



WALLY

ROTARY ENCODER



1. MEASUREMENTS – ANGULAR POSITIONING

a. General Description

The angular positioning measurements are performed with the use of the **Wally** rotary encoder. This measurement is used, for example, to characterize a movement quality of rotary axes or for very precise measurements of a rotation angle. The System measures angular positioning accuracy, repeatability and backlash by comparing the position to which the machine moves (i.e. the position displayed on the machine's readout) with the true position measured by the interferometer.

The laser measurement system HPI-3D together with the **Wally** rotary encoder is capable of measuring any rotation angle with precision down to 1 arcsec. The System allows measuring angle in different units. The parameters of the measurement can be set in the *Configuration->Rotary Encoder* option.

14

b. Measurement Setup

For angular positioning measurements an angular optics together with **Wally** rotary encoder should be used. Necessary components are (see also figure 14.1):

- Laser Head
- Power Supply
- **Wally** Rotary Encoder
- Angular Interferometer **IK1**
- Angular Retro-reflector **RK2**
- Machine tool holders
- Air Temperature Sensor (TH sensor)

Optional elements are:

- USB cable
- Manual Strobe
- Magnetic holder **UM2**
- Tripod stand
- Base temperature sensor

14



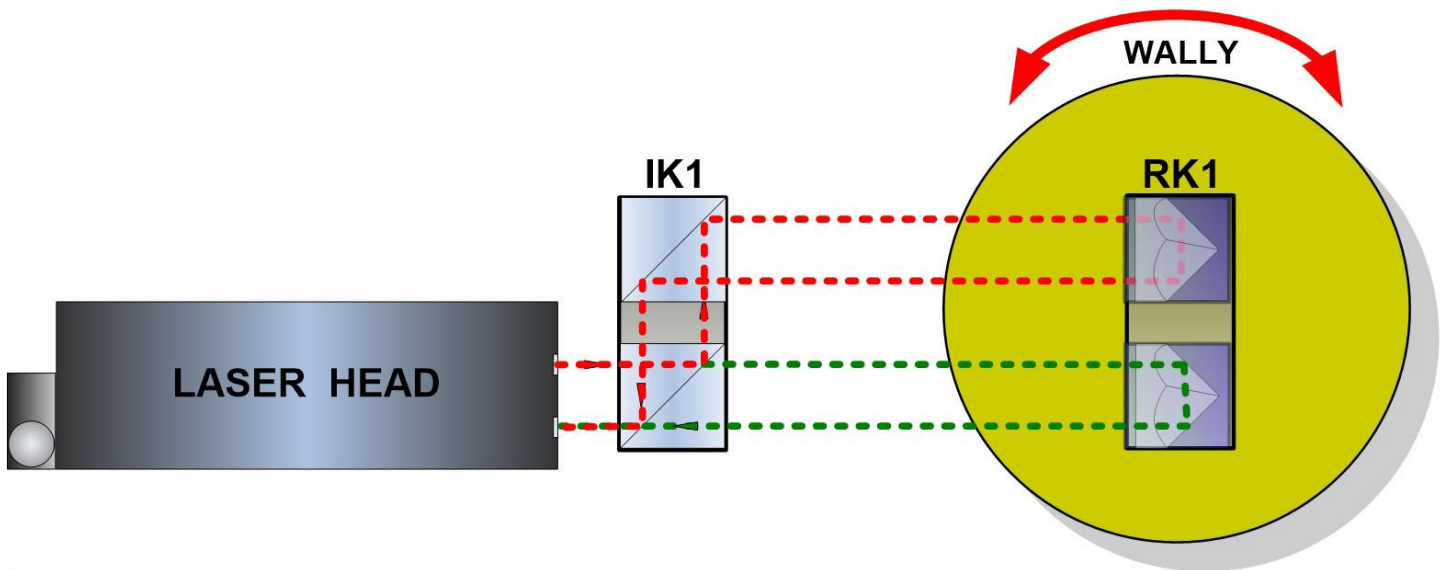


FIG.14.1. OPTICAL PATH SET UP FOR ANGULAR POSITIONING MEASUREMENTS-SCHEMATIC

14



FIG.14.2. OPTICAL PATH SET UP FOR ANGULAR POSITIONING MEASUREMENTS-PHOTO

Angular positioning measurements require usage of the **Wally** rotary encoder together with optical elements IK1 and RK2. The **Wally** Rotary Encoder is to be mounted precisely in the center of rotation of the measured axis using attached holders. On the **Wally** Rotary Encoder there is mounted the Angular Retro-reflector RK2. Outside the **Wally** Rotary Encoder there are placed the Laser Head and the Angular Interferometer IK1 as shown in the figures 14.1 and 14.2.

i. Theory of operation

The Angular Positioning measurements are performed with the use of two measurement instruments working together: **Wally** and the Laser Head. Both are controlled from the PC over Bluetooth interface. Laser head measures angular rotation of the **Wally** and sends value of the rotation to HPI software. The laser head controls and drives the whole process. Also there are no limitations for measurement range and number of steps. The measurements are performed with the use of angular optics – IK1 and RK2 and mechanical mounts. The presence of the powered on encoder is detected by the laser automatically and signalized by the yellow color on the **Wally link** field in the Status bar.

14

Proper rotary measurements are possible only if the laser sets up measurement link with the encoder. During the link set up procedure the wireless link quality and the optical signal strength are tested. Wally will rotate -5 degrees, then +10 degrees and then -5 degrees. If all the tests are succeed, then the link with the Wally encoder is set (*Wally link* field in the Status bar turns to green) and the measurements are possible.



The procedure of setting the **Wally link** requires optical path to be aligned. The **Wally link** is automatically broken when the optical path is broken.

