TOKO

TK84812

POWER FACTOR CONTROLLER

FEATURES

- **Boost Mode Power Factor Control**
- **Peak Current Sensing PFC Control**
- **Typical Power Factor > .996**
- **Over Voltage Protection**
- **Programmable Ramp Compensation**
- **Electrostatic Discharge Protection**
- **Pin Compatible with the ML4812**

APPLICATIONS

- **Switching Power Supplies with PFC**
- **Computers**
- **Work Stations**
- **Telecommunications Equipment**
- **Office Equipment**
- **Medical Electronics**
- **IEC-555 Power Supplies**

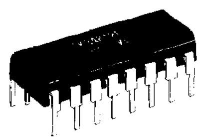
DESCRIPTION

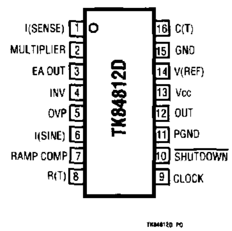
The TK84812 is a boost mode Power Factor Control (PFC) circuit. The low external parts count makes this IC economical to include active power factor control in power supplies of 50 watts and above.

The outputs of the controller provide high current (>1 A peak) and high slew rate for excellent control of MOSFET gates. The TK84812 utilizes peak current sensing control circuitry, with a current sense transformer or a SENSE FET device as a sense element. This method of current sensing improves overall efficiency. Special care has been taken to provide high system noise immunity. The device has under voltage lockout circuitry with 6 V hysteresis, wide common mode range current sense comparator. Ramp compensation is programmable by an external resistor, to provide stability at duty cycles greater than 50%. Over voltage protection eliminates output "runaway" when there is no or small output load.

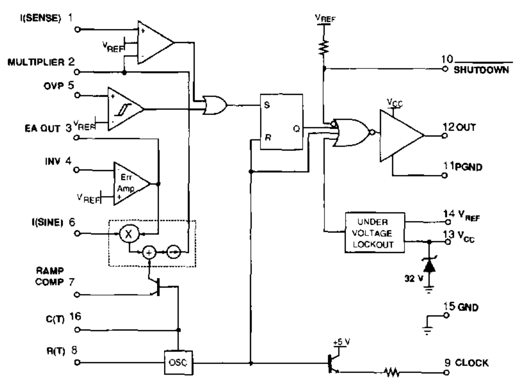
The TK84812 is temperature compensated and is offered in the commercial, industrial, and military temperature ranges. Both 16 pin plastic and ceramic dip packages are available.

TK84812





TK84812 BLOCK DIAGRAM



ORDERING INFORMATION

TK84812 □ □ □□

- Tape/Reel Code
- Temp. Range
- Package Code

PACKAGE CODE	TEMP. RANGE	TAPE/REEL CODE
D : Plastic	C : 0 to +70 °C	BX : Bulk/Bag
J : Ceramic	I : -40 to +85 °C	MG: Magazine
	M : -55 to +125 °C	

3

ABSOLUTE MAXIMUM RATINGS

Supply Voltage .... 36 V
Supply Current .... 33 mA
Output Current, Source or Sink (Pin 12) DC .... 1.0 A
Output Energy (Capacitive Load Per Cycle) .... 5 µj
Multiplier I(SINE) Input (Pin 6) .... 1.2 mA
Error Amp Sink Current (Pin 3) .... 10 mA
Oscillator Charge Current .... 2 mA
Analog Inputs .... -0.3 V to 5.5 V

Storage Temperature Range .... -65 to +150 °C
Operating Temperature Range
(Commercial) .... 0 to +70 °C
(Industrial) .... -40 to +85 °C
(Military) .... -55 to +125 °C
Lead Soldering Temp. (10 sec.) .... 260 °C
Junction Temperature .... 150 °C
Thermal Resistance, Plastic Dip .... 65 °C/W

ELECTRICAL CHARACTERISTICS

R_T = 14 kΩ, C_T = 1000 pF, T_A= Operating Temperature Range. V_{CC} = 15 V (Note 2)

