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FAN5340
Synchronous Constant-Current Series Boost LED Driver with PWM Brightness Control and Integrated Load Disconnect

Features
- Synchronous Current-Mode Boost Converter
- Up to 500mW Output Power
- Supports 2, 3, or 4 LEDs in Series
- 2.7V to 4.8V Input Voltage Range
- 1.2MHz Fixed Switching Frequency
- 1mA Maximum Quiescent Current
- Soft-Start Capability
- Input Under-Voltage Lockout (UVLO)
- Output Over-Voltage Protection (OVP)
- Short-Circuit Detection
- Thermal Shutdown (TSD) Protection
- 8-Lead 3.00 x 3.00mm MLP
- 8-Bump 1.57 x 1.57mm WLCSP

Applications
- Cellular Phones, Smart Phones
- Pocket PCs
- WLAN DC-DC Converter Modules
- PDA, DSC, PMP, and MP3 Players

Description
The FAN5340 is a synchronous constant-current LED driver capable of efficiently delivering up to 500mW to a string of up to four LEDs in series. Optimized for small form-factor applications, the 1.2MHz fixed switching frequency allows the use of chip inductors and capacitors.

For safety, the device features integrated short-circuit detection plus over-voltage and thermal shutdown protections. In addition, input under-voltage lockout protection is triggered if the battery voltage is low.

Brightness (dimming) control is implemented by applying a PWM signal of 300Hz to 1kHz on the EN pin. During shutdown, the FAN5340 disconnects the LED anodes from the output of the boost regulator, which holds the boost regulator’s voltage on COUT, reducing audible noise from the PWM dimming and removing power from the LED string.

Ordering Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Operating Temperature Range</th>
<th>Package</th>
<th>Packing</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAN5340UCX</td>
<td>-40 to 85°C</td>
<td>8-Bump, 1.57 x 1.57mm WLCSP</td>
<td>Tape and Reel</td>
</tr>
<tr>
<td>FAN5340MPX</td>
<td>-40 to 85°C</td>
<td>8-Lead, 3.00 x 3.00mm MLP</td>
<td>Tape and Reel</td>
</tr>
</tbody>
</table>
Table 1. Recommended External Components

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Vendor</th>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>22μH Nominal</td>
<td>Murata LQH3NPN220MGOK</td>
<td>L(^{(1)})</td>
<td>22</td>
<td>μH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COUT</td>
<td>4.7μF X5R or Better</td>
<td></td>
<td>DCR (Series R)</td>
<td>1100</td>
<td>mΩ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIN</td>
<td>4.7μF X5R or Better</td>
<td></td>
<td>C</td>
<td>4.7</td>
<td>μF</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
1. Minimum L (inductance) incorporates tolerance, temperature, and DC bias effects (L decreases with increasing current).
Pin Configuration

Figure 3. WLCSP Package, Top View

Figure 4. WLCSP Package, Bottom View

Figure 5. 8-Pin 3 x 3mm MLP, Top View

Pin Definitions

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSP A1</td>
<td>1</td>
<td>GND</td>
</tr>
<tr>
<td>CSP A2</td>
<td>2</td>
<td>EN</td>
</tr>
<tr>
<td>CSP A3</td>
<td>3</td>
<td>VLED</td>
</tr>
<tr>
<td>CSP B3</td>
<td>4</td>
<td>FB</td>
</tr>
<tr>
<td>CSP C3</td>
<td>5</td>
<td>PGND</td>
</tr>
<tr>
<td>CSP C2</td>
<td>6</td>
<td>SW</td>
</tr>
<tr>
<td>CSP C1</td>
<td>7</td>
<td>VOUT</td>
</tr>
<tr>
<td>CSP B1</td>
<td>8</td>
<td>VIN</td>
</tr>
</tbody>
</table>
Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{IN}$</td>
<td>$V_{IN}$</td>
<td>$-0.3$</td>
<td>$6.0$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{FB}$, $V_{EN}$</td>
<td>$V_{FB}$, $V_{EN}$</td>
<td>$-0.3$</td>
<td>$V_{IN} + 0.3$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{SW}$</td>
<td>$V_{SW}$</td>
<td>$-0.3$</td>
<td>$24.0$</td>
<td>V</td>
</tr>
<tr>
<td>$V_{OUT}$</td>
<td>$V_{OUT}$</td>
<td>$-0.3$</td>
<td>$24.0$</td>
<td>V</td>
</tr>
<tr>
<td>ESD</td>
<td>Electrostatic Discharge Protection Level</td>
<td>4.0</td>
<td>kV</td>
<td></td>
</tr>
<tr>
<td>$T_J$</td>
<td>Junction Temperature</td>
<td>$-40$</td>
<td>$+150$</td>
<td>°C</td>
</tr>
<tr>
<td>$T_{STG}$</td>
<td>Storage Temperature</td>
<td>$-65$</td>
<td>$+150$</td>
<td>°C</td>
</tr>
<tr>
<td>$T_L$</td>
<td>Lead Soldering Temperature, 10 Seconds</td>
<td>$+260$</td>
<td>°C</td>
<td></td>
</tr>
</tbody>
</table>

