

Introduction

The purpose of this board is to allow the user to evaluate the STEVAL-ILD003V2 SCR dimmer solution for low-consumption lamps, particularly CFL and LED lamps, without flickering phenomenon.

This light dimmer is a development tool that allows the user to test directly most of 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 modification if needed.

STEVAL-ILD003V2 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-control circuit.

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1 Operating conditions

The STEVAL-ILD003V2 operating conditions are:

- Line RMS voltage and frequency: 98 - 132 V, 60 Hz
- Maximum operating ambient temperature 60 °C
- Dimmable power range with halogen, CFL and LED lamps (with 27 °C/W heatsinks mounted on SCRs:
 - 3 to 350 W for 110/120 V rms line

Note: Higher power may be reached with a different filter inductor and bigger SCR heatsink. 200 W is the maximum allowed power without any SCR heatsink.

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 = 0.7 ms
 - Minimum power, turn-on delay = 8.4 ms
- Fuse to protect the SCR in case of lamp flash-over or accidental short-circuit (5 A fuse is required with $I^2t < 24.5 \text{ A}^2\text{s}$)
- LC noise filter: 29 μH - 100 nF
- Power efficiency @ 350 W / 120 V > 98.5%
- Standby losses @ 120 V < 0.3 W (could be reduced to 0 if potentiometer features a mechanical switch to open the circuit at minimum setting)

1.2 Safety instruction

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.

Intended use

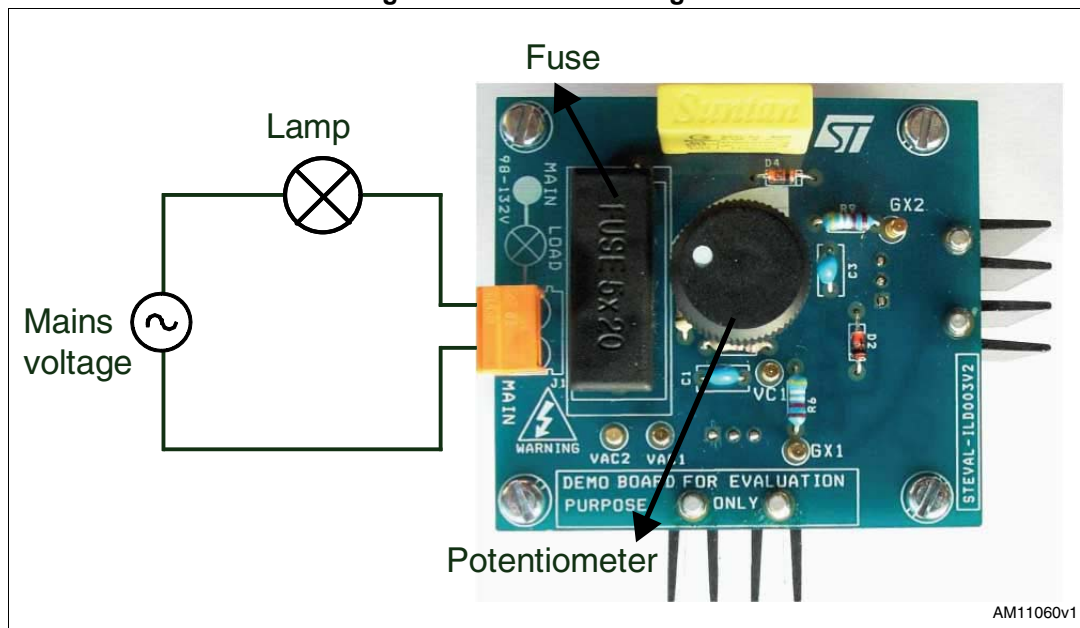
The SCR dimmer demonstration board is designed for demonstration purposes only, and should not be used for domestic installation or industrial installation.

2 Getting started

2.1 Connection diagram

Figure 1 shows how to connect the STEVAL-ILD003V2 to the lamp to be dimmed. Please remove line voltage before setting the different connections.

