

# Current Mode PWM Controller

## 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
- 500mA (Peak) Totem-pole Outputs
- $\pm 1\%$  Bandgap Reference
- Under-voltage Lockout
- Soft Start Capability
- Shutdown Terminal
- 500kHz Operation

## DESCRIPTION

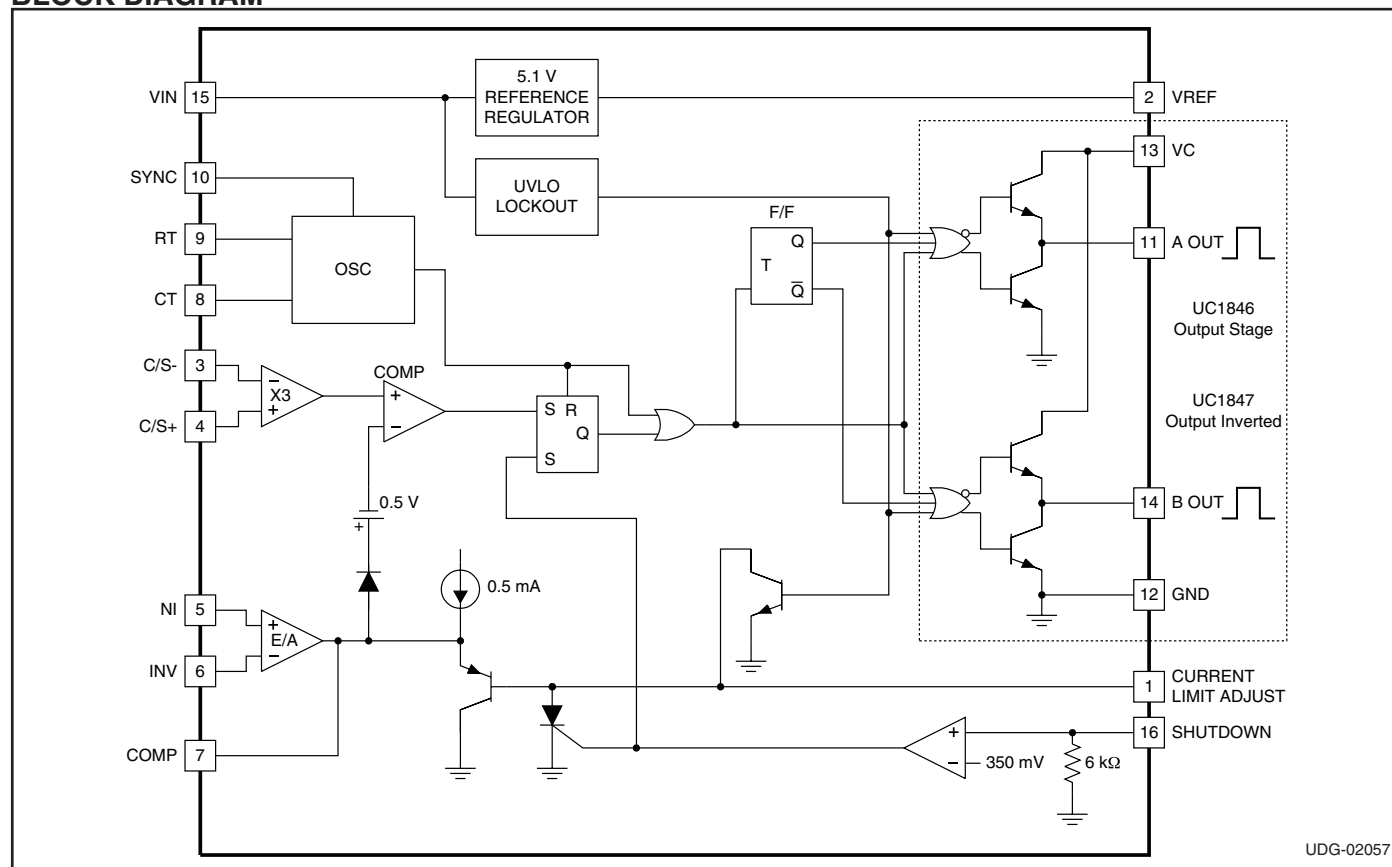
The UC1846/7 family of control ICs provides all of the necessary features to implement fixed frequency, current mode control schemes while maintaining a minimum external parts count. The superior performance of this technique can be measured in improved line regulation, enhanced load response characteristics, 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, deadline adjust capability, and a  $\pm 1\%$  trimmed bandgap reference.

The UC1846 features low outputs in the OFF state, while the UC1847 features high outputs in the OFF state.

