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Instructions

Integrated Displacement Transmitter Series DT-120

Non-contacting eddy current displacement transmitter, loop-powered

CE

Technical alterations reserved!

Instruction **Transmitter Series DT-120**, C107153002 / v03, en, Release date: 06/09/2019

Content

1 Safety

> **NOTE!**
>
> This instructions document is an integral part of the product. Read this instructions document carefully before using the product and keep it safely for future reference.

1.1 Pictograms and their meaning

> **NOTE!**
>
> This symbol gives general and useful information about using the product.

> This symbol warns you about dangerous situations that might arise if the product is misused.

1.2 Intended use

The integral displacement transmitter is exclusively for the measurement of mechanical distances and vibrations. It is primarily used for condition monitoring of plain bearing and rotating shafts.

When transmitters or cables are used in ways which are not described in the relevant operating instructions, it may cause impairment of function and protection and lead to severe injury to persons, death or severe, irreversible injuries.

- The transmitter may only be used for the purpose specified in the instructions document. Any other use will be considered as not in line with the intended use.
  Brüel & Kjær Vibro will not be liable for any damage caused by improper use. The risk will be borne solely by the user.
- Mounted displacement transmitters must not be used as a climbing aid (step).
- Cable installation must not apply any tensile forces to the mounted displacement transmitter.
- The device is only to be operated in permitted environmental conditions. These can be taken from the technical product specification.
- The electrical equipment must undergo regular maintenance. Problems such as loose connections, defective plug connections, etc., must be eliminated immediately.

Hot surfaces
- Devices, displacement transmitters or cables can reach dangerous temperatures due to assembly on external sources of heat or cold (e.g. machine components), whereby touching these can, amongst other things, cause burns.

1.2.1 Recommendation to the operator

If dangers should arise during use of the device in connection with machines or parts of the plant which are outside of Brüel & Kjær Vibro's responsibility, safety instructions or warnings must be issued and disseminated by the operating company and understood and confirmed by the personnel involved.

> **i** **NOTE!**
>
> If the device is installed in a machine or is specified to be part of the construction of a machine, commissioning is not permitted until the machine in which the device is installed complies with the requirements of the EU guidelines.

Prohibition of unauthorized modifications

The device and accessories may not be altered either constructively or safety-related, without our express agreement. Any unauthorized modification made excludes liability on our part for any damages arising.

1.3 Restrictions

The dynamic output allows connection of a potential-free portable measuring device for system setup or signal analysis. The dynamic output is current-limited and coupled with high impedance to the loop. Wrong wiring (for example a short circuit) does not impair the function of the loop. The dynamic output is not designed for long-term connection to subsequent electronics.

Not all of the possible installation and connection options are described in this document.

1.4 General information

Never use damaged products. Please make a claim for any damage immediately.

1.5 Personnel requirements

Transport, storage, installation, assembly, connection, commissioning, servicing and maintenance may only be performed by qualified specialist personnel. In doing so it is essential to observe:

- this technical documentation
- warning and safety instructions and symbols affixed to the product
- product-specific regulations and requirements
- all of the national and regional regulations covering safety and the prevention of accidents.
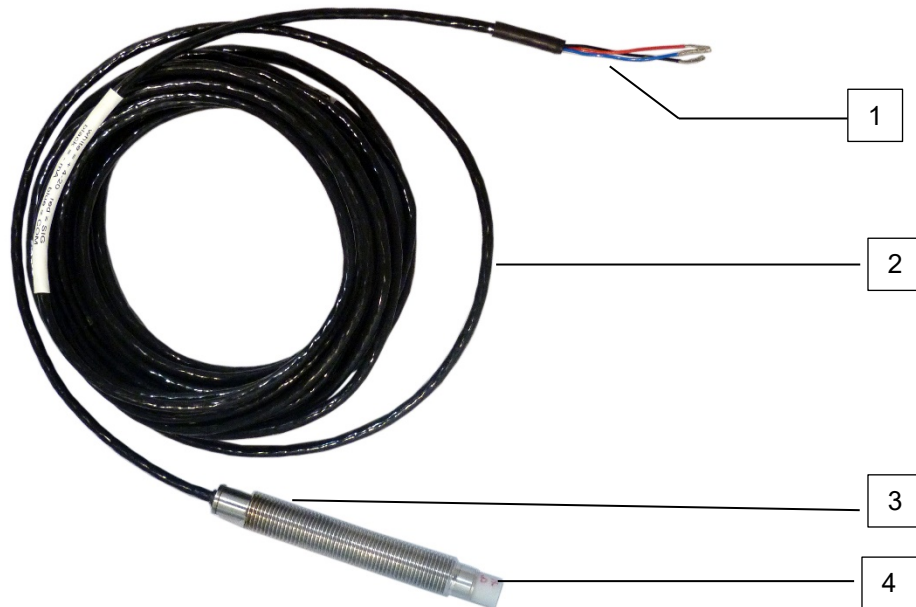
2 Product description

