

SynLink User Manual - EN

1 Introduction

1.1 Preface

Thank you for purchasing the SynLink astrophotography controller. Featuring highly integrated hardware and an intuitive, user-friendly App design, the SynLink supports and controls the vast majority of 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," bringing you a stable and highly efficient astronomical observation and imaging experience.

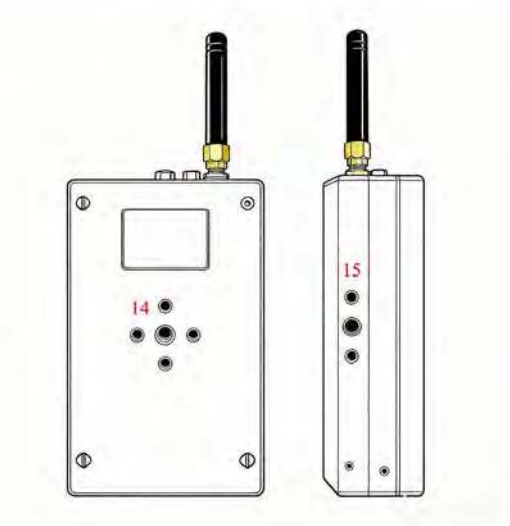
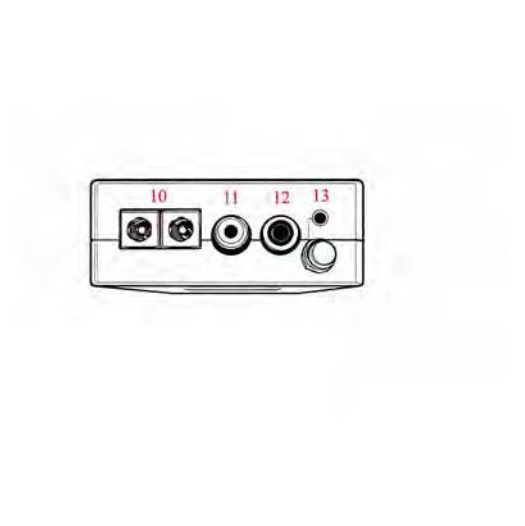
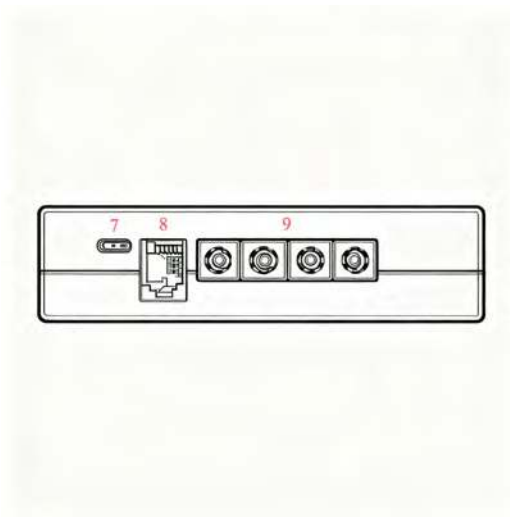
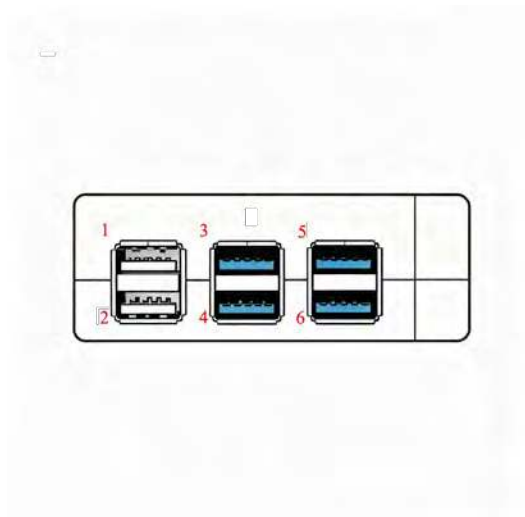
This manual is designed to help you become familiar with and master the SynLink. It details how to connect the SynLink to various astronomical devices, helping you smoothly build your observation system. It also provides an in-depth explanation of the App's core functions, guiding you on how to utilize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

1.2 What's in the Box

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SynLink x 1	0.3m Male-to-Male DC Power Cable x 2
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	1m Male-to-Female DC Power Cable x 1

1.3 Appearance & Interfaces



#	Name	Qty	Description
1 - 2	USB 2.0 Type-A	2	Connects various USB astrophotography devices.
3 - 6	USB 3.0 Type-A	4	High-speed interfaces. Priority for USB 3.0 cameras and external storage, downward compatible with other devices.
7	USB 2.0 Type-	1	Connects to a host PC or low-speed USB devices.

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8	Serial Port (RJ)	1	Connects to the serial port of the mount. Use the included cable to connect to Sky-Watcher or Celestron HC ports.
9	Power Output (12V)	4	Power external devices (e.g., cooled cameras, mounts, etc.).
10	Power Input (12V)	2	Parallel 12V power input jacks.
11 - 12	Dew Heater Ports	2	Connects to dew heater. Output power is adjustable via the App.
13	Sensor Port	1	Reserved port for future sensor expansion.
14 - 15	1/4" and 3/8" Mounting Holes	2	Used to secure the SynLink to a telescope or other hardware.
16	Power Switch with LED	1	Press to power on, release to power off.
17	Status LEDs	2	Indicates the current operational and network status.
18	Wi-Fi Antenna	1	Removable antenna to enhance wireless network signals.

Power Supply Precautions:

- For USB devices connected to ports **1, 2, and 7**, the total operating current must not exceed **3A**.
- For USB devices connected to ports **3, 4, 5, and 6**, the total operating current must not exceed **3A**.
- The maximum output for a single 12V power output jack (Port **9**) is **7A**, and the total output across all 4 jacks must not exceed **14A**.

