Tap The Sun

The SolarTrak® Controller System

Pro-Active Sun Tracking and Peripheral System Control

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Installation Guide for the SolarTrak® WAZ-125

The AZ-125 geardrive and frame is manufactured by Array Technologies, Inc.

Installation Sequence:

1. Assemble Frame
2. Install Mounting Post
3. Mount Geardrive On Post
4. Assemble PV Panel Frame
5. Mount Control and Battery Box
6. Mount Screwjack to Geardrive
7. Mount Frame on Geardrive
8. Mount PV Charge Panels on Frame
9. Connect Azimuth Motor Power
10. Turn on Controller Power
11. Fundamentals of LCD Monitor Operation
12. Test Array Motion Functions
13. Level Azimuth Drive Unit
14. Attach Reflective Sun Pointer
15. Set Controller Configuration Parameters using PC Interface
16. Put Controller in Automatic Mode and Perform Reference Check
17. Set Sun Position
18. Heliostat Option: Set Beam Target Position

WAZ-125 System Assembly Instructions

Tools Required:

Medium-sized Spade Blade Screwdriver
" " " Phillips " " "
Two 7/16" Open and Box-end hand wrenches
" 1/2" " " " " " " " "
" 3/4"
5/8" Open-end hand wrench
Medium-size Rubber Mallet (3-4")
Large carpenter's square
Small torpedo level
Long carpenter's level (or straight-edge to use with torpedo)
Two dozen 8" plastic cable ties

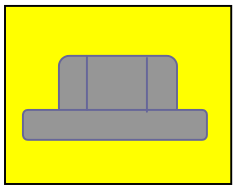
Equipment List:

5-6" Schedule 40 Post
6.5" Maximum O.D.
4' Minimum Height above ground, 6-8' ideal
Designed to local wind conditions using stifteners if necessary
(18" of clear pipe required at top)
MSDOS, PC-compatible computer (mouse not required)
with DB-9 Serial Comm Port
" 3.5" (bootable) Floppy Drive
Two each Bio-containers of Muscle & Elbow Grease

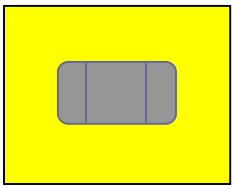
WAZ-125 Frame Assembly

The frame will be assembled face down. References to ***DOWN or BOTTOM*** will mean toward the face and ***UP or TOP*** will necessarily refer to the back of the frame.

There are two types of nuts used in the frame assembly, one with and one without a built-in washer.



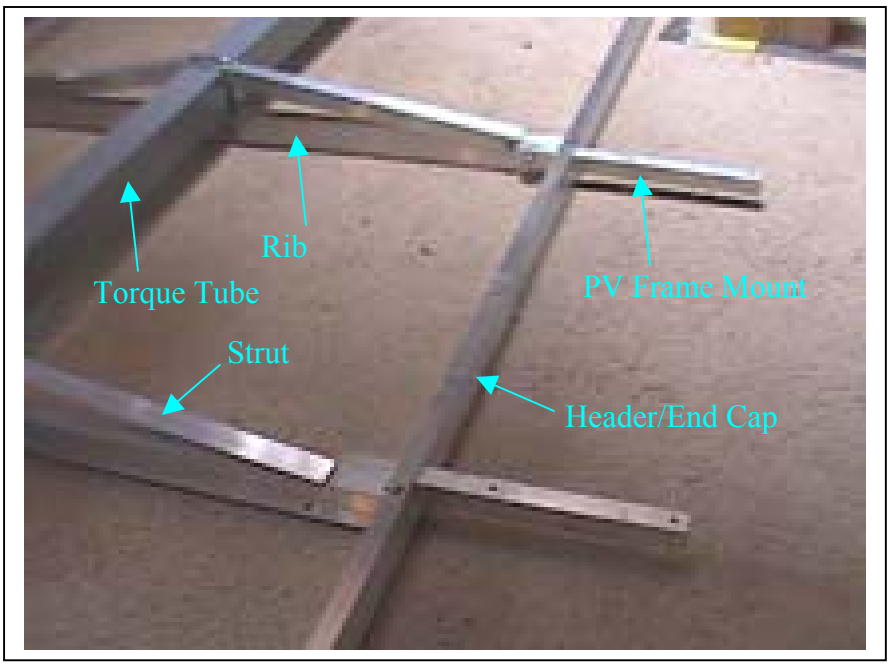
With Built-in Washer



Without (Standard)

The one without is normally used with a split-ring lock washer.

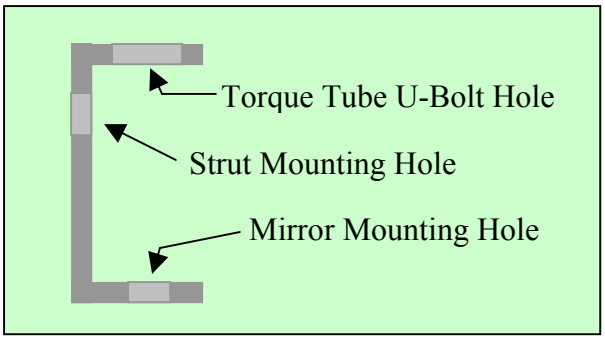
Bolts will generally use a flat washer under the head.