Figure 2-1) Displacement transmitter DT-121.RV/…

1) Cable end, open with 4 conductors (displacement transmitter using 2-conductor technology plus a dynamic signal output)
2) integral cable
3) displacement transmitter housing
4) ceramic tip

2.1 General function

The integrated Series DT-120 displacement transmitters are based on the non-contacting eddy current measurement principle, which has proven itself in the field of machine monitoring for several decades. It allows contactless measurement of the distance between the tip of the displacement transmitter and an electrically conductive surface to be measured (target).

2.1.1 Measurement type

Based on the distance signal the integral electronics perform one of the following measurements according to the selected model:

- **DT-12x.AP/…** AP = Axial Position, measurement of the axial shaft position
- **DT-12x.RV/…** RV = Radial Vibration, measurement of the radial shaft vibration (peak to peak value)

Upon connection of the transmitter to a downstream electronic device, the measured loop current must be converted into the corresponding measurand. The general approach to this is given by the following formula:

$$Measurement\ Value = \left(\frac{Loop\ Current - 4\ mA}{16\ mA} \times Full\ Scale\right) + Offset$$

In doing so *Full Scale* (FS) represents the not offset corrected measurement value of the transmitter for a loop output of 20 mA. *Offset* is the measurement value which is assigned to the transmitter output of 4 mA.

For a radial shaft vibration measurement, the *Offset* is 0 µm peak-peak which corresponds to a vibration amplitude of zero, i.e. → no vibration. For an axial position measurement, a transformation into the machine-oriented coordinate system can e.g. be performed by setting the *Offset* correspondingly.

The unit of the measurement value depends on the selected measurement type respectively transmitter model. In case of a radial shaft vibration measurement, this is [µm peak-peak] or [mil peak-peak], while in case of an axial shaft position measurement it is [µm] or [mil] respectively.

The system sensitivity present for a given measurement operation has a direct influence on the *Full Scale* value of the transmitter system. Due to the eddy current measurement principle the actual system sensitivity and therefore also the individual *Full Scale* value is dependent on the electrical properties of the target material which is used in the application.

As part of the production process the transmitter is tuned to its standard sensitivity in regard to the B&K Vibro reference target made out of 42CrMo4 (1.7225 according to EN 10027). In order to obtain a precise interpretation/conversion of the output loop current, the determination of the system sensitivity with reference to the shaft or target material used is a mandatory prerequisite.

Section 7.2.4 explains how one can determine the system sensitivity and from this the *Full Scale* value for the concrete application by aid of a static calibration device and a suitable material probe.

Section 4.2 contains an installation example for an axial position displacement transmitter.

