



FAN7340

LED Backlight Driving Boost Switch

Features

- Single-Channel Boost LED Switch
- Internal Power MOSFET for PWM Dimming:
 $R_{DS(on)} = 3.4\Omega$ at $V_{GS}=10V$, $BV_{DSS}=400V$
- Current Mode PWM Control
- Internal Programmable Slope Compensation
- Wide Supply Voltage Range: 10V to 35V
- LED Current Regulation: $\pm 1\%$
- Programmable Switching Frequency
- Analog and PWM Dimming
- Wide Dimming Ratio: On Time= $10\mu s$ to DC
- Cycle-by-Cycle Current Limiting
- Thermal Shutdown: $150^\circ C$
- Open-LED Protection (OLP)
- Over-Voltage Protection (OVP)
- Over-Current Protection (OCP)
- Error Flag Generation (for External Load Switch)
- Internal Soft-Start
- 16-Lead SOIC Package

Applications

- LED Backlight for LCD TV
- LED Backlight for LCD Monitor
- LED Lighting

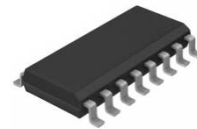
Description

The FAN7340 is a single-channel boost controller that integrates an N-channel power MOSFET for PWM dimming using Fairchild's proprietary planar Double-diffused MOS (DMOS) technology.

The IC operates as a constant-current source for driving high-current LEDs.

It uses Current Mode control with programmable slope compensation to prevent subharmonic oscillation. The IC provides protections including: open-LED protection, over-voltage protection, and direct-short protection for high system reliability.

The IC internally generates a FAULT signal with delay if an abnormal LED string condition occurs. PWM dimming and analog dimming functions can be implemented independently. Internal soft-start prevents inrush current flowing into output capacitor at startup.



Ordering Information

Part Number	Operating Temperature Range	Package	Packaging Method
FAN7340M	-40°C to +125°C	16-Lead, Small-Outline Integrated Circuit (SOIC)	Rail
FAN7340MX			Tape & Reel

