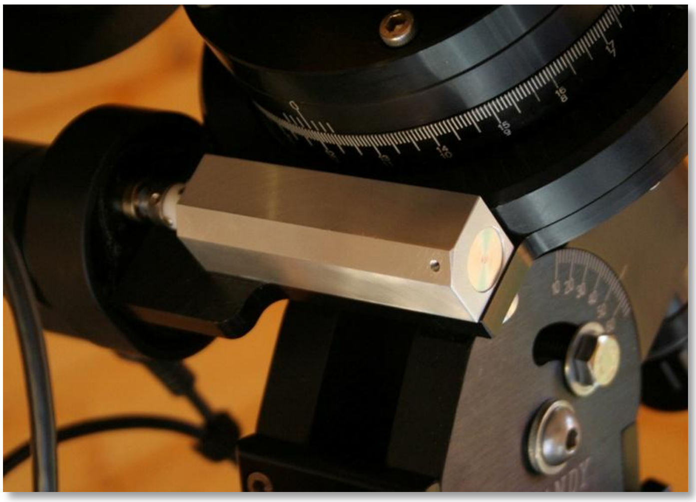
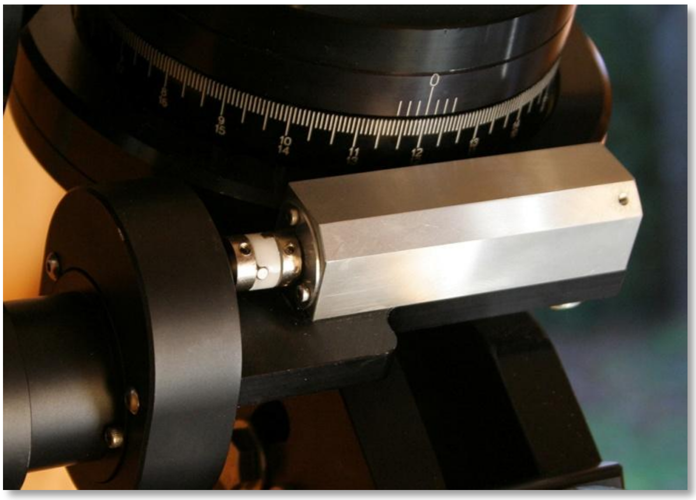
Data Captured Using Pre-production Block #2

These measurements were taken on 22nd November 2008 between 20:10 and 21:20 using the second prototype Martin Farmer block (MFB). The block was fitted with a standard Losmandy brass worm. The equipment used was a Stellarvue SV4 102mm f/6.4 Apo, a QHY5 CMOS camera, MaximDL for image capture, and PEMPro for data capture and analysis. The evening was not ideal, with intermittent high cloud passing fairly quickly, but this is the first time I have be able to get out for some time, so I had to make the most of it.





I had removed the temperature compensation washer for this test, as on my last abortive attempt to collect data (due to the clouds closing in) I had a suspicion that the washer was causing some unwanted variations in the periodic error.

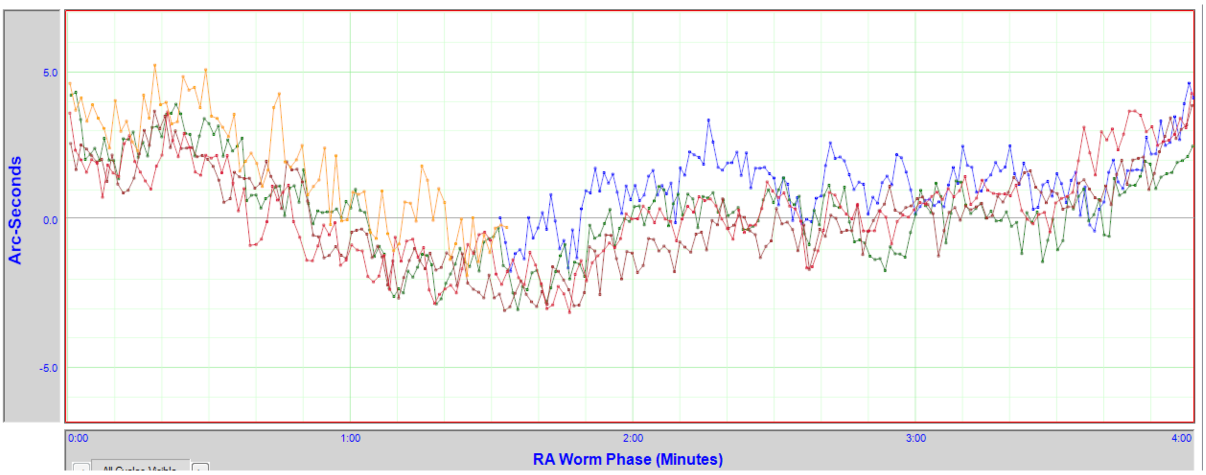
PEMPro's calibration process put the image scale at 1.692 arcseconds per pixel, a quick calculation shows the theoretical image scale to be 1.65 arcseconds per pixel; a pretty good match.

