

## Current-Mode PWM Controller

### FEATURES

- Low Start-Up Current (300µA Typical)
- Internal Precision Reference.
- 500KHz Current-Mode Operation.
- Pulse-by-Pulse Current Limiting.
- Automatic Feed-Forward Compensation.
- Optimized for Off-line and DC/DC Converters.
- Under-voltage Lockout with Hysteresis.
- Double Pulse Suppression.
- High Current Totem Pole Output.

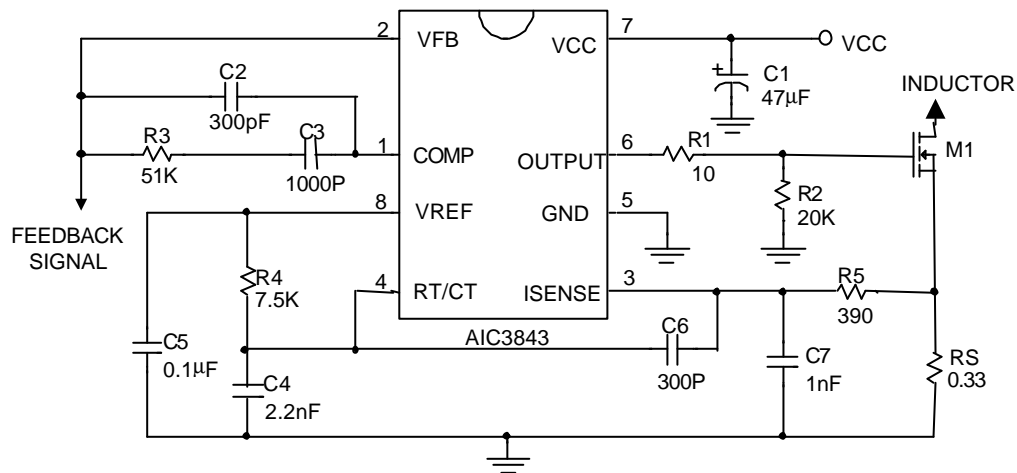
### APPLICATIONS

- AC/DC Off-line Converter.
- DC/DC Off-line Converter.

### DESCRIPTION

The AIC3843 control IC provides the features that are necessary to implement off-line or DC/DC Converter fixed-frequency current-mode schemes with a minimum number of external components. This integrated circuits features an under-voltage lockout (UVLO) with approximately 300µA start-up current, a precision reference trimmed for accuracy at the error amplifier input, high gain error amplifier, current sensing comparator, logic to insure latched operation, and a totem-pole output stage designed to source or sink high peak current. The output stage, suitable for driving the N-channel MOSFETs, is low in the off state.

### TYPICAL APPLICATION CIRCUIT



Current Mode PWM Control Circuit

## ORDERING INFORMATION

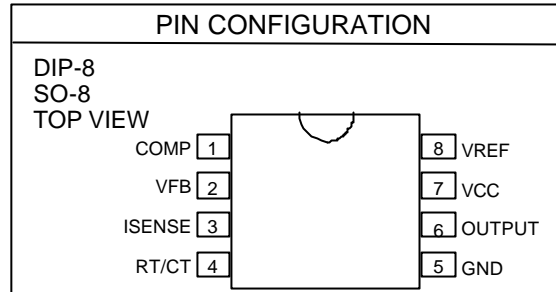
AIC3843CXXX

PACKING TYPE  
 TR: TAPE & REEL  
 TB: TUBE

PACKAGE TYPE  
 N: PLASTIC DIP  
 S: SMALL OUTLINE

Example: AIC3843CSTR

→ in SO-8 Package & Taping & Reel Packing Type  
 (CN is not available in TR packing type.)

