FAIRCHILD SEMICONDUCTOR®

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FAN5332A
High Efficiency, High Current Serial LED Driver and OLED Supply with 30V Integrated Switch

Features

- 1.5MHz Switching Frequency
- Low Noise
- Adjustable Output Voltage
- Up to 1.5A Peak Switch Current
- 1.5W Output Power Capability
- Low Shutdown Current: <1µA
- Cycle-by-Cycle Current Limit
- Over-Voltage Protection
- Fixed -Frequency PWM Operation
- Soft Start
- Internal Compensation
- Thermal Shutdown
- 5-lead SOT-23 Package

Applications

- Cell Phones
- PDAs
- Handheld Equipment
- Display Bias
- LED Bias
- Flash LED

Description

The FAN5332A is an LED driver that features fixed frequency mode operation and an integrated FET switch. The device's high output power makes it suitable to drive flash LEDs in serial connections. This device is designed to operate at high switching frequencies in order to minimize switching noise measured at the battery terminal of hand-held communications equipment. Quiescent current in both normal and shutdown mode is designed to be minimal in order to extend battery life. Normal or shutdown mode can be selected by a logic level shutdown circuitry.

The low ON-resistance of the internal N-channel switch ensures high efficiency and low power dissipation. A cycle-by-cycle current limit circuit keeps the peak current of the switch below a typical value of 1.5A. The FAN5332A is available in a 5-lead SOT23 package.

Typical Application

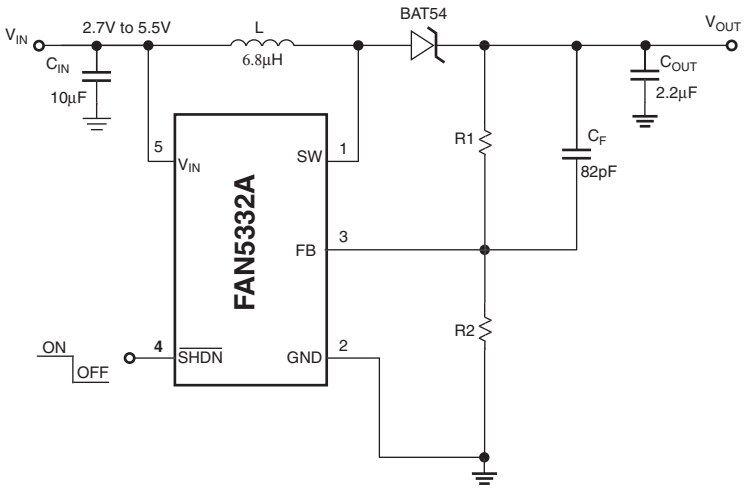
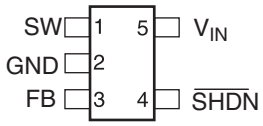


Figure 1. Typical Application Diagram

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Pin Assignment

Top View



5-Lead SOT-23

Figure 2. Pin Assignment

Pin Description

Pin No.	Pin Name	Pin Description
1	SW	**Switching Node.**
2	GND	**Analog and Power Ground.**
3	FB	**Feedback Pin.** Feedback node that connects to an external voltage divider.
4	$\overline{SHDN}$	**Shutdown Control Pin.** Logic HIGH enables, logic LOW disables the device.
5	V_{IN}	**Input Voltage Pin.**

Absolute Maximum Ratings (Note1)

Parameter		Min	Max	Unit
V_{IN} to GND			6.0	V
FB, $\overline{SHDN}$ to GND		-0.3	V_{IN} + 0.3	V
SW to GND		-0.3	35	V
Lead Soldering Temperature (10 seconds)			300	°C
Junction Temperature			150	°C
Storage Temperature		-55	150	°C
Thermal Resistance (Θ_{JA}) (Note 2)			200	°C/W
Electrostatic Discharge Protection (ESD) Level (Note 3)	HBM	2		kV
	CDM	1		