So, here is the data along with some of my comments:

No PEC Applied

Here is the data for the raw block and worm, with no PEC applied by the Gemini system.

First four full cycles displayed in PEMPro :-

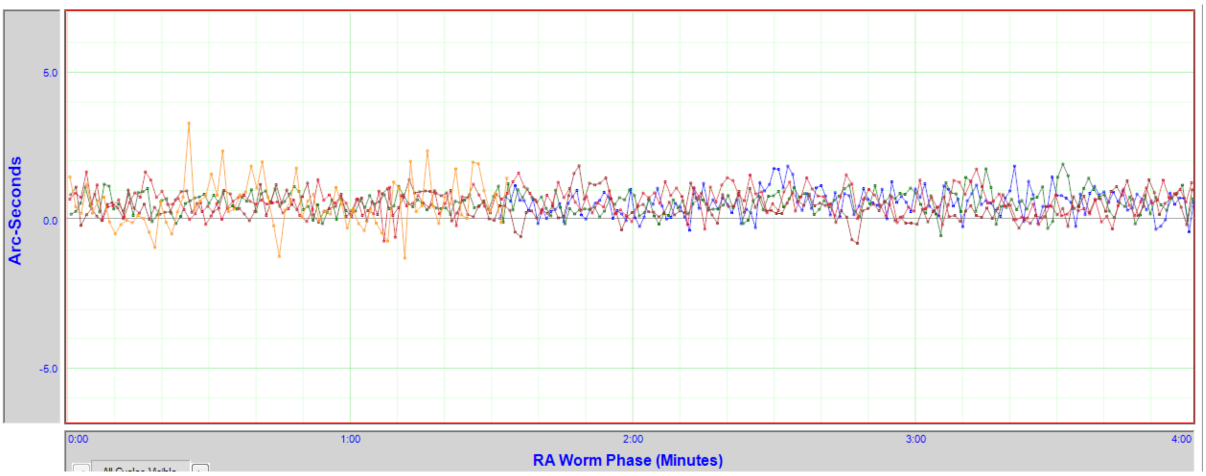


Comments:

For this screen PEMPro only applies a simple linear fit to the drift in RA and DEC. This works fine for DEC, but RA on my mount has a non-linear drift (due I think to an undersized RA shaft). This means that all the images in this document that display multiple curves do not overlay as well as they could. PEMPro uses more complex drift analysis when it comes to generating the PEC curves.

Note the total PE seems to be around +4/-3 arcsecs without any PEC being applied.

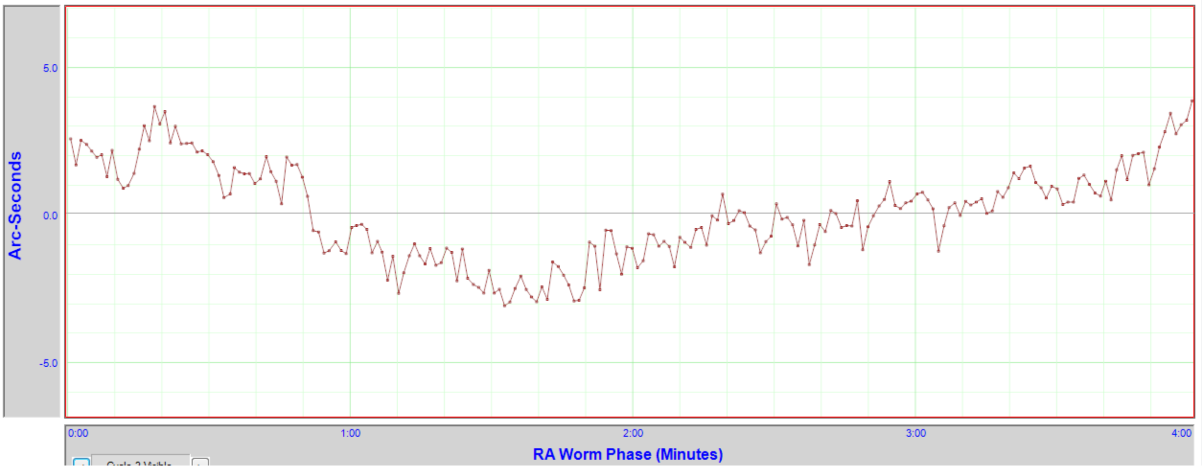
For reference here are the DEC curves :-



Comments:

The DEC curves can be used to characterise the seeing. Note that the larger excursions in DEC (mainly on the ‘orange’ cycle) do generally correspond to RA excursions.

