

# SG6846C

## Highly Integrated Green-Mode PWM Controller

### Features

- Low Start-up Current: 8µA
- Low Operating Current: 3.7mA
- Peak-current Mode Operation with Cycle-by-cycle Current Limiting
- PWM Frequency Continuously Decreasing with Burst Mode at Light Loads
- V<sub>DD</sub> Over-Voltage Protection (OVP)
- AC Input Brownout Protection with Hysteresis
- Constant Output Power Limit (Full AC Input Range)
- Internal Latch Circuit for OVP, OTP, and OCP
- Two-level OCP Delay: 110ms
- Programmable PWM Frequency with Frequency Hopping
- OCP Threshold is Half Peak Current Limit
- Feedback Open-loop Protection with 110ms Delay
- Soft Start-up Time: 5ms

### Applications

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

- Power Adapters
- Open-frame SMPS
- SMPS with Surge-current Output, such as for Printers, Scanners, Motor Drivers

### Description

A highly integrated PWM controller, SG6846C 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 under light-load conditions. Under zero-load conditions, the power supply enters burst-mode, which completely shuts off PWM output. Output restarts just before the supply voltage drops below the UVLO lower limit. This green-mode function enables power supplies to meet international power conservation requirements.

The SG6846C is 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 OCP threshold and lasts for 110ms, SG6846C shuts down immediately. SG6846C also integrates frequency-hopping function internally, which helps reduce EMI emission of a power supply with minimum line filters. The built-in synchronized slope compensation provides proprietary internal compensation for constant output power limit over a universal AC input range. The gate output is clamped at 18V to protect the external MOSFET from over-voltage damage.

Other protection functions include AC input brownout protection with hysteresis and V<sub>DD</sub> over-voltage protection. For over-temperature protection, an external NTC thermistor can be applied to sense the ambient temperature. When OCP, V<sub>DD</sub> OVP, or OTP are activated, an internal latch circuit latches off the controller. The latch resets when V<sub>DD</sub> supply is removed.

SG6846C is available in 8-pin SOP and DIP packages.

### Ordering Information

Part Number	Operating Temperature Range	OCP Latch	Package
SG6846CLSZ	-20 to +85°C	Yes	8-Pin Small Outline Package (SOP)
SG6846CLDZ	-20 to +85°C	Yes	8-Pin Dual Inline Package (DIP)



All standard Fairchild Semiconductor products are RoHS compliant and many are also "GREEN" or going green. For Fairchild's definition of "green" please visit: [http://www.fairchildsemi.com/company/green/rohs\\_green.html](http://www.fairchildsemi.com/company/green/rohs_green.html).

