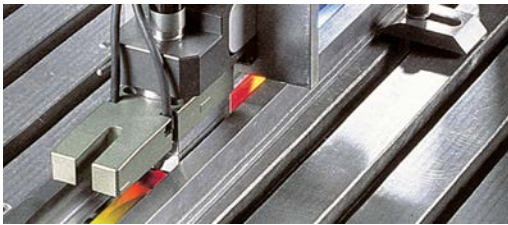




# HEIDENHAIN



User's Manual

## ACCOM

English (en)  
8/2015

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## Introduction

### Foreword

The efficiency of a machine tool from the point of view of dimensional accuracy or surface definition etc. depends to a large degree on the dynamic and static accuracy of the machine tool.

In precision machining it is therefore vital to be able to measure and, if necessary, compensate static and dynamic error.

Guidelines and standards for inspecting machine tools (ISO 230-2, ISO 230-3, ISO 230-4, German VDI/DGQ guideline 3441 and ISO 10791-6 K2 and K3) describe a number of measuring methods for determining dynamic and static error.

**Machine tool builders** use the results of machine measurements to develop constructive measures for improving accuracy. Such measurements also help them to optimize the commissioning parameters of the control loop wherever they influence the accuracy of a CNC machine.

**Machine tool users** need the results of machine measurements for acceptance testing and regular accuracy inspection of their machines.

### Dynamic measurements

Dynamic measurements, particularly for high traversing speeds, provide information on contouring behavior that permits conclusions both on the condition of the machine tool and on the parameter settings of the control loops (consisting of CNC control, drives and position feedback systems).

#### • Circular interpolation test with the KGM and DBB 110

In the circular interpolation test, the CNC control performs a circular interpolation in the working plane.

The **KGM Grid Encoder** measures the actual path of traverse. From this information, the **ACCOM** evaluation software determines deviations from an ideal circular path and displays them as a motion error trace on the screen. It also calculates the numerical values such as circular error, hysteresis and radial error according to ISO 230-4.

The **DBB 110 Double Ball Bar with integrated linear encoder** directly measures the radius changes in a circular machine movement.

The results of circular interpolation tests with large radii (e.g. with the **DBB 110**) provide information on the machine geometry.

On the other hand, circular interpolation tests with small radii (e.g. with the **KGM**) provide information on the accuracy of the control under high axis acceleration. The influence of the machine geometry on the result of measurement is insignificant. The control and drives, however, have a strong effect.

- **Free-form test with the KGM**

In the free-form test, the CNC control moves the machine axes in a plane on any programmed path. The **corner test**, for example, provides information on the dynamics of the position control loops with respect to overshoot and the resulting rounding error. Free-form tests can be conducted only with the **KGM** grid encoder.

Special free-form contours can be evaluated according to ISO 10791-6 K2—Feeds and K3—Interpolation.

- **Step response test with the KGM and VM 182**

The step response test can be used to measure the overshoot behavior in an axis (step-response function) and provide information on the influence of static friction and the accuracy with which positions can be held. This test is also intended for high-precision tasks requiring increments of as small as 0.1  $\mu\text{m}$  to 0.01  $\mu\text{m}$ . Step response test with can be performed with the **KGM** grid encoder or the **VM 182**.



## Static measurements

Static measurements, such as the measurement of position error in the linear axes using a comparator system, permit conclusions exclusively on the geometric accuracy of the machine.

- **Measuring the static positioning accuracy and guideway error with the KGM and the VM 182**

The positioning accuracy and repeatability of a machine tool is measured statically after the machine axis has been moved to certain positions. Besides the positioning accuracy, these devices also measure the guideway error perpendicular to the direction of machine tool traverse. The **KGM** can inspect accuracy in two axes within traverses up to 230 mm; the **VM 182** can inspect larger traverses up to 1520 mm parallel to one axis.

- **Measuring the static positioning accuracy with an angle encoder, such as the RON 905, RPN880, RON880 or the ROD 880**

The positioning accuracy and repeatability of a machine tool is measured statically after the machine axis has been moved to certain positions.

## Items supplied with the ACCOM evaluation software for PCs

The PC evaluation software ACCOM consists of:

- One setup CD
- One hardware key (Id. Nr. 590255-01 or 590255-02) to be plugged into a free USB interface

## General conditions for use of the software

- By paying the purchase price, the purchaser does not acquire the program itself but only a temporally unlimited right to use the program.
- The buyer is permitted to make copies of the CD only for backup purposes and to copy it to a hard disk. It is prohibited to sell such copies to a third party.  
All rights of possession are retained by the manufacturer.
- The transfer of the right to use the program to a third party requires the express written consent of the manufacturer.  
The transfer cancels the right of use for the original buyer. All backup copies must either be given along with the originals or destroyed without delay, and the manufacturer must be informed of this accordingly.
- The manufacturer is not responsible for damages of any kind that might result from the use of this program.

# Introduction

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## Hardware and operating system

- PC/Notebook as of Pentium III 1 GHz (or higher) with 256 MB RAM (XP), one free USB port and optional one Ethernet port.
- Windows 7/8 / Vista / XP / 2000 operating system (The PC hardware requirements for Windows 7/8 / Vista are much higher than for ACCOM.) Windows 7/8 64Bit operating system is supported as well.
- Approx. 18 MB free space on the hard disk
- To enable the PC to process measured values, the **EIB 741** or **IK 220** counter card for PCs must be installed according to the User's Manual. You need a separate Ethernet port for the **EIB 741**.



Ensure that the screen saver and energy savings functions are deactivated.

### Note

**ACCOM** can be operated either with the mouse or the keyboard.

## Installation

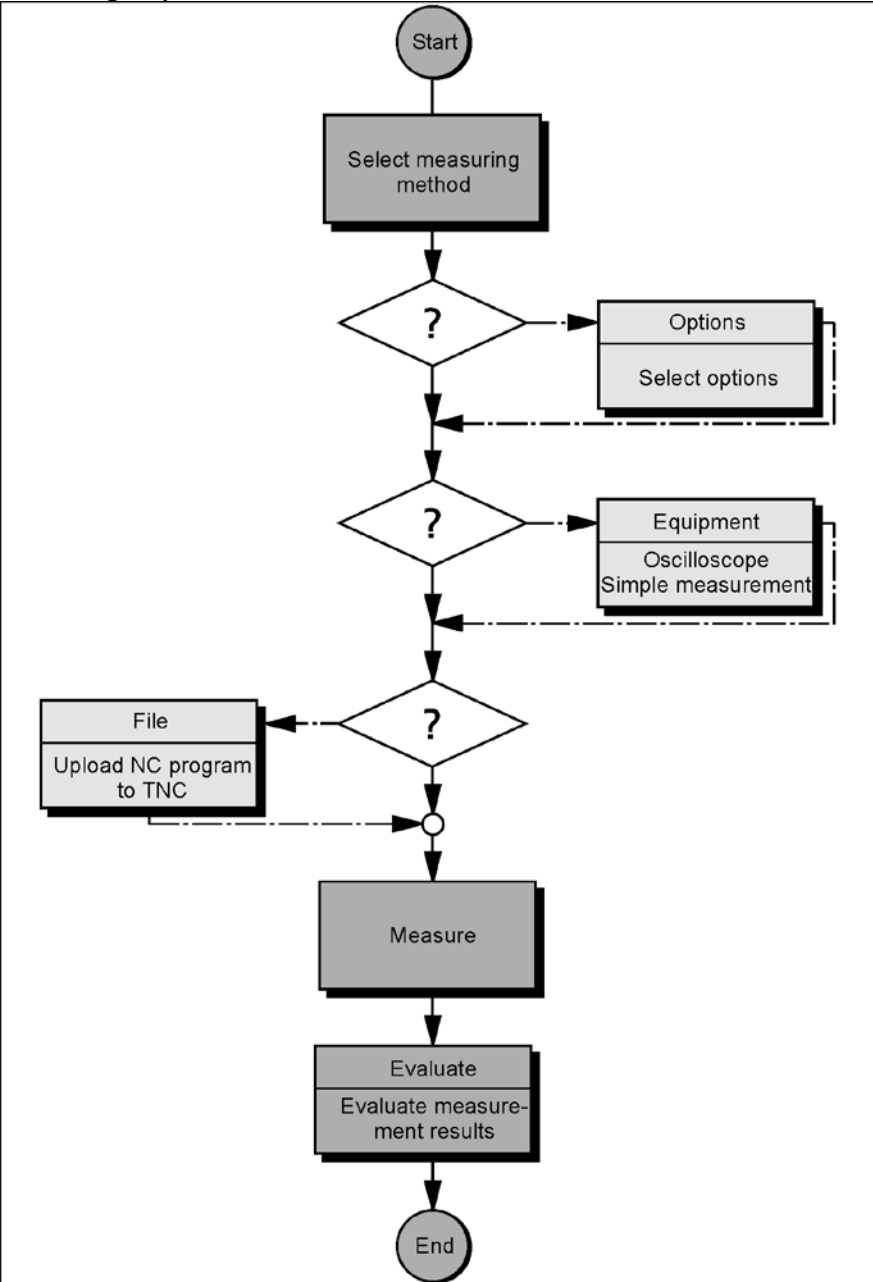
To install the **ACCOM** evaluation software on the hard disk of your PC, take the following steps:

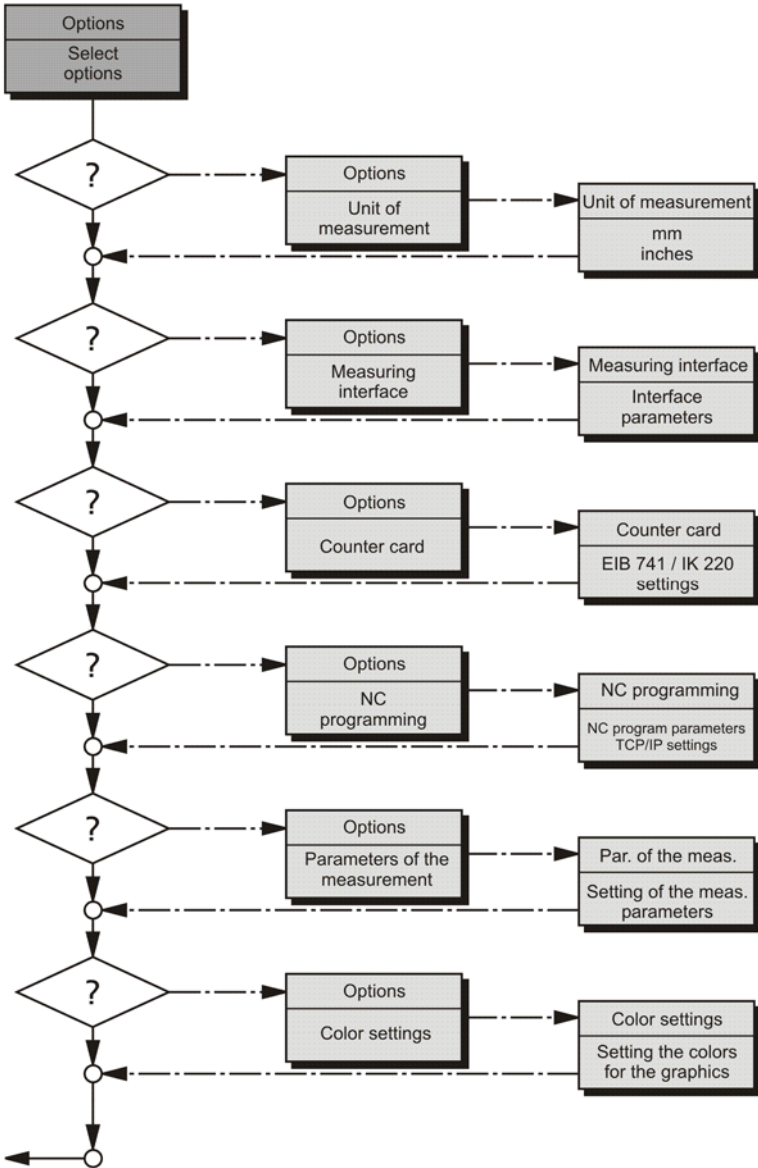
- Insert the CD in the drive. The setup program should start automatically (setup.exe can also be started from the Windows Explorer).
- Select the language and follow the instructions on the screen. The program is installed in the folder that you select. An **ACCOM** program group is created which includes the link symbol for the application.
- The driver for the hardware key must be installed separately. Click the hardware-key icon in the setup window.
- Install the driver for the **IK 220** according to the User's Manual. The **IK 220** driver for Windows 7/8 / Vista is part of the ACCOM CD.

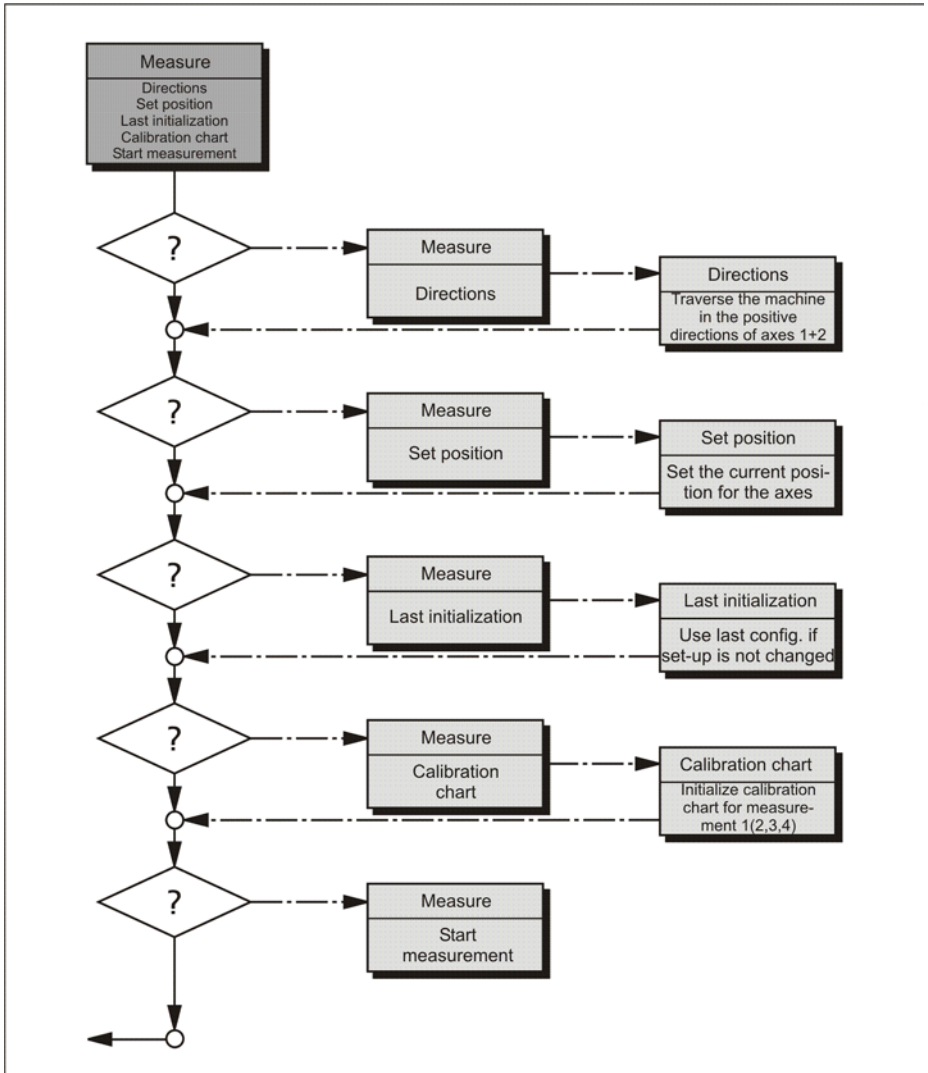
### Note

If you would like to put the link icon on the desktop (opening screen of Windows), click a free space on the screen with the right mouse key and use *New > Link* to make the program icon.

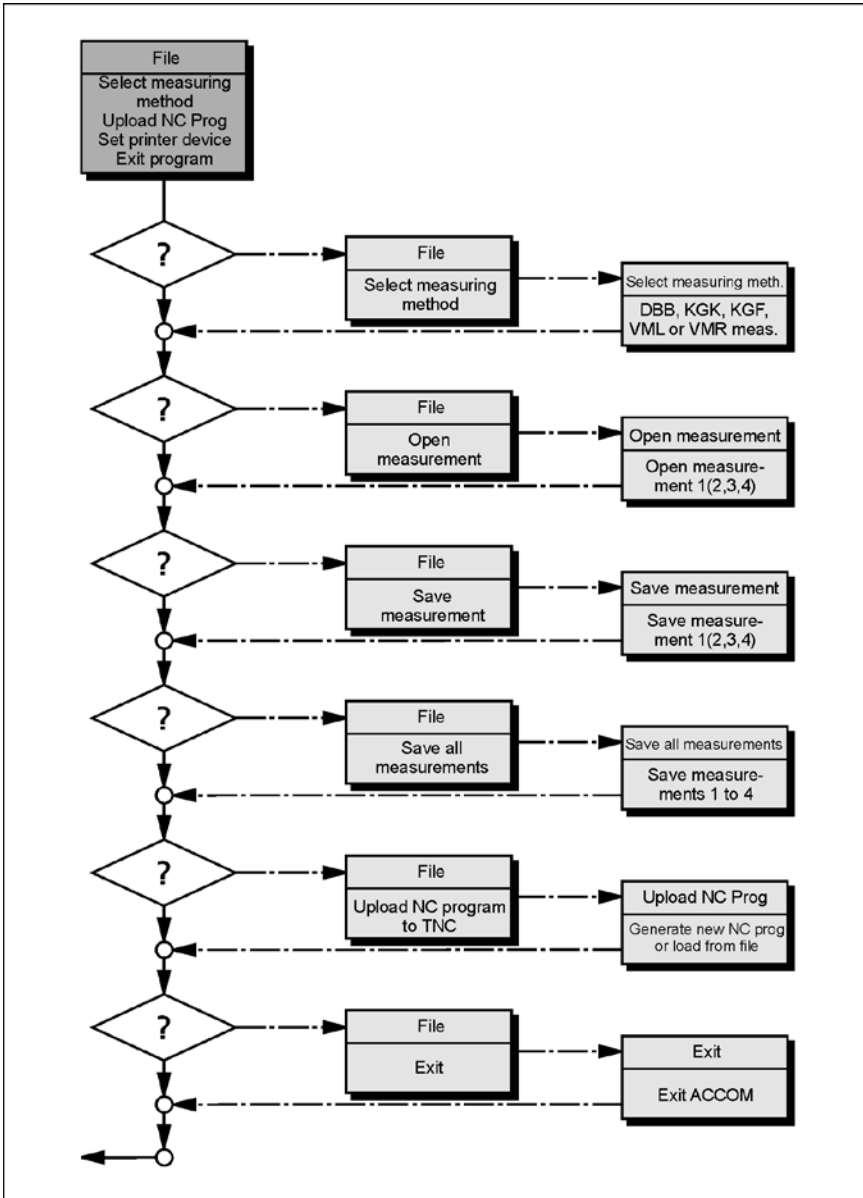
Measuring sequence





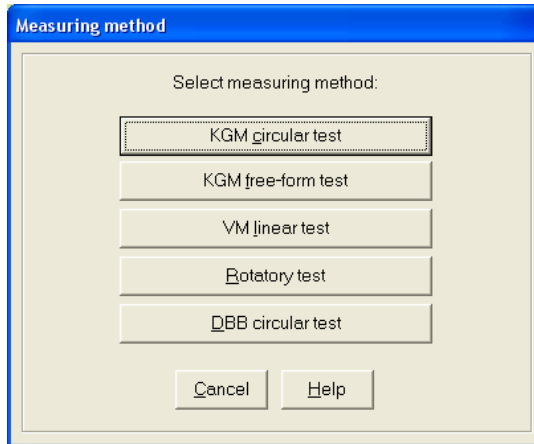


# Introduction



## ACCOM program start

- Open the **ACCOM** window in the program manage
- Click twice on the **ACCOM** symbol



## Select measuring method

- KGM circular test** Here you can select a circular test measurement using the **KGM 181** with measuring radii of 1  $\mu\text{m}$  to 60 mm, or the **KGM 182** with measuring radii of 1  $\mu\text{m}$  to 110 mm. This measurement is calculated and evaluated according to the internationally valid standard ISO 230-4.
- KGM free-form test** Here you select a free-form test with the **KGM 181** or **KGM 182**. A free-form test enables you to program and then measure any contour, for example a simulated NAS workpiece in a plane. In addition, you can enter and evaluate two special free-form contours according to ISO 10791-6 for the measurement of feed accuracy (K2) and the interpolation of two axes (K3).
- VM linear test** Here you select a linear measurement using the **VM 101**, **VM 182**, **KGM 181** or **KGM 182**. This measurement can determine the static positioning accuracy of a machine. It ascertains and calculates positioning accuracy according to the internationally valid standard ISO 230-2, ISO 230-3 or the German national standard VDI/DGQ 3441.

# Introduction

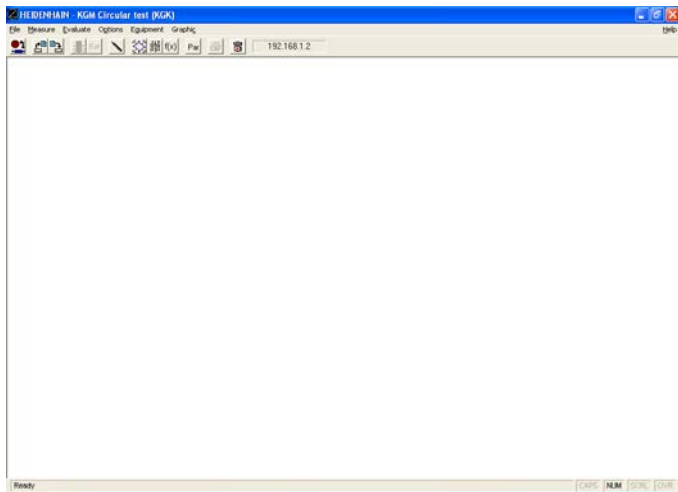
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**Rotatory test** Here you select a rotatory measurement using with a HEIDNEHAIN angular encoder, e.g. a **RON 905**, a **RPN 886**, a **RON 886** or a **ROD 880**. This measurement can determine the static positioning accuracy of rotary axes. It ascertains and calculates positioning accuracy according to the internationally valid standard ISO 230-2, ISO 230-3 or the German national standard VDI/DGQ 3441.

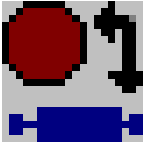
**DBB circular test** Here you select a circular test with the **DBB 110** for radii of 150 to 350 mm. This measurement is calculated and evaluated according to the internationally valid standard ISO 230-4.

## Home window—description of the symbols

In the home window of the **ACCOM** user interface you can select the functions of **ACCOM** in the menu bar through “pull-down menus,” or select the most frequently needed functions directly in the toolbar.



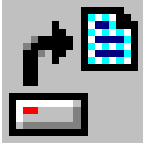




## Select Measuring Method

Here you can select from among the individual measuring methods.

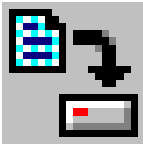
*(File > Select measuring method)*



## Open Measurement

Here you can directly call up measurements (all measuring methods) that have been saved.

*(File > Open measurement)*



## Saving a measurement

Here you can save measurements (all measuring methods) as files.

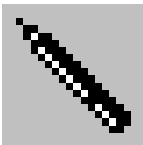
*(File > Save measurement)*



## Print

Here you can print the active graphic or the active evaluation window (all measuring methods).

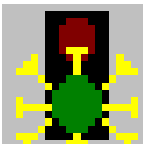
*(File > Print)*



## Calibration chart

Here you can select a calibration chart (all measuring methods) for measurement of individual entries.

*(Measure > Calibration chart)*



## Start measurement

Here you can start a measurement (all measuring methods).

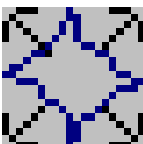
*(Measure > Start measurement)*



## Start measurement

Here you can start a measurement series (KGM—measuring method).

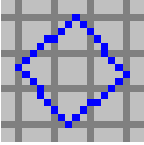
*(Measure > Start series of measurements)*



## Configuring the graphics for KGM circular tests using DBB and KGM

Here you can select the menu for configuring the graphics during circular measurements using the **DBB 110** or **KGM**.

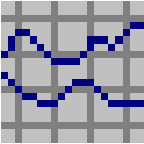
*(Evaluate > Graphic)*



## Configuring the graphics for KGM free-form measurements using the KGM

Here you can select the menu for configuring the graphics during free-form measurements using the **KGM**.

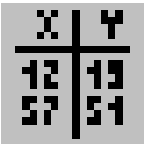
*(Evaluate > Graphic)*



## Configuring the graphics for VML linear tests using KGM and VM

Here you can select the menu for configuring the graphics during VM linear measurements using the **VM** or **KGM**.

*(Evaluate > Graphic)*



## Select raw data

Here you can select the raw data (all measuring methods) of the recorded measurements. In the raw data ACCOM shows the X/Y position values of the recorded measurement.

*(Evaluate > Raw data)*



## Select characteristic data

Here you can select the characteristic data (DBB, KGK, VML measuring methods and the ISO 10791-6 measurements in KGF) of the recorded measurements. The characteristics also show calculations according to international standards.

*(Evaluate > Characteristic data)*



## Parameters of measurement

Here you can select or change the parameters of the measurement (all measuring methods).

*(Options > Parameters of measurement)*



## Connect the EIB 741

Here you can connect the **EIB 741** via TCP/IP.

*(Options > Counter card > Connect)*

## Measuring Procedure for KGM Circular Test (KGK)

### Machine cleaning

→ Before beginning to mount the **KGM**, clean the area of the machine tool in which the measurements are made. Pay special attention to any chips and oil or grease residue that could fall onto the encoder.



Give the encoder time to adjust to the ambient temperature before you begin mounting it. This will help to prevent thermally induced error.

### Test program

To best enable the software to calculate and assign all error, a circular test should include at least one complete circle in positive direction and one in negative direction (see ISO 230-4). With HEIDENHAIN controls, the machine program can be transferred directly from **ACCOM**. For non-HEIDENHAIN controls, a typical test program could be as follows, whereby movement must be measured only in the measuring plane.

**Part 1, positive direction:** Motion without interruption from the circle center to the circumference at 0°, then a closed circular movement over 720° in counterclockwise direction, then back to the circle center, followed by 10 seconds wait if it is a series of measurements. For single measurements, the spindle stops instead of waiting, and you must save the results between measurements.

**Part 2, negative direction:** Motion without interruption from the circle center to the circle circumference at 0°, then a closed circular movement over 720° in clockwise direction followed by movement back to the circle center, where the spindle stops.

## Measuring Procedure for KGK

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Ensure that there are no “forgotten” compensation data saved in the control that could cause a movement perpendicular to the encoder or corrupt the measurement. The spindle must not rotate. If necessary, ask your machine tool builder how it can be fixed. You might try running the machine program without the encoder.

### Measuring assembly

→ Ensure that the **IK 220** PC counter card was installed in your PC according to the instructions in the User’s Manual. Alternatively you can use the **EIB 741**. Please ensure an available peer-to-peer network connection to the **EIB 741** (address and subnet mask of the TCP/IP connection). Now mount the **KGM** according to the instructions in the manual. Do not use any screws for mounting whose heads project above the height of the cross grid!



When connecting the measuring cables, be sure to leave enough slack to compensate any machine movement during measurement.

→ **Before starting ACCOM**, connect the enclosed hardware key with Id. No. 590255-01 or 590255-02 to one free USB port.

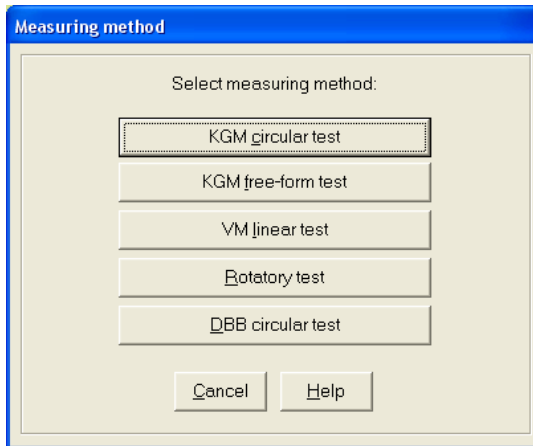
After calling **ACCOM**, proceed as follows:

## 1. Select measuring method

After **ACCOM** is started, a dialog box appears in which you can select the type of measurement.

→ Click the **KGK circular test** button to start the corresponding program part.

With the menu item *File > Select measuring method* or by clicking the icon you can select the individual measuring methods from within the running program.

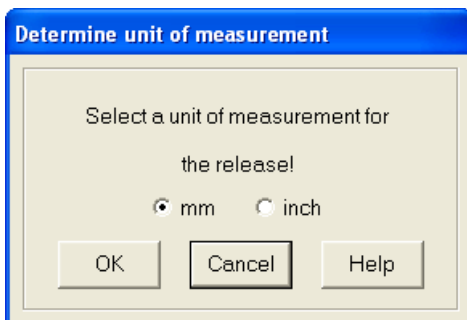


## Measuring Procedure for KGK

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### 2. Specifying the unit of measure

→ With the menu item *Options > Unit of measurement* you specify the desired unit of measure. Close the dialog box with **OK**.

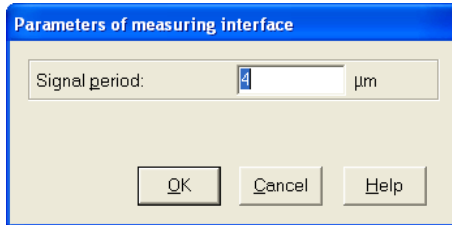


## 3. Settings of the encoder and the counter card

→ Under *Options > Measuring interface* you set the parameters for the encoder used.

- **Signal period:** Here you set the signal period (as its distance in  $\mu\text{m}$ ) of the encoder you are using. The default setting for the signal period is 4  $\mu\text{m}$ .

Input range: 0.1 to 20  $\mu\text{m}$



→ Under *Options > Counter card* you set the parameters for the PC counter card.

- **Type counter card:** Here you select the model of counter card that you are using.

- **Signal input:** Here you select the type of measuring signal.

- **Address EIB 741:** Here you enter the IP address of the **EIB 741** (see also **EIB 741** user manual). Alternatively you may use the DHCP hostname in a company network. However it is not recommended due to the high data acquisition rate. This setting is not needed for the **IK 220**.

- **Automatic connection at program start:** ACCOM connect to the **EIB 741** at the next program start automatically if chosen. A valid connection to the **EIB 741** is required!

- **Test IK (IK 220 only):** Here you can then test the counter card for proper function.

- **Connect/Disconnect (EIB 741 only):** The **EIB 741** will be connected or disconnected here.

**Counter card**

Type counter card:  IK220  EIB741

Signal input:  1Vpp  11  $\mu$ App

Address:

Automatic connection at program start



Ensure that you have entered the proper model, address and signal input of the counter card. If the signal period is entered incorrectly, the circles will be measured too large or too small.

### Note

**EIB 741 only:** Connect the **KGK** to the encoder inputs X11 and X12.



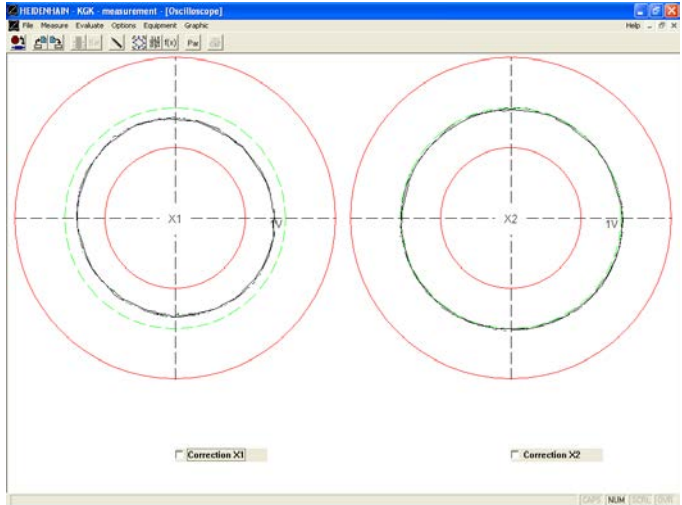
If you have problems receiving data from the counter card, use the test programs on the driver CD to check whether the counter card or external interface box can be used.



## 4. Fine adjustment of the measuring head

### Oscilloscope

→ With the menu item *Equipment > Oscilloscope* you can display the **KGK** measuring signals received by the PC counter card as Lissajous figures on the screen, which you need for the fine adjustment of the **KGK** (see mounting instructions of the **KGK**).



The measuring signals are displayed for the directions I and II in the oscilloscope display mode (for measuring signals 0° elec. and 90° elec.).

→ Move the machine tool slide slowly and evenly in diagonal direction. Use the adjusting screws on the measuring head to adjust the signal amplitude. In the ideal case, the measuring signal amplitude lies near the green circular path (1 V<sub>PP</sub>) between the red limit circles.

If the encoder signal is too large or small, the message **Amplitude too high / too low** appears in the status line of the **ACCOM** screen.

# Measuring Procedure for KGK

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## Optimizing the measuring signals

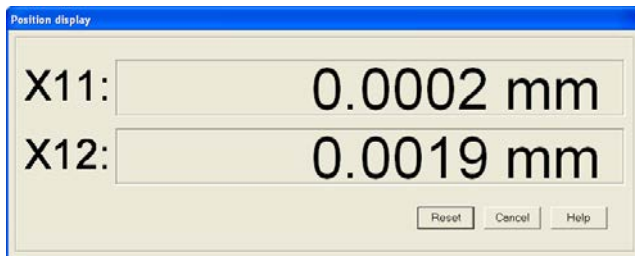
→ Through automatic signal adjustment, **ACCOM** can optimize the **measuring signals** to attain very high accuracy. Click the boxes **Compensation X1 (X11)** and **Compensation X2 (X12)** and move the machine slides slowly and evenly in diagonal direction. Then switch this function off by clicking both boxes Compensation X1 (X11) and Compensation X2 (X12) again, and go to the next item of the instructions. The **EIB 741** optimizes the analogue signals automatically. However, the optimized analogue signals are used only for the computation of the position values. Therefore it is possible to observe imperfect circular Lissajous figures.



If the displayed signal amplitude is too low, check whether the settings for the interface are correct and whether the encoder is correctly installed. Then start **ACCOM** again. Do not engage or disengage any connectors until you have exited **ACCOM**!

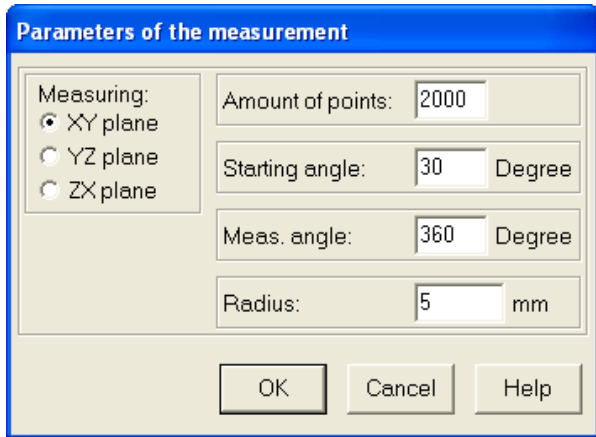
## Position display

→ With the menu item *Equipment > Position display* you can call the position display for the connected encoder and, for example, check the positive counting direction of the **KGK**. If you call this function after setting the position (see section 8, "Set datum"), before the test you should check again whether your datum is set correctly and, if not, enter it again.



## 5. Parameters of the measurement

→ By calling the menu item *Options > Parameters of the measurement* or by clicking the icon, you open the following dialog box in which you can adjust the **parameters of the measurement**.



- **Measuring plane:** The machine tool's working plane in which the measurement is to be made.

- **Amount of points:** Number of measuring points per measurement.

Input range: 36 to 8000 measuring points

- **Starting angle:** Here you enter the angle from which ACCOM is to begin the measurement.

Input range: 0 to 360 degrees

### Note

Since the orthogonality of the axes is measured at 45°, and the axis reversal movements occur at the quadrant transitions (0°, 90°, 180°, 270°), a **starting angle** of 30° is recommended.

- **Measuring angle:** Here you enter the angle over which the measurement is to be made.

Input range: 1 to 720 degrees

### Note

An angle of at least 360° is required for a complete calculated evaluation of a circular test.

- **Radius:** Here you enter the nominal radius of the circle.

Input range: 0.01 to 10 000 mm

0.0003937 to 3937 inches

→ Then conclude the input with **OK**.

# Measuring Procedure for KGK

## 6. Setting the NC interface

→ If you wish to transfer the measuring program in **ACCOM** to a HEIDENHAIN control, select *Options > NC programming* to open a dialog box in which you can configure the network connection.

Parameters for NC programming

Mode:  HEIDENHAIN conversational  
 HEIDENHAIN ISO  
 ISO format

Feed rate:  mm/min

Add feed rate to each block

Program name:

Decimal place:  1 µm  0.1 µm  
 10 nm  1 nm

Add M functions:

Add M functions to each block

TNC settings:

TCP/IP address:

- **Mode:** Choose between HEIDENHAIN or ISO format.
- **Feed rate:** Here you enter the nominal feed rate for the circular motion.  
Input range: 0.001 to 100 000 mm/min or  
0.000 04 to 3900 inches/min
- **Program name:** Here you give the program a name (the extension .H stands for HEIDENHAIN, .I stands for HEIDENHAIN ISO and .txt for general ISO).
- **Decimal place:** Select the decimal place of the NC programs.
- **M functions:** Here you enter additional M functions which are necessary to run the NC program on the control. The M functions are added to the first NC block.  
Example in HEIDENHAIN conversational programming:  
**2 L X0 F1000 M31**
- **TCP/IP address:** Here you enter the TCP/IP address or DHCP hostname of the control for the data transfer via network connection.

## G-Code options

→ By clicking the control button **Options** the following dialog box opens. Here you can configure some ISO format settings which are suitable to the control.

The image shows a screenshot of a software dialog box titled "Parameters for NC programming". The dialog is divided into two main sections. The top section, "GCode import options", contains several settings: "Mode" with radio buttons for "HEIDENHAIN conversational", "HEIDENHAIN ISO", and "ISO format" (which is selected); "Position (export)" with radio buttons for "Incremental" and "Absolute" (selected); "Circle center" with radio buttons for "Incremental" (selected) and "Absolute"; "Feedrate" with radio buttons for "Inch/min" (selected) and "0.1Inch/min"; and a checkbox for "Use G-Code G71/G70 for MM/Inch:" which is unchecked. Below these are "OK", "Cancel", and "Help" buttons. The bottom section, "Additional lines at program start:", has a text input field containing "G54". Below that, "Additional lines at program end:" has a text input field containing "M30". This section also has "OK", "Cancel", and "Help" buttons.

- **Position (export only):** This parameter is used in the export of an ISO NC program only. For absolute positions G90 is added at the NC program start, for incremental positions G91 is used. For absolute programming it is useful to add a datum shift (e.g. G54).
- **Circle center:** The input of the circle center point acc. to the German standard DIN 66025 is done incremental to the last position or absolute. Usually I, J, K are used with incremental positions. Valid is also an absolute position with I, J, K. (depends on the control).
- **Feed rate:** This parameter is only valid for an INCH program. The feed rate can be set in Inch/Min or Inch/10Min (HEIDENHAIN default).
- **G-code for Inch/MM:** You can choose whether to use G71/G70 for NC programs or not.

# Measuring Procedure for KGK

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In the dialog box **Parameters for NC-programming** you may add the following data for the ISO format programming:

- **Additional lines at program start:** Here you can add 2 user or control specific lines at program start (e.g. G54).
- **Additional lines at program end:** Here you can add 2 user or control specific lines at program end (e.g. M30).

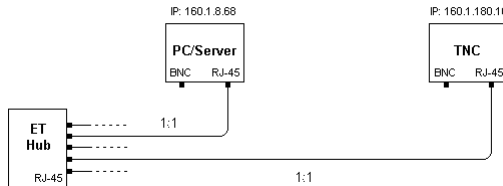
## Network cable

Connect the TNC by a (crossed) network cable directly to the PC or by using a standard network cable with a hub or a switch to the company network.

## Note

Peer-to-peer (direct connection): You need to set the IP-Address of the PC in *Control Panel / Network / TCP-IP / Properties* (depends on the operating system). As default the value for the IP-Address will be given automatically in a company network (from the DHCP Server).

## LAN (Network) with a 1:1 cable



## Peer-to-peer (direct connection) with a (crossed) cable!



## 7. Setting the Direction

→ Before the first measurement with the **KGM**, **ACCOM** must know the positive counting direction of each axis as well as the angular position of the **KGM** on the machine table. In the menu item *Measure > Directions*, **ACCOM** prompts you to move the machine slides in sequence in the direction shown in the dialog box. The directions depend on the setting of the measuring plane (see positive direction I and II on the **KGM**). The required accuracy data is calculated from the signals of the encoder (channel assignment, counting direction and angular position).



### Note

You can specify which traverse path is to be used to detect the first direction and, at the same time, the angular position. The larger the path, the more accurate is the angular position. For very high accuracy requirements you can use the entire maximum available traverse on the **KGM**. The traverse path for the second direction is set to 0.1mm and is used only to get the direction of the second machine axis.



During the **directional detection**, do **not** move the machine tool slide in a **diagonal direction**. Otherwise the detected angular position will be incorrect.

# Measuring Procedure for KGK

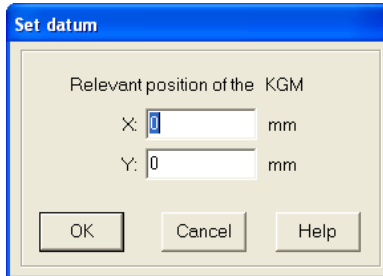
---

## 8. Set datum

→ In the menu item *Measure > Set datum* you assign **ACCOM** a position value in agreement with the control.

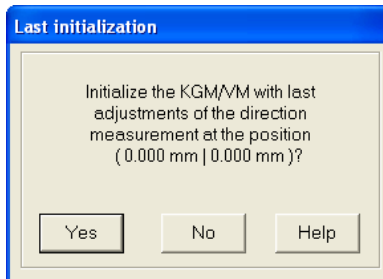
### Example:

If the spindle (scanning head) is located over the center of the **KGM** grid plate, you assign the coordinates X0 and Y0 to this position.



## Last initialization

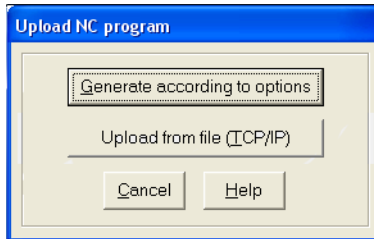
After you have started **ACCOM** you can use your previous settings by calling the menu item *Measure > Last initialization*, provided that the setup of the **KGM** on your machine has not changed and you move the scanning head to the position last set. Then continue with the next program item.





## 9. Generating and transferring an NC program for single measurement

→ If you wish to generate and transfer an NC program for single measurements (for measurement series see section 11a.1. “Edit Series of Measurements”), call the menu item *File > Upload NC program to TNC*, and select the form in which you would like to transfer the NC program.



- **Generate according to options:** This button calls a dialog box entitled *Generate NC program for measurement* in which you define the parameters for the NC program.
- **Load from file (TCP/IP):** In the TCP/IP operating mode, a finished NC program is transferred from the file system of your PC to the NC control by a network connection.

### Note

Alternatively you can use the HEIDENHAIN PC-Tool TNCRemo for the data transfer to the control.

