

ZVS Average Current PFC Controller

GENERAL DESCRIPTION

The ML4822 is a PFC controller designed specifically for high power applications. The controller contains all of the functions necessary to implement an average current boost PFC converter, along with a Zero Voltage Switch (ZVS) controller to reduce diode recovery and MOSFET turn-on losses.

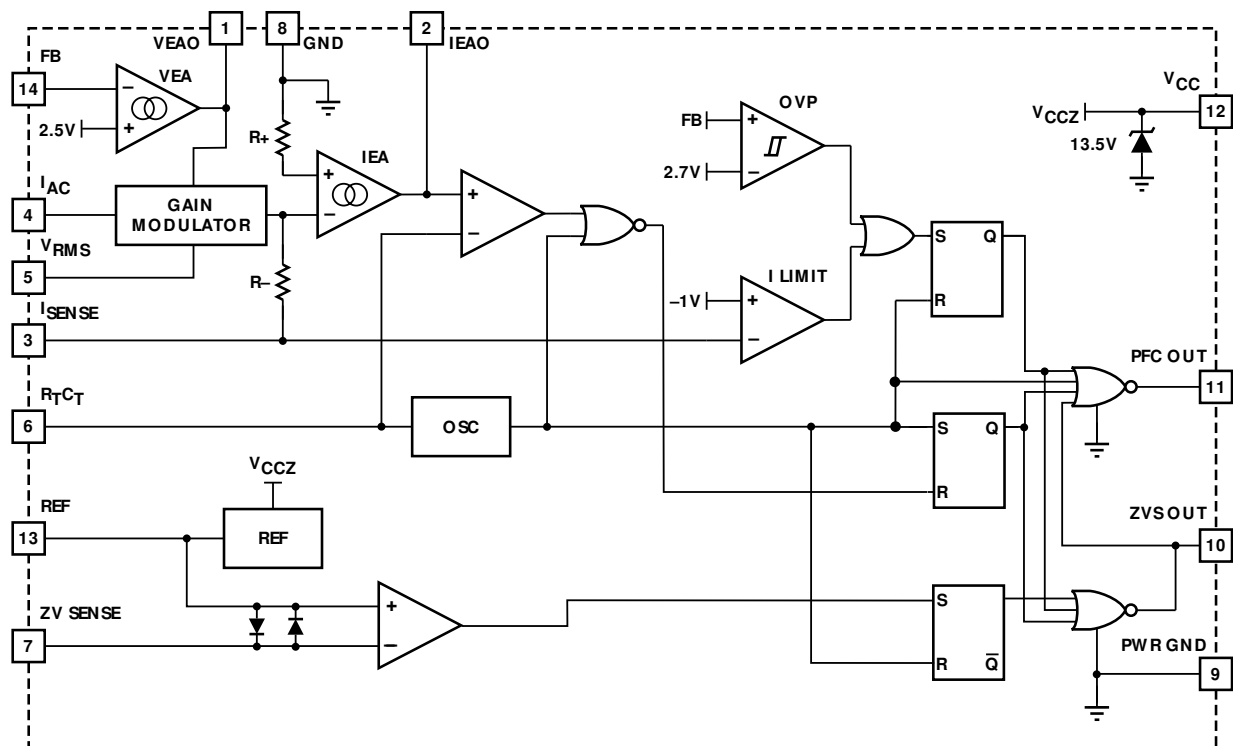
The average current boost PFC circuit provides high power factor (>98%) and low Total Harmonic Distortion (THD). Built-in safety features include undervoltage lockout, overvoltage protection, peak current limiting, and input voltage brownout protection.

The ZVS control section drives an external ZVS MOSFET which, combined with a diode and inductor, soft switches the boost regulator. This technique reduces diode reverse recovery and MOSFET switching losses to reduce EMI and maximize efficiency.

FEATURES

- Average current sensing, continuous boost, leading edge PFC for low total harmonic distortion and near unity power factor
- Built-in ZVS switch control with fast response for high efficiency at high power levels
- Average line voltage compensation with brownout control
- Current fed gain modulator improves noise immunity and provides universal input operation
- Overvoltage comparator eliminates output "runaway" due to load removal
- UVLO, current limit, and soft-start
- Precision 1% reference

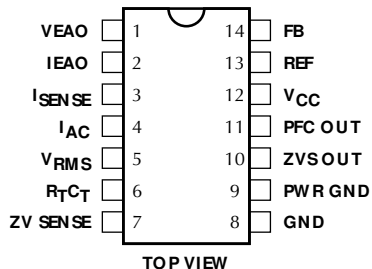
BLOCK DIAGRAM (Pin configuration shown for 14-pin package)



