14.0 Synchronized data collection

14.1 Introduction

The synchronized data collection is designed for automatic lead screw calibration or on the fly data collection. Usually a lead screw pitch error calibration system measures the pitch error of a lead screw. For high speed and high precision lead screw, it is import to measure the pitch errors at high speed and with several points per revolution.

Conventional technique for the calibration and compensation of pitch errors of a CNC machine is time consuming. The machine has to stop at every increment and dwell for a few seconds for the machine to settle then collect the positioning data. For a small increment or a large machine, this may take a long time. For example, at an increment of 1", dwell time 6 sec., axis length of 50", and 5 bidirectional runs, the total data collection time is more than 50 minutes.

Using a LDDM laser calibration system MCV-500, a high data rate PCMCIA interface card and an external trigger option, the data can be collected on-the-fly (without stopping) synchronously up to 10,000 data/sec. With such high data rate, the machine axis can be calibrated at a few hundred points in a few minutes, a significant time saving.

The key to the automatic lead screw calibration system is the synchronized data collection at high data rate. A schematic of the automatic lead screw calibration system is shown in Fig. 14-1. A lead screw is mounted on a vibration isolated table.
A retroreflector is mounted on a stable platform on a guide way. The laser head

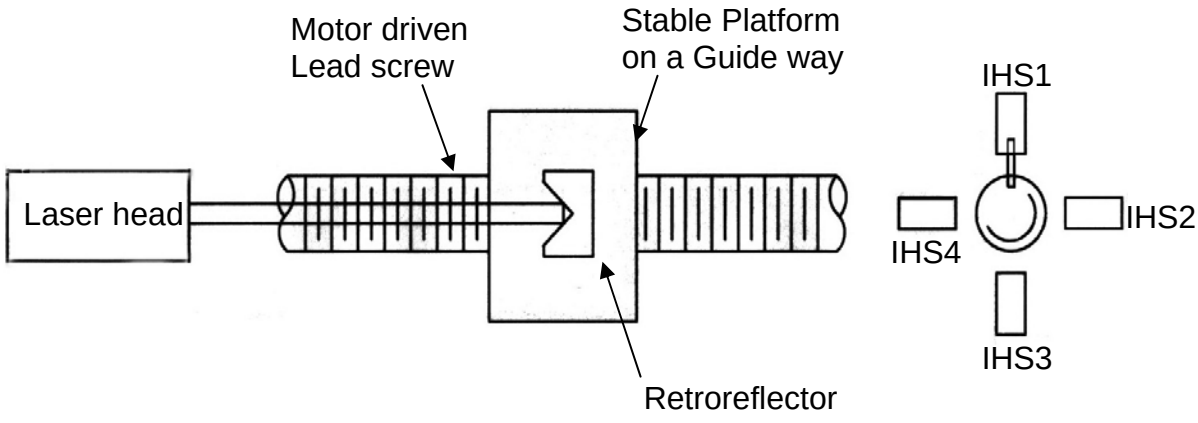

Fig 14-1, Schematics of an automatic lead screw calibration setup

of MCV-500 laser calibration system is mounted on the table. The position of the retroreflector or the stable platform is measured by the laser calibration system. The lead screw is motor driven with a blade to trigger the 4 position sensors (IHS) mounted every 90 degrees (more position sensors can be used to collect more data per revolution). The 4 position sensors are summed and produce 4 TTL pulses per revolution. A displacement reading will be collected synchronized with each TTL trigger pulse. With 4 position sensors, a TTL pulse is sent to the PCMCIA card at every 90 degrees angle. A typical measured pitch error is plotted in Fig. 14-2.

