Scopedog Lite

Advanced Alt-Az 'GoTo++' Telescope drive and tracking system

User Manual

mk3_Lite_18 Version

User Manual Version Lite
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Manual contents

System Description

ScopeDog Lite is an add-on drive kit for Dobsonian or AltAz telescopes

The ScopeDog Lite system includes,

- Stepper motor drives engaging through a gearbox and toothed belt
- ScopeDog Control Box
- CMOS camera and 50mm lens
- Hand-box
- USB GPS dongle
- Cables

An additional user interface is via a pc, tablet or smartphone running SkySafari or an equivalent planetarium software[1]. This device connects to ScopeDog via WiFi.

ScopeDog determines telescope RA & Dec from plate-solving and calculates and applies the appropriate Alt & Az tracking rates. The drive is accomplished by micro-stepping stepper motors with integral gearboxes. These engage through a final drive to the telescope via a toothed belt and pinion.

GoTo commands from the planetarium software are received by the ScopeDog control box, which converts the commanded RA & Dec to AltAz coordinates and drives the telescope to the required position through a cycle of acceleration, fast slew and deceleration. At the end of the first slew operation ScopeDog can checks the accuracy of the achieved position and if necessary, makes further small slew motions (optional GoTo++)

In between plate-solves ScopeDog Lite keeps track of telescope position through motor step counting, thus creating a 'virtual encoder'. This will not be very accurate due to mount tilt etc. Regular plate-solving is used to correct the position.

The telescope position is sent via wifi to the planetarium software to be displayed.

The ScopeDog hand-box includes a joystick to allow the telescope to be manually controlled. The hand-box provides three speeds of movement in any direction. The slowest speed direction is normally reversed in azimuth to match the view in the eyepiece.

The stepper motor drive modules use adjustable current power control to

[1] Currently supported Apps and programs are all those that support LX200 mount connection protocol. These include SkySafari (Plus & Pro), Starry Night, Cartes du Ciel, TheSky, AstroPlanner. Not all have been tested in practice.

maximize battery life while providing sufficient torque for any telescope size.

Two telescope configurations can be setup, with a simple switch selection at power up.

Installing and Connecting ScopeDog

Do not plug or unplug the drive motors with ScopeDog powered. Damage may occur to the servo cards.

All components should be installed where they are protected from knocks and direct rain or dew. The ScopeDog system can be configured to suit most installations, if in doubt please contact scopedog@astrokeith.com . Final system performance depends on the accuracy with which the encoders and drive components are installed.

The diagram opposite illustrates how the ScopeDog components are interconnected. The power supply cable and motor drive cables should be kept as short as practical.

