

ASTRO-PHYSICS GTO KEYPAD

Version v4.19.3



Flash RAM Updates

Keypad flash RAM updates can be accomplished through the Internet.
Check our web site www.astro-physics.com periodically for further information.

August 2018

CONTENTS

ABOUT THIS MANUAL	5
GTO KEYPAD CONTROLLER	6
Layout and Buttons of the Keypad	6
Vacuum Fluorescent Display	6
N-S-E-W Directional Buttons	6
RA/DEC REV Button:	6
STOP Button	7
Number Buttons	7
<PREV and NEXT> Buttons	7
GoTo Button	7
± Button	7
MENU Button	7
FOC Button	7
Retractable Hanger	7
Keypad Protector	8
Installation:	8
Keypad Care and Warranty	8
Warranty	8
Keypad Battery for 256K Memory Boards	8
Keypad Battery for 512K Memory Boards	8
Cleaning Keypad Display	8
Temperature Ratings	8
GETTING STARTED – DO THIS AT HOME, IF POSSIBLE	9
Setup your Mount and Cable Connections	9
Gather Basic Information	9
Enter Your Location, Date and Time	9
Resetting Daylight Savings and Time in the Spring and Fall	11
Setting Keypad to GMT (aka UTC)	12
Practice Using your Keypad	13
YOUR FIRST OBSERVING SESSION & FOR PORTABLE MOUNTS	14
Normal Startup Sequence for Mounts that are in the field	14
Assemble Your Mount	14
Startup sequence	14
Star Sync	14
Resume Last Position	15
New Setup → New Setup Start From Park Position (press 1, 2, 3, or 4)	15
Helpful Hints	15
AUTO-CONNECT SEQUENCE – FOR PERMANENT, POLAR-ALIGNED MOUNTS	16
Important Points	16
EXTERNAL STARTUP SEQUENCE – FOR COMPUTER CONTROLLED MOUNTS	17
Important Points	17
POLAR ALIGNMENT – WHICH METHOD TO CHOOSE?	18
N Polar Calibrate - Calibrating with Polaris	18
Two-Star Calibration	19
Polar Aligning in the Daytime – Northern Hemisphere	22
Polar Aligning in the Daytime – Southern Hemisphere	24
GTO Quick Star Drift Method of Polar Alignment	26

GTO Quick Star Drift Method of Polar Alignment Quick Reference Sheet	29
How to Find Objects if You Have Less Than Perfect Polar Alignment or Non-Orthogonal Systems	30
What if I Lose My Calibration?	30
OBJECTS MENU – HAVE SOME FUN!	31
Tips for Using the Buttons and Menus	31
Procedures Common to all Slewing Commands	31
M, NGC, IC	32
Common Object Names	32
Solar System Objects (Sol)	32
Common Star Names - Non-scientific	33
Greek Star Names, organized by constellation	33
Abell Galaxy Clusters	33
ADS Double Stars (Aitken Double Star Catalog)	33
Search for Objects by Type, Magnitude, Catalog and All Sky vs. Current Constellation	34
What's Up Now Function	34
Tour Objects within Constellations	35
Custom R.A. and Dec. Coordinates	35
Custom ALT / AZ Coordinates	35
Sun Warning	36
MAIN MENU FUNCTIONS	37
Brightness of the display screen	37
Directional buttons	37
Objects	37
Setup	37
Tools	37
Time/LST	37
Slew rate (S:)	37
Button rate (B:)	37
Guiding rate(A:)	38
Tracking rate (T:)	38
Casual observing	38
SETUP MENUS	39
Locations & Time Menu	39
Set Site Location	39
Set Date & Time	39
Get Time/Loc FrMnt	39
Mount Move Limits Menu	39
R.A. Backlash Adjustment (for Visual Observers)	39
Declination Backlash Adjustment (for Visual Observers)	40
Set Safe Zone Limits for Your Telescope	41
How to Determine Your Safe Zone	41
Set Your Safe Zone	41
Set Horizon Limits for Your Telescope	42
How to Determine Your Horizon Limit	42
How Horizon Limit Works	42
Set Your Horizon Limit	42
Keypad Options Menu	43
Auto-Connect	43
Reticle Illuminator Adjustment	43
Focus Adjustment	43

Special note for the lead-free GTOCP3 control boxes	43
Keypad Update Menu	44
PARK OPTIONS	45
Park Your Telescope	45
Park – 5 Positions	45
Power Down Wherever You Want – (a power loss will not lose your position)	46
Parking and Power Considerations	46
Calibrate Menu	46
What if I lose my calibration?	47
Specify Mount Type	47
TOOLS MENU	48
Permanent Error Memory Adjustment (PEM)	48
Record Permanent Error Memory	48
Playback PEM corrections	48
Special Features	48
Photographic Timer	49
SmartGuide	49
Why do I need SmartGuide?	49
How does SmartGuide work?	49
How do I use SmartGuide?	49
Is SmartGuiding better than Auto Guiding?	50
Status	50
SLEWING DURING THE DAY	51
Potential Dangers	51
How to Observe Safely	51
ORTHOGONALITY	52
Check Orthogonality	52
Effect of Non-orthogonality on Polar Alignment	53
Polar Alignment with Non-orthogonal Telescopes	53
Additional Tips for Non-Orthogonal Systems	54
ADVANCED FEATURES	55
Sync Function	55
Tweak Your Pointing Accuracy	56
Sync Explained in Detail and compared to Re-Calibrate	56
Meridian Delay / Advance Function	59
UNDERSTANDING THE KEYPAD AND GTO CONTROL BOX FUNCTIONS	60
Functions of the GTO Servo Control Box	60
Functions of the Keypad	60
Upgrading the GTO Servo Control Box	60
Upgrading the Keypad	61
Upgrading or Repairing the Keypad Database	61
TROUBLESHOOTING	62
APPENDIX A: COLLECTIVE RELEASE NOTES	66
Version 4.19.3 – 07-29-16	66
Version 4.19.2 – 01-19-16	66
Version 4.19.1 – 01-18-16	66
Version 4.19 – 01-18-16	66

Version 4.18 – Not released	66
Version 4.17 – 10-20-08	66
Version 4.12 – 09-06-04	67
Version 4.11 – 08-28-04	67
Version 4.10 – 08-26-04	67
Version 4.07 – 02-16-04	68
APPENDIX B: REMAINING KNOWN KEYPAD ISSUES	70
Summary of Remaining Keypad Issues:	70
Eastern Longitude Values	70
Western Longitudes with Eastern Time Zones	70
Incorrect GMT Offsets When Polling the Mount from the Keypad	71
Western Longitudes at Time Zone Zero	71
Eastern Longitudes and Time Zone 12	71
Eastern Longitude Limit	71
The International Date Line	71
Fractional Time Zones	72
APPENDIX C: COMMON STARS – BY CONSTELLATION	73
APPENDIX D: ALPHABETICAL STAR LIST	77
APPENDIX E: CONSTELLATION ABBREVIATIONS	82
APPENDIX F: COMMON OBJECT NAMES	83
APPENDIX G: AITKEN’S DOUBLE STAR (ADS) LIST	84
APPENDIX H: THE GREEK ALPHABET	86
APPENDIX I: SUGGESTED STARS FOR THE GTO QUICK STAR DRIFT METHOD	87
APPENDIX J: MENU LAYOUT	90

ASTRO-PHYSICS

GTO Keypad Version 4.19.3

ABOUT THIS MANUAL

Historically, we have always included a keypad with all of our GTO equatorial mounts. Starting in October of 2015 we began offering the Keypad as an optional purchase. Many users, especially those with personal observatories and those whose principle interest is imaging, are now controlling our mounts via computer software and increasingly find that the Keypad has been relegated to storage. We made the decision to offer the Keypad as an option in order to accommodate all our customers. The Keypad is a multi-function, portable, hand-held computer which gives one total freedom to set up in the field or at Star Parties without being tethered to the extra bulk of power-hungry computers. Using it is the best way to truly be "portable"!

The Keypad is used with all the GoTo mounts that we have ever produced and can be used with any of the control boxes (GTOCP1, GTOCP2, GTOCP3 and GTOCP4).

You should note that this manual is actually one component of a three document system. Since you chose to purchase the optional Keypad, you have received this manual. The Keypad Manual applies to all mounts, detailing the keypad's many features and extensively explains its operation. A second manual is the GTO Servo Motor Drive System. Like the Keypad Manual, the GTO Servo Manual is universal to all mounts that use the Astro-Physics GTO Servo Motor Drive System with the GTOCP4 (and earlier CPx units) Servo Control Box. The final manual is the Mount Manual and is specific to the individual mount that is chosen.

As always, we highly recommend the Technical Support Section of our Web site for the latest information and for future updated versions of this and other manuals.

A final note and an apology to our friends in the southern hemisphere. Many of the instructions in this manual are written entirely from the point of view of those of us in the northern hemisphere. Since descriptive terms like left and right are meaningless without a defined point of reference, we tend to use east and west to avoid ambiguity. The east and west sides of a German equatorial mount are, of course, reversed in the southern hemisphere. At one point, our thought was to always use phrases like the following: "... on the east side (west side in the southern hemisphere) ..." This quickly became cumbersome and made the text more difficult to read. For simplicity, we decided to leave many of the explanations in their northern hemisphere framework. To our southern hemisphere friends: We appreciate you no less and apologize for this unintended slight. We know, however, that you are all smart enough to make the necessary translation to "down under" appropriate instructions. Thank you for your understanding.

PLEASE RECORD THE FOLLOWING INFORMATION FOR FUTURE REFERENCE

Keypad Serial Number: _____

Purchase Date: _____

User Name _____ Password _____

GTO KEYPAD CONTROLLER

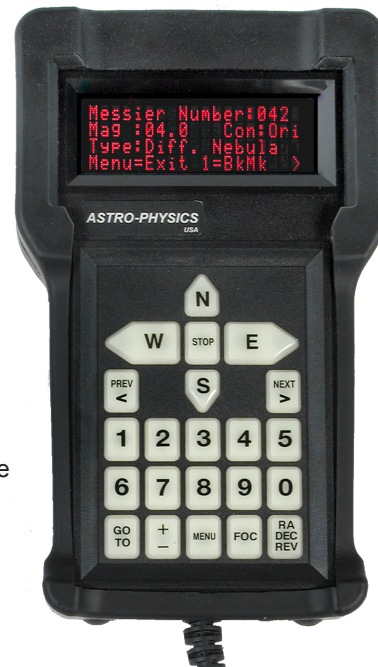
The GTO Keypad is the communication center for the operation of your GTO mount. We have designed this unit to be as intuitive and easy to use as possible while filling it with terrific features to make your observing session productive and pleasurable. With a few keystrokes, you can slew to objects by their common name or catalog number, set up search parameters to find all the open clusters (in the Messier catalog) that are visible on a given night, focus your telescope for astrophotography, set the countdown timer for the exposure, enter R.A. and Dec. coordinates to find the newest super nova, and much more.

Note: Please understand that the keypad is NOT the controller / brain of the mount. The real control is in the GTOCPx Control Box. The keypad simply provides data for the GTOCPx to do its job. Likewise, a computer with software can also duplicate everything that the keypad does. The mount can be operated using only the keypad, using only a computer, or using both.

The heart of the controller is the 4-line display screen that will guide you through all operations. The alphanumeric Keypad itself is translucent and backlit with red LEDs for easy visibility at night. The buttons are also made with a phosphoresce material that will glow in the dark for a brief time.

Button functions are clearly defined on the button itself or as an instruction on the display screen. You do not have to remember shift key patterns or complex keystroke sequences. The directional buttons are shaped like arrows to help you find them in the dark without looking at your Keypad. The stop button is readily accessible if you need to cancel any slewing request immediately.

The menu system is very easy to navigate. Each screen will display several choices, which correspond to a number button. Simply press the number button to initiate the command, e.g. "1=M, 2=NGC". When you press "1" the Messier entry screen will display and you can enter the number of the object that you wish to see. Press GoTo, which will cause the mount to slew. The <PREV and NEXT> buttons will allow you to scroll quickly through the lists of common names or to find more data about the object you are viewing. To adjust most settings, you will press the number indicated on the screen several times to scroll (toggle) through your choices and stop at the one you want.



Layout and Buttons of the Keypad

Vacuum Fluorescent Display

The Keypad features a four-line, 20 character alphanumeric display. The brightness of the display is adjustable with "dim" and "bright" settings. Please refer to the section entitled "Brightness of the display screen". If you are using the Keypad in the daylight, you will need to shade the screen from the direct light with your hand in order to see it more clearly.

N-S-E-W Directional Buttons

These four buttons are arranged so that the "E" and "W" buttons control the movement in right ascension and the "N" and "S" buttons control the declination. This is the "normal" orientation of objects in the eyepiece field. When you press the "N" button, the star should move in an upward direction toward the top of your eyepiece field. In addition, you can press two buttons simultaneously for diagonal movement, e.g. the "N" and "W" buttons will cause a "NorthWest" movement. *Note: north and south buttons can be misleading concepts in movement of the Dec. axis. The reality is that "N" moves the Dec. axis counterclockwise and "S" moves the Dec. axis clockwise.*

RA/DEC REV Button:

Press the RA/DEC REV button to access these functions, then press MENU to exit from this screen. This button serves several functions:

- **Reversing R.A. and Dec.:** If the star moves down when you push the "N" button, press the RA/DEC REV button in the lower right corner of the Keypad. A reversing menu will appear on the screen. If you want to reverse direction of the "N" and "S" button, press "2" on the Keypad and the display will change from "normal" to "reverse". You can make the same adjustment with the "E" and "W" buttons. When properly set up, the direction buttons will cause the object to move according to your orientation at the eyepiece.

RA / DEC Reverse Screen

1=Rev RA :Normal
2=Rev DEC:Normal
9=Re-Calibrate
Meridian < 0W >

- **Re-Calibrate:** If you wish to tweak your pointing accuracy, slew to an object, use the N-S-E-W directional buttons to center the object, then press the RA/DEC REV button and select “9”. This will re-calibrate your mount. Refer to the section later in the manual that for more detailed information.
- **Meridian Delay:** Advanced astro-photographers will appreciate this feature. Refer to the “Advanced Features” section of the manual that discusses “Meridian Swap” and the section on the “GTO Quick Star Drift” method of polar alignment. Do not change this setting unless you understand the consequences.

STOP Button

Press the STOP button to cancel a slewing command and stop the movement of the telescope immediately. The mount will know where it is, so you can proceed to your next command. If you move the telescope by hand, you must follow the re-calibration procedure.

Number Buttons

The buttons labeled 1–9 and 0 are used to enter numerical data and to make menu choices.

<PREV and NEXT> Buttons

These buttons are used for the following functions depending on the commands you are entering: move from one menu level to another, backspace to make corrections to number entry or scroll through lists of objects. The “<” and “>” symbols appear on many screen displays. They signify that you can press the <PREV and NEXT> buttons for more choices or additional information. These buttons are also used in conjunction with the FOCUS button as described below.

GoTo Button

Press the GoTo button after you have selected the object that you want to view. The mount will slew to the object. This button is also used for other functions, i.e. saving location data.

± Button

This button has two different functions:

- Use it to toggle between “+” and “-” when entering R.A. and Dec. coordinates.
- To change the rate of the N-S-E-W directional buttons, press the “±” button to display a selection screen. Use the <PREV and NEXT> buttons to scroll through the rates. Also you can change the guiding rate on this menu by pressing the “7=Guide Rate” button to scroll through the rates. These features can be accessed whenever the N-S-E-W buttons are active.

MENU Button

Press this button to move to a previous menu level or to cancel a prompt.

FOC Button

To use this function, you must have an electric focuser with a 6–9V DC motor (available from JMI and others) plugged into the GTO Control Panel (not available in the CP4) and the corresponding attachment to your focuser. Hold the FOCUS button with one finger and press the <PREV and NEXT> buttons to change focus. You can change the speed of the focus adjustment to either “High” or “Low”. Please refer to the Focus Adjustment section for detailed instructions and further information. **Note:** *This button does not function with modern stepper-motor focusers which have their own software. Also, the CP4 control box does not offer a focus option.*

Retractable Hanger

On the back of the controller, look for a slot with a thumb rest area. Push up to extend the hanger. A lanyard can be attached here to allow you to hang your Keypad on one of the lanyard posts or base knobs of the mount when it is not in use.

Keypad Protector

The Keypad protector is a heavy-duty molded rubber casing with a full 1/4" thickness on all impact surfaces. If you accidentally drop your Keypad, the rubber casing will absorb much of the blow. Your display, Keypad, electronics and the case itself will be protected from damage. In addition, the rubber prevents the Keypad from sliding when placed on a table or other flat surface and the Keypad will feel secure in your hands as you observe. The KEYPRO also offers protection during transport and storage.

Installation:

Caution: The KEYPRO fits closely around the Keypad controller. You must work it gently into place. If you force the rubber casing while it is being installed on your Keypad, you may tear the rubber.

1. Insert the connector and thread the cable through the opening at the bottom of the KEYPRO. Do not insert the cable and the bottom of the Keypad all the way at this time.
2. First, insert the top portion of the Keypad (the display end) into the KEYPRO.
3. Second, gently work the bottom portion with the cable connection into place.

Keypad Care and Warranty

Warranty

Keypad: Three (3) years parts and labor.

Battery: 90 days.

The Keypad manufacturer warrants that the product is free of defects in materials and/or workmanship from the date of shipment for a period of three years. This warranty does not apply to any products which have been subject to misuse, accident, alteration or if the unit has been serviced by anyone other than an authorized representative. During the warranty period, the manufacturer will, at its discretion, (1) repair the product to full working order; (2) replace the product with a comparable product. Replacement products will be new or serviceably used, comparable in function and performance to the original product. The product will be warranted for the remainder of the original warranty or ninety (90) days from the date of shipment of the product, whichever is longer. **DO NOT open a Keypad that is within its warranty period or you may void the warranty!**

Keypad Battery for 256K Memory Boards

Keypads with serial number 1565GTO or earlier that have the original 256K circuit board have a 3V Lithium battery that powers the memory so that information is retained from one session to the next. Battery life is estimated 5 years at room temperature. You can purchase replacement batteries from Astro-Physics (part # E0310) or from alternate sources. Instructions for replacement are in the Technical Support section of our website. Battery Number: CR1632

Keypad Battery for 512K Memory Boards

This includes Keypads with serial number 1568GTO or later (and some earlier Keypads that have been repaired or upgraded with a new 512K memory board). These Keypads also have a 3V Lithium battery with an estimated life of 5 years at room temperature. However, this battery has been wired into a special assembly, so the replacement battery must be purchased from Astro-Physics (part # E0334), but it can be installed by the customer. If the battery fails within the 3-year warranty period, it is best to have the manufacturer replace it. Opening the unit to replace the battery within the first three years may void the warranty.

Cleaning Keypad Display

The display window is made with a Mylar material. It is recommended to use a commercial glass cleaner to wipe down the display. Spray the cleaner on a cloth and rub the display lightly. Do not use solvents of any kind. **Note:** *It is a good idea to leave in place the protective plastic cover that ships with the Keypad, it will extend the display window's lifespan.*

Temperature Ratings

The real time clock, battery-backed RAM, Extended Temperature Vacuum Fluorescent display, and backlit panel are all rated to -40 degrees C (-40 degrees F).

GETTING STARTED – DO THIS AT HOME, IF POSSIBLE

Setup your Mount and Cable Connections

Refer to the instructions in the mount assembly manual to set up your mount. The following cables must be connected: R.A. and Dec. cables, and Keypad controller cable and power cable, preferably in that order. You do not need the mounting plate or telescope tube assembly for these setup procedures.

Gather Basic Information

You will need to enter your local parameters to ensure that the mount functions properly. The mount needs to know the local time (and if you are on daylight savings) and the longitude and latitude of your observing site. You can enter up to nine observing sites to be stored in memory.

To determine your longitude and latitude, do an internet Google search or use a GPS unit. The closer you can get the better, however, it is not necessary to be exact to the seconds (last two number entry fields) since the purpose of these entries is to calculate which objects are above your local horizon. Please make sure that your location information is in “Degrees: Hours: Seconds” format (i.e.: 42:22:00 Lat. 89:01:07 Long.), rather than “Decimal” format (i.e. 42.3667° Lat. 89.0186° Long.). Information on converting the format is in the Troubleshooting Section.

The time zone is determined from the Greenwich meridian. An excellent reference is the Standard Time Zones chart in Norton's 2000.0 Star Atlas. The Keypad will automatically determine if you are east or west of the Greenwich meridian based on your entered longitude, so entering a positive or negative number is not needed. If you live in the eastern hemisphere and observe daylight savings time, please consult “Using the Keypad and The Sky Together” for special instructions about your time zone. For your reference, these are the US time zones.

US Eastern standard time	05
US Central standard time	06
US Mountain standard time	07
US Pacific standard time	08
US Hawaii standard time	10

Most of this information will be entered only once and will be remembered by the Keypad. We recommend that you make these entries at home before you go to your observing session to ensure that you have the information that you need. If you have a GPS (Global Positioning System) device, you may want to enter the coordinates once you reach your site and have the proper numbers. Longitude and Latitude MUST be in degrees, minutes and seconds format. Decimal values must be converted – see the Troubleshooting Section. We also recommend keeping a “cheat sheet” with each location’s relevant data.

Enter Your Location, Date and Time

1. If the Location Selection Screen appears the first time you start up your mount, press “1” and GoTo, then proceed to step 2. If the Main Menu appears, begin these instructions with step 3.
2. Select option “3=ResumeLastPosition”, which will allow you to bypass this screen.
3. Main Menu should now be on the display. You will need to enter all of your Location, Time, Daylight Savings and Date settings.
4. DO NOT ATTEMPT TO SLEW TO ANY OBJECTS AT THIS POINT. You must first setup your location and time as described below and follow the instructions for Your First Observing Session.
5. Go to Keypad Options selection screen (Main Menu → 2=Setup → 3=Keypad Options). The top line displays “1=Auto-Connect”. Press “1” to toggle to “NO” if it is not set to “NO” already.
6. Press Menu to go back to the Setup Menu.
7. Press “1=Locations & Time”. Then, select “1=Site Location Data”.

Location Selection Screen

Location Selection
Enter number, then
Press GoTo to select
Location <1-9>: __

Sync, Align, and Resume Menu

1=Star-Sync
2=Polar Alignment
3=ResumeLastPosition
4=New Setup

Main Menu

1=Object	5=S:1200
2=Setup	6=B:600
3=Tools	7=A:1
4=Time/LST	8=T:Side

Setup Menu

1=Locations & Time
2=Mount Move Limits
3=Keypad Options
4=Park / Mount Opt.

8. You will now be presented with the Location Selection screen with locations 1–9 available.

9. Choose “Location 1” by entering “1” and pressing GoTo. We recommend that you set “Location 1” to the site that you observe from the most. Enter your Longitude, Latitude and Time Zone settings. Do not confuse your longitude and latitude values. We ask for longitude first – many sources will list latitude first. Choose east or west longitude and north or south latitude by using the direction buttons. If you do not wish to change the settings that are already entered, press the GoTo button to return to the “Locations & Time” menu. After you have entered the information, you **MUST** press GoTo to save your data and return to the “Locations & Time” menu. If you made a mistake, just use the <PREV and NEXT> keys to move back to it and fix it. The Keypad will beep when you exit to indicate that the data is saved.

Please note: Your longitude and latitude must be entered using the “degrees: hours: minutes” format. For help converting decimal values to this format, see the troubleshooting section.

Note on Time Zones and Daylight Savings: Like longitude, time zones are measured from the Prime Meridian. Time zones are entered into the Keypad as positive numbers, even though time zone 01 for central Europe is certainly different from time zone 01 for Iceland (2 hours different). The Keypad knows the difference because of the longitude value you enter, in particular, whether it is E or W. Daylight Savings settings allow you to keep the Keypad’s clock correct with respect to both your current local time and GMT without having to use a “fake” time zone setting.

Very Important – Daylight Savings Change: When the clocks change in the fall and spring, you must change BOTH the current local time and the daylight savings setting in order to keep the Keypad’s time consistent and correct. Please refer to “Resetting Daylight Savings and Time in the Spring and Fall” on the following page for a detailed “step-by-step”. Once you have completed the procedure go to the Main Menu press “4=TIME/LST”. Make sure that both your local time and GMT values are correct. If they are, you have done everything correctly. If they are not, you have made an error somewhere.

Locations and Time Menu

1=Site Location Data
2=Set Date & Time
3=Get Time/Loc FrMnt

Location Selection Screen

Location Selection
Enter number, then
Press GoTo to select
Location <1-9>: _

Location Input Screen

Long: W 000:00:00
Lat: N 00:00:00
Time Zone: 00
GoTo=Save MENU=Exit

10. If you wish to enter more locations (up to 9 different sites are available), please do the previous step again; changing the number for each location you enter. We suggest that you write the location number and a brief description on a piece of paper and tape it to the back of the Keypad to aid your memory.
11. After your location settings are complete, enter your time, date and daylight savings settings. Press MENU to return to the “Locations & Time” menu.
12. Press “2=Set Date & Time” on the “Locations & Time” menu. Enter the correct local time (24 – hour format), date, and current daylight savings settings, for your current location. If you made a mistake just use the <PREV and NEXT> keys to move back to it and fix it. If the settings are already correct, press the GoTo button to return to the “Locations & Time” menu. To save your changes you **MUST** press GoTo to return to the “Locations & Time” menu. The Keypad will beep to confirm your entries. Pressing MENU will exit the screen with the changes unsaved.

Time & Date Input Screen

Time: 19:23:11
Date: 08/15/2005
Daylight Savings: 1
1=Summer 0=Winter

Please note: Incorrect time settings are a common operator error. **You MUST enter the time in 24 hour format!** This is a common error when setting up in the evening. Use the correct local time as displayed on your watch AND be sure you have the correct daylight savings setting. You don’t want to change one without changing the other at the spring and fall time changes. As stated above, a good check is to look at the “4=Time/LST” screen from the main menu. **During normal time (winter) the difference between GMT and your local time should equal your time zone. During daylight savings time (summer) the difference will be your time zone MINUS 1 hour for western longitudes, and your time zone PLUS 1 hour for eastern time zones.**

13. After you have completed ALL of the above entries, turn off the power to your mount for 10–15 seconds.
14. If you wish to practice with your Keypad, refer to the next section. If you are set up at your site and are ready to observe, proceed to the section entitled “Your First Observing Session”.

IMPORTANT! There is a third choice in the “Locations and Time” menu: “3=Get Time/Loc FrMnt”. This should ONLY be used when your control box is connected to a computer and you are running a different program like *Starry Night™* or *The Sky™* to control the mount. Do not press this button to “check” the time and location. Use the “4=Time/LST” command from the Main Menu.

Resetting Daylight Savings and Time in the Spring and Fall

This revised procedure will allow you to maintain your pointing accuracy when changing the clock in your keypad to accommodate the semi-annual Daylight Savings time changes. This applies primarily to permanently mounted systems that have their keypad's Auto-connect feature set to "YES". The reason for this procedure is that the time change, when saved in the keypad, is sent to the servo as the new local time. However, the DST time change also results in a change in the net offset from GMT. The new offset is NOT sent to the servo when the time change is made, which results in a one hour error in the servo's calculated LST value. The following procedure will work around this problem in the current firmware and allow you to maintain the pointing accuracy of the mount through the time change.

1. Power up your mount as normal. You can go to an object and then center and re-calibrate if you wish.
2. Set your Auto-Connect feature to "NO"
 - a) 2 = Setup
 - b) 3 = Keypad Options
 - c) Press the "1" to toggle to 1 = Auto- Connect: NO
 - d) Press "Menu" 2 X to return to Main Menu
3. Set the tracking rate to "8 = T: Stop" by successively pressing the "8" button from the main menu.
4. Send the mount to any AP Park Position (v4.19.3 or later) or to Park 1 (v4.17 or earlier)
 - a) 2 = Setup;
 - b) 4 = Park / Mount Opt.
 - c) Press number corresponding to desired park position
 - d) Wait for the mount to slew to the Park position
 - e) Press "Menu" 3 X to return to Main Menu - mount will unpark, but tracking is stopped
5. Change Time and Daylight Savings settings
 - a) 2 = Setup
 - b) 1 = Locations & Time
 - c) 2 = Date & Time
 - d) Enter new time data and DST setting. **You MUST use 24 hour clock format.**
 - e) Press "GO TO" to save. You should hear a beep to confirm
 - f) DO NOT go to any objects or re-park the mount at this point!
6. Power down the mount and wait about 10 seconds.
7. Power the mount back up
8. At the prompt, enter your location number and then press "GO TO"
9. From the next menu:
 - a) Choose 4 = New Setup (v4.19.3 or later); select Start from Park Position (choose same as chosen in #4 above), or
 - b) Choose 4 = Resume Ref Park 1 (v4.17 or earlier) and the Main Menu should appear.
10. Set the tracking rate to "8 = T : Side" by pressing the "8" button once.
11. Go to your first object. You should be dead on.
12. Restore your preferred Auto-Connect setting if needed.

Setting Keypad to GMT (aka UTC)

Running everything on UTC is a great way to do things if the laptop is completely dedicated to astronomy endeavors. Professional astronomers all generally set everything including their lives to UTC. **The main thing to remember is that EVERYTHING needs to be set to UTC.** Normal commercial software intended for amateurs will often want to default you to a time zone. Once you have everything set up though, it's awesome.

1. From the Main menu, press 2=Setup
2. From the Setup menu, press 1=Location & Time
3. From the Location & Time menu, press 1=Site Location Data
4. On the next screen, enter the relevant site number, and then press GoTo
5. In the screen that follows, be sure to set the Time Zone = 00
6. Press GoTo to save
7. ***You MUST do this (steps 3 - 6) for all sites that you have entered
8. After the last GoTo save, press Menu to get back to the Location & Time screen.
9. Now, from the Location & Time menu, press 2=Set Date & Time
10. In the Set Date & Time screen, set the time to the current UTC time.
11. Press GoTo to save.
Hint: I often round the time up to the next minute and then watch my PC clock until it rolls over to time my press of the GoTo button. That way, they are time-synced, at least for a short while.
12. Press Menu to get back to the Main menu.
13. Press 4=Time/LST.
14. Verify that Local time = GMT
15. DONE!! Don't forget to set your astronomy computer to GMT.

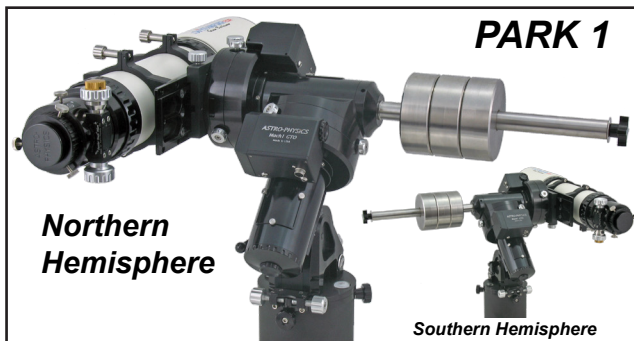
Practice Using your Keypad

You may want to try out your Keypad while the mount is set up at home. We suggest that you don't put the mounting plate, counterweights, counterweight shaft or telescope on the mount since you won't be truly polar-aligned and calibrating precisely. If your telescope is attached, you may cause it to hit the pier. Read the following instructions as you use your Keypad to simulate an observing session.

1. Use the clutches and physically move (with your hands) your mount to the Park 1 or Park 4 position as shown in the photos (note the northern and southern hemisphere differences below). Set both axes to be level with the ground. Although a bubble level would be important in a real observing session, for this purpose, a rough position is fine.

NOTE: For the southern hemisphere, the picture is mirror reversed (left to right). Also, be sure that the north / south switch on the GTOCPx control box is set correctly (the GTOCP4 does not have an N/S switch).

2. When you plug in the cable of your Keypad, the words Astro-Physics and the version number of the firmware will appear briefly. Then, the Location Selection screen will display since you have set Auto-Connect to NO in the procedure above. Please select your location by entering the desired number and press GoTo.



3. From the next screen, select "4=New Setup". The new setup screen will open and allow you to choose either Park 1, 2, 3 or 4 as your reference position. Choosing either Park 1 or Park 4 will allow you to reasonably level your mount by eye. With this information, you can reasonably simulate an observing session.
4. Proceed to the information on the Objects Menu or other topics of interest as discussed later in the manual.
5. When you are finished with your session, be sure to leave your Keypad in the "AutoConnect: NO" setting.

Sync, Align, Resume, New Setup

1=Star-Sync
2=Polar Alignment
3=ResumeLastPosition
4=New Setup

New Setup Menu

New Setup
Start From
Park Position:
Press: 1, 2, 3, 4

YOUR FIRST OBSERVING SESSION & FOR PORTABLE MOUNTS

These instructions apply to new mounts and if you are setting up your mount in different locations, for example when you travel to Star Parties.

In order for your mount to operate properly, it must have basic information: location, date, time, time zone and daylight savings. This information must come from an external computer source, i.e. the Keypad. These instructions assume that you have entered this data into your Keypad per instructions in the preceding section. Now, follow the procedures below titled "Normal Startup Sequence".

Normal Startup Sequence for Mounts that are in the field

If you are setting up your telescope in the field at a new location, you will have to use the normal startup procedure in order to provide your mount with essential information: location, date and time. Auto-Connect must be set to "NO". Additional information regarding the "YES" and "EXT" Auto-Connect selections is provided in later sections.

Assemble Your Mount

Refer to the instruction manual for your mount to set up at your observing site. Aim the polar axis toward Polaris (or the southern celestial pole) as closely as you can by sighting up the hole in the center of the polar axis or along the axis. *Using a compass App on your smart phone / device will greatly help the process.* Likewise, you will find our Right-Angle Polar Alignment Scope (RAPAS) a useful accessory for quick and easy setup.

Observers in the southern hemisphere may wish to use the Daytime Polar Alignment Routine followed by the GTO Quick Star Drift because of their lack of bright pole stars. The more accurately you polar align, the more accurate will be the centering of objects in a high-power field-of-view. Be sure that you connect your R.A. and Dec. cables, Keypad cable and power cable, preferably in that order. More information follows.



Startup sequence

1. When you turn on the power, the first display of the Keypad will briefly read "Astro-Physics" and then the firmware version number. The "Location Selection" screen will then display.

Note: If the Main Menu screen appears, that means that the Auto-Connect feature is set to "YES". Set the Auto-Connect feature to "NO" by selecting "2=Setup" and then "3=Keypad Options". Press "1" to toggle Auto-Connect to "NO". Then turn power off, wait 10–15 seconds and on again (this is called power cycling the mount) to lock in the change.

2. Choose location 1–9 and press GoTo. The next menu has 4 choices: "1=Star Sync", "2=Polar Alignment", "3=Resume-LastPosition", and "4=New Setup". If you click on Polar Alignment, you have two choices: "1=N Polar Calibrate" and "2=2 Star Calibrate". Each of these is described in following sections.

Important: We don't allow the user to back out of the startup routine (press Menu button to return to the previous screen) in order to prevent errors in the calibration process. It was possible to back out in the early versions of the Keypad; however, users erroneously thought they were calibrated when they were not. So, we force completion of this routine. If you enter information, then decide to change it, simply turn the power off, wait 10-15 seconds, and then turn it back on again. This will start the process again.

