

UM10564

UBA2017DB1064 2 x 28 W T5 demo board

Rev. 1 — 20 August 2012

User manual

Document information

Info	Content
Keywords	UBA2017P, 2 x 28 W T5 ballast, passive PFC, improved valley fill, continuous input current
Abstract	This document describes the UBA2017DB1064 demo board for 230 V (AC). The ballast drives two 28 W T5 lamps featuring the UBA2017P. This user manual describes the performances, technical data and wiring of the board. This demo board can also be modified to drive one T5 lamp with a power of either 21 W, 28 W or 35 W.



Revision history

Rev	Date	Description
v.1	20120820	first issue

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1. Introduction

WARNING

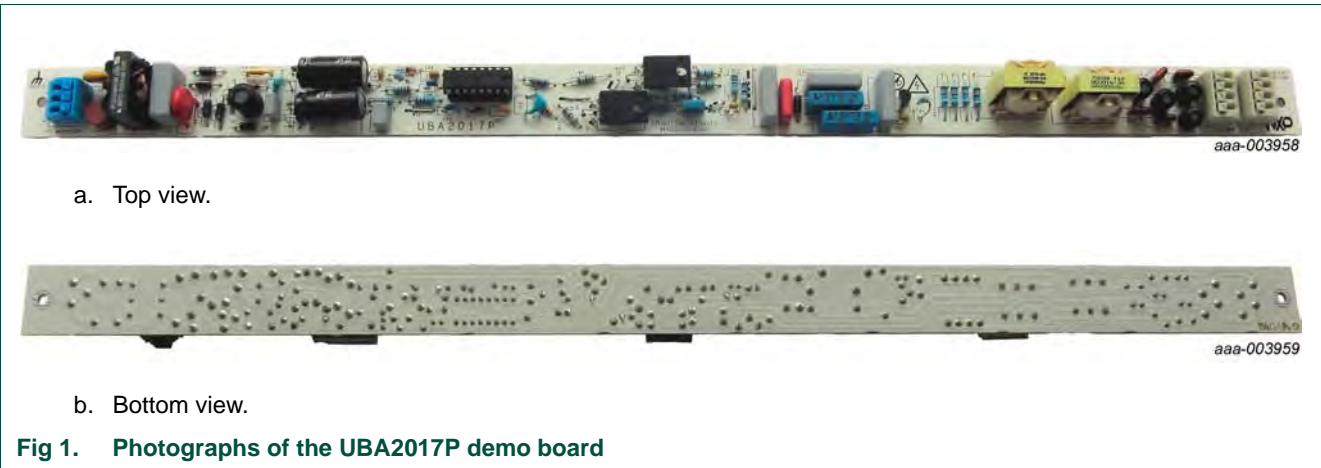
Lethal voltage and fire ignition hazard



The non-insulated high voltages that are present when operating this product, constitute a risk of electric shock, personal injury, death and/or ignition of fire.

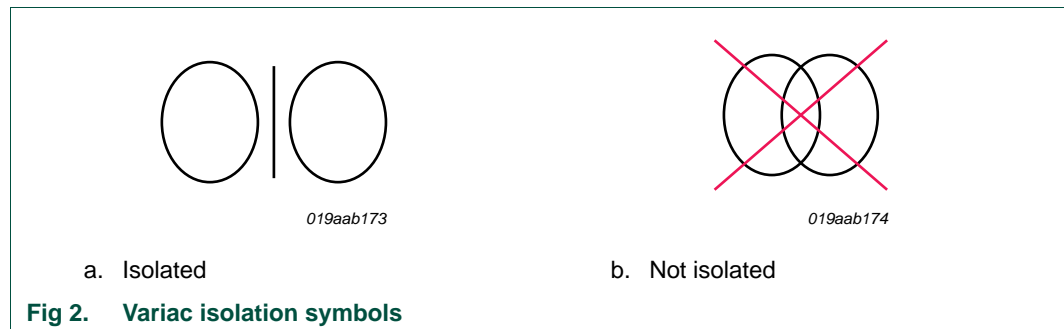
This product is intended for evaluation purposes only. It shall be operated in a designated test area by personnel qualified according to local requirements and labor laws to work with non-insulated mains voltages and high-voltage circuits. This product shall never be operated unattended.

The UBA2017DB1064 demo board is intended to serve as a two lamp ballast example using a passive PFC. This manual describes the specification and use of the UBA2017DB1064 board. The demo board can be reconfigured for single lamp operation which is described in [Section 11 on page 18](#).



2. Safety warning

Connect the board to the mains voltage. Avoid touching the board while it is connected to the mains voltage. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. Galvanic isolation of the mains phase using a variable transformer is always recommended.



3. Specifications

Table 1. Electrical specification

Description	comment
Ballast type	electronic
Starting method	programmed start with preheat
Starting time	< 1 s
Lamp terminals	2 × 4
Line voltage	230 V (AC), ±20 %
Line frequency	50 Hz/60 Hz
Lamp type	21 W/28 W/35 W T5
Number of lamps	2
Mains harmonics	complies with IEC 61000-3-2, Class-C
Conducted emission	complies with IEC55015

Table 2. Ballast performance

Lamp type	Number of lamps	Lamp power (W)	THD (%)	Power factor	I _{lamp} (A)	
					maximum crest factor	maximum
T5 28 W	2	28	15	0.984	1.65	165

4. Wiring diagram

Connect the ballast as shown in [Figure 3](#). Keep the wires connected to pins 1 and 2 of connector X1 and X2 short. One lamp connects to connector X1, the other lamp connects to connector X2. Connect the mains voltage of 230 V(AC) to pins 2 and 3 of connector X3.

