# The NMIH-0050 H-Bridge

## Features:

- 5 A continuous, 6 A peak current
- Supply voltages from 5.3V up to 40V
- Terminal block for power / motor
- Onboard LEDs for motor operation/direction
- Onboard LED for motor supply
- Single row header for inputs
- Onboard LEDs for input indication
- Onboard LED for digital supply 5V
- Very low RDS ON - typically 200 mOhm @ 25 °C per switch
- Internal freewheeling diodes
- No crossover current
- Undervoltage lockout with hysteresis
- Overtemperature protection with hysteresis
- Output short circuit protected
- Error Flag signal indicator for fault conditions
- Onboard LED for Error Flag for fault detection
- CMOS/TTL compatible inputs with hysteresis
- Wide temperature range; - 40 °C < Tj < 150 °C
- Operating frequency up to 33 kHz

## Benefits:

- Visual indication of status: power, inputs, and drive outputs
- Compact size
- Good thermal distribution
- Internally protected
- Simple connections
- Easy interface
- Easy mounting options w/brackets

The NMIH-0050 Full H-Bridge consists of a dual half h-bridge, screw terminal and pin connectors, single input inversion, and LED status indicators. It is usable for forward-reverse-stop control of many DC servomotors using TTL/CMOS compatible inputs to interface directly with most microcontrollers. It can also be used for phase control of steppers or brushless DC motors. With current handling to 5 A continuous, 6 A peak, it allows more flexibility in use with many small to mid range DC motors. Voltage supply range is from 5.3 to 40 V for the NMIH-0050. Switching characteristics allow PWM frequencies up to 33 KHz. Undervoltage protection, as well as Error Flag generation for shorted outputs, over temperature and over current are available for use.

# Connections for the NMIH-0050

The NMIH-0050 has TTL/CMOS compatible inputs. Looking at the module, screw terminals away from you, board with LED's up, the 0.1 spaced pin connections are the digital signals from the controlling processor. This is J3.
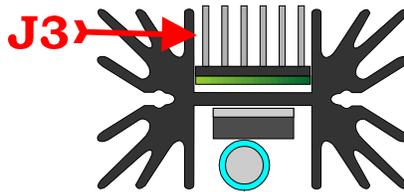


From left to right, these signals are:  Vdd, Gnd, IN1, IN2, IN1', and EF.

| Vdd | Gnd | IN1 | IN2 | IN1' | EF |
|-----|-----|-----|-----|------|----|

Vdd is a logic supply pin, accepting a voltage range of 3 to 6 volts (5 volt nominal) for powering the LED indicator functions on the module. A LED near the Vdd pin serves as a power indicator.  Gnd is a common ground pin, and the return point for the Vdd power signal as well as the ground reference for the other digital control signals. IN1 is the primary input to switch one half of the h-bridge, or both halves using Locked Anti-Phase mode from the microcontroller. IN2 is the secondary input to switch the other half of the h-bridge. Pins IN1 and IN2 also have input indicators to show how the module is being switched by a microcontroller. IN1' is an output pin, the inverted state of the input pin IN1. It is place next to IN2 so, if jumpered, a single signal on IN1 can control the whole H-bridge in Locked Anti-Phase mode. A jumper between IN2 and IN1' drives the module from a single PWM on IN1. Without this jumper, using both IN1 and IN2 pins, Sign Magnitude control can be used. EF is the error flag, an output from the module that your microcontroller can read to detect faults. The EF pin also has a visual LED indicator on the module just below that pin, to show if an error condition has been generated.

A 3-pin .1" connector is provided near the middle of the module as an alternative signal input point. It is J2.
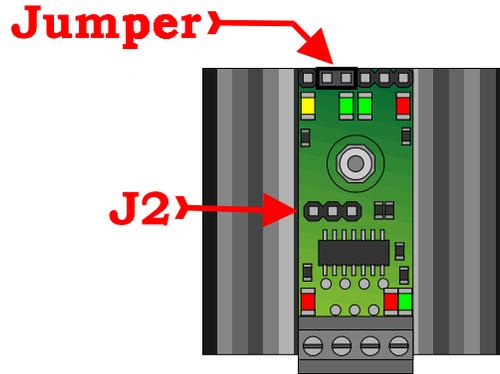


Viewed with screw terminal down, and looking down at the board, it's pins are from left to right: IN1, Vdd, and GND.

| IN1 | Vdd | Gnd |
|-----|-----|-----|

With a jumper between the upper IN2 and IN1' pins on the connector at the edge, J3, this center connector, J2, is a useful place to connect for Locked Anti-Phase control. RC servo pin out are compatible with this center connector. Several microcontrollers, such as the IsoPod™, have this pin out order. Hence this intended as a back up connection point with a different pin out the J3, useful for connecting to PWM outputs wired for RC Servo connections.

