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MANUFACTURER OF VIXEN OPTICAL GOODS

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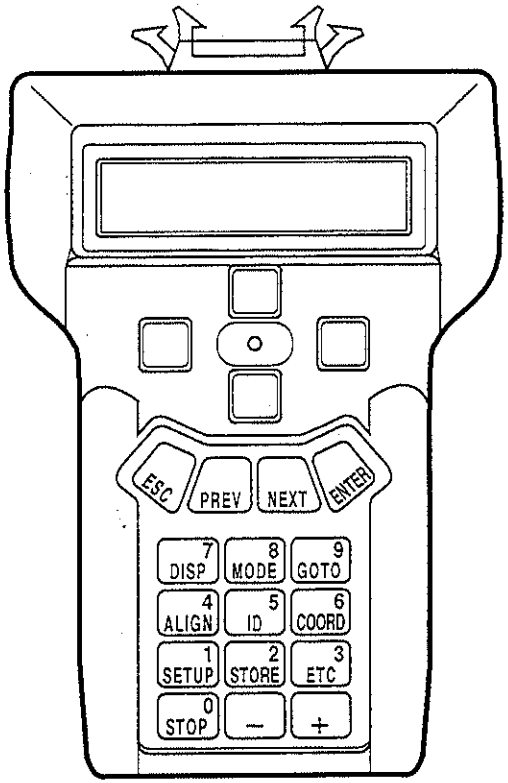
Astronomical Telescope Accessories

Sky Sensor 2000

User's Guide



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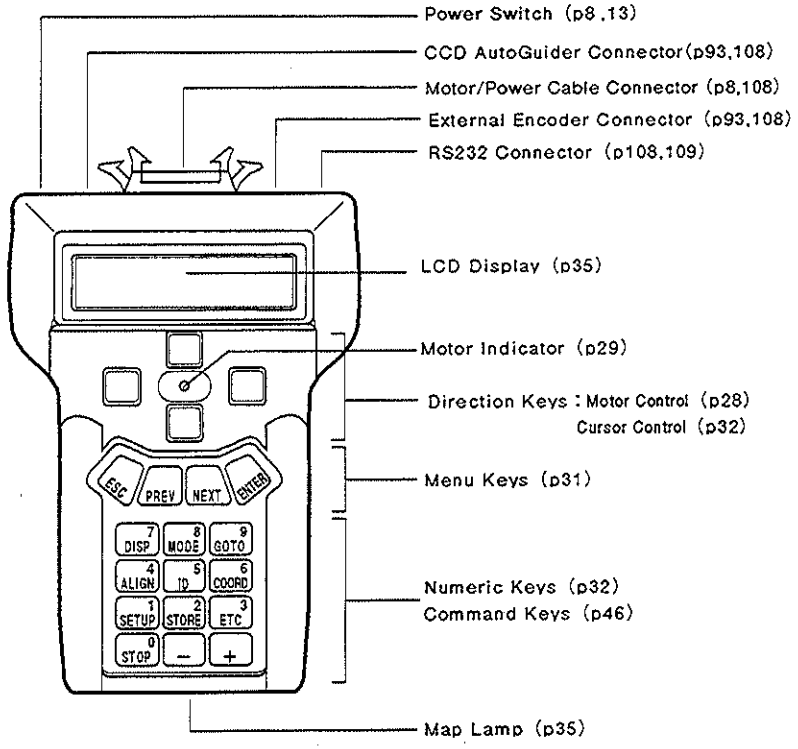

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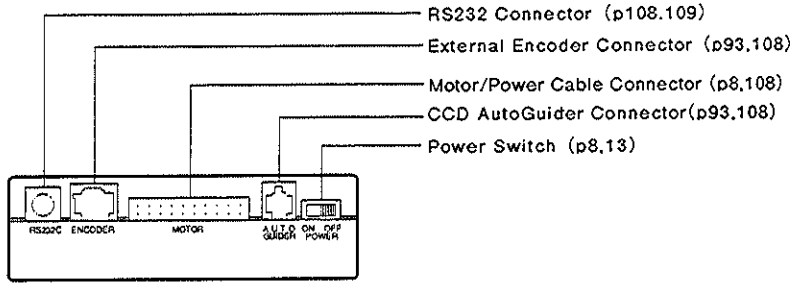


Chapter 1 Introduction

Thank you for your purchase of SkySensor 2000 astronomical telescope controller.

1.1 How to Use this User's Guide

SkySensor is designed to be versatile and powerful, yet simple to use. Its many functions and features makes it convenient to use, but even if you don't use all the features, you will find SkySensor easy to use to enjoy the wonders of astronomy.

This User's Guide explains the functions and the features of SkySensor in detail, but after reading this chapter and the next chapter, "Getting Started", you will be able to start using SkySensor right away to locate and view many astronomical objects. Please read the rest of the User's Guide as you need to get the most out of your SkySensor.

Chapter 3, "Basic Functions", explains the operations of the keys and the display of the controller, and the main menu which is at the heart of the operation.

Chapter 4, "Command Keys", explains the usage of the command keys. The command keys are used to execute many functions of SkySensor.

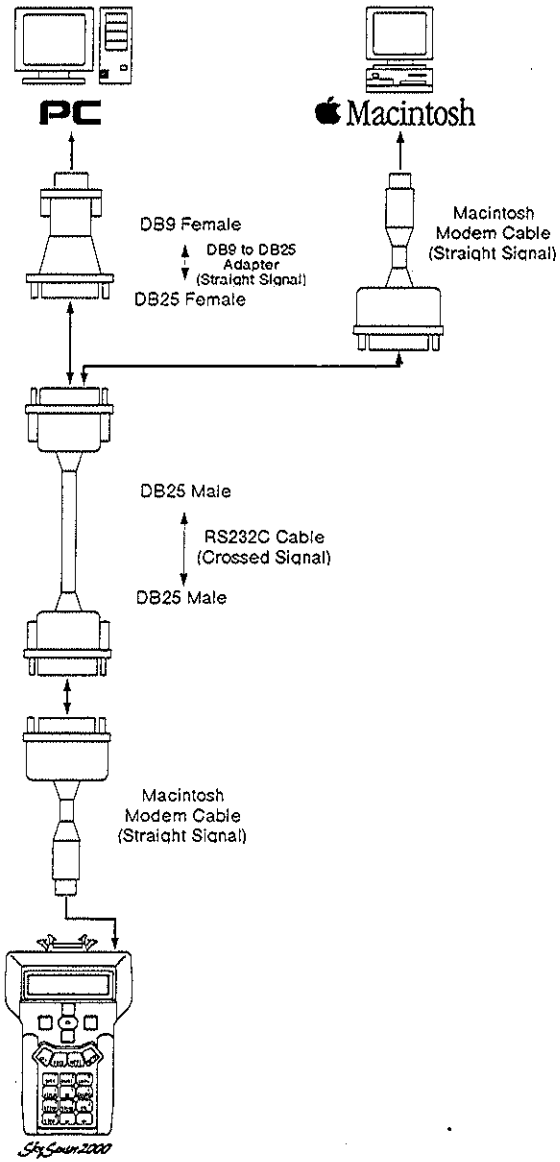
Chapter 5, "For Best Performance", explains how SkySensor operates and suggests many useful hints for getting the best performance from your SkySensor.

In Chapter 6, "Option Connections", the optional equipments that can be connected and used with SkySensor are described.

Chapter 7, "Operation Tips", gives many helpful hints for using SkySensor.

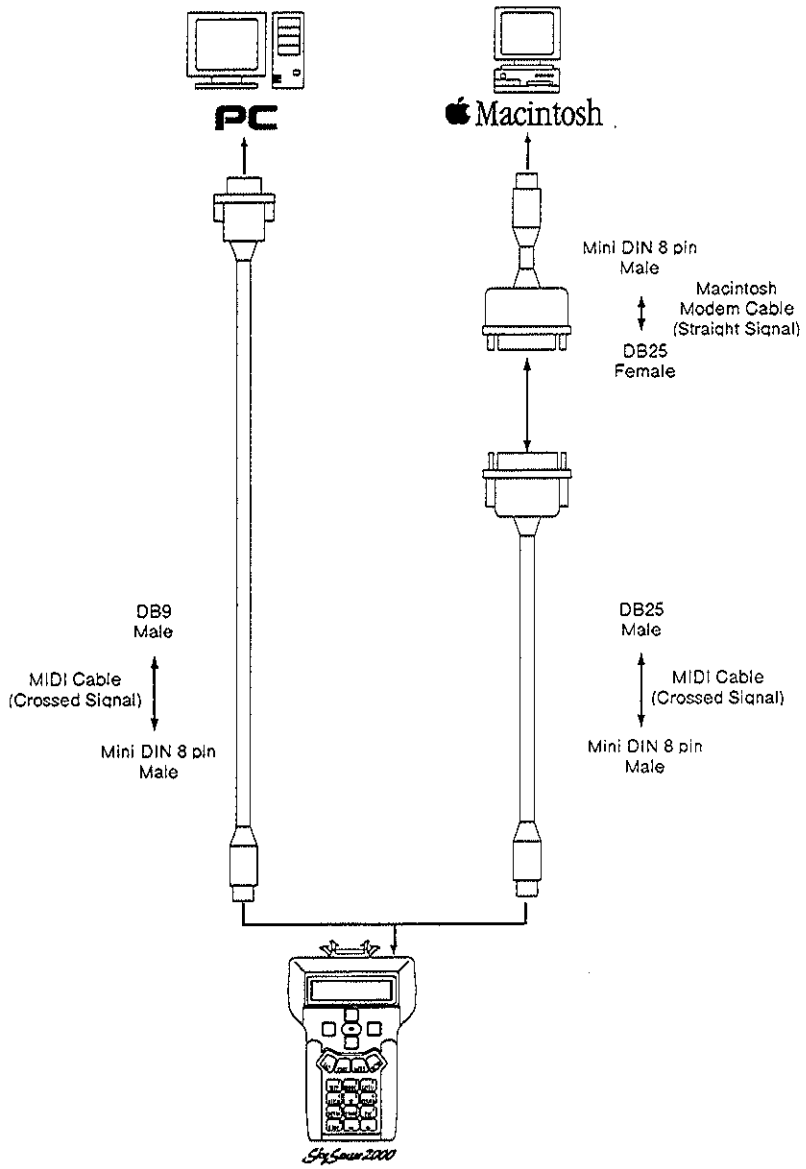
Cable Combinations: Example 2

This example uses widely available cables.
These cables come in several choice of cable lengths.



Cable Combinations: Example 1

This example uses minimum number of cables.



1.2 About Setting Up

This User's Guide covers the setup and operation of SkySensor 2000. On how to set up and use the telescope, please consult the manual which came with the telescope.

SkySensor is to be connected to DC motors and a power supply with the supplied connector cable. The procedure is discussed in Section 2.1: "Using SkySensor for the First Time".

1.3 About the Power Source

SkySensor may be used with the supplied battery box, a 12 volt battery, or a 12 volt AC adapter. The AC adapter should have a current capacity of 2 amperes or more.

When the battery box is used with a set of alkaline batteries, depending on the usage, they should last for approximately 10 hours of continuous use in ambient temperature of about 20°Centigrade. If the telescope is slewed frequently, or in cold temperature, the battery will wear out much faster. (In 0° Centigrade temperature, batteries would last only about two hours.) It is recommended to carry an extra set of batteries.

As the batteries wear out and the voltage drops, the slew speed will decrease, but otherwise it will not affect the performance such as pointing accuracy. When the voltage drops very low, SkySensor may get reset (acts as if the power switch was turned off and then on again). If this happens, you can resume operation simply by pressing on the ESC key. If the voltage drops so low that the motors do not work or SkySensor gets reset frequently, you should change the battery.

1.4 Before You Start

When you tighten the clamps on the mount, please be sure that the clamp knobs do not hit the motor case when the telescope rotate.

When using the telescope during daytime, please read Section 2.3.7, "About Daytime Viewing and the Sun", before you start to avoid possible injury resulting from the telescope pointing toward the Sun.

Chapter 2 Getting Started

This chapter is designed to get you off to a quick start in using SkySensor. Although SkySensor has many features to make it suit your need for observation, you don't need to wait until you master all features to enjoy observations with SkySensor. After you read this chapter, please go out and try using SkySensor. Afterwards, you can read about many features available to you in the following chapters.

2.1 Using SkySensor for the First Time

When you use SkySensor for the fist time, you need to set its internal clock and enter the coordinates of the observation site. In this section, we will make those settings, connect SkySensor to the mount and try moving the telescope. You can do this indoors in lighted area.

2.1.1 Setting Date, Time, and Location

We first set the internal clock and the coordinates of the observation site. You do not need to connect SkySensor to the telescope for this step.

1) Connect SkySensor to the battery box using the connector cable.

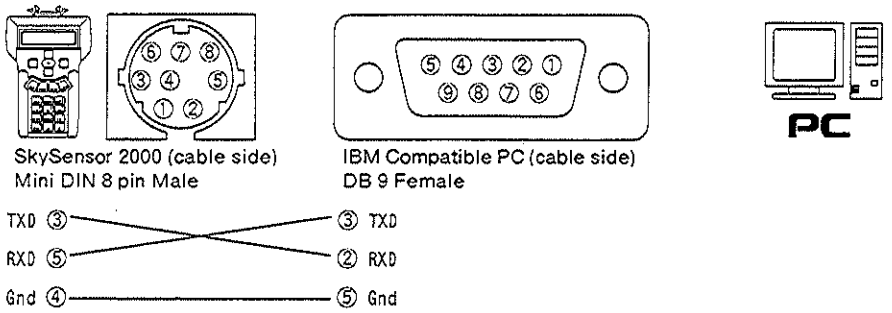
2) Turn the power switch on SkySensor to ON position. After SkySensor logo and the version number is displayed for a few seconds, the following display will appear.

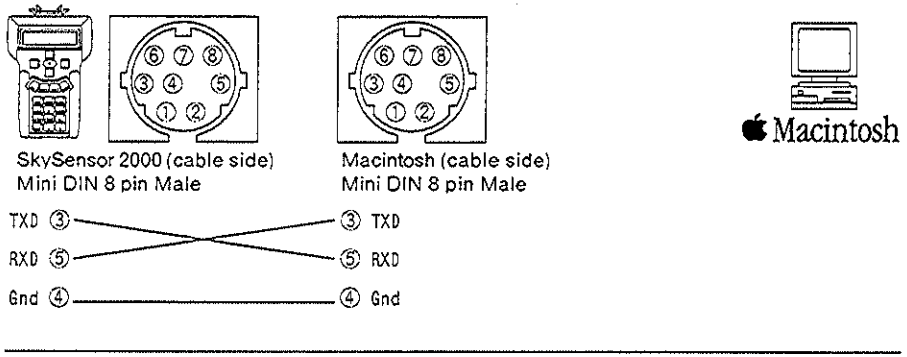
Note: If you press a wrong key and enter an unfamiliar menu, or want to get out of a menu without making changes, simply press ESC (escape) key. Pressing ESC key cancels the current operation and returns to the previous menu level. You can always return to the top of the main menu from anywhere by pressing ESC key repeatedly.

Connecting Personal Computer to SkySensor 2000

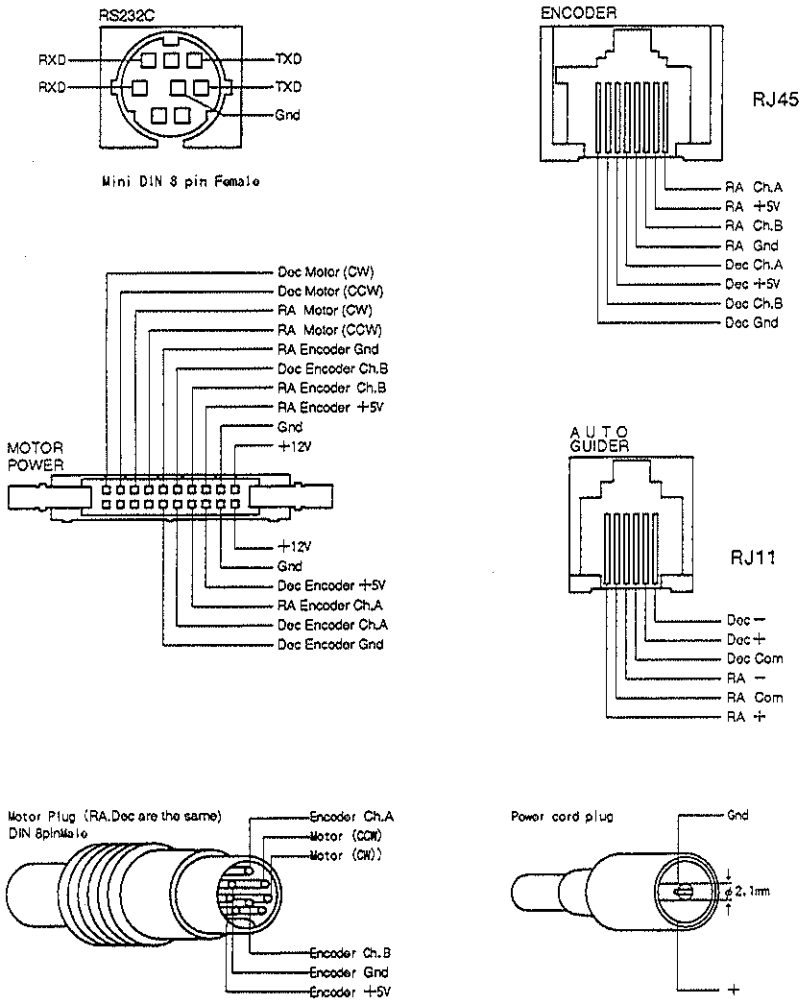
Please use commercially available cables to connect a personal computer to SkySensor 2000. The connector on SkySensor is the same type (Mini DIN 8) that is used on the Macintosh modem connectors.

- ☐ Please note carefully the connector type and the gender type.
- ☐ You can use either a single cable or a combination of cables, but the RS232C signals must be "crossed" overall.
- ☐ Some PC may have different type of connectors. Please verify the connector type on your PC and use an adapter if necessary.
- ☐ The printer cable for Macintosh cannot be used to connect a Macintosh and SkySensor.





Connectors




```
Set scope in horiz.
pos. and press ENTER
```

Display after switching on the power

For now, simply press the ENTER key on the controller to continue, and the next screen will appear on the display.

```
MAIN: Menu Selection
Main Menu> RefStar
```

Main menu display

3) Now press the SETUP key which is located at the numeric 1 key position on the controller. The display will show a menu to select a setup number.

```
Setup (Current)
#0 → Default Values
```

Setup number selection

4) Press ENTER key to select #0 setup ("Default Values"). The display now shows a setup category as shown.

(If a category other than "Location & Time" appears on the display, press NEXT key until you see the display as in the example.)

```
Setup Categories
   Location & Time
```

Setup category selection

5) Press ENTER key to select the "Location & Time" category. The display now shows the menu to set the time.

