

# Homing Routine Configuration Procedure

## ***Introduction***

This procedure describes the low level control of the PMAC environment with PEWIN32, in order to set up the homing data parameters in the PLC programs. It deals specifically with the Az., El and Focus drives of the 1m telescope at Mount Stromlo, but is adaptable to any EOST telescope.

## ***Principles of Homing***

Axis homing operates by finding a starting point quickly, then moving slowly along to each C reference mark on an encoder tape in turn. While passing the C reference marks, it looks for a known pattern of 2 adjacent distances, then agrees that it has found the third reference mark as the home position. If it fails on the slow scan, it keeps going for a specified number of extra C marks, looking for the specified pattern. If it fails to find the starting point, it tries again for a specified number of attempts. Ultimately, it fails to find the pattern and records an error, or it finds the pattern and sets the home flag.

## ***Azimuth Homing***

The following internal PLC variables are set up for use by the homing routine:

<b>Variable</b>	<b>Purpose</b>
P0150	Fast Home speed (4729 default = 2 deg/sec)
P0151	Fast home acceleration (default 0.591 = ¼ deg/ sec/ sec)
P0152	Slow home speed (used after COR switch found as start point)
P0153	Slow homing acceleration (0.591 default)
P0154	Mark1 – Mark 2 distance, from test table
P0155	Mark2 – Mark 3 distance, from test table
P0156	Mark 3 – absolute zero defined mark (single encoder counts, can be set to 0, or the complement of any encoder reading at a desired “zero count” location of the axis)
P0157	Homing error margin

P0158	Outer loop max tries before fail (3 typical)
P0159	Inner loop max tries along tape to find 2 correct separations (2 or 3 typical)

These parameters should be set in RAM first, during tests, then edited in *Allfiles.pmc* later. Editing the file is described further on.

### Watch Window Variables

M3596 is the azimuth COR switch status, and toggles as the COR switch is crossed

P0143 and P0144 set the state of M3596 on each side of the COR switch

### Azimuth Homing Procedure

- Jog to the –ve side of the COR switch, then slow to jog speed 100 (I922 =100), and watch M903 to record the encoder counts as the Cref marks are crossed in succession. Log the values as a table.
- Ignore the first M903 value after the COR switch is toggled. This allows for marginal situations where the two are aligned to within the switch hysteresis. Note the second, third and fourth values, and derive the separations from 2 to 3 and from 3 to 4. Call these distances A and B respectively.
- Enter the values of A and B into P0154 and P0155, then set up the M3596 to be '0' on the -ve side of the COR switch. Set up the 2 speeds as required for homing, then test the homing commands.
- When the homing works, repeat with the elevation axis, then update the PLC code file *Allfiles.pmc* as described below.

### Elevation Homing

The following internal PLC variables are set up for use by the homing routine:

Variable	Purpose
P0250	Fast Home speed (4729 default = 2 deg/sec)
P0251	Fast home acceleration (default 0.591 = ¼ deg/ sec/ sec)
P0252	Slow home speed (used after COR switch found as start point)
P0253	Slow homing acceleration (0.591 default)

P0254	Mark1 – Mark 2 distance, from test table
P0255	Mark2 – Mark 3 distance, from test table
P0256	Mark 3 – absolute zero defined mark (single encoder counts, can be set to 0)
P0257	Homing error margin
P0258	Outer loop max tries before fail (3 typical)
P0259	Inner loop max tries along tape to find 2 correct separations (2 or 3 typical)

### Watch Window Variables

M3597 is the elevation COR switch status, and toggles as the COR switch is crossed

P0243 and P0244 set the state of M3596 on each side of the COR switch

### Encoder Scaling Constants

The encoder drums and tapes have a specific number of cycles built into them. Each drum has a designed tape length and number of cycles associated with it. This number of cycles per drum revolution correlates with the number of encoder counts per encoder per degree revolution. Based on the number of encoders per axis, the number of encoder counts per degree adds by each encoder.

For the Keck telescopes, the azimuth and elevation encoder drums have the same diameter, and the same number of read heads per axis. Therefore the same number of encoder counts per degree apply to each axis.

