FEB110-001 User's Guide
Zero Voltage Switched Power Factor Controller

Featured Fairchild Product: FAN4822

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Contents

1. General Board Description

The FEB110-001 Evaluation Board is a power factor corrected 500 W off-line power supply with zero voltage switching. The supply has a single 400 Volt output and operates over an input voltage range of 85 VAC to 265 VAC. The Evaluation Board uses a boost PFC with added ZVS power components controlled by the ZVS section of the FAN4822 IC. In order to examine the waveforms of the FEB110-001 Evaluation Board a DC source ranging from 120 to 375 volts may be used for the input.

The FAN4822 IC is a Zero Voltage Switched (ZVS) Power Factor Controller (PFC). It includes Fairchild's leading edge modulated average current mode PFC section, along with a ZVS comparator, Flip-Flop, and Gate Drive Output.

When operating the FEB110-001 Evaluation Board there are two things to keep in mind. A minimum load of 5 to 10 watts is required to prevent VCC from decaying to the undervoltage lockout point. This will provide continuous operation and prevent the PFC from periodic shutdown due to undervoltage lockout. Also, there is no current inrush limiting included in the Evaluation Board. Because of this it is suggested that the input voltage is always ramped up slowly.

1.1. Contents of the FEB110-001 Evaluation Kit:

- FEB110-001 Evaluation Board
- FEB110-001 Evaluation Kit Users Guide
- CD ROM containing the following
  - FEB110-001 Evaluation Kit Users Guide
  - FAN4822 Data Sheet
  - ISL9R1560P2 Data Sheet
  - ISL9R860P2 Data Sheet
  - EGP30J Data Sheet
  - EGP10J Data Sheet
  - 1N4747A Data Sheet
  - 1N5401 Data Sheet
  - MBR0520L Data Sheet
  - RGF1A Data Sheet
  - GBPC2506 Data Sheet
  - FGH30N6S2D Data Sheet
  - IRF830B
  - Application Note AN-42032 - FAN4822 Power Factor Correction With Zero Voltage Resonant Switching
  - Application Note AN-42047 – Power Factor Correction (PFC) Basics

1.2. Power Supply Specification Table

Description	Condition	Min	Typ	Max	Units
Input Voltage		85		265	V_{AC}
Output Voltage			400		V
Output Current			1.25		A
Efficiency	120 V_{AC}		93		%
THD	120 V_{AC}		6.2		%
P. F.	120 V_{AC}		0.999		

