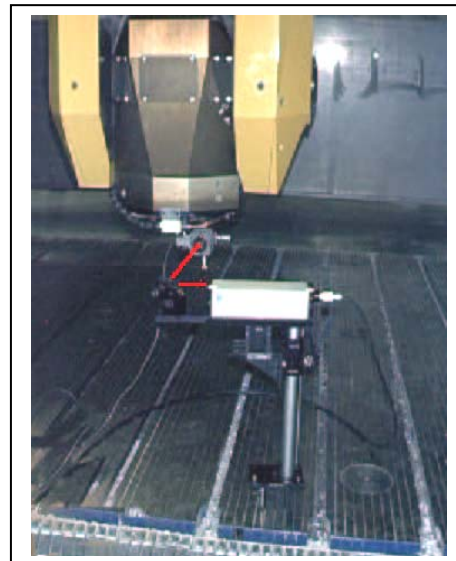


Squareness, Parallelism and Straightness Measurement

Intruduction

In determining machine geometry, a laser Beam is used to produce an ultra precision Equipment to the straight-edge. An optical Square is used to bend the laser beam Precisely at a 90° angle, and a quad-detector Is used to determine the centroid of the laser Beam.

A straightness measurement is the Measurement of perpendicular motion along a Travel path as shown in Fig. 1. The ideal travel path is a straight line. Any Deviation from the straight line in the horizontal Direction is called horizontal straightness. In The vertical direction it is called vertical Straightness.



Straightness measurement on the machine tool spindle

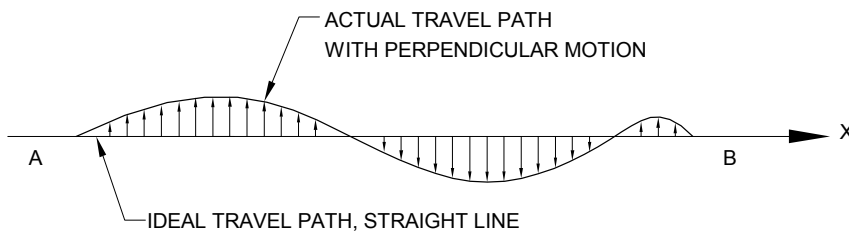
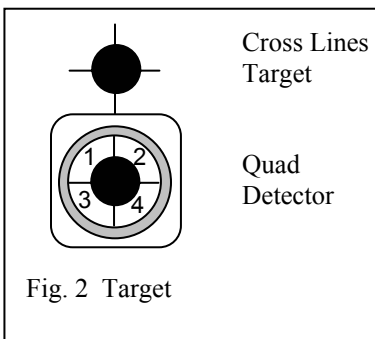


FIG. 1 DEFINITION OF STRAIGHTNESS



Attach a target with a cross in the center to the travel Mechanism and align the cross to the center of the laser beam. Assume the laser beam travels from A to B and follows the ideal path. The center of the cross should follow the actual travel path. By measuring how far the cross is deviated from the center of the laser beam along the travel path, we can determine the straightness. For more accurate measurement, the centroid of the laser beam can be measured by using a quad-detector which is a large area photodetector cut into four quadrants, as shown in Fig. 2.



Fig. 3 Mounting and Alignment of quidway

if a laser beam shines at the center of the quad-detector, the output from the four detector, 1, 2, 3 and 4 should be the same. However, when the quad-detector is moving to right, the quad-detector 1 and 3 should have higher outputs than detectors 2 and 4. Similarly, when the quad-detector is moved up, detectors 1 and 2 should have higher outputs than detectors 3 and 4. For example, for a laser beam diameter of 5 mm the minimum detectable deviation is: $\Delta=0.00001$ in. or $0.25 \mu\text{m}$.

Higher resolution can be obtained by averaging over a longer period of time, decreasing beam diameter or increasing the S/N.

When the laser beam is bent through a precise 90° angle By an optical square, it can be used to measure the squareness and parallelism. The optical square is a penta-prism, which bends the incoming laser beam to 90° . As shown in Fig. 4, because the two reflecting surfaces are at a fixed angle, the output laser beam is always $90^\circ \pm$ tolerance from the incident laser beam, independent of the incident angle. Typical accuracy for an optical square is 2-5 arcsec. Higher accuracy of less than 1 arcsec is available. The fix and known error is taken in consideration by software and zeroed. Using the incident beam direction as the axis of rotation, rotating the optical square will generate a plane perpendicular to the incident laser beam. Care must be taken to minimize any skew when using optical square for parallelism measurement.