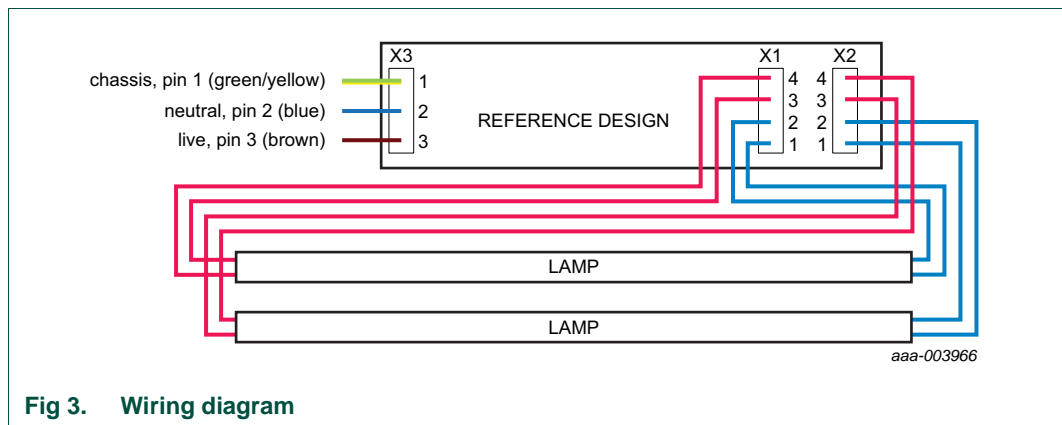


Fig 3. Wiring diagram

5. Board information

5.1 Block diagram

The block diagram includes the functions:

- The fuse
- ElectroMagnetic Interference (EMI) filter
- Full-wave rectifier
- Continuous Input Current (CIC) circuit
- Improved Valley Fill (IVF) circuit
- Half-bridge
- Resonant circuit
- UBA2017 half-bridge controller

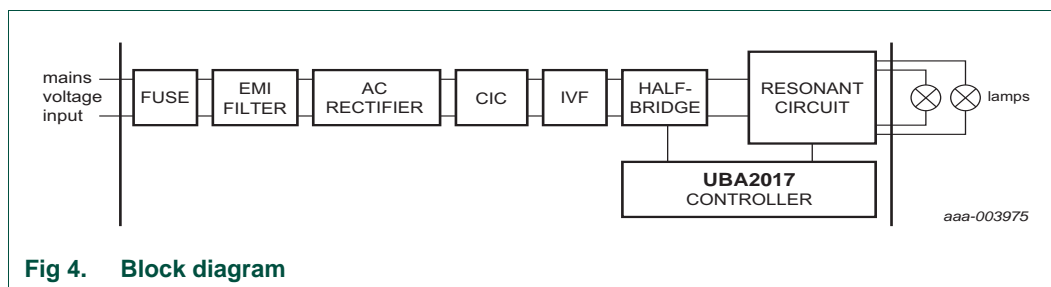


Fig 4. Block diagram

5.2 Operating principle

[Figure 5](#) is a simplified version of the complete diagram of the board. This section describes the basic functionality of the ballast.

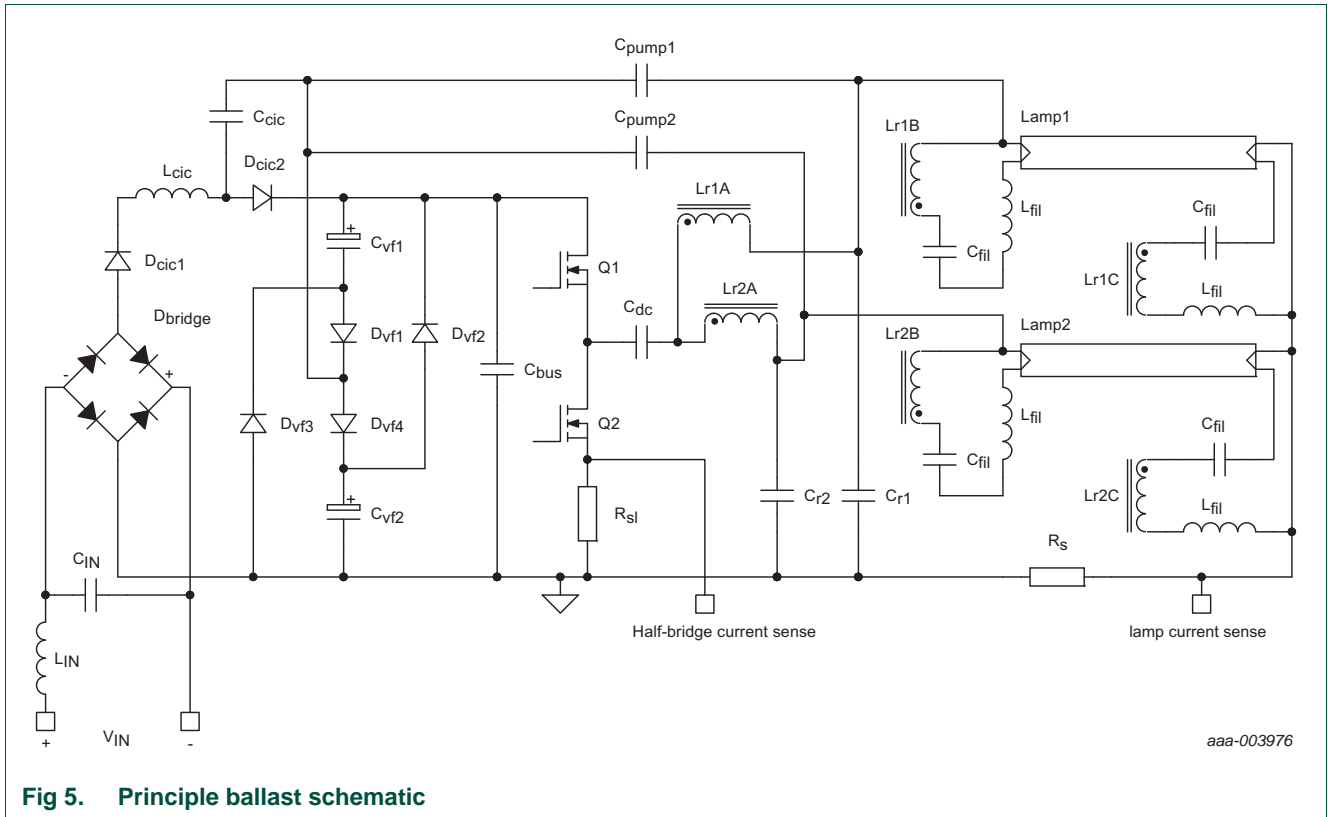
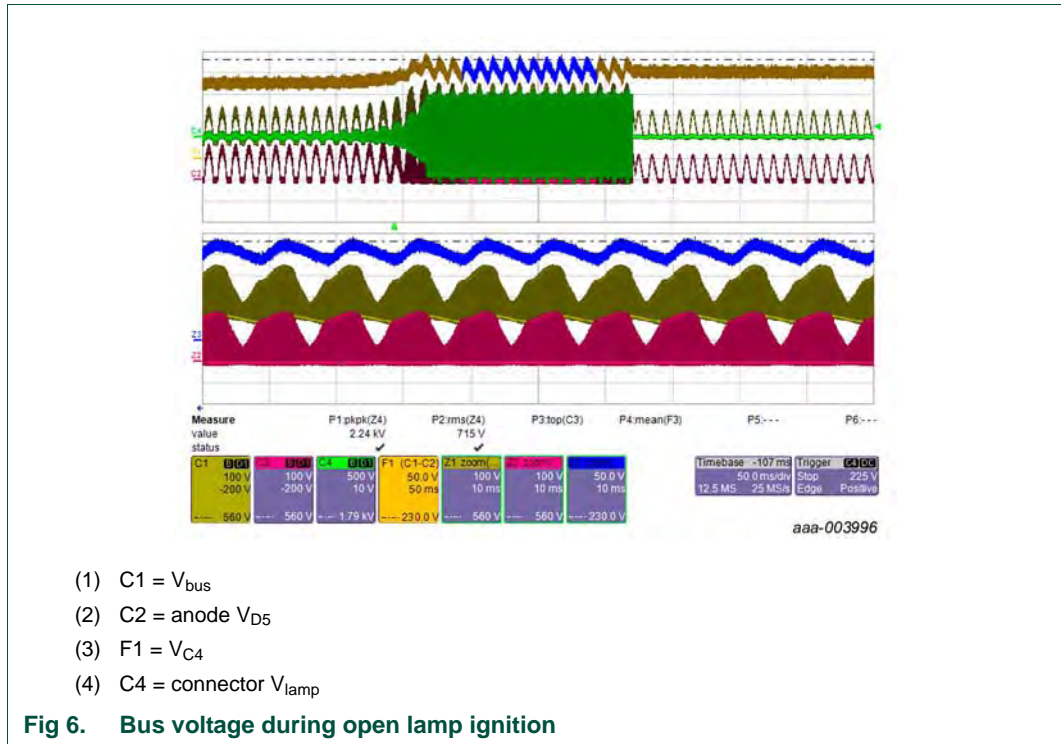