SYMBOL	PARAMETER	TEST CONDITION	TK84812C			TK84812I			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Oscillator									
$f_{INTL(OSC)}$	Initial Accuracy	T_J = 25 °C	91	98	105	91	98	105	kHz
$\Delta f_{V(OSC)}$	Voltage Stability	12 V< V_{CC} < 18 V		3.0			3.0		%
$\Delta f_{T(OSC)}$	Temperature Stability			6			6		%
$\Delta f_{(OSC)}$	Total Variation	Line, Temp	90		108	88		112	kHz
$V_{RVP\ (OSC)}$	Ramp Valley to Peak			3.3			3.3		V
$V_{RT(OSC)}$	R(T) Pin Voltage		4.8	5.0	5.2	4.8	5.0	5.2	V
$I_{D(OSC)}$	Discharge Current	T_J = 25 °C, $V_{PIN\ 16}$ = 2 V	7.5	8.4	9.3	7.5	8.4	9.3	mA
	(Pin 8 open)	$V_{PIN\ 16}$ = 2 V	7.2	8.4	9.5	7.2	8.4	9.5	mA
Reference Section									
$V_{(REF)}$	Output Voltage	I_O = 1 mA, T_J = 25 °C	4.95	5.00	5.05	4.95	5.00	5.05	V
$LI_{REG(REF)}$	Line Regulation	12 V < V_{CC} < 25 V		20	35		20	35	mV
$LD_{REG(REF)}$	Load Regulation	1 mA < I_O < 20 mA		6	20		6	20	mV
$\Delta V_{T(REF)}$	Temperature Stability			0.4			0.4		%
$\Delta V_{TOT(REF)}$	Total Variation	Line, Load, Temp	4.9		5.1	4.85		5.15	V
$V_{N(REF)}$	Output Noise Voltage	10 Hz to 10 kHz		50			50		µV
$V_{LT(REF)}$	Long Term Stability	T_J = 125 °C, 1000 hrs. (Note 1)		5	25		5	25	mV
$I_{SC(REF)}$	Short Circuit Current	V_{REF} = 0 V	-30	-85	-180	-30	-85	-180	mA
Error Amp Section									
$V_{OS(EA)}$	Input Offset Voltage		-15		+15	-15		+15	mV
$I_{B(EA)}$	Input Bias Current	$V_{PIN\ 4}$ = V_{REF} + 25 mV		-0.1	-1.0		-0.1	-1.0	µA
$A_{V(OL,EA)}$	Open Loop Gain	1 V < $V_{PIN\ 4}$ < 5 V	60	75		60	75		dB
$PSRR_{(EA)}$	PSRR	12 V < V_{CC} < 25 V	60	75		60	75		dB
$I_{SINK(EA)}$	Output Sink Current	$V_{PIN\ 3}$ = 1.1 V, $V_{PIN\ 4}$ = 6.2 V	2	12		2	12		mA
$I_{SOURCE(EA)}$	Output Source Current	$V_{PIN\ 3}$ = 5.0 V, $V_{PIN\ 4}$ = 4.8 V	-0.5	-1.0		-0.5	-1.0		mA
$V_{OH(EA)}$	Output High Voltage	I_{PIN3} = -0.5 mA, $V_{PIN\ 4}$ = 4.8 V	5.3	5.5		5.3	5.5		V
$V_{OL(EA)}$	Output Low Voltage	$I_{PIN\ 3}$ = 1 mA, $V_{PIN\ 4}$ = 6.2 V		0.5	1.0		0.5	1.1	V
$BW_{(EA)}$	Unity Gain Bandwidth			1.0			1.0		MHz

ELECTRICAL CHARACTERISTICS (CONT.)

R_T = 14 kΩ, C_T = 1000 pF, T_A= Operating Temperature Range. V_{CC} = 15 V (Note 2)

SYMBOL	PARAMETER	TEST CONDITION	TK84812C			TK84812I			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Multiplier									
$V_{ISINE(M)}$	I(SINE) Input Voltage	I(SINE) = 500 µA	0.4	.7	0.9	0.4	0.7	0.9	V
$I_{OUT(M)}$	Output Current (Pin 2)	I(SINE) = 500 µA, Pin 4 = V_{REF} -20 mV	460	480	510	460	480	510	µA
		I(SINE) = 500 µA, Pin 4 = V_{REF} +20 mV		3	10		3	10	µA
		I(SINE) = 1 mA, Pin 4 = V_{REF} -20 mV	900	950	1020	900	950	1020	µA
	$V_{PIN\ 7}$ = 50 µA	I(SINE) = 500 µA, Pin 4 = V_{REF} -20 mV		455			455		µA
BW(M)	Bandwidth			200			200		kHz
$PSRR_{(EA)}$	PSRR	12 V < V_{CC} < 25 V		70			70		dB
OVP Comparator									
$V_{OS(OVP)}$	Input Offset Voltage	Output Off	-15		+15	-15		+15	mV
$V_{H(OVP)}$	Hysteresis		80	105	130	80	105	130	mV
$I_{B(OVP)}$	Input Bias Current			-0.3	-3.0		-0.3	-3.0	µA
$\Delta t_{(OVP)}$	Propagation Delay			150			150		ns
I(SENSE) Comparator									
$V_{CMR(SENSE)}$	Input CMR		-0.2		5.5	-0.2		5.5	V
$V_{OS(SENSE)}$	Input Offset Voltage		-15		+15	-15		+15	mV
$I_{B(SENSE)}$	Input Bias Current			-2	-10		-2	-10	µA
$I_{OS(SENSE)}$	Input Offset Current		-1		+1	+1		-1	µA
$\Delta t_{(SENSE)}$	Propagation Delay			150			150		ns
$I_{LIM(SENSE)}$	I(limit) Trip Point	$V_{PIN\ 2}$ = 5.5 V	4.8	5	5.2	4.8	5	5.2	V
Output Section									
$V_{OL(O)}$	Output Voltage Low	I_{OUT} = -20 mA		0.1	0.4		0.1	0.4	V
		I_{OUT} = -200 mA		1.6	2.2		1.6	2.2	V
$V_{OH(O)}$	Output Voltage High	I_{OUT} = 20 mA	13	13.5		13	13.5		V
		I_{OUT} = 200 mA	12	13.4		12	13.4		V
$V_{ULVO(O)}$	V_{OUT} Low in UVLO	I_{OUT} = -5 mA V_{CC} = 8 V		.1	0.8		.1	0.8	V
$t_{R(O)}$; $t_{F(O)}$	Output Rise/Fall Time	C_L = 1000 pF		50			50		ns

Note 1: This parameter not 100% tested in production but guaranteed by design.
Note 2: V_{CC} is raised above the startup threshold first to activate the IC, then returned to 15 V.

