

## CURRENT MODE PWM CONTROLLER

### DESCRIPTION

The SG1846 family of control ICs provides all of the necessary features to implement fixed frequency, current mode control schemes while maintaining a minimum external parts count. The superior performance of this technique can be measured in improved line regulation, enhanced load response characteristics, and a simpler, easier-to-design control loop. Topological advantages include inherent pulse-by-pulse current limiting capability, automatic symmetry correction for push-pull converters, and the ability to parallel "power modules" while maintaining equal current sharing.

Protection circuitry includes built-in under-voltage lockout and programmable current limit in addition to soft start capability. A shutdown function is also available which can initiate either a complete shutdown with automatic restart or latch the supply off.

Other features include fully latched operation, double pulse suppression, deadtime adjust capability, and a  $\pm 1\%$  trimmed bandgap reference.

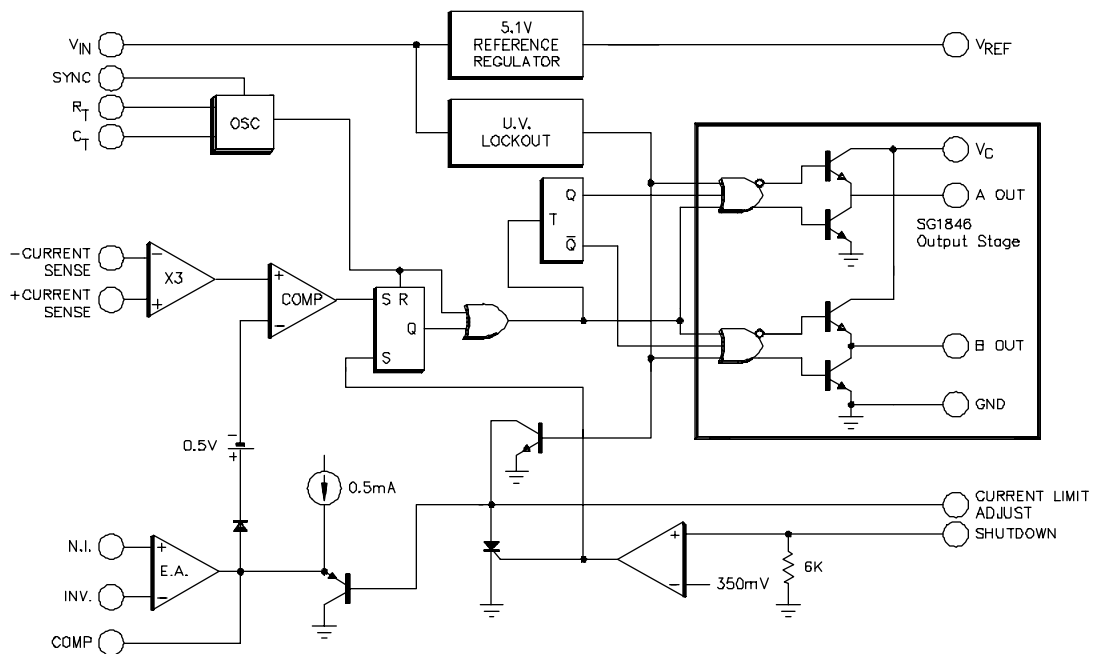
### FEATURES

- Automatic feed forward compensation
- Programmable pulse by pulse current limiting
- Automatic symmetry correction in push-pull configuration
- Enhanced load response characteristics
- Parallel operation capability for modular power systems
- Differential current sense amplifier with wide common mode range
- Double pulse suppression
- 200mA totem-pole outputs
- $\pm 1\%$  bandgap reference
- Under-voltage lockout
- Soft-start capability
- Shutdown capability
- 500KHz operation

### HIGH RELIABILITY FEATURES - SG1846

- ◆ Available to MIL-STD - 883
- ◆ Radiation data available
- ◆ LMI level "S" processing available

### BLOCK DIAGRAM



## ABSOLUTE MAXIMUM RATINGS (Note 1 and 2)

Supply Voltage (+V <sub>IN</sub> )	40V
Collector Supply Voltage(V <sub>C</sub> )	40V
Analog Inputs (Pins 3, 4, 5, 6, & 16)	-0.3V to +V <sub>IN</sub>
Logic Input	-0.3V to 5.5V
Source/Sink Load current (continuous)	200mA
Source/Sink Load Current (peak, 200ns)	500mA
Reference Load Current	30mA
Soft Start Sink Current	50mA

Note 1. Values beyond which damage may occur.

Note 2. Pin numbers refer to ceramic J package.

Sync Output Current	5mA
Error Amplifier Output Current	5mA
Oscillator Charging current (Pin 9)	5mA
Operating Junction Temperature	
Hermetic (J, L, F Packages)	150°C
Plastic (N, DW Package)	150°C
Storage Temperature Range	-65°C to 150°C
Lead Temperature (Soldering, 10 Seconds)	300°C
RoHS Peak Package Solder Reflow Temp. (40 sec. max. exp.)	260° (+0, -5)

## THERMAL DATA

J Package:

Thermal Resistance-Junction to Case, $\theta_{JC}$	30°C/W
Thermal Resistance-Junction to Ambient, $\theta_{JA}$	80°C/W

N Package:

Thermal Resistance-Junction to Case, $\theta_{JC}$	40°C/W
Thermal Resistance-Junction to Ambient, $\theta_{JA}$	65°C/W

DW Package:

Thermal Resistance-Junction to Case, $\theta_{JC}$	40°C/W
Thermal Resistance-Junction to Ambient, $\theta_{JA}$	95°C/W

F Package:

Thermal Resistance-Junction to Case, $\theta_{JC}$	70°C/W
Thermal Resistance-Junction to Ambient, $\theta_{JA}$	115°C/W

L Package:

Thermal Resistance-Junction to Case, $\theta_{JC}$	35°C/W
Thermal Resistance-Junction to Ambient, $\theta_{JA}$	120°C/W

Note A. Junction Temperature Calculation:  $T_J = T_A + (P_D \times \theta_{JA})$ .