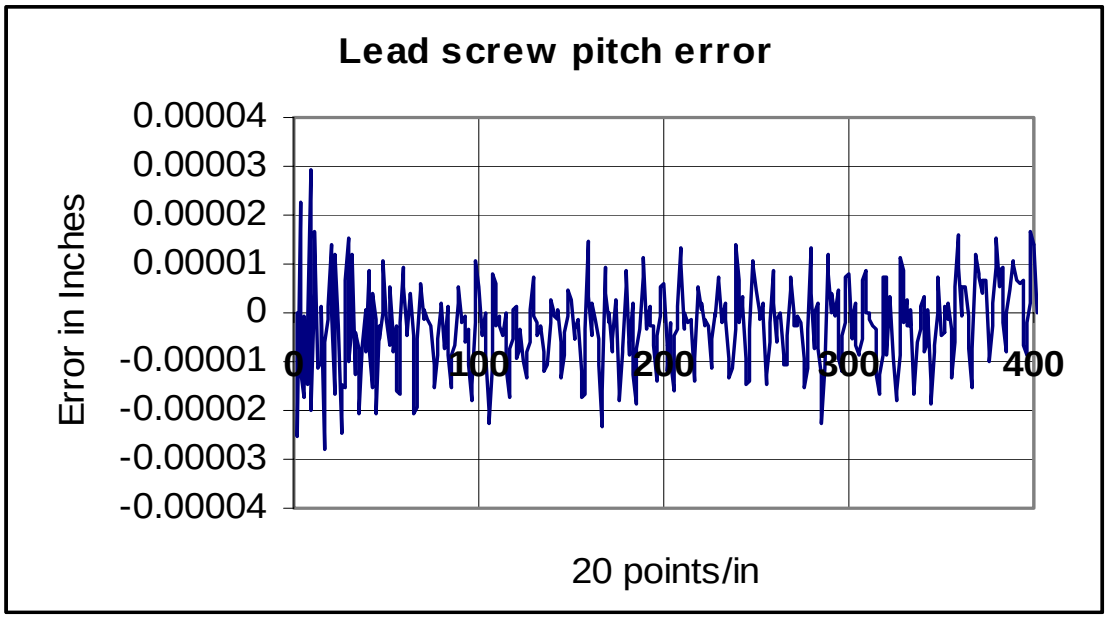

Fig. 14-2, a typical lead screw pitch error at 4 points per revolution and 20 points/in.

For on-the-fly data collection, align the laser beam to be parallel to the axis similar to regular laser calibration. However, instead program the spindle to move from the starting position to the ending position, stop at every increment with a 5 seconds dwell time, program the spindle to move from the starting position to the ending position continuously without stop. The synchronized trigger signal can either come from the machine encoder output or come from an external trigger switch mounted on the rotary wheel of the lead screw as shown in Fig. 14-3.

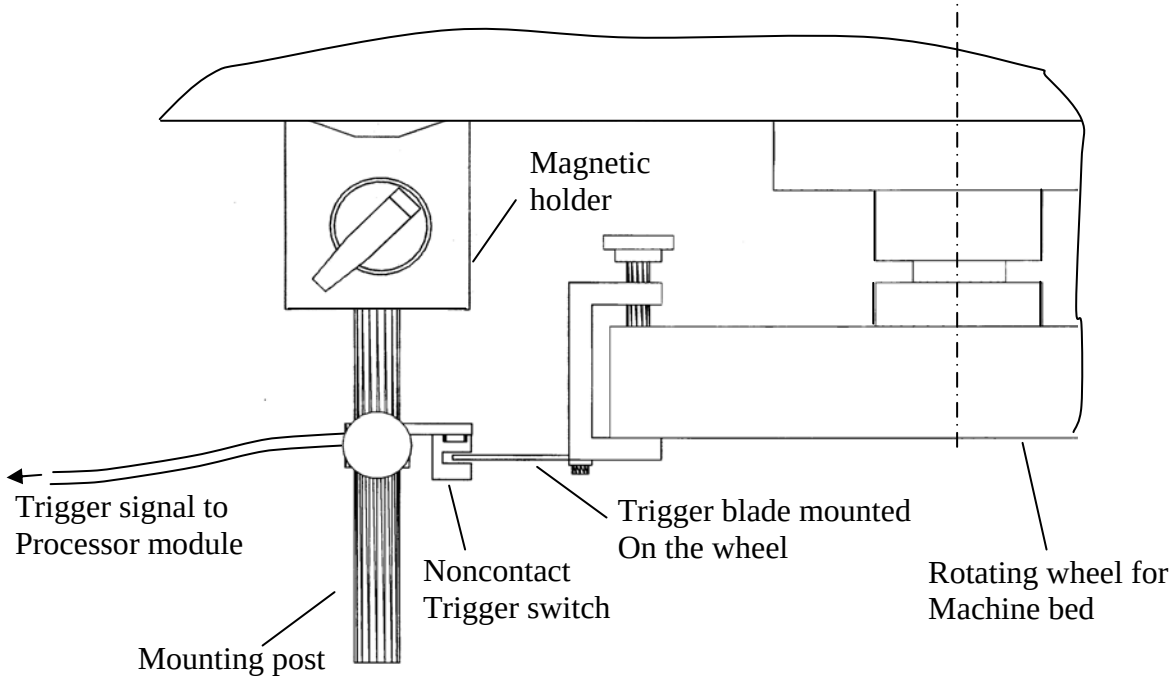

Fig. 14-3, Schematics of the external trigger set up for On-the-fly data collection

