SKYPIKIT ARDUINO SHIELD BOARDS
FOR TELESCOPE MOTORS: STEPPERS OR DC WITH ENCODERS

Revision 2020.02.17
This set includes boards that fit directly onto an ARDUINO. Each board is thus an Arduino shield which is used to control a telescope motor.

Usually two boards stacked on an Arduino are used to control the two motors of a telescope mount, right ascension and declination.

A third board could be stacked to control, for example, a motorized focuser motor.

The set currently includes two models of boards, a model for bipolar stepping motor and a model for DC motor with encoder.

In a real application, you must insert the Arduino and these boards inside a box and add all the necessary elements: cables, connectors, switches, fuse, simple handbox, power supply, etc.

The following pages describe in detail the operation and use of the bipolar stepper motor board.

Next is the description of the board for DC motor with encoder.
Arduino Skypikit Board for Bipolar Stepper Motor
Arduino Skypikit Board for Bipolar Stepper Motor
Arduino Skypikit Board for Bipolar Stepper Motor

- **ICSP connector, plus Index and Sensor**
- **Standard Arduino adapters**
- **Optional Arduino connections for soldering**
- **Connector to a quadrature encoder (optional)**
- **Limit switch connector**
- **Regulated 9 volts output for VIN (optional)**
- **Main 10 to 24 volts DC supply according to motor model**
- **Connections to the bipolar motor coils**
- **Connector to the autoguiding camera**

Board connectors functions
Only the following pins of the Arduino are used by the Skypikit board:

- GND
- VIN
- I2C communication: SDA and SCL

All the other pins of the Arduino are free to be used for other purposes and their use can be programmed in the Arduino sketch: for controller, Bluetooth communication,...
All the circuits can be powered by a single 10 to 24 volt DC power supply, depending on the motor used. The positive terminal is connected to VM and the negative terminal is connected to GND.

This power can come from a 12-volt car battery, a regulated power supply, or a wall adapter providing at least 3 amps.

In order for the main power supply to supply the Arduino and Skypikit circuits in addition to supplying the motor, the Skypikit board contains a LM7809 regulator which supplies a 9 volt DC source at a maximum of 1.5 amps and which is connected to the VIN Arduino input.
The main power must be connected to all Skypikit boards.

The power connector on each board contains two VM pins and two GND pins to facilitate the interconnection of power between the boards.

The 9-volt regulator is only present on the top board. By connecting the regularized 9-volt output to the VIN input on the top board, this powers all the boards, including the Arduino, since the VIN pins on all the boards are connected together by the Arduino adapters.

You can stack up to three Skypikit boards on the Arduino.
The motor can also be powered by a power supply different from that which powers the Arduino and the Skypikit.

This configuration is only allowed if there are no more than two Skypikit shields stacked on the Arduino, i.e. two motors to control, since the 9-volt source which powers the Arduino must also supply Skypikit boards via the VIN pin.
A bipolar stepper motor contains two coils, coil 1 and coil 2. We recognize a bipolar motor because it has four wires.

You can use a multimeter on the ohm scale to find which terminals are the ends of each coil. If your multimeter indicates a measurable resistance (usually between 5 and 100 ohms), you are connected to the ends of a coil. Take the opportunity to note the value of the resistance of each coil. This will be useful for adjusting the current limit of the A4988 driver (see below).
You can easily use a 6-wire unipolar motor as a bipolar motor. You simply do not connect the COM terminal of each coil.

You can use a multimeter on the ohm scale to find which terminals are the ends of each coil. The resistance between the two ends of a coil is twice the resistance between one end and the COM center of the coil.
With the A4988 module, a higher voltage than the nominal motor voltage can be used, since this circuit can actively limit the current in the coils. This allows the motor to run much faster than if only the nominal voltage were used.

The maximum current that can pass through each motor coil is equal to the nominal motor voltage indicated by the manufacturer divided by the resistance of the coil which you can measure with a multimeter:

\[ I_{\text{max}} = \frac{V_{\text{nominal}}}{R_{\text{coil}}} \]

For example, if you measure 60 ohms across each coil of a 6-volt stepper motor, the maximum current allowed will be 6 volts / 60 ohms, or 0.1 amps or 100 mA.

The maximum current is adjusted with a small current limit potentiometer located on the A4988 driver.

