UM0922
User manual

STEVAL-IHM029V1:
2000 W universal motor control based on the STM8S103F2

Introduction

The STEVAL-IHM029V1 is a low-cost universal motor control demonstration board designed for the home appliance market, with particular focus on vacuum cleaners, food processors and power tools.

This system features the 20-pin, 8-bit STM8S103F2 microcontroller running at 16 MHz (RC user-trimmable internal RC clock), featuring 4 KB of Flash memory, a 10-bit A/D converter, 8/16 bit timers, communication interfaces and 640 bytes E^2PROM.

The power supply circuitry is based on the VIPer16LN, an off-line converter with an 800 V avalanche-rugged power section, operating at 60 kHz.

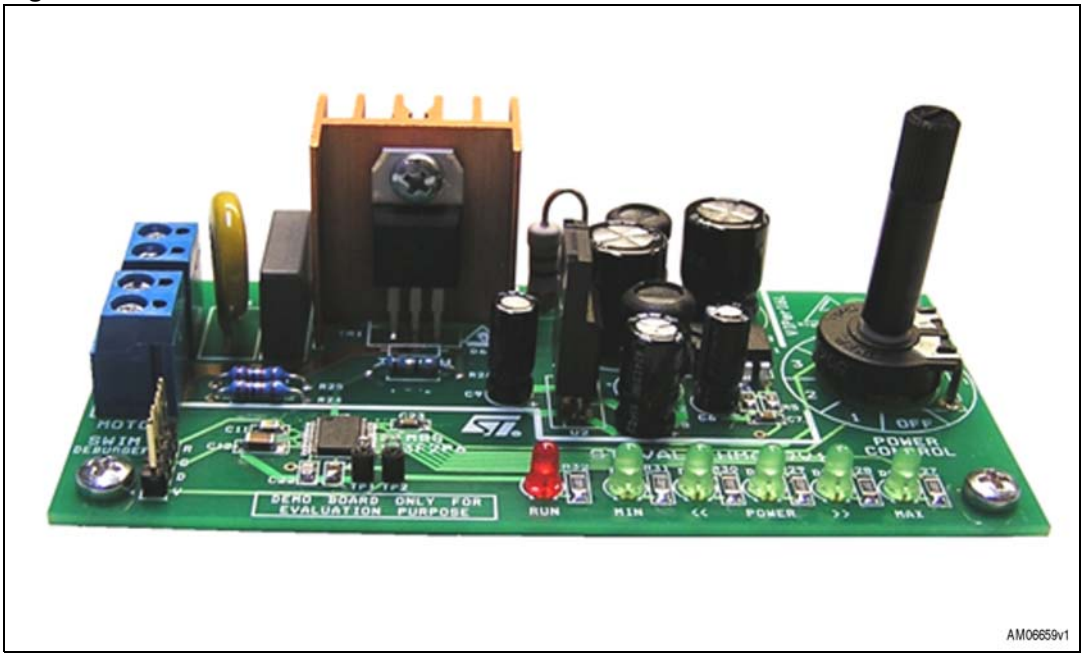
The STEVAL-IHM029V1 can control any universal motor up to 2000 W, thanks to the T1235H, a 12 A 600 V high temperature Triac. The motor control is based on phase-angle.

In order to limit the in-rush current and possible current peaks, the demonstration board features a soft-start routine and a smooth power change function.

The board has 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).

In standby mode, the STEVAL-IHM029V1 has an overall standby power consumption below 300 mW.

Figure 1. STEVAL-IHM029V1



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1 Safety instructions

Warning: The high voltage levels used to operate the STEVAL-IHM029V1 could present a serious electrical shock hazard. This demonstration board must be used in a suitable laboratory environment only, by qualified personnel who are familiar with the installation, use, and maintenance of power electrical systems.

Intended use

The STEVAL-IHM029V1 is designed for demonstration purposes only, and must not be used in domestic or industrial installations. The technical data, as well as the information concerning the power supply and working conditions, must be taken from the documentation included in the kit and strictly observed.

Installation

The installation of the STEVAL-IHM029V1 is described in this document.

The components must be protected against excessive strain. In particular, no components should be bent, or isolating distances altered during the transportation, handling or use.

No contact must be made with electronic components and contacts.

The STEVAL-IHM029V1 contains electrostatically sensitive components, which may be damaged if used improperly. To avoid risk of injury, ensure that electrical components are not mechanically damaged.

Electrical connection

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

Warning: Do not touch the board after disconnection from the mains, as several parts and power terminals could contain an electrical charge due to energized capacitors, which must be allowed to discharge completely.

2 Main features

The main features of the STEVAL-IHM029V1 demonstration board are listed below.