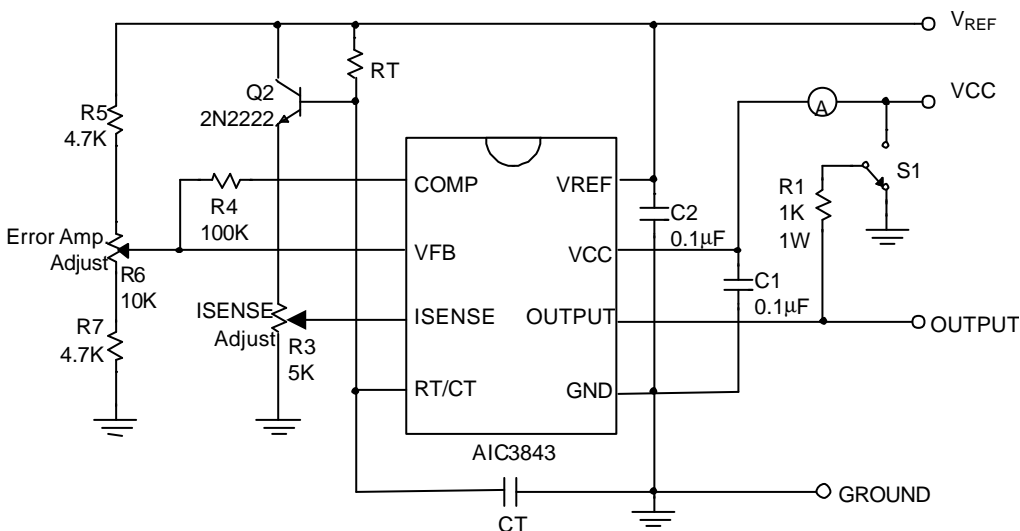


## ABSOLUTE MAXIMUM RATINGS

Supply Voltage (Low Impedance Source ) .....	30V
Supply Voltage ( $I_{CC} < 30\text{mA}$ ) .....	Self Limiting
Output Current .....	$\pm 1\text{A}$
Output Energy (Capacitive Load) .....	$5\mu\text{J}$
Analog Inputs (Pins 2, 3) .....	-0.3V to +6.3V
Error Amp Output Sink Current .....	10mA
Operation Temperature Range .....	-40°C~85°C
Power Dissipation at $T_A \leq 25^\circ\text{C}$ DIP Package .....	1W
SOIC Package .....	725mW
Storage Temperature Range .....	-65°C to +150°C
Lead Temperature (Soldering, 10 seconds) .....	300°C

Note 1: All voltages are with respect to Pin 5.  
 All currents are positive into the specified terminal.

## TEST CIRCUIT



■ **ELECTRICAL CHARACTERISTICS** { $V_{CC}=15V$  (see Note 2),  $-40^{\circ}C \leq T_A \leq 85^{\circ}C$ , unless otherwise specified.}

PARAMETERS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
<b>Reference Section</b>					
Output Voltage	$I_O=1mA$	4.9	5	5.1	V
Line Regulation	$V_{CC}=12V$ to 25V		5	20	mV
Load Regulation	$I_O=1mA$ to 20mA		5	25	mV
Temperature Coefficient of Output Voltage			0.2	0.4	mV/ $^{\circ}C$
Output Noise Voltage	$f=10Hz$ to 10KHz		50		$\mu V$
Output Voltage Long Term Drift	After 1000H at $T_A=25^{\circ}C$		5	25	mV
Short Circuit Output Current		-30	-85	-180	mA
<b>Oscillator Section</b>					
Oscillator Frequency (see Note 3)		47	52	57	KHz
Frequency Change with Supply Voltage	$V_{CC}=12V$ to 25V		0.2	1	%
Frequency Change with Temperature	$T_A=T_{LOW}$ to $T_{HIGH}$		5		%
Peak-to-Peak Amplitude at RT/CT			1.7		V
<b>Error Amplifier Section</b>					
Feedback Input Voltage	COMP at 2.5V	2.42	2.50	2.58	V
Input Bias Current			-0.3	-2	$\mu A$
Open-Loop Voltage Amplification	$V_O=2V$ to 4V	65	90		dB
Gain-Bandwidth Product		0.7	1		MHz
Supply Voltage Rejection Ratio	$V_{CC}=12V$ to 25V	60	70		dB
Output Sink Current	$V_{FB}$ at 2.7V, COMP at 1.1V	2	10		mA
Output Source Current	$V_{FB}$ at 2.3V, COMP at 5V	-0.5	-1		mA
High-Level Output Voltage	$V_{FB}$ at 2.3V, $R_L=15K\Omega$ to GND	5	6.2		V
Low-Level Output Voltage	$V_{FB}$ at 2.7V, $R_L=15\Omega$ to VREF		0.8	1.1	V

