AN3172
Application note

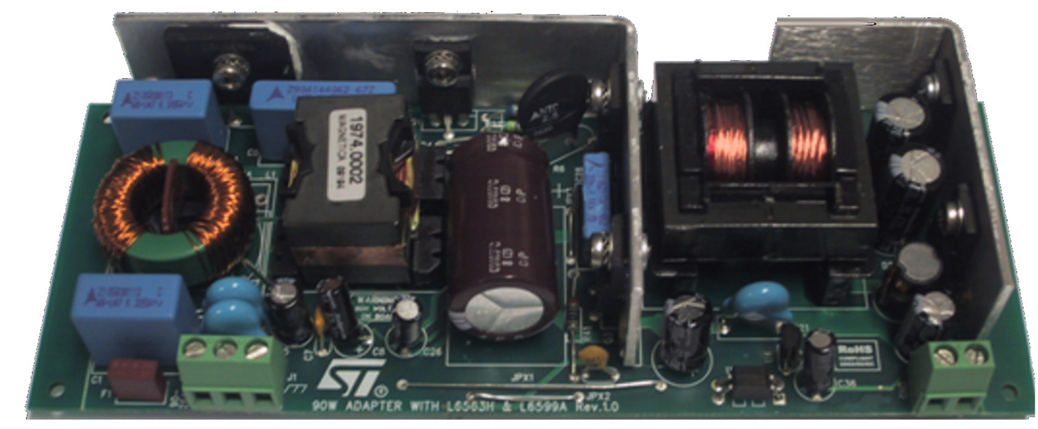
19 V - 90 W adapter with PFC for laptop computers using the L6563H and L6599A

Introduction

This application note describes the performance of a 90 W, wide-range mains, power-factor-corrected, AC-DC adapter demonstration board. Its electrical specification is tailored on a typical hi-end portable computer power adapter.

The architecture is based on a two-stage approach; a front-end PFC pre-regulator based on the L6563H TM PFC controller and a downstream LLC resonant half-bridge converter using the new L6599A resonant controller. Thanks to the chipset used, the main aspects of this design are very high efficiency, compliance with ENERGY STAR® Eligibility Criteria (EPA rev. 2.0 EPS), and very low input consumption at no-load (<0.3 W).

Figure 1. EVL6599A-90WADP: 90 W adapter demonstration board



Contents

List of figures

List of tables

1 Main characteristics and circuit description

The main features of the SMPS are:

- Universal input mains range: 90÷264 Vac - frequency 45 ÷ 65 Hz
- Output voltage: 19 V at 4.75 A continuous operation
- Mains harmonics: Acc. to EN61000-3-2 Class-D or JEITA-MITI Class-D
- Standby mains consumption: <0.3 W at 230 Vac
- Efficiency at nominal load: Better than 90 % at full load
- EMI: According to EN55022-Class-B
- Safety: According to EN60950
- Dimensions: 65x151 mm, 25 mm component maximum height
- PCB: Double side, 70 µm, FR-4, Mixed PTH/SMT

The circuit is composed of two stages; a front-end PFC using the L6563H and an LLC resonant converter based on the L6599A.

The PFC stage works as the pre-regulator and powers the resonant stage with a constant voltage of 400 V. The downstream converter operates only if the PFC is on and regulating its output voltage. In this way, the resonant stage can be optimized for a narrow input voltage range, improving the efficiency and the primary side power components.

1.1 Startup sequence

As previously indicated, the PFC acts as master and the resonant stage can operate only if the PFC output is delivering its nominal output voltage. Therefore the circuit is designed so that at startup the PFC starts first, then the downstream converter turns-on. At the beginning, the L6563H is supplied by the integrated high voltage startup circuit; once the PFC starts switching, a charging pump connected to the PFC inductor supplies both PFC and resonant controllers. Once both stages have been activated, the controllers are also supplied by the auxiliary winding of the resonant transformer, assuring correct supply voltage, even during standby operation.

Because the L6563H integrated HV startup circuit is turned off, and therefore not dissipative during normal operation, it makes a significant contribution to power consumption reduction once the power supply operates at light-load, in agreement with standby worldwide standards currently required.

1.2 Brownout protection

Brownout protection prevents the circuit from working with abnormal mains levels. It is easily achieved using the RUN pin (#12) of the L6563H; this pin is connected through a resistor divider to the VFF pin (#5) providing the information of the mains voltage peak value. An internal comparator allows IC operations if the mains level is correct, within the nominal limits. At startup, if the input voltage is below 90 Vac (typ.), circuit operations are inhibited.

The L6599A has similar protection on the LINE pin (#7). It is used to prevent the resonant converter from working with a too low input voltage which can cause incorrect capacitive mode operation. If the bulk voltage (PFC output) is below 380 V, the resonant stage startup is not allowed. The L6599A LINE pin internal comparator has a hysteresis allowing the turn-on and turn-off voltage to be set independently. The turn-off threshold has been set to 300 V in order to avoid capacitive mode operation but allow the resonant stage to operate even in the case of mains sag and a consequent PFC output dip.

1.3 Fast voltage feed forward

Voltage on the L6563H VFF pin (#5) has the same value as the peak value of the voltage on the MULT pin (#3) and it is generated by the RC network (R15+R26, C12) connected to VFF, completing an internal peak-holding circuit. This signal is necessary to derive information on the RMS input voltage to compensate the loop gain which is mains voltage dependent.

In general, if the VFF time constant is too small, the voltage generated is affected by a considerable amount of ripple at twice the mains frequency. Because the VFF signal is fed into the multiplier the excessive ripple causes distortion of the current reference resulting in high THD and poor PF. On the other hand, if the time constant is set too large there is a considerable delay in setting the right amount of feed-forward, resulting in excessive overshoot or undershoot of the pre-regulator's output voltage in response to large line voltage changes.

To overcome this issue, the L6563H implements the new Fast Voltage Feed Forward function. As soon as the voltage on the VFF pin decreases from a set threshold (40mV typically), a mains dip is assumed and an internal switch rapidly discharges the VFF capacitor via a 10 kΩ resistor. Thanks to this feature it is possible to set an RC circuit with a long time constant, assuring a low THD, but keeping a fast response to mains voltage variations.

1.4 Resonant power stage

The downstream converter implements the ST L6599A, incorporating all the functions necessary to properly control the resonant converter with a 50 percent fixed duty cycle and working with variable frequency.

The transformer uses the integrated magnetic approach, incorporating the resonant series inductance. Therefore, no additional external coil is needed for the resonance.

The transformer configuration chosen for the secondary winding is centre tap and makes use of a couple of power schottky rectifiers p/n STPS30H60CFP. A small LC filter has been added on the output, filtering the high frequency ripple.

D15, R56, R62, R65, R66, Q5, and Q6 implement an output voltage “fast discharge” circuit, quickly discharging the output capacitors when the converter is turned off. It has been implemented to quickly decrease the residual output voltage once the converter is turned off at no-load.

1.5 Output voltage feedback loop

The feedback loop is implemented by means of a typical circuit using a TL431 modulating the current in the optocoupler diode.

On the primary side, R34 - connecting pin RFMIN (#4) to the optocoupler's phototransistor - closes the feedback loop and its value sets the maximum switching frequency at about 130 kHz. This value has been chosen to limit the switching losses at light-load operation. R31, connecting the same pin to ground, sets the minimum switching frequency. The R-C series R44 and C18 sets both soft-start maximum frequency and duration.

1.6 L6599A overload and short-circuit protection

The current into the primary winding is sensed by the lossless circuit R41, C27, D11, D10, R39, and C25 and it is fed into the ISEN pin (#6). In the case of overcurrent, the voltage on the pin overpasses an internal comparator threshold (0.8 V), triggering a protection sequence. The capacitor (C45) connected to the DELAY pin (#2) is charged by an internal 150 µA current generator and is slowly discharged by the external resistor (R24). If the voltage on the pin reaches 2 V, the soft-start capacitor is completely discharged so that the switching frequency is pushed to its maximum value. As the voltage on the pin exceeds 3.5 V the IC stops switching and the internal generator is turned off, so that the voltage on the pin decays because of the external resistor. The IC is soft-restarted as the voltage drops below 0.3 V. In this way, under short-circuit conditions, the converter works intermittently with very low average input power.

1.7 PFC overvoltage and open-loop protection

Both circuit stages, PFC and resonant, are equipped with their own overvoltage protections.

The L6563H PFC controller monitors its output voltage via the resistor divider connected to a dedicated pin (PFC_OK, #7) protecting the circuit in the case of loop failures or disconnection of the feedback loop divider. In the case where a fault condition is detected, the PFC_OK circuitry latches the L6563H operations and, by means of the PWM_LATCH pin (#8), it also latches the L6599A, via the DIS pin (#8). The converter is kept latched by the L6563H HV circuit that supplies the IC charging the Vcc capacitor periodically. To resume converter operation mains restart is necessary.

