

TB058 (Rev2) - Manually Creating Ballscrew Compensation Tables

Overview and Setup

This document describes the procedures for manually creating ballscrew compensation tables for use with the laser and lead screw compensation software option. The first part of the document describes the procedure for CNC7 Version 7.50 and up and CNC10 Version 1.00 and up. The second part of the document describes the procedure for Version 7.17.

The control should have the software travel limits set and the laser and lead screw compensation option unlocked. A preliminary check should be made to ensure that the Motor Revs and Encoder counts entered in the Machine Configuration are such that commanded movement of an axis agrees closely with the measured movement.

The manual compensation tables may be edited by pressing **F1 - Setup** at the main menu, then **F3 - Config**, **F2 - Mach.**, and **F5 - M. Comp.**

To create the tables automatically see Tech Bulletin 48 and the "Laser" option in the PID configuration screen. Even if you create the tables automatically, you can still edit the resulting compensation tables manually to make minor adjustments.

Screw Comp Tables

Pressing F5 from the machine configuration screen will display the lead Screw Comp Table. This screen provides you with a method of manually entering lead screw adjustment information. There is a table for each axis and each table has three columns: Machine Position, Forward Correction, and Backward Correction as shown below.

WCS #2 (G55)	Current Position (inches)	Job Name: GTESTE . CNC		
X	+0.0000	Tool: T0 H0	Part	
Y	+0.0000	Feedrate: 149%	Count: 66	
Z	+0.0000	Spindle: 0	Feed Hold: Off	
Waiting for PLC operation				
Processing...				
Job finished				
Stopped				
Press CYCLE START to start job				
Screw Comp Table				
Axis:	X	Machine Position	Forward Correction	Backward Correction
		(Interval: 0.50 inch)	(Ten Thous.)	(Ten Thous.)
		-11.5000	+0.0000	+0.0000
		-11.0000	+0.0000	+0.0000
		-10.5000	+0.0000	+0.0000
		-10.0000	+0.0000	+0.0000
		-9.5000	+0.0000	+0.0000
		-9.0000	+0.0000	+0.0000
		-8.5000	+0.0000	+0.0000
		-8.0000	+0.0000	+0.0000
		-7.5000	+0.0000	+0.0000
		-7.0000	+0.0000	+0.0000
Next Axis				Save
F1				F10

Press **F1** to select an axis for compensation. Press **F10 - Save** to save adjustments on the currently displayed axis. Press **Esc** to exit without saving changes.

The machine positions listed are determined by the Travel (-) and Travel (+) settings in the machine configuration screen. At least one of the travel limits must be non-zero in order to use the compensation tables. The default interval is 0.5 inches in inches mode and 25.0 mm in millimeter mode. Automatic laser compensation can modify the interval. If a different interval is desired, use the automatic procedure to generate the tables and then edit the resulting tables.

The Forward Correction column is used to correct positioning when moving in the positive direction; the Backward Correction column is used when moving in the negative direction. In inches mode the values represent corrections in ten thousandths of an inch. In millimeter mode the units are microns. The first forward correction value and the last backward correction value must be zero. It is impossible to acquire meaningful data for these points.

CNC10 interpolates corrections for machine positions between the listed ones. When a table is enabled, CNC10 adds the interpolated correction value to the desired position.

To find and enter a correction value in the Forward Correction column, position the axis at some absolute position less than the interval position and then move to the interval position. (For example, if measuring X at 1.5, move to X 1.0 and then X 1.5.) Take a measurement at this position and calculate the error as a positive or negative value. Add the error to the existing correction value and enter the result.

To find and enter a correction value in the Backward Correction column, position the axis at some absolute position greater than the interval position and then move to the interval position. (For example, move to X 2.0 and then X 1.5.) Take a measurement, calculate the error as (DRO position - Measured position), and add it to the correction value.

Press **F10 - Save** to save the corrections. Repositioning as described above should cause the errors to be reduced. You must have moved in the positive direction to ensure that you are using the forward correction table. Likewise, you must have moved in the negative direction to ensure that you are using the backward correction table. If the error increases after entering a manual compensation, you may have added in a correction of the wrong sign. Always subtract the Measured position from the DRO position. Always add the error to the current correction value.

