Highly-Integrated Green-Mode PWM Controller **SG6846**

FEATURES

- Linearly decreasing PWM frequency at light load
- Burst-mode at light load and zero load
- Low start-up current (20uA)
- Low operating current (4mA)
- Leading-edge blanking
- Built-in synchronized slope compensation
- Totem pole output with soft driving
- Constant power limit over universal AC input range
- Peak current mode operation with cycle by cycle current limit
- Under voltage lockout (UVLO) for AC input with hysteresis
- One resistor to program PWM frequency
- GATE output maximum voltage clamped at 18V
- Two level over current protection (OCP) with the up/down counter delay time of 96ms
- VDD over voltage protection (OVP)
- Programmable over temperature protection (OTP)
- Internal latch circuit for OTP, OVP, OCP
- Very few external components

APPLICATIONS

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

- Power adapters
- Open-frame SMPS
- Specifically fit for the SMPS with surge current outputs, such as printer, scanner, motor driver, etc.

DESCRIPTION

The highly integrated SG6846 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 under light-load conditions. Under zero-load conditions, the power supply enters burst-mode. This completely shuts off PWM output. Then, the output restarts just before the supply voltage, VDD, drops below the UVLO voltage. This green-mode function enables the power supply to easily meet international power conservation requirements.

To further improve standby power consumption, the SG6846 series is manufactured using the BiCMOS process. This allows the start-up current to be reduced to 20uA, and the operating current to be reduced to 4mA. A large start-up resistance can be used for better power saving.

Built-in synchronized slope compensation ensures the stability of current mode control. Proprietary internal compensation ensures constant output power limiting over a universal range of AC input voltages, from 90VAC to 264VAC.

SG6846 controllers provide many protection functions. Under voltage lockout for AC input with hysteresis ensures safe operation during brown out. PWM output will be disabled as long as VDD remains higher than 26V. The gate output is clamped at 18V to protect the power MOS from over-voltage damage. An external NTC thermistor can be applied to sense the ambient temperature for over temperature protection. Cycle-by-cycle current limiting provides instantaneous protection for MOSFET and ensures a maximum output power. Furthermore, if the switching current is higher than 2/3 of the peak current threshold for longer than 96ms, over current protection will be activated such that SG6846 will be totally shutdown. This two level OCP feature is especially suitable for SMPS with surge current outputs. When OTP, OCP or VDD over voltage faults are detected, an internal latch circuit is used to latch-off the controller. The latch will reset when the AC input is removed.

SG6846 series controllers are available in both 8-pin DIP and SO packages.

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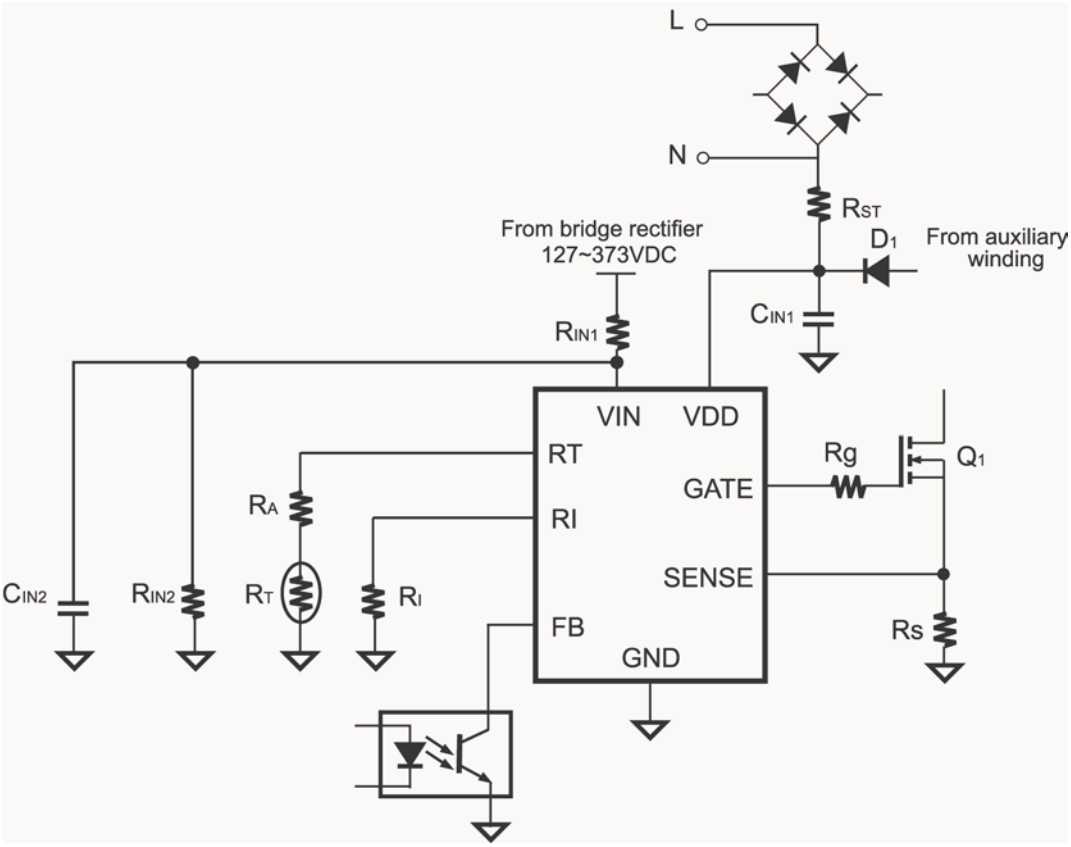
TYPICAL APPLICATION



