

User Guide for FEBFAN9673Q_B1H5000A Evaluation Board

5 kW Three-Channel CCM PFC with 12 V_{sв} Module Evaluation Board

Featured Fairchild Product: FAN9673Q

Direct questions or comments about this evaluation board to: "Worldwide Direct Support"

Fairchild Semiconductor.com

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This user guide supports the 5000 W evaluation board for a three-channel CCM PFC using the FAN9673. It should be used in conjunction with the FAN9673 datasheet as well as Fairchild's application notes and technical support team. Please visit Fairchild's website at www.fairchildsemi.com/.

1. Introduction

The FAN9673 is a 32-pin, Continuous Conduction Mode (CCM) Power Factor Correction (PFC) controller IC intended for PFC pre-regulators. The FAN9673 includes average current and boost-type power factor correction, which results in a power supply that fully complies with the IEC1000-3-2 specification. A TriFault Detect[™] function helps reduce external components and provides full protection for feedback loops, such as over voltage. An over-voltage comparator shuts down the PFC stage in the event of a sudden load decrease. The RDY signal can be used for power-on sequence control. The Channel Management (CM) function can enable / disable the each channel independently. The FAN9673 also includes PFC soft-start, peak current limiting, and input voltage brown-in/out protection.

1.1. Features

- Continuous Conduction Mode Control
- . Maximum Three-Channel PFC Control
- . Average Current Mode Control
- . PFC Slave Channels External Signal / Channel Management Function Control
- Programmable Operation Frequency Range: 18 kHz~40 kHz or 55 kHz~75 kHz
- . Programmable PFC Output Voltage
- Two Types of Current Limit
- TriFault Detect[™] Protects Against Feedback Loop Failure •
- . SAG Protection
- Programmable Soft Start
- Under-Voltage Lockout (UVLO) .
- **Differential Current Sensing**
- Available in 32-Pin LQFP Package

2. Evaluation Board Specifications

All data for this table was measured at an ambient temperature of 25°C.

Table 1.	Summary of I	Features and	Perform	ance

Description	Symbol	Value	Comments
Output Power	Po	5 kW	
Efficiency	Eff, η	>95%	
Input Voltage	V _{AC}	180~264 V	
Input Frequency		47~63 Hz	
Output Voltage	V _{OUT} , V _{PFC}	393 V	V _{PVO} =0 V
Brown In / Out Voltage	V _{AC}	170 V / 155 V	
PFC Frequency	f _{SW}	40 kHz	
PFC RDY	V _{RDY}	2.4 V / 1.55 V (96% / 62% of V _{PFC})	



3. Photograph



Figure 1. Top View of Evaluation Board



4. Printed Circuit Board



Figure 2. Top Side of Evaluation Board



Figure 3. Bottom Side of Evaluation Board





Figure 4. Top Side of Daughter Card



Figure 5. Bottom Side of Daughter Card











FAIRCHILD



6. Bill of Materials

Main Board (PLM281 REV.2)								
Reference	Qty.	Part Number	Value	Description	Manufacturer			
BD1, BD2, BD3	3	GBPC5006						
PLM0276AV0 x3	3			Transfer Card for Bridge				
C1, C2, C5	3		1 µF / 275 V					
C10	1		1 µF / 450 V					
C12, C13, C14	3		680 µF / 450 V					
C16	1		47 nF / 50 V					
C18	1		1 nF / 1 kV					
C19	1		0.1 µF					
C20	1		4.7 μF / 50 V					
C21, C25	2		22 µF/ 50 V					
C22, C23	2		330 µF / 25 V					
C24	1		10 nF / 50 V					
C3, C4	2		2.2 pF / 250 V					
C8	1		10 µF / 25 V					
C9	1		1 nF / 1 kV					
CN1	1			CON18				
D1, D2	2	S1J						
D11	1	UF1007						
D13	1	1N4935			Fairchild			
D14	1	EGP30D						
D3, D4	2	1N5406			Fairchild			
D5, D7, D9, D12	4	1N4148						
D6, D8, D10	3	FFH30S60STU			Fairchild			
F1	1	Slow Blow Fuse	40 A / 250 V					
HS1	1	H-sink						
HS2, HS3, HS4	3	H-sink						
L1, L2	2	FS4015H-2LB		EMI	FORMOSA SHING GA ENTERPRISE CO., LTE.			
L3, L4, L5	3	Core Type: QP3925H	100 µH					
L6	1		10 µH					
M1	1		MOV					
Q1	1	2N7002A						
Q2, Q5, Q8	3	2222A						
Q3, Q6, Q9	3	2907						
Q4, Q7, Q10	3	FGH40N60SMDF			Fairchild			
R1, R2, R4, R5, R6	5		1 MΩ					
R11, R21, R31	3		470 Ω					
R12, R22, R32	3		20 Ω					



