SG6841 Data Sheet

DESCRIPTION

This high-integrated PWM controller provides several special enhancements to satisfy the increasing needs for low standby power and better protection features. In standby mode, the PWM frequency is linearly reduced to lower the power consumption, and to provide a stable output voltage. Due to BiCMOS process, the start-up current and operation current is reduced to 30uA and 3mA, respectively, to improve power conversion efficiency. SG6841 is a fixed frequency PWM controller in normal operation of which the PWM frequency is programmable by an external resistor. Its patented green-mode function will decrease the PWM frequency in response to the decreasing of load condition. This green function dramatically reduces the power loss in no load and light load conditions, which assist the power supply to meet the power conservation requirement. The proprietary synchronized slope compensation ensures the stability of the current loop under continuous-mode operation. Built-in line-voltage compensation maintains constant output power limit for a wide AC input range. An NTC thermistor is applied to sense the ambient temperature for over-temperature protection. The limited power controller provides an over-power protection and supports the safety requirement of 'limited power source'. The SG6841 is available in 8-pin DIP and SO packages.

APPLICATIONS

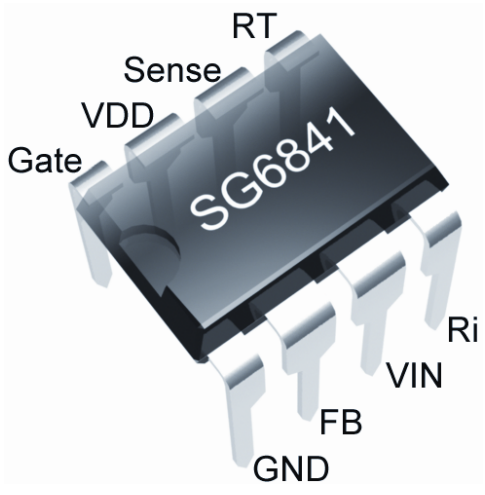
General-purpose switching mode power supplies and flyback power converters, and

- Power Adapter
- Open-frame SMPS
- Battery Charger Adapter

FEATURES OVERVIEW

- **Green-mode** PWM to support "Blue Angel" Norm
- Low start up current 30uA
- Low operation current 3mA
- Leading-edge blanking
- **Built-in synchronized slope compensation**
- Totem pole output includes soft driving for better EMI
- Constant output power limit
- Current mode operation
- Cycle-by-cycle current limiting
- Under voltage lockout (UVLO)
- Programmable PWM frequency
- GATE output maximum voltage clamped at 18V
- Build-in **limited-power-control** to meet safety requirement
- Short circuit protection
- Programmable over-temperature protection
- Few external components & low cost solution