(If a menu other than date and time is displayed, press NEXT key.)

```
Date Tue      Time TZ
70/01/01 20:00:02+09
```

Date and time setup menu

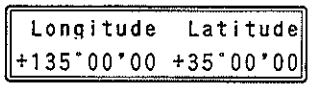
Using the numeric keys, enter the current year/month/day and time (in 24 hour format). If you enter a wrong number, you can use the right and left direction keys located in the upper part of the controller to move the cursor to enter or re-enter any of the numbers.

The last item TZ (for Time Zone) is the time difference between the local time and the Greenwich Mean Time (GMT). Its sign is plus if the local time is ahead of GMT (east of

Greenwich) and minus if the local time is behind GMT (west of Greenwich). As an example, TZ for Los Angeles (on Pacific Standard Time) is -8. When the correct date and time is entered, press ENTER key. The cursor will disappear to indicate that the data has been entered. (If you press ESC key or NEXT or PREV keys before pressing ENTER key, the data would not be entered.)

An error of a few minutes in the entered time will not affect the pointing accuracy of SkySensor.

6) After setting the date and time, press NEXT key to display the menu for setting the longitude and latitude of the observation site as shown below.



Menu for setting longitude and latitude of observation site.

Enter the longitude and latitude using the numeric keys, in the same way as was done for entering the time. The sign of longitude is positive for east and negative for west. The coordinates can be entered to minute and second, but for normal astronomical observation, accuracy to the degree is sufficient. As an example, the longitude for Los Angeles is about -118°and the latitude is about +34°.

After setting the numbers for longitude and latitude, press ENTER key to enter the data.

7) This completes the setting of date, time, and the site coordinates. Although you can press ESC key twice now to get back to the main menu, you can simply turn the power switch off at this point. The data you have entered will be kept in the SkySensor memory when you turn off the power, so you do not need to re-enter them every time you switch on the power.

2.1.2 Connecting to a Mount

Next, we will connect SkySensor to an equatorial mount. Before you start, please turn off the power switch on SkySensor.

1) Attach the DC motors to the equatorial mount. (Please refer to the separate instruction sheet for procedures for attaching the motors.)

Appendix B Specifications

Controller

Dimension	
Size:	100 X 188 X 45 (mm)
Cord Length:	Approx. 2 m
Weight:	370g
Voltage Requirement:	9 ~ 14V
Power Consumption:	15W Max
CPU:	32 Bit RISC Processor
Display:	20 Col. 2 Line Variable Backlight LCD
Operating Temperature Environment:	0 ~ 40°C

Database:

NGC Objects (Brighter than Mag 15.0)	4841 objects
IC Objects (Brighter than Mag 15.0)	1352 objects
Messier Objects	108 objects
SAO Objects (Brighter than Mag 4.0)	422 objects
Planets	8 objects
Sun	
Moon	

(Messier objects duplicates objects in NGC and IC catalogs)

User definable objects:

Celestial Objects (RA/Dec)	60 objects
Terrestrial Objects (Alt/Az)	30 objects
Comets (Orbital elements)	30 objects
Artificial Satellites (Orbital elements)	30 objects

Appendix A List of Reference Stars

No.	Magnitude	Name	Constellation
1	0.5	Achernar	Eridanus
2	1.6	Acrux	Crux
3	2.2	AlNair	Grus
4	3.2	Albireo	Cygnus
5	1.1	Aldebaran	Taurus
6	2.2	Alphard	Hydra
7	2.3	Alphecca	Corona Borealis
8	2.1	Alpheratz	Andromeda
9	0.9	Altair	Aquila
10	1.1	Antares	Scorpius
11	0.2	Arcturus	Bootes
12	0.4	Betelgeuse	Orion
13	-0.9	Canopus	Carina
14	0.2	Capella	Auriga
15	1.3	Deneb	Cygnus
16	2.2	Denebola	Leo
17	2.0	Diphda	Cetus
18	2.0	Dubhe	Ursa Major
19	1.3	Formalhaut	Piscis Austrinus
20	2.2	Hamal	Aries
21	2.6	Markab	Pegasus
22	1.9	Mirfak	Perseus
23	2.4	Mizar	Ursa Major
24	2.1	Nunki	Sagittarius
25	1.2	Pollux	Gemini
26	0.5	Procyon	Canis Minor
27	2.1	Rasalhague	Ophiuchus
28	1.3	Regulus	Leo
29	0.3	Rigel	Orion
30	0.1	RigilKentaurus	Centaurus
31	2.2	Schedar	Cassiopeia
32	-1.6	Sirius	Canis Major
33	1.2	Spica	Virgo
34	2.2	Suhail	Vela
35	0.1	Vega	Lyra

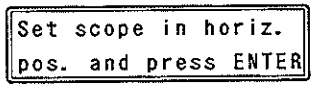
2) Balance the telescope carefully on the equatorial mount. (Please refer to the instruction sheet that came with the telescope on how to balance the telescope.) The altitude adjustment on the equatorial mount should be set roughly equal to the latitude of the observation site.

3) Attach the motor cable to the right-ascension and the declination DC motors. Connect the cable to the power supply and SkySensor, if not done so already. (Please refer to the separate instruction sheet on how to connect the cable.) SkySensor is now ready for use.

2.1.3 Testing the Motors

Let's now test the motor operation to make sure that everything is connected properly.

1) Switch the power switch on SkySensor to ON position. After displaying the logo and the software version number for a few seconds, the following message will appear.



Display after turning on the power switch.

Using the four direction keys on the upper part of SkySensor, position the telescope so that it is level and points towards the left side as you look from the south end (the side you position yourself when using the polar alignment scope) of the mount. The telescope should be positioned as shown on the diagrams ("Initial Position") on the next page. You can loosen the clamps on the mount to position the telescope for this step. After you position the telescope, tighten the clamps on the mount. Please do not loosen the clamps after this step.

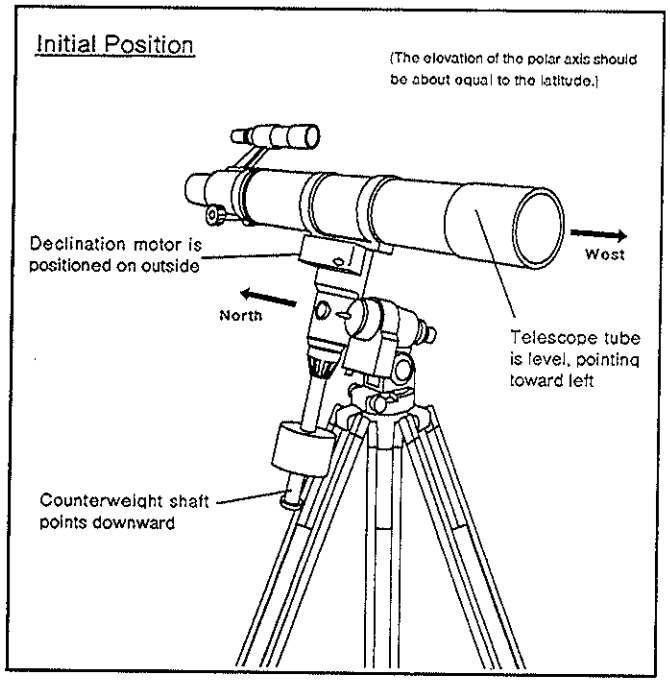
Please note that if you position the telescope correctly, the declination motor will be on the north side of the mount. (If you use the Accessory Plate to mount the telescope, please refer to "How do you position the telescope initially when using the Accessory Plate?" in Chapter 7.)

2) After positioning the telescope tube in the initial position, press ENTER key. (The display will now show a selection for the object menu.)

```
MAIN: Menu Selection
Main Menu> RefStar
```

Object Menu Selection

Now press the Up-direction key located on the upper part of SkySensor. If the cable is connected correctly and the telescope is positioned correctly, the motors will start to turn and move the telescope so that it points upwards. When you release the key, the telescope will gradually come to a stop.



[If nothing happens when you turn on the power]

Please check the following.

- ☐ Is the battery cable securely connected?
- ☐ Is the fuse on the battery cable OK?
- ☐ If you are using an AC adapter, is the polarity (+/-) set correctly?

[If the clock and parameter settings get erased]

SkySensor's memory and clock are maintained by an internal lithium battery. This battery should last about 5 years, but when it's worn out, the memory and the clock may get erased. Please have the unit serviced when this happens.

[When something is not right]

It may happen on an occasion that SkySensor gets lost and point the telescope in a completely wrong direction, or does not respond to key strokes.

- ☐ Cause: SkySensor's computational data may have become corrupted.
- ☐ Solution: Reset the power switch and start over again from the initial position. If this does not fix the problem, re-initialize the memory by referring to "Press 4 direction keys simultaneously while switching the power ON" in Section 3.1.5.

☐ Are gears too tight?

Please see Cause 3 of the previous tip.

☐ Is the motor speed limit set low?

Please see "Motor Speed Menu" in Section 4.7.3 on how to set the motor speed limits.

☐ Is the mount balanced?

If the mount is not balanced, it will put extra load on the motor and slow it down.

SkySensor is programmed to sense voltage drops and increase in motor resistance and limit the motor speed. If the telescope hit an obstacle and is stopped, the motor speed will be temporarily limited by this function, but when the obstacle is removed the speed will gradually recover.

[If telescope interferes with the tripod]

When you attach a camera or other accessories to the telescope, it may interfere with the tripod in certain position. The use of the optionally available half-pillar will extend the position of the telescope and help avoid the interference.

[If scope hit the tripod and it won't move]

When the telescope hit an obstacle, the motor speed will be limited by the program and this may cause the telescope to stop responding to motor keys. If this happens, press STOP key and you will be able to move the telescope again.

[If SkySensor gets reset]

If the motor is suddenly accelerated at high speed when the battery voltage is low, or if the battery cable has a loose connection, SkySensor may emit a beep and return to the state when it was first turned on. If this happens, you can resume observation simply by pressing ESC key.

Similarly, when you press Right or Left-direction key, the telescope will swing horizontally to right or left. You may press Up/Down and Right/Left keys simultaneously to move the telescope diagonally.

When you press on a direction key, the telescope first move slowly and then gradually moves faster, eventually reaching the maximum speed as you hold the key down. If you wish to move the telescope steadily at a lower speed, first release the key. As the motor gradually slows down and reaches the desired speed, press the key again to hold that speed. By controlling the timing of pressing and releasing the direction keys, you will be able to move the telescope at any speed you like. Please experiment with the motor keys a few times to become family with the control.

If you would like to quickly stop the telescope, press the opposite direction key, and the telescope will stop right away. If you keep pressing the opposite direction key, the telescope will start moving in the other direction after a few seconds. (If you would like to move the telescope in the opposite direction right away, release the opposite direction key momentarily and press it again.)

Do not touch the telescope or the mount while the motor is turning at high speed. Doing so may cause an accident or injuries. In an emergency, turn the power switch OFF to stop the motors.

2.2 Observing with SkySensor

As the sky begins to darken at dusk, let's get ready to observe with SkySensor. Before it gets completely dark, it is convenient to adjust the focus and align the finder using a distant landmark.

With SkySensor, there is no special alignment procedure with a special set of alignment stars to align the telescope. When the telescope is not pointing precisely on the selected object, you can center the telescope on the object and press ALIGN key to align the telescope for more accurate pointing.

You can slew the telescope to an object using GOTO function from the beginning. For the very first pointing with GOTO key, the pointing accuracy will probably be off by a few degrees. By centering the telescope on the object and pressing ALIGN key, SkySensor computes the alignment error and the pointing accuracy will improve for the next pointing using GOTO function.

2.2.1 Turning ON the Power Switch

Connect SkySensor to the motors and the power supply and turn the power switch to ON position. When the message "Set scope in horiz. pos. and press ENTER" is displayed, set the telescope in the "Initial Position" and press ENTER key. You do not need to align the polar axis on the equatorial mount, but point the right-ascension axis approximately toward North.

2.2.2 Selecting an Object

Look up in the darkening sky. Do you recognize any object? For the first pointing, select an object you can recognize so that you can verify that the telescope is pointing at the correct object. If you can see the Moon, that would be a great target. If the Moon is not up, then Jupiter, Saturn, or Venus are easily recognizable objects through a telescope. If you can recognize any of the stars, you can use that for the initial pointing.

To select the Moon, planets, or a star, you first select the menu for those objects.

Note: Positioning the equatorial mount so that its polar axis points toward North lets you slew to an object using GOTO key before the first alignment, but this is not a necessity. Please see Section 2.3.1: "About the Alignments".

☐ Cause 2: Battery voltage is low. When the battery becomes depleted and the voltage drops, the motor speed will decrease and will eventually stop.

☐ Solution 2: Replace the battery.

☐ Cause 3: The motor gears are adjusted too tightly. If the gears are too tight, the motor will turn sluggishly and may stop, especially when the voltage drops. The battery will also drain quickly.

☐ Solution 3: Remove the motor from the mount and turn the gear on the mount (not the gear on the motor) by hand. The gear should turn easily and smoothly.

If you need lots of force to turn the gear, then the worm gear on the mount needs adjustment or an overhaul. Please consult the dealer or the distributor to have the gears adjusted.

If the gear on the mount turns smoothly, then turn on the power switch on SkySensor and try moving the motor with motor keys without attaching it to the mount. If the motor turns smoothly, then reconnect the motor to the mount. When reconnecting, be sure that the gears are lined up straight and leave a slight gap between the gears.

☐ Cause 4: Malfunction in the SkySensor program.

☐ Solution 4: Please refer to "When something is wrong" at end of this chapter.

[The motor moves sluggishly]

Please check the following.

☐ Is battery weak?

SkySensor works even if the battery voltage drops somewhat, but the motor speed will decrease.

☐ Are clamps tightened?

The clamps may be slipping.

[If the telescope appears to move on its own]

Occasionally, the telescope may appear to move in an unexpected direction or stop suddenly while slewing and change its direction.

☐ Cause: The telescope is moving to avoid the Sun.

☐ Solution: SkySensor is programmed to move the telescope away from the Sun when it gets too close. There will be a warning message when this happens, but no warning beep will sound. This is a normal behavior. Please check the display for the warning message.

[If scope move erratically when a motor key is pressed]

When you move the telescope with motor keys while looking through the telescope, the scope may appear to move erratically.

☐ Cause: If the backlash compensation value is not adjusted, the telescope may move in zigzags or respond slowly or jump suddenly when motor keys are pressed. This is usually especially apparent in low speed modes.

☐ Solution: Adjust the backlash compensation. (Please see Section 5.6, "Setting the Backlash Compensation", for the procedure.) Also, setting the motor control mode to X-Y mode at low speed helps control the telescope smoothly.

[If motors stop moving]

The motor may suddenly stop while moving the motor or during automatic slewing, or the motor may stop tracking for no apparent reason. This may be accompanied by screeching noise.

☐ Cause 1: The motor case has ran into a clamp knob.

☐ Solution 1: Loosen the screw holding the clamp and reposition the clamp knob so that it does not hit the motor case when the clamp is tightened.

☐ To Select the Moon

To select the Moon for the object, first select the Moon menu from the SkySensor main menu selection. Currently in our example, the display shows the RefStar (Reference Stars) as the selected menu in the main menu.

```
MAIN: Menu Selection
Main Menu> RefStar
```

Main menu selection

When you press NEXT key (one of four green colored menu keys located at the center of SkySensor), the menu selection will change from RefStar to Messier, Planets, and then to Moon. Select Moon. If you go past the selection you want, you can press PREV key to scroll the list backwards.

```
MAIN: Menu Selection
Main Menu> Moon
```

Main menu selection showing Moon menu

Press ENTER key to show the object selection in Moon menu.

```
MAIN: Moon Menu
Moon >1 Moon Center
```

Moon menu

If the Moon is above the horizon, Moon menu will show "Moon Center" as the object selection. If the Moon is below the horizon, then the menu will display a 0.

Press ENTER key to select Moon Center as the object. The display will now show the data for the selected object. (In the following example, the right-ascension and declination (RaDec) of the center of Moon is displayed.)

```
MAIN Data: Moon Cent
RaDec 00:31.3 +01°50
```

Data display for Moon showing right-ascension and declination

Note: If an object appearing in the sky does not appear in the object menu, please see "Object in the sky does not appear in the menu" in Chapter 7. It is possible to select and see data for objects which are below horizon. Please see Section 3.3.2: "Object Menus" for details.

☐ To Select a Planet

To select a planet for the object, the planet menu must be selected from the main menu selection. In the main menu, scroll the menu selection by using NEXT/PREV keys until Planets is displayed.

```
MAIN: Menu Selection
Main Menu> Planets
```

Main menu selection showing planets menu

Press ENTER to enter the planet menu. In the planet menu, the first planet in the menu which appear above the horizon will be displayed.

```
MAIN: Planets Menu
Plan.>4 Jupiter
```

Planets menu

By pressing NEXT key, other planets which currently appear above the horizon can be displayed. When you press ENTER key, the data for the selected planet will be displayed. In the above example, if you press ENTER key, Jupiter will be selected and its data will be displayed.

```
MAIN Data: Jupiter
RaDec 18:11.8 -18°24
```

Data display for Jupiter

☐ To Select a Star

SAO menu contains 422 stars brighter than magnitude 3.9 which you can also use for alignments.

For the initial alignment, the reference stars menu from the main menu selection which contains 35 fairly well known bright stars is convenient to use.

In the main menu selection, select RefStar using NEXT or PREV key

```
MAIN: Menu Selection
Main Menu> RefStar
```

Main menu selection showing reference stars menu

[If the display appear stuck]

Occasionally, the second line of the LCD display may appear to be stuck.

☐ Cause: When the display on the first line is changing rapidly, the second line may appear stuck if the first line changes before the second line can be updated completely.

☐ Solution: The display will soon return to normal by itself.

[To move telescope past the pole]

With the motor control mode set to RaDec, the telescope will move toward the pole when you press Up key, but it will stop when it is pointed at the pole. This is because the Up key in RaDec mode is designed to always move the telescope in direction of the pole. If you want to move the telescope over and across the pole, set the control mode to X-Y.

[To verify the current motor mode]

Press Mode key to verify the motor modes. The current control mode and the speed mode will be displayed for 5 seconds on the status line. (If you press MODE key again while the mode is being displayed, it will cause the control mode to change.)

[To change speed mode without looking]

The motor speed mode is changed by pressing [+] and [-] keys. If you follow the following sequence, you can change the motor speed to the desired speed mode without looking at the mode on the display. (The [+] and [-] keys are positioned on the bottom row of the keypad, where with a little practice you can press them without looking.)

☐ High speed: Press [+] key twice.

☐ Medium speed: Press [+] key twice, then [-] key once.

☐ Low speed: Press [-] key twice.

