

# UM10525

120 V 20 W CFL demo board using the UBA2212

Rev. 1 — 19 April 2012

User manual

## Document information

Info	Content
<b>Keywords</b>	UBA2212, demo board, CFL, boost, 120 V (AC), 20 W
<b>Abstract</b>	This document is a user manual for the UBA2212 120 V, 20 W demo board



## Revision history

Rev	Date	Description
v.1	20120419	first issue

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For sales office addresses, please send an email to: [salesaddresses@nxp.com](mailto:salesaddresses@nxp.com)

## 1. Introduction

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The UBA2212 series is a family of high voltage monolithic integrated circuits for driving Compact Fluorescent Lamps (CFL) in half-bridge configurations. It is derived from the UBA2211 IC and modified to drive a 120 V (AC) application. The UBA2212 contains a boost feature, which boosts the lamp current for a certain time after ignition. This feature results in faster CFL warm-up and more light after ignition.

Run-up time is one of the key requirements for CFL. Normally, it is measured from the time lamp was powered until 80 % of light output is reached. Run-up time is long if a high temperature amalgam burner is used or a lamp is ignited in cold environment. The UBA2212 is designed to meet the needs of these situations in both indoor and outdoor applications.

In addition to the boost feature, the UBA2212 has the following features:

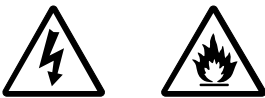
- Fixed frequency preheat with an adjustable preheat time
- RMS current control
- Saturation Current Protection (SCP)
- OverTemperature Protection (OTP)
- Capacitive Mode Protection (CMP)

This user manual is intended to describe a 120 V, 20 W application demo board using the UBA2212CT. See the *UBA2212 data sheet* for the functional description of this IC.

## 2. Safety Warning

### WARNING

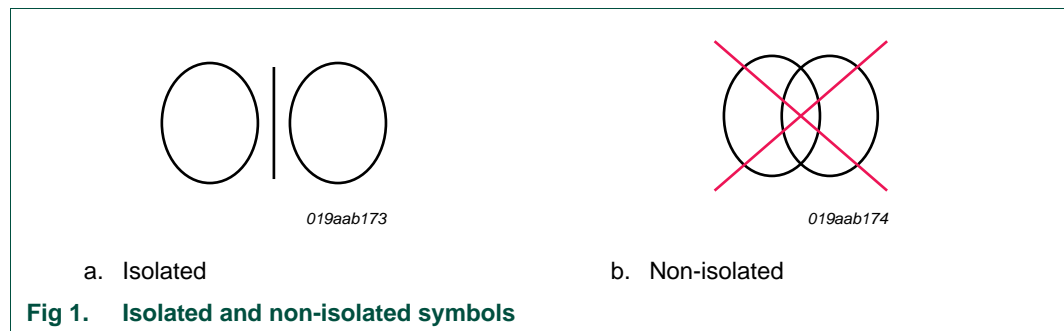
#### Lethal voltage and fire ignition hazard



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 demo board is powered by AC mains voltage. Avoid touching the board when power is applied. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. Always provide galvanic isolation of the mains phase using a variable transformer. The following symbols identify isolated and non-isolated devices.



**Fig 1. Isolated and non-isolated symbols**

### 3. Specifications

Table 1. Demo board specification

Parameter	State	Value	Comment
AC line input voltage	-	96 V (AC) to 144 V (AC)	board optimized for 120 V (AC), 60 Hz.
Lamp voltage ( $V_{lamp}$ )	steady	100 V	measured at 120 V (AC) mains; GE T3 Spiral 20 W burner used; <a href="#">Table 2 on page 10</a>
Lamp current ( $I_{lamp}$ )		170 mA	
Operating frequency ( $f_{osc}$ )		45 kHz	
Power Factor		>0.58	
Preheat current ( $I_{ph}$ )	preheat	150 mA	constant preheat current at 96 V (AC) to 144 V (AC); <a href="#">Table 2 on page 10</a>
Preheat time ( $t_{ph}$ )		0.8 s	
Lamp current ( $I_{lamp}$ )	boost	255 mA	measured at 120 V (AC) mains; see <a href="#">Figure 5 on page 8</a> and <a href="#">Table 2 on page 10</a>
boost time ( $t_{bst}$ )		40 s	
transition time from boost to burn ( $t_{i(bst-burn)}$ )		2 s	



