Application Note ***XPS – Positioner Mapping Compensation***
by BD

Scope

The Newport XPS motion controller offers different compensation methods that help improving the performance of a motion system. This application note shows possible improvements to the accuracy of a single axis linear translation stage when utilizing the XPS linear error compensation and positioner mapping functions. We will demonstrate an improvement of the accuracy of almost a factor of 10 between no compensation and the same stage with linear error compensation and positioner mapping. The resulting accuracy with mapping in this example is 0.35 µm.

The XPS linear error compensation and positioner mapping are available with all positioner types and work in parallel with other compensation methods. For more complex systems it is also possible to apply a 2-dimensional (XY) or 3-dimensional (XYZ) error mapping with the XPS controller, but in this note we will concentrate on a one dimensional mapping only.

Test Methodology

The applied test procedure follows Newport NPP-99156 procedure, which is a comprehensive combination of other widely known metrology procedures including ASME B5.57 and ISO 230-2. All tests consisted of 20 random data points, each approached from both directions and repeated 5 times. Each sampled value is taken as the average of 7 consecutive reads of the interferometer position with a delay of 30msec between each. The stage was given 300msec after the end of its theoretical trajectory before sampling began.

The selected stage, model XMS50, was taken from our demonstration lab and has been sent on trade shows all year. So it is a fair assumption to believe it represents well a worst-case stage. All stage parameters were default values - no special tuning, no variable PID's or notch filters were used. The motion parameters were: Acceleration = 400mm/sec^2; speed = 100mm/sec; jerk time = 0.02sec.

It is important to note, that mapping of accuracy and the measurement after mapping do not use the same data points. The actual target positions are generated randomly at the beginning of the measurements, so no two measurements actually have the same exact points. However, the points could be very close to each other. The test procedure produces 20 random points, but there is a constraint on the difference between max/min displacements between each two points. Also, there was a significant time span of several hours between the mapping and the measurement after mapping to get realistic values for the long term accuracy.

Rationale and test Results

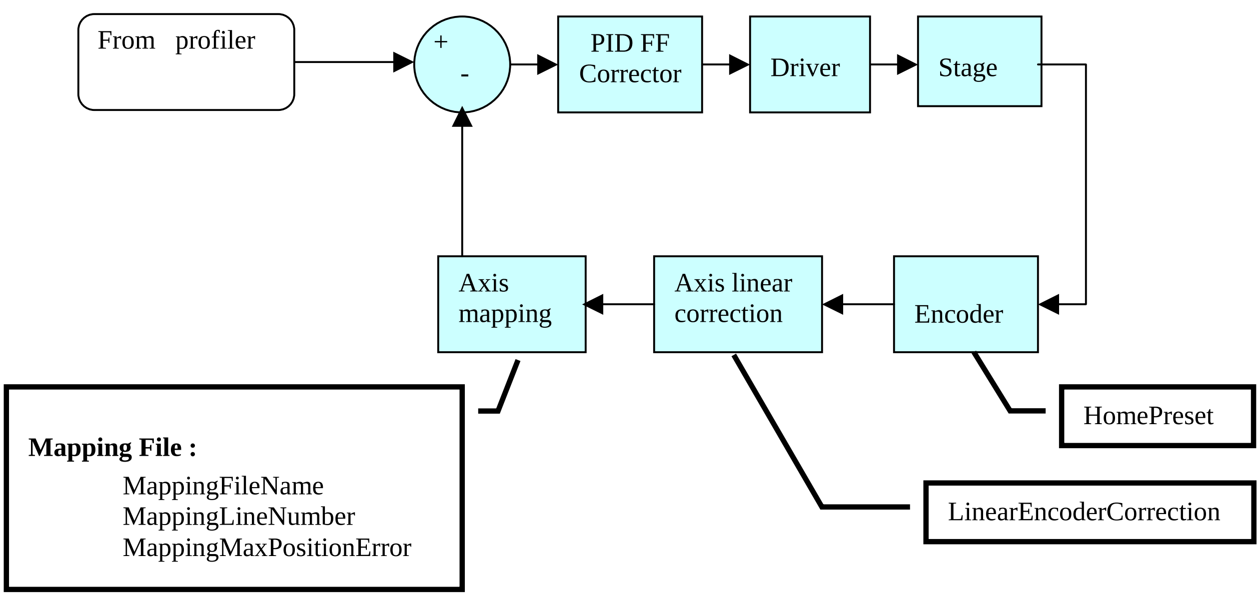
The first measurement is made as a baseline for the stage. It shows both linear and non-linear errors. From this graph, with no compensation implemented we note an accuracy of 3µm p-p

The next measurement is taken implementing a linear error compensation of -60ppm. The result is the removal of the linear error and improvement of the accuracy to 1µm p-p.

