MAGTROL

Series DI Displacement Transducers

Instruction Manual

1st Edition, Revision A – November 2006

MAGTROL

Revisions To This Manual

The contents of this manual is subject to change without prior notice. Should revisions be necessary, updates to all Magtrol User's Manuals can be found at Magtrol's website at www.magtrol.com/support/manuals.htm.

Please compare the date of this manual with the revision date on the website, then refer to the manual's Table of Revisions for any changes/updates that have been made since this edition.

REVISION DATE

1st Edition, Revision A – November 2006

TABLE OF REVISIONS

Date	Edition	Change	Section(s)

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Preface

PURPOSE OF THIS MANUAL

This manual contains information required for the installation and connection of the Magtrol DI series displacement transducers. To achieve maximum capability and ensure proper use, please read this manual in its entirety before operating. Keep the manual in a safe place for quick reference whenever a question should arise.

WHO SHOULD USE THIS MANUAL

This manual is intended for operators who wish to use displacement transducers to measure displacements or positions. It is assumed that the user has sufficient knowledge in mechanics and electronics to be able to install/operate these transducers without risk.

MANUAL ORGANIZATION

This section gives an overview of the structure of the manual and the information contained therein. Some information has been deliberately repeated in different sections of the document to minimize cross-referencing and to facilitate understanding through reiteration.

The structure of the manual is as follows:

Chapter 1 : INTRODUCTION – Contains technical data sheets of the DI series displacement transducers, which describe its technical characteristics and give a brief overview of its application fields.

Chapter 2 : INSTALLATION / CONFIGURATION – Provides information needed for the mounting and configuration of the DI series displacement transducers to secure a proper operation.

Chapter 3 : OPERATING PRINCIPLE – Describes the physical phenomena used to measure displacements and provides an overview of the DI series displacement transducer's specifications.

Chapter 4 : CALIBRATION – Provides the instructions for zero, gain and maximum output signal after amplification adjustments; it also describes the configuration procedure of the CST 113 signal converter used to provide a calibrated output voltage or current.

Chapter 5 : REPAIR – Provides information on how to return DI series displacement transducers for repair.

Appendix A : DECLARATION OF CE CONFORMITY – Contains the declaration of CE conformity of the Magtrol DI series displacement transducers.

CONVENTIONS USED IN THIS MANUAL

The following symbols and type styles may be used in this manual to highlight certain parts of the text:

Note: This is intended to draw the operator's attention to complementary information or advice relating to the subject being treated. It introduces information enabling the correct and optimal functioning of the product to be obtained.

Caution: This is used to draw the operator's attention to information, directives, procedures, etc. which, if ignored, may result in damage being caused to the material being used. The associated text describes the necessary precautions to take and the consequences that may arise if the precautions are ignored.

WARNING! INTRODUCES DIRECTIVES, PROCEDURES, PRECAUTIONARY MEASURES, ETC. WHICH MUST BE EXECUTED OR FOLLOWED WITH THE UTMOST CARE AND ATTENTION, OTHERWISE THE PERSONAL SAFETY OF THE OPERATOR OR THIRD PARTIES MAY BE PUT AT RISK. THE READER MUST ABSOLUTELY TAKE NOTE OF THE ACCOMPANYING TEXT, AND ACT UPON IT, BEFORE PROCEEDING FURTHER.

1. Introduction

1.1 GENERAL DESCRIPTION

The DI series displacement transducers have been specially developed for contactless displacement measuring in industrial installations. They are used specially in control, regulation and automation applications.

These transducers can be implemented in all sorts of static or dynamic displacement or position measurements. The biggest model features a maximum measuring range of 1000 mm.

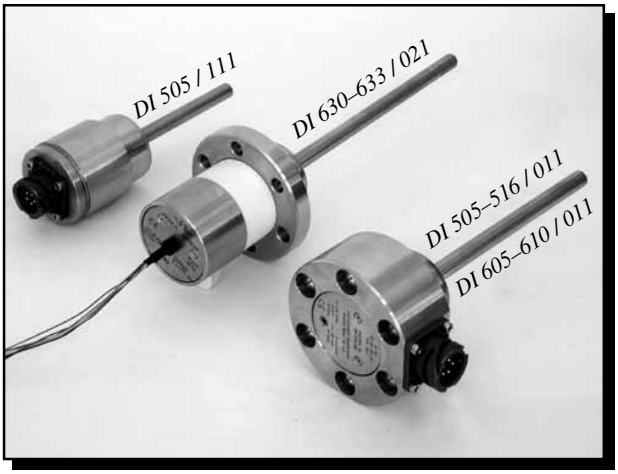
Magtrol offers two versions of position transducers: the standard (DI 5XX) and the high temperature transducer (DI 6XX). They can cope with the most demanding environments while still maintain 100 percent accuracy.

1.2 DATA SHEET

DI Series Displacement Transducers

FEATURES

- Large measuring range: Piston displacements from 50 to 1000 mm; 80 to 250 mm for DI 63X models
- Current-based output signal (4 to 20 mA) for displacement
- Built-in temperature measurement
- Very long life: No moving parts and therefore no wear of components (Eddy-current principle)
- Slim measuring system allowing large measuring range
- Insensitive to metallic impurities in the working fluid
- High shock and vibration resistance
- Capable of withstanding pressures up to 450 bar
- Robust construction, designed for permanent operation in hydraulic systems
- Standard temperature version, up to 80 °C (DI 5XX)
- High temperature versions, up to 125 °C (DI 60X and DI 61X) or up to 200 °C (DI 63X)
- EMC susceptibility conforms to European standards



DESCRIPTION

Magtrol's line of Displacement Transducers provide contactless measurement of absolute piston position in hydraulic and pneumatic cylinders and other applications. Their robust construction, large insensitivity to shocks and very long life (due to no moving parts and therefore no wear of components) make them both cost effective and very reliable. Magtrol transducers offer a wide range of operational temperatures and admissible pressure resistance for even the most demanding applications.

The transducer provides a direct 4–20 mA output signal corresponding to the measuring range, as well as VDC temperature output. As an option Magtrol offers the CST 113 Signal Converter, which allows the complete chain to be calibrated according to the specific needs, either in current or voltage output.

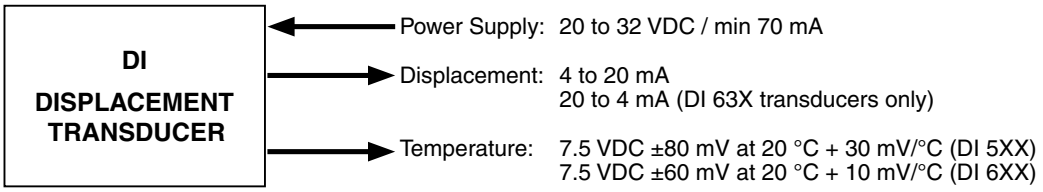
APPLICATIONS

The DI series of displacement transducers were developed principally for OEM applications in the hydraulic industry. They enable the direct and reliable measurement of the position of:

- Hydraulic Cylinders
- Control Valves
- Servo Controls
- Steam Inlet Valves
- Propellers
- Stone Crushers

Their design is such that the installation cost is kept to a minimum. This cost-effectiveness results from the limitation to one fixed standard signal of 4 to 20 mA with very precise determination of the measurement interval (from 0 to full scale) on the sensing element.

