

## 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.

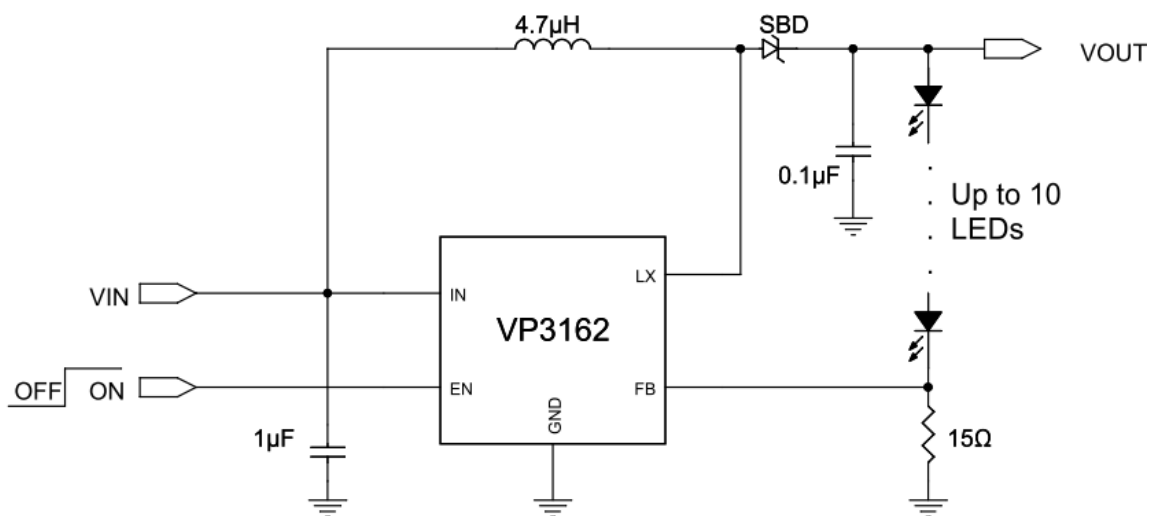
### Features

- 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

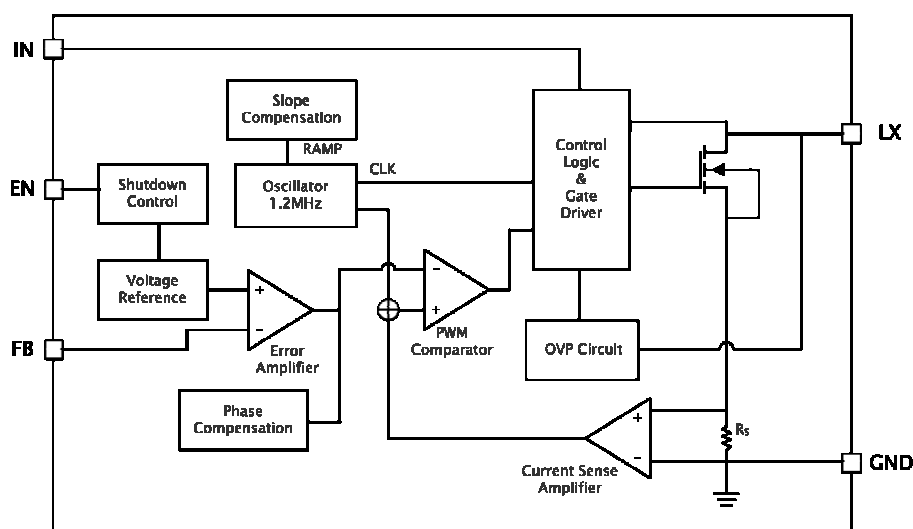
### Applications

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

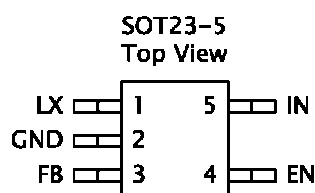
### Typical Application



## 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 | °C   |
| $T_{STG}$               | Storage temperature range             | -65 to 150  | °C   |
| Electrostatic discharge | Human body model                      | $\pm 2$     | kV   |
| Electrostatic discharge | Machine model                         | $\pm 200$   | V    |
| $\theta_{JC}$           | Thermal Resistance (Junction to Case) | 110         | °C/W |
| $\theta_{JA}$           | Thermal Resistance (Junction to Air)  | 220         | °C/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  | °C   |
| $T_J$    | Operating Junction range             | -40           | 125 | °C   |

## Electrical Characteristics

$T_A = 25^{\circ}\text{C}$ ,  $V_{IN} = 3.6\text{V}$ , unless otherwise noted

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

(\*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  $R_{ISET}$ .

