J “ZLM Flatness” Calibration Software

The ZLM Laser Interferometer can be used to ascertain the flatness error of plate-shaped components by measuring the deviations normal to the object plane along a pattern of measuring lines. Flatness deviations are dealt with in the "ISO 1101" standard.

Normally, a user of the “ZLM Flatness” measurement program will also use the “ZLM Position” program, which is described in section G. As the operation of “ZLM Flatness” has much in common with “ZLM Position”, the reader of the present section will be referred to section G wherever appropriate.

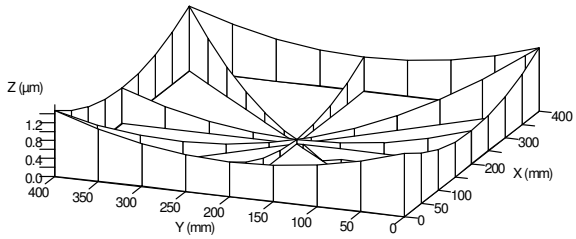
J 1 Measurement methods

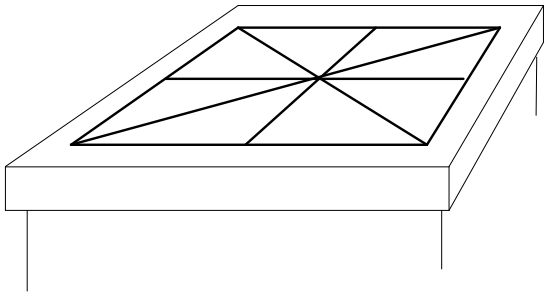
Along a specified pattern of lines placed over the object under test, the program measures height deviations normal to the object plane. The acquisition of measurement data on any one measuring line is similar to data acquisition in a straightness measurement. By combining the data measured on all measuring lines, the software determines the flatness error.

Either of two patterns of measuring lines may be used:

1. “Union Jack”

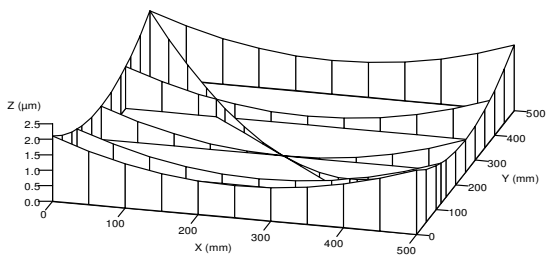
The “Union Jack” pattern invariably consists of eight measuring lines.

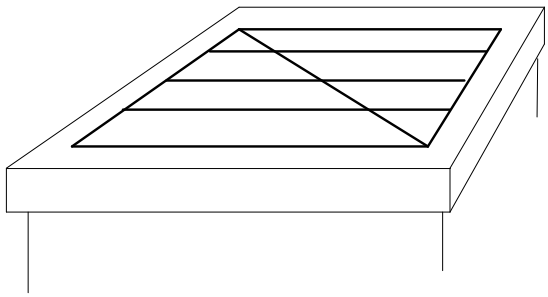




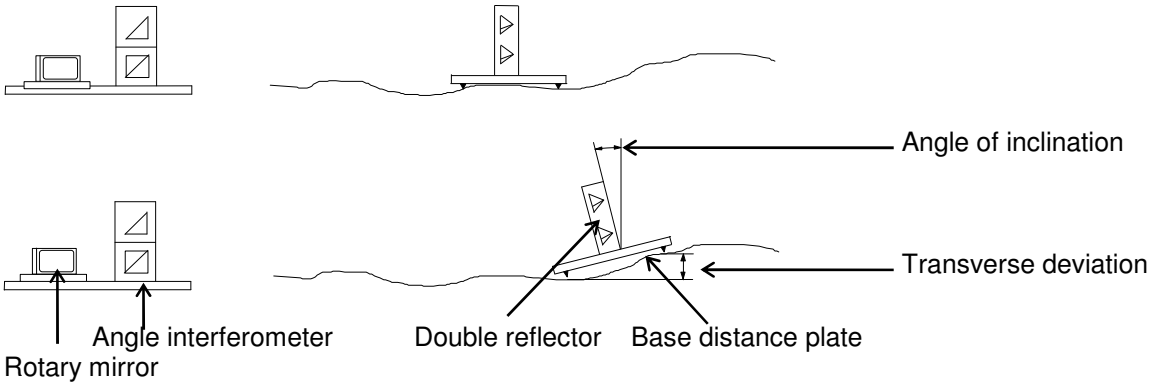
2. “Cross Jack”

