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User Manual: (Draft Version)

Inductive Distance Measurement (IDM) Tool Kit

1. INTRODUCTION:

The Inductive Distance Measurement (IDM) Tool Kit is a multi purpose measurement tool. Typically it is used to check the condition of rotating parts during operation (e.g. on Rotary Kilns, Dryers, Ball Mills). It measures variation of distances of moving metal surfaces without contact (typically steel surfaces) with high accuracy and high speed (up to 1000 measurements per second). It can be considered as a contactless dial gauge.

Typical applications:

- Run out measurement of girth gears on rotary kilns, rotary dryers and ball mills
- Run out measurement of kiln tires
- Roller shaft bending measurement of support rollers on rotary kilns
- Shaft movements in gear boxes and drives
- Roundness and run out check of trunnions on ball mills

More applications:

The control box in the tool kit can be used for any kind of sensor with an output of 0...10V.

Signal Converters are available, which allow also to measure signals with 0...20mA (included in kit from July 2011)

Hence there are much more applications possible. E.g.:

- High speed hydraulic pressure measurement on vertical roller mills and roller presses
- Shell deformation measurement on rotary kilns or ball mills with laser distance sensors
- Verification of values of any installed sensor output signal directly on site
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TABLE OF CONTENT

1.	Introduction:	1
1.1	Safety:.....	3
1.2	Measuring Principle:.....	4
1.3	Tool Kit includes:	5
2.	The Sensors	5
2.1	Components:.....	5
2.2	Features:.....	7
3.	Software:	7
3.1	Installation:.....	7
4.	Start the Tool:	8
4.1	Connect IDM Controller with PC.....	8
4.2	Adding a Channel.....	8
4.3	Adding a Sensor Scaling.....	9
4.4	Sampling Rate (Frequency) Adjustment	12
5.	Distance Measurement:	13
5.1	Purpose	13
5.2	Starting the Software Application.....	13
5.3	Take Measurements	14
6.	Roller Shaft Bending:	15
6.1	Measurement Principle	15
6.2	Place the Sensor	15
6.3	Start The Software Application	16
6.4	Take Measurements	17
6.5	Interpretation of Results	19
7.	Gear Run out:	20
7.1	Measurement Principle	20
7.2	Place the Sensor	20
7.3	Start The Software Application	22
7.4	Take Measurements	23
7.5	Results.....	24
8.	Report	24
8.1	Export to Excel	24
8.2	Create a report	24

1.1 Safety:

Rotary kilns, dryers and mills, where this tool typically is used, are huge rotating equipments with many pinch points, they can cause serious injuries. Therefore only specialized and trained personnel shall work close to these machines. To use the tool, follow strictly the local safety rules given by the respective plant / factory / local authorities and discuss the application with the safety engineer in charge.

The tools provided by TomTom-Tools GmbH have proven their functionality in various applications; nevertheless TomTom-Tools GmbH does not take any responsibility for the application on site regarding safety. The plant is responsible for the safety, according to the local law, in a way that nobody can be hurt or injured. The application and safety instructions below are guidelines and not exhausted which include the experience from previous measurement campaigns and might need to be adapted to the local safety requirements.

Caution:



Pinching Points:

Do not put your hands nor any items close or into pinching points (e.g. girth gear / pinion, kiln tires / support rollers,...)

Keep safe distance to avoid getting caught by moving parts.

For gear run out measurements, **never place sensors on the side where the teeth are engaging**; place them always on the out running side, to avoid the items get caught between



Magnet Fields:

Be aware of the strong magnet field of the magnet stands.

Keep the tool away from people with pace makers or any other sensitive item as credit cards or magnetic data carrier.



Clamping:

Do not put fingers between the magnets and magnetic surface. There is the risk for clamping or pinching, due to the strong magnetic force.



Gloves:

Wear proper gloves to protect your hands from hot and rough surfaces and sharp edges.

1.2 Measuring Principle:

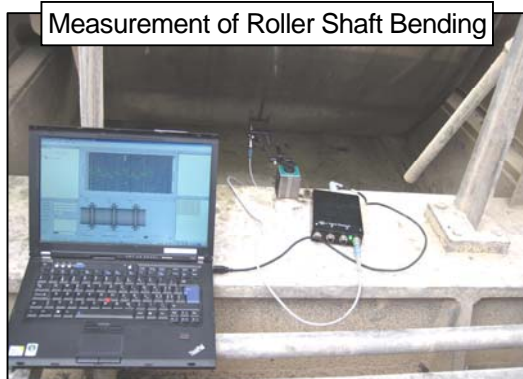
The Too Kit is equipped with different inductive distance sensors. These sensors use the physical effect of the change of a resonance circuit, which is caused by eddy current losses in conductive materials. A resonant circuit produces a high frequency alternating field. This field withdraws at the active surface of the sensor, if an electrically conductive material enters the field. The eddy currents occur according to the induction law which extract energy from the resonant circuit. This energy value is transformed internally into the 0...10V industrial standard analog output signal.

The signals of maximal four sensors are measured by the IDM Controller, which converts them into a digital signal and sends it via USB port to a PC.

The software **TomTom-Tools Measurement Studio** (for Windows), which comes together with the measurement tool is made to receive, store and process the values from the IDM Controller.

There are already 3 types of applications available in the software:

- **Raw Data Acquisition:**
In this mode the data are one to one displayed in real time on the computer screen.
- **Roller Shaft Bending Measurement**
This application is used on rotary kilns with 3 or more stations. It calculates automatically the variation of shaft deflections, which are caused by a crank in the kiln shell.
- **Run Out Measurement**
The application is calculating automatically the radial and axial run out (eccentricity and roundness) of rotating parts. (typically girth gears, kiln tires and mill trunnions)



Measurement of Girth Gear Run-Out



Measurement of Girth Gear Run-Out

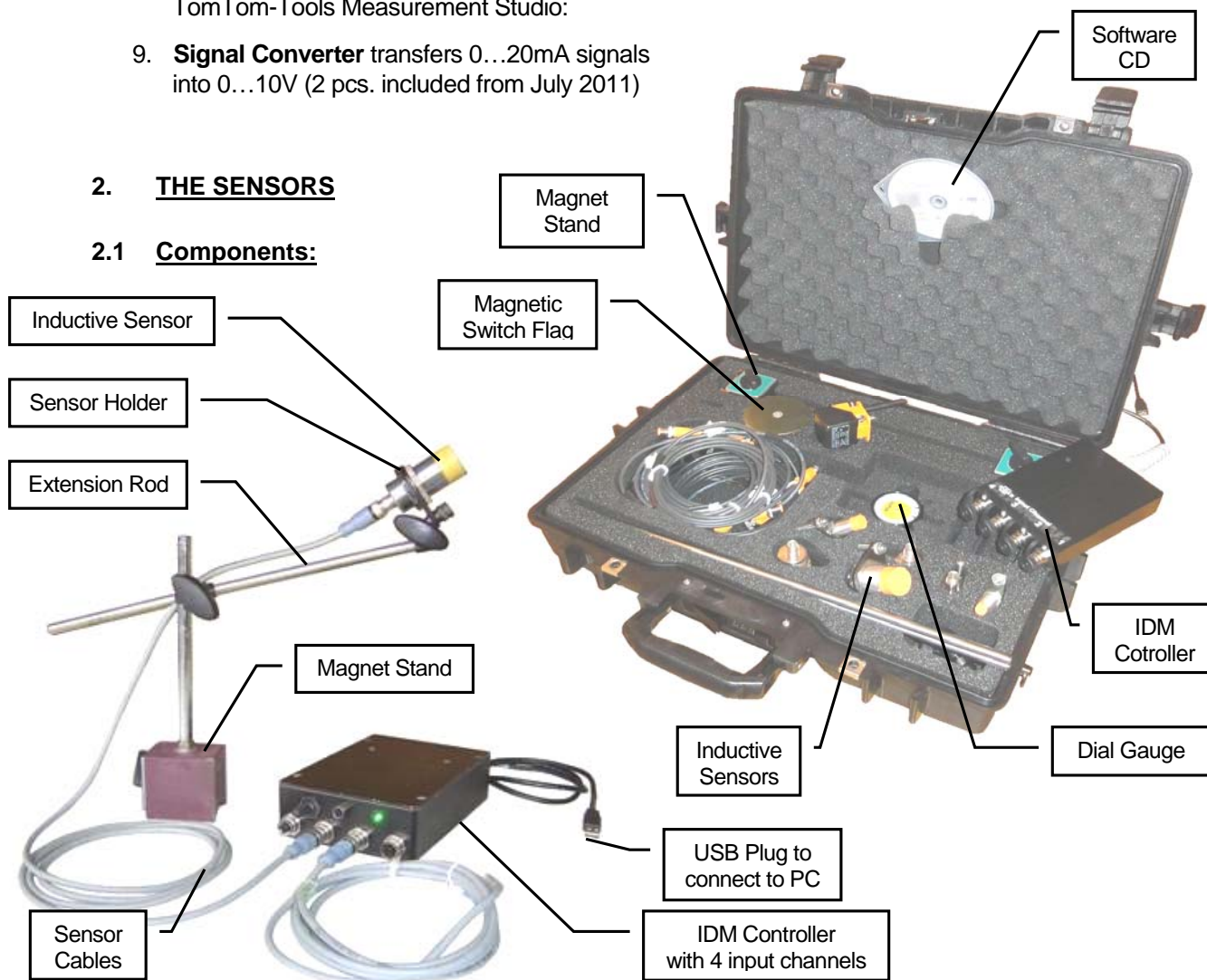
1.3 Tool Kit includes:

The IDM Tool is coming as a tool kit in a strong and tight transport case, which includes the following items:

1. **IDM Controller**
With four input channels 0...10V and an integrated 24VDC power supply for the sensors fed via USB
2. **Inductive Sensors**
2 Sensors Ø12mm, 2 Sensors Ø18mm, 2 Sensors Ø30mm, 1 Sensor 4x40mm
3. **Sensor Cables** with 2 and 5m length
4. **Magnet Stands**
Including connectors, extension rods and sensor holders
5. **Dial Gauge** for reference measurements
6. **Magnetic switch flag** with heat resistant magnet (up to 300°C) and extension rods
7. **Transport Case** with foam cushioning
extra tough, water and dust seal (suitable for air cargo)
8. **Manual** and **Software** for Windows (in lid)
TomTom-Tools Measurement Studio:
9. **Signal Converter** transfers 0...20mA signals into 0...10V (2 pcs. included from July 2011)

2. THE SENSORS

2.1 Components:



Inductive Sensors:

Any sensor with 0...10V output on Pin 2* can be connected to the IDM controller
(maximal power consumption of all connected sensors together: 100 mA @ 24VDC)

Name:	IFM Sensor D12 (0.4...4mm)	IFM Sensor D18 (0.8...8mm)	IFM Sensor D30 (1...15mm)	IFM Sensor 40x40 (1...25mm)
Diameter	Ø12mm	Ø18mm	Ø30mm	40x40mm
Operating Range	0.4...4mm	0.8...8mm	1...15mm	1...25mm
Slope (linear gradient)	0.36 mm/V	0.72 mm/V	1.4 mm/V	2.4 mm/V
Y-Intercept	0.4	0.8	1	1
Minimal Target Size	12x12mm	24x24mm	45x45mm	90x90mm
Linearity Error	±3% of UA max	±1% of UA max	±% of UA max	±3% of UA max
Repeatability	±2% of UA max	±1% of UA max	±1% of UA max	±2% of UA max
Temp. Coefficient	±10% of UA max	±5% of UA max	±5% of UA max (-25...70°C) ±10% of UA max (70...80°C)	±10% of UA max (-25...70°C)
Response Time	< 10 ms	< 10 ms	< 20 ms	< 20 ms
Operating Temperature	-25...80°C			
Output	0...10VDC (analog)			
Operating Voltage	15...30VDC			
Current Consumption	< 20 mA			
Short-circuit protection	yes			
Protection	IP 67			
Correction Factors	Mild Steel = 1 Stainless Steel = approx. 0.5 Aluminum = approx. 0.4 Copper = approx. 0.3			
Display	Within operating range: yellow (permanently lit) Outside the operating range: yellow (flashing)			
Mounting:	Non-flush mountable			
Wiring				

***Note:**

IDM Controllers before 2011 use Pin 4 for input signal; they can be re-wired internally, if required

2.2 Features:

The power for the sensors is taken from the USB port of the PC and transformed to 24VDC. The green light (LED) is indicating when these 24V are available on the four sensor plugs.

The sensors are also equipped with LEDs near their plugs, which indicate the function of the sensor. A **constant light** indicates that the sensor is working and is in normal range. A **blinking light** shows that the sensor is out of range. This means, that the surface to measure is too far away or too close to the sensor.

3. SOFTWARE:

3.1 Installation:

There are two software components required to be able to run the IDM Tool on the computer.

Step 1:

IDM-Drivers (Runtime Engine from National Instruments) File name: **NIDAQ922f0Core**

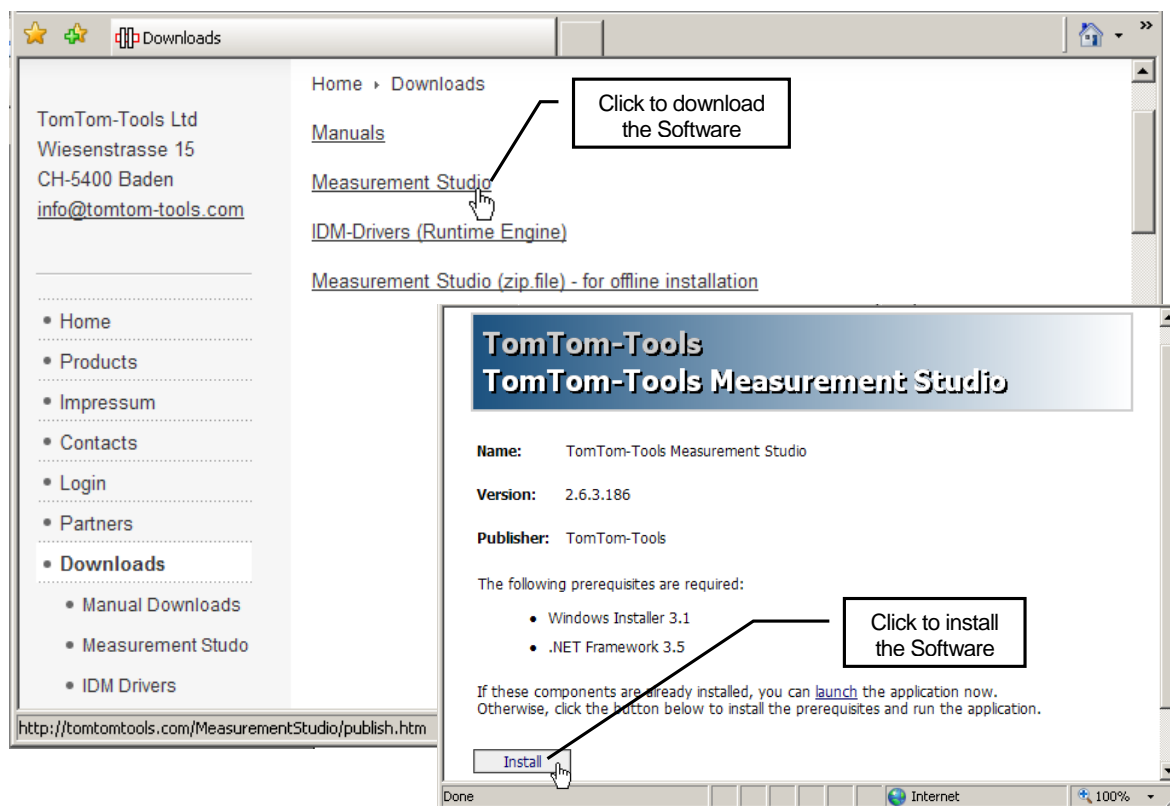
Install first this software component from the CD or download it from www.tomtom-tools.com or from the National Instruments website. (~160MB)

Step 2:

TomTom-Tools Measurement Studio

The software, which is used for the IDM Tool Kit and all the other TomTom-Tools, comes also along with the equipment on the CD. Nevertheless it is recommended to **install the software from www.tomtom-tools.com** , where always the latest version is available.

During any start of the Measurement Studio, it is checking for updates if the computer is connected to the internet. In case of available upgrades the user gets asked if they should be downloaded and installed.



4. START THE TOOL:

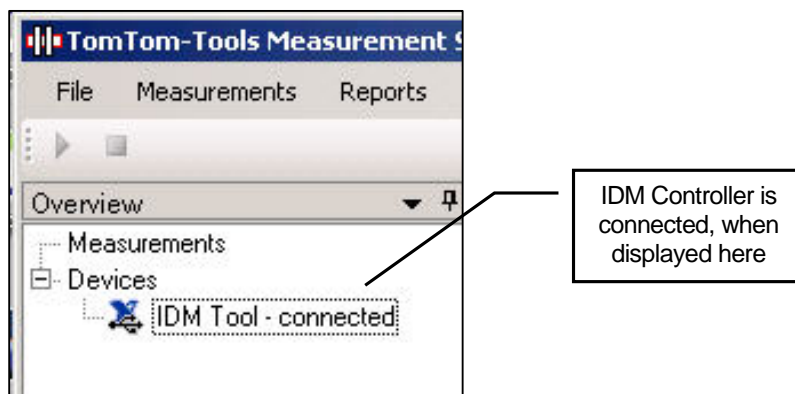
4.1 Connect IDM Controller with PC

After the software installation is completed, connect the controller to the USB port of your laptop PC.

Note: Do not use USB hubs or USB extension wires.

Whenever the Measurement Studio is started it will search for known devices; for TomTom-Tools. If a TomTom-Tool is detected, it will be displayed in the "Overview" Window under devices.

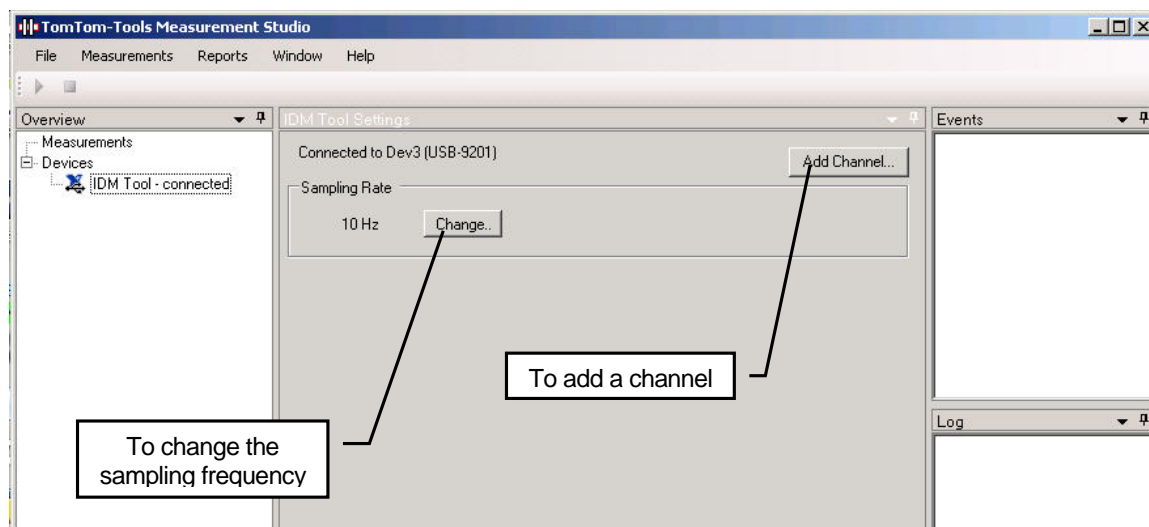
Fig. 4.1.1 (Device Window)



4.2 Adding a Channel

When the software is opened, the input channels have to be added in the software, in order to get the physical signal from the IDM controller input to the software.

