UM10418

UBA2211 demo board for 230 V, 12 W CFL

Rev. 2 — 10 January 2011 **User manual**

Document information

Info	Content
Keywords	UBA2211, demo board, low cost, high performance, CFL
Abstract	This document is a user manual for the UBA2211 12 W demo board

Revision history

Rev	Date	Description
v.2	20110110	second issue
v.1	20101026	first issue

1. Introduction

The UBA2211 is a high voltage power IC intended to drive and control electronically ballasted Compact Fluorescent Lamps (CFLs) with few external components needed. It provides all the necessary functions for sufficient preheating, ignition and burning operation of the lamp. It features a ballast IC with high performance price ratio and is integrated with the related protection functions.

This UBA2211 user manual is intended for 230 V application of a 12 W demo board.

2. Features

2.1 System integration

- Integrated half-bridge power MOSFET
  - UBA2211A: 13.5 Ω, 0.9 A maximum ignition current
  - UBA2211B: 9 Ω, 1.35 A maximum ignition current
  - UBA2211C: 6.6 Ω, 1.85 A maximum ignition current
- Integrated bootstrap diode
- Integrated low voltage supply
- Integrated level-shifter

2.2 Burner lifetime

- Adjustable preheat time and ignition time
- Adjustable preheat current independent from mains voltage variation
- Minimum glow time control to support cold start
- Adjustable lamp power
- Lamp power independent from mains voltage variations

2.3 Safety

- Soft start function
- Accurate 50 % duty cycle
- UnderVoltage LockOut protection (UVLO)
- Saturation current protection
- OverTemperature Protection (OTP)
- Capacitive Mode Protection (CMP)
- System protection for EOL
- Lamp removal protection

2.4 Ease of use

- Adjustable operating frequency for easy fit with various burners

3. Circuit diagram

Typical application circuit diagram is shown in Figure 1

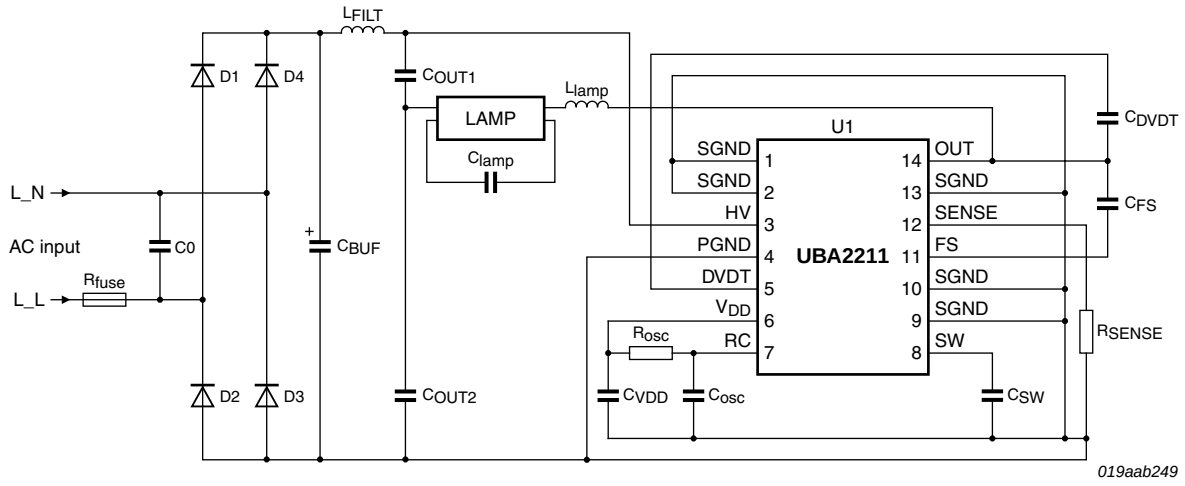

Fig 1. Typical application circuit for Compact Fluorescent Lamp

4. Specifications

The UBA2211B demo board is set up to drive a 12 W burner. The specifications for this setup are:

- 230 V (AC)
  - Input voltage range: 220 V to 240 V; 50 Hz
  - Input power: 12 W at 230 V (AC)
  - Input current: 80 mA at 230 V (AC)
  - Power factor: > 0.58
  - Operating frequency: 42 kHz
  - 800 ms preheat
- Burners
  - Baishi 3U 12 W burner
  - Other burners with 70 V lamp voltage and 150 mA current

5. Application photographs

The 230 V (AC) mains input connection and four connections for the burner are connected as shown in Figure 2.