Main Board (PLM281 REV.2)							
Reference	Qty.	Part Number	Value	Description	Manufacturer		
R13, R23, R33	3		12 Ω				
R14, R24, R34, R42	4		10 kΩ				
R15, R16, R25, R26, R35, R36	6		30 mΩ / 2 W				
R18, R19, R28, R29, R38, R39	6		470 Ω				
R20	1		1.5 MΩ				
R3	1		20 Ω				
R41	1		38.3 kΩ				
R43	1		20 kΩ				
R44	1		560 Ω				
R48	1		3.9 kΩ				
R49, R50, R52	3		0 Ω				
R51	1		100 kΩ				
R7	1		5.1 MΩ				
R8	1		4.7 MΩ				
R9A, R10	2		2.2 MΩ				
Relay1	1	Power Relay	40 A				
TX1	1	750342371		12 V _{SB} Transformer	Würth Elektronik		
U1	1	FSL126HR		Controller	Fairchild		
U2	1	PC-817					
U3	1	TL431					

Daughter Card (PLM0177A REV.6)							
Reference	Qty.	Part Number	Value	Description	Manufacturer		
C35, C40, C41, C42, C51, C54	6	SMD 0805	0.01 µF				
C38	1	SMD 0805	0.047 µF				
C31, C33, C43, C44, C61	5	SMD 0805	0.1 µF				
C36, C37, C39, C52, C53	5	SMD 0805	0.47 µF				
C45, C47, C49	3	SMD 0805	1.2 nF				
C46, C48, C50, C62	4	SMD 0805	100 pF				
C32	1		10 µ / 50 V				
C13, C14, C15	3	SMD 0805	2.2 nF				
C55, C56, C57, C58, C59, C60	6	SMD 0805	2.2 nF				
C34, C63, C64	1	SMD 0805	470 pF				
CN1	1			CON14			
D11	1		1N4148				



Daughter Card (PLM0177A REV.6)							
Reference	Qty.	Part Number	Value	Description	Manufacturer		
U1	1	FAN9673		Controller	Fairchild		
U2	1	LM358D			Fairchild		
R56, R65, R72, R71	4	SMD 0805	0 Ω				
R60	1	SMD 0805	10 kΩ				
R73	1	SMD 0805	12.1 kΩ				
R55	1	SMD 0603	16.2 kΩ				
R62, R63, R64	3	SMD 0805	17.4 kΩ				
R69	1	SMD 0805	43 kΩ				
R54	1	SMD 0805	200 kΩ				
R59	1	SMD 0805	20 kΩ				
VR1	1	SMD 0805	20 kΩ				
R52	1	SMD 0805	23.7 kΩ				
R57	1	SMD 0805	30 kΩ				
R58	1	SMD 0805	38.3 kΩ				
R61	1	SMD 0805	4.7 kΩ				
R68	1	SMD 0805	470 kΩ				
R66, R67, R70	3	SMD 0805	47 kΩ				
R53	1	SMD 0805	75 kΩ				
S1	1	DIP-4		Switch			



