

**WHITE LED STEP-UP CONVERTER****AP3032****General Description**

The AP3032 is an inductor-based DC/DC boost converter designed to drive up to 4 rows of LEDs with 7 series for each in parallel for backlight.

A constant frequency 1MHz PWM control scheme is employed in this IC, which means tiny external components can be used. Specifically, 1mm tall 6.8 $\mu$ H inductor and 1 $\mu$ F aluminum output capacitor for the typical application is sufficient.

The over output voltage protection is equipped in AP3032, which protects the IC under open load condition. The AP3032 includes UVLO, soft-start, stand-by mode, current limiting and OTSD to protect the circuit under over load condition

The AP3032 is available in SOT-23-6 package.

**Features**

- Efficiency Up to 81% ( $V_{IN}=5V, I_{OUT}=80mA$ )
- Drives up to 4 Rows of WLEDs with 7 Series for Each in Parallel ( $V_{IN}=5V$ )
- Fast 1 MHz Switching Frequency
- Wide Input Voltage Range: 2.7V to 9V
- Low Feedback Voltage: 200mV
- Output Over Voltage Protection
- Cycle-by-cycle Current Limit: 1.4A
- Built in Soft-start
- Built in Standby-mode to Achieve High Frequency PWM Dimming
- Built in Thermal Shutdown Function
- Under Voltage Lockout

**Applications**

- 7' to 10' LCD Panels
- Digital Photo Frame
- GPS Receiver

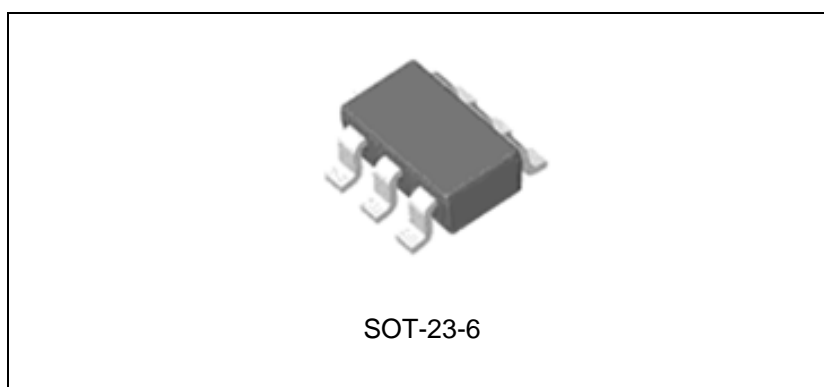


Figure 1. Package Type of AP3032

**WHITE LED STEP-UP CONVERTER**

**AP3032**

**Pin Configuration**

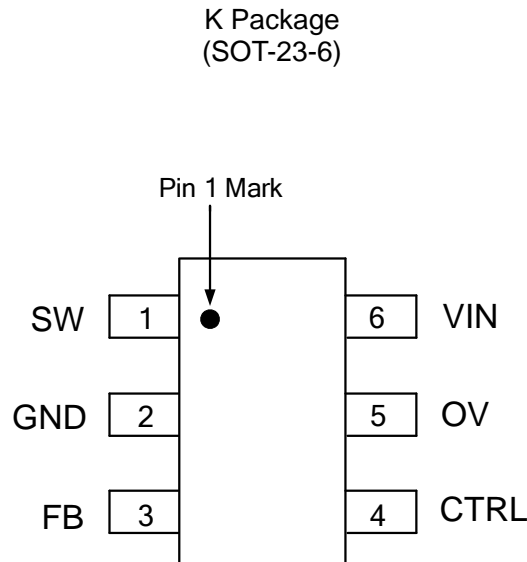


Figure 2. Pin Configuration of AP3032 (Top View)

**Pin Description**

| Pin Number | Pin Name | Function  |
|------------|----------|---|
| 1          | SW       | Switch pin. Connect external inductor and Schottky  |
| 2          | GND      | Ground  |
| 3          | FB       | Voltage feedback. Reference voltage is 200mV  |
| 4          | CTRL     | Enable and dimming control pin. Connect to a high input to enable the IC or a low input to disable the IC. Connect to a PWM input to achieve dimming control. If logic low time is less than about 0.7 ms, AP3032 is hold on standby mode, at which it shut down the power switch but shield the soft-start function, to achieve high frequency dimming |
| 5          | OV       | Over voltage protection input. Connect to the output directly. On OVP condition, the output voltage will clamp  |
| 6          | VIN      | Input supply pin. Must be locally bypassed  |

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**Functional Block Diagram**