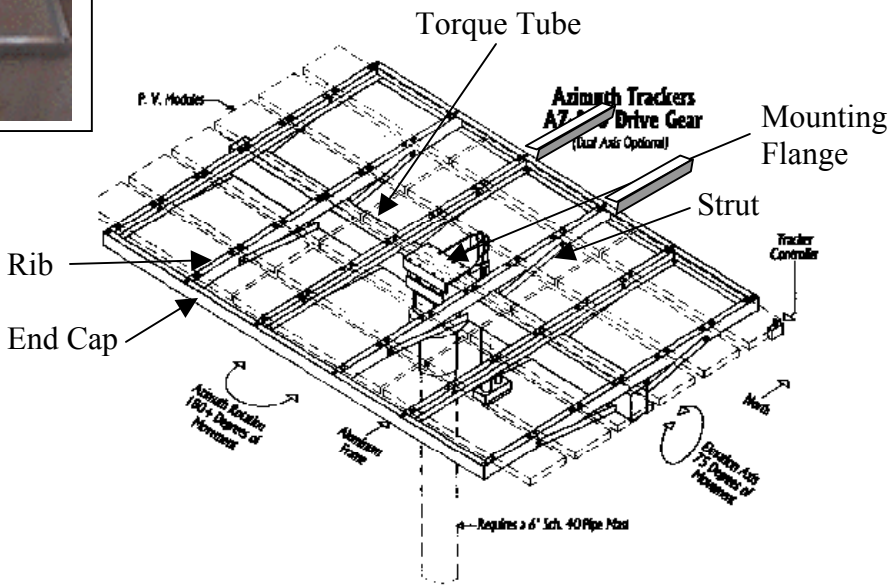


The two ribs with the PV Frame mount attached at the two central positions of the header. There are two square holes in one of the headers. The PV mounts are offset on the rib and will only fit one way through the header so the header/rib attachment holes will align.

The proper hole alignment of the ribs and headers will likely require the use of the rubber mallet. It is part of the design that everything fit together tightly.

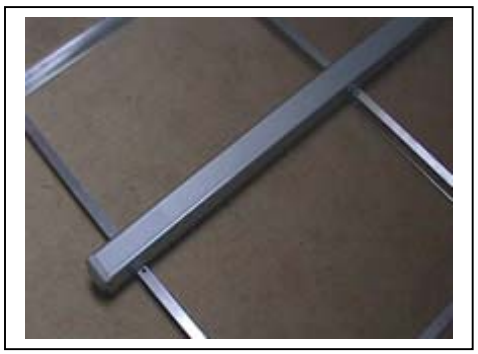
Layout ribs such that mirror mounting holes on flange are down.



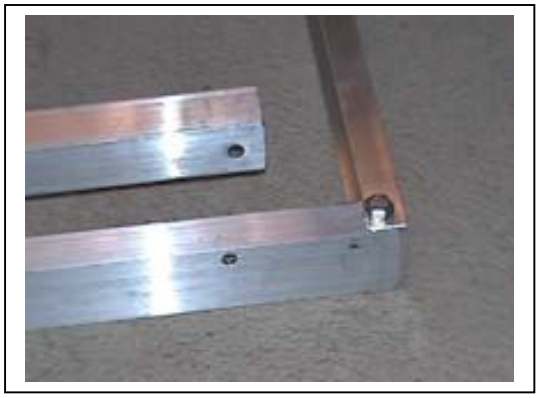


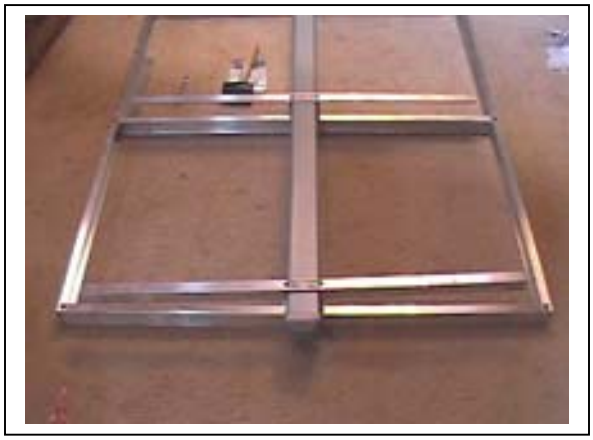
The frame is most easily assembled upside down on a properly flat surface. Lay out the vertical ribs on edge alternating orientation: **[ ] [*] [ ]**. The separation of the center two ribs* must be larger than the larger of the two torque tube mounting flanges. The end cap will be pre-drilled with appropriately spaced holes. The ribs fit inside the 'C' of the header/end cap.

Lay down the torque as shown. Center it between the pair of holes in the rib.

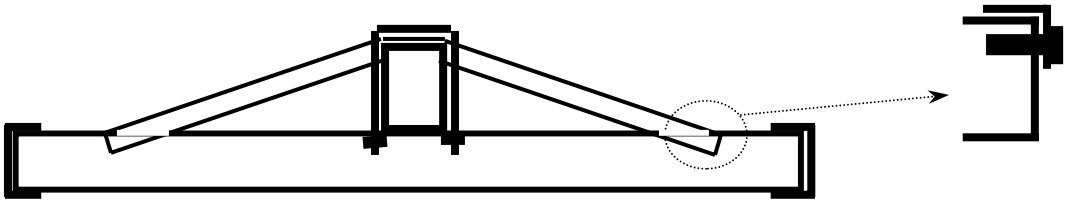


Lay down the struts across the torque tube such that they match up with the channels as shown to the right.
The holes should align with the ones in the ribs as shown below.





The struts bend across the torque tube then seat against the outside of the 'C' like spoons. Leave all screws just a little loose so the frame can be squared before final tightening.



The header/rib connections use the 5/16" screws with the built-in washer nut. It will likely look better if the screw is inserted from the outside of the 'C' channel with the nut on the inside but it will work either way. Get the nuts properly started but do not fully tighten.