Figure 1. Connection diagram

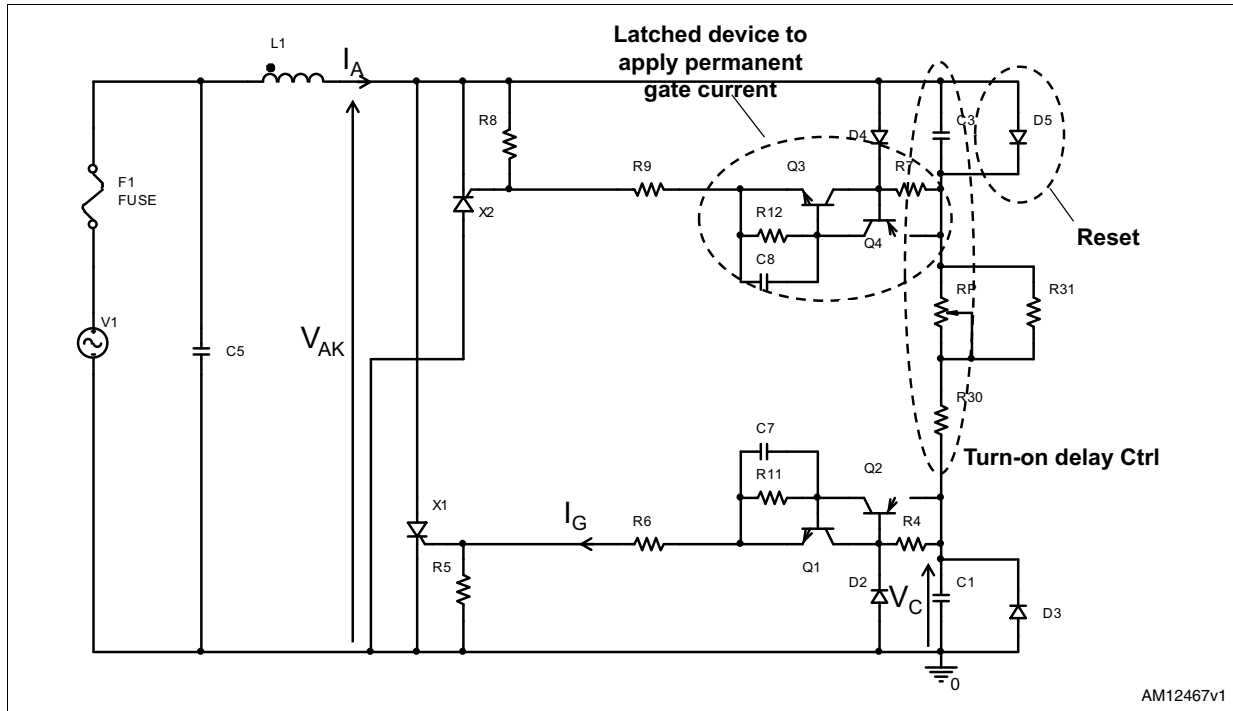


2.2 Schematic and board layout

Figure 2 shows the STEVAL-ILD003V2 schematic and highlights the different blocks of the control circuit.

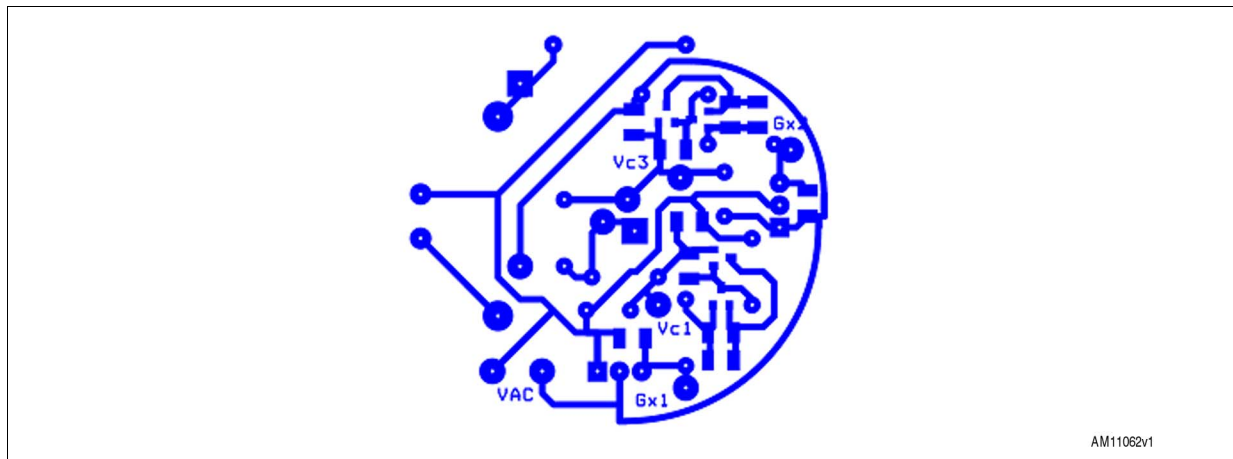
Figure 3 shows the copper tracks layer (bottom view).

