ML4824EVAL

Evaluation Kit User's Guide

Power Factor and PWM Combo

General Description

The ML4824 Evaluation Board is a power factor corrected, 100 Watt, off-line switching power supply with a single output of +12 VDC. The supply operates over the universal input range of 85 VAC to 265 VAC.

The ML4824 is a combination ('Combo') power supply controller IC which consists of a PFC input stage and a PWM output stage. The PFC "front end" is of the average-current, continuous-conduction type. The PWM section allows the construction of either a current- or voltage-mode regulator as the power supply's "back end." The Evaluation Board uses a two-switch, current-mode forward converter following the power factor corrector to produce its 12V output. Both stages operate at 100 kHz, using Fairchild's patented leading/trailing edge modulation technique.

Evaluation Kit Contents:

The evaluation kit contains the following items:

1. ML4824EVAL User's Guide.
2. ML4824 Data Sheet.
3. Application Notes 16, 33, and 34.
4. Fully Functional ML4824 Evaluation Board.
5. The 3.5" MS-DOS diskette containing: Gerber files for the ML4824 Evaluation Board.

Theory of Operation

For a complete theory of operation refer to Application Notes 33 and 34, included in this ML4824 Evaluation Board documentation package.

In a departure from the example given in Application Note 33, the voltage loop bandwidth of the PFC "front end" has been set to approximately 15 Hz. This allows the use of a smaller boost capacitor (C5) while maintaining good values for power factor and harmonic distortion at low line frequencies (*e.g.*, 47 Hz).

Test Driving the ML4824 Evaluation Board:

The following steps will demonstrate the functionality of the ML4824 Evaluation Board, and allow the measurement of its Power Factor (P.F.) and Total Harmonic Distortion (T.H.D.) under various conditions of AC input voltage and DC output loading:

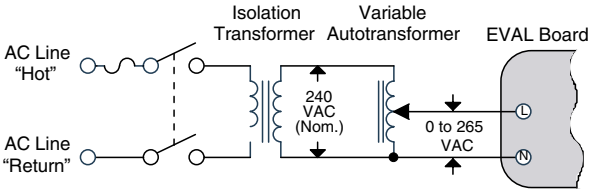

Figure 1.

1. Connect a variable autotransformer (such as a Variac) to the output of an isolation transformer, and to the input of the ML4824EVAL Board. Both transformers should be rated for 500 VA or greater, and in combination should be rated for an output voltage range of 0 VAC to approximately 265 VAC. The connections should be made as in Figure 1, with the Isolation Transformer NOT plugged into the AC line until step 5.
2. Ensure that the variable autotransformer is set to "zero output."
3. Connect an AC Voltmeter across the Evaluation Board's AC Input terminals. Set the meter range to 300 VAC or greater.
4. Connect a DC Voltmeter between the Evaluation Board's DC output terminals (+12V Out and +12V Return). Set the meter range to 15 VDC or greater.

Caution

The ML4824 Evaluation Board employs high voltages, capable of causing injury or death. Some components on the Board store these voltages after power to the Board is disconnected. The ML4824 Evaluation Board necessarily uses components which can shatter or explode if they should fail. Use appropriate high-voltage precautions when operating this board. Protective eye wear is strongly recommended. To safely observe circuit wave forms, an isolation transformer must be inserted between the AC line and the Evaluation Board. DO NOT operate the Board with input voltages outside of the design limits (of 85 VAC to 265 VAC). Replace components on the Evaluation Board ONLY with those shown in the parts list in this User's Guide.

5. Connect the input of the isolation transformer to the AC power line.

6. Slowly increase the AC input voltage to at least 85 VAC (**DO NOT exceed 265 VAC).**

7. The unloaded output voltage of the ML4824 Evaluation Board should be between 11.4V and 12.6V (12V ±5%).

8. Connect an 8.33 amp load across the Evaluation Board's +12 VDC output terminals. The fully-loaded (100W) output should remain between 11.4V and 12.6V while the line voltage is varied over the range of 85 VAC to 265 VAC.

9. With V_{IN} = 120 VAC, increase the current loading on the output until the foldback current limit circuit trips. This should occur at a load current of approximately 10.5 Amperes.

