FAIRCHILD SEMICONDUCTOR®

September 2008

FAN6751MR
Highly-Integrated Green-Mode PWM Controller

Features

- High-Voltage Startup
- Low Operating Current: 4mA
- Linearly Decreasing PWM Frequency to 18KHz
- Fixed PWM Frequency: 65KHz
- Peak-current-mode Control
- Cycle-by-cycle Current Limiting
- Leading-edge Blanking (LEB)
- Synchronized Slope Compensation
- Internal Open-loop Protection
- GATE Output Maximum Voltage Clamp: 18V
- V_{DD} Under-Voltage Lockout (UVLO)
- V_{DD} Over-Voltage Protection (OVP)
- Internal Recovery Circuit (OVP, OLP)
- Internal Sense Short-Circuit Protection
- External Constant Power Limit (Full AC Input Range)
- Internal OTP Sensor with Hysteresis
- Built-in 5ms Soft-Start Function
- Built-in V_{IN} Pin Pull HIGH (> 4.7V) Recovery Function for Second-Side Output OVP
- Brownout Protection with Hysteresis

Applications

General-purpose switch-mode power supplies and flyback power converters, including:

- Power Adapters
- Open-frame SMPS

Description

The highly integrated FAN6751 series of PWM controllers provides several features to enhance the performance of flyback converters.

To minimize standby power consumption, a proprietary green-mode function provides off-time modulation to linearly decrease the switching frequency at light-load conditions. To avoid acoustic-noise problems, the minimum PWM frequency is set above 18KHz. This green-mode function enables the power supply to meet international power conservation requirements. With the internal high-voltage startup circuitry, the power loss due to bleeding resistors is also eliminated. To further reduce power consumption, FAN6751 is manufactured using the BiCMOS process, which allows an operating current of only 4mA.

Built-in synchronized slope compensation achieves stable peak-current-mode control. The proprietary, external line compensation ensures constant output power limit over a wide AC input voltage range, from $90V_{AC}$ to $264V_{AC}$.

FAN6751 provides many protection functions. In addition to cycle-by-cycle current limiting, the internal open-loop protection circuit ensures safety should an open-loop or output short-circuit failure occur. PWM output is disabled until V_{DD} drops below the UVLO lower limit, when the controller starts up again. As long as V_{DD} exceeds ~26V, the internal OVP circuit is triggered.

FAN6751 is available in an 8-pin SOP package.

Ordering Information

Part Number	Operating Temperature Range	Eco Status	Package	Packing Method
FAN6751MRMY	-40°C to +105°C	Green	8-Lead, Small Outline Package (SOP-8)	Tape & Reel

For Fairchild's definition of "green" Eco Status, please visit: http://www.fairchildsemi.com/company/green/rohs_green.html.

