Scopedog

eFinder Lite

Advanced Digital Finder

Aligns & Syncs the Nexus DSC

User Manual Version 3

Manual contents

System Description

eFinder Lite is an add-on Digital Finder for Dobsonian or other telescopes. The eFinder Lite system comprises a single unit incorporating,

- Camera and lens
- Processor
- OLED display
- 5 way navigation switch
- 3 axis accelerometer
- Micro USB port

The eFinder Lite uses plate-solving to measure exactly where the eFinder Lite camera is looking. A semi-automatic calibration routine determines the offset between the eFinder Lite camera and the main telescope field of view, and this offset is saved and applied throughout the session. Therefore, the displayed RA & Dec solution is that of the main telescope.

The eFinder Lite is primarily designed to be used with a Nexus DSC (original or Pro).

The eFinder Lite communicates with the Nexus DSC exchanging data. During initial telescope 2-star alignment, and any subsequent Local Sync, the eFinder Lite sends the plate-solved solution to the Nexus DSC in place of using a catalogue object. Thus the alignment can be done on any part of the sky, not requiring an actual target object. This greatly simplifies the process and is very accurate.

The eFinder Lite includes a three line OLED text display and a 5 way navigation toggle switch. The display can show the Nexus DSC position, the solved position, a focus utility and setup parameters.

The accelerometer can automatcially determine how the eFinder Lite has been mounted on the telescope and invert the display and navigation buttons to suit. This is optional and can be set via the config file.

Installing and Connecting eFinder Lite

All components should be installed where they are protected from knocks and direct rain or heavy dew. The eFinder Lite system can be configured to suit most installations, if in doubt please contact efinder@astrokeith.com. Final system performance depends on the stability of the camera mounting and the accuracy of the mount and any drive components installed.

The eFinder Lite should be rigidly mounted to align with the main scope as far as is practicable. Care should be taken such that the field of view of the eFinder Lite is not obscured by parts of the main telescope.

Use a micro USB to USB A cable to connect the eFinder Lite to the USB socket on the Nexus DSC. The Nexus DSC firmware will need to be at least ver 1.4.14 or with a Nexus DSC Pro, ver 1.1.20. Copies of these are available from AstroDevices.com or efinder@astrokeith.com.

The Nexus DSC must be set to '2 star align w/o alt ref' in Setup/Align.

For ServoCat systems which are using the Nexus DSC USB port, the eFinder Lite can be configured to connect to the Nexus DSC via wifi.

The eFinder Lite incorporates a tilt sensor, such that regardless of which side of a telescope it is mounted, the display and switch orientation is corrected. This can be omitted, or overridden in the config file.

Nexus DSC settings

- Follow the Nexus DSC manual to set your encoder resolutions etc.
- In Settings/Align, set Align Method to 'Two stars w/o Alt Ref'
- In Setting/Communications/USB, set to LX200, 9600, 1, 8, None
- If using with a ScopeDog drive, in Setting/Communications/Serial, set to ScopeDog, 9600, 1, 8, None. For other drive systems refer to their instructions.
- If using Wifi to connect (ie no USB cable), set Wifi protocol to LX200, port 4060, JNow.

eFinder Lite settings

Using the display and 5 way switch, the user can adjust:

Camera exposure time and gain: Typically an exposure of 0.5 sec and gain of 10 will produce reliable solves. If solves consistently fail, then try varying these a little. Use of the focus utility will help greatly. Failure to solve is more usually down to scope movement or lens out of focus.

Enter Test Mode: Selecting '1' sets the eFinder Lite into a mode where pre-captured images are used instead of live camera shots. This can be useful for user familiarisation or to help resolve problems. For 'solve' and 'align' actions, an image near M14 in Ophiuchus is used. For Offset Calibration an image of the Polaris region is used.

Adjust display brightness: The OLED text display brightness can be adjusted (see screen Navigation Map). While adjusting the brightness changes immediately. On start up, the display starts at near full brightness. It will stay at that level until the lower status screen is accessed, whereupon it changes to the set value.

Drive Mode: If the Nexus DSC is connected to a compatible drive system, then GoTo++ mode can be enabled. At the end of a normal goto, the eFinder Lite automatically images, plate-solves and local syncs the Nexus DSC, before commanding a repeat of the goto.

Initial alignment

Offset Calibration

Connect the eFinder Lite to the Nexus DSC. Turn on the Nexus DSC. If the Nexus DSC has not been used for sometime, wait for it to acquire gps lock so that its date, time & location are accurate. Then power cycle the Nexus DSC.