Table 1. Power Supply Specification Table

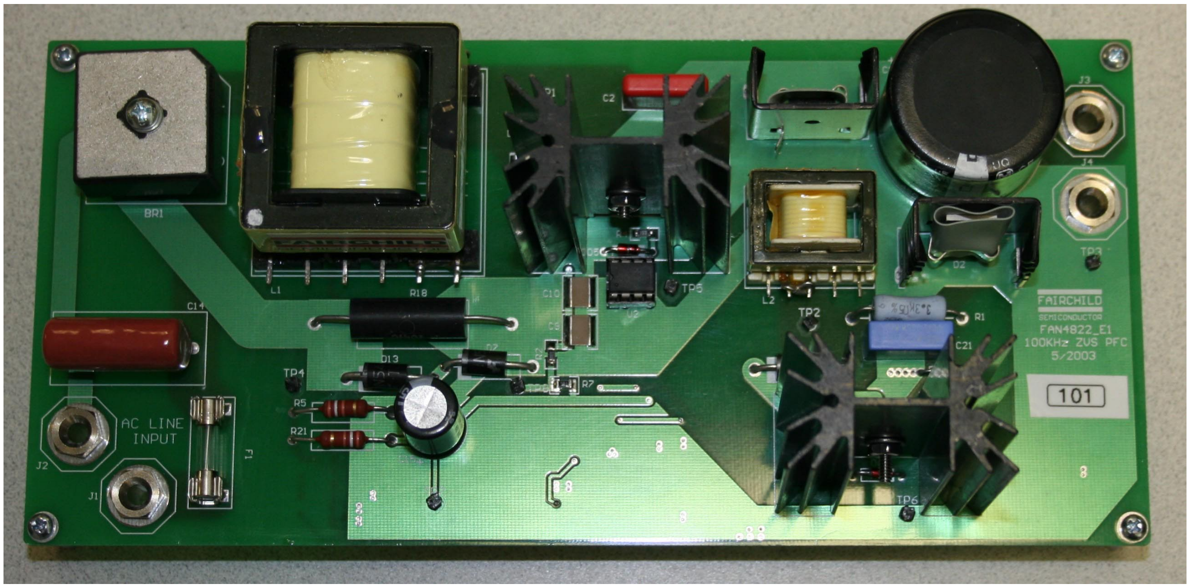
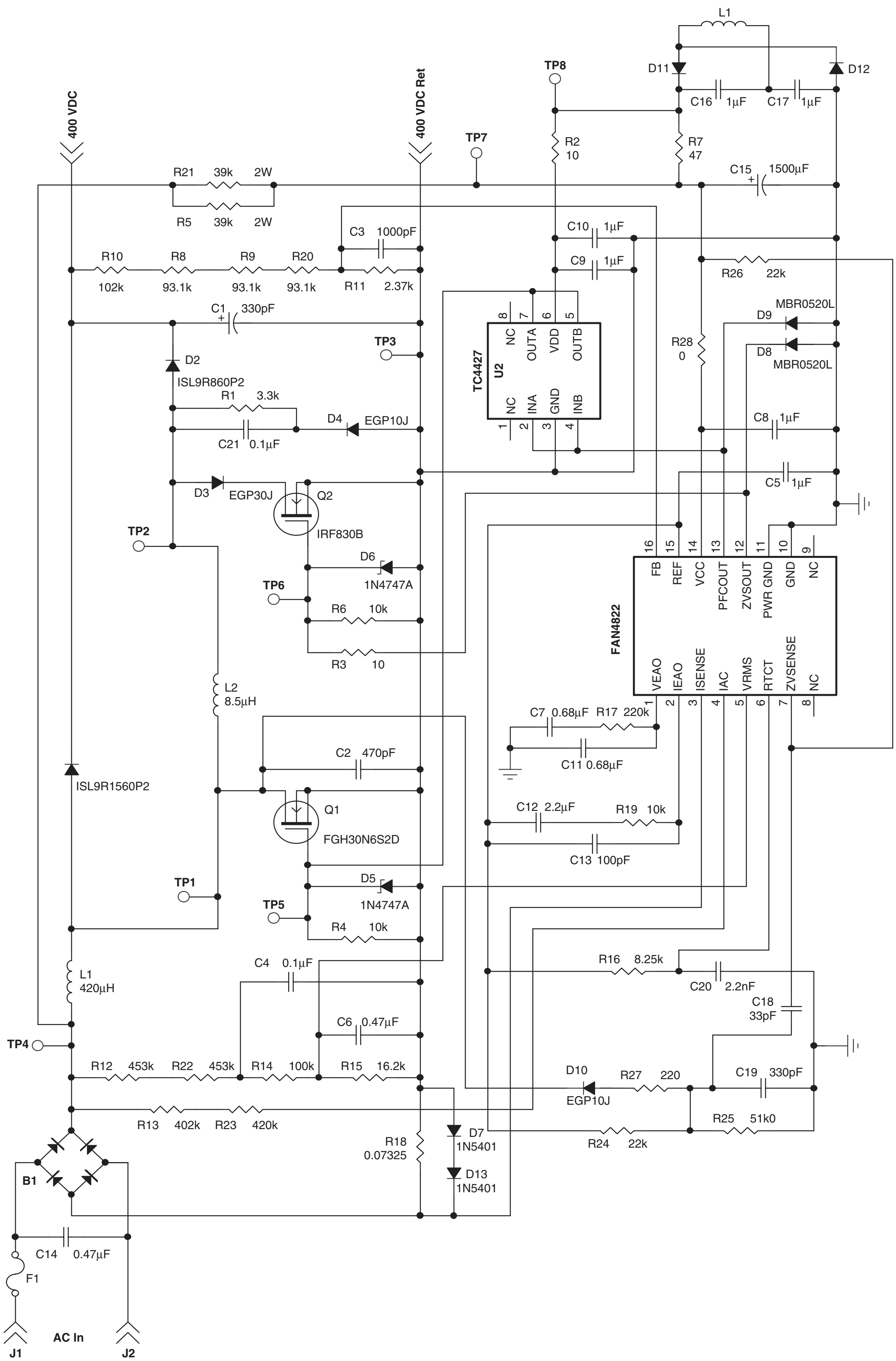