Position Granularity

The compensation values are limited by the position granularity of the axis. The granularity is inches/count and can be determined by dividing 1 by the revs/inch value and dividing the result by the counts/rev value. For example, if the axis has 5 revs/inch and 8000 counts/inch, its granularity is 0.000025 inches. In this case, the smallest correction value that will have any effect in the error correction tables is 0.25.

Example:

Position the X-axis at the home position using the Find Home routine of the CNC10 software. Press **ALT-D** to display machine coordinates. The word "Machine" will appear in the upper-left corner of the screen and the DRO should indicate a position of 0.0000. If the measuring instrument has a zeroing or reset feature, it should be used at this time. Use an MDI command to position the X-axis at the minus travel limit. (For example, X-11.5) Use an MDI command to move the X-axis 0.5000 inches in the positive direction (since the sign of the X-axis software travel limit is positive). The command for this movement is: G91X.5, which would be entered at

the MDI Block? Prompt. Record the actual distance moved as measured by a laser system, digital scales, or other measuring technique. Continue moving the X-axis 0.5000 inches and recording the measured position until the software travel limit is reached.

Repeat the measurements for the reverse direction. The command for this movement is: G91X-.5 Continue moving in the reverse direction and recording the measured position until the software travel limit is reached.

As an alternative to using MDI commands to move the axis, a G-Code program created by Intercon or a text editor could be used. The following program is an example for this case:

```
G91X.5  
G4P5  
M102
```

When this program is run, it will continue moving the X axis 0.5000 inches until it reaches the software travel limit, pausing for five seconds to allow the measured distance to be recorded and for machine movement to settle. A similar program may be constructed to move in the reverse direction:

```
G91X-.5  
G4P5  
M102
```

The following table demonstrates a simulated recording of some values for this example.

DRO position	Measured position	Forward Error Correction (* 0.0001 inches)
0.5	0.4995	5
1	0.9997	3
1.5	1.4999	4
2	2.0001	-1
2.5	2.5003	-3
3	3.0004	-4
3.5	3.50007	-0.7

Verification

The results can be checked and verified by running through the measurement procedure again and noting that the measured positions are markedly closer to the displayed positions. Remember that the direction of travel is critical to ensuring that the desired correction (forward or backward) is used.

Enabling and disabling compensation tables

Screw compensation tables can be enabled or disabled independently for each axis by toggling the "Screw Comp" setting in the machine configuration screen to "Y" or "N". Screw compensation data is preserved so that you can restore the table at a later time by choosing "Y". To completely erase all compensation data and start fresh, delete the corresponding CNC10a.TAB file from the CNC10 directory where "a" is the desired axis.

File Format:

Leadscrew compensation data are stored in /cncroot/c/cnc10 or /cncroot/c/cnc10t.

Leadscrew compensation data files have names in the form cnc10?.tab, where "?" is the lowercase axis label "x", "y", "z", etc. For example cnc10x.tab, cnc10y.tab, cnc10z.tab. The file name is case sensitive.

Each file has the following format.

Number of Lines	Contents
1	TableVersion, Entries, StepSize, UnitsCode, 1, 0 ; Comment
Entries + 1	Forward error correction data
1	"; backward data"
Entries + 1	Reverse error correction data

Description of values and allowed ranges:

Variable	Description	Minimum	Maximum	Typical Example
TableVersion	2			
Entries	Number of forward or reverse data points less one.	2		60
StepSize	Interval between points.			0.5000 (inches) or 25.0 (mm)
UnitsCode	English = 20 Metric = 21	20	21	
Comment	Comment describing contents of file.			"Version 2 Compensation data for X axis"
Error data	TargetPosition - MeasuredPosition English = * 0.0001 inches Metric = * .001 mm (microns) Start from most negative (smallest) position. Must be specified for the entire travel range. If the positive travel limit is at position 0.0000 (negative travel), the first point must be on an even multiple of the StepSize.	-999.9999	999.9999	1.000 (* 0.0001 inches), 25.400 (microns)

Rules for error data:

- Data must be given for the entire range specified in the software travel limits for the axis. If not, compensation data will not be applied correctly. If no data exists for a given interval, use an interpolated value or, if outside the work envelope, 0.0. A close approximation to the last reverse value may be calculated as $\text{LastForwardValue} - (\text{NextToLastForwardData} - \text{NextToLastReverseData})$.
- For negative travel, the first position must be an even multiple of StepSize. For example, for travel

limits of -32.6 to 0.0 and StepSize=0.5, the first data point must be at -32.5. In other words, starting from 0.0, -32.5 is the smallest attainable position at regular StepSize intervals from 0.0.