The strut/rib connections use the standard nuts with a slit-ring lock washer. The screw must be inserted from the strut side, usually at a slight angle. The nut will fit tightly against the inside of the channel flange. Get the nut started and down a few turns but do not tighten completely.

Use a carpenter's square to square up the rib/header connection.

Once the frame has been squared and will just lie there without springing back, tighten all the header/rib screws on the topside first, then all the strut/rib screws. The frame can now be raised slightly to allow access to the bottom header/rib screws without deforming the shape.

Be sure the torque tube is centered end to end on the frame then insert the smaller (3/8") diameter 3" u-bolts through the holes in the struts and around the torque tube and through the holes in the ribs.

Then attach the fiber-lock nuts on the bottom, inside the rib flange.

After all the lock nuts are started tighten them completely but not so tight that there is deformation in the rib flange.

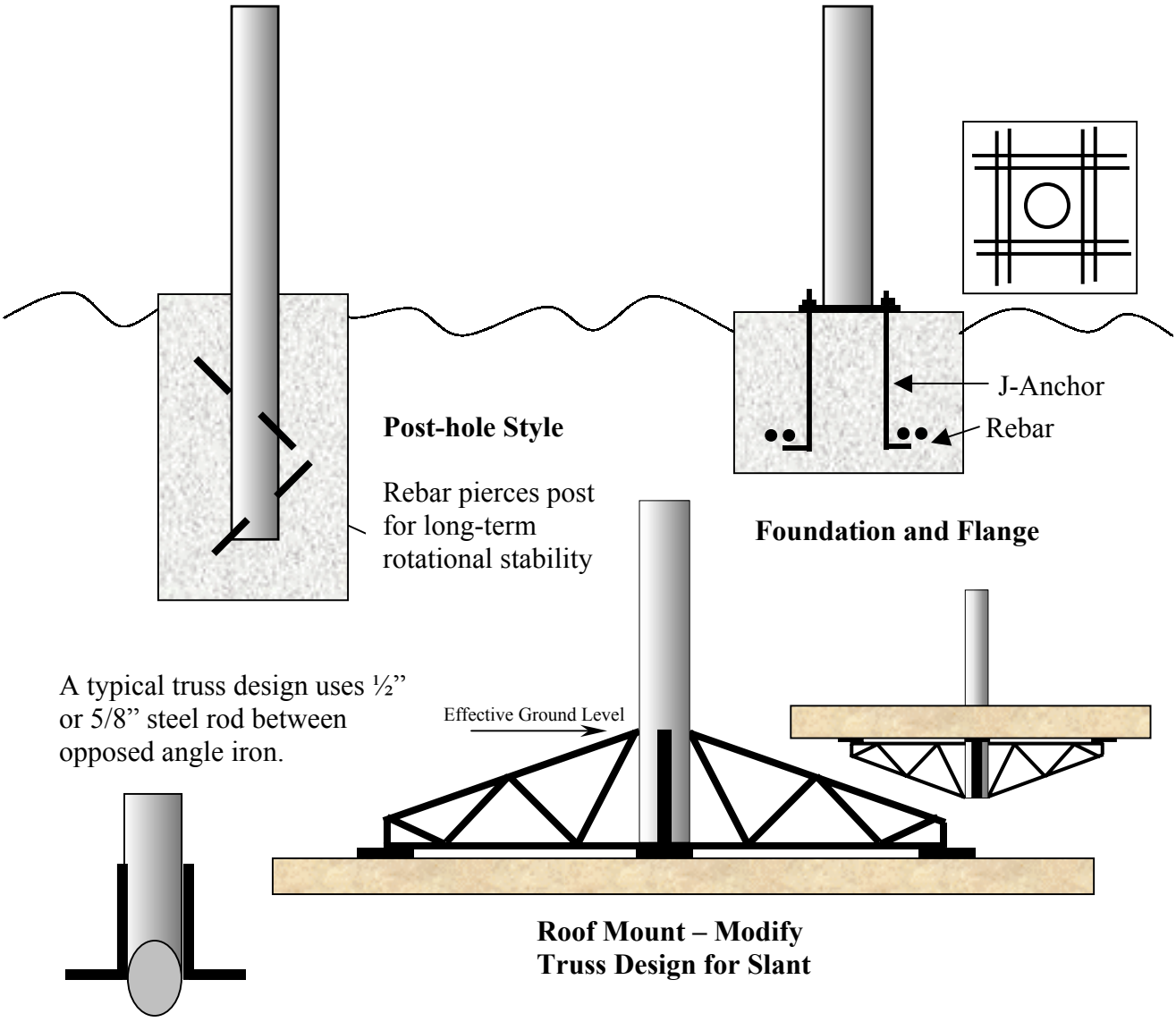
All done with the frame…

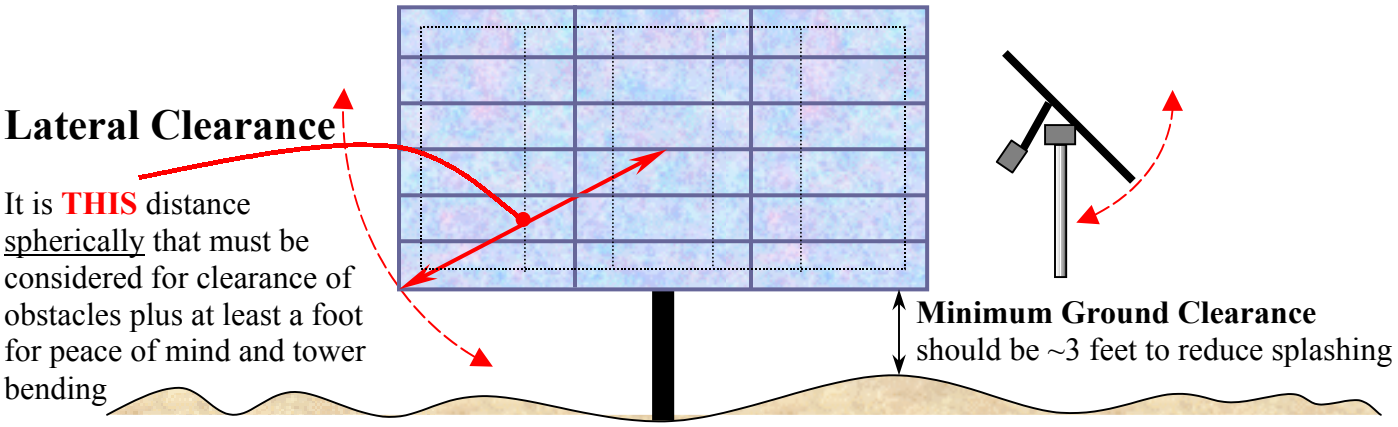
WAZ-125 Geardrive Installation

Install Schedule 40 Mounting Post

The WAZ-125 uses a 6-inch Schedule 40 Post (actual OD: 6.625 in.). The figures below depict three typical post foundation styles.

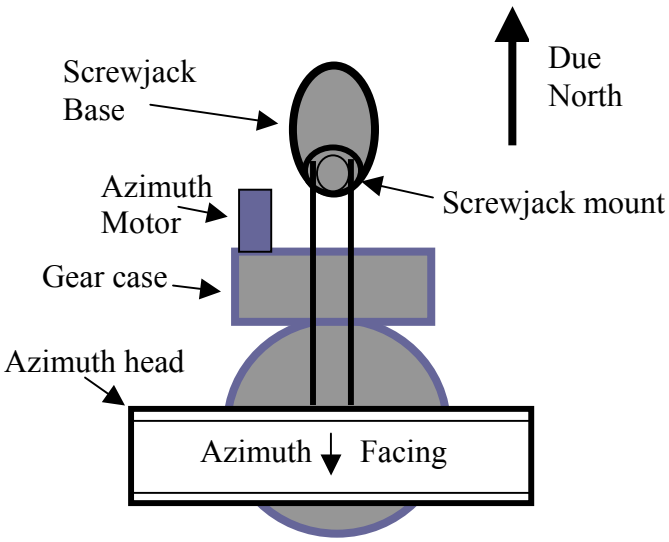
*** Warning: No implication is made as to the appropriate sizes of the foundations. Those specifications are best acquired from a local professional civil/mechanical engineer or from a local commercial sign installation company who would be familiar with local weather (wind), soil conditions and other relevant details. The geardrive is designed to withstand wind forces induced at 100 mph in the position shown below with the wind coming from the 'worst-case' direction with flatplate photovoltaic panels covering no more than 110% of the frame area. ***





Mount Geardrive On Post

1. The geardrive unit is shipped rotated to ~South in azimuth. It should be mounted with the screwjack base to the North (away from noon sun). If the Azimuth head is turned slightly (sometimes necessary for packing) turn the face of the gear case (with the WattSun™ sticker) to proper orientation. This adjustment affects the preset range of motion (~270 degrees from NE to NW around South) on the Azimuth axis. Minor errors in alignment will be removed later with the 'Set Sun Offset' function. The Range of Motion can also be adjusted to compliment the site.



