

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 μ H inductor and 1 μ 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

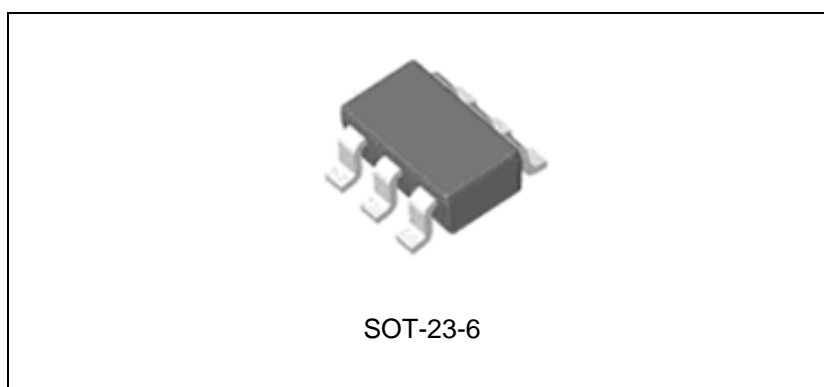


Figure 1. Package Type of AP3032

WHITE LED STEP-UP CONVERTER

AP3032

Pin Configuration

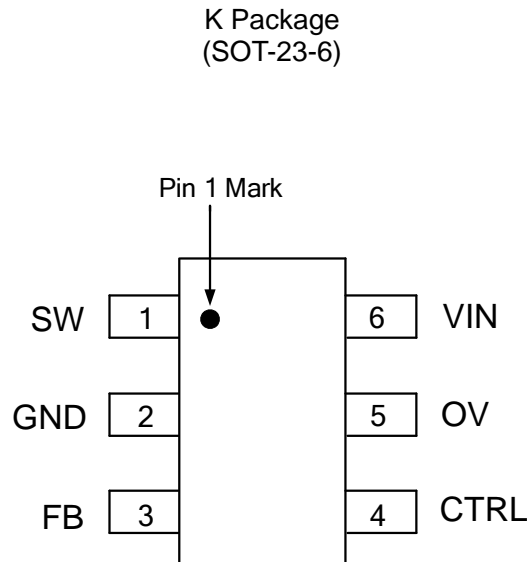


Figure 2. Pin Configuration of AP3032 (Top View)

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

WHITE LED STEP-UP CONVERTER

AP3032

Functional Block Diagram

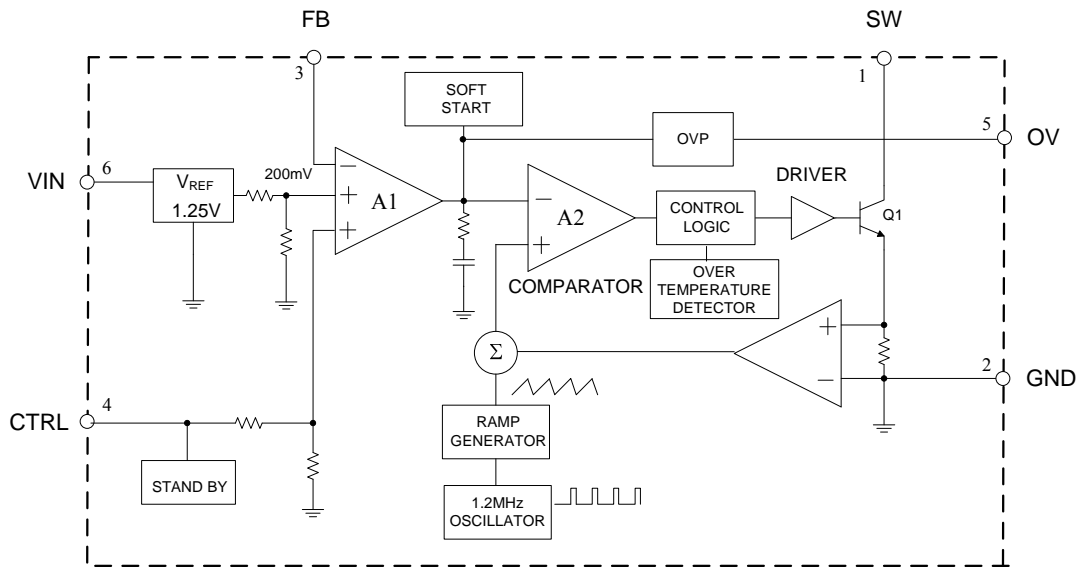
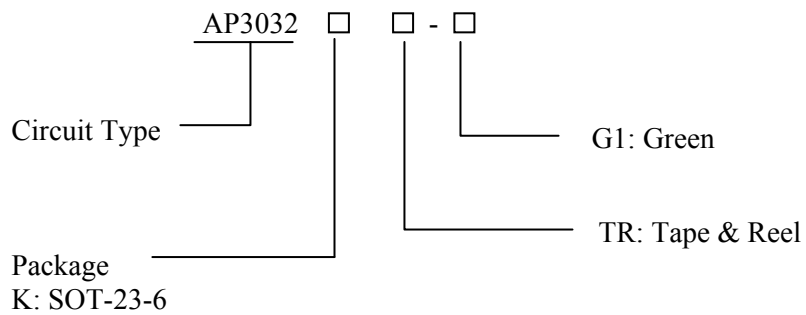