**ELECTRICAL CHARACTERISTICS (Continued)**

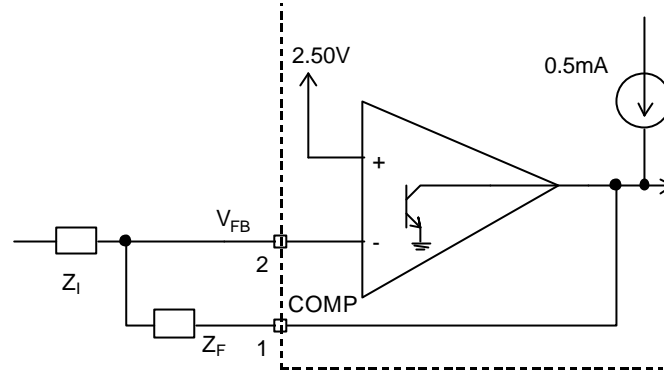
PARAMETERS	CONDITIONS	MIN.	TYP.	MAX.	UNITS
<b>Current Sense Section</b>					
Voltage Amplification	See Note 3 and 4	2.85	3	3.15	V/V
Current Sense Comparator Threshold	COMP at 5V, See Note 3	0.9	1	1.1	V
Supply Voltage Rejection Ratio	$V_{CC}=12V$ to 25V, See Note 3		70		dB
Input Bias Current			-2	-10	$\mu A$
Delay Time to Output			150	300	nS
<b>Output Section</b>					
High-Level Output Voltage	$I_{SOURCE}=20mA$	13	13.5		V
	$I_{SOURCE}=200mA$	12	13.4		V
Low-Level Output Voltage	$I_{SINK}=20mA$		0.1	0.4	V
	$I_{SINK}=200mA$		1.5	2.2	V
Rise Time	$C_L=1nF$		50	150	nS
Fall Time	$C_L=1nF$		50	150	nS
<b>Under voltage Lockout Section</b>					
Start Threshold Voltage		7.8	8.4	9.0	V
Minimum Operating Voltage after Start-Up		7.0	7.6	8.2	V
<b>Pulse-Width-Modulator Section</b>					
Maximum Duty Cycle		95	96	100	%
Minimum Duty Cycle				0	%
<b>Supply Voltage</b>					
Start-Up Current			0.3	0.5	mA
Operating Supply Current	$V_{FB}$ and $I_{SENSE}$ at 0V		12	17	mA
Limiting Voltage	$I_{CC}=25mA$	30	34		V

Note: 2: Adjust VCC above the start threshold before setting it to 15V.

3. These parameters are measured at the trip point of the latch with VFB at 0V.

4. Voltage amplification is measured between ISENSE and COMP with the input changing from 0V to 0.8V.

**Error AMP Configuration**



Error Amp can Source or Sink up to 0.5mA

Fig. 1

**Under-Voltage Lockout**

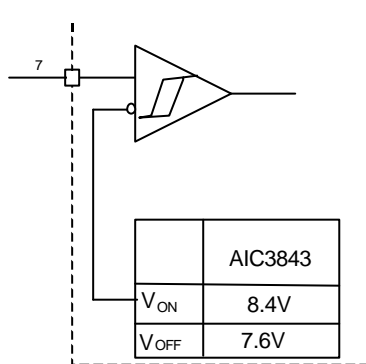


Fig. 2-1

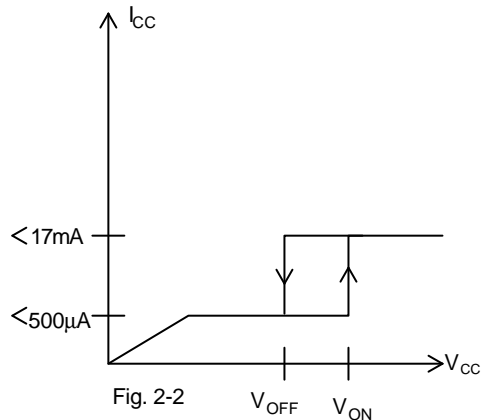
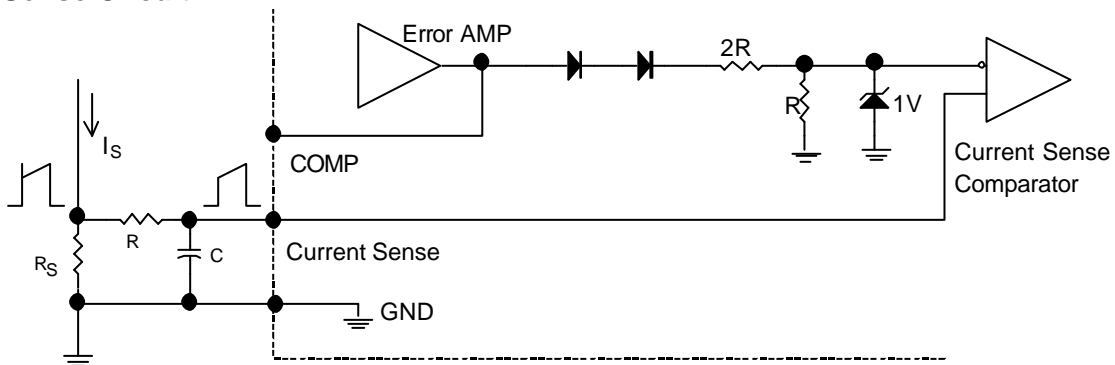