Assemble PV Mounting Frame

Spread the PV panels out in a line, face down. There are roman numerals written on the back. They should be arranged **V to II,** left to right with the markings at the top for alignment to the frame. Be sure the wires aren't tangled. The anemometer will be mounted in the center and as shown in the picture, the rotating part of the anemometer is pointing down and to the left. Lay out frame sections on top of the panel frames.

Two of the angles are marked with Roman numerals and should be placed on the top so the markings coincide with the ones on the panels. Align the holes of the outer two panels (leaving the inner two panels loose for the moment) and insert the short ¼-20 bolts. The nuts will fit tightly against the inside of the PV frame preventing them from turning while tightening the bolts from the outside. Align the two frame halves such that the short connecting angles match up with the holes. Place the anemometer frame over the short angles as shown and align the holes. Use the 5/8" long ¼-20 bolts to attach the anemometer, through the two angle sections with the nuts on the inside of the PV frame as before. To stiffen the connection, use the two remaining short ¼-20 bolts with the large flat washers to clamp the center point of the frame to the connecting angles.

The remaining two holes on either side of the inner panels will be used to mount them to the frame using the long ¼-20 bolts.

Mount Control and Battery Box

Remove the external limit switch from where it is tucked inside the rear support bracket and let it hang loose behind the controller/battery unit.

Lean the PV panel frame vertically against the post; lift the control unit and screwjack at the same time, laying the screwjack across the torque arms while the control unit is attached.

Attach the control unit using the two holes in the upper flange of the control back plate. The unit is offset to the left to account for weight distribution. The limit switch can now be attached under the worm gear housing as shown with the activation button nearest the post.

Mount Screwjack to Geardrive

Mount the two pivots of the screwjack using the large nuts as spacers for the top. Route the two wires attached to the anemometer and PV panels over the bolts as shown.