ELECTRICAL CHARACTERISTICS (CONT.)

R_T = 14 KΩ, C_T = 1000 pF, T_A= Operating Temperature Range. V_{CC} = 15 V (Note 2)

SYMBOL	PARAMETER	TEST CONDITION	TK84812C			TK84812I			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Under Voltage Lockout									
$V_{ST(UVLO)}$	Start-Up Threshold		15	16	17	15	16	17	V
$V_{SD(UVLO)}$	Shut-Down Threshold		9	10	11	9	10	11	V
V_{REFG}	V_{REF} Good Threshold			4.4			4.4		V
V_{IH}	Shutdown Input		2.0			2.0			V
V_{IL}	Shutdown Input				0.8			0.8	V
I_{IL}	Shutdown Input	$V_{PIN\ 10}$ = 0 V			-1.5			-1.5	mA
I_{IH}	Shutdown Input	$V_{PIN\ 10}$ = 5 V			10			10	µA
C_{VL}	Clock Voltage High	R_L = 16 k	3.0	3.5		3.0	3.5		V
C_{VH}	Clock Voltage Low	R_L = 16 k		0.2	0.5		0.2	0.5	V
Total Device									
I_{TOT}	Supply Current	Start-Up, V_{CC} = 14 V		0.8	1.2		0.8	1.2	mA
		Operating T_J = 25 °C		20	25		20	25	mA
				20	30		20	33	mA
V_Z	Internal Zener Voltage	ICC = 33 mA	25	30	34	25	30	34	V

Note 1: This parameter not 100% tested in production but guaranteed by design.
Note 2: V_{CC} is raised above the startup threshold first to activate the IC, then returned to 15 V.

PIN DESCRIPTION

PIN #	NAME	FUNCTION
1	I(SENSE)	Input from the Current Sense Transformer to the PWM comparator (+). Current Limit occurs when this point reaches 5 V.
2	MULTIPLIER	Output of the current multiplier. A resistor to ground on this pin converts the current to a voltage.
3	EA OUT	Output error amplifier
4	INV	Inverting input to error amplifier.
5	OVP	Input to the over voltage comparator.
6	I(SINE)	Current multiplier input
7	RAMP COMP	Buffered output from the oscillator ramp (C(T)). A resistor to ground sets a current, which is subtracted from the multiplier output.
8	R(T)	Oscillator timing resistor pin. A 5 V source across this resistor sets the charging current for C(T)
9	CLOCK	Digital Clock Output
10	SHUTDOWN	A TTL compatible low level on this pin turns off the output.
11	PGND	Return for the high current output
12	OUT	High current output.

PIN DESCRIPTION (CONT.)

PIN #	NAME	FUNCTION
13	Vcc	Positive Supply of the IC.
14	V_{REF}	Buffered 5 V reference output.
15	GND	Analog signal ground
16	C(T)	Timing capacitor for the oscillator.

FUNCTIONAL DESCRIPTION

OSCILLATOR

The TK84812 oscillator charges the external capacitor (C_T) with a current (I_{SET}) equal to $5/R_{SET}$. When the capacitor voltage reaches the upper threshold, the comparator changes state and the capacitor discharges to the lower threshold through Q1. While the capacitor is discharging, the clock pulse is high.

The Oscillator period can be described by the following relationship: $T_{OSC} = T_{RAMP} + T_{DEADTIME}$

where: $T_{RAMP} = \frac{C_V \times V}{I_{SET}}$

and: $T_{DEADTIME} = \frac{C_V \times V}{(8.4\ mA - I_{SET})}$

FUNCTIONAL DESCRIPTION (CONT.)

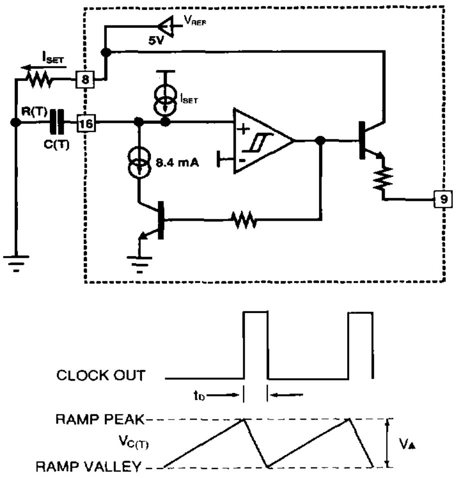


Figure 1. Oscillator Block Diagram

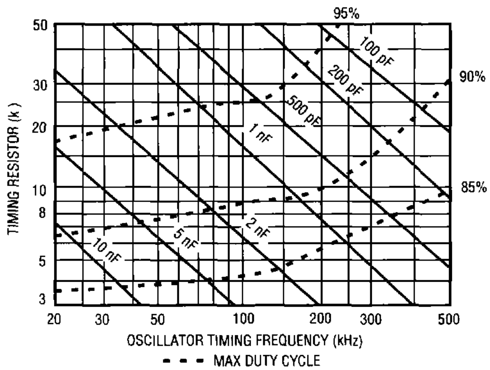


Figure 2. Oscillator Timing Resistance vs. Frequency

FUNCTIONAL DESCRIPTION (CONT.)