Block Diagram

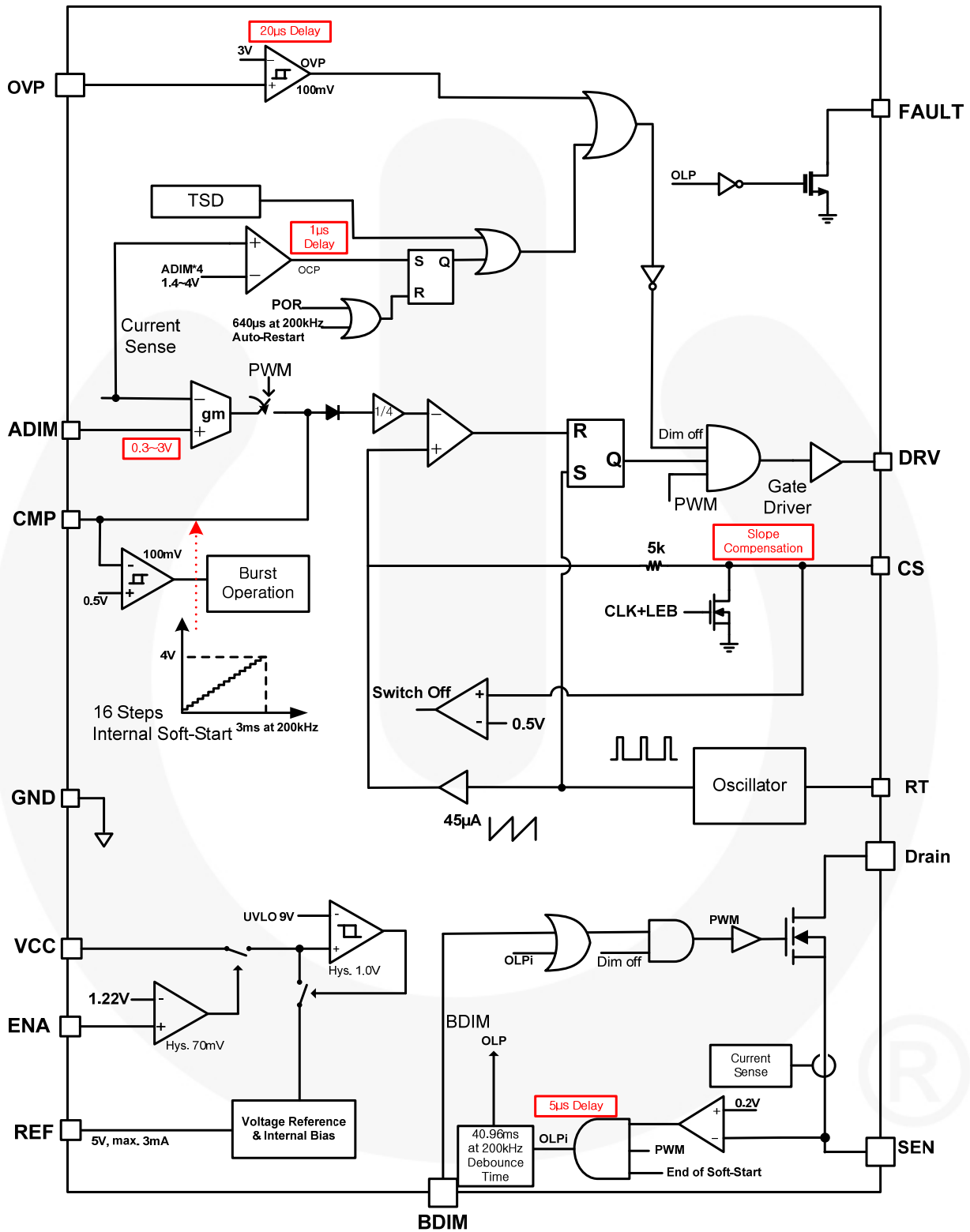


Figure 1. Internal Block Diagram

Pin Assignments

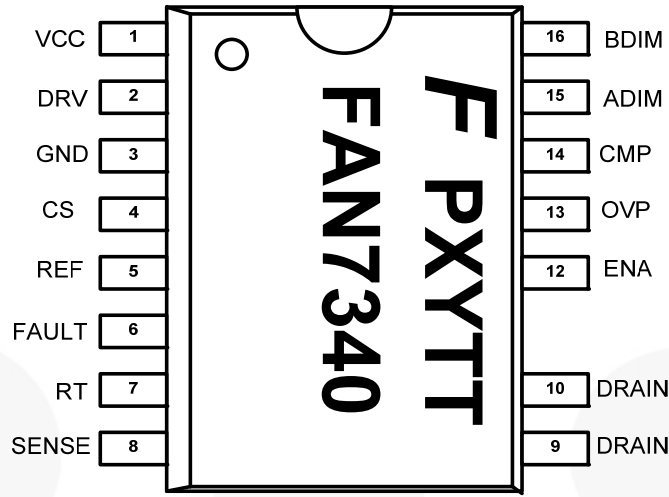


Figure 2. Package Diagram

Pin Definitions

Pin #	Name	Description
1	VCC	This pin is the supply voltage of the IC.
2	DRV	This pin is the gate drive signal of the boost switch.
3	GND	This pin is the ground of the IC.
4	CS	This pin is for sensing the current flowing through an external MOSFET. It includes a built-in 300ns blanking time. The peak of the current flowing through the MOSFET is limited to this pin voltage. Slope compensation of the boost controller can be programmed through the series resistor of this pin.
5	REF	This pin is the 5V reference voltage pin. Maximum current capability is 3mA.
6	FAULT	This pin is for indicating the fault signal. This pin is connected to the open drain. When OLP protection is occurred, the FAULT pin is pulled HIGH.
7	RT	Oscillator frequency set of the boost switch (50kHz ~ 300kHz).
8	SENSE	This pin is for sensing the current flowing through the LEDs. A sensing resistor is connected from this pin to ground. This pin is connected to the negative input of the internal error amplifier.
9, 10	DRAIN	Drain pin of PWM dimming power MOSFET.
12	ENA	Enable input pin. If voltage of this pin is higher than 1.22V, IC is starting to operate. If the voltage of this pin is lower than 1.15V, the IC stops operating.
13	OVP	Over-voltage protection input pin. Output voltage of the boost circuit is connected to this pin through a resistor divider circuit. If this pin voltage is higher than 3V, OVP is triggered.
14	CMP	This pin is the error amplifier output. Typically, a compensation capacitor and resistor are connected to this pin from the ground.
15	ADIM	This pin is for setting the current flowing through the LEDs. This pin is connected to the positive inputs of the internal error amplifier. Linear voltage range of ADIM is 0.3V~3.0V.
16	BDIM	This pin is for the burst dimming signal. If this pin voltage is HIGH, the internal dimming MOSFET is turned on. If this pin voltage is LOW, the dimming MOSFET is turned off.

Note:

- Pin 11 is a "No Connect" pin (not shown in Figure 2).

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. $T_A=25^{\circ}\text{C}$ unless otherwise specified.

Symbol	Parameter	Min.	Max.	Unit
V_{CC}	Supply Voltage	10	35	V
T_A	Operating Temperature Range	-40	+125	$^{\circ}\text{C}$
T_J	Junction Temperature		+150	$^{\circ}\text{C}$
T_{STG}	Storage Temperature Range	-65	+150	$^{\circ}\text{C}$
Θ_{JA}	Thermal Resistance Junction-to-Ambient ^(2, 3)		120	$^{\circ}\text{C}/\text{W}$
P_D	Power Dissipation		0.9	W

Notes:

- Thermal resistance test board; size 76.2mm x 114.3mm x 1.6mm (1S0P); JEDEC standard: JESD51-2, JESD51-3.
- Assume no ambient airflow.

Pin Breakdown Voltage

Pin #	Name	Value	Unit
1	VCC	35	V
2	DRV	20	V
3	GND		V
4	CS	6	V
5	REF	6	V
6	FAULT	35	V
7	RT	6	V
8	SENSE	6	V

Pin #	Name	Value	Unit
9	DRAIN	400	V
10	DRAIN	400	V
11	N/A		V
12	ENA	6	V
13	OVP	6	V
14	CMP	6	V
15	ADIM	6	V
16	BDIM	6	V

Electrical Characteristics

For typical values, $T_A = 25^\circ\text{C}$ and $V_{CC} = 15\text{V}$ unless otherwise specified. Specifications to $-40^\circ\text{C} \sim 125^\circ\text{C}$ are guaranteed by design based on final characterization results.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
Supply Voltage Section						
V_{CC}	Input DC Supply Voltage Range ⁽⁴⁾		10		35	V
I_{SD}	Shutdown Mode Supply Current	BDIM Connected to GND		2	4	mA
Under-Voltage Lockout Section						
V_{th}	Start Threshold Voltage		8.3	9.0	9.7	V
$V_{th,hys}$	Start Threshold Voltage Hysteresis		0.5	1.0	1.5	V
I_{st}	Standby Current	$V_{CC}=V_{th}-0.2$		200	300	μA
ON/OFF Section						
V_{on}	On-State Input Voltage		2		5	V
V_{off}	Off-State Input Voltage				0.8	V
Error Amplifier Section						
G_m	Error Amplifier Transconductance ⁽⁴⁾	$V_{ADIM}=1\text{V}$	100	300	500	μmho
$A_{V,ro}$	Error Amplifier Output impedance ⁽⁴⁾			20		M Ω
A_v	Error Amplifier Open-Loop Gain ⁽⁴⁾			60		dB
V_{offset}	Input Offset Voltage	$V_{ADIM}=1\text{V}$	-10		10	mV
I_{sin}	CMP Sink Current	$V_{ADIM}=1\text{V}, V_{SENSE}=2\text{V}$	100	200	300	μA
I_{sur}	CMP Source Current	$V_{ADIM}=1\text{V}, V_{SENSE}=0\text{V}$	100	200	300	μA
V_{IDR}	Input Differential Voltage Range		0		3	V
V_O	Output Voltage Range		0.7		4.0	V
Oscillator Section						
f_{osc}	Boost Oscillator Frequency	Min.		50		kHz
		$R_T=100\text{k}\Omega$	190	200	210	kHz
		Max.		300		kHz
D_{max}	Maximum Duty Cycle ⁽⁴⁾		86	90	94	%
Reference Section						
V_{REF}	5V Regulation Voltage		4.9	5.0	5.1	V
$V_{REF,Line}$	5V Line Regulation				25	mV
$V_{REF,Load}$	5V Load Regulation	$0<I_L<3\text{mA}$			25	mV
PWM Dimming Section						
$V_{PDIM,L}$	PWM Dimming Input Low Voltage				0.8	V
$V_{PDIM,H}$	PWM Dimming Input High Voltage		2		5	V
R_{PDIM}	PWM Dimming Pull-Down Resistance		100	160	220	k Ω
FET Section (for Dimming)						
BV_{DSS}	Drain-Source Breakdown Voltage ⁽⁴⁾	$V_{CC}=0\text{V}, I_D=250\mu\text{A}$	400			V
I_{DSS}	Zero-Gate-Voltage Drain Current ⁽⁴⁾	$V_{DS}=250\text{V}, T_A=25^\circ\text{C}$		1	30	μA
$R_{DS(ON)}$	Drain-Source On-State Resistance	$V_{GS}=10\text{V}, I_D=1\text{A}$		3.4		Ω
C_{ISS}	Input Capacitance ⁽⁴⁾	$V_{DS}=25\text{V}, V_{GS}=0\text{V}, f=1\text{MHz}$		173	225	pF
C_{OSS}	Output Capacitance ⁽⁴⁾	$V_{DS}=25\text{V}, V_{GS}=0\text{V}, f=1\text{MHz}$		30	40	pF

Continued on the following page...