- The home position must be the reference point. In other words, the error at the home position (0.0) must be 0. The best way to establish the home position as the reference point is to subtract any error at the home position from all forward and reverse data. The following table shows lists the possible cases and how to establish home as the reference point for each case.

Case	Location of Home (Reference Point)	Method of Establishing Home as the Reference Point
Home Switch All Positive Travel (e.g. 0.0 to 30.0)	First forward error data point.	Subtract the first forward error value from all forward and reverse error data.
Home Switch All Negative Travel (e.g. -30.0 to 0.0)	Last reverse error data point.	Subtract the last reverse error value from all forward and reverse error data.
Reference Mark Positive and Minus Travel	Forward position 0.0.	If forward position 0.0 is one of the data points, subtract its value from all forward and reverse error data. Otherwise, calculate (interpolate) the error correction from the two points on either side of 0.0 in the forward data and subtract this value from all forward and reverse error data.

Example: Z axis, Travel Limits: -2.6 to 0.0, Home Switch, StepSize = 1.0.

Data collected:

Direction	Machine Position	Laser Target Position	Laser Measured Position
Forward	-2.5	0.0	0.0000
	-2.0	0.5	0.4999
	-1.5	1.0	0.9998
	-1.0	1.5	1.4997
	-0.5	2.0	1.9996
	0.0	2.5	2.4995
Reverse	-0.5	2.0	2.0003
	-1.0	1.5	1.5002
	-1.5	1.0	1.0001
	-2.0	0.5	0.5000
	-2.5	0.0	-0.0001

Working data:

Direction	Machine Position	Laser Target Position	Laser Measured Position	Correction
Forward	-2.5	0.0	0.0000	0.0000
	-2.0	0.5	0.4999	0.0001
	-1.5	1.0	0.9998	0.0002
	-1.0	1.5	1.4997	0.0003
	-0.5	2.0	1.9996	0.0004
	0.0	2.5	2.4995	0.0005
Reverse	-2.5	0.0	-0.0001	0.0001
	-2.0	0.5	0.5000	0.0000
	-1.5	1.0	1.0001	-0.0001
	-1.0	1.5	1.5002	-0.0002
	-0.5	2.0	2.0003	-0.0003
	0.0	2.5		

Data after calculating error at turn-around point:

Direction	Machine Position	Laser Target Position	Laser Measured Position	Correction
Forward	-2.5	0.0	0.0000	0.0000
	-2.0	0.5	0.4999	0.0001
	-1.5	1.0	0.9998	0.0002
	-1.0	1.5	1.4997	0.0003
	-0.5	2.0	1.9996	0.0004
	0.0	2.5	2.4995	0.0005
Reverse	-2.5	0.0	-0.0001	0.0001
	-2.0	0.5	0.5000	0.0000
	-1.5	1.0	1.0001	-0.0001
	-1.0	1.5	1.5002	-0.0002
	-0.5	2.0	2.0003	-0.0003
	0.0	2.5		-0.0002

Correction data after establishing home as the reference point (subtract -0.0002 from all values):

Direction	Machine Position	Correction
Forward	-2.5	0.0002
	-2.0	0.0003
	-1.5	0.0004
	-1.0	0.0005
	-0.5	0.0006
	0.0	0.0007
Reverse	-2.5	0.0003
	-2.0	0.0002
	-1.5	0.0001
	-1.0	0.0000
	-0.5	-0.0001
	0.0	0.0000

Resulting contents of cnc10z.tab:

```

2 5 0.5000 20 1 0 ; Created by D&K Laser Software 01/11/2005 Z axis, inches, -5.0 to 0.0
2.0000
3.0000
4.0000
5.0000
6.0000
7.0000
; backward data
3.0000
2.0000
1.0000
0.0000
-0.0001
0.0000
    
```

Version 7.17 Overview and Setup

The following describes the procedures for manually creating ballscrew compensation tables for use with the laser and lead screw compensation software option in CNC7 Version 7.17. The control should have the software travel limits set and the laser and lead screw compensation option unlocked. A preliminary check should be made to ensure that the Motor Revs and Encoder counts entered in the Machine Configuration are such that commanded movement of an axis agrees closely with the measured movement.