OUTPUT DRIVER

The TK84812 output driver is a 1 amp peak output high speed totem pole circuit specially designed to drive capacitive loads, such as MOSFET gates.

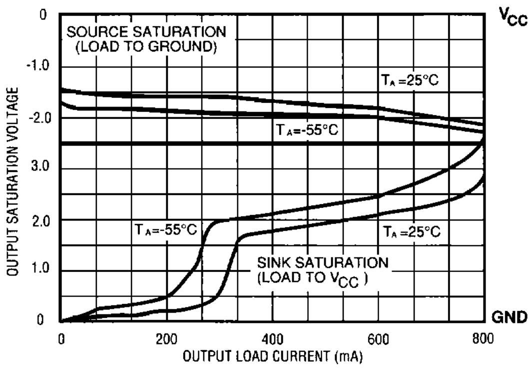


Figure 3. Output Saturation Voltage vs. Output Current

ERROR AMPLIFIER

The TK84812 error amplifier is a high open loop gain, wide bandwidth amplifier.

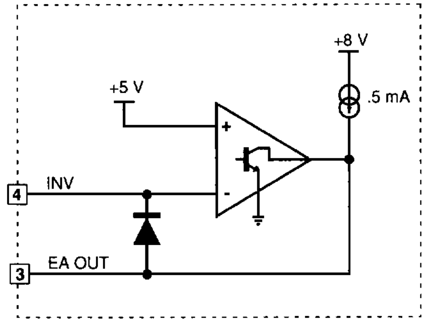


Figure 4. Error Amplifier

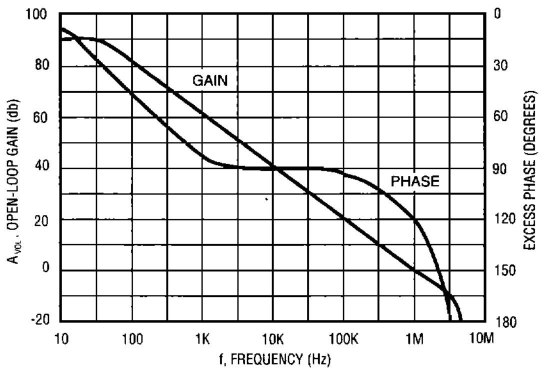


Figure 5. Error Amp Open-Loop Gain and Phase vs. Frequency

FUNCTIONAL DESCRIPTION (CONT.)

MULTIPLIER

The TK84812 multiplier receives the rectified line input sine wave through the multiplier input on pin 6.

The output of the multiplier is a current proportional to:

$$I_{OUT} \propto I(SINE) \times I(EA)$$

Where: I(SINE) is the current into pin 6, and I(EA) is a factor which varies from 0 to 1 proportional to the output of the error amplifier. When the error amplifier is saturated high, the output of the multiplier is approximately equal to the I(SINE) input current.

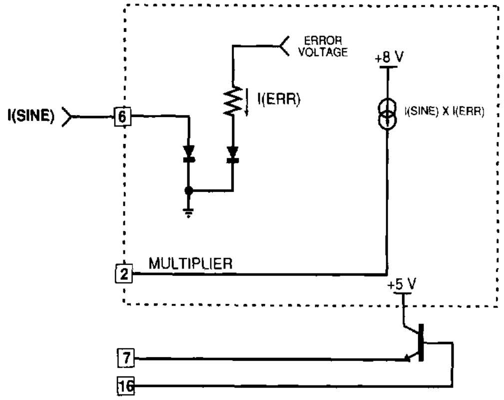


Figure 6. Multiplier Block Diagram

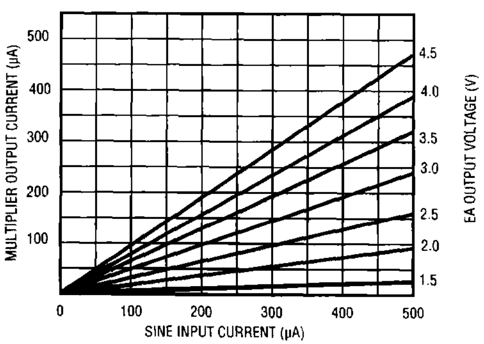


Figure 7. Multiplier Linearity

UNDER VOLTAGE LOCKOUT

On power up the TK84812 remains in the UVLO condition; output low and quiescent current low. The IC becomes operational when V_{CC} reaches 16 V. When V_{CC} drops below 10 V, the UVLO condition is imposed. During the UVLO condition, the 5 V V_{REF} pin is "off", making it usable as a "flag".