Figure 1. Photograph of FEB110-001 evaluation board

1.3 FEB110-001 Schematic



2. Test Procedure

2.1. Theory of operation

For a complete theory of operation refer to Application Note, AN42032, included in the FEB110-001 Evaluation Board CD.

CAUTION!

The FEB110-001 Evaluation Board contains voltage potentials capable of causing serious injury, and components that may shatter or explode if they fail. Appropriate precautions must be taken to prevent injury should such situations occur. The use of protective eyeware is strongly recommended.

To safely observe circuit waveforms, an isolation transformer should be used between the Evaluation Board and the AC line.

Do Not operate this board with DC/AC voltages outside the design limits.

Replace circuit components only with those recommended in the parts list of this User's Guide.

Use the following procedure to safely operate the power supply.

1. Connect a 0.25A load across the output terminals (J3 and J4). The load must be capable of dissipating 100W at 400V.
2. Connect a DC voltmeter across the output terminals.
3. Connect an isolated variable AC source (such as a variac) to input terminals J1 and J2. A DC source may be substituted at the input for easier examination of the waveforms.
4. Slowly increase the AC input voltage to at least 85VAC (Do not exceed 265VAC). If applying a DC input increase it to 120 Volts.
5. Confirm that the output voltage increases as the input voltage is increased.
6. As the input voltage approaches very close to 85VAC (120VDC) the Board output should read 404VDC within 5 sec.
7. Remove the AC input and verify that the output voltage has dropped to zero.
8. Connect a 1.1A load across the output terminals and reapply the AC input. The load must be capable of dissipating 500W at 400V.

3. Test Results

3.1 Performance Data

To measure the Eval Board performance across the range of permissible input voltages use an isolated Variac or adjustable AC source. It is suggested that the input voltage is increased slowly as the evaluation board has no inrush current limiting.

A typical FEB110-001 evaluation board will have the performance characteristics shown in Table 2 when operated as specified in the Test Conditions.

Table 2. FAN4822 Evaluation Board Test Results

	85VAC	120VAC	265VAC	Units
Efficiency	89	93	95	%
THD	6.1	6.2	7.1	%
P. F.	0.999	0.999	0.991	

Test Conditions: 500 Watt load on output at 25°C

Equipment Used: Voltech Digital Single-Phase Power Analyzer Model PM100, 362Ω 500W Resistive load.

3.2 Power Ratings

The FEB110-001 Evaluation Board is designed to provide up to 500W output with an input of 85VAC. Due to thermal limitations the actual output with no fan is limited to ≤500W at inputs below 115VAC, and up to 40°C ambient. The graph below displays the maximum power vs. line voltage with no fan. Above 115VAC input the maximum output power is 500W.

The unit will safely provide 500 W at 85 VAC input with adequate fan cooling. Note that even though the FEB110-001 Evaluation board can achieve 500 Watts with additional fan cooling, the heatsinks utilized are not optimal for use with a fan.

