MICRO-EPSILON

Instruction Manual

turboSPEED DZ140

DS05(03)
DS05(04)
DS05(07)
DS05(14)
DS05(15)

DS1
DS1(04)
DS1/T

Speed measuring system for turbo chargers

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Certified according to DIN EN ISO 9001: 2008

Contents

1. Safety

The handling of the system assumes knowledge of the instruction manual.

1.1 Symbols Used

The following symbols are used in this instruction manual.

⚠ CAUTION	Indicates a hazardous situation which, if not avoided, may result in minor or moderate injuries.
NOTICE	Indicates a situation which, if not avoided, may lead to property damage.
➡	Indicates a user action.
i	Indicates a user tip.
`Measure`	Indicates a hardware or a button/menu in the software.

1.2 Warnings

⚠ CAUTION

Connect the power supply and the display / output device in accordance with the safety regulations for electrical equipment.

> Danger of injury
> Damage to or destruction of the sensor and / or controller

The power supply must not exceed the specified limits.

> Danger of injury
> Damage to or destruction of the sensor and / or controller

NOTICE

Avoid shock and vibration to the sensor and / or controller.

> Damage to or destruction of the sensor and controller

Protect the sensor cable against damage

> Failure of the measuring device

1.3 Notes on CE Identification

The following applies to the turboSPEED DZ140:

- EU directive 2014/30/EU
- EU directive 2011/65/EU, “RoHS” category 9

Products which carry the CE mark satisfy the requirements of the EMC directives and the standards (EN) listed therein.

The EC declaration of conformity is kept available according to EC regulation, article 10 by the authorities responsible at

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The system is designed for use in industry and satisfies the requirements.

1.4 Proper Use

- The system is designed for use in industrial areas.
- It is used for speed measurement on turbo chargers.
- The system may only be operated within the limits specified in the Technical Data, see Chap. 2.4.

➡ Use the system in such a way that in case of malfunctions or failure personnel or machinery are not endangered.

➡ Take additional precautions for safety and damage prevention for safety-related applications.

1.5 Proper Environment

- Protection class controller: IP 65
- Operating temperature
  - Sensor: -40 ... +285 °C (-40 ... +545 °F)
  - Sensor cable: -40 ... +200 °C (-40 ... +392 °F)
  - Controller: -40 ... +125 °C (-40 ... +257 °F) (at max. 15 VDC power supply) [1)]
- Storage temperature
  - Sensor, sensor cable: -40 ... +200 °C (-40 ... +392 °F)
  - Controller: -40 ... +125 °C (-40 ... +257 °F)
- Humidity: 5 - 95 % (non-condensing)
- Ambient pressure: atmospheric pressure
- Supply: 9 ... 30 VDC / briefly 36 VDC / max. 50 mA

[1)] If power supply is higher, the max. acceptable ambient temperature decreases, see Fig. 14.

2. Functional Principle, Technical Data

2.1 Applications

The non-contacting compact revolution counter is designed for industrial application for turbo charger monitoring on test benches and for measurements during driving tests.

2.2 Functional Principle

A very fast proximity sensor responds to turbo charger blades (depending on initial state) made of electrically conducting materials passing by. The eddy current loss principle effects impedance changes in a measuring coil (sensor). This change of impedance gives rise to an electric signal.

2.3 Structure of the Complete Measuring System

The non-contacting single-channel measuring system consists of:

- Sensor and sensor cable
- Controller (installed in a compact aluminum housing)
- Power supply and signal cable, see Chap. 4.3

Individual components of the measuring system can be changed without limiting the functionality.

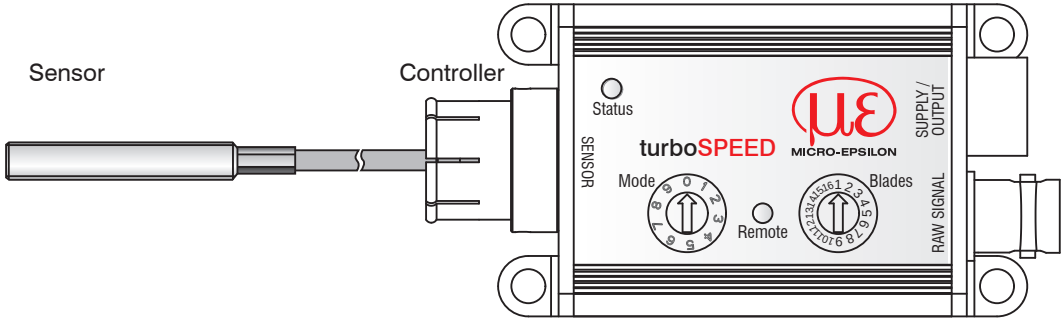


Fig. 1 Components for speed measurement

2.4 Technical Data

Model		**DZ140 (Controller)**							
Sensors		DS05(03)	DS05(04)	DS05(07)	DS05(14)	DS05(15)	DS1	DS1(04)	DS1/T
Measuring principle / Target (blade material)		eddy current principle / aluminum or titanium							
Maximum speed range (measuring range)		200 ... 400,000 RPM							
Operating temperature	Controller	-40 ... +125 °C [1], -40 ... +257 °F							
	Sensor	-40 ... +235 °C, -40 ... +455 °F (short-term +285 °C, +545 °F)							
	Sensor cable	-40 ... +200 °C, -40 ... +392 °F							
Integral sensor cable		0.5 m ±0.15 m					0.75 m ±0.15 m	0.8 m ±0.15 m	
Number of blades		rotary switch (accessible from the outside) for 1 up to 16 blades							
Digital output		1 pulse / blade (switch `Blades` on 1, TTL level, variable pulse duration) or 1 pulse / revolution (switch `Blades` on 2...16, TTL level with 100 µs pulse duration)							
Analog output		Mode 1, 3, 5: 0 ... 5 V (200 ... 200,000 rpm) Mode 0, 2, 4: 0 ... 5 V (200 ... 400,000 rpm) mode rotary switch, adjustable, accessible from outside							
Sensor temperature output (analog)		0 ... 5 V (-50 ... +300 °C)							
RAW signal		Analog measurement signal to control distance between sensor and blade by means of an oscilloscope, see Fig. 20; load resistance > 5 kOhm, load capacity max. 1 nF							
Output sensor temperature		0 ... 5 V (-50 ... +300 °C, -58 ... +572 °F)							
Power supply		9 V ... 30 VDC / max. 50 mA (short-term up to 36 VDC)							

