Stepper Motor Board

User Manual

1.0, Oct 2013

Table of Contents

Chapter 1. Stepper Motor Board

1. Overview

The Stepper Motor Board is designed to provide a stepper motor controller interface, for unipolar stepper motors, with opto-isolation, to the CPU/MCU development boards. The board incorporates N-channel TrenchMOS logic level FET PMV45EN from NXP Semiconductors to drive high current with fast switching action. The MOSFET driver PMD9002D is also from NXP.

This board offers a high degree of isolation with the use of high speed opto-isolators, between low voltage control side and high voltage motor drive side. It also comes with series of LEDs to indicate each phase of the stepper signals. Power-on delay circuit is provided to give sufficient time to MCU/ Control logic to initialise the stepper input signals to known state thereby avoiding momentary glitches on the motor circuit.

Heavy duty screw terminal blocks are provider for motor lines. A standard 6 PIN header is also provided for easy connection. The TTL compatible inputs allows this board to work with most micro-controllers and control systems. Standard 0.1" FRC headers are provided for easy connection to other control systems. The board can be used for prototype development by hobbyists, engineers and students.

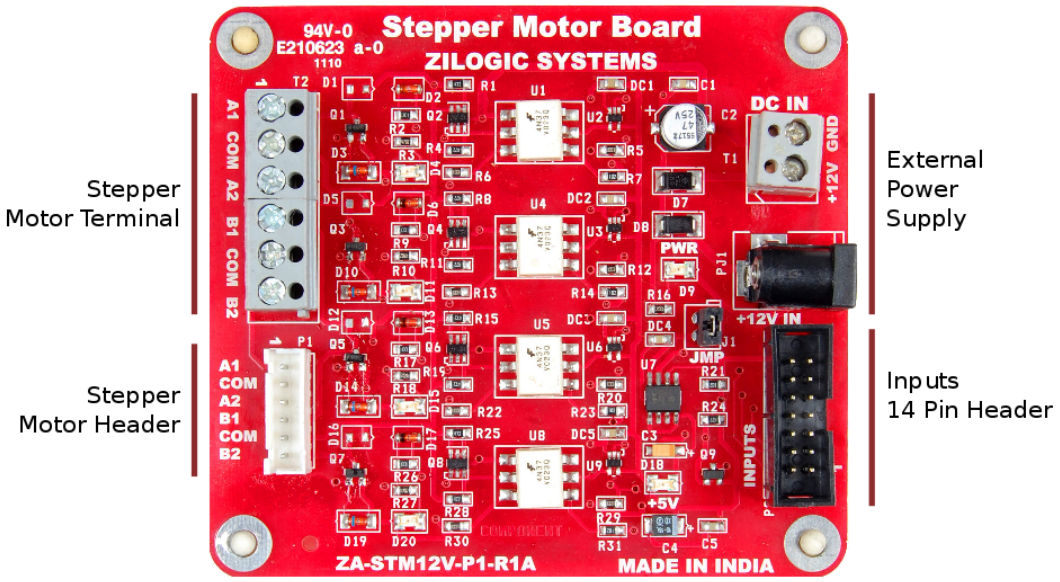
2. Features

- Supports 12V/1Amp Stepper motor
- MOSFET output drive
- Resistor-Equipped Transistor (RET) as MOSFET driver
- Heavy duty screw terminal blocks for motor connection
- High Speed Opto-isolated inputs
- LED Indication for each stepper phase.
- TTL compatible inputs
- Standard 0.1" FRC header for connection to control logic/MCU
- Ready to go with Zilogic's motherboards.

3. Locating Components

The location of the components on the board is indicated in the following diagram.