1.8 Standby power saving

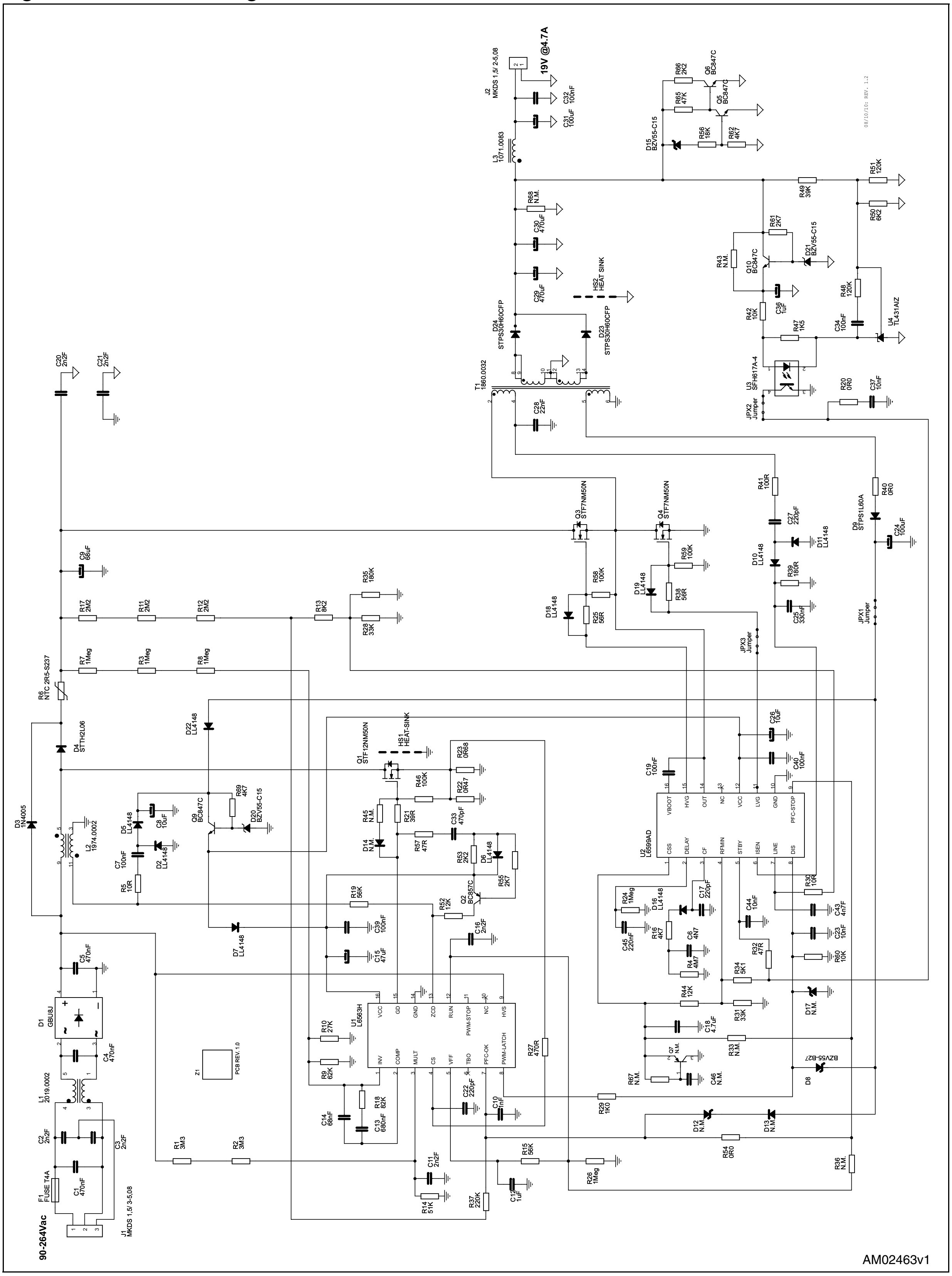
The board implements a burst-mode function allowing a significant power saving during light-load operation.

The L6599A's STBY pin (#5) senses the optocoupler's collector voltage which is related to the feedback control and is proportional to the output load. This signal is compared to an internal reference (1.24 V); if the load decreases and the voltage on the STBY pin goes lower than the reference, the IC enters an idle state and its quiescent current is reduced. Once the voltage exceeds the reference by 50 mV, the controller restarts switching. Burst-mode operation load threshold can be programmed by properly choosing the resistor connecting the optocoupler to the RFMIN pin (R34). On this board the controller operates in burst-mode if the load falls below ~15 W.

The L6563H implements its own burst-mode function. If the COMP voltage falls below 2.5 V, the IC stops switching, causing an output voltage decrease, as a consequence the COMP voltage rises again and the IC restarts switching.

In order to achieve a better load transient response, the PFC burst-mode operation is partially forced by the resonant converter; once the L6599A stops switching due to load drops, its PFC_STOP pin pulls down the L6563H's PFC_OK pin, disabling PFC switching. Thanks to this solution, the PFC is forced into idle state when the resonant stage is not switching and rapidly wakes-up when the downstream converter restarts switching. This solution prevents a significant drop of the bulk voltage in the case of abrupt load rising.

Figure 2. Electrical diagram



2 Efficiency measurement

EPA rev. 2.0 external power supply compliance verification.

Table 1 shows the no-load consumption and the overall efficiency, measured at the nominal mains voltages. At 115 Vac the average efficiency is 89.96 %, while at 230 Vac it is 91.12 %. Both values are much higher than the minimum required by EPA rev2.0 External power supply limits (87 %).

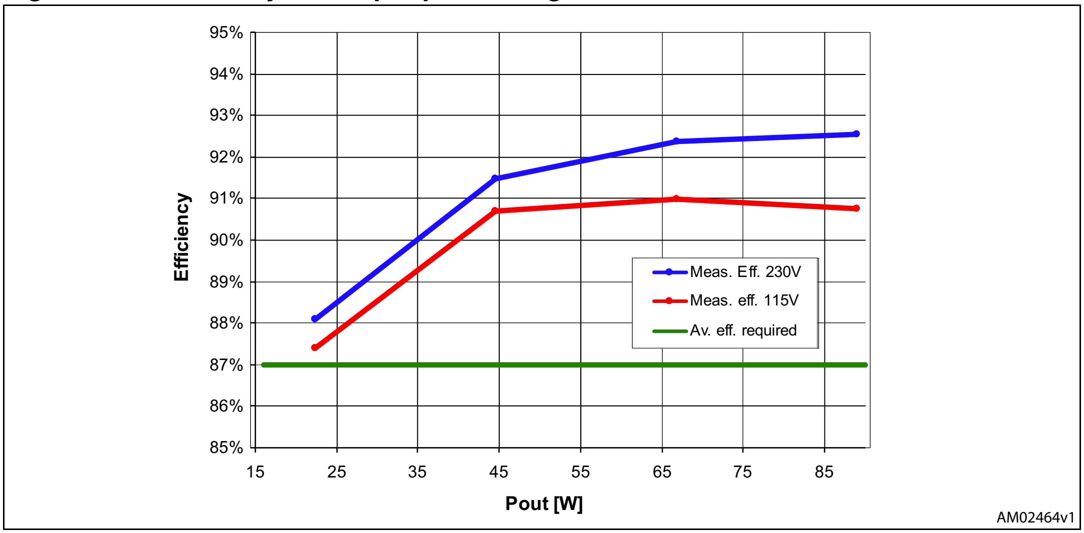
Measurements are also given in *Figure 3* for reference.

Even at no-load the board performance is superior; maximum no-load consumption at nominal mains voltage is less than 250 mW only; even this value is significantly lower than the 500 mW limit imposed by the ENERGY STAR program.

Table 1. Overall efficiency

Test	230 V-50 Hz					115 V-60 Hz				
	Vout [V]	Iout [A]	Pout [W]	Pin [W]	Eff. [%]	Vout [V]	Iout [A]	Pout [W]	Pin [W]	Eff. [%]
No load	18.98	0.00	0.00	0.246	------	18.97	0.00	0.00	0.235	------
100 % load eff.	18.93	4.700	88.97	96.15	92.53 %	18.93	4.700	88.97	98.04	90.75 %
75 % load eff.	18.94	3.526	66.78	72.29	92.38 %	18.94	3.526	66.78	73.40	90.98 %
50 % load eff.	18.95	2.352	44.57	48.72	91.48 %	18.95	2.352	44.57	49.14	90.70 %
25 % load eff.	18.96	1.177	22.32	25.33	88.10 %	18.96	1.177	22.32	25.53	87.41 %
Average eff.					91.12 %					89.96 %

Figure 3. Efficiency vs. output power diagram



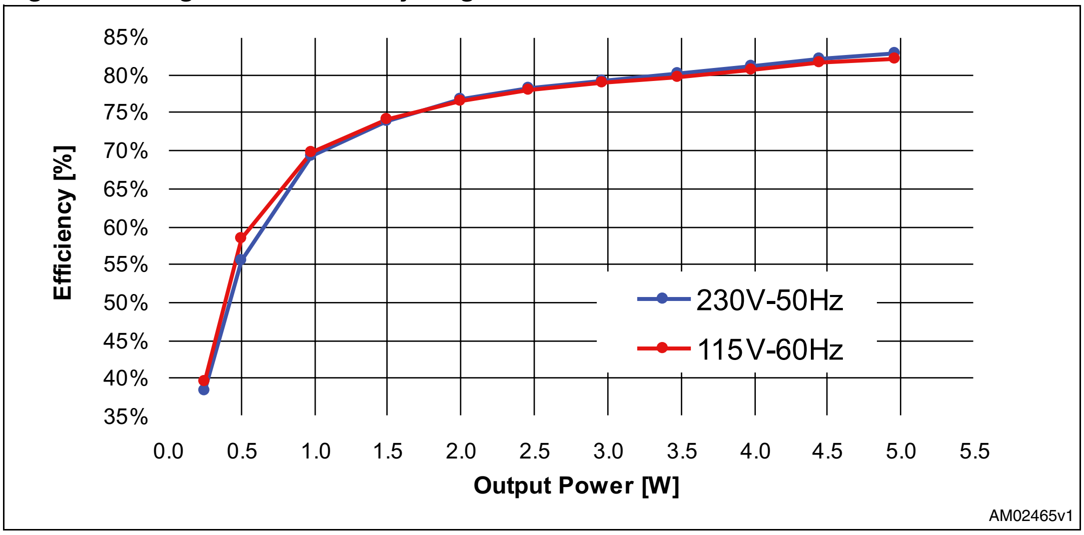
2.1 Light-load operation efficiency

Measurement results are given in *Table 2* and plotted in *Figure 4*. As seen, efficiency is better than 55 % even for very light loads such as 500mW.

