

# 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

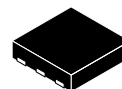
### Applications

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



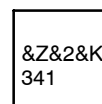
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**UDFN6 2 x 2, 0.65P  
CASE 517DS**

### 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.

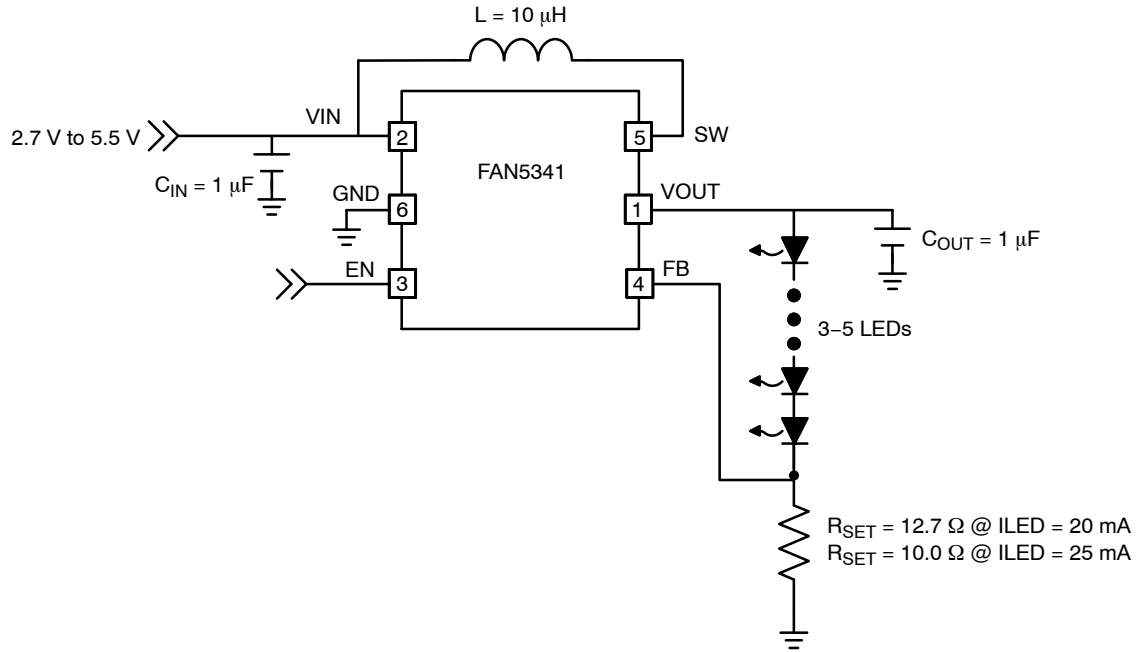
# FAN5341

**Table 1. ORDERING INFORMATION**

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

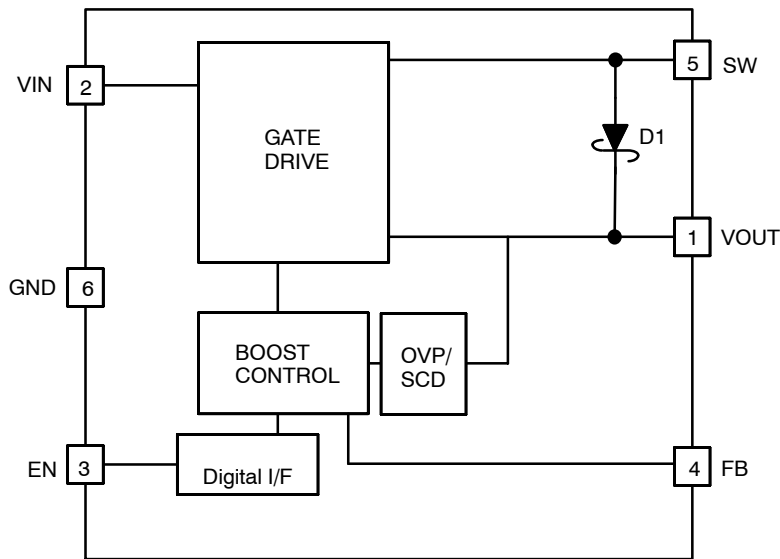
<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