14

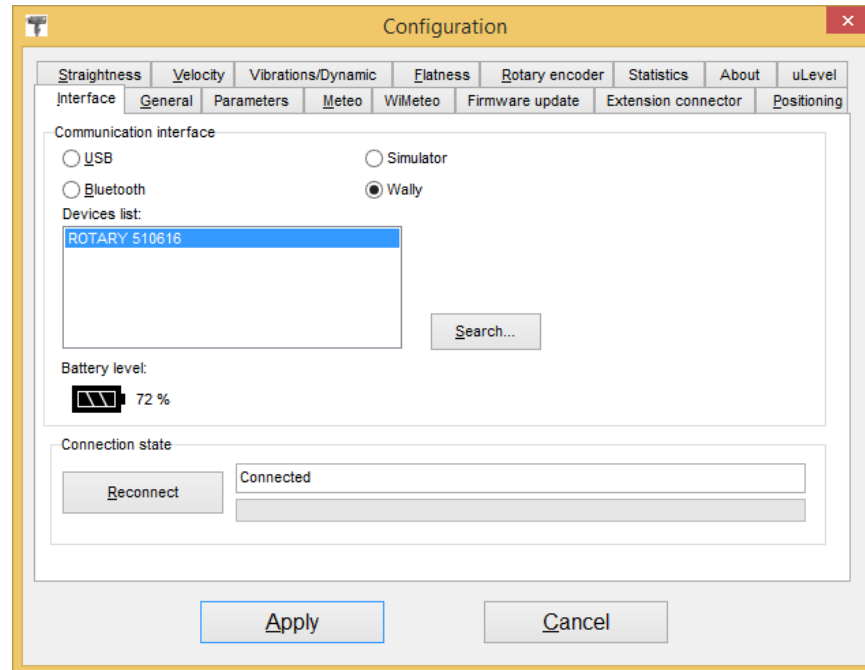
c. Software description

The described device option can be used either for measurement of any rotation angle or for angular positioning measurement.

i. Measurements of rotation angle

In order to start *Rotation* measurements Wally should be charged, turned on and connected with HPI-3D over USB or

Bluetooth interface within HPI Software. Wally can be connected same way as Laser Head (HPI Software > Configuration > Interface > Find Wally on Device list and press Connect and then Apply).



Then the **Display** button should be pressed in the **Main Menu**. On the screen there should appear a window **Display** as shown in the fig. 14.3. The functionality of the window is very similar to the one described in the chapter 3 with the difference that options necessary for rotary measurements and Wally battery level are visible (see figure 14.4).

The additional options and Wally battery level become visible in the bottom right corner of the window only after the **Measurement** type is set to **Wally**.

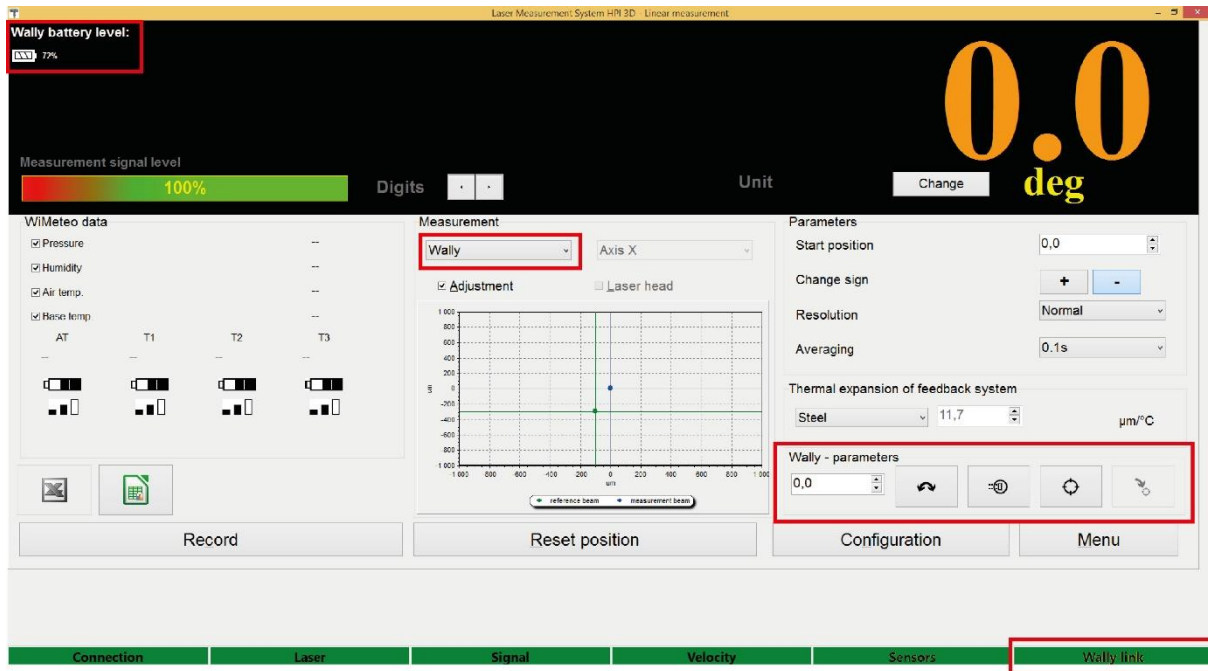


FIG.14.3. DISPLAY WINDOW WHEN WALLY IS PRESENT

Laser beam and optic elements should be aligned and crosses on the display should be as close to each other as possible. There are few options that could be helpful during this operation. There are few buttons that are controlling Wally optics movement. First button is used for manual rotation of any angle. Any angle degree can be putted in the window on the left side from the button. Next button is for automatic search for the optimum position of the Wally reflector RK2. Third button is for remembering actual position on the Wally which is useful when measured machine is to be turned off and on. Last one turn active after setting actual position and it has to be pressed to return to remembered position. For best results automatic search is recommended for optimum beam align.



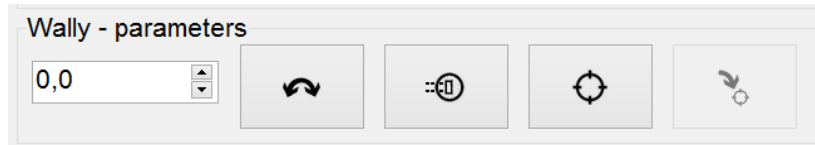


FIG.14.4. DISPLAY WINDOW OPTIONS FOR ROTARY

On the Status bar on the very bottom of the screen there is present a *Wally link* segment. As described in the chapter 3 this segment has three states:

- **gray** – Wally not present or not detected;
- **yellow** – Wally detected but no link to the laser or the link was broken;
- **green** – Wally properly connected and linked.

