Digilent PmodHB3™
2A H-Bridge Reference Manual

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Note: This document applies to REV D of the board.

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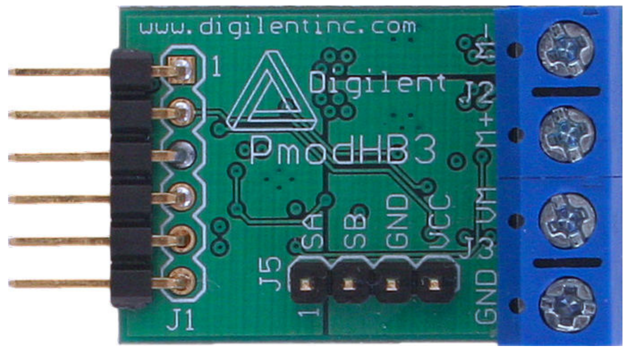
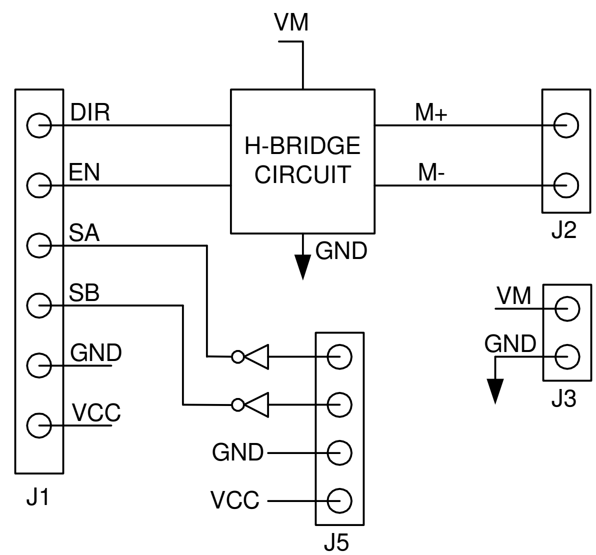
Overview

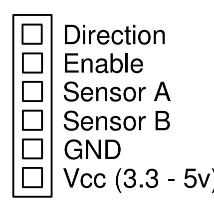
The Digilent PmodHB3™ 2A H-Bridge Module (the HB3) is an ideal solution for robotics and other applications where logic signals are used to drive small to medium-sized DC motors.

Features include:

- a 2A H-bridge circuit for voltages up to 12V
- two two-pin screw terminal blocks for connection to motor
- two buffered inputs for motor speed feedback
- small form factor (0.8" x 1.20")







HB3 6-Pin Header, J1

Functional Description

The HB3 works with power supply voltages from 2.5V to 5V, but is normally operated at 3.3V as this is the supply voltage on most Digilent system boards.

The HB3 is designed to work with either Digilent programmable logic system boards or embedded control system boards. Most Digilent system boards, such as the Nexys, Basys, or Cerebot, have 6-pin connectors that allow the HB3 to plug directly into the system board or to connect via a Digilent 6-pin cable.

Some older Digilent boards may need a Digilent Module Interface Board (MIB) and a 6-pin cable to connect to the HB3. The MIB plugs into the system board and the cable connects the MIB to the HB3.

Motor power is provided via a two-pin terminal block (J3) that can accommodate up to 18-gauge wire. The HB3 circuits can handle motor voltages up to 12V.

The HB3 is controlled by a system board connected to J1. The motor rotation direction is determined by the logic level on the Direction pin. Current will flow through the bridge when the Enable pin is brought high. Motor speed is controlled by pulse width modulating the Enable pin. See below for a description of pulse width modulation. The Direction of the motor should not be reversed while the Enable pin is active. If the direction is reversed while the bridge is enabled it is possible to create brief short circuits across the bridge as one leg will be turning on while the other leg is turning off. This could lead to damage to the transistors making up the bridge.

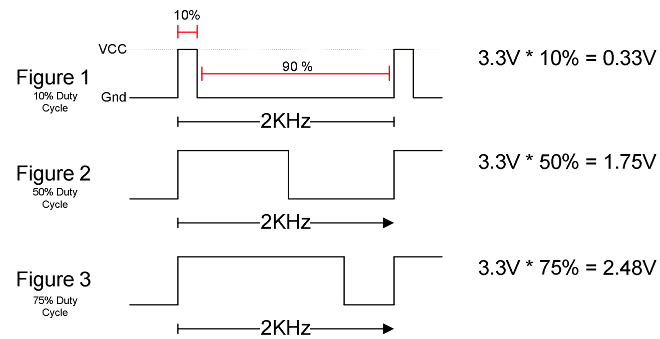
Two Schmitt trigger buffered inputs are provided on connector J5 to facilitate bringing motor speed feedback signals to the controlling system board. These can be connected to various kinds of sensors, such as optical or Hall Effect sensors, to detect motor rotation. These buffers have 5V tolerant inputs when operated at 3.3V.

Pulse Width Modulation and Motor Speed Control

In an analog circuit, motor speed is controlled by varying the input voltage to a circuit. In a digital circuit, however, only a logic high or logic low signal can be applied to the motor. Therefore, there are only two ways to control a motor digitally: use a variable resistance circuit to control the motor voltage, or, pulse the power to the motor. Since variable resistance circuitry is expensive, complicated, and wastes much energy in the form of heat, the better solution is pulse width modulation (PWM).

Pulse width modulation is a digital method of transmitting an analog signal, and while it is not a clean source of DC output voltage, PWM suits motors relatively well.

The figures below illustrate a PWM system with an input frequency of 2KHz. The motor speed is controlled by adjusting the time each wave is at peak output power. Figure 1 shows a 10% "duty cycle" where the signal is logic high for only 1/10 of a wavelength. This 10% positive peak is equal to 10% of the total 3.3V input, or 0.33V (shown in Figure 2). Figures 2 and 3 show duty cycles of 50% and 75%, respectively.



An H-bridge is a voltage amplification and direction control circuit that is used to format the signal to the appropriate motor voltage and polarity to spin the motor.

While voltage is being applied, the motor is driven by the changing magnetic forces. When voltage is stopped, momentum causes the motor to continue spinning a while. At a high enough frequency, this process of powering and coasting enables the motor to achieve a smooth rotation that can easily be controlled through digital logic.

PWM has two important effects on DC motors. Inertial resistance is overcome more easily at startup because short bursts of maximum voltage achieve a greater degree of torque than the equivalent DC voltage. Another effect is a higher level of heat generation inside the motor. If a pulsed motor is used for an extended time, heat dissipation systems may be needed to prevent damage to the motor. Because of these effects, PWM is best used in high-torque infrequent-use applications such as airplane flap servos and robotics.

PWM circuits can also create radio frequency interference (RFI) that can be minimized by locating motors near the controller and by using short wires. Line noise created by continually powering up the motor may also need to be filtered to prevent interference with the rest of the circuits. Placing small ceramic capacitors directly across the motor terminals and between the motor terminals and the motor case can be used to filter RFI emissions from the motor.

For more information see www.digilentinc.com.