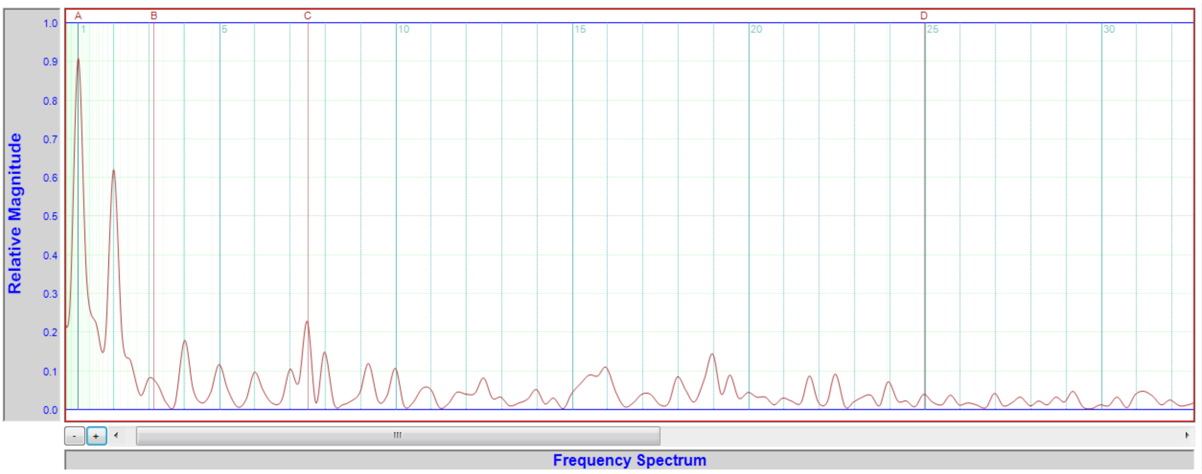
Below is the data for a single worm period :-



Comments:

There seems to be a fair amount of high frequency noise present. I am wondering if it would be worth while cleaning and re-greasing the worm wheel as this has not been done for a couple of years.

PEMPro's frequency analysis of this data :-



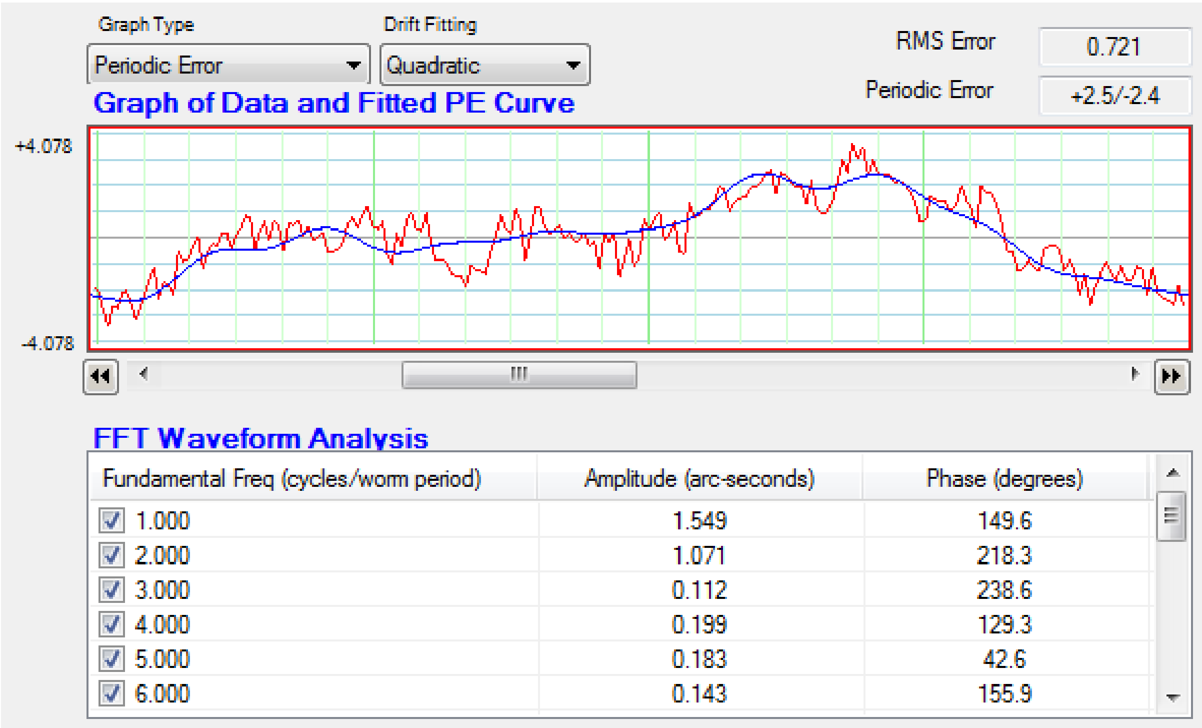
Comment:

The blue scale shows the worm frequency divisors, period/1, period/2 etc. The main contributors can be seen to be harmonics 1 and 2.

The red letters show some fundamental frequencies of the G11 mount. A = worm period, B = 76 second 'problem', C = gearbox intermediate gear, D= motor pinion. As can be seen the third largest component is coming from the gearbox intermediate gear. This 32 second period is non-harmonic and so cannot be removed with PEC.