Fig. 2-2

During under-voltage lockout, the output driver is biased to sink minor amounts of current. Pin 6 should be shunted to ground with a bleeder resistor to prevent activating the power switch with extraneous leakage currents.

**Current Sense Circuit**



Peak Current (Is) is Determined By The Formula

$$I_{S\text{MAX}} \approx \frac{1.0V}{R_S}$$

A small RC filter may be required to suppress switch transients.

Fig. 3

Oscillator Section

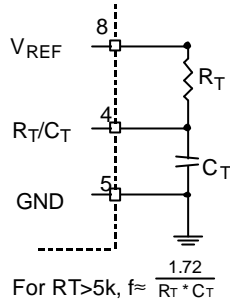
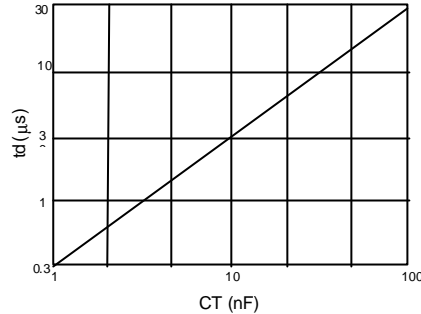
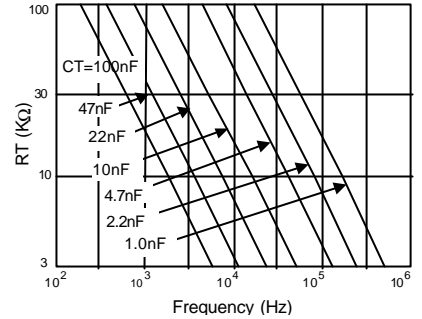