Star Sync

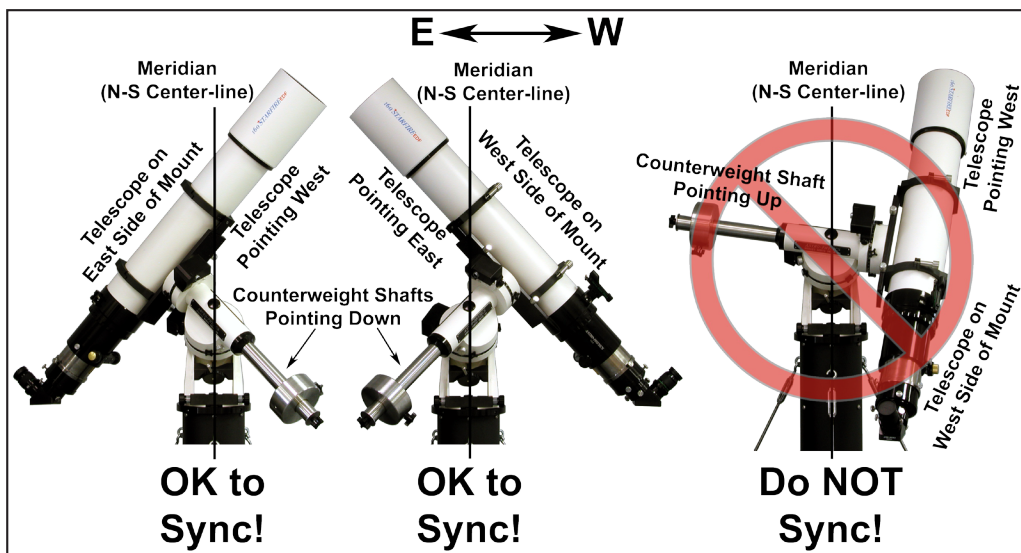
Choose Star Sync if you are properly polar-aligned by one of the other methods (polar scope, star drift, etc). Aim the scope at a known stellar or solar system object (at the end of the star list). If you need to change your button-centering rate, use the "±" key to do so. Scroll through the list to find the object, enter the object number, press the GoTo button (the mount will not actually go anywhere) and you are synchronized. The

Star Selection Menu - Polaris

Choose Star	Z=13:52
1=Polaris	<
2=Acamar	
3=Achernar	>

Main Menu will appear. You are now ready to enter any object from the Object Menu or go to the Setup Menu to make changes, as needed.

Very Important: You must point to stars in the west when your telescope is on the east side of the mount and stars in the east when your scope is on the west side. When the stars are high and close to the zenith, this can be tricky. However, you can tell which side the star is on by looking at the “z” number (also called the LST) in the upper right corner of the Choose Star screen, then comparing that number with the R.A. number of the star you choose. If the R.A. number is larger, the star is in the east; if the R.A. is smaller, the star is in the west. If your scope is not on the correct side when you sync, the mount will not slew properly and the telescope could strike the pier/tripod. Another way to tell is by looking at your counterweight shaft. If your mount is situated correctly, the shaft will point down and away from the mount. Please read the Advanced Features section of this manual for a complete discussion of the Sync command.



Resume Last Position

Choose “ResumeLastPosition” if you have previously parked the telescope after an observing session and have not moved the scope on the axes. The screen will advance to Main Menu and you are ready to enter objects or make changes in the Setup Menu.

Sync, Align, Resume, New Setup

1=Star-Sync
2=Polar Alignment
3=ResumeLastPosition
4=New Setup

New Setup → New Setup Start From Park Position (press 1, 2, 3, or 4)

For this start position you will need to have a bubble level (or at least a good eye). Physically move your mount to your chosen park position by setting both axes to be properly oriented for your positional choice. When the mount is in position, select this menu option. The Main Menu will display on the Keypad so that you can proceed with your session. This option is particularly useful when using the Polar Aligning in the Daytime procedure described in the next section.

New Setup Menu

New Setup
Start From
Park Position:
Press: 1, 2, 3, 4

Helpful Hints

- “ResumeLastPosition” is used when you parked the mount at the end of the previous session and wish to begin a new night of observing. Selecting it will initialize the mount and you’ll be ready to go to your first object.
- “New Setup” is only used when you are setting up the mount for the first time or if you have readjusted scope position via the clutches and wish to restart from a “Reference Position”.
- When resuming from a “Reference Position”, be sure that the mount is actually in the position that you wish to start in; otherwise, the misinformation will cause the mount to be lost and it could slew into the pier.
- If you are in a permanent setup, then you should set the Keypad to “AutoConnect: YES” so that when you power up the mount, it will automatically be initialized and ready to go to your first object. This is the most automated of the setups using the Keypad.

AUTO-CONNECT SEQUENCE – FOR PERMANENT, POLAR-ALIGNED MOUNTS

“Auto-connect: YES” is a simplified startup sequence appropriate for mounts that meet the following requirements:

- Remains at a fixed location and polar aligned.
- Telescope position was not disturbed since it was last used.
- You are not using an external computer to control your mount.

Please remember that you must follow the Normal Startup Sequence described in the previous section during your first session at this location before setting your Auto-Connect to “YES”.

This feature can be activated or de-activated in the Keypad Options menu. You can access this by pressing “2=Setup”, then pressing “3=Keypad Options”. Press button “1” to toggle between “YES”, “NO” and “EXT”.

When the Keypad is in the Auto-connect mode, all you need to do is connect power and the system will remember where you left off. The Main Menu will appear on the screen so that you can go directly to the Objects Menu and enter the desired objects to be viewed.

If the scope has been moved (but the mount has remained stationary), you will have to find a reference star, planet or other object in the eyepiece and sync the scope on that object with the following procedure:

1. **The Main Menu will display when you power up.**
2. **Point your telescope to a known star or solar system object.** Center in the eyepiece. (If the object drifts, you will know that you are not truly polar-aligned).
3. **Go to “1=Objects” → “5=Strs”.** Note: this list also includes solar system objects at the end of the list that you can use. The <PREV button will take you to the end of the list.
4. **Select your target object.** The Calibrate Star menu will appear for that object. Note the “>” sign in the upper right corner.
5. **Press NEXT> and the Sync menu will appear.** Double check to be sure the object is still centered.
6. **Press “1=Sync” current object and Menu to exit.**
7. **Note:** Alternatively, you may sync through the Stars/Constellation routine. It is also possible to sync on Messier, NGC, IC, Abell galaxies, ADS double stars and Objects/Constellation; however since these objects are not discrete points (or have two points, as in double stars), they are not the ideal choice for syncing.

If the scope is only off a small amount after slewing to an object, you can move the object into the center of the field with your N-S-E-W buttons or by physically pushing the tube assembly and then hit the “9=Recalibrate” in the RA/DEC Reverse menu (see Recalibration section).



**10" f/14.6 Maksutov-Cassegrain on 1200GTO
in AP observatory**

Important Points

Meridian Delay

- If you had used the Meridian Delay feature in the last observing session, then removed the power at the end of the session – when you apply power again, the meridian delay information is used to determine the position of the mount, then resets to zero. This forces you to set up the meridian delay for each session to prevent unintended consequences.
- If you parked the mount, but did not remove power – when you unpark the meridian delay setting will still be active. Be very careful to remember your settings.

EXTERNAL STARTUP SEQUENCE – FOR COMPUTER CONTROLLED MOUNTS

“Auto-Connect: EXT” is a simplified startup sequence appropriate for mounts that meet both of these requirements:

- Precisely polar-aligned
- Your mount is connected to a computer with telescope control software

This feature can be activated or de-activated in the Auto-Connect settings in the Keypad Options Menu. You can access this menu by pressing “2=Setup”, then pressing “3=Keypad Options” to enter into the Keypad Options menu. Press “1” to toggle between: “YES”, “NO”, and “EXT”.

Keypad Options Menu

1=Auto-Connect: EXT
2/3=Reticle: 0
4=Focus: Low
5=Keypad Update

Once Auto-Connect is set to “EXT”, press the Menu button until you get to the Main Menu, and then power cycle the mount (power off, wait 10–15 seconds, then power on) in order to activate this feature.

1. **Prepare your computer and software.** Ensure that your computer is connected to the mount. The CP1/2/3 will connect via a serial cable to the top serial port on the control box. The CP4 has multiple options from which to choose (see the Servo manual for explanations of the options). Check your computer’s Device Manager to see which COM port number to choose for the software connection.
2. **Power up your Mount and the External Startup Screen will appear on the Keypad.** This screen will check the mount every few seconds to see if the computer has sent it the location and time data it needs to complete the startup (initialization) process. It will patiently wait for the software connection.
3. **Connect to your mount in the computer software.** Once you make the software connection to the mount, initialization via the computer will take place and the display on the Keypad will change to the Main Menu.
4. **The Mount will now show the Main Menu and you are ready to use the Keypad or the computer.** If your telescope was moved since last time you used it, you may need to re-calibrate on a star. Refer to “Auto-Start Sequence – For Permanent, Polar-Aligned Mounts” in your GTO Keypad manual for this procedure.

Important Points

- If you have used the External Startup Sequence, do not attempt to change the time on your Keypad. Use the computer program to control the time.
- If your Keypad is set to “AutoConnect: EXT”, but you wish to start up manually, then push “Menu” and follow the procedure.

External Startup Screen

External Startup
Press MENU to cancel
external startup

POLAR ALIGNMENT – WHICH METHOD TO CHOOSE?

Important Note: We highly recommend the use of the Right-Angle Polar Alignment Scope (RAPAS) as the best and quickest way to align your mount. If you use the RAPAS for polar alignment, DO NOT follow up with either the N. Polar Calibrate or the 2-Star Calibrate alignments described below.

Use the following alignment methods if the polar scope is not available. Please note that although we include the “N Polar Calibrate” and the “2 Star Calibrate” below, they are the least accurate. The Daytime technique will get you aligned and able to look at planets and stars while the sun is still up. The GTO Quick Star Drift technique will be your most accurate method after the RAPAS.

The Keypad startup routine provides two methods: The North Polar Calibrate and the Two Star Calibrate. These two polar alignment methods, though no longer recommended, were designed for quick and coarse alignment in the field with portable setups. They are for visual observers only, not imagers. The Two Star Method is the better of the two as it is less affected by the extremely low resolution in RA near the pole and by orthogonality issues.

You need to be roughly polar-aligned before beginning the procedures. The closer you are to polar alignment when you start, the faster the procedures will be. Use a compass with magnetic offset and a level to rough align.

How accurately you need to be polar aligned is governed by your needs. If you wish to do some quick visual observing with low-power, wide-field eyepieces, you don't need to spend a lot of time aligning (see “How to Find Objects if You Have Less than Perfect Polar Alignment”). If you need accurate alignment for CCD imaging or high-power observing, you will want to use our Right-Angle Polar Alignment Scope (RAPAS) and follow-up with a comprehensive drift alignment (either traditional or Pole Align Wizard with CCD camera). Refer to the Alternate Polar Calibration Routine and Tips section.

ORTHOGONALITY - If you have difficulty achieving accurate polar alignment with the procedures below, refer to the section entitled “Orthogonality.”

N Polar Calibrate - Calibrating with Polaris

Note: We do not recommend this choice of polar alignment method due to its potential inaccuracy!

This routine uses a known star in the eastern or western sky and Polaris to align the mount. Since you are essentially using your telescope as a polar alignment scope in this routine, it is very important that the telescope be orthogonal to the mount. If it is not orthogonal, the stars will not converge no matter how many you use.

Try to pick a star that has a sufficiently different (\pm four hours) right ascension from Polaris, otherwise this method may not converge on the pole in a reasonable number of iterations. For instance, the star Arcturus is close in right ascension to Polaris and so would not be a good candidate. Arcturus is roughly 12 hrs different in R.A. from Polaris or 180 degrees opposite and close to the meridian in the south. So when the mount slews between Polaris and Arcturus, it only has to move a small amount in R.A. – about 45 minutes. Not a good choice. Your best stars for this routine will have right ascensions between 6:32 and 10:32 or between 18:32 and 22:32. Here are a few suggested stars. More possibilities can be found in Appendix I

WINTER			SUMMER		
Alphard	Alf Hya	RA 09:27:35	Altair	Alf Aql	RA 19:50:47
Pollux	Bet Gem	RA 07:45:19	Enif	Eps Peg	RA 21:44:11
Procyon	Alf CMi	RA 07:39:18	Kaus Borealis	Lam Sgr	RA 18:27:58
Regulus	Alf Leo	RA 10:08:22	Nunki	Sig Sgr	RA 18:55:16
Sirius	Alf CMa	RA 06:45:09	Vega	Alf Lyr	RA 18:36:56

1. **Check position of mount.** Be sure that the polar axis is pointed as close as possible toward Polaris (the North Star). If not, make these adjustments now. Follow the procedures to select your location in the previous section.

2. **At the Calibrate Menu, choose “1=N Polar Calibrate”.** The Choose Star display will appear. In the upper right of the screen, you will find the zenith hour displayed (e.g. Z=17:17). Zenith hour is synonymous with LST (local sidereal time). This allows you to open your star atlas to the page corresponding to the sky overhead to aid in your calibration star selection.

3. **Move telescope manually (grasp the telescope by hand and move it) to a known bright star, which will be your calibration star (Vega in this example) and center it in the eyepiece field with the N-S-E-W directional buttons.**

Calibrate Menu

Calibrate Menu
1=N Polar Calibrate
2=2 Star Calibrate

Star Selection Menu - Polaris

Choose Star Z=13:52
1=Polaris <
2=Acamar
3=Achernar >

We recommend that you use a reticle eyepiece.

Very Important: You must point to stars in the west when your telescope is on the east side of the mount and stars in the east when your scope is on the west side. When the stars are high and close to the zenith, this can be tricky. However, you can tell which side the star is on by looking at the “z” number (also called the LST) in the upper right corner of the Choose Star screen, then comparing that number with the R.A. number of the star you choose. If the R.A. number is larger, the star is in the east; if the R.A. is smaller, the star is in the west. If your scope is not on the correct side, the mount will not slew properly and the telescope could strike the pier/tripod.

4. **Select that star on Keypad.** Use the <PREV and NEXT> buttons to scroll through the star list to find the star you have chosen. Select this star by pressing the corresponding number. The R.A. and Dec. values of the star will be displayed. Please note that the LST (local sidereal time) values for your screen will be different than shown in these examples. If you have made a mistake, use the <PREV button to choose another star. There are 200 calibration stars from which to choose. Note: although the solar system objects display in the star list, you cannot use them in these calibration routines. Since the R.A./Dec. positions of these objects change with time, they are not suitable for slewing back and forth in multiple iterations. Do not use the solar system objects.

Calibrate Star Screen - Vega

< Cal Obj: Vega	
RA: 18:36:56	
DEC: +38:47:01	Press
LST:17:18:06	GoTo

5. **Press the GoTo button.** The scope will automatically slew to Polaris which should appear somewhere in the field of a low to medium power eyepiece. This will depend on how close your “rough” polar alignment is.
6. **Center Polaris with the altitude and azimuth adjusters of your mount.** Please refer back to the mount instructions. Do not use the N-S-E-W buttons to center Polaris.

If Polaris is not in the field at all, you will need to make larger adjustments to the position of your mount. Be sure that the R.A. axis is pointing as close as possible to the northern celestial pole.

Center Polaris Screen

Center Polaris in Eyepiece with Alt/Az GoTo to re-calibrate Next to Exit Cal. >

7. **Exit the calibration routine, or continue for more accurate alignment.** Remember, the more accurate your polar alignment, the more accurate your final pointing accuracy will be.
8. **To continue calibration, press GoTo again.** The star list containing the previous calibration star will display for your convenience. The mount will not slew; you are simply indicating that you wish to continue.
9. **Select the same calibration star or choose a different one from the “Choose Star” display.**
10. **Press GoTo.** The mount will slew to the star you have chosen.
11. **Center the star with the N-S-E-W buttons.**
12. **Press Menu.** The mount will slew to Polaris again.
13. **Make the altitude and azimuth adjustments to center Polaris as before.**
14. **Repeat as needed.** You can repeat this procedure any number of times until you feel that the mount is properly aligned. Each iteration should bring you closer to polar alignment.
15. **Press NEXT>.** Now that you are polar aligned, press the NEXT> button. The Main Menu will display and you are ready to observe.

Two-Star Calibration

Note: *This polar alignment method is more accurate than calibrating with Polaris, but does not have the accuracy of the Right-Angle Polar Alignment Scope.*

If Polaris is not visible, you will use the 2–Star method. The accuracy of your alignment will depend on how orthogonal the telescope is to the mount axes (refer to the “Orthogonality” section later in the manual).

If your tube assembly is not orthogonal, stay within ± 60 degrees of the celestial equator when doing a polar alignment routine. Select two stars on one side of the mount during calibration. When you are using the mount to slew to objects and it flips to the other side, use the procedure discussed in the section entitled “How to Find Objects if You Have Less Than Perfect Polar Alignment” below.

1. **Set up your mount so that the R.A. axis is pointing to the celestial pole as closely as you can.** Refer the instruc-

tion manual for your mount.

2. **At the Calibrate Menu, choose “2–Star Calibrate”.** In the upper right of the Choose Star screen, you will find the zenith hour displayed (e.g. Z=15:43). This allows you to open your star atlas to the page corresponding to the sky overhead. You can also choose stars from the lists in Appendix I based on this “Z” value.

Star Selection Menu - Polaris

Choose Star	Z=13:52
1=Polaris	<
2=Acamar	
3=Achernar	>

3. **Decide which star in the eastern sky to use as your 1st calibration star.** There are 200 calibration stars and all solar system objects from which to choose, e.g. Antares. Note: although the solar system objects display in the star list, you cannot use them in these calibration routines. Since the R.A./Dec. positions of these objects change with time, they are not suitable for slewing back and forth in multiple iterations. Do not use the solar system objects.

4. **Move telescope manually (grasp the telescope by hand and move it) to the star and center it in the eyepiece field with the N-S-E-W directional buttons.** We recommend that you use a reticle eyepiece.

Calibrate Star Screen

< Cal Obj: Antares
RA: 16:29:24
DEC: -26:25:55 Press
LST:13:53:56 GoTo

Very Important: You must point to stars in the west when your telescope is on the east side of the mount and stars in the east when your scope is on the west side. When the stars are high and close to the zenith, this can be tricky. However, you can tell which side the star is on by looking at the “Z” number (also called the LST) in the upper right corner of the Choose Star screen, then comparing that number with the R.A. number of the star you choose. If the R.A. number is larger, the star is in the east; if the R.A. is smaller, the star is in the west. If your scope is not on the correct side, the mount will not slew properly and the telescope could strike the pier or tripod. See illustration under “Star Sync” on a previous page.

5. **Select that star on Keypad.** Use the <PREV and NEXT> buttons to scroll through the star list to find the star you have chosen. Select this star by pressing the corresponding number. The R.A. and Dec. values of the star will be displayed. Please note that the LST (local sidereal time) values for your screen will be different than shown here. If you have made a mistake, use the <PREV button to choose another star.

6. **Press GoTo.** This enters the star in the calibration memory. The telescope will not move. The Choose Star screen will come up again.

7. **Choose your second star, ideally at least 6 hours difference in R.A and preferably 40 degrees or more different in Dec. (e.g. Algieba – Gam Leo).** Again, the Calibrate Star screen will appear with the coordinates of your star choice. Again, the lists in Appendix I may be helpful in choosing an appropriate second star.

Calibrate Star Screen - Algieba

< Cal Obj: Algieba
RA: 10:19:58
DEC: +19:50:28 Press
LST: 13:55:02 GoTo

8. **Press GoTo.** The mount will slew to this star. The target star should appear somewhere in the field of a low to medium power eyepiece.

9. **Center star with altitude and azimuth adjusters of the mount.** Please refer back to the mount instructions if needed. Do not use the N-S-E-W buttons to center the star. If the star is not in the field at all, you will need to make larger adjustments to the position of your mount.

Star RA / DEC Screen

Star: Algieba
RA: 10:19:58
DEC: +19:50:28
GoTo / Menu=Exit

10. **Press Menu to exit this screen.** The Choose star screen will appear.

11. **You may either end the calibration routine at this point, or continue for more accurate alignment.** Remember, the more accurate your polar alignment, the more accurate your final pointing accuracy will be.

12. **To end the calibration routine, press Menu again.**

13. **To continue calibration, choose the next star to which you want to slew.** You can choose a new star or go back to the first star. Again, at least 6 hours difference in R.A. and 40 degrees in Dec. would be ideal, however you can also pick a star with less difference. You can go back to the original star you chose (e.g. Antares) or some other star that is visible in the sky. The display will show the name of the star, R.A. and Dec. coordinates and the LST.

Calibrate Star Screen

< Cal Obj: Antares
RA: 16:29:24
DEC: -26:25:55 Press
LST:13:53:56 GoTo

14. **Press GoTo.** The mount will slew to this star.

15. **Center the star in the eyepiece.** NOTE: From this point on, and for all subsequent iterations, move half of the distance with the altitude and azimuth controls and the other half with the N-S-E-W buttons.

16. **Press Menu to exit this screen.** The Choose Star list will appear again.

17. **Choose a star.** The Calibrate Star screen will appear with the coordinates of your star choice.

18. **Press GoTo.** The mount will slew to this star. The target star should appear somewhere in the field of a low to medium power eyepiece.
19. **Center the star in the eyepiece – half of the distance with the altitude and azimuth controls and the other half with the N-S-E-W buttons.**
20. **You can repeat this procedure any number of times until you feel the mount is properly aligned.** Each iteration should bring you closer to good polar alignment.

Note: Each time you press the MENU button during this procedure, you re-calibrate on your current position.

Polar Aligning in the Daytime – Northern Hemisphere

Use the Park 1 or Park 4 position to polar align your telescope in the daytime or when Polaris is not visible. Note that Park 4 has been chosen for this procedure, as it is our recommended “horizontal” park position. Park 1 is only seconds away from tracking into a counterweight up status and, depending on your position, slews from Park 1 to western objects will cause the scope to point toward the ground when beginning the slew.

CALIBRATING IN THE DAYTIME

*Before calibrating on the sun, you MUST install a safe, quality solar filter. **DO NOT** use eyepiece solar filters as they may break in the intense heat of the sun. When you are slewing to any object in the daytime, the telescope may slew across or very near the sun. **DO NOT** look into the eyepiece as the telescope slews. **DO NOT** attempt to view any object, e.g. Venus, when it is near the sun. Permanent damage to your eye may result if you look directly at the sun with your telescope. Refer to the section on “Slewing During the Day” for further information and warnings.*

This is a great method in these situations:

- Solar observing.
- Get you up and running at a star party or observing site. You’ll have some fun pointing out the planets at twilight when the seeing may be steady.
- Get a head start on a night with a busy observing schedule. No more wasted time waiting for stars to appear to complete your setup.

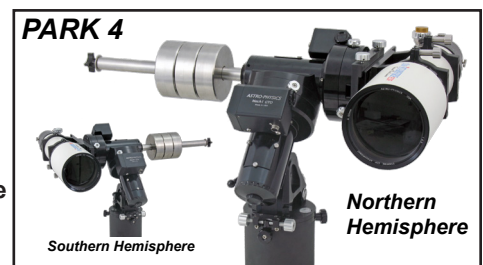
The accuracy of this method depends on how accurate your Keypad’s clock and your location has been set. Tests completed with an ordinary 7” carpenter’s level shows that the mount can be adjusted level to accuracy within 15 arc minutes. We used a Mayes brand “SUPER-CEDE” model that was purchased at a local hardware store. This level has a groove for accurate alignment on curved surfaces. It works well on both the counterweight shaft and the telescope tube.

1. Set Park 4 (or Park 1) position. *Note: Park 4 has been chosen for these instructions, but Park 1 can also be used by substituting the appropriate position changes.*

- Set up mount WITH the telescope and counterweights in a balanced state.** Be sure that your clutches are loose so that the telescope will not slew to an awkward position.
- Point the mount roughly north; a compass would be handy.** Remember that magnetic north is not true north. Compensate accordingly for your location. A little experience will tell you how many degrees magnetic north differs from true north at your site. See: < <http://www.ngdc.noaa.gov/geomag-web/#declination> > for a calculator.
- Go through the Keypad start-up routine.**
 - If auto-connect was set to “NO”, select your location and press GoTo. Next select “3=ResumeLastPosition”. This will take you to the Main Menu. Proceed directly to step “d.”
 - If auto-connect was set to “YES” (i.e. you always set up in the same spot), the Main Menu will appear right away.
- Enter “2=Setup” and then enter the “4=Park / Mount Opt.” Menu.**
- Select Park 4.** Ensure that your Dec. and R.A. clutches are loose. Hold your scope until the motors both stop. You are simply doing this to re-park the mount and temporarily stop the default sidereal tracking. When it is finished slewing, it will stop tracking and put Park 4 into memory. You will need this later. DO NOT press any more Keypad buttons at this time or tracking will resume!

2. Manually move mount to Park 4 position.

- Point the scope south and approximately level both axes.** Refer to the photo at right. The telescope tube should be on the EAST side of the mount. DO NOT use the Keypad buttons to move the mount. Move the axes via the loosened clutches.
- Place a carpenter’s level on the counterweight shaft and move the R.A. axis manually until the shaft is precisely level.** This will place your mount in the Park 4 position. At this point, the telescope tube does not need to be precisely leveled.



- c) Tighten the R.A. axis clutches so that the axis cannot be moved accidentally. Lightly tighten the Dec. clutch knobs.

3. Set Park 2 position.

- a) Your mount knows it is in the Park 4 position, and your Keypad screen should look like the image at the right.
- b) Press the MENU button once to resume from park and return to the SETUP's Park/ Mount Opt. Menu.
- c) Press "2" for Park 2. Wait until the scope has slewed to the Park 2 position.
- d) Using the bubble level, precisely level the tube manually with your hands by turning the Dec. axis only. Do not move the R.A. axis or use Keypad direction buttons.
- e) Tighten the Dec. clutches fully so that the Dec. axis cannot be accidentally moved.
- f) Press MENU to resume from park.

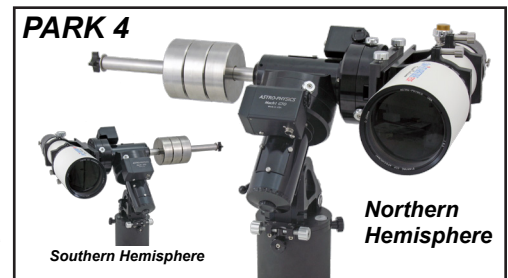
Mount Parking Screen

Pls wait till Scope reaches park point before power off MENU to Resume



4. Set Park 4 position and make altitude adjustments.

- a) Press Park 4. Wait until the scope slews to the Park 4 position.
- b) With the carpenter's level, precisely level the scope tube using the mount's altitude adjuster. DO NOT move the axes by hand or with the Keypad.
- c) Press MENU to resume from park.
- d) Optional. You may repeat the Park 2 / Park 4 procedure to improve altitude accuracy.



Use Altitude Adjuster to Level Tube

5. Slew to an object and make azimuth adjustments as needed.

- a) Scroll back to the Main Menu.
- b) Enter Objects Menu and choose the object to which you want to slew. The mount will now slew to where the object is, apart from the remaining error in the azimuth adjustment. These are some possible object choices.
 - i) Sun – The sun is the most visible choice, of course, but you must exercise extreme caution when using this target. You must use a proper solar filter if you wish to image the sun in your eyepiece. Failure to do so may damage your optics and your eyes!
 - ii) Bright star or planet - You may also choose a bright star or planet if the sun has already set or is low in the opposite side of the sky. (Remember that the bright stars can be seen in telescopes during the day!)
 - iii) Moon – BE CAREFUL OF THE SUN AROUND NEW MOON!
 - iv) If it is already dark, choose a star that is reasonably near the meridian and is in the northern or southern part of the sky. Since you are likely to be off by as much as a degree or two in azimuth, choose a star that is bright enough to find easily if it doesn't end up in the field of view of your eyepiece.
 - v) Alt/Az coordinates – If you can see a distant TV tower or other landmark, then you can check Google Maps and get an azimuth coordinate from your location and enter it into the Keypad for a Alt/Az GoTo slew.
- c) Make azimuth adjustments as needed to center the object. If the scope is pointed left or right of the object, simply turn the azimuth adjusters until the object is centered in the field.

Polar Aligning in the Daytime – Southern Hemisphere

CALIBRATING IN THE DAYTIME

Before calibrating on the sun, you **MUST** install a safe, quality solar filter. DO NOT use eyepiece solar filters as they may break in the intense heat of the sun. When you are slewing to any object in the daytime, the telescope may slew across or very near the sun. DO NOT look into the eyepiece as the telescope slews. DO NOT attempt to view any object, e.g. Venus, when it is near the sun. Permanent damage to your eye may result if you look directly at the sun with your telescope. Refer to the section on “Slewing During the Day” for further information and warnings.

This is a great method for those of you who live in the southern hemisphere, or for those of us from up north who are fortunate enough to travel “down under” for some southern skies observing and imaging. This method, combined with the GTO Quick Star Drift Method provides a quick and accurate method to achieve polar alignment in the southern hemisphere. As with the northern version, use this method for:

- Solar observing.
- A quick and simple way to get remarkably close polar alignment in the southern hemisphere – day or night.
- Get you up and running at a star party or observing site. You’ll have some fun pointing out the planets at twilight when the seeing may be steady.
- Get a head start on a night with a busy observing schedule. No more wasted time waiting for stars to appear to complete your setup.

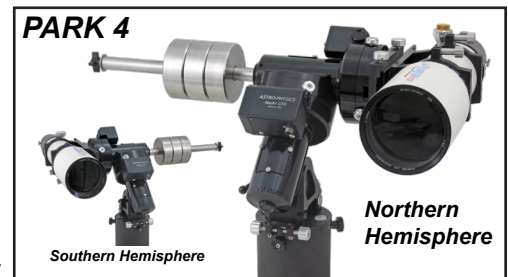
The accuracy of this method depends on how accurate your Keypad’s clock and your location has been set. Tests completed with an ordinary 7” carpenter’s level shows that the mount can be adjusted level to accuracy within 15 arc minutes. We used a Mayes brand “SUPER-CEDE” model that was purchased at a local hardware store. This level has a groove for accurate alignment on curved surfaces. It works well on both the counterweight shaft and the telescope tube.

1. Set Park 4 (or Park 1) position. *Note: Park 4 has been chosen for these instructions, but Park 1 can also be used by substituting the appropriate position changes. Park 4 is our recommended “horizontal” park position, as Park 1 is only seconds away from tracking into a counterweight up status and slews from Park 1 to western objects may cause the scope to point toward the ground when beginning the slew.*

- a) Set up mount WITH the telescope and counterweights in a balanced state.** Be sure that your clutches are loose so that the telescope will not slew to an awkward position.
- b) Point the mount roughly south; a compass would be handy.** Remember that magnetic south is not true south. Compensate accordingly for your location. A little experience will tell you how many degrees magnetic south differs from true south at your site. See: < <http://www.ngdc.noaa.gov/geomag-web/#declination> > for a calculator.
- c) Go through the Keypad start-up routine.**
 - i) If auto-connect was set to “NO”, select your location and press GoTo. Next select “3=ResumeLastPosition”. This will take you to the Main Menu. Proceed directly to step “d.”
 - ii) If auto-connect was set to “YES”, (i.e. you always set up in the same spot) the Main Menu will appear right away.
- d) Enter “2=Setup” and then enter the “4=Park / Mount Opt.” Menu.**
- e) Select Park 4.** Ensure that your Dec. and R.A. clutches are loose. Hold your scope until the motors both stop. You are simply doing this to re-park the mount and temporarily stop the default sidereal tracking. When it is finished slewing, it will stop tracking and put Park 4 into memory. You will need this later. **DO NOT** press any more Keypad buttons at this time or tracking will resume!

2. Manually move mount to Park 4 position.

- a) Point the scope north and approximately level both axes.** Refer to the photo at right. The telescope tube should be on the EAST side of the mount. **DO NOT** use the Keypad buttons to move the mount. Move the axes via the loosened clutches.
- b) Place a carpenter’s level on the counterweight shaft and move the R.A. axis manually until the shaft is precisely level.** This will place your mount in the Park 4 position. At this point, the telescope tube does not need to be



precisely leveled.

- c) **Tighten the R.A. axis clutches so that the axis cannot be moved accidentally. Lightly tighten the Dec. clutch knobs.**

3. Set Park 2 position.

- a) **Your mount knows it is in the Park 4 position, and your Keypad screen should look like the image at the right.**
- b) **Press the MENU button once to resume from park and return to the SETUP's Park/ Mount Opt. Menu.**
- c) **Press "2" for Park 2.** Wait until the scope has slewed to the Park 2 position.
- d) **Using the bubble level, precisely level the tube manually with your hands by turning the Dec. axis only.** Do not move the R.A. axis or use Keypad direction buttons.
- e) **Tighten the Dec. clutches fully so that the Dec. axis cannot be accidentally moved.**
- f) **Press MENU to resume from park.**

Mount Parking Screen

Pls wait till Scope reaches park point before power off MENU to Resume



4. Set Park 4 position and make altitude adjustments.

- a) **Press Park 4.** Wait until the scope slews to the Park 4 position.
- b) **With the carpenter's level, precisely level the scope tube using the mount's altitude adjuster.** DO NOT move the axes by hand or with the Keypad.
- c) **Press MENU to resume from park.**
- d) **Optional.** You may repeat the Park 2 / Park 4 procedure to improve altitude accuracy.



5. Slew to an object and make azimuth adjustments as needed.

- a) **Scroll back to the Main Menu.**
- b) **Enter Objects Menu and choose the object to which you want to slew.** The mount will now slew to where the object is, apart from the remaining error in the azimuth adjustment. These are some possible object choices.
 - i) Sun – The sun is the most visible choice, of course, but you must exercise extreme caution when using this target. You must use a proper solar filter if you wish to image the sun in your eyepiece. Failure to do so may damage your optics and your eyes!
 - ii) Bright star or planet - You may also choose a bright star or planet if the sun has already set or is low in the opposite side of the sky. (Remember that the bright stars can be seen in telescopes during the day!)
 - iii) Moon – BE CAREFUL OF THE SUN AROUND NEW MOON!
 - iv) If it is already dark, choose one of the stars from the table in Appendix I that accompanies the GTO Quick Star Drift Method. Pick a star that is currently reasonably near the meridian by comparing the R.A. value of the star to the LST displayed in your Keypad. Since you are likely to be off by as much as a degree or two in azimuth, choose a star that is bright enough to find easily if it doesn't end up in the field of view of your eyepiece. You will also be more accurate choosing a star that is not directly overhead, but is in the northern or southern part of the sky.
 - v) Alt/Az coordinates – If you can see a distant TV tower or other landmark, then you can check Google Maps and get an azimuth coordinate from your location and enter it into the Keypad for a Alt/Az GoTo slew.
- c) **Make azimuth adjustments as needed to center the object.** If the scope is pointed left or right of the object, simply turn the azimuth adjusters until the object is centered in the field.

Use Altitude Adjuster to Level Tube

GTO Quick Star Drift Method of Polar Alignment

(Using the Meridian Delay Feature and a Finderscope)

Note the selection of suggested stars for this procedure in Appendix I

We suggest that you use these detailed instructions the first couple times you perform this method. After you are comfortable with the procedure, a single-page Quick Reference Sheet is also provided for convenience.

The star-drift method is the favorite way that astro-photographers align their mounts. After all, they would like the least amount of drift possible during their long time exposures. An Astro-Physics GoTo mount makes it possible to simulate this method without spending a long time waiting for drift to show up. It is also easy because it separates the two adjustments of altitude and azimuth into separate operations.

This method is easiest to perform using a finder scope with a cross-hair eyepiece. There are a couple good reasons for this: First, it is easy to adjust a finder scope to make it perfectly orthogonal to the mount. Orthogonality is not a requirement for this method, but it does make the process much easier. Second, the wider field of a finder makes the first iteration or two much easier since you are very likely to already have the star of choice in the field of view. This is especially true if you would otherwise be using a long focal length telescope or a very short focal length reticle eyepiece. See the hints in #8 below.

