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JUMO CTI-500

Inductive Conductivity/Concentration and Temperature Transmitter with switch contacts

Type 202755

Brief description

The instrument is used for the measurement/control of conductivity or concentration in liquid media. It is particularly suitable for application in media where severe deposits of dirt, oil, grease or gypsum/lime precipitates are to be expected. The integrated temperature measurement enables fast and accurate temperature compensation, which is of special importance when measuring conductivity. Additional functions permit the combined changeover of measuring range and temperature coefficient.

Two built-in switching outputs can be freely programmed to monitor conductivity/concentration and/or temperature limits. It is also possible to assign alarm and control functions (dilution).

The instrument is operated either from the membrane keypad and plain-text graphics display (operator language can be changed over) or through the user-friendly PC setup program. The display can be read off by simply rotating the housing cover. This applies to the installation both in horizontally and vertically arranged pipes. By using the setup program, the instrument configuration data can be saved for plant documentation and printed out. To prevent any tampering, the instrument can also be supplied without keypad or display. In this case, the setup program is needed for programming.

The JUMO CTI-500 is available either as a combined unit (transmitter and measuring cell together in one unit) or as a split version (transmitter and cell connected by cable). The split version is particularly suitable for plant subjected to strong vibration and/or significant heat radiation at the measurement point, or for installation on sites that are difficult to access. Immersion models up to 2000 mm are available for application in open containers or sluices.

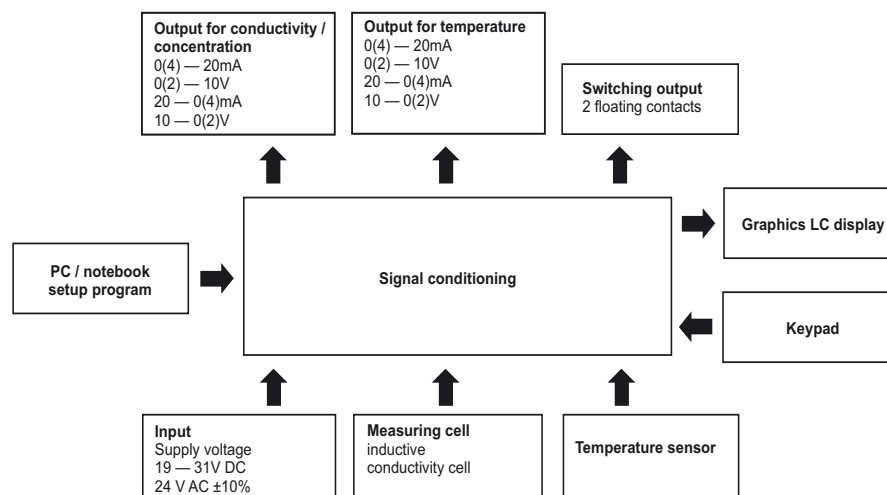
Typical areas of application: Freshwater and wastewater engineering, air conditioning systems and cooling tower monitoring (dilution control), rinsing baths (e.g. monitoring electroplating baths), inlet and final checks in factory water treatment plant, concentration monitoring, vehicle wash plant, etc.



Key features

- Activation of up to four ranges
- Activation of up to four temperature coefficients
- Concentration measurement of
 - caustic soda NaOH
 - nitric acid HNO₃
 - a freely definable curve (through the setup program)
- Fast-response temperature sensor
- Temperature compensation
 - linear
 - natural water
 - individual characteristic (learning function)
- Operation
 - via keypad and LC display
 - through setup program
- Operator languages: English, French, German, Italian, Dutch, Spanish, Polish, Portuguese, Russian, Swedish
- By using the setup program:
 - user-friendly programming
 - plant documentation
- Learning function for the temperature coefficient
- Individual characteristic for concentration indication
- Dilution control

Block structure



Functional description

The inductive measurement method permits largely maintenance-free acquisition of the specific conductivity, even in the toughest media conditions. As opposed to the conductive measurement method, problems such as electrode decomposition and polarization do not occur.

