LED Driver, Series Boost, with Integrated Schottky Diode and Single-Wire Digital Interface

FAN5341

Description

The FAN5341 is an asynchronous constant−current LED driver capable of efficiently delivering up to 500 mW to a string of up to five LEDs in series. Optimized for small form−factor applications, the 1.2 MHz fixed switching frequency allows the use of small chip inductors and capacitors.

The FAN5341 uses a simple single−wire digital control interface to program the brightness levels of the LEDs in 32 linear steps by applying digital pulses.

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

The FAN5341 is available in a very low profile, small form−factor 2 mm x 2 mm x 0.55 mm 6−lead UMLP package that is green and RoHS compliant.

Features

- Asynchronous Boost Converter
- Internal Schottky Diode
- Up to 500 mW Output Power
- Drives 3 to 5 LEDs in Series
- 2.7 V to 5.5 V Input Voltage Range
- Single−Wire Digital Control Interface to Set LED Brightness Levels
  - 32 Linear Steps
- 1.2 MHz Fixed Switching Frequency
- Soft−Start Capability
- Input Under−Voltage Lockout (UVLO)
- Output Over−Voltage Protection (OVP)
- Short−Circuit Detection
- Thermal Shutdown (TSD) Protection
- Low Profile 6−lead 2.0 x 2.0 x 0.55 mm UMLP Package
- This Device is Pb−Free, Halogen Free/BFR Free and is RoHS Compliant

Applications

- Cellular Mobile Handsets
- Mobile Internet Devices
- Portable Media Players
- PDA, DSC, MP3 Players

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UDFN6 2 x 2, 0.65P
CASE 517DS

MARKING DIAGRAM



&Z	= Assembly Plant Code
&2	= 2−Digit Date Code
&K	= Lot Code
341	= Specific Device Code

ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

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Table 1. ORDERING INFORMATION

Part Number	Temperature Range	Package	Packing Method†
FAN5341UMPX	−40°C to 85°C	6−lead, 2.0 x 2.0 mm UMLP	3000 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