Fig. 4-1



Deadtime vs CT (RT>5KΩ)  
Fig. 4-2



Timing Resistance vs. Frequency  
Fig. 4-3

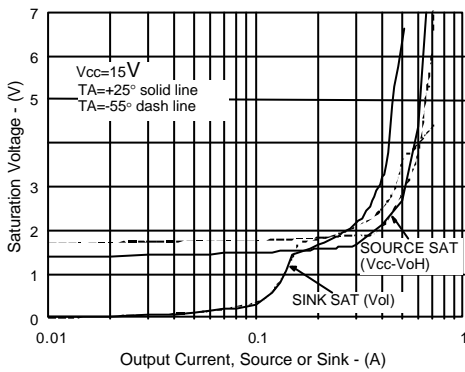


Fig. 4-4 Output saturation characteristics

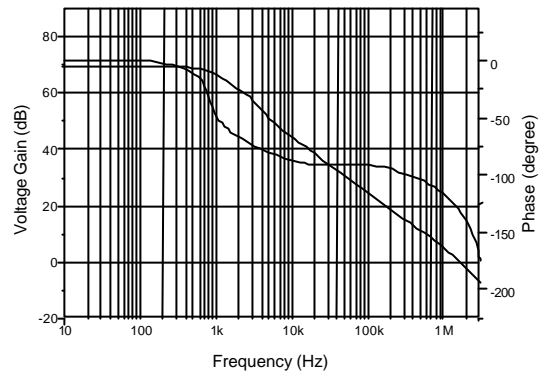
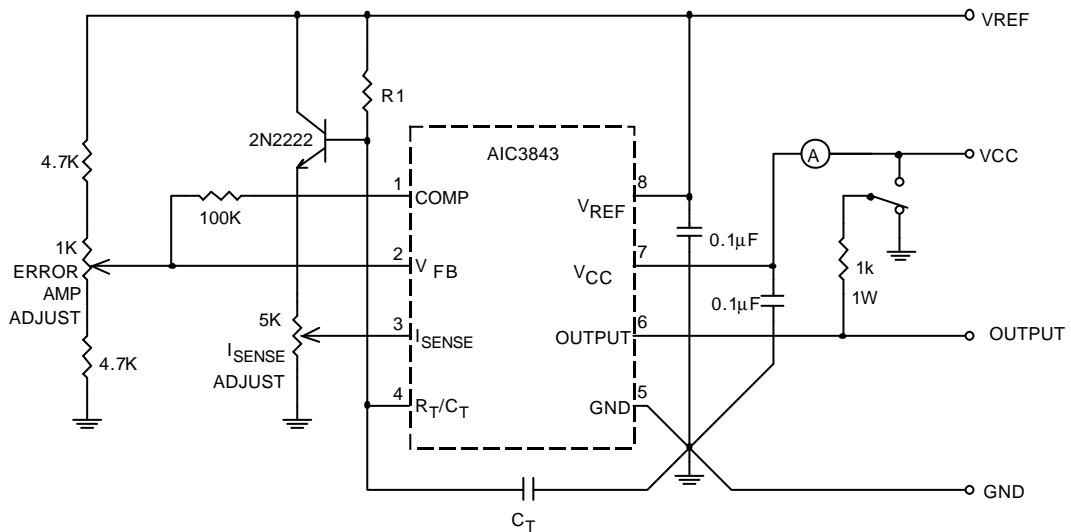


Fig. 4-5 Error Amplifier Open-Loop Frequency Response

Open-Loop Laboratory Fixture



High peak currents associated with capacitive loads necessitate careful grounding techniques. Timing and bypass capacitors should be connected close to pin 5 in a single point ground. The transistor and 5k potentiometer are used to sample the oscillator waveform and apply an adjustable ramp to pin 3.

Fig. 5

## Open-Loop Laboratory Fixture

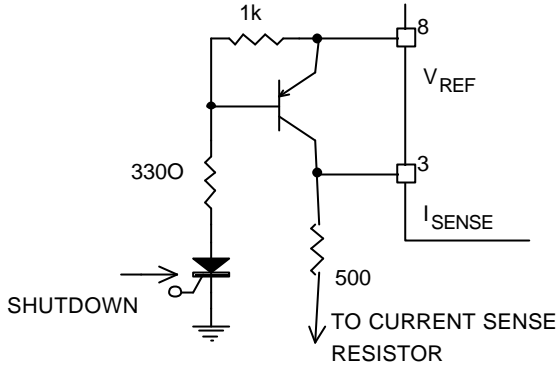


Fig. 6-1

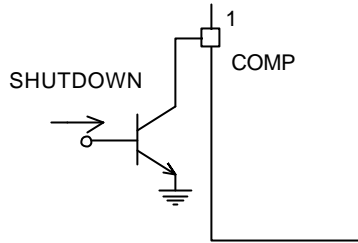
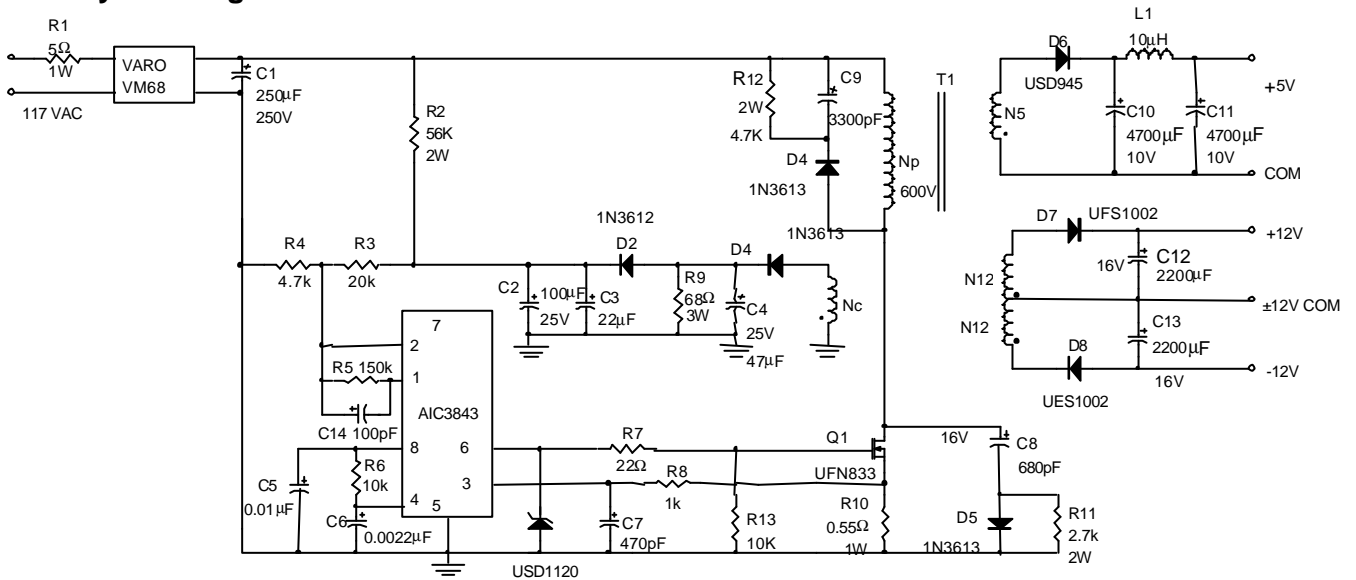