[1] If power supply is higher, the max. acceptable ambient temperature decreases, see Fig. 17.

Model		**DZ140 (Controller)**							
		DS05(03)	DS05(04)	DS05(07)	DS05(14)	DS05(15)	DS1	DS1(04)	DS1/T
Storage temperature	Sensor, sensor cable	-40 ... +200 °C, -40 ... +392 °F							
	Controller	-40 ... +125 °C, -40 ... +257 °F							
Cable		PC140-3 supply and output cable 3 m							
		PC140-6 supply and output cable 6 m							
		PC140-8 supply and output cable 8 m							
Weight		Controller DZ140: appr. 92 g							
Protection class		Controller DZ140: IP 65							

FSO = Full Scale Output

3. Delivery

3.1 Unpacking

1 Controller DZ140
1 Protection cover for the RAW SIGNAL output
1 Instruction manual
1 Multi corrugated spring

Separately available:
Sensor DSx or Sensor DSx/T including integrated sensor cable
Versorgungs- und Signalkabel PC140-x, see Chap. 4.3.

➪ Check the delivery for completeness and shipping damages immediately after unpacking.
➪ In case of damages or missing parts, please contact the manufacturer or supplier.

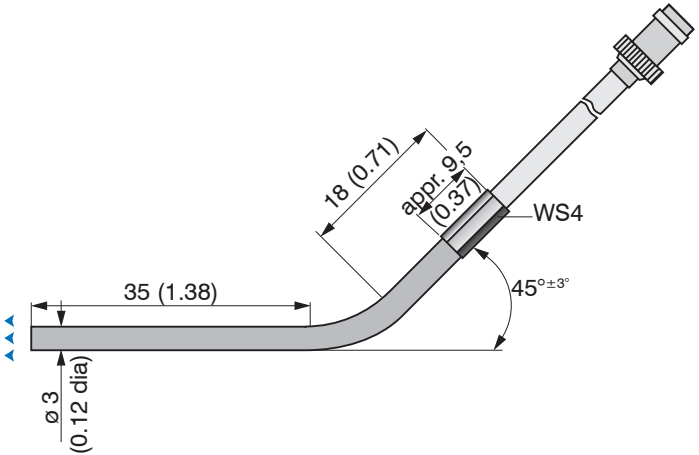
You will find further optional accessories in appendix, see Chap. A 1.

3.2 Storage

- Storage temperature:
  - Sensor and sensor cable: -40 ... +200 °C (-40 ... +392 °F)
  - Controller: -40 ... +125 °C (-40 ... +257 °F)
- Humidity: 5 - 95 % (non-condensing)

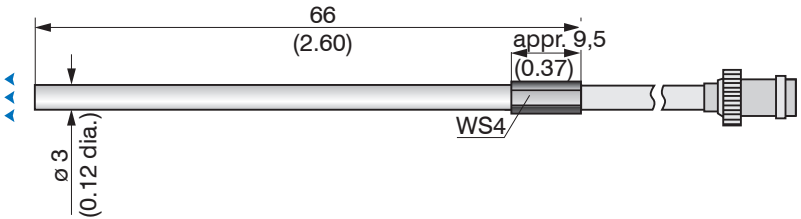
4. Mounting

4.1 Sensor



Sensor cable
ø approx. 3.5 mm
Length 0.5 m (±0.15 m)
with BNC connector

Fig. 2 Dimensional drawing DS05(03)



Sensor cable
ø approx. 3.5 mm
Length 0.5 m (±0.15 m)
with BNC connector

Fig. 3 Dimensional drawing DS05(04)

Measuring direction

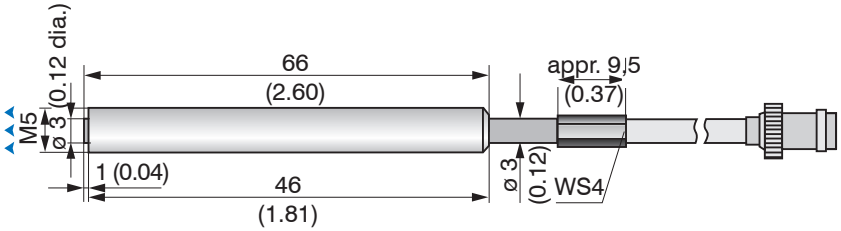


Fig. 4 Dimensional drawing DS05(07)

