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 0.22µF 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 0.22µF Output Capacitor

Applications

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

Pin Assignments

![Pin Assignments Diagram](Image)
Typical Applications Circuit

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

Pin Descriptions

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Pin Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SW</td>
<td>Switch pin. Connect external inductor</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>3</td>
<td>FB</td>
<td>Voltage feedback pin. Reference voltage is 200mV</td>
</tr>
<tr>
<td>4</td>
<td>CTRL</td>
<td>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</td>
</tr>
<tr>
<td>5</td>
<td>V_OUT</td>
<td>Output pin. Connect to the cathode of internal Schottky diode</td>
</tr>
<tr>
<td>6</td>
<td>V_IN</td>
<td>Input supply pin. Must be connected to a local bypass capacitor</td>
</tr>
</tbody>
</table>
Absolute Maximum Ratings (Note 1)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIN</td>
<td>Input Voltage</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>VSW</td>
<td>SW Pin Voltage</td>
<td>38</td>
<td>V</td>
</tr>
<tr>
<td>VFB</td>
<td>Feedback Voltage</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>VCTRL</td>
<td>CTRL Pin Voltage</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>( \theta_{JA} )</td>
<td>Thermal Resistance (Junction to Ambient, No Heat Sink)</td>
<td>265</td>
<td>(^{\circ}\text{C/W} )</td>
</tr>
<tr>
<td>TJ</td>
<td>Operating Junction Temperature</td>
<td>+150</td>
<td>(^{\circ}\text{C} )</td>
</tr>
<tr>
<td>TSTG</td>
<td>Storage Temperature Range</td>
<td>-65 to +150</td>
<td>(^{\circ}\text{C} )</td>
</tr>
<tr>
<td>TLEAD</td>
<td>Lead Temperature (Soldering, 10sec)</td>
<td>+260</td>
<td>(^{\circ}\text{C} )</td>
</tr>
<tr>
<td>-</td>
<td>ESD (Machine Model)</td>
<td>250</td>
<td>V</td>
</tr>
<tr>
<td>-</td>
<td>ESD (Human Body Model)</td>
<td>2000</td>
<td>V</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>T&lt;sub&gt;OP&lt;/sub&gt;</td>
<td>Operating Temperature Range</td>
<td>-40</td>
<td>+85</td>
<td>°C</td>
</tr>
<tr>
<td>V&lt;sub&gt;IN&lt;/sub&gt;</td>
<td>Input Voltage</td>
<td>2.5</td>
<td>16</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;CTRL&lt;/sub&gt;</td>
<td>CTRL Pin Voltage</td>
<td>–</td>
<td>16</td>
<td>V</td>
</tr>
</tbody>
</table>

