

SynLink User Manual

1 Introduction

1.1 Preface

Thank you for purchasing the SynLink astrophotography controller. Featuring highly integrated hardware and an intuitive, user-friendly App design, SynLink is compatible with most astrophotography equipment brands and types on the market. This includes imaging cameras, guide cameras, mounts, electronic focusers, filter wheels, rotators, and flat panels.

Furthermore, while providing a stable, all-in-one control experience, SynLink also comes with a comprehensive suite of automated astrophotography features, including Autofocus, Polar Alignment, Guiding, and Sequence Imaging. We look forward to SynLink becoming your powerful "astronomy assistant," delivering a stable and highly efficient astronomical observation and imaging experience.

This manual is designed to help you become familiar with and master SynLink. It details how to connect SynLink to various astronomical devices, allowing you to seamlessly build your observation system. It also provides an in-depth explanation of the app's core functions, guiding you on how to utilize automated workflows to achieve efficient and professional deep-sky astrophotography.

1.2 What's in the Box

SynLink x 1	0.3m Male-to-Male DC Power Cable x 1
Dovetail Kit x 1	0.5m Male-to-Male DC Power Cable x 1
Wi-Fi Antenna x 1	1m Male-to-Male DC Power Cable x 1
Sky-Watcher Mount Serial Cable x 1	0.5m Male-to-Female DC Power Cable x 1

1.3 Appearance & Interfaces



#	Name	Qty	Description
1 - 2	USB 2.0 Type-A	2	For various USB devices. <i>Note: Total current consumption should not exceed 3A for ports 1, 2, and 7.</i>
3 - 6	USB 3.0 Type-A	4	For various USB devices. Recommended for external storage and cameras. <i>Note 1: Total current consumption should not exceed 3A</i> <i>Note 2: Some USB 3.0 cameras might not work reliably and should work in USB 2.0 mode.</i>
7	USB 2.0 Type-C OTG	1	For various USB devices. Also serves as a USB storage device when connected to a PC. <i>Note: Total current consumption should not exceed 3A for ports 1, 2, and 7.</i>
8	Serial Port	1	Connects to a Sky-Watcher GOTO mount's hand control port; or, connects to a Celestron GOTO mount's AUX port with an optional adapter.
9	Power Supply Output	4	From the power supply input, controlled by the power switch, not regulated. I.D. = 2.0mm, O.D. = 5.5mm, Max. 5A / Outlet.
10	Power Supply Input	2	Paralleled dual power supply input. I.D. = 2.0mm, O.D. = 5.5mm. <i>Note: Max. 5A / Outlet, 10A in Total. Must connect to the same power supply.</i>
11 - 12	Dew Heater Ports	2	For the dew heaters. Output power is adjustable via the App.
13	Sensor Port	1	Reserved port for future sensor expansion.
14 - 15	M4 and 3/8" Mounting Holes	2	Used to secure the SynLink to a telescope or other hardware.
16	Power Switch	1	Push to turn power on/off, LED flashes to indicate working status.
17	Status LEDs	2	Indicates current operational and network status.
18	Wi-Fi Antenna	1	Removable antenna for enhanced wireless network strength.

2 Initial Setup

2.1 Mounting SynLink Controller

It is recommended to securely attach SynLink to the telescope tube or any equipment that does not move relative to the tube. This prevents center-of-gravity shifts or cable snagging during imaging.

1. Fasten the included dovetail mounting foot to the mounting holes **#14** (back) or **#15** (side) using screws.
2. Slide and lock the dovetail mounting foot into the finder shoe or a corresponding dovetail saddle on your telescope.

2.2 Connecting Hardware

Safety Warnings:

- Strictly distinguish between the 12V power input and output ports. Although protective circuits are built in, incorrect connections pose a risk of damaging the equipment.
- Use zip ties or cable wraps to secure cables. **Always leave enough slack to allow for full mount rotation (especially during a Meridian Flip)** to prevent cable snags, pull-outs, or damage to the ports.
- Keep data cables and power cables separated as much as possible. USB cables should be kept away from the Wi-Fi antenna to prevent signal interference.
- For long-distance USB connections, always use high-quality shielded cables to ensure stable data transmission.

1. Power Supply

Plug a 12V DC power supply into port **10**. The maximum input current per jack is 5A. If more than 5A current is required by the equipment, use two cables and plugs from **the SAME POWER SUPPLY** to provide extra power.

The SynLink itself can work with a 9V to 16 V power supply, and the voltage of the 4 output jacks and the two dew-heater outlets follow that of the power supply. It is recommended to use a higher voltage power supply if it also works with the other equipment.

2. Imaging Cameras and Guiding Cameras:

- Connect to one of the SynLink's USB ports.
- High-resolution USB 3.0 cameras are recommended for use with a USB 3.0 port.
- If a USB 3.0 camera does not work reliably on the SynLink, a user can try connecting the camera to the SynLink via a USB 2.0 port or cable.

- Currently supported camera brands:

Altair	Meade DSI	FLI	Mallincam	MI
OGMA	OmegonPro	Player One	QHY	ZWO
ToupTek (Include OEM: Bresser, EHD, Levenhuk, MallinCam, QSI, Rising, StarShootG, SVBONY...)				
Canon	Sony	Nikon	Fujifilm	

3. Equatorial Mount:

- Currently supported brands

Sky-Watcher	Celestron	ES/Losmandy PMCB	iOptron	RainBow
Takahashi	Vixen	ZWO		
LX200 Based Mount(<i>include: 10Micron, Astro-Physics, Avalon, EmCan, EQMac, Losmandy Gemini, Meade, OnStep, PegasusAstro, TeenAstro, etc.</i>)				

- Sky-Watcher SynScan:** Connect the SynLink's Port **8** to the hand controller port on the Skywatcher GOTO mount using the supplied RJ12-to-RJ45 Serial cable.
 - For the earlier EQ6 Pro mount, you need to prepare an RJ-45-to-RJ45 adapter.
 - For the mounts with an RJ-12 hand controller port, you need an RJ12-to-RJ12 straight-through cable.
- Celestron AUX:** Connect the SynLink's Port **8** to the AUX ports via an optional adapter and cables.
- Others:** Connect one of the SynLink's USB ports to the mount's USB port or the mount's hand controller.
- Connect one of the SynLink's power outputs to the mount to turn the mount on/off simultaneously with the SynLink.

4. Focuser, Filter Wheel, Rotator, and Flat Panels

- Currently supported focuser brands:

Astroasis	Baaader Planetarium	Celestron	Deep Sky Dad	FLI
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Lacerta	Lakeside ASTRO	Moon Lite	Optec	PegasusAstro
QHY	Shoestring	ZWO		

- Currently supported filter wheel brands:

Astroasis	Atik	FLI	Manual Wheel	MI
Optec	PegasusAstro	Player One	QHY	SX
Trutek	WandererAstro	ZWO		

- Currently supported rotator brands:

Optec	PegasusAstro	WandererAstro	ZWO	
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- Currently supported flat panel brands:

Artesky	Geoptik	Lacerta	Optec	PegasusAstro
WandererAstro				

- Connect one of the SynLink's USB ports to each of these devices.
- Connect one of the SynLink's power outputs to the device that requires an external power supply, if you want to turn the device on/off simultaneously with the SynLink.

5. External Storage:

- Connect an external storage to one of the USB ports.
- It is recommended to use a USB 3.0 storage device with the SynLink's USB 3.0 port.

6. Dew Heaters:

- Connect the dew heater(s) to Port 11 and/or Port 12

2.3 Installing the SynLink App

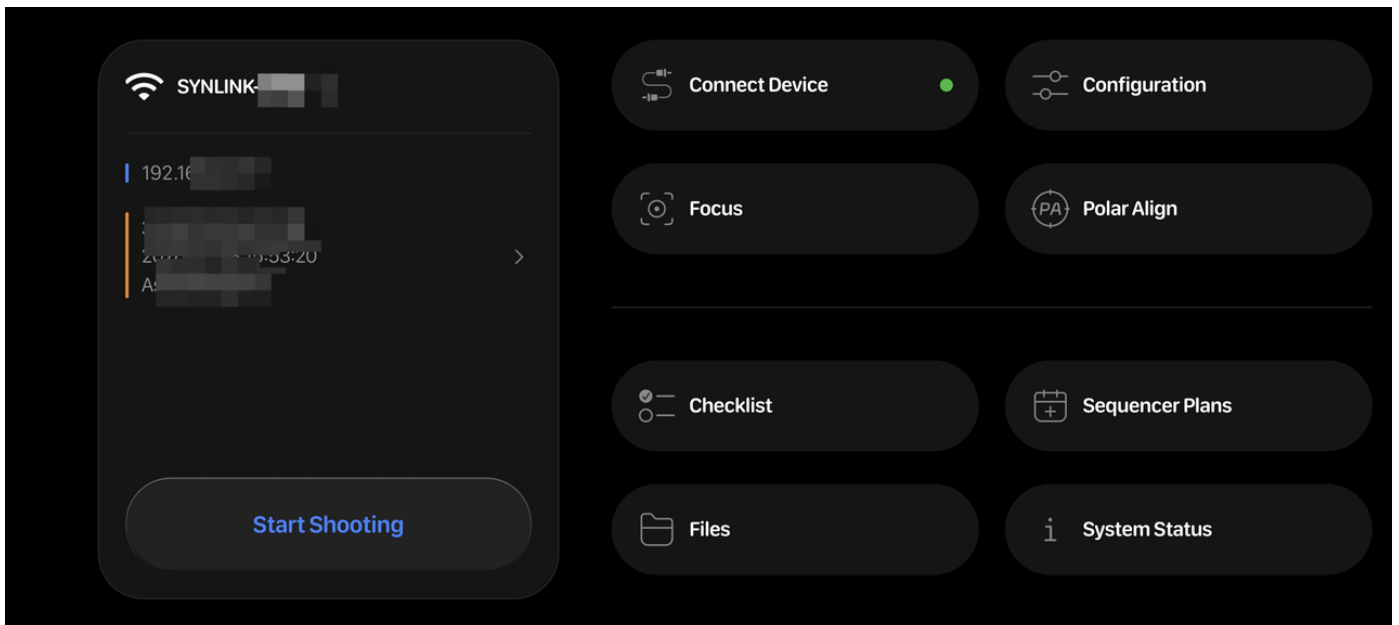
The SynLink controller works in conjunction with the SynLink App, which supports the following platforms.

- **iOS / macOS:** Install from the App Store.
- **Android:** Install from Google Play or the other major Android app stores.

- **Windows:** Download from the developer's website www.umainf.com.

2.4 Startup

- **Power On/Off:**
 - Push the SynLink's power button to turn on or turn off the SynLink and the devices that are powered from the SynLink.
 - The power button's LED will light up or blink while SynLink is running.
- **Connecting SynLink:**
 - A SynLink controller runs a Wi-Fi access point with a default SSID name in the form of "SYNLINK-XXXX"
 - Connect your device to this access point with the default password "12341234"
 - Launch the SynLink app on your device.
 - Make sure you grant sufficient permissions to the SynLink app, such as permissions to access the network, location, storage, etc.
 - The SynLink app will search and connect to the SynLink controllers in a while.
 - Upon a successful connection, the SynLink app will display the controller's name, IP address, location, and time information. Verify that the location and time are correct.



2.5 Setup Imaging System

Tap the "**Connect Device**" button in the SynLink app to set up the devices that will be used in the imaging system.