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Fig 2. Photos of a 12 W CFL with the UBA2211

6. Circuit description

The device is an integrated circuit for electronically ballasted compact fluorescent lamps. It provides all the necessary functions for sufficient preheat, ignition and on-state operation of the lamp.

Several protective measures safeguard the correct operation of the compact fluorescent lamp and controller. A typical system timing sequence is shown in Figure 3, with each phase described in greater detail in Section 6.1 to Section 6.7.

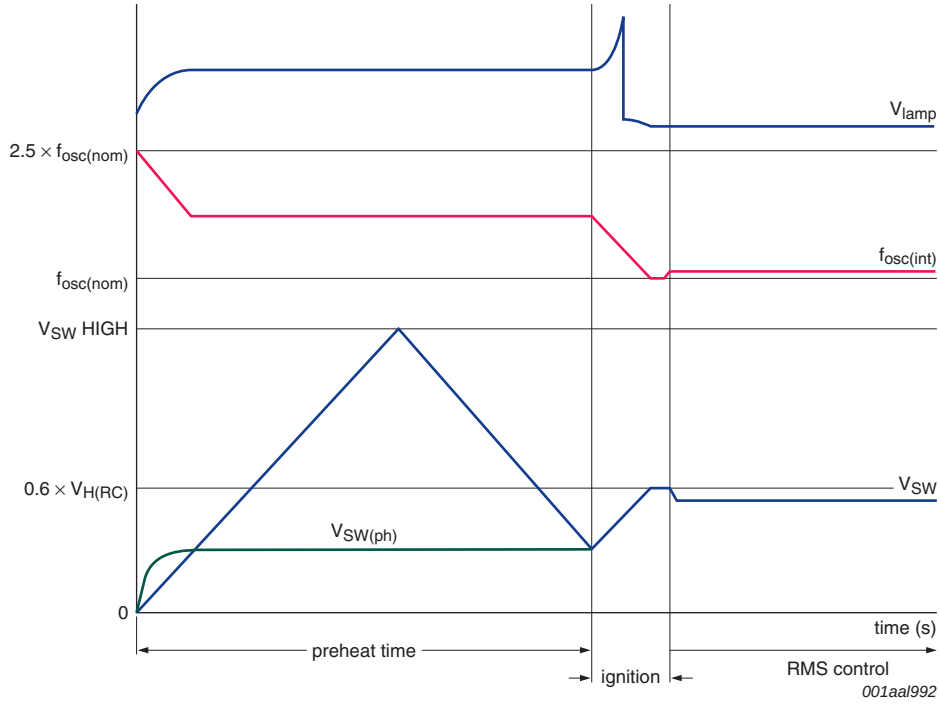


Fig 3. System timing sequence with warm ignition

In non-preheated applications, a patented glow time control minimizes the electrode damage directly after lamp ignition (see Figure 4).