2 Initial Setup

2.1 Installing SynLink

It is recommended to securely attach the 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 Devices to SynLink

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. Powering SynLink

Plug a 12V@3A-7A DC power supply into port **10**. The maximum input current per jack is 7A. The two input jacks are wired in parallel; if the total power consumption of your equipment is high, you can plug in two 12V 7A power supplies at the same time to ensure power stability.

2. Connecting Astronomy Equipment

USB ports **1 to 7** can connect to various devices, such as cameras, mounts, filter wheels, electronic focusers, flat panels, rotators, and USB flash drives. High-speed devices like USB 3.0 cameras and external storage should ideally be connected to ports **3 - 6**.

a. Imaging Cameras:

- Astro Cameras: If using a USB 3.0 camera, prioritize connecting it to ports 3 - 6. If it is a cooled camera, it must also be connected to a 12V power source via port 9. Supported brands include:

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

- **DSLR/Mirrorless Cameras:** Connect to a USB port using a data cable. Currently supports most mainstream models from Canon, Fujifilm, Nikon, and Sony.

b. Guide Cameras: Connect to any USB port (Ports 1 - 7). For supported brands, please refer to the Astro Cameras list above.

c. Equatorial Mounts: Can be powered by a separate 12V source or via SynLink's port 9. Currently supported brands include:

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

- **Sky-Watcher and Celestron mount:** they can be connected to port **8** via the included RJ Serial cable.
- **USB Connection:** If the mount has a built-in USB port, connect it directly to ports **1 - 6** using a USB data cable.
- **Others:** you can use adapters via the mount's hand controller, such as RJ-12 / RJ-11, USB B-A, RS232-USB, or USB A-Mini B cables, connected to SynLink ports **1 - 6**.

d. Focusers: Generally use the corresponding USB cable to connect to ports **1 - 7**. Currently supports:

Astroasis	Baaader Planetarium	Celestron	Deep Sky Dad	FLI
Lacerta	Lakeside ASTRO	Moon Lite	Optec - TCF-S Optec - FocusLynx	PegasusAstro - FC1/2
PegasusAstro - FC3	QHY	Shoestring	ZWO	

e. **Filter Wheels:** Generally use the corresponding USB cable to connect to ports **1 - 7**.
Currently supports:

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

f. **Rotators:** Generally use the corresponding USB cable to connect to ports **1 - 7**.
Currently supports:

Optec	PegasusAstro	WandererAstro	ZWO	
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g. **Flat Panels:** Generally use the corresponding USB cable to connect to ports **1 - 7**.
Currently supports:

Artesky	Geoptik	Lacerta	Optec	PegasusAstro
WandererAstro				

h. **External Storage:** Priority connection to ports **3 - 6** (USB 3.0) is recommended to ensure high-speed read/write.

i. **Dew Heaters:** Plug into ports **11** or **12**. Once connected, output power can be adjusted via a stepless slider within the App.

j. **Port 13** is a reserved sensor interface for future applications.

2.3 SynLink App Installation

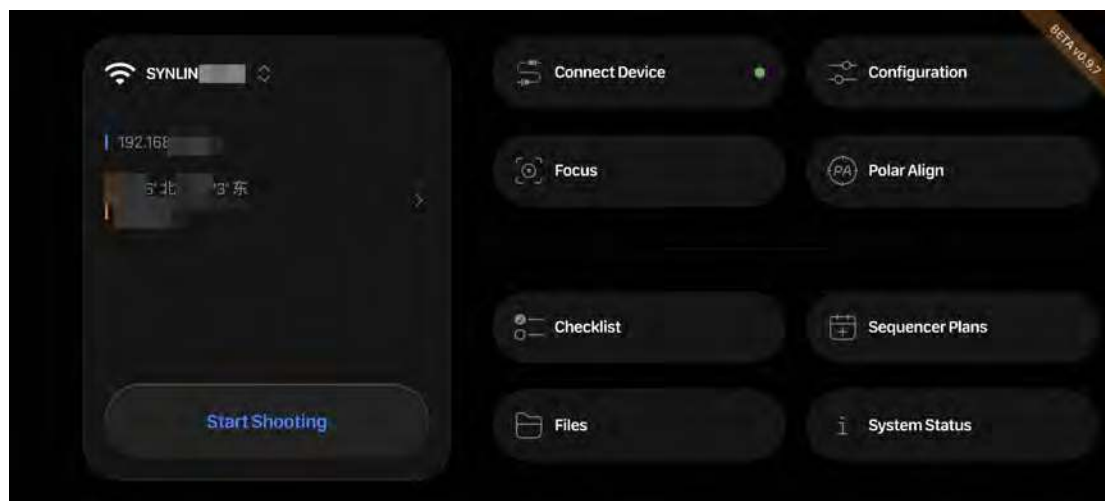
The SynLink App is now fully available across four major platforms: iOS, Android, macOS, and Windows.

- **iOS / macOS Users:** Search for **SynLink** in the App Store to install.
- **Android Users:** Search for **SynLink** in Google Play, or major Android app stores.
- **Windows Users:** Please visit the official SynLink website (www.umainf.com) to download the installation package.

Tip: Ensure you download through official channels for optimal compatibility and stability. See Appendix 9.2 for minimum system requirements.

2.4 Power On and Wi-Fi Connection

1. **Power On:** After connecting the power, press the power switch on the front of SynLink. Wait for the LED indicator to enter a "heartbeat" flashing state (about 30 seconds), indicating a successful boot.
2. **Wi-Fi Connection:** Open Wi-Fi settings on your device, find the network named **SynLink_XXXX**, and connect to it.
 - **Default Wi-Fi Name:** SynLink_XXXX (XXXX is the device's random code)
 - **Default Password:** 12341234
3. **Launch App:** Open the SynLink App. A successful connection is indicated when the controller name and connection status appear in the top-left corner of the Home screen.
4. **Verify Time & Location:** Please ensure the App is permitted to access your device's location and time. Verify if the time and latitude/longitude shown on the Home screen are accurate. This directly affects the calculation of the object database and the accuracy of the mount's GOTO function.