The 1m telescopes have different drum diameters, and different numbers of read heads per axis also. The Stromlo III 1m telescope has four read heads per axis, and the Beijing telescope has two read heads per axis. The scaling constants in the *Telescope.ini* files must therefore be different for each one.

	Azimuth Scaling Constant	Elevation Scaling Constant
Keck OT	2364444.4444	2364444.4444
Stromlo III 1m	1671111.1111	1457777.7777
Beijing 1m	835555.5555	728888.8888

## ***Homing Offsets in PMAC***

After homing, the telescope axes are located with respect to their Centre Of Rotation switch and a preset number of Cref marks from that switch crossing, in a certain direction. This is not yet related to the world location of the telescope in any useful way. This is done with certain P variables in the PMAC, and establishes the “zero” counts position of the axes in telescope space. As noted above, the P variables are P156 for azimuth, and P256 for elevation.

To establish the zero count position of the elevation axis, for example:

P256=0 ; offset value after homing

M3650=1 ;enable elevation axis via PLC commands

M3651=1 ;start homing the elevation axis

Wait for homing process...

Check M3675 until it equals 1, and the axis is homed. The PEWIN position should report as near –200,000 for the elevation axis.

Push the elevation axis near zenith (elevation PMAC reference location) as close as possible; if jacking to a known position is standard, then this should be done. At this point the axis position should report as somewhere near –50,000,000 for a 4 read head system. Divide this by 4 to get the tape counts, eg 12,500,000, and set the value of p0256 to the complement of this number, eg –12,500,000. This value will hereafter be added to the encoder readings after each homing process is completed, providing a “zero counts” figure at the desired location of each axis. For azimuth axis, the variable is P0156.

Home the axis again by setting M3651=1, and the reported position of the axis after homing should now be near –50,000,000. Send the axis to 0 with J:0 absolute move, and the elevation should move to zenith. The absolute position of zero counts has been set. PEWIN will report zero counts at zenith now.

Save the new value of P256 in allfiles.pmc, and load the PMAC with this new version of allfiles, remembering to add a revision level and comment.

Note that in the *telescope.ini* file, the elevation is based on horizon pointing, so the elevation encoder offset will be set to 90 degrees.

## ***Updating the PLC Code***

Save the old *Allfiles.pmc* as *Allfiles. Old* or similar archiving process.

Edit the PLC file *Allfiles.pmc* with the new variable data, then search the PLC1 code for the major and minor file version numbers. For parameter changes, update the minor version number only. Add a note to the history section, with the data of the change and your initials.

Having edited *Allfiles.pmc*, the saving process is:

\$\$\$\*\*\* Enter ; reset PMAC to factory default settings

File → File Download → browse for *Allfiles.pmc* OK ; load file to PMAC

### ***Advanced Setup: Secondary Drives***

The three focus drives are at risk of damage during setup, and the process to configure them for homing and limit switch setting must be very carefully understood. If in doubt, confirm your assumptions with Adrian Loeff or Mark Croft at EOST 0011 1 520 624 6399.

The three motors drive a threaded and preloaded drive axis each, providing both tip, tilt and focus control. Each drive axis has a travel limit switch at each end of travel, monitored by PLC software, and outside each EOT limit switch is a second switch, the Failsafe Limit switch. The Failsafe Limit switches (6 in total) are fed to the DIOP for direct hardware disconnection of drive power, whereas the inner EOS limits switches cause software controlled blocking of drive in one direction only.

The dangers in setting up this system are predominantly:

- Home position sensing is 1 mm from the physical end of travel of the encoder shafts. Both limit switches must operate inside this 1mm range. Setting them is very delicate, and failure to cut power before the shaft hits its mechanical stop will damage the encoder.
- Driving any motor independently of the other two causes tip or tilt. Uncontrolled tip or tilt can damage the flexures holding the reference plate onto the assembly. 3 extra limit switches are mounted around a tilt shaft, to act as additional failsafe limits if this occurs.

Setting up the limit switches means disabling the inner switches to test the outer switches. Extreme care must be taken to avoid mechanical damage.

## **Preliminary Checks**

As with other drive axes, the lowest level variables include the PMAC channel number. In this case, the focus drives are connected to PMAC channels 1, 2 and 3.