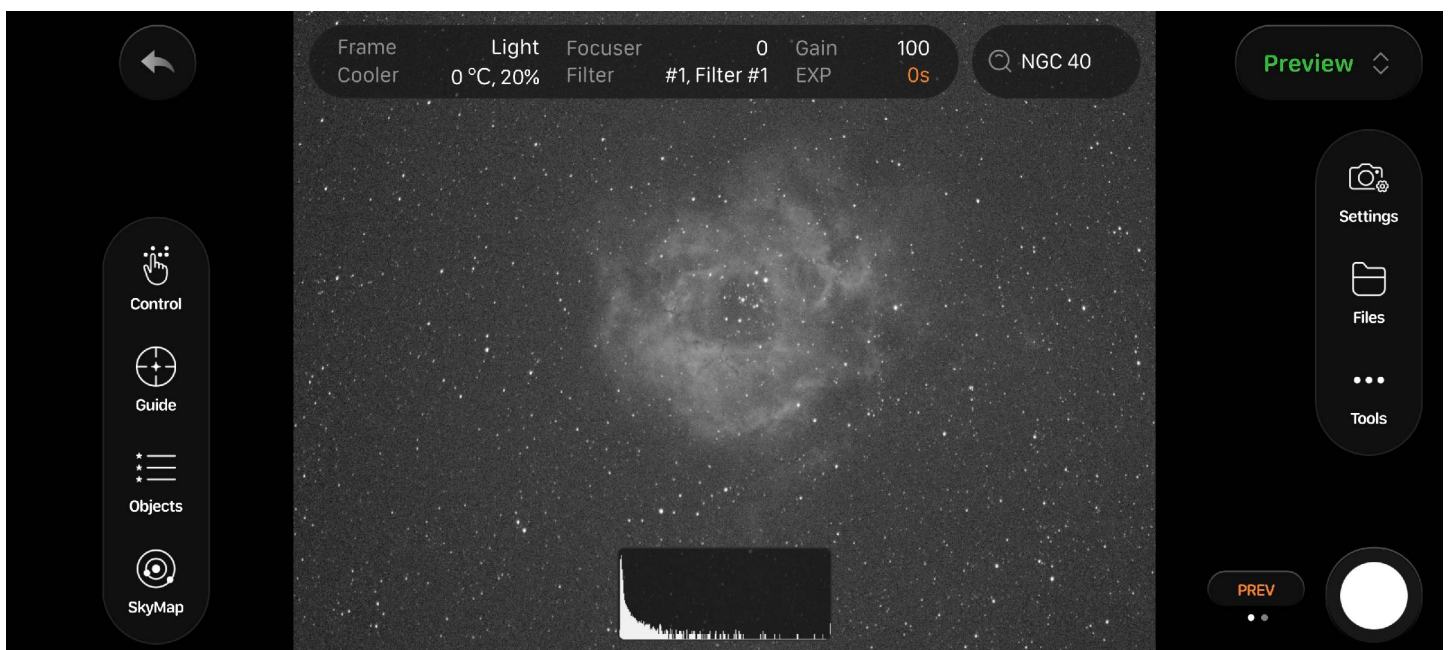
- The SynLink can detect and list all supported cameras(including DSLRs) that are connected to the USB ports and running normally. Tap "Image Camera" and "Guider Camera" to choose the proper one from the list.
- For the mount, focuser, filter wheel, rotator, and flat panel, SynLink will list the supported brands. Choose the brand that matches your device from the list.
- If a device no longer exists or you do not want to use it, choose "NONE" from the list.
- There is a colourized status indicator for each device category.
 - Grey for the status of Disconnected/Not Used.
 - Yellow for the status of In Connecting
 - Green for the status of Connected/Running Normally
 - Red for the status of Failed Connection/Error
- Simulators are provided for each device category for users to practice and become familiar with SynLink operation.
- Instructions on setting up DSLR/Mirrorless cameras:
 - Configurations for working with SynLink:
 - Common configurations:
 - Manual focus: Enable
 - Exposure: Bulb mode
 - Image format: RAW image
 - Image Size: Full resolution
 - Camera-dependent configurations:
 - Smart Phone Connection: Disable
 - PC Remote Control: Enable
 - Allow shutter release without lens: Enable
 - Noise Reduction: Disable
 - Auto Power Off: Disable
 - USB Power Supply: Enable
 - Drive Mode: Single Shooting
 - For DSLR/Mirrorless cameras that do not support releasing the shutter via USB connection, use an intervalometer or a physical shutter release cable instead.
- Instructions on setting up mounts:
 - Choose "Sky-Watcher GEM" for controlling a Sky-Watcher German equatorial mount.

- Choose "Sky-Watcher Alt-Az" for controlling a Sky-Watcher Alt-Az mount.
- Choose "Celestron HC" for controlling a Celestron mount via a USB connection to a NexStar hand controller.
- Choose "Celestron GEM AUX " for controlling a Celestron German equatorial mount via SynLink's Port 8. An adapter(purchased separately) is required to connect Port 8 and the AUX port on the mount.
- Choose "Celestron Alt-Az AUX " for controlling a Celestron alt-az mount via SynLink's Port 8. An adapter(purchased separately) is required to connect Port 8 and the AUX port on the mount.
- Instructions on setting up a manual-switch filter wheel
 - Choose "Manual wheel" from the list of "Connect Device\Filter Wheel".
 - Manually switch the physical filter, then synchronize the changes in the SynLink app during the imaging session to properly record the filter information in the FITS file.

3 Operation Overview

After completing the device connections, tap **Start Shooting** on the home page to enter the **preview** interface. Here, you can take preview exposures, manually control your equipment, and explore various automation and capture features.

3.1 Interface Overview



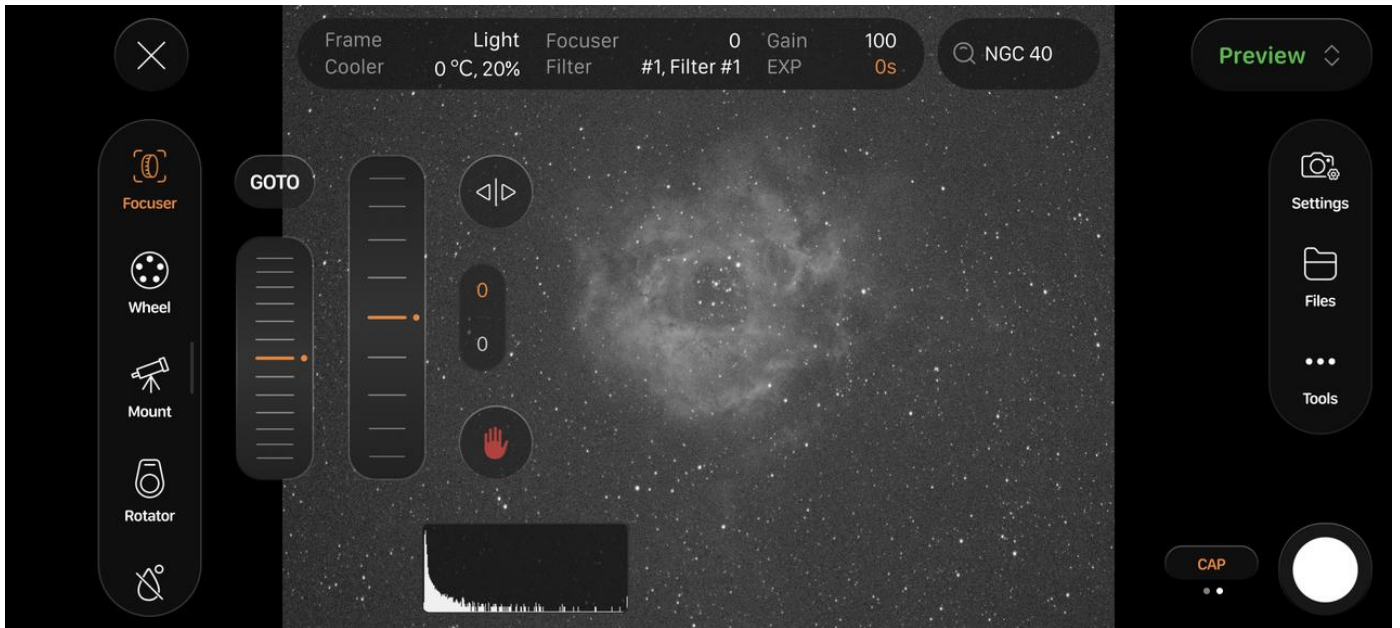
- Top Bar

- **Status Bar:** Displays the current frame type (Light/Dark, etc.), camera temperature, focuser position, filter wheel slot, Gain/ISO, and the remaining exposure time of the current capture.
- **Quick Target Search / Rename:** Tap to enter the catalog number or name of your desired target to search and execute a GOTO. Tap the **[Edit]** button to modify the name of the currently targeted object. The updated name will be automatically applied to subsequent image saves and sequence file names.
- **Mode Switch:** Allows you to toggle among **"Preview"**, **"Sequence"**, and **"Video"** modes (For detailed information on Sequence and Video modes, please refer to Sections 4.5 and 4.6 respectively).
- **Left Menu (Control Area)**
 - **Control:** Brings up the control panels for connected devices, including the mount, focuser, filter wheel, rotator, dew heater, and flat panel. For specific control instructions, please refer to Section 3.2.
 - **Guide:** Access the guiding setup and monitoring page.
 - **Objects:** Browse the built-in astronomical catalogs to filter and select the optimal observation targets.
 - **SkyMap:** An interactive, visual representation of the night sky designed to assist with framing and mosaic planning.
- **Right Menu (Configuration Area)**
 - **Settings:** Adjust the core parameters of the main camera (Exposure, Gain, Cooling, Mode) and the image preview display settings.
 - **Files:** Provides quick access to images and videos stored on local and external storage devices.
 - **Tools:** Contains various utilities including **Solver**, **Center**, **ROI**, **Collect**, **Reticle**, **Histogram**, and **Log**, along with a **Save** button for the current preview image. For detailed tool descriptions, please refer to Section 6.5.
- **Bottom Right (Action Area)**
 - **Mode Toggle:** Switches between **"PREV"** (Preview) and **"CAP"** (Capture) modes. In PREV mode, the camera continuously exposes and refreshes the screen without saving any files. CAP mode takes a single shot and automatically saves the image to your storage space upon successful completion.
 - **Shutter Button:** Starts or stops the current exposure task.

3.2 Device Control

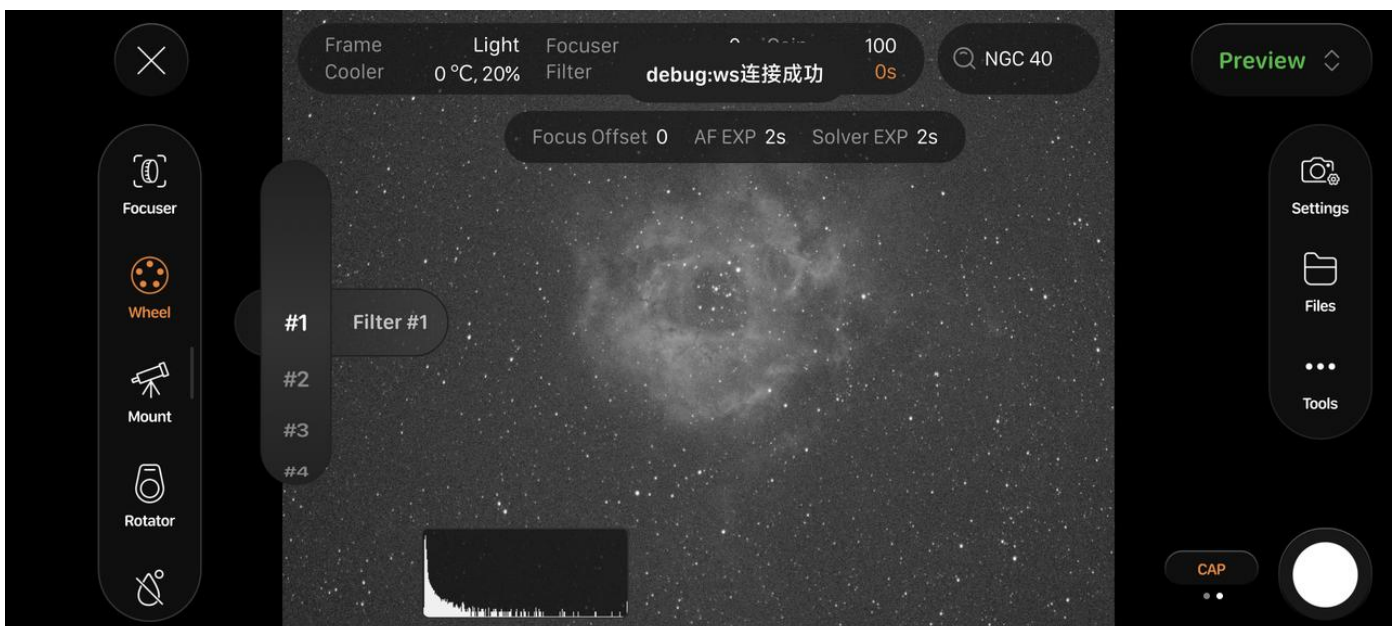
On the left side of the shooting page, tap **Control** and select the corresponding **Device** to expand its operation panel.