Mount Frame on Geardrive

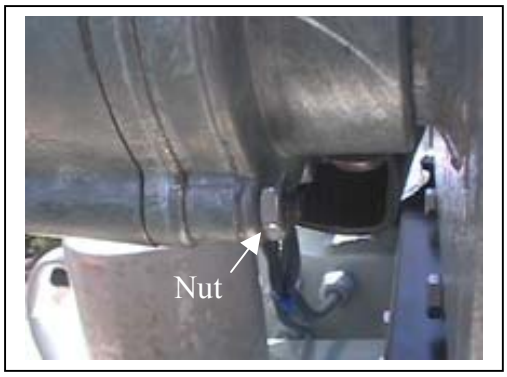
With the screwjack still retracted, lay the torque tube in its mounting cradle and stab the u-bolts through their holes. The tube may need a shim to adjust slight imperfections in the cradle orientation. It is recommended that all the lock nuts be tightened only slightly in the first pass then complete the process in two more passes, much like the pattern used to tighten the wheel of a car.

Mount PV Charge Panels on Frame

With the frame laying flat, place the PV frame across the two mounting posts extending from the upper frame header. Align the holes and use the two long ¼-20 bolts to attach the PV unit.

Route the wires along the inside of the torque arm and cable-tie them such that there is some looseness but they won't escape. Arrange the wires coming from the various PV panels and cable-tie them to the frame using the extra holes in the frame as anchors. The anemometer should swing easily on its pivot.

Connect Azimuth Motor Power



Remove the clip and pull back the plastic hood to reveal the two nuts on the end of the lower base plate screws. Remove the base plate of the azimuth motor. The nuts will drop off after a few turns on the screws and should be replaced along with the base plate.

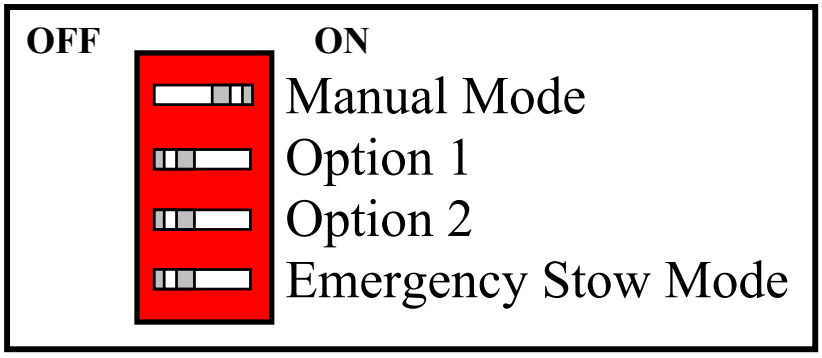
Insert the one unconnected four-strand wire in the wiring harness through the strain-relief in the base plate, as shown above, and connect to the left side of the terminal strip using the color code:

Green - Top
Red
White
Black - Bottom

Replace the base plate, making sure the plate seats all the way up to the base before tightening. Also be sure that the plastic insulator inside the top of the base plate remains in position. The longer pair of screws go on the bottom. Tighten all four screws, adding the two little nuts on the lower two screws after tightening. Pull the plastic rain cover back into place and re-attach the clip to hold it in place. Tighten the strain-relief nut to seal the hole.

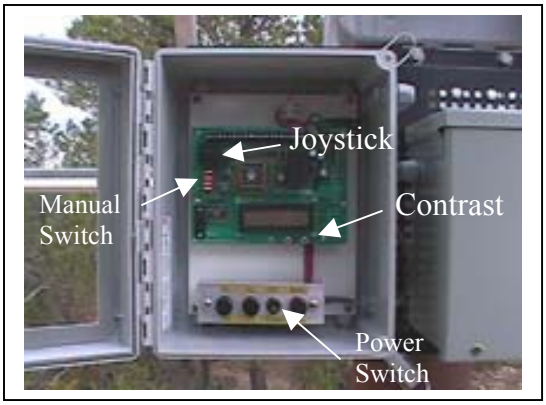
Turn On Controller Power

Prior to powering up the system, place the unit into MANUAL mode by turning on the Manual Mode switch just below the Joystick on the control board.



Turn on the power switch. The motors may grunt once as the controller takes control but they should stop immediately. If the display is not visible, roll the contrast thumbwheel UP.

The LCD Monitor should now be alternating between the local TIME and the current MODE, specifically 'MODE MANUAL' since the Manual switch should be on.



Fundamentals of LCD Monitor Operation

The current operational mode is displayed on the micro-monitor (Figure 1) alternating once per second with the current time. This alternating status screen is the default display and implicitly indicates that the SolarTrak® Controller is functioning normally in one mode or another. This function can be referred to as the 'Heartbeat'.

Adjust the thumbwheel to the right of the display screen by rolling it up to increase visibility. If there are odd characters or missing letters (like 'ode' instead of 'Mode'), press the Reset Button (to the right of the joystick) again to clear it up.

Additional display screens are available containing status or configuration data that can be viewed with the *Item Button*, and when applicable, edited with the *Adjust Button* and *Value Button*. The display will return to the default display screen after one minute of idleness except while in the *Adjust* mode. Please see section on Displaying and Editing Parameters.

Operational Modes

- Manual Mode: Top switch (MANUAL) to RIGHT (Overrides ALL automatic motion functions). All motion other than Joystick input is prevented.

- Tracking Mode: All toggle switches to LEFT (Joystick Inoperative) System goes through standard tracking scenario: Track during the daytime and assume a programmable Night Stow position while the Sun is below the horizon.

- Reflecting Mode: All toggle switches to LEFT (Joystick Inoperative) System goes through standard tracking scenario: Reflect during the daytime and assume a programmable Night Stow position while the Sun is below the horizon.

