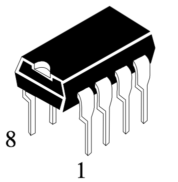
Power Factor Controllers

IL34262

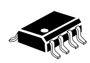
The are active power factor controllers specifically designed for use as a preconverter in electronic ballast and in off-line power converter applications.

These integrated circuits feature an internal startup timer for stand-alone applications, a one quadrant multiplier for near unity power factor, zero current detector to ensure critical conduction operation, transconductance error amplifier, quick start circuit for enhanced startup, trimmed internal bandgap reference, current sensing comparator, and a totem pole output ideally suited for driving a power MOSFET.

Also included are protective features consisting of an overvoltage comparator to eliminate runaway output voltage due to load removal, input undervoltage lockout with hysteresis, cycle-by-cycle current limiting, multiplier output clamp that limits maximum peak switch current, an RS latch for single pulse metering, and a drive output high state clamp for MOSFET gate protection. These devices are available in dual-in-line and surface mount plastic packages.



N SUFFIX
PLASTIC

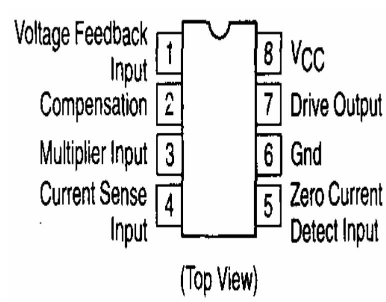


D SUFFIX
SOIC

ORDERING INFORMATION
IL34262N Plastic
IL34262D SOIC
T_A = 0° to 85° C for all packages.

- Overvoltage Comparator Eliminates Runaway Output Voltage
- Internal Startup Timer
- One Quadrant Multiplier
- Zero Current Detector
- Trimmed 2% Internal Bandgap Reference
- Totem Pole Output with High State Clamp
- Undervoltage Lockout with 6.0 V of Hysteresis
- Low Startup and Operating Current
- Supersedes Functionality of SG3561, TDA4817 and MC34262

PIN CONNECTIONS



IK Semiconductor

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Total Power Supply and Zener Current	(Icc + Iz)	30	mA
Output Current, Source or Sink	lo	500	mA
Current Sense, Multiplier, and Voltage Feedback Inputs	Vin	-1.0 to +10	V
Zero Current Detect Input High State Forward Current Low State Reverse Current	Iin	 50 -10	mA
Power Dissipation and Thermal Characteristics N Suffix, Plastic Package Maximum Power Dissipation @ T_A = 70°C Thermal Resistance, Junction-to-Air D Suffix, Plastic Package Maximum Power Dissipation @ T_A = 70°C Thermal Resistance, Junction-to-Air	 P_D $R_{\theta JA}$ P_D $R_{\theta JA}$	 800 100 450 178	 mW °C/W mW ^{0}C/W
Operating Junction Temperature	T_J	+150	°C
Operating Ambient Temperature	T_A	0 to + 85	°C
Storage Temperature	Tstg	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (Vcc =12 V, for min/max values T_A is the operating ambient temperature range that applies unless otherwise noted.)