Table 2. Light-load efficiency

Test	230 V - 50 Hz					115 V - 60 Hz				
	Vout [V]	Iout [mA]	Pout [W]	Pin [W]	Eff. [%]	Vout [V]	Iout [mA]	Pout [W]	Pin [W]	Eff. [%]
0.25 W	18.89	13.06	0.247	0.643	38.37 %	18.89	13.06	0.247	0.62	39.60 %
0.5 W	18.89	26.83	0.507	0.911	55.63 %	18.89	26.83	0.507	0.869	58.32 %
1.0 W	18.89	51.92	0.981	1.415	69.31 %	18.89	51.93	0.981	1.404	69.87 %
1.5 W	18.89	78.90	1.490	2.014	74.00 %	18.89	78.90	1.490	2.010	74.15 %
2.0 W	18.89	105.9	2.000	2.608	76.67 %	18.89	105.9	2.000	2.610	76.61 %
2.5 W	18.89	130.2	2.459	3.145	78.17 %	18.89	130.2	2.459	3.152	78.01 %
3.0W	18.89	157.2	2.970	3.748	79.23 %	18.89	157.2	2.970	3.762	78.93 %
3.5 W	18.89	184.2	3.480	4.337	80.23 %	18.88	184.2	3.478	4.358	79.80 %
4.0 W	18.88	211.2	3.987	4.919	81.04 %	18.88	211.2	3.987	4.936	80.76 %
4.5 W	18.88	235.4	4.445	5.415	82.08 %	18.88	235.4	4.445	5.453	81.51 %
5.0 W	18.88	262.4	4.954	5.983	82.81 %	18.88	262.4	4.954	6.031	82.14 %

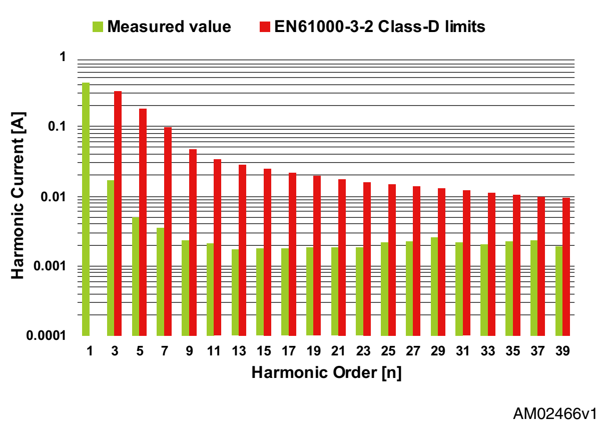
Figure 4. Light-load efficiency diagram



3 Harmonic content measurement

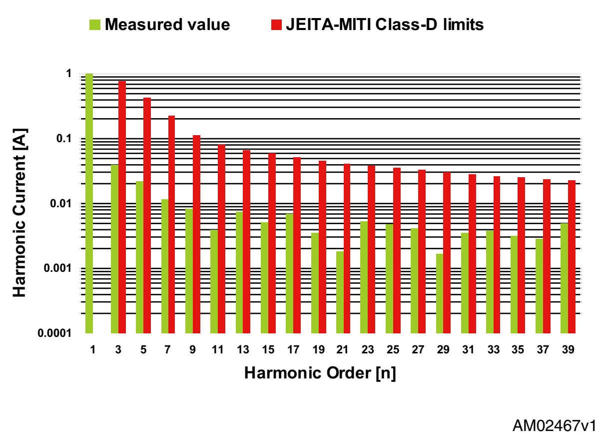
The board has been tested according to the European standard EN61000-3-2 Class-D and Japanese standard JEITA-MITI Class-D, at both the nominal input voltage mains. As shown in Figure 5 and 6, the circuit is able to reduce the harmonics well below the limits of both regulations.

Figure 5. Compliance to EN61000-3-2 at 230 Vac - 50 Hz, full load



THD = 5.13 % - PF = 0.965

Figure 6. Compliance to JEITA-MITI at 100 Vac - 50 Hz, full load



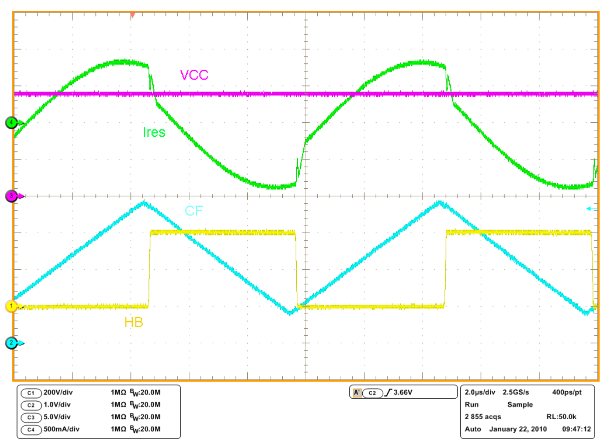
THD = 3.89 % - PF = 0.996

On the bottom side of the diagrams the total harmonic distortion and power factor have also been measured. The values in all conditions give a clear idea about the correct functioning of the PFC.

4 Functional check

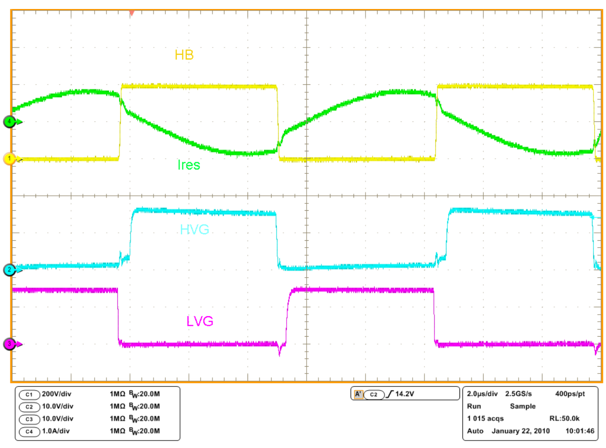
The following are some waveforms relevant to the resonant stage during steady-state operation. The selected switching frequency is about 100 kHz, in order to have a good trade off between transformer losses and dimensions. The converter operates above the resonance frequency. *Figure 8* shows the resonant ZVS operation. It is worth noting that both MOSFETs are turned on when resonant current is flowing through their body diodes and drain-source voltage is zero.

Figure 7. Resonant stage waveforms at 115 V - 60 Hz - full load



CH1: HB voltage	CH2: CF pin voltage
CH3: Vcc	CH4: Res. tank current

Figure 8. Resonant stage waveforms at 230 V - 50 Hz - full load

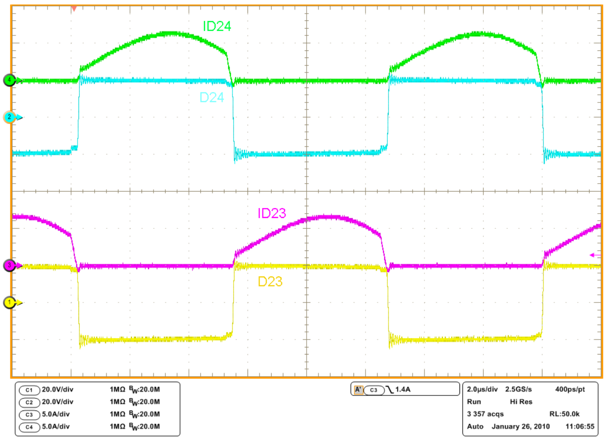


CH1: HB voltage	CH2: HV FET gate
CH3: LV FET gate	CH4: Res. tank current

In *Figure 9* typical waveforms relevant to the secondary side are represented; it is worth noting that the rectifiers reverse the working voltage and the current flowing through them.

