ASTRO-PHYSICS

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GTO KEYPAD
Version 4.17 Addendum

Plus Supplemental Information for Customers Outside of North America and the Revised GTO Quick Star Drift Method of Polar Alignment

CONTENTS

KEYPAD VERSION 4.17

Version 4.17 Release Notes - 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.

Special Notice to Mach1GTO, 1600GTO and 3600GTO Owners

Version 4.17 is based on v.4.12, which was developed before the introduction of the Mach1GTO, the 3600GTO or the 1600GTO German Equatorial Mounts. In the 2 = Setup; 4 = Park / Mount Opt. menu, there are no choices for these newer mountings. Your keypad has been set to 1200GTO. This is the correct setting. The parameters for the Mach1GTO, 900GTO, 1200GTO and 1600GTO are all identical with respect to the keypad. Either the 900 or 1200 setting will work fine. Do not, however, set the keypad to either 400 or 600E.

The keypad's 900GTO or 1200GTO parameters are also correct for the 3600GTO. However, bear in mind that the slew rates and the two fastest button rates on the keypad display need to be cut in half to accommodate the slew scaling that is in effect in the 3600GTO. Slew rates of 600X, 900X and 1200X become 300X, 450X and 600X. Likewise, button rates of 600X and 1200X become 300X and 600X. The slower button rates are NOT affected. Enjoy your Astro-Physics GTOCP3 Go-To Servo Drive System!

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.

1. Set the local time to GMT.

2. Set the time zone for ALL entered locations to 00.

3. Leave the Daylight Savings set to 0 = Winter all the time

4. Enter your longitude for all locations correctly using E or W as appropriate.

5. 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.

<u>Please note:</u> 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.

COMMAND LANGUAGE / TROUBLESHOOTING UPDATE

The following information relates to servocontroller issues and the Astro-Physics Command Language.

Motor Stalls in GTOCP1 and GTOCP2s with the E1 or KE1 Chip

In the Troubleshooting section of the v.4.12 keypad manual dated March 7, 2008, on page 69 under the "Motor Stall" entry, please add the following note to the "Solution" paragraphs: 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.

Horizon Check in the Servo

Command: **:ho#** **:hq#**
Response: **(none)**

A bug was found in the servo's internal horizon check in the E1 and KE1 microcontroller chips for the GTOCP1 and GTOCP2 control boxes. The bug existed in all prior versions of the chip. Later versions, beginning with F and going through R partially addressed the issue, but it will be version S (in beta testing as of 1-14-10) that will fully solve the problem.

Since most planetarium software and the Astro-Physics keypad firmware all perform their own horizon check calculations, this command is rarely activated. The horizon check was included in the command set for people who may be writing their own control software.

At this point, we recommend that ***NO ONE SHOULD USE THE HORIZON CHECK*** in the servo.

Variable Tracking

The following text replaces the text for these commands on page 87 of the v.4.12 keypad manual dated March 7, 2008 (Appendix B). It applies to GTO servo microcontroller chips version G through R. In addition to a more thorough explanation, ***please take special note of the difference between the northern and southern hemispheres for these commands.*** Also note that the command operates the same in both hemispheres starting with version S.

Command: **:RR sxx.xxxx#** **:RD sxx.xxxx#**
Response: **"1"**

This command sets the tracking rate in the RA axis ("RR") or DEC axis ("RD") to sxx.xxxx. The rate is expressed in terms of multiples of the sidereal rate and can be positive or negative. Note that earlier published text on this command had three digits to the left of the decimal. This was incorrect. Only two digits (not counting the sign) are allowed to the left of the decimal point. You can use up to four digits to the right of the decimal. The format above is correct.

For the Right Ascension, the rate is added to or subtracted from the default sidereal rate of 1.0000x. If you had the mount set to a different rate, like lunar, this is irrelevant to the command. It will always be implemented in terms of the sidereal rate.

This command operates differently depending on the hemisphere you are in.

- In the northern hemisphere, the rate is added to the sidereal rate. For example, :RR +0.1# would result in the mount tracking 10% faster than sidereal (1.0 + 0.1 = 1.1). :RR -1# would stop tracking (1.0 + (-1.0) = 0).

- In the southern hemisphere, the rate is subtracted from the sidereal. Using the same examples above, :RR +0.1# would result in the mount tracking 10% slower than sidereal (1.0 – 0.1 = 0.9). :RR -1# would result in the mount tracking at twice the sidereal rate (1.0 – (-1.0) = 2.0).