- Input voltage range: 90-265 VAC, 50/60 Hz
- 12 VDC / 5 VDC auxiliary power supply based on the VIPer16LN in buck converter topology
- Total power consumption below 300 mW in standby mode
- Maximum output power: 2000 W
- 20-pin, 8-bit STM8S103F2 MCU as main controller
- Employs zero-voltage switching (ZVS) to synchronize MCU events with the voltage mains
- Motor driven by T1235H high-temperature Triac in phase-angle control
- 5 power levels and standby mode selectable by potentiometer
- 5 LEDs to display the power level of the board
- “RUN” LED to indicate the board is functioning
- Standard in-circuit programming connector
- IEC 61000-4-4 pre-compliance test passed (burst up to 8 kV)
- IEC 61000-4-5 pre-compliance test passed (surge up to 2 kV)
- RoHS compliant

3 Target applications

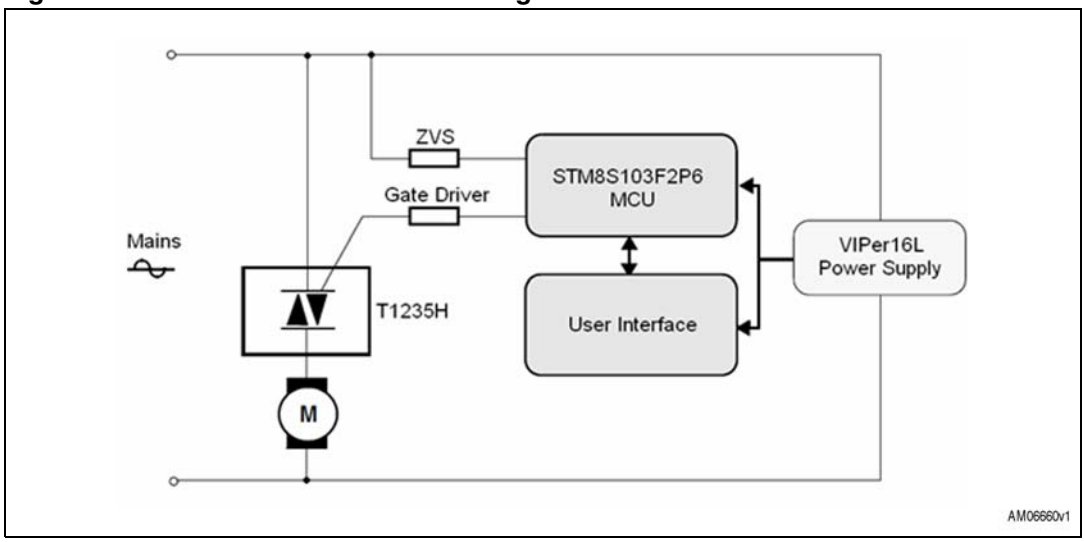
As a universal motor control demonstration, the STEVAL-IHM029V1 is mainly target at the home appliance market for applications including:

- vacuum cleaners
- food processors
- power tools

4 Block diagram

The universal motor control system can be divided into a few simple blocks.

Figure 2. STEVAL-IHM029V1 block diagram



Power supply

The power supply is designed using a buck converter topology and is based on the VIPer16LN, which works at a fixed frequency of 60 kHz. The wide range input voltage (90-265 VAC, 50/60 Hz), allows the demonstration board to operate at either 110 VAC/60 Hz, or 220 VAC/50 Hz. The converter output voltage is -12 VDC. This voltage is sent to a L7905CP linear regulator, which in turn provides a reference voltage of -5 VDC. The negative power supply is highly recommended when driving a Triac directly with a microcontroller.

ZVS

The zero-voltage switching signal is captured directly from the input mains. The MCU detects the ZVS after each period of the input mains, and synchronizes the routines and events accordingly (i.e. the driving of the Triac).

User interface

The user interface consists of a potentiometer to adjust the output power level, and 6 LEDs to indicate the status and the power level of the board.

Motor driving

The universal motor is driven by a high temperature Triac in phase-angle control.

STM8S103F2

The entire process is controlled by a 20-pin, 8-bit STM8S103F2 microcontroller.