Version 7.17 File names and locations

A text file must be created for each axis that compensation is desired for. The name of the file should be CNC7?.TAB, where ? is the axis label. The compensation file is to be placed in the C:CNC7 directory.

Version 7.17 File contents

The first line of the compensation file contains the number of compensation entries and the total travel over which the compensation is measured, separated by a space. The total travel over which the compensation is measured is formatted as an integer number of encoder counts, with the sign of the number the same as the software travel limit, except in cases where the Dir Rev field is set to Y, in which case the sign would be opposite that of the travel limit. The second line of information is the first compensation entry formatted as an integer number of encoder counts. Subsequent lines contain the second, third, etc.. compensation entries, one per line without any blank lines inserted.

Version 7.17 Example

The following example is a guide for creating a compensation file for the X-axis. The software travel limit for the X-axis is set to 33.0000 inches, the Motor Revs/in are 5.0000, and encoder counts are 8000. The direction-reversed field is N. Measurements will be recorded every 0.5000 inches.

Position the X-axis at the home position using the Find Home routine of the CNC7 software. Press **ALT-D** to display machine coordinates. The word "Machine" will appear in the upper-left corner of the screen and the DRO should indicate a position of 0.0000. If the measuring instrument has a zeroing or reset feature, it should be used at this time. Use an MDI command to move the X-axis 0.5000 inches in the positive direction (since the sign of the X axis software travel limit is positive). The command for this movement is: G91X.5, which would be entered at the MDI Block? Prompt. Record the actual distance moved as measured by a laser system, digital scales, or other measuring technique. Continue moving the X-axis 0.5000 inches and recording the measured position until the software travel limit is reached. For each measured position recorded, convert it to encoder counts using the following formula: Motor Revs * Encoder counts * (DRO position - Measured position). If the Dir Rev field for the X-axis is set to Y, the formula must be negated.

As an alternative to using MDI commands to move the axis, a G-Code program created by Intercon or a text editor could be used. The following program is an example for this case:

```
G91X-.5
G4P5
M102
```

When this program is run, it will continue moving the X axis 0.5000 inches until it reaches the software travel limit, pausing for five seconds to allow the measured distance to be recorded and for machine movement to settle.

The following table demonstrates a simulated recording of some values for this example.

DRO position	Measured position	Calculated encoder count value
0.5	0.4995	$20 = 5 * 8000 * (0.5 - 0.4995)$
1	0.9997	12
1.5	1.4999	4
2	2.0001	$-4 = 5 * 8000 * (2 - 2.0001)$
2.5	2.5003	-12
3	3.0004	-16
3.5	3.50007	-3

The CNC7X.TAB file will then be created as below:

66 1320000

20

12

4

-4

-12

-16

-3

... and so on for the other 59 values.

Notes:

66 entries = $33.0000 / 0.5$ or travel distance divided by move increment

$1320000 = 33.0000$ (travel distance) * 5 (Motor Revs/in) * 8000 (Encoder Counts/rev)

Version 7.17 Verification

After creating the compensation file and placing it into the C:CNC7 directory, the Machine Configuration should indicate a Y under the Screw Comp column for the axes, which have screw compensation table files. If there is an error in the compensation table file, a message will be displayed. The results can be checked and verified by running through the measurement procedure again and noting that the measured positions are markedly closer to the displayed positions.

Version 7.17 Enabling and disabling compensation tables

When screw compensation is disabled for an axis, the table file is renamed to CNC7?.BAK, where ? is the axis label. To re-enable screw compensation for an axis, simply rename the file back to CNC7?.TAB.

Document History

Rev2 Created on **2002-01-22**

[Rev1](#) Created on **1999-02-18**