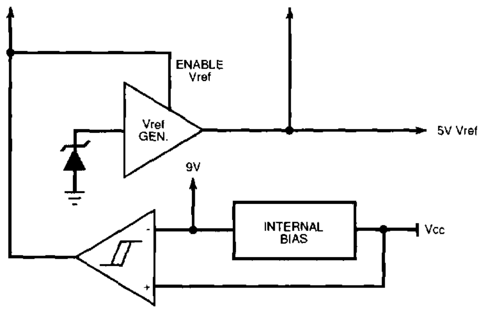


Figure 8. Under Voltage Lockout

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TYPICAL APPLICATIONS

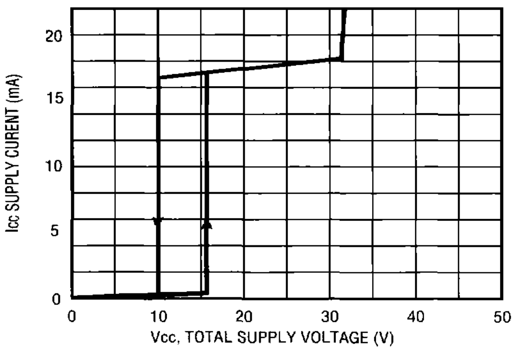

Figure 9. Total Supply Current vs. Supply Voltage

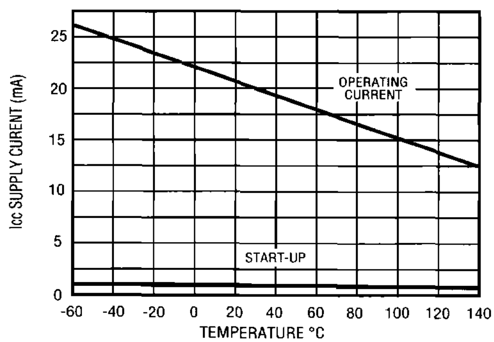

Figure 10. Total Supply Current vs. Temperature

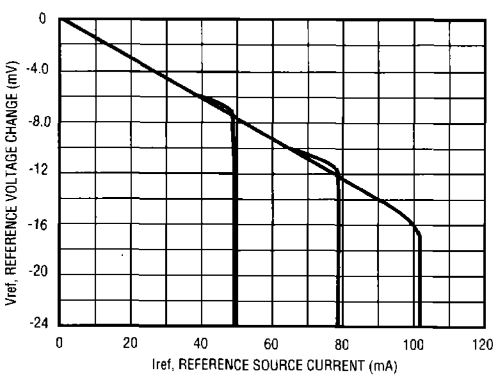

Figure 11. Reference Load Regulation

GENERAL

The power factor controller is a boost mode pre-regulator that provides approximately 380 volts DC for a PWM power supply. It utilizes peak current sensing to give a typical corrected power factor of .996 over all load conditions. The calculations in the following sections refer to the applications circuit.

INPUT INDUCTOR (L1) SELECTION

The central component in the regulator is the input boost inductor. The value of this inductor controls various critical operational aspects of the regulator. If the value is too low, the input current distortion will be high and will result in low power factor and increased noise at the input. This will require more input filtering. In addition, when the value of the inductor is low the inductor dries out (runs out of current) at low currents. Thus the power factor will decrease at lower power levels and/or higher line voltages. If the inductor value is too high, for a given operating current, the required size of the inductor core will be large and/or the required number of turns will be high. So a balance must be reached between distortion and core size. One more condition where the inductor can dry out is analyzed below, where it is shown to be maximum duty cycle dependent.

For the boost converter at steady state:

$$V_{OUT} = \frac{V_{IN}}{1 - D_{ON}}$$

Where D_{ON} is the duty cycle $(T_{ON}/(T_{ON} + T_{OFF})$. The input boost inductor will dry out when the following condition is satisfied:

$$V_{IN}(t) < V_{OUT} \times (1 - D_{ON})$$

$$V_{INDRY} = (1 - D_{ON\,(max)}) \times V_{OUT}$$

V_{INDRY} : Voltage where the inductor dries out

V_{OUT} : Output DC Voltage

The previous relationship shows that the resetting volt-seconds are more than setting volts-seconds. In energy transfer terms, this means that less energy is stored in the inductor during the ON time than it is asked to deliver during the OFF time. The net result is that the inductor dries out.

TYPICAL APPLICATIONS (CONT.)

The recommended maximum duty cycle is 95% at 100 kHz to allow time for the input inductor to dump its energy to the output capacitors.

For example:

if: $V_{OUT} = 380$ V and

$D_{ON\,(max)} = 0.95$

then substituting in (3) yields $V_{INDRY} = 20$ V . The effect of drying out is an increase in distortion at low voltages.

For a given output power, the instantaneous value of the input current is a function of the input sinusoidal voltage waveform, i.e. as the input voltage sweeps from zero volts to a maximum value equal to its peak so does the current.

The load of the power factor regulator is usually a switching power supply which is essentially a constant power load. As a result, an increase in the input voltage will be offset by a decrease in the input current.

By combining the ideas set forth above, some ground rules can be obtained for the selection and design of the input inductor:

Step 1: Find minimum operating current.

$$I_{IN(min)PEAK} = \frac{1414 X P_{IN(min)}}{V_{IN(max)}}$$

$V_{IN(max)} = 260$ V

$P_{IN(min)} = 50$ W

then: $I_{IN(min)} = 0.272$A

Step 2: Choose a minimum current at which point the inductor current will be on the verge of drying out. For this example 40% of the peak current found in step 1 was chosen.
then:

$I_{LDRY} = 100$ mA

Step 3: The value of the inductance can now be found using previously calculated data.

$$L1 = \frac{V_{INDRY} X D_{ON(max)}}{L_{INDRY} X f_{OSC}}$$

$$= \frac{20 V X 0.95}{100 mA X 100 kHz} = 2 mH$$

The inductor can be allowed to decrease in value when the current sweeps from minimum to maximum value. This allows the use of smaller core sizes. The only requirement is that the ramp compensation must be adequate for the lower inductance value of the core so that there is adequate compensation at high current.