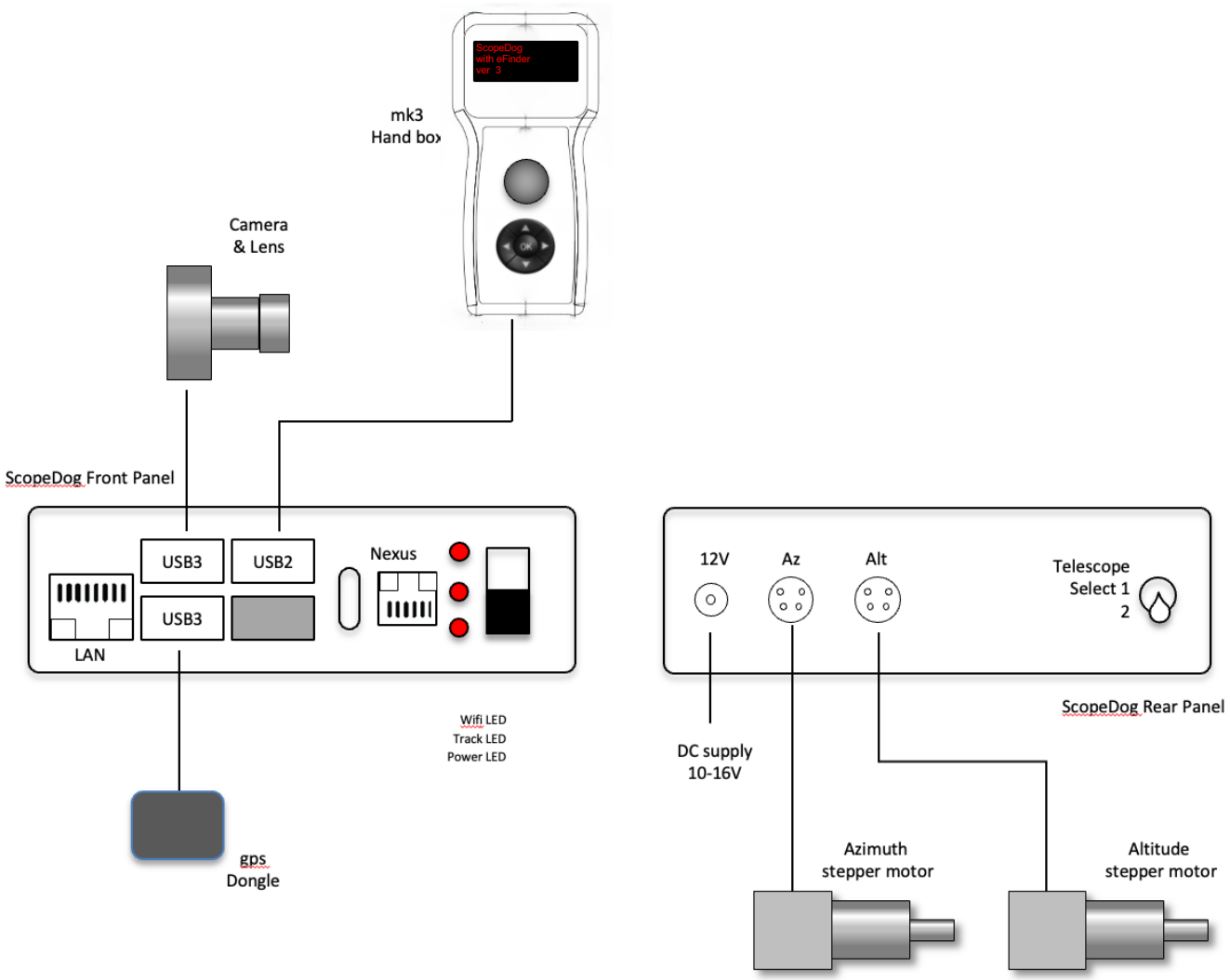
The hand box may be plugged into any available[2] USB port. The supplied cable may be changed for an alternative length by removing the back cover of the hand box.

The camera can be mounted via a suitable finder shoe and bracket. The camera needs to have a clear 6° field of view. It should be plugged into one of the USB 3 ports[3] (blue inserts) for optimum performance using a USB3 cable.

A USB gps dongle must be plugged into an available USB socket. To ensure the gps dongle receives adequate signal it is recommended that a cable mounted version is used.

[2] Do not attempt to use the lower USB socket furthest from the LAN socket. This is reserved for internal connections.

ScopeDog mk3 System Interconnections



Adjusting the camera lens

The camera aperture should be set to maximum. Using either the handpad Focus Utility, or saved image viewer, adjust the lens focus to achieve sharpest image. Use locking screws on the lens to fix the aperture and focus positions.

Parameter setup

ScopeDog needs to have mount and user preference parameters set before use. This is described on page 13.

Some parameters can be adjusted via the handset.

Initialisation

Select via the back panel switch, the telescope configuration, 1 or 2.

Note that the full ScopeDog mk3ef variant will run ScopeDog Lite if no Nexus DSC is found on start up. (mk3ef ver 3_16_5 or later)

Calibrate offset

ScopeDog includes a semi-automatic routine to measure, save and use the offset between the eFinder camera and the main scope sightline.

Navigate to the 'OK Offset star' menu screen. The current offset values are displayed, in arc minutes. Accurately point the main scope at a bright star, ideally Polaris. Use a reticule eyepiece if possible. If required the scope drive can be disabled for this alignment using the option on the Tracking Rate Screen. Alternatively, on power up ScopeDog assumes it is pointing at Polaris and so it is convenient to point the scope at Polaris before start up.

