

Description

The AP3019A is an inductor-based DC/DC converter designed to drive up to eight white LEDs in series for backlight. Only one feedback resistor is needed to control the LED current and obtain required brightness.

A constant frequency 1.2MHz PWM control scheme is employed in this IC, which means tiny external components can be used. Specifically, 1mm tall inductor and 0.22 μ F output capacitor for a typical application is sufficient. Additionally, the Schottky diode in boost circuit is integrated on this chip. The AP3019A also provides a disable pin to ease its use for different systems.

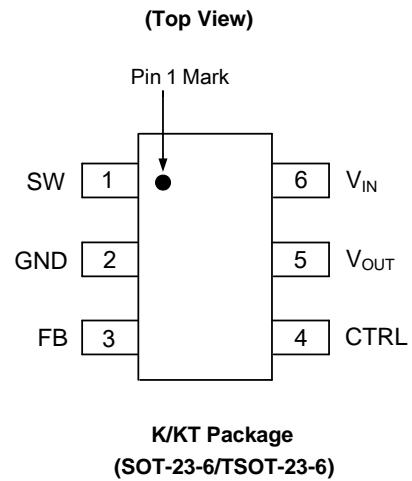
The output over-voltage protection is implemented in AP3019A. When any LED is broken or in other abnormal conditions, the output voltage will be clamped.

The AP3019A is available in standard SOT-23-6 and TSOT-23-6 packages.

Features

- Inherently Uniform LED Current
- High Efficiency up to 84%
- No Need for External Schottky Diode
- Output Over-voltage Protection (OVP)
- Fixed 1.2MHz Switching Frequency
- Uses Tiny 1mm Tall Inductor
- Requires only 0.22 μ F Output Capacitor

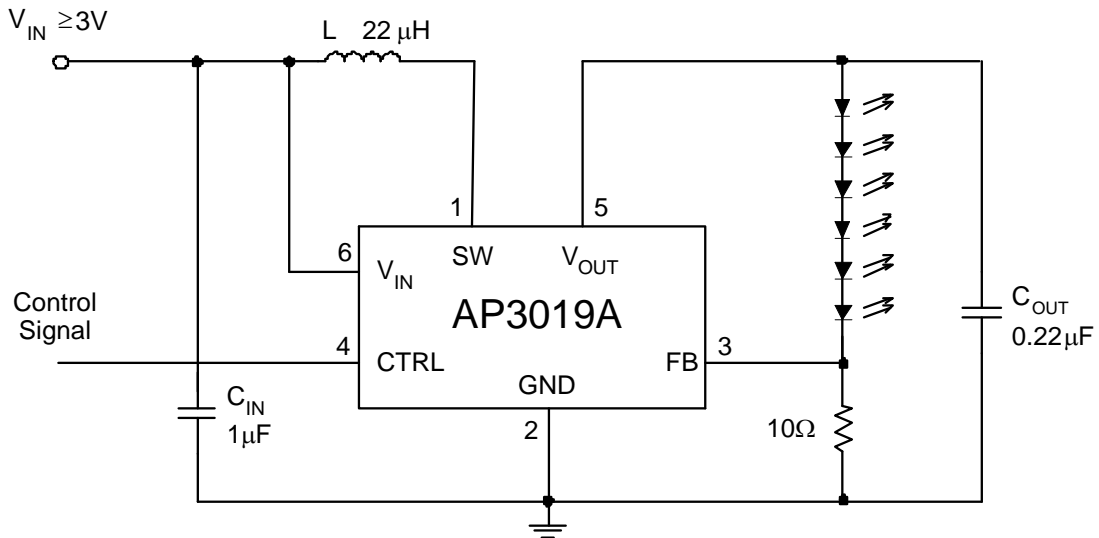
Pin Assignments



Applications

- Cellular Phones
- Digital Cameras
- LCD Modules
- GPS Receivers
- PDAs, Handheld Computers

