Parker Automation

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Application Notes:
ACR9000 BSC

BSC Ballscrew Compensation

Ballscrew compensation is primarily used to compensate for nonlinear position error introduced by mechanical ballscrews and linear encoders. Ballscrew commands are identical to cam commands. Both ballscrews and cams can be active at the same time, each with different settings and offset tables.

The main difference between ballscrew and electronic cam is that the default source for a ballscrew points to the primary setpoint, therefore the BSC SRC command is normally not required. The primary setpoint is used so that the ballscrew offset is not fed into the calculation of the ballscrew index, causing an unstable condition.

Note: The primary setpoint is the summation of the current position and the total cam, gear, and jog offsets. The secondary setpoint is the summation of the primary setpoint and the total ballscrew and backlash offsets. The secondary setpoint is the one that is actually used by the servo loop.

BSC with PPU

- When a PPU is set for an axis you must use a BSC SCALE equal to 1/PPU and enter all values in pulses

  PPU X 1000 : REM 1 mircon linear encoder, user units 1mm
  BSC SCALE X 0.001

- All entries in the Long array used to designate a BSC segment MUST be made in encoder pulses.

  LA0(0)=100 :REM Array entry in encoder pulses, 100 micron

- When a PPU is specified for the axis that is used as the Ballscrew, axis segment lengths must still be entered in encoder pulses.

  BSC SEG X(0,100000,LA0) :REM Master encoder pulses = 100000 microns or 100 mm

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Encoder Accuracy

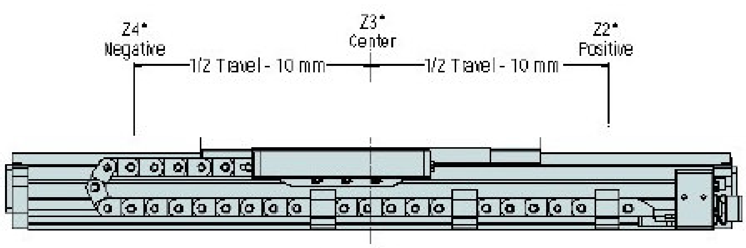
The 406LXR Series makes use of an optical linear encoder for positional feedback. This device consists of a *readhead*, which is connected to the carriage, and a *steel tape scale*, which is mounted inside the base of the 406LXR. The linearity of this scale is +/-3 microns per meter, however the absolute accuracy can be many times larger. To compensate for this error, an error plot of each 400LXR is done at the factory using a laser interferometer. From this plot a linear slope correction factor is calculated (figure 2). Then a second error plot is run using the slope correction factor. These tests are conducted with the Point of Measurement (P.O.M.) in the center of the carriage 50mm above the carriage surface.

Slope Correction

Slope correction is simply removing the linear error of the table. The graphs below show an example of a non-slope corrected error (figure 2) plot and the same plot with slope correction (Figure 3). As can be seen, the absolute accuracy has been greatly improved. The slope factor is marked on each unit. It is the slope of the line in microns per meter. This factor may be positive or negative, depending on the direction of the error.

If the application requires absolute accuracy, the slope factor must be incorporated into the motion program. This is a matter of either assigning variables for motion positions and using the slope correction in the variable equation. **The ACR series controllers include a Ballscrew compensation feature that simplifies error correction. Accuracy can be improved even more by using the actual data points and incorporating these into a Compensation array used by the BSC command (figure 4).**

NOTE: The zero position (or starting point) of the error plots is at the extreme NEGATIVE end of travel.



Front View
(Z-Channel Location)

* Z2, Z3, Z4 shows Carriage Center-line Location for Selected Z-Channel Position

Sample Data from LXR Error Report

Axis	**406T12LXRMP**
Location	
Title	
Increment Size	**25**
Total Travel	**1450**
Slope (um/mm)	**(0.034)**
Slope (um/meter)	**(34.31)**
Accuracy (um)	**61.7**
Bi-Dir Repeat(um)	**2.2**
Corrected Acc.(um)	**16.58**

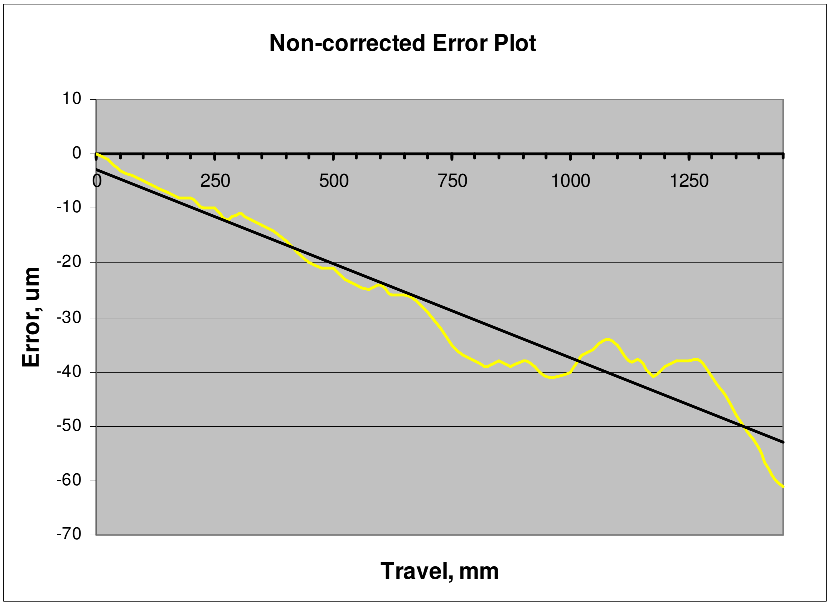


Figure 2
Actual error plot before correction

Slope value =-34.3

BSC using slope correction value

Slope value 34.3um/m. Value @ 1450mm 34.3*1.45=49.6

```
DIM LA(1)    :REM dimensions one long array for correction values
DIM LA0(2)   :REM dimension array zero with 2 data points
LA0(0)=0     :REM set first array value (negative end of travel) to zero
LA0(1)=50    :REM set last array value equal to inverse of slope
             :REM correction value
BSC DIM X1   :REM dimension one segment for correction values
BSC SEG X (0, 1450000, LA0)    :REM Segment 0 is 1450000 microns(1450mm)
BSC SCALE X 0.001        :REM scale = 1/PPU

BSC ON X     :REM Activate ballscrew compensation
```

