

STEVAL-IHT007V1, extension board with AC switches for the STM8S-DISCOVERY kit

1 Introduction

The STEVAL-IHT007V1 demonstration board is designed for the home appliance market, with a focus on the demonstration of ACST[™]/Triac control with the STM8S-DISCOVERY kit. The demonstration board is aimed at applications where ACS and Triacs are used. It may particularly help appliance designs where only 2 AC switches are required, for example, coffee machines, bread makers, low-end fridges, etc.

The STEVAL-IHT007V1 embeds an optical isolation of the power and control parts to allow designers to debug the software with a computer directly connected to the STM8S-DISCOVERY kit. Therefore, this demonstration board can also be used to evaluate opto-transistor circuits in applications where isolation between mains and control parts is required, such as high-end washing machines, dishwashers and dryers where a BLDC motor is used.

Opto-transistor control has been chosen, as against opto-Triac control, to allow better control of the duration of the gate current pulse and to ensure better AC switch triggering (especially for low current loads). The power supply is based on a capacitive power supply. The STEVAL-IHT007V1 uses SMD ACS/Triac to demonstrate a compact design with the possibility to control loads up to 500 W. The T1010H-6G, a 12 A 600 V high temperature Triac, can control loads up to 500 W. The ACS108-6SUF, a 0.8 A 600 V overvoltage protected ACSTM device, can control low power loads up to 100 W.

The demonstration board passed the pre-compliance tests for EMC directives IEC 61000-4-4 (burst up to 8 kV) and IEC 61000-4-5 (surge up to 2 kV). The STEVAL-IHT007V1 has an overall power consumption below 500 mW at 264 V/50 Hz due to the optimized capacitive power supply.

Figure 1. STEVAL-IHT007V1 demonstration board



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2 Demonstration board presentation

2.1 Package content

The STEVAL-IHT007V1 demonstration board package consists of:

- STEVAL-IHT007V1 extension board with AC switches for the STM8S-DISCOVERY kit
- CD-ROM

The CD-ROM content is:

- User manual UM1494 (this document) for the STEVAL-IHT007V1
- User manual UM0817 for the STM8S-DISCOVERY
- Reference manual RM0016 for the STM8S and STM8A microcontroller families
- Datasheets:
 - ACS108-6S - overvoltage protected AC switch (ACS™)
 - P6KE400CA - P6KE Transil™
 - STM8S105C6 - Access line, 16 MHz STM8S 8-bit MCU, up to 32 Kbytes Flash, integrated EEPROM, 10-bit ADC, timers, UART, SPI, I²C
 - T1010H - High temperature 10 A sensitive TRIACs
- Application notes:
 - AN302 - Thyristors and TRIACs: holding current - an important parameter
 - AN303 - Thyristors and TRIACs: latching current
 - AN533 - SCRs, TRIACs, and AC switches, thermal management precautions for handling and mounting
 - AN1476 - Low-cost power supply for home appliances
 - AN1966 - TRIAC overvoltage protection using a Transil™
- Marketing presentations:
 - ACS 600 V positioning in applications
 - ACS 600 V flyer
 - High temperature TRIACs flyer
 - High temperature TRIACs description
- Software C-code in self install .exe file
- Gerber files.

2.2 Kit purpose

This kit is a development tool that allows users to develop applications where an AC switch control must be implemented. Two AC switch controls can be directly evaluated with this board, covering a large number of different applications. For applications with a higher number of switches, the AC switch control can be easily duplicated for each load control.

Electrically isolated configuration is used to allow the user to develop the software with the STM8S -DISCOVERY kit connected to the computer.

SMD technology is used for promotion of the space effective control of the AC loads with ACS/Triacs.

The Kit purpose is the promotion of various kinds of applications where the AC switch is controlled in ON/OFF full-phase mode. The switch control is based on the information push button evaluated by the MCU.

As mentioned, the board software can easily be modified to final application requirements. Here below is a list of possible applications that can be addressed:

- Fridge
- Breadmaker
- Soy milk maker
- Coffee machine

Additionally, the list of loads that can be controlled with this board is as follows:

- Valves
- Pumps
- Door locks
- Heating resistors up to 500 W

The added advantages of this board are:

- Spark free operation
- No EMI or acoustic noise

2.3 Operation principle

The board operation principle is based on MCU software. Implemented software features are:

- 50/60 Hz detection implemented
- Full wave operation (zero voltage turn-on of the switch) according to push button action.

2.4 Operating conditions

The board operates in nominal line voltage 230 V in both 50/60 Hz power nets.