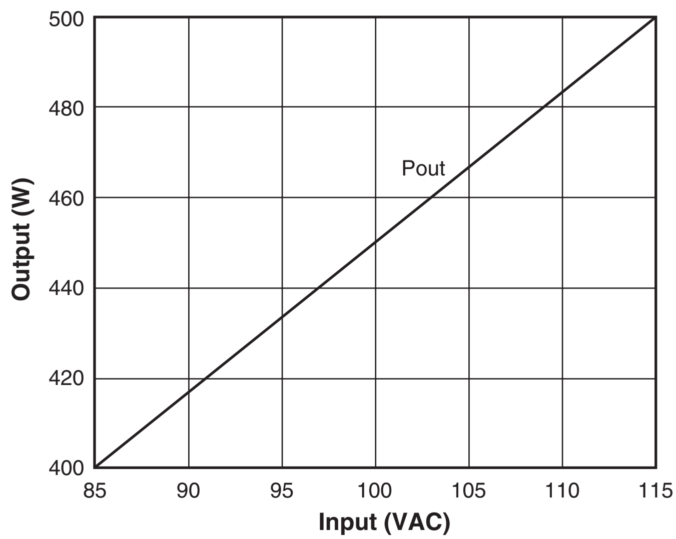


Figure 1. Output Power vs. Line Voltage

3.3 Typical Waveforms

Test pins are made available to the user. Reference Application Note AN42032 for typical waveforms.

4. FEB110-001 Evaluation Board Parts List

Item	Qty	Description	Vendor / Parts	Designation
Resistors				
1	1	3.3kΩ, 3W, 5%	Dale	R1
2	1	10Ω, _W, 5%, 1206	Dale	R2
3	1	10Ω, _W, 5%, 2010 Metal Glaze, Surface Mount	IRC	R3
4	3	10kΩ, _W, 5%, SMD 1206	Dale	R4, R6, R19
5	2	39kΩ, 2W, 5%, metal film	Dale	R5, R21
6	1	47Ω, _W, 5%, SMD 1210	Dale	R7
7	3	93.1kΩ, _W, 1%, SMD 1206	Dale	R8, R9, R20
8	1	102kΩ, _W, 1%, SMD 1206	Dale	R10
9	1	2.37kΩ, _W, 1%, SMD 1206	Dale	R11
10	2	453kΩ, _W, 1%, SMD 1206	Dale	R12, R22
11	2	402kΩ, _W, 1%, SMD 1206	Dale	R13, R23
12	1	100kΩ, _W, 1%, SMD 1206	Dale	R14
13	1	16.2kΩ, _W, 1%, SMD 1206	Dale	R15
14	1	8.25kΩ, _W, 1 %, SMD 1206	Dale	R16
15	1	220kΩ, _W, 5 %, SMD 1206	Dale	R17
16	1	0.0732Ω, 5W, 1%	IRC 4LPW Series	R18
17	2	22kΩ, _W, 5%, SMD 1206	Dale	R24, R26
18	1	51kΩ, _W, 5%, SMD 1206	Dale	R25
19	1	220Ω, _W, 5%, SMD 1206	Dale	R27
20	1	0Ω, Jumper, 1206	Dale	R28
Capacitors				
21	1	330μF, 450V, 20%, Electrolytic	Panasonic TSU-Series	C1
22	1	470pF, 1600V, 20%, Polypropylene	Wima FKP1	C2
23	1	1000pF, 50V, 20%, X7R Ceramic 1206	Murata / GRM42-6X7R102K050AB	C3
24	1	0.1μF, 50V, 10%, X7R Ceramic 1206	Murata / GRM42-6X7R104K050AB	C4
25	6	1μF, 50V, 20%, X7R Ceramic 1825	Murata / GRM43-4X7R105K050AB	C5, C8, C9, C10, C16, C17
26	1	0.47μF, 16V, 10% X7R Ceramic 1206	Murata / GRM42-6X7R474K016AB	C6
27	1	0.68μF, 50V, 10%, X7R Ceramic 1825	Murata / GRM43-4X7R684K050AB	C7
28	1	0.068μF, 50V, 10%, X7R Ceramic 1206	Murata / GRM42-6X7R683K050AB	C11
29	2	2.2nF, 50V, 10 %, X7R Ceramic 1206	Murata / GRM42-6X7R222K050AB	C12, C20
30	1	100pF, 50V, 5%, C0G Ceramic 1206	Murata / GRM42-6COG101K050AB	C13
31	1	0.47μF, 250 VAC, 20% Metallized Polyester	Wima MKS4-R	C14
32	1	1500μF, 25V, Electrolytic	Panasonic / ECA-1EFQ152L	C15
33	1	33pF, 50V, 5%, C0G Ceramic 1206	Murata / GRM42-6COG330K050AB	C18
34	1	330pF, 50V, 5%, C0G Ceramic 1206	Murata / GRM42-6COG331K050AB	C19
35	1	0.1μF, 250V, 20%, MKP10	Wima	C21
Diodes				
36	1	600V, 15A Stealth Diode	Fairchild ISL9R1560P2	D1
37	1	600V, 8A Stealth Diode	Fairchild ISL9R860P2	D2

