Highly Integrated Green-Mode PWM Controller **SG6846A**

FEATURES

- Two-level OCP with 1700ms delay time
- Output short-circuited delay time: 100ms
- Low start-up current (8µA)
- Low operating current (3.7mA)
- Peak-current mode operation with cycle-by-cycle current limiting
- Programmable PWM frequency with frequency hopping
- PWM frequency continuously decreasing with burst mode at light loads
- V_{DD} over-voltage protection (OVP)
- AC input brownout protection with hysteresis and constant output power limit
- Constant output power limit (full AC input range)
- Internal latch circuit for OVP, OTP, and OCP
- Built-in soft-start
- Open-loop protection with 1700ms delay time

APPLICATIONS

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

- Power adapters
- Open-frame SMPS
- Specifically fit for SMPS with surge-current output (such as for printers, scanners, motor drivers, etc.)

DESCRIPTION

The highly integrated SG6846A series of PWM controllers provides 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 under light-load conditions. Under zero-load conditions, the power supply enters burst-mode.

The SG6846A is especially designed for SMPS with surge-current output, incorporated with a two-level OCP function. Besides the cycle-by-cycle current limiting, if the switching current is higher than two thirds the peak-current threshold for 1700ms, over-current protection is activated and the SG6846A latches off.

If the switching current is higher than two thirds the peak-current threshold for 100ms and the voltage on the VDD pin is higher than V_{DD-OFF} + 1V, the PWM pulses are latched off immediately once V_{DD} voltage is lower than V_{DD-OFF} + 1V; useful if an output short-circuit occurs.

SG6846A also integrates a frequency hopping function that reduces EMI emission of a power supply with minimum line filters. Its built-in synchronized slope compensation provides proprietary internal compensation for constant output power limit over a universal AC input range. Also, the gate output is clamped at 18V to protect the external MOSFET from over-voltage damage. Internal soft-start is built-in to reduce stress on the MOSFET and start-up current during power-on period.

Other protection functions include: AC input brownout protection with hysteresis, V_{DD} over-voltage protection, and over-temperature protection. For over-temperature protection, an external NTC thermistor can be applied to sense the ambient temperature. When OCP, V_{DD} OVP, or OTP are activated, an internal latch circuit is used to latch-off the controller. The PWM pulses stay latched off until the power supply is unplugged from the main outlet.

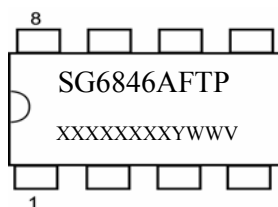SG6846A is available in an 8-pin SOP package.

TYPICAL APPLICATION

MARKING DIAGRAMS

SG6846AFTP

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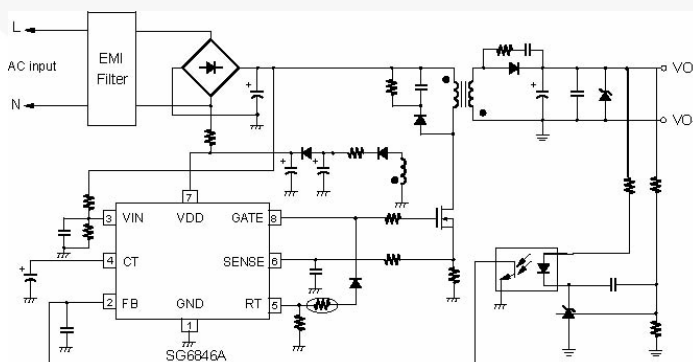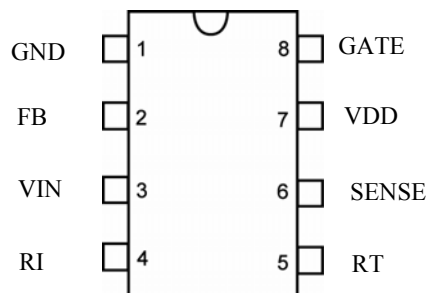
F: L=OCP Latch, C=OCP
   auto-recovery
T: S=SOP
P : Z=Lead Free
   Null=regular package
XXXXXXXX: Wafer Lot
Y: Year; WW: Week
V: Assembly Location

PIN CONFIGURATION

GND	1	8	GATE
FB	2	7	VDD
VIN	3	6	SENSE
RI	4	5	RT

ORDERING INFORMATION

Part Number	OCP Latch	Pb-Free	Package
SG6846ALSZ	Yes	🌿	8-Pin SOP
SG6846ACSZ (Preliminary)	No	🌿	8-Pin SOP