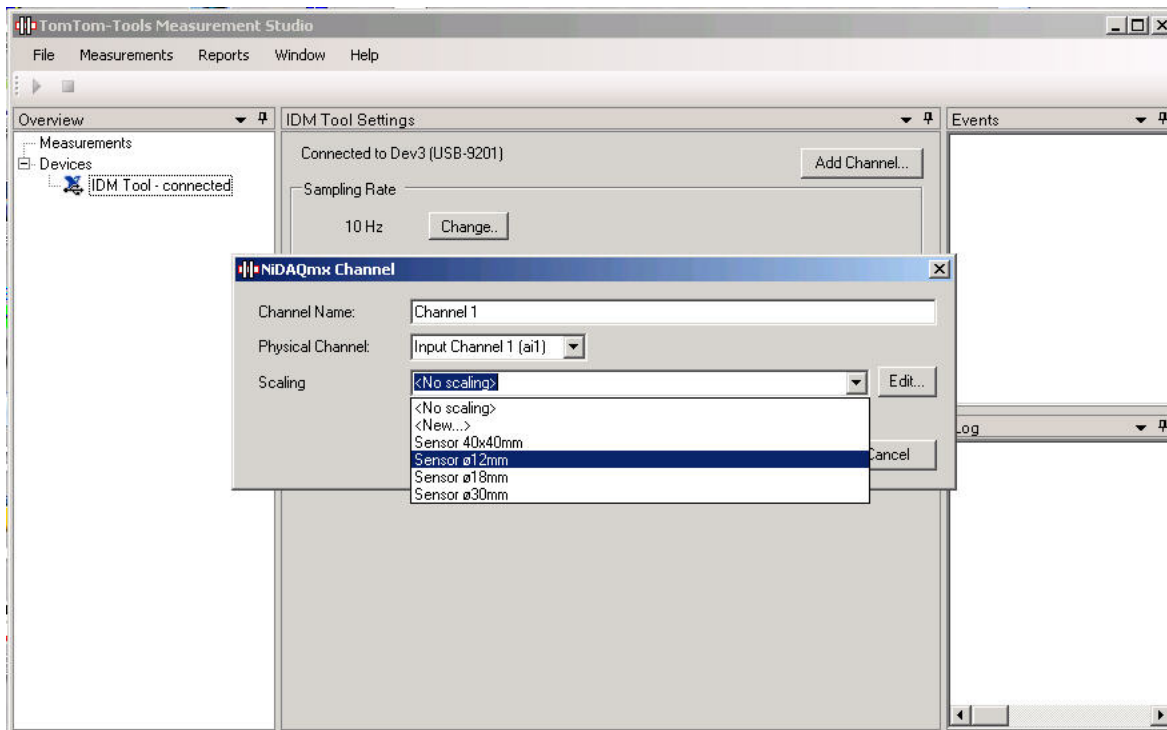
This can be done on the tool page (see picture below) or also later when a specific measurement application is opened.



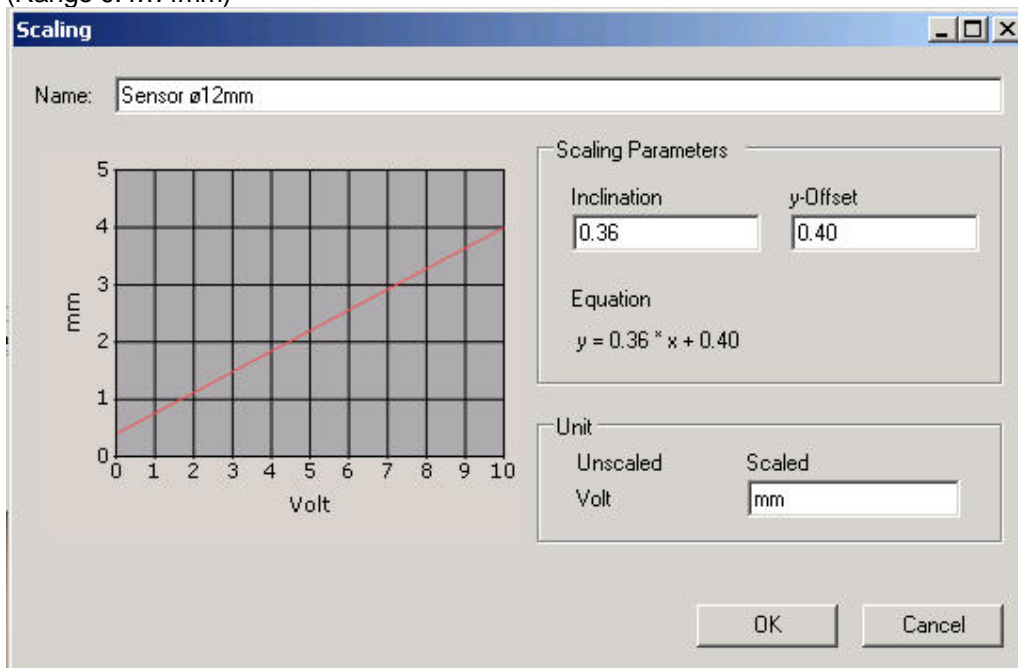
4.3 Adding a Sensor Scaling

The four inputs of the IDM Controller measure 0...10V which correspond to the measurement range of the sensors. Hence each type of sensor needs its scaling, which describes the relation between sensor distance and voltage output.

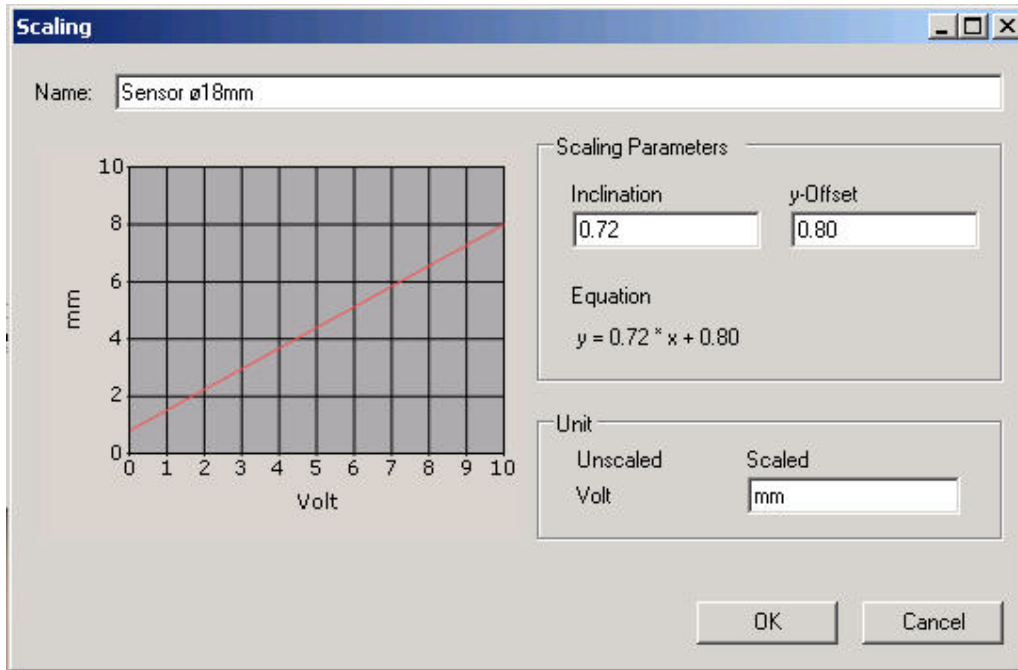
The scalings of the sensors, which are included in the IDM Tool Kit, are already defined in the software and can be selected as shown in the picture below.



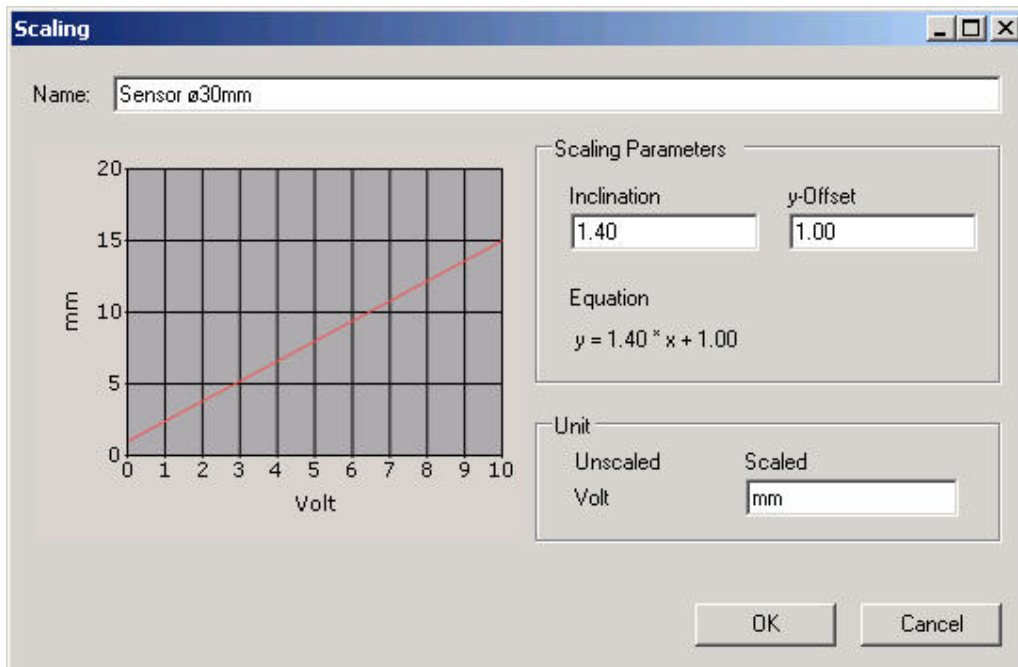
Scaling Sensor Ø12mm: (Range 0.4...4mm)



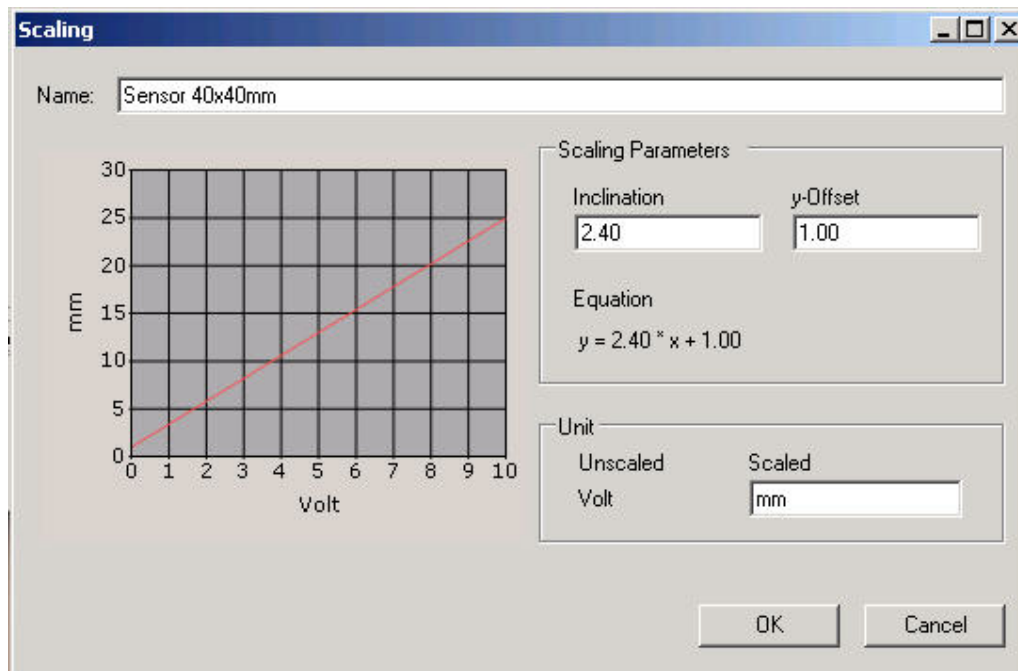
Scaling Sensor Ø18mm:
(Range 0.8...8mm)