The measurements are possible only when the link with encoder is set – i.e. when the *Wally link* segment is green. When the elements are aligned the *Wally link* segment should be **clicked**. The procedure of setting the link, as described in *Theory of operation* section, should be started. When the procedure is finished successfully the *Rotary link* segment turns green and the measurements are possible.

14

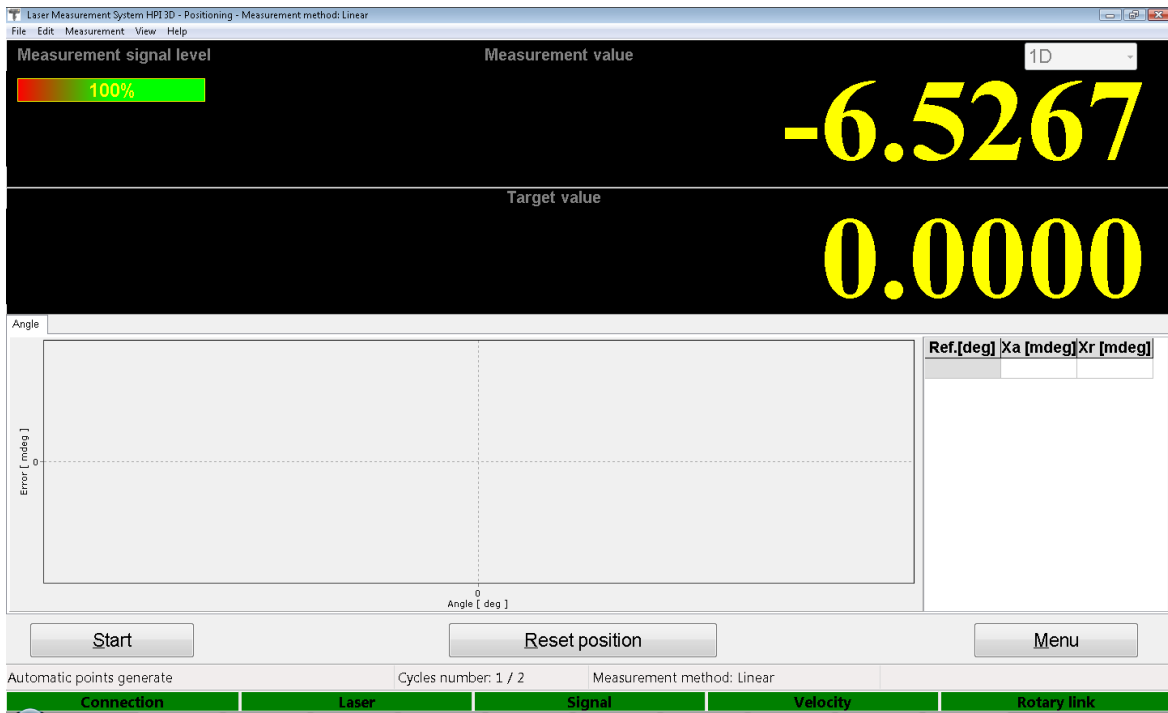


Wally link segment should be clicked to start measurements.

Breaking the link with the rotary table is done automatically when the laser beam path is broken. Only when *Wally link* is green the laser would trace machine rotation.

ii. Measurements of angular positioning

In order to start *Angular Positioning* measurements in the **Main Menu** the **Angular Positioning** button should be pressed. On the screen there appears a window **Angular Positioning** as shown in the fig. 14.5



14

FIG.14.5. ANGULAR POSITIONING WINDOW

iii. Pull down menu - File

The menu bar of this window contains following options: File, Edit, Measurement, View, and Help. In the File option (figure 14.6) there can be found commands for reading

measured data from a file, saving the data to a file, printing measurements results or exporting them to a file.

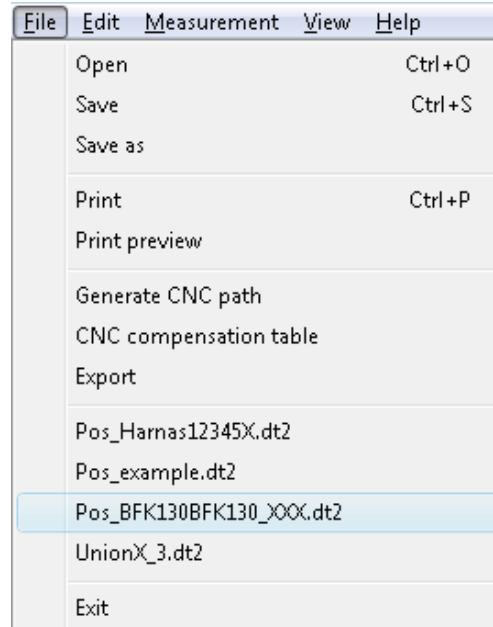


FIG.14.6. POSITIONING PULL-DOWN MENU *FILE*

Other important options available in the *File* menu are options for generating CNC path and preparing compensation table.

iv. Pull down menu - Edit

In the pull-down menu **Edit** option (fig. 14.7) there are commands for setting measured machine data (Fig 14.8), defining machine error limits (fig. 14.9), previewing obtained positioning results, editing positioning points (when option **Target Points from List** from menu **Measurement** is active) and changing overall positioning configuration.