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 from this pin and the current-sense signal from Pin 6.
3	VIN	Line-voltage Detection	Line-voltage detection. The line-voltage detection is used for brownout protection with hysteresis. Constant output power limit over a universal AC input range is also achieved using this VIN pin. Consider adding a low-pass filter to filter out line ripple on the bulk capacitor.
4	RI	Reference Setting	A resistor from the RI pin to ground generates a reference current source that determines the switching frequency. Increasing the resistance reduces the switching frequency. Using a 26kΩ resistor results in a 65kHz switching frequency.
5	RT	Temperature Detection	For over-temperature protection, an external NTC thermistor is connected from this pin to the GND pin. The impedance of the NTC decreases at high temperatures. Once the voltage of the RT pin drops below a threshold, PWM output is disabled.
6	SENSE	Current Sense	Current sense. The sensed voltage is used for peak-current-mode control and cycle-by-cycle current limiting. If the switching current is higher than two thirds of the peak-current threshold for longer than 100ms and V_{DD} is higher than 12V and lasts for 1700ms, over-current protection is activated. If an output short over-current also occurs and lasts for 100ms and V_{AUX} is lower than 12V, SG6846A turns off immediately. This two-level OCP feature is especially suitable for SMPS with surge current output. It also has built-in 5ms soft-start time as switching frequency operates at 65KHz.
7	VDD	Power Supply	Power supply. If an open-circuit failure occurs in the feedback loop, the internal protection circuit disables PWM output as long as V_{DD} exceeds the threshold.
8	GATE	Driver Output	The totem-pole output driver for the power MOSFET, internally clamped below 18V.

BLOCK DIAGRAM
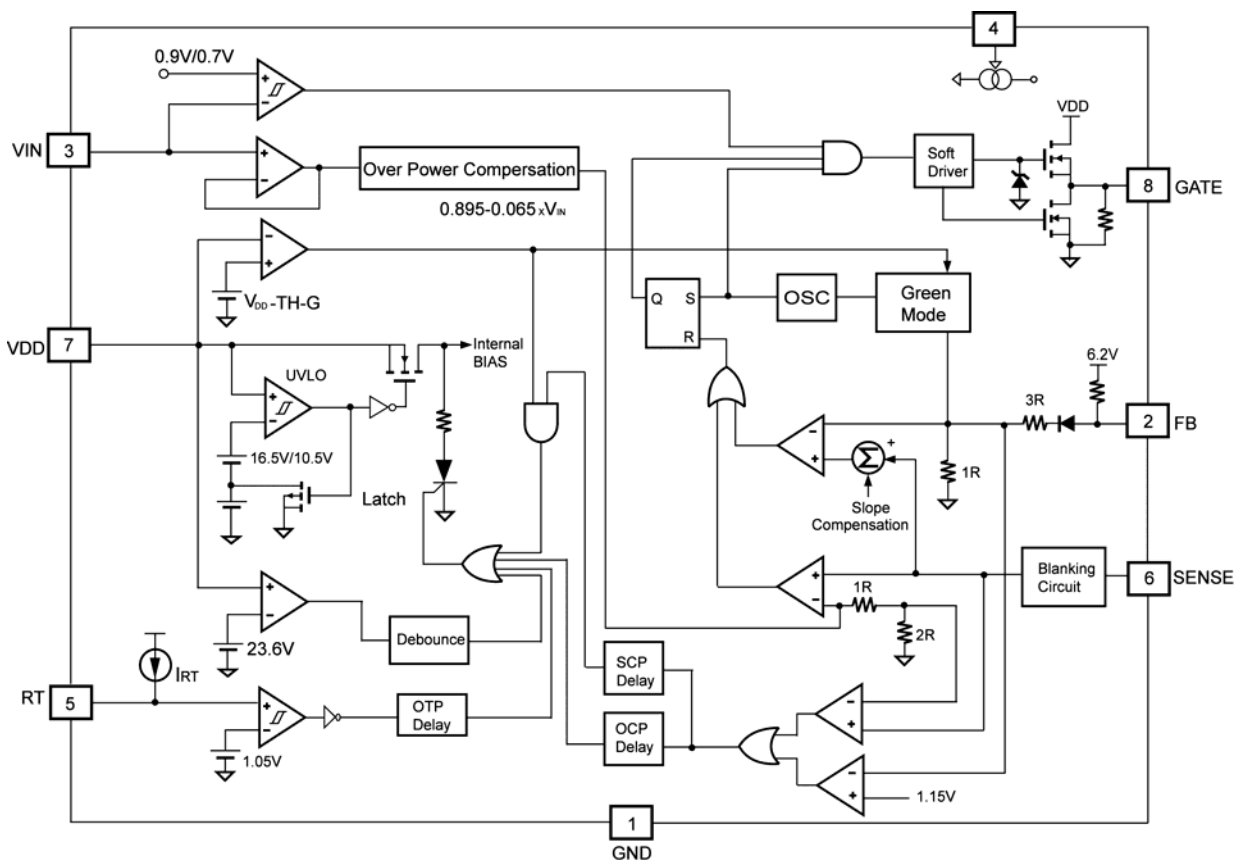
ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{VDD}	Supply Voltage	25	V
V_L	Input Voltage to VIN, FB, SENSE Pins	-0.3 to 7.0	V
P_D	Power Dissipation	400	mW
$R_{\Theta JC}$	Thermal Resistance (Junction-to-Case)	54.4	°C/W
T_J	Operating Junction Temperature	-40 to +125	°C
T_{STG}	Storage Temperature Range	-65 to +150	°C
T_L	Lead Temperature (Wave Soldering or Infrared, 10 Seconds)	260	°C
ESD	Electrostatic Discharge Capability, Human Body Model	5.0	kV
	Electrostatic Discharge Capability, Machine Model	200	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 JUNCTION TEMPERATURE