Fig 2. Photographs of a 20 W CFL Application with a UBA2212

## 4. Schematic and functional description

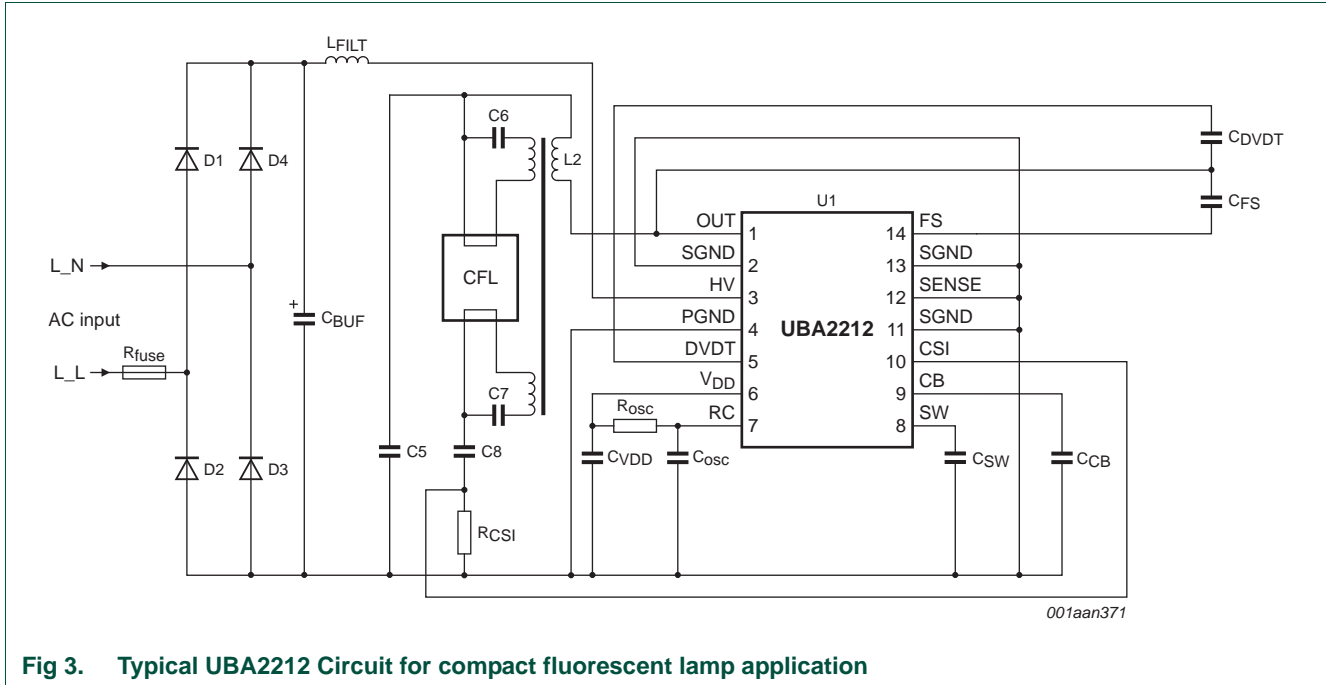


Fig 3. Typical UBA2212 Circuit for compact fluorescent lamp application

### 4.1 Functional description

The bridge rectifier (D1 to D4) rectifies the AC input power. The bulk storage capacitor  $C_{BUF}$  filters the rectified DC voltage. Power inductor  $L_{FILT}$  and capacitor  $C_{BUF}$  form an LC filter, which attenuates conducted differential mode EMI noise. Fusible resistor  $R_{fuse}$  provides protection against overcurrent failure.

During start-up, the internal current source connected to HV pin provides power. Once capacitor  $C_{DVDT}$  is charged, it provides the  $dV/dt$  supply for normal operation. Capacitor  $C_{FS}$  provides the high-side floating supply output and Capacitor  $C_{VDD}$  is used for VDD bypass.

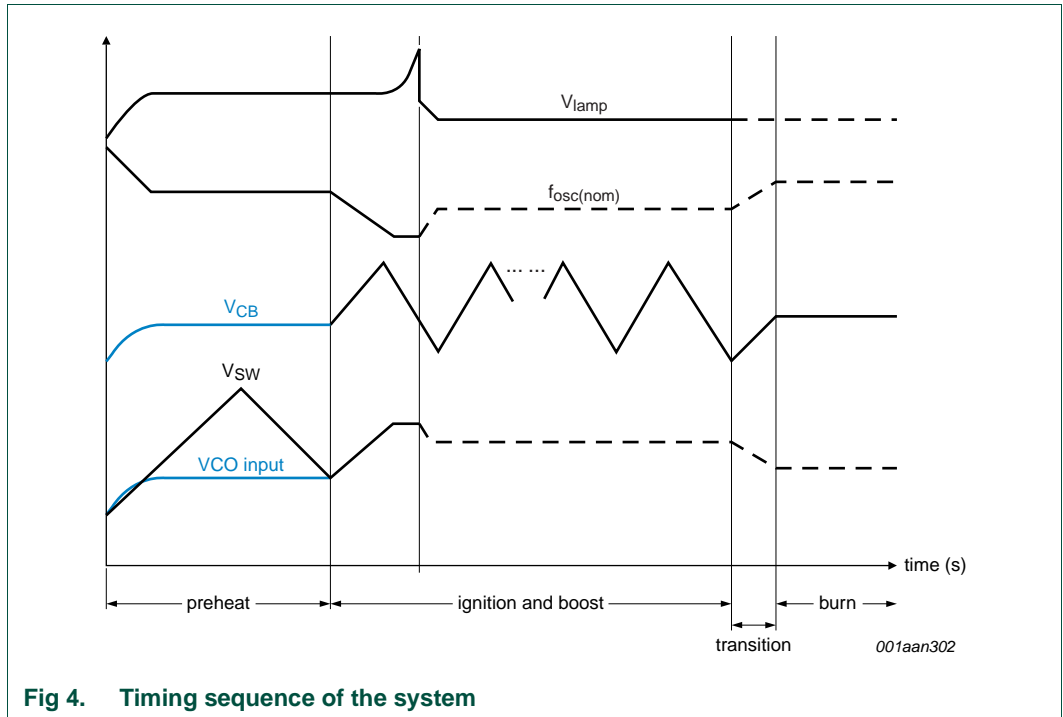
$C5$  and inductor  $L2$  primary winding (N1) form an LC tank translating power into the burner. The  $L2$  secondary windings N2 and N3 preheat the burner filaments. If preheat is not required in the application, leave off secondary windings and short the filaments.  $C8$  is DC blocking capacitor.  $R_{CSI}$  is used for burner current sensing during boost and RMS states.

