UM1856
User manual

STEVAL-IHM029V2: Universal motor control evaluation board based on the STM8S103F2 MCU and T1235T Triac

Introduction

This evaluation board specifically targets new vacuum cleaners which, from September 2017, must be limited to a maximum input power of 900 W to be compliant with the 2009/125/EC directive.

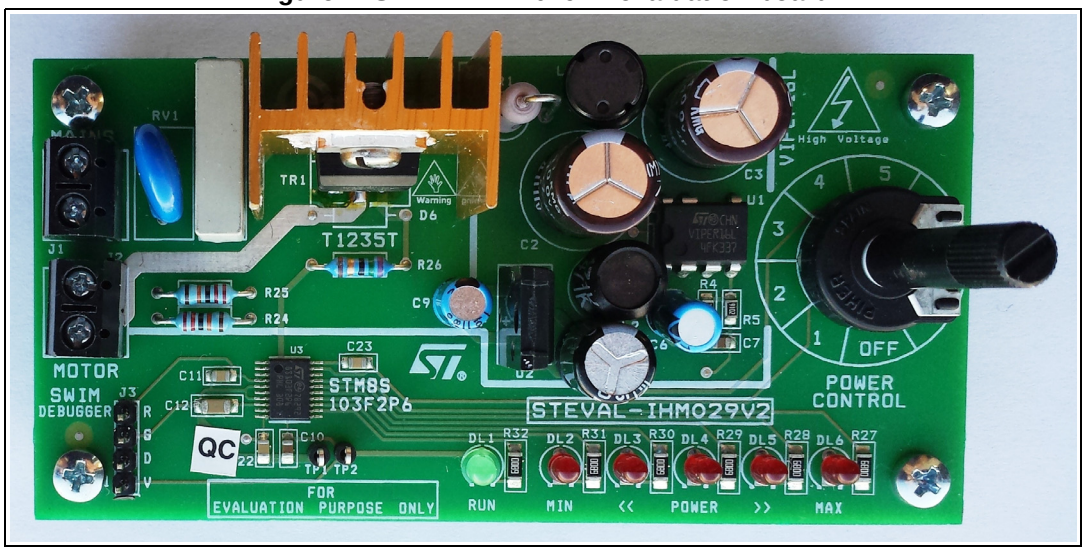
The evaluation board is based on the 20-pin 8-bit STM8S103 MCU running at 16 MHz (user-trimmable internal RC clock), featuring 4 kBytes of flash memory, a 10-bit A/D converter, 8-/16-bit timers, communication interfaces and 640 bytes of E²PROM. The power supply circuitry is based on VIPer16L, an off-line converter with an 800 V avalanche rugged power section operating at 60 kHz.

The STEVAL-IHM029V2 performs phase angle control of any universal motor up to 900 W, thanks to the T1235T-8T, a 12 A 800 V T-series TRIAC which is manufactured using high-temperature processes and can hence maintain operation up to 150 °C.

In order to limit the in-rush current, the evaluation board features a soft-start routine and a smooth power change function.This routine renders the board compliant with the IEC 61000-3-3 standard on voltage fluctuation and flicker.

The evaluation 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). When in stand-by mode, the overall STEVAL-IHM029V2 power consumption is below 300 mW.

Figure 1. STEVAL-IHM029V2 evaluation board



Contents

1 Safety instructions

Warning: The high voltage levels used to operate the STEVAL-IHM029V2 could present a serious electrical shock hazard. This evaluation 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 STEVAL-IHM029V2 is a component designed for demonstration purposes only, and must not be installed in any domestic or industrial equipment. 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 adhered to.

Installation

The STEVAL-IHM029V2 must only be installed according to the instructions in this user manual and the components must be protected against excessive strain. In particular, no components are to be bent and isolating distances must not be altered during transportation, use or handling. No contact must be made with electronic components and contacts. The STEVAL-IHM029V2 contains electrostatic-sensitive components that are prone to damage through improper use. To avoid potential health risks and injuries, electrical components must not be mechanically damaged or destroyed.

Electrical connection

Applicable national accident prevention regulations must be followed when working on the mains power supply. The electrical installation must be performed 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 evaluation 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).

Warning: Do not touch the board after disconnection from the Mains, as several parts and power terminals which contain possibly energized capacitors need to be allowed to discharge completely. Green “RUN” LED signals high voltage present on the board by blinking, when blinking disappears capacitors were discharged and it is safe to touch.

2 Main features

The STEVAL-IHM029V2 evaluation board main features are listed below.

