SYNSCAN APP USER'S MANUAL

2020-08-25

SynScan App is an application running on Android, iOS, and Windows, for controlling Sky-Watcher motorized telescope mount.

Never use your telescope to look directly at the sun. Permanent eye damage will result. Use a proper solar filter firmly mounted on the front of the telescope for viewing the sun. When observing the sun, place a dust cap over your finderscope or remove it to protect you from accidental exposure. Never use an eyepiece-type solar filter and never use your telescope to project sunlight onto another surface, the internal heat build-up will damage the telescope optical elements.

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The following sections explain using either an alt-azimuth or equatorial mount for visual observation.

RUNNING THE APP

App can be installed on Android, iOS, and Windows.

- Android and iOS
  - Make sure that you have granted SynScan app with permissions to access your device's location.
- Windows:
  - You should ensure that app has write permission to the folder it is in, so that it can store a settings file.
  - When app runs it would attempt to start a server. This can trigger a Windows firewall prompt on the first run. The server is needed for another app to tether to SynScan app, as described in [Collaborate with Third Party Software].

HOME POSITION

In order to ease subsequent setup steps, before you power up the mount, you should move the mount by hand into a particular pose, called the home position. This should be done unless you are only using [Point and Track], or if you are recovering axis position with [Hibernate].

HOME POSITION OF AN ALT-AZIMUTH MOUNT:
- Mount tripod is leveled as indicated by its bubble level
- The telescope tube is leveled and points to true north

HOME POSITION OF AN EQUATORIAL MOUNT
- Mount tripod is leveled as indicated by its bubble level
- RA axis points towards the northern or southern celestial pole, whichever is visible at your location
- The telescope tube points towards the visible celestial pole
- Counterweight rod point as close to the ground as possible

TIME AND LOCATION SETTING

The device running SynScan app should have correct system time and timezone setting. Also, review **Settings > Location** to ensure it matches your location.

CONNECT BY NETWORK

Power on your mount that is equipped with SynScan Wi-Fi (either built-in or with an external dongle), and by default a new Wi-Fi network with a name of the form `SynScan_WiFi_####` will appear. Use the system setting of your device running SynScan app to join the network. Open SynScan app and tap the **Connect** button on the top toolbar. If the mount supports being used in either alt-azimuth mode or equatorial mode, you will be prompted to choose one.

See [Network troubleshooting] for tips. Also [Connection] shows other ways to connect.

SLEWING THE MOUNT

Use the direction buttons at the bottom of app to command the mount axes to rotate (slew). The rate number at the center of the buttons indicate the slewing speed, where:

Rate	0	1	2	3	4	5	6	7	8	9
Speed	0.5X	1X	8X	16X	32X	64X	128X	400X	600X	Max

Speed is in multiples of sidereal (Earth's rotation) rate.

ALIGN THE FINDERSCOPE OR RED DOT FINDER

Point the primary telescope to a fixed target. Identify the object at the center of the telescope field of view, and then adjust screws on the finderscope or red dot finder until the reticle or red dot also points to the same object.

QUICK OBSERVATION WITH POINT AND TRACK

At this stage in the setup, you can already use an alt-azimuth mount to visually observe bright objects such as the moon and the planets. To do that, go to **Star > Solar System**, pick the target, and if it is visible, you can enable [Point and Track] at this target. Use the altitude and azimuth displayed on this page to identify the target in the sky. If you then manually (motor-driven and/or push-to) center the object in the telescope field of view, the mount will keep it there.

SIMPLE MOUNT ALIGNMENT

Alignment is a process that once performed, can allow accurate GOTO. To perform, go to **Alignment** menu, choose **Brightest star alignment** and follow the prompts. You will be prompted to use the slew buttons to center the alignment star in the telescope field of view. To make the task easier, first center the star in the finderscope or the red dot finder, and use an eyepiece with an illuminated reticle. Before you can confirm center, the last slewing buttons you press must be the *RIGHT* and *UP* buttons. The right and up buttons will blink to remind you of this. Use a planetarium app to help you identify stars.

GOTO

GOTO is a feature where the mount turns by itself to point to an object you specify. You can specify an object from a [Catalog] (such as **Star** or **Deep Sky**), from [User Objects], or from [Identify]. When arrived at a sky object, the mount will start tracking, and you will be prompted to optionally perform [Sync]. Sync involves making the target object more centered in the field of view, and it allows subsequent GOTO to this target or others near it to be more accurate.

How accurate GOTO is depends on the pointing model. See [Alignment] and [Sync] for how to improve it.

ALIGNMENT

Alignment is the process of building a pointing model, which is a description of how RA Dec coordinates correspond to axis positions. Pointing model determines pointing accuracy, which is how accurate GOTO, alt-azimuth tracking, and identify is.

DEFAULT POINTING MODEL

If alignment has not been done, the app uses default pointing model (location related), which allows roughly accurate GOTO and tracking. Accuracy of the default pointing model depends on how perfectly the mount was placed in [home position] before power on.