- Line RMS voltage range: 197 to 264 V, 50 or 60 Hz
- Operating ambient temperature 10 to 60 °C
- Load power ranges (for 230 V RMS voltage)
 - OUT 1 controlled by ACS108-6SUF: 0 to 100 W
 - OUT 2 controlled by T1010H-6G: 100 to 500 W

2.5 Board features

The STEVAL-IHT007V1 demonstration board features:

- Two different AC switches
- Optical isolation of the power part and control part
- Two push buttons for ON/OFF control of the AC switches
- Capacitive power supply (470 nF capacitor EPCOS B32923C3474)
 - 5 V \pm 10%
 - Average output current: 16 mA at 230 V
 - Standby power losses < 0.3 W at 230 V
- Overvoltage protection devices:
 - Varistor between mains voltage inputs (P/N example: B72205S271K101)
 - Transil between Triac A2-G terminals of the T1010H-6G (P/N: P6KE400CA)(Refer to AN1966)
 - Overvoltage protected AC switch ACS108

2.6 Safety instructions

Warning: The high voltage levels used to operate the STEVAL-IHT007V1 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 smart STEVAL-IHT007V1 demonstration board is a component designed for demonstration purposes only, and must not be used for domestic installation or for industrial installation. The technical data, as well as the information concerning the power supply and working conditions, is to be taken from the documentation included in the kit and strictly observed.

Installation

The installation of the STEVAL-IHT007V1 demonstration board must be taken from the present user manual and strictly observed. The components must be protected against excessive strain. In particular, no components are to be bent, or isolating distances altered during transportation, handling or use. No contact must be made with electronic components and contacts. The STEVAL-IHT007V1 demonstration board contains electrostatically sensitive components that are prone to damage through improper use. Electrical components must not be mechanically damaged or destroyed (to avoid potential risks and injury).

Electrical connection

Applicable national accident prevention rules must be followed when working on the mains power supply. The electrical installation must be completed in accordance with the appropriate requirements (e.g. cross-sectional areas of conductors, fusing, PE connections).

Board operation

A system architecture which supplies power to the demonstration board must be equipped with additional control and protective devices in accordance with the applicable safety requirements (e.g. compliance with technical equipment and accident prevention rules).

Note: Do not touch the board after disconnection from the mains power supply, as several parts and power terminals which contain possibly energized capacitors need to be allowed to discharge completely.

3 Getting started

3.1 Connection diagram

The STEVAL-IHT007V1 demonstration board does not contain the MCU and for proper functionality it must be plugged into the STM8S-DISCOVERY kit.

The STM8S-DISCOVERY kit must be supplied by an external power supply. The USB connector plugged into the PC is able to supply the STM8S-DISCOVERY kit. The second possibility is to use a SWIM connector to supply the STM8S-DISCOVERY kit.

Figure 2 and Figure 3 show how to connect the STEVAL-IHT007V1 to the STM8S-DISCOVERY kit. The proper fitting of each connector JP1, CN1, CN2 and CN3, are shown for the STEVAL-IHT007V1 and STM8S-DISCOVERY kit.

