Highly-Integrated Green-Mode PWM Controller **SG6841x3**

FEATURES

- Continuously Decreasing PWM Frequency
- Low Start-Up Current (8uA)
- Low Operating Current (4mA)
- Peak-current-mode Control
- Cycle-by-Cycle Current Limiting
- Programmable PWM frequency
- Leading-Edge Blanking
- Synchronized Slope Compensation
- Constant Power Limit (Full AC Input Range)
- Totem Pole Output with Soft Driving
- Programmable Over Temperature Protection (OTP)
- Internal Open-loop Protection
- V_{DD} Under-voltage Lockout (UVLO)
- GATE Output Maximum Voltage Clamp (18V)

APPLICATIONS

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

- Power Adapters
- Open-Frame SMPS

DESCRIPTION

The highly integrated SG6841x3 series of PWM controllers provides several features to enhance the performance of flyback converters.

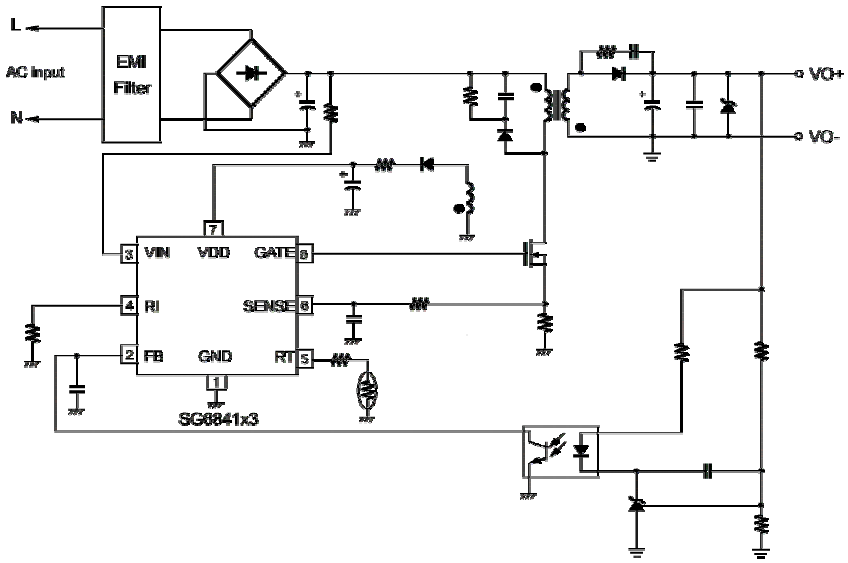
To minimize standby power consumption, a proprietary green-mode function provides off-time modulation to continuously decrease the switching frequency at light-load conditions. This green-mode function enables the power supply to easily meet international power conservation requirements. To further reduce power consumption, SG6841x3 is manufactured by using the BiCMOS process. This allows the lowest start-up current around 8uA, and the operating current is only 4mA. As a result, large start-up resistance can be used.

SG6841x3's built-in synchronized slope compensation achieves stable peak-current-mode control. The proprietary internal line compensation ensures constant output power limit over a wide AC input voltages, from 90VAC to 264VAC.

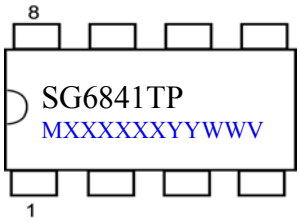
SG6841x3 provides many protection functions. In addition to cycle-by-cycle current limiting, the internal open-loop protection circuit ensures safety should an open-loop or output-short-circuit failure occur. PWM output is disabled till V_{DD} drops below the UVLO lower limit. Then, the controller starts up again. For OTP, an external NTC thermistor can be applied for over-temperature protection.

SG6841x3 is available in an 8-pin DIP or SOP package.

TYPICAL APPLICATION

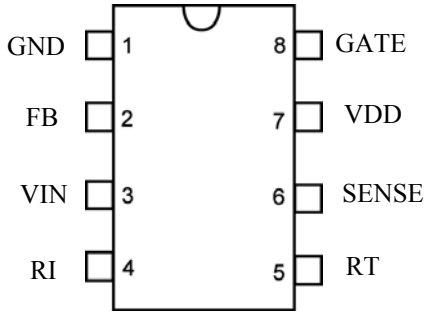


MARKING DIAGRAMS



T: D = DIP, S = SOP
P : Z =Lead Free + ROHS Compatible
M: Mask Version
XXXXXX: Wafer Lot
YY: Year; WW: Week
V: Assembly Location