1. Focuser

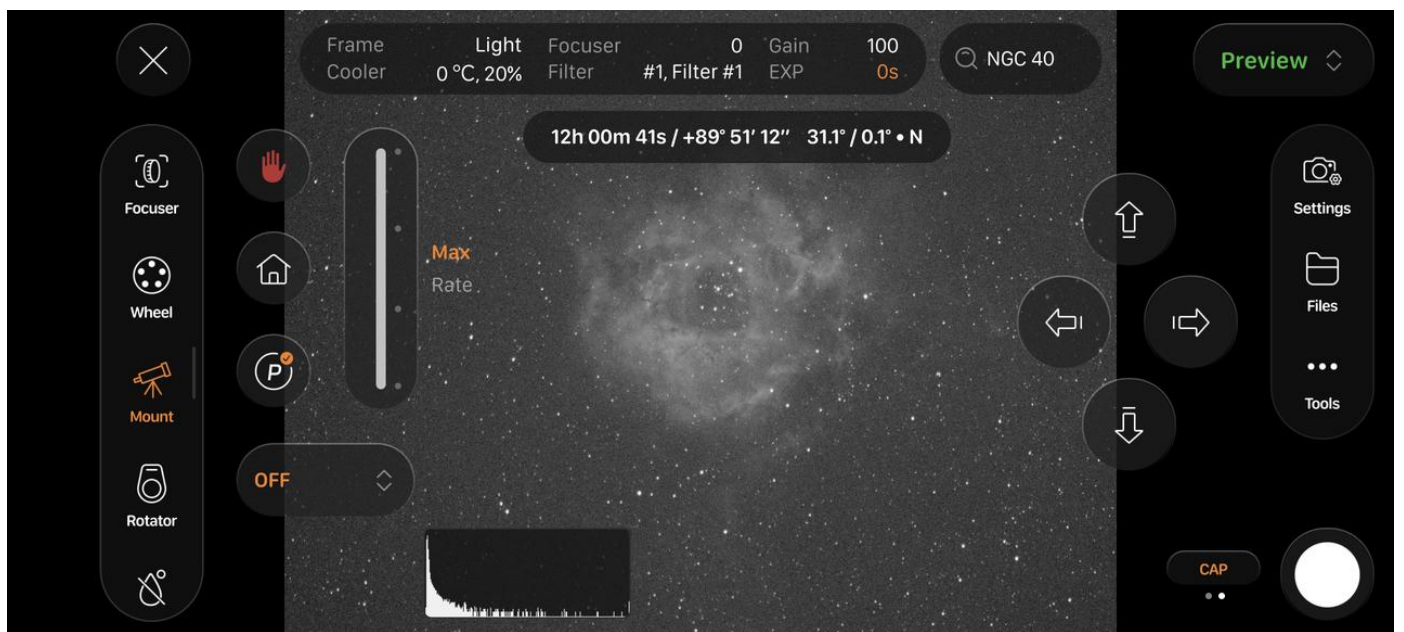


- **Movement Control:** The left slider is for fine adjustment (one notch = one fine step). The right slider is for coarse adjustment. Swipe down to move inward, and up to move outward. The top right number shows the current action; the bottom number shows the current position.
- **GOTO:** Enter a specific value to automatically move the focuser to that position.
- [**◀|▶**]: Tap to modify the step value.
- [**👉**] (**Stop**): Tap to immediately halt movement.

2. Filter Wheel: Swipe or tap a slot number to rotate the wheel.

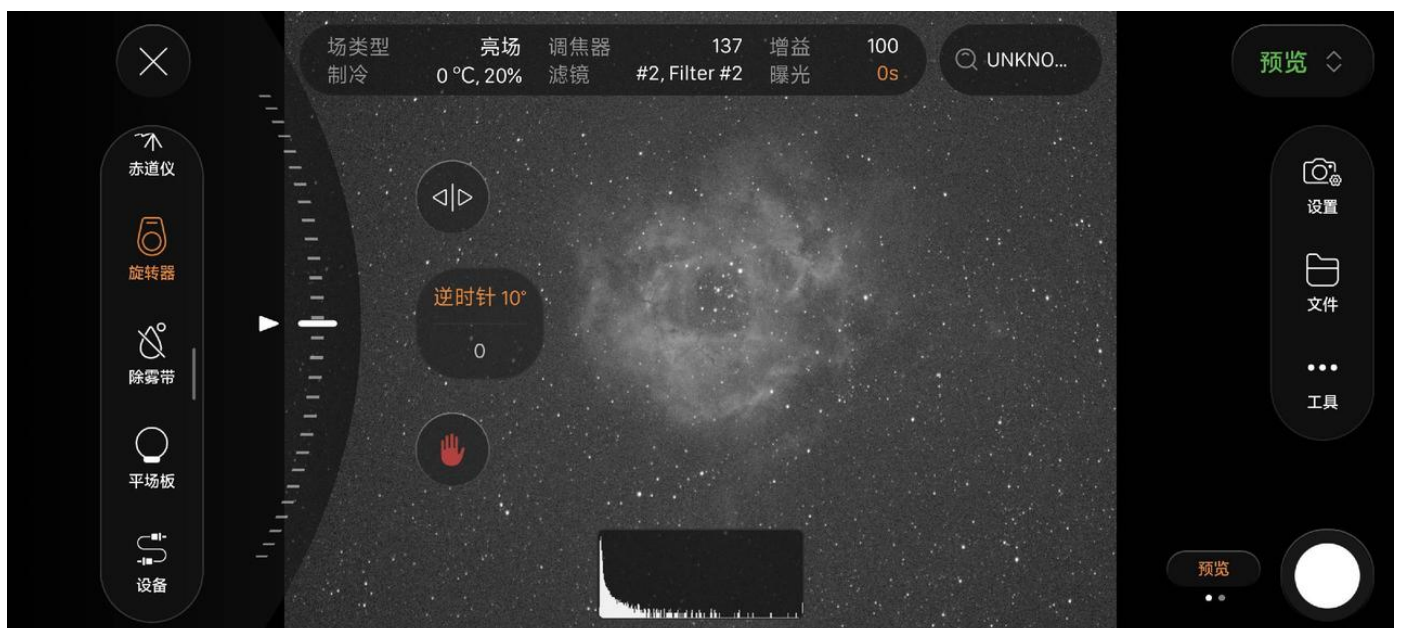


3. Mount:



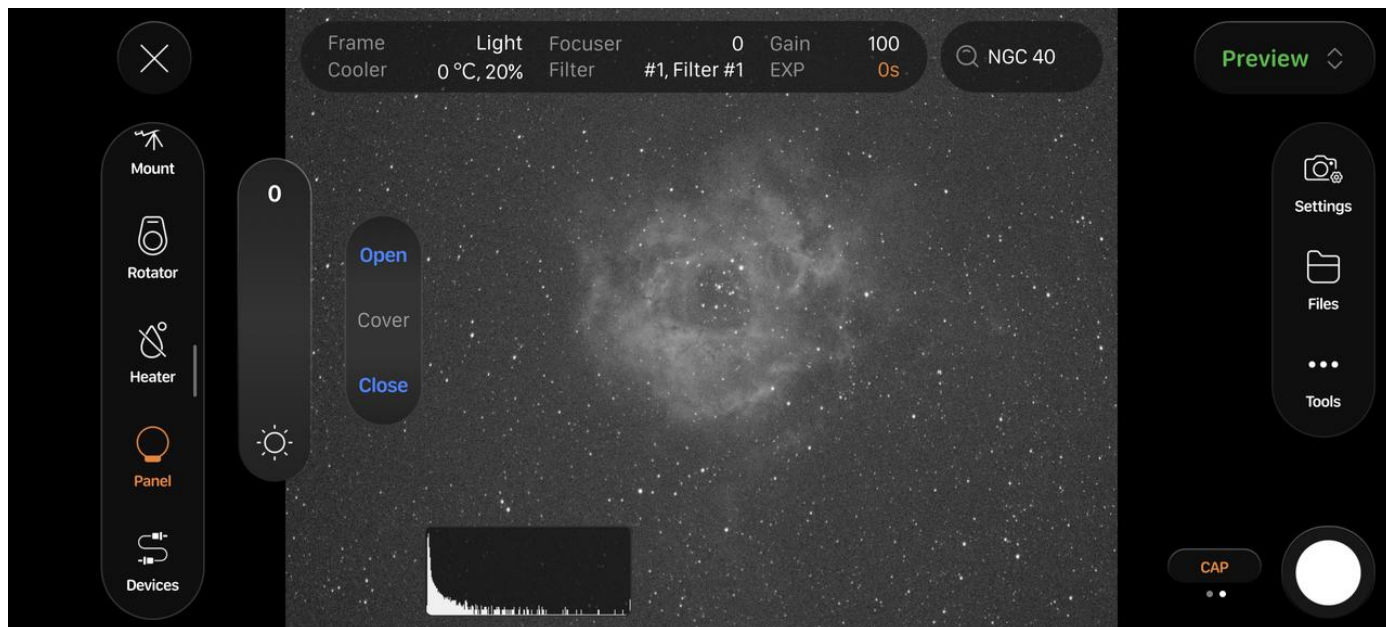
- **Direction Control:** Controls Dec (Up/Down) and RA (Left/Right) movements.
- **Rate Adjustment:** Swipe or tap the bar to select a slew rate: Min / Center / Find / Max. (Rates are normalized across mount brands).
- **Tracking:** Select Sidereal, Solar, Lunar, or turn off tracking.
- **[👋] (Stop):** Tap to immediately halt movement.
- **[🏠] (Home):** Tap to return to the home position (setup in Section 6.4).
- **[P] (Park):** Tap to move to the parking position (setup in Section 6.4). A "✓" symbol indicates that it is parked. Tap any direction to unpark.

4. Rotator:



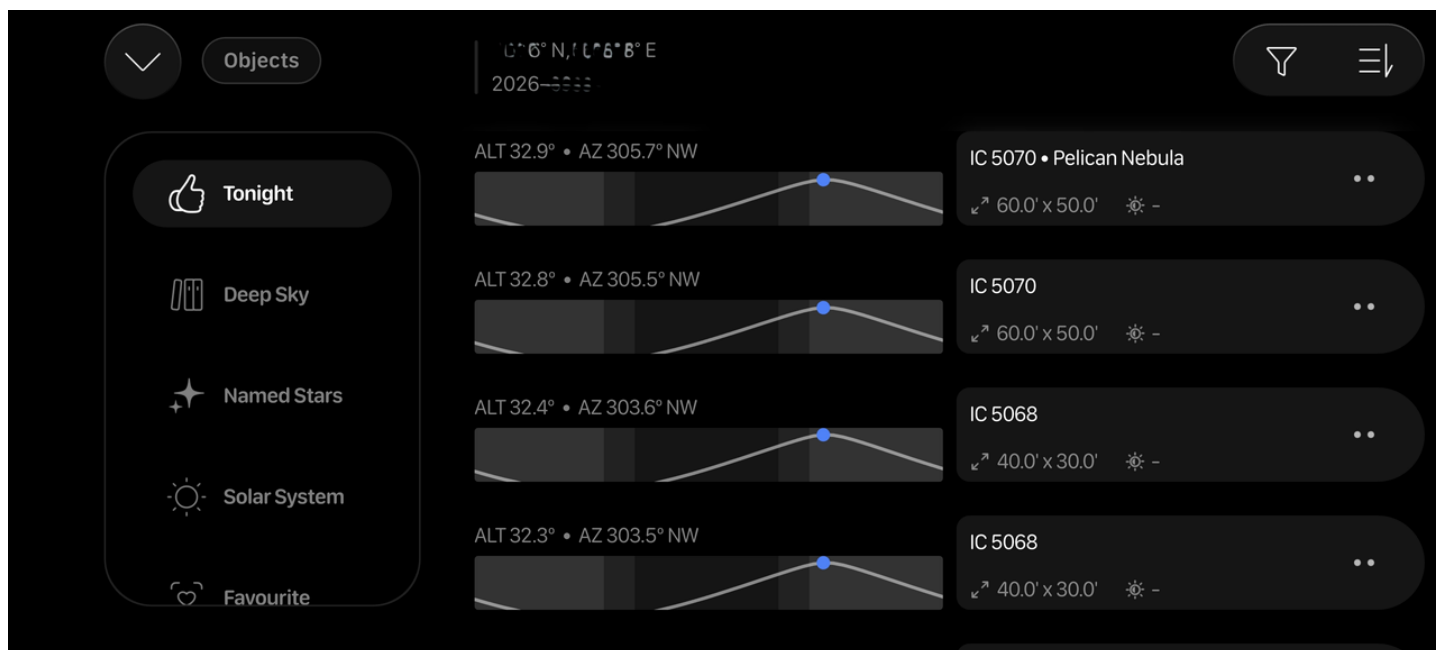
- **Arc Slider:** Swipe to set the angle. Swipe down for clockwise (1°/notch), and up for counterclockwise.
- The top right number shows the current action; the bottom shows the current angle.