- Input voltage range: 90-265 VAC, 50 / 60 Hz
- 12 VDC / 5 VDC auxiliary power supply based on VIPer16L in buck converter topology
- Total power consumption below 300 mW in stand-by mode
- Maximum output power 900 W for 220-240 V mains. Higher power motors may be used (up to 2 kW approx.) if the T1235T-8T case temperature remains within datasheet limits (refer to Fig. 2 of T1235T-8T datasheet)
- 20-pin 8-bit STM8S103F2P6 MCU as main controller
- Zero voltage switching (ZVS) to synchronize the MCU events with the voltage mains
- Motor driven by T1235T-8T 12 A, 800 V T-series TRIAC in phase angle control
- 5 power levels + stand-by mode selected by potentiometer
- 5 red LEDs to display the operating power level of the board
- A “RUN” green LED to ensure the board is functioning
- Standard in-circuit programming connector
- IEC 61000-4-4 pre-compliance test verified (burst up to 8 kV)
- IEC 61000-4-5 pre-compliance test verified (surge up to 2 kV)

3 Target applications

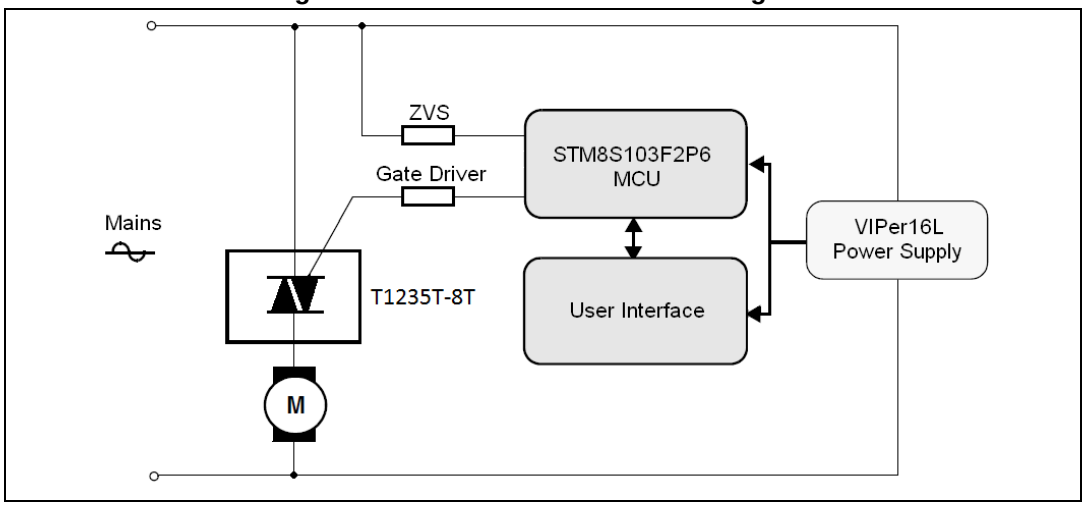
The STEVAL-IHM029V2 universal motor control evaluation board is mainly targeted at the domestic appliance market, including:

- Vacuum cleaners – the new 2009/125/EC directive requires decreased power consumption to below 900 W from September 2017
- Food processors
- Power tools

4 Block diagram

An universal motor control system can be split into a few simple blocks.

Figure 2. STEVAL-IHM029V2 block diagram



Power supply

The VIPer16L-based power supply uses a buck converter topology operating at 60 kHz fixed frequency. The wide input voltage range (90-265 VAC, 50 / 60 Hz) allows the evaluation 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 an L7905CP linear regulator, which in turn provides a reference voltage of -5 VDC. A negative power supply is highly recommended when driving a TRIAC directly from a microcontroller (refer to AN440, AN3168 and AN4564).

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. driving the TRIAC).

User interface

The user interface has a potentiometer to adjust the output power level and 6 LEDs indicating the status of the board and the actual power level of the board.