PIN CONFIGURATION



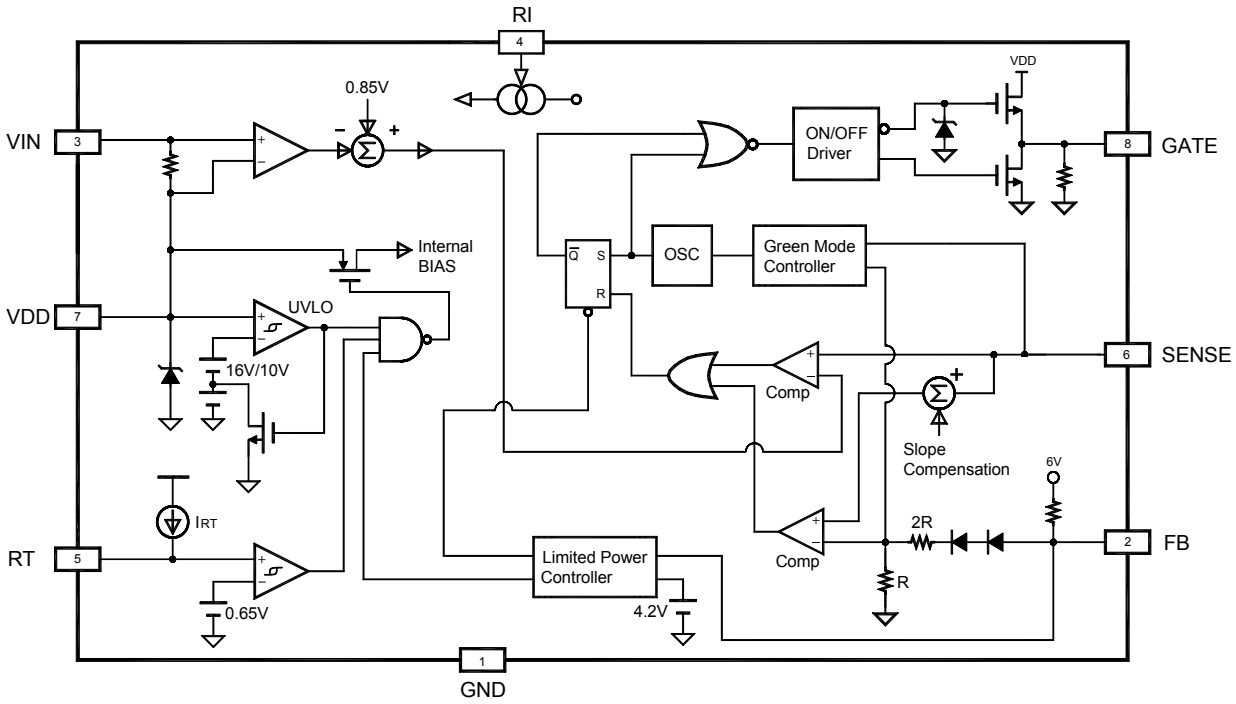
ORDERING INFORMATION

Part Number	Package
SG6841SZ3	8-Pin SOP (Lead Free)
SG6841DZ3	8-Pin DIP (Lead Free)

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. The PWM duty cycle is determined in response to the signal on this pin and the current-sense signal on Pin 6.
3	VIN	Start-Up Input	For start-up, this pin is pulled high to the line input via resistors. A large start-up resistance can be used to minimize power loss. This pin also serves to detect the line voltage for output-power-limit compensation.
4	RI	Reference Setting	A resistor connected from the RI pin to ground sets the internal reference current of SG6841x3. This determines the PWM frequency, open-loop-protection delay time, and RT pin current out. Increasing the resistance decreases the internal reference current, and thereby reduces the PWM frequency and delay time.
5	RT	Temperature Detection	An external NTC thermistor is connected from this pin to ground for over-temperature protection. The impedance of the NTC decreases at high temperatures. Once the voltage of the RT pin drops below a fixed limit, PWM output will be disabled.
6	SENSE	Current Sense	Current sense. The sensed voltage is used for peak-current-mode control and cycle-by-cycle current limiting.
7	VDD	Power Supply	Power Supply. The internal protection circuit disables PWM output as long as V_{DD} exceeds the OVP trigger point.
8	GATE	Driver Output	The totem-pole output driver. Soft driving waveform is implemented for improved EMI.