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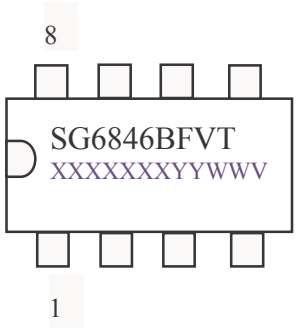
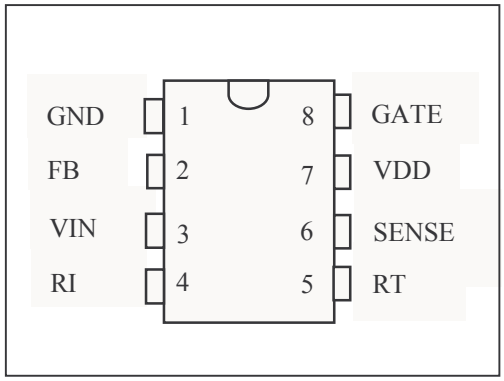
MARKING DIAGRAMS



B: B = Linearly Decreasing Frequency + Burst-Mode: Null = Linear
F: L = OTP Latch
C = Hysteresis OTP : The pin is reset when the temperature cools down.
V: V = OVP Latch
O = OVP + OCP Latch
T: D = DIP, S = SOP
XXXXXXX: Wafer Lot
YY: Year; WW: Week
V: Assembly Location

PIN CONFIGURATION



ORDERING INFORMATION

The SG6846 family of controllers is distinguished for its protection features and burst-mode functionality.

Part Number	Green-Mode Function: Linearly Decreasing Frequency and Burst-Mode				Package
	OTP Latch: Reset when AC is unplugged (L).	Hysteresis OTP: Reset when the temperature cools down (C).	OVP Latch: Reset when AC is unplugged (V).	OCP Latch: Reset when AC is unplugged (V).	
SG6846BLVS	✔		✔		8-Pin SOP
SG6846BLVD					8-Pin DIP
SG6846BCVS		✔	✔		8-Pin SOP
SG6846BCVD					8-Pin DIP
SG6846BLOS	✔		✔	✔	8-Pin SOP
SG6846BLOD					8-Pin DIP
SG6846BCOS		✔	✔	✔	8-Pin SOP
SG6846BCOD					8-Pin DIP

Note 1: All part numbers have the following default protection functions:

a. OTP. PWM output is turned off when an over-temperature condition is detected.
b. OVP. PWM output is turned off when an over-voltage condition is detected.

Note 2: Green-Mode:

a. Linear-Mode: The PWM frequency linearly decreases from the maximum frequency of 65kHz to around 12kHz. This happens when the output load goes from a high-load state to low-load/zero-load state.
b. Linear-Mode with Burst-Mode: After the PWM frequency linearly decreases from the maximum frequency of 65kHz to around 22kHz, the controller can enter into burst-mode. In burst-mode, PWM completely stops, and the V_{DD} voltage begins dropping. When V_{DD} drops to 11.75V (1.25V higher than the UVLO threshold), the SG6846 will start to send out PWM signals at a frequency of 27kHZ.