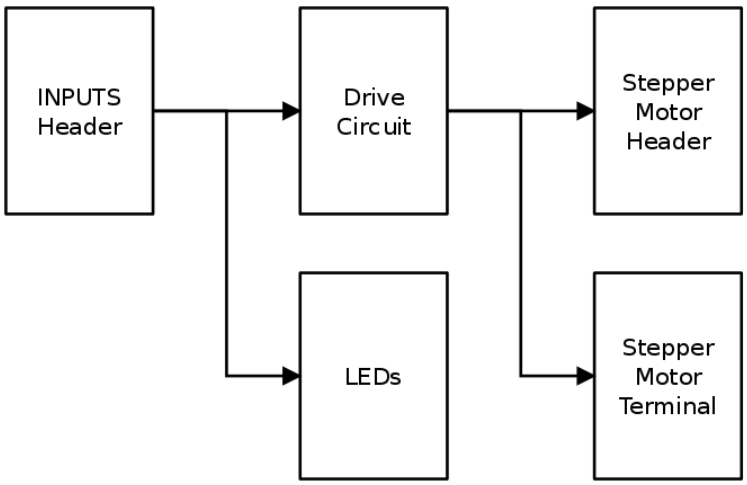
Figure 1.1. Front View



4. Block Diagram

The devices available on the board, is shown in the following block diagram. Each device is described in detail in the following sections.

Figure 1.2. Block Diagram



5. Power Supply

The Stepper Motor Board is powered from the motherboard through the `VCC` on the 14-pin FRC header. The stepper motor itself is powered from an external regulated power supply.

The external supply can be connected through the power jack, or a screw terminal connector. Detailed power supply specifications are available in section Specifications.

6. Control Inputs

The Stepper Motor is controlled through four CMOS/TTL inputs `Input 1` to `Input 4` in the `INPUTS` header. The mapping from the inputs to the stepper motor phases is shown in the following table. When the an input signal, is high the corresponding stepper motor phase is driven +12V.

Signal	Phase
`Input 1`	`A1`
`Input 2`	`A2`
`Input 3`	`B1`
`Input 4`	`B2`

7. Debug LEDs

The Debug LEDs indicate the state of the inputs `Input 1` to `Input 4`. If the input is high then the corresponding LED is turned ON, if the input is low then the corresponding LED is turned OFF.

8. Connectors and Headers

8.1. `INPUTS` Header

The control inputs for the Stepper Motor Board is provided through the `INPUTS` FRC header. The connector details are given below.

Table 1.1. `INPUTS` FRC-14 Header

Pin #	Signal	Signal Type
1	`VCC`	Supply from motherboard
2	`Input 1`	TTL In [1]
3	`Input 2`	TTL In [1]
4	`Input 3`	TTL In [1]
5	`Input 4`	TTL In [1]
6	Not Used	-
7	Not Used	-
8	Not Used	-
9	Not Used	-
10	Not Used	-
11	Not Used	-
12	Not Used	-
13	Not Used	-
14	`GND`	Ground

[1] 5V tolerant input

8.2. `DC IN` Connector

The `DC IN` connector is used to provide an external 12V power supply for the relays.

Table 1.2. `DC IN` Connector

Signal	Signal Type
`+12V`	+12V from external supply
`GND`	Ground

8.3. Stepper Motor Terminal

The relay contacts are used to connect the supply and the load's terminals.

Table 1.3. Stepper Motor Terminal

Signal	Description
`A1`	Winding A Terminal 1
`COM`	Winding A Common
`A2`	Winding A Terminal 2
`B1`	Winding B Terminal 1
`COM`	Winding B Common
`B2`	Winding B Terminal 2

9. Specifications

Parameter	Value	Condition
VCC		
Voltage	5V	
Max. Current	50mA	
External Power Supply		
Voltage	12V	
Max. Current	150mA	
Polarity		
Digital Inputs		
Input Low Voltage	0.0 - 0.8V	
Input High Voltage	2.0 - 5.0V	

Chapter 2. Board Usage

1. Stepper Motor Basics

A Stepper Motor just like any other motor, converts electrical energy into mechanical energy. A stepper motor consists of the following parts:

Stator — The stationary part of the motor. In a stepper motor, the stator is a set of electromagnets.

Rotor — The non-stationary part of the motor. In a stepper motor, the rotor is a permanent magnet.

The arrangement of the electromagnets and the permanent magnets in a simple stepper motor is shown in the following diagram.