The final measurement is taken with the addition of an error map, generated directly by the residual error of the previous measurement. Of note is that the map is comprised of the required values of 0, +25, and -25mm, as well as the 20 random points that were evaluated during the previous measurement. The 0 position has the constraint that its mapping error is 0 (it serves as the fiducial point). The +25 and -25 points were also set to 0 error. The remaining 20 points all had some compensation factor, again, based on the data previously taken. The result is Accuracy improvement to 0.35µm p-p.
The catalog specification for this stage model for On axis accuracy (including linear error compensation) is 1.5 µm.
A higher number of mapping points would yield better results, but the selected 20 points is considered a practical number that points to a significant improvement.

Implementation

Here is how XPS mapping is implemented.



The XPS controller reads the configuration files on power up and implements the compensation if the parameters in stages.ini file, section "Positioner Mapping" are properly set. Here is the actual section for the mapping implementation:

PositionerMappingFileName = MapTest.txt
PositionerMappingLineNumber = 23 ;Lines
PositionerMappingMaxPositionError = .000496 ;Units

The mapping file itself is an ASCII file. Each line represents one set of data, the position and the error at that position. The separator is tab. The error at Home position must be 0. The mapping file must cover the minimum and maximum positioner travel. The Mapping File must be in XPS folder: ..\admin\config folder. The actual file used in this testing is shown below:

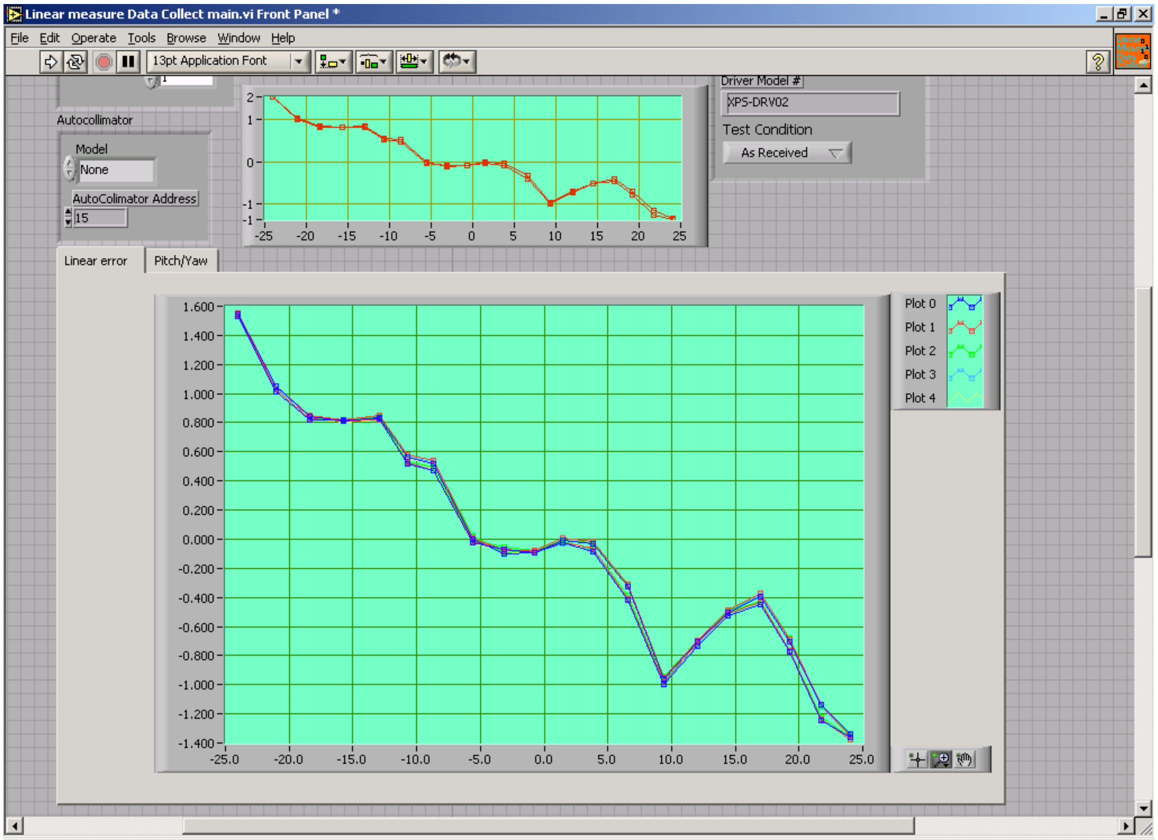
```
-25                               0
-24                           -.000048
-21.071209                     .000236
-18.585982                    0.000279
-16.343914                    0.000159
-13.45161                    -0.000061
-11.041824                    0.000115
-8.05763                      0.000224
-6.023917                     0.000273
-3.513156                     0.000329
-0.633309                     0.000114
0                                 0
1.266151                     -0.000065
4.37841                      -0.000118
6.939561                     -0.000022
9.579252                      0.000366
11.481565                     0.000110
14.087728                    -0.000407
16.905012                    -0.000496
19.268122                    -0.000436
21.47454                     -0.000121
24                            0.000016
25                                0
```