## BLOCK DIAGRAM



UDG-02057

## ABSOLUTE MAXIMUM RATINGS (Note 1)

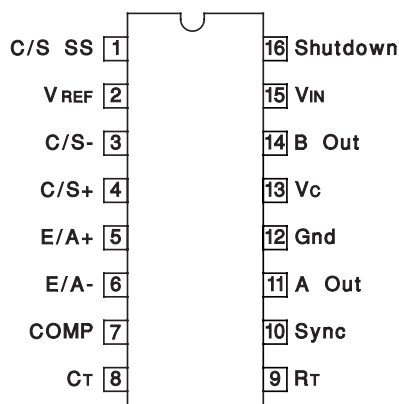
|                                               |                   |
|-----------------------------------------------|-------------------|
| Supply Voltage (Pin 15)                       | +40V              |
| Collector Supply Voltage (Pin 13)             | +40V              |
| Output Current, Source or Sink (Pins 11, 14)  | 500mA             |
| Analog Inputs (Pins 3, 4, 5, 6, 16)           | -0.3V to $V_{IN}$ |
| Reference Output Current (Pin 2)              | -30mA             |
| Sync Output Current (Pin 10)                  | -5mA              |
| Error Amplifier Output Current (Pin 7)        | -5mA              |
| Soft Start Sink Current (Pin 1)               | 50mA              |
| Oscillator Charging Current (Pin 9)           | 5mA               |
| Power Dissipation at $T_A=25^{\circ}\text{C}$ | 1000mW            |
| Power Dissipation at $T_C=25^{\circ}\text{C}$ | 2000mW            |
| Storage Temperature Range                     | -65°C to +150°C   |
| Lead Temperature (soldering, 10 seconds)      | +300°C            |

Note 1. All voltages are with respect to Ground, Pin 13. Currents are positive into, negative out of the specified terminal. Consult Packaging Section of Databook for thermal limitations and considerations of packages. Pin numbers refer to DIL and SOIC packages only.

## CONNECTION DIAGRAMS

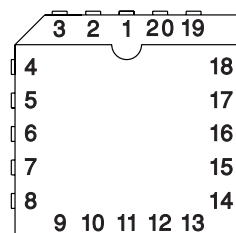
### DIL-16, SOIC-16 (TOP VIEW)

J or N Package, DW Package



### PLCC-20, LCC-20 (TOP VIEW)

Q, L Packages



| PACKAGE PIN FUNCTION |     |
|----------------------|-----|
| FUNCTION             | PIN |
| N/C                  | 1   |
| C/L SS               | 2   |
| VREF                 | 3   |
| C/S-                 | 4   |
| C/S+                 | 5   |
| N/C                  | 6   |
| E/A+                 | 7   |
| E/A-                 | 8   |
| Comp                 | 9   |
| CT                   | 10  |
| N/C                  | 11  |
| RT                   | 12  |
| Sync                 | 13  |
| A Out                | 14  |
| Gnd                  | 15  |
| N/C                  | 16  |
| Vc                   | 17  |
| B Out                | 18  |
| VIN                  | 19  |
| Shutdown             | 20  |

**ELECTRICAL CHARACTERISTICS** (Unless otherwise stated, these specifications apply for  $T_A=-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  for UC1846/7;  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  for the UC2846/7; and  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  for the UC3846/7;  $V_{IN}=15\text{V}$ ,  $R_T=10\text{k}$ ,  $C_T=4.7\text{nF}$ ,  $T_A=T_J$ .)

| PARAMETER                    | TEST CONDITIONS                      | UC1846/UC1847<br>UC2846/UC2847 |      |      | UC3846/UC3847 |      |      | UNITS |
|------------------------------|--------------------------------------|--------------------------------|------|------|---------------|------|------|-------|
|                              |                                      | MIN.                           | TYP. | MAX. | MIN.          | TYP. | MAX. |       |
| Reference Section            |                                      |                                |      |      |               |      |      |       |
| Output Voltage               | TJ=25°C, IO=1mA                      | 5.05                           | 5.10 | 5.15 | 5.00          | 5.10 | 5.20 | V     |
| Line Regulation              | VIN=8V to 40V                        |                                | 5    | 20   |               | 5    | 20   | mV    |
| Load Regulation              | IL=1mA to 10mA                       |                                | 3    | 15   |               | 3    | 15   | mV    |
| Temperature Stability        | Over Operating Range, (Note 2)       |                                | 0.4  |      |               | 0.4  |      | mV/°C |
| Total Output Variation       | Line, Load, and Temperature (Note 2) | 5.00                           |      | 5.20 | 4.95          |      | 5.25 | V     |
| Output Noise Voltage         | 10Hz ≤ f ≤ 10kHz, TJ=25°C (Note 2)   |                                | 100  |      |               | 100  |      | μV    |
| Long Term Stability          | TJ=125°C, 1000 Hrs. (Note 2)         |                                | 5    |      |               | 5    |      | mV    |
| Short Circuit Output Current | VREF=0V                              | -10                            | -45  |      | -10           | -45  |      | mA    |