BASIC CONFIGURATION



Specifications DI

OPERATING PRINCIPLES

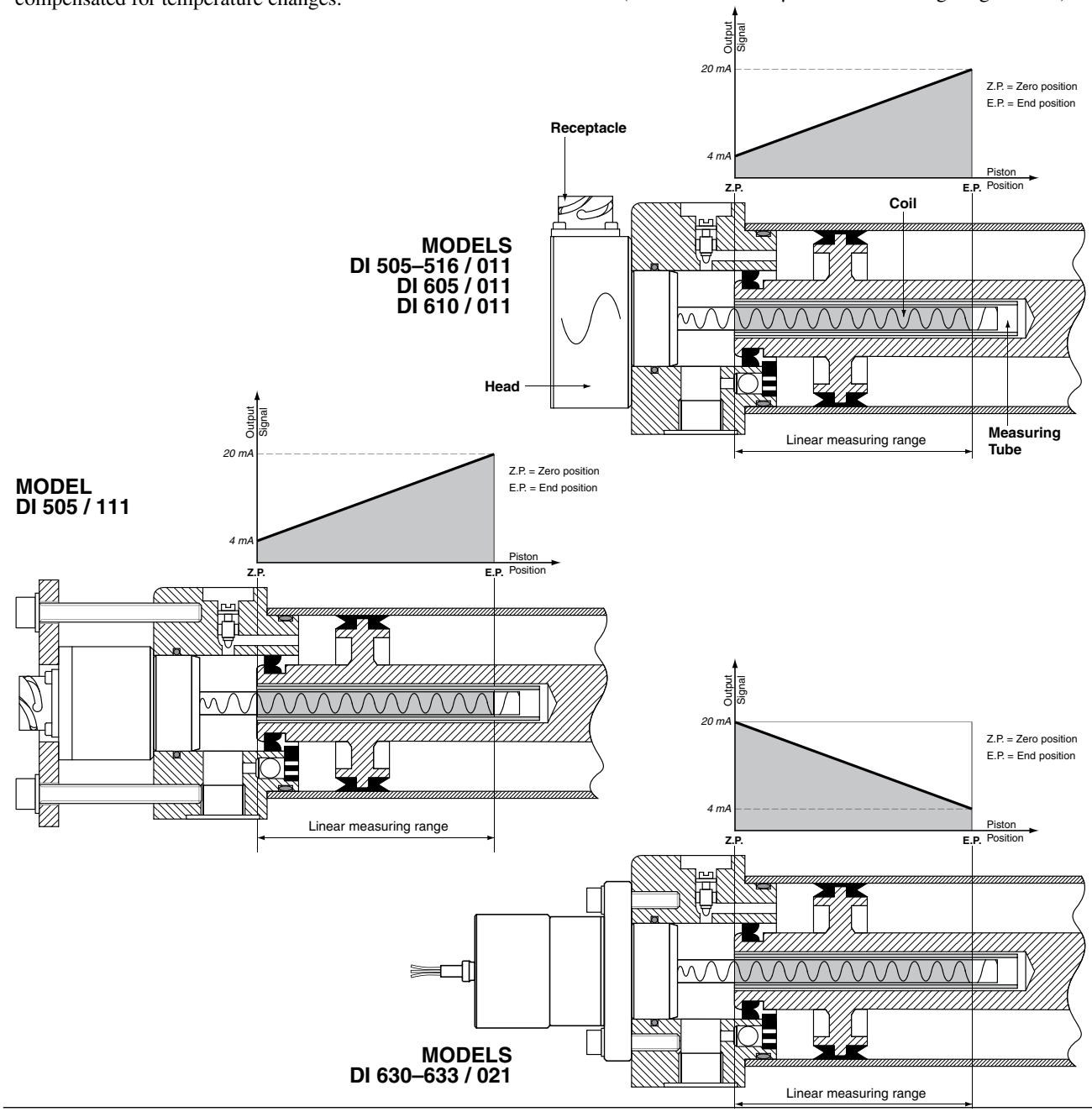
Eddy-Current Principle

Magtrol Displacement Transducers use the principle of Eddy-current measurement. An aluminum tube moves along the transducer's coil changing the induced Eddy-current losses, thus changing the coil impedance. An electronic circuitry housed in the transducer head, transforms the information of the measuring tube position into a linear signal. This circuitry uses modern SMD (surface-mounted device) technology, giving it robustness and reliability. The sensor is actively compensated for temperature changes.

Characteristics of the Output Signal

DI Series Displacement Transducers have a basic 3-wire configuration, providing a 4–20 mA current (20–4 mA for DI 63X transducers) proportional to the position of the aluminum tube. An indication of the temperature within the probe is also provided as a voltage output.

In closed-loop systems, a specific piston position can be repeatedly achieved with a precision better than 0.05‰ full scale (i.e. better than 50 µm for a measuring range of 1 m).



Specifications DI

Version:	Standard Temperature	High Temperature	
Series:	**DI 5XX**	**DI 60X and DI 61X**	**DI 63X**
MEASUREMENT RANGES *			
Rated Values	50, 100, 160, 250, 300, 400, 630 and 1000 mm, according to dimension “D” on drawing	50,100 and 160 mm, according to dimension “D” on drawing	80, 130, 200 and 250 mm, according to dimension “D” on drawing
Zero Position	Defined by inserting the transducer probe into the measurement tube as far as X_{min}		
Full-scale Position	Defined by inserting the transducer probe into the measurement tube as far as X_{max}		
OUTPUT SIGNAL **			
Displacement Output:	Current source with imposed 4 to 20 mA signal. The output current is independent of the load resistance, provided it remains within limits.		
• Zero • Full Scale • Admissible Load • Frequency Response	Adjusted to 4 mA ±0.08 mA Adjusted to 20 mA ±0.15 mA 0 to 500 Ω 0 to 1000 Hz (-1 dB) with 4th-order Butterworth-type response		Adjusted to 20 mA ±0.08 mA Adjusted to 4 mA ±0.15 mA 0 to 500 Ω 0 to 820 Hz (-1 dB) with 4th-order Butterworth-type response
Accuracy: • Linearity Error • Resolution • Repeatability • White noise on output current	0.5%, typically < 1% of FSD < 0.05% of FSD < 0.05% of FSD < 0.2 μA_{eff} / $\sqrt{Hz}$ (DC to 1 kHz)		
Temperature Influence: • On Zero • On Sensitivity • On Drift (zero + sensitivity)	< 150 ppm/°C of FSD < 150 ppm/°C of FSD < 1.5% of FSD over the entire operating temperature range		
Supply Voltage Influence: • On Displacement Measurement • On Temperature Measurement	< 10 ppm of FSD for 1 V variation (DC to 100 Hz) < 0.1°C over the range 20 to 32 VDC		
Temperature Output: • Offset Voltage • Temperature Signal • Output Resistance	7.5 VDC ±80 mV at 20 °C 30 mV/°C, accuracy ±5% typically (±10% max.) 1 kΩ	7.5 VDC ±60 mV at 20 °C 10 mV/°C, accuracy ±10% typically (±20% max.) 1 kΩ	7.5 VDC ±60 mV at 20 °C 10 mV/°C, accuracy ±10% typically (±15% max.) 1 kΩ
POWER SUPPLY			
Supply Voltage	20 to 32 VDC		
Consumption	≤ 70 mA		
Connection	Watertight 5-pole bayonet connector; Watertight mating plug (straight or elbowed)		7 silicon wires: 0.09 mm² length: 0.6 m
Protection Against Polartiy Inversion	No danger to the transducer in event of incorrect connection		
ENVIRONMENTAL			
Operating Temperature	-40° C to +80 °C	-40 °C to +125 °C	Measuring Rod: -40 °C to +200 °C Electronics: -40 °C to +125 °C
Storage Temperature	-45 °C to +130 °C		
Maximum Admissible Pressure	450 bar		
Admissible Shock	Half-sine, duration 3 ms, radial 100 g, axial 300 g		
Protection Class	IP 66, according to DIN 40050		
EMC	According to EN-50081-2 (Generic Emission Standard) and EN-50082-2 (Generic Immunity Standard)		

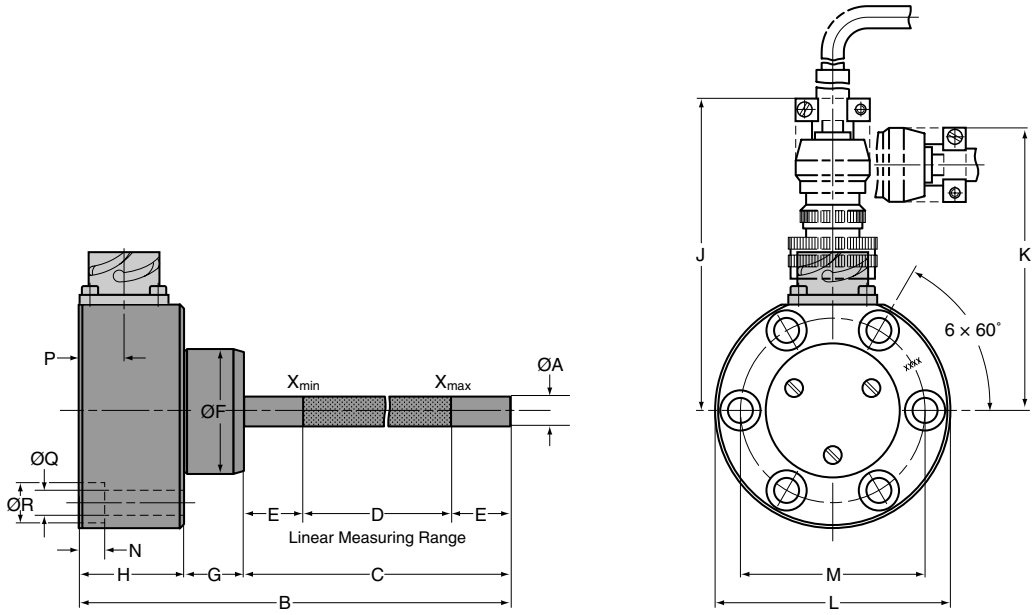
** Refer to drawings on pages 4 and 5.*

*** Calibrated standard signal. Transducer and measuring tube are calibrated in the factory for above-mentioned standard measuring ranges.*

Dimensions DI

NOTE:
Original dimensions are in Metric units. All dimensions listed on this data sheet have been converted to English units, rounded up 2 or 3 decimal places.