Symbol	Parameter	Value	Unit
T_A	Operating Ambient temperature	-20°C ~ 85°C	V

*For proper operation

ELECTRICAL CHARACTERISTICS

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

V_{DD} SECTION

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V_{DD-OP}	Continuously Operating Voltage				20	V
V_{DD-ON}	Turn-on Threshold Voltage		15.5	16.5	17.5	V
V_{DD-OFF}	Turn-off Voltage		9.5	10.5	11.5	V
I_{DD-ST}	Start-Up Current	$V_{DD-ON} - 0.16V$			30	μA
I_{DD-OP}	Operating Supply Current	GATE open			5	mA
V_{DD-OVP}	V_{DD} Over-Voltage Protection (Latch off)		22.6	23.6	24.6	V
$t_{D-VDDOVP}$	V_{DD} OVP Debounce Time	R_I=26KΩ		100		μs
I_{DD-OVP}	V_{DD} OVP Latch-up Holding Current	V_{DD}=5V			70	μA
V_{DD-SCP}	Threshold Voltage on V_{DD} for Short-Circuit Protection	V_{CS}>V_{STH} lasts for $T_{DELAY-Short}$	V_{DD-OFF} + 0.5V	V_{DD-OFF} + 1V	V_{DD-OFF} + 1.5V	V

V_{IN} SECTION

Symbol	Parameter	Min.	Typ.	Max.	Unit
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}+0.18	V_{IN-OFF}+0.2	V_{IN-OFF}+0.22	V

FEEDBACK INPUT SECTION

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
A_V	Input Voltage to Current-Sense Attenuation	At Green Mode		1/4		V/V
Z_{FB}	Input Impedance			5.5		kΩ
$V_{FB-OPEN}$	FB Pin Open Voltage		5.6	6.2	6.6	V
V_{FB-OLP}	FB Open-Loop Trigger Level		4.7	5.2	5.7	V
t_{D-OLP}	Delay Time of FB Pin Open-Loop Protection	R_I=26KΩ	1600	1700	1800	ms

CURRENT-SENSE SECTION

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
Z_{SENSE}	Input Impedance			12		kΩ
t_{PD}	Delay to Output				250	ns
t_{LEB}	Leading-Edge Blanking Time		270	360		ns
V_{STH1V}	Threshold Voltage for Current Limit	V_{IN}=1V		0.83		V
V_{STH3V}	Threshold Voltage for Current Limit	V_{IN}=3V		0.70		V
$V_{STH1V-2/3}$	2/3 Threshold Voltage for Current Limit	V_{IN}=1V	0.58	0.61	0.64	V
$V_{STH3V-2/3}$	2/3 Threshold Voltage for Current Limit	V_{IN}=3V	0.48	0.51	0.54	V
t_{D-OCP}	*Delay Time for Over-Current Protection	R_I=26KΩ	1500	1600	1700	ms
V_{SLOPE}	Slope Compensation	Duty=DCY_{MAX}		0.33		V
$t_{D-Short}$	*Output Short Delay Time	V_{CS}> V_{STH}, R_I=26KΩ	92	100	108	ms
$t_{SS-65KHz}$	Soft-Start Time	R_I=26KΩ		5		ms
$t_{SS-130KHz}$	Soft-Start Time	R_I=13KΩ		2.5		ms