The EOT limit switches are coded as per all other channels, as Mx21 and Mx22. For focus axis 1, therefore, the watch window should mimic the status of M121 and M122. We wish to set up the homing mark to be inside this limit switch response.

With no servo axes active, check the smoothness of the encoder shaft movement, and the firmness of the encoder clamping. All encoders should mount against the reference plate to assure zero tip and tilt when homing marks are all found. Total shaft travel should be 25mm, and we wish to use 20mm of this, but the fully compressed hard stop is very near (1mm) the home position. If all drives are evenly positioned by eye, close the loop on all three drives and jog by 800,000 cts (=1 mm).

Eg #1 j:800000 #2 j:800000 #3 j:80000 Enter

## **Safety**

Use a watcher with ESTOP in hand to prevent driving into the encoder shaft hard stops (shoulder on shaft hits housing).

Set the watch window to display M103, M203, M303. These are the home position encoder values, toggling at each home sensor crossing.

Use small moves of 400,000 on all three axes to show the first home sensor crossing (change of one variable above). Continue on remaining axes separately to see that all three axes cross their home sensor with ~1mm of remaining travel. This gives confidence for the remaining steps.

## **Limit Switch Setup**

Disable PLC operations with ctrl-D.

Position each axis exactly on its home counts, as recorded in M103, M203, M303. Use “HMZ” command to zero all encoder readings at this point. Check visually to ensure that the reference plate looks untilted.

Jog +150,000 on all three axes (200 microns)

Set the three inner limit switches to trigger at this point, loosening them until they can slide in their mounting sleeve, then sliding until a click is heard or Mx21 value toggles in the watch window. (Recall that Mx21 is –ve LIM, which allows –ve movements only – PMAC standard usage: very strange definition).

Test the hysteresis of all switches, such that the limits switches repeatably disengage well above zero counts on all axes. Do this by driving each axis in 50,000 step intervals until the Mx21 value toggles, then recording the toggle value. Switches toggling between 0 and +50,000 are too close to the home position of 0 counts.

This completes the inner switch setup (encoder shaft compressed side).

To set up the outer failsafe switches, the inner EOT switches must be disabled (*high risk procedure follows*). Ix24 should be set to hex value \$800000, which respects EOST switches for channel x. Edit Ix24 to be hex value \$820000, which disables the EOT limit switches. Notify the watched with the ESTOP that he/ she is the final safeguard now, should the failsafe hardware not operate correctly on the last switch.

Jog to position 200,000 on all three axes:

Set all Failsafe Limit switches to trip at this position. Test the hysteresis of these switches by reversing out in – 20,000 increments with the Failsafe Override switch operated (DANGER: incorrect direction of move here may crush encoder shaft(s)).

When all tests are done, drive all axes to 0 position, and enable PLC1 to restart the PLC programs.

### **Status At This Point**

At this point the telescope can know where its third encoder C Reference mark is located. Now there are two pairs of offsets to be defined which will position the telescope in the geocentric coordinate system.

1. P0156 and P0256 are the Az and El absolute home position offsets. These are offsets from the third Cref mark in positive or negative direction, and define the homed location of the telescope with respect to the encoder tapes. Think of this as the desired position in the dome for working clearances after homing.
2. Onto this position, values of offset must be defined for true North and for true horizon pointing. If the homed location above is at 315 degrees true az and 45 degrees above horizon, then the *Telescope.ini* file values for **azimuth encoder offset** and **elevation encoder offset** will be –45 degree and +45 degrees respectively. These are first order approximations only facilitating the finding of the first star.

Once these are set correctly, the first *Starcal* process can be performed, which will correct the azimuth and elevation encoder offsets to fine tuned values, and add other higher order corrections as more stars are mapped.

## ***First Light Tests***

Focus will be incorrect, as will pointing. The moon is the best focus target, and the eye in the Coude path is the best wide field sensor. Find a glow in the Coude FoV, and focus until the glow disappears, then bias the telescope until the glow is seen more brightly. Eventually a useable focus will be obtained. Then find a bright star, and record offsets biases. Perform a *Starcal* of 5 stars with these biases and a Coude camera, which will update the first 4 Starcal parameters into a useable form.

The system is now ready for a 20 star calibration. Commissioning is complete.