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Test Condition		Value	Unit
V_{DD}	Supply Voltage			30	V
V_{IN}	Input Terminal			30	V
V_L	Input Voltage to FB, SENSE, RT, RI, CS Pin			-0.3 to 7V	mA
P_D	Power Dissipation	T_A < 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			-40 to +125	°C
T_{STG}	Storage Temperature Range			-55 to +150	°C
T_L	Lead Temperature (Soldering)	10 sec 10 sec	DIP SOP	260 230	°C
	ESD Capability, HBM Model			3.0	kV
	ESD Capability, Machine Model			250	V

*All voltage values, except differential voltages, are given with respect to GND pin.

* Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device.

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Value	Unit
T_A	Operating Ambient Temperature	-20 to +85	°C
R_I	Current source Setting	26	kohms

ELECTRICAL CHARACTERISTICS (VDD = 15V, T_A = 25°C, unless noted)

VDD Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_{OP}	Continuously Operating Voltage				24.7	V
V_{TH-ON}	On Threshold Voltage		15	16	17	V
V_{TH-OFF}	Off Threshold Voltage		9	10	11	V
I_{DD-ST}	Start-up Current	V_{DD} = 14.5V			30	uA
I_{DD-OP}	Operating Supply Current	V_{DD} = 15V, RI = 26kΩ, GATE = open		4	5	mA
T_{OVP}	V_{DD} Over-voltage-protection Debounce	RI = 26kΩ		100		uS

RI Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
RI_{NOR}	R_I Operating Range		13		36	kΩ
RI_{MAX}	Max. R_I value for Protection			1		MΩ
RI_{MIN}	Min. R_I value for Protection			6		kΩ

Oscillator Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
F_{OSC}	Normal PWM Frequency	RI = 26kΩ	62	65	68	kHz
$F_{OSC-G-MIN}$	Green-Mode Min. Frequency	RI = 26kΩ	4	10	16	kHz
F_{DV}	Frequency Variation Versus V_{DD} Deviation	VDD = 11.5V to 22V			5	%

F_{DT}	Frequency Variation Versus Temp. Deviation	T_A = -30°C ~ 85°C			5	%

Feedback Input Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
A_V	FB Input to Current Comparator Attenuation		1/3.75	1/3.2	1/2.75	V/V
Z_{FB}	Input Impedance		4		7	kΩ
V_{HIGH}	Output High Voltage	FB pin open	5	6		V
V_{FB-OL}	FB Open-loop Trigger Level		4.2	4.5	4.8	V
T_{OLP}	FB Open-loop Protection Delay	RI = 26kΩ	26	29	32	mS
V_N	Green-mode Entry FB Voltage	RI = 26kΩ		2.1		V
V_G	Green-mode Ending FB Voltage			V_N - 0.5		V
V_{ZERO}	Zero-duty FB Voltage			V_N - 0.7		V
I_{ZERO}	Zero-duty FB Current				1.5	mA

Current-Sense Section

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
Z_{CS}	Input Impedance			12		kΩ
V_{TH80}	Threshold voltage for current limit@80uA	I_{VIN} = 80uA, RI = 26kΩ	0.81	0.84	0.87	V
V_{TH160}	Threshold voltage for current limit@160uA	I_{VIN} = 160uA, RI = 26kΩ	V_{TH80}-55	V_{TH80}-70	V_{TH80}-85	mV
T_{PD}	Propagation Delay to GATE Output			150	200	nS
T_{LEB}	Leading Edge Blanking Time		200	270	350	nS
V_{SLOPE}	Slope Compensation	SENSE = 2kΩ, Duty = DCY_{MAX}		0.37		V