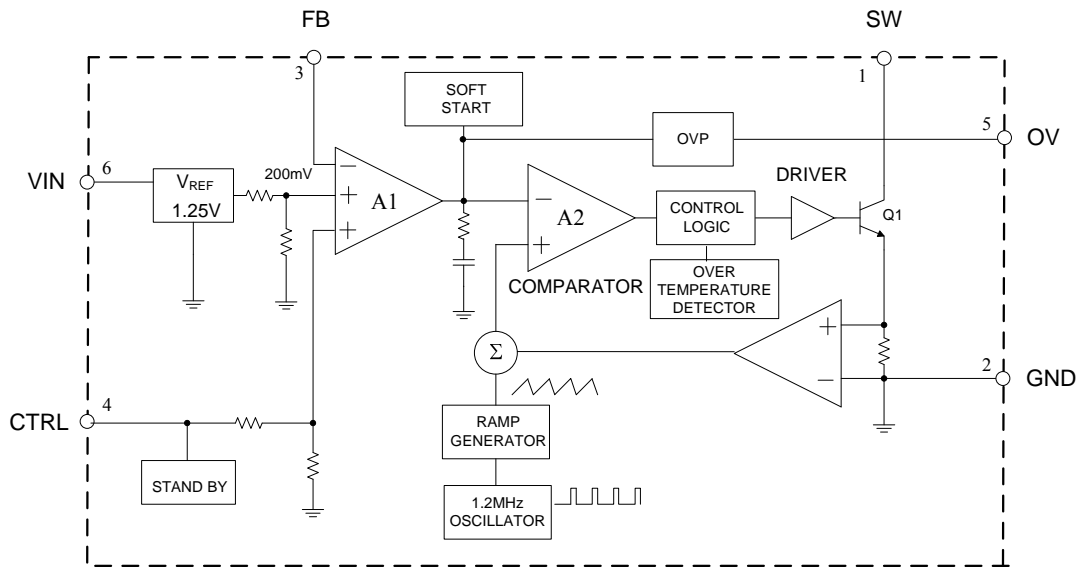
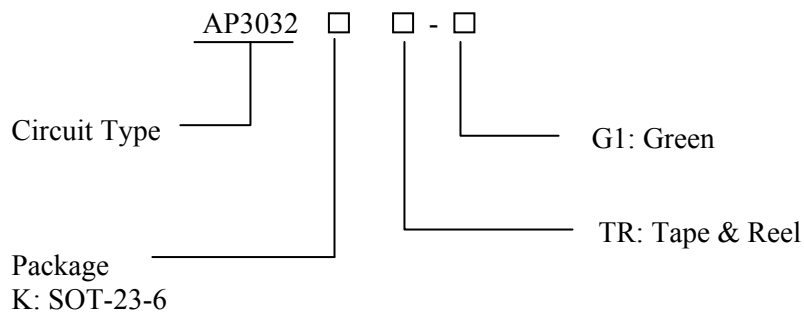


Figure 3. Functional Block Diagram of AP3032

**Ordering Information**



| Package  | Temperature Range | Part Number  | Marking ID | Packing Type |
|----------|-------------------|--------------|------------|--------------|
| SOT-23-6 | -40 to 85°C       | AP3032KTR-G1 | GJL        | Tape & Reel  |

BCD Semiconductor's Pb-free products, as designated with "G1" suffix in the part number, are RoHS compliant and green.

**WHITE LED STEP-UP CONVERTER****AP3032****Absolute Maximum Ratings (Note 1)**

| Parameter  | Symbol        | Value      | Unit |
|--|---------------|------------|------|
| Input Voltage  | $V_{IN}$      | 20         | V    |
| SW Pin Voltage   | $V_{SW}$      | 38         | V    |
| FB Pin Voltage   | $V_{FB}$      | 20         | V    |
| OV Voltage   | $V_{OV}$      | 35         | V    |
| CTRL Pin Voltage                                       | $V_{CTRL}$    | 20         | V    |
| Thermal Resistance (Junction to Ambient, No Heat Sink) | $\theta_{JA}$ | 265        | °C/W |
| Operating Junction Temperature                         | $T_J$         | 150        | °C   |
| Storage Temperature Range                              | $T_{STG}$     | -65 to 150 | °C   |
| Lead Temperature (Soldering, 10sec)                    | $T_{LEAD}$    | 260        | °C   |
| ESD (Machine Model)                                    |               | 200        | V    |
| ESD (Human Body Model)                                 |               | 2000       | V    |

Note 1: Stresses greater than those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “Recommended Operating Conditions” is not implied. Exposure to “Absolute Maximum Ratings” for extended periods may affect device reliability.