4. FEB110-001 Evaluation Board Parts List (Continued)

Item	Qty	Description	Vendor / Parts	Designation
38	1	600V, 3A Fast Rectifier Diode	Fairchild EGP30J	D3
39	2	600V, 1A Fast Rectifier Diode	Fairchild EGP10J	D4, D10
40	2	20V 1W Zener Diode	Fairchild 1N4747A	D5, D6
41	2	100V, 3A Rectifier Diode	Fairchild 1N5401	D7, D13
42	2	20V, 500mA Schottky Rectifier	Fairchild MBR0520L	D8, D9
43	2	50V, 1A Fast Recovery Diode	Fairchild RGF1A	D11, D12
44	1	600V, 25A Bridge Rectifier	Fairchild GBPC2506	B1
Transistors				
45	1	600V, 45A N-Channel IGBT	Fairchild FGH30N6S2D	Q1
46	1	500V, 4.5A N-Channel MOSFET	Fairchild IRF830B	Q2
ICs				
47	1	FAN4822IM ZVS Power Factor Cont.	Fairchild Semiconductor	U1
48	1	TC4427CPA	TelCom	U2
Magnetics				
49	1	420µH, 10A	Premier Magnetics Inc. / TSD-902 Pulse / P0316	L1
50	1	8.5µH, 14A	Premier Magnetics Inc. / TSD-903 Pulse / P0317	L2
Fuse				
51	1	8 Amp 250 VAC Fast Acting	Little Fuse / Series 217	F1
Hardware				
52	2	5x20 Fuse Clips	Little Fuse	
53	2	TO220 Heatsinks	Aavid / 534265BO3453	(Ref. D1, D2)
54	2	TO220/TO218 Heatsink	Thermalloy / 6300B	(Ref. Q1, Q2)
55	2	TO220 Insulator, Sarcon Tube	Fujipoly / 30T-11-1000L	(Ref. D1, D2)
56	1	TO218 Insulator	Fujipoly / 30T-TO-3PF Bergquist / K10-104	(Ref. Q1)
57	4	Standard Banana Plug	Johnson Comp. / 108-0740-001	J1, J2, J3, J4
58	2	6-32 1/2" Phillips Machine Screw		(Ref. Q1, Q2)
59	1	6-32 1" Phillips Machine Screw		
60	3	6-32 Lock Washer		(Ref. Q1, Q2)
61	3	6-32 Hex Nut		(Ref. Q1, Q2)
62	5	4-40 5/16" Phillips Machine Screw		
63	5	4-40 Lock Washer		
64	5	4-40 0.875" Hex threaded spacers	Johnson Components Digi-Key / J176-ND	
65		Silicon Grease	Chemtronics / CT40-5	(Ref. Q2)
66	1	Unthreaded round aluminum or nylon Spacer, 1/4" OD, 0.140" ID, 1/4"Length	Johnson Components Digi-Key / J169-ND	
67	1	Blank Evaluation Board		
68	8	Thru-Hole Test Pins, 3M Series 2400	Digi-Key / 929834-02-36-ND	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8