Application Diagram

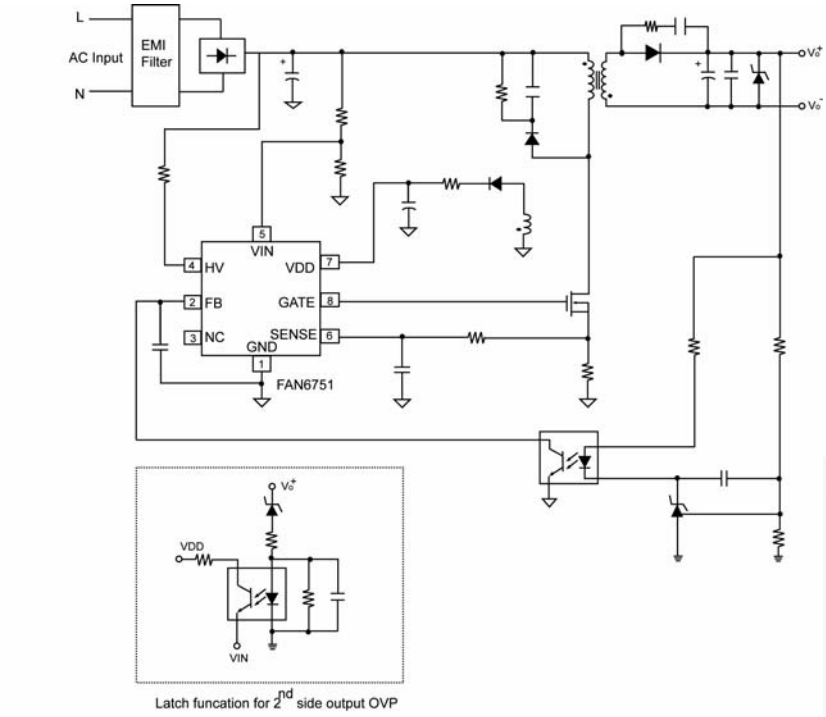


Figure 1. Typical Application

Internal Block Diagram

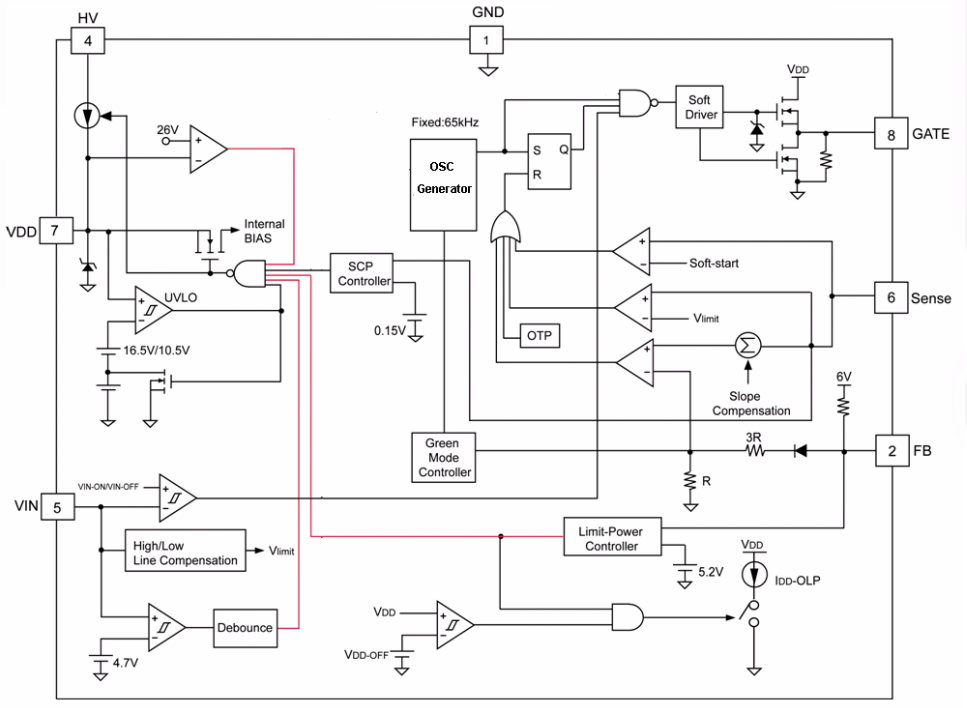
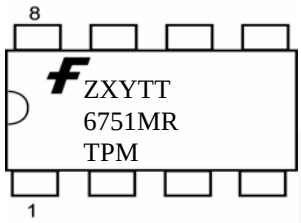


Figure 2. Functional Block Diagram

Marking Information



F: Fairchild logo
Z: Plant code
X: 1 digit year code
Y: 1 digit week code
TT: 2 digits die run code
T: Package type (N:DIP, M:SOP)
P: Y=Green package
M: Manufacture flow code

Figure 3. Top Mark

Pin Configuration

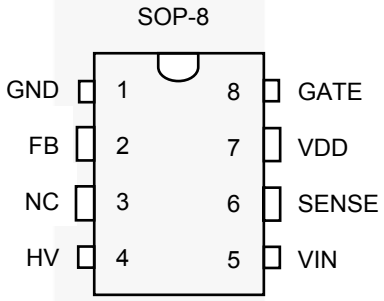


Figure 4. Pin Configuration (Top View)

Pin Definitions

Pin #	Name	Description
1	GND	Ground.
2	FB	The signal from the external compensation circuit is fed into this pin. The PWM duty cycle is determined in response to the signal on this pin and the current-sense signal on the SENSE pin.
3	NC	No connection.
4	HV	For startup, this pin is pulled high to the line input or bulk capacitor via resistors.
5	VIN	Line-voltage detection. The line-voltage detection is used for brownout protection with hysteresis. Constant output power limit over universal AC input range is also achieved using this VIN pin. It is suggested to add a low pass filter to filter out line ripple on bulk capacitor. VIN pulling high triggers latch protection.
6	SENSE	Current sense. The sensed voltage is used for peak-current-mode control and cycle-by-cycle current limiting.
7	VDD	Power supply. The internal protection circuit disables PWM output as long as V_{DD} exceeds the OVP trigger point.
8	GATE	The totem-pole output driver. Soft-driving waveform is implemented for improved EMI.

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.