Figure 2. SCR dimmer schematic



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Figure 3. SCR dimmer PCB layout



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3 Experimental tests and results

3.1 STEVAL-ILD003V2 SCR dimmer operation with 20 W incandescent lamp

Figure 4, 5, 6 and 7 show the good SCR dimmer operation for a 120 V-20 W incandescent lamp, respectively, for 5 ms and 0.5 ms (refer to t_{ON} in the figures). SCR dimming is OK and no light flickering occurs.

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

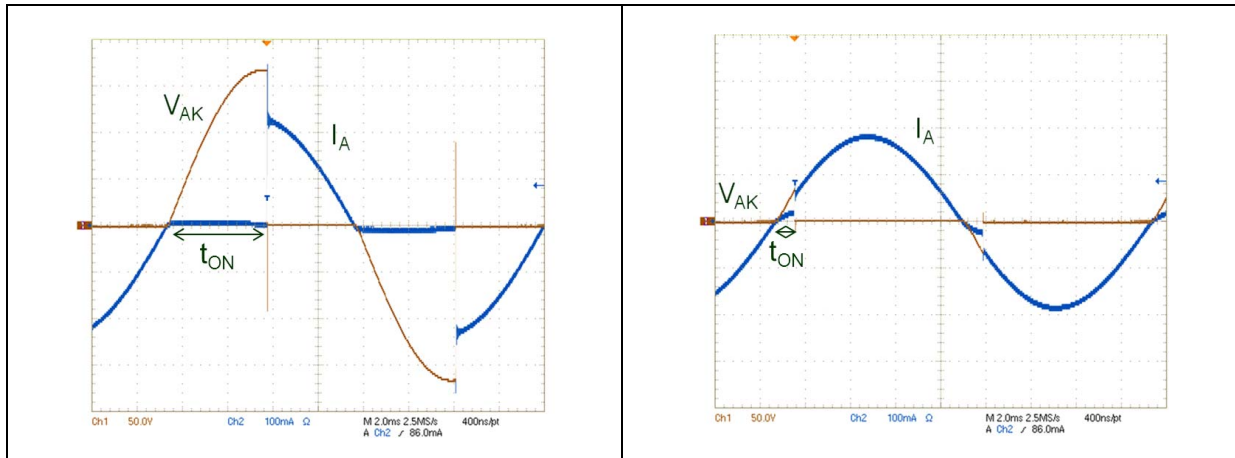
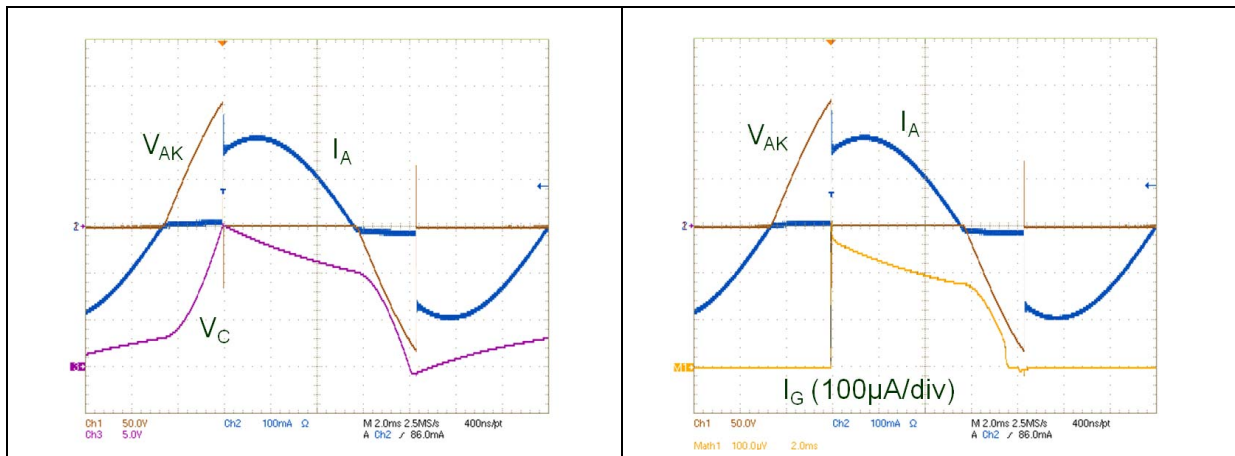


Figure 6. Capacitor discharge voltage after turn-on

Figure 7. SCR continuous gate current



SCR gate current must be higher than 100 μA to keep the SCR ON whatever the Anode current.

3.2 STEVAL-ILD003V2 SCR dimmer working with LED lamp

Figure 8 shows an image of a 120 V - 8 W dimmable LED lamp and a 120 V - 14 W CFL lamp. Figure 9, 10, 11 and 12 show LED and CFL lamp operation at different turn-on delays.