The “Cross Jack” pattern may consist of six or more lines (the illustration shows a case with eight lines).
The number of measuring lines parallel to the X axis may be varied (the illustration shows five).
These lines are spaced at equidistant intervals.



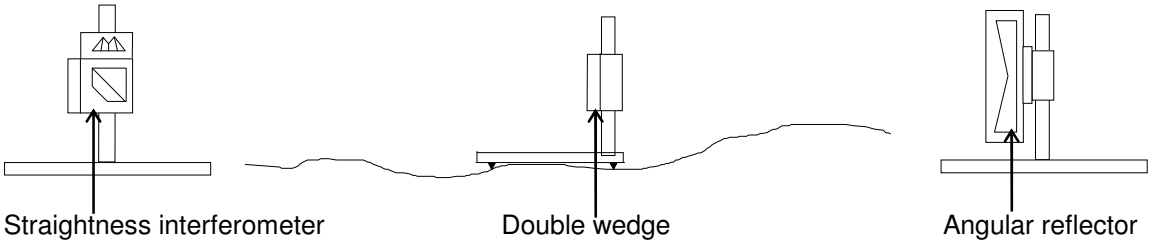


To determine the deviations normal to the plane, you can use either the angle or straightness optics, same as in straightness measurement. Use of the angle optics involves less mounting work. Mount the double reflector on a base distance plate. During a measurement, displace the base distance plate repeatedly along a measuring line by the distance between the two rest points of the plate.
From the angles measured at a position, the program determines the deviation normal to the plane at that position.



The angle interferometer can be mounted on a base plate with rotary mirror. The rotary mirror facilitates conversion when you have completed the measurements on one measuring line and want to proceed with another, as the laser head will hardly ever have to be relocated if the mirror is used. A drawback of this arrangement is that you need to take great care to ensure that you displace the reflector in the correct direction. Shifting in the wrong direction will supply measurements with the sign reversed.

If you prefer to use the straightness optics, you need a straightness interferometer with beam offset prism, a double wedge and an angular reflector.



The program directly measures the displacement of the double wedge normal to the plane.

J 2 Parameters

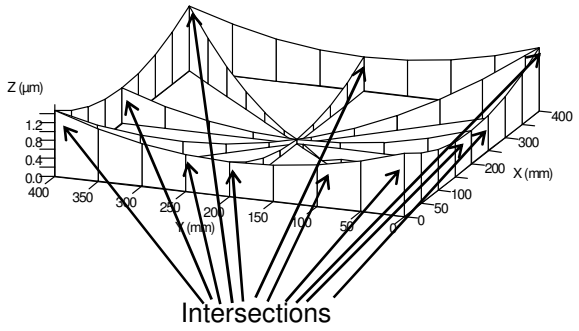
ISO 1101 defines the flatness deviation as the minimum distance between two parallel planes that include between them all measured data.

As measurement data are acquired on individual measuring lines, the software has to assign the measured data to positions. It does so by taking advantage of the axiom that the deviations normal to the plane, measured on two intersecting measuring lines, ought to be equal at the point of intersection of the two lines.

For determining the flatness deviation, the program proceeds in three steps.

1. Interpolation and extrapolation:

When the program links a measuring line that is parallel to one of the coordinate axis with one that is diagonal, it may happen that the intersection between the two lines comes to lie somewhere between points at which data were measured, rather than coinciding with such a point. In such a case the program interpolates the value at the intersection from the values measured at the neighbouring points. At the corners of the measuring area, the value for the intersection with a diagonal line is extrapolated.



