WHITE LED STEP-UP CONVERTER AP3033

General Description

The AP3033 is an inductor-based DC/DC boost converter designed to drive LED arrays. 1.3A switching current allows AP3033 to be used in different 7' to 10' LCD panel backlights (3S8P LED arrays typically).

A constant frequency 1MHz PWM control scheme is employed in this IC, which means tiny external components can be used. Specifically, 1mm tall 10μH inductor and 10μF output capacitor for the typical application is sufficient.

The over output voltage protection is equipped in AP3033, which protects the IC under open load condition. The AP3033 includes UVLO, soft-start, standby mode, current limit and OTSD to protect the circuit.

The AP3033 is available in standard TSOT-23-6 package.

Features

- Up to 92% Efficiency (V_{IN}=9V, I_{OUT}=160mA)
- Up to 88% Efficiency (V_{IN}=5V, I_{OUT}=160mA)
- Fast 1MHz Switching Frequency
- Wide Input Voltage Range: 3V to 16V
- Low 200mV Feedback Voltage
- Output Over Voltage Protection
- Cycle by Cycle Current Limit: 1.3A
- High Frequency PWM Dimming
- Built-in Soft-start
- Built-in Thermal Shutdown Function
- Under Voltage Lockout

Applications

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

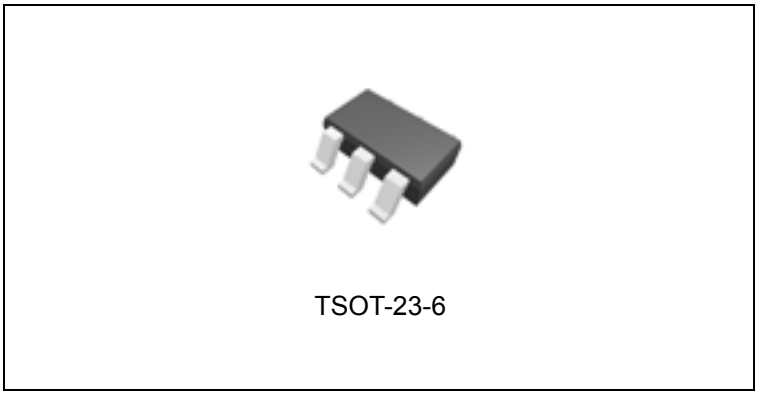


Figure 1. Package Type of AP3033

Pin Configuration

KT Package
(TSOT-23-6)

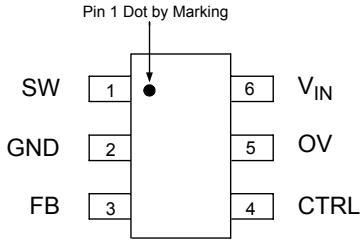


Figure 2. Pin Configuration of AP3033 (Top View)

Pin Description

Pin Number	Pin Name	Function
1	SW	Switch Pin. Connect external inductor and Schottky
2	GND	Ground Pin
3	FB	Voltage Feedback Pin. 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. If logic low time is more than about 0.45ms and then enable the IC, the AP3033 will soft start to protect system departments. If logic low time is less than about 0.45ms and then enable the IC, the AP3033 will hold on standby mode and start directly to achieve high frequency dimming
5	OV	Over-voltage Protection Input Pin. Connect to the output directly or connect to the V_{OUT} through a resistor divider to set the OVP voltage. On OVP condition, the output voltage will be clamped
6	V_{IN}	Input Supply Pin. Must be locally bypassed

