Description

This motor speed controller board is designed to work with three-phase brushless DC motors with hall sensors. The board model is ZS-Z11H.

Screw Terminal Connector (5-pin)

The five pin connector has connections for driving the motors phases and the power supply input.

- MA – Motor Phase A
- MB – Motor Phase B
- MC – Motor Phase C
- VCC – Power Supply Input 6 to 60VDC
- GND – Power Supply Return

The pin-out is printed in silk screen on the bottom of the board under the connector.

Screw Terminal Connector (6-pin)

The six pin connector has connections for controlling the motor speed, direction, and braking. The board has on on-board 5V 78L05 voltage regulator with a 5V output pin which is intended to be used to power the external potentiometer and to apply voltage to the brake pin through a switch or a relay.

- 5V – Power output from the on-board voltage regulator.
- ANALOG CTRL – Speed control input. 0 to 5V signal that can be driven from the wiper terminal of a potentiometer connected to 5V and ground, or an analogue output of a Digital to Analogue Converter (DAC).
- GND – Ground connection
- DIR – Direction control. This signal is active low. Connecting this pin to ground or applying a logic 0 changes the motor direction. Leaving the pin floating or applying logic 1 will spin the motor in the default direction.
- BRAKE – Controls the motor brake. This signal is active high. Connecting this pin to 5V or applying logic 1 will apply the motors brake. Leaving the pin floating or applying logic 0 will disconnect the brake and allow the motor to spin.
- STOP – Functions as an enable input for the board. This signal is active low. Connecting this pin to ground or applying logic 0 will disable the drive signals. This could be considered a coast or free spin mode. Leaving the pin floating or applying logic high will enable the boards drive signals.

The pin-out is printed in silk screen on the bottom of the board under the connector.

Aux Control Pads and Hall Sensor Connector

The auxiliary control pads allow a user to control the speed of the user using a Pulse Width Modulated (PWM) signal and to read the speed of the motor via the SC speed pulse output interface.

Aux Control Pads:

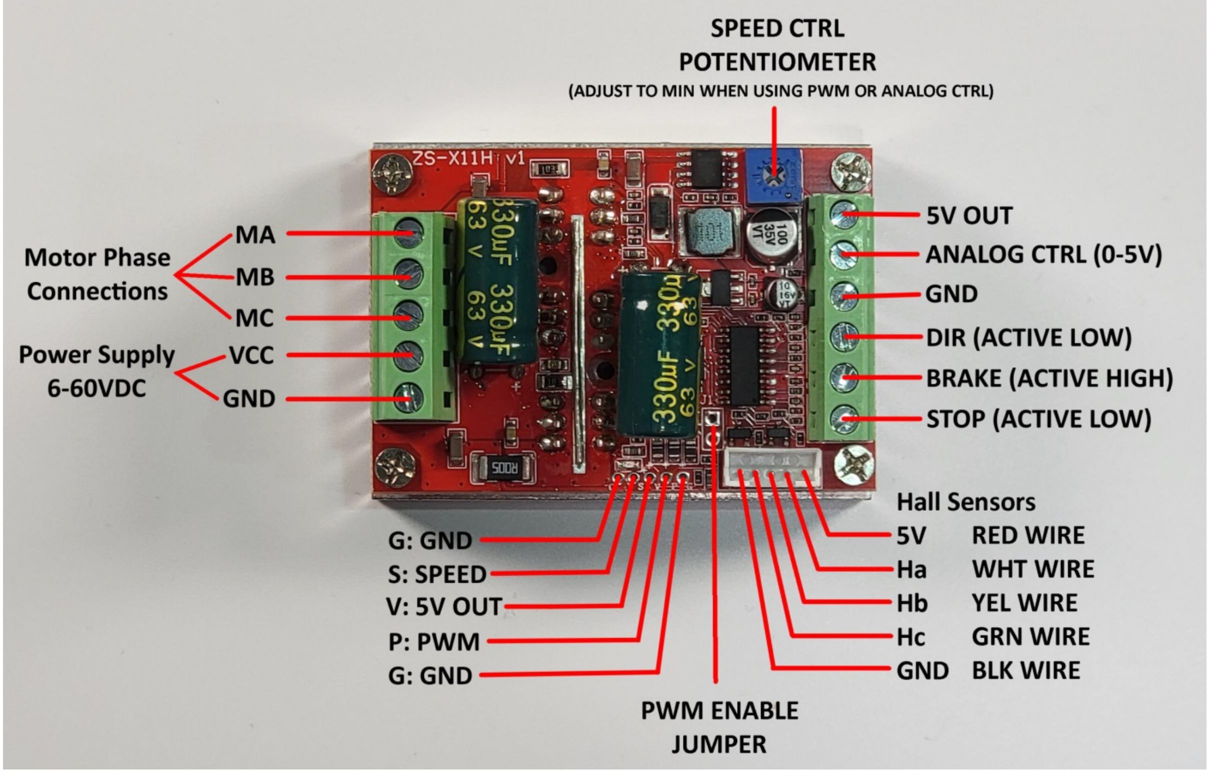
- G – GND: Ground connection for the auxiliary signals.
- S – SC: Speed pulse output interface. This outputs a pulsed signal that can be used to read the speed of the motor. The documents claim this is a reserved interface and they don't provide any technical support regarding this signal. See the Speed Pule Output section for the evaluation of the signal.
- V – 5V: The documentation claims this pin is reserved for a future use. It can however be used to power low current devices.
- P – PWM: This pin can be used to control the motor via a Pulse Width Modulated (PWM) signal. The documentation states the frequency can be from 50Hz to 20 kHz, with an amplitude of 2.5V to 5V. The typically Arduino PWM signal is either 490Hz or 980Hz so it should be no problem controlling the motor speed via this pin. The PWM Jumper must be shorted and the Speed Control Potentiometer must be adjusted to the minimum when using the PWM control pin.
- G – GND: Ground connection for the auxiliary signals.

