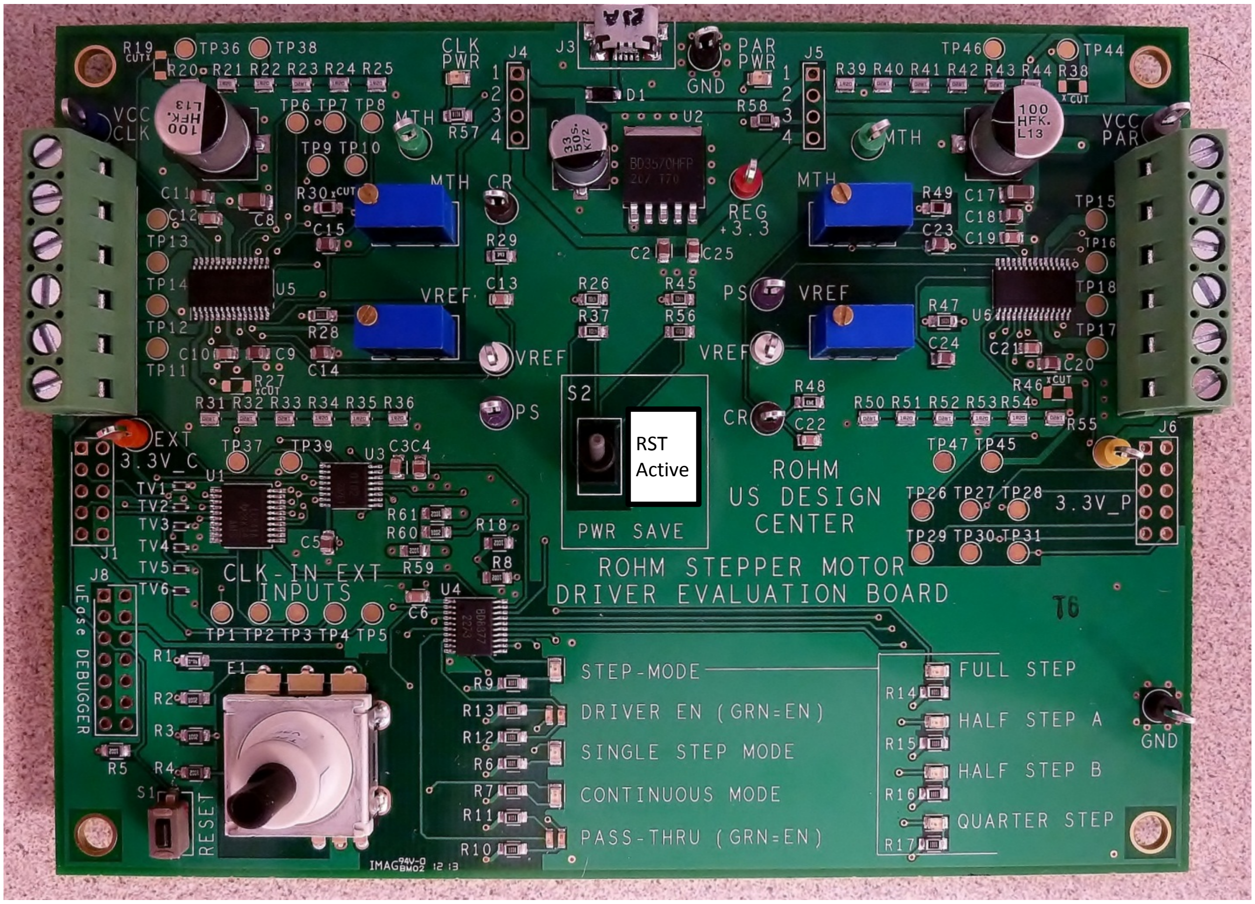
ROHM SEMICONDUCTOR

STEPPER MOTOR EVAL BOARD USER MANUAL



Evaluation Board Objective

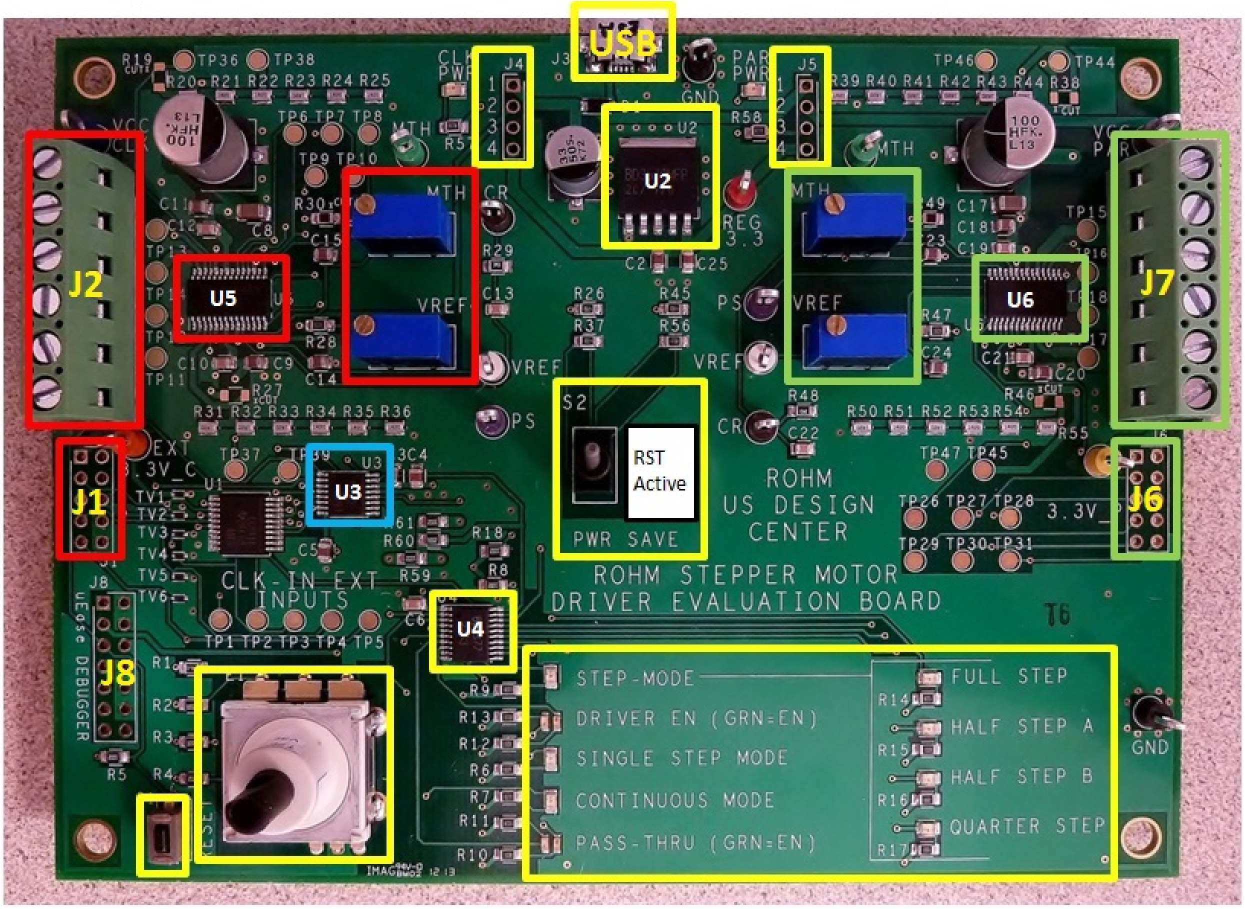
To allow customers and applications support the ability to evaluate any of Rohm's BD637xx High Performance and BD638xx Micro Stepping Motor Drivers in a quick and easy environment. This document will describe the operation and functionality of the evaluation board.

Functionality

The evaluation board has two drivers installed, the **BD63720** Clock-in and the **BD63876** Parallel input type. The BD63720 clock-driven High Performance Stepper Motor Driver is connected to an on-board LAPIS micro (ML610Q102) for demonstration purposes.

Each circuit can also be connected to a user's external MCU to control the driver and operate the attached stepper motor. Additionally, the BD63720 circuit can be controlled manually in a single step or continuous mode. The BD63720 and BD63876 are the 2A versions of each type. Users of lower current devices will be able to use these for evaluation as well.