2.1.2   Mechanical versions

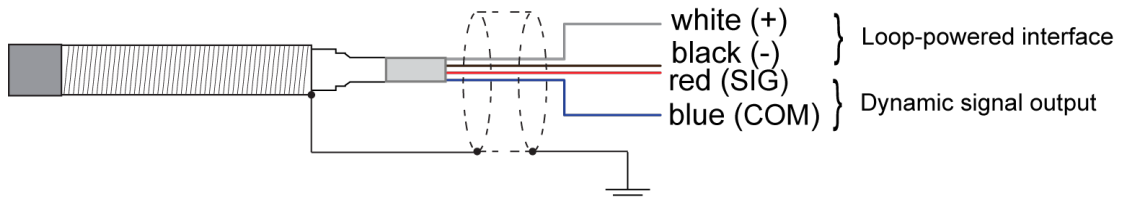The displacement transmitter is available in both a forward and a reverse mount installed version.

- **DT-121…**   Displacement transmitter with continuous thread
- **DT-122…**   Displacement transmitter with continuous thread and pressure-tight corrugated tube protective hose
- **DT-123…**   Displacement transmitter for reverse mounting

2.1.3 Wire assignments

The displacement transmitter has a 4-core integral cable.

Figure 2-2) Displacement transmitter of Series DT-120

Loop-powered interface:

- White .... '**+**' Loop ....4-20 mA
- Black .... '**–**' Loop ....4-20 mA

Via the loop-powered interface the displacement transmitter is supplied with +24 VDC and a 4 – 20 mA signal is outputted.

Dynamic signal output:

- Red .... '**+**'.................. ....SIG
- Blue .... '**–**' ....COM

The additional dynamic signal output can be used for simple system set up or signal analysis.[i] It is not designed for long-term connection to subsequent electronics.

In order to connect the loop-powered interface of the displacement transmitter to a downstream machine control system or process control system, we recommend using the connection module AC-2140 which can be obtained separately as an accessory.

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[i] *Both connections can be used in parallel. Limitations in the application can be taken from the technical data.*

3 Delivery, storage, transport

⚠️ **BEWARE!**

The ceramic tip is sensitive to impacts and can get damaged as a result of improper handling. Displacement transmitters with a defective ceramic tip should not be mounted and must be exchanged.

Protect the displacement transmitter during storage and during transport from possible impacts, dust and dirt.
Only transport and store the displacement transmitter using the provided, applied rubber protective cap. Always keep the rubber protective cap in a safe place to use again at a later date.

3.1 Delivery

Check the packaging on delivery for any signs of damage and ensure that your delivery is complete.

Scope of delivery

The scope of delivery of a displacement transmitter of the DT-120 series is:

- Series DT-120 displacement transmitter with integral cable
- Instructions document
- Inspection certificate BASIC
- Measurement report
- Two nuts (pre-mounted)[ii]

3.2 Storage

Protect the displacement transmitter during storage and during transport from possible impacts, dust and dirt. We therefore recommend safekeeping in the original packaging.

[ii] *with a thread, either M10x1 or 3/8-24 UNF-2A, dependent on the individual order*

4 Installation

> ⚠️ **BEWARE!**
>
> Risk of injury from moving machine parts. Switch off your machine before installing the displacement transmitter.

Prerequisites

- The necessary clearances and the width of the measuring track are taken into account (see Chapter 7.2.2 and Chapter 7.2.3.)
- The sensitivity of the displacement transmitter for the target material used is known (see Chapter 7.2.4).
- The displacement transmitter housing must be earthed (if necessary during assembly).

Sequence

Use this sequence for installation of the displacement transmitter:

- 4.1 Mounting of the displacement transmitter
- 4.2 Adjustment of the displacement transmitter installation position
- 4.3 Laying of connecting cable
- 4.4 Electrical connection

4.1 Assembly of the displacement transmitter

> ⚠️ **BEWARE!**
>
> If a ceramic tip is damaged, loose ceramic particles can get inside the machine and damage it.

Check the tip of the displacement transmitter, the transmitter housing and the integral cable for any damage before every assembly operation. Damaged displacement transmitters must not be mounted. To avoid damage, particularly ensure during assembly and operation of the machine, that the ceramic tip does not come into contact with other objects and that the integral cable is protected from mechanical damage.