$R_{osc}$  and  $C_{osc}$  determine the nominal oscillating frequency based on the Built-in 555-timer function. The input to the SW pin generates the  $V_{SW}$  signal which determines the preheat time. Capacitor  $C_{CB}$  sets the boost time.

### 4.2 Timing

The UBA2212 based 20 W demo board provides all the functions needed for correct CFL operation. These functions include preheat, ignition, boost and on-state operation.

Several protection features safeguard the correct operation of the CFL and controller IC. The typical system timing is shown in [Figure 4](#).



**Fig 4. Timing sequence of the system**

In preheat, current  $I_{SW}$  charges capacitor  $C_{SW}$  generate the preheat timing ( $t_{ph}$ ).

Capacitor  $C_{CB}$  connected to pin CB is connected to the boost timer input to control the boost time. After preheat, the  $C_{CB}$  voltage sweeps up and down at the boost timing ( $t_{bst}$ ). The boost ends after 25  $C_{CB}$  sweeping cycles.

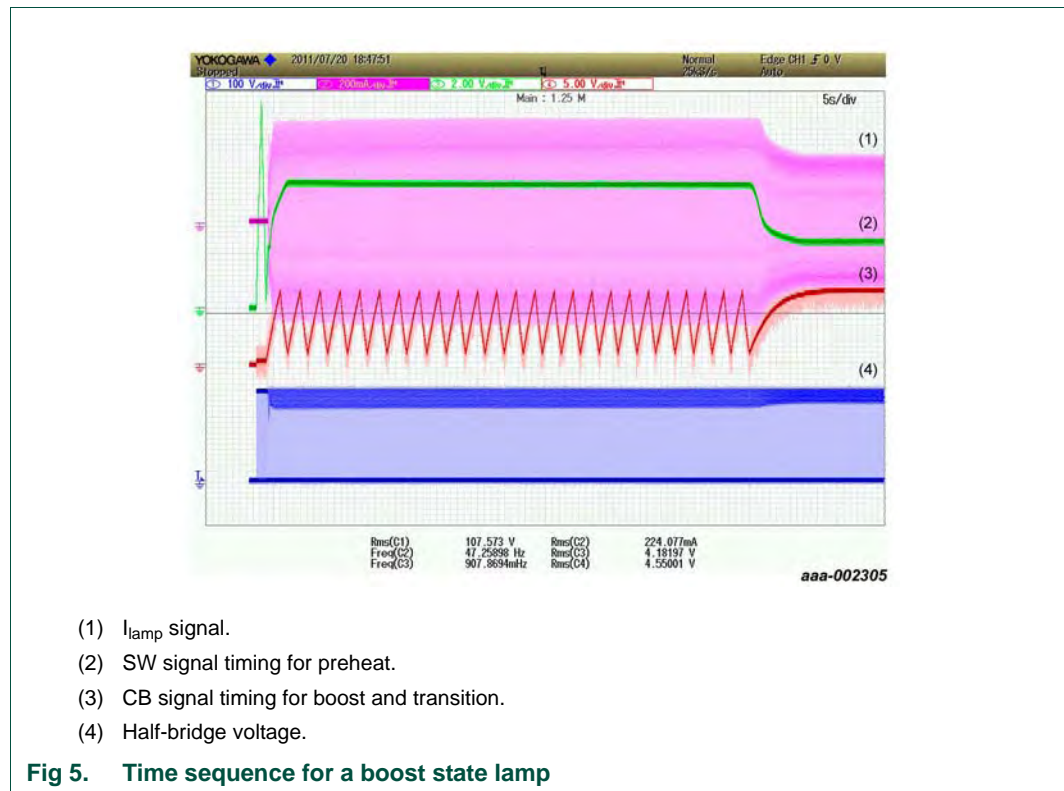
The transition from the boost state to the burn state is triggered when the boost timer indicates the end of the boost state. During the boost to burn transition, the boost transition timer is active. The timer defines transition time which is also realized using capacitor  $C_{CB}$  on CB pin.

When the RMS current control circuit leaves the system operating at the normal lamp current, it enters the burn state. In this state, a feedback loop controls the  $V_{SW}$  voltage on pin SW. This feature makes the lamp current independent mains or lamp voltage variations.