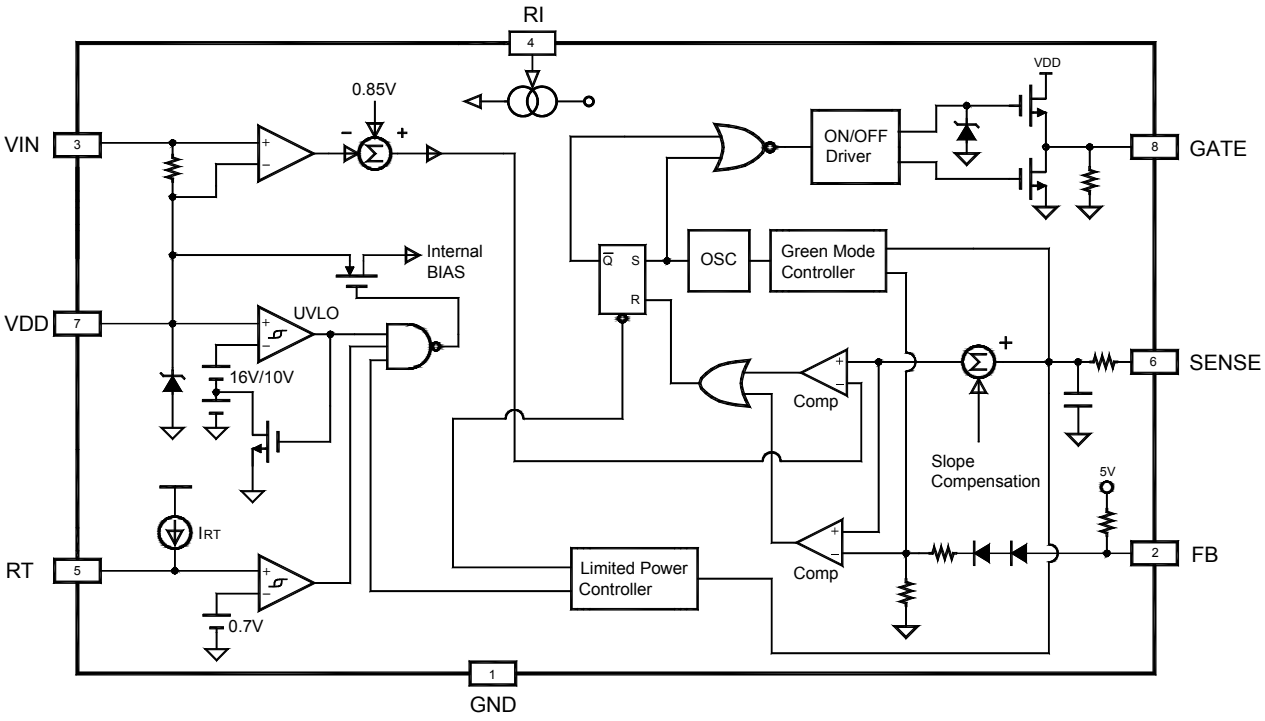
PIN CONFIGURATION



PIN DESCRIPTIONS

Pin No.	Symbol	Function	Description
1	GND	Ground	Ground.
2	FB	Feedback	Feedback. The FB pin provides the information of the regulation. The PWM duty cycle is controlled by FB pin.
3	VIN	Start-Up Current In	The start-up current input. A start-up resistor is connected from the line-input to this pin, such as 1.5MΩ for off-line converter. Adjust the start-up resistor to vary the line voltage compensation for constant output power limit.
4	Ri	Reference Setting	Reference setting. Typical voltage is 1.3V. Connect a resistor to ground to generate a constant current for SG6841. Increase the resistance decrease the current and reduce the switching frequency. Ri = 26K ohm (typical).
5	RT	Temperature Protection	For over-temperature protection. A constant current is sourcing out. An NTC thermistor is connected from this pin to ground to sense the temperature. When the voltage in this pin is lower than the limit, this will enable the over-temperature protection.
6	SENSE	Current Sense	Current sense. It senses the voltage on a sense resistor. When it reaches the internal threshold, the PWM output is disabled. Therefore, the over-current protection is realized.
7	VDD	Power supply	Power Supply.
8	GATE	Driver Output	The totem-pole output driver to drive the power MOSFET.

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
VDD	DC Supply Voltage Zener clamp Zener current	30 32 10	V V mA
Iout	Gate Output Current	500	mA
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
Pd	Power Dissipation	1	W
T_J	Operating Junction Temperature	150	℃
T_A	Operating Ambient Temperature	-25 to 85	℃
Tstg	Storage Temperature Range	-55 to +150	℃
	ESD Capability, HBM model	3.0	kV
	ESD Capability, Machine model	300	V

ELECTRICAL CHARACTERISTICS (VDD=15V, TA=25℃)

Feedback Input Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
Av	Input-voltage to current-sense attenuation		1/4.5	1/5	1/5.5	V/V
Zfb	Input impedance		3	4.5	6	KΩ
Ifb	Bias current				2	mA
Voz	Input voltage for zero duty cycle				1.2	V

Current Sense Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
Zcs	Input impedance		8	12	16	KΩ
T_{PD}	Delay to Output			150	200	nsec
Vth	Threshold voltage for current limit		0.8	0.85	0.9	V
ΔVth @ Iin	The change of threshold voltage versus the input current of the Vin	Iin = 220 uA	-0.09	-0.15	-0.21	V
Tdelay-Ips	The delay time of limited-power-control	Ri=26KOhms		31		msec

Oscillator Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
Fosc	Frequency	Ri=26KOhms	60	65	70	KHz
Fosc-green	Frequency in green mode	Ri=26KOhms		10	15	KHz
Vg	Green mode voltage (Vg = Vfb - Vd)			1.3		V
Vn	Normal mode voltage (Vn = Vfb - Vd) Vn = 4 V for maximum duty cycle		1.7	2	2.3	V
Sg	Slope for green mode modulation	Ri=26KOhms	50	80	120	Hz/mV
Fdv	Frequency variation versus VDD deviation	VDD=10 to 20V			5	%
Fdt	Frequency variation versus Temp. deviation	TA=-25 to 85 ℃			5	%