2. Approximation at the intersections:

After extrapolation and interpolation, deviation data exist for all intersections between all measuring lines.
The program mow determines the tilts and displacements of each measuring line normal to the object plane, approximating the measuring lines in such a way as to minimize the sum of the squares of deviations at the intersections. Only the "Cross Jack" method using six measuring lines guarantees that the deviations at the intersections can be approximated to zero. In all other cases the values at the intersections may deviate from zero.
The maximum deviation is registered as "maximum approximation error". It can be regarded as a measure of the accuracy of the measurement.

3. Determination of the flatness error:

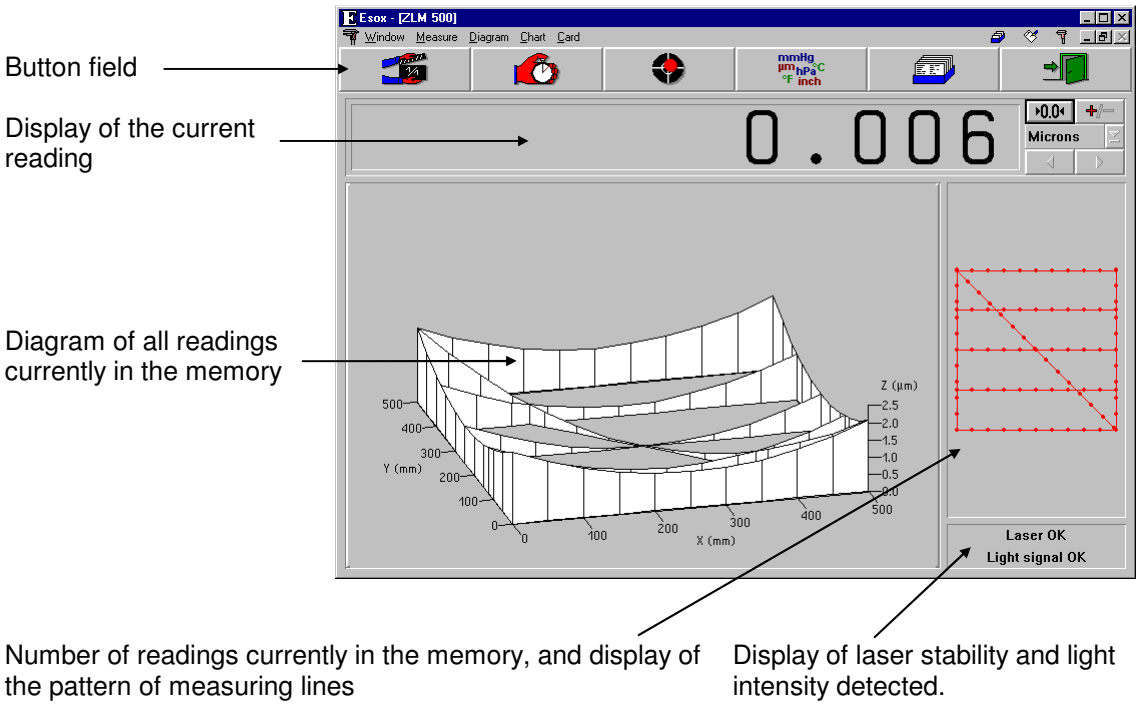
After the measured data have been assigned to positions, the program determines the flatness deviation according to ISO 1101.