Electrical Characteristics (Continued)

For typical values, $T_A = 25^\circ\text{C}$ and $V_{CC} = 15\text{V}$, unless otherwise specified. Specifications to $-25^\circ\text{C} \sim 85^\circ\text{C}$ are guaranteed by design based on final characterization results.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
Output Section (Boost / Dimming)						
V_{DRV}	Gate Output Voltage	$V_{CC}=15\text{V}$	10.8	11.8	12.8	V
V_{uv}	Gate Output Voltage Before Startup		-0.5		0.5	V
I_{dsur}	Gate Output Drive Source Current ⁽⁴⁾		80	180	280	mA
I_{dsin}	Gate Output Drive Sink Current ⁽⁴⁾		80	180	280	mA
t_{rh}	Gate Output Rising Time (Boost) ⁽⁴⁾	$C_L=2.0\text{nF}$		200		ns
t_{fl}	Gate Output Falling Time (Boost) ⁽⁴⁾	$C_L=2.0\text{nF}$		120		ns
Current Sense Section						
t_{blank}	Leading-Edge Blanking ⁽⁴⁾		150	300	450	ns
$t_{delay,cl}$	Delay to Output of Current-Limit Comparator ⁽⁴⁾				180	ns
$V_{offset,clc}$	Offset Voltage of Current-Limit Comparator ⁽⁴⁾		-20		20	mV
Slope Compensation Section						
I_{slope}	Ramp Generator Current		36	45	54	μA
R_{slope}	Slope Compensation Resistor ⁽⁴⁾			5		k Ω
Soft-Start Section						
t_{ss}	Soft-Start Period ⁽⁴⁾	$f_{osc}=200\text{kHz}$		3		ms
Protection Section						
$t_{d,ovp,tr}$	Delay for Triggering Over-Voltage Protection ⁽⁴⁾		15	20	25	μs
$t_{d,ovpr}$	Delay for Releasing Over-Voltage Protection ⁽⁴⁾		10	14	18	μs
$t_{d,ocp}$	Delay for Over-Current Protection ⁽⁴⁾			1		μs
t_{AR}	Auto-Restart Time for Over-Current Protection ⁽⁴⁾	$f_{osc}=200\text{kHz}$		640		μs
$t_{d,olpi}$	Delay for Triggering Open-LED Protection ⁽⁴⁾		3	5	7	μs
$t_{d,olp}$	Delay for Open-LED Protection	$f_{osc}=200\text{kHz}$		40.96		ms
$V_{th,ovp}$	Over-Voltage Protection Threshold Voltage		2.85	3.00	3.15	V
$V_{hys,ovp}$	Over-Voltage Protection Voltage Hysteresis			0.1		V
$V_{th,csocp}$	Boost Switch Current Limit Threshold Voltage		0.45	0.50	0.55	V
$V_{th,ocp}$	LED Over-Current Protection Threshold Voltage		1.4 (Min. Clamp)	$4.0 \times V_{ADIM}$	4.0 (Max. Clamp)	V
$V_{th,olp}$	Open-LED Protection Threshold Voltage ⁽⁴⁾		0.15	0.20	0.25	V
T_{SD}	Thermal Shutdown Temperature ⁽⁴⁾		140	150	160	$^\circ\text{C}$
T_{HYS}	Thermal Shutdown Hysteresis ⁽⁴⁾			20		$^\circ\text{C}$

Notes:

4. These parameters, although guaranteed, are not tested in production.

Typical Performance Characteristics

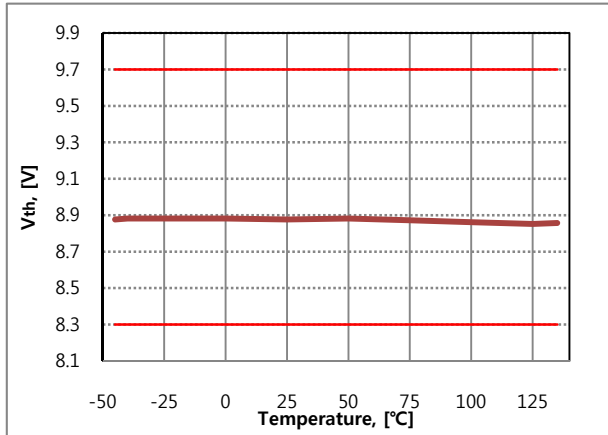


Figure 3. Start Threshold Voltage vs. Temperature

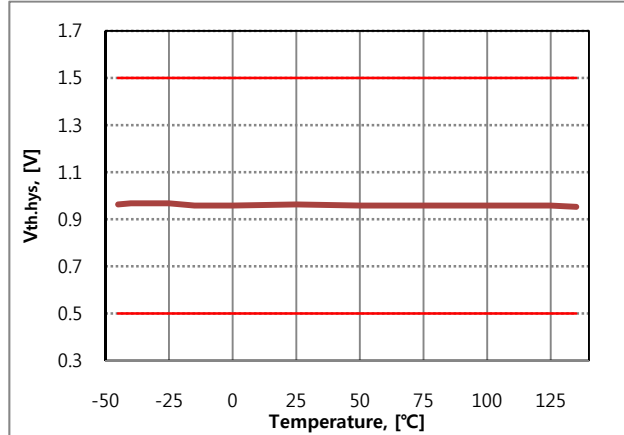


Figure 4. Start Threshold Voltage Hysteresis vs. Temperature

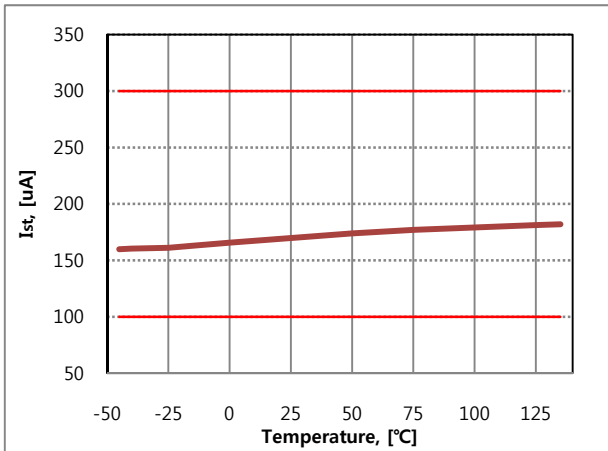


Figure 5. Standby Current vs. Temperature

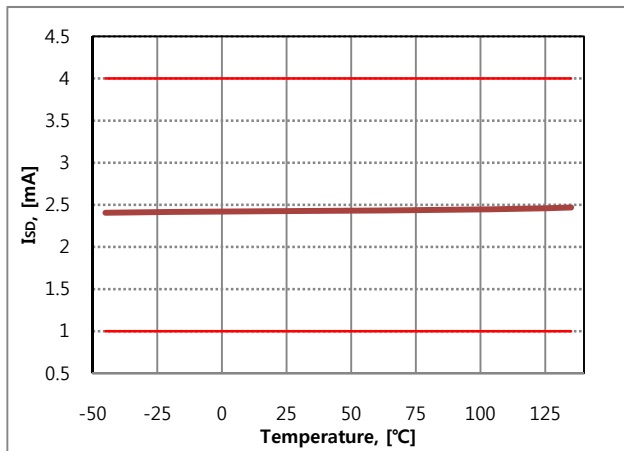


Figure 6. Shutdown Mode Supply Current vs. Temperature

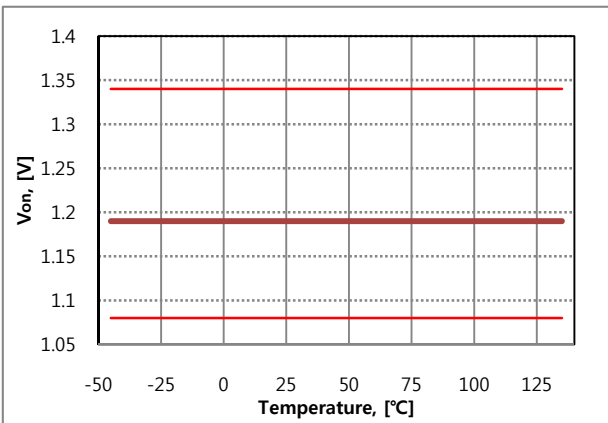


Figure 7. On-State Input Voltage vs. Temperature

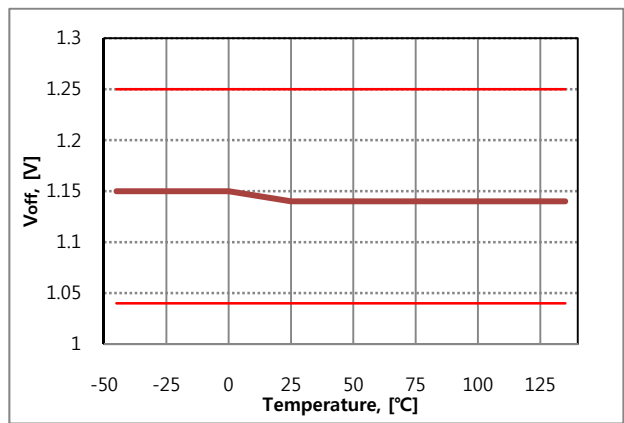


Figure 8. Off-State Input Voltage vs. Temperature

Typical Performance Characteristics (Continued)

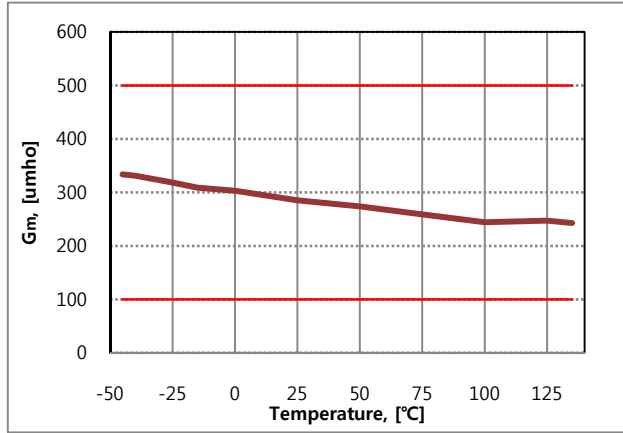


Figure 9. Error Amplifier Transconductance vs. Temperature

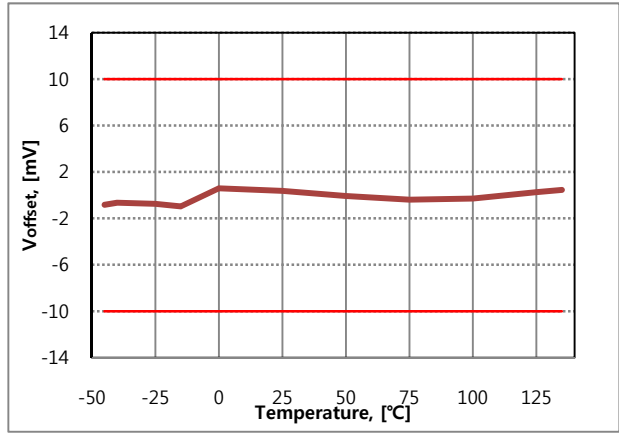


Figure 10. Input Offset Voltage vs. Temperature

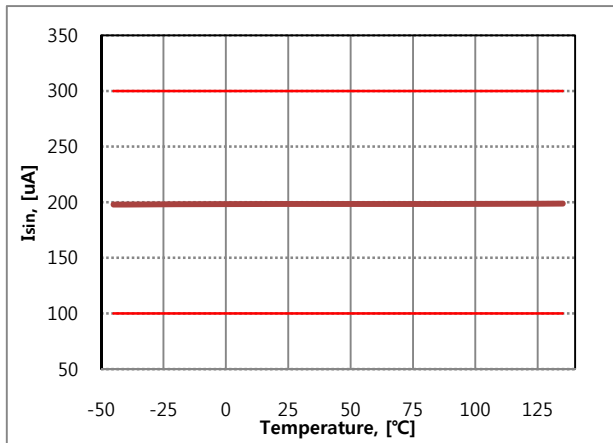


Figure 11. CMP Sink Current vs. Temperature

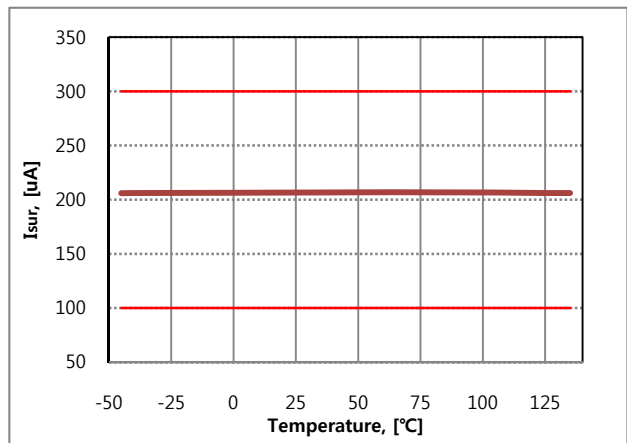


Figure 12. CMP Source Current vs. Temperature

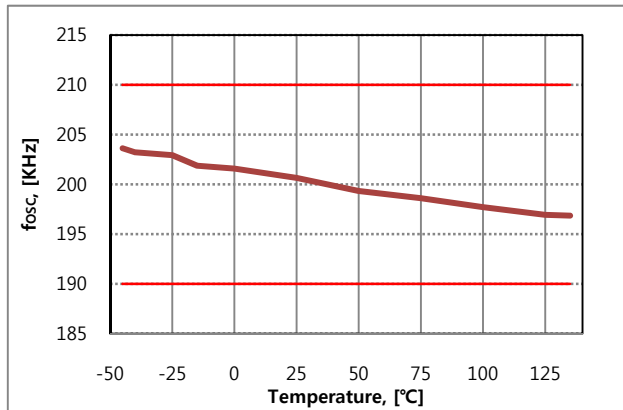


Figure 13. Boost Oscillator Frequency vs. Temperature

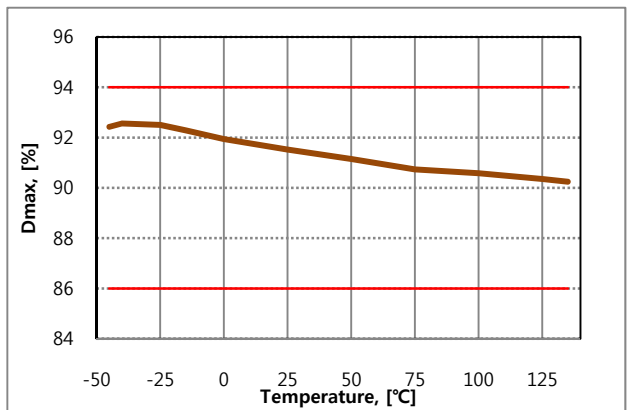


Figure 14. Maximum Duty Cycle vs. Temperature

Typical Performance Characteristics (Continued)