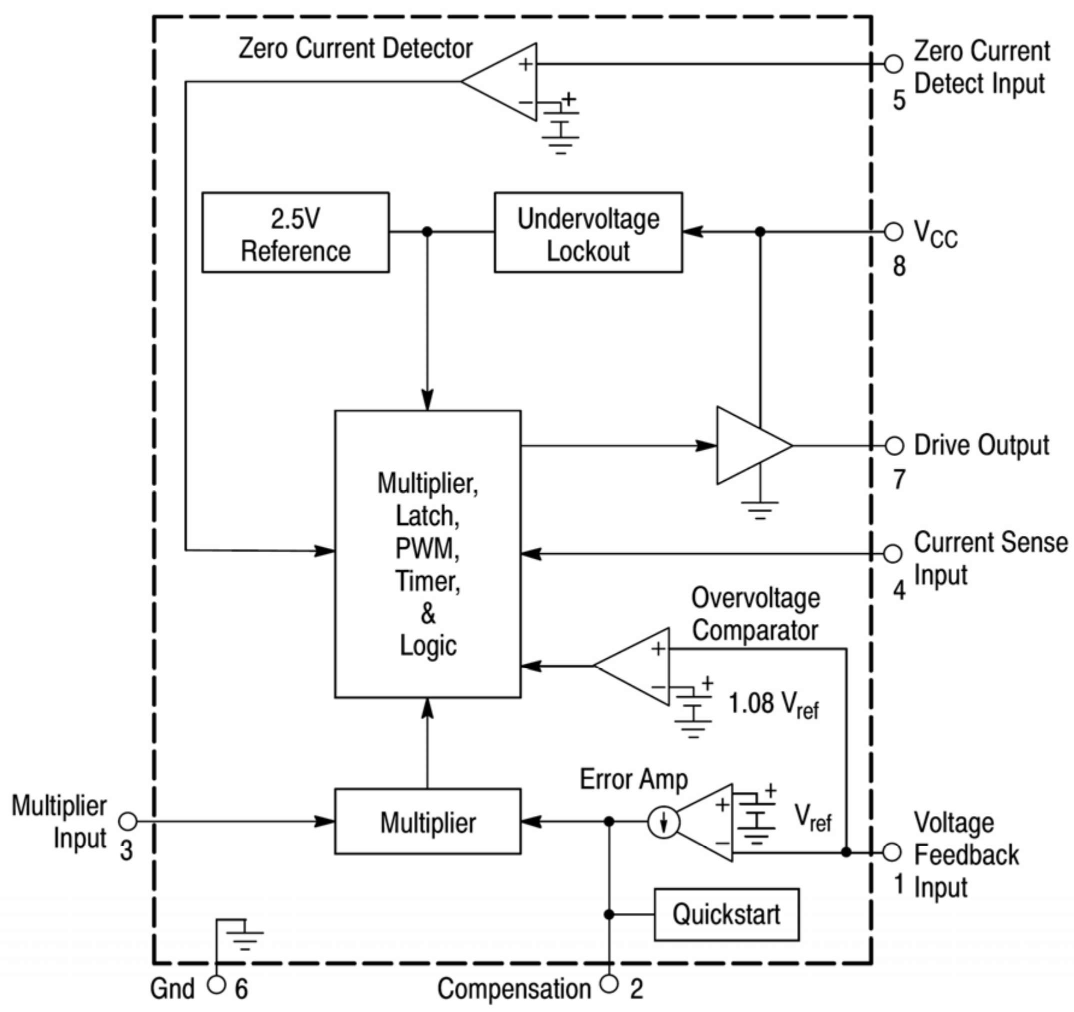
Characteristic	Symbol	Min	Max	Unit
ERROR AMPLIFIER				
Voltage Feedback Input Threshold T_A=25°C T_A = Tlow to Thigh (Vcc = 12 V to 28 V)	V_{FB}	 2.465 2.44	 2.535 2.54	V
Line Regulation (V_{CC} = 12 V to 28 V, T_A = 25°C)	Reg_{line}	—	10	mV
Input Bias Current (V_{FB} = 0 V)	I_{IB}	—	-0.5	μA
Transconductance (T_A = 25°C)	g_m	80	130	μmho
Output Current Source (V_{FB} = 2.3 V) Sink (V_{FB} = 2.7 V)	lo	 — —	 — —	μA
Output Voltage Swing High State (V_{FB} = 2.3 V) Low State (V_{FB} = 2.7 V)	 V_{OH}(ea) V_{OL}(ea)	 5.8 —	 — 2.4	V