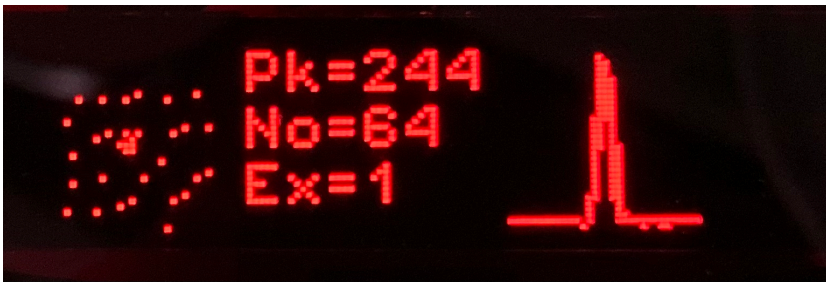
Enter 'OK' on the handset. An image is captured and the brightest star identified. Its name is displayed along with the offset in arc minutes. You just need to check the star name is the one you expected. The offset value is saved and used for all subsequent actions. It is overwritten if the calibration is repeated, or the 'Reset' option is used.

Having completed offset calibration, whenever ScopeDog takes and solves an image, the reported RA, Dec, Azimuth and Altitude is that of the main scope sightline, and not the camera image centre. However, this will be affected by any flex in the telescope OTA or its components, eg secondary mirror holder.

Note: the offset is *'dx,dy'* in arc minutes which relates directly to the image seen in the eyepiece. *dy* is equal to altitude angle, but *dx* is not the same as azimuth. As the apparent value of an azimuth angle decreases with altitude (becomes zero at the zenith) it is more convenient to use *dx*.

Use of the Focus Utility

Navigate to the Focus Utility screen. Press ‘OK’ to grab an image from the camera with the current settings. The eFinder Lite will attempt to find stars in the image. At the left of the screen is a crude image of the patch around the brightest star. In the centre is displayed, number of stars found, and the peak intensity of the brightest star (0-255). At the right of the screen a PSF (point spread function) of that star intesity is plotted.



With an exposure of between 0.5 and 1 seconds on a reasonable dark sky, a focused image should produce between 40 and 150 stars. If none or very few stars are found then try adjusting focus. Make a small adjustment and take another measurement. Repeat as necessary until stars are resolved and brought into sharpest focus. If the focus is a long way off then this may take some time, but thereafter should not need significant change, if at all. Use the locking screw on the camera lens to fix the set focus.

After good focus has been achieved, the utility is then useful to refine exposure time. You should aim for a peak intensity no more than about 200. Stars that saturate and become extended will be ignored by the star detection process. Avoiding this is key during the Offset Calibration routine, else the bright star being used for alignment may be ignored.

Initial alignment

Next step is to align ScopeDog with the sky.

Navigate to the 'OK Align' menu screen. The page should be showing Not aligned'. Point the main scope at a clear region of sky at around 45° altitude. Enter 'OK'. An image is taken and plate solved. Now ScopeDog starts to track. ScopeDog uses motor steps to maintain virtual encoders which are used to position the telescope.

The front panel of ScopeDog has three LEDs to indicate status;

Power	Steady when power switched on
Serial	Flashes at whatever readout rate has been set in SkySafari (or other App)
Tracking	Pulses at 1Hz when ScopeDog program is tracking

If not already done, open SkySafari (or equivalent) and connect to the telescope. The display should now correctly depict the position of the telescope sightline.

Connecting to SkySafari

ScopeDog can connect to an existing infrastructure wifi network, or generate its own wifi Access Point, with SSID ‘scopedog’, password ‘scopedog’. Connect your device (tablet, phone, etc) to the wifi.

The status screen shows the ScopeDog local network hostname, and its IP address.

In SkySafari telescope set up, enter the following

- Telescope type select Goto Altaz
- Meade LX200 Classic protocol
- port 4060 and IP address as shown.
- readout rate 2.

SkySafari should now be able to connect to ScopeDog and display the current telescope position. The ‘Align, ‘Goto’ and ‘telescope move’ functions (4 arrows buttons) in SkySafari will operate.

Observing

Joystick Control

The hand-box has a light-touch joystick that allows the scope to be driven manually at a choice of three speeds. The Planetarium software display will continually update to show the current position of the telescope.

Speed: The current speed is always shown at the bottom right corner of the handpad display. The speed is changed by pressing the joystick paddle to sequence through the range:

	Speed
1	Slow, normally used when looking through the eyepiece for small corrections
2	Medium
3	Fast Slew

The drive speeds can be specified via the ScopeDog configuration page, described on page 13 of this manual. The maximum slew speed is first set for both axes. This setting is used for GoTo and joystick Fast Slew. The medium and slow joystick speeds are then set as a fraction of the fast speed. The choice of fast slew speed will largely depend on telescope mount dynamics, whilst the medium and slow speeds will be down to personal preference when observing.