2.5 Device Connection

In the **Preparation** area on the App's Home screen, tap **Connect Device** to enter the configuration page. Before connecting, confirm that all cables are securely plugged in and untangled. After selecting the device brands/models, SynLink will automatically attempt to connect. Establishing the connection may take some time. Devices that require initial physical calibration, like filter wheels, will take longer.

- **Connection Status Indicator:** Gray (Disconnected) / Yellow (Connecting) / Green (Connected) / Red (Connection Failed).
- **Simulator Testing:** All devices can be connected via simulators. You can tap the ... icon in the top-right corner to connect all simulators at once, or select and connect them under corresponding device categories to familiarize yourself with the operating workflow in advance.

For dedicated astro **Imaging Cameras** and **Guide Cameras**, tapping the option will display the camera models connected to SynLink; tap them to connect automatically.

If using a **DSLR/Mirrorless Camera**, it is recommended for use as the main imaging camera only. Before connecting in the SynLink App, you need to configure the following settings on your camera:

- **Mode:** M (Manual)
- **Shutter:** Bulb
- **Image Format:** RAW
- **Image Size:** Maximum
- **Other auxiliary settings** (Configure if your camera has these options):
 - Smartphone Connection: OFF
 - PC Remote Control: OFF
 - Release Shutter w/o Lens: ON (if not using a DSLR lens)
 - Long Exposure Noise Reduction: OFF
 - Drive Mode: Single Shooting
 - Auto Power Off: OFF
 - USB Power Supply: ON

After configuration, plug it in using a sturdy USB cable. *Note: Some early DSLR models can be set to Bulb mode, but SynLink cannot trigger the shutter via USB. You can use an intervalometer or a physical shutter release cable as a workaround.*

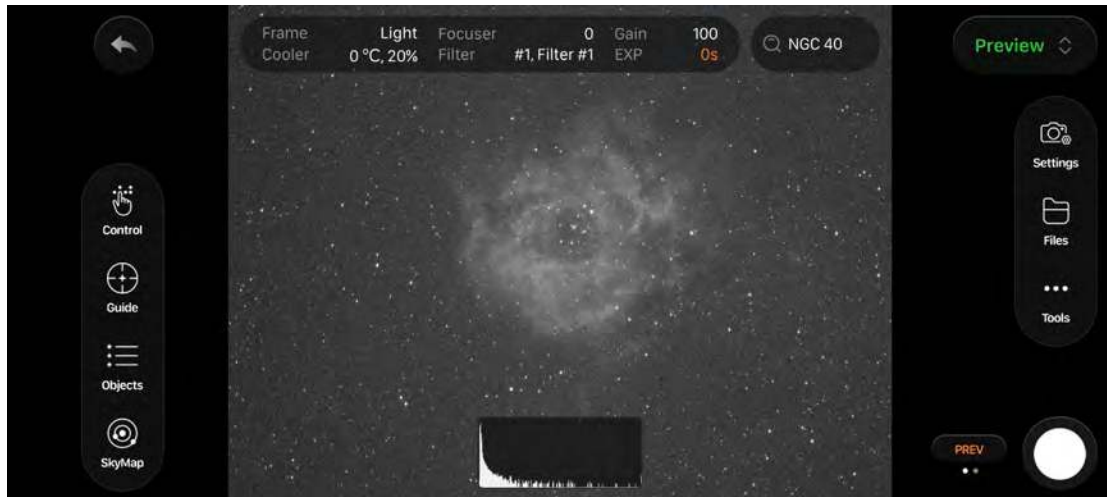
- **Mount Connection:**
 - **Sky-Watcher:**
 - Via RJ12 cable: select **Sky-Watcher Synscan**.
 - Via USB cable or hand controller: Select **Sky-Watcher Legacy**.
 - **Celestron:**
 - Via RJ12 cable: select **Celestron AUX**.
 - Via USB cable or hand controller: Select **Celestron w/ HC**.
 - **Other Mounts:** Select the corresponding brand from the list.

For **Focusers, Filter Wheels, Rotators, and Flat Panels**, simply tap the category and select your equipment's brand to connect. *Note: The **Manual Wheel** option under Filter Wheels is specifically designed for filter drawers and manual filter wheels. Once selected and connected, you can manually configure filter information, which will be recorded in the image metadata (FITS header) to help you identify frames taken with different filters for processing.*

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



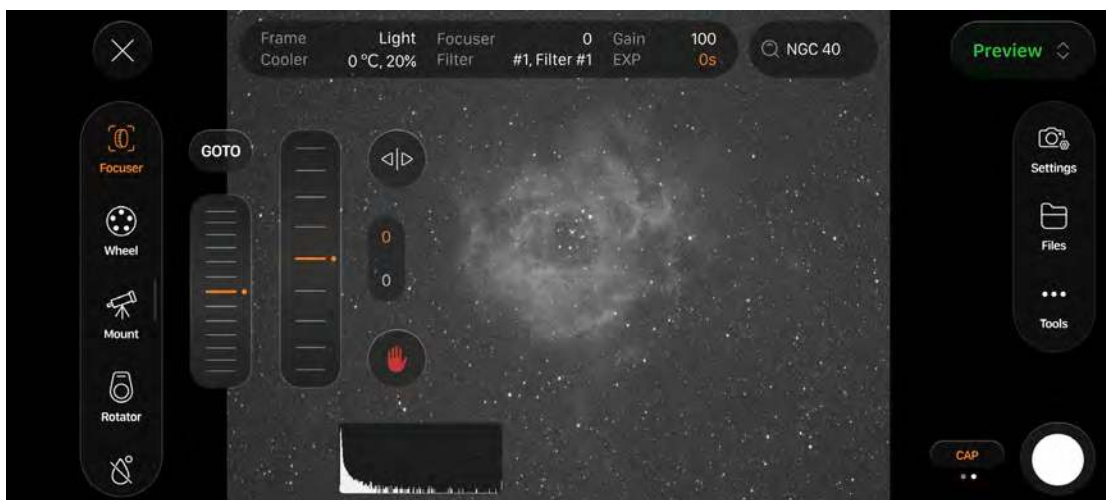
- **Top Bar**
 - **Status Bar:** Displays the current frame type (Light/Dark, etc.), camera temperature, focuser position, filter wheel slot, Gain/ISO, and the remaining exposure time of the current capture.
 - **Quick Target Search / Rename:** Tap to enter the catalog number or name of your desired 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.