Typical Applications Circuit



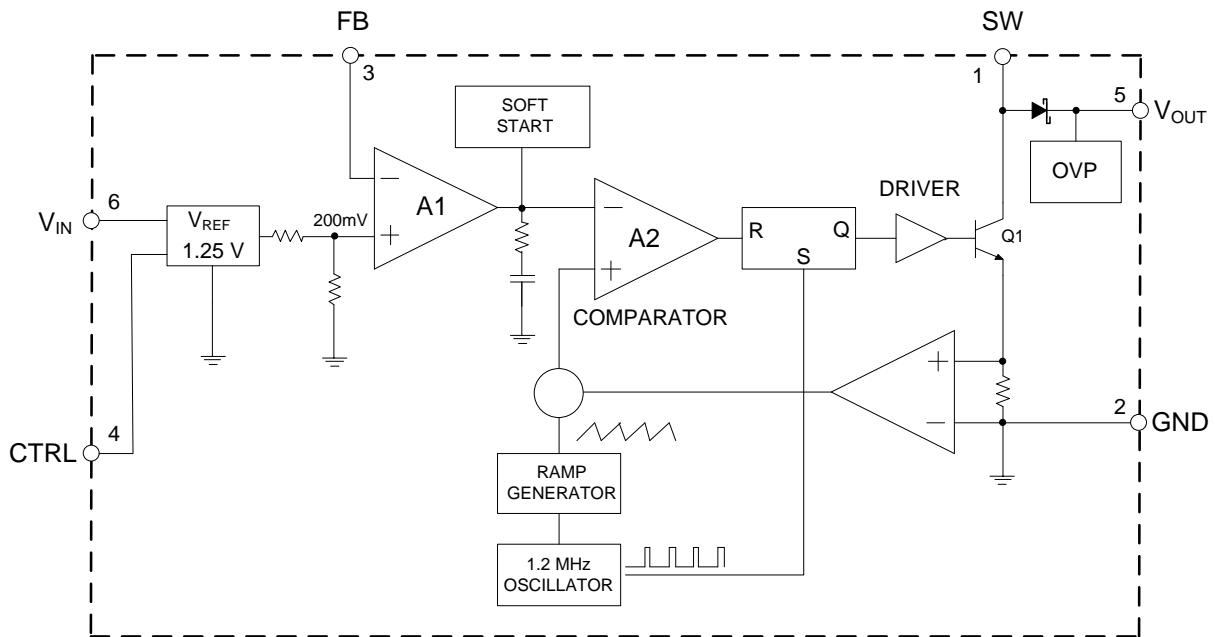
C: X5R or X7R dielectric
 L: SUMIDA CDRH5D28R-220NC or equivalent
 This circuit can work in full temperature

Pin Descriptions

Pin Number	Pin Name	Function
1	SW	Switch pin. Connect external inductor
2	GND	Ground
3	FB	Voltage feedback pin. Reference voltage is 200mV
4	CTRL	Shutdown and dimming pin. Connect to 1.8V or higher to enable device; Connect to 0.5V or less to disable device; Connect to a PWM signal to achieve LEDs brightness dimming
5	V _{OUT}	Output pin. Connect to the cathode of internal Schottky diode
6	V _{IN}	Input supply pin. Must be connected to a local bypass capacitor

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Functional Block Diagram



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Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Rating	Unit
V_{IN}	Input Voltage	20	V
V_{SW}	SW Pin Voltage	38	V
V_{FB}	Feedback Voltage	20	V
V_{CTRL}	CTRL Pin Voltage	20	V
θ_{JA}	Thermal Resistance (Junction to Ambient, No Heat Sink)	265	$^{\circ}C/W$
T_J	Operating Junction Temperature	+150	$^{\circ}C$
T_{STG}	Storage Temperature Range	-65 to +150	$^{\circ}C$
T_{LEAD}	Lead Temperature (Soldering, 10sec)	+260	$^{\circ}C$
-	ESD (Machine Model)	250	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

Symbol	Parameter	Min	Max	Unit
T _{OP}	Operating Temperature Range	-40	+85	°C
V _{IN}	Input Voltage	2.5	16	V
V _{CTRL}	CTRL Pin Voltage	-	16	V

Electrical Characteristics (@V_{IN}=3V, V_{CTRL}=3V, T_A=+25°C, unless otherwise specified.)

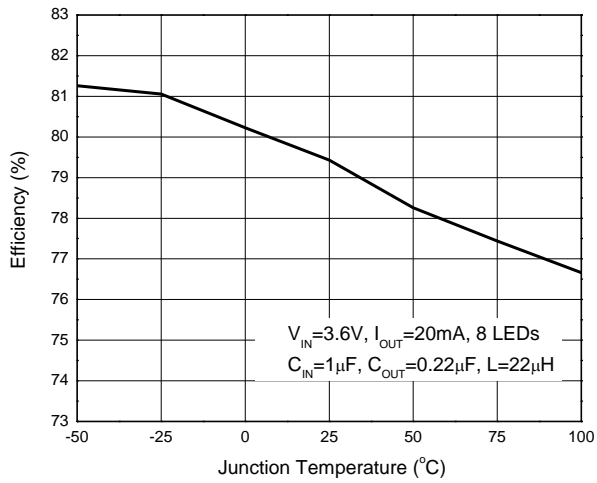
Symbol	Parameter	Condition	Min	Typ	Max	Unit
V _{IN} (MIN)	Minimum Operating Voltage	-	2.5	-	-	V
V _{IN} (MAX)	Maximum Operating Voltage	-	-	-	16	
V _{FB}	Feedback Voltage (Note 2)	I _{OUT} =20mA, 4 LEDs, T _A =-40°C to +85°C	188	200	212	mV
I _{FB}	FB Pin Bias Current	-	-	35	100	nA
I _Q	Quiescent Current	V _{FB} =V _{IN} , No Switching	1.5	2.5	3.2	mA
I _{SHDN}	Shutdown Quiescent Current	V _{CTRL} =0V	2.0	4.0	6.0	μA
f	Switching Frequency	-	0.9	1.2	1.5	MHz
D _{MAX}	Maximum Duty Cycle	-	90	93	-	%
I _{LIMIT}	Switch Current Limit (Note 3)	D=40%	-	550	-	mA
		D=80%	-	550	-	
V _{CESAT}	Switch V _{CE} Saturation Voltage	I _{SW} =250mA	-	360	-	mV
-	Switch Leakage Current	V _{SW} =5V	-	0.01	5	μA
V _{CTRL}	CTRL Pin Voltage	High	1.8	-	-	V
		Low	-	-	0.5	
I _{CTRL}	CTRL Pin Bias Current	-	-	100	-	μA
V _{OV}	OVP Voltage	-	-	30	-	V
V _{DROP}	Schottky Forward Drop	I _D =150mA	-	0.7	-	V
-	Schottky Leakage Current	V _R (Reverse Voltage)=23V	-	0.1	4	μA
		V _R (Reverse Voltage)=27V	-	-	150	
t	Soft Start Time	-	-	300	-	μs
θ _{JC}	Thermal Resistance (Junction to Case)	SOT-23-6	-	60	-	°C/W
		TSOT-23-6	-	60	-	