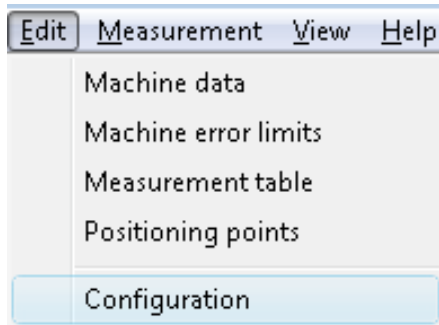
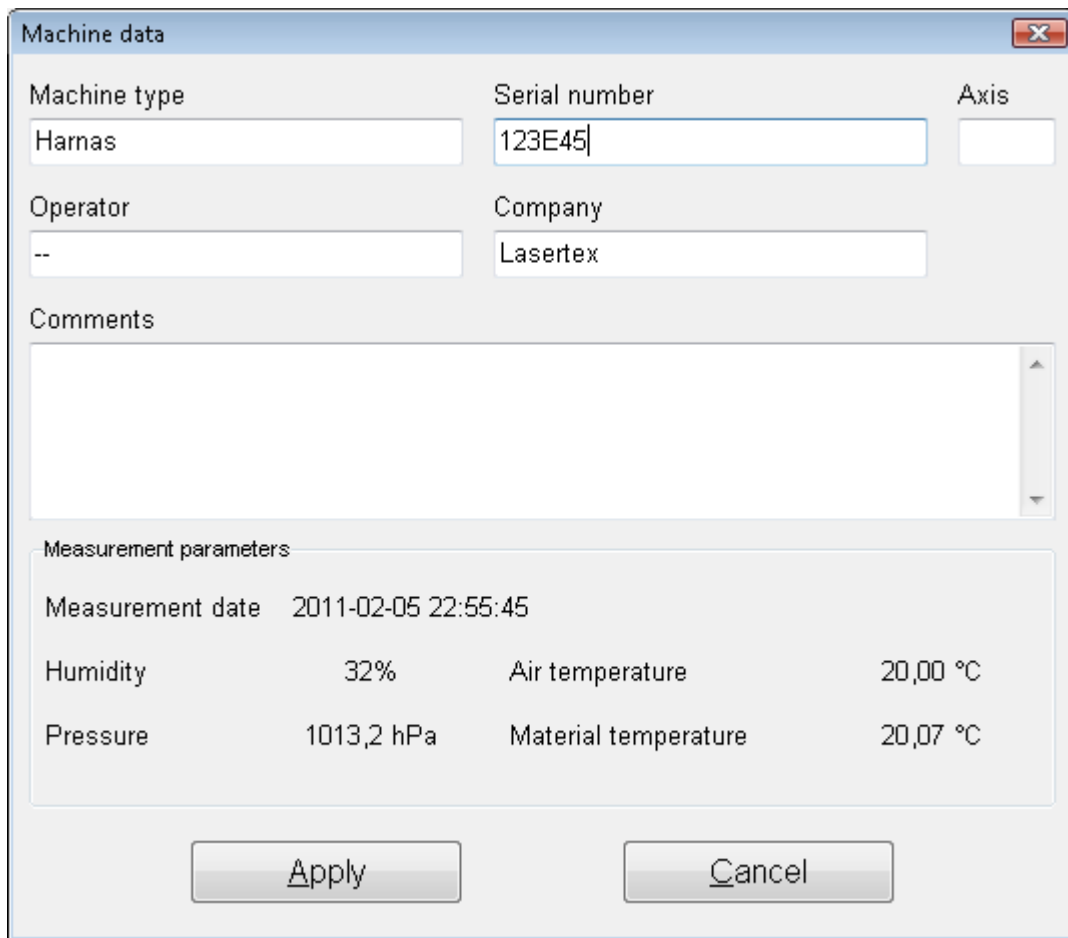