[To list all objects in the database]

In the object menus, you can list objects, such as NGC, with NEXT/PREV keys even if you don't their number. The object which are listed with NEXT/PREV keys are those items which meet the criteria you set in the setup. You can view all objects in the database with NEXT/PREV keys if you set the criteria to meet all objects in the database,

To specify all objects, in the "Object Direction Menu" (see Section 4.7.4), set "Elev" to -90, "Azimuth" to 000>360, and "Cnst" to "---".

```
Elv(Bk) Azimuth Cnst
-90(00) 000>360 ---
```

Object direction menu

The object type in Object Type Menu should be set to "---" also, as in the following example.

```
 Mag  Size(') Type
-9>20 000>900 ---
```

Object type menu

[To delete an user menu object]

To delete an object from an user menu (User1, User2, Land, Comets, or Satellite menu), select Object Deletion Screen from the data editor in each menu and press ENTER key. (Please see Section 3.3.2 about the data editor for each menu.)

When you delete an object, that object will be removed from the list of objects in that menu, but data itself (except for the label) will remain in the memory. If you edit the data for that selection number, those data will be displayed again. If you want to completely erase the data, please refer to "Press 4 direction keys simultaneously while switching the power ON", in Section 3.1.5.

When you press ENTER to enter the reference stars menu, the first star in the reference stars menu which currently appear above the horizon.

```
MAIN: RefStar Menu
RefSt>4  Albireo
```

Reference star menu

Other stars that currently appear above the horizon can be displayed by pressing NEXT key. Scroll through the list to see if you can recognize the stars. If the name doesn't change when you press NEXT key, that is the last item in the menu that currently appears above the horizon. By pressing PREV key, you can scroll backwards through the list.

Press ENTER key to select a star and display its data.

```
MAIN Data: Vega
RaDec 18:36.8 +38°47
```

Data display for a reference star (Vega)

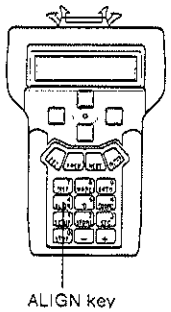
2.2.3 Automatic GOTO Function

Now that you have selected an object, let's point the telescope to it. Simply press GOTO key, and the telescope will start to slew toward the object. (If you want to stop the slewing, press STOP key located at the left bottom of the key pad.)

When the telescope stops slewing, look in the finder scope. For the very first pointing, the pointing error may be large and the object may not be in the finder's view, but you should see the Moon, planet, or a bright star that you have selected as the object. Using the direction keys to control the motors, position the object at the center of finder's view.

After placing the object at the center of finder's view, look through the main telescope, using a low power eyepiece. If the finder is adjusted, you will see the object in the main telescope's field of view. Now while looking through the main telescope, position the object at the center of the field of view.

When you look through the main telescope, the motors may move too fast to be able to control the telescope motion precisely. To make it easier to control, you can change the motor speed mode to a lower setting. The speed mode is initially


ALIGN key

set to Fast (variable 0-1200x speed). Pressing [-] (minus) key on the keypad once changes the speed mode to Medium (fixed 32x speed), and pressing [-] key once again changes the speed mode to Slow (fixed 2x speed). By pressing [+] (plus) key, you can change speed mode back from Slow to Medium to Fast.

(Also, if the backlash compensation is not adjusted, the telescope may appear to move in zigzags, especially at low speed mode. To adjust the backlash compensation, please see Section 5.6, "Setting the Backlash Compensation".)

When you position the object at the center of the field of view, press ALIGN key located at the numeric 4 key of the keypad to align the telescope. The ALIGN function will not be activated until the key is pressed for about 3 seconds, in order to prevent its unintentional operation. When you keep pressing ALIGN key for 3 seconds or longer, SkySensor will sound a double beep to confirm that the alignment function was activated.

2.2.4 Finding the Next Object

The procedure for pointing the telescope toward the next object is the same as for the first object, but the pointing accuracy will be much improved.

The display should be currently displaying data for the first object. Press ESC key to return to the object selection menu level. To select another object from the same menu, you can press NEXT or PREV key to display other objects in this menu. If you want to select an object from another menu, then press ESC key once more to return to the menu selection level.

After you select a new object, press GOTO key to slew the telescope to it. This time, the object should be in the finder's view, or very close to it. As before, first center the object in the finder's view, and then center it in the main telescope's field of view, and press ALIGN key until it double beeps. Every time you align the telescope with a new object, SkySensor

Note: You can increase the accuracy of the second alignment by selecting a second reference object which is far away from the first reference object. However, it is OK even to use the same reference objects repeatedly for the alignment, as SkySensor will automatically select a optimal combination of reference objects from the previous alignments for best accuracy.

☐ For observing satellites, the longitude and latitude of the observation site must be set very accurately. This is because the apparent position of a satellite in a low Earth orbit depends greatly on longitude/latitude.

☐ If you don't see the satellite in the finder, look in the direction the telescope is pointed without using the telescope for what looks like a star that seems to move slowly across the sky.

For more details, please see Section 5.8, "Observing Satellites".

[When the object is in sky, but not in the menu]

For example, you may see the Moon in the sky, but the Moon does not get displayed in Moon menu.

☐ Cause: The date/time or longitude/latitude settings in the setup is incorrect; OR, the position of the Moon is outside the region specified in "Object Direction Menu" in the setup.

☐ Solution: Check to see that the date, time, longitude, and latitude are set correctly in the Location and Time category of the setup. Check that the day of the week displayed on the first line of Date and Time Menu is correct.

If an object such as NGC object does not get displayed, you can enter its number directly into the menu and check the data display for its altitude and azimuth to see if it agrees with the apparent direction. If the object is not in the database, a message "No data" will be displayed.

[To enter coordinates directly]

You enter the coordinates directly by using COORD key. Please see Section 4.6, "COORD Key: Entering Coordinates", for details.

[Modes for taking celestial photography]

To take celestial photography with SkySensor, align the polar axis accurately using the polar axis scope and set the mount mode to Polar-Aligned Equatorial. Although SkySensor follows the motion of the star without aligning the polar axis, the field would rotate, causing the star images away from the center to become blurred. The use of PEC function and the optional Autoguider will help track stars accurately.

[To photograph a comet]

To photograph a comet, the use of a camera mounted on top of the telescope with a camera lens with focal length between 50 mm to 300 mm is recommended. Exposure time between about 5 minutes and 20 minutes with a high speed film will be needed. For celestial photography, the polar axis needs to be aligned accurately.

Since SkySensor can follow the individual motion of a comet from its orbital elements, it is well suited for photographing a fast moving comet.

[If you don't see the satellite]

When the satellite alarm goes off and you slew the telescope to it, you may not see a satellite where the telescope is pointed.

Because the satellites move very fast and their position can vary greatly with a small change in the orbital elements, initially use the direction the telescope is pointed as a rough pointer.

Please check the following points.

☐ The satellites are visible only for a short time after the sunset and for a short time before the sunrise. This is because the satellite must reflect the sunlight to be seen.

combines its coordinate with the previous object's coordinates enabling it to point the telescope more accurately.

As you align SkySensor with more reference points, it will quickly become accurate enough so that you will see the object in the main telescope view every time you press GOTO key, and you will be able to point the telescope to nebulas and other objects which are difficult to find in the finder scope.

2.2.5 When You are Done

When you are done with the observation, you can switch the SkySensor's power off at any time. The data that have entered will be kept in the memory for the next time.

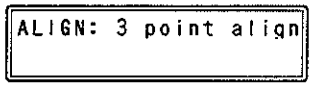
The next time you power on SkySensor, you can start with the steps in Section 2.2.1. However, if you have not moved the telescope or the mount, you can press ESC key when the message "Set scope in horiz. pos. and press ENTER" is displayed, and pick up where you left off the last time you turned the power off. This way, you can start off with an aligned telescope from the beginning.

2.3 Things You Should Know

2.3.1 About the Alignment

Initially, SkySensor behaves as though its right-ascension axis is aligned with the polar axis. That's how, by setting the equatorial mount with its right-ascension approximately northwards, you can execute a GOTO command before the first alignment. It is convenient, but not necessary to execute a GOTO command before you align using ALIGN key. You can set the mount at any direction and do the first alignment using the motor keys to manually center the object in the field of view.

The pointing accuracy increases as the number of the object that are used as reference points increase from two to three. SkySensor uses maximum of three points to do the alignment calculation. When you align on the fourth object, SkySensor takes the coordinate of the last object and combines with the coordinates of two previous reference points which are automatically selected to yields best pointing accuracy. When SkySensor completes the alignment, it displays for a few seconds the number of reference points it has used for the alignment. For example, if it has used three reference points, you will see the following display.



Display showing the number of reference points used for alignment

The pointing accuracy with one or two reference points depends on how the telescope was set up, but as a rough guide, one reference point will get the object somewhere in the finder's view, and two reference points will point the telescope so that the object is near the center of the finder's view. With three reference points for the alignment, the pointing accuracy will normally be good enough to locate any objects in the field of view of low to medium powered eyepiece regardless of small errors in the initial setup position or the parameters.

You will generally get better pointing accuracy if you use objects which are far apart as reference points. But you can use reference points which are close together, or even the same reference objects over again, as SkySensor automatically selects the best combination of reference points for the alignment.

[Initial position for a scope on the accessory plate]

When the telescope tube is mounted on an accessory plate, the tube is mounted 90 degrees from the normal position and it cannot be positioned as shown in the diagram in Section 2.1.3. In this case, the telescope tube should point West as shown in the diagram but the declination motor would be on the left side (toward the front of the telescope). The reason the declination motor position is specified is to prevent the motor housings from colliding.

[To setup the telescope before it gets dark]

You can setup and align the telescope before it is completely dark if you can see the Moon or a bright planet. It is also possible to use the land objects stored from the previous observation session as reference points. Or, if you have not moved the telescope or the mount since the last observation session, you can simply switch on the power and press ESC key to start observing without needing to realign.

[To use land objects for alignments]

You can use land objects as reference points for the alignment. You need to first align the telescope at that observation site using celestial objects and store the land objects in the Land menu with STORE key. Then the next time you do observation at that point, you can select the land objects from the menu, center it in the view and press ALIGN key to do the alignment, just as you would with celestial objects.

[To stop the tracking motion to look at land]

To stop the tracking motion, select Land menu from the main menu selection. Please see Section 2.3.6, "About Daytime Viewing and the Sun".

[To observe the Sun]

To observe the Sun, select Sun menu from the main menu selection. Please see Section 2.3.6, "About Daytime Viewing and the Sun", for details.

[To stop motors in an emergency]

To stop the motor in an emergency, turn the power switch OFF. You can later continue by pressing ESC key after turning the power back on. However, if the power switch is turned off while the motors are turning at high speed, the encoder reading may become slightly off and a realignment may become necessary.

[To reduce the motor noise]

When observing late at night, you may want to keep everything quiet. To lower the motor noise, set the maximum speed setting of the motor to a low speed. By setting the speed to about 500x, they will be considerably quiet. If you set them to about 300x, they will run very quietly. Please see "Motor Speed Menu" in Section 4.7.3 on how to set the motor speed.

[To make batteries last longer]

When using dry cell batteries for power, especially when it's cold, the batteries may not last long. Here are some tips on how to increase the battery life.

☐ Keep batteries warm:

Batteries wear out quickly when they are cold.

☐ Use high performance alkaline batteries:

Alkaline battery performance may vary by as much as a factor of 2 depending on the make.

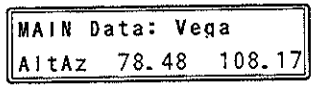
☐ Set the maximum motor speed to a low setting:

Motors uses less current at lower speed, increasing battery life.

Slewing the telescope increases the current drain several folds. Avoid unnecessary slewing. In very cold climate, the use of rechargeable 12 volt wet-cell battery is recommended. The use of cigarette lighter outlet of a car is not recommended because of possible power surges which may damage SkySensor.

The objects from Messier, NGC, and IC menus cannot be used for alignment because these objects are often extended over a wide area and using them may cause the alignment to become inaccurate. If you try to align on these objects, you will get a warning message.

After the first alignment, you should be able to point the telescope to most any stars accurately enough to be able to identify it in the finder, but for the first alignment, you may not be able to identify any star to use for the alignment. In this case, it is often helpful to display the AltAz (altitude and azimuth) data for that star to help you locate it.



Display showing AltAz data of a star

In the above example, the first number is the altitude of the object above the horizon (90 degrees is the zenith), and the second number is the azimuthal angle measured clockwise from North, so that North is 0 degree, East is 90 degrees, South is 180 degrees, and West is 270 degrees. Look in the direction indicated for a bright star. Most of the stars listed in the reference star menu are bright and can be found easily. You can check the brightness (magnitude) of the star in the data display by pressing NEXT key to scroll through the data.

2.3.2 About How the Motors Move

Motors may be moved manually using four direction keys when the motor indicator at the center is lit. When the indicator is not lit, the direction keys are used for controlling the cursor, so they cannot be used to control the motors.

When the direction keys are pressed, the motors turn so that the telescope move vertically/horizontally (AltAz control mode) , but it is possible to make them move along the right-ascension/declination axis (RaDec control mode) or individually (X-Y control mode).

AltAz control mode makes it easy to bring the object into the field of view of the finder scope, but for precise positioning of the object within the field of view, X-Y mode is better suited. (This is because in X-Y mode, the telescope does not move in zigzags, caused by backlash effects.)

2.3.3 About the Backlash

Backlash is a "slop" in the gears, causing time lags for the telescope to move in the opposite direction when the direction of the motor rotation is reversed. Some backlash is necessary for the motor to operate smoothly. SkySensor takes the backlash into account when it computes the telescope position and commands the motors to move. Since the amount of backlash can vary, the amount of compensation for backlash is set as adjustable parameters.

If the amount of backlash compensation differs by a large amount from the actual amount of backlash, the motor response may seem slow or the telescope may seem to jump suddenly when the direction keys are pressed. If this happens, please see Section 5.6, "Setting the Backlash Compensation".

2.3.4 When the Power Goes Out

If the power cable is accidentally disconnected, or when it is disconnected in order to change the batteries, you can reconnect the cable and keep on going by pressing ESC key when the message "Set scope in horiz. pos and press ENTER" is displayed.

When the battery voltage is low, the voltage may momentarily dip even lower when the motors are commanded to move at high rate, causing SkySensor's circuit to reset. (When reset, SkySensor will emit a beep and displays the message "Set scope in horiz. pos and press ENTER".) If this happens, simply press ESC key to continue the observation. When the battery voltage becomes very low, lowering the maximum motor speed setting to 300x or less will help prevent resets due to voltage fluctuations.

Please see "Motor Speed Menu" in Section 4.7.3 on how to set the maximum motor speed.

2.3.5 About Telescope Reversal

When the telescope is pointing close to meridian, if the balance weight shaft rotates above the horizontal level while the motor is being moved at high speed, then the motor will stop and the following message will be displayed to prevent the telescope from hitting the tripod.

When GOTO key is pressed, the telescope will move so that the telescope reversal will not be necessary.

Chapter 7 Operation Tips

Contents

- ☐ In the Encoder menu in the setup (please see Section 4.7.3), select External encoder.
- ☐ If the motors are not going to be used, set "Mtr" to Off. Setting this to off helps prevent encoder read error when the telescope is moved rapidly. In this mode, you do not need to connect the motor cables.
- ☐ It the motors are going to be used, then "Mtr" is set to On, but in this case, avoid turning the telescope faster than 200 encoder pulse counts per second (about 3000x speed for GP Encoder). If the telescope is turned faster, it may cause some encoder pulses to be missed. If the right ascension motor is to turn at the sidereal rate, set "Gde" setting in the Encoder menu to On also. (Setting "Mtr" to On by itself will not cause the motor to track at the sidereal rate. For tracking, the polar axis needs to be aligned.)
- ☐ When external encoders are used, you can point the telescope to an object by displaying the X-Y coordinates of the telescope on the status line and the X-Y coordinates of the object on the data line and move the telescope, either by hand or by using the motors, until the coordinates are matched.

X-Y	14.87	-2.06
X-Y	14.87	-2.05

X-Y coordinate of telescope
X-Y coordinate of the object

The above example shows how the coordinates are matched in the display to bring the object into the view.

Scope is now stopped
Press '0' to reverse

Telescope stop warning

By pressing the numeric 0 key, you can have the telescope reverse its position to the other side of the meridian and continue. If you would like to stop the motor while the telescope is in the reversal motion, press 0 key again.

For more details on telescope tube reversal, please see Section 5.4: "About Telescope Movement".

If the telescope crosses the meridian while tracking an object, the following warning message will be displayed every 30 seconds, but the tracking motion will not be stopped. This is so as not to interfere with the observation, but reverse the telescope at earliest convenient time to prevent the telescope from hitting the tripod.

Scope may hit tripod
Press '0' to reverse

Telescope reversal warning

2.3.6 Observing Land Objects

When you select any menu other than Land menu, the telescope will automatically start sidereal motion to follow the celestial movement. (When an object is selected from a menu, SkySensor will start tracking that object. For example, when the Moon is selected as the object, it will start tracking the motion of the Moon.) Therefore, you should select the Land menu for land observations in order to stop the tracking motion.

To enter the Land menu, select Land from the main menu selection and press ENTER key. If there are no objects registered in the Land menu, SkySensor will display 0 for the object number. Pressing ENTER key will stop the sidereal motion and you will be able to move the motor manually with direction keys. (The display will show a warning message that the selection number 0 is invalid, but this will not cause any harm.) If an object is registered, then you can select that as well.

When observing land objects during daytime, please read the warning message in the next section.

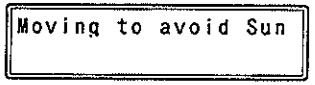
2.3.7 About Daytime Viewing and the Sun

Warning

For safety reasons, before using GOTO function during daytime, place caps on both the telescope and the finder scope and remove them only after making sure that the telescope is not pointing near the sun. Permanent eye damage may result if you look at the sun through a telescope or a finder scope.

The procedure for pointing the telescope to the Sun using GOTO function is the same as for the other objects, by selecting the Sun menu from the main menu selection. However, because the observation of sun is dangerous without using proper equipment and method, the Sun menu will not show up on the menu selection unless specified in the setup menu. Please see "Sun Observation Menu" in Section 4.7.4 on how to enable selection of the Sun menu.

During observation of objects other than the Sun, if SkySensor determines that the telescope is pointing too close to the Sun (closer than approximately 15 degrees), it will automatically move the telescope away from the Sun, and the following warning message will be displayed. (The warning beep will not sound for this.)



Sun avoidance warning

You can point the telescope toward to the Sun only when you have selected the Sun menu from the menu selection. This safety feature is effective only when the telescope is properly aligned, so it is not a fail-safe mechanism for preventing the telescope from pointing toward the Sun. Also, this automatic Sun avoidance function is not active before the initial alignment when SkySensor is switched on.

2.3.8 For Better Pointing Accuracy

Here are some tips to improve the pointing accuracy.

☐ Achieve 3 point alignments using stars.