Scaling Sensor Ø30mm:
(Range 1...15mm)



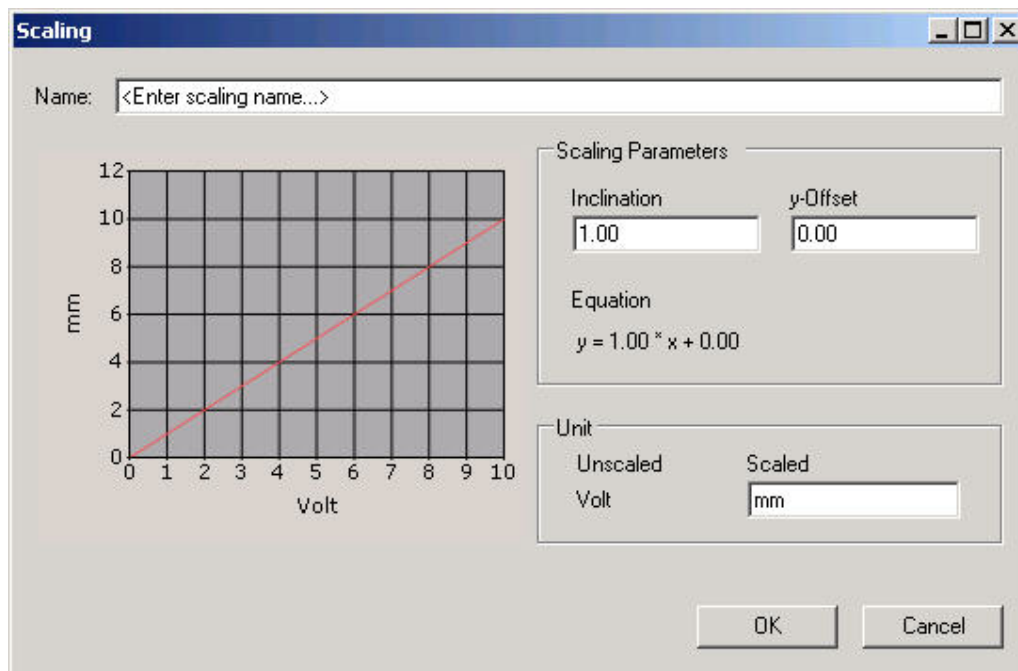
Scaling Sensor 40x40mm:
(Range 1...25mm)



Create a new Scaling:

If an other sensor (with output 0...10V) has to be connected, a new scaling can be created by selecting **<New...>**

If a pressure sensor, flow meter or temperature probe is connected, just replace the unit [mm] to [bar] or [°C] or any kind of unit.



4.4 Sampling Rate (Frequency) Adjustment

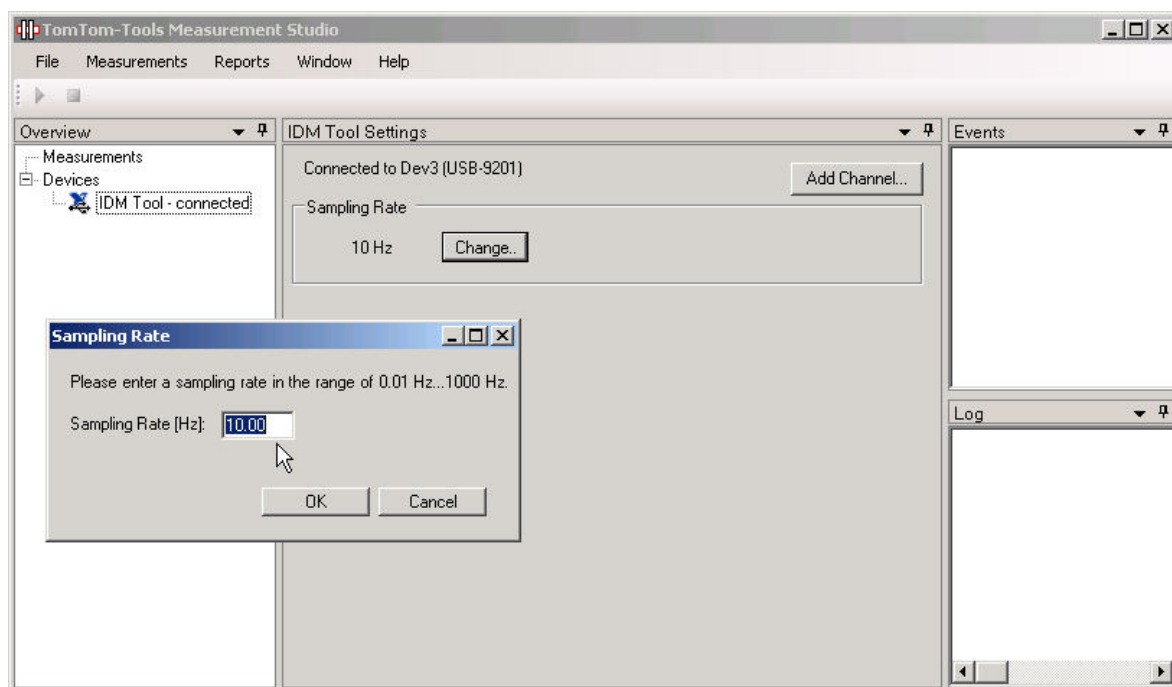
The sampling rate is the numbers of measurements, which are taken within one second; hence the unit is Hz (Hertz). It is important to adjust the sampling rate to the measurement application.

In case of fast changing signals (e.g. run-out measurement of a kiln girth gear under full speed), the frequency has to be high to catch each tooth tip (e.g. 100Hz)

In case of slow changing signals (e.g. kiln support roller shaft bending), the frequency can be low (e.g. 10Hz) because the interesting value, varies only once over one complete kiln revolution.

Of coarse, slow applications could also be measured with a high sampling rate, but then, unnecessary big data files would be created.

Some guidelines about the adequate sampling rates are also given later in the chapters of the different measurement applications.



Attention:

In case, the sampling rate is too low while measuring tooth wheels on the tooth tip, the results will not be useful. **Adjust the sampling rate to min. 5 times the gear mesh frequency.**

5. DISTANCE MEASUREMENT:

5.1 Purpose

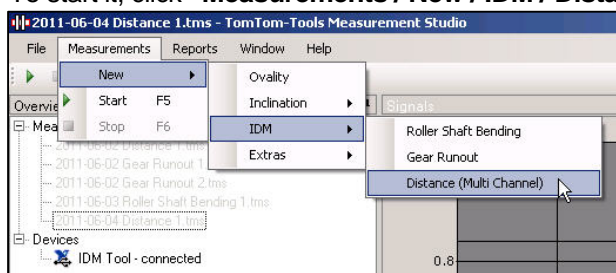
The **Distance (Multi Channel)** application is general and multipurpose to measure distances with the inductive sensors, which are included in the tool kit. Any kind of other sensor with an output of 0...10V (or 0...20mA with additional Signal Converter) can be used and displayed as mentioned in Chapter 4.

This application is typically used, when measurements have to be taken, where no specific application is available in the Measurement Studio.

The values are directly displayed in the screen, where different zoom functions can be used. For further analysis, the data can also be exported to Excel.

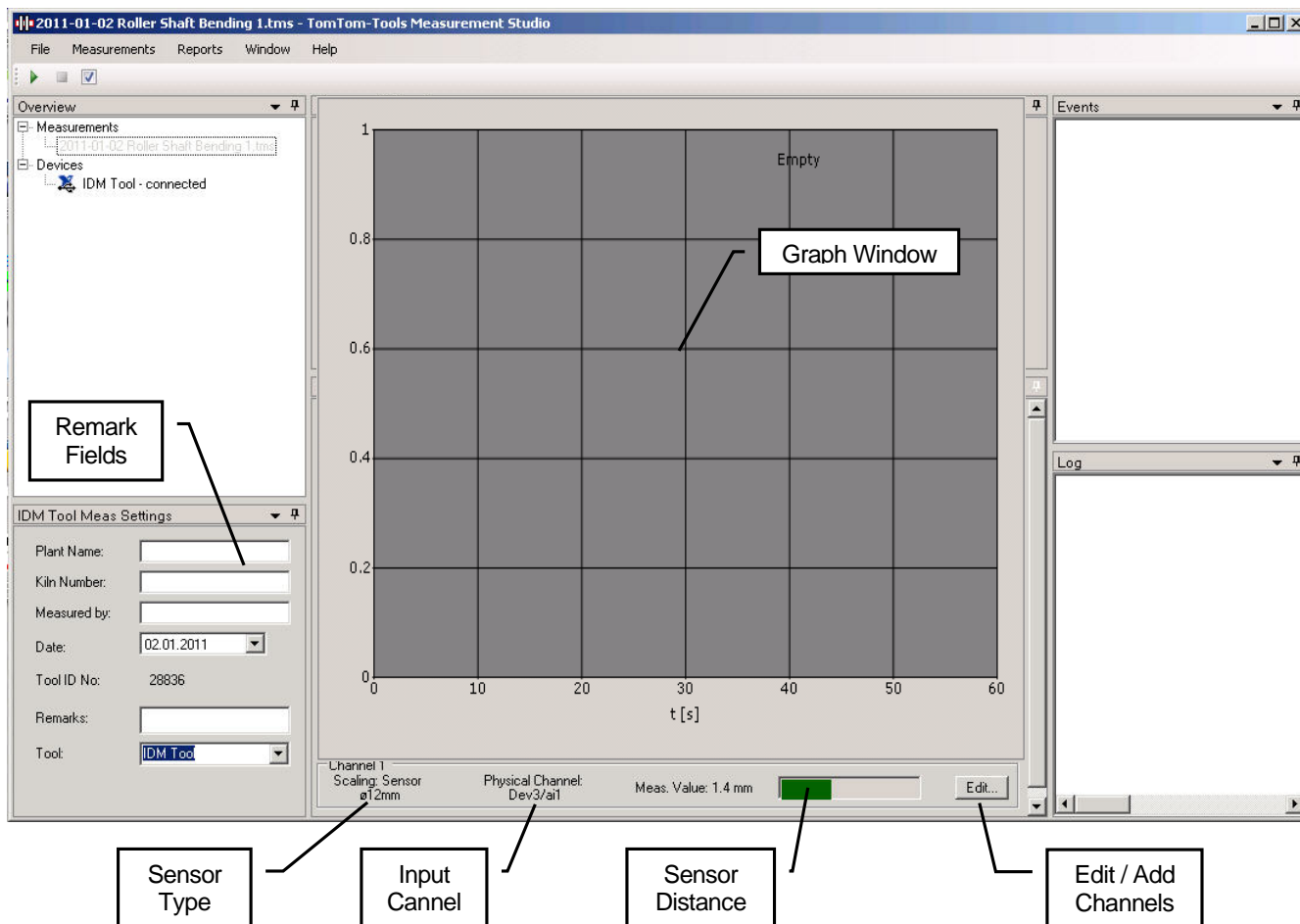
5.2 Starting the Software Application

To start it, click “**Measurements / New / IDM / Distance (Multi Channel)**”



The computer screen will show the graph window with the empty sensor window below.

