

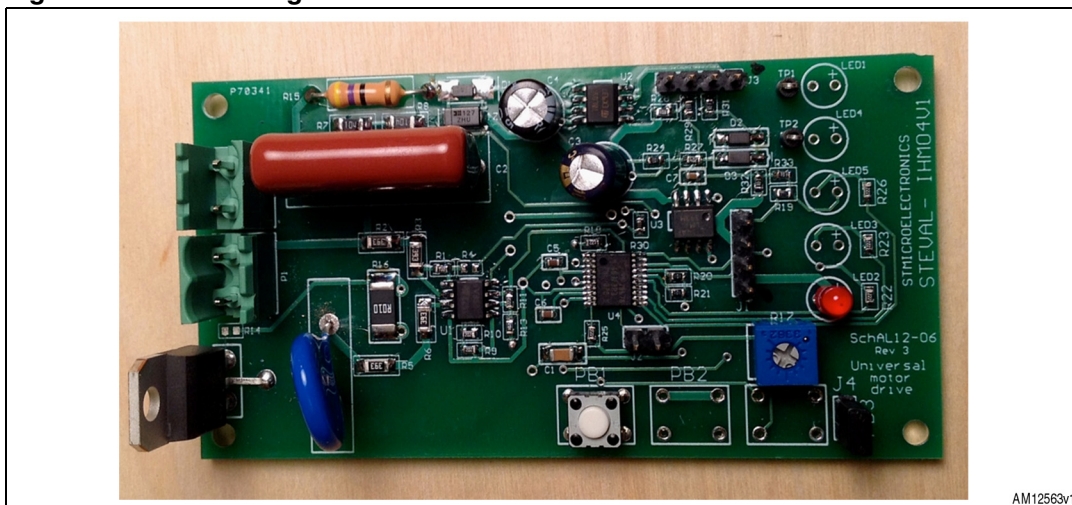
## Introduction

The STEVAL-IHM041V1 is a Triac based phase angle control for universal motor speed control using an STM8S103F3, 8-bit microcontroller, to set the conduction angle of the Triac. The board may be operated in either open loop mode or in closed loop speed control mode, with an AC tach, hall sensor or opto sensor feedback. The open loop mode may also be used as a lamp dimmer.

The board is designed to operate from a 120 V/60 Hz mains, but may be easily modified to operate on other mains voltages by changing components in the power supply and motor voltage sensing circuits. Suggested component values for other mains voltages are shown in the alternate bill of materials.

On power-up, the firmware determines if jumper J4 is installed or not. The board operates in open loop mode if J4 is not installed and in closed loop mode if J4 is installed. When operating in closed loop mode, an AC tach or a hall effect device is connected to J3 to provide speed feedback.