Symbol	Parameter		Min.	Max.	Unit
V_{DD}	DC Supply Voltage[1, 2]			30	V
V_{FB}	FB Pin Input Voltage		-0.3	7.0	V
V_{SENSE}	SENSE Pin Input Voltage		-0.3	7.0	V
V_{VIN}	VIN Pin Input Voltage		-0.3	7.0	V
V_{HV}	HV Pin Input Voltage			500	V
P_D	Power Dissipation (T_A＜50°C)			400	mW
Θ_{JA}	Thermal Resistance, Junction-to-Air			141	°C/W
T_J	Operating Junction Temperature		-40	+150	°C
T_{STG}	Storage Temperature Range		-55	+150	°C
T_L	Lead Temperature (Wave Soldering or IR, 10 Seconds)			+260	°C
ESD	Electrostatic Discharge Capability, Human Body Model: JESD22-A114	All pins except HV pin		4	kV
	Electrostatic Discharge Capability, Machine Model: JESD22-A115	All pins except HV pin		200	V

Notes:
1. All voltage values, except differential voltages, are given with respect to the network ground terminal.
2. Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device.

Electrical Characteristics

V_{DD}=15V, T_A=25°C, unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
V_{DD} Section						
V_{OP}	Continuously Operating Voltage				22	V
V_{DD-ON}	Start Threshold Voltage		15.5	16.5	17.5	V
V_{DD-OFF}	Minimum Operating Voltage		9.5	10.5	11.5	V
I_{DD-ST}	Startup Current	V_{DD-ON} – 0.16V			30	µA
I_{DD-OP}	Operating Supply Current	V_{DD}=15V, GATE Open		4	5	mA
I_{DD-OLP}	Internal Sink Current	V_{TH-OLP}+0.1V	30	70	90	µA
V_{TH-OLP}	I_{DD-OLP} Off Voltage		6.5	7.5	8.0	V
V_{DD-OVP}	V_{DD} Over-Voltage Protection		25	26	27	V
$t_{D-VDDOVP}$	V_{DD} Over-Voltage Protection Debounce Time		75	130	200	µs
HV Section						
I_{HV}	Supply Current Drawn from HV Pin	V_{AC}=90V (V_{DC}=120V), V_{DD}=10µF, V_{DD}=0V		2.0	3.5	mA
I_{HV-LC}	Leakage Current after Startup	HV=500V, V_{DD}=V_{DD-OFF}+1V		1	20	µA
Oscillator Section						
f_{OSC}	Frequency in Nominal Mode	Center Frequency	62	65	68	KHz
f_{OSC-G}	Green-Mode Frequency		14	18	22	KHz
f_{DV}	Frequency Variation vs. V_{DD} Deviation	V_{DD}=11V to 22V			5	%
f_{DT}	Frequency Variation vs. Temperature Deviation	T_A=-40 to 85°C			5	%
V_{IN} Section						
V_{IN-OFF}	PWM Turn-off Threshold Voltage		0.65	0.70	0.75	V
V_{IN-ON}	PWM Turn-on Threshold Voltage		V_{IN-OFF}+ 0.20	V_{IN-OFF}+ 0.22	V_{IN-OFF}+ 0.24	V
$V_{IN-LATCH}$	PWM Latch-off Threshold Voltage		4.5	4.7	4.9	V
$T_{VIN-LATCH}$	PWM Latch-off Debounce Time		60	100	140	µs

Continued on following page…

Electrical Characteristics

V_{DD}=15V, T_A=25°C, unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
Feedback Input Section						
A_V	Input Voltage to Current-Sense Attenuation		1/4.5	1/4.0	1/3.5	V/V
Z_{FB}	Input Impedance		4		7	kΩ
$V_{FB-OPEN}$	Output High Voltage	FB Pin Open	5.5			V
V_{FB-OLP}	FB Open-loop Trigger Level		5.0	5.2	5.4	V
t_{D-OLP}	Delay Time of FB Pin Open-loop Protection			56		ms
V_{FB-N}	Green-Mode Entry FB Voltage			2.1		V
V_{FB-G}	Green-Mode Ending FB Voltage			1.6		V
V_{FB-ZDC}	Zero Duty-Cycle Input Voltage			1.1		V
Current-Sense Section						
Z_{SENSE}	Input Impedance			12		KΩ
V_{TH-P} at V_{IN}=1V	Threshold Voltage for Current Limit	V_{IN}=1V	0.80	0.83	0.86	V
V_{TH-P} at V_{IN}=3V	Threshold Voltage for Current Limit	V_{IN}=3V	0.67	0.70	0.73	V
t_{PD}	Delay to Output			100	200	ns
t_{LEB}	Leading-Edge Blanking Time		230	280	330	ns
V_{S-SCP}	Threshold Voltage for SENSE Short-Circuit Protection		0.10	0.15	0.20	V
t_{D-SSCP}	Delay Time for SENSE Short-Circuit Protection	V_{SENSE}<0.15V	100	150	200	µs
T_{SS}	Period During Soft-Startup Time	Startup Time	4.5	5.0	5.5	ms