Here the trigger blade is mounted on the rotating wheel of the machine bed and the noncontact trigger is mounted on a mounting post with magnetic holder. The trigger signal is send to the Processor.

14.2 Hardware Required

The basic hardware and software required for the circular test are listed below:

a. Single Aperture Laser Head	L-109
b. Processor Module with RS-232 Interface	P-108D
c. Metrology/Analysis Program with IPC5-1000	W-500/w-500lb
d. Magnetic Base	LD-03
e. Adapter Platform	LD-14D
f. 12 ft Cable Set	LD-21L
g. PC Card and Cable	IPC5-1000
h. Notebook PC	Not supplied

Option, External trigger generator:

a. Noncontact trigger	LD-
b. Trigger blade and mounting	LD-

FIG. 14-4 HARDWARE FOR EXTERNAL TRIGGER

14.3 Operating Specifications

Accuracy: The laser stability at an atmospheric pressure of 29.9 in Hg and an air temperature of 68°F is 0.1 ppm. At other pressures and temperatures, the measurement accuracy depends upon the velocity of light compensation and the material thermal expansion correction. With manual compensation and correction, the accuracy depends upon the accuracy of the measured air temperature, air pressure, and the material temperature. With automatic temperature and pressure compensation, an accuracy of ±1 ppm could be achieved. For more detailed discussion on accuracy see Appendices H and J.

Resolution: Standard resolution is 1 μin (0.01 μm).

Maximum Velocity: 144 inch/sec (3600 mm/sec)

Measurement Range:	Up to 50 ft (15 m)
Temperature Range:	60°F to 90°F or (15.5°C to 32°C) Option 40°F to 100°F or (5°C to 37°C)

14.4 Reference Material

[1] Charles Wang and Bob Griffin, “A non-contact laser technique for circular contouring accuracy measurement”, Review of Scientific Instruments, Vol 72, No.2, pp1594-1596 (Feb. 2001)

[2] Application Notes, “Measurement of Settling Time and Resonance Frequency of a Stage or Machine,” Ap-1107.

[3] Application Notes, “Harmonic Motion Test on the Acceleration and Deceleration of a Machine Tool,” Ap-1111.

14.5 Installation and Alignment

14.5.1 Important Considerations
See Section 7.5.1.1

14.5.2 Installation

14.5.2.1 Set up LDDM Program
See Section 7.5.2.1.

14.5.2.2 Starting LDDM Program
See Section 7.5.2.2.

14.5.2.3 Install PCMCIA Card and external trigger

Set the PC Notebook near the Processor module. Insert the interface PCMCIA Card (IPC5-1000) to the PC Notebook. Each card is for a single channel and up to 2 PCMCIA Cards or 2 channels for two laser systems (MCV-500). Make sure all the hardware is installed and aligned properly. Make sure the PCMCIA Card is plug-in firmly with good contact and proper communication established. For some PC, the PCMCIA Card has to be inserted before boot. There is a push button on the cable for the PCMCIA Card for manual trigger. The push button can be replaced by a TTL trigger signal generated externally. For a noncontact trigger generator, connect the trigger generator to the LDDM processor box directly.

14.6 Software Description

14.6.1 General Description

For general description, windows, installation and starting LDDM program, see section 7.6.

14.6.2 2D Time Base Data Collection

The 2D time base collects data through a special PCMCIA card. The maximum data rate is 10,000 data/sec, and the maximum number of data point is 24,000 points/record. Click on the “2D time base” button in the main menu to get the data collection screen as shown in Fig.8-6. For two PCMCIA cards, the available address are: 350,110, 220,100 and 300.