**Figure 1. Board image**



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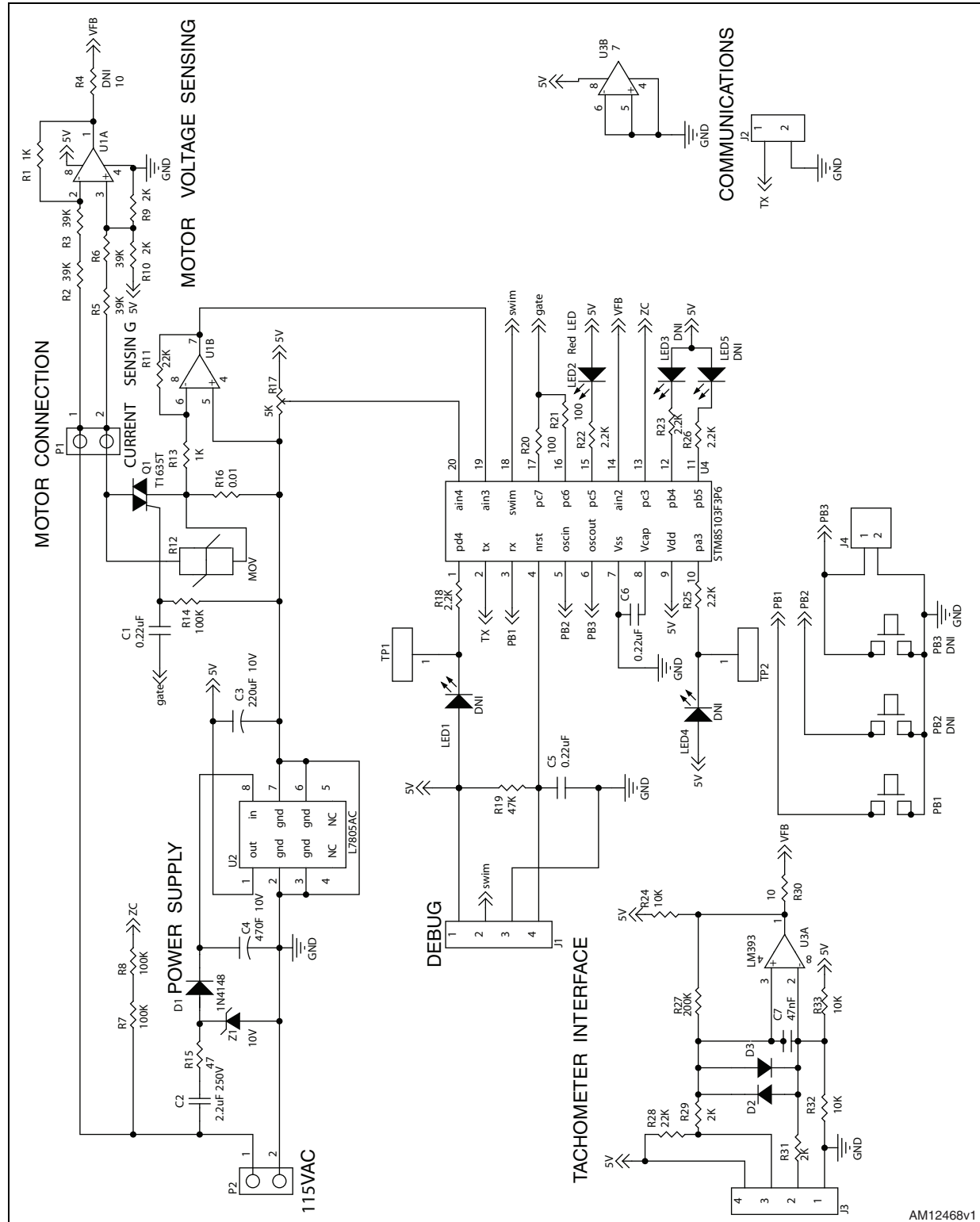
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# 1 Main features

- Input voltage 120 V/60 Hz
  - 230 V/50 Hz (with component change)
- Motor current 7A RMS
- Phase control for universal motor drive
- Open loop or closed loop speed regulation
- Voltage and current sensing, for sensorless operation (optional)
- Debug outputs
- AC tach, hall sensor or opto sensor for speed feedback.

## 2 Schematic and bill of material

Figure 2. STEVAL-IHM041V1 schematic



AM12468v1

Table 1. BOM

| Designator              | Part/value        | Manufacturer       | Manufacturer part no. |
|-------------------------|-------------------|--------------------|-----------------------|
| C1                      | 0.22 $\mu$ F      |                    |                       |
| C2                      | 2.2 $\mu$ F 250 V | Panasonic          | EF2225                |
| C3                      | 220 $\mu$ F 10 V  |                    |                       |
| C4                      | 470 $\mu$ F 10 V  |                    |                       |
| C5, C6                  | 0.22 $\mu$ F      |                    |                       |
| C7                      | 47 nF             |                    |                       |
| D1,D2, D3               | 1N4148            | Diodes Inc         | 1N4148FDICT           |
| J1, J3                  | 4Pos .100 header  |                    |                       |
| J2                      | 2Pos .100 header  |                    |                       |
| J4                      | 2Pos .100 header  |                    |                       |
| LED2                    | Red LED           |                    |                       |
| LED1, LED3, LED4, LED5  | DNI               |                    |                       |
| P1, P2                  | 2Pos locking 5 mm |                    |                       |
| PB1                     |                   |                    |                       |
| PB2, PB3                | DNI               |                    |                       |
| Q1                      | T1635T            | STMicroelectronics | T1635T-81             |
| R1, R13,                | 1 k $\Omega$      |                    |                       |
| R14                     | 100 k $\Omega$    |                    |                       |
| R2, R3, R5, R6          | 39 k $\Omega$     |                    |                       |
| R4                      | DNI               |                    |                       |
| R7, R8                  | 100 k $\Omega$    |                    |                       |
| R9, R10, R29, R31       | 2 k $\Omega$      |                    |                       |
| R11, R28                | 22 k $\Omega$     |                    |                       |
| R12                     | MOV               | Epcos              | S14K275               |
| R15                     | 47 $\Omega$       |                    |                       |
| R16                     | 0.01              |                    |                       |
| R17                     | 5 k $\Omega$ pot  |                    |                       |
| R18, R22, R23, R25, R26 | 2.2 k $\Omega$    |                    |                       |
| R19                     | 47 k $\Omega$     |                    |                       |
| R20, R21                | 100 $\Omega$      |                    |                       |
| R24, R32, R33           | 10 k $\Omega$     |                    |                       |
| R27                     | 200 k $\Omega$    |                    |                       |
| R30                     | 10 $\Omega$       |                    |                       |