Recommended Operating Conditions

Parameter	Min	Typ	Max	Unit
Input Voltage	2.7		5.5	V
Output Voltage	12		30	V
Operating Ambient Temperature	-40	25	85	°C
Output Capacitance (Note 4)	1.6			µF

Notes:

1. Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Absolute maximum ratings apply individually only, not in combination.
2. Junction to ambient thermal resistance, θ_{JA}, is a strong function of PCB material, board thickness, thickness and number of copper planes, number of via used, diameter of via used, available copper surface, and attached heat sink characteristics.
3. Using EIA/JESD22A114B (Human Body Model) and EIA/JESD22C101-A (Charge Device Model).
4. This load capacitance value is required for the loop stability. Tolerance, temperature variation, and voltage dependency of the capacitance must be considered. Typically a 2.2µF ceramic capacitor is required to achieve specified value at V_{OUT} = 30V.

Electrical Characteristics

Unless otherwise noted, V_{IN} = 3.6V, No external load,T_A = -40°C to +85°C, Typical values are at T_A = 25°C, Test Circuit, Figure 3.

Parameter	Conditions	Min.	Typ.	Max.	Units
Output Voltage Accuracy		-3		+3	%
Switch Current Limit	V_{IN} = 3.2V	1.1	1.5		A
Load Current Capability	V_{OUT} > 18.5V, V_{IN} ≥ 2.7V	50			mA
	V_{OUT} > 19.7V, V_{IN} ≥ 3.2V, T_{ON} < 0.4Sec.	75			mA
Switch On-resistance	V_{IN} = 5V		0.6		Ω
	V_{IN} = 3.6V		0.7		Ω
Quiescent Current	$V_{\overline{SHDN}}$ = 3.6V, No Switching		0.7		mA
	$V_{\overline{SHDN}}$ = 3.6V, Switching, V_{OUT} = 20.7V		4.5		mA
OFF Mode Current	$V_{\overline{SHDN}}$ = 0V		0.1	3	µA
Shutdown Threshold	Device ON	1.5			V
	Device OFF			0.5	V
Shutdown Pin Bias Current	$V_{\overline{SHDN}}$ = 0V or $V_{\overline{SHDN}}$ = 5.5V		1	100	nA
Feedback Voltage	T_A= 25°C	1.205	1.230	1.255	V
Feedback Pin Bias Current			1	100	nA
Line Regulation	3.2V < V_{IN} < 5.5V, V_{OUT} = 20.7V, T_A= 25°C		0.5	1.5	%
Load Regulation	0mA < I_{Load} < 75mA, V_{OUT} = 20.7V		0.8		%
Switching Frequency		1.2	1.5	1.8	MHz
Maximum Duty Cycle		87	93		%
Enable Delay	V_{IN} = 2.7V, I_{OUT} = 50mA, V_{OUT} = 20.7V		1.5	5	mS
Power on Delay	V_{IN} = 2.7V, I_{OUT} = 50mA, V_{OUT} = 20.7V		1.5	5	mS
Switch Leakage Current	No Switching, V_{IN} = 5.5V			1	µA

