User Guide for

FEBFAN6602R_CH10U40A

Evaluation Board

Fairchild Computing Notebook Adapter

Featured Fairchild Product:

FAN6602R

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

Fairchild Semiconductor.com

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This user guide supports the evaluation kit for the FAN6602R. It should be used in conjunction with the FAN6602R datasheets as well as Fairchild's application notes and technical support team. Please visit Fairchild's website at https://www.fairchildsemi.com/

1. Introduction

This document is an engineering report describing a 40 W power supply using the FAN6602R, which is targeted for notebook adapters. It also describes the simple, low cost and high performance reference design evaluation board.

The operating current in the FAN6602R is as small as 3 mA. The small operating current results in higher efficiency and reduces the VDD hold-up capacitance requirement. Once the FAN6602R enters deep-green mode, the operating current is reduce to 0.6 mA, thus assisting the power supply to easily meet the power conservation.

By using the FAN6602R, an adapter can be implemented with fewest external components and minimized cost.

2. Evaluation Board Specifications

All data in Table 1 was measured with 90 V_{AC}~264 V_{AC} line input at an ambient temperature of 25°C.

Table 1. Summary of Features and Performance

Specification	Min.	Max.	Unit
Input Voltage	90	264	V_{AC}
Input Frequency	47	63	Hz

Description	Design Spec.	Test Result	Comments
Output Voltage	18.05~19.95 V	0.9%	CV<±5% Regulation CC<±5% Regulation
Output Current Protection	2.5 ~3.5 A	2.93~3.02 A	
Input Power	< 100 mW	85 mW	264 V_{AC}
Ripple		345 mVp-p (Max.)	Measured at PCB End
Startup Time	< 2 S	1.8 S	Full Load
Dynamic	>18.5 V	18.7 V	Measure at PCB End
Voltage Stress	600 V	582 V	264 V_{AC}
	100 V	93 V	264 V_{AC}
Efficiency	Avg. 85.29%	89.09% at 115 V 89.16% at 230 V	Meets Energy Star v2.0.
Conducted EMI	Under 6 dB	3 dB Margin	Meets CISPER22B/EN55022B/IEC950/UL1950 Class II