7. Transformer and Winding Specifications

7.1. TX2 Specification

- Core: EE-16 (3C94)
- Bobbin: 10 Pins



Figure 8. Transformer Specifications & Construction

No.	Winding	Pin (S \rightarrow F)	Pin (S \rightarrow F)Wire		Winding Method			
1	N1	3 → 2	0.29φ×1	36	Solenoid Winding			
2	Insulation: Polyes	ster Tape t = 0.025 m	m, 3-Layer					
3	N2	10	Solenoid Winding					
4	Insulation: Polyes	ster Tape t = 0.025 m	ım, 3-Layer					
5	N1	$2 \rightarrow 1$	0.29φ×1	18	Solenoid Winding			
6	Insulation: Polyes	ster Tape t = 0.025 m	ım, 6-Layer					
7	N3 $5 \rightarrow 6$ 0.15 ϕ ×1 13 Solenoid Windi							
8	Insulation: Polyester Tape t = 0.025 mm, 3-Layer							
9	Copper-Foil 1.2T to PIN6							

Table 3. Electrical Characteristics

	Pins	Specifications
Inductance	3 - 1	800 µH ±5%



7.2. L1 & L2 Specification

FORMOSA SHING GA ENTERPRISE CO., LTD.



SPECIFICATION FOR PRODUCTS

CUST		FAIR	IRCHILD OUT DWG NO.									
ITEM		SN-40	03215-A		DATE		2014/06/16					
PART	PART NO. REV:A2											
1.SCHEMATIC DIMENSION:												
	A B SPEC.(mm)											
										MAX		
CLAPBO	3.2t	hr.				1 œ		-02	В	+	27.0	MAX
EP	oxy_					N	11 7 K	2	С	+	49.0	MAX
	Ũ		L	í W		4 0		-03	D		10.0	±1.0
	G	U	Mlm				- Offici		Е	_	4.01	MAX
	(4	E					-	F	_	10.0	REF
			F	2	G 📕			L	G		24.0	REF
					*V:	acuun	n Varnish Pro	cessed				
2.WIN	DING &	ELEC	FRONICS: (150	kHz 0.1V)30	°C							
ITEM	START	FINIS	H MATE	RIAL	TURNS	COLC	DR IND	UCTAN	NCE	DCR(m 2		$CR(m \Omega)$
N1	1	4	2UEW	ф 1.6*2Р	16TS	Ν	1.0)mH M	MIN /		/	
N2	2	3	2UEW	ф 1.6*2Р	16TS	Ν	1.0	0mH M	MIN /			/
3.TES	TINSTRU	MENT	S: L.C.R.CH-10	52;502B								
4.MAT	FERIAL LIS	ST:										
NO	ITEM	[MATERIAL		SU	PPLIE	R			ULN	NO.	CLASS
1	CORE		SN403215-A	FORMOSA	SHING GA	ENTE	RPRISE CO.,	LTD.				
2	WIRE	:	2UEW	PACIFIC E	LECTRIC W	IRE&	CABLE CO.,	LTD.		E201	757	130°C
3	EPOX	Y	G-9008	GUDAK CI	HEMISTRY	ГЕСН	.(D.G)LTD			E218	090	90°C
4	4 CLAPBOARD FR-4 HUIZHOU JIANYONG INSULATED PRODUCT CO.,LTT							ГD	E123	995	130℃	
5 MYLAR TAPE CT-280 HUIZ			HUIZHOU	YAHUA STI	CKIN	G TAPE CO.	LTD		E165	111		
6 VARNISH V1630FS ELANTAS E					LECTRICAL IN	ISULA	TION ELANTA	S PDG II	NC	E752	25	
	CUSTOME	R	APPI	ROVAL	0	THECH	(ED		DRAWN			
			AI-H	PING	STE	VEN	CHANG		SA	AND	Y CH	EN

