AP3031

WHITE LED STEP-UP CONVERTER

Description

The DIODES™ AP3031 is an inductor-based DC/DC boost converter designed to drive LED arrays. 1.4A switching current allows AP3031 to be used in different 7' to 10' LCD panel backlights (3*13 LED arrays typically).

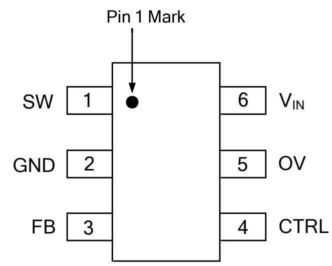
A constant frequency 1MHz PWM control scheme is employed in this IC, which means tiny external components can be used. Specifically, 1mm tall 4.7µH inductor and 0.47µF output capacitor for the typical application is sufficient.

The over output voltage protection is equipped in AP3031, which protects the IC under open load condition. The AP3031 includes UVLO, soft-start, current limit and OTSD to protect the circuit.

The AP3031 is available in standard SOT-23-6 package.

Pin Assignments

(Top View)



SOT-23-6

Applications

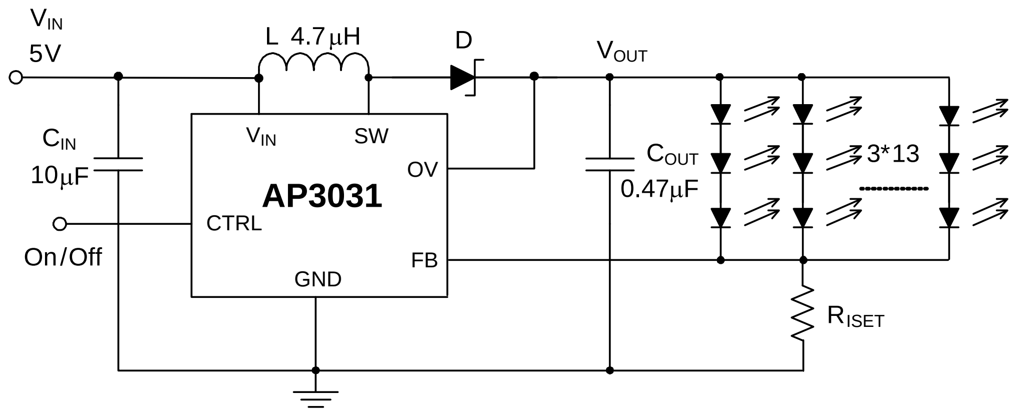
- 7' to 10' LCD panels
- Digital photo frames
- GPS receivers
- EPC
- PDVD

Features

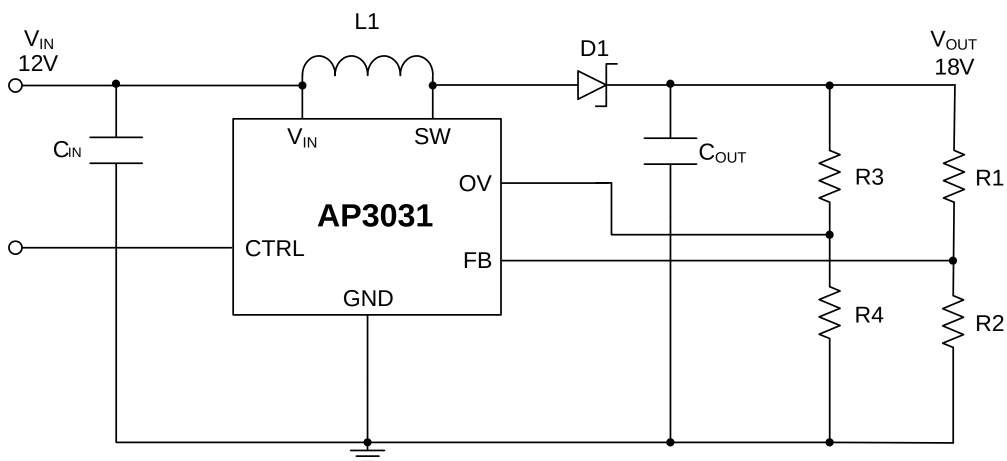
- Up to 92% Efficiency (V_{IN} = 9V, I_{OUT} = 260mA)
- Up to 84% Efficiency (V_{IN} = 5V, I_{OUT} = 260mA)
- Fast 1MHz Switching Frequency
- Wide Input Voltage Range: 2.7V to 16V
- Low 200mV Feedback Voltage
- Output Overvoltage Protection
- Cycle by Cycle Current Limit: 1.4A
- Built-in Soft-Start
- Built-in Standby Mode to Achieve High Frequency PWM Dimming
- Built-in Thermal Shutdown Function
- Undervoltage Lockout
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/104/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative.** **https://www.diodes.com/quality/product-definitions/**

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds .

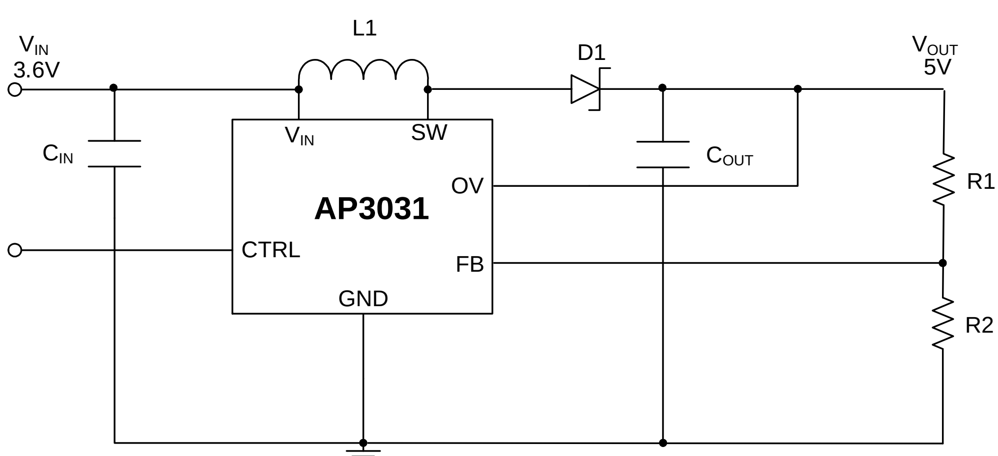
Typical Applications Circuit



3 x 3 WLEDs



Booster for LNB Application (Note 4)



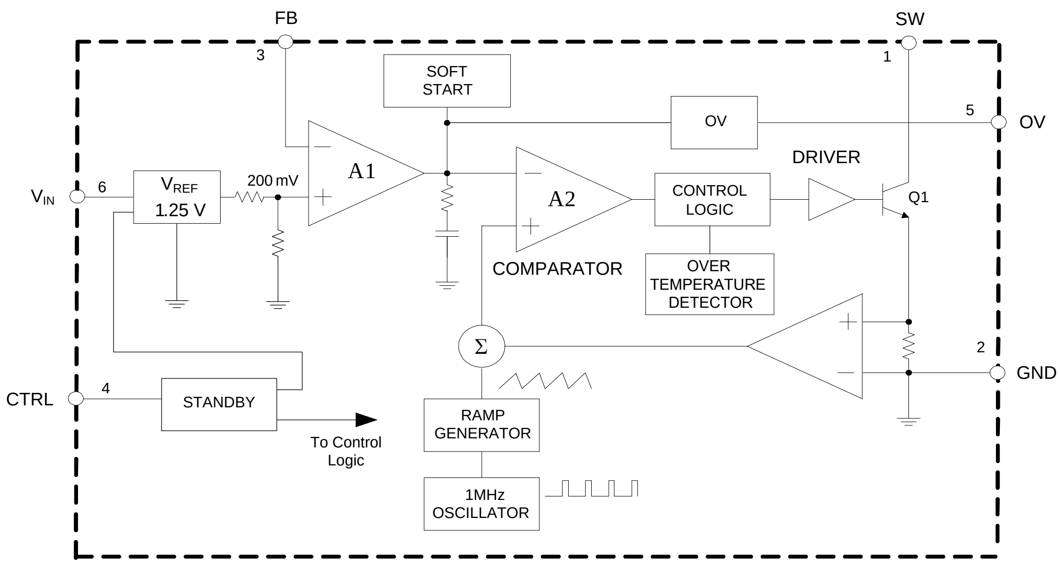
Booster for Portable Charger Application (Note 4)

Note: 4. $V_{OUT} = (1+R1/R2)*V_{FB}$.