Fig 5. Principle ballast schematic

5.2.1 Improved valley fill function

The topology of this board is an improved valley fill (IVF), consisting of C_{vf1} , C_{vf2} , D_{vf1} , D_{vf2} , D_{vf3} , D_{vf4} and C_{bus} . The charge pump capacitors C_{pump1} and C_{pump2} which connect to the lamp voltage signal improve the valley fill function. Both electrolytic capacitors have a rating of 250 V. Do not exceed the maximum rating of the electrolytic capacitors. Channel F1 in Figure 5 shows the voltage across the upper electrolytic capacitor $C_{vf1} = C4$ in the schematic when the lamp does not ignite.



5.2.2 Mains harmonics

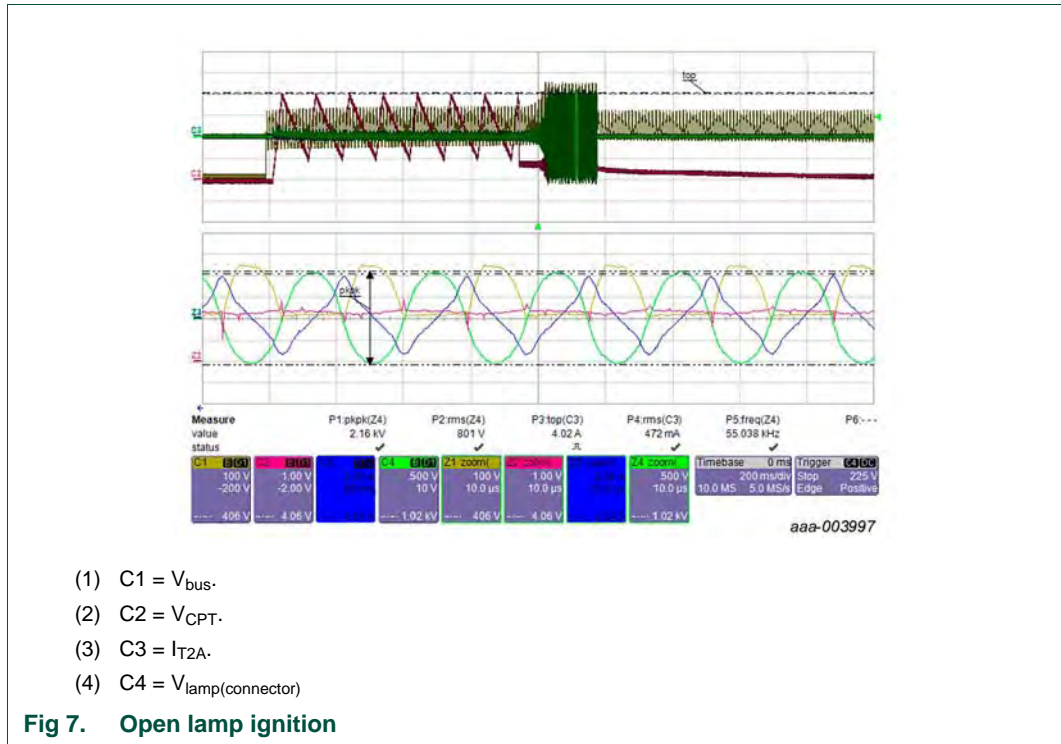
The Continuous Input Current (CIC) circuit manages the IEC mains harmonics class-C requirements. The CIC circuit consists of D_{cic1} , D_{cic2} , L_{cic} , C_{cic} . D_{cic1} is a fast diode in series with the diode bridge. D_{cic1} ensures a fast switch off behavior of the bridge diodes.

5.2.3 Lamp current crest factor

To meet the lamp current crest factor for IEC requirements, the lamp current control loop is used. The lamp current control loop reduces the peak of the lamp current when the mains voltage is at the maximum. The lamp current is sensed using resistor R_{sense} . Below 50 kHz the quasi-peak conducted emission requirements of IEC is 110 dB μ V. Therefore the half-bridge frequency is kept below 50 kHz, so there is headroom to allow some HF ripple in the mains current.

5.2.4 Small and low-cost half-bridge coil

If a lamp cannot ignite, the ballast generates a voltage of 750 V (RMS) which is sufficient to ignite any T5 lamp. The ignition voltage is maintained over approximate 150 ms to guarantee ignition of cold and old lamps. In this ignition phase, the LC tank inductor is saturating. The UBA2017 controller increases the half-bridge frequency instantaneously when the saturation current occurs. The level of saturation is set using a sense resistor in the source of the low side switch. [Figure 7](#) shows the saturating current and the open lamp voltage during ignition.