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to absolute maximum ratings.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{IN}$</td>
<td>$V_{IN}$ Supply Voltage</td>
<td>$2.7$</td>
<td>$4.8$</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{OUT}$</td>
<td>$V_{OUT}$ Voltage</td>
<td>$6.2$</td>
<td>$16.0$</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$I_{OUT}$</td>
<td>$I_{OUT}$ Load Current</td>
<td>$5$</td>
<td>$40$</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>$f_{EN_PWM}$</td>
<td>EN pin PWM Dimming Frequency</td>
<td>$100$</td>
<td>$300$</td>
<td>$1000$</td>
<td>Hz</td>
</tr>
<tr>
<td>$T_A$</td>
<td>Ambient Temperature</td>
<td>$-40$</td>
<td>$+85$</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>$T_J$</td>
<td>Junction Temperature</td>
<td>$-40$</td>
<td>$+125$</td>
<td>°C</td>
<td></td>
</tr>
</tbody>
</table>

Thermal Properties

Junction-to-ambient thermal resistance is a function of application and board layout. This data is measured with four-layer 2s2p evaluation boards in accordance to JEDEC standard JESD51. Special attention must be paid not to exceed junction temperature $T_{J(max)}$ at a given ambient temperate $T_A$.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Typ.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta_{JA}$</td>
<td>Junction-to-Ambient Thermal Resistance</td>
<td>$110$</td>
<td>°C/W</td>
</tr>
<tr>
<td></td>
<td>WLCSP Package</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MLP Package</td>
<td>$49$</td>
<td>°C/W</td>
</tr>
</tbody>
</table>
## Electrical Specifications

\( V_{IN} = 2.7V \) to 4.8V and \( T_A = -40^\circ C \) to +85°C unless otherwise noted. Typical values are at \( T_A = 25^\circ C \) and \( V_{IN} = 3.6V \).