TYPICAL APPLICATION DIAGRAM

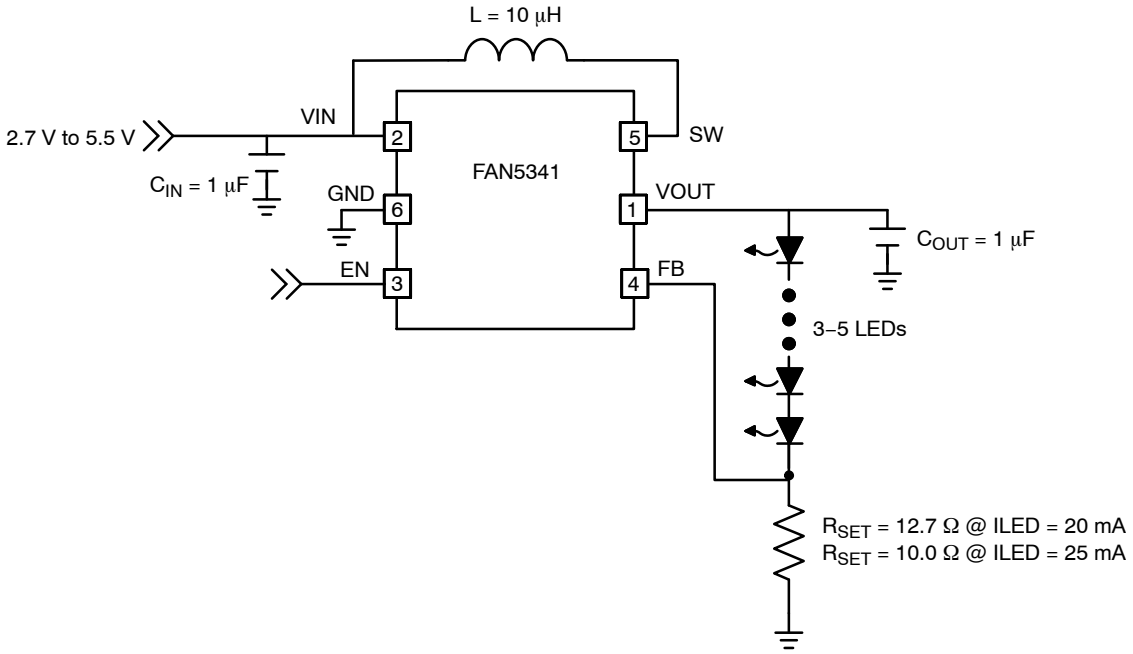


Figure 1. Typical Application

BLOCK DIAGRAM

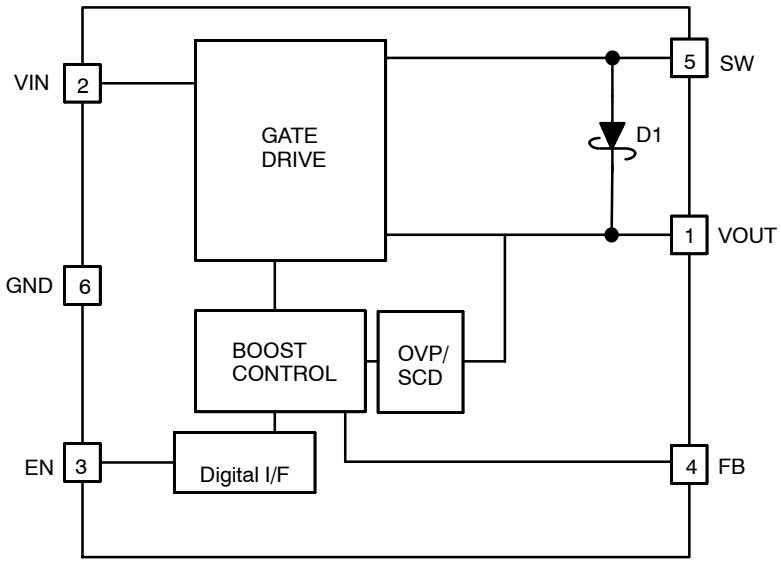


Figure 2. Functional Block Diagram

PIN CONFIGURATION

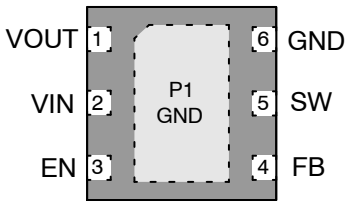


Figure 3. UMLP6 Package (Top View)

Table 2. PIN DEFINITIONS

Pin #	Name	Description
1	VOUT	Boost Output Voltage. Output of the boost regulator. Connect the LEDs to this pin. Connect C_{OUT} (Output Capacitor) to GND.
2	VIN	Input Voltage. Connect to power source and decouple with C_{IN} to GND.
3	EN	Enable Brightness Control. Program dimming levels by driving pin with digital pulses.
4	FB	Voltage Feedback. The boost regulator regulates this pin to 0.253 V to control the LED string current. Tie this pin to a current setting resistor (R_{SET}) between GND and the cathode of the LED string.
5	SW	Switching node. Tie inductor L1 from VIN to SW pin.
6	GND	Ground. Tie directly to a GND plane.

Table 3. ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter		Min.	Max.	Units
V_{IN}	VIN Pin		−0.3	6.0	V
V_{FB}, V_{EN}	FB, EN Pins		−0.3	V_{IN} + 0.3	V
V_{SW}	SW Pin		−0.3	22.0	V
V_{OUT}	VOUT Pin		−0.3	22.0	V
ESD	Electrostatic Discharge Protection Level	Human Body Model per JESD22−A114	3.3		kV
		Charged Device Model per JESD22−C101	2.0		
T_J	Junction Temperature		−40	+150	°C
T_{STG}	Storage Temperature		−65	+150	°C
T_L	Lead Soldering Temperature, 10 Seconds			+260	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

Table 4. RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter		Min.	Max.	Units
V_{IN}	V_{IN} Supply Voltage		2.7	5.5	V
V_{OUT}	VOUT Voltage (Note 1)		6.2	17.5	V
I_{OUT}	VOUT Load Current	500 mW Maximum Output Power	5	25	mA
T_A	Ambient Temperature		−40	+85	°C
T_J	Junction Temperature		−40	+125	°C

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

1. Application should guarantee that minimum and maximum duty−cycle should fall between 20−85% to meet the specified range.