# Measuring Procedure for KGK



**Generate NC-Program**

Mode:  HEIDENHAIN conversational  
 HEIDENHAIN ISO  ISO format

Feed rate: 5000 mm/min

Program name: TEST.H

Measuring plane:  XY  YZ  ZX

1st direction of rotation:    

Starting angle: 30 Degree

Measurement angle: 360 Degree

Radius: 5 mm

Save Cancel Help

Upload in: TCP/IP...

- **Mode:** Choose the format of the NC program.
- **Feed rate:** Enter here the nominal feed rate of motion.  
Input range: 0.001 to 100 000 mm/min  
0.000 04 to 3900 inches/min
- **Program name:** In TCP/IP mode you add the extension .H for HEIDENHAIN format or .I for ISO format to the NC program.
- **Measuring plane:** Click the working plane of the machine tool.
- **1. Direction of rotation:** Select the direction in which the first of the two circular movements defined by the control is to be made.
- **Starting angle:** Enter here the same starting angle as you did before under menu item *Parameters of measurement*.
- **Measurement angle:** Enter here the same measuring angle as you did before under menu item *Parameters of measurement*.
- **Radius:** Enter here the same radius as you did before under menu item *Parameters of measurement*.
- **Save:** Click to save the NC program.
- **Cancel:** Click to close the dialog box.
- **Upload:** Click to start the upload.

Now an NC program is generated for both directions of rotation and transferred in default settings to the root directory of the TNC. Data transfer via TCP/IP opens a new file dialog window, where you can select the target directory on the control.



The following prerequisites must be met for the correct execution of the NC program with two circular movements in opposite directions.

1. The datum of the NC program must match the datum defined in "Set datum."
2. The spindle head must be located at the datum when the program starts.



The TNC does not answer if the network is not connected.

# Measuring Procedure for KGK

## 10. Generating a calibration chart

→ Through the menu item *Measure > Calibration chart* or by clicking the icon you can define the calibration chart for the measurement by entering information on the measurements in the calibration window. By clicking **yes** or **no** you can specify whether the **chart window** will open automatically after each measurement.

**Calibration chart of measurement 1**

Customer:

Type of machine:

SrNo. /Year of mnt.:  /

Remark 1:

Remark 2:

Remark 3:

Inspector:

HEIDENHAIN Reference meas. system:

ID number:  Serial number:

Position of axis X:  mm

Position of axis Y:  mm

Position of axis Z:  mm

Position of axis IV:  mm

Position of axis V:  mm

Open chart window automatically after a measurement?  
 Yes  No

If you enter the chart data only for measurement 1, they will automatically apply also to the other measurements. The charts can also be saved or edited later in the course of evaluation. **ACCOM** saves these data together with the measured data and prints them through the menu items *Evaluate > Measured data*, *Evaluate > Characteristic data* and *Graphic > Print*.


## 11a.1. Edit series of measurements

→ If you would like to make **two or more measurements in sequence**, you can use *Measure > Edit series of measurements* to list a series of measurements that are performed together. In this case it is best to give the machine tool a break of approx. 10 sec. between the measurements in the series.

If you would like to make only **single measurements**, you can skip this section and go directly to section 11b of this Manual.

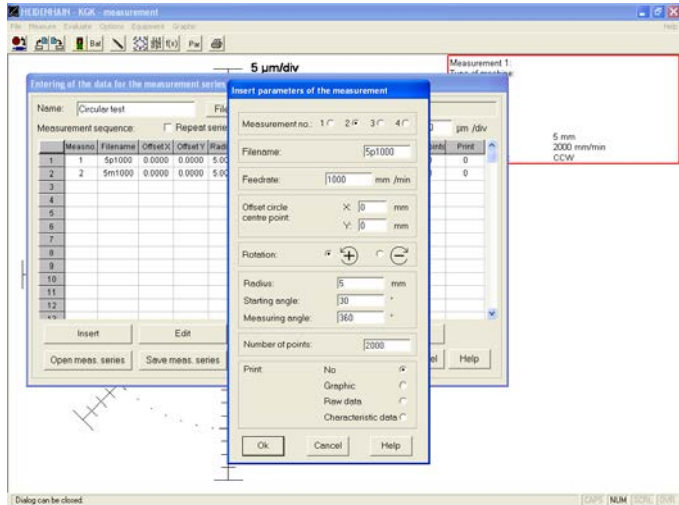
Measno	Filename	Offset X	Offset Y	Radius	Feedrate	Rotation	Startangle	Meas. angle	Meas. points	Print	
1	1	5p1000	0.0000	0.0000	5.000	1000.000	+	30	360	2000	0
2	2	5m1000	0.0000	0.0000	5.000	1000.000	-	30	360	2000	0
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											

- **Name:** Here you can enter a name.
- **Graphics:** Enter here the resolution for displaying the circular form. You can change the resolution at any time during the evaluation.

 When you change the resolution you also change the window for starting the measurement (criterion for start of measurement: nominal radius  $\pm 5 \times$  resolution).

- **Repeat series of measurements:** With this function you can repeat a series of measurement as often as desired and overwrite the old measuring data; this is intended for use, for example, in sales presentations and trade shows.
- **Insert:** After clicking this button you can specify the measuring parameters of the individual series of measurements and in this manner determine the automatic execution of the measurement program:

# Measuring Procedure for KGK



- **Measurement No.:** The measurement is displayed later under this number. In the subsequent graphic evaluation no more than four motion error traces can be displayed at once.
- **File name:** Each measuring line must be given its own name under which the results can then be automatically saved.
- **Feed rate:** Here you enter the nominal feed rate for the movement.  
Input range: 0.001 to 100 000 mm/min or 0.000 04 to 3900 inches/min
- **Offset of circle center:** Here you can shift the circle center with respect to the datum selected under *Set datum*.
- **Direction of rotation:** Here you enter the direction of rotation of the circle to be measured. For a complete computational evaluation of a circular test you always need two circles with equal radius and feed rate and opposite direction of rotation.
- **Radius:** Here you enter the nominal radius of the circle.  
Input range: 0.01 to 10 000 mm  
0.0003937 to 3937 inches
- **Starting angle:** The angle at which **ACCOM** starts to record the measurement. A start angle of 30° is recommended in order not to hamper the orthogonality measurement (at 45°) and the reversal motion of the machine axes (at 0°, 90°, 180°, 270°).  
Input range: 0 to 360°
- **Measuring angle:** Here you enter the angle over which the measurement is to be made. A complete computational evaluation requires at least 360°.  
Input range: 1 to 720°

- **Amount of points:** Number of measuring points per measurement.

Input range: 36 to 8000 measuring points

- **Print:** Here you can specify whether and in what form you wish to print the results between measurements.

You can always print the results after the measurements.

Choices:

**No printout**

**Graphic**

**Measurement data**

**Characteristic values**

→ You then confirm your entry with **OK**.

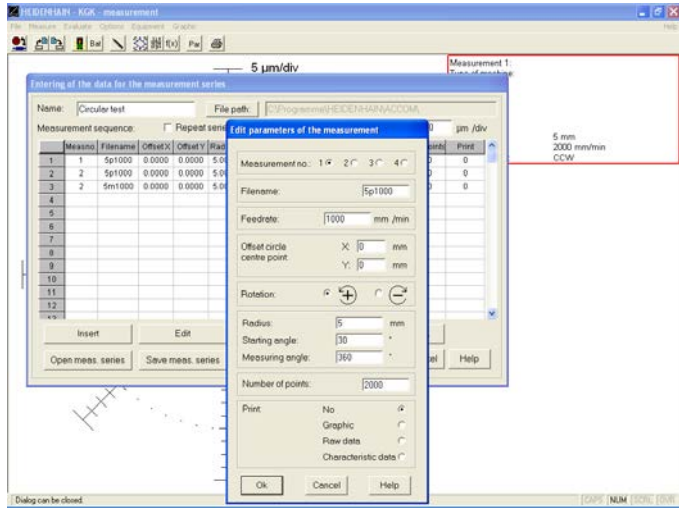
- **File path:** Select here the folder in which subsequent measurements are to be saved. Do not enter a file name here. You have already specified that in the single measurement.



The OK button of the dialog box remains disabled until you select the file path.

# Measuring Procedure for KGK

- **Edit:** This button calls the dialog box illustrated below in which you can edit existing parameters of measurement settings.



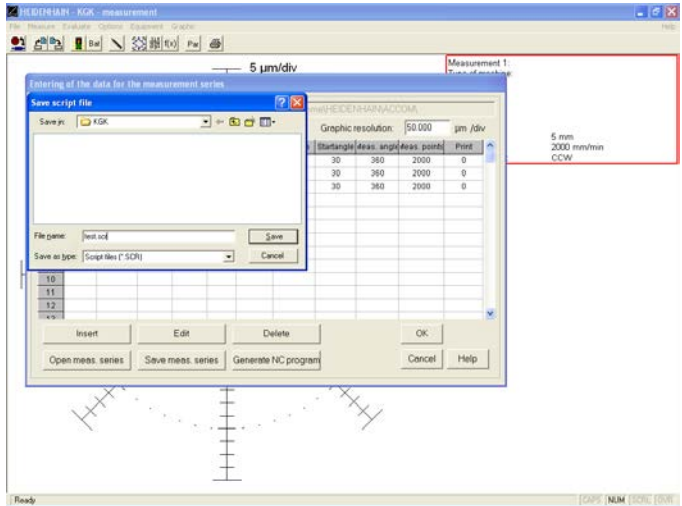
After editing the parameters, close the dialog box by clicking **OK**.

- **Delete:** To delete existing measurement settings, select the row and click this button.

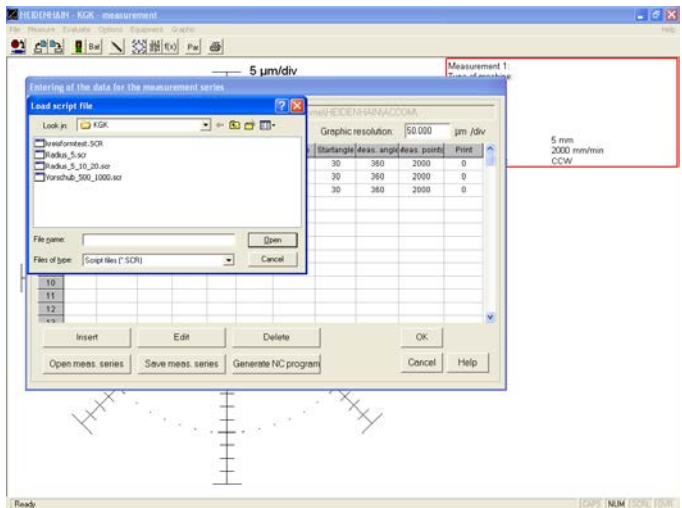


# Measuring Procedure for KGK

- **Save measuring script:** This button calls the following dialog box in which you can save the measurement series.



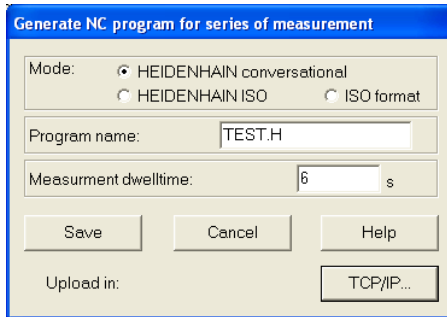
- **Open measuring script:** This button calls the following dialog box in which you call a file containing a measurement series.



## Measuring Procedure for KGK

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- **Generate NC program:** This button opens a dialog box in which you can generate an NC program for the series of measurements.



Generate NC program for series of measurement

Mode:  HEIDENHAIN conversational  
 HEIDENHAIN ISO  ISO format

Program name: TEST.H

Measurement dwelltime: 6 s

Save Cancel Help

Upload in: TCP/IP...

- **Mode:** Choose the format of the NC program.
- **Program name:** In TCP/IP mode you add the extension .H for HEIDENHAIN format or .I for ISO format to the NC program.
- **Measuring dwell time:** Here you enter the dwell time between the measurements.
- **Save:** Click to save the NC program.
- **Cancel:** Click to close the dialog box.
- **Transfer:** Click to start the upload.

Now an NC program is generated for the measurement series and transferred to the root directory of the TNC in the default setting. Data transfer via TCP/IP opens a new file dialog window, where you can select the target directory on the control.



The following prerequisites must be met for the correct execution of the NC program.

1. The datum of the NC program must match the datum defined in "Set datum."
2. The spindle head must be located at the datum when the program starts.



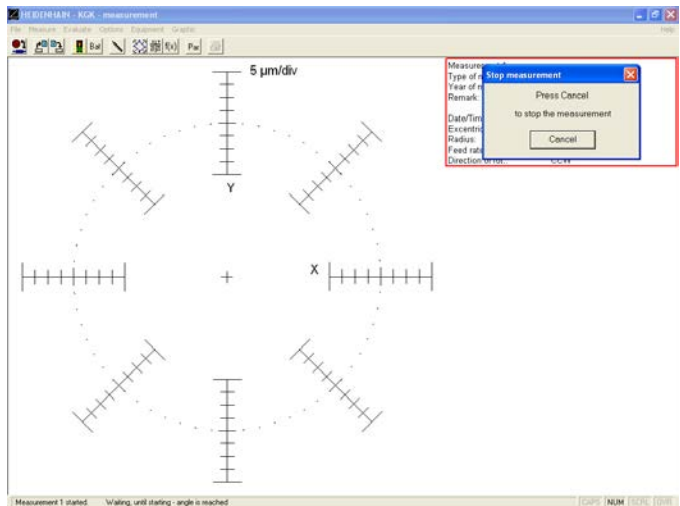
The TNC does not answer if the network is not connected.

→ When you have completed all entries, close the dialog box with **OK**.

## 11a.2. Start series of measurements

→ With the menu item *Measure > Start series of measurements* or by clicking the associated button you can now begin the measurement. **ACCOM** waits for the beginning of measurement. Start the program on the machine tool.

In the status line, **ACCOM** shows the condition of measurement. You can terminate the measurement at any time with **Cancel**. After the measurement has ended the results are saved automatically under the name of the measurement series in the file path that you have specified.







If **ACCOM** does not begin measuring although the circular movement was made on the machine tool, wait for a period of 15 to 30 seconds after the movement ends. If the menu item *Evaluate > Graphic > Representation* was set to *Center* or *Radius compensation* (see point 16, Graphic Display of Circular Test Results), there is no online display. If after some time there is no result, check whether the circle center, feed rate and radius of the NC program agree with the values specified in **ACCOM**. Pay special attention to any offset of the circle center.

## 11b. Start Single Measurement

→ If you want to take only individual measurements, select the menu item *Measure > Start measurement* or click the associated button to open a dialog box with which you can start measurements after entering the following parameters.

**KGM circular test**

Measurement 1  
 Measurement 2  
 Measurement 3  
 Measurement 4

Direction of rotation:  
   

Feed rate:  
 mm/min

Resolution:  
 µm/div

- **Measurement 1-4:** Click the number under which the measurement is to be shown later.
- **Direction of rotation:** Select here the direction of rotation for the circular movement.
- **Feed rate:** Enter here the nominal feed rate of motion.  
Input range:           0.001 to 100.000 mm/min  
                              0.000 04 to 3900 inches/min
- **Graphics:** Enter here the resolution for displaying the circular form. You can change the resolution at any time during the evaluation.

# Measuring Procedure for KGK

Input range: 0.1 to 10.000  $\mu\text{m}/\text{div}$ .  
0.000 04 to 0.4 inches/div.

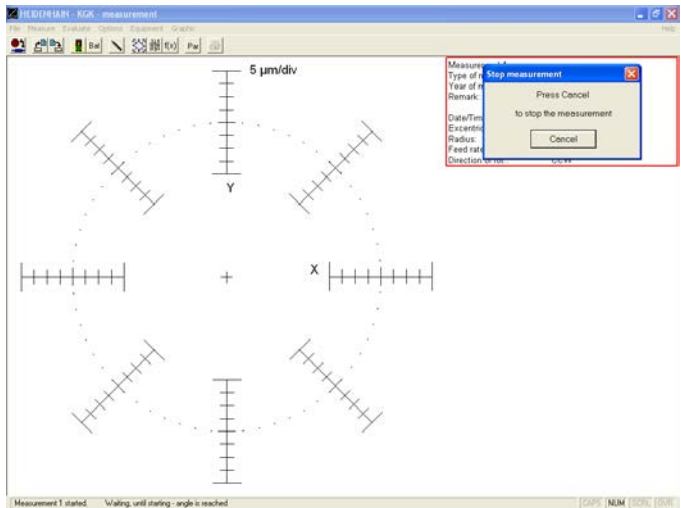


When you change the resolution you also change the window for starting the measurement (criterion for start of measurement: nominal radius  $\pm 10 \times$  resolution).

## Note

A complete circular test according to ISO 230-4 is supposed to include two complete circles of the same radius, center, and feed rate, but with different direction of rotation.

→ **Start:** After you click this button, **ACCOM** waits for the beginning of measurement. Start the circular movement on the machine tool. In the status line, **ACCOM** shows the condition of measurement. You can terminate the measurement with **Cancel**.



# Measuring Procedure for KGK

## Note

If **ACCOM** does not begin measuring although the circular movement was made on the machine tool, wait for a period of 15 to 30 seconds after the movement ends. If the menu item *Evaluate > Graphic > Representation* was set to *Center* or *Radius compensation* (see point 16, Graphic Display of Circular Test Results), there is no online display. If after some time there is no result, check whether the circle center, feed rate and radius of the NC program agree with the values specified in **ACCOM**. Pay special attention to any offset of the circle center.

## Data storage

After conclusion of measurement, the following dialog box appears for data storage.

Measurement 1:	ACC10N13.KGK
Type of machine:	Milling machine
Year of mef.:	1995
Remark:	
KV 4	
DateTime:	11.10.1995 09:44:05
Excentricity:	
Radius:	10 mm
Feed rate:	1000 mm/min
Direction of rot.:	CW

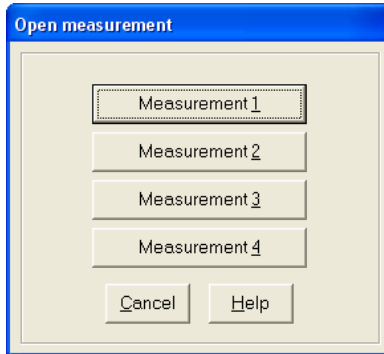
  

Measurement 2:	ACC10P13.KGK
Type of machine:	Milling machine
Year of mef.:	1995
Remark:	
KV 4	
DateTime:	11.10.1995 09:45:27
Excentricity:	
Radius:	10 mm
Feed rate:	1000 mm/min
Direction of rot.:	CW

With *Measure > Start measurement* you can start further measurements.

## 12. Open measurement

→ Through *File > Open measurement* or by clicking the associated button you can load the measured data for further evaluation and display. The following screen appears.



Since up to four measurements can be shown simultaneously, this dialog box enables you to open the measurements in any sequence.

This menu item also enables you to call other motion error traces to the screen for further evaluation.



The results of measurement are loaded into the system with menu item *Open measurement*. This is a prerequisite for display. Through the menu item *Evaluate > Graphic* you can influence how and whether the motion error traces are displayed (see also section 16, "Graphic Display").

# Measuring Procedure for KGK

## 13. Evaluate measured data

→ You can view the raw measurement data through the menu item *Evaluate > Raw data* or by clicking the associated symbol. **ACCOM** shows every measured deviation including the associated angle.

**Raw data of the measurement 1**

Customer: John Doe  
Type of machine: Milling machine  
SrNo. / year of mnt.: 123 / 1995

Position of axis:  
X: 0 mm Y: 0 mm Z: 0 mm IV: 0 mm V: 0 mm

File name: ACC10N13.KGK Measuring method: KGK  
Measuring plane: XY Measuring points: 1984 Direction of rotation: CW  
Nominal radius: 10 mm Feed rate: 1000 mm /min  
Starting angle: 45 Degree Meas. angle: 360 Degree

KV 4

Date of meas.: 11.10.1995 09:44:05 Inspector: FI

	X-position [mm]	Y-position [mm]	Angle [Degree]	Deviation [mm]
1	6.432551	7.659449	49.975821	0.002243
2	6.437512	7.655188	49.938361	0.002173
3	6.851000	7.286977	46.766287	0.001812
4	6.874691	7.264574	46.579502	0.001770
5	6.898348	7.242234	46.393106	0.001858
6	6.921934	7.220109	46.207862	0.002157
7	6.945336	7.198082	46.023779	0.002504
8	6.968375	7.175871	45.840468	0.002568

Cancel Help

### Note

The ACCOM data is saved in an ASCII file. The raw data are saved line by line, separated by tabs. You can load or import this file for further processing in other programs like Matlab, Origin, Microsoft Excel or Open Office.

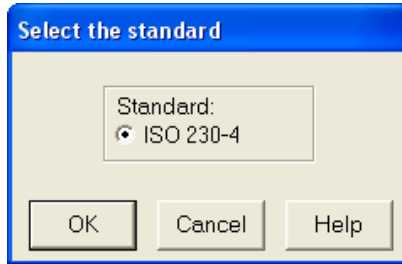
To **print** the raw data, click the print symbol.

If you click **Cancel**, the dialog box closes.



### 14. Select standard for evaluation

→ In the menu item *Evaluate > Standard* you can select the guideline for evaluating the circular test. At present only the ISO 230-4 standard is available.



# Measuring Procedure for KGK

## 15. Characteristic Data of the Circular Test

→ With the menu item *Evaluate > Raw data*, or by clicking the associated symbol, you can call the accuracy data calculated from the measured data according to ISO 230-4. In addition, **ACCOM** calculates the mean radius, the backlash, the reversal peaks, and center deviation and the orthogonality (squareness) of the axes.

**Characteristic data of the measurement 1**

Customer:  
Type of machine: Milling machine  
SrNo. / year of mnf.: 123 / 1995

Position of axis:  
X: 0 mm Y: 0 mm Z: 0 mm IV: 0 mm V: 0 mm

File name: ACC10N13e.KGK Measuring method: KGK  
Measuring plane: XY Measuring points: 1984 Direction of rotation: CW  
Nominal radius: 10 mm Feed rate: 1000 mm /min  
Starting angle: 45 Degree Meas. angle: 360 Degree  
no compensation

Characteristic data of the measurement according to ISO 230-4 Centre used

Circular deviation Gyx:	0.0294 mm
Circular deviation Gxy:	0.0298 mm (Acc10p13e.kgk)
Bi-directional circular deviation G(b)xy:	0.0298 mm ACC10N13e.KGK / Acc10p13e.kgk
Radial deviation Fyx min:	-0.0016 mm
Radial deviation Fyx max:	0.0278 mm
Mean bi-directional radial deviation Dxy:	0.0008 mm ACC10N13e.KGK / Acc10p13e.kgk

Mean radius:	10.0008 mm	Mean feed rate:	1007.2101 mm /min
Backlash:	X+: 0.0005 mm	X-: 0.0001 mm	
	Y+: 0.0009 mm	Y-: 0.0002 mm	
Reversal spikes:	X+: 0.0105 mm	X-: 0.0112 mm	
	Y+: 0.0260 mm	Y-: 0.0274 mm	
Centre point comp. val.:	X: 0.0013 mm	Y: 0.0019 mm	
Squareness error:	-19.5719 µm/m	ACC10N13e.KGK / Acc10p13e.kgk	
Axis length difference:	Y is 0.015 % longer as X		
Date of meas.:	11.10.1995 09:44:05	Inspector:	FI



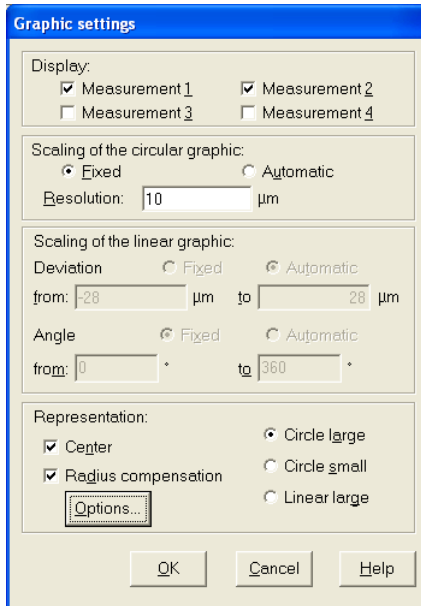
Two circles are required—once each in positive and negative direction—for complete calculation of all accuracy data, particularly the circular backlash H. **ACCOM** issues a warning if you have forgotten to load the second file.

To **print** the accuracy data, click the print symbol.

If you click **Cancel**, the dialog box closes.

## 16. Graphic display of circular test results

→ You can specify the display mode of the motion error traces through the menu item *Evaluate > Graphic* or by clicking the associated symbol.



- **Release:** Here you can select up to four previously opened measurements to be displayed.

You can choose in principle between circular and linear diagrams and configure the respective settings. **Scaling** can then either be set to a **fixed** value or can be selected **automatically** by the system.

- **Scaling of the circular graphic:** In the circular graphic you can set the desired resolution.

Input range of resolution: 0.1 to 10 000 µm  
0.000 004 to 0.4 inch

- **Scaling of the linear graphic:** In linear graphics you can set the upper and lower limit or the displayed angular range for the deviations from an ideal circular path.

Error from/to: -10 000 to +10 000 µm  
-0.4 to 0.4 inch

Angle from/to: 0 to 360°

# Measuring Procedure for KGK

- **Representation:**

**Center:** With this function you can display a centered view of the measurement **ACCOM** shows you the calculated actual circle center.

**Radius compensation:** Here the radius error is compensated by ACCOM in the graphic and displayed in the box.



**Before measuring** you should **switch off** the **centering** and **radius compensation** function, since otherwise the graphic will not be shown online.

You have the choice between the following display modes:

**Circle large**

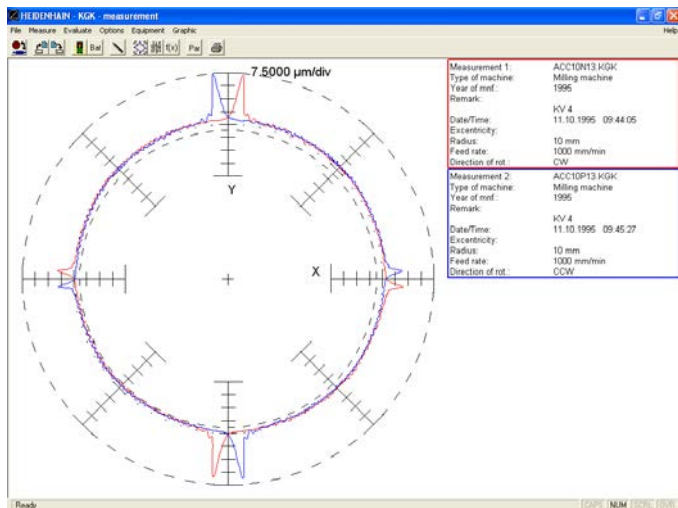
**Circle small**

**Linear large**

- **Circle large:** Here, **ACCOM** draws up to four motion error traces in **one** circular graphic. You can switch the error traces on and off with the menu item *Evaluate > Graphic > Release measurement 1-4*.

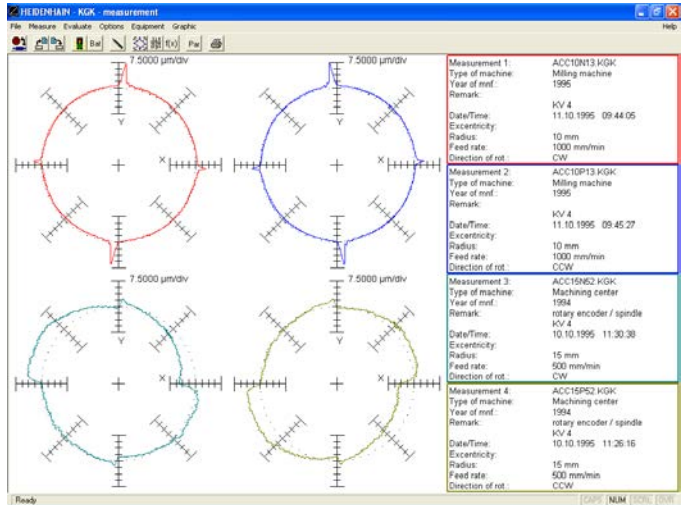
The nominal radius is shown as a **dotted line** in the measurement graphic.

The **largest** and **smallest radius errors** are shown as a **dashed line** in the graphic.



You can load new measurements with *File > Open measurement* or by clicking on the associated button.

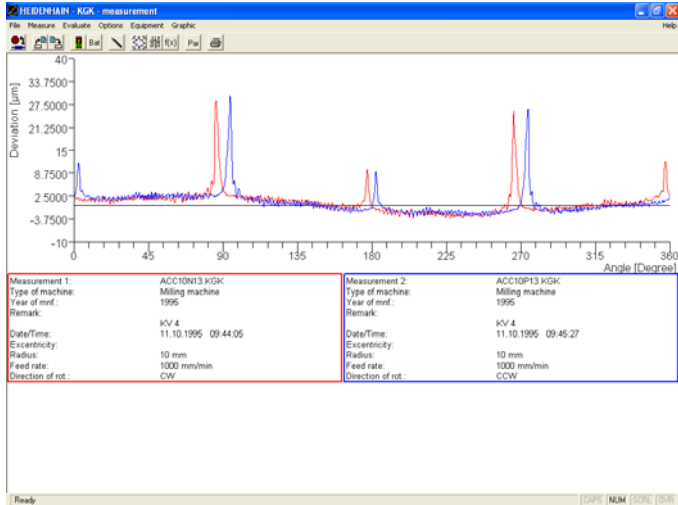
- **Circle small:** Here, **ACCOM** draws each motion error traces in a separate circular graphic. You can switch the error traces on and off with the menu item *Evaluate > Graphic > Release measurement 1-4*.



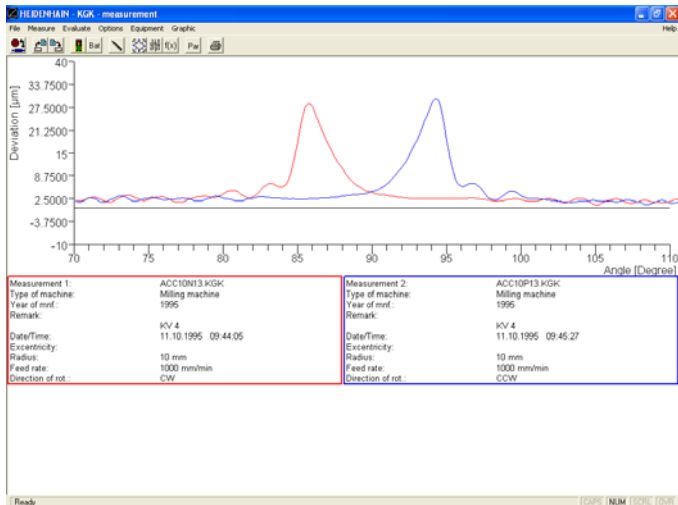
You can load new measurements with *File > Open measurement* or by clicking on the associated button.

# Measuring Procedure for KGK

- **Linear large:** Here, **ACCOM** draws up to four motion error traces in **one** linear graphic. You can switch the error traces on and off with the menu item *Evaluate > Graphic > Release measurement 1-4*. In the example the **scaling is fixed** and the angle of **0 to 360°** is selected.

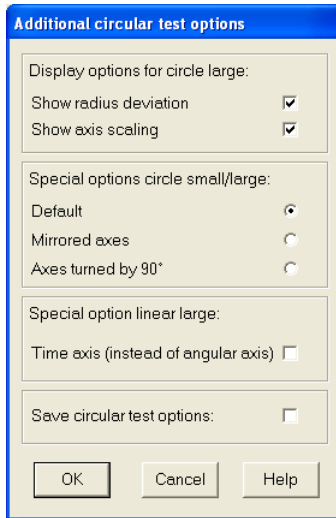


As an alternative you can also display an **angular range**. In the example the **scaling is fixed** and the angle of **80 to 100°** is selected.



## Additional circular test options

→ By clicking on the control button **Options** the following dialog box opens. Here you can set additional display options.



- **Display options for circle large/small:** In the circular test graphic you can disable the auxiliary lines for the minimum and maximum radius deviation and/or the scaling values.
- **Special options for circle large/small:** In the default graphic for the circular test the first measurement axis is shown right and the second axis is shown top. Alternatively the axis can be displayed mirrored (1st axis top, 2nd axis right). The third display option is: 1st axis is shown top and 2nd axis is shown left (axes are turned by 90 degrees).
- **Special option linear large:** Alternatively you may use a path-time diagram for the radius deviation (time instead of angle).
- **Save circular test options:** Here the special options for the circular test representation can be saved (at program end or change of measurement type).

# Measuring Procedure for KGK

## DTA-file import

You can transfer a circular measurement from a new HEIDENHAIN control by using the menu item *File > DTA file import* or *File > DTA file download > via TCP/IP* and evaluate it.

Requirements for the DTA import:

- The recorded measurement has two different channels for the circular measurement (e.g. X and Y)
- The internal oscilloscope uses the circular mode (CIRC).
- You need two channels with the data contour deviation (channel 32).
- Start and end of the measurement have to be (0/0).

Accept measurement data of DTA-file

Scaling:  
 fixed     automatic  
Resolution: 3 µm

Rotation:  
 +     -

Starting angle: 47.616 Degree  
Meas. angle: 454.02 Degree  
Radius: 10 mm  
Feedrate: 500 mm /min

Choose the first and last value of the imported measurement data points and adjust the feed rate and radius of the measurement.

First value:  
Meas. point: 80  
Angle: 47.616 Degree  
Radius: 9.99873 mm

Last value:  
Meas. point: 222  
Angle: 41.490 Degree  
Radius: 9.99829 mm

Accept    Help

- **Scaling:** Enter here a resolution suitable for transferring the DTA file.
- **Rotation:** The direction of rotation is calculated from the measured data.
- **Starting angle:** The starting angle is calculated from the measured data.
- **Meas. angle:** The measurement angle is calculated from the measured data.
- **Radius:** Here you enter the nominal radius for the imported measurement data. At first, the maximum radius is calculated from the measured data and entered.



- **Feed rate:** Enter the nominal feed rate for the imported measurement data.
- **First measuring point:** Enter the first measuring point to be transferred for the circular measurement.
- **Last measuring point:** Enter the last measuring point to be transferred for the circular measurement.

→ **Accept** Click this button for ACCOM to adopt the imported DTA file as a circular measurement. It can now be saved and evaluated as an ACCOM circular measurement.

### Color settings of the graphic

If you would like to change the **color setting of the graphics**, you can change the color of the error traces, of the coordinate system and the graphic background with the menu item *Options > Color setting*.

### Saving/loading the options

You can save these settings with the menu item *Options > Save options*.

You can call these settings with the menu item *Options > Load options*.

### Exporting the measurement graphic

If you wish to **export the measured graphic as a file** without a log, you can save it as a bitmap using the menu item *Graphic > Save*.

### Printing the graphic

You can **print** the graphic with the menu item *Graphic > Print*. You can change the **printer settings** through the menu item *File > Printer setup*.

### Editing the calibration charts

If you would like to **edit the calibration charts** you can select the desired chart through the menu item *Measure > Calibration chart* or by clicking the associated symbol.

# Measuring Procedure for KGK

**Calibration chart of measurement 1**

Customer:	John Doe	
Type of machine:	Milling machine	
StNo. / Year of mntf.:	123	/ 1995
Remark 1:		
Remark 2:	KV 4	
Remark 3:		
Inspector:	FI	

HEIDENHAIN Reference meas. system:	KGM 182	
ID number:	349166-02	Serial number: X1234567890

Position of axis X:	167.548	mm
Position of axis Y:	24.55	mm
Position of axis Z:	324.432	mm
Position of axis IV:	0	mm
Position of axis V:	0	mm

Open chart window automatically after a measurement?

Yes     No

## Saving a measurement

If you make **changes to a calibration chart**, you can save them through the menu item *File > Save measurement* or by clicking the **save** button.

As an alternative, you can also save the measured data through the menu item *File > Save all measurements*.

## Clearing the screen

To remove the motion error traces from the screen, you can **clear the screen** with the menu item *Graphic > Close*.

## Measuring Procedure for KGM Free-Form Test (KGF)

### Machine cleaning

→ Before beginning to mount the **KGM**, clean the area of the machine tool in which the measurements are made. Pay special attention to any chips and oil or grease residue that could fall onto the encoder.



Give the encoder time to adjust to the ambient temperature before you begin mounting it. This will help to prevent thermally induced error.

### Test program

In the free-form test, the CNC control moves the machine axes in a plane on any programmed path. The corner test provides information on the dynamics of the position control loops with respect to overshoot and the resulting rounding error. You can also test workpieces of any contour on the grid plate to obtain a first impression of the contour accuracy to be expected within the measuring plane without first having to machine a workpiece.

Free-form contours according to ISO 10791-6 K2—Feeds and K3—Interpolation of two axes can be measured in the **KGM** free-form test.

On machine tools with HEIDENHAIN controls, the machine program can be transferred directly from **ACCOM**. For machine tools without HEIDENHAIN controls, the NC program must be written manually, whereby movement must be measured only in the measuring plane.



Ensure that there are no “forgotten” compensation data saved in the control that could cause a movement perpendicular to the encoder or corrupt the measurement. The spindle must not rotate. If necessary, ask your machine tool builder how it can be fixed. You might try running the machine program without the encoder.

# Measuring Procedure for KGF

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## Measuring assembly

→ Ensure that the **IK 220** PC counter card was installed in your PC according to the instructions in the User's Manual. Alternatively you can use the **EIB 741**. Please ensure an available peer-to-peer network connection to the **EIB 741** (address and subnet mask of the TCP/IP connection). Connect the **KGM** cables to X11 and X12 of the **EIB 741**. Now mount the **KGM** according to the instructions in the manual. Do not use any screws for mounting whose heads project above the height of the cross grid!



When connecting the measuring cables, be sure to leave enough slack to compensate any machine movement during measurement.

→ **Before starting ACCOM**, connect the enclosed hardware key with Id. No. 590255-01 or 590255-02 to one free USB port.

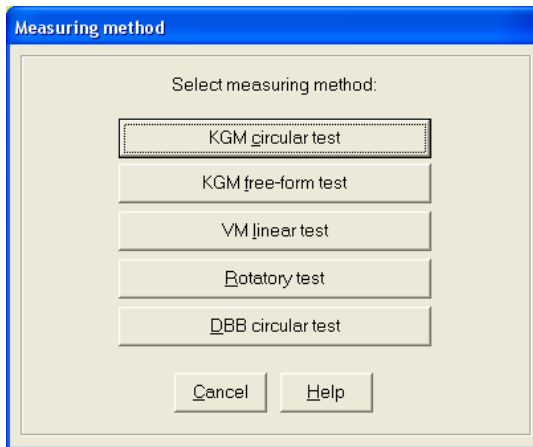
After calling **ACCOM**, proceed as follows:

## 1. Select measuring method

After **ACCOM** is started, a dialog box appears in which you can select the type of measurement.

→ Click the **KGM free-form test** button to start the corresponding program part.

With the menu item *File > Select measuring method* or by clicking the icon you can select the individual measuring methods from within the running program.

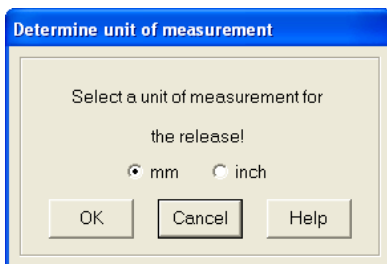


# Measuring Procedure for KGF

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## 2. Specifying the unit of measure

→ With the menu item *Options > Unit of measurement* you specify the desired unit of measure. Close the dialog box with **OK**.



## 3. Settings of the encoder and the counter card

→ Under *Options > Measuring interface* you set the parameters for the encoder used.

- **Signal period:** Here you set the signal period (as its distance in  $\mu\text{m}$ ) of the encoder you are using. The default setting for the signal period is 4  $\mu\text{m}$ .

Input range: 0.1 to 20  $\mu\text{m}$

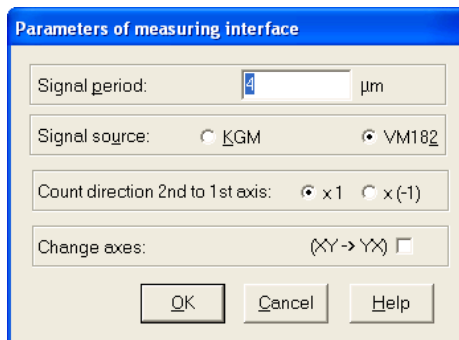
- **Signal source:** Select the model of encoder being used.

- **Count direction 2nd axis to 1st axis (VM 182 only):**

According to the set-up of the VM 182 it can be necessary to manually set the count direction for the 2nd axis (orthogonal axis).

- **Change measurement axis (VM 182 only):** If the VM 182 is aligned to the 2nd axis (of the chosen plane) you should check this box to get a correct display of the measurement.

Example: Measurement in XY plane, **VM 182** aligned in Y direction



→ Under *Options > Counter card* you set the parameters for the PC counter card.

- **Type counter card:** Here you select the model of counter card that you are using.

- **Signal input:** Here you select the type of measuring signal.

- **Address EIB 741:** Here you enter the IP address of the **EIB 741** (see also **EIB 741** user manual). Alternatively you may use the DHCP hostname in a company network. However it is not recommended due to the high data acquisition rate.

This setting is not needed for the **IK 220**.

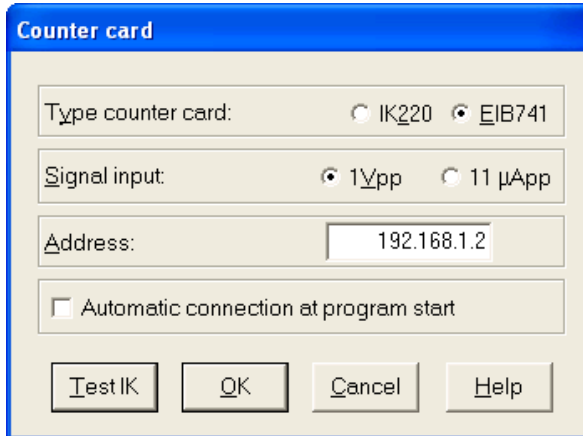
- **Automatic connection at program start:** ACCOM connect to the **EIB 741** at the next program start automatically if chosen. A valid connection to the **EIB 741** is required!

- **Test IK (IK 220):** Here you can then test the counter card for proper function.

## Measuring Procedure for KGF

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- **Connect/Disconnect (EIB 741 only):** The **EIB 741** will be connected or disconnected here.



Counter card

Type counter card:  IK220  EIB741

Signal input:  1Vpp  11 µApp

Address:

Automatic connection at program start



Ensure that you have entered the proper model, address and signal input of the counter card. If the signal period is entered incorrectly, the distances will be measured too large or too small.

### Note

Only EIB 741: Connect the encoder cables of the **KGM/VM** to the encoder inputs X11 and X12.



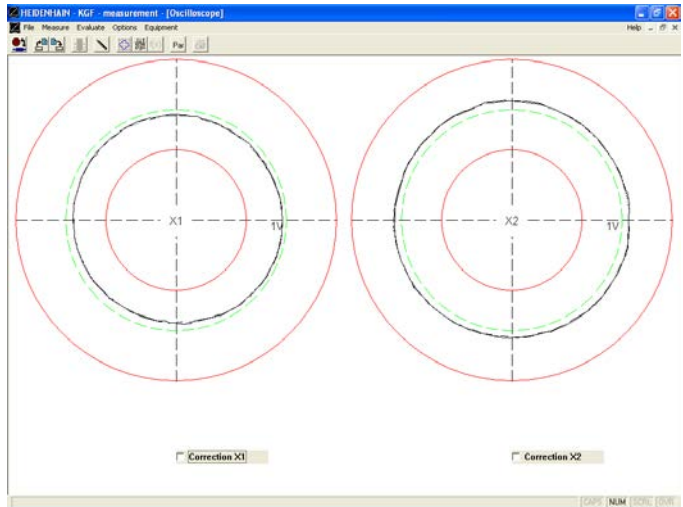
If you have problems receiving data from the counter card, use the test programs on the provided driver CD to check whether the card can be used.