**Recommended Operating Conditions**

| Parameter                   | Symbol     | Min | Max | Unit |
|-----------------------------|------------|-----|-----|------|
| Operating Temperature Range | $T_{OP}$   | -40 | 85  | °C   |
| Input Voltage               | $V_{IN}$   | 2.7 | 9   | V    |
| CTRL Pin Voltage            | $V_{CTRL}$ |     | 9   | V    |

**WHITE LED STEP-UP CONVERTER****AP3032****Electrical Characteristics**

$V_{IN}=V_{CTRL}=5.0V$ , unless otherwise specified. Specification with standard typeface are for  $T_A=25^\circ C$ , and those in boldface type apply over the full operating temperature range ( $T_A=-40^\circ C$  to  $85^\circ C$ ).

| Parameters                         | Symbol        | Conditions                         | Min        | Typ        | Max        | Unit       |
|------------------------------------|---------------|------------------------------------|------------|------------|------------|------------|
| <b>SUPPLY VOLTAGE (VIN PIN)</b>    |               |                                    |            |            |            |            |
| Input Voltage                      | $V_{IN}$      |                                    | 2.7        |            | 9          | V          |
| Quiescent Current                  | $I_Q$         | $V_{FB}=V_{IN}$ ,<br>Not Switching | 3.0        | 4.0        | 5.0        | mA         |
| Shutdown Supply Current            | $I_{SHDN}$    | $V_{CTRL}=0V$                      |            | 50         |            | $\mu A$    |
| <b>ENABLE (EN PIN)</b>             |               |                                    |            |            |            |            |
| CTRL Pin Voltage                   | $V_{CTRL}$    |                                    |            | 1.2        |            | V          |
| CTRL Pin Bias Current              | $I_{CTRL}$    |                                    |            | 60         |            | $\mu A$    |
| <b>OUTPUT VOLTAGE</b>              |               |                                    |            |            |            |            |
| OVP Voltage                        | $V_{OVP}$     |                                    |            | 27         |            | V          |
| <b>VOLTAGE REFERENCE (FB PIN)</b>  |               |                                    |            |            |            |            |
| Feedback Voltage                   | $V_{FB}$      |                                    | <b>188</b> | <b>200</b> | <b>212</b> | mV         |
| Feedback Bias Current              | $I_{FB}$      |                                    |            | 35         | 100        | $\mu A$    |
| <b>SWITCHING REGULATOR</b>         |               |                                    |            |            |            |            |
| Switching Frequency                | f             |                                    | 0.75       | 1          | 1.3        | MHz        |
| Maximum Duty Cycle                 | $D_{MAX}$     |                                    | 90         | 93         |            | %          |
| Switch Current Limit               | $I_{LIMIT}$   | D=60%                              | 1.2        | 1.4        |            | A          |
| Switch $V_{CE}$ Saturation Voltage | $V_{CE\_SAT}$ | $I_{SW}=1A$                        |            | 300        |            | mV         |
| Switch Leakage Current             |               | $V_{SW}=9V$                        |            | 0.01       | 5          | $\mu A$    |
| <b>THERMAL SHUTDOWN</b>            |               |                                    |            |            |            |            |
| Thermal Shutdown                   | $T_{OTSD}$    |                                    |            | 160        |            | $^\circ C$ |
| Thermal Shutdown Hysteresis        | $T_{HYS}$     |                                    |            | 20         |            | $^\circ C$ |
| <b>SOFT START</b>                  |               |                                    |            |            |            |            |
| Soft-start Time                    | $t_{SS}$      |                                    |            | 300        |            | $\mu s$    |
| Standby Time                       | $t_{STANDBY}$ |                                    |            | 0.7        |            | ms         |

**WHITE LED STEP-UP CONVERTER**

**AP3032**

**Typical Performance Characteristics**

The WLED forward voltage ( $V_F$ ) is 3.2V at  $I_{LED}=20mA$ , unless otherwise noted.