Fig. 6-2

Shutdown of the AIC3843 can be accomplished by two methods; either raise pin 3 above 1V or pull pin 1 below a voltage two-diode drops above ground. Either method causes the output of the PWM comparator to be high (refer to block diagram). The PWM latch is reset dominant so that the output will remain low until the next clock cycle after the shutdown condition at pin 1 and/or 3 is removed. In one example, an externally latched shutdown may be accomplished by adding an SCR, which will be reset by cycling Vcc below the lower UVLO threshold. At this point the reference turns off, allowing the SCR to reset.

## Offline Flyback Regulator

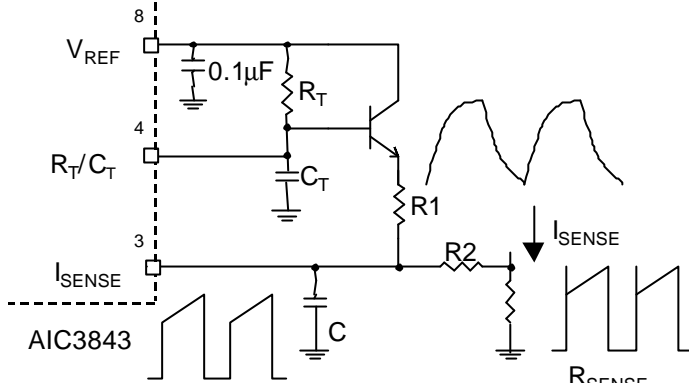


### Power Supply Specifications

- |                           |                                |                                 |
|---------------------------|--------------------------------|---------------------------------|
| 1. Input Voltage          | 95VAC to 130VAC<br>(50Hz/60Hz) | 5. Output Voltage:              |
| 2. Line Isolation         | 3750V                          | A. +5V, ±5%; 1A to 4A load      |
| 3. Switching Frequency    | 40kHz                          | Ripple voltage: 50mV P-P Max    |
| 4. Efficiency @ Full Load | 70%                            | B. +12V, ±3%; 0.1A to 0.3A load |
|                           |                                | Ripple voltage: 100mV P-P Max   |
|                           |                                | C. -12V, ±3%; 0.1A to 0.3A load |
|                           |                                | Ripple voltage: 100mV P-P Max   |

