

## Introduction

The purpose of this board is to allow the user to evaluate the STEVAL-ILD003V1 SCR (silicon controlled rectifier) dimmer solution to dim low-consumption lamps, particularly CFL and LED lamps, without flickering phenomenon.

This light dimmer allows the user to evaluate the SCR dimmer concept by directly testing the dimmable loads on the market today.

Through-hole technology is used for the most important components such as the LC filter, gate resistor, turn-on delay capacitor, etc., in order to allow board modifications if needed, to fit particular application requirements.

STEVAL-ILD003V1 light dimmers based on SCR allow flickering phenomenon to be solved thanks to the continuous current applied through the gate. The SCR dimmer may easily replace a standard low-cost analog Triac light dimmer using a Diac and potentiometer for its control circuit.

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# 1 Operating conditions

The STEVAL-ILD003V1 operating conditions are:

- Line RMS voltage and frequency: 198 - 264 V, 50 Hz
- Ambient temperature range: 0 to 60 °C
- Dimmable power range with halogen, CFL and LED lamps (without heatsinks mounted on SCRs):
  - 3 to 350 W for 230 V rms line

*Note:* A higher load power may be reached with a different filter inductor and a bigger SCR heatsink (refer to AN533).

## 1.1 Basic features

The board circuit features:

- Two TS820-600FP SCRs in reverse parallel connection
- A single potentiometer to set the turn-on delay of both SCRs
  - Maximum power, turn-on delay = 0.8 ms
  - Minimum power, turn-on delay = 7.7 ms

*Note:* When dimming power is at minimum setting, the lamp may show low residual brightness. This is due to the reduced maximum turn-on angle chosen for proper operation with LED or CFL lamps. This phenomenon may be suppressed if a longer maximum turn-on angle is set or if a potentiometer with an integrated switch (to open the circuit in OFF position) is used.

- Fuse to protect the SCR in case of lamp flash-over or accidental short-circuit (2.5 A fuse is required to avoid SCR failure)
- LC noise filter: 2.4 mH - 100 nF (to pass the EN55015 standard with a 350 W - 230 V halogen lamp)
- Power efficiency @ 350 W / 230 V > 99%
- Standby losses @ 230 V < 0.5 W (could be reduced to 0 if potentiometer features a mechanical switch to open the circuit at minimum setting)

## 1.2 Safety instruction

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**Warning:** The high voltage levels used to operate the SCR dimmer demonstration board may present a serious electrical shock hazard. This demonstration board must be used in a suitable laboratory by qualified personnel only, familiar with the installation, use, and maintenance of power electrical systems.

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**Intended use**

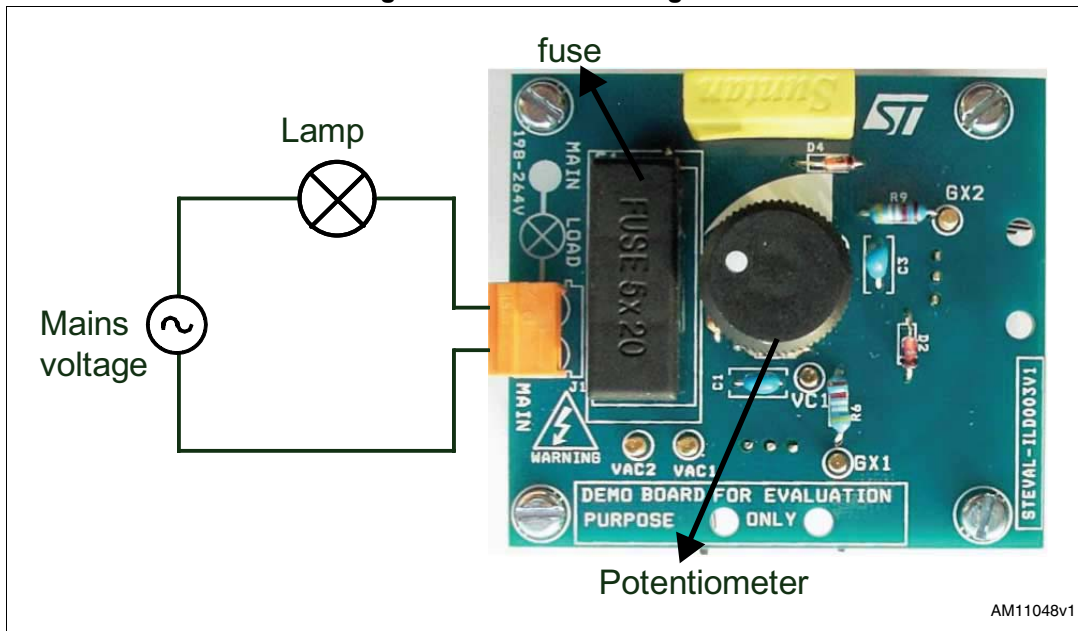
The SCR dimmer demonstration board is designed for demonstration purposes only, and should not be used for domestic installation or for industrial installation.