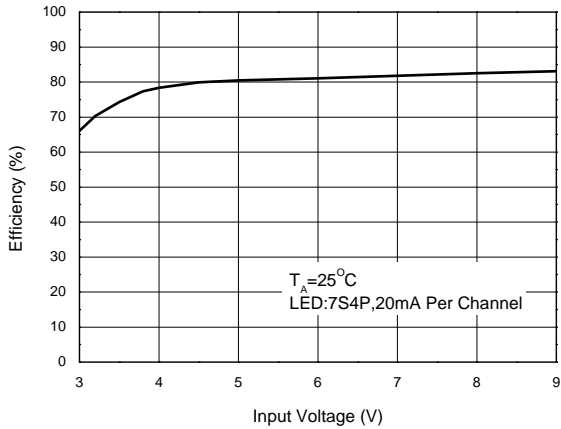


Figure 4. Efficiency vs. Input Voltage

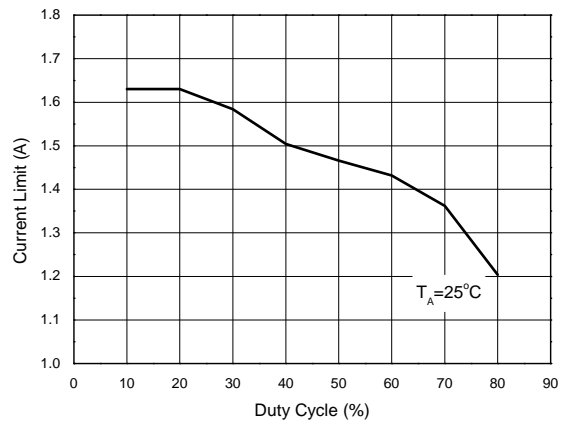


Figure 5. Switch Current Limit vs. Duty Cycle

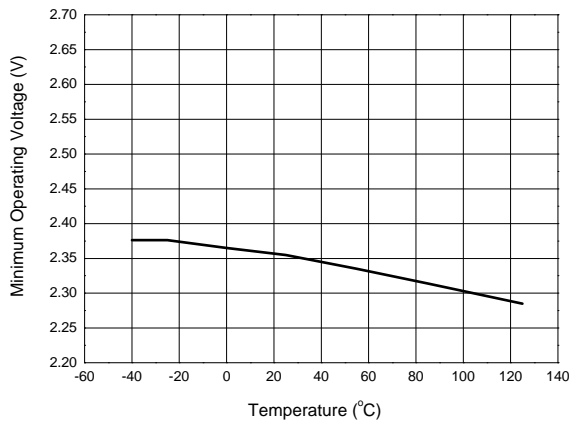


Figure 6. Minimum Operating Voltage vs. Temperature

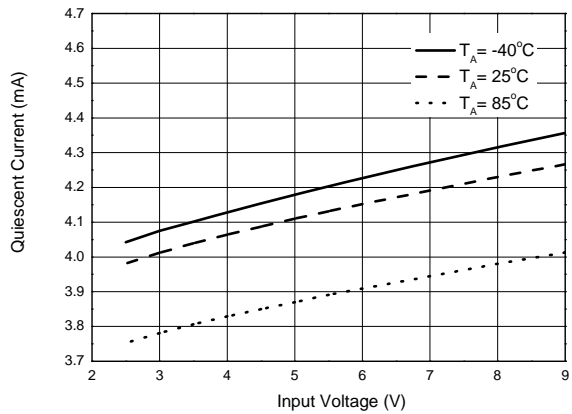


Figure 7. Quiescent Current vs. Input Voltage

**Typical Performance Characteristics (Continued)**

The WLED forward voltage ( $V_F$ ) is 3.2V at  $I_{LED}=20mA$ , unless otherwise noted.