Note B. The above numbers for  $\theta_{JC}$  are maximums for the limiting thermal resistance of the package in a standard mounting configuration. The  $\theta_{JA}$  numbers are meant to be guidelines for the thermal performance of the device/pc-board system. All of the above assume no ambient airflow.

## RECOMMENDED OPERATING CONDITIONS (Note 3)

Supply Voltage Range	8V to 40V
Collector Supply Voltage Range	4.5V to 40V
Source/Sink Output Current (continuous)	100mA
Source/Sink Output Current (peak 200ns)	200mA
Reference Load Current	0 to 10mA
Oscillator Frequency Range	1KHz to 500KHz

Note 3. Range over which the device is functional.

Oscillator Timing Resistor (R <sub>T</sub> )	2K $\Omega$ to 100K $\Omega$
Oscillator Timing Capacitor (C <sub>T</sub> )	1000 pF to 0.1 $\mu$ F
Operating Ambient Temperature Range	
SG1846	-55°C to 125°C
SG2846	-25°C to 85°C
SG3846	0°C to 70°C

## ELECTRICAL CHARACTERISTICS

(Unless otherwise specified, these specifications apply over the operating ambient temperatures for SG1846/SG1847 with -55°C ≤ T<sub>A</sub> ≤ 125°C, SG2846 with -25°C ≤ T<sub>A</sub> ≤ 85°C, SG3846 with 0°C ≤ T<sub>A</sub> ≤ 70°C, +V<sub>IN</sub> = 15V. Low duty cycle pulse testing techniques are used which maintains junction and case temperatures equal to the ambient temperature.)

Parameter	Test Conditions	SG1846 SG2846			SG3846			Units
		Min.	Typ.	Max.	Min.	Typ.	Max.	
<b>Reference Section</b>								
Output Voltage	T <sub>J</sub> = 25°C, I <sub>O</sub> = 1mA	5.05	5.10	5.15	5.00	5.10	5.20	V
Line Regulation	V <sub>IN</sub> = 8V to 40V		5	20		5	20	mV
Load Regulation	I <sub>L</sub> = 1mA to 10mA		3	15		3	15	mV
Temperature Stability (Note 4)			0.4			0.4		mV/°C
Total Output Variation (Note 4)	Line, Load and Temperature	5.00		5.20	4.95		5.25	V
Output Noise Voltage (Note 4)	10Hz ≤ f ≤ 10KHz, T <sub>J</sub> = 25°C		100			100		μV
Long Term Stability (Note 4)	T <sub>J</sub> = 125°C, 1000Hrs.		5			5		mV
Short Circuit Output Current	V <sub>REF</sub> = 0V	-10	-45		-10	-45		mA

## ELECTRICAL CHARACTERISTICS (continued)

Parameter	Test Conditions	SG1846 SG2846			SG3846			Units
		Min.	Typ.	Max.	Min.	Typ.	Max.	
<b>Oscillator Section</b> (Note 9)								
Initial Accuracy	$T_J = 25^\circ\text{C}$	39	43	47	39	43	47	KHz
Voltage Stability	$V_{IN} = 8\text{V to }40\text{V}$		1	2		1	2	%
Temperature Stability (Note 4)	Over Operating Range		1			1		%
Sync Output High Level		3.9	4.35		3.9	4.35		V
Sync Output Low Level			2.3	2.5		2.3	2.5	V
Sync Input High Level	Pin 8 = 0V	3.9			3.9			V
Sync Input Low Level	Pin 8 = 0V			2.5			2.5	V
Sync Input Current	Sync Voltage = 5.25V, Pin 8 = 0V		1.2	1.5		1.2	1.5	mA
<b>Error Amp Section</b>								
Input Offset Voltage			0.5	5		0.5	10	mV
Input Bias Current			-0.6	-1		-0.6	-2	$\mu\text{A}$
Input Offset Current			40	250		40	250	nA
Common Mode Range	$V_{IN} = 8\text{V to }40\text{V}$	0		$V_{IN}-2\text{V}$	0		$V_{IN}-2\text{V}$	V
Open Loop Voltage Gain	$V_O = 1.2\text{V to }3\text{V}$ , $V_{CM} = 2\text{V}$	80	105		80	105		dB
Unity Gain Bandwidth (Note 4)	$T_J = 25^\circ\text{C}$	0.7	1.0		0.7	1.0		MHz
CMRR	$V_{CM} = 0\text{V to }38\text{V}$ , $V_{IN} = 40\text{V}$	75	100		75	100		dB
PSRR	$V_{IN} = 8\text{V to }40\text{V}$	80	105		80	105		dB
Output Sink Current	$V_{ID} = -15\text{mV to }-5\text{V}$ , $V_{PIN7} = 1.2\text{V}$	2	6		2	6		mA
Output Source Current	$V_{ID} = 15\text{mV to }5\text{V}$ , $V_{PIN7} = 2.5\text{V}$	-0.4	-0.5		-0.4	-0.5		mA
High Level Output Voltage	$R_L = 15\text{K}\Omega$ (Pin 7)	4.3	4.6		4.3	4.6		V
Low Level Output Voltage	$R_L = 15\text{K}\Omega$ (Pin 7)		0.7	1		0.7	1	V
<b>Current Sense Amplifier Section</b>								
Amplifier Gain (Notes 5 & 6)	$V_{PIN3} = 0\text{V}$ , Pin 1 Open	2.5	2.75	3.0	2.5	2.75	3.0	V
Maximum Differential (Note 6)	Pin 1 Open $R_L = 15\text{K}\Omega$ (Pin 7)							
Input Signal ( $V_{PIN4} - V_{PIN3}$ )(Note 5)		1.1	1.2		1.1	1.2		V
Input Offset Voltage (Note 5)	$V_{PIN1} = 0.5\text{V}$ , Pin 7 Open		5	25		5	25	mV
CMRR	$V_{CM} = 1\text{V to }12\text{V}$	60	83		60	83		dB
PSRR	$V_{IN} = 8\text{V to }40\text{V}$	60	84		60	84		dB
Input Bias Current (Note 5)	$V_{PIN1} = 0.5\text{V}$ , Pin 7 Open		-2.5	-10		-2.5	-10	$\mu\text{A}$
Input Offset Current (Note 5)	$V_{PIN1} = 0.5\text{V}$ , Pin 7 Open		0.08	1		0.08	1	$\mu\text{A}$
Input Common Mode Range		0		$V_{IN}-3$	0		$V_{IN}-3$	V
Delay to Outputs (Note 4)	$T_J = 25^\circ\text{C}$		200	500		200	500	ns
<b>Current Limit Adjust Section</b>								
Current Limit Offset Voltage(Note 5)	$V_{PIN3} = 0$ , $V_{PIN4} = 0\text{V}$ , Pin 7 Open	0.45	0.5	0.55	0.45	0.5	0.55	V
Input Bias Current	$V_{PIN5} = V_{REF}$ , $V_{PIN6} = 0\text{V}$		-10	-30		-10	-30	$\mu\text{A}$
<b>Shutdown Terminal Section</b>								
Threshold Voltage		250	350	400	250	350	400	mV
Input Voltage Range		0		$V_{IN}$	0		$V_{IN}$	V
Minimum Latching Current								
( $I_{PIN1}$ ) (Note 7)		3.0	1.5		3.0	1.5		mA
Maximum Non-Latching Current								
( $I_{PIN1}$ ) (Note 8)			1.5	0.8		1.5	0.8	mA
Delay to Outputs (Note 4)	$T_J = 25^\circ\text{C}$		300	600		300	600	ns
<b>Output Section</b>								
Collector Emitter Voltage		40			40			V
Collector Leakage Current	$V_C = 40\text{V}$			200			200	$\mu\text{A}$
Output Low Level	$I_{SINK} = 20\text{mA}$		0.1	0.4		0.1	0.4	V
	$I_{SINK} = 100\text{mA}$		0.4	2.1		0.4	2.1	V
Output High Level	$I_{SOURCE} = 20\text{mA}$	13	13.5		13	13.5		V
	$I_{SOURCE} = 100\text{mA}$	12	13.5		12	13.5		V
Rise Time (Note 4)	$C_L = 1\text{nF}$ , $T_J = 25^\circ\text{C}$		50	300		50	300	ns
Fall Time (Note 4)	$C_L = 1\text{nF}$ , $T_J = 25^\circ\text{C}$		50	300		50	300	ns