OSCILLATOR SECTION

Symbol	Parameter		Test Condition	Min.	Typ.	Max.	Unit
F_{OSC}	Normal PWM Frequency	Center Frequency	R_I=26KΩ, V_{FB}>V_N	62	65	68	kHz
		Jitter Range			±4.2		
$F_{OSC,MAX}$	Maximum PWM Frequency	Center Frequency	R_I=13KΩ, V_{FB}>V_N	124	130	136	kHz
		Jitter Range			±8.4		
$F_{OSC,MIN}$	Minimum PWM Frequency	Center Frequency	R_I=36KΩ, V_{FB}>V_N	44.8	47.0	49.2	kHz
		Jitter Range			±2.9		
t_{hop-1}	Jitter Period		R_I=26KΩ, V_{FB}>V_N		4.4		ms
F_{OSC-G}	Green-Mode Minimum Frequency		R_I=26KΩ	18.0	22.5	25.0	kHz
V_{FB-N}	FB Pin Frequency Reduction Threshold	Pin, FB Voltage	R_I=26KΩ, V_{FB}=V_N		2.1		V
		Jitter Range			4.2		KHz
V_{FB-G}	FB Voltage at $F_{OSC-GREEN}$	Pin, FB Voltage	R_I=26KΩ, V_{FB}=V_G		1.6		V
		Jitter Range			1.45		KHz
S_G	Slope for Green-Mode Modulation		R_I=26KΩ		85		Hz/mV
F_{DV}	Frequency Variation vs. V_{DD} Deviation		V_{DD}=11.5V to 20V			5	%
F_{DT}	Frequency Variation vs. Temperature Deviation		T_A=-20 to 85 °C		1.5	5.0	%
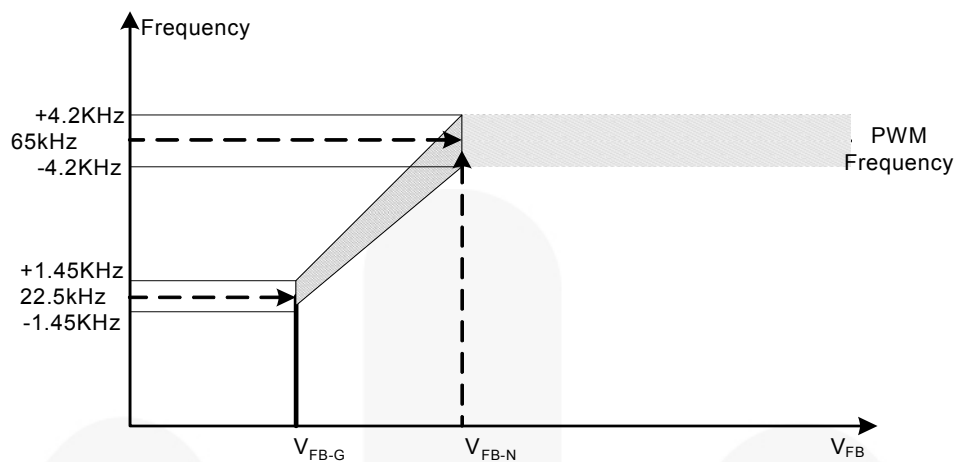
PWM OUTPUT SECTION

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
DCY_{MAX}	Maximum Duty Cycle				90	%
V_{GATE-L}	Output Voltage Low	V_{DD}=15V, I_O=50mA			1.5	V
V_{GATE-H}	Output Voltage High	V_{DD}=12V, I_O=50mA	8			V
t_R	Rising Time	GATE=1nF		350		ns
t_F	Falling Time	GATE=1nF		50		ns
$V_{GATE-CLAMP}$	Gate Output Clamping Voltage	V_{DD}=20V			18	V

OVER-TEMPERATURE PROTECTION SECTION

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
I_{RT}	Output Current of RT Pin	R_I=26KΩ	64	70	76	µA
V_{RTTH}	Threshold Voltage for Over-Temperature Protection		1.015	1.065	1.115	V
t_{D-OTP}	Over-Temperature Latch-Off Debounce	R_I=26KΩ		100		ms

RI SECTION

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
RI_{NOR}	RI Operating Range		13		36	kΩ