Table 5. THERMAL PROPERTIES

Symbol	Parameter	Typical	Units
θ_{JA}	Junction−to−Ambient Thermal Resistance, UMLP6 Package	70	°C/W

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

Table 6. ELECTRICAL SPECIFICATIONS

(V_{IN} = 2.7 V to 5.5 V and T_A = −40C to +85°C unless otherwise noted. Typical values are at T_A = 25°C and V_{IN} = 3.6 V.)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
POWER SUPPLIES						
I_{SD}	Shutdown Supply Current	EN = GND, V_{IN} = 3.6 V		0.30	0.75	μA
V_{UVLO}	Under−Voltage Lockout Threshold	V_{IN} Rising	2.10	2.35	2.60	V
		V_{IN} Falling	1.90	2.15	2.40	
V_{UVHYST}	Under−Voltage Lockout Hysteresis			250		mV
EN: ENABLE PIN						
V_{IH}	HIGH−Level Input Voltage		1.2			V
V_{IL}	LOW−Level Input Voltage				0.4	V
R_{EN}	EN Pull−Down Resistance		200	300	400	kΩ
T_{LO}	EN Low Time for Dimming	V_{IN} = 3.6 V; See Figure 14	0.5		300	μs
T_{HI}	Time Delay Between Steps	V_{IN} = 3.6 V; See Figure 14	0.5			μs
T_{SD}	EN Low, Shutdown Pulse Width	V_{IN} = 3.6 V; from Falling Edge of EN	1			ms
FEEDBACK AND REFERENCE						
V_{FB}	Feedback Voltage	I_{LED} = 20 mA from −40°C to +85°C, 2.7 V ≤ V_{IN} ≤ 5.5 V	240	253	266	mV
I_{FB}	Feedback Input Current	V_{FB} = 253 mV		0.1	1.0	μA
POWER OUTPUTS						
$R_{DS(ON)_Q1}$	Boost Switch On−Resistance	V_{IN} = 3.6 V, I_{SW} = 100 mA		600		mΩ
		V_{IN} = 2.7 V, I_{SW} = 100 mA		650		
$I_{SW(OFF)}$	SW Node Leakage (Note 2)	EN = 0, V_{IN} = V_{SW} = V_{OUT} = 5.5 V, V_{LED} = 0		0.1	2.0	μA
$I_{LIM−PK}$	Boost Switch Peak Current Limit	V_{IN} = 3.6 V		750		mA
OSCILLATOR						
f_{SW}	Boost Regulator Switching Frequency		1.0	1.2	1.4	MHz
OUTPUT AND PROTECTION						
V_{OVP}	Boost Output Over−Voltage Protection		18.0	18.9	21.0	V
	OVP Hysteresis			0.8		
V_{TLSC}	V_{OUT} Short Circuit Detection Threshold	V_{OUT} Falling		V_{IN} − 1.4		V
V_{THSC}	V_{OUT} Short Circuit Detection Threshold	V_{OUT} Rising		V_{IN} − 1.2		V
D_{MAX}	Maximum Boost Duty Cycle (Notes 3, 4)		85			%
D_{MIN}	Minimum Boost Duty Cycle (Notes 3, 4)				20	

Table 6. ELECTRICAL SPECIFICATIONS (continued)
(V_{IN} = 2.7 V to 5.5 V and T_A = −40C to +85°C unless otherwise noted. Typical values are at T_A = 25°C and V_{IN} = 3.6 V.)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
T_{TSD}	Thermal Shutdown			150		°C
T_{HYS}	Thermal Shutdown Hysteresis			35		°C

2. SW leakage current includes the leakage current of 2 internal switches, SW to GND and SW to VOUT.
3. Not tested in production and guaranteed by design.
4. Application should guarantee that minimum and maximum duty cycle should fall between 20−85% to meet the specified range.