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 0.7ms and then the IC is enabled, the AP3031 will soft start to protect system departments. • If logic low time is less than about 0.7ms and then the IC is enabled, the AP3031 will hold on standby mode and start directly to achieve high frequency dimming.
5	OV	Overvoltage Protection Input Pin. Connect to the output directly. On OVP condition, the output voltage will be clamped.
6	V_{IN}	Input Supply Pin. Must be locally bypassed.

Functional Block Diagram



Absolute Maximum Ratings (Note 5)

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	°C/W
T_J	Operating Junction Temperature	+150	°C
T_{STG}	Storage Temperature Range	-65 to +150	°C
T_{LEAD}	Lead Temperature (Soldering, 10sec)	+260	°C
—	ESD (Machine Model)	600	V
—	ESD (Human Body Model)	4000	V

Note: 5. Stresses greater than those listed under *Absolute Maximum Ratings* can 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 can affect device reliability.

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
T_{OP}	Operating Temperature Range	-40	+85	°C
V_{IN}	Input Voltage	2.7	16	V
V_{CTRL}	CTRL Pin Voltage	—	16	V

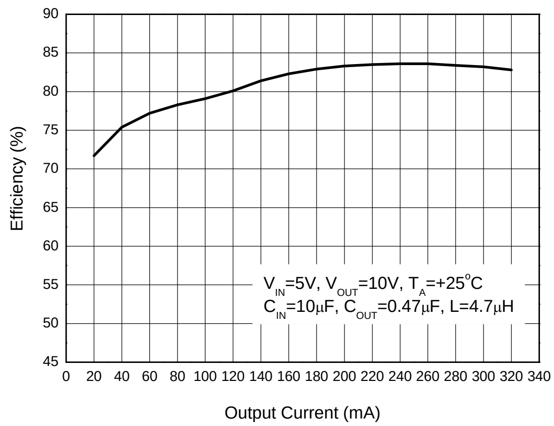
Electrical Characteristics (@V_{IN} = 5.0V, V_{CTRL} = 5.0V, T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{IN}	Operating Voltage	—	2.7	—	16	V
V_{FB}	Feedback Voltage (Note 6)	I_{OUT} = 20mA, 3 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	3.0	4.0	5.0	mA
I_{SHDN}	Shutdown Quiescent Current	V_{CTRL} = 0V	20	50	80	µA
f	Switching Frequency	—	0.75	1	1.3	MHz
D_{MAX}	Maximum Duty Cycle	—	90	93	—	%
I_{LIMIT}	Switch Current Limit (Note 7)	D = 60%	1.2	1.4	—	A
V_{CESAT}	Switch V_{CE} Saturation Voltage	I_{SW} = 0.6A	—	300	—	mV
—	Switch Leakage Current	V_{SW} = 16V	—	0.01	5	µA
V_{CTRL}	CTRL Pin Voltage	Active High	1.8	—	—	V
		Active Low	—	—	0.5	
I_{CTRL}	CTRL Pin Bias Current	—	35	60	85	µA
V_{OVP}	OVP Voltage	—	15.5	17.5	19.5	V
t_{SS}	Soft-Start Time	—	—	250	—	µs
t_{STB}	Standby Time	—	—	0.7	—	ms
T_{OTSD}	Thermal Shutdown	—	—	+155	—	°C
θ_{JC}	Thermal Resistance (Junction to Case)	—	—	60	—	°C/W

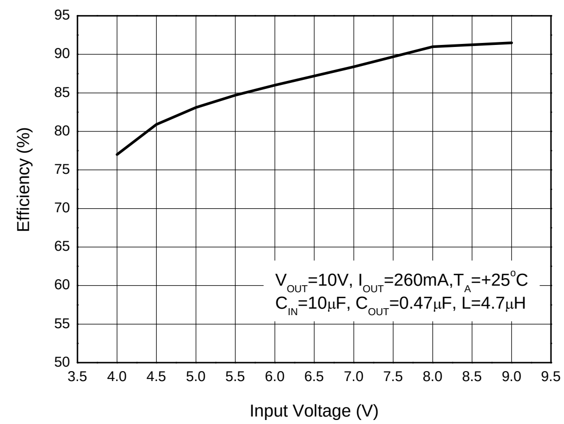
Notes: 6. The bold type specifications of full temperature range are guaranteed by design (GBD).
7. The switch current limit is related to duty cycle. Please refer to Figure Switch Current Limit vs. Duty Cycle for detail.