**ELECTRICAL CHARACTERISTICS (cont.)** (Unless otherwise stated, these specifications apply for  $T_A = -55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  for UC1846/7;  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  for the UC2846/7; and  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  for the UC3846/7;  $V_{IN} = 15\text{V}$ ,  $R_T = 10\text{k}$ ,  $C_T = 4.7\text{nF}$ ,  $T_A = T_J$ .)

| PARAMETER                                            | TEST CONDITIONS                              | UC1846/UC1847<br>UC2846/UC2847 |      |        | UC3846/UC3847 |      |        | UNITS |
|------------------------------------------------------|----------------------------------------------|--------------------------------|------|--------|---------------|------|--------|-------|
|                                                      |                                              | MIN.                           | TYP. | MAX.   | MIN.          | TYP. | MAX.   |       |
| Oscillator Section                                   |                                              |                                |      |        |               |      |        |       |
| Initial Accuracy                                     | TJ=25°C                                      | 39                             | 43   | 47     | 39            | 43   | 47     | kHz   |
| Voltage Stability                                    | VIN=8V to 40V                                |                                | -1   | 2      |               | -1   | 2      | %     |
| Temperature Stability                                | Over Operating Range (Note 2)                |                                | -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=3.9V, Pin 8=0V                  |                                | 1.3  | 1.5    |               | 1.3  | 1.5    | mA    |
| Error Amp Section                                    |                                              |                                |      |        |               |      |        |       |
| Input Offset Voltage                                 |                                              |                                | 0.5  | 5      |               | 0.5  | 10     | mV    |
| Input Bias Current                                   |                                              |                                | -0.6 | -1     |               | -0.6 | -2     | μA    |
| Input Offset Current                                 |                                              |                                | 40   | 250    |               | 40   | 250    | nA    |
| Common Mode Range                                    | VIN=8V to 40V                                | 0                              |      | VIN-2V | 0             |      | VIN-2V | V     |
| Open Loop Voltage Gain                               | ΔVo=1.2 to 3V, VCM=2V                        | 80                             | 105  |        | 80            | 105  |        | dB    |
| Unity Gain Bandwidth                                 | TJ=25°C (Note 2)                             | 0.7                            | 1.0  |        | 0.7           | 1.0  |        | MHz   |
| CMRR                                                 | VCM=0V to 38V, VIN=40V                       | 75                             | 100  |        | 75            | 100  |        | dB    |
| PSRR                                                 | VIN=8V to 40V                                | 80                             | 105  |        | 80            | 105  |        | dB    |
| Output Sink Current                                  | VID=-15mV to -5V, VPIN 7=1.2V                | 2                              | 6    |        | 2             | 6    |        | mA    |
| Output Source Current                                | VID=15mV to 5V, VPIN 7=2.5V                  | -0.4                           | -0.5 |        | -0.4          | -0.5 |        | mA    |
| High Level Output Voltage                            | RL=(Pin 7) 15kΩ                              | 4.3                            | 4.6  |        | 4.3           | 4.6  |        | V     |
| Low Level Output Voltage                             |                                              |                                | 0.7  | 1      |               | 0.7  | 1      | V     |
| Current Sense Amplifier Section                      |                                              |                                |      |        |               |      |        |       |
| Amplifier Gain                                       | VPIN 3=0V, Pin 1 Open (Notes 3 & 4)          | 2.5                            | 2.75 | 3.0    | 2.5           | 2.75 | 3.0    | V     |
| Maximum Differential Input<br>Signal (VPIN 4-VPIN 3) | Pin 1 Open (Note 3)<br>RL (Pin 7)=15kΩ       | 1.1                            | 1.2  |        | 1.1           | 1.2  |        | V     |
| Input Offset Voltage                                 | VPIN 1=0.5V, Pin 7 Open (Note 3)             |                                | 5    | 25     |               | 5    | 25     | mV    |
| CMRR                                                 | VCM=1V to 12V                                | 60                             | 83   |        | 60            | 83   |        | dB    |
| PSRR                                                 | VIN=8V to 40V                                | 60                             | 84   |        | 60            | 84   |        | dB    |
| Input Bias Current                                   | VPIN 1=0.5V, Pin 7 Open (Note 3)             |                                | -2.5 | -10    |               | -2.5 | -10    | μA    |
| Input Offset Current                                 | VPIN 1=0.5V, Pin 7 Open (Note 3)             |                                | 0.08 | 1      |               | 0.08 | 1      | μA    |
| Input Common Mode Range                              |                                              | 0                              |      | VIN-3  | 0             |      | VIN-3  | V     |
| Delay to Outputs                                     | TJ=25°C, (Note 2)                            |                                | 200  | 500    |               | 200  | 500    | ns    |
| Current Limit Adjust Section                         |                                              |                                |      |        |               |      |        |       |
| Current Limit Offset                                 | VPIN 3=0V, VPIN 4=0V, Pin 7 Open<br>(Note 3) | 0.45                           | 0.5  | 0.55   | 0.45          | 0.5  | 0.55   | V     |
| Input Bias Current                                   | VPIN 5=VREF, VPIN 6=0V                       |                                | -10  | -30    |               | -10  | -30    | μA    |
| Shutdown Terminal Section                            |                                              |                                |      |        |               |      |        |       |
| Threshold Voltage                                    |                                              | 250                            | 350  | 400    | 250           | 350  | 400    | mV    |
| Input Voltage Range                                  |                                              | 0                              |      | VIN    | 0             |      | VIN    | V     |
| Minimum Latching Current<br>(IPIN 1)                 | (Note 6)                                     | 3.0                            | 1.5  |        | 3.0           | 1.5  |        | mA    |