- Starting with version S, the command operates the same in both hemispheres and follows the convention used for the northern hemisphere above. Also note that Rev, S and later add another digit to the right of the decimal to increase the fine resolution of the command. The command is therefore: :RR sxx.xxxxx#

The variable Dec. rate works from a mechanical perspective. With regard to the commands in the servo, :RD +xx.xxxx# will cause clockwise rotation of the Dec. axis when viewed from above; :RD –xx.xxxx# will cause counter-clockwise rotation. The pier side makes no difference, nor does the hemisphere. It is better to think in terms of the mechanical rotation of the axis because it is consistent. Remember that in the northern hemisphere, on the west side, clockwise is south; on the east side clockwise is north and just the opposite holds true in the southern hemisphere.

As with the Right Ascension, versions S and later add another digit to the right of the decimal in declination.

REVISED 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 astrophotographers 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 crosshair 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 crosshair 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.

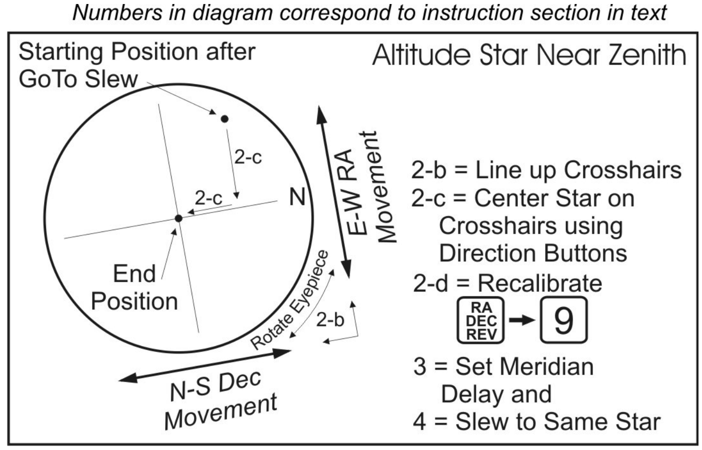
1. **Follow one of the start-up alignment procedures from earlier in the manual (one complete cycle) to get close.** We have found this method particularly effective following the Daytime Polar Alignment Routine, for aligning without a polar scope. This is especially useful: 1.) in the southern hemisphere, 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.

2. **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 crosshairs 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.

Numbers in diagram correspond to instruction section in text



   c) **Center the star** on the crosshairs 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.

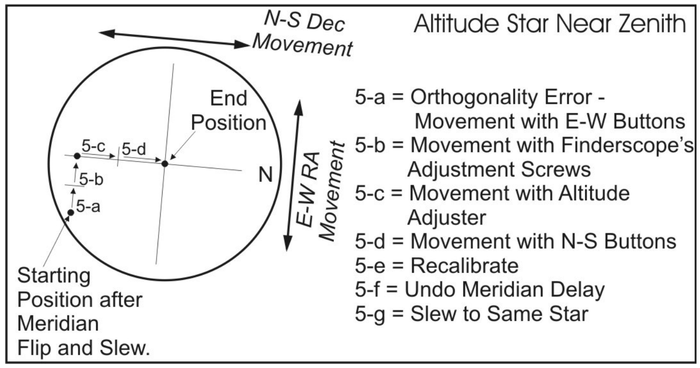
3. **In the RA/DEC/REV menu look at the Meridian Delay selection.** If the star is in the west, advance the meridian by 1 hour so that the display shows Meridian<1W>. Use the PREV< and NEXT> buttons to advance the hour and also change the direction to either W or E (pressing PREV< multiple times will 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 RA value to the current "z" or LST value. A larger RA value indicates it is in the east; a smaller RA 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.)

4. **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 RA and DEC on the crosshairs.

5. **Make altitude adjustments.**

   a) **The RA (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 crosshair with the E or W direction button.

   Numbers in diagram correspond to instruction section in text



   b) **Use the finerscope's adjustment screws to finish the movement onto the N-S crosshair.** Try to only adjust the finder in the E-W direction. Do not move it north or south.

   c) **Use the mount's altitude adjustment to bring the star half way toward the center of the reticle in the N-S direction.**

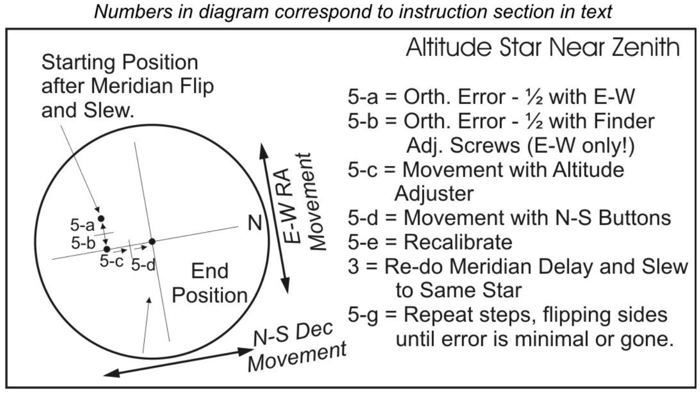
   d) **Center the star the rest of the way using the N-S buttons.**

   e) **Press the Recal button #9 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.)

   f) **Set the Meridian Delay display back to <0W>.** Press MENU to return all the way back to the Objects Menu.

