Engineering Test & Characterization Report

FAN6961+FSFR2100 200W Street Lighting Converter

Featured FSC Products: FAN6961, FSFR2100, FDPF20N50,FFPF08H60S,FFPF12UP20DN,

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Table of Contents

1. Introduction

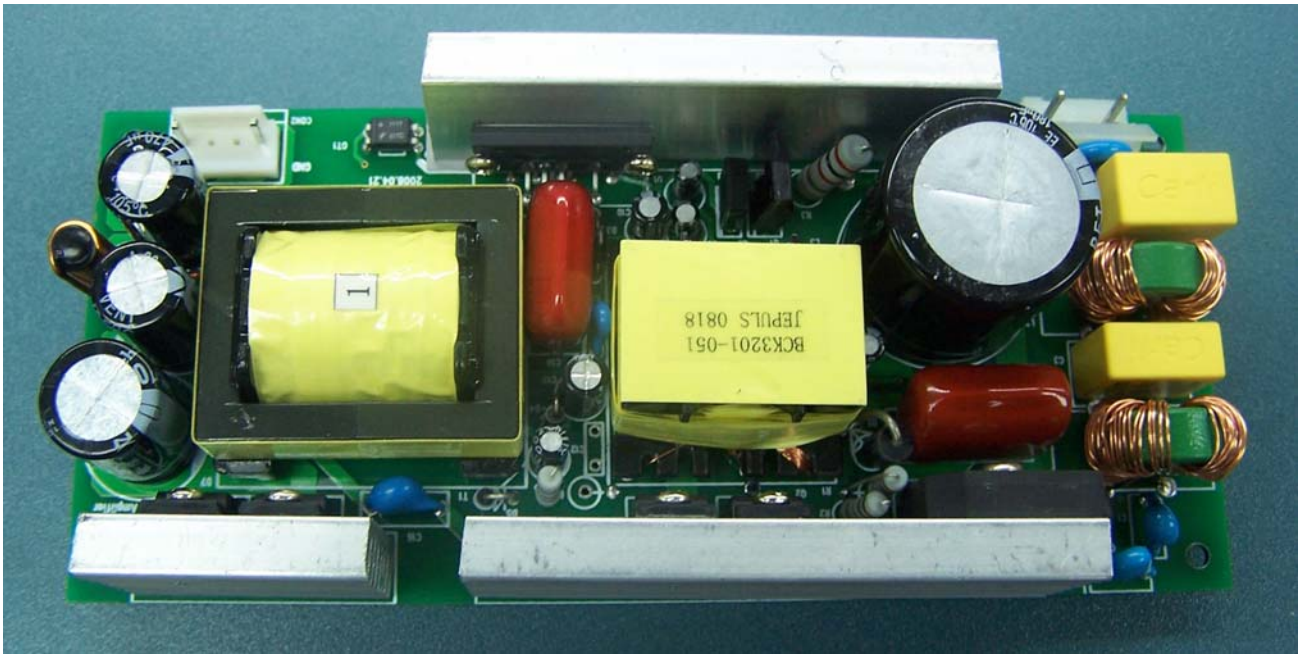
1.1. Product Description

This document describes the performances of a 200W reference board, with wide-range operation and power-factor-correction (PFC). High efficiency is achieved by using the soft-switching technology of ZVS, and also has a good EMI result. Its electrical specification is mainly applied to the Street Lighting.

The main feature of this design solution is including with the PFC stage, the main PFM converter . The Power Supply mainly utilizes the semiconductor components of Fairchild, for example: FAN6961 – An advanced CRM PFC controller, FSFR2100 – A high-efficiency half-bridge resonant converter control IC. The single output 52.5V-4A.

This document contains some important information (e.g. Schematic, Bill of Materials, Transformer documentation, Printed circuit layout and electrical performance data). Additional soft copy of the above item could also be obtained from the related sales channels of Fairchild (or visit *http://www.fairchildsemi.com*).

1.2. Finished Assembly



2. Electrical Requirements

2.1 Input Requirements

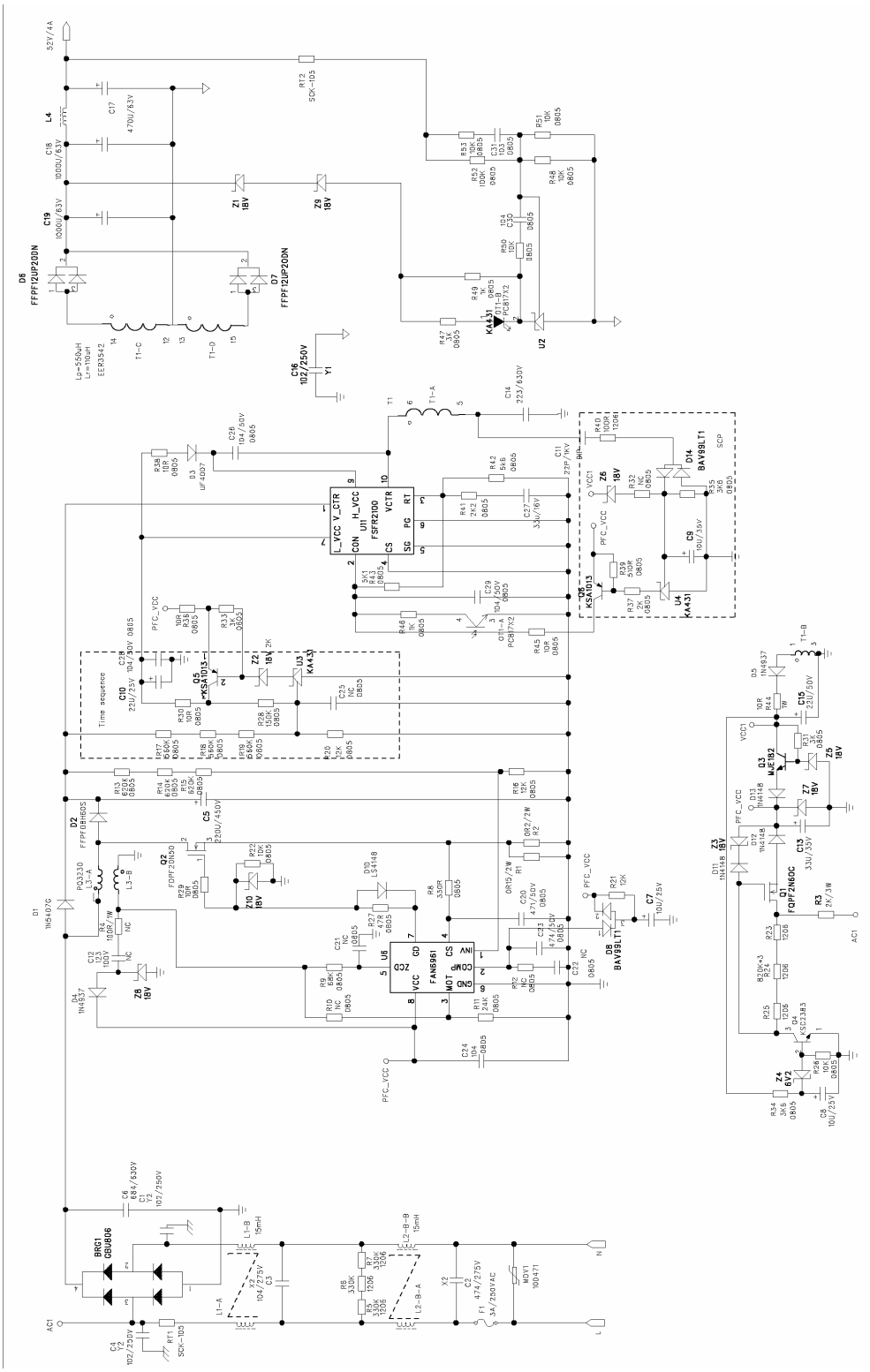
Voltage range: 90 to 264 Vac
Frequency: 47 to 63 Hz

