Multicomponent Dynamometer

Wide force measuring range, up to 30 kN, cover plate 140x190 mm

Multicomponent dynamometer for measuring the three orthogonal components of a force. The stiff and robust design as well as the large measuring range permit the measurement of large forces, for example in high-performance cutting applications.

- Wide measuring range
- Patented and largely temperature-compensated design
- Compact and very robust design
- High natural frequency

Description

By using piezoelectric force sensors, this dynamometer not only measures large forces, but can also accurately measure small forces in the Newton range. The high natural frequency and the high sensitivity of piezoelectric sensors permit the acquisition of high-quality measuring signals of very dynamic processes in machining or in general force measurement applications.

The dynamometer consists of four 3-component force sensors mounted under high preload between the cover plate and the two lateral base plates.

A low temperature error is obtained by this special mounting of the sensors. Each force sensor contains three crystal rings, of which one is sensitive to pressure in the y-direction and the two others to shear in the x- and z-directions. The forces are measured practically without displacement.

The outputs of the four mounted force sensors are fed to the 9-pole flanged socket. There are also multicomponent force-moment measurements possible.

The four sensors are fitted so that they are ground-isolated. This largely eliminates ground loop problems.

The dynamometer is corrosion-resistant and protected against penetration by splashing water or cutting fluid. The dynamometer including connecting cable Type 1687B5 or Type 1677A5 meets the degree of protection IP67.

Application examples

- Multicomponent force measurement of large forces
- Cutting force measurement in high performance applications for example in
  - milling
  - surface grinding
  - drilling

Technical data

| Measuring range (centrical) single component | \( F_x, F_y, F_z \) | kN | –30 ... 30 |
| Measuring range when components act simultaneously (centrical) 71 mm above dynamometer, \( M_x, M_y, M_z = 0 \) | \( F_{x,y,z} \) | kN | –20 ... 20 |

Calibrated measuring range

| 100 % | \( F_x, F_y, F_z \) | N | 0 ... 30 000 |
| 10 % | \( F_x, F_y, F_z \) | N | 0 ... 3 000 |
| 1 % | \( F_x, F_y, F_z \) | N | 0 ... 300 |

Threshold | N | <0.01 |

Sensitivity

| \( F_x \) | pC/N | –8.2 |
| \( F_y \) | pC/N | –4.2 |

Linearity

| Meas. range | 1 ... 100 % | %/FSO | ≤0.3 |
| Meas. range | 0 ... <1 % | %/FSO | ≤0.5 |

Hysteresis

| Meas. range | 1 ... 100 % | %/FSO | ≤0.3 |
| Meas. range | 0 ... <10 % | %/FSO | ≤0.5 |

Crosstalk

| \( F_z \rightarrow F_x, F_y \) | %/FSO | ≤2 |
| \( F_x, F_y \rightarrow F_z \) | %/FSO | ≤2 |

Natural frequency

| (without additional mass) | \( f_x, (x) \) | kHz | ≈2.9 |
| | \( f_y, (y) \) | kHz | ≈2.9 |
| | \( f_z, (z) \) | kHz | ≈3.0 |

Operating temperature range | °C | –20 ... 70 |
Insulation resistance (20 °C) | Ω | >10¹³ |
Ground isolation | Ω | >10¹³ |
Degree of protection EN60529 | – | IP67 |

Weight

| Dynamometer | kg | 12.9 |
| Cover plate | kg | 6.5 |

Mounting surface | mm | 140x190 |

1) with connection cables Type 1687B5, 1689B5, 1677A5, 1679A5
Multicomponent Dynamometer – Wide force range, up to 30 kN, cover plate 140x190 mm, Type 9139AA

Dimensions

Mounting

The dynamometer can be mounted with eight screws to any face-ground, clean mounting surface such as on a machine tool table. The measuring instrument can also be mounted on a magnetic plate. It must be noted that uneven contact surfaces may cause internal distortions, placing additional heavy stresses on the individual measuring elements and increasing the cross talk.

There are M10 tapped blind holes in the mounting plate for clamping the force-introducing components such as workpieces. It is also possible to mount parts from below. The contact surfaces of the force-introducing parts must be surface ground to achieve good mechanical coupling to the cover plate.

Pin allocation

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Output signals 16878/16989</th>
<th>Output signals 1677A/1679A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ground</td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>$F_x$</td>
<td>$F_{x1} + 2$</td>
</tr>
<tr>
<td>3</td>
<td>--</td>
<td>$F_{x3} + 4$</td>
</tr>
<tr>
<td>4</td>
<td>$F_y$</td>
<td>$F_{y1} + 4$</td>
</tr>
<tr>
<td>5</td>
<td>--</td>
<td>$F_{y2} + 3$</td>
</tr>
<tr>
<td>6</td>
<td>$F_z$</td>
<td>$F_{z1}$</td>
</tr>
<tr>
<td>7</td>
<td>--</td>
<td>$F_{z2}$</td>
</tr>
<tr>
<td>8</td>
<td>--</td>
<td>$F_{z3}$</td>
</tr>
<tr>
<td>9</td>
<td>--</td>
<td>$F_{z4}$</td>
</tr>
</tbody>
</table>

Fig 1: Dimensions of dynamometer Type 9139AA

Fig 2: Mounting of dynamometer Type 9139AA
Processing the measurement signals
Charge amplifier channels are also needed to build a complete measuring system (e.g. Type 5080A...). These convert the measurement signal into an electrical voltage. The measured value is exactly proportional to the force acting.