Direction: Move the joystick in any direction, including a combination of both axes and the motors will be commanded accordingly.

It is usual for fast and medium speeds to set the joystick direction such that pushing the joystick left, moves the scope left. For slow speed, it is recommended to reverse the azimuth direction so as to make scope movement more intuitive whilst looking at an object in the eyepiece. Joystick direction for each axis and

speed can be set via the scopedog.config file. See page 13.

ScopeDog will also respond to the telescope move buttons on SkySafari. The SkySafari rate select will change the slew speed.

Solve & Local Sync Control

From almost any screen, a short ‘OK’ will trigger an image capture and plate-solve at the current telescope position. The ‘Sol’ screen shows the actual RA & Dec from the plate-solve. It also shows the number of stars found in the image and the time taken to solve. This can help adjust exposure time etc if conditions change.

From the ‘OK Syncs’ screen, a short OK will trigger the same capture and solve process except that this time the virtual encoders will be synced to the true RA & Dec. Note that if GoTo++ is enabled, this Local Sync is automatically executed at the end of the first goto iteration, and is then followed by the GoTo++ refinement, (see GoTo Control section below).

Home Screen Shortcuts

The home screen displays the current telescope position, the tracking drive rate and the current joystick slew rate.

A short OK press will trigger a local sync (image,solve and virtual encoderl sync).

A long OK will trigger a repeat of the last GoTo, (including Goto++ if enabled)

GoTo Control

For SkySafari (similar functions apply in other planetarium programs), any object in the display may be highlighted and then the 'GoTo' command engaged. This command may also be done from the object search result.

ScopeDog will plate-solve its current posiiton and then calculate the required change of telescope position, smoothly accelerate the drives up to the fast slew speed, and decelerate as the computed target nears.

In normal use, a GoTo command should result in the target object being found in a wide field of view eyepiece. However, a number of factors strongly affect GoTo performance – mount tilt, mount stability and mount accuracy.

If at the 'Home' screen on the ScopeDog handset, a long press of 'OK' will repeat the last GoTo.

A GoTo can be stopped from SkySafari, but also during a GoTo by pressing the

joystick paddle (as if changing speed). This will decelerate the motion to a fairly rapid stop. A useful emergency stop facility to avoid collisions.

ScopeDog Lite has an optional GoTo++ feature. After completion of a conventional GoTo the eFinder images, plate-solves and syncs the virtual encoders before commanding a repeat of the GoTo. Since the scope was very close to the target, this process effectively cancels out any encoder or mount errors. After completing this GoTo++ another image and plate-solve is automatically done and the distance (delta) between main scope and target displayed in arc minutes. Depending on the telescope drive backlash, this delta should be around 1 arc minute or less. Note: this is the actual distance between the main telescope sightline and the target, not one inferred from encoders etc.

The GoTo++ action can be set to be undertaken automatically at the end of any GoTo. It can be manually initiated by simply pressing the OK button on the home screen after a conventional goto.

During a GoTo, the hand pad displays the distance to be travelled during each iteration.

eFinder plate-solver

From any menu screen, except align/local sync, offset calibration and reset, a short press of the 'OK' button will command an image, plate-solve and display of current absolute telescope position.

Hand pad display brightness

The OLED display will initially show at near full brightness. This is convenient for setting up under any lighting conditions.

An 'observing' brightness level can be set. This level is implemented when the status screen is first displayed (two down presses from the home screen). This lower level is pre-set using the Hand pad Display Adj screen.