## TYPICAL APPLICATION DIAGRAM



**Figure 1. Typical Application**

## BLOCK DIAGRAM



**Figure 2. Functional Block Diagram**

## PIN CONFIGURATION

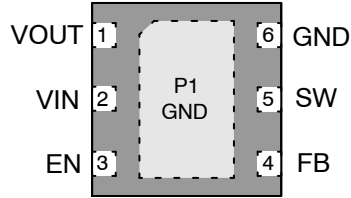


Figure 3. UMLP6 Package (Top View)

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 <sub>OUT</sub> (Output Capacitor) to GND.
2	VIN	Input Voltage. Connect to power source and decouple with C <sub>IN</sub> 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 <sub>SET</sub> ) 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 <sub>IN</sub>	VIN Pin		−0.3	6.0	V
V <sub>FB</sub> , V <sub>EN</sub>	FB, EN Pins		−0.3	V <sub>IN</sub> + 0.3	V
V <sub>SW</sub>	SW Pin		−0.3	22.0	V
V <sub>OUT</sub>	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 <sub>J</sub>	Junction Temperature		−40	+150	°C
T <sub>STG</sub>	Storage Temperature		−65	+150	°C
T <sub>L</sub>	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 <sub>IN</sub>	V <sub>IN</sub> Supply Voltage		2.7	5.5	V
V <sub>OUT</sub>	VOUT Voltage (Note 1)		6.2	17.5	V
I <sub>OUT</sub>	VOUT Load Current	500 mW Maximum Output Power	5	25	mA
T <sub>A</sub>	Ambient Temperature		-40	+85	°C
T <sub>J</sub>	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
$\theta_{JA}$	Junction-to-Ambient Thermal Resistance, UMLP6 Package	70	$^{\circ}\text{C}/\text{W}$

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  $T_{J(\text{max})}$  at a given ambient temperature  $T_A$ .

**Table 6. ELECTRICAL SPECIFICATIONS**

( $V_{IN} = 2.7\text{ V}$  to  $5.5\text{ V}$  and  $T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  unless otherwise noted. Typical values are at  $T_A = 25^{\circ}\text{C}$  and  $V_{IN} = 3.6\text{ V}$ .)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
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**POWER SUPPLIES**

$I_{SD}$	Shutdown Supply Current	EN = GND, $V_{IN} = 3.6\text{ V}$		0.30	0.75	$\mu\text{A}$
$V_{UVLO}$	Under-Voltage Lockout Threshold	$V_{IN}$ Rising	2.10	2.35	2.60	V
		$V_{IN}$ Falling	1.90	2.15	2.40	
$V_{UVHYS}$	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	$k\Omega$
$T_{LO}$	EN Low Time for Dimming	$V_{IN} = 3.6\text{ V}$ ; See Figure 14	0.5		300	$\mu\text{s}$
$T_{HI}$	Time Delay Between Steps	$V_{IN} = 3.6\text{ V}$ ; See Figure 14	0.5			$\mu\text{s}$
$T_{SD}$	EN Low, Shutdown Pulse Width	$V_{IN} = 3.6\text{ V}$ ; from Falling Edge of EN	1			ms

**FEEDBACK AND REFERENCE**

$V_{FB}$	Feedback Voltage	$I_{LED} = 20\text{ mA}$ from $-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ , $2.7\text{ V} \leq V_{IN} \leq 5.5\text{ V}$	240	253	266	mV
$I_{FB}$	Feedback Input Current	$V_{FB} = 253\text{ mV}$		0.1	1.0	$\mu\text{A}$

**POWER OUTPUTS**

$R_{DS(ON)_Q1}$	Boost Switch On-Resistance	$V_{IN} = 3.6\text{ V}$ , $I_{SW} = 100\text{ mA}$		600		m $\Omega$
		$V_{IN} = 2.7\text{ V}$ , $I_{SW} = 100\text{ mA}$		650		
$I_{SW(OFF)}$	SW Node Leakage (Note 2)	EN = 0, $V_{IN} = V_{SW} = V_{OUT} = 5.5\text{ V}$ , $V_{LED} = 0$		0.1	2.0	$\mu\text{A}$
$I_{LIM-PK}$	Boost Switch Peak Current Limit	$V_{IN} = 3.6\text{ V}$		750		mA