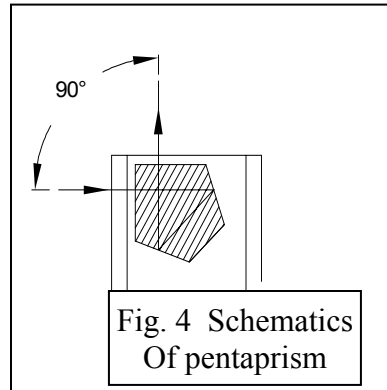


Fig. 4 Schematics Of pentaprisim

A HeNe laser produces an intense beam of red light which is a straight line of the greatest accuracy in a vacuum. In atmosphere, the straightness of a laser beam may be changed by temperature gradients or air currents. Accuracy is determined by the straightness of the laser beam which is controlled by the temperature gradient or the air current across the laser beam. For a typical indoor condition, the stability of the laser beam is about 0.0001 in. per 12 inches or $2.5 \mu\text{m}$ per 300 mm.



Fig. 5 Squareness measurement on a large machine tool, the laser head on he left, the pentaprisim in the center and the quad detector on the right

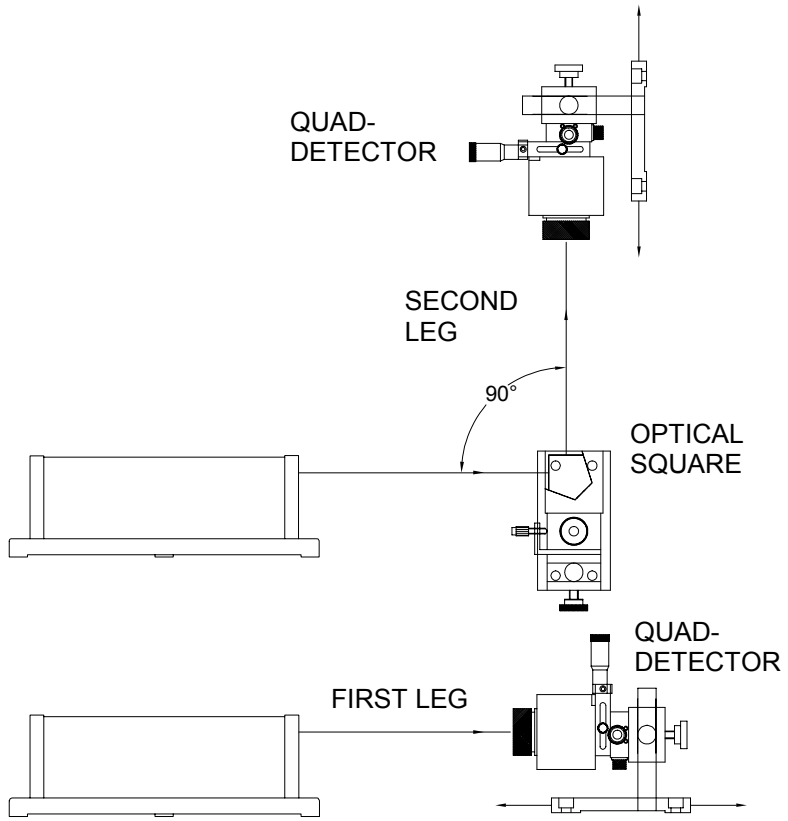


FIG. 6 SQUARENESS MEASUREMENT SETUP

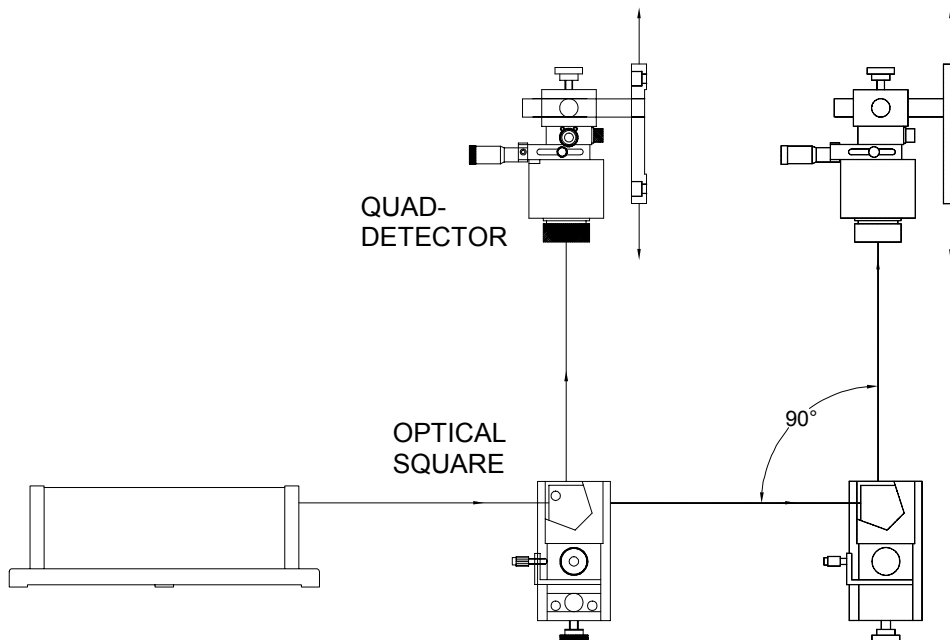
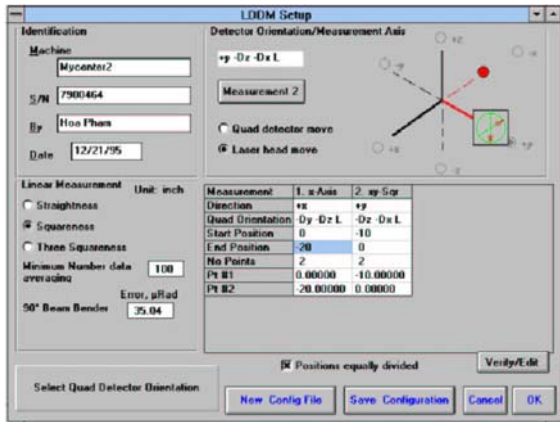


FIG. 7 PARALLELISM MEASUREMENT SETUP

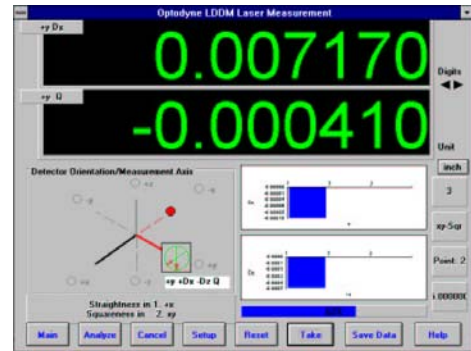
Example of a straightness or Squareness Measurement

Open LDDM software , go to the setup screen Enter the type of measurement, **Straightness, Squareness** (1 optical square). Enter your **machine information** and Determine which piece is fixed, the **quad detector** or the **laser head**. Rotate the quad detector icon so that the arrows are pointed in