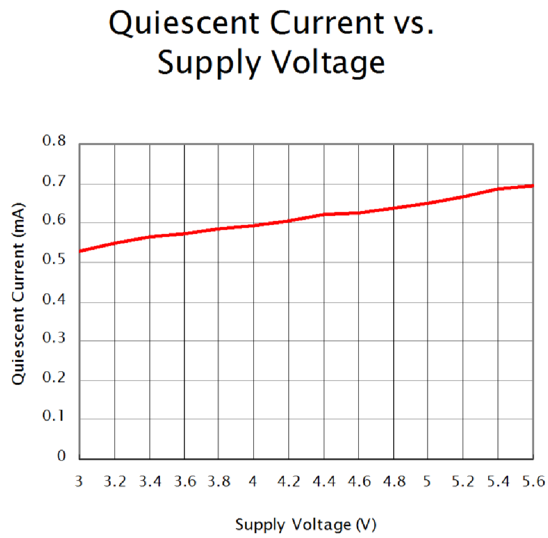


Figure 7. Quiescent Current vs. Supply Voltage

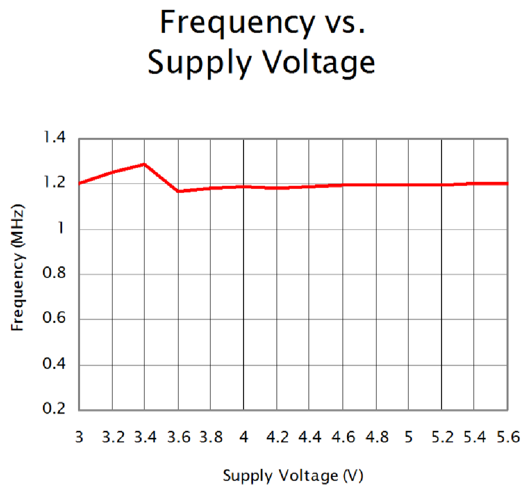


Figure 8. Frequency vs. Supply Voltage

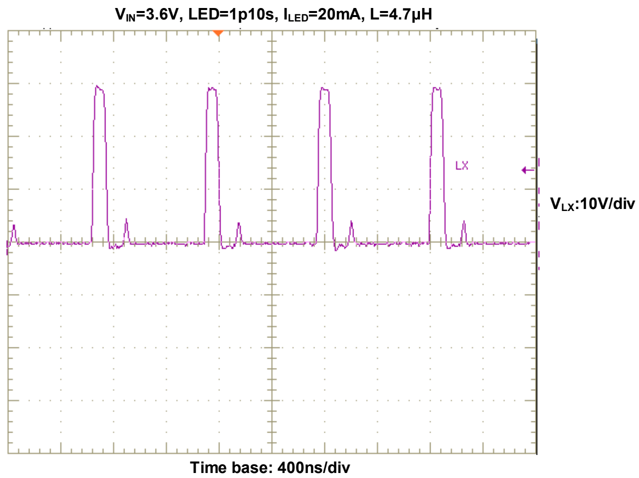


Figure 9. Switching Waveform

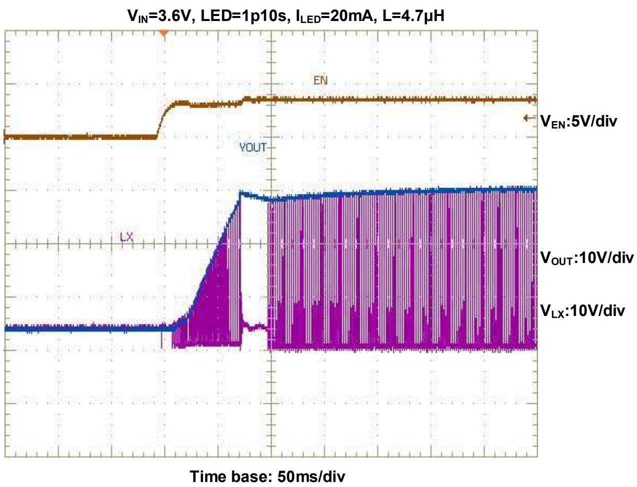


Figure 10. Soft-Start Waveform

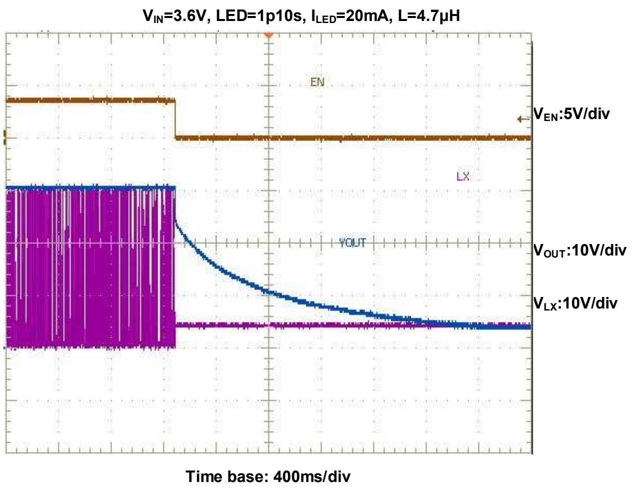


Figure 11. Shutdown Waveform

Typical Application Circuits

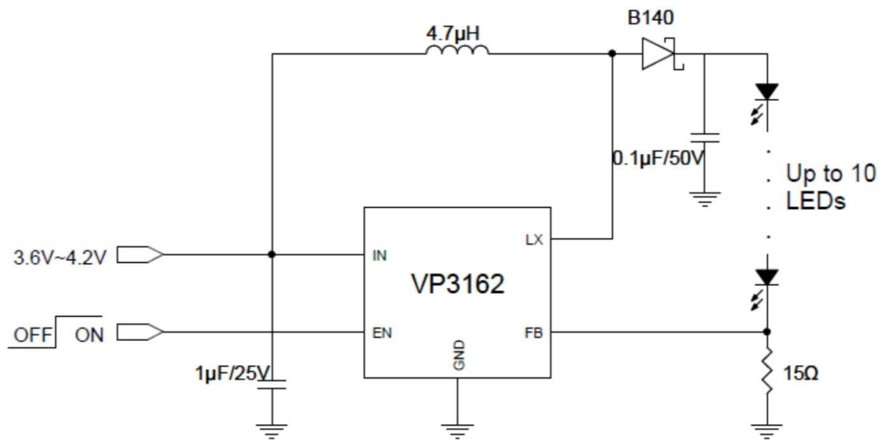


Figure 12. Typical Application with Driving 1p10s WLEDs

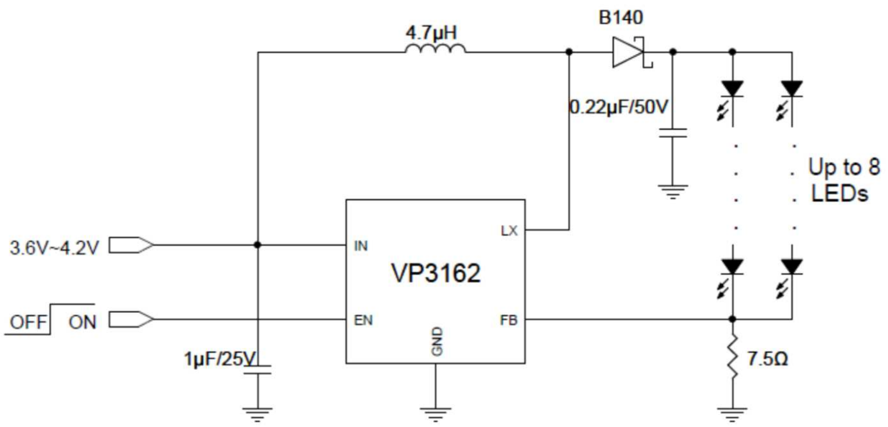
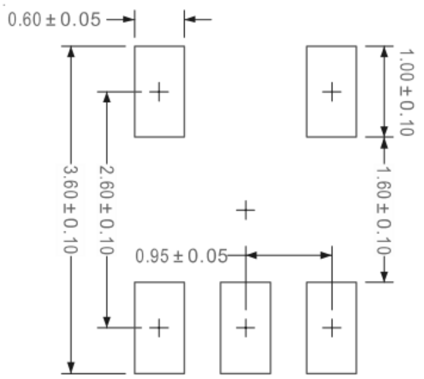


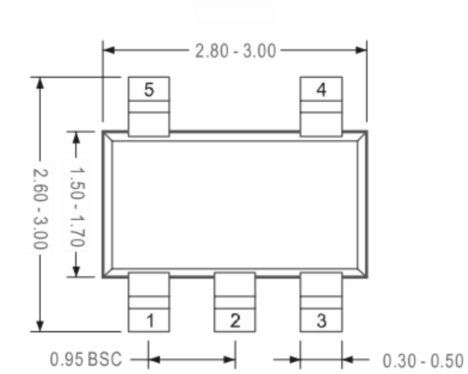
Figure 13. Typical Application with Driving 2p8s WLEDs