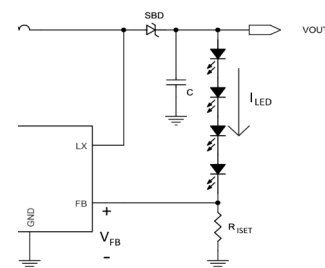


Figure 1. Setting LED current

### 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 its 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:

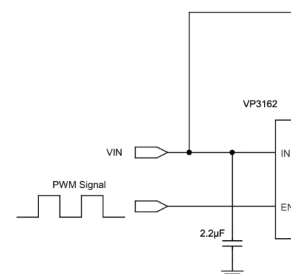


Figure 2. PWM dimming control

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:

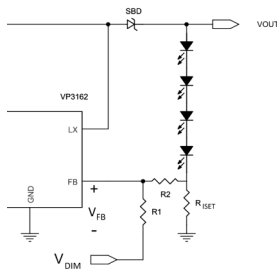


Figure 3. Dimming with a DC voltage

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:

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

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:

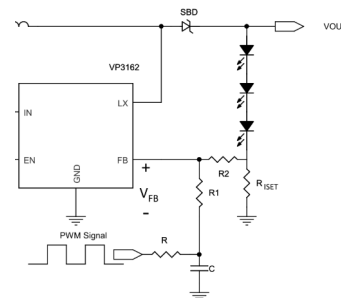


Figure 4. Dimming with filtered PWM waveform

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

$$I_{LED} = \frac{V_{REF} - \frac{R_2 \times (V_{PWM} \times Duty - V_{FB})}{R + R_1}}{R_{SET}}$$

where Duty is the duty of the PWM waveform.

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

## Over Temperature Protection

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

## 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  $3.3\mu\text{H}$  to  $4.7\mu\text{H}$ . 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.