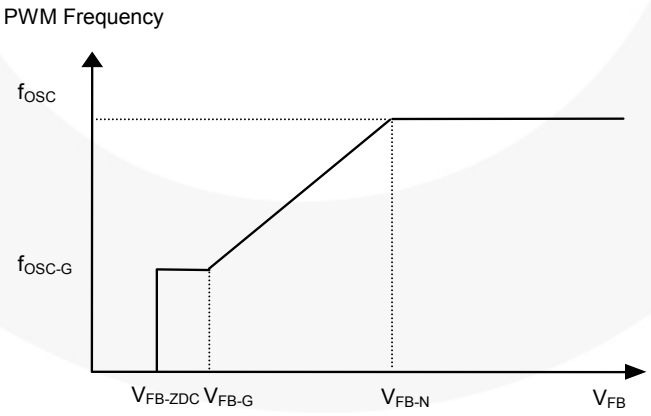


Figure 5. V_{FB} vs. PWM Frequency

Electrical Characteristics

V_{DD}=15V, T_A=25°C, unless otherwise noted.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
GATE Section						
DCY_{MAX}	Maximum Duty Cycle			75		%
V_{GATE-L}	Gate Low Voltage	V_{DD}=15V, I_O=50mA			1.5	V
V_{GATE-H}	Gate High Voltage	V_{DD}=12V, I_O=50mA	8			V
t_r	Gate Rising Time	V_{DD}=15V, C_L=1nF	150	250	350	ns
t_f	Gate Falling Time	V_{DD}=15V, C_L=1nF	30	50	90	ns
$I_{GATE-SOURCE}$	Gate Source Current	V_{DD}=15V, GATE=6V	250			mA
$V_{GATE-CLAMP}$	Gate Output Clamping Voltage	V_{DD}=22V			18	V
Over-Temperature Protection Section (OTP)						
T_{OTP}	Protection Junction Temperature(3)			+135		°C
$T_{Restart}$	Restart Junction Temperature(4)			T_{OTP}-25		°C

Notes:
3. When activated, the output is disabled and the latch is turned off.
4. The threshold temperature for enabling the output again and resetting the latch, after over-temperature protection has been activated.