ELECTRICAL SPECIFICATIONS

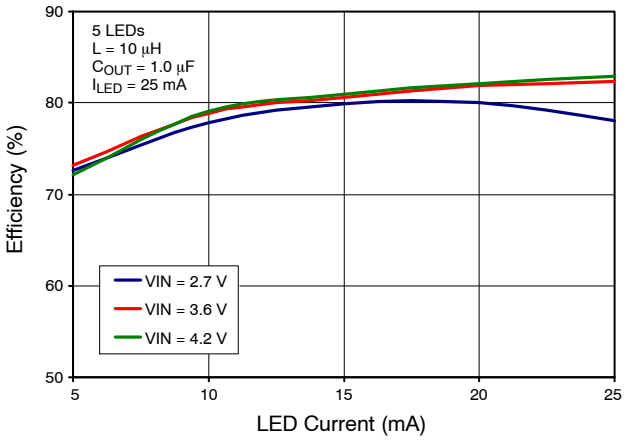


Figure 4. 5 LEDs: Efficiency vs. LED Current vs. Input Voltage

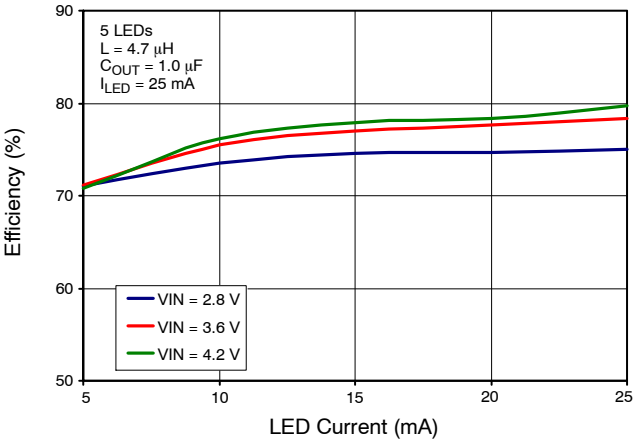


Figure 5. 5 LEDs: Efficiency vs. LED Current vs. Input Voltage

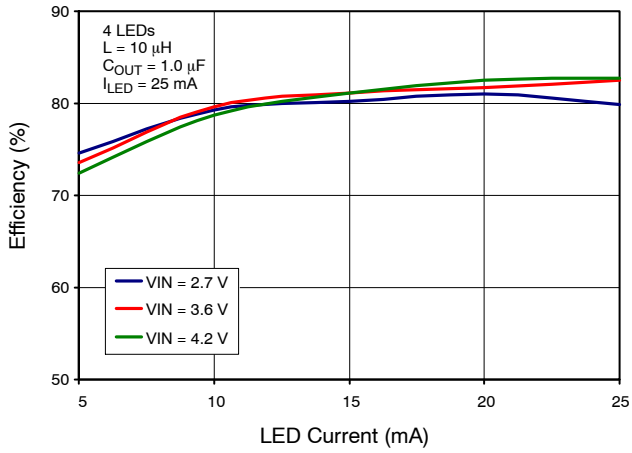


Figure 6. 4 LEDs: Efficiency vs. LED Current vs. Input Voltage

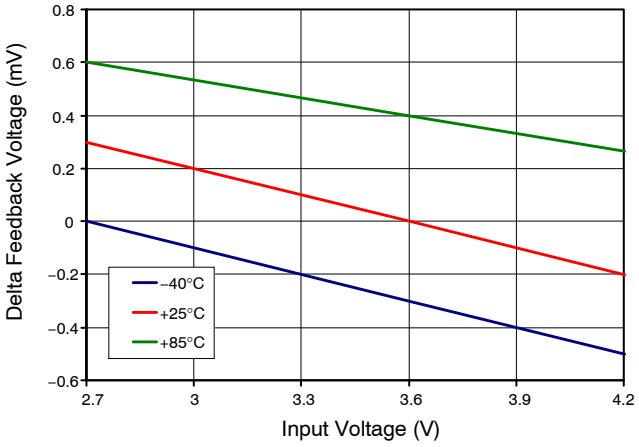


Figure 7. Delta of V_{FB} over Input Voltage and Temperature for 4 LEDs with L = 10 μH and C_{OUT} = 1.0 μF at I_{LED} = 25 mA