Functional Block Diagram

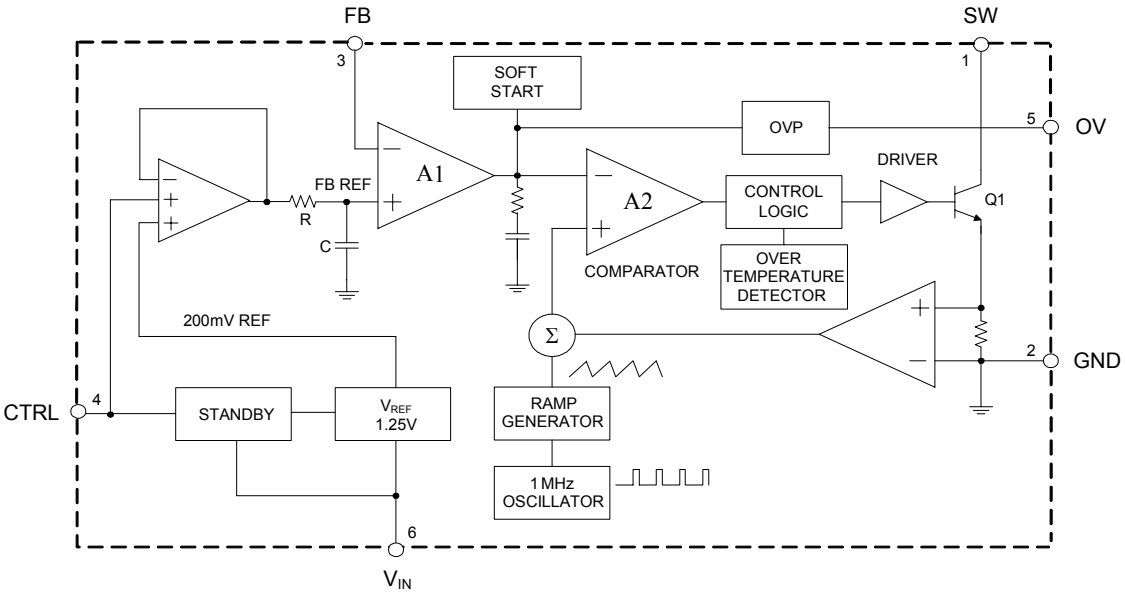
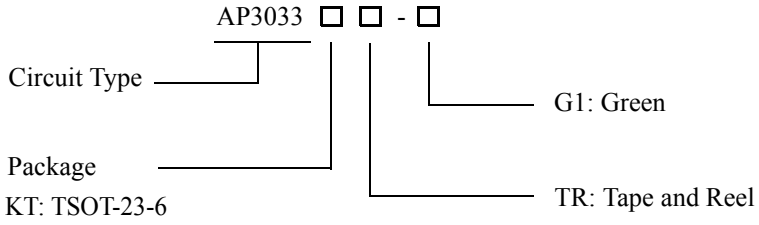


Figure 3. Functional Block Diagram of AP3033

Ordering Information



Package	Temperature Range	Part Number	Marking ID	Packing Type
TSOT-23-6	-40 to 85°C	AP3033KTTR-G1	L8G	Tape & Reel

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

Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Value	Unit
Input Voltage	V_{IN}	20	V
SW Voltage	V_{SW}	38	V
FB Voltage	V_{FB}	20	V
OV Voltage	V_{OV}	20	V
CTRL 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)		600	V
ESD (Human Body Model)		4000	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}	3	16	V
CTRL Voltage	V_{CTRL}		16	V

Electrical Characteristics

(V_{IN}=5.0V, V_{CTRL} =5.0V, T_A=25°C, unless otherwise specified.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Operating Voltage	V_{IN}		3.0		16	V
Quiescent Current	I_Q	V_{FB}=V_{IN}, no switching	4.0	5.0	6.0	mA
Shutdown Quiescent Current	I_{SHDN}	V_{CTRL}=0V		50		μA
Feedback Voltage (Note 2)	V_{FB}	I_{OUT}=20mA, 3 LEDs, T_A=-40°C to 85°C	**188**	**200**	**212**	mV
FB Pin Bias Current	I_{FB}			35	100	nA
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	1.3		A
Switch V_{CE} Saturation Voltage	V_{CESAT}	I_{SW}=0.6A		350		mV
Switch Leakage Current		V_{SW}=38V		0.01	5	μA
CTRL Pin Voltage	V_{CTRL}			1.2		V
CTRL Pin Bias Current	I_{CTRL}			60		μA
OVP Voltage	V_{OVP}			17		V
Soft-start Time	t_{SS}			80		μs
Standby Time	t_{STB}			0.45		ms
Thermal Shutdown	T_{OTSD}			150		°C

Note 2: The bold type specifications of full temperature range are guaranteed by design (GBD).

Typical Performance Characteristics

(WLED forward voltage (V_F)=3.2V at I_F=20mA, unless otherwise noted.)