Notes: 2. The bold type specifications of full temperature range are guaranteed by design (GBD).
 3. The switch current limit is related to duty cycle. Please refer to Figure **Current Limit vs. Duty Cycle** for detail.

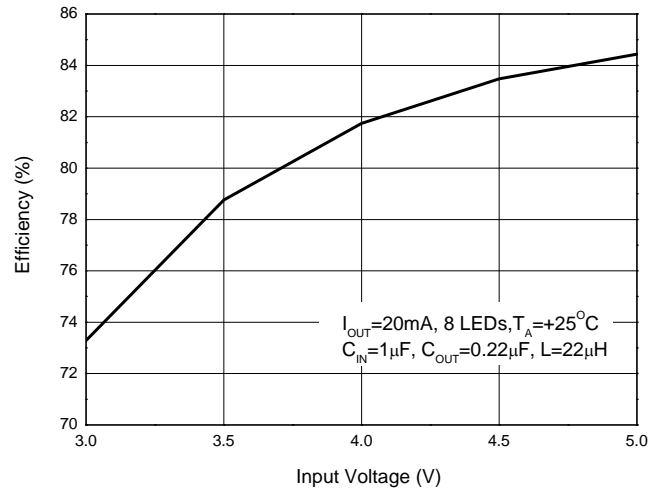
Performance Characteristics (WLED forward voltage (V_F) is 3.45V at $I_F=20\text{mA}$, unless otherwise noted.)

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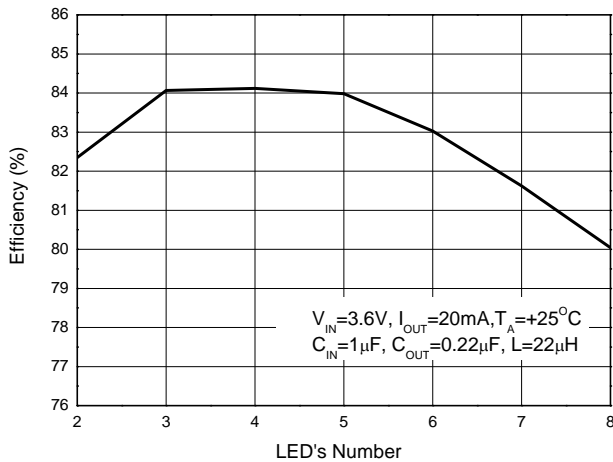
Efficiency vs. Junction Temperature