## 2 Getting started

### 2.1 Connection diagram

*Figure 1* shows how to connect the STEVAL-ILD003V1 to the lamp to be dimmed. Please unplug the circuit from the line before setting the different connections.

**Figure 1. Connection diagram**



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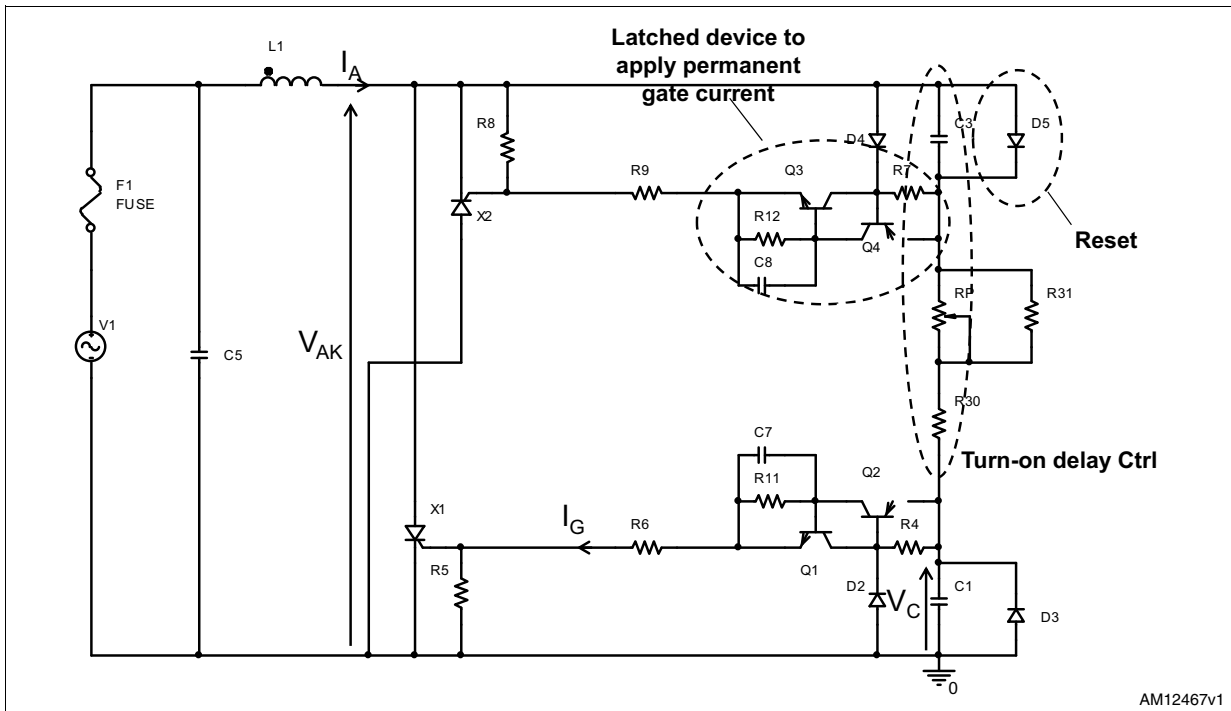
### 2.2 Schematic and board layout

*Figure 2* shows the STEVAL-ILD003V1 schematic and highlights the different blocks of the control circuit.

*Figure 3* shows the board copper tracks layer (bottom view).