Typical Performance Characteristics

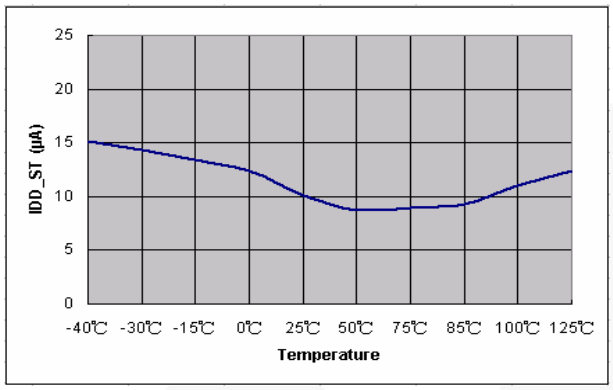


Figure 6. Startup Current (I_{DD-ST}) vs. Temperature

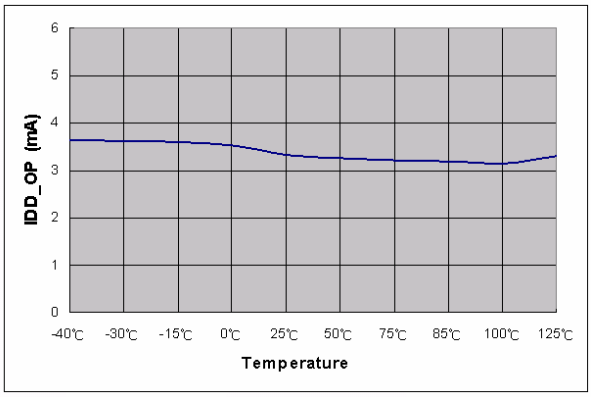


Figure 7. Operation Supply Current (I_{DD-OP}) vs. Temperature

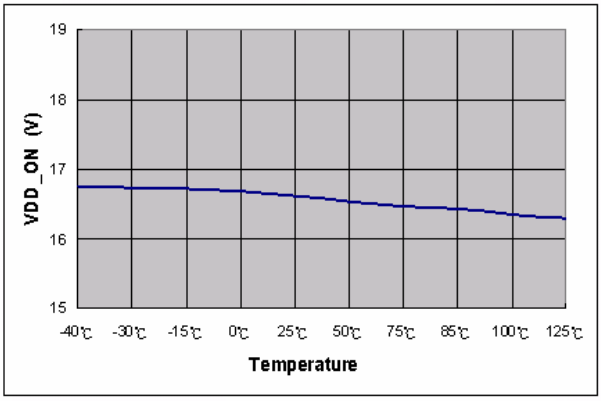


Figure 8. Start Threshold Voltage (V_{DD-ON}) vs. Temperature

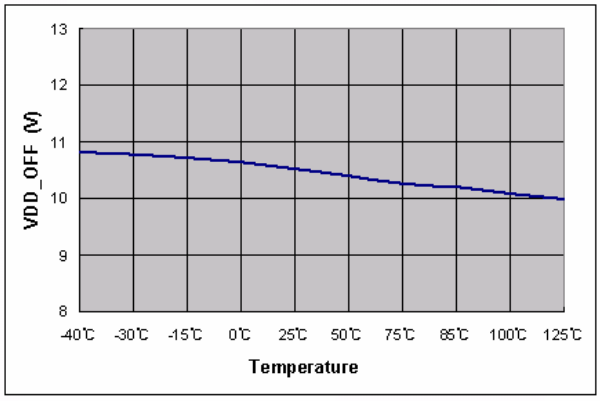


Figure 9. Minimum Operating Voltage (V_{DD-OFF}) vs. Temperature

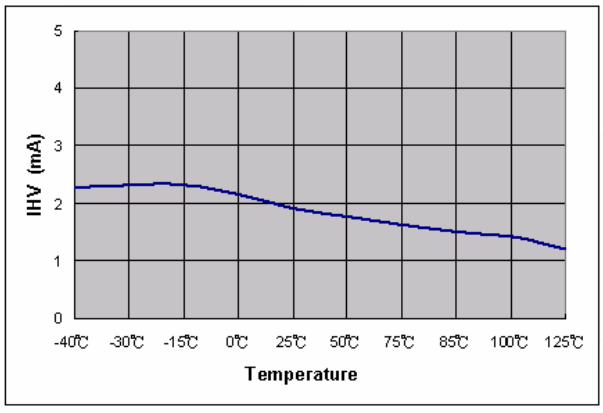


Figure 10. Supply Current Drawn from HV Pin (I_{HV}) vs. Temperature

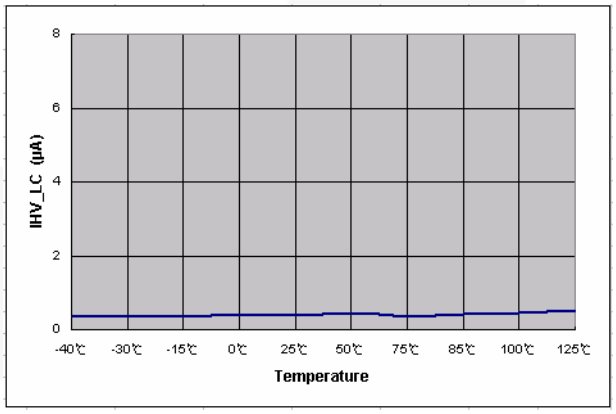


Figure 11. HV Pin Leakage Current After Startup (I_{HV-LC}) vs. Temperature

Typical Performance Characteristics (Continued)