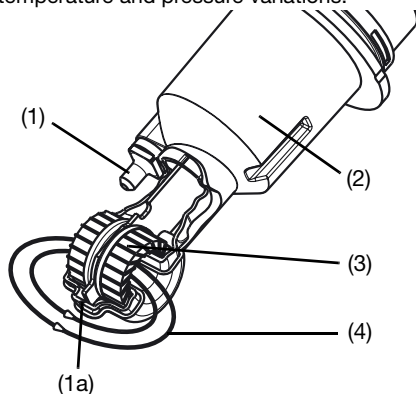
The conductivity is measured using an inductive probe. A sinusoidal a.c. voltage feeds the transmitting coil. Depending on the conductivity of the liquid to be measured, a current is induced in the receiver coil. The current is proportional to the conductivity of the medium.

Instrument description

Measuring cell

The measuring cell consists of a hermetically sealed polypropylene (PP) or polyvinylidene fluoride (PVDF) body inside which the two measurement coils are arranged. A bore in the measuring cell enables the medium to flow through. The measurement principle entails an inevitable electrical isolation between the sample medium and the signal output.

The measuring cell is largely unaffected by temperature and pressure variations.



- (1) Temperature sensor, exposed
- (1a) optionally: internal
- (2) Cell body in PP
- (3) Measurement coils
- (4) Liquid loop

Exposed temperature sensor

The sensor (in a stainless steel sleeve) exhibits a very fast response to temperature variations. This is especially important for CIP processes (phase separation).

Internal temperature sensor

The sensor is integrated in the PP body. This construction ensures that no metal parts come into contact with the sample medium (important with corrosive media). However, temperature acquisition is somewhat slower here.

Temperature compensation

Since conductivity largely depends on the temperature of the medium, it is usually necessary to compensate for the temperature effect.

The instrument allows both linear and non-linear temperature compensation.

If required, temperature compensation can be switched off, for example, when the temperature conditions on the measurement site are stable or when temperature compensation is carried out in the software, in external evaluation devices (PLC or similar).

Process connections

To cover a wide variety of applications, the instrument can be supplied with different process connections (also as an immersion model), see dimensions.

Installation at the measurement point

The operating position is generally unrestricted. However, it is essential to ensure that there is a continuous exchange of the sample liquid in the flow channel.

Transmitter

The CTI-500 transmitter has been designed for use on site. A rugged housing protects the electronics and the electrical connections from corrosive environmental conditions (IP67).

A vent screw with a PTFE membrane prevents condensation.

Operation

The JUMO CTI-500 can be operated either from the instrument keys and the graphics LC display and/or through the setup program from a PC or laptop.

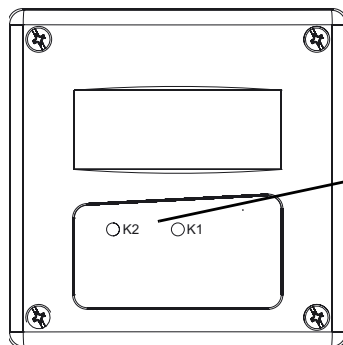
The instrument can be secured against unauthorized alteration by a password.

Functions of the outputs

Analog outputs

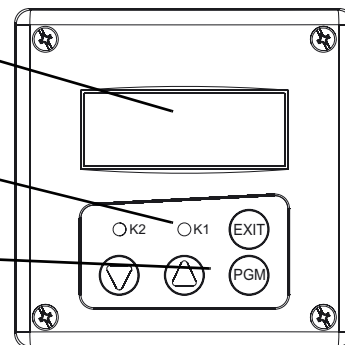
- ❑ One analog signal output for conductivity/concentration and temperature respectively.
- ❑ The analog output signals are freely scalable (range start and end values).
- ❑ The response of the analog outputs to over/underrange or alarm can be programmed.
- ❑ Simulation of the signal output:
The analog signal outputs can be freely set in the manual mode.
Application: "Dry-run" start-up of the plant, trouble-shooting, servicing.