**ELECTRICAL CHARACTERISTICS** (continued)

Parameter	Test Conditions	SG1846 SG2846			SG3846			Units
		Min.	Typ.	Max.	Min.	Typ.	Max.	
<b>Under-Voltage Lockout Section</b>								
Start-Up Threshold			7.7	8.0		7.7	8.0	V
Threshold Hysteresis			0.75			0.75		V
<b>Total Standby Current</b>								
Supply Current			17	21		17	21	mA

Note 4. These parameters although guaranteed over the recommended operating conditions, are not tested in production.

Note 5. Parameter measured at trip point of latch with  $V_{PIN5} = V_{REF}$ ,  $V_{PIN6} = 0V$ .

Note 6. Amplifier gain defined as :  $G = \frac{\Delta V_{PIN7}}{\Delta V_{PIN4}}$ ;  $V_{PIN4} = 0V$  to  $1.0V$

Note 7. Current into Pin 1 guaranteed to latch circuit in shutdown state.  
Note 8. Current into Pin 1 guaranteed not to latch circuit in shutdown state.

Note 9.  $R_T = 10K\Omega$ ,  $C_T = 4.7nF$

**CHARACTERISTIC CURVES**

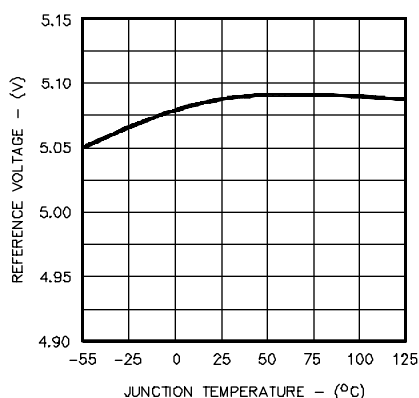


FIGURE 1. REFERENCE VOLTAGE VS. TEMPERATURE

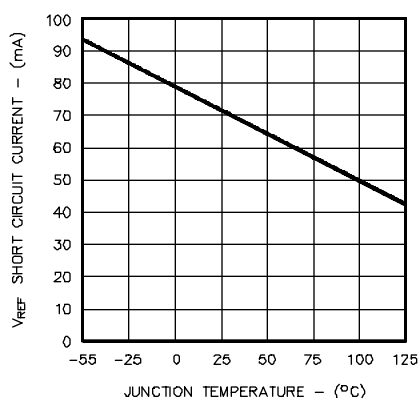


