AN2331
Application note

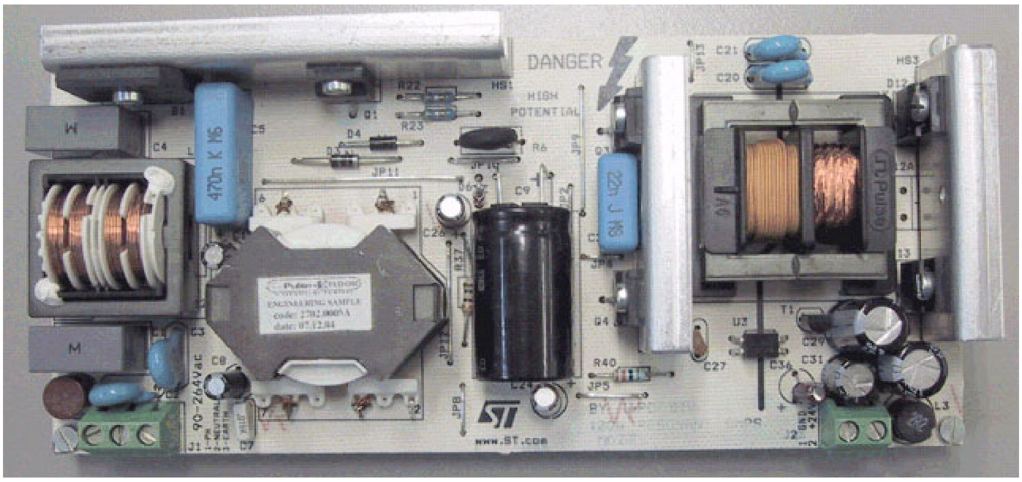
Reference design: 100W high performance, half bridge LLC multi-resonant SMPS with PFC

Introduction

This note describes the performances of a 100 W, wide-range mains, power-factor-corrected AC-DC adapter reference board (EVAL6598-100W). The peculiarities of this design are the high efficiency and the low no-load input consumption. The architecture is based on a two-stage approach: a front-end PFC pre-regulator based on the L6563 TM PFC controller and a downstream multi-resonant half-bridge converter using the L6598 resonant controller.

The PFC TM operation and the top-level efficiency performance of the HB-LLC topology provide very good overall circuit efficiency.

Figure 1. L6598 and L6563 100W resonant SMPS reference board



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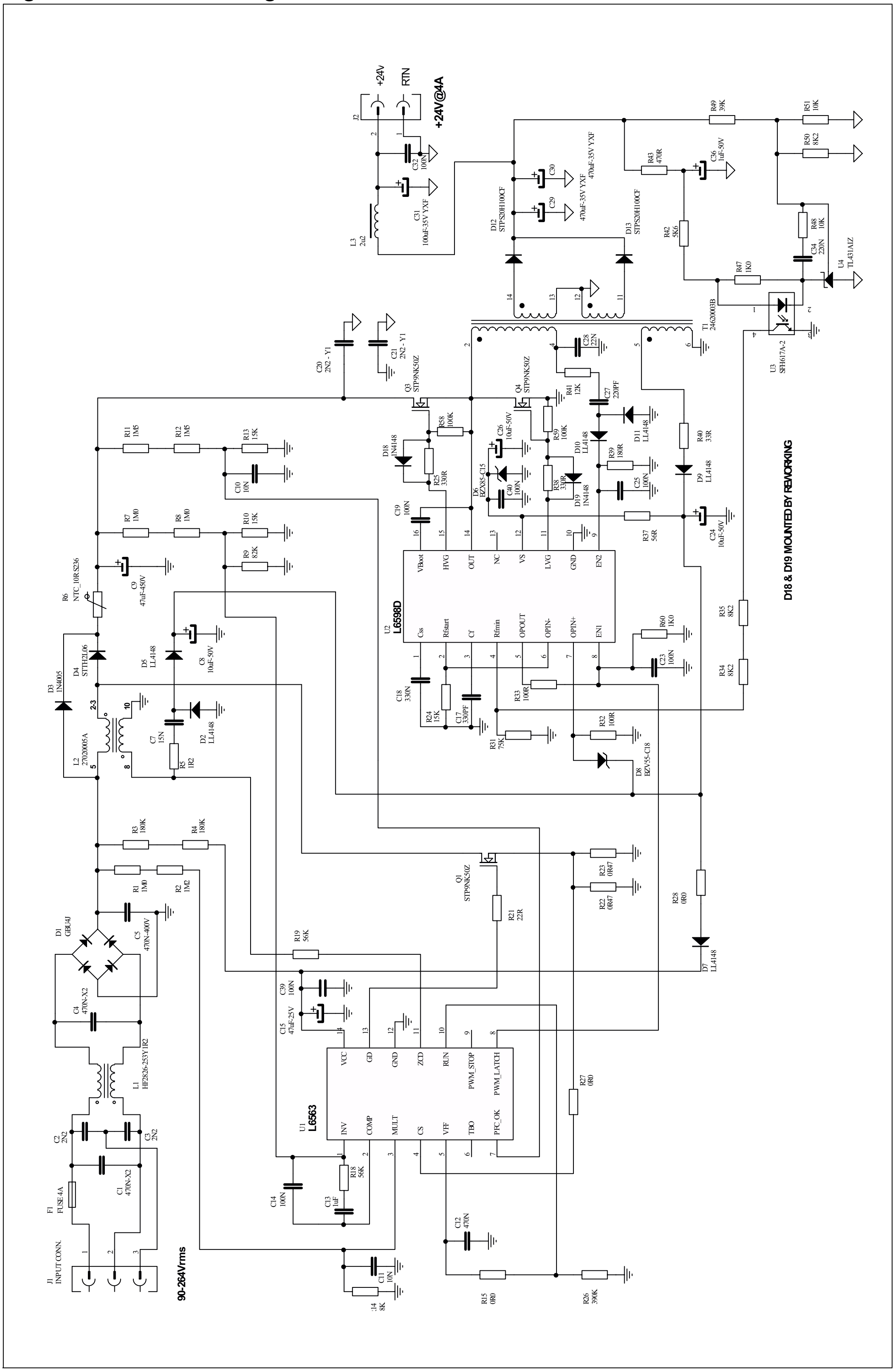
1 Main characteristics