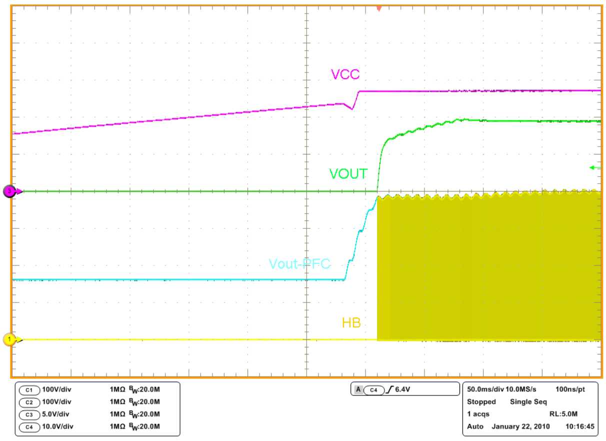
The waveforms during the start at 90 Vac and full load are shown in *Figure 10*. It is possible to note the sequence of the two stages; at power-on the L6563H and L6599A Vcc voltages increase up to the turn-on thresholds of the two ICs. The PFC starts and its output voltage increases from the mains rectified voltage to its nominal value. In the meantime the L6599A is kept inactive by the LINE pin (#7) until the PFC voltage reaches the set threshold. Then the resonant starts operating and the output voltage reaches the nominal level.

Figure 9. Rectifier waveforms



CH1: D23 anode voltage CH2: D24 anode voltage
CH3: D23 current CH4: D24 current

Figure 10. Startup waveforms

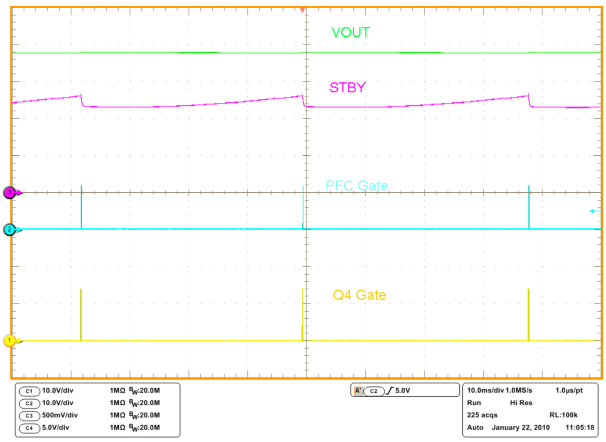


CH1: HB voltage CH2: Vout PFC
CH3: Vcc CH4: Output voltage

4.1 Standby and no-load operation

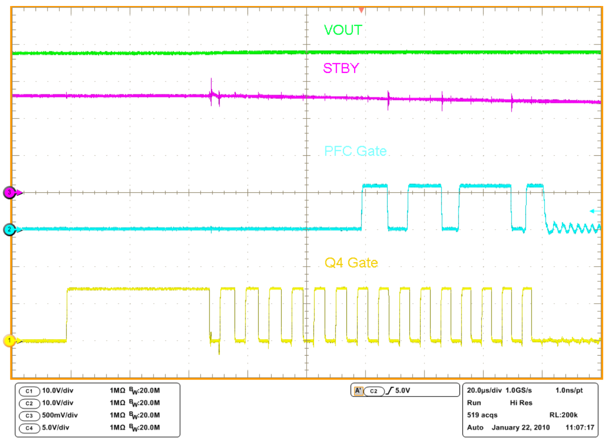
In *Figure 11* and *Figure 12*, some burst-mode waveforms are given. As seen, both L6599A and L6563H operate in burst-mode. In *Figure 11* it may also be noted that PFC and LLC bursts are synchronized.

Figure 11. No-load operation



CH1: Q4 gate CH2: PFC gate voltage
CH3: STBY pin CH4: Output voltage

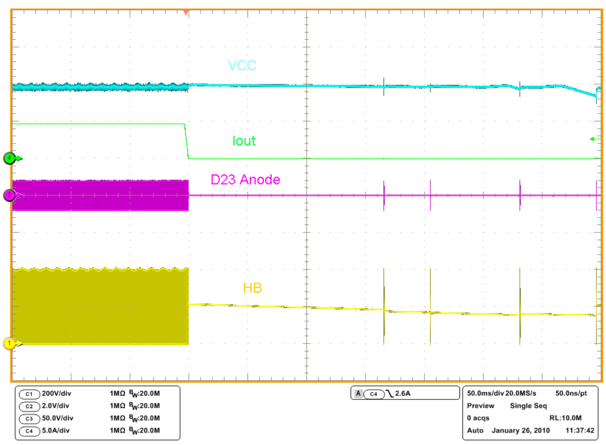
Figure 12. No-load operation - detail



CH1: Q4 gate CH2: PFC gate voltage
CH3: STBY pin CH4: Output voltage

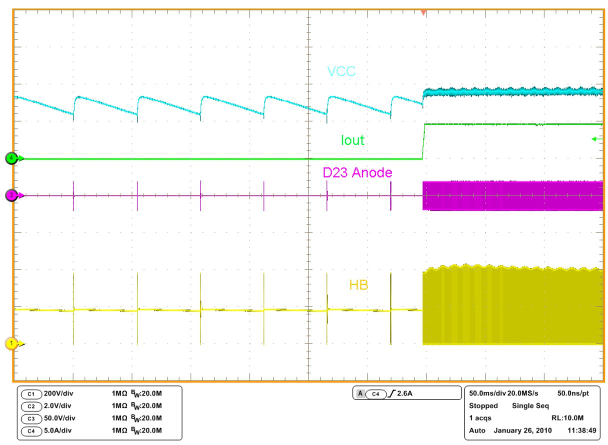
In *Figure 13* and *14* the transitions from full load to no-load and vice versa, at maximum input voltage, have been checked. The maximum input voltage has been chosen because it is the most critical input voltage for transition; in fact at no-load the burst pulses have the lower repetition frequency and the Vcc may drop, causing restart cycles of the controller. As seen in *Figure 13* and *14*, both transitions are clean and there isn't any output voltage or Vcc dip.

Figure 13. Transition full load to no-load at 265 Vac - 50 Hz



CH1:HB voltage	CH2:Vcc
CH3:D23 Anode	CH4:Output current

Figure 14. Transition no-load to full load at 265 Vac - 50 Hz



CH1:HB voltage	CH2:Vcc
CH3:D23 Anode	CH4:Output current

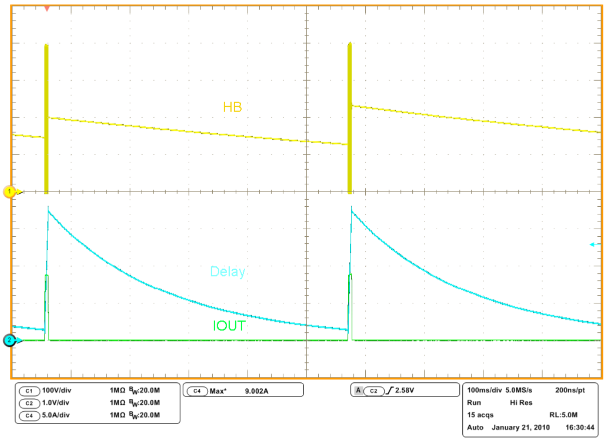
4.2 Overcurrent and short-circuit protection

The L6599A is equipped with a current sensing input (pin #6, ISEN) and a dedicated overcurrent management system. The current flowing in the resonant tank is detected and the signal is fed into the ISEN pin. It is internally connected to a first comparator, referenced to 0.8 V, and referenced to 1.5 V in a second comparator. If the voltage externally applied to the pin exceeds 0.8 V, the first comparator is tripped causing an internal switch to be turned on and to discharge the soft-start capacitor CSS.

Under output short-circuit, this operation results in a nearly constant peak primary current.

With the L6599A the user can externally program the maximum time that the converter is allowed to run overloaded or under short-circuit conditions. Overloads or short-circuits lasting less than the set time do not cause any other action, therefore providing the system with immunity to short duration phenomena. If, instead, the overload condition continues, a protection procedure is activated which shuts down the L6599A and, in the case of continuous overload/short-circuit, results in continuous intermittent operation with a user defined duty cycle. This function is realized with the DELAY pin (#2), by means of a capacitor C45 and the parallel resistor R24 connected to ground. When the voltage on the ISEN pin exceeds 0.8V the first OCP comparator, in addition to discharging CSS, turns on an internal 150 µA current generator that, via the DELAY pin, charges C45. When the voltage on C45 is 3.5 V, the L6599A stops switching and the PFC_STOP pin is pulled low. Also the internal generator is turned off, so that C45 is now slowly discharged by R24. The IC restarts when the voltage on C45 is less than 0.3 V. Additionally, if the voltage on the ISEN pin reaches 1.5 V for any reason (e.g. transformer saturation), the second comparator is triggered, the L6599A shuts down and the operation is resumed after an off-on cycle.

Figure 15. **Short-circuit at full load and 115 Vac - 60 Hz**



CH1: HB Voltage CH3: DELAY pin CH4: Output current

In *Figure 15* the narrow operating time with respect to the off time of the converter may be seen; consequently, the average output current, as well as the average primary current, are very low, avoiding over-heating of components and consequent failure.

