# UM10395

## UBA2014 evaluation board

**Rev. 2 — 16 September 2010** **User manual**

### Document information

| Info | Content |
|---|---|
| **Keywords** | UBA2014, evaluation board, TL, CFL |
| **Abstract** | This user manual describes the UBA2014 evaluation board, which is designed to be a flexible tool for demonstrating the many UBA2014 fluorescent tube driver applications. |

### Revision history

| Rev | Date | Description |
|---|---|---|
| v.2 | 20100916 | • Illustrations amended to new standard<br>• Section 11 “Legal information” amended to include new items |
| 01 | 20091014 | First issue |

## Contact information

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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.

This document describes the UBA2014 evaluation board. The board is designed to be a flexible tool that demonstrates the many different applications that are possible with the UBA2014 fluorescent tube driver. Please note that this board is not a complete ballast design for fluorescent tubes. The default setup is made such that a T5 HE 35W fluorescent lamp can be demonstrated.

# 2. Safety warnings

The board is intended as an evaluation board to build different TL and or CFL applications. To optimize flexibility, almost no protection is built in (except for IC internal protection). The board does not conform with any safety norm.

WARNINGS:

- Do not supply voltages to the board without a daughter board correctly inserted. Failing to do so may damage the board.
- Always operate with burner (lamp) connected to the board and connected to the resonant circuit. Failing to do so may damage the board.
- Many parts contain dangerous high voltages. It is necessary to take relevant safety precautions before using this board.
- Do not touch any part of the board during or shortly after operation of the board.

# 3. Board description

The board consists of two separate Printed-Circuit Boards (PCBs). The main board with the resonant circuit and a small daughter board with the UBA2014 IC.

## 3.1 Daughter board

The daughter board contains the UBA2014 IC with the preheat, sweep and oscillator capacitor, the $V_{DD}$ generation and some other low voltage components.

The daughter PCB can be easily replaced in case of damage. Care should be taken that the board is inserted properly. Pin 11 has been removed from the daughter board to prevent the board being inserted incorrectly.

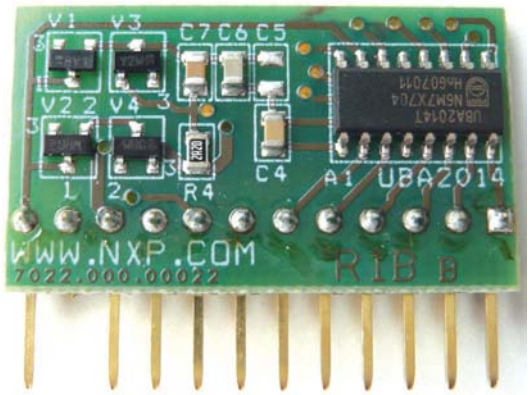


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**Fig 1. Daughter board**

## 3.2 Main board

The main board has all the other necessary circuit to make a Tubular Lamp (TL) or Compact Fluorescent Lamp (CFL) application. The board consists of the following:

- DC and AC input connector
- Dimming input
- 2 sockets for FETs
- 2 different transformers
- Area for experiments
- Connections for up to 4 burners.

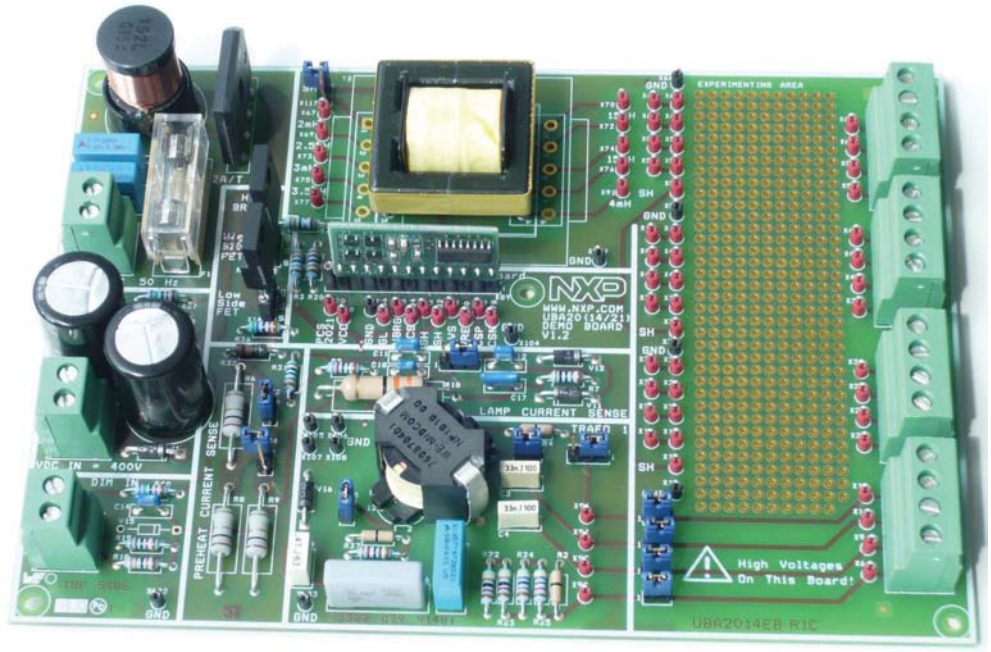


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**Fig 2. UBA2014/21 main board with UBA2014 daughter board inserted**

## 4. Schematics

The schematics of the daughter board with the UBA2014 IC can be found in Figure 3. The settings for the oscillator and sweep are R1 = 33 kΩ (to pin IREF), C3 = 100 pF (to pin CF) and C1 = 330 nF (to pin CT). This will provide a minimum oscillator frequency of 40.5 kHz and a preheat time of 1.8 s.