Characteristic	Symbol	Min	Max	Unit
OVERVOLTAGE COMPARATOR				
Voltage Feedback Input Threshold	V_{FB}(OV)	1.065VFB	1.095VFB	V
MULTIPLIER				
Input Bias Current, Pin 3 (VFB = 0 V)	IIB	—	-0.5	µA
Input Threshold, Pin 2	Vth(M)	1.05 $V_{OL(EA)}$	—	V
Dynamic Input Voltage Range Multiplier Input (Pin 3) Compensation (Pin 2)	 Vpin3 Vpin2	 0 to 2.5 Vth(M) to (Vth(M)+1.0)	 — —	 V
Multiplier Gain (Vpin 3 = 0.5 V, Vpin 2 = Vth(M) + 1.0 V)	K	0.43	0.87	1/V
ZERO CURRENT DETECTOR				
Input Threshold Voltage (Vjn Increasing)	Vth	1.33	1.87	V
Hysteresis (Vin Decreasing)	VH	100	300	mV
Input Clamp Voltage High State (IDET = + 3.0 mA) High State (IDET = - 3.0 mA)	VIH VIL	6.1 0.3	— 1.0	V
CURRENT SENSE COMPARATOR				
Input Bias Current (Vpin 4 = 0 V)	I_{IB}	—	-1.0	µA
Input Offset Voltage (Vpm 2 = 1.6 V, Vpm 3 = 0 V)	V_{IO}	—	25	mV
Maximum Current Sense Input Threshold (Note 1)	$V_{th(max)}$	1.3	1.8	V
Delay to Output	$t_{PHL(in/out)}$	—	400	ns
DRIVE OUTPUT				
Output Voltage (V_{CC} = 12 V) Low State (I_{sink} = 20 mA) (I_{sink} = 200 mA) High State (I_{source} = 20 mA) (I_{source} = 200 mA)	 V_{OL} V_{OH} 	 — — 9.8 7.8	 0.8 3.3 0.8 3.3	V
Output Voltage (V_{CC} = 30 V) High State (I_{source} = 20 mA, C_L = 15 pF)	$V_{O(max)}$	14	18	V
Output Voltage Rise Time (C_L 1.0 nF)	t_r	—	120	ns
Output Voltage Fall Time (C_L 1.0 nF)	t_f	—	120	ns
Output Voltage with UVLO Activated (Vcc = 7.0 V,I_{Sink}= 1.0mA)	$V_{O(UVLO)}$	—	0.5	V
RESTART TIMER				
Restart Time Delay	tDLY	200	—	µs

Note 1: This parameter is measured with V_{FB} =0V, and V_{Pin3}=3.0V

Characteristic	Symbol	Min	Max	Unit
UNDERVOLTAGE LOCKOUT				
Startup Threshold (V_{CC} Increasing)	$V_{th(on)}$	11.5	14.5	V
Minimum Operating Voltage After Turn-On (V_{CC} Decreasing)	$V_{Shutdown}$	7.0	9.0	V
Hysteresis	V_H	3.8	6.2	V
TOTAL DEVICE				
Power Supply Current Startup (Vcc = 7.0 V) Operating Dynamic Operating (50 kHz, C_L = 1.0 nF)	I_{CC}	—	0.4 12 20	mA
Power Supply Zener Voltage (Ice = 25 mA)	V_Z	30	—	V