The main characteristics of the SMPS are listed here below:

- Universal input mains range: 90 to 264Vac - frequency 45 to 65 Hz
- Output voltage: 24V@4A continuous operation, peak current up to 5A
- Mains harmonics: Compliance with EN61000-3-2 specifications
- Standby mains consumption: <2W
- Overall efficiency: better than 90% @230Vac
- EMI: Compliance with EN55022-class B specifications
- Safety: Compliance with EN60950 specifications
- Simple resonant trafo winding: using the integrated magnetic approach
- Low profile design, 25mm maximum height
- Low-cost approach:
  - Low part count & diversity
  - Mixed PTH/SMT for PCB and labor cost reduction
  - PCB single layer 78x170 mm

Figure 2. Electrical diagram



2 Circuit description and test results

The circuit consists of two stages: a front-end PFC implementing the L6563 and a resonant DC/DC converter based on the L6598. The PFC stage delivers a stable 400Vdc and provides for the reduction of the mains harmonic in compliance with European standard EN61000-3-2. The controller is the L6563 (U1), working in transition mode and integrating all functions are needed to perform the PFC. The power stage of the PFC is a conventional boost converter connected to the output of the rectifier bridge. It includes the coil L2, the diode D4 and the capacitor C9. The boost switch is represented by the power MOSFET Q1. The L2 secondary winding (pins 8-10) and related circuitry are dedicated to power the L6563 during normal operation, after the start-up phase and provide for the energy at start-up to the L6598. It provides also the information about the PFC coil core demagnetization to the L6563 via the ZCD pin.

The divider R1, R2 and R14 provides to the controller the information of the instantaneous voltage that is used to modulate the boost current and to derive some further information such as the average value of the AC line, used by the V_{FF} (voltage feed-forward) function. This function allows keeping almost independent the output voltage by the mains one. The divider R7, R8, R9, R10 is dedicated to detecting the output voltage. The second divider R11, R12, R13 is dedicated to protect the circuit in case of voltage loop fail.

The second stage is a resonant converter, half bridge topology, working in ZVS. The control is based on the L6598, incorporating the necessary functions to drive properly the Half-bridge by a 50 percent fixed duty cycle with dead-time, working with variable frequency. The transformer uses the integrated magnetic approach, incorporating the resonant series inductance. Thus, no any external additional coil is needed for the resonance. The transformer configuration chosen for the secondary winding is centre tap, using two Schottky rectifiers. The feedback loop is implemented by means of a classical configuration using a TL431 to adjust the current in the optocoupler diode. The optocoupler transistor modulates the current from pin 4, so the frequency will change accordingly, thus achieving the output voltage regulation. In case of short circuit, the current into the primary winding is detected by the lossless circuit R41, C27, D11, D10, R39, and C29 and it is fed into the pin 9, keeping the current at a safe level.

In case of output voltage loop failure, the intervention of the zener diode via the spare op amp activates the latched enable (EN1) of the L6598. The EN1 pin is also activated by the L6563 via the PWM_LATCH pin in case of PFC loop fail. In this case, the complete circuit is disabled until a power recycle.

2.1 Efficiency measurements

Table 1, *Table 2* and *Figure 3* show the overall circuit efficiency measured for different loads at the nominal input mains range.

Table 1. Efficiency measurements - Vin=115Vac

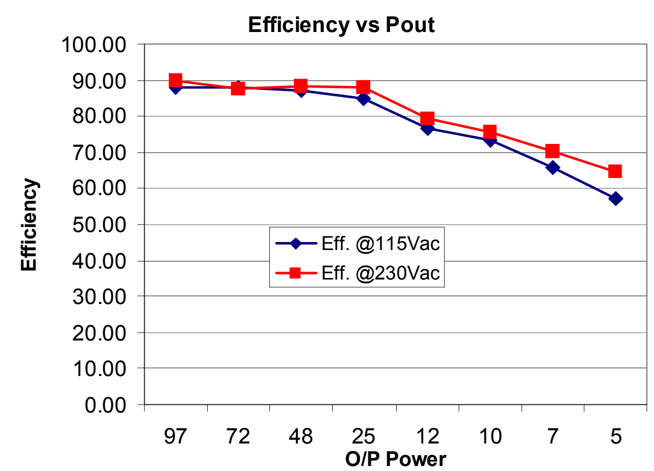
Vout [V]	Iout [A]	Pout [W]	Pin [W]	Efficiency [%]
23.88	4.06	96.95	110.40	87.82
23.90	3.0	71.70	81.50	87.98
23.90	2.0	47.80	54.80	87.23
23.90	1.03	24.62	29.00	84.89
23.90	0.504	12.05	15.70	76.72
23.90	0.401	9.58	13.10	73.16
23.90	0.303	7.24	11.00	65.83
23.90	0.203	4.85	8.50	57.08

Table 2. Efficiency measurements - Vin=230Vac

Vout [V]	Iout [A]	Pout [W]	Pin [W]	Efficiency [%]
23.88	4.06	96.95	107.70	90.02
23.90	3.0	71.70	81.70	87.76
23.90	2.0	47.80	54.00	88.52
23.90	1.03	24.62	28.00	87.92
23.90	0.504	12.05	15.20	79.25
23.90	0.401	9.58	12.70	75.46
23.90	0.303	7.24	10.30	70.31
23.90	0.203	4.85	7.50	64.69

Thanks to the good efficiency of the PFC working in transition mode and to the high efficiency of the resonant stage working in ZVS, the overall efficiency measured is a significantly high number for a two stage converter with 4 amps of output current.