the correct MACHINE axes. To rotate, click the left mouse button on the **quad detector square** icon. Edit the **measurement setup**, enter the start/end MACHINE coordinates and the number of points. Press **View/Edit** to check your increments. Now you are ready to take measurements.

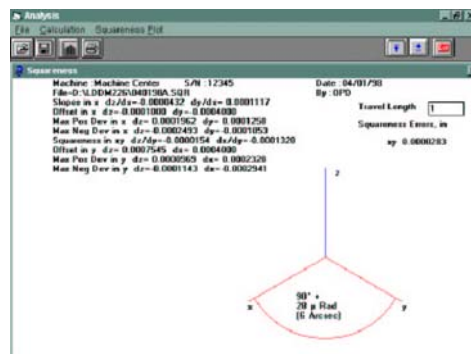


Taking Data Points for a straightness or Squareness Measurement

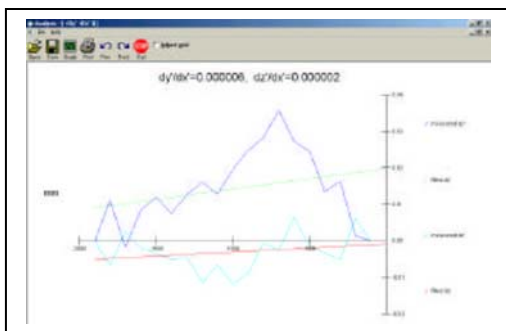
Align the laser beam parallel to the movement to be measured and the quad detector centered on the laser beam as illustrated by the set-up schemes in fig 6 and 7 . Press Start. Move to each point along the first axis and press the **Take** button. A countdown of data points being averaged is shown After finishing all of your data points, a save file message will appear. Press **Yes** and type in your **filename** to save your data (the extension of .SQR is automatically added).



Data Analysis : Check your results by clicking on the **Analysis** button and opening your file for squareness. you can choose between screens of data and plots.



Squareness Plot: This will show the angle between the POSITIVE X, Y and Z axes of your machine.



Straightness plot: of vertical and horizontal straightness

Need more information

Call Optodyne at 310-635-7481 or your local representative