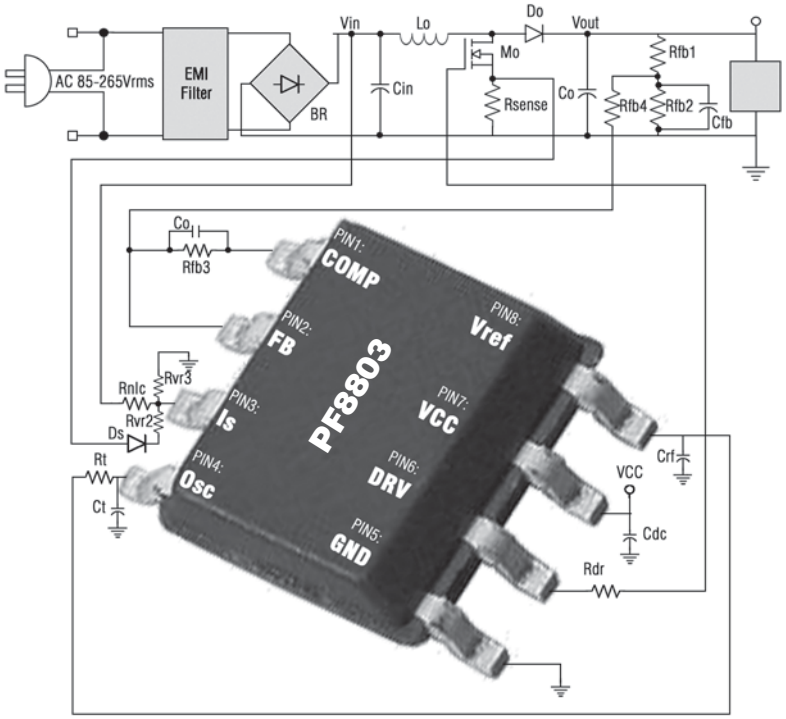
Advanced PFC Controller Circuit

The PF8800 series represents a new generation of low-cost / high performance Power Factor Correction controllers. It's advanced design and versatility help designers gain near unity Power Factor in the 60-400 Watt range, constant frequency operation with continuous or discontinuous mode operation. The advanced design enables leading edge operational efficiencies (>95%) and reduces stress on supporting components, eliminating about 11 components and reducing footprint while gaining designers extremely high power densities when compared to a classic PFC Pre-Regulation Circuit.

These controllers meet all international safety standards and meet the industry standard package pin out, allowing designers to improve existing designs without the re-design of existing circuitry as well as designing next generation power systems.

Features include:

- PWM Current and Voltage mode operations
- High Accuracy performance (down to 40nS pulse) voltage mode controller
- Near Unity (~0.99) PFC Voltage Preregulator in the 60-500 Watt power range
- Eliminates 8 to 11 external components with built-in:
  - 100nS Current Spike Filter (IsF) circuit
  - Soft Start (SS) circuit
  - Over-voltage protection
  - 20Vmax clamped output voltage circuits
- Extremely accurate Minimum Duty Cycle control capability (0.1% or less).
- Pin-for-Pin compatibility with other industry solutions with Superior performance in all classic applications.
- Built-in Analog Reset System (ARS) circuit guarantees fastest response of the PWM comparator
- Built-in Voltage Ramp, Slope Compensation Driver (VRD) circuit for voltage mode (or over 50% duty cycle current mode) applications
- Less than 0.2% min duty cycle at 50 kHz operating frequency (0.4% @ 100 kHz).
- Progressive decrease of the ON time driving pulse, down to less than 100nS.



Performance Highlight:

60-500 Watt PFC: Discontinuous Mode
Low Line (90VAC) & Full Load Operation: Efficiency=93%, PFC=0.99
High Line (264VAC) & Full Load Operation: Efficiency=97%, PFC=0.98

3140 De La Cruz Blvd, # 200
Santa, Clara, CA 95054
Tel: (408) 855-9220
Fax: (408) 855-9225

www.powerfactor1.net
sales@powerfactor1.net

Absolute Maximum Ratings:

Rating	Symbol	Value	Unit
Supply Voltage	VCC, VC	20	V
Total Reference Output Current	Iref	50	mA
Output Current, Source or Sink (1A peak current drive capability)	Isource / Isink	±1	A
Output Energy (Capacitive Load per Cycle)		5.0	µJ
Current Sense & Voltage Feedback Inputs	Vin	-0.3 ~ +5.5	VDC
Error Amp Output Sink / Source Current	IO	10	mA
Plastic Package Thermal Resistance (SOIC-8)			
Maximum Power Dissipation @ TA= 25°C	PD	1200	mW
Thermal Resistance, Junction–to–Ambient	RqJA	104	°C/W
Plastic Package Thermal Resistance (PDIP-8)			
Maximum Power Dissipation @ TA= 25°C	PD	1453	mW
Thermal Resistance, Junction–to–Ambient	RqJA	86	°C/W
Operating Junction Temperature	TJ	+150	°C
Operating Ambient Temperature			
Option CT Models	TA	0 to + 70	°C
Option IT Models	TA	-25 to + 85	°C
Option ET Models	TA	-40 to + 105	°C
Storage Temperature Range	Tstg	– 65 to +150	°C