Sensor cable
ø approx. 3.5 mm
Length 0.5 m (±0.15 m)
with BNC connector

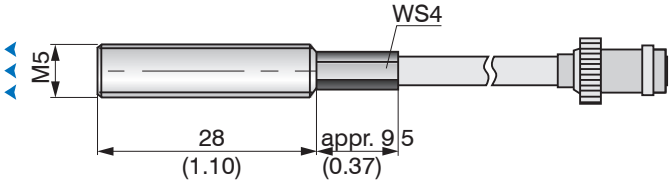


Fig. 5 Dimensional drawing DS05(14

Sensor cable
ø approx. 3.5 mm
Length 0.5 m (±0.15 m)
with BNC connector

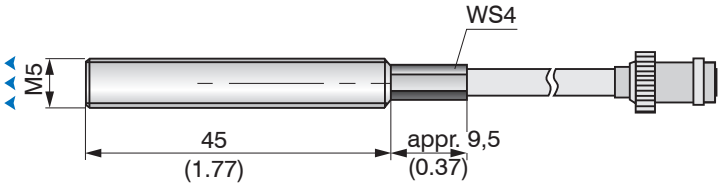


Fig. 6 Dimensional drawing DS05(15)

Sensor cable
ø approx. 3.5 mm
Length 0.5 m (±0.15 m)
with BNC connector

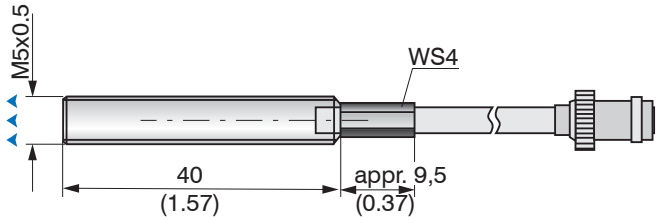


Fig. 7 Dimensional drawing DS1

Sensor cable
ø approx. 3.5 mm
Length 0.75 m (±0.15 m)
with BNC connector

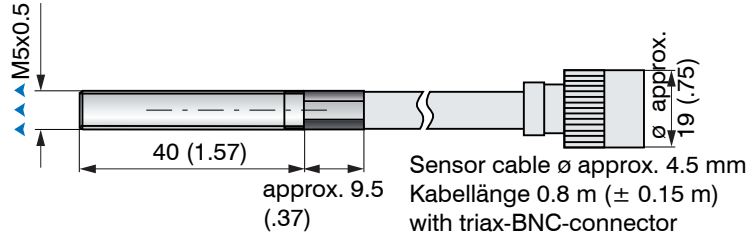


Fig. 8 Dimensional drawing DS1/T

Sensor cable with 2 shields
(triax cable)
ø approx. 5 mm
Length 0.8 m (±0.15 m)
with triax cable socket

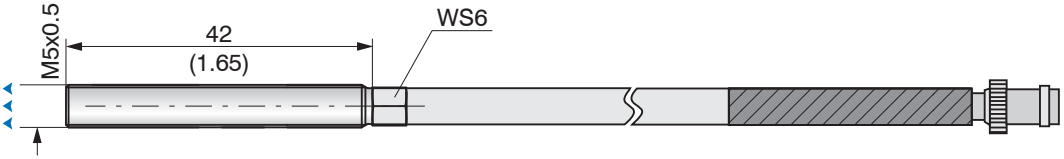


Fig. 9 Dimensional drawing DS1(04)

Sensor cable with metal protection hose
stainless steel IP 40
ø appr. 6.0; cable length 0.8 m
(± 0.15 m)
with BNC-connector

Dimensions in mm (inches), not to scale

Measuring direction

4.2 Sensor Cable

➡ Mount the sensor cable in such a way that the cable sheath is not exposed to any sharp-edged or heavy objects. Do not kink the cable.

i Never come below the proper bending radius of the sensor cable:
10 x diameter in the case of dynamic application,
5 x diameter in the case of static application.

➡ Make sure that the plug connectors at the sensor and at the controller fit tightly.

i As the capacity and the adjustment of the measuring system change, please do not shorten the matched sensor cables.

4.3 Supply and Signal Cable

i Never come below the proper bending radius of the supply and signal cable:
7.5 x cable outer diameter.

Fig. 10 Supply and signal cable, 3, 6 or 8 m long

4.4 Controller DZ140

The controller DZ140 is installed in an aluminum housing. The controller demodulates and amplifies the speed-dependent measuring signal.

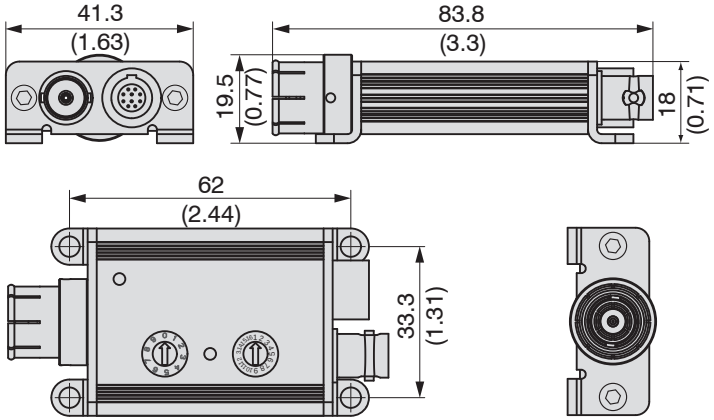
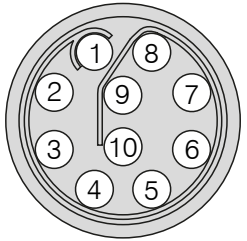


Fig. 11 Dimensions controller, dimensions in mm (inches), not to scale

4.5 Electrical Connections

4.5.1 Supply, Outputs

Supply/Output		Labeling and color PC140-x	
Pin	**Assignment**		
1	Analog output speed 0 ... +5 V	U_a	blue
2	Analog output temperature 0 ... +5 V	U_{Temp}	yellow
5	GND	GND	black
3	TTL impulse, digital	TTL	green
5	GND	GND	black
4	Reserved, do not connect		
Housing		PE	black
6	Reserved, do not connect		
7	Supply -	SUPPLY-	white
8	Power supply + 9 ... 30 VDC	SUPPLY+	brown



View on solder cup side,
10-pole cable connector

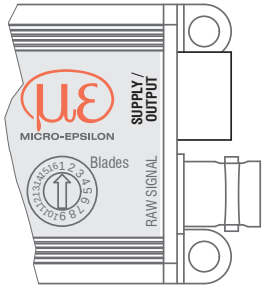


Fig. 12 Pin assignment female connector SUPPLY/OUTPUT and PC140-x

The connector housing / electronics housing is connected with the housing electronics and connector “PE”.