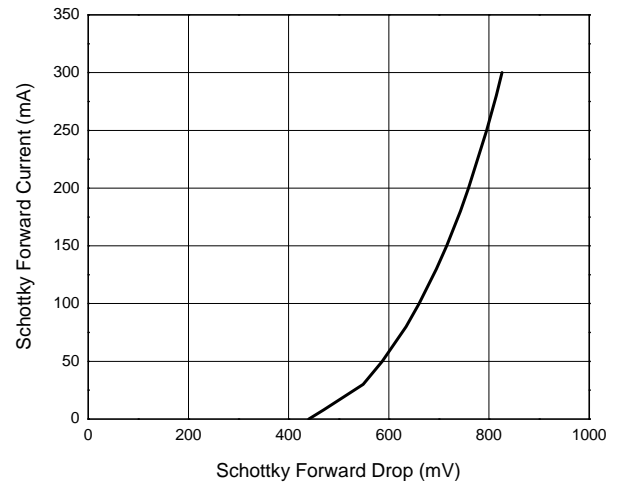
Efficiency vs. Input Voltage



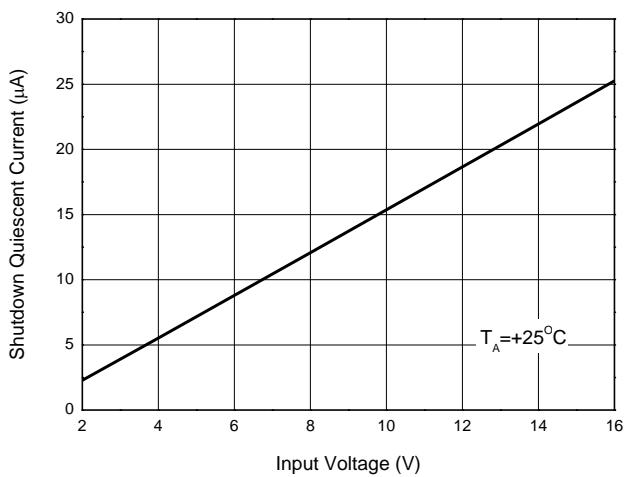
Efficiency vs. LED's Number



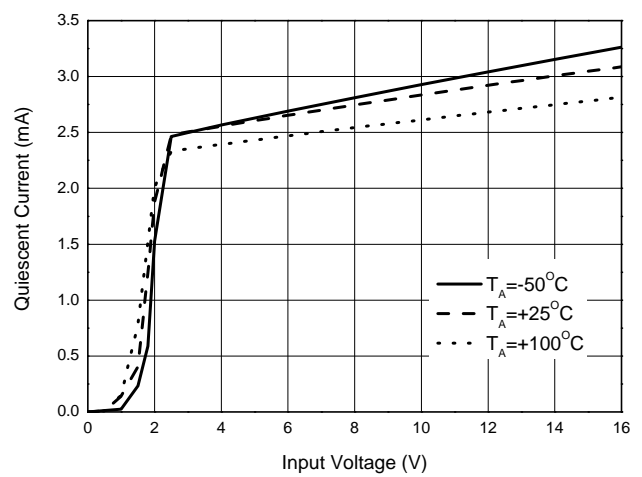
Schottky Forward Current vs. Schottky Forward Drop



Shutdown Quiescent Current vs. Input Voltage

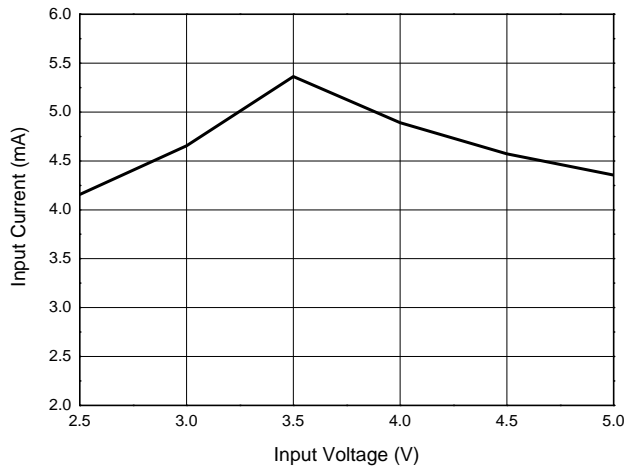


Quiescent Current vs. Input Voltage

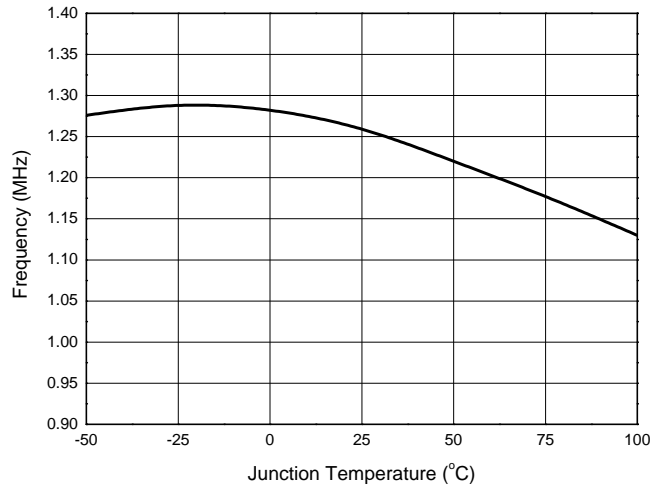


Performance Characteristics (WLED forward voltage (V_F) is 3.45V at $I_F=20mA$, unless otherwise noted.) (Cont.)

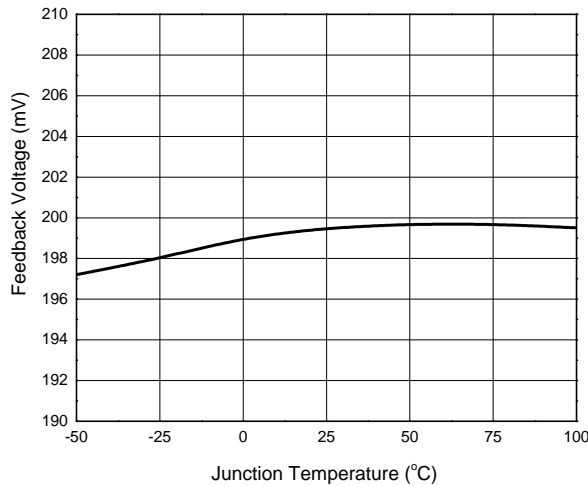
Input Current in Output Open Circuit vs. Input Voltage