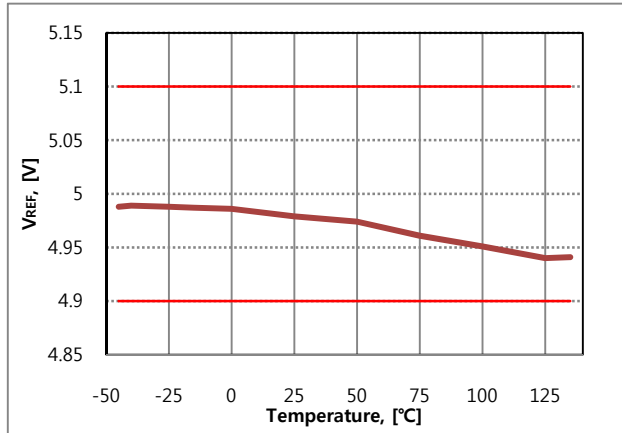


Figure 15. 5V Regulation Voltage vs. Temperature

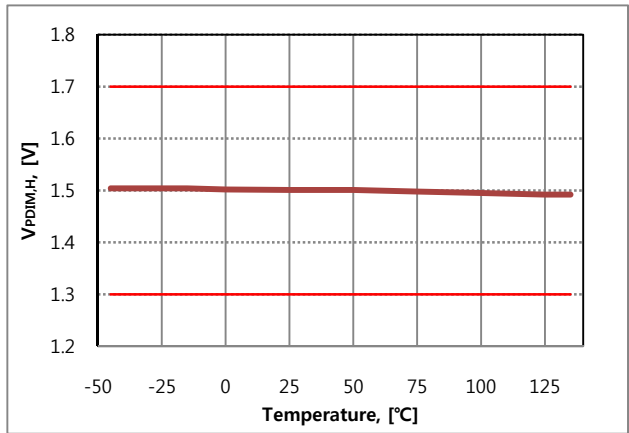


Figure 16. PWM Dimming Input High Voltage vs. Temperature

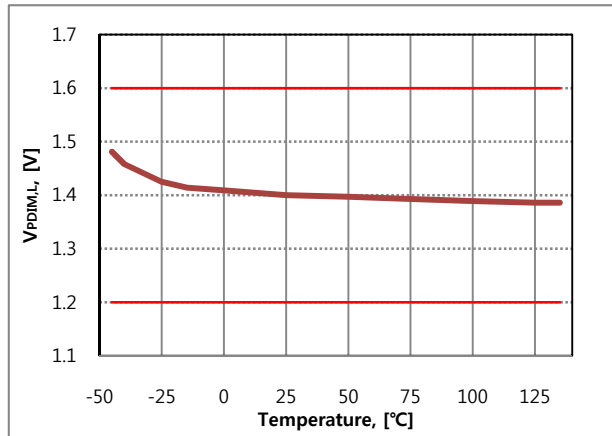


Figure 17. PWM Dimming Input Low Voltage vs. Temperature

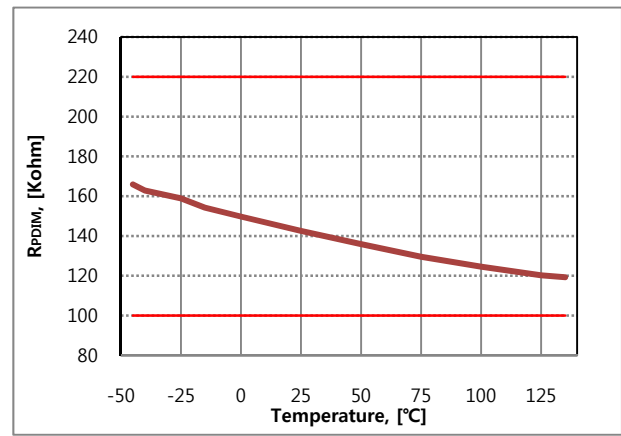


Figure 18. PWM Dimming Pull-Down Resistance vs. Temperature

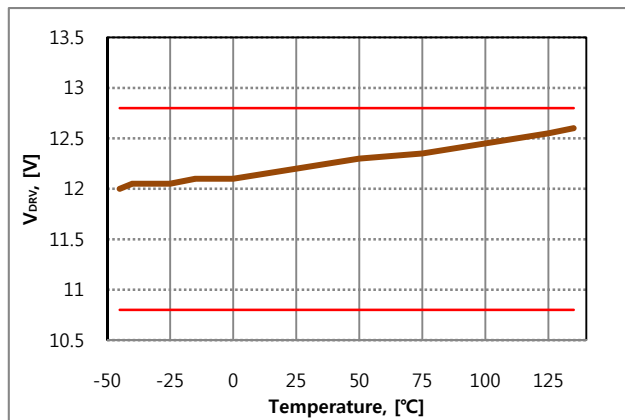


Figure 19. Gate Output Voltage vs. Temperature

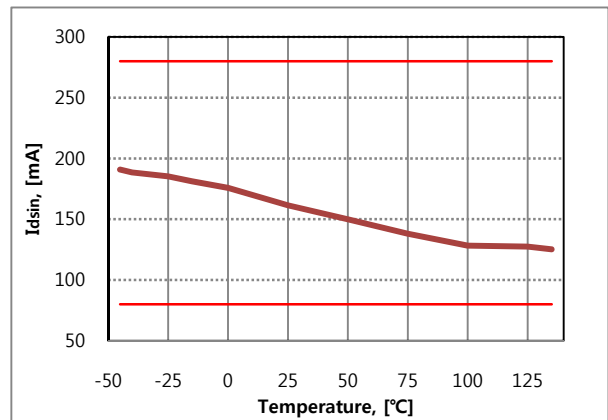


Figure 20. Gate Output Drive Sink Current vs. Temperature

Typical Performance Characteristics (Continued)