MODELS DI 505–516/011 AND DI 605–610/011

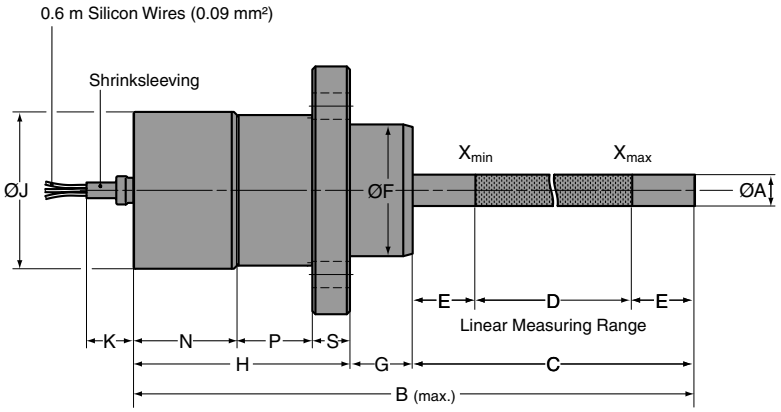


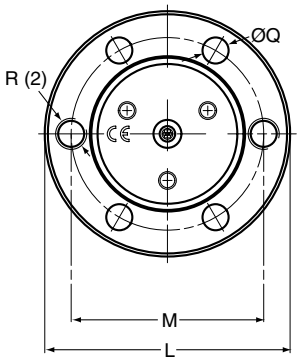
Model	units	ØA	B	C	D	E	ØF	G	H	J	K	L	M	N	P	ØQ	ØR	Weight
DI 505/011* **DI 605/011**	*mm*	10	145	90	50	20	42m6	20	35	≈105	≈95	79	62	8.5	15	8.4	13.5	1.15 kg
	in	0.39	5.71	3.54	1.97	0.79	1.6539/1.6545	0.79	1.38	4.13	3.74	3.11	2.44	0.335	0.59	0.33	0.53	2.54 lb
DI 510/011* **DI 610/011**	*mm*	10	195	140	100	20	42m6	20	35	≈105	≈95	79	62	8.5	15	8.4	13.5	1.25 kg
	in	0.39	7.68	5.51	3.94	0.79	1.6539/1.6545	0.79	1.38	4.13	3.74	3.11	2.44	0.335	0.59	0.33	0.53	2.76 lb
DI 511/011* **DI 611/011**	*mm*	10	255	200	160	20	42m6	20	35	≈105	≈95	79	62	8.5	15	8.4	13.5	1.30 kg
	in	0.39	10.04	7.87	6.30	0.79	1.6539/1.6545	0.79	1.38	4.13	3.74	3.11	2.44	0.335	0.59	0.33	0.53	2.87 lb
DI 512/011*	*mm*	10	345	290	250	20	42m6	20	35	≈105	≈95	79	62	8.5	15	8.4	13.5	1.40 kg
	in	0.39	13.58	11.41	9.84	0.79	1.6539/1.6545	0.79	1.38	4.13	3.74	3.11	2.44	0.335	0.59	0.33	0.53	3.09 lb
DI 513/011	*mm*	20	505	450	400	25	42m6	20	35	≈105	≈95	79	62	8.5	15	8.4	13.5	1.85 kg
	in	0.79	19.88	17.72	15.75	0.98	1.6539/1.6545	0.79	1.38	4.13	3.74	3.11	2.44	0.335	0.59	0.33	0.53	4.08 lb
DI 514/011	*mm*	20	735	680	630	25	42m6	20	35	≈105	≈95	79	62	8.5	15	8.4	13.5	2.20 kg
	in	0.79	28.94	26.77	24.80	0.98	1.6539/1.6545	0.79	1.38	4.13	3.74	3.11	2.44	0.335	0.59	0.33	0.53	4.86 lb
DI 515/011	*mm*	20	1105	1050	1000	25	42m6	20	35	≈105	≈95	79	62	8.5	15	8.4	13.5	2.60 kg
	in	0.79	43.50	41.33	39.37	0.98	1.6539/1.6545	0.79	1.38	4.13	3.74	3.11	2.44	0.335	0.59	0.33	0.53	5.73 lb
DI 516/011*	*mm*	10	395	340	300	20	42m6	20	35	~105	~95	79	62	8.5	15	8.4	13.5	1.70 kg
	in	0.39	15.55	13.39	11.81	0.79	1.6539/1.6545	0.79	1.38	4.13	3.74	3.11	2.44	0.335	0.59	0.33	0.53	3.75 lb

**These transducers are sometimes available with the same head as the DI 505/111 Please consult your Magtrol sales representative.*

Dimensions DI

MODELS DI 630–633/021





NOTE: The cover may have a ±30˚ angular position shift.

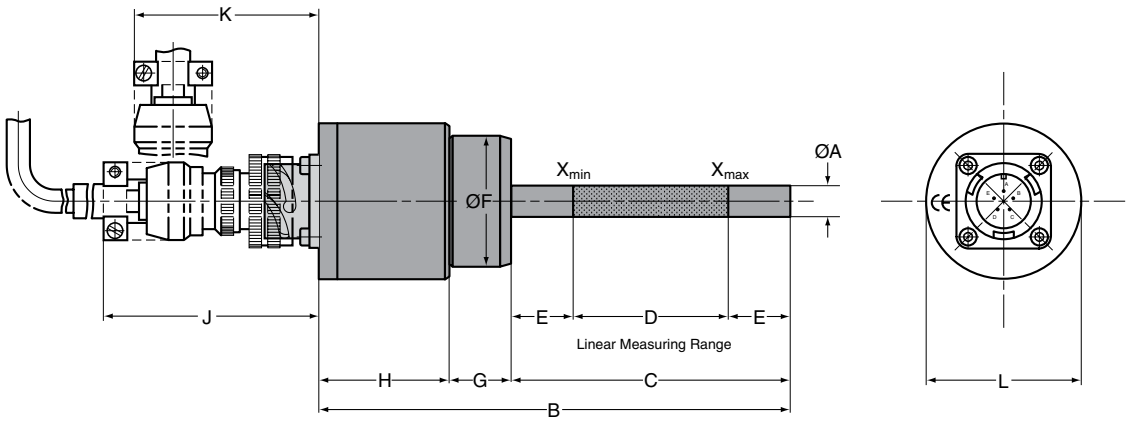
Model	units	ØA	B	C	D	E	ØF	G	H
DI 630/021	*mm*	10	209	120	80	20	42m6	20	69 ±0.05
	in	0.39	8.23	4.72	3.15	0.79	1.6539/1.6545	0.79	2.7146/2.7185
DI 631/021	*mm*	10	259	170	130	20	42m6	20	69 ±0.05
	in	0.39	10.20	6.69	5.12	0.79	1.6539/1.6545	0.79	2.7146/2.7185
DI 632/021	*mm*	10	329	240	200	20	42m6	20	69 ±0.05
	in	0.39	12.95	9.45	7.87	0.79	1.6539/1.6545	0.79	2.7146/2.7185
DI 633/021	*mm*	10	379	290	250	20	42m6	20	69 ±0.05
	in	0.39	14.92	11.42	9.84	0.79	1.6539/1.6545	0.79	2.7146/2.7185

Model	units	ØJ	K	ØL	M	N	P	ØQ	R	S	Weight
DI 630/021	*mm*	50	15	79	62	33	24	8.4	M10	12	1.0 kg
	in	1.97	0.59	3.11	2.44	1.30	0.94	0.33	---	0.47	2.20 lb
DI 631/021	*mm*	50	15	79	62	33	24	8.4	M10	12	1.2 kg
	in	1.97	0.59	3.11	2.44	1.30	0.94	0.33	---	0.47	2.65 lb
DI 632/021	*mm*	50	15	79	62	33	24	8.4	M10	12	1.5 kg
	in	1.97	0.59	3.11	2.44	1.30	0.94	0.33	---	0.47	3.31 lb
DI 633/021	*mm*	50	15	79	62	33	24	8.4	M10	12	1.7 kg
	in	1.97	0.59	3.11	2.44	1.30	0.94	0.33	---	0.47	3.75 lb

Note : The models DI 63x are also available with protection cover (see picture below) and 3 meter cable. Please contact Magtrol.

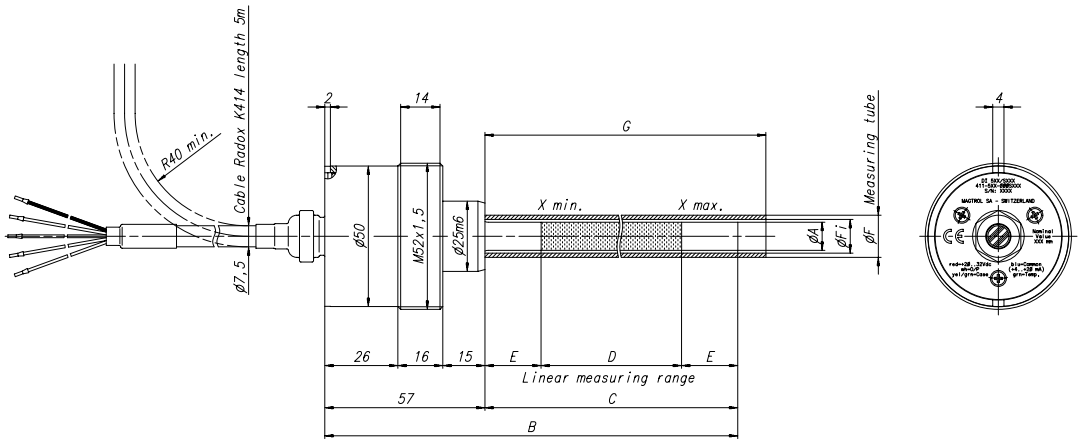
DI

MODEL DI 505/111



Model	units	ØA	B	C	D	E	ØF	G	H	J	K	L	Weight
DI 505/111	*mm*	10	153	90	50	20	42m6	20	43	70	60	50	1.1 kg
	in	0.39	6.02	3.54	1.97	0.79	1.6539/1.6545	0.79	1.69	2.76	2.36	1.97	2.43 lb

MODELS WITH THREADED HEAD M52 x 1.5

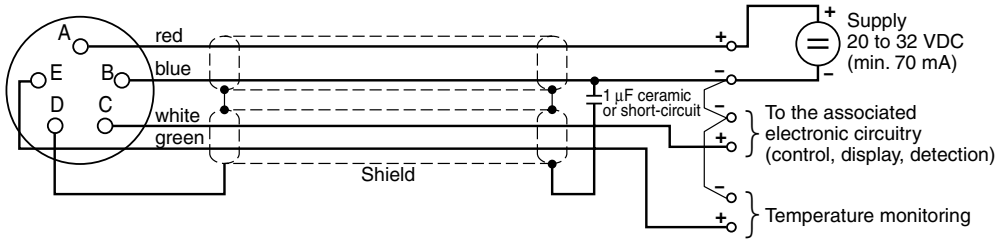


Model	units	ØA	B	C	D	E	ØF	ØFi	G
DI 510/S006	*mm*	10	197	140	100	20	15	12	150
	in	0.39	7.75	5.51	3.9	0.79	0.6	0.47	6
DI 511/S006	*mm*	10	257	200	160	20	15	12	210
	in	0.39	10.12	7.87	6.3	0.79	0.6	0.47	8.27
DI 512/S006	*mm*	10	347	290	250	20	15	12	300
	in	0.39	13.66	11.42	9.84	0.79	0.6	0.47	11.81
DI 516/S006	*mm*	10	397	340	300	20	15	12	350
	in	0.39	15.63	13.38	11.81	0.79	0.6	0.47	13.78