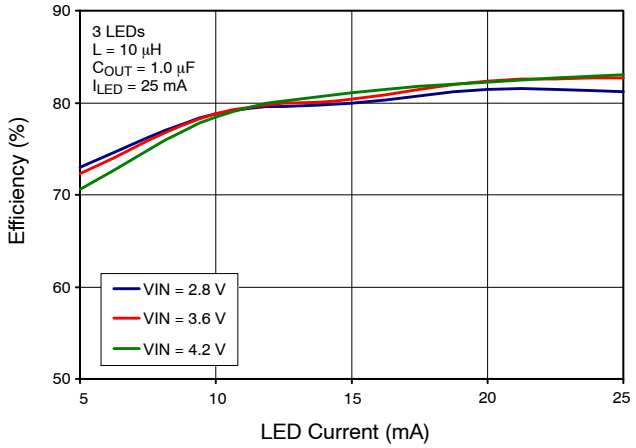


Figure 8. 3 LEDs: Efficiency vs. LED Current vs. Input Voltage

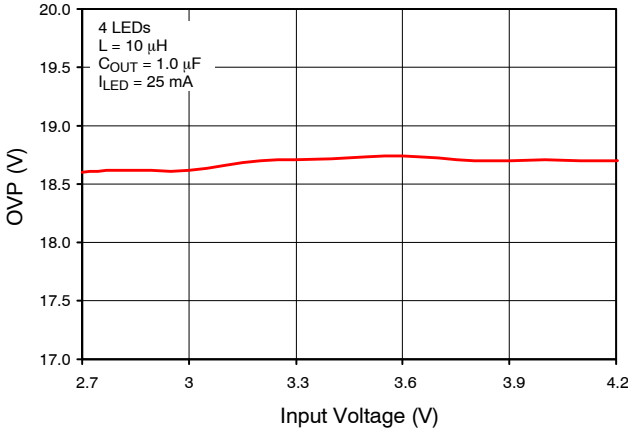


Figure 9. Over−Voltage Protection vs. Input Voltage

ELECTRICAL SPECIFICATIONS (continued)

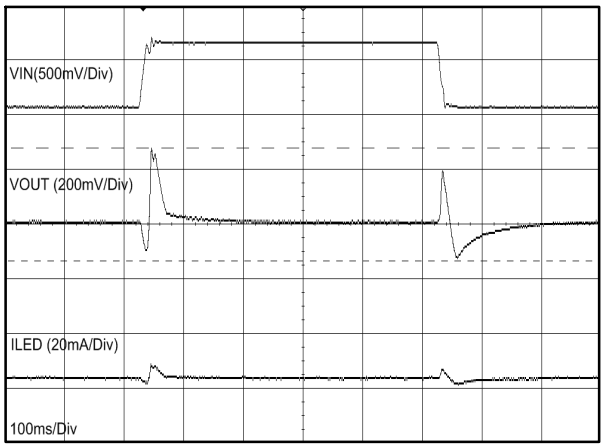


Figure 10. Line Transient Response for 4 LEDs at V_{IN} = 3.6 V ± 0.6 V with L = 10 μH, C_{OUT} = 1.0 μF and I_{LED} = 25 mA

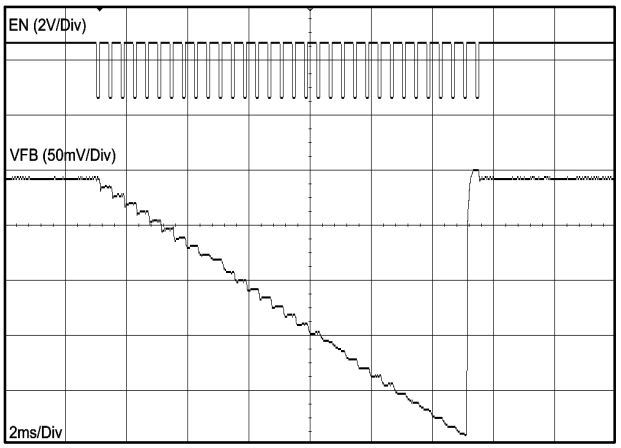


Figure 11. FAN5341 Dimming Operation at V_{IN} = 3.6 V for 4 LEDs with L = 10 μH, C_{OUT} = 1.0 μF and I_{LED} = 25 mA