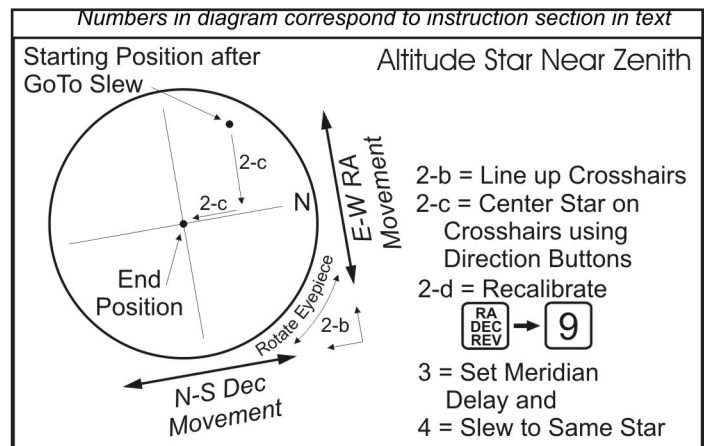
NOTE: The diagrams below portray a hypothetical example to illustrate the concept. What you actually see in your finder's reticle eyepiece will almost certainly be considerably different. In particular, your starting point will depend on whether you are east or west of the pole in azimuth, and whether you are above or below the pole in altitude. Also note that the number references in each diagram (i.e. 2-b or 5-c) refer to the corresponding instruction section in the text.

- Follow one of the start-up alignment procedures from earlier in the manual (one complete cycle) to get close.**
We have found this method particularly effective following the Daytime Polar Alignment Routine, for aligning without a polar scope. This is especially useful: 1.) in the southern hemisphere, 2.) with the 3600GTO, or 3.) in a situation where the pole is not visible. You will be at the Main Menu when you finish your start-up routine.
- Slew to a bright star that is within 1 hour of the meridian, either east or west, and as close to straight overhead in the N-S direction as possible.** The stars listed in the table in Appendix I will provide some good possibilities. See the instructions that accompany the table on how to select stars from the lists for more details.

a) **Be sure that your telescope is on the west side of the mount when pointing to a star in the east and vice versa.** Choose a bright star that is right at or just south of your zenith if you are in the northern hemisphere, and right at or just north of your zenith if you are down under. This is to protect your instrument from hitting the pier when you flip sides.

b) **Use the direction buttons to line up the reticles of your finderscope's eyepiece with the movement of the axes by turning the finderscope's eyepiece until N-S movements parallel one hair and E-W movements parallel the cross hair.**

c) **Center the star on the reticles using the N-S-E-W buttons**

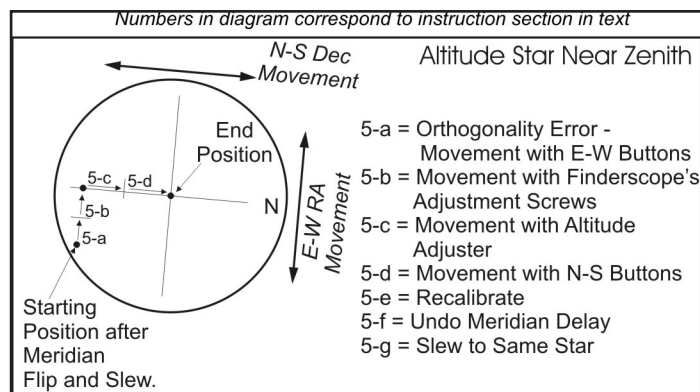


d) **Press the RA/DEC REV button; then select the "9=Re-calibrate" option (from the RA/DEC REV menu).** You will hear a beep letting you know you successfully re-calibrated.

- In the RA/DEC REV menu look at the Meridian Delay selection.** If the star is in the west, advance the meridian by 1 hour so that the display shows Meridian<1W>. Use the <PREV and NEXT> buttons to advance the hour and also change the direction to either W or E (pressing <PREV multiple times will display the hours in the east). If the star is in the east, enter <1E>. (You can verify if the star is in the east by comparing its R.A. value to the current "z" or LST value. A larger R.A. value indicates it is in the east; a smaller R.A. value indicates it is in the west.) Press MENU a couple times to return all the way back to the Objects Menu. (Don't stop at your star. Go all the way to the Objects Menu.)
- Choose the same star again, beginning from the Objects menu, and press GoTo.** Now the telescope will swap sides. The star will (hopefully) appear again in the finderscope eyepiece, but may be displaced both in R.A. and Dec. on the reticles.

5. Make altitude adjustments.

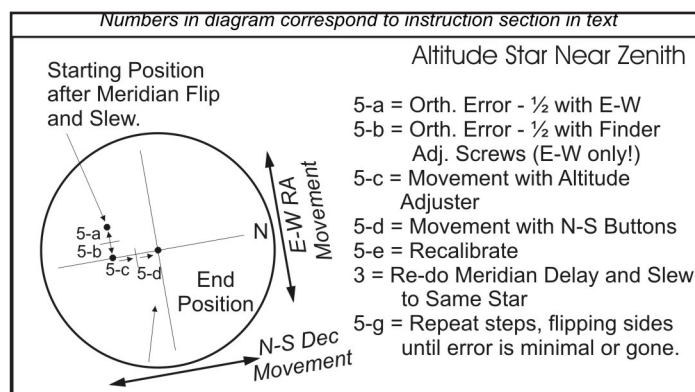
- The R.A. (east/west) error is a function of the orthogonality of the finderscope.** To make the rest of the process easier, we will adjust this out. Move one half of the E-W distance to the N-S reticle with the "E" or "W" direction button.
- Use the finderscope's adjustment screws to finish the movement onto the N-S reticle.** Try to only adjust the finder in the E-W direction. Do not move it north or south.
- Use the mount's altitude adjustment to bring the star half way toward the center of the reticle in the N-S direction.**



- Center the star the rest of the way using the N-S buttons.**
- Press the "9=Recalibrate" again in the RA/DEC REV menu.** You will hear a beep letting you know you re-calibrated. (Any time you use the Keypad's direction buttons to center an object, it is a good idea to re-calibrate.)
- Set the Meridian Delay display back to <0W>.** Press MENU to return all the way back to the Objects Menu.

g) Enter the same star again and press GoTo.

The scope will again swap sides and acquire the star on the reticles. Repeat the mechanical alignment procedure until the star remains on or close to the reticle. Each time you make an adjustment, move half the distance with the altitude adjuster (5-c) and half with the N-S buttons (5-d). Likewise for any remaining orthogonality error – half with the buttons, half with the finder's adjustment screws. Then do the re-calibration on the Keypad (5-e) before doing the next meridian swap (3).

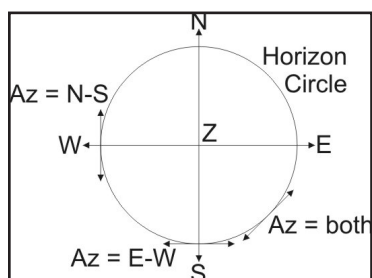


6. Make azimuth adjustments:

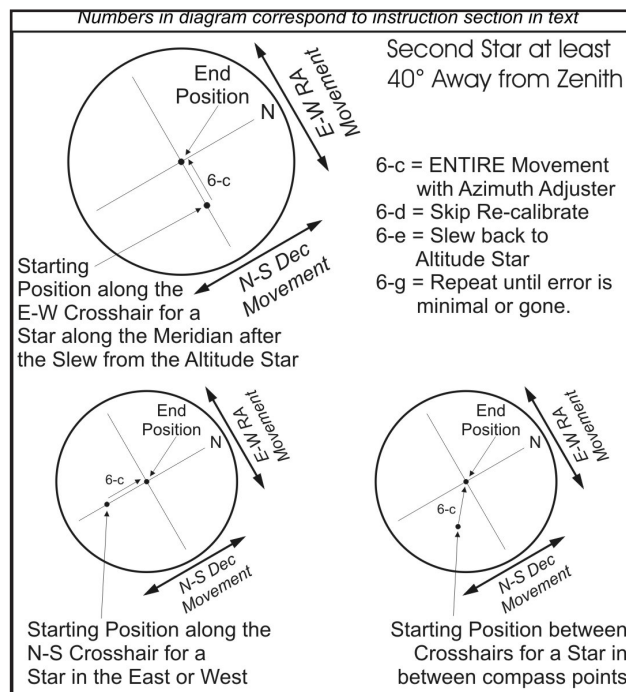
- Pick a second star that is at least 40 degrees away from the first star, and that is away from the pole.** Choose a star that is in the south, east, or west, if you are in the northern hemisphere; in the north, east or west if you are in the southern hemisphere. You can choose this star from the table in Appendix I if you wish. If you have not eliminated all of the orthogonality error, make sure that your second star is on the same side of the meridian as the first star from the altitude adjustment portion of the procedure. You do not want the telescope to swap sides and introduce any remaining orthogonality issues into the azimuth adjustment.

b) Use the GoTo to slew to the second star.

- Make THE ENTIRE centering correction with the azimuth adjuster.** Note that this movement could be along either reticle, or from a point in between depending on where in the sky you chose your second star. As the Horizon Circle diagram at left shows, stars that are in the east or west will result in azimuth adjustments that are N-S. A star along the meridian in the south (or in the north if you are in the southern hemisphere) will result in azimuth adjustments that are E-W. A star chosen between the cardinal compass points will not parallel either reticle as it is adjusted. Wherever you



adjustments that are N-S. A star along the meridian in the south (or in the north if you are in the southern hemisphere) will result in azimuth adjustments that are E-W. A star chosen between the cardinal compass points will not parallel either reticle as it is adjusted. Wherever you



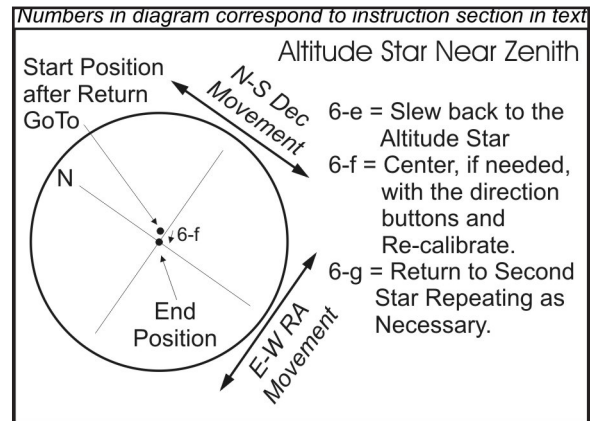
land after the GoTo slew, however, the azimuth adjustment will take you toward the center of the reticles. (Ignore any small perpendicular displacement as your azimuth adjustment brings you to the center of the eyepiece reticles, especially if your second star is near the horizon, as it will likely be from atmospheric refraction.)

- d) **No need to Re-calibrate since you have NOT used the direction buttons to do any final centering.** If you do end up tweaking with the direction buttons, then go ahead and re-calibrate, but you should not really need to do this.

- e) **Slew back to the first star (Altitude Adjustment Star).** Since it is almost directly overhead, it should be virtually centered in the reticle. This is because the azimuth adjustment you made is mostly rotating the mount around an imaginary axis that would go straight up through this star.

- f) **If needed, center with the direction buttons only, and then re-calibrate.**

- g) **Repeat as needed.** Slew back and forth between the altitude star and second star, making the adjustment described in 6-c above on the second star each time.



7. **When these two adjustments are finished, you will be very accurately polar-aligned.** If you wish, you can refine this further by using a reticle eyepiece in your main instrument and repeating the procedure. The higher magnification of the main instrument will allow greater precision than the finderscope. However, the finderscope had its orthogonality error removed during the altitude portion of the alignment. If you move to the main instrument, you will see the effects of any orthogonality error in your main instrument assembly, and you can't simply remove this error by turning adjustment screws. The accuracy when using your main instrument also depends on how well your telescope holds its orthogonality. Any mirror shifting or diagonal misalignment (that applies to refractor diagonals as well) will not only compromise the polar alignment, but also the ability to accurately center objects when slewing from one to another. Please refer to the Orthogonality section for further discussion.

8. SOME HINTS & COMMENTS:

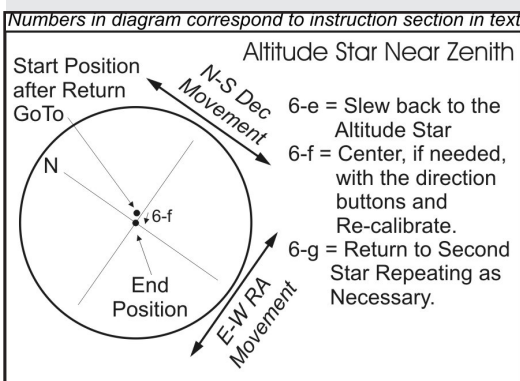
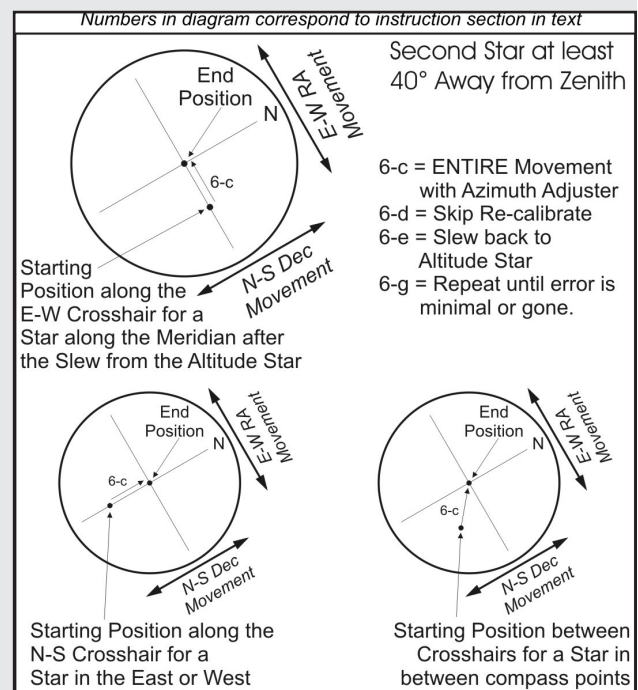
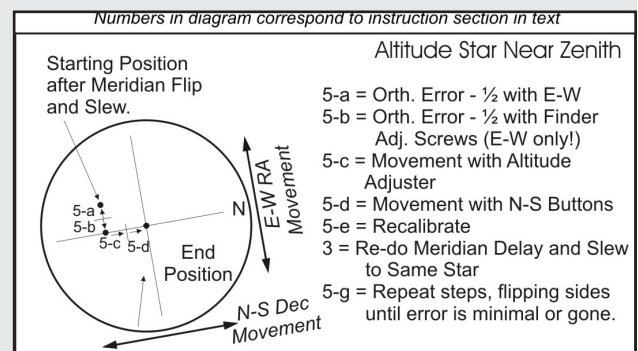
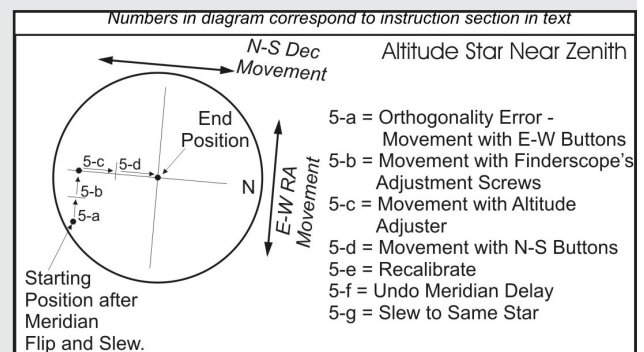
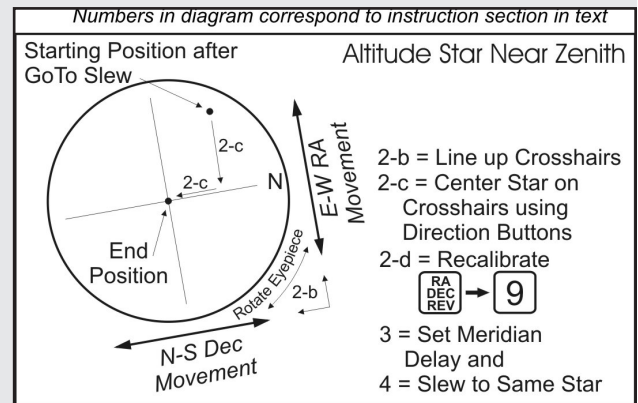
- a) You may not have a good conveniently placed star just hanging around at the zenith waiting for you to polar align. That's OK. Pick the best available star. Remember to set the meridian delay accordingly if you are more than one hour in R.A. from the meridian, and take special care to be sure that your scope will not hit the pier when you flip to the other side of the meridian (see 2-a above). Also, if your first star, your "Altitude Star" is a ways away from the zenith, the azimuth adjustment process may also need a bit of modification. In that case, first pick your second star so that it is in line with an imaginary line going through both the altitude star and the zenith. Then, ask yourself: "What is the relationship between the altitude star, the zenith and the second star?" If the Altitude star is further from the second star than the zenith point (in other words, you cross the zenith slewing from star to star), your azimuth correction can be a slight bit under and then finish the last little bit with the direction buttons. If the altitude star is closer to the second star than the true zenith, then you can very slightly over-correct with the azimuth adjuster, and then come back to the perfect center with the direction buttons. If you do this and use the direction buttons, remember to re-calibrate.
- b) The illustrations above are simply representative illustrations and will almost certainly differ somewhat from what you see in your own eyepiece. You may be starting out on the other side in either azimuth or altitude depending on whether you are east or west of the pole in azimuth and above or below it in altitude. The concept is the same.
- c) It is not necessary to do this at high power, nor is it necessary to get the star to fall exactly on the reticle. A standard 10 x 60 finderscope was used in our tests with this procedure to achieve enough accuracy to take 30 second unguided frames at a 3810 mm focal length!
- d) YES!! Performing this procedure does take the finder scope out of alignment with the main optical tube. That is, in part, why the method works so well! However, it is very quick and easy to realign the finder back to the main telescope optical axis, and it takes only a few moments. Many of those who use this method have found that they no longer really need their finders for anything other than performing the alignment anyway. The subsequent GoTo's are simply that good! As a result, they simply leave the little scope adjusted to be orthogonal to the mount, and let the mount find their targets.

GTO Quick Star Drift Method of Polar Alignment Quick Reference Sheet

1. Rough align the mount
2. Slew to star near the zenith. This will be the "Altitude Star".
 - a) Double check correct mount orientation.
 - b) Line up finderscopes reticles with direction buttons.
 - c) Center the star with the direction buttons.
 - d) Re-calibrate.
3. Set Meridian Delay:

**Star in west (R.A. value < "z" or LST value) – advance <1W>

**Star in East (R.A. value > "z" or LST value) – set back <1E>
4. Select Altitude Star again and GoTo.
5. Make Altitude Adjustments.
 - a) E-W Error = orthogonality. Correct half with E or W direction button.
 - b) Orthogonality part 2. Correct remaining E-W error with finderscope adjustment screws.
 - c) N-S error = altitude. Correct half with altitude adjuster.
 - d) Altitude part 2. Correct remaining half of N-S error with N or S direction button.
 - e) Recalibrate.
 - f) Return Meridian Delay to normal <0W>.
 - g) Select Altitude Star again and GoTo.
6. Make Azimuth Adjustments
 - a) Choose second star at least 40 deg. from altitude star that is away from the pole.
 - b) Use GoTo to slew to second star.
 - c) Correct ENTIRE error with Azimuth Adjuster.
 - d) Skip Re-calibrate.
 - e) Select and slew back to Altitude Star.
 - f) Center, if needed with direction buttons and Re-calibrate.
 - g) Repeat process until adequately aligned.



How to Find Objects if You Have Less Than Perfect Polar Alignment or Non-Orthogonal Systems

Yes, it is possible to find objects with the mounting not perfectly polar aligned. One simple and effective way is to use the Tour Mode to find and center a bright star in the constellation or area of the sky where you wish to find a faint object. Choose a bright star (use α , β or any of the first few stars in the constellation list) in the area of the sky that you wish to explore, press GoTo and center the star in your finder and/or telescope field with the N-S-E-W buttons. Press the RA/DEC REV button on your Keypad, then, select "9=Re-calibrate". Now you can tour around the neighborhood of that constellation and, unless your polar alignment is way off, you should be able to find objects in your telescope eyepiece.

While you are in a particular constellation, be sure to check out the prominent doubles. You can access them by pressing button "6=More" then button "2=ADS Double Stars". Some constellations have up to a dozen interesting doubles, which are fun to observe.

How far off is off? If your polar alignment is off by 1 degree and you calibrate on a star near the celestial equator on the meridian, your error will be about ± 1 degree going from the eastern to the western horizon. If you start in an area 1 hour from the calibration star, your error will be about ± 5 arc minutes. An 8" f/10 scope with a 12 mm Plössl ocular has an 18 arc-minute field, so the object would appear within the center 1/3 of the eyepiece field of view.

What if I Lose My Calibration?

Assuming that you are polar-aligned, you can use the re-calibrate or sync functions as described under Advanced Features later in the manual.

- A very quick way to recover from any mount orientation errors is to loosen the R.A. and Dec. clutches and while holding the scope, command it to go to a reference park position (Parks 1, 2, 3, 4). When the motors stop, put the scope in that chosen position and tighten the clutches. You are now correct once again. When you resume you will just need a slight object centering and a ReCal.

OBJECTS MENU – HAVE SOME FUN!

Tips for Using the Buttons and Menus

- **Correcting data entries** – When entering catalog numbers into the Keypad, you can use <PREV button to delete last digit entered. Enter correct digit.
- **Scrolling object lists** – Some of the object selection screens will display “<” and/or “>”, usually in the corners. These symbols indicate that you can scroll a list of objects using the <PREV or NEXT> buttons. If you hold these buttons, the object names will scroll quickly in some screens (e.g. stars).
- **N–S–E–W directional buttons** – The N-S-E-W directional buttons can be used when you are in the Main Menu, Objects menu, Photographic Timer, most Setup menus, and when the object data screens are displayed. They are not active when you are in object selection screens, i.e. when entering a Messier number.
- **Review object data of catalog items prior to slew** – Enter the number of the object that you are considering, then press NEXT>. The magnitude, object type (galaxy, globular cluster, etc.) and constellation will display. You can press GoTo in this screen to initiate a slew, if you wish, or press MENU to exit to make an alternate selection.
- **Display current object** – Return to Objects menu and press <PREV button. The object data for the last object that was selected for a slew (or that you synced on) will display.
- **Display coordinates of catalog object after a slew** – Press <PREV button. The catalog R.A. and Dec. coordinates will display. Note that the coordinates of the solar system objects display on the selection screen before you slew.
- **Actual current R.A./Dec. coordinates** – When you are in Objects menu, press NEXT>. The R.A./Dec. coordinates of the exact position of your mount will display. These may be slightly different from the above display since the calculations that compensate for atmospheric refraction and precession will change the coordinates slightly. Also, if you move the mount with the N-S-E-W directional buttons or with a software program such as *TheSky*™, this display screen will be updated.
- **Actual current Alt/Az coordinates** – When you are in Objects menu, press NEXT>. The Alt/Az coordinates of the exact position of your mount will display. Also, if you move the mount with the N-S-E-W directional buttons or with a software program such as *TheSky*™, this display screen will be updated and the display by current object screen will not.
- **Re-calibration** – You can re-calibrate on current object at any time to fine-tune your calibration. Simply press the RA/DEC REV button on the Keypad, center the object in your eyepiece with the N-S-E-W directional buttons and select 9=Re-calibrate. Please read section of the manual that discusses the uses of the re-calibrate and sync functions.
- **Sync** – You can sync on a current object after a slew by pressing the NEXT> button and selecting 1. Please read section of the manual that discusses the uses of the re-calibrate and sync functions.
- **Cancel slewing at any time** – Press STOP to cancel a slewing operation. Your telescope will stop immediately. The mount will know where it is, so proceed to the next object using the N-S-E-W buttons or catalog requests described below. Do not move the telescope by hand or you will lose calibration.

Objects Menu

<=Object RA/DEC=>		
1=M	4=Sol	7=R/D
2=NGC	5=STRS	8=Tour
3=IC	6=More	9=AIAz

Procedures Common to all Slewing Commands

- Begin all slewing requests at the Objects menu (Main Menu → “1=Objects”).
- When you press GoTo, if the object is visible from your location and within your safe-zone setting, the mount will slew automatically. If not, the screen will display the message “Object below horizon” or “Outside Safe Zone Slewing canceled ...”
- When you are ready to choose the next object to observe, press MENU once or twice as needed to return to a selection menu.
- Although the procedures for each catalog are outlined below, you will find that it is very easy to navigate. The commands are either intuitive or the screen provides instruction. You will quickly move from one object to another.
- If you move the telescope manually at any time, other than the initial calibration routine, you will lose calibration. See section “What if I lose my calibration?”
- A word about catalog databases. The R.A. and Dec. coordinates for the objects in these catalogs are based on the year 2000. Nevertheless, you will undoubtedly find differences when comparing the data to other sources even if they are also based on the year 2000. Slight differences are acceptable. We have added precession and atmospheric

refraction calculations, so the actual R.A. and Dec. coordinate position to which you will slew will vary slightly from the catalog numbers. Please let us know if you find gross discrepancies.

The separation data of double stars in the ADS catalog is based on “average” numbers. As you know the apparent separation can vary from year to year. Please consult an ephemeris for the most accurate data.

Magnitudes are estimates and may vary from one source to another. Also, some stars are variable. Some values are missing from the database and will display zeros in the field.

M, NGC, IC

These are the most common catalogs used in astronomy and include the brightest and most famous objects including galaxies, diffuse (bright) nebulae, planetary nebulae, globular clusters and open clusters. Many faint objects visible only in larger instruments are included also. A few objects are listed in more than one catalog, so there is some overlap. M (Messier) = 110 objects, NGC (New General Catalog) = 7,840 objects, IC (Index Catalog) = 5,386 objects.

1. **Go to Objects menu.**
2. **Choose M, NGC or IC** – press the number that corresponds to your choice (e.g. “1=M”).
3. **Enter the catalog number with your Keypad.**
4. **Choose action:**
 - a) **Press GoTo to initiate slewing.**
 - b) **Press NEXT> to view the object data, then press GoTo to slew.**
 - c) **Press NEXT> again to go to the Sync Menu, if you wish (assuming that you are already pointing at that object.**
 - d) **Press MENU to return to Objects menu.**

Common Object Names

This is one of our favorite features. Many of us can't remember the catalog number of an object; however we remember the common name. Use this procedure to view 100 of your favorites.

1. **From Objects menu, select “8=Tour”.**
2. **Select “3=Common Obj. Names”.** Use <PREV and NEXT> to scroll through list of names.
3. **Choose object.** The screen will display the magnitude, type of object and the constellation where it is found.
4. **Press GoTo to initiate slewing, NEXT> to go to the Sync Menu or <PREV to display R.A. and Dec. coordinates.**

Common Object Names Menu

Common Names:		
1=47 Tuc		<
2=Andromeda Galaxy		
3=Antennae		>

Solar System Objects (Sol)

WARNING - Observing during the daytime can be dangerous. You must refer to the section entitled “Slewing During the Day” for precautions.

All the planets, the Moon and the Sun

1. **From Objects menu, select “4=Sol” (Solar).**
2. **Press the number that corresponds to your choice.** The coordinates of the object will display. If not, the display will indicate that it is below the horizon.
3. **Press GoTo to initiate slewing or “Menu=Exit”.** If you select GoTo, the mount will slew to the object. The magnitude and constellation data will not display for these objects. If the object is below the horizon, the display will provide that information.

Solar System Menu

Solar Menu		7=Satn
1=Sun	4=Ven	8=Uran
2=Moon	5=Mars	9=Nept
3=Merc	6=Jupt	0=Plu

Common Star Names - Non-scientific

Many of these names are of Arabic origin. Refer to "Appendix D: Alphabetical Star List" for the stars that we have included. The appendix also shows the Flamsteed-Bayer names and the approximate magnitude of each star.

1. From Objects menu, choose "5=Strs" (Stars).
2. Select the star you wish to observe. Scroll the stars list by pressing the <PREV or NEXT> buttons. Hold button down for a more rapid scroll rate. Press the number that corresponds to your choice. The R.A. and Dec. coordinates will display.
3. Press GoTo to initiate slewing, NEXT> to Sync, <PREV to select another star or MENU to return to the Objects menu.

Star Selection Menu - Polaris

Choose Star	Z=13:52
1=Polaris	<
2=Acamar	
3=Achernar	>

Greek Star Names, organized by constellation

This menu showcases the brightest stars in each constellation.

1. From Objects menu, select "8=Tour".
2. Select "1=Stars/Constell". The display will identify the constellation to which your telescope is pointing and offer choices of stars with Greek names within that constellation. Refer to "Appendix H: Constellation Abbreviations" for the full names of the constellation and "Appendix K: The Greek Alphabet" to help read your star charts.
 - a) Use <PREV and NEXT> buttons to scroll through constellation lists. Choose a constellation that is visible.
 - b) Press "6=Prev" or "Next=0" to scroll through the list of stars available within the current constellation.
3. Choose a star. Screen will display the magnitude of the star.

Stars / Constellations Menu

< -	Cons: And	+ >
1=alf	3=chi	
2=bet	4=del	
6=Prev Stars	Next=0	

4. You have several choices: Press GoTo to initiate slewing, NEXT> to sync, <PREV for R.A. and Dec. coordinates or MENU to exit to the Stars/Constellation menu.

Constellation Star Screen

And alf
Mag: 02.6 Con: And
Type: Stars
GoTo / MENU=Exit

Abell Galaxy Clusters

We have included 2,712 of the Abell Galaxy Clusters.

1. From Objects menu, choose "6=More". This will bring you to the More Objects menu.
2. Choose "1=Abell Galaxies".
3. Enter Abell Number. Note that not all Abell Galaxies are in the database
4. Choose action:
 - a) Press GoTo to initiate slewing. If the number that you have entered is not in the database or is below the horizon, the display will let you know.
 - b) Press NEXT> to view the object data, then press GoTo to slew or NEXT> to display the sync menu.
5. Press MENU to return to "More Objects menu" to make an alternate choice.

More Objects Menu

1=Abell Galaxies
2=ADS Double Stars
3=Search
4=What's Up Now

ADS Double Stars (Aitken Double Star Catalog)

We have included 215 of the most popular double stars in this catalog. Please refer to Appendix G: Aitken's Double Star (ADS) list for the ADS numbers that we have included and the corresponding Greek star name.

1. From Objects menu, choose "8=More". This will bring you to the More Objects menu.
2. Choose "2=ADS Double Stars". The screen will display the name of the constellation to which your telescope is pointed. A list of ADS objects within that constellation is shown.

ADS Double Stars Menu

< -	Cons: Cep	+ >
1=13524	3=15600	
2=15032	4=15719	
6=Prev ADS	Next=0	

- a) Use <PREV and NEXT> buttons to scroll through constellation lists. Choose a constellation that is visible.
 - b) Press “6=Prev” or “Next=0” to scroll through the list of stars available within the current constellation.
3. **Choose a double star.** When you select an object, the screen will display the approximate separation of the stars, constellation and object type. Remember that apparent separation may vary from year to year. Consult an ephemeris for the most accurate data.
4. **Press GoTo to initiate slewing, NEXT> to sync, <PREV to view R.A. and Dec. coordinates or MENU to exit.**

Search for Objects by Type, Magnitude, Catalog and All Sky vs. Current Constellation

Use this routine to specify search parameters, e.g. if you want to view all the open clusters in the Messier catalog up to 9th magnitude that are visible in the entire sky. This is particularly useful to tailor the list to your aperture or observing preferences, or just for fun.

1. **From Objects menu, select “8=More”.** This will bring you to the More Objects Menu.
2. **Select Search Function.** The screen shown will appear.
3. **Use the Keypad to make selections to narrow the range of your search.**

Search Screen

1=Range: All Sky	
2=Type: All	
3=Mag:10	4=DB:Mess
GoTo=SrcH Menu=Exit	

- a) **Range** – Press “1” to alternate between these choices: “All Sky” and “Cur. Con.” (current constellation).
- b) **Type** – Press “2” to alternate between these choices: “All”, “Galaxy”, “Open Clus” (open cluster), “Glob Clus” (globular cluster), “Planetary” (planetary nebula), “Nebula”, “Dbl. Star” (double star)
- c) **Mag (magnitude)** – Press “3” to scroll between magnitude levels of 1–20. This will identify the highest magnitude that will be included. Use this to limit your search range to objects that are easily viewed in your telescope.

The search looks at the whole number of the magnitude so if you specify a limit of 10 in your search, objects between 10–11 will appear also (e.g. 10.6).

If an object does not have magnitude data available, it is stored as “0”. As a result, these objects will appear in your search even if they actually exceed your limit.

- d) **DB (database or catalog)** – Press “4” to alternate between these choices: “Mess” (Messier), “NGC” and “IC”.
- e) **Press GoTo.** The screen will display “Searching”.
 - i) The display will show the first item of the search and give you several choices as shown.
 - ii) If there are no objects that meet this criterion, the Search Menu screen will reappear. Specify new search criterion.
 - iii) The search times may be 30 seconds or longer if you are searching a large database, like NGC objects.
- f) **Press GoTo again if you want to slew to this object.** The mount will slew and object data will display. Press NEXT> for the sync menu or <PREV to show R.A. and Dec. coordinates.
- g) **Press Menu.** The next search object will display or if there aren’t any more, the search menu selection screen will reappear.
- h) **Press MENU again to return to Objects menu.**

What’s Up Now Function

1. **Go to the “What’s Up Now” screen.** (Main Menu → “1=Objects” menu → “6=More” → “4=What’s Up Now”)

2. **Press the Next>.** The Keypad will search its M, NGC, and IC databases and randomly suggest an object that is above the horizon at your location. Due to the complex calculations that are made to select an object, you may notice a slight pause with a message **what’s up** after pressing the NEXT> button. This is normal. The selection is random but based on what is above your current sky ho-

More Objects Menu

1=Abell Galaxies	
2=ADS Double Stars	
3=Search	
4=What’s Up Now	

hizon and if there is any horizon limit set in the Keypad. See "Set Horizon Limits For Your Telescope" for more information about this feature.

3. A typical response from What's Up shows the catalog #, magnitude, object type and constellation. You may then press GoTo to slew to that object or NEXT> to find a new one.

Tour Objects within Constellations

If you are observing within a constellation and want to know what other Messier, NGC or IC objects are nearby, this tour will provide you with lots of observing ideas.

1. From Objects menu, select "8=Tour".
2. Select "2=Objects/Constell". The display will identify the constellation to which your telescope is pointing and offer choices of objects within that constellation.
3. Use <PREV and NEXT> buttons to scroll through the alphabetical constellation lists. Choose a constellation that is visible.
4. Press "6=Prev" or "Next=0" to scroll through the list of objects available within the current constellation.
5. Choose an object. Screen will display object data including magnitude, object type and the constellation.
6. Press GoTo to initiate slewing, NEXT> to sync or <PREV to display R.A. and Dec. coordinates.

Custom R.A. and Dec. Coordinates

This menu option allows you to slew to any position in the sky as long as you know the R.A. and Dec. coordinates. This feature is particularly handy if you wish to locate comets, super novae, asteroids or any object that is not included in our catalogs.

1. From Objects menu, select "7=R/D". The Custom R.A./Dec. entry will appear.
2. Enter R.A. and Dec. coordinates. Press NEXT> to bypass any numbers that you do not wish to change. Press <PREV if you want to back up to correct an error. To change the "+" or "-" press the "±" button.
3. Press GoTo to initiate slew or "Menu=Exit".