FIGURE 2.  $V_{REF}$  SHORT CIRCUIT CURRENT VS. TEMPERATURE

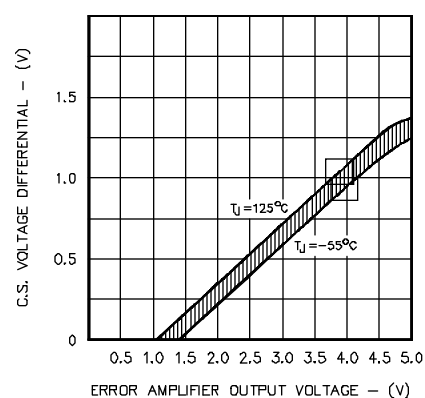


FIGURE 3. CURRENT SENSE THRESHOLD VS. ERROR AMPLIFIER OUTPUT

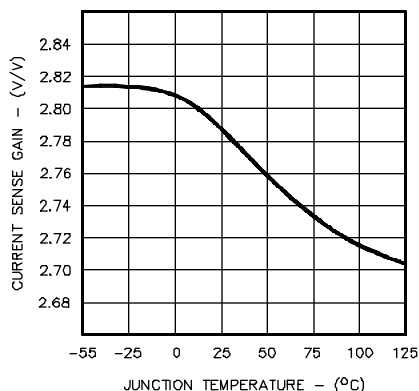


FIGURE 4. CURRENT SENSE GAIN VS. TEMPERATURE

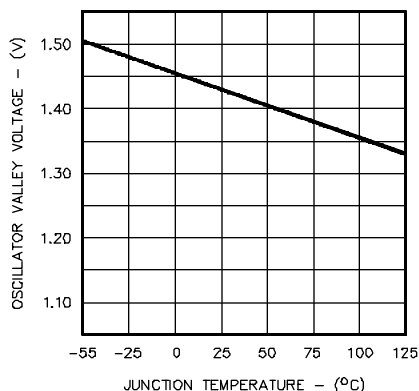


FIGURE 5. OSCILLATOR VALLEY VOLTAGE VS. TEMPERATURE

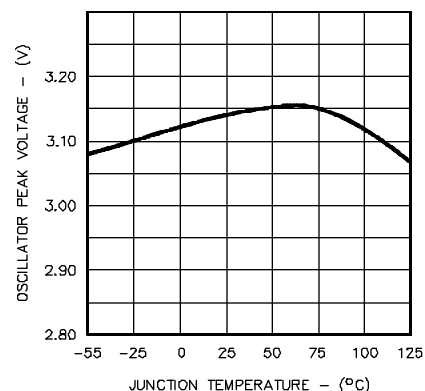


FIGURE 6. OSCILLATOR PEAK VOLTAGE VS. TEMPERATURE

CHARACTERISTIC CURVES (continued)

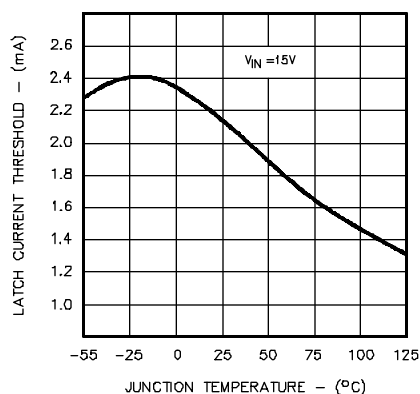


FIGURE 7. MINIMUM SCR LATCH CURRENT

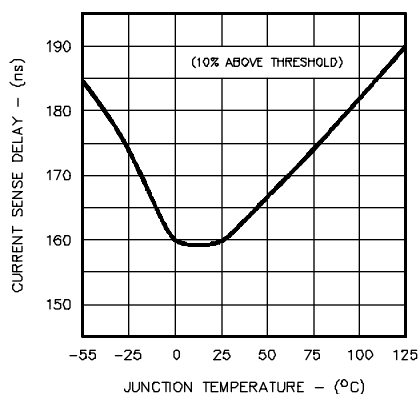


FIGURE 8. CURRENT SENSE DELAY VS. TEMPERATURE

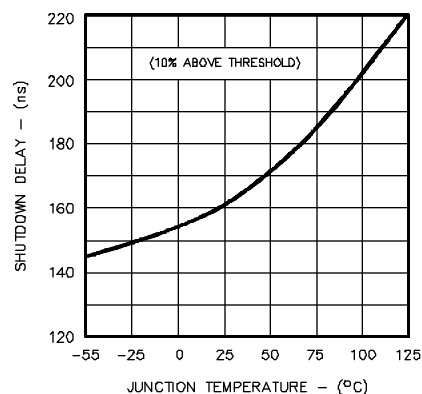


FIGURE 9. SHUTDOWN DELAY TO OUTPUT VS. TEMPERATURE

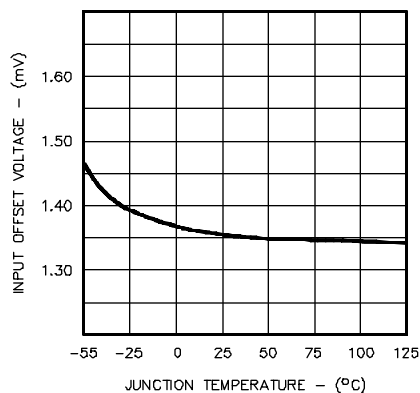


FIGURE 10. ERROR AMPLIFIER INPUT OFFSET VOLTAGE VS. TEMPERATURE

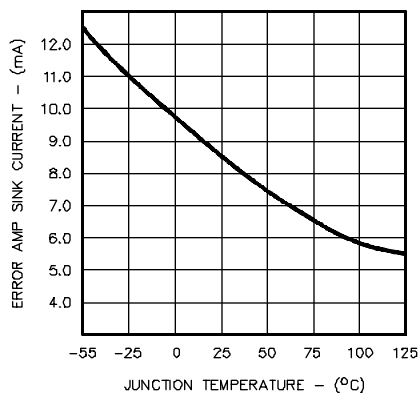


FIGURE 11. ERROR AMP SINK CURRENT VS. TEMPERATURE

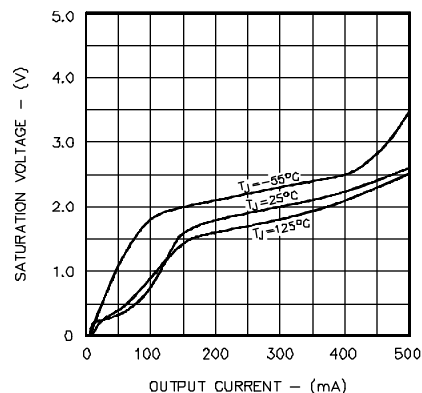


FIGURE 12. OUTPUT TRANSISTOR SATURATION VOLTAGE VS. OUTPUT CURRENT (SINK TRANSISTOR)

