MOTORIZE YOUR TELESCOPE WITH ARDUINO AND SKYPIKIT

by Jean Vallières v. 2023-01-20

Motorize a telescope mount to enable it to do astronomical photography and visual observation using ARDUINO and SKYPIKIT microcontrollers.

Why such a project ?

- Improve the control of an existing telescope, for example add the possibility of GoTo or autoguiding to a telescope which does not have one;
- replace the circuits of a telescope whose electronics have stopped working;
- motorize a home made telescope;
- motorize the focuser of a telescope;
- want to understand how your telescope works and be able to repair it yourself rather than relying on random after-sales services from certain manufacturers.

To meet these goals, I developed an open motorization and telescope control system which could be reproduced and modified to apply to several situations and several models of telescopes.

This new system is based on the ARDUINO platform and on a microcontroller chip, called SKYPIKIT, capable of performing all the complex tasks of controlling a telescope mount, which greatly simplifies the design and programming of the other components of the system.

Photos taken with a mount modified by the author of this project.

Work and skills required

Attention : The SKYPIKIT project is not a turnkey system, even if the printed circuit boards are already assembled and tested.

This project requires certain basic skills and knowledge to be undertaken successfully.

Here are some of the tasks you will need to be able to perform:

- Interpret and understand the instructions, diagrams and electronic diagrams of the documents included in this site;
- Test and optimize the operation of your circuits with the Skypikit Motor Tester Tuner application;
- Find the right values of the PID parameters with this same SMTTA application if you have DC motors with encoders;
- Find the right current limit values if they are stepper motors;
- Correctly connect your motors, encoders, cables, connectors, etc. to the Skypikit system;
- Mount the circuits in a case and do some soldering properly if necessary;
- Install and operate the necessary software: Coelix, Skypikit FEX, ASCOM driver and others;
- Install the Arduino platform and be able to modify the generic Arduino sketch according to the properties of your mount, then upload it to the Arduino microcontroller;
- Enter the correct control parameters in the Skypikit Fex and ASCOM applications according to the properties of your mount;
- Finally, do the real tests on the sky, and make the corrections if necessary for fast movement speeds (slew, goto), for sidereal tracking (tracking) and for autoguiding.

The ARDUINO or compatible platform

ARDUINO is an open-source and flexible electronic prototyping platform based on easy-to-use hardware and software. It is intended for creators, designers, amateurs and anyone interested in creating interactive objects or environments.

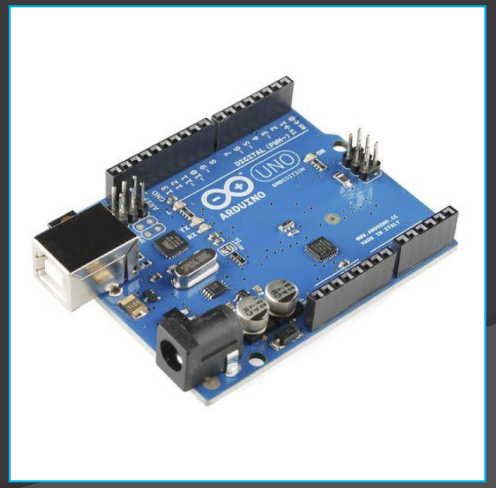
It is therefore a highly documented platform on the Internet and used by electronic DIY enthusiasts around the world. In addition, it is mounted on a relatively cheap circuit (about 20 USD).

The ARDUINO is programmed with a simplified C language since it can be used by amateurs and in schools for initiation to robotics and programming.

You can also find many compatible circuits if you don't want to use the original ARDUINO.

In this project, we assume that you have already used an ARDUINO or that you know how to program it.

Otherwise, you can get an ARDUINO or an ARDUINO experiment kit and consult the abundant documentation that exists on the Web.



ARDUINO UNO board

The SKYPIKIT chip

The SKYPIKIT chip is a microcontroller specialized in the control of telescope motors. It contains all the internal electronic devices and a firmware program specially programmed to accomplish all the complex tasks of controlling an equatorial telescope mount, which greatly simplifies the design and programming of the other components of the system.

The fact that several tasks are executed in hardware inside the chip rather than programmed increases the performance of the control: speed of response, precision, etc.

The SKYPIKIT is capable of controlling both a DC motor with encoder and a stepper motor.