Figure 3. Functional Block Diagram of AP3032

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)	θ_{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
SUPPLY VOLTAGE (VIN PIN)						
Input Voltage	V_{IN}		2.7		9	V
Quiescent Current	I_Q	$V_{FB}=V_{IN}$, Not Switching	3.0	4.0	5.0	mA
Shutdown Supply Current	I_{SHDN}	$V_{CTRL}=0V$		50		μA
ENABLE (EN PIN)						
CTRL Pin Voltage	V_{CTRL}			1.2		V
CTRL Pin Bias Current	I_{CTRL}			60		μA
OUTPUT VOLTAGE						
OVP Voltage	V_{OVP}			27		V
VOLTAGE REFERENCE (FB PIN)						
Feedback Voltage	V_{FB}		188	200	212	mV
Feedback Bias Current	I_{FB}			35	100	μA
SWITCHING REGULATOR						
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	μA
THERMAL SHUTDOWN						
Thermal Shutdown	T_{OTSD}			160		$^{\circ}C$
Thermal Shutdown Hysteresis	T_{HYS}			20		$^{\circ}C$
SOFT START						
Soft-start Time	t_{SS}			300		μs
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.

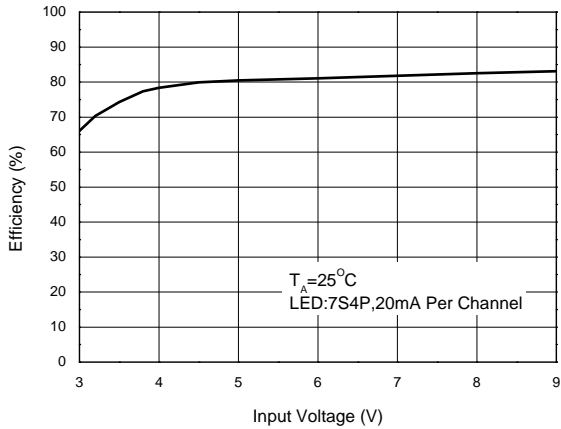


Figure 4. Efficiency vs. Input Voltage

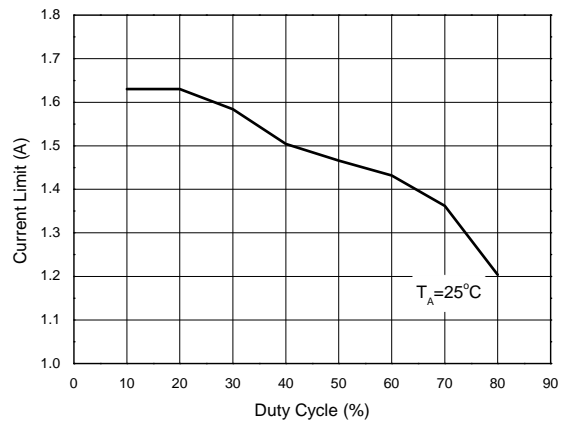


Figure 5. Switch Current Limit vs. Duty Cycle

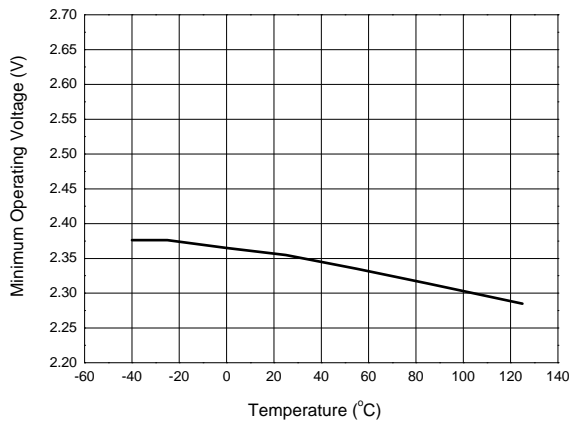


Figure 6. Minimum Operating Voltage vs. Temperature

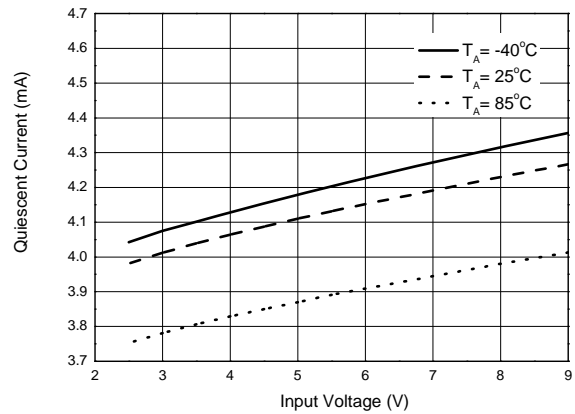


Figure 7. Quiescent Current vs. Input Voltage

Typical Performance Characteristics (Continued)