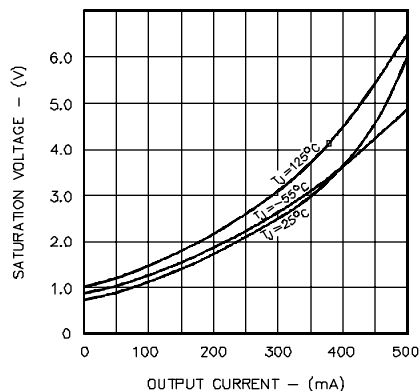


FIGURE 13. OUTPUT TRANSISTOR SATURATION VOLTAGE VS. OUTPUT CURRENT (SOURCE TRANSISTOR)

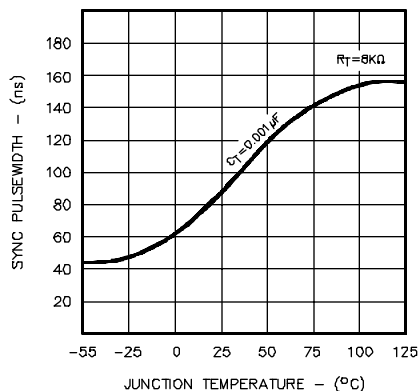


FIGURE 14. SYNC PULSEWIDTH VS. TEMPERATURE

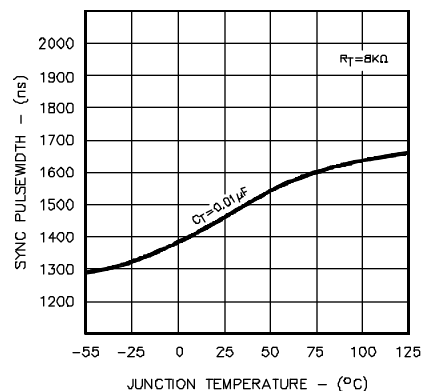


FIGURE 15. SYNC PULSEWIDTH VS. TEMPERATURE

CHARACTERISTIC CURVES (continued)

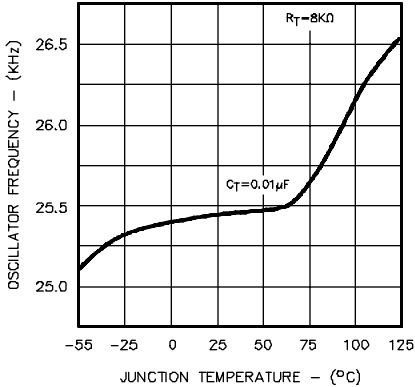


FIGURE 16. OSCILLATOR FREQUENCY VS. TEMPERATURE

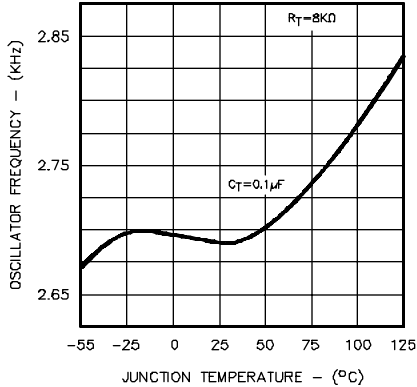


FIGURE 17. OSCILLATOR FREQUENCY VS. TEMPERATURE

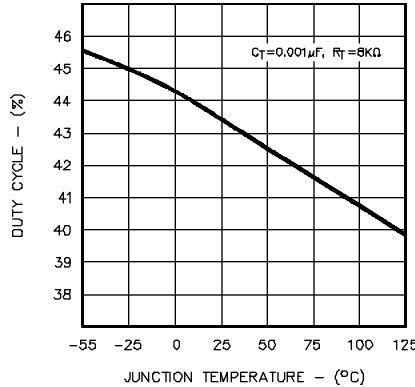


FIGURE 18. DUTY CYCLE VS. TEMPERATURE

APPLICATION INFORMATION

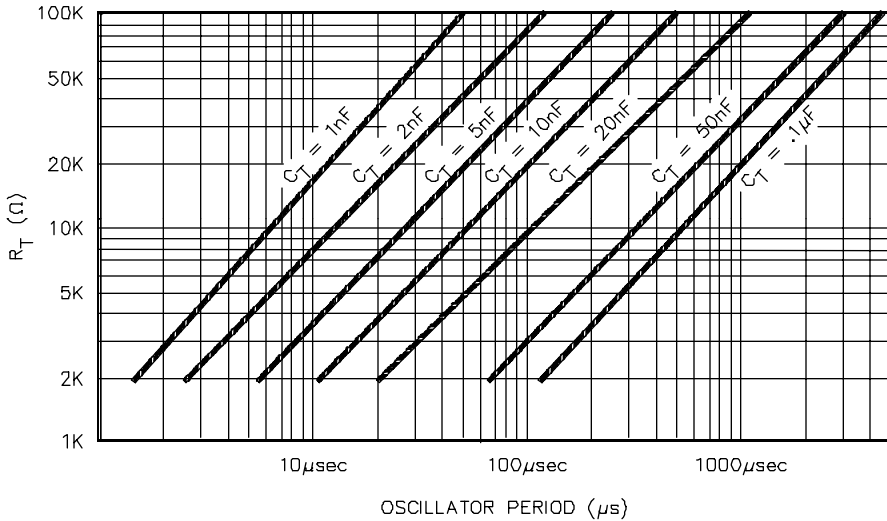
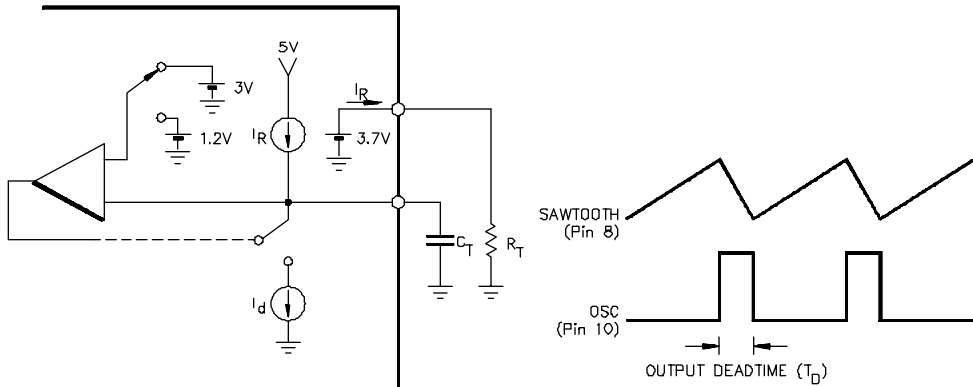