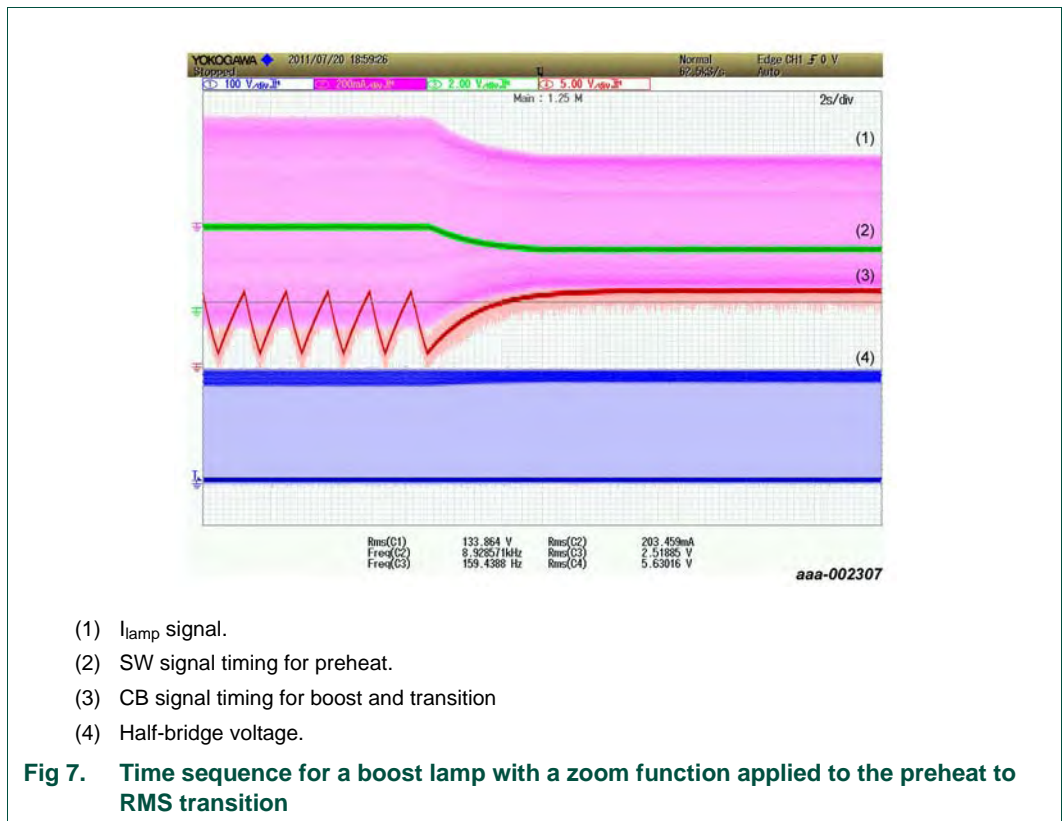
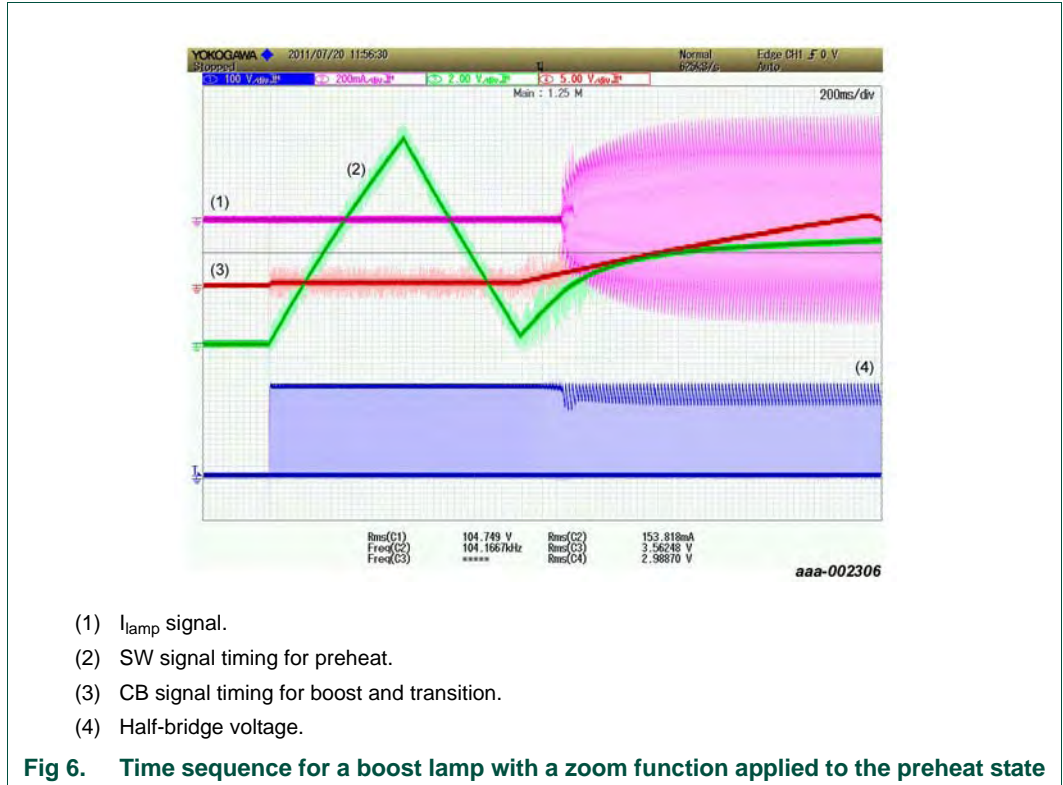
## 5. Measurement results

Using a typical 20 W lamp, the measurements show that the boost effect is visible to the human eye when the light is powered up. The same situation is not visible when the same lamp is used without boost feature.

Figure 4 shows the states after power-on. The preheat, ignition, boost, transition and burn states are clearly visible. The preheat and transition states are also zoomed in greater detail.







**Table 2. Electrical parameters 12 W boost lamp (UBA2212BT N1B)**

Boost ratio = 1.49; boost time = 38.5 s (25 cycles); transition time = 2 s.

State	V <sub>IN</sub> (V)	P <sub>in</sub> (W)	PF	V <sub>lamp</sub> (V)	I <sub>lamp</sub> (mA)	I <sub>hb</sub> (mA)	P <sub>lamp</sub> (W)	f <sub>osc</sub> (kHz)	T <sub>ph</sub> (s)	I <sub>ph</sub> (mA)
Normal	120	21.3	0.589	107	169	366	18.1	44.3	0.76	150
Boost	-	23.1	-	80.5	252	470	20.3	39.7	-	-

The boost feature provides a fast run-up time. However when a hot lamp is powered, the lamp does not need boost or only a short boost time. The UBA2212 sets a boost overtemperature (T<sub>ji(end)bst</sub>) to allow for the reduced boost time. The IC detects its die temperature and ends the boost state when the temperature trigger point is reached. The lamp then enters the burn transition.