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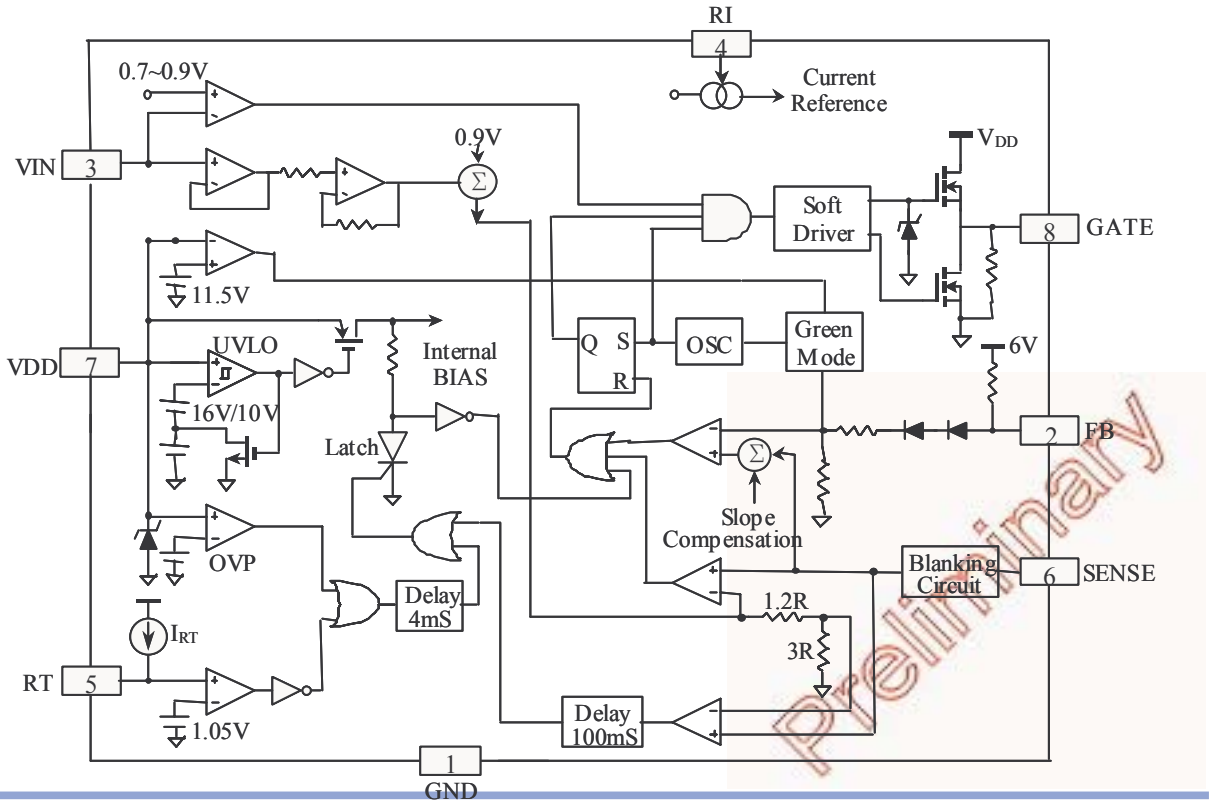
PIN DESCRIPTIONS

Pin No.	Symbol	Function	Description
1	GND	Ground	Ground.
2	FB	Feedback	The signal from the external compensation circuit is fed into this pin. This FB pin and the current-sense signal from Pin 6 determine the PWM duty cycle.
3	VIN	Line voltage Detection	Line voltage detection. The line voltage detection is used for brownout protection with hysteresis (0.9v ~ 0.7v). Constant output power limit over universal AC input range is also achieved using this VIN signal. It is suggested to add low pass filter to filter out line ripple on bulk capacitor.
4	RI	Reference Setting	A resistor from the RI pin to ground will generate a constant current source for the SG6846. This current charges an internal capacitor. This determines the switching frequency. Increasing the resistance will decrease the amplitude of the current from the current source, and thereby reduce the switching frequency. Using a 26kΩ resistor Ri results in a 50uA constant current Ii and a 65kHz switching frequency.
5	RT	Temperature Detection	For over-temperature protection. An external NTC thermistor is connected from this pin to ground. The impedance of the NTC will decrease at high temperatures. Once the voltage of the RT pin drops below a fixed limit of 1.05V, PWM output will be disabled.
6	SENSE	Current Sense	Current sense. The sensed voltage is used for peak current mode control and current limiting. Cycle-by-cycle current limiting provides instantaneous protection for MOSFET and ensures a maximum output power. Furthermore, if the switching current is higher than 2/3 of the peak current threshold for longer than 96ms, over current protection will be activated such that SG6846 will be totally shutdown. This two level OCP feature is especially suitable for SMPS with surge current outputs
7	VDD	Power Supply	Power Supply. The internal protection circuit will disable PWM output as long as VDD remains higher than 26V.
8	GATE	Driver Output	The totem-pole output driver for the power MOSFET. A soft driving waveform is implemented for improved EMI.

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Test Condition	Value	Unit
V_{DD}	Supply Voltage	Low Impedance Source, Zener Clamp	28 30	V V
I_Z	Zener Current	-	10	mA
V_{IN}	Input Voltage to VIN Pin	-	-0.3 to 7V	V
V_{FB}	Input Voltage to FB Pin	-	-0.3 to 7V	V
V_{SENSE}	Input Voltage to SENSE Pin	-	-0.3 to 7V	V
V_{RT}	Input Voltage to RT Pin	-	-0.3 to 7V	V
V_{RI}	Input Voltage to RI Pin	-	-0.3 to 7V	V
P_D	Power Dissipation	at Ta < 50°C DIP SOP	800 400	mW
$R_{\Theta J-A}$	Thermal Resistance	Junction-Air DIP SOP	82.5 141	°C/W
T_J	Operating Junction Temperature	-	150	°C
T_A	Operating Ambient Temperature	-	-40 to 125	°C
T_{STG}	Storage Temperature Range	-	-65 to +150	°C
T_L	Lead Temperature (Soldering)	10 sec DIP 10 sec SOP	260 230	°C
	ESD Capability, HBM Model	-	2.0	kV
	ESD Capability, Machine Model	-	200	V