# **ELECTRICAL CHARACTERISTICS (cont.)**

(Unless otherwise stated, these specifications apply for TA=-55°C to +125°C for UC1846/7; -40°C to +85°C for the UC2846/7; and 0°C to +70°C for the UC3846/7; VIN=15V, RT=10k, CT=4.7nF, TA=TJ.)

| PARAMETER                                          | TEST CONDITIONS                                    | UC1846/UC1847<br>UC2846/UC2847 |      |      | UC3846/UC3847 |      |      | UNITS |
|----------------------------------------------------|----------------------------------------------------|--------------------------------|------|------|---------------|------|------|-------|
|                                                    |                                                    | MIN.                           | TYP. | MAX. | MIN.          | TYP. | MAX. |       |
| Shutdown Terminal Section (cont.)                  |                                                    |                                |      |      |               |      |      |       |
| Maximum Non-Latching Current (I <sub>PIN 1</sub> ) | (Note 7)                                           |                                | 1.5  | 0.8  |               | 1.5  | 0.8  | mA    |
| Delay to Outputs                                   | T <sub>J</sub> =25°C (Note 2)                      |                                | 300  | 600  |               | 300  | 600  | ns    |
| Output Section                                     |                                                    |                                |      |      |               |      |      |       |
| Collector-Emitter Voltage                          |                                                    | 40                             |      |      | 40            |      |      | V     |
| Collector Leakage Current                          | V <sub>C</sub> =40V (Note 5)                       |                                |      | 200  |               |      | 200  | μA    |
| Output Low Level                                   | I <sub>SINK</sub> =20mA                            |                                | 0.1  | 0.4  |               | 0.1  | 0.4  | V     |
|                                                    | I <sub>SINK</sub> =100mA                           |                                | 0.4  | 2.1  |               | 0.4  | 2.1  | V     |
| Output High Level                                  | I <sub>SOURCE</sub> =20mA                          | 13                             | 13.5 |      | 13            | 13.5 |      | V     |
|                                                    | I <sub>SOURCE</sub> =100mA                         | 12                             | 13.5 |      | 12            | 13.5 |      | V     |
| Rise Time                                          | C <sub>L</sub> =1nF, T <sub>J</sub> =25°C (Note 2) |                                | 50   | 300  |               | 50   | 300  | ns    |
| Fall Time                                          | C <sub>L</sub> =1nF, T <sub>J</sub> =25°C (Note 2) |                                | 50   | 300  |               | 50   | 300  | ns    |
| Under-Voltage Lockout Section                      |                                                    |                                |      |      |               |      |      |       |
| Start-Up Threshold                                 |                                                    |                                | 7.7  | 8.0  |               | 7.7  | 8.0  | V     |
| Threshold Hysteresis                               |                                                    |                                | 0.75 |      |               | 0.75 |      | V     |
| Total Standby Current                              |                                                    |                                |      |      |               |      |      |       |
| Supply Current                                     |                                                    |                                | 17   | 21   |               | 17   | 21   | mA    |

Note 2. These parameters, although guaranteed over the recommended operating conditions, are not 100% tested in production.

Note 3. Parameter measured at trip point of latch with VPIN 5 = VREF, VPIN 6 = 0V.