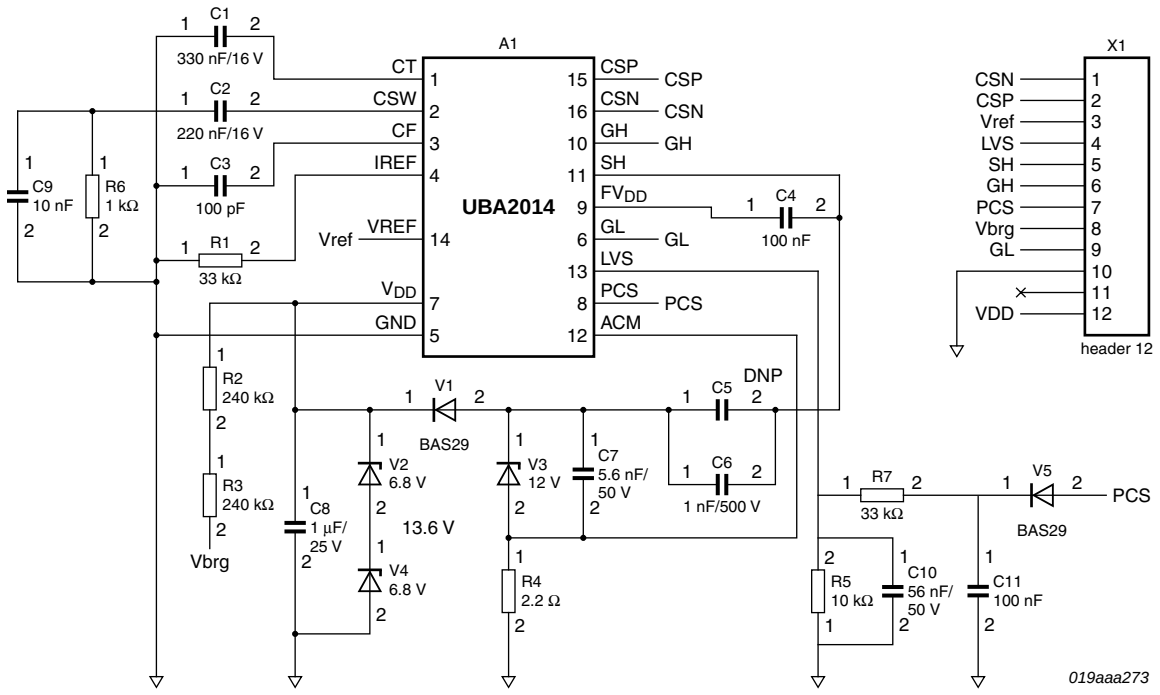



**Fig 3. Daughter board with UBA2014 circuit (version R1B)**

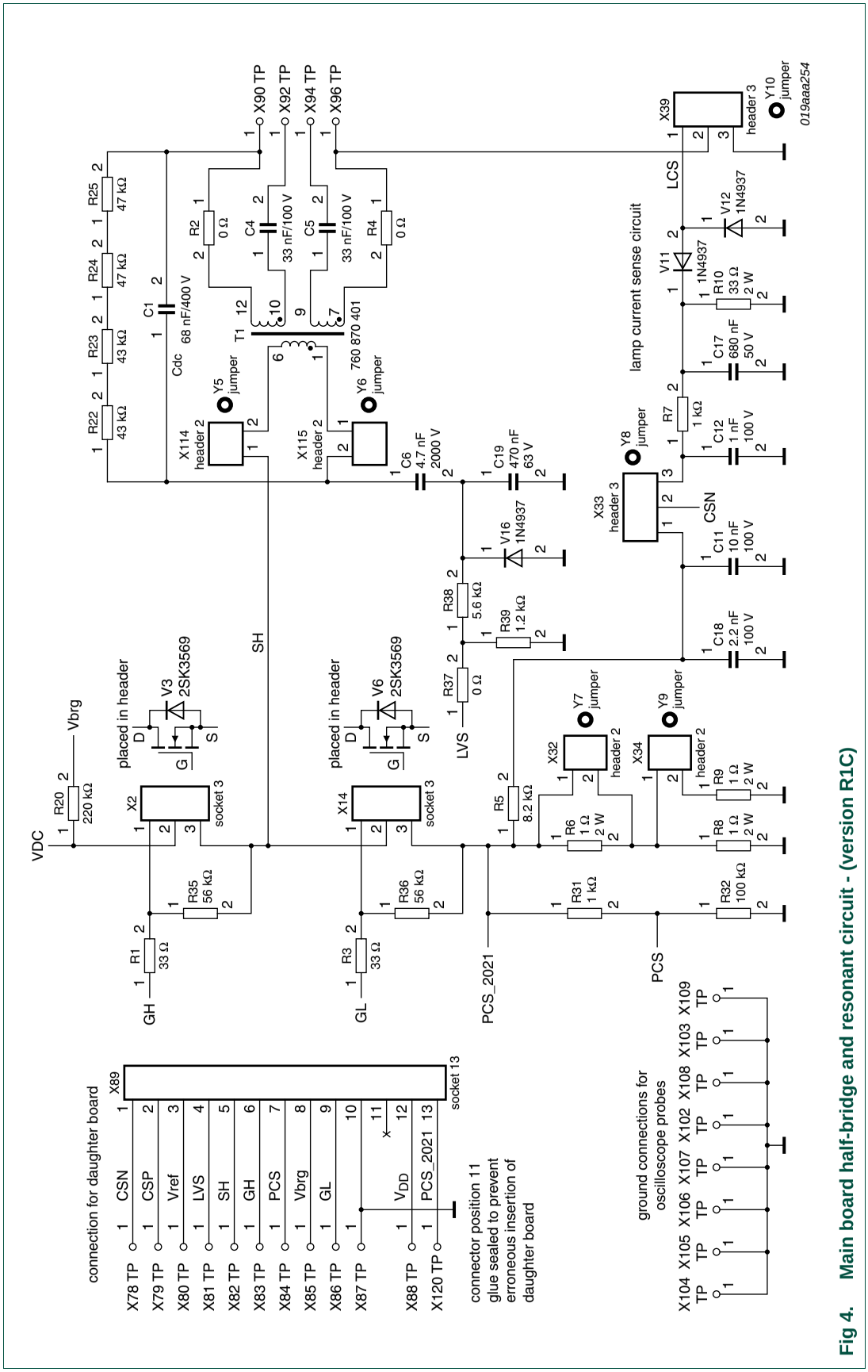



**Fig 4. Main board half-bridge and resonant circuit - (version R1C)**

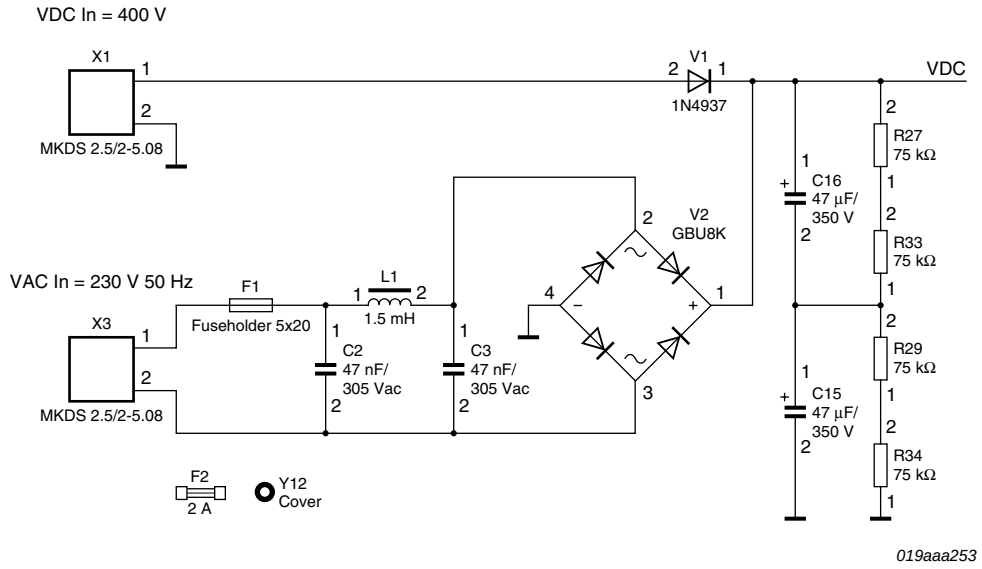



**Fig 5. Main board input section**

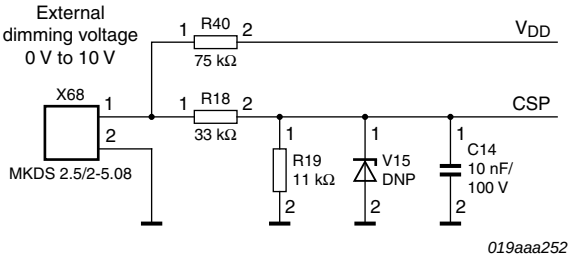



**Fig 6. Main board dimming input**

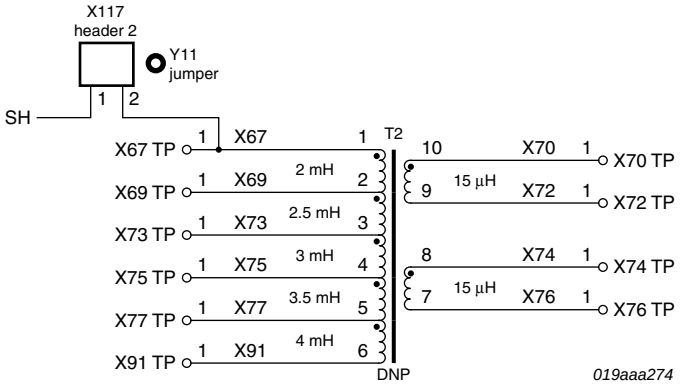