PWM Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
$DC_{(MAX)}$	Maximum Duty Cycle		75	80	90	%
$DC_{(MIN)}$	Minimum Duty Cycle		-	-	0	%
Bnk	Leading edge blanking time		200	270	350	nsec

Output Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
Vol	Output Voltage Low	VDD= 12V, Io = 150mA			1.5	V
Voh	Output Voltage High	VDD= 12V, Io = 50mA	8V			V
tr	Rising Time	VDD=13V, CL=1nF	150	250	350	nsec
tf	Falling Time	VDD=13V, CL=1nF	30	50	90	nsec

Under-voltage Lockout Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
$V_{TH(ON)}$	Start Threshold Voltage		15	16	17	V
$V_{DD(min)}$	Min. Operating Voltage		9	10	11	V

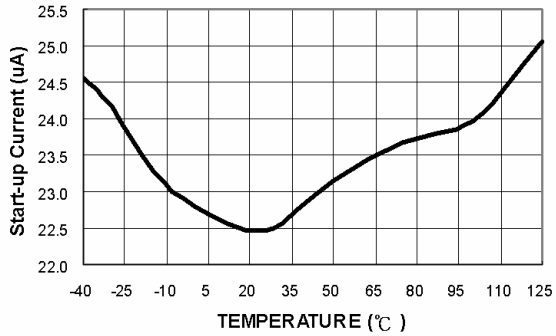
Over-Temperature Protection Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
Irt	Output current of pin RT	Ri=26KOhms	92	100	108	uA
$V_{OTP,STOP}$	Threshold voltage for over-temperature protection. Turn-off point. Duty cycle is reduced to 0%.		0.585	0.62	0.655	V
$V_{OTP,START}$	Threshold voltage for over-temperature protection. Starting point. Duty cycle starts to decrease.			0.65		V

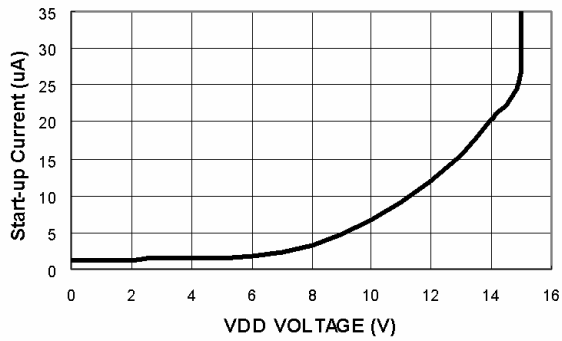
Total Standby Current Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
$I_{DD\ ST}$	Start-up Current	VDD=14.5V		30	40	uA
$I_{DD\ OP}$	Operating Supply Current	FB=SENSE=0V GATE=1000pF VDD=15.5V	-	3	5	mA

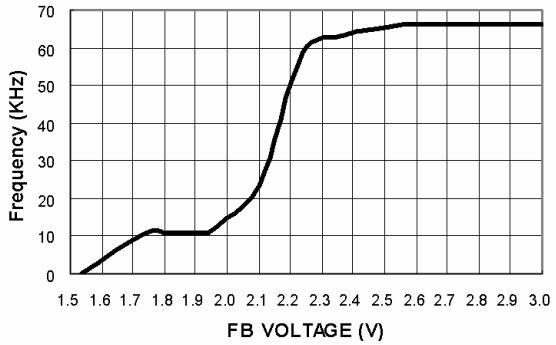
Start-up Current ($I_{DD\ ST}$) vs Temperature



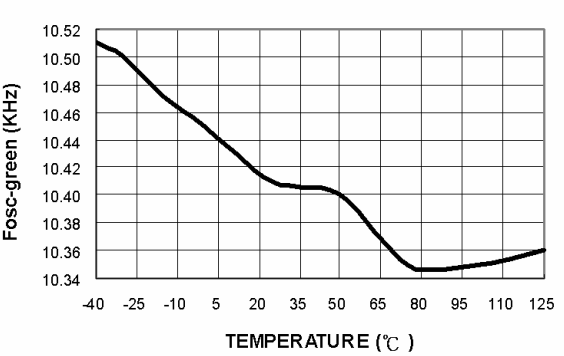
Start-up Current ($I_{DD\ ST}$) vs VDD Voltage