Fig. 7

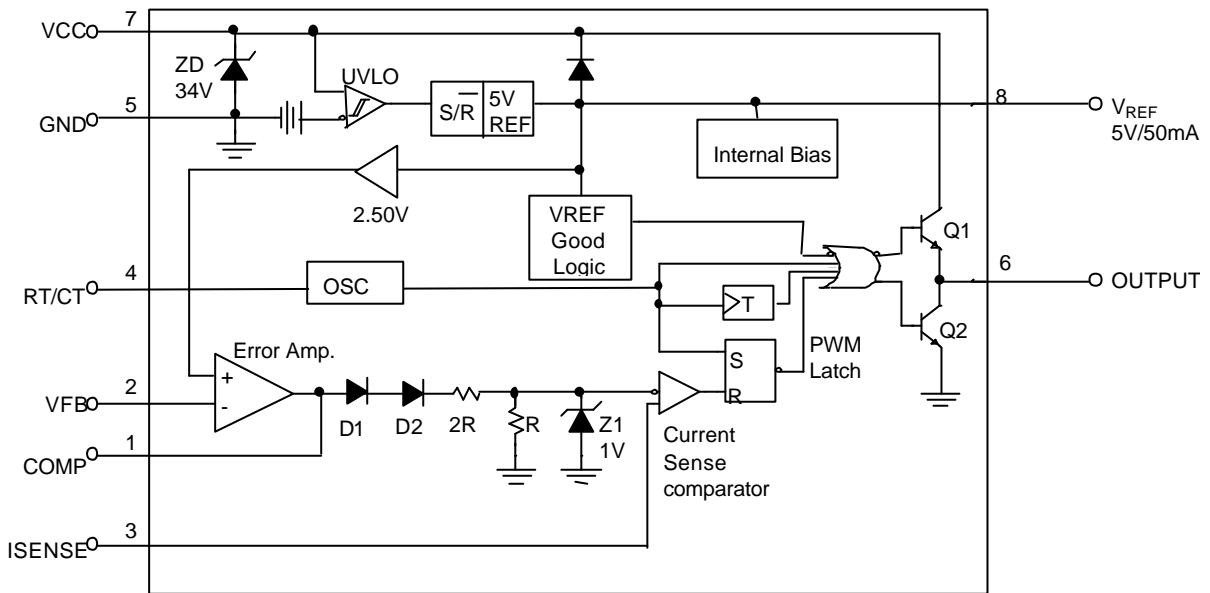
Slope compensation



A fraction of the oscillator ramp can be resistively summed with the current sense signal to provide slope compensation for converters requiring duty cycles over 50%. Note that capacitor, C forms a filter with R2 to suppress the leading edge switch spikes.

Fig. 8

**BLOCK DIAGRAM**





## ■ PIN DESCRIPTIONS

- PIN 1: COMP - This pin is the error amplifier output and is made available for loop compensation.
- PIN 2: VFB - This is the inverting input of the error amplifier. It is normally connected to the switching power supply output through a resistor divider.
- PIN 3: ISENSE - A voltage proportional to inductor current is connected to this input. The PWM uses this information to terminate the output switch conduction.
- PIN 4: RT/CT - The oscillator frequency and maximum output duty cycle are programmed by connecting resistor  $R_T$  to  $V_{REF}$  and capacitor  $C_T$  to ground. It is feasible to operate when  $f > 500\text{KHz}$ .
- PIN 5: GND - This pin is the combined control circuitry and power ground.
- PIN 6: OUTPUT- This output directly drives the gate of a power MOSFET. Peak currents up to 1A are sourced and sunk by this pin.
- PIN 7: VCC - This pin is the positive supply of the control IC.
- PIN 8: VREF - This is the reference output. It provides charging current for capacitor CT through resistor RT.

## ■ APPLICATION INFORMATIONS

### Under voltage Lockout

There are two separate under voltage lockout comparators incorporated to make sure that the IC is fully functional before the output stage is enabled. One is for power supply voltage (VCC) and the other is for reference output voltage (VREF). Each has a built in hysteresis to prevent erratic output behavior when their respective thresholds are crossed. For VCC comparator the upper and lower thresholds are 8.4V and 7.6V, respectively. The large hysteresis and low start up current (0.3mA) of the AIC3843 make it ideally suited in off-line converter applications where

efficient bootstrap startup techniques are required. A 34V zener is connected as a shunt regulator from VCC to ground. Its purpose is to protect the IC from excessive voltage that can occur during system start-up.

### Reference Output

The 5.0V reference output is trimmed to  $\pm 2.0\%$  tolerance at  $T_A=25^\circ\text{C}$ . It supplies charging current to the oscillator timing capacitor and is capable of providing current in excess of 20mA for powering additional control system circuitry. In case of overload, the reference is short-circuit protected at

about 85mA.

### **Error Amplifier**

A fully compensated error amplifier is provided with inverting input and output externally accessible. The non-inverting input is internally biased at 2.5V. The converter output voltage is usually divided down and connected to the inverting input.