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

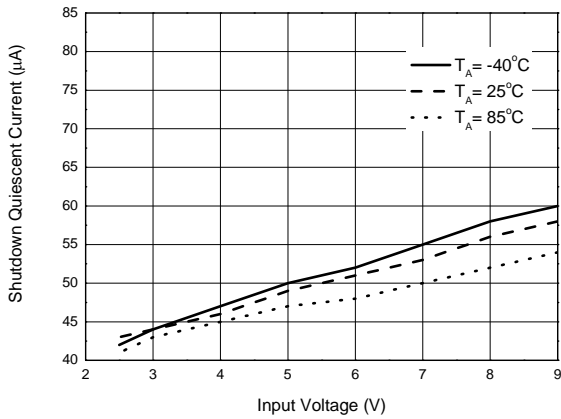


Figure 8. Shutdown Quiescent Current vs. Input Voltage

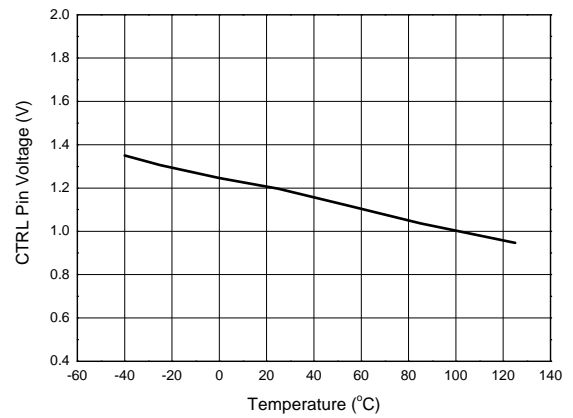


Figure 9. CTRL Pin Voltage vs. Temperature

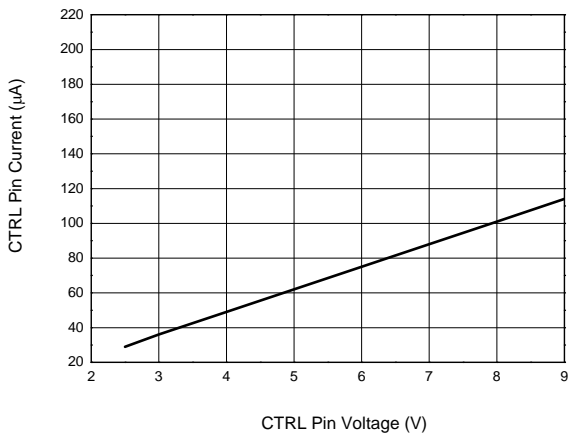


Figure 10. CTRL Pin Current vs. CTRL Pin Voltage

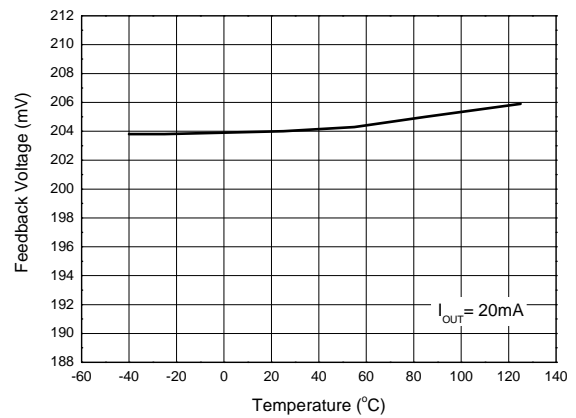


Figure 11. Feedback Voltage vs. Temperature

Typical Performance Characteristics (Continued)