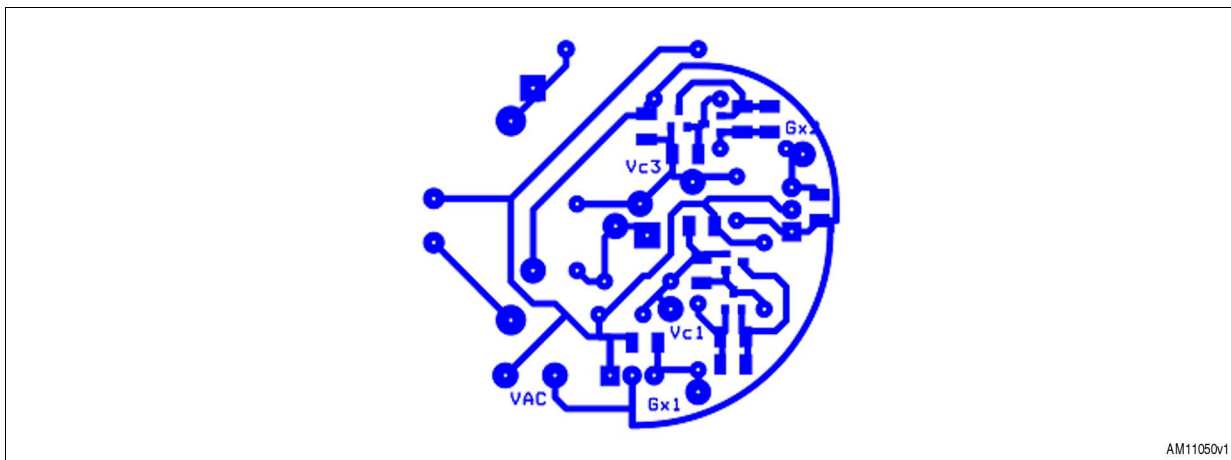
Capacitors C1 and C3 are 1  $\mu\text{F}$ ; these two capacitors are used to have a constant current through the gate of each SCR. This high capacitor value, compared to a standard value of 100 nF in Triac/Diac light dimmers, imposes more current to charge it. This average current passes through the potentiometer  $R_p$ , so the maximum power dissipated through the potentiometer is about 0.4 W. The potentiometer  $R_p$  should be 0.5 W minimum.

Figure 2. SCR dimmer schematic



AM12467v1

Figure 3. SCR dimmer PCB layout



AM11050v1

### 3 Experimental tests and results

#### 3.1 STEVAL-ILD003V1 SCR dimmer operation with 40 W incandescent lamp

Figure 4, 5, 6 and 7 show the good SCR dimmer operation for a 230 V-15 W incandescent lamp for a turn-on delay of 5 ms and 0.5ms (refer to  $t_{ON}$  in the figures). Figure 2 shows the measurement location of the voltages and the currents.

Refer to Figure 2 for  $V_{AK}$ ,  $I_A$ ,  $V_C$  and  $I_G$  definitions.

Figure 4. SCR dimmer operation for 5 ms turn-on delay      Figure 5. SCR dimmer operation for 0.5 ms turn-on delay