Software for Distance Measurement:

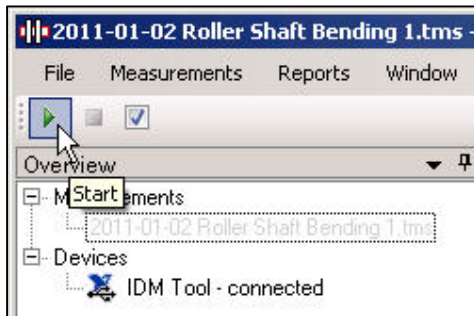


To add a sensor channel, click the button “**Add Channel**” (see picture above).
Select an existing scaling or create a new one (as described in chapter 4.3)

See the green bar, which indicates the **Sensor Distance** (gap between roller surface and sensor).

5.3 Take Measurements

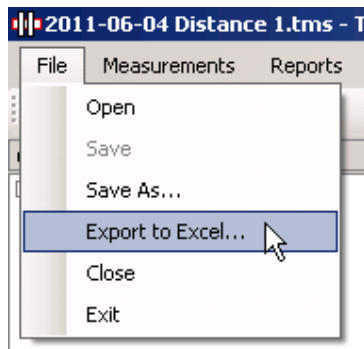
To **start** the measurements push the **Start** button or **[F5]**.



After starting the measurement, the values will appear on the computer screen. Each channel has its own curve with its own color. The lines can be hidden or displayed by clicking to the tick mark.

To **stop** the measurements push the **Stop** button or **[F6]**.

To **extract** the data in to Excel click: “**File / Export to Excel...**”



6. ROLLER SHAFT BENDING:

6.1 Measurement Principle

On a kiln support roller, the variation of the deflection of the roller shafts show possible cranks in the kiln shell. Cranks are straightness errors in the kiln shell, which are affecting the loads on the roller stations with each kiln revolution.

There are two types of cranks:

- **Permanent / Mechanical Crank:**
Caused by plastic deformations in the kiln shell or errors during the kiln construction.
- **Thermal Crank:**
Caused by uneven temperature distribution / thermal expansion around the kiln shell circumference. (most severe close to the middle tire)

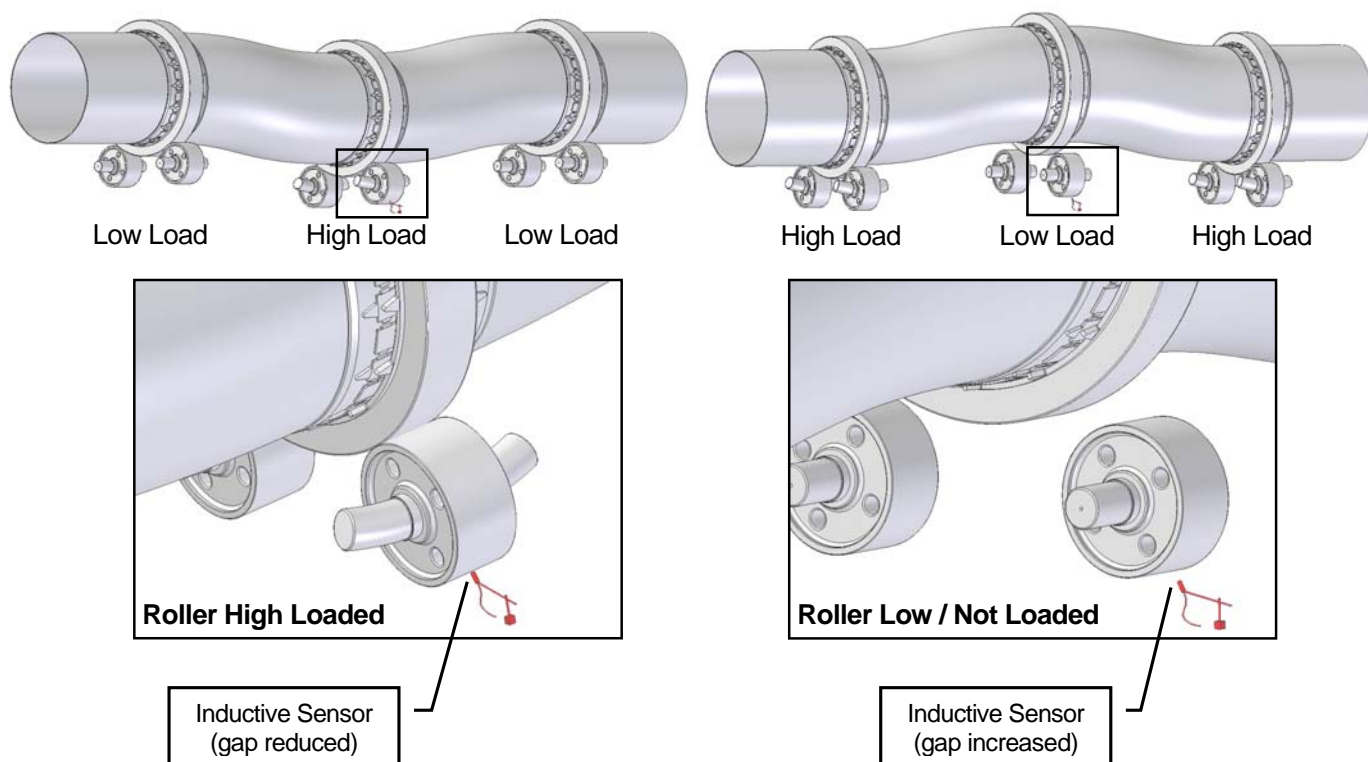
The load changes caused by cranks can be very strong and overload the tires and rollers, which results in cracks in tires, rollers and roller shafts.

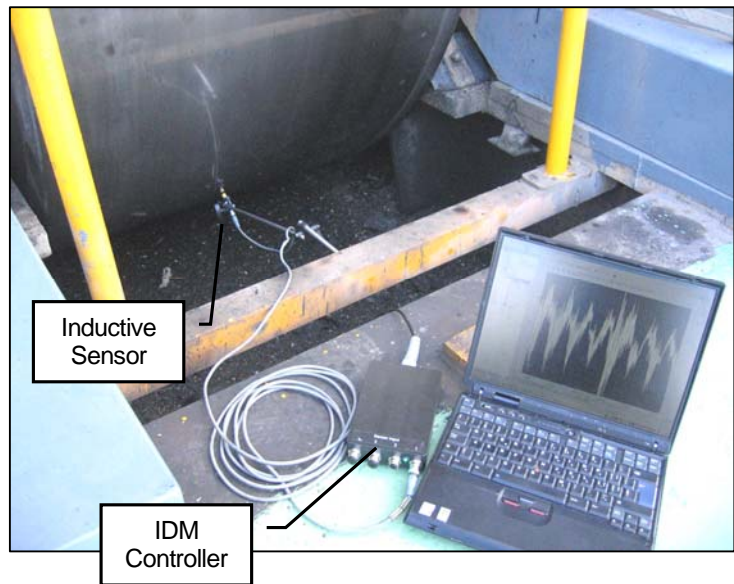
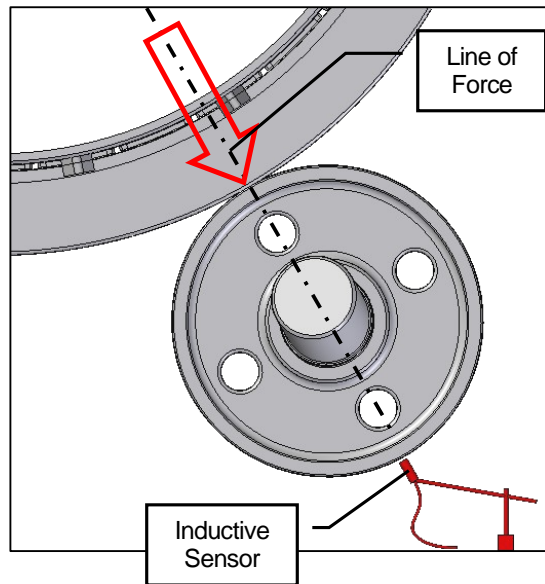
The crank pushes the roller down; hence the distance between the sensor and the roller surface is reduced. Half a kiln revolution later, the crank turns up and the load gets reduced on this station; hence the distance to the sensor is getting bigger.

6.2 Place the Sensor

To measure the effect of a crank, an inductive sensor, typically Ø12mm is placed under the support roller in the line of force. That means on the opposite side of the contact to the kiln tire. (See pictures below)

Due to the high stiffness of the roller shafts, these movements are very small (within tenths of millimeter), therefore it is recommended to use the smallest sensor of the IDM Tool Kit (Ø12mm) to have the highest accuracy

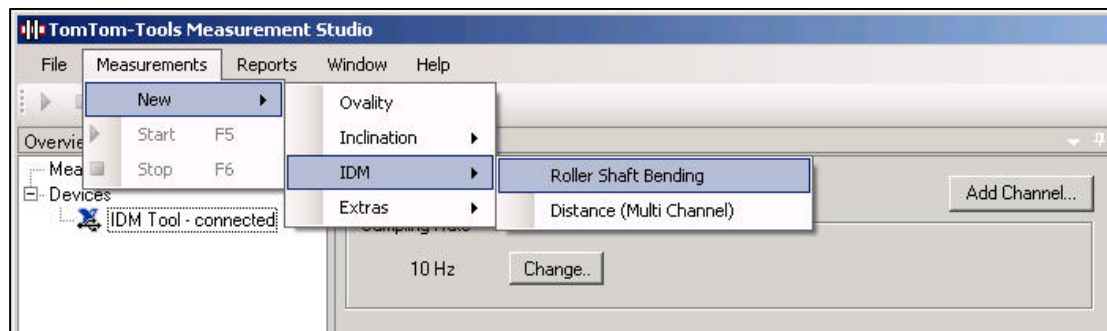




6.3 Start The Software Application

The Measurement Studio includes a specific application to measure and calculate the variation of the roller shaft bending.