PWM Jumper

- J1 Jumper – The J1 jumper is used to connect the PWM control line. To use the PWM for motor control the J1 jumper must be shorted. Also the Speed Control Potentiometer must be adjusted to the minimum.

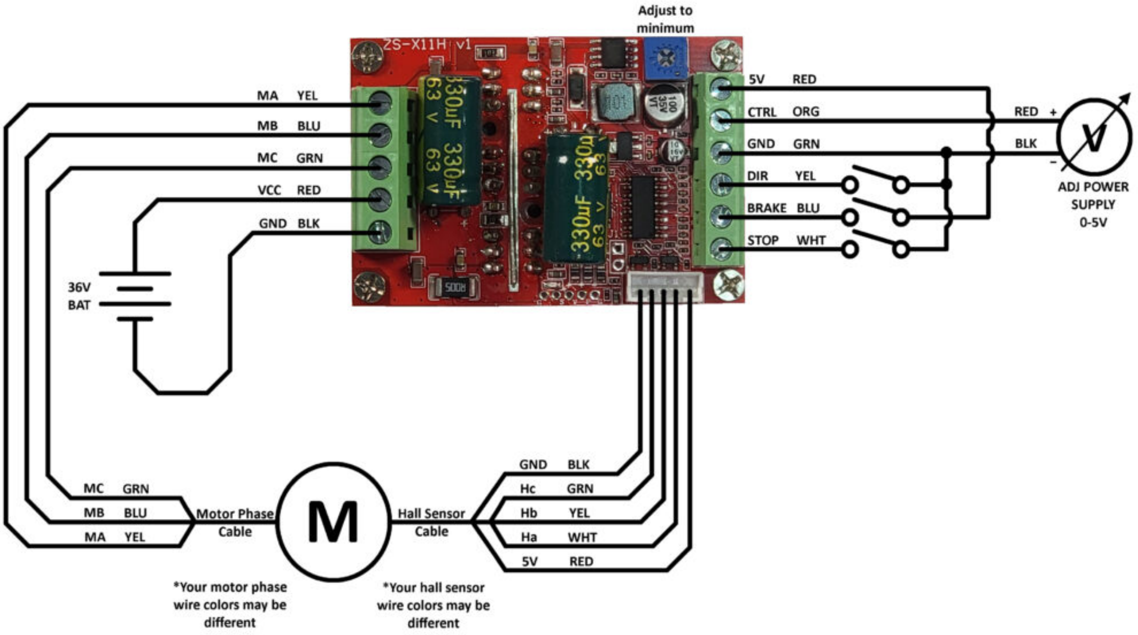
Hall Sensor Connector – A multi-colour cable is provided with the board to connect the motors hall sensors.