- **Morning Reference Check:** Once each day the SolarTrak will seek out its Eastern and Northern limit to reset its position count reference to zero.

- Night STOW: Normal tracking Function for standard overnight position.

- Emergency STOW: Bottom switch (STOW) to RIGHT (all others LEFT)
Array moves to a programmed safe position. This position is used for responding to the STOW switch, a High-Wind Condition (indicated by 'Mode Wind Stow') or a Low-Battery Condition (indicated by 'Mode Batt Stow').

Display/Edit Parameters on SolarTrak® Controller Board

Displaying Parameters with LCD Micro-Monitor

The LCD Micro-Monitor allows display of a limited combination of calibration parameters and status values. It may be necessary to adjust the contrast using the thumb-pot just above the LCD. The standard display shows the current Time alternating with the current controller Mode. The three pushbuttons just below the monitor are, from left to right, ITEM, ADJUST and VALUE.

The mode will be one of the following:

1. Tracking	Array is tracking normally
2. Night Stow	Array is parked for the night (will wake in morning)
3. Emergency Stow	Array is Stowed manually
4. Manual	Array is in Manual Mode
5. Morning Ref. Check	Array is seeking its reference
6. Wind Stow	Array is in Stow position due to high winds
7. Battery Stow	Array is in Stow position due to low battery

There are several parameters and status values that may be displayed on the micro-monitor screen. The following values are accessible:

1. Time/Mode	Local 24 Hr. Standard, NEVER Daylight Savings
2. Date	Year 2000 compliant
3. Position Count	Axis 1,2 Turncount reading (use 'VAL' to toggle)
4. Wind xx mph	Current Windspeed
5. Temperature	Use 'VAL' to toggle between C & F
6. Set Sun Offset	Calibration Command Function
7. Tracker/Reflector	Current Tracking mode for optional Heliostat Function
8. Set Reflector Offset	Set Beam Target Bearing (Azimuth & Elevation)
9. Seconds/Day	Clock correction each day
10. Seconds/Week	Clock correction once per week
11. Latitude	+ Northern Hemisphere, - Southern (+/- 90 degrees)
12. Longitude	0 = Greenwich, UK (Range 0 – 360 degrees West)
13. Time Zone	0 = Greenwich, 5 = East Coast, 8 = West
14. Version	Version Series and Date

These values may be displayed, one at a time, by pressing the ITEM button, located just below the monitor. (See Figure 1). Due to space limitations on the screen, the above item descriptions will most often be abbreviated. The buttons are scanned once per second so it may take a moment to see the response. The button should be held down until it registers. The button will repeat its function once per second as long as it is held. After the last screen is displayed, it will start over with the Time. After approximately one minute of inattention (unless in Adjust Mode), the display will revert back from any screen to alternating between the Time and Mode.

There are three basic types of screen content:

- **Status Information**
- **Configuration Parameters**
- **Command Functions**

Status Information is set dynamically by the SolarTrak® during the course of operation. Some values are strictly informative such as the STATE of a switch or voltage level. Others are a relative value that must be referenced to an initial state such as the array position with respect to a limit switch. Still others, such as the Time and Date, must not only be initialized but also calibrated.

Examples of Status Information are:

Description	Available Operations
Operating Mode	Read Only (Controlled Elsewhere)
Local Standard Time	Modify (Calibrated Elsewhere)
Date	Modify
Array Position Count	Initialize to Zero, Switch between Ax1 & Ax2 with **VAL** button
Battery Voltage	Read Only (Calibrated Elsewhere)
Wind Speed	Read Only (Calibrated Elsewhere)
Temperature	Read Only, Switch between 'F' and 'C' scales with **VAL** button
Version	Read Only

Configuration Parameters are stored in non-volatile memory (EEPROM) and dictate tracking options, geometric specifications and emergency operation guidelines to the Controller. Such information is installation-specific but will not usually change once installed.

Examples of Configuration Parameters are:

Latitude, Longitude
Time Zone
Tower-Tilt Error
Seconds-per-Day, Seconds-per-Week Clock Correction
Sun-reference Offsets
Beam Target Bearings
Width/Spacing ratio of rows for Backtracking

Command Functions perform specific operations that generally involve multiple parameters or high-level control options. Examples of Command Functions are:

Zero Position Count	Set current axis position to zero (Set Reference Point)
Set Sun Offset	Adjust Sun-reference Offsets for both axes
Track/Reflect	Switch between Direct and Reflective tracking
Set Reflector Offset	Set Target Azimuth/Elevation
Backtracking On/Off	Toggle Optional Function (single-axis flatplate system)

To support these screen-types, there are three types of button operations:

- **Set a Quantity**
- **Invoke Command**
- **Swap Screens**

Giving a name to the type simply provides a way to interpret how each screen-type will respond to the buttons.

Set a Quantity:

***** NOTE: It is strongly recommended that the array be placed in MANUAL mode prior to changing parameters to avoid jumps, spurts and wasted time**.

The ADJUST MODE is indicated by a flashing cursor square on the screen. This must be turned OFF by pressing the ADJUST Button before the ITEM Button can be used to change screens again.

- Using the ITEM button, select the screen that displays the desired quantity.
- Press ADJUST once to make the Cursor (Black Rectangle) appear.
- Press ITEM (Surprise! ITEM now makes the cursor move to the RIGHT) to highlight the offending digit. It will 'wrap-around' if you miss.
- Press VALUE to increment until you're satisfied. Note that the digit value will always wrap-around to zero. If the digit has a known limit other than '9', such as the hour digit in time (2), it will not exceed it but will wrap-around sooner. If the value being entered is NEGATIVE, FIRST set the value to a NON-ZERO number (this computer does not acknowledge –0) then change sign by highlighting it with ITEM then pressing VALUE once.
- Repeat steps 3 & 4 to produce the desired result then press ADJUST once again to remove the Cursor.
- Press ITEM to get to the next screen, back to the Time/Mode (default) display or just wait 60 seconds for the screen to revert to the default automatically.