FIGURE 19- OSCILLATOR FREQUENCY CURVES



Oscillator frequency is approximated by the formula:  $f_T \approx \frac{2.2}{R_T C_T}$

FIGURE 20 - OSCILLATOR CIRCUIT

APPLICATION INFORMATION (continued)

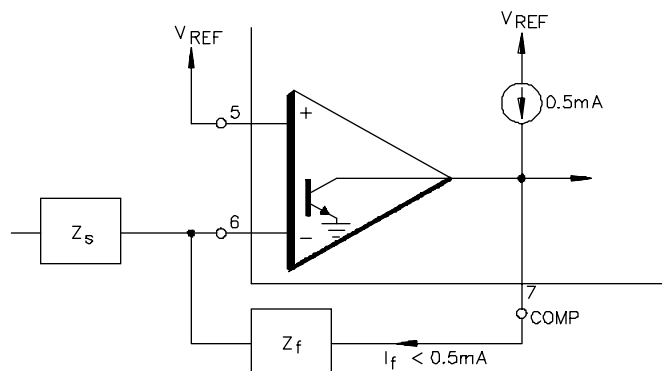


FIGURE 21 - ERROR AMP OUTPUT CONFIGURATION  
(Error amplifier can source up to 0.5mA)

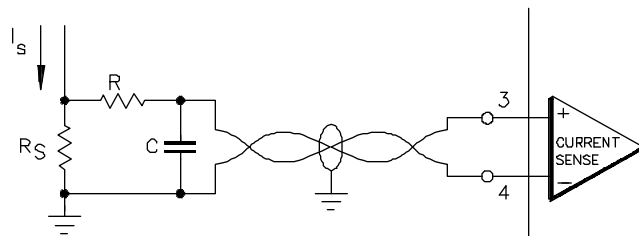


FIGURE 22 - CURRENT SENSE AMP CONNECTIONS

A small RC filter may be required in some applications to reduce switch transients. Differential input allows remote, noise free switching.

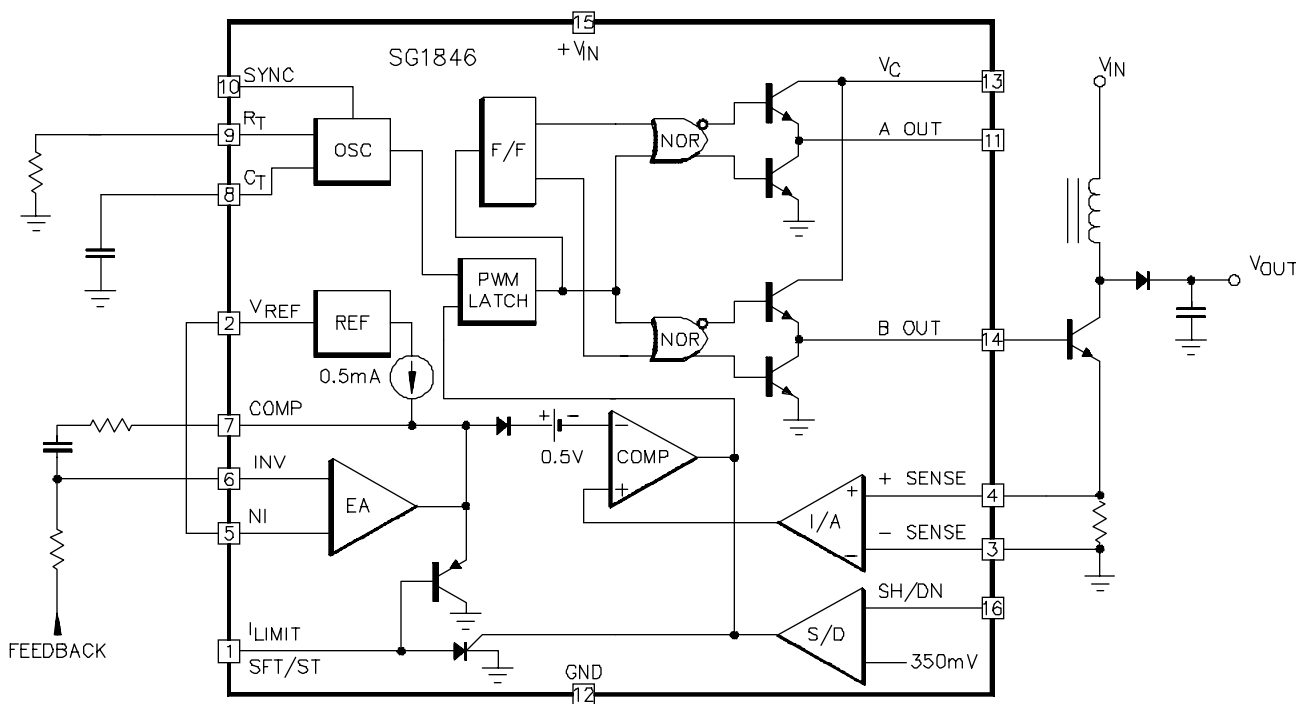


FIGURE 23 - SINGLE ENDED BOOST CONFIGURATION

APPLICATIONS INFORMATION (continued)