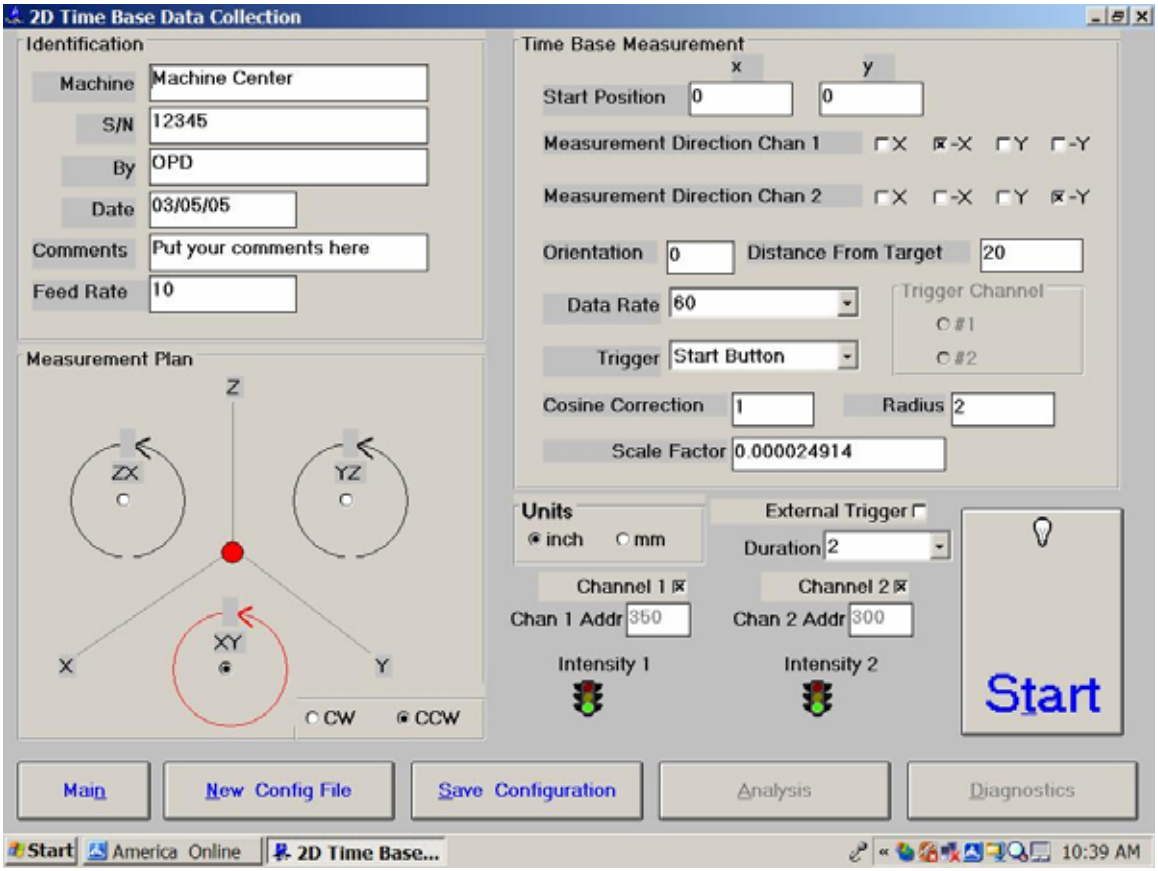

FIG. 14-5 2D TIME BASE DATA COLLECTION SCREEN

Choices on the data collection screen are as follows:

Identification: Input the machine type, serial number, operator, date, your comments or remarks and feed rate in/min or mm/min.

Measurement plan: For the synchronized data collection these selection are not applicable.

Time base measurement: Enter start position, measurement Direction (-x means the laser beam is pointing in the –x direction), and distance from the target. The orientation is the angle between the measurement direction and the first-axis direction. The data rate is determined by the selected feed rate and radius (see section 8.5.3). Trigger mode is “start button” only. The displacement or velocity trigger will be added later. Cosine correction is 1 for normal operation. It is 2cos(angle) for double pass and the angle is the angle between outgoing and return beams. The radius is not applicable here. The scale factor is 0.000024914 in or 0.000632816 mm. Click “in” for inch unit and “mm” for metric unit. Click both channels for 2 channel data collection.

Data Rate: Select a data rate up to 10,000 Hz.