Step 4: The presence of the ramp compensation will change the dry out point, but the value found above can be considered a good starting point. Based on the amount of power factor correction the above value of L1 can be optimized after a few iterations.

Gapped Ferrites, Molypermalloy, and Powered Iron cores are typical choices for core material. The core material selected should have a high saturation point and acceptable losses at the operating frequency.

One ferrite core that is suitable at around 200 W is the T157-18 made by Micrometals. Two of these toroids are stacked with 140 turns of AWG #20 to provide 2 millihenries at 2 amps DC.

OSCILLATOR COMPONENT SELECTION

The oscillator timing components can be calculated by using the following expression:

$$f_{OSC} = \frac{1.36.}{R_T\ C_T}$$

For example:

Step 1: At 100 KHz with 95% duty cycle $T_{OFF} = 500$ ns calculate C_T using the following formula:

$$C_T = \frac{T_{OFF} X I_{DIS}}{V_{OSC}} = 1000\,pf$$

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TYPICAL APPLICATIONS (CONT.)

Step 2: Calculate the required value of the timing resistor.

$$R_T = \frac{1.36}{f_{OSC} X C_T} = \frac{1.36}{100\ kHz\ X\ 1000\ pF} = 13.6\ k$$

Choose $R_T = 14$ k

CURRENT SENSE AND SLOPE (RAMP) COMPENSATION COMPONENT SELECTION

Slope compensation in the TK84812 is provided internally. The amount of slope compensation should be at least 50% of the downslope of the inductor current during the off time as reflected on pin 1. Note that slope compensation is a requirement only if the inductor current is continuous and the duty cycle is more than 50%. The highest inductor downslope is found at the point of inductor discontinuity:

$$\frac{d_{IL}}{d_t} = \frac{V_b - V_{INDRY}}{L} = \frac{380\ V - 20\ V}{2\ mH}$$

The downslope as reflected to the input of the PWM comparator is given by:

$$S_{PWM} = \frac{V_b - V_{INDRY}}{L1}\ X\ R11/Nc$$

Where NC is the turns ratio of the current transformer (T1) used. In general, current transformers simplify the sensing of switch currents especially at high power levels where the use of sense resistors is complicated by the amount of power they have to dissipate. Normally the primary side of the transformer consists of a single turn and the secondary consists of several turns of either enameled magnet wire or insulated wire. We have used a standard Beckman Industrial HM31-20100 current sense transformer. The rectifying diode at the output of the current transformer can be a 1N4148 for secondary currents up to 75 mA average. Sense FETs or resistive sensing can also be used to sense the switch current, the sensed signal has to be amplified to the proper level before it is applied to the IC.

The value of ramp compensation (SC_{PWM}) as seen at pin 1 is:

$$SC_{PWM} = \frac{2.5\ X\ R9}{R16\ X\ C6\ X\ R18}$$

The required value for R18 can be found by:

$$SC_{PWM} = A_{SC}\ X\ S_{PWM}$$

where A_{SC} is the amount of slope compensation and solving for Rsc.

The value of R_M (pin 2) depends on the selection of Rp (pin 6)

$$R_M = \frac{V_{IN(max)\ PEAK}}{I_{sine(PEAK)}} = \frac{260\ X\ 1.414}{0.72\ mA} = 510\ k$$

$$R_P > \frac{V_{CLAMP}\ X\ R2}{V_{IN(min)}} = \frac{4.8\ X\ 510\ k}{80\ X\ 1414} \approx 22\ k$$

Choose $R_M = 27$ k

The peak inductor current can be found approximately by:

$$Ilpeak = \frac{1.414\ X\ P_{OUT}}{V_{IN(min)RMS}} = \frac{1.414\ X\ 200}{90} = 3.14\ A$$

The selection of Nc which depends on the maximum switch current, assume 4A for this example is 80 turns,

$$R_{S1} = \frac{V_{CLAMP}\ X\ Nc}{I_{PEAK}} = \frac{4.8\ X\ 80}{4} \approx 100\ \Omega$$

Where R_S is the sense resistor, and Vclamp is the current clamp at the inverting input of the PWM comparator. The clamp is internally set to 5 V. In actual application it is a good idea to assume a value less than 5 V to avoid unwanted current limiting action due to component tolerances. In the application Vclamp was chosen as 4.8 V.