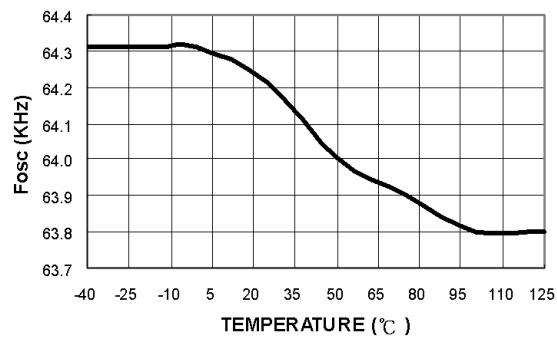
FB Voltage vs Frequency



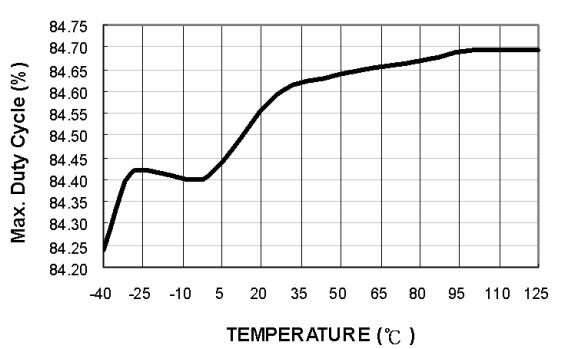
Frequency in green mode (Fosc-green) vs Temperature

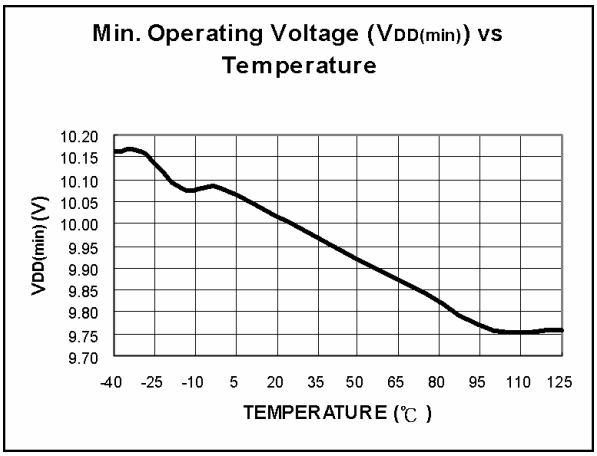


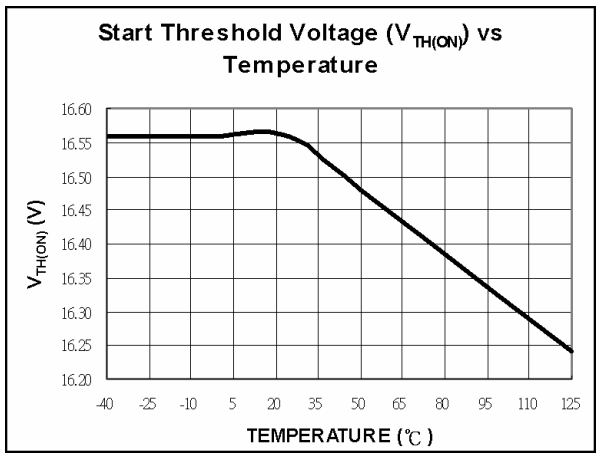
PWM Oscillator Frequency (Fosc) vs Temperature

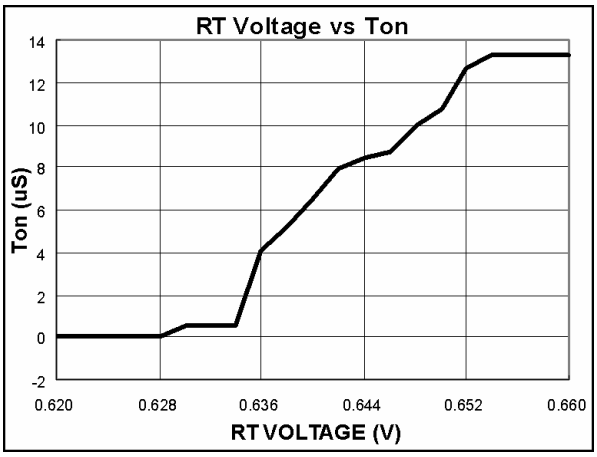


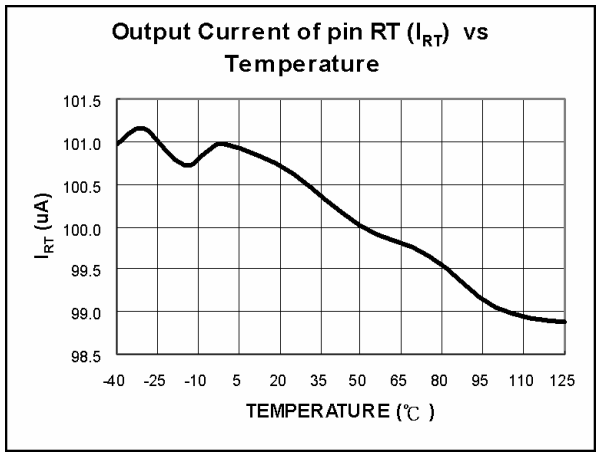
Maximum Duty Cycle DC($_{MAX.}$)vs Temperature