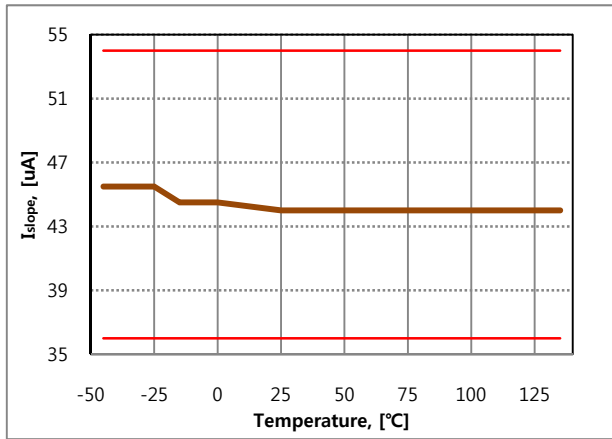


Figure 21. Ramp Generator Current vs. Temperature

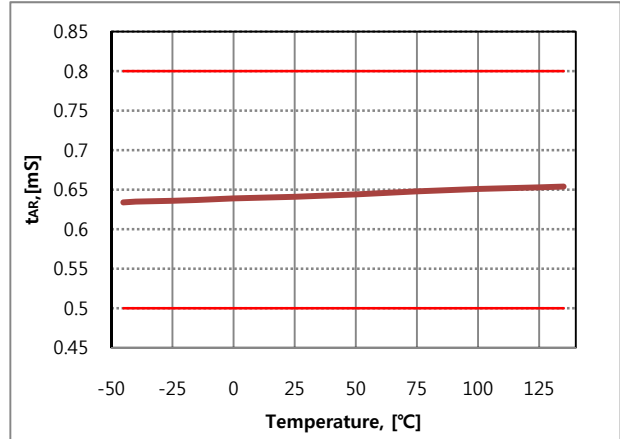


Figure 22. Auto-Restart Time for OCP vs. Temperature

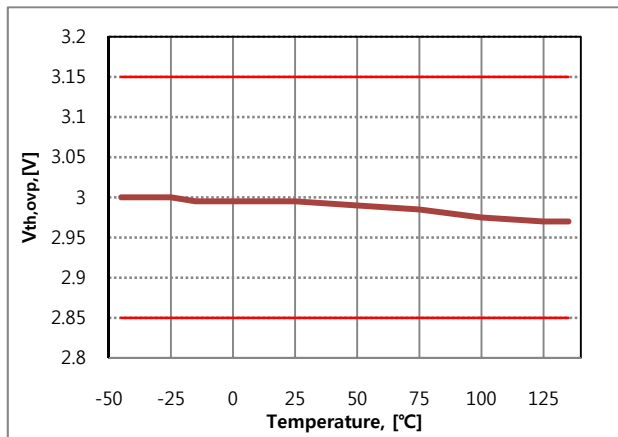


Figure 23. OVP Threshold Voltage vs. Temperature

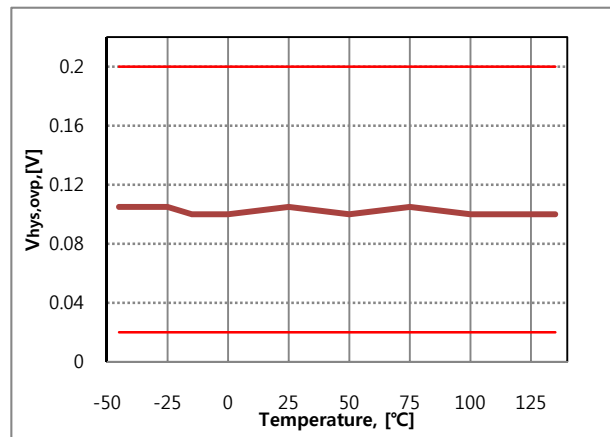


Figure 24. OVP Hysteresis Voltage vs. Temperature

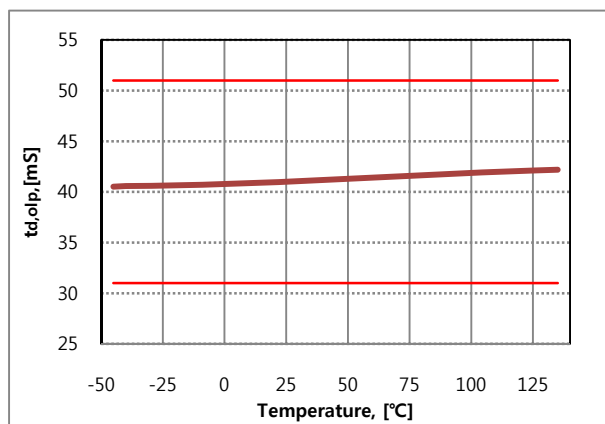


Figure 25. Delay for Over-Current Protection vs. Temperature

Functional Description

The FAN7340 operates as a constant-current source for driving high-current LEDs. It uses Current-Mode control with programmable slope compensation to prevent sub-harmonic oscillation.

The IC provides protections such as open-LED protection, over-voltage protection, and over-current protection for improved system reliability. The IC internally generates a FAULT OUT signal with a delay in case an abnormal LED string condition occurs. PWM dimming and analog dimming functions can be implemented independently. Internal soft-start prevents inrush current flowing into output capacitor at startup. Circuit operation is explained in the following sections.

V_{CC} Under-Voltage Lockout (UVLO)

An internal regulator provides the regulated 5V used to power the IC. The Under-Voltage Lockout (UVLO) turns off the IC in the event of the voltage dropping below the specific threshold level. The UVLO circuit inhibits powering the IC until a voltage reference is established up to predetermined threshold level.

Enable

Applying voltage higher than 1.22V (typical) to the ENA pin enables the IC. Applying voltage lower than 1.15V (typical) to the ENA pin disables the IC. If ENA pin voltage is higher than 1.22V (typical) and V_{CC} is higher than 9.0V (typical.), the IC starts to supply 5V reference voltage from V_{CC}.

Oscillator (Boost Switching Frequency)

Boost switching frequency is programmed by the value of the resistor connected from the RT pin to ground. RT pin voltage is set to 2V. The current through the RT pin resistor determines boost switching frequency according to formula:

$$f_{OSC} = \frac{1}{(46.5 \times RT[k\Omega] + 350) \times 10^{-6}} \text{ [kHz]} \quad (1)$$

Soft-Start Function at Startup

During initial startup, the switching device can be damaged due to the over-current coming from the input line by the negative control. This can result in the initial overshoot of the LED current. Therefore, during initial startup, the soft-start control gradually increases the duty cycle so that the output voltage can rise smoothly to control inrush current and overshoot.

FAN7340 adapts the soft-start function in the boost converter stage. During soft-start period, boost switch turn-on duty is limited by clamped CMP voltage. The soft-start period is dependent on boost switching frequency, which is decided by the RT resistor (Equation 1). Soft-start period is set to be cumulative time when the BDIM (PWM dimming) signal is HIGH:

$$T_{SS} = 600 / f_{OSC} \text{ [sec]} \quad (2)$$

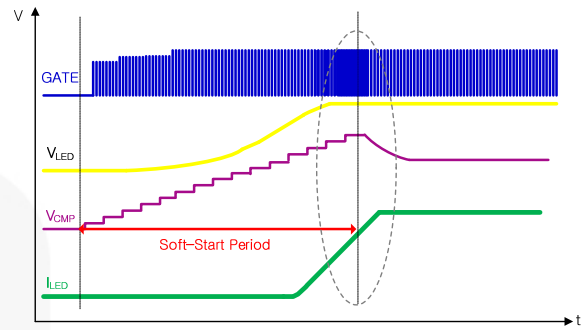


Figure 26. Soft-Start Waveforms

LED Current Setting

During the boost converter operating periods, the output LED current can be set by equation:

$$I_{LED} = \frac{ADIM(V)}{R_{SENSE} + 60m\Omega} \quad (3)$$

where ADIM(V) is ADIM pin applied voltage and, R_{SENSE} is the sensing resistor value. An additional 60mΩ comes from an internal wire bonding resistor. To calculate LED current precisely, consider the wire bonding resistor.