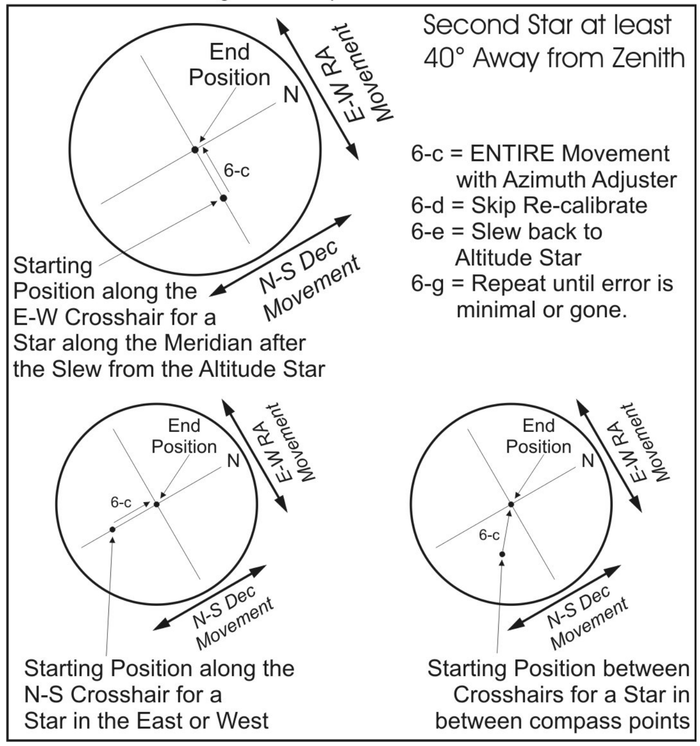
   g) **Enter the same star again and press GOTO.** The scope will again swap sides and acquire the star on the crosshairs. Repeat the mechanical alignment procedure until the star remains on or close to the crosshair. Each time you make an adjustment, move half the distance with the altitude adjuster (5-c) 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).

   Numbers in diagram correspond to instruction section in text



6. **Make azimuth adjustments:**

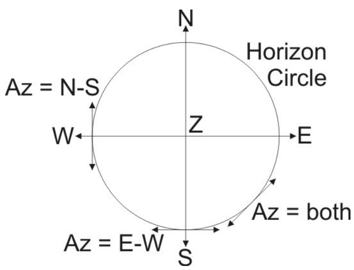
Numbers in diagram correspond to instruction section in text



a) **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.**

c) **Make THE ENTIRE centering correction with the azimuth adjuster.** Note that this movement could be along either crosshair, 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 crosshair as it is adjusted. Wherever you land after the GoTo slew, however, the azimuth adjustment will take you toward the center of the crosshairs. (Ignore any small perpendicular displacement as your azimuth adjustment brings you to the center of the eyepiece crosshairs, especially if your second star is near the horizon, as it will likely be from atmospheric refraction.)



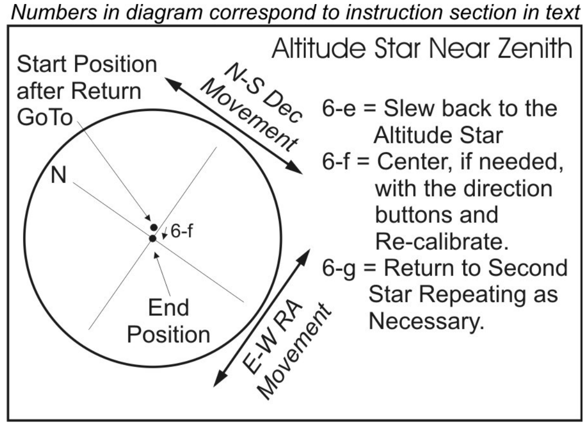
d) **No need to Re-calibrate since you have NOT used the direction buttons to do any final centering.** If you do end up tweaking with the direction buttons, then go ahead and re-calibrate, but you should not really need to do this.

e) **Slew back to the first star (Altitude Adjustment Star).** Since it is almost directly overhead, it should be virtually centered in the crosshair. 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.