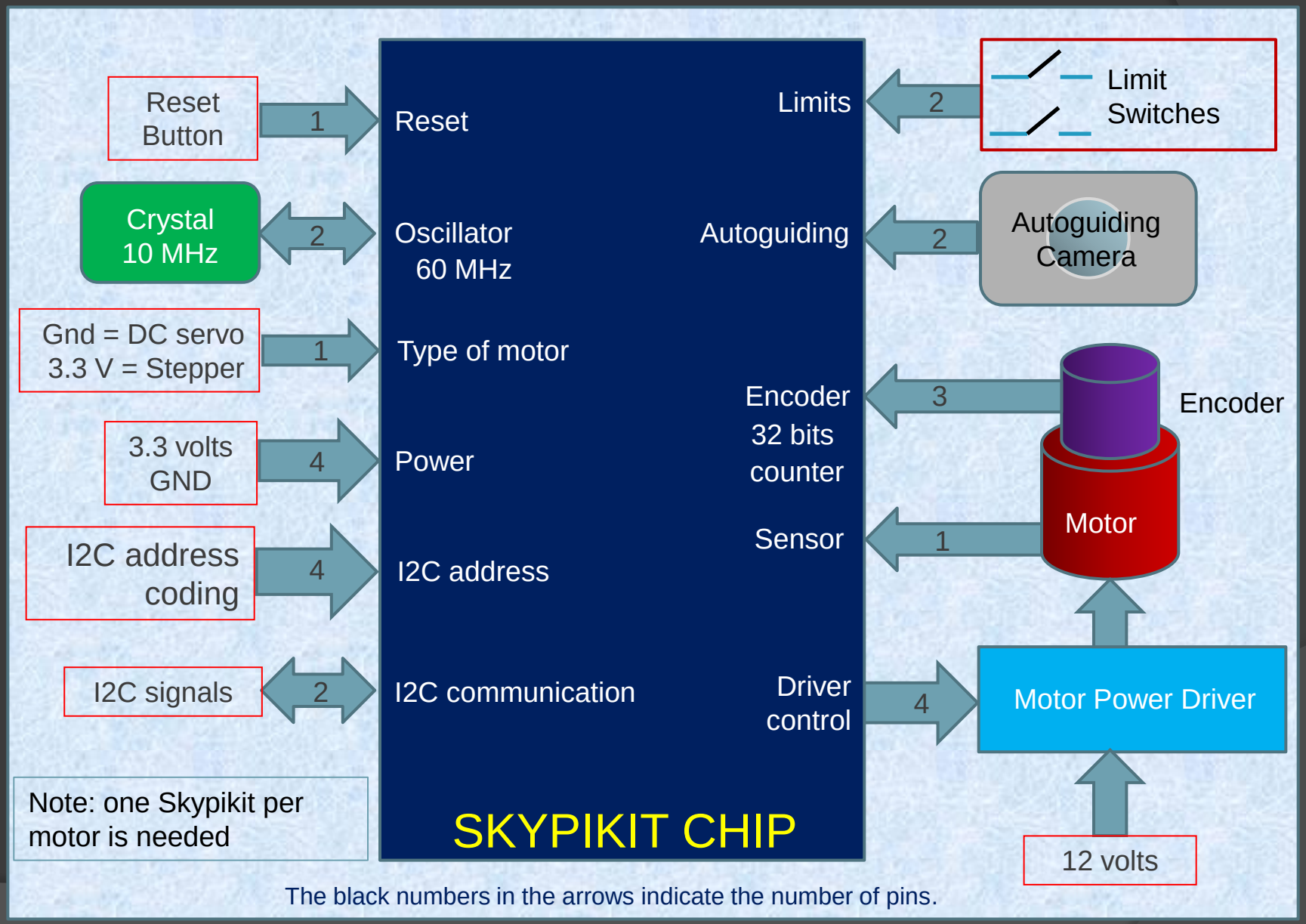
The SKYPIKIT communicates with the ARDUINO by an I2C link. It receives the ARDUINO commands (GoTo, Track, Slew, Stop, etc.) and returns the controller states (positions, movement status (tracking, slewing, etc.)) to it.

On the motor side, pins connect to a motor power driver and other pins can receive signals from a position encoder.

SKYPIKIT chip

SKYPIKIT chip (inputs and outputs)

See the SKYPIKIT manual for more details.



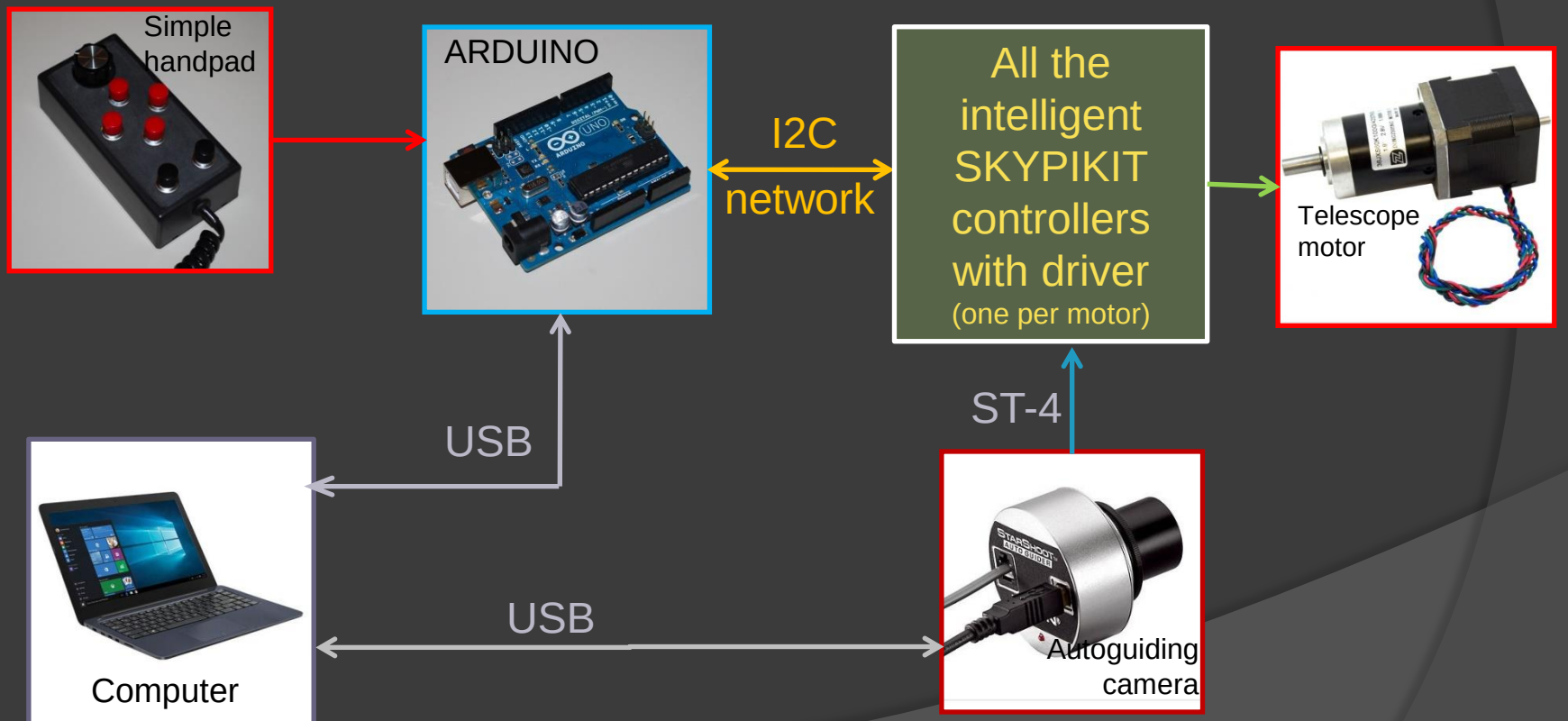
What the SKYPIKIT can do and what you do not need to program in the ARDUINO