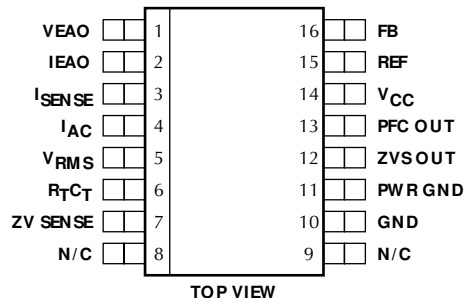
ML4822

PIN CONFIGURATION

ML4822
14-Pin DIP (P14)



ML4822
16-Pin SOIC (S16W)



PIN DESCRIPTION (Pin number in parentheses is for 16-pin package)

PIN	NAME	FUNCTION	PIN	NAME	FUNCTION
1 (1)	VEAO	Transconductance voltage error amplifier output.	8 (10)	GND	Analog signal ground.
2 (2)	IEAO	Transconductance current error amplifier output.	9 (11)	PWR GND	Return for the PFC and ZVS driver outputs.
3 (3)	ISENSE	Current sense input to the PFC current limit comparator.	10 (12)	ZVS OUT	ZVS MOSFET driver output.
4 (4)	IAC	PFC gain modulator reference input.	11 (13)	PFC OUT	PFC MOSFET driver output.
5 (5)	VRMS	Input for RMS line voltage compensation.	12 (14)	VCC	Shunt-regulated supply voltage.
6 (6)	RTCT	Connection for oscillator frequency setting components.	13 (15)	REF	Buffered output for the internal 7.5V reference.
7 (7)	ZV SENSE	Input to the high speed zero voltage crossing comparator.	14 (16)	FB	Transconductance voltage error amplifier input.

ABSOLUTE MAXIMUM RATINGS

Absolute maximum ratings are those values beyond which the device could be permanently damaged. Absolute maximum ratings are stress ratings only and functional device operation is not implied.

Shunt Regulator Current (I_{CC})	55mA
Peak Driver Output Current	±500mA
Analog Inputs	-0.3 to 7V
Junction Temperature	150°C
Storage Temperature Range	-65°C to 150°C

Lead Temperature (Soldering, 10 sec)	150°C
Thermal Resistance (θ_{JA})	
Plastic DIP	80°C/W
Plastic SOIC	110°C/W

OPERATING CONDITIONS

Temperature Range	
ML4822CX	0°C to 70°C
ML4822IX	-40°C to 85°C

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, $R_T = 52.3k\Omega$, $C_T = 470pF$, $T_A =$ Operating Temperature Range (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
VOLTAGE ERROR AMPLIFIER					
Input Voltage Range		0		7	V
Transconductance	$V_{NON-INV} = V_{INV}$, $V_{EAO} = 3.75V$	50	70	120	$\mu\Omega$
Feedback Reference Voltage	$V_{EAO} = V_{FB}$	2.4	2.5	2.6	V
Open Loop Gain		60	75		dB
PSRR	$V_{CCZ} - 3V < V_{CC} < V_{CCZ} - 0.5V$	60	75		dB
Output Low			0.65	1	V
Output High		6.0	6.7		V
Source Current	$\Delta V_{IN} = \pm 0.5V$, $V_{OUT} = 6V$	-40	-80		μA
Sink Current	$\Delta V_{IN} = \pm 0.5V$, $V_{OUT} = 1.5V$	40	80		mA
CURRENT ERROR AMPLIFIER					
Input Voltage Range		-1.5		2	V
Transconductance	$V_{NON-INV} = V_{INV}$, $I_{EAO} = 3.75V$	130	195	310	$\mu\Omega$
Input Offset Voltage			±3	±15	mV
Open Loop Gain		60	75		dB
PSRR	$V_{CCZ} - 3V < V_{CC} < V_{CCZ} - 0.5V$	60	75		dB
Output Low			0.65	1	V
Output High		6.0	6.7		V
Source Current	$\Delta V_{IN} = \pm 0.5V$, $V_{OUT} = 6V$	-40	-80		μA
Sink Current	$\Delta V_{IN} = \pm 0.5V$, $V_{OUT} = 1.5V$	40	80		μA
OVP COMPARATOR					
Threshold Voltage		2.6	2.7	2.8	V
Hysteresis		80	120	150	mV
I_{SENSE} COMPARATOR					
Threshold Voltage		-0.8	-1.0	-1.15	V
Delay to Output			150	300	ns