Test Circuit

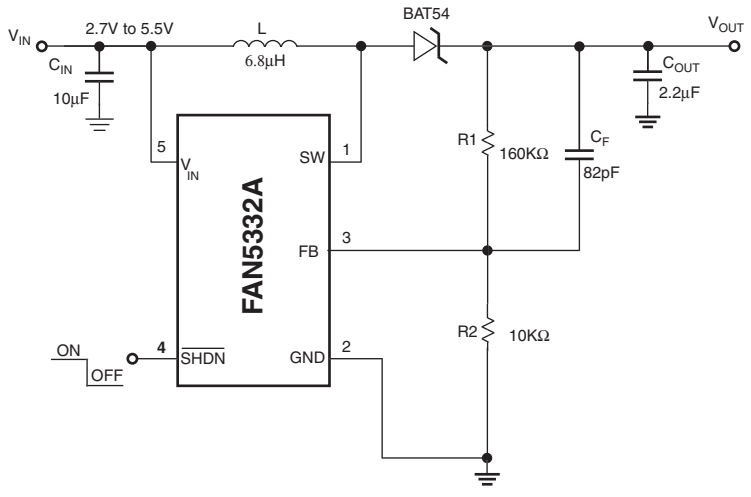
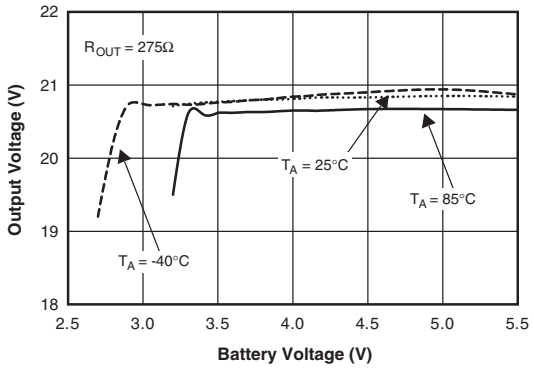


Figure 3. Test Circuit

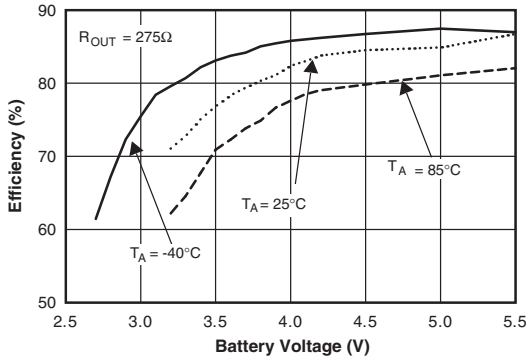
Typical Performance Characteristics

T_A = 25°C, C_{IN} = 10µF, C_{OUT} = 2.2µF, L = 6.8µH, unless otherwise noted.

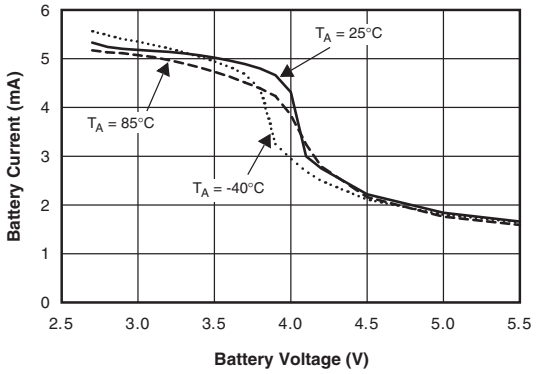
Line Regulation



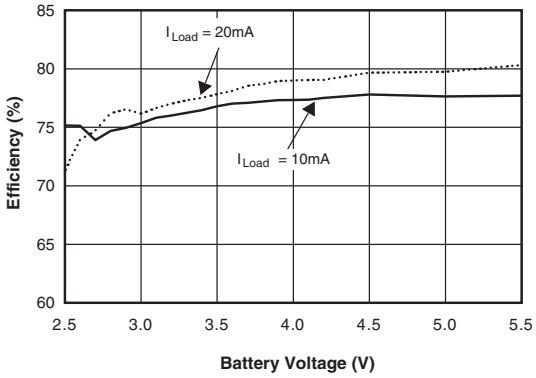
Full Load Efficiency



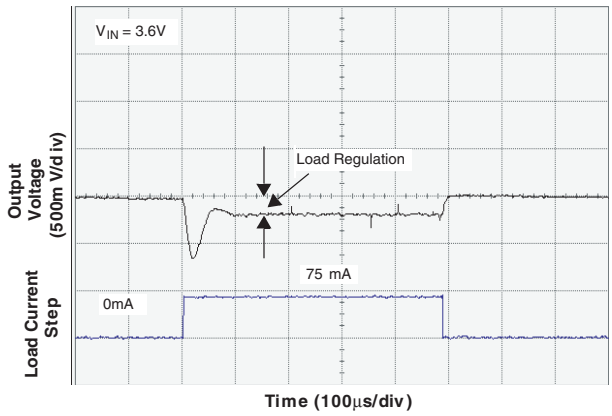
No Load Battery Current vs. Battery Voltage