10. Turn the input voltage down to zero volts. Remove the load on the output. Bring the input voltage back to 120 VAC. Verify that the overcurrent condition has been cleared, and that the output of the ML4824 Evaluation Board is again at +12 VDC – 5% for any load between 0 Amperes and 8.33 Amperes DC.

11. Disconnect the isolation transformer from the power line. Wait at least three (3) minutes for high voltages stored on the board to bleed down.

12. Connect an AC Power Analyzer (a Power Factor Meter) between the output of the variable autotransformer and the AC input to the Evaluation Board, in accordance with the manufacturer's instructions. **Follow these instructions carefully!** Failure to do so can result in erroneous readings, equipment damage, or personal injury. (Note: Different AC Power Analyzers/Power Factor Meters may give different results on the same PFC board. We have had good results with the DSP-based Voltech series of AC Power Analyzers, including the Model PM1000).

13. Connect the isolation transformer to the power line. Slowly raise the voltage at the output of the variable autotransformer until the input to the Evaluation Board is between 85 VAC and 265 VAC.

Operation of the ML4824 Evaluation Board may now be evaluated over the full input voltage range. If a variable load is used, operation may also be tested over the full output current range (0 ADC ≤ I_{LOAD} ≤ 8.33 ADC).

Performance Data

A typical ML4824 Evaluation Board will have the following performance characteristics:

	85 VAC	120 VAC	265 VAC	Units
V_{OUT}	12.09	12.09	12.09	VDC
$I_{LIMIT\ AT}$	10.32	10.50	9.92	ADC
Efficiency	79.3	81.4	82.2	%
T.H.D.	6.0	8.5	9.5	% I_{AC}
P. F.	0.997	0.996	0.982	

Test Conditions: I_{LOAD} = 8.33 ADC
T_A = 25°C

Equipment: Voltech PM1000 AC Power Analyzer
Kikusui PLZ152WA Electronic Load
Fluke Model 8050A DMM

Typical Waveforms

The 4824 Evaluation Board functions as a continuous-current, average-mode (CCAM) PFC followed by a synchronized PWM (DC/DC converter) stage. This is augmented by the leading/trailing edge modulation used in the ML4824. For more information on CCAM power factor correction and its resulting waveforms, please refer to Application Note #16 (while Application Note #16 specifically covers the ML4821 PFC IC, the ML4821 and the PFC stage of the ML4824 are very similar in concept and performance).

Layout Considerations

The ML4824 Evaluation Board contains high impedance, low level circuits and low impedance, high level circuits. This mandates careful attention to component placement, grounding and PC trace routing. The ML4824 Evaluation Board makes use of two ground planes (one for the PFC/PWM stages, and one for the 12V output stage. This, combined with judicious component layout, achieves stable, noise-free operation. When laying out PC boards for off-line power supplies various precautions must be observed. The following list enumerates some of the most important items to keep in mind when laying out boards using the ML4824:

1. Return the low side of the timing capacitor (C18) directly to the IC ground pin.

2. Bypass the reference and supply voltage pins directly to the IC ground pin with a 0.01 μF or greater, low ESR (e.g., ceramic) capacitor.

3. Make a direct, low resistance connection from the IC ground to the PFC current sense resistor (R1).

4. Return all appropriate compensation components directly to the IC ground pin. Keep compensation component lead lengths as short as possible.

5. Use a ground plane (if permissible) for all ground connection points.Whether using a ground plane or a single point ground layout, use heavy traces from the sense resistor and the source of Q1.

6. Separate low impedance switching nodes, such as Q1's drain, from sensitive, high impedance circuits, such as the timing capacitor, error amplifier input/output, etc.

7. **Much of the power circuitry on this board uses voltages as high as 265 VAC and 380 VDC.** Use proper PC board trace spacing, augmented as necessary by non-conductive coatings (e.g., solder mask).

The ML4824EVAL Evaluation Board is designed for evaluation purposes only. Therefore, it does not incorporate EMI or RFI filtering or shielding. The attention required by these matters will be determined by individual end user applications.