Figure 3. Efficiency vs. Pout



2.2 Stand-by and No-load performance

The circuit has been tested for light load and zero load operation, thus simulating a load disconnection as shown below. The input power at zero load is always below 2W. In this condition the resonant circuit works at its maximum frequency, while the PFC works skipping switching cycles according to the load.

During the no load operation at low mains, the PFC controller is supplied by the self-supply winding of the resonant, because at low load and low mains the PFC self supply cannot deliver the suitable voltage value for correct operations.

Table 3. Stand-by consumption - Vin=115Vac

Vout [V]	**Iout** [A]	**Pout** [W]	**Pin** [W]
23.90	0.1	2.39	5.1
23.90	0.022	0.53	2.03
24.00	0	0	1.5

Table 4. Stand-by consumption - Vin=230Vac

Vout [V]	**Iout** [A]	**Pout** [W]	**Pin** [W]
23.90	0.1	2.39	4.9
23.90	0.022	0.53	2.16
24.00	0	0	1.7

2.3 Short circuit protection

The circuit protects itself in case of an output short circuit. The primary current flowing into the resonant capacitor provides a proportional voltage drop across it that is detected and fed into the pin unlatched enable pin (#9). In case of over current, if the voltage on pin 9 exceeds the internal threshold the soft start capacitor is discharged and the circuit is pushed to work at maximum frequency, thus limiting the current flowing at primary side and the power delivered to the secondary. In short-circuit condition, the average value of the output current is kept constant around 6.5A and the input power is limited to 17W only. At short-circuit removal, the circuit will automatically restart via a soft-start cycle.

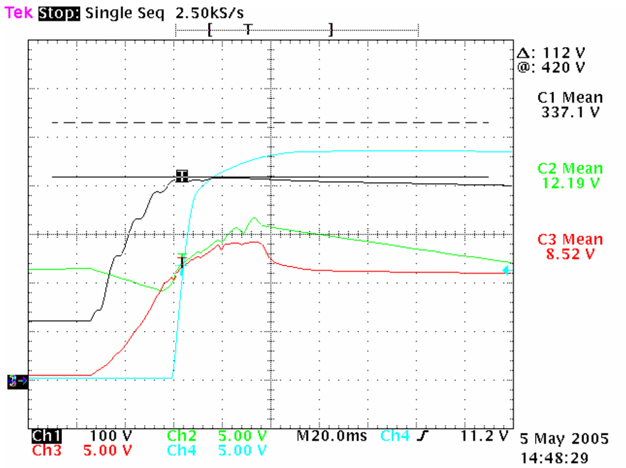
2.4 Over voltage protections

Both circuit stages, PFC and resonant, are equipped with their own over voltage protection. The PFC controller L6563 is internally equipped with a dynamic and a static over voltage protection circuit sensing the error amplifier via the voltage divider dedicated to the feedback loop to detect the PFC output voltage. If the internal threshold is exceeded, the IC limits the voltage to a programmable, safe value. Moreover, in the L6563 there is an additional protection against loop failures using an additional divider (R11, R12, R13) and a dedicated pin (PFC_OK, #7) for protecting the circuit in case of loop failures or disconnection. Hence the PFC output voltage is always under control and in case a fault condition is detected, the PFC_OK circuitry will latch the L6563 operations and, by means of the PWM_LATCH pin (#8), it will latch the L6598 as well.

The resonant stage is also equipped against over voltage or loop disconnections. In fact, the zener diode D8 detects the auxiliary voltage and in case of over voltage the latched enable pin of the L6598 will be activated and it will stop the operations. In this case the L6563 will not be latched but will remain active.

2.5 Start-up sequence

Figure 4. Start-up @90Vac - full load



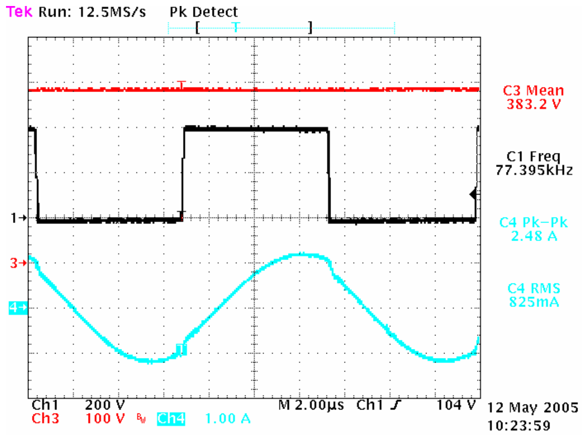
CH1: +400V PFC Output voltage
CH2: L6563 - V_{PIN14}(Vcc voltage)
CH3: L6598 V_{PIN12}(Vcc voltage)
CH4: +24V Output voltage

Figure 4 shows the waveforms during the start at 90Vac and full load. It is possible to note the sequence of the two stages: at power-on the L6563 Vcc increase up to the turn-on threshold and the PFC output voltage increases from the mains rectified voltage to its nominal value, with a small overshoot. In the meantime, the L6598 Vs capacitor (C26) is charged by the L6563 Vcc and, as soon as it reaches the L6598 turn-on threshold, the resonant starts to operate. Hence the output voltage rises according to the soft-start and reaches the nominal level.

This sequence provides for the advantages of a perfect sequencing of the circuit at start-up with the PFC acting as master and avoids complex additional circuitry for the correct start-up of the circuit in all conditions. The circuit has been tested in all line and load conditions showing a correct start-up sequence.

