KISTLER
measure. analyze. innovate.

Wireless 4-Component Dynamometer (RCD)

Type 9170B...

Rotating – for measuring cutting forces on a rotating tool

Rotating 4-component dynamometer for measuring the forces and torque on a rotating tool during cutting processes.

- Cutting force measurement on the rotating tool
- 4-component measurement: F_x, F_y, F_z and M_z
- Up to max. 16 000 min^{-1}
- Wireless data transmission
- Internal cutting fluid supply possible
- Available for conventional machine spindle interfaces
- Tool holder with ER clamps
- High run-out and balance quality
- Complete measuring system

Description

The complete measuring system comprises a sensory tool holder (Rotating Cutting Force Dynamometer), that can be mounted directly at the machine spindle and a wireless receiver, that receives the data through wireless from the tool holder. The spindle type on the machine tool determines which rotor version is required. The piezoelectric 4-component sensor, four charge amplifiers and the digital transmission electronics are integrated into the tool holder. It measures the radial forces F_x and F_y, the axial force F_z and the torque M_z.

For highest measurement quality, each channel has four measuring ranges to adapt the measurement setup for finishing operations or rough machining. Parameter setting and data transfer to a PC can be done via the Ethernet port of the wireless receiver. Furthermore, the system has a remote input for starting and stopping the measurements. To connect the system to analog inputs of machine controllers, the wireless receiver has analog 10 V outputs. This allows a wide range of setups from laboratory to fully automated machine integration.

The software for this is the PTS (Piezo Tool System) App. This software enables systematic data recording and analysis. Adjustable analysis templates allow large quantities of measurement data to be easily and quickly viewed and evaluated in batch analyses.

Applications

A rotating dynamometer is used to measure the three orthogonal forces F_x, F_y and F_z, as well as the torque M_z during cutting production processes (milling and drilling, in particular). A rotating dynamometer enables the:

- Recording of the mechanical load during the cutting process
- Wear analysis
- Optimization of cutting parameters
- Calculation of material-specific constants (e.g. the specific cutting force)
- Optimization of tool geometry and coating
- Verification of cutting simulations
- Process analysis of machining process

The forces and the torque are measured close to the cutting edge of the tool. This allows the active force vector on single-point tools to be measured directly. Due to the newly developed piezoelectric sensor located in the rotor, it is possible to record highly dynamic signals.

9170B_003-608e-05.25

KISTLER
measure. analyze. innovate.

Advantages of a rotating Dynamometer

Employing a rotating dynamometer as a measuring tool offers a number of advantages to the user. For example:

- The torque to be applied during the machining process is measured directly. This permits an accurate assessment of the condition of the tool, such as its state of wear
- The rotor of a rotating dynamometer rotates with the tool and allows the direct quantification of the mechanical load of the tool
- Thanks to the independence of workpiece mass, size and shape, the cutting force and torque can be measured on complex and cost-intensive components, e.g. structural parts of aircraft or Blisks (Blade Integrated Disc)

Technical data

Rotor Type 9170B...

Speed, max.		min^{-1}	≤16 000
Measuring range 1, nominal	F_x, F_y	N	–500 ... 500 [1]
	F_z	N	–2 500 ... 2 500 [1]
	M_z	N·m	–10 ... 10 [1]
Measuring range 2, nominal	F_x, F_y	N	–1 000 ... 1 000 [1]
	F_z	N	–5 000 ... 5 000 [1]
	M_z	N·m	–20 ... 20 [1]
Measuring range 3, nominal	F_x, F_y	N	–2 500 ... 2 500 [1]
	F_z	N	–10 000 ... 10 000 [1]
	M_z	N·m	–50 ... 50 [1]
Measuring range 4, nominal	F_x, F_y	N	–5 000 ... 5 000 [1]
	F_z	N	–20 000 ... 20 000 [1]
	M_z	N·m	–100 ... 100 [1]
Linearity		%FSO	≤±1.0
Hysteresis		%FSO	≤1.0
Crosstalk	F_x <–> F_y	%FSO	≤±2.0
	$F_{x,y}$ –> F_z	%FSO	≤±3.0
	F_z –> $F_{x,y}$	%FSO	≤±1.0
	F_z –> M_z	mN·m/N	≤±1
	M_z –> F_z	N/N·m	≤±1

[1] Small spindle adapters limit the useable force range of the RCD. The rotors are calibrated in accordance with limit values (see page 5).