When a lamp burns for a long time, is switched off and then after a short delay switched on again. The end of boost is reached after only 6 s of boost. In Figure 5, SW counted only 5 cycles. Normally SW sweeps through 25 cycles when OTP is not triggered.



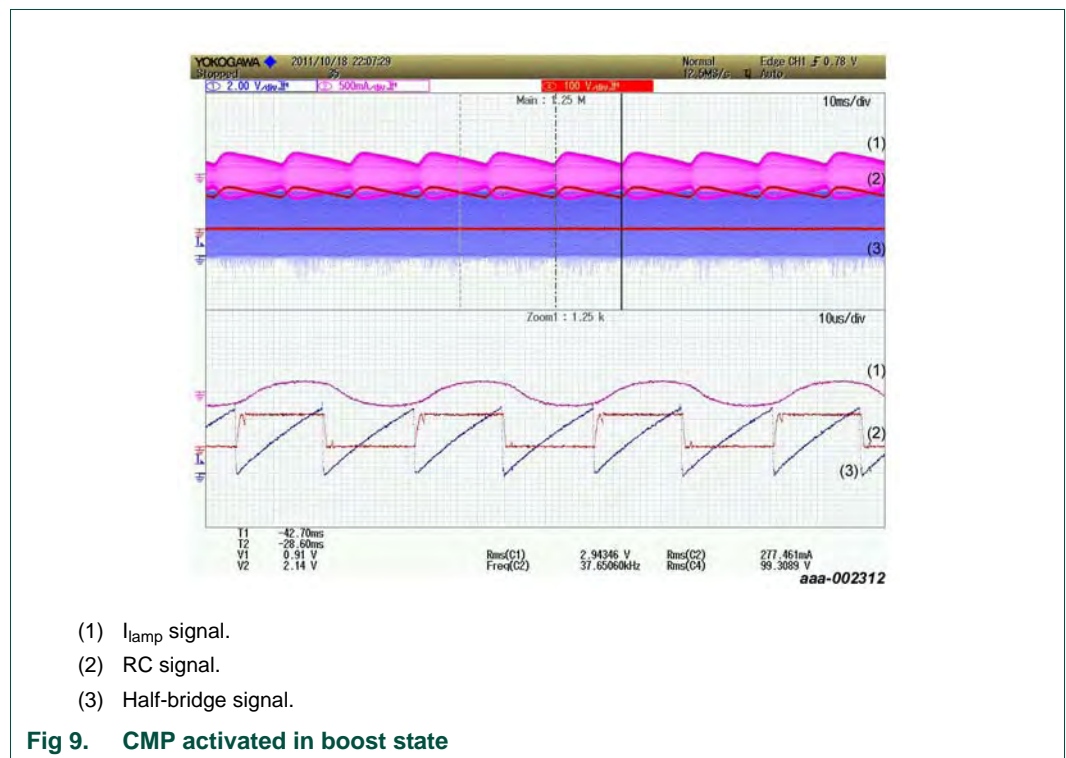
**5.1 Boost lamp with high lamp voltage**

During boost state, lamps consume more power. As a result, the half-bridge valley voltage value is pulled low. In addition, CM or hard switching occurs especially when a high lamp voltage with used with a low mains input.

The UBA2212 detects switched operation prevent stress on MOSFETs using the internal active Zero-Voltage Switching (ZVS) control circuit.

When capacitive mode is detected, the internal current source discharges the internal capacitor. Consequently, the SW voltage is lower and the RMS circuit controlled boost frequency increases until the system is at the zero-voltage switching border.

Figure 6 shows the Capacitive Mode (CM) protection response in the boost state.



The ratio of boost lamp current to RMS lamp current ( $I_{bst} : I_{RMS}$ ) is lower because of CMP.

If a significant boost effect is needed, the system parameters need adjusted. A bigger lamp capacitor, for example, reduces the need for CM and LC tank to be adjusted to supply a larger power gain. However, the larger power gain is at the cost of a higher half-bridge current which leads to low-power efficiency and a narrow RMS operation range.

## 5.2 RMS control in boost and steady states

When ignition frequency is reached, the lamp ignites.  $V_{SW}$  increases to a given voltage to set the lamp current at the level defined by the internal boost reference and resistor  $R_{CSI}$ .

The calculation is shown in [Equation 1](#):

$$\text{Boost } I_{lamp} = \frac{V_{ref(bst)}}{R_{CSI}} \quad (1)$$

When the RMS current control circuit leaves the system operating at the normal lamp current, it enters the steady state. In this state, the voltage on pin CB is fixed and a feedback loop controls the voltage on pin SW. This feature enables the lamp current to be independent of the mains or lamp voltage. The lamp current calculation is shown in [Equation 2](#):