2.2 Output Requirements

Voltage (V)				Regulation	Ripple Voltage (mV)	Current (A)	
Output	Min	Nom	Max			Min	Max
52.5V	49.875	52.5	55.125	5%	300	0.1	4

3. Solution

3.1 Schematic



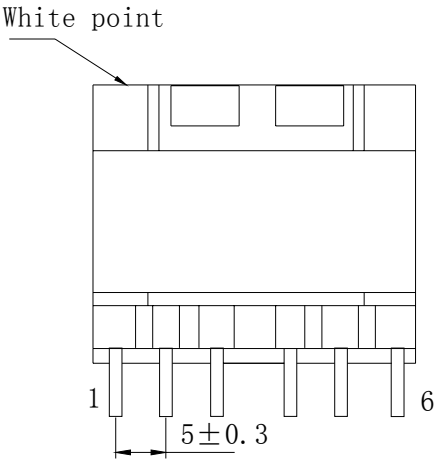
3.2 Circuit description

The circuit consists of two main blocks; the first is a Boost converter whose control is implemented through the Fairchild's FAN6961 controller, whose function is correcting the PF value and decreasing the pollution to the power net. This second block is a half-bridge resonant converter, utilizing the FSFR2100 controller which is a highly integrated power switch, easy designing and high efficiency.

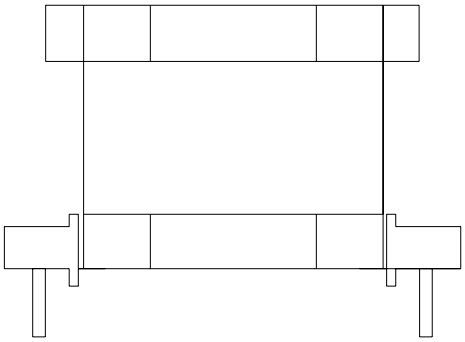
3.3 Magnetic components specification

3.3.1 PFC Inductor specification

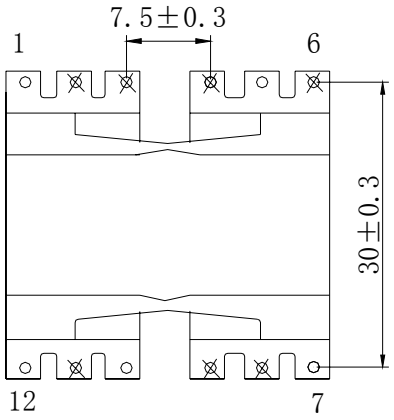
Sketch chart



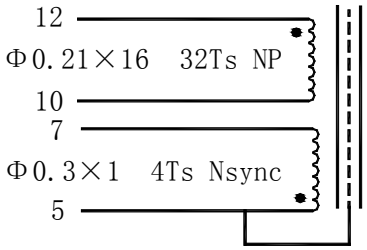
Main view



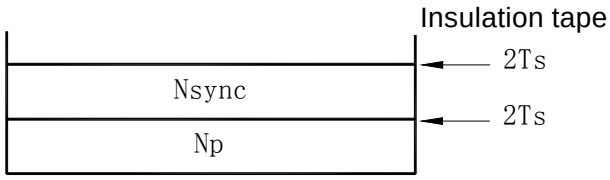
Side view



Bottom view



Theory diagram



Winding diagram

Electrical performance：

1. Inductance：L(12—10)=200uH±10%

Winding request：

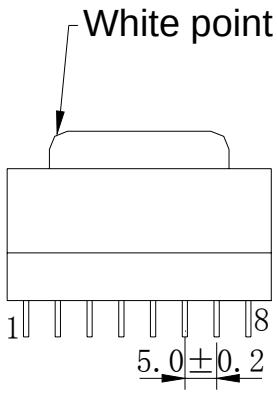
1. Winding should be tight, no crossing and should fill in the whole window averagely;
2. Three layer insulating tape should be placed at the external layer after finishing winding the wire;
3. Pin1 should be highlighted with white point on the bobbin;

Material：

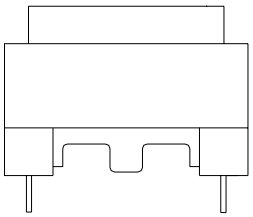
1. Magnetic Core：TDK PC40 PQ3225
2. Bobbin：PQ3235, 12pin，Pin distance 5mm, Row distance 30mm

3.3.2 Main transformer specification

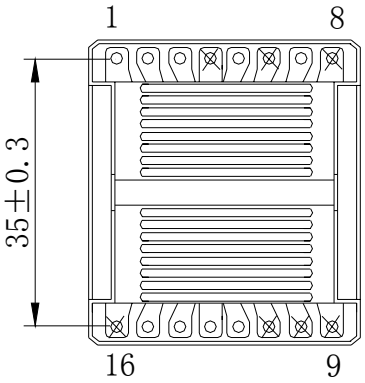
Sketch chart



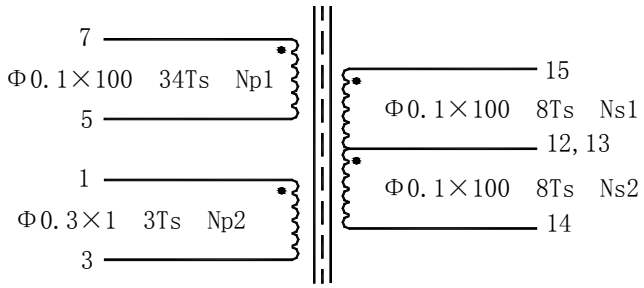
Main view



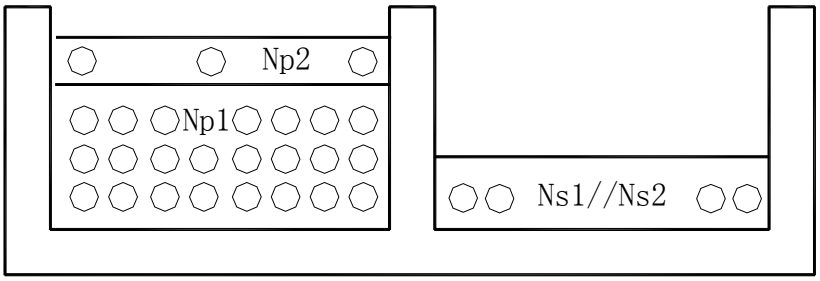
Side view



Bottom view



Theory diagram



Winding diagram

Material :

1、Magnetic core: TDK PC40 EER3542
2、Bobbin: EER3542 Horizontal 16Pin

Winding request:

1、No margin tape, The gap be gotten through rubbing the center pole;
2、Pin1 should be highlighted with white point on the bobbin;

Electrical request:

Inductance : Lp(7---5) = 550uH±10% @ 100KHz, 1V
Lr(7---5) = 110uH±10% @ 100KHz, 1V, short the winding Ns1,Ns2