Natural frequency [1]	$f_{0, Fx,y}$	Hz	≈2 000
	$f_{0, Fz}$	Hz	≈5 300
Sampling rate per channel [2]		kHz	2.5 / 5 / 10
Bandwidth		kHz	≈ 0 ... 0.8 / 1.6 / 3.2
Resolution		bit	16
Battery life (active measurement)		h	>5
Supply voltage (charging)		V	5
Battery charging time		h	<4
Max. storage time until recharge		months	3
Transmission type			GFSK
Frequency range (data transmission)		MHz	2 400 ... 2 480
Max. transmission power		dBm	+8
Range [3]		m	≤5
Operating temperature		°C	0 ... 60
Charging temperature		°C	0 ... 45
Storage temperature		°C	–20 ... 45
Degree of protection (IEC 60529)			IP67
Degree of pollution (DIN EN 61010-1)			2
Internal cutting fluid pressure, max.		bar	≤70
Balancing class		G	≤2.5
Weight (rotor only) [1]		kg	2

[1] Applies to Type 9170B131 (RCD with HSK-A63 spindle adapter and ER clamp adapter, without tool, collet and clamping nut).

[2] Selectable sampling rate per channel (not separately selectable).

[3] External influencing factors (such as objects, other radio waves) can affect the range and connection stability.

LabAmp WL-Receiver Type 5347A4...

Number of channels		4
Digital low-pass filter [1] Cutoff-frequency (–3 dB) Selection in 1 Hz steps	Hz	≥10
Scaling analogue output [2]	V	±10
Time shift analogue output	ms	320 ... 400
Output impedance typically	Ω	10
Max. Output current	mA	±2
Signal output conncetor type		BNC neg.
Ethernet interface [3]		2 x RJ45
Remote control		D-Sub 9f
Supply voltage	VDC	18 ... 30
Operating temperature	°C	0 ... 60
Degree of protection (IEC 60529)		IP20
Outer dimensions incl. feet and connectors (WxHxD)	mm	218x50x223
Weight	Kg	1.2

[1] The PTS App offers selectable ranges.

[2] Corresponds to the selected full measuring range of the calibration.

[3] The Sync Out connection is not active.

KISTLER
measure. analyze. innovate.

Signals of a rotating Dynamometer (RCD)

The Type 9170B... rotating dynamometer is based on a piezoelectric 4-component sensor. The rotor of the measuring system is connected to the machine spindle. This means that the coordinate system of the RCD also rotates around the vertical Z-axis. Due to the rotating coordinate system of the RCD, it is possible to directly assess the mechanical loads of the tool cutting edge.

Here are some typical examples of measurement signals acquired with an RCD:

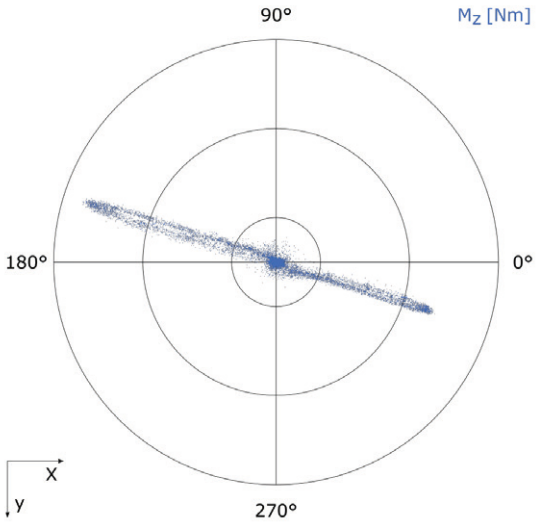

Fig. 1: Polarplot milling with double-edged tool for finishing

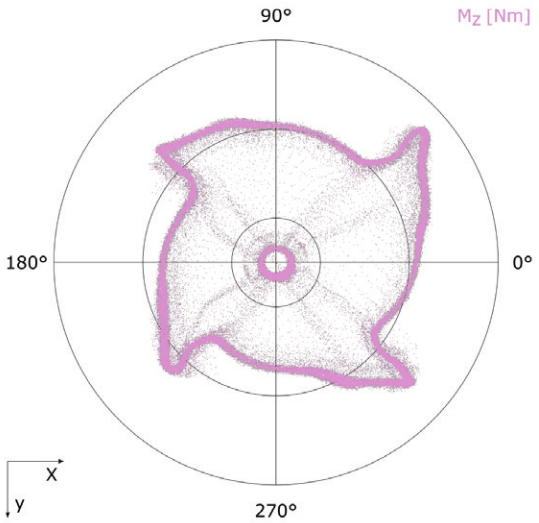

Fig. 2: Polarplot milling with four-edged tool in half section

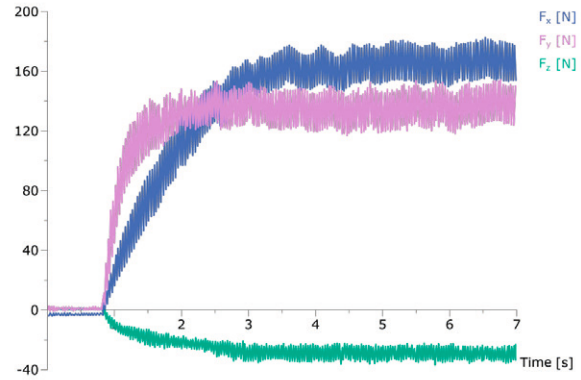

Fig. 3: Measurement data during milling

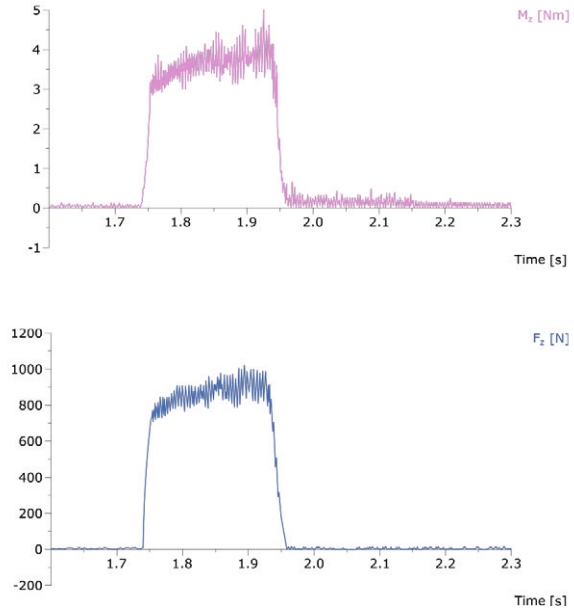

Fig. 4: Measurement data during drilling

KISTLER
measure. analyze. innovate.

Mounting the RCD Type 9170B…
Like a conventional tool, the rotating dynamometer is pulled into the machine spindle through the spindle adapter.

Handling the RCD Type 9170B... during operation
The Wireless RCD may only be inserted **manually** into the spindle without explicit approval from Kistler and may not be changed with the automatic tool changer.