3. Photographs

Figure 1. Photograph (W x L: 34 x 84 mm2) Top View

Figure 2. Photograph (W x L: 34 x 84 mm2) Bottom View

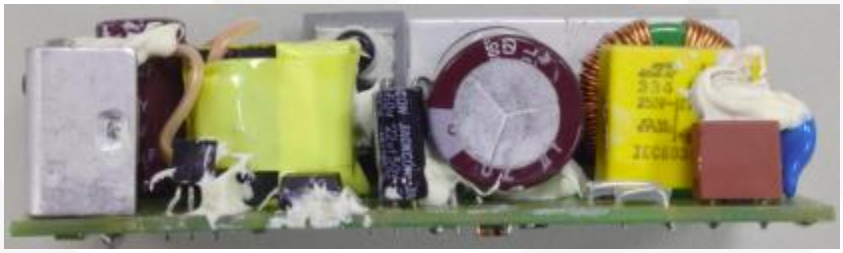

Figure 3. Photograph (H:24 mm) Side View

4. Printed Circuit Board

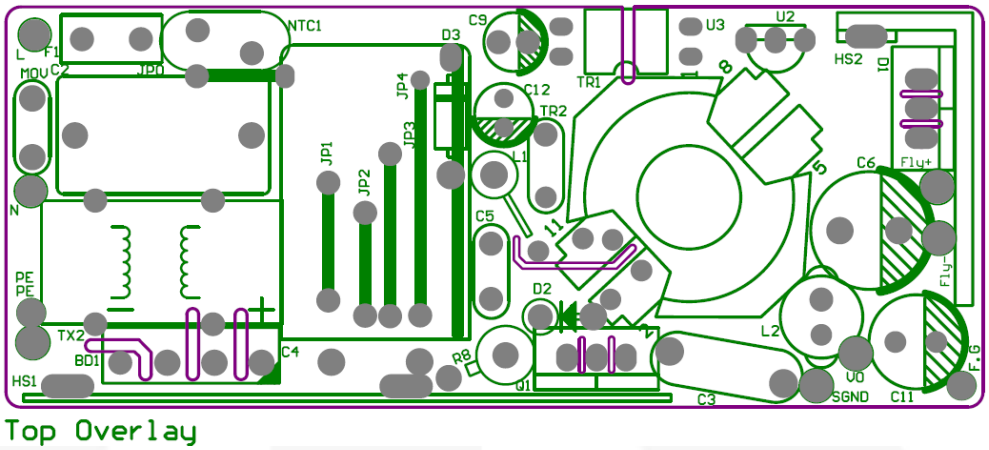

Figure 4. Top View

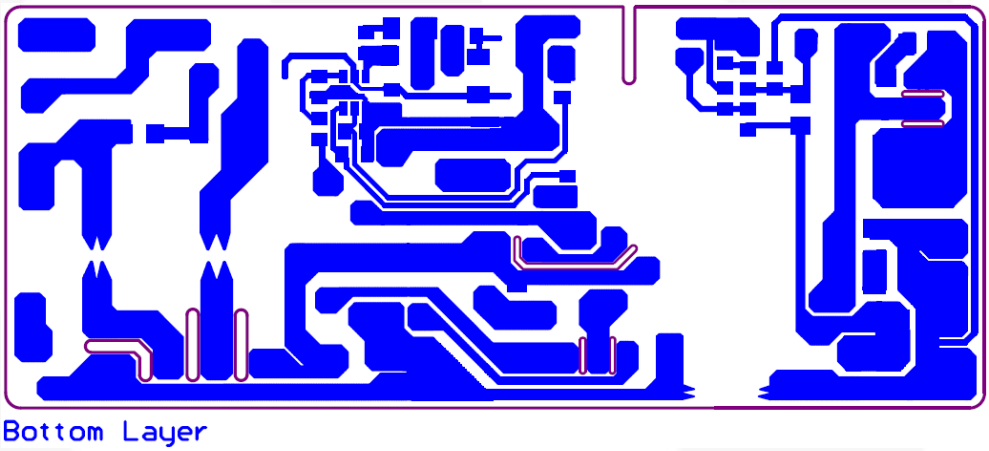

Figure 5. Bottom View

5. Schematic

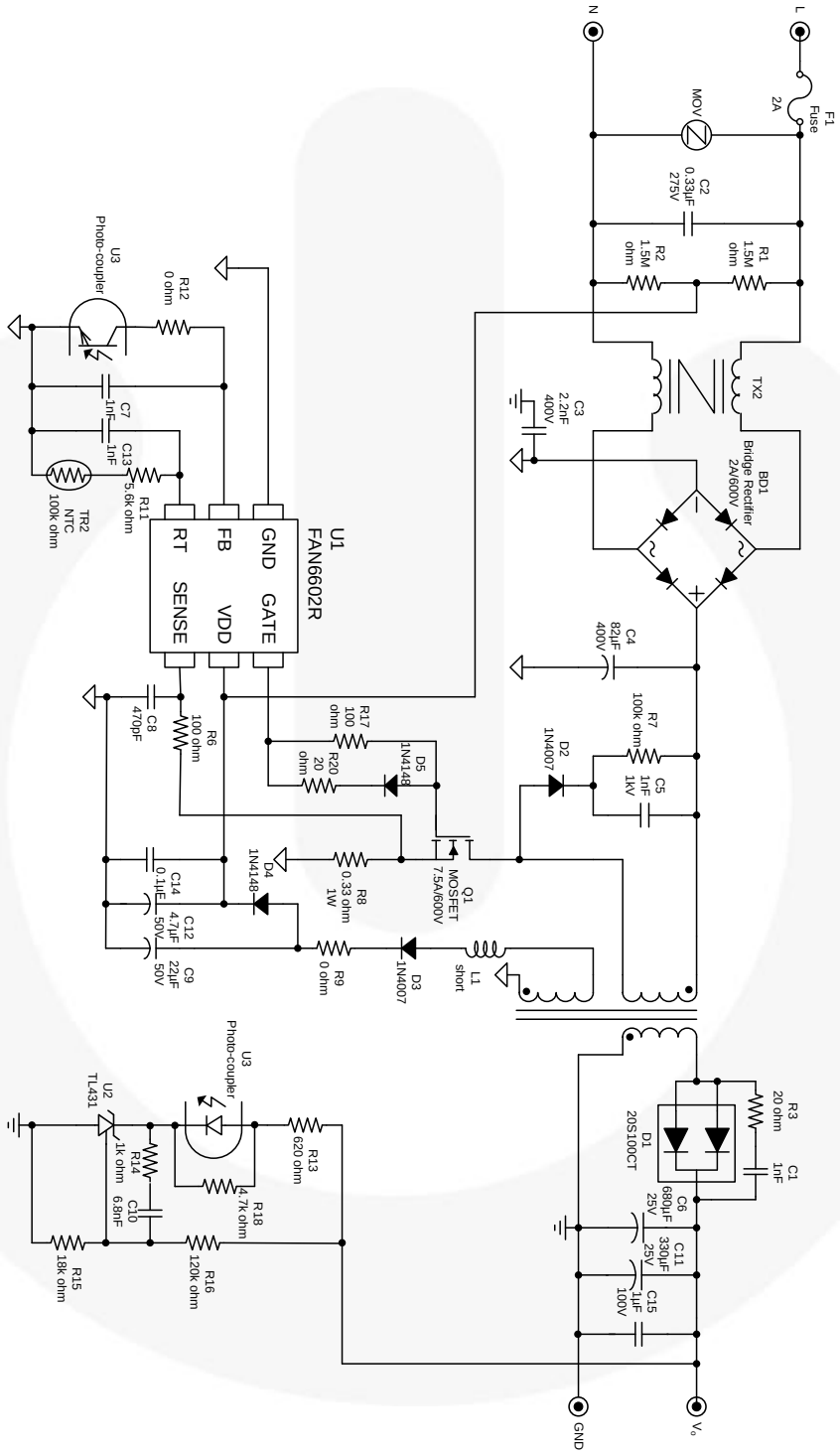

Figure 6. Evaluation Board Schematic

6. Bill of Materials

Part Specification	Package	Qty.	No.
JUMPER WIRE 0.8ψ(mm)	REEL	8	JP0~JP4, NTC1, L1, L2
Metal-Oxide Resister 1 W 0.33 Ω ±10%	REEL	1	R8
SMD Resister 0805 0 Ω ±5%	REEL	1	R9, R12
SMD Resister 0805 20 Ω ±5%	REEL	1	R20
SMD Resister 0805 100 Ω ±5%	REEL	2	R6
SMD Resister 0805 620 Ω ±5%	REEL	1	R13
SMD Resister 0805 1 kΩ ±5%	REEL	1	R14
SMD Resister 0805 5.6 kΩ ±5%	REEL	1	R11
SMD Resister 0805 18 kΩ ±5%	REEL	1	R15
SMD Resister 0805 4k7 Ω ±5%	REEL	1	R18
SMD Resister 1206 20Ω ±5%	REEL	1	R3
SMD Resister 1206 100 Ω ±5%	REEL	1	R17
SMD Resister 1206 100 kΩ ±5%	REEL	1	R7
SMD Resister 1206 120 kΩ ±5%	REEL	1	R16
SMD Resister 1206 1.5 MΩ ±5%	REEL	2	R1, R2
0805 X7R ±0% 1 nF 50 V	REEL	2	C7, C13
0805 X7R ±10% 470 pF 50 V	REEL	1	C8
0805 X7R ±10% 6.8 nF 50 V	REEL	1	C10
0805 X7R ±10% 0.1 µF 50 V	REEL	1	C14
1206 X7R ±10% 1 nF 100 V	REEL	1	C1
1206 X7R ±10% 1 µF 100 V	REEL	1	C15
Ceramic Capacitor 1 nF 1 kV	REEL	1	C5
Electrolytic Capacitor 82 µF 400 V 105°C	REEL	1	C4
Electrolytic Capacitor 680 µF 25 V 105°C	REEL	1	C6
Electrolytic Capacitor 22 µF 50 V 105°C	REEL	1	C9
Electrolytic Capacitor 330 µF 25 V 105°C	REEL	1	C11
Electrolytic Capacitor 4.7 µF 50 V 105°C	REEL	1	C12
X2 Capacitor 0.33 µF 275 V ±10 %	REEL	1	C2
Y1 Capacitor 2.2 nF 250 V ±20 %	REEL	1	C3
MOV Oxide Varistor 471	REEL	1	MOV
Common Choke 25 mH ±10 %	SUMIDA (04291-T145)	1	TX2
Transformer RM-8 920 µH	SUMIDA (10344-T018)	1	TR1
FUSE GLASS 250 V/2 A 36SG Slow-Blow	3.6ψ x 10 mm	1	F1
NTC Resister 100 kΩ	REEL	1	TR2
SMD Diode 1 A/1000 V SOD-80	LL4148 REEL	2	D4, D5
Diode 1 A/700 V DO-41	1N4007 REEL	2	D2, D3