Numbers in diagram correspond to instruction section in text



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 crosshair 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 RA 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.

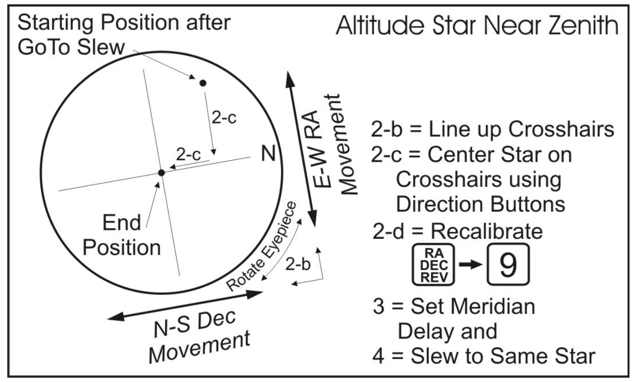
c) It is not necessary to do this at high power, nor is it necessary to get the star to fall exactly on the crosshair. A standard 8x50 finderscope was used in our tests with this procedure to achieve enough accuracy to take 30 second unguided frames at a 3810 mm focal length!

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 GoTos 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.

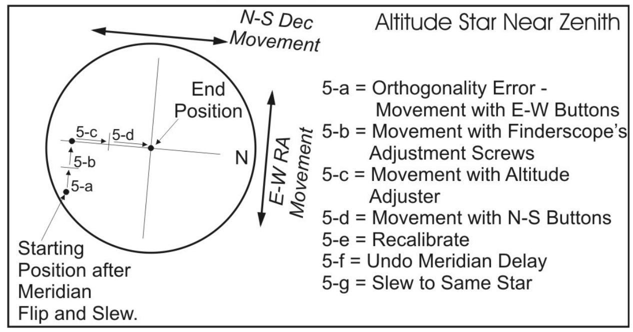
GTO Quick Star Drift Method of Polar Alignment Quick Reference Sheet

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 crosshairs with direction buttons
   c) Center the star with the direction buttons
   d) Re-calibrate.
3. Set Meridian Delay:
   **Star in west (RA value < “z” or LST value) – advance <1W>
   **Star in East (RA 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.

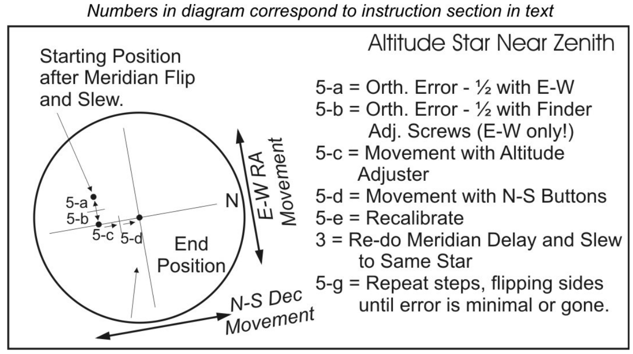
Numbers in diagram correspond to instruction section in text



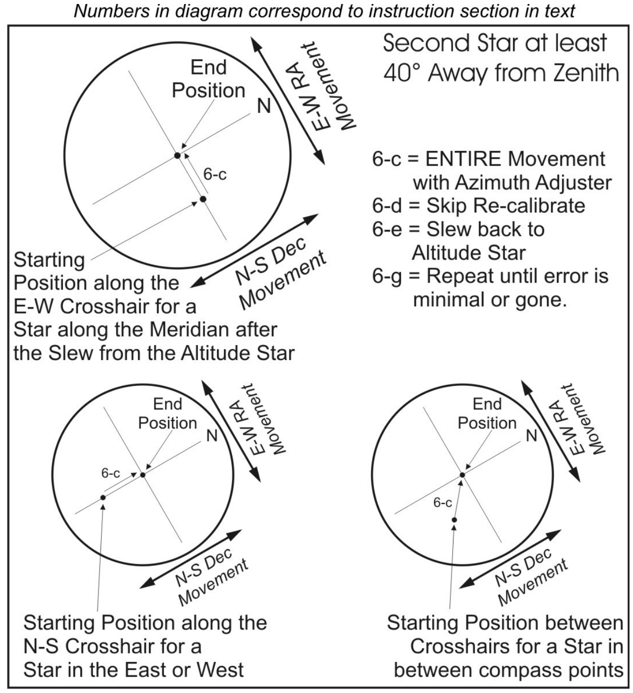
Numbers in diagram correspond to instruction section in text



Numbers in diagram correspond to instruction section in text



Numbers in diagram correspond to instruction section in text



Numbers in diagram correspond to instruction section in text