Duration: Select a duration. The maximum duration is limited by the maximum size of the record, 24,000 data/record.

External trigger: For external trigger, click on “External Trigger” box. A special cable with external trigger connector is needed. The trigger pulses should be TTL standard, the pulse width larger than 30 µsec, and the repetition rate less than 3000 Hz. For 2 channels, connect the trigger pulses to channel #1 and both channels will collect data synchronized with the trigger pulse. The data age is a few microseconds.

Intensity: The green light indicates the laser is aligned properly and the red light indicates the alignment is off. Block the laser beam to check whether the PCMCIA Card is installed properly.

Start/stop: Click “start” to start the data collection and for low data rate click on “stop” to stop the data collection. For high data rate, do not click on “stop”, it will stop after the selected duration. After stop, enter the filename to save the data collected. The extension .2dr will be added automatically.

14.6.3 Data Analysis

To analyze data, go to the main menu first then click on the “analysis”. Click on “file” to open a file with extension .2dr. After the .2dr data shown on the screen, click on “data selection” and “displacement 1”, a popup screen on “Enter a timer interval factor”. Enter 0 and OK. Another popup screen “Invalid value” and click on OK. Again, a popup screen on “Enter a timer interval factor”, click on “Cancel”.
The displacement values will be calculated and displayed on the screen.

The parameters “Slope” and “Threshold” are used for the generation of 2dd files.

After the displacement values are displayed, click on the “graph” to plot the displacement.