ELECTRICAL CHARACTERISTICS (Continued)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
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ZV SENSE COMPARATOR

Propagation Delay	100mV Overdrive			50	ns
Threshold Voltage		7.35	7.5	7.65	V
Input Capacitance			6		pF

GAIN MODULATOR

Gain (Note 2)	$I_{IAC} = 100\text{mA}$, $V_{VRMS} = 0\text{V}$, $V_{FB} = 0\text{V}$	0.36	0.51	0.66	
	$I_{IAC} = 50\text{mA}$, $V_{VRMS} = 1.2\text{V}$, $V_{FB} = 0\text{V}$	1.20	1.72	2.24	
	$I_{IAC} = 100\mu\text{A}$, $V_{VRMS} = 1.8\text{V}$, $V_{FB} = 0\text{V}$	0.55	0.78	1.01	
	$I_{IAC} = 100\mu\text{A}$, $V_{VRMS} = 3.3\text{V}$, $V_{FB} = 0\text{V}$	0.14	0.20	0.26	
Bandwidth	$I_{IAC} = 250\mu\text{A}$		10		MHz
Output Voltage	$V_{FB} = 0\text{V}$, $V_{VRMS} = 1.15\text{V}$, $I_{IAC} = 250\mu\text{A}$	0.72	0.8	0.9	V

OSCILLATOR

Initial Accuracy	$T_A = 25^\circ\text{C}$	74	80	86	kHz
Voltage Stability	$V_{CCZ} - 3\text{V} < V_{CC} < V_{CCZ} - 0.5\text{V}$		1		%
Temperature Stability			2		%
Total Variation	Line, temperature	72		88	kHz
Ramp Valley to Peak Voltage			2.5		V
Dead Time		100	300	450	ns
C_T Discharge Current		4.5	7.5	9.5	mA

REFERENCE

Output Voltage	$T_A = 25^\circ\text{C}$, $I_{REF} = 1\text{mA}$	7.425	7.5	7.575	V
Line Regulation	$V_{CCZ} - 3\text{V} < V_{CC} < V_{CCZ} - 0.5\text{V}$		2	10	mV
Load Regulation	$1\text{mA} < I_{REF} < 20\text{mA}$		2	15	mV
Temperature Stability			0.4		%
Total Variation	Line, load, and temperature	7.395		7.605	V
Long Term Stability	$T_j = 125^\circ\text{C}$, 1000 hours		5	25	mV
Short Circuit Current	$V_{CC} < V_{CCZ} - 0.5\text{V}$, $V_{REF} = 0\text{V}$	-15	-40	-100	mA

PFC COMPARATOR

Minimum Duty Cycle	$V_{IEAO} > 6.7\text{V}$			0	%
Maximum Duty Cycle	$V_{IEAO} < 1.2\text{V}$	90	95		%

ELECTRICAL CHARACTERISTICS (Continued)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
MOSFET DRIVER OUTPUTS					
Output Low Voltage	$I_{OUT} = -20\text{mA}$		0.3	0.8	V
	$I_{OUT} = -100\text{mA}$		0.6	3.0	V
	$I_{OUT} = -10\text{mA}, V_{CC} = 8\text{V}$		0.8	1.5	V
Output High Voltage	$I_{OUT} = 20\text{mA}$	9.5	10.3		V
	$I_{OUT} = 100\text{mA}$	9	10.3		V
Output Rise/Fall Time	$C_L = 1000\text{pF}$		40		ns
UNDERVOLTAGE LOCKOUT					
Threshold Voltage		$V_{CCZ} - 0.9$	$V_{CCZ} - 0.6$	$V_{CCZ} - 0.2$	V
Hysteresis		2.5	2.8	3.2	V
SUPPLY					
Shunt Voltage (V_{CCZ})	$I_{CC} = 25\text{mA}$	12.8	13.5	14.2	V
Load Regulation	$25\text{mA} < I_{CC} < 55\text{mA}$		± 150	± 300	mV
Total Variation	Load and temperature	12.4		14.6	V
Start-up Current	$V_{CC} < 12.3\text{V}$		0.7	1.1	mA
Operating Current	$V_{CC} = V_{CCZ} - 0.5\text{V}$		22	28	mA

Note 1: Limits are guaranteed by 100% testing, sampling, or correlation with worst-case test conditions.