**OSCILLATOR**

$f_{SW}$	Boost Regulator Switching Frequency		1.0	1.2	1.4	MHz
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**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	

## FAN5341

**Table 6. ELECTRICAL SPECIFICATIONS** (continued)

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

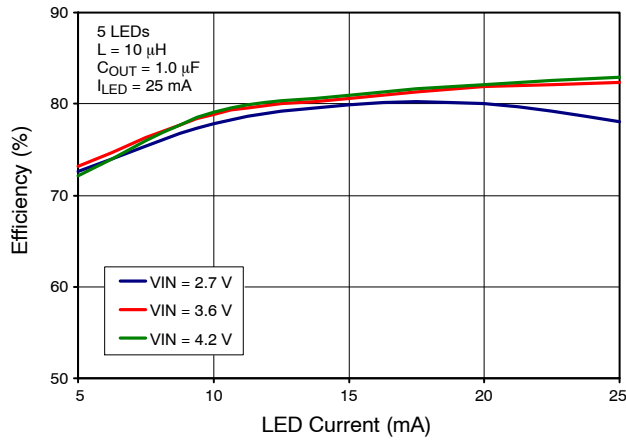
Symbol	Parameter	Conditions	Min	Typ	Max	Units
$T_{TSD}$	Thermal Shutdown			150		°C
$T_{HYS}$	Thermal Shutdown Hysteresis			35		°C

2. SW leakage current includes the leakage current of 2 internal switches, SW to GND and SW to VOUT.

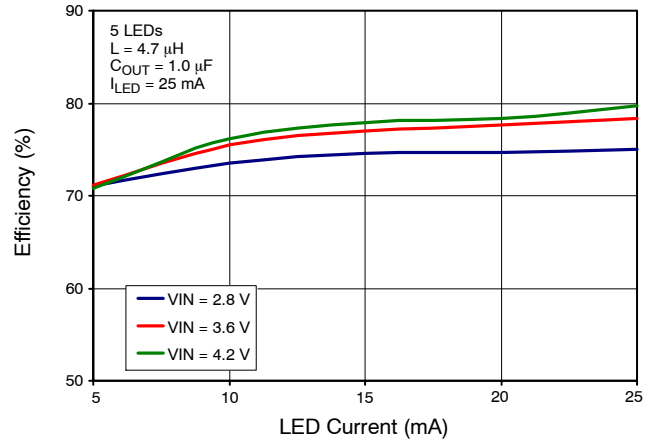
3. Not tested in production and guaranteed by design.

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

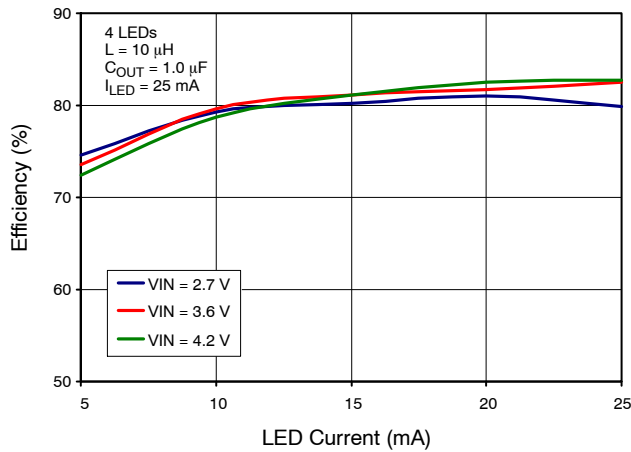
## ELECTRICAL SPECIFICATIONS



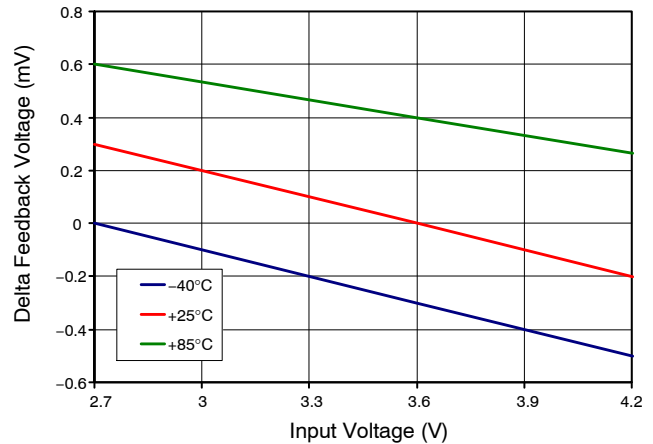
**Figure 4. 5 LEDs: Efficiency vs. LED Current vs. Input Voltage**