5 Thermal map

In order to check the design reliability, a thermal mapping by means of an IR Camera was done. In *Figure 16* and *17* the thermal measurements of the board, component side, at nominal input voltage, are shown. Some pointers, visible in the images, have been placed across key components or showing high temperature. The ambient temperature during both measurements was 27 °C.

Figure 16. Thermal map at 115 Vac - 60 Hz - full load

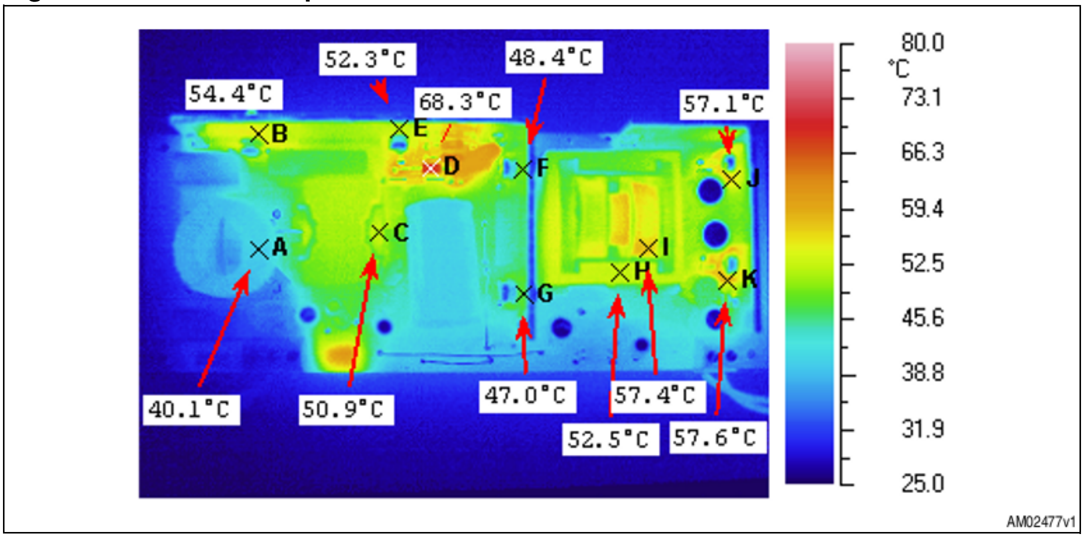


Figure 17. Thermal map at 230 Vac - 50 Hz - full load

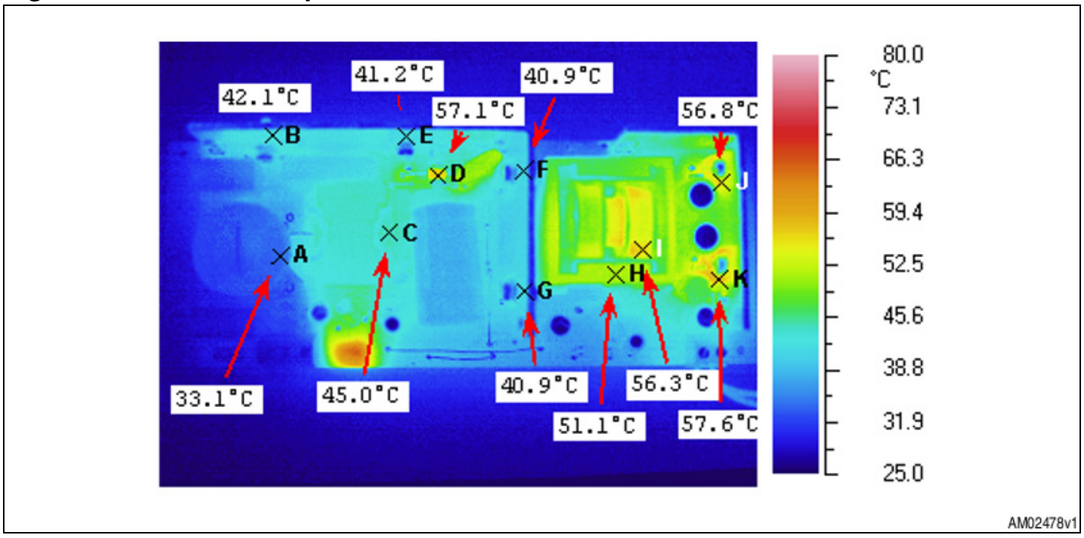


Table 3. Thermal maps reference points

Point	Reference	Description
A	L1	EMI filtering inductor
B	D1	Bridge rectifier
C	L2	PFC inductor – hottest point
D	D4	PFC output diode
E	Q1	PFC MOSFET
F - G	Q3 & Q4	Resonant HB MOSFETs
H - I	T1	Resonant power transformer
J - K	D23 & D24	Output rectifiers

6 Conducted emission pre-compliance test

The following figures are the average measurement of the conducted noise at full load and nominal mains voltages. The limits shown in the images are EN55022 Class-B, which is the most popular standard for domestic equipment and has more severe limits compared to Class-A, dedicated to IT technology equipment. As seen in *Figure 18* and *19*, in all test conditions the measurements are far below the limits.

Figure 18. CE Peak measurement at 115 Vac and full load

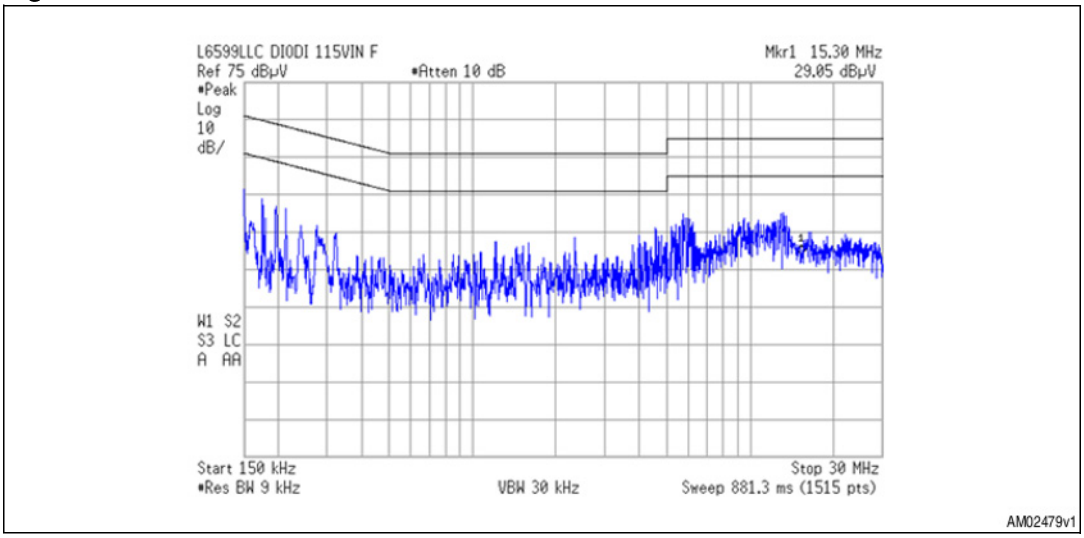
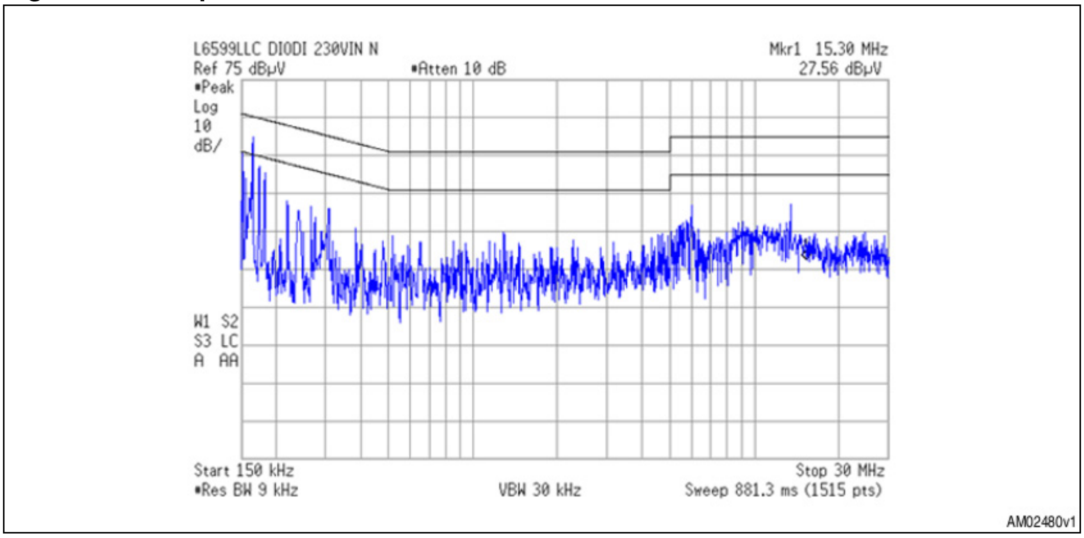