To Invoke a Command:

As before:

- Display the Command Prompt screen with the ITEM button.
- Press the ADJUST button to bring up the Cursor (arm the function)
- Press the VALUE button to actually invoke it

  or
- Alternatively, pressing the ADJUST button again instead of pressing VALUE will 'disarm' the situation and allow further ITEM button-presses to continue changing the screen display.

To Swap Screen Displays:

Several displayed quantities have a separate value for each axis or, in the case of temperature, two different sets of units. When such a quantity is currently being displayed on the screen, pressing the VALUE button will toggle back and forth or 'swap' the displayed values. Once toggled, if the quantity is available for modification (temperature is not) and you choose to do so, have at it.

This method of input, though handy for small things, is tedious, time-consuming and resource-hungry. A great deal of very limited program storage space in the micro-controller chip is used to store the characters you read on the LCD, space better utilized for control strategy options, so not many parameters are available for this type of access.

With so many things to keep track of during any period of time, the SolarTrak® places the buttons at a low priority and samples the button's state only once per second or so. This results in some inconsistency in their response. If you don't use them much you won't care and if you use them a lot, you'll get used to it.

RESET Button:

The single button to the right of the Joystick in the upper left of the board is the **RESET** button. **When all else fails and there is no response from the board**, pressing this button will restart the SolarTrak program and display the default alternating time/mode.

Test Array Motion Functions

Joystick Operation – **Manual Mode** – SolarTrak facing north, operator facing south:

LEFT ➔ EAST
RIGHT➔ WEST
UP ➔ NORTH (Screwjack retracts) (Up = toward the TOP of the box)
DOWN➔ SOUTH (Screwjack extends) (Down = toward the Bottom)

An additional feature is the ability to use the joystick as a toggle switch rather than the standard momentary operation. Turn ON the 'Option 1' toggle, just under the Manual Mode Toggle. Now the joystick operates as a 'Touch On-Touch OFF' toggle for each axis. Touch the joystick in the desired direction to turn ON then again to turn OFF.

For this test leave Opt. 1 OFF.

The current position of the geardrive should still be facing south in azimuth and fully retracted in elevation pointing essentially straight up.

Move the joystick to the LEFT and hold it there. The array should pan toward the east.

Let go of the joystick, wait for about 5 seconds and move the joystick to the RIGHT. The array should pan to the west. Let go of the joystick.

Now press the joystick DOWN. The screwjack should start to extend. Hold it there until it has extended about 1-2 inches then let it go.

Wait 5 seconds then press the joystick UP and verify that the screwjack retracts.

If either axis moves in the wrong direction, the motor leads are reversed.

The next section will utilize the Opt. 1 – 'Sticky' Joystick function.

For practice, turn ON the Opt. 1 switch. And Touch (and release) the joystick to the left. The array should start moving to the east.

To verify that the east limit switch is working (before you need it) while the unit is panning to the east press the button on the limit switch. The unit should stop completely and instantly. Then let the button go to resume motion.

Touch the joystick to the LEFT again to stop the motion.

Touch the joystick to the RIGHT immediately. The unit will wait for a few seconds then take off.

Turn OFF the Opt.1 switch. You must still touch the joystick again to stop the motion.

Level Azimuth Geardrive

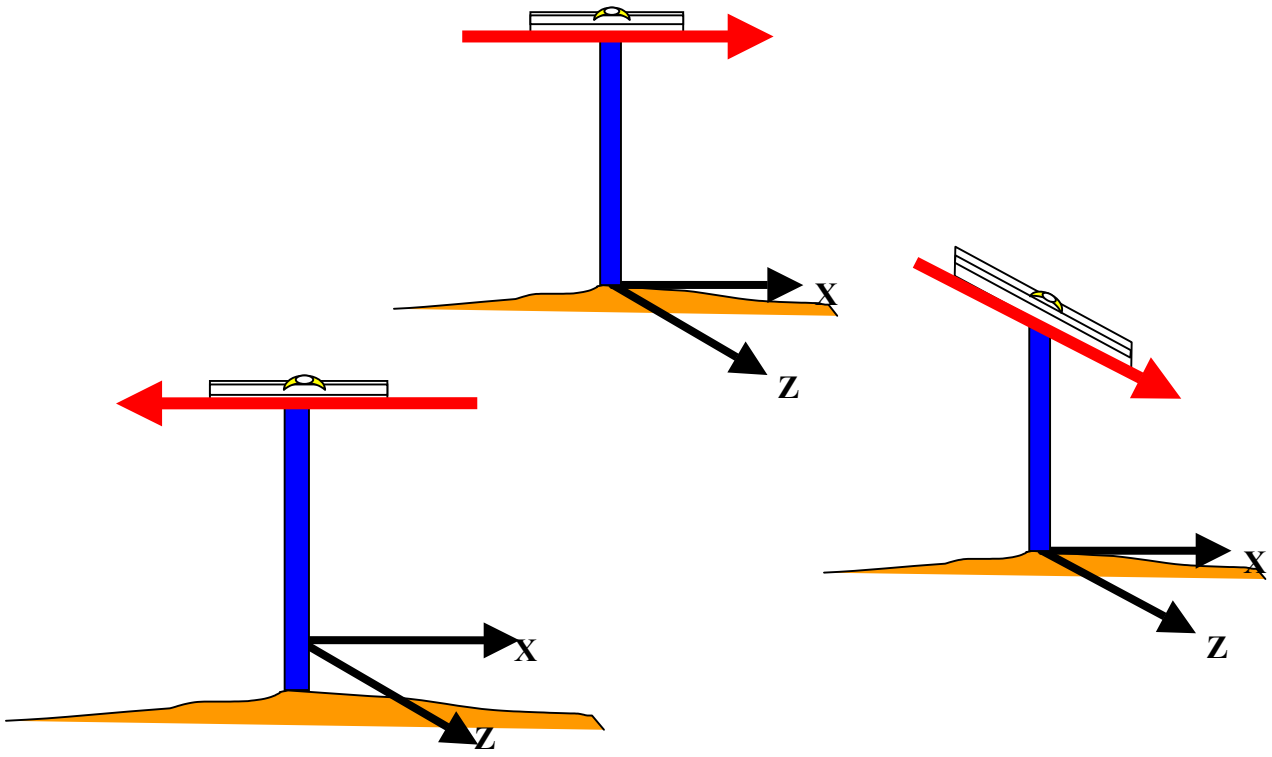
Use of a Leveling Instrument for Mechanical Alignment