## 4. Fine adjustment of the measuring head

### Oscilloscope

→ With the menu item *Equipment > Oscilloscope* you can display the **KGM** measuring signals received by the PC counter card as Lissajous figures on the screen, which you need for the fine adjustment of the **KGM** (see mounting instructions of the **KGM**).



The measuring signals are displayed for the directions I and II in the oscilloscope display mode (for measuring signals  $0^\circ$  elec. and  $90^\circ$  elec.).

→ Move the machine tool slide slowly and evenly in diagonal direction. Use the adjusting screws on the measuring head to adjust the signal amplitude. In the ideal case, the measuring signal amplitude lies near the green circular path ( $1 V_{PP}$ ) between the red limit circles.

If the encoder signal is too large or small, the message **Amplitude too high / too low** appears in the status line of the **ACCOM** screen.

# Measuring Procedure for KGF

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## Optimizing the measuring signals

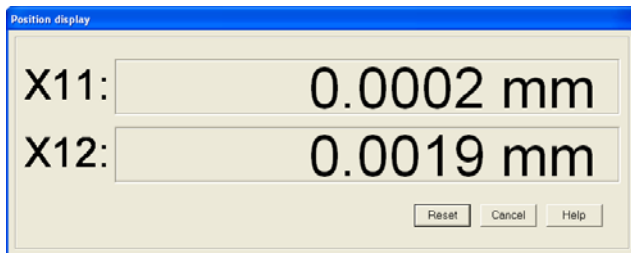
→ Through automatic signal adjustment, **ACCOM** can optimize the **measuring signals** to attain very high accuracy. Click the boxes **Compensation X1 (X11)** and **Compensation X2 (X12)** and move the machine slides slowly and evenly in diagonal direction. Then switch this function off by clicking both boxes Compensation X1 (X11) and Compensation X2 (X12) again, and go to the next item of the instructions. The **EIB 741** optimizes the analogue signals automatically. However, the optimized analogue signals are used only for the computation of the position values. Therefore it is possible to observe imperfect circular Lissajous figures.



If the displayed signal amplitude is too low, check whether the settings for the interface are correct and whether the encoder is correctly installed. Then start **ACCOM** again. Do not engage or disengage any connectors until you have exited **ACCOM**!

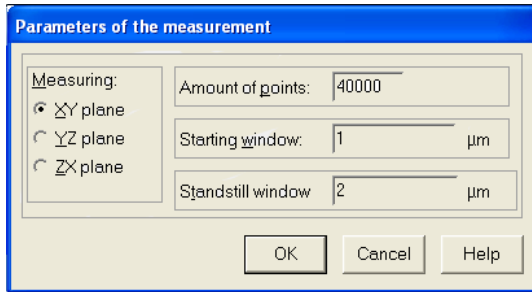
## Position display

With the menu item *Equipment > Position display* you can call the position display for the connected encoder and, for example, check the positive counting direction of the **KGM**. If you call this function after setting the position (see section 7, "Set datum"), before the test you should check again whether your datum is set correctly and, if not, enter it again.



## 5. Parameters of the measurement

→ By calling the menu item *Options > Parameters of the measurement* or by clicking the icon, you open the following dialog box in which you can adjust the **parameters of the measurement**.



- **Measuring plane:** The machine tool's working plane in which the measurement is to be made.

- **Amount of points:** Number of measuring points per measurement.

Input range: 36 to 100000 measuring points

- **Starting window:** Enter here the size of the starting window for the motion detection.

Input range: 0.01 to 100 µm

0.000 001 5 to 0.004 inches

- **Standstill window:** Enter here the size of the standstill window for the computation of the path time.

Input range: 0.01 to 100 µm

4e-7 to 0.004 inches

Conclude the input with **OK**.

### Note

The sampling interval is calculated from the number of measurement points and the measurement time. The measurement time is shown in the start window (see No.12, Start measurement). The measurement time can be set manually.

Example: 40000 measurement points and 4s measurement time

⇒ Sample rate 10kHz

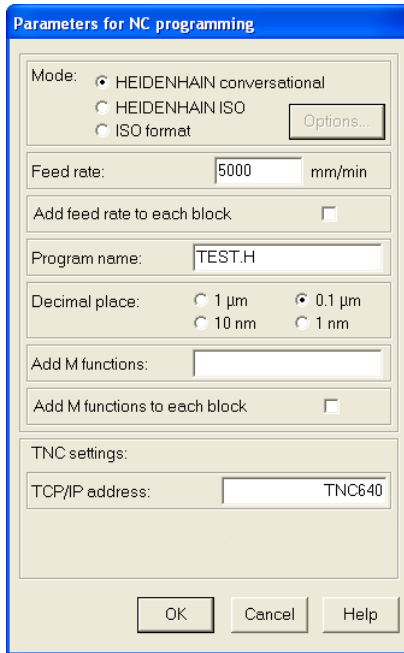
(Max. sample rate of the EIB 741: 50 kHz,

Max. sample rate of the IK 220: 10 kHz)

# Measuring Procedure for KGF

## 6. Setting the NC interface

→ If you wish to transfer the measuring program in **ACCOM** to a HEIDENHAIN control, select *Options > NC programming* to open a dialog box in which you can configure the network connection.



- **Mode:** Choose between HEIDENHAIN or ISO format.
- **Feed rate:** Here you enter the nominal feed rate for the circular motion.  
Input range: 0.001 to 100 000 mm/min or 0.000 04 to 3900 inches/min
- **Program name:** Here you give the program a name (the extension .H stands for HEIDENHAIN, .I stands for HEIDENHAIN ISO and .txt for general ISO).
- **Decimal place:** Select the decimal place of the NC programs.
- **M functions:** Here you enter additional M functions which are necessary to run the NC program on the control. The M functions are added to the first NC block.  
Example in HEIDENHAIN conversational programming:  
**2 L X0 F1000 M31**
- **TCP/IP address:** Here you enter the TCP/IP address or DHCP hostname of the control for the data transfer via network connection.

## G-Code options

→ By clicking the control button **Options** the following dialog box opens. Here you can configure some ISO format settings which are suitable to the control.

The image shows a screenshot of a software dialog box titled "Parameters for NC programming". The dialog is divided into two main sections. The top section, titled "GCode import options", contains several radio button options: "Mode" (HEIDENHAIN conversational, HEIDENHAIN ISO, ISO format), "Position (export)" (Incremental, Absolute), "Circle center" (Incremental, Absolute), and "Feedrate" (Inch/min, 0.1Inch/min). There is also a checkbox for "Use G-Code G71/G70 for MM/Inch:". The bottom section, titled "Additional lines at program start:" and "Additional lines at program end:", contains text input fields with "G54" and "M30" respectively. Both sections have "OK", "Cancel", and "Help" buttons.

- **Position (export only):** This parameter is used in the export of an ISO NC program only. For absolute positions G90 is added at the NC program start, for incremental positions G91 is used. For absolute NC programs it is useful to add a datum shift (e.g. G54).
- **Circle center:** The input of the circle center point acc. to the German standard DIN 66025 is done incremental to the last position or absolute. Usually I, J, K are used with incremental positions. Valid is also an absolute position with I, J, K. (depends on the control).
- **Feed rate:** This parameter is only valid for an INCH program. The feed rate can be set in Inch/Min or Inch/10Min (HEIDENHAIN default).
- **G-code for Inch/MM:** You can choose whether to use G71/G70 for NC programs or not.

# Measuring Procedure for KGF

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In the dialog box **Parameters for NC-programming** you may add the following data for the ISO format programming:

- **Additional lines at program start:** Here you can add 2 user or control specific lines at program start (e.g. G54).
- **Additional lines at program end:** Here you can add 2 user or control specific lines at program end (e.g. M30).

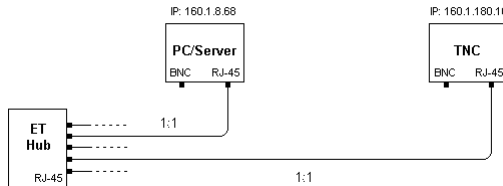
## Network cable

Connect the TNC by a (crossed) network cable directly to the PC or by using a standard network cable with a hub or a switch to the company network.

## Note

Peer-to-peer (direct connection): You need to set the IP-Address of the PC in *Control Panel / Network / TCP-IP / Properties* (depends on the operating system). As default the value for the IP-Address will be given automatically in a company network (from the DHCP Server).

## LAN (Network) with a 1:1 cable



## Peer-to-peer (direct connection) with a (crossed) cable!



## 7. Setting the direction

→ Before the first measurement with the **KGM**, **ACCOM** must know the positive counting direction of each axis as well as the angular position of the **KGM** on the machine table. In the menu item *Measure > Directions*, **ACCOM** prompts you to move the machine slides in sequence in the direction shown in the dialog box. The directions depend on the setting of the measuring plane (see positive direction I and II on the **KGM**). The required accuracy data is calculated from the signals of the encoder (channel assignment, counting directions and angular position).



### Note

You can specify which traverse path is to be used to detect the first direction and, at the same time, the angular position. The larger the path, the more accurate the angular position. For free-form tests, HEIDENHAIN recommends that you exploit the maximum available traverse on the **KGM**.



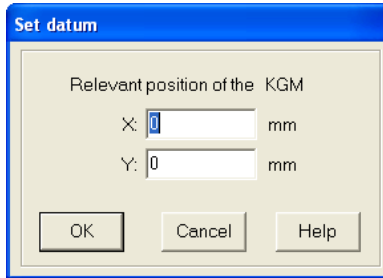
During the **directional detection**, do **not** move the machine tool slide in a **diagonal direction**. Otherwise the detected angular position will be incorrect.

# Measuring Procedure for KGF

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## 8. Set datum

→ In the menu item *Measure > Set datum* you assign **ACCOM** a position value in agreement with the control.



Set datum

Relevant position of the KGM

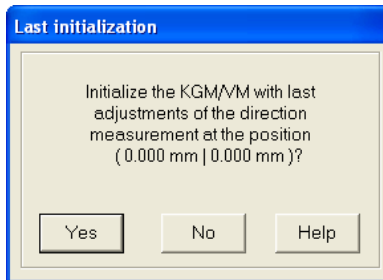
X: 0 mm

Y: 0 mm

OK Cancel Help

## Last initialization

After you have started **ACCOM** you can use your previous settings by calling the menu item *Measure > Last initialization*, provided that the setup of the **KGM or VM** on your machine has not changed and you move the scanning head to the position last set. Then continue with the next program item.



Last initialization

Initialize the KGM/VM with last adjustments of the direction measurement at the position (0.000 mm | 0.000 mm)?

Yes No Help



## 9. Generating a calibration chart

→ Through the menu item *Measure > Calibration chart* or by clicking the icon you can define the calibration chart for the measurement by entering information on the measurements in the calibration window. By clicking **yes** or **no** you can specify whether the **chart window** will open automatically after each measurement.

The screenshot shows a dialog box titled "Calibration chart of measurement 1". It contains the following fields and options:

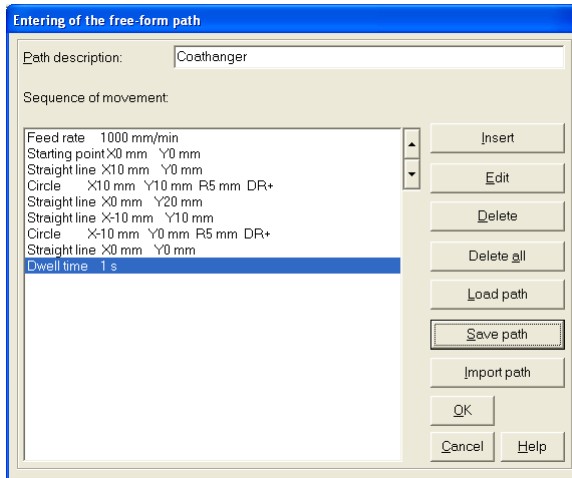
- Customer: John Doe
- Type of machine: Milling machine
- SrNo. / Year of mnt.: 12345 / 1995
- Remark 1: Coat hanger
- Remark 2: (empty)
- Remark 3: (empty)
- Inspector: DS
- HEIDENHAIN Reference meas. system: KGM 182
- ID number: 349166-02
- Serial number: X1234567890
- Position of axis X: 123.45 mm
- Position of axis Y: 234.567 mm
- Position of axis Z: -345.678 mm
- Position of axis IV: 0 mm
- Position of axis V: 0 mm
- Open chart window automatically after a measurement?  
 Yes  No
- Buttons: OK, Cancel, Help

If you enter the chart data only for measurement 1, they will automatically apply also to the other measurements. The charts can also be saved or edited later in the course of evaluation. **ACCOM** saves these data together with the measured data and prints them through the menu items *Evaluate > Measured data*, *Evaluate > Characteristic data* and *Graphic > Print*.

# Measuring Procedure for KGF

## 10a. Enter path

→ With the menu item *Measure > Enter path* you open the dialog box for describing a free-form path. Before **ACCOM** can start a measurement, you must either enter, open, or import a path.



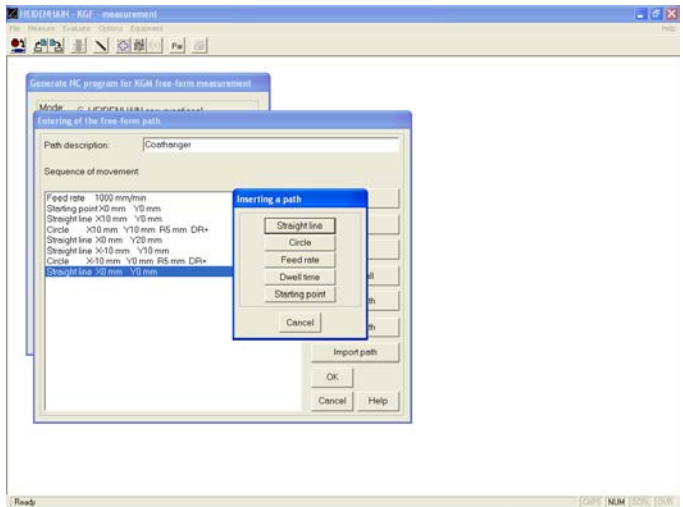
- **Path description:** Here you can enter a name for the free-form path.
- **Arrow keys:** Here you can change the sequence of the path elements.

### Note

A feed rate has to be programmed before the first line or circle element.

The starting point may only be used at the beginning of the path sequence.

- **Insert:** By clicking this button you open the dialog box with which you can generate contour elements.



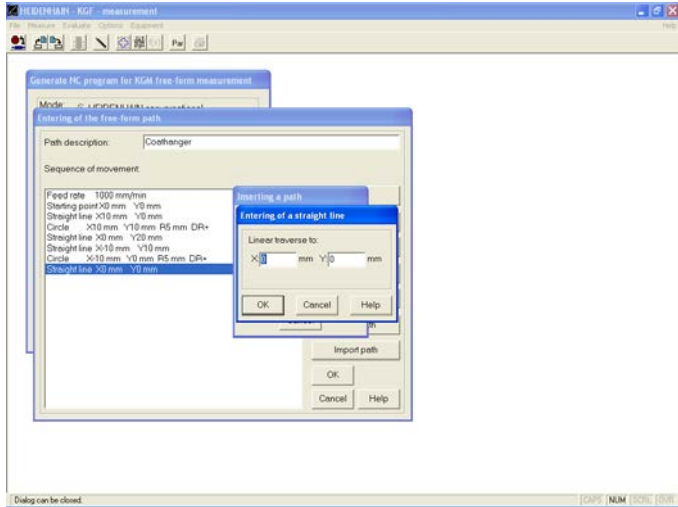
- After you have entered all contour elements, close the "inserting a path" dialog box with **Cancel**.

# Measuring Procedure for KGF

- **Straight line:** Here you can enter the coordinates of the end point of a straight line segment.

Input range:           -10 000 to +10 000 mm  
                          -390 to +390 inches

Click the button to call the following dialog box.



## Measuring Procedure for KGF

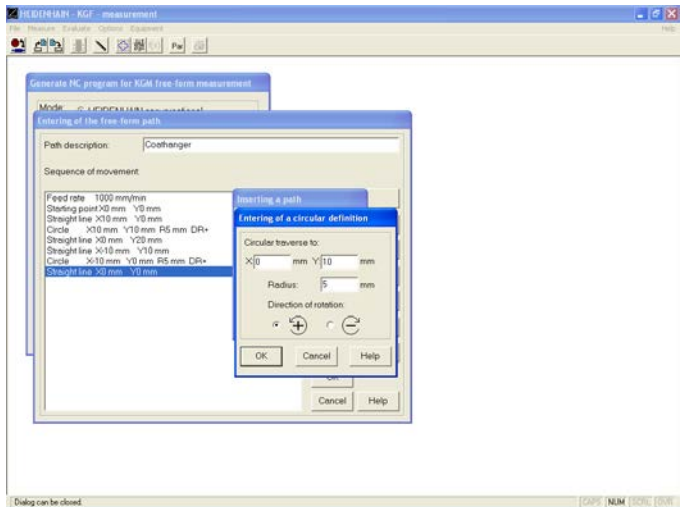
• **Circle:** After clicking the button, the following dialog box appears in which you enter **coordinates of the end point** of the circular path.

Input range:               -10 000 to +10 000 mm  
                                  -390 to +390 mm

You also enter the **radius of the arc**.

Input range:               -10 000 to +10 000 mm  
                                  -390 to +390 mm

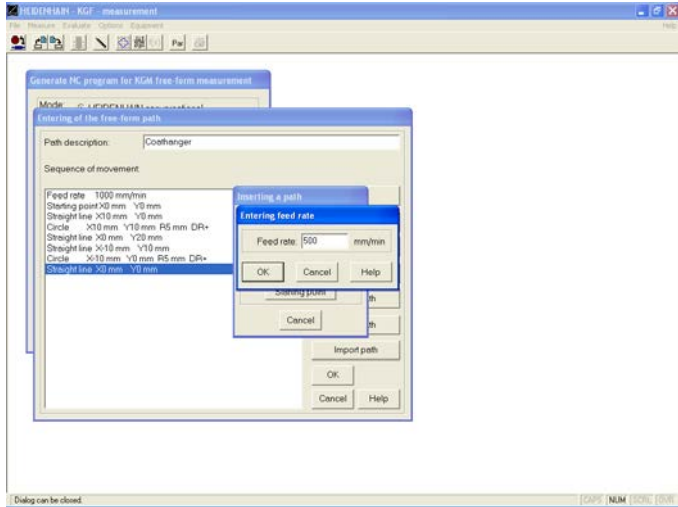
Enter also the **direction of rotation** of the circular movement.  
The machine tool then moves on an arc from the end point of the last contour segment to the new end point.



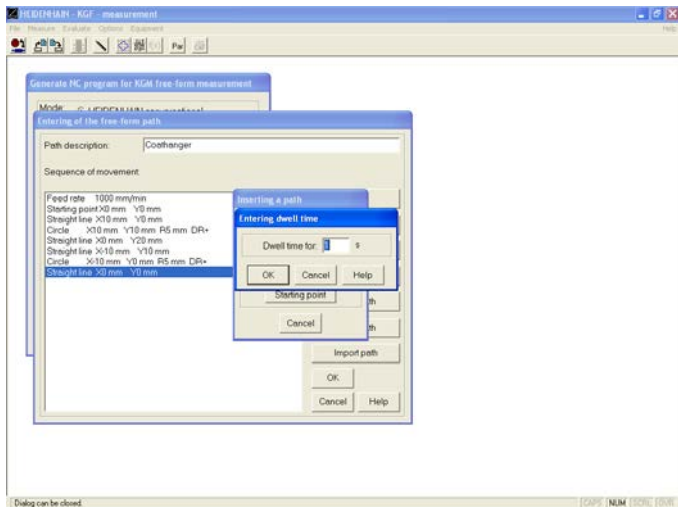
The radius must be large enough to enable the arc to extend from the end point of the last contour element to the end point of the arc.

# Measuring Procedure for KGF

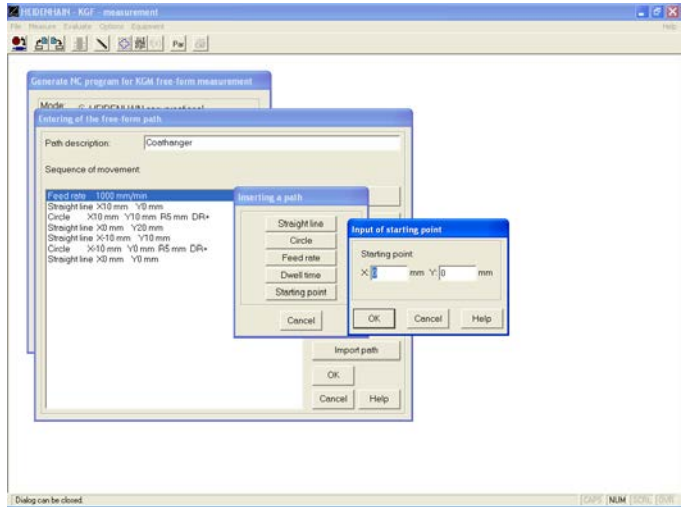
- **Feed rate:** Enter the feed rate in the **first line**. After clicking the button, the dialog box appears in which you enter the nominal feed rate for the subsequent contour elements.  
Input range: 0.001 to 100 000 mm/min  
0.000 04 to 3900 inches/min



- **Dwell time:** Here you specify how long the machine is to wait at the current position until it begins the next movement.

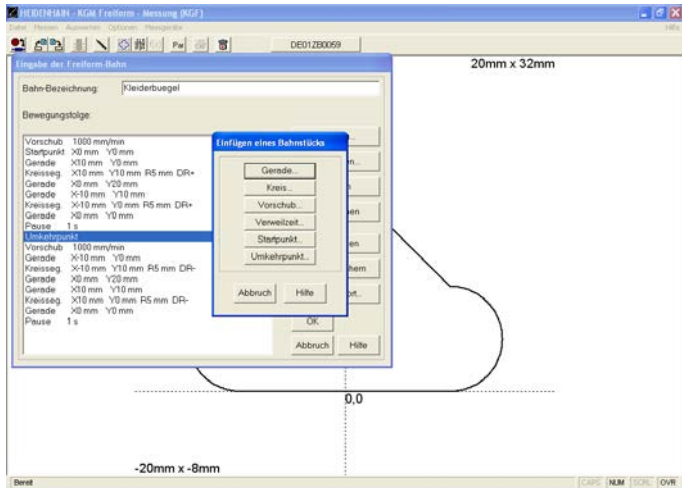


- **Starting point:** In the next line you can enter a starting point if it differs from the datum specified under “Set datum.” After clicking the button, the following dialog box appears in which you enter coordinates of the starting point.



# Measuring Procedure for KGF

- **Reversal point:** In the next line you can enter a reversal point. A reversal point marks the end point of the last path element (line or circle) as a reversal point. Measurement data points after a reversal point are shown in a second color. Using more than one reversal point toggles the display color of the measurement. In that way some forward and backward movements can be displayed separately in 2 colors.



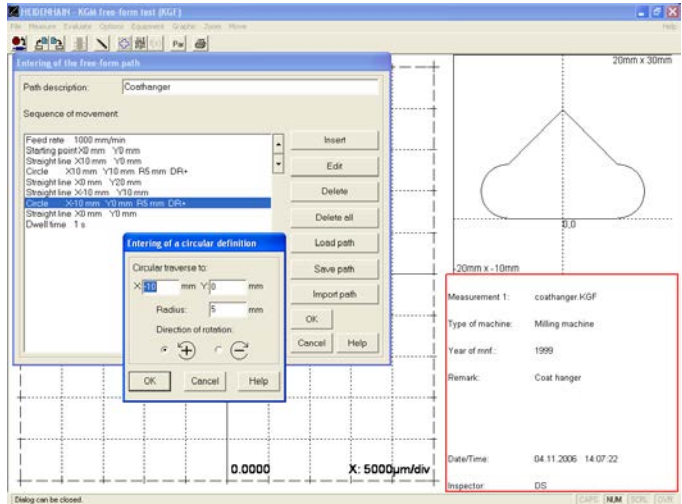
## Note

The free-form contour does not have to end at its starting point. The starting and end points can be specified as desired.

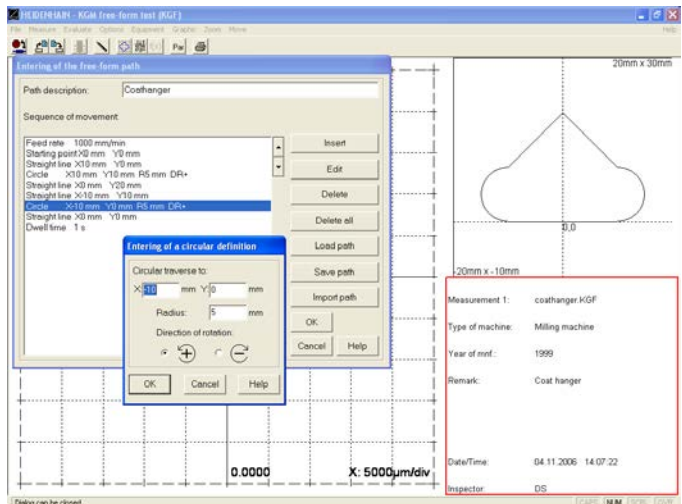


# Measuring Procedure for KGF

- **Edit:** To edit a contour element, use the cursor to select the desired line in the sequence and click the **Edit** button. In this example, the last contour element is to be edited and therefore has a dark background.

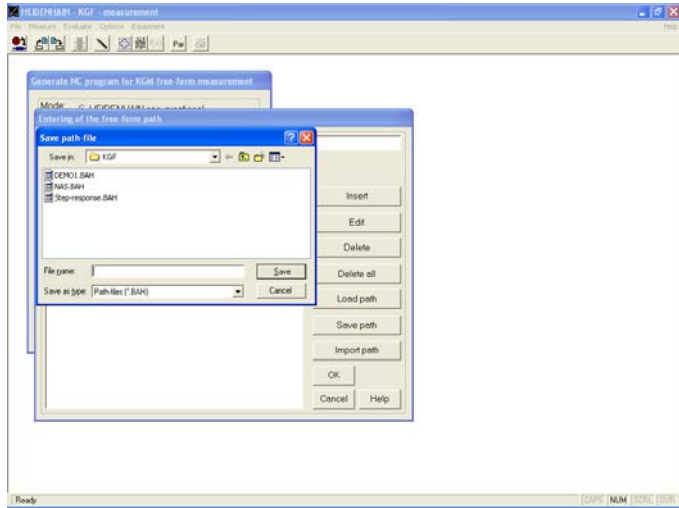


- **Delete:** To delete a contour element, use the cursor to select the desired line in the sequence and click the **Delete** button. In this example, the last contour element is to be deleted and therefore has a dark background.

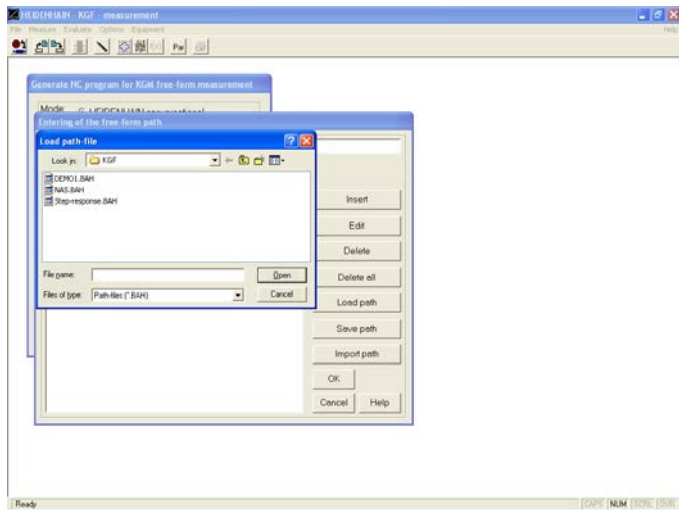


# Measuring Procedure for KGF

- **Save path:** This button calls the following dialog box with which you can save the entered contour.

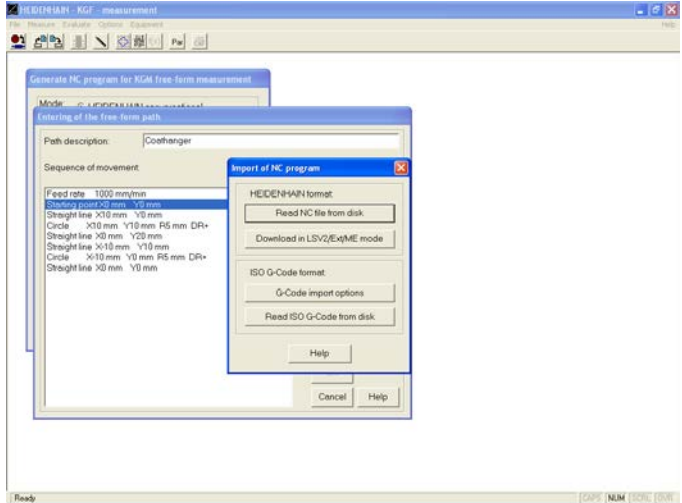


- **Load path:** This button calls the following dialog box with which you can find a contour and open it.

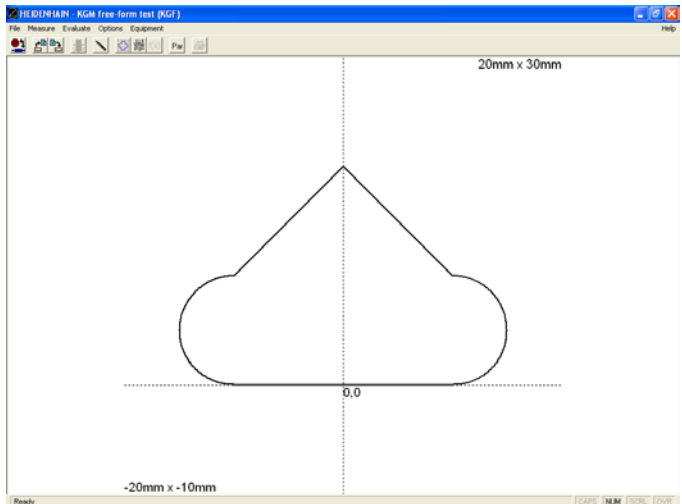


# Measuring Procedure for KGF

- **Import path:** This button opens a dialog box in which you can load a contour in the form of a HEIDENHAIN NC program from file or transfer it from a HEIDENHAIN control via network connection.



→ When you have completed all entries to describe a contour, close the dialog box with **OK**. The contour that you have programmed appears on the screen.



# Measuring Procedure for KGF

## 10b. Entering a path according to ISO 10791-6 (K2) Feeds

→ With the menu item *Measure* > *Enter path according to ISO 10791-6 (K2) Feeds* you open the dialog box for creating a free-form path according to ISO 10791-6 (K2).

**Entering of the path acc. to ISO 10791-6 (K2 - Feeds)**

Path description: Test

	Feed rate:	Start position:	End position:
v1:	100 mm /min	0 mm	10 mm
v2:	1000 mm /min	0 mm	50 mm
v3: max. feed rate	4000 mm /min	0 mm	100 mm
v4: Rapid traverse	4000 mm /min	0 mm	100 mm

Sequence of movement:

- Starting point X0 mm Y0 mm
- Feed rate 100 mm/min
- Straight line X10 mm Y0 mm
- Dwell time 1 s
- Straight line X0 mm Y0 mm
- Feed rate 1000 mm/min
- Straight line X50 mm Y0 mm
- Straight line X0 mm Y0 mm
- Dwell time 1 s

Max. feed rate = rapid traverse

Meas. plane:  XY  YZ  ZX

Meas axis:  X  Y  Z

Start position Y axis: 0 mm

Dwelltime: 1 s

Buttons: Generate path, Open path, Save path, OK, Cancel, Help

- **Path description:** Here you can enter a name for the free-form path according to ISO 10791-6-K2.
- **Feed rate:** Enter here the maximum feed rate and rapid traverse speed for the machine to be tested.
- **Start position:** Here you enter the start position of the measurement axis.
- **End position:** Here you enter the end position of the measurement axis. The measuring lengths may vary for the different feed rates.
- **Maximum feed rate = rapid traverse:** If on the machine to be tested the rapid traverse speed corresponds to the maximum feed rate, select this check box. As a result, only three different feed rates will be tested.
- **Measuring plane:** Here you select the measuring plane.

- **Measurement axis:** Select here the axis of measurement.
- **Start position X/Y/Z axis:** Here you enter the start position of the second axis in the measuring plane.
- **Dwell time:** Here you specify how long the machine is to wait at the end of a straight line until it begins the next straight line (recommended: minimum of 1s).
- **Generate path:** Click this button to generate and display the path according to the specified options.
- **Save path:** Click this button to save the entered ISO 10791-6 (K2) path.
- **Open path:** Click this button to select and open an ISO 10791-6 (K2) path.

## 10c. Entering a path according to ISO 10791-6 (K3) Interpolation

→ With the menu item *Measure* > *Enter path according to ISO 10791-6 (K3) Interpolation* you open the dialog box for creating a free-form path according to ISO 10791-6 (K3).

**Entering of the path acc. to ISO 10791-6 (K3 - Interpolation)**

Path description:

Feed rate:  mm /min

Meas. plane:  XY  YZ  ZX

Start position X:  mm Y:  mm

Line length:  mm

Meas. choice:  
 dY/dX = 0.05  
 dY/dX = 1  
 dX/dY = 0.05

Working stroke:  % of line length

Dwelltime:  s

Sequence of movement:

Starting point X0 mm Y0 mm  
Feed rate 250 mm/min  
Straight line X9.98752 mm Y0.499376 mm  
Straight line X0 mm Y0 mm  
Dwell time 1 s  
Straight line X7.07107 mm Y7.07107 mm  
Straight line X0 mm Y0 mm  
Dwell time 1 s  
Straight line X0.499376 mm Y9.98752 mm  
Straight line X0 mm Y0 mm

Generate path  
Load path  
Save path  
OK  
Cancel  
Help

- **Path description:** Here you can enter a name for the free-form path.
- **Feed rate:** The default feed rate of 250 mm/min is entered automatically for this test.

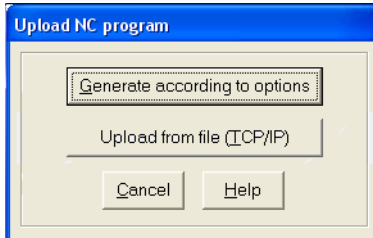
## Measuring Procedure for KGF

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- **Start position:** Here you enter the start position for the test.
- **Measuring length:** Here you enter the measuring length for the test.
- **Dwell time:** Here you specify how long the machine is to wait at the end of a straight line until it begins the next straight line (recommended: minimum of 1s).
- **Working stroke:** Enter the working stroke in dependency to the path length (1-10%).
- **Measuring plane:** Here you select the measuring plane.
- **Measuring choice:** Here you can select the oblique straight lines to be traversed for the ISO 10791-6 (K3) test.
- **Generate path:** Click this button to generate and display the path according to the specified options.
- **Save path:** Click this button to save the entered ISO 10791-6 (K3) path.
- **Open path:** Click this button to select and open an ISO 10791-6 (K3) path.

## 11. Generating and transferring an NC program

→ If you wish to generate and transfer an NC program, call the menu item *File > Upload NC program to TNC*, and select the form in which you would like to transfer the NC program.



- **Generate according to options:** This button calls a dialog box entitled *Generate NC program for measurement* in which you define the parameters for the NC program.
- **Load from file (TCP/IP):** In the TCP/IP operating mode, a finished NC program is transferred from the file system of your PC to the NC control by a network connection.

### Note

Alternatively you can use the HEIDENHAIN PC-Tool TNCRemo for the data transfer to the control.

## Measuring Procedure for KGF

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Generate NC program for KGM free-form measurement

Mode:  HEIDENHAIN conversational  
 HEIDENHAIN ISO  ISO format

Program name: COATHANGER.H

Measuring plane:  XY  YZ  ZX

Description of path:  
Coathanger  
Select/enter

Save Cancel Help

Upload in: TCP/IP...

- **Mode:** Choose the format of the NC program.
- **Program name:** In TCP/IP mode you add the extension .H for HEIDENHAIN format or .I for ISO format to the NC program.
- **Measuring plane:** Click the working plane of the machine tool.
- **Description of path—Select/enter:** Here you select the program of the contour that is to be recorded with the **KGM**. You can also enter the measuring program here (see section 10, “Enter a Path”).
- **Save:** Click to save the NC program.
- **Cancel:** Click to close the dialog box.
- **Upload:** Click to start the upload.

Now an NC program is generated for the free-form contour and transferred to the root directory of the TNC in the default setting. Data transfer via TCP/IP opens a new file dialog window, where you can select the target directory on the control.



The TNC does not answer if the network is not connected.



## 12. Start measurement

→ With the menu item *Measure > Start measurement* or by clicking the associated button you can now begin the measurement.

**KGM free-form measurement**

Measurement 1     Measurement 2  
 Measurement 3     Measurement 4

Scaling of the graphic:  
 fixed     automatic

P1: -50 mm    -50 mm  
P2: 50 mm    50 mm

Path description:  
Test  
Select/enter  
Display path

Times:  
nom. time: 16.4 s  
max. dwelltime: 1 s  
act. time: 0.00 s    Check

Start    Cancel    Help

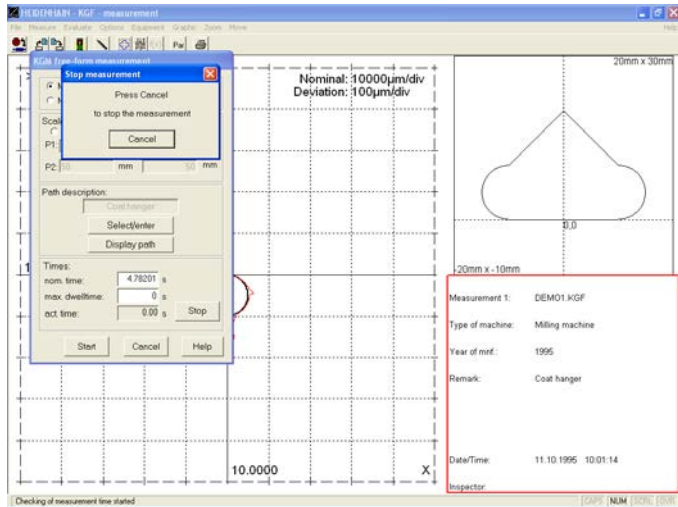
- **Measurement 1 – 4:** Here you can specify the number under which your measurement will appear in the graphic.
- **Scaling of the graphic:** Either you can preset the scaling as a **fixed** square with the diagonal corner points P1 (below left) and P2 (above right), or you can have the system generate it **automatically**.  
Input range P1, P2: -10 000 to +10 000 mm  
-390 to +390 inches
- **Description of path—Select/enter:** Here you select the program of the contour that is to be recorded with the **KGM**. You can also enter the measuring program here (see section 10, “Enter a Path”).
- **Display path:** You can display the programmed contour.
- **Measuring times:** The **nominal time** is the calculated ideal time needed for a contour, i.e. without considering the approach and braking behavior of the machine tool.

# Measuring Procedure for KGF

The **maximum dwell time** is the time that a machine can remain still before **ACCUM** stops recording the measured data, normally 1 second. If this time is too short or too long, you can change it here.

The **actual time** is the time actually required by the machine tool to machine the programmed contour. This time is needed by ACCUM to record the measured data. It can be measured through **check**, after which it is used automatically during the measurement. If there is no checking, the nominal time, which can also be changed manually is used for recording the measured data.

• **Check:** After you click this button, **ACCUM** prompts you to start the measuring program on the machine. Ensure that the feed rate is correct.



After the machine stops moving, a warning might appear that the nominal time has been exceeded (in practice, the machine might not reach the specified feed rate).

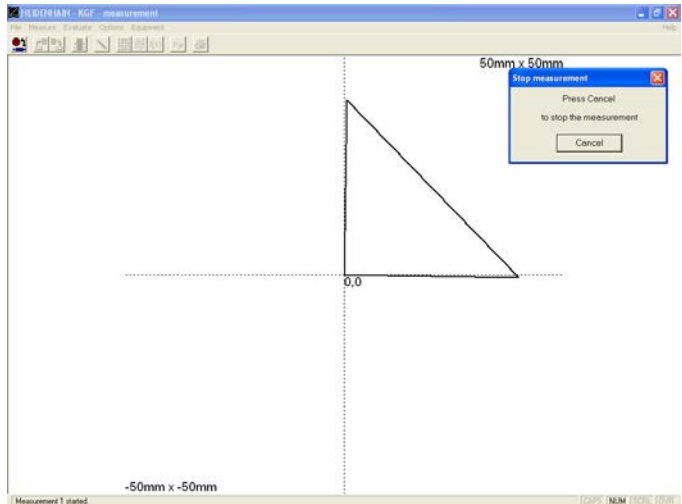
→ Click **OK**.

Now the actual time is displayed and is available to the system for the following measurement.

## Measuring Procedure for KGF

→ **Start:** After you click this button, **ACCOM** waits for the beginning of measurement.

→ Now start the NC program on the machine tool. In the status line, **ACCOM** shows the condition of measurement. You can terminate the measurement with **Cancel**.



Before you start the measurement, the scanning head of the **KGM** must be at the starting point. Otherwise the actual path will not agree with the nominal path.

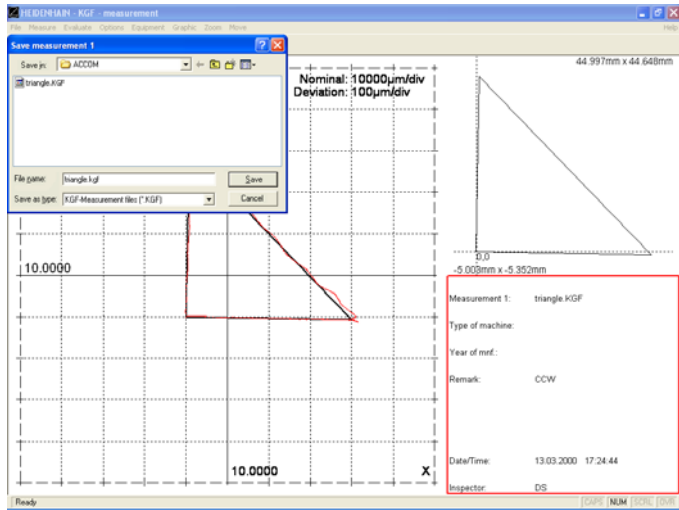
### Note

You can measure any path of traverse on the machine tool, even if it is not identical with the path entered in **ACCOM**. Pay attention to the duration of measurement and the size of the starting window (indicates the path of traverse at which the recording begins). This capability can be useful when you must measure complicated movements that are too difficult to program in **ACCOM**. In this case the nominal contour does not agree with the actual contour.

# Measuring Procedure for KGF

## Data storage

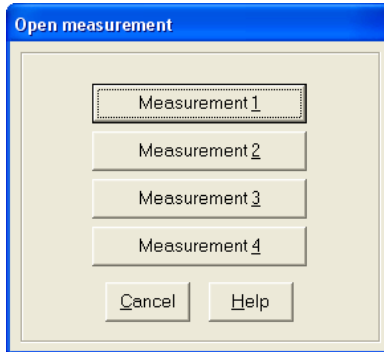
After conclusion of measurement, the following dialog box appears for data storage.



With *Measure > Start measurement* you can start further measurements.

## 13. Open measurement

→ Through *File > Open measurement* or by clicking the associated button you can load the measured data for further evaluation and display. The following screen appears.