➡ Connect the PE connector (outer shielding braid) and the electronic housing with motor housing, test stand ground or protective earth.

An interior shielding braid (PIN 5) meshs the signals PIN 1 and 2 and the signal on Pin 3. PC140-x is a 3, 6 or 8 m long, pre-assembled 8-wired power and signal cable. It must be ordered as the sensor separately. The outputs are temporary short-circuit proof.
Pin 9 and 10 are not assigned.

4.5.2 Power Supply

Power supply U_V: +9 ... 30 VDC (temporarily up to 36 VDC)

Current consumption: I max < 50 mA

The controller is protected against voltage reversal and overvoltage.

Only use the power supply for measuring devices and not simultaneously for drives or similar pulse interference. MICRO-EPSILON recommends the power supply unit PS2020, see Chap. A 1. 12 V on-board power supply is possible.

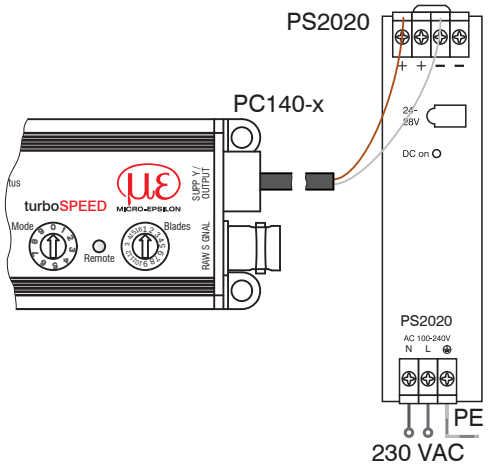


Fig. 13 Connection Power Supply

Wire color PC140-x		Assignment
SUPPLY +	brown	+9 … 30 VDC
SUPPLY -	white	Supply -

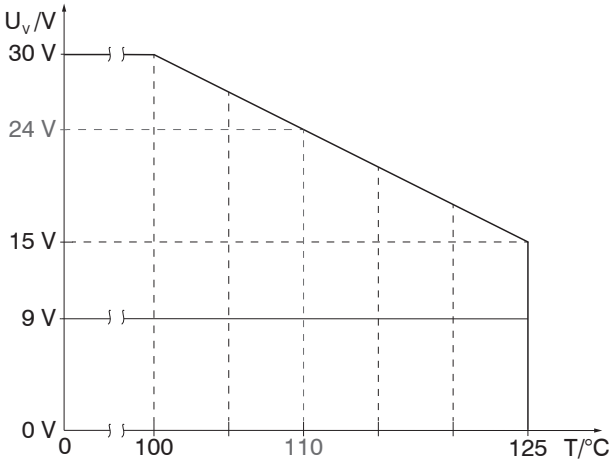


Fig. 14 Derating curve

The power supply U_V has to be limited at 100 °C ambient temperature and it must not exceed 15 VDC at 125 °C, see Fig. 14.

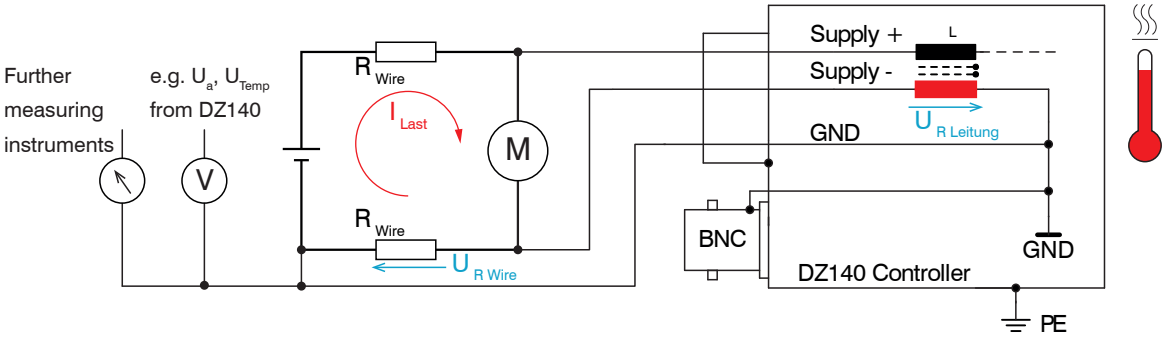


Fig. 15 Thermal overheating possible by measuring loop - avoid

If the GND line is connected to the negative pole of the power supply (e.g. due to connected measuring instruments), avoid connecting the controller to loads with high currents, e.g. starter.