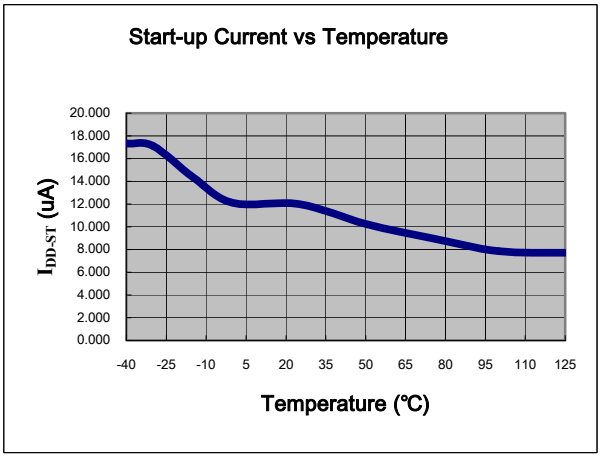
GATE Section

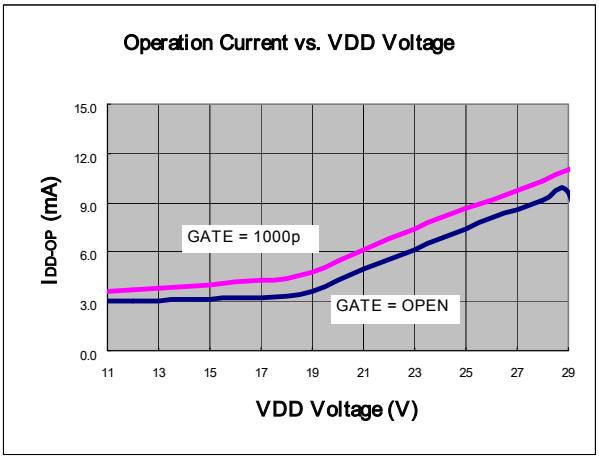
Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
DCY_{MAX}	Maximum Duty Cycle		80	85	90	%
V_{OL}	Output Voltage Low	V_{DD} =15V, I_O = 50mA			1.5	V
V_{OH}	Output Voltage High	V_{DD} =12V, I_O = 50mA	8V			V
T_R	Rising Time	V_{DD} =15V, C_L = 1nF	150	250	350	nS
T_F	Falling Time	V_{DD} =15V, C_L = 1nF	30	50	90	nS
V_{clamp}	Gate Output Clamping Voltage	V_{DD} = 22V		18	19	V

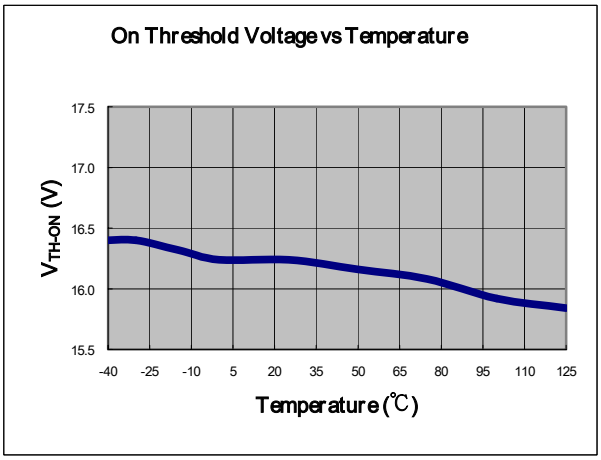
RT Section

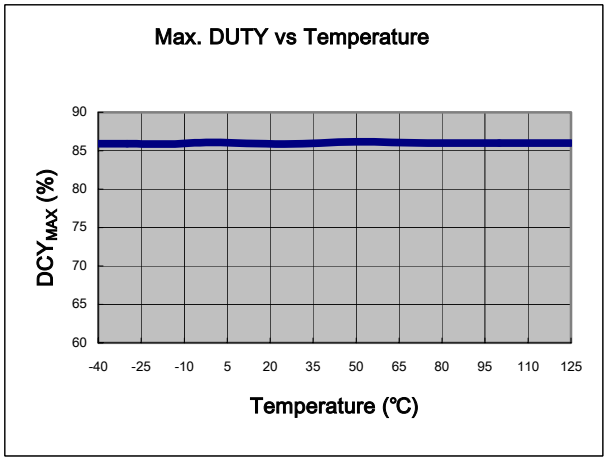
Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
I_{RT}	Output Current of RT pin	RI = 26kΩ	92	100	108	uA
$V_{OTP-STOP}$	Trigger Voltage for Over-temperature Protection		0.585	0.62	0.655	V
$V_{OTP-RLS}$	OTP Release Voltage			$V_{OTP-STOP}$ +0.03		V