$$\text{Burn } I_{lamp} = \frac{V_{ref(burn)}}{R_{CSI}} \quad (2)$$

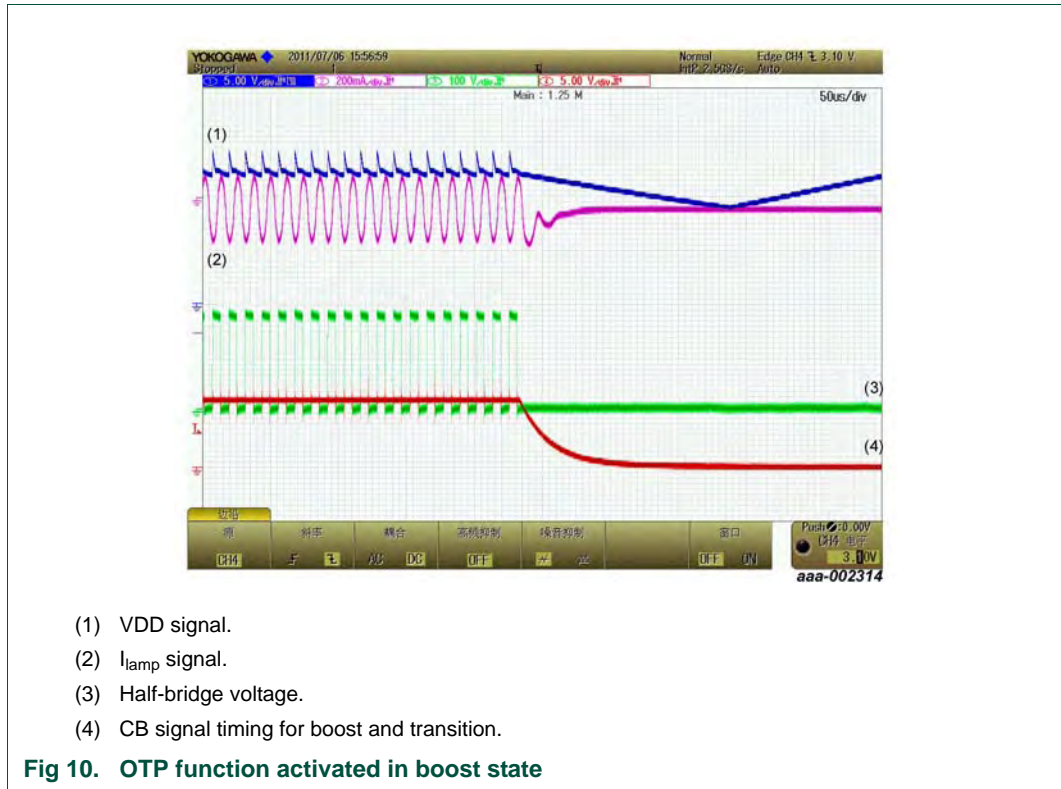
Therefore, the boost-burn ratio can be found as shown in [Equation 3](#):

$$\text{Boost to burn ratio} = \frac{V_{ref(bst)}}{V_{ref(burn)}} \quad (3)$$

## 5.3 Overtemperature protection

OTP is active in all states except boost. When the die temperature reaches the OTP activation threshold ( $T_{th(act)otp}$ ), the oscillator is stopped and the power switches (LSPT/HSPT) are set to the start-up state. When the oscillator is stopped, the DVDT supply no longer generates the supply current  $I_{DVDT}$ . Voltage  $V_{DD}$  gradually decreases and the start-up state is entered. OTP is reset when the temperature  $< T_{th(rel)otp}$ .

During boost state, the threshold of temperature is  $T_{j(end)bst}$  which is lower than  $T_{th(otp)}$ . When the die temperature has reached  $T_{j(end)bst}$ , the boost state ends, the IC enters steady state and OTP is enabled.



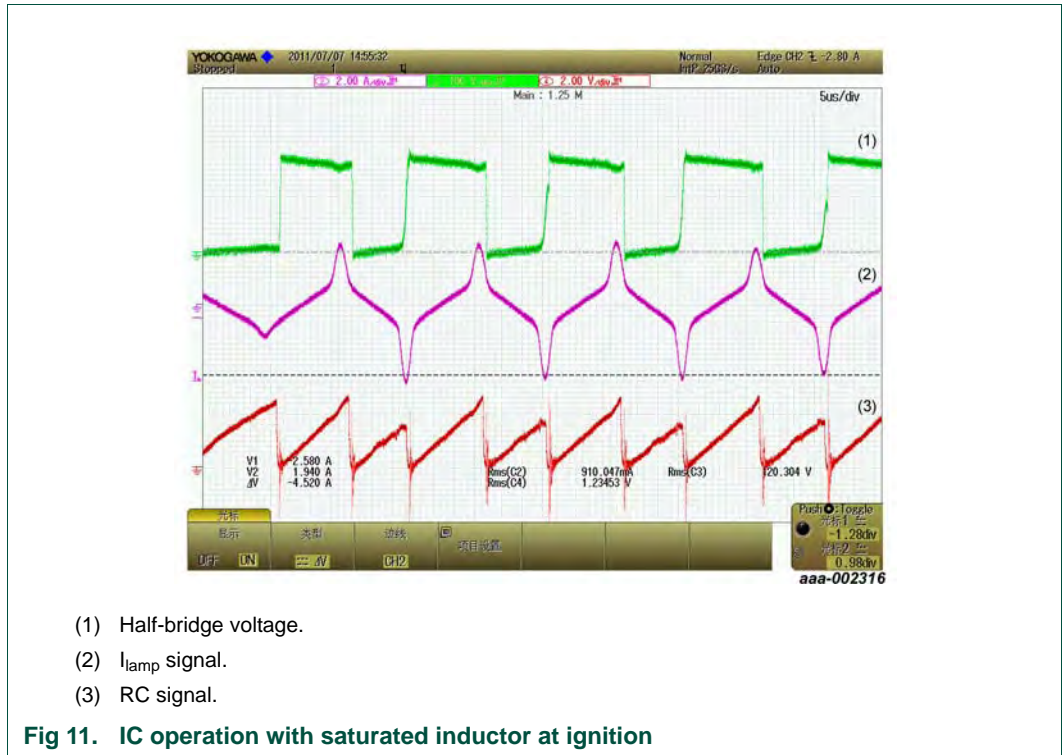
### 5.4 Saturation Current protection

A critical parameter in the design of the lamp inductor is its saturation current. When the momentary inductor exceeds its saturation current, the inductance drops significantly. This drop causes the inductor current and the current flowing through the LSPT and HSPT power switches to increase rapidly. The increase can cause the current to exceed the half-bridge power transistors maximum ratings.