### Typical Application

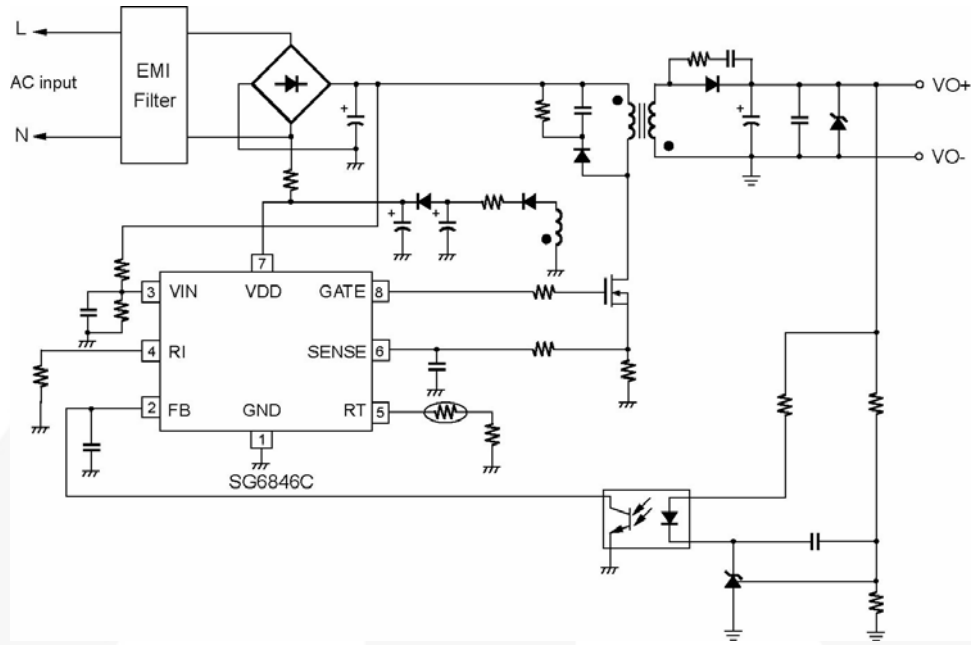


Figure 1. Typical Application

### Block Diagram

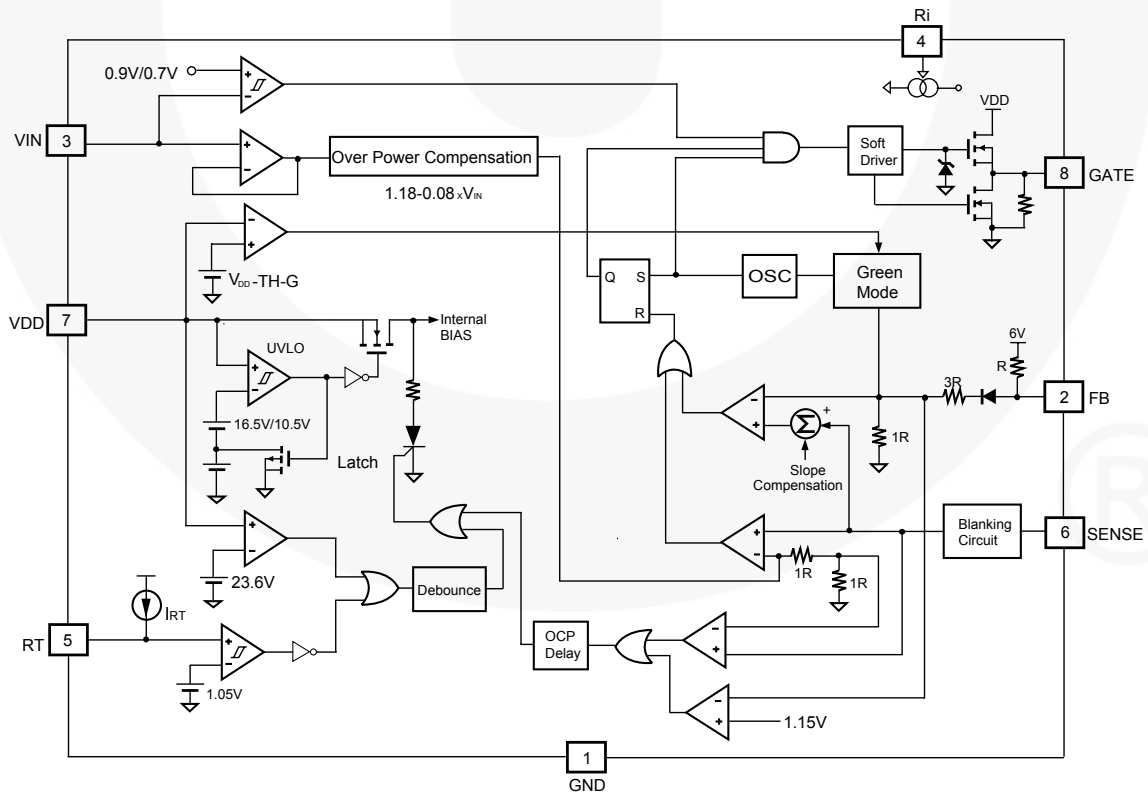


Figure 2. Block Diagram

## Marking Information

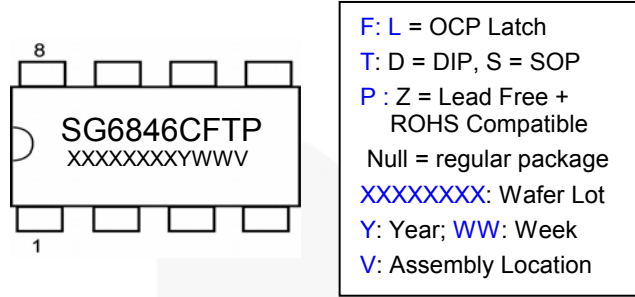


Figure 3. Top Mark

## Pin Configuration

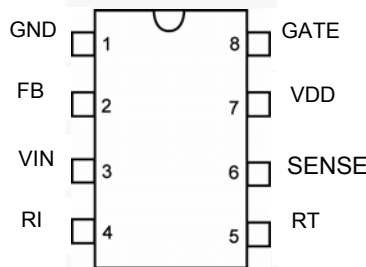


Figure 4. Pin Configuration

## Pin Definitions

Pin #	Name	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, used for brownout protection with hysteresis. Constant output power limit over universal AC input range is also achieved using this pin. Add a low-pass filter to filter out line ripple on 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 OCP threshold and lasts for 110ms, SG6846C turns off immediately. This two-level OCP feature is especially suitable for SMPS with surge current output.
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 <sub>DD</sub> exceeds a threshold.
8	GATE	Driver Output	The totem-pole output driver for the power MOSFET. It is internally clamped below 18V.

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

Symbol	Parameter	Min.	Max.	Unit
V <sub>DD</sub>	Supply Voltage		25	V
V <sub>L</sub>	Input Voltage to FB, SENSE, VIN, RT,RI Pin	-0.3	7.0	V
P <sub>D</sub>	Power Dissipation at T <sub>A</sub> <50°C	DIP	800	mW
		SOP	400	
Θ <sub>JC</sub>	Thermal Resistance (Junction-to-Case)	DIP	67.1	°C/W
		SOP	54.4	
T <sub>J</sub>	Operating Junction Temperature	-40	+150	°C
T <sub>STG</sub>	Storage Temperature Range	-65	+150	°C
T <sub>L</sub>	Lead Temperature, Wave Soldering, 10 Seconds		+260	°C
ESD	Electrostatic Discharge Capability	Human Body Model	5.5	kV
		Machine Model	250	V

## Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameter	Min.	Max.	Unit
T <sub>A</sub>	Operating Ambient Temperature	-20	+85	°C

## Electrical Characteristics

$V_{DD} = 15V$ ,  $T_A = 25^\circ C$ , unless noted.