The alignment become more precise when 3 points are

command that caused the error. The third number is the cumulative number of errors that has occurred (the error count). If you are sending a batch of commands from a file, you can check to see if there was an error by checking the error count at the end. The error count can be cleared by sending CLEAR command. When RES_CODE is set to 1, then only the numbers within [ ] will be returned.

6.2 CCD Autoguider

SkySensor may be used in conjunction with the optional CCD Autoguider AGA-1. When connected to AGA-1, SkySensor will receive signals from AGA-1 to guide the telescope.

☐ Setup and align the telescope and SkySensor. For the use with AGA-1, the polar axis of the mount needs to be aligned accurately. Set the backlash compensation on the SkySensor to 0. (Backlash compensation is done by AGA-1.)

☐ Connect SkySensor to AGA-1 using optionally available connector cable. In Autoguider Menu in the setup (please see Section 4.7.3), set Autoguider to ON . The speed setting in the Autoguider is initially set to 0.5x, but try different speeds and use the speed setting that gives the best result.

☐ Slew the telescope to the object by using GOTO key or by using the motor keys, then set AGA-1 on the guide star following the instruction manual for AGA-1 to start guiding.

6.3 External Encoder

SkySensor can be used with external encoder units such as the GP Encoder. When using the external encoders, SkySensor computes the telescope position using the signals from them, so it becomes possible to loosen the clamps and move the telescope by hand. However, the motor control becomes limited, and they can be used only like two-axis drive corrector units.

☐ Connect external encoders and SkySensor using optionally available connector cable.

Example 1 sets the orbital elements for selection number 1 in the Satellite menu and labels it "Mir".

Example 2:

```
satel 3: tle          #TLE data for satellite No. 3
STS-80
1 24660U 96065A  96326.21586775 .00000869 00000-0 35321-5 0  141
2 243660 28.4664 178.5099 0007823 282.1037 88.3192 15.72025106  215
```

Example 2 enter orbital elements in TLE format for selection number 3 in the Satellite menu. The first line of Example 2 contains two commands. "Satel 3" sets the selection in Satellite menu to 3. "tle" specifies that the next three lines are TLE format form of the orbital elements. In the data for TLE command, lines beginning with "#" and blank lines are skipped.

If RES_CODE is set to 0 (the default value), the following response may be returned.

Response	Description
[0/1:0] done: 'command'	'command' was executed normally.
[1/1:1] Unknown command: 'command'	'command' is not recognized.
[2/1:1] Invalid satellite number: m	m is not a valid satellite selection number.
[3/1:1] Invalid comet number: m	m is not a valid comet selection number.
[4/1:1] Object type not yet specified	SATEL or COMET command must be sent first.
[5/1:1] PERIH is for comets only	PERIH command was sent without COMET command.
[6/1:1] MANOM is for satellites only	MANOM command was sent without SATEL command.
[7/1:1] REVDAY is for satellites only	REVDAY command was sent without SATEL command.
[8/1:1] DRAG is for satellites only	DRAG command was sent without SATEL command.
[9/1:1] Invalid TLE format line 1: 'line'	The first TLE data line was invalid.
[10/1:1] Invalid TLE format line 2: 'line'	The second TLE data line was invalid.
[11/1:1] Invalid drag value: 'n'	n is outside of valid range for drag.
[12/1:1] Invalid eccentricity value: 'n'	n is outside of valid range for eccentricity.
[13/1:1] Invalid rev/day value: 'n'	n is outside of valid range for revolution per day.

The first number inside [ ] is the error code and the second number is the number of commands that was processed in that line. If there was an error, it indicates the position of the

used for the alignment calculation. The use of stars as reference points avoids possible error due to inaccuracy of the coordinates of the observation site which affects the position calculation of the Moon and the planets. (The stars in SAO menu have the same accuracy as the reference stars.) 3 point alignment is easier to achieve if you select objects which are far apart. (If the reference points are not suited for the 3 point alignment calculation, then 2 point alignment procedure will automatically be used.)

☐ Set the backlash compensation accurately

The accuracy of backlash compensation directly affects the position accuracy of the alignment objects. Please see Section 5.6, "Setting the Backlash Compensation", on how to adjust the backlash parameters.

☐ Center the objects as accurately as possible, using a high powered eyepiece.

The use of reticle eyepiece or accessory such as Guide Adapter GA4 will make it easier to position the objects precisely.

2.3.9 About some Terms

The following glossary is used in SkySensor.

RaDec — This is an abbreviation for right-ascension/declination, a coordinate system used for celestial objects.

J2000 — J2000 is also a right-ascension/declination coordinate system, but it uses the vernal equinox of Epoch 2000 as the reference point. It is often referred to as Epoch 2000 coordinates. Star charts often uses J2000 coordinates. J2000 coordinates differ slightly from RaDec coordinates. J stands for Julian.

AltAz — This is an abbreviation for Altitude/Azimuth coordinate system. Altitude is 0 degree for the horizon and 90 degrees for zenith. Azimuth is 0 degree for North and is measured East-wise.

X-Y — This is the motor coordinate system. X is the coordinate of the declination motor and Y is the coordinate of the right-ascension motor. X for the initial tele-

scope position is -90 degrees, and it increases as you rotate the telescope toward the pole, reaching 0 degree when the tube is parallel to the right-ascension axis. Y for the initial telescope position is 0 degree and it increases as you rotate the telescope clockwise as you look from behind (the side you look into the polar axis scope) the equatorial mount.

The direction the telescope moves in X-Y mode is such that if you position the right-ascension axis vertically (as for the alt-azimuth mount mode), the telescope will move toward right if you press the Right-direction key and moves up if you press the Up-direction key.

There are three motor control modes, designated RaDec, AltAz, and X-Y modes. In each mode, the telescope moves along the designated coordinate axes when direction keys are pressed. Please see "Motor Control Modes" in Section 3.1.1 for details.

2.4 Useful Things to Know

2.4.1 Selection Criteria for Objects

In SkySensor object menus, you can scroll through a list of objects which appear above horizon by pressing NEXT/PREV keys. You can specify the criteria such as the altitude, direction, brightness, size, and type for those objects, and list only those object which match your observation purpose and the terrain. You can also list objects in a specific constellation. Please see "Object Direction Selection Menu" and "Object Type Selection Menu" in Section 4.7.4 for details.

2.4.2 User Menus

SkySensor has three menus that the user can register objects by their coordinates: User1, User2, and Land. Each menu holds 30 objects.

User1 and User2 are for celestial objects. You can store celestial coordinates (RaDec or J2000) in these menus. You can

The following commands can be used with SkySensor.

SATEL n	Set satellite selection number to n
COMET n	Set comet selection number to n
EPOCH n	Set epoch time (for satellite) or time of passage in perihelion (for comet) to n
PERIH n	Set perihelion distance to n (for comet)
ECCEN n	Set eccentricity to n (for comet/satellite)
ANODE n	Set ascending node to n (for comet/satellite)
APERG n	Set argument of perigee/perihelion to n (for comet/satellite)
INCLI n	Set inclination to n (for comet/satellite)
MANOM n	Set mean anomaly to n (for satellite)
REVDAY n	Set revolution per day to n (for satellite)
DRAG n	Set drag to n (for satellite)
LABEL s	Set name label to s (for comet/satellite) (s is a character string)
TLE	Next three lines are TLE formats (for satellite)
DELETE	Delete the object (for comet/satellite)
VERIFY	List the orbital elements (for comet/satellite)
RES_CODE n	This command specify the command response n= 0 : Return response code and description n= 1 : Return response code only n= 2 : Do not return response code
CLEAR	Set error count to 0

Before sending commands to enter the orbital elements, you must specify the selection number by sending either SATEL (for satellites) or COMET (for comets)

commands. All orbital elements you enter will be assigned to the selection number you last specified.

Example 1:

Satel	1	#Elements for satellite No. 1
label	Mir	#Name of the satellite
epoch	96319.1935422	#Orbital elements
incli	107.997	
anode	125.125	
eccen	0.000241	
aperg	236.845	
manom	123.246	
revday	14.3813252	
drag	-6.e-7	

Chapter 6 Option Connections

6.1 Entering Orbital Elements from a PC

You can connect SkySensor to a PC and enter orbit^ elements for satellites and comets. A RS232C cable with a Mini-DIN 8 pin connector is used for the connection. (Please see Appendix B, "Specification", about the cable).

The communication parameters on the PC should be set as follows:

Data Bits = 8
Stop Bits = 1
Baud Rate = 300
Flow Control = Xon/Xoff

Most common communication terminal software can be used and are usually most convenient to use. After connecting with SkySensor, press Return key on the PC. You will see "ready" if the connection is working correctly.

The commands may be edited on a file with a text editor and then sent by the terminal software using "Send File" function. The upper and lower case will not be distinguished unless it is a part of the name for the LABEL command. Spaces and tabs can be inserted freely before, after, or between commands. Numbers can be entered as whole numbers, decimal points, or in scientific notation like -1.02e-5. "#" character marks the rest of the line as comments. You can cancel a command before hitting Return key by pressing Delete key.

Multiple commands can be entered on a single line by separating them with semicolons (;). One line is limited to 80 characters. SkySensor will process one line at a time and return a response code.

enter the coordinates directly into the menu, or copy it from other menus using STORE command. Please see "User1 Menu" and "User2 Menu" in Section 3.3.2 on how to store or delete objects in these menus.

Land menu is for land objects. You can store alt-azimuth coordinates in this menu. Please see "Land Menu" in Section 3.3.2 on how to store or delete objects in Land menu.

2.4.3 To Locate Objects Not on the Menu

You can locate an object which is not on the menu by entering its coordinates directly. You can also store its coordinates in the User menu and slew to it using GOTO function at anytime. Please see Section 4.6, "COORD: Entering Coordinates", for details on how to enter coordinates directly.

2.4.4 Observing Satellites and Comets

You can automatically slew to and track artificial satellites and comets by entering their orbital elements in Artificial Satellite menu and Comet menu. Please see "Comet menu" in Section 3.3.2 for the use of Comet menu and Section 5.8, "Observation of Artificial Satellites", for more details on how to observe artificial satellites.

2.4.5 ID Function

You can search for nearby celestial objects or find out the identity of an object you see in the sky by using the ID function to search through SkySensor database of celestial objects. Please see Section 4.5, "ID key: Object Identification", for details.

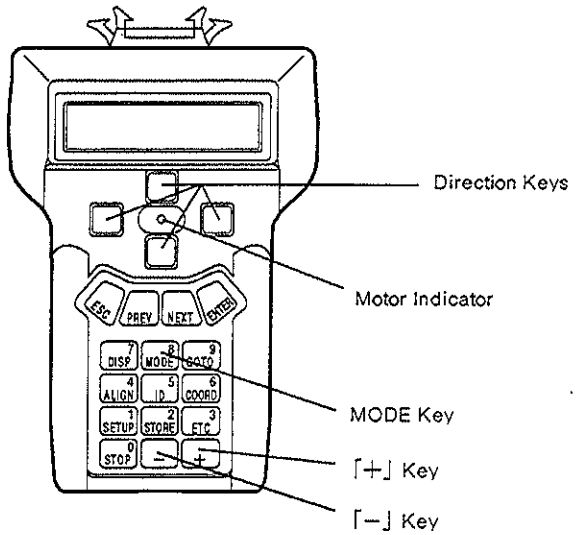
Chapter 3 Basic Functions

SkySensor's basic functions are explained in detail in this chapter.

3.1 Keys

The keys on SkySensor can be grouped by their function into 4 direction keys for controlling the motors; 4 green menu keys for selecting menus; and 12 command keys. The direction keys and command keys also functions as cursor control keys and numeric entry keys for data entries.

3.1.1 Motor Control Keys



When the motor indicator lamp is lit, the direction keys func-

observation site, the speed, longitude and latitude, and altitude can be displayed in the data display.

- ☐ The apparent position of satellites is affected greatly by a slight change in the orbital elements. If you cannot find the satellite right away, watch the sky in the general direction the telescope is pointing and look for a moving star. The brightness of a satellite in a low Earth orbit appear usually around magnitude 3 or 4, but a large satellite may sometimes appear brighter than magnitude 0. Some satellites may shine on and off at regular intervals instead of shining steadily. If you use the latest orbital elements and set all parameters accurately, the accuracy of SkySensor orbit prediction is such that you should be able to easily locate the satellite in a finder scope. Once you locate the satellite in the finder scope, it is possible to guide it into the field of view of the main telescope.

- ☐ If the telescope reversal warning appears while tracking a satellite, you can press 0 to reverse the telescope as usual. However, the tracking motion will stop when the telescope is reversed, so you should press GOTO key to start tracking again. If you are looking for a particular satellite, you can predict the time the satellite will appear (you can set the time in the setup to just after sunset and check the longitude and latitude of the satellite to predict if the satellite would appear that day, then check the altitude to see the actual time it will appear above the horizon) and the direction it will appear. You can avoid the telescope reversal during tracking by setting the direction of the polar axis approximately parallel to the path of the satellite.

Satellite menu" in Section 3.3.2. The orbital elements may be entered from a PC through the RS232C connector. Please see Section 6.1, "Entering Orbital Elements from a PC", for details. Often, the orbital elements come in TLE (Two Line Elements) format. You can extract the orbital elements out of TLE format (you will need to read the explanation of the TLE format), but you can enter the TLE's directly into SkySensor from a PC. This is a very fast and easy way to enter the orbital elements. The details for entering TLE format are in Section 6.1.

☐ Setup and align the telescope using SkySensor. The apparent position of satellites in a low Earth orbit ' greatly affected by the location and time. Please set the longitude and latitude of the observation site and the clock as accurately as possible. (A clock error of more than 5 seconds is likely to put the satellite out of finder's view, even with everything else being exact.)

☐ Satellites are visible only when they reflect the Sun's light, which limits the time they can be seen to just after the sunset and a short time before the sunrise. They cannot be seen when they are in Earth's shadow. For a satellite in low Earth orbit (altitude of about 500 Km), they can be seen up to about an hour and a half directly overhead and up to about three hours after sunset near the western horizon.

☐ If you set the satellite alarm, a beep and a message showing the name of the satellite will be displayed when a satellite comes into view or when it rises above the horizon, depending on the alarm setting. (Please see "Satellite Alarm Menu" in Section 4.7.4 for explanation of the satellite alarm.)

When the satellite alarm goes off, select the Satellite menu from the main menu selection. By pressing NEXT or PREV key, you can list the satellites which are currently in view. (If the satellite alarm was set to go off when the satellite rises above the horizon, the satellite will not be listed if it's not in view yet, but you can still list it by entering the selection number.)

☐ Press ENTER key to select the satellite. You can slew to it and start tracking by pressing GOTO key. You can see the data for the satellite, including its distance from the

tions as motor keys to move the motors manually .

The direction the telescope moves when motor keys are pressed (control mode), and the speed (speed mode), can be changed.

☐ Motor Control Mode

The direction the telescope moves when direction keys are pressed is controlled by the control mode. There are 3 control modes: AltAz mode, X-Y mode, and RaDec mode.

In AltAz mode, the telescope moves horizontally or vertically when direction keys are pressed. This mode is useful for guiding an object into the finder's field of view and for land observations.

In X-Y mode, the direction keys control the motors individually. This mode is suited for the fine control of the telescope, as it avoids telescope moving in zigzags due to combined effect of backlashes. Also, X-Y mode is the only mode that can move the telescope manually across the meridian. (You can also move the telescope across the meridian by entering the coordinate of a point on the other side of meridian and using GOTO function.)

In RaDec mode, the telescope moves along the right-ascension/declination axis, even if the polar axis is not aligned. If the polar axis is aligned, then X-Y mode and RaDec mode are nearly the same, except that in RaDec mode the telescope always moves toward the north pole and stops there when Up key is pressed while the telescope will move over and across the North pole in X-Y mode.

When MODE key is pressed, the current control mode and the speed mode (described in the next section) is displayed for about five seconds.

Motor control and speed mode display

To change the control mode, press MODE key again while the current mode is still displayed. The mode will change recursively from AltAz to X-Y to RaDec.

☐ Motor Speed Mode

The speed at which the motor turns when the direction keys are pressed is controlled by the speed mode. There are three speed modes: Fast, Medium, and Slow.

The speed mode is changed by pressing [+] (plus) and [-] (minus) keys. When [+] key is pressed, the speed mode changes from Slow to Medium to Fast. When [-] key is pressed, the speed mode changes from Fast to Medium to Slow.

When [+] or [-] keys are pressed, the mode display similar to the one displayed when MODE key is pressed will be displayed for two seconds so that you can confirm the new speed mode. If you would like to see the current speed mode without changing the speed mode, use MODE key to see the display.

The actual speed for Fast, Medium, and Slow speed mode can be set in the setup menu. (Please see "Motor Speed Menu" in Section 4.7.3 on how to set the speed.) The speeds are defined as multiples of the sidereal tracking rate. The Low speed can set from 0.1x to 9.9x, and the Medium speed can be set from 1x to 99x.

The High speed is variable. As you press the direction key, speed gradually increases and when you release it, the speed gradually decreases. If you press the key while the motor is slowing, the motor holds that speed while the key is pressed. The upper and the lower limits of the High speed mode, and the rate at which the motor accelerates and decelerate can be set in the "Motor Speed Menu". If you set the upper and the lower limit to the same speed, it effectively becomes a fixed speed mode.

When the motor is decelerating in High speed mode, you can stop it immediately by pressing on the opposite direction key. If you keep pressing on the opposite direction key, the motor will start to move in the opposite direction after a few seconds. If you want to move the motor immediately in the opposite direction, release the opposite direction key momentarily and press it again.

When you execute a GOTO command, the motor moves at the upper speed limit set for the High speed mode. If you want to observe quietly, you can lower the motor sound by setting a low upper speed limit.

a polar axis scope. But if Polaris is not visible, you can still align the polar axis by switching the mount mode of SkySensor.

To align the polar axis, first place the equatorial mount so that its polar axis points approximately toward north. Set the mount mode to Unaligned Equatorial and align the telescope until a 3 point alignment is achieved and the objects can be slewed to with GOTO function accurately. Now select a star (avoid using a star near the zenith) and use the GOTO function to point the telescope to it. Center the star in the view and do an alignment on that star so that the star centered when GOTO function is executed.

In the setup, set the mount mode to Polar-Aligned Equatorial. Then while looking through the finder, press GOTO key, and you will see that the star will shift its position. Follow the movement so that you know where it is. Using only the azimuth and the elevation adjustment screws, center the star again in the field of view of the telescope. The polar axis should now be aligned.

If the star cannot be centered within the adjustment range of the screws, then you need to move the tripod to center the star, but the polar alignment may not be very accurate when this happens; repeat the above procedure in this case.

You will be able to achieve a fairly accurate polar alignment with this method if you make sure that the 3 point alignment is accurate enough to be able to accurately point to stars in different parts of the sky.