Figure 8. Example of dimmable LED and CFL lamps



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Figure 9. SCR dimmer operation for 5 ms turn-on delay with LED lamp

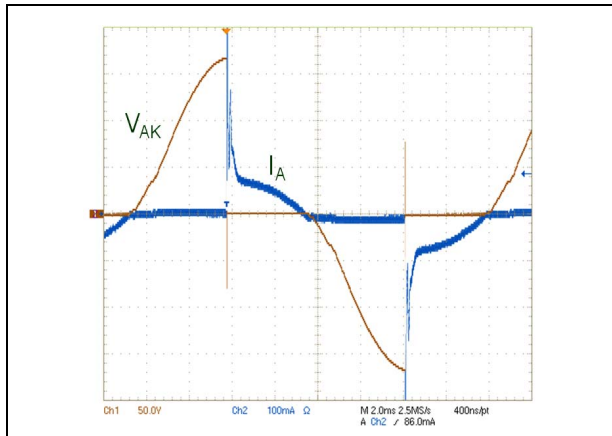


Figure 10. SCR dimmer operation for 7.5 ms turn-on delay with LED lamp

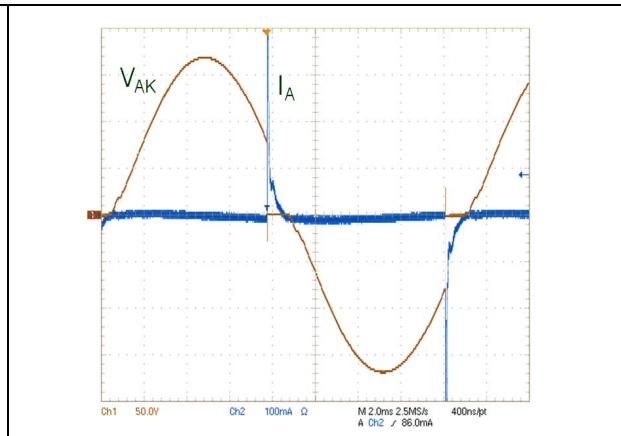
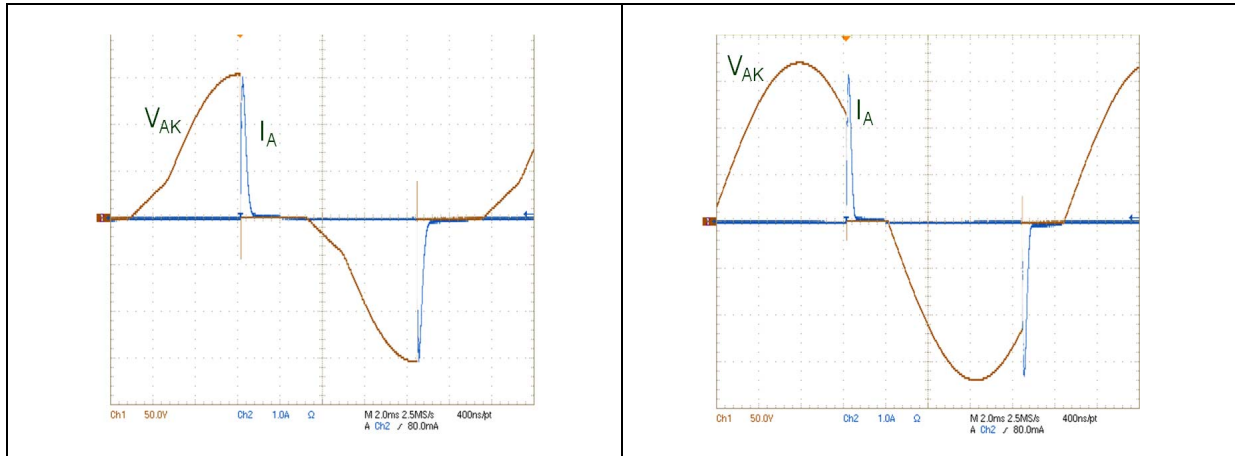


Figure 11. SCR dimmer operation for 5 ms turn-on delay with CFL lamp

Figure 12. SCR dimmer operation for 6.5 ms turn-on delay with CFL lamp



Dimmable CFL and LED lamps function well with the SCR dimmer without flickering.

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 5-20 μs ripple on the turn-on delay (due to the dimmer analog control) may lead to a different brightness order set by the ballast if no feature is embedded to filter the turn-on delay information.