Reversing the board, look at it with J1, the 0.35mm spaced screw terminals toward you, board side up.
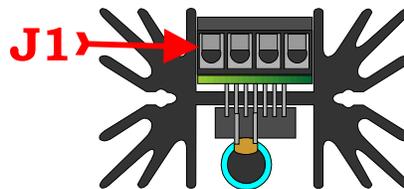


The connector layouts are: GND, V+, OUT2, OUT1.

| Gnd | V+ (motor) | OUT2 | OUT1 |
|-----|------------|------|------|

The left two screw terminals are for the power (or battery) motor supply. GND is the common ground for the motor supply, the driver chip tab, and the heatsink, and a common connection to the digital side ground. Vmotor is the positive voltage motor supply of up to 40 volts for the motor. A power indicator LED here above the V+ supply pin to indicate battery power coming into the module. If you reverse the battery and

motor connections, you will cause the error flag LED to intermittently light and have the motor turning at normal speed with IN1 high, slow speed in the same direction with IN1 low. This could damage your module, but typically it should still function once motor power and motor outputs are connected correctly.
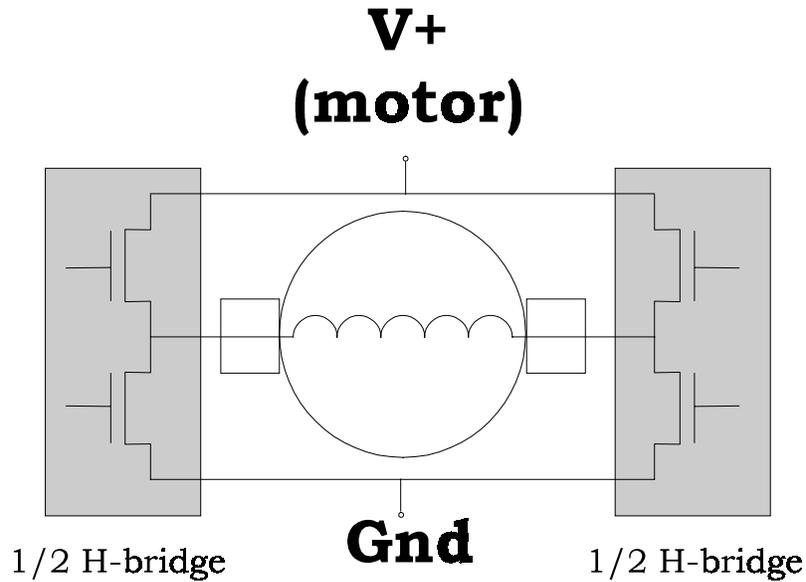


OUT2 is one half of the H-bridge, the output connection to one side of the motor. This half of the H-bridge corresponds to the input IN2 signal. OUT1 is the other half of the H-bridge, the output connection to one side of the motor. This half of the H-bridge corresponds to the input IN1 input. Above the OUT1 output, a pair of LEDs indicates the direction the motor is being driven.
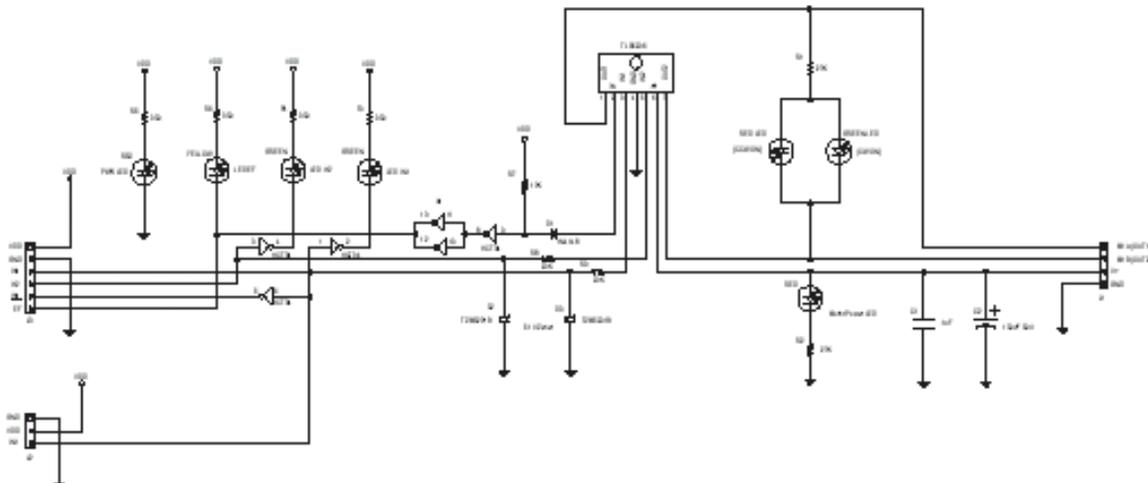
## Functional Truth Table