5.2.5 Electrode/filament heating

A winding coupled to the main LC tank inductor heats each electrode. The peak of the transfer is at 90 kHz. The components C_{fil} and L_{fil} set this peak frequency. The resonance frequency of the electrode circuit (C_{fil} , L_{fil} and electrode resistance) determines this peak frequency. The UBA2017 sets the preheat frequency at 90 kHz.

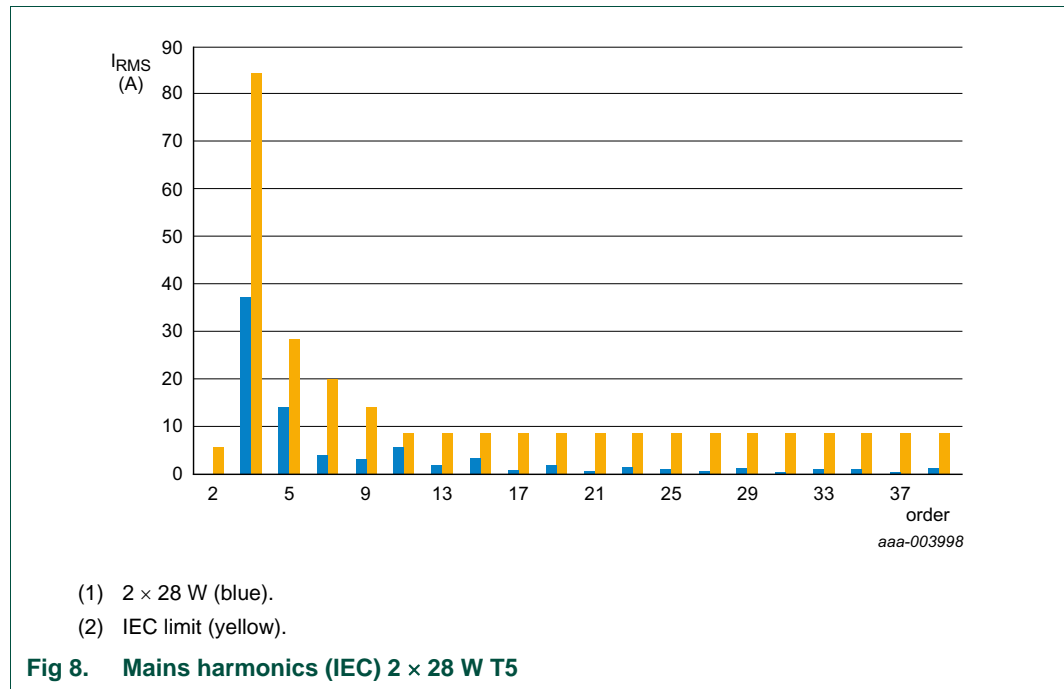
There are several advantages to this type of heating circuit:

- During the preheat phase, there is enough energy to allow preheat times below 1 second.
- During the ignition phase, the load of the electrode resistance is small because of the 2nd order roll off the C_{fil} and L_{fil} filter. This feature increases the Q of the LC tank enabling either:
 - a higher ignition voltage to be achieved
 - the use of a smaller resonance inductor
- During normal operation, the electrode current is small at 45 kHz because of the 2nd order roll off from the C_{fil} and L_{fil} filter. This results in a lower Sum of Squares and higher ballast efficiency.

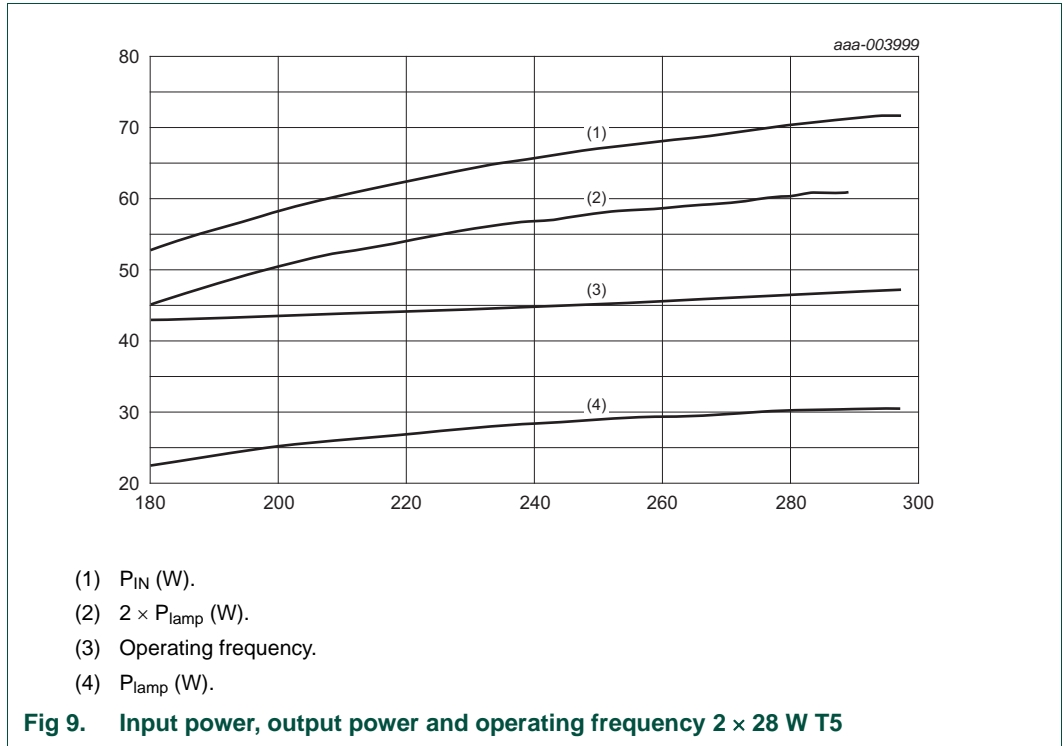
6. Performance indicators

This section includes some of the measurements on the board. The measurements are made using an Everfine HB-6 ballast analyzer.