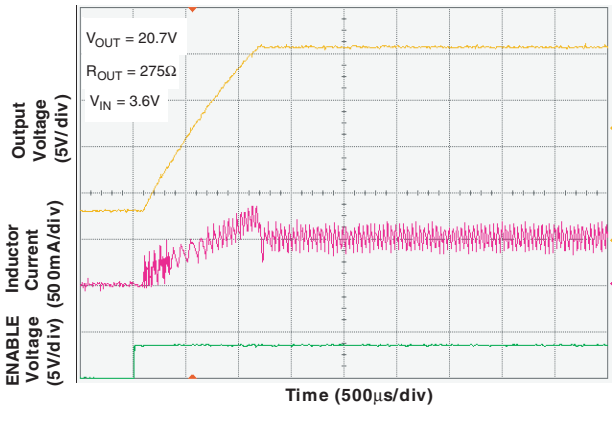
Light Load Efficiency



Load Transient Response



Start-Up Response



Block Diagram

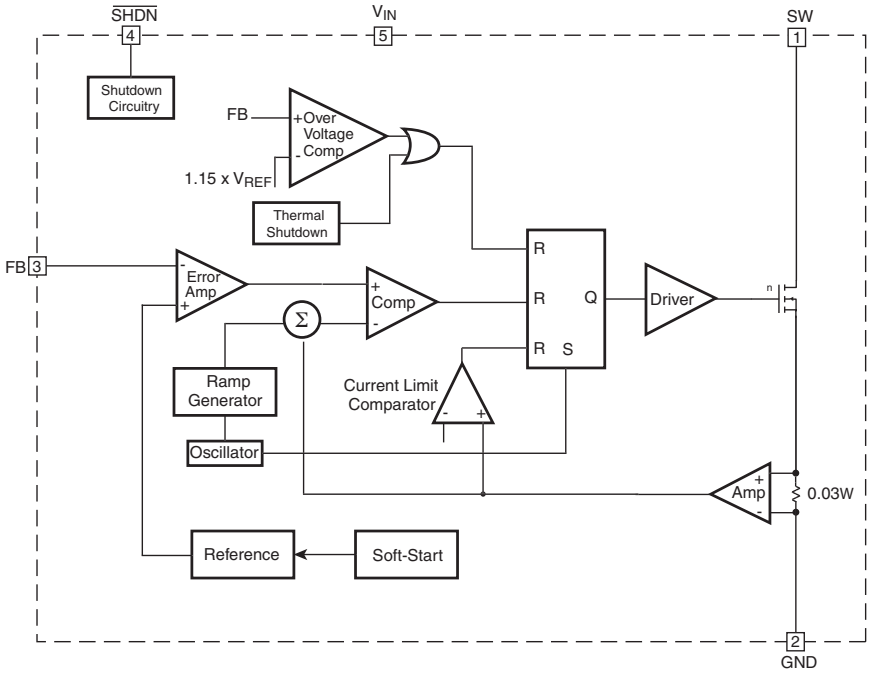


Figure 4. Block Diagram

Circuit Description

The FAN5332A is a pulse-width modulated (PWM) current-mode boost converter. The FAN5332A improves the performance of battery-powered equipment by significantly minimizing the spectral distribution of noise at the input caused by the switching action of the regulator. To facilitate effective noise filtering, the switching frequency was chosen to be high, 1.6MHz. An internal soft start circuitry minimizes in-rush currents. The timing of the soft start circuit was chosen to reach 95% of the nominal output voltage within maximum 5mS following an enable command when V_{IN} = 2.7V, V_{OUT} = 20.7V, I_{LOAD} = 35mA and $C_{OUT\ (EFFECTIVE)}$ =2.2µF.