COMPARING ALTERNATIVES TO ALIGNMENT

	Mount position before power on	Procedure after power on	Typical accuracy
Default pointing model	In home position	Nothing	GOTO and AZ tracking: Satisfactory
Alignment (non-default pointing model)	Home position not critical, but is helpful	Perform alignment	GOTO and AZ tracking: Good
[Point And Track]	Mount is leveled	Manually point the telescope at the target to track	AZ Tracking: Satisfactory

PERFORM ALIGNMENT

You choose an alignment variation and choose one or more alignment stars. App will prompt you with instructions and will eventually ask you to center a star in the telescope field of view. An eyepiece with an illuminated reticle can help you do this accurately. Before you can confirm center, the last slewing buttons you press must be the *RIGHT* and *UP* buttons. The right and up buttons will blink to remind you of this.

Alignment has a few variations:

Name	Stars required	Alt-Azimuth	Equatorial	First action
1 Star Alignment	1	Yes	Yes	App starts rough GOTO to first star
Brightest Star Alignment	2	Yes	Yes	You manually point to first star
North Level Alignment	2	Yes		You manually point the telescope level and to north

2 Star Alignment	2		Yes	App starts rough GOTO to first star
3 Star Alignment	3	Yes	Yes	App starts rough GOTO to first star

- Brightest star alignment is recommended for beginners as it limits the choice of first star to the few brightest stars.
- Aligning with 2 stars results in better alignment compared to using one star. It is needed for [Polar Alignment Without Polar Scope]
- Aligning with 3 stars can compensate for "cone error" of the mount.

SAVING POINTING MODEL

When app has non-default pointing model, stars will be shown at the top of the alignment menu corresponding to how many stars were used in the alignment procedure. App will keep using the same pointing model when it reconnects to the same mount. App considers that it has connected to the same mount by comparing mount model and the mount mode (alt-azimuth or equatorial). As a result, you do not need to perform alignment in the following cases as long as the mount is not relocated:

- The mount does not lost power, the device running SynScan app disconnects from the mount then reconnects later on.
- The mount is put to [Hibernate].

App reverts to default pointing model when

- You choose **Alignment > Reset Alignment**, or
- App connects to a different mount

On Windows platform, data of pointing model is stored in file "Settings.txt" in the SynScan Pro app's folder. Users can make a copy of this file as a backup.

See [preserving pointing accuracy] for how to keep pointing model valid.

PM (POINTING MODEL) SHARING

Pointing model is stored in each individual app instance. This means if you performed alignment using one app instance, only it will have the newly created pointing model. If another app instance connects to the same mount, it will not have access to the new pointing model.

PM sharing (**Utility > PM Sharing**) allows one app instance to send a copy of its pointing model to another app instance. For it to work, the devices running the app instances must be on the same local area network (e.g. connect to the same Wi-Fi network). The sending instance turns on **Share my pointing model**, while the receiving instance turns off this option. The receiving instance should then see the shared pointing model appear in a list. Loading pointing model overwrites the previous pointing model.

PM sharing is pending patent.

SYNC

The sync features improves pointing accuracy in a small region of the sky about 5 degree by 5 degree to very high precision. On the other hand, alignment improves pointing accuracy over the entire sky, but to a lower precision. Sync is useful for you to record the pointing error of a brighter object so that subsequent GOTO to a fainter object nearby is more accurate.

Sync should be done after alignment. This is because sync is meant to correct the residual error of alignment.

Like pointing model, sync data is stored in each individual app instance. Sync data is restored when app reconnects to the same mount. When pointing model changes, sync data will be automatically reset.

PERFORMING NORMAL SYNC

After you perform GOTO to any object, the object may not be exactly centered in the field of view. Therefore after a GOTO the app will prompt you to use the direction buttons to make the object fully centered. This centering procedure is sync. An eyepiece with an illuminated reticle can help you do this accurately. Before you can confirm center, the last slewing buttons you press must be the *RIGHT* and *UP* buttons. The right and up buttons will blink to remind you of this.

A third party planetarium app tethered to SynScan app can also cause sync to be performed. To do that you first slew and center an object in the field of view. Then in the planetarium app, select the sync function while specifying that object. This causes planetarium app to request SynScan app to perform a sync.

ALIGN WITH SYNC

Under normal circumstances when a planetarium app requests SynScan app to perform a sync, SynScan app would do as requested. However, if in SynScan app the **Alignment > Align with Sync** menu is opened when the sync request is received, SynScan app would act as if an alignment star has been centered. This would allow you to use the planetarium app's catalog to perform alignment.

Re-purposing the sync request is necessary because the communication interface between SynScan app and planetarium app lacks a separate "alignment" request.

The **Align with Sync** page shows the last three objects you aligned to. You can delete the last aligned object to undo the last alignment step.