- Control both DC motors with quadrature encoder and stepper motors, by connecting to several types of motor power drivers;
- operate in a sidereal reference system to control a right ascension motor or in a fixed reference system to control a declination, focuser or field rotator motor;
- make GoTos and manual movements with configurable acceleration and deceleration speeds and ramps, and making a final approach always in the same direction if desired to take into account the backlash in the gears;
- make movements by adjustable steps or by pressing a button;
- tracking at any desired speed;
- vary the tracking speed during tracking, which could be used for an azimuth mount or for automatic adjustment of the tracking speed;
- autoguiding directly from the signals of a guide camera or from “Pulse Guide” commands;
- autoguiding at an adjustable guide speed;
- reverse the direction of movement, tracking and guiding, which can be used when the telescope makes a meridian flip or if it is used in the southern hemisphere;
- detect limit switches and automatically stop the motors if the telescope moves outside the safe limits;
- Optional: detect an Index signal, which could be used to start a periodic error correction sequence;
- Optional: detect a current that is too high at the motor with a Sensor pin and automatically stop it if this current exceeds a configurable safety value.

Diagram of a system with ARDUINO and SKYPIKIT

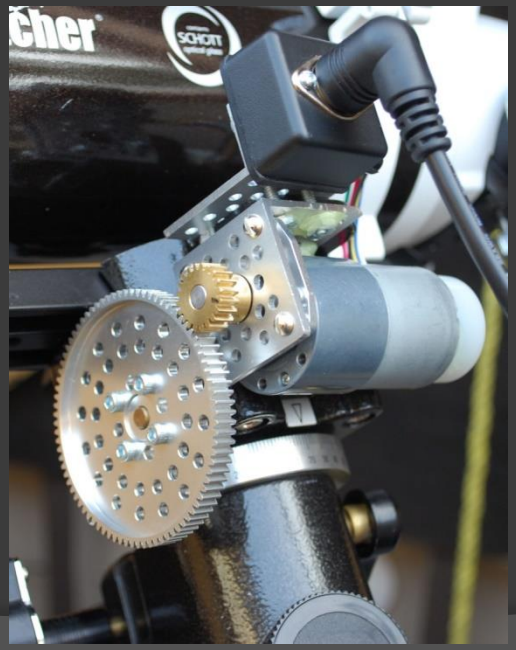
The control functions of the telescope motors are all in the SKYPIKITs.

The ARDUINO program contains only interfaces with external elements: computer, simple handpad, etc.



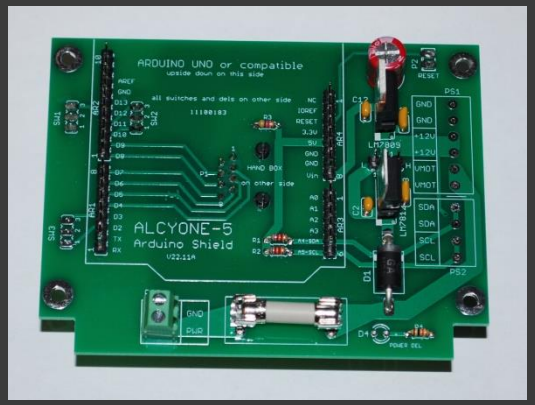
The circuits using Skypikit can control the original motors of your mount…

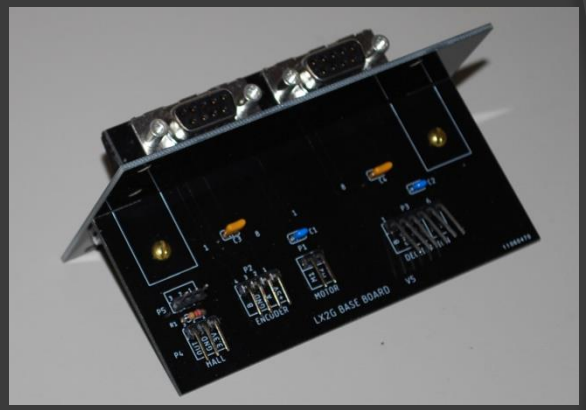
… as well as the motors that you added to your mount