5 Schematic diagram and bill of material

Figure 3. STEVAL-IHM029V1 circuit schematic

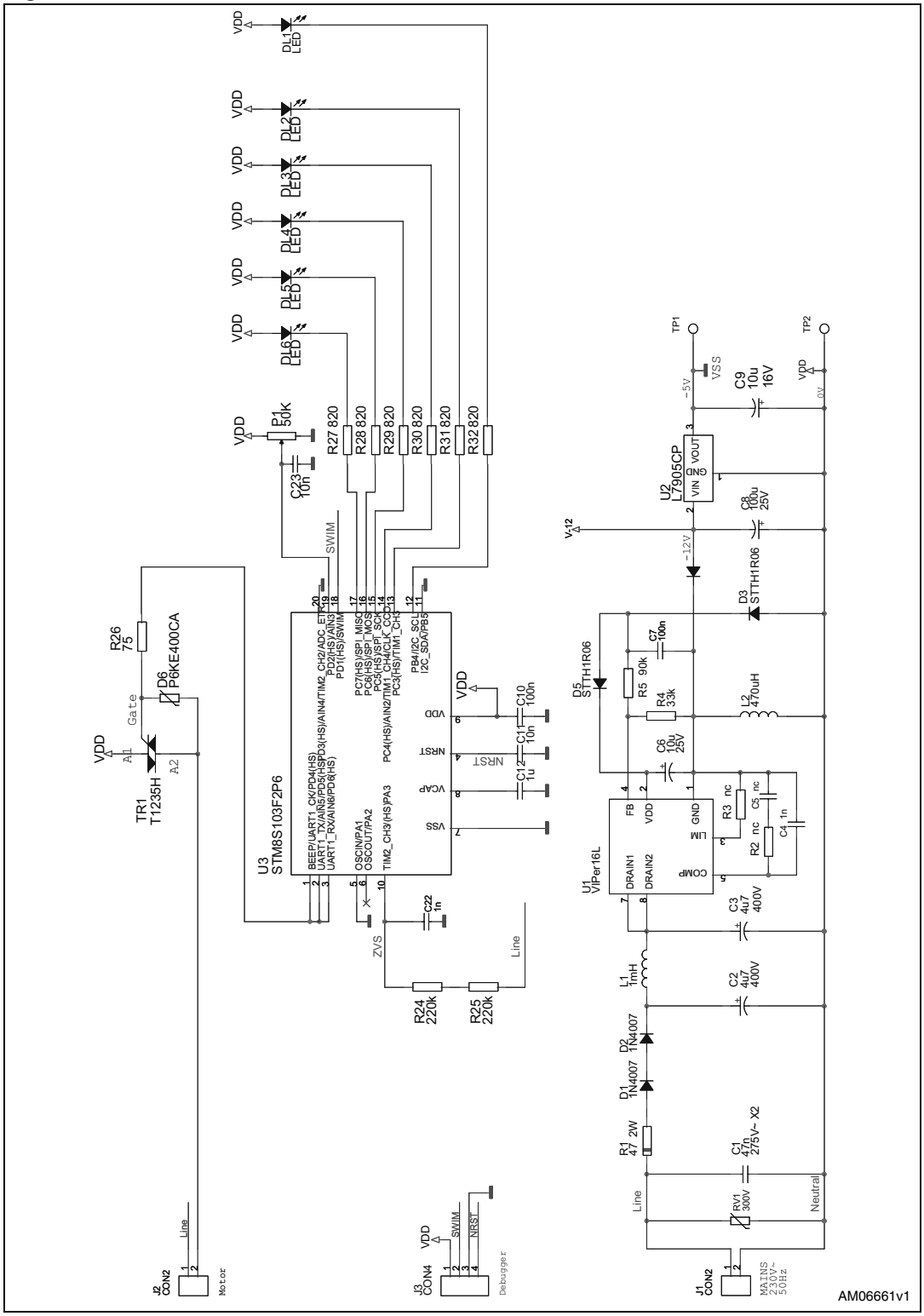


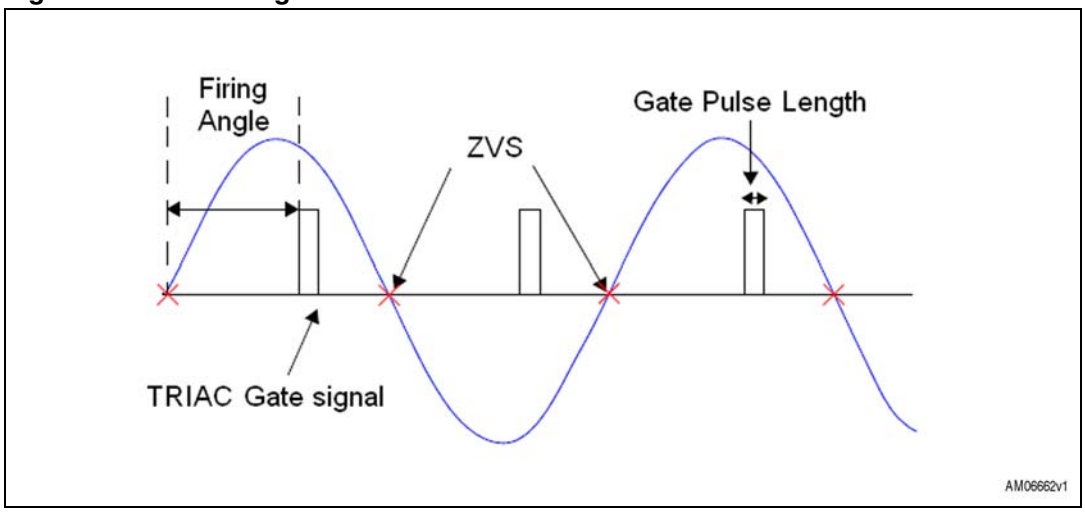
Table 1. BOM

Reference	Part	Supplier
C1	47 nF, 275 V, X2	EPCOS
C2, C3	4.7 µF, 400 V	EPCOS
C6, C9	10 µF, 25 V	
C4, C22	1 nF, 0805 SMD	
R2, R3, C4	Not mounted	
C7, C10	100 nF, 0805 SMD	
C8	100 µF, 25 V	
C11, C23	10 nF, 0805 SMD	
C12	1 µF, 1208 SMD non-pol	
DL1	10 mA, 3 mm, radial-green	
DL2, DL3, DL4, DL5, DL6	10 mA, 3 mm, radial-red	
D1, D2	1N4007	
D3, D4, D5	STTH1R06	STMicroelectronics
D6	P6KE400CA Transil™	STMicroelectronics
J1, J2	CON 2-pin 5 mm	
J3	Strip line 4-pin 2.54 mm	
L1	1 mH radial	Coilcraft
L2	470 µH radial	Coilcraft
P1	50 kΩ trimmer	
RV1	300 V 595+ varistor	
R1	47 Ω 2 W flame proof	
R4	33 kΩ 0805 SMD	
R5	90 kΩ 0805 SMD	
R24, R25	220 kΩ 0.6 W 5%	
R26	75 Ω 0.6 W 5%	
R27, R28, R29, R30, R31, R32	820 Ω 1208 SMD	
TP1, TP2	Test point	