Motor driving

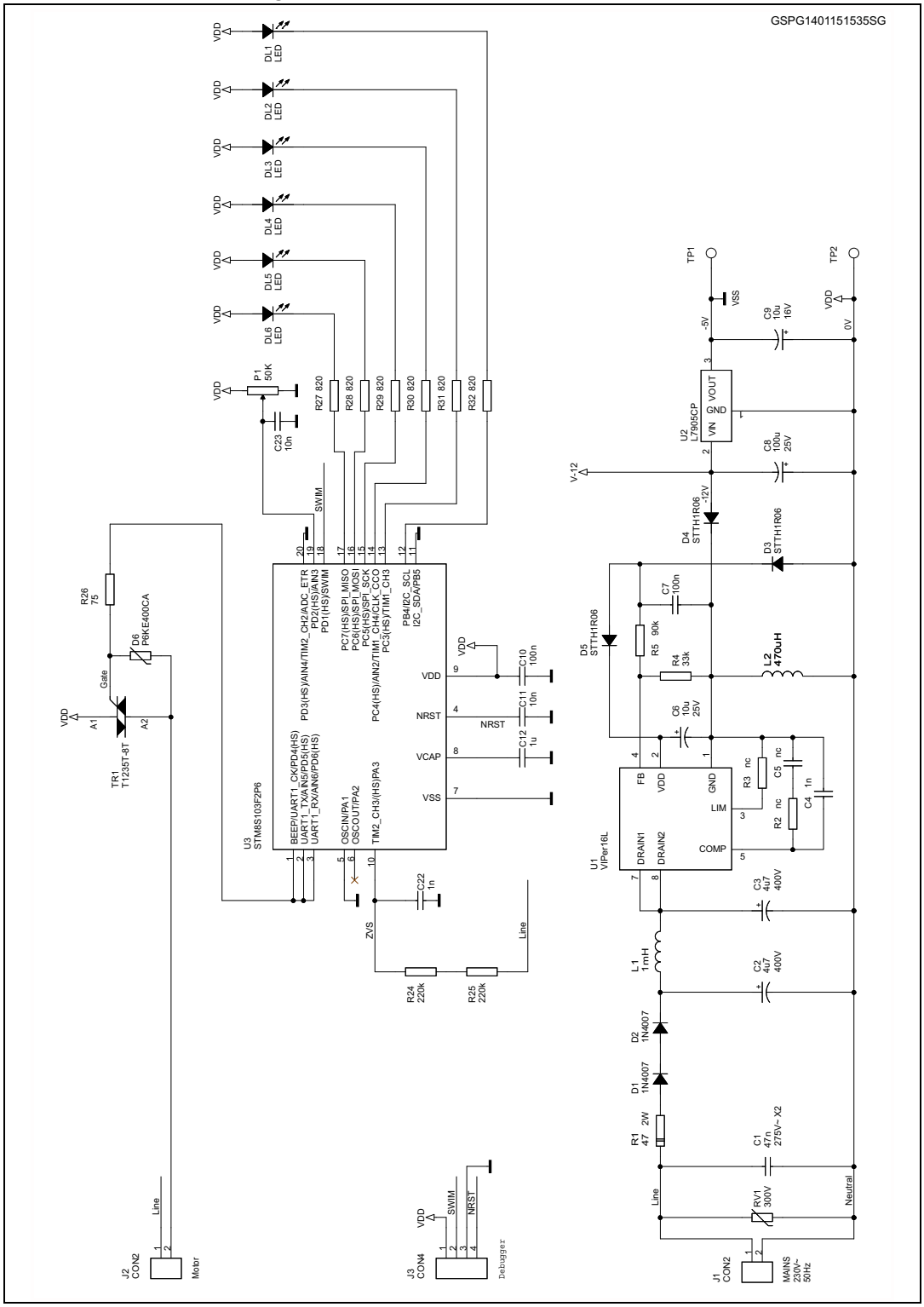
The universal motor is driven by a T-series TRIAC T1235T-8T in angle phase control.

STM8S103F2P6

The entire process is controlled by a 20-pin 8-bit STM8S microcontroller.

5 Schematic

Figure 3. STEVAL-IHM029V2 schematic



6 Bill of material

Table 1. Bill of material (BOM)

Index	Qty	Ref.	Value	Package	Manufact.	Ord.le N	Supp.	Supp.ordering code
1	1	C1	47nF 275V~ X2	Foil X2 capacitor, RM 15mm	Any		Any	
2	2	C2,C3	4.7uF/400V (450V)	El. capacitor, 5mm, 105°C	Any		Any	
3	2	C6,C9	10uF/25V	El. capacitor, 2.5mm	Any		Any	
4	2	C4,C22	1nF	Capacitor, SMD 0805	Any		Any	
5	3	R2,R3, C5	not mounted	-	-			
6	2	C7,C10	100nF	Capacitor, SMD 0805	Any		Any	
7	1	C8, C58	100µF/25V	El. capacitor, 3.5mm	Any		Any	
8	2	C11,C23	10nF	Capacitor, SMD 0805	Any		Any	
9	1	C12	1µF	Capacitor, SMD 1206	Any		Any	
10	1	DL1	LED Green	Universal LED 3mm, 20mA	Any		Any	
11	5	DL2,DL3 DL4,Dl5, DL6	LED Red	Universal LED 3mm, 20mA	Any		Any	
12	2	D1,D2	1N4007	Standard rectifier, SMD	Any		Any	
13	3	D3,D4, D5	STTH1R06	Ultrafast HV rectifier, SMA	STM	STTH1R06		
14	1	D6 (not mounted)	P6KE400CA (not mounted)	Transil DO-15	STM	P6KE400CA		
15	2	J1,J2	CON 5mm, 2P	Connector RM 5mm, 2-pole, screw	Any		Any	

Table 1. Bill of material (BOM) (continued)