ML4824 Evaluation Kit (Rev. A) Parts List

Qty	Ref	Description	Mfr.	Part Number
Resistors				
2	R1A, 1B	499 kΩ, 1/4W, 1%, Metal Film	Any	
2	R2A, 2B	453 kΩ, 1/4W, 1%, Metal Film	Any	
1	R3	75.0 kΩ, 1%, surface mount, 1206	Any	
1	R4	13.0 kΩ, 1%, surface mount, 1206	Any	
4	R5A, 5B, 5C, 5D	1.2 Ω, 1/4W, 5%, Carbon Composition, Metal Film, or Carbon Film	Any	
1	R6	41.2 kΩ, 1%, surface mount, 1206	Any	
2	R7A, 7B	178 kΩ, 1/4W, 1%, Metal Film	Any	
1	R8	2.37 kΩ, 1%, surface mount, 1206	Any	
1	R9	1 kΩ, 5%, surface mount, 1206 (optional, foldback current limit)	Any	
1	R10	6.2 kΩ, 5%, surface mount, 1206	Any	
1	R11	750 kΩ, 5%, surface mount, 1206	Any	
1	R12	27 kΩ, 5%, surface mount, 1206	Any	
2	R13, 16	10 kΩ, 5%, surface mount, 1206 (optional, foldback current limit)	Any	
2	R14, 17	33 Ω, 5%, surface mount, 1206	Any	
1	R15	3 Ω, 5%, surface mount, 1206	Any	
1	R18	220 Ω, 1W, 10%, Carbon Composition, Metal Film, or Carbon Film	Any	
1	R19	220 Ω, 5%, surface mount, 1206	Any	
2	R20A, 20B	2.2 Ω, 1/4W, 5%, Carbon Film or Carbon Composition	Any	
1	R21	22 Ω, 5%, surface mount, 1206	Any	
1	R22	8.66 kΩ, 1%, surface mount, 1206	Any	
1	R23	1.5 kΩ, 5%, surface mount, 1206	Any	
1	R24	1.21 kΩ, 1%, surface mount, 1206	Any	
1	R25	2.26 kΩ, 1%, surface mount, 1206	Any	
1	R26	10 kΩ, 5%, surface mount, 1206	Any	
1	R27	22 kΩ, 2W, 10%, Carbon Film or Carbon Composition	Any	
1	R28	240 Ω, 1/2W, 5%, Carbon Film or Carbon Composition	Any	
1	R30	4.7 kΩ, 5%, surface mount, 1206	Any	

ML4824 Evaluation Kit (Rev. A) Parts List (continued)