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

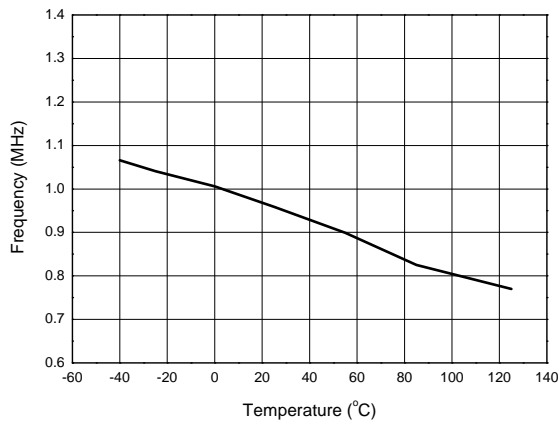


Figure 12. Frequency vs. Temperature

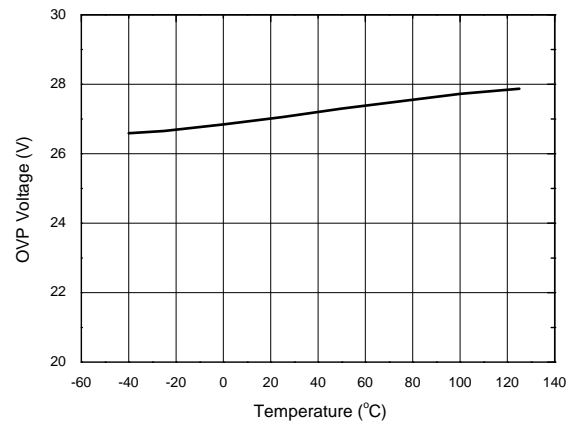


Figure 13. OVP Voltage vs. Temperature

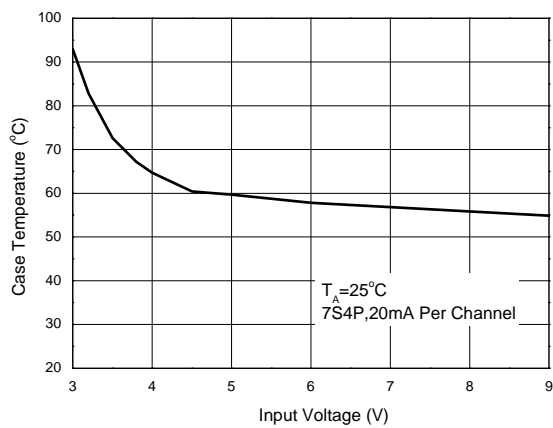


Figure 14. Case Temperature vs. Input voltage

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.

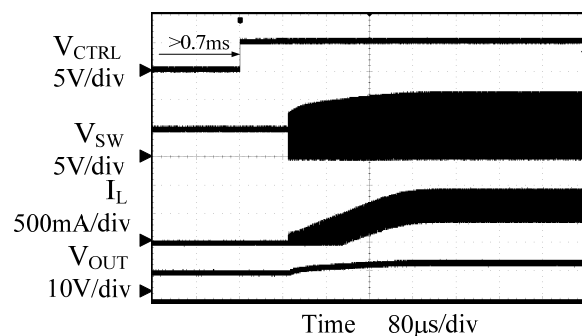


Figure 15. Soft Start Waveform

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.