CHOOSING ALIGNMENT STAR

Since when performing align with sync, SynScan app does not help you choose which alignment stars to use, you must take care to follow the alignment star choosing rules:

- Alt-azimuth mount
  - Altitude is between 15 and 60 degrees
  - Difference between altitudes is between 10 and 30 degrees
  - Difference between azimuth is between 45 and 135 degrees
  - For 3-Star alignment, the first two stars should have similar altitude and the 3rd star should have 30 degree or more variant in altitude compared to at least one of the first two stars.
- Equatorial mount
  - First star and second star (for 2-Star alignment and 3-Star alignment):
    - Difference in RA should be between 3 to 9 hours
    - Must on the same side of the meridian, while on the same side of celestial equator recommended.
    - The sum of their declination should be greater than 10 degree or less than -10 degree.
    - Similar declinations is highly recommended; especially when performing 2-Star alignment for polar alignment.
  - Third star:
    - On different side of the meridian than the previous two star
    - Higher declination is recommended.

TRACKING

Open the tracking menu from the top toolbar or from **Utility > Tracking**.

When tracking is enabled, the mount will stay pointed to the object it is currently pointing to. That is, mount will turn at the same rate as that of the object moving across the sky. Turn off tracking to observe stationary object on the ground.

You can turn on tracking for objects moving at different speeds:

• Solar: the Sun
• Lunar: the Moon
• Sidereal: all other objects

Tracking accuracy is determined by

• [Alignment] accuracy for alt-azimuth mounts, and
• [Polar Alignment] accuracy for equatorial mounts

Alt-azimuth mount tracking is a long running task, so you need to take the precautions in [Maintaining Long Running Task] to prevent it from being interrupted.

Alt-azimuth mounts have the ability to perform an alternative type of tracking called [Point And Track]. You have the option to turn off **Point And Track** here. See [Point And Track] for how to turn it on.

PPEC playback is only applicable to equatorial mount with PPEC support. When **PPEC playback** is enabled, mount compensates for periodic error during tracking. PPEC playback requires previously recorded PPEC training data. For how to record see [PPEC (Permanent Periodic Error Correction)].

CATALOG

App has these built-in sky object catalogs:

• **Star**: stars, planets, comets
    – The comet catalog requires regular updates from the internet. Date of the comet data can be found in the comet catalog menu.
• **Deep Sky**: galaxies, nebulas, clusters
• **Utility > Tonight's Best**: most visible deep sky objects, planets, double stars in the current sky.

Open a catalog to view, search, sort and filter objects.

The comet catalog data is from the IAU Minor Planet Center.

USER OBJECTS

You can use **User Objects** to save your own coordinates in a list. You can later retrieve the coordinates for [GOTO]. There are two user object lists:

- **Celestial Objects** where you enter RA Dec coordinates.
- **Terrestrial Objects** where you record mount axis position.

How accurately mount can point given an RA Dec coordinates depends on the pointing model built by [Alignment] and [Sync]. On the other hand, axis position coordinates does not depend on alignment or sync. The physical pointing location of the mount given an axis position is determined only by mount physical orientation and axis position origin.

SELECTED CATALOG OBJECT

Once a visible object is selected from a catalog, you can use it for [GOTO] or Point And Track. A visible object is one with an altitude within the [Altitude Limit].

POINT AND TRACK

Point And Track is an alternative way to track an object, without the need to perform star alignment, and is only available to alt-azimuth mounts. This feature is useful for tracking the Sun, Moon and planets in daytime, when there are no stars visible for performing alignment.

To perform Point And Track, ensure that the mount tripod is level, as indicated by its bubble level. Next, choose the object to track from the catalog and select Point And Track. If you then manually (motor-driven and/or push-to) center the object in the telescope field of view, the mount will keep it there. Once started, Point And Track can be turned off in the [Tracking] menu. Performing GOTO also turns off Point And Track.

Accuracy of Point And Track is determined only by how perfectly level the mount tripod is. Whether [alignment] had been done or not does not affect the accuracy of Point And Track. See [Alignment] section for a comparison of this feature and alignment.

Point And Track is a long running operation. See [Maintaining Long Running Task] for how to ensure it does not get interrupted.

UTILITY

POINT AND GO

Point the long axis of your mobile device to a region in the sky and tap **Utility > Point and Go**, and the telescope will GOTO to that rough region. Next, app will show you a list of objects in the region. You can then select an object and perform another, higher precision, GOTO to that object.

This function is available for a mobile device that has tilt sensor and compass. The accuracy of the compass sensor in the mobile device is typically around plus and minus 20 degrees. On some Android devices, denying app's location permission also affects its ability to read the compass.

IDENTIFY

Utility > Identify show a list of objects around the location where

- The telescope points, or
- The long axis of the mobile device points. (Requires tilt sensor and compass, similar to [Point and Go])

The list contains, and is sorted by, angular distance of the object from the location being pointed to.