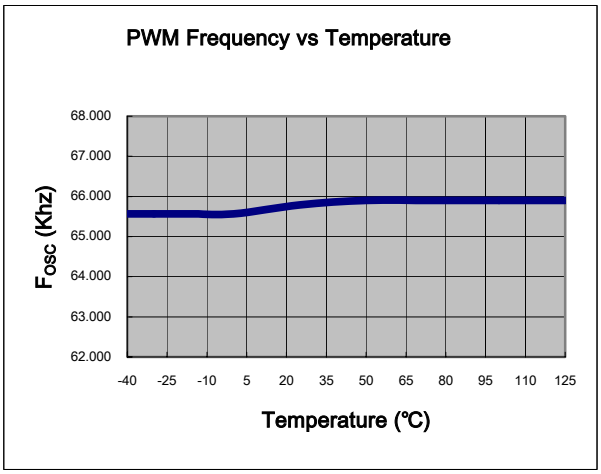
TYPICAL CHARACTERISTIC

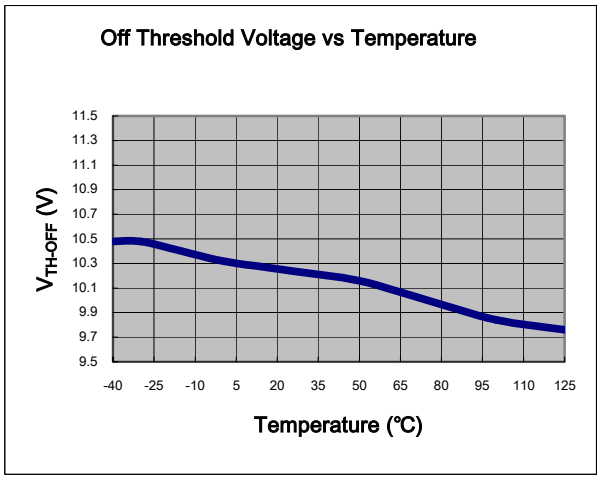


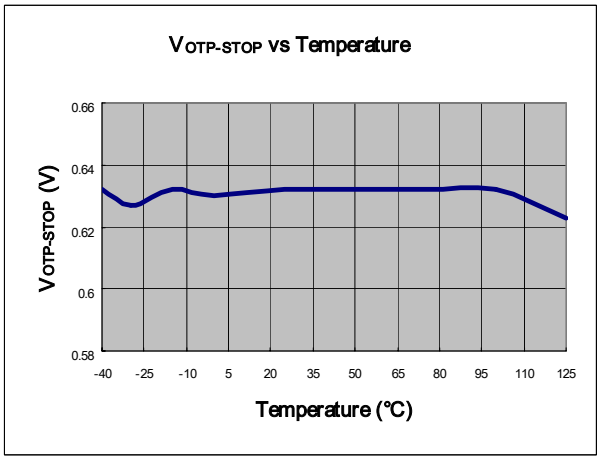


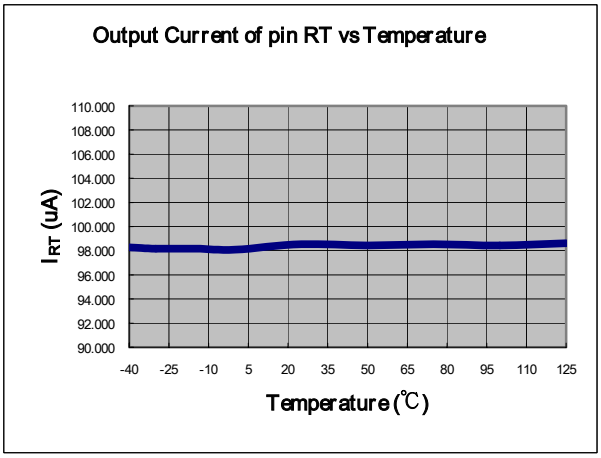


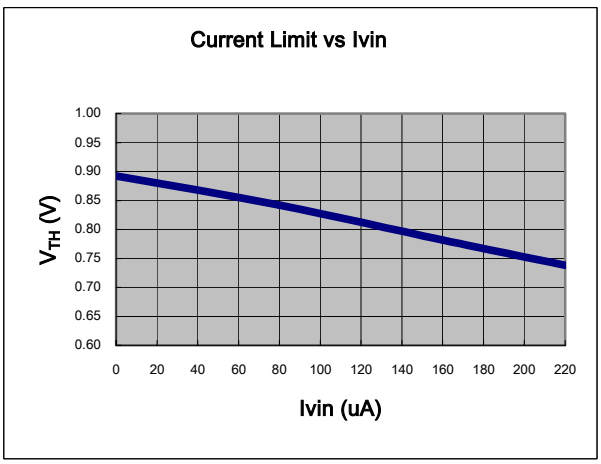







VOTP-STOP vs Temperature
VOTP-STOP (V)
0.66
0.64
0.62
0.6
0.58
-40 -25 -10 5 20 35 50 65 80 95 110 125
Temperature (°C)


Output Current of pin RT vs Temperature
IRT (uA)
110.000
108.000
106.000
104.000
102.000
100.000
98.000
96.000
94.000
92.000
90.000
-40 -25 -10 5 20 35 50 65 80 95 110 125
Temperature (°C)


Current Limit vs Ivin
VTH (V)
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0 20 40 60 80 100 120 140 160 180 200 220
Ivin (uA)

OPERATION DESCRIPTION

Start-up current

Typical start-up current is only 8uA so that a high resistance, and low-wattage, start-up resistor can be used to minimize power loss. For an AC/DC adapter with universal input range, a 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 is around 4mA. 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 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 will be continuously decreased to the minimum green mode frequency around 10kHz (RI =26kΩ).