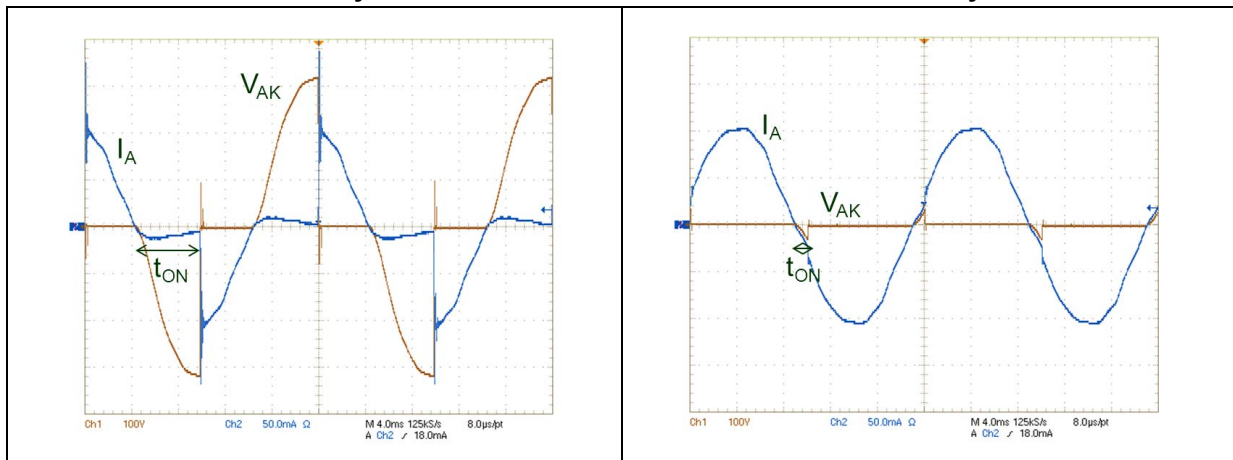
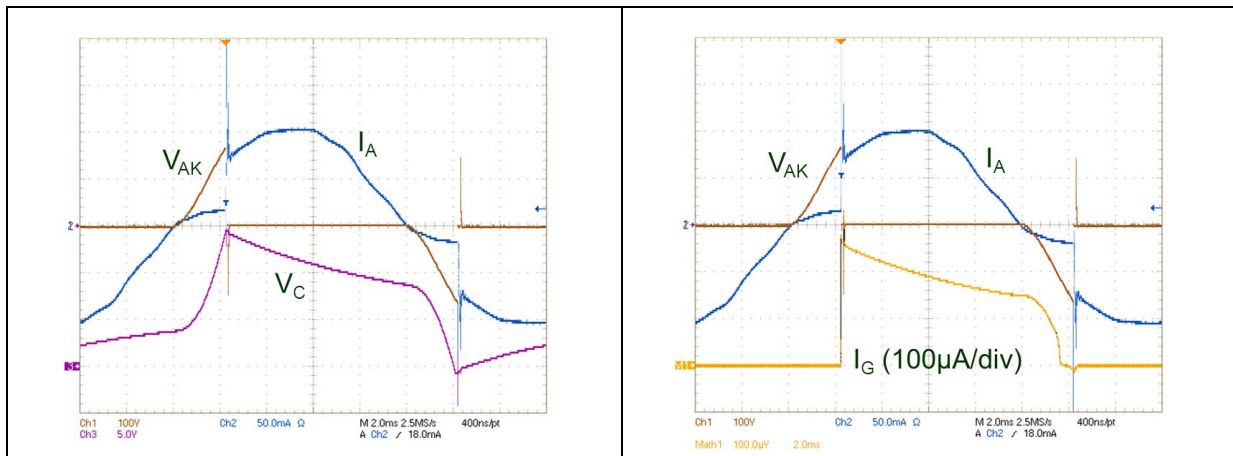


Figure 6. Capacitor discharge voltage after turn-on

Figure 7. SCR continuous gate current



SCR gate current must be higher than 100  $\mu$ A to keep the SCR ON whatever the Anode current is.

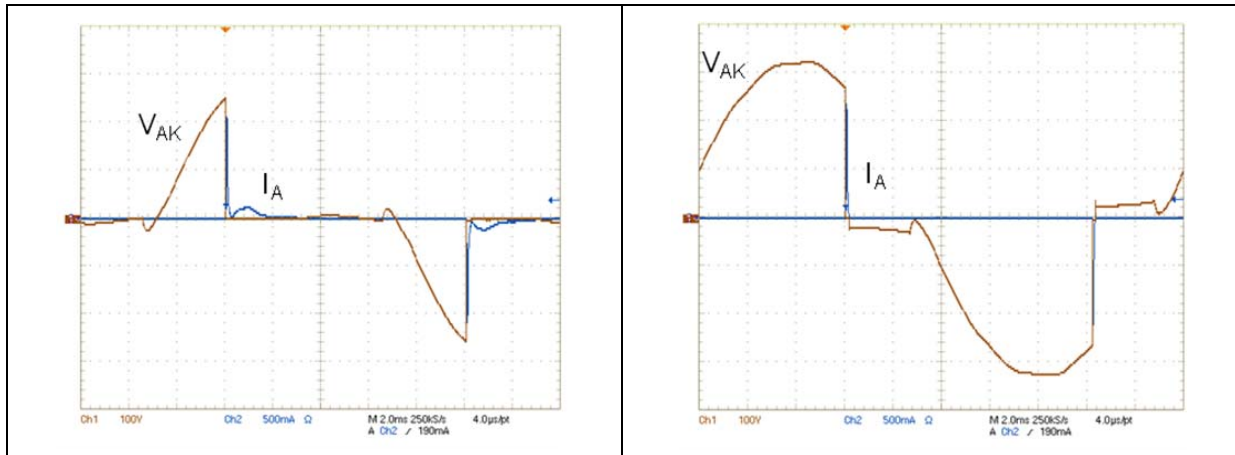


### 3.2 STEVAL-ILD003V1 SCR dimmer working with LED lamp

Figure 8 and 9 show a 6 W LED lamp operation with the SCR dimmer at different turn-on delays. Dimmable CFL and LED lamps function well with the SCR dimmer without flickering.