5.8 Observing Satellites

With SkySensor, you can automatically slew to and track artificial satellites.

☐ To tracking a satellite, you need to have its orbital elements. The orbital elements for the satellites are available in selected magazines and from many Internet web sites related to satellites. The orbital elements for satellites changes frequently, so be sure to use the latest available elements. There are 8 orbital elements for each satellite.

☐ Enter the orbital elements into SkySensor. To enter the elements using SkySensor keypad, please see "Artificial

The direction the telescope moves when you press motor key can be reversed by setting the directions in the "Motor Key Direction Menu" in the setup.

5.6 Setting the Backlash Compensation

Setting the backlash compensation accurately will make the motor control operate smoother and improve the pointing accuracy of GOTO function.

To check the backlash compensation, use land objects. First, stop the sidereal tracking motion of the telescope by selecting Land menu from the main menu selection and select any object. (If no objects are registered in the Land menu, a 0 will be displayed and when you press ENTER key, a warning message "Invalid Data Number" will be displayed, but you can ignore it for this purpose.)

If you are adjusting the backlash compensation at night, you can use Polaris as the object. Polaris is the first object in SAO menu.

Next, select a land object and center it in the field of view of the telescope using a medium to high powered eyepiece. Set the motor control mode to X-Y mode and set the speed mode to Low. (Please refer to Section 3.1.1 on how to set the control mode and the speed mode.) Press Right key and check that the object moves in the field of view. Then press on the Left key. If there is a lag between the time the motor starts to move and when you press Left key, the backlash compensation for the right-ascension motor is too small. If the motor moves suddenly in a big step when you press the Left key, then the backlash compensation is too large.

To adjust the backlash compensation, press SETUP key and from the Telescope Configuration category, select Backlash menu and enter the value for RA.

Repeat the above procedures and adjust the backlash compensation until the motor moves smoothly.

The procedure for adjusting the backlash compensation for Up/Down keys is the same. To adjust the compensation for Up/Down keys, change the DEC value in the Backlash menu.

5.7 Aligning Polar Axis without Polar Star

The polar axis can be aligned quickly and accurately by using

By setting the function of ETC key to guide speed function, you can use ETC key to set the speed mode to Guide sped mode. (Please see Section 4.9, "ETC key: Multi-function Key", about details on ETC key.) Guide speed is set initially to 0.5x, but you can set it from 0.1x to 9.9x in the setup menu, so you can use it like a second Low speed mode.

When ETC key is used as Guide speed key, the speed mode is set to Guide anytime you press ETC key. If you press [+] or [-] key while in Guide speed mode, the speed mode changes as though ETC key was not pressed. For example, if you press ETC key to set speed mode to Guide while the speed mode is Medium, then pressing [+] next would set the speed mode to High, while pressing [-] next would set it to Low.

3.1.2 Menu Keys

Four menu keys are used for controlling menu selection.

ESC (escape) key is used to return to the previous menu.

PREV (previous) key is used to display the previous menu item.

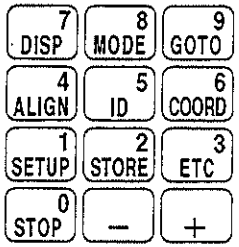
NEXT key is used to display the next menu item.

ENTER key is used to enter or select the current selection.

If you press ESC key before selecting a menu item by pressing ENTER key, the selection will not be made before returning to the previous menu level.

When the cursor at the selection item is a steady underscore, it shows that the item may either be selected by pressing ENTER key or the next or the previous item may be displayed by using NEXT/PREV keys. When the cursor is a blinking block, it shows that the value of the item may be changed by using the data entry keys. When no cursor is present, it shows that data is being displayed and ENTER key is not operational, but NEXT or PREV key may be used to display next or previous data.

3.1.3 Command Keys



Command keys are used to execute various functions of SkySensor. (The numeric pad numbers on the command keys are not related to the command key functions.)

Please see Chapter 4 for detailed description of command keys.

3.1.4 Data Entry

When the cursor is a blinking block, it shows that the selection item may be modified by using data entry keys. There are three types of data entry.

☐ **Item Selection Entry**

Item selection is for selecting non-numeric entries, such as selecting from items A, B, or C. You can select items by using Up or Down keys to scroll the items list. If there are more than one selection entry in the menu, use Right or Left keys to move the cursor.

☐ **Numeric Entry**

Numeric entry can be made by using the direction keys or the numeric key pad.

Up and Down keys can be used to raise the lower the value of the number at the cursor position. Usually, Up direction key can be used to raise the number up to 9 and the Down direction key can be used to lower the number down to 0, but if the valid range for the number is limited, you won't be able to change the number to outside the valid range. There are some numbers, such as the tens digit of the year entry, which you

the motor will stop completely.

When the telescope reversal warning (including when the motors are stopped) is issued, you can cancel the warning and move the telescope freely if you press ESC key for more than three seconds. Once the telescope moves back into the normal operating region, the warning will be enabled again.

When the mount is in Alt-Azimuth mode, there is no telescope reversal. When the GOTO function is executed, if the azimuth angle between the telescope position and the object is less than 90 degrees, then the telescope will move by the short way. But if the azimuth angle to be moved is 90 degrees or greater, than the telescope will move so that the telescope is positioned within ± 180 degree from the initial telescope position. This is to help avoid cord wraps.

5.5 About the Motor Control

The method of motor control is described in "Motor Control Key" in Chapter 3. The motor speed is represented as number of times the sidereal tracking rate speed (approximately 15 arc second per second).

For the equatorial mount, the apparent motion in right ascension of the telescope is slow near the pole. To compensate for this, the actual speed near the pole is increased up to 10 times the nominal speed for the right ascension motor in RaDec control mode. This also applies for the azimuth motor in AltAz control mode and the Y-axis motor in X-Y control mode.

AltAz control mode is convenient for guiding the object into the finder's view. But once aligned, the object is usually already inside the finder view when slewed by using GOTO key, and setting the control mode to X-Y mode will make it easier to control the telescope movement as it is affected less by the backlash.

After the alignment, setting motor speed mode to Medium or Low speed mode will make it easier to center the object in the telescope's field of view. You will be able to make fine adjustments if you make series of short clicks on the motor keys. Adjusting the backlash compensation is important for a good motor control.

You can also set the time and location on a setup to use it as an astronomical almanac, to check the data on the Moon and planets on certain date and location.

5.4 About Telescope Movement and Limits

When you press GOTO key to slew to an object, SkySensor will automatically start tracking that object. For example, when you slew to a planet with GOTO key, SkySensor continuously computes the position of the planet to track its movement. This is the same for the Moon, the Sun, comets, and artificial satellites. The motor does not turn at a predetermined rate, but instead follows the movement of the object as its apparent position is computed more than twenty times a second, including the effects such as the atmospheric refraction. (If the telescope is moved by using the motor key, the amount of the movement is added to the tracking movement.) The tracking continues until another object is selected from the menu, or until you get out of that menu by pressing ESC key.

When you first turn on the power switch and press ENTER key, SkySensor is set to track at the sidereal rate. Therefore, if you want to observe land objects, you need to select Land menu to stop the sidereal tracking motion.

For artificial satellites only, the tracking motion will stop when STOP key is pressed or when ESC key is pressed and the menu return to the object selection screen. This is to avoid possible accidents because of the fast tracking motion for the satellites.

When the mount mode in Equatorial mode, if the balance weight shaft rotates so that it is near the level position, a warning message will be displayed that the telescope may hit the tripod. (If the motor is moving at speeds greater or equal to 100x speed, or when it is tracking an artificial satellite, the motors will stop.) The exact angle at which the warning is issued is tilted slightly toward the side opposite of the motor housing, and there is a five degree overlap region between both sides to avoid excessive reversals.

When the telescope reversal warning is issued, the tracking motion continues and you will be able to move the motors at low speed (99x or less), but if the motors are moved at high speed, a warning that the telescope is stopped is issued and

can scroll 9 ⇄ 0 ⇄ 1. To shift the cursor position, use Right and Left keys.

The numbers may also be entered by using the numeric key pad. When a number is entered by pressing a numeric key, the cursor will shift to the next position. If the number pressed is outside the valid range, a number inside the valid range will be entered instead.

To enter a negative value, press [-] key while the cursor is on the number you want to make negative. To change to sign to positive, similarly press [+] key. For example, to change "+135° 00'00" to "-135°00'00", press [-] key when the cursor is positioned on the first 1, the last 0, or somewhere in-between.

☐ Character Entry for Labels

You can enter alphabets and numeric characters as labels for user defined menu items and Setup names.

To enter alphabets and numeric characters, use Up and Down direction keys to scroll the characters at the cursor position. Right and Left direction keys are used to shift the cursor position. The character will scroll in the following order.

「 ABCDEFGHIJKLMNOPQRSTUVWXYZ+-0123456789. ' '=◇ →← ↑ ↓ #&:□()@*」

When the alphabet list is scrolled from A, the characters will be in upper case. When the alphabets are scrolled from z, the characters will be lower case.

The numeric pad keys can be used to enter numeric characters. Pressing [+] key will change the alphabet at the cursor position from lower to upper case, and [-] key will change it from upper to lower case.

3.1.5 Special Use of Keys

Keys are sometimes used in special ways.

☐ "Press 4 direction keys simultaneously while switching the power ON" will initialize the memory. The message "Memory Cleared" will be display when this happens. This procedure will clear all memory, including the user defined menu items and setup menu settings, so use it with caution. You will need to set the date, time, and the site coordinates over again.

☐ "Pressing ENTER key for more than three seconds while the user defined menu item is being displayed" will let you enter the data entry mode to edit that item. This applies to all user menus, including Satellite and Comet menus.

☐ "Pressing ESC key for more than three seconds when the motor stop warning or scope reversal warning is displayed" will cancel the warning and you will be able to move the telescope freely in the restricted zone. Once the warning is cancelled, the warning system will not be reactivated until the next time the telescope returns to the normal operating zone, so use this feature with caution. Even when the warning is cancelled, you can still reverse the telescope by pressing 0 key.

☐ "Pressing + or - key at the item selection of NGC, IC, SAO, or ID menu" will change the description format of that item. The display formats are different for each menu. Please see the description of each menu for details.

☐ The closest star (#01) will be displayed first, so press ENTER key to select it.

```
ID: Objects
#01/02: Sulafat
```

The result of the search (Sulafat is the closest star)

☐ Press GOTO key to slew to the star.

```
ID Data: Sulafat
Dist=1°10' Az=-45°
```

Data display for the nearby star

☐ Using a low powered eyepiece, find the star and center it in the field of view. The star is bright, so it should be easy to identify.

☐ Change the eyepiece to a high powered eyepiece and center the star in the center of view. Press ALIGN key to do an alignment.

☐ Press ESC key twice to return to the data display for M57. Press GOTO key to slew to M57. M57 should be at the center of the field.

5.3 About the Setups

There are 10 setups, numbered from #0 to #9. The parameters in setup #0 are specially designated as default values and are also used by setup #1 to #9 whose parameters are specified to use the default values. By setting the parameters in setup #0 to the most commonly used values and using setup #1 to #9 to set values specific to an observation situation, you can utilize the setups efficiently.

For example, you can set motor speeds to different values in several setups and designate them to be used for guided photography or the quiet mode. If you use several sites for observations, you can set the site coordinates and the object direction parameters to match each site. Or if you use a SkySensor with more than one mount, you can set the mount mode and backlash parameters for each mount.

the alignment accuracy, so set this as accurately as possible also.

Terrestrial objects can be used as reference points for the alignment. The use of terrestrial objects for alignment is convenient for the solar observation and setting the alignment before it's dark. To use the terrestrial objects, you can either have the coordinate stored in the Land menu in the previous observation session or record their coordinates and enter it using COORD function.

5.2 When a Precise Pointing is Required

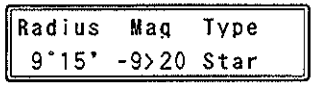
If an especially precise pointing is required, you can increase the pointing accuracy near the area where the telescope is pointed by using a nearby star for an alignment.

The procedure is to first use GOTO function to slew to the object and use ID function to search for a nearby star. To do the search, set the ID search parameter to at least 9 degree search radius and set the object type to Star. In the search result, the closest star will be displayed first, so select it and use GOTO key to slew to it. The object star is a relatively bright (the stars in the database are brighter than magnitude 4.0), so you should be able to locate it easily. Center the star in the field of view and by use ALIGN key to do the alignment. (Note: when Star is selected as the object type for the search, double stars and variable stars will not be listed in the search result.)

Example: To point accurately to M57

☐ Select M57 from Messier menu and press GOTO key to slew to it.

☐ Press ID key to search for a nearby star. Set the search parameter as in the following example and press ENTER key.



Set ID search parameter

3.2 Display

3.2.1 LCD Display

The first line of LCD display normally displays the status of the telescope, and the second line shows the information on the object selection and data.

You can select what status to display on the first line, such as the coordinate the telescope is pointed, the time, the timer, or the guide display. For details on how to make the status display selection, please see Section 4.1, "DISP Key: Status Display Selection".

The second line of LCD normally displays the object menu selection or object data. The object and data selections are made using the menu keys. GOTO function, ALIGN function, and STORE functions all act on the current object selected and displayed on the second line of the display. To choose the object on the second line, you can either select it from the main menu, select it from ID menu, or enter its coordinate directly using COORD command. Please see Section 3.3 on the main menu and data selection.

3.2.2 Lights

SkySensor lighting includes backlight for LCD display, keypad lighting, motor indicator light, and map lamp. The intensity of these lights can be adjusted in the setup menu. (Please see "Light and Sound Menu" in Section 4.7.5.) The light intensity cannot be adjusted individually.

3.2.3 Sound

The beep that sounds when keys are pressed can be set separately for the direction keys and keypad keys. (Please see "Light and Sound Menu" in Section 4.7.5 on how to set it.) When keypad beeps are set to sound, direction keys will not beep when used to control the motors, but will beep when used as cursor control keys.

The beep that sounds for warnings and alarms cannot be turned off.

3.3 Main Menu

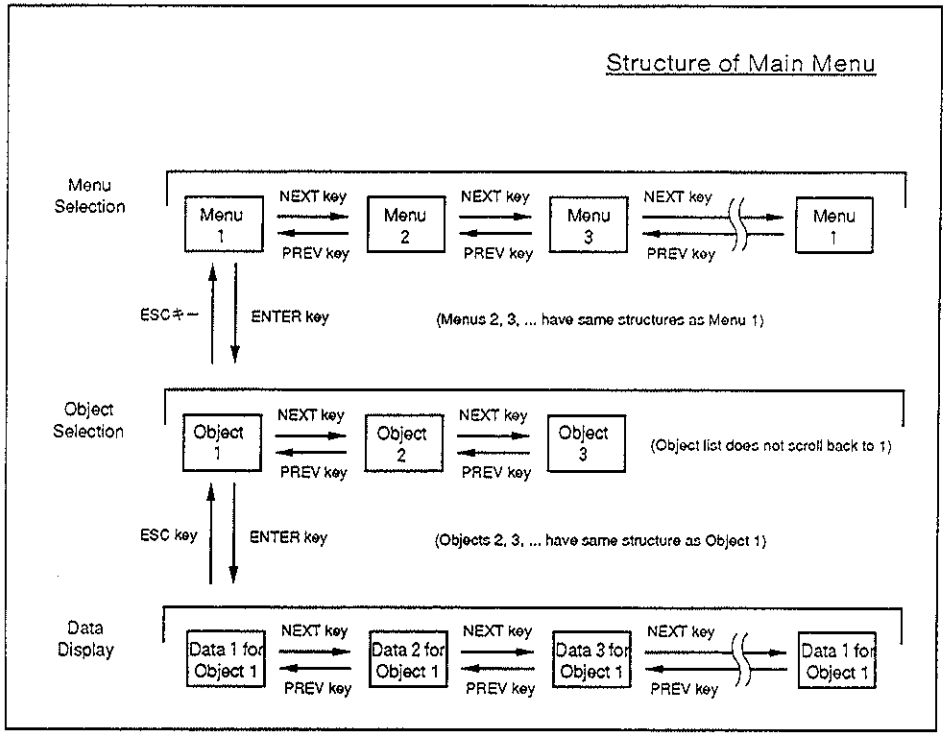
SkySensor's main menu consists of eight menus with pre-defined objects and five menus with user defined objects.

3.3.1 Menu Selection

The top level of the main menu is the object menu selection. The object menu list can be scrolled by using NEXT/PREV keys. To select an object menu, press ENTER key.

3.3.2 Object Menus

In the object menus, object selections are made. To make the object selection, you can either use NEXT/PREV keys to scroll the list of objects or by entering the object number directly. When NEXT/PREV keys are pressed, only those objects which



If, after a 2 point or a 3 point alignment, the alignment goes back to a 1 point alignment, it may be caused by a wrongly identified reference point. When this happens, the subsequent pointing error will be often very large, and it is often better to start over from the initial alignment. Also, there are more than one solution to the 2 point alignment calculation, and although the algorithm selects the one which it judges to be the best solution, occasionally a wrong solution may be selected. You can check the computed value of the polar axis direction in "Polar Axis Direction" in the setup. If the displayed coordinate of the telescope or the objects is clearly in error, or if the telescope points in clearly wrong direction, turn the power switch OFF and start over from the initial alignment.

In "Alignment Parameter" menu in the setup, the mechanical alignment compensation factors computed in the 3 point alignment are displayed (the last two of the four numbers). These factors does not vary much unless the telescope tube is remounted or the eyepiece adapter is exchanged (a diagonal prism is attached, for example), so you can enter the values known from the previous observations directly. If the AltAz mount mode is used or if only a part of the sky is visible, then a 3 point alignment may be difficult to achieve because of the limited motion of the telescope and entering the numbers directly may be convenient.

Objects which are closer then about 5 degrees from the polar axis may cause a large error in the alignment calculation and cannot be used for alignments. If you try to align with them, a warning message will be displayed.

There is no difference in the alignment algorithm between the mount mode in Unaligned Equatorial and Alt-Azimuth modes. In Polar-Aligned Equatorial mode, its 1 point alignment differ from the others in that the polar axis is assumed to be aligned, and instead of computing the direction polar axis, the initial position error of the telescope tube and the weight shaft are computed. The 2 point and 3 point alignments for Polar-Aligned Equatorial mode are the same as others; the direction of the polar axis is also recomputed.

To increase the pointing accuracy, the centering of the object in the field of view of the telescope should be done as accurately as possible. For accurate centering, the use of a cross-haired reticle or a guide-adapter such as GA-4 is recommended. The error in backlash compensation will also affect

used over again), 1 point alignment will be repeated using the second reference point. If the 2 point alignment was successful, then the error in the initial position of the telescope tube and the weight shaft will be computed.