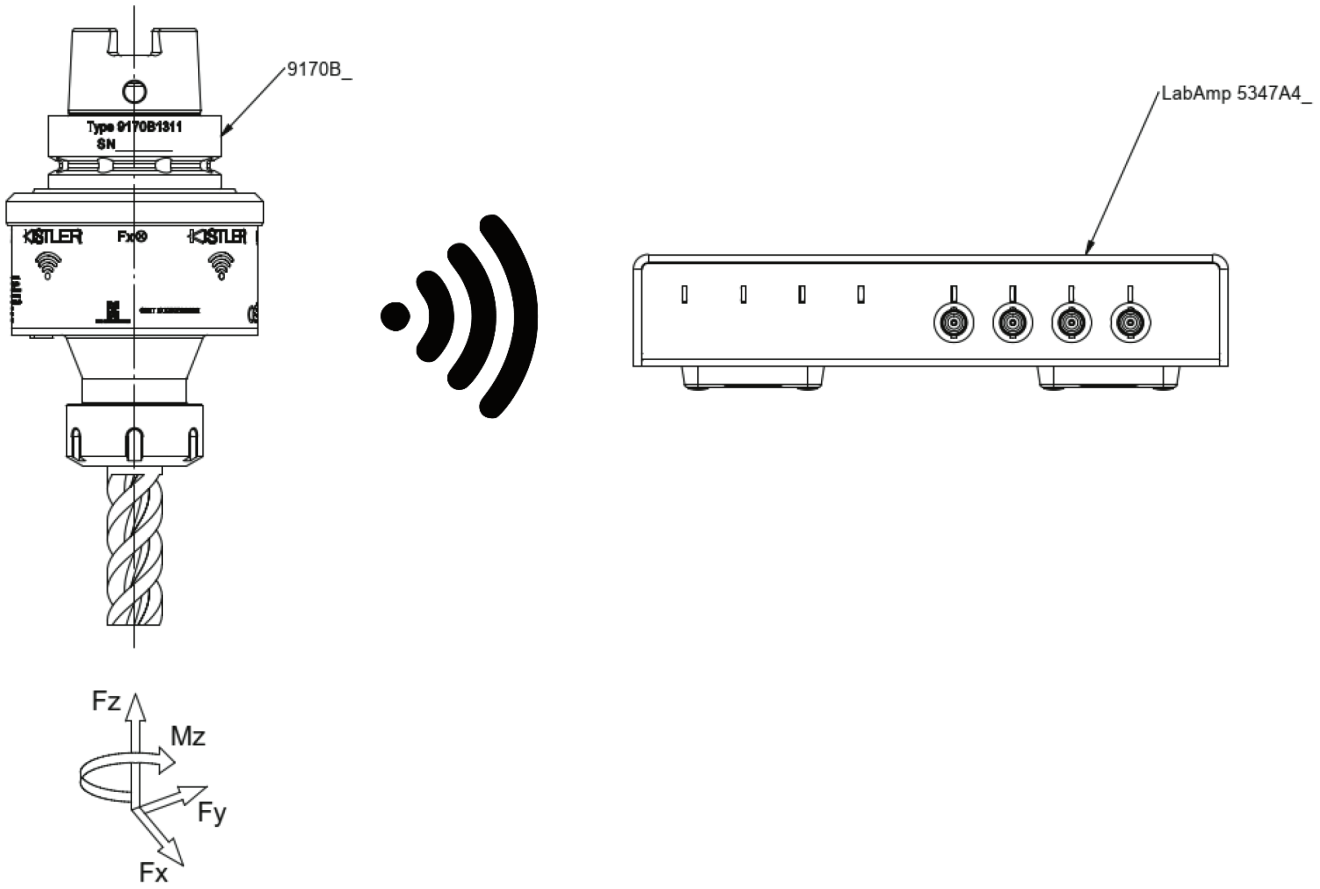

Fig. 5: Scheme of the measuring chain

Typical measuring chain with PTS App

					
Dynamometer Type 9170B…	Radio link	Receiver dongle	Extension cable	WL receiver Type 5347A4…	Notebook (from customer side) with PTS App
	Receiver				

KISTLER
measure. analyze. innovate.

Calibration ranges of the different RCD Types

Type	Machine adapter			Calibration range 1	Calibration range 2	Calibration range 3	Calibration range 4
9170B111x	HSK-A40	F_x, F_y	N	500	1 000	-	-
		F_z	N	1 500	3 000	6 000	12 000
		M_z	N·m	10	20	40	80
9170B121x	HSK-A50	F_x, F_y	N	500	1 000	1 500	-
		F_z	N	2 500	5 000	10 000	20 000
		M_z	N·m	10	20	50	100
9170B131x	HSK-A63	F_x, F_y	N	500	1 000	2 000	3 000
		F_z	N	2 500	5 000	10 000	20 000
		M_z	N·m	10	20	50	100
9170B161x	HSK-E40	F_x, F_y	N	500	1 000	-	-
		F_z	N	1 500	3 000	6 000	12 000
		M_z	N·m	5	15	-	-
9170B171x	HSK-E50	F_x, F_y	N	500	1 000	1 500	-
		F_z	N	2 500	5 000	10 000	20 000
		M_z	N·m	5	10	20	35
9170B181x	HSK-E63	F_x, F_y	N	500	1 000	2 000	3 000
		F_z	N	2 500	5 000	10 000	20 000
		M_z	N·m	10	20	40	70
9170B211x	DIN ISO 7388-1 - AD30 (DIN 69871-AD30)	F_x, F_y	N	500	1 000	-	-
		F_z	N	1 500	3 000	6 000	12 000
		M_z	N·m	10	20	40	80
9170B221x	DIN ISO 7388-1 - AD40 (DIN 69871-AD40)	F_x, F_y	N	500	1 000	2 000	3 000
		F_z	N	2 500	5 000	10 000	20 000
		M_z	N·m	10	20	50	100
9170B241x	JIS B 6339-2 JD 30 (MAS 403 BT 30)	F_x, F_y	N	500	1 000	-	-
		F_z	N	1 500	3 000	6 000	12 000
		M_z	N·m	10	20	40	80
9170B251x	JIS B 6339-2 JD 40 (MAS 403 BT 40)	F_x, F_y	N	500	1 000	2 000	3 000
		F_z	N	2 500	5 000	10 000	20 000
		M_z	N·m	10	20	50	100
9170B271x	ANSI / ASME B5.50-30 (CAT 30)	F_x, F_y	N	500	1 000	-	-
		F_z	N	1 500	3 000	6 000	12 000
		M_z	N·m	10	20	40	80
9170B281x	ANSI / ASME B5.50-40 (CAT 40)	F_x, F_y	N	500	1 000	2 000	3 000
		F_z	N	2 500	5 000	10 000	20 000
		M_z	N·m	10	20	50	100
9170B311x	Capto C5	F_x, F_y	N	500	1 000	1 500	-
		F_z	N	1 000	2 000	4 000	8 000
		M_z	N·m	10	20	30	60
9170B321x	Capto C6	F_x, F_y	N	500	1 000	2 000	3 000
		F_z	N	1 250	2 500	5 000	10 000
		M_z	N·m	10	20	40	80

9170B_003-608e-05.25

KISTLER
measure. analyze. innovate.