3.4 Bill Of Material

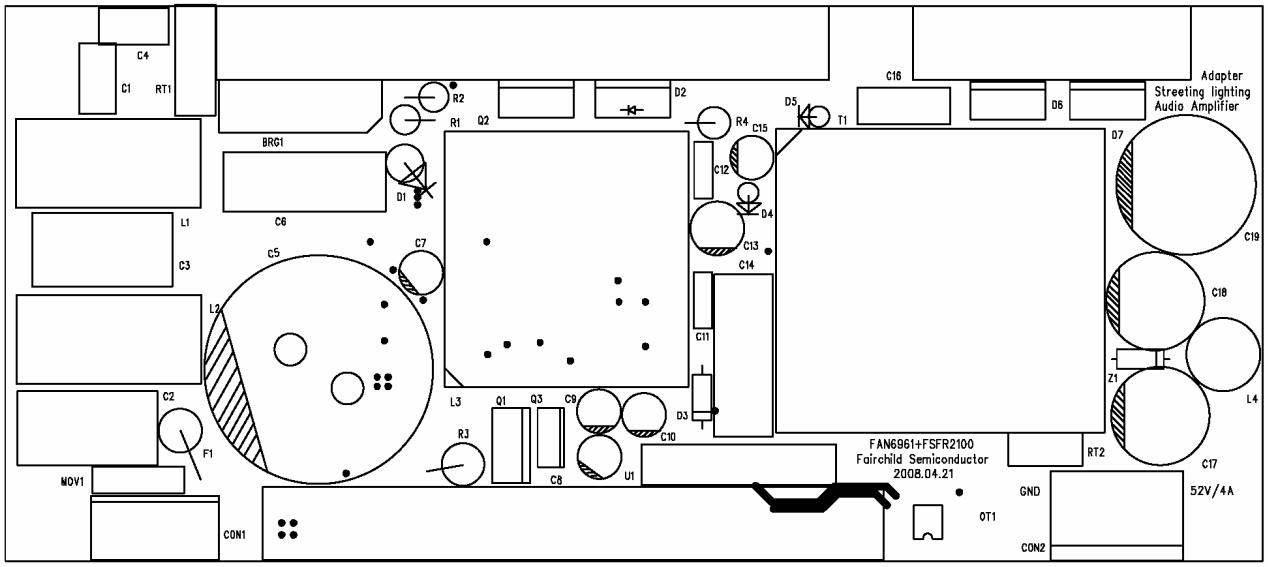
Reference	Qty	Part Name	Item
C12, C21, C22, C25, R12, R32, R4	7	NC	
RT2	1	Jumper	
C1, C4	2	102/250VAC	Ceramic Capacitor
C16	1	102/250VAC	
C11	1	22P/1KV	
C2	1	474/275VAC	Film Capacitor
C3	1	104/275VAC	
C6	1	684/630VDC	
C14	1	223/1600VDC	
C27	1	33uF/16V	Electric Capacitor
C7, C8, C9	3	10uF/25V	
C10	1	22uF/25V	
C13	1	33uF/25V	
C15	1	22uF/50V	
C17, C18	2	470uF/63V	
C19	1	1000uF/63V	
C5	1	220uF/450V	
C20	1	471/50V	SMD Capacitor
C23	1	474/50V	
C31	1	103	
C24, C26, C28, C29, C30	2	104/50V	
BRG1	1	GBU806	Rectifier Bridge
D8, D14	2	BAV99	SMD Diode
D1	1	1N5408	Diode
D3	1	UF4007	
D4, D5	2	1N4937	
D10, D11, D12, D13	4	LS4148	
D6, D7	2	FFPF12UP20DN	
D2	1	FFPF08H60S	
Z1, Z3, Z5, Z6, Z7, Z8, Z9, Z10	8	18V	Zener Diode
Z2	1	18V/2K	
Z4	1	6V2	
Q1	1	FQPF2N60C	Mosfet
Q2	1	FDPF20N50	
Q4	1	MMBT4401	Transistor
Q5, Q6	2	MMBT4403	
Q3	1	MJE182	
U11	1	FSFR2100	Main IC

U2, U3, U4	3	KA431SMF	Reference shunt
U6	1	FAN6961	PFC IC
OT1	1	FOD817C	Opto-couple
MOV1	1	10D471	MOV
F1	1	3A/250VAC	Fuse
CON1	1	Input terminal	2PIN
CON2	1	Output terminal	4PIN
L4	1	Deferential Inductor	10mH
L1, L2	2	Common Inductor	15mH
T1	1	EER3542	Main Transformer
R44	1	10R	1W
R1, R2	2	0R15	
R3	1	2K	3W
R5, R6, R7	3	330K	SMD 1206
R23, R24, R25	3	820K	
R40	1	100R	
R8	1	330R	SMD 0805
R9	1	68K	
R10	1	NC	
R11	1	20K	
R22, R26, R48, R50, R51	6	10K	
R13, R14, R15	3	620K	
R16, R20, R21	3	12K	
R17, R18, R19	3	560K	
R27	1	47R	
R28	1	150K	
R29, R30, R36, R38, R45	5	10R	
R43, R47	2	5K1	
R31, R33	2	3K	
R34, R35	1	3K6	
R37	1	2K	
R39	1	510R	
R41	1	2K2	
R42	1	5K6	
R46, R49	2	1K	
R52	1	100K	
RT1	1	SCK105	NTC

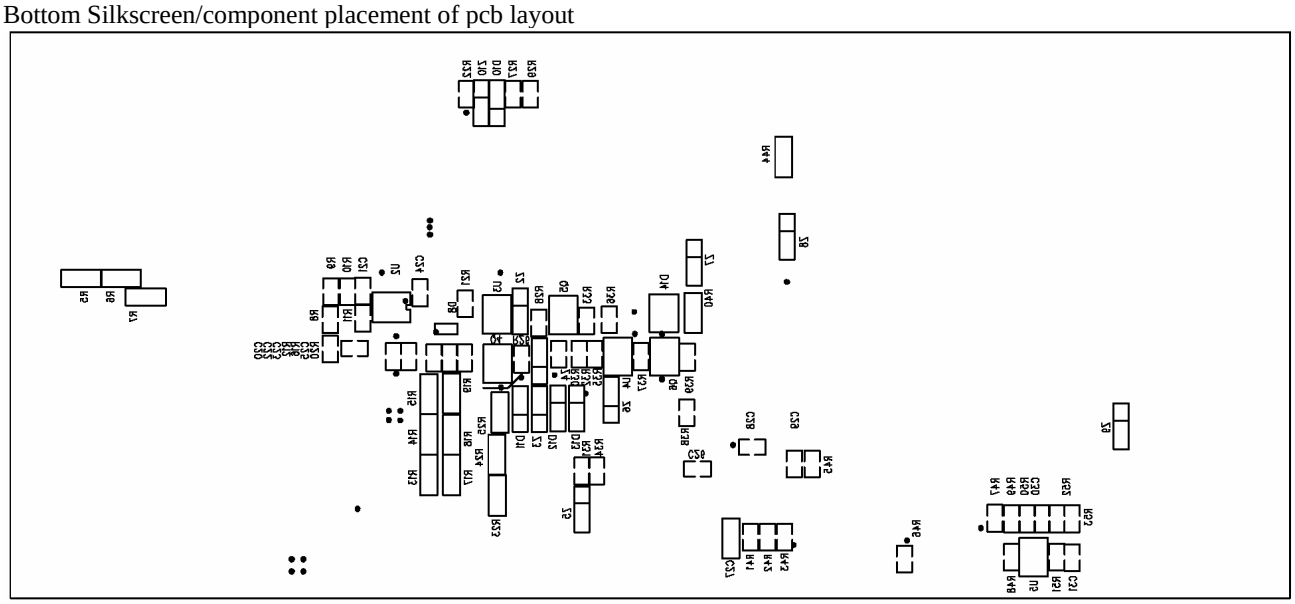
3.5 PCB layout

The PCB is a single sided board made of FR4 with 2oz copper.