Oscillator Operation

A resistor from RI pin to ground will generate a constant current source. This current is used to charge an internal capacitor and hence the internal clock and switching frequency are determined. Increase the resistance will decrease the current source and reduce the switching frequency. A 26kΩ resistor creates a 50uA constant current and generates 65kHz switching frequency. The relation between R_I and switching freauency is:

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

The range of the PWM oscillation frequency is designed as 47kHz ~ 130kHz.

Current sensing and PWM current limiting

Peak-current-mode control is utilized in SG6841x3 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 $V_{COMP} = (V_{FB}–1.0)/3$, a switch cycle will be terminated immediately. V_{COMP} is internally clamped to a variable voltage around 0.85v for output power limit.

Leading Edge Blanking

Each time when the power MOSFET is switched on, a turn-on spike will inevitably occur 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 threshold of SG6841x3 are fixed internally at 16V/10V. During start-up, the hold-up capacitor must be charged to 16V through the start-up resistor so that IC will be enabled. The hold-up capacitor will continue to supply V_{DD} before the energy can be delivered from auxiliary winding of the main transformer. V_{DD} must not drop below 10V during this start-up process. This UVLO hysteresis window insures that hold-up capacitor is adequate to supply V_{DD} during start-up.

Gate Output / Soft Driving

The SG6841 BiCMOS output stage is a fast totem pole gate driver. Cross conduction has been avoided to minimize heat dissipation, increases efficiency and enhances reliability. The output driver is clamped by an internal 18V Zener diode in order to protect power MOSFET transistors against undesirable gate over voltage. A soft driving waveform is implemented to minimize EMI.

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 will improve stability or prevent sub-harmonic oscillation.

SG6841x3 inserts a synchronized positive-going ramp at every switching cycle.

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 after a small delay t_D. This delay will introduce an additional current proportional to t_D* V_{IN} / L_P. Since the delay is nearly constant regardless of the input voltage $V_{IN.}$ Higher input voltage will result in a larger additional current and hence the output power limit is also higher than that under low input line voltage. To compensate this variation for wide AC input range, the threshold voltage is adjusted by the VIN current. Since VIN pin is connected to the rectified input line voltage through the start-up resistor, a higher voltage will generate higher current into the VIN pin. The threshold voltage is decreased if the current is increased. Smaller threshold 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 line input. This proprietary internal compensation ensures a constant output power limit for wide AC input voltage from 90VAC to 264VAC.

Thermal Protection

An NTC thermistor R_{NTC} in series with a resistor Ra can be connected from pin RT to ground. A constant current I_{RT} is output from pin RT. The voltage on RT pin can be expressed as $V_{RT} = I_{RT} \times (R_{NTC} + Ra)$, in which $I_{RT} = 2 \times (1.3V / R_I)$.

At high ambient temperature, R_{NTC} will be smaller such that V_{RT} will decrease. When V_{RT} is less than 0.65V, the PWM will be completely turned off.