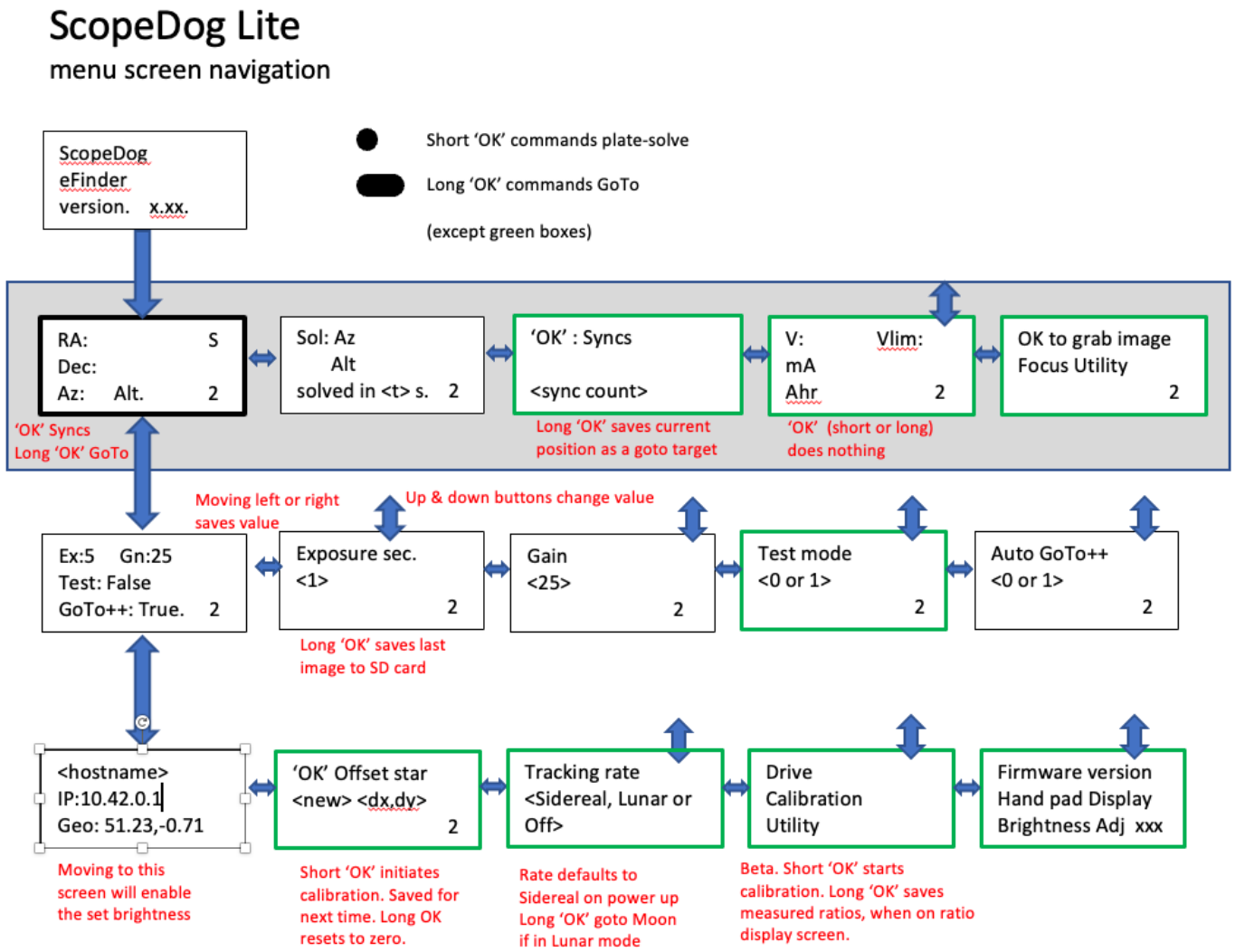
Power Supply Monitor

If the power monitor hardware (INA260) has been installed, this screen displays the input voltage, current being drawn and power used since last power up. A minimum voltage limit can be set (up and down arrows) which will trigger a warning in all screens if the input voltage falls below the set value. This value is saved for future sessions.

The display is updated every second and the current being drawn will be seen to

vary a little. This is due to the ScopeDog unit drawing varying power as it cycles through various loops. The power used is displayed as Ah (amp hours) and gives an indication of how much battery capacity maybe remaining.

ScopeDog Lite screen navigation

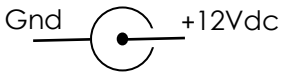


Delta and Offset numbers are in arc minutes. Offset is *'dx,dy'* (equivalent to 'delta x, delta y'). Delta y is the same as a delta altitude.
Delta x is the horizontal delta as would be seen in the eyepiece. ie it is

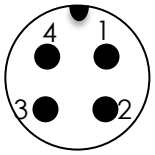
delta x = delta azimuth * cos(scope altitude)

Most screens show the slew speed in the bottom right corner.
1 = Slow, 2 = Medium, 3 = Fast

Connections



Motor
socket view



Pin	Motor wire
1	Black
2	Green
3	Red
4	Blue

Specification

Drive Speeds	Fast	Up to 6 deg/sec depending on telescope size and mount
	Medium	typically 1/3 of fast (user adjustable)
	Slow	typically 1/40 of medium (user adjustable)
Drive resolution steps		typically less than 1 arcsec, depending on final output drive ratio.
eFinder accuracy		Typically 15 arc sec
Power supply		10.5 -16 Vdc
Power consumption		Typically 7-10W depending on scope size

Configuration Setup

ScopeDog

Access to ScopeDog configuration data is via wifi or LAN.