Figure 19. CE peak measurement at 230 Vac and full load



7 BOM list

Table 4. EVL6599A-90WADP demonstration board: BOM list

Des.	Part type/ Part value	Case style /Package	Description	Supplier
C1	470 nF	9.0 × 18.0 p.15 mm	X2 - MKP FILM CAP - B32922C3474K	EPCOS
C10	1 nF	0805	50 V cercap - general purpose	AVX
C11	2n2F	0805	50 V cercap - general purpose	AVX
C12	1 uF	0805	25 V cercap - general purpose	AVX
C13	680 nF	1206	25 V cercap - general purpose	AVX
C14	68 nF	0805	50 V cercap - general purpose	AVX
C15	47 uF	DIA6.3X11 (mm)	50 V aluminium elcap - YXF series - 105 °C	RUBYCON
C16	2n2F	1206	50 V cercap - general purpose	AVX
C17	220 pF	0805	50 V - 5 % - C0G - cercap	AVX
C18	4.7 uF	1206	6.3 V cercap - general purpose	AVX
C19	100 nF	1206	50 V cercap - general purpose	AVX
C2	2n2F	DWG	Y1 safety cap. DE1E3KX222M	MURATA
C20	2n2F	DWG	Y1 safety cap. DE1E3KX222M	MURATA
C21	2n2F	DWG	Y1 safety cap. DE1E3KX222M	MURATA
C22	220 pF	0805	50 V cercap - general purpose	AVX
C23	10 nF	0805	50 V cercap - general purpose	AVX
C24	100 uF	DIA10X12.5 (mm)	50 V aluminium elcap - YXF series - 105 °C	RUBYCON
C25	330 nF	0805	50 V cercap - general purpose	AVX
C26	10 uF	DIA6.3X11 (mm)	50 V aluminium elcap - YXF series - 105 °C	RUBYCON
C27	220 pF	5x3 mm	500 V cercap - 5MQ221KAAAA	AVX
C28	22 nF	5x18 p.15 mm	1000 V - mkp film cap - B32652A0223K000	EPCOS
C29	470 uF	DIA10X20 (mm)	35 V aluminium elcap - ZL series - 105 °C	RUBYCON
C3	2n2F	DWG	Y1 safety cap. DE1E3KX222M	MURATA
C30	470 uF	DIA10X20 (mm)	35 V aluminium elcap - ZL series - 105 °C	RUBYCON
C31	100 uF	DIA8X11 (mm)	35 V aluminium elcap - YXF series - 105 °C	RUBYCON
C32	100 nF	0805	50 V cercap - general purpose	AVX
C33	470 pF	0805	50 V - 5 % - C0G - cercap	AVX
C34	100 nF	0805	50 V cercap - general purpose	AVX
C36	1 uF	DIA6.3X11 (mm)	50 V aluminium elcap - YXF series - 105 °C	RUBYCON
C37	10nF	0805	50 V cercap - general purpose	AVX
C39	100 nF	0805	50 V cercap - general purpose	AVX

Table 4. EVL6599A-90WADP demonstration board: BOM list (continued)

Des.	Part type/ Part value	Case style /Package	Description	Supplier
C4	470 nF	9.0 × 18.0 p.15 mm	X2 - MKP film cap - B32922C3474K	EPCOS
C40	100 nF	1206	50 V cercap - general purpose	AVX
C43	4n7F	1206	50 V cercap - general purpose	AVX
C44	10 nF	1206	50 V cercap - general purpose	AVX
C45	220 nF	0805	25 V cercap - general purpose	AVX
C46	N.M.	0805	Not mounted	
C5	470 nF	7.0 x 16.0 p. 22.5	400 V - film cap - B32673Z5474	EPCOS
C6	4N7	0805	50 V cercap - general purpose	AVX
C7	100 nF	PTH	100 V cercap - general purpose	AVX
C8	10 uF	DIA6.3X11 (mm)	Aluminium elcap - YXF series - 105 °C	RUBYCON
C9	68 uF	Dia. 18X32 mm	450 V aluminium elcap - KXG series - 105 °C	United chemicon
D1	GBU8J	STYLE GBU	Single-phase bridge rectifier	VISHAY
D10	LL4148	Minimelf SOD-80	High speed signal diode	VISHAY
D11	LL4148	Minimelf SOD-80	High speed signal diode	VISHAY
D12	N.M.	Minimelf SOD-80	Not mounted	VISHAY
D13	N.M.	Minimelf SOD-80	Not mounted	VISHAY
D14	N.M.	Minimelf SOD-80	Not mounted	
D15	BZV55-C15	Minimelf SOD-80	Zener diode	VISHAY
D16	LL4148	Minimelf SOD-80	High speed signal diode	VISHAY
D17	N.M.	Minimelf SOD-80	Not mounted	
D18	LL4148	Minimelf SOD-80	High speed signal diode	VISHAY
D19	LL4148	Minimelf SOD-80	High speed signal diode	VISHAY
D2	LL4148	Minimelf SOD-80	High speed signal diode	VISHAY
D20	BZV55-C15	Minimelf SOD-80	Zener diode	VISHAY
D21	BZV55-C15	Minimelf SOD-80	Zener diode	VISHAY
D22	LL4148	Minimelf SOD-80	Fast switching diode	VISHAY
D23	STPS30H60CFP	TO-220FP	Power Schottky rectifier	STMicroelectronics
D24	STPS30H60CFP	TO-220FP	Power Schottky rectifier	STMicroelectronics
D3	1N4005	DO-41	General purpose rectifier	VISHAY
D4	STTH2L06	DO-41	Ultrafast high voltage rectifier	STMicroelectronics
D5	LL4148	Minimelf SOD-80	High speed signal diode	VISHAY
D6	LL4148	Minimelf SOD-80	High speed signal diode	VISHAY
D7	LL4148	Minimelf SOD-80	High speed signal diode	VISHAY
D8	BZV55-B27	Minimelf SOD-80	Zener diode	VISHAY

Table 4. EVL6599A-90WADP demonstration board: BOM list (continued)

Des.	Part type/ Part value	Case style /Package	Description	Supplier
D9	STPS1L60A	SMA	Power Schottky rectifier	STMicroelectronics
F1	FUSE T4A	8.5x4 p.5.08mm	Fuse 4A - time lag - 3921400	Littlefuse
HS1	HEAT-SINK	DWG	Heat sink for D1, Q1, Q3, Q4	
HS2	HEAT SINK	DWG	Heat sink for D23, D24	
J1	MKDS 1,5/ 3-5,08	DWG	PCB term. block, screw conn.,pitch 5mm 3 W.	Phoenix contact
J2	MKDS 1,5/ 2-5,08	DWG	PCB term. block, screw conn.,pitch 5mm 2 W.	Phoenix contact
JPX1	Jumper	Wire	Bare copper wire jumper	
JPX2	Jumper	Wire	Bare copper wire jumper	
JPX3	Jumper	Wire	Bare copper wire jumper	
L1	2019.0002		CM inductor 2x18mH 1.8A	MAGNETICA
L2	1974.0002	DWG	PFC inductor - 0.52mH (X08141-01-B)	MAGNETICA
L3	1071.0083	DWG	1 uH - 5 A inductor	MAGNETICA
Q1	STF12NM50N	TO-220FP	N-channel power MOSFET	STMicroelectronics
Q10	BC847C	SOT-23	NPN small signal BJT	VISHAY
Q2	BC857C	SOT-23	PNP small signal BJT	VISHAY
Q3	STF7NM50N	TO-220FP	N-channel power MOSFET	STMicroelectronics
Q4	STF7NM50N	TO-220FP	N-channel power MOSFET	STMicroelectronics
Q5	BC847C	SOT-23	NPN small signal BJT	VISHAY
Q6	BC847C	SOT-23	NPN small signal BJT	VISHAY
Q7	N.M.	SOT-23	PNP small signal BJT - not used	
Q9	BC847C	SOT-23	NPN small signal BJT	VISHAY
R1	3M3	1206	SMD STD film res, 1/4 W, 5 %, 250 ppm/°C	VISHAY
R10	27 K	0805	SMD STD film res, 1/8 W, 1 %, 100 ppm/°C	VISHAY
R11	2M2	1206	SMD STD film res, 1/4 W, 1 %, 100 ppm/°C	VISHAY
R12	2M2	1206	SMD STD film res, 1/4 W, 1 %, 100 ppm/°C	VISHAY
R13	8K2	1206	SMD STD film res, 1/4 W, 1 %, 100 ppm/°C	VISHAY
R14	51 K	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R15	56 K	1206	SMD STD film res, 1/4 W, 1 %, 100 ppm/°C	VISHAY
R16	4K7	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R17	2M2	1206	SMD STD film res, 1/4 W, 1 %, 100 ppm/°C	VISHAY
R18	82 K	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R19	56 K	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R2	3M3	1206	SMD STD film res, 1/4 W, 5 %, 250 ppm/°C	VISHAY
R20	0R0	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY

Table 4. EVL6599A-90WADP demonstration board: BOM list (continued)