> ℹ️ **NOTE!**
>
> The measurement value can be influenced by electromagnetic interference. In the event of interferences, we recommend an earthed steel protective conduit (e.g. AC-2202) for the protection of the displacement transmitter signal cable.
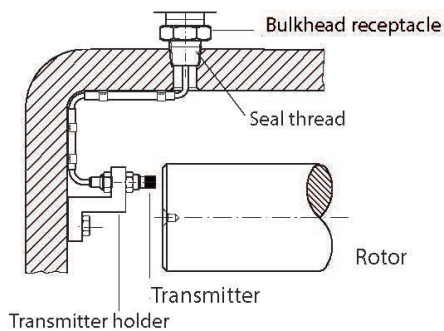
> ℹ️ **NOTE!**
>
> For the performance of contactless displacement measurements only fasten the displacement transmitter to machine parts whose own vibration cannot falsify the measurement results.

4.1.1   DT-121 and DT-122 forward mountable displacement transmitter

Dependent on the application forward mounting can take place inside a machine, outside a machine or through the machine housing. To avoid measurement errors, we always recommend using a suitable holder for the transmitter mounting. For this purpose the transmitter holder is to be mounted at a location which does not move relative to the measurement object during machine operation.

1. Remove the protective cap on the ceramic tip.
2. Fasten the displacement transmitter with the aid of a transmitter holder suitable for the type of assembly being undertaken.
3. Position the displacement transmitter so that it is perpendicular to the measuring track.
4. Ensure that the ceramic tip does not touch the measurement object to avoid damage.
5. Adjust the installation position of the displacement transmitter by means of its dynamic signal output, see Chapter 4.2.
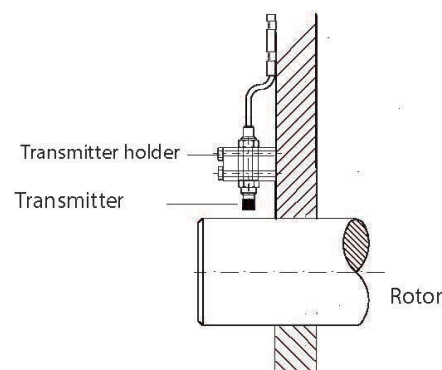

Figure 4-1)   Mounting layout for a forward mountable displacement transmitter (schematic diagram)

4.1.2   DT-123 reverse mountable displacement transmitter

The reverse mountable displacement transmitter is preferably mounted by means of a transmitter holder with adjusting spindle.

- Fasten the displacement transmitter with the aid of a transmitter holder suitable for the type of assembly being undertaken. We recommend to use the holder AC-3101.
- Adjust the installation position of the displacement transmitter by means of its dynamic signal output, see Chapter 4.2.

4.2 Adjusting the installation position of the displacement transmitter

The displacement transmitter must be adjusted while the rotor is stationary. For the measurement setup the displacement transmitter must be supplied with voltage over the loop-powered interface (black, white). The target position for the installation position must be known before setting up. To determine this in advance, for setting up an axial position transmitter for example, the exact location of the rotor in relation to its possible axial bearing play during operation must be known. To set up a radial vibration transmitter, it may be necessary to take account of the 'lift off' of the rotor during operation. The target position must be determined in such a way that any contact of the transmitter tip with the rotor is totally excluded during operation. The GAP voltage to be set must be derived from the determined target position (see example) for adjustment of the installation position.

Example

DT-12x.AP/0/… measurement of an axial shaft position (nominal measurement range 1.2 mm)

The following variables are known for the concrete application: Full Scale: 1.18 mm for a sensitivity of 8.14 mV/µm or 73.75 µm/mA with regard to the target material used in the application.
The shaft is in the middle position when installing the transmitter. While operation the shaft can move ±0.35 mm in both directions.

The loop output of the AP transmitter is designed in such a way that loop measurement range begins (4 mA) for a GAP voltage of 2 VDC at the DYN_OUT output. The maximum change in distance, which represents a loop current of 20 mA, is outputted for this measurement range of nominal 1.2 mm at a GAP voltage of 11.6 V. This value arises from the nominal sensitivity of 8 mV/µm and the nominal measurement range (= 2 V + 1.2 mm * 8 mV/µm).