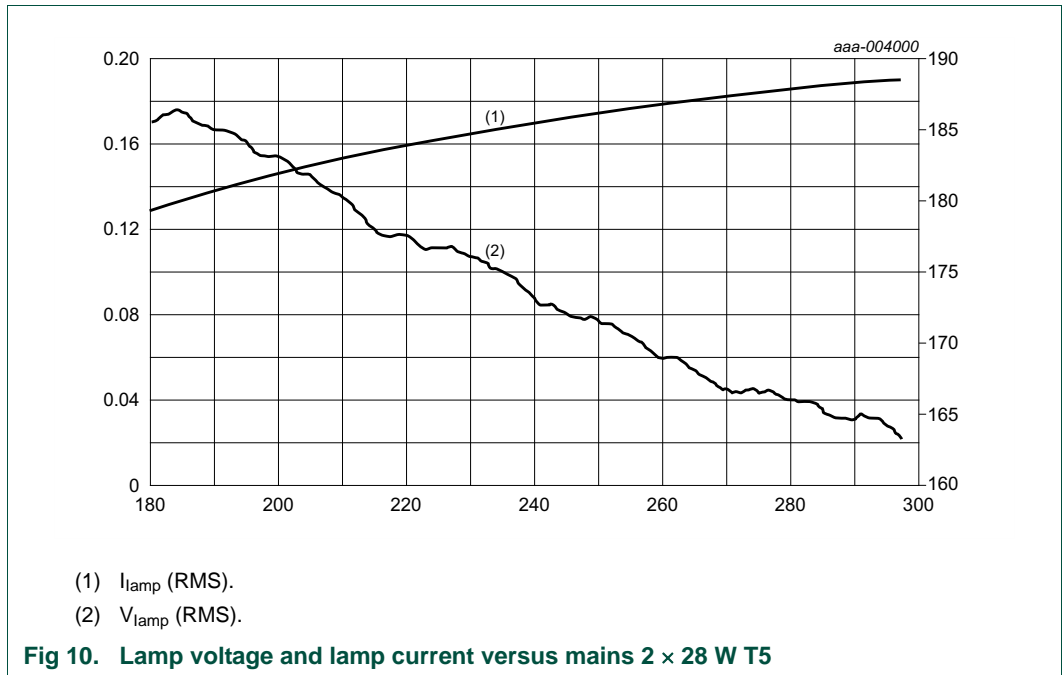
6.1 Mains harmonics data



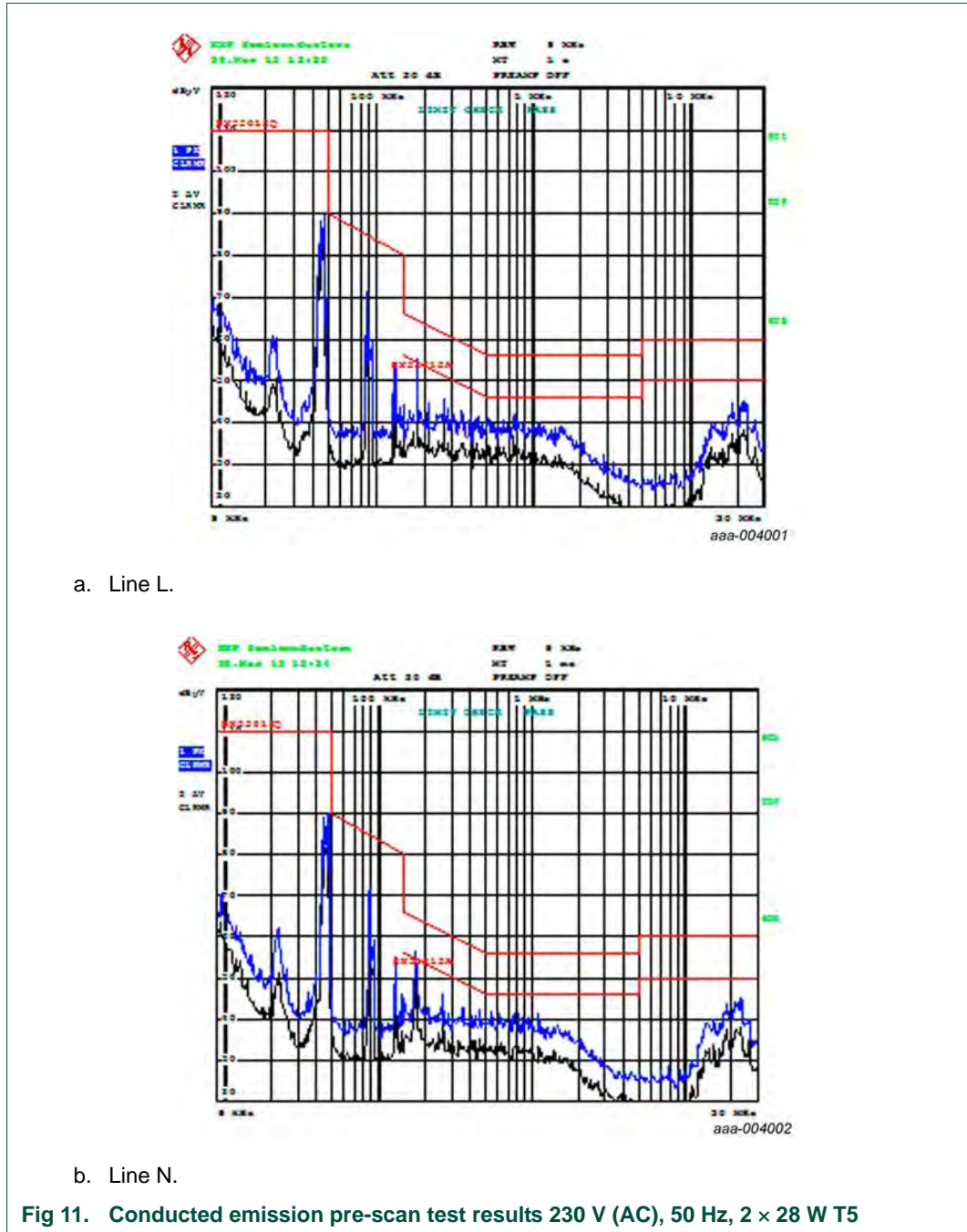
6.2 Input and output power versus mains input voltage