The B (76 sec) error is close to 3rd harmonic, the graph above shows a peak that actually falls on the 3rd harmonic rather than the 76 second line.

Calculated PE curve :-



Comments:

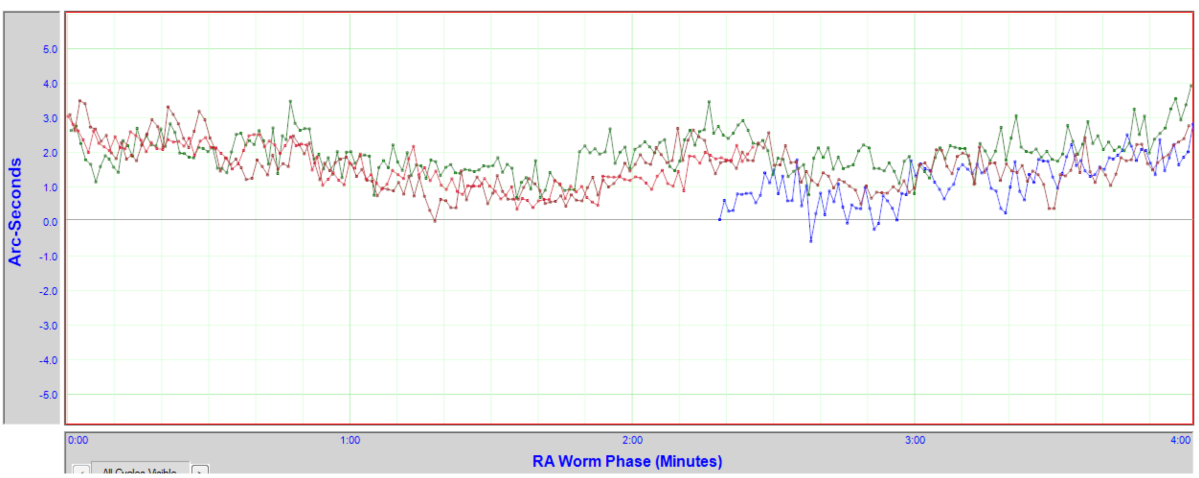
The image above shows the curve PEMPro calculated when using the first 10 harmonics. Whilst a pretty good fit there is some noise around the curve. Note PEMPro's estimate of the total PE underlying the noise - +2.5/-2.4 arcseconds.

Using this data and a couple more short refinement runs (PEMPro was not reducing the PE as expected, it turned out later that a 'glitch' in PEMPro meant that it was only removing half the error each time ☹) I generated a PEC curve to apply to Gemini.

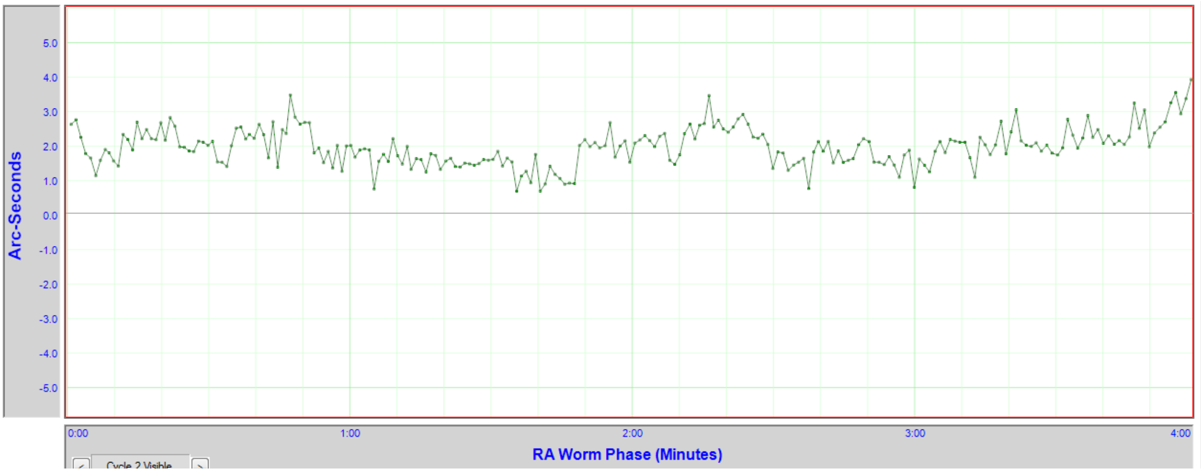
PEC On

Applying the PEC curve created above should remove most of the harmonics from the data. I wanted to see what the contributions were from the 76 second error and the gearbox 32 second error.