It may seem that the quickest way to align everything together is to use a leveling device and that is true as long as the entire system is leveled from the ground up with each successive component adjusted in the correct order. Although the SolarTrak software can incorporate an error function to correct a tower misalignment (tilt), if a level is to be used to align the rest of the system, the tower tilt must actually be corrected first, physically, not mathematically. If the tower (or actually the azimuth axis of rotation) remains physically tilted, all subsequent leveling operations will be mathematically tilted by the same amount, which, although a different way to achieve non-orthogonality, is just as wrong.

Use of this method is actually recommended since it will (if properly done) preclude the need for performing the final calibration step.

Steps to level system:

1. Orient secondary axis parallel to the established X-direction and adjust to level.
2. Orient to the Z-direction (90° - rotation about Y-axis) and level again.
3. Orient to the – X direction to check level.
4. Repeat steps 1, 2 & 3 until no adjustment is necessary.
5. Attach and/or check mounting surface used for mirror of reflective pointer in both directions to verify level with secondary and primary axes.
6. All other adjustments should be made while reference pointer is on-sun and the unit is tracking.



Attach Reflective Sun Pointer

It is necessary, at least temporarily, to use a precision reference to set up the tracking parameters.

Mount a version of the sun pointer described in Appendix B of the PC Interface Instructions.

Set Controller Configuration Parameters using PC Interface

References will be made throughout to **SolarTrak® PC Interface Instructions**

It should be necessary only to set the Local (Standard) Time, the Date, Latitude, Longitude and Time Zone.

All this can be done on the LCD using the buttons but it's a pain…

Set the PC system clock to local time verifying that if it is Daylight Savings Time, the DAYLIGHTSAVINGS = ON appears in the ST_NET.cfg file.

Establish communications with the SolarTrak® controller following the startup procedures in the PCI Instructions.

From the Main Control Panel enter the command:

/CFG

The first page of parameters contains the Lat. Long and Time Zone.

Set all three to the appropriate local values using the procedures in the PCI Instructions.

Now press **F9** to set the time.

In the upper right portion of the screen there is a box indicating the current System Time (bottom) and the current SolarTrak® Time on the top.

Double check that the system time is correct then press **F3** to set the time and date.

Put Controller in Automatic Mode and Perform Reference Check

The unit is now ready to place in automatic tracking mode.

For Heliostat units, verify that the unit is in Tracker mode. Use the ITEM button on the SolarTrak® to move up through the screens to the next screen after 'Set Sun Offset'. The screen should say either Tracker or Reflector. If it is Reflector, Press the ADJUST button (the blinking cursor must come on) then the VALUE button to change it.

Press the RESET button (firmly but quickly) to re-boot the computer.

Flip all four switches to the LEFT.

The LCD monitor should read 'Mode Morn Ref'.

The first motion will be both axes moving away from their reference limit switches to assure that they are not triggered (on the limit) then both will stop.

The next motion will take each axis all the way to its limit. The azimuth will move to the northeast and the elevation will move up to the north (fully retracted).

Once both have reached their respective limits, the display will change to 'Mode TRACKING' and begin moving off toward the Sun.

Once the unit gets where it 'Thinks' the Sun is, it will start its standard update and wait cycle.

Set Sun Position

The Sun Reference Offsets can now be set with the joystick.

Press the Item button on the controller board until you reach the 'Set Sun Offset' screen.

Press the ADJUST button to display 'Position Array' on the screen.

The joystick is now active for you to move the array to the actual on-sun position using the reflective pointer to indicate an on-sun condition.

When the halo is exactly centered on the hole, press and hold the VALUE button until the screen snaps to the Time/Mode screen. The unit should continue to track the sun now, updating every few seconds.

Heliostat Option: Set Beam Target Position

Once the unit is tracking satisfactorily, the Beam Target can be set with the joystick.

Press the Item Button to go back to the Tracker/Reflector screen.

Change the unit to ‘Reflector’.

Move to the next screen, ‘Set Refl Target’.

The array will be moving to shoot the beam approximately south and horizontal (factory setting).

To stop the array and set the reflector target location, press the ADJUST button to display ‘Position Mirror’ on the screen.

The joystick is now active to position the beam to the selected target location.

To save the target azimuth and elevation, press the VALUE button.

Make Lots’a Watts!