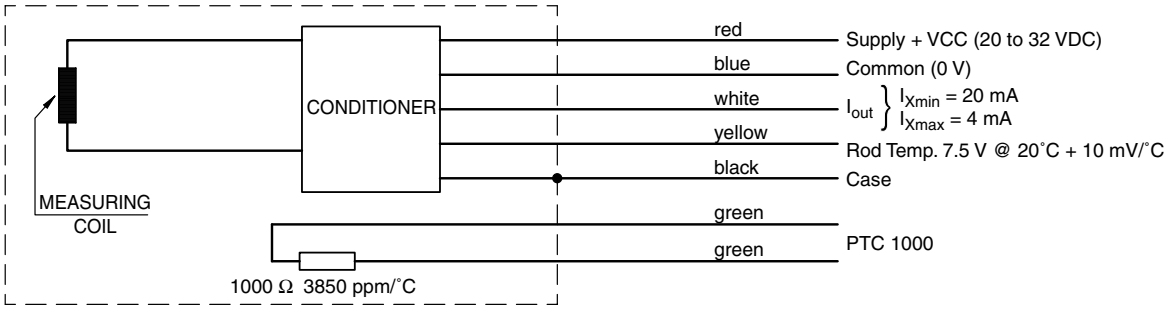
Specifications DI

WIRING DIAGRAMS

DI 5XX, DI 60X and DI 61X Transducers



DI 63X Transducers



TUBE DIMENSIONS

Measurement Tube

Magtrol supplies the DI displacement transducer with the appropriate measurement tube, which is manufactured from EN AW-6060 T6 aluminum (Al Mg Si 0.5). This ensemble constitutes the calibrated system (4 to 20 mA; 20 to 4 mA for DI 63X).

Tube in Transducer Model	Outer Diameter		Inside Diameter		Length		Part Number*
	mm	*in*	*mm*	*in*	*mm*	*in*	
DI 505 / DI 605	13±0.15	0.5157/0.5079	11	0.43	100	3.94	411-505-021-011
DI 510 / DI 610	15±0.15	0.5945/0.5866	12	0.47	150	5.91	411-210-121-011
DI 511 / DI 611	15±0.15	0.5945/0.5866	12	0.47	210	8.27	411-211-121-011
DI 512 / DI 633	15±0.15	0.5945/0.5866	12	0.47	300	11.81	411-212-121-011
DI 513	26±0.20	1.0283/1.0189	22	0.87	460	18.11	411-213-122-011
DI 514	26±0.20	1.0283/1.0189	22	0.87	690	27.17	411-214-122-011
DI 515	28±0.20	1.1102/1.0945	24	0.94	1060	41.73	411-215-123-011
DI 516	15±0.15	0.5945/0.5866	12	0.47	350	13.78	411-216-121-011
DI 630	15±0.15	0.5945/0.5866	12	0.47	130	5.12	111-230-901-011
DI 631	15±0.15	0.5945/0.5866	12	0.47	175	6.89	111-231-901-011
DI 632	15±0.15	0.5945/0.5866	12	0.47	245	9.65	111-232-901-011

2. Installation / Configuration

2.1 DISPLACEMENT TRANSDUCERS COMPONENTS

DI series displacement transducers contain two components:

- the displacement transducer encapsulated in a watertight stainless steel housing
- the aluminium measuring tube EN AW-6060 T6 (Al Mg Si 0.5).

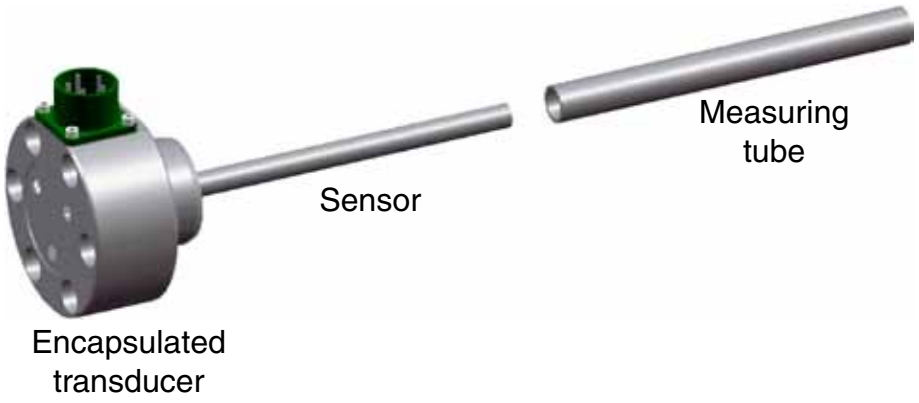


Fig. 2–1 Displacement transducers components

The aluminium tube must be placed in the mobile part, the transducer's body must be placed in the fixed part of the installation. *Figure 2–2* shows how both parts are fitted in a hydraulic cylinder.

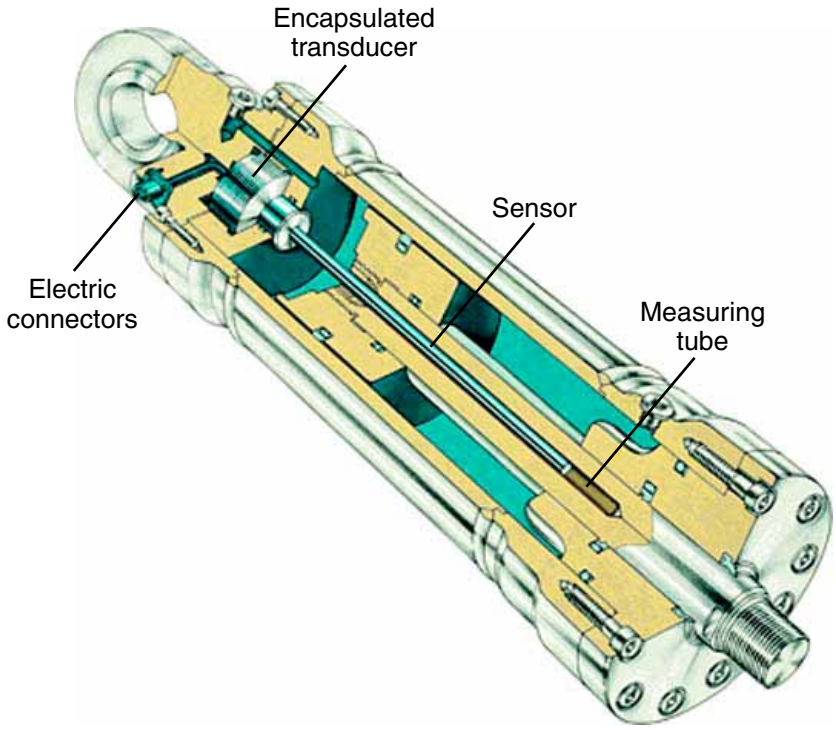


Fig. 2–2 Installation of both transducer parts

2.2 OUTPUT SIGNAL

The DI series displacement transducers deliver a current output signal in the range of 4 to 20 mA for the DI 5XX, DI 605 and DI 610 models, where 20 mA correspond to the maximum position. For the DI 63X models the output signal ranges from 20 to 4 mA, where in this case 20 mA correspond to the minimum position. Between those extreme values the measuring is linear. In *figures 2–3* and *2-4* P_{min} corresponds to the measure with retracted measuring tube, P_{max} corresponds to the reading when the measuring tube is in its drawn-out position.