TR1	T1235H-6I	STMicroelectronics
U1	VIPER16LN	STMicroelectronics
U2	L7905CP	STMicroelectronics
U3	STM8S103F2P6	STMicroelectronics

6 Functional description

The driving of the motor is based on phase-angle control.

Figure 4. Phase-angle control



The MCU operation is synchronized with the voltage mains thanks to the zero-voltage switching (ZVS) signal. This signal is sent directly to an MCU input pin, which is set as external interrupt.

The Triac is turned on by sending a pulse to the Triac gate. The Triac turns off when the voltage mains crosses 0 V.

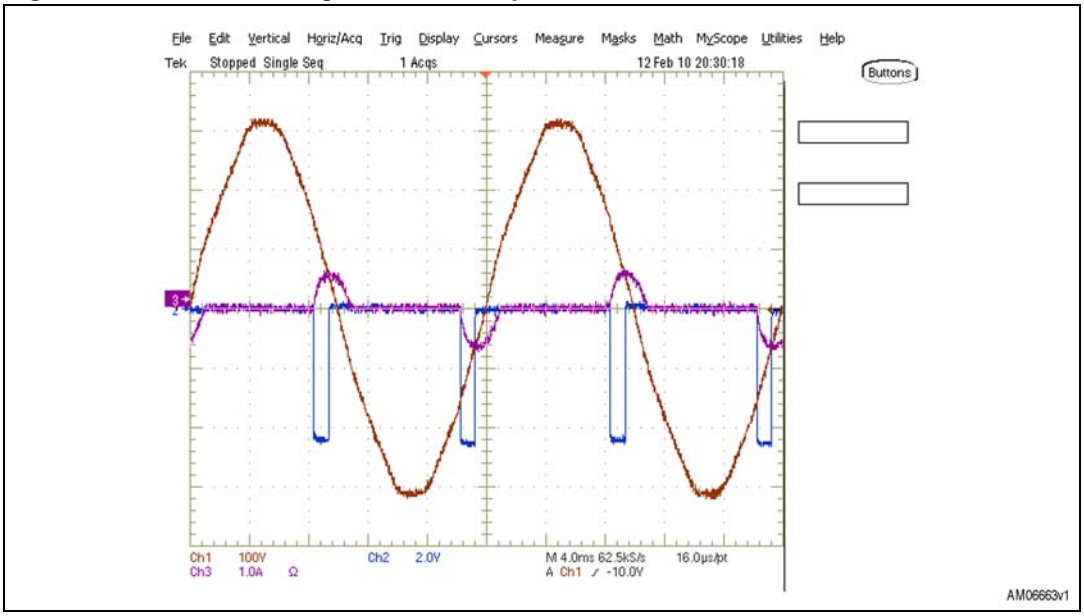
The firing angle determines the power delivered to the motor; the lower the angle, the higher the power.

Firing angle and gate pulse length are defined by software. At a mains frequency of 50 Hz, the demonstration board has a firing angle ranging between 2.5 ms and 8.5 ms, and a constant gate pulse length of 1 ms.