Simplified Block Diagram



Notes	Calculation	Formula
Calculate the maximum required output power.	Required Converter Output Power	$P_O = V_O I_O$
Calculated at the minimum required ac line voltage for output regulation. Let the efficiency η = 0.92 for low line operation.	Peak Inductor Current	$I_{L(pk)} = \frac{2\sqrt{2} P_O}{\eta Vac_{(LL)}}$
Let the switching cycle t = 40 µs for universal input (85 to 265 Vac) operation and 20 µs for fixed input (92 to 138 Vac, or 184 to 276 Vac) operation.	Inductance	$L_P = \frac{t\left(\frac{V_O}{\sqrt{2}} - Vac_{(LL)}\right) \eta\, Vac_{(LL)}^2}{\sqrt{2} V_O P_O}$
In theory the on–time t_{on} is constant. In practice t_{on} tends to increase at the ac line zero crossings due to the charge on capacitor C_5. Let Vac = $Vac_{(LL)}$ for initial t_{on} and t_{off} calculations.	Switch On–Time	$t_{on} = \frac{2 P_O L_P}{\eta\, Vac^2}$
The off–time t_{off} is greatest at the peak of the ac line voltage and approaches zero at the ac line zero crossings. Theta (θ) represents the angle of the ac line voltage.	Switch Off–Time	$t_{off} = \frac{t_{on}}{\frac{V_O}{\sqrt{2}\, Vac \lvert \sin\theta \rvert} - 1}$
The minimum switching frequency occurs at the peak of the ac line voltage. As the ac line voltage traverses from peak to zero, t_{off} approaches zero producing an increase in switching frequency.	Switching Frequency	$f = \frac{1}{t_{on} + t_{off}}$
Set the current sense threshold V_{CS} to 1.0 V for universal input (85 Vac to 265 Vac) operation and to 0.5 V for fixed input (92 Vac to 138 Vac, or 184 Vac to 276 Vac) operation. Note that V_{CS} must be <1.4 V.	Peak Switch Current	$R_7 = \frac{V_{CS}}{I_{L(pk)}}$
Set the multiplier input voltage V_M to 3.0 V at high line. Empirically adjust V_M for the lowest distortion over the ac line voltage range while guaranteeing startup at minimum line.	Multiplier Input Voltage	$V_M = \frac{Vac\sqrt{2}}{\left(\frac{R_5}{R_3} + 1\right)}$
The $I_{IB} R_1$ error term can be minimized with a divider current in excess of 50 µA.	Converter Output Voltage	$V_O = V_{ref}\left(\frac{R_2}{R_1} + 1\right) - I_{IB} R_2$
The calculated peak–to–peak ripple must be less than 16% of the average dc output voltage to prevent false tripping of the Overvoltage Comparator. Refer to the Overvoltage Comparator text. ESR is the equivalent series resistance of C_3	Converter Output Peak to Peak Ripple Voltage	$\Delta V_{O(pp)} = I_O \sqrt{\left(\frac{1}{2\pi f_{ac} C_3}\right)^2 + ESR^2}$
The bandwidth is typically set to 20 Hz. When operating at high ac line, the value of C_1 may need to be increased. (See Figure 25)	Error Amplifier Bandwidth	$BW = \frac{gm}{2\pi C_1}$

The following converter characteristics must be chosen:

V_O — Desired output voltage

I_O — Desired output current

ΔV_O — Converter output peak–to–peak ripple voltage

Vac — AC RMS line voltage

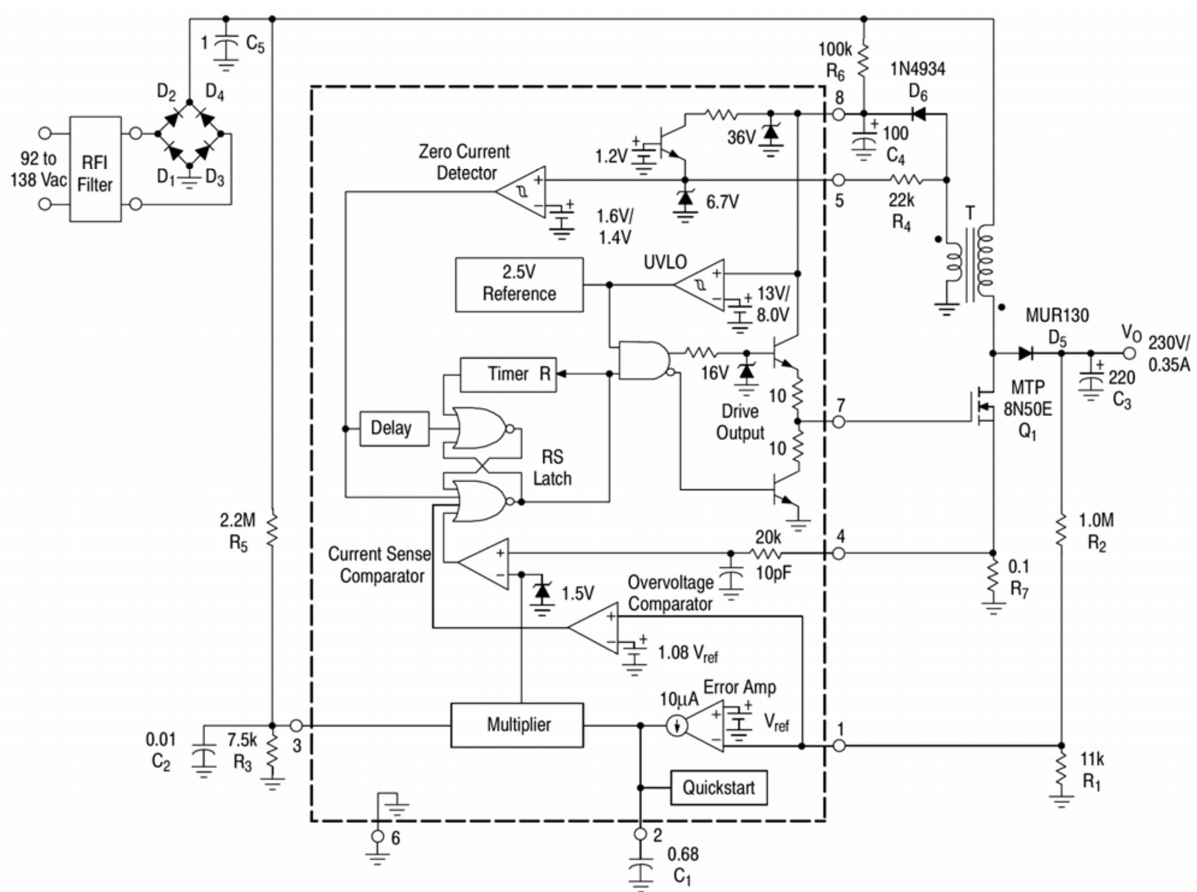
$Vac_{(LL)}$ — AC RMS low line voltage

<Design Equations>

APPLICATION INFORMATION

The application circuits shown in Figures 19, 20 and 21 reveal that few external components are required for a complete power factor preconverter. Each circuit is a peak detecting current-mode boost converter that operates in critical conduction mode with a fixed on-time and variable off-time. A major benefit of critical conduction operation is that the current loop is inherently stable, thus elimination the need for ramp compensation. The application in Figure 19 operates over an input voltage range if 90 Vac to 138 Vac and provides an output power of 80W (230V at 350mA) with an associated power factor of approximately 0.998 at nominal line. Figures 20 and 21 are universal input preconverter examples that operate over a continuous input voltage range of 90 Vac to 268Vac. Figure 20 provides an output power of 175W (400V at 440mA) while Figure 21 provides 450W (400V at 1.125A). Both circuits have an observed worst-case power factor of approximately 0.989. The input current and voltage waveforms of Figure 20 are shown in Figure 22 with operation at 115 Vac and 230 Vac. The data for each of the applications was generated with the test set-up shown in Figure 24.