### Electrical Characteristics (@V<sub>IN</sub>=3V, V<sub>CTRL</sub>=3V, T<sub>A</sub>=+25°C, unless otherwise specified.)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Condition</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V&lt;sub&gt;IN&lt;/sub&gt; (MIN)</td>
<td>Minimum Operating Voltage</td>
<td>–</td>
<td>2.5</td>
<td>–</td>
<td>–</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;IN&lt;/sub&gt; (MAX)</td>
<td>Maximum Operating Voltage</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>16</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;FB&lt;/sub&gt;</td>
<td>Feedback Voltage (Note 2)</td>
<td>I&lt;sub&gt;OUT&lt;/sub&gt;=20mA, 4 LEDs, T&lt;sub&gt;A&lt;/sub&gt;=-40°C to +85°C</td>
<td>188</td>
<td>200</td>
<td>212</td>
<td>mV</td>
</tr>
<tr>
<td>I&lt;sub&gt;FB&lt;/sub&gt;</td>
<td>FB Pin Bias Current</td>
<td>–</td>
<td>–</td>
<td>35</td>
<td>100</td>
<td>nA</td>
</tr>
<tr>
<td>I&lt;sub&gt;Q&lt;/sub&gt;</td>
<td>Quiescent Current</td>
<td>V&lt;sub&gt;FB&lt;/sub&gt;=V&lt;sub&gt;IN&lt;/sub&gt;, No Switching</td>
<td>1.5</td>
<td>2.5</td>
<td>3.2</td>
<td>mA</td>
</tr>
<tr>
<td>I&lt;sub&gt;SHDN&lt;/sub&gt;</td>
<td>Shutdown Quiescent Current</td>
<td>V&lt;sub&gt;CTRL&lt;/sub&gt;=0V</td>
<td>2.0</td>
<td>4.0</td>
<td>6.0</td>
<td>μA</td>
</tr>
<tr>
<td>f</td>
<td>Switching Frequency</td>
<td>–</td>
<td>0.9</td>
<td>1.2</td>
<td>1.5</td>
<td>MHz</td>
</tr>
<tr>
<td>D&lt;sub&gt;MAX&lt;/sub&gt;</td>
<td>Maximum Duty Cycle</td>
<td>–</td>
<td>90</td>
<td>93</td>
<td>–</td>
<td>%</td>
</tr>
<tr>
<td>I&lt;sub&gt;LIMIT&lt;/sub&gt;</td>
<td>Switch Current Limit (Note 3)</td>
<td>D=40%</td>
<td>–</td>
<td>550</td>
<td>–</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D=80%</td>
<td>–</td>
<td>550</td>
<td>–</td>
<td>mA</td>
</tr>
<tr>
<td>V&lt;sub&gt;CESAT&lt;/sub&gt;</td>
<td>Switch V&lt;sub&gt;CE&lt;/sub&gt; Saturation Voltage</td>
<td>I&lt;sub&gt;SW&lt;/sub&gt;=250mA</td>
<td>–</td>
<td>360</td>
<td>–</td>
<td>mV</td>
</tr>
<tr>
<td>–</td>
<td>Switch Leakage Current</td>
<td>V&lt;sub&gt;SW&lt;/sub&gt;=5V</td>
<td>–</td>
<td>0.01</td>
<td>5</td>
<td>μA</td>
</tr>
<tr>
<td>V&lt;sub&gt;CTRL&lt;/sub&gt;</td>
<td>CTRL Pin Voltage</td>
<td>High</td>
<td>1.8</td>
<td>–</td>
<td>–</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>–</td>
<td>–</td>
<td>0.5</td>
<td>V</td>
</tr>
<tr>
<td>I&lt;sub&gt;CTRL&lt;/sub&gt;</td>
<td>CTRL Pin Bias Current</td>
<td>–</td>
<td>–</td>
<td>100</td>
<td>–</td>
<td>μA</td>
</tr>
<tr>
<td>V&lt;sub&gt;OVP&lt;/sub&gt;</td>
<td>OVP Voltage</td>
<td>–</td>
<td>–</td>
<td>30</td>
<td>–</td>
<td>V</td>
</tr>
<tr>
<td>V&lt;sub&gt;DR&lt;/sub&gt;OP</td>
<td>Schottky Forward Drop</td>
<td>I&lt;sub&gt;D&lt;/sub&gt;=150mA</td>
<td>–</td>
<td>0.7</td>
<td>–</td>
<td>V</td>
</tr>
<tr>
<td>–</td>
<td>Schottky Leakage Current</td>
<td>V&lt;sub&gt;S&lt;/sub&gt;(Reverse Voltage)=23V</td>
<td>–</td>
<td>0.1</td>
<td>4</td>
<td>μA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V&lt;sub&gt;R&lt;/sub&gt;(Reverse Voltage)=27V</td>
<td>–</td>
<td>–</td>
<td>150</td>
<td>μA</td>
</tr>
<tr>
<td>t</td>
<td>Soft Start Time</td>
<td>–</td>
<td>–</td>
<td>300</td>
<td>–</td>
<td>μS</td>
</tr>
<tr>
<td>θ&lt;sub&gt;JC&lt;/sub&gt;</td>
<td>Thermal Resistance (Junction to Case)</td>
<td>SOT-23-6</td>
<td>–</td>
<td>60</td>
<td>–</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