Continued on the following page…

Part Specification	Package	Qty.	No.
Bridge Rectifier 2 A/600 V	2KBP06M	1	BD1
Schottky Diode 20 A/100 V TO-220	YM20S100CT	1	D1
MOSFET 7.5 A/600 V TO-220	FQP8N60C	1	Q1
REGULATOR ±1% TO-92	FAN431ACZ-AP	1	U2
Photo Coupler DIP	FOD817A	1	U3
PWM Controller SOT23-6L	FAN6602RM6X	1	U1
Heat Sink 55 x 20 x 1.5 mm	MCH0636	1	HS1
Heat Sink 11.5 x 24.9(L) x 17(H) x 1.5(W) mm	MCH0637	1	HS2
PCB PLM0068 REV0	For FAN6602R 40 W	1	

7. Transformer and Winding Specifications

- Core: RM-8
- Bobbin: RM-8

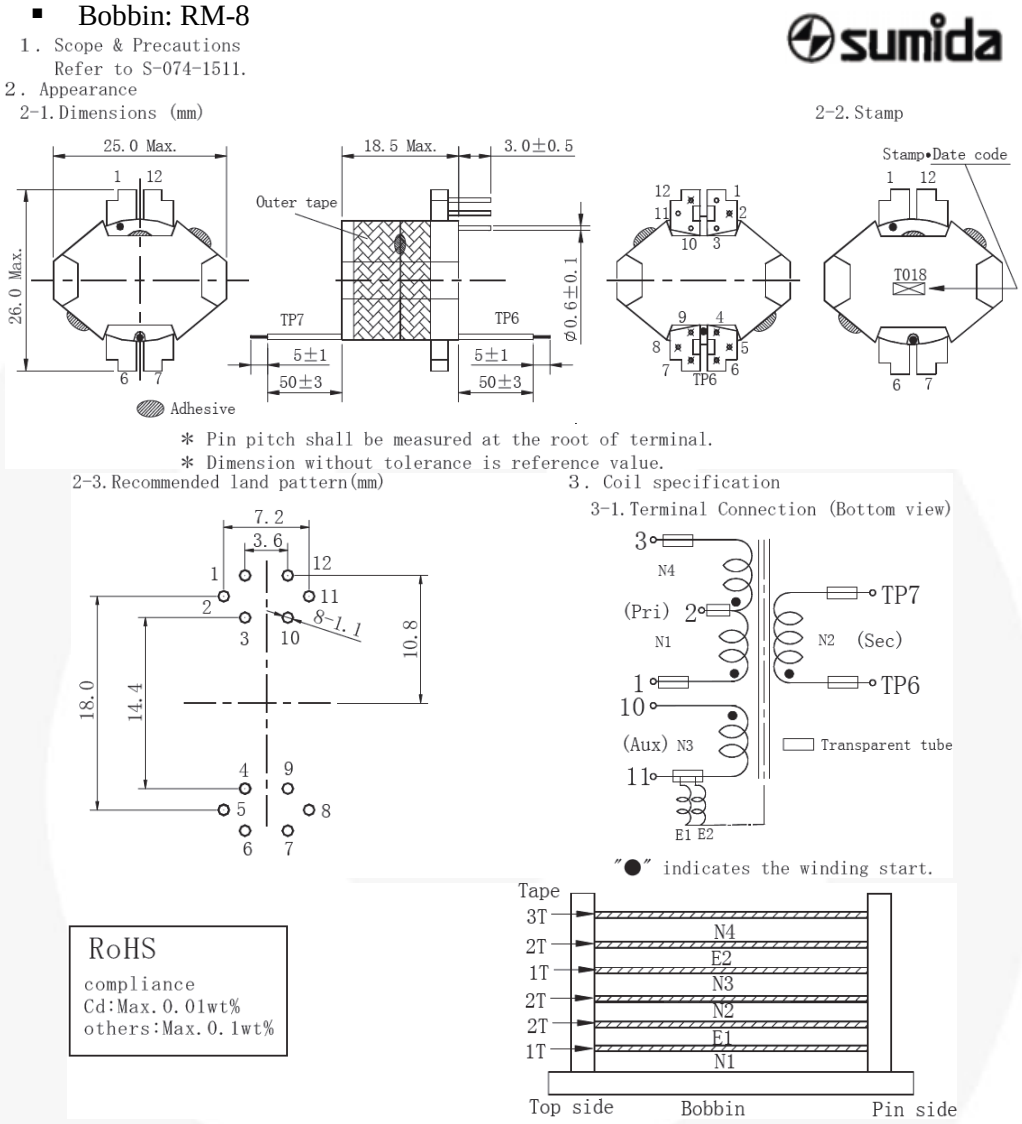

Figure 7. Transformer Specifications & Construction

Table 2. Winding Specifications

Winding	Terminal		Winding	Turns	Isolation Layer
	Start Pin	End Pin			Turns
N4	2	3	0.25 mm*1	33	4
Copper Shielding (E2)	11	Open	Copper Foil 0.025 mm	1.2	3
N3	10	11	0.25 mm*1	9	1
N2	TP6	TP7	0.5 mm*1	12	3
Copper Shielding (E1)	11	Open	Copper Foil 0.025 mm	1.2	3
N1	1	2	0.25 mm*1	33	2

Table 3. Electrical Characteristics

	Pin	Specification	Remark
Inductance	3 - 1	920 µH ±10%	1 kHz, 1 V
Effective Leakage	3 - 1	50 µH Max.	Short Other Pin

8. Test Conditions & Test Equipment

Table 4. Test Conditions & Test Equipment

Evaluation Board #	FEBFAN6602RM6X_CH10U40A
Test Date	2014-12-02
Test Temperature	25℃
Test Equipments	AC Power Source: 6800 AC POWER SOURCE Electronic Load: Chroma 63030 and 63102 Power Meter : WT210 Oscilloscope : LeCory 24Xs-A

9. Performance of Evaluation Board

9.1. Input Wattage at No Load Condition

Test Condition:

Measure the input wattage at no load condition.