Figure 2.1. Stepper Motor Construction

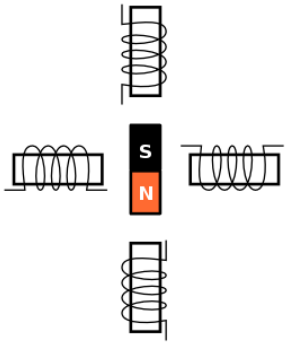
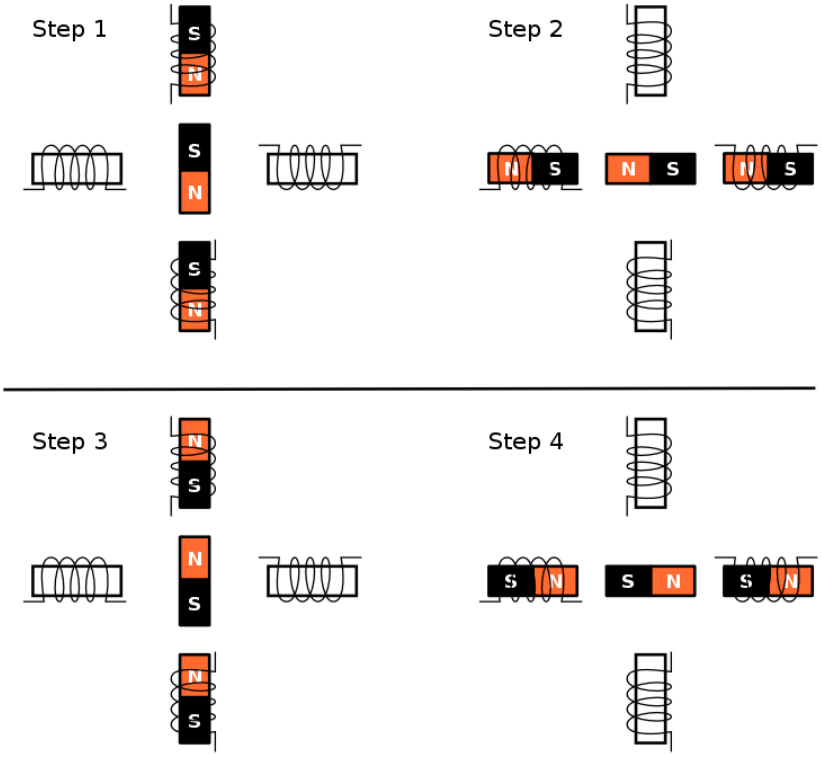


Figure 2.2. Stepper Motor Operation



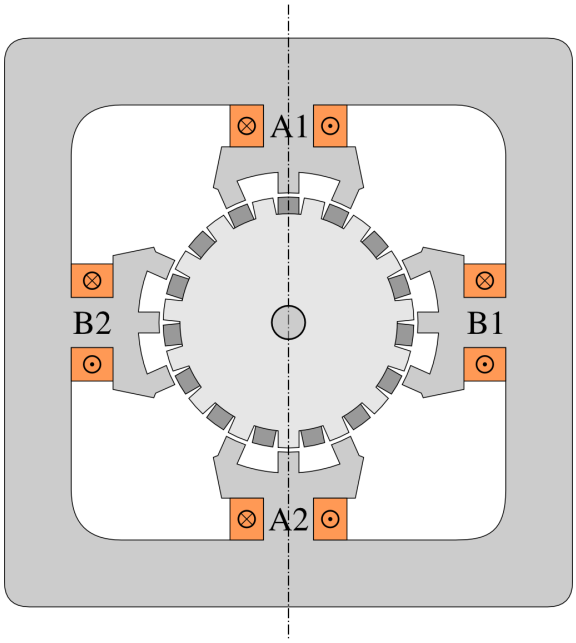
When each of the electromagnet pairs is energized successively, the permanent magnet is attracted to the electromagnet, and aligns with it. This results in rotation of the permanent magnet. This is illustrated in Figure 2.2, “Stepper Motor Operation”. The stepper motor gets its name from the fact that the rotor rotates in discrete step increments.

The simple stepper motor shown in Figure 2.1, “Stepper Motor Construction”, has a step angle of 90 degrees. More complex stepper motors can have step angles as low as 3.6 degrees. These stepper motors have more no. of poles in the rotor.

A complex stepper motor is shown in Figure 2.3, “Complex Stepper Motor”. The dark grey areas on the rotor are South poles and light grey areas on the rotor are North poles. The stator and the poles are arranged such that, when A1 and A2 is aligned with poles on the stator, B1 and B2 are slightly offset by a small angle from the poles on the stator.