Analog Dimming and PWM Dimming

Analog dimming is achieved by varying the voltage level at the ADIM pin. This can be implemented either with a potentiometer from the VREF pin or from an external voltage source and a resistor divider circuit. The ADIM voltage level is adjusted to be the same as the feedback level (V_{SENSE}). A V_{ADIM} range from 0.3V to 3V is recommended.

PWM dimming (BDIM) helps achieve a fast PWM dimming response in spite of the shortcomings of the boost converter. The PWM dimming signal controls three nodes in the IC; gate signal to the switching FET, gate signal to the dimming FET, and output connection of the trans-conductance amplifier. When the PWM dimming signal is HIGH, the gates of the switching FET and dimming FET are enabled. At the same time, the output of the transconductance ap-amp is connected to the compensation network. This allows the boost converter to operate normally.

Dynamic Contrast Ratio

The Dynamic Contrast Ratio (DCR) means the maximum contrast ratio achievable by adjusting the amount of light (dimming) of the screen instantaneously using the backlight during the extremely short period of time. FAN7340 can normally drive the LED backlight under 0.1% dimming duty cycle at 200Hz dimming frequency. Even operating at 5μs-dimming FET turn-on time and extremely low dimming duty, FAN7340 can operate LEDs with normal peak current level.

In system operation, OLP is triggered in only direct-short condition. Direct short means that some point of the LED string is shorted to set ground. In direct-short condition, the boost controller cannot control the LED current and a large current flows into the LED string directly from input power. To prevent this abnormal condition, the FO signal is used to turn off input power or the total system. FO signal is only triggered in OLP condition.

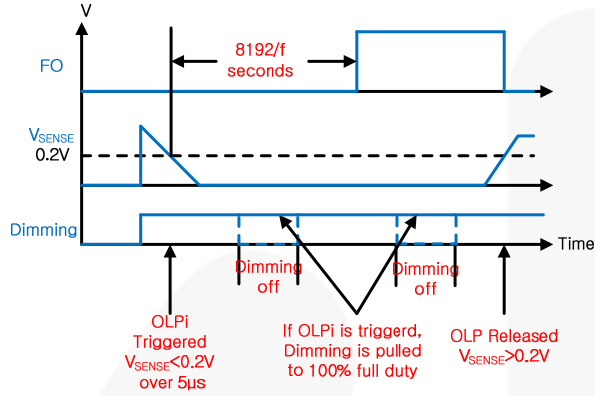


Figure 29. Open-LED Protection

In LED open load condition, OVP is triggered ahead of OLP.

Over-Voltage Protection (OVP)

Over-voltage protection is triggered when the voltage of the external output voltage trip point meets 3V. After triggering OVP, the dimming switch and boost switch are turned off. The protection signal is recovered when the output voltage divider is below 2.9V.

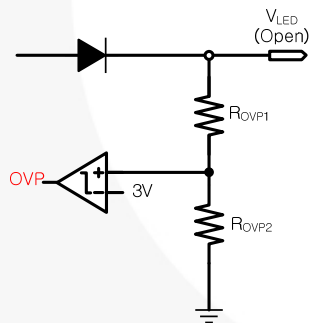


Figure 30. Over-Voltage Trip Point

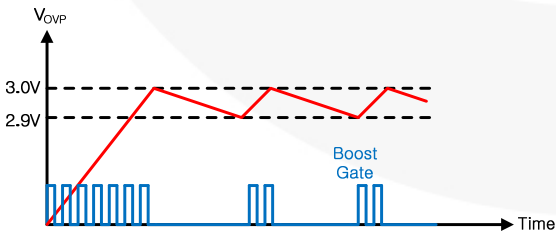


Figure 31. OVP Trigger and Release

LED Over-Current Protection (OCP)

The primary purpose of the over-current protection function is to protect the internal dimming MOSFET from excessive current. The OCP is triggered when the feedback voltage meets the clamping level (1.4V ~ 4V) of the ADIM voltage x4. At 1µs delay after the OCP is triggered, the IC turns off both the boost FET and dimming FET and restarts the gate signal every t_{AR} automatically. t_{AR} can be calculated as:

$$t_{AR} = 128 / f_{OSC} \text{ [sec]} \quad (7)$$

1. When V_{ADIM}=0.3V (V_{ADIM}x4=1.2V).
2. OCP threshold level is set to 1.4V.
3. OCP is triggered at feedback voltage level = 1.4V.

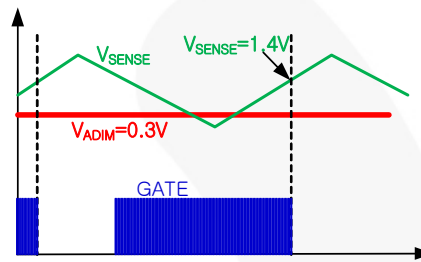


Figure 32. OCP Waveforms at V_{ADIM}=0.3V

1. When V_{ADIM}=0.8V (V_{ADIM}x4=3.2V).
2. OCP threshold level is set to 3.2V.
3. OCP is triggered at V_{SENSE} = 3.2V.

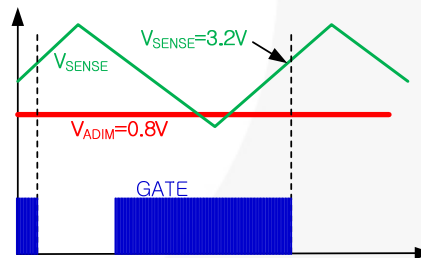


Figure 33. OCP Waveforms at V_{ADIM}=0.8V

1. When V_{ADIM}=1.2V (V_{ADIM}x4=4.8V).
2. OCP threshold level is set to 4.0V.
3. OCP is triggered at V_{SENSE} = 4.0V.

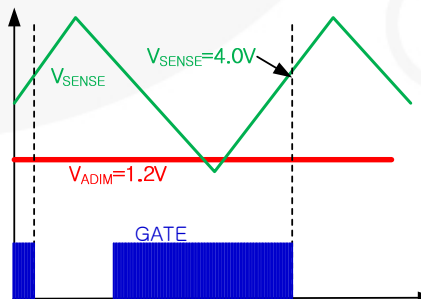


Figure 34. OCP Waveforms at V_{ADIM}=1.2V

Typical Application Circuit (Boost Topology for LED Backlight)

Application	Input Voltage Range	Rated Output Power	Output current (Rated Voltage)	LED
LED Backlight TV	120V _{DC} ±10%		250mA (230V)	72-LEDs/1-String

Features

- High Efficiency
- Constant Current Boost Converters
- High-Voltage, High-Current LED Driving