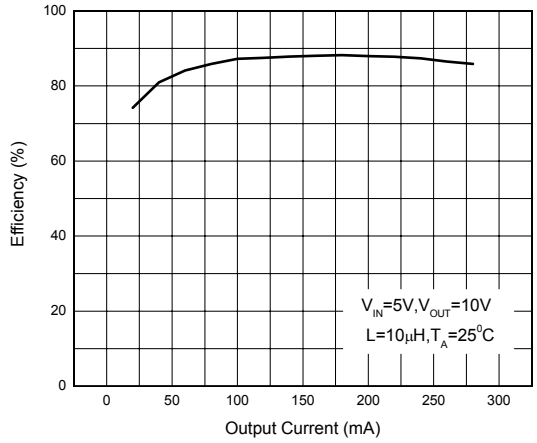


Figure 4. Efficiency vs. Output Current

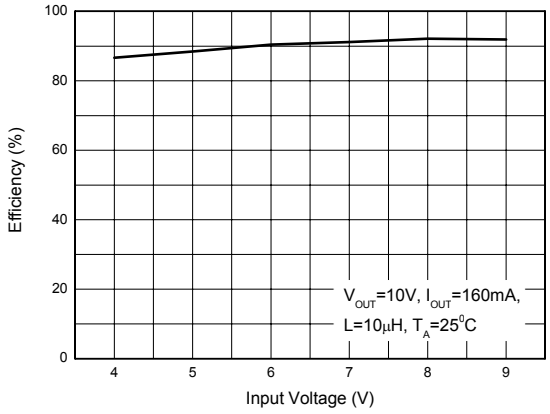


Figure 5. Efficiency vs. Input Voltage

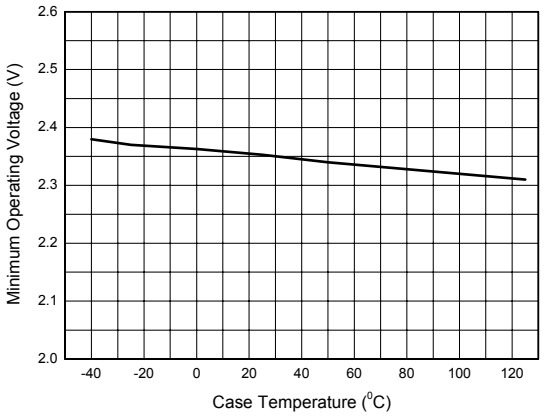


Figure 6. Minimum Operating Voltage vs. CaseTemperature

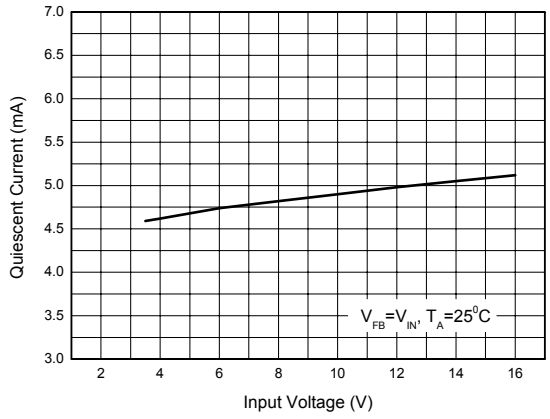


Figure 7. Quiescent Current vs. Input Voltage

Typical Performance Characteristics (Continued)

(WLED forward voltage (V_F)=3.2V at I_F=20mA, unless otherwise noted.)