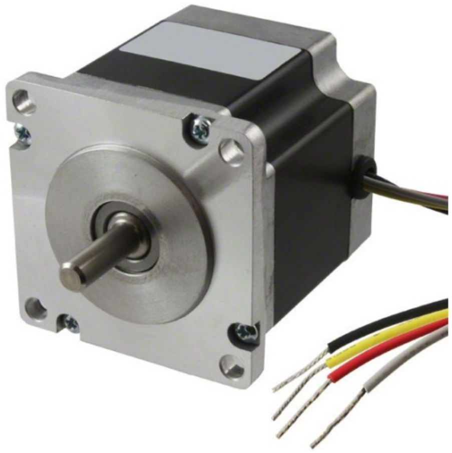
Overview



Getting to know your Stepper Motor Eval Board

- The RED Blocks in the Picture above highlight the key portions of the **ROHM BD63720 Clock-in Stepper Motor Driver LSI (U5)**. The green terminal Block (**J2**) is where you will add Power for the Stepper Motor (i.e.: 24Vdc & GND), as well as where you will connect the 4 legs of the Bi Polar Stepper Motor windings if you want this IC to drive the Motor. This motor driver LSI is designed to be controlled via on-board pre-programmed **Lapis ML610Q102** mcu (Blue Box above) (**U3**), or able to control via external mcu provided by the user (**J1**)
- The Green Blocks in the Picture above highlight the key portions of the **ROHM BD63876 Parallel-in Stepper Motor Driver LSI (U6)**. The green terminal Block (**J7**) is where you will add Power for the Stepper Motor (i.e.: 24Vdc & GND), as well as where you will connect the 4 legs of the Bi Polar Stepper Motor windings if you want this IC to drive the Motor. This motor driver LSI is designed to be controlled only via external mcu provided by the user (**J6**)
- The ROHM (**SML-21 Series**) **LED's** in the lower corner of the board are controlled via a **ROHM BD8377 12-ch. LED Driver** (**U4**), and are used to indicate which Machine State the eval board in currently in in (adjustable via the push button encoder knob (**E1**)):
  - 4 possible Step Modes (Full, Half-A, Half-B or Quarter Step)
  - 2 possible Driver States (Disabled or Enabled)
  - 2 Possible Operation Modes (Single-Step or Continuous Mode)
  - 2 Possible Pass-Thru States (Disabled or Enabled)

- **Suggested Motor**
  - Portescap 23H118D10B Stepper Motor (1.8 Deg Step Angle; BiPolar)
  - Availible at DigiKey: http://www.digikey.com/product-detail/en/23H118D10B/403-1039-ND/1894182



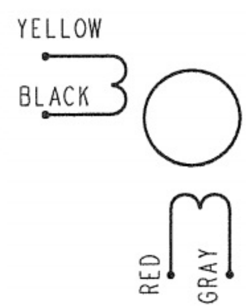
- **Motor Wiring Diagram**

PORTESCAP 23H 118D 10B BiPolar Stepper Motor

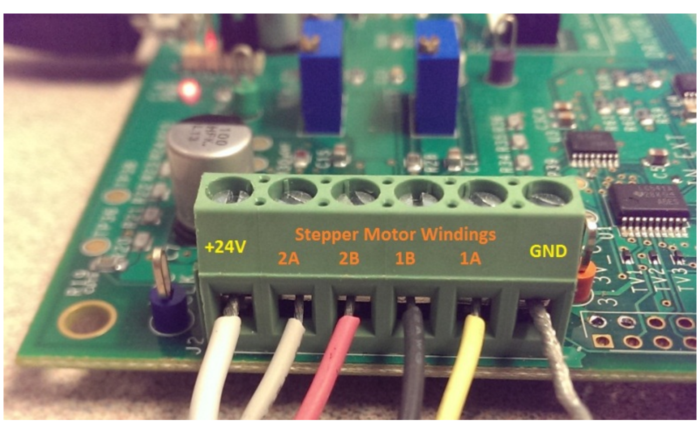
BIPOLAR COIL			
RED	GRAY	YELLOW	BLACK
+	-	+	-
+	-	-	+
-	+	-	+
-	+	+	-
+	-	+	-

IN ↓ ↑ OUT

VIEWED FROM OUTPUT SHAFT



- **Terminal Block Connections**



- **Key Potentiometer & Switch Settings**
  - **MTH** => Current decay mode setting terminal (SLOW, MIXED or FAST Decay)
  - **VREF** => Output current value setting terminal
  - **CR** => Terminal to set the Chopping Frequency of output
  - **PS** => Power Save terminal - can put circuit in standby mode state and allow motor to operate
  - **J4 & J5** => Both should jump pins 3 & 4 together to allow powering control circuitry (3.3V) on the eval board from the power provided in the USB connector (5V) which is regulated down to 3.3V via the **ROHM BD3570HFP LDO Voltage Regulator (U2)**.