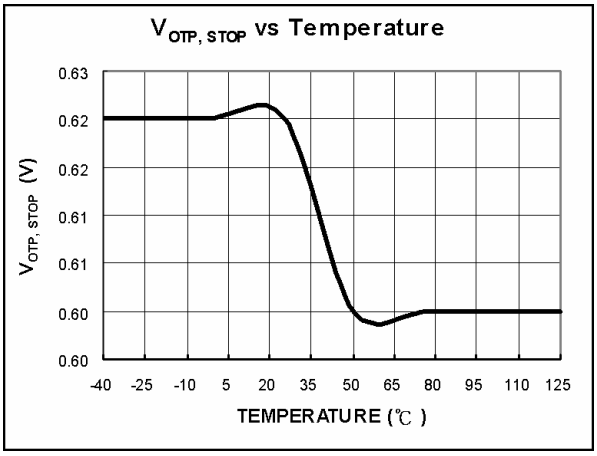












OPERATION DESCRIPTION

●Start-up Current

Typical start-up current is only 30uA. This ultra low start-up current allows users to use a high resistance, and low-wattage, start-up resistor to supply the start-up power required by SG6841. Take a wide input-range (100V_{AC}~240V_{AC}) of AC-to-DC power adapter as an example, an 1.5 MΩ, 0.25W, start-up resistor and a 10uF/25V VDD hold-up capacitor are enough for this application.

●Operating Current

Operating current has been reduced to 3mA. The low operating current enables a better efficiency and reduces the requirement of VDD hold-up capacitance.

●Green Mode Operation

The patented green-mode function provides an off-time modulation to reduce the switching frequency in the light load and no load conditions. The feedback voltage, which is derived from the voltage feedback loop, is taken as the reference. Once the feedback voltage is lower than the threshold voltage, switching frequency will linearly decrease until the minimum green mode frequency around 10kHz (R_i =26kΩ). We can find that all of the losses are in proportional to the switching frequency, such as the switching loss of the transistor, the core loss of the transformer and inductors, and the power loss of the snubber, etc. The off-time modulation in the PWM controller can reduce the power consumption of the power supply in light load and no load conditions. In normal load and high load conditions, the PWM frequency is at its maximum frequency around 65kHz (R_i =26kΩ) and not affected by the off-time modulation.

●Oscillator Operation

An external resistor R_i determines the PWM oscillation frequency. A 26kΩ resistor R_i creates a 50uA constant current I_i and generates 65kHz switching frequency.

I_i (mA) = 1.3V / R_i (kΩ);

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

The range of the PWM oscillation frequency is designed as 50kHz ~ 100kHz.

●Current sensing and PWM current limiting

SG6841 consists of two feedback loops: voltage loop and current loop, to control the load regulation. SG6841's current sense input is designed for the current-mode control. A current-to-voltage conversion is done externally through a current-sense resistor Rs. Under normal operation, the FB voltage V_{FB} controls the peak voltage across the sense resistor Rs, hence the PWM duty cycle, as follows:

Ipk = (V_{FB} – 1.4) / 5Rs;
where V_{FB} is the voltage on pin FB
5 is the resistor dividing ratio

When the DC output voltage of secondary side decreases due to heavy load conditions, the FB voltage V_{FB} will increase such that the PWM duty cycle increases to regulate the output voltage of secondary side back to its normal voltage. The inverting input to SG6841's current-sense comparator is internally clamped to a variable voltage around 0.85V (note: see Constant Output Power Limit section). The current limiting occurs if the voltage of SENSE pin reaches this 0.85V threshold value, such as Ipk (max) = 0.85V/Rs. The value of sense resistor Rs decides the maximum power limit. Larger Rs, whose Ipk is smaller, results in a smaller power limit.