2.6 Resonant stage operating waveforms

Figure 5. Resonant circuit primary side waveforms

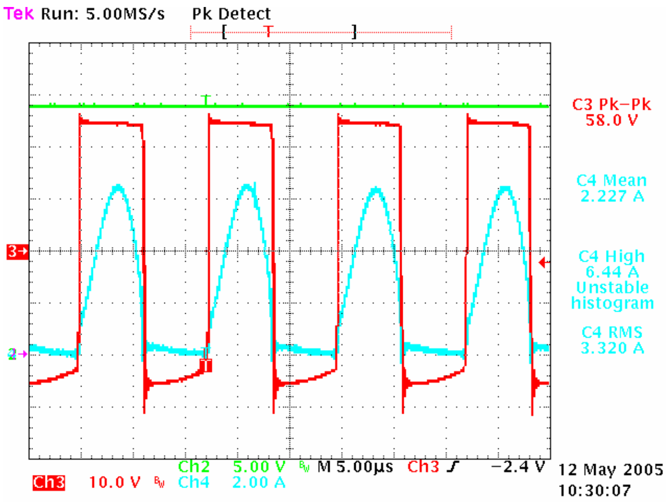


CH1: L6598 - V_{PIN14} (HB voltage)
CH3: +400V - PFC Output voltage
CH4: T1 primary winding current

Figure 5 shows some waveforms during steady state operation at full load of the circuit. The red trace (CH3) is the PFC output voltage, powering the resonant stage. In *Figure 3*, this voltage is a bit lower than the nominal because over imposed there is the 120 Hz ripple that the PFC cannot reject and the picture has been captured when the voltage is at the minimum. The black trace is the half bridge waveform, driving the resonant circuit. In the picture it is not evident, but the switching frequency is normally slightly modulated following the PFC ripple that is rejected by the resonant control circuitry. The selected switching frequency is approximately 80 kHz, in order to have a good trade off between losses in the transformer and its dimensions. The transformer primary current wave shape is almost sinusoidal, because the operating frequency is very close to the resonance of the leakage inductance and the resonant capacitor (C28).

This enables the circuit to have a good margin for ZVS operations providing good efficiency and the sine wave shape provides an extremely low EMI generation.

Figure 6. Resonant circuit secondary side waveforms



CH2: +24V Output voltage
CH3: D12 rectifiers anode voltage
CH4: D12 rectifiers current

Figure 6 shows some waveforms relevant to the secondary side where the current in each diode is a rectified sine wave. The diode reverse voltage is indicated on the right of the picture and it is a bit higher than the theoretical value that would be 2Vout, then 48V. It is possible to notice there is a small ringing on the bottom side of the wave form, responsible for this difference.

Thanks to the advantages of the resonant converter, the high frequency ripple and noise of the output voltage is only 60mV (0.25%) including spikes, while the residual ripple at mains frequency is 120mV at maximum load and any line condition.

3 Conducted emission pre-compliance test

The limits indicated in both diagrams at 115Vac and 230Vac comply with EN55022 Class-B specifications. The values are measured in peak detection mode.

Figure 7. CE peak measure at 115Vac and full load

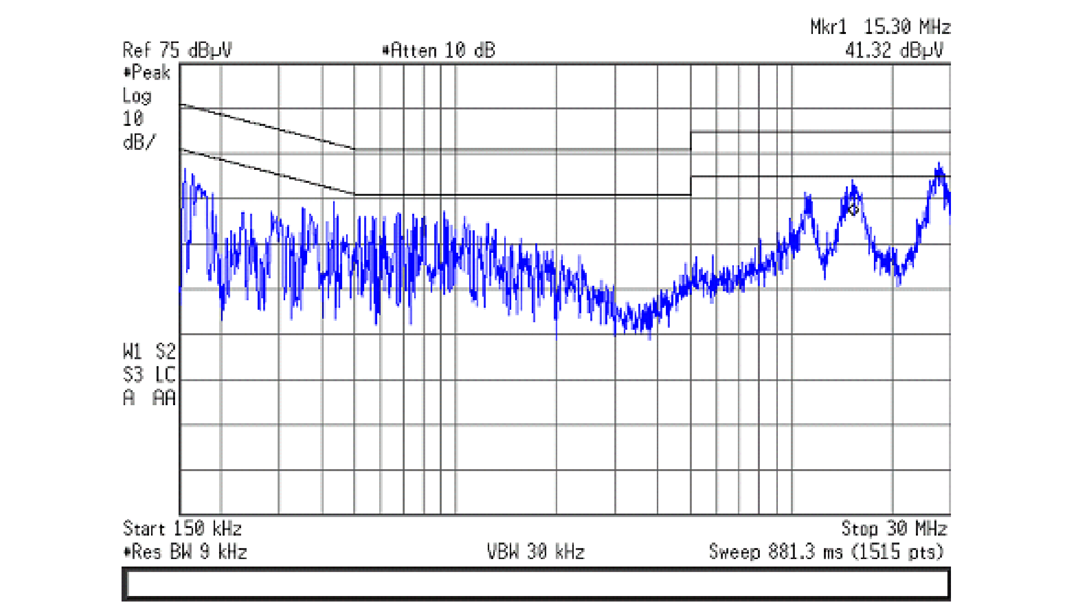
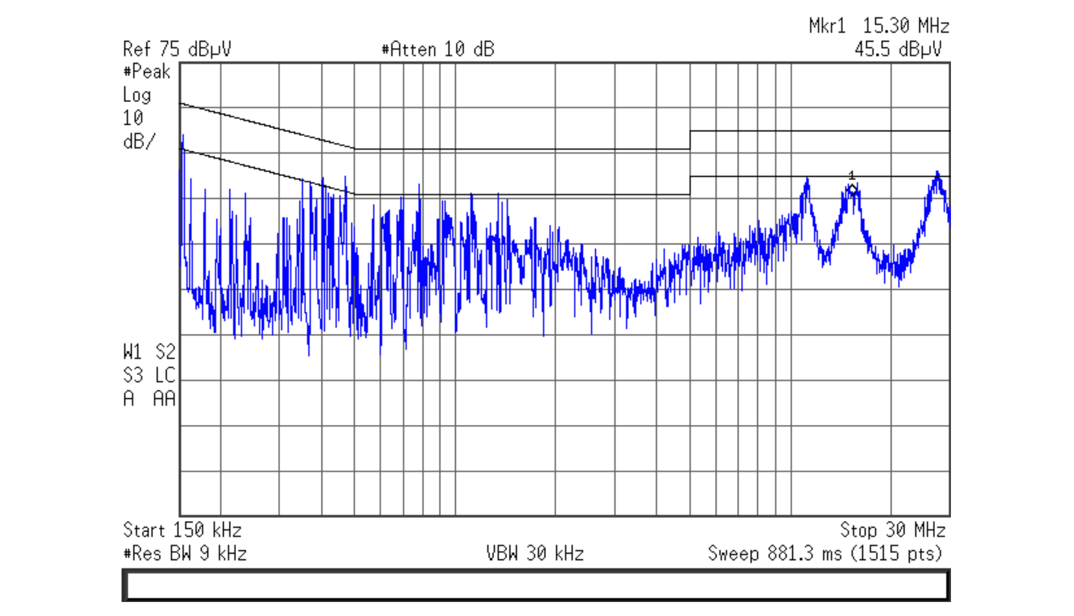