| IN1 | IN2 | OUT1 | OUT2 | Comments |
|-----|-----|------|------|----------|
| L | L | L | L | Brake; both low side transistors turned-ON |
| L | H | L | H | Motor turns counterclockwise |
| H | L | H | L | Motor turns clockwise |
| H | H | H | H | Brake; both high side transistors turned-ON |

## Notes for Output Stage

| Symbol | Value |
|--------|-------|
| L | Low side transistor is turned-ON<br>High side transistor is turned-OFF |
| H | High side transistor is turned-ON<br>Low side transistor is turned-OFF |

**Control of a DC motor with the NMIH-0050**

The inputs IN1 and IN2 drive the corresponding OUT1 and OUT2 outputs according to the above table:

The module can be driven directly with 2 pins from the controller to the IN1 and IN2 inputs to follow the above table. In Sign Magnitude control, the two pins must be used. IN1 must be switched High with PWM applied to IN2 for forward rotation, or IN2 switched High with PWM applied to IN1 for reverse rotation. The module can be driven directly with a single pin at IN1, if the IN2 input pin is jumpered to the IN1' output pin. The motor is driven constantly forward based on input IN1 being driven high. Or, the motor is driven constantly backward if input IN1 being driven low. In a similar mode, Locked Anti-Phase drives PWM this input, IN1 and the IN2 signal jumpered to IN1' gets a complementary PWM. A 50% duty cycle PWM signal produces a stopped motor, a net braking effect. Higher duty cycle signals produce motor drive in one direction, and lower duty cycle PWM signals drive in the other direction.

**Diagnosis of EF (Error Flag)**

Various errors as listed in the table "Diagnosis" are detected. Short circuits and overload result in turning off the output stages after a delay $t$dSD and setting the error flag simultaneously [EF = L]. Changing the inputs to a state where the fault is not detectable resets the error flag (input toggling). The short circuit from OUT1 to OUT2 (load short circuit) is an exception and shows a constant flag.

| Flag | IN1 | IN2 | OUT1 | OUT2 | EF | Remarks |
|---|---|---|---|---|---|---|
| Short circuit from OUT1 to OUT2 | 0 | 0 | L | L | 1 | Not detectable |
| | 0 | 1 | X | X | 0 | |
| | 1 | 0 | X | X | 0 | |
| | 1 | 1 | H | H | 1 | Not detectable |
| Short circuit from OUT1 to GND | 0 | 0 | GND | L | 1 | Not detectable |
| | 0 | 1 | GND | X | 1 | Not detectable |
| | 1 | 0 | GND | L | 0 | |
| | 1 | 1 | GND | X | 0 | |
| Short circuit from OUT2 to GND | 0 | 0 | L | GND | 1 | Not detectable |
| | 0 | 1 | L | GND | 0 | |
| | 1 | 0 | X | GND | 1 | Not detectable |
| | 1 | 1 | X | GND | 0 | |
| Short circuit from OUT1 to $V_s$ | 0 | 0 | $V_s$ | X | 0 | |
| | 0 | 1 | $V_s$ | H | 0 | |
| | 1 | 0 | $V_s$ | X | 1 | Not detectable |
| | 1 | 1 | $V_s$ | H | 1 | Not detectable |
| Short circuit from OUT2 to $V_s$ | 0 | 0 | X | $V_s$ | 0 | |
| | 0 | 1 | X | $V_s$ | 1 | Not detectable |
| | 1 | 0 | H | $V_s$ | 0 | |
| | 1 | 1 | H | $V_s$ | 1 | Not detectable |
| Overtemperature or undervoltage | 0 | 0 | Z | Z | 0 | |
| | 0 | 1 | Z | Z | 0 | |
| | 1 | 0 | Z | Z | 0 | |
| | 1 | 1 | Z | Z | 0 | |

IN:  0 = Logic LOW       OUT:  Z = Output in tristate condition       EF:  1 = No error
      1 = Logic HIGH             L = Output in sink condition                  0 = Error
                                 H = Output in source condition
                                 X = Voltage level undefined

# Bipolar Stepper Motor Control

Using 2 NMIH-0050 modules, bipolar steppers can be sequenced by a microcontroller. Connecting one modules OUT1 and OUT2 outputs to the A coil and a second modules OUT1 and OUT2 to the B coil, and then driving the two pair of IN1, IN2 inputs, each coil of the stepper can be sequenced according to the desired motion for the stepper. Complementary driving of the IN1 and IN2 will apply power to the stepper coil. Same signal driving of IN1 and IN2 will remove power. Therefore, having a varying PWM on one of the pair and grounding the other can be used as a chopper circuit to control power applied. By using Locked Anti-Phase, micro stepping of some bipolar stepper motors should be possible as well.