How accurately mount can determine where the telescope is pointing to depends on the pointing model, as described in [Alignment].

HIBERNATE

Utility > Hibernate allows you to turn off the mount without losing its axis position origin. It works by saving the axis position from the mount to the app before mount is powered off, then restore it when the mount is powered back on. Axis position origin is one of a few things required to keep pointing model valid. See [Preserving Pointing Accuracy] for details as well as other ways to restore axis position origin.

SAVING HIBERNATE DATA

Use either option to save hibernate data:

- **At Current Position**: saving axis position from mount to app
- **At Home Position**: perform GOTO to [home position] first then save axis position from mount to app

To allow restoring to the same axis position origin, the mount axes must not be moved in the time between when hibernate data is saved and when it is restored.

RESTORING HIBERNATE DATA

Reconnect to the mount using the same app instance that you last used to perform hibernate. You will be prompted to either restore hibernate data or to erase it.

CONNECTION

Press the **Connect** button on the app's top toolbar to establish connection between app and mount. If the mount supports being used in either alt-azimuth mode or equatorial mode, you will be prompted to choose one. You must re-connect if you wish to change mode. After connecting, you can disconnect by pressing the text on the top toolbar. The simplest way to connect a mount is by the mount's built-in or external SynScan Wi-Fi adapter, as described in [Connect by Network].

The **Settings > Connect Settings** menu lets you specify how app tries to connect when the **Connect** button is pressed:

NETWORK CONNECTION

Connect by IP network.

If **Find Device** is enabled, the app searches the network for mount when connecting. If it finds multiple mounts in the same network, it will list all of them and the user should choose the right one by refereeing to the IP addresses.

If **Find Device** is disabled, you must specify the IP address of the mount in the network in the **Fixed IP** field. This way of connecting is quicker compared to search.

NETWORK TROUBLESHOOTING

- If you are using iOS, you may need to wait about one minute after joining the SynScan Wi-Fi hot spot for the first time.
- If the device running the app is joining the SynScan Wi-Fi hot spot, you may need to disable the device's cellular internet connection on connecting. Cellular connection can be enabled after SynScan app successfully connects to the SynScan Wi-Fi hot spot.
- On Windows, if using **Find Device** fails to connect, try disabling unused network adapters in "Network and Sharing Center > Change adapter settings". Alternatively, turn off **Find Device**.

EMULATOR CONNECTION

Connects to a virtual mount. This is useful for testing features in the app without a physical mount.

SERIAL CONNECTION

Connect to a mount that (directly, or indirectly through an adapter) presents a serial interface to the app.

USB PORT ON MOUNT

Some mounts are equipped with a USB port. Connect it to a USB host (Windows and some Android devices) and the host would detect the mount as a serial device.

Android devices must support USB On-The-Go (OTG) in order to act as a USB host. To see if your device is capable, search your device's app store for "USB OTG" checking tool.

HC PORT ON MOUNT

All mounts are equipped with a HC (Hand Control) port. On equatorial mounts it is a 8-pin RJ-45 port. On alt-azimuth mounts it is a 6-pin RJ-12 port.

The options to connect mount by HC port to a USB host are:

* Using a SynScan-USB adapter, which converts USB to TTL. Or, using a third party adapter with the same capability as SynScan-USB.
* Using a SynScan Hand Controller. Where a hand controller with "SynScan Relay" firmware is connected between the mount and the USB host. See SynScan Hand Controller manual for how to change firmware.

Connecting RS-232 signal directly to HC port, without appropriate electrical level conversion, risks damaging the mount.

COMMUNICATION PARAMETERS

If you connect by network or serial, you can fine tune communication parameters:

* **Resend tries**: how many times to resend a command to mount if mount did not respond
* **Read timeout (ms)**: how many milliseconds to wait for response from mount

The default values assume an unreliable communication channel (such as over an unreliable Wi-Fi connection) so has many retries and long read timeout. If you know the communication channel is reliable and you wish to have the app report an error quicker, you can reduce retries and read timeout values.

SYNSCAN WI-FI SETTINGS

The **Settings > SynScan Wi-Fi** page configures the internal or external SynScan Wi-Fi adapter. Here you can edit settings like AP/STA mode, SSID, or password.

You must be connected to mount through the SynScan Wi-Fi adapter to configure it. That is, you cannot configure a mount's built-in SynScan Wi-Fi when you are connecting to the mount by serial.

SYNSCAN WI-FI PARAMETERS

SynScan Wi-Fi adapter can works in Access Point (AP) Mode and/or Station (STA) Mode.

Access Point mode

- This is the default mode after a reset.
- SynScan Wi-Fi adapter creates a Wi-Fi network. The device running the app joins this network to connect to mount. By default, the network name (SSID) is of the form `SynScan_WiFi_####` and there is no password.
- Wi-Fi adapter consumes more power from mount
- SynScan Wi-Fi adapter will assign to itself the IP `192.168.4.1`
- In Access Point only mode, it is recommended to configure the Wi-Fi channel to a less congested one to obtain more stable communication.