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Min.	Max.	Unit
V_{DD}	Supply Voltage	-	20	V
T_A	Operating Ambient Temperature	-30	85	°C

ELECTRICAL CHARACTERISTICS

VDD Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
$V_{TH(ON)}$	On Threshold Voltage		15.5	16.5	17.5	V
$V_{TH(OFF)}$	Off Threshold Voltage		9.5	10.5	11.5	V
$I_{DD\ ST}$	Start-Up Current (VDD = 15.5V)			8	20	uA
$I_{DD\ OP}$	Operating Supply Current (FB=SENSE=0V, VDD =15V, GATE Open)	-		3.7	5	mA
V_{DD-OVP}	VDD Over Voltage Protection (Disable PWM Output). For Protection Against Open Feedback Loops.		23.5	25.5	28	V
$T_{D-VDD-OVP}$	VDD Over Voltage Protection Debounce (Disable PWM Output)			200		nsec
$T_{DOVP-LATCH}$	Over-voltage Latch-Off Debounce.		1	2	4	msec
$V_{DD-ZENER}$	VDD ZENER Crowbar	IDD = 10mA	27	30	33	V
$V_{DD-TH-G}$	VDD Low-Threshold Voltage to Exit Green-OFF Mode		VTH(OFF) + 0.8	VTH(OFF) + 1.25	VTH(OFF) + 1.7	V

VIN Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
$V_{IN\ (ON)}$	Hysteresis Brownout turn on PWM Threshold Voltage		0.85	0.9	0.95	V
$V_{IN\ (OFF)}$	Hysteresis Brownout turn off PWM Threshold Voltage		0.65	0.7	0.75	V

Feedback Input Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
A_V	Input-Voltage to Current-Sense Attenuation		1/3.5	1/4	1/4.5	V/V
Z_{FB}	Input Impedance		3	4.5	6	KΩ
I_{FB}	Bias Current				2	mA
V_{OZ}	Zero Duty-Cycle Input Voltage		1.2			V

Current Sense Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
Z_{CS}	Input Impedance		8	12	16	kΩ
T_{PD}	Delay to Output			100	200	nsec
V_{TH}	Cycle-by-cycle Current Limit Threshold Voltage		0.8	0.85	0.9	V
ΔV_{TH-P} @ I_{IN}	Threshold Voltage Change versus the Input Current of the VIN Pin	IIN =80 uA	0.73	0.78	0.83	V
ΔV_{TH-P} @ I_{IN}	Threshold Voltage Change versus the Input Current of the VIN Pin	IIN = 160 uA	0.65	0.7	0.75	V
ΔV_{TH-P} @ I_{IN}	Threshold Voltage Change versus the Input Current of the VIN Pin	IIN = 220 uA	-0.09	-0.15	-0.21	V
Bnk	Leading Edge Blanking Time		260	360	460	nsec
V_{TH-OCP}	Over Current Protection Threshold Voltage		0.53	0.57	0.61	V
ΔV_{TH-O} @ I_{IN}	Threshold Voltage Change versus the Input Current of the VIN Pin	IIN = 80 uA	0.50	0.55	0.60	V

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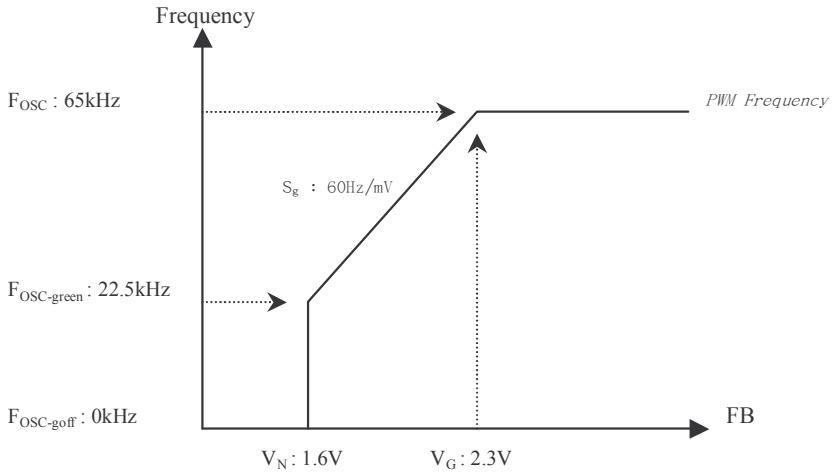
ΔV_{TH-O} @ I_{IN}	Threshold Voltage Change versus the Input Current of the VIN Pin	IIN = 160 uA	0.45	0.50	0.55	V
ΔV_{TH-O} @ I_{IN}	Threshold Voltage Change versus the Input Current of the VIN Pin	IIN = 220 uA	-0.06	-0.1	-0.14	V
$T_{DELAY-OCP}$	The Delay Time for over current protection.	Ri=26KΩ		96		msec