Data acquisition and analysis
Kistler offers with the Type 5697A1 DAQ system an universal and easy to operate package, consisting of a hardware for the data acquisition and the DynoWare software. For details see data sheet 5697A_000-745.

3-component force measurement $F_x$, $F_y$, $F_z$

Dynamometer
Type 9139AA

Connection cable
Type 1687B5

Multicomponent charge amplifier
Type 5080Axx3x001

Output ±10 V
Ch1 $F_x$
Ch2 $F_y$
Ch3 $F_z$

Degree of protection EN60529

Fig. 3: Measuring system for 3-component measurement with multichannel charge amplifier

Laboratory charge amplifier
Type 5167A41xK

Connecting cable
Type 1687B5

Output ±10 V
Ch1 $F_x$
Ch2 $F_y$
Ch3 $F_z$

Degree of protection EN60529

Fig. 4: Measuring system for 3-component measurement with laboratory charge amplifier
6-component measurement $F_x, F_y, F_z, M_x, M_y, M_z$

**Dynamometer**
Type 9139AA

**Connection cable**
Type 1677A5

**Multichannel charge amplifier**
Type 5080Axx8x004

```
Output ±10 V
Ch1 $F_{x1+2}$
Ch2 $F_{x3+4}$
Ch3 $F_{y1+4}$
Ch4 $F_{y2+3}$
Ch5 $F_z1$
Ch6 $F_z2$
Ch7 $F_z3$
Ch8 $F_z4$
```

Degree of protection EN60529

**Output ±10 V**
Ch1 $F_x1+2$
Ch2 $F_x3+4$
Ch3 $F_y1+4$
Ch4 $F_y2+3$
Ch5 $F_z1$
Ch6 $F_z2$
Ch7 $F_z3$
Ch8 $F_z4$

Fig. 5: Measuring system for 6-component measurement with multichannel charge amplifier

Value a,b für Type 9139AA:

<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>78,5</td>
</tr>
</tbody>
</table>

**Dynamometer**
Type 9139AA

**Connection cable**
Type 1677A5

**Laboratory charge amplifier**
Type 5167A81xK

```
Output ±10 V
Ch1 $F_x1+2$
Ch2 $F_x3+4$
Ch3 $F_y1+4$
Ch4 $F_y2+3$
Ch5 $F_z1$
Ch6 $F_z2$
Ch7 $F_z3$
Ch8 $F_z4$
```

Degree of protection EN60529

**Output ±10 V**
Ch1 $F_x1+2$
Ch2 $F_x3+4$
Ch3 $F_y1+4$
Ch4 $F_y2+3$
Ch5 $F_z1$
Ch6 $F_z2$
Ch7 $F_z3$
Ch8 $F_z4$

Fig. 6: Measuring system for 6-component measurement with laboratory charge amplifier

Value a,b für Typ 9139AA:

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### Typical measuring chain with DAQ system Type 5697A1

<table>
<thead>
<tr>
<th>Dynamometer Type 9139AA</th>
<th>Connection cable, high impedance Type 16xx</th>
<th>Charge amplifier Type 5080A</th>
<th>Connecting cable Type 1700A111A2</th>
<th>DAQ system Type 5697A1</th>
<th>Notebook (from customer side) with DynoWare</th>
</tr>
</thead>
</table>

### Typical measuring chain with LabAmp system Type 5167A...

<table>
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<tr>
<th>Dynamometer Type 9139AA</th>
<th>Connection cable, high impedance Type 16xx</th>
<th>Charge amplifier with integrated DAQ Type 5167A...</th>
<th>Notebook (from customer side) with DynoWare</th>
</tr>
</thead>
</table>

### Ordering code
- Multicomponent dynamometer Type 9139AA
  - up to 30 kN, cover plate 140x190 mm

### Included accessories
- Mounting screws M10x60 (8 pieces) 65012838

### Optional accessories

#### For 3-component force measurement $F_x$, $F_y$, $F_z$
- Connecting cable, 3 wire, with flexible metal sheath ($L = 5$ m) 1687B5
- Connecting cable, 3 wire, steel braided, flexible ($L = 5$ m) 1687BQ02
- Extension cable, 3 wire, high insulation ($L = 5$ m) 1688B5
- Connecting cable, 3 wire, with flexible metal sheath and angle connector ($L = 5$ m) 1689B5

#### For 6-component force and moment measurement $F_x$, $F_y$, $F_z$ / $M_x$, $M_y$, $M_z$
- Connecting cable, 8 wire, with flexible metal sheath ($L = 5$ m) 1677A5
- Connecting cable, 8 wire, with steel braided, flexible ($L = 5$ m) 1677AQ02
- Extension cable, 8 wire, high insulation ($L = 5$ m) 1678A5
- Connecting cable, 8 wire, with flexible metal sheath and angle connector ($L = 5$ m) 1679A5