On powering up, the eFinder Lite code starts, and looks for and connects to the camera and Nexus DSC. For about 20 seconds the eFinder Lite screen will be blank while the internal processor loads its operating system.

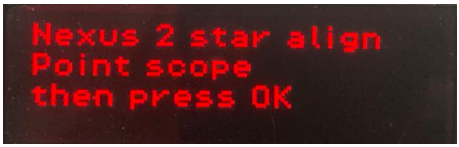
First task is to calibrate the offset correction between eFinder Lite and your main telescope.

Point your main scope as accurately as possible at a bright star. Polaris is best but not essential. Go to the 'OK Bright Star' screen on the handpad. Any previous measured offset will be displayed (x&y in arc minutes). Press the 'OK' button. eFinder Lite will take an image and determine the brightest star in the image. It will then display that star name, and the new offset. This offset will be saved and used until a new measurement is made. If the expected star isnt displayed, try adjusting exposure time (using the focus screen utility), as over exposed stars can be ignored by the solver.

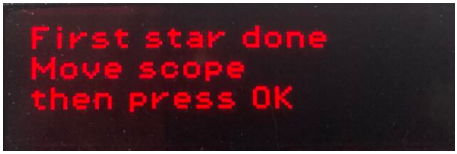
Telescope Initial Alignment (also known as, DSC 2 'star' alignment)

Scroll to the home screen showing the Nexus RA & Dec.

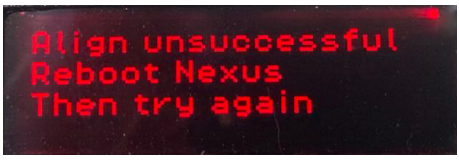
Short press the OK button. You will be asked to point the telescope at the sky and press OK again.



After a successsful solve, you will be asked to move the scope and press OK again. Move the scope at least 90 degrees in azimuth.



After the second solve the display will confirm success, or otherwise ask you to reboot the Nexus DSC and try again.



Note: The top row of the Home screen displays mode or alignment status. After successful two star alignment it will change to 'Nexus Aligned" if not in Test mode. The same button is used on the eFinder Lite for both initial alignment and subsequent Local Syncs. The Nexus DSC takes the first two received as initial alignment points, and thereafter takes them to be Local Syncs (and also stores these for an MPoint analysis).

Observing

General use of the Handpad

The ‘OK’ button will start the capture and solve process from most screens. But the result is not sent to the Nexus DSC. That can only be done from the home screen. Refer to the screen menu diagram, page 11.

After a successful solve, the screen will show the solution as RA & Dec. Also the number of stars found and how long the solve took. The first solve after power up always takes longer as data is transferred from the SDcard. Solve time should then generally be less than 0.5 seconds and at least 40 stars. The focus utility can be used to adjust settings if required.

If a solve fails, usually due to the scope moving, then the screen shows the 'solution' screen, but "no solution" is displayed.

Use of the 'Home' screen (top left box on page 10 diagram).

The Home screen shows a live relay of the Nexus DSC RA & Dec, updated every half second.
A short 'OK' press will action a Nexus DSC align/local sync, after which the displayed RA & Dec will be very accurate.
A long 'OK' press actions a repeat of the last goto, (if drive connected).
Also at top right is a 'N' for not aligned, or 'T' for aligned.

Local Sync

The main usefulness of the eFinder Lite is the Local Sync function. As with most encoder based systems the Nexus DSC accuracy is heavily dependent on mount build, stability and the initial alignment process. Thus the Nexus DSC includes a Local Sync function where the telescope is pointed at a nearby bright star and the Nexus DSC is sync’d to the catalogue position for that object. eFinder Lite provides a Local Sync to true sky coordinates, without having to move the telescope away from the target area.

While observing the process of finding an object would be:

1. Select catalogue object on Nexus DSC (or attached planetarium App)
2. Either, push scope to object or use Goto.
3. At this point the scope will be near to the object but typically anywhere up to 30 arc minutes away due to the contributing errors already mentioned.
4. While on the eFinder Lite home screen (top left on menu page xx), press 'OK'. The eFinder Lite will image, plate-solve and send the true sky coordinates of the telescope position to the Nexus DSC as a Local Sync.
5. The Nexus DSC (or planetarium App) display will change and now show the extra small distance the scope must be moved to reach the exact position of the object.
6. The scope can now be pushed to the object, or a Goto repeated. As the movement required is now small, the object will be centred with accuracy.
7. With compatible drives, a long 'OK' on the home screen will automatically perform steps 4,5 & 6.