**Fig 7. Main board transformer T2/T3**

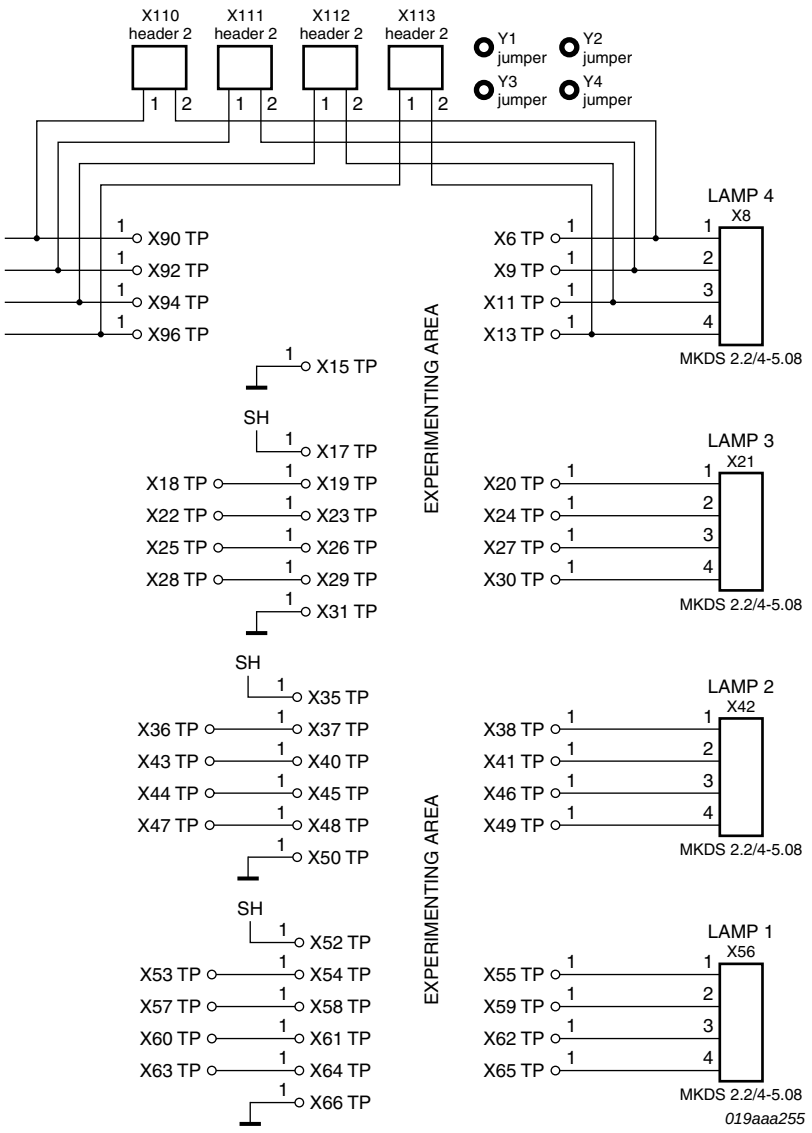



**Fig 8. Main board lamp connectors and experimenting area**

# 5. Connectors

## 5.1 Power supply connectors

The board can be supplied by either a high voltage DC or a mains AC input. For most applications the high voltage DC input should be used. In the final product, a Power Factor Correction (PFC) of choice may be used to replace the high voltage DC supply.