Table 5. Test Results

Input Voltage	Input Wattage	Output Voltage
90 V_{AC} / 60 Hz	38 mW	19.27 V
115 V_{AC} / 60 Hz	42 mW	19.27 V
230 V_{AC} / 50 Hz	76 mW	19.27 V
264 V_{AC} / 50 Hz	85 mW	19.27 V

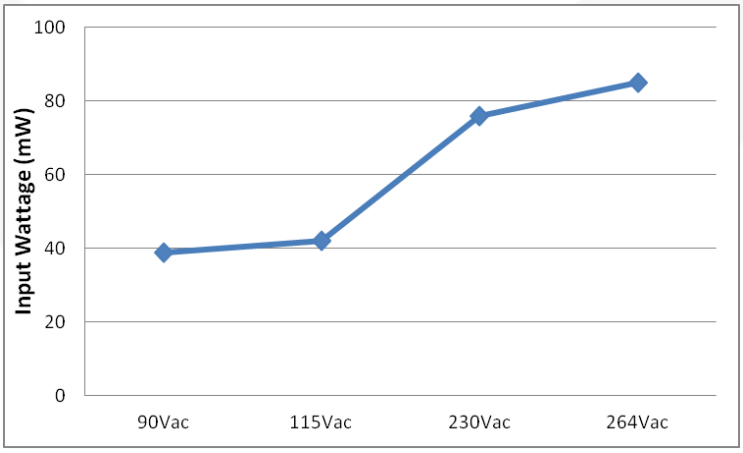

Figure 8. Input Wattage Curve

9.2. Startup Time

Test Condition:

Measure the time from the AC plug-in to nominal output voltage build-up at full load condition.

Table 6. Test Results

Input Voltage	Startup Time	Specification
90 V_{AC} / 60 Hz	1.8 s	<2 sec
264 V_{AC} / 50 Hz	0.537 s	<2 sec

Waveforms:

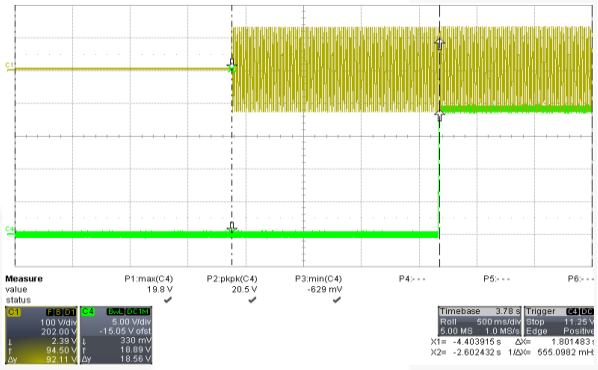

Figure 9. C1[V_{IN}], C4[V_O], 90 V_{AC} / 60 Hz

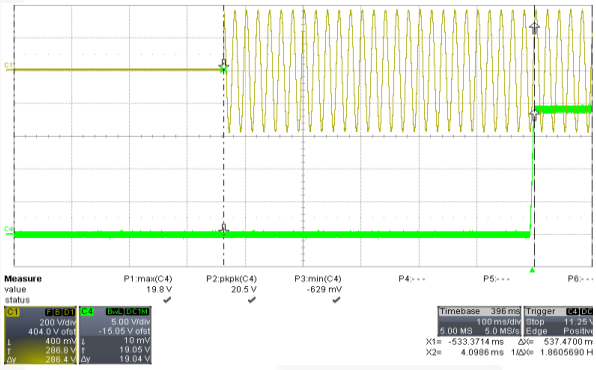

Figure 10. C1[V_{IN}], C4[V_O]. 264 V_{AC} / 50 Hz

9.3. Hold-up Time

Test Condition

Set output at maximum load. Measure the time interval between AC off and output voltage falling to lower limit of rated value. The AC waveform should be off at zero degree.

Table 7. Test Results

Input Voltage	Hold-up Time
90 V_{AC} / 60 Hz	7.9 ms
115 V_{AC} / 60 Hz	15.1 ms
230 V_{AC} / 50 Hz	83.9 ms
264 V_{AC} / 50 Hz	119 ms

Waveforms:

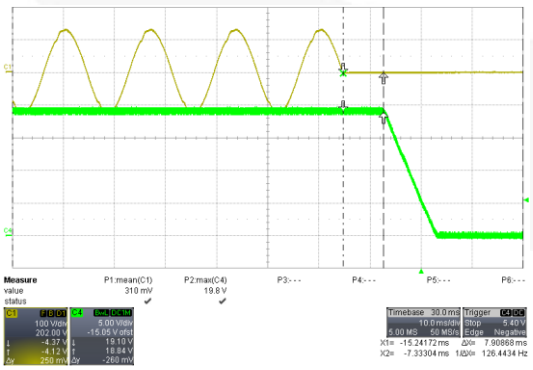

Figure 11. C1[V_{IN}], C4[Vo], 90 V_{AC} / 60 Hz

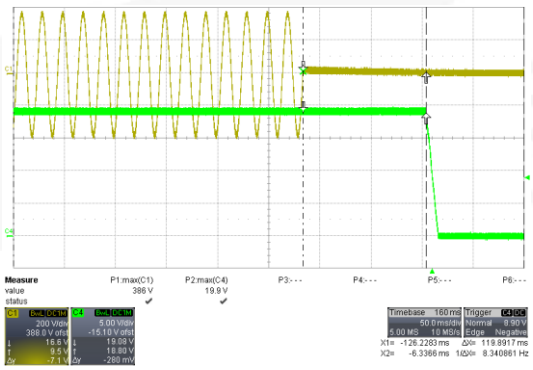

Figure 12. C1[V_{IN}], C4[Vo], 264 V_{AC} / 50 Hz

9.4. Input Current

Test Condition:

Measure the AC input current at maximum output loading, where the maximum input power occurs.