FIG.14.7. POSITIONING PULL-DOWN MENU EDIT



14

FIG.14.8 MACHINE DATAWINDOW

v. Machine error limits

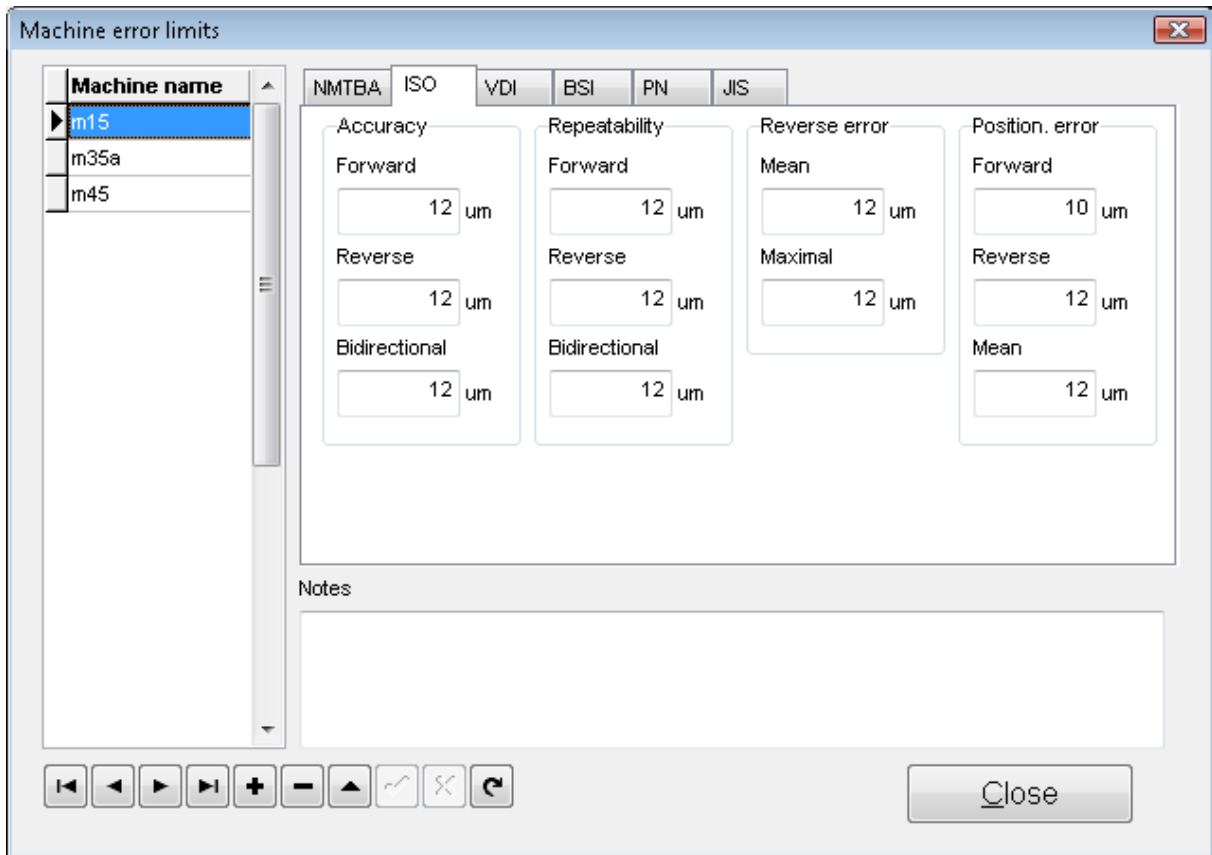


FIG.14.9. MACHINE ERROR LIMITS WINDOW

In the **Edit** option allowable error limits of the machine for different norms (option **Machine error** limits - Fig. 14.9) are configured. The results of the angular positioning measurements are compared with these limits (see Fig. 14.10). This option is especially useful when there are checked many machines of the same type and the same requirements on their accuracy are expected.

Results

Norm

Machine

Param.	Max.	Value
Accuracy:	[μm]	[μm]
forward	12,0	3,1
reverse	12,0	3,2
overall A	12,0	6,7
Repeatability:	[μm]	[μm]
forward R	12,0	2,5
reverse R	12,0	2,1
bidirectional R	12,0	6,3
Reverse error:	[μm]	[μm]
mean	12,0	3,6
maximal	12,0	3,9
Position. deviation:	[μm]	[μm]
forward E	10,0	2,0
reverse E	12,0	1,3
mean E	12,0	1,5

FIG.14.10. MACHINE ERROR LIMITS COMPARATION PANEL



vi. Positioning points generation

If option **Target Points from List** from **Measurement** menu is active, then the program expects the measured machine to stop in points defined in the Positioning points window as shown in the figure 14.11. Points can be entered manually or can be generated from the input parameters: start position, distance and interval or number of points. The points are calculated when *Calculate* button is pressed. Obtained points can be saved to a file.

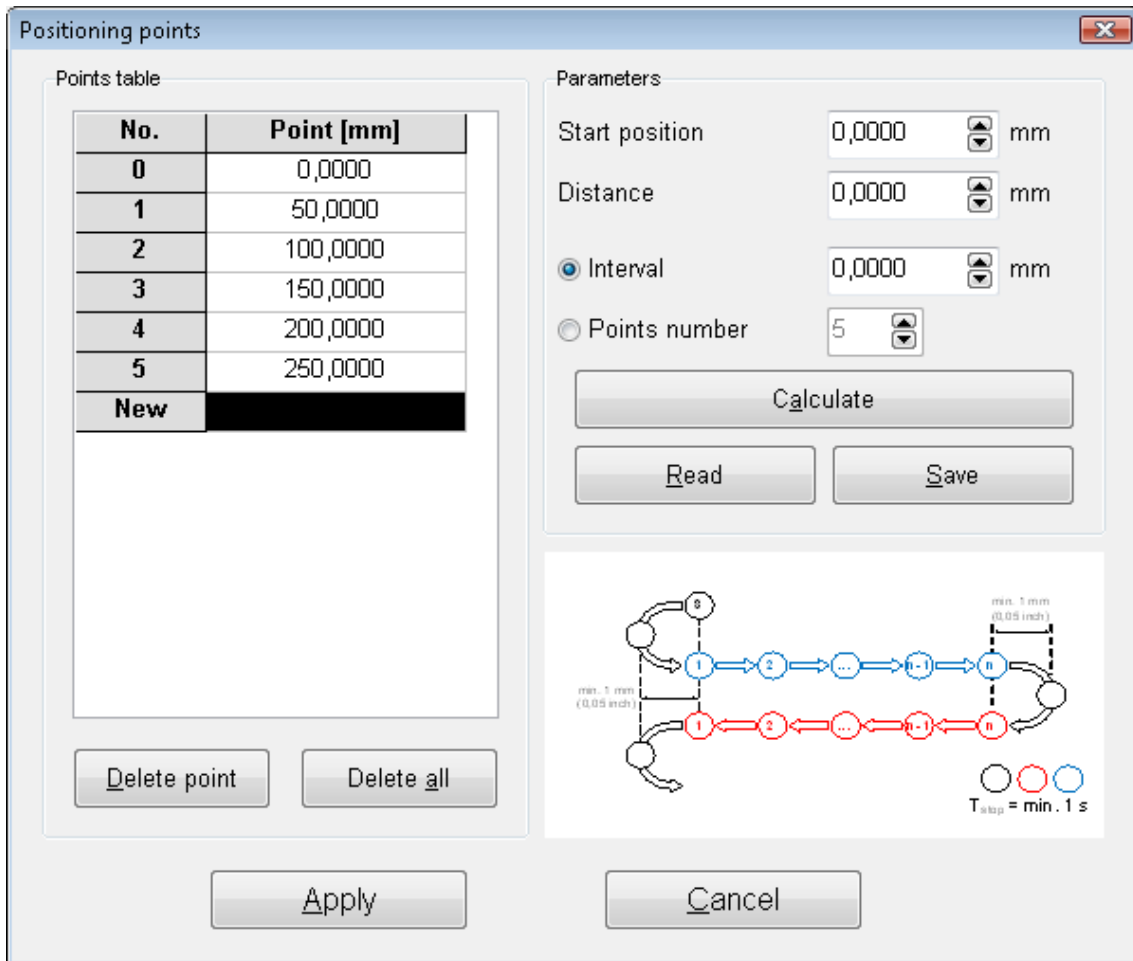
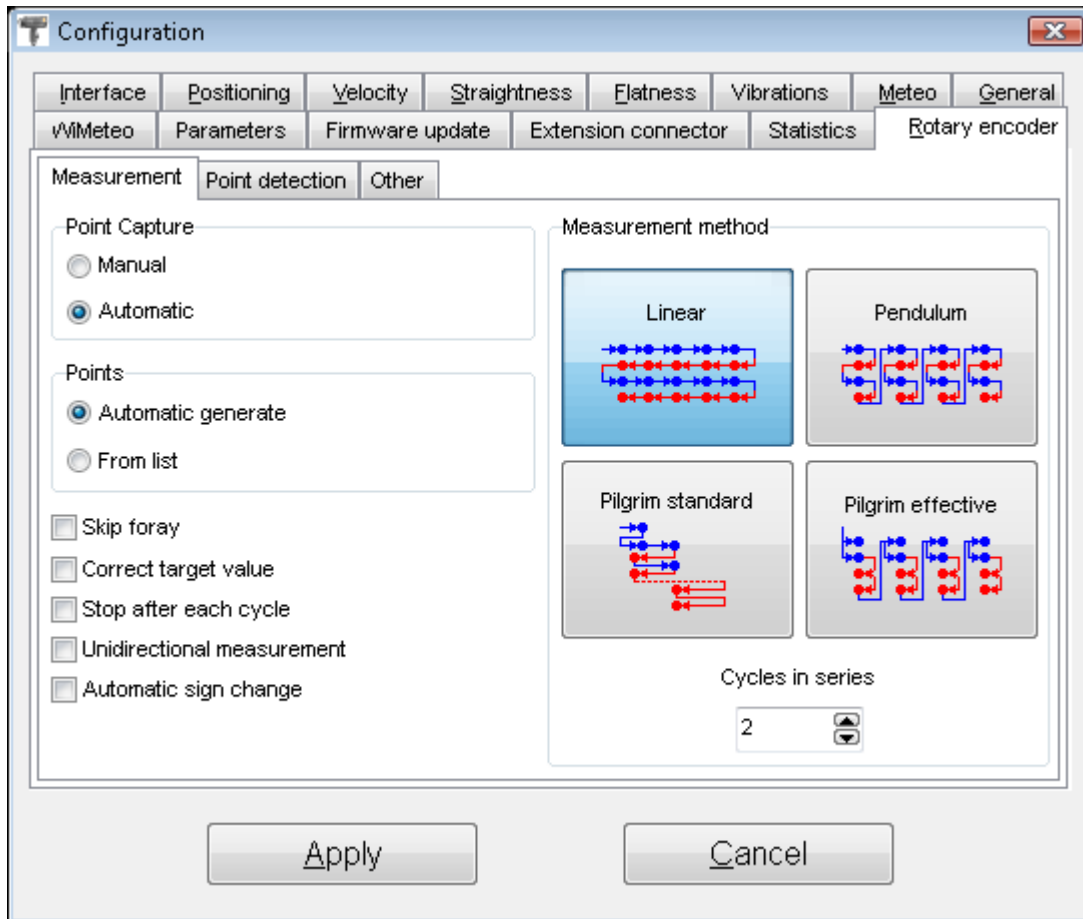