TEL: 886-2-87875958 FAX: 886-2-87875969 E-MAIL: philip01@ms2.hinet.net



N1

 Table 4.
 Winding Specifications

No.	Winding	$\textbf{Pin}~(\textbf{S} \rightarrow \textbf{F})$	Wire	Turns	Winding Method				
1	1 N1 $1 \rightarrow 6, 7$		0.2φ×35 *1	25	Solenoid Winding				
2	Insulation: F	Insulation: Polyester Tape t = 0.025 mm, 2-Layer							
3	Copper-Foil	Copper-Foil 1.2T to PIN4, 5							

Figure 9. Transformer Specifications & Construction

7

6

4

5

Table 5. Electrical Characteristics

	Pin	Specifications
Inductance	$1 \rightarrow 6, 7$	100 µH ± 5%



7.4. L11 Specification

- Core: Ferrite core DRWW 6x10(6ψ*10 mm)
- Bobbin: 2 Pins



Figure 10. Transformer Specifications & Construction

Table 6. Winding Specifications

No.	Winding	$\textbf{Pin}~\textbf{(S} \rightarrow \textbf{F)}$	Wire	Turns	Winding Method
1	N1	$1 \rightarrow 2$	0.55 mm	18	Solenoid Winding
2	Ferrite core DRWW 6x10 (6ψ*10 mm)				

Table 7. Electrical Characteristics

	Pin	Specifications
Inductance	1 - 2	10 µH ± 5%



8. Test Conditions & Test Equipment

8.1. Features

Table 8. Test Conditions & Test Equipment

Test Mode	FEBFAN9673Q_B1H5000A
Test Date	Nov.4, 2013
Test Temperature	Ambient 25°C
Test Equipment	AC Source: EXTECH 6220 AC/DC Electronic Load: Chroma 63020 Power Meter: HIOKI 3390 Oscilloscope: Lecroy Wavesurfer 424
Test Items	 AC Trim Up & Trim Down PFC ON/OFF & RDY Ripple & Noise Efficiency Current Harmonic

8.2. Test Procedure

Before powering up the board, verify that the AC voltage source is connected to line input terminals on the evaluation board and the AC-DC electronic load is connected to the PFC output.

- 1. Set the electronic load to no-load or light-load condition and apply the AC voltage across the input of the evaluation board.
- 2. When the AC voltage (180~264 V_{AC}) is supplied to the board, the FAN9673 begins normal operation and the on-board flyback converter provides the 12 V_{SB} output. The Flyback transformer's auxiliary winding supplies the V_{DD} voltage for the FAN9673 to power up the PFC stage.
- 3. PFC startup is controlled by the V_{EA} level. Prior to the soft-start voltage reaching 6 V, the V_{EA} level is limited by soft start.
- 4. After the bulk capacitor or PFC output voltage reaches the steady-state value, 392 V, the load condition of the electronic load can be changed to test system performance.

Hint:

1. It is recommended that an external fan be added to help dissipate the heat on the NTC, IGBT, diode, and bridge on the evaluation board.



9. Performance of Evaluation Board

9.1. AC Trim Up & Trim Down

Test Condition:

Switch the input voltage from 180 V to 264 V or from 264 V to 180 V, the output voltages should be normal and the output of PFC bus should be less than 450 V.

Test Result:



Figure 11. 180 V→264 V 5000 W Load

Figure 12. 264 V→180 V 5000 W Load

9.2. PFC ON / OFF & RDY

Test Result:





Figure 14. PFC OFF



Figure 15. 180 V / 50 Hz

Figure 16. 264 V / 50 Hz

9.4. Efficiency

Test Condition:

Measure efficiency at min., mid., and max. loading.