Figure 8. CE peak measure at 230Vac and full load



4 Bill of material

Table 5. Bill of material

Rf. Des.	Part Type/ Part Value	Description	Supplier
C1	470N-X2	X2 FILM CAPACITOR - R46-I 3470--M1-	ARCOTRONICS
C10	10N	50V CERCAP - GENERAL PURPOSE	AVX
C11	10N	50V CERCAP - GENERAL PURPOSE	AVX
C12	470N	25V CERCAP - GENERAL PURPOSE	AVX
C13	1uF	25V CERCAP - GENERAL PURPOSE	AVX
C14	100N	50V CERCAP - GENERAL PURPOSE	AVX
C15	47uF-25V	ALUMINIUM ELCAP - YXF SERIES - 105°C	RUBYCON
C17	330PF	50V - 5% - C0G - CERCAP	AVX
C18	330N	25V CERCAP - GENERAL PURPOSE	AVX
C19	100N	50V CERCAP - GENERAL PURPOSE	AVX
C2	2N2	Y1 SAFETY CAP.	MURATA
C20	2N2 - Y1	DE1E3KX222M - Y1 SAFETY CAP.	MURATA
C21	2N2 - Y1	DE1E3KX222M - Y1 SAFETY CAP.	MURATA
C23	100N	50V CERCAP - GENERAL PURPOSE	AVX
C24	10uF-50V	ALUMINIUM ELCAP - YXF SERIES - 105°C	RUBYCON
C25	100N	50V CERCAP - GENERAL PURPOSE	AVX
C26	10uF-50V	ALUMINIUM ELCAP - YXF SERIES - 105°C	RUBYCON
C27	220PF	500V CERCAP - 5MQ221KAAAA	AVX
C28	22N	630V - PHE450MA5220JR05	EVOX-RIFA
C29	470uF-35V YXF	ALUMINIUM ELCAP - YXF SERIES - 105°C	RUBYCON
C3	2N2	Y1 SAFETY CAP.	MURATA
C30	470uF-35V YXF	ALUMINIUM ELCAP - YXF SERIES - 105°C	RUBYCON
C31	100uF-35V YXF	ALUMINIUM ELCAP - YXF SERIES - 105°C	RUBYCON
C32	100N	50V CERCAP - GENERAL PURPOSE	AVX
C34	220N	50V CERCAP - GENERAL PURPOSE	AVX
C36	1uF-50V	ALUMINIUM ELCAP - YXF SERIES - 105°C	RUBYCON
C39	100N	50V CERCAP - GENERAL PURPOSE	AVX
C4	470N-X2	X2 FILM CAPACITOR - R46-I 3470--M1-	ARCOTRONICS
C40	100N	50V CERCAP - GENERAL PURPOSE	AVX
C5	470N-400V	PHE426KD6470JR06L2 - POLYPROP. FILM CAP	EVOX-RIFA
C7	15N - 100V	100V CERCAP - GENERAL PURPOSE	AVX
C8	10uF-50V	ALUMINIUM ELCAP - YXF SERIES - 105°C	RUBYCON

Table 5. Bill of material (continued)