Since up to four measurements can be shown simultaneously, this dialog box enables you to open the measurements in any sequence.

This menu item also enables you to call other motion error traces to the screen for further evaluation.



The results of measurement are loaded into the system with menu item *Open measurement*. This is a prerequisite for display. Through the menu item *Evaluate > Graphic* you can influence how and whether the motion error traces are displayed (see also section 15, "Graphic Display").

# Measuring Procedure for KGF

## 14. Evaluate measured data

→ You can view the raw measurement data through the menu item *Evaluate* > *Raw data* or by clicking the associated symbol. **ACCOM** shows the coordinates of the measurement points.

**Raw data of the measurement 1**

Customer: Mustermann  
Type of machine: Fräsmaschine  
SrNo. / year of: 12345 / 1995

Position of axis:  
X: 0 mm Y: 0 mm Z: 0 mm IV: 0 mm V: 0 mm

File name: DEMO1.KGF Measuring method: KGF  
Measuring plane: XY Measuring points: 999

Kleiderbügel

Date of: 11.10.1995 10:01:14 Inspector:

	X-position [mm]	Y-position [mm]
1	0.001155	0.001107
2	0.001555	0.001207
3	0.001547	0.001195
4	0.001547	0.001207
5	0.001559	0.001207
6	0.001543	0.001199
7	0.001555	0.001207
8	0.001555	0.001195

Cancel  
Help

### Note

The ACCOM data is saved in an ASCII file. The raw data are saved line by line, separated by tabs. You can load or import this file for further processing in other programs like Matlab, Origin, Microsoft Excel or Open Office.

To **print** the raw data, click the print symbol.

If you click **Cancel**, the dialog box closes.

## 15. Characteristic data acc. to ISO 10791-6 (K2, K3)

→ With the menu item *Evaluate > Raw data*, or by clicking the associated symbol, you can evaluate the characteristic data of the sequence of movements measured according to ISO 10791-6 (K2, K3).

### • Evaluation according to ISO 10791-6 K2—Feeds

**Characteristic data of the measurement 1**

Customer:  
 Type of machine: Test machine  
 S/No. / year of mnf.: /

Position of axis:  
 X: 0 mm Y: 0 mm Z: 0 mm IV: 0 mm V: 0 mm

File name: iso10791k-kgf Measuring method: KGF  
 Measuring plane: XY Measuring points: 19230

Characteristic data acc. to ISO 10791-6 (K2) Feeds			
Prog. feed rate:	Direction:	Actual feed:	Deviation (%):
100.00 mm/min	Forward	100.33	0.33
100.00 mm/min	Backward	100.20	0.20
1000.00 mm/min	Forward	1 002.92	0.29
1000.00 mm/min	Backward	1 003.55	0.36
Max. feed rate:	Forward	4 007.88	0.20
4000.00 mm/min	Backward	4 012.47	0.31
Rapid traverse:	Forward	4 007.88	0.20
4000.00 mm/min	Backward	4 012.47	0.31

Date of meas.: 24.02.2003 15:53:17 Inspector: DS

### • Evaluation according to ISO 10791-6 K3—Interpolation of two axes

**Characteristic data of the measurement 1**

Customer:  
 Type of machine:  
 S/No. / year of mnf.: /

Position of axis:  
 X: 0 mm Y: 0 mm Z: 0 mm IV: 0 mm V: 0 mm

File name: test\_k3.kgf Measuring method: KGF Line length: 80 mm  
 Measuring plane: XY Measuring points: 10000 Working stroke: 10 %

Characteristic data acc. to ISO 10791-6 (K3) Linear interpolation of 2 axes		
	Forwards	Backwards
Maximum deviation:		
a) $\frac{dY}{dX} = 0.05$ (= 2.86°)	9.9500 $\mu\text{m}$	10.164 $\mu\text{m}$
b) $\frac{dY}{dX} = 1$ (=45°)	6.8469 $\mu\text{m}$	6.7450 $\mu\text{m}$
c) $\frac{dX}{dY} = 0.05$ (=87.14°)	10.809 $\mu\text{m}$	9.9184 $\mu\text{m}$

Date of meas.: 24.02.03 14:44 Inspector: DS

# Measuring Procedure for KGF

## 16. Graphic display of free-form test results

→ You can specify the display mode of the motion error traces through the menu item *Evaluate > Graphic* or by clicking the associated symbol.

**KGM free-form graphic**

Display:  
 Measurement 1     Measurement 2  
 Measurement 3     Measurement 4

Representation:  
 Normal     Path zoom     Feedrate/Path  
Options    Path zoom-factor: 100

Style:  
 XY     Xt     Yt     Vt  
Y/X-factor: 1

Resolution: 20000  $\mu\text{m}$   
 fixed     automatic

Size of the overview window:  
 fixed     automatic  
P1: 0 mm x 0 mm  
P2: 99.994 mm x 99.994 mm

Active nominal path:  
 Measurement 1     Measurement 2  
 Measurement 3     Measurement 4

OK    Cancel    Help

- **Release:** Click the measurements to be displayed.
- **Representation—Normal:** The nominal and actual paths are shown in the same scale.
- **Representation—Path zoom:** The error along the contour is shown magnified in relation to the nominal path, whereby you can control the magnification factor.
- **Representation Feed rate/Path:** The feed rate curve is zoomed in relation to the nominal path. The magnification can be chosen with the magnification factor. A factor of 0.001 means the scaling of the feed rate is 1000 (mm/min)/div if the scaling of the nominal path is 1 mm/div. If the sampling rate is higher than 1 kHz the feed rate is filtered by a gliding average filter.



- **Style—XY:** The curve is shown in the measuring plane. You can vary the size ratio between the two coordinate axes with the **X/Y factor**.
- **Resolution:** You can set a fixed resolution for the graphic.

### Note

The XY scaling factor is useful for contours with large aspect ratios.

- **Style—Xi/Yt/Zt:** This display style of the trace over the measuring time can be selected only with **normal representation**.

With the **time factor** you can vary the display ratio of path to time axis (mm/div to 1s/div).

- **Style—Vt:** Display of the feed rate curve in relation to the measurement time.

- **Size of the overview window:** The scaling of the graphic is fixed as a square with the diagonal corner points P1 (below left) and P2 (above right).

Input range P1, P2: -10 000 to +10 000 mm  
-390 to +390 inches

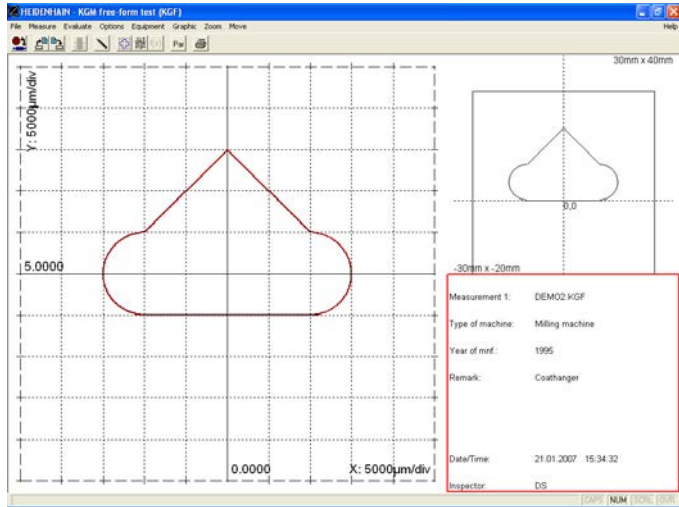
- **Active nominal path:** Here you select the measurement whose further data is to be shown in the legend.

- **Options in mode path zoom:** Here you can choose the method used by ACCOM to calculate and display the magnified deviation to the nominal path. (-> Path zoom options)

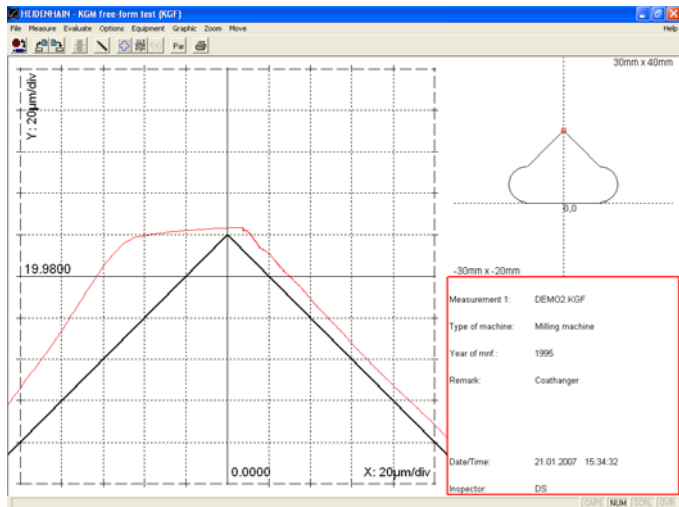
# Measuring Procedure for KGF

## Representation—Normal:

The nominal path and actual path can be **magnified**, **reduced**, or **shifted** by an equal factor through the menu items *Zoom* and *Move*.



Details can be magnified both in the right and left windows by clicking and pulling with the mouse. The example below shows the magnified point of the contour.

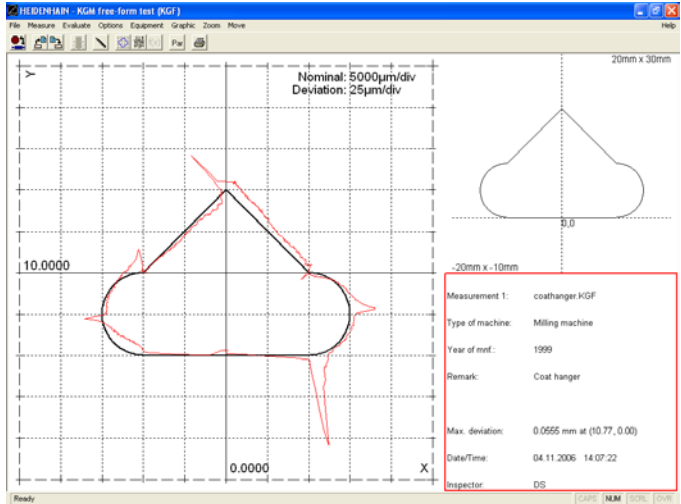


# Measuring Procedure for KGF

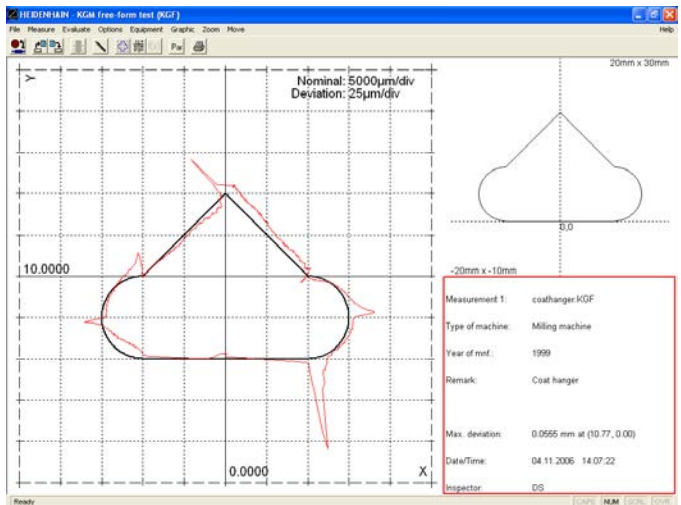
## Representation—Path zoom:

In this display mode, the error is shown magnified with respect to the contour elements.

## Vanishing point zoom at corners enabled:



## Vanishing point zoom at corners disabled:



# Measuring Procedure for KGF

Details of the contour can be **magnified, reduced, or shifted** through the menu items *Zoom* and *Move*.

Details can be magnified both in the right and left windows by clicking and pulling with the mouse.

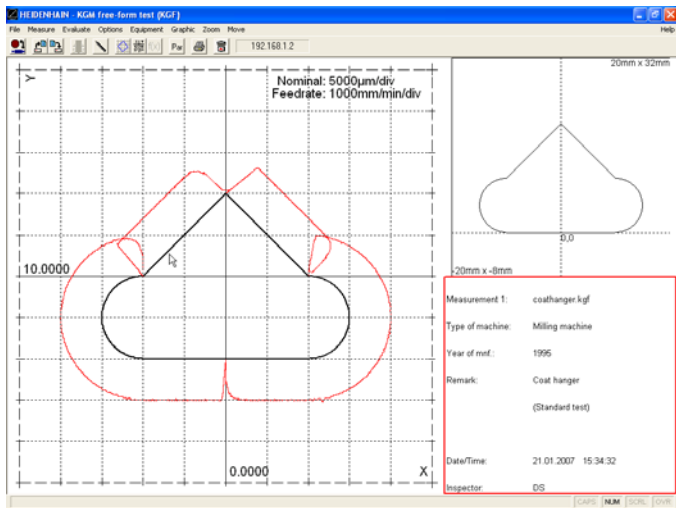
You can load new measurements with *File > Open measurement* or by clicking on the associated button.



An excessive number of contour elements can lead to calculational problems.

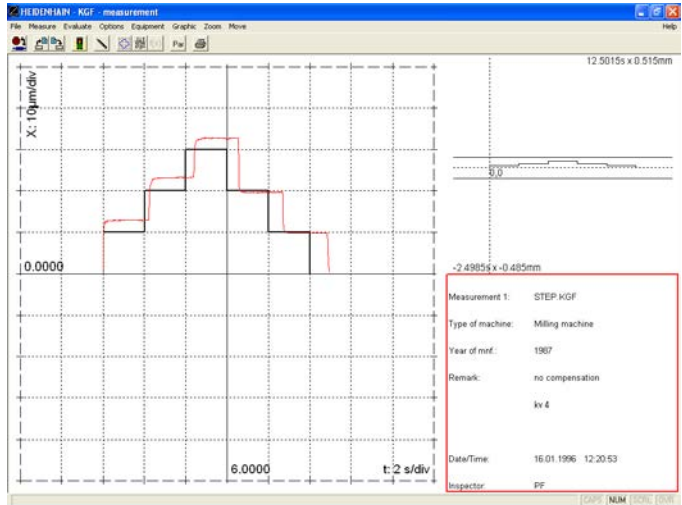
## Representation—Feed rate/path:

The feed rate curve is zoomed in relation to the nominal path.



## Style Xt / Yt / Zt:

In this display mode the course of the path can be shown over time. This example shows a step-response test as is used to measure overshoot behavior in an axis, including the influences of static friction. It also serves to measure positioning accuracy. This test is made on machine tools for high-precision parts where increments of 0.01 to 0.1  $\mu\text{m}$  are required.

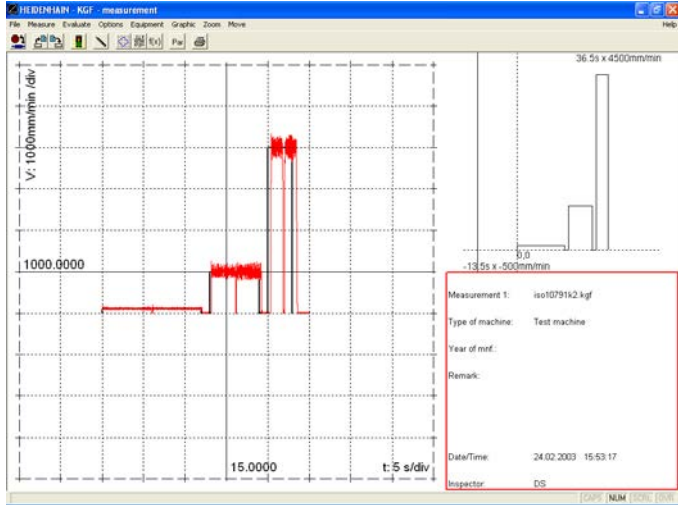


You can load new measurements with *File > Open measurement* or by clicking on the associated button.

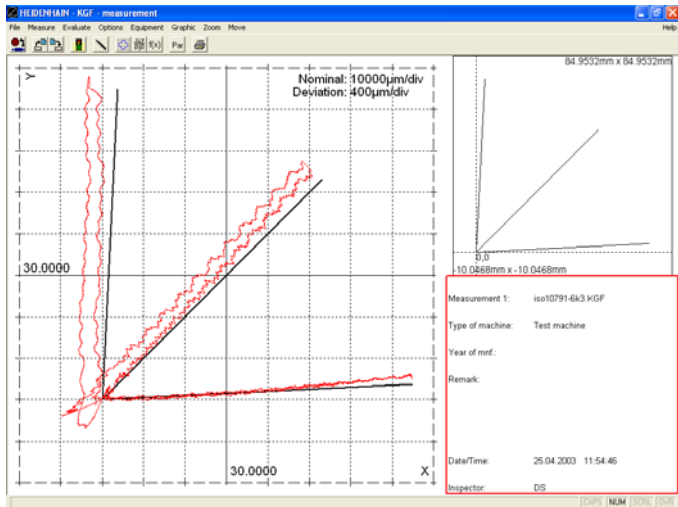
# Measuring Procedure for KGF

## Style Vt:

In this display mode the course of the feed rate can be shown over time. This example shows a measurement acc. to ISO 10791-6 K2.



## Path zoom of a ISO 10791-6 K3 measurement



## Path zoom options:

Here you can choose the method used by ACCOM to calculate and display the magnified deviation to the nominal path. Option 1, 2 and 7 directly affect the path zoom computation. The other options are display options only.

**Path zoom options**

1. Vanishing point zoom:  Active  
Relative distance:

2. Magnification at start/end of path:  
 Line (Default)  
 Corner (ACCOM 3.1)

3. Corner gap:  Active  
Length of the gap:  mm

4. Representation (up to/above limit):  
 No limitation (Default)  
 (a) Up to limit  
 (b) Above limit  
Limit:  mm

5. Show nominal path:  
 Yes (Default)  
 No

6. Show measurement:  
 All (Default)  
 (a) Only forward measurement  
 (b) Only backward measurement

7. Closed representation:  
 Off (Default)  
 (a) Closed representation  
 (b) Best fit (to nominal path)  
 (c) Standard with ref. meas. no.:  
 (d) Best fit with ref. meas. no.:

Measurement 1  Measurement 2  
 Measurement 3  Measurement 4

OK Cancel Help

**1. Vanishing point zoom:** The visualization of the magnified deviation of the actual data to the NC-path can be optimized around corners when choosing the vanishing point zoom.

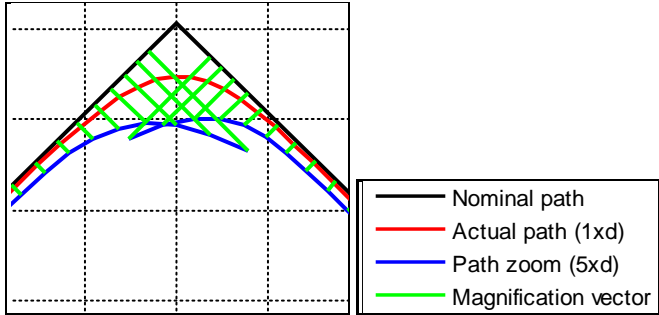
• **Relative distance:** Here you can choose the distance of the vanishing point from the corner relative to the shortest adjacent line.

Input range: 0.01 to 0.25

Without the vanishing point zoom option ACCOM calculates the magnified deviation identically for the complete path. This means the shortest distance from the measured data to the nominal path is calculated and displayed which is exactly the method used in all previous ACCOM versions.

The next figure shows the path zoom functionality at a corner without the vanishing point zoom. A path zoom factor of 5 is used here.

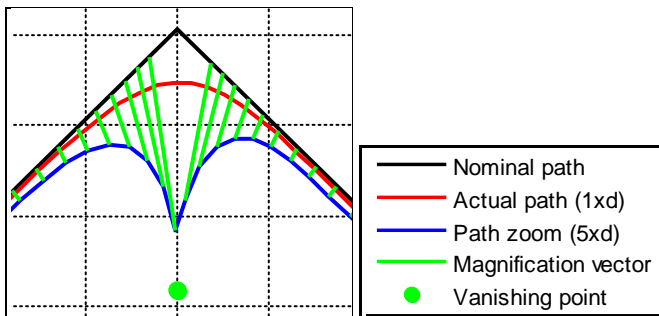
# Measuring Procedure for KGF



## Note

Because the magnification is shown with respect to the contour elements, the discontinuous transitions between the elements are not defined. The deviation at corners is most likely calculated too small with this method.

• **Vanishing point zoom:** Choosing the magnification of the deviation at corners towards a vanishing point on the bisecting line can optimize the display of the deviation to the nominal path geometry. The next figure shows in principle the calculation of the magnified measurement data. A path zoom factor of 5 is used here.



## Note

The vanishing point zoom deforms continuously the magnified actual data from the perpendiculars to the NC-path to the corner.

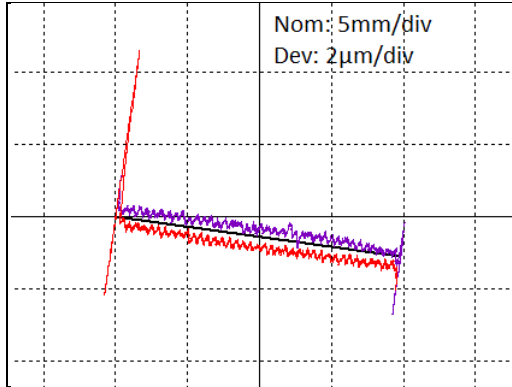
## Note

If the path zoom factor is too large or the distance of the vanishing point to the corner is too small a part of the magnified measured data would be point reflected.

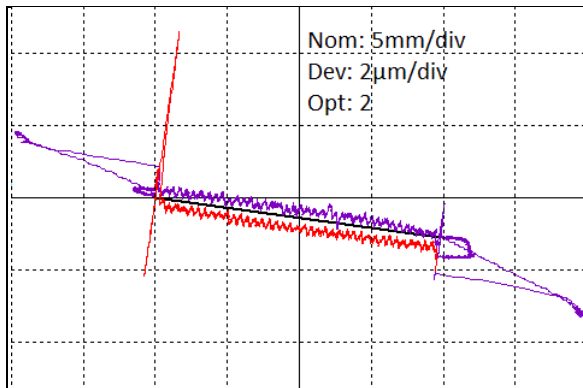


## 2. Magnification at start/end of path:

Default behavior of the path zoom at start/end of the path: The actual data points (outside the nominal path) are magnified orthogonally to the extended nominal path (similar to older ACCOM versions).



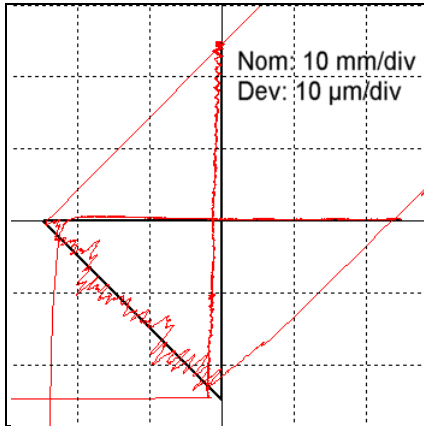
Alternatively you may use the evaluation of ACCOM 2.8-3.1. Here, the actual data points are magnified to the start/end point of the path (2D distance).



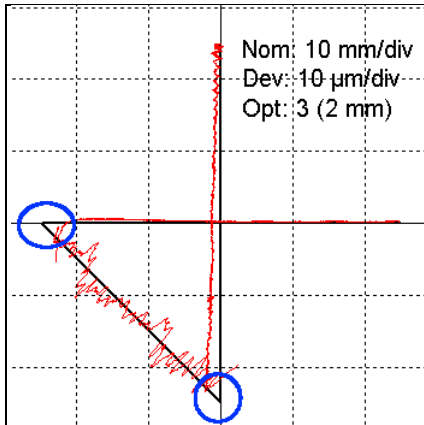
# Measuring Procedure for KGF

### 3. Corner gap:

If you are not interested in the deviations at path transitions, you may leave a gap in the magnified data representation.



Standard path zoom



Option 3: Corner gap active (Example: 2 mm)

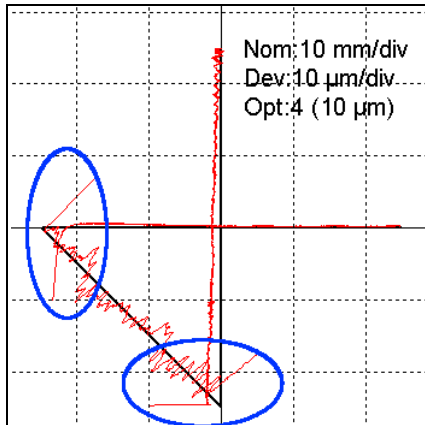
- **Length of the gap:** Here you can set the length of the corner gap.  
Input range: 0.001 to 10.0

### Note

Option 1 and 3 cannot be used at the same time.

## 4. Representation up to/above limit:

a) Here you can set an upper limit up to the magnified measurement data is plotted.



Option 4a: Representation up to a limit (here 10 μm)

b) Here you can set a lower limit from which the magnified measurement data is plotted.

- **Limit:** Here you can set the limit value for the upper or lower limit.

Input range: 0.0001 to 1.0

## 5. Show nominal path:

Here you can avoid the display of the nominal path. This option can be useful when comparing two measurements with different feed rates (slow/fast) in respect to the dynamic behavior of the machine. Global geometric errors to the nominal path are therefore suppressed (not visible) with this option.

## 6. Show measurement:

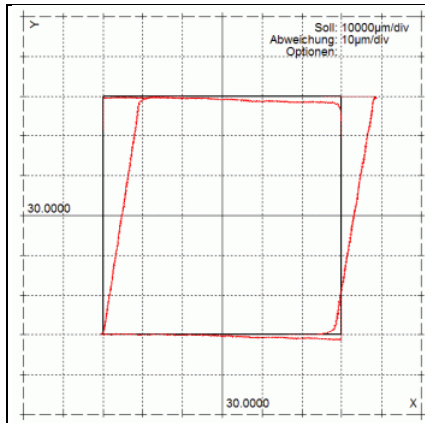
The default representation shows the complete measurement. If the nominal path has at least one reversal point, you can decide to show only the forward or backward part of the measurement.

## 7. Closed representation:

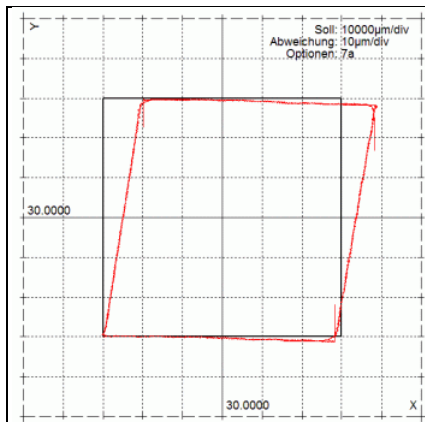
The default representation shows the magnified deviation perpendicular to the nominal path. With option 7a the path zoom is shown in a closed representation. Here the magnification of the measurement data is not always shown perpendicular to the nominal path, especially around corners. As a mathematical intermediate step a best-fit optimization is computed (option 7b). Here a minimum deviation of the complete measurement is computed.

### Example

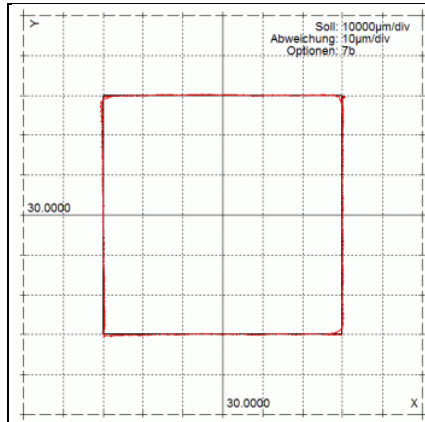
The following simple nominal path (square) demonstrates the use of the option „Closed representation“.



Standard path zoom



Option 7a: Closed representation



Option 7b: Best-fit representation

## Note

The closed representation is not suitable for all nominal and measurement data. Therefore it is not generally recommended as the standard representation in ACCOM.

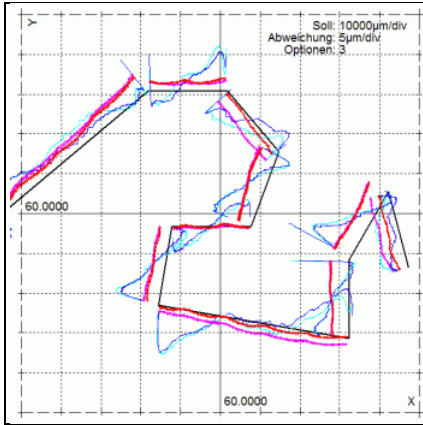
When using the closed representation with more than one measurement (different nominal paths or feed rates) the best-fit optimization of one measurement can be used for all measurements (7c and 7d). The best-fit optimization should be computed with a reference measurement at a low feed rate. Using this option offers a better look at dynamic effects with the same nominal path. A second measurement with higher feed rate uses the best-fit optimization of the reference measurement (7c). To avoid global geometric deviations in the representation of dynamic deviations you may use option 7d. Again, a slow reference measurement and a fast measurement are necessary.

## Example

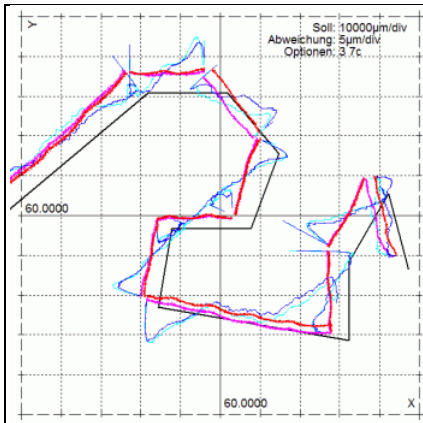
The following free-form path demonstrates the use of the „Closed representation with reference measurement“. The next three graphics show a reference measurement (red/pink,  $F=200$  mm/min) and a dynamic measurement (blue/light blue),  $F = 15000$  mm/min) with a forward (red and blue) and backward part (pink and light blue).

In addition option 3 is used here (corner gap) to avoid the visualization of the path deviations at the transitions.

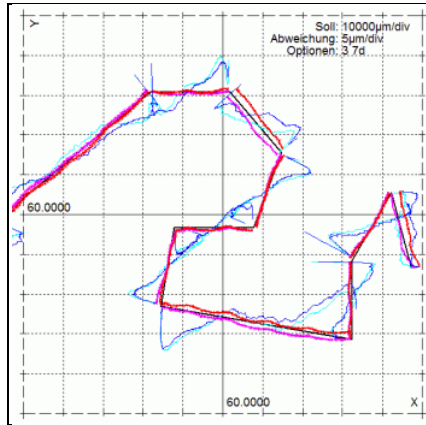
# Measuring Procedure for KGF



Standard path zoom



Option 7c: Closed representation with reference measurement



Option 7d: Best-fit representation with reference measurement

## Note

Using options 7a-d (closed and best-fit representation):  
The deformation of the magnified contour deviation could lead to a misinterpretation of the actual deviation. Especially with option 7b and 7d the global geometric error of the measurement is removed. The closed representation is primarily a display tool. Simple and ideal contours (e.g. square or cross) show nearly the same deviations with option 7a and the default path zoom display. Large deviations in the measurement data could lead to a deformation of the magnified path zoom after the best-fit algorithm.

## Note

The used options are shown in the graphics display.

# Measuring Procedure for KGF

## Evaluation of contour deviation and path time

The area between the measurement data and the nominal path could be used as a more objective value for various measurements (mean deviation). The calculation of the effective deviation will additionally reduce noise effects. A machine tool is normally not fully compensated at the time of the measurement. Missing linear or nonlinear axis compensations, kinematic errors or missing thermal compensations affect the calculation of the maximum, mean and effective deviation. A more objective calculation can be achieved by using an additional reference measurement to reduce global deviations of the measurements to the nominal path (2 offsets, 2 axis scalings, 1 squareness and 1 rotation). This procedure is especially beneficial by using a low feed rate measurement as a reference measurement before a dynamic high speed measurement.

Maximum deviation		Path time	
Meas. 1	1.239 [µm] at 102.45mm/64.76mm	194.058 [s]	
Meas. 2	7.397 [µm] at -3.47mm/20.36mm	6.180 [s]	
Meas. 3	[µm] at	[s]	
Meas. 4	[µm] at	[s]	

Mean deviation		Effective deviation	
Meas. 1	0.293 [µm]	0.373 [µm]	Save
Meas. 2	1.616 [µm]	2.052 [µm]	Close
Meas. 3	[µm]	[µm]	Help
Meas. 4	[µm]	[µm]	

Active option(s): 3 - 0.600mm, 7d - Best-fit representation to meas. 1

### Maximum deviation:

Maximum contour deviation of all measurement points

### Path time:

Looking at the measurement data until standstill is used as path time (the standstill window is used as a threshold)

### Mean deviation:

Mean contour deviation of all measurement points (Absolute values)

$$\text{dev}_m = \text{sum}(\text{da} \cdot \text{dl}) / l$$



**Effective deviation:**

Effective contour deviation of all measurement points (RMS value)

$$\text{dev\_eff} = \sqrt{\sum(\text{da} * \text{da} * \text{dl}) / \text{l}}$$

da: Mean deviation of 2 neighboring data points (Absolute value)

dl: Distance between the 2 neighboring data points (at the base points)

l: Total length (Sum of all used elements dl)

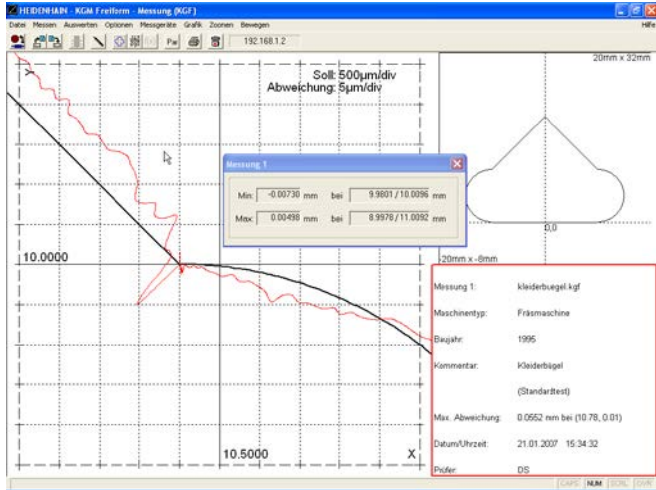
**Note**

The used method for the path-zoom calculation is documented in the lower status window.

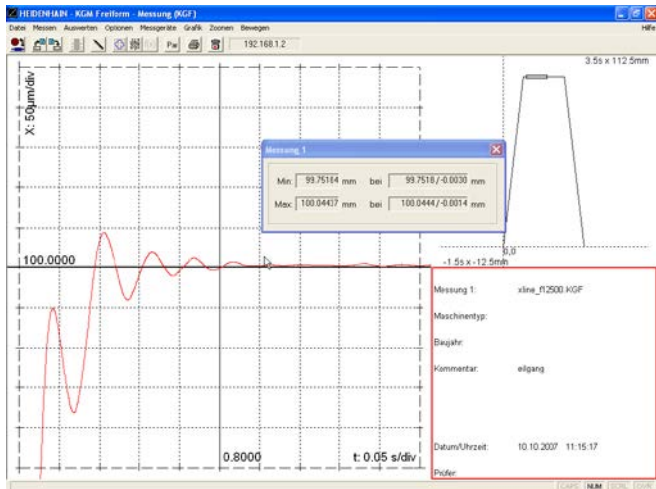
# Measuring Procedure for KGF

## Current evaluation

The maximum deviation of the current detail in the display mode path-zoom is shown here. The sign of the deviation value is determined by the movement: Deviations on the right side of the moving direction are shown with a positive sign.



The minimum and maximum value of the specified axis is shown in the display mode Xt (Yt / Zt).



## Color settings of the graphic

If you would like to change the **color setting of the graphics**, you can change the color of the error traces, of the coordinate system and the graphic background with the menu item *Options > Color setting*.

The 2 colors of each measurement are used

## Saving/loading the options

You can save these settings with the menu item *Options > Save options*.

You can call these settings with the menu item *Options > Load options*.

## Exporting the measurement graphic

If you wish to **export the measured graphic as a file** without a log, you can save it as a bitmap using the menu item *Graphic > Save*.

## Printing the graphic

You can **print** the graphic with the menu item *Graphic > Print*.

You can change the **printer settings** through the menu item *File > Printer setup*.

## Saving a measurement

If you make **changes to a calibration chart**, you can save them through the menu item *File > Save measurement* or by clicking the **save** button.

As an alternative, you can also save the measured data through the menu item *File > Save all measurements*.

## Clearing the screen

To remove the motion error traces from the screen, you can **clear the screen** with the menu item *Graphic > Close*.

# Measuring Procedure for KGF

## Editing the calibration charts

If you would like to **edit the calibration charts** you can select the desired chart through the menu item *Measure > Calibration chart* or by clicking the associated symbol.

**Calibration chart of measurement 1**

Customer:

Type of machine:

SrNo. / Year of mntf.:  /

Remark 1:

Remark 2:

Remark 3:

Inspector:

HEIDENHAIN Reference meas. system:

ID number:  Serial number:

Position of axis X:  mm

Position of axis Y:  mm

Position of axis Z:  mm

Position of axis IV:  mm

Position of axis V:  mm

Open chart window automatically after a measurement?  
 Yes  No

## Measuring Procedure for VM Linear Test (VML)

### Machine cleaning

→ Before beginning to mount the VM, clean the area of the machine tool in which the measurements are made. Pay special attention to any chips and oil or grease residue that could fall onto the encoder.



Give the encoder time to adjust to the ambient temperature before you begin mounting it. This will help to prevent thermally induced error.

### Test program

For non-HEIDENHAIN controls, a typical test program for comparative linear measurements with reverse cycle could be written as follows, whereby movement must be measured parallel to the measuring axis. With HEIDENHAIN controls, the machine program can be transferred directly from **ACCOM**.

**Part 1, forward cycle:** The measuring head starts at a reversal point. Forward movement to the datum, dwell time and automatic recording of the measuring point. Forward movement to the next position, dwell time and automatic recording of the measuring point, ... , last position, dwell time and automatic recording of the measuring point.

**Part 2, reverse cycle:** Movement by the reversal path forward, dwell time, backward movement to the last position, dwell time and automatic recording of the measuring point, backward movement to the point before last, dwell time and automatic recording of the measuring point, ..., datum, dwell time and automatic recording of the measuring point.

**Possible further cycles:** Like the 1st forward cycle, this cycle would also begin with a backward movement by the reversal path.



Ensure that there are no “forgotten” compensation data saved in the control that could cause a movement perpendicular to the encoder or corrupt the measurement. The measuring head must maintain a constant angular position. You might try running the machine program without the encoder.

# Measuring Procedure for VML

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## Measuring assembly

→ Ensure that the **IK 220** PC counter card was installed in your PC according to the instructions in the User's Manual. Alternatively you can use the **EIB 741**. Please ensure an available peer-to-peer network connection to the **EIB 741** (address and subnet mask of the TCP/IP connection). Connect the encoder cables to X11 and X12. Now mount the **VM** or **KGM** according to the instructions in the manual. When mounting the KGM, do not use any screws whose heads project above the height of the cross grid! Use a dial gauge to align the VM parallel to the axis by approx. 10 µm.



When connecting the measuring cables, be sure to leave enough slack to compensate any machine movement during measurement.

→ Before starting ACCOM, connect the enclosed hardware key with Id. No. 590255-01 or 590255-02 to one free USB port.

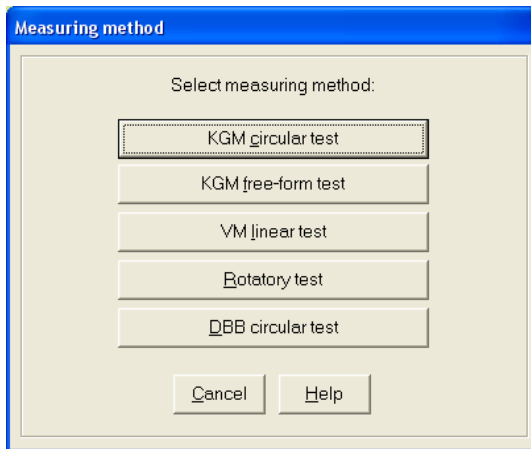
After calling **ACCOM**, proceed as follows:

## 1. Select measuring method

After **ACCOM** is started, a dialog box appears in which you can select the type of measurement.

→ Click the **VM linear test** button to start the corresponding program part.

With the menu item *File > Select measuring method* or by clicking the icon you can select the individual measuring methods from within the running program.

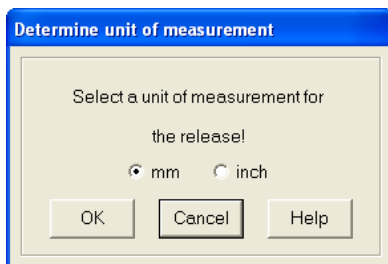


## Measuring Procedure for VML

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### 2. Specifying the unit of measure

→ With the menu item *Options > Unit of measurement* you specify the desired unit of measure. Close the dialog box with **OK**.





## 3. Settings of the encoder and the counter card

→ Under *Option > Measuring interface* you set the parameters for the encoder used.

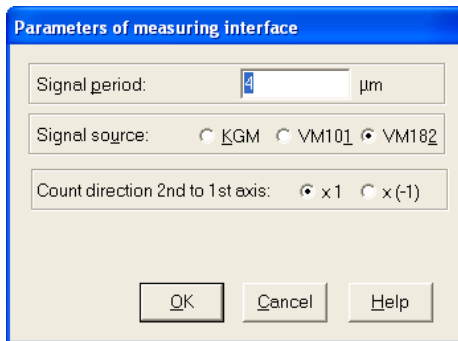
- **Signal period:** Here you set the signal period (as its distance in  $\mu\text{m}$ ) of the encoder you are using. The default setting for the signal period is 4  $\mu\text{m}$ .

Input range: 0.1 to 20  $\mu\text{m}$

- **Signal source:** Select the model of encoder being used.

- **Count direction 2nd axis to 1st axis (VM 182 only):**

According to the set-up of the **VM 182** it can be necessary to manually set the count direction for the 2nd axis (orthogonal axis).



→ Under *Option > Counter card* you set the parameters for the counter card.

- **Type counter card:** Here you select the model of counter card that you are using.

- **Signal input:** Here you select the type of measuring signal.

- **Address EIB 741:** Here you enter the IP address of the **EIB 741** (see also **EIB 741** user manual). Alternatively you may use the DHCP hostname in a company network. However it is not recommended due to the high data acquisition rate. This setting is not needed for the **IK 220**.

- **Automatic connection at program start:** ACCOM connect to the **EIB 741** at the next program start automatically if chosen. A valid connection to the **EIB 741** is required!

- **Test IK (IK 220):** Here you can then test the counter card for proper function.

- **Connect/Disconnect (EIB 741 only):** The **EIB 741** will be connected or disconnected here.

## Measuring Procedure for VML

---

Counter card

Type counter card:  IK220  EIB741

Signal input:  1Vpp  11 µApp

Address: 192.168.1.2

Automatic connection at program start

Test IK OK Cancel Help



Ensure that you have entered the proper model, address and signal input of the counter card. If the signal period is entered incorrectly, the distances will be measured too large or too small.