Solve

The Sol: screen normally shows the RA & Dec from the last successful plate solve. The bottom line shows the number of stars found and the time taken to plate-solve. This can give help to adjusting exposure and gain.

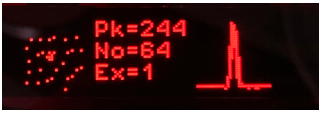
A short OK press on this and most other screens will command an image capture and plate-solve. The result is not passed to the Nexus DSC – that requires a Local Sync or Align, see above.

A long OK will cause the eFinder to save the last image to the sdCard. This can then be rerieved using a filesharing app, or viewed using a web brower.

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 intensity is plotted.



With an exposure of about 0.5 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.

Goto++ *(only available if connected to a compatible drive system)*

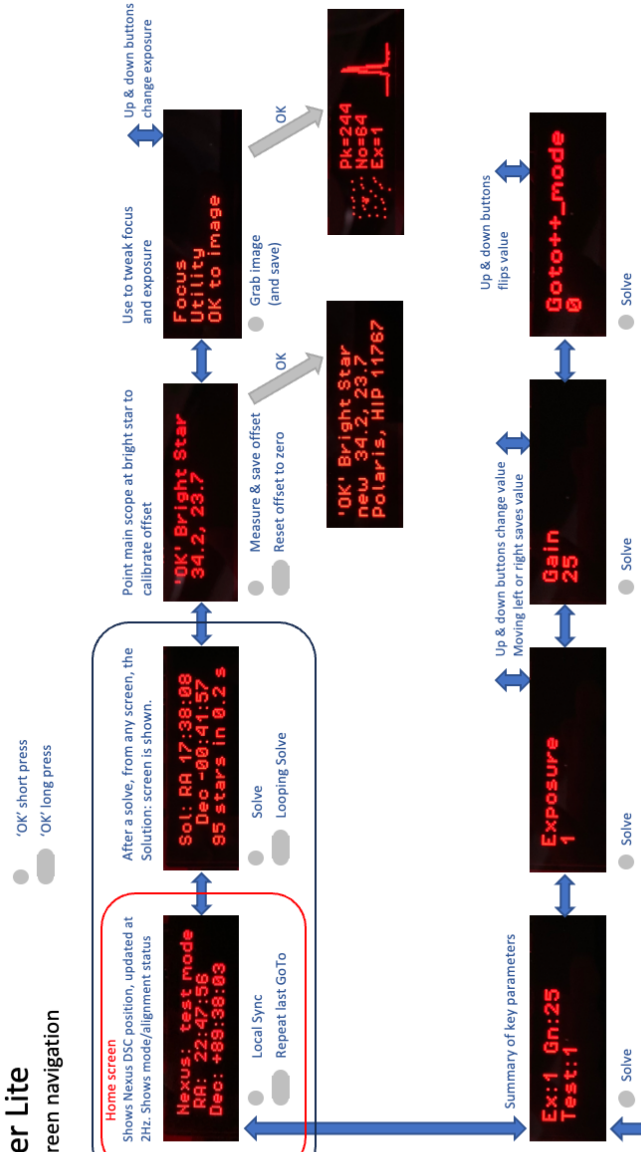
After a normal goto, the telescope is likely to be 10-20 arc minutes away from target. This is due primarily down to a combination of initial alignment and mount build errors.

After such a normal goto, the Nexus DSC and scope drive will 'think' it is at the target though. Performing a local sync, and repeating the goto will bring the scope to the actual correct RA & Dec.

A longer press on the ‘OK’ button causes the eFinder Lite to read the current goto target & RA & Dec, perform a local sync, and then resend the original target back to the Nexus DSC and command a goto. Since this new goto starts with the scope near to the target and accurately aligned, the result will be very accurate. This action is called a 'GoTo++'.

Using the setup menu, this Goto++ action can be made automatic at the end of all goto’s.

eFinder Lite Handpad Menu Screen Navigation



eFinder Lite Accuracy

The plate-solved solution will be accurate to about 1/2 of a camera pixel. With a 25mm lens this will be about 25 arc seconds. The displayed solution includes the offset as calibrated by the user and hence will be affected by this. Using Polaris and a short focal length reticule eyepiece, a calibration of around 30 arc seconds can be readily achieved. Thus a total or error of around an arc minute.