Initially, assume that A1 and A2 are energized such that they form North and South poles, respectively. When B1 and B2 are energized to form North and South poles, the rotor rotates in the anti-clock wise direction, to align with the limbs of the electromagnet. And in the next step A1 and A2 are energized such that they form South and North poles, and so on.

Figure 2.3. Complex Stepper Motor

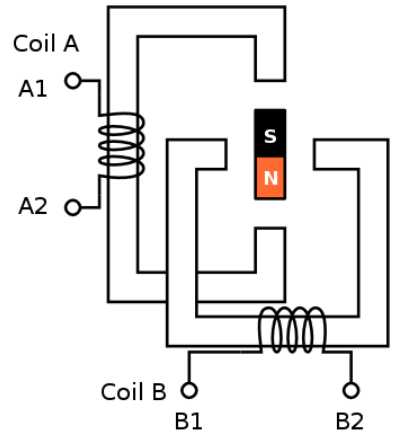


2. Stepper Motor Winding

The stepper motor shown in Figure 2.1, “Stepper Motor Construction” is generally constructed using two electromagnets as shown in Figure 2.4, “Bipolar Wound Stepper Motor”. The stepper motor will have two windings, indicated as `A` and `B`. For the stepper motor, to function, a mechanism should be available to switch the direction of current flow in the coils. This is required so that during Step 1, as indicated in Figure 2.2, “Stepper Motor Operation”, the current in Coil A flows in one direction, and during Step 3, the current in Coil A flows in the opposite direction.

2.1. Bipolar Stepper Wound Motor

Figure 2.4. Bipolar Wound Stepper Motor



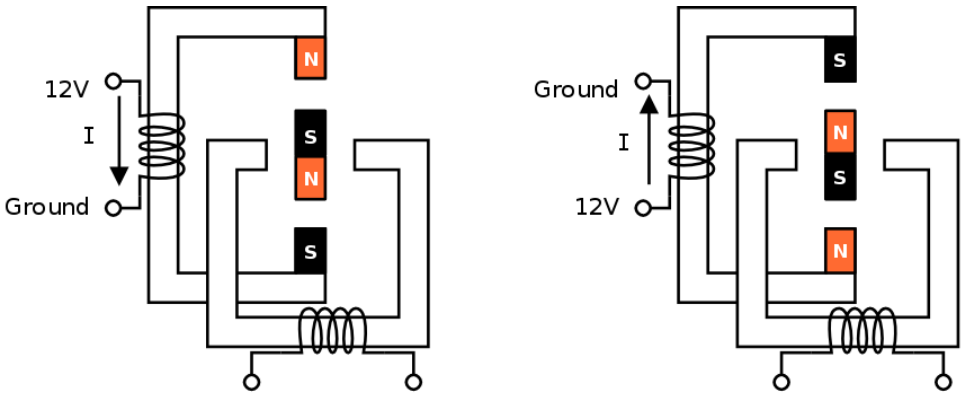
Consider the winding shown in Figure 2.4, “Bipolar Wound Stepper Motor”. During Step 1, Coil A has to be energized as follows. This will result in the required magnetic poles on the electromagnet.

Phase	Voltage
A1	12V
A2	Ground

During Step 3, Coil A polarity has to be reversed. To reverse the poles of the electromagnet, Coil A has to be energized as shown below

Phase	Voltage
A1	Ground
A2	12V

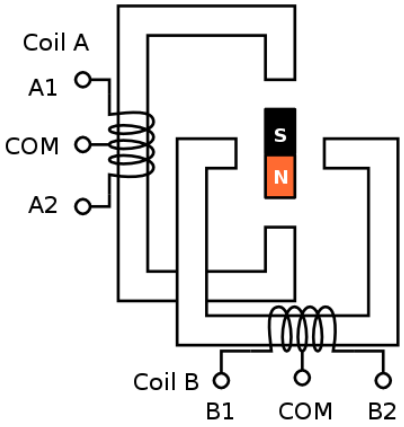
Figure 2.5. Bipolar Stepper Motor in Step 1 and Step 3



The same applies to Coil B. This type of stepper motor is called Bipolar Wound Stepper Motor.