Limited Power Control

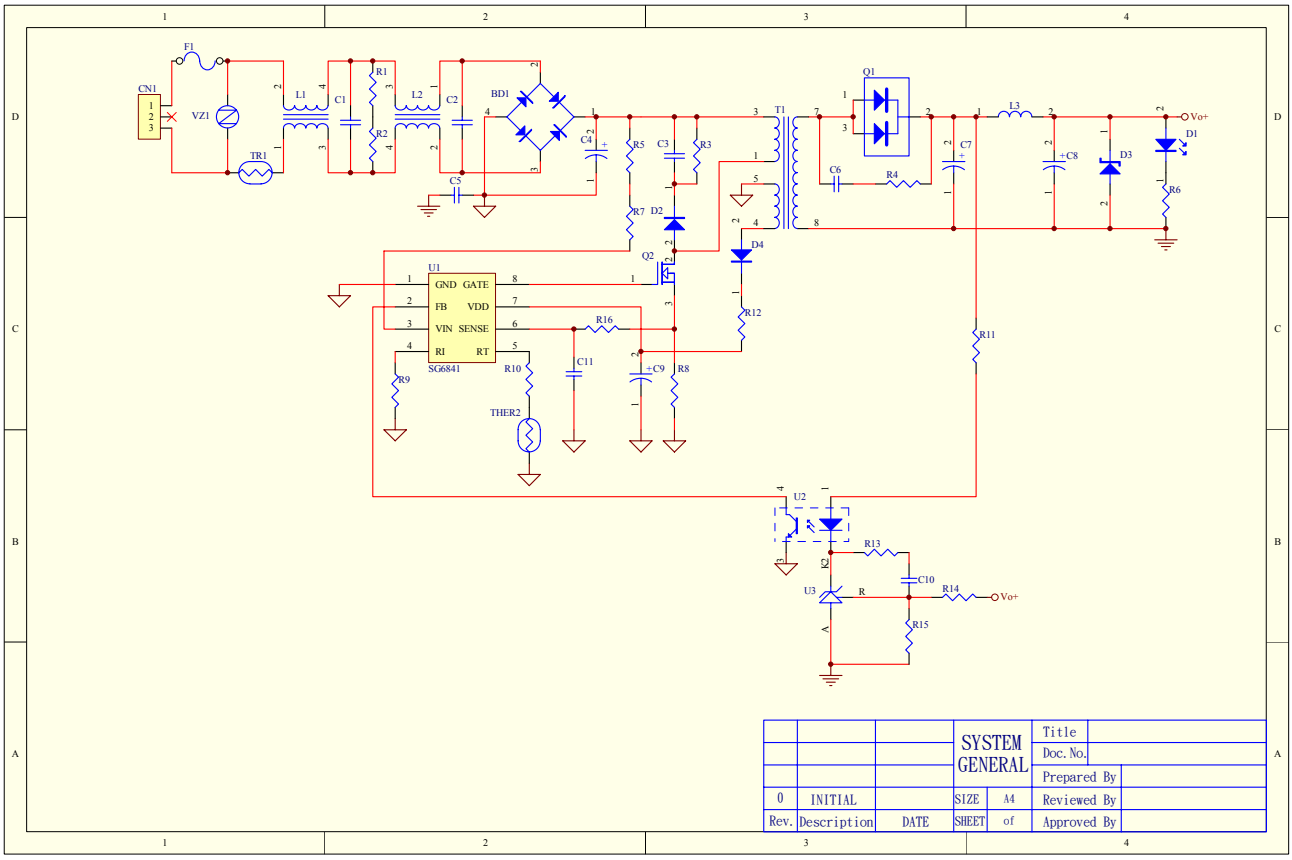
Every time when the output of power supply is shorted or over loaded, the FB voltage will increase. If the FB voltage is higher than a designed threshold, 4.2V, for longer than 29mS, the PWM output will then be turned off eternally. V_{DD}, the supply voltage for SG6841x3, will decrease due to the supply current. When V_{DD} is lower than the turn-off threshold such as 10V, SG6841x3 will be totally shut down. Due to the start up resistor, V_{DD} will be charged up to the turn-on threshold voltage 16V until SG6841x3 is enabled again. If the over loading condition still exists, above protection will take place repeatedly. This will prevent the power supply from being overheated under over loading condition.

Noise immunity

Noise on the current sense or control signal may cause significant pulse width jitter, particularly in the 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 to the SG6841x3, and increasing the power MOS gate resistance will always help.