To start it, click **“Measurements / New / IDM / Roller Shaft Bending”**

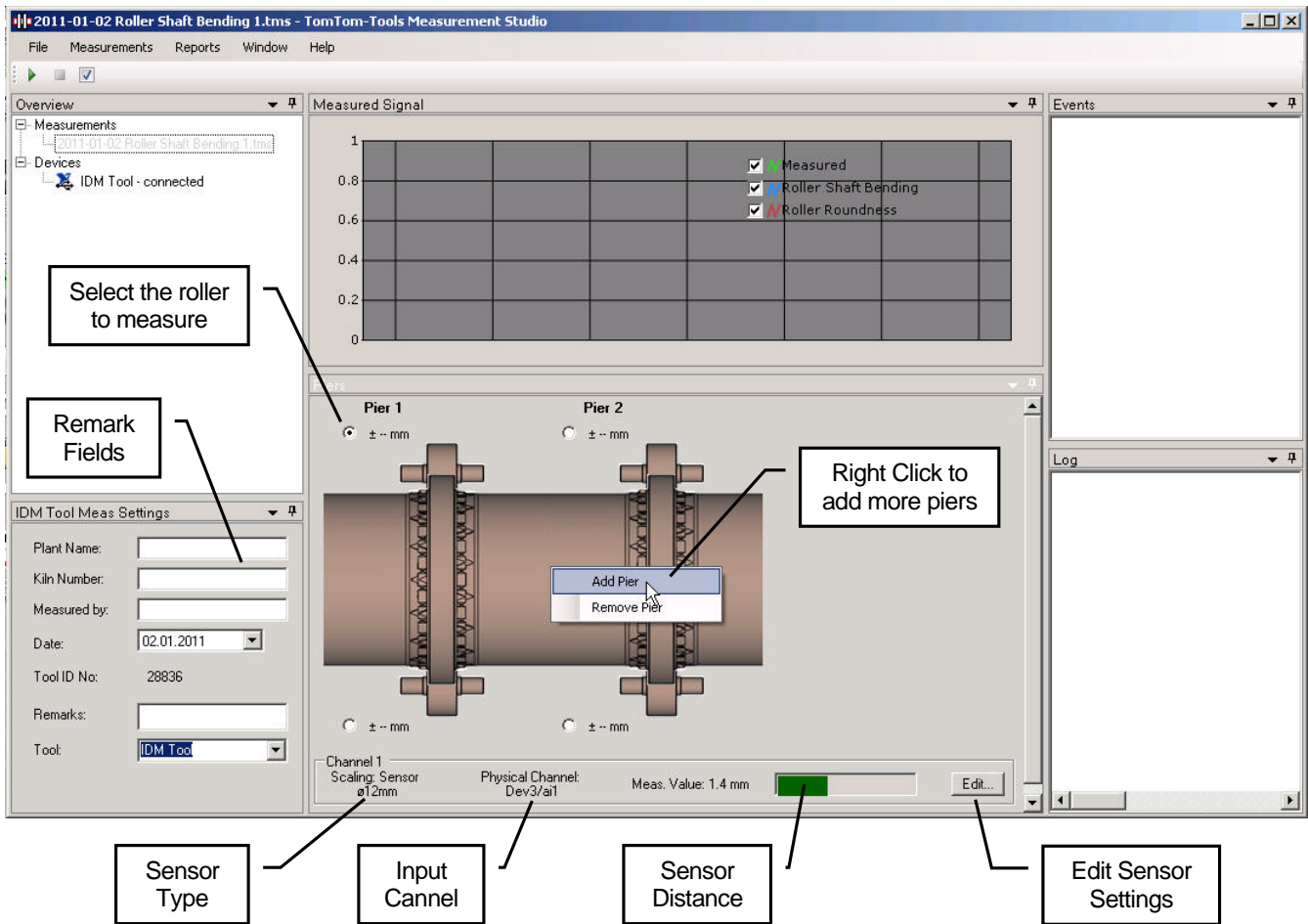


The computer screen will show a kiln tire with two rollers (top view).

To add more tires, click right mouse button and select **“Add Pier”** (see picture below)

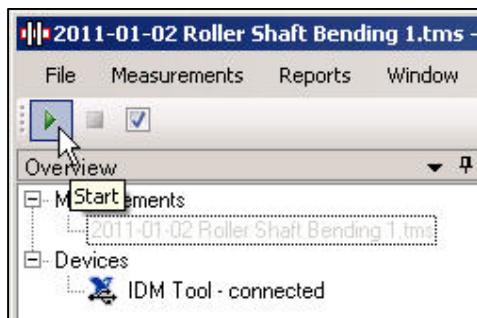
See the green bar, which indicates the **Sensor Distance** (gap between roller surface and sensor). It should be approximately in the middle of the sensor range, at least never go to one of the extreme positions.

Software for Roller Shaft Bending Measurement:



6.4 Take Measurements

To start the measurement, select the roller on the computer screen and push the **Start** button or **[F5]**.



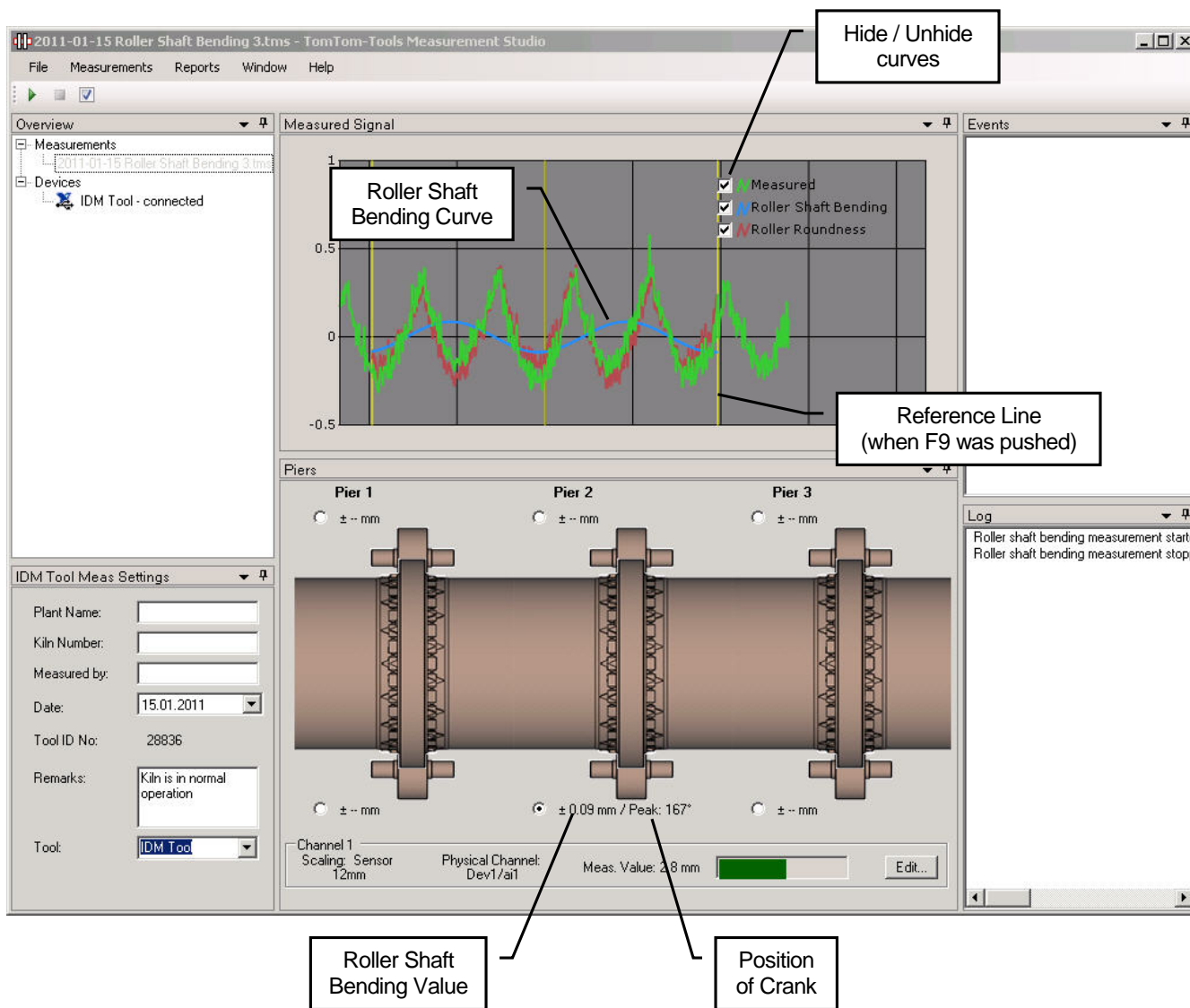
After starting the measurement, the values will appear on the computer screen (green curve)




Note:

To be able to calculate the roller shaft bending value and its position around the kiln, the software needs a reference signal, when the reference point is passing the roller, which is measured.

Typically the manhole in the kiln shell is used as reference point.

Each time when this reference point is passing the direction of the measured roller, push the **button [F9]** to indicate the kiln rotation. A yellow line in the graph will show the position of the reference point.



-  The **green** curve shows the **measured values**
-  The **blue** curve is sinusoidal and shows the variation of **roller shaft bending** coming from a crank in the kiln shell
-  The **red** curve indicates the **roundness of the support roller** and is the difference between the measured curve (green) and the shaft bending curve (blue).

After about 3 kiln revolutions, sufficient data are collected and the measurement can be stopped. **To stop** the measurements push the **Stop** button or **[F6]**.

6.5 Interpretation of Results

To detect a crank on a 3 Station Kiln measuring the roller shaft bending on the middle station is normally sufficient. And both rollers of a station should deflect in the same way. Nevertheless it is recommended to measure both rollers on the middle station, to double check the result.

Note:

TomTom-Tools Ltd. does not provide guide lines about roller shaft limits.