FIG.14.11. POSITIONING POINTS GENERATION WINDOW

vii. Configuration of Positioning measurement

In the **Rotary encoder** tab in the **Configuration** window the important parameters of the angular positioning measurements can be set (Fig. 14.12). There are four available methods for checking machine’s positioning: Linear, Pendulum, Pilgrim standard and Pilgrim effective (buttons in *Measurement method* panel).



14

FIG.14.12 LINEAR POSITIONING COFIG WINDOW

In the *Cycles in series* field the number of complete measurements cycles is set. The greater number of cycles is used the better result is achieved.

Max Acceptable Error is an option where the maximal acceptable error level is set. Above this limit, the software generates a warning.

Options **Point capture after** and **Vibrations** are valid only when the automatic point capture is chosen. These options are used to configure a time delay required by the machine to settle the position successfully and the acceptable level of

vibration (level of vibration depends mainly on the measured machine).

Min Points Interval configures minimal distance between positioning points.

viii. Pull down menu - Measurement

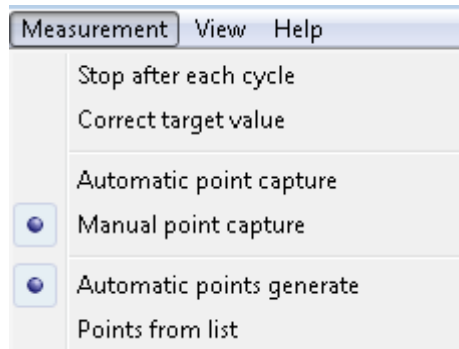


FIG.14.13. POSITIONING PULL-DOWN MENU MEASUREMENT

Measurement menu includes the options related to the measurement process:

Stop after each cycle – if this option is active program breaks the measurement when a measuring cycle is completed; if it is not active the configured number of cycles is executed.

Correct target value – setting this option enables to change an earlier defined distance value of a measuring point during the measurement process. Before the point is captured, appears a window in which a new distance value can be written. In the edit field there are only marked places after comma what causes that it is not necessary to write the whole distance.

Automatic point capture - program captures measurement points automatically using settings from *Configuration*. In this mode the system itself recognizes the moment of stop, the value of target point, the direction of movement and the series number. Option exclusive with “Manual point capture”.

Manual point capture - measured points are captured by the program when a **Manual Capture** button, *Space* key or a remote *Strobe* button is pressed. Option exclusive with “Automatic point capture”.

Automatic points generate - positioning points are calculated automatically by the program. Points calculation is performed in first measuring cycle. Option exclusive with “Points from list”.

Points from list - when this option is selected on the screen appears a window for positioning points edition. This window enables to write or calculate distance values for positioning points which are compared to measured points during positioning measurement. Option exclusive with “Automatic points generate”.