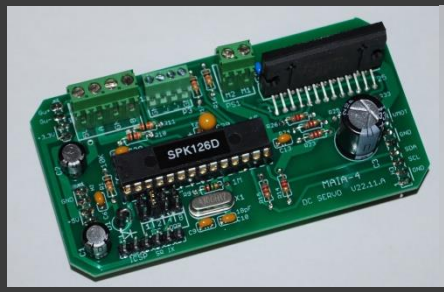


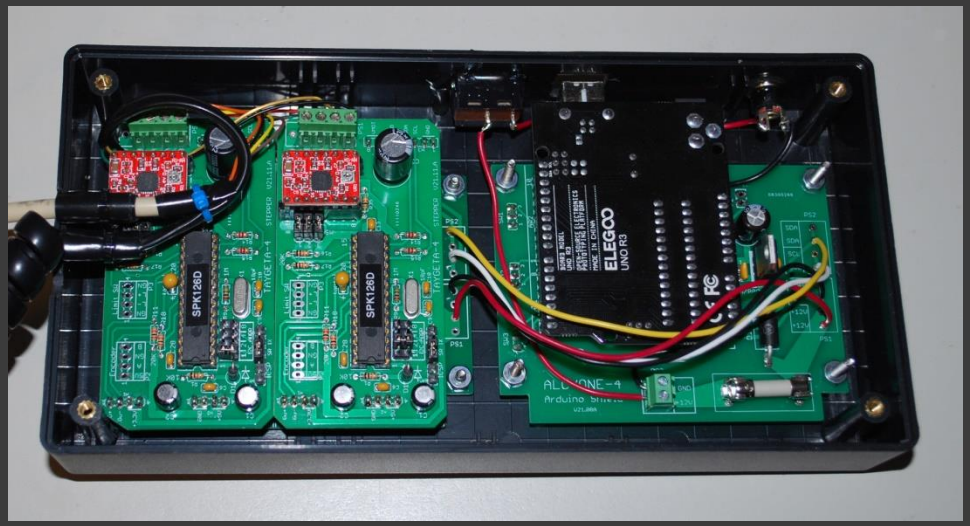
Sets of SKYPIKIT boards available to build a telescope control

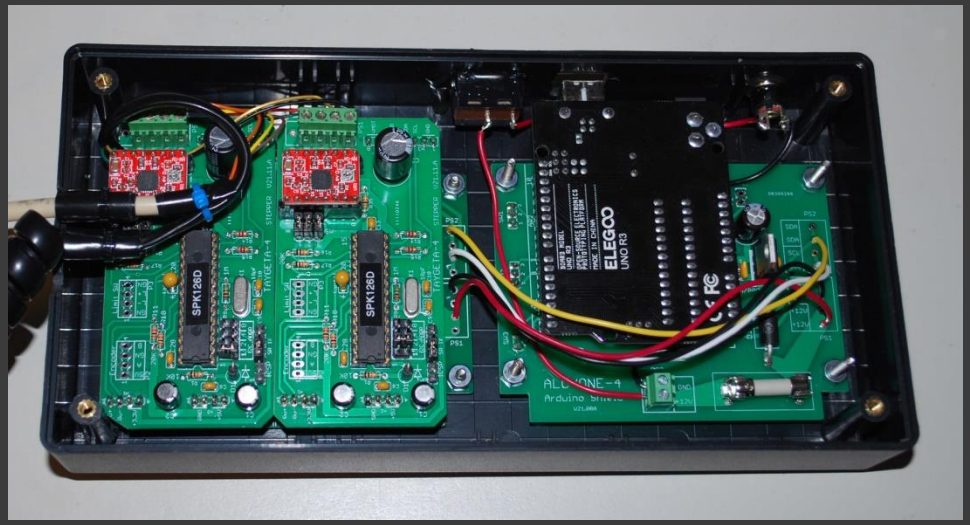
There are several printed circuit boards containing the SKYPIKIT and other components to drive a telescope. There are therefore several ways to set up a project. You can choose the boards that best suit the type of telescope or project you want to undertake. In addition to the PLEIADES series boards which can be adapted to any type of project, there are also specific boards for the Meade LX200GPS and RCX400 telescopes.











PLEIADES SET

The boards in this set are made to simplify mounting since they already contain many elements that you do not need to install:

connector for a simple handpad,
connector for autoguiding camera,
buttons to set the tracking speed in autonomous mode.

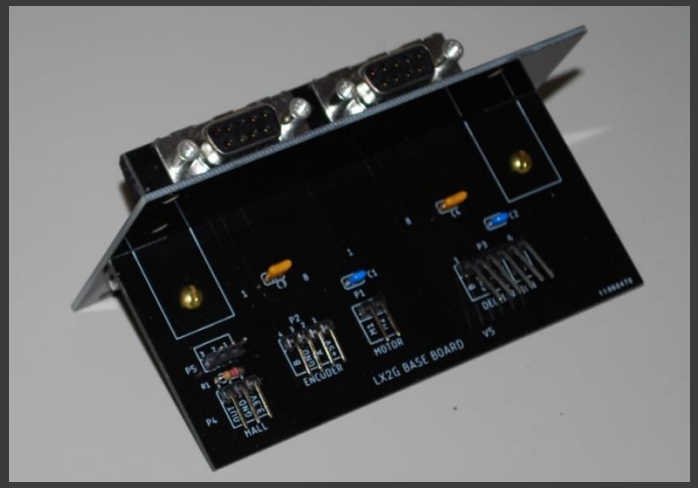
This is the recommended set in most cases.