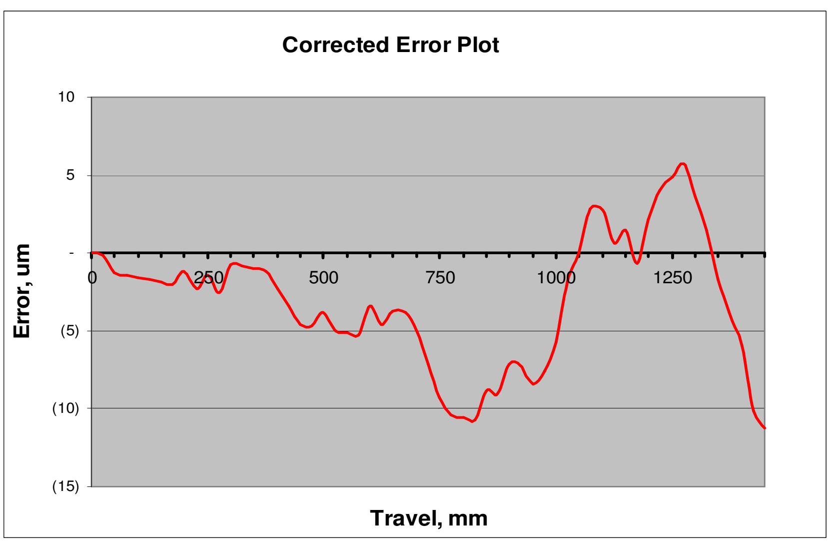
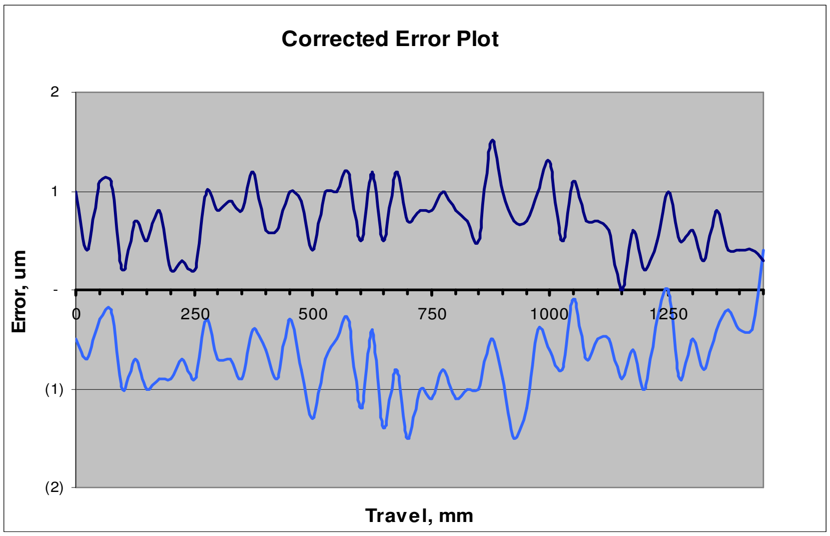


Figure 3
Corrected error plot using slope correction value

BSC using error data points from laser report

```
DIM LA(1)    :REM dimensions one long array for correction values
DIM LA0(59) :REM dimension array 0 with 59 data points
LA0(0)=0
LA0(1)=1
LA0(2)=3
LA0(3)=4
LA0(4)=5
LA0(5)=6
LA0(6)=7
LA0(7)=8
LA0(8)=8
LA0(9)=10
LA0(10)=10
LA0(11)=12
LA0(12)=11
LA0(13)=12
LA0(14)=13
LA0(15)=14
LA0(16)=16
LA0(17)=18
LA0(18)=20
LA0(19)=21
LA0(20)=21
LA0(21)=23
LA0(22)=24
LA0(23)=25
LA0(24)=24
LA0(25)=26
LA0(26)=26
LA0(27)=27
LA0(28)=29
LA0(29)=32
LA0(30)=35
LA0(31)=37
LA0(32)=38
LA0(33)=39
LA0(34)=38
LA0(35)=39
LA0(36)=38
LA0(37)=39
LA0(38)=41
LA0(39)=41
LA0(40)=40
LA0(41)=37
LA0(42)=36
LA0(43)=34
LA0(44)=35
LA0(45)=38
LA0(46)=38
LA0(47)=41
LA0(48)=39
```



```
LA0(49)=38
LA0(50)=38
LA0(51)=38
LA0(52)=41
LA0(53)=44
LA0(54)=48
LA0(55)=51
LA0(56)=54
LA0(57)=59
LA0(58)=61

BSC DIM X1  :REM dimension one segment for correction values
BSC SEG X (0, 1450000, LA0)   :REM Segment 0 is 1450000 microns(1450mm)
BSC SCALE X 0.001       :REM scale = 1/PPU
BSC ON X    :REM Activate ballscrew compensation
```