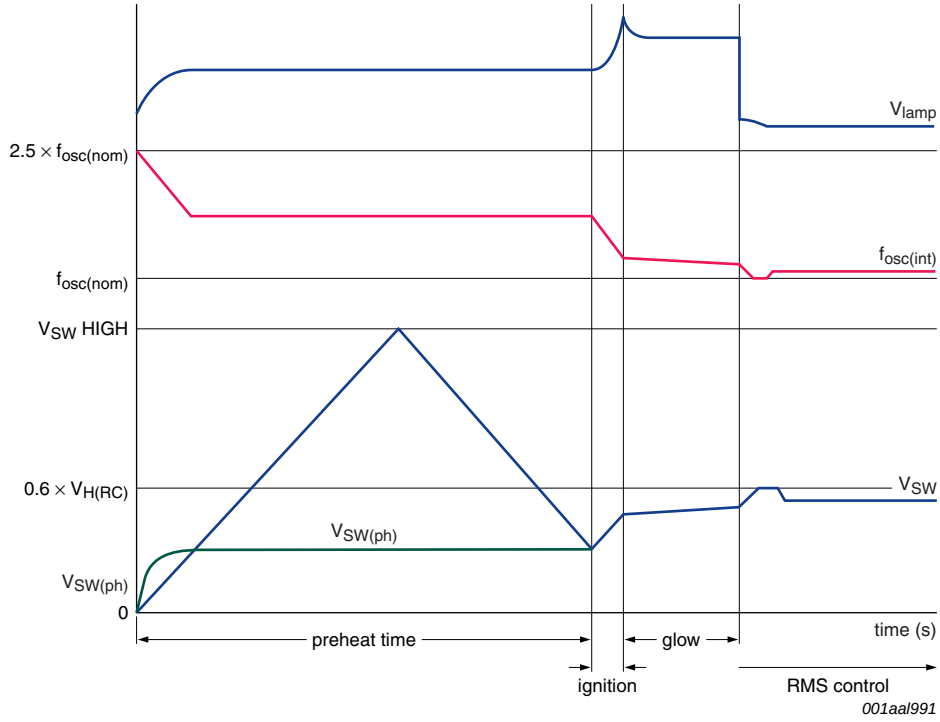


Fig 4. System timing sequence with cold ignition

6.1 Supply voltage

The UBA2211 is powered using a start-up current source and the DVDT supply. The start-up current source is integrated in to the IC and the DVDT supply is provided by the C_{DVDT} capacitor. V_{DD} is used for low-side switch driving and logic circuit operation. As well as the V_{DD} supply, a floating supply is needed for high-side switch driving. This is supplied by a bootstrap capacitor connected to the HB output node which is also connected to C_{DVDT}. The schematic diagram Figure 5 illustrates how the low voltage supplies are easily obtained by setting the capacitors.

The UBA2211 has an UnderVoltage LockOut (UVLO) function for both V_{DD} and V_{FS}. Refer to Ref. 1 “Data sheet UBA2211” for further details regards supply threshold values. The start-up current source is enabled when the voltage on pin V_{DD} is below $V_{DD(stop)}$ level. The high-side transistor is switched off when the voltage on pin FS is less than the high-side lockout voltage $V_{FS(lock)}$.

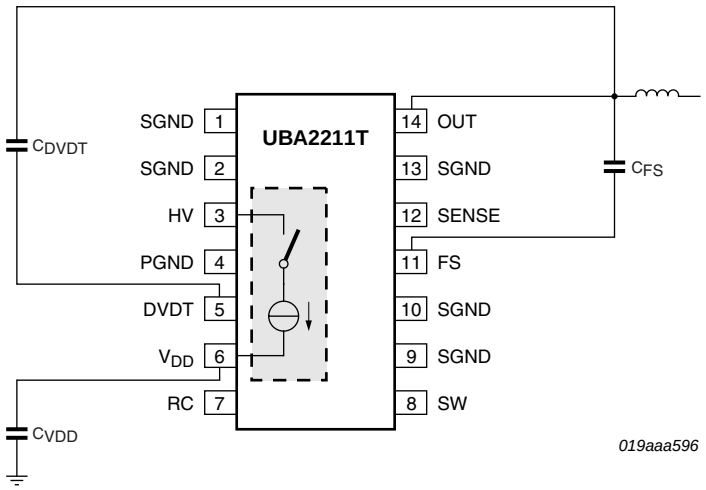


Fig 5. Low voltage supply

6.2 Preheat state

UBA2211 features a patented, current controlled preheat circuit during start-up where the preheat current is independently regulated from the mains voltage. The preheat time is set by the value of the external capacitor (C_{SW}).

The IC enters the preheat state when the voltage on pin V_{DD} is above $V_{DD(start)}$ and OTP is not active. The capacitor on pin SW (C_{SW}) is charged by the sweep current (I_{SW}) (integrated in the IC) until the decreasing C_{SW} voltage equals $V_{SW(ph)}$; see Figure 3:

The preheat current is monitored using the external resistor R_{SENSE} and can be determined by Equation 1:

$$I_{ph(peak)} = \frac{V_{ref(ph)}}{R_{SENSE}} \quad (1)$$

The preheat current can be determined by the value of resistor R_{SENSE} selected.

Figure 6 shows the scope waveform in real application.