REFERENCE CIRCUIT

Circuit

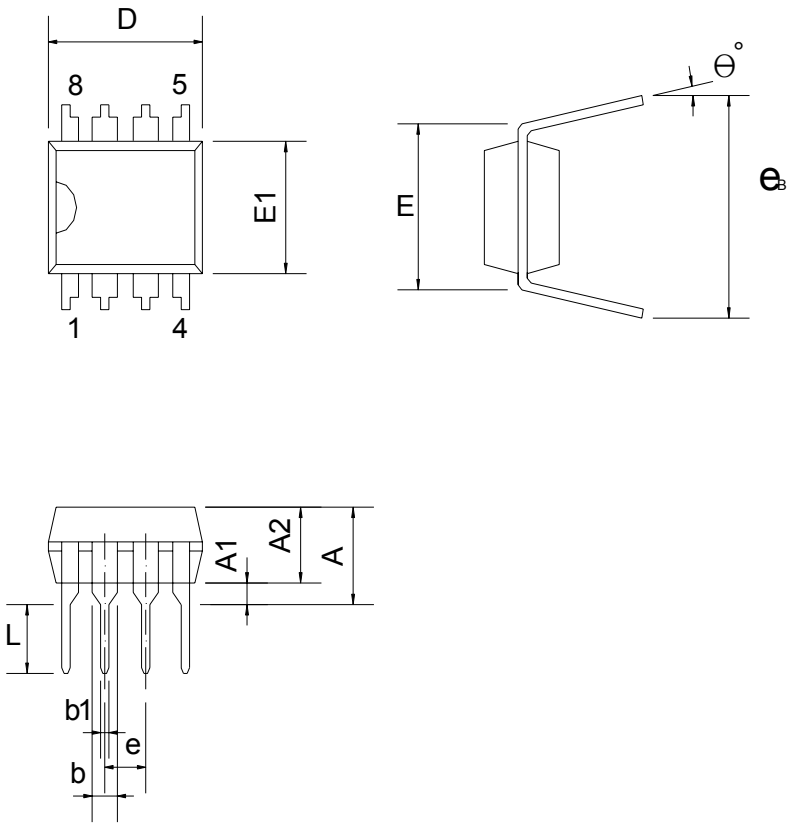


BOM

Reference	Component	Reference	Component
BD1	BD 4A/600V	R1,R2	R 1Mohm 1/4W
C1	XC 0.1uF/275V	R3	R 100Kohm 1/2W
C2	XC 0.22uF/275V	R4	R 47ohm 1/4W
C3	CC 0.01uF/500V	R5,R7	R 750Kohm 1/4W
C4	EC 120u/400V	R6	R 20Kohm 1/8W
C5	YC 222p/Y1	R8	R 0.3ohm 2W
C6	CC 1000pF/100V	R9	R 33Kohm 1/8W
C7	CC 1000pF/50V	R9	R 20Kohm 1/8W 1%
C8	EC 1000uF/35V	R11	R 220ohm 1/8W
C9	EC 220uF/35V	R12	R 4.7ohm 1/8W
C11	CC 470pF/50V	R13	R 6.8Kohm 1/8W
D1	LED	R14	R 154Kohm 1/8W
D2	Diode FR157	R15	R 390Kohm 1/8W
D3	ZD 18V	R16	R 100ohm 1/8W
D4	Diode FR102	THER1	Thermistor SCK054
F1	FUSE 4A/250V	T1	Transformer
L1	900uH	U1	IC SG6841x3
L2	15mH	U2	IC PC817
Q1	Diode 20A100V	U3	IC TL431
Q2	MOS 7A/600V	VZ1	VZ 9G

PACKAGE INFORMATION

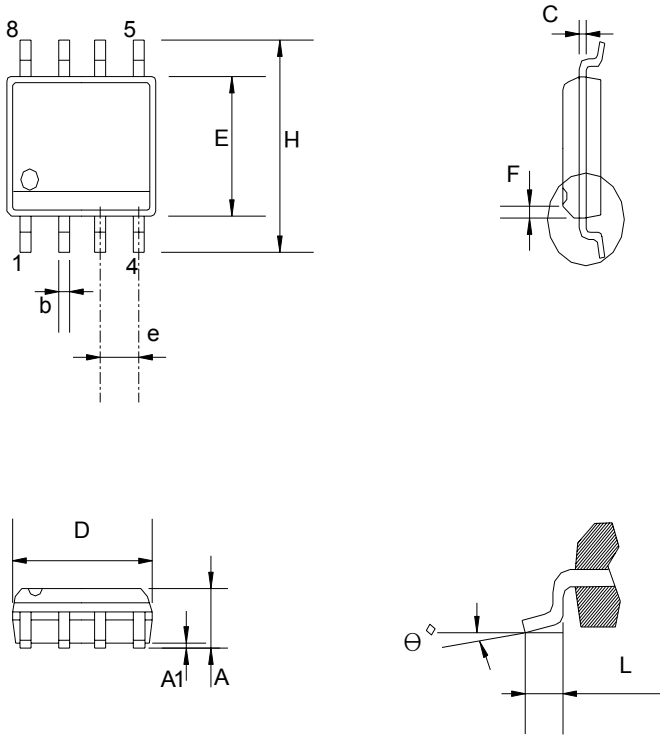
8 PINS-DIP(D)



Dimensions

Symbol	Millimeters			Inches		
	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
eB	8.509	9.017	9.525	0.335	0.355	0.375
θ°	0°	7°	15°	0°	7°	15°

8 PINS-SOP(S)



Dimensions

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	3.810		3.987	0.150		0.157
e	1.016	1.270	1.524	0.040	0.050	0.060
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°

DISCLAIMERS

LIFE SUPPORT

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