Table 8. Test Results

Input Voltage	Input Current	Specification
90 V_{AC} / 60 Hz	964 mA	
264 V_{AC} / 50 Hz	445 mA	

9.5. DC Output Rising Time

Test Condition:

Measure the time interval between 10% to 90% of the output voltage during startup.

Table 9. Test Results

Input Voltage	Minimum Load	Full Load	Specification
90 V_{AC}/60 Hz	4.32 ms	5.87 ms	<20 ms
264 V_{AC}/50 Hz	3.7 ms	5.06 ms	

Waveforms:

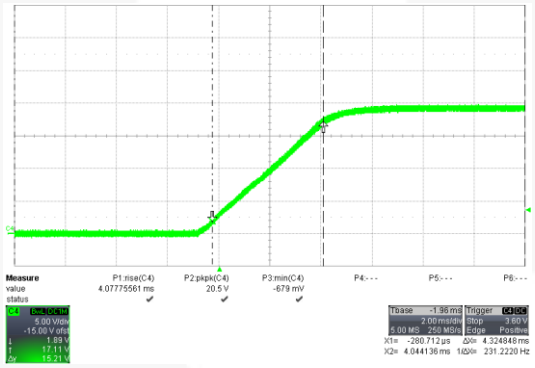

Figure 13. C4[V_O], 90 V_{AC}/60 Hz, Minimum Load

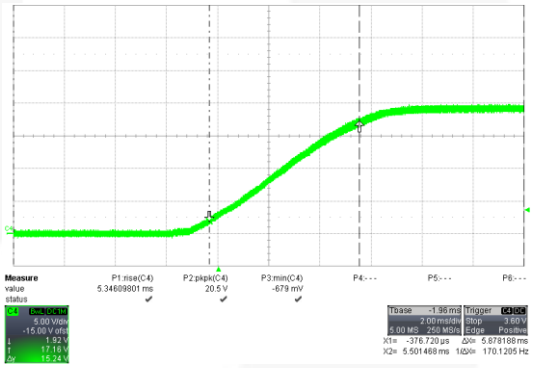

Figure 14. C4[V_O], 90 V_{AC}/60 Hz, Full Load

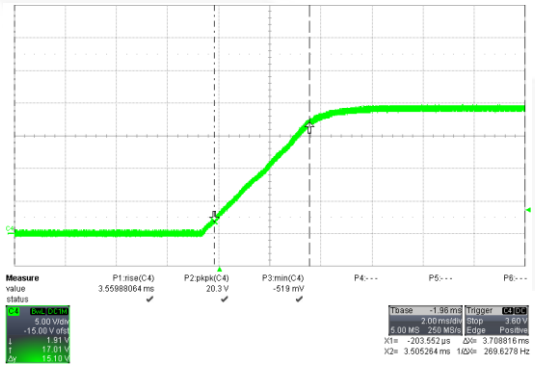

Figure 15. C4[V_O], 264 V_{AC}/50 Hz, Minimum Load

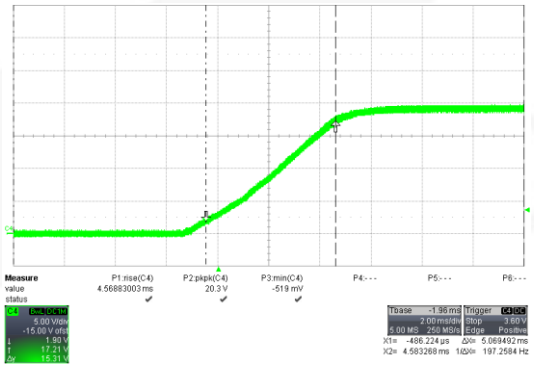

Figure 16. C4[V_O] 264 V_{AC}/50 Hz, Full Load

9.6. Dynamic Response

Test Condition

Dynamic loading (20%~80%), 50% duty cycle (5 ms), 2.5 A/µsec rise/fall time. Measured at PCB end.

Table 10. Test Results

Input Voltage	Overshoot	Undershoot	Specification
115 V_{AC}/60 Hz	262 mV	102 mV	
230 V_{AC}/50 Hz	301 mV	128 mV	

Waveforms:

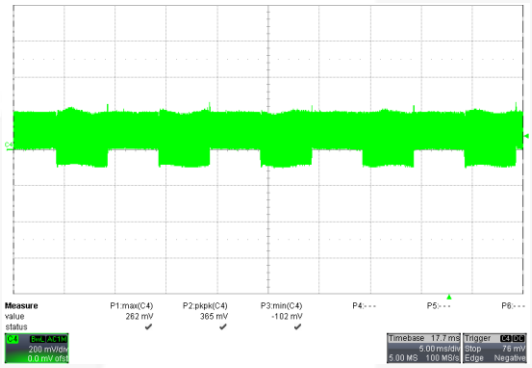

Figure 17. C4[V_O], 115 V_{AC} / 60 Hz

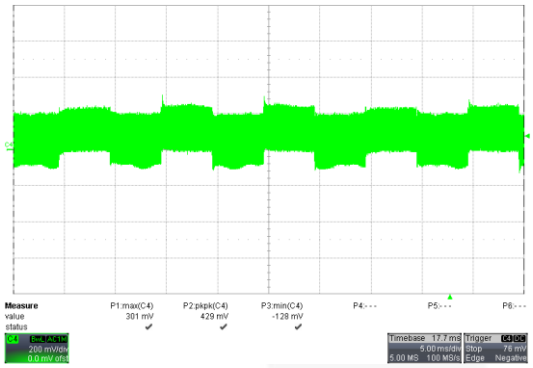

Figure 18. C4[V_O], 230 V_{AC} / 50 Hz

9.7. Output Ripple & Noise

Test Condition

Measure the output voltage ripple at full load condition at EVB end with 10 µF electrolytic capacitor in parallel with 0.1 µF MLCC.