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

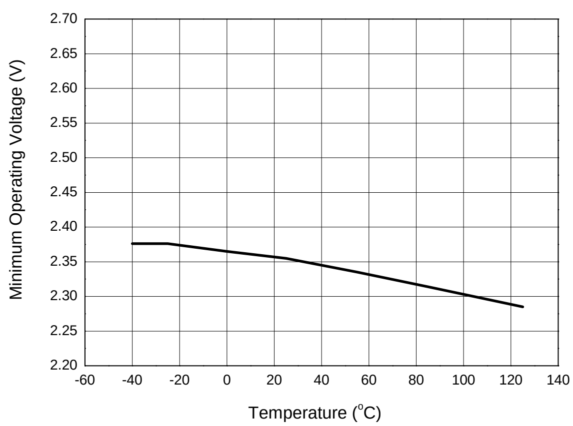
Efficiency vs. Output Current



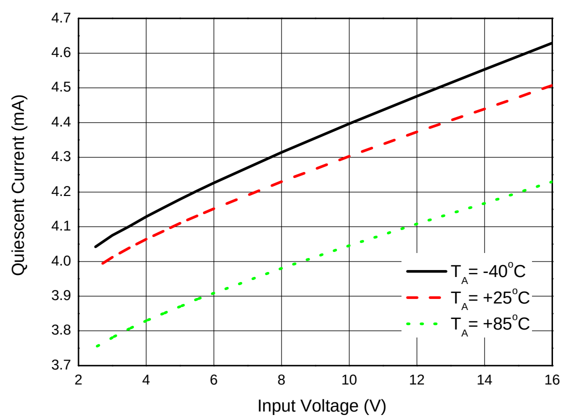
Efficiency vs. Input Voltage



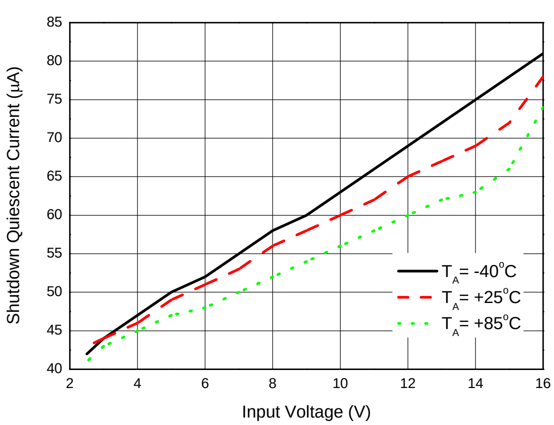
Minimum Operating Voltage vs. Temperature