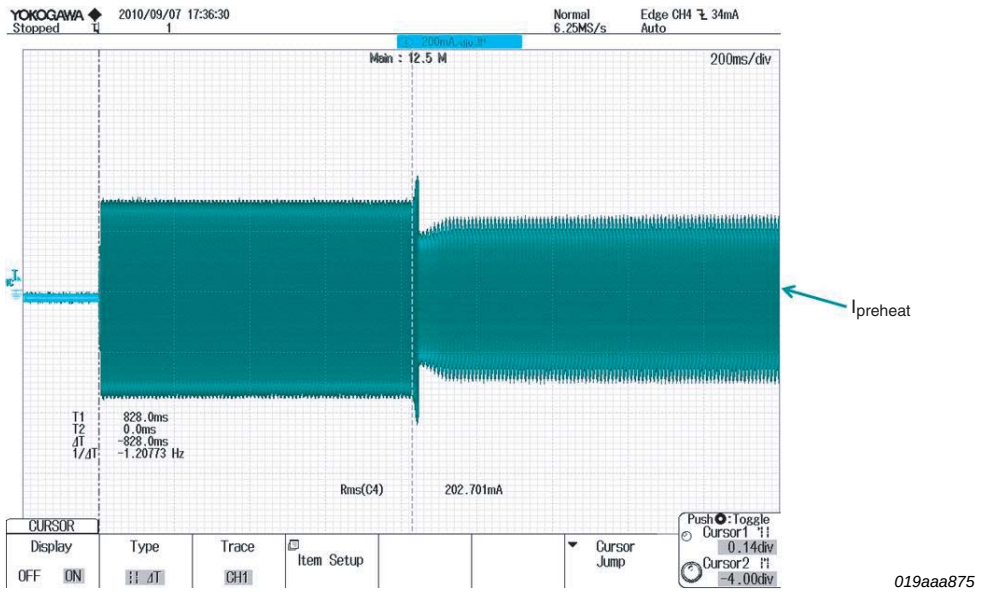


Fig 6. Preheat state

6.3 Ignition state

The ignition state is entered after the preheat state has finished. The capacitor on pin SW (C_{SW}) is charged by I_{SW} up to $0.6 \times V_{H(RC)}$ which corresponds to the frequency $f_{osc(nom)}$.

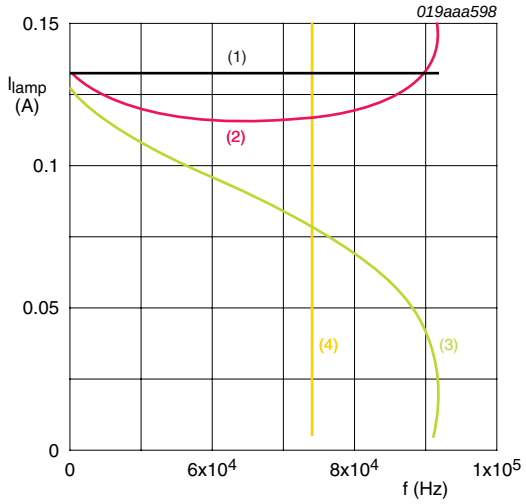
During this frequency sweep, the resonance frequency is reached resulting in the ignition of the lamp (see Figure 3). The resonance frequency is set by the lamp inductor (L_{lamp}) and lamp capacitor (C_{lamp}). The ignition state ends when the voltage on pin SW (V_{SW}) reaches $0.6 \times V_{H(RC)}$.

6.4 Steady state

Another distinctive feature is the RMS current control function. The RMS current control only becomes active when the mains voltage rises above the nominal value. The IC dissipation and lamp current are limited in this way and ensures that input power is nearly constant while AC mains input increases. This results in constant IC dissipation and temperature at a fixed ambient temperature.

$$RMS\ V_{SENSE} = V_{O(ref)RMS} = R_{SENSE} \times I_{LSPT} \quad (2)$$

A constant current flows through the power switches and the lamp which is defined by the internal reference voltage ($V_{O(ref)RMS}$) and the external R_{SENSE} resistor; see Equation 2. Figure 7 shows the RMS control trend calculated using the calculation tool. The lamp operating point is the intersection of curves (1) and (2).