●Leading Edge Blanking

Each time when the power MOSFET is switched on, a leading spike is generated due to parasitic capacitance. To avoid premature termination of the switching pulse, this leading edge spike is blanked out with a time constant 270 nsec. During this time period, the current-limit comparator is disabled and cannot switch off the gate drive regardless how big the SENSE voltage is.

●Under-voltage lockout (UVLO)

The UVLO Under-Voltage Lockout (UVLO) function ensures the supply voltage V_{DD} for SG6841 is adequate to fully function before enabling the output stage. The turn-on and turn-off threshold voltages are fixed internally at 16V/10V. The hysteresis voltage between turn-on and turn-off prevents V_{DD} from being unstable during power on/off sequencing. Start-up current is typically 30uA for efficient bootstrapping from the rectified input for an off-line converter. During the normal operation, V_{DD} is developed from an auxiliary winding of the transformer. At the moment of start-up, V_{DD} hold-up capacitor C_{IN} must be charged up to 16V through the start-up resistor R_{IN} before enabling the output switch. With an ultra small start-up current of 30uA, R_{IN} can be as large as 1.5 MΩ and still be able to charge up the hold-up capacitor C_{IN} even when V_{AC} = 90Vrms. Power dissipation of this large resistance R_{IN} would then be less than 70mW (0.07W) even under high line (V_{AC} = 240Vrms) conditions. After the IC is start-upped and in normal operation, the supply voltage V_{DD} is generated from the transformer's auxiliary winding to supply the operation current of SG6841.

●Gate Output / Soft Driving

The SG6841 BiCMOS output stage is a fast totem pole gate driver, which is designed to avoid cross conduction current. This minimizes heat dissipation, increases efficiency and enhances reliability. The output driver is clamped by an internal 18V Zener diode in order to improve the control of the power MOSFET transistors and protect them against undesirable gate over-voltage. By controlling the rising time of the switch-on waveform and falling shape of the switch-off waveform, the output stage is optimized to

reduce switching noise, improve EMI, and to provide a stable MOSFET gate drive.

●Built-in Slope Compensation

Current mode control regulates the peak transformer/ inductor current via the current control loop. In a continuous mode operation, the current is the average current, and composed of both AC and DC components. Since the output is proportional to the average, not the peak current, this causes oscillation when input voltage is changed. Adding the slope compensation to the current loop (reduce the current loop gain) to correct the problem is a simple approach. The SG6841 inserts a synchronized 0.33V positive-going ramp at every switching cycle to stabilize the current loop. Vs-comp = 0.33V.

●Constant Output Power Limit

Every time when the SENSE voltage, across the sense resistor Rs, is larger than the threshold voltage around 0.85V, the output GATE drive is turned off after a small propagation delay t_D. Since the propagation delay is constant regardless the input line voltage V_{IN}, the output power would not be equal for the wide input voltage V_{IN} of 90Vrms to 265Vrms. To compensate the different output power limit between high line voltage and low line voltage, the internal threshold voltage is adjusted dependent on the input line voltage V_{IN} through the VIN pin. The threshold voltage is decreased from 0.85V to a smaller voltage when input line voltage V_{IN} increases. Smaller threshold voltage, at higher input line voltage, forces the output GATE drive to terminate earlier, thus reduce the total PWM turn-on time and make the output power equal to that of low input line voltage.

●Thermal Protection

A constant current I_{RT} is output from pin RT. The resistor in pin Ri decides the current I_{RT}.

I_{RT} = 2 x (1.3V / Ri);

An NTC thermistor Rntc in series with a resistor Ra can be connected from pin RT to ground. The over-temperature protection is enabled as,

I_{RT} × (Rntc + Ra) < 0.65V

When the voltage on RT pin is less than 0.65V ($V_{OTP,START}$) due to high ambient temperature, the PWM duty cycle starts to decrease. The decreasing of the PWM duty cycle will lower down the SMPS power output level, such that the temperature will start to decrease. If the over heating situation getting worse and the temperature continue climbing, the RT voltage decreases further to 0.62V ($V_{OTP,STOP}$), then the PWM duty cycle drops to 0% and the SMPS is completely turned off.