- [$\triangleleft$ || $\triangle$]: Tap to modify the angle.
 - [] (**Stop**): Tap to immediately halt rotation.
- Dew Heater:** Two independent sliders control ports 11 and 12. Swipe up to increase power.
 - Flat Panel:** The left slider controls brightness (requires hardware support). The right [Open/Close] buttons open/close the mechanical cover.



3.3 Objects

Tap Objects in the left menu on the shooting page to browse celestial catalogs. Use the search box in the top right to look up targets by name or catalog number (supports plain numbers, catalog + number, and common names).



1. **Catalogs:** Includes Tonight (smart recommendations based on your location), Deep Sky, Named Stars, and Solar System. Use the top-right filter and sort functions to quickly locate suitable targets.
2. **Object Info:** The list displays basic details such as catalog number, Field of View (FOV), and visual magnitude. Tap a target to view comprehensive data:
 - **Altitude Chart:** Shows the target's altitude changes over a 24-hour period, along with current Alt/Az info. The light gray area represents daytime. The dark gray area represents twilight transitions (Sunset to Astronomical Twilight, and Astronomical Dawn to Sunrise). The solid black area is nighttime (the optimal imaging window). Tap anywhere on the curve to view the exact time, Azimuth, and Altitude for that specific point.
 - **Details:** Includes J2000 coordinates, Alt/Az, Rise/Set times, Transit time, visible duration, and physical properties (e.g., size, Moon distance, visual magnitude, and photographic magnitude).
3. **Favorites and Custom Objects**
 - **Favorites:** Tap the [⋯] button on the far right of the target's info page to favorite it. These targets are saved in the "Objects -> Favorites" directory for quick access.
 - **Custom Objects:** Scroll down the catalog list to find **Custom**, then tap **Add** in the top right. Enter the target's name and RA/DEC coordinates (J2000) to create it. Alternatively, tap "Use Current Pointing" for quick creation. Custom objects can also be added to your Sequence plans.

GOTO Safety Note: Complete Polar Alignment before executing any GOTO. See Chapter 4 for the full procedure.

3.4 Shooting Preview

Use Preview mode to test your imaging setup before starting a session.

- **Exposure Settings:** Open **Settings** on the right menu. Set the frame type to **Light**, then adjust the Exposure and Gain.
- **Histogram Check:** Open **Tools** -> **Histogram**. The data peak must fall within the visible range — avoid clipping at the right edge (overexposure) or a peak pushed to the far left (underexposure).
- **Display Stretch:** Adjust the image stretch level in **Settings**. Note that this only alters the on-screen display and does not affect the saved original RAW/FITS data.

3.5 Target Name

After finding a target via Search, tap Edit in the top right to rename it. The modified name is used as the save file name for both single captures and Sequence sessions (when using current

pointing). After a new GOTO, the name updates automatically to the new target.

4 Shooting Workflow

A standard deep-sky imaging session follows this sequence: Focusing → Polar Alignment → GOTO & Framing → Guiding → Capture.

4.1 Focusing

Access: Home > Focus. Point the telescope at a clear, unobstructed area of sky, enable continuous preview, and set an appropriate exposure.

 **EAF Safety Limit Warning:** Before using an electronic focuser, set the min and max travel limits to match the physical range of the focuser drawtube. Limits must not exceed actual physical travel. Without proper limits, the motor may continue running after the drawtube bottoms out, causing equipment damage. See Section 6.4 for setup instructions.

First, point your telescope at a clear, star-rich patch of the night sky (ensure no clouds or obstructions). On the App home page, tap **Focus** to enter the focusing page. Start a continuous preview and adjust to appropriate exposure settings.

1. Without EAF (Manual Focus):

- a. Turn the coarse adjustment knob on your focuser until stars become visible on the screen.
- b. Tap a star on the screen to select it. Its HFD (Half Flux Diameter) value will be displayed below.
- c. Turn the fine adjustment knob to find the position with the lowest HFD value. This indicates the sharpest focus.

2. With EAF (Auto-Focus):

- a. Tap **Control** → **Focuser** on the left menu to open the panel. Swipe the coarse slider until the stars are roughly in focus on the screen.
- b. Tap the [▶] (Start) button in the bottom right to begin the auto-focus routine. The system will automatically calculate the optimal focus position.
- c. Once completed, tap the [√] button in the bottom right to finish the process and exit the focus page.

4.2 Polar Alignment (PA)

Access: Home > Polar Alignment. **Prerequisites:** The mount must be at the Home position (RA axis pointing toward the celestial pole, error < 5°) and the camera must be in focus.

1. Parameter Settings:

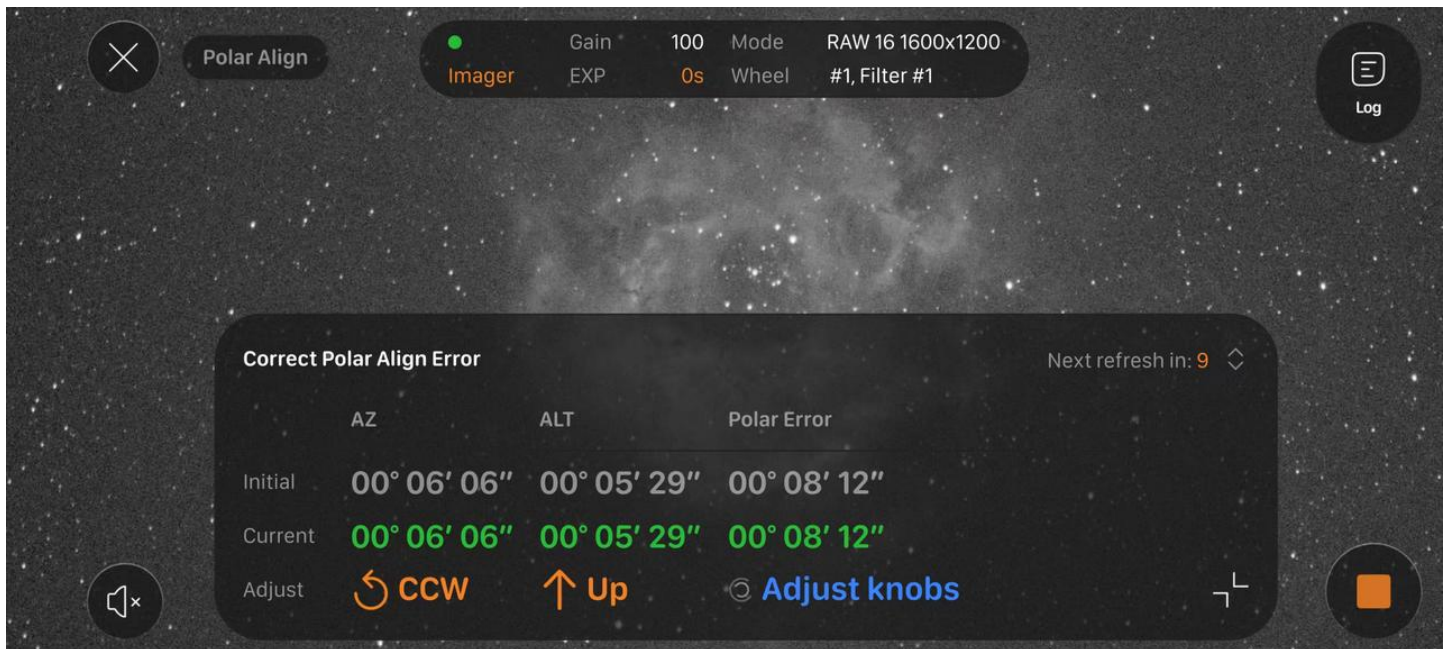
- **Exposure Settings:** Set an appropriate exposure time in the right **Settings** menu to ensure enough stars are captured for plate solving. We recommend testing this first via **Tools -> Solver**.
- **Camera Selection:** The main camera is used by default. If your main scope's FOV (Field of View) is too narrow, or plate solving is too slow due to a large sensor, you can switch to the Guide Camera via **Tools -> Switch** on the right. For large sensors, you can also set an ROI (Region of Interest) crop to speed up solving.
- **Rotation Range:** The default starting position is East. If obstructed, change the starting position, rotation angle, and direction in the top-right Settings. Regardless of starting position, the following conditions must all be met:
 - i. The starting position is far from the celestial pole.
 - ii. The mount does not cross the meridian during movement.
 - iii. The final position is not close to exactly East (90°) or exactly West (270°).
 - iv. The mount has sufficient clearance in the chosen direction (at least twice the step distance) to prevent equipment collisions.

2. Start Polar Alignment:

- Tap the [▶] button in the bottom right. The mount will slew to the starting position, take an image, and plate solve.
- Upon a successful solve, the mount will automatically slew to the next position for another capture and solve. This repeats until all 3 positions are completed.

3. Manual Adjustment

- Once solving is complete, adjust the mount's physical Alt/Az knobs based on the Azimuth and Altitude error values shown on screen.
- Refresh the polar alignment error. Three refresh methods are available:
 - Auto: Refreshes automatically at the set interval.
 - Manual: Tap the refresh button after each knob adjustment.
 - Voice: Say "Refresh" to trigger a refresh, or "Switch to Auto" to enable auto mode. Enable Voice Readout in the bottom left to complete the entire adjustment without looking at the App screen.
- Continue adjusting the Alt/Az knobs until the total error is below 10' (arcminutes), then lock all knobs securely.



4.3 GOTO and Framing

After completing polar alignment, go to **Home** -> **Start Shooting**.

1. **GOTO Target:** Select a target from the left-side Object Library or SkyMap, then tap GOTO. The mount slews to the target and enables Sidereal tracking automatically.
 - GOTO has no effect if the target is below the horizon.
2. **Framing Adjustment:**
 - **Adjusting the Center:** Open **Tools** -> **Center** on the right. Drag the yellow box to the desired center point for off-center framing.
 - **Adjusting the Angle:** Tap **Control** -> **Rotator** on the left (if equipped) and rotate to the target angle.
3. **Setting Optimal Exposure Parameters:**
 - Use Preview mode to dial in exposure settings. Open Tools > Histogram and go to Settings > Camera to adjust parameters.
 - **Gain:** Refer to your camera's spec sheet and set gain based on Unity Gain, lowest read noise, or maximum full well capacity. Unity Gain (also referred to as Mid Gain) is a reliable starting point.
 - **Histogram:** Adjust Offset and Exposure time until the histogram peak sits at roughly 1/4 to 1/3 from the left edge, with no clipping on the left side. This preserves faint nebula detail while avoiding large overexposed areas.
 - **Cooling (if supported):** Turning on cooling suppresses dark current noise. Avoid setting the target temperature too low — Running the cooler at maximum load can cause temperature fluctuations.

4.4 Guiding

Guiding corrects tracking errors during long exposures, keeping stars sharp throughout a deep-sky session.

1. Guide Focus

Tap Guiding on the shooting page to enter continuous preview. Manually adjust the guide scope focuser until stars appear small and sharp. Adjust exposure parameters on the right — increasing the RMS contrast value in the floating window improves star detection accuracy.

2. Set Detection Area (Optional)

If edge stars are distorted, or the guide camera's sensor is too large, we recommend tapping **Tools** -> **Selection** or **ROI**. Draw a box around a central area with good star shapes and a clean background. The system will strictly use this area for guide star detection, preventing distorted stars from interfering with corrections.

3. Set Focal Length

An accurate guide scope focal length is critical for error calculation. On the guiding page, tap **Tools** -> **Solver** on the right. Upon a successful plate solve, the system will automatically fill in the precise focal length. Alternatively, you can return to **Home** > **Config** > **Device** to manually enter the correct guide scope focal length.

4. Select Guiding Method

Choose the appropriate communication mode based on your hardware connection. *Note: If the software setting does not match your physical wiring, guiding will not work.*

- **Pulse Guiding (Recommended):** The mount must be connected to SynLink via USB or serial cable and connected within the App. Delivers high accuracy and fast response.
- **ST4 Guiding:** Requires a dedicated ST4 cable connecting the guide camera's ST4 port to the mount's Guider port. This is primarily for legacy mounts or those lacking pulse communication protocols.

5. Calibration & Start

Before guiding begins, the system must perform a calibration to learn the mount's correction directions and step sizes.

- Calibrate near the Celestial Equator ($\text{Dec} \approx 0^\circ$) and as close to the Meridian as possible. RA motion is most pronounced in this region, producing the most accurate calibration data.
- If the guide camera has been rotated or the guide optical train physically changed, the previous calibration is invalid — recalibrate before starting.
- Tap [**Calibrate**] in the bottom right. Once calibration completes, tap [Guide] to start guiding corrections.