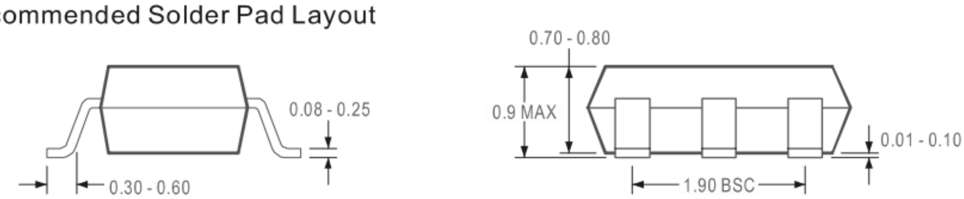
Package Information

SOT23-5



Recommended Solder Pad Layout





Notes:

1.Package Outline Unit Description:
  BSC: Basic. Represents theoretical exact dimension or dimension target.
  MIN: Minimum dimension specified.
  MAX: Maximum dimension specified.
  REF: Reference. Represents dimension for reference use only. This value is not a device specification.
  TYP: Typical. Provided as a general value. This value is not a device specification.
2.Dimensions in Millimeters.

Ordering Information

VP3162□□□

- 5: Pin Count
- G: Green & RoHS Compliant
- ST: SOT-23

Part No.	Q`ty/Reel
VP3162STG5	3,000

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