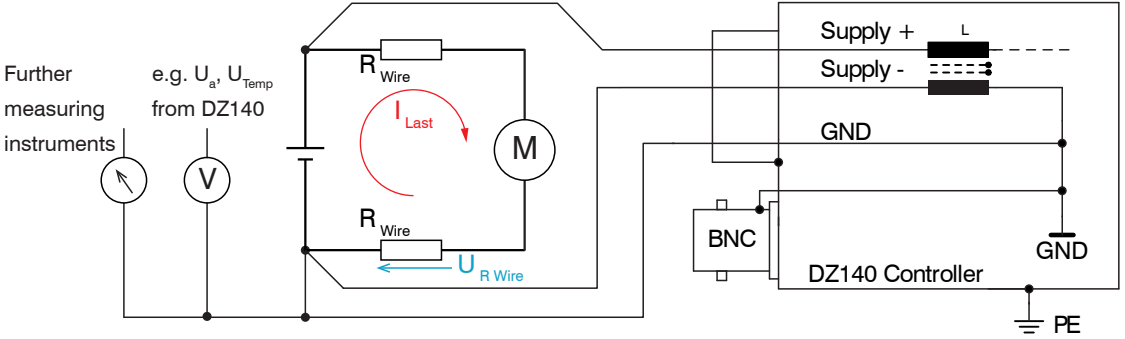


Fig. 16 Short connection leads directly to the supply - recommendation

i Also consider the possible ground loops, which can result from the use of the multi corrugated spring (connection between GND and PE), see Chap. 6.

4.5.3 RAW SIGNAL

Via a BNC socket `RAW SIGNAL` the controller provides an analog voltage of 2.8 ... 5 V to align the sensor, see Fig. 20, see Chap. 5.3.2. Load resistance > 5 kOhm.

➡ Disconnect the connected measuring devices after alignment of the sensor distance and close the female connector with the delivered protection cap.

4.5.4 Ground Concept

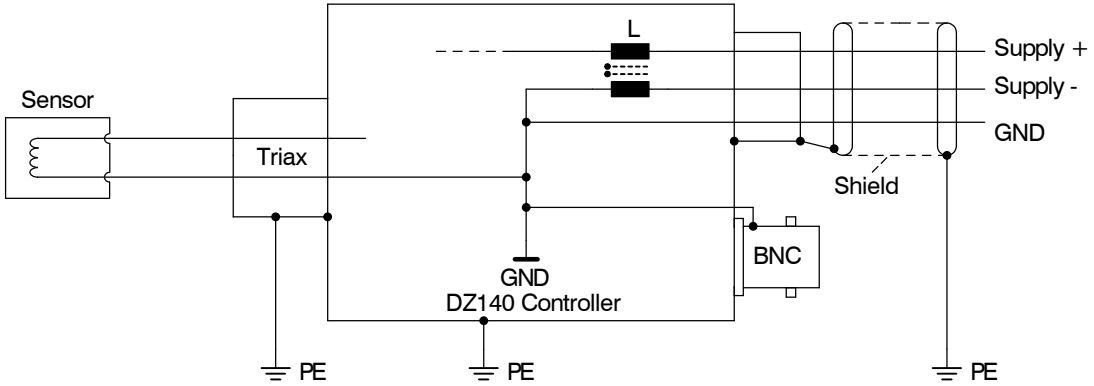


Fig. 17 Ground concept for DSx sensors

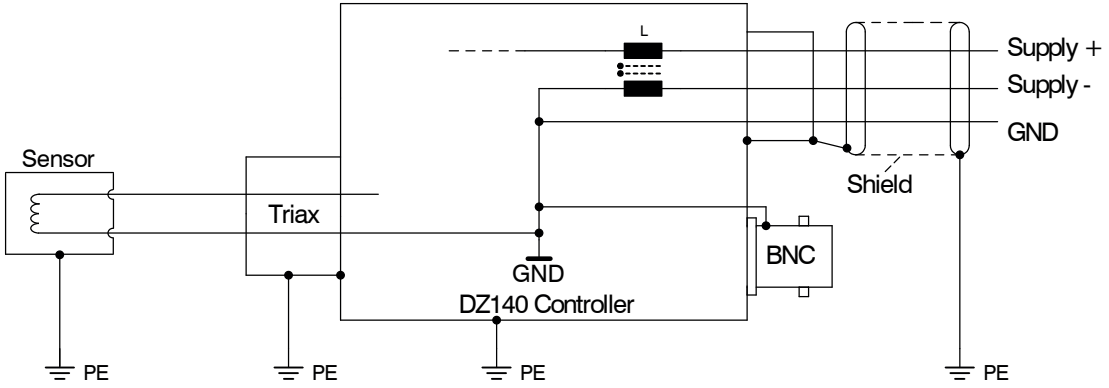


Fig. 18 Ground concept for DSx/T sensors

5. Operation

5.1 Connecting the Measuring System

By means of the female connector SUPPLY OUTPUT, the power supply for the controller is created and signals are output simultaneously.

- Install the sensor into the turbocharger and place it flush with the inner wall of the loader.
- Connect the sensor, see Fig. 1.
- Setup the power supply for the controller by using the connecting and signal cable PC140-x, cable length x = 3, 6 or 8 m, see Chap. 4.5.2.

The connection and signal cable has a push-pull lock on the connector side. Push-pull connections have a very user-friendly locking mechanism. If the connector is plugged into the device, the lock claws on the connector in device snap and form a reliable connection between the two parts.
Disconnection is not possible when pulling on the connector cable.
By contrast, the connector can be easily separated from the device when the outer sleeve is retracted.

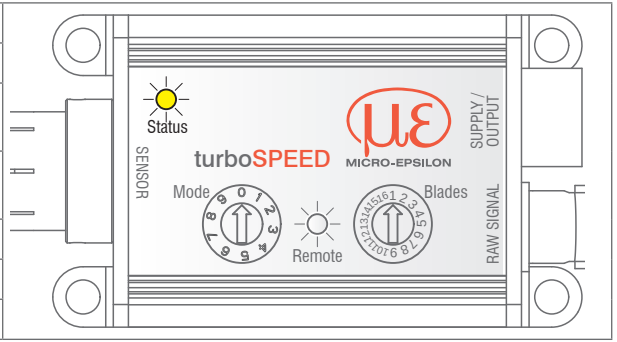
- Connect measuring signal displays or recorders also to the 10-pole cable socket on the controller resp. on the PC140-x cable.
- Switch on the power supply unit.