For some applications (such as CFL applications) the rectified mains is sufficient. In these cases a mains input of 230 V AC may be used.

**Table 1. DC high voltage input connector X1**

| Connector | Signal | Comment |
|---|---|---|
| X1-1 | + | + 400 V (DC) in |
| X1-2 | GND | ground |

**Table 2. AC input connector X3**

| Connector | Signal | Comment |
|---|---|---|
| X3-1 | ~ | mains 230 V (AC) |
| X3-2 | ~ | mains 230 V (AC) |

## 5.2 Dimming input

The UBA2014 has dimming functionality. An input with a voltage divider has been provided so that a 0 V to 10 V signal can be used. If no voltage is supplied to the dimming input, the lamp operates at approximately 50 % of its nominal power.

Please note that there is no galvanic isolation between the dimming input and the rest of the circuit, it is therefore advisable to use a mains isolation transformer to separate the board ground from the mains. If required, a Zener diode (V15) can be used as protection against input voltages that are too high.

**Table 3. Dimming input connector X68**

| Connector | Signal | Comment |
|---|---|---|
| X68-1 | + | 0 V to 10 V dimming input (max 10 V) |
| X68-2 | GND | ground |

## 5.3 Lamp connectors

There are connections for four lamps on the board. In the following tables, the connectors are listed together with the names of the test points connected to them.

**Table 4. Lamp 1 (X56)**

| TP | Comment |
|---|---|
| X55 | connection for filament 1 |
| X59 | connection for filament 1 |
| X62 | connection for filament 2 |
| X65 | connection for filament 2 |

**Table 5. Lamp 2 (X42)**

| TP | Comment |
|---|---|
| X38 | connection for filament 1 |
| X41 | connection for filament 1 |
| X46 | connection for filament 2 |
| X49 | connection for filament 2 |

**Table 6. Lamp 3 (X21)**

| TP | Comment |
|---|---|
| X20 | connection for filament 1 |
| X24 | connection for filament 1 |
| X27 | connection for filament 2 |
| X30 | connection for filament 2 |

**Table 7. Lamp 4 (X8)**

| TP | Comment |
|---|---|
| X6 | connection for filament 1 |
| X9 | connection for filament 1 |
| X11 | connection for filament 2 |
| X13 | connection for filament 2 |

## 5.4 Test points

Eight ground pins are distributed over the board so that (oscilloscope) probes can be grounded without the need for long grounding wires.

**Table 8. Ground test points**

| TP | Color | Signal |
|---|---|---|
| X102 | black | GND |
| X103 | black | GND |
| X104 | black | GND |
| X105 | black | GND |
| X106 | black | GND |
| X107 | black | GND |
| X108 | black | GND |
| X109 | black | GND |

**Remark:** A test pin is available for each pin of the daughter board.

**Table 9. Daughter board connections**

| TP | Name | Comment |
|---|---|---|
| X78 | CSN | negative input for the average current sensor [1] |
| X79 | CSP | positive input for the average current sensor [1] |
| X80 | Vref | reference voltage output [2] |
| X81 | LVS | lamp voltage sensor input [1] |
| X82 | SH | source for the high-side switch |

**Table 9. Daughter board connections** *...continued*

| TP | Name | Comment |
|---|---|---|
| X83 | GH | gate output for the high-side switch |
| X84 | PCS | preheat current sensor input [1]<br>(also connected to LVS via V5, R7/C11, R5/C10) |
| X85 | Vbrg | connection to VDC via R20 (220 kΩ) |
| X86 | GL | gate output for the low-side switch |
| X87 | GND | ground |
| X88 | $V_{DD}$ | low voltage supply |
| X120 | PCS_2021 | preheat current sense for the UBA2021 daughter board |

[1] For UBA2014 daughter board.

[2] From UBA2014 daughter board.

## 5.5 Transformer T1

Transformer T1 is used In the default setup, and it is connected with jumpers to lamp connector 4 (X8). The transformer specifications are listed in Section 6.1.

**Table 10. Default connection transformer T1**

| Header | Comment |
|---|---|
| X110 | insert to connect T1 to filament 1, lamp 4 |
| X111 | insert to connect T1 to filament 1, lamp 4 |
| X112 | insert to connect T1 to filament 2, lamp 4 |
| X113 | insert to connect T1 to filament 2, lamp 4 |
| X114 | insert to connect SH to transformer T1 |
| X115 | insert to connect T1 to resonant capacitor C6 (4.7 nF; 2000 V) |

## 5.6 FET

Two NMOST FETs should be placed in X2 and X14. The supplied NMOSTs are Toshiba 2SK3569 ($V_{DS}$ = 600 V; $I_D$ = 10 A; $R_{DSon}$ = 0.54 Ω). When using different NMOS types, the values of gate resistors R1 and R3 (default 33 Ω) can be changed.

## 5.7 Current sense selection

There are two ways to use current sensing. Sensing of the half-bridge current or sensing of the lamp current.

**Table 11. Current sensing selection**

| X33 | Pins 1 to 2 | Pins 2 to 3 |
|---|---|---|
| half-bridge | shorted | open |
| lamp current | open | shorted |

### 5.7.1 Half-bridge current sensing

Pins 1 and 2 of jumper X33 should be shorted in order to connect the sense resistor network in the half-bridge to the CSN pin of the UBA2014. With jumpers X32 and X34, different values of the sense resistor can be selected. In this case, X39 should be shorted between pins 2 and 3 in order to connect the lamp to ground.

**Table 12. Current sensing selection**

| X32 | X34 | Resistance (Ω) |
|---|---|---|
| short | short | 0.5 |
| short | open | 1.0 |
| open | short | 1.5 |
| open | open | 2.0 |

### 5.7.2 Lamp current sensing

Pins 2 and 3 of jumper X33 should be shorted to connect the lamp current sense network to the CSN pin. X39 should be shorted between pins 1 and 2 to connect the lamp to the sensing circuit.

## 5.8 Using transformer T3

To use the flexible transformer T3, jumper X117 should be inserted. This connects SH to pin 1 of the transformer. Table 13 shows the different inductance values that can be made with this transformer. The specifications of the transformer are listed in Section 6.2.