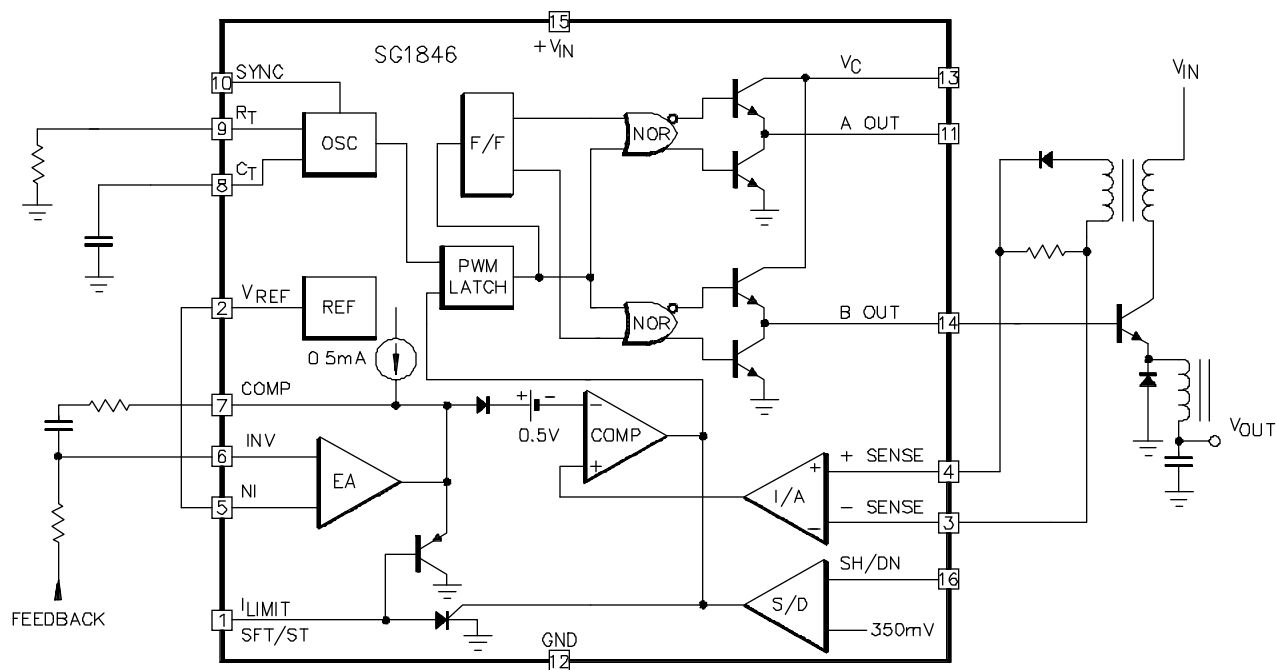


FIGURE 24 - BUCK CONVERTER WITH CURRENT SENSE WINDING

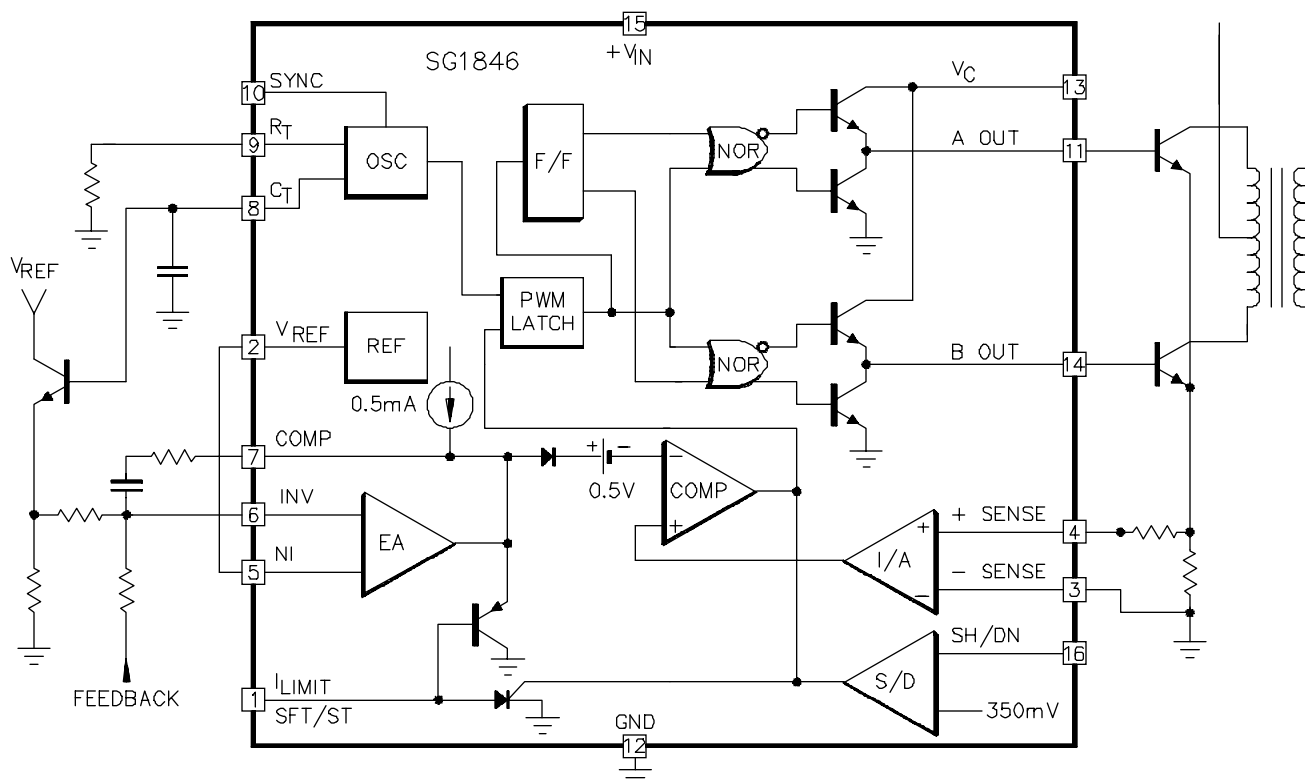
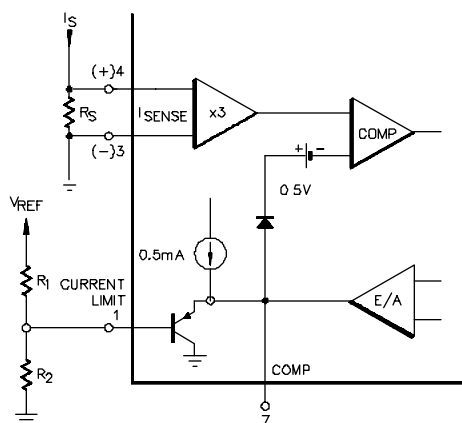