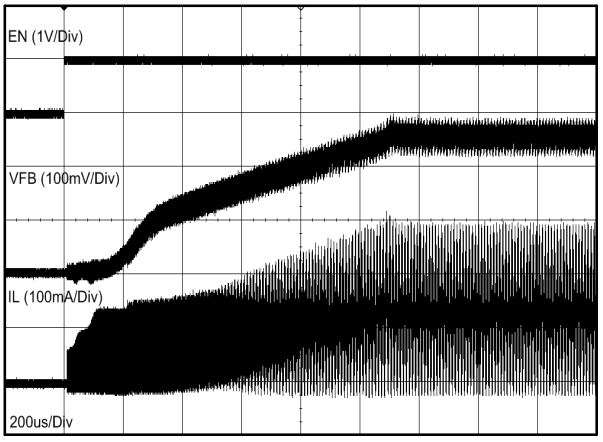


Figure 12. Startup Waveform for Switch Voltage, Inductor Current, V_{FB} and EN for 4 LEDs at V_{IN} = 3.6 V ± 0.6 V with L = 10 μH, C_{OUT} = 1.0 μF and I_{LED} = 25 mA

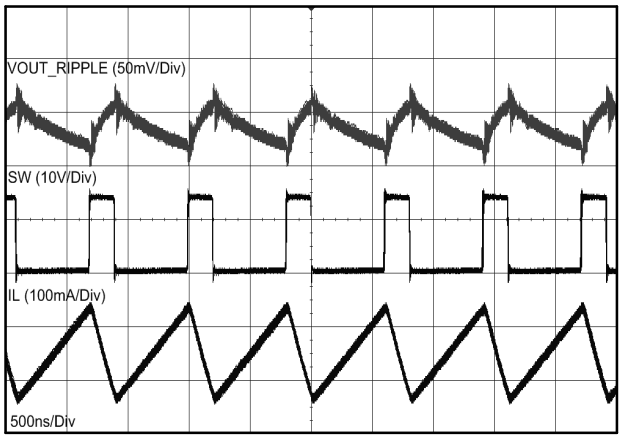


Figure 13. Steady−State Waveform for VOUT, Switch Voltage and Inductor Current for 4 LEDs at V_{IN} = 3.6 V ± 0.6 V with L = 10 μH, C_{OUT} = 1.0 μF and I_{LED} = 25 mA

CIRCUIT DESCRIPTION

Overview

The FAN5341 is an inductive current−mode boost serial LED driver that achieves LED current regulation by maintaining 0.253 V across the R_{SET} resistor. The current through the LED string (I_{LED}) is therefore given by:

$$I_{LED} = \frac{0.253}{R_{SET}} \quad \text{(eq. 1)}$$

The voltage V_{OUT} is determined by the sum of the forward voltages across each LED, plus the voltage across R_{SET}, which is always 253 mV.

Driving Five LEDs in Series

FAN5341 can drive five LEDs in series but, the forward voltage (V_F) of the LED MUST be less than 3.5 V such that it remains under the over−voltage specification of 18.9 V.

UVLO and Soft−Start

If EN has been low for more than 1 ms, the IC may initiate a “cold start” soft−start cycle when EN rises, provided V_{IN} is above the UVLO threshold.

Digital Interface

The FAN5341 implements a single−wire digital interface to program the LED brightness to one of thirty−two (32) levels spaced in linear steps. With this single−wire solution, the FAN5341 does not require the system processor to constantly supply a signal to it to drive the LEDs.

Digital Dimming Control

The FAN5341 starts driving the LEDs at the maximum brightness level. After startup, the control logic is ready to accept programming pulses to decrease the brightness level by the number of positive edges applied to the EN pin. Figure 14 shows the digital pulse dimming control.

Over−Current and Short−Circuit Detection

The boost regulator employs a cycle−by−cycle peak inductor current limit of ~750 mA.

Over−Voltage / Open−Circuit Protection

If the LED string is an open circuit, FB remains at 0 V and the output voltage continues to increase in the absence of an over−voltage protection (OVP) circuit. The FAN5341’s OVP circuit disables the boost regulator when V_{OUT} exceeds 18.9 V and continues to keep the regulator off until V_{OUT} drops below 18.1 V.

Thermal Shutdown

When 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.