Station mode

- SynScan Wi-Fi adapter joins an existing Wi-Fi network
    - If the network is created by a wireless router, device running the SynScan app needs to join the same network to connect mount.
    - Alternatively, if the device running the app is capable, it can create the Wi-Fi network (also known as a mobile hotspot).
- Wi-Fi adapter consumes less power from mount
- You can control what IP SynScan Wi-Fi adapter uses in this network
    - **Use DHCP**: whether SynScan Wi-Fi adapter should request an IP assignment from the DHCP server in the network
    - **Fixed IP**: when **Use DHCP** is disabled, you must use this field to specify the IP that SynScan Wi-Fi adapter assigns to itself
- IMPORTANT: The access point (router) that the SynScan Wi-Fi adapter is configured to join must be ready before you turn on the mount; otherwise, the SynScan Wi-Fi adapter will work in Access Point only mode.

RESET SYNSCAN WI-FI ADAPTER

If you cannot connect to the SynScan Wi-Fi adapter (for example, you have forgotten its password), you can reset it to the default Access Point mode. To do that just leave the adapter powered on for an hour without accessing it.

BACKLASH

Backlash is the mechanical slack in the mount's gears. To observe the amount of backlash in a mount axis, move the axis in one direction for a few seconds. When you reverse movement direction at low speed, there will be a noticeable time delay between when the axis motor starts moving, and when the object in the field of view starts moving.

You can set an amount of backlash for the app to compensate in **Settings > Backlash**. When backlash compensation is enabled, whenever an axis reverses direction, app turns the axis quickly for the specified backlash amount to quickly re-engage the gears, thereby shortening the above mentioned time delay.

ALTITUDE LIMIT

In **Settings > Altitude Limit**, you can set an altitude range, outside of which GOTO is disabled. It is useful to prevent accidental GOTO to a position that results in the telescope tube bumping into obstructions.

When the **Catalog Filter** option is turned on, sky objects that exceed the limits will not appear in catalog lists.

Regardless of the setting, app does not restrict you from pointing the telescope beyond the altitude limits using the slew direction buttons.

USER INTERFACE (UI) SETTINGS

In **Settings > User Interface** you can adjust:

- **Night Mode**: Dark screen display for preserving dark adaptation of your eyes at night.
- **Vibration**: Vibration feedback on mobile device when pressing slew buttons and when GOTO finishes.
- **Footer Padding**: The amount of spacing between the slew direction buttons and the Android system buttons. Increase the footer padding to avoid triggering the system buttons accidently
- **Keep screen on**: iOS only. Enable to prevent screen from locking when app is running

COLLABORATE WITH THIRD PARTY SOFTWARE

SynScan App can work with some third party apps to control mount.

BY NATIVE SUPPORT USING SYNSCANLINK

To let a third party app that supports SynScanLink control mount:

1. Perform mount alignment in SynScan App.
2. On the same device, switch to the third party app. Choose "SynScanLink" in the connection setting, then connect.

Supported apps:

*   Luminos, iOS, Provided by Wobbleworks LLC
*   Skysafari 6 Plus/Pro, iOS, Privided by Simulation Curriculum Corp.

BY TETHERING TO SYNSCAN APP

With tethering, the third party app and SynScan App run at the same time, and maintain communication between themselves using TCP/UDP connections. The two apps can run on different devices, or they can run on the same device, with an exception on iOS:

	Third party app on another device	Third party app on same device
SynScan App on iOS	Yes	No
SynScan App on Android or Windows	Yes	Yes

SynScan app will only allow third party app to tether to it after SynScan app had connected to the mount.

On Windows, ensure that you have not blocked app's ability to run a network server, for example, in Windows Firewall settings.

When another app tethers to SynScan app, you must ensure that SynScan app continues to run and communicate with the mount, as detailed in [Maintaining Long Running Task].

PARAMETERS TO ENTER IN THIRD PARTY APP

Enter SynScan App's IP address into the third party app:

*   If SynScan App and third party app run on the same device, enter `127.0.0.1`

- If SynScan App and third party app run on different devices, make sure both devices are in the same network, then enter the IP of the device running SynScan App. (Caution: It is not the IP address of the SynScan Wi-Fi adapter. It is not 192.168.4.1).
- Some software may auto-detect IP

Additional parameters depend on the type of protocol used:

- By SynScan Communication Protocol
    - Supported apps
        - Sky Safari 5 Plus/Pro, Android and iOS, Provided by Simulation Curriculum Corp.
        - StarSeek 5, Android and iOS, Provided by Optronic Technologies, Inc.
        - Stellarium Mobile Plus, Android and iOS, Provided by Noctua Software Ltd.
    - Telescope mount: Sky-Watcher/Orion SynScan
    - Connection type: TCP
    - Port: 11882 (Do not use port 11880 or 11881)
- By Stellarium Telescope Server
    - Supported apps
        - Stellarium Mobile Plus, Android and iOS, Provided by Noctua Software Ltd.
        - Stellarium, Desktop, Provided by the Stellarium community
    - Coords: J2000
    - Port: 10001

SYNSCAN APP ASCOM DRIVER

ASCOM platform is a very widely used telescope control interface used by many third party planetarium or autoguider apps on Windows. In this setup, a third party app supporting ASCOM (i.e. an ASCOM client) sends its requests to ASCOM platform which forward the requests to SynScan app, and SynScan app then communicates with the mount.