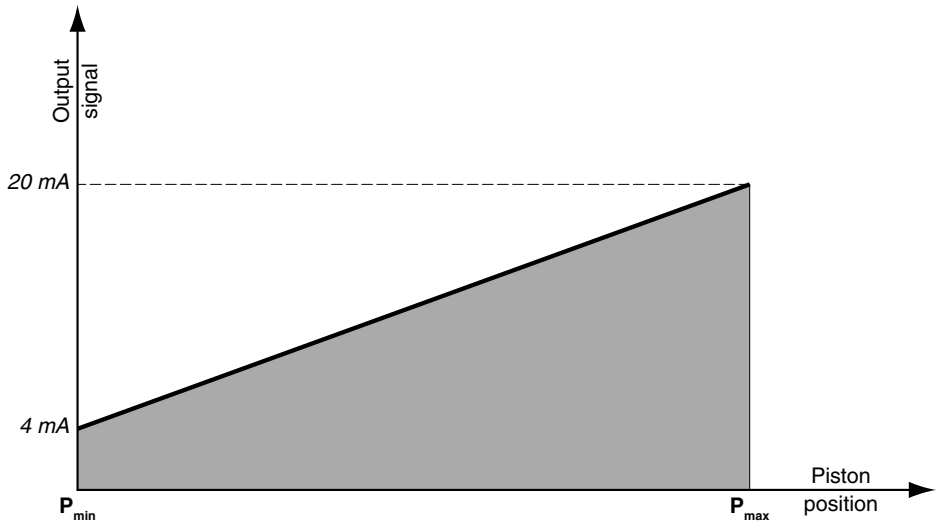


Fig. 2–3 DI 5XX, DI 605 and DI 610 models output signal

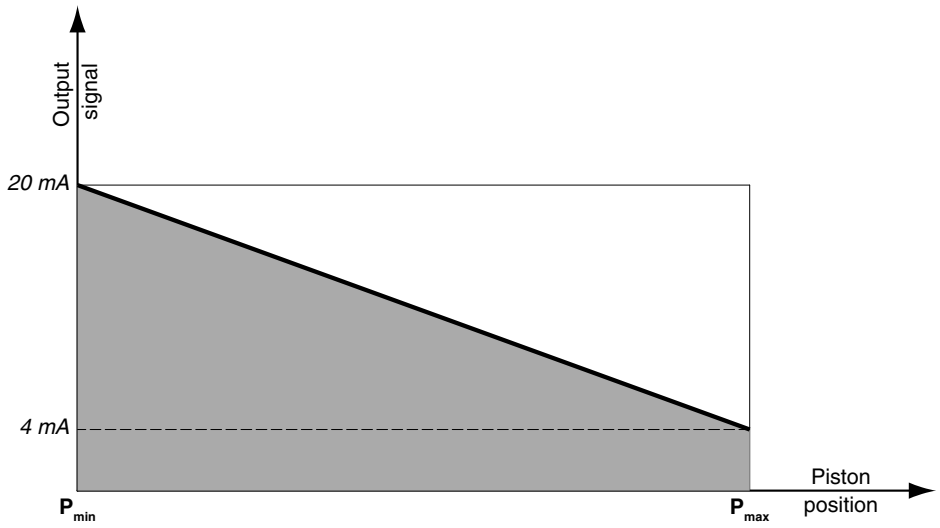


Fig. 2–4 DI 63X model output signal

Note: The measuring range does not correspond to the full length of the transducer. In fact, 20 or 25 mm at each end of the transducer, depending on the model, do not provide a linear measuring signal and can therefore not be used (see data sheet).

2.3 MOUNTING INSTRUCTIONS

The DI 5XX/011, DI 605/011 and DI 610/011 displacement transducers are screwed into the fixed part by means of 6 M8 hexagon socked-head cap screws, which length depends on the thickness of the wall on which the displacement transducer has to be fixed.

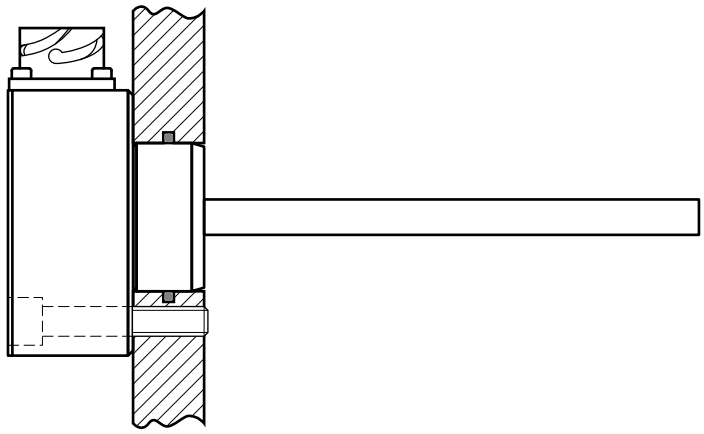


Fig. 2–5 DI 510/011 displacement transducer mounting

The DI 63X/021 displacement transducer are fixed by means of 4 M8 hexagon socked-head cap screws and washers. Both M10 size threaded holes allow for an easy extraction of the transducer from his seat.

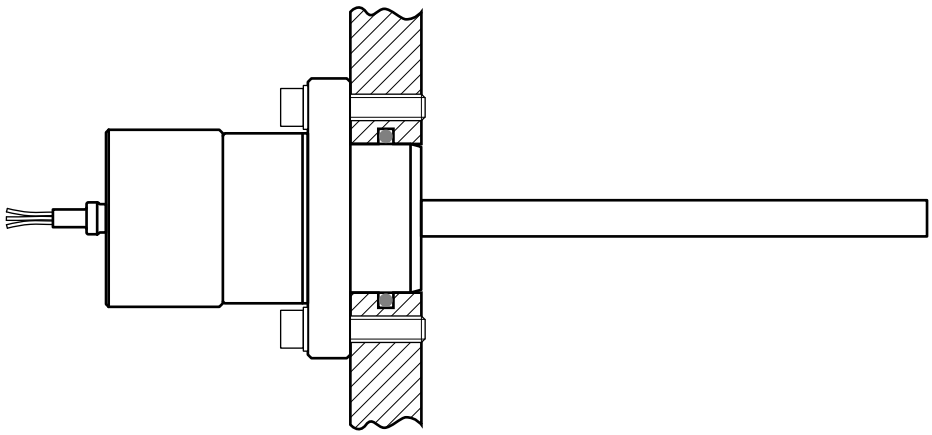


Fig. 2–6 DI 630/021 displacement transducer mounting

The DI 505/111 displacement transducer is fixed by means of a plate and at least 4 screws with as many washers. The size of the fixing components depends on the measuring application.

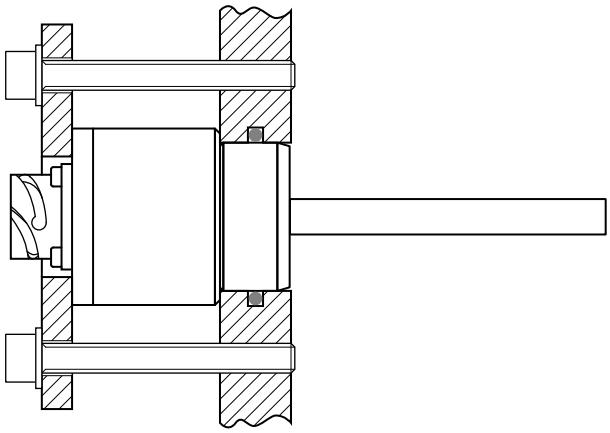


Fig. 2–7 DI 510/111 displacement transducer mounting

The necessary tightness between the fixed part and the transducer is provided by an O-ring type sealing mounted in a grove. The choice of sealing and the exact dimensions of the grove depend on the operating pressure inside the cylinder. This is specially important for hydraulic applications. The sealing ring manufacturer is qualified to advise the user of the correct choice.

If the DI displacement transducer is mounted near strong magnetic fields or near another DI it may be necessary to provide shielding for the probe. If the transducer mounting is similar to that shown in *figures 2–5* to *2-7*, the sides of the cylinder provide the shielding.

2.4 MEASURING TUBE MOUNTING

The aluminium measuring tube EN AW-6060 T6 (Al Mg Si 0.5), which is intended to be inserted into the measuring object can be pressed, glued or screwed. *Figures 2–8* and *2-9* show examples of fixings by means of headless screws or by clamping.

Fig. 2–8 Measuring tube fixing using headless screws

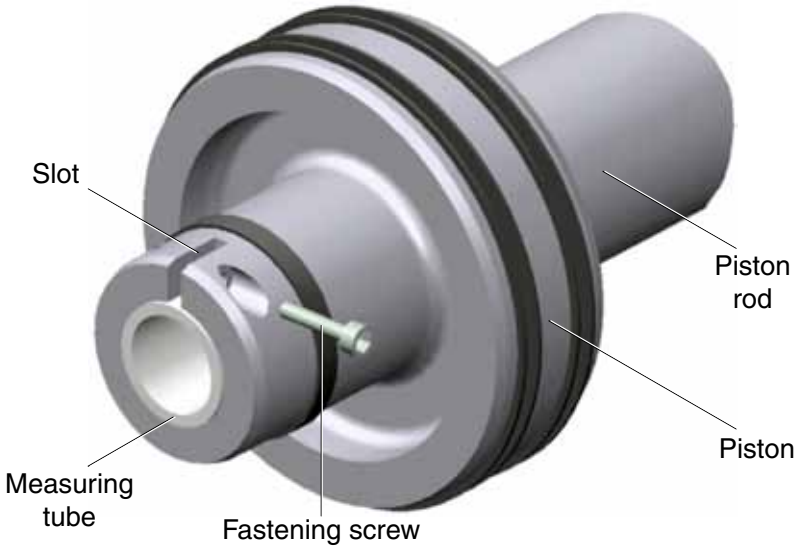


Fig. 2–9 Measuring tube fixing by clamping

Note: Slightly eccentrically mounted measuring tubes do not influence the measuring signal. However they increase the risk of the transducer rubbing against the tube.

2.4.1 ALUMINIUM MEASURING TUBE

If the diameters $D_{outside}$ and D_{inside} of the following table are not respected there will probably be a degradation in the system's linearity, as well as in the sensitivity and temperature compensation. Additionally, this will deregulate the calibration of the output signal that was performed in the factory.

Transducer	Outside diameter	Inside diameter	Length
DI 505/011	13 ±0.1	11	100
DI 505/011	13 ±0.1	11	100
DI 510/011	15 ±0.1	12	150
DI 511/011	15 ±0.1	12	210
DI 512/011	15 ±0.1	12	300
DI 513/011	26 ±0.12	22	460
DI 514/011	26 ±0.12	22	690
DI 515/011	28 ±0.2	24	1060
DI 516/011	15 ±0.1	12	350
DI 605/011	13 ±0.1	11	100
DI 610/011	15 ±0.1	12	150
DI 630/021	15 ±0.1	12	130
DI 631/021	15 ±0.1	12	175
DI 632/021	15 ±0.1	12	245
DI 633/021	15 ±0.1	12	300

2.5 ELECTRICAL CONNECTIONS

2.5.1 DI 5XX, DI 605 AND DI 610 TRANSDUCER WIRING

The DI 5XX, DI 605 and DI 610 displacement transducers are fitted with a bayonet type connector. This connector is wired as shown in *figure 2–10* with 4 shielded 0.38 mm^2 wires protected by a RADOX type sleeve. Three lengths are available: 3 m. 5 m and 10 m.