2.2. Unipolar Wound Stepper Motors

Figure 2.6. Unipolar Wound Stepper Motor



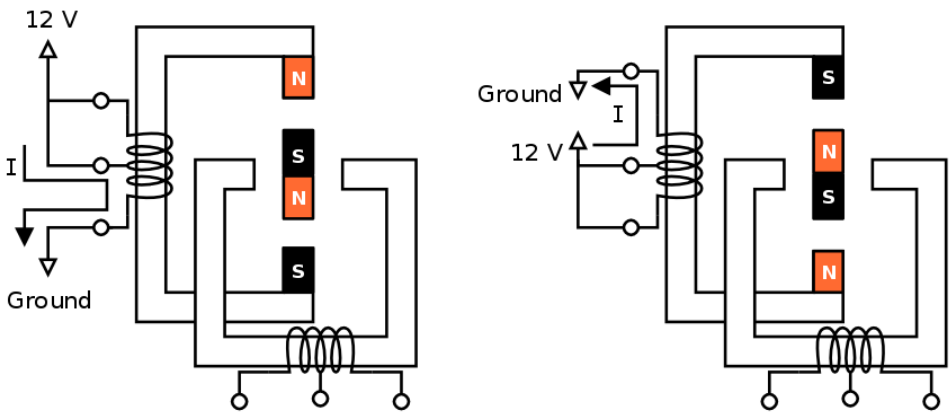
Bipolar Wound Stepper Motors, require additional circuits to reverse the polarity of the coils. To simplify this, another class of stepper motors called Unipolar Wound Stepper Motors, provide an additional center tap in the windings. The center tap is always connected to the power supply, say 12V. With the center tap in place, during Step 1, the phases will be driven as shown below

Phase	Voltage
A1	12V
COM	12V
A2	Ground

During Step 3, to reverse the magnetic poles, the phases will be driven as shown below.

Phase	Voltage
A1	Ground
COM	12V
A2	12V

Figure 2.7. Unipolar Stepper Motor in Step 1 and Step 3



3. Drive Modes

The Drive Mode, indicates the order in which the coils are energized for the stepper motor to complete one turn. For the drive mode shown in Figure 2.2, “Stepper Motor Operation”, the excitation sequence is shown in the following table. The phases indicated with a *, are driven 12V, while the other phases are connected to ground.

Phase	Step 1	Step 2	Step 3	Step 4
A1	*			
B1		*		
A2			*	
B2				*

This drive mode, is called the Wave Drive. This is the simplest drive mode. The disadvantage is that, in the case of bipolar motors, only 50% of the winding is utilized, and in the case of unipolar motors, only 25% of the winding is utilized.

The Full Step Drive mode, utilizes the 100% of the winding in the case of bipolar motors and 50% of the winding in the case of unipolar motors. The excitation sequence is shown in the following table.

Phase	Step 1	Step 2	Step 3	Step 4
A1	*			*
B1	*	*		
A2		*	*	
B2			*	*

Since the winding utilized is higher than the Wave Drive mode, the Full Step Drive mode provides a higher holding torque compared to the Wave Drive mode.

Appendix A. Legal Information

1. Copying

2. Limited Hardware Warranty

The warranties provided by Zilogic Systems in this Limited Hardware Warranty apply only to Hardware Products you purchase for your use, and not for resale. The term "Hardware Product" means a computing device with a specific function and limited configuration ability.

2.1. LIMITED HARDWARE WARRANTY

Zilogic Systems warrants that the hardware components of its Hardware Product shall be free from material defects in design, materials, and workmanship and will function, under normal use and circumstances, in accordance with the documentation provided, for a period of one (1) year from the date of purchase of the Hardware Product.

Your sole and exclusive remedy, and Zilogic Systems' sole and exclusive liability for defective hardware components, shall be that Zilogic Systems, subject to the terms and conditions of this Section, and solely upon confirmation of a defect or failure of a hardware component to perform as warranted, shall at its sole option, either repair or replace the nonconforming hardware component. All replacement parts furnished to you under this warranty shall be refurbished and equivalent to new, and shall be warranted as new for the remainder of the original warranty period. All defective parts, which have been replaced, shall become the property of Zilogic Systems. All defective parts that have been repaired shall remain your property.