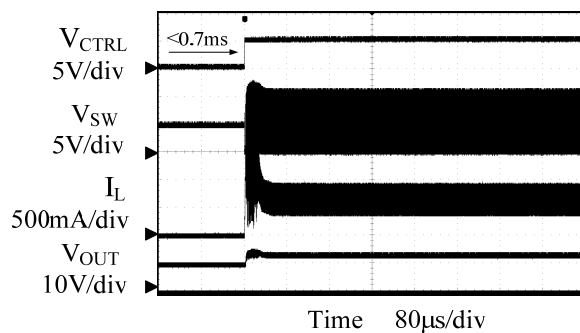


Figure 16. Standby Waveform

WHITE LED STEP-UP CONVERTER

AP3032

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.

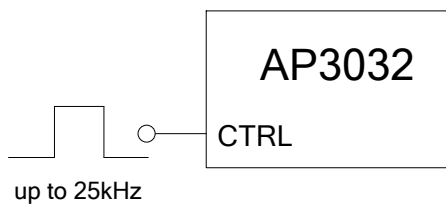


Figure 17. Dimming Control Using a PWM Signal on CTRL Pin

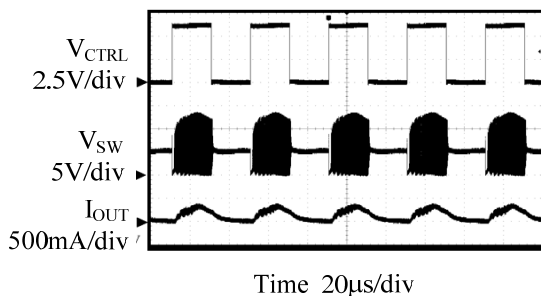


Figure 18. High Frequency (25kHz) Dimming Waveform

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.

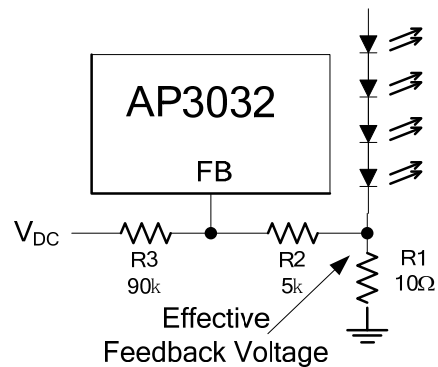


Figure 19. Dimming Control Using DC Voltage

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.

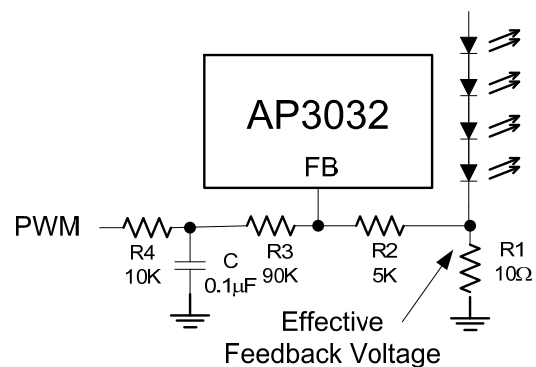


Figure 20. Dimming Control Using Filtered PWM Voltage

WHITE LED STEP-UP CONVERTER

AP3032

Typical Application

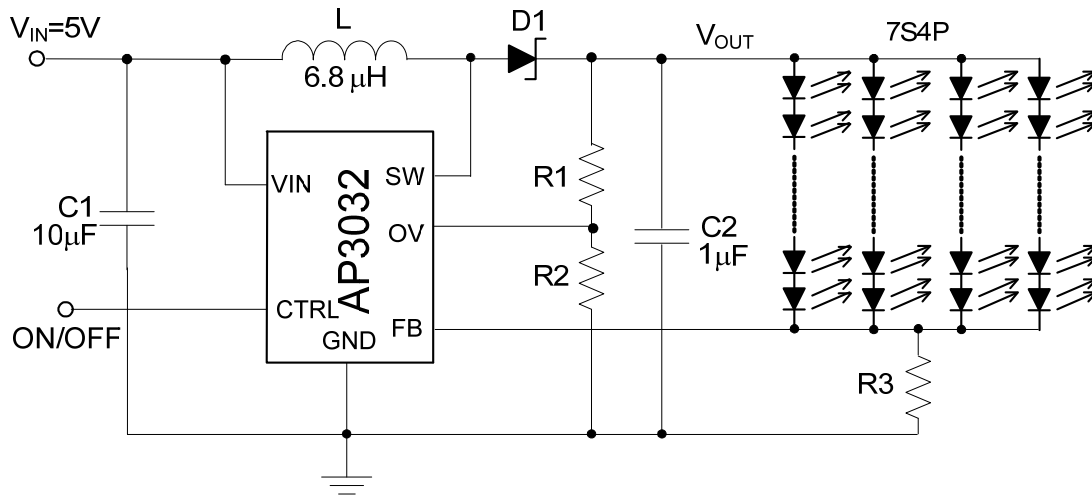


Figure 21. Typical Application of AP3032 (7S4P)