Custom RA / DEC Entry Screen

Custom RA / DEC Entry
RA: 09:02:17
DEC: +27:58:01
GoTo / MENU to Exit

When the slew is complete, press MENU to return to the Objects menu. If you press NEXT>, the R.A. and Dec. coordinates will appear.

Important Note: When you enter custom R.A. and Dec. coordinates they should preferably be entered as precessed coordinates (JNow or Topocentric coordinates). The Keypad automatically precesses objects in its database, and any prior ReCals will have been done on precessed coordinates. However, the keypad cannot know the epoch of the coordinates that you are entering, so it only applies the small refraction transformations. Therefore, for accurate pointing, you will want to maintain consistency and enter precessed coordinates.

Custom ALT / AZ Coordinates

This menu option allows you to slew to any position in the sky as long as you know the altitude and azimuth angles. This feature is particularly handy if you wish to take your dark frame for CCD imaging or observe terrestrial objects with the tracking turned off.

1. From Objects menu, select "9=AlAz". The Custom Alt/Az Entry will appear.
2. Enter Altitude and Azimuth coordinates.
3. Press GoTo to initiate slew or "MENU=Exit". Use <PREV to make corrections.
You will now return to the Objects menu.

Custom Alt / Az Entry Screen

Custom Alt / Az Entry
Alt: 00:00:00
Az: 000:00:00
GoTo / MENU to Exit

Sun Warning

It is important to remember that slewing to objects near the sun can be quite dangerous to your eyesight. If the sun is above the horizon, the Keypad will go through an additional check routine to be sure that the object or position that you select is outside a safe viewing zone. If the object is the sun itself or within 15 degrees of the sun, the following warning will display:

Please be sure that you have installed a good quality SAFE filter that covers the optics in front of the telescope. Never use eyepiece filters since they may break due to the intense heat of the sun. Do not use solar filters that are cracked (glass), torn (Mylar) or have many pinholes (either glass and Mylar).

Bookmark Tools Menu

**WARNING: Looking at
or near the SUN can
DAMAGE your eyes.
GoTo / MENU to Exit**

MAIN MENU FUNCTIONS

Brightness of the display screen

Use the <PREV and NEXT> buttons to adjust the brightness of the display to a bright or dim setting.

Note: Even when the Keypad is set to the bright setting, it will be difficult to see during daylight hours. You will need to shield it with your hands. This is an unfortunate drawback of the vacuum-fluorescent screen. We originally chose this display because of its excellent performance in cold weather down to -40° F (-40° C, yes, the number is the same). Alternative displays scroll very slowly at temperatures below freezing and would not work well at all in extreme temperatures. Since many of our customers (and ourselves) observe during the cold Midwestern winter months, we opted for performance.

Main Menu	
1=Object	5=S:1200
2=Setup	6=B:600
3=Tools	7=A:1
4=Time/LST	8=T:Side

Directional buttons

The N-S-E-W buttons are active at this point.

Objects

This is your gateway to all object databases, tour functions and the R.A./Dec. coordinate entry screen.

Refer to the previous section of the manual for a complete discussion of the options available here.

Setup

Refer to the next section of the manual for a complete discussion of the options available here.

Tools

Refer to a later section of the manual for a complete discussion of the options available here.

Time/LST

This display screen will show your local time, date, LST (local sidereal time, also known as the zenith hour) and GMT (Greenwich Mean Time, also known as UST – Universal Standard Time). If you have not gone through the startup routine, only the local time and date will display. It cannot calculate LST and GMT until you enter your location (unless Auto-start is set to “yes”). Press and hold MENU button a few seconds to exit screen. In addition, the current selected location will appear in the lower right corner. For example, LOC=1 indicates that location 1 is currently selected.

Time Display Screen	
Time: 20:26:03	
Date: 08:16:2005	
GMT: 01:26:03	
LST: 05:14	Loc: 1

You will notice that the display will appear to skip a second once in a while. This happens because the display does not update exactly in sync with the clock. As a result, it gets slightly behind and has to skip a second to catch up. This is not a problem.

This is a display screen only. You must go into the Location and Time menu to change the data, time and location.

Slew rate (S:)

Press “5” on your Keypad to change slew rate: 1200x, 900x, or 600x. Note that the selection changes (toggles) each time you press the button. We recommend that you use slower rates in cold weather.

Button rate (B:)

Press “6” on your Keypad to change the button rate: 0.25x, 0.5x, 1x, 12x, 64x, 600x, or 1200x. This determines the rate that the mount will move when the N-S-E-W directional buttons are pushed. The selection changes each time you press the button. This rate can also be changed on a display screen accessed by the “±” button.

Guiding rate(A:)

Press “7” on your Keypad to change the Guiding rate: 0.25x, 0.5x, or 1x. This determines the rate that the mount will move when an auto-guider or computer guiding program moves the mount through the auto guider port on the control box. The selection changes each time you press the button. [The 0.25x and 0.5x rates date back to manual guiding with reticle eyepieces and should not be used with modern guide cameras.]

Note: The GTO servo control box on your mount uses the last guide rate command sent to it. The guide rate can either be controlled by the Keypad or an external source. If an external source sends the last command, the display of the Keypad cannot display the new rate.

Very Important Note: *Always choose the 1x setting when calibrating and guiding with a guide camera. Not doing so can create instability and cause the guiding corrections to continually overshoot. Also be sure that backlash compensation is set to zero in the keypad and in any computer software.*

Tracking rate (T:)

Press “8” on your Keypad to change the tracking rate: “Side” (Sidereal), “Sol” (Solar), “Lun” (Lunar) and “Stop”.

Casual observing

If you just want to make quick casual visual observations with your telescope and do not plan to use the go-to features of the Keypad controller, you can operate your telescope totally from this screen. Since you have set up your mount with the polar axis pointing toward Polaris (or the southern celestial pole) the R.A. tracking rate will help to keep your object in the field of view. You will, of course, have to move your telescope by hand from one object to another or use the directional buttons.

SETUP MENUS

Locations & Time Menu

Set Site Location

Refer to the earlier “Getting Started – Do This at Home” section for this information.

Set Date & Time

Refer to the earlier “Getting Started – Do This at Home” section for this information.

Setup Menu

1=Locations & Time
2=Mount Move Limits
3=Keypad Options
4=Park / Mount Opt.

Get Time/Loc FrMnt

If you are using an external computer to control your telescope, the mount and the Keypad could be using different location and time settings. This command will sync the Keypad with the last location that was sent to the mount by the computer through the RS-232 serial port. This feature is extremely handy for computers synced with atomic clocks and GPS units. When this feature is selected, a display will appear with the information the Keypad has obtained from the mount. Compare this screen to your computer's settings to be sure they match. If they do not match closely you may need to send the computer settings to the mount again by using the initialize command in *TheSky™* or by sending a slew command in other telescope control programs.

Get Time / Loc fr Mnt Screen

Time: 21:01:22
Long: W 089:25:00
Lat: N 42:38:00/06
Press MENU to Exit

Press MENU to leave this prompt. You will also notice if you have used this feature that your location indicator in the Time/LST menu will show LOC: E. This indicates that you are using the external information in the mount to establish your location and time rather than your preset locations in the Keypads memory.

Note: You cannot manually edit the time with your Keypad if you have selected the “Get Time/Loc Fr Mnt”. If you need to update your time, please enter the “Get Time/Loc Fr Mnt” command again.

Mount Move Limits Menu

R.A. Backlash Adjustment (for Visual Observers)

Since the R.A. motor is always running, there is no backlash or delay in the R.A. motion in 0.25x, 0.5x, and 1x. Where R.A. backlash becomes noticeable is in the 12x, 64x and higher slew rates. Here, backlash will manifest itself as a delay in the continuation of the R.A. drive. In other words, the star will continue to drift for a number of seconds after letting go of one of the two directional buttons (E or W). This is the time it takes for the motor gear train to completely reverse again in order to begin the normal tracking. For that reason, we added a short pulse of 64x sidereal to get the gearbox to re-engage quickly. There is no drift in the other direction because you are not unwinding the gear train. Adjustment of the backlash is very simple.

Mount Move Limits Screen

1=RA Backlash: 0
2=DEC Backlash: 0
3=Safe Zone: 00
4=Horizon Limit: 00

Very Important Note: Always choose the 1x guide setting when calibrating and guiding with a guide camera. Not doing so can create instability and cause the guiding corrections to continually overshoot. Also be sure that backlash compensation is set to zero in the keypad and in any computer software.

1. **At Main Menu, press 6=B.** This controls the speed of your N-S-E-W directional buttons. Continue to press 6 to scroll (toggle) through choices. You can also access your button speed anywhere you can use them by pressing the ± button and using the Button rate menu.
2. **Select 12x or any higher speed.** We recommend 12x since this is the easiest to evaluate.
3. **Choose “2=Setup” from the Main Menu.**
4. **Choose “2=Mount Move Limits” from the Setup menu.**
5. **Press “1=RA Backlash”.** As you continue to press 1, the number field will scroll 0-9. Zero will have no compensation and 9 will probably be overcompensated.

6. **Stop selection on 3 (or any other number you choose).** We recommend that you start with 3 if you are beginning your adjustment.
7. **While viewing a star at high power through an eyepiece, use the E-W buttons to test this setting at 12x.** With the proper backlash setting, the star will appear to stop moving right when the button is released. Too high a setting will cause the star to jump back a bit. If this happens select the previous number. You can now test this with out leaving the Mount Move Limits menu.
8. **Repeat process, increasing or decreasing the RA Backlash setting by 1 each time to evaluate changes.**
9. **The number will remain in permanent memory and will not need to be set again.**

The R.A. and Dec. backlash settings are retained in the Keypad memory. Each time you initialize the mount with the Keypad, these values are sent to the ROM chip in the GTO control box. The amount of backlash can vary depending on load and orientation of the telescope. It can never be precisely set, so there will always be a small delay or small overshoot.

Declination Backlash Adjustment (for Visual Observers)

When using the 1x, 0.5x and 0.25x guide rates in declination, you may find that there is a delay when attempting to reverse the motion of the star. Normally declination drift is only in one direction and will require correction with only one button. However, occasionally it may be necessary to reverse the motion. The multiple gear trains inside the drive motors take a number of encoder pulses to unwind and rewind in the opposite direction. To compensate for this, we have included a circuit that pulses the motor very rapidly for a moment before continuing at the slower rate. Because the delay varies with each motor, we have programmed a 10-position adjustment, which can be used to dial in the exact amount of compensation.

Very Important Note: *Always choose the 1x guide setting when calibrating and guiding with a guide camera. Not doing so can create instability and cause the guiding corrections to continually overshoot. Also be sure that backlash compensation is set to zero in the keypad and in any computer software.*

1. **At Main Menu, press “6=B”.** This controls the speed of your N-S-E-W directional buttons. Continue to press 6 to scroll (toggle) through choices. You can also access your button speed anywhere you can use them by pressing the “±” button and using the Button rate menu.
2. **Select 0.25x.**
3. **Choose “2=Setup” from the Main Menu.**
4. **Choose “2=Mount Move Limits” from the Setup menu.**
5. **Press “2=DEC Backlash”.** As you continue to press “2”, the number field will scroll 0–9.
6. **Stop selection on “3” (or any other number you choose).** We recommend that you start with “3” if you are beginning your adjustment.
7. **While viewing a star at high power through an eyepiece, use the N-S buttons to test this setting at 0.25x.** You have set the compensation number correctly when the telescope will move almost instantaneously when reversing the direction in declination. You can now test this with out leaving the Mount Move Limits menu.
8. **Repeat process, increasing DEC Backlash setting by “1” each time to evaluate changes.**
9. **The number will remain in permanent memory and will not need to be set again.**

Normally, Dec. backlash is adjusted only for manual guided astrophotography where the scope is always in one orientation for a long time. Even here, a different adjustment may be needed in different parts of the sky.

Set Safe Zone Limits for Your Telescope

Astro-Physics mounts are used with a wide variety of telescopes, piers, tripods and accessories. You may determine that if the telescope attempts to point to some areas of the sky, it may hit the pier or tripod. The safe zone function will allow you to control the area in which the scope is allowed to slew. Based on your safe zone setting, the Keypad will determine whether the object that you have selected for slewing is within a restricted zone or the safe zone. If the object is in an area of the sky within the restricted zone, your Keypad will display “Outside Safe Zone, Slewing canceled...” However, if you are slewing with the N-S-E-W buttons, there are no restrictions, so you must watch carefully.

How to Determine Your Safe Zone

Set up your telescope with all of the accessories you plan to use and balance your load. Move your scope through its range of motion. Can you point the scope straight up without hitting the pier or tripod? If so, leave your safe zone set at 0 degrees. This means that the entire sky can be accessed. The telescope in the photograph does not require a safe zone setting. It will move safely into all positions with a camera.

If your telescope is in danger of hitting the tripod, you must set your safe zone to some number between 0-20 degrees.

To determine this setting, move your counterweight bar to a position parallel with the ground. Take care that the telescope and accessories are moved out of the way of the pier or tripod. Note the position setting of the R.A. circle when the counterweight shaft is in this parallel position. Now, gradually move your telescope by hand to the limit of the safe zone you wish to set – as close to the pier/tripod that you are comfortable. Note the change in the position of the R.A. setting circle. You can calculate the safe zone setting based on this difference, knowing that each hour is equal to 15 degrees. For each of these mounts, each tic mark on the R.A. setting circle is equivalent to these values:

- 1200GTO – 1 degrees
- 900GTO – 1.25 degrees
- 600EGTO – 2.5 degrees
- 400GTO – 2.5 degrees
- The *Mach1*GTO, 1100GTO and 1600GTO do not have manual setting circles. Use an inclinometer or simply use your best educated guess.

The safe zone setting may vary depending on what accessories are on your scope, e.g. CCD camera with filter wheel, Daystar H-alpha filter or just an eyepiece. Remember that if you set your safe zone to a number greater than 0, you will also lose a corresponding amount of the zenith as shown in the photo.

The software that controls the mount sets the safe zone. In this manual, we are discussing Keypad control. However, if you are using an external software program, that program controls the safe zone. The Keypad settings are not active in that situation. For instance, you can set your “safe zone” in the “Telescope Limit Line” in *TheSky*™. The programs themselves do the calculations for the target object (is it within the safe zone or out-of-bounds?) to determine whether the mount should slew or not. If it is safe, the R.A./Dec. numbers are sent to the mount. If not, you are informed that the object is outside the limits. If the software program does not contain some sort of safeguard to assure the safe position of your telescope, you must be very careful and watch the movements during a slew. The mount will slew wherever it is told, even if it is not safe.



Set Your Safe Zone

1. **Go to Mount Move Limits Menu.** (Main Menu → “2=Setup” → “2=Mount Move Limits”).
2. **Press “3=Safe Zone”.** Notice that the number field changes.
3. **Enter number of degrees.** As you continue to hold “3”, the number choices increase from 0–20 and back to zero. Release “3” to stop the scroll through the numbers.

Set Horizon Limits for Your Telescope

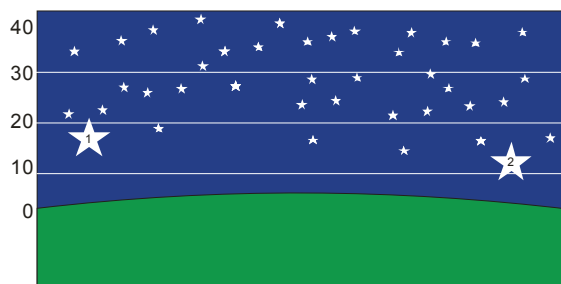
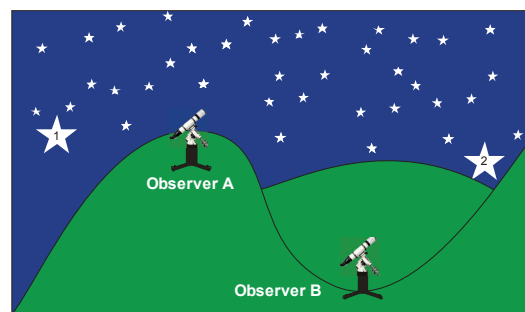
Astro-Physics mounts are used in wide variety of locations. You may determine that if the telescope attempts to point to some areas of the sky, that the object will end up behind a wall, a hill or some other obstruction that limits your horizon.

The horizon limit function will allow you to control the area in which the scope is allowed to slew. Based on your horizon limit setting, the Keypad will determine whether the object that you have selected for slewing is above the horizon or not. If the object is in an area of the sky that is below the Horizon Limit that was set, your Keypad will display "Object Below Horizon Limit. Altitude: [Value]". The value indicates how many degrees the object is above the actual horizon if you were viewing from a perfectly flat location. If the number is within a degree or two of the limit you have set or you know you have a lower horizon in the direction the object is in, you can hit GoTo and mount will slew to the object. Alternately you may hit menu to cancel the slew and choose another object from the objects menu.

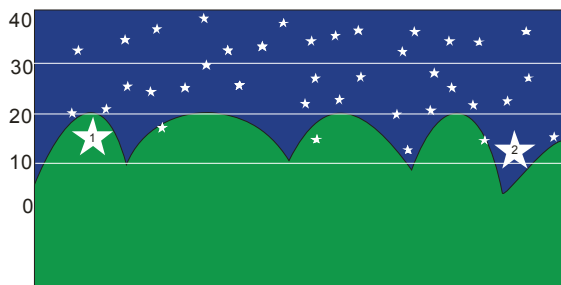
How to Determine Your Horizon Limit

Set up your telescope at the observing location. Take note of any area around the horizon that may be obstructed, i.e. by trees, houses, observatory walls, mountains, hills and so on. If you are in a valley or an observatory with high walls, your horizon limit setting will be higher than an observer on a hilltop or on an island looking over a large body of water.

Move your scope through its range of motion, notice where you cannot see the sky through the telescope. If you can see the sky in every direction you slew the scope then leave your horizon limit set at 0 degrees. This means that the entire sky can be accessed and observed without obstruction. If you do end up with obstructions you can consider setting the horizon limit.



Observer A View Horizon Limit Setting = 0



Observer B View Horizon Limit Setting = 20

How Horizon Limit Works

Observer A's site is on a hill with a very long distant local horizon, whereas Observer B is in a valley with a very close and obstructed horizon. Observer A would set their horizon limit at 0 because they can see the entire sky. Whereas Observer B in the valley would set their horizon limit to around 20 to tell the mount to prompt them if they attempt to slew to an object that would be below their local horizon.

If Observer B attempted to view Star 1 the object would be below their horizon (hidden by a nearby hill) and the Keypad would prompt to tell them this. If Observer B attempted to view Star 2 the Keypad would prompt them that the object was below the horizon but Observer B would know they could see Star 2 and would press GoTo to override the horizon limit slew to mount to observe it.

Remember that if you set your horizon limit to a number greater than 0, you will be prompted to view any object below the limit. If you are prompted often for objects that are visible above the horizon, adjust your limit lower. If you are not being prompted for objects that are below the horizon at your location, consider raising the number.

The software that controls the mount sets the horizon limit. In this manual, we are discussing Keypad control. However, if you are using an external software program, that program controls the horizon. The Keypad settings are not active in that situation and you might end up slewing to an object below your local horizon.

Set Your Horizon Limit

1. **Go to Mount Move Limits Menu.** (Main Menu → "2=Setup" → "2=Mount Move Limits").
2. **Press "4=Horizon Lim".** Notice that the number field changes.
3. **Enter number of degrees.** As you continue to hold "4", the number choices increase from 0–50 and back to zero. Release "4" to stop the scroll through the numbers.

Keypad Options Menu

Auto-Connect

These are the options that control how your Keypad will connect to your mount when you start up at the beginning of each session. Toggle these options by pressing “1”.

- If Auto-Connect is set to “NO”, the Location Selection screen will appear when you start up your mount. Refer to the section entitled: “Normal Startup Sequence for Mounts that are in the field” in this manual.
- If Auto-Connect is set to “YES”, the Main Menu will appear. Refer to the section entitled: Auto-Connect Sequence – For Permanent, Polar-aligned Mounts”
- If Auto-Connect is set to “EXT”, the Keypad will wait until location and time data is sent to the mount through the serial port. Refer to the section entitled: “External Startup Sequence – For Mounts that are Controlled by an External Computer” for instructions regarding this feature. If you are not using external software during that session, press Menu. The Location Selection screen will appear so that you can initialize the mount with the Keypad. Follow the procedures in the “External Startup Sequence – For Computer Controlled Mounts” section of the manual.

Keypad Options Menu

1=Auto-Connect: NO
2/3=Reticle: 0
4=Focus: Low
5=Keypad Update

Reticle Illuminator Adjustment

The brightness of an illuminated reticle can be adjusted with the Keypad. Plug the cord of the reticle into the connector on the GTO Servo Control Box. Note: This function is not available on the CP4.

1. **Go to the Keypad Options Menu.** (Main Menu → “2=Setup” → “3=Keypad Options”).
2. **Press the “2” and “3” buttons to desired brightness level from 0–9.** Button “3” will increase, “2” will decrease.

Focus Adjustment

If you are using an electric focuser that has a 6–9V DC motor (like the JMI Motofocus), you can control the in and out focus movement with the Keypad. This function will only work with DC motors. You cannot operate focusers that incorporate stepper motors with the GTO Keypad and control box. Stepper motor focuser systems (RoboFocus, OPTEC, StarLight Instruments, etc.) will each have their own unique stepper driver and must be used with their own control devices.

Note: This function is not available on the CP4.

1. **Plug the power cord of the focus unit into the CP1/2/3 Servo Control Box.**
2. **Hold the “FOC” button on the Keypad with one finger and press the <PREV or NEXT> buttons to change focus.**
3. **To change the speed, go to Keypad Options Menu.** (“2=Setup” → “3=Keypad Options”).
4. **Press “4=Focus”.** The rate choice will alternate (toggle) between Low and High. Note that the Low speed may not work with some focus motors.
5. **Select rate.**

Special note for the lead-free GTOCP3 control boxes

(shipped to the European Union between November, 2006 and June, 2007)

In order to comply with the lead-free requirements that became effective in the European Union on July 1, 2006, Astro-Physics redesigned the GTOCP3 control box using lead-free components. Unfortunately, we were unable to obtain an equivalent focus motor driver chip to replace the original chip until mid 2007. As a result, 6–9V DC focus motors will not function at both slow and fast speeds when plugged into the control box. Fortunately, these focus motors have their own control devices so you will still be able to use them. Please read the section below for more information regarding DC focus motor function, if you use one.

Most of the new focus motors now on the market employ stepper motors that are operated with their own controllers and our GTOCP3 control box is not used to power them. Current models from Optec (TCFS, TCFS3), StarLight Instruments (Digital FeatherTouch System), Technical Innovations (RoboFocus) and Finger Lakes Instruments (DF-2, PDF and Atlas) all have stepper motors with both proprietary controllers and ASCOM compatibility. If you are using these focus units, you will continue to use them in the same way that you always have. The reduced focus function of the GTOCP3 control box will not impact you at all.

Keypad Update Menu

This feature allows updates of the Keypad object database when they are available in the future. It also will allow you to set your Keypad back to all of the factory default values resetting all of your entered location data and settings. You will not need to go into this menu during the normal use of your mount. If you enter this screen by mistake, press the menu button to exit.

There are two parts of the Keypad firmware. One controls the actual program function/features which sends commands to the mount, i.e. the CPx control box. The version number (v4.19.3) is briefly seen upon power up.

The second controls the object databases (R.A./Dec. coordinates, magnitudes, constellations). It is to be noted that the internal Keypad battery's function is to maintain the database. When the battery fails (average 5–6 years), then the database will need to be downloaded and reinstalled.

If you press "1=Reset Keypad", your personal settings (location, time, time zone, daylight savings, R.A. and Dec. backlash) will all be set to the default zero values. This may be useful if you purchase a used mount and wish to set the parameters yourself.

PARK OPTIONS

Park Your Telescope

The Keypad allows you to park the telescope at the end of your observing session. You can then turn off the power and the mount will retain this position for the next session. When the park command is cancelled, you are ready to resume without going through the calibration routine. Once the telescope is parked, it cannot be moved by hand or the calibration will be lost and you will have to repeat the startup sequence at the beginning of your next observing session.

In January 2016, Astro-Physics added new park positions to the Keypad: Park 4 and Park 0. These are now offered in addition to Park 1, 2 and 3. Please read the descriptions of each below and determine which best suits your needs.

It is important to understand that parking is a state of being. When the mount is next powered up, it will not begin tracking until it is told to do so. This is a very safe state.

Park 0 ("Park in Place") was created to allow the Keypad to park the mount in its current position, wherever that might be, and to remain parked when next powered up. This is an important distinction from simply powering off the mount as described below.

There are six options to parking. You may choose one of four pre-determined park positions, plus the "Park in Place", or you may simply remove the power and the drive electronics will store the information regarding the last position in its memory (though it will immediately begin tracking when next powered up).

Park – 5 Positions

- Go to Mount Menu.** Main Menu → "2=Setup" → "4=Park / Mount Opt".
- Choose either 0, 1, 2, 3 or 4 with the buttons.** Depending on which number you choose, the scope will slew to one of the park positions shown in the photos (Park 0 will park at the current location). The screen will state, "Pls wait till scope reaches park point before power off". If you press MENU, the mount will unpark and start tracking.



- Remove the power to avoid potential damage by lightning.** Disconnect the power supply from the wall for optimal protection.

- Turn the power on when you are ready to begin your next observing session.**

- If Auto-connect is set to "YES", the mount will initialize and begin tracking in R.A. when you apply power.
- If Auto-connect is set to "NO", the mount will not begin tracking in R.A. until you choose your location from the Site Menu, then select "ResumeLast-Position".

- If Auto-connect is set to "EXT", the mount will not begin tracking in R.A. until it receives location and time data from an external computer.



Park 0 (Park in Place)

Northern Hemisphere and Southern Hemisphere

Park 0 is used to put the mount into a parked state at your current position. "Park" is more than just a position. It is a state-of-being in which the motors are de-energized. The mount will remain in a parked state when it is powered up the next time. It will await initialization from the control program, whether it be the Keypad or a computer program.

If the mount is not parked before power down, it may begin tracking when next powered up.

Power Down Wherever You Want – (a power loss will not lose your position)

Although we offer various park positions for your convenience, you can simply power off and the mount will remember where it is pointed. The position is saved to the control box memory. Assuming that your keypad is set to "AutoConnect: YES", this is quite useful if you have a brief power outage during an imaging session since it will resume tracking immediately. However, if your keypad is set to "AutoConnect: NO", the mount must be initialized right away to avoid a timing error which has the potential to track into a counterweight up position before initializing and cause the first GoTo slew to take the scope into the pier!

1. Set Auto-connect to "YES". Main Menu → "2=Setup" → "3=Keypad Options". Toggle "1" to set "YES" (the other choices are "NO" and "EXT").
2. When you have finished your observing session, simply turn the power off. *Please do not power down the mount with the counterweights higher than the telescope...it is not a recommended position from which to restart.*
3. When you restore the power, the Keypad will display the Main Menu and will begin tracking in R.A. again. It will have remembered your location, date/time and will know where your scope is pointed (assuming that you have not moved your telescope via clutches in the interim) and be ready to go to your first object. **This will also be true if you experience an abrupt power loss! The CPx will write its position and other information to memory via residual capacitor power.**

Parking the mount in an established position (Park 1, 2, 3, 4 or 0) avoids that timing error since the mount will remain parked after power up until initialized. If you must park in a custom location, we recommend Park 0.

Parking and Power Considerations

12V DC powers the mount; however you can use a 110 to 12V DC power supply (5 amp minimum) whenever 110V is available. If you have a heavy load, you may consider up to 16V. We recommend that you do not leave your mount plugged into 110V current when you are not observing. It is better to remove the power plug and all connections to other electronic equipment that is plugged into a power source, i.e. serial cables connected to your computer, so that if your observatory is struck by lightning or a severe power surge occurs, your drive electronics will not be damaged. We recommend that you take the same precautions with your drive electronics that you would take with any fine electronic equipment.

The Park function in the Keypad will stop the R.A. tracking – the mount goes into a non-driven quiescent mode. All power is removed from the servomotors, but the micro-controller does not sleep and is waiting for a command to start moving again. Normally, this would be a software signal from the Keypad or planetarium program, but it is possible that a surge or glitch in the power can mimic a command to start moving. If you don't turn off the power, you may find your scope jammed up against the mount or the ceiling of your observatory the next morning. We suggest the following routine. Park the scope and wait for the motors to stop moving. Pull the plug on the battery or disconnect from the power supply. Never walk away from the scope during the parking slew and then forget to remove power.

If you have a permanent observatory with remote operation and are using a 12-volt power supply, we suggest that you turn the power off with some kind of switch. We strongly recommend that this switch cut BOTH sides of the line to prevent any possibility of damage from a nearby lightning strike. If even one wire is connected to the 110-volt line, there is the possibility of a ground loop picking up electrical energy and feeding it into the servo drive. The 12-volt input is filtered and can take quite a bit of energy; however lightning can generate enormous currents in a length of wire that can cause damage.

Calibrate Menu

You can also access a calibration menu from the Setup Menu, as follows, if you accidentally move the mount and telescope, without removing power, and must re-calibrate. Normally, this procedure would not be used in the middle of an observing session.

1. **Go to Park / Mount Opt. Menu.** (Main Menu → 2=Setup → 4=Park / Mount Opt.)
2. **Choose 5=Calibrate menu.** You have two choices. Refer to the appropriate sections in the Normal Startup Sequence section.
 - a) 1=N Polar Calibrate
 - b) 2=2 Star Calibrate

What if I lose my calibration?

Assuming that the mount itself did not move and you are polar-aligned, you can use the sync function as described under Advanced Features later in the manual. This is the quickest and easiest method.

Alternatively, go to calibrate Menu as described above and follow the “N Polar Calibrate” or “2-Star Calibrate” procedure. Since you will already be polar aligned and your location has been selected, you are simply telling the mount where it is pointing. No further adjustments should be needed. Note: do not use the solar system objects in these routines since the R.A./Dec. positions change with time.

Specify Mount Type

This setting is made at Astro-Physics. To check or make corrections, follow this procedure.

1. **Go to the Park/Mount Options Menu.** Main Menu → “2=Setup” → :4=Park/ Mount Opt”.
2. **Press “6=Mount Type”.** Notice that the number field changes each time you press 6.

Park / Mount Options Menu

0, 1, 2, 3, 4 =Mount Park
5=Calibrate Menu
6=Mount Type: AP1600

Scroll through choices – Continue to press “6” to choose: AP400, AP600E, AP900, AP1200, Mach1, AP1100, AP1600 and AP3600. If you own a mount produced by Parallax Instruments or Mountain Instruments, check with them for your proper setting.

TOOLS MENU

Permanent Error Memory Adjustment (PEM)

Astrophotography and CCD Imaging demand the highest tracking accuracy to obtain pinpoint star images throughout your photographic exposure. You do not need PEM unless you are engaged in one of these activities.

The servo drive electronics contain a very sophisticated permanent periodic error compensation circuit (other manufacturers call this PPEC). Because a majority of the periodic error is due to the R.A. drive worm and is quite predictable, it is possible to significantly reduce it by simply having the controller “memorize” the corrections you make with your button inputs and automatically play them back for each cycle of the worm. This circuit has some unique features that makes it easy to operate and almost totally foolproof.

Polar align your mount so that you have minimum R.A. and Dec. drift. Be sure that the night is steady enough with minimum atmospheric motion, and pick a star near the zenith to minimize atmospheric refraction errors. You must use an eyepiece with a reticle. The recording process will take about 7 minutes to complete for the 1600, 1200, 1100 and 900 mounts and 8 minutes for the 600E and 400 mounts. The Keypad will display the PEM recording screen for the full 8 minutes. However, the actual recording will only occur for the appropriate length of time for your mount. This timing information is stored in the GTO Servo Control Box.

Tools Menu

1=PEM	0=Status
2=Smart Guide	
3=Photo Timer	
4=Bookmark Tools	

Record Permanent Error Memory

1. **Select response rate for N-S-E-W buttons at the Main Menu.** For medium power, use 1x, for higher powers use 0.5x or 0.25x.
2. **Go to PEM setup screen (Main Menu → Tools → PEM).**
3. **Be sure the PEM state is set to NONE.**
4. **Put star on reticle.** Place a medium brightness star on the reticle at moderately high power so you can easily see the R.A. gear drift. It is sometimes easier if you defocus the star a bit. Practice moving the star with your N-S-E-W directional buttons to get the feel of guiding. To change the response rate for the N-S-E-W buttons, press “±” button.
5. **Choose Record.** The record cycle will begin approximately 10 seconds later, signalled with a single audible beep. The screen will show “Recording” throughout the entire cycle.
6. **Keep star on reticle.** During the 7-minute recording period, it is necessary to keep the star on the reticle using the N-S-E-W directional buttons. Every button input will be recorded. Avoid trying to guide out any atmospheric scintillation since this will add a random noise error into your final guide rate. If an autoguiding camera is available, it can be used to guide, and the controller will faithfully remember each error correction that it makes. An autoguider is extremely accurate and will place into memory a very smooth correction of the gear error. A countdown timer is provided for your convenience. You cannot cancel the recording session.
7. **Screen will return to PEM setup screen and you will hear a beep when the recording cycle is complete.**
8. **The PEM state will change to Play upon completion of the cycle.** You can watch the reticle again to see how accurately your corrections were made. If you are not satisfied with your results, record again using the same procedure.

PEM Setup Screen

PEM Setup
PEM State: None
1=Rec 2=Play 3=None
Press MENU to Exit

Playback PEM corrections

Activate the corrections when guiding astrophotos or CCD images if you satisfied with the quality of your recording. When autoguiding, the signal from the autoguider will override the PEM correction as needed. The recording itself will remain unchanged until you record over it again.

1. **Choose Play from the PEM Setup Screen.** The controller will automatically play back the correct portion of the worm gear error at whatever tracking, slewing or directional button rate that you choose.
2. **If you do not want PEM to be active.** Toggle to the NONE setting.

Special Features

A most valuable feature of this circuit is that it automatically compensates for any drift inadvertently introduced by the

operator in the process of recording the gear error. For instance, if the mount was not properly polar aligned in altitude, the right ascension drift rate would be in error. The circuitry automatically subtracts this slow drift from the PE data recorded in memory, so that the overall long-term drive rate remains exactly at the sidereal rate for the worm cycle being recorded. This way, the PE-compensated driving rate will never be skewed by the recorded drift and will always be correct for any other position in the sky and for any other time that the mount is set up in the field. This way, the PEM compensation only corrects the actual PE of the worm. When the mount is properly aligned, it is possible to take 15 to 30 minute unguided astrophotos without trailed star images. For more critical exposures, the controller memory allows the astro-photographer to check the guide star only occasionally during a long exposure.

Photographic Timer

Activate the countdown photographic timer to remind you when your exposure is completed. An audible beep will alert you that the time has expired.

1. **Go to “Photographic Timer” screen.** (Main Menu → “3=Tools” → 3=Photo Timer). The “Photographic Timer” screen will appear.
2. **Enter hours, minutes and seconds.** The timer will activate.
3. **When the timer reaches “0”, a series of audible beeps will sound.** The display will begin to show negative numbers to let you know the time that has elapsed since the timer went off.
4. **Press MENU to cancel timer at any time.**

Photo Timer Setup Screen

Photo Timer
Enter hh:mm:ss now
Timer: 00:00:00
Goto / MENU to Exit

SmartGuide

Smart guide is a new variable tracking rate tool for your Astro-physics GTO mount. It can be found in the “3=Tools” in the version 4.x firmware.

SmartGuide Main Screen

1=R: EST 4/5=RM: 0
2=D: NOR 9/0=DM: 0
3=S: 1 6/7=PE: 1000
GoTo / MENU / More >

Why do I need SmartGuide?