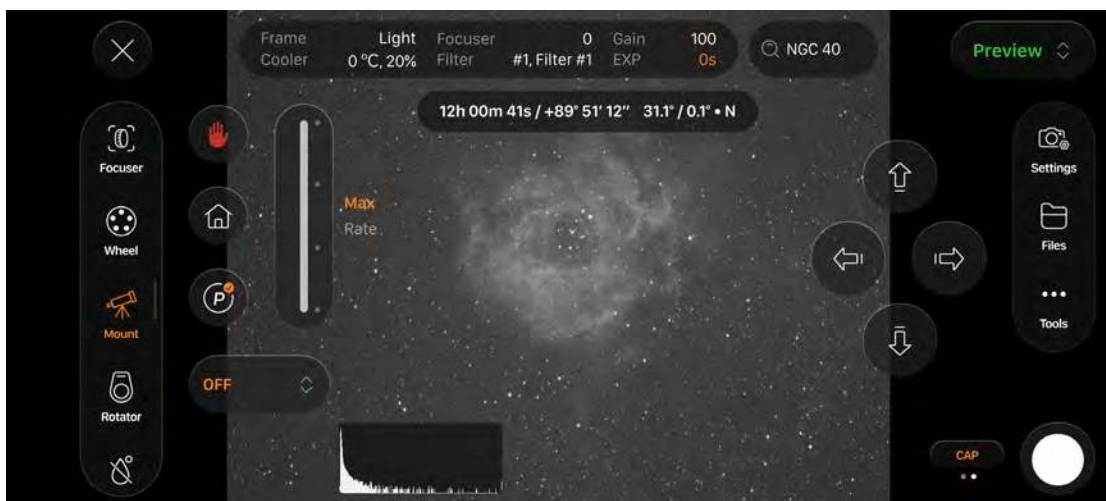
1. Focuser



- **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.

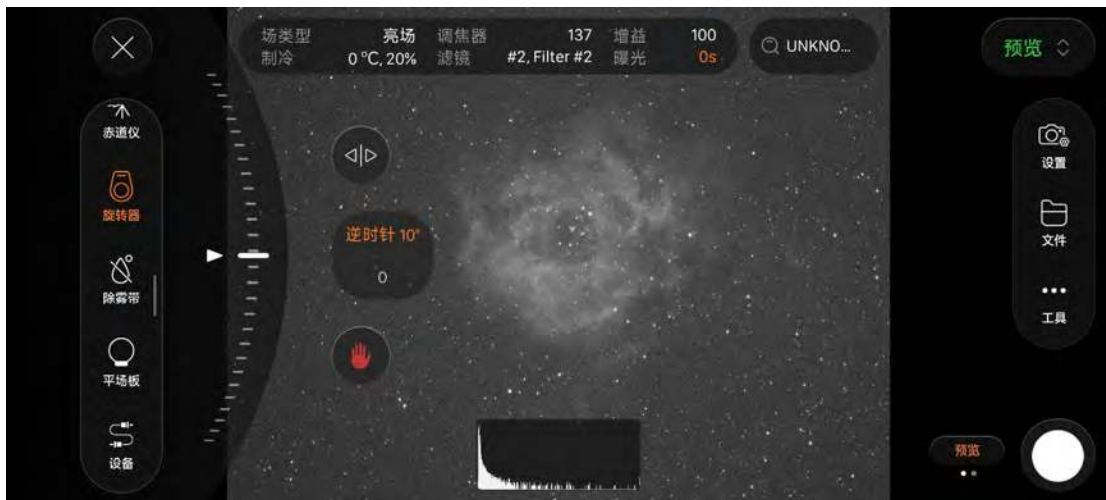


3. Mount:



- **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 '✓' indicates it's parked. Tap any direction to unpark.

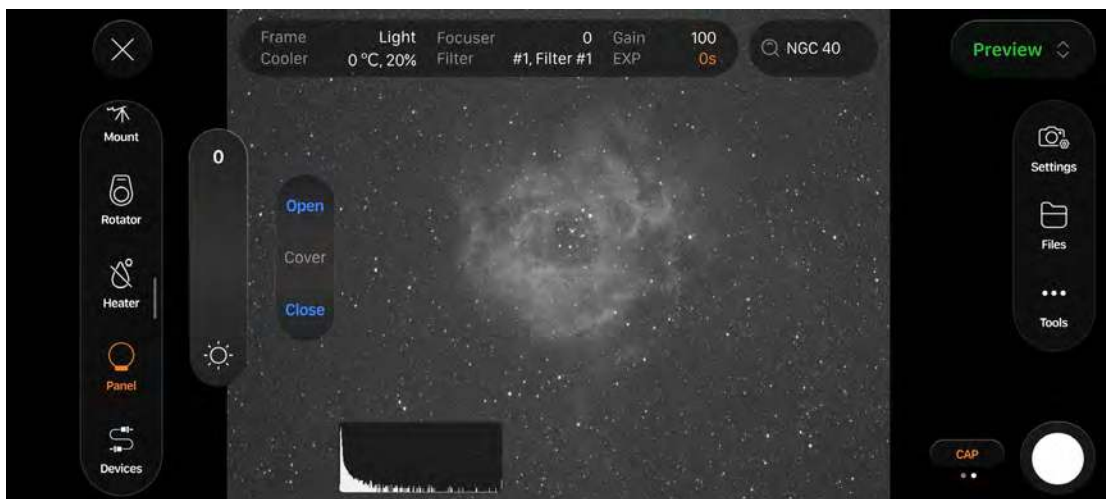
4. Rotator:



- **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.
- [**<|>**]: Tap to modify the angle.
- [**👉**] (**Stop**): Tap to immediately halt rotation.

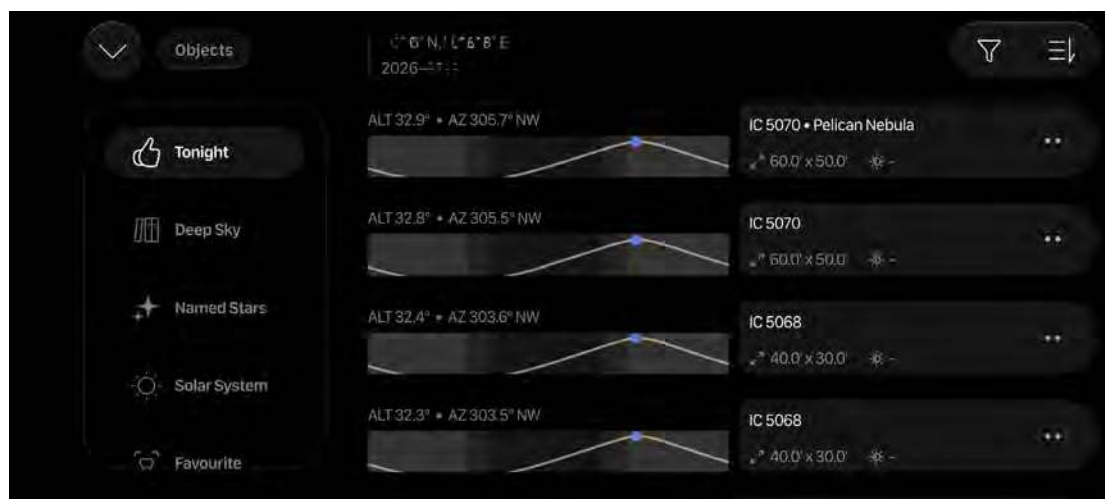
5. **Dew Heater:** Two independent sliders control ports 11 and 12. Swipe up to increase power.

6. **Flat Panel:** Left slider controls brightness (requires hardware support). Right [**Open/Close**] buttons open/close the mechanical cover.



3.3 Objects

On the shooting page, tap **Objects** on the left menu to browse celestial catalogs and lists. Alternatively, use the top-right search box for a quick lookup by name or catalog number (supports pure numbers, catalog + numbers, 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: To ensure equipment safety and pointing accuracy, we highly recommend performing Polar Alignment before executing any GOTO operations. Please refer to Chapter 4 for detailed steps.

3.4 Shooting Preview

Once familiar with the device controls and basic operations, you can perform an initial imaging test in **Preview** mode.

- **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**. Observe the pixel distribution: A proper exposure should show the data peak within the visible range. Avoid severe overexposure (data heavily clipped at the right edge) or 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.

4 Shooting Workflow

A complete deep-sky astrophotography workflow typically includes: Focusing -> Polar Alignment -> GOTO & Framing -> Guiding -> Capture.

4.1 Focusing

Whether you have an Electronic Focuser or not, SynLink helps you achieve precise focus.

⚠ EAF Safety Limit Warning: If using an EAF, we highly recommend setting its maximum step limit first. This represents the full travel range of the focuser and should be less than or equal to the telescope drawtube's maximum extension. If the limit is set too high, the motor may continue applying force after the drawtube reaches its physical end, potentially causing damage. Although EAFs generally have torque limits, relying on them is unsafe for long-term equipment health. Refer to Section 6.4 for setup steps.

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):

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

2. With EAF (Auto-Focus):

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

4.2 Polar Alignment (PA)

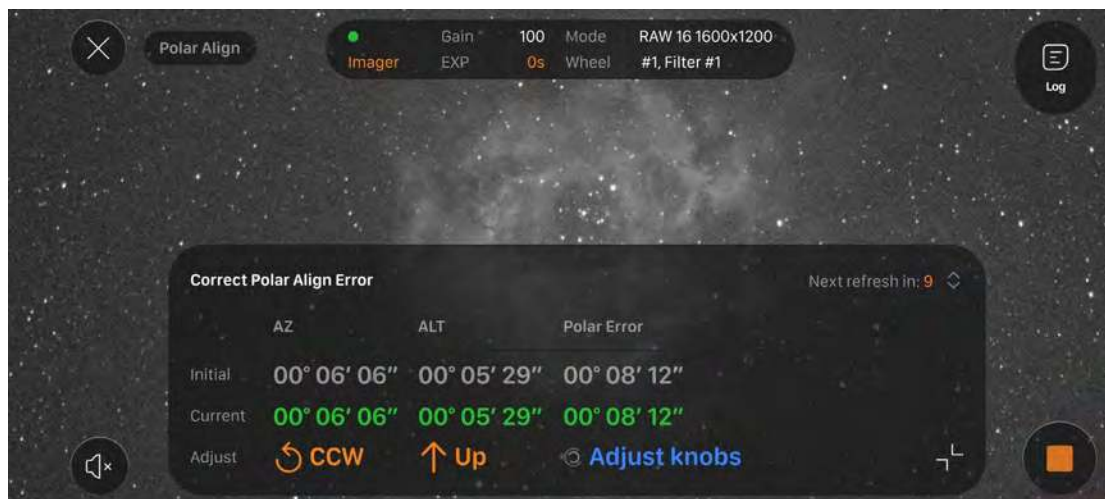
Back to the home page, tap Polar Align to enter. Before starting Polar Alignment, ensure your mount is at the Home position (i.e., the RA axis points toward your hemisphere's celestial pole with an error of no more than 5°). Also, ensure the camera is in focus.