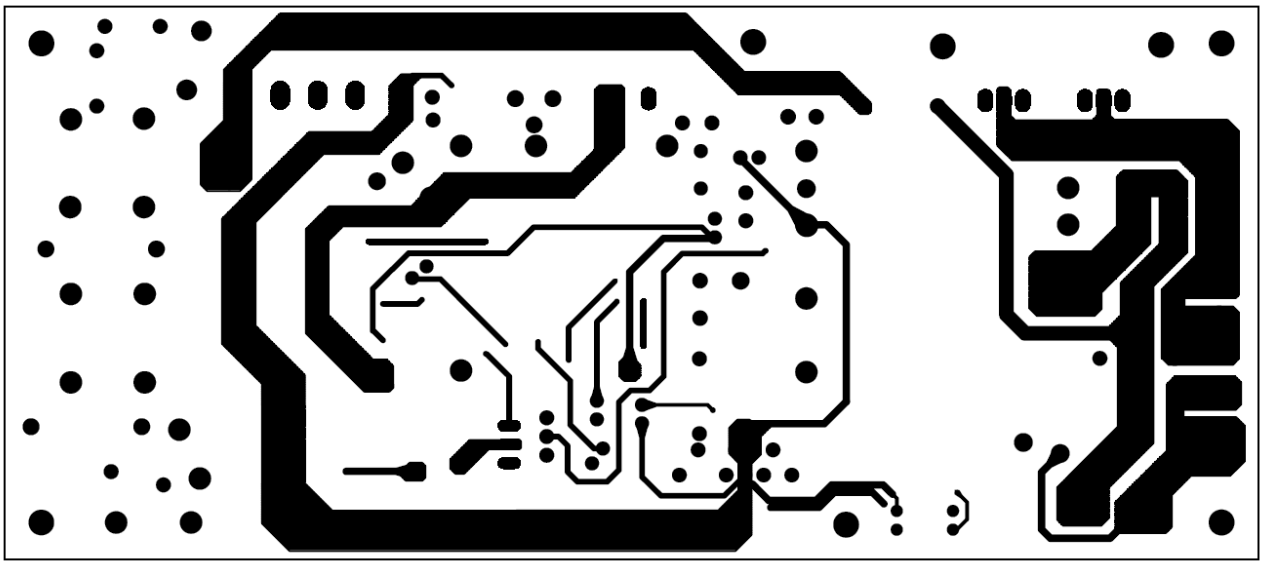
Top Silkscreen/component placement of pcb layout**.**



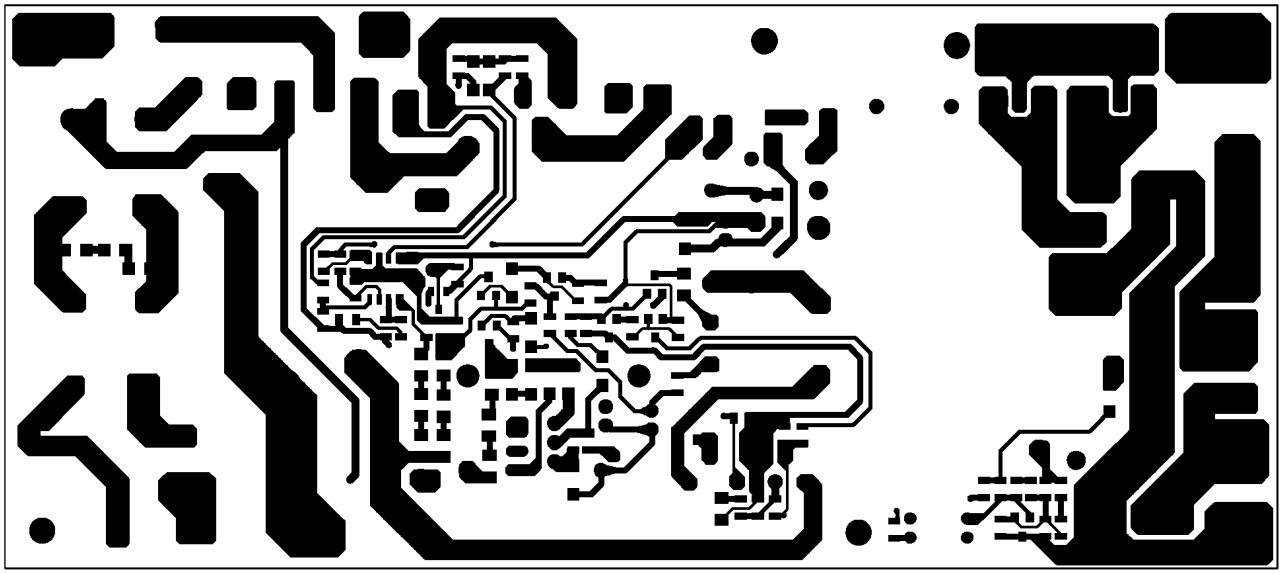
Bottom Silkscreen/component placement of pcb layout



Top routing of pcb layout



Bottom routing of pcb layout



4. Test Results

4.1 Line and load Regulation

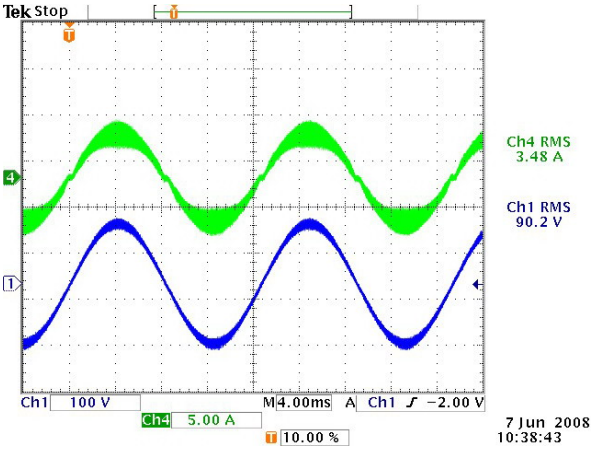
Input Voltage	Load condition	52.5Voutput(V)
		49.875-55.125
90Vac	4A	52.3
	0.1A	52.3
110Vac	4A	52.3
	0.1A	52.3
220Vac	4A	52.3
	0.1A	52.3
264Vac	4A	52.3
	0.1A	52.3

4.2 Efficiency

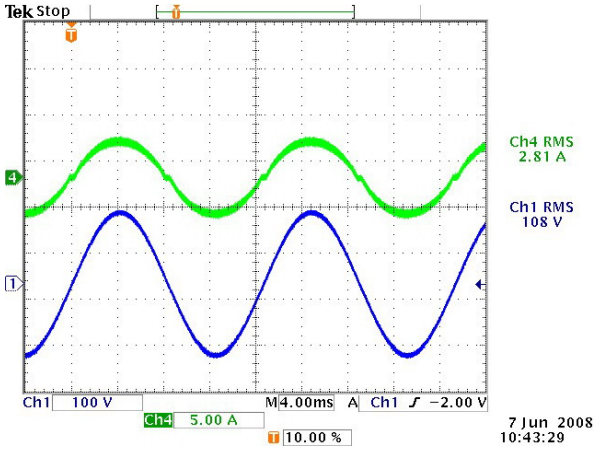
Input Voltage	Load condition	Output Power(w)	Input Power(w)	Efficiency (%)	Power Factor
90Vac	52.5V/4A	209.46	238.7	87.75	0.9916
110Vac	52.5V/4A	209.46	234.2	89.44	0.9982
220Vac	52.5V/4A	209.46	226.2	92.60	0.9867
264Vac	52.5V/4A	209.46	225.0	93.09	0.9783