Table 11. Test Results

Input Voltage	Full Load	Specification
90 V_{AC} / 60 Hz	345 mV_{P-P}	
115 V_{AC} / 60 Hz	312 mV_{P-P}	
230 V_{AC} / 50 Hz	292 mV_{P-P}	
264 V_{AC} / 50 Hz	299 mV_{P-P}	

Waveforms:

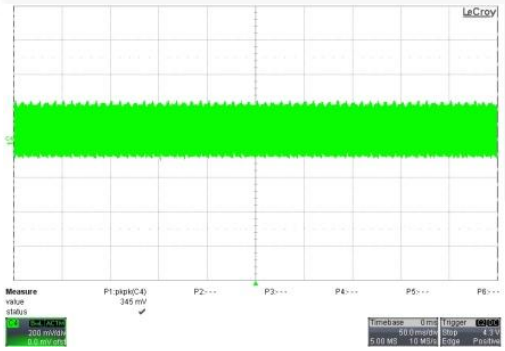

Figure 19. C4[V_O], 90 V_{AC} / 60 Hz

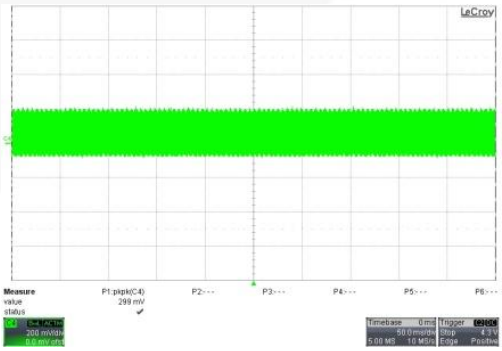

Figure 20. C4[V_O], 264 V_{AC} / 50 Hz

9.8. VDD Voltage Level

Test Condition

Measure VDD voltage at minimum, maximum loading and close over current protection point.

Table 12. Test Result

Input Voltage	Minimum load	Maximum load	Near OCP	Specification
90 V_{AC} / 60 Hz	12.45 V	14.8 V	16.4 V	< 22.5 V
264 V_{AC} / 50 Hz	12.6 V	14 V	154 V	

Waveforms:

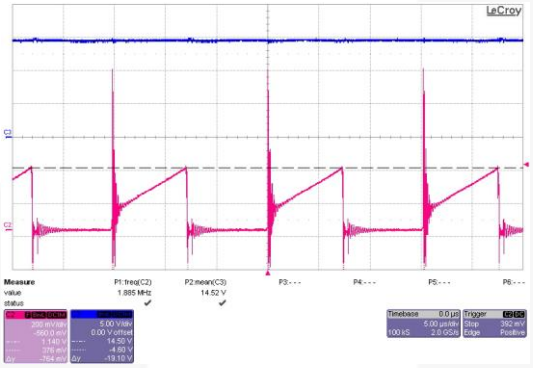

Figure 21. C2[V_{CS}], C3[V_{DD}] 90 V_{AC} / 60 Hz & Max. Load

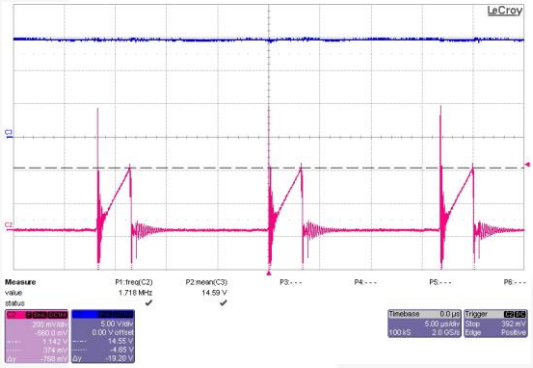

Figure 22. C2[V_{CS}], C3[V_{DD}] 264 V_{AC} / 50 Hz & Max. Load

9.9. Short-Circuit Protection (SCP)

Test Condition

Short output terminal, then the controller should enter hiccup mode protection with less than 10 ms.

Table 13. Test Results with Input Power

	Maximum Output Load	Minimum Output Load	Specification
90 V_{AC} / 60 Hz	7.18 ms	7.31 ms	< 10 ms
264 V_{AC} / 50 Hz	7.04 ms	7.14 ms	

Waveforms:

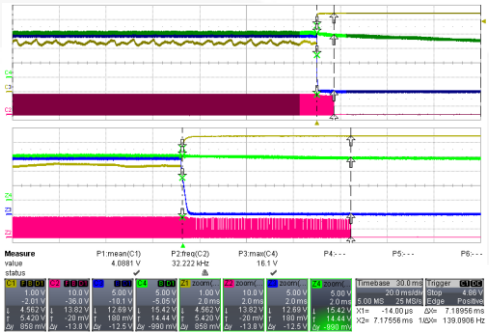

Figure 23. C1[FB], C2[GATE], C3[V_O], C4[V_{DD}], 90 V_{AC}/60 Hz

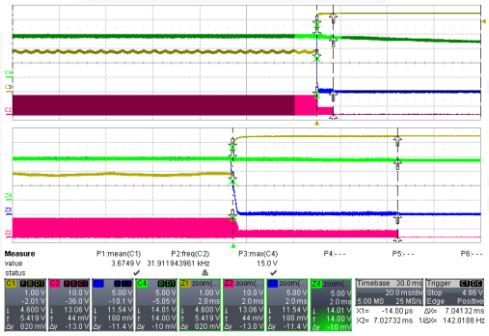

Figure 24. C1[FB], C2[GATE], C3[V_O], C4[V_{DD}], 264 V_{AC}/50 Hz

9.10. Overload Protection (OLP)

Test Condition:

Increase output loading gradually to trigger OLP and measure the debounce time.