It has to be according to the equipment manual or discussed with the suppliers, how much roller shaft bending can be allowed.

Nevertheless based on the experience of different kiln supplier the following guide values were established.

It has also been seen, that the values are valid for small and for big kilns, because the ratio between the load on the rollers and the dimensions is for all kilns similar.

Roller Shaft Bending Value:

> $\pm 0.2\text{mm}$	HH	Alarm
> $\pm 0.15\text{mm} \dots \pm 0.2\text{mm}$	H	Warning
0... $\pm 0.15\text{mm}$		Normal

The **position of the crank peak** is indicated by the angle in ° (deg) relatively to the reference point on the kiln shell (e.g. manhole).

For example, the value 167° means that the peak of the crank is located 167° after the manhole (consider the sense of kiln rotation).

Note:

The angle value of the crank peak is not important to judge the severity of a crank, but it helps to find out, if it is a permanent or a thermal crank.

Thermal cranks occur randomly; hence the peak angle will change.

Permanent / mechanical cranks stay on the same position, hence the peak angle will stay more or less same (within $\pm 30^\circ$), at least in the same quadrant of the kiln. In case of indication for a permanent crank, it is recommended to perform the roller shaft bending measurement also in cold kiln condition (~2 revolutions with auxiliary drive) to be sure; no thermal effect is taking place.

7. GEAR RUN OUT:

7.1 Measurement Principle

Most rotary kilns and many ball mills are driven by open gear drives (pinion and girth gear). Due to difficulties during the installation or later during the operation, the girth gears might do not run concentrically nor straight.

The so-called axial and radial run-out can be measured, both in the same time, with the IDM Tool Kit during normal operation.

- **Radial Run-Out:**
Results in a change of centre distance and affects the tooth engagement it is measured on the tip of the teeth.
- **Axial Run-Out:**
Affects the load distribution over the tooth width and is measured on a machined side face of the girth gear or on the side face of the teeth.

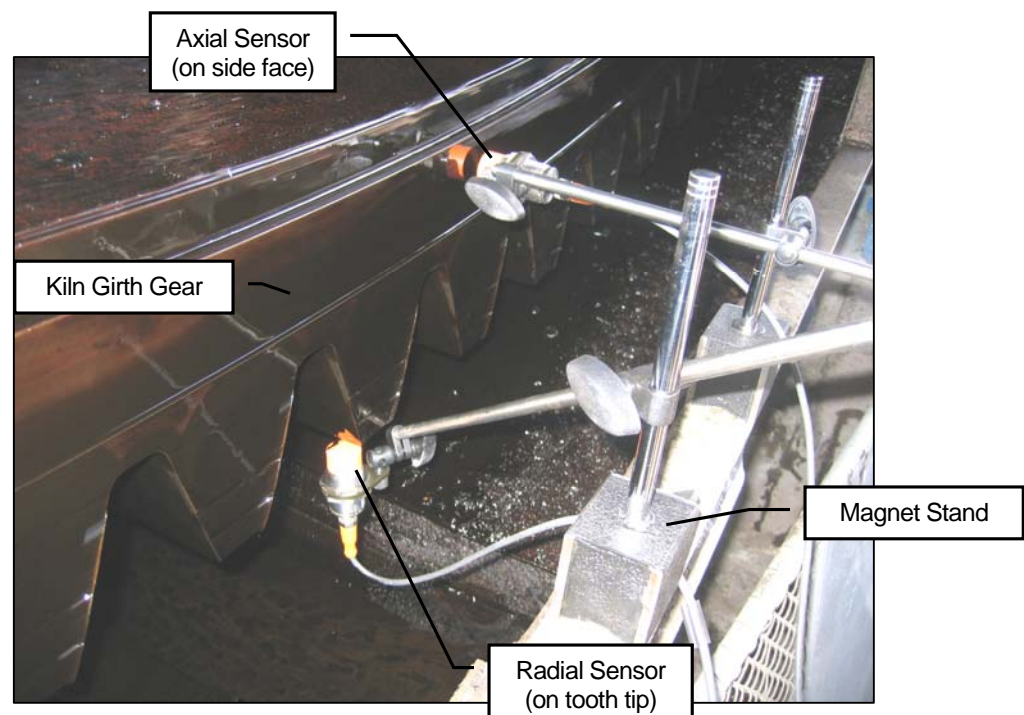
7.2 Place the Sensor

To measure the axial and radial run-out, two inductive sensors, typically $\varnothing 18\text{mm}$ are placed somewhere on an inspection window in the girth gear cover where is access to the tooth tip and to a machined side face of the girth gear.

(See pictures below)

Safety (first see page 3):

Never place sensors where the teeth are engaging; place them always on the out running side or far away from the pinion, to avoid items get caught between.

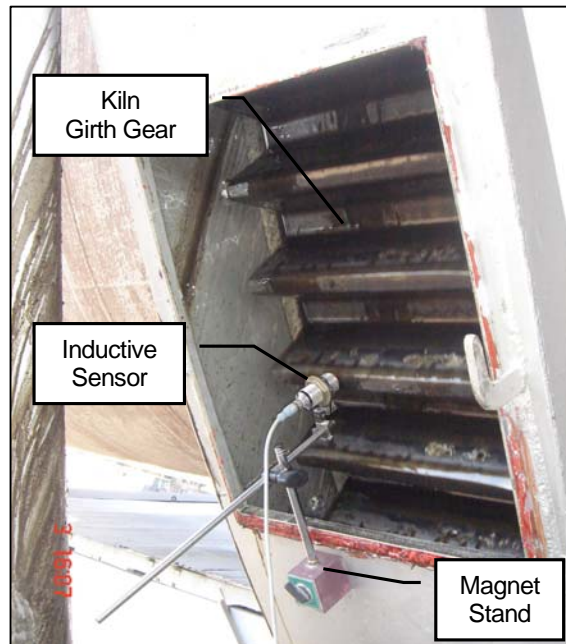
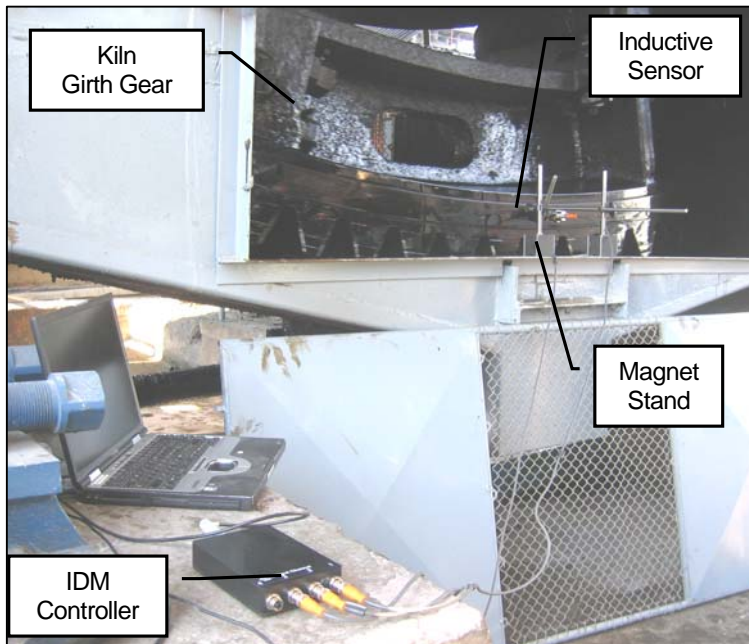
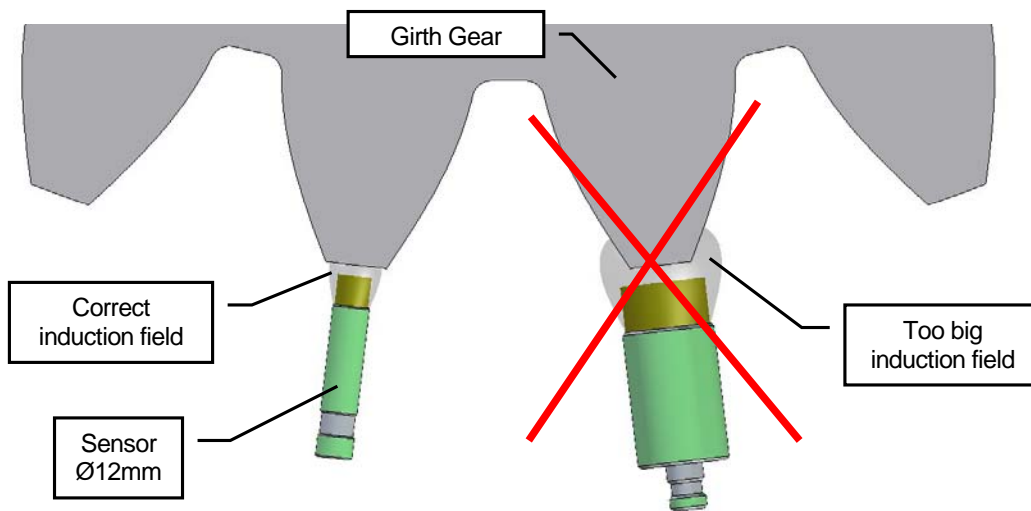


Sensor Size:

In this application it is also recommended to use the smallest possible sensor to have the highest accuracy. Unfortunately often is the sensor range not sufficient, hence a bigger sensor with more range has been used, especially on kilns.

Note:

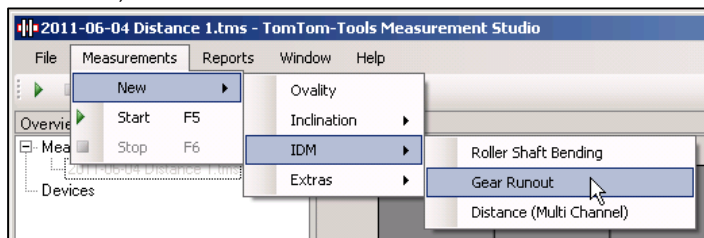
The surface which gets measured has to be bigger than the sensor diameter, in order to get the correct distance value (see picture below). On small surface use small sensor, otherwise the error has to be evaluated case by case and corrected in the sensor scaling.



7.3 Start The Software Application

The Measurement Studio includes a specific application to measure and calculate the run-out of gears. It can also be used for measuring the axial run-out of kiln tires.