The sky unfortunately does not move at precisely the same rate of motion everywhere, nor is a perfectly precise polar alignment easy to obtain. Both of these factors can contribute to mount motion that is slightly off the sidereal rate of motion. With today’s CCD cameras these challenges for precision are bigger than ever. Also some object such as the moon, asteroids, and comets do not move at the sidereal rate; therefore, SmartGuide can reduce the guiding errors on these objects.

How does SmartGuide work?

One way to compensate for changes in the motion of the skies is to introduce small corrections into the motion of the mount to cancel out the effects of a less than perfect polar alignment or variability in tracking due to atmospheric refraction. These corrections are done in the Keypad software by periodically sending short pulses of movement to the mount in the axis that needs the adjustment. This effectively compensates for almost any kind of drift.

How do I use SmartGuide?

To use smart guide you will need either a CCD camera or a reticle eyepiece

- Make sure your PEM is recorded and active if you wish to use PEM to reduce periodic error. It cannot be accessed once you go into Smart Guide.
- Select a bright star or object near the area you wish to image.
- Enter the smart guide menu by hitting “3=Tools” on the Main Menu, then select option “2=SmartGuide”. Press the NEXT> button to move to the More Menu.
- Take note of the button speed setting. We recommend making your adjustments at 1x button speed or slower. Button speed can be adjusted by pressing the “±” button to bring up the speed setting.
- Press “1” on the pad to enter Auto Smart Guide setup.
- When using image-processing software, center the star with the assistance of the cursor or cross hair on your computer screen (or reticle if you are using an eyepiece) and press “1” to activate the smart guide recording.

- Let your mount run for 5–10 minutes then go back and precisely center the object on the screen (or reticle if you are using an eyepiece).
- Press “1” as soon as you have the object centered again.
- The Keypad display will now show 5 significant numbers on it.
 - RM: – The amount in arc seconds the mount has moved in R.A.
 - DM: – The amount in arc seconds the mount has moved in Dec.
 - Time: – In seconds that you recorded your measurement
 - RS: – The amount of RA drift per second in arc seconds RM/Time
 - DS: – The amount of DEC drift per second in arc seconds DM/Time
- These are the values that SmartGuide will now use to compute the button on time, in milliseconds, to track the object at the chosen tracking rate.
- Hit GoTo to start SmartGuide running.
- The Keypad display will now show the following. The asterisks will blink as the pulses are delivered.
 - R: – The movement direction in R.A.
 - D: – The movement direction in Dec.
 - S: – Speed
 - RM: – Length of pulse in milliseconds sent to the R.A. axis
 - DM: – Length of pulse in milliseconds sent to the Dec. axis
 - PE: – The length of wait time between pulses
- Setup your CCD or camera and image away.

Auto SmartGuide Data Screen

RM: 15	RS: 0.02825
DM: 16	DS: 0.03013
Time: 531 Seconds	
Press GoTo Now	

SmartGuide Run Screen

1=R: EST 4/5=RM: 50*	
2=D: NOR 9/0:=DM: 50*	
SP: .25x	PE: 3635*
Hold STOP to Exit	

Is SmartGuiding better than Auto Guiding?

Auto guiding is always more accurate than matching drift rates with SmartGuide. It would always be the preferred method except in circumstances where a guide star is not available (filtered shots, star-poor regions, H-alpha imaging etc.). Matching drift rates with SmartGuide is akin to setting your car's speed on cruise control and trying to match exactly the car in front of you who also has his set on cruise. If you don't adjust your speed from time to time (i.e. guiding), eventually you will either hit him, or drift farther apart. It's even more difficult if the car in front is slowly increasing or decreasing his speed.

If you plan to use your computer to control your mount, consider using PulseGuide™, by Ray Gralak of Sirius Imaging. This program will simulate all functions of your Keypad for remote control of your telescope, including PulseGuide, which is similar to SmartGuide in its function. PulseGuide is available as a free download from the Astro-Physics website.

Status

If your mount stops functioning, you can get an idea of possible causes by checking the status. Information pertaining to the program code level and database level is also displayed here.

When you press “0=Status” in the tools menu, the screen will display “Press North Key to check mount status.” When you do this, the Keypad probes the motors at 64x (please note that your button rate will then change to 64x). These are the possible messages you may see when you check the status:

- Code level version # (refers to the actual program)
- DB level version # (refers to the database)
- All Systems Go
- Motor Stalled – This may be due to a stalled motor, mount cable not connected properly, broken wire connection in a mount cable or motor box, worm gear jammed too tightly against worm or foreign particle in gearbox, which jammed the teeth of a gear. Please call Astro-Physics for help correcting this error.
- Low Battery – When your 12V power source dips below 11V, this message will appear. At this point, the battery has approximately 5% of its energy, which is not enough to power the mount.

SLEWING DURING THE DAY

You must take extra precautions when observing during the daytime. If not done correctly, you may suffer permanent damage to your eyesight. Be sure to supervise all children and other observers who may not be aware of the dangers.

Observing in the daytime offers many rewards – finding the planets and stars, and observing sunspots and solar prominences of the sun itself.

Potential Dangers

- As the telescope is slewing from one part of the sky to another, it may pass across the face of the sun or near enough so that looking through the telescope would be dangerous unless you have a proper solar filter. **DO NOT LOOK DIRECTLY INTO THE TELESCOPE OR VIEWFINDER WHILE THE TELESCOPE IS SLEWING.**
- The position of the planet or star that you wish to see may be too close to the sun to observe safely. **CHECK THE POSITION OF THE TELESCOPE BEFORE YOU LOOK INTO THE EYEPiece OR VIEWFINDER. BE SURE THAT IT IS NOT POINTING AT OR ANYWHERE NEAR THE SUN.** Remember that the finder has a wide field of view so you can see a large portion of the sky.
- **PLEASE DO NOT OVERRIDE THE SUN SAFE ZONE DURING THE DAY.** This feature is in the Keypad for your safety.
- Observing the sun. Be sure that you have installed a good quality **SAFE** solar filter that covers the optics in front of the telescope. Never use eyepiece filters since they may break due to the intense heat of the sun. Do not use solar filters that are cracked (glass), torn (Mylar) or have many pinholes (either glass or Mylar). If you use a photographic solar filter, be sure to use an additional neutral-density filter when viewing through and eyepiece or the viewfinder of your camera.

How to Observe Safely

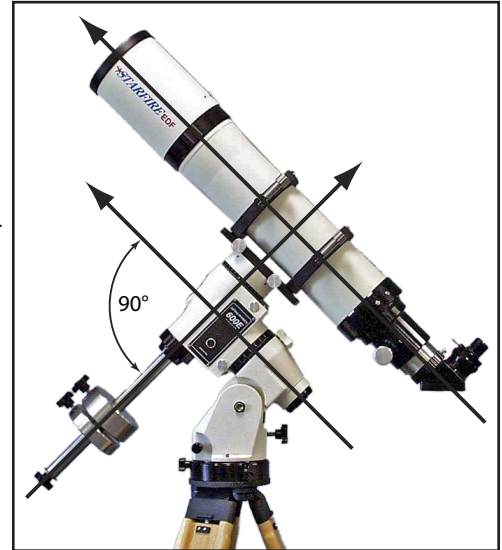
1. Place dust cover or proper solar filters on the main objective of the telescope and the finder scope before you slew the telescope, use the N-S-E-W directional buttons or move it manually. Be sure to inspect your solar filter beforehand to be sure that it is not damaged in any way that will allow light through. Use a black marker to cover the pinholes that may appear in the coating.
2. Slew or move the telescope.
3. Visually check the position of the telescope to be sure that it is not pointing at or anywhere near the sun.
4. If you are observing planets, the moon or stars – remove the dust cover or filter only when you are sure that it is safe.
5. To observe the sun – **ALWAYS** leave your solar filter in place over the front of the objective and finder.
6. Put the solar filters or dust covers back on the telescope before slewing to the next object.

ORTHOGONALITY

A telescope is said to be orthogonal when its optical axis is exactly 90 degrees from the declination axis as shown in the photo. In Alt-Az fork mounts, orthogonality is not an issue. Pointing is straightforward, the scope never has to flip sides and the mount does not need to be polar-aligned. However, in German equatorial mounts, a non-orthogonal telescope will cause errors in any routine that uses the scope for polar alignment (such as the N Polar Calibrate routine) and will reduce the pointing accuracy of the system by exactly twice the orthogonal error.

Telescope orthogonality requires that two conditions be met:

1. The R.A. and Dec. axes of the mount are at precise right angles to each other. Astro-Physics mounts are very accurately machined and fulfil this condition.
2. The optical axis of the telescope must be parallel to the R.A. (polar) axis. Some of the factors which could affect this condition include:
 - a) Improperly machined rings.
 - b) Wedge in the mounting plate or brackets.
 - c) Incorrect position and tilt of a diagonal mirror or diagonal assembly that is not machined square.
 - d) Set screws in focusers, diagonals or adapters which tilt the optical axis.
 - e) Die-cast tube assemblies that lack the precision squareness of a CNC machined part. The tube points in one direction while the optics can point several degrees off in another direction.
 - f) Diagonal displacement or tilt in a Newtonian.
 - g) Mirror shift in a catadioptric. The optics are not tied down to a reference plane, but can move around and point in different directions depending on focus position.
 - h) Collimation adjustment. There is enough freedom in the tilt of a secondary mirror to allow the image to be moved completely out of the eyepiece field. Therefore, collimating the scope may disturb or change orthogonality.



Whatever the reason, orthogonality can be easily checked and adjusted, if needed.

Check Orthogonality

The optical axis must be parallel to the polar axis and 90 degrees to the declination axis

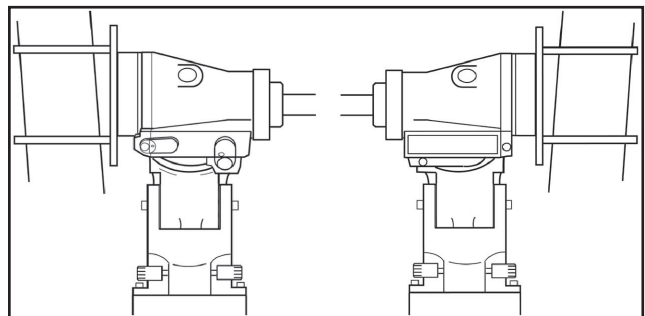
To do an orthogonal check, the mount should be close to polar aligned, however the alignment does not need to be perfect. Next, you need to slew between two stars that are straddling either side of the meridian.

For instance, in early summer at 9 p.m. (northern hemisphere), the constellation Boötes is straight up and Alpha Boötes (Arcturus) and Epsilon Boötes are on either side of the meridian. Follow this procedure using a reticle eyepiece:

While Arcturus is not a suitable star to use in the N-polar alignment routine, it works well in this application.

1. From Objects menu, select “8=Tours”.

Exaggerated illustration of error caused by mounting rings with varying thickness at base of ring. Shows how scope will not point to desired target and the displacement that will occur on either side of mount.



Exaggerated illustration of error caused by mounting rings with varying thickness at base of ring. Shows how scope will not point to desired target and the displacement that will occur on either side of mount.

2. Choose “1=Stars/Constell” and scroll to “Cons:Boo”. (If the stars you want to use are listed in the common star names list, you can choose “5=Strs” from the Objects menu and select the stars from that list).

3. **Choose “alf”.** The magnitude will display.
4. **Press GoTo.** The scope will now slew to Arcturus in the west.
5. **Center the star on reticle using your N-S-E-W buttons.**
6. **Press the RA/DEC REV Button.**
7. **Press “9=Re-Calibrate”.** You will hear a beep letting you know you re-calibrated. This will re-calibrate your scope precisely on Arcturus.
8. **Return to Tours.** In this example, the constellation Boötes will display since you are now pointed to it.
9. **Choose “eps”.**
10. **Press GoTo.** The scope will now slew all the way around the Dec. axis to point east to Epsilon Boötes. If the polar alignment was not exact, the new star will appear displaced north or south in declination. Ignore that error for the moment (you can bring the star back in Dec. with the buttons, but NOT R.A.). The amount that the star is displaced in R.A. will be equal to twice the optical tube assembly orthogonal error.
11. **Correct orthogonality.** Simply shim up one of the tube rings to bring the star half way toward the reticle. You can use commercially available shim material from your hardware store or pieces cut from a soda can.
12. **Center the star with the N-S-E-W buttons.**
13. **Press the RA/DEC REV Button**
14. **Press “9=Re-Calibrate”.** You will hear a beep letting you know you re-calibrated.
15. **Slew back to the first star.** Add additional shims as necessary (or adjust your optics if that is the problem) until both stars appear on the centerline of the reticles.

This procedure can be carried out on the SAME star for even more accuracy by using the Meridian Delay feature. For instance, point the scope to a star within 1 hour of the meridian, then advance the meridian delay by 1 hr E. Slew to the same star. This time, the scope will point to the star from the other (east) side of the mount. This feature is detailed in the GTO Quick Star Drift method for polar alignment.

Effect of Non-orthogonality on Polar Alignment

The whole idea of polar alignment is to achieve drift-free tracking. Therefore, it is the mount that needs to point to the pole, not the optical axis of the scope. When the optics are not orthogonal, you cannot use the scope to point accurately near the pole. As an example, if the scope had a 1 degree orthogonal error, the mount would be off by 4 minutes in R.A. at the celestial equator, about 8 minutes in R.A. at 80 degrees Dec, and a whopping 6 hrs in R.A. at 89 degrees Dec. Anything beyond 89 degrees cannot be reached at any orientation of the mount. Therefore, when the scope has an orthogonal error, it is useless to try to polar align using Polaris or any star near the pole.

Polar Alignment with Non-orthogonal Telescopes

In this situation, a 2-step method to align the mount is recommended. See the section on the “GTO Quick Star Drift Method” of Polar Alignment under the “Alternate Polar Calibration Routines & Tips” section earlier in the manual.

1. Choose 2 stars with nearly the same R.A. on the same side of the mount. Do not use 2 stars where the mount has to flip sides. Avoid stars above 60 degrees (“N”) or below -60 degrees (“S”) in declination. As an example, in the summer we have Vega in the north and Kaus Borealis (Lam Sag – the top of the teapot’s lid) in the south. Using the 2-star alignment, select one as a pivot star, and use the other to adjust the azimuth axis.
2. To set the altitude axis, choose a 3rd star different in R.A. and Dec, such as Enif (ePegasus) and slew back & forth between it and Nunki.

Very Important: You must point to stars in the west when your telescope is on the east side of the mount and stars in the east when your scope is on the west side. When the stars are high and close to the zenith, this can be tricky. However, you can tell which side the star is on by looking at the “z” number (also called the LST) in the upper right corner of the Choose Star screen, then comparing that number with the R.A. number of the star you choose. If the R.A. number is larger, the star is in the east; if the R.A. is smaller, the star is in the west. If your scope is not on the correct side, the mount will not slew properly and the telescope could strike the pier/tripod.

For a more foolproof way to adjust the altitude (step 2 of the process above), you can pick a constellation on the meridian and slew back & forth using the Stars Tour mode. If conveniently placed, stars of the same constellation, e.g. alpha, beta etc., can be on either side of the meridian. Slewing between them will cause the telescope to switch sides, and any Dec. error corresponds to twice the altitude movement you must make on the mount. R.A. error will show you how far out your orthogonality is. This only takes 1 or 2 iterations to get very close alignment of the optical axis. Roland personally uses a variation of this method, using the same star (GTO Quick Star Drift Method). By advancing the clock by 1 hour or using the meridian swap feature, the scope will slew to the west side of the mount, where a precise compensation can be made to the altitude axis. This avoids any discrepancy in R.A. and Dec. co-ordinate data.

Using our Right-Angle Polar Alignment Scope (RAPAS) is another alternative. It is easier and quicker than either of the above methods. However, keep in mind that the Polar Alignment Scope must also be aligned with the mount (it will be very accurate out-of-the-box) so that it is orthogonal. Once this is done in the first session, subsequent polar alignment will be very quick.

Additional Tips for Non-Orthogonal Systems

Additional suggestions for improving pointing accuracy and living with non-orthogonal systems are provided in these prior sections of the manual:

- Using Tour Mode to Compensate for Imperfect Polar Alignment or Non-Orthogonal Systems.
- Using Software, such as Astro-Physics Command Center (APCC), to Improve Pointing Accuracy.

ADVANCED FEATURES

The following paragraphs detail some very important and powerful features of your Keypad and servo drive system. Be sure you read this section carefully and understand the material presented. Sync and Re-Calibrate are vital parts of the GoTo system. The Meridian Delay feature is a tremendous asset when imaging, as well as being an integral part of the GTO Quick Star Drift method of polar alignment. They are only of value, however, when used correctly. With both Sync and Re-Calibrate, the best calibration objects to use are single bright stars. Single bright stars are easy to distinguish, and you don't have to guess at where the center is. Solar system objects are useful for daytime observing and setup, but be careful! If you use the sun as your sync object, you must be sure to use a solar filter on both your finder scope and your objective to protect your eyes! Other solar system objects, although useful for daylight and twilight calibrations are never as good as a single bright star. Because the moon and planets move in relation to the rest of the sky, their positions must be calculated. They are also not point sources, so again you must estimate the center, (not too hard with Mars, but more of a challenge with a crescent moon).

Sync Function

Please note: The Sync command should only be used **AFTER** you are properly polar aligned!

Sync is used typically at the start of an observing session or after the mount has been moved by hand. Sync calibrates the mount on a known object in the database, one to which you have positioned your telescope manually. Sync also establishes the orientation of the mount with respect to the telescope, counterweight shaft and pier. Sync assumes that you have placed your telescope on the proper side of the meridian, i.e. a telescope placed on the west side of the mount pointing to a star in the east. This assures that the telescope will be positioned on the proper side of the mount for all subsequent objects. PLEASE READ THE COMPARISON BETWEEN "SYNC" AND "RE-CALIBRATE" BELOW TO AVOID POTENTIAL PROBLEMS! These are typical uses of Sync.

Startup – Your mount is polar aligned and Auto-start is set to “no”

1. The Site Menu will display when you power up the mount. If you had not parked, the mount will start tracking in R.A. immediately. However, if you had parked in positions 1, 2, 3, 4 or 0 at the end of the last session, the mount will NOT start tracking until you choose your location from the site menu.
2. Choose your location. This will send location, date, time and daylight savings information to the mount. The Sync, Align, and Resume menu will now appear.
3. Point your telescope to a known bright star or solar system object. Make sure the object is on the opposite side of the meridian from the telescope – see below. Center it in the eyepiece. (If the object drifts, you will know that you are not truly polar-aligned).
4. Select: “1=Star Sync” and scroll through the common star names using <PREV and NEXT> until you find the one that is centered in your eyepiece. The solar system objects are at the end of the list. Remember, you can use the <PREV button to scroll from the back of the list.
5. Select your target object by pressing the corresponding number (1, 2 or 3) and then press GoTo. This will sync on the object. The mount will not actually slew anywhere. The Main Menu will appear. Begin observing. Note: to help prevent mistakes (maybe you pressed “1” for Algedi when you meant to press “2” for Algenib ??) the Keypad will not allow you to sync on an object that is below your horizon.

Startup – Your mount is polar-aligned, Auto-start is set to “yes”, however the telescope has been moved

1. The Main Menu will display when you power up and the mount will start tracking (whether you parked at the end of the last session or not).
2. Manually point your telescope to a known star or solar system object. Make sure the object is on the opposite side of the meridian from the telescope – see below. Center in the eyepiece (if the object drifts, you will know that you are not truly polar-aligned).
3. Go to “1=Objects” → “5=Stars”. The Star Selection Menu will appear. (The solar system objects are at the end of the list.) Use <PREV and NEXT> to scroll through the list.
4. Select your target object by pressing the corresponding number (1, 2 or 3). The Star Selection screen for that star will appear. Note: the “>” sign has been left off of the screen to help prevent accidental syncing. DO NOT press GoTo. Also note: to help prevent mistakes (maybe you pressed “1” for Algedi when you meant to press “2” for Algenib ??) the Keypad will not allow you to sync on an object that is below your horizon.
5. Press NEXT> and the Sync confirmation screen will appear.

6. Double check to be sure the object is still centered and that your mount's orientation is correct. Press "1=Sync current object". The Keypad will beep and display an – Object Synced – message. Press MENU to exit.

Your mount is polar-aligned and you were moving the telescope manually to look at a few objects before slewing with the go-to feature.

Use the same procedure as above, beginning with step 2.

Tweak Your Pointing Accuracy

You slew to an object and center it in your eyepiece with your N-S-E-W directional buttons. You have two choices, either re-calibrate (preferred) or sync. Both are possible; however re-calibrate is safest and easiest and involves the least number of keystrokes. Many things can affect the pointing accuracy of your system. The accuracy of your clock and location settings and especially the orthogonality of your entire system can play a role. Don't drive yourself crazy trying to make every slew hit the dead center of a high power eyepiece.

If orthogonality issues are affecting your pointing accuracy, use a smart strategy to compensate. Organize your observing around one or several regions of sky. The regions can be on opposite sides of the meridian, but slews within the region should not require you to cross the meridian. When you finish a region, slew to a bright star in the next region and re-calibrate. As long as you are not swapping sides by crossing the meridian, you should be able to slew to objects within a reasonable radius of your calibration star with satisfactory accuracy. The useful radius will simply depend on the degree to which your system is not orthogonal, but you should be able to observe in a radius of 20 to 30 degrees before re-calibrating.

Re-calibrate

Re-calibrate is used to calibrate the position of the mount if an object does not appear in the center of the field. Re-calibrate can be used even when the object is past the meridian and the telescope is below the mount. "9=Re-Calibrate" calibrates on the last object to which the telescope was sent.

Let's say that you slew to "3=Caph" and center using N-S-E-W buttons. Simply press the RA/DEC REV button and select "9=Re-Calibrate".

Note: You can only use the re-calibration option if the Keypad has the target object in its memory, i.e. you just gave a slew command and the Keypad already knows it should be at that object. You CANNOT use this option if you manually move the telescope to another position, since the Keypad would have no way of knowing what that object is. In this situation, use sync as described below.

Sync

As in the example above, let's say that you slew to Caph, then, by hand, center the object in your eyepiece. From the "Star Object" screen for Caph, press the NEXT> button which will display the "Sync Confirmation" screen – make sure your telescope is positioned correctly (see below). Press "1=Sync", the Keypad will beep, and then press MENU to exit. Before syncing:

- Make sure your mount and telescope are properly oriented.
- You must be polar aligned
- Do NOT have your Meridian Delay feature turned on

Star Object Screen - Caph

Star: Caph	
RA: 00:09:11	
DEC: +59:09:00	
Menu=Exit	1=BkMk

The sync procedure is outlined above and the command is described further in the following section.

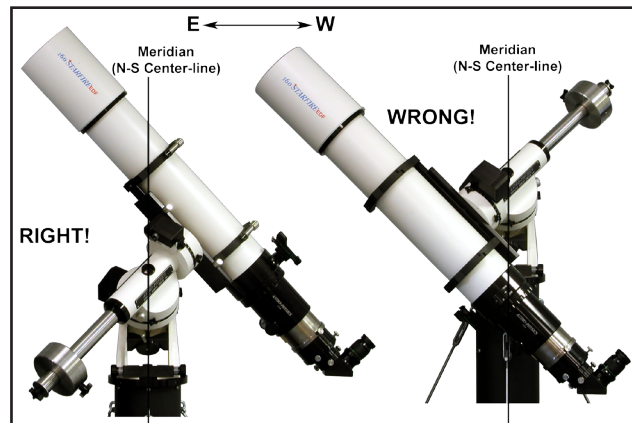
Sync Explained in Detail and compared to Re-Calibrate

Sync and Re-calibrate are often used as synonyms in everyday use, but to the Keypad and GTO Control Box directing the movements of your mount, they are different and distinct. Understanding this distinction will aid you in enjoying your Astro-Physics GoTo system.

The Sync command is typically used at the beginning of an observing or imaging session. Sync tells the mount where it is pointing and defines which is the telescope side and which is the counterweight side. It is a powerful command in that it disregards earlier slewing commands and starts over. It does not take the last entered position into account, but tells the mount – "You are here," based on the object displayed on the Keypad screen. It assumes that the telescope is correctly pointed with the sync object and the telescope on opposite sides of the meridian. Each time you use sync, you redefine the orientation of the telescope and counterweight to the mount. If used in the wrong way, the sync command will cause the mount to slew incorrectly and possibly cause damage to equipment. It should therefore be used with caution.

Why is the Sync command a potential problem if used incorrectly? There are two main reasons. The first reason comes from the fact that both axes of the mount are full 360° circles that are not restricted in their motion. The second comes from the fact that the mount must rely on the information it is given: in particular, the date, time, daylight savings and location data to know where the meridian is. As smart and sophisticated as these systems are, they cannot see the sky or their own orientation and must rely on the operator to give them their proper start.

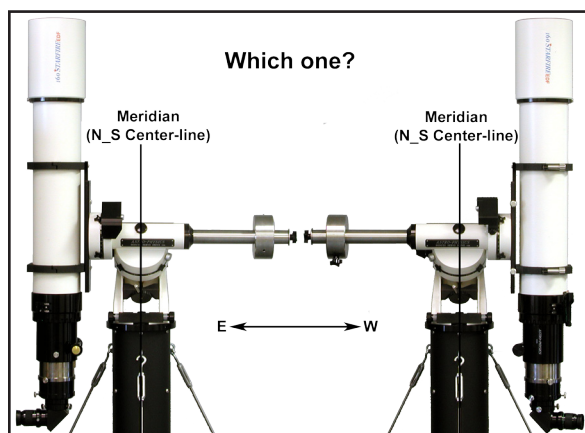
Let's examine the first issue. Why would the full circular nature of the axes create a problem potential? First, if you loosen your clutches, and then remove your telescope, mounting hardware and counterweight shaft, you can simply turn both axes round and round to your heart's content. Since the clutches were disengaged, the servo drive system can not possibly have any idea where the axes are pointing before you tell it by syncing the mount. This is a critical problem because of the fact that for any location in the sky, there would be two possible ways to point at it if there were no obstructions (like a pier) in the way. See the illustration at right. Both images show a telescope pointing at the same object. The image on the right is obviously wrong, and no experienced astronomer would position his or her mount like this, but the mount cannot know which alternative has been chosen. The software was therefore written to subsequently slew the mount assuming the sync position was correct as shown on the left. It bases its assumption of where the meridian is and where the pier is on the correct orientation of the system when it is synced.



Well, you might ask, if no one would be dumb enough to sync with their mount positioned like the one on the right in the illustration above, why even bring it up? The reason is that things aren't always as easy as the above illustration – it was designed to make the point obvious. Take a look at the next illustration. Is it OK to use sync in either of these situations? The answer is maybe, but I wouldn't really advise it.

This brings us to the second main reason that sync can be a problem if used incorrectly. The illustration at left shows that it can be difficult to tell which side of the meridian you are pointing at when pointing near the meridian. This assumes that

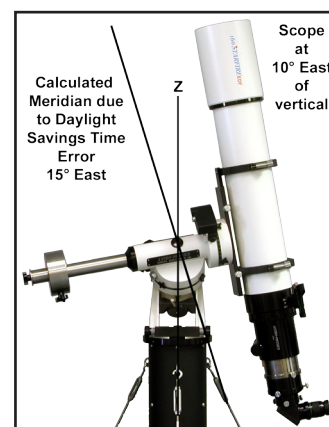
the meridian is where it's supposed to be. Now wait a minute, you say. We all know that the meridian is the north – south line that is straight up: directly overhead. It goes through the zenith. It has to be where it's supposed to be! That is true, but the mount can't see like you and I can. It can't look up and see the meridian; it has to calculate the meridian based on the data we give it. That data is the location, the date, the time and whether or not daylight savings is in effect. Errors in this data will result in errors in the calculated position of the meridian with respect to the object being synced.



Daylight savings is an easy example to understand. It changes our clocks by one hour, forward each spring, backward each fall. Each hour is equivalent to 15° of sky.

Therefore, a simple mistake in the

entered value (off or on) for daylight savings will throw the calculated meridian off by a whopping 15°. The next illustration at right shows this. The telescope is 10° east of the true meridian. If syncing on a star with the telescope in this position, you would think that everything is fine, but if you have your daylight savings turned off=0 (and it should be on=1), the calculated meridian will be 5° too far to the east to sync! Likewise, just entering the wrong location (i.e. your back yard location number instead of your darksite location number) can throw you off by enough to make any sync close to the meridian worth reconsidering.



Sync is a very important, handy and powerful command. Don't be scared to use it, just follow these safe guidelines now that you understand how it works:

1. Your mount **MUST** be polar aligned. Since sync establishes the mount's orientation with respect to the telescope, counterweight shaft and pier, polar alignment is a prerequisite.
2. **NEVER** sync if your counterweight shaft is pointing up. Avoid syncing if your counterweight shaft is close to horizontal. Remember that the sync object and the telescope must be on opposite sides of the mount / meridian.

3. Do not use sync if your meridian delay feature is turned on. Meridian delay overrides the mount's orientation / clock information and can lead to the same problem as syncing when the mount is improperly oriented.

4. Compare the current "Z" value in the Star Selection Menu Screen with the R.A. value for the star you will be syncing on. Remember that the "Z" value changes along with time; you can't use the "Z" value you remember from several hours ago. If the R.A. number is larger than the "Z" value, the star is east of the mount's calculated meridian and the scope should be on the west side of the mount. If the R.A. value is smaller, the star is west of the calculated meridian and the scope should be on the east. This is an especially good way to check, since it uses the mount's calculated meridian and therefore bypasses any errors in time or location data.

Star Selection Menu - Altair

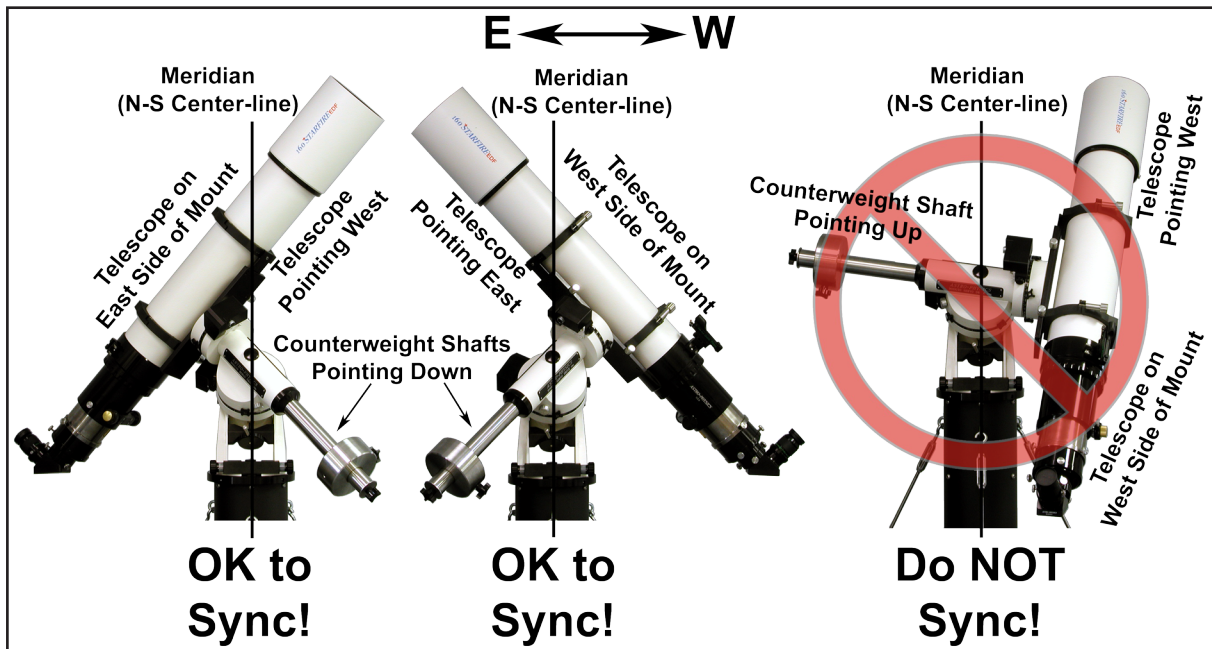
Choose Star	Z=16:54
1=Alshain	<
2=Altair	
3=Altais	>

5. To verify that everything is set correctly once you have synced, go to your Objects Menu and Choose 7=R/D for the custom RA / DEC Entry screen. For the R.A., enter the "Z" value from step 2 above. (If it has been more than a minute or two, get a fresh "Z" value from the Star Selection Menu). For the Dec. value, enter your latitude +/- 20°. (The +/- 20° is in case you have safe zone limits set for your system. If your system allows the scope to point straight up, you can just enter your latitude). Press GoTo. After slewing, your counterweight shaft should be perfectly horizontal. If you were able to enter just your latitude for a Dec. value, the scope will be pointing straight up as well. This is a good test because it also indicates whether your time and location data are correct.

Star Object Screen - Altair

Star: Altair
RA: 19:50:47
DEC: +08:52:06
GoTo / Menu=Exit

6. Your sync will result in greater pointing accuracy if you sync to a single star that is close to the celestial equator, rather than close to your pole. This has nothing to do with the sync command itself, but instead is because of the geometry of the celestial sphere. Think of the longitude lines on a globe, how they are widest at the equator, but converge at the poles. A small error in centering a star near the pole would translate into a larger R.A. error than the same centering error on a star near the celestial equator.



In summary, you use the sync command once in an observing or imaging session unless the telescope gets physically moved by hand or by accident (as opposed to moved with the N-S-E-W buttons). While it can be used to tweak pointing accuracy, we prefer to use re-calibrate for that. We also recommend that you Sync on objects that are at least 15 deg. (1 hour) from the meridian. This will help safeguard you from a potential clock related problem – i.e. you forgot about daylight savings time, and it makes it easier to see that the object and telescope are on opposite sides of the meridian. If you are permanently mounted and do not disturb the scope position, you do not need to use it after the very first setup.

Re-calibrate is the "tweak" command. It is quick and easy and is perfect for fine-tuning your pointing accuracy during your observing or imaging session. Rather than telling the mount where it is pointing, re-calibrate corrects its minor pointing inaccuracies. Re-calibrate works on the object in memory that the mount thinks it is already pointing at. It does not care what object is displayed on the screen at the time, only where the last GoTo command sent it. Since it does not re-establish the mount's position in memory, it doesn't matter if the telescope and Re-cal object are both on the same side of the meridian. It is therefore a safer command to use during your session.

Remember that for both commands, the preferred object of choice will always be a single bright star because it is a single

point source. Avoid double or multiple stars if possible. Solar system objects can be useful for daylight syncing or re-calibrating. In addition, remember that pointing accuracy is also dependent on the accuracy of the polar alignment and the orthogonality of the entire system.

CAUTION: It is important to note that external software programs may not make the same distinction between the 2 terms, so be careful when syncing or re-calibrating (or whatever they call it) with other programs. For safety sake you may want to treat any similar command in external software like a Sync command and use it only with the object and telescope on opposite sides of the meridian.

Meridian Delay / Advance Function

This function should be used with caution to prevent accidental telescope contact with the pier.

In normal use, the telescope will track through the meridian when you are following an object. However, when you enter the object again, or if you enter a nearby object that has drifted past the meridian and then slew, the telescope automatically switches sides so that the scope will be “right side up” instead of diving under the mount. Sometimes, for astro-photography, you may wish to delay the meridian swap, especially if you are imaging mosaics and the area is beginning to drift across the meridian.

Remember, it is the GoTo slew that will flip the mount...not tracking!