Figure 2. STEVAL-IHT007V1 control headers

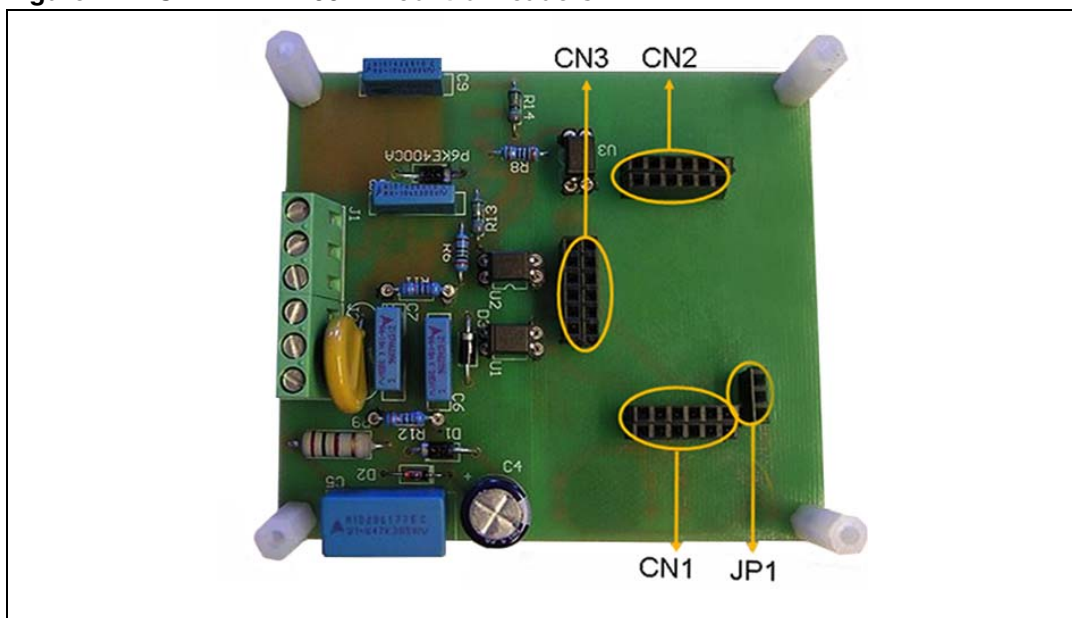


Figure 3. STM8S-DISCOVERY kit connection diagram

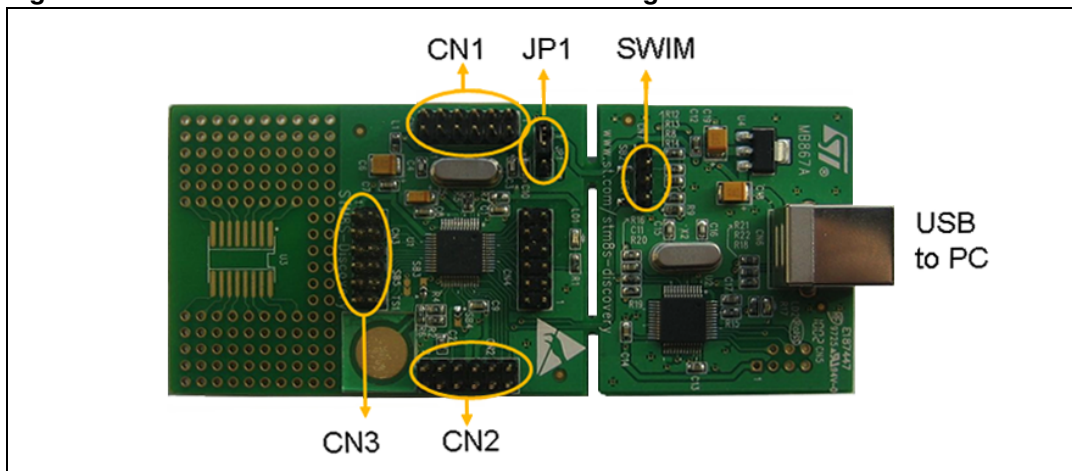
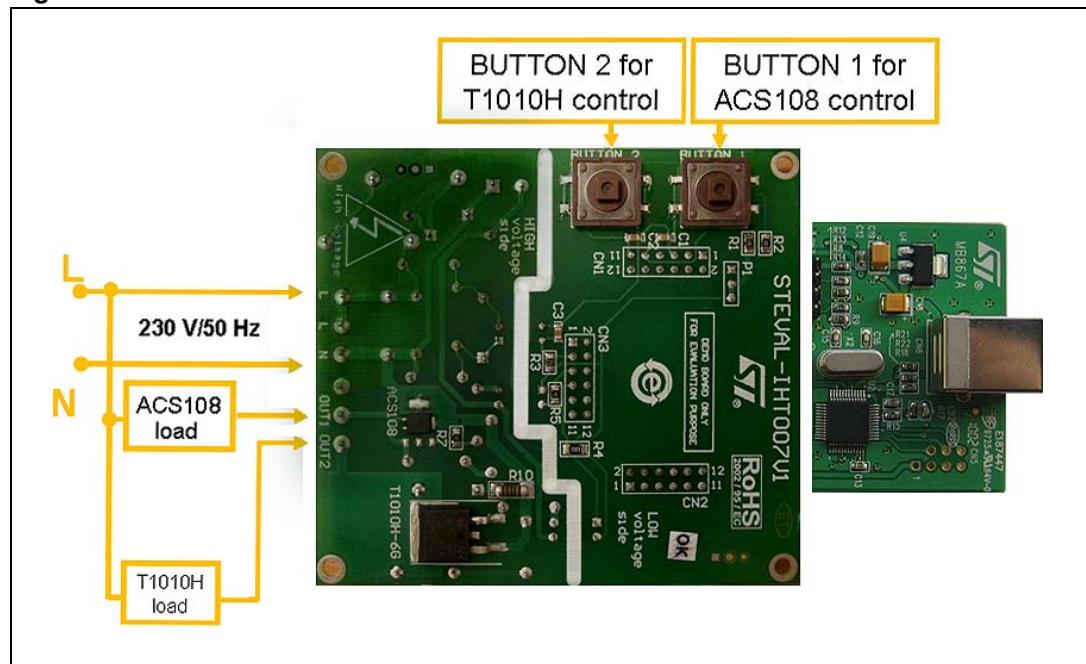


Figure 4 shows the final connection of the STEVAL-IHT007V1 and STM8S-DISCOVERY kit with a connection diagram of the mains and loads.

Figure 4. Connection of the mains and loads



3.2 Running the board

This section describes how to properly run the board from an application point of view. Proper connection is described in [Figure 4](#).

The ACS108 is controlled by BUTTON 1 and the T1010H is controlled by BUTTON 2, as shown in [Figure 4](#).

After reset, both switches are put into the OFF state. When any button is pushed once, the corresponding ACS/Triac turns ON after the start of the next mains period. Holding the button pressed has no influence on the behavior. When any button is pressed for the second time the corresponding ACS/Triac turns OFF at the end of the current period. Turn-off delay is not implemented. Holding the button pressed has no influence on the behavior.