6. Curve Monitoring & Adjustment

Once guiding starts, a real-time error graph is generated. If your RMS error remains consistently high, observe the graph and fine-tune the correction aggressiveness (Aggr) in the settings:

- **Scenario A: Over-correction (Violent sawtooth oscillations)** The correction amount is too large, pushing the mount in the opposite direction. *Solution: Decrease the aggressiveness.*
- **Scenario B: Under-correction (Slowly drifting from the center line and failing to return)** The correction amount is too small to counteract the tracking error. *Solution: Increase the aggressiveness.*

For details on the guiding algorithm logic and advanced parameter settings, please refer to Chapter 7.2.

4.5 Sequencer

Sequencer is an automated workflow designed specifically for deep-sky astrophotography. It handles multi-batch, multi-target, and calibration frame capture in a fully automated pipeline — including Meridian Flips and Auto-Focus — for unattended all-night imaging.

Access: Home > **Start Shooting** > tap the top right to switch to **Sequence** mode > tap **Plans** to enter the settings. Toggle between EASY and PRO modes in the top-left corner.

4.5.1 EASY Mode

Suitable for single-target, multi-target, and mosaic deep-sky imaging sessions.

1. Calibration Frames

- a. Calibration frames include Bias, Dark Flat, Dark, and Flat.
- b. Edit Save Folder: Tap Edit at the top to rename the save folder for each frame type.
- c. Add Batch: Tap Add Batch on the right to enter exposure parameters manually, or import matching parameters from an existing Light batch or Light file.

2. Light Frames

- a. **Add Targets:** Tap **Add** and choose one of the following:
 - Current Pointing: Use the telescope's current pointing as the target.
 - Object/ SkyMap: Select one or more targets from the object library or SkyMap. Supports multi-target queues.
 - Mosaic: Two methods available:
 - Add > Import Mosaic CSV: Paste a CSV exported from SkyGuide or Telescopius, and set the mosaic plan name on the right.

- SkyMap > tap Mosaic (bottom right): Adjust panel rows, columns, and overlap percentage directly on the SkyMap, then tap Add to confirm.

b. Target Settings

- **Skip GOTO:** Enable when the telescope is already accurately pointed at the target to begin shooting immediately.
- **Skip Center:** Enable when the target altitude is too low or plate solving is likely to fail. The system skips centering validation to prevent task interruption.
- **Start Time:** Sets a forced start time for this target. When the set time is reached, the system switches to this target immediately, regardless of whether the previous target has finished.

c. Add Batches

After adding a target, the **Batch** addition prompt will pop up (or tap a target to enter its details and add a batch).

- Select the filter (if any), set the frame type, exposure, Gain/ISO, Offset, and the number of frames, then tap **[Add]**.
- Multiple batches can be added per target for different filters or exposure parameters.
- Tap **[⋯⋯]** in the top-right corner of the batch page to apply the current batch settings to all targets in the list, or to all targets after the current one.
- Target name and batch repeat count can be edited at the bottom of the detail page.

d. **Plan Settings** Before initiating the sequence, go to **Sequence > Settings** to adjust the global execution details:

i. Start

- Sequence Start / End Time: Set the automatic start time and forced stop time for the sequence.
- Batch Delay: Wait time before each batch begins.
- Exposure Delay: Interval between consecutive exposures.

ii. During

- Auto-Focus Triggers: Set conditions to trigger auto-focus automatically — options include Filter Change and Target Change.
- Guiding: Enable automatic guiding during the sequence. Recommended for long single exposures.
- Dithering: Shifts the frame between exposures to eliminate fixed pattern noise. Recommended. Supports Guide Dither and Direct Dither (no guiding required).
- After Transit: Controls when the sequence pauses and the Meridian Flip executes.

- Negative value (e.g., -0.5h): Stops shooting 0.5 hours before the meridian; resumes and flips 0.5 hours after meridian passage.
- Positive value (e.g., 0.5h): Continues shooting until 0.5 hours past the meridian, then executes the flip.

iii. End

- Focuser Return to Zero: Moves the focuser to the zero position after the sequence ends.
- Park Mount: Returns the mount to the Park position and stops tracking and guiding after the sequence ends.
- Warm Up Camera (cooled cameras only): Gradually warms the camera to ambient temperature (approx. 20°C) over a set duration after the sequence ends, preventing thermal shock to the sensor.



e. Final Check & Start Shooting

- Return to the target list and check the targets to include in this session.
- Review the Altitude Chart for each target, focusing on the green highlighted area (the actual shooting window):
 - Green area starts below the horizon: the system will skip this target and move to the next.
 - Green area ends below the horizon: the latter part of the session for this target may not be completed.
- If the time allocation needs adjustment, tap Edit in the top right to reorder targets or modify individual frame counts to optimize the night's schedule.

- Once all targets' shooting windows are confirmed at safe altitudes, tap [▶ Start] to launch the sequence.

All captured files can be viewed in the "Files" module. Refer to Chapter 5 for details.

4.5.2 PRO Mode

PRO mode provides fully customizable sequence automation using an instruction flow format, with support for scheduling sessions days in advance.

Access: Home > Sequencer Plans (or switch to "PRO" in the Sequence settings on the shooting page).

1. Add Plan

Tap **Add Plan** in the top right, or duplicate a preset template and modify it into a custom plan.

2. Add Individual

Add individual action instructions for specific devices, or call a preset Instruction Set and adjust parameters as needed.

3. Start Shooting

Under **Start Shooting > Sequence > PRO**, select your configured plan and tap [▶]. The system will execute all instructions in order until the plan concludes. *For a full description of each instruction, please refer to Appendix 9.3.*

4.6 Live Mode

Live Mode automatically aligns and stacks each frame as it is captured, progressively improving signal-to-noise ratio to reveal deep-sky detail in real time.

Access: **Home** > **Start Shooting**, then switch to **Live** mode at the top.

1. Create Calibration Frames (Recommended)

Calibration frames eliminate thermal noise, readout noise, and vignetting, improving stacking quality.

- Go to **Settings** > **Camera** on the right. Select a calibration frame type (Dark, Flat, or Bias) and configure the corresponding capture parameters.
- Return to the shooting page, set up your equipment for the selected calibration frame type, and tap **Shoot** to begin.
- Once the set frame count is reached, the system saves the calibration frames automatically.
- Repeat for each calibration frame type as needed.

2. Configure Live Stacking Settings

- a. **Camera Parameters:** Go to **Settings** > **Camera** on the right. Set exposure time, gain, ISO, and capture mode.
- b. **Load Calibration Frames:** Tap **Dark**, **Bias**, and **Flat** respectively to select the calibration frame directory matching your current light frame parameters. Skip this step if no calibration frames are available.
- c. **Stacking Options:** Tap **Stack** to configure the following:
 - **Stack Limit:** Sets the total number of frames to stack. Stacking stops automatically when this count is reached.
 - **Stack Snapshot:** The system automatically saves a stacking snapshot at the set frame interval, letting you review how the signal-to-noise ratio improved throughout the session.
- d. **Start Stacking:** Tap **Shoot** to begin. The system automatically aligns and integrates each frame into the stacked result as it is captured.

3. File Saving

- Every individual frame is saved automatically during the session.
- A master light file is saved each time the set frame count is completed.
- If stacking is stopped manually, the current stacked result is saved automatically.

4.7 Video Mode

Video mode is designed for short-exposure, high-frame-rate imaging of bright targets — planets, the lunar surface, and the Sun.

 **Safety Warning:** Before observing or imaging the Sun, ensure that proper solar filters are securely installed. **NEVER** execute a GOTO to the Sun or look directly at it through any optical device without proper protection. Doing so will cause permanent equipment damage and irreversible, severe eye injury!

1. **Targeting & Centering:** Use **Objects** to GOTO the target's vicinity. Then, use the **Control** > **Mount** panel on the left to fine-tune the direction and center the target perfectly in the frame.
2. **Exposure Testing:** Open **Settings** > **Camera** on the right to adjust the Gain and Exposure time, and confirm there is no highlight clipping on the histogram.
3. **Enable ROI:** If the target occupies a small portion of the frame, use **Tools** > **ROI** on the right to crop the image to reduce data transfer load and increase frame rate.
4. **Fine Focusing:** Use **Control** > **Focuser** to dial in the absolute sharpest focus position.

5. Start:

- Go to **Settings** -> **Camera** on the right, find the video recording options, and set your desired recording limits (e.g., duration or frame count).
- Tap the Shutter button. The system will automatically stop recording once the specified limit is reached and save the file to your storage.

5 File Management

Data Safety and Storage Recommendations

Do Not Power Off Immediately After Shooting: After a capture session completes, the system requires time to write cached data to the storage media (whether internal or an external USB drive). **NEVER** turn off the SynLink's power immediately after a task finishes, as this can easily lead to file corruption or complete data loss.

Safely Eject External Storage: When using a USB storage device, please wait 1 to 2 minutes after shooting ends, and **ALWAYS** tap "**Safely Eject**" in the App's File Management interface before physically unplugging the drive.

Storage Format Recommendation: For faster read/write speeds and enhanced stability, the FAT32 format is not recommended.

5.1 File Saving

Files generated during Preview(CAP mode), Sequencer, and Video are automatically saved to your storage space by default. You can modify the storage location, file format, and file name template by navigating to **Home > Configuration > Operation > Image & Video**.

- During Preview (CAP mode), while the original image is saved to the main storage, a JPEG thumbnail is also saved to the local photo album of the device running the SynLink App.
- If a compatible external storage device is detected, the system will automatically prioritize it. External storage supports exFAT, FAT32, ext4, and NTFS formats. *(Note: FAT32-formatted drives cannot store individual video files larger than 4 GB).*

Supported File Formats:

- **Images:** Supports RAW, TIFF, XISF, and FITS formats. *(Note: DSLR cameras do not support direct TIFF output).*
- **Videos:** Supports SER (+RAW) and AVI (+JPEG).

Custom File Name: Tap "**FileName Template**" to check the information variables you wish to include in your file names (e.g., Target Name, Filter, Temperature, etc.). Drag the [≡] icon on the right to freely adjust the order of these fields.

5.2 File Browsing

Go to **Home** > **Files** or tap **Files** on the right menu from any shooting mode interface. In the File Management page, select the corresponding storage space and shooting mode to browse your media files. Files are automatically categorized into folders based on target names, and you can view or delete them as needed.

- **Image Preview**

- View basic file info (Exposure, Gain, etc.), the target's altitude curve, and the FITS header information. Manually stretch the histogram to adjust the on-screen display effect.
- Tap **Add** to directly add the file's corresponding target to your Sequence shooting plan; tap **GOTO** to slew the telescope to the corresponding target.
- Tap **Save** to save the current image as a JPEG to the device photo library.
- **PSF:** See Section 6.5.

- **Video Preview**

- Tap **Stretch** in the top right corner to adjust the display stretch level of the video preview.

5.3 File Export

Files On SynLink Internal Storage:

- **Method 1: Via Type-C Port**

- Keep the SynLink controller powered on. Connect SynLink's Type-C port to a computer or smartphone using a data cable. The internal storage will mount as an external drive for direct file transfer. *(Note: This mode is read-only. Files cannot be modified or deleted from the connected computer).*

- **Method 2: External Storage Device**

- Plug a USB flash drive or other external storage into any of SynLink's USB Type-A ports. In the App's **View Files** page, select the files or folders you want to export, tap **Move**, and select your USB drive as the destination. Wait for the copy to complete. When the transfer is complete, tap **Eject USB** in the top-right corner of the File Management page before unplugging the device.

Files On USB/External Storage:

If files were saved directly to a USB drive during shooting, wait 2 minutes after the task ends to ensure all data is fully written. Then, tap **Eject USB** in the top right corner of the File Management page, unplug the drive, and plug it into your computer to read the files.

6 Extended Features

6.1 Observation Time and Location Editing

You can manually modify the device's time and location information to plan observation or imaging sessions for different locations in advance.

Path: Home > **Configuration** > **Operation** > **Observing Time & Location**, tap **Custom**.

- **Date & Time:** Swipe up/down to adjust the year, month, day, hour, and minute (24-hour format). Tap [✓] in the top right to confirm.
- **Lat/Lon:** Swipe up/down to toggle N/S hemisphere, E/W longitude, and coordinate degrees/minutes/seconds. Tap [✓] to confirm.
- **Elevation:** Enter the local elevation (in meters).

6.2 Equipment Checklist

To prevent forgetting crucial gear, SynLink features a built-in equipment checklist. **Path:** Home > **Others** > **Checklist**.