J 3 Operation

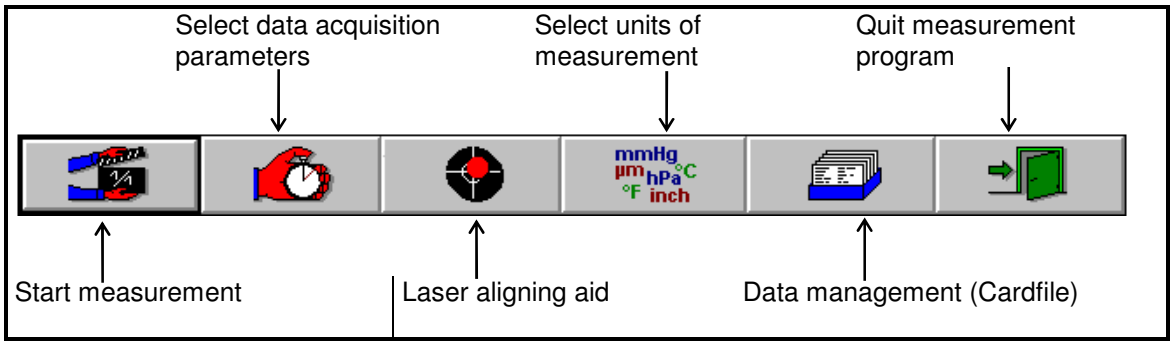
To start "ZLM Flatness", proceed as in starting "ZLM Position"
(see sections G 3.1 for starting "ZLM Position" and C 3 for general information on starting a measurement program).

J 3.1 Elements of the "ZLM Flatness" window

The element of the "ZLM Flatness" window are arranged similarly to those of the “ZLM Position” window.



To operate the display of readings and to select the units of measurements, proceed as in the “ZLM Position” program module.



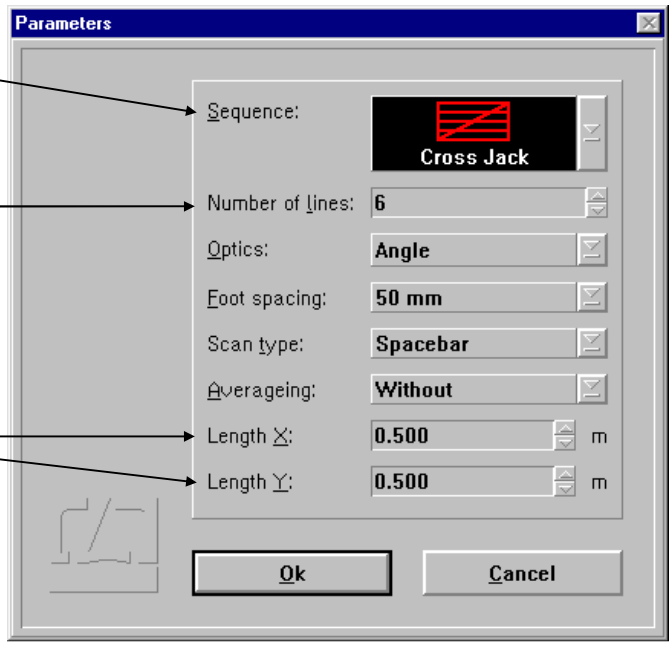
J 3.2 Preparation for a measurement

Select the **"Configuration"** option in the **"Measure"** menu or click the  button to open the **"Parameters"** dialog box.

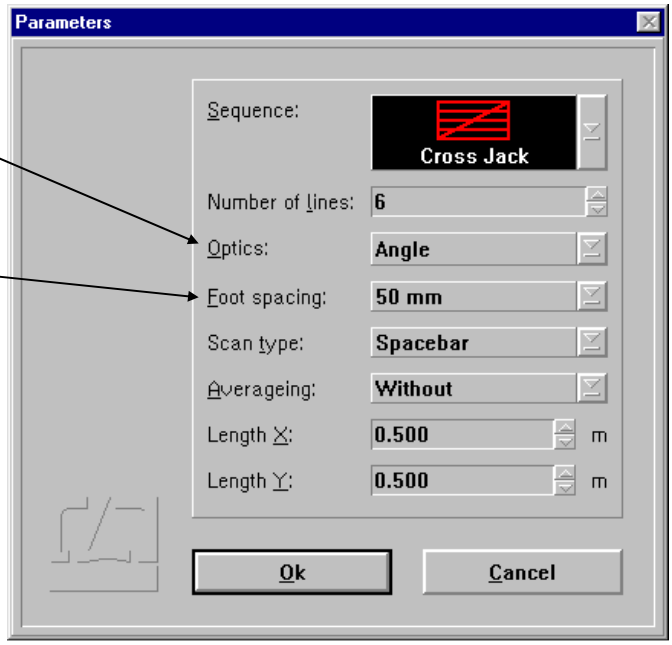
In the drop-down list box **"Method/Sequence"**, select whether readings are to be taken with the “Union Jack” or “Cross Jack” pattern of measuring lines.