In this example the sensitivity is 8.14 mV/µm. Therefore, in this case, the maximum *Full Scale* voltage value of 11.6 V is already achieved for a distance of 1.18 mm (= 2 V + 1.18 mm * 8.14 mV/µm).

In the example it is assumed that the shaft is located in its middle position during installation of the axial position transmitter. Therefore, it is recommended in this case, to also position the distance between shaft and transmitter tip for the adjustment of the transmitter installation position to the middle of its measurement range. This therefore corresponds to the transmitter target position for installation.

Calculation of the GAP voltage to be set for the installation takes place using the following approach: The transmitter measurement range begins, as mentioned above, at a GAP voltage of 2 VDC. In this case the transmitter should be adjusted to the middle of its measurement range. Half of the FS of the transmitter measurement range is 0.59 mm = ½ * 1.18 mm.
This results in the following value for the required GAP voltage U $_{target}$ for installation:

$$\mathrm{U}_{target}(0{,}59\,mm) = 2\,\mathrm{V} + 0{,}59\,\mathrm{mm} \cdot 8{,}14\,\frac{\mathrm{mV}}{\mathrm{\mu m}}$$

$$= 2\,\mathrm{V} + 4{,}8\,\mathrm{V}$$

$$= 6{,}8\,\mathrm{V}$$

The target position is set up over the dynamic output (blue, red) with the aid of a voltmeter (see **Figure 4-2**).
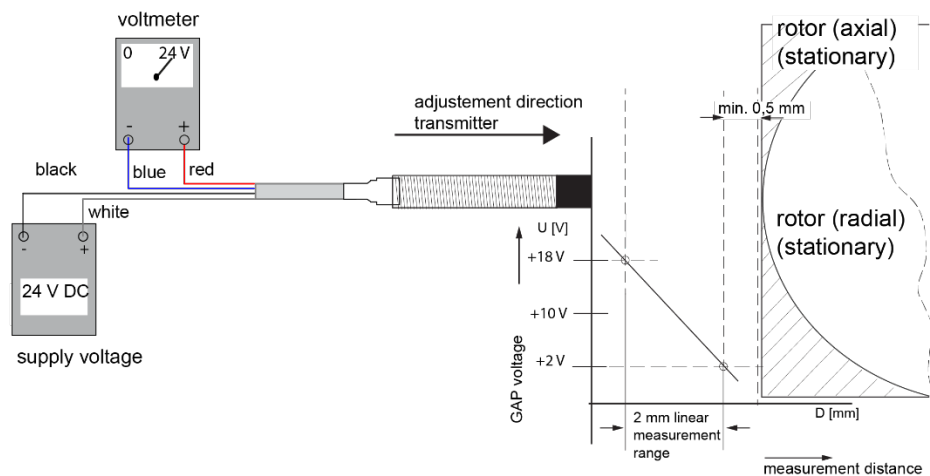
Figure 4-2)   Measurement setup for adjustment (axial / radial)[iii]

- For the purpose of power supply, the displacement transmitter is connected, for example, to a process control system over its loop-powered interface.
- The displacement transmitter is pre-mounted in such a way that the distance between the transmitter tip and the rotor lies outside of its measurement range.
- Switch on the voltage at the loop-powered interface.
- Position the displacement transmitter through careful turning in, in such a way that it comes into the linear measurement range.
- At the dynamic signal output you obtain the GAP voltage proportional to the measuring distance in the range of 2 V ... 18 V (linear displacement measurement range). The sensitivity of the displacement transmitter is nominal 8 mV/μm or 8 V/mm[iv] respectively. The corresponding mechanical distance (D [mm]) is in the range of min. 0.5 mm to max. 2.5 mm.
- During setup ensure that the transmitter cable is not twisted. The minimum distance of 0.5 mm to the shaft must be maintained at all times to avoid damaging the ceramic tip (observe the GAP voltage).
- While observing the dynamic signal output, position the displacement transmitter in such a way that the GAP voltage corresponding to the target position is set. This guarantees that the rotor does not leave the linear measurement range at its maximum deflection and the minimum distance of 0.5 mm is always maintained.
- Fix the displacement transmitter with the locknuts provided (tightening torque 5 Nm). The displacement transmitter must not be twisted when locking since this would change the target position and hence the corresponding GAP voltage. Use a suitable screw lock (e.g. LOCTITE 243 medium-strength) to fix the transmitter in its target position.
- Check the output voltage again.
- Remove the power supply and voltmeter.
- Mount the connecting cable and route it; see the next chapter.