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
<b>V<sub>DD</sub> Section</b>						
V <sub>DD-OP</sub>	Continuously Operating Voltage				20	V
V <sub>DD-ON</sub>	Turn-on Threshold Voltage		15.5	16.5	17.5	V
V <sub>DD-OFF</sub>	Turn-off Voltage		9.5	10.5	11.5	V
V <sub>DD-LH</sub>	Threshold Voltage for Latch-off Release		3	4	5	V
I <sub>DD-ST</sub>	Start-up Current	V <sub>DD-ON</sub> – 0.16V		8	30	μA
I <sub>DD-OP</sub>	Operating Supply Current	GATE Open		3.7	5.0	mA
V <sub>DD-OVP</sub>	V <sub>DD</sub> Over-Voltage Protection (Latch off)		22.6	23.6	24.6	V
t <sub>D-VDDOVP</sub>	V <sub>DD</sub> OVP Debounce Time	R <sub>I</sub> = 26kΩ	60	100	140	μs
I <sub>DD-OVP</sub>	V <sub>DD</sub> OVP Latch-off Holding Current	V <sub>DD</sub> = 5V	30	50	70	μA
<b>V<sub>IN</sub> Section</b>						
V <sub>IN-OFF</sub>	PWM Turn-off Threshold Voltage		0.65	0.70	0.75	V
V <sub>IN-ON</sub>	PWM Turn-on Threshold Voltage		V <sub>IN-OFF</sub> +0.1 8	V <sub>IN-OFF</sub> +0.2 0	V <sub>IN-OFF</sub> +0.2 2	V
<b>Feedback Input Section</b>						
A <sub>V</sub>	Input-Voltage to Current-Sense Attenuation		1/3.5	1/4.0	1/4.5	V/V
Z <sub>FB</sub>	Input Impedance		4.0	5.5	7.0	kΩ
V <sub>FBO</sub>	FB Pin Open Voltage			6.2		V
V <sub>FB-OLP</sub>	Threshold Voltage of Open-loop Protection		4.7	5.2	5.7	V
t <sub>D-OLP</sub>	Open-loop Protection Delay Time	R <sub>I</sub> = 26kΩ	100	110	120	ms
<b>Current Sense Section</b>						
Z <sub>SENSE</sub>	Input Impedance			12		kΩ
t <sub>PD</sub>	Delay to Output			100	250	ns
t <sub>LEB</sub>	Leading-edge Blanking Time		270	360		ns
V <sub>SLOPE</sub>	Slope Compensation	Duty = DCY <sub>MAX</sub>	0.30	0.33	0.36	V
V <sub>STH1V</sub>	Threshold Voltage for Current Limit	V <sub>IN</sub> = 1V	1.07	1.10	1.13	V
V <sub>STH3V</sub>	Threshold Voltage for Current Limit	V <sub>IN</sub> = 3V	0.91	0.94	0.97	V
V <sub>STH1V-1/2</sub>	OCP Threshold Voltage for Current Limit	V <sub>IN</sub> = 1V	0.52	0.55	0.58	V
V <sub>STH3V-1/2</sub>	OCP Threshold Voltage for Current Limit	V <sub>IN</sub> = 3V	0.44	0.47	0.50	V
t <sub>D-OCP</sub>	Delay Time for Over-Current Protection	R <sub>I</sub> = 26kΩ	100	110	120	ms
t <sub>SS-65KHz</sub>	Period During Start up Time	R <sub>I</sub> = 26kΩ	4.5	5.0	5.5	ms
t <sub>SS-130KHz</sub>		R <sub>I</sub> = 13kΩ	2.25	2.50	2.75	ms

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### Electrical Characteristics (Continued)

$V_{DD} = 15V$ ,  $T_A = 25^\circ C$ , unless noted.