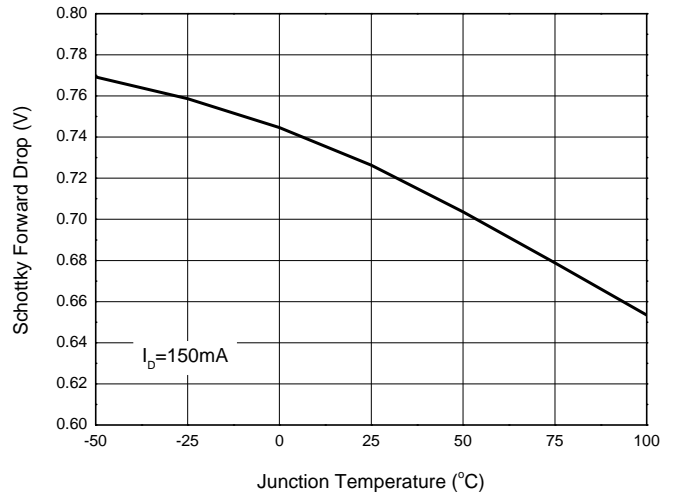
Frequency vs. Junction Temperature



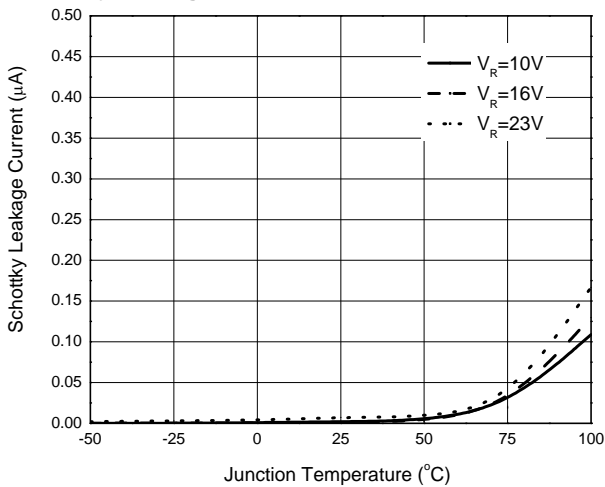
Feedback Voltage vs. Junction Temperature



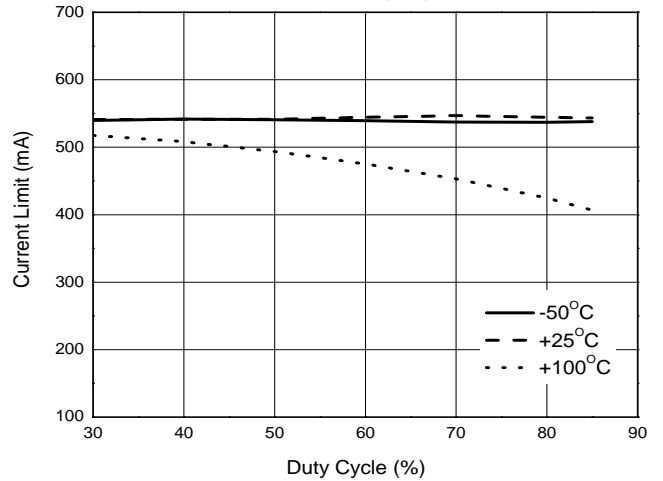
Schottky Forward Drop vs. Junction Temperature



Schottky Leakage Current vs. Junction Temperature

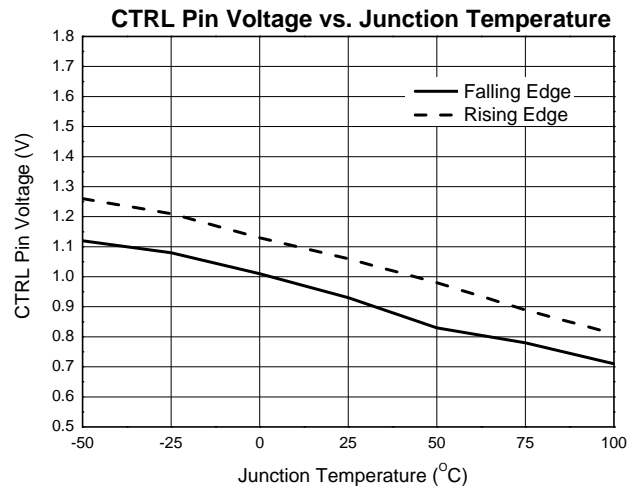
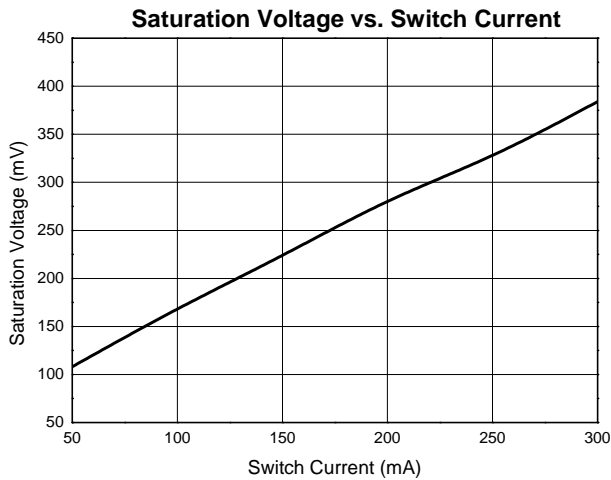


Current Limit vs. Duty Cycle



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Performance Characteristics (WLED forward voltage (V_F) is 3.45V at $I_F=20mA$, unless otherwise noted.) (Cont.)