3.3 Functional description

The ACS/Triac is controlled in full wave control mode as shown in *Figure 5*. Zero voltage crossing interrupt is recognized in advance of the real zero voltage crossing. The recognition level for interrupt detection is ~2.5 V for the STM8S MCU. The delay is implemented to turn on ACS/Triac when mains voltage really cross zero. The delay setting and gate current pulse duration are defined in the file define.h. Initial setting of the delay is 800 μs for 50 Hz (ZVC_Delay_50HZ) and 600 μs for 60 Hz (ZVC_Delay_60HZ). Initial setting of the gate current pulse lengths with names are given in *Table 1*.

Figure 5. Functional description of ACS/Triac control strategy

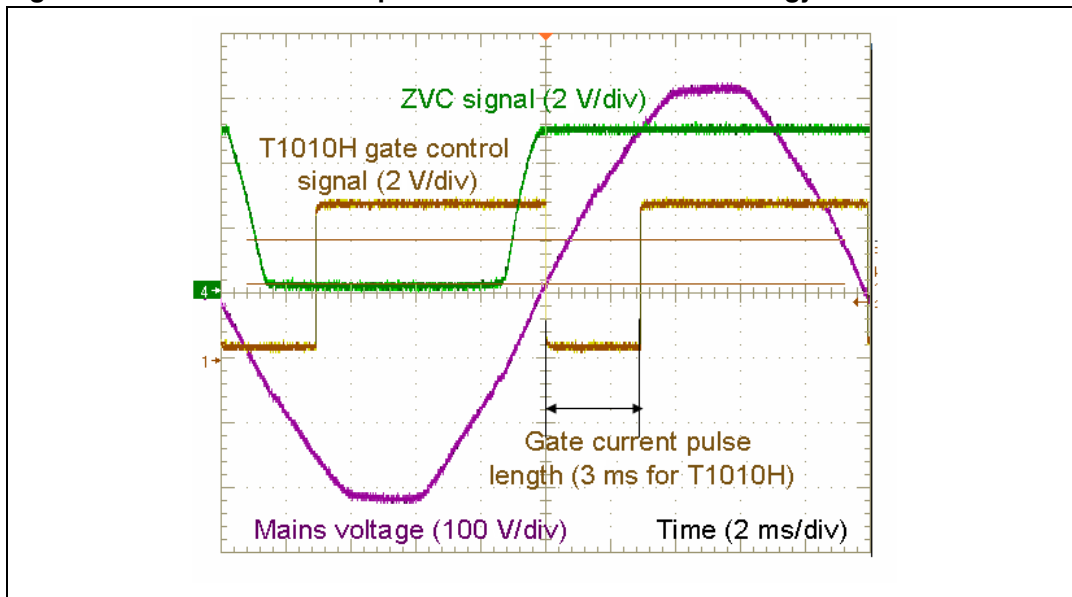


Table 1. Gate current pulse duration (default program, version v1.0)

Initial gate pulse duration	ACS108 (ACS108_Pulse_Length_(1))	T1010H (T1010H_Pulse_Length_(1))
50 Hz	10 ms	3.0 ms
60 Hz	8.3 ms	2.4 ms

1. 50 or 60 Hz.

4 Triac control

4.1 Maximum allowed load current

Maximum allowed current depends on the ability of the device to dissipate the energy into ambient to keep the junction of the device at 125 °C (150 °C for high temperature Triac). Refer also to AN533.

Dissipated power for full wave operation is given by:

Equation 1 Dissipated power estimation

$$P_d = V_{to} \cdot |I_{RMS}| + R_d(I_{RMS})^2$$

where V_{to} (V) and R_d (Ω) values are given by the AC switch datasheets.

Maximum junction temperature of the device is then:

Equation 2 Maximum junction temperature estimation

$$T_j = T_{amb} + P_d \cdot R_{th(j-a)}$$

where T_{amb} (°C) is ambient temperature, and $R_{th(j-a)}$ (°C/W) is junction to ambient thermal resistance. Thermal resistance consists of one part in the case of SMD package and is defined in the datasheet depending on the PCB heatsink area.

[Table 2](#) gives the maximum RMS current each ACS/Triac can control, at maximum ambient temperature 60 °C, to keep junction temperature below max. allowed value.

Dissipated power during the ON state (P_D) is given for indication.

Table 2. Maximum load RMS current for $T_{amb} = 60$ °C

AC switch	Package	PCB heatsink (cm ²)	$R_{th(j-a)}$ (°C/W)	RMS current (A)	P_D (W)
ACS108	SMBFlat	1	115	0.56	0.55
T1010H-6G	D2PAK	3	40	2.6	2.15

Higher load current can be controlled using forced cooling. The AN533 is dedicated for a full description of thermal management.

4.2 Gate current width and minimum load current

Gate current pulse is generated by the MCU. The length of the pulse is set by software and can be changed separately for each load. Gate current pulse length is an important value to be set according to minimum load current. Load current must reach latching current level to keep Triac ON before the gate pulse is removed. Latching current (I_L) is specified in the AC switch datasheet. It is important to check for low power loads when RMS current is low as it takes a longer time for the load current to reach latching current level. When gate current is

removed before the load current reaches the latching current level, the device may turn off. Refer to AN302 for further information on latching current.