V (DC) = V (DC) nominal

(1) IC controlled half-bridge current; f = f_{min}; V_i = 230 V; RMS takes control at V_i > 230 V (AC)

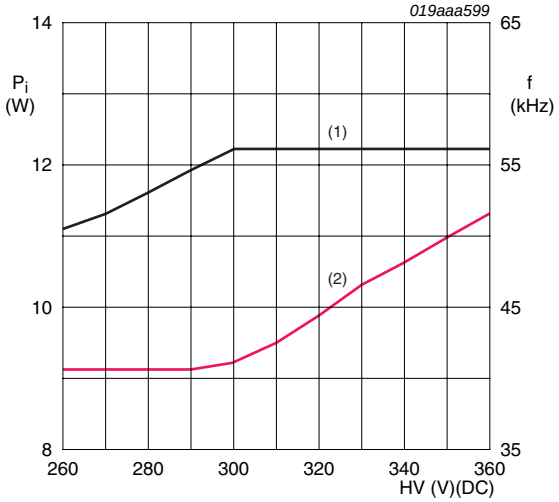
(2) Half-bridge current as a function of frequency; operating point at intersection with curve (1)

(3) Burner current as a function of frequency

(4) Maximum frequency set by RMS control

Fig 7. RMS control in calculation tool

Control behavior of the lamp power is shown by the test results in real application; see Figure 8.



(1) P_i (W)

(2) f (kHz)

Fig 8. RMS control in real application

The preheat and steady state half-bridge (~lamp) currents are both set by the resistor R_{SENSE}. That results in fixing the ratio between these two currents equal to 1.2. This is a perfect setting for the majority of the burners. However for an extended burner covering this ratio can be enlarged by adding a resistor across capacitor C_{SW}.

Table 1 lists the typical settings. The resistor should not be chosen smaller than 10 MΩ to prevent malfunctioning of the preheat timer.

Table 1. Typical ratio setting of I_{ph} / I_{RMS}

R_{SW} (MΩ)	I_{ph} / I_{RMS}
none	1.2
25	1.3
20	1.4
15	1.5
11	1.7

6.5 Overtemperature protection (OTP)

OTP is active in all states. When the die temperature reaches the OTP activation threshold ($T_{th(act)otp}$), the oscillator is stopped, the LS switch remains in the on state and the HS switch remains in the off state.

This allows the inductor energy to resonate and damp out gradually. With the oscillator now stopped the DVDT supply no longer generates a supply current. Voltage V_{DD} gradually decreases and the start-up state is entered when V_{DD} falls below $V_{DD(stop)}$.

The OTP is reset when the temperature falls below the release threshold ($T_{th(rel)otp}$).

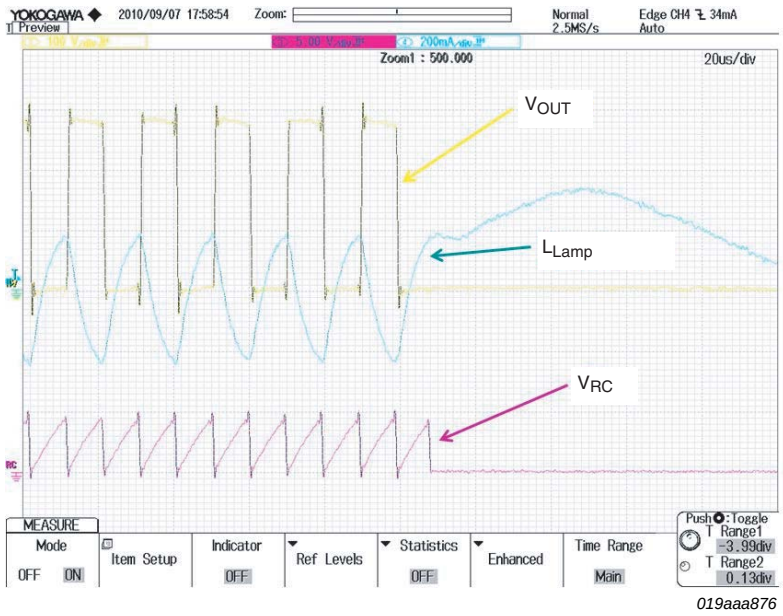


Fig 9. OTP function

6.6 Saturation Current Protection (SCP)

A critical parameter in the design of the lamp inductor is its saturation current.

Saturation of the lamp inductor is likely to occur in cost-effective and miniaturized CFLs. The UBA2211 internally monitors the power transistor current. When this current exceeds the momentary rating of the internal half-bridge power transistors, the conduction time is reduced and the frequency is slowly increased (by discharging C_{SW}). This causes the system to balance at the edge of the current rating of the internal power switches.