6.3 Lamp voltage and lamp current versus mains input voltage



6.4 ElectroMagnetic Interference (EMI) prescan data



7. Schematic

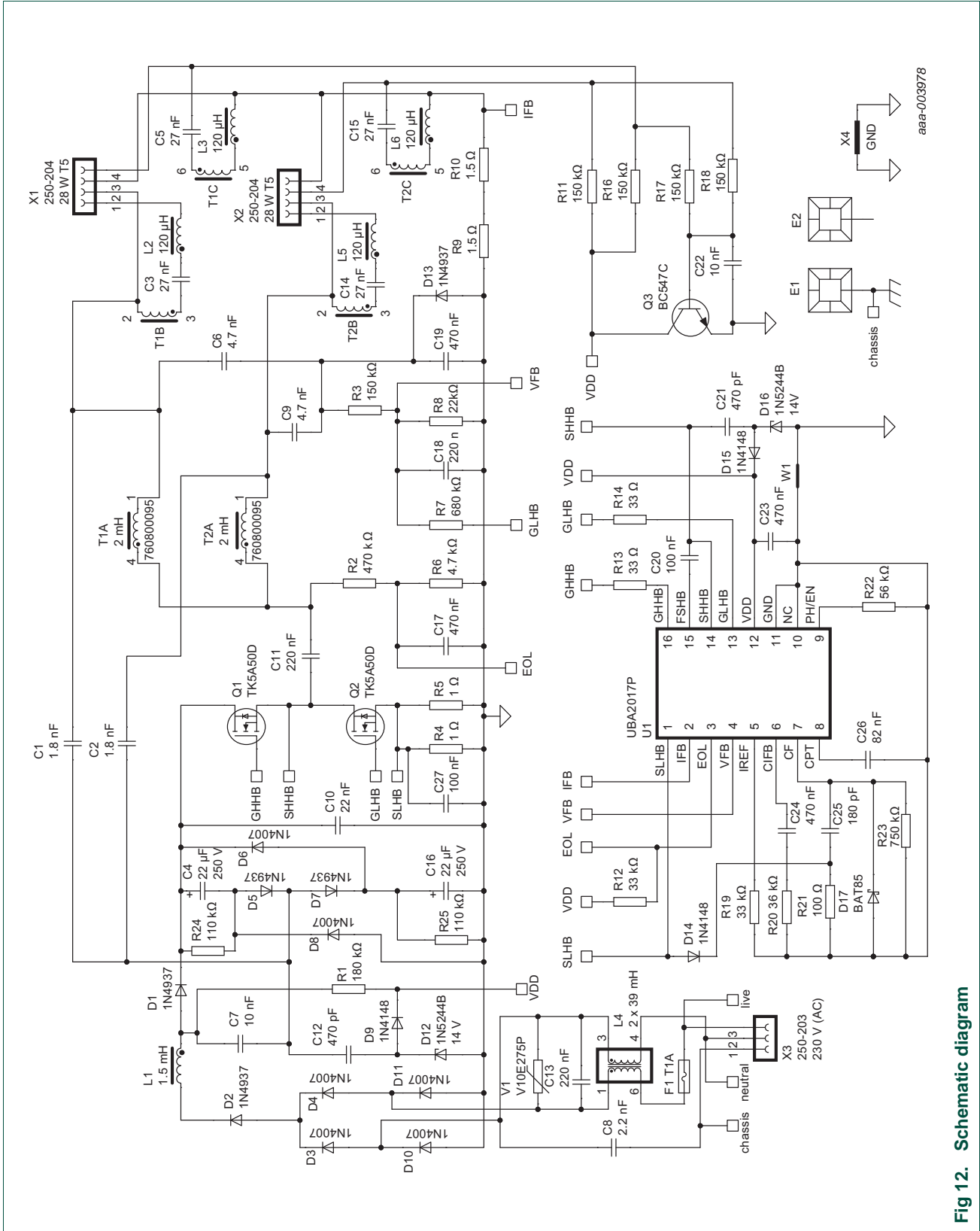


Fig 12. Schematic diagram

8. PCB layout

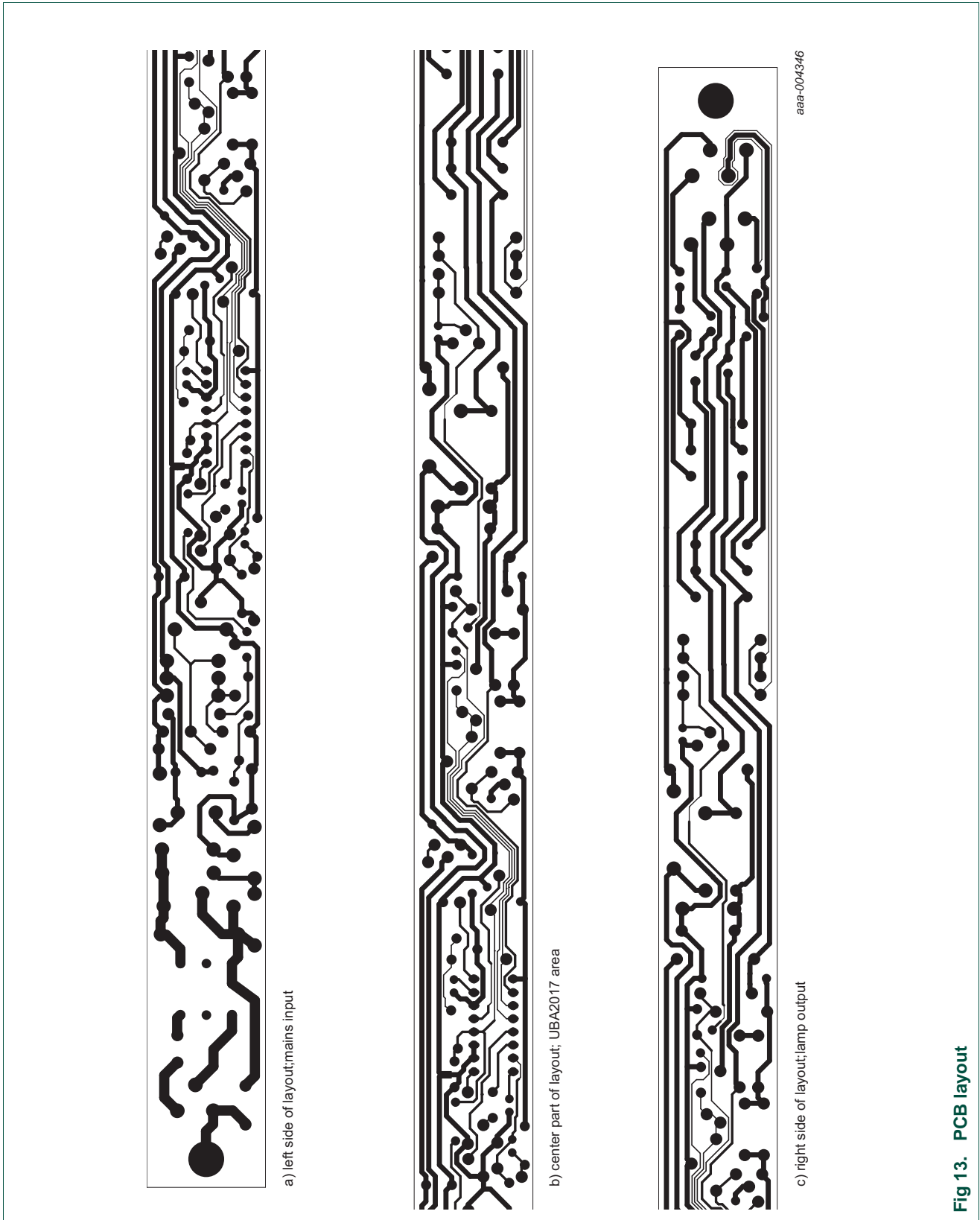


Fig 13. PCB layout

9. Bill of materials

Table 3. Bill of materials

Part reference	Description and value	Part number	Manufacturer
C1	capacitor; 1.8 nF; 1.6 kV	B32652A1182J	EPCOS
C2	capacitor; 1.8 nF; 1.6 kV	B32652A1182J	EPCOS
C3	film capacitor; 27 nF; 100 V	ECQV1273JM	Panasonic
C4	capacitor; 22 μ F; 250 V	EEUED2E220	Panasonic
C5	capacitor; 27 nF; 100 V	ECQV1273JM	Panasonic
C6	capacitor; 4.7 nF; 2 kV	BFC238560472	Vishay
C7	capacitor; 10 nF; 400 V	BFC237051103	Vishay
C8	Y-capacitor; 2.2 nF	VY2222M35Y5US63V7	Vishay
C9	capacitor; 4.7 nF; 2 kV	BFC238560472	Vishay
C10	capacitor; 22 nF; 400 V	BFC237051223	Vishay
C11	capacitor; 220 nF; 400 V	B32562J6224K000	EPCOS
C12	ceramic disc capacitor; 470 pF; 1 kV	DEBB33A471KC1B	Murata
C13	capacitor; 220 nF; 400 V	BFC233922224	Vishay
C14	film capacitor; 27 nF; 100 V	ECQV1273JM	Panasonic
C15	film capacitor; 27 nF; 100 V	ECQV1273JM	Panasonic
C16	capacitor; 22 μ F; 250 V	EEUED2E220	Panasonic
C17	capacitor; 470 nF; X7R	FK28X7R1C474K	TDK
C18	capacitor; 220 nF; 63 V	B32529C224J000	EPCOS
C19	film capacitor; 470 nF; 63 V	MKS4D034703C00KSSD	WIMA
C20	capacitor; 100 nF; X7R	C326C104K5R5TA	KEMET
C21	ceramic disc; 470 pF; 1 kV	DEBB33A471KC1B	Murata
C22	capacitor; 10 nF; X7R	C316C103K5R5TA	KEMET
C23	capacitor; 470 nF; X7R	FK28X7R1C474K	TDK
C24	capacitor; 470 nF; X7R	FK28X7R1C474K	TDK
C25	capacitor (COG); 180 pF; 5 %	C315C181J1G5TA	KEMET
C26	capacitor; 82 nF; X7R	C320C823K5R5TA	KEMET
C27	capacitor; 100 nF; X7R	C326C104K5R5TA	KEMET
D1	diode; 1N4937	1N4937-E3_54	Vishay
D2	diode; 1N4937	1N4937-E3_54	Vishay
D3	diode; 1N4007	1N4007-E3_54	Vishay
D4	diode; 1N4007	1N4007-E3_54	Vishay
D5	diode; 1N4937	1N4937-E3_54	Vishay
D6	diode; 1N4007	1N4007-E3_54	Vishay
D7	diode; 1N4937	1N4937-E3_54	Vishay
D8	diode; 1N4007	1N4007-E3_54	Vishay
D9	diode; 1N4148	1N4148-TR	NXP Semiconductors