4.3 Operation Waveform

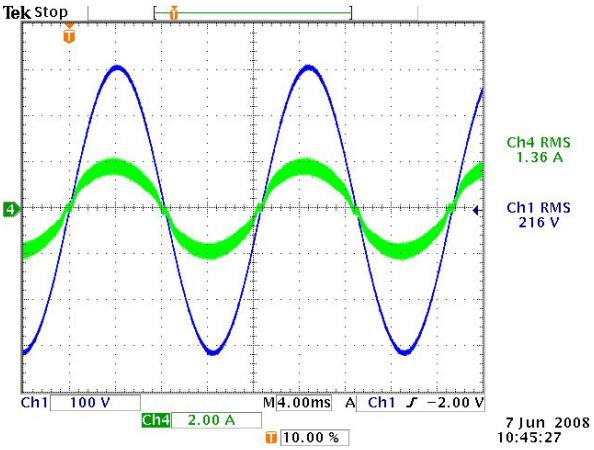
90Vac input, fullload, normal, Vin VS Iin



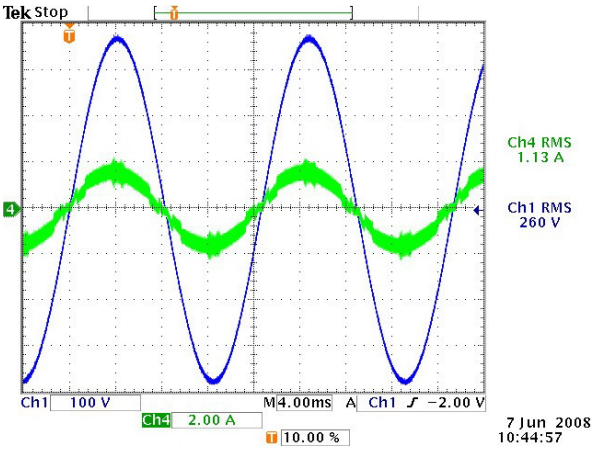
110Vac input, fullload, normal, Vin VS Ii



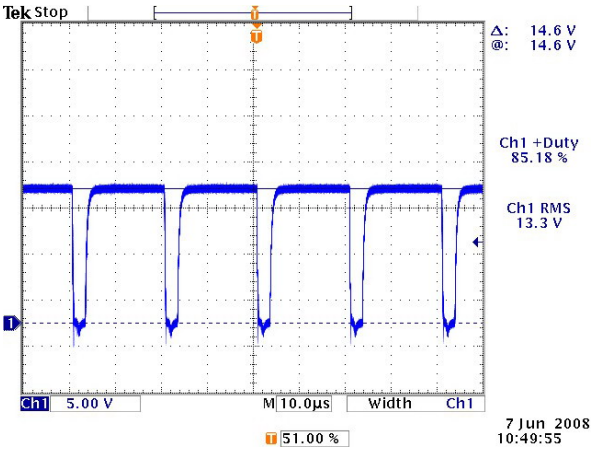
220Vac input, fullload, normal, Vin VS Iin



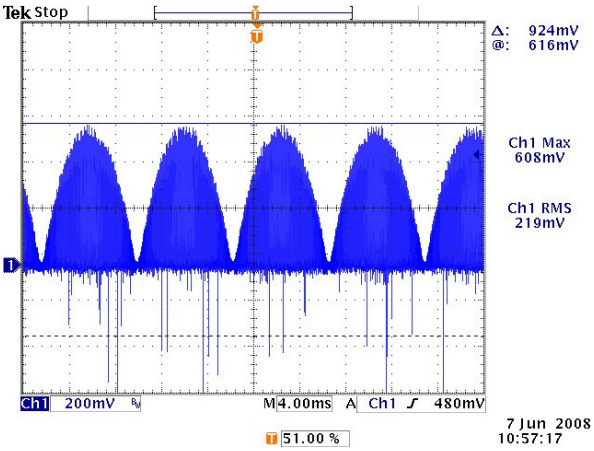
264Vac input, fullload, normal, Vin VS Iin



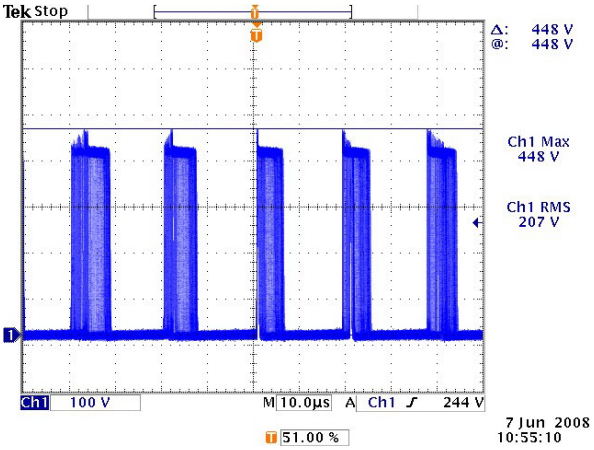
110Vac input， normal, PFC mosfet driver (Dmax)



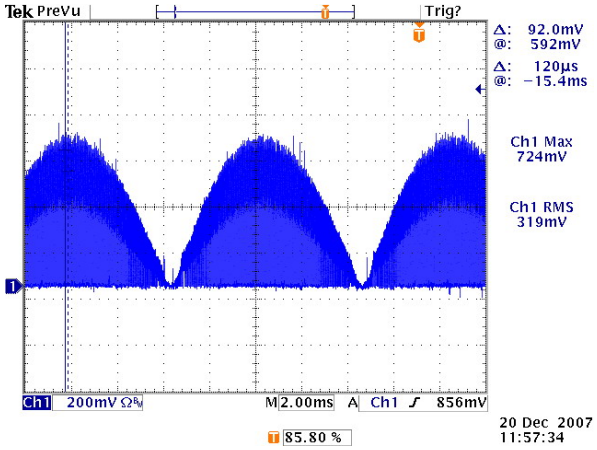
110Vac input, normal, Voltage of the sense resistor