For ASCOM client to use this setup, the SynScan App ASCOM Driver must be installed on the Windows computer where the ASCOM client is. You can download this driver from http://www.skywatcher.com/download/software/ascom-driver/. After install, the ASCOM client can choose `SynScan App Driver` (previously called `SynScanMobile Telescope`) from ASCOM's dialog "ASCOM Telescope Chooser" for connecting to SynScan app.

Note that `SynScan App Driver` is distinct from `SkyWatcher Telescope`, which is another driver that is used with the SynScan hand controller.

By default, the driver searches for SynScan app in the network. If searching fails or if you wish to have driver connect to SynScan app quicker, enter the IP of the device running SynScan app in the properties dialog of SynScan App ASCOM driver.

DEVELOPER RESOURCES

Resources for developer can be found at http://www.skywatcher.com/download/manual/application-development/

Where:

- SynScan App Command Set is for sending commands to SynScan app over TCP or UDP
- SynScanLink iOS SDK is for controlling mount without tethering to SynScan app

MAINTAINING LONG RUNNING TASK

Some tasks that the app performs require the app to continually run and communicate with the mount. These long running tasks are:

- Tracking when in alt-azimuth mode
- Point And Track
- Camera Timer
- Being tethered to

Things to note in mobile environment:

- Android
  - App is able to continue long running tasks after app has been moved to the background, unless Android system disallow it. On applicable Android systems, please ensure this setting is used: *Android System > SynScan App > Battery Usage Detail > Don't Restrict*
- iOS
  - iOS interrupts app's communication with mount when the iOS device's screen is locked or when app is switched to background
    - To have app keep the screen on while you leave it to perform long running tasks, enable **Settings > User Interface > Keep screen on**

PRESERVING POINTING ACCURACY

Pointing accuracy refers to how accurately the mount can point to a target in the sky, given its RA Dec coordinates. Pointing accuracy determines how accurately mount can perform GOTO, alt-azimuth mount tracking or identifying an object. To have good pointing accuracy, build a good pointing model by performing [Alignment] then [Sync].

For pointing model to stay valid, three things need to stay the same. Specifically, at pointing time, these three things need to be the way they were at alignment time. The next sections explain what they are and, if they were lost, how to recover them.

MOUNT PHYSICAL ORIENTATION

- This refers to orientation of mount chassis relative to the ground plus the geographical location of the mount.
- To avoid losing mount physical orientation by an accidental bump, anchor the mount tripod well or use a permanent pier.

AXIS POSITION ORIGIN

- More specifically, this refers to the position of the axis relative to the chassis when the axis reading is zero.
- It is lost when mount is powered off, or when the clutch is released while the [auxiliary encoder] is off.
- It loses precision whenever auxiliary encoder is turned on.
- Use [Auto Home] to restore axis position origin on supported mounts.
- A way to avoid losing axis position origin if the mount has to be powered off, is to perform [Hibernate] before powering the mount off, then not moving the mount before reconnecting app with mount.

TIME AND LOCATION SETTING

- This refers to the location setting in the app and the system time of the device running the app. Same system time means the system time has not been adjusted.
- To recover:
    - Location: You do not need to do anything because when pointing model is loaded, its associated location is also loaded. This has the side effect that if you set location before loading pointing model, what you entered will be overwritten.
    - Time: It is good practice to keep the system time synced with network time on all devices running app. That way, if pointing model moves between devices during [PM (Pointing Model) Sharing], there would not be a time discrepancy.

PART II: ADVANCED USE AND ASTROPHOTOGRAPHY

The following sections explain topics involved in using an equatorial mount for astrophotography.

ADVANCED MENU

The **Utility > Advanced** menu is available only in SynScan Pro App.

POLAR ALIGNMENT

Polar alignment is the process of aligning the RA axis of an equatorial mount along Earth's axis of rotation. Accurate polar alignment improves equatorial mount's tracking accuracy. The polar alignment obtained from roughly putting the equatorial mount in [home position] is often good enough for visual observation. Higher accuracy polar alignment is needed for astrophotography.

Polar alignment involves making fine adjustment to the equatorial mount's altitude and azimuth orientation. Consult reference material for your mount for how to do that.