14

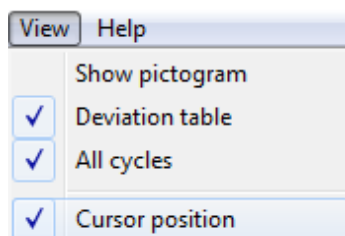


FIG.14.14. POSITIONING PULL-DOWN MENU VIEW

View menu is used to switch on or off a **Deviation table** and to switch on schematic diagram of selected measurement method.

d. Measurement procedure

If the system is ready to work, then two digital displays and the gauge of measuring signal level appear on the screen. On the upper display the measured value is shown. On the bottom display the value of the target position (read from data points table or appointed automatically) is shown. Under the displays on the left side there is shown a graph on which the results of measurements are shown. On the right side an **Error Table** can be found. Under the graph three buttons can be found: **Start** - begins the measurement, **Reset Position** - resets the measured value and the button **Main Menu** - re-enters to the Main menu.

In the bottom part of the window a status bar can be found which presents a configuration of the positioning measurements. In the first field the information about the points capture method is placed (manual or automatic). The next field informs about number of cycles in series (number of cycles executed one after one, if not active is the option **Stop After Cycle**). In the third field there is shown the information about measurement method selected in the **Configuration**.

14

The angular positioning measurement requires target positions which define the points where positioning errors are calculated. The target points can be automatically defined during the first cycle in the measurement, or manually written to the list or calculated (**Target Points From List**). Points are detected with 1 degree tolerance in automatic mode. In case of manual mode accuracy is also defined.

During the measurement points can be captured automatically or manually as described earlier in this chapter.

i. Rules of automatic positioning measurement

For correct operation of the automatic positioning measurement option below rules should be followed:

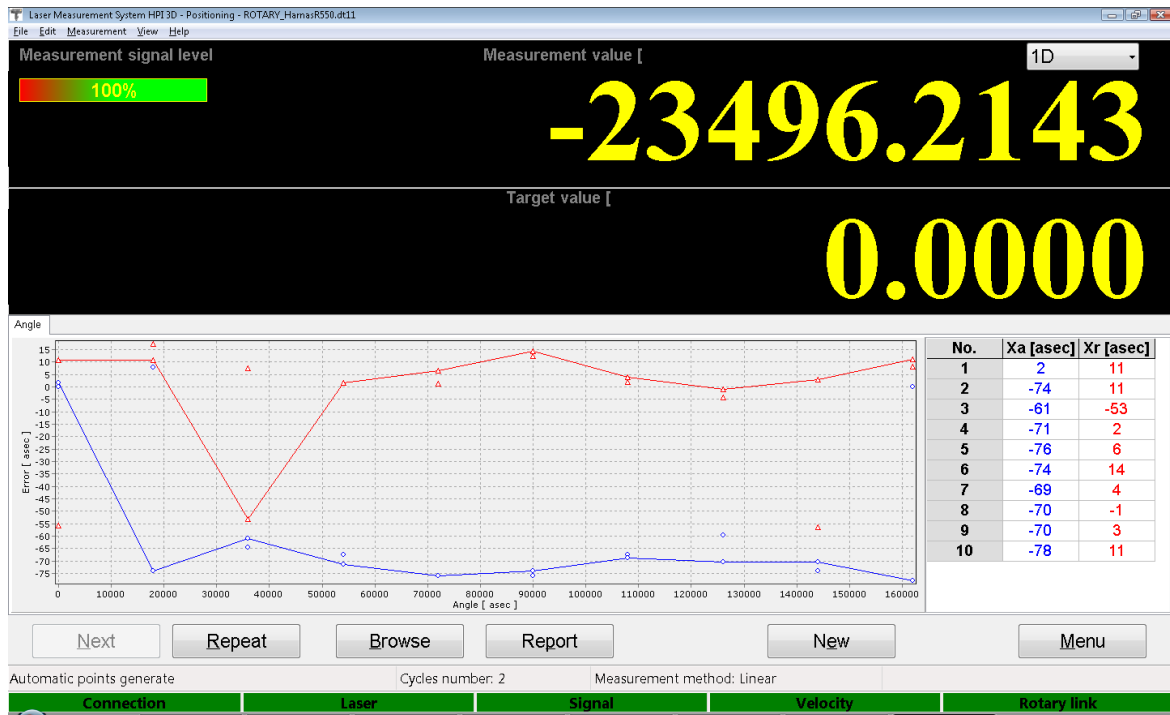
1) The time of machine stand still duration in the positioning point must be no less than 10 second – default value (this can be changed in the *Configuration->Positioning->Point detection->Point capture after*),

2) Vibrations of the target should be less than 10 arcsec - default value (this can be changed in the *Configuration->Positioning->Point detection->Vibrations less than*),

3) Backlash compensation move of the machine should exceed 1 arcmin.

If vibrations are too large and system does not capture points, the option Manual Capture should be switched on in the Measurement menu.

ii. Remarks on measurements and data analysis



14

FIG.11.15. POSITIONING WINDOW AFTER FINISHING A FULL MEASUREMENT CYCLE

Examination of angular positioning of machine consists of at least 2 measuring cycles.