TYPICAL CHARACTERISTICS

Turn-on Threshold Voltage (V_{DD-ON}) vs Temperature

Turn-off Voltage (V_{DD-OFF}) vs Temperature

Start-Up Current (I_{DD-ST}) vs Temperature

Start-Up Current vs VDD Voltage

PWM Turn-off Threshold Voltage (V_{IN-OFF}) vs Temperature

PWM Turn-on Threshold Voltage (V_{IN-ON}) vs Temperature

Normal PWM Frequency (F_{OSC}) vs Temperature

PWM Frequency vs FB Voltage

Current - limit Threshold vs Vin Voltage

2/3 Current - limit Threshold vs Vin Voltage

Output Current of RT Pin (I_{RT}) vs Temperature

FB Output High Voltage (V_{RTTH}) vs Temperature
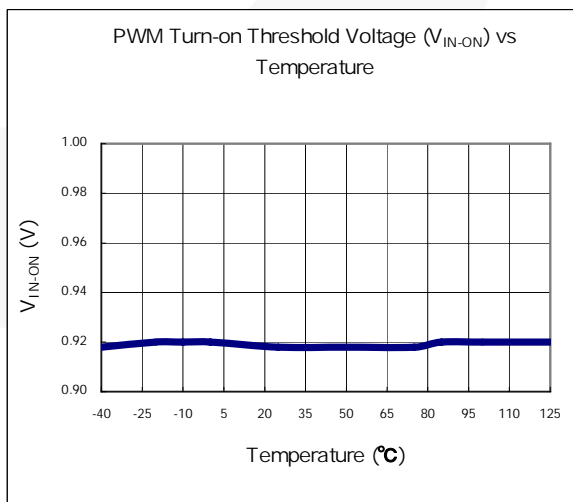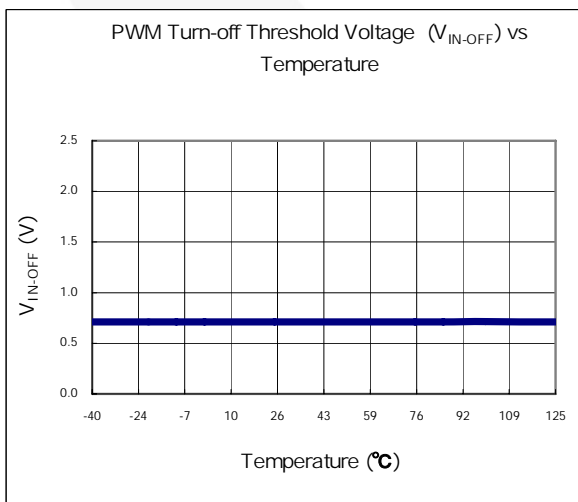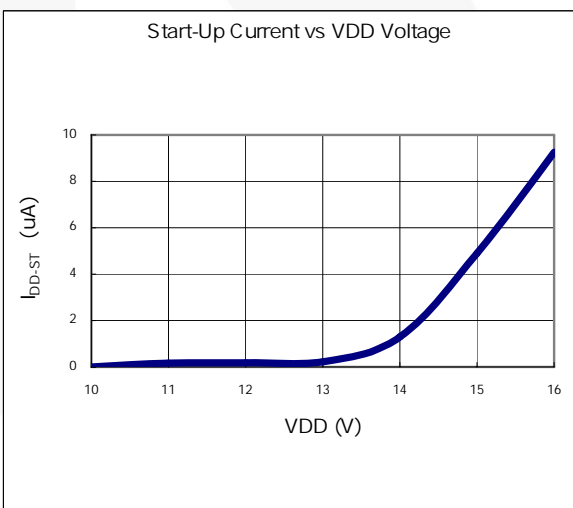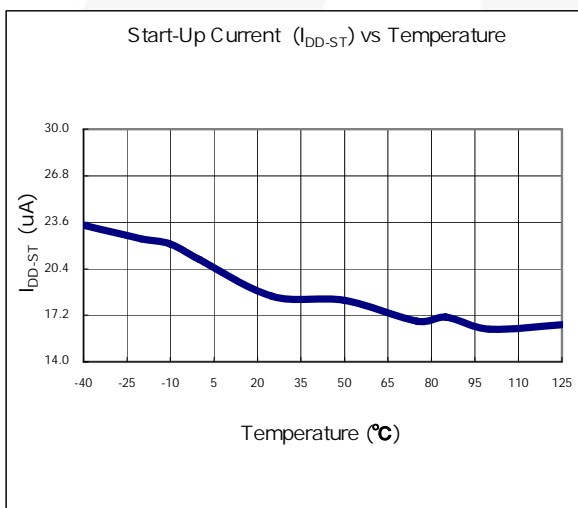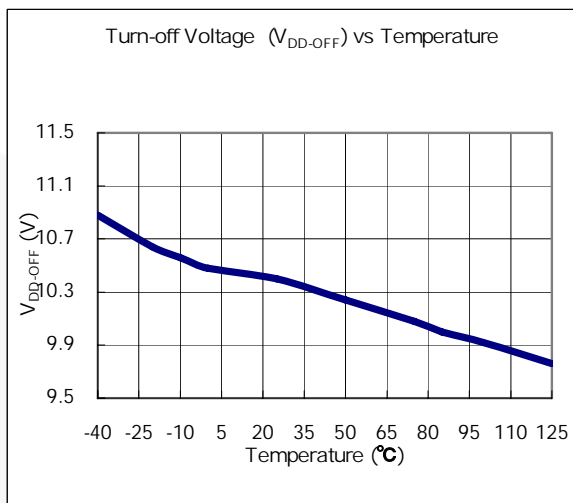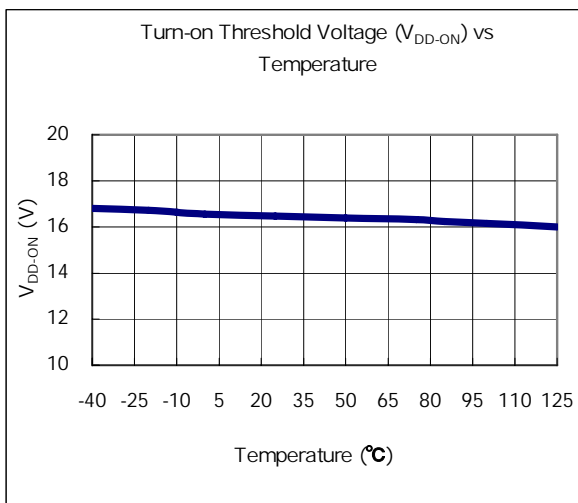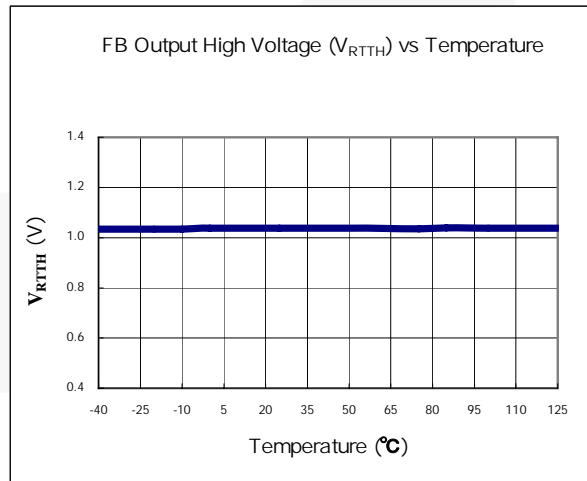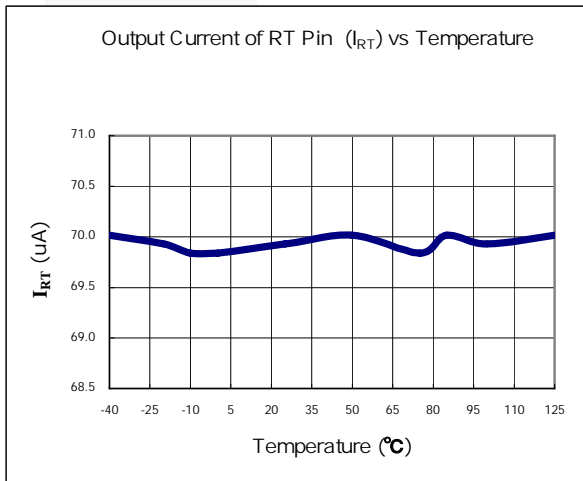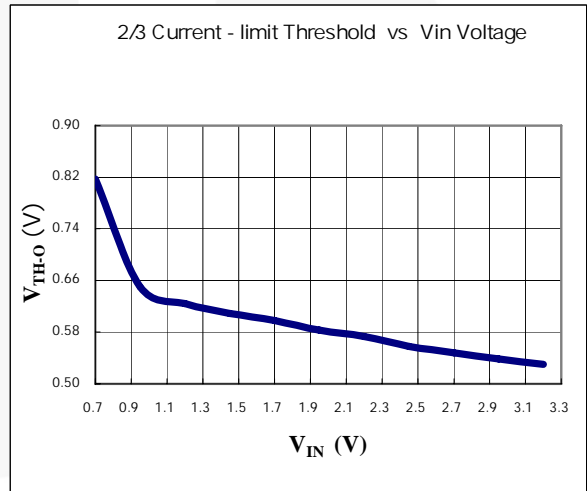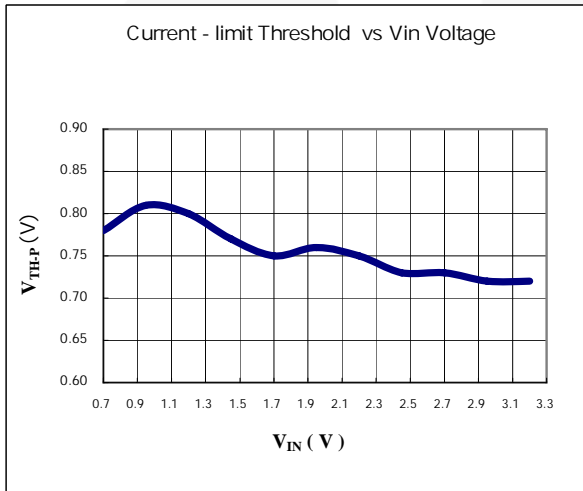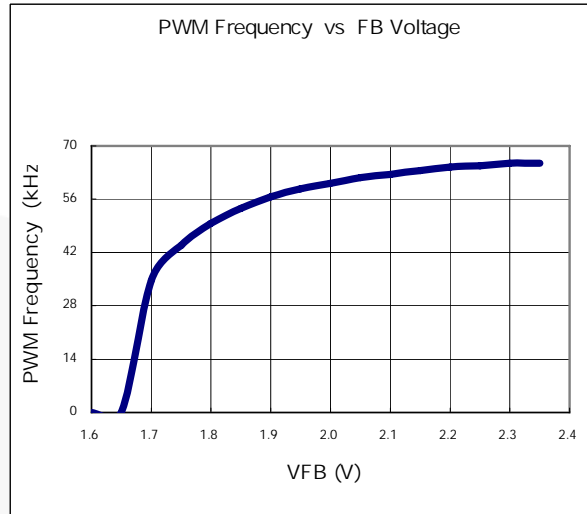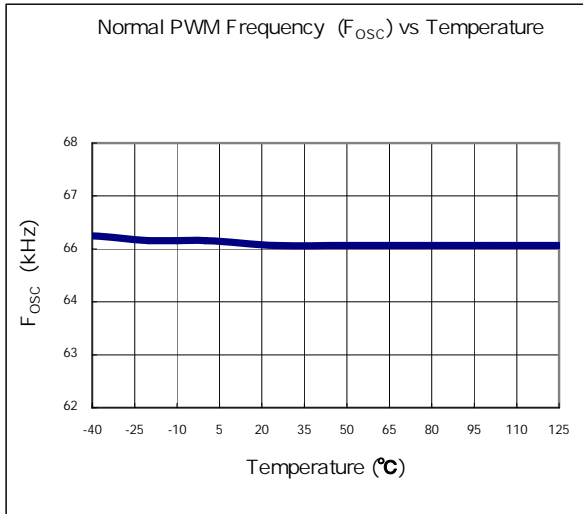
OPERATION DESCRIPTION