Figure 8. SCR dimmer operation for 3 ms turn-on delay with LED lamp

Figure 9. SCR dimmer operation for 7 ms turn-on delay with LED lamp



Note that, for low conduction angles, some low light variation may occur with some CFL and LED lamps. This variation is due to the lamp ballast behavior. Indeed, a 5 to 20  $\mu$ s ripple on the turn-on delay (due to the dimmer analog control accuracy) may lead to a different brightness order set by the ballast. This is the case for some lamp brands, if the ballast has no feature embedded to filter the turn-on delay information.

### 3.3 Electromagnetic compatibility test

#### 3.3.1 Fast transient voltage immunity

Immunity against transient voltage has been tested according to the IEC61000-4-4 standard with the following conditions:

- 230 V RMS - 50 Hz mains voltage
- L-C filter (2.4 mH - 100 nF)
- 40 W - 230 V incandescent lamp load
- Test procedure: potentiometer is set to the minimum lamp brightness and a step-by-step increase in the burst voltage level until it reaches at least one spurious half-cycle conduction of the SCR.

The dimmer is able to withstand a minimum withstanding of 2 kV before the one SCR turns on (refer to Table 1).

Table 1. Fast transient immunity test results at 5 kHz

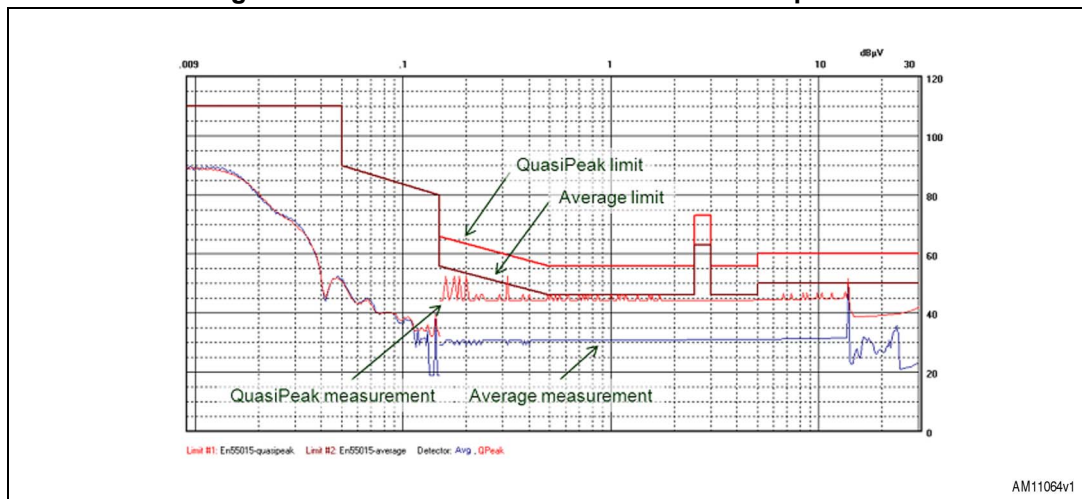
Coupling mode	L + / PE	L - / PE	N + / PE	N - / PE
Immunity level at 5 kHz	2 kV	2 kV	2 kV	2 kV

### 3.3.2 Radio disturbance compliance according to EN 55015

Radio disturbance has been checked according to the EN 55015 standard in the following conditions:

- 230 V RMS - 50 Hz mains voltage
- L-C filter (2.4 mH - 100 nF)
- 350 W - 230 V incandescent lamp load
- The potentiometer is set at different angles, *Figure 10* gives the measurement of the maximum conducted noise which is reached for a 50% output power ( $t_{ON}$ ).

**Figure 10. SCR dimmer radio disturbance compliance**



According to *Figure 10*, average and quasi-peak measurements are lower than the standard limits, so the SCR dimmer successfully passes the EN55015 standard.

## 4 Conclusion

The STEVAL-ILD003V1 SCR dimmer is able to successfully drive halogen lamp, CFL and LED dimmable lamps.

Thanks its DC gate current control, the STEVAL-ILD003V1 has no minimum power limitation. The minimum lamp power is set at 3 W which seems to be the lowest dimmable lamp power today on the market.

The only flickering that may occur is a low-frequency lamp brightness variation if the lamp internal ballast doesn't feature any filtering on dimming angle detection.