7 Oscilloscope waveforms

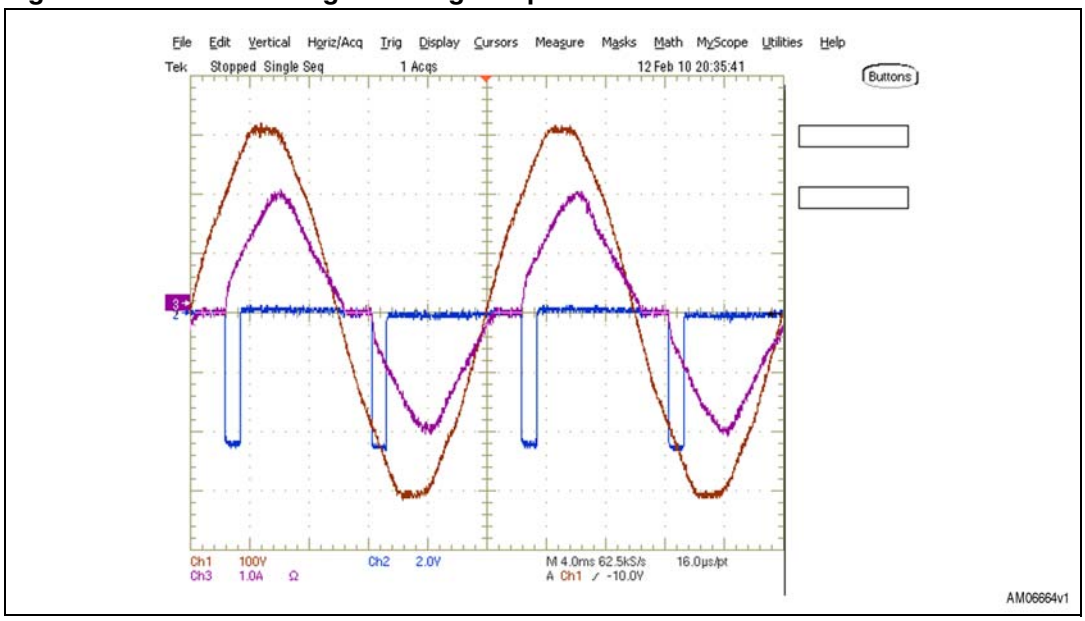
The following waveforms were taken while testing the demonstration board with a 300 W universal motor and no load applied. The purpose of these waveforms is to show how MCU signals are managed and synchronized to the voltage mains. These signals are valid and remain unchanged for any universal motor connected to the demonstration board. The only signal to change is the output current, which depends on the selected working level and motor size.

Figure 5. Motor running at the lowest power level



The gate pulse (blue) is applied to the Triac with a firing angle of 8.5 ms with respect to the voltage mains (brown). Once the pulse is applied, the Triac turns on and begins delivering power to the motor. The purple waveform shows the current flowing through the motor. The demonstration board is now working at level 1, delivering the minimum power to the motor.

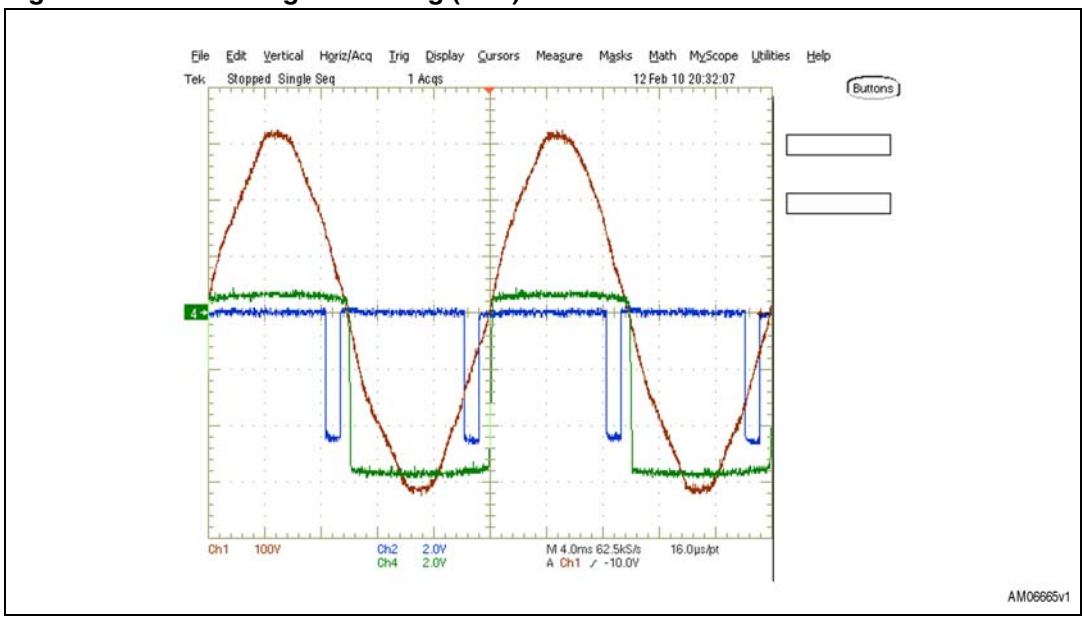
Figure 6. Motor working at the highest power level



The gate pulse (blue) is now applied to the Triac with a firing angle of 2.5 ms with respect to the voltage mains (brown). Once the pulse is applied, the Triac turns on and begins delivering power to the motor. At this point the purple waveform shows a higher current flowing through the motor.

The demonstration board is now working at level 5, delivering the maximum power to the motor.