1/2 H-bridge B

1/2 H-bridge A

1/2 H-bridge A

1/2 H-bridge B
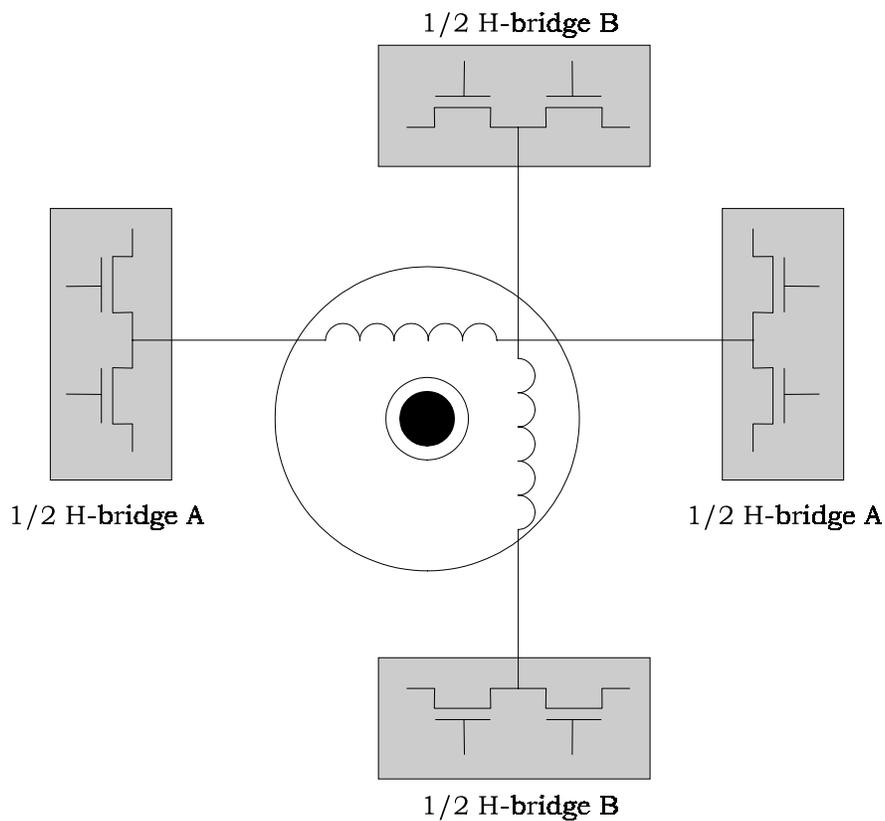
# Circuit Comments

There is no fuse protection on this product. Any fuse protection desired must be provided externally.

The 5.1V Zeners to ground in series with a 20K resistor to the inputs on the board provide protection for the input lines of a controller from the motor supply forcing back into the drive inputs if the internal chip circuitry should catastrophically fail.

Use of 0.1 uf caps on each outgoing line at the motor terminals is recommended. The capacitors are for limiting noise from the motor itself. A much less desirable placement would be at the connector of the H-bridge, which lets the RFI travel through the connections, using them as antennas. Terminate them at the source, the motor, if possible. Typical applications is for one directly across the two motor posts, and another each from the posts to the motor case.

## Mounting the NMIH-0050

Grooves provided in the heat sink of the NMIH-0050 make excellent mounting points. They are sized to accept a 4-40 screw. Self-tapping screws can easily be driven into the soft aluminum heat sink by hand to hold the heat sink to mounting brackets, which can then be attached to any flat surface. Up to two on each end of the heat sink.

For detailed mechanicals, and thermal characteristics of heat sink used in the NMIH-0050 is from Wakefield Engineering. See:
http://www.wakefield.com/pdf/Board_Level_Heat_Sink.pdf at bottom of page 16 of the pdf file (labeled page 45 in text), Part # 647-15ABP. This heat sink can be secured to any flat surface by using Keystone Mounting bracket, item Cat. # 619. See:
http://www.keyelco.com/kec/standpro/specpage/spec36.htm.