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, which is ideal if your location has few obstructions. If obstructed, you can change it to West in the top-right **Settings**, or manually set a different starting position. Regardless of the starting point, you can customize the rotation angle (step distance) and direction for each movement, but you **MUST** ensure that:
 - 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.
 - If any issues occur, tap the **[🛑] (Stop)** button on the screen to immediately halt the mount's movement.
- Once completed, the screen will display your polar alignment error along with adjustment recommendations for Azimuth and Altitude. Follow the prompts and manually adjust the Alt/Az knobs on your mount until the total error is under 10' (arcminutes). Finally, remember to securely lock the mount's adjustment knobs to finish the PA routine.



4.3 GOTO and Framing

After completing focusing and polar alignment, you can accurately point the telescope at your target. Return to the home page -> **Start Shooting**.

1. **GOTO Target:** Search for your target in the left **Objects** menu, or select a location in the **SkyMap** module, then tap the **[GOTO]** button. The mount will automatically slew to that area and enable Sidereal tracking by default.

- You can tap the **[👉] (Stop)** button at any time to halt the mount.
- If the target is below the horizon, tapping GOTO will not trigger any mount movement.

2. **Framing Adjustment:**

- **Adjusting the Center:** Open **Tools** -> **Center** on the right. You can drag the yellow box on the screen to select a new center point for custom off-center framing.
- **Adjusting the Angle:** Tap **Control** -> **Rotator** on the left (if equipped). Swipe up or down on the adjustment dial to rotate to the desired angle.

3. **Setting Optimal Exposure Parameters:** Once your framing is set, use **PREV** mode to find the best exposure settings for your final capture. Open **Tools** -> **Histogram**, and navigate to **Settings** -> **Camera** to adjust the parameters.

- **Gain:** For deep-sky imaging, it is generally recommended to consult your camera's spec sheet and set the gain based on Unity Gain, lowest read noise, or maximum full well capacity (to balance dynamic range and low read noise). A good starting point is usually Unity Gain (often referred to as Mid Gain).
- **Observe the Histogram:** Adjust the Offset and Exposure time while monitoring the histogram's peak. Proper exposure should shift the peak away from the far-left edge (typically sitting at about 1/4 to 1/3 from the left) without any data clipping on the left side. This ensures faint nebula details are preserved while avoiding massive overexposure across the image.

- **Cooling (if supported):** Turning on cooling effectively suppresses dark current noise. However, setting the temperature too low is not advised. Running the cooler at maximum load can cause temperature fluctuations, which may lead to issues during later calibration.

4.4 Guiding

Deep-sky imaging usually requires longer exposures, making guiding essential for maintaining image quality and sharp stars.

1. Guide Focus

Tap **Start Shooting > Guiding** to enter continuous preview. Manually adjust the guide scope's focuser until stars appear small and sharp. Adjust the camera's exposure parameters on the right. You can reference the RMS contrast value in the floating window for fine-tuning; higher contrast improves the guiding algorithm's star detection.

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 the SynLink via USB or a serial cable, and connected within the App. In this mode, SynLink sends highly precise digital pulse commands to the mount, offering superior 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.

- It is highly recommended to calibrate near the Celestial Equator (Declination $\sim 0^\circ$) and as close to the Meridian as possible. RA movement is most pronounced in this region, yielding the most accurate calibration data.

- If your guide camera has been rotated or the guiding optical train physically altered, the old calibration data becomes invalid, and you **must** recalibrate.
- Tap **[Calibrate]** in the bottom right. Once calibration completes successfully, tap the **[Guide]** button to officially 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 enables fully automated imaging of multiple batches, multiple targets, and both Light and Calibration frames. It intelligently handles complex procedures like Meridian Flips and Auto-Focusing, helping you easily achieve unattended, all-night imaging.

Access: Home > **Start Shooting** > tap the top right to switch to **Sequence** mode > tap **Plans** to enter the settings. Sequence has two modes: **EASY** and **PRO**. Tap the top left corner to toggle between them.

4.5.1 EASY Mode

EASY mode is suitable for the vast majority of regular deep-sky imaging tasks, supporting single-target, multi-target, and mosaic shooting.

1. Select Frame Type and Target

- **Calibration Frames:** Includes Bias, Dark Flat, Dark, and Flat frames.
 - Tap the **Edit** button at the top to modify the corresponding save folder name.
 - Tap **Add Batch** on the right to manually set exposure parameters, or directly import matching parameters from existing Light batches or Light files.
- **Light Frames:** First, tap **Add** for the targets you wish to shoot.
 - You can use the telescope's current pointing, or import one or multiple targets from the **Objects** database.

- The **Add** button on the right allows appending targets from various sources, supporting single or multi-target queues.
- **Mosaic:** The system offers two ways to add mosaic targets:
 - Add > Import Mosaic CSV: Export a CSV file from the framing simulators of SkyGuide or Telescopius and paste it here. You can customize the mosaic plan's name on the right.
 - SkyMap > tap Mosaic (bottom right): Visually adjust the number of vertical/horizontal panels and overlap percentage directly on the SkyMap. Confirm and tap Add.