Note 2: $\text{Gain} = K \times 5.3 \text{ V}$; $K = (I_{GAINMOD} - I_{OFFSET}) \times I_{AC} \times (V_{EAO} - 1.5)^{-1}$.

Q1 Turn-On

The turn-on event consists of the time it takes for the current through L2 to ramp to the L1 current plus the resonant event of L2 and the ZVS capacitor. The total event should occur in a minimum of 350–450ns, but can be longer at the risk of increasing the total harmonic distortion. Setting these times equal should minimize conducted and radiated emissions.

$$t_{Q1(OFF)} = t_{IL2} + t_{RES} = 400ns \quad (1)$$

Where I_{L2} is equal to I_{L1} .

The value of L2 is calculated to remain in discontinuous-mode:

$$(2)$$

The resonant event occurs in 1/4 of a full sinusoidal cycle. For example, when a 1/4 cycle occurs in 200ns, the frequency is 1.25MHz.

$$(3)$$

Rearranging and solving for L2:

$$(4)$$

The resonant capacitor (C_{ZVS}) value is found by setting equations 2 and 4 equal to each other and solving for C_{ZVS} .

$$(5)$$

APPLICATION

Figure 3 displays a typical application circuit for a 500W ZVS PFC supply. Full design details are covered in application note 33, ML4822 Power Factor Correction With Zero Voltage Resonant Switching.