3.3 Electromagnetic compatibility test

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

- 120 V - 60 Hz mains voltage
- L-C filter (29 μH - 100 nF)
- 150 W - 120 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 result gives a minimum withstanding of 5 kV.

Table 1. Immunity against transient voltage

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

4 Conclusion

The STEVAL-ILD003V2 SCR dimmer is able to successfully drive halogen, CFL and LED dimmable lamps from 3 W to 350 W.

Thanks its DC gate current control, the STEVAL-ILD003V2 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.

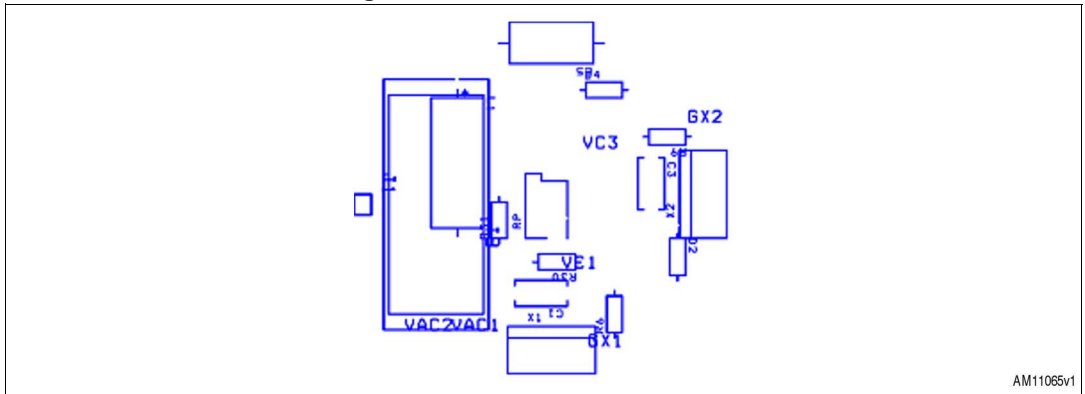
The circuit presented on this board also fulfills the standard requirements for the EMC European directive:

- IEC61000-4-4 fulfillment with a withstanding higher than 5 kV.

Appendix A Assembly information

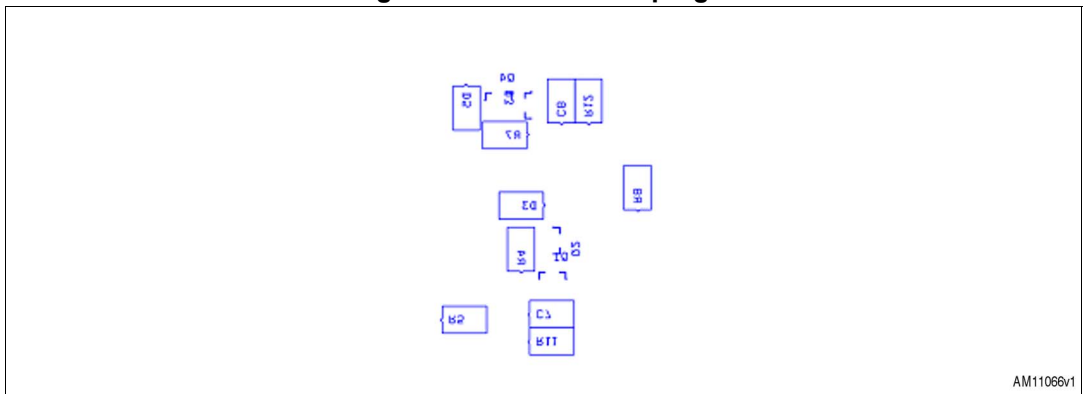
A.1 Component assembly layout

Figure 13. Silkscreen bottom left



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Figure 14. Silkscreen top right



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A.2 Bill of materials

Table 2. BOM

Reference	Part
C1, C3	1 μ F / 25 V
C5	100 nF X2 / 400 V
C7, C8	10 nF / 25 V
D2, D4	BZX84C15
D3, D5	1N4148
F1	FUSE / 5 A
Vc1, Vac1, Gx1, Vac2, Gx2, Vc3	TP
J1	CON2

Table 2. BOM (continued)

Reference	Part
L1	29 μ H / 5 A
Q1, Q3	2N2222
Q2, Q4	2N2907
RP	220 k Ω / 1 W
R4, R5, R7, R8	10 k Ω / 0.125 W
R6, R9	50 k Ω / 0.25 W
R11, R12	20 k Ω / 0.125 W
R30	1 k Ω / 0.25 W
R31	82 k Ω / 0.25 W
X1, X2	TS820-600FP

Revision history

Table 3. Document revision history

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

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