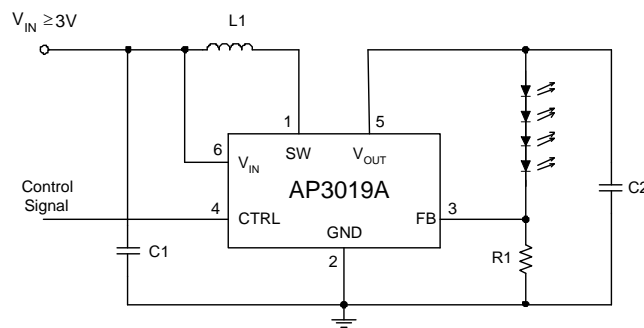
Application Information

Operation

The AP3019A 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 **Functional Block Diagram of AP3019A**.

At the start of each oscillator cycle, the SR latch is set and 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 SR latch is reset and 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.



Typical Application Circuit to Decide R1

LED Current Control

Refer to Figure **Typical Application Circuit to Decide R1**, the LED current is controlled by the feedback resistor R1. 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 R1 is in inverse proportion to the LED current since the feedback reference is fixed at 200mV. The relation for R1 and LED current can be expressed as below:

$$R_1 = \frac{200mV}{I_{LED}}$$

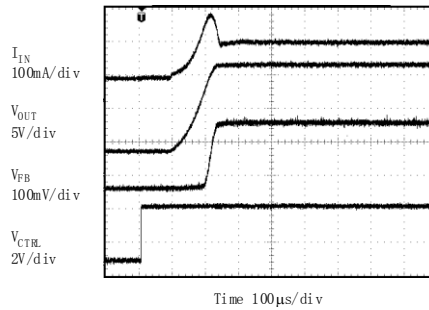
Application Information (Cont.)

Over Voltage Protection

The AP3019A has an internal open-circuit protection circuit. When the LEDs are disconnected from circuit or fail open, the output voltage is clamped. The AP3019A will switch at a low frequency, and minimize input current.

Soft Start

The AP3019A has an internal soft start circuit to limit the inrush current during startup. The time of startup is controlled by internal soft start capacitor. Please refer to Figure **Soft Start Waveform**.



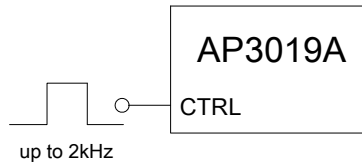
Soft Start Waveform
 $V_{IN}=3.6V$, 5 LEDs, $I_{LED}=20mA$

Dimming Control

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.

(1) Adding a Control Signal to CTRL Pin

Add a PWM Signal to CTRL pin directly. The AP3019A is turned on or off by the PWM signal when it is applied on the CTRL pin. The typical frequency of this PWM signal can be up to 2kHz. Please refer to Figure **Dimming Control Using a PWM Signal in CTRL Pin**.

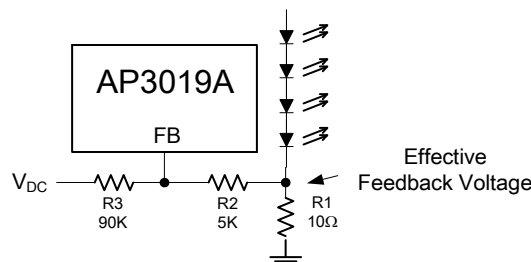


Dimming Control Using a PWM Signal in CTRL Pin

(2) Changing the Effective Feedback Voltage

There are three methods to change the effective feedback voltage.

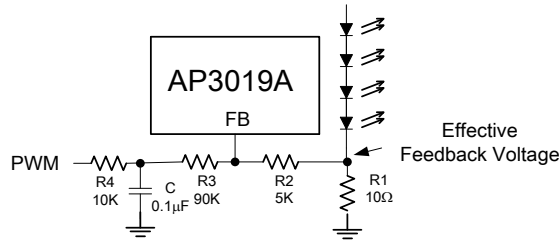
First, adding a constant DC voltage through a resistor divider to FB pin can control the dimming. Changing the DC voltage or resistor between the FB Pin and the DC voltage can get appropriate luminous intensity. Comparing with all kinds of PWM signal control, this method features a stable output voltage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



Dimming Control Using DC Voltage

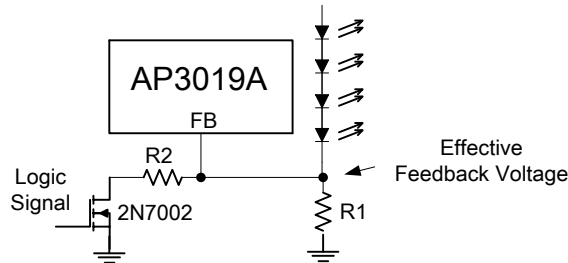
Application Information (Cont.)