Symbol	Parameter		Test Condition	Min.	Typ.	Max.	Unit
<b>Oscillator Section</b>							
$f_{OSC}$	Normal PWM Frequency	Center Frequency	$R_I = 26k\Omega$ , $V_{FB} > V_N$	62	65	68	kHz
		Jitter Range		$\pm 3.7$	$\pm 4.2$	$\pm 4.7$	
$f_{OSC,MAX}$	Maximum PWM Frequency	Center Frequency	$R_I = 13k\Omega$ , $V_{FB} > V_N$	124	130	136	kHz
		Jitter Range		$\pm 7.4$	$\pm 8.4$	$\pm 9.4$	
$f_{OSC,MIN}$	Minimum PWM Frequency	Center Frequency	$R_I = 36k\Omega$ , $V_{FB} > V_N$	44.8	47.0	49.2	kHz
		Jitter Range		$\pm 2.54$	$\pm 2.90$	$\pm 3.26$	
$t_{hop-1}$	Jitter Period		$R_I = 26k\Omega$ , $V_{FB} \geq V_N$	3.9	4.4	4.9	ms
$t_{hop-3}$	Jitter period		$R_I = 26k\Omega$ , $V_{FB} = V_G$	10.2	11.5	12.8	ms
$f_{OSC-G}$	Green-mode Minimum Frequency		$R_I = 26k\Omega$	18.0	22.5	25.0	kHz
$V_{FB-N}$	FB Pin Frequency Reduction Threshold	Pin, FB voltage	$R_I = 26k\Omega$ , $V_{FB} = V_N$	1.9	2.1	2.3	V
		Jitter Range		3.7	4.2	4.7	KHz
$V_{FB-G}$	FB Voltage at $f_{OSC-G}$	Pin, FB voltage	$R_I = 26k\Omega$ , $V_{FB} = V_G$	1.4	1.6	1.8	V
		Jitter Range		1.27	1.45	1.62	KHz
$S_G$	Slope for Green-Mode Modulation		$R_I = 26k\Omega$		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		$T_A = -30$ to $85^\circ C$		1.5	5.0	%

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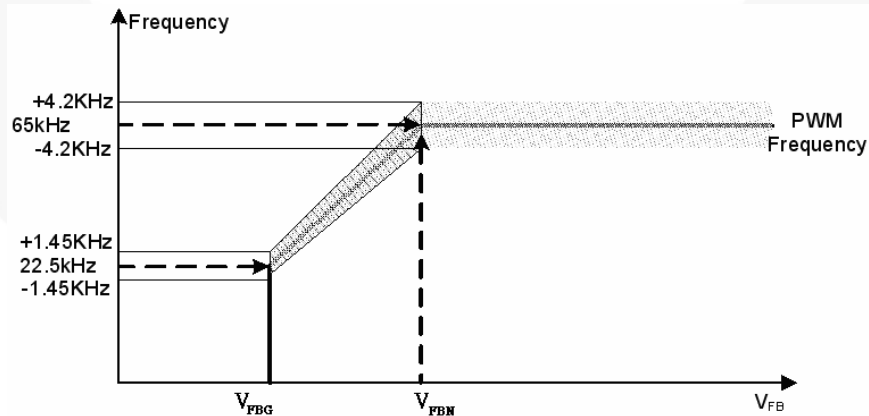


Figure 5. PWM Frequency

**Electrical Characteristics** (Continued)V<sub>DD</sub> = 15V, T<sub>A</sub> = 25°C, unless noted.

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
<b>PWM Output Section</b>						
DCY <sub>MAX</sub>	Maximum Duty Cycle		80	85	90	%
V <sub>OL</sub>	Output Voltage Low	V <sub>DD</sub> = 15V, I <sub>O</sub> = 50mA			1.5	V
V <sub>OH</sub>	Output Voltage High	V <sub>DD</sub> = 12V, I <sub>O</sub> = 50mA	8			V
t <sub>R</sub>	Rising Time	GATE = 1nF		350		ns
t <sub>F</sub>	Falling Time	GATE = 1nF		50		ns
V <sub>CLAMP</sub>	Gate Output Clamping Voltage	V <sub>DD</sub> = 20V			18	V
<b>Over-Temperature Protection (OTP) Section<sup>(1)</sup></b>						
I <sub>RT</sub>	Output Current of RT Pin	R <sub>I</sub> = 26kΩ	64	70	76	μA
V <sub>RTTH</sub>	Threshold Voltage for OTP		1.00	1.05	1.10	V
t <sub>DOTP-LATCH</sub>	Over-Temperature Latch-off Debounce	R <sub>I</sub> = 26kΩ		100		μs
R <sub>RT-OFF</sub>	Equivalent Impedance of RT for OTP <sup>(1)</sup>	R <sub>I</sub> = 26kΩ	14	15	16	kΩ
<b>R<sub>I</sub> Section</b>						
R <sub>I</sub> <sub>NOR</sub>	R <sub>I</sub> Operating Range		13		36	kΩ
R <sub>I</sub> <sub>MAX</sub>	Maximum R <sub>I</sub> Value for Protection		10			MΩ
R <sub>I</sub> <sub>MIN</sub>	Minimum R <sub>I</sub> Value for Protection				6	kΩ

**Note:**

- The relationship between R<sub>RT-OFF</sub> and R<sub>I</sub> is:  $R_{RT-OFF} = V_{OTP-LATCH-OFF} / I_{RT} = V_{RT} / (70\mu A \times 26 / R_I (K\Omega))$  (1)