Index	Qty	Ref.	Value	Package	Manufact.	Ord.le N	Supp.	Supp.ordering code
16	1	J3	Stip line 4P 2.54mm	Standard vertical, 2.54mm	Any		Any	
17	1	L1	1mH	Radial inductor, 5mm	Any		Any	
18	1	L2	470uH	Radial inductor, 5mm	Any		Any	
19	1	P1	50kΩ Trimmer + Shaft	15mm Horizontal + 25.5mm Shaft	Any		Any	
20	1	RV1	Varistor 275VV 595+	275V~ 7.5mm	Any		Any	
21	1	R1	47Ω	2W 5% Metal or Carbon	Any		Any	
22	1	R4	33kΩ	Resistor, SMD 0805, 1%	Any		Any	
23	1	R5	90kΩ	Resistor, SMD 0805, 1%	Any		Any	
24	2	R24,R25	220kΩ 0.6W 1%	Metal resistor, through hole, 1%	Any		Any	
25	1	R26	75Ω 0.6W 1%	Metal resistor, through hole, 1%	Any		Any	
26	6	R27,R28 R29,R30 R31,R32	680Ω	Resistor, SMD 1206, 1%	Any		Any	
27	2	TP1,TP2	Test Point	Any	Any		Any	
28	1	TR1	T1235T-8T	12A TRIAC, TO-220AB	STM	T1235T-8T		
29	1	H1	Heatsink	V7142A 25x23x16 Gold or Black	Any		GM	620-030
30	1	U1	VIPer16LN	Off-line converter, DIP-7	STM	VIPer16LN		

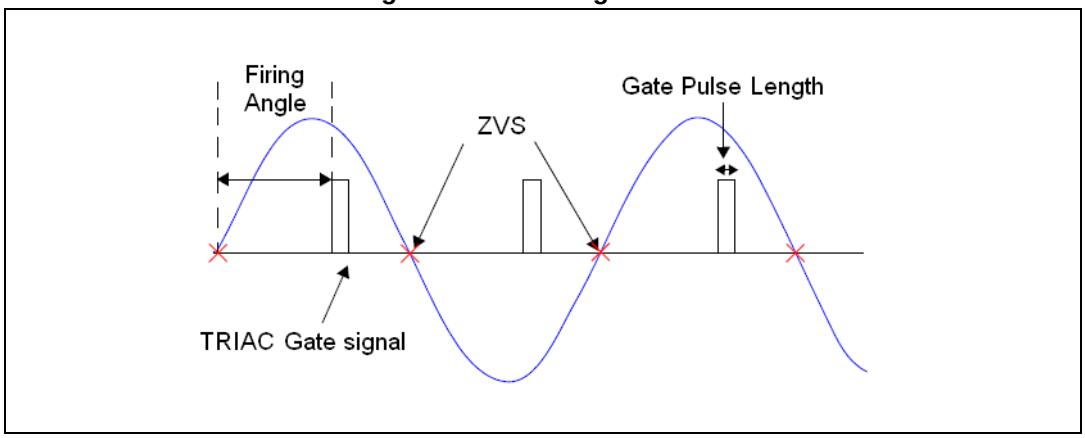
Table 1. Bill of material (BOM) (continued)

Index	Qty	Ref.	Value	Package	Manufact.	Ord.le N	Supp.	Supp.ordering code
31	1	U2	L7905CP	Neg. voltage regulator in TO-220FP	STM	L7905CP		
32	1	U3	STM8S103F 2P6	8-bit MCU, 4kBytes, TSSOP20	STM	STM8S103F2P6		
33	5	SCR1,SC R2,SCR3 SCR4, SCR5	Screw	M3, 10mm long	Any		Any	
34	4	DST1,DS T2,DST3, DST4	Distance	M3, 15mm long	Any		Any	
35	1	CD	CD/DVD burning		Any		Any	
36	1	Label	CD/DVD Label		Any		Any	
37	1	Box	Box label		Any		Any	

7 Functional description

The motor is driven via phase angle control.

Figure 4. Phase angle control



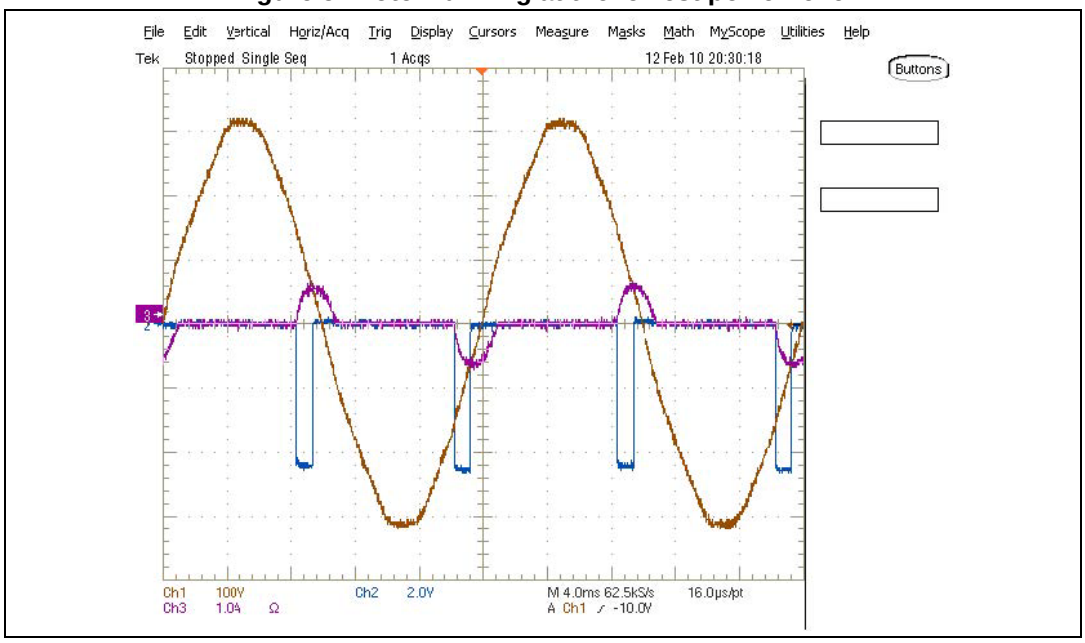
The MCU operation is synchronized with the mains voltage thanks to the zero voltage switching (ZVS) signal. This signal is sent directly to a MCU input pin, which is set as the external interrupt. The TRIAC is turned on by sending a pulse to the TRIAC gate. The TRIAC turns off when the current through the triac drops below the holding current level.