Oscillator Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
F_{OSC}	Normal Mode Frequency	Ri=26KΩ	60	65	70	KHz
$F_{OSC-GREEN}$	Green-ON Mode Frequency	Ri=26KΩ	20	22.5	25	KHz
$F_{OSC-GOFF}$	Green-OFF Mode Frequency (Burst-Mode Version)	Ri=26KΩ			0	KHz
V_G	Green-OFF Mode Voltage at FB pin	VDD=15V		1.6		V
V_N	FB Pin Threshold for Beginning the Reduction of Frequency	VDD=15V		2.3		V
S_G	Slope for Green-Mode Modulation	Ri=26KΩ		60		Hz/mV
F_{DV}	Frequency Variation Versus VDD Deviation	VDD=11 to 20V			5	%
F_{DT}	Frequency Variation Versus Temp. Deviation	Ta=-30 to 85℃		1.5	5	%



PWM Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
$D_{CY\ (MAX)}$	Maximum Duty Cycle		80	85	90	%
V_{OL}	Output Voltage Low	VDD= 12V, Io = 50mA			1.5	V
V_{OH}	Output Voltage High	VDD= 12V, Io = 50mA	8V			V
T_R	Rising Time	VDD=15V, CL=1nF	--	250	--	nsec
T_F	Falling Time	VDD=15V, CL=1nF	--	50	--	nsec
V_{CLAMP}	Gate Output Clamping Voltage	VDD=25V		18		V

Over Temperature Protection Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
I_{RT}	Output Current of RT Pin	Ri=26KΩ	64	70	76	uA
$V_{OTP-LATCH-OFF}$	Threshold Voltage for Over Temperature Protection. Turn-Off and Latch-Off.		1.015	1.05	1.085	V

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$T_{DOTP-LATCH}$	Over-Temperature Latch-Off Debounce.		1	2	4	msec
$V_{OTPRESET-ON}$	Threshold Voltage (Hysteresis) for Over Temperature Latch-Off Reset. At this Threshold, the Latch is Reset and PWM is Turned On.		1.05	1.15	1.25	V

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TYPICAL CHARACTERISTICS

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OPERATION DESCRIPTION

Start-Up Current

The typical start-up current is only 20uA. This allows a high resistance, low-wattage start-up resistor to be used, to minimize power loss. A 1.5 MΩ, 0.25W, start-up resistor and a 10uF/25V VDD hold-up capacitor would be sufficient for an AC/DC adapter with a universal input range.

Operating Current

The required operating current has been reduced to 4mA. This enables higher efficiency and reduces the VDD hold-up capacitance requirement.

Green Mode Operation

The proprietary Green-mode function provides off-time modulation to linearly decrease the switching frequency under light-load conditions. On-time is limited to provide protection against abnormal conditions and brownouts. To further reduce power consumption under zero-load conditions, the PWM output will be completely turned off, and the power supply will enter burst-mode. After the PWM oscillator is turned off, the IC's supply voltage VDD will drop gradually. Before the VDD voltage drops below the UVLO voltage, the PWM oscillator will be turned on again. This Green-mode function dramatically reduces power consumption under light-load and zero-load conditions. Power supplies using a SG6846 controller can easily meet even the most restrictive international regulations regarding standby power consumption.

Oscillator Operation

A resistor connected from the RI pin to ground generates a constant current source for a SG6846 controller. This current is used to charge an internal capacitor. The charge of the capacitor determines the internal clock and the switching frequency. Increasing the resistance will decrease the amplitude of the current source and reduce the switching frequency. Using a 26kΩ resistor R_i results in a 50uA constant current I_i, and a corresponding 65kHz switching frequency. The relationship between R_i and the switching frequency is:

$$f_{PWM} = \frac{1690}{R_I\ (k\Omega)} (kHz) \quad \text{---------- (1)}$$

SG6846 controllers are designed to operate at a PWM oscillation frequencies ranging from 50kHz to 100kHz. If an open circuit or short circuit to ground occurs in the RI pin, the internal protection circuit will immediately shut down the PWM.

Leading Edge Blanking

Each time the power MOSFET is switched on, a turn-on spike will inevitably occur at the sense-resistor. To avoid premature termination of the switching pulse, a 360nsec leading-edge blanking time is built in. Conventional RC filtering is not necessary. During this blanking period, the current-limit comparator is disabled, and it cannot switch off the gate drive.

Under-Voltage Lockout (UVLO) for VDD

The turn-on/turn-off thresholds are fixed internally at 16.5V/10.5V. To enable a SG6846 controller during start-up, the hold-up capacitor must first be charged to 16.5V, through the start-up resistor.

The hold-up capacitor will continue to supply VDD before energy can be delivered from the auxiliary winding of the main transformer. VDD must not drop below 10.5V during this start-up process. This UVLO hysteresis window ensures that the hold-up capacitor can adequately supply VDD during start-up.