[iii] *Cable colours: black, blue, red, white*
[iv]*Regarded under the B&K Vibro standard conditions; use of standard materials*
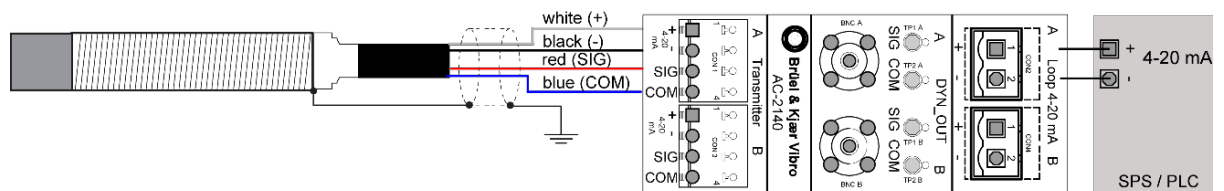
4.3 Laying of connecting cable

1. Laying the connecting cable.
2. While laying the connecting cable, observe the limitation of the maximum allowable total cable length of 15 m (including transmitter integrated cable length) for the dynamic signal output.
3. When fixing in place with cable clamps, we recommend using a suitable protective conduit.
4. Earth the cable shield.

For assembly inside the machine:

- Seal the housing opening with the aid of a housing feed-through in such a way that the medium inside the machine (for example gas or oil) cannot escape to the outside.
  We assume no liability for improper installation.

4.4 Electrical connection

The displacement transmitter is attached over the two conductors of the loop-powered interface to a subsequent control system (PLC / PCS). We recommend using the connection module AC-2140 (**Figure 4-3**).

Figure 4-3) Connecting the displacement transmitter to a control system (PLC / PCS)[v]

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[v] programmable logic controller (PLC) or a process control system (PCS)

5 Functional test

5.1 Short test

> ⚠️ **BEWARE!**
>
> Risk of injury from moving machine parts. Switch off your machine when you perform measurements.
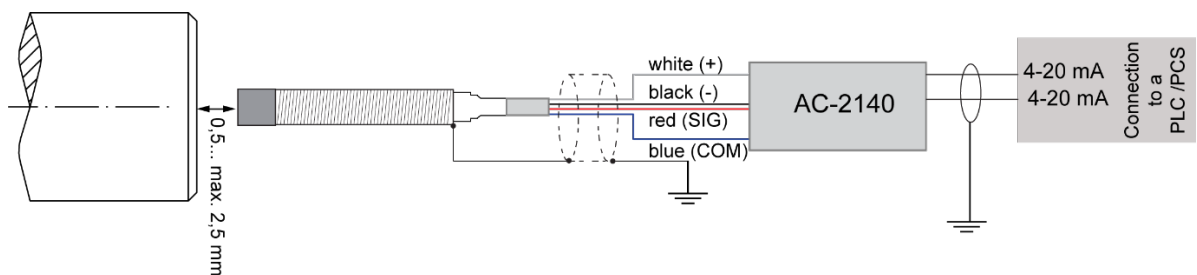

Figure 5-1) Connecting the displacement transmitter to a monitoring system

Once your displacement transmitter is installed you can then check the measurement values. If your displacement transmitter is in a proper operating state, you will obtain the following values:

Operating voltage U$_B$	Operating current I$_B$
-24 VDC	≥ 4.0 mA (DT-12x.RV/x), 4…20 mA (DT-12x.AP/x)

5.2 Troubleshooting

If the measurement results obtained are different, proceed in the sequence we recommend:
Check the output voltage of the dynamic signal output using a voltmeter.

a. Output signal > 18 V, or the signal shifts between two values: the distance is still too large and therefore outside of the measurement range. In this case reduce the distance until a stable output signal is obtained.

b. Output signal < 2 V
It is possible that the distance between the target and the ceramic tip is too low.
Adjust the displacement transmitter to a larger distance to the target and check the output signal again. If the output signal does not change, there is a defect in the displacement transmitter system.