Rf. Des.	Part Type/ Part Value	Description	Supplier
C9	47uF-450V	ALUMINIUM ELCAP - ED SERIES - 105°C	PANASONIC
D1	GBU4J	SINGLE PHASE BRIDGE RECTIFIER	VISHAY
D10	LL4148	FAST SWITCHING DIODE	VISHAY
D11	LL4148	FAST SWITCHING DIODE	VISHAY
D12	STPS20H100CF	POWER SCHOTTKY RECTIFIER	STMICROELECTRONICS
D13	STPS20H100CF	POWER SCHOTTKY RECTIFIER	STMICROELECTRONICS
D18	1N4148	FAST SWITCHING DIODE	VISHAY
D19	1N4148	FAST SWITCHING DIODE	VISHAY
D2	LL4148	FAST SWITCHING DIODE	VISHAY
D3	1N4005	GENERAL PURPOSE RECTIFIER	VISHAY
D4	STTH2L06	ULTRAFAST HIGH VOLTAGE RECTIFIER	STMICROELECTRONICS
D5	LL4148	FAST SWITCHING DIODE	VISHAY
D6	BZX85-C15	ZENER DIODE	VISHAY
D7	LL4148	FAST SWITCHING DIODE	VISHAY
D8	BZV55-C18	ZENER DIODE	PHILIPS SEM.
D9	LL4148	FAST SWITCHING DIODE	VISHAY
F1	FUSE 4A	FUSE T4A - TIME DELAY	WICHMANN
HS1		HEAT SINK FOR D1&Q1	DWG
HS2		HEAT SINK FOR Q3&Q4	DWG
HS3		HEAT SINK FOR D12&D13	DWG
J1	MKDS 1,5/ 3-5,08	PCB TERM. BLOCK, SCREW CONN., PITCH 5MM - 3 W.	PHOENIX CONTACT
J2	MKDS 1,5/ 2-5,08	PCB TERM. BLOCK, SCREW CONN., PITCH 5MM - 2 W.	PHOENIX CONTACT
L1	HF2826-253Y1R2-T01	EMI INPUT FILTER	TDK
	60010049A	EMI INPUT FILTER	PULSE - ELDOR
L2	27020005A	PFC INDUCTOR	PULSE- ELDOR
L3	RFB0807-2R2	2u2 - RADIAL INDUCTOR	COILCRAFT
Q1	STP9NK50ZFP	N-CHANNEL POWER MOSFET	STMICROELECTRONICS
Q3	STP9NK50ZFP	N-CHANNEL POWER MOSFET	STMICROELECTRONICS
Q4	STP9NK50ZFP	N-CHANNEL POWER MOSFET	STMICROELECTRONICS
R1	1M0	SMD STANDARD FILM RES - 1/4W - 5% - 250ppm/°C	BC COMPONENTS
R10	15K	SMD STANDARD FILM RES - 1/8W - 1% - 100ppm/°C	BC COMPONENTS
R11	1M5	SMD STANDARD FILM RES - 1/4W - 1% - 100ppm/°C	BC COMPONENTS
R12	1M5	SMD STANDARD FILM RES - 1/4W - 1% - 100ppm/°C	BC COMPONENTS

Table 5. Bill of material (continued)

Rf. Des.	Part Type/ Part Value	Description	Supplier
R13	15K	SMD STANDARD FILM RES - 1/8W - 1% - 100ppm/°C	BC COMPONENTS
R14	18K	SMD STANDARD FILM RES - 1/4W - 5% - 250ppm/°C	BC COMPONENTS
R15	0R0	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R18	56K	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R19	56K	SMD STANDARD FILM RES - 1/4W - 5% - 250ppm/°C	BC COMPONENTS
R2	1M2	SMD STANDARD FILM RES - 1/4W - 5% - 250ppm/°C	BC COMPONENTS
R21	22R	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R22	0R47	SFR25 AXIAL STAND. FILM RES - 0.4W - 5% - 250ppm/°C	BC COMPONENTS
R23	0R47	SFR25 AXIAL STAND. FILM RES - 0.4W - 5% - 250ppm/°C	BC COMPONENTS
R24	15K	SMD STANDARD FILM RES - 1/8W - 1% - 100ppm/°C	BC COMPONENTS
R25	330R	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R26	390K	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R27	0R0	SMD STANDARD FILM RES - 1/4W - 5% - 250ppm/°C	BC COMPONENTS
R28	0R0	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R3	180K	SMD STANDARD FILM RES - 1/4W - 5% - 250ppm/°C	BC COMPONENTS
R31	75K	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R32	100R	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R33	100R	SMD STANDARD FILM RES - 1/4W - 5% - 250ppm/°C	BC COMPONENTS
R34	8K2	SMD STANDARD FILM RES - 1/4W - 5% - 250ppm/°C	BC COMPONENTS
R35	8K2	SMD STANDARD FILM RES - 1/4W - 5% - 250ppm/°C	BC COMPONENTS
R37	56R	SFR25 AXIAL STAND. FILM RES - 0.4W - 5% - 250ppm/°C	BC COMPONENTS
R38	330R	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R39	180R	SMD STANDARD FILM RES - 1/4W - 5% - 250ppm/°C	BC COMPONENTS
R4	180K	SMD STANDARD FILM RES - 1/4W - 5% - 250ppm/°C	BC COMPONENTS
R40	33R	SFR25 AXIAL STAND. FILM RES - 0.4W - 5% - 250ppm/°C	BC COMPONENTS
R41	12K	SMD STANDARD FILM RES - 1/4W - 5% - 250ppm/°C	BC COMPONENTS
R42	5K6	SMD STANDARD FILM RES - 1/4W - 5% - 250ppm/°C	BC COMPONENTS
R43	470R	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R47	1K0	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R48	10K	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R49	39K	SMD STANDARD FILM RES - 1/4W - 5% - 250ppm/°C	BC COMPONENTS
R5	1R2	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R50	8K2	SMD STANDARD FILM RES - 1/8W - 1% - 100ppm/°C	BC COMPONENTS
R51	10K	SMD STANDARD FILM RES - 1/8W - 1% - 100ppm/°C	BC COMPONENTS

Table 5. Bill of material (continued)