The device architecture is that of a current mode controller with an internal sense resistor connected in series with the N-channel switch. The voltage at the feedback pin tracks the output voltage at the cathode of the external Schottky diode (shown in the test circuit). The error amplifier amplifies the difference between the feedback voltage and the internal bandgap reference. The amplified error voltage serves as a reference voltage to the PWM comparator. The inverting input of the PWM comparator consists of the sum of two components: the amplified control signal received from the 30mΩ current sense resistor and the ramp generator voltage derived from the oscillator. The oscillator sets the latch, and the latch turns on the FET switch. Under normal operating conditions, the PWM comparator resets the latch and turns off the FET, thus terminating the pulse. Since the comparator input contains information about the output voltage and the control loop is arranged to form a negative feedback loop, the value of the peak inductor current will be adjusted to maintain regulation.

Every time the latch is reset, the FET is turned off and the current flow through the switch is terminated. The latch can be reset by other events as well. Over-current condition is monitored by the current limit comparator which resets the latch and turns off the switch instantaneously within each clock cycle. Over-voltage condition is detected by a fast comparator limiting the duty cycle in a similar manner to over-current monitoring described above. Dimming may be accomplished by PWM modulating the $\overline{SHDN}$ input at a frequency around 100Hz.

Over-Voltage Protection

The voltage on the feedback pin is sensed by an OVP Comparator. When the feedback voltage is 15% higher than the nominal voltage, the OVP Comparator stops switching of the power transistor, thus preventing the output voltage from going higher.

Applications Information

Setting the Output Voltage

The internal reference (V_{REF}) is 1.23V (Typical). The output voltage is divided by a resistor divider, R1 and R2 to the FB pin. The output voltage is given by

$$V_{OUT} = V_{REF}\left(1 + \frac{R_1}{R_2}\right)$$

According to this equation, and assuming desired output voltage of 20.7V, good choices for the feedback resistors are, R_1=160kΩ and R_2=10kΩ.

Inductor Selection

The inductor parameters directly related to device performances are saturation current and dc resistance. The FAN5332A operates with a typical inductor value of 6.8µH. The lower the dc resistance, the higher the efficiency. Usually a trade-off between

inductor size, cost and overall efficiency is needed to make the optimum choice.

The inductor saturation current should be rated around 1.5A, which is the threshold of the internal current limit circuit. This limit is reached only during the start-up and with heavy load condition; when this event occurs the converter can shift over in discontinuous conduction mode due to the automatic turn-off of the switching transistor, resulting in higher ripple and reduced efficiency.

Some recommended inductors are suggested in the table below:

Inductor Value	Vendor	Part Number	Comment
6.8µH	TDK	SLF7028T6R8M1R3	Low Profile
6.8µH	MURATA	LQ566C6R8M04	High Efficiency
6.8µH	COOPER	SD414-6R8	Small Size

Table 1: Recommended Inductors

Capacitors Selection

For best performance, low ESR input and output capacitors are required. Ceramic capacitors of C_{IN} = 10µF and C_{OUT} = 2.2µF placed as close to the IC pins, are recommended for the lower input and output ripple. The output capacitor voltage rating should be according to the V_{OUT} setting. Some capacitors are suggested in the table below.

Capacitor Value	Vendor	Part Number
10µF	Murata	GRM31CR70J106KA01B
2.2µF	Murata	GRM32RR71E225KC01B

Table 2: Recommended Capacitors

A feed forward capacitor C_F, is required for stability. The recommended value (R_1 x C_F) is around 13µS.

Diode Selection

The external diode used for rectification is usually a Schottky diode. Its average forward current and reverse voltage maximum ratings should exceed the load current and the voltage at the output of the converter respectively. A barrier Schottky diode such as BAT54 is preferred, due to its lower reverse current over the temperature range.