Note 4. Amplifier gain defined as:  $G = \frac{\Delta V_{PIN7}}{\Delta V_{PIN4}}$ ;  $V_{PIN4} = 0$  to 1.0V

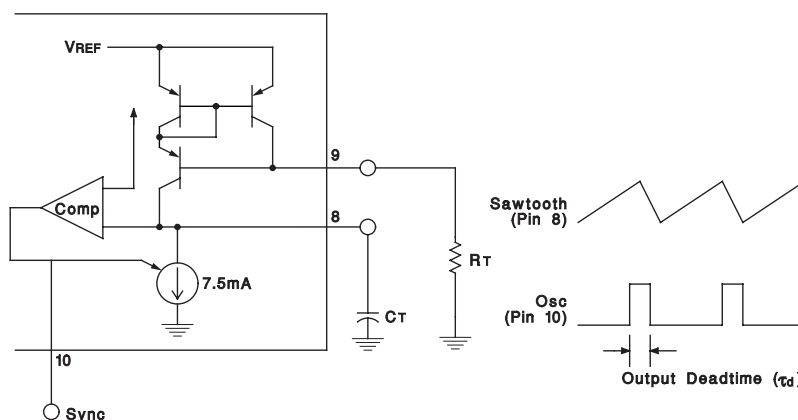
Note 5. Applies to UC1846/UC2846/UC3846 only due to polarity of outputs.

Note 6. Current into Pin 1 guaranteed to latch circuit in shutdown state.

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

## **APPLICATIONS DATA**

### **Oscillator Circuit**



Output deadtime is determined by the external capacitor, CT, according to the formula:  $\tau_d (\mu s) = 145CT (\mu f) \left( \frac{ID}{ID - \frac{3.6}{RT (k\Omega)}} \right)$ .

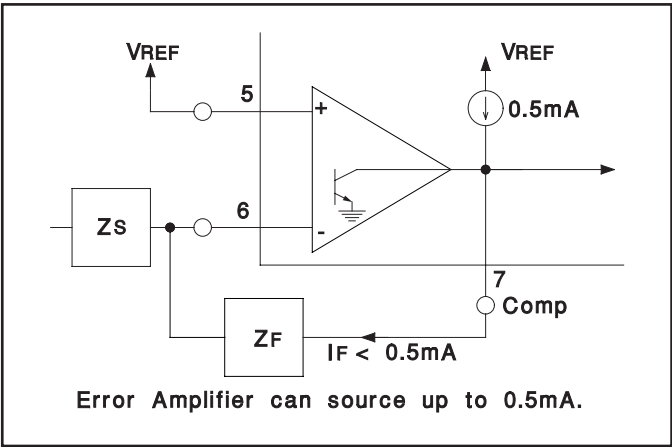
ID = Oscillator discharge current at 25°C is typically 7.5.

For large values of RT:  $\tau_d (\mu s) \approx 145CT (\mu f)$ .

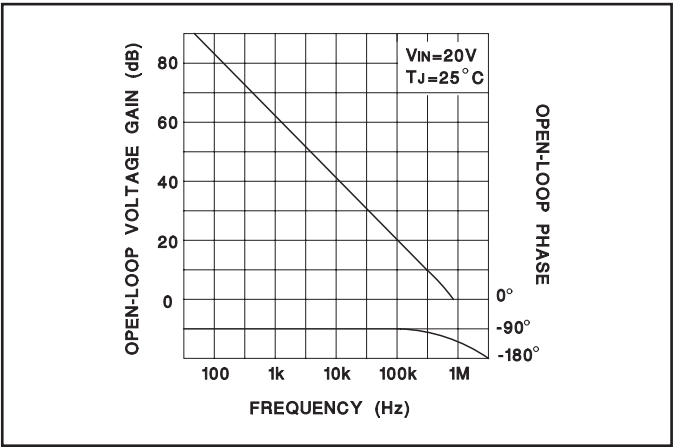
Oscillator frequency is approximated by the formula:  $fT (kHz) \approx \frac{2.2}{RT (k\Omega) \cdot CT (\mu f)}$ .