## Typical Performance Characteristics

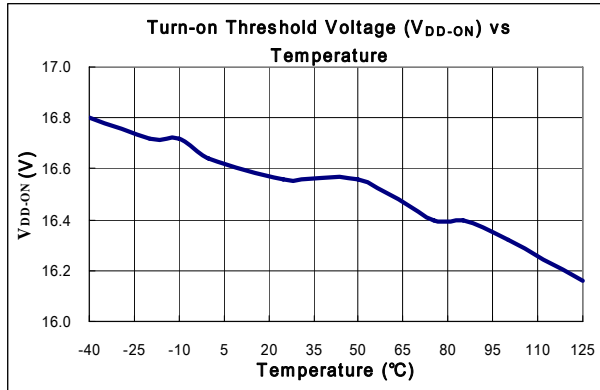


Figure 6. Turn-on Threshold Voltage (V<sub>DD-ON</sub>) vs. Temperature

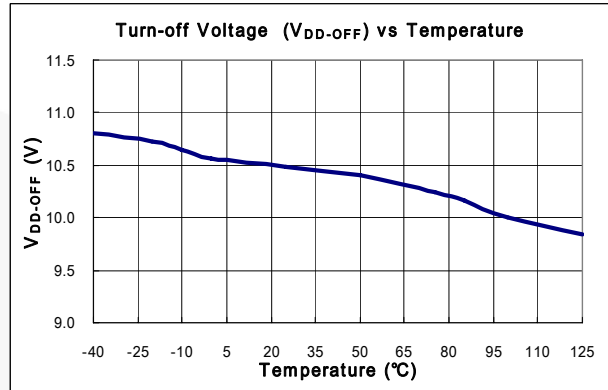


Figure 7. Turn-off Threshold Voltage (V<sub>DD-OFF</sub>) vs. Temperature

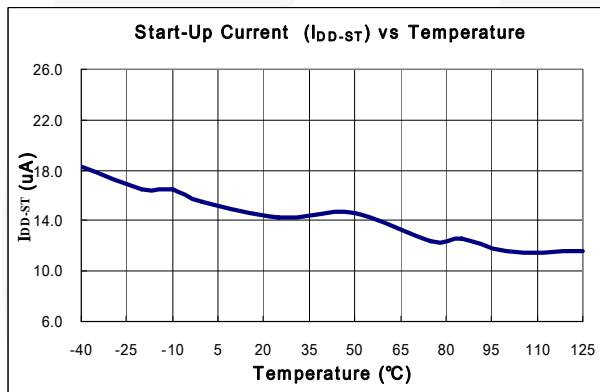


Figure 8. Start-up Current (I<sub>DD-ST</sub>) vs. Temperature

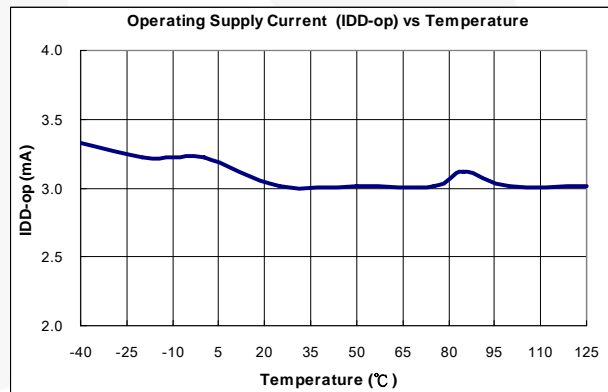


Figure 9. Operating Supply Current (I<sub>DD-OP</sub>) vs. Temperature

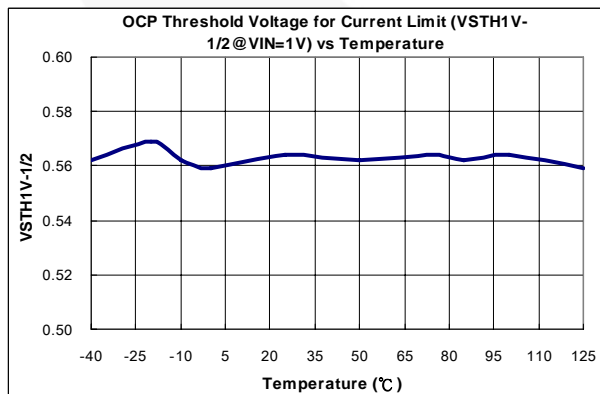


Figure 10. OCP Threshold Voltage for Current Limit (V<sub>STH1V-1/2</sub> at V<sub>IN</sub> = 1V) vs. Temperature