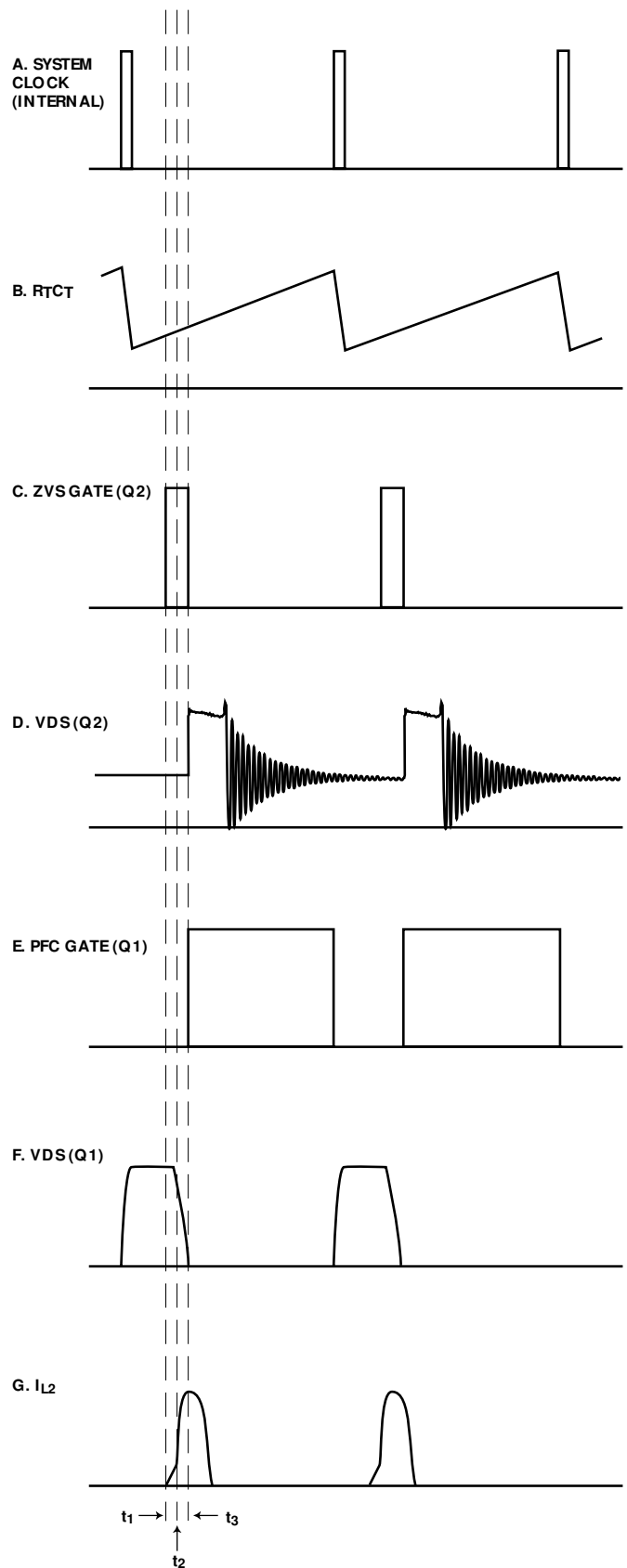


Figure 2. Timing Diagrams

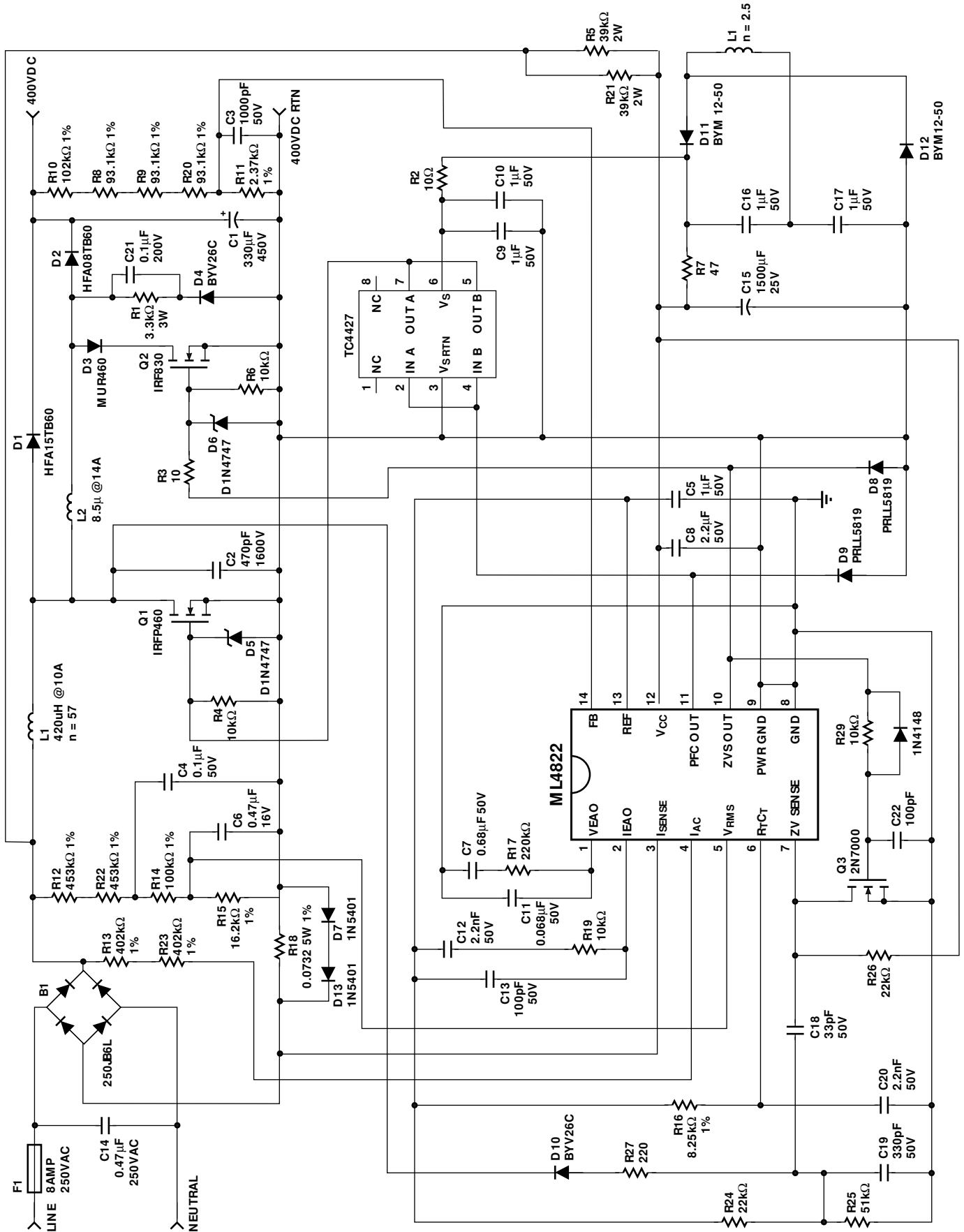
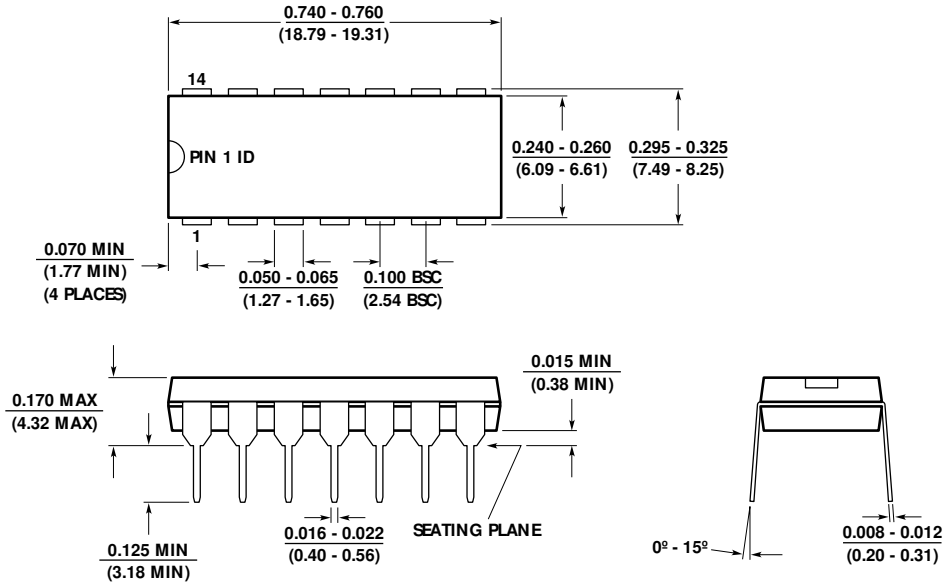