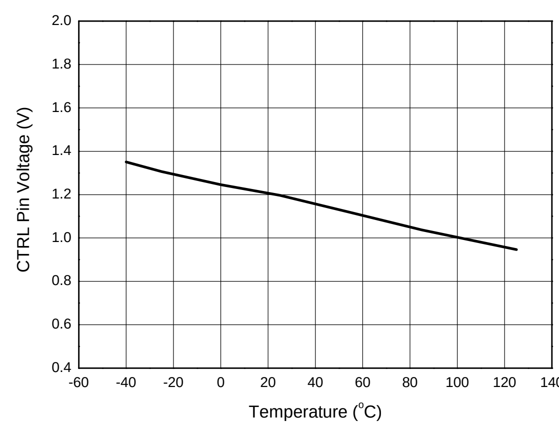
Quiescent Current vs. Input Voltage



Shutdown Quiescent Current vs. Input Voltage

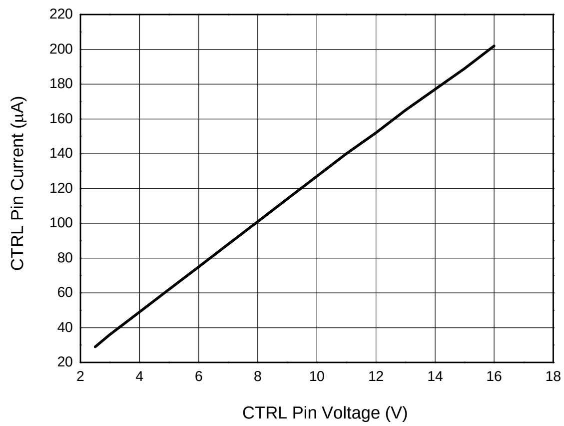


CTRL Pin Voltage vs. Temperature

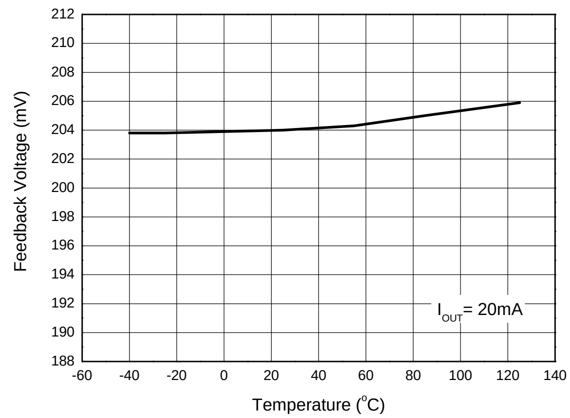


Performance Characteristics (WLED forward voltage (V_F) = 3.2V at I_F = 20mA, unless otherwise noted.) (continued)