Gate current is given by hardware settings. Gate current can be changed by changing the value of the gate resistor. R6 is the gate resistor for control of the ACS108 and R8 is the gate resistor for control of the T1010H.

Maximum value and length of the gate current the board can provide depends on capacitive power supply rating. The typical average current that the board can provide is 15 mA in the operation conditions at 230 V RMS and 470 nF capacitor.

5 Software

The STEVAL-IHT007V1 is provided with the software that must be programmed into the STM8S-DISCOVERY kit. The STM8S-DISCOVERY kit is provided with a built-in ST-LINK programmer, no additional programming device is necessary.

Software is available for download at www.st.com/evalboards.

Software is developed in the STVD programming environment with compiler COSMIC. The source files are provided and for use with a different GUI they must be adapted.

5.1 Source files

The program is located in three source files.

The define.h file is where variables for user customization are located. The user can change the ZVC delay setting and gate current pulse duration for each ACS/Triac independently. Initial settings of the variables in the file define.h is given in [Table 3](#).

Table 3. Initial settings of the control variables

Variable name	Initial value (value/time) ⁽¹⁾
ACS108_Pulse_Length_50 HZ	100/10 ms
ACS108_Pulse_Length_60 HZ	83/8.3 ms
T1010H_Pulse_Length_50 HZ	30/3 ms
T1010H_Pulse_Length_60 HZ	24/2.4 ms
ZVC_Delay_50 HZ	8/0.8 ms
ZVC_Delay_60 HZ	6/0.6 ms
Half_Period_Length_50 HZ	100/10 ms
Half_Period_Length_60 HZ	83/8.3 ms

1. Timer interrupt is launched every 100 μ s.

The STM8_interrupt_vector.c file is where the interrupt table and interrupts are located.

The Main.c file is where the basic functions to set up the MCU after reset are defined and also where the routines for frequency detection and each ACS/Triac status setting are defined and handled.

5.2 Main routines description

The program has separate routines to control AC switches. These routines should not be changed by the user unless a change in program functionality is required.

5.2.1 ZVC interrupt

The MCU uses a zero voltage crossing (ZVC) event to synchronize all the routines.

ZVC interrupt handles switch gate pulse at the beginning of each mains period, turns on Timer2 to handle gate current pulse duration within mains period, and refreshes variables used for ACS/Triac control and mains frequency detection.

5.2.2 Timer2 interrupt

Timer2 interrupt is launched every 100 μ s to control gate current pulse duration within the mains period. Turn-on in the first half wave is controlled by ZVC interrupt and in the second half wave it is controlled by Timer2 interrupt when the ACS108 and/or T1010H status is ON.

Gate current pulse duration is controlled by Timer2 interrupt.

5.2.3 ACS108 status and T1010H status

The status of the ACS108 and the T1010H are set in these routines, if they are ON or OFF. The decision is based on the number of pushes of the corresponding button. An odd number of pushes means that the status of the ACS108 and/or the T1010H is ON. An even number of pushes means that the status of the ACS108 and/or the T1010H is OFF.

5.2.4 Frequency setting

Frequency setting is launched once after the reset and it chooses between a 50 and 60 Hz setting according to the measured value of line frequency. Continuous frequency measurement during program running is not implemented.