2. Target Special Settings

- **Skip GOTO:** If the telescope is already accurately pointing at the target, enable this to save time and start shooting directly.
- **Skip Center:** Enable this if the target's altitude is too low or other conditions might cause plate solving to fail. The system will skip the centering validation to prevent task interruption.

3. Add Shooting 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]**. You can reference your preview mode test results for these parameters.
- You can set multiple batches for a single target (e.g., assigning different filters or exposure times).
- **Quick Apply:** On the batch page, tap **[...]** in the top right to apply the current target's batch settings to all targets in the list, or to all targets ordered after the current one (including unselected ones) with one click.

4. Pre-run Settings Before initiating the sequence, go to **Sequence > Settings** to adjust the global execution details:

- **Start Time:** Set a specific time for the sequence plan to start automatically.
- **End Time:** Set a specific time for the sequence plan to forcibly stop.
- **Batch Delay:** Set a wait time before each individual shooting batch begins.
- **Exposure Delay:** Set the pause time between individual exposures.
- **Auto-Focus Triggers:** Configure the trigger conditions for auto-focus. You can choose whether the system automatically focuses on specific events like "Filter Change" or "Target Change".
- **Guiding:** Choose whether to automatically start guiding during the sequence. Highly recommended for long exposures.

- **Dithering:** Shifts the mount by a few pixels between frames to effectively eliminate the camera's fixed pattern noise (walking noise). Generally recommended to be left on. The system supports "Guide Dither" and "Direct Dither" (no guiding required) modes.
- **After Transit:**
 - **Negative Values:** The system stops tracking and imaging prior to the meridian and waits until the equivalent time has elapsed after the meridian passage to execute the flip and resume.
 - *Example:* A setting of **-0.5h** will stop the sequence 0.5 hours before the meridian and perform the flip/resume 0.5 hours after the meridian passage.
 - **Positive Values:** The system continues tracking and imaging past the meridian until the specified time offset is reached, at which point it executes the flip.
 - Pause shooting before or after the meridian. A negative value stops shooting *before* the meridian and waits for the flip; a positive value delays the flip *after* passing the meridian by the set time.
 - *Note: Pausing the shoot also stops tracking and guiding, which will automatically resume after the meridian flip completes.*
- **Park Mount:** If enabled, the mount will automatically return to the designated "Park" position and completely stop tracking and guiding after the entire sequence finishes, ensuring equipment safety.
- **Gradually Warms Camera(Cooled cameras only):** If enabled, the camera will slowly warm up to ambient temperature (approx. 20°C) over a set duration after the sequence finishes. This effectively prevents condensation or thermal shock to the sensor caused by rapid heating.



5. Final Check & Start Shooting

After configuring everything, return to the target list and check the targets you want to shoot. We strongly recommend reviewing the **Altitude Chart** on the right of each target for a final check:

- **Orange Highlighted Area:** Represents the estimated actual shooting time window for that target.
 - If the start of the orange area is below the horizon, the system may directly skip this target and move to the next.
 - If the end of the orange area is below the horizon, the latter part of the target's session may fail to execute normally.
- **Reorder:** If you find the time allocation unreasonable, tap **Edit** in the top right to drag and reorder the targets, or modify the number of frames per target to optimize your all-night imaging efficiency.
- **Start:** Once confirming all targets' shooting windows are at safe altitudes, tap the ► **Start** button on the interface to launch tonight's automated exploration!

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

4.5.2 PRO Mode

PRO mode uses an "instruction flow" format to provide highly customized sequence automation control, even allowing you to plan shooting tasks 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

Instructions or Sets You can add individual action instructions for specific devices, or directly call up preset "Instruction Sets" to handle specific events, while flexibly adjusting their parameters.

3. Start Shooting

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

4.6 Video Mode

For short-exposure/high-frame-rate imaging of bright targets such as Solar System planets, the lunar surface, and the Sun (requires safe solar filtering equipment), we recommend using **Video** mode.

⚠ **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. Observe the histogram to ensure the target's highlights are not overexposed (avoiding data clipping).
3. **Enable ROI:** If the target occupies a small portion of the frame, use **Tools > ROI** on the right to crop the image. This drastically reduces the data transfer load and significantly increases the video recording frame rate (FPS).
4. **Fine Focusing:** After enabling ROI to magnify the target, use **Control > Focuser** to carefully find 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 automatically saved to the local photo album of the device (phone/tablet) 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: Due to system limitations, FAT32-formatted drives cannot record individual video files larger than 4GB).*

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.). Tap and hold the [≡] drag 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 command the telescope to point directly at that target.
 - Tap **Save** to save the current image as a JPEG to your phone/tablet's system photo album.
 - **PSF:** Please refer to 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 Saved to SynLink Internal Storage:

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

- Keep the SynLink controller powered on. Use a data cable to connect its Type-C port directly to a computer or smartphone, allowing it to be read as an external drive for copying files. *(Note: By default, this mode is read-only. You cannot directly modify or delete internal SynLink files from the 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. Once finished, you **MUST** tap **Eject USB** in the top right corner of the File Management page before unplugging the device.

Files Saved Directly to 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 directly.

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. Head out to your stargazing site with peace of mind once everything is verified.
- **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 acquired 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. Due to physical differences among various brands and models, the specific configurable items are subject to what is actually displayed on the App interface.

1. Telescope

- Enter the Aperture and Focal Length for both the Imager Scope and Guide Scope in millimeters (mm).

- This data can usually be found in the telescope's specifications. Entering it correctly greatly accelerates plate solving. If you are unsure of the exact focal length, you can enter 0; the system will automatically update it to the effective focal length (accounting for optical elements like reducers) 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 successfully connected.