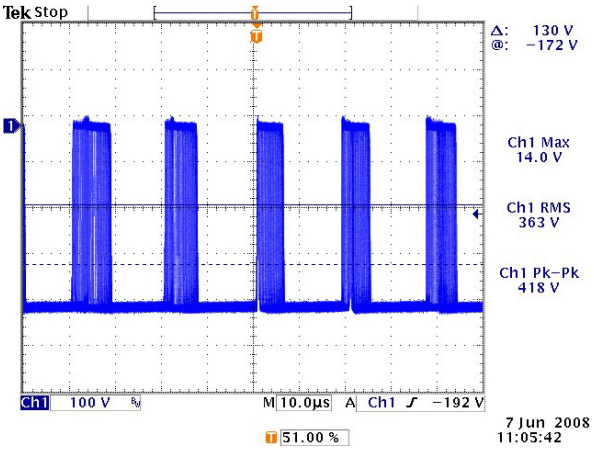
110Vac input ,normal, Vds of PFC mosfet



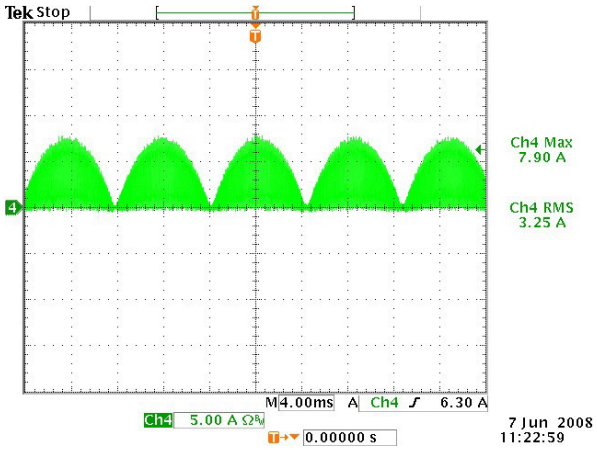
110Vac input, normal, Id of PFC mosfet



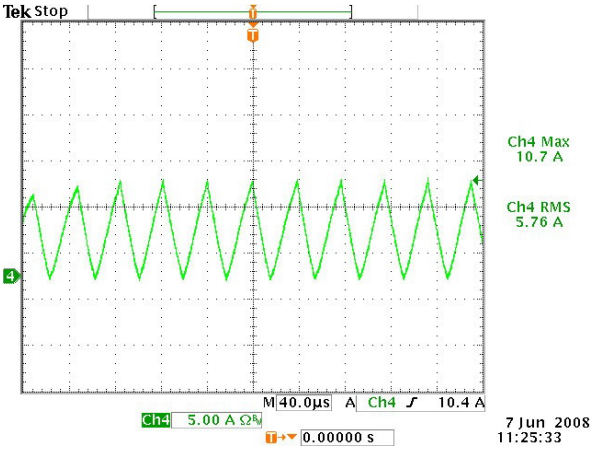
110Vac input ,normal, Vak of PFC diode



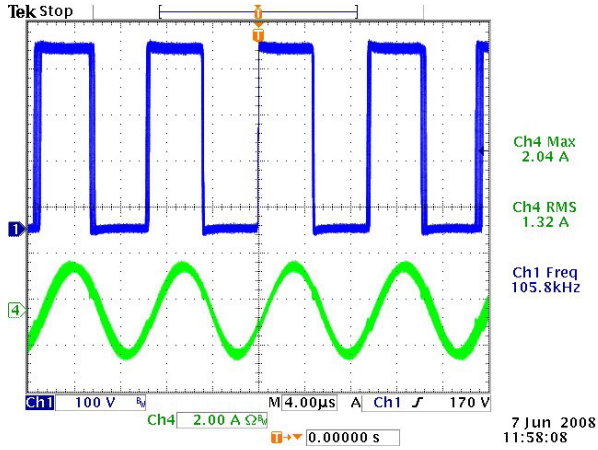
110Vac input, normal, current of PFC inductor



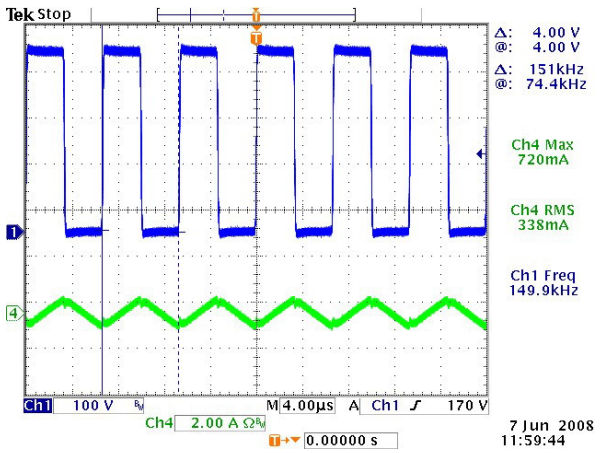
110Vac input, startup, current of PFC inductor



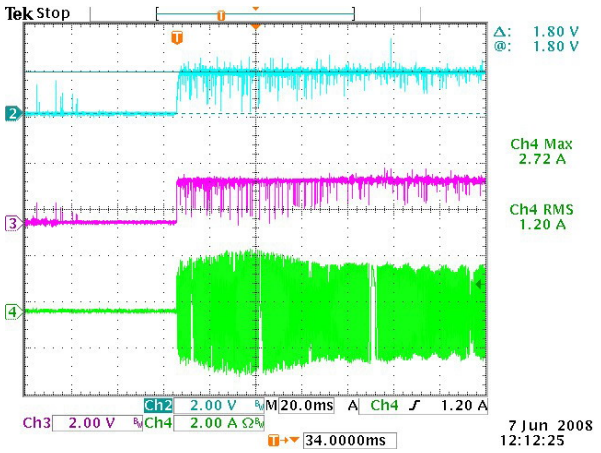
110Vac input, fullload, Icr vs Vds(low side mosfet)



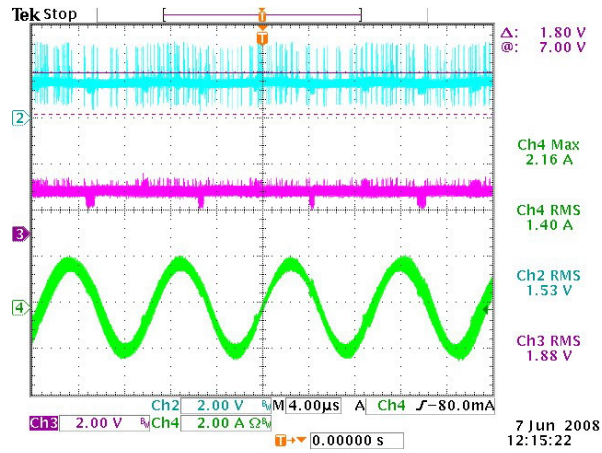
110Vac input, lightload, Icr vs Vds(low side mosfet)



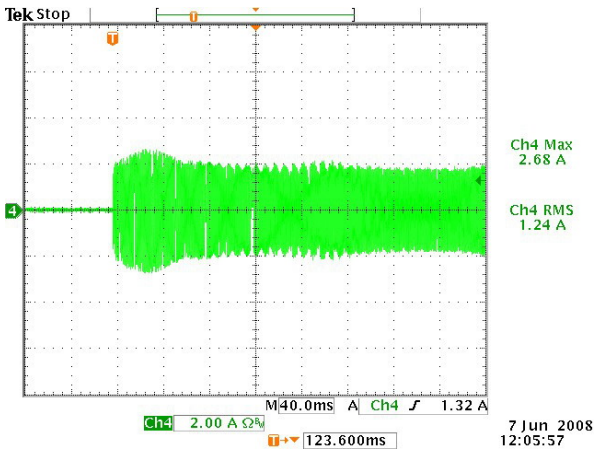
110Vac input,startup, Icr(CH4) Vcon(CH2) V_Rt(CH3)



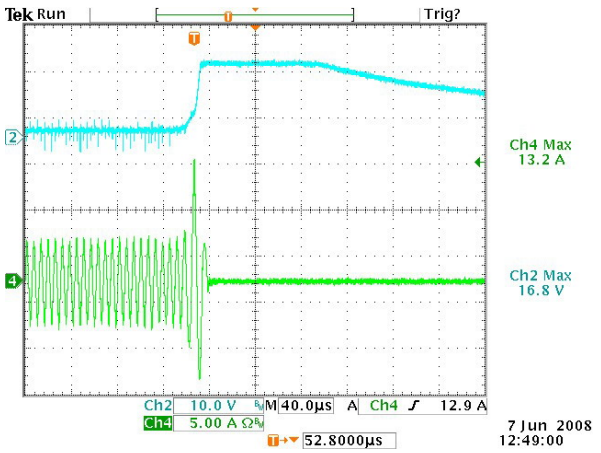
110Vac input,startup, Icr(CH4) Vcon(CH2) V_Rt(CH3)