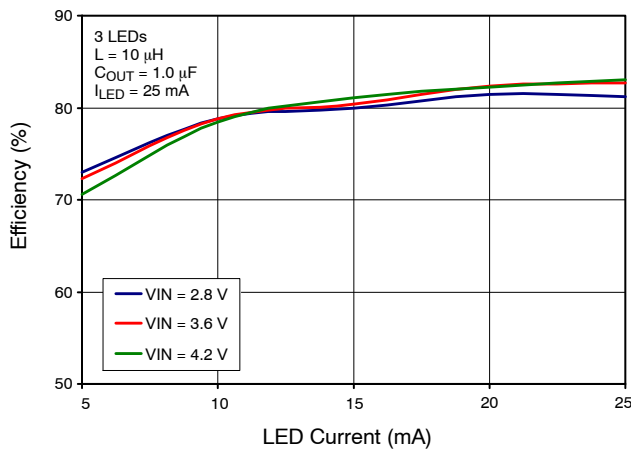
**Figure 5. 5 LEDs: Efficiency vs. LED Current vs. Input Voltage**



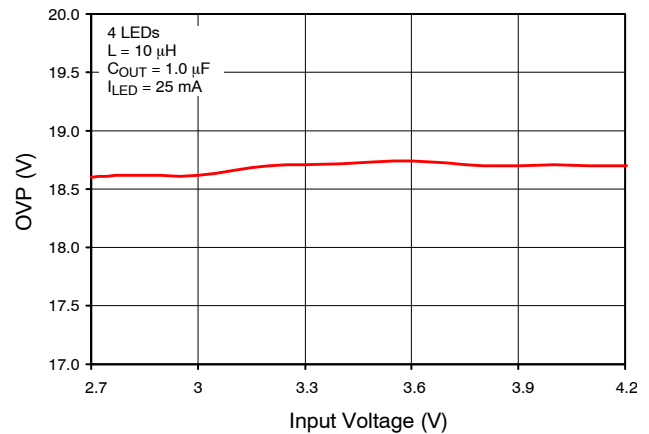
**Figure 6. 4 LEDs: Efficiency vs. LED Current vs. Input Voltage**



**Figure 7. Delta of  $V_{\text{FB}}$  over Input Voltage and Temperature for 4 LEDs with  $L = 10 \mu\text{H}$  and  $C_{\text{OUT}} = 1.0 \mu\text{F}$  at  $I_{\text{LED}} = 25 \text{ mA}$**