Gate Output / Soft Driving

The BiCMOS output stage of a SG6846 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 in order to protect the power MOSFET transistors against any harmful over-voltage

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gate signals. A soft driving waveform is implemented to minimize EMI.

Slope Compensation

The sensed voltage across the current sense resistor is used for current mode control and pulse-by-pulse current limiting. The built-in slope compensation function improves power supply stability and prevents peak current-mode control from causing sub-harmonic oscillations. With every switching cycle, a positively sloped, synchronized ramp is activated by SG6846 controllers.

Constant Output Power Limit

When the SENSE voltage across the sense resistor RS reaches the threshold voltage (around 0.85V), the output GATE drive will be turned off following a small propagation delay tD. This propagation delay will introduce an additional current proportional to tD*VIN/LP. The propagation delay is nearly constant regardless of the input line voltage VIN. Higher input line voltages will result in larger additional currents. Thus, under high input-line voltages the output power limit will be higher than under low input-line voltages.

Over a wide range of AC input voltages, the variation can be significant. To compensate for this, the SENSE threshold voltage is adjusted by the voltage of VIN pin. Since the VIN pin is connected to the rectified AC input line voltage through the voltage divider, a higher line voltage will generate a higher VIN voltage through the VIN pin.

The threshold voltage decreases if the VIN voltage increases. A small threshold voltage will force the output GATE drive to terminate earlier, thus reducing total PWM turn-on time, and making the output power equal to that of low line input. This proprietary internal compensation feature ensures a constant output power limit over a wide range of AC input voltages (90VAC to 264VAC).

Brownout Protection

Since VIN pin is connected thru a voltage divider to the rectified AC input line voltage, it is used as the sense pin for brownout protection. If the VIN voltage is less than 0.7V, the PWM output will be shut off. If the VIN voltage is larger than 0.9V, the PWM output will be turned on again. The hysteresis window for ON/OFF is 0.2V.

VDD Over-Voltage Protection

VDD over-voltage protection has been built in to prevent any over voltage destruction. When VDD voltage is abnormally over 25.5V, the PWM output will be immediately disabled. If this condition sustains longer than 2msec, SG6846 will be latched off. The over-voltage condition is usually caused by feedback open loop.

Thermal Protection

An external NTC thermistor can be connected from the RT pin to ground. The impedance of the NTC will decrease at high temperatures. When the voltage of the RT pin drops below 1.05V, the SG6846 will be latched off.

Over Current Protection with Two Thresholds

The cycle-by-cycle current limiting will shut down the PWM immediately when the switching current is over the peak current threshold. In addition to the cycle-by-cycle current limit, there is an over-current protection circuit built-in. Whenever the switching current is higher than 2/3 of the peak current threshold, the internal counter starts counting up. When the switching current is lower than 2/3 of the peak current threshold, the internal counter will count down. When the total accumulated up-counting time minus the total down-counting time is more than 96ms, the PWM will be turned off.

This two OCP protection levels and up/down counter are especially suitable for SMPS with a surge current outputs such as printer, scanner, motor driver, etc.

Protection Latch Circuit

In some applications, latch operation for OVP, OTP or OCP may be necessary. For the SG6846 family, the

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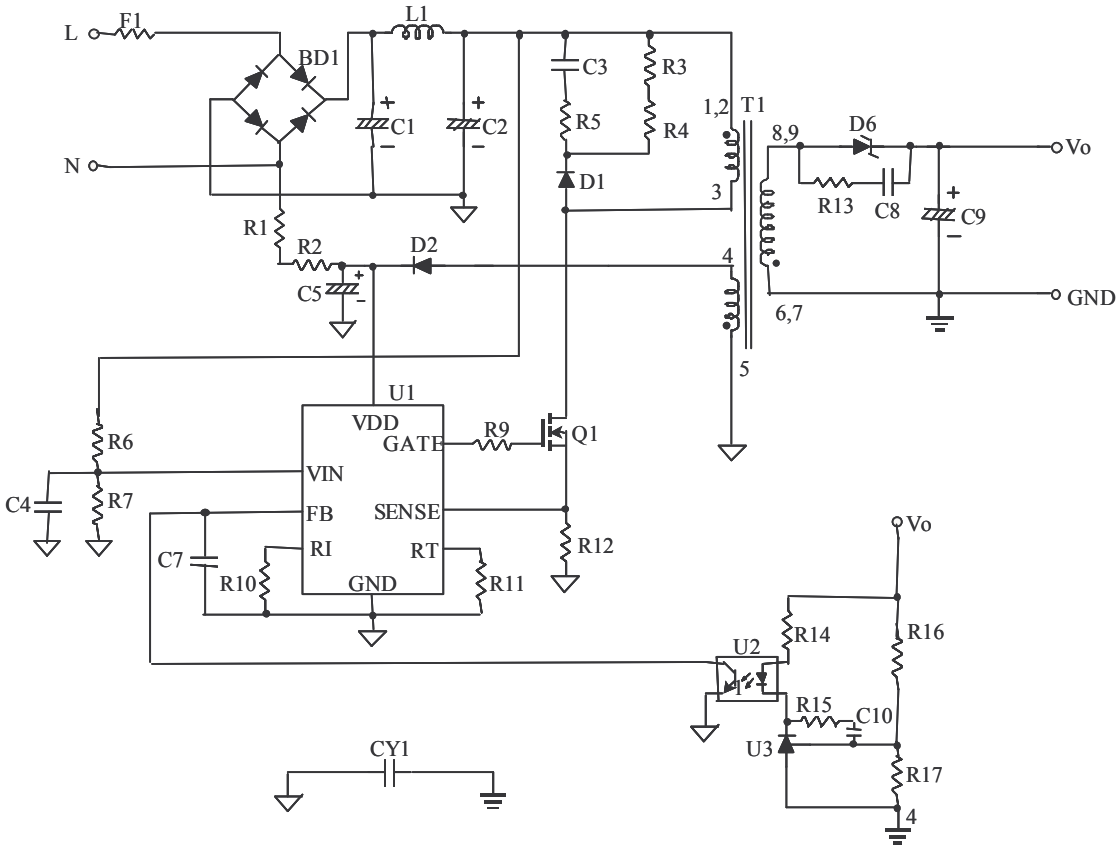
optional built in latch function provides a versatile protection feature that does not require external components. See ordering information for a detailed description. To reset the latch circuit, it is necessary to disconnect the AC line voltage of the power supply, or to wait until the temperature cools down.