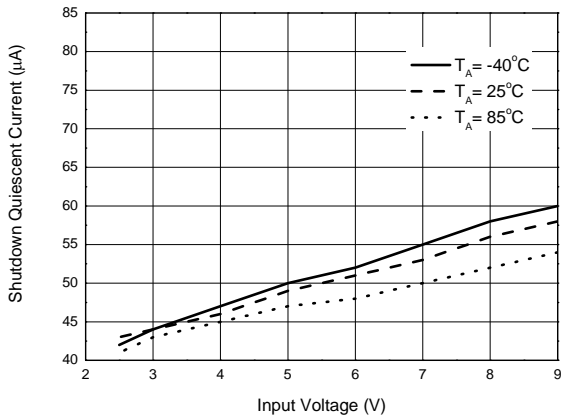


Figure 8. Shutdown Quiescent Current vs. Input Voltage

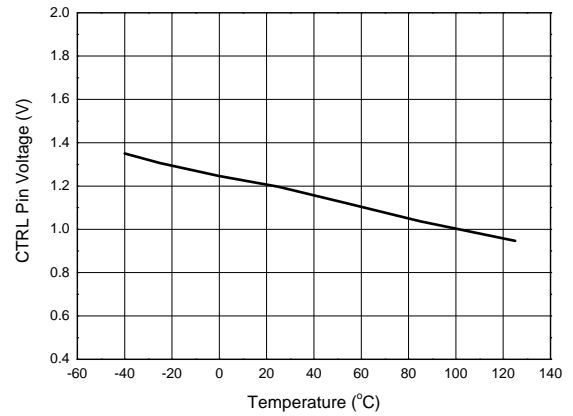


Figure 9. CTRL Pin Voltage vs. Temperature

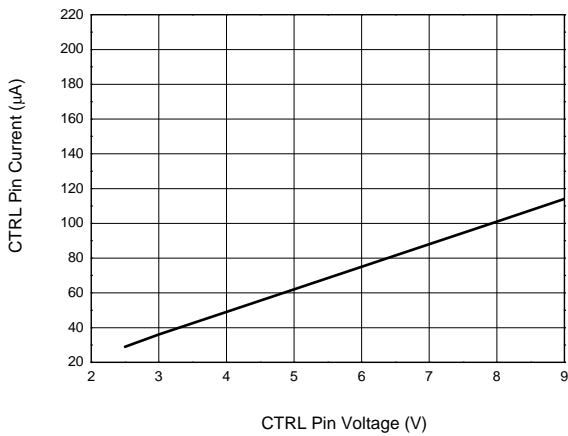


Figure 10. CTRL Pin Current vs. CTRL Pin Voltage

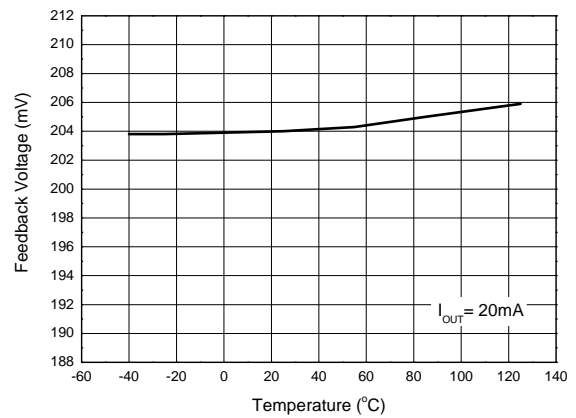


Figure 11. Feedback Voltage vs. Temperature

**WHITE LED STEP-UP CONVERTER**

**AP3032**

**Typical Performance Characteristics (Continued)**

The WLED forward voltage ( $V_F$ ) is 3.2V at  $I_{LED}=20mA$ , unless otherwise noted.