Saturation of the lamp inductor is likely to occur in cost-effective and miniaturized CFLs. The UBA2212 family internally monitors the power transistor current. When the current exceeds the momentary rating of the internal half-bridge power transistors, the conduction time is reduced. In addition, the frequency increases slowly by discharging  $C_{SW}$ . This function causes the system to balance at the edge of the current rating of the power switches.

[Figure 11](#) shows the Saturation Current Protection (SCP) in real application which uses an easily saturated inductor. SCP enables the burner to ignite despite the inductor saturating effect. When the same parameters are used with an IC without SCP, the IC failed during the ignition.





- (1) Half-bridge voltage.
- (2)  $I_{lamp}$  signal.
- (3) RC signal.

Fig 11. IC operation with saturated inductor at ignition

### 5.5 Capacitive mode protection

The UBA2212 detects hard switching operations to prevent stress on MOSFETs using the internal Zero-Voltage Switching (ZVS) control circuit. In preheat stage, when CMP is detected, discharge of capacitor  $C_{CB}$  occurs by a current source which is a function of the hard switching level. The frequency increases very slowly until hard switching is no longer detected. Once CMP is no longer active, the system increases to the preheating frequency as defined preheat current.

In boost and burn state,  $V_{SW}$  determines the operating frequency. Under normal conditions, the RMS current control circuit is used. During CMP, the CMP circuit controls the frequency.

The CMP circuit controls capacitor  $C_{SW}$  when capacitive mode is detected. A current source (which is also dependent on the hard switching voltage level) discharges Capacitor  $C_{SW}$ . The operating frequency  $f_{osc}$ , increases until CMP is no longer detected. See [Figure 12](#).

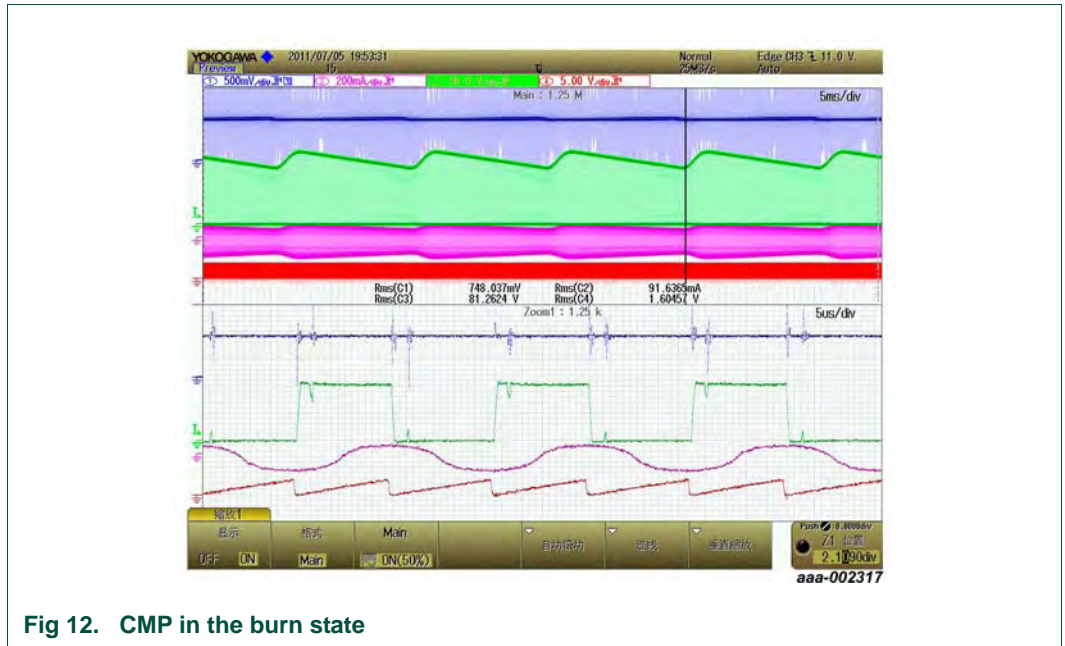


Fig 12. CMP in the burn state





Table 3. Bill of materials ...continued

Number	Reference	Typical value	Quantity
16	L2	PC40-EE16; 1.5 mH; 1 A; N = 180:6:6; diameter 0.23 mm	1
18	U1	UBA2212CT; SO14	1
19	Burner	burner; T3 Spiral 20 W	1

## 7. PCB layout

Figure 14 shows the layout of the PCB.