6   Disassembly

> ⚠️ **BEWARE!**
>
> Risk of injury from moving machine parts. Switch off your machine when you exchange or disassemble the displacement transmitter.

To disassemble proceed according to the opposite sequence:

6.1   Exchanging a displacement transmitter

1. Switch off the power for the loop-powered interface.
2. Disassemble the displacement transmitter. Proceed in the reverse order of installation (see chapter 4.1).
3. Mount a new displacement transmitter. Proceed during assembly and adjustment of the displacement transmitter as described in Chapter 4.
4. Connect the displacement transmitter to the subsequent control system (see chapter 4.4).
5. Check that all parts are properly connected.
6. Switch on the power for the loop-powered interface.

7 Technical data

The following performance data applies under the following standard conditions, unless stated otherwise:
+18 °C to +27 °C ambient temperature, +24 VDC supply voltage, 250 Ω loop resistance, dynamic output not connected, material no. 1.7225 (42CrMo4) B&K Vibro reference material, a +6 V gap voltage; all components are at operating temperature (approx.. 1 hour)

7.1 Series DT–120 non-contacting displacement transmitter

Measurement type	
Radial Vibration (RV)	Radial shaft vibration in [µm peak-peak]
Axial Position (AP)	Axial shaft position in [µm]
Measuring principle	Eddy current method
Dynamic characteristics:	
Dynamic output	
Usage	Connection of a potential-free portable measuring device for system setup or signal analysis; not designed for continuous operation
Electrical properties:	
Operating voltage	+24 VDC (+12 VDC ... +32 VDC)
Current consumption	max. 21 mA
Cable length	max. 15 m (including transmitter integrated cable length)
Cable capacity	max. 150 pF/m
Mechanical properties	
Cable:	
Structure	4-core
Cable sheath und colour	PTFE, black
Wire assignments	
Loop	white (+), black (-)
Dynamic output	red (+), blue (-)
Diameter	Ø 2.9 mm (±0.15 mm)
Core cross-section	0.16 mm²
Length	5 m or 10 m
Transmitter tip:	
Material	Ceramic
Diameter of the tip	Ø 7.2 mm (± 0.1 mm)
Transmitter sleeve	
Material	Stainless steel (Material no. 1.4404 (X2CrNiMo17-12-2) according to EN10088-3)
Recommended tightening torque	5 Nm
Environment:	
Pressure tightness:	
Ceramic tip	25 bar
Temperature range	
Operating temperature range	-40 °C ... +105 °C.
Storage temperature range	-55 °C ... +125 °C.
IP range	IP68, IP69

7.2 Environmental requirements

7.2.1 Resistance of the displacement transmitter to different media

If the displacement transmitter is used in media such as water, it can have an impact on the measurement result. For example, an increase in the electrical conductivity of the surrounding medium usually causes an increase in the measurement error.

> **NOTE!**
>
> Without additional protective measures, the rear of the displacement transmitter is not media proof. The values in the following table refer to the ceramic sensor tip only.

Material	Fraction	resistant	not resistant	Note	Test
Water		X			
Salt water	7,5 %	X		Suitable to a limited extent for the use of sea water; steel 1.4301	
Hexane		X			
Heptane		X			
Isopropanol		X			
Soap Solution		X			
Sulfuric acid	20%	-	X		70°C, 240h
Ammonia	32%	X			25°C, 150h
Nitric acid	15%	-	X		70°C, 240h
Acetone		X			
Methylene Chloride			X[1]		
Methanol		X			
Salt spray test		X		Tested 28 days for conformance with DIN EN ISO 9227	
Hydrochloric acid			X		

1   in presence of moisture it can form a bond with hydrochloric acid. There is a risk of pitting corrosion.