Qty	Ref	Description	Mfr.	Part Number
Capacitors				
1	C1	0.68µF, 275VAC “X-2” Rated Capacitor	Wima Roderstein	MP3-X2/0.68/275/20 F1772-468-3000
1	C2	0.47 µF, 25V, surface mount, 1206 [Z5U type]	Any	
4	C3, 13, 23, 25	0.1 µF, 50V, surface mount, 1206 [Z5U type]	Any	
1	C4	.01 µF, 1000V, ceramic disc (radial through-hole, 0.4” spacing)	Any	
1	C5	100 µF, 400V, electrolytic	Panasonic Nichicon	ECO-S2GA101BA LGQ2G151MHSA
2	C6, C31	1000 pF, 25V, surface mount, 1206 [X7R type]	Any	
1	C7	220 pF, 25V, surface mount, 1206 [X7R type]	Any	
1	C8	82 nF, 25V, surface mount , 1206 [X7R type]	Any	
1	C9	8.2 nF, 25V, surface mount, 1206 [X7R type]	Any	
1	C10	15 µF, 10V, tantalum, surface mount, “C” Case (optional, foldback current limit)	AVX “TAJ” (or equivalent)	TAJC156M010 (or equivalent)
2	C11,15	.01 µF, 25V, surface mount, 1206 [Z5U type]	Any	
1	C12	10 µF, 35V, electrolytic	Panasonic	ECE-A1VU100
5	C14,16, 19,20, 24	1 µF, 25V, surface mount, 1206 [Z5U type]	Any	
1	C17	220 pF, 25V, surface mount, 1206 [X7R type]	Any	
1	C18	470 pF, 25V, surface mount, 1206 [NPO type]	Any	
1	C21	1800 µF, 25V, electrolytic	Panasonic Nichicon	ECA-1EFQ182L (ECA-1EFQ182 is OK) UPL1E182MRH
1	C22	4.7 µF, 25V, tantalum, surface mount, “C” Case	AVX “TAJ” (or equivalent)	TAJC475M025 (or equivalent)
1	C30	330 µF, 25V, electrolytic	Panasonic	ECA-1EFQ331
Diodes				
1	BR1	4A, 600V bridge rectifier	Fairchild	KBL06
1	D1	8A, 600V fast recovery epitaxial diode (FRED)	Fairchild	15L9R460P2
1	D2	3A, 600V rectifier diode (not stuffed)	Fairchild	1N5406
3	D3, 5, 6	600V fast recovery rectifier (250 nS)	Fairchild	RGF1J
1	D4	Zener diode, 5.1 V, 0.35W (optional, foldback current limit)	Fairchild	MMBZ5231B
1	D7	Zener diode, 15 V, 0.35W	Fairchild	MMBZ5245B
3	D8, 9, 10	1A, 40V Schottky rectifier	Fairchild	MBRS140
1	D11	Dual Schottky rectifier, 30A, 45V	Fairchild	MBR2545CT
ICs				
1	U1	PFC/PWM Power Supply Control IC	Fairchild	ML4824CP-1
1	U2	Optoisolator	Fairchild	MOC8112
1	U3	Precision Shunt Regulator	Fairchild	TL431

ML4824 Evaluation Kit (Rev. A) Parts List (continued)

Qty	Ref	Description	Mfr.	Part Number
Transistors				
1	Q1	Power MOSFET	Fairchild	IRF840
2	Q2,3	Power MOSFET	Fairchild	IRF830
1	Q4	Small-signal NPN Transistor (optional, foldback current limit)	Fairchild	MMBT3904
Magnetics				
1	T1	Gate Drive Transformer, PWM output stage (1:1 turns ratio, 675 µH nominal)	Premier Magnetics	TSD-736
1	T2	Switching Transformer, PWM output stage	Premier Magnetics	TSD-735
1	L1	Inductor, PFC Boost Stage, 3.1mH nominal	Premier Magnetics	TSD-734
1	L2	Inductor, Output Filter, 50 µH Nominal	Hurricane Electronics Lab Premier Magnetics	HL-8786 VPT-05007
Connectors				
1	J1	2 Screw terminal strip	Augat/RDI	LC6-P107-02
	J2, j3	1/4” Jack/with nut	E.F. Johnson	108-0740-001
14	Test Points	0.025” Square contact post	3M, etc.	
3	PJ1, 2, 3	Oscilloscope Probe Tip Jack and Grounding Collar	Tektronix, etc.	131-4353-00 or equiv.
1	U1 (ref.)	16 Pin I.C. socket	AMP, etc.	2-641600-5 or equiv.
1	U2 (ref.)	8 Pin I.C. socket	AMP, etc.	2-640463-4 or equiv.
2	F1 (ref.)	Fuse Clips, PC Mount, for 5 x 20 mm fuse	Littelfuse, etc.	111501 or equiv.
Hardware				
1	Q1 (ref.)	Single TO-220 heatsink	Thermalloy	6399B
2	D11 (ref.)	Single TO-220 heatsink	Thermalloy	6398B
3	D1,Q2, Q3 (ref.)	Single TO-220 heatsink	Thermalloy	6022PB
5	D1,D11 Q1,Q2, Q3 (ref.)	Thermal Insulator for TO-220 Package	Thermalloy	53-77-2
5	D1,D11 Q1,Q2, Q3 (ref.)	Insulating Shoulder Washer for TO-220 Package	Thermalloy	7721-7PPS
4		6-32, 1/4” X 3/4” Standoff for EVAL P.C Board	Waldom, etc.	
4		6-32 X 1/4” Screw and lock washer (for standoffs)		
1		ML4824EVAL P.C. Board	Fairchild	Rev. B
Fuse				
1	F1	3.15 A, 250 VAC, Slow-Blow, 5 x 20 mm	Wickmann Littlefuse	19195 Series 218 Series