After applying the supply voltage, the controller initializes. It is shown by means of fast red-yellow-green flashing of the Status LED, see Chap. 5.2.

- Set the mode and the number of blades, see Chap. 5.5.1, see Chap. 5.3.2.
- Make sensor positioning, see Chap. 5.3.

5.2 LEDs on the Controller

Status	red, yellow, green	Initialization
	red	No sensor
	red, flashes (1 sec. Takt)	Teach to sensor
	red, flashes quickly	Error
	yellow	Controller ready
	green	Blade detected
	green, flares	Mode 8 (test pulse)



5.3 Positioning of the Sensor

5.3.1 Open Turbine Chamber

The best method of positioning the sensor is, when the turbine chamber is opened and you can see the front of the sensor.

➡ Fix the sensor so that the front of the sensor is in line with the inside wall of the turbine.

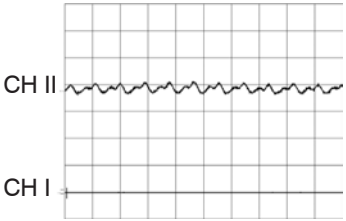
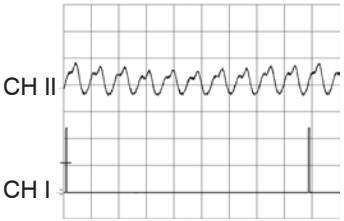
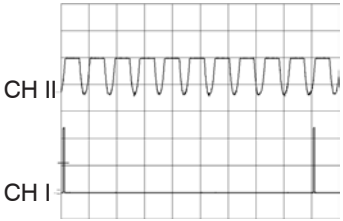
In this case you have the best signal and the best suppression of electromagnetic interference. The RAW SIGNAL signal is exclusively used for the sensor mounting. Signal range: 2.8 ... 5 V.

5.3.2 Closed Turbine Chamber

With the help of the light-emitting diode Status on the controller the sensor can be positioned roughly.

➡ Connect the signal TTL impulse (pin 3, female connector supply/output) to an oscilloscope, channel I.

➡ Connect the RAW SIGNAL to an oscilloscope, channel II.

<table>
<tr><th>Step 1</th><th>Step 2</th><th>Step 3</th></tr>
<tr><td colspan="3">➡ Start to set the compressor in slow rotation and carefully push or turn the sensor in to the mounting hole respectively in to the thread of the charger.</td></tr>
<tr><td>---</td><td>➡ Continue to turn in the sensor.</td><td>➡ Turn in the sensor for max. one further thread turning.</td></tr>
<tr><td colspan="3">CH I, TTL impulse: 2V/DIV;
CH II, RAW SIGNAL: 1V/DIV; TB: 2 ms/DIV; trigger: CH I</td></tr>
<tr><td> 
</td><td> 
</td><td> 
</td></tr>
<tr><td>LED status: shines yellow</td><td>LED status: shines green</td><td>LED Status: shines green</td></tr>
</table>

5.4 Test Signal

The controller provides a test signal on pin 1 and 3 of the 10-pole male cable socket SUPPLY OUTPUT no matter a sensor is connected.
The signal can be used to check the wiring of the measurement setup without requiring the loader to be operated.

Procedure:

➡ Set the switch Mode to 8.

The LED Status flares green.

Pin 1, analog output turbo charger speed: 2.5 VDC.

Pin 3, TTL impulse: The signal provides 100,000 pulse/revolution, this corresponds to a frequency of 1666.7 Hz.

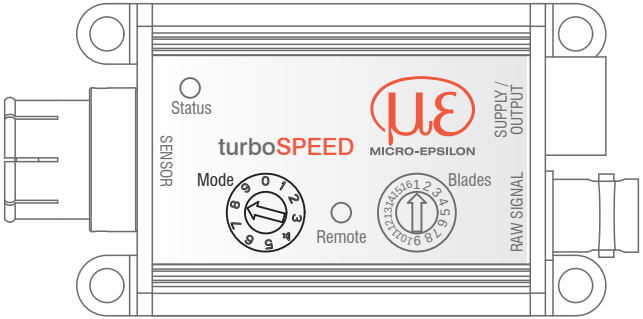


Fig. 19 Settings for the test signal

i The temperature signal is output independently from the test signal. If no sensor is connected, no temperature signal is output (respectively 5 VDC).

5.5 Settings

5.5.1 Mode (Turbo Charger Speed, Sensitivity, Test Signal)

The maximum measurable speed depends on the measuring distance. The smaller the measuring distance, the higher the measurable speed. The digital output may exceed 400,000 rpm, but my also fall below if the distance is too large.

The electronic controls the internal RAW voltage at infinite distance, thus between the individual blades, to approximately 2.8 V. The sensitivity of the electronics can be increased in order to detect a blade at a greater distance between the sensor and the turbocharger blade. In the example the turbocharger blades 2 and 3 were reliably detected at a `Med` sensitivity setting. A `Low` sensitivity setting guarantees the best immunity to interference.
Ex factory the controller is delivered with a `High` (mode 0) sensitivity setting.

$$T_{meas}\,[°C] = U_{temp}\,[V] * \frac{350\ °C}{5\ V} - 50\ °C$$

Fig. 20 Sensitivity setting for detecting single turbocharger blades, RAW SIGNAL

➡ Set the maximum speed to be measured using the switch `Mode` on the controller, see Fig. 21.