The firing angle determines the power delivered to the motor: the lower the firing angle, the higher the delivered power. The firing angle and gate pulse length are defined by software. For a mains frequency of 50 Hz, the evaluation board has a firing angle ranging of between 2.5 ms and 8.5 ms, and a constant gate pulse length of 1 ms.

8 Scope waveforms

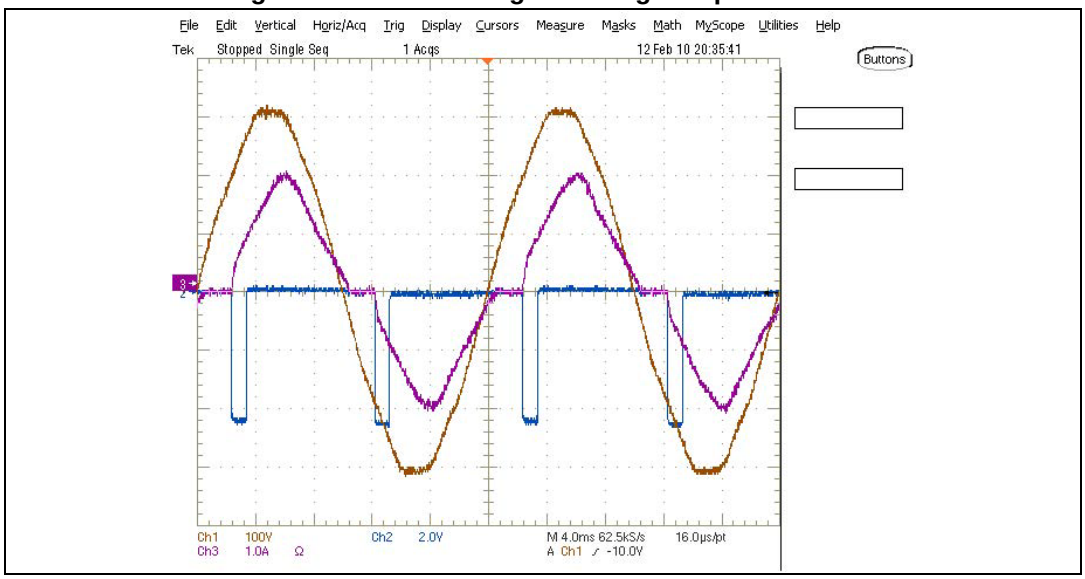
The following waveforms have been taken while testing the evaluation board with a 300 W universal motor and no load applied. The purpose of these waveforms is to show how MCU signals are managed and synchronized with the mains voltage. These signals are valid and remain unchanged for any universal motor connected to the evaluation board. Only the output current signal changes, which is dependent on the selected working speed 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 mains voltage (brown). Once the pulse is applied, the TRIAC turns on and starts delivering the power to the motor. The purple waveform shows the current flowing through the motor. The evaluation board in this example is operating at level 1, delivering minimum power to the motor.

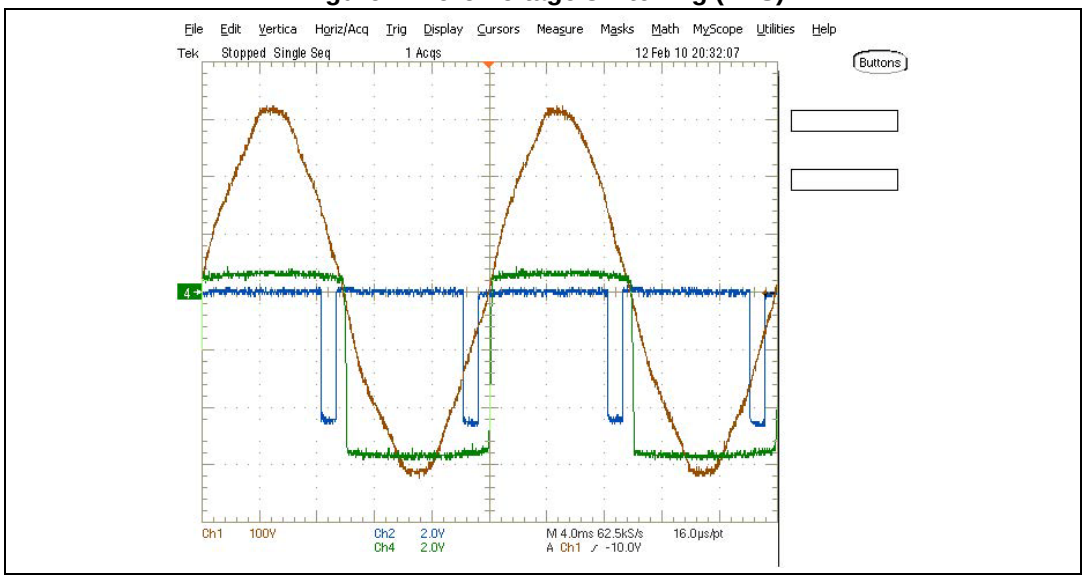
Figure 6. Motor running at the highest power level