Figure 10 shows SCP in real application using an easily saturated inductor. When an IC without this protection function was tested under identical conditions, it failed during ignition.

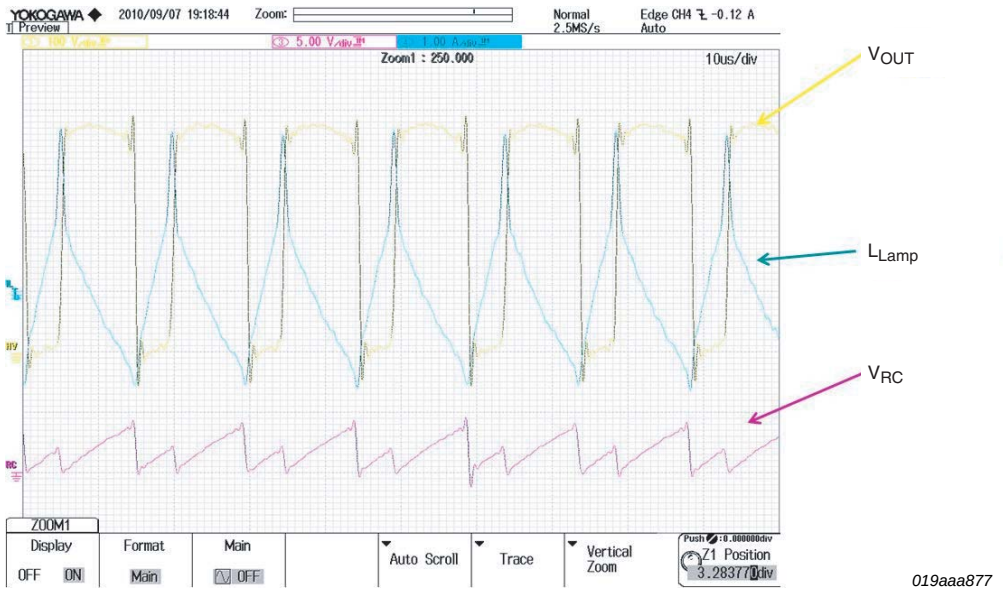


Fig 10. Correctly functioning IC with saturated inductor at ignition

6.7 Capacitive Mode Protection (CMP)

UBA2211 detects switch operation through an internal active Zero-Voltage Switching (ZVS) control circuit preventing stress on the MOSFETs.

When capacitive mode is detected, capacitor C_{SW} is discharged causing the frequency to increase. The system sets itself to the operating point where capacitive mode switching is minimized. CMP is active during the ignition state and in the steady state; see Figure 11.