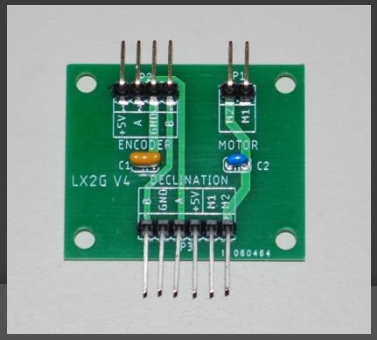
All you need to add are cables to connect the motors, an ON-OFF button and a power connector.

For the rest, just drill the holes in the right places in a case large enough to hold the boards.

This set allows you to have up to 4 Skypikit controllers connected to the Arduino.

This set includes boards to control DC motors with encoder and bipolar and unipolar stepper motors.





LX200 GPS SET

This set is intended to replace the electronic circuits of a MEADE LX200 GPS or RCX400 mount which has stopped working properly.

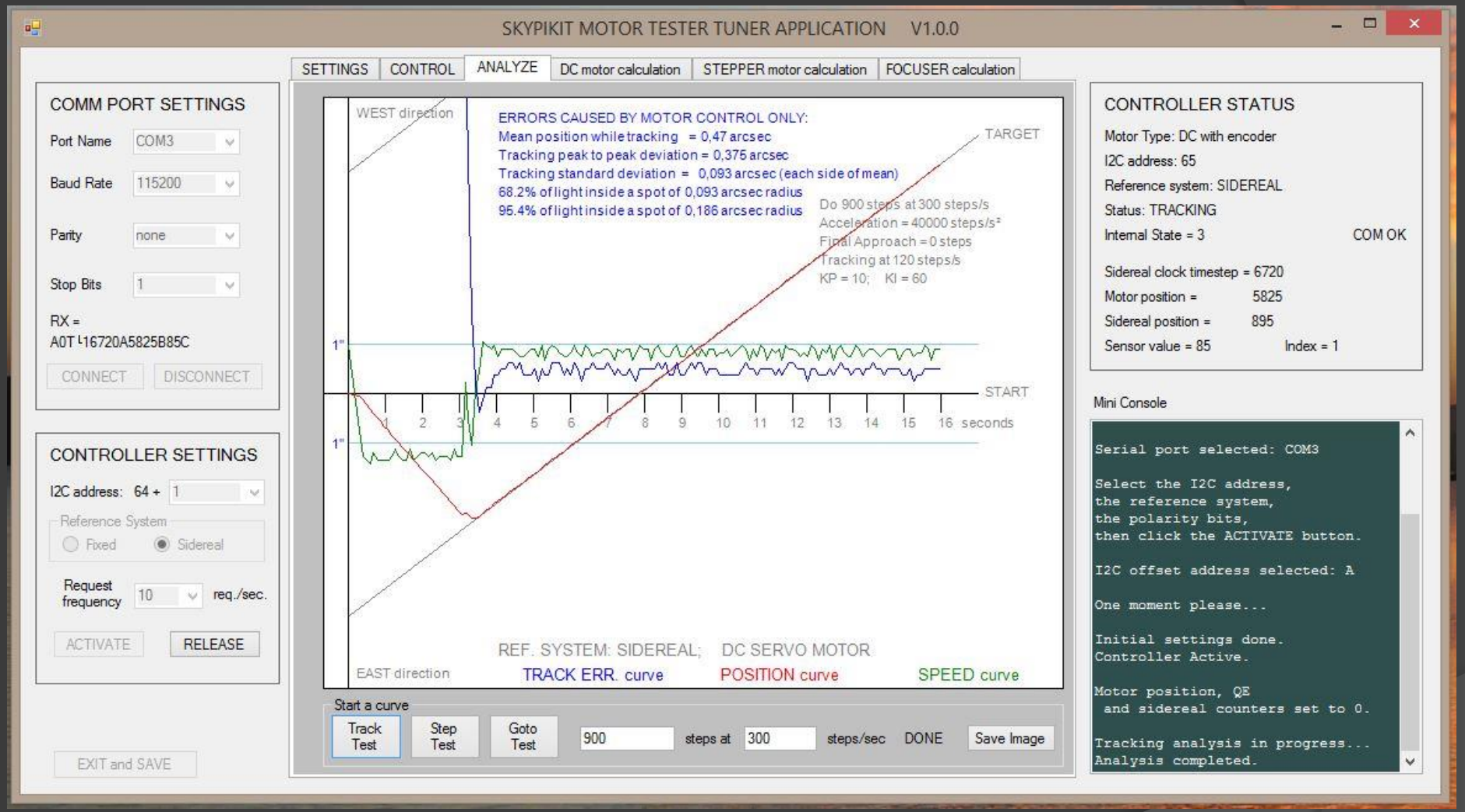
This set first includes an external box which contains the ARDUINO and a few boards from the PLEIADES series, including the right ascension and declination motor control boards.

Signals from the external control box are transmitted to the mount by DB9 cables connected to a new front panel, then to the motors by some of the original Meade cables inside the mount.

There is no longer electronics inside the mount but it takes a few boards (shown in the pictures) to interconnect all the cables.