Start-up Operation

The turn-on/turn-off thresholds are fixed internally at 16.5V/10.5V. To enable the SG6846A during start-up, the hold-up capacitor must first be charged to 16.5V through the start-up resistor.

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

The typical start-up current is only 8µA, which allows a high-resistance, low-wattage start-up resistor to minimize power loss. A 1.5MΩ/0.25W start-up resistor and a 10µF/25V V_{DD} hold-up capacitor are sufficient for a universal input range.

The required operating current has been reduced to 3.7mA, which enables higher efficiency and reduces the V_{DD} hold-up capacitance requirement.

Green-Mode Operation

The proprietary green-mode function provides off-time modulation to continuously decrease the switching frequency under light-load conditions. Maximum on-time is limited to provide protection against abnormal conditions. To further reduce power consumption under zero-load condition, the PWM oscillator is completely turned off and the power supply enters burst-mode. This green-mode function dramatically reduces power consumption under light-load and zero-load conditions. Power supplies using the SG6846A can meet even the most restrictive international regulations regarding standby power consumption.

Oscillator Operation

A resistor connected from the RI pin to GND generates a reference current source used to determine the PWM frequency. Increasing the resistance decreases the amplitude of the current source and reduces the PWM frequency. Using a 26kΩ resistor results in a

corresponding 65kHz switching frequency. The relationship between R_I and the switching frequency is:

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

If an open-circuit or short-circuit to ground occurs at the RI pin, the internal protection circuit immediately shuts down the controller.

Two-Level Over-Current Protection

The cycle-by-cycle current limiting shuts down the PWM immediately when the switching current is over the peak-current threshold. Additionally, when the switching current is higher than two thirds the peak-current threshold, the internal counter counts down. When the total accumulated counting time is more than around 1600ms (R_I=26kΩ), the controller is latched off the internal counter counting up. When the switching current is lower than two thirds of the peak current threshold, the internal counter counts down. When the total accumulated counting time is more than about 1700ms (R_I=26kΩ), the controller is latched off.

This two-level OCP protection and up/down counter are especially designed for SMPS with surge current for printers, scanners, motor drivers, etc.

Constant Output Power Limit

For constant output power limit over a 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.

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 shuts off. If the V_{IN} voltage is over 0.9V, the PWM output turns on again. The hysteresis window for ON/OFF is around 0.2V.

V_{DD} Over-voltage Protection

V_{DD} over-voltage protection is built-in to prevent the controller from over-voltage destruction. When V_{DD} voltage is over 23.6V, the SG6846A is latched off.

Over-Temperature Protection

An external NTC thermistor can be connected from the RT pin to GND. The impedance of the NTC decreases at high temperatures. When the voltage of the RT pin drops below 1.065V, the SG6846A is turned off. For the protection modes options, please see ORDER INFORMATION.