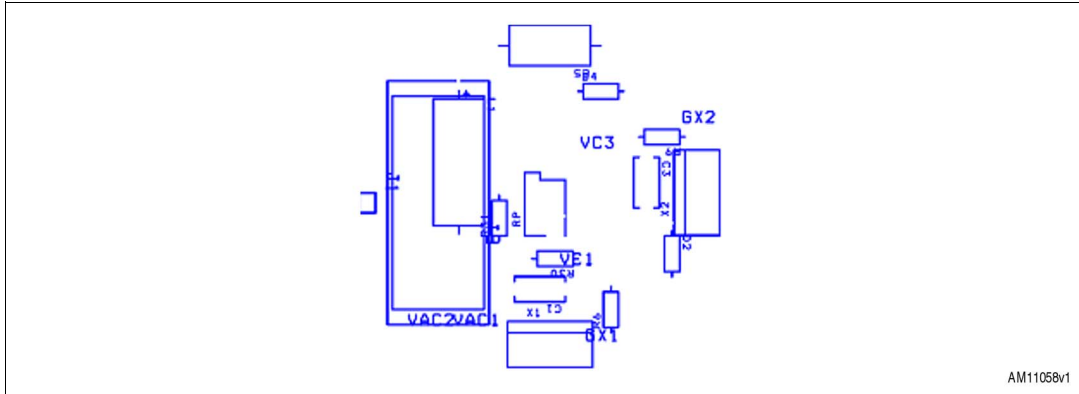
The circuit presented on this board also fulfills the standard requirements for the EMC European directive

- IEC61000-4-4 fulfillment with a withstanding higher than 2 kV
- EN55015 conducted noise.

## Appendix A Assembly information

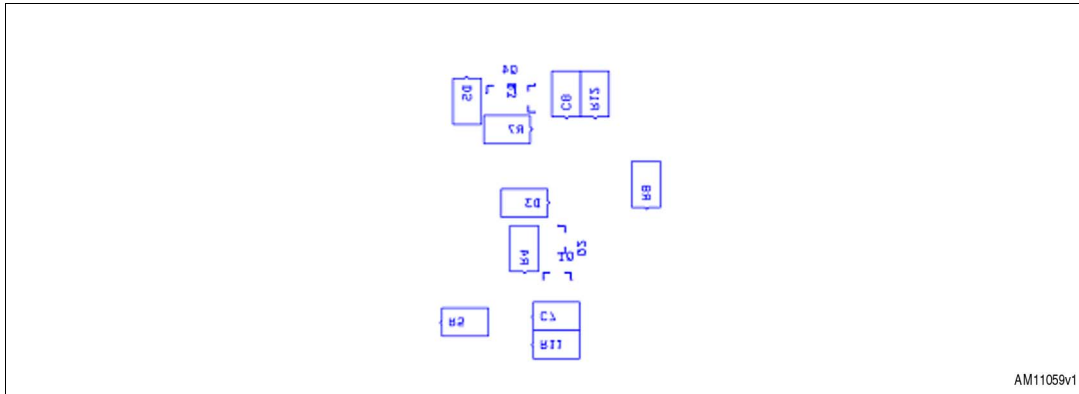
### A.1 Component assembly layout

Figure 11. Silkscreen bottom left



AM11058v1

Figure 12. Silkscreen top right



AM11059v1

### A.2 Bill of materials

Table 2. BOM

Reference	Part
C1,C3	1 $\mu$ F / 25 V
C5	100 nF X2 / 400 V
C7,C8	10 nF / 25 V
D2,D4	BZX84C15
D3,D5	1N4148
F1	FUSE / 2.5 A
Vc1,Vac1,Gx1,Vac2,Gx2,Vc3	TP
J1	CON2

Table 2. BOM (continued)

Reference	Part
L1	2.4 mH / 500 W
Q1,Q3	2N2222
Q2,Q4	2N2907
RP	220 k $\Omega$ / 1 W
R4,R5,R7,R8	10 k $\Omega$ / 0.125 W
R6,R9	50 k $\Omega$ / 0.25 W
R11,R12	20 k $\Omega$ / 0.125 W
R30	1 k $\Omega$ / 0.25 W
R31	360 k $\Omega$ / 0.25 W
X1,X2	TS820-600FP

## Revision history

**Table 3. Document revision history**

Date	Revision	Changes
02-Jul-2012	1	Initial release
26-Feb-2013	2	Adding power efficiency, standby losses, and minimum power to be dimmed.

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