Figure 7. Zero-voltage switching (ZVS)

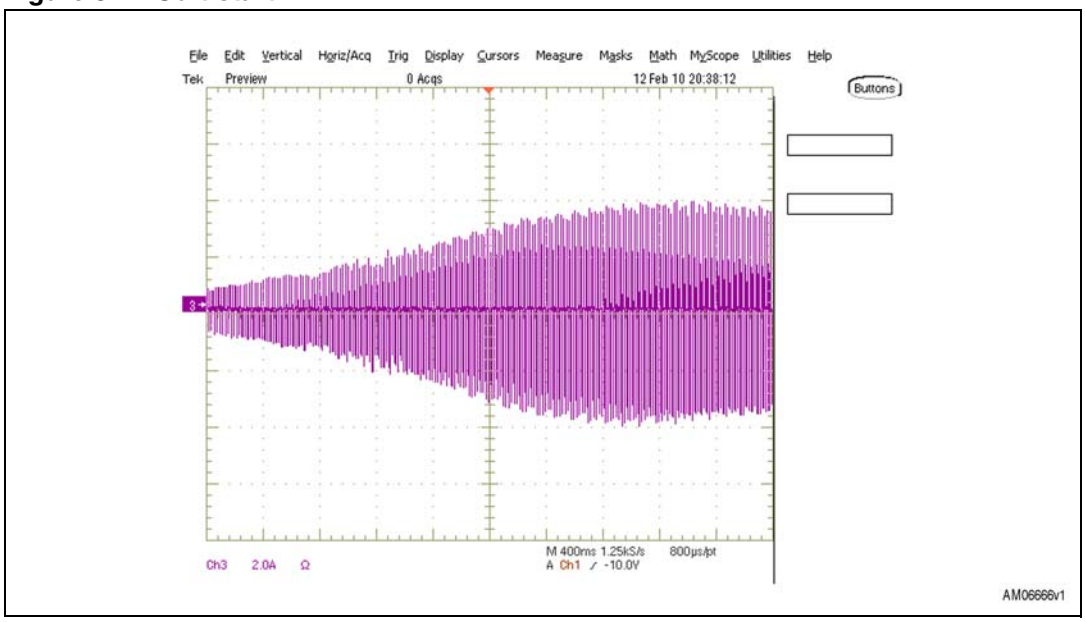


The green waveform shows the zero-voltage switching signal (ZVS) applied to the MCU. The signal is toggled every time the voltage mains crosses zero.

The ZVS signal is used by the MCU as a reference to calculate the firing angle and to synchronize the Triac gate signal with the voltage mains.

The ZVS signal ranges from 0.6 V and 5.6 V. This is due to the cutting diodes inside the MCU I/O port.

Figure 8. Soft-start



The waveform shows the output current behavior from start to the maximum output power.

The output current is slowly and smoothly increased until the working level is reached. In the example, the working level is reached in about 4 seconds.

8 EMC test results

The STEVAL-IHM029V1 demonstration board has successfully 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).

Table 2 lists the IEC-61000-4-4: Electrical fast transient/burst immunity test results.

Table 2. IEC-61000-4-4 test results

STEVAL-IHM029V1 V_{IN} 250 VAC - 50Hz	2 kV	4 kV	6 kV	8 kV
Standby + L Level 3 (5.5 ms)	A A	A A	A A	B B
Standby + N Level 3 (5.5 ms)	A A	A A	A A	B B
Standby + L+N Level 3 (5.5 ms)	A A	A A	A B	B B
Standby - L Level 3 (5.5 ms)	A A	A B	A B	B B
Standby - N Level 3 (5.5 ms)	A A	B B	B B	B B
Standby - L+N Level 3 (5.5 ms)	A A	B A	B B	B B

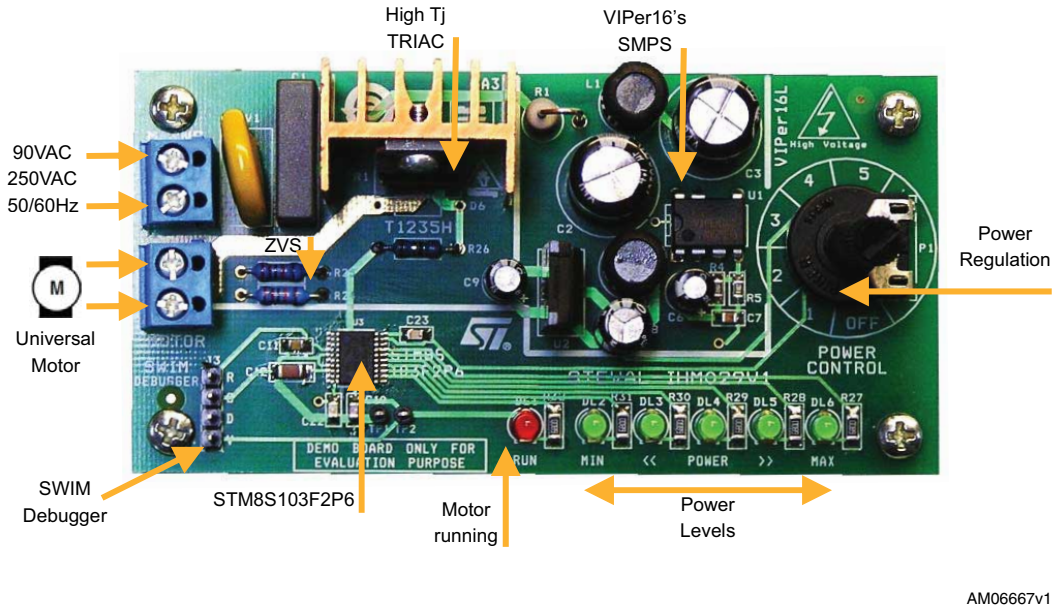
- A: No changes in functionality. The board works properly, no reset occurs.
- B: Reset occurs, but the board recovers without external intervention.
- C: Reset occurs, but the board cannot recover without external intervention.