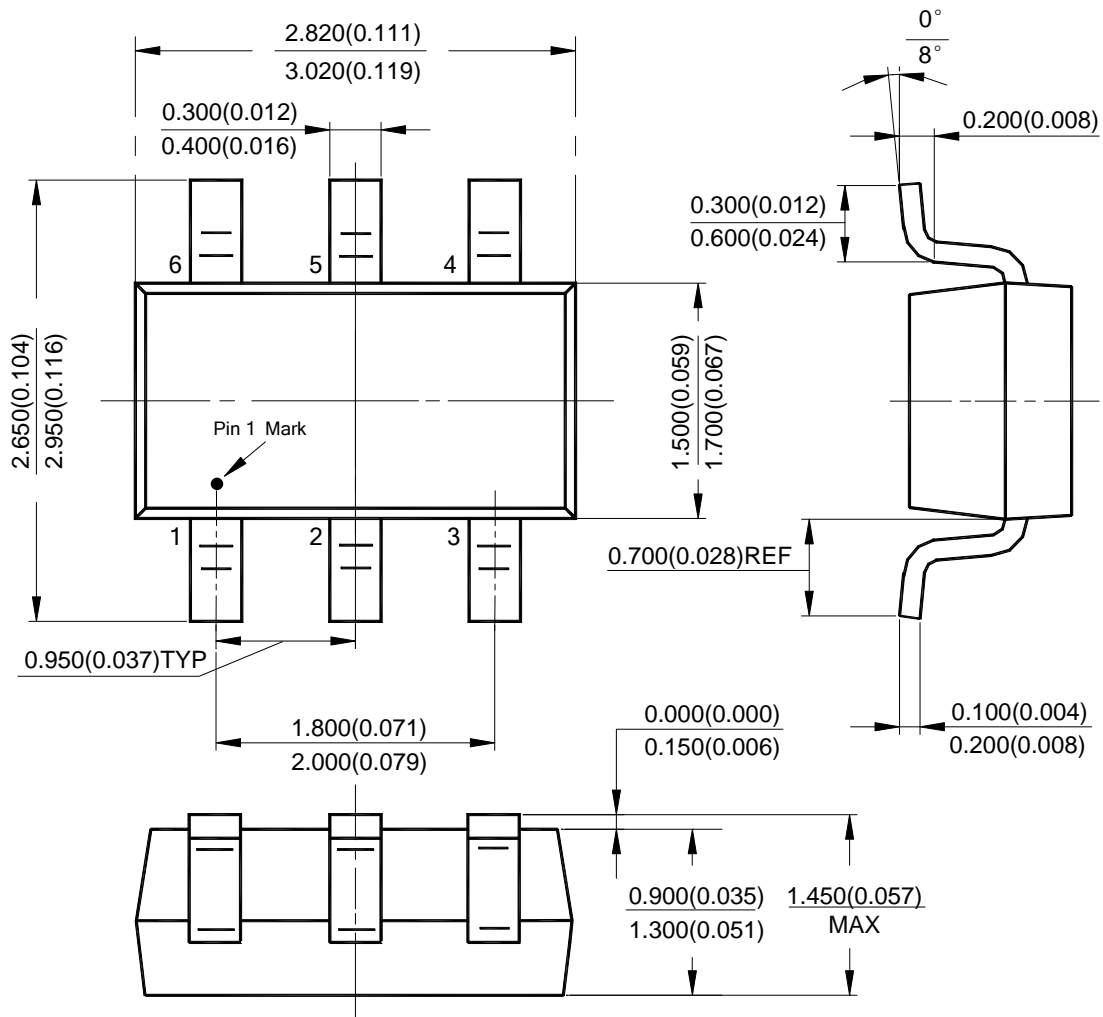
WHITE LED STEP-UP CONVERTER

AP3032

Mechanical Dimensions

SOT-23-6

Unit: mm(inch)





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