To start it, click “**Measurements / New / IDM / Gear Runout**”

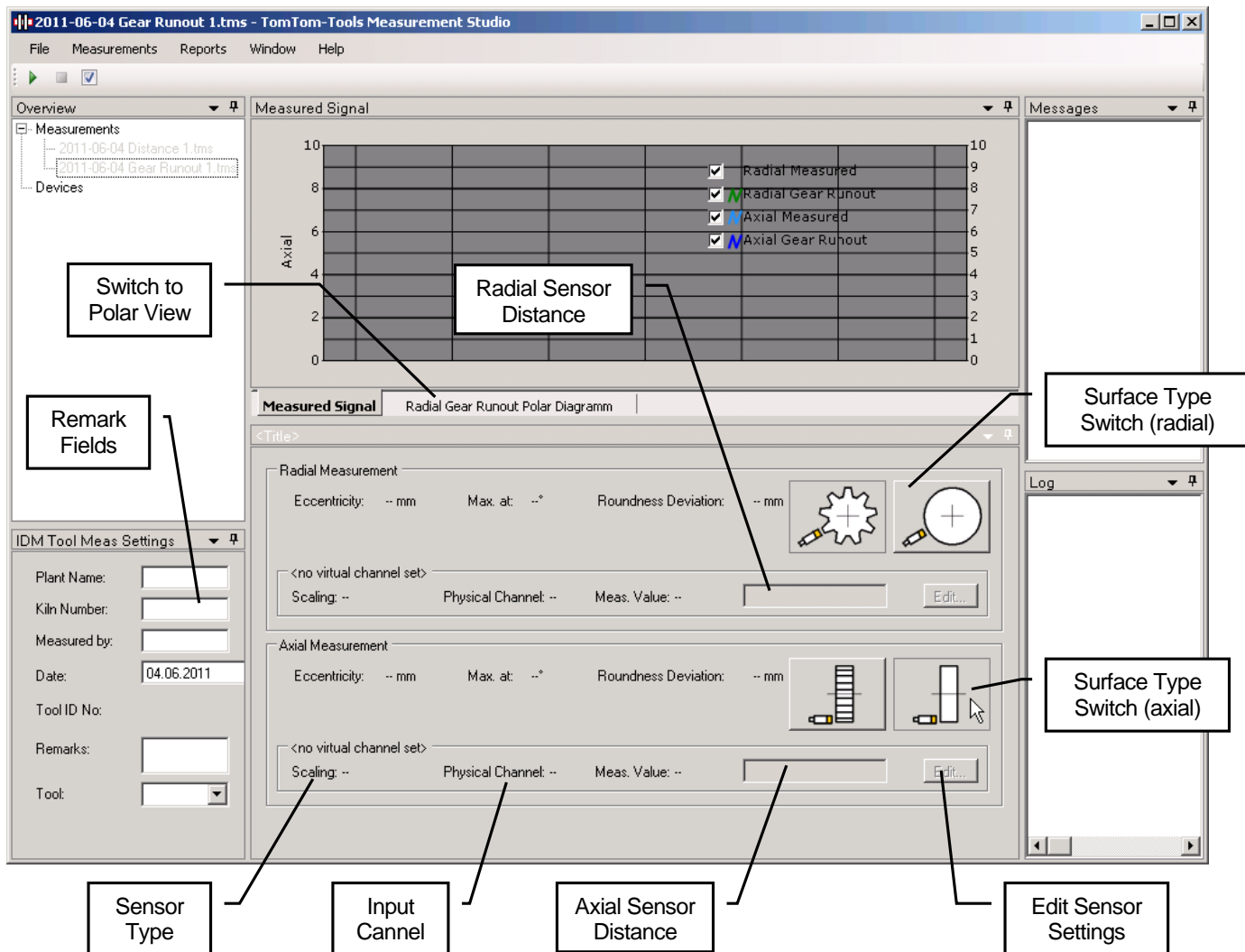


The computer screen will show the graph window with the value window below. Both types of measurements (radial and axial) are equipped with two buttons to **select the surface type**. In case of measuring the run-out on tooth tips, click on the left button; this activates the measurement filter, which will hide automatically the not useful measurement points between the teeth. For evaluation this filter function can also after measuring be activated and deactivated.

See the green bar, which indicates the **Sensor Distance** (gap between measured surface and sensor). It should be approximately in the middle of the sensor range, at least never go to one of the extreme positions unless between teeth, where the distance is out of range.

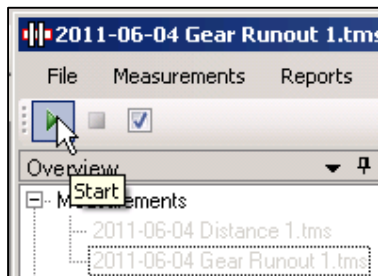
Attention:

For measuring tooth wheels on the tooth tip, **adjust the sampling rate to min. 5 times the gear mesh frequency**. (See also chapter 4.4)



7.4 Take Measurements

To start the measurements push the **Start** button or [F5].



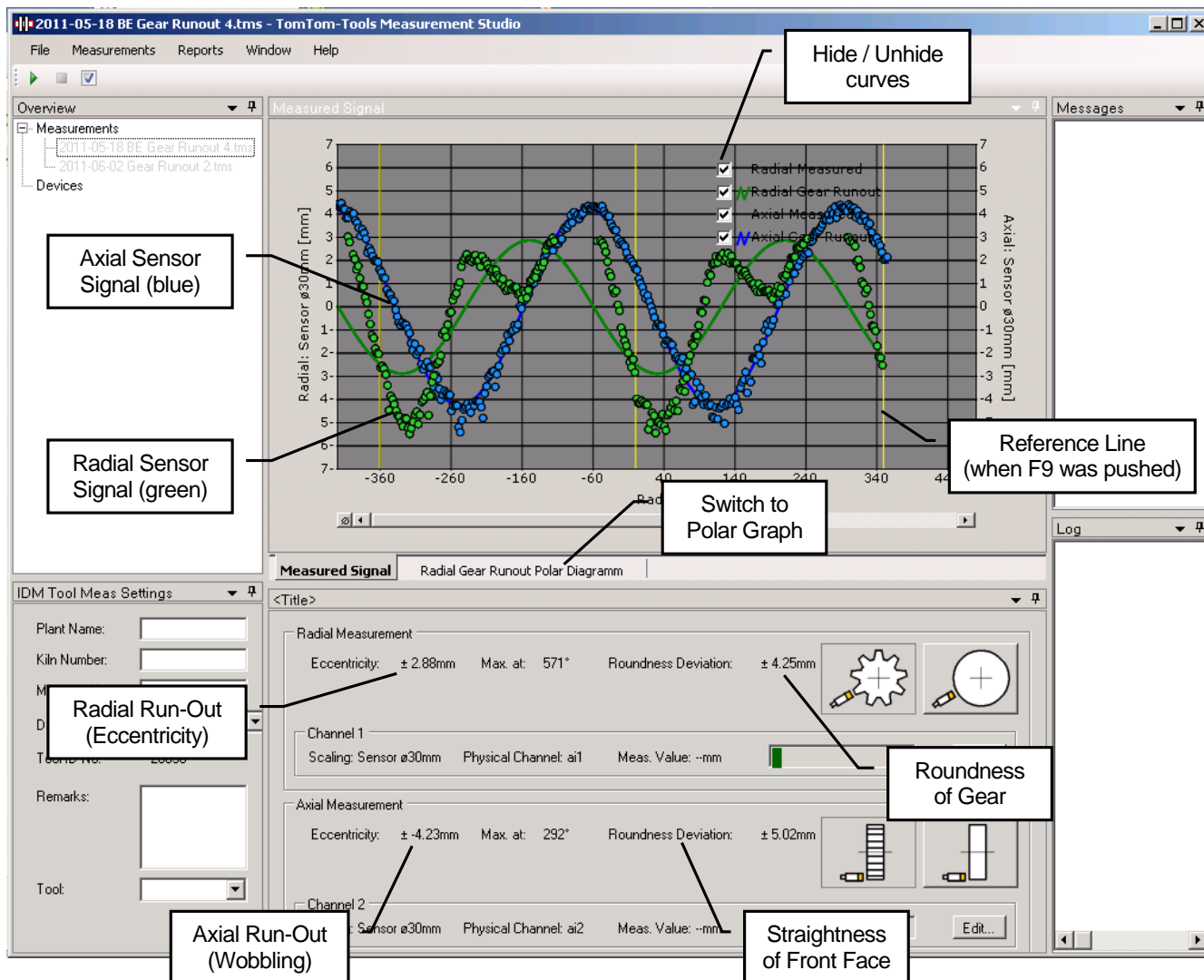
After starting the measurement, the values will appear on the computer screen (green curve)





Note:

To be able to calculate the run-out value and its position, the software needs a reference signal, when the reference point is passing the sensors position.

Typically the manhole in the kiln or mill shell is used as reference point.

Each time when this reference point is passing the position of the sensors, push the **button [F9]** to indicate the rotation. A yellow line in the graph will show the position of the reference point.



-  The **green** graph shows the **measured values** from the **radial** sensor
-  The **green** curve is the calculated sinus from the radial readings
-  The **blue** graph shows the **measured values** from the **axial** sensor
-  The **blue** curve is the calculated sinus from the axial readings

After about 3 kiln revolutions, sufficient data are collected and the measurement can be stopped. **To stop** the measurements push the **Stop** button or **[F6]**.

7.5 Results

The Results are shown as graphs in the graph window and as numbers below.

The radial run-out can also be seen as polar graph (click “**Radial Gear Run-Out Polar Diagram**”)

Note:

TomTom-Tools Ltd. does not provide guide lines about acceptable run-out limits.

It has to be according to the equipment manual or discussed with the suppliers, how much run-out and roundness error can be allowed.

Out of experience the following table can be taken as an example for **kiln girth gears** but **might need to be adjusted to the specific case**:

Run-Out [mm]	As Installed	Need Re-Alignment
Radial	$\pm 0.035 M$	$\pm 0.0875 M$
Axial	$\pm 0.00015 D - 0.25$	$\pm 0.000375 D - 0.25$

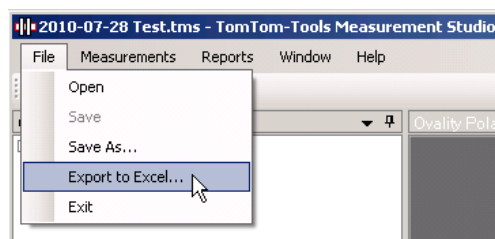
M: Module [mm]
D: Gear Diameter [mm]

8. REPORT

8.1 Export to Excel

All data can easily be exported to excel.

Fig.8.1.1



8.2 Create a report

The measurements can be extracted into a report. All additional information from “Setting Window” is included in the report as well.

Fig. 8.2.1