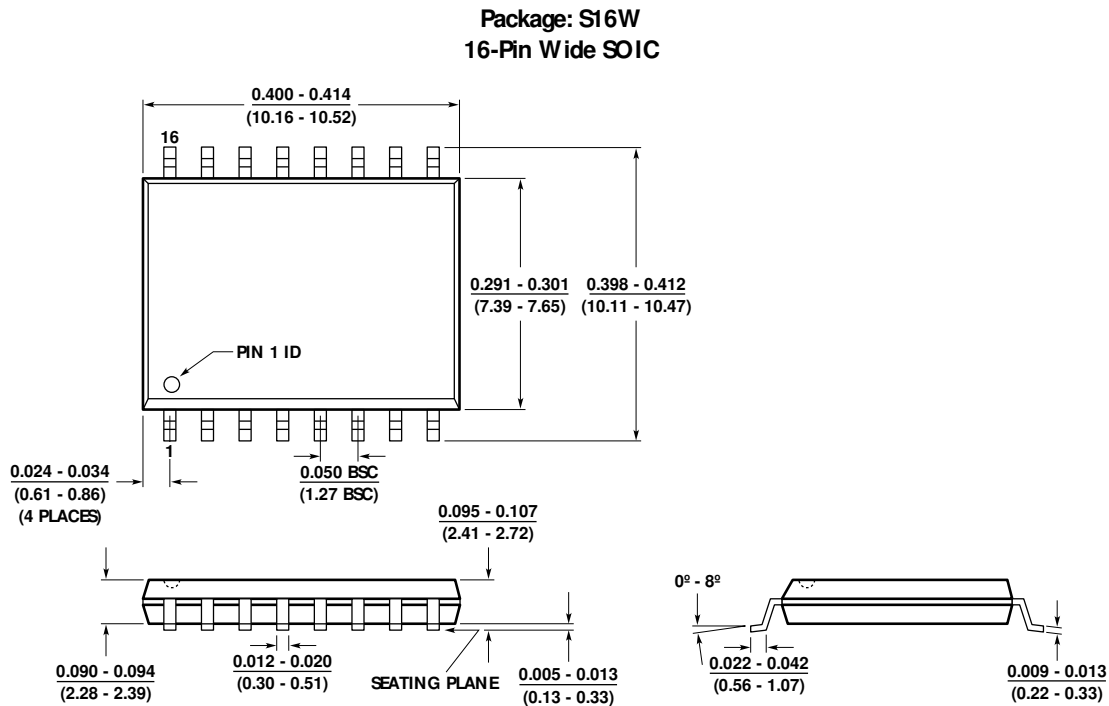
Figure 3. ML4822 Schematic

PHYSICAL DIMENSIONS inches (millimeters)

Package: P14
14-Pin PDIP



PHYSICAL DIMENSIONS inches (millimeters)



ORDERING INFORMATION

PART NUMBER	TEMPERATURE RANGE	PACKAGE
ML4822CP ML4822CS	0°C to 70°C 0°C to 70°C	14-Pin PDIP (P14) 16-Pin Wide SOIC (S16W)
ML4822IP ML4822IS	-40°C to 85°C -40°C to 85°C	14-Pin PDIP (P14) 16-Pin Wide SOIC (S16W)

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