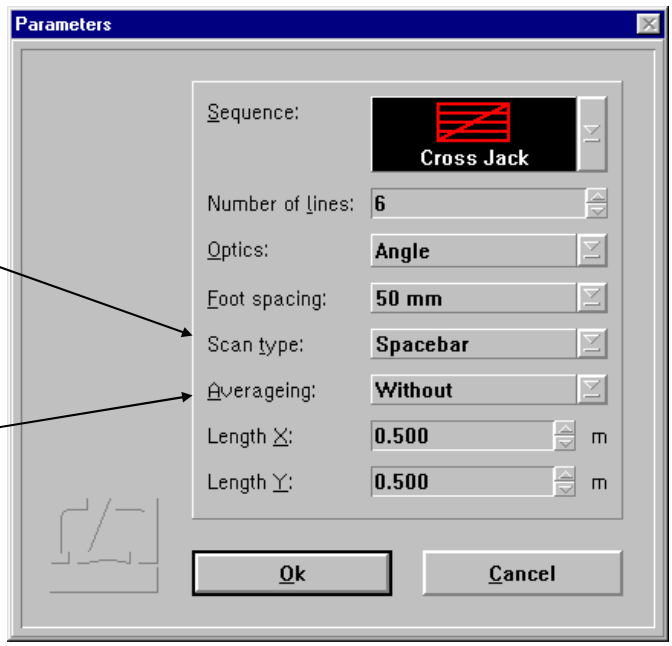
If you select "Cross Jack”, you need to enter the total number of measuring lines.

In the two text boxes at the bottom, specify the size of the measuring area.



In the “**Optics**” drop-down list box you can select between using angle optics and the 2m or 10m straightness optics.
If you use angle optics, you need to specify the base distance plate to be used. The value set here determines the interval of the grid of measuring points, no matter whether you use angle or straightness optics.





In the **"Scan type"** list box you can select the event to trigger data acquisition, i.e. either by hitting the space bar of the computer keyboard or by an external signal (remote control).

It is recommended to work with **short term averaging** in order to filter out any vibrations.
The options are the same as in the "ZLM Position" program module.

J 3.3 Measurement procedure

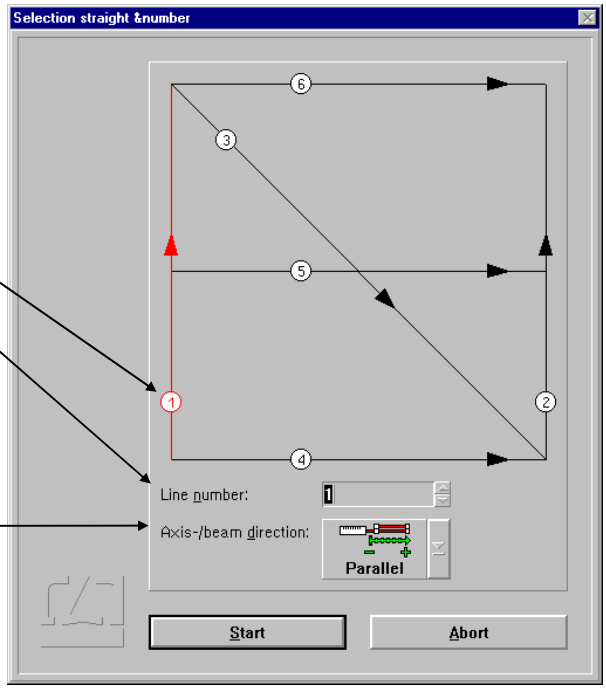
Start the measurement by selecting the "Start measure(ment)" option in the "Measure" menu or by clicking the  button.

This opens the dialog box **“Selection of line number”**.

In the "Line number" text box you can enter the number of the measuring line you want to begin with. This selection can also be made by clicking on the encircled number in the line pattern display. A colour monitor will show the line selected in red.