# APPLICATIONS DATA (cont.)

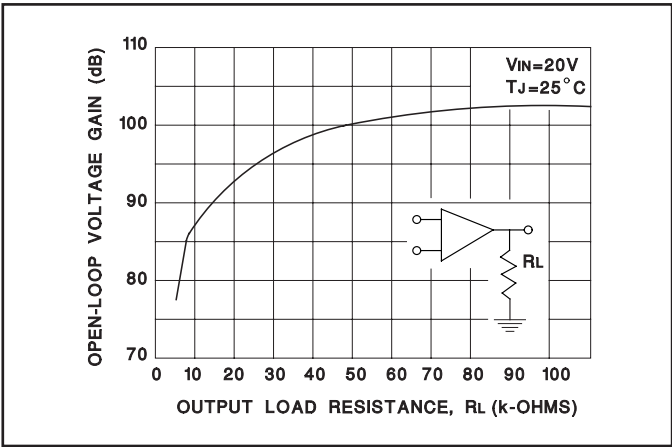
Error Amp Output Configuration



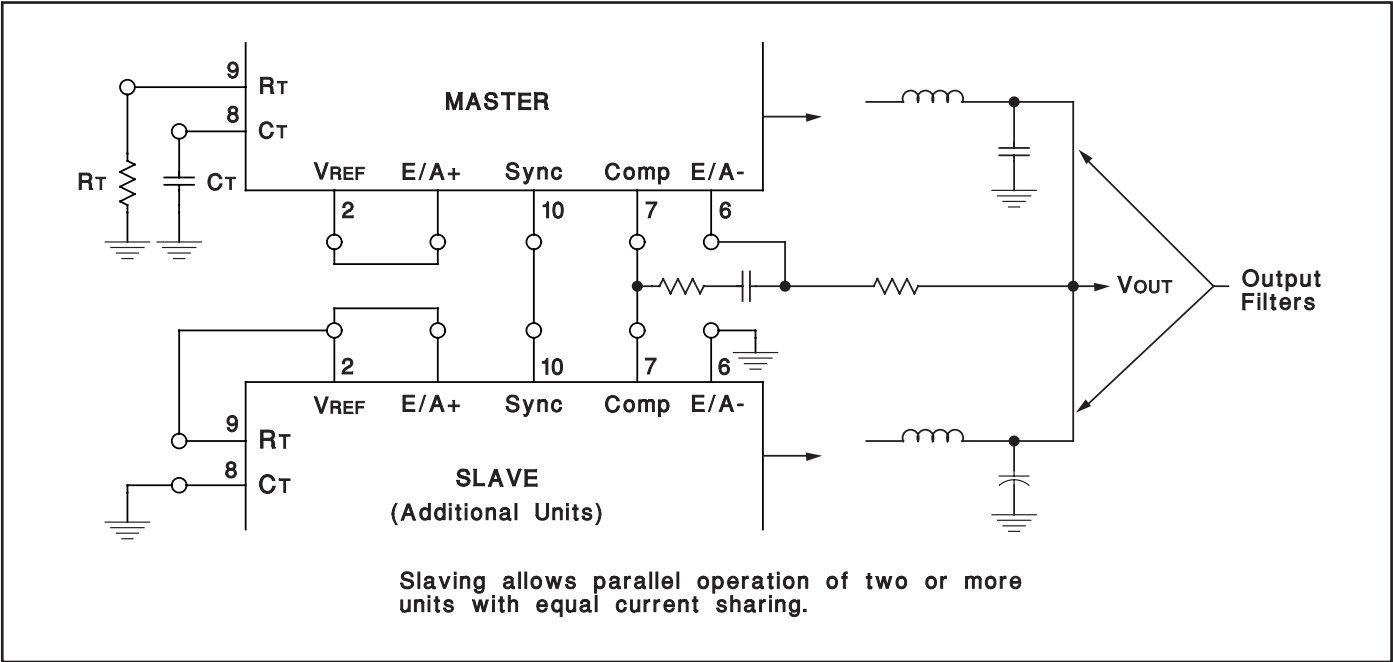
Error Amp Gain and Phase vs Frequency