5. Printed Circuit Board

5.1 PCB Layout

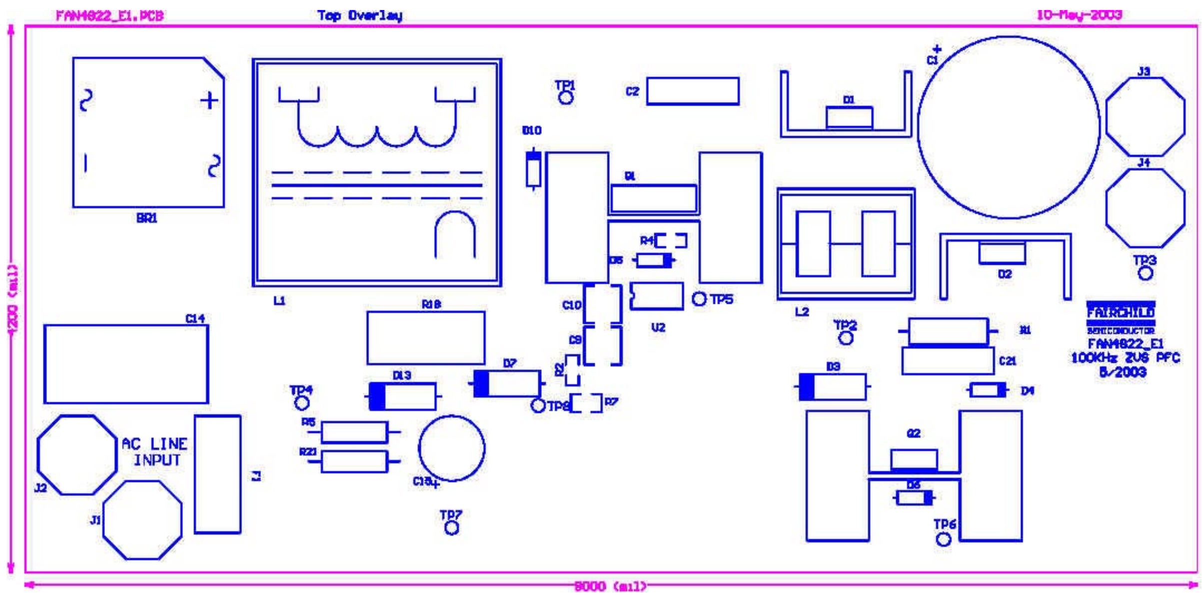


Figure 2. Top Silkscreen

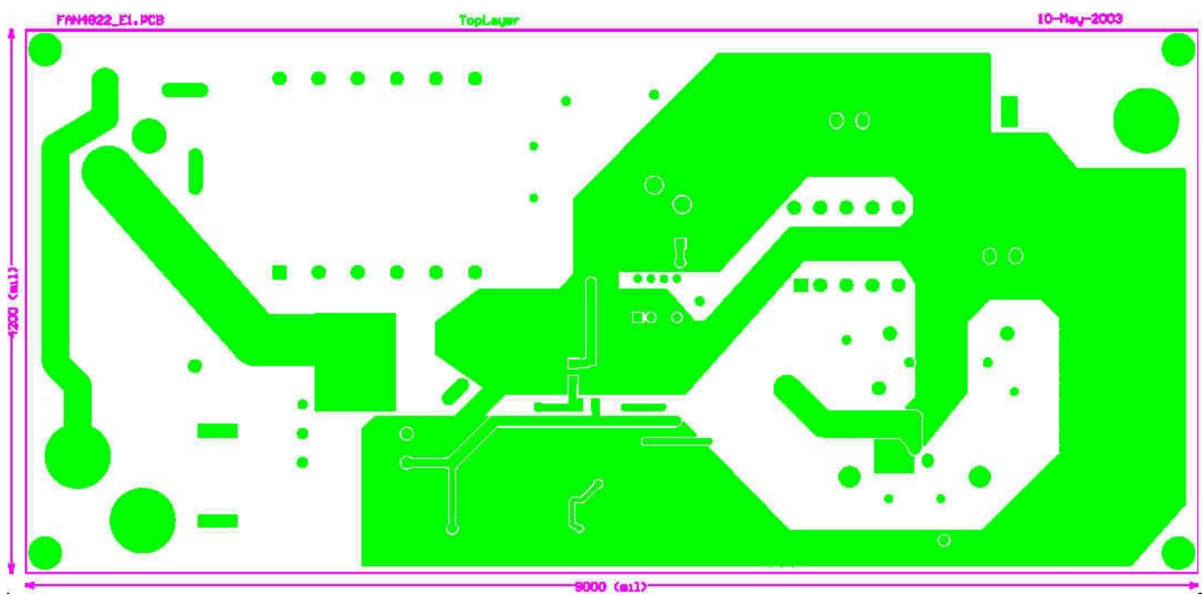


Figure 3. Top Layer

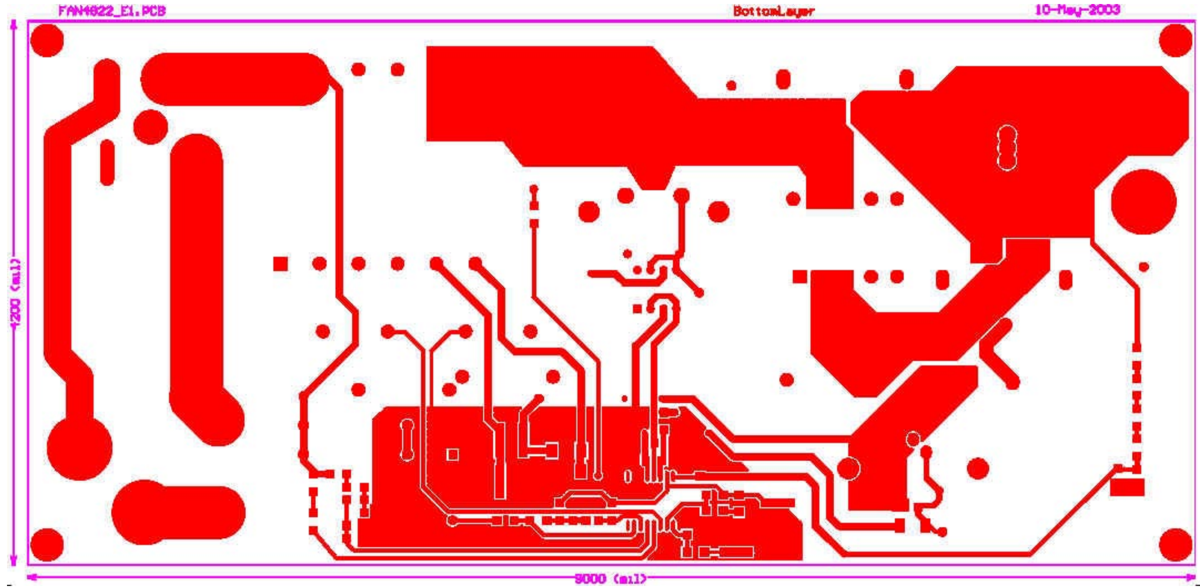


Figure 4. Bottom Layer

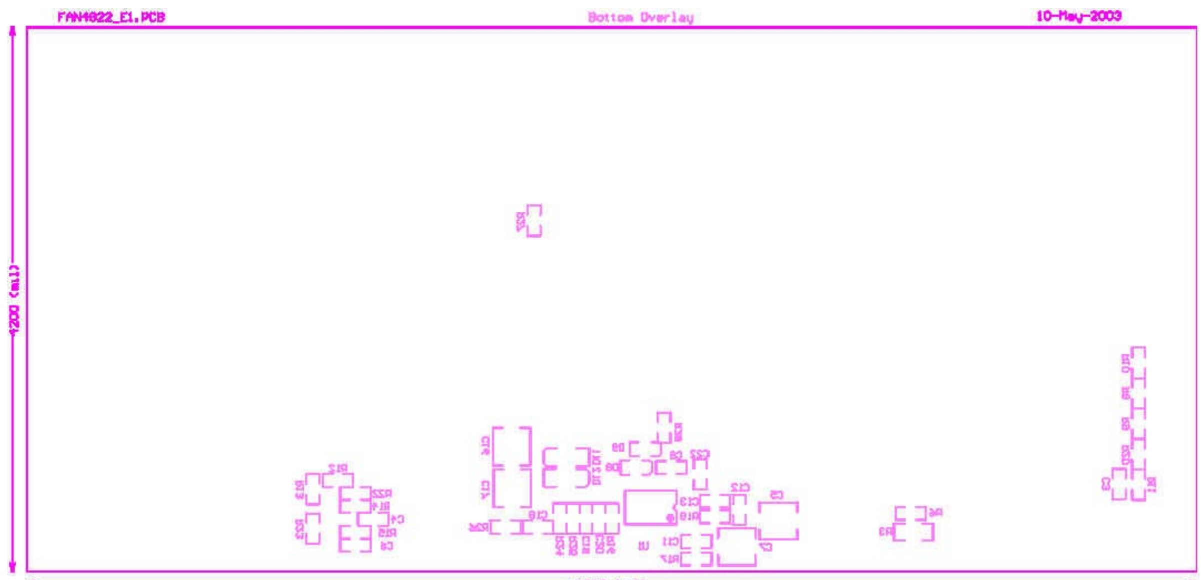


Figure 5. Bottom Silkscreen

5.2. Layout Considerations

The FEB110-001 Evaluation board contains high impedance, low-level signals and low impedance, high level circuits; consequently extra care is required in component placement, grounding and PC trace routing. In order to shield low-level circuits from the high level signals, control circuits were placed in surface mount form on the bottom side of the board. This allowed a return shield to be placed on the top-side. Since the current sense for the FAN4822 is not differential, care must be taken to prevent a large di/dt from occurring across the PCB trace joining the output cap (assumed to be the reference return for the IC) to the current sense resistor. Since the best reference for the IC is at the output cap return potential (the most stable potential), the difference between this potential and the current sense resistor return potential must be kept to a