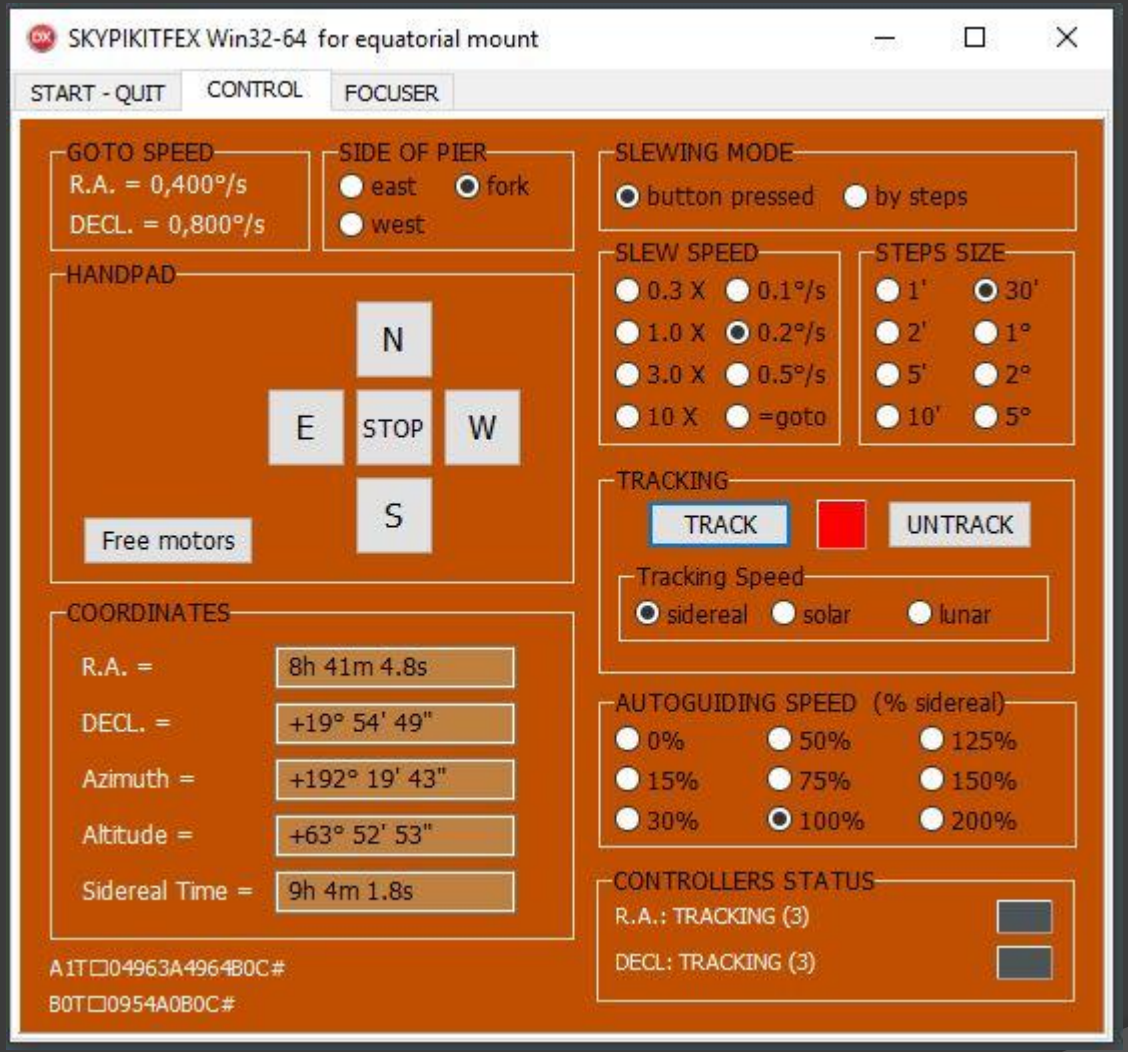
It is obvious that the modified telescope is no longer compatible with the Meade protocol. The telescope can be controlled directly with the COELIX software and the Skypikit FEX application. An ASCOM Skypikit driver also allows you to control it from many other astronomy programs, for example N.I.N.A.