Noise immunity

Noise from the current sense or the 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. The designer should avoiding long PCB traces and component leads. Compensation and filter components should be located near the SG6846. Finally, increasing the power-MOS gate resistance is advised.

REFERENCE CIRCUIT

Application circuit for 12V/5A output



BOM

Reference	Component	Reference	Component
F1	FUSE 4A/250V	C9	EC 1000uF/25V
BD1	BD 4A/600V	R1,R2	R 330KΩ 1/4W
CY1	YC 222P/250V	R3,R4	R 47KΩ 1/4W
L1	UU10.5-10mH	R5	R 47Ω 1/4W
U1	IC SG6846	R6	R 5000KΩ 1/4W
U2	IC PC-817	R7	R 50KΩ 1/4W
U3	IC TL431	R9,R13	R 51Ω 1/4W
T1	Transformer PQ2620	R10	R 26KΩ 1/8W 1%
D1	BYV95C	R11	Thermistor SCK054
D2	FR103	R12	R 0.34Ω 1W 1%
C1,C2	EC 56uF/400V	R14	R 220Ω 1/4W
C3	CC 103P/500V	R15	R 4.7KΩ 1/8W
C4	CC 0.1uF/50V	R16	R 154KΩ 1/8W 1%
C5	EC 4.7uF/50V	R17	R 39KΩ 1/8W 1%
C8	CC 102P/100V	Q1	MOS PHX7NQ60E
C7,C10	CC 222P/50V		

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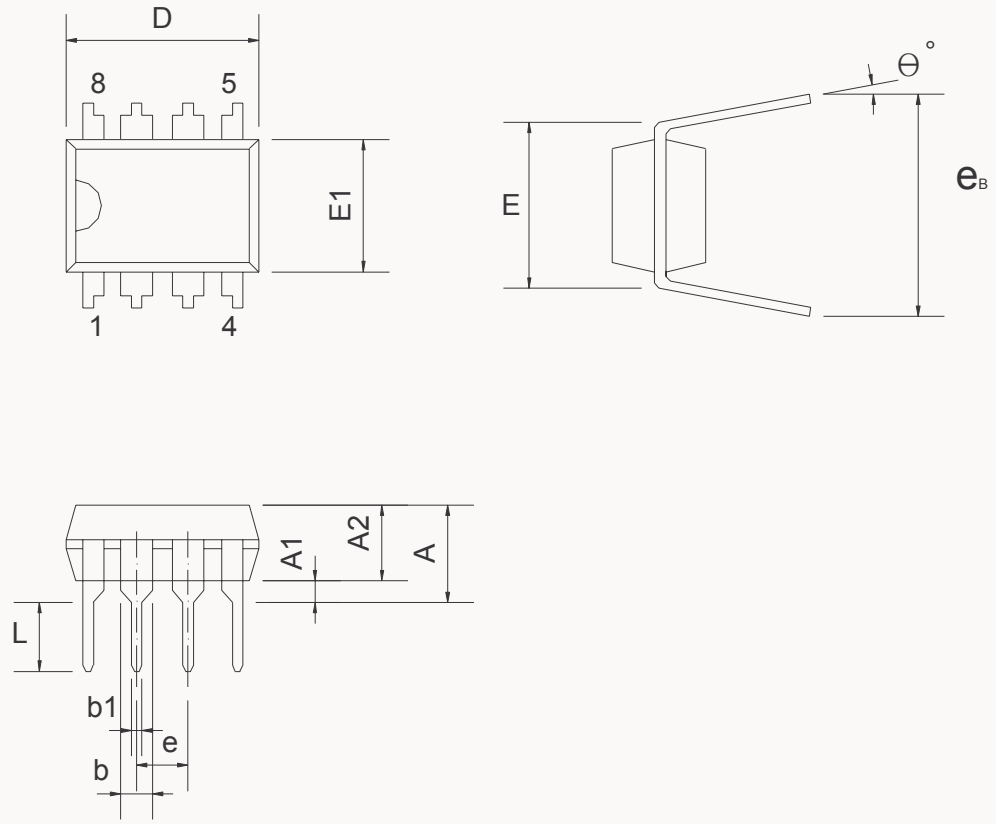
PACKAGE INFORMATION