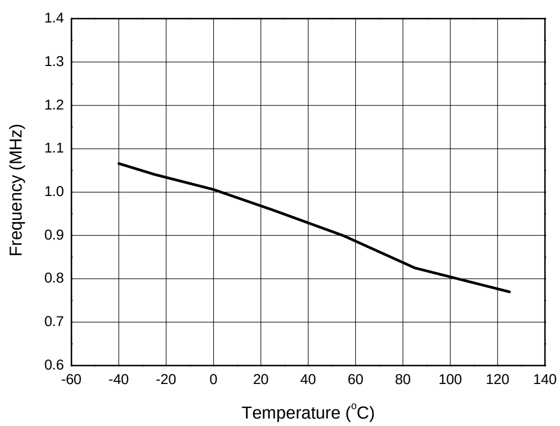
CTRL Pin Current vs. CTRL Pin Voltage



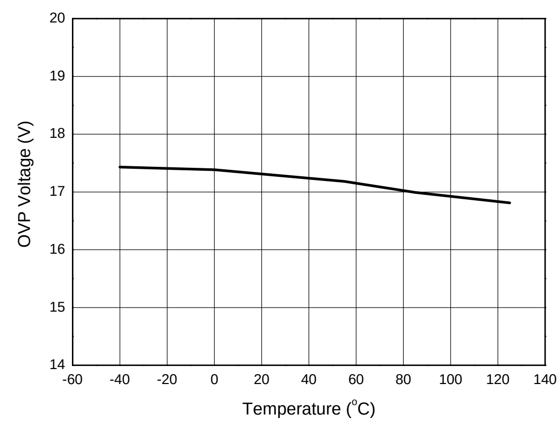
Feedback Voltage vs. Temperature



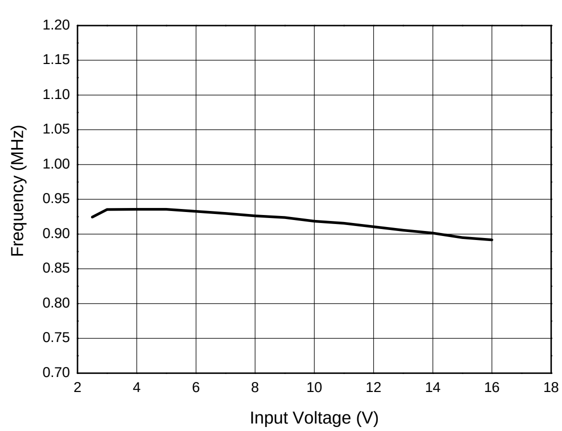
Frequency vs. Temperature



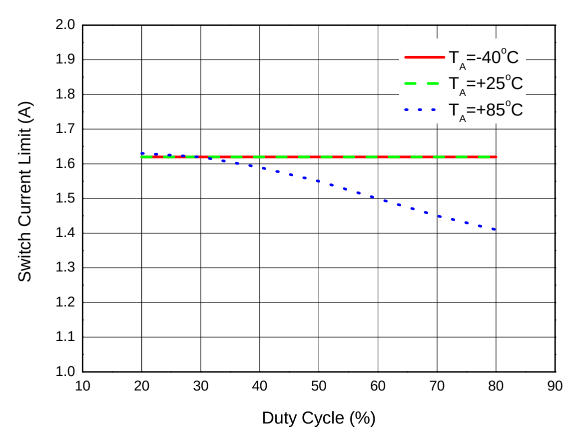
OVP Voltage vs. Temperature



Frequency vs. Input Voltage

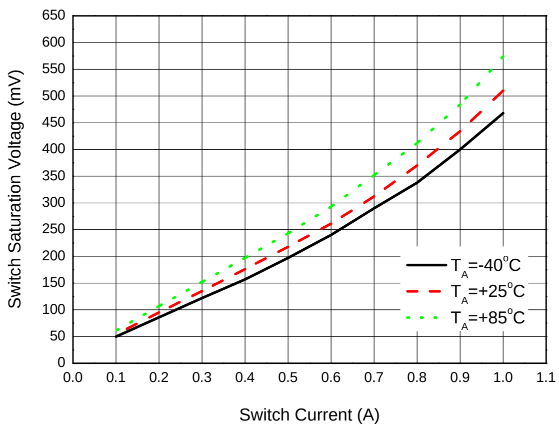


Switch Current Limit vs. Duty Cycle

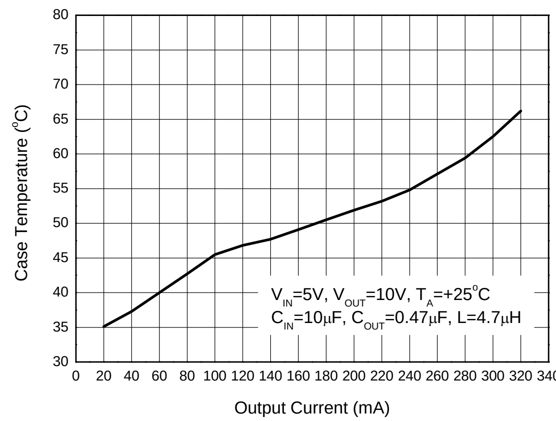


Performance Characteristics (WLED forward voltage (V_F) = 3.2V at I_F = 20mA, unless otherwise noted.) (continued)

Switch Saturation Voltage vs. Switch Current



Case Temperature vs. Output Current



Application Information

Operation

The AP3031 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 *Function Block Diagram* and *Typical Applications Circuit*.

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 *Typical Applications Circuit*, the LED current is controlled by the feedback resistor R_{ISET}. LEDs' current accuracy is determined by the feedback voltage and resistor R_{ISET}, 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:

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

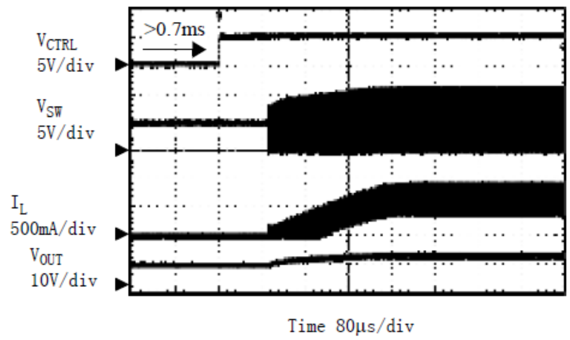
Overvoltage Protection

The AP3031 has an internal open load protection circuit. When the LEDs are disconnected from circuit or fail open, the output voltage is clamped at about 17.5V. The AP3031 will switch at a low frequency, and minimize current to avoid input voltage drop.

Soft-Start

The AP3031 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 the IC is enabled, the AP3031 will start smoothly to protect the supplier. The time of startup is controlled by internal soft-start capacitor. For details please refer to the Figure of Soft-Start Waveform.

Application Information (continued)

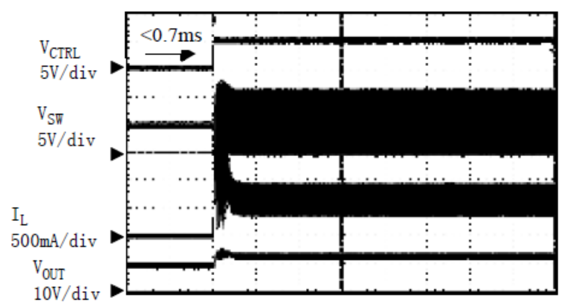


Soft-Start Waveform

V_{IN} = 5V, 3 x 13 LEDs, I_{LED} = 260mA

Standby and Dimming

To avoid audio noise and achieve high frequency dimming, AP3031 is equipped with standby function. If logic low time on CTRL pin is less than about 0.7ms and then the IC is enabled, the AP3031 will hold on standby mode and start directly to achieve high frequency dimming. For details please refer to the Figure of Standby Waveform.