Evaluation Board Objective

To allow customers and applications support the ability to evaluate any of Rohm's BD63720 & BD63876 High Performance Stepping Motor Drivers in a quick and easy environment.

Functionality

The evaluation board has two drivers installed, the BD63720 Clock-in and the BD63876 Parallel input type. Each circuit can be connected to a user's MCU to control the driver and operate the attached stepper motor. Additionally, the BD63720 circuit can be controlled manually in a single step or continuous mode.

LED INDICATORS

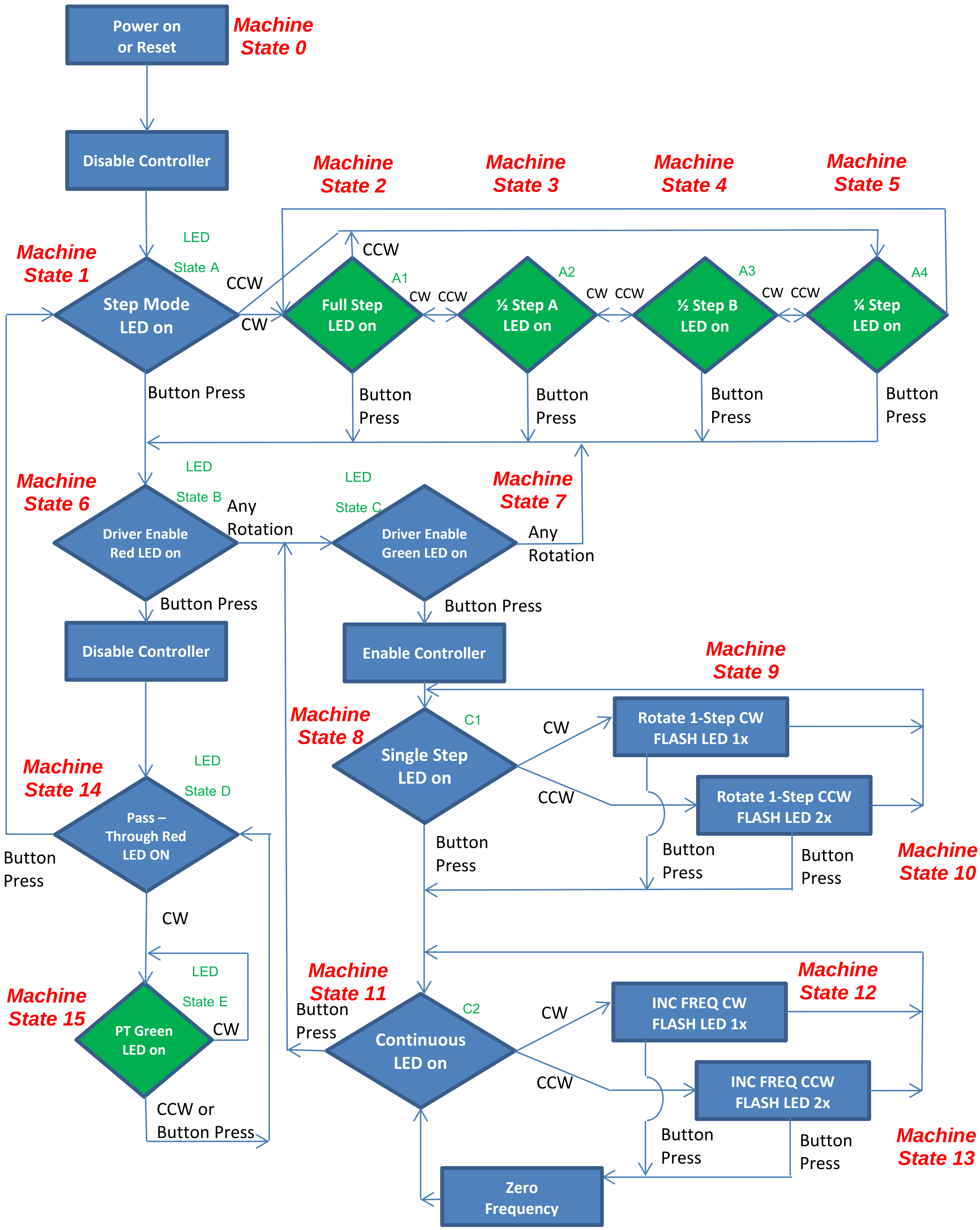
- Step Mode — Indicates that the step modes can be selected by rotating the knob.
  - **Full Step** — Indicates that the Full Step Mode has been selected for manual mode
  - **Half Step A** — Indicates that the Half Step A Mode has been selected for manual mode.
  - **Half Step B** — Indicates that the Half Step B Mode has been selected for manual mode.
  - **Quarter Step** — Indicates that the Quarter Step Mode has been selected for manual mode.
- Driver Enabled - RED — Indicates that the Manual mode is ready but currently disabled
- Driver Enabled - GREEN — Indicates that the driver is now enabled for Manual mode
- Single Step Mode — Indicates that the board is prepared to operate in single step mode.
- Continuous — Indicates that the board is prepared to operate in continuous mode.
- Pass Through - RED — Indicates that the Pass-Through mode has been selected but disabled
- Pass Through - GREEN — Indicates that the Pass-Through mode is now enabled