Test results for IEC-61000-4-5: Surge immunity are as follows:

Test passed at 2 kV (conditions: V_{IN} 250 VAC, 50 Hz, both in standby and at working level 3).

9 How to connect the STEVAL-IHM029V1

Figure 9. Demonstration board overview



Referring to *Figure 9*, on the left side of the board connect the mains voltage to the upper connector, and the motor to the lower connector. The output power is controlled by the potentiometer P1 on the right.

10 How to operate the STEVAL-IHM029V1

The demonstration board can be tested with or without a load. Even if no motor is connected to the demonstration board, all signals are visible by means of an oscilloscope.

While not required, it is recommended to turn potentiometer P1 to the OFF position before powering the demonstration board. The STEVAL-IHM029V1 is ready to operate as soon as it is plugged into the mains.

The output power level is adjusted by using potentiometer P1. Power regulation is broken into 5 power levels: from 1 (minimum power), to 5 (maximum power). A green LED shows the current power level.

Turning potentiometer P1 clockwise increments the output power, while turning the potentiometer P1 counter-clockwise decreases the output power.

While the motor is running, the red LED marked RUN is on to indicate that the MCU is properly driving the Triac.

Turning potentiometer P1 to the OFF position puts the STEVAL-IHM029V1 in standby mode (total power consumption below 300 mW).

In the absence of the ZVS signal, the motor control is stopped, and the red LED starts blinking. Once the ZVS signal is applied again, the motor control is restored.

11 Firing angle table

The firing angles are set by software, and depend on the mains frequency:

Table 3. Firing angles

Working level	50 Hz mains frequency	60 Hz mains frequency
1	8.5 ms	7.0 ms
2	7.0 ms	6.0 ms
3	5.5 ms	5.0 ms
4	4.0 ms	3.5 ms
5	2.5 ms	2.0 ms

12 The STEVAL-IHM029V1 layout

The STEVAL-IHM029V1 is a standard, double-layer, coppered PCB with a copper thickness of approximately 45 µm. The PCB material is FR-4.

- PCB dimensions:
  - Length: 100 mm
  - Width: 50 mm
  - Thickness: 1.55 mm

Figure 10. STEVAL-IHM029V1 silkscreen (top)