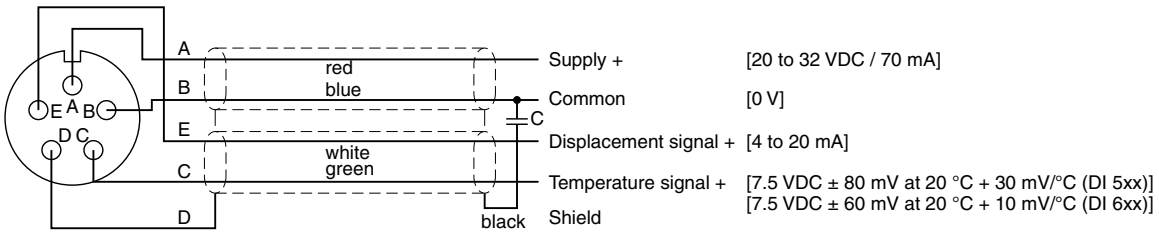


Fig. 2–10 Connecting cable

Note: The 1 µF condenser C may be replaced by a short-circuit.

Straight or right angle watertight mating plugs are available (see *figure 2–11)*.

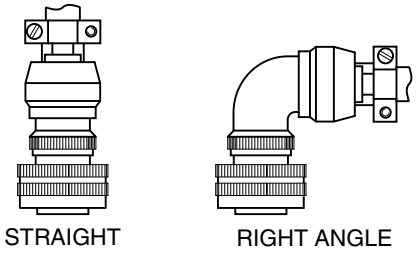


Fig. 2–11 Mating plugs

Note: The DI series displacement transducers are protected against short-circuits and polarity reversal.

2.5.2 DI 63X TRANSDUCER WIRING

The DI 63X displacement transducers are supplied with a wire assembly jutting out of the transducer head and held together with a stuffing gland and a shrinksleeving. The connections are to be carried out as shown on *figure 2–12*. The connecting cable is 600 mm long and the 0.09 mm^2 wires are silicon isolated.

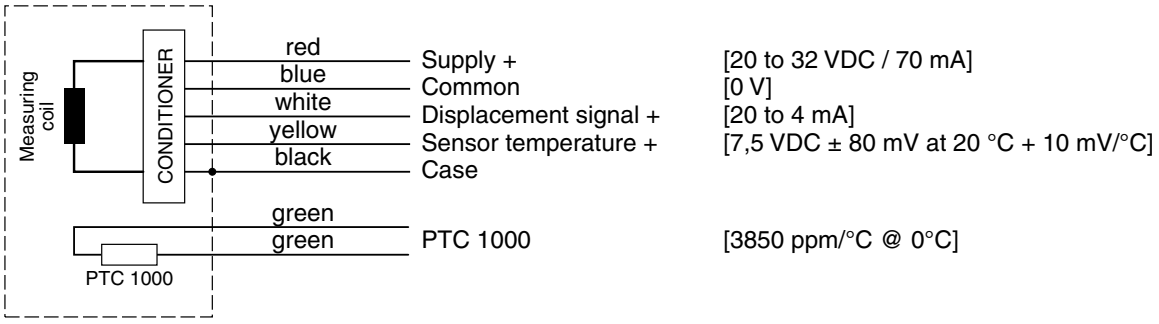


Fig. 2–12 DI 63X displacement transducer connecting cable

Contrary to the rest of the transducers the DI 63X series transducers generate an output current of 20 mA, when the sensor is completely retracted in the measuring tube, and of 4 mA, when it is in its drawn-out position.

The green wires are used to measure the temperature of the housing containing the electronic components. Temperature measurement is carried out by means of a platinum type PTC 1000 resistance.

Note: The DI series displacement transducers are protected against short-circuits and polarity reversal.

2.5.3 TRANSMITTED SIGNALS

2.5.3.1 Supply

- The supply unit must be connected between terminal "Supply +" and "Common (0 V)".
- The supply voltage must range between 20 and 32 V.
- The supply current must range between 50 mA and 70 mA.

2.5.3.2 Measuring signal

- The displacement value is available as a current-based signal between terminal "Displacement signal +" and "Common (0 V)".

2.5.3.3 Temperature signal

- The temperature value is available as a voltage-based signal between terminal "Sensor temperature +" and "Common (0 V)".
- This output can be used to make temperature measurements or to signal alarms.
- The voltage drop in the power supply return line produces a static error in the temperature measurement. This error is often neglected as it is < +1.7 °C for 10 m of cable.

3. Operating Principle

3.1 MEASUREMENT PRINCIPLE

The DI series displacement transducers contain a sensor, the impedance of which is used for measurement. The transducers are fitted with a coil generating a 10 kHz magnetic field when using sensors of less than 10 mm diameter and of 4 kHz with all other sensors. This field propagates along the sensor and leaves it radially. If passing through a metallic conductor it generates Eddy currents. The loss of energy caused by these Eddy currents generates a change in the coil impedance, which is proportional to the displacement. The embarked electronics measure the variation of the impedance and generates an output current between 4 and 20 mA, or 20 and 4 mA for the DI 63X transducers.

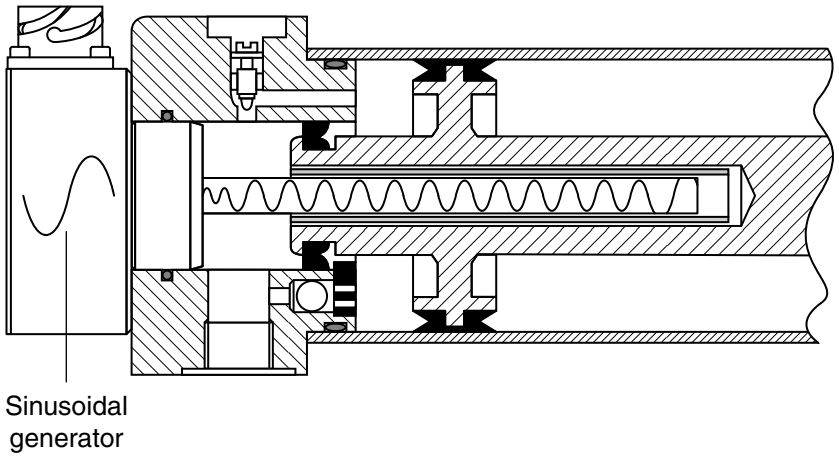


Fig. 3–1 Measuring principle

To secure the measuring repeatability as well as its temperature stability the tube in which the transducer's sensor moves must feature an electric conductivity in relation with the temperature behaviour of the sensor. The material best coping with this criteria is aluminium EN AW-6060 T6 (Al Mg Si 0.5). As the installations in which the transducers are mounted do not use this alloy, Magtrol supplies a measuring tube with each transducer.

3.2 TEMPERATURE MEASUREMENT

The DI series displacement transducers are fitted with a temperature measuring system used to compensate the effect of the temperature on the measuring circuit and to raise the sensor operating temperature. The temperature measuring signal obeys to following laws:

3.2.1 FOR THE DI 5XX MODELS

$$\text{Temperature [°C]} = \frac{\text{Measured voltage [V]} - 7.5\text{ [V]}}{0.03\text{ [V/°C]}} + 20\text{ [°C]}$$

3.2.2 FOR THE DI 6XX MODELS

$$\text{Temperature [°C]} = \frac{\text{Measured voltage [V]} - 7.5\text{ [V]}}{0.01\text{ [V/°C]}} + 20\text{ [°C]}$$

Note: Additionally, the DI 63X models are fitted with a PTC 1000 temperature sensor. To know the temperature just measure the resistance between both terminals of the green cable. At 0 °C this resistance of 1000 Ω obeys the following law: $R_{PTC\ 1000}\ [\Omega] = 1000\ [\Omega]\ (1 + 3.85 \cdot 10^{-3}\ [°C^{-1}] \cdot T\ [°C^{-1}])$

3.3 ADVANTAGES COMPARED TO OTHER MEASURING PRINCIPLES

The DI series displacement transducers have been developed to cope with the disadvantages suffered by other displacement and position measuring systems. Magtrol displacement transducers offer the advantage of contactless measurement of displacement and position.

3.3.1 EASY MOUNTING

The DI series displacement transducers are relatively easy to mount. Compared to transducers using a mobile ferromagnetic core, Magtrol transducers don't require a precise guiding of the core. In fact, as long as the transducers sensor does not touch the EN AW-6060 T6 aluminium measuring tube, there will be no wear and the displacement measurement will remain optimal.

3.3.2 INSENSITIVENESS TO MECHANICAL PERTURBATIONS

The DI series displacement transducers are insensitive to shocks and vibrations as they are contactless. They are therefore by far superior to transducers using potentiometers with respect to their reliability and operating life. Additionally they offer a full-scale resolution < 0.05%. This represents a precision in the order of 50 µm for the biggest model featuring a full scale of 1000 mm.

3.3.3 ROBUST CONSTRUCTION

The DI series displacement transducer's electronics is encapsulated in a stainless steel housing. The transducer's sensor is also in stainless steel. It offers great resistance to chemical attacks and supports pressures of up to 450 bars. With their particularly robust construction and IP 66 (DIN 40050) protection class these transducers can be used in the most extreme conditions. They are specially appreciated in the hydraulic and in the metal processing industry, as well as in steam turbine power stations.

4. Calibration

The DI series displacement transducers deliver a current between 4 and 20 mA. This signal must be processed to obtain the displacement or position information. The output can remain as a current-based signal or be converted into a voltage by using a signal converter such as the CST 113 converter proposed by Magtrol.

Note: It may be interesting to output a signal expressing directly millimetres, centimetres, metres, inches or yards.