- **Custom Items:** Tap [Add Custom Item] in the top right, enter the item name and category, then press Enter.
- **Usage:** While packing, tap the circle to check off an item once it's packed. Ensure no important gear is left behind.
- **Reset:** Before your next trip, tap **Reset** in the top right to clear the statuses and reuse the list.

6.3 Viewing System Status and Info

Path: Home > **Others** > **System Status**. This panel provides real-time data for the entire system:

- **Version Info:** The top right corner displays the current controller firmware version and App version.
- **SynLink:** Displays the hardware status of the SynLink controller.
 - **Input Voltage:** The current input voltage of the controller.
 - **CPU Temp:** The controller's core operating temperature.
 - **Dew Heater #11, #12:** The current output power percentage of the two heater ports. The one closer to the power input is #11, and the other is #12.
 - **Internal Storage:** The remaining available space on the controller's internal storage.
- **Observing Site:** Displays Location (Longitude/Latitude), Local Time, Time Zone (representative city), and Local Sidereal Time (LST). This is typically obtained from the device running the App. If "Custom" is selected, it displays the custom location info.
- **Telescope Pointing:** Real-time display of the telescope's current Right Ascension (RA) and Declination (DEC) based on JNow, Hour Angle (HA), and Altitude/Azimuth (Alt/Az).

- **Device Connection:** Displays the connection status of the Imager Camera, Guider Camera, Mount, Focuser, Wheel, Rotator, and Flat Panel.
- **Sequencer:** Displays info for the currently running sequence:
 - **Mode:** Indicates whether the current sequence is in EASY or PRO mode.
 - **Frame:** Indicates whether a Light or Calibration frame is currently being captured.
 - **Exposure/Step:** In EASY mode, this shows the remaining exposure time of the current image. In PRO mode, this shows the number of completed instructions.
 - **Guider:** The total guiding error in arcseconds ("). Displays 0 if guiding is off.
 - **Frames:** The number of successfully captured frames.
 - **Transit:** The time remaining until the target crosses the meridian.
 - **Progress:** The overall completion percentage of the current task.
 - **Rem. EXP:** Shows the remaining exposure time of the current image.

6.4 Device Configuration and Operation

Go to **Home > Config > Device** or **Operation** to modify the settings for each device. Available options vary by brand and model — refer to the App interface for the exact configurable items on your setup.

1. Telescope

- Enter the Aperture and Focal Length for both the Imager Scope and Guide Scope in millimeters (mm). Accurate focal length values significantly speed up plate solving. If the exact focal length is unknown, enter 0 — the system will automatically update it to the effective focal length after the first successful plate solve.

2. Imager Camera

- **Enable Cooler When Connected:** Enable this option and set a target temperature in the camera config page. The camera will automatically start cooling down once connected.

3. Mount

- **Home Position:** Located under **Config > Devices**, this is the initial reference point (usually the Celestial Pole). The power-on position is the default Home position. Tap to set the current pointing as Home or tap **Auto Search** for a precise physical reset (requires mechanical sensors).
- **Park Position:** Go to **Config > Devices**. A safe resting posture after shooting to prevent collisions or sun exposure. Manually move the telescope to a safe angle and tap to save it as the Park position.

- **Reverse Directions:** Go to **Config > Operation**. Check **Reverse RA** or **Reverse DEC** if the directional keys move the mount in the opposite direction.
 - **Solver & GOTO:** Go to **Config > Operation**.
 - **Skip Plate Solve:** Enable ONLY for simulation. **ALWAYS** disable during actual shooting to ensure accurate Polar Alignment and GOTO.
 - **Sync Before GOTO:** Solves the current position to confirm coordinates before executing a GOTO, preventing uncalibrated slewing and potential collisions.
 - **GOTO Center Retries:** Increase this value if targets are consistently off-center. The system will retry solving and adjusting until perfectly centered.
4. **Focuser** Go to **Config > Device > Focuser**. Before using an Electronic Focuser for the first time, you must set its travel range.
- **Fine Move Steps:** Customize the step size for a single tap of the fine adjustment button on the control panel. Increase this value for internal focusing systems or those with reduced microfocusers.
 - **Coarse Move Steps:** Customize the step size for a single tap of the coarse adjustment button on the control panel.
 - **Min Limit Steps (0 Position):** Typically corresponds to the position when the focuser drawtube is fully retracted (shortest). For internal focusing telescopes like SCTs or Maksutovs, you can set the 0 position directly near the prime focus.
 - **Max Limit Steps:** Set based on the position when the drawtube is fully extended. Must not exceed the actual physical limit.
5. **Wheel (Filter Wheel)** Go to **Config > Device > Wheel**.
- **Label:** Assign a custom name to each filter slot (e.g., L, R, G, B, etc.), making it intuitive to distinguish during shooting and sequence planning.
 - **AF/Solver Exposure:** You can individually set the exposure time for Auto-Focus (AF) and plate solving for different filters (e.g., narrowband filters require longer exposure times to solve).
 - **Focus Offset:** Supports setting relative focus offset steps based on a "Reference Filter" to achieve parfocal switching without refocusing. Specific offsets can be tested on the focusing page. Refer to Chapter 7.3 for a detailed tutorial.
6. **Rotator**
- Customize the current angle to calibrate the 0° - 359° limit range, preventing equipment cables from tangling or colliding.
 - Invert the motion.

6.5 Tools

The **Tools** module, accessible from the right menu in the Focus, Polar Alignment, and Shooting pages, includes the following practical features:

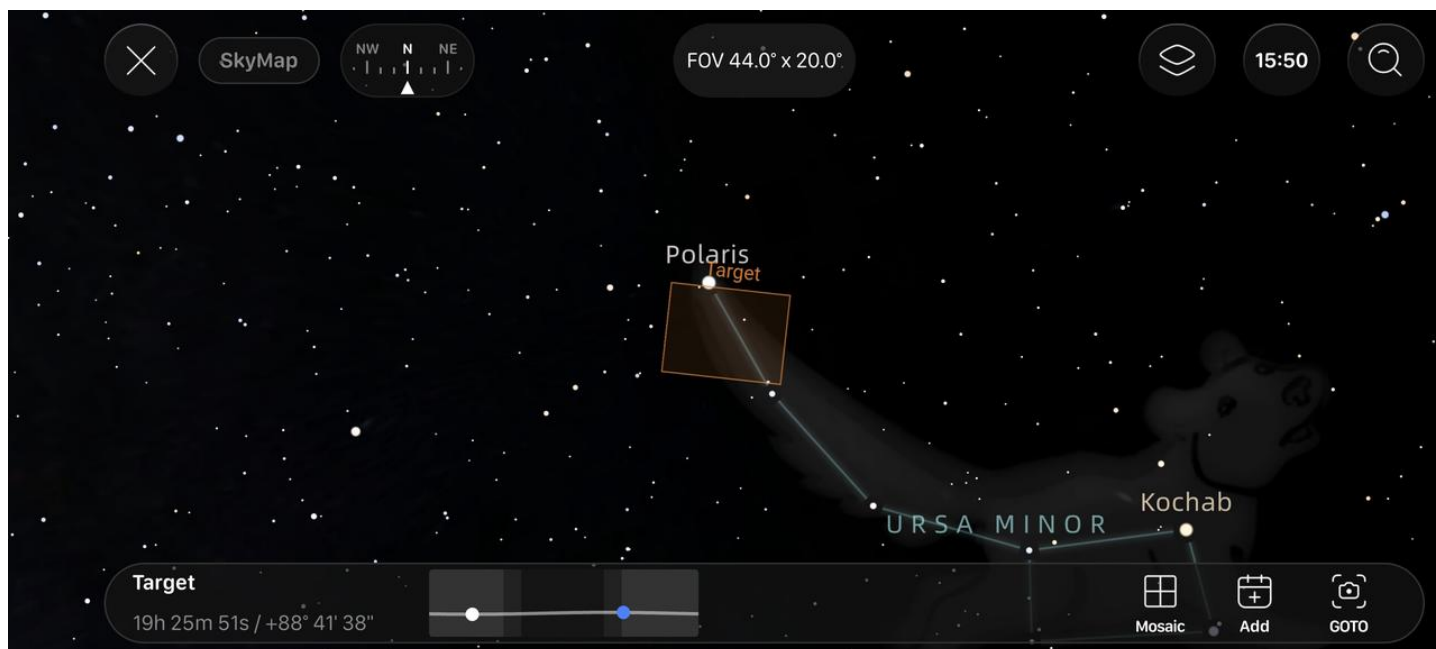
- **Reticle:** Overlays a crosshair in the center of the frame to assist with manual target centering.
- **ROI:** Reads only a specified area of the sensor to increase the frame rate. Supports original, custom ratios or square framing. Tap $\checkmark$ to confirm.
- **Center:** Drag the selection box over the image to pick a new center point, then tap to execute a GOTO and center it for custom off-center framing.
- **Histogram:** Opens a floating histogram window to monitor pixel distribution. Drag to reposition; tap to expand for a detailed view.
- **Solver:** Takes an image at the current pointing, plate solves it to calculate precise coordinates and syncs them to the mount. If plate solving fails, try increasing the exposure time.
- **Log:** View the system operation logs for the current connection to help troubleshoot issues. Supports scrolling back through history by date.
- **PSF:** Used to evaluate star quality and optical path aberrations. It contains two sub-modules:
 - **PSF:** The left side displays the number of detected stars, average roundness, and max difference. Swipe up/down on the right side to adjust the detection radius and display results.
 - Radius: Default is Auto. Use a large radius for short focal lengths/wide FOVs, and a small radius for long focal lengths/high resolutions.
 - Display: Defaults to displaying stars and their roundness scores. **N-R** shows the "Number of stars - Average Roundness" for each section of a 3x3 grid. **Tilt** annotates the field tilt.
 - **Grids:** Automatically generates a 9-panel grid slice (center, edges, and corners) to visually compare star roundness across the entire field. Use this to diagnose backfocus distance and sensor tilt. Tap the bottom right to switch zoom levels.

6.6 SkyMap

Access: Home > **Start Shooting** > select **SkyMap** from the left menu.

- **Sky Visualization:** Displays elements like coordinate grids, landscapes, constellation lines, and the meridian. Enable gravity sensing to point your device at any part of the sky and view the corresponding simulated star field. Pinch to zoom in/out. The top indicates the current azimuth and FOV size.

- **Target Search & Planning:** Modify the simulated time and time flow speed in the top right to preview upcoming sky events. Tap [🔍] to search for a specific target; once selected, execute a one-click **GOTO** or add it to a Sequence plan.
- **Mosaic:** Tap **Mosaic** in the bottom right to visually frame wide-field targets directly on the SkyMap. Adjust the number of rows/columns and the overlap percentage, import it into an automated Sequence.



7 Advanced Features

7.1 Auto Focus (AF)

Path: Home > **Focus** > **Settings** to enter the Auto Focus configuration page. SynLink provides professional AF algorithms tailored to different optical systems.