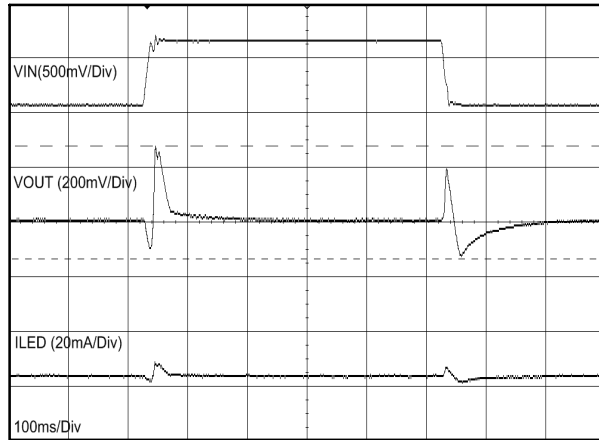


**Figure 8. 3 LEDs: Efficiency vs. LED Current vs. Input Voltage**

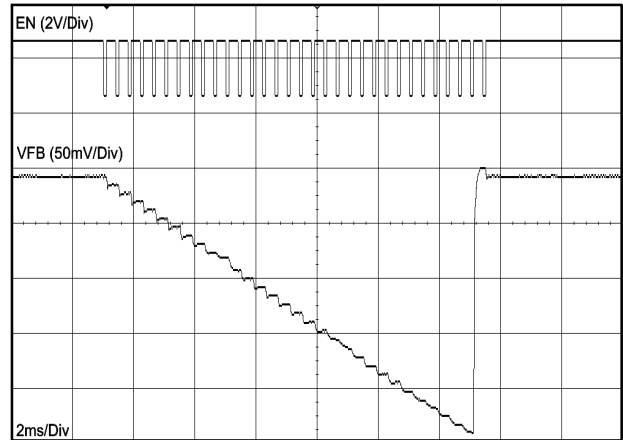


**Figure 9. Over-Voltage Protection vs. Input Voltage**

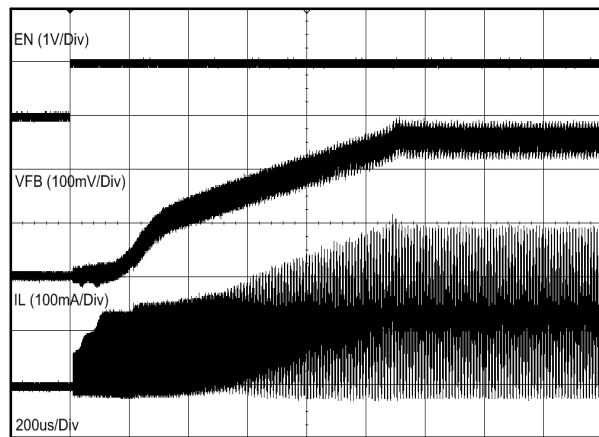
## ELECTRICAL SPECIFICATIONS (continued)



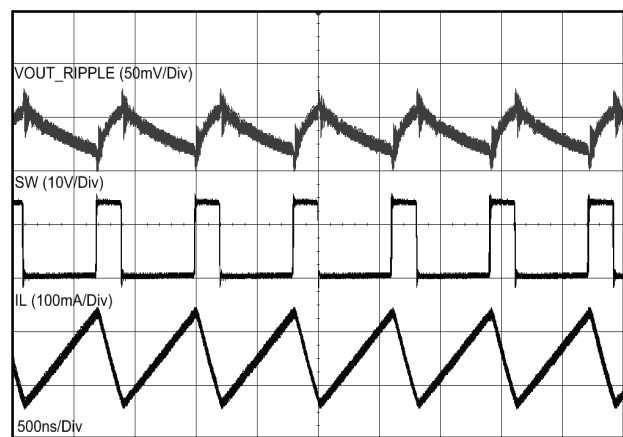
**Figure 10. Line Transient Response for 4 LEDs**  
at  $V_{IN} = 3.6\text{ V} \pm 0.6\text{ V}$  with  $L = 10\text{ }\mu\text{H}$ ,  
 $C_{OUT} = 1.0\text{ }\mu\text{F}$  and  $I_{LED} = 25\text{ mA}$



**Figure 11. FAN5341 Dimming Operation at  $V_{IN} = 3.6\text{ V}$**   
for 4 LEDs with  $L = 10\text{ }\mu\text{H}$ ,  $C_{OUT} = 1.0\text{ }\mu\text{F}$   
and  $I_{LED} = 25\text{ mA}$



**Figure 12. Startup Waveform for Switch Voltage,**  
Inductor Current,  $V_{FB}$  and EN for 4 LEDs  
at  $V_{IN} = 3.6\text{ V} \pm 0.6\text{ V}$  with  $L = 10\text{ }\mu\text{H}$ ,  
 $C_{OUT} = 1.0\text{ }\mu\text{F}$  and  $I_{LED} = 25\text{ mA}$



**Figure 13. Steady-State Waveform for VOUT,**  
Switch Voltage and Inductor Current for 4 LEDs  
at  $V_{IN} = 3.6\text{ V} \pm 0.6\text{ V}$  with  $L = 10\text{ }\mu\text{H}$ ,  $C_{OUT} = 1.0\text{ }\mu\text{F}$   
and  $I_{LED} = 25\text{ mA}$