3. Mount

- **Home Position:** Go to **Config > Devices**, the initial reference point (usually the Celestial Pole). The power-on position is the default Home. 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 blind slewing and 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. For internal focusing systems or those with reduction microfocusers, we recommend increasing this value.
- **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. It **MUST** be less than or equal to the actual physical limit.

5. Wheel (Filter Wheel) Go to **Config > Device > Wheel**.

- **Label:** Allows you to customize the name for each 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

- a. customize the current angle to calibrate the 0° - 359° limit range, preventing equipment cables from tangling or colliding.
- b. Invert the motion.

6.5 工具

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

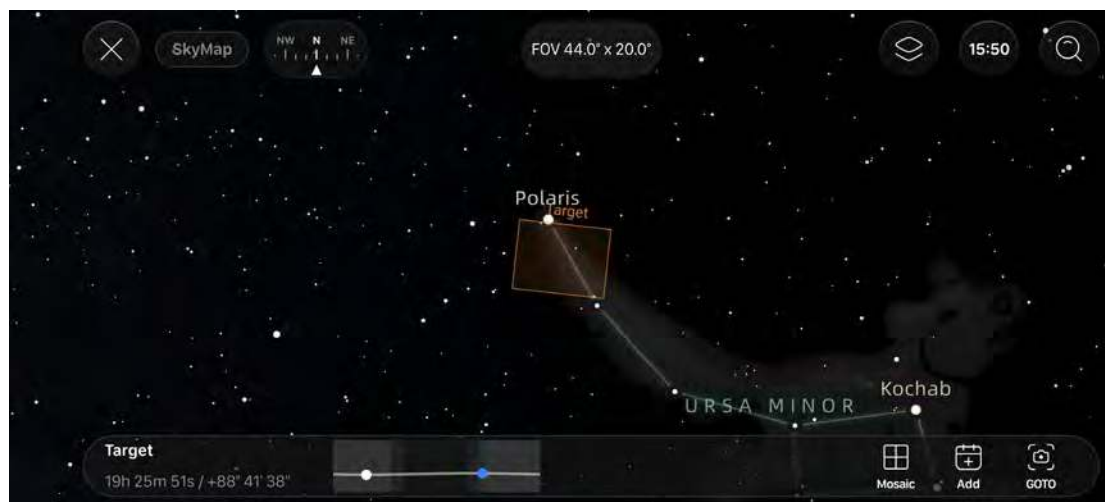
- **Reticle:** Overlays a crosshair in the center of the frame to assist with manual target centering.
- **ROI:** Reads only a specified area of the sensor to increase the frame rate. Supports original, custom ratios, or square framing. Tap $\sqrt{}$ to confirm.
- **Center:** Drag the selection box over 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. You can freely drag to reposition it or tap to enlarge for detailed information.
- **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:* "Auto" is generally recommended. 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. This greatly assists in adjusting backfocus (flattener spacing) 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. It supports mobile device gravity sensors—simply move your device to view the simulated sky in that direction. 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 future astronomical events. Tap [🔍] to search for a specific target; once selected, you can 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, then directly 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.

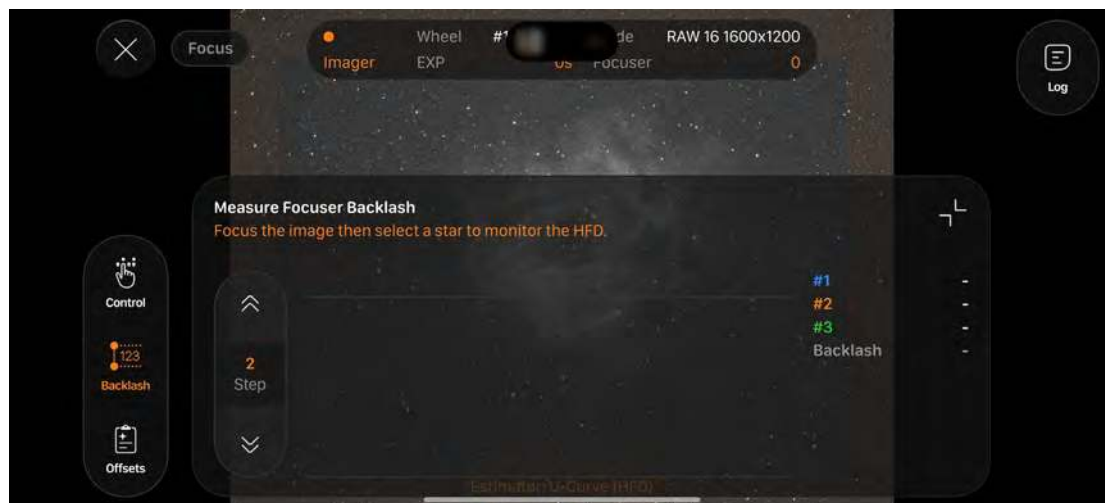
General Parameters:

- **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 across 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 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 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. *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. Detailed descriptions of the algorithms and parameters are as follows:

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. A successful calibration is indicated by the two axes being as close to a right angle (90°) as possible.

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 higher influence. Suitable for multi-star guiding with uneven brightness.
 - **Dounts:** 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. A radius too small may cause star loss; 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. If the move is smaller than this value, calibration will fail. Try increasing the Max Steps or Calibration Step.

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 Hysteresis or 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 mobile device (phone/tablet) has an active data connection or is connected to a Wi-Fi network with internet access.
- 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 while it is powered off, then turn it on.
- Wait approximately 2 minutes; the system will automatically read the instruction and flash the factory firmware.
- Observe the LED:** 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. (Note: You must reconnect to the new hotspot in your phone's system settings after modification). 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. Insert the USB drive into a USB port on the SynLink while it is powered off, then turn it on.
- 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. 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
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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

To ensure a smooth user experience and stable connection, please ensure your device meets the following minimum requirements:

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

9.2 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
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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

9.3 Warranty & Support

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