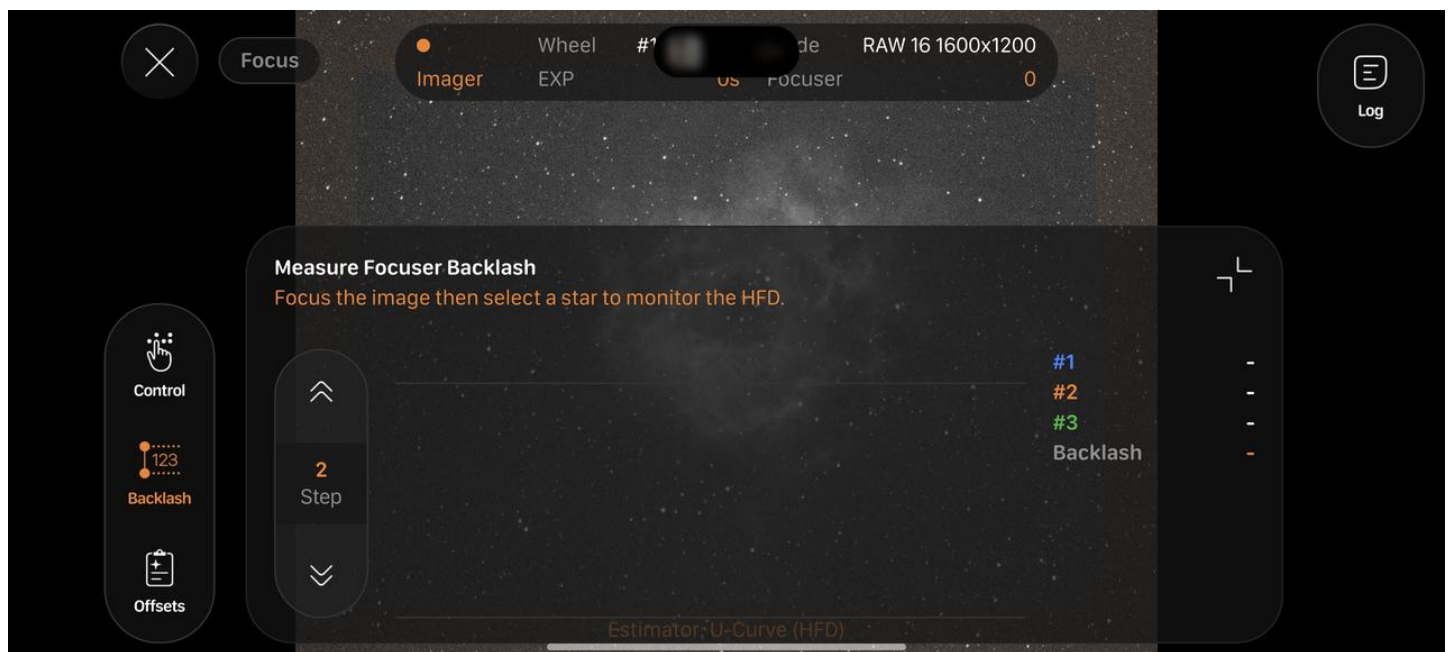
General Parameters:

- **Max Used Star:** Limits the number of stars used for calculation. Fewer stars result in faster calculation but higher noise sensitivity; more stars provide a more stable average at the cost of processing time.
- **Star Detect Radius:** Defines the search range for star centroids.
 - *U-Curve algorithm:* 10–20 pixels recommended.
 - *Iterative algorithm:* 8–10 pixels recommended.
- **Backlash:** Compensates for mechanical play in the focuser system. Refer to Section 7.2 for backlash measurement. (Not supported in RMS algorithms).
- **Backlash Overshoot Factor:** Defines additional movement compensation when clearing backlash. Recommended for systems with significant play or heavy loads (e.g., SCTs with primary mirror focusing).

Estimator Selection:

1. **U-Curve (HFD) - Recommended** High precision, suitable for long focal lengths and high-end deep-sky imaging. The system measures HFD values around the current focus point and uses parabolic fitting to find the absolute sharpest point (the bottom of the U-curve).
 - **Fitting Samples:** The number of data points collected to build the curve. More samples improve accuracy but take longer.
 - **Sample Steps:** The movement distance between samples. Increase this for SCTs or systems with micro-focusers.
 - **Samples per Point:** Takes multiple images at each position and averages the results to counteract errors caused by seeing.
2. **Iterative (HFD)** Fast calculation with slightly lower precision, suitable for quick adjustments. The system takes small steps around the current position until the HFD stops decreasing.
 - **Initial Step:** The distance moved at the start to quickly approach the focus zone.
 - **Final Step:** The smaller distance is used for precise positioning once near focus.
 - **Samples per Point:** Multiple captures per step to minimize seeing interference.
3. **Iterative (RMS)** Designed for high-contrast targets like planets, the lunar surface, or solar sunspots.
 - It calculates the RMS (Root Mean Square) based on brightness variations (contrast) in a local area, moving until the contrast reaches its peak.
 - **Initial Step:** The distance moved at the start to quickly approach the focus zone.
 - **Final Step:** The smaller distance is used for precise positioning once near focus.
 - **Samples per Point:** Multiple captures per step to minimize seeing interference.

7.2 Measuring Focuser Backlash



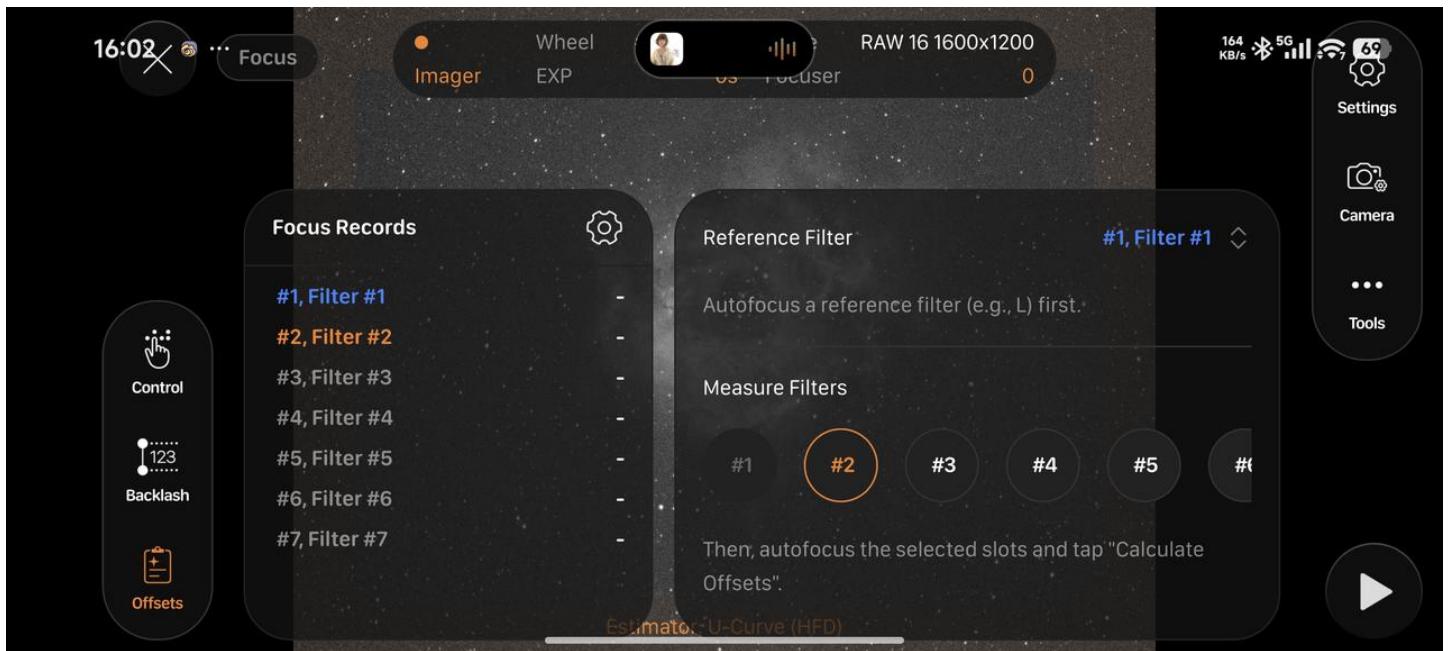
Backlash refers to the "lost motion" or mechanical play between gears and screws when the focuser motor changes direction. This directly affects focusing precision. You can measure it via **Focus > Backlash** (Note: Not supported in RMS mode).

1. Ensure **Backlash** is temporarily set to **0** in **Focus > Settings**.
2. Move the focuser to a near-perfect focus state. Select a star to monitor its **HFD**.
3. Move the focuser in a single direction in very small increments (1–2 steps) until the HFD increases, indicating you have left the focus zone. Record this position (e.g., **8000**). Allow the HFD to stabilize over a few exposures (it will fluctuate slightly due to seeing).
4. Move the focuser back by the same number of steps in the opposite direction. If the HFD does not change, the focuser is "idling" due to mechanical play.
5. Continue moving in this reverse direction 1 step at a time until the HFD begins to steadily decrease (indicating the gears have re-engaged and physical movement has resumed). Record this position (e.g., **8016**).
6. **Calculate the Difference:** $8016 - 8000 = 16$. Your system's backlash is **16 steps**. Enter this value into the Backlash settings.
7. *Note: If the HFD decreases immediately in Step 4, your step size was either too large, or your system has negligible backlash.*

7.3 Filter Focus Offsets

Differences in the refractive index of light at different wavelengths or variations in filter glass thickness cause the focal point to shift when switching filters. By configuring **Focus Offsets**, the system automatically compensates for these step differences, eliminating the need for a full auto-focus routine after every filter change (achieving a **parfocal** setup).

Path: Home > **Focus** > tap the **Offset** icon in the bottom left.



1. Select a **Reference Filter** as your baseline.
2. Check the **Target Filters** you wish to measure (multiple selections supported).
3. Tap [▶] to start the automated calibration routine. The system will perform a high-precision auto-focus for each filter and calculate the coordinate delta relative to the reference filter.
4. Once testing is complete, tap [√] to permanently save the offset results.

7.4 Guiding Algorithms

Guiding consists of three major modules: Calibration, Guiding Correction, and Dithering.

7.4.1 Guiding Calibration

The goal of calibration is to establish a mapping between star movement on the sensor (pixels) and the mount's correction direction and pulse duration. The closer the two calibration axes are to 90°, the better the calibration quality.

1. Star Detection

- There are three detection methods:
 - **Selection:** Centroid tracking for selected stars. Suitable for most scenarios.
 - **Weighted Selection:** Adds SNR-based weighting where brighter stars have a stronger influence. Suitable for multi-star guiding with uneven brightness.
 - **DONUTS:** Analyzes the star structure across the entire frame or a specified area. Designed for complex scenarios with defocused stars, comatic stars, or sensor hot pixels.
- **Max Used Star:** The maximum number of stars used simultaneously for guiding calculations. The system automatically selects the most suitable stars. More stars increase resistance to seeing but require more processing power.

- **Star Detect Radius:** Limits the detection range for finding star centroids. Too small risks missing stars or losing lock; too large may introduce interference from neighboring stars or noise.
2. **Clear Backlash** Since the mount axes frequently reverse direction during guiding, the system performs a small compensation movement during calibration to eliminate gear play and ensure accurate results.
- **Max Steps:** The maximum number of pulses allowed for backlash clearing.
 - **Min Drift:** The minimum pixel displacement required to confirm that backlash has been successfully cleared.
3. **Calibration Parameters**
- **Calibration Step:** The pulse duration for a single move during calibration.
 - **Max Steps:** The maximum allowed pulses during the calibration process.
 - **Min Drift:** The threshold to determine if the star has moved far enough. Falling below this value will cause calibration to fail — increase Max Steps or Calibration Step to resolve

7.4.2 Guiding Settings

The system stabilizes long exposures by sending correction pulses to the mount based on detected star displacement. There are four correction modes available (PI is the default).

- **RA Axis Supports:** PI, Hysteresis, and Linear Trend.
- **DEC Axis Supports:** PI, Hysteresis, Linear Trend, and Resist Switch.

1. Correction Algorithms:

a. PI (Proportional-Integral) - Default

Suitable for most scenarios, especially for correcting slight polar alignment errors or moderate periodic errors.

- **Proportional (P / Aggressiveness):** Reacts to the current error for rapid correction. If the curve shows high-frequency "sawtooth" oscillations, decrease this value.
- **Integral (I / Gain):** Corrects for persistent errors or consistent drifts (like polar misalignment) by using historical averages. Set to 0 to disable. Decrease this in poor seeing or high-noise conditions.
- *Note: If DEC backlash is significant, the Integral term may cause oscillations during reversals. In such cases, use a Hysteresis or a Resist Switch for the DEC axis.*

b. Hysteresis

Ideal for scenarios with low SNR or significant atmospheric seeing interference. It blends a fraction of the previous correction with the current error to filter out high-frequency

noise and smooth out spikes.

- **Hysteresis Aggressiveness:** The overall strength of the correction (Default: 70%).
- **Hysteresis %:** The weight of previous corrections. A higher percentage results in a smoother but slower response.
- c. **Linear Trend** Best for targets with smooth, constant drift (e.g., atmospheric refraction or slight DEC drift). It fits a trend line to recent error history to predict the next position, reacting to the current error while anticipating future drift.
 - **Aggressiveness:** The correction ratio of the estimated trend (Default: 80%).
- d. **Resist Switch (DEC Only)** Specifically designed for Declination axes with significant backlash. It resists changing the correction direction unless the opposite drift becomes consistent and severe, avoiding "hunting" within the gear play zone.
 - **Aggressiveness:** Overall correction strength (Default: 100%).
 - **Fast Switch Threshold:** The pixel threshold (e.g., 0.6 px). If the reverse drift exceeds this value, the system overrides the resistance and switches the correction direction immediately.

2. DEC Guiding Mode:

- **North & South:** Corrects in both directions (Recommended for most setups).
 - **None:** Disables DEC correction (Used for single-axis trackers).
 - **South / North:** Restricts correction to a single direction to combat consistent unidirectional drift without crossing the backlash zone.
3. **Apply DEC Backlash:** Automatically applies a compensation pulse when the DEC axis reverses direction to overcome mechanical play.
4. **Reverse DEC After Meridian Flip:** Automatically inverts the DEC correction logic after a Meridian Flip to maintain consistent tracking performance.