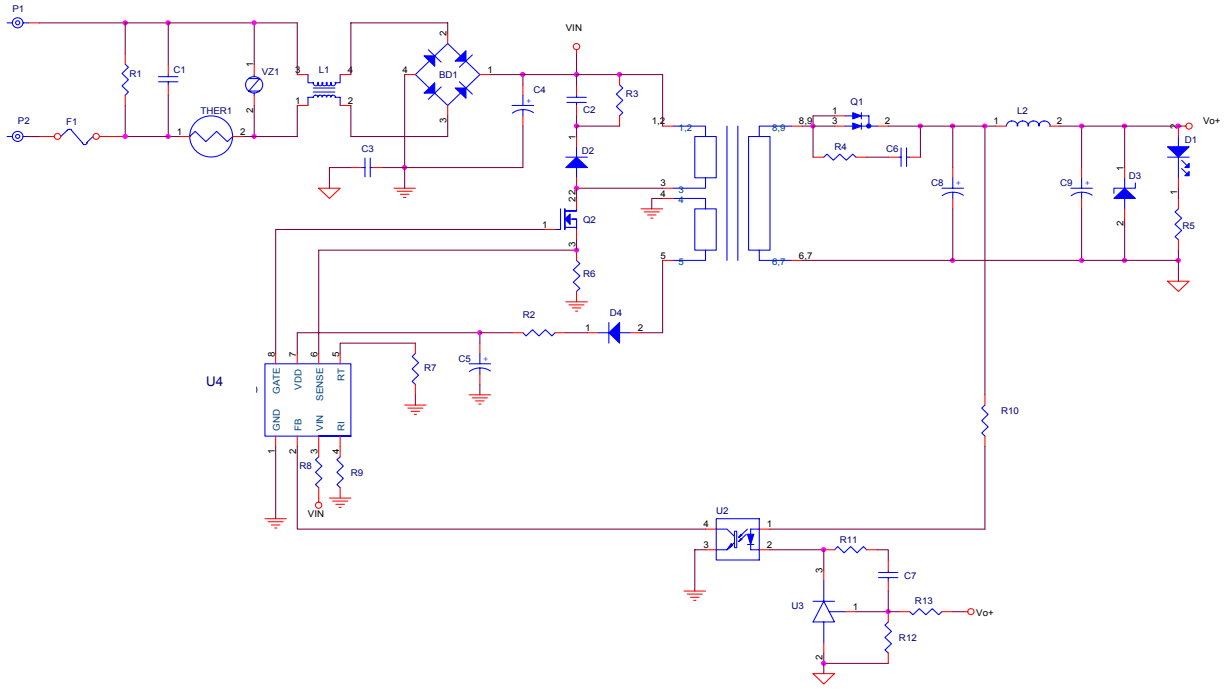
●Limited Power Control

The built-in limited power controller provides an over-power protection and supports the limited power source for safety requirement. The current limiting occurs if the current-sense input of SG6841 reaches the threshold value, e.g. 0.85V. When this current limiting condition last more than a period of delay (31msec, T*delay-lps*), the limited power controller will disable the PWM output and latch the SG6841 into the shutdown mode. The latch condition will be reset when VDD is discharged lower than the turn-off threshold such as10V, and SG6841 will be enabled again once VDD is charged up to the turn-on threshold voltage 16V. The limited power controller provides this protection function for the power supply to limit output duty-cycle, and limits total power output during the over-power conditions.

●Noise immunity

Noise on the current sense or control signal can cause significant pulse width jitter, particularly with the continuous-mode operation. While slope compensation helps alleviate this problem. Note that the SG6841 has a single ground pin. High sink current in the output therefore cannot be returned separately. Good high frequency or RF layout practices should be followed. Avoid long PCB traces and component leads. Locate components such as Ri, Rt and VDD capacitor near to the SG6841. The noise, which often causes the problem, is caused by the output (pin 8) being pulled below ground at turn-off by external parasitic. This is particularly true when driving MOSFET. A resistor (10 ~ 20 ohms) series connected from the output (pin 8) to the gate of MOSFET will prevent such output noise.