**Table 1. BOM (continued)**

| Designator | Part/value   | Manufacturer       | Manufacturer part no. |
|------------|--------------|--------------------|-----------------------|
| TP1, TP2   | Test point   |                    |                       |
| U1         | TSV358IYDT   | STMicroelectronics | TSV358IYDT            |
| U2         | L7805AC      | STMicroelectronics | L7805ACD2T-TR         |
| U3         | LM393        | STMicroelectronics | LM393AD               |
| U4         | STM8S103F3P6 | STMicroelectronics | STM8S103F3P6          |
| Z1         | 10 V         |                    |                       |

**Table 2. Alternate bill of materials for 230 V/50 Hz operation**

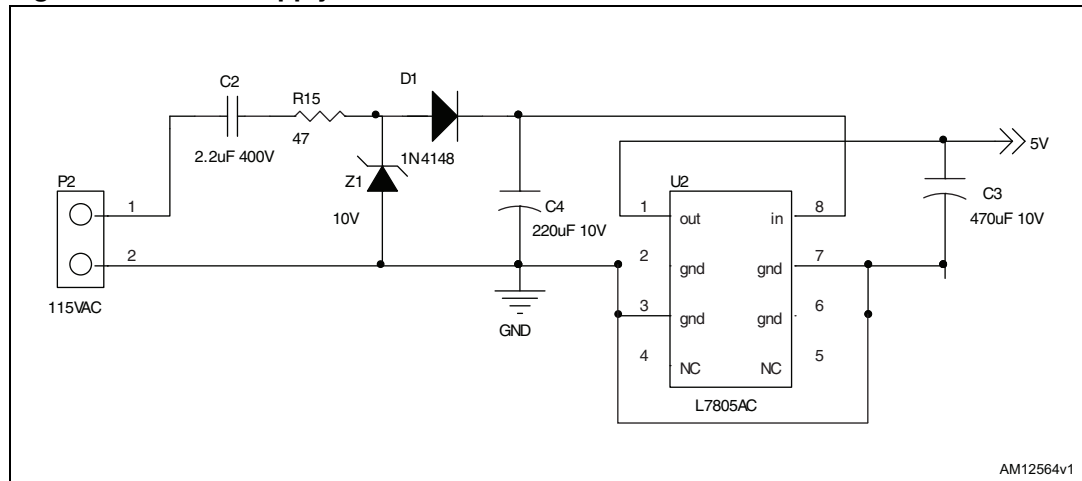
| Designator     | Value            |
|----------------|------------------|
| C2             | 1 $\mu$ F, 400 V |
| R2, R3, R5, R6 | 82 k $\Omega$    |

### 3 Circuit description

#### Power supply

The power for the STM8 and the associated control circuit is derived from the mains input using a capacitive drop power supply followed by a 5 V linear regulator, as shown in [Figure 3](#).

**Figure 3. Power supply**



C2, R15, Z1, D1 and C4 form the capacitive drop supply that provides an unregulated 10 V to the L7805 linear regulator. Zener diode Z1 sets the peak value of the unregulated supply. A value of 10 V was chosen to maintain the minimum voltage of 8 V at the input of the L7805. The power supply section was designed to use with a 120 V/60 Hz mains. The power supply can be modified to be used on 230 V/50 Hz mains by changing C2. Component changes needed to modify the board to work on a 230 V/50 Hz mains are shown in [Table 2](#).

#### Line sync interface

To synchronize the gate drive for the Triac to the AC mains, the STM8 senses the zero crossings of the AC mains voltage at the timer1 capture input. A pair of series current limiting resistors, R1 and R2, connect the AC line input to the timer1 capture input pin. Two 1206 case resistors are used in series to provide sufficient voltage rating. The voltage at the pin is clamped to 5 V and ground by the internal diodes in the STM8. The values of the resistors are selected to limit the current to within the allowable range for the STM8.

#### Triac power stage

Triac Q1 is connected in between the mains and the load and functions as a phase controlled switch to provide power to the motor. The gating signal is generated by the STM8 at GPIO pins PC6 and PC7. The pins are paralleled in order to increase the available gate current drive and the control must operate these two outputs in unison.