7.4.3 Dithering

Dithering eliminates "walking noise" caused by the camera's fixed pattern noise. Parameters can be adjusted in **Guide > Settings > Dithering**.

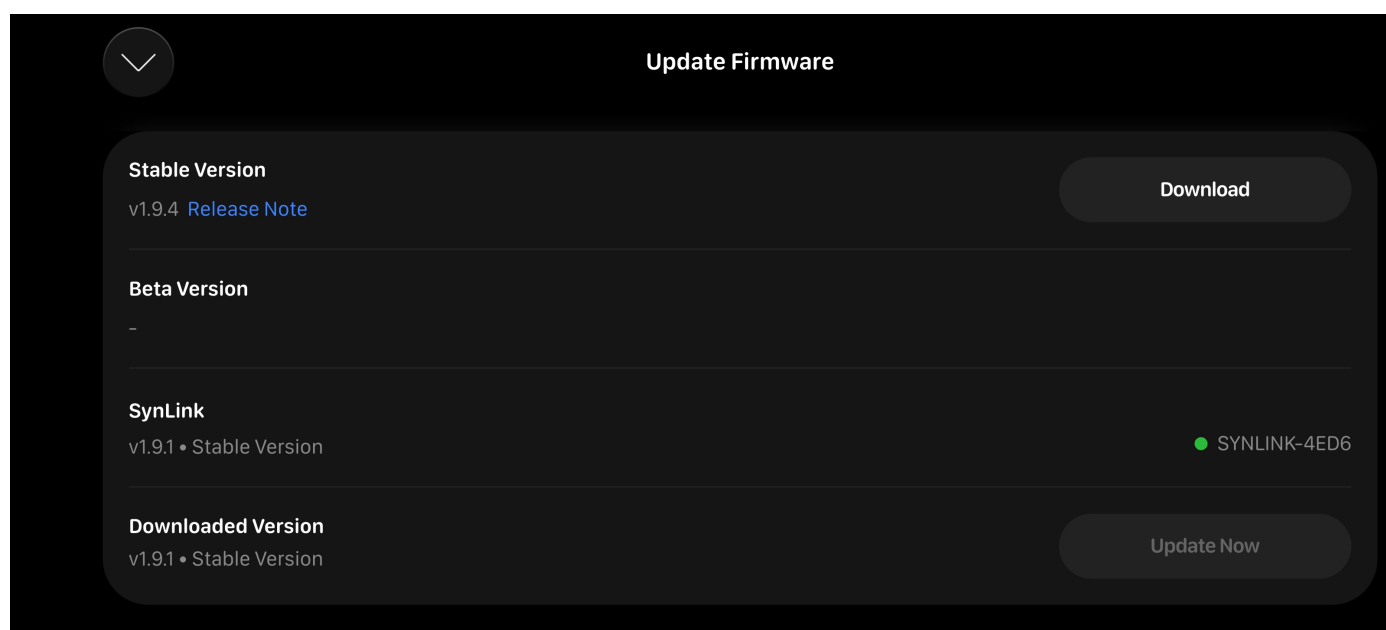
- **Strategy:**
 - **Random:** Moves the mount in a random direction.
 - **Spiral:** Moves outward along a predefined spiral path.
 - **Randomized Spiral:** A combination of both (Highly Recommended).
- **Amount:** The pixel offset range relative to the **Main Camera**.
 - *Recommended:* 3 px if FWHM < 2 px; 5–8 px if FWHM > 3 px.

- **Max Settle Down Time:** The maximum time allowed for the guide error to stabilize after a dither. If exceeded, the next exposure will start regardless.
- **Min Settle Down Frames:** Minimum number of guide frames that must be accumulated post-dither before settle can be declared, regardless of RMSE.

8 Controller and App Settings

8.1 Firmware Update and Reset

1. Firmware Update



- Ensure your phone or tablet has an active internet connection (cellular or Wi-Fi)
- Go to **Home > Config > SynLink > Firmware Update**. (A notification will appear on the home page if a new version is available).
- Download the latest firmware package (available in **Stable** and **Beta** versions).
- Connect to the SynLink controller's Wi-Fi. Ensure the controller is powered and has a stable power supply. Tap **[Update Now]** on the update page.
- Please stay on this page during the process. The system will automatically restart once the update is successful.

2. Firmware Reset

Use this method to restore the system to factory firmware in case of anomalies.

- Prepare a USB drive and create an empty text file named `synlink.txt` in the root directory.
- Insert the USB drive into a USB port on the SynLink controller while it is powered off, then turn it on.

- c. Wait approximately 2 minutes; the system will automatically read the instruction and flash the factory firmware.
- d. When the LED returns to its "heartbeat" flashing frequency, the reset is complete and the system has restarted normally.

8.2 Network Configuration

SynLink supports both 2.4GHz and 5GHz dual-band switching. Adjust this in **Config > SynLink**.

1. Modifying Wi-Fi SSID and Password

- While connected to the controller, tap the Wi-Fi name (SSID) or password fields to modify them. After saving, reconnect to the updated network in your device's system Wi-Fi settings. For security, it is highly recommended to change the default password upon first use.
- *Note: SSID and password modifications are only available when directly connected to the SynLink network.*

2. Resetting Wi-Fi

If you forget your Wi-Fi name or password, follow these steps to reset:

- a. Prepare a USB drive and create an empty text file named `wifi.txt` in the root directory.
- b. With the controller powered on, insert the USB drive into a USB port on the SynLink controller.
- c. Observe the LED; a rapid, consistent flash indicates the reset is in progress.
- d. Once the "heartbeat" flash returns, the Wi-Fi credentials have been reset to default.

3. STA Mode (Bridge Mode)

STA mode allows the controller to join your home router or mobile hotspot, enabling control while maintaining internet access.

Join a Home Network:

- a. Connect to SynLink, go to **Config > SynLink**, and enable **[Join Wi-Fi Network]**.
- b. Select a network from the available list or enter the credentials manually.
- c. Once connected, reconnect your phone to the same home router/hotspot. You can then discover and control SynLink within the LAN (Local Area Network).

Join a Mobile Hotspot:

- a. Turn on your mobile hotspot and note the SSID and password.
- b. Connect to SynLink, go to **Config > SynLink**, and enable **[Join Wi-Fi Network]**.

- c. Scroll to the bottom of the list and tap **[Add Personal Hotspot]**, then enter the credentials.
- d. The hotspot connection may take 3–5 minutes. Once successful, you can control SynLink while keeping your phone's data connection active.

4. Pre-connection Auth

In STA mode, you can enable authentication to prevent unauthorized access from other users on the same router.

- a. While directly connected to the SynLink network, go to **Config > SynLink** and enable **[Authentication Before Connection]**. The system will generate a random 4-digit code.
- b. Any new device attempting to connect to your SynLink via the LAN for the first time will be required to enter this code.

Note: Once a device is verified, it will not need to re-authenticate unless the code is changed. Disabling and re-enabling this feature will refresh the code.

8.3 App Settings

Path: Home > **Config** > **App**.

- **Language:** Choose between **Simplified Chinese**, **English**, or **Follow System**.
- **Palettes for Red-Green CVD:** Optimizes status indicator colors to help users with red-green color vision deficiency distinguish between different states.
- **Night Mode:** Applies a low-contrast black and orange theme to minimize screen glare and protect night vision during observation.
- **Haptics:** When enabled (and supported by your device), a slight vibration will occur when performing key operations.

9 Appendix

9.1 Technical Specifications

Specification	Details
CPU	RK3566
RAM	4GB LPDDR4
Storage (ROM)	64GB eMMC
WiFi	Dual-band 2.4GHz / 5GHz

Power Input	DC 5.5 × 2.1 mm (Center Positive)
Dimensions	[TBD] mm
Weight	[TBD] g
Operating Temp	-10°C to 40°C

LED Indicator Meanings

LED Location	Flashing Pattern	Status Meaning
Power LED	Heartbeat	System running normally
	Solid On	System error or network module failure
	Timer Mode (Rapid Flash)	Firmware update or factory reset in progress
Guiding LED	Heartbeat	Guiding in progress
	Rapid Flash	Guiding calibration/calculation in progress
	Off	Guiding inactive
Sequence LED	Heartbeat	Sequence plan in progress
	Rapid Flash	Sequence delay/countdown in progress
	Off	Sequence inactive

*Note: If the Power LED causes light pollution during imaging, you can enable "**Disable Power LED upon Shooting**" in **Home > Config > Operation**.*

9.2 App System Requirements

Minimum requirements for stable performance:

- **iOS / iPadOS:** 12.0 or higher
- **Android:** 7.0 or higher
- **macOS:** 12.4 or higher
- **Windows:** Windows 7 or higher

9.3 Instruction Reference (PRO Mode)

1. General Control Instructions

Instruction	Description	Parameters
Repeat	Loops a nested set of instructions	Adjust start/end positions manually
Wait	Pauses the sequence for a set duration	1–20 seconds
Wait Until	Triggers the next step at a specific absolute time	Future time (5-min increments)
Send Message	Logs a custom text string to the system log	Custom string
Continue on Failure	Continues to the next instruction if a failure occurs	None
Abort on Failure	Immediately halts the sequence if a failure occurs	None
Recover on Failure	Rolls back to the last "Restore Point" on failure	None
Recovery Point	Sets a checkpoint for error Rollback	None

2. Target Instructions

Instruction	Description	Parameters
Slew to	Moves the mount to specific coordinates	Target from catalog or RA/DEC (deg)
Sync Center	Syncs coordinates to mount and centers the target	Exposure time (s)
Precise GOTO	Slew to target with plate-solve centering	Target from catalog or RA/DEC (deg)
Set Object Name	Sets the object name or alias for the session	Max 16 alphanumeric characters

3. Mount Instructions

Instruction	Description	Parameters
Home Mount	Commands the mount to return to Home	None

Park Mount	Commands the mount to its Park position	None
Unpark Mount	Releases the mount from its Park state	None
Enable Tracking	Starts sidereal tracking	None
Disable Tracking	Stops tracking	None

4. Meridian Flip Instructions

Instruction	Description	Parameters
Enable Meridian Flip	Enables automated Meridian Flip	Re-center (On/Off), Pause Time (hrs)
Disable Meridian Flip	Disables automated Meridian Flip	None

5. FITS Header Instructions

Instruction	Description	Parameters
Set FITS Header	Adds custom keywords and values to FITS data	String (1–32 characters)

6. Accessory Control Instructions

Instruction	Description	Parameters
Select Filter	Rotates the filter wheel to a specific slot	Slot number or Alias
Set Focuser Position	Moves the focuser to a specific step position	Manual step value (within travel range)
Set Rotator Angle	Rotates the camera to a specific angle	0° to 359°

7. Focusing Instructions

Instruction	Description	Parameters
Focus	Auto-focus (Stops sequence on failure)	AF exposure time (0.5–5s)
Focus (Continue On Failure)	Auto-focus (Continues sequence on failure)	AF exposure time (0.5–5s)
Clear Focuser Selection	Clears the selected star for auto-focus	None

8. Guiding Instructions

Instruction	Description	Parameters
Calibrate Guiding	Performs guiding calibration	Exposure time (s)
Start Guiding	Starts guiding corrections	Exposure time (s)
Stop Guiding	Stops guiding corrections	None
Clear Guider Selection	Clears the selected guide star	None
Enable Dithering	Enables dithering to eliminate walking noise	Amount (px), Timeout (s), Skip frames
Disable Dithering	Stops dithering	None

9. Imaging Instructions

Instruction	Description	Parameters
Enable Camera Cooler	Turns on camera cooling	Target temp (-40°C to 40°C)
Disable Camera Cooler	Turns off camera cooling	None
Set Frame Type	Selects the type of frame to be captured	LIGHT, BIAS, DARK, FLAT, DARKFLAT
Set Camera Mode	Sets the camera's readout mode	Depends on camera connection
Set Gain	Sets the imaging camera Gain	Integer
Set Offset	Sets the imaging camera Offset	Integer

Capture Batch	Executes a capture batch	Exposure time (s), Frame count
Select ISO	Sets ISO (for DSLRs/Mirrorless)	ISO value selection
Apply Focus Offset For Filters	Enables filter focus offsets	None
Disable Focus Offset For Filters	Disables filter focus offsets	None

9.4 Warranty & Support

Please visit the UMa official website at <https://www.umaif.com/synlink> for the latest after-sales and warranty information.