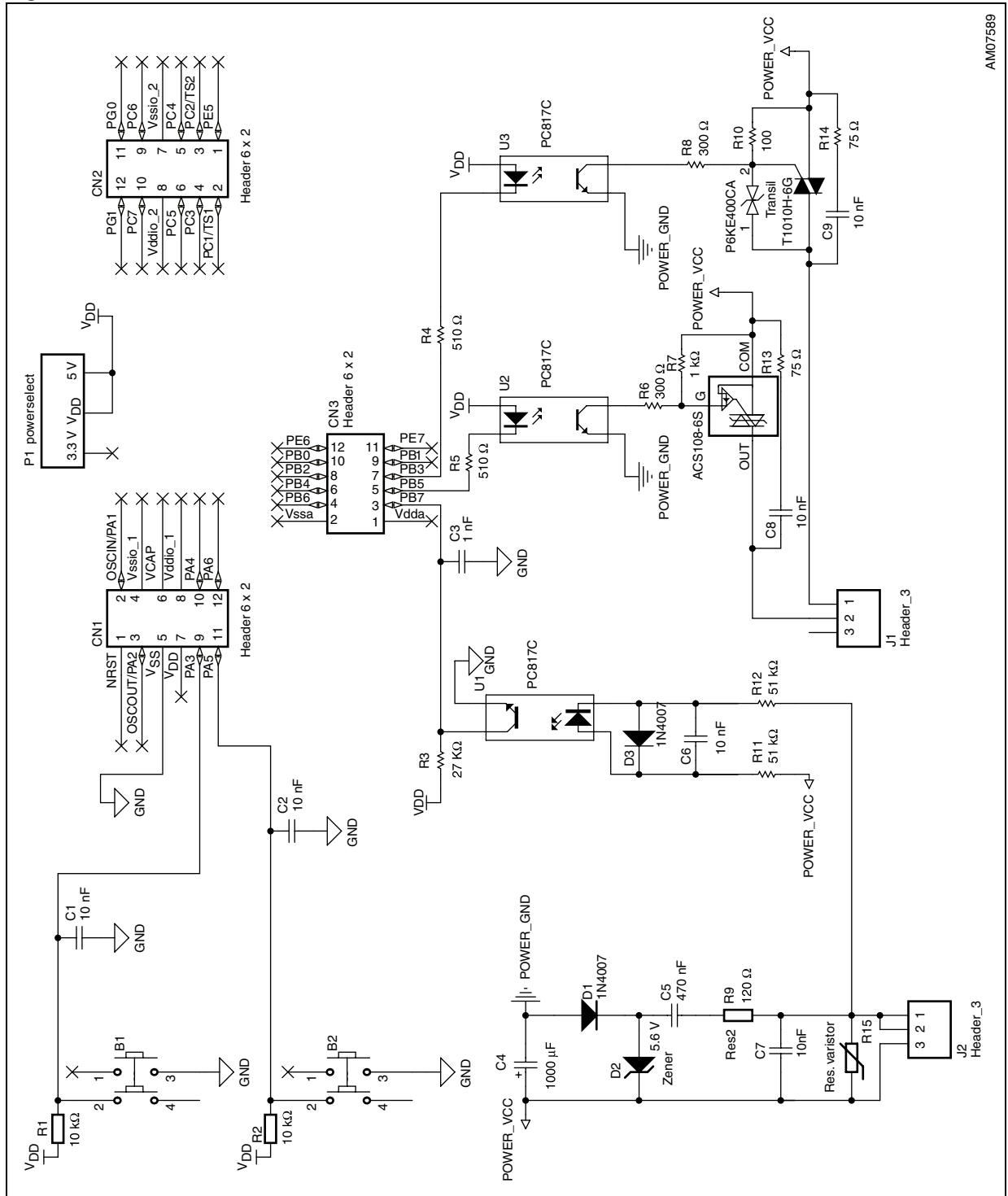
5.2.5 Main routine

In the main routine the status of the ACS/Triac is checked and the software watchdog is cleared.