To delay the swap, press the button marked RA/DEC REV. The last menu item is the meridian, set normally to zero. By using the <PREV and NEXT> buttons you can enter a 1 hour to 6 hour delay or advance of the meridian swap. A setting of 1W means that the scope will continue to slew to objects up to 1 hour past the meridian in the west. It effectively delays the meridian swap by 1 hour. A 6 hour delay means the scope will slew all the way to the horizon on the “wrong” side of the mount. Entering a 1E means that the scope can be placed on the other side of the mount by 1 hour earlier than normal.

**Mnemonic devices: “E” will flip the mount early and “W” will wait to flip! ...or...
“E” will move the meridian east and “W” will move the meridian west.**

As a general rule, objects on the pole side of your zenith are poor choices for using the meridian delay. When the telescope is pointed at an object on the pole side, the back of the instrument can hit the pier if you go past the meridian. Objects away from the pole (south if you are in the north and north if you are in the south) are less likely to be a problem. You can see this quite easily by loosening your clutches and swinging your telescope around your mount. Point your scope at various points in the sky along a north / south line and then see how far you can swing the R.A. past the meridian before striking the pier. In so doing, you can learn a range of “safe” declination values and meridian delay parameters for your location and particular setup.

When you turn the power off, the meridian hour offset will return to the default setting of “0W.” You will have to make a conscious decision to change it during each observing session. If you are permanently mounted and leave your power on after parking, be sure to remember that you have made this setting. We encourage you to return to “0W” at the end of your observing session.

Note to programmers: The meridian delay is accomplished by sending a time to the mount that is from 1 to 6 hours different than the clock time. 6 hours plus delays the meridian to the east; 6 hours minus delays the meridian to the west. So, if you want to delay the meridian from your computer terminal, just send the revised time to the servo drive per the AP protocol. **Caution:** If you park the mount with this fake time and turn off the power, then unpark it later, the mount will point at the wrong R.A. It will be off by the amount you faked. If you are going to send a fake time to the mount with your computer, then make sure you reset to the correct time before you park the mount and turn off the power.

UNDERSTANDING THE KEYPAD AND GTO CONTROL BOX FUNCTIONS

Functions of the GTO Servo Control Box

These notes apply to the GTOCP1, GTOCP2, GTOCP3 and GTOCP4 models of the control box. The model number is silk-screened on the face plate of the box.

The main function of the servo control box is to drive the R.A. and Dec. motors. The motors are DC servos with built-in shaft encoders. The rotation rate of the motors is controlled with a servo feedback loop. The servo looks at the return pulses from the shaft encoders and adjusts the current to the motor so that the rate is identical to the commanded rate (i.e. from 0.25x sidereal to 1200x sidereal). The servo is digitally controlled, and the shaft position is updated at a rate of 2000 times per second.

The central computer in the servo is a microprocessor that converts input commands to electrical signals to move the motor. The input commands are in the form of the AP protocol, e.g. :Sr 02:45:32.5# which would define a move position of 2hr 45min 32.5sec in right ascension. The microprocessor converts those numbers to specific shaft angles of the two axes, and determines whether the telescope should access that position from the east side or west side of the mount. The servo responds to commands to move in R.A. or Dec. when any of the 4 buttons are pushed, according to the rate set on the Keypad (from 0.25x to 1200x). The servo will also initiate movement in the 4 directions from inputs sent to the CCD guider port at rates set by the Keypad, typically 1x, 0.5x or 0.25x the sidereal rate.

The servo microprocessor stores vital date, time and location information sent to it from the Keypad, or a planetarium program via one of the input ports. It stores worm periodic error information (PEM) so that it can be played back when required for high-accuracy tracking.

The main function of the servo control box is to convert input data from the Keypad or a planetarium program (in the form of the AP protocol) to electrical signals to the motor to produce the desired motor motion and to result in the telescope pointing at the desired object in the sky.

Functions of the Keypad

The Keypad controller is really a small hand held computer with planetarium software. It has a database for tens of thousands of objects that can be accessed by Keypad entry or scrolling through a menu.

To orient the system properly with respect to the sky requires date, time and location information. The Keypad contains an accurate date and time clock powered by a lithium battery. Together with the location data that is entered by the user, the Keypad uses this information to calculate what part of the sky is up at any given time. The Keypad also sends this information to the servo controller to calculate where the horizon limits are, and where the meridian line is located. This prevents the scope from pointing into the ground and allows the servo to do a meridian swap so the tube assembly does not dive under the mount and hit the pier.

The main function of the Keypad is to send R.A. and Dec. numbers to the mount for the objects that the user enters into the Keypad. This is exactly the same as the functions of a typical planetarium program. In fact, most of the Keypad functions can be replaced with those contained in PulseGuide by Ray Gralak, or an advanced planetarium program, like *TheSky6™* or *TheSkyX™* from Software Bisque or *StarryNight Pro Plus™* from Imaginova. You can therefore disconnect the Keypad entirely from the mount without losing any of the functions of the mount including parking, jogging, centering or moving to various parts of the sky. You can also control things like focus motors and reticle brightness from your desktop computer. Not all planetarium programs support all of these functions; please check the features of the program you are considering.

We have separated the functions of the servo control box and Keypad to allow for maximum flexibility to the user. The servo is a stand-alone unit that can be controlled entirely by the Keypad, by a desktop computer with a suitable planetarium program without the Keypad, or with both Keypad and desktop attached.

Upgrading the GTO Servo Control Box

Upgrades to the logic of the GTO control box (GTOCP1, GTOCP2 or GTOCP3 models) are made by installing a new ROM chip, since the chip is housed in a removable carrier, the old one can be popped out easily and the new one eased into place. All upgrades to the GTOCP4 control box are accomplished through an internet download.

Upgrading the Keypad

The Keypad has flash RAM memory. Version 4.x and future versions of the Keypad firmware is available through an Internet download. The GTO control box must have a version "C" or higher version of the micro-controller chip in order to accomplish the Internet download. The version number is written on the chip and was issued after January 22, 2001. **Please refer to the technical support section of our web site for additional information and upgrade procedure.**

Upgrading or Repairing the Keypad Database

The object database is stored in a separate memory location within the Keypad than the control firmware. It is stored in memory which is powered by a small 3V Lithium battery. Should this battery fail, the database become corrupted or a new database become available, you can upgrade or repair your database using a utility found in the technical support section of the Astro-Physics website. The GTO control box must have a version "C" or higher version of the micro-controller chip in order to accomplish the Internet download. The version number is written on the chip and was issued after January 22, 2001. **Please refer to the technical support section of our web site for additional information and upgrade / reload procedure.**

TROUBLESHOOTING

Additional tips related to specific mounts are in the mount instruction manual.

The Keypad displayed the message “motor stall.”

This error message indicates that the Keypad and servo box are unable to communicate with each other. If the mount was shipped after February 16, 2000, the LED on the control box will also turn yellow indicating that the overload protection feature has been activated. Although older mounts do not have the yellow LED, the overload protection feature is active. These are the conditions that will cause the error message:

- Your telescope is not balanced properly. Refer to your mount manual for guidance.
- The motors are not connected to the servo box. Be sure all connectors are locked in place.
- A wire connection in one of the mount cables is broken.
- One of the motors is not functioning.
- The mesh of the worm gear and worm wheel is too tight. This will cause the motors to overload, which will cause the overload protection feature of the servo box to activate and shut down the signal to the motors.
- The microprocessor chip, which contains the program logic, is missing from the servo box.
- One of the small gears in the motor box of the 1200 or 900 is jammed.
- Foreign material got into the motor gearbox.

Solution:

Check all possibilities above and correct, if possible. To initiate tracking again, press the N-S-E-W buttons, initiate a slew or go to Main Menu and press “0” Status (if you still get an error message, press the button a second time, just to be sure that the buffer cleared). If you have not moved the telescope while diagnosing the problem, the position will still be in memory and you can continue as if nothing ever happened.

If the “motor stall” message appears again, you have not corrected the cause of the problem. If you are unable to resolve it, check the technical support section of our website before contacting Astro-Physics. Additional troubleshooting and adjustment information will be posted there in the future.

A problem was discovered in the E1 and KE1 chips (in GTOCP1 and GTOCP2 control boxes) that makes recovery from a motor stall a bit more problematic. This ONLY applies to the E1 and KE1 chips. Initiating movements with the direction buttons does not always fully reset the stall condition with these two chips. If you experience a motor stall with the E1 or KE1 chip, it is recommended that you power-cycle the mount. The mount will NOT be lost if the scope has not been moved by hand.

The Keypad display says “low battery.”

Your battery output has dropped below 11 volts. If you plug in your Kendrick heater, CCD camera or other power-hungry device into the same battery that operates your mount, your battery voltage will drop momentarily. We recommend that you power your mount from a separate battery. You might consider a large marine battery. If 110V is available, we recommend that you use a power supply (filtered and regulated) with a minimum output of 5 amps at 12V DC. DO NOT use a wall-transformer.

The Keypad locks up on the “Astro-Physics” screen and will not advance to the next screen.

There are several conditions that may cause this to occur.

- Battery power has dropped. If you measure the output of your battery to be above 11.5V, but the Keypad is locking up, please contact Astro-Physics. If your battery measures below 11.5V, recharge or replace your battery.
- Recent lightning strike or power surge damaged components in the control box. The control box will have to be returned to Astro-Physics. Please call ahead for a return authorization number.
- Other unknown chip failure in the control box. Contact Astro-Physics.
- The Keypad was loaded with version 4.12 with Auto-Connect set to yes and Keypad was not reset to default values. This may have occurred during programming at Astro-Physics or following an internet download before this issue was discovered. To remedy, refer to the Technical Support section of the website and read the revised instructions pertaining to the 4.12 upgrade.

- Keypad locks up in cold weather but works fine when used in warmer temperatures. This is a rare problem caused by a defective real-time clock in the Keypad. Contact Astro-Physics.
- Corroded circuit board in the Keypad.

The Keypad display text blinks on and off, but there is no clicking sound.

- Battery power has dropped below the required threshold. If you measure the output of your battery to be above 11.5V, but the Keypad is still blinking one and off, please contact Astro-Physics. If your battery measures below 11.5V, recharge or replace your battery.

The Keypad is resetting – making a clicking sound as the screen display disappears and reappears

- If Auto-Connect had been set to “NO”, the Location Selection menu will appear each time requesting you to startup again.
- If Auto-Connect had been set to “YES” or “EXT”, the display will reappear wherever you left off. The clicking noise will be annoying, but you will not lose functionality.

There are several potential causes and detailed solutions, which are outlined on our website in the Technical Support section.

The R.A. drive makes random movements and jumps in position as it is tracking.

- It is possible that someone programmed the PEM correction in a random manner. Check the PEM setup screen to see if the PLAY setting is active. If it is, change the setting to NONE and observe the action of the mount. This is most likely to occur when a group of people use the mount and one person experiments, unbeknownst to the others. To remedy, leave the setting to NONE until a proper PEM recording is made.

The telescope slewed in the wrong direction toward the pier.

As long as you provide the mount with proper information, your telescope will slew safely from one part of the sky to another. These are a few scenarios that can cause a problem:

- You did not start your first session at that location by following the Normal Startup Procedure outlined in the manual.
- Your time or daylight savings is not set correctly (if it applies to your state or country). In the location menu, press the “0” number button if daylight savings is not in effect (e.g. winter). Enter “1” if daylight savings is in effect (e.g. summer). Remember to change this when we “spring forward” or “fall back”.
- When you selected your calibration star, the scope was set up on the wrong side of the mount. Or, in conjunction with the daylight savings issue, if the daylight savings is set incorrectly and you choose a star near the meridian, the scope may be on the wrong side of the mount according to the time set on the Keypad.

You must point to stars in the west when your telescope is on the east side of the mount and stars in the east when your scope is on the west side. When the stars are high and close to the zenith, this can be tricky. However, you can tell which side the star is on by looking at the “z” number in the upper right corner of the Choose Star screen, then comparing that number with the R.A. number of the star you choose. If the R.A. number is larger, the star is in the east. If your scope is not on the correct side, the mount will not slew properly and the telescope could strike the pier/tripod.

- You identified a star incorrectly when you selected it.
- Your time setting sent to the mount by the computer may be inaccurate.

I pressed the Keypad button and it jumped ahead two steps.

This happens if you hold the button too long. Just give it a short press.

The power light goes out and the motors stop.

The voltage of your battery has probably gone below 10 volts.

The motors moved when I disconnected one of the cables.

This is caused when the contacts of the connectors disconnect briefly, then reconnect again as you remove the cable. We recommend that whenever you disconnect any of the cables, you do so quickly with a firm outward movement.

I parked the mount last night, but it started moving again.

Please read "Parking and Power Considerations" under the Parking Your Telescope Section.

The Time/LST Screen doesn't exit right away when I hit the menu button.

Please push and hold the menu button until you are brought back to the main menu. A quick push may not be recognized right away in this menu due to the way the time software is handled.

The Keypad doesn't save my data when I press the MENU button to leave the entry screen.

Due to the change in the way the cursor control works from Version 3.2 and lower, you MUST press the GoTo button to save your data, i.e. location or date/time. Pressing the MENU button will exit the screen and lose any data you entered. This change was made to accommodate the full cursor control enabled by pressing the <PREV and NEXT> buttons.

The GoTo button now acts like the ENTER or GO button on a computer or web browser and the Menu button acts like the ESC or BACK button on a computer or web browser.

The Keypad will not accept my location data I received from my GPS or a Website.

Many websites and GPS units return your location in a decimal number of Lat and Long

i.e. 42.3589 Latitude 89.0409 Longitude

The Keypad's input is in Degrees, Minutes, Seconds

i.e. 42° 21' 32" Latitude 89° 02' 27" Longitude

If you were to type the decimal data into your Keypad it would give you an error message. This happens because the decimal number is not equivalent to the Degrees, Minutes, Seconds format. The 4.x Keypad has error checking that will not allow more than 60 minutes or 60 seconds to be entered. It is possible to have inaccurate location data in your mount if none of the minute or second values you entered were over 60.

Please double check your location data to make sure you entered it in the correct format.

Here is a link to a free online converter that will give you the proper format for entry into your Keypad.

<http://www.fcc.gov/mb/audio/bickel/DDDMMS-decimal.html>

It is also relatively easy to calculate the conversion. Using the example above:

1. Separate whole degrees from decimal portion: 42° + 0.3589° Lat. and 89° + 0.0409° Long.
2. Multiply the decimal portion times 60. This will give you the minutes:
3. 0.3589 x 60 = 21.534 Minutes Latitude – DO NOT round – use 21'
4. 0.0409 x 60 = 2.454 Minutes Longitude – DO NOT round – use 02'
5. Repeat the multiplication with the decimal portion of the minutes calculated in step 2. This will give the seconds:
6. 0.534 x 60 = 32.04 Seconds Latitude – round to 32"
7. 0.454 x 60 = 27.24 Seconds Longitude – round to 27"
8. Combine: Latitude: 42° + 21' + 32" and Longitude: 89° + 02' + 27"

The Mount will not park correctly, nor will it point properly, it also indicates that an object is below the horizon when I can clearly see it is not.

This can occur if you did not enter your location, date and time data and follow the Normal Startup Procedure. Every time you start up at a new location or change your time, you must follow the Normal Startup procedure to send vital date, time and location data to your mount. Otherwise, it will be lost.

I am trying to upgrade my Keypad and the loader is telling me that it finds the mount but the firmware is the incorrect version.

There are few possible causes:

The first is that your control box firmware is in fact a version that does not support online Keypad upgrades (Version B or lower). Please call Astro-Physics to get your chip upgraded.

The second is that your computer is set to an incorrect COM port and is communicating with another device on your COM port, most commonly a modem. Verify your COM port settings with another program like PulseGuide or The Sky to make sure that you have communication with the mount. Check the COM port setting in the program and make sure the same COM port is selected in the Keypad loading program.

I am upgrading my Keypad from the website and the loader appears to be working but no data is appearing on the screen other than sending page x...

In most cases this is caused by attempting to load the Keypad through the bottom port on the control box. The Keypad MUST be loaded through top COM port on the control box or the load will fail. If you have already attempted to load your Keypad in this manner and are only left with a blinking cursor on the screen, you can start the loading steps from the start and your Keypad will load properly. Please follow all download instructions very carefully.

When I enter an object it slews to the wrong place, tells me that it is below the horizon by several degrees and has completely incorrect object data.

If all 3 of these symptoms are occurring it is likely that your Keypad's database has been corrupted or lost. Many things can cause this to happen, removing the internal Keypad battery improperly, having a dead or dying battery or power surges caused by lightning strikes are all common triggers for this. To reload your Keypad's database you will need to download a utility from the Astro-Physics website to repair your database. If the database continues to fail after you have reloaded it, please call Astro-Physics for further instructions.

My motorized focuser won't operate at the slow speed setting.

Please refer to the section earlier in the manual on using the focus control functions. You probably have a GTOCP3 control box with RoHS compliant lead-free components. The lead-free driver chip does not support the slow focus speed for all motors. You can still use the external controller that came with the focus motor.

APPENDIX A: COLLECTIVE RELEASE NOTES

Version 4.19.3 – 07-29-16

- **Fixed display bug in Get Time / Location from Mount function.** Time loaded from mount correctly; however, first display of time showed zeros in hours field. Subsequent displays were fine. Time now displays correctly.
- **Corrected version number returned by status command.** Correct firmware version is now being displayed when seeking keypad status via "3=Tools → 0=Status → (North Key) → Code Level: V4.19.3".
- **Clarified New Setup Menus.** The wording was changed on the "New Setup" screen in order to clarify the function. It now says "New Setup / Start From / Park Position / Press: 1, 2, 3, 4". (Previously it was "New Startup / Resume From / Reference Position / Press: 1, 2, 3, 4".)

Version 4.19.2 – 01-19-16

"Auto-Connect: YES" will restore the last used location for all locations 0-9 when the mount is powered up again. In prior versions, only locations accept 1-9 were remembered, not location "0" (hard-coded Astro-Physics latitude and longitude).

Version 4.19.1 – 01-18-16

Fixed variable reset in startup routine. Fixed a bug that prevented the keypad from slewing to a target object after the new startup routine.

Version 4.19 – 01-18-16

- **Fixed Park 1 leap-year related issue that caused incorrect movement.** Although the issue would resolve itself on March 1st, after the leap-year day of February 29, we felt it was important to fix this problem since many people rely on Park 1.
- **New Park 4 Position.** This position has been available in the AP V2 ASCOM driver and APCC for some time and is now added to the Keypad.
- **New Park 0 Position.** This position allows you to park anywhere you wish. Simply move the mount (via the servo, not the clutches) to the desired position and select Park 0. The mount will NOT start tracking when you power up again.
- **New Sync, Align, Resume Menu.** This menu now offers new selections: "3=ResumeLastPosition" and "4=New Setup". "ResumeLastPosition" is used when you have parked the mount at the end of the previous session and wish to begin a new session. Selecting it will initialize the mount and you'll be ready for your first object. If you select "4", the new Setup Menu will display.
- **New Setup Menu.** "New Setup" is only used when you are setting up the mount for the first time or if you have readjusted scope position via the clutches and wish to restart from a "Reference Position". The "Reference Position" can be either 1, 2, 3 or 4. If using "Reference Position", you must be certain that your mount is actually in that position, otherwise, the misinformation will cause the mount to be lost.
- **New Park/ Mount Options Menu.** In addition to the expanded park position selections discussed above, additional mount types are available for selection: *Mach1GTO*, *1100GTO*, *1600GTO* and *3600GTO*.

Version 4.18 – Not released

Version 4.17 – 10-20-08

- **Version 4.17 replaces v.4.16 from 7-7-08 which had a bug that caused occasional random freeze-ups during initialization of the mount, especially when resuming from Reference Park 1.**
- **Version 4.16 replaced v.4.15 from 3-24-08 which had a bug that only affected older keypads – Serial numbers 1490GTO and earlier.**
- **Eastern Longitudes.** The accuracy of eastern longitude values that are sent to the mount has been improved by including minutes in the calculation. We are unable to add seconds into the calculation at this time, due to memory space limitations in the keypad.

- **Eastern Time Zones When Polling the Mount.** The 3=Get Time/Loc FrMnt command (how you “poll” the mount) now returns correct time zone values for people in eastern longitudes using the GTOCP3 control box. (GTOCP1 & 2 control boxes already returned the correct time zone values in version 4.12 and continue to do so in version 4.16)
- **Shipping Notice.** Because these changes only applied to eastern longitudes, a small number of keypads with v.4.12 were shipped to US addresses after the March 24, 2008 introduction of v.4.15. A larger number of keypads were also shipped with v.4.15, which contained a bug that only affected older keypads (S#1490 and earlier). Because this bug only affected older keypads, it was of no consequence to these new keypads. That bug, however, was fixed with v.4.16 which, unfortunately, had its own problem during initialization. Keypads shipped between March and July of 2008 will have v.4.15. Keypads shipped between July and October of 2008 will have v.4.16 and should be re-programmed to v.4.17. The following applies equally to all three versions: v.4.15, v.4.16 and v.4.17. For simplicity, most references from this point on will be to v.4.17 only.

Starting in March, 2008, Astro-Physics customers began receiving GTO keypads that had been programmed with a new version of our keypad firmware. This new keypad version – v.4.15 – and its immediate successors – v.4.16 and v.4.17 - address some of the issues that have faced customers in eastern time zones. Other issues pertaining to southern latitudes were addressed in the latest ROM chip version in the GTOCP3 control box: the “Q” chip. (Only people using their mounts in the southern hemisphere need the “Q” ROM chip.) In terms of operation, version 4.17 is identical to version 4.12, and the manual included with the keypad is, in fact, the v.4.12 Keypad Manual. This supplemental document will explain the differences, as well as the limitations and remaining issues with this new firmware. We anticipate that all remaining issues will be resolved in the next major firmware release which will be v.4.20.

Some of the discussion below may not make sense to new users of the Astro-Physics GoTo Servo System who are not already familiar with keypad operations. We have therefore included references to the pages of the v.4.12 manual where the related operations are explained in detail. If you are new to our system, it is suggested that you read the entire “Getting Started” section of the manual before worrying about any of the details below.

Version 4.12 – 09-06-04

- **GMT and LST issues for E longitude.** Fixed bug. Keypad now interprets correctly all E longitude data when polling the mount for location, time and time zone data.
- **Set Date & Time.** Fixed bug that caused LOC:-3 display in 4=Time/LST and error message when Set Date & Time screen was selected under certain circumstances.
- **Auto-Connect set to YES.** Fixed bug. Locations 2-9 will Auto-Connect correctly.
- **Reset Command.** The keypad will reset all user-defined values to the default setting of 0 in real time.
- **Error checking in Site Location Data screen.** Only N-S-E-W values will be accepted. If incorrect, an error message will appear.

Version 4.11 – 08-28-04

- **Resume from Park.** Fixed bug. Now works properly.
- **Site Location Data screen.** Changed name from Set Site Location to more clearly define its function. Also fixed bug. If you press MENU when exiting Site Location Data screen, it will not impact the location display of 4=Time/LST screen.
- **Sync command in Messier, NGC and IC input screens.** The Sync command was removed from this screen since it was not valid. You must press NEXT> twice to enter the Sync command screen.

Version 4.10 – 08-26-04

- **Syncing on Planets.** This version now allows you to synchronize on the Sun, Moon, Venus, Mars, Jupiter and Saturn. Press the <PREV button to take you back out to the Sol Menu if you entered from it.
- **Default display of R.A./Dec. co-ordinates in Objects screen.** Press the <PREV button to display the object data on this screen. This increases the speed of the keypad and allows the function of the N-S-E-W buttons in more places.
- **Sync on almost any object, before or after moving to the object.** To sync on the object currently selected press the NEXT> button. This is now common for all objects in all menus.
- **Fixed a minor bug in the resumption of tracking after parking the mount.** The mount now tracks at whatever speed was last selected when coming out of park.

- **PEM display now automatically changes to PLAY after recording.** Fixed condition that required you select PLAY manually.
- **The meridian delay is saved but automatically resets to 'zero' after the mount is restarted.** This allows the mount to know where it is when the session starts, but forces you to set up the meridian delay for each session to prevent unintended consequences.
- **Stars heading after selecting the star has been changed to 'Objects:'** This change has been made due to the addition of planets to these screens. Planets are obviously not stars.
- **Re-Calibrate command.** Fixed bug. The keypad now sends the proper re-calibrate command from the RA/DEC REV menu.
- **RA/Dec Readout.** Fixed bug. N-S-E-W buttons will work correctly.
- **Keypad Update Menu added.** This new menu is found under the Keypad Options menu. It allows you to update the keypad database without losing your personal settings. It is now possible to reset back to the factory default settings. In prior versions, this was a one-part command that reset the keypad whenever the database was loaded (this was only done at Astro-Physics, it was not available for internet download at the time). Now, there is a two-part menu that allows you to maintain your personal settings when re-loading a database (this will be handy for future additions to the object databases) or you can reset your settings back to the defaults without having to shut down your mount (handy if you purchase a used mount and wish to remove prior settings in order to enter your own).

Version 4.07 – 02-16-04

- **Re-designed menu system.** Startup and setup displays have been re-designed for easier use and access. Other displays are totally new. Please look through all of the menus to make note of the changes before you go out observing.
- **Full cursor control in all entry areas.** The keypad's cursor can be moved backwards and forwards with the <PREV and NEXT> in all of the areas where data is entered. Great for fixing any mistakes you make without having to start from the beginning again. This feature will be especially handy for time and location settings. When you hit the last column of entry data the cursor will move back to the start. You must press GoTo to save or to run your entry or MENU to exit from the screen.
- **All entry screens will only enter or save when GoTo is pressed.** Also pressing MENU will exit you from any screen with the entered data being lost. Adds built in confirmation of all entries.
- **Saved variables.** The keypad will now store the important user variables, tracking, slewing and guiding rates and other settings, after it is shut down or unplugged.
- **Four button (N-S-E-W) + Stop.** Now available throughout the keypad, in all menus, object screens and most input areas.
- **Guide speed / button speed settings.** Separate settings for external auto-guider operation and button speeds. Auto-guider settings of 0.25x, 0.5x, 1x are now independent of the button speed settings.
- **± Button.** Now permits auto-guide value to be changed on this menu as well.
- **Start from Reference Park.** This allows you to start the mount in the field by placing the telescope in Park 1 position for quick daytime polar alignment.
- **External auto connect.** Now you can start the servo from an external computer and send time, date and location from that source at startup without having to unplug the keypad each time. This insures that the keypad, mount and computer will all be synchronized with each other automatically. The keypad will go directly to the Main Menu as soon as the external program initializes the mount. All values of time, date and location will be transferred to the keypad. The keypad can then be used in the normal manner at any time.
- **SmartGuide control.** Adds variable speed capability to both axes. Designed to null out drift during unguided exposures. Great for tracking slow-moving, non-sidereal objects such as lunar craters, comets and asteroids.
- **Get time and location from mount.** You can now ask the mount for the time and location and set that value to the keypad. This value could be sent to the mount via your external computer program. This allows the mount, the keypad and external computer to all be in sync.
- **9 Locations.** Longitude, Latitude and time zone now can be set to 9 different places. We suggest noting them on a piece of paper on the back of your keypad so that you can keep track of them all.
- **Altitude/Azimuth display.** Added to real-time R.A./Dec. display. Alt/Az values change as mount is moved in R.A./

Dec. directions. With tracking rate set to zero, mount can be positioned for fixed targets to any Alt/Az point.

- **Altitude/Azimuth input.** This new option allows you to slew to any position in the sky as long as you know the Altitude and Azimuth angles.
- **New local horizon limit setting.** Useful for keeping your telescope from slewing to objects below your observing site's horizon.
- **Audible feedback with Re-calibration command.** You will now hear a beep when you re-calibrate the mount to confirm that the operation is complete. Re-Calibrate has also been removed from the objects menu. It is still located in the RA/DEC/REV screen 9=Re-Calibrate.
- **What's Up Now?** Tied to horizon limit as well using the M, NGC, and IC databases of objects in the keypad. What's up Now function will suggest objects to view based on what is actually above the horizon at the time 'What's Up' is requested.
- **Auto initialization routine.** Detects when new firmware is loaded to the keypad and if saved values need to be re-initialized. This new 'power on' routine will now auto-decide if the keypad needs to be re-set to factory defaults when new saved values are added. When a new future release of the code is loaded into the keypad, the user will no longer have to manually reset all his/her custom keypad settings, i.e. locations and daylight savings.
- **Full error checking.** Added to Location, Date/Time, R.A./Dec., Alt/Az entry - with notification if entry is not valid. Will not allow impossible settings.

Please see the Vintage Products section of our website's Technical Support page for information regarding earlier versions of the Keypad firmware.

APPENDIX B: REMAINING KNOWN KEYPAD ISSUES

Summary of Remaining Keypad Issues:

- Slightly inaccurate eastern longitude values are still being sent to the mount. Accuracy has been improved to within +/- an arc minute.
- Western longitudes with eastern time zones – a remaining issue. We suggest operating on GMT with no offsets.
- Polling the Mount (3=Get Time/Loc FrMnt command) returned incorrect GMT offset values
 - General issue resolution for most users.
 - Special problems with time zone zero and west longitudes
 - Issue with time zone 12 East and Daylight Savings Time
- Longitude limit for people near 180° East Longitude
- Dealing with the International Date Line and fractional time zones

Eastern Longitude Values

(see pp. 14-16) Keypad v.4.17 will give the mount a more accurate value for your eastern longitude than v.4.12. The servo only accepts longitude values as west values, so the keypad must convert your eastern longitude to a western value by subtracting it from 360 degrees. In v.4.12 and all previous versions, only the degrees were subtracted while the minutes and seconds were ignored. This could result in up to almost a 2 degree error in the longitude in the servo. V.4.17 now also takes the minutes into account by subtracting from 359° 60'. There was not sufficient memory space in the relevant sector to also account for the seconds without a major re-allocation of the code, so the full fix will be accomplished in v.4.20.

For this version, it is recommended that those of you in the east round your longitude to the nearest minute, and enter zeros in the “seconds” field when entering your location data. With v.4.17, the mount will not receive any “seconds” data from the keypad at all. This ONLY applies to eastern longitudes. Latitudes and western longitudes can be entered normally. DO NOT try to enter your eastern longitude as a western longitude by doing the arithmetic yourself. (Actually, the keypad won't let you.) To correctly calculate the sidereal time, both the keypad and the mount must know whether you are east or west of the Prime Meridian. The error you would introduce by trying to “trick” the mount is considerably larger than the 30 arc second maximum error in longitude that you would have by rounding to the nearest minute. External software like PulseGuide can initialize the mount with the full eastern longitude including seconds.

Western Longitudes with Eastern Time Zones

(see pp. 14-16) There is currently no provision in the keypad for dealing with the situation in far western Europe and parts of Africa (i.e. western France, western Algeria and most of Spain) where the longitude is a west value, but the local time is on the CET standard of one hour east (local CET = GMT + 1) or two hours east in the summer (CEST = GMT + 2). There are no cases of locales in eastern longitudes that are on western time zones that we are aware of.

The keypad uses four pieces of information to calculate the correct GMT (and thus the correct LST and horizon coordinates). To calculate GMT, it needs: 1 – local time; 2 – time zone; 3 – daylight savings factor; and 4 – whether the longitude is east or west. Version 4.20 will address the situation of western longitudes with eastern time zones, probably with a separate E or W setting for the time zone that is not tied to the longitude, but the current firmware does not.

For people in this situation, probably the easiest solution is to keep the keypad entirely set to GMT.

9. Set the local time to UTC (aka GMT).
10. Set the time zone for ALL entered locations to 00.
11. Leave the Daylight Savings set to 0 = Winter all the time
12. Enter your longitude for all locations correctly using E or W as appropriate.
13. Remember that in use, your keypad will no longer display the local time. If you wish to know “what time it is,” you will need to either look at your watch or convert GMT to local.

Please note: This is a more serious issue than many of those that follow. This affects how the servo is initialized, and

therefore affects proper operation of the mount from the very beginning. It is important if you are in a western longitude with an eastern time zone that you make the adjustments outlined above to ensure correct and safe operation. Both the servo and the keypad use the “equations of time” to calculate the meridian and the horizons. The equations of time start from GMT, and then incorporate your longitude. The important thing to remember is that both the keypad and the servo must be able to determine the correct GMT in order to know where the meridian and the horizons are in terms of right ascension values. From the main menu, you can always check the 4=Time/LST button to verify that GMT is correct.

Incorrect GMT Offsets When Polling the Mount from the Keypad

(see p. 44) Keypad v.4.17 addresses a bug with the 3=Get Time/Loc FrMnt command in the 2=Setup => 1=Locations & Time menu. Earlier versions of the keypad firmware did not return the correct value for the GMT offset from the mount when polled from the keypad in eastern time zones. This problem only occurred with GTOCP3 control boxes because they return negative numbers for eastern offsets whereas the older GTOCP1 & 2 returned text for the negative values. In all cases, the correct values were being sent to the mount’s servo, and all other mount functions relating to the GMT offset were handled correctly. Version 4.17 will now return the correct values for all time zones except for the special cases below.

Western Longitudes at Time Zone Zero

(see p. 44) There is one major issue that remains when using the 3=Get Time/Loc FrMnt command: Customers in western longitudes who are in time zone 0 cannot poll the mount and get the correct offset when daylight savings time is in effect. This will affect customers in Great Britain, Portugal and West Africa. The keypad sends the correct information to the mount servo, but it cannot retrieve it correctly at this juncture, because it wants to apply the “west” standard to the “01” that is returned from the mount. This erroneously puts the offset as one hour behind GMT instead of one hour ahead of GMT. Customers affected by this bug have two options until version 4.20 is released: 1. Do not use the 3=Get Time/Loc FrMnt command when daylight savings is in effect, or 2. Keep your keypad, computer etc. on standard time so that the system’s time always equals GMT.

Eastern Longitudes and Time Zone 12

There is an additional minor remaining issue with the 3=Get Time/Loc FrMnt command, but it should be of no consequence to anyone that we are aware of. If you happen to be in time zone 12 east and observe daylight savings time giving an offset to GMT of local time – 13 hours, AND you are using a GTOCP1 or 2, you cannot use this command. Again, all data sent to the mount is fine; you just can’t have the keypad poll the mount for your time and location data.

Eastern Longitude Limit

(see pp. 14-16) The last issue will only affect people in the Fiji Islands and in far north-eastern Siberia. Because of the longitude issue outlined above, an eastern longitude above 178° 59’ 00” should not be used. At this time, we know of no one who is affected.

The International Date Line

The region on either side of the International Date Line (IDL) has the potential to pose some problems. First of all, the IDL is not a straight line at exactly 180° from the Prime Meridian. There are Pacific Islands (Tonga, parts of Fiji, Chatham etc.) whose longitudes would be measured as West, but who are in an eastern time zone. Likewise, many of the western Aleutians are actually in eastern longitudes, but have western time zones. The keypad will not allow a time zone greater than 12 or a longitude higher than 180° either east or west. Fortunately, we again know of no customers in these locations, but you never know... This is where we would have to trick the system.

Let’s say you have taken your Mach1GTO on a South Pacific Dream Vacation in Tonga at 175° 08’ West Longitude, but at 13 hours east time zone. (Thank goodness there’s no DST in Tonga!) Since you want to begin with some solar observing you decide to use the Daytime Polar Alignment Routine which requires accurate time, date and location information to be successful. (The mount must know the exact LST to know the RA and Dec values for the Park Positions. (See pp. 23-28) The key to successfully tricking your mount is to remember that your DATE must be backed up by one day if in a western longitude with an eastern time zone, and it must advance by one day if in an eastern longitude with a western time zone. For my Tonga example, let’s assume it is Feb. 15th, and local time is 3:15pm (15:15:00). You already entered the correct longitude of 175° 08’ 15” W and the correct latitude of 21° 10’ 47” S and then entered the time zone as 24 – 13 = 11 hours west. (The keypad will assign the west time zone because the longitude is west.) You check the GMT by pressing the 4=Time/LST button and see that it correctly reads 02:15:00. The problem is that your mount will be calculating LST one day off amounting to about +4 minutes of LST error or about 1° off (west) in your Daytime Polar Alignment Routine. To

correct this, just set your keypad's date back to Feb. 14th, wish everyone Happy Valentines Day once again, and proceed with polar aligning and observing.