D10	diode; 1N4007	1N4007-E3_54	Vishay
D11	diode; 1N4007	1N4007-E3_54	Vishay
D12	diode; 1N5244B	1N5244B-TAP	Vishay

Table 3. Bill of materials ...continued

Part reference	Description and value	Part number	Manufacturer
D13	diode; 1N4937	1N4937-E3_54	Vishay
D14	diode; 1N4148	1N4148-TR	NXP Semiconductors
D15	diode; 1N4148	1N4148-TR	NXP Semiconductors
D16	diode; 1N5244B	1N5244B-TAP	Vishay
D17	diode; BAT85	BAT85_133	NXP Semiconductors
F1	fuse; 1 A	38211000000	Littelfuse
L1	inductor; 1.5 mH	RL-5480-4-1500	Renco
L2	inductor; 120 μ H	RLB0712-121KL	Bourns
L3	inductor; 120 μ H	RLB0712-121KL	Bourns
L4	inductor; 2 \times 39 mH	B82731T2551A020	EPCOS
L5	inductor; 120 μ H	RLB0712-121KL	Bourns
L6	inductor; 120 μ H	RLB0712-121KL	Bourns
Q1	transistor; TK5A50D	TK5A50D	Toshiba
Q2	transistor; TK5A50D	TK5A50D	Toshiba
Q3	transistor; BC547C	BC547CBU	Fairchild
R1	resistor; 180 k Ω	MRS25	Vishay
R2	resistor; 470 k Ω	MRS25000C4703FC100	Vishay
R3	resistor; 150 k Ω	MRS25000C1503FC100	Vishay
R4	resistor; 1 Ω	MRS25000C1008FC100	Vishay
R5	resistor; 1 Ω	MRS25000C1008FC100	Vishay
R6	resistor; 4.7 k Ω	MRS25000C4701FC100	Vishay
R7	resistor; 680 k Ω	MRS25000C6803FC100	Vishay
R8	resistor; 22 k Ω	MRS25000C2202FC100	Vishay
R9	resistor; 1.5 Ω	MRS25000C1508FC100	Vishay
R10	resistor; 1.5 Ω	MRS25000C1508FC100	Vishay
R11	resistor; 150 k Ω	MRS25000C1503FC100	Vishay
R12	resistor; 33 k Ω	MRS25000C3302FC100	Vishay
R13	resistor; 33 Ω	MRS25000C3309FC100	Vishay
R14	resistor; 33 Ω	MRS25000C3309FC100	Vishay
R16	resistor; 150 k Ω	MRS25000C1503FC100	Vishay
R17	resistor; 150 k Ω	MRS25000C1503FC100	Vishay
R18	resistor; 150 k Ω	MRS25000C1503FC100	Vishay
R19	resistor; 33 k Ω	MRS25000C3302FC100	Vishay
R20	resistor; 36 k Ω	MRS25000C3602FC100	Vishay
R21	resistor; 100 k Ω	MRS25000C1000FC100	Vishay
R22	resistor; 56 k Ω	MRS25000C5602FC100	Vishay
R23	resistor; 750 k Ω	MRS25000C7503FC100	Vishay
R24	resistor; 120 k Ω	MRS25000C1203FC100	Vishay
R25	resistor; 120 k Ω	MRS25000C1203FC100	Vishay
T1	transformer; 2.0 mH	760800095	Würth Elektronik
T2	transformer; 2.0 mH	760800095	Würth Elektronik