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



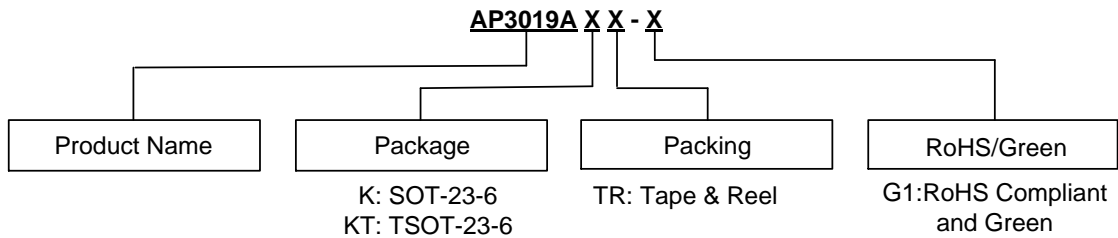
Dimming Control Using a Filtered PWM Voltage

Third, using a logic signal can change the feedback voltage. For example, the FB pin is connected to the GND through a MOSFET and a resistor. And this MOSFET is controlled a logic signal. The luminous intensity of LEDs will be changed when the MOSFET turns on or off.



Dimming Control Using Logic Signal

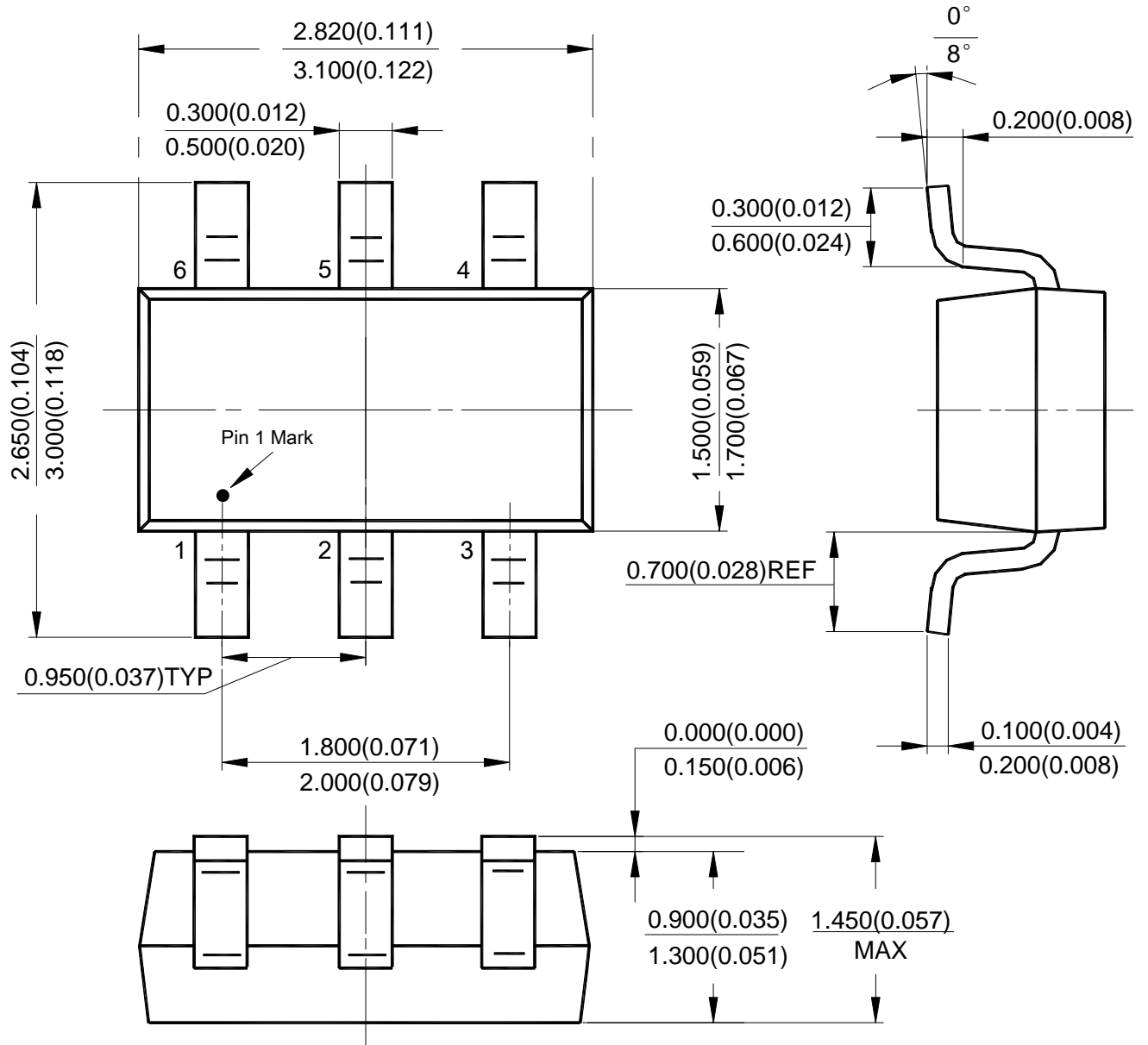
Ordering Information



Package	Temperature Range	Part Number	Marking ID	Packing Type
SOT-23-6	-40 to +85°C	AP3019AKTR-G1	GAS	Tape & Reel
TSOT-23-6	-40 to +85°C	AP3019AKTTR-G1	L8E	Tape & Reel