**Table 13. Transformer T3 primary connections**

| Connection | Inductance |
|---|---|
| X69 | 2.0 mH |
| X73 | 2.5 mH |
| X75 | 3.0 mH |
| X77 | 3.5 mH |
| X91 | 4.0 mH |

Two secondary connections are available for filament (pre-)heating, as shown in Table 14

**Table 14. Transformer T3 secondary connections**

| Connection | Inductance |
|---|---|
| X70 to X72 | 15 μH |
| X74 to X76 | 15 μH |

Transformer T3 has a double footprint that enables the use of different types of transformers. The transformers are named “T2” and “T3” on the schematic drawings.

# 6. Transformer specifications

## 6.1 Transformer T1

### 6.1.1 Schematic diagram

- Manufacturer: Würth Elektronik
- Part number: 760870401

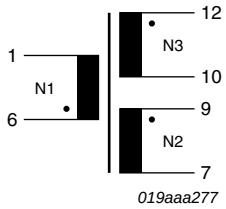



**Fig 9. Transformer T1 schematic diagram**

### 6.1.2 Electrical properties

**Table 15. Electrical characteristics of transformer T1**

| Properties | Test conditions | | Value | Unit | Tolerance |
|---|---|---|---|---|---|
| Inductance N1 | 50 kHz/0.1 V | $L_0$ | 2.9 | mH | ±5 % |
| Turns ratio N1 to N3 | N1: N2: N3 | TR | 26.1 : 1 : 1 | | ±3 % |
| DC-resistance N1 | at 20 °C | $R_{DC1}$ | 2.7 | ? | maximum |
| DC-resistance N2 | at 20 °C | $R_{DC2}$ | 180 | m? | maximum |
| DC-resistance N3 | at 20 °C | $R_{DC3}$ | 180 | m? | maximum |
| Saturation current N1 | dL / L = 20 % | $I_{SAT}$ | 1.6 | A | typical |
| Leakage inductance N1 | 200 kHz/0.1 V other windings shorted | $L_S$ | 350 | µH | maximum |
| Coupling capacitance | 20 kHz/1 V all windings | $C_{WW}$ | 11.0 | pF | typical |
| Hipot test | 3 mA, 1s all windings | HV | 1.2 | kV | |

### 6.1.3 Core and bobbin T1

- Core: RM-8 (Ferroxcube RM/I or equivalent)
- Core material: 3F3, N87 or equivalent
- Bobbin: RM-8 (12 pin, vertical type)

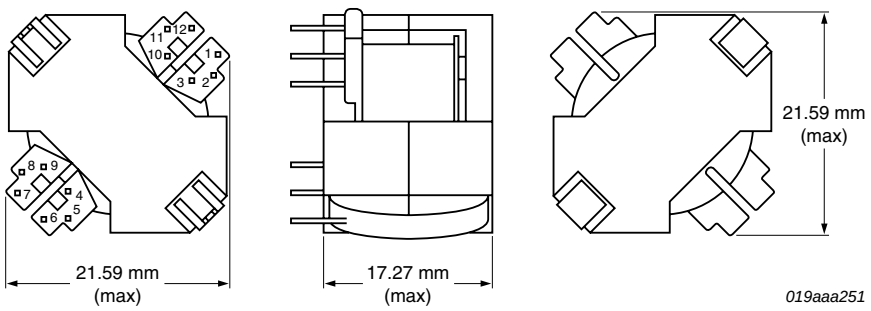



**Fig 10. Pin out and dimensions of Transformer T1**

## 6.2 Transformer T3

### 6.2.1 Schematic diagram

- Manufacturer: Würth Elektronik
- Part number: 760870402

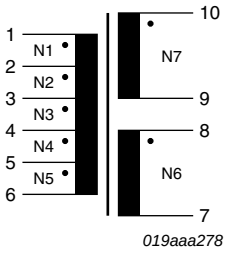



**Fig 11. Transformer T3 schematic diagram**

**Table 16. Electrical characteristics for transformer T3**

| Properties | Test conditions | | Value | Unit | Tolerance |
|---|---|---|---|---|---|
| Inductance N1 to N5 | 50 kHz/0.1 V | $L_0$ | 4.0 | mH | ±5 % |
| Turns ratio N1 to N5 | N1: N2: N3: N4: N5: N6: N7 | TR | 12 : 1.33 : 1.25 : 1.17 : 1.17 : 1 : 1 | | ±3 % |
| DC-resistance N1 to N5 | at 20 °C | $R_{DC1-5}$ | 1.85 | ? | ±20 % |
| DC-resistance N6 | at 20 °C | $R_{DC6}$ | 135 | m? | ±20 % |
| DC-resistance N7 | at 20°C | $R_{DC7}$ | 140 | m? | ±20 % |
| Saturation current N1 to N5 | dL / L = 20 % | $I_{SAT}$ | 1.0 | A | typical |
| Leakage inductance N1 to N5 | 200 kHz/0.1 V other windings shorted | $L_S$ | 275 | µH | typical |
| Coupling capacitance | 20 kHz/1 V all windings | $C_{WW}$ | 30.0 | pF | typical |
| Hipot test | 3 mA, 1 s all windings | HV | 3.0 | kV | |

### 6.2.2 Core and bobbin T3

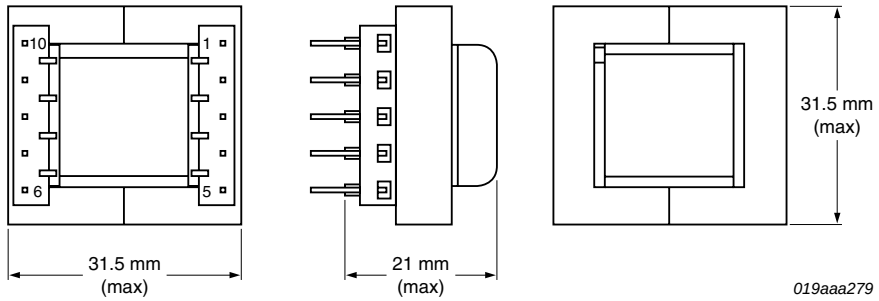



**Fig 12. Transformer T3**

- Core: E30/15/7
- Core material: ferrite
- Air gap in center leg: 1100 μm
- Bobbin: CSH-E30/7-1S-10P

## 7. Application example

### 7.1 Default application T5 HE 35 W

The default settings of the board are for a T5 HE 35 W burner.