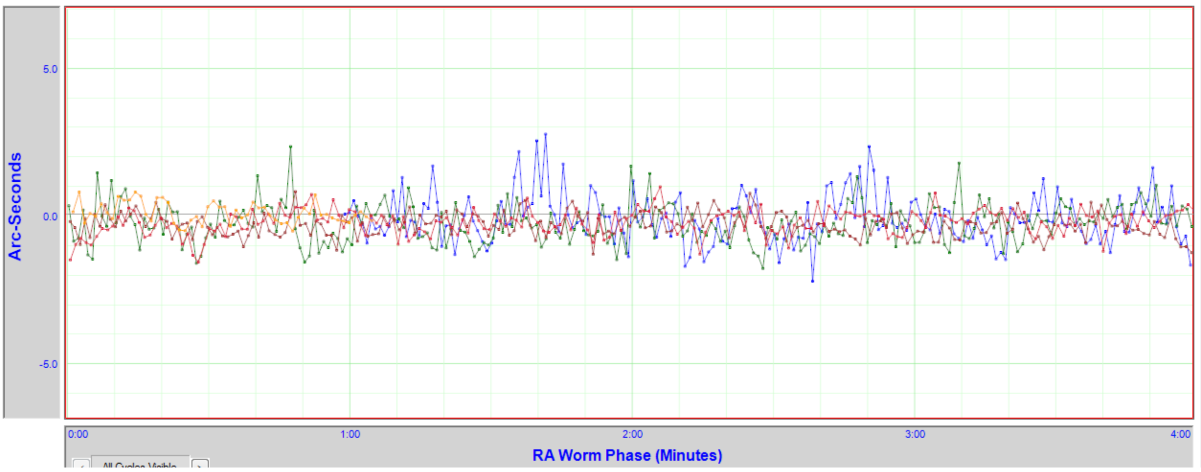
All three cycles :-



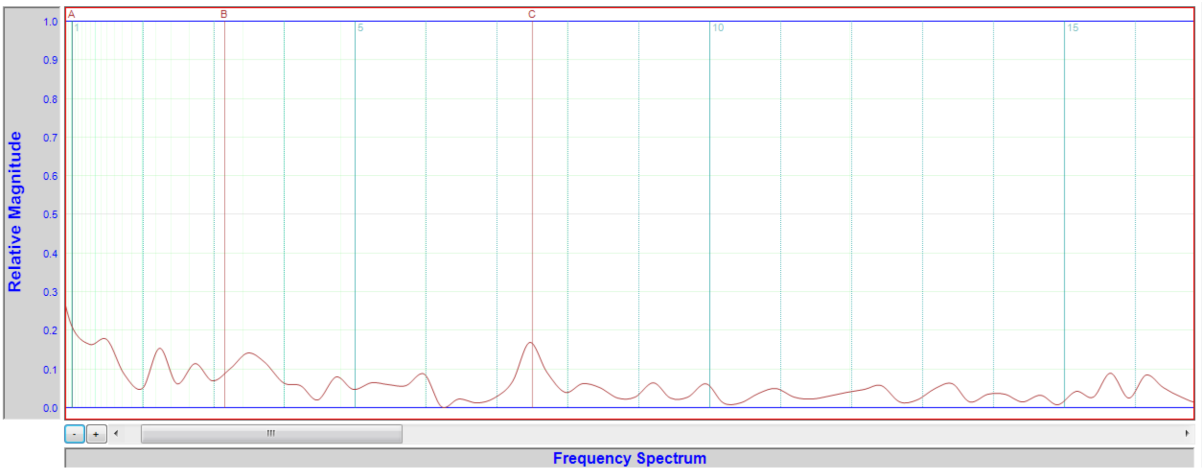
Cycle 2 only :-



All the DEC Cycles :-



PEMPro's frequency analysis :-



Comments:

This graph clearly shows that the 76 second error (B) has all be been eliminated, and the intermediate gearbox gear (C) is now a major contributor to the remaining error.

The DEC plot shows that the seeing had deteriorated slightly from the no PEC run.

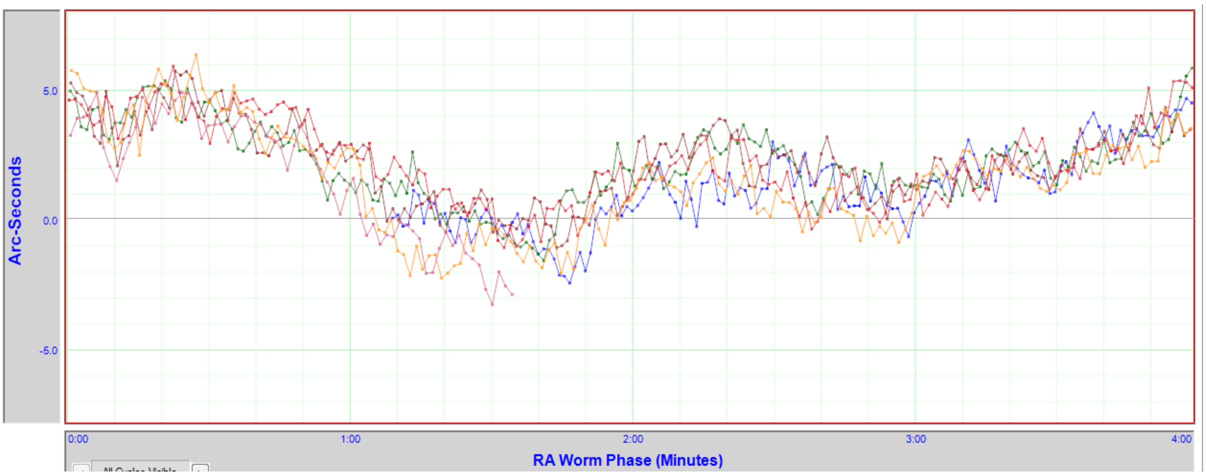
Another Night Another Data Plot

On the 27th November I tried again, this time increasing the pre-load on the bearings to see what the effect would be.