There is a further error that may occur due to flexure of the telescope components during the session that disturbs the alignment between the finder and main telescope. This will be unknown but can be measured and reduced by repeating the offset calibration routine during the session. Refer to Appendix B for a fuller treatment of accuracy.

WiFi access to eFinder Lite

The eFinder Lite can be configured to join a known WIFI (infrastructure mode) or create its own WIFI Access Point. A device on the same LAN can view and update the eFinder.config file (Appendix A) and view the latest saved image, (refer to the next section for details).

If the eFinder Lite WIFI has been configured to join a Nexus DSC Pro WIFI in AP mode to enable ServoCat connection, then this feature is not available.

Save and View camera images

If desired the camera image can be saved and/or viewed.

After a successful capture and solve, the Sol: screen will show the result. A long press of 'OK' while on the Sol: screen will save the image to the sdCard (/home/efinder/Solver/images/image.png). This is overwritten on subsequent saves. The latest image can be retrieved using Samba file sharing over LAN. It can be viewed immediately by browsing to efinder.local.

While using the Focus Utility screen, the image captured is automatically saved to /home/efinder/Solver/images/image.png and can be retrieved or viewed in the same way. This image includes an additional window showing a magnified section of the brightest star. Unlike the basic solution image, the focus image is contrast stretched to enhance the star images.

Appendix A

Edit eFinder.config file

Connection method A

Using a device connected to the same LAN, enter efinder.local in the browser address (assuming you kept efinder as the efinder hostname during setup). You should see a web page like …

efinder.config file

d_x	34.19	Finder to Main scope x offset, set automatically
d_y	23.66	Finder to Main scope y offset, set automatically
Brightness	100	OLED display brightness, 1 to 255
Exposure	0.2	Default camera exposure time
Gain	10.0	Default camera gain
Ramdisk	True	set to 'True' to use RAM for temporary image storage (recommended), else 'False'
Camera	RPI	Enter 'ASI' or RPI' as appropriate
Flip	left	Enter 'auto', 'right' or 'left' as appropriate
Drive	none	Enter 'scopedog', 'servocat' or 'none'
Test_mode	1	Enter '1' to cause eFinder to use test images for solving (ie not the camera), else '0'
Goto++_mode	0	Enter '1' to enable automatic GoTo++ mode' else '0'
Lens_focal_length	25	Enter camera lens focal length, in millimeters

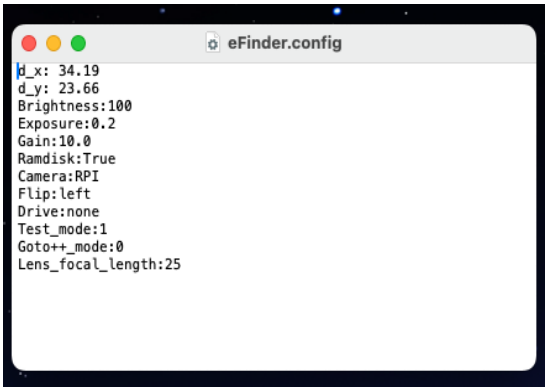
Save Config File

Values can can updated, and saved using the 'Save Config file' button.

Connection method B

Follow the instructions on page 9 of the manual to establish a remote computer connection to the eFinder Lite. Use the remote computer file manager to display the contents of the folder /Solver

You will find a file eFinder.config – right click and select text editor, which will open the file ready for editing. It should look like this image.



When editing a line, only change characters to the right of the colon and ensure no extra spaces before or after your text have been entered.

Updating entries

The following explains the lines and valid entry options

1. d_x & d_y: This is the latest offset measurement in arc minutes. Should not be manually changed.
2. Brightness: OLED display brightness, 1 to 255
3. Exposure: Current camera exposure value. Set via eFinder Lite screen
4. Gain: Current camera gain. Set via eFinder Lite screen. Refer to camera specification for acceptable values
5. Ramdisk: True or False. Recommend True so that the eFinder Lite stores temporary working files in RAM rather than potentially wearing out the micro SD card.
6. Camera: The eFinder Lite should recognise most models within the specified manufacturer's range. Enter ASI or RPI.
7. Flip: The display and button orientation change depending on which side of the scope it is mounted. Enter 'auto', 'left' or 'right'
8. Drive: Enter your scope drive type (scopedog, servocat or sitech) or 'none'
9. Test mode: 1 or 0. (= True or False) Set via handset
10. Goto++ mode: 1 or 0. Set via eFinder Lite screen.
11. Lens_focal_length: camera focal length in millimeters.