**Table 17. Default settings**

| Jumper | Position | Comment |
|---|---|---|
| X32 | shorted | half-bridge sense resistor 1 Ω (used for PCS) |
| X34 | open | - |
| X33 | 1 to 2 open, 2 to 3 shorted | use lamp current sensing |
| X114 | shorted | connect transformer T1 |
| X115 | shorted | - |
| X39 | 1 to 2 shorted, 2 to 3 open | connect lamp to lamp current sense circuit |
| X110, X111, X112, X113 | shorted | connect to lamp 4 |
| X117 | open | do not connect transformer T3 |

**Table 18. External connections for T5 HE 35 W**

| Jumper | Position | Comment |
|---|---|---|
| X1 | VDC | 400 V (DC) |
| X68 | external dimming | 10 V for full power |
| X8 | burner | T5 HE 35 W burner |

When no external dimming voltage is supplied, the lamp power is 20 W.

# 8. Bill of Materials (BOM)

**Table 19. BOM daughter board**

| Reference | Value | Component |
|---|---|---|
| A1 | UBA2014T | NXP |
| C1 | 330 n /16 V | capacitor ceramic X7R, 16 V, 10 % |
| C2 | 220 nF/16 V | capacitor ceramic X7R, 16 V, 10 % |
| C3 | 100 pF | capacitor ceramic C0G, 50 V, 5 % |
| C4, C11 | 100 nF | capacitor ceramic X7R, 50 V, 10 % |
| C5 | not mounted | |
| C6 | 1 nF/500 V | capacitor ceramic 500 V NP0 5 % |
| C7 | 5.6 nF/50 V | capacitor ceramic 50 V X7R 10 % |
| C8 | 1 μF/25 V | capacitor ceramic X7R 25 V 10 % |
| C9 | 10 nF | capacitor ceramic X7R, 50 V, 10 % |
| C10 | 56 nF/50 V | capacitor ceramic 50 V X7R 10 % |
| R1, R7 | 33 kΩ | resistor 1 % 0.125 W 100 ppm RC12H |
| R2, R3 | 240 kΩ | resistor 1 % 0.125 W 100 ppm RC12H |
| R4 | 2.2 Ω | resistor 1 % 0.125 W 0 to + 500 ppm RC12H |
| R5 | 10 kΩ | resistor 1 % 0.125 W 100 ppm RC12H |
| R6 | 1 kΩ | resistor 1 % 0.125 W 100 ppm RC12H |
| V1, V5 | BAS29 | NXP, diode, 50 ns 90 V 250 mA |
| V3 | BZX84C12V | NXP, Zener, 250 mW, 5 % [Y2t/Y2p/Y2W] |
| V2, V4 | BZX84-B6V8 | NXP, Zener, 250 mW, 2 % [Z61 or R6] |

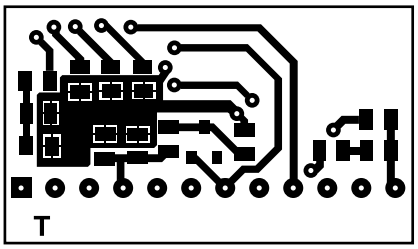
**Table 20. BOM Main board**

| Reference | Value | Component |
|---|---|---|
| C1 | 68 nF/400 V | capacitor, MKP Class X2, 20 % |
| C2, C3, C4, C5 | 47 nF/305 V (AC) | capacitor, MKP Class X2, 20 % |
| C4, C5 | 33 nF/100 V | capacitor, MKT 100 V (DC), 5 % |
| C6 | 4.7 nF/2000 V | capacitor MKP radial potted, 5 % |
| C11, C14 | 10 nF/100 V | capacitor ceramic disc X7R, 10 % |
| C12 | 1 nF/100 V | capacitor ceramic disc X7R, 10 % |
| C15, C16 | 4.7 μF/450 V | cap. elco rad 450 V 105C 20 % |
| C17 | 680 nF/50 V | capacitor ceramic disc X7R, 10 % |
| C18 | 2.2 nF/100 V | capacitor ceramic disc X7R, 10 % |
| C19 | 470 nF/63 V | capacitor, MKT 63 V (DC), 5 % |
| F1 | fuse holder 5 mm x 20 mm | fuse holder for 5 mm x 20 mm |
| F2 | 2 A | fuse 5 mm x 20 mm time lag |
| L1 | 1.5 mH | inductor choke current rating = 850 mA, R = 580 mΩ |
| R1, R3 | 33 Ω | resistor 1 % 0.6 W 50 ppm MRS25 |
| R2, R4 | 0 Ω | zero ohm link, current rating = 25 A at 25 °C |
| R5 | 8.2 kΩ | resistor 1 % 0.6 W 50 ppm MRS25 |
| R6, R8, R9 | 1.2 Ω | resistor power 5 % 2 W 100 ppm/°C MFP |

**Table 20. BOM Main board** *…continued*

| Reference | Value | Component |
|---|---|---|
| R7 | 1 kΩ | resistor 1 % 0.6 W 50 ppm MRS25 |
| R10 | 33.2 Ω | resistor Power 5 % 2 W 450 ppm/°C Carbon Film |
| R18 | 33 kΩ | resistor 1 % 0.6 W 50 ppm MRS25 |
| R19 | 11 kΩ | resistor 1 % 0.6 W 50 ppm MRS25 |
| R20 | 220 kΩ | resistor 1 % 0.6 W 50 ppm MRS25 |
| R22, R23 | 43 kΩ | resistor 1 % 0.6 W 50 ppm MRS25 |
| R24, R25 | 47 kΩ | resistor 1 % 0.6 W 50 ppm MRS25 |
| R27, R29, R33, R34 | 75 kΩ | resistor 1 % 0.6 W 50 ppm MRS25 |
| R31 | 1 kΩ | resistor 1 % 0.6 W 50 ppm MRS25 |
| R32 | 100 kΩ | resistor 1 % 0.6 W 50 ppm MRS25 |
| R35, R36 | 56 kΩ | resistor 1 % 0.6 W 50 ppm MRS25 |
| R37 | 0 Ω | Zero ohm link $I_m$ = 25 A at 25 °C |
| R38 | 5.6 kΩ | resistor 1 % 0.6 W 50 ppm MRS25 |
| R39 | 1.2 kΩ | resistor 1 % 0.6 W 50 ppm MRS25 |
| R40 | 75 kΩ | resistor 1 % 0.6 W 50 ppm MRS25 |
| T1 | 760870401 | Würth Elektronik: part number 760870401 |
| T3 | 760870402 | Würth Elektronik: part number 760870402 |
| V1, V11, V12, V16 | 1N4937 | diode, fast-recovery, 600 V, 1 A |
| V2 | GBU8K | bridge 800 V 8 A TH |
| V3, V6 | 2SK3569 | FET MOS N-ch 600 V, 10 A 0,54E |
| V15 | not mounted | |
| X1, X3, X68 | MKDS 2,5/2-5,08 | terminal block (screw) 2-p, p = 2e, 2.5 $mm^2$ |
| X2, X14 | Socket 3 | socket straight p = 2.54 mm, h = 7 mm |
| X8, X21, X42, X56 | MKDS 2,5/4-5,08 | terminal block (screw) 4-p, p = 2e, 2.5 $mm^2$ |