KEY Components

BD63720EFV - 36V Extra High-performance & High Reliability Stepper Motor Driver

The BD63720EFV is a bipolar low-consumption driver that is driven by PWM current. Rated power supply voltage of the device is 36 V, and rated output current is 2.0A. CLK-IN driving mode is adopted for input interface, and excitation mode is corresponding to FULL STEP mode, HALF STEP mode (2 types) and QUARTER STEP mode via a built-in DAC. In terms of current decay, the FAST DECAY/SLOW DECAY ratio may be set without any limitation, and all available modes may be controlled in the most appropriate way. In addition, the power supply may be driven by one single system, which simplifies the design.

Microcontroller Firmware Logic Diagram (Rev 2.2)



STEPPER THEORY

A **stepper motor** is an electromechanical device which converts electrical pulses into discrete mechanical movements. The shaft or spindle of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in the proper sequence. The motors rotation has several direct relationships to these applied input pulses. The sequence of the applied pulses is directly related to the direction of motor shafts rotation. The speed of the motor shafts rotation is directly related to the frequency of the input pulses and the length of rotation is directly related to the number of input pulses applied.

Advantages

1. The rotation angle of the motor is proportional to the input pulse.
2. The motor has full torque at stand-still (if the windings are energized)
3. Precise positioning and repeat-ability of movement since good stepper motors have an accuracy of 3–5% of a step and this error is non-cumulative from one step to the next.
4. Excellent response to starting/stopping/reversing.
5. Very reliable since there are no con-tact brushes in the motor. Therefore the life of the motor is simply dependent on the life of the bearing.
6. The motors response to digital input pulses provides open-loop control, making the motor simpler and less costly to control.
7. It is possible to achieve very low speed synchronous rotation with a load that is directly coupled to the shaft.
8. A wide range of rotational speeds can be realized as the speed is proportional to the frequency of the input pulses.
9. **Open Loop Operation:**
   One of the most significant advantages of a stepper motor is its ability to be accurately controlled in an open loop system. Open loop control means no feedback information about position is needed. This type of control eliminates the need for expensive sensing and feedback devices such as optical encoders. Your position is known simply by keeping track of the input step pulses.

Disadvantages

1. Resonances can occur if not properly controlled.
2. Not easy to operate at extremely high speeds.

There are three basic stepper motor types.

They are:

- Variable-reluctance
- Permanent-magnet
- Hybrid

Theory

What are the advantages of using step motors?

1. Speed can be easily determined and controlled by remembering that speed equals steps per revolution divided by pulse rate.
2. A step motor can make fine incremental moves.
3. A step motor doesn't require encoder feed-back (Open loop).
4. Non-cumulative positioning error.
5. Excellent low speed/high torque characteristics without gear reduction.
6. Holding torque of the step motor can be used to hold loads in stationary position without over -heating.
7. Ability to operate on a wide speed range.

40% more torque

The number of turns is doubled in bipolar mode and Ip equals $1/\sqrt{2}$ of Ic when two coils are connected in series. The torque is approximately proportional to the Amps times the turns. If the NI represents unipolar drive torque, then the $2N*(1/\sqrt{2})\ I\ (=\sqrt{2}\ NI)$ will represent the bipolar drive when coils connected in series. $\sqrt{2}$ are approximately 40% more than 1. The number of turns is the same in bipolar mode and Ip equals $\sqrt{2}$ of Ic when two coils are connected in parallel. If the NI represents unipolar drive torque, then the $N*\sqrt{2}\ I\ (=\sqrt{2}\ NI)$ will represent the bipolar drive when coils connected in parallel. $\sqrt{2}$ are approximately 40% more than 1.