Maximum ratings are those values beyond which device damage may occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability affected

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Electrical Characteristics:

Assumptions
VCC=15V (Adjust VCC above the Start-up threshold before setting to 15V
RT=8.2k
CT=2.2nF
For Typical Values TA=25°C, for min / max values TA is the operating ambient temperature range that applies unless otherwise noted (Low duty pulse techniques are utilized to maintain junction temperature as close to ambient as possible)

Reference Section:

Characteristics	Symbol	Min	Typ	Max	Unit
Reference Output Voltage (IO= 1.0 mA, TJ= 25°C)	Vref	4.95	5	5.05	V
Line Regulation (VCC= 12 V to 18 V)	Regline	–	3.0	15	mV
Load Regulation (IO= 1.0 mA to 20 mA)	Regload	–	3.0	25	mV
Temperature Stability	TS	–	0.2	–	mV/°C
Total Output Variation over Line, Load, and Temperature	Vref	4.9	–	5.1	V
Output Noise Voltage (f = 10 Hz to 10 kHz, TJ= 25°C)	Vn	–	50	–	mV
Long Term Stability (TA= 125°C for 1000 Hours)	S	–	5.0	–	mV
Output Short Circuit Current	ISC	–30	-50	–60	mA

Error Amplifier Section:

Description	Symbol	Min.	Typ.	Max.	Unit
Voltage Feedback Input (VO = 2.5 V)	VFB	2.45V	2.5V	2.55	Unit
Voltage Feedback Input UVLO Activated (Vcc = 6.0V, IFB = 0.1 mA)	VOL(UVLO)		0.1		V
Input Bias Current (VFB = 5.0 V)	IIB	–	– 0.1	–1.0	μA
Open Loop Voltage Gain (VO = 2.0 V to 4.0 V)	AVOL	65	90	–	dB
Unity Gain Bandwidth (TJ = 25°C)	BW	5.0	10.0	–	MHz
Power Supply Rejection Ratio (VCC = 12 V to 18 V)	PSRR	60	70	–	dB
Output Current					
Sink (VO = 1.1 V, VFB = 2.7 V)	ISink	2.0	12	–	mA
Source (VO = 5.0 V, VFB = 2.3 V)	ISource	– 0.5	–1.0	–	mA
Output Voltage Swing					
High State (RL = 15 k to ground, VFB = 2.3 V)	VOH	5.0	6.2	–	V
Low State (RL = 15 k to Vref, VFB = 2.7 V)	VOL	–	0.8	1.1	V

Oscillator Section:

Description	Symbol	Min.	Typ.	Max.	Unit
Frequency f(osc) = 100kHz (T=25*C)	f(OSC)	90	100	110	kHz
Frequency Change with Voltage (Vcc = 12 V to 18V)	Δfosc/ΔV	-	0.2	1	%
Frequency Change with Temperature, TA = Tlow to Thigh	Δfosc/ΔV	-	1	-	%
Oscillator Voltage Swing (Peak-to-Peak)				1.62	V
Discharge Current (VOSC = 2.0 V), TJ = 25°C	Idischg	7.5	8.4	9.3	ma

Pulse Width Modulation (PWM) Section:

Description	Symbol	Min.	Typ.	Max.	Unit
Maximum Duty Cycle (T=10μS)	D/C(max)	94	96	-	%
Minimum (before drop out) Duty Cycle (T=10μS)	D/C(min)	0.2	0.4	0.6	%

Output Section:

Description	Symbol	Min.	Typ.	Max.	Unit
Output Voltage					
Low State (ISink = 20 mA)	VOL	-	0.1	0.4	V
(ISink = 200 mA)	VOL	-	1.6	2.2	V
High State (ISource = 20 mA)	VOL	13.5	14.0	-	V
(ISource = 200 mA)	VOL	12.5	13.5	-	V
Output Voltage UVLO Activated (Vcc = 6.0V, ISink = 1.0 mA)	VOL(UVLO)	–	0.1	1.1	V
Output Voltage Rise Time (CL = 1.0 nF, TJ = 25°C)	tr	–	30	50	ns
Output Voltage Fall Time (CL = 1.0 nF, TJ = 25°C)	tf	–	30	50	ns