Fractional Time Zones

There is no provision in the keypad firmware at this time for fractional time zones as are found in Central Australia, Iran, Afghanistan, India, Nepal and several other locations. To get proper function from your keypad, you will have to adjust the keypad's clock to a time value that does not match the clock on your wall. The important thing is that the keypad calculates the correct GMT.

APPENDIX C: COMMON STARS – BY CONSTELLATION

Constellation	Star Name	Flamsteed-Bayer Designation	Abbrev	Magnitude(SAO)
Andromeda	Alpheratz	21-Alpha Andromedae	Alf And	2.1
	Mirach	43-Beta Andromedae	Bet And	2.4
	Almach	57-Gamma1 Andromedae	Gam And	2.3
Aquarius	Sadalmelik	34-Alpha Aquarii	Alf Aqr	3.2
	Sadalsuud	22-Beta Aquarii	Bet Aqr	3.1
	Skat	76-Delta Aquarii	Del Aqr	3.5
	Albali	2-Epsilon Aquarii	Eps Aqr	3.8
Aquila	Altair	53-Alpha Aquilae	Alf Aql	0.9
	Alshain	60-Beta Aquilae	Bet Aql	3.9
	Tarazed	50-Gamma Aquilae	Gam Aql	2.8
Aries	Hamal	13-Alpha Arietis	Alf Ari	2.2
	Sheratan	6-Beta Arietis	Bet Ari	2.7
	Mesarthim	5-Gamma2 Arietis	Gam Ari	4.8
Auriga	Capella	Alpha Aurigae	Alf Aur	0.1
	Menkalinan	34-Beta Aurigae	Bet Aur	2.1
Boötes	Arcturus	16-Alpha Boötis	Alf Boo	0.2
	Nekkar	42-Beta Boötis	Bet Boo	3.6
	Seginus	27-Gamma Boötis	Gam Boo	3.0
	zar	36-Epsilon Boötis	Eps Boo	2.7
	Muphrid	8-Eta Boötis	Eta Boo	2.8
	Alkalurops	51-Mu1 Boötis	Mu Boo	4.5
Cancer	Acubens	65-Alpha Cancri	Alf Cnc	4.3
	Asellus Borealis	43-Gamma Cancri	Gam Cnc	4.7
	Asellus Australis	47-Delta Cancri	Del Cnc	4.2
Canis Major	Sirius	9-Alpha Canis Majoris	Alf CMa	-1.6
	Mirzam	2-Beta Canis Majoris	Bet CMa	2.0
	Wezen	25-Delta Canis Majoris	Del CMa	2.0
	Adhara	21-Epsilon Canis Majoris	Eps CMa	1.6
	Furud	1-Zeta Canis Majoris	Zet CMa	3.1
	Aludra	31-Eta Canis Majoris	Eta CMa	2.4
Canis Minor	Procyon	10-Alpha Canis Minoris	Alf CMi	0.5
	Gomeisa	3-Beta Canis Minoris	Bet CMi	3.1
Canis Venatici	Cor Caroli	12-Alpha Canum Venaticorum	Alf CVn	2.9
	Chara	8-Beta Canum Venaticorum	Bet CVn	4.3
Capricornus	Algedi	6-Alpha2 Capricorni	Alf Cap	3.8
	Dabih	9-Beta1 Capricorni	Bet Cap	3.3
	Nashira	40-Gamma Capricorni	Gam Cap	3.8
	Deneb Algedi	49-Delta Capricorni	Del Cap	3.0
Carina	Canopus	Alpha Carinae	Alf Car	-0.9
	Miaplacidus	Beta Carinae	Bet Car	1.8
	Avior	Epsilon Carinae	Eps Car	1.7
	Aspidiske	Iota Carinae	Iot Car	2.3
Cassiopeia	Schedar	18-Alpha Cassiopeiae	Alf Cas	2.5
	Caph	Beta Cassiopeia	Bet Cas	2.3
	Navi	27-Gamma Cassiopeiae	Gam Cas	2.8
	Ruchbah	37-Delta Cassiopeiae	Del Cas	2.7
Centaurus	Alpha Centauri	Alpha1 Centauri	Alf Cen	0.1
	Hadar	Beta Centauri	Bet Cen	0.9

Constellation	Star Name	Flamsteed-Bayer Designation	Abbrev	Magnitude(SAO)
Cepheus	Menkent	5-Theta Centauri	Tet Cen	2.3
	Alderamin	5-Alpha Cephei	Alf Cep	2.6
	Alfirk	8-Beta Cephei	Bet Cep	3.3
	Erral	35-Gamma Cephei	Gam Cep	3.4
	Kurhah	17-Xi Cephei	Xi Cep	4.6
Cetus	Menkar	92-Alpha Ceti	Alf Cet	2.8
	Diphda	16-Beta Ceti	Bet Cet	2.2
	Kaffaljidhma	86-Gamma Ceti	Gam Cet	3.6
	Baten Kaitos	55-Zeta Ceti	Zet Cet	3.9
	Mira	Omicron Ceti	Omi Cet	2.1
Columba	Phact	Alpha Columbae	Alf Col	2.8
	Wazn	Beta Columbae	Bet Col	3.2
Corona Borealis	Alphecca	5-Alpha Coronae Borealis	Alf CrB	2.3
	Nusakan	3-Beta Coronae Borealis	Bet CrB	3.7
Corvus	Alchiba	1-Alpha Corvi	Alf Crv	4.2
	Gienah	4-Gamma Corvi	Gam Crv	2.8
	Algorab	7-Delta Corvi	Del Crv	3.1
Crater	Alkes	7-Alpha Crateris	Alf Crt	4.2
Crux	Acrux	Alpha2 Crucis	Alf Cru	1.6
	Mimosa	Beta Crucis	Bet Cru	1.5
	Gacrux	Gamma Crucis	Gam Cru	1.6
Cygnus	Deneb	50-Alpha Cygni	Alf Cyg	1.3
	Albireo	6-Beta1 Cygni	Bet Cyg	3.2
	Sadr	37-Gamma Cygni	Gam Cyg	2.3
Draco	Thuban	11-Alpha Draconis	Alf Dra	3.6
	Rastaban	23-Beta Draconis	Bet Dra	3.0
	Eltanin	33-Gamma Draconis	Gam Dra	2.4
	Altais	57-Delta Draconis	Del Dra	3.2
	Edasich	12-Iota Draconis	Iot Dra	3.5
	Giasar	1-Lambda Draconis	Lam Dra	4.1
	Alrakis	21-Mu Draconis	Mu Dra	5.1
	Grumium	32-Xi Draconis	Xi Dra	3.9
Equuleus	Kitelpha	8-Alpha Equulei	Alf Equ	4.1
Eridanus	Achernar	Alpha Eridani	Alf Eri	0.6
	Cursa	67-Beta Eridani	Bet Eri	2.9
	Zaurak	34-Gamma Eridani	Gam Eri	3.2
	Azha	3-Eta Eridani	Eta Eri	4.0
	Acamar	Theta Eridani	Tet Eri	3.2
	Beid	38-Omicron Eridani	Omi Eri	4.1
	Keid	40-Omicron2 Eridani	Omi Eri	4.5
Gemini	Castor	66-Alpha Geminorum	Alf Gem	1.6
	Pollux	78-Beta Geminorum	Bet Gem	1.2
	Alhena	24-Gamma Geminorum	Gam Gem	1.9
	Wasat	55-Delta Geminorum	Del Gem	3.5
	Mebstuta	27-Epsilon Geminorum	Eps Gem	3.2
	Mekbuda	43-Zeta Geminorum	Zet Gem	3.9
	Propus	Eta Geminorum	Eta Gem	3.3
Grus	AlNair	Alpha Gruis	Alf Gru	2.2
Hercules	Rasalgethi	64-Alpha Herculis	Alf Her	3.5
	Kornephoros	27-Beta Herculis	Bet Her	2.8

Constellation	Star Name	Flamsteed-Bayer Designation	Abbrev	Magnitude(SAO)
Hydra				
	Alphard	30-Alpha Hydrae	Alf Hya	2.2
Leo				
	Regulus	32-Alpha Leonis	Alf Leo	1.3
	Denebola	94-Beta Leonis	Bet Leo	2.2
	Algieba	41-Gamma2 Leonis	Gam Leo	2.6
	Zosma	68-Delta Leonis	Del Leo	2.6
	Adhafera	36-Zeta Leonis	Zet Leo	3.6
	Alterf	4-Lambda Leonis	Lam Leo	4.5
	Chertan	70-Theta Leonis	Tet Leo	3.4
	Rasalas	24-Mu Leonis	Mu Leo	4.1
	Arneb	11-Alpha Leporis	Alf Lep	2.7
	Nihal	9-Beta Leporis	Bet Lep	3.0
Libra				
	Zubenelgenubi	9-Alpha2 Librae	Alf Lib	2.9
	Zubeneschamali	27-Beta Librae	Bet Lib	2.7
Lyra				
	Vega	3-Alpha Lyrae	Alf Lyr	0.1
	Sheliak	10-Beta Lyrae	Bet Lyr	3.9
	Sulafat	14-Gamma Lyrae	Gam Lyr	3.3
Ophiuchus				
	Rasalhague	55-Alpha Ophiuchi	Alf Oph	2.1
	Cebalrai	60-Beta Ophiuchi	Bet Oph	2.9
	Yed Prior	1-Delta Ophiuchi	Del Oph	3.0
	Yed Posterior	2-Epsilon Ophiuchi	Eps Oph	3.3
	Sabik	35-Eta Ophiuchi	Eta Oph	2.6
	Marfik	10-Lambda Ophiuchi	Lam Oph	3.9
Orion				
	Betelgeuse	58-Alpha Orionis	Alf Ori	0.6
	Rigel	19-Beta Orionis	Bet Ori	0.3
	Bellatrix	24-Gamma Orionis	Gam Ori	1.7
	Alnilam	46-Epsilon Orionis	Eps Ori	1.8
	Mintaka	34-Delta Orionis	Del Ori	2.5
	Alnitak	50-Zeta Orionis	Zet Ori	2.0
	Trapezium	41-Theta1 Orionis	Tet Ori	5.4
	Saiph	53-Kappa Orionis	Kap Ori	2.2
	Meissa	39-Lambda Orionis	Lam Ori	3.7
Pavo				
	Peacock	Alpha Pavonis	Alf Pav	2.1
Pegasus				
	Markab	54-Alpha Pegasi	Alf Peg	2.6
	Scheat	53-Beta Pegasi	Bet Peg	2.6
	Algenib	88-Gamma Pegasi	Gam Peg	2.9
	Enif	8-Epsilon Pegasi	Eps Peg	2.5
	Homam	42-Zeta Pegasi	Zet Peg	3.6
	Matar	44-Eta Pegasi	Eta Peg	3.1
	Biham	26-Theta Pegasi	Tet Peg	3.7
Perseus				
	Mirfak	33-Alpha Persei	Alf Per	1.9
	Algol	26-Beta Persei	Bet Per	2.9
	Atik	44-Zeta Persei	Zet Per	2.9
	Menkib	46-Xi Persei	Xi Per	4.0
Phoenix				
	Ankaa	Alpha Phoenicis	Alf Phe	2.4
Pisces				
	Alrescha	113-Alpha Piscium	Alf Psc	4.3
Piscis Austrinus				
	Fomalhaut	24-Alpha Piscis Austrini	Alf PsA	1.3
Sagittarius				
	Rukbat	Alpha Sagittarii	Alf Sgr	4.1
	Arkab	Beta1 Sagittarii	Bet Sgr	4.3
	Alnasi	10-Gamma2 Sagittarii	Gam Sgr	3.1
	Kaus Media	19-Delta Sagittarii	Del Sgr	2.8
	Kaus Australis	20-Epsilon Sagittarii	Eps Sgr	2.0
	Ascella	38-Zeta Sagittarii	Zet Sgr	2.7

Constellation	Star Name	Flamsteed-Bayer Designation	Abbrev	Magnitude(SAO)
Scorpius	Kaus Borealis	22-Lambda Sagittarii	Lam Sgr	2.9
	Nunki	34-Sigma Sagittarii	Sig Sgr	2.1
	Antares	21-Alpha Scorpii	Alf Sco	1.1
	Graffias	8-Beta Scorpii	Bet Sco	2.9
Serpens	Shaula	35-Lambda Scorpii	Lam Sco	1.7
	Lesath	34-Upsilon Scorpii	Ups Sco	2.8
Taurus	Unukalhai	24-Alpha Serpentis	Alf Ser	2.8
	Alya	63-Theta Serpentis	Tet Ser	4.5
	Aldebaran	87-Alpha Tauri	Alf Tau	1.1
	Elnath	112-Beta Tauri	Bet Tau	1.8
	Alcyone	25-Eta Tauri	Eta Tau	3.0
	Celaeno	16 Tauri	16 Tau	5.4
	Electra	17 Tauri	17 Tau	3.8
	Taygeta	19 Tauri	19 Tau	4.4
	Maia	20 Tauri	20 Tau	3.9
	Sterope	21 Tauri	21 Tau	5.9
	Merope	23 Tauri	23 Tau	4.3
	Atlas	27 Tauri	27 Tau	3.8
Triangulum Australe	Pleione	28 Tauri	28 Tau	5.2
	Atria	Alpha Trianguli Australis	Alf TrA	1.9
Ursa Major	Dubhe	50-Alpha Ursae Majoris	Alf UMa	2.0
	Merak	48-Beta Ursae Majoris	Bet UMa	2.4
	Phecda	64-Gamma Ursae Majoris	Gam UMa	2.5
	Alioth	77-Delta Ursae Majoris	Eps UMa	1.7
	Megrez	69-Delta Ursae Majoris	Del UMa	3.4
	Mizar	79-Zeta Ursae Majoris	Zet UMa	2.4
	Alkaid	85-Eta Ursae Majoris	Eta UMa	1.9
	Talitha	9-Iota Ursae Majoris	Iot UMa	3.0
	Tania Borealis	33-Lambda Ursae Majoris	Lam UMa	3.5
	Tania Australis	34-Mu Ursae Majoris	Mu UMa	3.2
	Alula Borealis	54-Nu Ursae Majoris	Nu UMa	3.7
	Alula Australis	53-Xi Ursae Majoris	Xi UMa	3.9
	Muscida	1-Omicron Ursae Majoris	Omi UMa	3.5
	Alcor	80 Ursae Majoris	80 UMa	4.0
Ursa Minor	Polaris	1-Alpha Ursae Minoris	Alf UMi	2.1
	Kochab	7-Beta Ursae Minoris	Bet UMi	2.2
	Pherkad	13-Gamma Ursae Minoris	Gam UMi	3.1
Vela	Regor	Gamma2 Velorum	Gam Vel	1.9
	Suhail	Lambda Velorum	Lam Vel	2.2
Virgo	Spica	67-Alpha Virginis	Alf Vir	1.2
	Zavijava	5-Beta Virginis	Bet Vir	3.8
	Porrina	29-Gamma Virginis	Gam Vir	2.9
	Vindematrix	47-Epsilon Virginis	Eps Vir	3.0
	Zaniah	15-Eta Virginis	Eta Vir	4.0
	Syrma	99-Iota Virginis	Iot Vir	4.2

APPENDIX D: ALPHABETICAL STAR LIST

These stars are listed in the same order as they appear on your display when you are either following the calibration routine or have chosen Stars from the Objects Menu. Note that Polaris appears twice.

Common Name	Flamsteed-Bayer Designation	Abbrev.	Magnitude (SAO)
Polaris	Alpha Ursae Minoris	Alf UMi	2.1
Acamar	Theta Eridani	Tet Eri	3.2
Achernar	Alpha Eridani	Alf Eri	0.6
Acrux	Alpha2 Crucis	Alf Cru	1.6
Acubens	65-Alpha Cancri	Alf Cnc	4.3
Adhafera	36-Zeta Leonis	Zet Leo	3.6
Adhara	21-Epsilon Canis Majoris	Eps CMa	1.6
Albali	2-Epsilon Aquarii	Eps Aqr	3.8
Albireo	6-Beta1 Cygni	Bet Cyg	3.2
Alchiba	1-Alpha Corvi	Alf Crv	4.2
Alcor	80 Ursae Majoris	80 UMa	4.0
Alcyone	25-Eta Tauri	Eta Tau	3.0
Aldebaran	87-Alpha Tauri	Alf Tau	1.1
Alderamin	5-Alpha Cephei	Alf Cep	2.6
Alfirk	8-Beta Cephei	Bet Cep	3.3
Algedi	6-Alpha2 Capricorni	Alf Cap	3.8
Algenib	88-Gamma Pegasi	Gam Peg	2.9
Algieba	41-Gamma2 Leonis	Gam Leo	2.6
Algol	26-Beta Persei	Bet Per	2.9
Algorab	7-Delta Corvi	Del Crv	3.1
Alhena	24-Gamma Geminorum	Gam Gem	1.9
Alioth	77-Epsilon Ursae Majoris	Eps UMa	1.7
Alkaid	85-Eta Ursae Majoris	Eta UMa	1.9
Alkalurops	51-Mu1 Boötis	Mu Boo	4.5
Alkes	7-Alpha Crateris	Alf Crt	4.2
Almach	57-Gamma1 Andromedae	Gam And	2.3
AlNair	Alpha Gruis	Alf Gru	2.2
Alnasl	10-Gamma2 Sagittarii	Gam Sgr	3.1
Alnilam	46-Epsilon Orionis	Eps Ori	1.8
Alnitak	50-Zeta Orionis	Zet Ori	2.0
Alpha Centauri	Alpha1 Centauri	Alf Cen	0.1
Alphard	30-Alpha Hydrae	Alf Hya	2.2
Alphecca	5-Alpha Coronae Borealis	Alf CrB	2.3
Alpheratz	21-Alpha Andromedae	Alf And	2.1
Arakis	21-Mu Draconis	Mu Dra	5.1
Alrescha	113-Alpha Piscium	Alf Psc	4.3
Alshain	60-Beta Aquilae	Bet Aql	3.9
Altair	53-Alpha Aquilae	Alf Aql	0.9
Altais	57-Delta Draconis	Del Dra	3.2
Alterf	4-Lambda Leonis	Lam Leo	4.5
Aludra	31-Eta Canis Majoris	Eta CMa	2.4
Alula Australis	53-Xi Ursae Majoris	Xi UMa	3.9
Alula Borealis	54-Nu Ursae Majoris	Nu UMa	3.7

Common Name	Flamsteed-Bayer Designation	Abbrev.	Magnitude (SAO)
Alya	63-Theta Serpentis	Tet Ser	4.5
Ankaa	Alpha Phoenicis	Alf Phe	2.4
Antares	21-Alpha Scorpii	Alf Sco	1.1
Arcturus	16-Alpha Boötis	Alf Boo	0.2
Arkab	Beta1 Sagittarii	Bet Sgr	4.3
Arneb	11-Alpha Leporis	Alf Lep	2.7
Ascella	38-Zeta Sagittarii	Zet Sgr	2.7
Asellus Australis	47-Delta Cancri	Del Cnc	4.2
Asellus Borealis	43-Gamma Cancri	Gam Cnc	4.7
Aspidiske	Iota Carinae	Iot Car	2.3
Atik	44-Zeta Persei	Zet Per	2.9
Atlas	27 Tauri	27 Tau	3.8
Atria	Alpha Trianguli Australis	Alf TrA	1.9
Avior	Epsilon Carinae	Eps Car	1.7
Azha	3-Eta Eridani	Eta Eri	4.0
Baten Kaitos	55-Zeta Ceti	Zet Cet	3.9
Beid	38-Omicron Eridani	Omi Eri	4.1
Bellatrix	24-Gamma Orionis	Gam Ori	1.7
Betelgeuse	58-Alpha Orionis	Alf Ori	0.6
Biham	26-Theta Pegasi	Tet Peg	3.7
Canopus	Alpha Carinae	Alf Car	-0.9
Capella	Alpha Aurigae	Alf Aur	0.1
Caph	Beta Cassiopeiae	Bet Cas	2.3
Castor	66-Alpha Geminorum	Alf Gem	1.6
Cebalrai	60-Beta Ophiuchi	Bet Oph	2.9
Celaeno	16 Tauri	16 Tau	5.4
Chara	8-Beta Canum Venaticorum	Bet CVn	4.3
Chertan	70-Theta Leonis	Tet Leo	3.4
Cor Caroli	12-Alpha2 Canum Venaticorum	Alf CVn	2.9
Cursa	67-Beta Eridani	Bet Eri	2.9
Dabih	9-Beta1 Capricorni	Bet Cap	3.3
Deneb	50-Alpha Cygni	Alf Cyg	1.3
Deneb Algedi	49-Delta Capricorni	Del Cap	3.0
Denebola	94-Beta Leonis	Bet Leo	2.2
Diphda	16-Beta Ceti	Bet Cet	2.2
Double Double			6.0
Dubhe	50-Alpha Ursae Majoris	Alf UMa	2.0
Edasich	12-Iota Draconis	Iot Dra	3.5
Electra	17 Tauri	17 Tau	3.8
Elnath	112-Beta Tauri	Bet Tau	1.8
Eltanin	33-Gamma Draconis	Gam Dra	2.4
Enif	8-Epsilon Pegasi	Eps Peg	2.5
Errai	35-Gamma Cephei	Gam Cep	3.4
Fomalhaut	24-Alpha Piscis Austrini	Alf PsA	1.3
Furud	1-Zeta Canis Majoris	Zet CMa	3.1
Gacrux	Gamma Crucis	Gam Cru	1.6

Common Name	Flamsteed-Bayer Designation	Abbrev.	Magnitude (SAO)
Giasar	1-Lambda Draconis	Lam Dra	4.1
Gienah	4-Gamma Corvi	Gam Crv	2.8
Gomeisa	3-Beta Canis Minoris	Bet CMi	3.1
Graffias	8-Beta ScorpII	Bet Sco	2.9
Grumium	32-Xi Draconis	Xi Dra	3.9
Hadar	Beta Centauri	Bet Cen	0.9
Hamal	13-Alpha Arietis	Alf Ari	2.2
Hinds Crimson Star			6.0
Homam	42-Zeta Pegasi	Zet Peg	3.6
Izar	36-Epsilon Boötis	Eps Boo	2.7
Kaffaljidhma	86-Gamma Ceti	Gam Cet	3.6
Kaus Australis	20-Epsilon Sagittarii	Eps Sgr	2.0
Kaus Borealis	22-Lambda Sagittarii	Lam Sgr	2.9
Kaus Media	19-Delta Sagittarii	Del Sgr	2.8
Keid	40-Omicron2 Eridani	Omi Eri	4.5
Kitalpha	8-Alpha Equulei	Alf Equ	4.1
Kochab	7-Beta Ursae Minoris	Bet UMi	2.2
Kornephoros	27-Beta Herculis	Bet Her	2.8
Kurhah	17-Xi Cephei	Xi Cep	4.6
Lesath	34-Upsilon ScorpII	Ups Sco	2.8
Maia	20 Tauri	20 Tau	3.9
Marfik	10-Lambda Ophiuchi	Lam Oph	3.9
Markab	54-Alpha Pegasi	Alf Peg	2.6
Matar	44-Eta Pegasi	Eta Peg	3.1
Mebsuta	27-Epsilon Geminorum	Eps Gem	3.2
Megrez	69-Delta Ursae Majoris	Del UMa	3.4
Meissa	39-Lambda Orionis	Lam Ori	3.7
Mekbuda	43-Zeta Geminorum	Zet Gem	3.9
Menkalinan	34-Beta Aurigae	Bet Aur	2.1
Menkar	92-Alpha Ceti	Alf Cet	2.8
Menkent	5-Theta Centauri	Tet Cen	2.3
Menkib	46-Xi Persei	Xi Per	4.0
Merak	48-Beta Ursae Majoris	Bet UMa	2.4
Merope	23 Tauri	23 Tau	4.3
Mesarthim	5-Gamma1 Arietis	Gam Ari	4.8
Miaplacidus	Beta Carinae	Bet Car	1.8
Mimosa	Beta Crucis	Bet Cru	1.5
Mintaka	34-Delta Orionis	Del Ori	2.5
Mira	Omicron Ceti	Omi Cet	2.1
Mirach	43-Beta Andromedae	Bet And	2.4
Mirfak	33-Alpha Persei	Alf Per	1.9
Mirzam	2-Beta Canis Majoris	Bet CMa	2.0
Mizar	79-Zeta Ursae Majoris	Zet UMa	2.4
Muphrid	8-Eta Boötis	Eta Boo	2.8
Muscida	1-Omicron Ursae Majoris	Omi UMa	3.5
Nashira	40-Gamma Capricorni	Gam Cap	3.8

Common Name	Flamsteed-Bayer Designation	Abbrev.	Magnitude (SAO)
Navi	27-Gamma Cassiopeiae	Gam Cas	2.8
Nekkar	42-Beta Boötis	Bet Boo	3.6
Nihal	9-Beta Leporis	Bet Lep	3.0
Nunki	34-Sigma Sagittarii	Sig Sgr	2.1
Nusakan	3-Beta Coronae Borealis	Bet CrB	3.7
Peacock	Alpha Pavonis	Alf Pav	2.1
Phact	Alpha Columbae	Alf Col	2.8
Phecda	64-Gamma Ursae Majoris	Gam UMa	2.5
Pherkad	13-Gamma Ursae Minoris	Gam UMi	3.1
Pleione	28 Tauri	28 Tau	5.2
Polaris	1-Alpha Ursae Minoris	Alf UMi	2.1
Pollux	78-Beta Geminorum	Bet Gem	1.2
Porrima	29-Gamma Virginis	Gam Vir	2.9
Procyon	10-Alpha Canis Minoris	Alf CMi	0.5
Propus	Eta Geminorum	Eta Gem	3.3
Rasalas	24-Mu Leonis	Mu Leo	4.1
Rasalgethi	64-Alpha Herculis	Alf Her	3.5
Rasalhague	55-Alpha Ophiuchi	Alf Oph	2.1
Rastaban	23-Beta Draconis	Bet Dra	3.0
Regor	Gamma2 Velorum	Gam Vel	1.9
Regulus	32-Alpha Leonis	Alf Leo	1.3
Rigel	19-Beta Orionis	Bet Ori	0.3
Ruchbah	37-Delta Cassiopeiae	Del Cas	2.7
Rukbat	Alpha Sagittarii	Alf Sgr	4.1
Sabik	35-Eta Ophiuchi	Eta Oph	2.6
Sadalmelik	34-Alpha Aquarii	Alf Aqr	3.2
Sadalsuud	22-Beta Aquarii	Bet Aqr	3.1
Sadr	37-Gamma Cygni	Gam Cyg	2.3
Saiph	53-Kappa Orionis	Kap Ori	2.2
Scheat	53-Beta Pegasi	Bet Peg	2.6
Schedar	18-Alpha Cassiopeiae	Alf Cas	2.5
Seginus	27-Gamma Boötis	Gam Boo	3.0
Shaula	35-Lambda Scorpii	Lam Sco	1.7
Sheliak	10-Beta Lyrae	Bet Lyr	3.9
Sheratan	6-Beta Arietis	Bet Ari	2.7
Sirius	9-Alpha Canis Majoris	Alf CMa	-1.6
Skat	76-Delta Aquarii	Del Aqr	3.5
Spica	67-Alpha Virginis	Alf Vir	1.2
Sterope	21 Tauri	21 Tau	5.9
Suhail	Lambda Velorum	Lam Vel	2.2
Sulafat	14-Gamma Lyrae	Gam Lyr	3.3
Syrma	99-Iota Virginis	Iot Vir	4.2
Talitha	9-Iota Ursae Majoris	Iot UMa	3.1
Tania Australis	34-Mu Ursae Majoris	Mu UMa	3.2
Tania Borealis	33-Lambda Ursae Majoris	Lam UMa	3.5
Tarazed	50-Gamma Aquilae	Gam Aql	2.8

Common Name	Flamsteed-Bayer Designation	Abbrev.	Magnitude (SAO)
Taygeta	19 Tauri	19 Tau	4.4
Thuban	11-Alpha Draconis	Alf Dra	3.6
Trapezium	41-Theta1 Orionis	Tet Ori	5.4
Unukalhai	24-Alpha Serpentis	Alf Ser	2.8
UU	none	none	5.1
Vega	3-Alpha Lyrae	Alf Lyr	0.1
Vindemiatrix	47-Epsilon Virginis	Eps Vir	3.0
Wasat	55-Delta Geminorum	Del Gem	3.5
Wazn	Beta Columbae	Bet Col	3.2
Wezen	25-Delta Canis Majoris	Del CMa	2.0
Yed Posterior	2-Epsilon Ophiuchi	Eps Oph	3.3
Yed Prior	1-Delta Ophiuchi	Del Oph	3.0
Zaniah	15-Eta Virginis	Eta Vir	4.0
Zaurak	34-Gamma Eridani	Gam Eri	3.2
Zavijava	5-Beta Virginis	Bet Vir	3.8
Zosma	68-Delta Leonis	Del Leo	2.6
Zubenelgenubi	9-Alpha2 Librae	Alf Lib	2.9
Zubeneschamali	27-Beta Librae	Bet Lib	2.7
Sun			
Moon			
Venus			
Mars			
Jupiter			

APPENDIX E: CONSTELLATION ABBREVIATIONS

And	Andromeda	LMi	Leo Minor
Ant	Antlia	Lep	Lepus
Aps	Apus	Lib	Libra
Aqr	Aquarius	Lup	Lupus
Aql	Aquila	Lyn	Lynx
Ara	Ara	Lyr	Lyra
Ari	Aries	Men	Mensa
Aur	Auriga	Mic	Microscopium
Boo	Boötes	Mon	Monoceros
Cae	Caelum	Mus	Musca
Cam	Camelopardalis	Nor	Norma
Cnc	Cancer	Oct	Octans
CVn	Canes Venatici	Oph	Ophiuchus
CMa	Canis Major	Ori	Orion
CMi	Canis Minor	Pav	Pavo
Cap	Capricornus	Peg	Pegasus
Car	Carina	Per	Perseus
Cas	Cassiopeia	Phe	Phoenix
Cen	Centaurus	Pic	Pictor
Cep	Cepheus	Psc	Pisces
Cet	Cetus	PsA	Piscis Austrinus
Cha	Chamaeleon	Pup	Puppis
Cir	Circinus	Pyx	Pyxis
Col	Columba	Ret	Reticulum
Com	Coma Berenices	Sge	Sagitta
CrA	Corona Australis	Sgr	Sagittarius
CrB	Corona Borealis	Sco	Scorpius
Crv	Corvus	Sci	Sculptor
Crt	Crater	Sct	Scutum
Cru	Crux	Ser	Serpens
Cyg	Cygnus	Sex	Sextans
Del	Delphinus	Tau	Taurus
Dor	Dorado	Tel	Telescopium
Dra	Draco	Tri	Triangulum
Equ	Equuleus	TrA	Triangulum Australe
Eri	Eridanus	Tuc	Tucana
For	Fornax	UMa	Ursa Major
Gem	Gemini	UMi	Ursa Minor
Gru	Grus	Vel	Vela
Her	Hercules	Vir	Virgo
Hor	Horologium	Vol	Volans
Hya	Hydra	Vul	Vulpecula
Hyi	Hydrus		
Ind	Indus		
Lac	Lacerta		

APPENDIX F: COMMON OBJECT NAMES

These objects are listed in the order in which they appear on the screen.

47Tuc	Hourglass Nebula	Eta Carina Nebula
Andromeda Galaxy	Hubble's Variable Nebula	Gamma Cas Nebula
Antennae	Jewel Box	Gamma Cygnus Nebula
Barnard's Galaxy	Lacework Nebula	Kappa Cru Cluster
Baxendell's Nebula	Lagoon Nebula	Lambda-1 Cen Nebula
Bear Paw Galaxy	Little Dumbell	Lambda-2 Cen Nebula
Beehive Cluster	Little Gem	Omega Cen
Black-eye Galaxy	Maia Nebula	Rho Oph Nebula
Blinking Planetary	Merope Nebula	
Blue Snowball	The Mice	
Blue Planetary	Network-1 Nebula	
Bode's Nebula	Network-2 Nebula	
Box	North American Nebula	
Box Nebula	Omega Nebula	
Bubble Nebula	Owl Nebula	
Bug Nebula	Papillon	
Butterfly Cluster	Pelican Nebula	
Butterfly Nebula	Pin-wheel Nebula	
California Nebula	Polarissima Australis	
Christmas Tree Cluster	Polarissima Borealis	
Cocoon Nebula	Praesepe	
Cone Nebula	Ring Nebula in Lyra	
Copeland's Septet	Rosette Nebula	
Crab Nebula	Saturn Nebula	
Crescent Nebula	Sculptor Galaxy	
Double Cluster	Siamese Twins	
Dumbell Nebula	Sombrero Galaxy	
Eagle Nebula	Southern Pleiades	
Eight-burst Planetary	Spindle Galaxy	
Eskimo Nebula	Star Queen Nebula	
The Eyes	Stephan's Quintet	
Filamentary Nebula	Struve's Lost Nebula	
Flaming Star Nebula	Sunflower Galaxy	
Ghost of Jupiter	Tarantula Nebula	
Great Cluster in Hercules	Toby Jug Nebula	
Great Nebula in Andromeda	Triangulum Galaxy	
Great Nebula in Orion	Trifid Nebula	
Helix Galaxy	Veil Nebula	
Helix Nebula	Whirlpool Galaxy	
Hind's Variable Nebula	Wild Duck Cluster	
Horsehead Nebula	Witch Head Nebula	

APPENDIX G: AITKEN'S DOUBLE STAR (ADS) LIST

These commonly observed double stars were chosen from R. G. Aitken's New General Catalog of Double Stars. Please note that the separations are approximate and may vary from year to year. If you are an avid double star observer, please consult an ephemeris for the most accurate data.