80W Power Factor Controller



Power Factor Controller Test Data

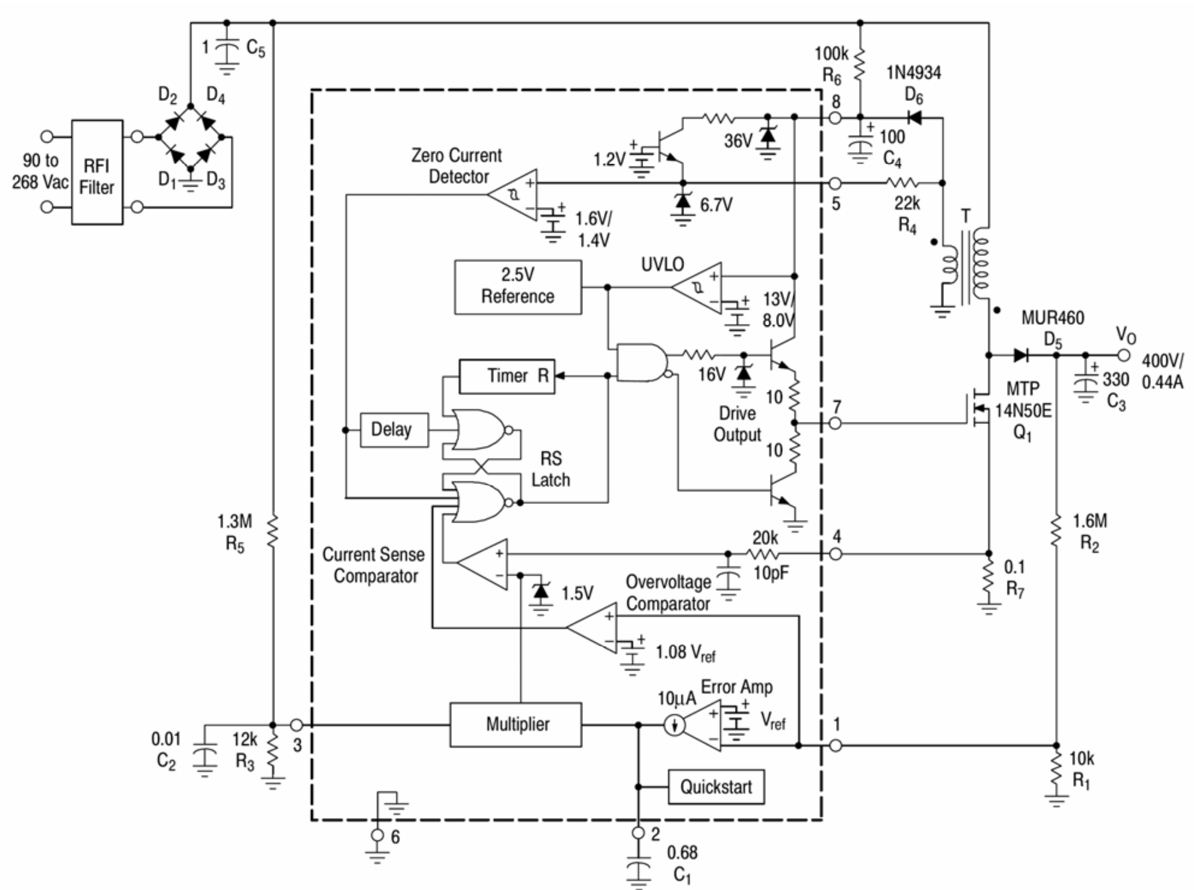
AC Line Input									DC Output				
				Current Harmonic Distortion (% I_{fund})									
V_{rms}	P_{in}	PF	I_{fund}	THD	2	3	5	7	$V_{O(pp)}$	V_O	I_O	P_O	η(%)
90	85.9	0.999	0.93	2.6	0.08	1.6	0.84	0.95	4.0	230.7	0.350	80.8	94.0
100	85.3	0.999	0.85	2.3	0.13	1.0	1.2	0.73	4.0	230.7	0.350	80.8	94.7
110	85.1	0.998	0.77	2.2	0.10	0.58	1.5	0.59	4.0	230.7	0.350	80.8	94.9
120	84.7	0.998	0.71	3.0	0.09	0.73	1.9	0.58	4.1	230.7	0.350	80.8	95.3
130	84.4	0.997	0.65	3.9	0.12	1.7	2.2	0.61	4.1	230.7	0.350	80.8	95.7
138	84.1	0.996	0.62	4.6	0.16	2.4	2.3	0.60	4.1	230.7	0.350	80.8	96.0

This data was taken with the test set–up shown in Figure 24.