Wifi

1. Wifi: ScopeDog can be configured at initial build to connect to an existing wifi network (infrastructure mode) or generate its own wifi hotspot (AP mode).
   or
   LAN: Use an Ethernet cable to connect ScopeDog unit to an existing LAN.
2. Open a browser on the device and enter scopedogmk3.local as the target address.
3. Examples of the 3 set up pages are shown on page 15.
4. The first page shows buttons to select either ScopeDog or eFinder configuration data. Below the buttons will be displayed the last saved image.
5. Make a note of the current parameters before making any changes!
6. The ScopeDog configuration page will be similar as shown on the page 15 of this manual. Two sets of data will be shown, one for each telescope option.
   Autostart must be left at True for the ScopeDog to start at power up. If False, the code will exit allowing manual starting from the command line.
7. The eFinder configuration page is also shown on page 15.
8. After making changes, save them using the button at the bottom of the page.
9. Changes take affect after a re-start.

Drive Calibration Utility

This utility is at beta release standard and may contain bugs.

Under a clear sky perform the standard offset caliibration and 2-star alignment. Then position the scope pointing approximately due South and at 45 deg altitude. From the Drive Calibration Utility screen, a short OK will trigger a specific measurement routine. First the drives will make a small movement to take up backlash, then follows a plate-solve to measure true telescope position. Then a large scope movement (+30° Az, +15° Alt) is executed finishing with another plate-solve. Finally the scope is driven back (-30° Az, -15° Alt) and another plate-solve.

The ScopeDog processes the measurements and displays (use up and down arrows), measured axes gear ratios and axes drive backlash.

A long OK whilst on the Gear Ratio screen will save the new values to the scopedog.config file.

ScopeDog System Access

It is possible to login to the ScopeDog operating system via Wifi or LAN. This is only recommended for expert users and requires some familiarity with the Raspberry Pi Debian operating System and Linux.

Computer hostname is: scopedogmk3
Username is: scopedog
password is: scopedog

eFinder

Access the eFinder set up summary menu page screen, (one 🡻press from the home screen). This will show current set exposure time (seconds), camera gain, test mode status, and GoTo++ status. Navigating 🡺 will access each of these 4 parameters in turn. At each one, the 🡹 and 🡻 buttons will change the value. Leaving that screen saves the value.

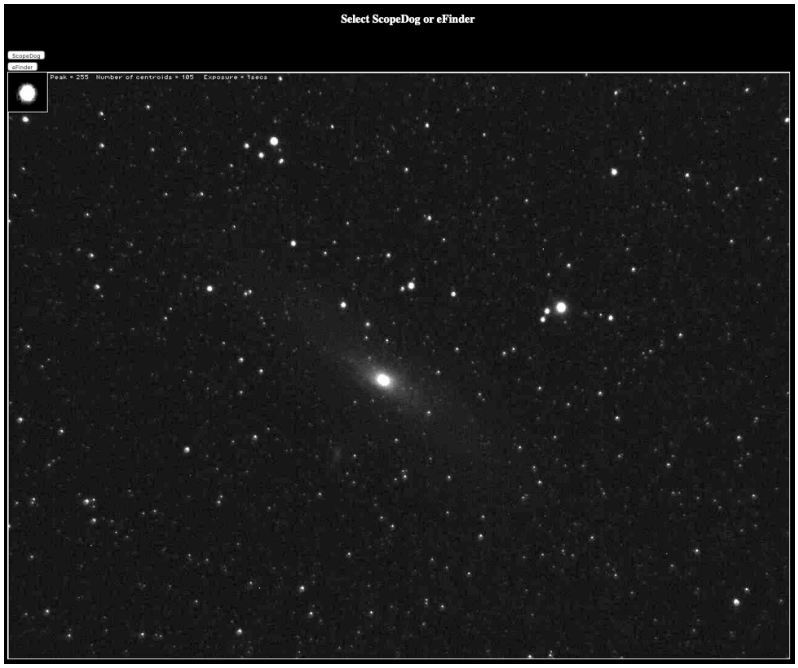
A map of the menu screens is shown on page 11.