Typical Application Circuit

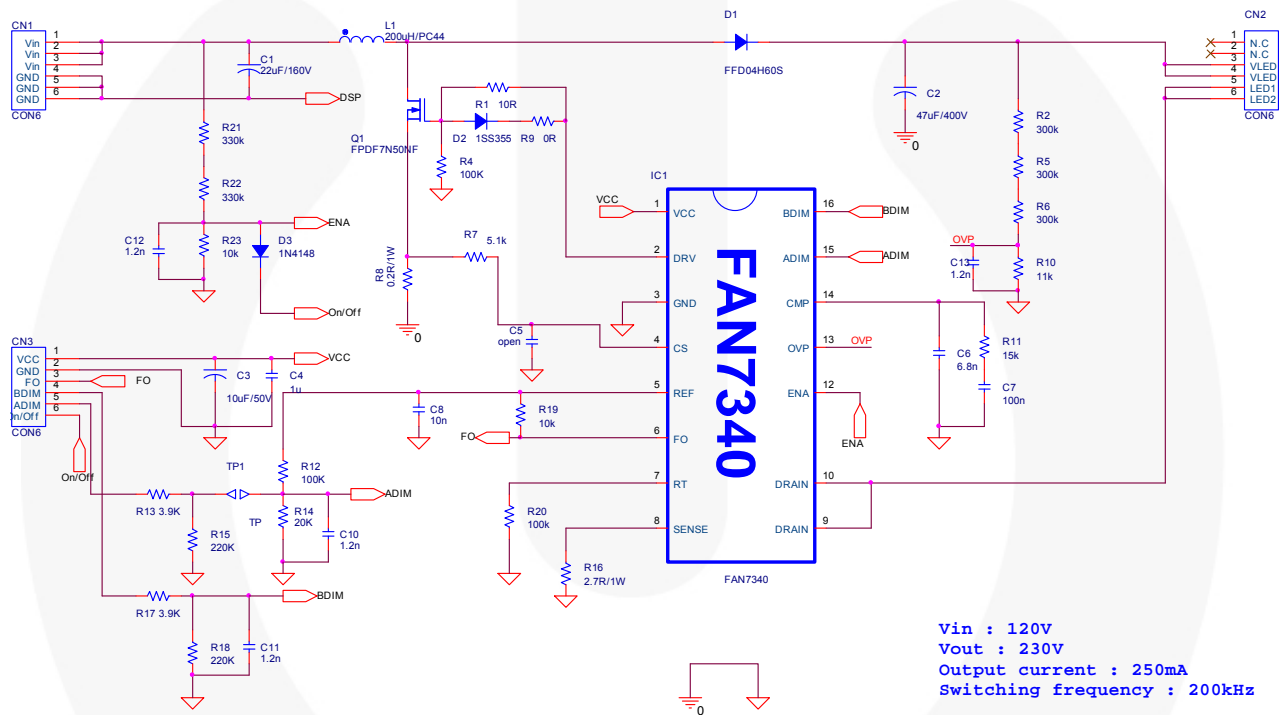


Figure 35. Typical Application Circuit

Physical Dimension

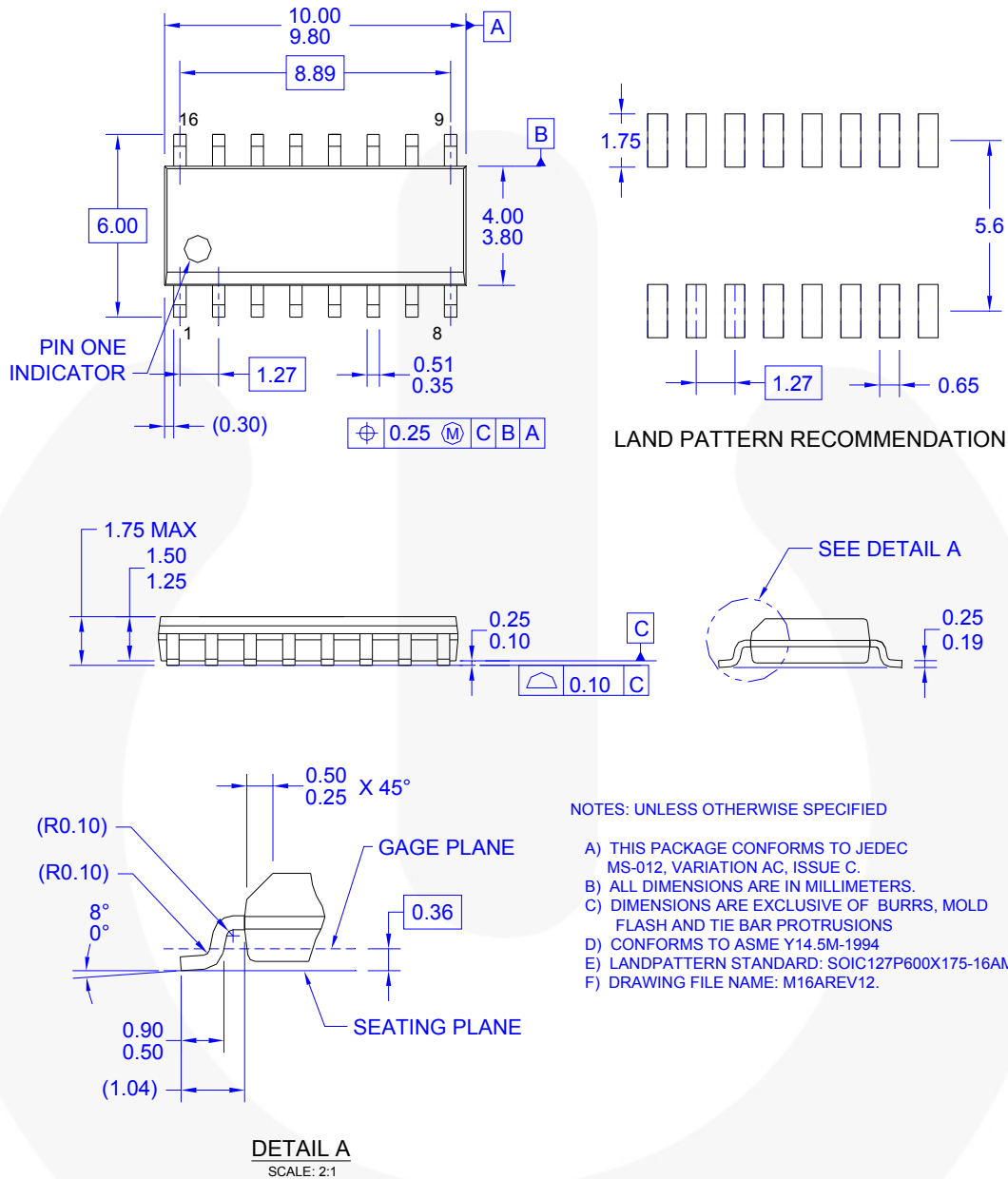


Figure 36. 16-Lead, Small Outline Integrated Circuit (SOIC)



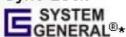
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