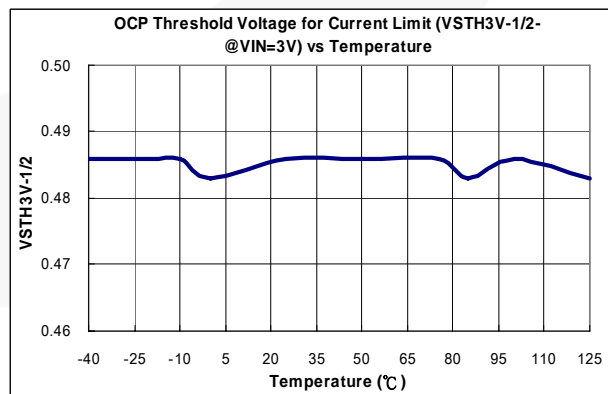
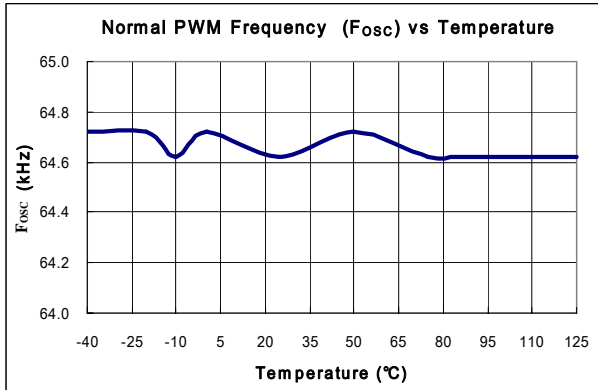


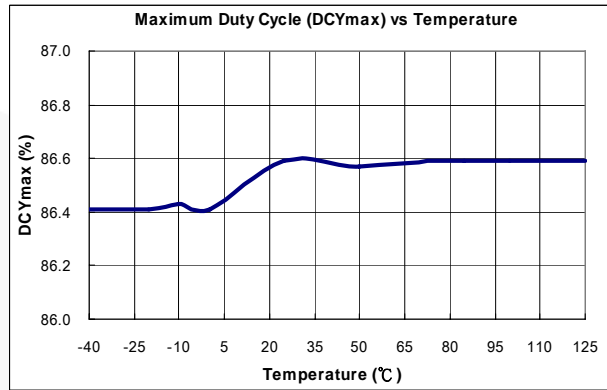
Figure 11. OCP Threshold Voltage for Current Limit (V<sub>STH3V-1/2</sub> at V<sub>IN</sub> = 3V) vs. Temperature



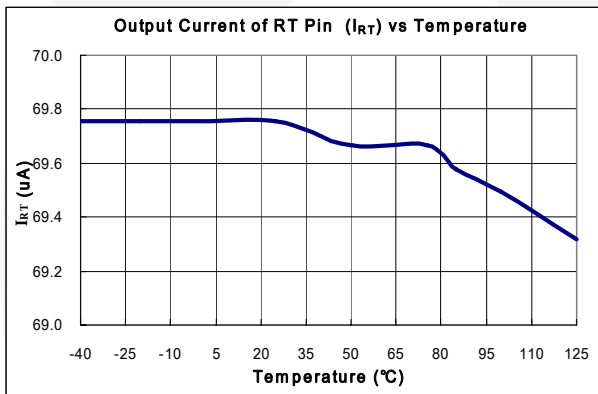
## Typical Performance Characteristics (Continued)



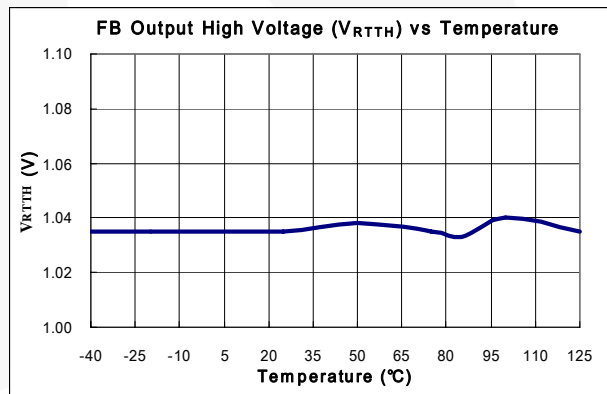
**Figure 12. Normal PWM Frequency ( $f_{osc}$ ) vs. Temperature**



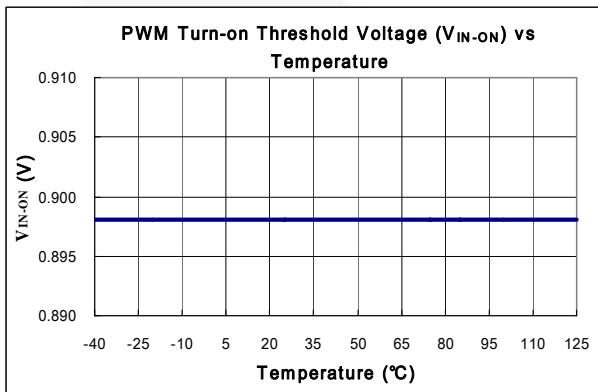
**Figure 13. Maximum Duty Cycle ( $DCY_{MAX}$ ) vs. Temperature**



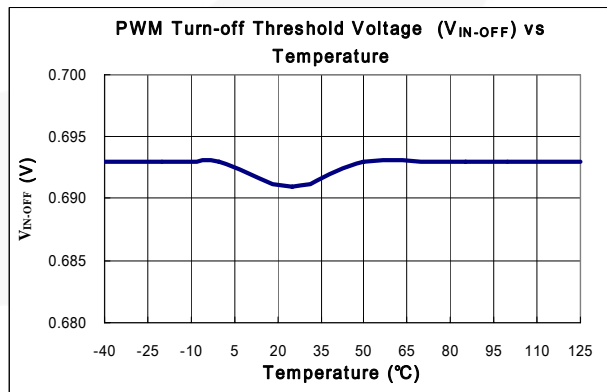
**Figure 14. Output Current of RT Pin ( $I_{RT}$ ) vs. Temperature**