Rf. Des.	Part Type/ Part Value	Description	Supplier
R53	0R0	0R0 JUMPER	BC COMPONENTS
R54	0R0	0R0 JUMPER	BC COMPONENTS
R55	0R0	0R0 JUMPER	BC COMPONENTS
R56	0R0	0R0 JUMPER	BC COMPONENTS
R57	0R0	0R0 JUMPER	BC COMPONENTS
R58	100K	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R59	100K	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R6	NTC_10R S236	NTC RESISTOR P/N B57236S0100M000	EPCOS
R60	1K0	SMD STANDARD FILM RES - 1/8W - 5% - 250ppm/°C	BC COMPONENTS
R61	0R0	0R0 JUMPER	BC COMPONENTS
R62	0R0	0R0 JUMPER	BC COMPONENTS
R7	1M0	SMD STANDARD FILM RES - 1/4W - 1% - 100ppm/°C	BC COMPONENTS
R8	1M0	SMD STANDARD FILM RES - 1/4W - 1% - 100ppm/°C	BC COMPONENTS
R9	82K	SMD STANDARD FILM RES - 1/8W - 1% - 100ppm/°C	BC COMPONENTS
T1	26420003B	RESONANT POWER TRANSF.	PULSE- ELDOR
U1	L6563	TRANSITION-MODE PFC CONTROLLER	STMICROELECTRONICS
U2	L6598D	HIGH VOLTAGE RESONANT CONTROLLER	STMICROELECTRONICS
U3	SFH617A-2	OPTOCOUPLER	INFINEON
U4	TL431AIZ	PROGRAMMABLE SHUNT VOLTAGE REFERENCE	STMICROELECTRONICS

5 PCB lay-out

Figure 9. Thru-hole component placing and top silk screen

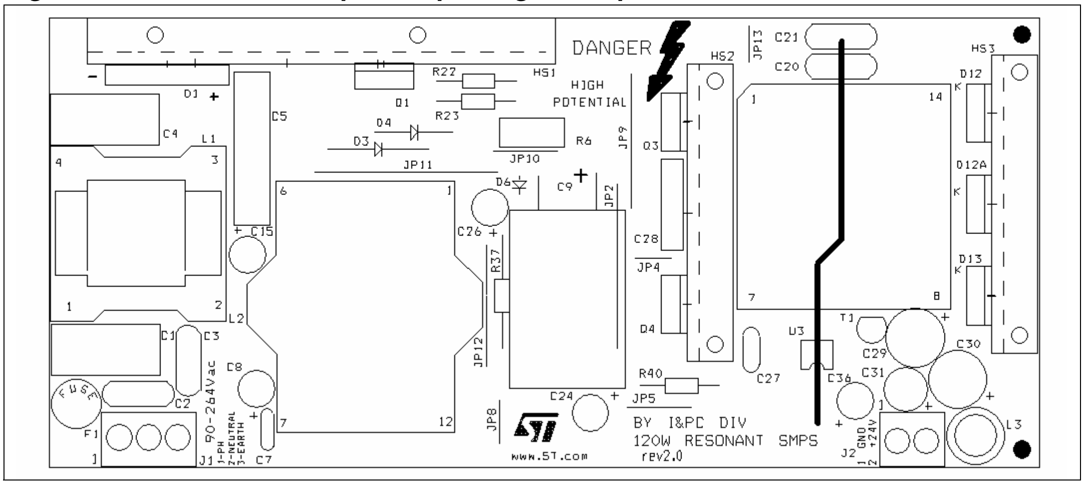


Figure 10. SMT component placing and bottom silk screen

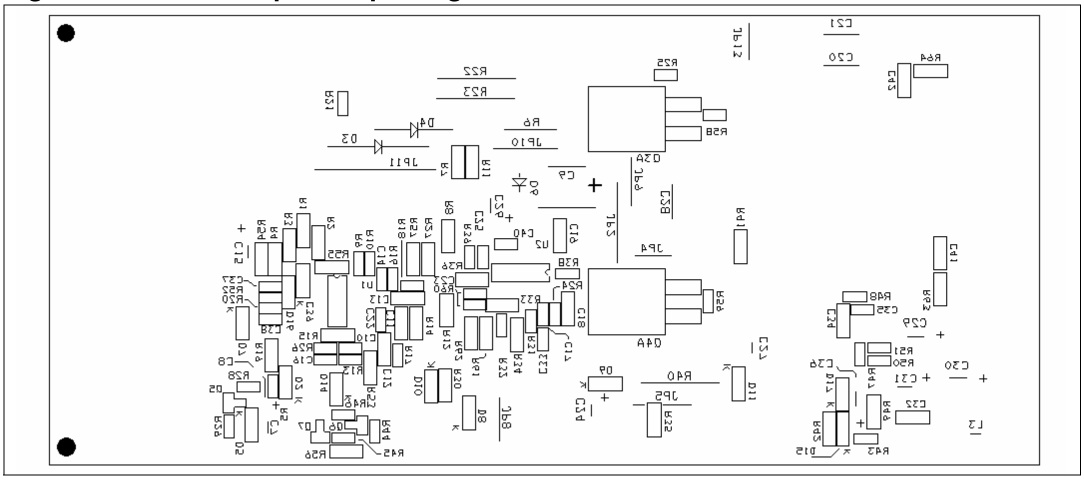
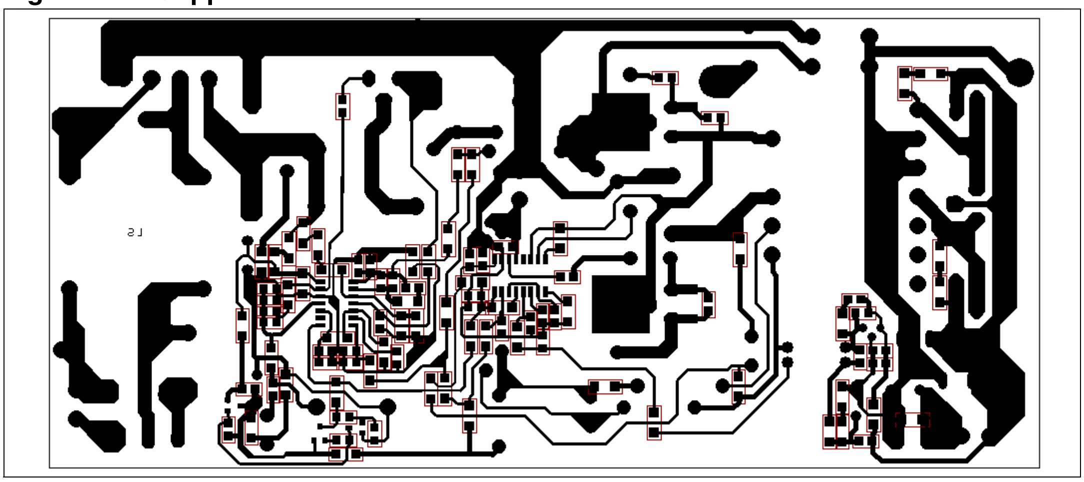