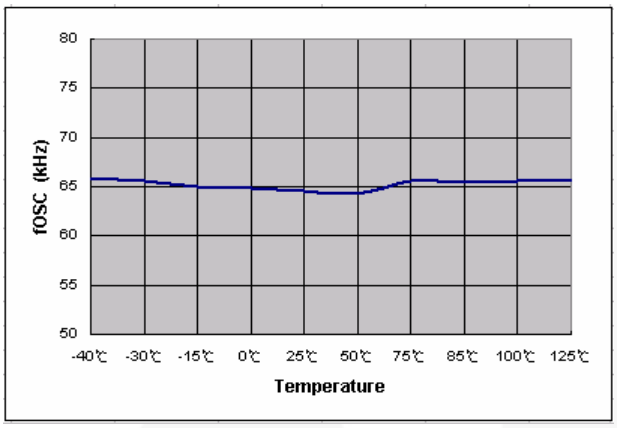


Figure 12. Frequency in Nominal Mode (f_{OSC}) vs. Temperature

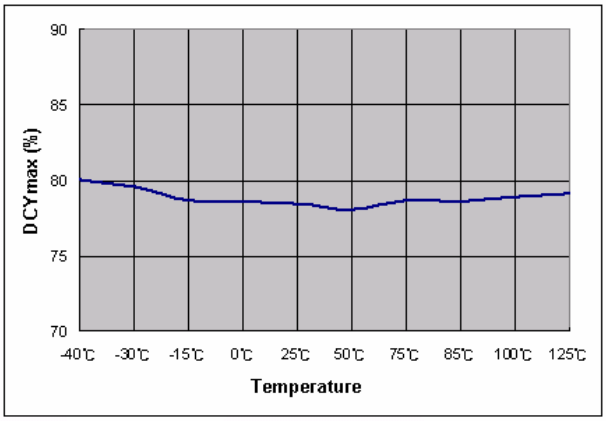


Figure 13. Maximum Duty Cycle (DCY_{MAX}) vs. Temperature

Functional Description

Startup Current

For startup, the HV pin is connected to the line input (1N4007 / 100KΩ recommended) or bulk capacitor through a resistor, R_{HV}. Typical startup current drawn from pin HV is 2mA and charges the hold-up capacitor through the diode and resistor. When the V_{DD} capacitor level reaches V_{DD-ON}, the startup current switches off. At this moment, the V_{DD} capacitor only supplies the FAN6751 to keep the V_{DD} before the auxiliary winding of the main transformer to provide the operating current.

Operating Current

Operating current is around 4mA. The low operating current enables better efficiency and reduces the requirement of V_{DD} hold-up capacitance.

Green-Mode Operation

The proprietary green-mode function provides off-time modulation to reduce the switching frequency in the light-load and no-load conditions. The on time is limited for better abnormal or brownout protection. V_{FB}, which is derived from the voltage feedback loop, is taken as the reference. Once V_{FB} is lower than the threshold voltage, switching frequency is continuously decreased to the minimum green-mode frequency of around 18KHz.

Current Sensing / PWM Current Limiting

Peak-current-mode control is utilized to regulate output voltage and provide pulse-by-pulse current limiting. The switch current is detected by a sense resistor into the SENSE pin. The PWM duty cycle is determined by this current sense signal and V_{FB}, the feedback voltage. When the voltage on SENSE pin reaches around $V_{COMP}=(V_{FB}–1.2)/4$, a switch cycle is terminated immediately. V_{COMP} is internally clamped to a variable voltage around 0.85V for output power limit.

Leading-Edge Blanking (LEB)

Each time the power MOSFET is switched on, a turn-on spike occurs on the sense-resistor. To avoid premature termination of the switching pulse, a leading-edge blanking time is built in. During this blanking period, the current-limit comparator is disabled and it cannot switch off the gate driver.

Under-Voltage Lockout (UVLO)

The turn-on and turn-off thresholds are fixed internally at 16.5V and 10.5V respectively. During startup, the hold-up capacitor must be charged to 16.5V through the startup resistor to enable the IC. The hold-up capacitor continues to supply V_{DD} before the energy can be delivered from auxiliary winding of the main transformer. V_{DD} must not drop below 10.5V during this process. This UVLO hysteresis window ensures that hold-up capacitor is adequate to supply V_{DD} during startup.

Gate Output / Soft Driving

The BiCMOS output stage is a fast totem-pole gate driver. Cross conduction has been avoided to minimize heat dissipation, increase efficiency, and enhance reliability. The output driver is clamped by an internal 18V Zener diode to protect power MOSFET transistors against undesirable gate over voltage. A soft-driving waveform is implemented to minimize EMI.

Soft-Start

For many applications, it is necessary to minimize the inrush current at startup. The built-in 5ms soft-start circuit significantly reduces the startup current spike and output voltage overshoot.

Built-in Slope Compensation

The sensed voltage across the current-sense resistor is used for peak-current-mode control and pulse-by-pulse current limiting. Built-in slope compensation improves stability and prevents sub-harmonic oscillation. FAN6751 inserts a synchronized positive-going ramp at every switching cycle.