Ordering example: 9170B1312I111111
Tested RCD Type 9170B... measuring system consisting of:
- Integrated spindle adapter HSK-A63
- Integrated collet holder ER, size 32 (DIN 6499-B32)
- Receiver dongle
- WL Receiver
- PTS App network license (valid for 1 year)

The individual system components can also be ordered separately:

Component	Type/Mat. No.
• Rotor	9170B
• Power supply* 5 V	55245931
• Country-specific plug set	55255315
• Magnetic charging cable to power supply	55245928
• WL Receiver	5347A
• Power supply* 24 V incl. country-specific plug	5779A2
• Ethernet cable (Cat. 6e) l = 2.0 m	55117964
• Receiver dongle	55250534
• USB 2.0 A extension cable	55255530
• License for PTS App	2935A
• Peli Case roller case	55245041

Fig. 6: Peli Case roller case

Included accessories	Type/Mat. No.
• Clamping wrench for ER collets	65007932
• Clamping nut Hi-Q/ER32 for ER collet	65007915

Optional accessories	Type/Mat. No.
• Collets DIN 6499-B32-UP	9169Axx

Ordering key Collets

Type 9169A ☐

Collets DIN 6499-B32-UP

Tool diameter d	
1 ... 2 mm	**02**
2 ... 3 mm	**03**
3 ... 4 mm	**04**
4 ... 5 mm	**05**
5 ... 6 mm	**06**
6 ... 7 mm	**07**
7 ... 8 mm	**08**
8 ... 9 mm	**09**
9 ... 10 mm	**10**
10 ... 11 mm	**11**
11 ... 12 mm	**12**
12 ... 13 mm	**13**
13 ... 14 mm	**14**
14 ... 15 mm	**15**
15 ... 16 mm	**16**
16 ... 17 mm	**17**
17 ... 18 mm	**18**
18 ... 19 mm	**19**
19 ... 20 mm	**20**

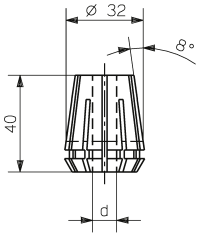

Fig. 7: Collet Type 9169A...

9170B_003-608e-05.25

KISTLER
measure. analyze. innovate.

Ordering key RCD

Rotating 4-Component Dynamometer (RCD) **Typ 9170B** ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Spindle adapter (integrated)

HSK-A40	**11**
HSK-A50	**12**
HSK-A63	**13**
HSK-E40	**16**
HSK-E50	**17**
HSK-E63	**18**
DIN ISO 7388-1 - AD30 (DIN 69871-AD30)	**21**
DIN ISO 7388-1 - AD40 (DIN 69871-AD40)	**22**
JIS B 6339-2 JD 30 (MAS 403 BT 30)	**24**
JIS B 6339-2 JD 40 (MAS 403 BT 40)	**25**
ANSI / ASME B5.50-30 (CAT 30)	**27**
ANSI / ASME B5.50-40 (CAT 40)	**28**
Capto C5	**31**
Capto C6	**32**

Other spindle adapters available on request

Tool holder (integrated)

Collet holder ER (DIN 6499 – B32)	**1**

Measuring system

Rotor only	**0**
Complete system with rotor, WL Receiver Type 5347A4 and BT dongle	**2**

License configuration

Initial buy of hardware and licenses	**I**
Additional licenses for existing device	**A**

Sampling rate 2.5 kHz	**0**
Sampling rate 2.5 kHz, 5 kHz, 10 kHz	**1**

Channels F_z and M_z not available	**0**
Channels F_z and M_z activated	**1**

Channels F_x and F_y not available	**0**
Channels F_x and F_y activated	**1**

PTS App

Without PTS App	**00**
DAQ-License (valid 1 year)	**11**
DAQ-License (valid 5 year)	**15**

DAQ-License Type

Single workstation licenses	**1**
Network license	**2**

Configuration examples:
RCD with mounted HSK-A40 spindle adapter and tool holder ER32 incl. 5 years license for single workstation and all channels activated
Type 9170B1112I111151
Additional license for the activation of the measuring channels F_z and M_z for an existing device
9170B---A010--

Capto is a registred trademark of the Sandvik Group.

9170B_003-608e-05.25