The program expects that you move from one position to the next invariably in the direction indicated by the arrow.

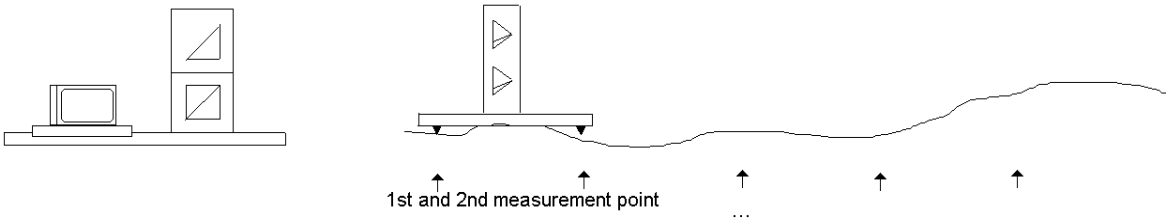
If you use angle optics, the direction from which the laser beam arrives is important. In the “**Axis/beam direction**” list box you need to specify whether the directions of displacement and laser beam are parallel or antiparallel (i.e. in opposite directions).
A wrong setting here will attach the wrong sign to the readings taken on the line selected, causing a wrong measurement result.



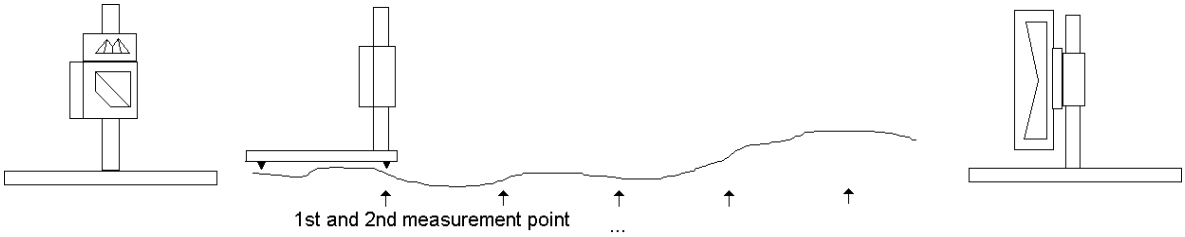
With all settings made, you can start to set up the equipment for measurement on the line selected. Clicking the Start button makes the laser aligning aid feature available. (select the **"Adjustment”** item of the **"Measure"** menu or click the button).

After setting up and laser alignment, move the base distance plate to the first measuring position. This position differs, depending on whether you are using angle or straightness optics.

Angle optics: The feet of the plate rest on the first and second measuring points.

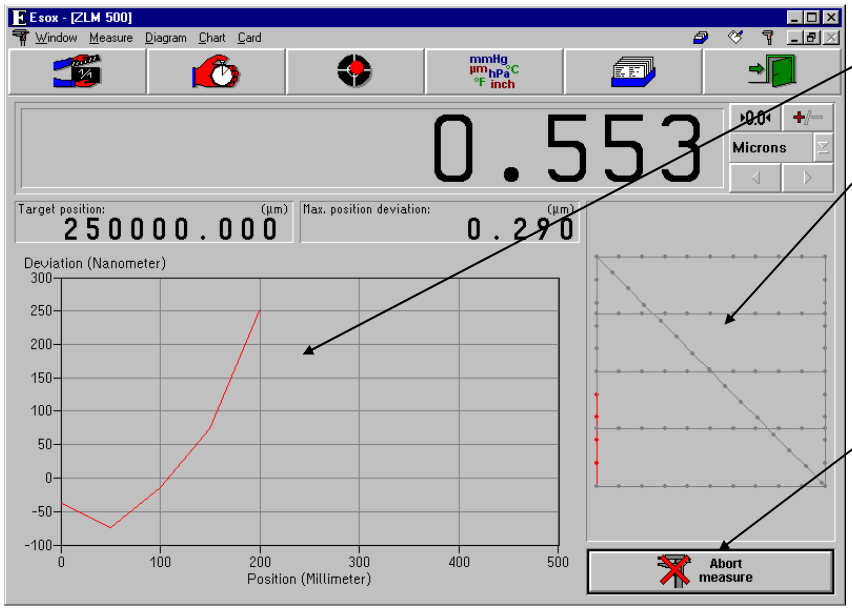


Straightness optics: The double wedge is above the first measuring point.