Error Amp Open-Logic D.C. Gain vs Load Resistance

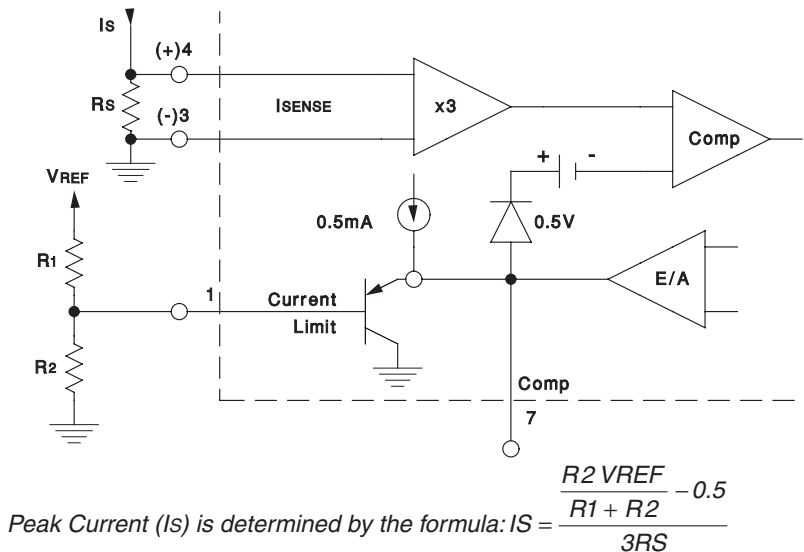


Parallel Operation

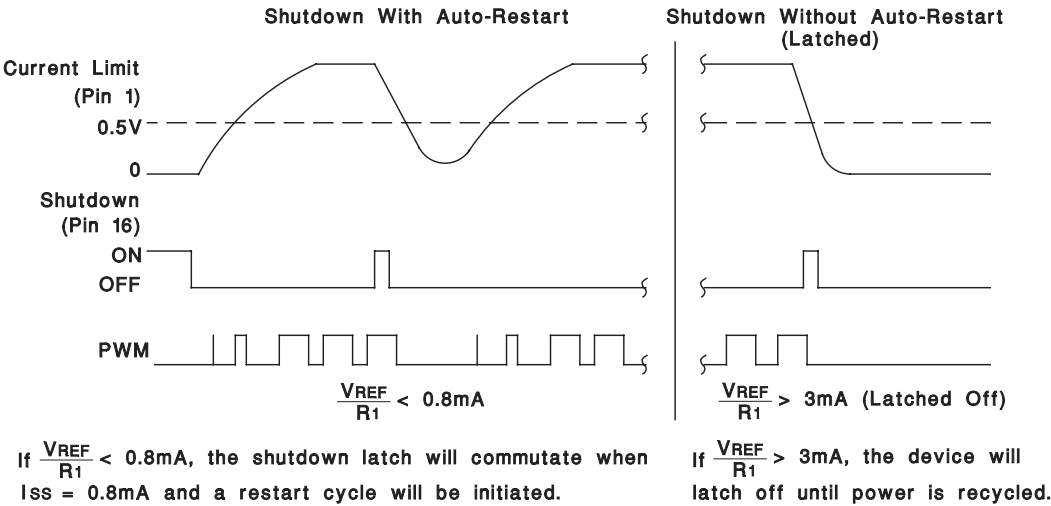
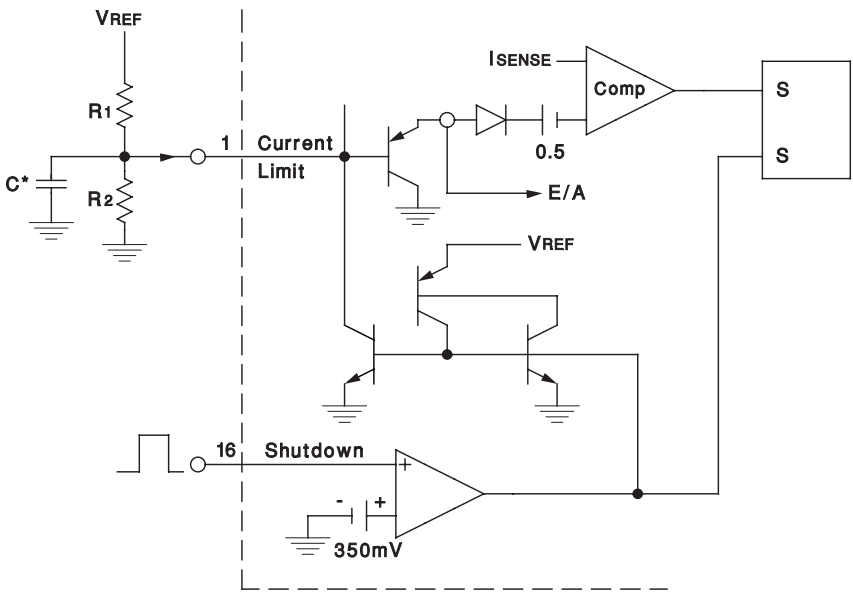