- Mode 0: 400k high (400.000 rpm, high sensitivity)
- Mode 1: 200k high (200.000 rpm, high sensitivity)
- Mode 2: 400k med (400.000 rpm, medium sensitivity)
- Mode 3: 200k med (200.000 rpm, medium sensitivity)
- Mode 4: 400k low (400.000 rpm, low sensitivity)
- Mode 5: 200k low (200.000 rpm, low sensitivity)
- Mode 8: test signal, see Chap. 5.4

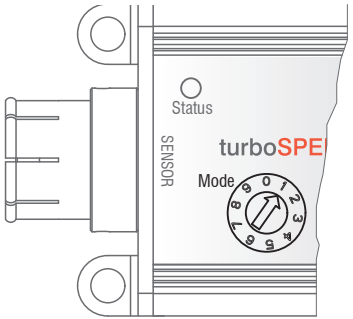


Fig. 21 Rotary switch for speed, sensitivity and test mode

The list of modes is fixed as a quick guide on the back side of the turboSPEED DZ140 and can be also printed separately if it is covered during the measurement, see Chap. A 2.

5.5.2 Number of Blades

Set the number of blades of the turbo charger using the switch `Blades` on the controller, see Fig. 22.

- Blades 1 ... 16 (number of blades)

The settings for a turbo charger with 8 blades are shown, see Fig. 22.

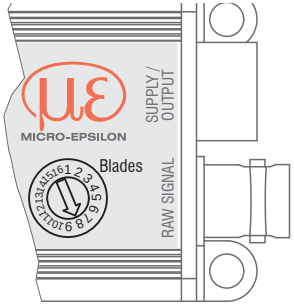


Fig. 22 Rotary switch for the number of blades

One pulse per blade with variable duration

- Impulse duration depends on compressor rotation speed
- Amplitude: LOW = 0 V, HIGH = 5 V

Set the number of blades of the turbo charger with the switch `Blades` on the controller to value 1, see Fig. 22.

Also detects up to 16 blades at a maximum speed of 400,000 rpm.

One pulse per revolution

- Duration about 100 µsec
- Programming of the number of blades with the corresponding position of the switch `Blades`. Number of blades: 2 ... 16; Amplitude: LOW = 0 V, HIGH = 5 V

5.6 Analog Output

- Range 0 ... +5 V
- Linear, depends on rotation speed

Mode 1, 3, 5

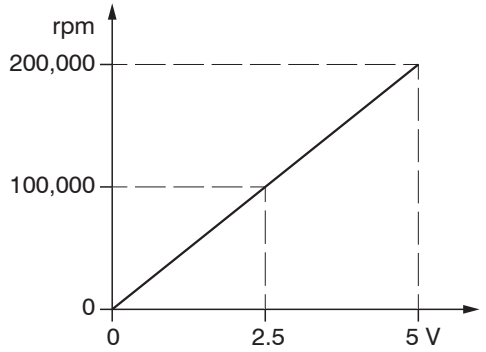


Fig. 23 Analog signal for max. 200,000 rpm

Mode 0, 2, 4

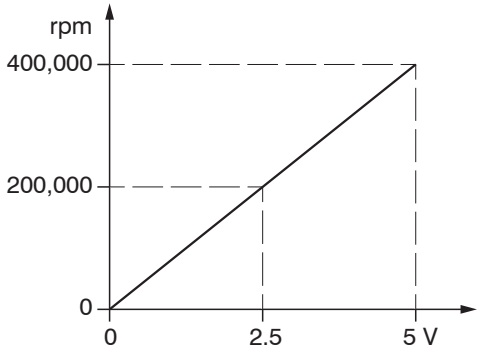


Fig. 24 Analog signal fo max. 400,000 rpm

5.7 Sensor Temperature

The temperature of the sensor is measured by the controller during the measurement and is output as analog signal.

- Temperature range: -50 up to 300 °C (-58 up to 572 °F),
- Amplitude: 0 V up to 5 V

Temperature voltage DZ140 (correction factor)

- First determine the ambient temperature T_{real} of sensor, e.g. via the room temperature.
- Measure the temperature voltage (U_{temp}).
- Set the measured temperature voltage U_{temp} in the formula A, see Fig. 25.

$$T_{meas}\,[°C] = U_{temp}\,[V] * \frac{350\ °C}{5\ V} - 50\ °C$$

Fig. 25 Formula A (without correction factor)

- Set the T_{real} and T_{meas} in formula B, see Fig. 26, and calculate the temperature correction.

$$k\,[°C] = T_{real}\,[°C] - T_{meas}\,[°C]$$

Fig. 26 Formula B

- Now set the temperature voltage and the temperature correction into formula C, see Fig. 27 and calculate the temperature.

$$T_{korr}\,[°C] = U_{temp}\,[V] * \frac{350\ °C}{5\ V} - 50\ °C + k$$

Fig. 27 Formula C (with correction factor)

The temperature correction k applies for the current combination of turboSPEED DZ140 and connected sensor.

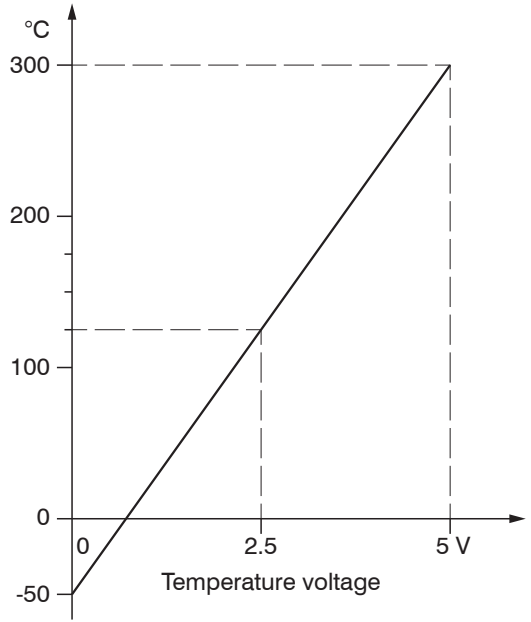


Fig. 28 Temperature voltage, characteristic without correction factor

6. Troubleshooting

Try the following options if during the measurements (possibly also only at different speeds) faults occur despite the above noted points:

- Adjust the sensitivity (mode switch).
- Connect the controller with its own power supply.