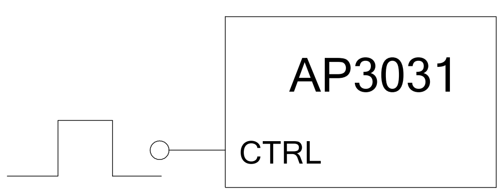


Standby Waveform

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.

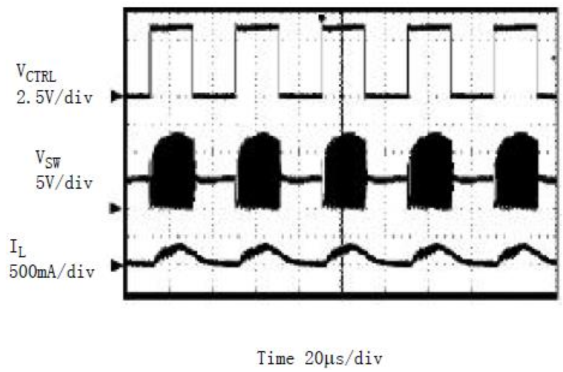
(1) Adding a Control Signal to CTRL Pin

Add a PWM signal to CTRL pin directly, the AP3031 is turned on and off by this signal. When the PWM frequency is lower than 1kHz (Typ.), the IC works in the soft-start mode to dimming the light. On contrary, when the PWM frequency is higher than 1kHz (Typ.), the IC works in the standby mode: the converter ceaselessly switches off and directly starts to achieve light dimming. This standby function allows AP3031 to support high frequency dimming (up to 25kHz or higher) to avoid audio noise. For more details please refer to the Figure of Dimming Control Using a PWM Signal in CTRL Pin and the Figure of High Frequency (25kHz) Dimming Waveform.



Dimming Control
Using a PWM Signal in CTRL Pin

Application Information (continued)

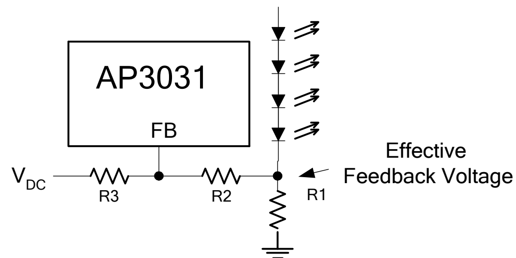


High Frequency (25kHz)
Dimming Waveform

(2) Changing the Effective Feedback Voltage

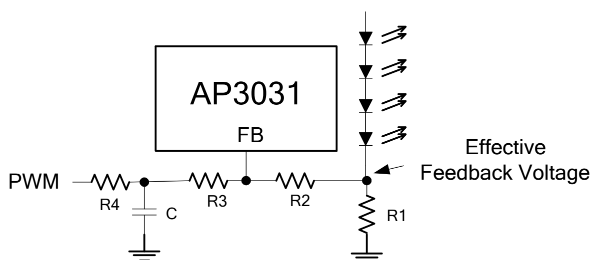
There are two popular methods to change the effective feedback voltage.

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 the Figure of Dimming Control Using DC Voltage.



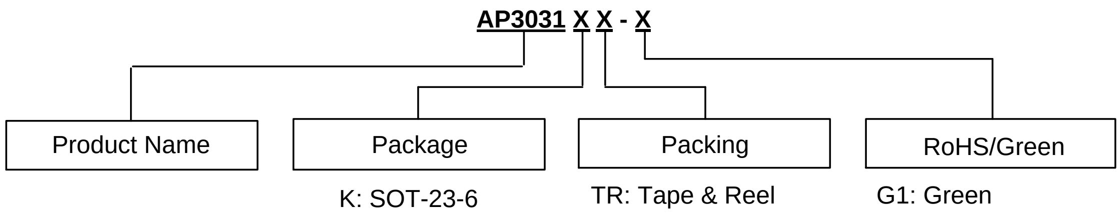
Dimming Control
Using DC Voltage

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 the Figure of Dimming Control Using Filtered PWM Voltage.