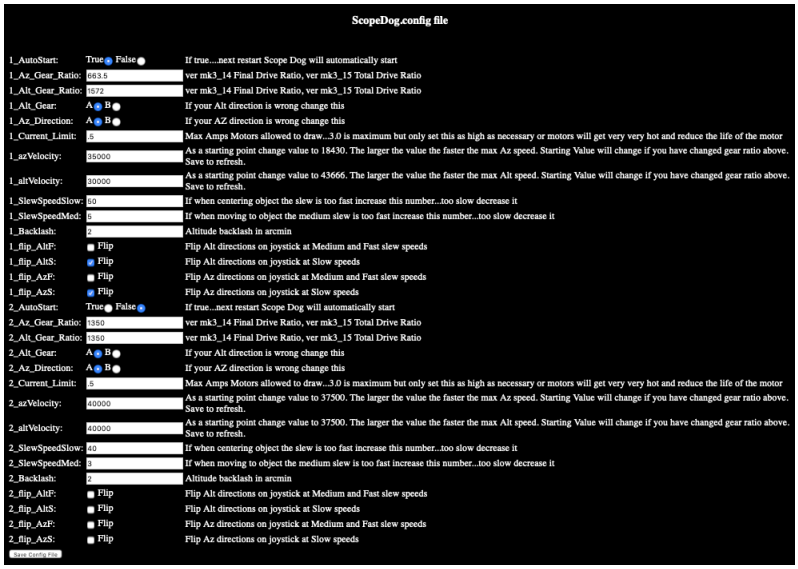
If test mode is set to '1', then the plate-solver either uses a pre-saved image of M31 instead of taking a camera image, or in offset calibration it uses a pre-saved image of Polaris. This provided a useful check of eFinder operation. A camera still needs to be connected however.

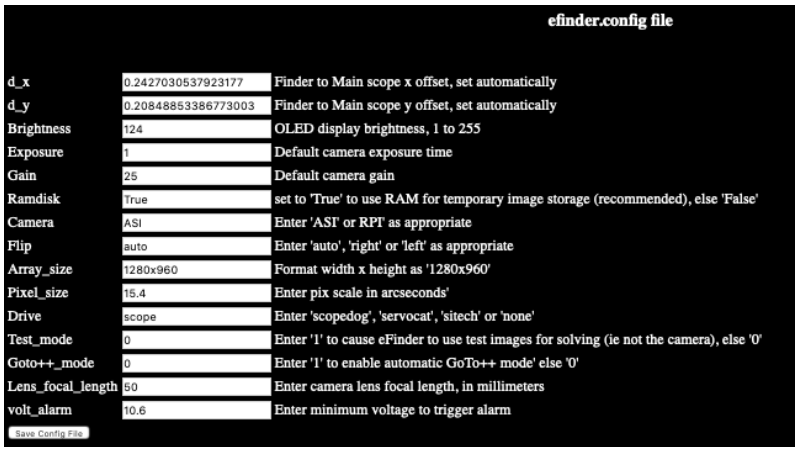
If Auto GoTo++ is set to '1', then after a normal GoTo, the system will automatically attempt a GoTo++ action, without user intervention.

ScopeDog Lite Configuration Setup

Example screens, actual values will vary according to the installation.







Copy of User ScopeDog Parameters

Scope1	
Az gear ratio	
Alt gear ratio	
Alt Gear	
Az direction	
Current Limit	
Az velocity	
Alt velocity	
Backlash	
Slow slew speed	
Medium slew speed	
flip altitude fast & medium slew	
flip altitude slow slew	
flip azimuth fast & medium slew	
flip azimuth slow slew	
Scope2	
Az gear ratio	
Alt gear ratio	
Alt Gear	
Az direction	
Current Limit	
Az velocity	
Alt velocity	
Backlash	
Slow slew speed	
Medium slew speed	
flip altitude fast & medium slew	
flip altitude slow slew	
flip azimuth fast & medium slew	
flip azimuth slow slew	

eFinderSd	
Brightness	
Exposure	
Gain	
Ramdisk	
Camera	
Flip	
Array size	
Pixel size	
Drive	
Test mode	
Goto mode	
Lens focal length	
Volt alarm	