Noise Immunity

Noise from the current sense or the control signal may cause significant pulse jitter, particularly in continuous-conduction mode. Slope compensation helps alleviate this problem. Good placement and layout practices should be followed. Avoid long PCB traces and component leads. Compensation and filter components should be located near the SG6846A. Usually an RC network is put on between sensing resistor and the CS pin to filter high-frequency switching noise, as shown Figure 1.
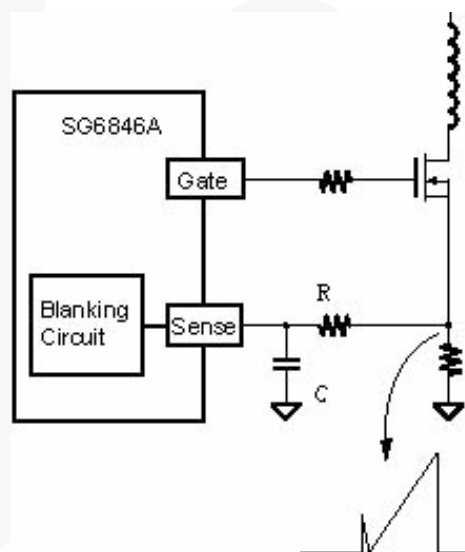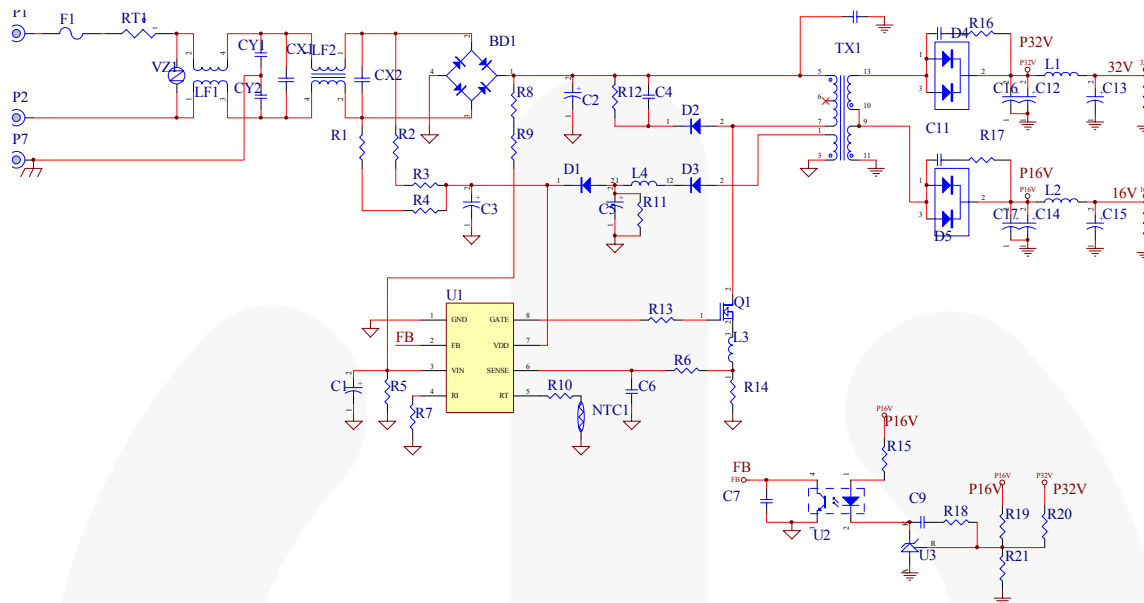

FIG-1 Current Sense RC Filter

REFERENCE CIRCUIT
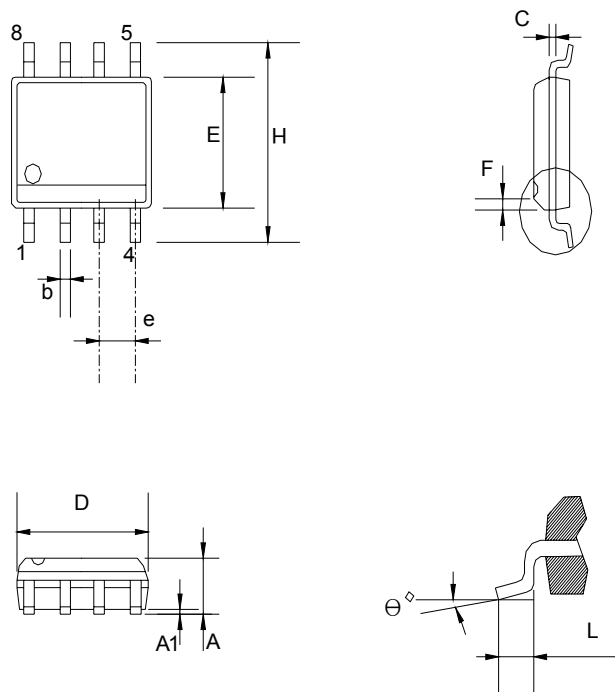
Application Circuit for 32V/16V Output

BOM

PART NO.	VALUE	PART NO.	VALUE	PART NO.	VALUE
R1, R2, R3, R4	470KΩ +/-5%	C4	103 P 630V	D3	FR103 1.0A 200V
R8, R9	S1MΩ +/-1%	C10,C11	102 P 1KV	BD1	DBL406G
R5	16K2Ω +/-1%	C6,C7	102 P 50V	D4	BYT28-300
R15	1K5Ω +/-5%	C9	222 P 50V	D5	BYV32-150
R13	10Ω +/-5%	C14,C17	470µ 25V	F1	250V4A QUICK
R18	4K7Ω +/-5%	C15	220µ 25V	L1,L2	1.8µH
R21	15KΩ +/-1%	C13,C16	220µ 50V	L4	10µH
R7	27KΩ +/-5%	C2	150µ 400V	U3	TL431 +/-1%
R6	330Ω +/-1%	C1	4µ7 50V	U1	SG 6846
R19	102KΩ +/-1%	C3	10µ 50V	U2	PC817
R14	0Ω22 +/-5%	CX1	X1 0.47µ 275V	Q1	7NB60
R16, R17	1W 20Ω +/-5%	C8	Y2 222P 250V	TX1	EI-33
R11	20KΩ +/-5%	C5	100µ 50V	RT1	SCK053
R12	100KΩ +/-5%	CX2	X2 0.1µF 275V	VZ1	14ψ 470V
R20	887KΩ +/-1%	D1	1N4148		
R22	10KΩ +/-1%	D2	BYV95C		

PACKAGE INFORMATION8PINS-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°

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As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.

2. A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This 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	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild Semiconductor. The datasheet is printed for reference information only.

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