No PEC Applied

Here is the data for the raw block and worm, with no PEC applied by the Gemini system.

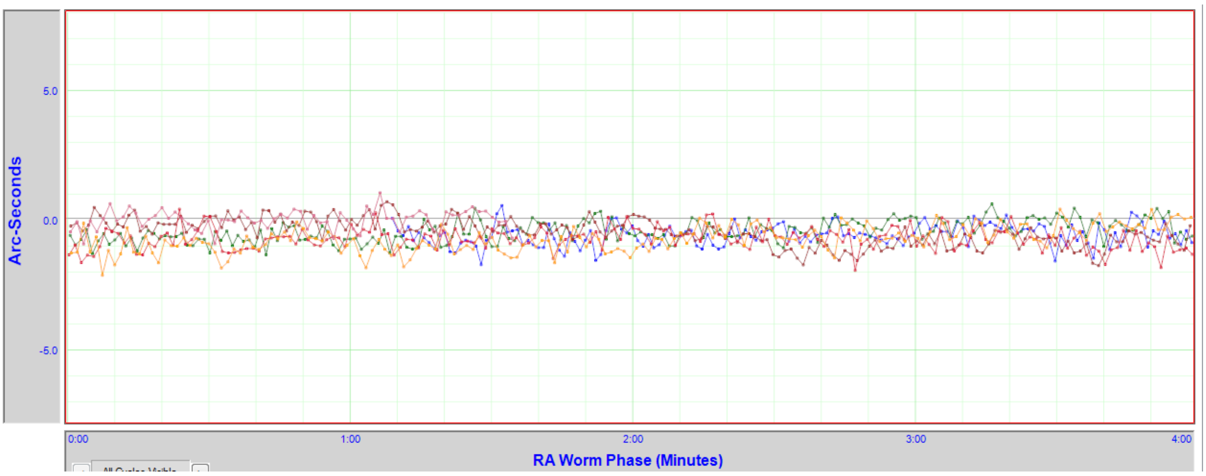
First four full cycles displayed in PEMPro :-



Comments:

Again a non-linear drift causes PEMPro problems displaying the data, however it looks like the total PE is of the order of about 7 arc seconds, the same as the first run.

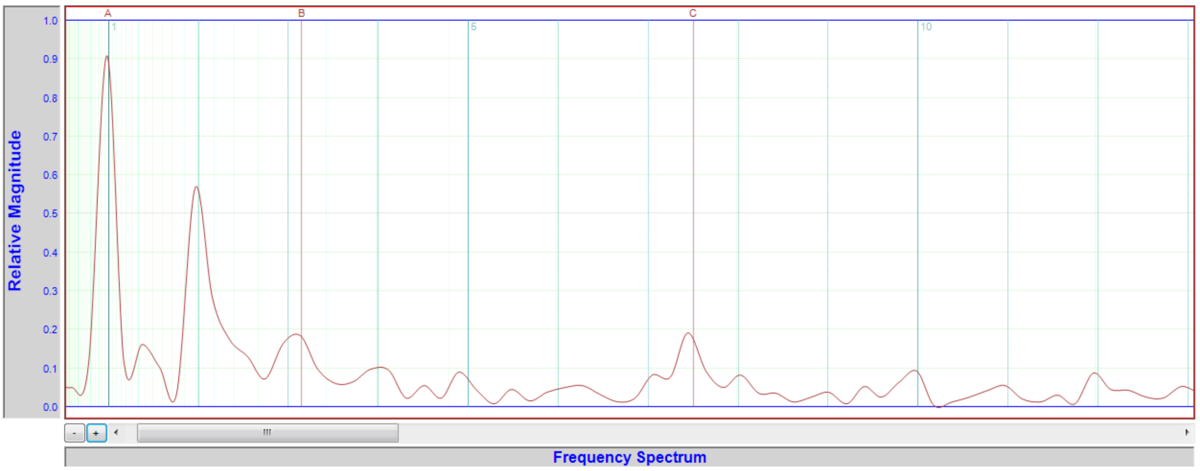
For reference here are the DEC curves :-



Comments:

The seeing was slightly better than the first run, there are no large excursions on the plot.