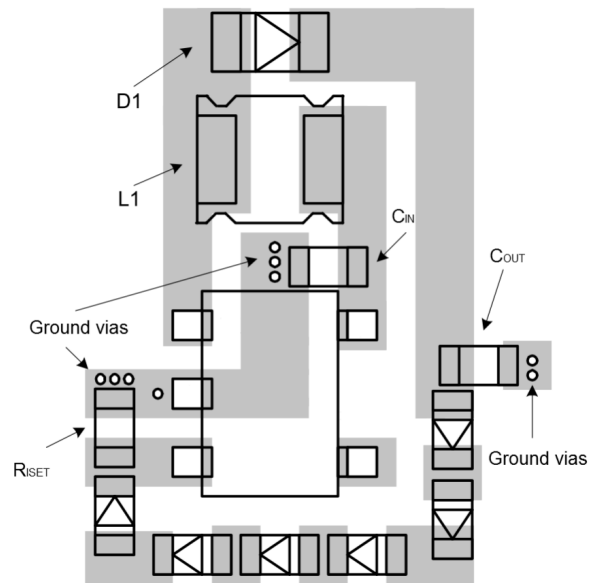


Figure 5. VP3162 layout recommendation

## Typical Characteristics

$T_A = 25^\circ\text{C}$ ,  $V_{IN} = 3.6\text{V}$ , unless otherwise noted

### Efficiency vs. Supply Voltage

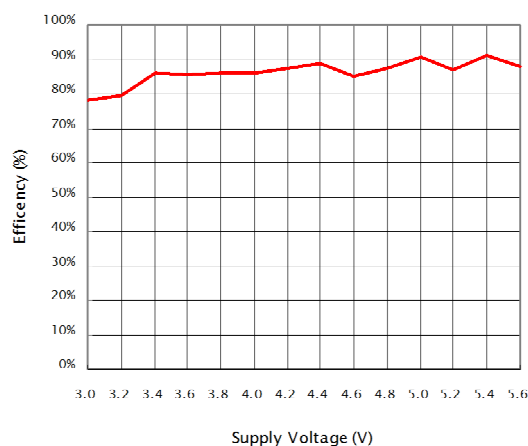


Figure 6. Efficient vs. Supply Voltage

### Quiescent Current vs. Supply Voltage

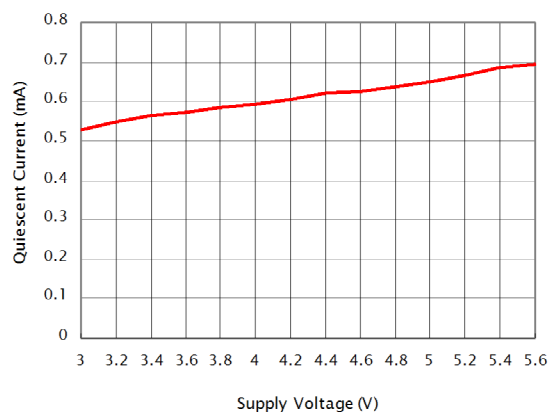


Figure 7. Quiescent Current vs. Supply Voltage

### Frequency vs. Supply Voltage

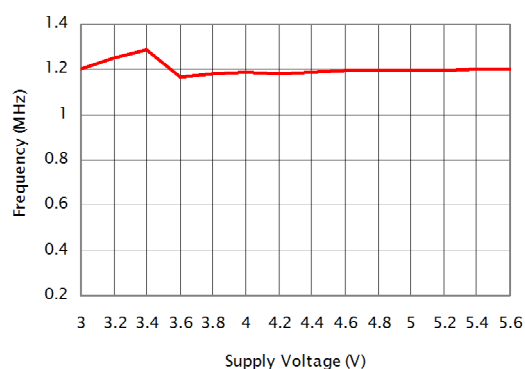


Figure 8. Frequency vs. Supply Voltage

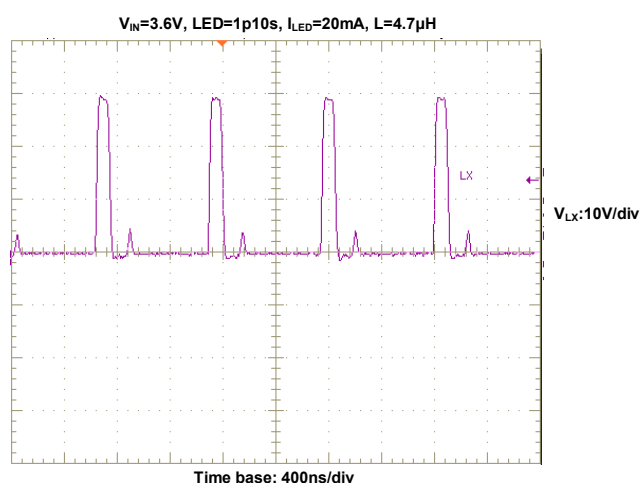


Figure 9. Switching Waveform

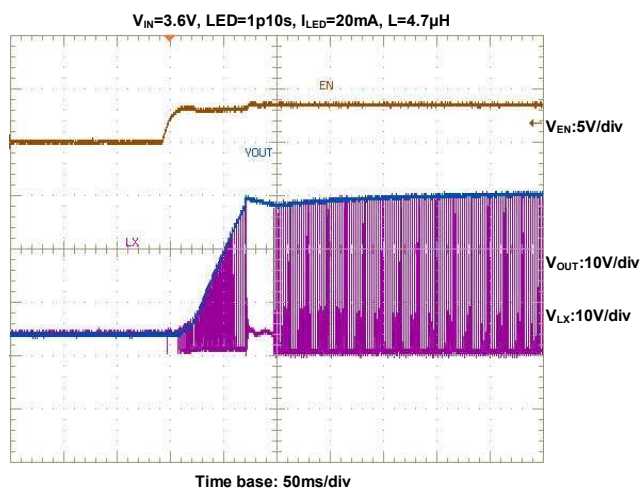


Figure 10. Soft-Start Waveform

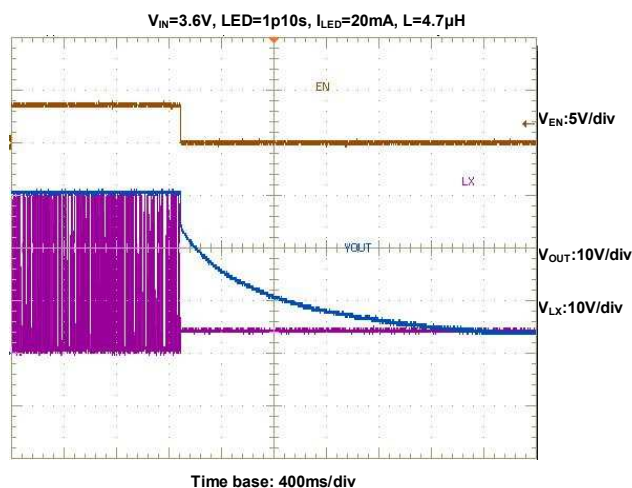


Figure 11. Shutdown Waveform



## Typical Application Circuits

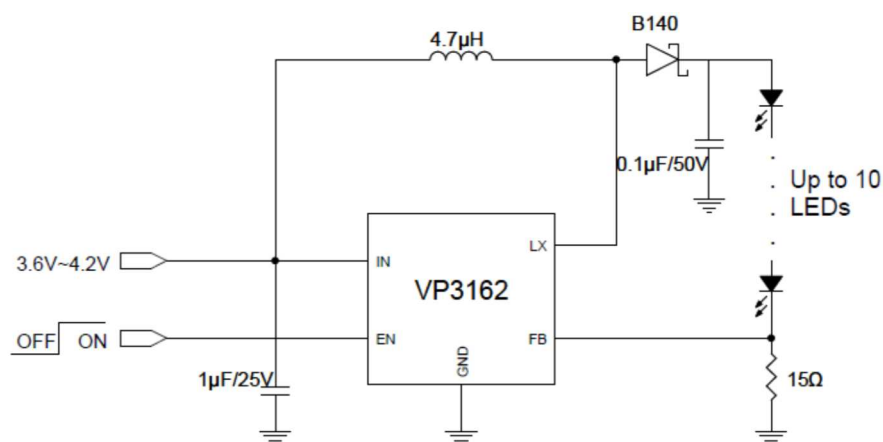