Current Sense Section:

Description	Symbol	Min.	Typ.	Max.	Unit
Voltage Gain (AV-V Output Compensation -V Current Sense Input)	Av	2.85	3.0	3.15	V/V
Current Sense Threshold	Vth	0.9	1.0	1.1	V
PSRR		-	70	-	dB
Input Sense Current	Is	-2.0	-10		µA
Delay to Output	Tplh	-	300	350	nS

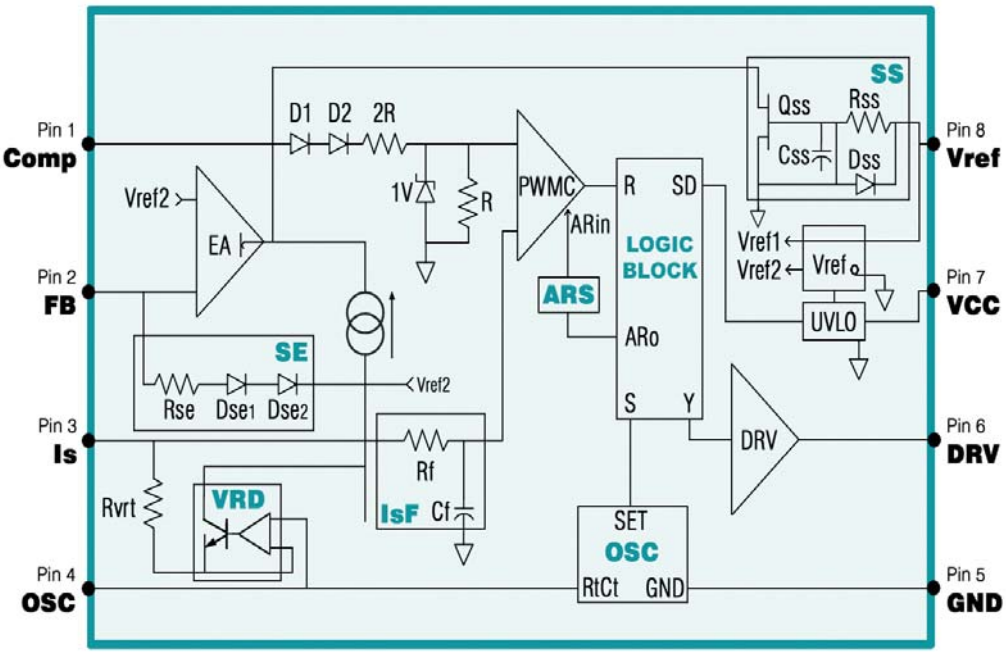
UnderVoltage Lock-Out Section:

Description	Symbol	Min.	Typ.	Max.	Unit
VCC Start-Up Threshold	Vth	7.8	8.1	9.0	V
Minimum Operating Voltage After Turn–On (VCC)	VCC(min)	6.8	7.5	8.2	V
Maximum Operating Voltage	VCC(max)	-	-	18	V

Total Device:

Description	Symbol	Min.	Typ.	Max.	Unit
Power Supply Current					
Startup	mA	0.19	0.28	0.4	mA
Operating	mA	6.5	8.4	14	mA
Power Supply Zener Voltage	Vz	18.4	19	19.5	V

Figure 1: Internal Circuit Block Diagram:



Abbrev.	Description
SS	Soft Start Circuit
VRD	V Ramp / Slope Compensation Driver
IsF	100ns Input Current Spike Filter
ARS	Analog Reset System Circuit

Figure 2: Timing Resistor vs. Oscillator Frequency:

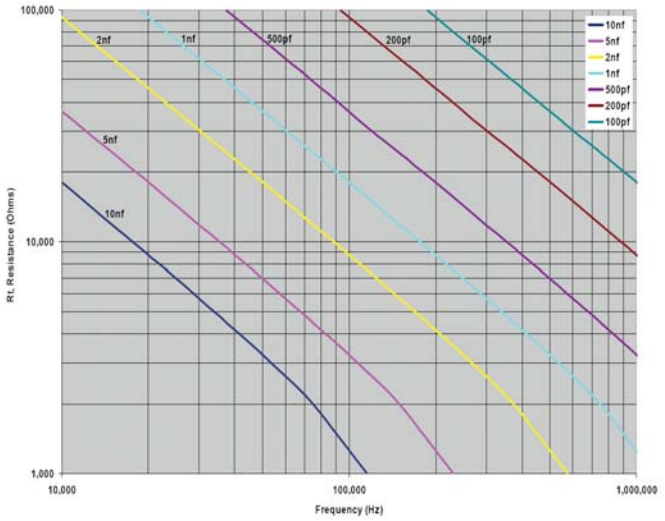


Figure 3: Output Dead-Time vs. Oscillator Frequency:

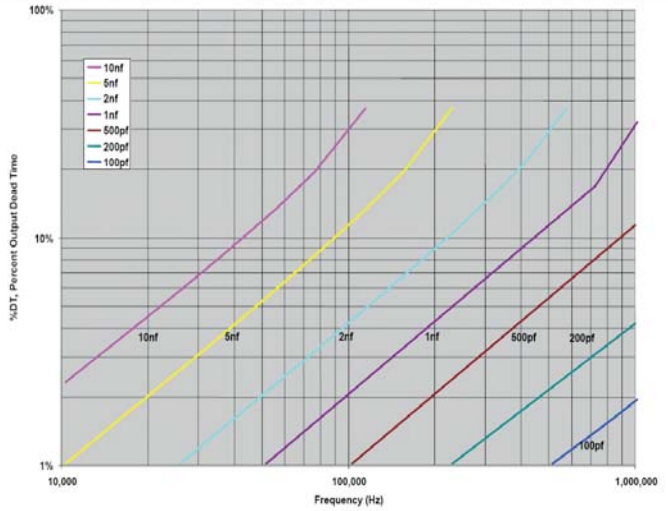


Figure 4: Error Amplifier Open Loop Gain vs. Frequency

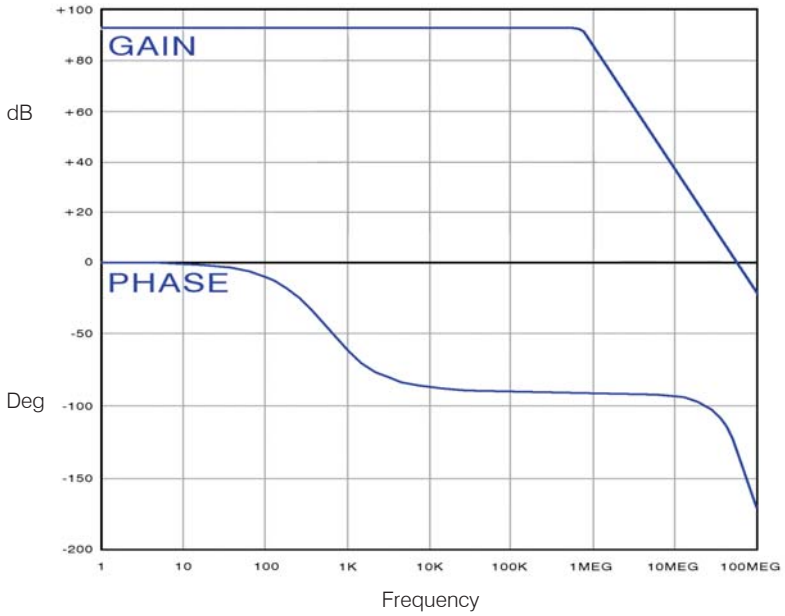


Figure 5: Supply Current vs. Supply Voltage:

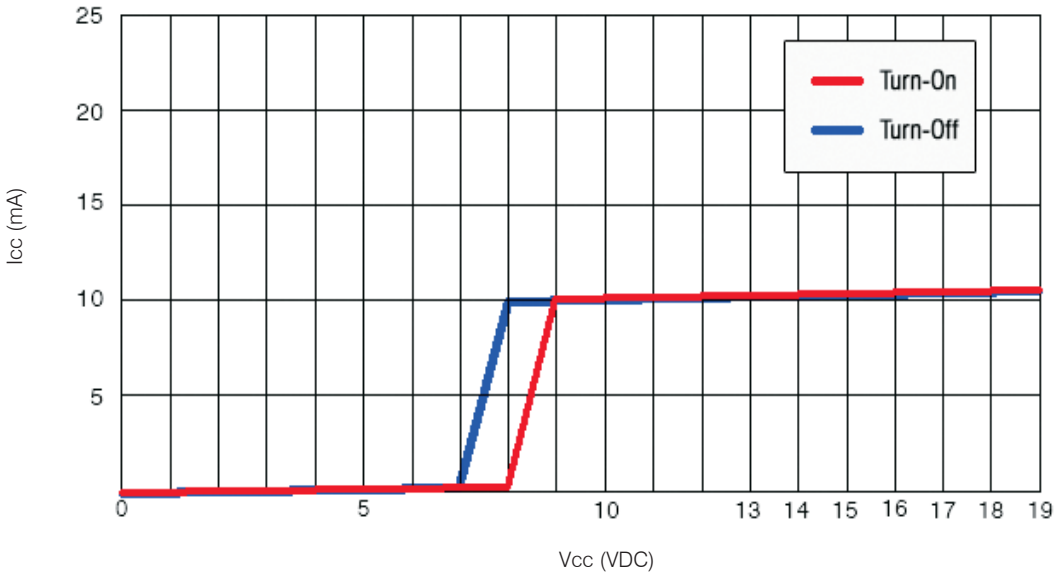
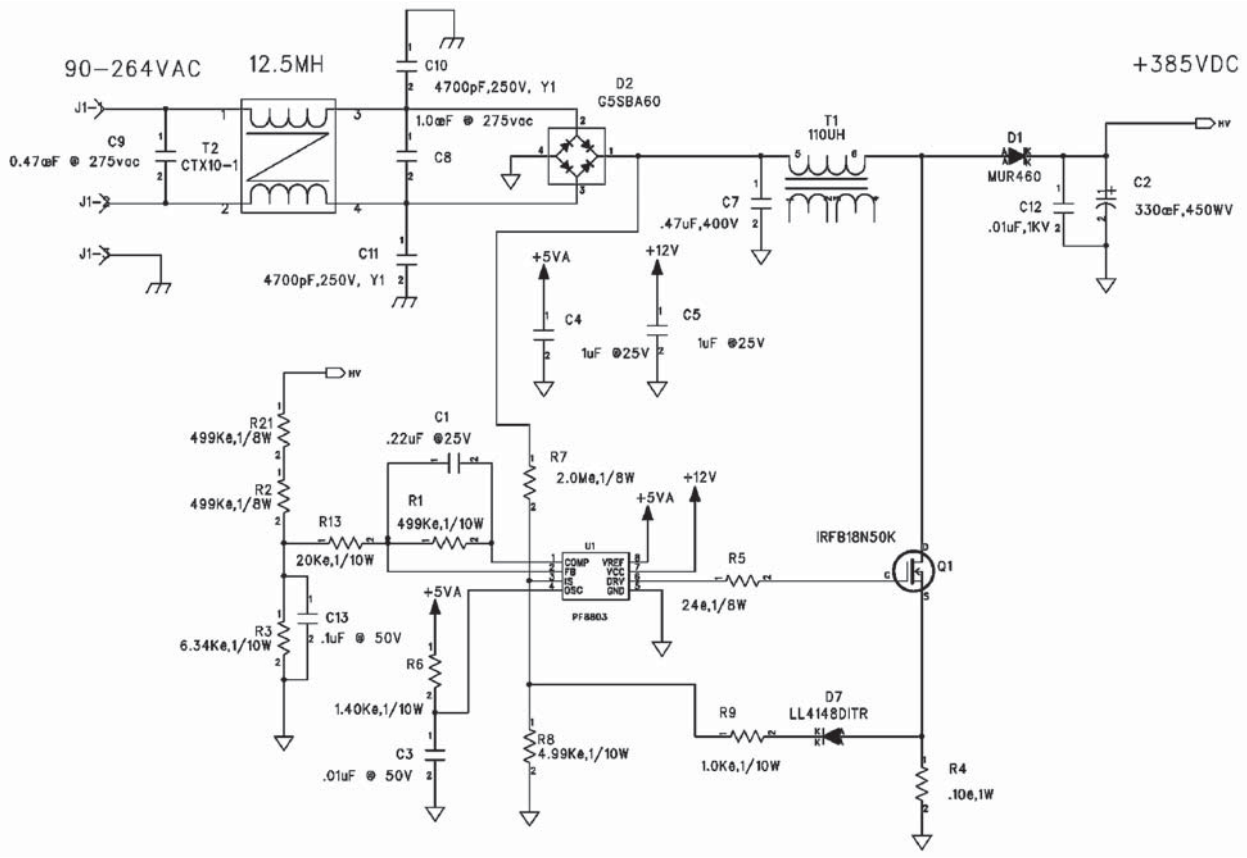


Figure 6: 300 Watt PFC PreRegulater Circuit



Performance Characteristics

AC Line Input					DC Output				
Vin	Va (Vrms)	Iin (Arms)	Pin (W)	PF	Vout	Iout (mA)	Rload	Power (W)	Efficiency
90	259.7	2.89	258.8	0.997	379	632	600	240.0	92.8%
110	259.2	2.35	258.3	0.997	382	637	600	243.2	93.8%
135	259.7	1.92	258.5	0.996	384	640	600	245.8	95.1%
220	261.7	1.19	258.0	0.986	388	646	600	251.0	97.3%
264	275.0	1.04	258.0	0.938	389	648	600	252.0	97.8%

Pin Function Descriptions

Pin	Function	Description
1	Compensation	This pin is the Error Amplifier output and is made available for loop compensation
2	Voltage Feedback	This is the inverting input of the Error Amplifier. It is normally connected to the switching power supply output through a resistor divider.
3	Current Sense	A voltage proportional to inductor current is connected to this input. The PWM uses this information to terminate the output switch conduction.
4	R_T / C_T	The Oscillator frequency and maximum Output duty cycle are programmed by connecting resistor RT to Vref and capacitor CT to ground. Operation to 500 kHz is possible.
5	GND	This pin is the combined control circuitry and power ground.
6	Output	This output directly drives the gate of a power MOSFET. Peak currents up to 1.0 A are sourced and sunk by this pin.
7	V_{CC}	This pin is the positive supply of the control IC.
8	V_{REF}	This is the reference output. It provides charging current for capacitor CT through resistor RT.