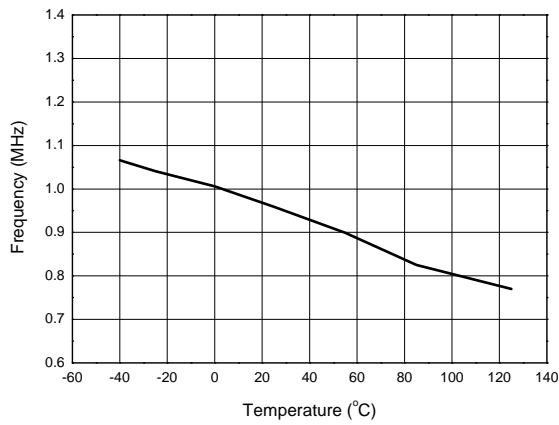


Figure 12. Frequency vs. Temperature

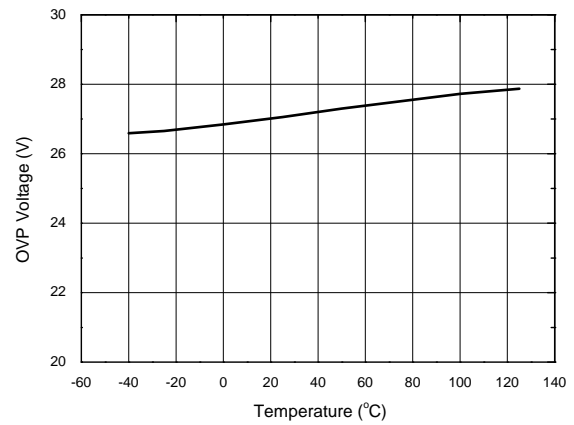


Figure 13. OVP Voltage vs. Temperature

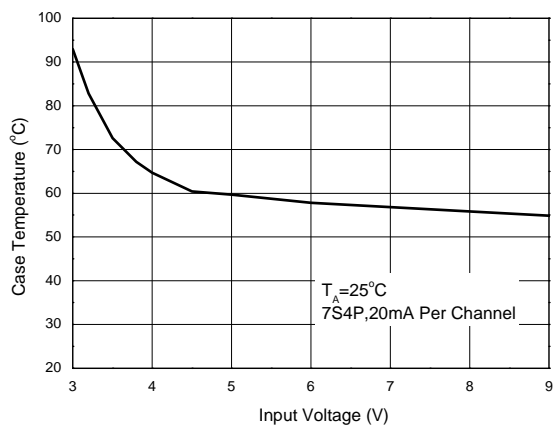


Figure 14. Case Temperature vs. Input voltage



## Application Information

### 1. Operation

The AP3032 is a boost DC-DC converter which uses a constant frequency, current mode control scheme to provide excellent line and load regulation. Operation can be best understood by referring to the Figure 21.

At the start of each oscillator cycle, switch Q1 turns on. The switch current will increase linearly. The voltage on sense resistor is proportional to the switch current. The output of the current sense amplifier is added to a stabilizing ramp and the result is fed into the non-inversion input of the PWM comparator A2. When this voltage exceeds the output voltage level of the error amplifier A1, the switch is turned off.

It is clear that the voltage level at inversion input of A2 sets the peak current level to keep the output in regulation. This voltage level is the output signal of error amplifier A1, and is the amplified signal of the voltage difference between feedback voltage and reference voltage of 200mV. So, a constant output current can be provided by this operation mode.

### 2. LED Current Control

Refer to Figure 21, the LED current is controlled by the feedback resistor  $R_{ISET}$ . LEDs' current accuracy is determined by the regulator's feedback threshold accuracy and is independent of the LED's forward voltage variation. So the precise resistors are preferred. The resistance of  $R_{ISET}$  is in inverse proportion to the LED current since the feedback reference is fixed at 200mV. The relation for  $R_{ISET}$  and LED current ( $I_{LED}$ ) can be expressed as below:

$$R_{ISET} = \frac{200mV}{I_{LED}}$$

### 3. Over Voltage Protection

The AP3032 has an internal open-load protection circuit. When the LEDs are disconnected from circuit or fail open, the output voltage is clamped at 27V. The AP3032 will switch at a low frequency, and minimize current to avoid input voltage drop.

### 4. Soft Start

The AP3032 has an internal soft start circuit to limit

the inrush current during startup. If logic low time on CTRL pin is more than about 0.7ms and then enable the IC, the AP3032 will start smoothly to protect system departments. The time of startup is controlled by internal soft start capacitor. Details please refer to Figure 15.

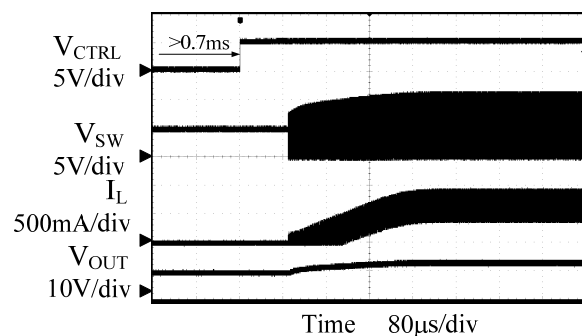


Figure 15. Soft Start Waveform

### 5. Standby and Dimming

To avoid audio noise and achieve high frequency dimming, AP3032 setup a standby function. If logic low time on CTRL pin is less than about 0.7ms and then enable the IC, AP3032 will hold on standby mode and start directly to achieve high frequency dimming. Details please refer to Figure 16.

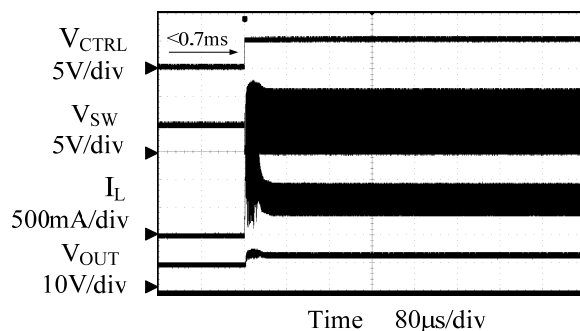


Figure 16. Standby Waveform

## Application Information (Continued)

Two typical types of dimming control circuit are present as below. First, controlling CTRL Pin voltage to change operation state is a good choice. Second, changing the feedback voltage to get appropriate duty and luminous intensity is also useful.

