

# XPS LINEAR ERROR CORRECTION TO IMPROVE ACCURACY

Absolute accuracy is a term used by high precision motorized stage manufacturers to describe the difference between ideal and real positions. The Accuracy found in specifications of MKS motorized positioning products is the difference between ideal and real positions after compensation of linear errors (for example, cosine error, inaccuracy of screw or linear scale pitch, Abbe error, thermal expansion effects, etc). For more details on these errors please refer to Motion Basics Terminology & Standards tech note found on our web site.

The relation between absolute accuracy and accuracy is as follows:

**Absolute Accuracy = Accuracy + Corrector Factor x Travel**, where

Corrector Factor is the ratio between encoder resolution and the true increment found in the control report supplied with the stage/ actuator.

Excerpt from control report:

True increment	0.0010000043	Unité	Unit
Unidir Repeatabilit	± 0.518	mdeg	
Accuracy	± 2.894		
Bidir. repeatability	± 0.835		

Linear error correction is applicable to all positioners and works in parallel with any other compensation (for example backlash compensation or error mapping).

There are 2 ways to enable linear error correction, using XPS series controllers

1. Set the value for “LinearErrorCorrection” in stages.ini file
2. Adjust the encoder resolution based on the true increment found in the control report in stages.ini file

## Option 1 : Setting Linear Error Correction parameter:

The value of LinearEncoderCorrection is specified in ppm (parts per million) in stages.ini file ( 0 by default)

; --- Position encoder interface parameters

; --- <Encoder.AquadB>

**EncoderType = AquadB**

**EncoderResolution = 0.001 ; Unit**

**LinearEncoderCorrection = 0 ; Ppm**

**PositionerMappingFileName =**

**PositionerMappingLineNumber = 0**

**PositionerMappingMaxPositionError = 0 ; Unit**

**EncoderIndexOffset = 0 ; Unit**

With the example values given above the calculation of the LinearEncoderCorrection in ppm is as follows:

$$\text{LinearEncoderCorrection} = ((\text{True increment} / \text{Encoder resolution}) - 1) \times 10^6 = (0.0010000043 / 0.001 - 1) \times 10^6 = 4.3\text{ppm},$$

so in stages.ini new LinearEncoderCorrection=4.3;ppm

The correction is applied relative to the physical home position of the positioner (the Encoder position by definition is set to the HomePreset value at the home position). This hardware reference for linear error correction has the advantage of being independent of the value of the HomePreset.

When set, the corrected positions are calculated in the following way:

**Corrected position = HomePreset +(EncoderPosition – HomePreset) x (1 + LinearEncoderCorrection/10^6)**

## Option 2 : Adjusting Encoder Resolution:

The second way is to adjust the EncoderResolution parameter in stages.ini file to the “true increment” value found in the control report for a given stage:

; --- Position encoder interface parameters

; --- <Encoder.AquadB>

**EncoderType = AquadB**

**EncoderResolution = 0.0010000043 ; 0.001; Unit**

**LinearEncoderCorrection = 0 ; Ppm**

**PositionerMappingFileName =**

**PositionerMappingLineNumber = 0**

**PositionerMappingMaxPositionError = 0 ; Unit**

**EncoderIndexOffset = 0 ; Unit**

For stepper motor driven stages without encoders, the error compensation can be achieved by adjusting “DisplacementPerFullStep” parameter in the stages.ini file to the “true increment” value provided in the control report for a given stage.

; --- Driver command interface parameters

; --- <MotorDriverInterface.AnalogStepperPosition>

**MotorDriverInterface = AnalogStepperPosition**

**DelayAfterMotorOnToSetClosedLoop = 0.05 ; sec #**  
**Not used in all firmwares**

**ScalingCurrent = 3 ; Amp**

**DisplacementPerFullStep = 0.001 ; Unit**

**PeakCurrentPerPhase = 1 ;Amp**

**StandbyPeakCurrentPerPhase = 0.5 ;Amp**

**BaseVelocity = 0 ; Unit/Sec**

Note, that correction will evolve with temperature and depend on pitch (Abbe error).