Package Outline Dimensions (All dimensions in mm(inch).)

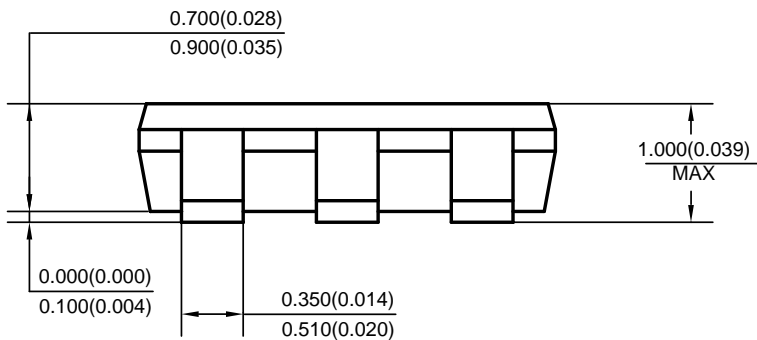
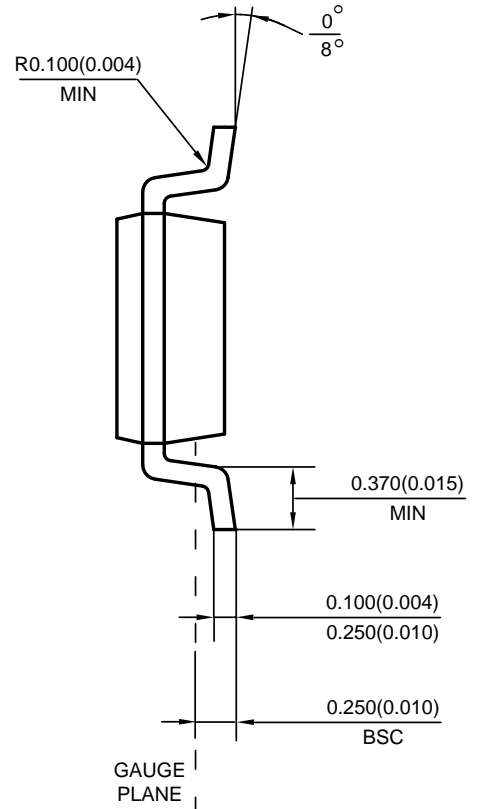
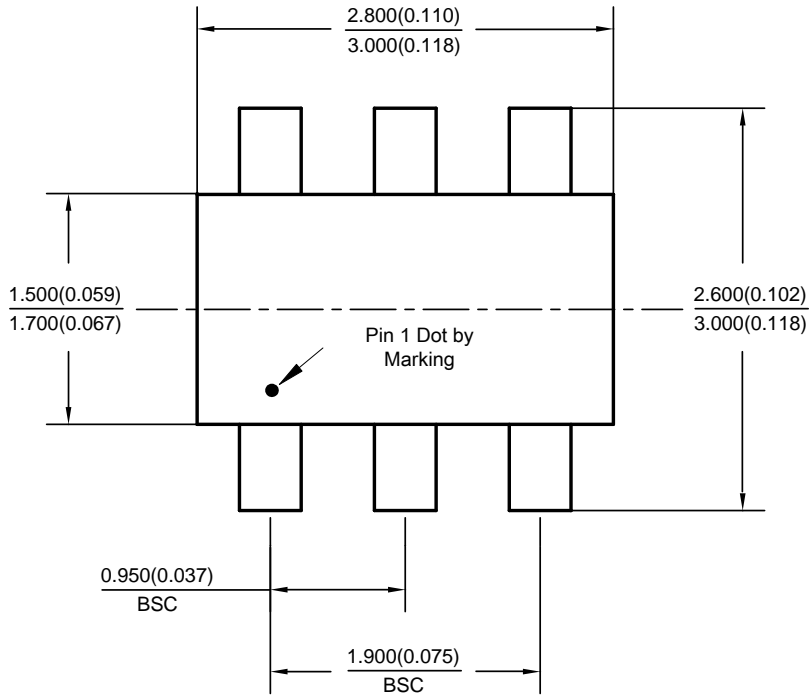
(1) Package Type: SOT-23-6



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Package Outline Dimensions (All dimensions in mm(inch).) (Cont.)

(2) Package Type: TSOT-23-6



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