The SKYPIKIT MOTOR TESTER TUNER application



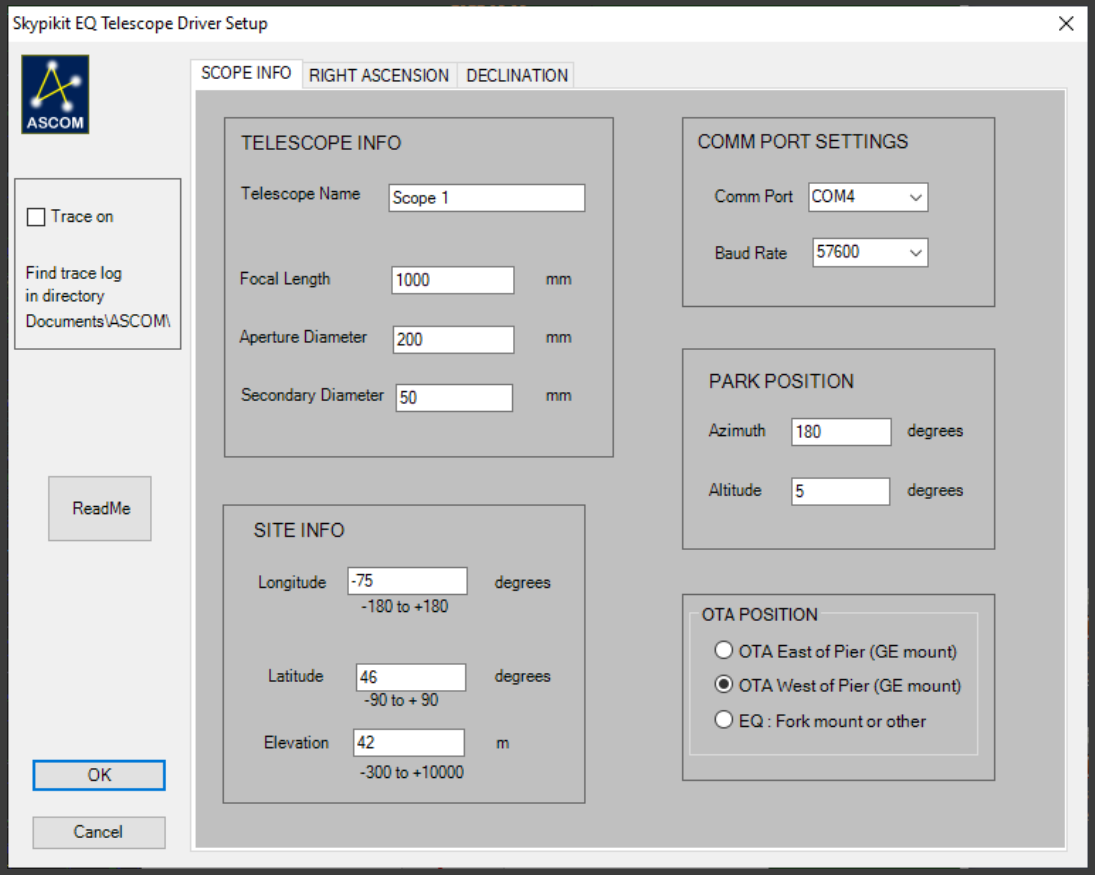
The Skypikit Motor Tester Tuner application allows you to experiment, test, calculate and adjust parameters and analyze the behavior of motor control, even before installing it on the telescope. This PC application connects to the Arduino via its USB port. This app is free. See the document on this application.

The SKYPIKIT FEX application



The free SKYPIKIT FEX app is used to directly control a skypikitized mount from the COELIX astronomy software. See the document on the Skypikit FEX application.

The ASCOM SKYPIKIT driver

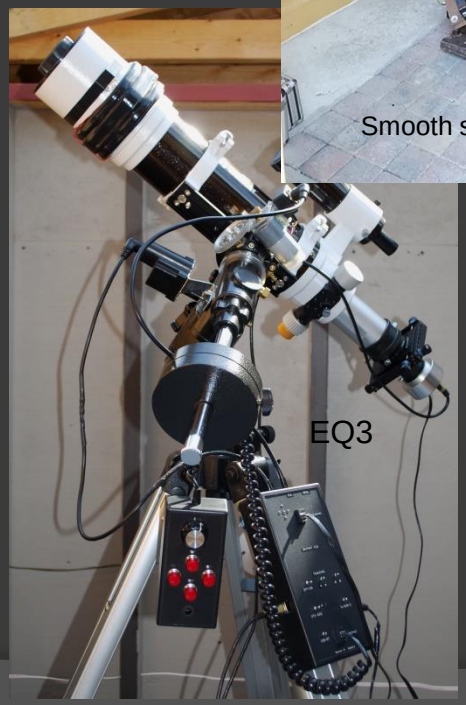


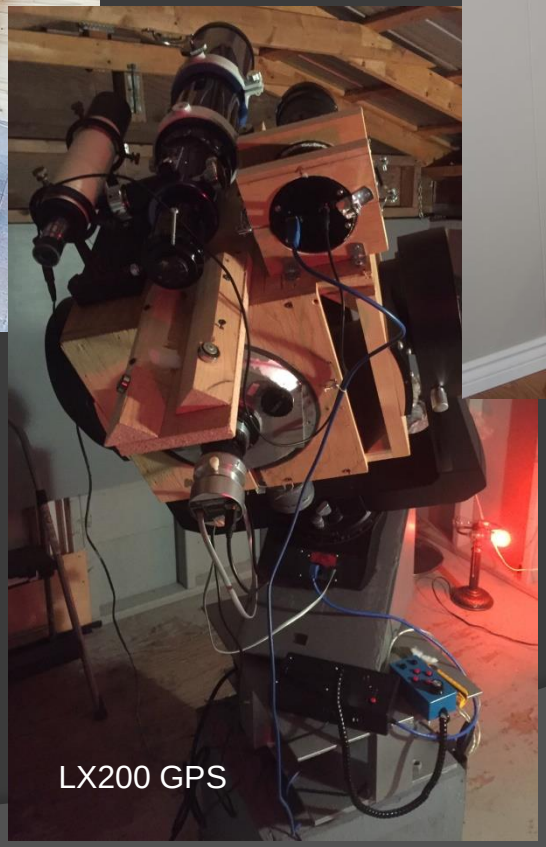
An ASCOM Skypikit driver allows you to control your telescope from many astronomy programs, in addition to Coelix, for example N.I.N.A.There is also an ASCOM Skypikit motorized focuser driver. See the documents on these ASCOM drivers.

Photos obtained with skypikitized mounts

See the photos on the following pages ...