### 5.1 Adding a Control Signal to CTRL Pin

Adding a PWM signal to CTRL pin directly, the AP3032 is turned on and off by this signal. When the PWM frequency is lower than 2.5kHz (Typ), the IC works in the soft-start mode to dimming the light. But we intense suggest set the PWM signal frequency higher than 25kHz to avoid audio noise. In this situation, IC works in the standby mode and start directly to achieve dimming the light. More details please refer to Figure 17 and Figure 18.

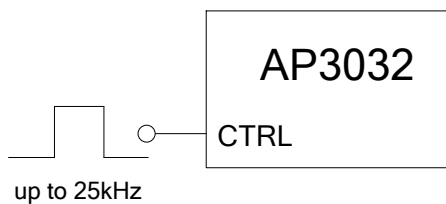


Figure 17. Dimming Control Using a PWM Signal on CTRL Pin

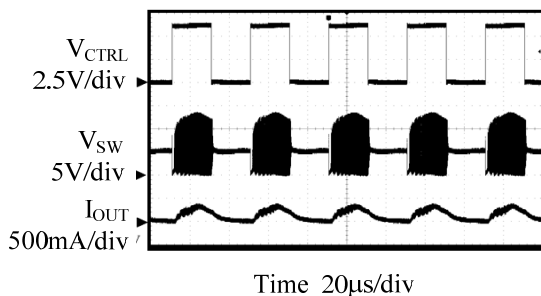


Figure 18. High Frequency (25kHz) Dimming Waveform

### 5.2 Changing the Effective Feedback Voltage

There are two popular methods to change the effective feedback voltage.

First, adding a constant DC voltage through a resistor divider to FB pin can control the dimming. Changing the DC voltage or resistor between the FB Pin and the DC voltage can get appropriate luminous intensity. Comparing with all kinds of PWM signal control, this method features a stable output voltage and LEDs current. Please refer to Figure 19.

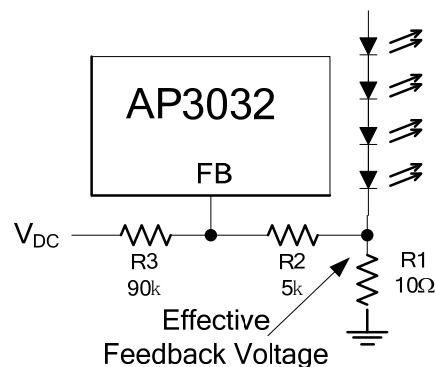


Figure 19. Dimming Control Using DC Voltage

Second, using a filtered PWM signal can do it. The filtered PWM signal can be considered as a varying and adjustable DC voltage. Please refer to Figure 20.

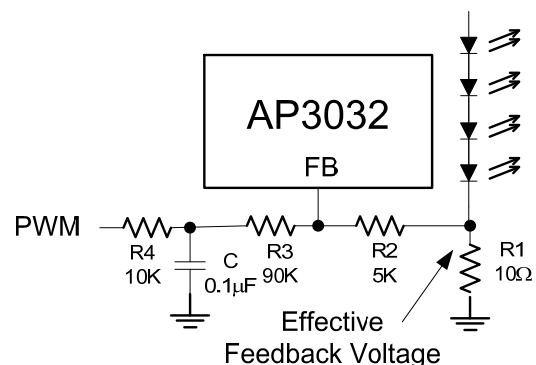


Figure 20. Dimming Control Using Filtered PWM Voltage

**WHITE LED STEP-UP CONVERTER**

**AP3032**

**Typical Application**

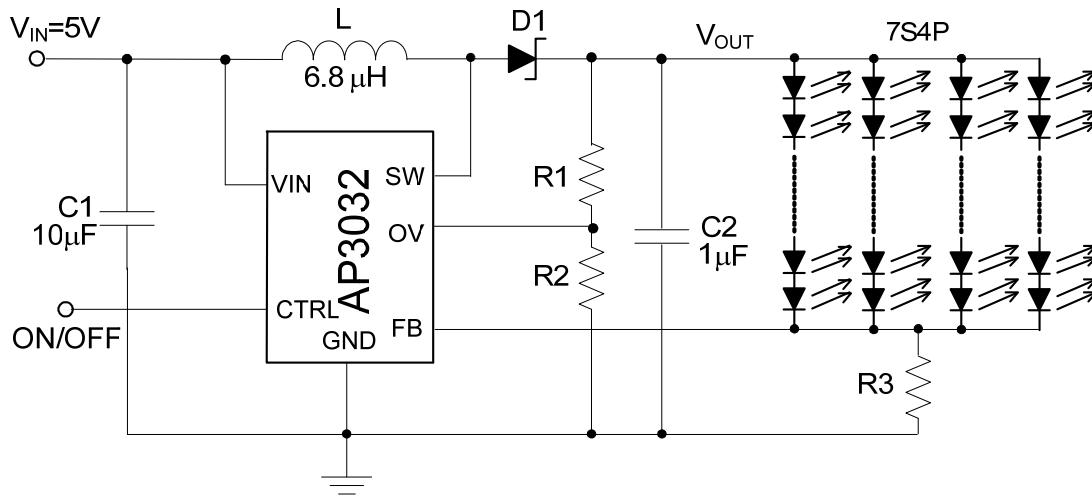


Figure 21. Typical Application of AP3032 (7S4P)