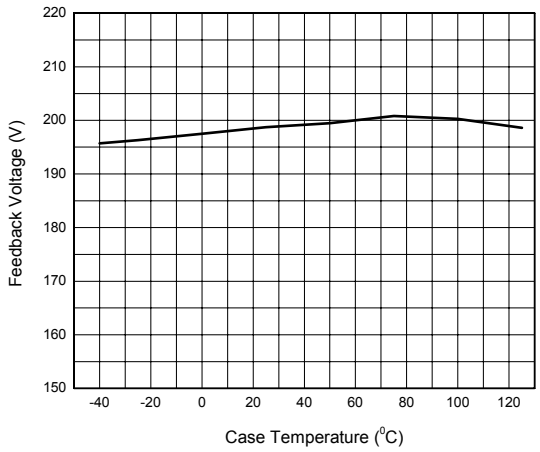


Figure 8. Feedback Voltage vs. Case Temperature

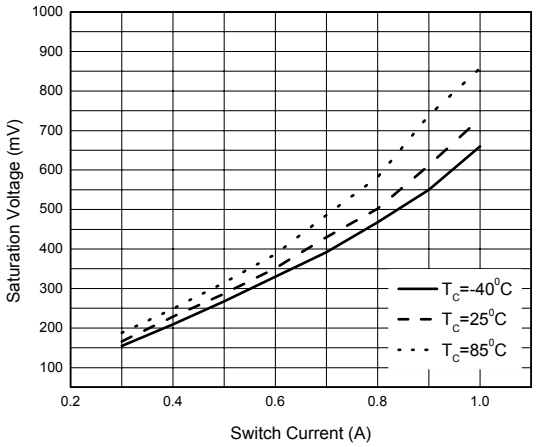


Figure 9. Saturation Voltage vs. Switch Current

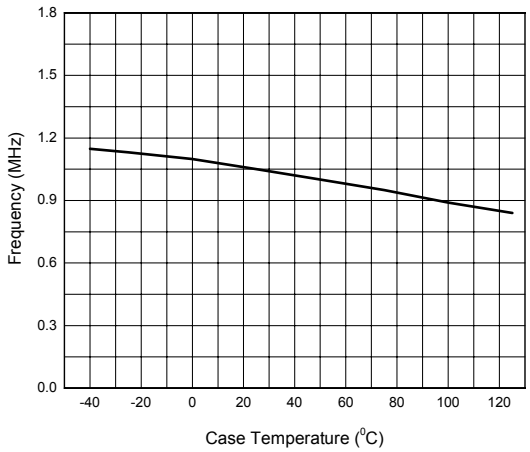


Figure 10. Frequency vs. Case Temperature

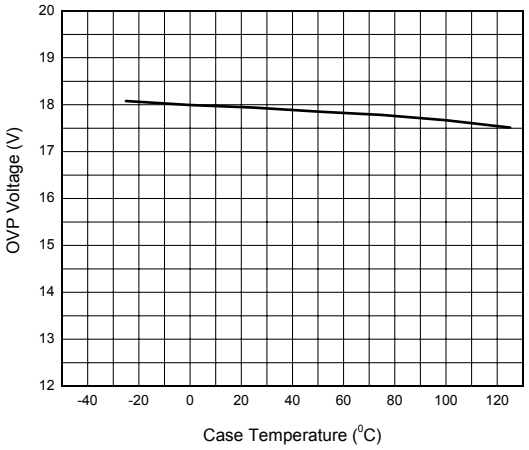


Figure 11. OVP Voltage vs. Case Temperature

Typical Performance Characteristics (Continued)

(WLED forward voltage (V_F)=3.2V at I_F=20mA, unless otherwise noted.)

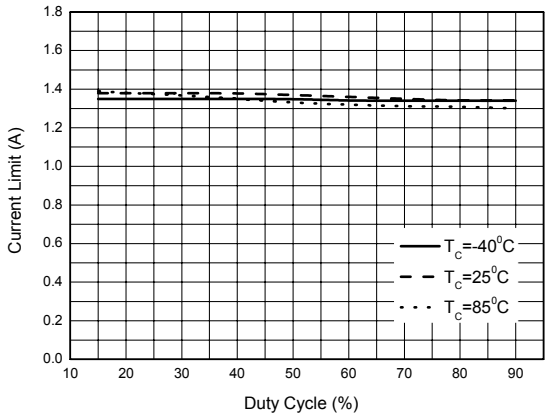


Figure 12. Current Limit vs. Duty Cycle

Application Information

Operation

The AP3033 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 Figure 3 and Figure 17.

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.

LED Current Control

Refer to Figure 17, 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:

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

Over Voltage Protection

The AP3033 has an internal open load protection circuit. When the LEDs are disconnected from circuit or fail open, the output voltage is clamped at about 17V. The AP3033 will switch at a low frequency, and minimize current to avoid input voltage drop.

Soft Start

The AP3033 has an internal soft start circuit to limit the inrush current during startup. If logic low time on CTRL pin is more than about 0.45ms and then enable the IC, the AP3033 will start smoothly to protect system departments. The time of startup is controlled by internal soft-start capacitor. Details please refer to Figure 13.