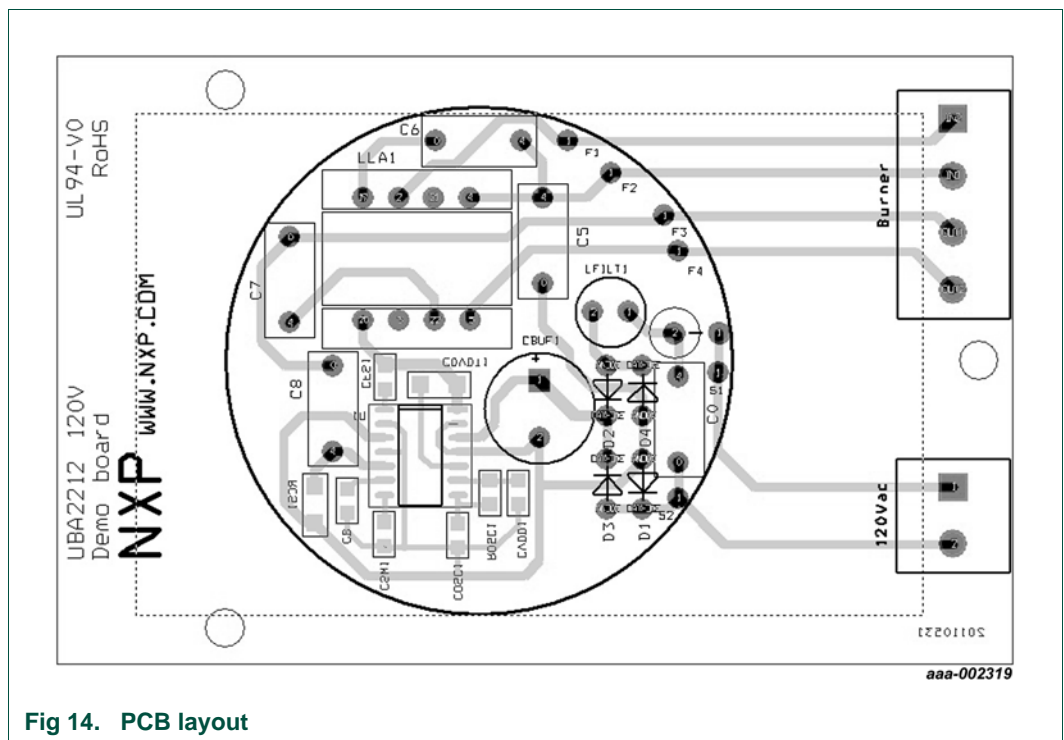


Fig 14. PCB layout

## 8. Alternative CFL examples

Some other lamps were measured in the lab, including 8 W, 12 W, 15 W, 20 W. Two boost lamps using UBA2212BT are listed Table 4 with their LC tank, start up-to-burn scope picture and related electrical parameters.

Table 4. Electrical parameters 12 W boost lamp (UBA2212BT N1B)

Boost ratio = 1.54.;  $C_{BUF} = 22 \mu F, 250 V$ ;  $L2 = 1.7 mH, 2 \Omega$ ;  $C5 (res) = 6 nF, 1 kV$ ;  $C6$  and  $C7 = 100 nF, 100 V$ ;  $C8 (DC) = 10 nF, 400 V$ ;  $R_{CSI} = 2.2 \Omega, 1 W$

State	$V_{IN}$ (V)	$P_{in}$ (W)	PF	$V_{lamp}$ (V)	$I_{lamp}$ (mA)	$I_{hb}$ (mA)	$P_{lamp}$ (W)	$f_{osc}$ (kHz)	$t_{ph}$ (s)
Normal	120	11.3	0.59	75	127	248	9.5	48.3	0.8
Boost	-	16.1	-	67	196	338	13.1	40.34	-

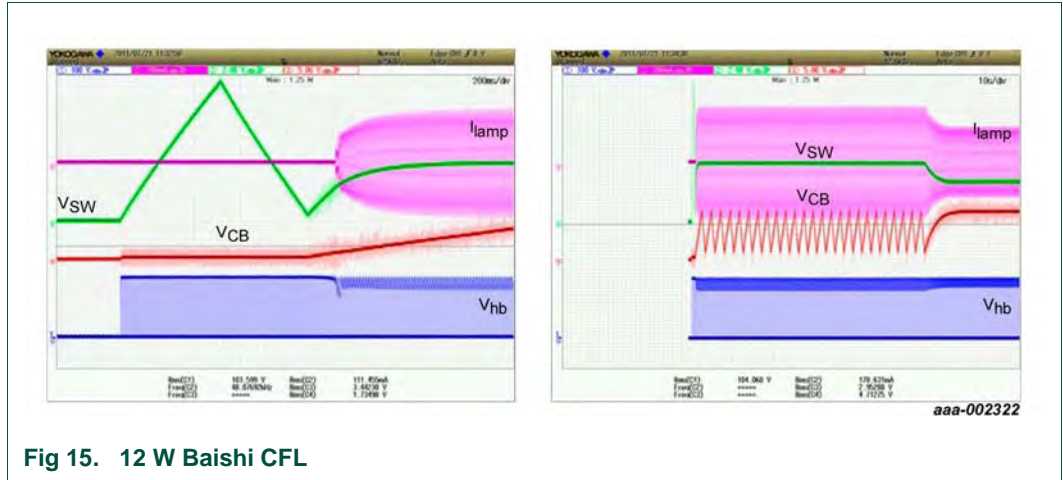


Table 5. Electrical parameters 12 W boost lamp (UBA2212BT N1B)

Boost ratio = 1.56.;  $C_{BUF} = 22 \mu F, 250 V$ ;  $L2 = 1.75 mH, 2 \Omega$ ;  $C5 (res) = 7.4 nF, 1 kV$ ;  
 $C6 \text{ and } C7 = 100 nF, 100 V$ ;  $C8 (DC) = 15 nF, 400 V$ ;  $R_{CSI} = 2.7 \Omega, 1 W$

State	V <sub>IN</sub> (V)	P <sub>in</sub> (W)	PF	V <sub>lamp</sub> (V)	I <sub>lamp</sub> (mA)	I <sub>hb</sub> (mA)	P <sub>lamp</sub> (W)	f <sub>osc</sub> (kHz)	t <sub>ph</sub> (s)
Normal	120	13.7	0.6	113.3	102	302	11.6	47.38	0.8
Boost	-	17.7	-	95	159	309	15.1	39.16	-



## 9. References

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- [1] **UBA2212** — Half-bridge power IC family for CFL lamps data sheet.

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