Having calculated Rs the value S_{PWM} and of Rsc can now be calculated:

$$S_{PWM} = \frac{380\ V - 20}{2\ mH}\ X\ \frac{100}{80} = 0.225\ V/\mu s$$

$$R_{SC} = \frac{2.5\ X\ R_M}{A_{SC}\ X\ S_{PWM}\ X\ R_T\ X\ C_T}$$

TYPICAL APPLICATIONS (CONT.)

$$R_{SC} = \frac{2.5 \ X \ 27\,k}{0.7 \ X \ (.225 \ X \ 10^6) X \ 14\,k \ X \ 1\,nf} \approx 30 \ k$$

Choose R_{SC} = 33 k

The following values were used for calculation:

R_M = 27 k
Asc = 0.7
Rt = 14 k
Ct = 1 nF

Voltage Regulation Components

The value of the voltage regulation loop components are calculated based on the operating output voltage. Note that safety regulations require the use of sense resistors that have adequate voltage rating. The input bias current of the error amplifier is approximately 0.5 μA, therefore the current available from the voltage sense resistors should be significantly higher than this value. the total power rating is 1/2 W. The operating power is set to be 0.4 W, then with 380 V output voltage, the value can be calculated as follows:

$R9 = (380 \ V)^2 / 0.4 \ W = 361 \ k$

Therefore choose a 357 k 1/2 W 1% resistor.Then R10 can be calculated as below:

$$R10 = \frac{V_{REF} X \ R5}{V_B - V_{REF}} = \frac{5 \ V \ X \ 357 \ k}{380 \ V - 5 \ V} \approx 4.747 \ k$$

Choose 4.53 k in series with a 500 ohm adjustment pot.

One more critical component in the voltage regulation loop is the feedback capacitor for the error amplifier. The voltage loop bandwidth should be set such that it rejects the 120 Hz ripple which is present at the output. If this ripple is not adequately attenuated, it will cause distortion of the input current waveform. Typical bandwidths range anywhere from a few Hz to 15 Hz. The main compromise is between transient response and distortion. The feedback capacitor can be calculated using the following formula:

$$C8 = \frac{1}{3.142 \ X \ R5 \ X \ BW} =$$

$$C8 = \frac{1}{3.162 \ X \ 357 \ k \ X \ 2 \ Hz} = 0.44 \ \mu F$$

OVERVOLTAGE PROTECTION (OVP)

The OVP loop should be set so that there is no interaction with the voltage control loop. Typically it should be set to a level where the power components are safe to operate. Ten to fifteen volts above Vout seems to be adequate. This sets the maximum transient output voltage to about 395 V.

By choosing the high voltage side resistor of the OVP circuit the same way as above, (R7 = 356 k) then R8 can be calculated as:

3

$$R8 = \frac{V_{REF} X \ R7}{V_{OVP} - V_{REF}} = \frac{5 \ V \ X \ 357 \ k}{395 \ V - 5 \ V} = 4.576 \ k$$

Choose 4.53 k 1%

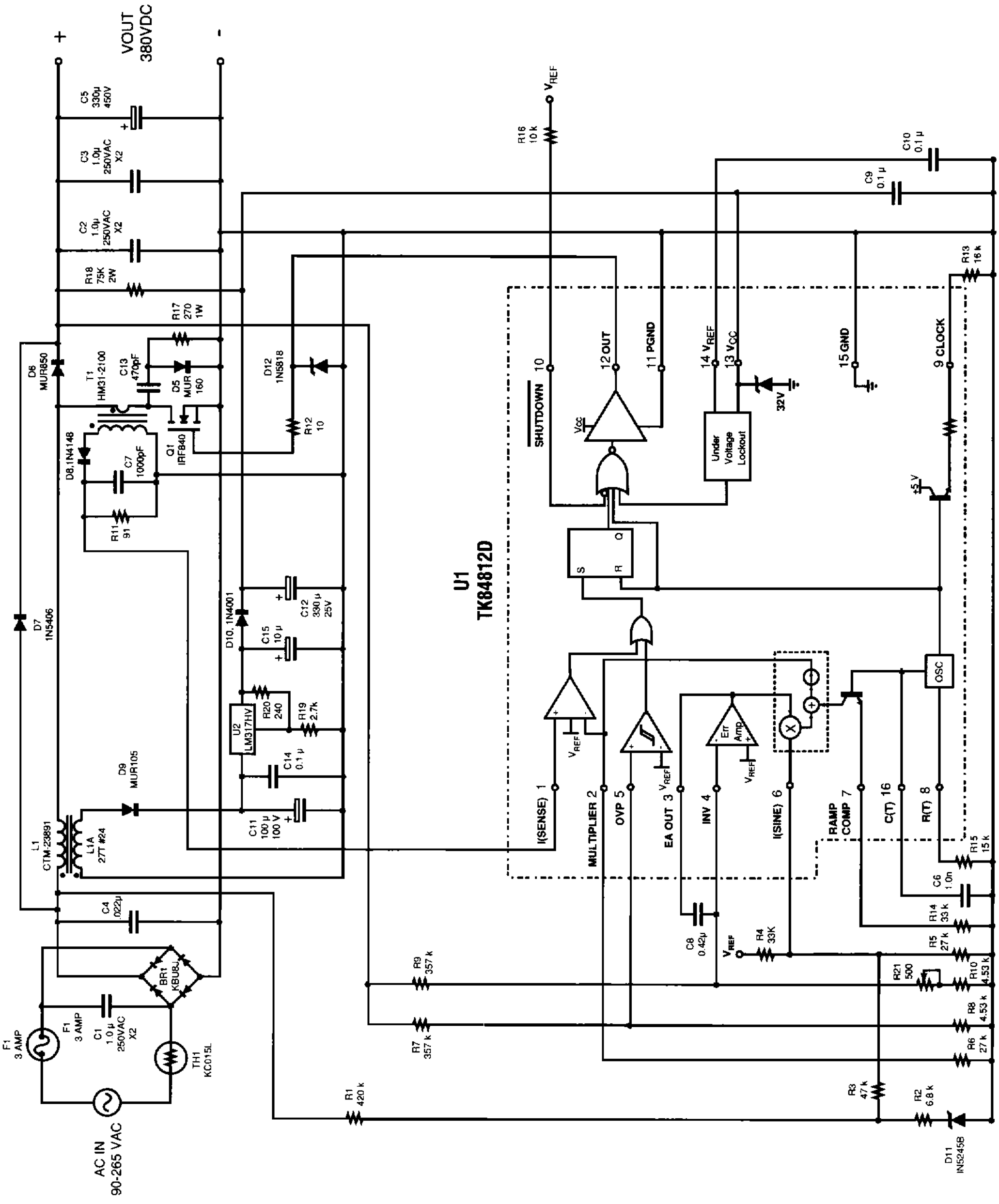
Note that R7, R8, R9, and R10 should be 1% or better tolerance.