## 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.

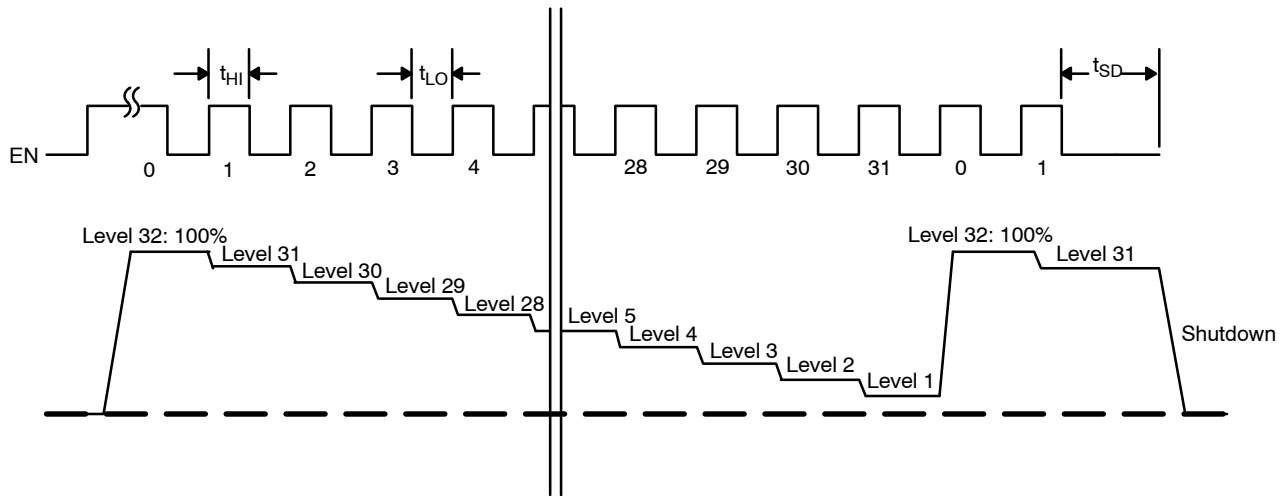


Figure 14. Digital Pulse-Dimming Control Diagram



## APPLICATION INFORMATION

## Inductor &amp; Output Capacitor Selection

Table 7. RECOMMENDED EXTERNAL COMPONENTS

# of LEDs	Inductor (L)	Part Number	Manufacturer	Min C <sub>OUT</sub>	Part Number	Manufacturer
3, 4, 5	10.0 $\mu$ H	LQH43MN100K03	Murata	1.00 $\mu$ F	CV105X5R105K25AT	AVX/Kyocera
		NLCV32T-100K-PFR	TDK			
		VLF3010AT-100MR49-1	TDK			
	4.7 $\mu$ H	LQH43MN4R7K03	Murata	1.00 $\mu$ F	CV105X5R105K25AT	AVX/Kyocera
		NLCV32T-4R7M-PFR	TDK			
		LPF2010T-4R7M	ABCO			