T = Coilcraft N2881–A
- Primary: 62 turns of # 22 AWG
- Secondary: 5 turns of # 22 AWG
- Core: Coilcraft PT2510, EE 25
- Gap: 0.072″ total for a primary inductance (L_P) of 320 µH

Heatsink = AAVID Engineering Inc. 590302B03600, or 593002B03400

175W Universal Input Power Factor Controller



Power Factor Controller Test Data

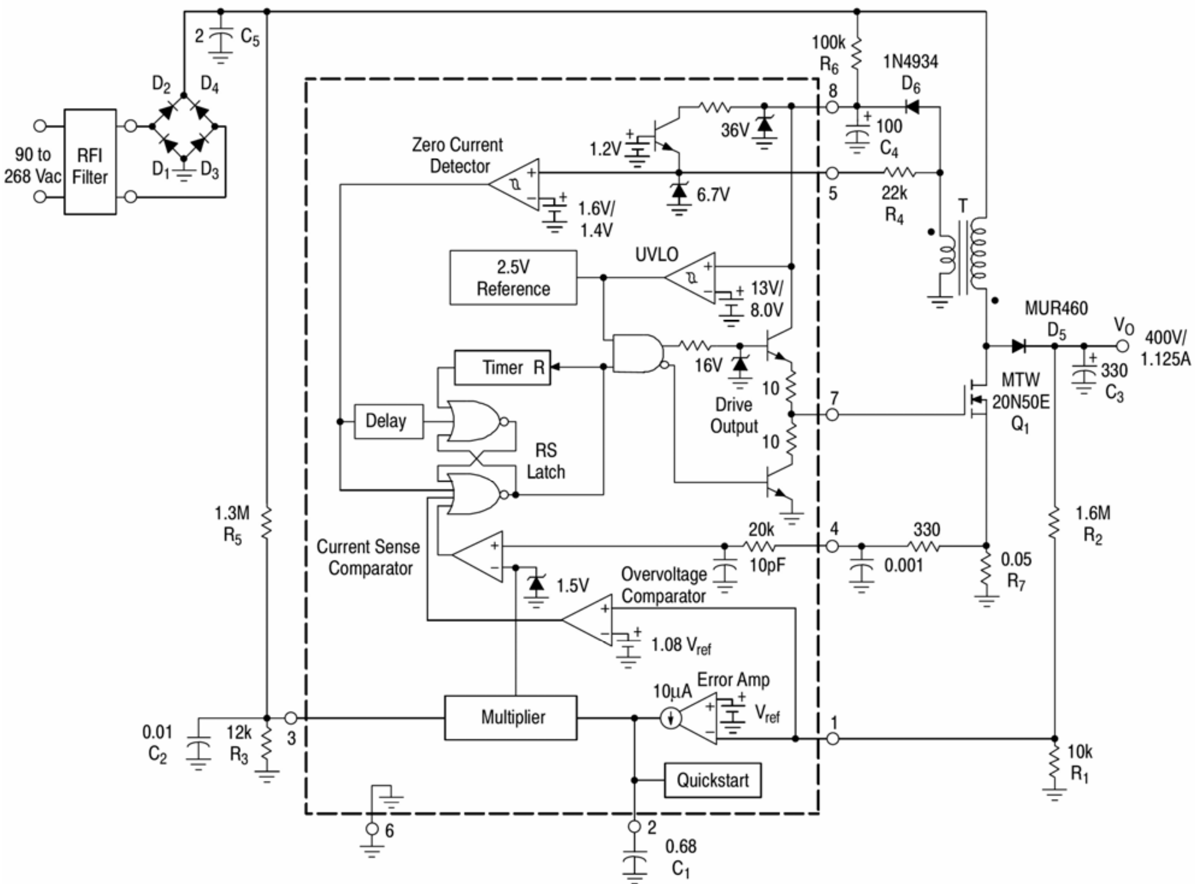
AC Line Input									DC Output				
				Current Harmonic Distortion (% I_{fund})									
V_{rms}	P_{in}	PF	I_{fund}	THD	2	3	5	7	$V_{O(pp)}$	V_O	I_O	P_O	η(%)
90	193.3	0.991	2.15	2.8	0.18	2.6	0.55	1.0	3.3	402.1	0.44	176.9	91.5
120	190.1	0.998	1.59	1.6	0.10	1.4	0.23	0.72	3.3	402.1	0.44	176.9	93.1
138	188.2	0.999	1.36	1.2	0.12	1.3	0.65	0.80	3.3	402.1	0.44	176.9	94.0
180	184.9	0.998	1.03	2.0	0.10	0.49	1.2	0.82	3.4	402.1	0.44	176.9	95.7
240	182.0	0.993	0.76	4.4	0.09	1.6	2.3	0.51	3.4	402.1	0.44	176.9	97.2
268	180.9	0.989	0.69	5.9	0.10	2.3	2.9	0.46	3.4	402.1	0.44	176.9	97.8

This data was taken with the test set–up shown in Figure 24.