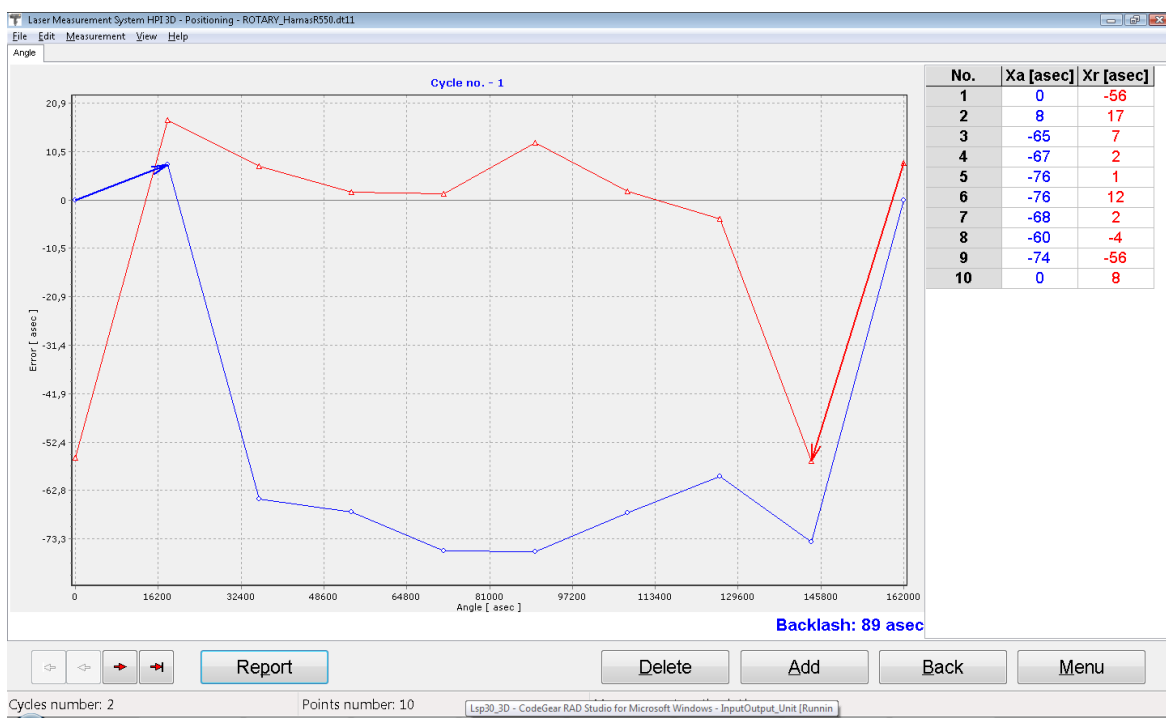
In every cycle the measured machine rotates the retro-reflector for programmed distance clockwise and counterclockwise.

After each rotation the machine should stop for a short time (at least one second).

The measured angle by the laser system is saved in the table of results.

After one cycle, if **Stop after each cycle** is set or after the whole measurement process, the window with results appears (figure 14.15).

Buttons **Remove** and **Add** can be used to remove or add the measurement cycle. It is possible to change the measuring cycle in which accidental error is possible. **Browse** button opens data browsing window (figure 14.16) where each data cycle can be viewed and analyzed.



14

FIG.14.16. DATA BROWSING WINDOW

Both from main positioning window and from data browsing window the measurement report can be generated. If at least two series of measuring cycles are completed, statistical calculations can be performed and the report can be generated. In order to get the final report the **Report** button has

to be pressed. The screen of the computer after pressing the **Report** button is presented in fig. 14.17.

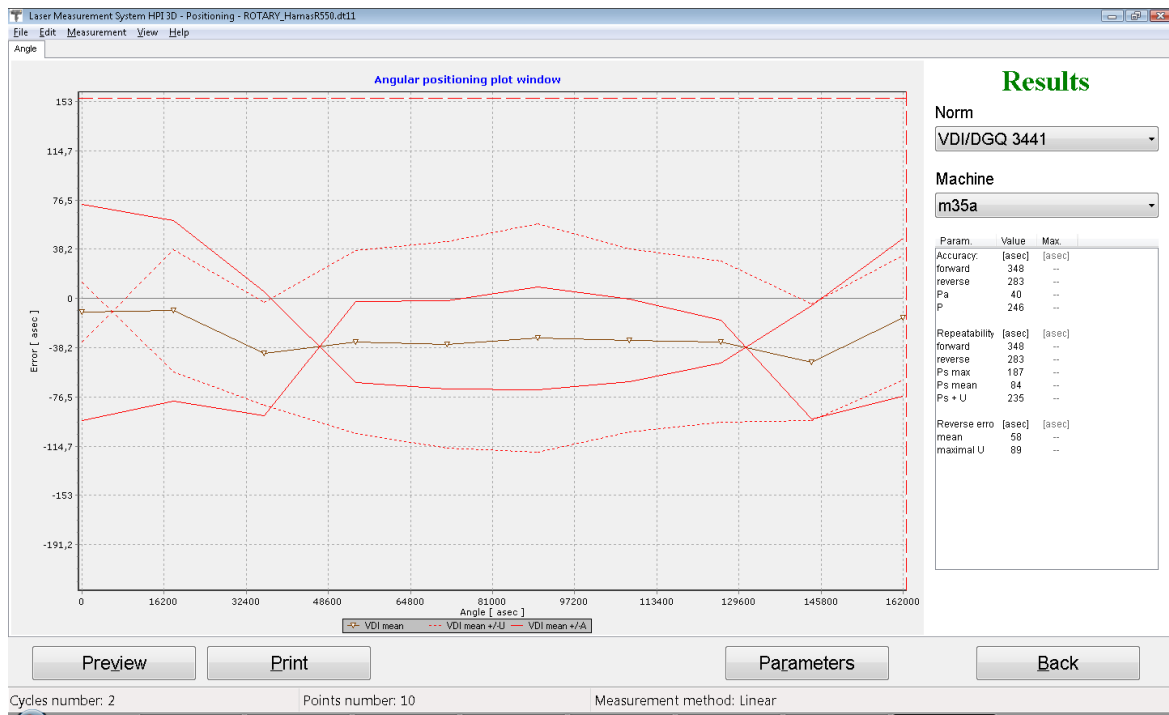


FIG.14.17. ANGULAR POSITIONING REPORT WINDOW

14

The positioning results are presented on the graph and in the **Results** panel. This panel is also used to set measurement data processing parameters. The norm defines a statistical method used in calculations and can be chosen from a pull-down list. Norm selection causes recalculation of the results. Limit values for measured machine parameters are presented in this panel. They are assigned to the machine that is chosen from **Machine** pull-down list. If the error value exceeds limits for the machine, this error is displayed in red.

Under the graph there are: buttons used for report **Preview**, **Print** the report, change of the graph **Parameters**, and return to the previous window.

The axis scale can be changed using **Axis Scale** (automatic scaling or assignment, minimum and maximum values) option available by right mouse click on the graph.

The report can be generated in a simplified or an extended form. The selection window is shown each time the **Preview** or **Print** buttons is pressed. The simplified version consists of three pages: the title page, the results page and the chart page. The logo on the title page can be changed in the **Configuration**. In the Extended Report additional pages with measurement results are added. The number of additional pages depends on the number of measurement points.

14