- GND – Black wire. Used as a ground for the hall sensors.
- Hc – Green wire. Hall sensor for the motor C phase.
- Hb – Yellow wire. Hall sensor for the motor B phase.
- Ha – White wire. Hall sensor for the motor A phase.
- 5V – Red wire. Hall sensor power.



Schematic

Here is the schematic of the motor driver test setup:



3-Phase Motor Driver Test Setup Schematic

Testing

On board potentiometer: To test the on board potentiometer, disconnect the adjustable power supply from the analogue control screw terminal. Turning the pot clockwise increases the motor speed and counter-clockwise decreases the speed.

Analogue Control: For testing the analogue control, the on board potentiometer should be turned all the way counter-clockwise so it does not interfere with the analogue signal. The motor starts to slowly turn around 0.07V. Increasing the voltage increases the motor speed up to a maximum of 5V. Do not apply voltages above 5V as this will damage the board.

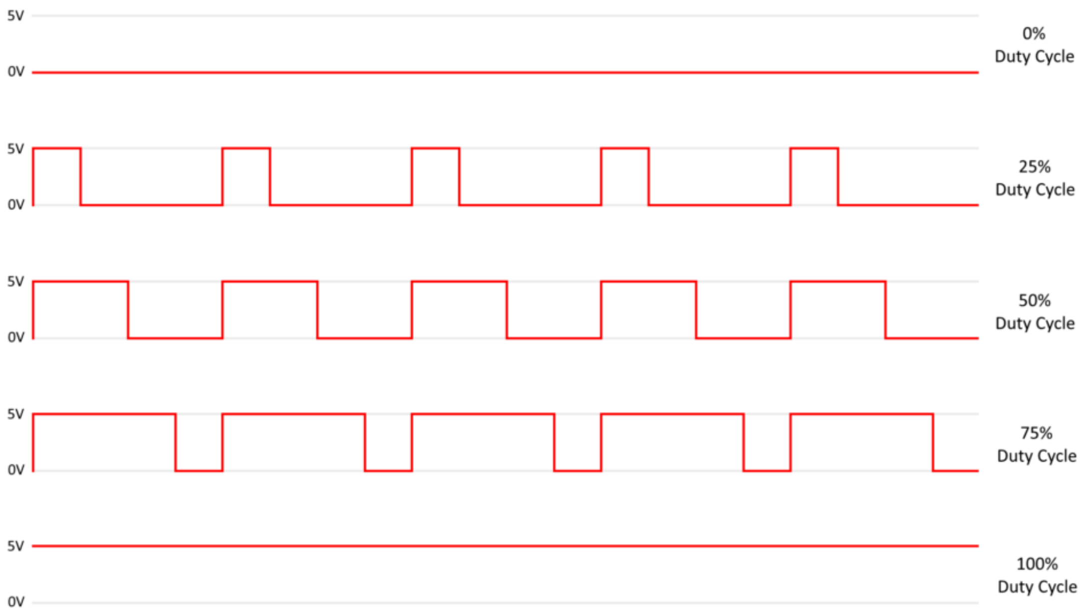
Stop Switch: The stop switch disconnects the motor drive signals. If the motor is spinning flipping the switch will cause the motor to coast to a stop. The motor can easily be rotated with the stop switch engaged. Turning off the stop switch reengages the motor drive signals and the motor will start spinning again if the drive is active.

Brake Switch: The brake switch quickly stops the motor and prevents it from turning. With the brake engaged there is noticeable resistance for the motor to turn. Turning off the switch disengages the brake and the motor starts spinning again. The brake still functions with the stop switch engaged.

Direction Switch: The direction switch changes the direction the motor spins. With the switch turned off the motor spins counter-clockwise. When turned on the motor spins clockwise. Flipping the switch when the motor is turning at high speed works, but is not recommended. It would be best to stop the motor or slow it down before changing directions.