In the third alignment (when the previous alignment was a 2 point alignment), a 3 point alignment will be attempted. If the third reference point is not suitable for a 3 point alignment, then a 2 point alignment using the second and the third reference points will be attempted. If that's not successful, then a 2 point alignment using the first and the third reference point will be attempted. If that fails, a warning will be issued and no alignment will be done. If the 3 point alignment was successful, then the mechanical alignment error of the mount and the telescope tube alignment error will be computed and compensated.

In the fourth and the successive alignments (when the previous alignment was a 3 point alignment), a 3 point alignment using reference points 2,3,4 will be attempted. If this cannot be done, then a 3 point alignment using reference points 1,3,4, then 1,2,4, will be attempted. If they all fail, then 2 point alignments using reference points 2,4, then 1,4, will be tried.

In all cases, the new reference points will be tried first, and the last reference point will always be used. Thus even if the alignment is repeated using the same point or a point nearby, most appropriate points are used for an accurate alignment calculation. You can see which objects were used as the reference points in "Alignment Parameters" menu in the setup.

With a 3 point alignment, the pointing accuracy will be much improved over the 2 point alignment. You are more like to get a 3 point alignment if you select as reference points the objects which are far apart in X coordinate of the X-Y coordinate system, that is, differing in the angles from the tip of the polar axis. (When the telescope moves over the tip of the polar axis, for example from +30 degrees to -30 degrees, those points are considered different in the X coordinate.) When the mount mode is set to Alt-azimuth mode, the X coordinate that the telescope will move is limited to 0 to 90 degrees, so you will be more limited in ability to achieve a 3 point alignment. Once a 3 point alignment is achieved, you are more likely to get another 3 point alignment for the next alignment because there are more possible reference point combinations .

matches the selection criteria set in the object selection menu will be displayed. If the object number is entered directly, any object (including those below horizon) can be displayed. For example, in Messier menu, you can enter "31" to display Messier object M31. If the object entered is not in the database, you will see the message "no data". You can combine the entry methods and enter, for example, 5000 using numeric key and then press NEXT key to display the first object numbered above 5000 that matches the object selection criteria.

☐ Reference Star Menu

Reference star menu contains 35 bright stars listed in Appendix B. When you press NEXT/PREV key to scroll the reference star menu, the altitude and the azimuth criteria of the object selection criteria will be applied, but the constellation, brightness, size, and type criteria will not be applied. This is so that you can still use the objects in this menu for alignments when you have set the object type, for example. (It is possible to do alignments using objects in other menus.)

The objects in the reference star menu is numbered from 1 to 35, in alphabetical order. If the object is a double star, their brightness and the separation angle can be displayed.

☐ Messier Menu

There are 108 objects in Messier menu, numbered M1 to M109. (There is no M40.) Messier objects consists of many popular objects such as nebulas and star clusters which are relatively easy to observe.

When selecting a Messier object, if you press [-] key, the object's type will be displayed; if you press [+] key, the object's common name will be displayed if there is one, otherwise its type will be displayed.

☐ Planets Menu

There are 8 planets in Planets menu. Planets are numbered, in order of closeness from the Sun, 1-Mercury, 2-Venus, 3-Mars, 4-Jupiter, 5-Saturn, 6-Uranus, 7-Neptune, 8-Pluto.

J2000 coordinates displayed for planets are the coordinate as seen from the center of the Earth, but RaDec coordinates are coordinates as seen from the observation site and includes the parallax effect.

☐ MoonMenu

Moon menu contains the data for the center of the Moon. J2000 coordinates for the Moon are the coordinates as seen from the center of Earth, but RaDec coordinates are the coordinates as seen from the observation site and includes the parallax effect.

☐ NGC Menu

NGC (New General Catalog) menu contains 4841 NGC objects are brighter than magnitude 15.

When selecting a NGC object, if you press [-] key, the object's type will be displayed; if you press [+] key, the object's common name will be displayed if there is one, otherwise its type will be displayed.

☐ IC Menu

IC (Index Catalog) menu contains 1352 IC objects brighter than magnitude 15.

When selecting an IC object, if you press [-] key, the object's type will be displayed; if you press [+] key, the object's common name will be displayed if there is one, otherwise its type will be displayed.

☐ SAO Menu

SAO (Smithonian Astrophysical Observatory) menu contains 422 stars brighter than magnitude 4.0.

When selecting a SAO object, you can use [+] and [-] keys to display the type of object, the constellation and alphabet or number designation, or its common name. (If the object does not have a common name, its constellation and alphabet or number designation will be displayed.) For example, when you display SAO27876 (Beta star in URSA Major, whose common name is Merak), you can change the display format as follows using [+] and [-] keys.

(Star) ⇄ Beta [UMa] ⇄ Merak

For double stars, their brightness and separation angle will be displayed in the data display.

5.1.2 Effects of the Initial Settings

The initial settings which can affect the pointing accuracy are the clock setting and the coordinate of the observation site which are set as parameters in the setup, and the positioning accuracy of the initial telescope position.

The clock and the longitude/latitude are used in the computation of the altitude, so it affects the position accuracy through computed atmospheric refraction effect, but the error is small if the settings are accurate to within a few degrees. The clock and the longitude/latitude would affect more greatly the computation of the apparent position of the solar system objects, especially the Moon, through computed parallax effect. For the computation of the apparent position of an artificial satellite in a low orbit, this factor would have a very large effect, so for observing satellites, please set the clock and the longitude/latitude as accurately as possible.

As for the accuracy of the initial positioning of the telescope, since SkySensor behaves as though the polar axis is aligned and the telescope is initially positioned correctly before the first alignment, they do affect the pointing accuracy before the first alignment and to a lesser extent the accuracy before the second alignment. However, since errors in these positioning are all computed by the second alignment, they do not need to be set very accurately.

5.1.3 About the Alignment

SkySensor uses three different algorithms for the alignment calculation: an alignment using one reference point ("1 point alignment"), another using two reference points ("2 point alignment"), and a third using three reference points ("3 point alignment").

The very first alignment after the initial positioning would of course be a 1 point alignment. 1 point alignment computes the azimuth and the elevation the polar axis is pointing. So after the first alignment, SkySensor is able to compute the approximate position of the objects even if the telescope's polar axis was pointed at a random direction.

In the second alignment, a 2 point alignment will be attempted. If the second reference point is not suitable for a 2 point alignment (if too close to the first point, or if the same point was

Chapter 5 For Best Performance

In this chapter, hints on using SkySensor and the principle of how SkySensor operates are given so you can get the best performance from your SkySensor.

5.1 For Better Pointing Accuracy

When slewing to an object using GOTO function, the pointing accuracy can depend on many factors. Those factors include the accuracy of the computed object position, the accuracy of the parameters set in the setup, the mechanical alignments, the accuracy of the initial positioning, and the accuracy of the alignment procedure. We will explain their effects and how SkySensor computes and compensates for them.

5.1.1 About Computed Object Position

The coordinates for celestial objects such as stars and nebulas in the SkySensor's database are in Epoch 2000 coordinate system. Coordinates in other coordinate systems are derived from this coordinate. For the computation of RaDec coordinates, the effects of precession of equinoxes, annual aberration, and nutation are taken into account, but individual star motions are not included.

For the Sun, planets, and the Moon, the aberration and parallax effects from the observation site are also included.

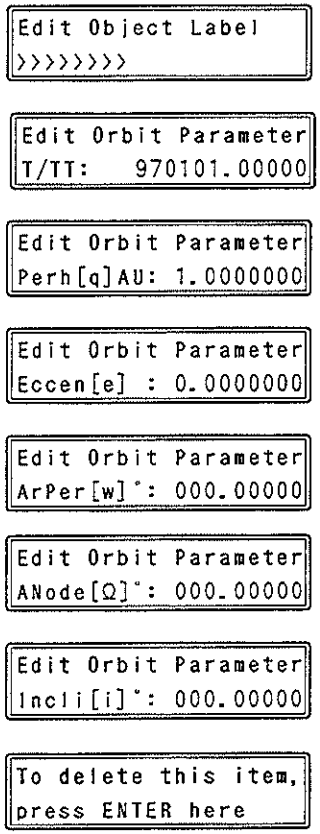
The computed apparent altitude of the object includes the effect of the atmospheric refraction.

Normally, the accuracy of the internal representation of the object position is better than the number of digits shown on the display.

☐ Comet Menu

In Comet menu, the user can register orbital elements of up to 30 comets. SkySensor computes the position of the comets from the orbital elements.

If you select the Comet menu when no objects are registered, you will see a 0 in the display. To register an object, first enter a number between 1 and 30, inclusive, and press ENTER key. You will first see a message "no data". If you keep pressing the ENTER key for a few seconds, SkySensor will beep and show the screens for entering and editing data. (If an object is already registered, you can still enter the editor by keep pressing ENTER key when its data is displayed.) There are 8 editor screens for Comet menu which you can select by pressing NEXT/PREV keys.



To delete an object from the menu, press ENTER key when the Object Deletion Screen is displayed.

You can obtain the orbital elements in selected astronomical magazines and from Internet web sites related to astronomy.

You can edit the comet orbital elements on a personal computer and enter them into SkySensor through its RS232 port. For details, please see Section 6.1, "Entering Orbital Elements from a PC".

☐ Artificial Satellite Menu

In Artificial Satellite menu, you can register orbital elements of up to 30 satellites. SkySensor computes the position of the satellites from the orbital elements.

If you select the Artificial Satellite menu when no objects are registered, you will see a 0 in the display. To register an object, first enter a number between 1 and 30, inclusive, and press ENTER key. You will first see a message "no data". If you keep pressing the ENTER key for a few seconds, SkySensor will beep and show the screens for entering and editing data. (If an object is already registered, you can still enter the editor by keep pressing ENTER key when its data is displayed.) There are 10 editor screens for Satellite menu which you can select by pressing NEXT/PREV keys.

Edit Object Label >>>>>>>	Label editor screen
Edit Orbit Parameter T(UT): 97001.0000000	Epoch time (yyddd.fraction-day)
Edit Orbit Parameter Incli[i]°: 000.00000	Inclination of orbit
Edit Orbit Parameter ANode[Ω]°: 000.00000	Right ascension of ascending node
Edit Orbit Parameter Eccen[e] : 0.0000000	Eccentricity

4.10 STOP Key : Motor Stop

If STOP key is pressed while the telescope is slewing to an object, the motor will stop. If STOP key is pressed continuously, the tracking motion will be stopped while the key is pressed.

Pressing STOP key may not stop the motor in certain situations. To stop the motor in an emergency, turn the power switch OFF.

4.11 [−] Key : Down Speed Mode

When you press [-] key, the motor speed mode will change from High to Medium to Low. When the key is pressed, the motor mode will be displayed for about two seconds.

4.12 [+] Key : Up Speed Mode

When you press [+] key, the motor speed mode will change from Low to Medium to High. When the key is pressed, the motor mode will be displayed for about two seconds.

message will be displayed. After the last object in the menu, the tour will continue with the first object in the menu.

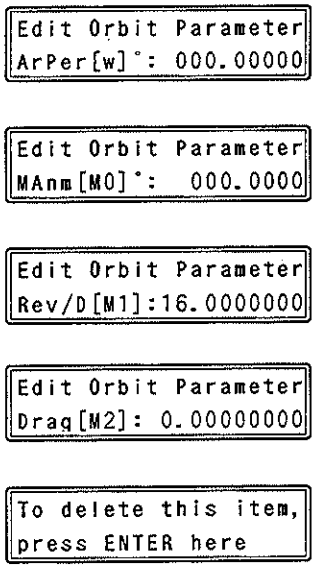
By storing the selected objects that you want to observe beforehand in a user menu, you can conveniently observe all objects by touring the user menu.

During the tour, you can move the telescope by using the motor keys or change the display using DISP, NEXT, or PREV key. The tour will end when you press ESC key. The tour will also end if you use SETUP, ID, COORD, or STORE key functions. When the tour ends, you can resume the tour at the point it was terminated by pressing ETC key (in Sky Tour function mode) again.

4.9.2 Guide Speed Function

When ETC key function is set to Guide Speed, then ETC key can be used to change the motor speed mode to Guide mode. The speed for the Guide mode can be set from 0.1x to 9.9x in the "ETC Key Function Menu" in the setup.

For details on the Guide speed mode, please see "Motor Speed Mode" in Section 3.1.1.



Argument of perigee

Mean anomaly

Mean motion (Revolution per day)

Drag (one half of time derivative of mean motion)

Object deletion screen

To delete an object from the menu, press ENTER key when the Object Deletion Screen is displayed. You can obtain the orbital elements in selected astronomical magazines and from Internet web sites related to satellites.

You can edit the satellite orbital elements on a personal computer and enter them into SkySensor through its RS232 port. For details, please see Section 6.1, "Entering Orbital Elements from a PC".

When you enter the orbital elements, many data for the satellite will be displayed, including its altitude/azimuth, right-ascension/declination, longitude/latitude, speed, altitude, and the distance from the observation site.

Artificial satellites are visible only when they reflect the light from the Sun. Because of that, you can observe the satellites in low orbits only for a short time after sunset and for a short time before sunrise.

The data shown for the satellites includes the correction due to atmospheric refraction, but this correction is not included in the tracking calculation. Therefore, during tracking of a satellite at a lot altitude, you may see a slight difference in the

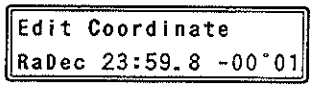
position data for the satellite and the telescope position.

☐ User1 Menu

In User1 menu, you can register up to 30 celestial objects. If you select User1 menu when no objects are registered, you will see a 0 in the display. To register an object, first enter a number between 1 and 30, inclusive, and press ENTER key. You will first see a message "no data". If you keep pressing the ENTER key for a few seconds, SkySensor will beep and show the screens for entering and editing data. (If an object is already registered, you can still enter the editor by keep pressing ENTER key when its data is displayed.) There are 4 editor screens for User1 menu which you can select by pressing NEXT/PREV keys.

Label editor screen

Epoch 2000 coordinates editor



Right-ascension/ declination editor

Object deletion screen

To delete an object from the menu, press ENTER key when the Object Deletion Screen is displayed.

You can enter the coordinates in either Epoch 2000 coordinates or current epoch (RaDec) coordinates. Since these coordinates are related, editing one will automatically change the other.

You can register an object in User1 menu by using STORE key. When STORE key is pressed, the currently selected object is stored in the User menu. For example, if you want to register M17 in the User menu, first select M17 from Messier

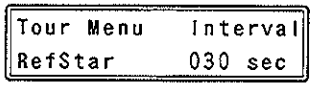
4.9 ETC Key : Multi-function Key

ETC key is a user selectable multi-function key. The ETC key function may be selected from either Sky Tour or Guide Speed function. The selection is made in "ETC Key Function Menu" in the setup.

4.9.1 Sky Tour Function

When ETC key function is set to Sky Tour, then if you press ETC key the Sky Tour function will be activated. With the Sky Tour function, you can automatically slew successively through objects in any object menu.

At the start of the Sky Tour function, the Sky Tour menu to select the object menu and the time interval between slewing will be displayed.



Sky Tour menu

You can select any object menu, including user menus, by pressing NEXT or PREV key. The time interval can be set up to 999 seconds. (If you select 0 second, then the time interval is set to infinite, and the telescope will not slew to the next object until you press ENTER key.)

If you press ENTER key at the Sky Tour menu, the tour will start.

In the Sky Tour function, the telescope slews successively to objects in the selected menu. When the telescope slews to an object, it tracks that object for the time interval set in the Sky Tour menu. It will then display a waning message and a beep and slew to the next object after three more seconds. If you press ENTER key while observing, the telescope will move to the next object immediately.

The objects in the menu to be toured will be selected by the same selection criteria set in the object direction menu and object type menu as in the main menu selection. The first object to be toured is the object that would be selected in the main menu if you press the NEXT key in that object menu. If there are no object in that menu that can be toured, a warning

4.8 STORE Key : Storing Objects

STORE key is used to store the object currently selected on the display into the user memory. Normally, the displayed object is selected from the main menu, but the object may also be selected by entering its coordinates with COORD key or from the ID search result list.

When STORE key is pressed, a menu to enter the selection number is displayed.

```
STORE: Store Object
User1>1
```

STORE menu

If the displayed object is a terrestrial object (an object from Land menu or AltAz coordinates from the COORD function), then the data must be stored in Land menu. If the displayed object is a celestial object, you can store it in either User1 or User2 menu, which you can select by pressing NEXT or PREV key. For the selection number, a number which is not being used will automatically be displayed, but you can enter any number from 1 to 30. If you enter a number which is being used, the data for that number will be overwritten. If all numbers are being used, then 0 will be displayed.

If you enter a two digit selection number, or if you move the cursor to right by pressing Right key, then the cursor will move over to the label position. If the selection already has a object registered, then its label would have been displayed here, but the label display will disappear when you move the cursor over.

If you store a celestial object from an object menu by using STORE key, then besides the coordinates, its label, size, magnitude, and type will also be copied. The orbital elements will not be copied, so if you store Moon, planets, comets, or satellites, its coordinates at the moment you press STORE key will be stored.

When you press ENTER key at the STORE menu, the data will be stored in the selected user menu and the display will return to the main menu. If you want to cancel the STORE operation, press ESC key.

menu. If you then press STORE key and then ENTER key, M17 will be stored in an User menu selection number which is not being used. If you use STORE key to store an object, in addition to the object's coordinates, its name, size, brightness, and type will also be stored. (You can only edit the label and the coordinates of the object in the editor screen.)

If you would like to store the coordinates of the position the telescope is currently pointed, you can press COORD key to select the current coordinate as the object and then store it with STORE key. This method, besides being faster and error-free, copies the coordinates in the internal format with more precision.

Please see Chapter 4 on the usage of STORE and COORD keys.

☐ User2 Menu

User2 menu is functionally identical to User1 menu, to be used as needed. You may, for example, use User1 and User2 menus to store different types of objects.

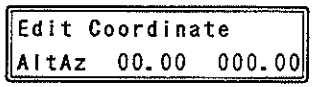
When you use the Sky Tour function to do the observation, it is convenient to group all Sky Tour objects in one of the User menu.

☐ Land Menu

In Land menu, you can register up to 30 terrestrial objects.

If you select Land menu when no objects are registered, you will see a 0 in the display. To register an object, first enter a number between 1 and 30, inclusive, and press ENTER key. You will first see a message "no data". If you keep pressing the ENTER key for a few seconds, SkySensor will beep and show the screens for entering and editing data. (If an object is already registered, you can still enter the editor by keep pressing ENTER key when its data is displayed.) There are 3 editor screens for Land menu which you can select by pressing NEXT/PREV keys.

Label editor screen



Altitude/Azimuth editor screen

Object deletion editor

To delete an object from the menu, press ENTER key when the Object Deletion Screen is displayed.

As in User1 and User2 menus, you can store objects in Land menu using STORE key and COORD key. For Land menu, the only objects you can store using STORE key is the alt-azimuth coordinates from the COORD function and other objects from Land menu.