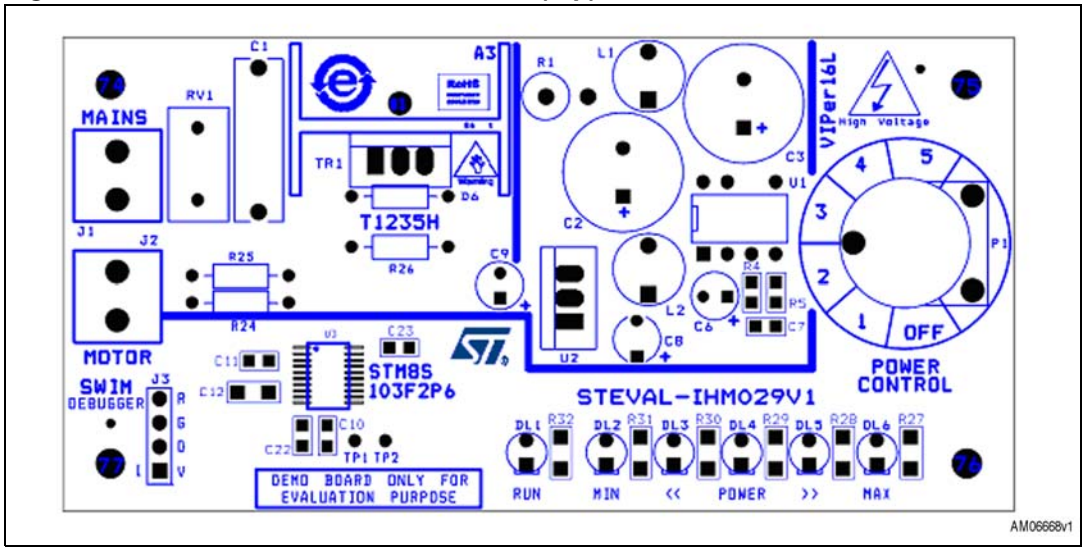


Figure 11. STEVAL-IHM029V1 top layer

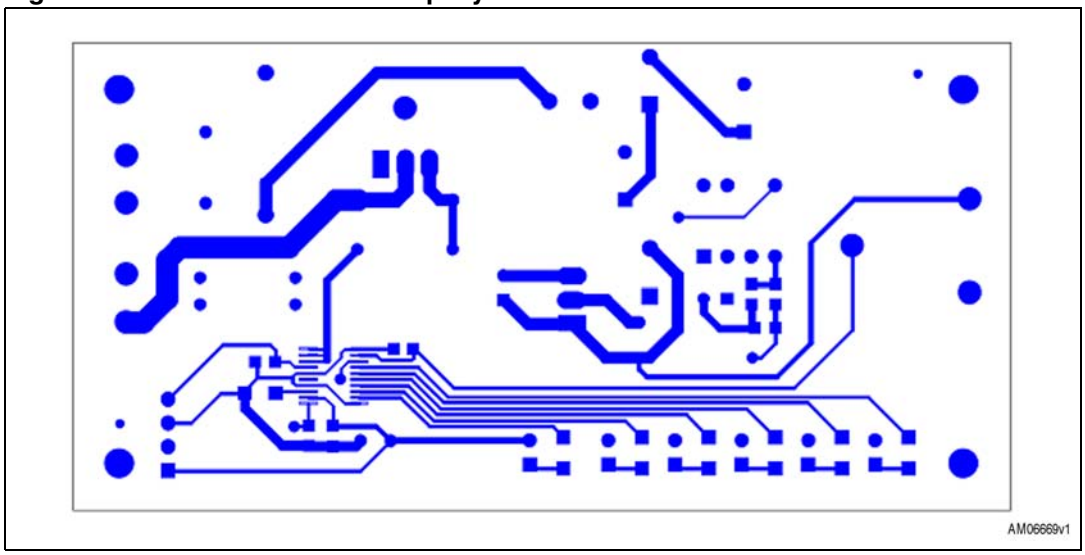
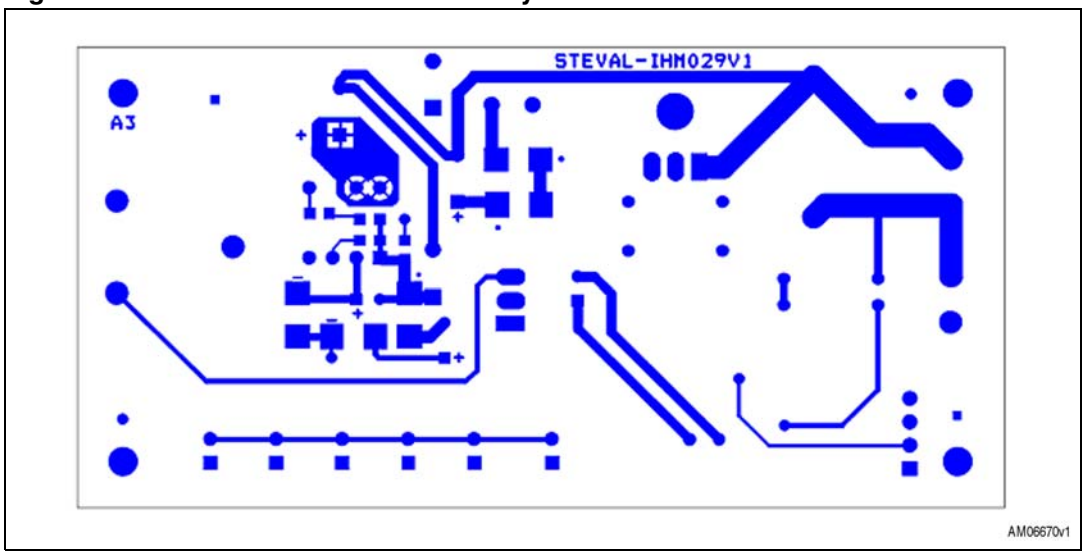


Figure 12. STEVAL-IHM029V1 bottom layer



13 Ordering information

The 2000 W universal motor control demonstration board is available through the standard STMicroelectronics ordering system through order code STEVAL-IHM029V1. The kit includes an assembled demonstration board and all related documentation.

14 References

For additional information and specifications for the ST devices featured in the STEVAL-IHM029V1 demonstration board, refer to the datasheets for the following products:

1. STM8S103F2
2. T1235H
3. VIPer16
4. L7905C
5. STTH1R06
6. P6KE

Note: The datasheets for these products are available for download at www.st.com.

15 Revision history

Table 4. Document revision history

Date	Revision	Changes
24-May-2010	1	Initial release.

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