2.2. EXCLUSIONS

The foregoing warranties and remedies shall be void as to any Hardware Products damaged or rendered unserviceable by one or more of the following: (1) improper or inadequate maintenance by anyone other than Zilogic Systems or Zilogic Systems' authorized engineers, (2) interfacing supplied by anyone other than Zilogic Systems, (3) modifications, alterations or additions to the Hardware Products by personnel not certified by Zilogic Systems or Zilogic Systems' authorized engineers to perform such acts, or other unauthorized repair, installation or other causes beyond Zilogic Systems' control, (4) unreasonable refusal to agree with engineering change notice programs, (5) negligence by any person other than Zilogic Systems or Zilogic Systems' authorized engineers, (6) misuse, abuse, accident, electrical irregularity, theft, vandalism, fire, water or other peril, (7) damage caused by containment and/or operation outside the environmental specifications for the Hardware Products, (8) alteration or connection of the Hardware Products to other systems, equipment or devices (other than those specifically approved by Zilogic Systems) not in accordance to the board and on-board device specifications (9) any use that is inconsistent with the user manual supplied with the Hardware Product. The warranty period is not extended if Zilogic Systems repairs or replaces a warranted product or any parts. Zilogic Systems may change the availability of limited hardware warranties, at its discretion, but any changes will not be retroactive.

2.3. HARDWARE RETURN PROCEDURES

If a Hardware Product or one of its component parts does not function as warranted during the warranty period, and such nonconformance can be verified by Zilogic Systems, Zilogic Systems, at

its election, will provide either return and replacement service or replacement with a refurbished part/unit for the Hardware Product under the type of warranty service Zilogic Systems designates for that Hardware Product. A defective Hardware Product or one of its component parts may only be returned to Zilogic Systems upon Zilogic Systems' prior written approval. Any such approval shall reference an RMA number issued by an authorized Zilogic Systems service representative. If you do not register the Hardware Product with Zilogic Systems, you may be required to present proof of purchase as evidence of your entitlement to warranty service. The Hardware Product's serial number will be required for all RMA cases.

Transportation costs, if any, incurred in connection with the return of a defective item to Zilogic Systems shall be borne by You. Any transportation costs incurred in connection with the redelivery of a repaired or replacement item to You by Zilogic Systems shall be borne by Zilogic Systems; provided, however, that if Zilogic Systems determines, in its sole discretion, that the allegedly defective item is not covered by the terms and conditions of the warranty or that a warranty claim is made after the warranty period, the cost of the repair by Zilogic Systems, including all shipping expenses, shall be reimbursed by You.

2.4. HARDWARE REPLACEMENT PROCEDURES

Zilogic Systems will attempt to diagnose and resolve your problem over the phone or e-mail. Upon determination of the hardware issue is related to a malfunction of one of the Hardware Product components, an RMA process will be initiated by Zilogic Systems.

For Warranty Replacement service, it is required that you deliver the faulty unit to a location Zilogic Systems designates, and provide courier name and tracking number to Zilogic Systems. After the Faulty unit is returned to Zilogic Systems, Zilogic Systems will use commercially reasonable efforts to ship the replacement hardware within fourteen (14) business days. Actual delivery times may vary depending on availability of the spares and customer's location.

2.5. ADDITIONAL RESPONSIBILITIES

You agree:

- To provide Zilogic Systems or its partner with sufficient and safe access to your facilities to permit Zilogic Systems to fulfill its obligations.
- To ship back the faulty Hardware Product (or replaceable unit) suitably packaged, quoting the RMA number, to the Zilogic Systems designated location.
- You shall ship the faulty Hardware Product once Zilogic Systems approves the RMA and provide the courier name and tracking number.
- To securely erase from any Hardware Product you return to Zilogic Systems for any reason all programs and data not provided by Zilogic Systems with the Hardware Product. You acknowledge that in order to perform its responsibilities under this Limited Hardware Warranty, Zilogic Systems may ship all or part of the Hardware Product or its software to third party locations around the world, and you authorize Zilogic Systems to do so.

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