ADS Number	Name	Separation	ADS Number	Name	Separation
00111	Kappa1 Sci	1.4	04002	Eta Ori	1.5
00191	35 Psc	11.6	04066	Beta Lep	2.5
00434	Lambda Cas	0.6	04134	Delta Ori	52.6
00513	Pi And	35.9	04177	19 Cam	1.3
00520	Beta 395 Cet	0.5	04179	Lambda Ori	4.4
00558	55 Psc	6.5	04186	Theta1 Ori	
00624	HN 122	36.1	04241	Sigma Ori	0.2
00671	Eta Cas	12.9	04263	Zeta Ori	2.3
00683	65 Psc	4.4	04334	Gamma Lep	96.3
00755	36 And	0.9	04566	Theta Aur	3.6
00782	Gamma Cas	2.1	04773	41 Aur	7.7
00899	Psi1 Psc	30.0	04841	Eta Gem	1.6
00996	Zeta Psc	23.0	04990	Mu Gem	121.7
01003	37 Cet	49.7	05012	Epsilon Mon	13.4
01081	42 Cet	1.6	05107	Beta Mon	7.3
01129	Psi Cas	25.0	05166	20 Gem	20.0
01394	Epsilon Scl	4.7	05253	Nu1 CMa	17.5
01457	1 Air	2.8	05400	12 Lyn	1.7
01477	Alpha UMi	18.4	05423	Alpha CMa	4.6
01507	Gamma Ari	7.8	05514	14 Lyn	0.4
01538	Sigma 186 Cet	1.1	05559	38 Gem	5.2
01563	Lambda Ari	37.4	05605	Mu CMa	3.0
01598	48 Cas	0.9	05654	Epsilon CMa	7.5
01615	Alpha Psc	1.8	05961	Lambda Gem	9.6
01630	Gamma And	9.8	05983	Delta Gem	5.8
01631	10 Ari	1.1	06101	Eta CMi	4.0
01683	59 And	16.6	06175	Alpha Gem	3.9
01697	6 Tri	3.9	06190	n Pup	9.6
01703	66 Cet	16.5	06255	k Pup	9.9
01778	Omicron Cet	0.1	06321	Kappa Gem	7.1
01860	Iota Cas	2.5	06420	9 Pup	0.2
01954	Omega For	10.8	06650	Zeta Cnc	6.0
02080	Gamma Cet	2.8	06724	Sigma 1193 UMa	43.1
02157	Eta Per	28.3	06815	Phi2 Cnc	5.1
02200	20 Per	14.1	06914	Beta 208 Pyx	1.6
02257	Epsilon Ari	1.4	06988	Iota Cnc	30.5
02312	Rho2 Eri	1.8	06993	Epsilon Hya	2.7
02362	Beta Per	81.0	07114	Iota UMa	2.0
02402	Alpha For	5.1	07203	Sigma2 UMa	3.9
02616	7 Tau	0.8	07292	38 Lyn	2.7
02799	Omicron Sigma 65 Tau	0.2	07307	Sigma 1338 Lyn	1.0
02843	Zeta Per	12.9	07351	Kappa Leo	2.1
02867	Omicron Sigma 67 Cam	12.9	07390	Omega Leo	0.6
02888	Epsilon Per	8.8	07402	23 UMa	22.7
03079	39 Eri	6.4	07545	Phi UMa	0.3
03093	Omicron2 Eri	83.4	07555	Gamma Sex	0.6
03137	Phi Tau	52.1	07654	Alpha Leo	176.9
03161	Chi Tau	19.4	07724	Gamma Leo	4.4
03321	Alpha Tau	121.7	07846	Beta 411 Hya	1.4
03572	Omega Aur	5.4	08119	Xi UMa	1.8
03797	Rho Ori	7.0	08123	Nu UMa	7.2
03800	Kappa Lep	2.6	08148	Iota Leo	1.7
03823	Beta Ori	9.5	08153	Gamma Crt	5.2

ADS Number	Name	Separation	ADS Number	Name	Separation
08175	57 UMa	5.4	11635	Epsilon Lyr	207.7
08196	88 Leo	8.4	11639	Zeta Lyr	43.7
08197	Omicron Sigma 235 UMa	0.6	11745	Beta Lyr	45.7
08406	2 Com	3.7	11853	Theta Ser	22.3
08539	Sigma 1639 Com	1.7	12197	Eta Lyr	28.1
08572	Delta Crv	24.2	12540	Beta Cyg	34.4
08573	Beta 28 Crv	2.2	12789	Sigma 2573 Dra	18.2
08600	24 Com	20.3	12880	Delta Cyg	2.5
08630	Gamma Vir	1.8	12962	Pi Aql 1.4	
08682	Sigma 1694 Cam	21.6	13007	Epsilon Dra	3.1
08695	35 Com	1.2	13148	Psi Cyg	3.2
08706	Alpha CVn	19.4	13371	Sigma 2640 Dra	5.6
08801	Theta Vir	7.1	2	Theta Sge	11.9
08891	Zeta UMa	14.4	13524	Kappa Cep	7.4
08974	25 CVn	1.8	13632	Alpha1 Cap	45.4
09000	84 Vir	2.9	13645	Alpha2 Cap	6.6
09025	Tau Boo	4.8	13765	Gamma Cyg	41.2
09085	au Vir	80.0	13887	Rho Cap	0.5
09173	Kappa Boo	13.4	14158	49 Cyg	2.7
09198	Iota Boo	38.5	14259	52 Cyg	6.0
09273	Phi Vir	4.8	14279	Gamma Del	9.6
09338	Pi Boo	5.6	14296	Lambda Cyg	0.9
09343	Zeta Boo	0.8	14360	4 Aqr	0.8
09372	Epsilon Boo	2.8	14499	Epsilon Equ	0.8
09396	Mu Lib	1.8	14636	61 Cyg	30.3
09406	39 Boo	2.9	14787	Tau Cyg	0.8
09413	Xi Boo	6.6	15032	Beta Cep	13.3
09425	Omicron Sigma 288 Boo	0.8	15270	Mu Cyg	1.2
09494	44,i Boo	2.2	15281	Kappa Peg	0.2
09532	Iota1 Lib	57.8	15536	Eta PsA	1.7
09584	5 Ser	11.2	15600	Xi Cep	8.2
09617	Eta CrB	0.8	15719	Sigma 2883 Cep	14.6
09626	Mu Boo	108.3	15753	41 Aqr	5.0
09701	Delta Ser	4.4	15764	Sigma 2893 Cep	28.9
09737	Zeta CrB	6.3	15828	Sigma 2894 Lac	15.6
09909	Xi Sco	0.4	15934	53 Aqr	3.1
09913	Beta Sco	13.6	15971	Zeta Aqr	2.1
09951	Nu Sco	41.1	15987	Delta Cep	41.0
09979	Alpha CrB	7.1	16095	8 Lac	22.4
10049	Rho Oph	3.1	16261	Xi Peg	11.5
10058	Eta Dra	5.2	16268	Tau1 Aqr	23.7
10074	Alpha Sco	2.6	16538	Pi Cep	1.1
10087	Lambda Oph	1.5	16633	Psi1 Aqr	49.6
10157	Zeta Her	0.8	16666	Omicron Cep	2.8
10279	20 Dra	1.3	16672	94 Aqr	12.7
10345	Mu Dra	1.9	16836	72 Peg	0.5
10418	Alpha Her	4.6	16957	78 Peg	1.0
10424	Delta Her	8.9	16979	107 Aqr	6.6
10526	Rho Her	4.1	17022	6 Cas	1.6
10628	Nu Dra	61.9	17140	Sigma Cas	3.0
10660	26 Dra	1.7	17175	85 Peg	0.7
10759	Psi1 Dra	30.3			
10786	Mu Her	33.8			
10875	90 Her	1.6			
11005	Tau Oph	1.7			
11046	70 Oph	4.5			
11061	40/41 Dra	19.3			
11483	Omicron Sigma 358 Her	1.3			

APPENDIX H: THE GREEK ALPHABET

We have included this list for your reference to help you translate Greek letter designations that may be used in your star atlas or other reference. The abbreviations are used in the keypad's Stars/Constell Tour as described previously under the heading "Greek Star Names, organized by constellation." They are also used in Appendices C & D and in many publications and planetarium programs.

Symbol		Translation	Abbreviation
A	α	Alpha	Alf
B	β	Beta	Bet
Γ	γ	Gamma	Gam
Δ	δ	Delta	Del
E	ε	Epsilon	Eps
Z	ζ	Zeta	Zet
H	η	Eta	Eta
Θ	θ	Theta	Tet
I	ι	Iota	Iot
K	κ	Kappa	Kap
Λ	λ	Lambda	Lam
M	μ	Mu	Mu
N	ν	Nu	Nu
Ξ	ξ	Xi	Xi
O	ο	Omicron	Omi
Π	π	Pi	Pi
P	ρ	Rho	Rho
Σ	σ	Sigma	Sig
T	τ	Tau	Tau
Υ	υ	Upsilon	Ups
Φ	φ	Phi	Phi
X	χ	Chi	Chi
Ψ	ψ	Psi	Psi
Ω	ω	Omega	Omg (or Ome)

APPENDIX I: SUGGESTED STARS FOR THE GTO QUICK STAR DRIFT METHOD

The following list of stars is intended to make the GTO Quick Star Drift Method much quicker and easier. Since hunting through a star atlas for suitable stars can take as long as performing the actual method itself, we put together this list of suggested stars to give you a big head start in most situations. The paired columns suggest pairs of stars that are found in the keypad's database for the northern and southern hemispheres. The stars in each row are very close in Right Ascension, but differ substantially in Declination. Use the pairings for the azimuth portion of this method. Since the rows are all relatively close in R.A., you usually have the option of choosing a replacement star if one of the suggested stars is obstructed in some way. Stars on the list that are near the celestial equator are good choices for the altitude iterations.

Two additional partial columns of stars were added in the middle to increase your number of choices. Stars were added here if we felt that a gap needed filling in a particular R.A. row, or if one of the polar stars was very close to the pole, and therefore not suitable for a non-orthogonal system. There are, unfortunately, some parts of the sky where suitable stars are simply not to be found.

For the altitude portion of the adjustment, most people will find that the ideal star will be in the column for the other hemisphere's non-polar side. In other words, people in the north may find the best choice in the southern hemisphere's "NORTH" column, and those in the south will find good choices in the northern hemisphere's "SOUTH" column. These will tend to be stars that are not too far from the celestial equator, but are also somewhat overhead. If there is a star listed in the "Optional Additional Star" column, it may also be an excellent choice for the altitude adjustment. Choose a star that is slightly south of your zenith if you are in the northern hemisphere, and north of your zenith if you are down under. This is to protect your instrument from hitting the pier when you flip sides.

For the azimuth portion, make sure that BOTH stars are on the same side of the meridian. For example, in the southern hemisphere, if the LST is at 06:30, do not choose Canopus at R.A. 06:23 and Alhena at R.A. 06:37. Choose a pairing one or two rows above or below them in the list. Alternatively, you could wait a few minutes until the LST has gone past the higher R.A., or you could activate the meridian delay feature to put both stars on the same side of the meridian. Also, keep in mind that you can be several hours east or west of the meridian with your azimuth pairs. The main advantage to being relatively close to the meridian is that you won't be as likely to lose stars in the atmospheric soup.

Remember also that any given R.A. value is equivalent to that same value plus or minus 12. What this means is that people in far northern or far southern latitudes can often substitute a circumpolar star 12 hours different in R.A. for one of the suggested stars. No matter what time of day or year, you should have available stars within one or two hours of the meridian. For example: assume you are at a latitude of +50 deg, and the LST is 02:30. You would choose the row with Eta Persei that has R.A. values near 02:50. Eta Persei, however, might be fine for someone at a latitude of 30 degrees, but at a latitude of 50, it is almost directly overhead. For the northern star in the azimuth routine, you could substitute Kochab which will have an equivalent R.A. of 14:50 and will be much lower in the north. Likewise, a person using this method from the southern tip of New Zealand when the LST is at 06:30 might decide that Canopus at R.A. 06:23 is too much straight overhead and choose Zeta Pavonis at R.A. 18:43 as the southern star instead in the azimuth routine.

Please note: The stars below that are listed by their Bayer designation must be accessed through the 1=Objects => 8=Tour => 1=Stars/Constell. menu system. The stars listed with common names are accessed through 1=Objects => 5=Strs.

SUGGESTED STARS FOR GTO QUICK STAR DRIFT METHOD

Northern Hemisphere Azimuth Pairs			Southern Hemisphere Azimuth Pairs		
North	South (Southern Hemisphere Altitude)	Optional Additional Stars	North (Northern Hemisphere Altitude)	South	
Star: Caph	Iot Cet	Bet 2 Tuc	Algenib	Bet Hyi	
RA: 00:09:11	00:19:25	00:31:33	00:13:14	00:25:45	
Dec: +59°09:00	-08°49:00	-62°57:00	+15°11:01	-77°15:00	
Star: Tet Cas	Eta Cet		Eps Psc	Zet Phe	
RA: 01:11:06	01:08:35		01:02:56	01:08:23	
Dec: +55°09:00	-10°10:00		+07°53:00	-55°14:00	
Star: Eps Cas	Baten Kaitos	Alrescha	Sheratan	Alf Hyi	
RA: 01:54:23	01:51:28	02:02:03	01:54:38	01:58:46	
Dec: +63°40:00	-10°20:05	+02°45:49	+20°48:28	-61°34:00	

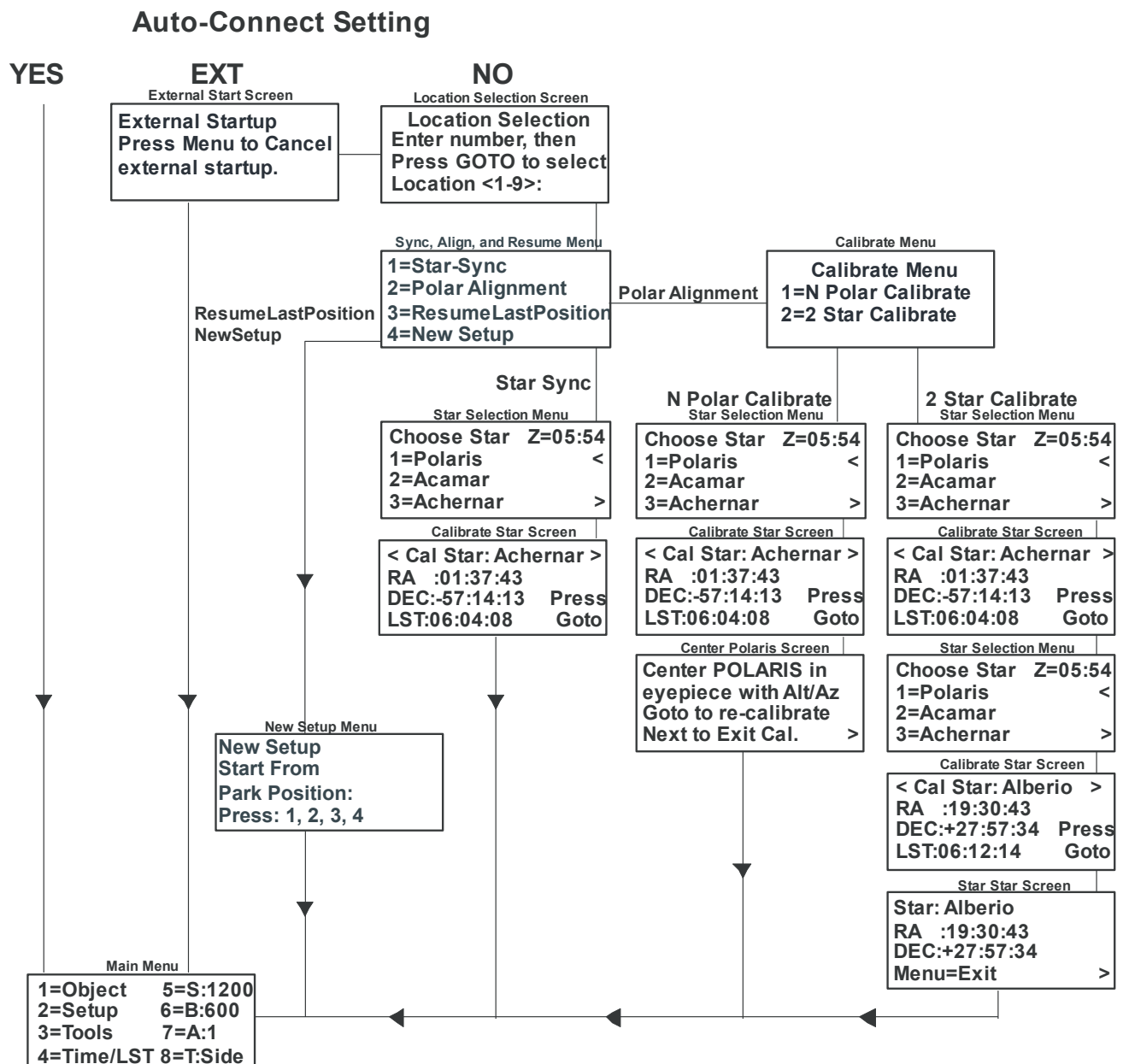
Northern Hemisphere			Optional Stars		Southern Hemisphere	
	North	South			North	South
Star:	Eta Per	Tau 2 Eri	Azha	Acamar	Mu Cet	Nu Hyi
RA:	02:50:41	02:51:02	02:56:26	02:58:16	02:44:56	02:50:28
Dec:	+55°53:00	-21°00:00	-08°53:53	-40°18:18	+10°06:00	-75°04:00
Star:	Gam Cam	Tau 8 Eri	Lam Tau	Del Ret	Atik	Gam Hyi
RA:	03:50:21	03:53:42	04:00:40	03:58:44	03:54:08	03:47:14
Dec:	+71°19:00	-24°36:00	+12°29:00	-61°24:00	+31°53:02	-74°14:00
Star:	Alf Cam	Omg Eri			Aldebaran	Alf Dor
RA:	04:54:03	04:52:53			04:35:55	04:33:59
Dec:	+66°20:00	-05°27:00			+16°30:33	-55°02:00
Star:	Menkalinan	Eta Lep			Betelgeuse	Gam Pic
RA:	05:59:32	05:56:24			05:55:10	05:49:49
Dec:	+44°56:52	-14°10:00			+07°24:25	-56°10:00
Star:	Tet Gem	Adhara	Sirius		Alhena	Canopus
RA:	06:52:47	06:58:38	06:45:09		06:37:43	06:23:57
Dec:	+33°57:00	-28°58:19	-16°42:57		+16°23:57	-52°41:45
Star:	Pollux	Alf Mon		Chi Car	Procyon	Zet Vol
RA:	07:45:19	07:41:14		07:56:46	07:39:18	07:41:49
Dec:	+28°01:34	-09°33:00		-52°58:00	+05°13:29	-72°36:00
Star:	Rho Uma	Gam Pyx	Alphard		Acubens	Miaplacidus
RA:	09:02:32	08:50:31	09:27:35		08:58:29	09:13:12
Dec:	+67°37:00	-27°42:00	-08°39:31		+11°51:27	-69°43:03
Star:	Tania Australis	Mu Hya	Rho Leo	Tet Car	Algieba	Gam Cha
RA:	10:22:20	10:26:05	10:32:48	10:42:57	10:19:58	10:35:28
Dec:	+41°29:59	-16°50:00	+09°18:00	-64°23:00	+19°50:28	-78°36:00
Star:	Giausar	Zet Crt	Zavijava		Denebola	Lam Mus
RA:	11:31:24	11:44:45	11:50:42		11:49:04	11:45:36
Dec:	+69°19:53	-18°21:00	+01°45:52		+14°34:18	-66°43:00
Star:	Alioth	Psi Vir		Mimosa	Vindemiatrix	Del Mus
RA:	12:54:02	12:54:21		12:47:43	13:02:11	13:02:16
Dec:	+55°57:36	-09°32:00		-59°41:20	+10°57:32	-71°32:00
Star:	Mizar (brighter)	Spica			Zet Vir	Eps Cen
RA:	13:23:50	13:25:12			13:34:41	13:39:53
Dec:	+54°55:31	-11°09:41			-00°35:00	-53°27:00
Star:	Thuban	Pi Hya	Tau Vir		Muphrid	Hadar
RA:	14:04:23	14:06:22	14:01:38		13:54:41	14:03:49
Dec:	+64°22:34	-26°40:00	+01°32:00		+18°23:51	-60°22:23
Star:	Kochab	Zubenelgenubi	Mu Vir	Alf Aps	Izar	Alf Cen
RA:	14:50:42	14:50:53	14:43:03	14:47:51	14:44:59	14:39:36
Dec:	+74°09:20	-16°02:30	-05°39:00	-79°02:00	+27°04:26	-60°50:00
Star:	Tet Dra	Del Sco	Mu Ser		Gam Ser	Bet TrA
RA:	16:01:53	16:00:19	15:49:37		15:56:27	15:55:08
Dec:	+58°33:00	-22°37:00	-03°25:00		+15°39:00	-63°25:00
Star:	Eta Dra	Antares	Lam Oph	Eps Nor	Kornephoros	Gam Aps
RA:	16:23:59	16:29:24	16:30:54	16:27:11	16:30:13	16:33:27
Dec:	+61°30:00	-26°25:55	+01°59:00	-47°33:00	+21°29:22	-78°53:00
Star:	Del Umi	Xi Ser	Rastaban		Rasalhague	Del Ara
RA:	17:32:12	17:37:35	17:30:23		17:34:56	17:31:05
Dec:	+86°35:00	-15°23:00	+52°18:04		+12°33:36	-60°41:00

	Northern Hemisphere		Optional Stars		Southern Hemisphere	
	North	South			North	South
Star:	Chi Dra	Kaus Borealis	Eta Ser		Vega	Xi Pav
RA:	18:21:03	18:27:58	18:21:18		18:36:56	18:23:13
Dec:	+72°43:00	-25°25:18	-02°53:00		+38°47:01	-61°29:00
Star:	Rho Dra	Eta Aql			Gam Sge	Del Pav
RA:	20:02:48	19:52:28			19:58:45	20:08:43
Dec:	+67°52:00	+01°00:00			+19°29:00	-66°10:00
Star:	Alfirk	Sadalsuud	Pi 1 Cyg	Del Ind	Enif	Nu Oct
RA:	21:28:39	21:31:34	21:42:05	21:57:55	21:44:11	21:41:28
Dec:	+70°33:40	-05°34:15	+51°11:00	-54°59:00	+09°52:30	-77°23:00
Star:	Iot Cep	Skat		Eps Gru	Homam	Bet Oct
RA:	22:49:40	22:54:39		22:48:33	22:41:27	22:46:03
Dec:	+66°12:00	-15°49:14		-51°19:00	+10°49:53	-81°22:00

APPENDIX J: MENU LAYOUT

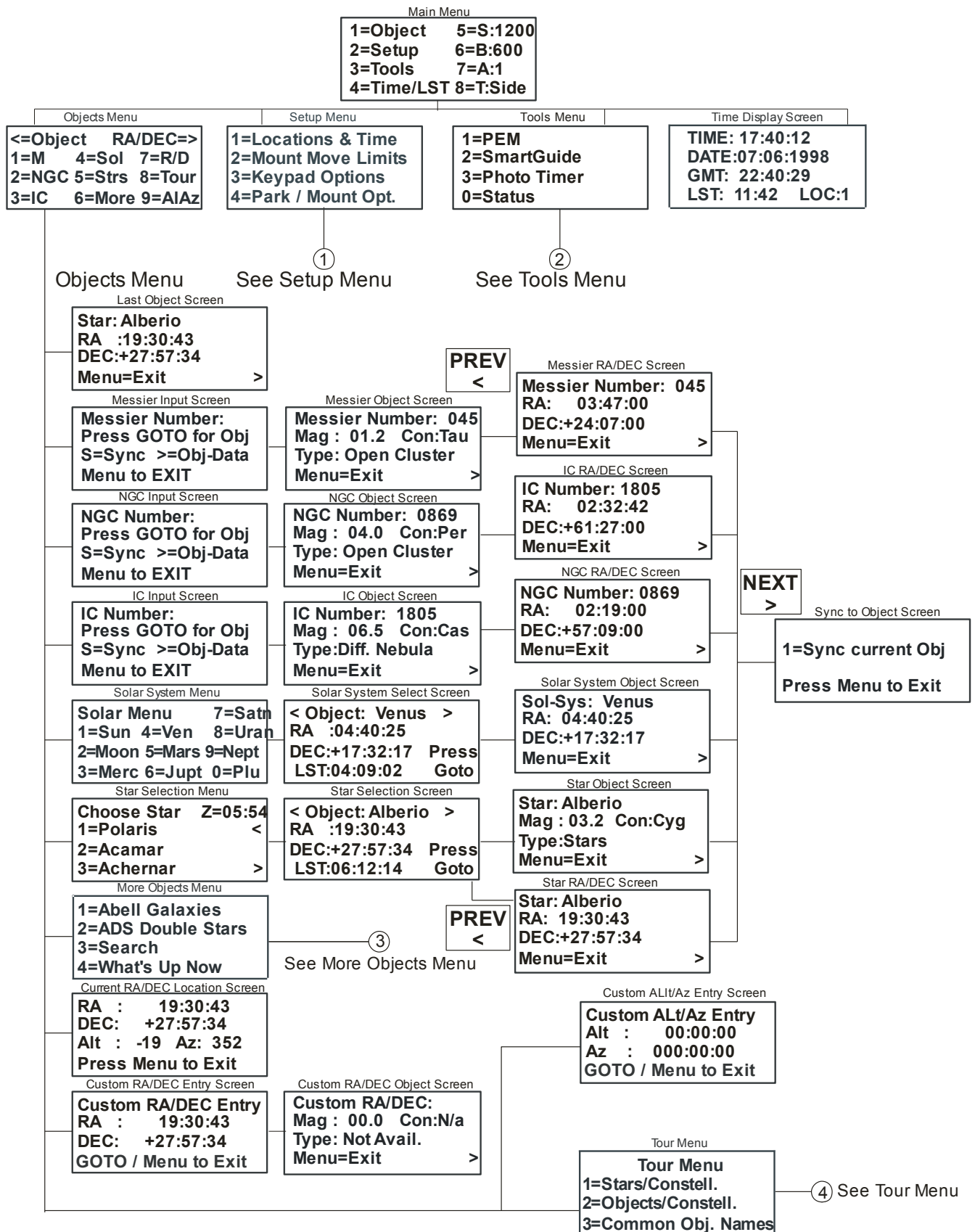
We have included this menu layout for your reference and to help you learn the menu system. Please understand that there may be some errors found in the screen representations due to changes that have taken place as a result of upgrades.

Keypad Version 4.19.3 Screens and Map Startup to Main Menu



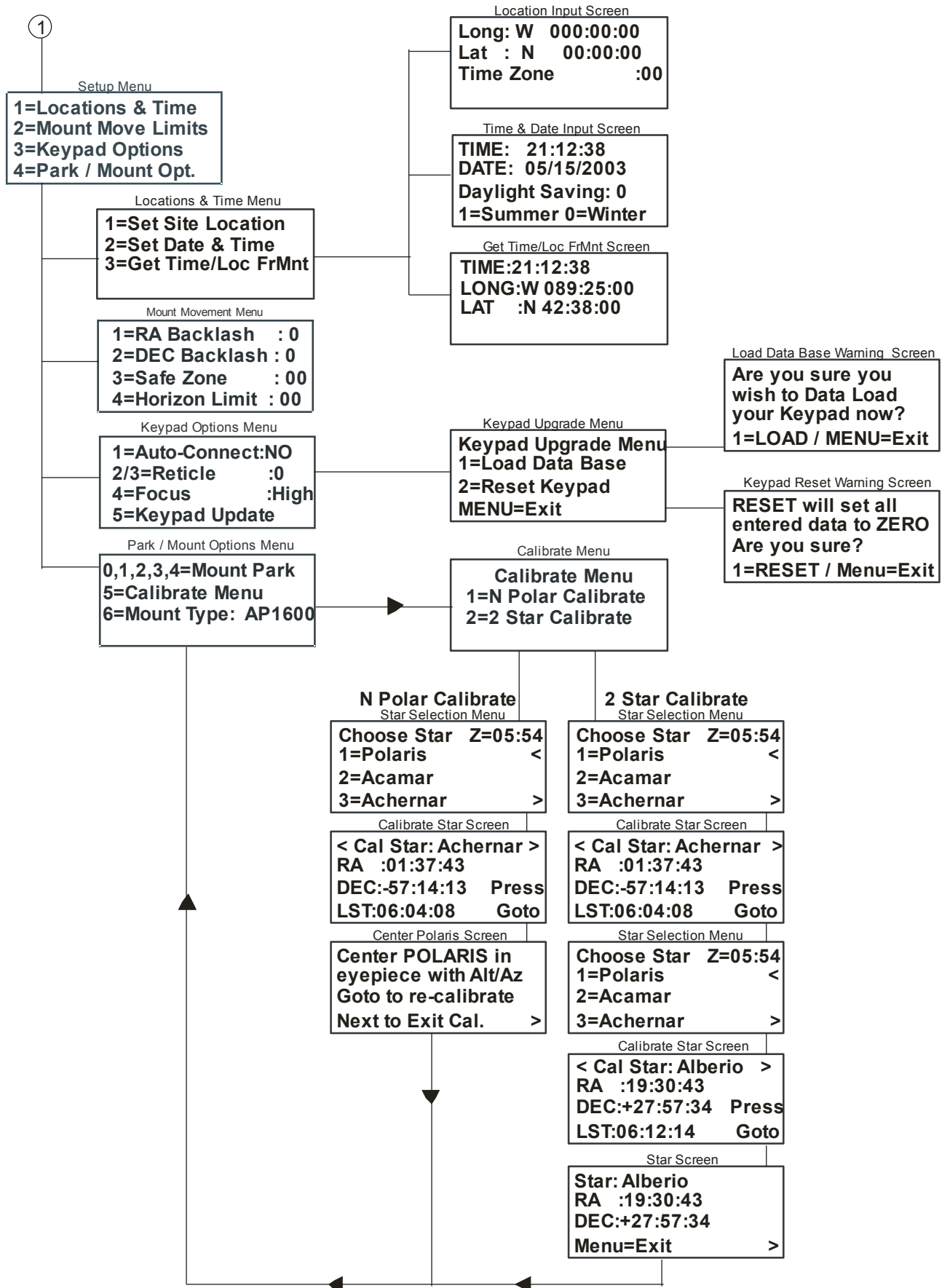
Keypad Version 4.19.3 Screens and Map

Main Menu to Sub Menus

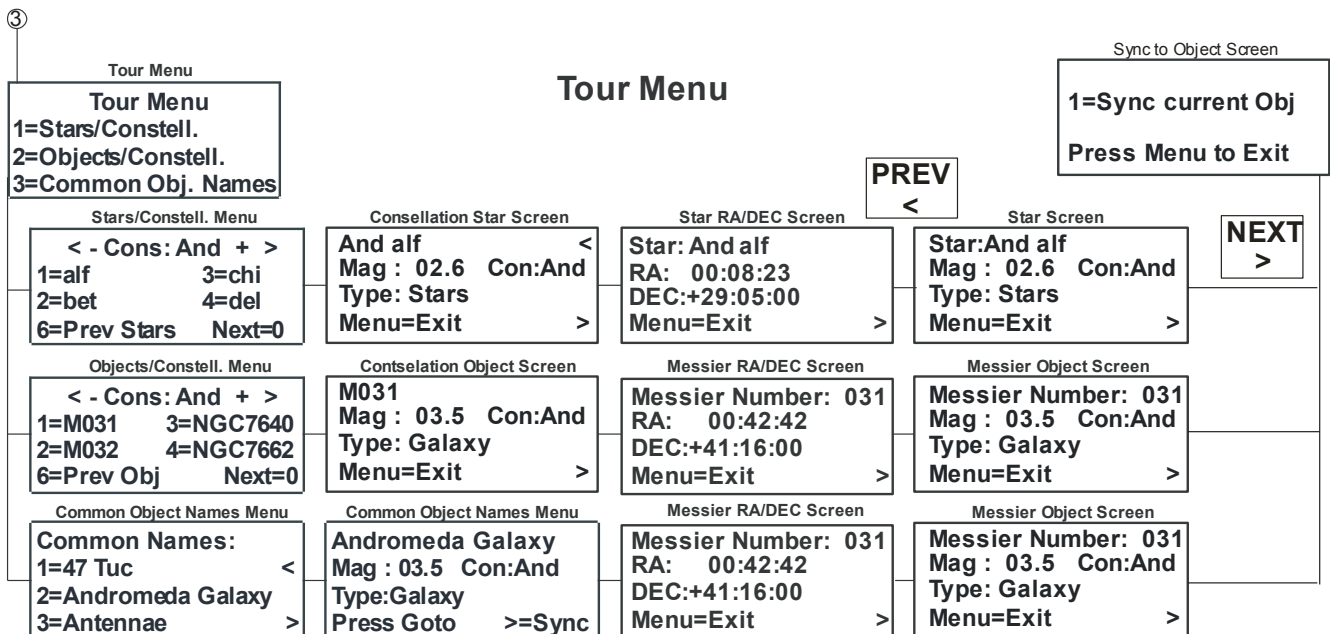
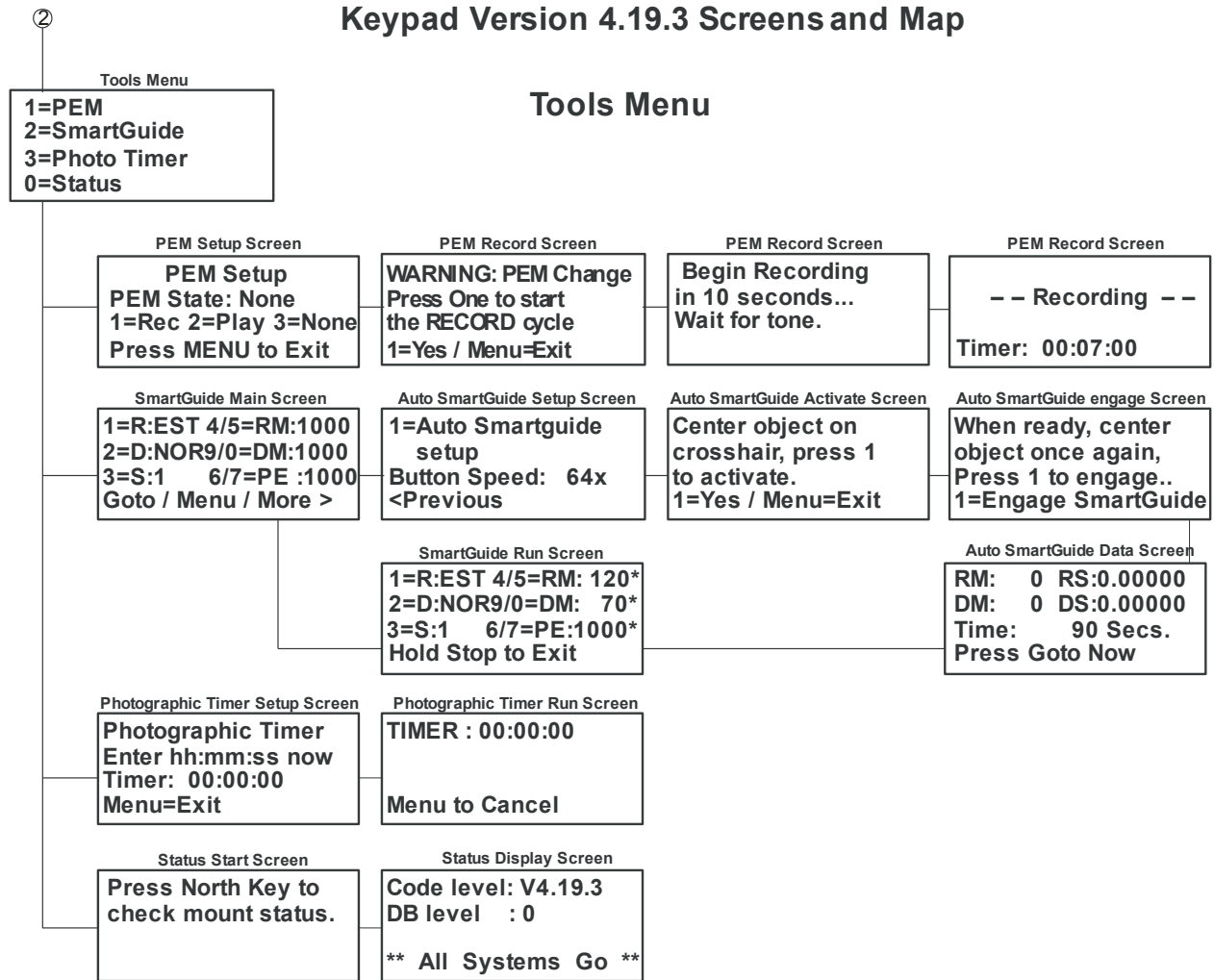


Keypad Version 4.19.3 Screens and Map

Setup Menu



Keypad Version 4.19.3 Screens and Map



Keypad Version 4.19.3 Screens and Map

More Objects Menu