The output of the error amplifier is accessible for external loop compensation, with an offset at two diode drops ( $\cong 1.4V$ ) and divided by three, before connected to the inverting input of the current sense comparator. This guarantees that no drive pulse appears at the output (pin 6).

### **Oscillator**

The oscillator frequency can be programmed through the setting of timing components  $R_T$  and  $C_T$ . Capacitor  $C_T$  is charged from the 5.0V reference output through  $R_T$  to about 2.8V and discharged to about 1.2V by the internal discharge current. When  $C_T$  is discharged the output (pin 6) must be in the low state, thus producing a controlled amount of output deadtime. Note that many values of  $R_T$  and  $C_T$  can produce the same frequency but only one combination will yield a specific output deadtime at a given frequency.

### **Current Sense Comparator and PWM Latch**

The output switch of AIC3843 is initiated by the

oscillator and terminated when the peak inductor current reaches the threshold level established by the error amplifier output (pin 1). The AIC3843 is operated at a current mode since the inductor current is monitored cycle-by-cycle and decides the duty cycle.

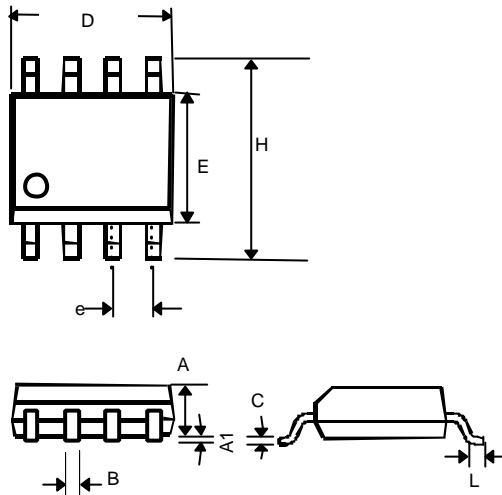
The inductor current is converted to a voltage by inserting the ground referenced sense resistor  $R_S$  in series with the source of output switch M1. This voltage is monitored by the current sense input (pin 3) and is compared to a level derived from the error amplifier output. In the normal operating conditions the peak inductor current is controlled by the voltage at pin 1 where

$$I_{PK} = \frac{V(\text{pin } 1) - 1.4V}{3R_S}$$

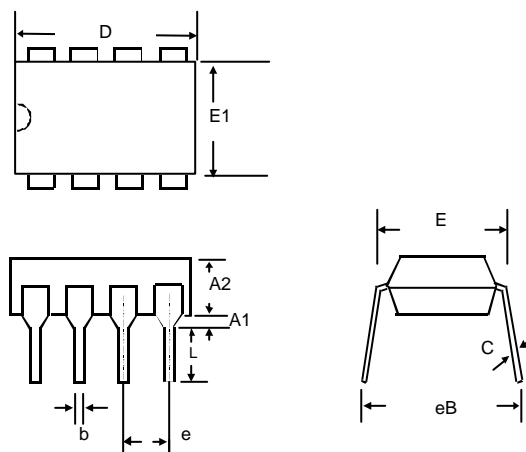
PWM Latch is used to ensure that only a single pulse appears at the output during any given oscillator cycle. However, a narrow spike on the leading edge of the current waveform can usually be observed and may cause the power supply to exhibit an instability when the output is tightly loaded.

### **Output Switch**

The AIC3843 contains a single totem-pole output stage that was specifically designed for direct drive of power MOSFET. If any under voltage lockout is detected, internal circuitry will keep the output switch in a sinking current mode, no external pull down resistor is needed.

**PHYSICAL DIMENSIONS**
**8 LEAD PLASTIC SO (unit: mm)**


SYMBOL	MIN	MAX
A	1.35	1.75
A1	0.10	0.25
B	0.33	0.51
C	0.19	0.25
D	4.80	5.00
E	3.80	4.00
e	1.27(TYP)	
H	5.80	6.20
L	0.40	1.27

**8 LEAD PLASTIC DIP (unit: mm)**


SYMBOL	MIN	MAX
A1	0.381	—
A2	2.92	4.96
b	0.35	0.56
C	0.20	0.36
D	9.01	10.16
E	7.62	8.26
E1	6.09	7.12
e	2.54 (TYP)	
eB	—	10.92
L	2.92	3.81