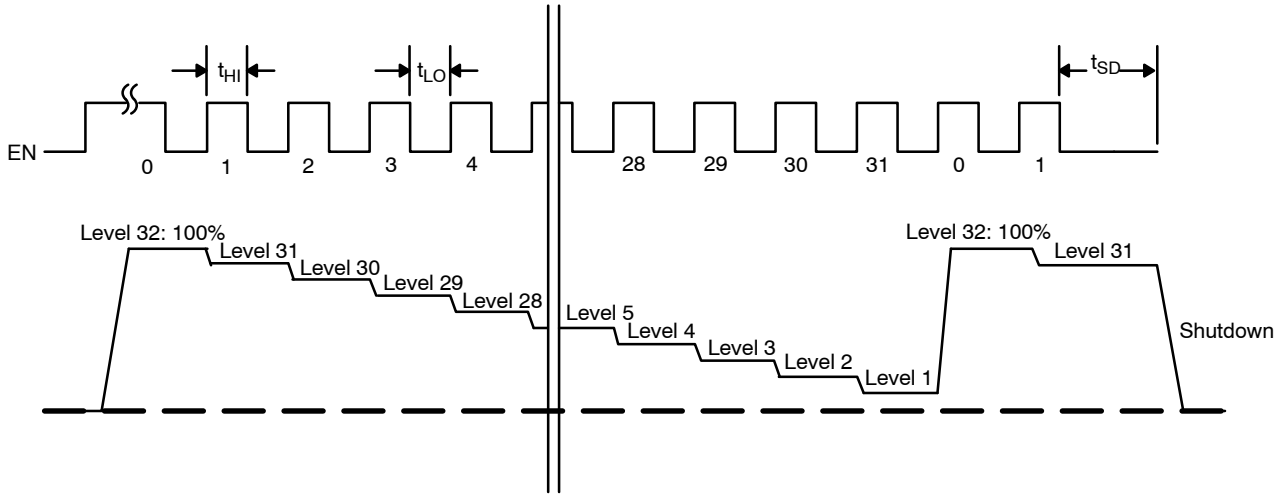


Figure 14. Digital Pulse−Dimming Control Diagram

APPLICATION INFORMATION

Inductor & Output Capacitor Selection

Table 7. RECOMMENDED EXTERNAL COMPONENTS

# of LEDs	Inductor (L)	Part Number	Manufacturer	Min C_{OUT}	Part Number	Manufacturer
3, 4, 5	10.0 μH	LQH43MN100K03	Murata	1.00 μF	CV105X5R105K25AT	AVX/Kyocera
		NLCV32T−100K−PFR	TDK			
		VLF3010AT−100MR49−1	TDK			
	4.7 μH	LQH43MN4R7K03	Murata	1.00 μF	CV105X5R105K25AT	AVX/Kyocera
		NLCV32T−4R7M−PFR	TDK			
		LPF2010T−4R7M	ABCO			