**Figure 15. FB Output High Voltage ( $V_{RTTH}$ ) vs. Temperature**



**Figure 16. PWM Turn-on Threshold Voltage ( $V_{IN-ON}$ ) vs. Temperature**



**Figure 17. PWM Turn-off Threshold Voltage ( $V_{IN-OFF}$ ) vs. Temperature**

## Operation Description

### Start-up Operation

The turn-on/turn-off thresholds are fixed internally at 16.5V/10.5V. To enable the SG6846C 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 8 $\mu$ A, which allows a high-resistance, low-wattage start-up resistor to be used to minimize power loss. A 1.5M $\Omega$ /0.25W start-up resistor and a 10 $\mu$ F/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 SG6846C 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, inside the SG6846C, used to determine the PWM frequency. Increasing the resistance decreases the amplitude of the current source and reduces the PWM frequency. Using a 26k $\Omega$  resistor results in a corresponding 65kHz switching frequency. The relationship between  $R_i$  and the switching frequency is:

$$f_{\text{PWM}}(\text{kHz}) = \frac{1690}{R_i(\text{k}\Omega)} \quad (2)$$

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 (OCP)

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 half of the peak-current threshold, the internal counter counts down. When the total accumulated counting time is more than ~110ms ( $R_i = 26\text{k}\Omega$ ), the controller is latched off and the internal counter counts up. When the switching current is lower than half of the peak current threshold, the internal counter will count down. When the total accumulated counting time is more than ~110ms ( $R_i = 26\text{k}\Omega$ ), the controller is latched off.

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

### 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  $V_{IN}$  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 in Figure 18). R and C should put on less than 300 $\Omega$  and 1000pF respectively.

### 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. As the  $V_{IN}$  over 0.9V, the PWM output is turned on again. The hysteresis window for ON/OFF is ~0.2V.

### $V_{DD}$ Over-voltage Protection (OVP)

$V_{DD}$  over-voltage protection is built in to prevent damage. When  $V_{DD}$  is over 23.6V, the SG6846C is latched off.

### Over-temperature Protection (OTP)

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 1.05V, the SG6846C is turned off. *For protection-mode options, see Ordering Information.*

**Operation Description** (Continued)

**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. Avoid long PCB traces and component leads. Compensation and filter components should be located near the SG6846C.