When you use COORD and STORE keys to store the coordinates of the current telescope position, the status of the backlash will also be stored automatically. This eliminates the error due to backlash for more accurate pointing when slewed to that object using GOTO key.

It is possible to use the Sky Tour function to tour the objects in Land menu.

☐ Sun Menu

Since it is dangerous to point the telescope toward the Sun without proper preparation, Sun menu is not normally displayed. To display Sun menu, set the display option in "Sun Observation Menu" in the setup.

Observation of the Sun is dangerous if not done using proper method and equipments. If not done correctly, it may cause permanent and irreversible eye damage.

SkySensor is programmed to move the telescope away from the Sun when it gets too close. SkySensor will point the telescope near the Sun only when the Sun menu is selected.

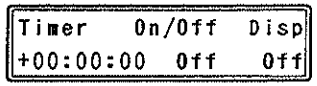
English and Japanese.

Language menu

☐ Setup Label Editor

This menu lets you edit the label which is displayed when selecting the setup number. Labeling the setups will make it easier to identify the content of the setup. #0 setup is initially labeled "Default Values", but this label too may be edited. Please see Section 3.1.4, "Character Entry for Labels", on how to enter labels.

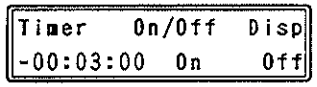
Setup label editor



Timer Menu

The timer value may be set up to ±99 hours 59 minutes 59 seconds. (The timer will turn to 0 after +99:59:59, but the alarm will not sound when this happens.) The timer will start when the on/off status is set to ON. If the Disp setting is set to ON, you can have the timer value displayed on the status line using DISP key.

Example: To set the timer to sound an alarm in 3 minutes, set the timer menu as follows.



Timer set to sound an alarm in 3 minutes

The timer will keep its time even when you switch the power off.

☐ Light and Sound Menu

This menu sets the LED light level and the key touch sounds settings.

Light and sound menu

The light level setting affects the backlighting of LCD display, the motor indicator, the key panel illumination, and the map lamp. The light level can be set from 0 (off) to 7 (maximum).

The key touch sound can be set separately for the four direction keys and the keypad. The warning beep will sound regardless of the key touch sound settings.

☐ Language Menu

This menu selects the language for the display. The display may be in English or Japanese. If Japanese is selected, the constellation names may be selected independently between

3.3.3 Object Data Display

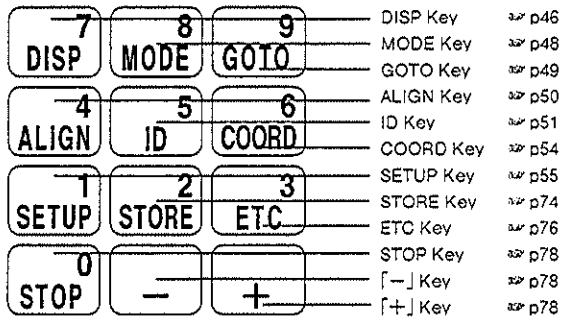
To view the next or previous data items for an object, press NEXT or PREV key. The data category displayed for the objects are different for each menu.

The altitude/azimuth of the object will always be displayed.

The right-ascension/declination coordinates (RaDec and J2000) of the object will be displayed in the epoch selected to be displayed in the status display. (Please refer to Section 4.1, "Changing Status Display", about the status display.) For example, if RaDec coordinates are set to be displayed in the status display, then RaDec coordinates will be displayed for the data; if J2000 coordinates are set to be displayed in the status display, then J2000 coordinates will be displayed for the data. If both RaDec and J2000 coordinates are set to be displayed in the status display, then both coordinates will also be displayed for the data display. If neither RaDec nor J2000 coordinates are set to be display in the status display, then RaDec coordinate will be displayed in the data display.

The X-Y coordinates of the object will be displayed only if X-Y coordinates are set to be displayed in the status display.

Chapter 4 Command Keys



Twelve command keys on the lower half of SkySensor are used to execute various SkySensor functions. The names of the commands are printed on the lower half of the key. The commands will not function when the keys are being used as numeric keys for data entries. (Normally, the keys function as command keys when the motor indicator is lit.)

4.1 DISP Key : Status Display

When you press DISP (display) key, the status display on the first line of LCD will scroll to the next display. The items to be display in the status display can be selected in the setup menu.

The selected statuses will be displayed as shown in the following diagram. The statuses which are not selected will be skipped. The order in which statuses are displayed cannot be reversed, so the display will easier to use if you set not to display the status you don't need.

4.7.5 Display Option Category

In Display Option category, you can select what to display in the status line, the lights, and the sound settings. These selection can be made according to the user's preference.

☐ Coordinate Display Menu

In this menu, you can select which coordinates to display on the status line.

```
Coord:  RD J2 AA XY
Display=On OffOn Off
```

Coordinate display menu

The coordinates are abbreviated RD for RaDec (right-ascension/declination), J2 for J2000 (Epoch 2000), AA for AltAz (altitude/azimuth), and XY for X-Y motor coordinates. Each coordinates may be displayed on the status line by using DISP key if "Display" is set to On and not be displayed if it is set to Off.

☐ Time Display Menu

In this menu, you can select which time to display on the status line.

```
Time: Sidereal Local
Display=   Off   Off
```

Time display menu

The sidereal and the local time may be displayed on the status line by using DISP key if "Display" is set to On and not be displayed if it is set to Off.

☐ Timer Menu

This menu sets the timer function. You can set the timer value, on/off status, and whether the timer is to be display on the status line. The timer always counts up. If the timer is set to a negative value, an alarm will sound and a message will be displayed when the timer reaches 0, independent of the status line display setting.

ber, but the default value from setup #0 will not be applied to other setups. Please make the selection separately for each setup.

☐ Satellite Alarm Menu

In this menu you can set the satellite alarm to "Off", "When above horizon", or "When in view".

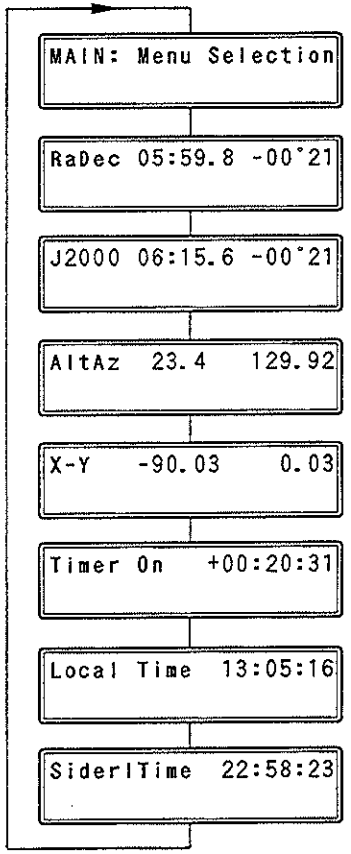
Satellite alarm menu

If the alarm is set to "Off", then the alarm will not operate.

If the alarm is set to "When above horizon", then the alarm will sound and the name of the satellite will be displayed when one of the satellite in the Satellite menu rises above the horizon.

If the alarm is set to "When in view", then the alarm will sound and the name of the satellite will be displayed when a satellite comes into the view direction set by the "Object Direction Menu".

To see the satellite that was displayed in the alarm, select Satellite menu from the main menu and press ENTER key. You can list the satellites currently in the view by pressing NEXT or PREV key. Select the satellite by pressing ENTER key. You can then slew to and track the satellite by pressing GOTO key.



[Guide Display]
Guide display can always be displayed

[RaDec] Right-ascension/declination
Selected in Coord Display Menu

[J2000] Epoch 2000 coordinates
Selected in Coord Display Menu

[AltAz] Altitude/Azimuth
Selected in Coord Display Menu

[X—Y]
Selected in Coord Display Menu

[Timer]
Selected in Timer Menu

[Local Time]
Selected in Time Menu

[Sidereal Time]
Selected in Time Menu

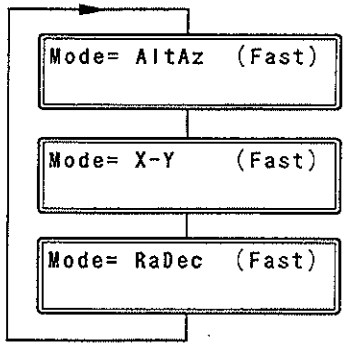
The coordinates for the status display are labeled "J2000", "RaDec", "AltAz", and "x-y". But if the coordinate corresponds to the current motor control mode, then the label will be displayed in upper case letters as "J2000","RADEC", "ALTAZ", and "X-Y". For example, if the motor control mode is set to AltAz, then as you press DISP key to change the coordinate display, the label will be displayed as "RaDec" → "J2000" → "ALTAZ" → "x-y".

For details on menus to set the status display, please see Section 4.7.5, "Display Option Category".

4.2 MODE Key : Motor Mode

When MODE key is pressed, the current motor control mode will be displayed in the status display for five seconds. If you press MODE key again while the control mode is still being displayed, the control mode will change to the next mode.

Please see Section 3.1.1 for explanation of the control modes.



The mode changes as you press MODE key repeatedly.

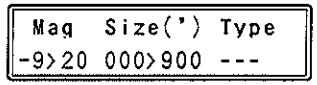
If MODE key is not pressed within five second when the control mode is displayed, then the control mode will not be changed and the display will return to the normal status display.

The mode display will also display the current motor speed mode, so you can use MODE key to check the speed mode. The mode display are also be shown when [+] and [-] keys are pressed, but unlike MODE key, [+] and [-] causes speed mode to change immediate when the keys are pressed, so MODE key is better suited for viewing the current modes.

"Cnst" column specify the constellation of the objects, When you press Up or Down key, the list of constellations will scroll in the alphabetical order. If the constellation is not specified, all constellations will be listed.

☐ Object Type Menu

In this menu, you can specify the brightness (magnitude), size, and type of the object to be listed in the main menu.



Object Type Menu

The above example specifies magnitude of -9 to 20 (this covers all objects in the database), and size of 0 to 900 arc minutes (this covers all objects in the database.)

"Type" specifies the object type such as nebulas and star clusters. If the type is not specified, all types will be listed.

☐ Sun Observation Menu

In this menu, you can choose to have the Sun menu displayed in the main menu. The observation of the Sun requires preparation and safety precautions. Please read Section 2.3.7, "About Daytime Viewing and the Sun", before enabling the Sun menu.

Sun observation menu

The Sun menu setting can be selected from "No", "This session only", and "Yes". If you select "No", the Sun menu will not be displayed. If you select "This session only", then Sun menu will be displayed until the next time you switch on SkySensor and press ENTER key for restarting from the Initial Position. If you select "Yes", Sun menu will always be displayed.

The selection can be made separately for each setup num-

4.7.4 Object Selection Category

In Object Selection category, parameters about the objects of observation are set. By setting the parameters to list only objects that you want to see, SkySensor will be more efficient and easier to use.

☐ Object Direction Menu

In this menu, you can specify the altitude and the direction of the objects to be listed in the main menu. By matching the direction to the terrain of the observation site, you can have the menu list only the objects you can observe from that site. For example, if a mountain or city light is obstructing your view to North, you can have the menu list only object you can view in southern direction.

The direction is divided into "front" and "back", and you can specify the range and altitude for each.

```
Elv(Bk) Azimuth Cnst
+00(00) 000>360 ---
```

Object Direction Menu

The azimuth angle for front is specified by numbers in the "Azimuth" column. The number represents the angle in degrees from North; 0 is North, 90 is East, 180 is South, and 270 is West. In the above example, "000>360" (0 to 360 degrees) specifies the entire horizon. "090>270" would specify the southern half of the horizon, and "270>090" would specify the northern half. The direction not included in "front" is "back".

Under the "Elv" column, the signed number specifies the altitude for the front, and the number inside the parenthesis specifies the altitude for the back. In the main menu, only the objects which are higher than the specified altitude will be listed.

The use of the front and the back specification will let you configure the altitude specification to match the terrain of the observation site, but aside from being able to assign a negative number for the front altitude, there is no difference between the front and the back.

If you specify the entire horizon as the front and -90 degree for the altitude limit, you can have the entire database displayed in the main menu by using NEXT/PREV keys.

4.3 GOTO Key : Slew to Objects

GOTO (go to) key is used to slew the telescope to the object currently selected in the display. Normally, the displayed object is selected from the main menu, but the object may also be selected by entering its coordinates with COORD key or from the ID menu.

When GOTO key is pressed, the motor will rotate at the maximum speed set for the high speed mode in the setup.

If the selected object is below the horizon, or if the object is too close to the Sun (within about 15 degrees), a warning will be displayed and the telescope will not be slewed. If the selected object is a land object, the telescope will slew even if the tube must point downward, but if the object is too close to the Sun, there will be a warning and the telescope will not slew.

4.4 ALIGN Key : Telescope Alignment

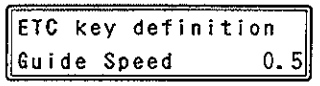
ALIGN key is used to align the direction the telescope is pointed with the coordinates of the object selected in the display. Normally, the displayed object is selected from the main menu, but the object may also be selected by entering its coordinates with COORD key or from the ID menu.

To prevent an unintentional operation of the alignment function, ALIGN key must be pressed for about three seconds to activate the alignment function. When the alignment takes place, SkySensor will double beep to confirm the operation.

After slewing the telescope to an object using GOTO function, if the object is not at the center of field of view, then you can re-align by manually centering the object in the field of view with motor keys and pressing ALIGN key until it double beeps. SkySensor will use this object as a reference point and combine it with previous reference points to re-align the telescope.

When an alignment takes place, a message showing how many points were used in the alignment will be displayed for a few seconds. An alignment will be more accurate when more points are used for the alignment. Please see Section 5.1.3, "About the Alignment", for detailed explanation of the alignment.

can also select the motor speed.



Guide Speed selection for ETC key function

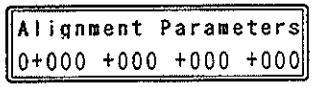
By moving the cursor to the number on the right, the guide speed may be set from 0.1x to 9.9x.

Please see Section 4.9, "ETC Key: Multi-function Key", about the ETC key functions.

Reference point display

The number in the first column is the reference index number, which is 3 in this case to indicate that this is the 3rd reference point. You can press Up and Down keys to change the index number, and see the second and the first reference points.

When you change the index number to 0, or if there is no reference point yet, then the display shows four alignment parameters as shown below.



Alignment parameters display

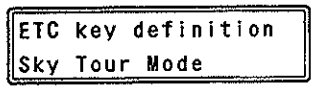
The first two numbers are the computed correction value for the initial setting angles for the telescope tube direction and the balance weight shaft direction, and the last two numbers are the compensation parameters for mechanical alignments computed by 3 point alignments. These numbers are computed automatically in the alignment computations, but if the values are known from the previous observation sessions, then it is possible to enter their values. These parameters are common to all setups and will be modified when a new alignment is performed. For explanation of the alignment parameters, please see Section 5.1.3, "About the Alignment".

☐ ETC Key Function Menu

Sky Tour is an automatically timed slewing function.

This menu is for selecting the ETC key function. ETC key function may be set to be either Sky Tour function or Guide speed function.

To set ETC key function to Sky Tour, select Sky Tour and press ENTER key.



Sky Tour function selection for ETC key function

To set ETC key function to Guide speed, select Guide Speed and press ENTER key. For the Guide Speed function, you

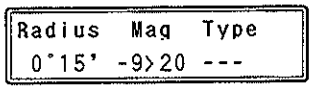
4.5 ID Key : Object Identification

ID key is used to search and identify objects near the direction the telescope is pointing. This function may be used to find out the name of the object you may see in the telescope, or to look for some objects close to where you are looking.

The object found by ID function may be stored in User menu by using STORE key, or slewed to by using GOTO key, or may be used as a reference point for alignment by using ALIGN key.

To use ID key to find out the name of an object, if the telescope is already pointing toward the object, simply press ID key. If the telescope is not pointed toward the object, then first use the motor keys to manually point the telescope toward the object.

When ID key is pressed, a menu to set the search parameters will be displayed as follows.



Setting search parameters

"Radius" is the search radius measured from the center of the field of view. In the above example, it is set to 0 degree 15 minutes, which approximately covers the field of view of a hundred magnification power. This parameter may set up to 19 degrees 59 minutes. (To enter the 10's place digit, move the cursor to left using the direction key.)

"Mag" is the upper and the lower limits of the brightness of the object to be searched. You can enter a negative magnitude by pressing [-] key when the cursor is on the magnitude number.

"Type" is the type of the object to be searched. If "---" is shown, all types of objects will be searched.

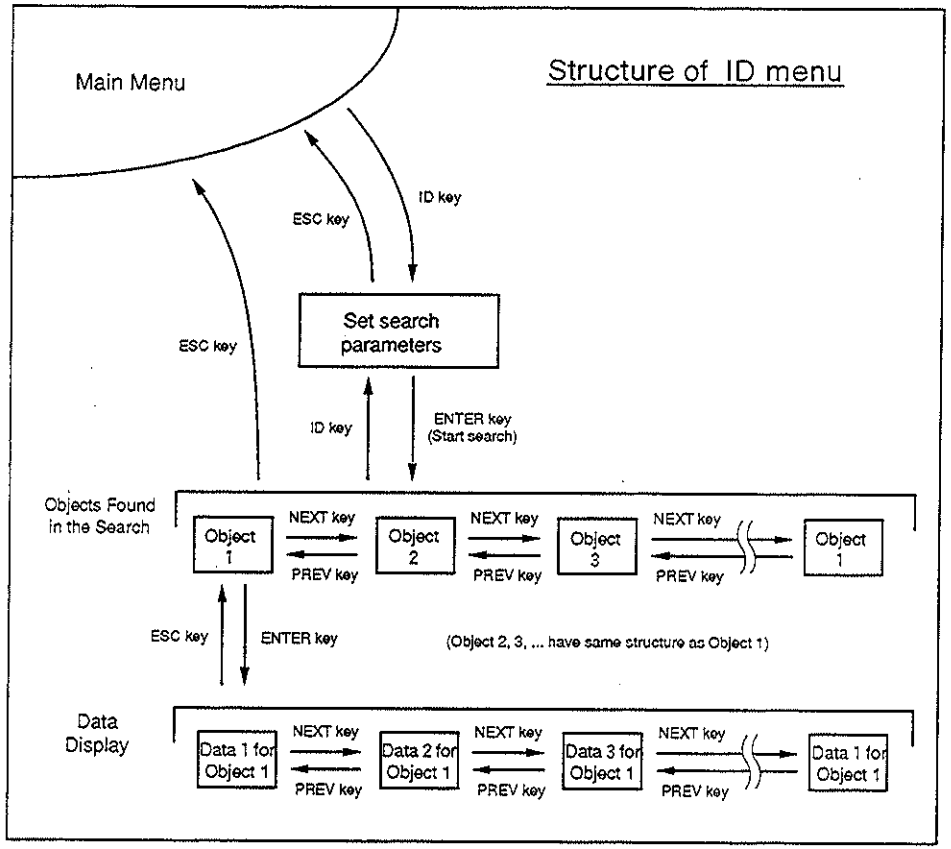
When you press ENTER key in the search parameter menu, SkySensor will search the database to look for objects which match the specified parameters and show the search result as in the following example.