Controller Shutdown

The TK84812 provides a shutdown pin which can be used to disable the IC. Caution should be taken because when this pin is used power supply sequencing problems could arise if the 380 V bus supplies power to a regulator that has a bootstapped housekeeping circuit. A circuit could be devised using V_{REF} as a flag to inhibit the PWM section of the supply as an example.

Power Factor Enhancement Circuit

Predistortion is added to rectified AC input waveform before it is applied to the $I_{(SINE)}$ input (pin 6) by a soft clamping technique. Tests have shown that the power factor can be improved by the inclusion of this circuit as implemented in the application schematic.



TK84812 APPLICATIONS CIRCUIT

TK84812

TK84812 APPLICATIONS BOARD PARTS LIST

ITEM	PART NUMBER	MANUFACTURER	DISTRIBUTOR
U1	TK84812	TOKO	
U2	LM317HVH	National	(Digi-Key)
Q1	IRF840	Internat. Rect.	(Digi-Key)
BR1	KBU8J Bridge Rectifier	Gen. Inst.	(Newark)
D5	MUR160	Motorola	(Newark)
D6	MUR850	Motorola	(Newark)
D7	1N5406	Gen. Inst.	(Digi-Key)
D8	1N4148	Diodes Inc.	(Digi-Key)
D9	MUR105	Motorola	(Newark)
D10	1N4001	Diodes Inc.	(Digi-Key)
D11	1N5254B	Diodes Inc.	(Digi-Key)
D12	1N5818	Diodes Inc.	(Digi-Key)
C1	1 µF 250VAC X P4616		(Digi-Key)
C2	1 µF 250VAC X P4616		(Digi-Key)
C3	1 µF 250VAC X P4616		(Digi-Key)
C4	2200 pF 1 kV P4113		(Digi-Key)
C5	330 µF 450 V P6443		(Digi-Key)
C6	1000 pF 50 V ± 5% NPO 87F4866		(Newark)
C7	1000 pF 50 V P4812		(Digi-Key)
C8	0.47 µF 50 V 87F4755		(Newark)
C9	0.1 µF 50 V P4887		(Digi-Key)
C10	0.1 µF 50 V P4887		(Digi-Key)
C11	100 µF 100 V P530		(Digi-Key)
C12	330 µF 450 V P5278		(Digi-Key)
C13	470 pF 1 kV P4124		(Digi-Key)
C14	1 µF 100 V P4910		(Digi-Key)
C15	10 µF 100 V P5297		(Digi-Key)
R1	420 k 1/4 W 5%		(Digi-Key)

3

TK84812 APPLICATIONS BOARD PARTS LIST (CONT.)

ITEM	PART NUMBER	MANUFACTURER	DISTRIBUTOR
R2	6.8 k 1/8 W 5%		(Digi-Key)
R3	47 k 1/8 W 5%		(Digi-Key)
R4	33 k 1/8 W 5%		(Digi-Key)
R5	27 k 1/8 W 5%		(Digi-Key)
R6	27 k 1/8 W 5%		(Digi-Key)
R7	357 k 1/4 W 1%		(Digi-Key)
R8	4.53 k 1/4 W 1%		(Digi-Key)
R9	357 k 1/4 W 1%		(Digi-Key)
R10	4.53 k 1/4 W 1%		(Digi-Key)
R11	91 1/8 W 5%		(Digi-Key)
R12	10 1/4 W 5%		(Digi-Key)
R13	16 k 1/8 W 5%		(Digi-Key)
R14	33 k 1/8 W 5%		(Digi-Key)
R15	15 k 1/8 W 5%		(Digi-Key)
R16	10 k 1/8 W 5%		(Digi-Key)
R17	270 1 W 5%		(Digi-Key)
R18	75 k 2 W 5%		(Digi-Key)
R19	2.7 k 1/4 W 5%		(Digi-Key)
R20	240 1/4 W 5%		(Digi-Key)
TH1	KC015L (Thermistor)	Keystone Carbon	(Digi-Key)
F1	3A 250 V		(Digi-Key)
L1	CTM28992	CTM Magnetics (602) 967-9447	
T1	HM3210100	Beckman Industrial (714) 447-2345	