Appendix A STEVAL-IHT007V1 demonstration board

A.1 Schematic

Figure 6. Board schematic



AM07589

A.2 Demonstration board PCB layout

Figure 7. PCB layout - top side

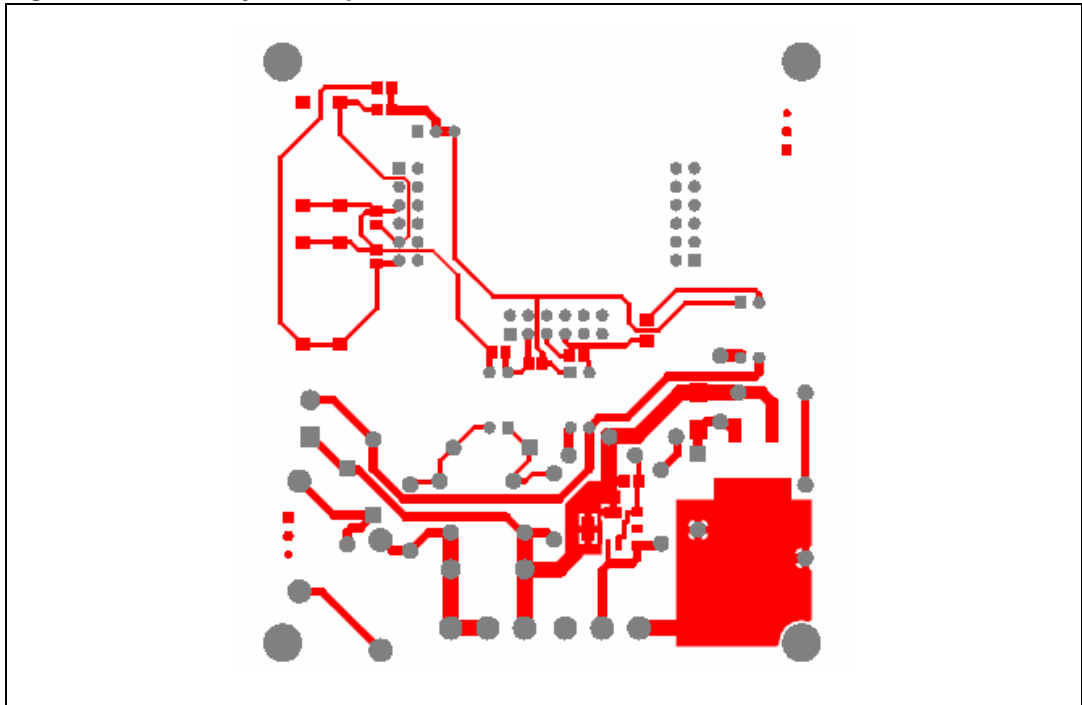


Figure 8. PCB silkscreen - top side

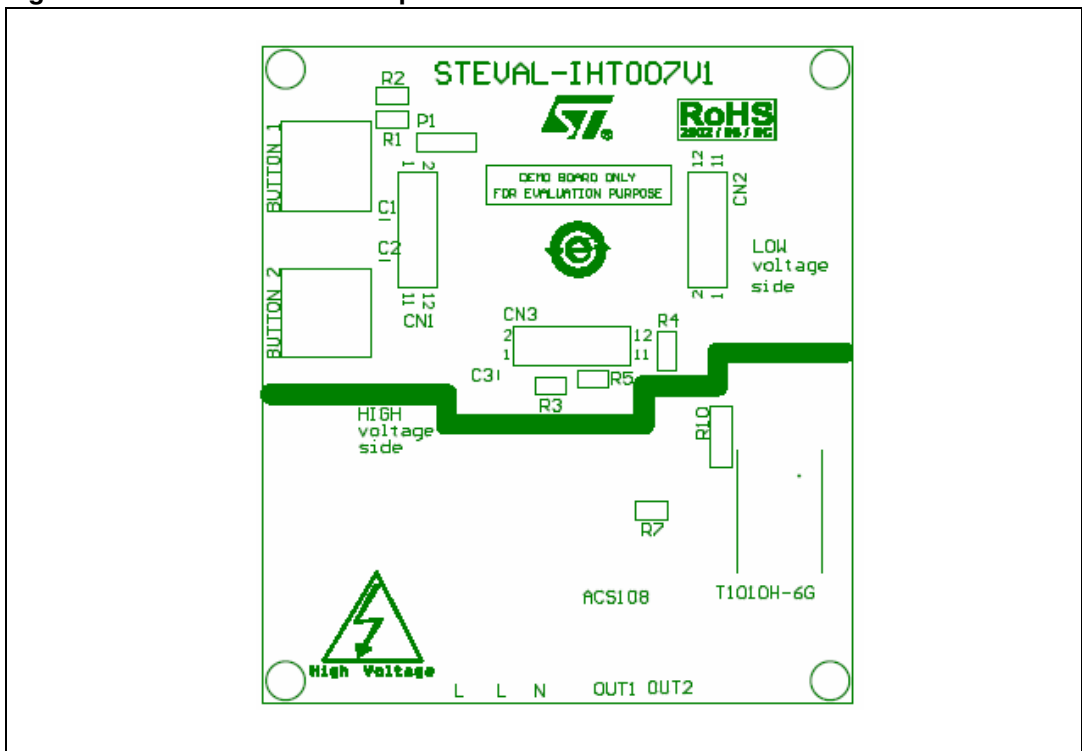
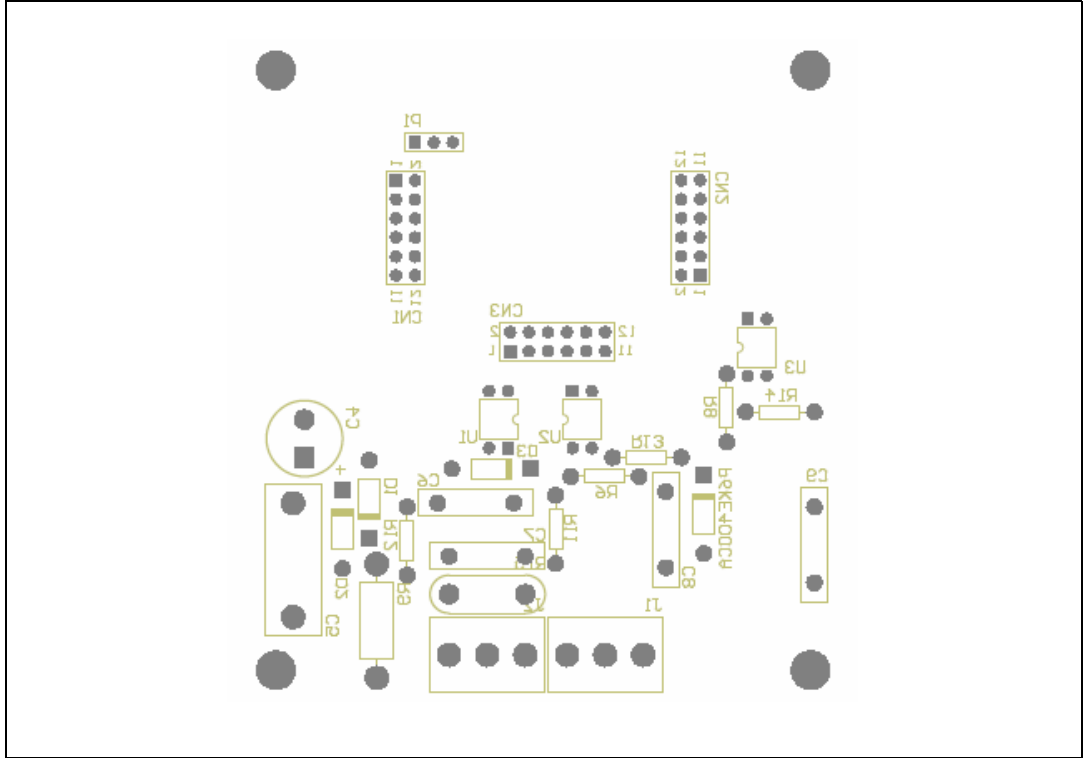