### Note

**Only EIB 741:** Connect the **KGM/VM** to the encoder inputs X11 and X12.

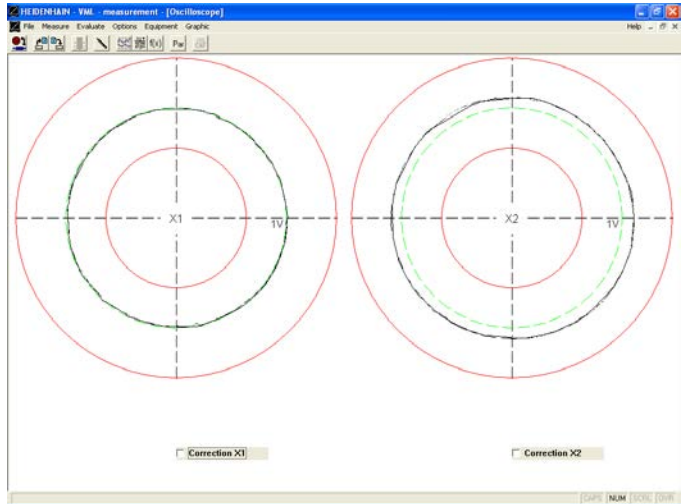


If you have problems receiving data from the counter card, use the test programs on the provided driver CD to check whether the card can be used.

## 4. Fine adjustment of the measuring head

### Oscilloscope

→ With the menu item *Equipment > Oscilloscope* you can display the measuring signals received by the PC counter card as Lissajous figures. You need this for the fine adjustment of the encoder (see mounting instructions of the **KGM** or **VM**).



The measuring signals are displayed for the directions I and II in the oscilloscope display mode (for measuring signals 0° elec. and 90° elec.).

→ **When using the KGM**, move the machine tool slide slowly and evenly in diagonal direction. Use the adjusting screws on the measuring head to adjust the signal amplitude. In the ideal case, the measuring signal amplitude lies near the green circular path (1 V<sub>PP</sub>) between the red limit circles.

If the encoder signal is too large or small, the message **Amplitude too high / too low** appears in the status line of the **ACCOM** screen.

# Measuring Procedure for VML

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## Optimizing the measuring signals

→ Through automatic signal adjustment, **ACCOM** can optimize the **measuring signals** to attain very high accuracy. Click the boxes **Compensation X1 (X11)** and **Compensation X2 (X12)** and, **when using the KGM**, move the machine slides slowly and evenly in diagonal direction. **When using the VM**, move only in paraxial direction. Then switch this function off by clicking both boxes Compensation X1 (X11) and Compensation X2 (X12) again, and go to the next item of the instructions. The **EIB 741** optimizes the analogue signals automatically. However, the optimized analogue signals are used only for the computation of the position values. Therefore it is possible to observe imperfect circular Lissajous figures.



If the displayed signal amplitude is too low, check whether the settings for the interface are correct and whether the encoder is correctly installed. Then start **ACCOM** again. Do not engage or disengage any connectors until you have exited **ACCOM**!

## Position display

With the menu item *Equipment > Position display* you can call the position display for the connected encoder and, for example, check the positive counting direction of the **KGM/VM**. If you call this function after setting the position (see section 8, "Set datum"), before the test you should check again whether your datum is set correctly and, if not, enter it again.

The screenshot shows a dialog box titled "Position display" with a blue border. It contains two rows of data:

X11:	0.0002 mm
X12:	0.0019 mm

At the bottom right of the dialog box, there are three buttons: "Reset", "Cancel", and "Help".

## 5. Parameters of the measurement

→ By calling the menu item *Options > Parameters of the measurement* or clicking the icon, you open the following dialog box in which you can adjust the **parameters of the measurement**.

**Parameters of the measurement**

Axis:  X axis  Y axis  Z axis

Orthogonal axis:  X axis  Y axis  Z axis

Trigger mode:  Automatic  Manual

Position window: ± 0.1 mm

Standstill speed: 10 mm/min

Nominal positions:

Position list:

0.0000  
50.0000  
100.0000  
150.0000  
200.0000  
250.0000  
300.0000  
350.0000  
400.0000  
450.0000  
500.0000  
550.0000

Amount of pos.: 13

1st / 2nd point  
1st / Last point  
1st / stepwidth  
All points

Cycles: 5

Reversal dist.: 5 mm

Dwell time: 1 s

Meas. mode:  Linear  Step-cycle

Backward cycles

Check position traverse  
(Can be turned off for ISO 230-3 measurements. Should be used for ISO 230-2 standard measurements.)

Ok Cancel Help

- **Axis:** Select here the axis of measurement.
- **Orthogonal axis:** The orthogonal axis can be selected here when using the **KGM** or the **VM 182**.

- **Amount of pos.:** The number of positions is defined automatically when the nominal positions are specified.

- **Nominal positions:** You have a choice among four possibilities: **1st/2nd point**

- 1st/last point**

- 1<sup>st</sup> point/step width**

- All points**

**1st/2nd point:** Here you enter the first and second measuring points as well as the total number of measuring points (including the first and last). **ACCOM** automatically calculates all measuring points and shows them in the **position list**.

# Measuring Procedure for VML

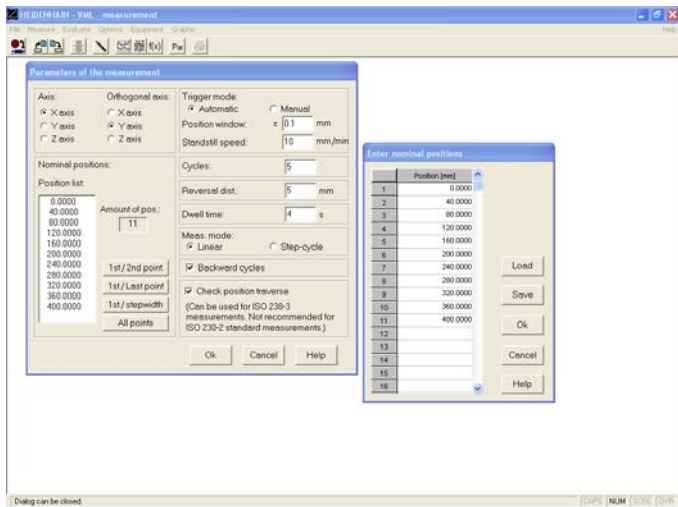
**1st/last point:** Here you enter the first and last measuring points as well as the total number of measuring points (including the first and last). **ACCOM** automatically calculates all measuring points and shows them in the **position list**.

**1st point/step width:** Here you enter the first measuring points and the step width between the measurement points as well as the total number of measuring points (including the first and last). **ACCOM** automatically calculates all measuring points and shows them in the **position list**.

**All points:** Here you can enter all positions, which are then shown in the **position list**. The positions must be entered in ascending order.

## Note

The nominal positions have to be in monotonically increasing order.



### Note

With *Save* you can save the file under any name and edit it later with the editor or a spreadsheet program such as Microsoft Excel or Open Office. In this way you can also generate random values. With *Load* you can read existing files into the measuring program.

- **Trigger mode—Manual:** In this setting you must use the *Save* key in the measuring dialog box to manually confirm that the measuring position has been reached.
- **Trigger mode—Automatic:**
  - Position window:** Enter here the size of the positioning window (nominal position  $\pm$  position range) within which a momentary position is considered to have been reached. If the range is too small, a measuring cycle will be interrupted by large error values. If it is too large, the measured value will be Saved too soon.
  - Standstill speed:** For automatic position detection, the change in position must be smaller than the standstill speed specified here.
- **Cycles:** Here you enter how many times in a row the nominal positions are to be scanned. You must previously have clicked **Backward cycles** (positions are also approached backward), otherwise only one forward cycle is possible.
- **Reversal dist.:** The distance to be traversed so that the same nominal position can be approached from the opposite direction. **ACCOM** recognizes the backward movement after half the distance. For extremely high traversing speeds, enter a dwell time at the end of the reversal distance in the NC program.
- **Dwell time:** Here you specify how long the machine is to wait at one position until it approaches the next position. **ACCOM** automatically records the measured values after half the dwell time.
- **Measuring mode—Linear:** All positions are traversed in sequence.
- **Measuring mode—Step cycle:** Each nominal position is approached in positive and negative direction as many times as is defined under Cycles. The process is repeated in sequence at all positions.
- **Backward cycles:** Here you specify whether the nominal position will also be approached backwards. If the backward cycles are not checked, you can run only the **linear** measuring process with **one** forward cycle.

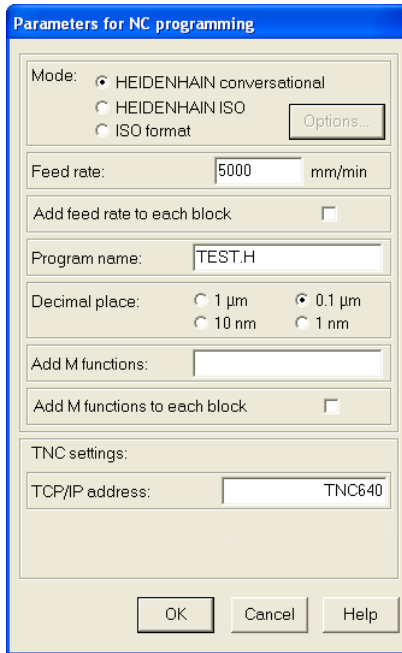
- **Check position traverse:** This option should be enabled for all ISO-230-2 measurements. ACCOM then always checks whether a measurement position has been skipped. If that happens the trigger conditions "position range" and "standstill range" should be increased.

However this option has to be disabled for ISO 230-3 measurements with additionally heating cycles in between the measurement cycles. Here the trigger conditions have to be increased as well.



## 6. Setting the NC interface

→ If you wish to transfer the measuring program in **ACCOM** to a HEIDENHAIN control, select *Options > NC programming* to open a dialog box in which you can configure the network connection.



- **Mode:** Choose between HEIDENHAIN or ISO format.
- **Feed rate:** Here you enter the nominal feed rate for the circular motion.  
Input range: 0.001 to 100 000 mm/min or 0.000 04 to 3900 inches/min
- **Program name:** Here you give the program a name (the extension .H stands for HEIDENHAIN, .I stands for HEIDENHAIN ISO and .txt for general ISO).
- **Decimal place:** Select the decimal place of the NC programs.
- **M functions:** Here you enter additional M functions which are necessary to run the NC program on the control. The M functions are added to the first NC block.  
Example in HEIDENHAIN conversational programming:  
**2 L X0 F1000 M31**
- **TCP/IP address:** Here you enter the TCP/IP address or DHCP hostname of the control for the data transfer via network connection.

## G-Code options

→ By clicking the control button **Options** the following dialog box opens. Here you can configure some ISO format settings which are suitable to the control.

The image shows a screenshot of a software dialog box titled "Parameters for NC programming". It has a blue header bar. Below the header, there are several sections. The first section is "Mode:" with three radio buttons: "HEIDENHAIN conversational", "HEIDENHAIN ISO", and "ISO format" (which is selected). There is an "Options..." button to the right. The second section is "GCode import options" with a blue header bar. It contains four rows of settings: "Position (export):" with "Incremental" and "Absolute" radio buttons (the latter is selected); "Circle center:" with "Incremental" and "Absolute" radio buttons (the former is selected); "Feedrate:" with "Inch/min" and "0.1Inch/min" radio buttons (the former is selected); and "Use G-Code G71/G70 for MM/Inch:" with an unchecked checkbox. At the bottom of this section are "OK", "Cancel", and "Help" buttons. The third section is "Additional lines at program start:" with a text input field containing "G54". Below it is "Additional lines at program end:" with a text input field containing "M30". At the bottom of the dialog are "OK", "Cancel", and "Help" buttons.

- **Position (export only):** This parameter is used in the export of an ISO NC program only. For absolute positions G90 is added at the NC program start, for incremental positions G91 is used.

For absolute NC programs it is useful to add a datum shift (e.g. G54).

- **Circle center:** The input of the circle center point acc. to the German standard DIN 66025 is done incremental to the last position or absolute. Usually I, J, K are used with incremental positions. Valid is also an absolute position with I, J, K. (depends on the control).

- **Feed rate:** This parameter is only valid for an INCH program. The feed rate can be set in Inch/Min or Inch/10Min (HEIDENHAIN default).

- **G-code for Inch/MM:** You can choose whether to use G71/G70 for NC programs or not.

In the dialog box **Parameters for NC-programming** you may add the following data for the ISO format programming:

- **Additional lines at program start:** Here you can add 2 user or control specific lines at program start (e.g. G54).
- **Additional lines at program end:** Here you can add 2 user or control specific lines at program end (e.g. M30).

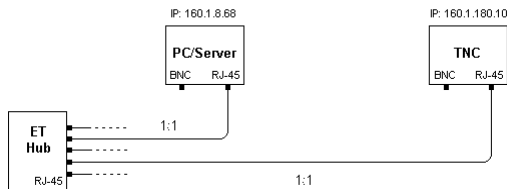
## Network cable

Connect the TNC by a (crossed) network cable directly to the PC or by using a standard network cable with a hub or a switch to the company network.

## Note

Peer-to-peer (direct connection): You need to set the IP-Address of the PC in *Control Panel / Network / TCP-IP / Properties* (depends on the operating system). As default the value for the IP-Address will be given automatically in a company network (from the DHCP Server).

## LAN (Network) with a 1:1 cable



## Peer-to-peer (direct connection) with a (crossed) cable!

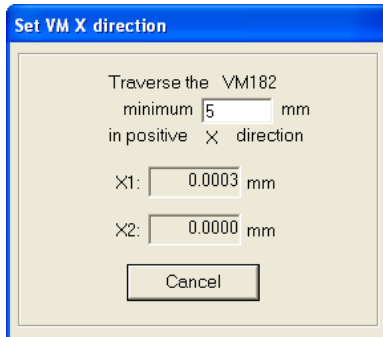


# Measuring Procedure for VML

## 7. Setting the direction

→ **KGM**: Before the first measurement with the **KGM**, **ACCOM** must know the positive counting direction of each axis as well as the angular position of the **KGM** on the machine table. In the menu item *Measure > Directions*, **ACCOM** prompts you to move the machine slides in sequence in the direction shown in the dialog box. The directions depend on the setting of the measuring plane (see positive direction I and II on the **KGM**). To optimize the angle compensation, enter if possible your entire traverse distance in the dialog box. The required accuracy data is calculated from the signals of the encoder (channel assignment, counting direction and angular position).

→ **VM**: Before the first measurement with the VM, **ACCOM** needs to know the positive counting direction. In the menu item *Measure > Directions*, **ACCOM** prompts you to move the machine slides in sequence in the direction shown in the dialog box. The directions depend on the setting of the measuring axes. The positive counting direction of the orthogonal axis can be recognized with the “right-hand rule.” The VM has no automatic angular error compensation. It is therefore important that the encoder is aligned exactly.



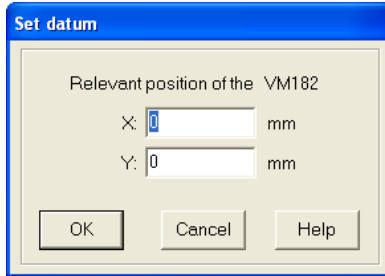
During the **directional detection**, do **not** move the machine tool slide in a **diagonal direction**. Otherwise the detected angular position will be incorrect. Movement in diagonal direction will result in damage to the VM!

## 8. Set datum

→ In the menu item *Measure > Set datum* you assign **ACCOM** a position value in agreement with the control.

### Example:

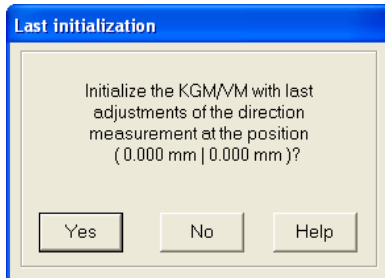
If the scanning head is located at the starting position, you assign it the coordinates X0 and Y0.



When using “Set datum” and “Set direction” do not forget the influence on the measurement of the backlash in NC axes, especially at the beginning of the measurement.

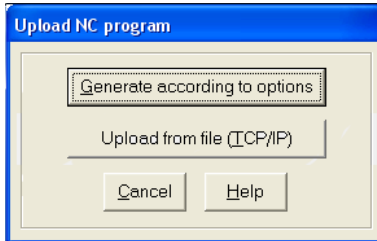
## Last initialization

After you have started **ACCOM** you can use your previous settings by calling the menu item *Measure > Last initialization*, provided that the setup of the **VM 182** on your machine has not changed and you move the scanning head to the position last set. Then continue with the next program item.



## 9. Generating and transferring an NC program

→ If you wish to generate and transfer an NC program, call the menu item *File > Upload NC program to TNC*, and select the form in which you would like to transfer the NC program.



- **Generate according to options:** This button calls a dialog box entitled *Generate NC program for measurement* in which you define the parameters for the NC program.
- **Load from file (TCP/IP):** In the TCP/IP operating mode, a finished NC program is transferred from the file system of your PC to the NC control by a network connection.

### Note

Alternatively you can use the HEIDENHAIN PC-Tool TNCRemo for the data transfer to the control.

Generate NC program for VM measurement

Mode:  HEIDENHAIN conversational  
 HEIDENHAIN ISO  ISO format

Feed rate:  mm/min

Program name:

Measuring axis:  X  Y  Z

Save Cancel Help

Upload in:

- **Mode:** Choose the format of the NC program.
- **Feed rate:** Enter here the nominal feed rate of motion.  
Input range: 0.001 to 100 000 mm/min  
0.000 39 to 3937 inches/min
- **Program name:** In TCP/IP mode you add the extension .H for HEIDENHAIN format or .I for ISO format to the NC program, Ext/ME mode there is no extension.
- **Axis:** Select here the machine axis being used.
- **Save:** Click to save the NC program.
- **Cancel:** Click to close the dialog box.
- **Upload:** Click to start the upload.

Now an NC program is generated for the VM linear measurement and transferred to the root directory of the TNC in default setting. Data transfer via TCP/IP opens a new file dialog window, where you can select the target directory on the control.



The following prerequisites must be met for the correct execution of the NC program.

1. At program start, the scanning head must be located at the starting point.
2. The correct program is selected at the control.



The TNC does not answer if the network is not connected.

# Measuring Procedure for VML

## 10. Generating a calibration chart

→ Through the menu item *Measure > Calibration chart* or by clicking the icon you can define the calibration chart for the measurement by entering information on the measurements in the calibration window. By clicking **yes** or **no** you can specify whether the **chart window** will open automatically after each measurement.

Calibration chart of measurement 1

Customer:

Type of machine:

SrNo. / Year of mnt.:  /

Remark 1:

Remark 2:

Remark 3:

Inspector:

HEIDENHAIN Reference meas. system:

ID number:  Serial number:

Position of axis X:  mm

Position of axis Y:  mm

Position of axis Z:  mm

Position of axis IV:  mm

Position of axis V:  mm

Open chart window automatically after a measurement?  
 Yes  No

OK Cancel Help

If you enter the chart data only for measurement 1, they will automatically apply also to the other measurements. The charts can also be saved or edited later in the course of evaluation.

**ACCOM** saves these data together with the measured data and prints them through the menu items *Evaluate > Measured data*, *Evaluate > Characteristic data* and *Graphic > Print*.



## 11. Start measurement

→ Select the menu item *Measure > Start measurement* or click the associated button to open a dialog box with which you can start the measurement after entering the following parameters.

The screenshot shows a dialog box titled "VML measurement". It features four radio buttons labeled "Measurement 1", "Measurement 2", "Measurement 3", and "Measurement 4", with "Measurement 1" selected. Below this, there are two sections for axis scaling. The first section, "Scaling of the measuring axis:", has input fields for "Dmax:" (value 10) and "Dmin:" (value -10), both followed by the unit "µm". The second section, "Scaling of the orthogonal axis:", has similar input fields for "Dmax:" (value 10) and "Dmin:" (value -10), also followed by "µm". A checkbox labeled "Display orthogonal axis" is checked. At the bottom of the dialog are three buttons: "Start", "Cancel", and "Help".

- **Measurement 1-4:** Click the number under which the measurement is to be shown later.
- **Scaling Dmax/Dmin:** Enter here the upper and lower limit of the expected error. You can change the scaling at any time later during the evaluation.
- **Display orthogonal axis:** Here you can deactivate the display of the orthogonal axis when you are using the **KGM** or **VM 182**. The measured values of the orthogonal axis are nevertheless recorded.
- **Scaling of the orthogonal axis Dmax/Dmin:** If you are using the **KGM** or **VM 182**, enter here the upper and lower limit of the expected error in orthogonal direction. You can change the scaling at any time later during the evaluation.

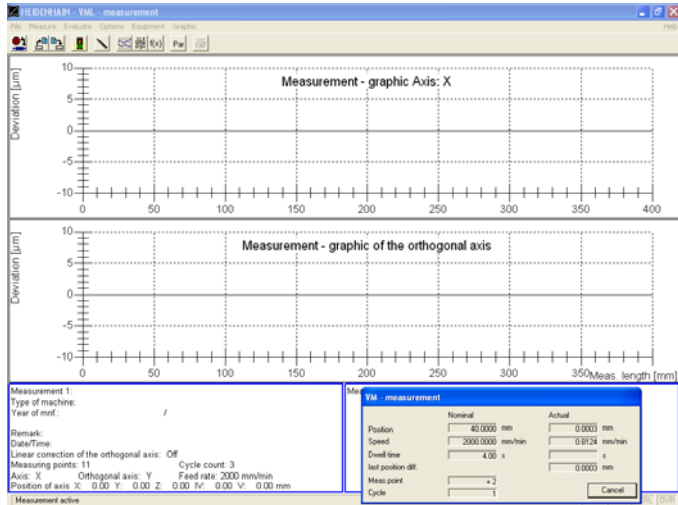


The following conditions must be fulfilled for a correct measurement:

1. The measurement parameters entered in **ACCOM** must correspond to reality.
2. The scanning head must be at the starting position.
3. The correct NC program must be selected.

# Measuring Procedure for VML

→ **Start:** After you click this button, **ACCOM** waits for the beginning of measurement. Start the measuring program on the machine tool. The progress of measurement is shown on the screen. You can terminate the measurement with **Cancel**. The measured cycles can be saved through the menu item *File > Save measurement* or evaluated with the menu items *Evaluate > Raw data, Characteristic data* and *Graphic*.



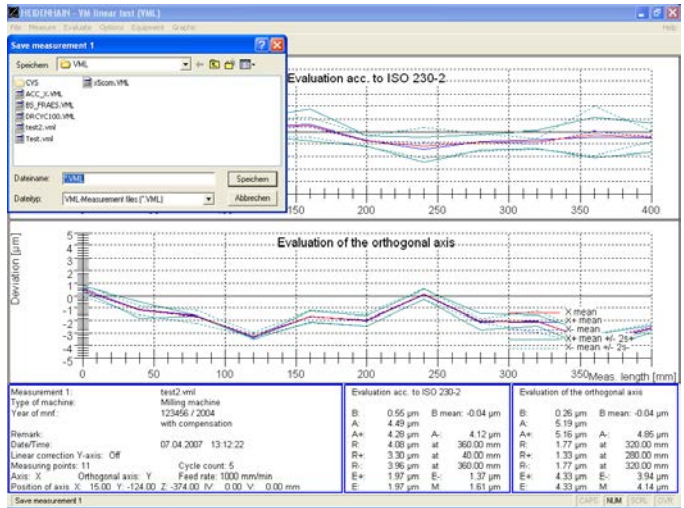
When using the NC program generated by **ACCOM**, at the beginning of measurement the scanning head should be at the reversal position. Recording begins after the subsequent forward motion to the starting point.

## Note

While the VM measurement is running, the measurement data is saved in a temporary file. After a PC or program crash the temporarily saved data can be recovered in the menu item *File > Open measurement*.

## Data storage

After conclusion of measurement, the following dialog box appears for data storage.



With *Measure > Start measurement* you can start further measurements.

# Measuring Procedure for VML

## Entering temperature values

If you wish to save the ambient temperature values and other temperature values, the ISO 230-3 standard must be selected under the menu item *Evaluate > Standard*. Then select the menu item *Evaluate > Temperature table* to open a dialog box in which you can enter the temperature for each cycle.

### Note

It suffices to enter at least two temperature values. The temperature curve between them is interpolated linearly.

Then save the file through the menu item *File > Save measurement*.

	Cycle	Time [min]	Ambient temp. [°C]	Temperature [°C]
1	1	0.00	21	0.0
2	2	0.45	0.0	0.0
3	3	0.90	0.0	0.0
4	4	1.37	0.0	0.0
5	5	1.82	0.0	0.0
6	6	2.28	0.0	0.0
7	7	2.73	0.0	0.0
8	8	3.20	0.0	0.0
9	9	3.65	0.0	0.0
10	10	4.10	0.0	0.0
11	11	4.57	0.0	0.0
12	12	5.02	0.0	0.0
13	13	5.48	0.0	0.0
14	14	5.93	0.0	0.0
15	15	6.40	0.0	0.0

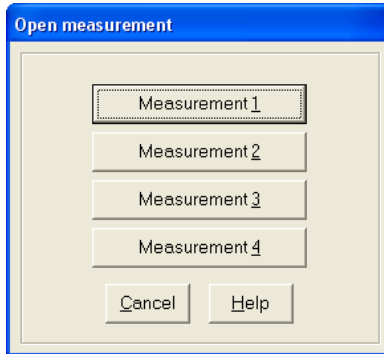
Scaling temperature axis:  
 Fixed  Automatic

from: 21 °C to 28 °C

OK  
Cancel  
Help

## 12. Open measurement

→ Through *File > Open measurement* or by clicking the associated button you can load the measured data for further evaluation and display. The following screen appears.



This dialog window enables you to open the measurements in any sequence.

This menu item also enables you to call other motion error traces to the screen for further evaluation.



The results of measurement are loaded into the system with menu item *Open measurement*. This is a prerequisite for display. Through the menu item *Evaluate > Graphic* you can influence how and whether the motion error traces are displayed (see also section 16, “Graphic Display”).

# Measuring Procedure for VML

## 13. Evaluate measured data

→ You can view the raw measurement data through the menu item *Evaluate > Raw data* or by clicking the associated symbol. **ACCOM** shows every measured deviation including the associated coordinates.

**Raw data of the measurement 1**

Customer: Jane Doe  
Type of machine: Test machine  
SrNo. / year of mnt.: 123 / 1998

Position of axis:  
X: -383.6000mm Y: -204.1500 mm Z: -277.1900 mm IV: 0.0000 mm V: 0.0000 mm

File name: Test.vml Meas. mode: VML Meas. method: Linear  
Reversal dist.: 0.9000 mm Measuring points: 11 Measuring axis: X  
Dwell time: 1.00 s Cycles: 3 Orthogonal axis: Y  
Feed rate: 1000 mm /min Linear correction of the orthogonal axis: Off  
with compensation

Date of meas.: 17.02.1998 09:43:31 Inspector: HK

Pos.	Cycle	Direction	Nom. position [mm]	Act. position [mm]	Diff. [µm]	Orthogonal axis [µm]
1	1	+	0.0000	-0.0001	-0.05	0.62
1	1	-	0.0000	-0.0001	-0.14	0.28
1	2	+	0.0000	-0.0009	-0.87	0.59
1	2	-	0.0000	-0.0009	-0.89	0.64
1	3	+	0.0000	-0.0002	-0.22	0.45
1	3	-	0.0000	-0.0005	-0.50	0.18
2	1	+	40.0000	39.9994	-0.57	-0.87
2	1	-	40.0000	39.9997	-0.27	-1.06

### Note

The ACCOM data is saved in an ASCII file. The raw data are saved line by line, separated by tabs. You can load or import this file for further processing in other programs like Matlab, Origin, Microsoft Excel or Open Office.

To **print** the raw data, click the print symbol.

If you click **Cancel**, the dialog box closes.

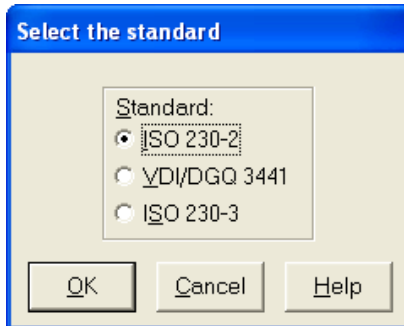
### 14. Select standard for evaluation

→ In the menu item *Evaluate > Standard* you can select the guideline for further evaluation.

**ISO 230-2**

**VDI/DGQ 3441**

**ISO 230-3**



# Measuring Procedure for VML

## 15. Characteristic values

→ With the menu item *Evaluate > Characteristic data*, or by clicking the associated symbol, you can display the results calculated from the measured data according to **ISO 230-2** or **VDI/DGQ 3441**.

To **print** the accuracy data, click the print symbol in the menu bar.

You can **save** the characteristic values in an ASCII file (\*.csv).

If you click **Cancel**, the dialog box closes.

- Example of accuracy data as per **ISO 230-2**:

**Characteristic data of the measurement 1 acc. to ISO 230-2**

Customer: test  
Type of machine: Milling machine Save Cancel Help  
SrNo. / year of mnf.: 123456 / 2004  
Position of axis:  
X: 15,0000 mm Y: -124,0000 mm Z: -374,0000 mm IV: 0,0000 mm V: 0,0000 mm  
File name: test2.vml Meas. mode: VML Meas. method: Linear  
Reversal dist.: 0,90 mm Measuring points: 11 Measuring axis: X  
Dwell time: 1,00 s Cycles: 5 Orthogonal axis: Y  
Feed rate: 1000 mm /min Linear correction Y-axis: Off  
with compensation

Pos.	Nom. pos. [mm]	+ Xmit [µm]	- Xmit [µm]	Xmit [µm]
1	0,0000	-0,41	-0,50	
2	40,0000	-0,29	-0,02	
3	80,0000	0,34	0,14	
4	120,0000	0,39	0,28	
5	160,0000	0,52	0,35	
6	200,0000	-0,76	-0,78	

Measuring axis: B: 0,55 µm R: 4,08 µm at 360,00 mm  
B mean: -0,04 µm R+: 3,30 µm at 40,00 mm  
M: 1,61 µm R-: 3,96 µm at 360,00 mm  
A: 4,49 µm A+: 4,28 µm A-: 4,12 µm  
Orthogonal axis: E: 1,97 µm E+: 1,97 µm E-: 1,37 µm  
B: 0,26 µm R: 1,77 µm at 320,00 mm  
B mean: -0,04 µm R-: 1,33 µm at 280,00 mm  
M: 4,14 µm R-: 1,77 µm at 320,00 mm  
A: 5,19 µm A+: 5,16 µm A-: 4,85 µm  
E: 4,33 µm E+: 4,33 µm E-: 3,94 µm

Date of 07.04.2007 13:12:22 Inspector: Smith



- Example of accuracy data as per VDI/DGQ 3441:

**Characteristic data of the measurement 1 acc. to VDI/DGQ 3441**

Customer: test  
 Type of machine: Milling machine  
 SrNo. / year of mnf.: 123456 / 2004

Position of axis:  
 X: 15,0000 mm Y: -124,0000 mm Z: -374,0000 mm IV: 0,0000 mm V: 0,0000mm

File name: test2.vml Meas. mode: VML Meas. method: Linear  
 Reversal dist.: 0,90 mm Measuring points: 11 Measuring axis: X  
 Dwell time: 1,00 s Cycles: 5 Orthogonal axis: Y  
 Feed rate: 1000 mm /min Linear correction Y-axis: Off  
 with compensation

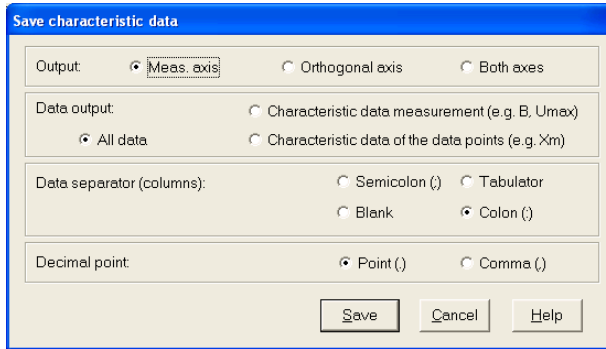
Pos.	Nom. pos. [mm]	+ Xmit [ $\mu$ m]	- Xmit [ $\mu$ m]	Xmit [ $\mu$ m]
1	0,0000	-0,41	-0,50	
2	40,0000	-0,29	-0,02	
3	80,0000	0,34	0,14	
4	120,0000	0,39	0,28	
5	160,0000	0,52	0,35	
6	200,0000	-0,76	-0,78	

Measuring axis: U mean: 0,22  $\mu$ m U max: 0,55  $\mu$ m U min: 0,02  $\mu$ m  
 Ps mean: 2,75  $\mu$ m Ps max: 5,37  $\mu$ m Ps min: 1,28  $\mu$ m  
 P: 5,87  $\mu$ m Pa: 1,61  $\mu$ m

Orthogonal axis: U mean: 0,11  $\mu$ m U max: 0,26  $\mu$ m U min: 0,02  $\mu$ m  
 Ps mean: 1,22  $\mu$ m Ps max: 2,00  $\mu$ m Ps min: 0,39  $\mu$ m  
 P: 5,63  $\mu$ m Pa: 4,14  $\mu$ m

Date of 07.04.2007 13:12:22 Inspector: Smith

- **Save characteristic data**



- **Output:** Here you can select the measurement axes for the data output.
- **Data output:** Here you can select the kind of data which will be saved in the CSV-file.
- **Data separator:** Here you can select the data separator used in the CSV-file.
- **Decimal point:** Here you can select the decimal point used in the CSV-file.
- **Save:** Here you can save the characteristic data. A file dialog window opens and the data is then saved in an ASCII file (\*.csv).

**Example:**

Settings: Meas. axis only, Characteristic data of the measurement only, Data separator: tabulator, decimal point: comma

Output of the ISO 230-2 characteristic data in 2 lines

B [µm]	Bm [µm]	A [µm]	A+ [µm]	A- [µm]	R [µm]
1,12	-0,28	10,41	10,37	10,16	5,12

R+ [µm]	R- [µm]	E [µm]	E+ [µm]	E- [µm]	M [µm]
4,40	5,12	8,23	7,98	8,17	8,04

## 16. Graphic display of measurement results

→ You can specify the display mode of the motion error traces in accordance with the selected standard through the menu item *Evaluate > Graphic* or by clicking the associated symbol.

**VM graphic settings**

Display:  Measurement 1  Measurement 3  
 Measurement 2  Measurement 4

Scaling of measurement axis deviation:  
from:   $\mu\text{m}$  to:   $\mu\text{m}$   Automatic

Scaling of orthogonal axis deviation:  Linear correction  
from:   $\mu\text{m}$  to:   $\mu\text{m}$   Automatic

Scaling measurement length (abscissa):  
from:  mm to:  mm  Automatic

Representation:  Seperate cycles  
 Characteristic data  
 ISO 230-2  
 Averaged deviation  
 Backlash  
 Repeatability  
 Position drift (Cycle)  
 Position drift (Time)

Show:  
 Measurem. axis  
 Orthogonal axis  
 Both axes

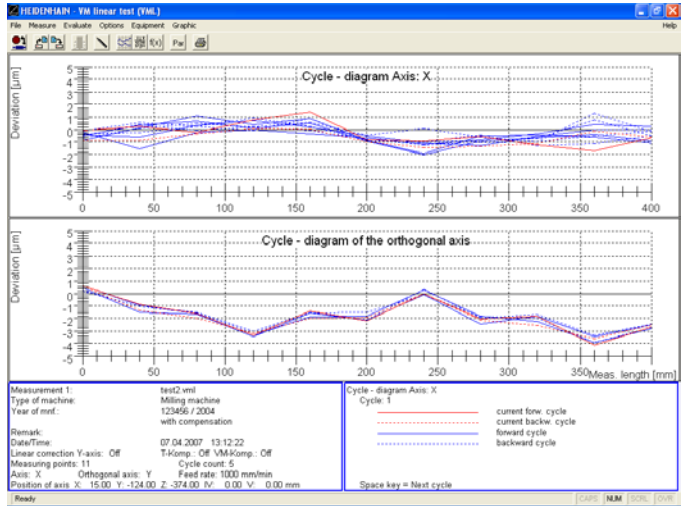
OK Cancel Help

## Measuring Procedure for VML

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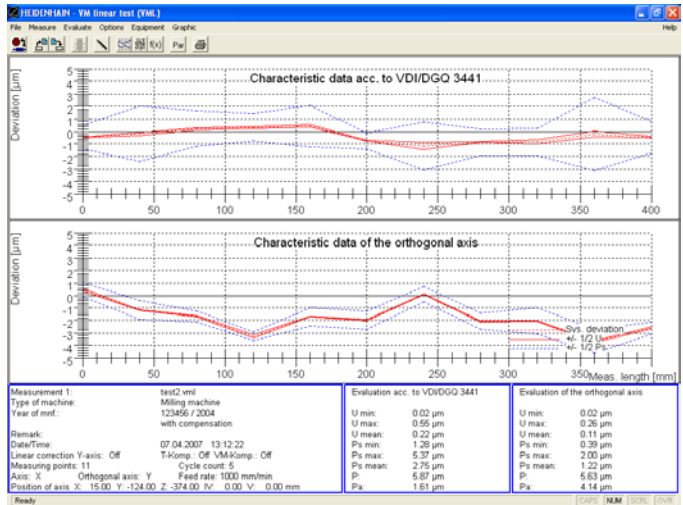
- **Release:** Select the measurement to be displayed.
- **Scaling of measured axis deviation:**
  - Fixed:** Enter the upper and lower limit of the error display.
  - Automatic:** The scale is determined automatically.
- **Scaling of orthogonal axis deviation:**
  - Fixed:** Enter the upper and lower limit of the error display.
  - Automatic:** The scale is determined automatically.
  - Linear correction:** If you activate this check box, a linear regression over the error curve is calculated and the calculated linear error is subtracted from the measured error and displayed. This is useful whenever the **VM 182** cannot be set up parallel to the measuring direction.
- **Scaling of measurement length (abscissa):**
  - Fixed:** Enter the upper and lower limit of the abscissa.
  - Automatic:** The limits of the abscissa are determined automatically.
- **Display:**
  - Measuring axis:** Only the axis of traverse is displayed.
  - Orthogonal axis:** Only the axis perpendicular to the axis of traverse is displayed.
  - Both axes:** Both axes are displayed.
- **Representation:** The available display modes depend on the selected evaluation standard.
  - ISO 230-2: **Separate cycles**  
**ISO 230-2**  
**Averaged deviation**  
**Backlash**  
**Repeatability**
  - VDI/DGQ 3441: **Separate cycles**  
**Characteristic values**
  - ISO 230-3: **Position drift as per cycles**  
**Position drift as per time**

## • Separate cycles



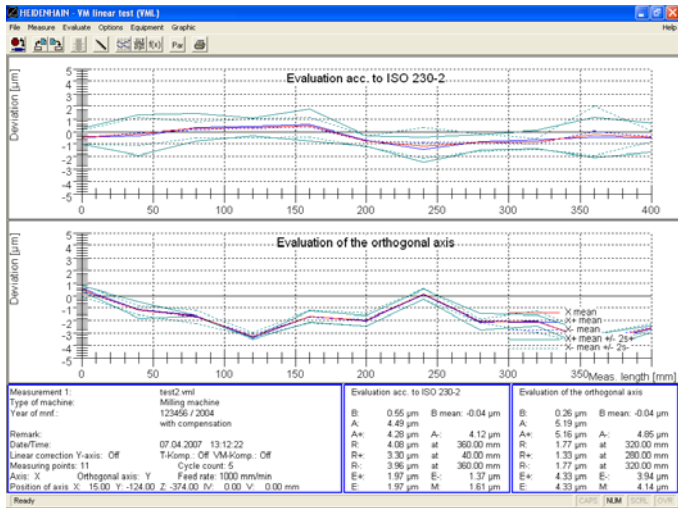
## • Characteristic values

Graphic as per VDI/DGQ 3441

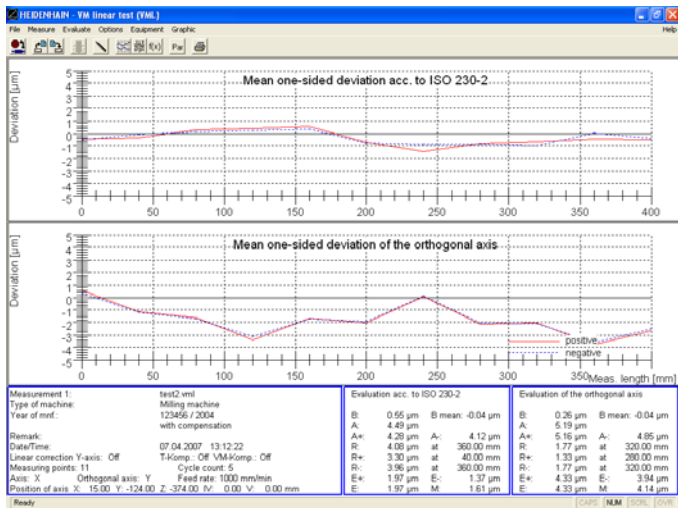


# Measuring Procedure for VML

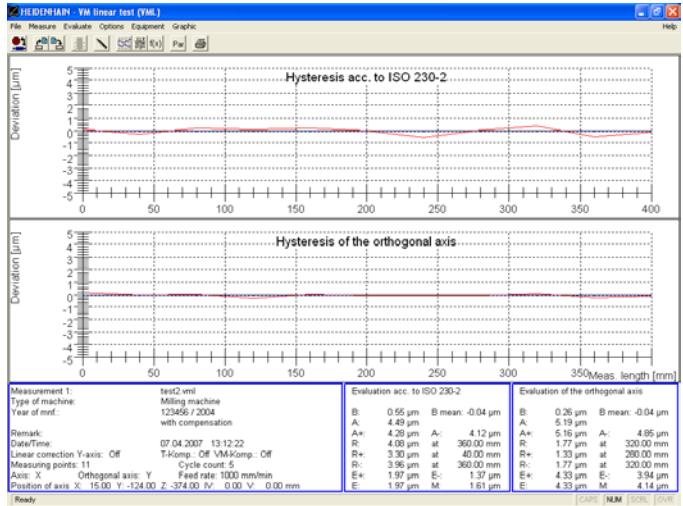
- Graphic as per ISO 230-2



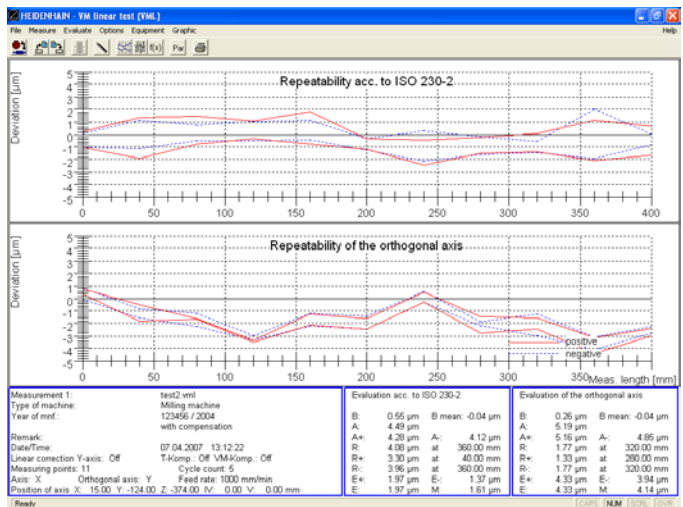
- Averaged deviation
- Graphic as per ISO 230-2



## • Backlash Graphic as per ISO 230-2



## • Repeatability Graphic as per ISO 230-2

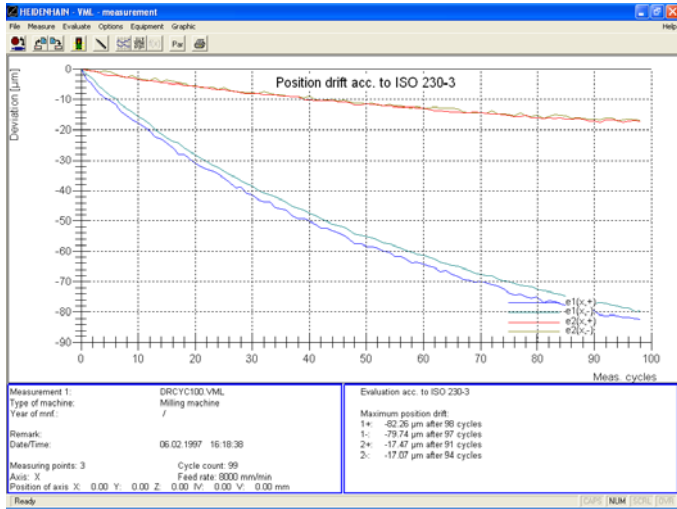


# Measuring Procedure for VML

## • Position drift (cycles)

Graphic as per ISO 230-3.