In *Figure 6*, the gate pulse (blue) is applied to the TRIAC with a firing angle of 2.5 ms with respect to the mains voltage (brown). Once the pulse is applied, the TRIAC turns on and starts delivering the power to the motor. The purple waveform now shows a higher current flowing through the motor.

The evaluation board is now operating at level 5, delivering maximum power to the motor.

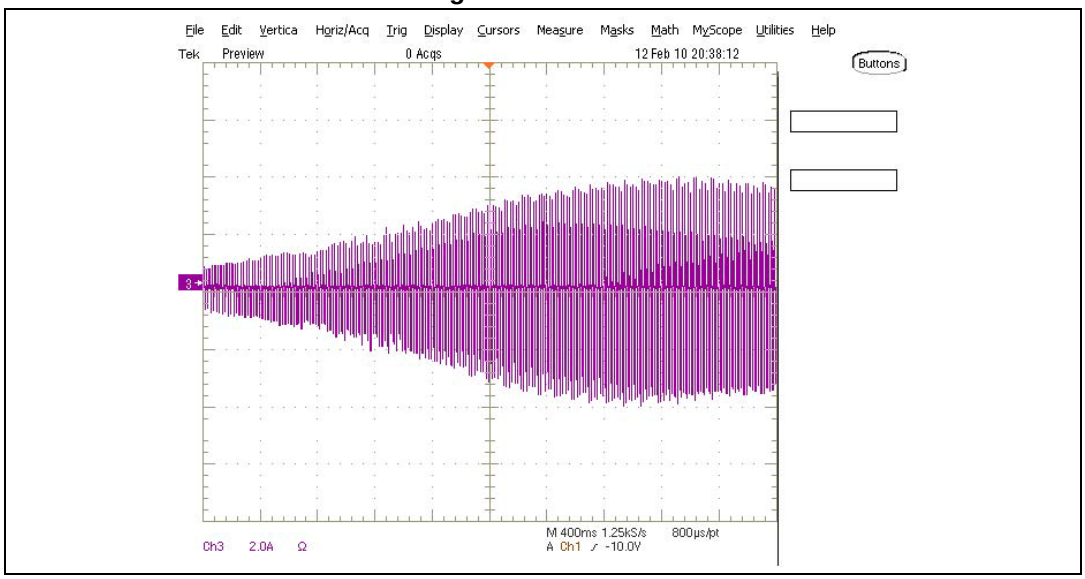
Figure 7. Zero voltage switching (ZVS)



The green waveform shows the zero voltage switching signal (ZVS) applied to the MCU. The signal is toggled whenever the mains voltage 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 mains voltage.

The ZVS signal ranges between 0.6 V and 5.6 V due to the cutting diodes inside the MCU's I/O port.

Figure 8. Soft-start



The waveform shows the output current behavior when connecting the board while the potentiometer is set to the maximum output power setting. 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.

9 EMC test results

The STEVAL-IHM029V2 evaluation 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).

9.1 Electrical fast transient / burst immunity test results (IEC-61000-4-4)

Table 2. Electrical fast transient / burst immunity test results

STEVAL-IHM029V2 V_{IN} 250 VAC-50 Hz				
	2 kV	**4 kV**	**6 kV**	**8 kV**
Stand-by + L Level 3 (5.5 ms)	A A	A A	A A	B B
Stand-by +N Level 3 (5.5 ms)	A A	A A	A A	B B
Stand-by + L +N Level 3 (5.5 ms)	A A	A A	A B	B B
Stand-by - L Level 3 (5.5 ms)	A A	A B	A B	B B
Stand-by -N Level 3 (5.5 ms)	A A	B B	B B	B B
Stand-by - L +N Level 3 (5.5 ms)	A A	B A	B B	B B