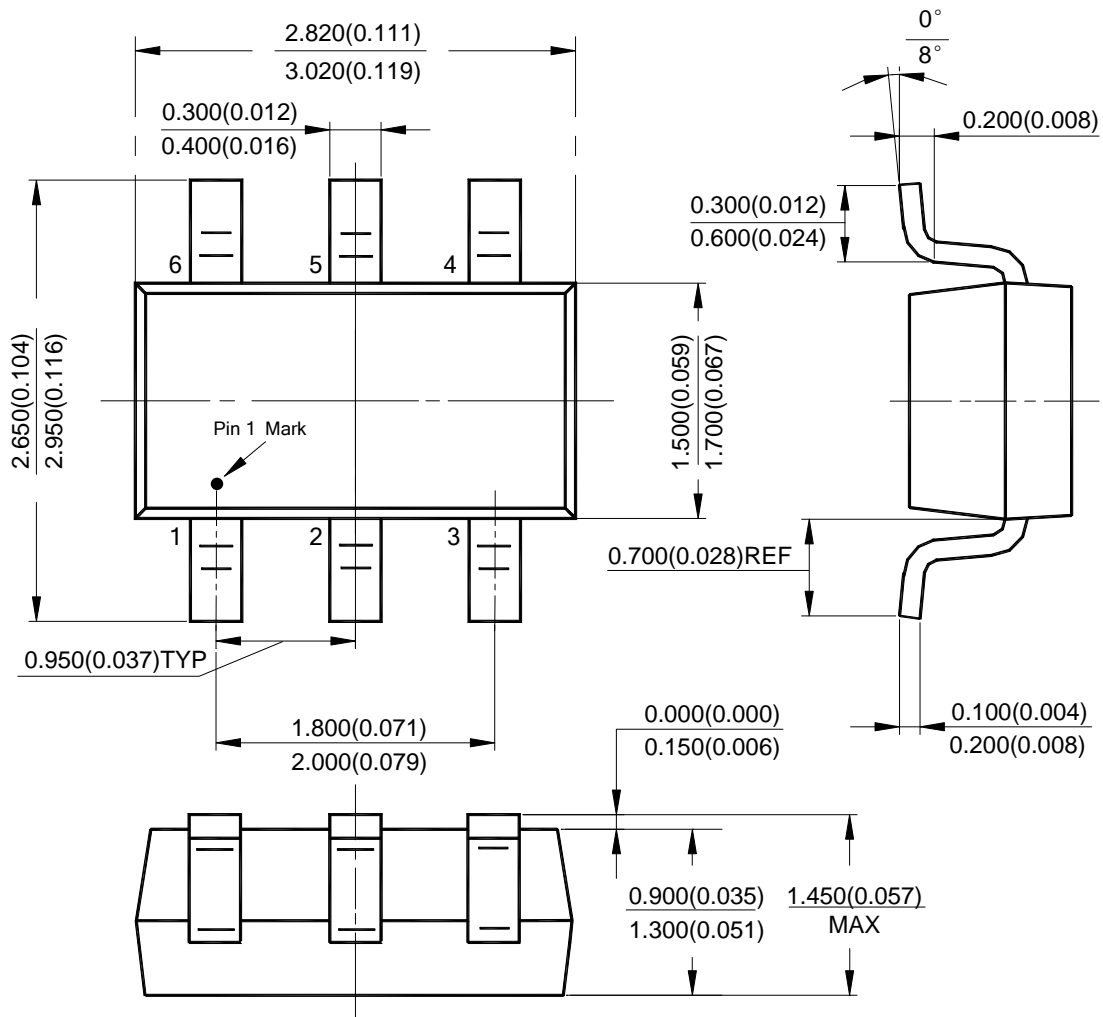
**WHITE LED STEP-UP CONVERTER**

**AP3032**

**Mechanical Dimensions**

**SOT-23-6**

**Unit: mm(inch)**





## **BCD Semiconductor Manufacturing Limited**

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