Display of search result

This example shows that 12 objects were found in the search, and the object closest to the center is M31. You can scroll the object list by using NEXT and PREV keys. You can press ESC key to end the search. (To get back to search parameter menu, press ID key.)

You can change the display format (type, number, common name) of the objects using [+] and [-] keys as in the main menu.

The data displayed for the objects are the same as for that object in the main menu, but in addition, the distance and the direction of the object from the center of field of view will also be displayed as in the following example.



changed if other mounts are used. For GP and SP mounts, please do not change the initial values.

☐ Motor Parameter Menu

This menu is used to set the motor control parameter of SkySensor to match the operating characteristic of the DC motor. Please leave the settings at 1 for the normal use.

Motor Parameters
RA= Set 1 DC= Set 1

Motor Parameters Menu

☐ Polar Axis Direction

The polar axis direction menu shows the direction the polar axis of the mount is pointed as computed by SkySensor's alignment calculation. This menu is primarily for checking the value of the polar axis direction, but if the direction is known from the previous observation session, the value may be entered.

These parameters are common for all setups and cannot be set individually for each setup. The values will be modified when an alignment is performed.

Polar Axis Direction
El=(35.0) Az=(000.0)

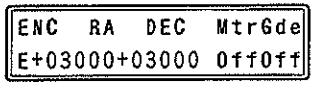
Polar Axis Direction Menu

☐ Alignment Parameters

The alignment parameter menu shows the current value of parameters used for the alignment.

If one, two, or three reference points were used as reference points for the last alignment, the menu will initially show the last reference point. For example, if three reference points were used for the alignment, then the display will look like the following example, which shows that the last (third) reference point was Aldebaran.

When external encoders are selected, SkySensor will compute the telescope position using the inputs from the external encoder connector and the signal from the internal encoder will not be used. The motors need not be connected to SkySensor.



Encoder menu (External encoder screen)

The numbers in the "RA" and "DEC" columns shows the number of external encoder pulse per revolution. (The external encoder is assumed to rotate once for each revolution of right-ascension or declination axis.) The initial value of 3000 is the value for the optional GP encoder.

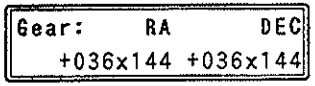
The "Mtr" column parameter enables or disables the motor operation. When this parameter is On, you can use motor keys to move the motors in X-Y mode. However, if you enable the motor, some encoder signal may be lost if you turn the telescope rapidly by hand. If the setting is Off, the motors will not operate.

The "Gde" column parameter sets the sidereal tracking operation for the right-ascension motor. When this parameter is On (the "Mtr" parameter has to be ON also), the right-ascension motor will start to turn at the sidereal rate.

Please see Section 6.3, "External Encoders", for more details.

☐ Gear Ratio Menu

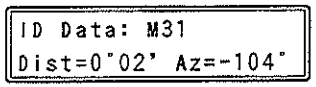
This menu set the gear ratio for the motor and worm gears.



Gear Ratio Menu

In the above example, 36 is the gear ratio of the motor gear, and 144 is the gear ratio of the worm gear. The worm gear ratio is also used in the PEC computation. The sign of the gear ratio represent the direction of rotation of the final gear.

The initial values for the parameters in this menu is set to the values for GP and SP equatorial mounts. The values may be



Data for objects found in the search

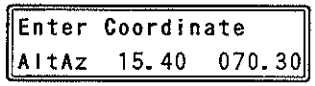
In the display, "Dist" is the angular distance from the center and "Az" is the direction measured clockwise from the downward direction.

If more than 100 objects are found as the result of the search, only the first 99 objects closest to the center will be listed. Objects in user defined menus, including satellites and comets, are not subject to search.

4.6 COORD Key : Entering Coordinates

COORD key is used to enter coordinates directly. The coordinates you enter may be used as the object to slew to with GOTO key, stored in User menu with STORE key, or used as a reference point for the alignment with ALIGN key.

When you press COORD key, the coordinate of the direction the telescope is currently pointed will be displayed. This coordinate may be edited so you can enter any coordinate.



Entering coordinates

When the coordinate displayed is labeled AltAz, you can enter altitude/azimuth coordinates. When the coordinate displayed is labeled RaDec, you can enter right-ascension/declination coordinates. You can switch between the coordinate systems by using NEXT or PREV keys. When you press NEXT or PREV keys, the coordinates being displayed will be converted to the coordinates in the other coordinate system.

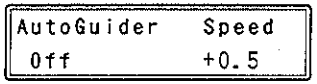
To enter the value of the displayed coordinate, press ENTER key. When the value is entered, the cursor will disappear.

When the coordinate is entered, you can use GOTO, STORE, or ALIGN key on it. To return to the main menu, press ESC key. If you store the coordinate using STORE key, the display will automatically return to the main menu after storing the coordinates.

As the periodic error varies slightly by the position of right-ascension, it may become necessary to re-record PEC if right-ascension position is moved by a large amount. To re-record PEC, you would repeat the above procedure, but the PEC compensation may be set to either ON or OFF during the recording.

☐ Autoguider Menu

This menu is for setting parameters for the optional CCD Autoguider.



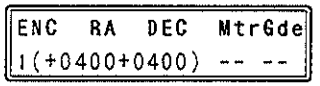
Autoguider menu

When the Autoguider status is ON, SkySensor reads the outputs from the Autoguider and sends correction signals to the motors. "Speed" is the motor speed setting for the correction signal. The initial value for the motor speed is 0.5x, but this can be set from -9.9x to +9.9x.

Please see Section 6.2, "CCD Autoguider", on how to use the Autoguider with SkySensor.

☐ Encoder Menu

This menu selects the encoder type (Internal or External), and sets the pulse count per revolution when external encoder is selected.



Encoder menu (Internal encoder screen)

When the first column of the menu is "I" (for Internal), it indicates that the Internal encoder which is built in to the DC motor is selected. The number inside the parenthesis () is the number of pulse per revolution (400) for the internal encoder. This number cannot be changed.

You can change the first column of the menu to "E" (for External) by pressing Up or Down key to select the external encoder.

less of the motor speed mode setting. (The motor control mode will still be in effect. Set the control mode to RaDec or X-Y mode to make guide adjustments easier.)

The last column, "Mode", can be selected from "Execute", "Record", and "Reset". For normal operations, set it to "Execute".

To record the periodic error, set "Mode" to "Record" and press ENTER key. The display will change to the following PEC standby display.

```
PEC: Worm=000(+0)
Press ENTER to start
```

PEC standby

In this display, the first number on line 1 shows the position of the worm gear in counts from 0 to 299 and the number in parenthesis shows the current compensation value in effect. (This value will be 0 when PEC is not operating.)

After you position the guide star at the center of field of view (at this point, the motor will be operating at the speed set in the PEC menu), press ENTER to start recording. PEC recording may be started at any position on the worm gear.

```
PEC: Worm=056(+0)
Count=300 Corr=+0
```

PEC recording display

When you start recording, the count starts at 300 as shown above and will count down. When the count reaches 0, SkySensor will sound a beep and display a message "Recording is done", and then return to the PEC menu. "Corr" is the cumulative compensation value. If the compensation value does not end at 0 at the end of recording, then the whole recording will be adjusted so that the net compensation value at the end is 0. After the recording, PEC status will be automatically set to ON.

When "Mode" in the PEC menu is set to "Reset", the recorded PEC compensation value will be reset to 0.

The PEC compensation value will remain effective even if the motors are operated, or the clamps are loosened, or the power has been switched off. (If you move the motor manually while the power is turned off, you will need to record again.)

4.7 SETUP Key : Setting Parameters

SETUP key is used to set various parameters used by SkySensor. You need to set the time and the observation site coordinate to make SkySensor work, but other parameters need not be set initially; set those parameters according to your preference. All parameter settings are saved in memory when you turn the power switch off, so you don't need to set them each time you use SkySensor.

4.7.1 Selecting the Setup Number

SkySensor has 10 sets of setups, numbered 0 to 9, to make it easier to configure the parameters for different observation settings. The parameters in setup #0 are specially designated as default values. The items in setup #1 through #9 may be specified to use the default value in setup #0. This allows you to change common parameters in all setups at once by changing the default value in setup #0. The items in setup #1 through #9 may be set individually to any value.

When you press SETUP key, you will first see a menu to select the setup number.

```
Setup (Current)
#0 → Default Values
```

Selection of setup number

You can specify the setup number by using NEXT, PREV, Up-direction, or Down-direction keys; or you can enter the setup number directly by using the numeric keys.

If you want to change the current setup number (the setup in use), then enter the setup number and press Right-direction key. When the setup displayed is the current setup, the first line of the display will show "(Current)" to indicate that it is the current setup.

If you want to change the parameters of the setup number being displayed, then press ENTER key to enter the setup menu. It is possible to change the parameters of the setup which is not the current setup.

Note: The label for the setups which is displayed at the setup selection menu may be edited in setup's "Setup Label" menu.

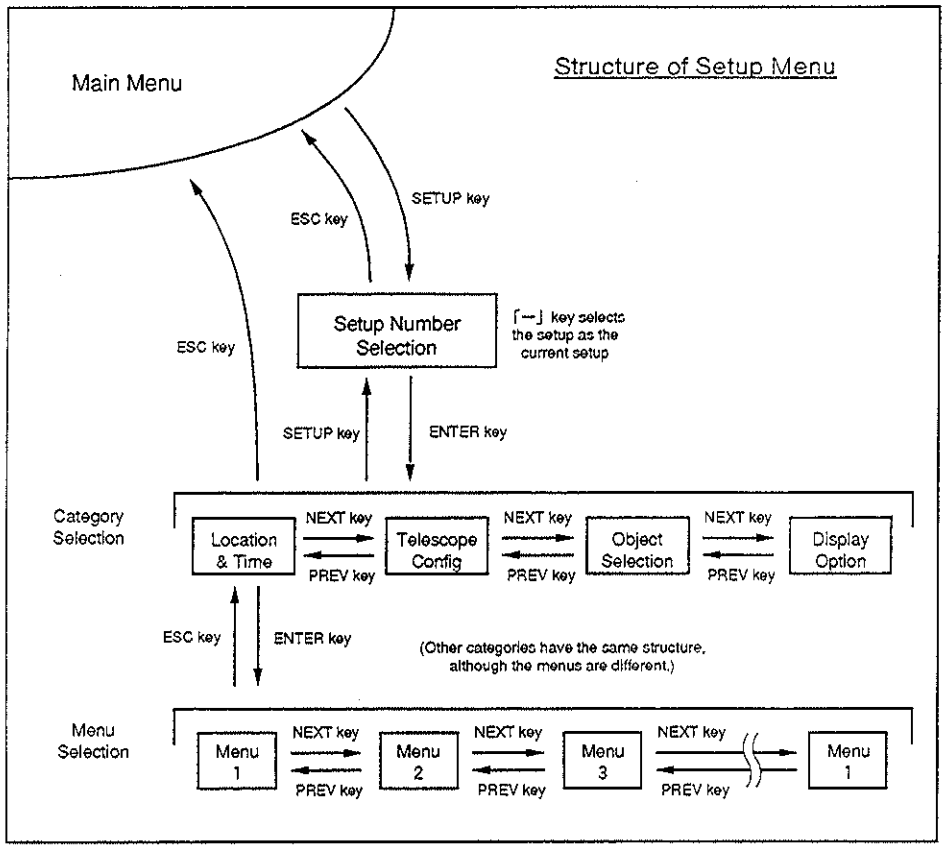
When ENTER key is pressed, the menu category selection will be displayed.

```
Setup Categories
  Location & Time
```

Setup category selection

Setup menus are divided into 4 set of categories as shown in the diagram.

Select a category by using NEXT/PREV key and press ENTER key. A menu in that category will then be displayed. For setup #0, the menu will look like the following example and



☐ Mount Mode Menu

The mount mode can be selected from "Unaligned Equatorial", "Polar-Aligned Equatorial", and "Alt-Azimuth". Use Up- and Down keys to scroll the selection.

```
Mount Mode
Unaligned Equatorial
```

Mount mode menu

When using GP/SP equatorial mounts without aligning the polar axis, select "Unaligned Equatorial". "Polar-Aligned Equatorial" mode is used mostly for taking photography of celestial objects. PEC function cannot be used unless the mount mode is set to "Polar-Aligned Equatorial".

The difference between Alt-Azimuth mode and Unaligned Equatorial is that in Unaligned Equatorial mode, the telescope is reversed when the counterweight shaft rotates above level position to prevent the telescope from colliding with the tripod, but the azimuthal (counterweight shaft) movement is not restricted (i.e., there is no telescope reversal) in Alt-Azimuth mode.

Note: Although the polar axis on SP mounts can be positioned vertically, the motor case would collide with the mount if it is used in AltAz mount mode.

Please see Section 5.1.3, "About Alignment", for more explanation on the differences between the mount modes.

☐ PEC Menu

This menu is for setting PEC functions. PEC function can only be used when the mount is in Polar-Aligned Equatorial mode. PEC menu is not displayed unless the mount mode is Polar-Aligned Equatorial.

```
PEC: Speed    Mode
 Off  0.2     Execute
```

PEC menu

The first item in the menu specifies the status of PEC function. If this setting is ON, then PEC is operating; when it's OFF, PEC is not operating.

The "Speed" column specifies the motor speed for PEC recording. The speed can be set from 0.1x to 0.9x. During PEC recording, the motors will turn at this speed setting regard-

The speed for the medium speed mode is initially set to 32x. The medium speed may be set from 0 to 99x.

The speed for the low speed mode is initially set to 2x. The low speed may be set from 0.0 to 9.9x.

☐ Motor Key Direction Menu

This menu lets you reverse the direction the telescope moves when motor keys are pressed. The direction for up-down and right-left can be changed individually. This function is useful when you want to coordinate the sense of direction in your field of view and the direction of the key.

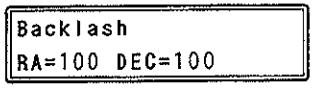
Motor control direction menu

The setting made here applies to all control modes (RaDec, AltAz, and X-Y).

☐ Backlash Menu

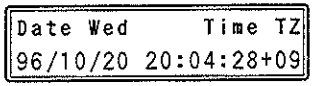
Backlash is a slop in the gear.

This menu is for setting the backlash compensation for right-ascension and declination gears. The numbers represent one-half of the encoder pulse counts to be skipped when the motor is reversed. If the compensation is too big (the telescope jumps suddenly when the motor is reversed), then number should be smaller; if the compensation is too small (the motor response is delayed), then make the number larger. Please see Section 5.6, "Setting Backlash Compensation", for detailed explanation on how to set the backlash compensation.



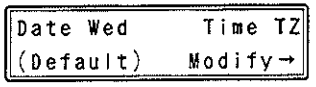
Backlash compensation menu

you will be able to modify the values displayed.



An example of setup menu

For setup #1 through #9, if the menu is set to use the default value, the menu will look like the following example to indicate that the default value is being used.



Menu showing the use of default setting

On the menu, the cursor is positioned on the right-arrow at lower right corner. If you would like to view or modify the value of the parameter, press Right key and you will get the same type of menu as in setup #0. When you change the value of the parameters in this menu, the change is only for this setup number and it will not affect the default values. If you press ENTER key to set the parameter values, then those values (even if you have not changed them) will now be used for this setup number instead of the default values.

When the menu is set not to use the default value, the menu with the values will be displayed. If you would like to set the menu back to use the default values, then press Left key when the cursor is at the left end of the line. You will then get back the default value screen. Press ENTER key to enter the choice. When entered, the display "Modify →" will disappear.

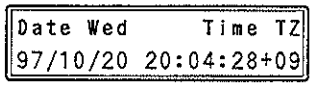
To select next or previous menus in each category, press NEXT/PREV keys.

4.7.2 Location & Time Category

In Location & Time category, parameters about the observation site are set. These parameters are used by SkySensor to compute the object's altitude and direction. The accuracy of the parameters do not affect the telescope's pointing accuracy directly, but the time should be accurate to within about 20 minutes and the coordinates of the observation site should be accurate to within about 5 degrees. However, in case of satellite observations, these parameters will greatly affect the apparent direction of the object, so they should be set as accurately as possible.

☐ Date and Time Menu

Date is entered in year/month/day format. Only the last two digits of the year is entered, from 70 (1970) to 49 (2049). Time is entered in 24 hour format, as hour:minute:second.

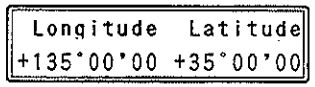


Date and time menu

The time zone (TZ) is the time difference between the local time and the Greenwich Mean Time (GMT). Its sign is plus if the local time is ahead of GMT (east of Greenwich) and minus if the local time is behind GMT (west of Greenwich). As an example, TZ for Los Angeles (on Pacific Standard Time) would be -8.

☐ Longitude and Latitude Menu

Longitude and latitude of the observation site are entered in degree-minute-second format. The sign of longitude is positive for east and negative for west. As an example, the longitude for Los Angeles is about -118 degrees and the latitude is about +34 degrees.



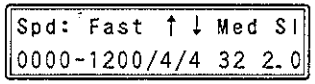
Longitude and latitude menu

4.7.3 Telescope Configuration Category

In Telescope Configuration category, parameters related to the mount, motors, and external connections are set. These parameters do not need to be set especially different from their default values for SkySensor to work. When you get familiar with the operation of SkySensor, you may want to adjust backlash compensation and set the motor speed to your preference. Other parameters may be set as need arises.

☐ Motor Speed Menu

In this menu, upper and lower limits and acceleration rates for the high speed mode, and speeds for the medium and the low speed modes are set. The initial values for these parameters are shown in the following example.



Motor speed menu

The initial speed setting for the high speed mode is 0x for the lower limit and 1200x for the upper limit.

In the high speed mode, as you press the motor keys, the motor start turning at the lower limit and accelerates until the motor speed reaches the upper limit. The acceleration rate for the motor to go from the lower limit to the upper limit is specified in the time required (in seconds) under the up arrow key. When you release the motor key, the motor will decelerate. The deceleration time to go from the upper limit to the lower limit is shown in seconds under the down arrow key. The time for acceleration and deceleration can be set from 0 to 9 seconds.

The upper and the lower limits for the high speed mode may be set from 0x to 1999x. The lower limit may not be set higher than the upper limit. If the upper limit and the lower limit are set to the same speed, then the high speed mode becomes in effect a fixed speed mode. If the upper limit is set to a speed higher than what the motor is mechanically capable to turning, then the high speed limit will be limited by the mechanical limit. When the upper limit is set much higher than the mechanical limit, the acceleration time may become inaccurate and the motor's response to the motor key may become slow.