# APPLICATIONS DATA (cont.)

## Pulse by Pulse Current Limiting

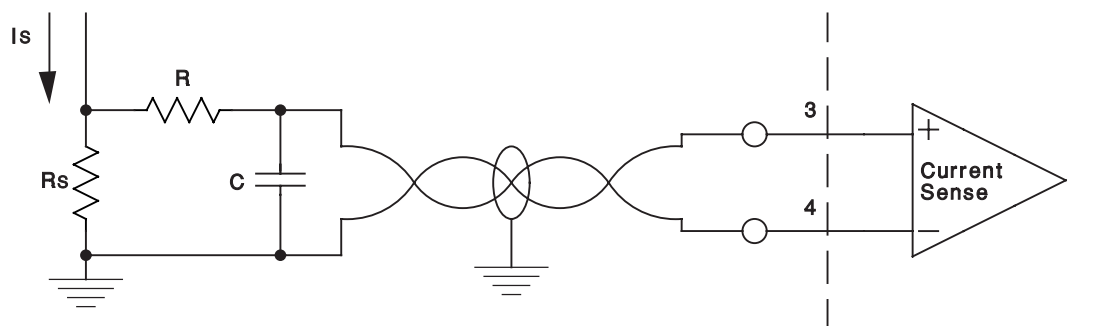


## Soft Start and Shutdown /Restart Functions



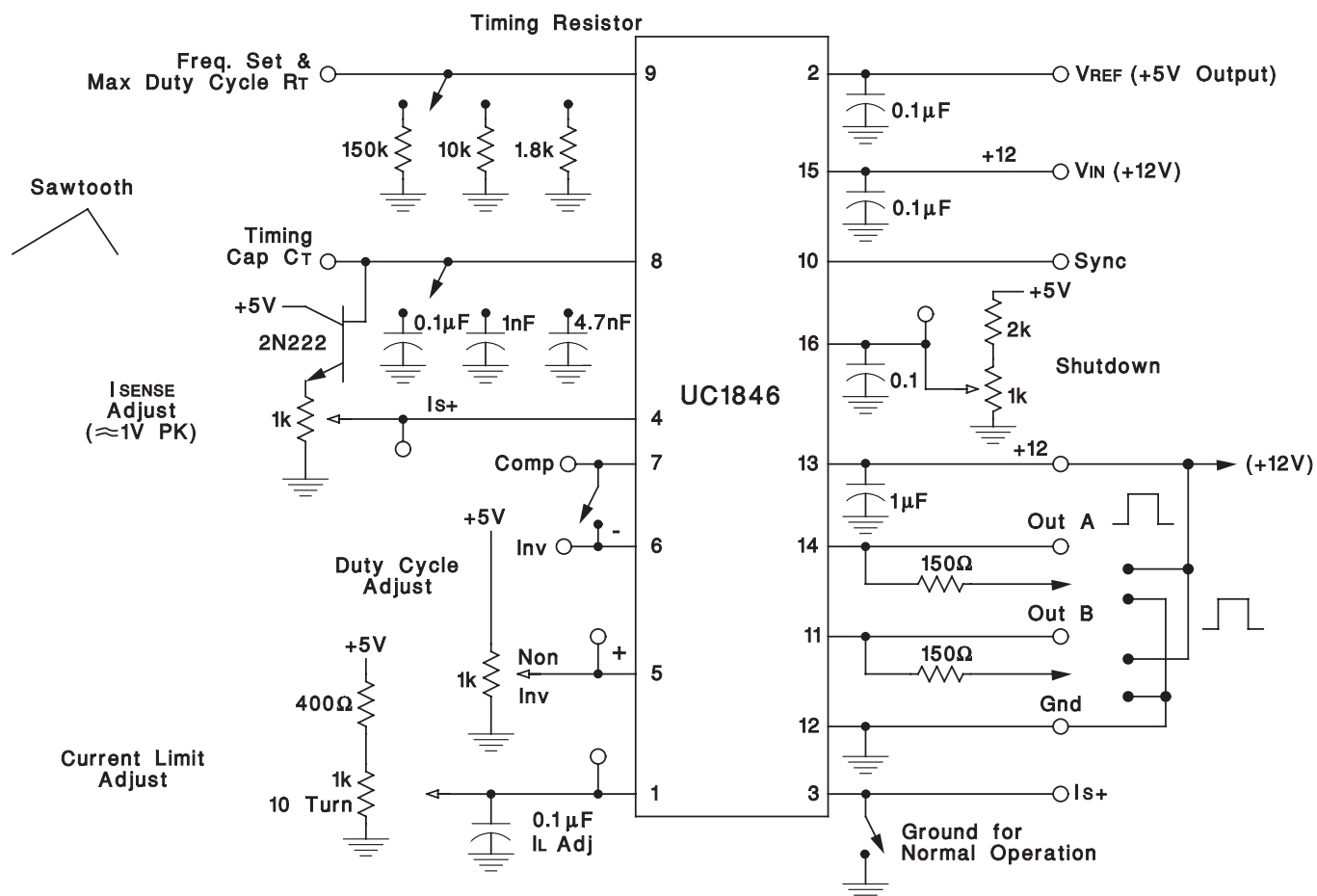
# APPLICATIONS DATA (cont.)

## Current Sense Amp Connection



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

## UC1846 Open Loop Test Circuit



-Bypass Caps Should Be Low ESR & ESL Type  
-Short Pins 6 & 7 for Unity Gain Testing

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Mailing Address:

Texas Instruments  
Post Office Box 655303  
Dallas, Texas 75265