Dimming Control
Using Filtered PWM Voltage

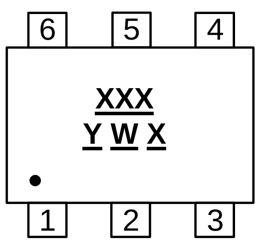
Ordering Information



Part Number	Package	Temperature Range	Identification Code	Packing	
				Qty.	Carrier
AP3031KTR-G1	SOT-23-6	-40 to +85°C	GEC	3000	Tape & Reel

Marking Information

(Top View)



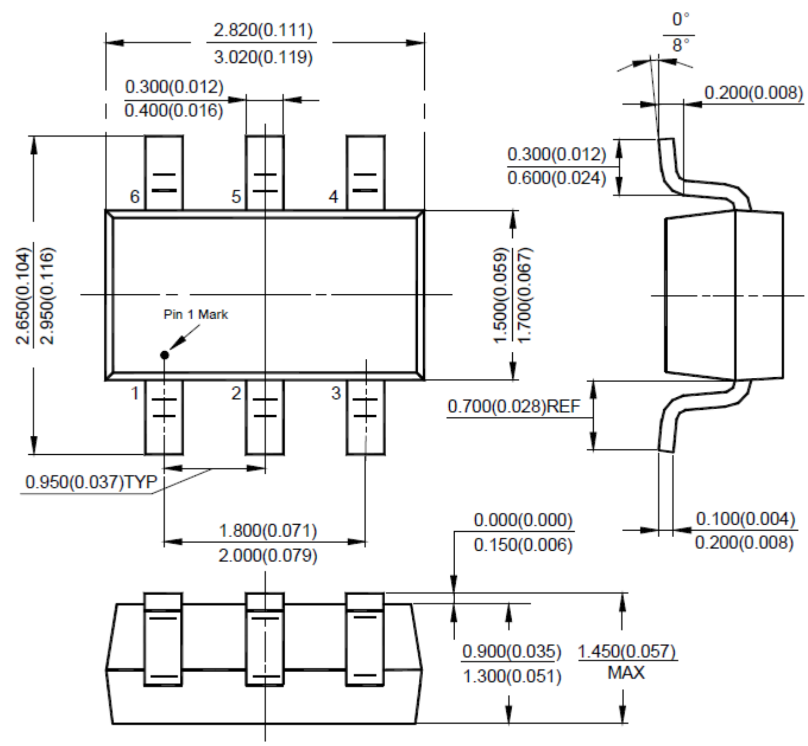
XXX : Identification Code
Y : Year 0 to 9 (ex: 2 = 2022)
W : Week : A to Z : week 1 to 26
a to z : week 27 to 52; z represents week 52 and 53
X : Internal Code

Part Number	Package	Identification Code
AP3031KTR-G1	SOT-23-6	GEC

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

Please see http://www.diodes.com/package-outlines.html for the latest version.

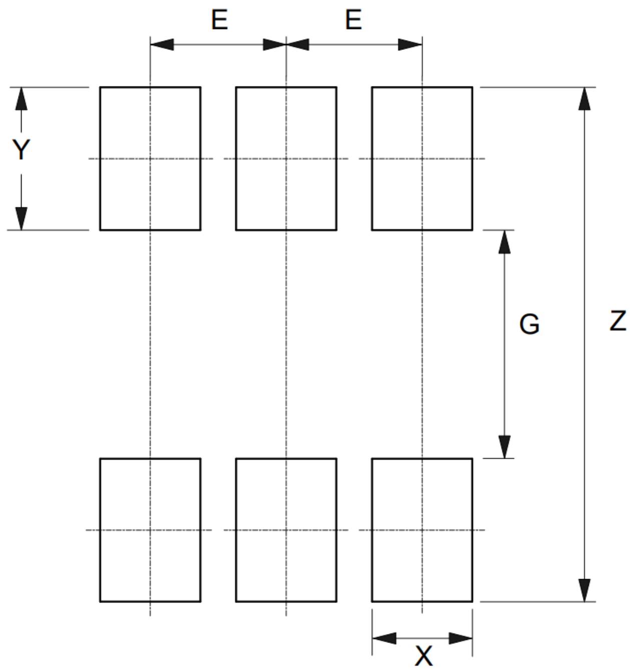
SOT-23-6



Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

SOT-23-6



Dimensions	Z (mm)/(inch)	G (mm)/(inch)	X (mm)/(inch)	Y (mm)/(inch)	E (mm)/(inch)
Value	3.600/0.142	1.600/0.063	0.700/0.028	1.000/0.039	0.950/0.037

Mechanical Data

- Moisture Sensitivity: Level 3 per JESD22-A113
- Terminals: Matte Tin Plated Leads, Solderable per M2003 JESD22-B102 e3
- Weight: 0.016 grams (Approximate)

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