FIGURE 25 - PUSH/PULL CONVERTER WITH SLOPE COMPENSATION



APPLICATIONS INFORMATION (continued)



Peak Current ( $I_S$ ) is determined by the formula: 
$$I_S = \frac{R_2 V_{REF} - 0.5}{R_1 + R_2} \cdot \frac{1}{3R_S}$$

FIGURE 26 - PULSE BY PULSE CURRENT LIMITING

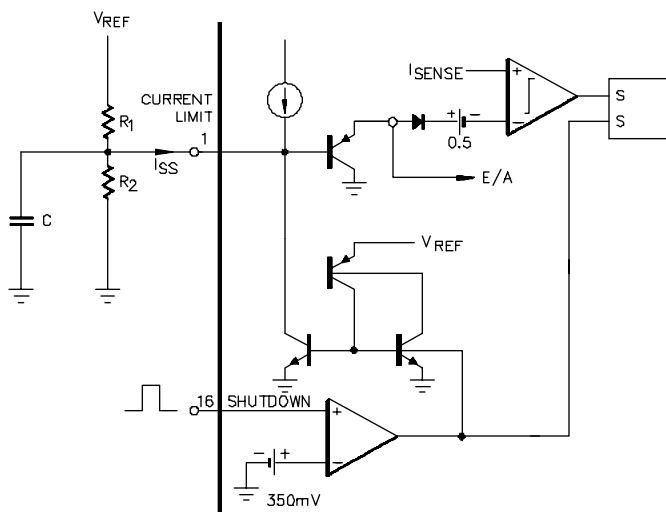
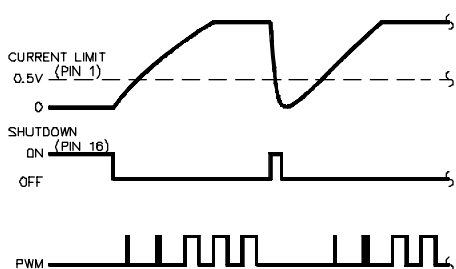


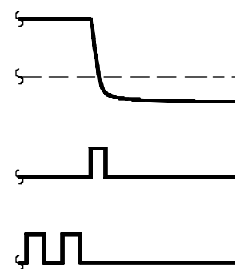
FIGURE 27 - SOFT START AND SHUTDOWN/RESTART FUNCTIONS



$$\frac{V_{REF}}{R_1} < 0.8mA$$

FIGURE 28 - SHUTDOWN WITH AUTO-RESTART

If  $\frac{V_{REF}}{R_1} < 0.8mA$  the shutdown latch will commutate when  $I_{SS} < 0.8mA$  and a restart cycle will be initiated.



$$\frac{V_{REF}}{R_1} > 3mA \text{ (LATCHED OFF)}$$

FIGURE 29 - SHUTDOWN WITHOUT AUTO-RESTART (LATCHED)

If  $\frac{V_{REF}}{R_1} > 3mA$  the device will latch off until power is recycled.

## CONNECTION DIAGRAMS & ORDERING INFORMATION (See Notes Below)

Package	Part No.	Ambient Temperature Range	Connection Diagram
16-PIN CERAMIC DIP J - PACKAGE	SG1846J/883B SG1846J/DESC SG1846J SG2846J SG3846J	-55°C to 125°C -55°C to 125°C -55°C to 125°C -25°C to 85°C 0°C to 70°C	<p>N Package: RoHS Compliant / Pb-free Transition DC: 0503 N Package: RoHS / Pb-free 100% Matte Tin Lead Finish</p>
16-PIN PLASTIC DIP N - PACKAGE	SG2846N SG3846N	-25°C to 85°C 0°C to 70°C	
16-PIN WIDEBODY PLASTIC S.O.I.C DW - PACKAGE	SG2846DW SG3846DW	-25°C to 85°C 0°C to 70°C	<p>DW Package: RoHS Compliant / Pb-free Transition DC: 0516 DW Package: RoHS / Pb-free 100% Matte Tin Lead Finish</p>
16-PIN CERAMIC FLAT PACK F - PACKAGE (Note 3)	SG1846F/DESC	-55°C to 125°C	
20-PIN CERAMIC LEADLESS CHIP CARRIER L - PACKAGE (Note 3)	SG1846L/883B SG1846L/DESC SG1846L	-55°C to 125°C -55°C to 125°C -55°C to 125°C	

Notes: 1. Contact factory for JAN and DESC part availability.  
2. All parts are viewed from the top.  
3. Consult factory for product availability.