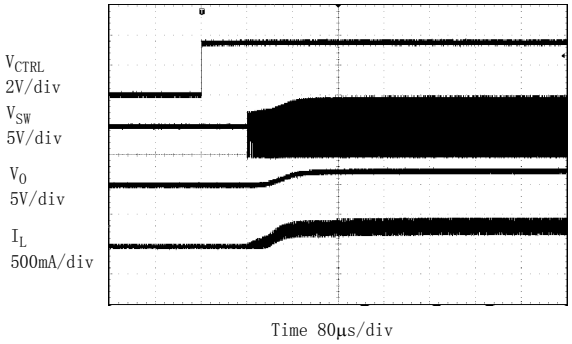


Figure 13. Soft-start Waveform
V_{IN}=5V, 3×8 LEDs, I_{LED}=160mA

Dimming Control

For controlling LED brightness, the AP3033 provides typically 200mV feedback voltage when the CTRL pin is pulled constantly high. However, CTRL pin allows a PWM signal to reduce this regulation voltage by changing the PWM duty cycle to achieve LED brightness dimming control. Detail circuit, as show in Figure 14. The relationship between the duty cycle and LED current can be expressed as below:

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

where D_{PWM} is the duty cycle of PWM signal and 200mV is internal reference voltage.

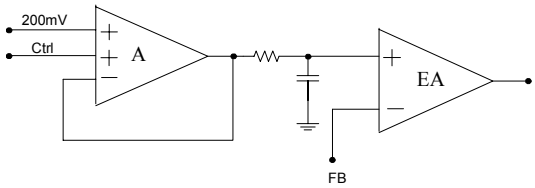


Figure 14. Bolck Diagram of Programmable FB Voltage Using PWM Signal

Application Information (Continued)

Two other typical types of dimming control circuit are presented as below.

(1) Using DC Voltage to Change the Effective Feedback Voltage

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 15.

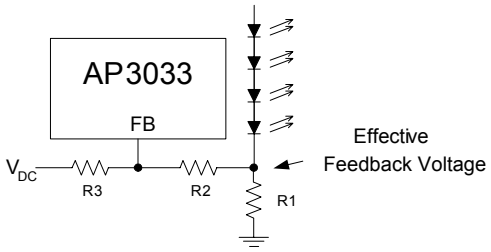


Figure 15. Dimming Control Using DC Voltage

(2) Using Filtered PWM Signal to Change the Effective Feedback Voltage

The filtered PWM signal can be considered as a varying and adjustable DC voltage, please refer to Figure 16.