Figure 9. PCB silkscreen - bottom side



A.3 Gate current consumption

Gate current consumption is based on [Equation 3](#). Values used for the calculation are shown in the datasheet for the AC switch or Triac.

Equation 3 Gate resistor calculation

$$R_g \leq \frac{1}{1 + \frac{R_{g_tolerance}}{100}} \left(\frac{V_{CC_Min} - V_{GT_Max} - V_{CE(Sat)}}{I_G(10^\circ C)} \right)$$

where $R_{g_tolerance}$ is the tolerance of the used resistor (typically 1% or 5%), V_{CC_Min} is the minimum supply voltage (typically 5 V for capacitive power supply with 5.6 V Zener diode), V_{GT_Max} is maximum gate voltage that appears between the gate and A1 or the COM pin (typically 0.8 V), I_G gate current for the minimum ambient temperature (normally 0 or 10 °C for household applications) is given in the datasheet, $V_{CE(Sat)}$ is saturation voltage of the opto-coupler [maximum value is given by the PC817 datasheet (0.2 V)]. Standard resistor choice is shown in [Table 4](#).

Please note that the STEVAL-IHT007V1 demonstration board uses gate resistors with 1% dispersion.

Table 4. Gate resistor estimation

AC switch	Tolerance of R _g (%)	R _g (Ω)	R _g standard (Ω)
T1010H	1	304	300
	5	293	270
ACS108	1	304	300
	5	293	270

A.4 EC 61000-4-4

The IEC 61000-4-4 standard is designed for testing the fast transient robustness of an application. The main affected device in the application is the MCU. The MCU is isolated from mains. The main source of functionality changes is spurious triggering of the ACS/Triac. Three possible states are defined:

- class A: no functionality change
- class B: functionality change, self repair
- class C: functionality change, user intervention required (turn ON/OFF)

Table 5. Pre-compliance IEC 61000-4-4 results

STEVAL-IHT007V1 V _{IN} 250 VAC - 50 Hz	2 kV	4 kV	6 kV	8 kV
+ L	A	B	B	B
+ N	A	B	B	B
+ L and N	A	B	B	B
- L	A	B	B	B
- N	A	B	B	B
- L and N	A	B	B	B

The board withstands 2 kV in class A for all tested configurations.

A.5 Bill of material

Table 6. Bill of material

Designator	Value	Description	Vendor
ACS108-6SUF		0.8 A overvoltage protected AC switch	STMicroelectronics™
D2	5.6 V	Zener diode	
P1		Header, 3-pin	
P6KE400CA		600 W 400 V Transil™	STMicroelectronics
R15		Varistor 275 V R = 14 mm	EPCOS/B72214S0271
T1010H-6G		10 A 600 V, high temperature Triac	STMicroelectronics
D1, D3	1N4007	1 A, 1000 V diode	
J1, J2		ARK128V-A-3P	
CN1, CN2, CN3		Header, 6-pin, dual row	
U1, U2, U3	PC817	4-pin phototransistor opto-coupler	
R1, R2	10 kΩ	1% resistor, 0805 SMD	
R3	27 kΩ	1% resistor, 0805 SMD	
R4	510 Ω	1% resistor, 1206 SMD	
R5	510 Ω	1% resistor, 0805 SMD	
R7	1 kΩ	1% resistor, 0805 SMD	
R6, R8	300 Ω	1%resistor, 0.6 W, through hole	
R9	120 Ω	5% resistor, 2 W, wire, flameproof	
R10	100 Ω	1% resistor, 0207 SMD, high peak power	Farnell/3086720
R11, R12	51 kΩ	1% resistor, 0.6 W, through hole	
R13, R14	75 Ω	1% resistor, 0.6 W, through hole	
C1, C2	10 nF	10% capacitor, 50 V, 0805 SMD	
C3	1 nF	10% capacitor, 50 V, 0805 SMD	
C4	1 mF	20% polarized capacitor, 16 V, through hole	
C5	470 nF	Capacitor 470 nF/X2	EPCOS/B32922C3474
C6, C7, C8, C9	10 nF	Capacitor 10 nF/X2	EPCOS/B32921C3103
B1, B2	SMD button	SMD button DTSM24N	

Revision history

Table 7. Document revision history

Date	Revision	Changes
13-Mar-2012	1	Initial release.

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