Figure 12. Typical Application with Driving 1p10s WLEDs

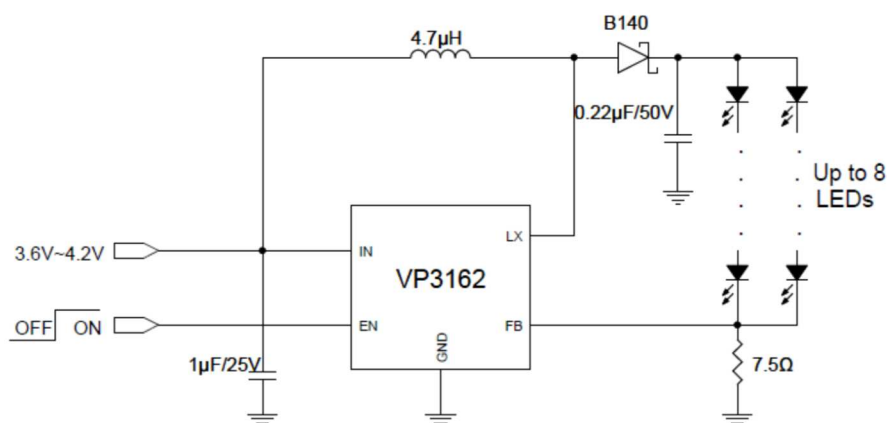
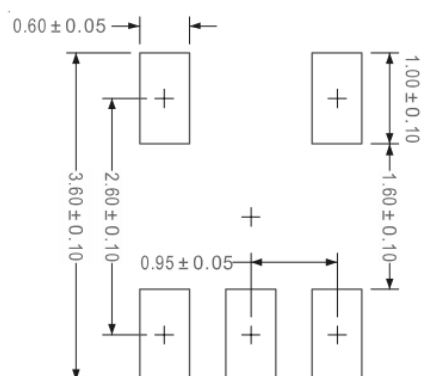


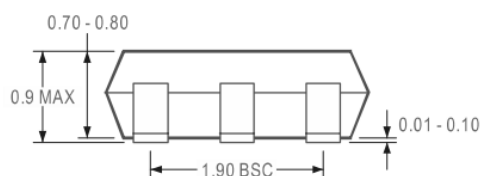
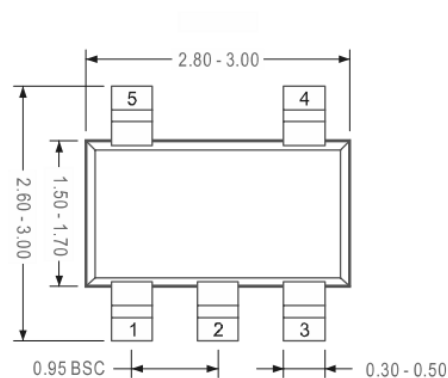
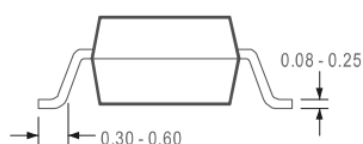
Figure 13. Typical Application with Driving 2p8s WLEDs

## 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.

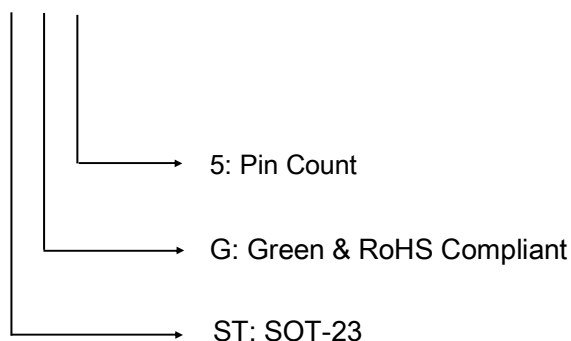
REF: Reference. Represents dimension for reference use only. This value is not a device specification.

TYP: Typical. Provided as a general value. This value is not a device specification.

##### 2.Dimensions in Millimeters.

## Ordering Information

VP3162□□□



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

## Contact Information

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