## 9. Layout

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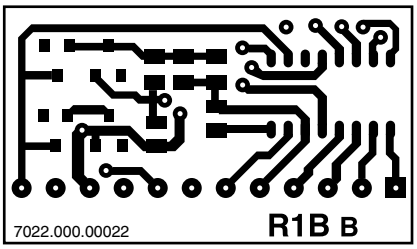
Top view

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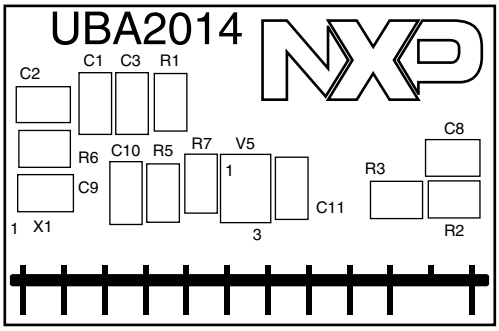
Bottom view

**Fig 13. UBA2014 daughter board layout**

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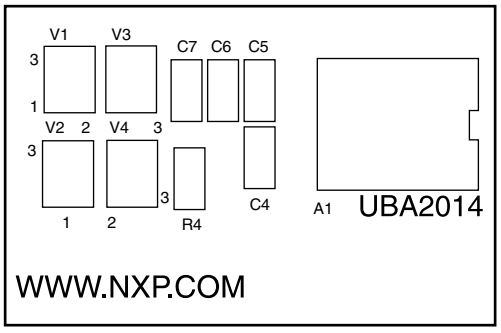
Top view

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Bottom view

**Fig 14. UBA2014 daughter board silk screen**

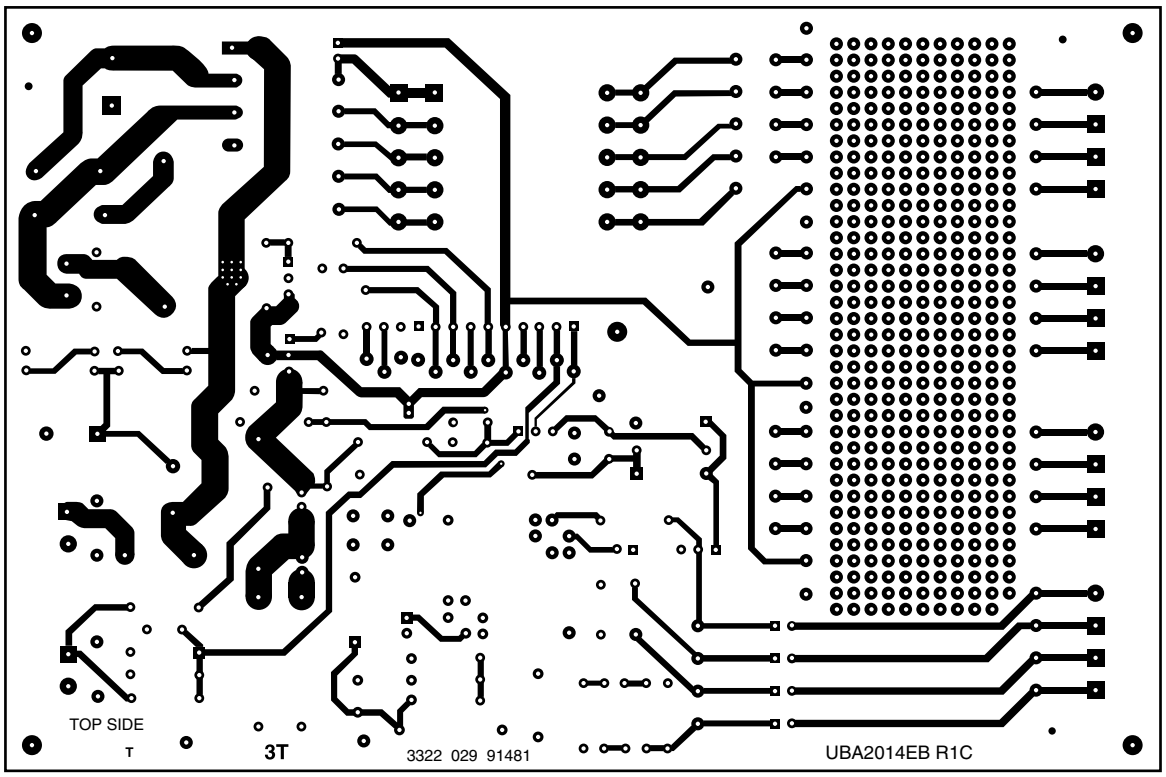
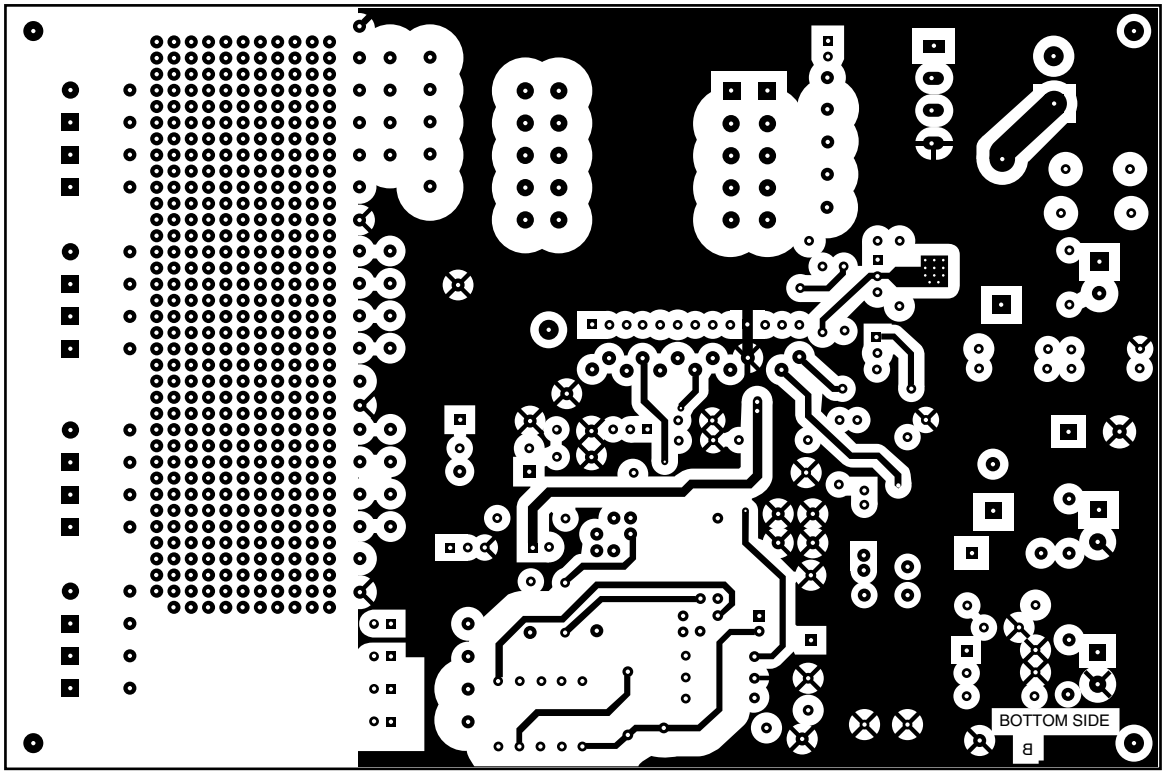