DIP-8 Outline Dimensions



Dimension

Symbol	Millimeter			Inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			5.334			0.210
A1	0.381			0.015		
A2	3.175	3.302	3.429	0.125	0.130	0.135
b		1.524			0.060	
b1		0.457			0.018	
D	9.017	9.271	10.160	0.355	0.365	0.400
E		7.620			0.300	
E1	6.223	6.350	6.477	0.245	0.250	0.255
e		2.540			0.100	
L	2.921	3.302	3.810	0.115	0.130	0.150
e_B	8.509	9.017	9.525	0.335	0.355	0.375
θ°	0°	7°	15°	0°	7°	15°

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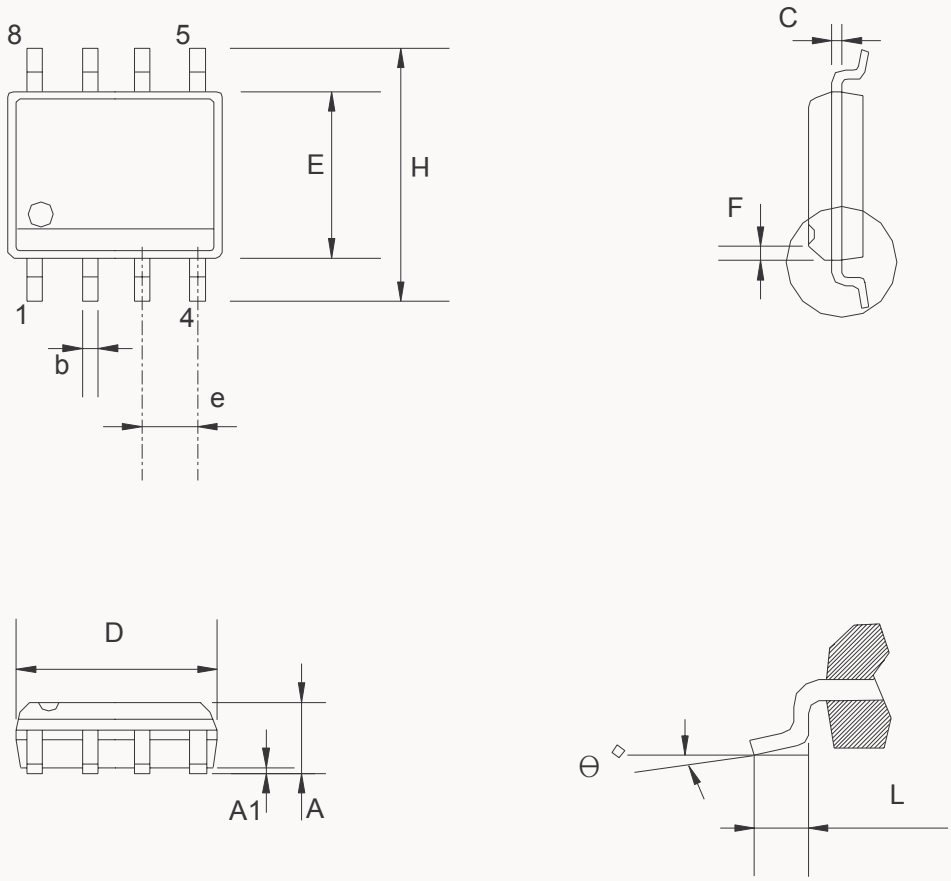
SOP-8 Outline Dimensions



Dimension:

Symbol	Millimeter			Inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	1.346		1.752	0.053		0.069
A1	0.101		0.254	0.004		0.010
b		0.406			0.016	
c		0.203			0.008	
D	4.648		4.978	0.183		0.196
E	0.381		3.987	0.150		0.157
e		1.270			0.050	
F		0.381X45°			0.015X45°	
H	5.791		6.197	0.228		0.244
L	0.406		1.270	0.016		0.050
θ°	0°		8°	0°		8°

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DISCLAIMERS

LIFE SUPPORT

System General's products are not designed to be used as components in devices intended to support or sustain human life. Use of System General's products in components intended for surgical implant into the body, or other applications in which failure of System General's products could create a situation where personal death or injury may occur, is not authorized without the express written approval of System General's Chief Executive Officer. System General will not be held liable for any damages or claims resulting from the use of its products in medical applications.

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