4.1 SENSOR SENSITIVITY

Each DI series displacement transducer features a specific sensitivity $S_{I/P}$ indicated in the following table :

Model	Sensor sensitivity $S_{I/P}$
	mA/mm
DI 505	0.32
DI 510	0.16
DI 511	0.10
DI 512	0.64
DI 513	0.04
DI 514	0.0254
DI 515	0.016
DI 516	0.0533
DI 605	0.32
DI 610	0.16
DI 630	-0.20
DI 631	-0.123
DI 632	-0.080
DI 633	-0.064

4.2 VOLTAGE OUTPUT

To confirm an application specific output voltage proceed as follows:

- Calculate the output sensitivity: $S_{O/P}$ [V/mm]
- Determine the sensor sensitivity: $S_{I/P}$ [mA/mm]
- Calculate the ratio $K_U = S_{O/P} / S_{I/P}$ [V/mA]

4.2.1 Calculation of the output sensitivity $S_{O/P}$

The output sensitivity $S_{O/P}$ is calculated according to the effective distance measured by the displacement transducer in a given application and the desired full-scale output voltage. The sensitivity is therefore simply calculated by selecting the maximum voltage, for example 10 V, and dividing it by the displacement of the sensor, for instance 200 mm for a DI 512 series transducer.

By using these values one gets the following output sensitivity $S_{O/P}$ = 10 V / 200 mm = 0.05 V/mm.

4.2.2 Determination of the sensor sensitivity $S_{I/P}$

The sensitivity $S_{I/P}$ of the sensor to be used is indicated in *Section 4.1–Sensor sensitivity*.

4.2.3 Calculation of the ratio K_U

The ration K_U corresponds to the gain to be applied on the input signal to obtain the required output signal. It is calculated by dividing the output sensitivity by the input sensitivity.

Example: $K_U = S_{O/P} / S_{I/P}$ = 0.05 V/mm / 0.064 mA/mm = 0.781 V/mA.

4.3 CURRENT OUTPUT

To confirm an application specific output voltage proceed as follows:

- Calculate the output sensitivity: $S_{O/P}$ [mA/mm].
- Calculate the input sensitivity: $S_{I/P}$ [mA/mm].
- Calculate the ratio $K_I = S_{O/P} / S_{I/P}$.

4.3.1 Calculation of the output sensitivity $S_{O/P}$

The output sensitivity $S_{O/P}$ is calculated according to the effective distance measured by the displacement transducer in a given application and the desired full-scale output voltage. The sensitivity is therefore simply calculated by selecting the maximum current, for example 16 mA and dividing it by the displacement of the sensor, for instance 200 mm for a DI 512 series transducer.

With the preceding example one gets the following output sensitivity $S_{O/P}$ = 16 mA / 200 mm = 0.080 mA/mm.

4.3.2 Determination of the sensor sensitivity $S_{I/P}$

The sensitivity $S_{I/P}$ of the sensor to be used is indicated in *Section 4.1–Sensor sensitivity*.

4.3.3 Calculation of the ratio K_I

The ration K_I corresponds to the gain to be applied on the input signal to obtain the required output signal. It is calculated by dividing the output sensitivity by the input sensitivity.

Example: $K_I = S_{O/P} / S_{I/P}$ = 0.080 mA/mm / 0.064 mA/mm = 1.25.

4.4 CST 113 SIGNAL CONVERTER CONFIGURATION

CAUTION : ELECTROSTATIC DISCHARGES CAN DAMAGE THE CST 113 SIGNAL CONVERTER. THEREFORE ALWAYS USE AN ANTISTATIC BRACELET WHEN HANDLING THE CONVERTER.

To configure the CST 113 simply proceed as follows:

- Configure the micro-switches SWA9 and SWA10
- Configure the micro-switches SWB1 to SWB5
- Adjust the mechanical zero
- Adjust the offset
- Adjust the output signal selected for the maximum position.

The various adjustable components are show in *figure 4–1*. Do not touch any other elements on the board.

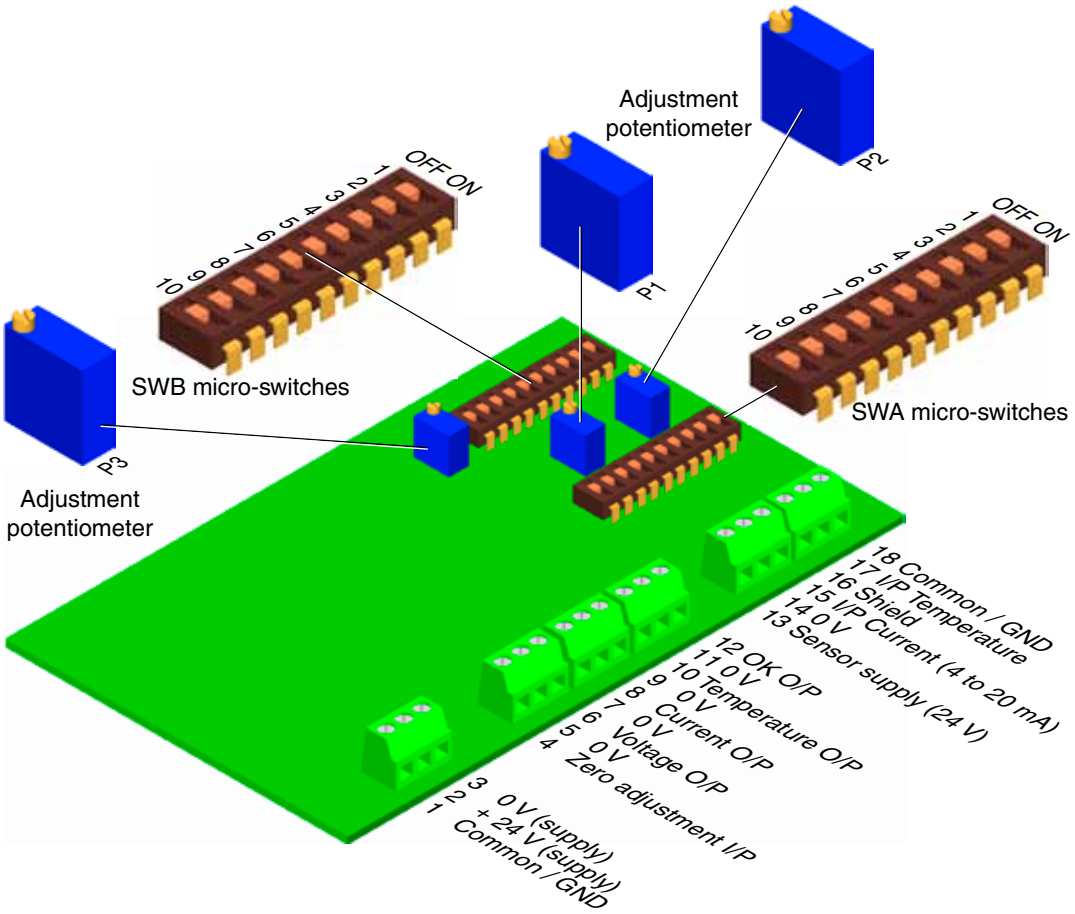
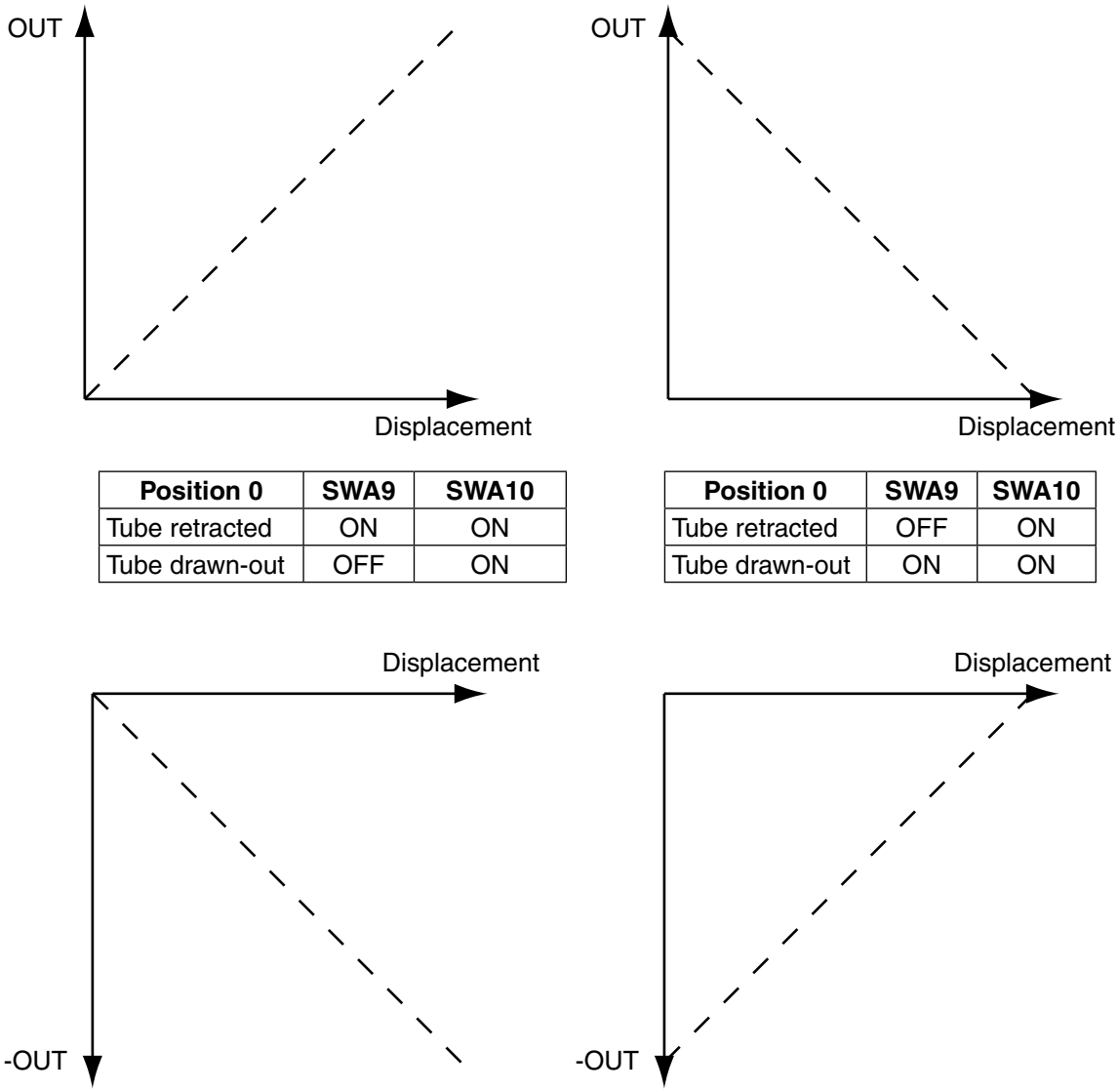