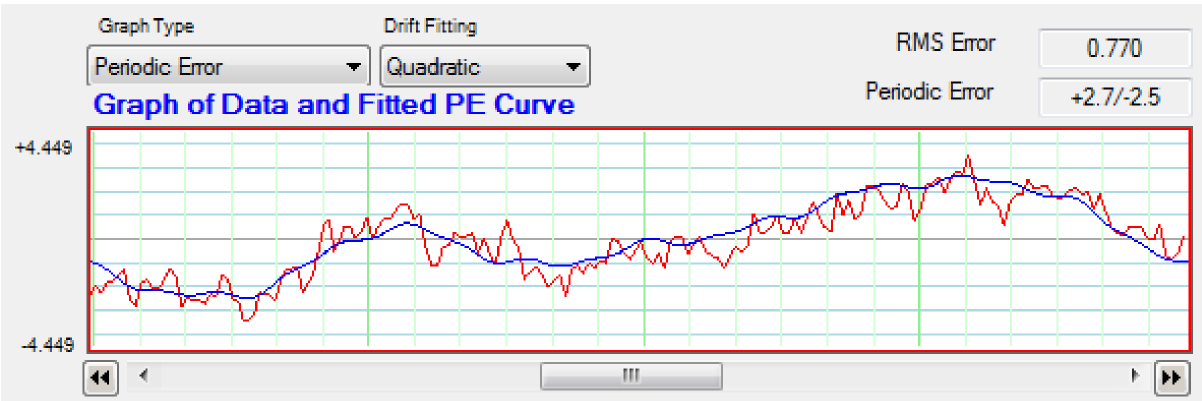
PEMPro's frequency analysis of this data :-



Comment:

Again the main contributors are harmonics 1 & 2. The gearbox problem is still at about the same level as the previous run (0.2 of the total PE), but the third harmonic and potential 76 second problem is now much larger – up from 0.08 to just under 0.2. This doesn't look good.

Calculated PE curve :-



FFT Waveform Analysis

Fundamental Freq (cycles/worm period)	Amplitude (arc-seconds)	Phase (degrees)
1.000	1.628	98.8
2.000	1.205	144.1
3.000	0.417	85.7
4.000	0.222	327.5
5.000	0.175	211.0
10.000	0.162	334.8

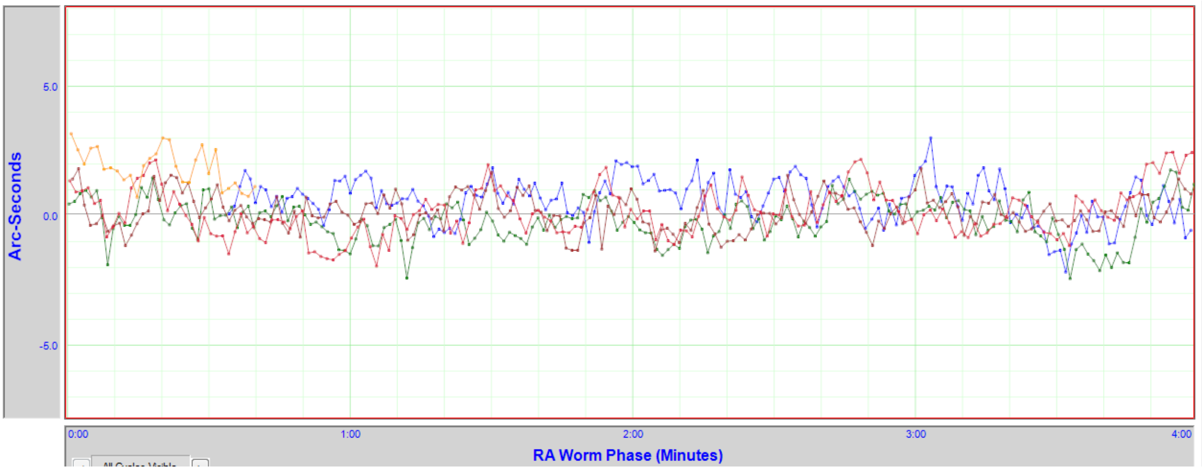
Comments:

PEMPros estimate of the underlying PE is now +2.7/-2.5 (total 5.2) compared to the previous run at 4.9 arcseconds. Not too different.