Component Placement and PCB Recommendations

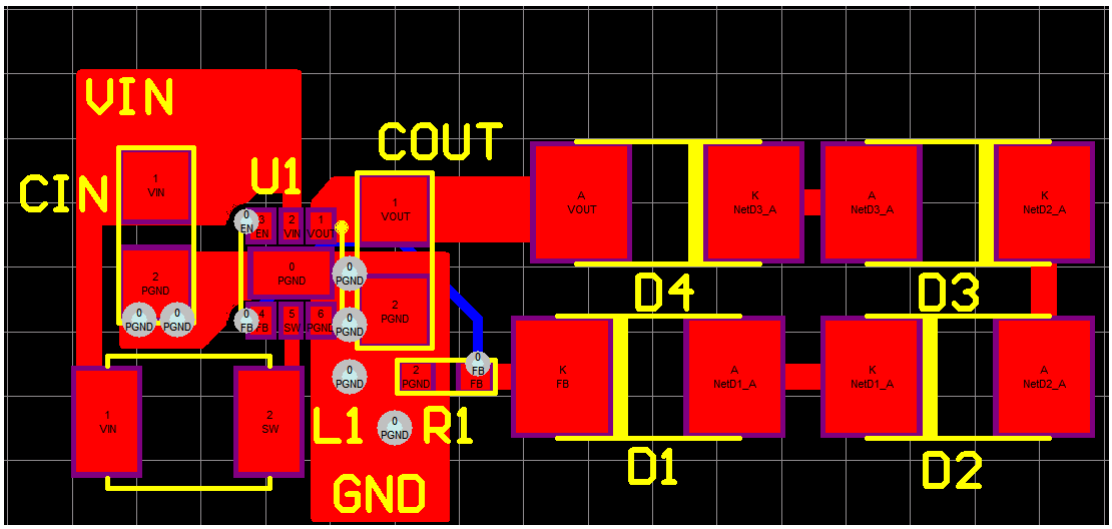


Figure 15. Recommended Component Placement

Input Capacitance

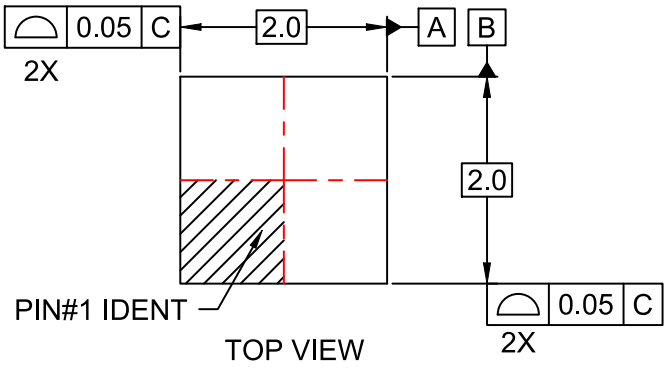
In a typical application, the input and output capacitors should be placed as close to the IC as possible; no additional capacitance is needed to ensure proper functionality. However, in a testing environment, where the FAN5341 is typically powered by a power supply with relatively long cables, an additional input capacitor (10 μF) may be needed to ensure stable functioning. This capacitor should be placed close to where the power supply cables attach to the FAN5341 evaluation board.

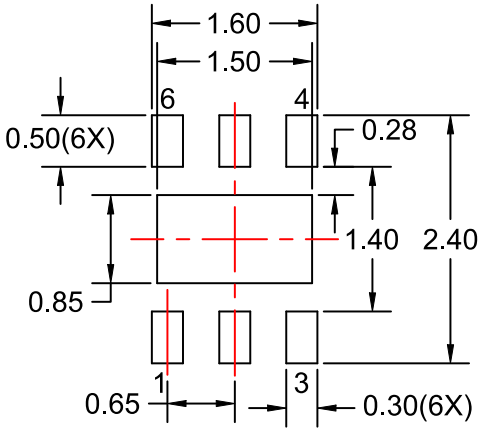
PCB Recommendations

- The inductor can be connected to VIN with vias through another layer if needed.
- The feedback pin should be connected back to the IC on a sub−layer.

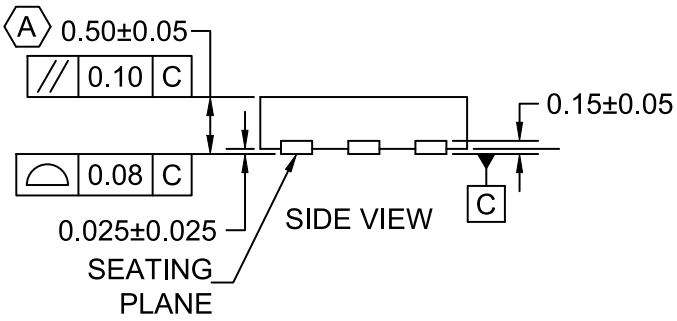
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DATE 31 OCT 2016





RECOMMENDED
LAND PATTERN



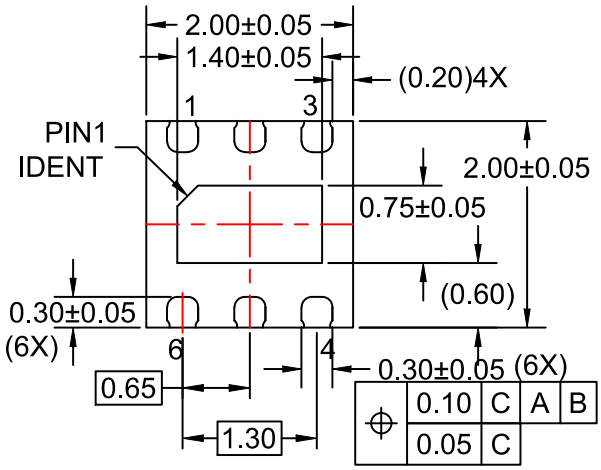
NOTES:

A. CONFORM TO JADEC REGISTRATIONS MO-229, VARIATION VCCC, EXCEPT WHERE NOTED.

B. DIMENSIONS ARE IN MILLIMETERS.

C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 2009.

D. LAND PATTERN RECOMMENDATION IS EXISTING INDUSTRY LAND PATTERN.



BOTTOM VIEW

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