7.2.2 Properties of the measuring track

The material characteristic of the measurement object change the static and dynamic measurements. In order to obtain repeatable and traceable measurements, we recommend to adjust the whole measurement loop to the respective shaft material and the corresponding system sensitivity.
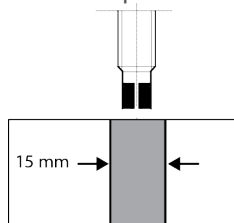

The measuring track must be at least 15 mm wide, demagnetised and free of scratches and cavities. The following values must be observed and maintained to obtain meaningful measurements:

- Roughness $R_a \leq 3.6$
- Roughness depth $R_z < 5$ µm[vi]

Please observe the axial movement of the shaft, too.

Figure 7-1)   Width of the measuring track

[vi] *for large areas of unevenness (2 x 2 mm)*

7.2.3   The required clearances and minimum distances for displacement transmitters

The clearances and minimum distances specified below must be strictly observed when installing the transmitter.

---

i   **NOTE!**

If these clearances and minimum distances must be lowered for design reasons, consult with Brüel & Kjær Vibro beforehand.

	Ceramic tip protruding		Distance to shaft shoulder, displacement transmitter parallel to electrically conductive material
	Ceramic tip flush		Required minimum shaft diameter for a displacement transmitter
	Distance to shaft end		Required minimum shaft diameter for two displacement transmitters mounted at 90° angle
	Distance to the shaft shoulder parallel to electrically conductive material		Displacement transmitters arranged in parallel

7.2.4 Calibration

Calibration allows one to determine the sensitivity of the transmitter system in relation to a given material. This requires recording of a characteristic curve for the material using the DT-120 displacement transmitter:

1. Connect the displacement transmitter as described in the measurement setup (**Figure 4-2**) and align perpendicular to the suitable material sample.
2. Position the displacement transmitter to a small distance voltage U_1 = 2.5 ... 3.5 V and read out and note the voltage U_1 and the measurement distance (D_1) in the unit [mm].
3. Increase the distance D in steps of 0.25 mm (D_x) and read out and note it together with the associated voltages (U_x) in the unit [V]. Repeat this step until a distance voltage U_x > 15 VDC is achieved.
4. Calculate the local sensitivities S_x using the formula:

$$S_x = \frac{U_{x+1} - U_x}{D_{x+1} - D_x} \left[\text{mV/µm}\right] .$$

5. The sensitivity S of the transmitter system results from the arithmetic mean of the calculated local sensitivities S_x.

We recommend performing calibration with the aid of our static calibration device AC-126. There is also the option to send in a suitable sample of the material to have a calibration certificate created.

Calculation of the 20 mA Full Scale value from the transmitter calibration

Based on the determined sensitivity S, the Full Scale value @ 20 mA, which is needed for conversion of the loop current values into measurement values, can now be calculated.

Measurement of the axial position

Calculation of the current AP Full Scale value is done by multiplication of the nominal measurement range of the AP transmitter by the quotient from the nominal sensitivity of 8 mV/µm or 203.2 mV/mil and the sensitivity obtained from the calibration, with reference to the target material used:

$$Full\ Scale_{AP}\ (20\ mA)\ =\ Measurment\ Range_{nom} \cdot \frac{S_{nom}}{S}$$

Measurement of the radial vibration

Calculation of the current RV Full Scale value is done by multiplication of the nominal measurement range of the RV transmitter by the quotient from the nominal sensitivity of 8 mV/µm or 203.2 mV/mil and the sensitivity obtained from the calibration, with reference to the target material used:

$$Full\ Scale_{RV}\ (20\ mA)\ =\ Measurement\ Range_{nom} \cdot \frac{S_{nom}}{S}$$

8   Disposal

Dispose of the devices, cables or displacement transmitters after use in an environmentally friendly manner according to the applicable national regulations.

WEEE Reg. No. DE 69572330

Contact