## Component Placement and PCB Recommendations

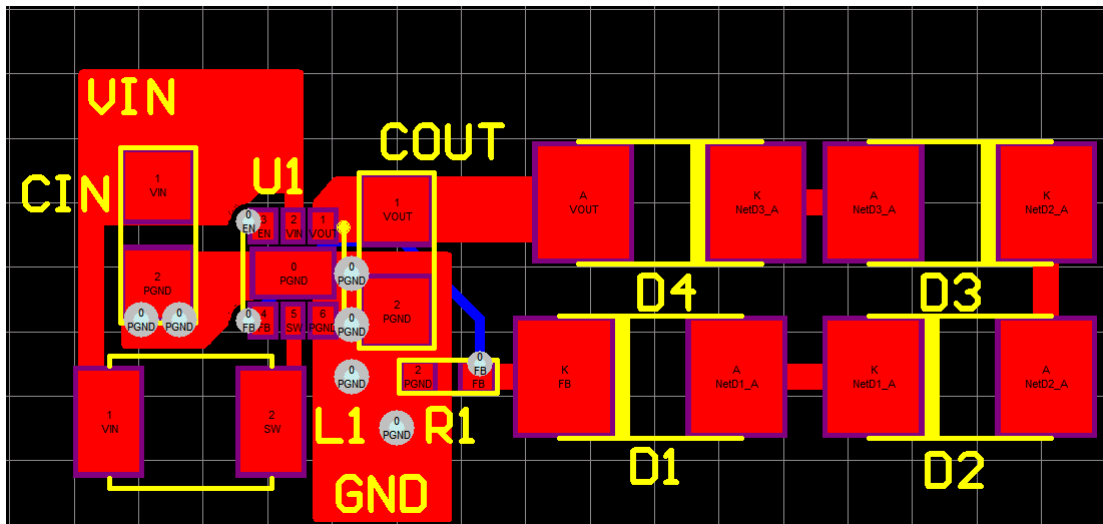


Figure 15. Recommended Component Placement

## Input Capacitance

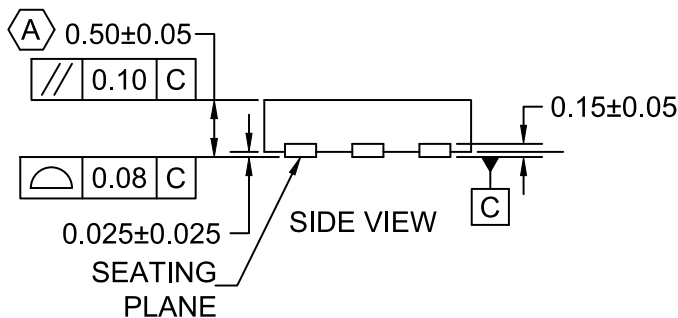
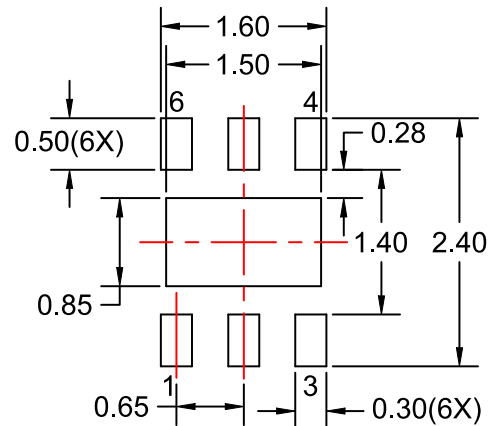
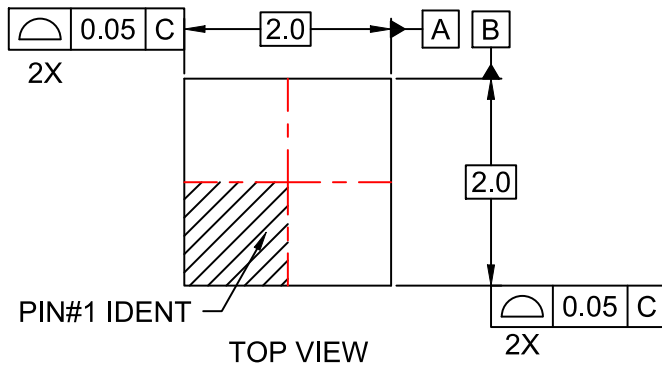
In a typical application, the input and output capacitors should be placed as close to the IC as possible; no additional capacitance is needed to ensure proper functionality. However, in a testing environment, where the FAN5341 is typically powered by a power supply with relatively long cables, an additional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

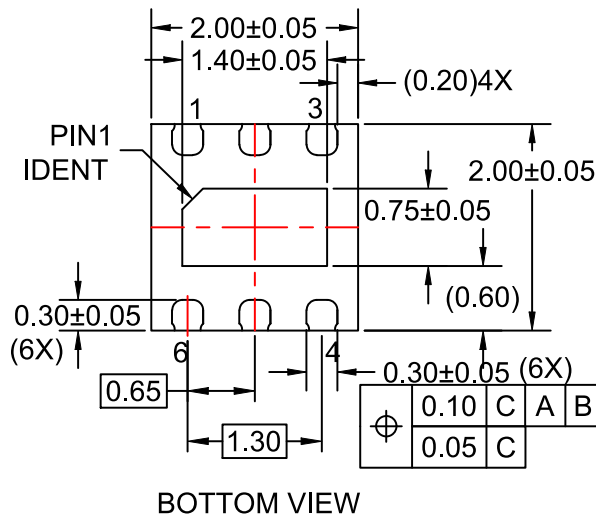
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


**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.



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