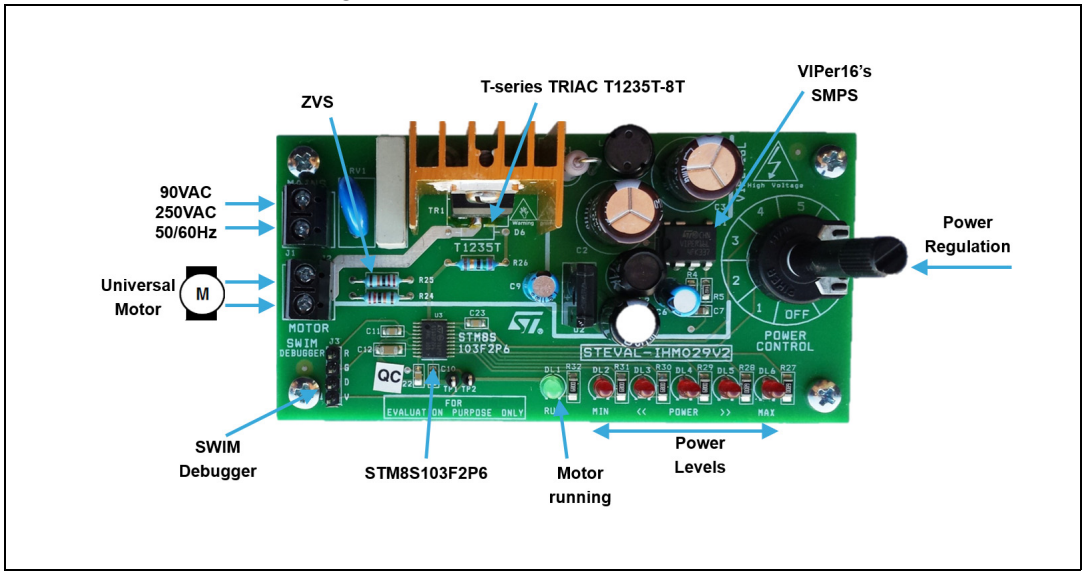
Note: A: No changes in functionality. The board works properly, no reset occurs.
B: Reset occurs but the board recovers without external intervention.
C: Reset occurs but the board cannot recover without external intervention.

9.2 Surge immunity test results (IEC-61000-4-5)

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

10 How to connect the STEVAL-IHM029V2

Figure 9. Evaluation board overview



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.

10.1 How to operate the STEVAL-IHM029V2

The evaluation board can be tested with or without a load. Even if no motor is connected to the evaluation board, all signals are visible via a scope. Turn the potentiometer P1 to the "OFF" position before powering the evaluation board.

The STEVAL-IHM029V2 is ready to operate as soon as it is plugged in to the mains. The output power level is adjusted by turning the potentiometer P1. The power regulation is broken into 5 power levels: from 1 (minimum power) to 5 (maximum power), with a red LED indicating the current power level. Turning the potentiometer P1 clockwise increments the output power and vice-versa. While the motor is running, the green LED marked "RUN" blinks to indicate that the MCU is properly driving the TRIAC.

Turning the potentiometer P1 to the OFF position places the STEVAL-IHM029V2 in stand-by mode (total power consumption below 300 mW).