Table 14. Test Results

Input Voltage	Minimum Load	Maximum Load	Specification
90 V_{AC} / 60 Hz	63.8 ms	64.1 ms	54 ms < t_{D-OLP} <66 ms
264 V_{AC} / 50 Hz	63.5 ms	60.1 ms	

Waveforms:

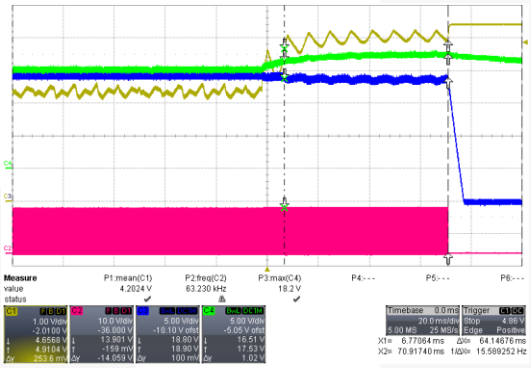

Figure 25. C1[FB], C2[GATE], C3[V_O], C4[V_{DD}], 90 V_{AC}/60 Hz

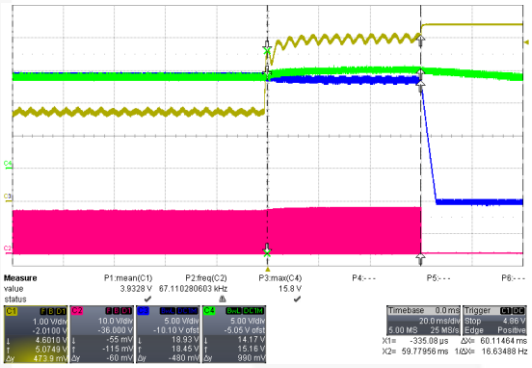

Figure 26. C1[FB], C2[GATE], C3[V_O], C4[V_{DD}], 264 V_{AC}/50 Hz

9.11. Voltage Stress on MOSFET & Rectifiers

Test Condition

Measure the voltage and current stress on MOSFET and secondary rectifier under below the conditions where the maximum voltage stress occurs.

Table 15. Test Results

		90 V_{AC}/ 60 Hz	264 V_{AC}/ 50 Hz	Specification
		Full Load	Full Load	
Normal	MOSFET	322 V	582 V	V_{DS}<600 V V_D<100 V
	Rectifier	55 V	86 V	
Short Circuit	MOSFET	294 V	502 V	
	Rectifier	28 V	93 V	

Waveform:

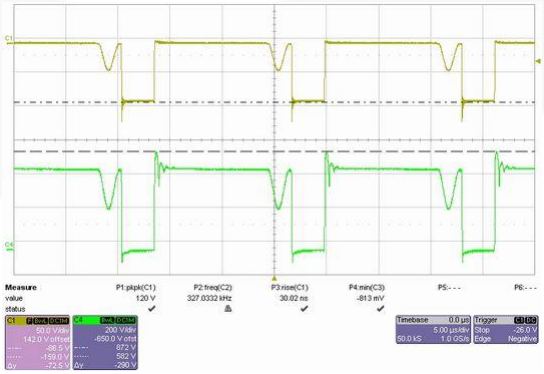

Figure 27. C1[V_{AK}], C4[V_{DS}] 264 V_{AC}/50 Hz, Full Load

9.12. Line & Load Regulation

Test Condition

Measure the line/load regulation according universal input and minimum to maximum loading.

Table 16. Test Results

Input Voltage	Output Voltage at Maximum Loading	Output Voltage at Minimum Loading	Load Regulation	Specification
90 V_{AC} / 60 Hz	19.11 V	19.276 V	0.8%	< ±5%
115 V_{AC} / 60 Hz	19.09 V	19.276 V	0.9%	
132 V_{AC} / 60 Hz	19.09 V	19.274 V	0.9%	
180 V_{AC} / 50 Hz	19.10 V	19.274 V	0.8%	
230 V_{AC} / 50 Hz	19.08 V	19.272 V	0.9%	
264 V_{AC} / 50 Hz	19.09 V	19.27 V	0.9%	
Line Regulation	0.13%	0.031%		

9.13. Efficiency

Test Condition

Measure the efficiency at universal input voltage and maximum loading.

Table 17. Test Results

Input Voltage	Output Voltage	Output Current	Input Wattage	Efficiency	Average Efficiency
90 V_{AC} / 60 Hz	19.224 V	0.52 A	11.26 W	88.78%	88.42%
	19.178 V	1.042 A	22.53 W	88.70%	
	19.134 V	1.571 A	33.97 W	88.49%	
	19.108 V	2.109 A	45.94 W	87.72%	
115 V_{AC} / 60 Hz	19.216 V	0.52 A	11.29 W	88.51%	89.09%
	19.188 V	1.044 A	22.36 W	89.59%	
	19.132 V	1.571 A	33.61 W	89.43%	
	19.088 V	2.109 A	45.32 W	88.83%	
230 V_{AC} / 50 Hz	19.226 V	0.52 A	11.29 W	88.55%	89.16%
	19.184 V	1.044 A	22.39 W	89.45%	
	19.138 V	1.571 A	33.66 W	89.32%	
	19.094 V	2.109 A	45.08 W	89.33%	
264 V_{AC} / 50 Hz	19.222 V	0.52 A	11.34 W	88.14%	88.85%
	19.174 V	1.044 A	22.61 W	88.53%	
	19.134 V	1.571 A	33.7 W	89.2%	
	19.128 V	2.094 A	44.74 W	89.53%	

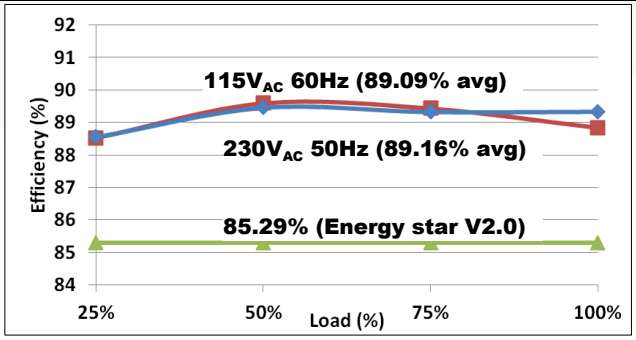

Figure 28. 4 Points Efficiency Curve

9.14. Over-Current Protection(OCP)

Test Condition

Increase output loading current gradually and measure the output maximum current.