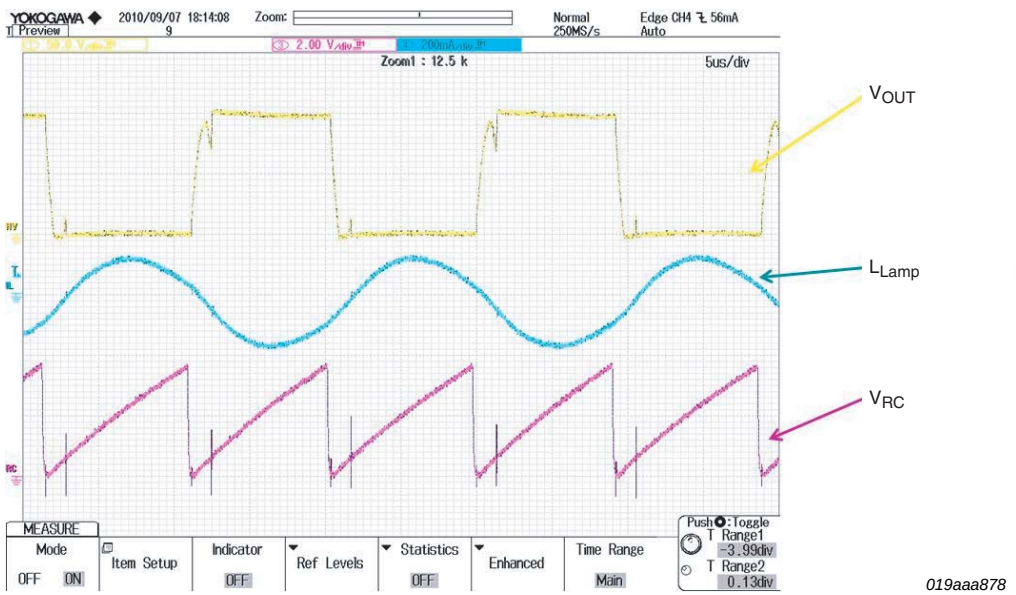


Fig 11. Capacitive mode protection in RMS state

7. Bill Of Materials (BOM)

The components used for the 230 V demo board are given in Table 2

Table 2. BOM

Number	Reference	Alias	Typical value	Quantity
1	R_{fuse}		10 Ω; 1 W	1
2	D1, D2, D4, D5		M7	4
3	C_{BUF}	C1	2.7 µF; 400 V; 105 °C; 10*16	1
4	C_{FS}	C5	10 nF; 50 V; 0805	1
5	C_{SW}, C_{VDD}	C6	100 nF; 50 V; 0805	2
6	C_{DVDT}	C9	220 pF; 500 V	1
7	C_{osc}	C7	220 pF; 50 V; 0805	1
9	C0, C_{OUT1}, C_{OUT2}	C0, C2, C3	100 nF; 400 V; CL21	3
10	C_{lamp}	C4	2.2 nF; 1 kV; CBB28	1
11	L_{FILT}	L1	3 mH; LGB	1
12	L_{lamp}	L2	3 mH; EE13; PC40	1
13	R_{osc}	R1	100 kΩ; 1 %; 0805	1
14	R_{SENSE}	R2	1.8 Ω; 1 W; 1 %	1
15	PCB		UBA2211-1; UBA2211-8	2
16	IC		UBA2211B	1
17	Burner		3U-12 W; 2700k	1

8. PCB layout

Figure 12 shows the PCB layout.

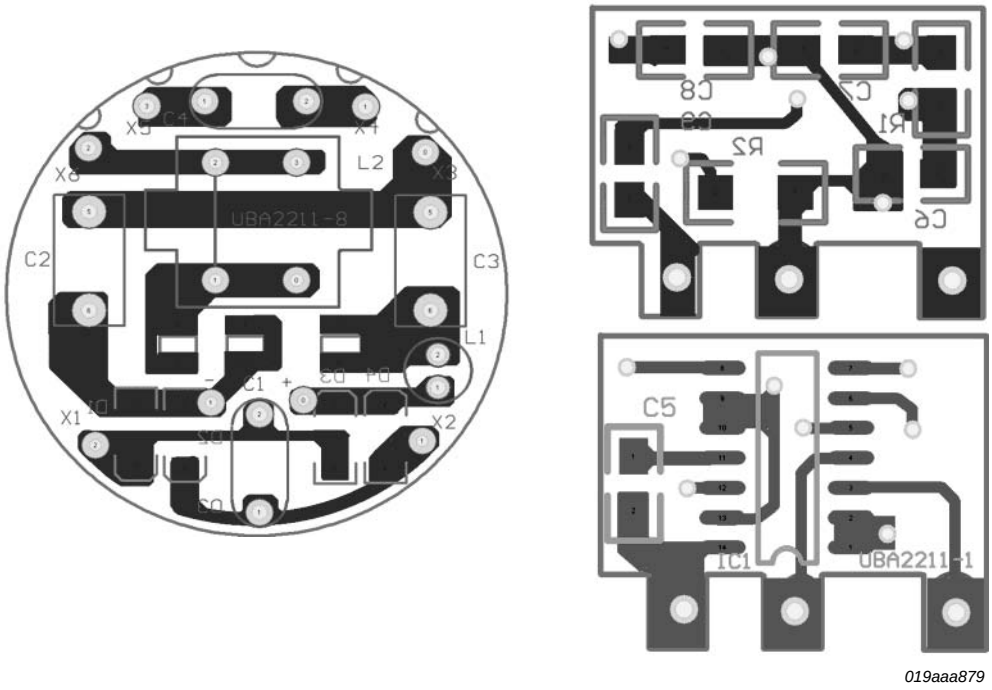


Fig 12. PCB layout: Motherboard (left) and daughter board (right)

9. References

[1] Data sheet UBA2211 — Half-bridge power IC family for CFL lamps.

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11. Contents

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