Des.	Part type/ Part value	Case style /Package	Description	Supplier
R21	39 R	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R22	0R47	PTH	SFR25 axial stand. film res, 0.4 W, 5 %, 250 ppm/°C	VISHAY
R23	0R68	PTH	SFR25 axial stand. film res, 0.4 W, 5 %, 250 ppm/°C	VISHAY
R24	1 Meg	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R25	56 R	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R26	1 Meg	0805	SMD STD film res, 1/8 W, 1 %, 100 ppm/°C	VISHAY
R27	470 R	1206	SMD STD film res, 1/4 W, 5 %, 250 ppm/°C	VISHAY
R28	33 K	0805	SMD STD film res, 1/8 W, 1%, 100 ppm/°C	VISHAY
R29	1K0	1206	SMD STD film res, 1/4 W, 5 %, 250 ppm/°C	VISHAY
R3	1 Meg	1206	SMD STD film res, 1/4 W, 1 %, 100 ppm/°C	VISHAY
R30	10 R	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R31	33 K	0805	SMD STD film res, 1/8 W, 1 %, 100 ppm/°C	VISHAY
R32	47 R	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R33	N.M.	0805	Not mounted	
R34	5K1	1206	SMD STD film res, 1/4 W, 1 %, 100 ppm/°C	VISHAY
R35	180 K	0805	SMD STD film res, 1/8 W, 1 %, 100 ppm/°C	VISHAY
R36	N.M.	0805	Not mounted	
R37	220 K	1206	SMD STD film res, 1/4 W, 5 %, 250 ppm/°C	VISHAY
R38	56 R	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R39	180 R	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R4	4M7	0805	SMD STD film res, 1/8W, 5 %, 250 ppm/°C	VISHAY
R40	0R0	1206	SMD STD film res, 1/4 W, 5 %, 250 ppm/°C	VISHAY
R41	100 R	PTH	SFR25 axial stand. film res, 0.4 W, 5 %, 250 ppm/°C	VISHAY
R42	10 K	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R43	N.M.	0805	Not mounted	
R44	12 K	1206	SMD STD film res, 1/4 W, 5 %, 250 ppm/°C	VISHAY
R45	N.M.	0805	Not mounted	
R46	100 K	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R47	1K5	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R48	120 K	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R49	39 K	0805	SMD STD film res, 1/8 W, 1 %, 100 ppm/°C	VISHAY
R5	10 R	1206	SMD STD film res, 1/4 W, 5 %, 250 ppm/°C	VISHAY

Table 4. EVL6599A-90WADP demonstration board: BOM list (continued)

Des.	Part type/ Part value	Case style /Package	Description	Supplier
R50	6K2	0805	SMD STD film res, 1/8 W, 1 %, 100 ppm/°C	VISHAY
R51	120 K	0805	SMD STD film res, 1/8 W, 1 %, 100 ppm/°C	VISHAY
R52	12 K	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R53	2K2	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R54	0R0	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R55	2K7	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R56	18 K	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R57	47R	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R58	100 K	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R59	100 K	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R6	NTC 2R5-S237	DWG	NTC resistor P/N B57237S0259M000	EPCOS
R60	10 K	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R61	2K7	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R62	4K7	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R65	47K	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R66	2K2	1206	SMD STD film res, 1/4 W, 5 %, 250 ppm/°C	VISHAY
R67	N.M.	0805	Not mounted	
R68	N.M.	1206	Not mounted	
R69	4K7	0805	SMD STD film res, 1/8 W, 5 %, 250 ppm/°C	VISHAY
R7	1Meg	1206	SMD STD film res, 1/4 W, 1 %, 100 ppm/°C	VISHAY
R8	1Meg	1206	SMD STD film res, 1/4 W, 1 %, 100 ppm/°C	VISHAY
R9	62 K	0805	SMD STD film res, 1/8 W, 1 %, 100 ppm/°C	VISHAY
T1	1860.0032	DWG, ETD34	Resonant power transformer	MAGNETICA
U1	L6563H	SO-16	High voltage startup TM PFC controller	STMicroelectronics
U2	L6599AD	SO-16	Improved HV resonant controller	STMicroelectronics
U3	SFH617A-4	DIP-4, 10.16 mm	Optocoupler	Infineon
U4	TL431AIZ	TO-92	Programmable shunt voltage reference	STMicroelectronics
Z1	PCB REV. 1.0			

8 PFC coil specification

General description and characteristics:

- Application type: consumer, home appliances
- Transformer type: open
- Coil former: vertical type, 6+6 pins
- Max. temp. rise: 45 ºC
- Max. operating ambient temperature: 60 ºC
- Mains insulation: n.a.
- Unit finishing: varnished

Electrical characteristics:

- Converter topology: boost, transition mode
- Core type: PQ26/20-PC44 or equivalent
- Min. operating frequency: 40 kHz
- Typical operating frequency: 120 kHz
- Primary inductance: 520 µH±15 % at 1 kHz-0.25 V

Electrical diagram and winding characteristics:

Figure 20. PFC coil electrical diagram

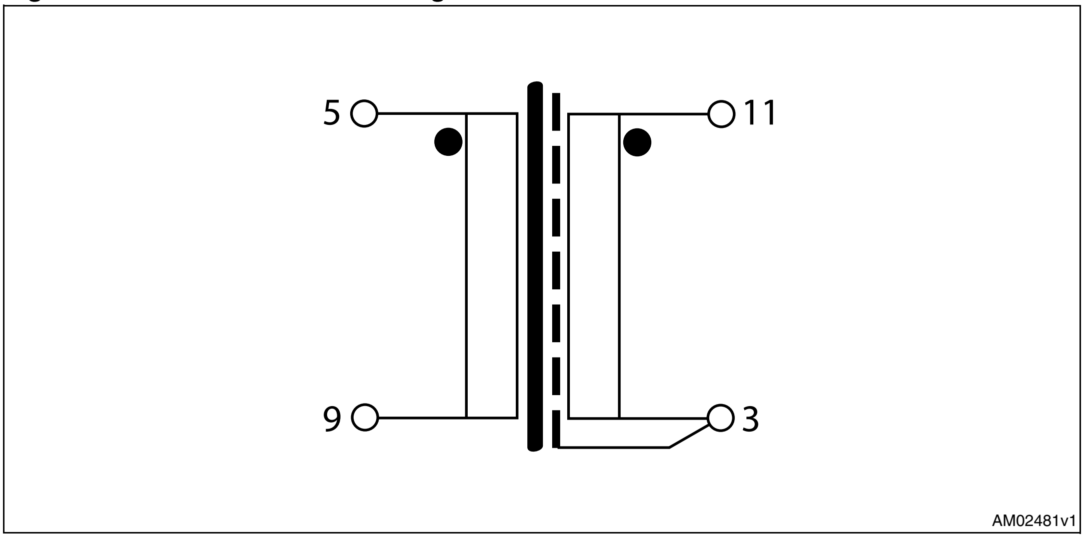


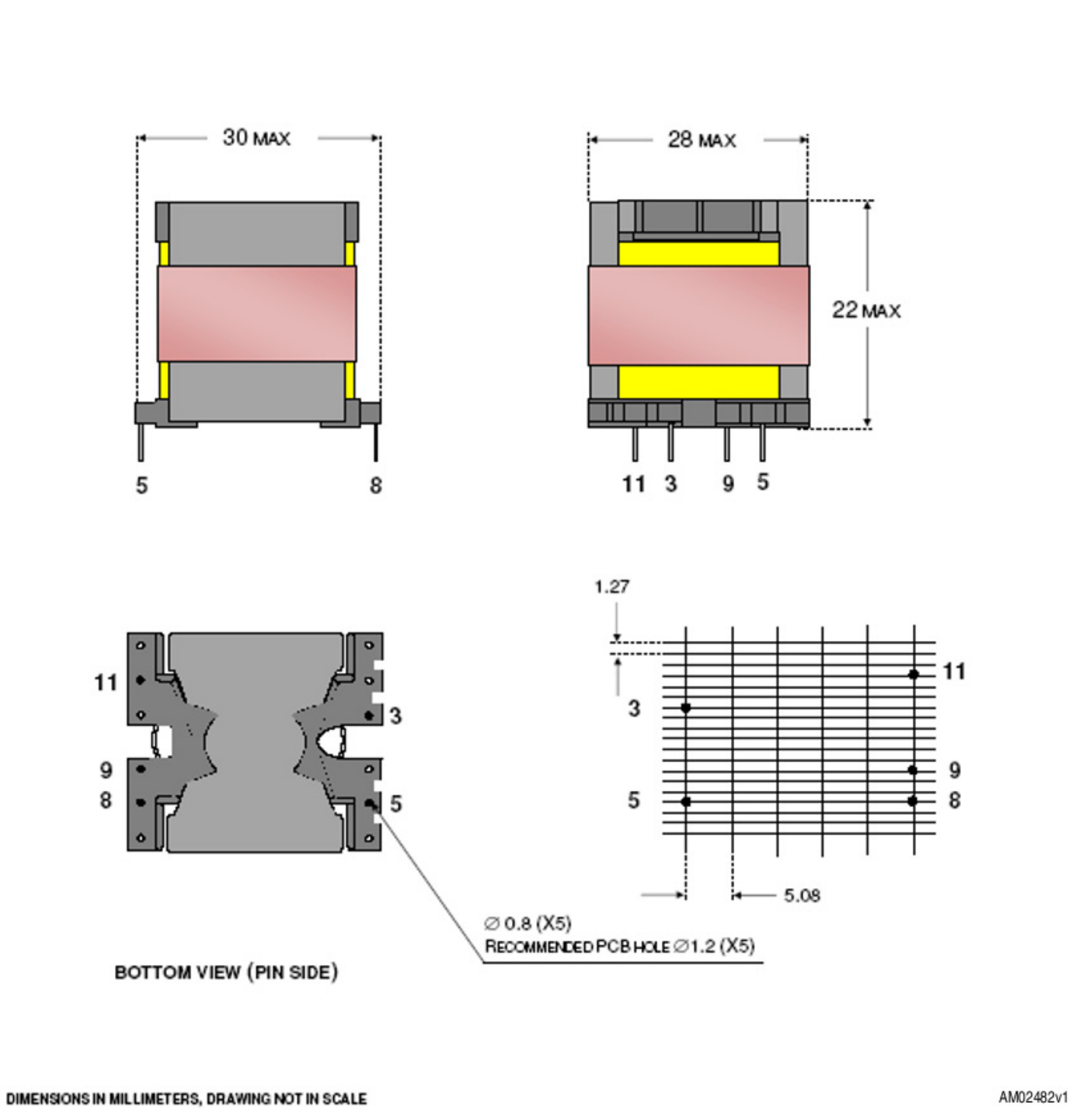
Table 5. PFC coil winding data

Pins	Windings	DC resistance	Number of turns	Wire type
11 - 3	AUX	125 mΩ	5.5	ϕ 0.28 mm – G2
5 - 9	PRIMARY	267 mΩ	57.5	30xϕ 0.1 mm – G1

8.1 Mechanical aspect and pin numbering

- Maximum height from PCB: 22 mm
- Coil former type: vertical, 6+6 Pins (Pins #1, 2, 4, 6, 7, 10, and 12 are removed)
- Pin distance: 3.81 mm
- Row distance: 25 mm
- External copper shield: not insulated, wound around the ferrite core and including the coil former. Height is 8 mm. Connected to pin #3 by a soldered solid wire.

Figure 21. PFC coil mechanical aspect



Manufacturer:

- MAGNETICA, R. Volpini - Italy
- Inductor P/N: 1974.0002

9 Transformer specifications

General description and characteristics:

- Application type: consumer, home appliances
- Transformer type: open
- Coil Former: horizontal type, 7+7 pins, two slots
- Max. temp. rise: 45 ºC
- Max. operating ambient temperature: 60 ºC
- Mains insulation: Acc. with EN60065

Electrical characteristics:

- Converter topology: half-bridge, resonant
- Core type: ETD34-PC44 or equivalent
- Min. operating frequency: 60 kHz
- Typical operating frequency: 100 kHz
- Primary inductance: 1200 μH±8 % at 1 kHz-0.25 V [a]
- Leakage inductance: 200 μH at 100 kHz-0.25 V [b]

Electrical diagram and winding characteristics:

Figure 22. Transformer electrical diagram

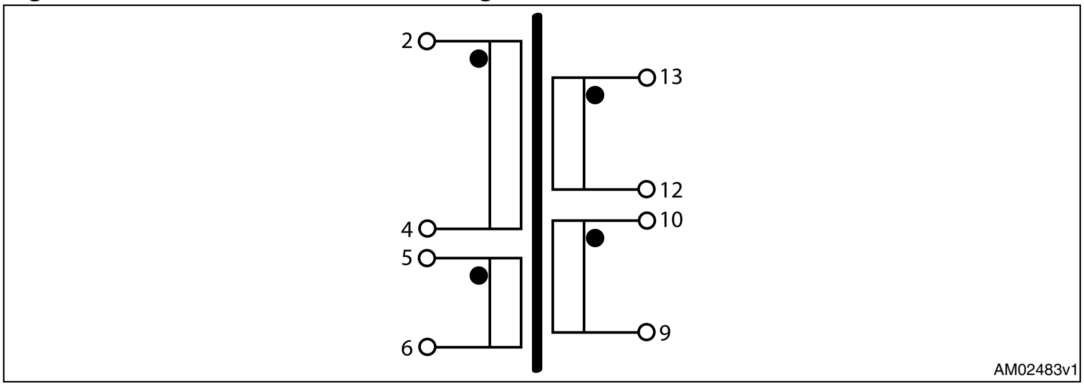


Table 6. Transformer winding data

Pins	Winding	DC resistance	Number of turns	Wire type
2-4	Primary	235 mΩ	50	30xϕ 0.1 mm – G1
13-12	SEC - A[1]	9 mΩ	5	90xϕ 0.1 mm – G1
10-9	SEC – B [1]	9 mΩ	5	90xϕ 0.1 mm – G1
5-6	AUX [2]	94 mΩ	4	ϕ 0.28 mm – G2

1. Secondary windings A and B are in parallel
2. Aux winding is wound on top of primary winding

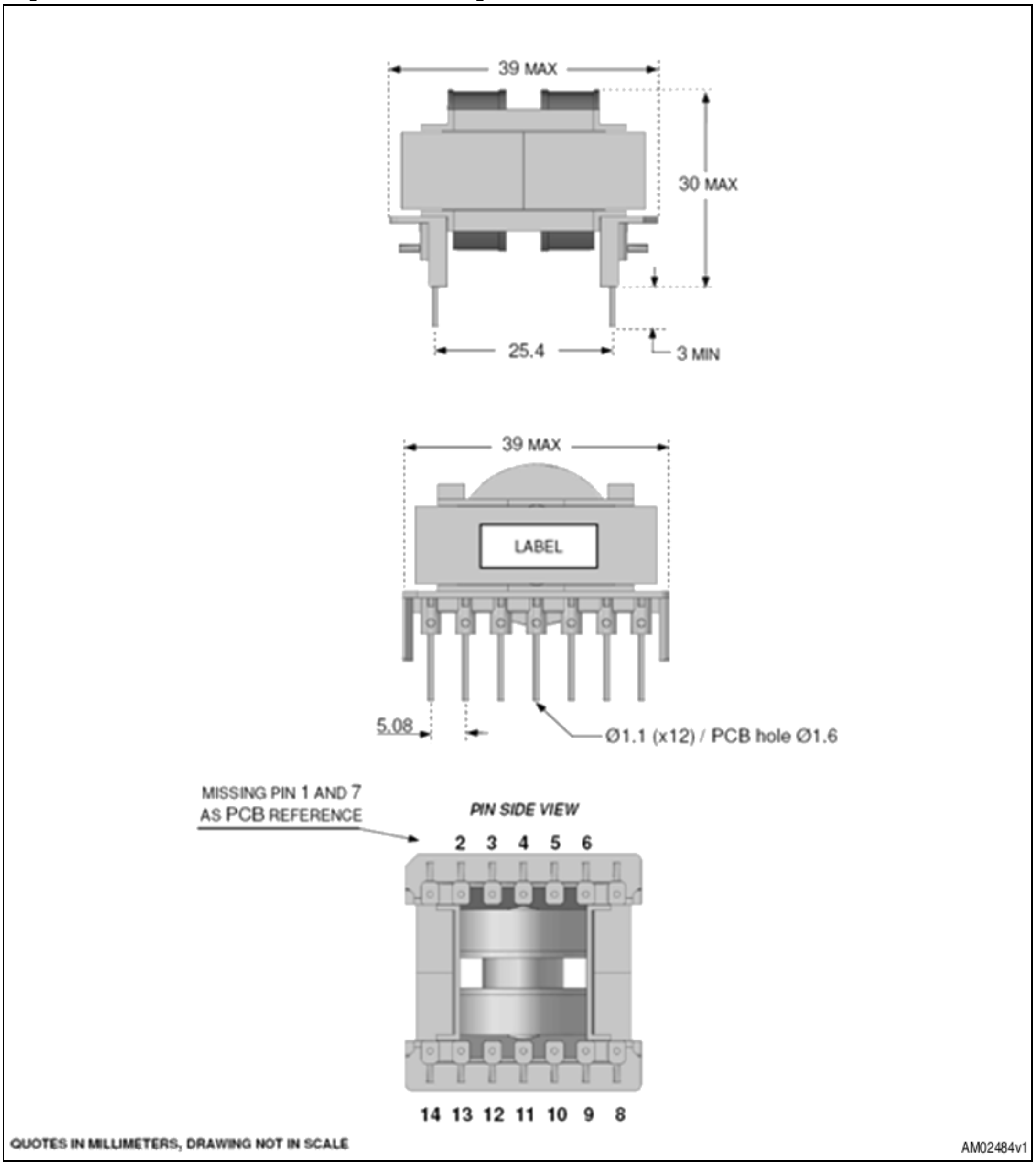
a. Measured between pins 2-4

b. Measured between pins 2-4 with only one secondary winding shorted

9.1 Mechanical aspect and pin numbering

- Maximum Height from PCB: 30mm
- Coil Former Type: horizontal, 7+7 pins (pins #1 and 7 are removed)
- Pin distance: 5.08mm
- Row distance: 25.4mm

Figure 23. Transformer overall drawing



Manufacturer:

- MAGNETICA, R. Volpini - Italy
- Transformer P/N: 1860.0032

10 Revision history

Table 7. Document revision history

Date	Revision	Changes
14-Dec-2010	1	Initial release

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com