**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 \( I_F=20mA \), unless otherwise noted.)

Efficiency vs. Junction Temperature

\[
V_{in}=3.6V, I_{out}=20mA, 8 \text{ LEDs} \\
C_{in}=1\mu F, C_{out}=0.22\mu F, L=22\mu H
\]

Efficiency vs. Input Voltage

\[
I_{out}=20mA, 8 \text{ LEDs}, T_A=+25^\circ C \\
C_{in}=1\mu F, C_{out}=0.22\mu F, L=22\mu H
\]

Efficiency vs. LED's Number

\[
V_{in}=3.6V, I_{out}=20mA, T_A=+25^\circ C \\
C_{in}=1\mu F, C_{out}=0.22\mu F, L=22\mu H
\]

Schottky Forward Current vs. Schottky Forward Drop

Schottky Forward Current (mA)

\[
0 2 4 6 8 10 12 14 16
\]

Schottky Forward Drop (mV)

\[
0 50 100 150 200 250 300 350
\]

Shutdown Quiescent Current vs. Input Voltage

\[
0 \quad 2 \quad 4 \quad 6 \quad 8 \quad 10 \quad 12 \quad 14 \quad 16
\]

Quiescent Current vs. Input Voltage

\[
0.0 \quad 0.5 \quad 1.0 \quad 1.5 \quad 2.0 \quad 2.5 \quad 3.0 \quad 3.5
\]
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
**Performance Characteristics** (WLED forward voltage (V_F) is 3.45V at I_F=20mA, unless otherwise noted.) (Cont.)

![Saturation Voltage vs. Switch Current](image1)

![CTRL Pin Voltage vs. Junction Temperature](image2)

**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](image3)

**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:

\[
R_1 = \frac{200\text{mV}}{I_{\text{LED}}}
\]
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](image)

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](image)

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](image)

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.

![Diagram showing dimming control using filtered PWM voltage](image)

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.

![Diagram showing dimming control using logic signal](image)

Dimming Control Using Logic Signal

### Ordering Information

<table>
<thead>
<tr>
<th>Package</th>
<th>Temperature Range</th>
<th>Part Number</th>
<th>Marking ID</th>
<th>Packing Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOT-23-6</td>
<td>-40 to +85°C</td>
<td>AP3019AKTR-G1</td>
<td>GAS</td>
<td>Tape &amp; Reel</td>
</tr>
<tr>
<td>TSOT-23-6</td>
<td>-40 to +85°C</td>
<td>AP3019AKTTR-G1</td>
<td>L8E</td>
<td>Tape &amp; Reel</td>
</tr>
</tbody>
</table>
Package Outline Dimensions (All dimensions in mm (inch).)

(1) Package Type: SOT-23-6
Package Outline Dimensions (All dimensions in mm(inch).) (Cont.)

(2) Package Type: TSOT-23-6

Pin 1 Dot by Marking

- 2.600(0.102)
- 3.000(0.118)
- 1.500(0.059)
- 1.700(0.067)
- 0.950(0.037)
- 1.900(0.075)
- 0.700(0.028)
- 0.900(0.035)
- 0.000(0.000)
- 0.100(0.004)
- 0.350(0.014)
- 0.510(0.020)

R0.100(0.004)
MIN

0.370(0.015)
MIN

0.100(0.004)
0.250(0.010)

BSC

0.000(0.000)
0.100(0.004)
0.350(0.014)
0.510(0.020)

1.000(0.039)
MAX

0.700(0.028)
0.900(0.035)

BSC

0.100(0.004)

Gauge Plane

0.900(0.035)

MIN

0.370(0.015)

0.250(0.010)

0.100(0.004)

0.370(0.015)

MIN

0.100(0.004)

0.250(0.010)

0.100(0.004)

0.250(0.010)

0.100(0.004)

0.250(0.010)

0.100(0.004)

0.250(0.010)
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