You can see the amount of polar alignment error (**Tilt**) in **Utility > Information** once you have performed an alignment involving at least two stars. You can use this to decide whether you need to perform accurate polar alignment.

POLAR SCOPE

Utility > Advanced > Polar Scope helps you use the polar scope to polar align an equatorial mount. This page shows where Polaris or Octans should be aligned in the reticle of the polar scope.

You can also adjust the brightness of polar scope reticle light. This is only applicable for mounts that have this hardware.

POLAR ALIGNMENT WITHOUT POLAR SCOPE

Utility > Advanced > Polar Alignment is for polar aligning an equatorial mount without using a polar scope. To use this feature you must have performed an alignment involving exactly two stars which have similar declination values. 3-Star alignment is NOT recommended for polar alignment.

When the routine starts you will be prompted to choose a star. Use one of the stars that you used for alignment for best result. Then follow the prompts to adjust the mount's altitude and azimuth orientation.

AUTO HOME

Auto Home (**Utility > Advanced > Auto Home**) is an automated process that recovers axis position origin to axis home index position. Axis position origin is an element required to keep previously performed alignment valid, as described in [Preserving Pointing Accuracy].

Auto home also has the effect of turning the two axes to a specific position relative to the chassis. The axes will be turned such that, if the chassis was upright and polar aligned to north celestial pole, then:

- RA axis position would result in the counterweight rod pointing down, and
- Dec axis position would result in the telescope pointing to the direction of north celestial pole, plus a **Dec Offset** that you can specify.

PPEC (PERMANENT PERIODIC ERROR CORRECTION)

PPEC a feature where mount compensate for its periodic error. Periodic error refers to the small, time-varying deviation in physical axis speed from the ideal axis speed. Periodic error is due to imperfection in the gear system. The magnitude of this error is small enough to not impact visual observation, and is only of concern to tracking during long exposure astrophotography. Since typically only equatorial mount is used for astrophotography, PPEC is not relevant to alt-azimuth mounts. Not all equatorial mounts support PPEC.

The extent that periodic error can be corrected by PPEC is limited. Like autoguiding, PPEC is a way to improve astrophotography performance of a mount. Compared to autoguiding, PPEC requires less setup (after a one-time training process). Autoguiding on the other hand, can compensate for more sources of error.

How PPEC works is that PPEC training records periodic error compensation data, then PPEC playback uses the data to compensate for periodic error. Compensation data is stored in the mount. Meaning that once training had been done, any instance of SynScan app that connects to the mount can perform playback. Compensation data stays valid until you make mechanical changes to the RA axis gear system.

Ensure you have accurate [Polar Alignment] before starting PPEC training and playback, as it is something also required for accurate equatorial tracking.

The time it takes for PPEC training to complete or for PPEC playback to become stable depend on the periodic error cycle length. It varies depending on the mount model, and is typically about 10 minutes.

PPEC TRAINING

To start PPEC training, perform polar alignment, and set up autoguider to track a star near the celestial equator and away from the horizon. While the mount is tracking the star steadily, go to **Utility > Advanced > PPEC** and choose **Start**. Mount will start to record compensation data, and report completion after some time. Training time can take up to twice the mount's periodic error cycle length.

It is also possible to perform training without an autoguider. You can do that by keeping the star centered in the field of view using the slew direction buttons.

PPEC PLAYBACK

Turn on PPEC playback in **Utility > Tracking**. It can take up to one periodic error cycle for playback to become stable.

CAMERA CONTROL

You can use the app to control a camera to take a series of photos of varying exposure time. You can also use the app as a remote to manually open and close the camera shutter. The camera control features in this app is intended for astrophotography. For a much richer set of ground photography tasks including timelapse and panorama, use the *SynScan Photo* Android/iOS app.

Setup for camera control requires you to attach an adapter cable from the SNAP port on the mount to the shutter release port on the camera. Your vendor may have compatible cables for shutter release ports on Canon, Nikon and Sony cameras. The exposure time setting on the camera should be set to *BULB* to allow control of both the timing and length of exposure from its shutter release port.

CAMERA TIMER

The **Timer** page in **Utility > Advanced > Camera Control** can be used to specify a list of items called exposure groups. Each exposure group represent a number of photos to take with the same exposure time. You can add items to and modify the list, and let the app run it.

In each exposure group you can also specify pause time between each photos. It is useful for waiting for the camera sensor to cool.

To keep camera timer running you need take measures as detailed in [Maintaining Long Running Task].

BULB MODE

The **Bulb** page in **Utility > Advanced > Camera Control** is for manually controlling the camera shutter. Press and hold the **Bulb Shutter** button to open the shutter. Release the button to close the shutter.

DIAGNOSTICS

In **Utility > Advanced > Diagnostic > Response Time** you can see the statistics of communication between the app and the mount. You can use measured response time to adjust [Communication Parameters].