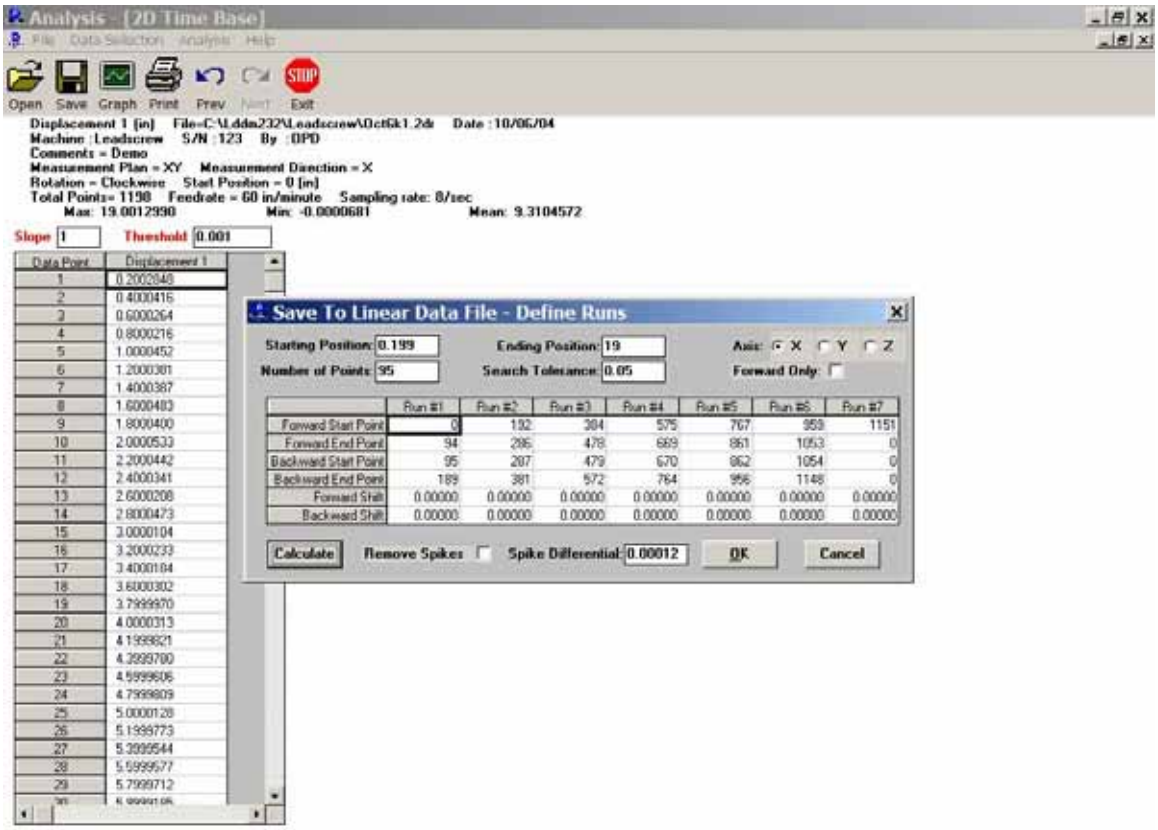

FIG. 14-6 THE ANALYSIS SCREEN WITH DISPLACEMENT DATA

Click on “save”, select “Lin” and OK, a popup screen “Save to linear data file” as shown in Fig. 14-6. Enter the starting position, ending position, number of points, and click on the axis. Click on “Calculate”, the forward starting point, forward ending point, backward starting point, backward

ending point, for all runs will be calculated. User may change these values. Forward shift and backward shift are shifts in displacement values, positive and negative values for shift up or down respectively. Click “Remove spikes” to remove spikes in the data file. Spike Differential is the value used to select the spikes. After fill all the values in the table, click OK to generate the Lin data files. Enter a filename to save the data file. The extension .lin will be added automatically.

14.7 Accuracy and Error Sources

14.7.1 The general accuracy and error sources are discussed in section 7.7 and appendix J.

14.7.2 The data age error

The data age, time between the trigger pulse and latched displacement reading, is less than a few microseconds.

14.7.3 Alignment errors

The cosine error is due to the laser beam not parallel to the machine travel. The error is proportional to the square of the misalignment angle in radian times the distance.

14.8 Taking a Measurement

14.8.1 Set up

1, Connect all cables and turns on the power.
2, Make sure all of the hardware is installed and aligned properly.
3, The PCMCIA card should be plugged into the notebook pc, and make sure the proper driver is selected and communication established.
4, Load the MCV-500 program and click on the “2d time base”.
5, Make sure the PCMCIA card is properly connected and functioning and the green light is on when aligned.
6, Determine the feed rate, the data rate, the duration, and axis of measurement.

14.8.2 Alignment

1, Mount the laser head on the bed and pointing the laser beam in the direction of travel.
2, Mount the retroreflector target on the spindle. Make sure the return beam enters the laser aperture and the green light on 2D time base data collection screen is on.

14.8.3 Data collection

1. Click on the LDDM Logo to start.
2. Click on the “2D Time Base” in the main menu to get the data collection screen.
3. Enter machine identification and feed rate.
4. Enter the start position, the measurement direction, orientation, and distance from target. Enter the feed rate F[in/minute] and select the data rate S[data/sec] and duration [sec].
   The Maximum data rate is 10,000 data/sec and the maximum data file size is 20,000 points.
5. Trigger—start button only
   Cosine Correction—Single pass = 1
   Double pass = $2\cos\theta$
   Radius of circular path N/A
   Scale factor = 0.000024914 in, or 0.000632816 mm
   External trigger—data collected will be synchronized with the external trigger pulses or the noncontact trigger generater pulses.
   Channel number – automatically selected by your PC or manual selection.
   Intensity – green means okay and red means out of alignment.
   Start – press start to start collecting data and press end to stop.
6. Save data, enter the file name and an extension .2DR will be added automatically.

14.8.4 Data Analysis

1. To analyze data, go to the main menu first, then click on “Analysis”.
   Click on “File” to open a file with extension .2DR.
   The .2DR data will show on the screen. Click on “data selection” and “displacement 1”, a popup screen on “Enter a timer interval factor”. Enter 0 and OK. Another popup screen “Invalid value” and click on OK. Again, a popup screen on “Enter a timer interval factor”, click on “Cancel”.
   The displacement values will be calculated and displayed on the screen.
   Click on “Graphics” to plot the displacement data. Enter starting point and ending point for the plot.
   Click on “File”, “Save” and “Lin”. Enter the starting position, ending position, number of points, and click on the axis. Click on “Calculate”, the forward starting point, forward ending point, backward starting point, backward ending point, for all runs will be calculated. Forward shift and backward shift are shifts in

displacement values. Click “Remove spikes” to remove spikes in the data file. After fill all the values in the table, click OK to generate the Lin data files.

A “Save Displacement Data” screen will pop up. Enter the filename and “OK”. The data will be saved in the file with extension .Lin.

Go the main menu and click on “Linear”.

8. Follow the instruction for Linear analysis in Section 7.6.