Unipolar vs. Bipolar

Unipolar - A unipolar driver's output current direction cannot be changed.
There are two sets of the coils for each phase in a motor.
Only one set of the coils can be energized at a time.
Each coil represents one phase.
Therefore, only 50% of the winding is utilized in the unipolar drive. The number of mechanical phases equals the number of electrical phases.
Due to the fact unipolar drivers only use 50% of the windings, the performance ranges from low to moderate.
The benefit of this is that it doesn't generate too much heat.

Bipolar - A bipolar driver's output current direction can be changed. 100% of the winding is utilized in the bipolar drive.
That means the two sets of the coils in each phase can be connected either in series or in parallel to become one set of a coil.
Current direction changed from the driver creates another mechanical phase.
The number of mechanical phases is always twice the number of electrical phases.
Bipolar drivers provide 40% more holding torque than unipolar drivers, but typically run at higher temperatures.
For this reason, proper heat dissipation is important with bipolar drivers.

1.8 degree or 0.9 degree?

Step accuracy is the primary character of a step motor. Without step accuracy, the motor is useless. Based on motor manufacturing capability, step accuracy is rated at +/- 5% of the full step. That means a 1.8-degree motor would have step error of +/- 5.4 arc minutes, while 0.9-degree motor would have step error at +/- 2.7 arc minutes. This is because the motor step accuracy is determined by the torque stiffness, and the torque stiffness is determined by maximum holding torque and the number of rotor teeth.

Motor torque function: $T(\theta) = To*Sin(N\theta)$

Torque stiffness: $dT(\theta)/d = N*To*Cos(N\theta)$

(where To=maximum holding torque, N=number of rotor teeth,
θ=rotor displacement)

A 1.8-degree motor has a 50-tooth rotor and 0.9-degree motor has a 100-tooth rotor. With the same manufacturing capability, a 0.9-degree motor will have twice the step accuracy of a 1.8-degree motor.

How can 4 wire, 6 wire and 8 wire motors be connected?

First of all two drivers exist: Unipolar and Bipolar. Unipolar drives output to 6 leads of a step motor and Bipolar output to 4 leads of a step motor. So a 4 lead motor can only be connected to a Bipolar driver. A 6 lead and 8 lead motor can either be connected to a Unipolar driver and or a Bipolar driver.

Holding Torque vs. Dynamic Torque

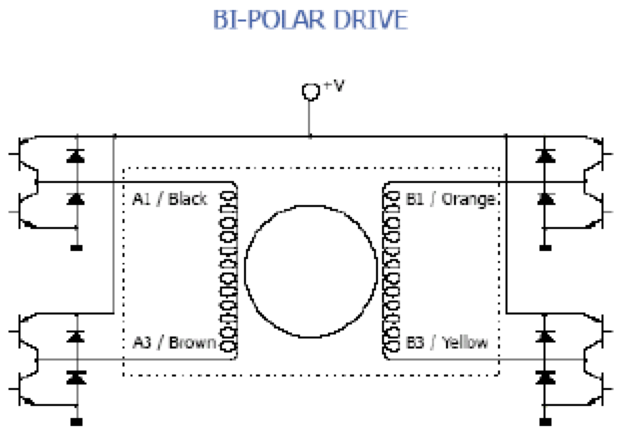
Holding torque is the maximum restoring torque developed by the rotor when one or more phases of the motor are energized.
The dynamic torque is called running torque or pullout torque.
It varies at different speed by different driver technologies and power input.
As a rule of thumb, the maximum dynamic torque is about 70% of the holding torque.

How fast can I run my step motor?

Most stepper motors are designed for low speed (3000 rpm or less) operation. Once you get into higher speeds, servo motors are typically used.

Bi-Polar Motor Drive Wiring

Example Diagram:



Inputs and Outputs

Except for the Circuit Ground, the two circuits on the PCB will be completely separate so as not to back feed or cause erroneous inputs to the operating circuit. There are four I/O types on the board: Terminal Block (TB), Test Point (TP), Micro USB (MU) and Header (HDR). Terminal blocks are used to connect to power, ground and the motor. Test Points are used on all of the I/O signals to allow for easy monitoring with an oscilloscope or meter or to allow quick connection with a test lead. Header connections are used on the control inputs to allow an easy cable connection to an MCU.