T = Coilcraft N2880–A
Primary: 78 turns of # 16 AWG
Secondary: 6 turns of # 18 AWG
Core: Coilcraft PT4215, EE 42–15
Gap: 0.104″ total for a primary inductance (L_P) of 870 µH

Heatsink = AAVID Engineering Inc. 590302B03600

450W Universal Input Power Factor Controller



Power Factor Controller Test Data

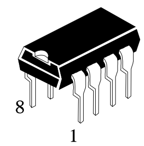
AC Line Input									DC Output				
				Current Harmonic Distortion (% I_{fund})									
V_{rms}	P_{in}	PF	I_{fund}	THD	2	3	5	7	$V_{O(pp)}$	V_O	I_O	P_O	η(%)
90	489.5	0.990	5.53	2.2	0.10	1.5	0.25	0.83	8.8	395.5	1.14	450.9	92.1
120	475.1	0.998	3.94	2.5	0.12	0.29	0.62	0.52	8.8	395.5	1.14	450.9	94.9
138	470.6	0.998	3.38	2.1	0.06	0.70	1.1	0.41	8.8	395.5	1.14	450.9	95.8
180	463.4	0.998	2.57	4.1	0.21	2.0	1.6	0.71	8.9	395.5	1.14	450.9	97.3
240	460.1	0.996	1.91	4.8	0.14	4.3	2.2	0.63	8.9	395.5	1.14	450.9	98.0
268	459.1	0.995	1.72	5.8	0.10	5.0	2.5	0.61	8.9	395.5	1.14	450.9	98.2

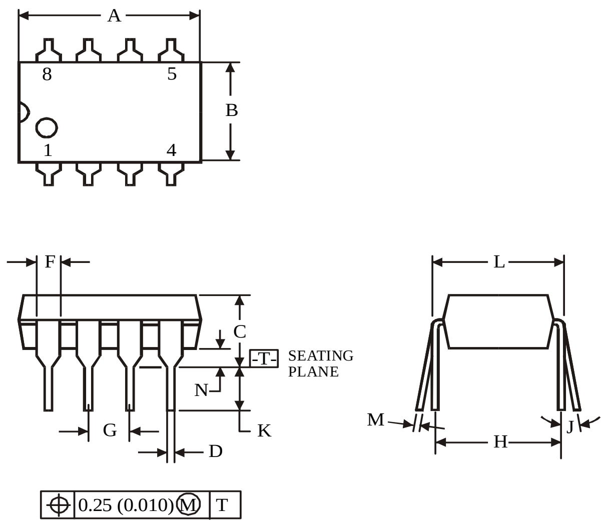
This data was taken with the test set–up shown in Figure 24.

T = Coilcraft P3657–A
Primary: 38 turns Litz wire, 1300 strands of #48 AWG, Kerrigan–Lewis, Chicago, IL
Secondary: 3 turns of # 20 AWG
Core: Coilcraft PT4220, EE 42–20
Gap: 0.180″ total for a primary inductance (L_P) of 190 µH

Heatsink = AAVID Engineering Inc. 604953B04000 Extrusion

N SUFFIX PLASTIC DIP
(MS – 001BA)





	Dimension, mm	
Symbol	**MIN**	**MAX**
A	8.51	10.16
B	6.1	7.11
C		5.33
D	0.36	0.56
F	1.14	1.78
G	2.54	
H	7.62	
J	0°	10°
K	2.92	3.81
L	7.62	8.26
M	0.2	0.36
N	0.38	

NOTES:

1. Dimensions "A", "B" do not include mold flash or protrusions. Maximum mold flash or protrusions 0.25 mm (0.010) per side.