Care should be taken to avoid any short circuit of V_{OUT} to GND, even with the IC disabled, since the diode can be instantly damaged by the excessive current.

Thermal Shutdown

When the die temperature exceeds 150°C, a reset occurs and will remain in effect until the die cools to 130°C, at that time the circuit will be allowed to restart.

Heavy Load Limitations

In heavy load applications (P_{OUT} >1.5W) the power dissipated in steady state at high ambient temperature can increase the die temperature to the point where the thermal shutdown kicks in. To prevent this, a limited time operation should be considered in applications such as a flash LED driver. An operation time of 0.4Sec. at maximum load, followed by a 3.6Sec. OFF time ensures stable operation even in the worst case, provided that the IC heat dissipation is optimized to lower the junction to ambient thermal resistance.

The external passive components and the layout of the PCB play an important role in reaching the highest efficiency of the boost converter. For best results, the data sheet recommendations regarding external components and PCB layout should be followed closely.

PCB Layout Recommendations

The inherently high peak currents and switching frequency of power supplies require careful PCB layout design. Therefore, use wide traces for high current paths and place the input capacitor, the inductor, and the output capacitor as close as possible to the integrated circuit terminals. The resistor divider that sets the output voltage should be routed away from the inductor to avoid RF coupling. A two layer PCB with the bottom layer as ground plane connected to the pin 2 of the IC is recommended. This ground plane acts as an electromagnetic shield to reduce EMI and parasitic coupling between components.

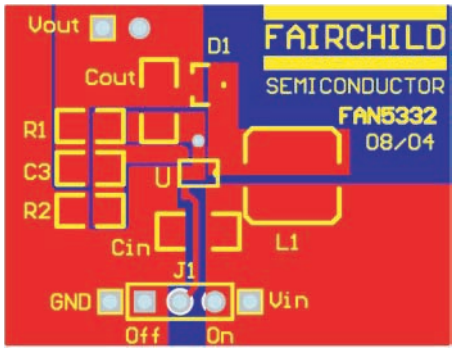
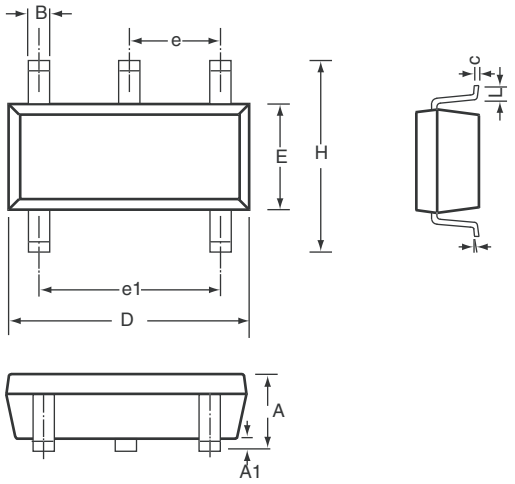


Figure 5. Recommended PCB Layout

Mechanical Dimensions

5-Lead SOT-23Package



Symbol	Inches		Millimeters		Notes
	Min	Max	Min	Max	
A	.035	.057	.90	1.45	
A1	.000	.006	.00	.15	
B	.008	.020	.20	.50	
c	.003	.010	.08	.25	
D	.106	.122	2.70	3.10	
E	.059	.071	1.50	1.80	
e	.037 BSC		.95 BSC		
e1	.075 BSC		1.90 BSC		
H	.087	.126	2.20	3.20	
L	.004	.024	.10	.60	
α	0º	10º	0º	10º	

Ordering Information

Product Number	Package Type	Order Code
FAN5332A	5-Lead SOT23	FAN5332ASX

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QS™
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SPM™
Stealth™
SuperFET™
SuperSOT™-3
SuperSOT™-6
SuperSOT™-8
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