Alternatively, you may also perform a galvanic separation.

- If you are using the RAW SIGNAL via the BNC socket, disconnect and plug the female connector with the supplied protective cap.
- If you are using measuring devices (e.g. an oscilloscope), in which the signal ground (GND) is connected to the protective earth conductor of the mains socket, add a galvanic separation (e.g. by means of an isolating transformer).
- Make sure that any possible interference from other components are minimized (e.g. by shielding).
- Connect the signal ground (GND) with the housing ground (PE), e.g. by clamping the supplied multi corrugated spring ring between controller housing and BNC cap (or BNC connector), see Fig. 29, see Fig. 30, see Fig. 31.

i Note that the spring ring rests entire surface on both sides.

NOTICE

First remove any contamination on the contact surfaces of the fire ring (housing, BNC plug, etc.)
> Bad connection between GND and PE

Fig. 29 Multi corrugated spring ring

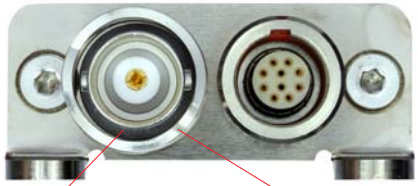


Fig. 30 Front view controller turboSPEED with multi corrugated spring ring

NOTICE

Note also if the ground supply (supply -) is already connected to the housing ground (PE) e.g. in the vehicle via the negative pole of the car battery since the signal (GND) and housing ground (PE) are connected together by the spring ring.
> Unwanted ground loops

The improved shielding of the Triax line against a coaxial line can be impaired.

Fig. 31 Side view controller turboSPEED with multi corrugated spring ring

7. Warranty

All components of the device have been checked and tested for perfect function in the factory. In the unlikely event that errors should occur despite our thorough quality control, this should be reported immediately to MICRO-EPSILON.
The warranty period lasts 12 months following the day of shipment. Defective parts, except wear parts, will be repaired or replaced free of charge within this period if you return the device free of cost to MICRO-EPSILON.
This warranty does not apply to damage resulting from abuse of the equipment and devices, from forceful handling or installation of the devices or from repair or modifications performed by third parties.
No other claims, except as warranted, are accepted. The terms of the purchasing contract apply in full.
MICRO-EPSILON will specifically not be responsible for eventual consequential damages. MICRO-EPSILON always strives to supply the customers with the finest and most advanced equipment. Development and refinement is therefore performed continuously and the right to design changes without prior notice is accordingly served. For translations in other languages, the data and statements in German language operation manual are to be taken as authoritative.

8. Service, Repair

In the event of a defect on the sensor, sensor cable, supply and signal cable or controller the parts concerned must be sent back for repair or replacement. In the case of faults the cause of which is not clearly identifiable, the whole measuring system must be sent back to:

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GmbH & Co. KG
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94496 Ortenburg / Germany

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Fax +49 (0) 8542 / 168-90
info@micro-epsilon.de
www.micro-epsilon.com

9. Decommissioning, Disposal

➡ Disconnect the power supply and signal cable on the sensor.

Incorrect disposal may cause harm to the environment.

➡ Dispose of the device, its components and accessories, as well as the packaging materials in compliance with the applicable country-specific waste treatment and disposal regulations of the region of use.

Appendix

A 1 Optional Accessories

PS2020		Power supply unit for mounting on DIN-rail, Input 230 VAC, Output 24 VDC/2.5 A
DD241PC(11)-U		Digital process display, Display of a selected measuring value, Connection to the analog output 0 - 10 V

A 2 Labels on Rear Side of Controller for Printing

i The list of modes, see Chap. 5.5.1, is fixed as a quick guide on the back side of the turboSPEED DZ140.

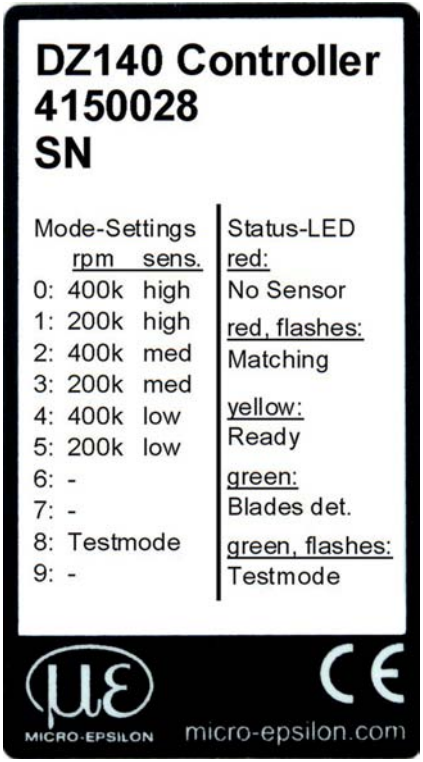

Fig. 32 Label - big

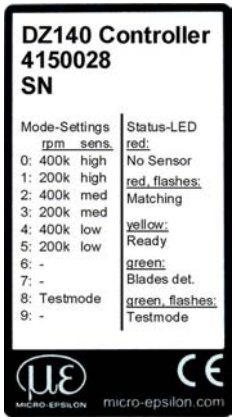

Fig. 33 Sticker - small

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