minimum. This is done by star-grounding all the 400V return connections to the output capacitor, and/or maintaining very low inductive/resistive paths from all power devices to the output capacitor return.

Some general layout guidelines:

A. Return the low side of the timing capacitor (CT) directly to the IC ground pin.

B. Bypass the reference and supply voltage pins directly to the IC ground pin with a 1 µF, low ESR/ESL capacitor.

C. Return all compensation components directly to the IC ground pin, keeping the lead lengths as short as possible.

D. Make sure that low-level, noise free, returns do not share return paths with high-level, or noisy, signals (*e.g.*, gate drive).

E. Isolate and/or shield rapidly changing waveforms, such as the drains of Q1 and Q2, from sensitive, high impedance circuits, such as the timing capacitor, PFC current sense input, error amplifier input/output, *etc*.

6. Featured Products

6.1 FAN4822 Description

The FAN4822 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, over- voltage 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.

6.1.1 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 1.3% reference

7. Resources/References

7.1 Application Notes

Application Note AN-42032	FAN4822 Power Factor Correction With Zero Voltage Resonant Switching
Application Note AN-42047	Power Factor Correction (PFC) Basics

WARNING AND DISCLAIMER

This Evaluation Board may employ high voltages so appropriate safety precautions should be used when operating this board. Replace components on the Evaluation Board only with those parts shown on the parts list in the User's Guide. Contact an authorized Fairchild representative with any questions. The Evaluation board is for demonstration purposes only and neither the Board nor this User's Guide constitute a sales contract or create any kind of warranty, whether express of implied, as to the applications or products involved. Fairchild warranties that its products will meet Fairchild's published specifications but does not guarantee that its products will work in any specific application. Fairchild reserves the right to makes changes without notice to any products described herein to improve reliability, function, or design. Either the applicable sales contract signed by Fairchild and Buyer, or if no contract exists Fairchild's Stand Terms and Conditions on

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