For best operation, the Triac should be operated in the second and third quadrant, always using a negative pulse on the gate to turn the device on. Since the STM8 operates from a positive 5 V supply, it is not possible to directly drive the gate with a negative pulse. Capacitor C1 AC couples the gate signal from the STM8 to the Triac so that a falling edge on the output of PC6 and PC7 generates a negative voltage on the Triac gate for turn-on. The

example control software provides a series of “picket fence” pulses to the gate, to improve the reliability of the gating, always finishing with the pins back high, ready for the next gating.

### Current sensing

Shunt resistor R7 is used to sense the motor current during the Triac conduction angle. Using a value of  $0.01\ \Omega$  generates a signal that is  $10\ \text{mV/A}$ . This signal is amplified by U1 to get a signal of  $220\ \text{mV/A}$  that is fed into an ADC input of the STM8. With a  $5\ \text{V}$  full scale value on the ADC, the circuit can read peak currents up to  $22.7\ \text{A}$ .

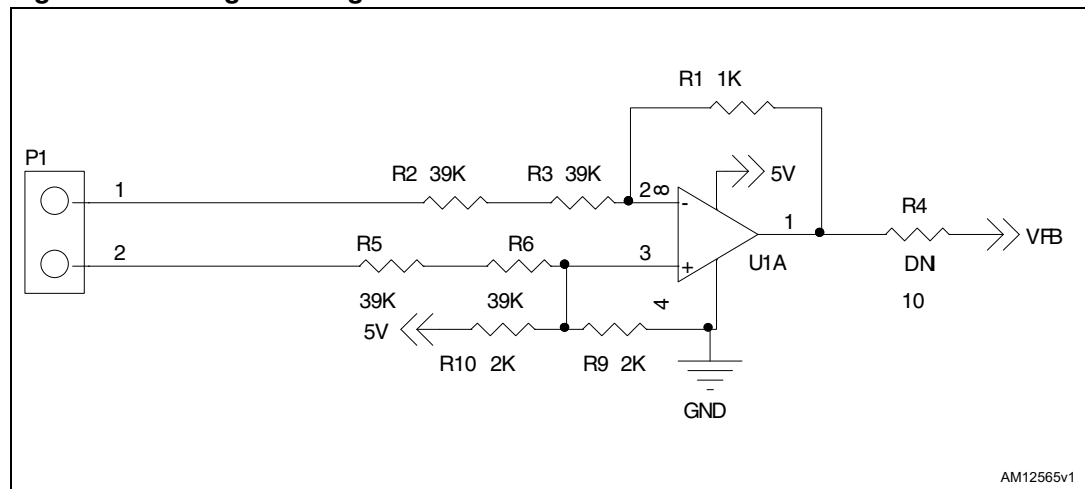
Although the current through R7 is both positive and negative, the inverting configuration circuit amplifies only the negative current since the amplifier output cannot go below ground. An alternate configuration would be to add a bias to the amplifier circuit so that at zero current the output would be half of the full scale voltage, or  $2.5\ \text{V}$ . In this way both positive and negative current may be measured but the peak current capability would be reduced by  $\frac{1}{2}$  if the gain stayed the same.

The current sensing is included primarily for a sensorless speed control algorithm. The algorithm senses current during the negative half cycle and performs the speed regulation calculations during the positive half cycle.

The current sensing is not needed for the open loop or closed loop speed control with tachometer feedback.

### Motor voltage sensing

**Figure 4. Voltage sensing circuit**



The measured motor voltage is also required for a sensorless speed estimation algorithm of the software. Since neither side of the motor terminal voltage is at ground potential, a conventional differential amplifier stage, built around U1A, is used to interface the signal to the ground referenced STM8 ADC input, as shown in [Figure 4](#). The differential amplifier also provides attenuation, biasing and resistive isolation. The gain of this circuit is  $1\ \text{k}\Omega/78\ \text{k}\Omega$ . Since the circuit is biased at  $2.5\ \text{V}$  out for  $0\ \text{V}$  in, the input voltage range is  $\pm 195\ \text{V}$  peak over the full scale range of  $0$  to  $5\ \text{V}$  on the ADC input.

Two 1206 case resistors are used in series for the input resistors to provide sufficient voltage rating. For operation on  $230\ \text{V}/50\ \text{Hz}$  mains, the values of input resistors R2, R3, R5 and R6 are changed to  $82\ \text{k}\Omega$ .

The voltage sensing is not needed for the open loop or closed loop speed control with tachometer feedback.