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>( i_Q )</td>
<td>Quiescent Current</td>
<td>( EN = V_{IN}, Device ) Not Switching</td>
<td>1</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>( i_{SD} )</td>
<td>Shutdown Supply Current</td>
<td>( EN = GND, V_{IN} = 3.6V )</td>
<td>0.3</td>
<td>1.0</td>
<td></td>
<td>( \mu A )</td>
</tr>
<tr>
<td>( V_{UVLO} )</td>
<td>Under-Voltage Lockout</td>
<td>( V_{IN} ) Rising</td>
<td>2.30</td>
<td>2.40</td>
<td>2.50</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( V_{IN} ) Falling</td>
<td>2.00</td>
<td>2.15</td>
<td>2.25</td>
<td>V</td>
</tr>
<tr>
<td>( V_{UVHYST} )</td>
<td>Under-Voltage Lockout Hysteresis</td>
<td></td>
<td>250</td>
<td></td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>EN: Enable Pin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( V_{IH} )</td>
<td>HIGH-Level Input Voltage</td>
<td></td>
<td>1.2</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>( V_{IL} )</td>
<td>LOW-Level Input Voltage</td>
<td></td>
<td>0.4</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>( R_{EN} )</td>
<td>EN Pull-Down Resistance</td>
<td></td>
<td>200</td>
<td>300</td>
<td>400</td>
<td>k( \Omega )</td>
</tr>
<tr>
<td>( t_{SD} )</td>
<td>EN Low to Shutdown Delay</td>
<td>From Falling Edge of EN</td>
<td>20</td>
<td></td>
<td></td>
<td>ms</td>
</tr>
<tr>
<td>Feedback and Reference</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( V_{FB} )</td>
<td>Feedback Voltage</td>
<td>( V_{FB} = 500mV )</td>
<td>480</td>
<td>500</td>
<td>520</td>
<td>mV</td>
</tr>
<tr>
<td>( I_{FB} )</td>
<td>Feedback Input Current</td>
<td></td>
<td>0.1</td>
<td>1.0</td>
<td></td>
<td>( \mu A )</td>
</tr>
<tr>
<td>Power Outputs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( R_{DS(ON)}Q1 )</td>
<td>Boost Switch On-Resistance</td>
<td>( V_{IN} = 3.6V, V_{OUT} = 10V, I_{SW} = 100mA )</td>
<td>600</td>
<td></td>
<td></td>
<td>m( \Omega )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( V_{IN} = 2.7V, V_{OUT} = 10V, I_{SW} = 100mA )</td>
<td>850</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( R_{DS(ON)}Q2 )</td>
<td>Synchronous Rectifier On-Resistance</td>
<td>( V_{OUT} = 10V, I_{SW} = 100mA )</td>
<td>2.0</td>
<td></td>
<td></td>
<td>( \Omega )</td>
</tr>
<tr>
<td>( R_{DS(ON)}Q3 )</td>
<td>Load Switch On-Resistance</td>
<td>( V_{OUT} = 10V, I_{LED} = 10mA )</td>
<td>2.8</td>
<td></td>
<td></td>
<td>( \Omega )</td>
</tr>
<tr>
<td>( I_{SW(OFF)} )</td>
<td>SW Node Leakage(a)</td>
<td>EN = 0, ( V_{IN} = V_{SW} = V_{OUT} = 5.5V, ) ( V_{LED} = 0 )</td>
<td>0.1</td>
<td>1.0</td>
<td></td>
<td>( \mu A )</td>
</tr>
<tr>
<td>( I_{ILIM,PK} )</td>
<td>Boost Switch Peak Current Limit</td>
<td>( V_{IN} = 3.6V )</td>
<td>325</td>
<td>400</td>
<td>475</td>
<td>mA</td>
</tr>
<tr>
<td>Oscillator</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( f_{SW} )</td>
<td>Boost Regulator Switching Frequency</td>
<td></td>
<td>1.0</td>
<td>1.2</td>
<td>1.4</td>
<td>MHz</td>
</tr>
<tr>
<td>PWM Dimming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \Delta_{PWM} )</td>
<td>PWM Duty Cycle(3)</td>
<td>PWM Dimming Frequency ( \leq 1kHz )</td>
<td>1.0</td>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Output and Protection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( V_{OPV} )</td>
<td>Boost Output Over-Voltage Protection</td>
<td>( V_{IN} )</td>
<td>18.0</td>
<td>19.0</td>
<td>20.0</td>
<td>V</td>
</tr>
<tr>
<td>( V_{OVPHYST} )</td>
<td>OVP Hysteresis</td>
<td></td>
<td>0.8</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>( V_{THSC} )</td>
<td>V_{LED} Short-Circuit Detection Threshold</td>
<td>( V_{OUT} ) Falling</td>
<td>( V_{IN} - 1.5 )</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( V_{OUT} ) Rising</td>
<td>( V_{IN} - 1.3 )</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>( \Delta_{MAX} )</td>
<td>Maximum Boost Duty Cycle(3)</td>
<td></td>
<td>85</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>( \Delta_{MIN} )</td>
<td>Minimum Boost Duty Cycle(3)</td>
<td></td>
<td>20</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>( T_{SD} )</td>
<td>Thermal Shutdown</td>
<td></td>
<td>150</td>
<td></td>
<td></td>
<td>°C</td>
</tr>
<tr>
<td>( T_{HYS} )</td>
<td>Thermal Shutdown Hysteresis</td>
<td></td>
<td>25</td>
<td></td>
<td></td>
<td>°C</td>
</tr>
</tbody>
</table>

**Notes:**
1. \( \Delta_{SD} \) leakage current includes the leakage current of three internal switches; SW to GND, \( V_{OUT} \) to \( V_{LED} \), and SW to \( V_{OUT} \).
2. Guaranteed by design.

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FAN5340 • Rev. 1.0.1
Typical Characteristics

$V_{IN} = 3.6V$, $T_A = 25^\circ C$, $I_{LED} = 20mA$, $L = 22\mu H$, $C_{OUT} = 4.7\mu F$.

- Figure 6. Efficiency vs. LED Current: Two LEDs
- Figure 7. Efficiency vs. LED Current: Three LEDs
- Figure 8. Efficiency vs. LED Current: Four LEDs
- Figure 9. $f_{SW}$ vs. Input Voltage vs. Temperature
- Figure 10. FB Voltage vs. Input Voltage vs. Temperature
- Figure 11. OVP vs. Input Voltage vs. Temperature
Typical Characteristics (Continued)

Figure 12. PWM Linearity Over Full Dimming Duty Cycle Range, Four LEDs

Figure 13. PWM Linearity with Dimming Duty Cycle <2.5%, Four LEDs

Figure 14. Maximum Output Current at V_{OUT}

Figure 15. Line Transient with 10µs Line Step, Four LEDs

Figure 16. Over-Voltage Protection: Soft-Start into Open LED String
Figure 17. Cold-Start Waveform with 100% Duty Cycle at 1ms/Div.

Figure 18. Cold-Start Waveform with 100% Duty Cycle Showing Startup, Shutdown and Startup at 10ms/Div.