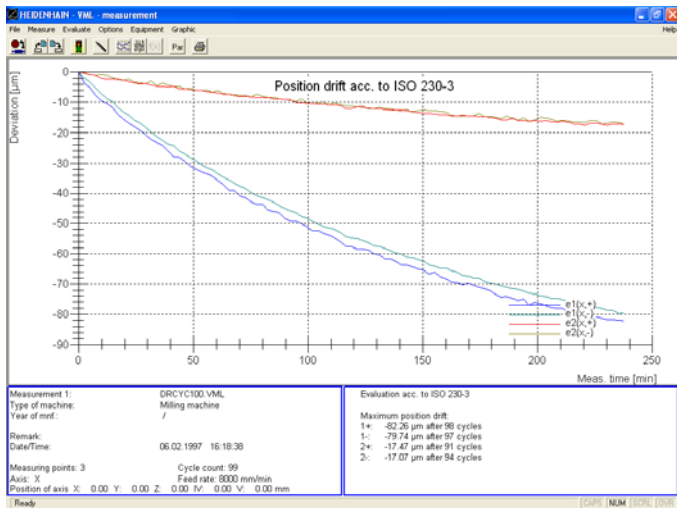
Temperature input under *Evaluate* > *Temperature* table.



## • Position drift (time)

Graphic as per ISO 230-3.

Temperature input under *Evaluate* > *Temperature* table.



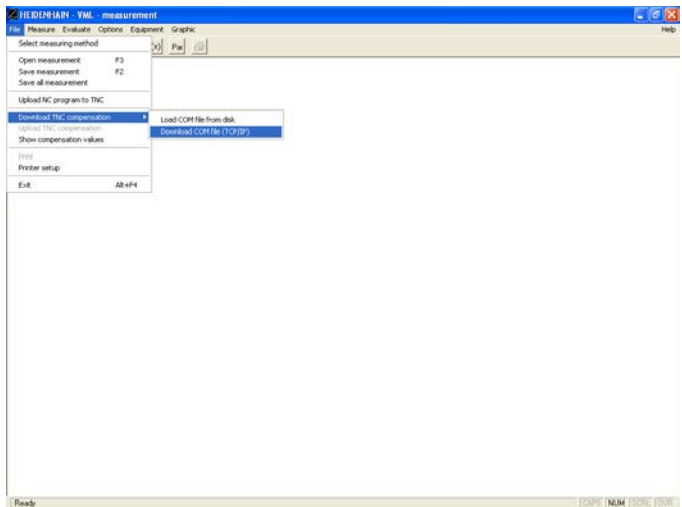


## 17. Run linear compensation on NC control

**ACCOM** enables you to read the compensation positions defined in the TNC and output the correct compensation values after the measurement.

Proceed as follows:

→ Before entering the measuring parameters, use the menu item *File > Download TNC compensation* to transfer the compensation position table in the TNC to **ACCOM**. Select between the standard **format COM** for current HEIDENHAIN controls.

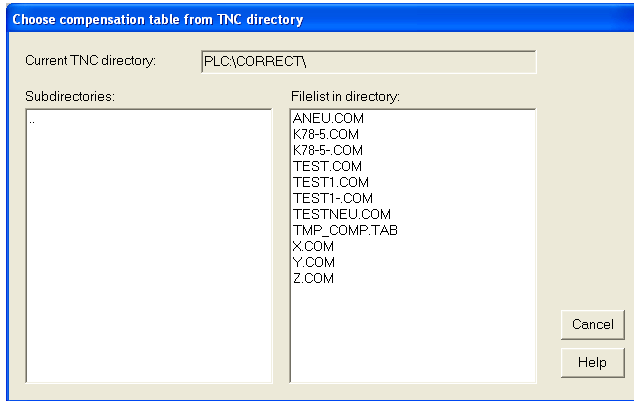


The following window with the PLC directory of the HEIDENHAIN control appears in TCP/IP mode. Before you can access the PLC directory it is necessary to enter the PLC code number. For this purpose a dialog box appears once. In the PLC directory you can choose explicitly the compensation value table which should be written into by ACCOM.

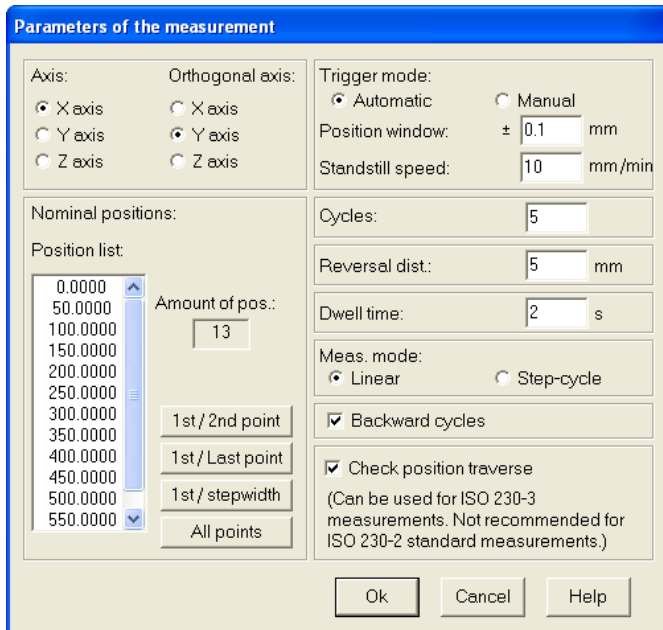
### Note

To build a new table see technical manual of the TNC.

# Measuring Procedure for VML



→ Enter the measuring parameters through the menu item *Options > Parameters of measurement*. ACCOM automatically transfers the position values from the TNC compensation table.



- Specify the NC interface.
- Run the directional detection and set the position.
- Generate the NC program and transfer it.

# Measuring Procedure for VML

- Generate the calibration chart.
- Run the measurement. The position error values are then used as compensation data.
- After the measurement, use the menu item *File > Show compensation values* to call a list of compensation values.

**Show compensation values**

	Position no.	Nominal pos. [mm]	compensation value [mm]	Comp. value ortho. [mm]
1	1	0.0000	-0.0004	0.0012
2	2	40.0000	-0.0010	-0.0002
3	3	80.0000	-0.0014	-0.0005
4	4	120.0000	-0.0022	-0.0019
5	5	160.0000	-0.0026	-0.0001
6	6	200.0000	-0.0048	-0.0002
7	7	240.0000	-0.0059	0.0021
8	8	280.0000	-0.0063	0.0001
9	9	320.0000	-0.0073	0.0004
10	10	360.0000	-0.0075	-0.0011
11	11	400.0000	-0.0085	0.0002

Compensation  
 Mean value  
 Forward cycles  
 Backward cycles

Save  
Cancel  
Help

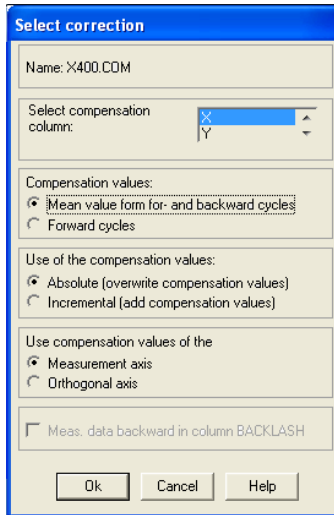
- If you click **Save**, you can later read the ASCII file with a text editor or e.g. Microsoft Excel or Open Office.

The screenshot displays the 'VEDERMAN - VML - measurement' software interface. A 'Show compensation values' dialog box is open, showing a table of compensation data and a 'Save compensation values' sub-dialog. The main window features a graph of position error over time, with a legend for 'actual flow cycle', 'actual backw. cycle', 'forward cycle', and 'backward cycle'. The graph shows a sawtooth pattern with a peak around 100 mm and a trough around 350 mm. The x-axis is labeled 'Meas. length [mm]' and ranges from 0 to 400. The y-axis ranges from -10 to 5. The bottom of the window contains a status bar with machine information: 'Measurement 1: Test vml', 'Type of machine: Testmaschine', 'Year of mnt.: 123 / 1998', 'Date/Time: 17.02.1998 09:43:31', 'Linear correction of the orthogonal axis: off', 'Measuring points: 11', 'Cycle count: 3', 'Axis: X Orthogonal axis: Y Feed rate: 1000 mm/min', 'Position of axis X: -363.60 Y: -204.15 Z: -277.19 I.V. 0.00 V. 0.00 mm'. The status bar also indicates 'Dialog can be closed' and 'Space key = Next cycle'.

## Measuring Procedure for VML

---

→ Output the compensation value table through the menu item *File > Upload TNC compensation*. In the following dialog box you can select the compensation values.



- **Select compensation column:** Choose the column of the compensation table which you would like to correct.
- **Compensation values:**
  - Mean value:** The mean value of the position error of all forward and backward cycles will be used as compensation values.
  - Forward cycles:** The position error of the forward cycles will be used as compensation values.
- **Use of the compensation values:**
  - Absolute:** Existing values in the chosen column will be overwritten. You should use this option if there was no non-linear axis compensation active while measuring or the specified column was empty.
  - Incremental:** This option allows adding a position error to existing compensation values in the specified column.
- **Use compensation values of the:**
  - Measurement axis:** Compensation values of the position error will be inserted into the chosen column.
  - Orthogonal axis:** Compensation values of the straightness error will be inserted into the chosen column.

- **Compensation of the backward cycles:**

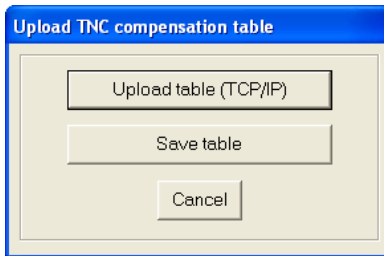
**TNC 640/TNC 620::** The position error of the backward cycles will be written in column BACKLASH in the same file.

**iTNC 530:** Choosing this option will generate a second compensation file with the position error of the backward cycles in the same column. This compensation table may be used by newer TNCs for the negative direction of traverse.

Example: Name of the compensation table: x.com -> then the name of the file for the negative direction of traverse is: x-.com.

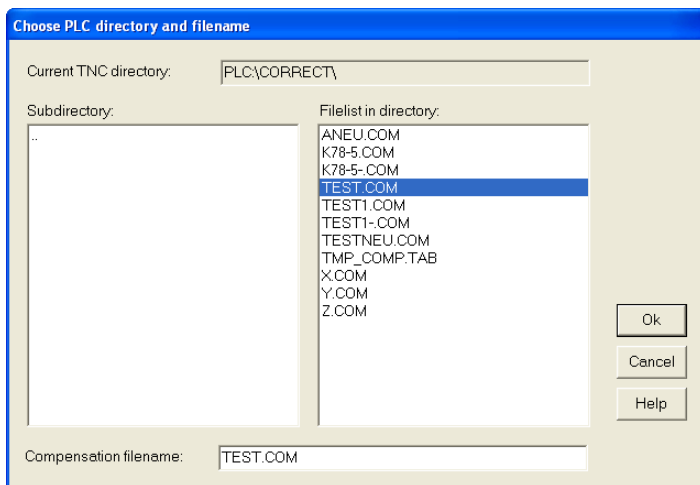
After confirmation with Ok the next dialog box will be displayed where you can select the output.

- **Upload table by network (TCP/IP):** Output by network connection in TCP/IP protocol.
- **Save:** Output to the file system.



The following window with the PLC directory of the HEIDENHAIN control appears in TCP/IP mode. Here you can choose the directory and filename of the compensation value table on the TNC.

## Measuring Procedure for VML



After you have installed the compensation values, be sure to run an inspection measurement.

## Color settings of the graphic

If you would like to change the **color setting of the graphics**, you can change the color of the error traces, of the coordinate system and the graphic background with the menu item *Options > Color setting*.

## Saving/loading the options

You can save these settings with the menu item *Options > Save options*.

You can call these settings with the menu item *Options > Load options*.

## Exporting the measurement graphic

If you wish to **export the measured graphic as a file** without a log, you can save it as a bitmap using the menu item *Graphic > Save*.

## Printing the graphic

You can **print** the graphic with the menu item *Graphic > Print*. You can change the **printer settings** through the menu item *File > Printer setup*.

## Saving a measurement

If you make **changes to a calibration chart**, you can save them through the menu item *File > Save measurement* or by clicking the **save** button.

As an alternative, you can also save the measured data through the menu item *File > Save all measurements*.

## Clearing the screen

To remove the motion error traces from the screen, you can **clear the screen** with the menu item *Graphic > Close*.

# Measuring Procedure for VML

## Editing the calibration charts

If you would like to **edit the calibration charts** you can select the desired chart through the menu item *Measure > Calibration chart* or by clicking the associated symbol.

**Calibration chart of measurement 1**

Customer: Jane Doe

Type of machine: Test machine

SrNo. / Year of mnf.: 123 / 1998

Remark 1: with compensation

Remark 2:

Remark 3:

Inspector: HK

HEIDENHAIN Reference meas. system: VM182

ID number: 353987-12 Serial number: X123456789

Position of axis X: -383.6 mm

Position of axis Y: -204.15 mm

Position of axis Z: -277.19 mm

Position of axis IV: 0 mm

Position of axis V: 0 mm

Open chart window automatically after a measurement?

Yes  No

OK Cancel Help



## Measuring Procedure for Rotatory test (VMR)

### Machine cleaning

→ Before mounting the encoder, clean the area of the machine tool in which the measurements are made. Pay special attention to any chips and oil or grease residue that could fall onto the encoder.



Give the encoder time to adjust to the ambient temperature before you begin mounting it. This will help to prevent thermally induced error.

### Test program

For non-HEIDENHAIN controls, a typical test program for rotary table inspection with backward cycle could be written as follows. With HEIDENHAIN controls, the machine program can be uploaded directly from **ACCOM**.

**Part 1, forward cycle:** The angle encoder starts at the reversal point. Forward movement to the datum, dwell time and automatic recording of the measuring point. Forward movement to the next position, dwell time and automatic recording of the measuring point, ... , last position, dwell time and automatic recording of the measuring point.

**Part 2, reverse cycle:** Movement by the reversal path forward, dwell time, backward movement to the last position, dwell time and automatic recording of the measuring point, backward movement to the point before last, dwell time and automatic recording of the measuring point, ..., datum, dwell time and automatic recording of the measuring point.

**Possible further cycles:** Like the 1st forward cycle, this cycle would also begin with a backward movement by the reversal path.



Ensure that there are no “forgotten” compensation data saved in the control that could cause an undesired movement in the wrong direction or corrupt the measurement. You might try running the machine program without the encoder.

### Measuring assembly

→ Ensure that the **IK 220** PC counter card was installed in your PC according to the instructions in the User’s Manual. Alternatively you can use the **EIB 741**. Please ensure an available peer-to-peer network connection to the **EIB 741** (address and subnet mask of the TCP/IP connection).

## Measuring Procedure for VMR

---

Now mount the encoder according to the instructions in the manual.



When connecting the measuring cables to the X1 input of the IK card (or X11 of the EIB 741), be sure to leave enough slack to compensate any machine movement during measurement.

→ **Before starting ACCOM**, connect the enclosed hardware key with Id. Nr. 590255-01 or 590255-02 to one free USB port.

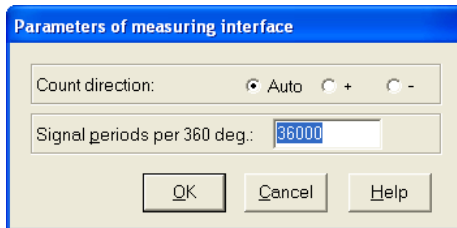
After calling **ACCOM**, proceed as follows:

## 1. Settings for the angle encoder and the counter card

→ Under *Options > Settings for angle encoder* you set the parameters for the angle encoder used.

- **Count direction:** Here you can manually choose the count direction or activate the automatic direction initialization under *Measure > Directions*.

- **Signal periods per 360 degree:** Here you enter the line count (signal periods/revolution) of the encoder you are using. (Automatically read out from an Endat angular encoder).  
Input range: 16384 to 180 000



→ Under *Options > Counter card* you set the parameters for the PC counter card.

- **Type counter card:** Here you select the model of counter card that you are using.

- **Signal input:** Here you select the type of measuring signal (1Vpp or 11µApp). With an EIB 741 you can use Endat devices as well

- **Address EIB 741:** Here you enter the IP address of the **EIB 741** (see also **EIB 741** user manual). Alternatively you may use the DHCP hostname in a company network. However it is not recommended due to the high data acquisition rate.

This setting is not needed for the **IK 220**.

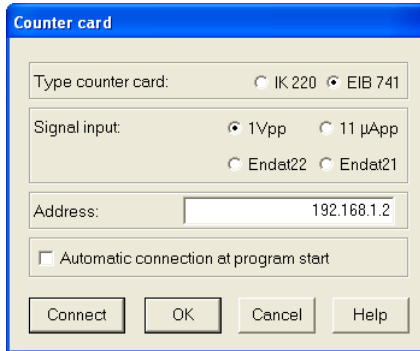
- **Automatic connection at program start:** ACCOM connect to the **EIB 741** at the next program start automatically if chosen. A valid connection to the **EIB 741** is required!

- **Test IK (IK 220):** Here you can then test the counter card for proper function.

- **Connect/Disconnect (EIB 741 only):** The **EIB 741** will be connected or disconnected here.

# Measuring Procedure for VMR

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Ensure that you have entered the proper model, address and signal input of the counter card. If the line count is entered incorrectly, the distances will be measured too large or too small.

## Note

Connect the angle encoder to the X1 input on the counter card and respectively to X11 on the external interface box.



If you have problems receiving data from the counter card, use the test programs on the provided driver CD to check whether the card can be used.

## Note

If you would like to check the amplitude of the measuring signals from an encoder, you can use the menu item *Equipment* > *Oscilloscope* to display the incoming measuring signals as Lissajous figures.

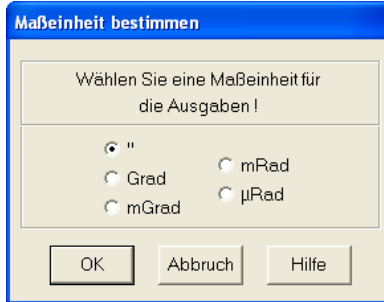


If the displayed signal amplitude is too low, check whether the settings for the interface are correct and whether the encoder is correctly installed. Then start **ACCOM** again. Do not engage or disengage any connectors until you have exited **ACCOM!**

## 2. Specifying the unit of measure

→ With the menu item *Options > Unit of measurement* you specify the desired unit of measure. Close the dialog box with **OK**.

- The units can be displayed as angular seconds ("), milli-degrees or milli-radians.

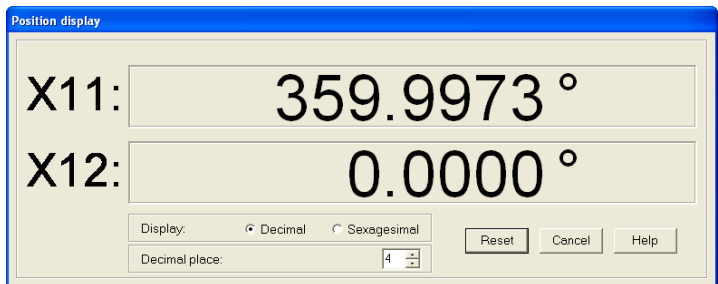


### Note

1" is approximately 0.005 milli-radians or 5 µm per meter.

## Position display

With the menu item *Equipment > Position display* you can call the position display for the connected encoder and, for example, check the positive counting direction of the angle encoder. If you call this function after setting the position (see section 6, "Set datum"), before the test you should check again whether your datum is set correctly and, if not, enter it again.



# Measuring Procedure for VMR

## 3. Measurement parameters

→ By calling the menu item *Options > Measurement parameters* or by clicking the icon, you open the following dialog box in which you can adjust the **measurement parameters**.

Parameters of the measurement

Measurement axis:

- A axis
- B axis
- C axis

Trigger mode

- Automatic
- Manual

Position window: ± 0.5 °

Standstill speed: 10 /min

Nominal positions:

Position list:

- 0.0000
- 30.0000
- 60.0000
- 90.0000
- 120.0000
- 150.0000
- 180.0000
- 210.0000
- 240.0000
- 270.0000
- 300.0000
- 330.0000
- 360.0000

Amount of pos.: 13

1st/2nd point

1st/Last point

1st/ stepwidth

All points

Cycles: 5

Reversal angle: 5 °

Dwell time: 1 s

Meas. mode:

- Linear
- Rotatory
- Step-cycle

Backward cycles

Check position traverse  
(Can be turned off for ISO 230-3 measurements. Should be used for ISO 230-2 standard measurements.)

OK Cancel Help

- **Measurement axis:** Select here the axis of measurement.
- **Amount of pos.:** The number of positions is defined automatically when the nominal positions are specified.
- **Nominal positions:** You have a choice among three possibilities:

**1st/2nd point**

**1st/last point**

**1st point/step width**

**All points**

**1st/2nd point:** Here you enter the first and second measuring points as well as the total number of measuring points (including the first and last). **ACCOM** automatically calculates all measuring points and shows them in the **position list**.

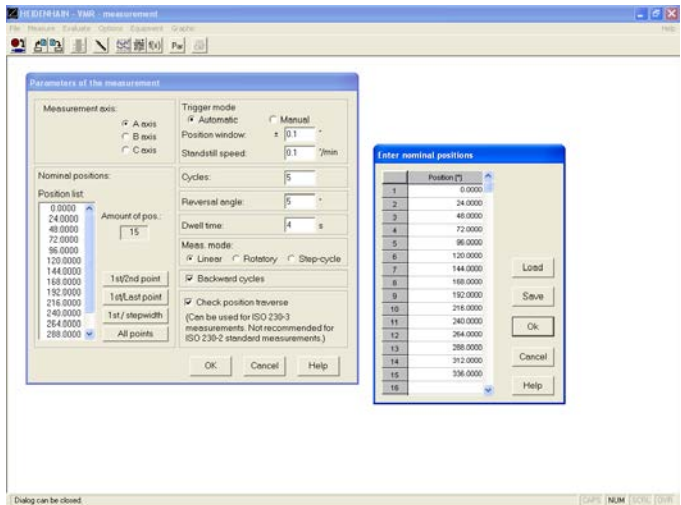
**1st/last point:** Here you enter the first and last measuring points as well as the total number of measuring points (including the first and last). **ACCOM** automatically calculates all measuring points and shows them in the **position list**.

**1st point/step width:** Here you enter the first measuring points and the step width between the measurement points as well as the total number of measuring points (including the first and last). **ACCOM** automatically calculates all measuring points and shows them in the **position list**.

**All points:** Here you can enter all positions, which are then shown in the **position list**.

## Note

The nominal positions have to be either in monotonically increasing or in monotonically decreasing order.



## Note

With **Save** you can save the file under any name and edit it later with the editor or a spreadsheet program such as Microsoft Excel or Open Office. In this way you can also generate random values. With **Load** you can read existing files into the measuring program.

## Measuring Procedure for VMR

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- **Trigger mode—Manual:** In this setting you must manually confirm that the measuring position has been reached.
- **Trigger mode—Automatic:**
  - **Position window:** Enter here the size of the positioning window (nominal position  $\pm$  position range) within which a momentary position is considered to have been reached. Be sure not to enter too small a range, otherwise measurements will be interrupted by large error values.
  - **Standstill speed:** For automatic position detection, the change in position must be smaller than the standstill speed specified here.
- **Cycles:** Here you enter how many times in a row the nominal positions are to be scanned. You must previously have clicked **Backward cycles** (positions are also approached backward), otherwise only one forward cycle is possible.
- **Reversal angle:** The angle to be traversed so that the same nominal position can be approached from the opposite direction. **ACCOM** recognizes the backward movement after half the reversal angle. For extremely high traversing speeds, enter a dwell time at the end of the reversal angle in the NC program.
- **Dwell time:** Here you specify how long the machine is to wait at one position until it approaches the next position. **ACCOM** automatically records the measured values after half the dwell time.
- **Measuring mode—Linear:** All positions are traversed in sequence.
- **Measuring mode—Rotatory:** The axis moves forward by the entered number of measuring cycles and then reverses its direction to move backward and return to the starting point. Last position of measurement mode "Rotatory" must be less than 360°.
- **Measuring mode—Step cycle:** Each nominal position is approached in positive and negative direction as many times as is defined under Cycles. The process is repeated in sequence at all positions.
- **Backward cycles:** Here you specify whether the nominal position will also be approached backward. If **Backward cycles** is not checked, you can run only the **linear** measuring process with **one** forward cycle.



- **Check position traverse:** This option should be enabled for all ISO-230-2 measurements. ACCOM then always checks whether a measurement position has been skipped. If that happens the trigger conditions "position range" and "standstill range" should be increased.

However this option has to be disabled for ISO 230-3 measurements with additionally heating cycles in between the measurement cycles. Here the trigger conditions have to be increased as well.

## 4. Setting the NC interface

→ If you wish to transfer the measuring program in **ACCOM** to a HEIDENHAIN control, select *Options > NC programming* to open a dialog box in which you can configure the network connection.

Parameters for NC programming

Mode:  HEIDENHAIN conversational  
 HEIDENHAIN ISO

Feed rate: 1000 /min

Add feed rate to each block

Program name: TEST.H

Decimal place:  0.001 \*  0.0001 \*

Add M functions:

Add M functions to each block

TNC settings:

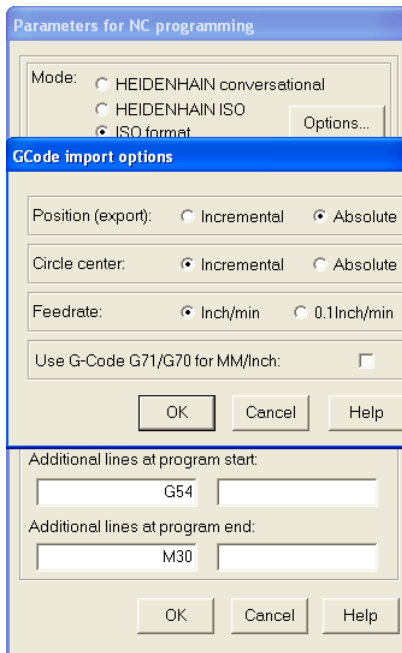
TCP/IP address: WZM2010

OK Cancel Help

- **Mode:** Choose between HEIDENHAIN or ISO format.
- **Feed rate:** Here you enter the nominal feed rate for the circular motion.  
Input range: 0.001 to 100 000 mm/min or  
0.000 04 to 3900 inches/min
- **Program name:** Here you give the program a name (the extension .H stands for HEIDENHAIN, .I stands for HEIDENHAIN ISO and .txt for general ISO).
- **Decimal place:** Select the decimal place of the NC programs.
- **M functions:** Here you enter additional M functions which are necessary to run the NC program on the control. The M functions are added to the first NC block.  
Example in HEIDENHAIN conversational programming:  
**2 L X0 F1000 M31**
- **TCP/IP address:** Here you enter the TCP/IP address or DHCP hostname of the control for the data transfer via network connection.

## G-Code options

→ By clicking the control button **Options** the following dialog box opens. Here you can configure some ISO format settings which are suitable to the control.



- **Position (export only):** This parameter is used in the export of an ISO NC program only. For absolute positions G90 is added at the NC program start, for incremental positions G91 is used. For absolute NC programs it is useful to add a datum shift (e.g. G54).
- **Circle center:** The input of the circle center point acc. to the German standard DIN 66025 is done incremental to the last position or absolute. Usually I, J, K are used with incremental positions. Valid is also an absolute position with I, J, K. (depends on the control).
- **Feed rate:** This parameter is only valid for an INCH program. The feed rate can be set in Inch/Min or Inch/10Min (HEIDENHAIN default).
- **G-code for Inch/MM:** You can choose whether to use G71/G70 for NC programs or not.

# Measuring Procedure for VMR

---

In the dialog box **Parameters for NC-programming** you may add the following data for the ISO format programming:

- **Additional lines at program start:** Here you can add 2 user or control specific lines at program start (e.g. G54).
- **Additional lines at program end:** Here you can add 2 user or control specific lines at program end (e.g. M30).

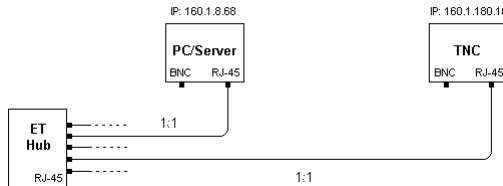
## Network cable

Connect the TNC by a (crossed) network cable directly to the PC or by using a standard network cable with a hub or a switch to the company network.

## Note

Peer-to-peer (direct connection): You need to set the IP-Address of the PC in *Control Panel / Network / TCP-IP / Properties* (depends on the operating system). As default the value for the IP-Address will be given automatically in a company network (from the DHCP Server).

## LAN (Network) with a 1:1 cable



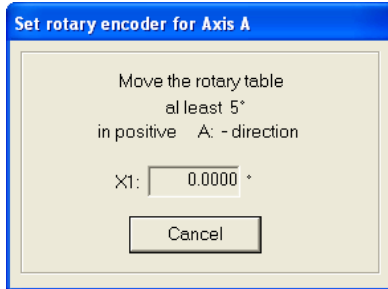
## Peer-to-peer (direct connection) with a (crossed) cable!



## 5. Directional detection

→ Before the first measurement, **ACCOM** needs to know the positive counting direction of the rotary movement. In the menu item *Measure > Directions*, **ACCOM** prompts you to turn the machine axis in the direction and by the angle shown in the dialog box.

This menu item is not shown if deactivated under *Options > Settings for the angular encoder*.



# Measuring Procedure for VMR

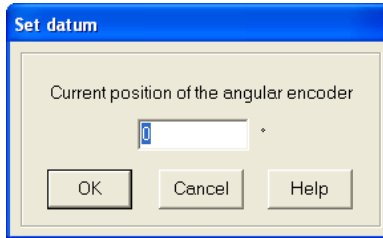
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## 6. Set datum

→ In the menu item *Measure > Set datum* you assign **ACCOM** a position value in agreement with the control.

**Example:**

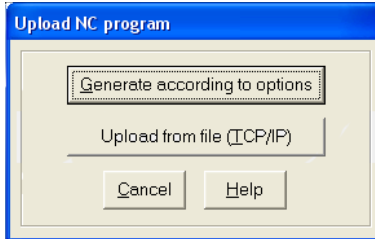
If the measuring axis is located at the starting position (e.g. 0°), you assign this position the value (0° too).



When using “Set datum” and “Set direction,” do not forget the influence on the measurement of the backlash in NC axes, especially at the beginning of the measurement.

### 7. Generating and transferring an NC program

→ If you wish to generate and transfer an NC program, call the menu item *File > Upload NC program to TNC*, and select the form in which you would like to transfer the NC program.



- **Generate according to options:** This button calls a dialog box entitled "Generate NC program for measurement" in which you define the parameters for the NC program.
- **Load from file (TCP/IP):** In the TCP/IP operating mode, a finished NC program is transferred from the file system of your PC to the NC control by a network connection.

Generate NC program for VMR measurement

Mode:  HEIDENHAIN conversational  
 HEIDENHAIN ISO  ISO format

Feed rate: [1000] /min

Program name: [VMRC30.H]

Measuring axis:  A  B  C

Save Cancel Help

Upload in: TCP/IP...

- **Mode:** Choose the format of the NC program.
- **Feed rate:** Here you enter the nominal feed rate for the positioning motion. The input is in °/min.
- **Program name:** In TCP/IP mode you add the extension .H for HEIDENHAIN format or .I for ISO format to the NC program.
- **Axis:** Select here the machine axis being used.
- **Save:** Click to save the NC program.
- **Cancel:** Click to close the dialog box without saving changes.
- **Upload in:** Click to start the upload.

This generates an NC program for the VM rotary table measurement and transfers it to the TNC. You may choose a directory on the TNC directly from ACCOM in TCP/IP mode.



The following prerequisites must be met for the correct execution of the NC program.

1. At program start, the rotary axis must be located at the starting point.
2. The correct program must be selected on the control.



The TNC does not answer if the network is not connected.



## 8. Generating a calibration chart

→ With the menu item *Measure > Calibration chart* or by clicking the icon you can define the calibration chart for the measurement by entering information on the measurements in the calibration window. By clicking **yes** or **no** you can specify whether the **chart window** will open automatically after each measurement.

The screenshot shows a dialog box titled "Calibration chart of measurement 1". It contains the following fields and options:

- Customer: [ ]
- Type of machine: [ ]
- StrNo. / Year of mnt.: [ ] / [ ]
- Remark 1: [ ]
- Remark 2: [ ]
- Remark 3: [ ]
- Inspector: [ ]
- HEIDENHAIN Reference meas. system: [ RPN 886 ]
- ID number: [ 355890-08 ]
- Serial number: [ X1234567890 ]
- Position of axis X: [ 0 ] mm
- Position of axis Y: [ 0 ] mm
- Position of axis Z: [ 0 ] mm
- Position of axis IV: [ 0 ] mm
- Position of axis V: [ 0 ] mm
- Open chart window automatically after a measurement?  
 Yes  No
- Buttons: OK, Cancel, Help

If you enter the chart data only for measurement 1, the data will automatically also apply to the other measurements. The charts can also be saved for editing later in the course of evaluation. **ACCOM** saves this data together with the measured data, and outputs it with the menu items *Evaluate > Raw data*, *Evaluate > Characteristic data* and *Graphic > Print*.

### Note

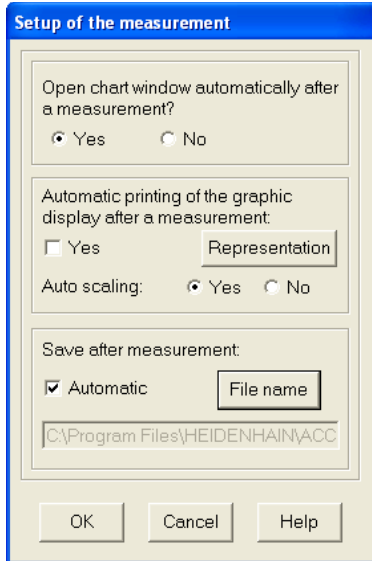
The HEIDENHAIN reference measurement system must be specified in the chart to do a printout.

# Measuring Procedure for VMR

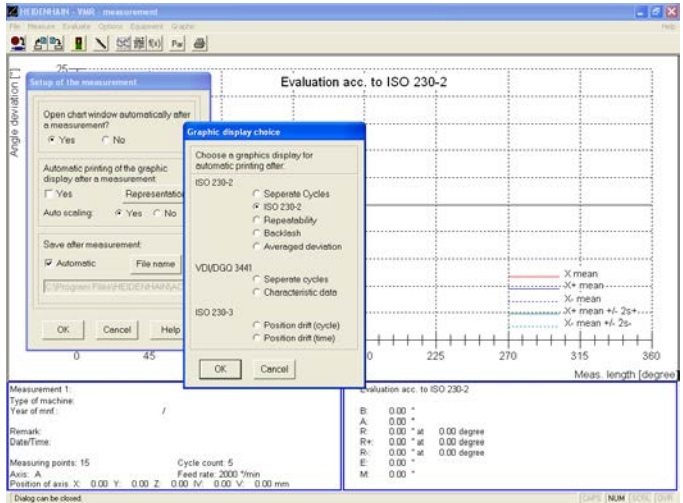
---

## 9. Settings for automatic measurement

→ If you would like to automate the measuring process you can use the menu item *Measure* > *Setup* to specify the desired sequence of operations.



- **Open chart window automatically after a measurement:**
  - Yes:** The calibration chart window opens automatically after each measurement:
  - No:** You can make the calibration chart entries later.
- **Automatic printing of graphic display after a measurement:**
  - Yes:** Click the **Representation** button to select the type of print.
  - Auto scaling—Yes/No:** Choose whether the graphic is to be scaled automatically.



- **Save after measurement:**

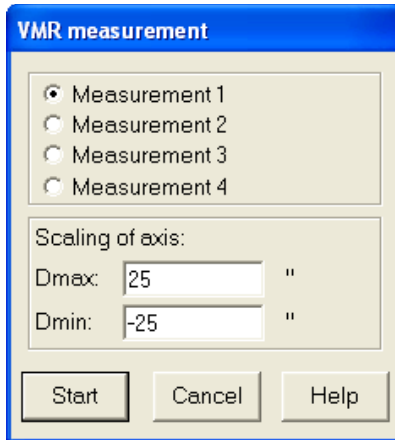
**Automatic:** If you would like to save the measurement automatically, click **File name** and enter the desired name and path.

# Measuring Procedure for VMR

---

## 10. Start measurement

→ Select the menu item *Measure > Start measurement* or click the associated button to open a dialog box with which you can start the measurement after entering the parameters.



- **Measurement 1-4:** Click the number under which the measurement is to be shown later.
- **Scaling Dmax/Dmin:** Enter here the upper and lower limit of the expected error. You can change the scaling at any time later during the evaluation.

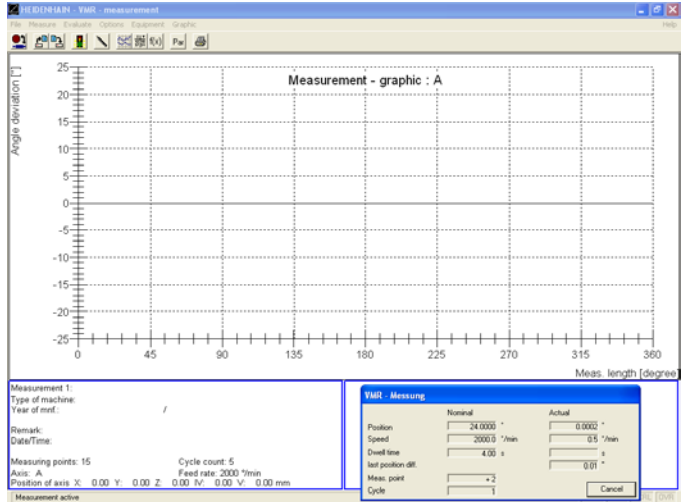


The following conditions must be fulfilled for a correct measurement:

1. The measurement parameters entered in **ACCOM** must correspond to reality.
2. The measured axis and the encoder must be at the starting position.
3. The correct NC program must be selected.

# Measuring Procedure for VMR

→ **Start:** After you click this button, **ACCOM** waits for the beginning of measurement. Start the measuring program on the machine tool. The progress of measurement is shown on the screen. You can terminate the measurement with **Cancel**.



When using the NC program generated by **ACCOM**, at the beginning of measurement the angle encoder should be at the reversal position. Recording begins after the subsequent forward motion to the starting point.

If you have not automated the measuring sequence, a dialog box for saving data appears after the measurement.

With *Measure > Start measurement* you can start further measurements.

# Measuring Procedure for VMR

## Entering temperature values

If you wish to save the ambient temperature values and other temperature values, the ISO 230-3 standard must be selected under the menu item *Evaluate > Standard*. Then select the menu item *Evaluate > Temperature table* to open a dialog box in which you can enter the temperature for each cycle.

### Note

At least two temperature values are required. The temperature curve between them is interpolated linearly.

Then save the file with the menu item *File > Save measurement*.

Entering temperature values

	Cycle	Time [min]	Ambient temp. [°C]	Temperature [°C]
1	1	0.00	21	0.0
2	2	0.45	0.0	0.0
3	3	0.90	0.0	0.0
4	4	1.37	0.0	0.0
5	5	1.82	0.0	0.0
6	6	2.28	0.0	0.0
7	7	2.73	0.0	0.0
8	8	3.20	0.0	0.0
9	9	3.65	0.0	0.0
10	10	4.10	0.0	0.0
11	11	4.57	0.0	0.0
12	12	5.02	0.0	0.0
13	13	5.48	0.0	0.0
14	14	5.93	0.0	0.0
15	15	6.40	0.0	0.0

Scaling temperature axis:

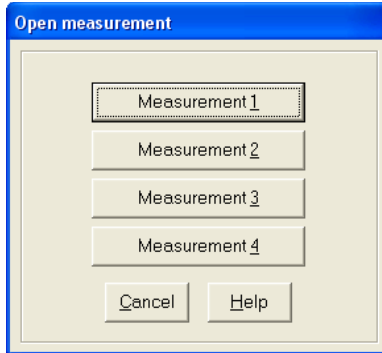
Fixed  Automatic

from: 21 °C to 28 °C

OK  
Cancel  
Help

## 11. Open measurement

→ With *File > Open measurement* or by clicking the associated button you can load the measured data for further evaluation and display. The following screen appears.



This dialog window enables you to open the measurements in any sequence.

This menu item also enables you to call other motion error traces to the screen for further evaluation.



The results of measurement are loaded into the system with the menu item *Open measurement*. This is a prerequisite for display. With the menu item *Evaluate > Graphic* you can influence how and whether the motion error traces are displayed (see also section 15, "Graphic Display").

# Measuring Procedure for VMR

## 12. Evaluate raw data

→ You can view the raw measurement data with the menu item *Evaluate > Raw data* or by clicking the associated symbol.

**ACCOM** shows every measured nominal position together with the associated error in degrees and the selected unit of measurement (see section 2, "Specifying the unit of measurement").

**Raw data of the measurement 1**

Customer: John Doe  
Type of machine: Milling machine  
SrNo. / year of mnf.: /

Position of axis:  
X: 0.0000 mm Y: 0.0000 mm Z: 0.0000 mm IV: 0.0000 mm V: 0.0000 mm

File name: motorenco-.VMR Meas. mode: VMR Meas. method: Linear  
Reversal dist.: 1.0000 ° Measuring points: 15 Measuring axis: A  
Dwell time: 3.00 s Cycles: 5  
Feed rate: 420 °/min  
Motor encoder

Date of meas.: 29.07.1999 15:56:02 Inspector: DS

Pos.	Cycle	Direction	Nom. position [°]	Act. position [°]	Diff. [°]
1	1	+	0.0000	0.0010	3.5856
1	1	-	0.0000	0.0122	43.9812
1	2	+	0.0000	0.0012	4.3596
1	2	-	0.0000	0.0122	43.8408
1	3	+	0.0000	0.0012	4.4640
1	3	-	0.0000	0.0121	43.6284
1	4	+	0.0000	0.0012	4.4640
1	4	-	0.0000	0.0122	43.8048

### Note

The ACCOM data is saved in an ASCII file. The raw data is saved line by line, separated by tabs. You can load or import this file for further processing in other programs like Matlab, Origin, Microsoft Excel or Open Office.

To **print** the raw data, click the print symbol.

Click **Cancel** to exit the dialog box.



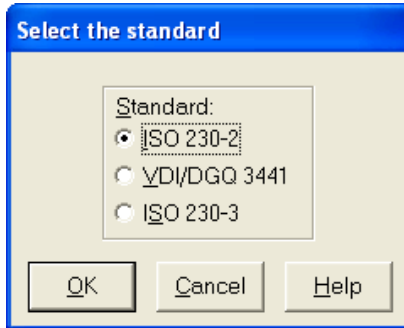
### 13. Select standard for evaluation

→ In the menu item *Evaluate* > *Standard* you can select the guideline for further evaluation.

**ISO 230-2**

**VDI/DGQ 3441**

**ISO 230-3**



# Measuring Procedure for VMR

## 14. Characteristic values

→ With the menu item *Evaluate > Characteristic data*, or by clicking the associated symbol, you can display the results calculated from the measured data according to **ISO 230-2** or **VDI/DGQ 3441**.