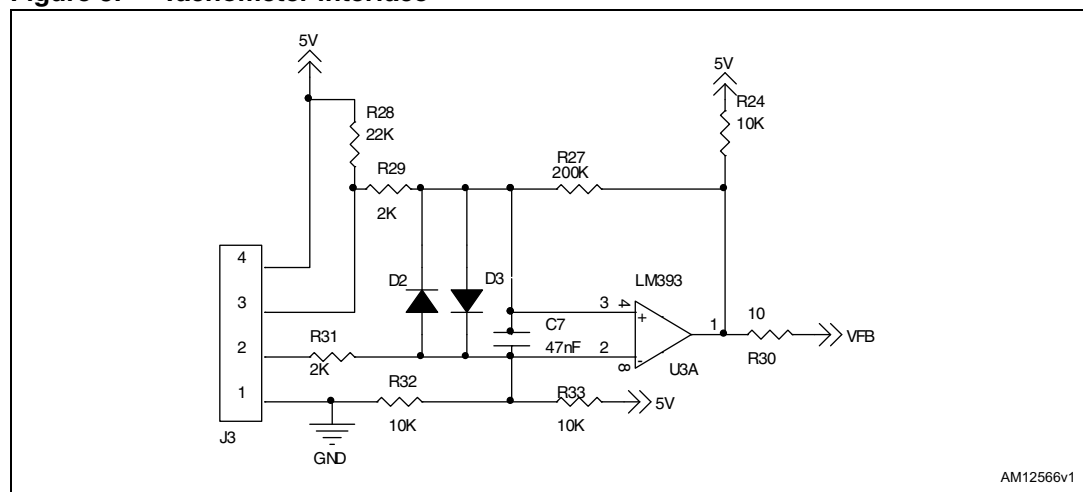
### Potentiometer

PCB mounted potentiometer R8 is connected between 5 V and ground with the wiper providing an input signal to STM8 ADC input Ain4. This can be used as a general analog input signal. In the example software, this signal is used as either a closed loop speed command or an open loop gating phase angle command.

### Tachometer interface circuit

For closed loop speed control, a tachometer signal can be connected to connector J3. The circuit supports a pure magnet pickup coil type, a hall sensor type pulse tachometer or an opto interrupter or reflector type of pick-up.

**Figure 5. Tachometer interface**



For active devices like a hall sensor or opto pick-up, the 5 V power supply and ground is available on pins 1 (GND) and 4 (5v) and the device output should be connected to pin 3. A pull-up resistor, R28, is provided for open collector devices, but totem pole outputs can be accommodated as well.

For AC pick-up coil type devices, the output wires should be connected at pins 2 and 3. The differential signal is biased to approximately 1/2 of the supply voltage and diodes D2 and D3 clamp the signals to safe levels for the comparator inputs. A small hysteresis in the comparator should still provide sufficient sensitivity for low speed operation. The sensitivity can be improved by removing the pull-up resistor R28, which is not actually needed for the AC tach.

The example software requires a setting of the number of pulses (rising and falling edges) per rotation to scale the speed calculation.

### User and debug interface

Connector J1 is the standard 4-pin SWIM connector for programming and debug connections.

Up to three pushbuttons can be installed to provide simple command inputs. The standard board configuration populates only PB1, which is used by the example software as a start/stop command. The other two pushbuttons may be installed and used by user

developed software. Jumper J4, used by the example software, is connected in parallel to PB3, so either J4 or PB3 may be used.

The board layout allows for up to 5 LEDs that user developed software can use. Only LED2 is populated on the standard configuration board and the example software uses it to display motor on/off status.

The two outputs on pins 11 and 12 of the STM8 were designed for a dual function. If a 10uF capacitor is installed in the position marked for LED3 and LED5, the signal on the positive terminal of each capacitor can be used as a diagnostic analog output. The capacitor, along with the 2.2 kΩ series resistor, forms a low pass filter that filters the PWM output from the STM8 to provide a simple DAC function. The example software uses these two PWM outputs to provide useful analog diagnostic signals that can be displayed on a scope. By default, the RPM command (before accel/decel slew limiting) and actual speed are presented. These signals can also be observed at the test points without the capacitors as a pure PWM signal.

*Note: The circuit ground of the PCB is “hot” with respect to the AC mains so it is necessary to operate the board from an isolated supply, such as an isolation transformer, or use an isolated input oscilloscope to make these observations. This warning also applies to the connection of a PC to the swim connector. The board must be powered by an isolation transformer or the connection to the programming dongle must be through an isolating interface.*

Connector J2 is provided to give a serial data output from the UART that may be used for diagnostics to send data to another board. The example software does not use this function.

## 4 Revision history

**Table 3. Document revision history**

| Date        | Revision | Changes          |
|-------------|----------|------------------|
| 28-Nov-2012 | 1        | Initial release. |

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