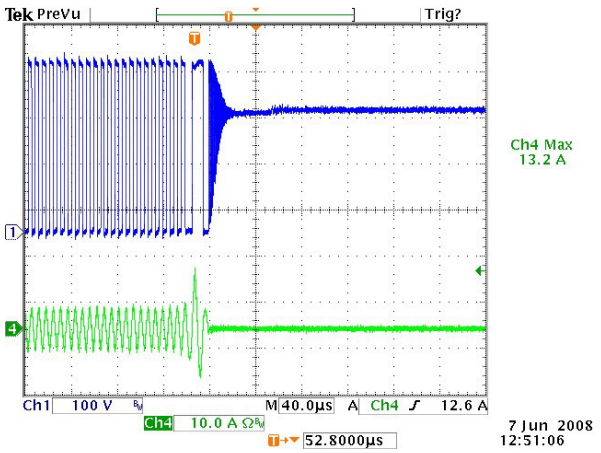
110Vac input, start-up, Icr



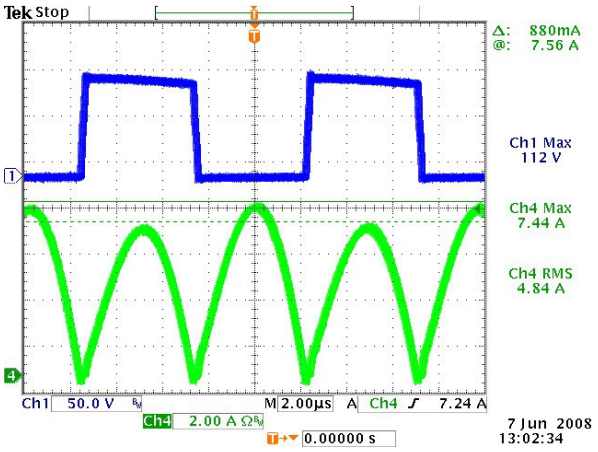
Output short circuit, Icr VS Vcon



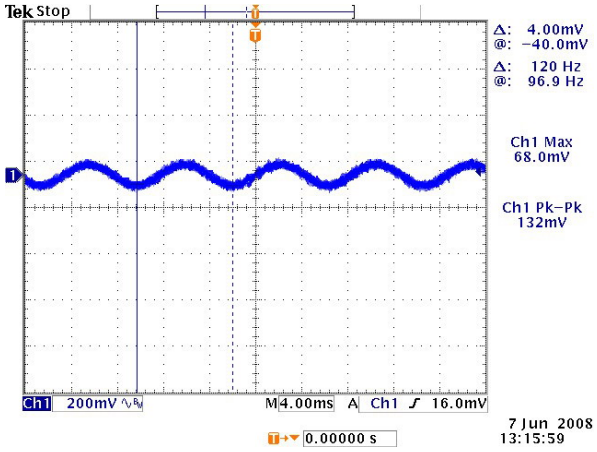
Output short circuit, Icr VS Vds



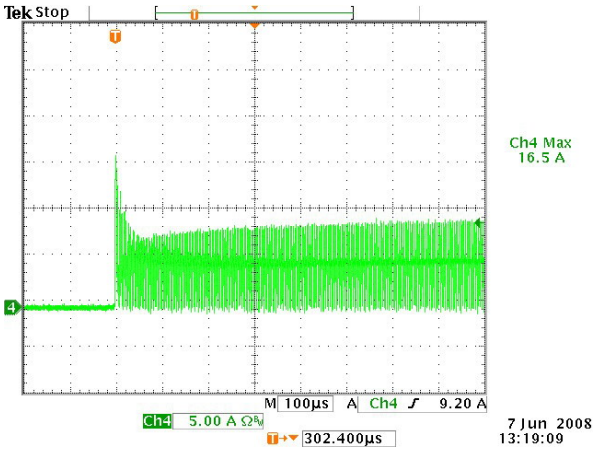
Current and voltage stress of rectifier diode



Output ripple and noise



Output short circuit, current of rectifier diode



4.4 Protection

4.4.1 Output Short Test

If output is short, the control IC can auto-restart, and the protection mode is hiccup.
When output is overvoltage or open loop, the output voltage will be clamped a constant value.

5. Featured Products

5.1 FAN6961

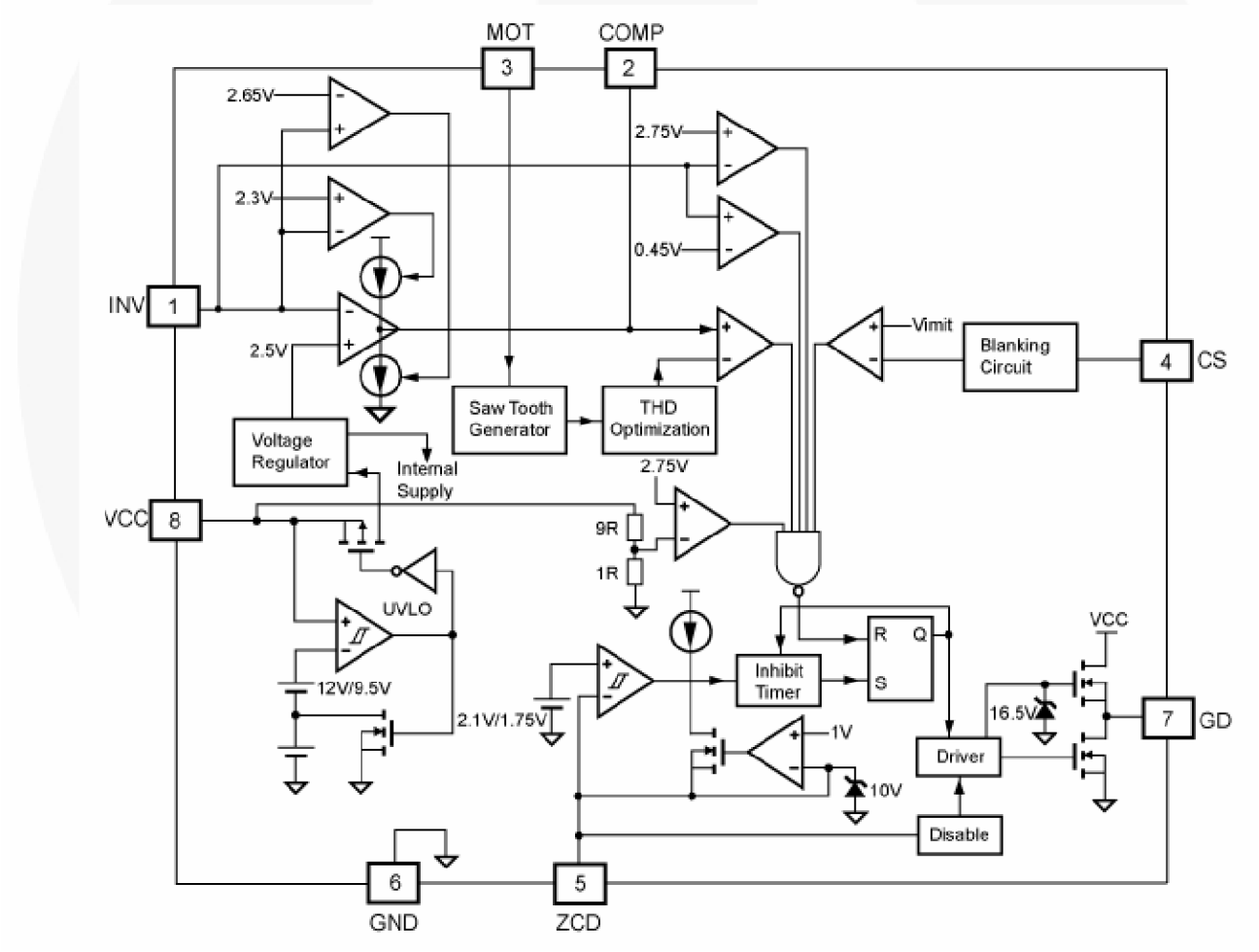
5.1.1 Product Description

The FAN6961 is an 8-pin, boundary-mode, PFC controller IC intended for controlling PFC pre-regulators. The FAN6961 provides a controlled on-time to regulate the output DC voltage and achieve natural power factor correction. The maximum on-time of the external switch is programmable to ensure safe operation during AC brownouts. An innovative multi-vector error amplifier is built in to provide rapid transient response and precise output voltage clamping. A built-in circuit disables the controller if the output feedback loop is opened. The start-up current is lower than 20µA and the operating current has been reduced to under 6mA. The supply voltage can be up to 25V, maximizing application .