PWM Control

The motor can be controlled using a Pulse Width Modulated (PWM) signal. A PWM signal has a fixed frequency but changes the duty cycle to communicate data. A duty cycle of 0% (constant low) will not drive the motor causing it to be in a free spin. A duty cycle of 100% (constant high) will drive the motor at full speed.



PWM Duty Cycle Examples.

The board's documentation states that a PWM frequency anywhere from 50Hz to 20 kHz should work.

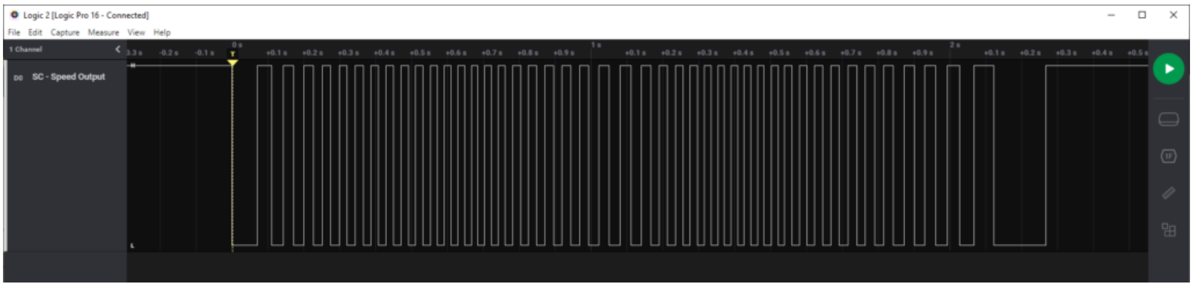
To use the PWM input, J1 link need to be installed. Besides the PWM signal to PWM input, the ground G must be connected to the unit generating the PWM signal.

The speed control potentiometer needs to be adjusted to the off position (counter-clockwise) so it does not interfere with the PWM signal.

SC – Speed Pulse Output

The output signal changes state whenever one of the hall sensors changes state. Effectively the output changes state 90 times for one rotation of the wheel.

The output signal for one rotation is shown below.



Speed pulse output signal for one wheel rotation.

The speed of the wheel can be calculated by measuring the time between two transitions and multiplying the time by 90. The result is the time taken for the wheel to rotate one full revolution. Revolutions per second (RPS) can be calculated by taking the inverse of the rotation time. Multiplying the result 60 will convert the reading to revolution per minute (RPM)

Revolutions per Second:

RPS = 1 / (w * 90)

Revolutions per Minute:

RPM = RPS * 60

This is the output signal at maximum speed.

Speed pulse output signal at maximum speed.

At maximum speed the measured pulse width is 1.1536ms which is 0.0011536 seconds.

RPS = 1/ (0.0011536 * 90)
RPS = 9.632

This means that the wheel is rotating a little over 9 1/2 times per second. Multiplying by 60 gives the RPM.

RPM = 9.632 * 60
RPM = 577.92

Calculating Miles Per Hour

Sometimes it makes more sense to have the speed in miles per hour. To do this the wheel diameter (d) needs to be known. The formula to calculate MPH knowing the RPM and wheel diameter (d) in feet:

MPH = (d * π * RPM * 60) / 5280

For a wheel diameter of about 6.5 inches, this is about 0.542 feet. Working in feet is easier when Calculating MPH.

MPH = (0.542 * π * 577.92 * 60) / 5280
MPH = 11.18

So at max speed the wheel is going about 11 miles per hour. Since for this test, the wheel is operating without any resistance, this is the unloaded speed. It will go slower depending on the load.

Calculating Kilometres Per Hour

Sometimes it makes more sense to have the speed in kilometres per hour. To do this the wheel diameter (d) needs to be known. The formula to calculate KPH knowing the RPM and wheel diameter (d) in meters:

KPH = (d * π * RPM * 60) / 1000

For a wheel diameter of about 16.5 centimetres, which is 0.165 meters?

KPH = (0.165 * π * 577.92 * 60) / 1000
KPH = 17.97

So at max speed the wheel is going about 18 kilometres per hour. Since for this test, the wheel is operating without any resistance this, is the unloaded speed. It will go slower depending on the load.