10.2 Firing angle table

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

Table 3. Mains frequency

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

10.3 The STEVAL-IHM029V2 layout

Figure 10. STEVAL-IHM029V2 silk screen top

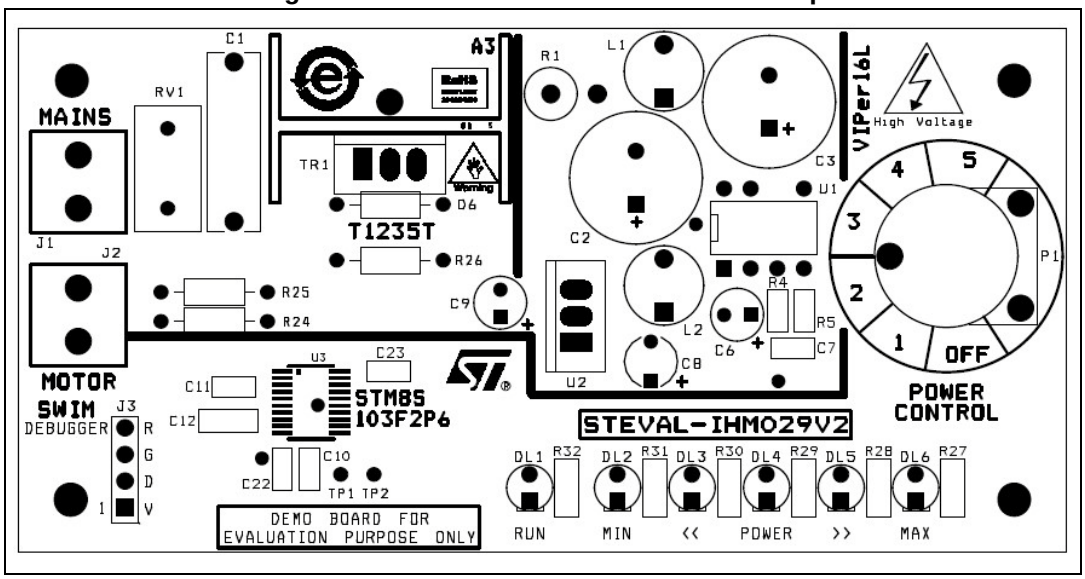


Figure 11. STEVAL-IHM029V2 top layer

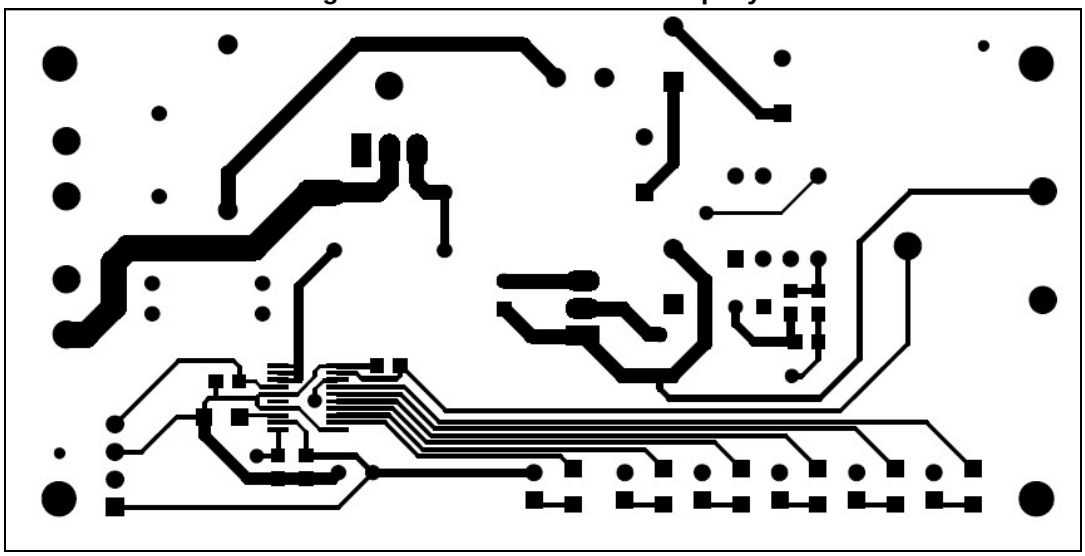
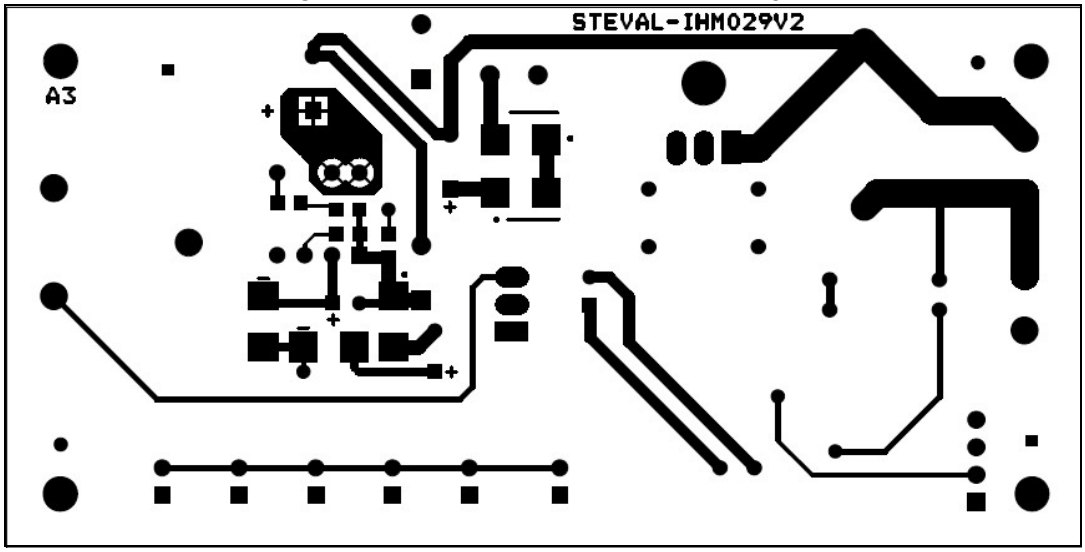


Figure 12. STEVAL-IHM029V2 bottom layer



11 Ordering information

Use the order code “STEVAL-IHM029V2” to order through the standard ordering system. The kit includes an assembled evaluation board and the associated documentation.

12 References and related material

For specific information regarding the basic functionality of each integrated circuit, please refer to the following documentation:

1. STM8S103F2P6 datasheet
2. T1235T-8T datasheet
3. VIPer16L datasheet
4. L7905CP datasheet
5. STTH1R06 datasheet
6. P6KE400CA datasheet
7. L7905CP datasheet

13 Revision history

Table 4. Document revision history

Date	Revision	Changes
20-Feb-2015	1	Initial release.

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