To **print** the accuracy data, click the print symbol.

Click **Cancel** to exit the dialog box.

- Example of accuracy data as per **ISO 230-2**:

**Characteristic data of the measurement 1 acc. to ISO 230-2**

Customer: John Doe  
Type of machine: Milling machine  
SrNo. / year of mnt.: /

Position of axis:  
X: 0.0000 mm Y: 0.0000 mm Z: 0.0000 mm IV: 0.0000 mm V: 0.0000 mm

File name: motorenco-.VMR Meas. mode: VMR Meas. method: Linear  
Reversal dist.: 1.00 Measuring points:15 Measuring axis: A  
Dwelltime: 3.00 s Cycles: 5  
Feed rate: 420 \*min  
Motor encoder

Pos.	Nom. pos. [degree]	+ Xmit ["]	- Xmit ["]	Xmit ["]
1	0.0000	4.23	43.78	
2	24.0000	9.87	48.82	
3	48.0000	15.90	56.10	
4	72.0000	13.11	52.50	
5	96.0000	14.31	52.49	
6	120.0000	17.87	50.33	

Measuring axis: B: 43.31 " R: 43.97 " at 288.00 degree  
A: 61.49 " R+: 1.48 " at 0.00 degree  
E: 60.35 " R-: 1.36 " at 312.00 degree  
M: 21.08 "

Date of meas.: 29.07.1999 15:56:02 Inspector: DS

- Example of accuracy data as per VDI/DGQ 3441:

**Characteristic data of the measurement 1 acc. to VDI/DGQ 3441**

Customer: John Doe  
 Type of machine: Milling machine  
 SrNo. / year of mnf.: /

Position of axis:  
 X: 0.0000 mm Y: 0.0000 mm Z: 0.0000 mm IV: 0.0000 mm V: 0.0000 mm

File name: motorenco-.VMR Meas. mode: VMR Meas. method: Linear  
 Reversal dist.: 1.00 Measuring points:15 Measuring axis: A  
 Dwelltime: 3.00 s Cycles: 5  
 Feed rate: 420 °/min

Motor encoder

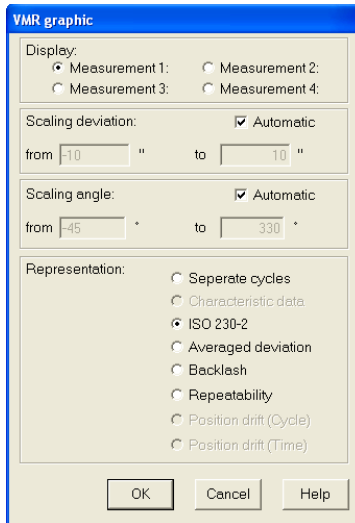
Pos.	Nom. pos. [degree]	+ Xmit ["]	- Xmit ["]	Xmit ["]
1	0.0000	4.23	43.78	
2	24.0000	9.87	48.82	
3	48.0000	15.90	56.10	
4	72.0000	13.11	52.50	
5	96.0000	14.31	52.49	
6	120.0000	17.87	50.33	

Measuring axis: U 36.53 " U max: 43.31 " U min: 28.31 "  
 Ps 1.14 " Ps max: 1.77 " Ps min: 0.64 "  
 P: 61.71 " Pa: 21.08 "

Date of meas.: 29.07.1999 15:56:02 Inspector: DS

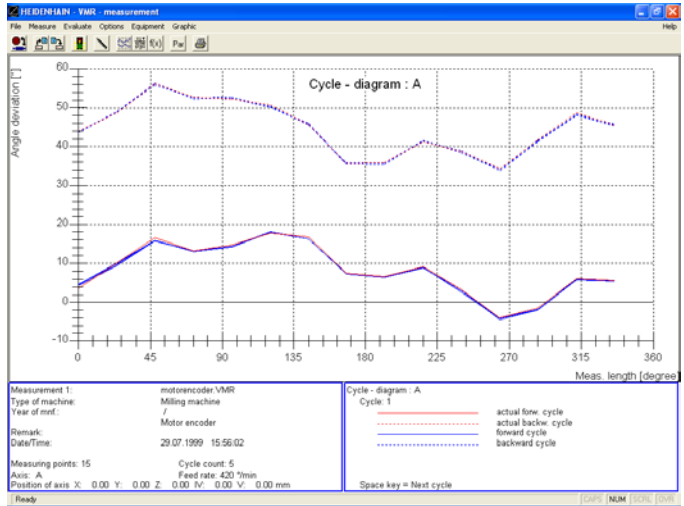
## 15. Graphic display of measurement results

→ You can specify the display mode of the motion error traces according to the selected standard with the menu item *Evaluate* > *Graphic* or by clicking the associated symbol.



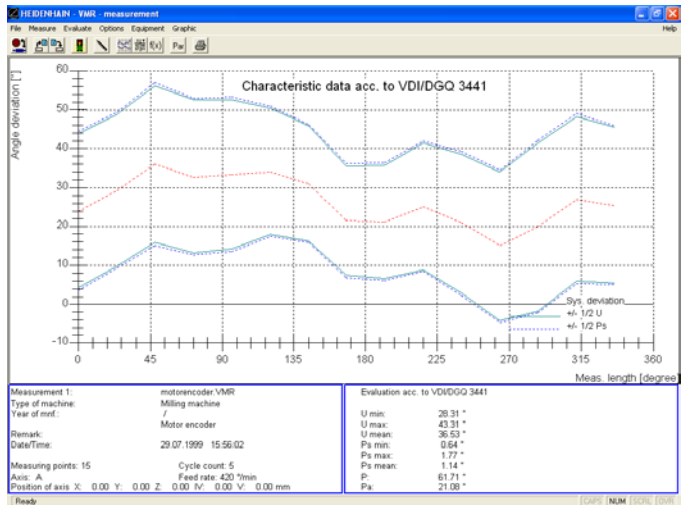
- **Display:** Select the measurement to be displayed.
- **Scaling deviation:**
  - Fixed:** Enter the upper and lower limit of the error display.
  - Automatic:** The scale is determined automatically.
- **Scaling angle (abscissa):**
  - Fixed:** Enter the upper and lower limit of the abscissa.
  - Automatic:** The limits of the abscissa are determined automatically.
- **Representation:** The available display modes depend on the selected evaluation standard.
  - ISO 230-2: **Separate cycles**  
**ISO 230-2**  
**Averaged deviation**  
**Backlash**  
**Repeatability**
  - VDI/DGQ 3441: **Separate cycles**  
**Characteristic values**
  - ISO 230-3: **Position drift as per cycles**  
**Position drift as per time**

- Separate cycles



- Characteristic values

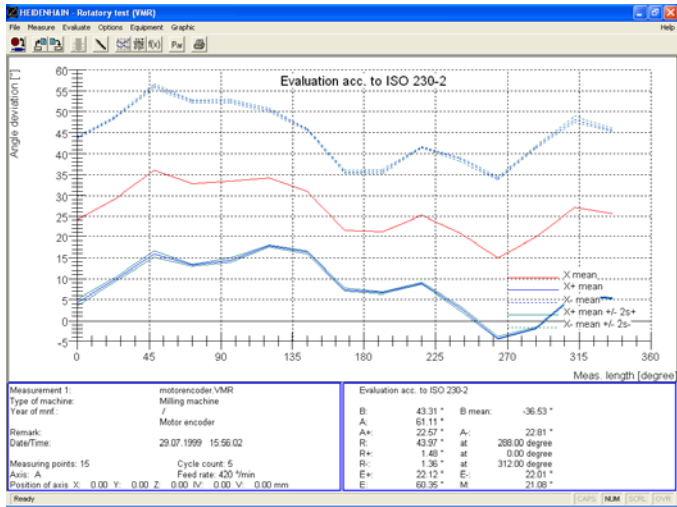
Graphic as per VDI/DGQ 3441



# Measuring Procedure for VMR

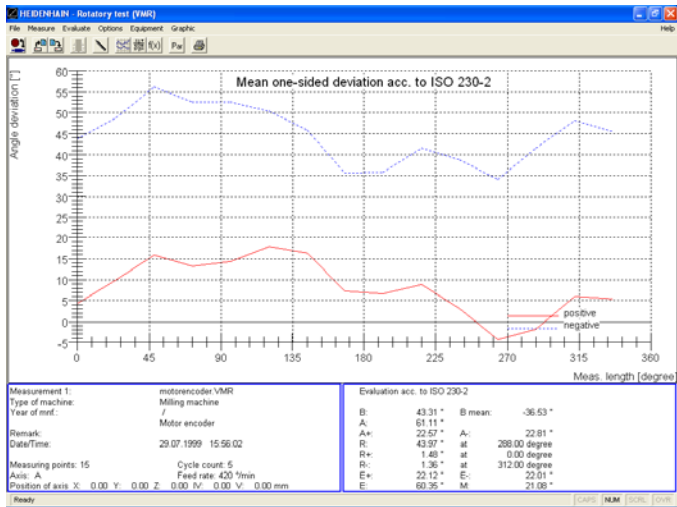
## • ISO 230-2 Characteristic values

Graphic as per ISO 230-2



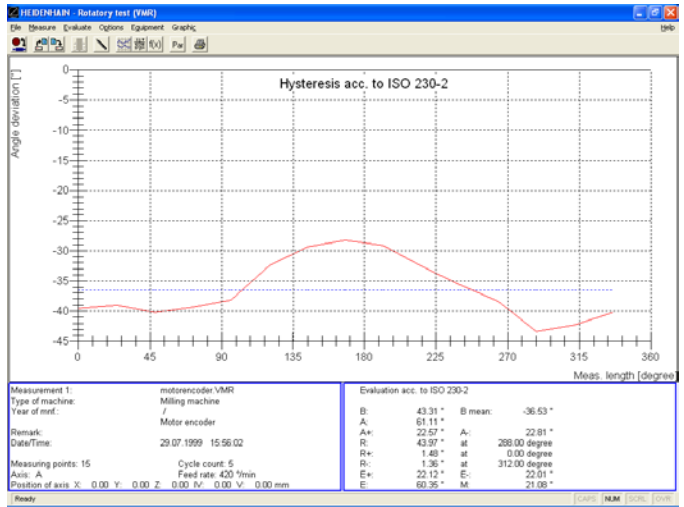
## • Averaged deviation

Graphic as per ISO 230-2



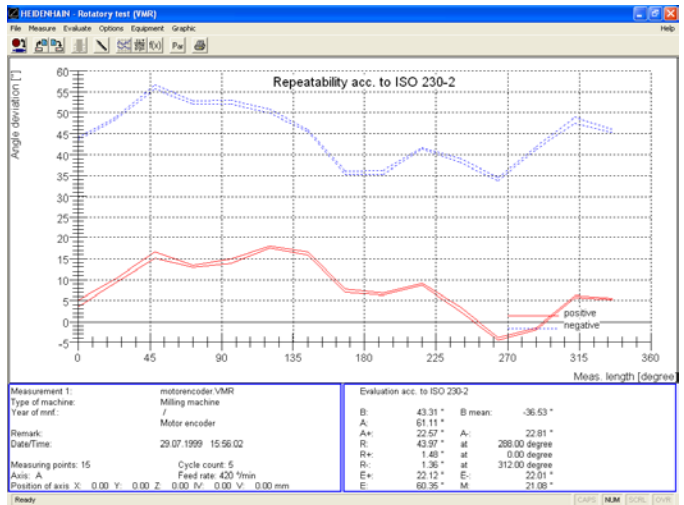
## • Backlash

Graphic as per ISO 230-2



## • Repeatability

Graphic as per ISO 230-2

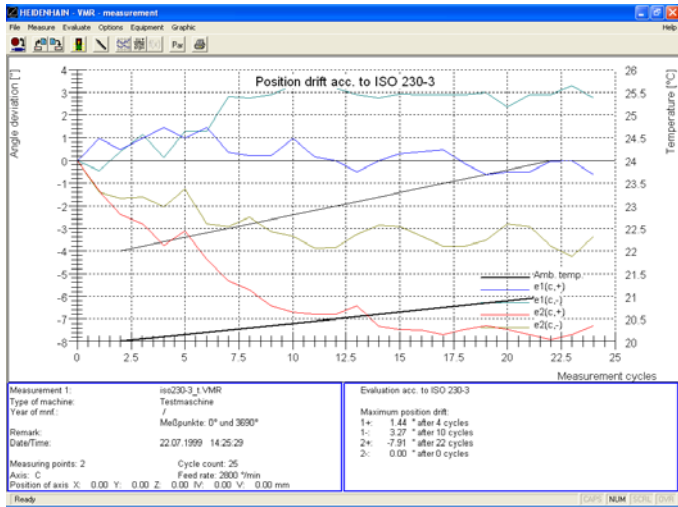


# Measuring Procedure for VMR

## • Position drift (cycles)

Graphic as per ISO 230-3

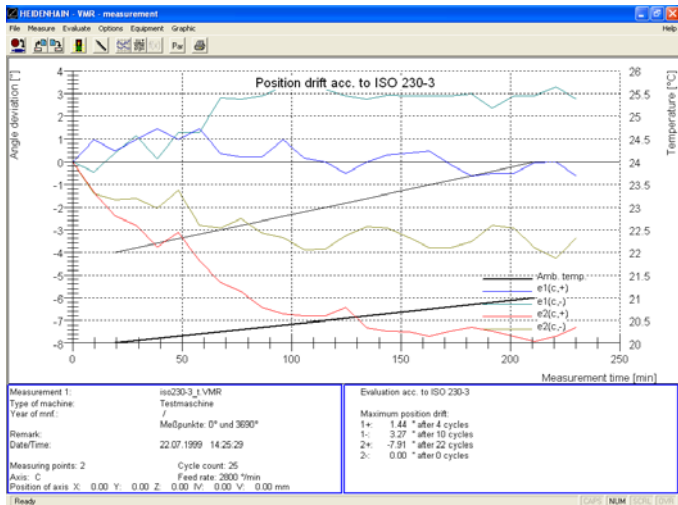
Temperature input under *Evaluate* > *Temperature* table.



## • Position drift (time)

Graphic as per ISO 230-3

Temperature input under *Evaluate* > *Temperature* table.



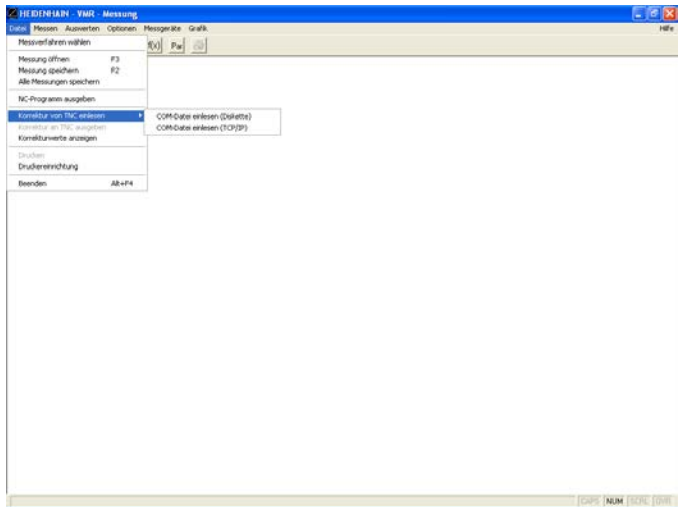


## 16. Running linear compensation on an NC control

**ACCOM** enables you to read the compensation positions defined in the TNC and output the correct compensation values after the measurement.

Proceed as follows:

→ Before entering the measuring parameters, use the menu item *File > Download TNC compensation* to transfer the compensation position table from the TNC to **ACCOM**. Select between the standard **format COM** for current HEIDENHAIN TNC controls.

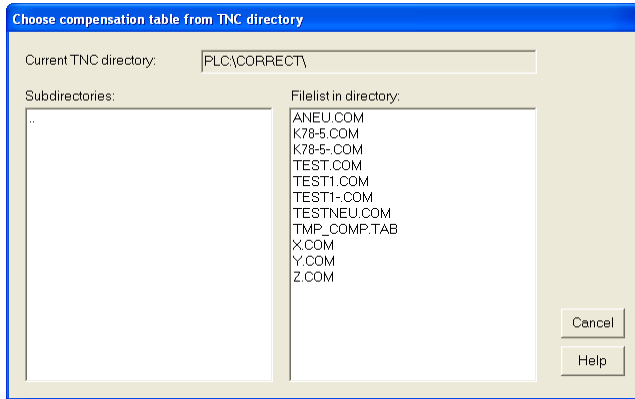


The following window with the PLC directory of the HEIDENHAIN control appears in TCP/IP mode. Before you can access the PLC directory it is necessary to enter the PLC code number. For this purpose a dialog box appears once. In the PLC directory you can choose explicitly the compensation value table which should be written into by ACCOM.

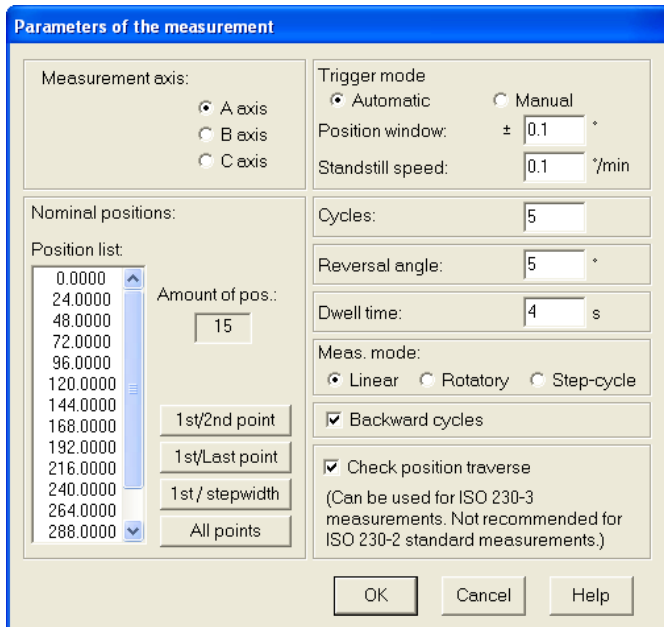
### Note

To build a new table see technical manual of the TNC.

# Measuring Procedure for VMR



→ Enter the measuring parameters with the menu item *Options* > *Measurement parameters*. ACCOM automatically transfers the position values from the TNC compensation table.



- Specify the NC interface.
- Run the directional detection and set the position.
- Generate the NC program and transfer it.

# Measuring Procedure for VMR

→ Generate the calibration chart.

→ Run the measurement. The position error values are then used as compensation data.

→ After the measurement, use the menu item *File > Show compensation values* to call a list of compensation values.

- You can display and save the compensation values averaged from either all measuring cycles or just from the forward or backward cycles.

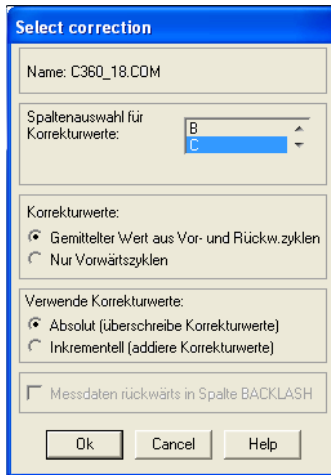
	Position no.	Nominal pos. [mm]	Compensation value [mm]
1	1	0.0000	-0.0398
2	2	4.0960	-0.0347
3	3	8.1920	-0.0328
4	4	12.2880	-0.0300
5	5	16.3840	-0.0289
6	6	20.4800	-0.0317
7	7	24.5760	-0.0368
8	8	28.6720	-0.0437
9	9	32.7680	-0.0443
10	10	36.8640	-0.0414
11	11	40.9600	-0.0438
12	12	45.0560	-0.0349
13	13	49.1520	-0.0339
14	14	53.2480	-0.0341
15	15	57.3440	-0.0313
16	16	61.4400	-0.0327

→ If you click *Save*, you can later read the ASCII file with a text editor or e.g. Microsoft Excel or Open Office.

Measurement 1  
Type of machine: MS4\_c\_vmr  
Year of mnt. /  
Remark: Testdaten für alle Korrekturtabellen  
Date/Time: 30.04.1998 13:54:46  
Measuring points: 64  
Axis: C  
Position of axis X: 0.00 Y: 0.00 Z: 0.00 V: 0.00 W: 0.00 V: 0.00 mm  
Cycle count: 1  
Feed rate: 1000 mm/min

Save compensation values  
Dateiname:   
Dateip: Contab-Res (\*XDR)

→ Output the compensation value table through the menu item *File > Upload TNC compensation*. In the following dialog box you can select the compensation values.



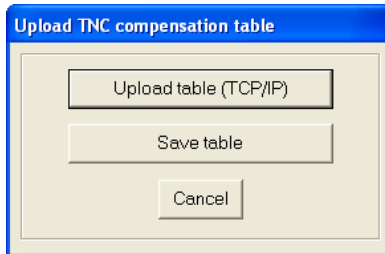
- **Select compensation column:** Choose the column of the compensation table which you would like to correct.
- **Compensation values:**
  - **Mean value:** The mean value of the position error of all forward and backward cycles will be used as compensation values.
  - **Forward cycles:** The position error of the forward cycles will be used as compensation values.
- **Use of the compensation values:**
  - **Absolute:** Existing values in the chosen column will be overwritten. You should use this option if there was no non-linear axis compensation active while measuring or the specified column was empty.
  - **Incremental:** This option allows adding a position error to existing compensation values in the specified column.
- **Compensation of backward cycles:**
  - **TNC 640:** The position error of the backward cycles will be written in column BACKLASH in the same file

**iTNC 530:** Choosing this option will generate a second compensation file with the position error of the backward cycles in the same column. This compensation table may be used by newer iTNCs for the negative direction of traverse.

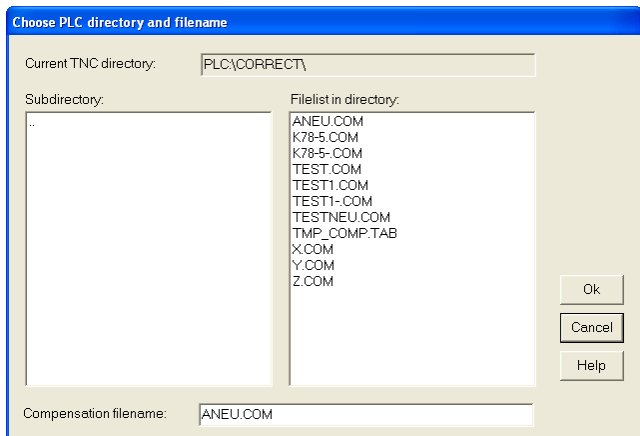
Example: Name of the compensation table: **c.com** -> then the name of the file for the negative direction of traverse is: **c-.com**.

After confirmation with Ok the next dialog box will be displayed where you can select the output.

- **Upload table by network (TCP/IP):** Output by network connection in TCP/IP protocol.
- **Save:** Output to the file system.



The following window with the PLC directory of the HEIDENHAIN control appears in TCP/IP mode. Here you can choose the directory and filename of the compensation value table on the TNC.





After you have installed the compensation values, be sure to run an inspection measurement.

### Color settings of the graphic

If you are not satisfied with the **color setting of the graphics**, you can change the color of the error traces, of the coordinate system and of the graphic background with the menu item *Options > Color setting*.

### Saving/loading the options

You can save these settings with the menu item *Options > Save options*.

You can call these settings with the menu item *Options > Load options*.

### Exporting the measurement graphic

If you wish to **export the measurement graphic as a file** without a log, you can save it as a bit map using the menu item *Graphic > Save*.

### Printing the graphic

You can **print** the graphic with the menu item *Graphic > Print*.

You can change the **printer settings** with the menu item *File > Printer setup*.

### Saving a measurement

If you make **changes to a calibration chart**, you can save them with the menu item *File > Save measurement* or by clicking the **Save** button.

As an alternative, you can also save the measured data with the menu item *File > Save all measurements*.

### Clearing the screen

To remove the motion error traces from the screen, you can **clear the screen** with the menu item *Graphic > Close*.

## Editing the calibration charts

If you would like to **edit the calibration charts** you can select the desired chart with the menu item *Measure > Calibration chart* or by clicking the associated symbol.

**Calibration chart of measurement 1**

Customer:	John Doe		
Type of machine:	Milling machine		
SrNo. / Year of mnt.:		/	
Remark 1:	Motor encoder		
Remark 2:			
Remark 3:			
Inspector:	DS		
HEIDENHAIN Reference meas. system:		RPN 886	
ID number:	355890-08	Serial number:	X1234567890
Position of axis X:	123	mm	<input checked="" type="radio"/> Yes <input type="radio"/> No
Position of axis Y:	-325	mm	
Position of axis Z:	145.66	mm	
Position of axis IV:	0	mm	
Position of axis V:	0	mm	

OK   Cancel   Help

# Measuring Procedure for DBB

---

## Measuring Procedure for DBB circular test

### Machine cleaning

→ Before beginning to mount the encoder, clean the area of the machine tool in which the measurements are made. Pay special attention to any chips and oil or grease residue that could fall onto the encoder. The **DBB 110** has magnetic parts that can attract metal chips!



Give the encoder time to adjust to the ambient temperature before you begin mounting it. This will help to prevent thermally induced error.

### Test program

To best enable the software to calculate and assign all error, a circular test should include at least one complete circle in positive direction and one in negative direction (see ISO 230-4). With HEIDENHAIN controls, the machine program can be transferred directly from **ACCOM**. For non-HEIDENHAIN controls, a typical test program for complete circles could be as follows, whereby movement must be measured only in the measuring plane.

**Part 1, positive direction:** The spindle is on the circle radius at 30° (see radius of **DBB 110**). The center point is the tower of the DBB. Closed circular counterclockwise movement without interruption over 360°. Stop (you must save between measurements).

**Part 2, negative direction:** Closed circular clockwise movement without interruption over 360°. Stop.



Ensure that there are no “forgotten” compensation data saved in the control that could cause a movement perpendicular to the encoder or corrupt the measurement. The spindle must not rotate. If necessary, ask your machine tool builder how it can be fixed. You might try running the machine program without the encoder. There must be no radial movements. The maximum measuring range is  $\pm 5$  mm.

### Measuring assembly

→ Ensure that the **IK 220** PC counter card was installed in your PC according to the instructions in the User's Manual. Alternatively you can use the **EIB 741**. Please ensure an available peer-to-peer network connection to the **EIB 741** (address and subnet mask of the TCP/IP connection).



Now mount the **DBB 110** according to the instructions in the manual.



When connecting the measuring cable to input X1 (X11), be sure to leave enough slack to compensate any machine movement during measurement.

→ **Before starting ACCOM**, connect the enclosed hardware key with Id. No. 590255-01 or 590255-02 to one free USB port.

After calling **ACCOM**, proceed as follows:

# Measuring Procedure for DBB

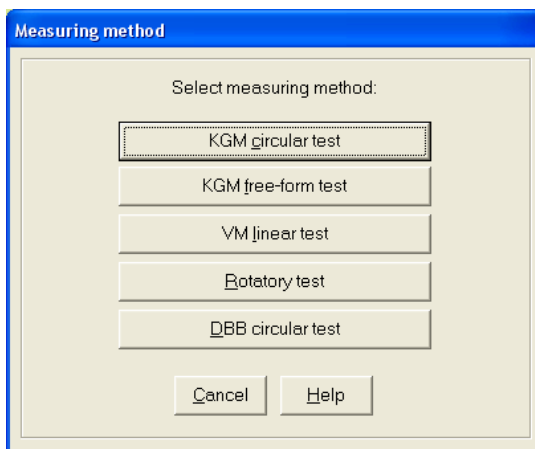
---

## 1. Select measuring method

After **ACCOM** is started, a dialog box appears in which you can select the type of measurement.

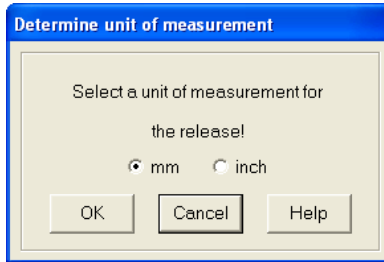
→ Click the **DBB circular test** button to start the corresponding program part.

With the menu item *File > Select measuring method* or by clicking the icon you can select the individual measuring methods from within the running program.



### 2. Specifying the unit of measure

→ With the menu item *Options > Unit of measurement* you specify the desired unit of measure. Close the dialog box with **OK**.



# Measuring Procedure for DBB

---

## 3. Settings of the encoder and the counter card

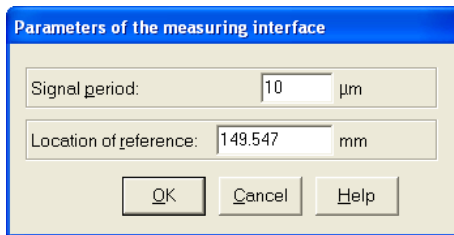
→ Under *Options > Measuring interface* you set the parameters for the encoder used.

- **Signal period:** Here you set the signal period (as its distance in  $\mu\text{m}$ ) of the encoder you are using. The default setting for the signal period is 10  $\mu\text{m}$ .

Input range: 0.1 to 20  $\mu\text{m}$

- **Location of reference:** Here you enter the position of the reference point printed on the **DBB 110**. The measured values are expressed with respect to this position after *Measure > Traverse over reference point*.

Input range: 10 to 500 mm



→ Under *Options > Counter card* you set the parameters for the counter card.

- **Type counter card:** Here you select the model of counter card that you are using.

- **Signal input:** Here you select the type of measuring signal.

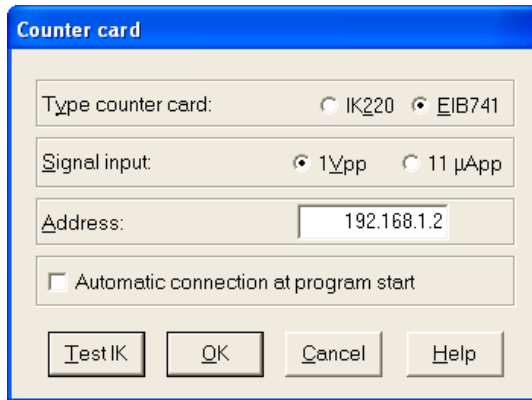
- **Address EIB 741:** Here you enter the IP address of the **EIB 741** (see also **EIB 741** user manual). Alternatively you may use the DHCP hostname in a company network. However it is not recommended due to the high data acquisition rate.

This setting is not needed for the **IK 220**.

- **Automatic connection at program start:** ACCOM connect to the **EIB 741** at the next program start automatically if chosen. A valid connection to the **EIB 741** is required!

- **Test IK (IK 220):** Here you can then test the counter card for proper function.

- **Connect/Disconnect (EIB 741 only):** The **EIB 741** will be connected or disconnected here.



Ensure that you have entered the proper model, address and signal input of the counter card. If the signal period is entered incorrectly, the circles will be measured too large or too small.



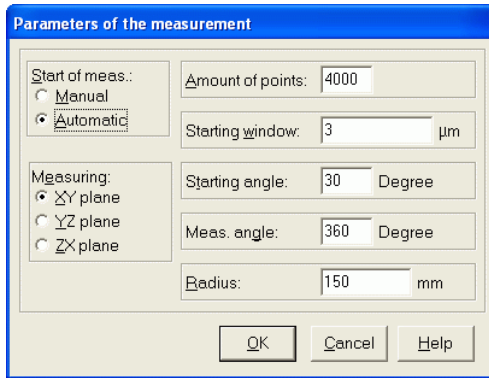
If you have problems receiving data from the counter card, use the test programs on the provided driver CD to check whether the card can be used.

### Note

If you would like to connect an encoder other than the **DBB 110**, you can use the menu item *Equipment > Oscilloscope* to display the incoming measuring signals as Lissajous figures and use them if necessary to make the fine adjustment of measuring signals.

## 4. Parameters of the measurement

→ By calling the menu item *Options > Parameters of the measurement* or by clicking the icon, you open the following dialog box in which you can adjust the **parameters of the measurement**.



- **Start of measurement—manual:** A countdown of 5 seconds begins. In the last three seconds a peep tone is output. After the third peep tone the measurement starts.
- **Start of measurement—automatic:** The measurement starts as soon as the radius has changed by the value shown in the starting window.
- **Measuring plane:** Click the working plane of the machine tool.
- **Amount of points:** Number of measuring points per measurement.  
Input range: 36 to 8000 measuring points
- **Starting window:** Enter here the size of the starting window for the automatic start detection.  
Input range: 1 to 100 μm  
0.000 04 to 0.004 inches
- **Starting angle:** Here you enter for the working plane the angle from which ACCOM is to begin the measurement.  
Input range in XY plane: 0 to 360°  
Input range in YZ plane: 0 to 180°  
Input range in ZX plane: 0 to 90° or 270 to 360°

### Note

Since the orthogonality of the axes is measured at 45°, and the axis reversal movements occur at the quadrant transitions (0°, 90°, 180°, 270°), a **starting angle** of 30° is recommended for the XY plane.

- **Measuring angle:** Here you enter the angle over which the measurement is to be made in the adjusted measuring plane and starting angle (YZ and ZX plane).  
Input range in XY plane: 1 to 720°  
Input range in YZ plane: Depending on the start angle 1 to 180°  
Input range in ZX plane: Depending on the start angle 1 to 180°



The measuring angle and starting angle together must not exceed the maximum traverse range of the machine tool or the input range of **ACCOM**.

- **Radius:** Here you enter the nominal radius of the circle.  
Input range:                   100 to 500 mm  
                                      4 to 19.6 inches

Then conclude the input with **OK**.

### Note

With the menu item *Equipment > Position display* you can call the position display for the connected encoder.

## 5. Setting the NC interface

→ If you wish to transfer the measuring program in **ACCOM** to a HEIDENHAIN control, select *Options > NC programming* to open a dialog box in which you can configure the network connection.

Parameters for NC programming

Mode:  HEIDENHAIN conversational  
 HEIDENHAIN ISO  
 ISO format

Feed rate:  mm/min

Add feed rate to each block

Program name:

Decimal place:  1 µm  0.1 µm  
 10 nm  1 nm

Add M functions:

Add M functions to each block

TNC settings:

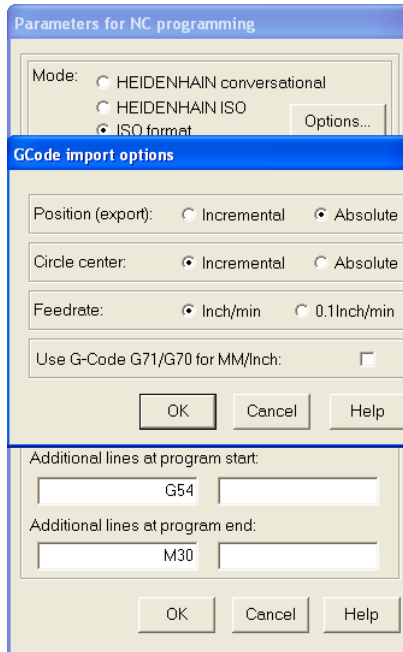
TCP/IP address:

- **Mode:** Choose between HEIDENHAIN or ISO format.
- **Feed rate:** Here you enter the nominal feed rate for the circular motion.  
Input range: 0.001 to 100 000 mm/min or  
0.000 04 to 3900 inches/min
- **Program name:** Here you give the program a name (the extension .H stands for HEIDENHAIN, .I stands for HEIDENHAIN ISO and .txt for general ISO).
- **Decimal place:** Select the decimal place of the NC programs.
- **M functions:** Here you enter additional M functions which are necessary to run the NC program on the control. The M functions are added to the first NC block.  
Example in HEIDENHAIN conversational programming:  
**2 L X0 F1000 M31**
- **TCP/IP address:** Here you enter the TCP/IP address or DHCP hostname of the control for the data transfer via network connection.



## G-Code options

→ By clicking the control button **Options** the following dialog box opens. Here you can configure some ISO format settings which are suitable to the control.



- **Position (export only):** This parameter is used in the export of an ISO NC program only. For absolute positions G90 is added at the NC program start, for incremental positions G91 is used. For absolute NC programs it is useful to add a datum shift (e.g. G54).
- **Circle center:** The input of the circle center point acc. to the German standard DIN 66025 is done incremental to the last position or absolute. Usually I, J, K are used with incremental positions. Valid is also an absolute position with I, J, K. (depends on the control).
- **Feed rate:** This parameter is only valid for an INCH program. The feed rate can be set in Inch/Min or Inch/10Min (HEIDENHAIN default).
- **G-code for Inch/MM:** You can choose whether to use G71/G70 for NC programs or not.

# Measuring Procedure for DBB

In the dialog box **Parameters for NC-programming** you may add the following data for the ISO format programming:

- **Additional lines at program start:** Here you can add 2 user or control specific lines at program start (e.g. G54).
- **Additional lines at program end:** Here you can add 2 user or control specific lines at program end (e.g. M30).

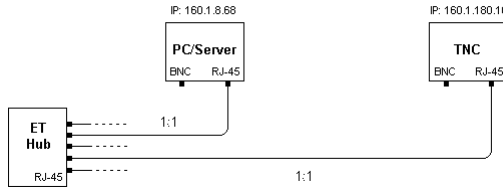
## Network cable

Connect the TNC by a (crossed) network cable directly to the PC or by using a standard network cable with a hub or a switch to the company network.

## Note

Peer-to-peer (direct connection): You need to set the IP-Address of the PC in *Control Panel / Network / TCP-IP / Properties* (depends on the operating system). As default the value for the IP-Address will be given automatically in a company network (from the DHCP Server).

## LAN (Network) with a 1:1 cable

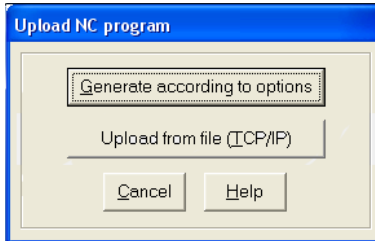


## Peer-to-peer (direct connection) with a (crossed) cable!



### 6. Generating and transferring an NC program

→ If you wish to generate and transfer an NC program, call the menu item *File > Upload NC program to TNC*, and select the form in which you would like to transfer the NC program.



- **Generate according to options:** This button calls a dialog box entitled *Generate NC program for measurement* in which you define the parameters for the NC program.
- **Load from file (TCP/IP):** In the TCP/IP operating mode, a finished NC program is transferred from the file system of your PC to the NC control by a network connection.

## Measuring Procedure for DBB

Generate NC program for DBB circular test

Mode:  HEIDENHAIN conversational  
 HEIDENHAIN ISO  ISO format

Feed rate: 1000 mm/min

Program name: DBB.H

Measuring plane:  XY  YZ  ZX

1st direction of rotation:  +  -

Starting angle: 0 Degree

Measurement angle: 360 Degree

Save Cancel Help

Upload in: LSV2/Ext/ME...

- **Mode:** Choose the format of the NC program.
- **Feed rate:** Enter here the nominal feed rate of motion.  
Input range: 0.001 to 100 000 mm/min  
0.000 39 to 3937 inches/min
- **Program name:** In TCP/IP mode you add the extension .H for HEIDENHAIN format or .I for ISO format to the NC program.
- **Measuring plane:** Click the working plane of the machine tool.
- **1st Direction of rotation:** Select the direction in which the first of the two circular movements defined by the control is to be made.
- **Starting angle:** Enter here the same starting angle as you did before under menu item *Parameters of measurement*.
- **Measurement angle:** Enter here the same measurement angle as you did before under menu item *Parameters of measurement*.



The measuring angle and starting angle together must not exceed the maximum traverse range of the machine tool or the input range of **ACCOM**.

- **Save:** Click to save the NC program.
- **Cancel:** Click to close the dialog box.
- **Upload:** Click to start the upload.

Now an NC program is generated for both directions of rotation and transferred to the root directory of the TNC.



A program is generated that consists exclusively of circular arcs with constant radius. The following two prerequisites must be met:

1. The mounting point of the **DBB 110** on the milling machine table must match the datum of the NC machine. Set the datum if necessary.
2. The spindle head must be at the 0° position of the test circle.

These two conditions are met if the **DBB 110** has been installed according to the instructions of the operating manual.

The program first moves the spindle head into the starting angle position and stops there. **Here you can start the**

**measurement through ACCOM.** Then start the NC machine, which moves on by the measurement angle and then stops.

**When it starts again the spindle head moves from the end angle back to the starting angle.**



The TNC does not answer if the network is not connected.

# Measuring Procedure for DBB

## 7. Generating a calibration chart

→ Through the menu item *Measure > Calibration chart* or by clicking the icon you can define the calibration chart for the measurement by entering information on the measurements in the calibration window. By clicking **yes** or **no** you can specify whether the **chart window** will open automatically after each measurement.

**Calibration chart of measurement 1**

Customer:

Type of machine:

SrNo. /Year of mnt.:  /

Remark 1:

Remark 2:

Remark 3:

Inspector:

HEIDENHAIN Reference meas. system:

ID number:  Serial number:

Position of axis X:  mm

Position of axis Y:  mm

Position of axis Z:  mm

Position of axis IV:  mm

Position of axis V:  mm

Open chart window automatically after a measurement?

Yes  No

OK Cancel Help

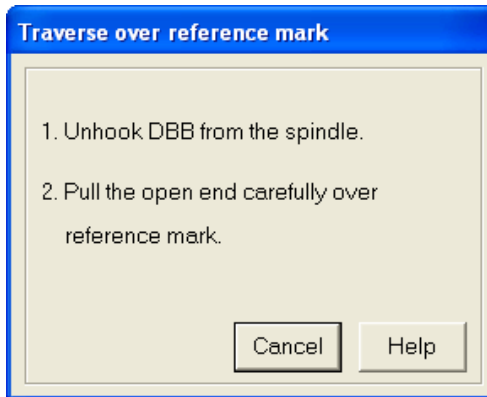
If you enter the chart data only for measurement 1, they will automatically apply also to the other measurements. The charts can also be saved or edited later in the course of evaluation.

**ACCOM** saves these data together with the measured data and prints them through the menu items *Evaluate > Measured data*, *Evaluate > Characteristic data* and *Graphic > Print*.

## 8. Calibrating the measuring assembly

### Traversing the reference mark

→ The measuring assembly must be calibrated before the first measurement. To do so, call the menu item *Measure > Traverse over reference point*. Follow the instructions in the dialog box. If the message *The DBB has been referenced* appears, rehook the DBB. Now you can go directly to the menu item *Measure > Start measurement*.



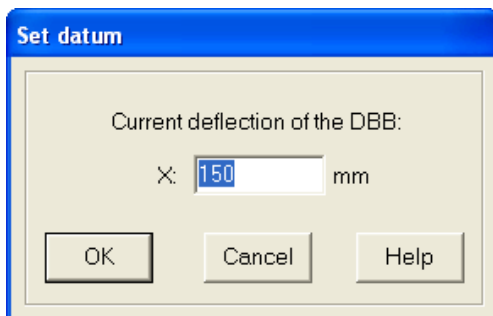
When you rehook the **DBB 110**, ensure that the measuring cable has enough slack for the rotary movements.

## Measuring Procedure for DBB

---

### Datum setting

→ If you are using a **DBB without reference mark** or **without calibrated extension**, you must enter the current deflection under the menu item *Measure > Set datum*.



If you omit this point, the point that you have entered under menu item *Options > Measuring interface > Location of reference* appears automatically.





## 9. Start measurement

→ To start measuring, select the menu item *Measure > Start measurement* or click the symbol. Then the dialog box appears in which you can start measuring after entering the following parameters.