Figure 19. FAN5340 \(I_{LOAD}\) Step from 20mA to 30mA by Enabling FAN5640 at 10mA, Three LEDs

Figure 20. FAN5340 \(I_{LOAD}\) Step from 30mA to 20mA by Disabling FAN5640 at 10mA, Three LEDs
Circuit Description

Overview
The FAN5340 is an inductive current-mode boost serial LED driver that achieves LED current regulation by maintaining 0.5V across RSET. The current through the LED string (ILED) is therefore:

\[ I_{LED} = \frac{0.5}{R_{SET}} \]  

While the forward-voltage across the LEDs determines VOUT, the FAN5340’s boost regulator output can also support additional loads on VOUT (see Figure 21) provided its input current limit is not exceeded.

Over-Voltage Protection
If the LED string is open circuit, FB remains at 0V and the output voltage continues to increase in the absence of an Over-Voltage Protection (OVP) circuit. The FAN5340’s OVP circuit disables the boost regulator when VOUT exceeds 19.0V and continues to keep the regulator off until VOUT drops below 18.2V.

Thermal Shutdown
If the die temperature exceeds 150°C, a reset occurs and remains in effect until the die cools to 125°C, at which time the circuit is allowed to begin the soft-start sequence.

Applications

Using VOUT to Drive Additional LED Strings
The VOUT pin can be used as a supply for simple current sources (shown in Figure 22 using the FAN5640) or discrete current sinks. To avoid dragging VOUT down when the EN pin is LOW, the auxiliary strings should not be enabled unless the EN pin is HIGH. The auxiliary strings can therefore be PWM dimmed using either the same line as the EN line as shown below or enabled separately, but within the on-time of the FAN5340.

Short-Circuit Detection
If VOUT falls below VIN – 1.5V, Q3 turns off and remains off until VOUT recovers to at least VIN – 1.3V.
Physical Dimensions

Product-Specific Dimensions

<table>
<thead>
<tr>
<th>Product</th>
<th>D</th>
<th>E</th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAN5340UC</td>
<td>1.570</td>
<td>1.570</td>
<td>0.285</td>
<td>0.285</td>
</tr>
</tbody>
</table>

Figure 23. 8-Bump, 1.57 x 1.57mm Wafer Level Chip-Scale Package (WLCSP)

Package drawings are provided as a service to customers considering Fairchild components. Drawings may change in any manner without notice. Please note the revision and/or date on the drawing and contact a Fairchild Semiconductor representative to verify or obtain the most recent revision. Package specifications do not expand the terms of Fairchild’s worldwide terms and conditions, specifically the warranty therein, which covers Fairchild products.

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Physical Dimensions (Continued)

Figure 24. 8-Pin, 3 x 3mm Molded Leadless Package (MLP)

NOTES:

A. CONFORMS TO JEDEC REGISTRATION MO-229, VARIATION VEEC, DATED 11/2001
B. DIMENSIONS ARE IN MILLIMETERS.
C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994
D. FILENAME: MKT-MLP08Drev2

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- CorePOWER™
- CROSSVOLT™
- CTL™
- Current Transfer Logic™
- DEUXPEED™
- Dual Cool™
- Ecospark™
- EfficientMax™
- ESBIC™
- F™
- Fairchild®
- FACT Quiet Series™
- FACT™
- FAST™
- FlashXtreme™
- FFS™
- F-PFS™
- FFET™
- Global Power Resource™
- Green FPS™
- Green FPS™ e-Series™
- Gx™
- GTO™
- InFPAK™
- ISOLplanar™
- MegaBuck™
- MicroCoupler™
- MicroFET™
- MicroFET2™
- MillerCree™
- MotionMax™
- Motion-SPM™
- OptiH™
- OPTO-LOGIC™
- OPTOPLANAR™
- POP™
- Power-SPM™
- ProPowerTrench™
- PowerSx™
- Programmable Active Drive™
- QFET™
- Qx™
- Quiet Series™
- RapidConfigure™
- Saving our world. Think Green.™
- Signal Sync™
- SmartMerz™
- SMART START™
- SPM™
- STEALTH™
- Sub40™
- Super SOT™
- SuperSOT™ 2B
- SuperSOT™ 4B
- SyncFET™
- SyncLock™
- TinyBoost™
- TinyCalc™
- TinyLogic™
- TINYOpto™
- TinyPower™
- TinyPWM™
- TinyXtreme™
- TRUECURRENT™
- TrueDiss™
- uTP™
- UniFET™
- UniPower™
- Vx™
- ValuaMax™

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# PRODUCT STATUS DEFINITIONS

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<th>Definition of Terms</th>
<th>Product Status</th>
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<td>Advance Information</td>
<td>Formative / In Design</td>
<td>Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.</td>
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<td>Preliminary</td>
<td>First Production</td>
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