Conclusion

The XPS linear error compensation and positioner mapping allows compensating for any repeatable defects and hence can improve accuracy of positioning considerably. The results in this example are 3 µm accuracy without compensation, 1 µm accuracy with linear error compensation, and 0.35 µm accuracy with linear error compensation and positioner mapping. The implementation is fairly easy and straightforward.

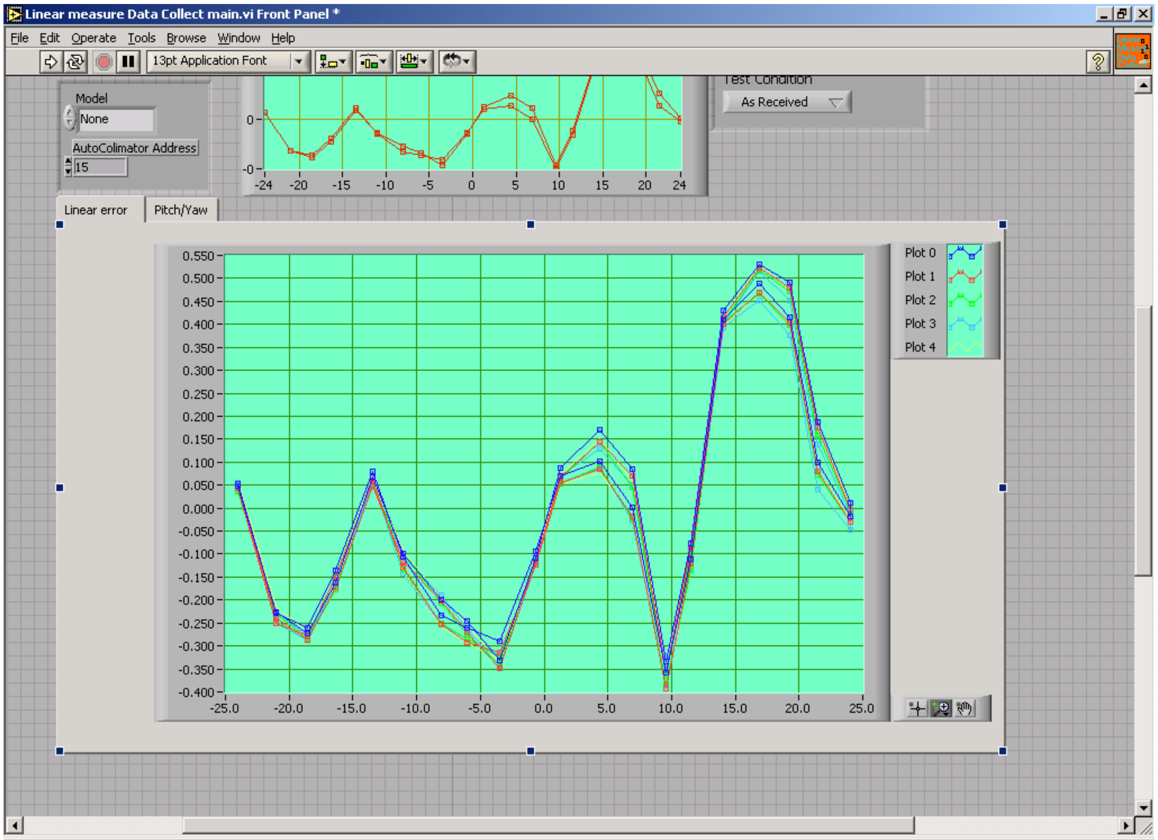
Metrology Plots:

NO COMPENSATION:



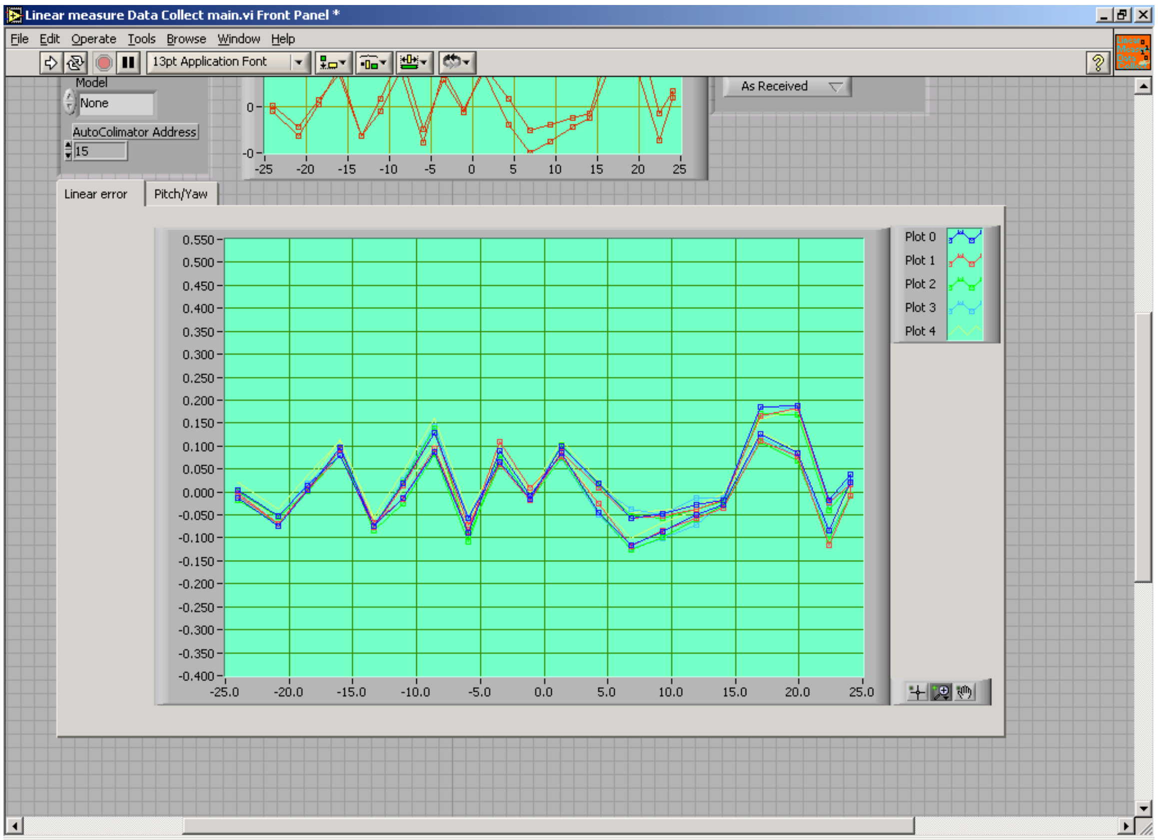
Accuracy = 3µm p-p

WITH LINEAR ERROR COMPENSATION, BUT NO POSITIONER MAPPING:



Accuracy 1µm p-p

WITH LINEAR ERROR COMPENSATION AND POSITIONER MAPPING



Accuracy 0.35µm p-p