**Fig 15. UBA2014/21 main board PCB layout top**




019aaa293

**Fig 16. UBA2014/21 main board PCB layout bottom**

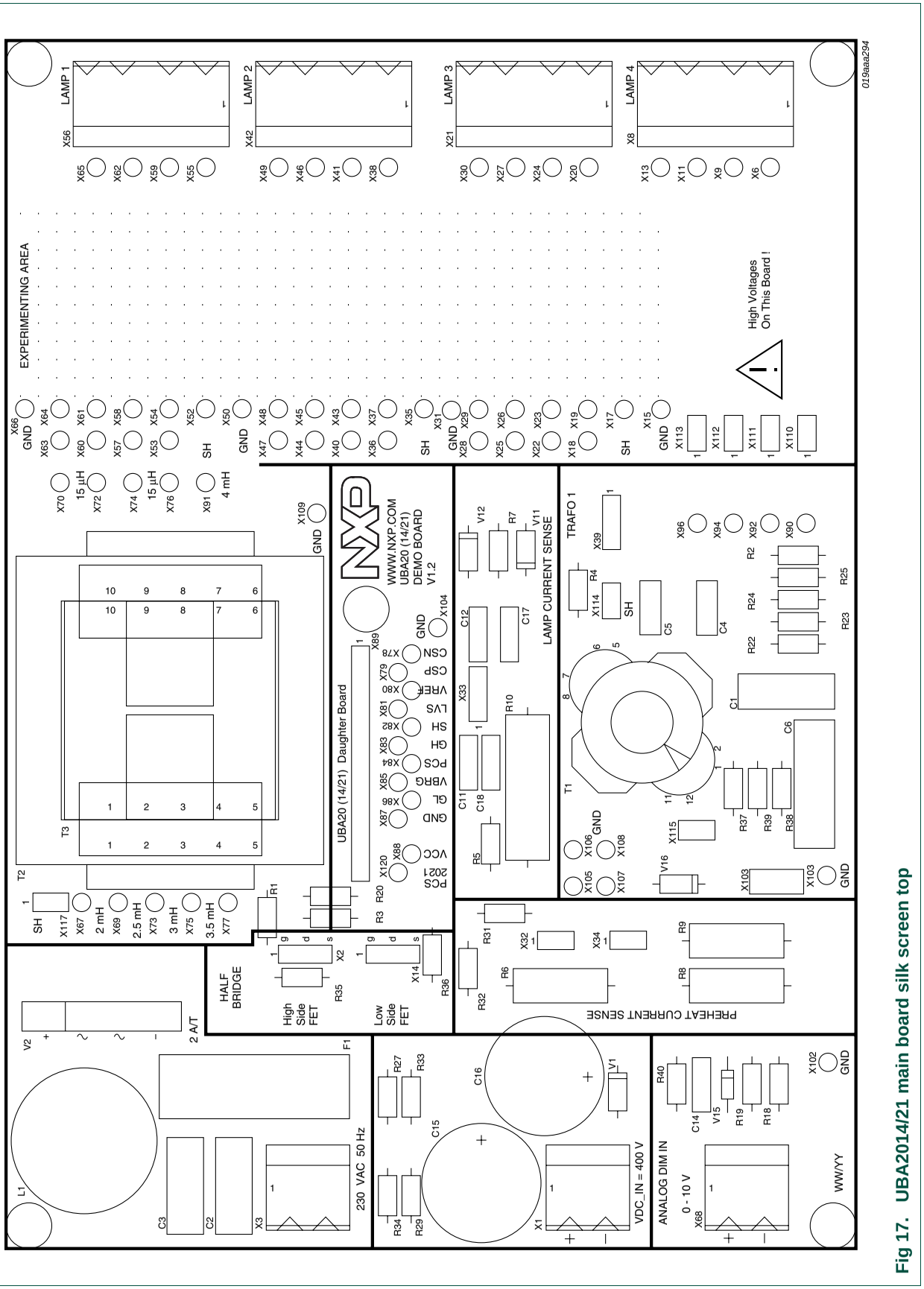



Fig 17. UBA2014/21 main board silk screen top

## 10. Glossary

**CFL —** Compact Fluorescent Lamp

**FET —** Field-Effect Transistor

**NMOST —** Negative channel Metal–Oxide–Semiconductor Transistor

**TL —** Tubular Lamp

# 11. Legal information

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