APPLICATION 1

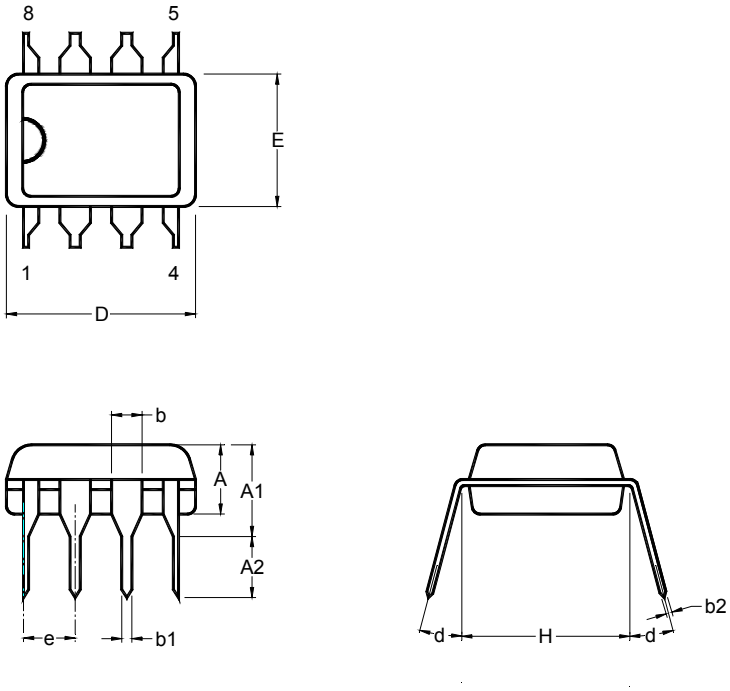


BOM

Reference	Component	Reference	Component
BD1	BD 1A/600V	Q2	MOS 2A/600V
C1	XC 0.22u	R1,R2	R 470KΩ 1/4W
C2	EC 0.1u 250V	R3	R 47Ω 1/4W
C3,C6,C7	YC 222p	R4	R 22Ω 1/4W
C4	EC 68u/400V	R5	R 4.7KΩ 1/4W
C5	CC 102p/1KV	R6	R 0.5Ω 1W
C8	EC 1200u/16V	R8,R12	R 510KΩ 1/4W
C9	EC 680u/16V	R9	R 20KΩ 1/8W 1%
C10	EC 10u/25V	R10	R 100Ω 1/8W
D1	LED	THER1	Thermistor SCK054
D3	ZD 12V	T1	Transformer EI28
F1	FUSE 2A/250V	U1	IC SG6841
L1	UU10.5	U2	IC 4N35D
L2	L04	U3	IC TL431
Q1	DIODE	VZ1	VZ 9G

MECHANICAL DIMENSIONS

●8 PINS – PLASTIC DIP (D)

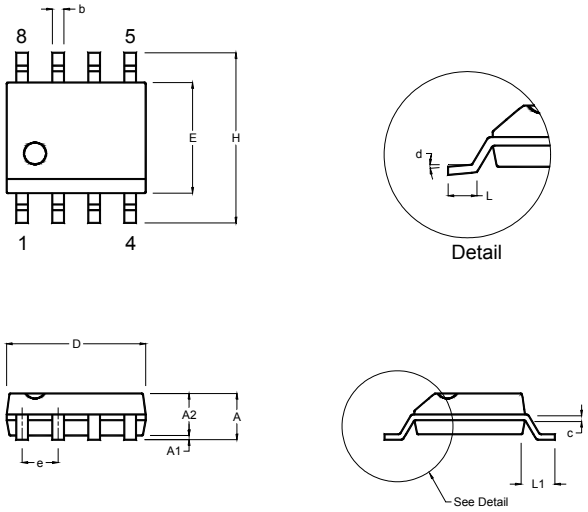


●Dimension:

Symbol	Millimeter			Inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A		3.4			0.134	
A1			4.5			0.177
A2	3.0			0.118		
b		1.5			0.059	
b1	0.4	0.5	0.6	0.016	0.020	0.024
b2	0.25	0.3	0.4	0.010	0.012	0.016
d	0°		15°	0°		15°
D		9.3			0.366	
E		6.5			0.256	
e	2.29	2.54	2.79	0.090	0.100	0.110
H		7.6			0.299	

MECHANICAL DIMENSIONS

●8 PINS – PLASTIC SMD (S)



●Dimension:

Symbol	Millimeter			Inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	1.35	1.63	1.75	0.053	0.064	0.069
A1	0.10	0.15	0.25	0.004	0.006	0.010
A2	1.30	1.40	1.50	0.051	0.055	0.059
b	0.33	0.41	0.51	0.013	0.016	0.020
c	0.19	-	0.25	0.007	-	0.010
d	0°	-	8°	0°	-	8°
D	4.80	4.90	5.00	0.189	0.193	0.197
E	3.80	3.90	4.00	0.150	0.154	0.157
e	-	1.27	-	-	0.050	-
H	5.80	6.00	6.20	0.228	0.236	0.244
L	0.40	0.64	1.27	0.016	0.025	0.050
L1	-	1.07	-	-	0.042	-
Y	-	-	0.10	-	-	0.004