Then either click the 0.0 button or select the **"Reset"** item of the **"Measure"** menu to set the display to zero.

Now you can trigger the first measurement with either the Space bar or the remote control pushbutton. Then shift the base distance plate to the second measuring position and trigger the next reading, etc.



The diagram shows the readings so far taken on a measuring line.

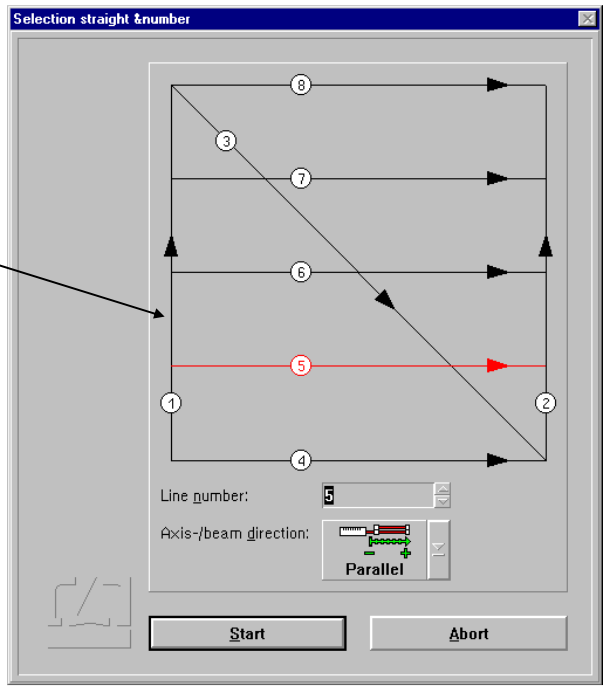
From the graph on the right you can see which positions have already been measured.

Taking readings on a measuring line can be terminated at any time by clicking the Abort measure button. This does not abort the complete measurement but gets you back to the measuring line selection box.

When all positions on a measuring line have been measured, the measuring line selection box reappears, and you can select the next measuring line.

In the line selection box, lines already measured will be shown in grey by a colour monitor.

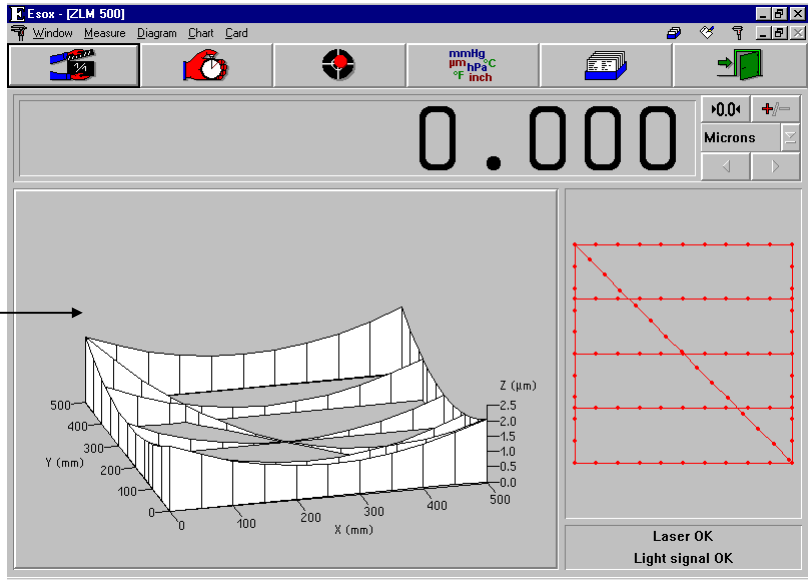
If you should have noticed any error, you can select the respective line again and repeat all measurements on that line.