Constant Output Power Limit

For constant output power limit over universal input-voltage range, the peak-current threshold is adjusted by the voltage of the VIN pin. Since the VIN pin is connected to the rectified AC input line voltage through the resistive divider, a higher line voltage generates a higher V_{IN} voltage. The threshold voltage decreases as the V_{IN} voltage increases, making the maximum output power at high-line input voltage equal to that at low-line input. The value of R-C network should not be so large it affects the power limit (shown as Figure 14). Usually, R and C are less than 100Ω and 470pF, respectively.

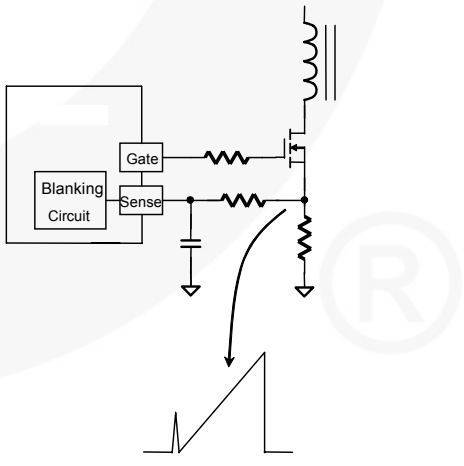


Figure 14. Current Sense R-C Filter

V_{DD} Over-Voltage Protection (OVP)

V_{DD} over-voltage protection is built-in to prevent damage due to abnormal conditions. Once the V_{DD} voltage is over the over-voltage protection voltage (V_{DD-OVP}), and lasts for $t_{D-VDDOVP}$, the PWM pulses are disabled until the V_{DD} voltage drops below the UVLO, then starts again. Over-voltage conditions are usually caused by open feedback loops.

Brownout Protection

Since the VIN pin is connected through a resistive divider to the rectified AC input line voltage, it can also be used for brownout protection. If the V_{IN} voltage is less than 0.7V, the PWM output is shut off. If the V_{IN} voltage over 0.92V, the PWM output is turned on again. The hysteresis window for on/off is around 0.22V. The brownout voltage setting is determined by the potential divider formed with RUpper and RLower. To calculate the resistors:

$$V_{IN} = \frac{R_{Lower}}{R_{Lower} + R_{Upper}} \times V_{AC}, (unit = V) \quad (1)$$

Thermal-Overload Protection

Thermal-overload protection limits total power dissipation. When the junction temperature exceeds T_J = +135°C, the thermal sensor signals the shutdown logic and turns off most of the internal circuitry. The thermal sensor turns internal circuitry on again after the IC's junction temperature drops by 25°C. Thermal-overload protection is designed to protect the FAN6751 in the event of a fault condition. For continual operation, do not exceed the absolute maximum junction temperature rating of T_J = +150°C.