**DBB circular test**

Measurement 1  
 Measurement 2  
 Measurement 3  
 Measurement 4

Direction of rotation:  
   

Feed rate:  
 mm/min

Resolution:  
 µm/div

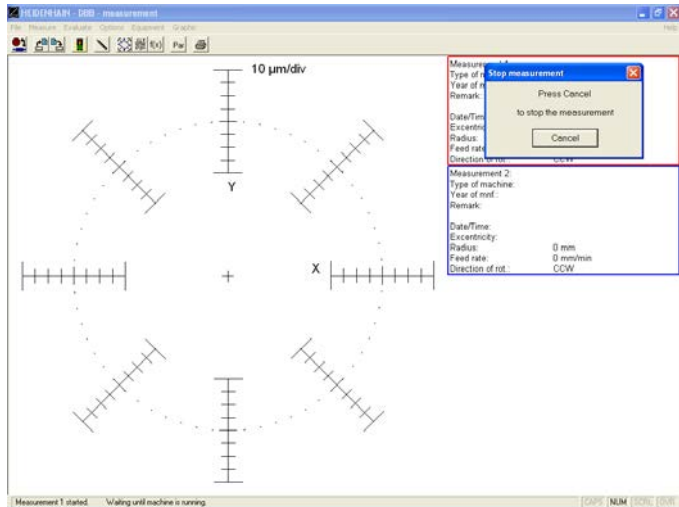
- **Measurement 1-4:** Click the number under which the measurement is to be shown later.
- **Direction of rotation:** Select here the direction of rotation for the circular movement.
- **Feed rate:** Enter here the nominal feed rate of motion.  
Input range: 0.001 to 100.000 mm/min  
0.000 04 to 3900 inches/min
- **Graphics:** Enter here the resolution for displaying the circular form. You can change the resolution at any time during the evaluation.  
Input range: 0.1 to 10.000 µm/div.  
0.000 04 to 0.4 inches/div.

### Note

A complete circular test should include at least two complete circles of the same radius, center, and feed rate, but with different direction of rotation.

# Measuring Procedure for DBB

→ **Start:** After you click this button, **ACCOM** waits for the beginning of measurement. Start the circular movement on the machine tool. In the status line, **ACCOM** shows the condition of measurement. You can terminate the measurement with **Cancel**.

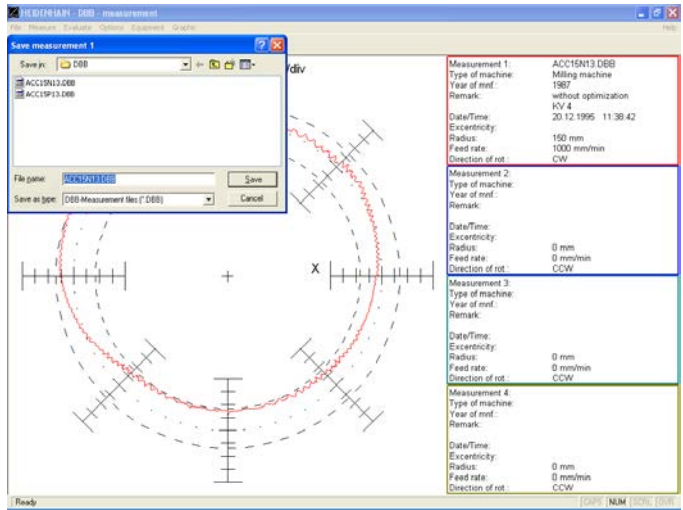


## Note

If **ACCOM** does not begin measuring although the circular movement was made on the machine tool, wait for a period of 15 to 30 seconds after the movement ends. If the menu item *Evaluate > Graphic > Representation* was set to *Center* or *Radius compensation* (see point 14, Graphic Display of Circular Test Results), there is no online display.

## Data storage

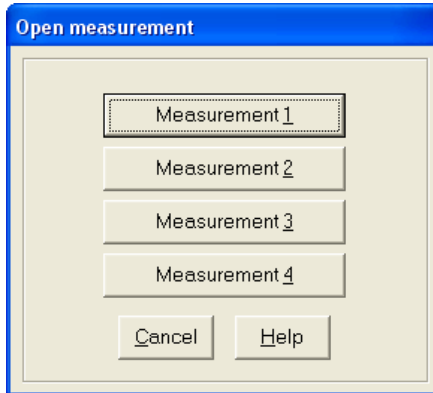
After conclusion of measurement, the following dialog box appears for data storage.



With *Measure > Start measurement* you can start further measurements.

### 10. Open measurement

→ Through *File > Open measurement* or by clicking the associated button you can load the measured data for further evaluation and display. The following screen appears.



Since up to four measurements can be shown simultaneously, this dialog box enables you to open the measurements in any sequence.

This menu item also enables you to call other motion error traces to the screen for further evaluation.



The results of measurement are loaded into the system with menu item *Open measurement*. This is a prerequisite for display. Through the menu item *Evaluate > Graphic* you can influence how and whether the motion error traces are displayed (see also section 14, “Graphic Display”).

## 11. Evaluate measured data

→ You can view the raw measurement data through the menu item *Evaluate > Raw data* or by clicking the associated symbol. **ACCOM** shows every measured deviation including the associated angle.

**Raw data of the measurement 1**

Customer: John Doe  
Type of machine: Milling machine  
SrNo. / year of mnf.: 123 / 1987

Position of axis:  
X: -82.43 mm Y: -82.935 mm Z: 254.255 mm IV: 0 mm V: 0 mm

File name: ACC15N13.DBB Measuring method: DBB  
Measuring plane: XY Measuring points: 1000 Direction of rotation: CW  
Nominal radius: 150 mm Feed rate: 1000 mm /min  
Starting angle: 45 Degree Meas. angle: 360 Degree

KV 4

Date of meas.: 20.12.1995 11:38:42 Inspector: PF

	Angle [Degree]	Deviation [mm]
1	44.999991	0.006877
2	44.652950	0.006320
3	44.292560	0.005197
4	43.932169	0.005178
5	43.571836	0.003498
6	43.211446	0.002893
7	42.851055	0.007639
8	42.490665	0.007854

Cancel  
Help

### Note

The ACCOM data is saved in an ASCII file. The raw data are saved line by line, separated by tabs. You can load or import this file for further processing in other programs like Matlab, Origin, Microsoft Excel or Open Office.

To **print** the raw data, click the print symbol.

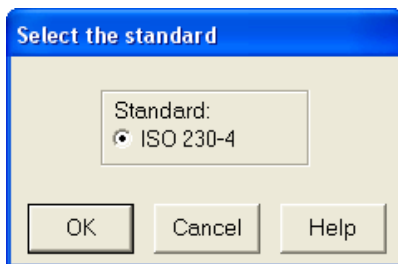
If you click **Cancel**, the dialog box closes.

## Measuring Procedure for DBB

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### 12. Select standard for evaluation

→ In the menu item *Evaluate > Standard* you can select the guideline for evaluating the circular test. At present only the ISO 230-4 standard is available.



## 13. Characteristic data of the circular test

→ With the menu item *Evaluate > Characteristic data*, or by clicking the associated symbol, you can call the accuracy data calculated from the measured data according to ISO 230-4. In addition, **ACCOM** calculates the mean radius, the backlash, the reversal peaks, center deviation and the orthogonality (squareness) of the axes.

**Characteristic data of the measurement 1**

Customer:  
 Type of machine: Milling machine  
 SrNo. / year of mnf.: 123 / 1987

Position of axis:  
 X: -82.43 mm Y: -82.935 mm Z: 254.255 mm IV: 0 mm V: 0 mm

File name: ACC15N13E.DBB Measuring method: DBB  
 Measuring plane: XY Measuring points: 1000 Direction of rotation: CW  
 Nominal radius: 150 mm Feed rate: 1000 mm /min  
 Starting angle: 45 Degree Meas. angle: 360 Degree

without optimization  
KV 4

Characteristic data of the measurement according to ISO 230-4 Centre used

Circular deviation Gyx:	0.0170 mm
Circular deviation Gxy:	0.0240 mm (ACC15P13E.DBB)
Bi-directional circular deviation G(b)xy:	0.0272 mm ACC15N13E.DBB / ACC15P13E.DBB
Radial deviation Fyx min:	-0.0102 mm
Radial deviation Fyx max:	0.0067 mm
Mean bi-directional radial deviation Dxy:	-0.0022 mm ACC15N13E.DBB / ACC15P13E.DBB

Mean radius:	149.9979 mm		
Backlash:	X+:	-0.0023 mm	X-: 0.0007 mm
	Y+:	0.0001 mm	Y-: -0.0002 mm
Reversal spikes:	X+:	0.0062 mm	X-: 0.0029 mm
	Y+:	0.0038 mm	Y-: 0.0034 mm
Centre point comp. val.:	X: -0.0046 mm	Y: 0.0114 mm	
Squareness error:	32.1053 µm/m ACC15N13E.DBB / ACC15P13E.DBB		
Axis length difference:	X is 0.000 % longer as Y		

Date of meas.: 20.12.1995 11:38:42 Inspector: PF



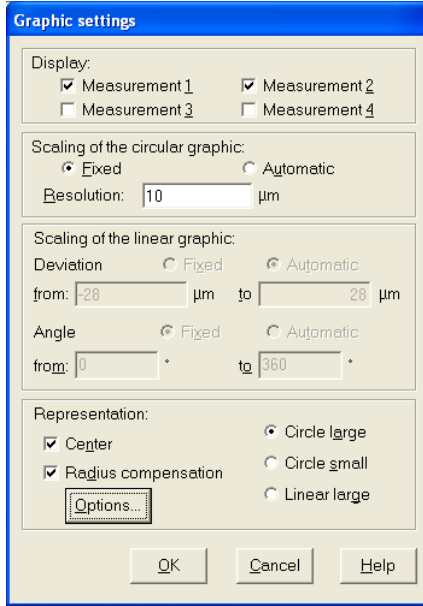
Two circles are required—once each in positive and negative direction—for complete calculation of all accuracy data, particularly the circular backlash H. **ACCOM** issues a warning if you have forgotten to load the second file.

To **print** the accuracy data, click the print symbol.

If you click **Cancel**, the dialog box closes.

## 14. Graphic display of circular test results

→ You can specify the display mode of the motion error traces through the menu item *Evaluate > Graphic* or by clicking the associated symbol.



- **Release:** Here you can select up to four previously opened measurements to be displayed.

You can choose in principle between circular and linear diagrams and configure the respective settings. **Scaling** can then either be set to a **fixed** value or can be selected **automatically** by the system.

- **Scaling of the circular graphic:** In the circular graphic you can set the desired resolution.

Input range of resolution:      0.1 to 10 000 µm  
   0.000 004 to 0.4 inch

- **Scaling of the linear graphic:** In linear graphics you can set the upper and lower limit or the displayed angular range for the deviations from an ideal circular path.

Error from/to:                        -10 000 to +10 000 µm  
   -0.4 to 0.4 inch

Angle from/to:                        0 to 360°



- **Representation:**

**Center:** With this function you can display a centered view of the measurement **ACCOM** shows you the calculated actual circle center.

**Radius compensation:** Here the radius error is compensated by ACCOM in the graphic and displayed in the box.



**Before measuring** you should **switch off** the **centering** and **radius compensation** function, since otherwise the graphic will not be shown online.

You have the choice between the following display modes:

**Circle large**

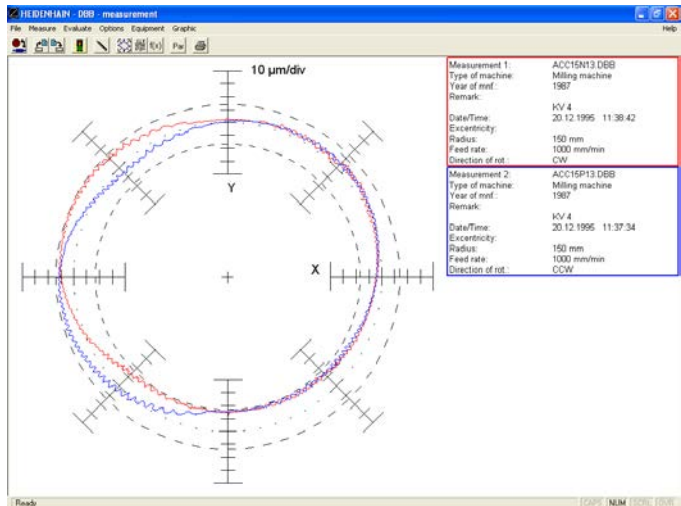
**Circle small**

**Linear large**

- **Circle large:** Here, **ACCOM** draws up to four motion error traces in **one** circular graphic. You can switch the error traces on and off with the menu item *Evaluate > Graphic > Release measurement 1-4*.

The nominal radius is shown as a dotted line in the measurement graphic.

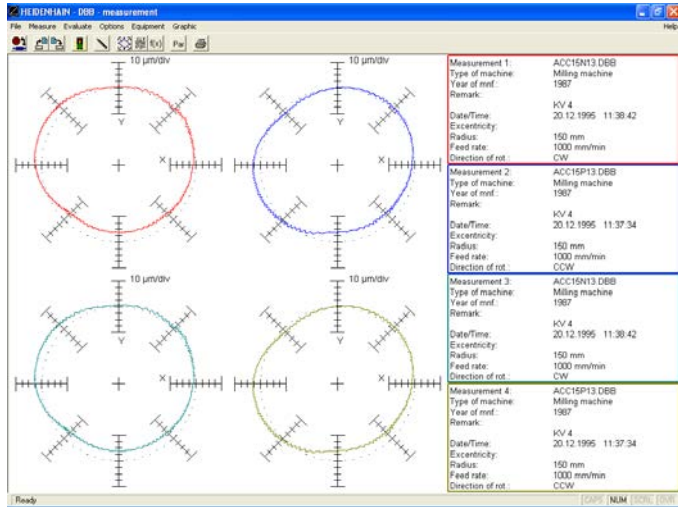
The **largest** and **smallest radius errors** are shown as a **dashed line** in the graphic.



You can load new measurements with *File > Open measurement* or by clicking on the associated button.

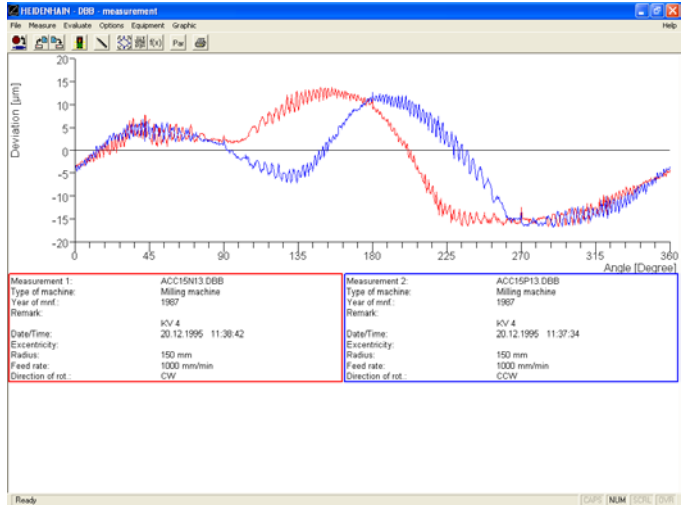
# Measuring Procedure for DBB

- **Circle small:** Here, **ACCOM** draws each motion error traces in a separate circular graphic. You can switch the error traces on and off with the menu item *Evaluate > Graphic > Release measurement 1-4.*

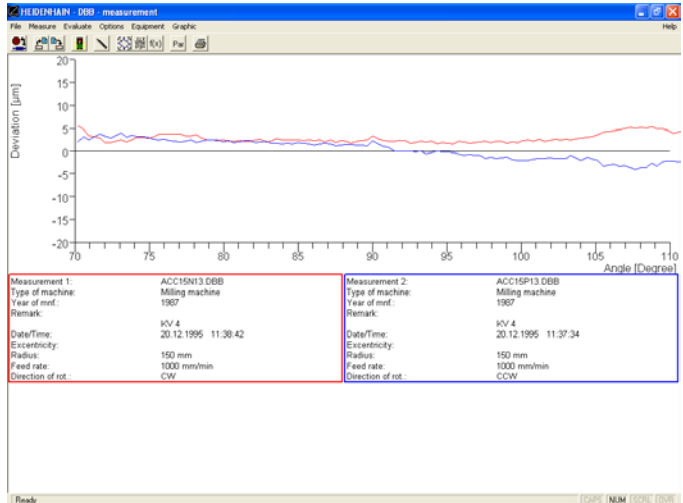


# Measuring Procedure for DBB

- **Linear large:** Here, ACCOM draws up to four motion error traces in **one** linear graphic. You can switch the error traces on and off with the menu item *Evaluate > Graphic > Release measurement 1-4*. In the example the **scaling is fixed** and the **angle of 0 to 360°** is selected.

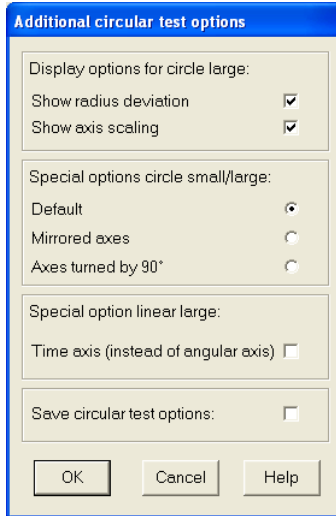


- As an alternative you can also display an **angular range**. In the example the **scaling is fixed** and the **angle of 70 to 110°** is selected.



## Additional circular test options

→ By clicking on the control button **Options** the following dialog box opens. Here you can set additional display options.



- **Display options for circle large/small:** In the circular test graphic you can disable the auxiliary lines for the minimum and maximum radius deviation and/or the scaling values.
- **Special options for circle large/small:** In the default graphic for the circular test the first measurement axis is shown right and the second axis is shown top. Alternatively the axis can be displayed mirrored (1st axis top, 2nd axis right). The third display option is: 1st axis is shown top and 2nd axis is shown left (axes are turned by 90 degrees).
- **Special option linear large:** Alternatively you may use a path-time diagram for the radius deviation (time instead of angle).
- **Save circular test options:** Here the special options for the circular test representation can be saved (at program end or change of measurement type).

## Open measurement

You can load new measurements with *File > Open measurement* or by clicking on the associated button.

## Color settings of the graphic

If you would like to change the **color setting of the graphics**, you can change the color of the error traces, of the coordinate system and the graphic background with the menu item *Options > Color setting*.

## Saving/loading the options

You can save these settings with the menu item *Options > Save options*.

You can call these settings with the menu item *Options > Load options*.

## Exporting the measurement graphic

If you wish to **export the measured graphic as a file** without a log, you can save it as a bitmap using the menu item *Graphic > Save*.

## Printing the graphic

You can **print** the graphic with the menu item *Graphic > Print*.  
You can change the **printer settings** through the menu item *File > Printer setup*.

## Saving a measurement

If you make **changes to a calibration chart**, you can save them through the menu item *File > Save measurement* or by clicking the **save** button.

As an alternative, you can also save the measured data through the menu item *File > Save all measurements*.

## Clearing the screen

To remove the motion error traces from the screen, you can **clear the screen** with the menu item *Graphic > Close*.

# Measuring Procedure for DBB

## Editing the calibration charts

If you would like to **edit the calibration charts** you can select the desired chart through the menu item *Measure > Calibration chart* or by clicking the associated symbol.

**Calibration chart of measurement 1**

Customer:

Type of machine:

SrNo. / Year of mnt.:  /

Remark 1:

Remark 2:

Remark 3:

Inspector:

HEIDENHAIN Reference meas. system:

ID number:  Serial number:

Position of axis X:  mm

Position of axis Y:  mm

Position of axis Z:  mm

Position of axis IV:  mm

Position of axis V:  mm

Open chart window automatically after a measurement?  
 Yes  No

## Typical Motion Error Traces of the Circular Test

The motion error traces shown below are the typical results of measurements performed with the **DBB 110** or **KGM**. The chapter contains examples of the typical error traces for most of the common error sources. Each trace is described together with the possible causes of the error. This will help you to diagnose the errors on your machine, but it is not a complete discussion of this topic. For a detailed work on the diagnostic procedures please refer to the "Circular Test" by Knapp and "Accuracy Inspection of NC Machine Tools by Double Ball Bar Method," Kakino.

The **DBB 110** and the **KGM** are complete calibration systems. The results of the **DBB** system should be used to identify error sources and to suggest which type of measurements or actions are required to improve the accuracy of the machine. The **DBB 110** and **KGM** help you to find the best error compensation method. The values for the machine compensation can be calculated and adjusted until the desired results are achieved.

### Typical error types

#### Roundness error:

- Reversal peaks
- Backlash and backlash compensation
- Center offset
- Cyclic Error
- Deviation caused by ball bar cable (only with DBB 110)
- Directional vibrations
- Incorrect feed rate
- Rolling of the spindle head
- Screw-pitch error
- Radial error
- Random vibration
- Encoder error
- Mismatching of position loop gain
- Squareness error
- Stick slip
- Straightness error

## Typical Motion Error Traces of the Circular Test

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The circularity error gives some basic information on the overall condition of the machine tool. However, the error sources and the significance of individual errors are not revealed because the circular plot graph represents the total effect of all errors.

Circularity is most often calculated with one of the following methods:

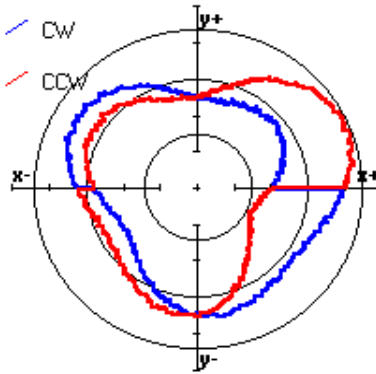
- LS** Least squares circle
- MZ** Minimum zone circles
- MC** Minimum circumscribed circle
- MI** Maximum inscribed circle

Circularity is the difference of the maximum and minimum points of the trace pattern.

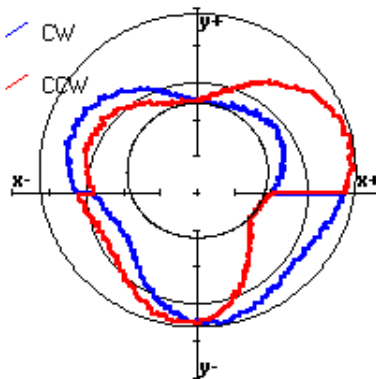


# Typical Motion Error Traces of the Circular Test

## LSC circularity



## MZC circularity



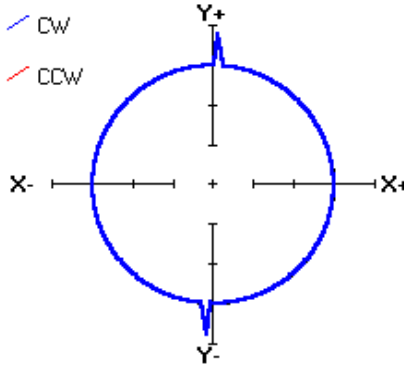
MZC always leads to a value smaller than or equal to LSC.

# Typical Motion Error Traces of the Circular Test

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## Reversal peaks

As the name of the error describes, reversal peaks occur shortly after the direction of the motion of an axis is reversed. At this point, the axis stops momentarily and then moves rapidly to catch up with the movement in the reverse direction. The magnitude of the spike is dependent on the servo rigidity, the feed rate and the radius of the circle.



### Possible causes

These peaks are caused by a type of hysteresis at the reversal points. Possible causes of error:

- Large lag error caused by low loop gain
- Backlash in the drive and feedback system, especially with rotary encoders.

This type of error is very common on large machines and machines using rotary encoders as position feedback devices.

### Suggestions

Increasing the position loop gain might decrease the size of the peaks. Care should be taken to find a suitable value for the position loop gain so that the drive system does not oscillate.

Some advanced controls offer the possibility of compensating the reversal peaks.

When measuring reversal peaks, use the largest possible number of measuring points.

## Backlash and backlash compensation

Backlash error appears on plots in two different ways: as positive and negative backlash. When moving to the defined test direction, positive backlash can be seen on the plot as a step *outwards* starting on the axis. Negative backlash appears as a step *inwards* starting on the axis.

### Backlash Step — Positive

Normally, a positive backlash is caused by a deformation or play in the machine structure.

### Backlash Step — Negative

Negative backlash is often caused by backlash overcompensation at the controller: the compensation value exceeds the value of the actual backlash error.

Normally, the step occurs at approximately the same magnitude at both reversal points of the axis. However, due to deformations in the machine tool structure the values may also be different in actual cases.

### Possible causes

The backlash is normally caused by some deformation or play in the machine structure and not by the encoder.

This type of error can be detected on machines using linear encoders. It is normally significantly larger than the inherent backlash of the linear encoder, which is typically under 1 micron.

### Suggestions

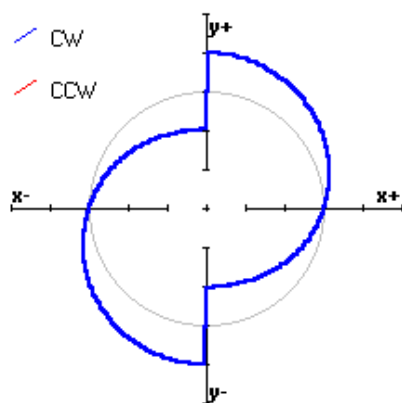
If backlash compensation is not available in the controller, check the machine for possible sources of backlash:

- Drive belts or couplings between spindle and rotary encoders
- Movement of the table
- Play in the machine guideways

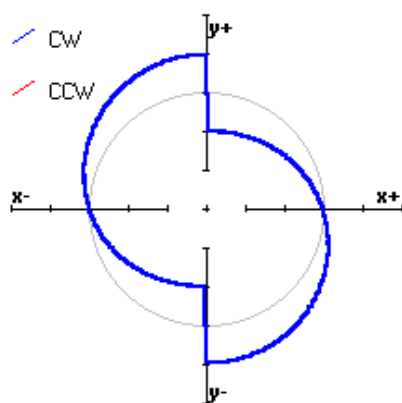
## Typical Motion Error Traces of the Circular Test

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### Backlash — Positive



### Backlash — Negative



## Center offset

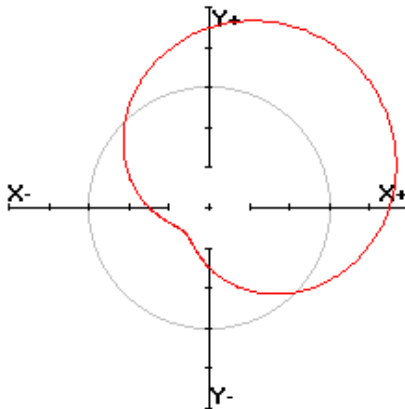
**Possible causes** Extreme error symmetrical through the center point.

This is a typical trace eccentricity error due to center offset, commonly seen in DBB circular tests.

When setting up the Double Ball Bar it is very difficult to mount the tower at the exact center of rotation with the human eye. It is therefore very important to determine the numerical values for the center offset. These values are called Center Offsets and it is advisable that their values remain below 100  $\mu\text{m}$  for both axes. Otherwise, the reliability of the measurement could be affected.

Such a trace also appears if a correctly centered trace is compensated with offset values that do not apply to this measurement.

## Center offset



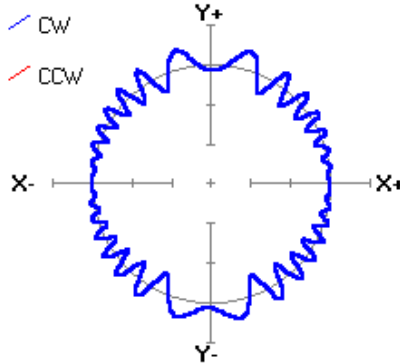
The example plot contains a 15 micron offset in both axes. The scale of the plot is 10 microns.

# Typical Motion Error Traces of the Circular Test

---

## Cyclic error

Cyclic error appears as a cyclically changing sinusoidal motion error on the circular plot. The phase of the ballscrew will vary depending on where the test is performed on the machine.

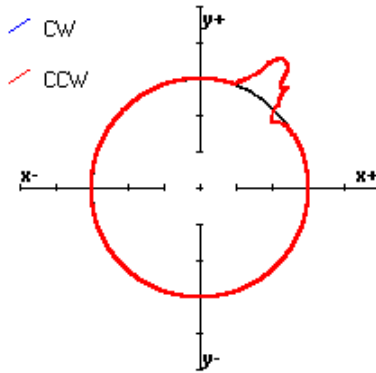


## Possible causes

Because the possible causes of cyclic error are manifold (ballscrews, encoders, resolvers, transmission, etc.), it is of extreme importance to know the structure of the machine tool and its driving mechanism in order to reach a correct diagnosis.

## Deviation caused by the DBB cable

Radial error as one angular position.



### Possible causes

The cable may have become caught up on the machine and exerted a force on the ball bar that causes a radial deviation to be registered.

### Suggestions

Always carry out two measurements: one in the positive direction followed by one in the negative direction. This allows the cable to wind and unwind during each measurement. If several measurements are carried out in one direction the cable will wind up until it causes a measuring error and may damage the ball bar.

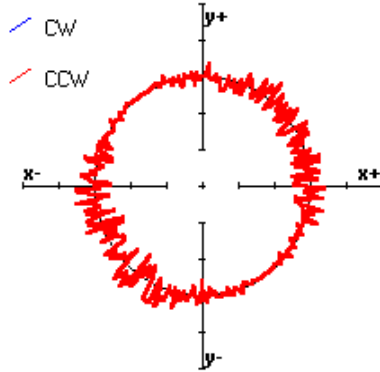
Make sure that the cable cannot catch on any part of the machine, bolts, clamps etc. during the measurement. On a vertical machine hang the cable above the spindle and allow it to hang down to the ball bar without touching the table.

# Typical Motion Error Traces of the Circular Test

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## Directional vibrations

If vibration is caused by a particular reason, the location and influencing direction of the error source most probably will cause a directional bias in the vibration pattern.



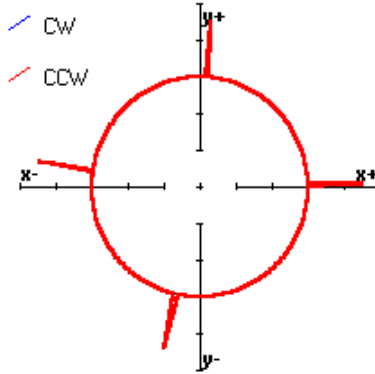
### Possible causes

If the direction of vibrations is parallel with one or both axes, it is likely that vibrations are caused by the machine itself. In other cases, the cause might be peripheral devices, the machine foundation or damping systems, etc.



## Incorrect feed rate

The reversal peaks are not located on the quadrant transitions. The picture below illustrates the appearance of reversal peaks when the feed rate is incorrect.



### Possible causes

If the reversal peaks are spaced more than 90 degrees apart, the machine feed rate is lower than the value entered in the DBB software.

If the spacing is less than 90 degrees, it is higher.

### Suggestions

Use the feed-rate override control to set the speed correctly. The 100% setting of this control does not always correspond exactly to 100% of the feed rate.

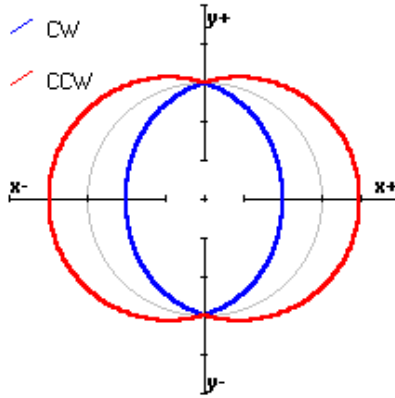
- Check the programmed feed rate and adjust it if necessary.
- Check the maximum feed rate allowed by the control for circular interpolation.
- Check the maximum circular acceleration values.

# Typical Motion Error Traces of the Circular Test

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## Rolling of the spindle head

Angular movement about the Y axis results from play in the Z axis in the machine's guideway. Therefore, depending on the test direction and on the algebraic sign of the error, the resulting path will be either inside or outside the nominal circle when observed from the other axis' point of view. Usually the traces are nearly symmetrical about both axes. However, there are also cases in which the wear is unequal at the ends of an axis. In these cases, the trace will be symmetrical only about the axis that has the error.

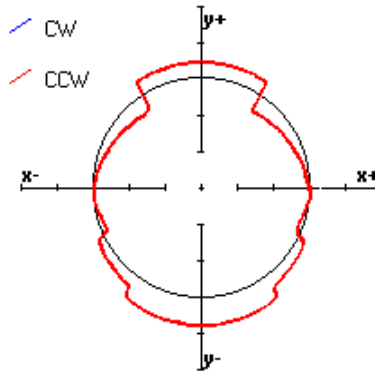


### Possible cause

The type of error presented in the picture is most frequently caused by play in the Z-axis guideway.

## Screw-pitch error

Screw-pitch error is symmetrical about one axis.



### Possible causes

Some control systems offer the possibility of compensating non-linear positioning errors in one axis.

The position in one axis is not continuously compensated according to the measured position of this axis ( $X=F(X)$ ).

If these compensation values are incorrect they may lead to the type of trace shown above.

Guideway error coming from ball bearing or some other repeating part of the machine construction.

### Suggestions

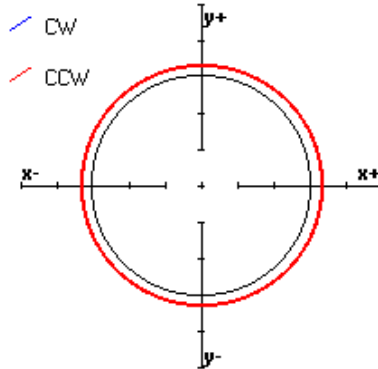
- Check the non-linear compensation parameters in the control.
- Use a comparator measuring system such as the **VM 182** and **ACCOM**-VML evaluation software to measure the positioning accuracy of the axes in question

# Typical Motion Error Traces of the Circular Test

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## Radial error

A constant radial deviation over the whole trace. A trace whose mean value lies inside or outside the nominal path.



### Possible causes

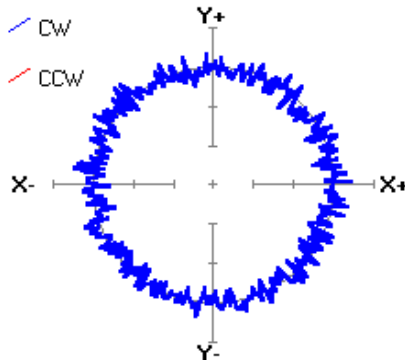
- The user did not correctly calibrate the DBB/KGM before the measurement.
- The radius of the programmed contour is not the same as the nominal radius in the **ACCOM** software.
- The DBB/KGM has been set to zero at a point other than on the reference mark (non-calibrated mode) and/or a circle of a different radius has been programmed.
- The DBB/KGM has not been mounted horizontally to within the specified tolerances.
- A large temperature difference between the DBB/KGM and the machine has distorted the measurement.
- Both servos have an identical response error and both axes will either overshoot or lag to the same extent.
- Identical scale errors on both axes.

### Suggestions

- Check that the radius in the NC program equals the radius value entered in the **ACCOM** software.
- Allow the machine and DBB/KGM to attain the same temperature.
- Repeat the test using different feed rates.

## Random vibration

The plot shown below presents the effect of random vibration, often also called as noise.



## Possible causes

The vibration may be generated by the machine itself, for instance by insufficient lubrication or clearances in the slide-guideway systems. The vibration can also be induced by the surrounding environment, such as other machine tools, compressors, ventilation fans, material handling devices or vehicles used for transportation.

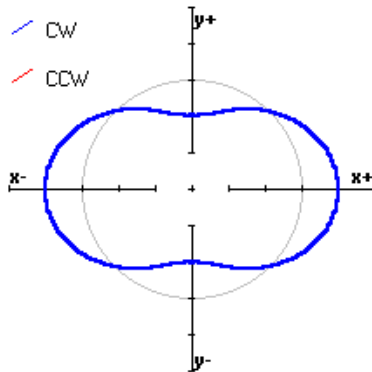
If analyzed deeper, in the case of one single cause, it can be noticed that the amplitude of random vibration varies around the circle, but frequency does not. If several causes of vibration exist, the result is very probably the sum of differing frequencies and amplitudes.

# Typical Motion Error Traces of the Circular Test

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## Encoder error

Encoder error indicates the error in the linear movements of the axes. If no encoder error is present, the displayed path will be a perfect circle. However, if either one or both axes exhibit encoder error, the path will have an oval shape. The major axis of the ellipse will be parallel with one of the axes of movement. The ellipse does not change significantly with different feed rates or when the direction of rotation is changed from positive to negative.



## Possible causes

Linear encoders are manufactured with high precision. However, when fixed on a machine tool, an error like that shown in the figure above may occur from mounting the encoder nonparallel to the axis.

The ballscrew itself is also manufactured with high precision. However, when feed motions are repeated with high speed, the ballscrew expands due to the heat generated in the nut and the bearing. In a semi-closed loop type of NC, for example with indirect encoders, this expansion will instantly cause a positioning error. To avoid this, the ballscrew is normally manufactured with a slightly smaller pitch and is installed with pre-tension in order to absorb thermal expansion.

Other possible causes are:

- Faulty ballscrews and guideways that are not straight
- Erroneous pitch error compensation or false compensation parameters, when positioning measurements are realized with a ballscrew and rotary encoder
- In the case of linear encoders, poor scale alignment can also lead to an encoder error.
- Tilt of the machine table.

## Suggestions

- Work in calibrated mode with an absolute radius so that you know which of the axes is too small or too long.
- Check the linear/non-linear compensation values in the control.
- Repeat the measurement at a different height in the plane of measurement. If the magnitude of the error varies with the height of the measuring plane, the error source is likely to be a tilt of the machine table.

## Further information

In positioning measurements of linear axes, the quantities measured are the linearity and local error of the linear encoder. The momentary position of a point on a moving slide is however an inseparable combination of the three dominating independent degrees of freedom.

Other factors that influence contouring accuracy are the weights, the acceleration rates and correspondingly the deceleration rates of the moving masses. To promote the practical aspects, the most frequently used workpiece and/or fixture should be fastened on the table during measurements. This would produce the most realistic measuring conditions.

To obtain more information, the tests should be repeated at different locations on the worktable.

# Typical Motion Error Traces of the Circular Test

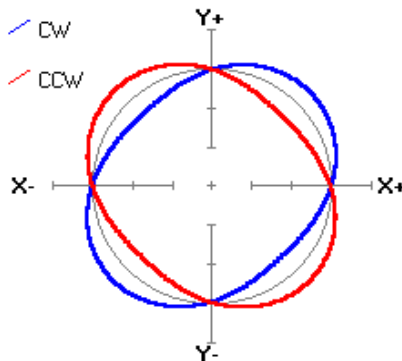
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## Mismatching of position loop gain

The magnitude of this error will tell how well the machine's position control loop will respond to commands. If the length of the DBB bar has been calibrated, an absolute difference between the nominal and actual values can be obtained. If this is not the case, the unbalance will be seen as a relative value.

### Possible causes

If the control of both axes is ideal, the test results in a perfect circle. If the control of either axis has a deviation from nominal (either overshoot or lag), an oval trace pattern appears with its major axis tilted  $\pm 45^\circ$  from the machine axes. The ellipse rotates by  $90^\circ$  depending on the direction of the test. The magnitude of the error increases with an increasing feed rate.



### Suggestions

→ Adjust the position loop gain of the axes either at the servo amplifiers or in the control using the machine parameters for the position loop gain.

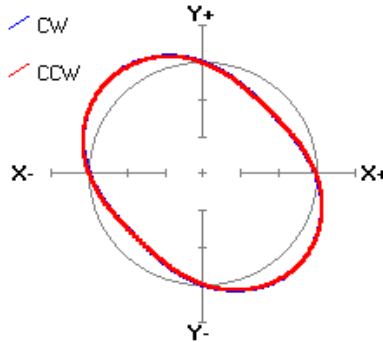
If the servo amplifiers cannot be sufficiently adjusted and high product accuracy is required, you should use low feed rates when interpolating circles and arcs.

Squareness error and servo response error have basically same kind of trace patterns. They can be distinguished only by comparing measurements from clockwise and counterclockwise traverse.



## Squareness error

Squareness error appears as an ellipse with a main axis tilted approx.  $+45^\circ$  (negative squareness error) or  $-45^\circ$  (positive squareness error) compared to the  $0^\circ$  axis. The ellipse does not change when the direction of rotation is changed from positive to negative. The magnitude of the error is unaffected by the feed rate.



### Possible causes

An ellipse with its major axis in the second and fourth quadrants ( $90^\circ$  to  $180^\circ$  and  $270^\circ$  to  $360^\circ$ ) means that the angle between the axes is larger than  $90^\circ$ . An ellipse with its major axis in the first and third quadrant ( $0^\circ$  to  $90^\circ$  and  $180^\circ$  to  $270^\circ$ ) means that the angle between the axes is less than  $90^\circ$ .

Repeating the test at several locations will tell whether the axes are bent locally or the axis is misaligned along its whole length.

The measurement and evaluation of straightness and squareness error of the slide movements are problematic, because their effects combine.

### Suggestions

- Repeat the measurements in both directions with feed rates 500, 1000, 2000 mm/min. The shape of the traces should not change by any large amount and the ellipses should be rotated in the same direction independent of the direction of rotation.
- When necessary check the machine's squareness error, for example by using a measuring probe and a granite block calibrated for squareness.

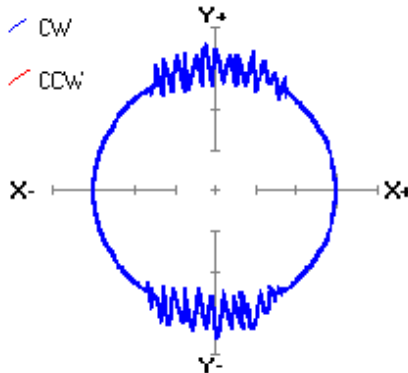
## Typical Motion Error Traces of the Circular Test

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Squareness error and servo response error have basically same kind of trace patterns. They can be distinguished only by comparing measurements from clockwise and counterclockwise traverse.

## Stick slip

Stick slip appears as oscillations on the plot near the reversal points of an axis. The sample figure below shows an example of stick slip motion as the negative and positive reversal points of the Y axis are approached.



As the reversal point is approached, the feed rate in the Y guideway decreases, finally approaches zero and again starts to slowly increase in the other direction. At these low feed rates the static friction of the guideway has a significant influence. A form of stick slip effect takes place and the axis oscillates until the feed rate is high enough to overcome the static friction.

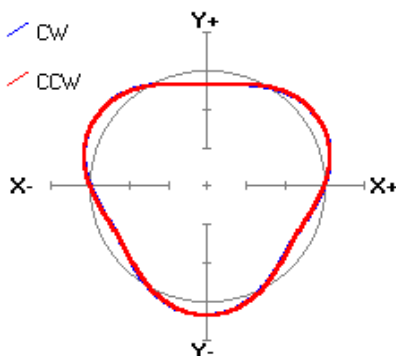
### Possible causes

The cause of the error may be insufficient lubrication, allowing metal to metal contact in guideways. At higher feed rates the axis “floats” on an oil film on the guideway and the stick-slip motion disappears.

### Suggestions

- If a stick-slip pattern occurs, repeat the measurements at low and high feed rates. The oscillations should increase at low feed rates and decrease at high feed rates.
- Inspect the guideway for wear. Check the axis adjustments and lubrication system, too.

### Straightness error



#### Possible causes

- Lubrication system. Pulses from the hydrodynamic lubrication system usually cause effects resembling random straightness error.
- Wear of the slides or guideways. For example, failures in the lubrication system can cause excessive wearing of the sliding parts and thus produce straightness errors in the movement of the axis.
- Mass of the moving bodies. If the stiffness of the construction is not sufficient to handle the mass of the moving bodies (especially the table and the column), significant straightness errors can result.

Other reasons could be collisions caused by erroneous NC programs or by other errors in the manufacturing process, improper machine tool basement or carelessness when moving the machine tool to a new location. To get a better picture of the nature and exact location of the error, measurements should be made at several positions in the tested plane.

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