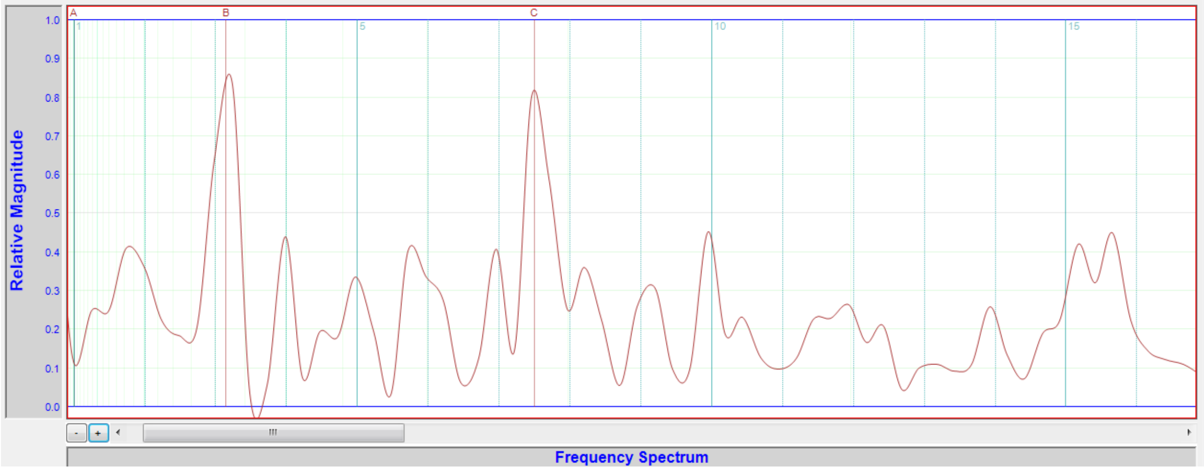
I used this default curve generated by PEMPro to program the Gemini PEC.

PEC On

All three cycles :-



PEMPro's frequency analysis :-



Comments:

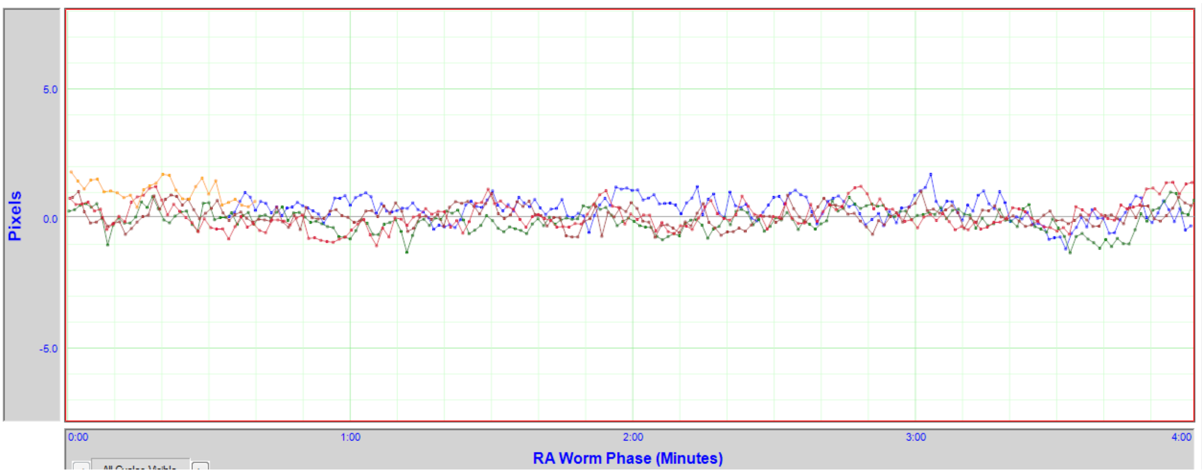
This confirms it; the 76 second error is back, and at virtually the same level as the 32 second error from the gearbox. This means that it is still at quite a low level, but it is there.

Conclusions

The two runs were an interesting comparison. The first with a very low pre-load on the bearings showed no sign on the dreaded 76 second error. The second with the high pre-load began to show signs of the 76 second error – I estimate at about 1 arcsecond magnitude – this is not too surprising, as a high pre-load will show up any defects present in the bearings or the block.

In mitigation: The bearings used to gather this data have now been pressed in and out various blocks many times, sometimes with a reasonable amount of force being applied; I would not be surprised if the races or ball bearings had been slightly dimpled at some stage. I should also add that some 'hand finishing' with wet'n'dry emery paper had to performed on this pre-production block as the bore the bearings fit into was slightly undersized due to the use of a worn machine tool.

After the second run, I took an auto-guided image with the SV4 and my QHY8 camera. Over the 10 minutes exposures the auto-guider was having a much bigger problem coping with the drift in DEC that the PE in RA. Here is the PEC enabled data expressed in pixels rather than arcseconds:



You can see that the maximum drift is about two 5.2micron pixels with my 102mm Apo.

The block performs perfectly with a very low pre-load, so I will be setting it that way in the future.

I conclude that Martin's second prototype worm block, like the first one, does a great job in controlling the 76 second error so long as the pre-load is kept low. This was all I wanted from the block, and it delivers on that front. A bonus is that the monolithic block makes adjusting the worm clearance much easier than the standard dual Losmandy blocks.

The standard Losmandy brass worm has a very low total PE of about 6 or 7 arcseconds; this is excellent by any standards. The results above show that the setup is showing a fair amount of 'noise', my next steps will be to find the source of this. It should be borne in mind that this second prototype MFB block has shifted the worm laterally (the original prototype had a dimensional error) so that a new 'virgin' section of the worm is now being used. The noise may reduce as the worm is used and beds in.

The application of PEC reduced the total PE markedly, though the remaining error from 'noise' and the gearbox are of a little concern.

Mark Crossley
November 2008