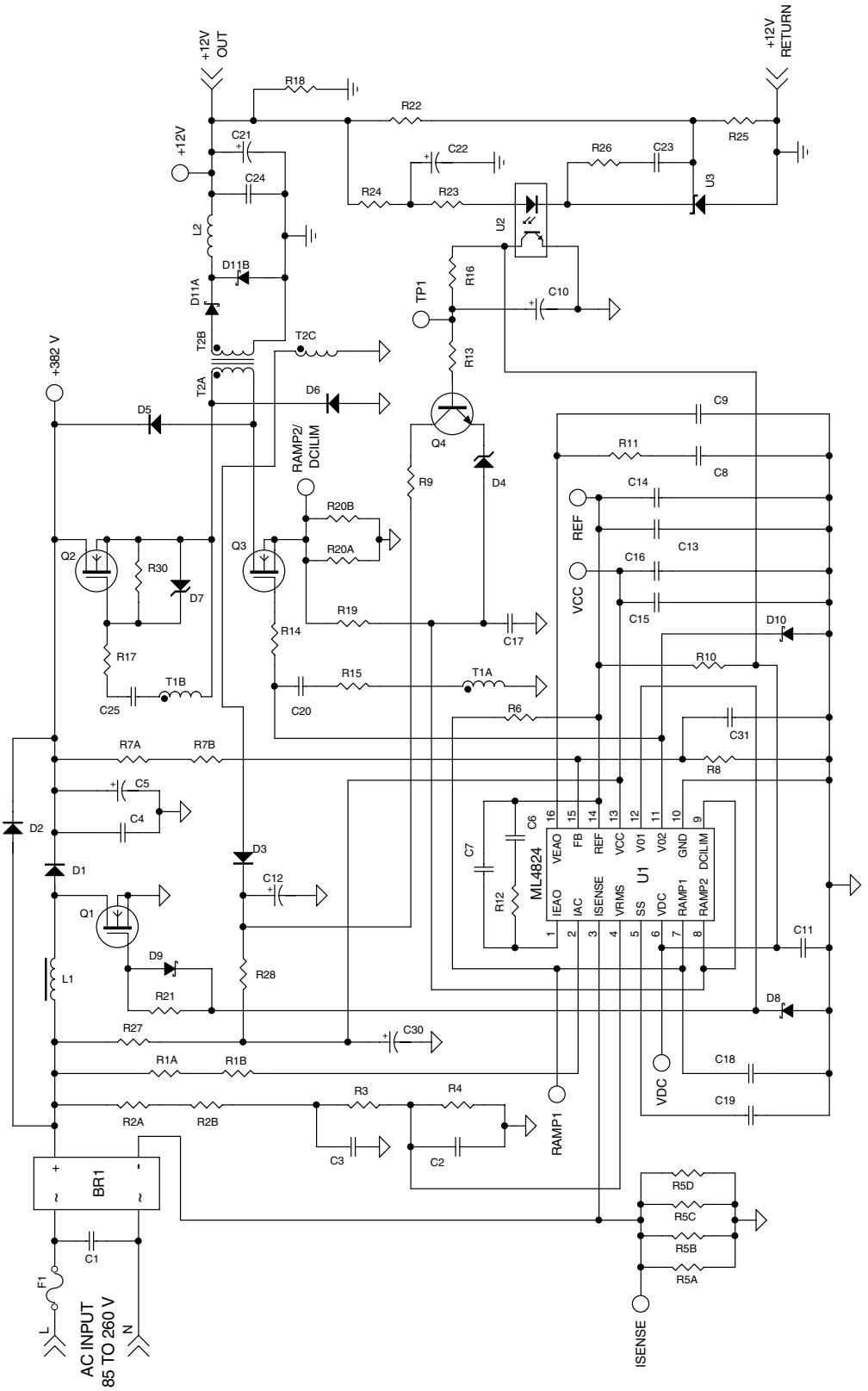

Figure 2. Schematic

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