5.1.2 Feature

- **Boundary Mode PFC Controller**
- **Low Input Current THD**
- **Controlled On-Time PWM**
- **Zero-Current Detection**
- **Cycle-by-Cycle Current Limiting**
- **Leading-Edge Blanking instead of RC Filtering**
- **Low Start-up Current: 10µA Typical**
- **Low Operating Current: 4.5mA Typical**
- **Feedback Open-Loop Protection**
- **Programmable Maximum On-Time (MOT)**
- **Output Over-Voltage Clamping Protection**
- **Clamped Gate Output Voltage 16.5V**

5.1.3 Internal Block Diagram



5.2 FSFR2100

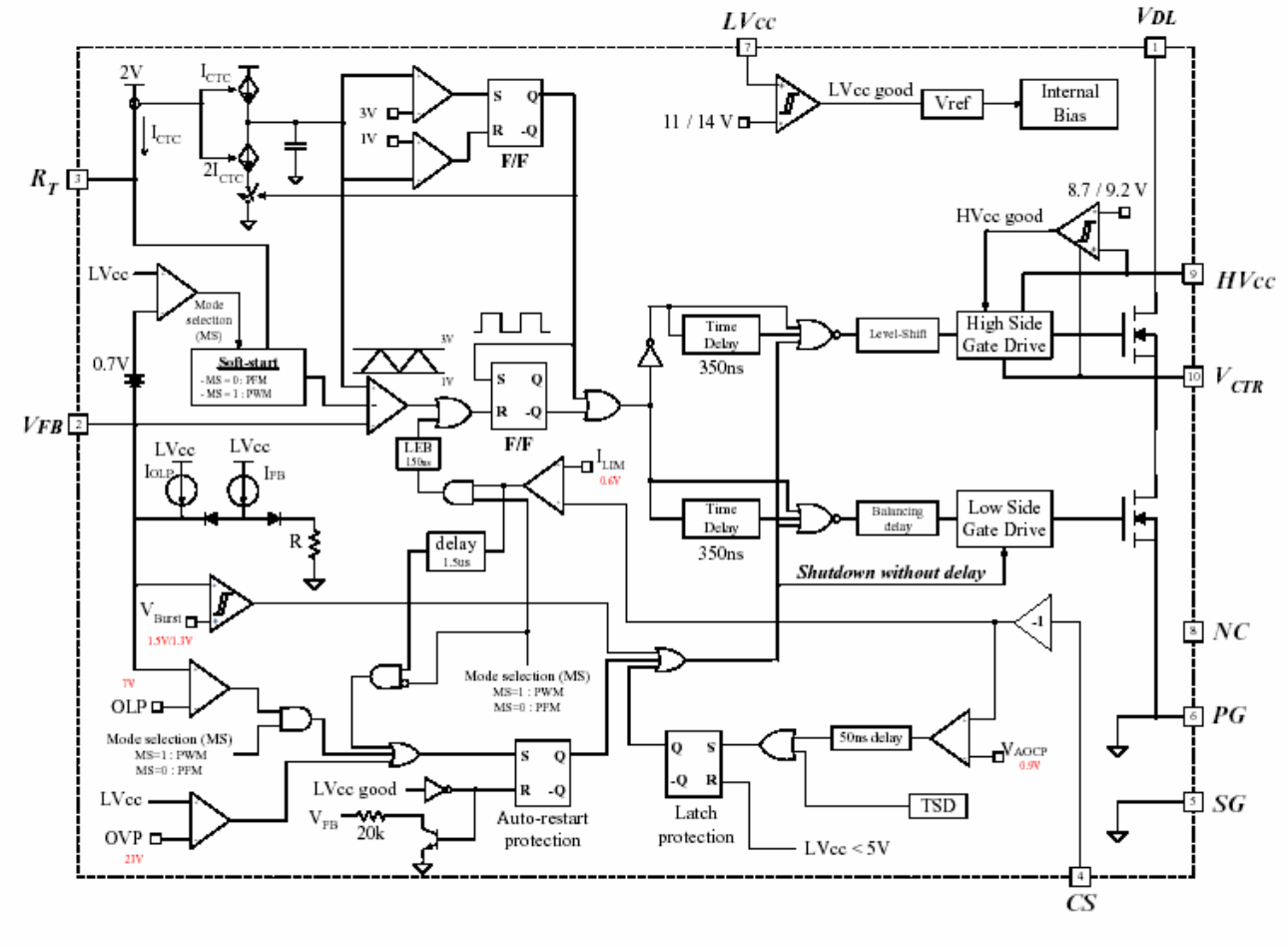
5.2.1 Product Description

The growing demand for higher power density and low profile in power converter designs has forced designers to increase switching frequencies. Operation at higher frequencies considerably reduces the size of passive components such as transformers and filters. However, switching losses have been an obstacle to high frequency operation. In order to reduce switching losses, allowing high frequency operation, resonant switching and PWM soft-switching techniques have been developed. These techniques allow the switching devices to be softly commutated. Therefore, the switching losses and noise can be dramatically reduced. FSFR2100 is an integrated Pulse Width Modulation (PWM)/Pulse Frequency Modulation (PFM) controller and Super FETs specifically designed for Zero Voltage Switching (ZVS) half-bridge converters with minimal external components. The internal controller includes an oscillator, under voltage lockout, leading edge blanking (LEB), optimized high side / low side gate driver, internal soft start, temperature compensated precise current sources for a loop compensation and self protection circuitry. Compared with discrete MOSFET and PWM controller solution, FSFR2100 can reduce total cost, component count, size and weight, while simultaneously increasing efficiency, productivity, and system reliability.

5.2.2 Feature

- **According to the feedback circuit configuration, it can be used for PWM (Pulse-Width-Modulation) control or PFM (Pulse-Frequency-Modulation) control.**
- **Can be applied to various topologies : Asymmetric PWM half bridge converter, LLC resonant Half-bridge converter, Asymmetric PWM flyback converter, Active clamp flyback converter**
- **High efficiency through zero voltage switching (ZVS)**
- **Internal soft-start (Duty cycle controlled soft-start for PWM operation and Frequency controlled soft-start for PFM operation**
- **Internal SuperFET with Fast Recovery Type Body Diode (trr=120ns)**
- **Pulse-by-Pulse Current Limit**
- **Various Protection functions: Over Load Protection (OLP), Over Voltage Protection (OVP), Over Current Protection (OCP), Abnormal Over Current Protection (AOCP), Internal Thermal Shutdown (TSD)**

5.2.3 Internal Block Diagram



6. Warning and Disclaimer

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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