Table 18. Test Results

Input Voltage	Over Current Protection	Specification
90 V_{AC} / 60 Hz	2.95 A	
115 V_{AC} / 60 Hz	3.02 A	
230 V_{AC} / 50 Hz	2.93 A	
264 V_{AC} / 50 Hz	2.96 A	

Curve:

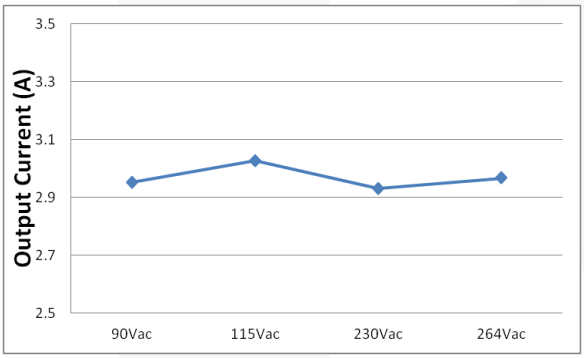

Figure 29. Output Current Protection Curve

9.15. Conducted Electromagnetic Interference (EMI)

Test Condition

- Frequency Range: 150 kHz – 30 MHz, Probe: 2-Line-LISN ENV216
- Signal Path: Receiver-2-Line-LISN ENV216, Detectors: Average
- Output Load: 9.025 Ω

Test Results:

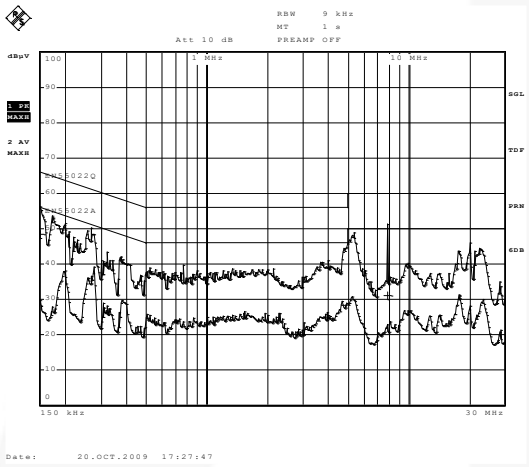

Figure 30. Line: 115 V_{AC} / 60 Hz

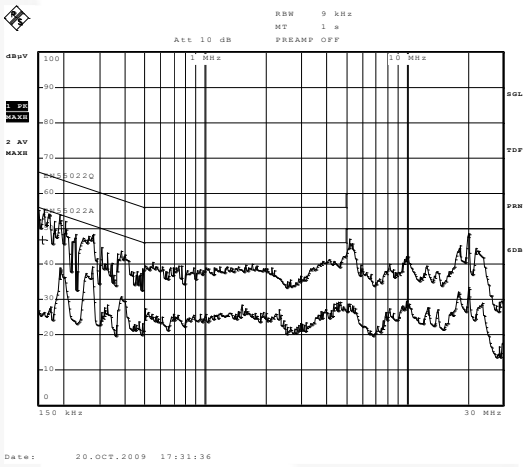

Figure 31. Neutral: 115 V_{AC} / 60 Hz

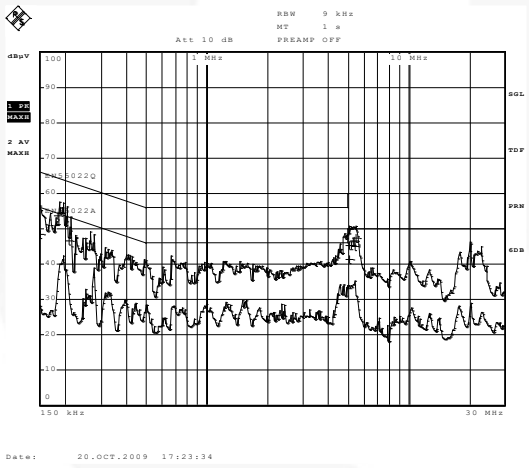

Figure 32. Line: 230 V_{AC} / 50 Hz

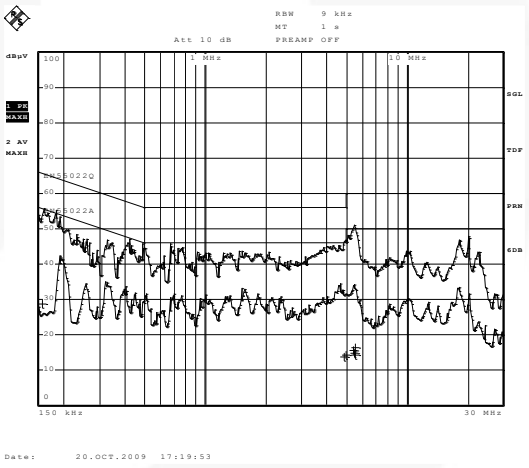

Figure 33. Neutral: 230 V_{AC} / 50 Hz

9.16. Surge Test

Test Condition

- 230 V_{AC} / 50 Hz, maximum load.
- N-PE / L-PE: (Positive & Negative) 1 kV ~ 4 kV, Phase 0°, 90°, 180°, 270°.
- L-N: (Positive & Negative) 500 V ~ 1 kV, Phase 0°, 90°, 180°, 270°.

Table 19. Test Results

	L-PE	N-PE	L-N
Result	±4.4 kV	±4.4 kV	±2 kV

9.17. ESD Test

Test Condition:

- 230 V_{AC} / 50 Hz, maximum load.
- Air discharge: (Positive & Negative) 8 kV ~ 16 kV, 20 times per level.
- Contact discharge: (Positive & Negative) 4 kV ~ 8 kV, 20 times per level.

Table 20. Test Result

	Air Discharge	Contact Discharge
Result	±16.5 kV	±8.8 kV

10. Revision History

Rev.	Date	Description
1.0	January 2015	Initial Release
1.1	June 2015	BOM updated, Figure 7 replaced, Table 2, 3,

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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