To know the adjusted current limit, you must use a multimeter on the 200 millivolt scale, and measure a voltage \( V_{\text{ref}} \) proportional to this current using the following formula:

\[ V_{\text{ref}} = 8 \times R_{\text{cs}} \times I_{\text{max}} \]

where \( I_{\text{max}} \) is the maximum wanted current and \( R_{\text{cs}} \) a resistance whose value is 0.1 ohm for the A4988 modules distributed with the boards.

For example, for a wanted current of 100 mA, we obtain

\[ V_{\text{ref}} = 8 \times 0.1 \text{ ohm} \times 100 \text{ mA} = 80 \text{ mV} \]

If the motor is noisy with the current limit obtained, you can make tests by slightly reducing this limit.
The A4988 power driver can be configured to operate with different micro-step per step values.

The board is delivered with the configuration to have 16 micro-steps per step, which is recommended, with bridges already installed in positions MS1, MS2 and MS3.

If you want to modify this configuration, you can do so by cutting certain bridges according to the positions given in the table.

Check the results using the SKYPIKIT MOTOR TESTER TUNER app.

<table>
<thead>
<tr>
<th>MS1</th>
<th>MS2</th>
<th>MS3</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Full step</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Half step</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4 micro-steps/step</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8 micro-steps/step</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>16 micro-steps/step</td>
</tr>
</tbody>
</table>

The table shows the positions where bridges must be installed for each configuration.
The stepper motors are controlled in open loop and do not need a quadrature encoder to know their position.

The Skypikit only counts the micro-step pulses it sends to the power driver to know the position of the stepping motor.

Normally, a quadrature encoder is not used with stepper motors and the encoder connector is not used.

However, nothing prevents you from using a quadrature encoder for another use. The Skypikit is then able to count the steps of an encoder at the same time as controlling an open-loop stepper motor.

Please note: the encoder must operate on a 5-volt supply.
Arduino Skypikit Board for Bipolar Stepper Motor

The autoguiding cameras are supplied with a modular 6-wire RJ12 cable, according to the ST-4 standard. The wires have colors in a specific order. Be careful to respect the order of the connections.

<table>
<thead>
<tr>
<th>Numéro du fil</th>
<th>Couleur</th>
<th>Assignation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>white</td>
<td>NC (not connected)</td>
</tr>
<tr>
<td>2</td>
<td>black</td>
<td>GND (Ground)</td>
</tr>
<tr>
<td>3</td>
<td>red</td>
<td>RA+ (R.A. correction, towards East)</td>
</tr>
<tr>
<td>4</td>
<td>green</td>
<td>DE+ (Decl. correction, towards North)</td>
</tr>
<tr>
<td>5</td>
<td>yellow</td>
<td>DE- (Decl. correction, towards South)</td>
</tr>
<tr>
<td>6</td>
<td>blue</td>
<td>RA- (R.A. correction, towards West)</td>
</tr>
</tbody>
</table>

Connection to an autoguiding camera
A 6-wire cable can be used for connections to the simple handbox. See the handbox diagram on the next page. The effects of the actions when the buttons are pressed are programmed in the ARDUINO sketch.
Arduino Skypikit Board for Bipolar Stepper Motor

SIMPLE HANDPAD with FOCUS
for SPK-SHIELD boards

<table>
<thead>
<tr>
<th>Button</th>
<th>V out</th>
<th>Value x</th>
</tr>
</thead>
<tbody>
<tr>
<td>iddle</td>
<td>0 V</td>
<td>0</td>
</tr>
<tr>
<td>east</td>
<td>5.00 V</td>
<td>1023</td>
</tr>
<tr>
<td>west</td>
<td>2.50 V</td>
<td>512</td>
</tr>
</tbody>
</table>

Pot. V out = 0 V to 5.00 V
Pot. values = 0 to 1023

REV. 19.06.04
Arduino Skypikit Board for Bipolar Stepper Motor

Example shown with normally open limit switches.

LIMIT+ towards North or East
LIMIT- towards South or West
Electronic circuit diagram for the bipolar stepper motor board
Arduino Skypikit Board for Bipolar Stepper Motor

Component identification
Arduino Skypikit Board for DC Motor with Encoder
Arduino Skypikit Board for DC Motor with Encoder
The DC motor is closed loop controlled and needs a quadrature encoder so the Skypikit can know its position and speed.

Warning: the encoder of the selected motor must work with a 5 volt supply.

All other functions and connections on this board are identical to those on the bipolar stepper motor board.

See the description of the bipolar stepper motor board for the other functions of this board.
Arduino Skypikit Board for DC Motor with Encoder

Electronic diagram of the board for the DC motor with encoder
Arduino Skypikit Board for DC Motor with Encoder

Component identification