Smooth sector mount


EQ3


LX200 GPS


Losmandy
G11

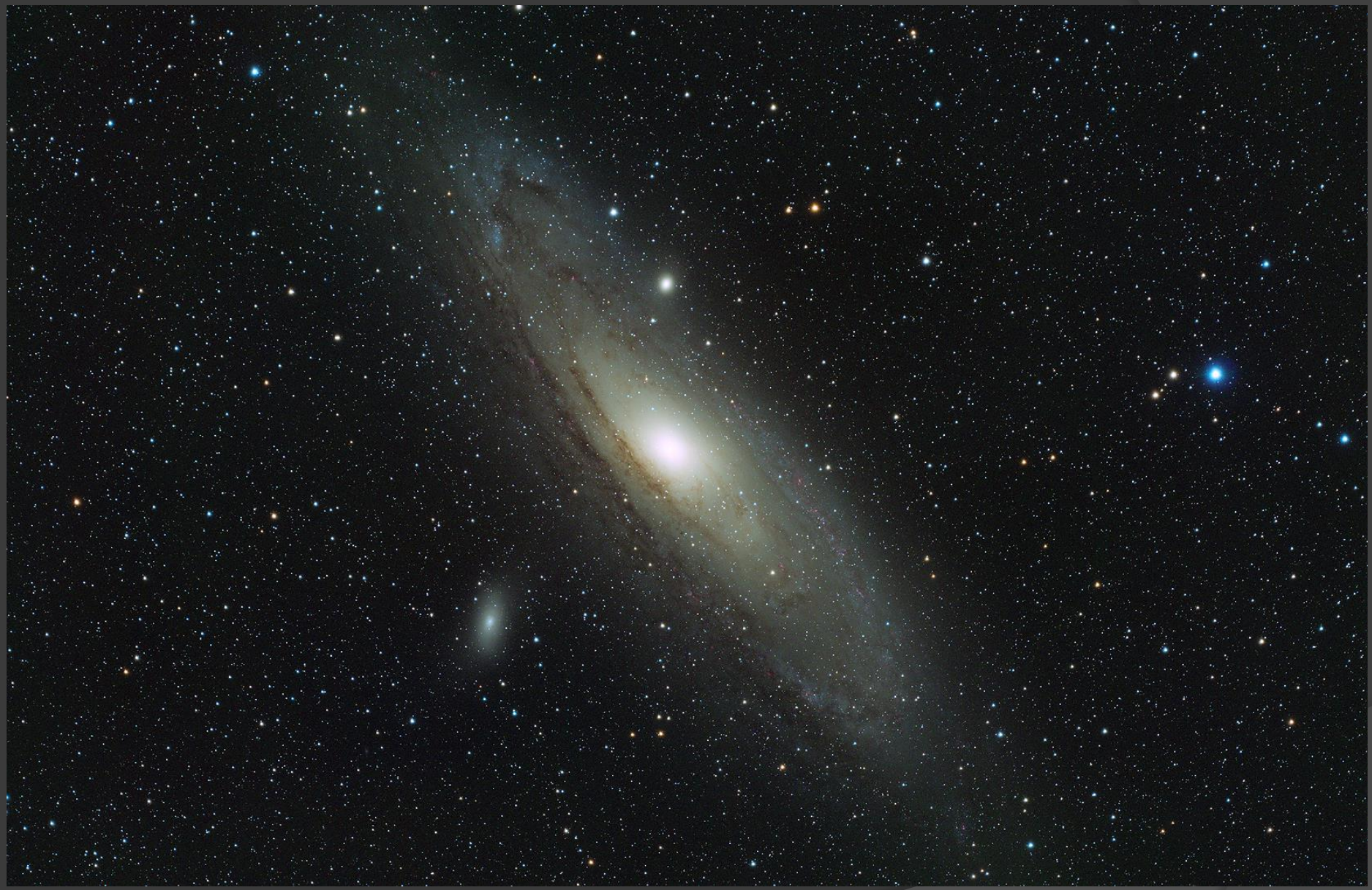
Double cluster of Perseus, by Pedro Borquez, EQ3 mount, Canon T3, ISO 800, 80ED refractor, focal length = 600 mm, 9 exposures of 240 seconds.

Buble Nebula and M 52, by Jean Vallières, Losmandy G11 mount, Mak-Newton 152mm telescope, focal length = 731 mm, RGB and H alpha filters.

Pleiades Cluster, M45, by Jean Marc Gillard, smooth sector home made mount, Newton telescope 250 mm, focal length = 1100 mm, 3 exposures of 300 s. with Nikon D3 camera fitted with a coma corrector and CLS Astronomik filter.

Triangle Galaxy, M33, by Jean Marc Gillard, smooth sector home made mount, Newton telescope 250 mm, focal length = 1100 mm, 10 exposures of 660 s. and 5 exposures of 600 s. with Nikon D3 camera with coma corrector and CLS Astronomik filter.

BARNARD 42 (not far from Antares): 24 exposures of 300 seconds, LX200 GPS mount, 200 mm Canon lens, QHY 168C camera. By Luc Bellavance.



The Great Andromeda Nebula, M 31, by Jean Vallières. William Optics RedCat 71 telescope with QHY268M camera and R, G, B and Halpha filters.

Pelican nebula in Cygnus, by Jean Vallières, Losmandy G11 mount, 152mm Mak-Newton telescope, focal length = 731 mm, RGB, H alpha, OIII and SII filters.

Leo trio, by Jean Marc Gillard, smooth sector home made mount,
Newton telescope 250 mm, focal length = 1100 mm, 23 exposures of 300 s with Nikon D3 camera and CLS Astronomik filter.

END

For more information, you can consult
the other documents on this website
www.ngc7000.com/telescope-motorization.htm