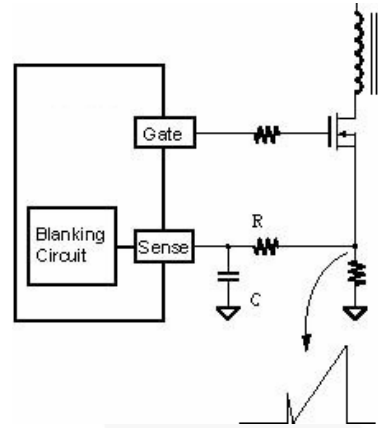


Figure 18. Current Sense R-C Filter



## Reference Circuit

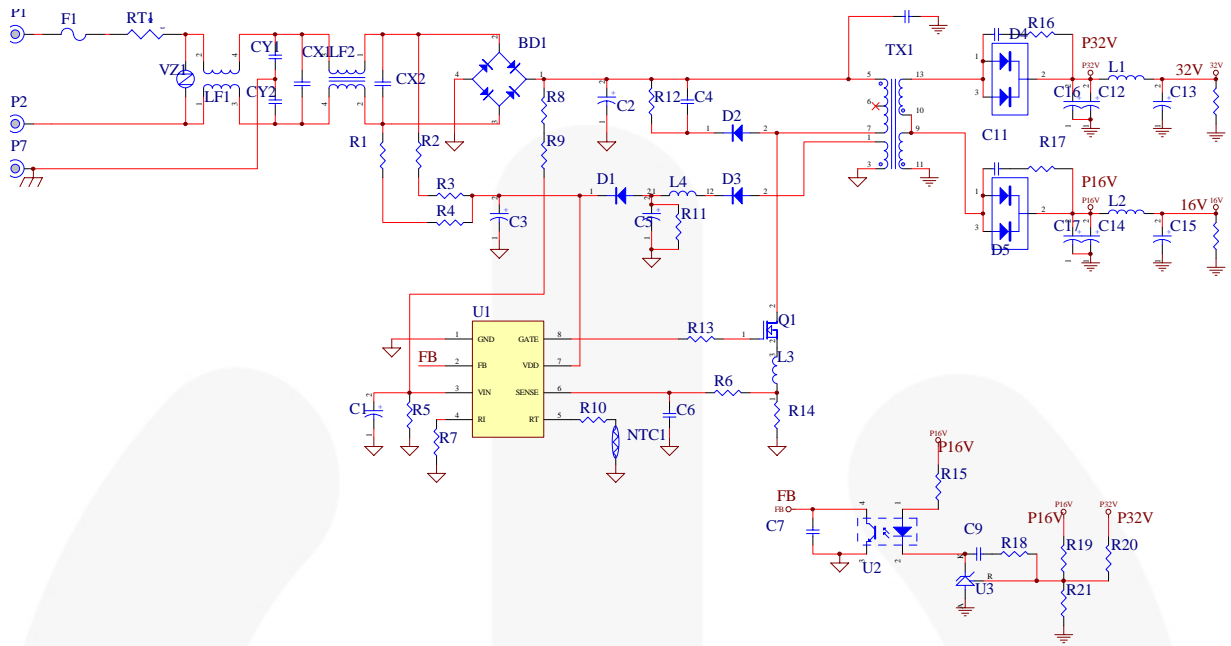


Figure 19. Application Circuit for 32V / 16V Output

## 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	51MΩ +/-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		

## Physical Dimensions

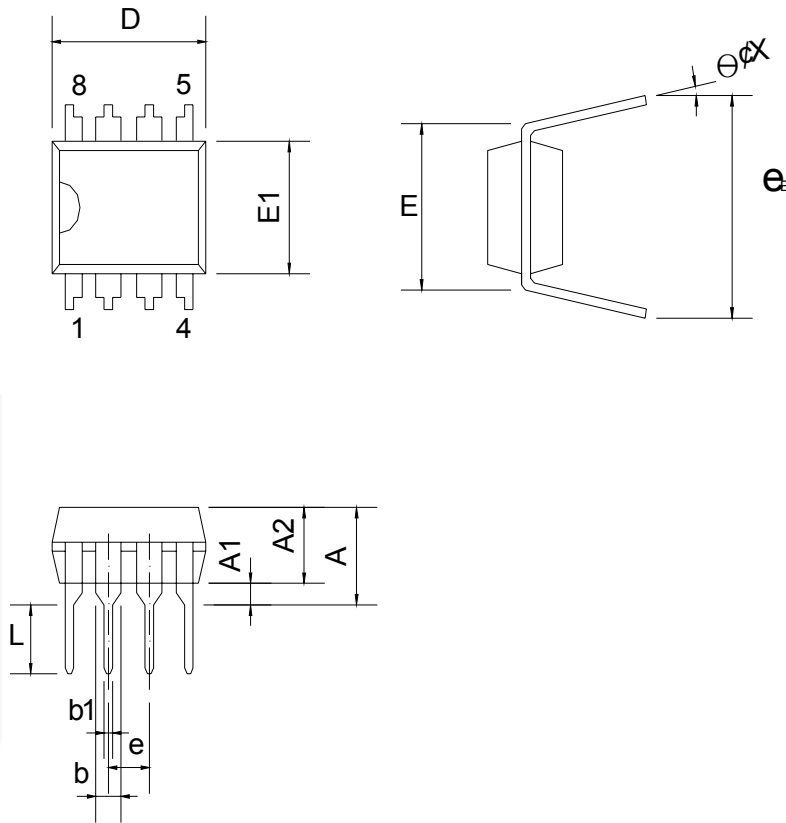


Figure 20. 8-Pin DIP

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 <sub>B</sub>	8.509	9.017	9.525	0.335	0.355	0.375
θ°	0°	7°	15°	0°	7°	15°

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## Physical Dimensions

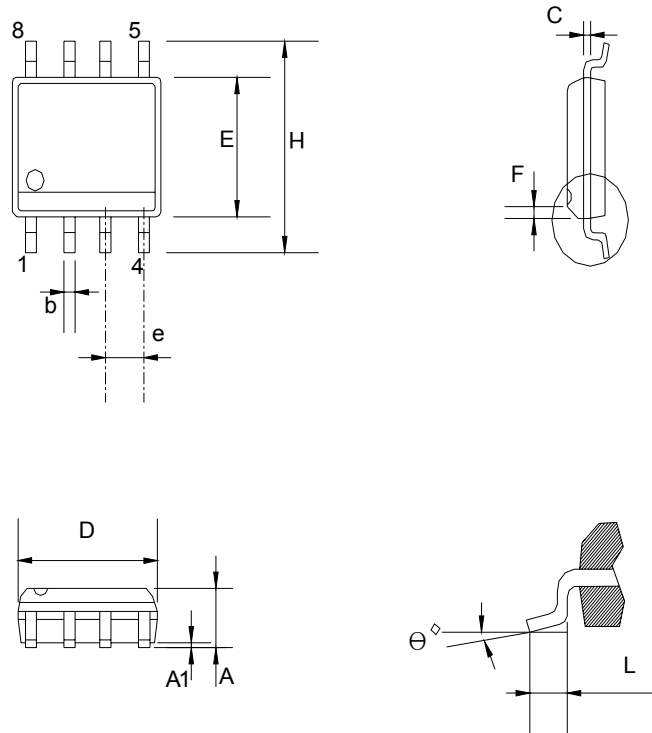


Figure 21. 8-Pin SOP

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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