Operating Description:

Overview
The PF8803 series are high performance, fixed frequency, current mode controllers which are specifically designed for Off-Line and dc-to-dc converter applications offering a cost-effective solution with minimal external components (block diagram is shown in Figure 1).

Oscillator
The oscillator frequency is programmed by the values selected for the timing components R_T and C_T. Capacitor C_T is charged from the 5.0 V reference through resistor R_T to approximately 2.8 V and discharged to 1.2 V by an internal current sink. During the discharge of C_T, the oscillator generates an internal blanking pulse that forces the Output into a low state, thus producing a controlled amount of Output Dead Time. This causes the Output to be in a low state, thus producing a controlled amount of output deadtime. Figure 2 shows R_T versus Oscillator Frequency and Figure 3, Output Dead time versus Frequency, both for given values of C_T. Note that many values of R_T and C_T will give the same oscillator frequency but only one combination will yield a specific output dead time at a given frequency. The oscillator thresholds are temperature compensated to within ±6% at 50 kHz. Also because of industry trends moving the PF8803 into higher and higher frequency applications, the PF8803 is guaranteed to within ±10% at 250 kHz. These internal circuit refinements minimize variations of oscillator frequency and maximum output duty cycle. For noise-sensitive applications it may be desirable to frequency-lock the converter to an external system clock. This can be accomplished by applying a clock signal to the circuit. For reliable locking, the free-running oscillator frequency should be set about 10% less than the clock frequency. By tailoring the clock waveform, accurate output duty cycle clamping can be achieved.

Error Amplifier
A fully compensated Error Amplifier with access to the inverting input and output is provided. It features a typical dc voltage gain of 90 dB, and a unity gain bandwidth of 20 MHz. The non-inverting input is internally biased at 2.5 V and is not pinned out. The converter output voltage is typically divided down and monitored by the inverting input. The maximum input bias current is -2.0μA which can cause an output voltage error that is equal to the product of the input bias current and the equivalent input divider source resistance. The Error Amp Output (Pin 1) is provided for external loop compensation. The output voltage is offset by two diode drops (~1.4 V) and divided by three before it connects to the non-inverting input of the Current Sense Comparator. This guarantees that no drive pulses appear at the Output (Pin 6) when pin 1 is at its lowest state (VOL). This occurs when the power supply is operating and the load is removed, or at the beginning of a soft-start interval. The Error Amp minimum feedback resistance is limited by the amplifier's source current (0.5 mA) and the required output voltage (VOH) to reach the comparator's 1.0 V clamp level:

$$Rf(min) \sim (3.0\ (1.0\ V) + 1.4\ V) / 0.5\ mA = 8800\ ohms$$

Reference
The 5.0 V bandgap reference is trimmed to ±1.0% tolerance at TJ = 25°C. Its primary purpose is to supply charging current to the oscillator timing capacitor. The reference has short-circuit protection and is capable of providing in excess of 20 mA for powering additional control system circuitry.

Current Sense Comparator and PWM Latch
The PF8803 operate as a current mode controller, whereby output switch conduction is initiated by the oscillator and terminated when the peak inductor current reaches the threshold level established by the Error Amplifier Output/Compensation (Pin 1). Thus the error signal controls the peak inductor current on a cycle-by-cycle basis. The Current Sense Comparator PWM Latch configuration used ensures that only a single pulse appears at the Output during any given oscillator cycle. The inductor current is converted to a voltage by inserting the ground-referenced sense resistor RS in series with the source of output switch Q1. This voltage is monitored by the Current Sense Input (Pin 3) and compared to a level derived from the Error Amp Output. The peak inductor current under normal operating conditions is controlled by the voltage at pin 1 where: $I_{pk} = (V(Pin\ 1) - 1.4\ V)/(3\ RS)$

Abnormal operating conditions occur when the power supply output is overloaded or if output voltage sensing is lost. Under these conditions, the Current Sense Comparator threshold will be internally clamped to 1.0 V. Therefore the maximum peak switch current is:

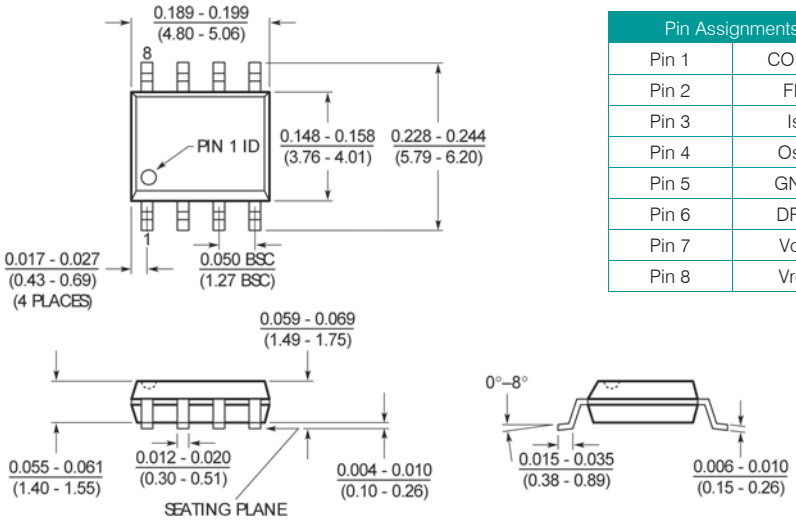
$$I_{pk(max)} = 1.0\ V/RS$$

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 lightly loaded. This spike is due to the power transformer interwinding capacitance and output rectifier recovery time. The addition of an Internal RC filter on the Current Sense Input with a time constant that approximates the spike duration will usually eliminate the instability.

Undervoltage Lockout
Two under voltage lockout comparators have been incorporated to guarantee that the IC is fully functional before the output stage is enabled. The positive power supply terminal (VCC) and the reference output (Vref) are each monitored by separate comparators. Each has built-in hysteresis to prevent erratic output behavior as their respective thresholds are crossed. The VCC comparator upper and lower thresholds are 8.4 V/7.6 V. The Vref comparator upper and lower thresholds are 3.6 V/3.4 V. The PF8803 is intended for lower voltage dc-to-dc converter applications. A 20 V 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 startup. The minimum operating voltage (VCC) is 8.2 V for the PF8803. The device contains a single totem pole output stage that was specifically designed for direct drive of power MOSFETs. It is capable of up to ±1.0 A peak drive current and has a typical rise and fall time of 50ns with a 1.0 nF load.

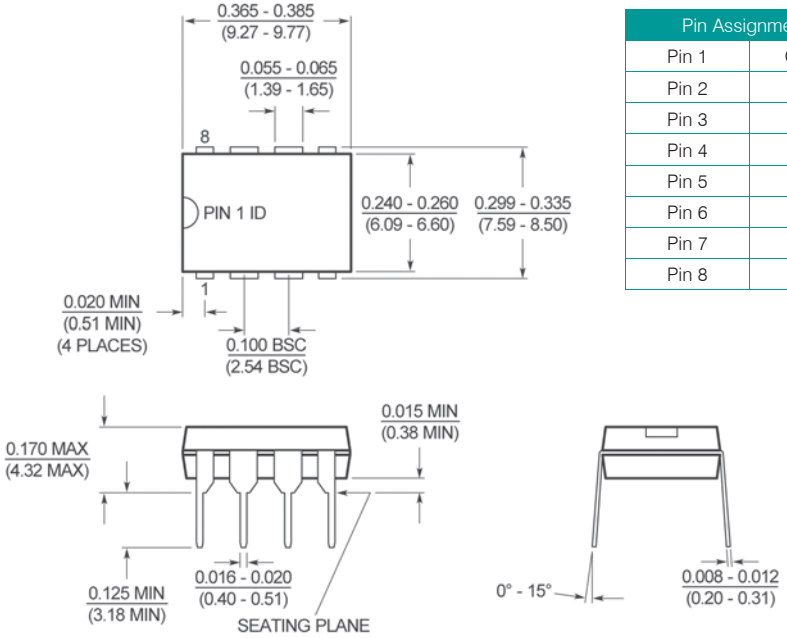
Additional internal circuitry has been added to keep the Output in a sinking mode whenever an undervoltage lockout is active. This characteristic eliminates the need for an external pull-down resistor.