Table 3. Bill of materials ...continued

Part reference	Description and value	Part number	Manufacturer
U1	Half-bridge controller IC	UBA2017P/N1	NXP Semiconductors
V1	Varistor; V10E275P	V10E275PL1B	Littelfuse
X1	connector; 4-pin	250-204_000-009	WAGO
X2	connector; 4-pin	250-204_000-009	WAGO
X3	connector; 3-pin	250-203_000-009	WAGO

10. Inductor appearance and dimensions

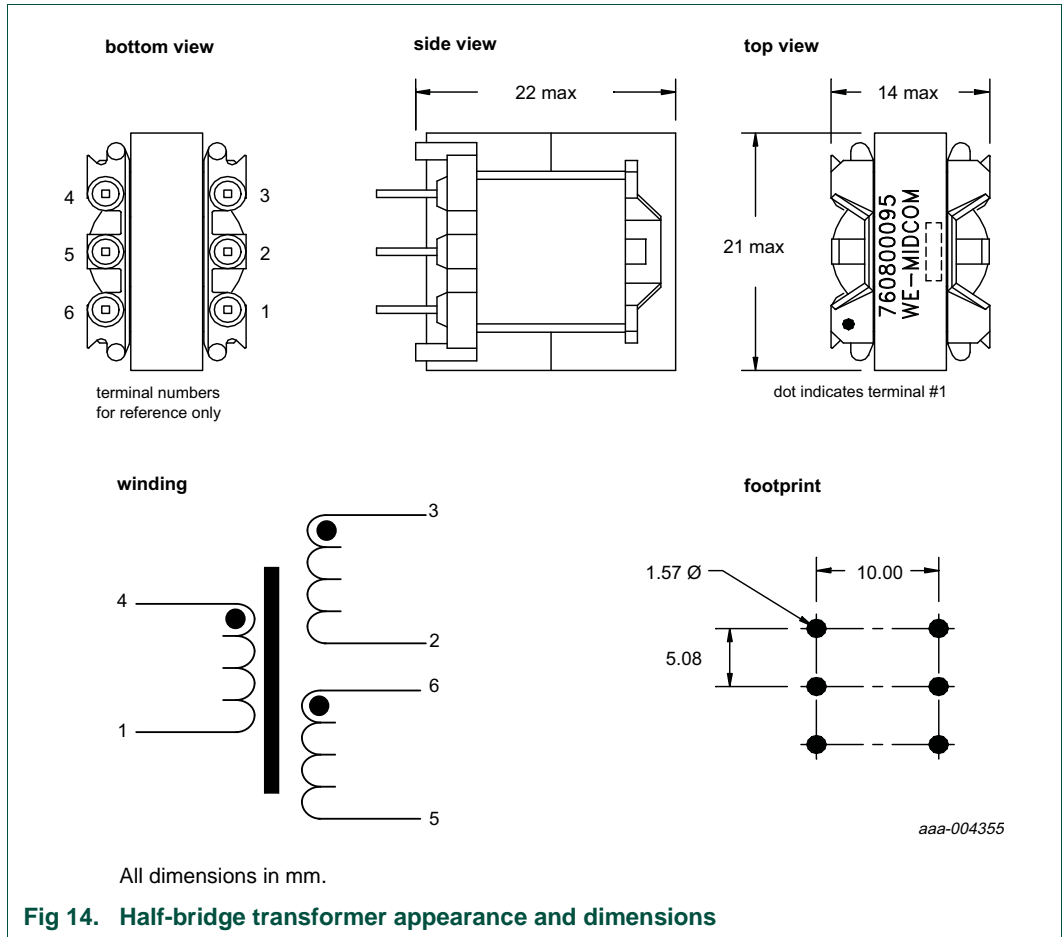


Fig 14. Half-bridge transformer appearance and dimensions

Table 4. Half-bridge transformer electrical specifications

Parameter	Value
Core	EE20/10/6
Inductance (4 to 1)	2.0 mH
Saturation current (4 to 1)	1.1 A
DC resistance (4 to 1)	4.95 Ω
Inductance (3 to 2)	10 μH
Inductance (6 to 5)	10 μH
Operating temperature	-40 °C to +125 °C

11. Single lamp 21 W/28 W/35 W T5 PCB variant

To modify the board to drive a single 21 W/28 W/35 W T5 lamp replace or remove the items in the BOM ([Table 3](#)) using the components from [Table 5](#).

Table 5. Table 5.Modified parts of the bill of material for single lamp operation

Part reference	Comment	Manufacturer	Part number
C2; C9; C14; C15; L5; L6; R11; R18; T2	Remove	-	-
L1	2.2 mH	Renco	RL-5480-2200
L4	2 × 68 mH	EPCOS	B82731T2351A020
C4; C16	10 μF; 250 V	Panasonic	ECA-2EHG100
C10	10 nF; 400 V	Vishay	BFC237051103
R9; R10	3.3 Ω	Vishay	MRS25

12. References

- [1] **UBA2017** — 600 V fluorescent lamp driver with linear dimming function
- [2] **UBA2017DB1064** — Demo board
- [3] **AN10971** — TL applications with NXP ballast controllers
- [4] **AN10958** — Fluorescent lamp driver with PFC using the UBA2015/16/17 family
- [5] **UBA2016A_15_15A** — 600 V fluorescent lamp driver with PFC, linear dimming and boost function
- [6] **UM10561** — UBA2017AT reference design for 420 V (DC)

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Date of release: 20 August 2012

Document identifier: UM10564