Test Result:

	FAN9673	Input Watts (W)	Output Watts (W)	Efficiency
Α.	V _{IN} =180 V at 25% Load	1295	1250	96.5%
В.	V _{IN} =180 V at 50% Load	2590	2500	96.5%
C.	V _{IN} =180 V at 75% Load	3885	3750	96.5%
D.	V _{IN} =180 V at 100% Load	5195	5000	96.2%
E.	V _{IN} =220 V at 25% Load	1288	1250	97.0%
F.	V _{IN} =220 V at 50% Load	2573	2500	97.1%
G.	V _{IN} =220 V at 75% Load	3856	3750	97.2%
Н.	V _{IN} =220 V at 100% Load	5149	5000	97.1%
Ι.	V _{IN} =264 V at 25% Load	1280	1250	97.6%
J.	V _{IN} =264 V at 50% Load	2553	2500	97.9%
K.	V _{IN} =264 V at 75% Load	3836	3750	97.7%
L.	V _{IN} =264 V at 100% Load	5122	5000	97.6%



9.5. Current Harmonic

Test Results:

FAN9673			
Input Voltage	Condition	PF	THD (%)
	25% Load	0.9912	10.55
190 V / 50 H .,	50% Load	0.9947	9.17
100 07 30 112	75% Load	0.9971	6.62
	100% Load	0.9974	6.40
	25% Load	0.9800	14.32
220 V / 50 H 7	50% Load	0.9868	14.36
220 07 30 112	75% Load	0.9905	12.55
	100% Load	0.9924	11.26
	25% Load	0.9365	25.85
264 V / 50 H 7	50% Load	0.9369	33.22
204 7 30 112	75% Load	0.9526	29.59
	100% Load	0.9600	27.29



180 V / 50 Hz Input Current Waveform & Harmonic



Figure 17. 25% Load





Figure 18. 50% Load





Figure 19. 75% Load



Figure 20. 100% Load



220 V / 50 Hz Input Current Waveform & Harmonic



Figure 21. 25% Load





Figure 22. 50% Load









Figure 24. 100% Load



264 V / 50 Hz Input Current Waveform & Harmonic



Figure 25. 25% Load









Figure 27. 75% Load



Figure 28. 100% Load



10. Notice Letter

To properly operate the high-power interleaved CCM PFC evaluation board, cooling fans must be enabled to remove the heat from switching IGBTs and diodes. The fans are usually set up as shown in the following picture.



Figure 29. Recommended Fan Setup

Note:

2. Fans are not provided with the evaluation board. Supply fans for testing.



11. Safety Precautions





Before applying power to the FEBFAN9673Q_B1H5000A evaluation board, it is imperative that all involved personnel read and understand the safety precautions and understand the power on/off procedures.

The FEBFAN9673Q_B1H5000A evaluation board operates at lethal voltages and has bulk capacitors that store significant charge. Accidental contact can lead to lab equipment damage, personnel injury, and may be fatal. Be exceptionally careful when probing and handling this board. Always observe normal laboratory precautions, including:

- A. All connected computers and measurement equipment MUST be isolated from the AC mains before operating voltages are applied to the board. Alternatively, AC/DC power to the board may be isolated.
- B. When using an oscilloscope with this board, it must be isolated from the AC line. Alternatively, high-voltage (700 V+) isolated probes may be utilized.
- C. Start with a clean working surface, clear of any conductive material.
- D. Be careful while turning on the power switch to the AC source.
- E. Never probe or move a probe on the board while the AC line voltage is present.
- F. Ensure the bulk capacitors are discharged before disconnecting the high power load.

Note:

3. Even when a computer is isolated from AC mains through external supply, a connection to earth-potential may exist through LAN, VGA, or other connections to peripherals.



12. Revision History

Rev.	Date	Description
1.0.0	Jan 2014	Initial release
1.0.1	April 2014	Update to BOM
1.0.2	July 2014	Update to BOM
1.3	March 2014	Updated Part number to FEBFAN9673Q_B1H5000A

WARNING AND DISCLAIMER

Replace components on the Evaluation Board only with those parts shown on the parts list (or Bill of Materials) in the Users' Guide. Contact an authorized Fairchild representative with any questions.

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