ADVANCED SETTINGS

AUXILIARY ENCODER

Auxiliary encoder (aux encoder) is a sensor that keeps track of axis position while the clutch on an axis is released. When aux encoder is enabled, you can release the clutch and turn the axis independently of the gear system without losing axis position origin. Axis position origin is something required to keep previously performed alignment valid as described in [Preserving Pointing Accuracy]. Not all mounts are equipped with auxiliary encoders.

Find auxiliary encoder setting in **Settings > Advanced**.

Enabling auxiliary encoder lowers the resolution of axis positions. Therefore, do not enable aux encoder if you do not need to disengage the clutch.

GUIDING RATE

The guiding rate setting in the app determines how fast an axis moves, when the mount or app receives an autoguiding signal (which consists of only a direction and duration). Find guiding rate setting in **Settings > Advanced**.

An autoguider can send autoguiding signal in two ways:

- to the mount directly (through the mount's ST-4 port), or
- to the app (by ASCOM interface)

The guiding rate setting applies to both situations.

FLIPPING

Flipping Mode (in **Settings > Advanced**) is the setting to determine the exact pointing pose of a German equatorial mount (GEM) when performing GOTO. For any given target in the sky, a GEM can point to in two different poses. In one pose, the counterweight rod points down, and in the other pose it points up. By default, the setting value is **Auto**, and the mount will always choose the pose where the counterweight rod points down, so that the telescope tube is far away from the tripod legs and the likelihood of their collision is minimized.

There may be a situation where you wish to perform a GOTO that places the GEM in a counterweight rod pointing-up pose. For example, when tracking an object past the meridian, you could start tracking with the counterweight rod point up. The setting to achieve this depends on the location of the mount and where the pointing target is.

Setting to make counterweight rod point up after GOTO:

	Pointing to object in East hemisphere	Pointing to object in West hemisphere
GEM mount located in North hemisphere	Forced	No
GEM mount located in South hemisphere	No	Forced

When performing such a GOTO, you should be cautious of collision.

Flipping Mode will always reset to **Auto** after a GOTO is completed.

ALIGNMENT COMPENSATION

Alignment Compensation (in **Settings > Advanced**) lets you specify known mechanical error in the mount. This is used to improve pointing accuracy as a part of pointing model.

- **CH**: Cone error. How much the telescope optical axis is not perpendicular to the Dec/altitude axis.
  - CH value will be applied to 1-Star alignment and 2-Star alignment to compensate cone error; thus, it is important to enter an accurate value or keep it as zero.
  - You can enter/edit the CH value manually; or, using 3-Star alignment to calculate and update CH value.
  - Reset alignment will also reset CH to zero.
  - CH can be set to zero for alt-azimuth mount as they are not sensitive to it.
- **NP**: Non-perpendicular error. How much the mount's two axes are not perpendicular.
  - Generally, this error is very small and can be set to 0.
  - NP value will be applied to 1-Star alignment, 2-Star alignment and 3-Star alignment to compensate NP error; thus, it is important to enter an accurate value or keep it as zero.
  - Currently, you can only enter NP manually.

SPEED COMPENSATION

Speed Compensation (in **Settings > Advanced**) is useful for correcting tracking speed error caused by inaccurate rate of mount's internal clock. Typically, such error would be in the order of a few ppm (parts per million).

The sign of the compensation value determines direction of compensation. For example, if you measured that the tracking rate of the mount is 10ppm faster than the ideal, then enter -10ppm in Speed Compensation to counteract the error.

The resolution of the compensation value a mount accepts depends on its model. The compensation value you entered is rounded to the closest accepted value. For example, if a mount has compensation value resolution of 30ppm, then setting compensation value to 25ppm equals setting it to 30ppm.

OBSERVING SUN

To observe the sun, make sure your telescope is designed to observed the sun, or is equipped with accessory that is. Make sure to carefully follow the instruction of your sun observation equipment. Observing the sun improperly can be dangerous to both people and equipment.

To allow app to display object within 5 degree of the sun in catalog or alignment star menu, turn on the setting in **Settings > Advanced > Observe Sun**. Regardless whether or not this setting is enabled, app will not prevent you from pointing the telescope to the sun using the slew direction buttons.

To have the mount track the sun, perform one-star alignment with the sun. If you are using an alt-azimuth mount, an alternative is to turn on [Point And Track] targeting the sun.

MULTIPLE CONTROLLERS CONTROLLING SAME MOUNT

It is possible for multiple instances of app to connect to the same mount by network, but there are precautions to take.

It is safe to read data from the mount using one app instance while another instance controls its motion. However, you must not let two instances perform motion control at the same time, including GOTO, slewing, and tracking. To prevent interference, stop motion control in one app instance before performing motion control in another instance.

Be cautious on Android, because when app is switched to the background, it can still perform long running motion control tasks. To see what task is long running, see [Maintaining Long Running Task].

You can perform alignment using one instance of the app, then use [PM (Pointing Model) Sharing] to share the result with another app instance.