Mechanical Drawing: 8 Pin SOIC Package



Pin Assignments	
Pin 1	COMP
Pin 2	FB
Pin 3	Is
Pin 4	Osc
Pin 5	GND
Pin 6	DRV
Pin 7	Vcc
Pin 8	Vref

Mechanical Drawing: 8 Pin DIP Package



Pin Assignments	
Pin 1	COMP
Pin 2	FB
Pin 3	Is
Pin 4	Osc
Pin 5	GND
Pin 6	DRV
Pin 7	Vcc
Pin 8	Vref

Ordering Options:

PF	880x	xx	08	xx	x	xx
Power Factor One	Series Operating Voltage	Operating Temperature	Pin Count	Package Type	RoHS	Shipping Format
	8802=11V 8803=8V	CT=0~+70C IT=-25~+85C ET=-40+105C		SO=SOIC PD=PDIP	G=RoHS N=Non-RoHS	TR=Tape & Reel TB=Tube TA=Tape & Ammo

Part Number	UVLO Threshold	Operating Temperature	Package Type	RoHS Compliant	Shipping Format	Min. Order Qty.
PF8803CT08SOGTR	8V	0-70C	8-Pin SOIC	Compliant	Tape & Reel	2500
PF8803CT08SOGTB	8V	0-70C	8-Pin SOIC	Compliant	Tube	98
PF8803CT08SOGTA	8V	0-70C	8-Pin SOIC	Compliant	Tape & Ammo	2500
PF8803CT08SONTR	8V	0-70C	8-Pin SOIC	N/A	Tape & Reel	2500
PF8803CT08SONTB	8V	0-70C	8-Pin SOIC	N/A	Tube	98
PF8803CT08SONTA	8V	0-70C	8-Pin SOIC	N/A	Tape & Ammo	2500
PF8803CT08PDGTR	8V	0-70C	8-Pin DIP	Compliant	Tape & Reel	2500
PF8803CT08PDGTB	8V	0-70C	8-Pin DIP	Compliant	Tube	50
PF8803CT08PDGTA	8V	0-70C	8-Pin DIP	Compliant	Tape & Ammo	2500
PF8803CT08PDNTR	8V	0-70C	8-Pin DIP	N/A	Tape & Reel	2500
PF8803CT08PDNTB	8V	0-70C	8-Pin DIP	N/A	Tube	50
PF8803CT08PDNTA	8V	0-70C	8-Pin DIP	N/A	Tape & Ammo	2500
PF8803IT08SOGTR	8V	-25~+85C	8-Pin SOIC	Compliant	Tape & Reel	2500
PF8803IT08SOGTB	8V	-25~+85C	8-Pin SOIC	Compliant	Tube	98
PF8803IT08SOGTA	8V	-25~+85C	8-Pin SOIC	Compliant	Tape & Ammo	2500
PF8803IT08SONTR	8V	-25~+85C	8-Pin SOIC	N/A	Tape & Reel	2500
PF8803IT08SONTB	8V	-25~+85C	8-Pin SOIC	N/A	Tube	98
PF8803IT08SONTA	8V	-25~+85C	8-Pin SOIC	N/A	Tape & Ammo	2500
PF8803IT08PDGTR	8V	-25~+85C	8-Pin DIP	Compliant	Tape & Reel	2500
PF8803IT08PDGTB	8V	-25~+85C	8-Pin DIP	Compliant	Tube	50
PF8803IT08PDGTA	8V	-25~+85C	8-Pin DIP	Compliant	Tape & Ammo	2500
PF8803IT08PDNTR	8V	-25~+85C	8-Pin DIP	N/A	Tape & Reel	2500
PF8803IT08PDNTB	8V	-25~+85C	8-Pin DIP	N/A	Tube	50
PF8803IT08PDNTA	8V	-25~+85C	8-Pin DIP	N/A	Tape & Ammo	2500
PF8803ET08SOGTR	8V	-40~+105C	8-Pin SOIC	Compliant	Tape & Reel	2500
PF8803ET08SOGTB	8V	-40~+105C	8-Pin SOIC	Compliant	Tube	98
PF8803ET08SOGTA	8V	-40~+105C	8-Pin SOIC	Compliant	Tape & Ammo	2500
PF8803ET08SONTR	8V	-40~+105C	8-Pin SOIC	N/A	Tape & Reel	2500
PF8803ET08SONTB	8V	-40~+105C	8-Pin SOIC	N/A	Tube	98
PF8803ET08SONTA	8V	-40~+105C	8-Pin SOIC	N/A	Tape & Ammo	2500
PF8803ET08PDGTR	8V	-40~+105C	8-Pin DIP	Compliant	Tape & Reel	2500
PF8803ET08PDGTB	8V	-40~+105C	8-Pin DIP	Compliant	Tube	50
PF8803ET08PDGTA	8V	-40~+105C	8-Pin DIP	Compliant	Tape & Ammo	2500
PF8803ET08PDNTR	8V	-40~+105C	8-Pin DIP	N/A	Tape & Reel	2500
PF8803ET08PDNTB	8V	-40~+105C	8-Pin DIP	N/A	Tube	50
PF8803ET08PDNTA	8V	-40~+105C	8-Pin DIP	N/A	Tape & Ammo	2500

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