Fig. 4–1 Position of the adjustable components on the board and terminal allocation

4.4.1 CONFIGURATION OF THE SWA-MICRO-SWITCHES

The micro-switches SWA9 and SWA10 are used to select the signal amplification type: inverting or non-inverting, with positive or negative offset. The configuration of the micro-switches depends on the sensor position while taking the zero reference.



Position 0	SWA9	SWA10
Tube retracted	ON	ON
Tube drawn-out	OFF	ON

Position 0	SWA9	SWA10
Tube retracted	OFF	ON
Tube drawn-out	ON	ON

Position 0	SWA9	SWA10
Tube retracted	OFF	OFF
Tube drawn-out	ON	OFF

Position 0	SWA9	SWA10
Tube retracted	ON	OFF
Tube drawn-out	OFF	OFF

Fig. 4–2 Gain configuration

Note: Unlike all other transducers, the DI 63X series displacement transducers generate their maximum current of 20 mA when their measuring tube is drawn-out and the minimum current of 4 mA, when it is retracted.

4.4.2 Configuration of the SWB1 to SWB5 Micro-switches

Having calculated the gain K_U or K_I, the micro-switches SWB1 to SWB5 allow to select the gain range for the signal converter. The following tables show the different operating ranges depending on the configuration of the micro-switch SWB.

For a voltage-based operation of the converter the gains are indicated in the following table:

$K_{U\ min}$	$K_{U\ max}$	SWB1	SWB2	SWB3	SWB4	SWB5
0.217	0.364	OFF	OFF	OFF	OFF	OFF
0.346	0.585	ON	OFF	OFF	OFF	OFF
0.548	0.924	ON	ON	OFF	OFF	OFF
0.864	1.459	ON	ON	ON	OFF	OFF
1.387	2.346	ON	ON	ON	ON	OFF
2.191	3.705	ON	ON	ON	ON	ON

For a current-based operation of the converter the gains are indicated in the following table::

$K_{I\ min}$	$K_{I\ max}$	SWB1	SWB2	SWB3	SWB4	SWB5
0.434	0.728	OFF	OFF	OFF	OFF	OFF
0.692	1.170	ON	OFF	OFF	OFF	OFF
1.096	1.848	ON	ON	OFF	OFF	OFF
1.728	2.918	ON	ON	ON	OFF	OFF
2.774	4.692	ON	ON	ON	ON	OFF
4.382	7.410	ON	ON	ON	ON	ON

4.4.3 Mechanical zero adjustment

The mobile elements must be placed in minimum position for mechanical zero adjustment. Proceed as follows to carry out the mechanical zero adjustment:

1. Connect a voltmeter between terminals 4 and 5 of the electronic board.
2. Check that the micro-switches SWA1 to 8 are on OFF.
3. Switch successively the micro-switches SWA1 to 8 ON to get a voltage as close as possible to 0 V.
4. Adjust the potentiometer P1 to obtain 0 V ±10 mV.

4.4.4 Offset adjustment

After having adjusted the mechanical zero, the mobile element must remain in minimum position. Proceed as follows to carry out the offset adjustment:

1. Connect a voltmeter between terminals 6 and 7 or an ammeter between terminals 7 and 8 depending on the desired output (voltage or current).
2. Check that the micro-switches SWA6 to 10 are OFF.
3. Switch successively the micro-switches SWA6 to 10 ON to get a voltage as close as possible to 4 mA.
4. Adjust the potentiometer P2 to obtain the requested voltage or current.

4.4.5 OUTPUT SIGNAL ADJUSTMENT

After having determined the gain range the mobile element must be placed in maximum position to carry out the fine adjustment of the gain. Proceed as follows to adjust the output signal:

1. Connect a voltmeter between terminals 6 and 7 or an ammeter between terminals 8 and 9 depending on the desired output (voltage or current).
2. Adjust the potentiometer P3 to obtain the desired voltage or current (for example 10 V in maximum position).

4.4.6 SIGNAL MONITORING

The CST 113 signal converter is fitted with a function for monitoring the signal generated by the sensor. This function is accessible between terminals 12 (OK O/P) and 11 (0 V) as an open collector output used only to supply an information and interfering in no way with the measuring chain.

During normal operation, the open collector output is closed. The sensor supply current is < 80 mA and its measuring signal is between 2 mA and 22 mA.

When a problem arises, the open collector output is opened and indicates either a defect link between the sensor and the signal converter or a supply short-circuit. Anomalies on the temperature measuring chain are not taken into account.

Note: For more information on the CST 113 signal converter see its data sheet, downloadable on *www.magtrol.com*.

5. Repair

5.1 REPAIR

In case of a defect please return the product defect report with the dynamometer and the following information:

- Model number, part number P/N, serial number S/N, order number and date of purchase.
- Description of the defect and the conditions in which it appeared.
- Description of the application (drawing, photographs, sketches, etc.).
- Description of the instrumented element (drawing, photographs, sketches, etc.).
- Description of the test cycle.

To guaranty the measuring precision and the repair of the product in the best possible time follow the procedure outlined here :

- Carefully pack the displacement transducer.
- Join the product defect report indicating the problem(s) encountered.

Note : Do not hesitate to contact Magtrol's Customer Service for any additional information.

Appendix A : Declaration of CE conformity

MAGTROL SA SWITZERLAND	Formulaire - Q **Declaration of conformity CE**	*Document No :* **Do033E** *Date :* 26.02.2002 *Visa :*evon

	Declaration of conformity	DEC No : **005**	CE

We,

MAGTROL SA
Rte de Moncor 4B
CH-1701 Fribourg (Suisse)

Herewith declare that the following products :

Family Types

Contactless displacement transducers : DI series

which are mentioned in this declaration, meet all requirements defined in:

89/336/CEE Electromagnetic compatibility (EMC) / applicable for Magtrol products.
93/68/CEE Instruction of marking of 89/336/CEE (and the following).

Those products have been developed and manufactured according to the processes described in Magtrol's Manual conformity with the EN29001 / ISO 9001 norm.

For the evaluation of these products, following norms have been taken into account:

EN 50081-2 generic EMISSION Standard part 2 : industrial environment

EN 50082-2 generic IMMUNITY Standard part 2 : industrial environment.

	Place and date of emission	Name and signature
Duly allowed Magtrol's Representative	Fribourg - 3 MAI 2002	J. Cattin
		E. Vonlanthen

Magtrol Limited Warranty

Magtrol, Inc. warrants its products to be free from defects in material and workmanship under normal use and service for a period of twenty-four (24) months from the date of shipment. Software is warranted to operate in accordance with its programmed instructions on appropriate Magtrol instruments. This warranty extends only to the original purchaser and shall not apply to fuses, computer media, or any other product which, in Magtrol's sole opinion, has been subject to misuse, alteration, abuse or abnormal conditions of operation or shipping.

Magtrol's obligation under this warranty is limited to repair or replacement of a product which is returned to the factory within the warranty period and is determined, upon examination by Magtrol, to be defective. If Magtrol determines that the defect or malfunction has been caused by misuse, alteration, abuse or abnormal conditions of operation or shipping, Magtrol will repair the product and bill the purchaser for the reasonable cost of repair. If the product is not covered by this warranty, Magtrol will, if requested by purchaser, submit an estimate of the repair costs before work is started.

To obtain repair service under this warranty, purchaser must forward the product (transportation prepaid) and a description of the malfunction to the factory. The instrument shall be repaired at the factory and returned to purchaser, transportation prepaid. **MAGTROL ASSUMES NO RISK FOR IN-TRANSIT DAMAGE.**

THE FOREGOING WARRANTY IS PURCHASER'S SOLE AND EXCLUSIVE REMEDY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, OR FITNESS FOR ANY PARTICULAR PURPOSE OR USE. MAGTROL SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OR LOSS WHETHER IN CONTRACT, TORT, OR OTHERWISE.

CLAIMS

Immediately upon arrival, purchaser shall check the packing container against the enclosed packing list and shall, within thirty (30) days of arrival, give Magtrol notice of shortages or any nonconformity with the terms of the order. If purchaser fails to give notice, the delivery shall be deemed to conform with the terms of the order.

The purchaser assumes all risk of loss or damage to products upon delivery by Magtrol to the carrier. If a product is damaged in transit, PURCHASER MUST FILE ALL CLAIMS FOR DAMAGE WITH THE CARRIER to obtain compensation. Upon request by purchaser, Magtrol will submit an estimate of the cost to repair shipment damage.

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