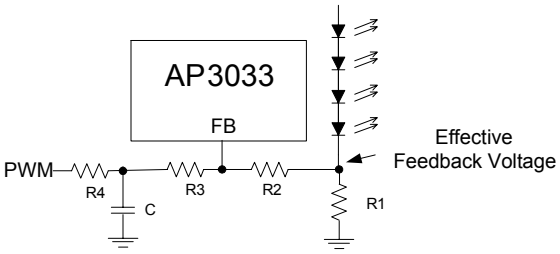


Figure 16. Dimming Control Using Filtered PWM Voltage

Typical Application

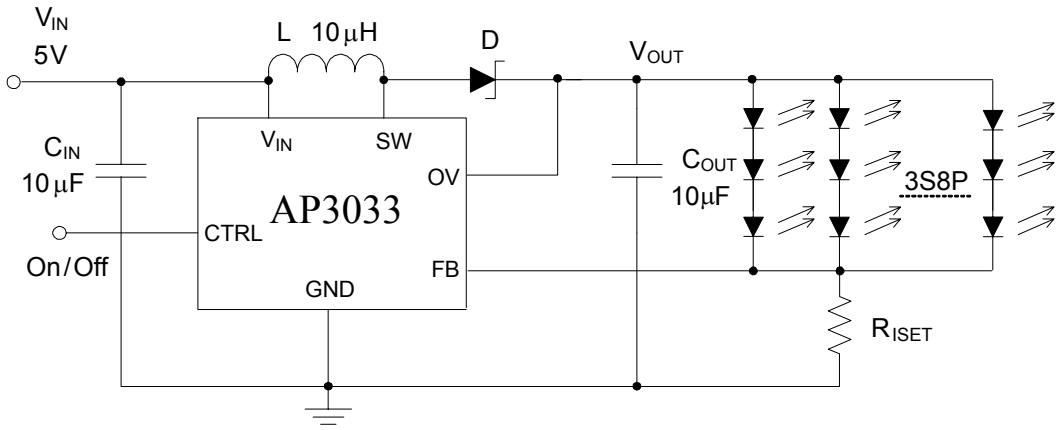
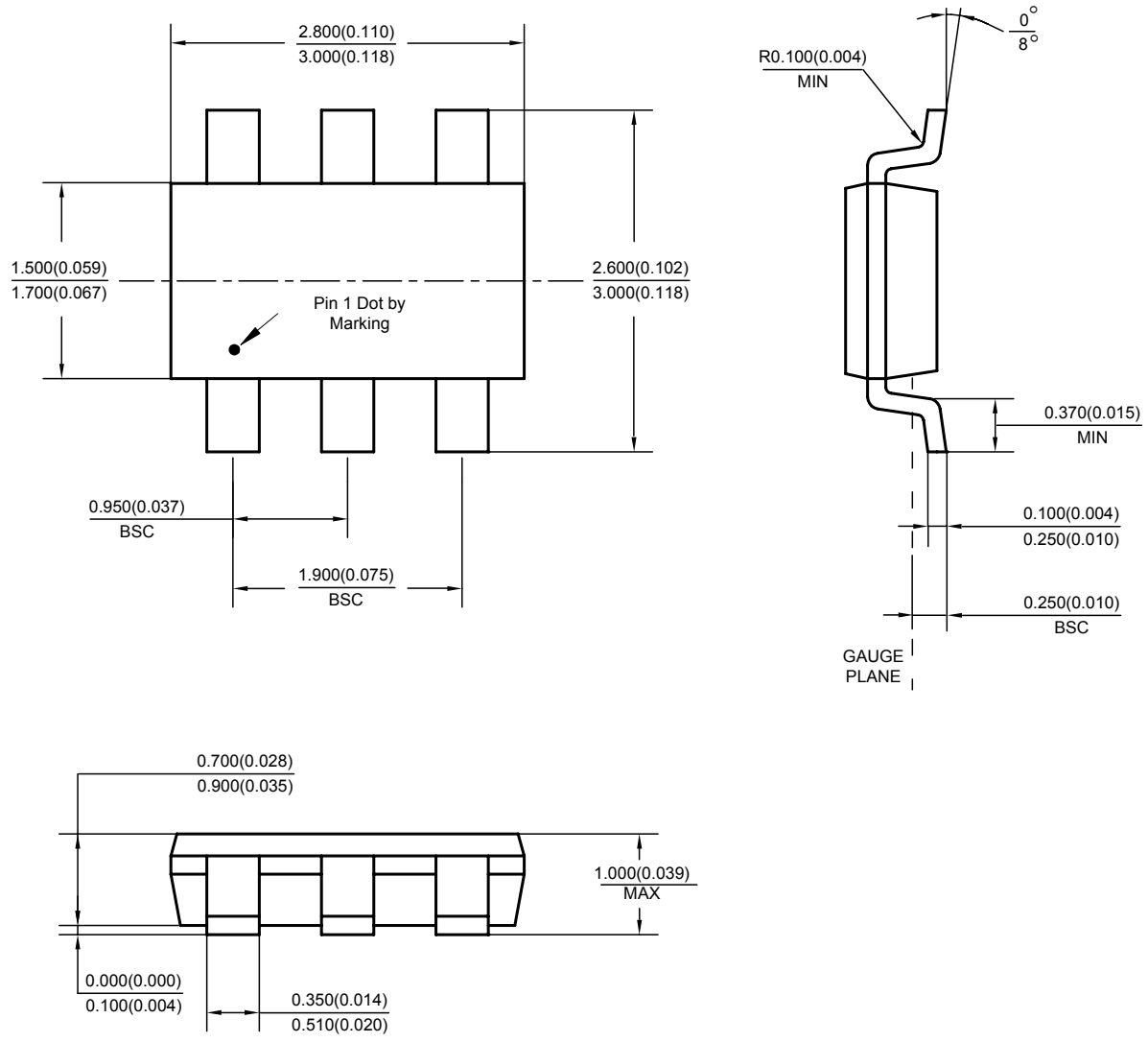


Figure 17. Typical Application of AP3033 (3S8P WLEDs)

Mechanical Dimensions

TSOT-23-6 **Unit: mm(inch)**



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