Item 1 is set by the system
Items 2,3,4,5,8 & 9 can be set via the display & navigation switch.

Record of settings:

	Initial Value	user update
LAN hostname	efinder	
Initial password	efinder	
New password		
eFinder Lite firmware		
Exposure	1	
Gain	25	
Ramdisk	True	
Camera	RPI	
Drive	none	
GoTo++ mode	0	
Lens focal length	25	

Note: the username 'efinder' cannot be changed.

Understanding eFinder accuracy

eFinder will improve your pointing accuracy, but it's not a silver bullet! Here's an explanation …

Let's assume Polaris is used for the offset measurement routine. You centre Polaris in the main scope (accuracy required!). The eFinder routine finds and saves where in the captured image Polaris is (the offset). It can do this to better than a pixel, so about 15 arc seconds depending on your eFinder lens focal length. So far so good. So from now on, the eFinder uses that offset to guide the drive or the manual 'pusher'. It is the offset that is used to sync the Nexus DSC.

When you do a sync (aka align) the Nexus gets what should be the scope RA & Dec, using the offset. In fact it gets the eFinder camera image RA & Dec and infers the main scope RA & Dec using the offset. So the stability of the offset is critical. Things that can affect the offset …

- eFinder Lite / eFinder camera mounting stability
- Primary mirror movement
- Secondary mirror movement (eg. sag with changes in altitude)
- Tube/truss movement

Normally the user isnt aware of these, just knows that encoders dont always find the target. The eFinder exposes them! You can measure them using the offset measurement function in eFinder. After initial collimation, do a series of offset measurements, noting the results, for a few stars spread in azimuth and altitude. Typically you will get a 'settling down' at first (primary mirror moving on support, and secondary mirror adjustment mechanism relaxing). Then you get movement as you move the telescope, especially in altitude. I personally reviewed a large number of eFinder installations and found an enormous range of movement. Up to a degree!

However the eFinder is a good diagnostic tool and helps remedy these problems.

Next we have to consider the encoders. When you do an eFinder sync, the Nexus DSC now knows where it is pointing (notwithstanding the offset error above), and will calculate the distance to the object. The distance on the Nexus display will be accurate. But when you move the scope to zero out the distance, the Nexus is using the encoders to continually display the new distance. Problems here are …

- Encoder resolution. 10k encoders give 2 arc minute steps for instance. As you move the scope the Nexus might see in worse case up to 2 arc minutes at the start and 2 at the end.
- Encoder mounting. The tangent arms on which the encoders are mounted often have a little play at their 'free' end.
- Mount. Eg. Typically scopes can move a little in azimuth by skewing on the altitude teflon pads. Slack in azimuth centre spindle can be a major cause.
- Encoder noise. Not that common, but some ServoCat & SiTech installations have shown this (shorten encoder cables and keep them away from motor cables.)

eFinder and two 'star' alignment. Normal 2 star alignment requires the scope to be pointed at 2 actual stars with accuracy. The accuracy is required so that the DSC can compute the orientation of the mount. It could be argued that DSC accuracy isn't required when an eFinder is used, but it is still worth doing the process as accurately as possible to improve the rest of the observing session.

During the 2 'star' alignment process, the eFinder sends to the DSC the RA & Dec of the main telescope (albeit with a small offset accuracy error), so no aligning on actual stars is required at this stage. This both speeds up the process and improves accuracy. The improvement in accuracy comes from the same small offset accuracy error being applied to both 'stars', rather than a random error generated at each real star alignment in the normal process.

Finally the drive, if you have one. Goto++ works by syncing the Nexus DSC when near the target and then repeating the last goto. The drive has a known starting point now, but is again relying on the encoders to tell it when it has reached target. Now we have the encoders errors above, plus the drive 'backlash'. This 'backlash' is a number that when reached the drive stops trying anymore. Typically this is a couple of encoder steps.

From the above you can see that the overall pointing accuracy is dependent on many factors. After a little use of eFinder you will know what accuracy you are able to achieve. If desired then you can work through the sources to reduce them, using the eFinder to check progress. Go for 'the low hanging fruit' approach. Most systems I have looked at have had only one or two big error sources, tackle these and perhaps live with the rest. Nearly all systems I have help commission have been got to the region of 1-5 arc minutes. My own, after reworking 4 times is about 15 arc seconds.