Figure 11. Copper tracks



6 PFC coil specification

- Application type: consumer, Home Appliance
- Transformer type: Open
- Coil former: Vertical type, 6+6 pins
- Max. temp. rise: 45°C
- Max. operating ambient temp.: 60°C
- Mains insulation: N.A.
- Finishing: varnished

6.1 PFC coil electrical characteristics

- Converter topology: Boost, Transition mode
- CORE type: RM14 - PC40 or equivalent
- Min. operating frequency: 20 kHz
- Primary inductance:700 µH ±10% @1kHz - 0.25V (see *Note 1*)
- Peak primary current 5 Apk
- RMS primary current 1.8 Arms

Note: 1 Measured between pins #2 & #5

Figure 12. Electrical diagram

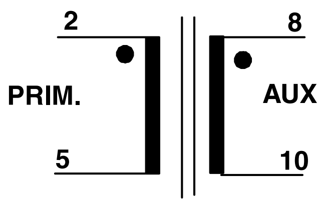


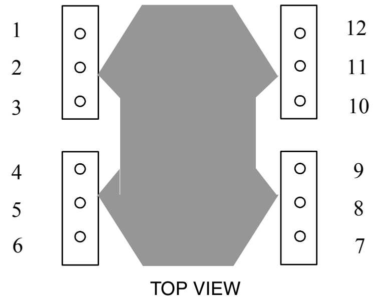
Table 6. Winding characteristics

Pins	Winding	RMS current	Number of turns	Wire type
2-5	PRIMARY	1.8 A_{RMS}	53	STRANDED 7 x ϕ0.28 mm
8 - 10	AUX	0.05 A_{RMS}	4 SPACED	ϕ0.28 mm – G2

2 Auxiliary winding is wound on top of primary winding

6.2 PFC mechanical aspect and pin numbering

Figure 13. PFC mechanical aspect and pin numbering



- Maximum height from PCB: 22 mm
- COIL former type: vertical, 6+6 pins
- Pin distance: 5.08 mm
- Row distance: 35.56 mm
- Pins #1, 3, 4, 6, 7, 9, 11, 12 are removed

7 Resonant trafo specification

- Application type: Consumer, Home Appliance
- Transformer type: Open
- Coil former: Horizontal type, 7+7 pins, 2 Slots
- Max. temp. rise: 45°C
- Max. operating ambient temp.: 60°C
- Mains insulation: Compliance with EN60065 specifications
- Finishing: Varnished

7.1 Resonant trafo electrical characteristics

- Converter topology: half-bridge, resonant
- Core type: EF32 - PC40 or equivalent
- Typical operating frequency: 100 kHz
- Primary inductance: 810 µH ±10% @1kHz - 0.25V (see *Note 1*)
- Leakage inductance: 200 µH ±10% @1kHz - 0.25V (see *Note 1* and *Note 2*)

Note: 1 *Measured between pins 1-4.*

2 *Measured between pins 1-4 with a secondary winding shorted.*

Figure 14. Electrical diagram and winding characteristics

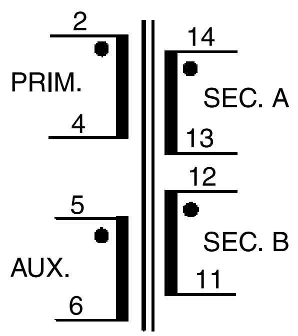


Table 7. Winding characteristics

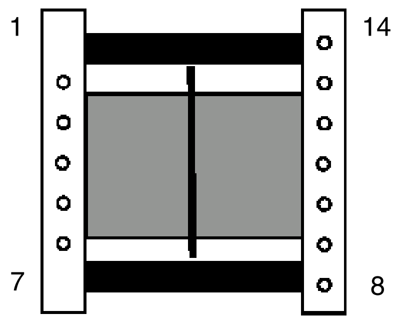
Pins	Winding	RMS current	Number of turns	Wire type
2 - 4	PRIMARY	1 A_{RMS}	60	ϕ0.40mm-TIW
14 - 13	SEC. A (1)	4 A_{RMS}	7	ϕ0.1x60 - G2
12 - 11	SEC. B (2)	4 A_{RMS}	7	ϕ0.1x60 - G2
5-6	AUX (2)	0.05 A_{RMS}	4 SPACED	ϕ0.40mm-TIW

1. Secondary windings A and B must be wound in parallel
2. Auxiliary winding is wound on top of primary winding

7.2 Mechanical aspect and Pin numbering

- Maximum height from PCB: 22 mm
- Coil former type: horizontal, 7+7 pins (pins 1 and 7 are removed)
- Pin distance: 5 mm
- Row distance: 30 mm

Figure 15. Pin lay-out, top view



8 Revision history

Table 8. Revision history

Date	Revision	Changes
7-Jun-2006	1	Initial release