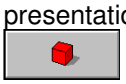
When all readings on the last line have been taken, the readings are saved on a card file, same as in the “ZLM Position” program module.

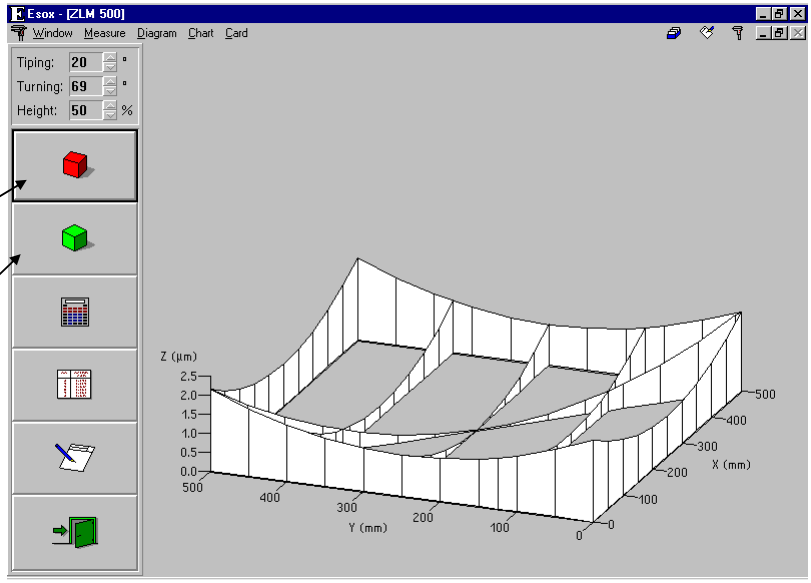
J 3.4 Analysis of a measurement

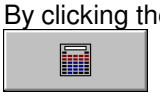
To open diagram presentation, click the large button, or select the **"Diagram"** item in the **"Diagram"** menu.



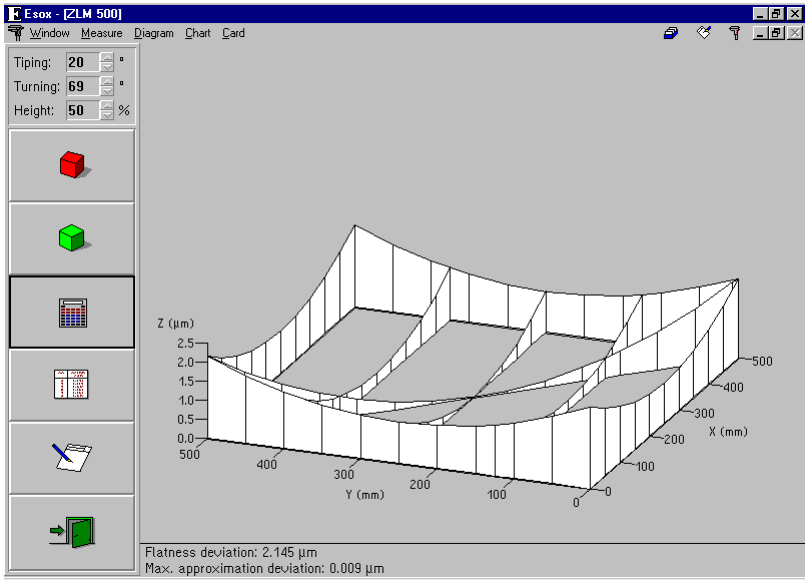
Tilt, rotation and height (Z expansion) of the diagram shown can be changed in the text input boxes in the top left portion of the window.

To select between dimetric and isometric presentation, click the  or  button, respectively.



By clicking the  button or selecting the **"Parameters"** item of the “**Diagram"** menu you can have the flatness deviation and the maximum approximation error displayed below the diagram.

See section J2 "Parameters" for the meaning of the maximum approximation error.



The display of a table of measured data, the recording of measurement results, exiting the diagram presentation and the loading of data measured earlier can be carried out in the same manner as described for the “ZLM Position" program module.