Limited Power Control

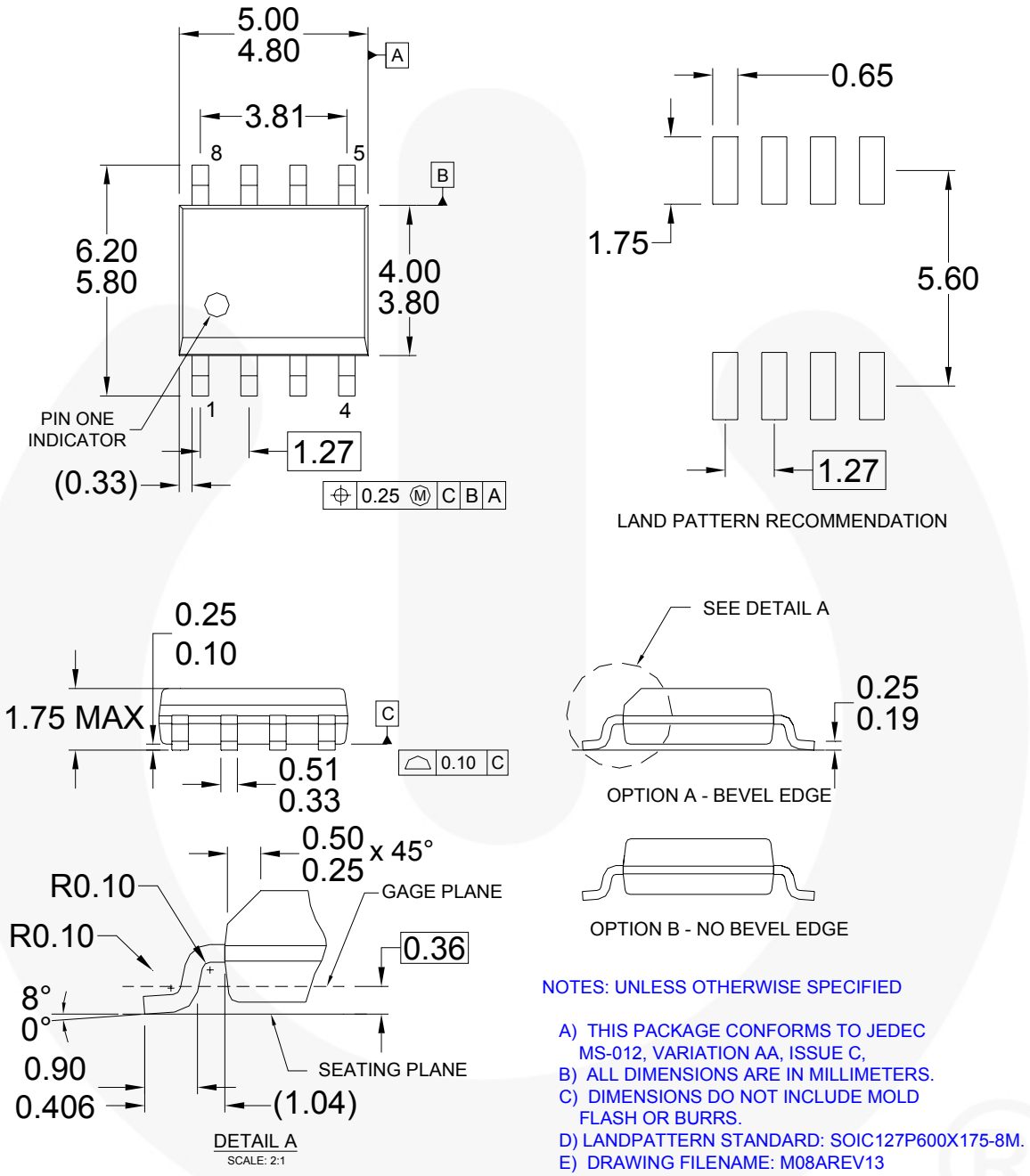
The FB voltage increases every time the output of the power supply is shorted or overloaded. If the FB voltage remains higher than a built-in threshold for longer than t_{D-OLP}, PWM output is turned off. As PWM output is turned off, V_{DD} begins decreasing.

When V_{DD} goes below the turn-off threshold (~10.5V), the controller is totally shut down. V_{DD} is charged up to the turn-on threshold voltage of 16.5V through the startup resistor until PWM output is restarted. This protection feature continues as long as the overloading condition persists. This prevents the power supply from overheating due to overloading conditions.

Noise Immunity

Noise on the current sense or control signal may cause significant pulse-width jitter, particularly in continuous-conduction mode. Slope compensation helps alleviate this problem. Good placement and layout practices should be followed. Avoiding long PCB traces and component leads, locating compensation and filter components near the FAN6751, and increasing the power MOS gate resistance improve performance.

Physical Dimensions



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E) DRAWING FILENAME: M08AREV13

Figure 15. 8-Pin, Small Outline Package (SOP)

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ANTI-COUNTERFEITING POLICY

Fairchild Semiconductor Corporation's Anti-Counterfeiting Policy. Fairchild's Anti-Counterfeiting Policy is also stated on our external website, www.fairchildsemi.com, under Sales Support.

Counterfeiting of semiconductor parts is a growing problem in the industry. All manufacturers of semiconductor products are experiencing counterfeiting of their parts. Customers who inadvertently purchase counterfeit parts experience many problems such as loss of brand reputation, substandard performance, failed applications, and increased cost of production and manufacturing delays. Fairchild is taking strong measures to protect ourselves and our customers from the proliferation of counterfeit parts. Fairchild strongly encourages customers to purchase Fairchild parts either directly from Fairchild or from Authorized Fairchild Distributors who are listed by country on our web page cited above. Products customers buy either from Fairchild directly or from Authorized Fairchild Distributors are genuine parts, have full traceability, meet Fairchild's quality standards for handling and storage and provide access to Fairchild's full range of up-to-date technical and product information. Fairchild and our Authorized Distributors will stand behind all warranties and will appropriately address any warranty issues that may arise. Fairchild will not provide any warranty coverage or other assistance for parts bought from Unauthorized Sources. Fairchild is committed to combat this global problem and encourage our customers to do their part in stopping this practice by buying direct or from authorized distributors.

PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative / In Design	Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
No Identification Needed	Full Production	Datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design.
Obsolete	Not In Production	Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only.

Rev. I36