Displays and controls



Version without a display
 Operation/configuration through the setup program only

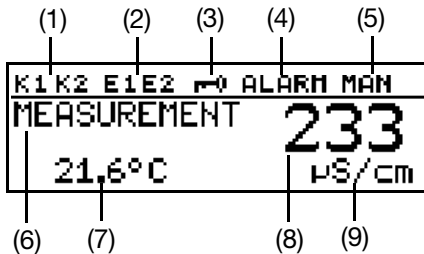
- (1) Graphics LC display
- (2) LEDs for the switching status indication of the outputs K1 and K2
- (3) Keys



Version with a display
 Operation/configuration from the keys or through the setup program



Graphics LC display



- (1) Switching output 1 or 2 is active
- (2) Binary input 1 or 2 is operated
- (3) Keypad is inhibited
- (4) Alarm has been activated
- (5) Instrument is in manual mode
- (6) Instrument status
- (7) Temperature of medium
- (8) Conductivity measurement
- (9) Unit of conductivity measurement

Switching outputs

The instrument features two floating switching outputs (solid-state relays) as standard.

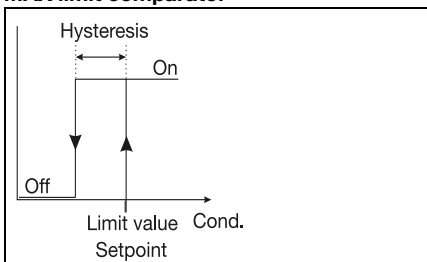
These can be used freely for monitoring the conductivity/concentration or the temperature.

The following functions can be assigned:

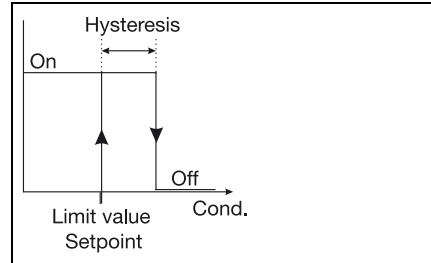
- ☐ Limit monitoring (MAX. or MIN. limit comparator) with programmable hysteresis
- ☐ Pulse function (the output switches briefly on reaching the switching point, then opens again).
- ☐ Pull-in and drop-out delay
- ☐ Inverted switching outputs
- ☐ Response to overrange/underrange or with activated measuring circuit monitoring (pull-in/drop-out).
- ☐ "Calibration timer run down" signal.

Contact functions

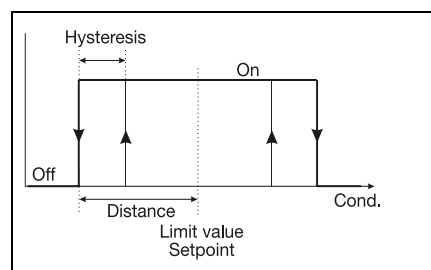
MAX limit comparator



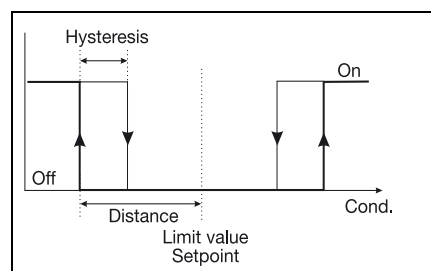
MIN limit comparator



Alarm window 1

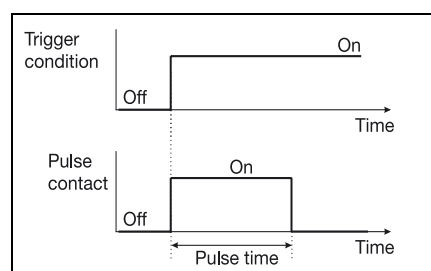


Alarm window 2



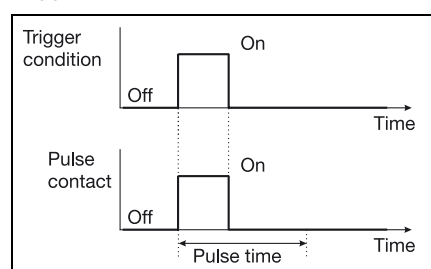
Pulse contact

Trigger conditions longer than pulse time



Pulse contact

Trigger conditions shorter than pulse time



Binary inputs

The two binary inputs serve to implement the following functions:

- Key inhibit
- HOLD mode
- 4-fold range changeover
- 4-fold temperature coefficient changeover
- Initiation of dilution function and biocide dosing

Special functions

- The learning function for the temperature coefficient enables exact measurement of media with a non-linear characteristic. During a temperature change, the instrument "learns" the temperature coefficient of the present medium and stores the profile. The stored values then enable the correct indication of the temperature-compensated conductivity.

- Individual characteristic for concentration indication.

An individual characteristic with 20 interpolation points can be entered through the setup program. This function can be used to generate special characteristics for specific media (e.g. special detergents). This results in correct measurements that contribute to assuring the quality and saving costs.

- Dilution control
Various processes that find their application in wet cooling towers are stored as sequence control (biocide dosing and subsequent inhibiting of dilution). Additional information can be found in the operating manual.

- Calibration timer
The calibration timer draws your attention to a calibration schedule. This function is activated by entering a number of days, after which recalibration has to be carried out (plant or operator requirement).

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Function of the binary inputs

Setting parameters		Binary input 1	Binary input 2
Measuring range/ temperature coefficient changeover	Range1/TC1	open	open
	Range2/TC2	closed	open
	Range3/TC3	open	closed
	Range4/TC4	closed	closed
Key inhibit		closed	X
"Hold" function		X	closed
Start dilution function		close (edge 0 - 1)	open
Stop dilution function		open	close (edge 0 - 1)

Meas. ranges Transmitter	Tolerance (in % of range span)
0 — 500 µS/cm	≤0.5%
0 — 1000 µS/cm	
0 — 2000 µS/cm	
0 — 5000 µS/cm	
0 — 10 mS/cm	
0 — 20 mS/cm	
0 — 50 mS/cm	
0 — 100 mS/cm	
0 — 200 mS/cm	
0 — 500 mS/cm	
0 — 1000 mS/cm	
0 — 2000 mS/cm ¹	

Note:

The overall tolerance is made up of the tolerance of the transmitter + the tolerance of the sensor.

Technical data

General

A/D converter

resolution: 15 bit
 sampling time: 500msec = 2 meas. per sec

Supply

For operation with SELV and PELV circuits.
 As standard:
 19 — 31 V DC (24 V DC nominal),
 the instrument incorporates reverse-polarity protection
 ripple: < 5%
 extra code 844:
 24 V AC ±10%, 50 — 60 Hz
 power consumption
 with display: ≤ 3 W
 power consumption
 without display: ≤ 2.6 W

Rating of the solid-state relays

U < 50 V AC/DC
 I ≤ 200 mA

Electrical connection

plug-in screw terminals 2.5 mm² or
 M12 plug/socket connectors

Display (option)

graphics LCD with background lighting;
 contrast is adjustable
 dimensions: 62 x 23 mm

Permissible ambient temp. (transmitter)

-5 to +50°C
 max. 93% rel. humidity, no condensation

Permissible storage temp. (transmitter)

-10 to +75°C
 max. 93% rel. humidity, no condensation

Enclosure protection (transmitter)

IP67

Housing

polyamide (PA)

Weight

depending on version and process connection
 approx. 0.3 — 2 kg

Conductivity/concentration transmitter

Concentration measurement

(implemented in the instrument software)

- NaOH (caustic soda)
 0 — 15 % by weight or 25 — 50 % by weight
- HNO₃ (nitric acid)
 0 — 25 % by weight or 36 — 82 % by weight
- customer-specific concentration curve,
 reely programmable through the setup program (see "special functions")

Calibration timer

adjustable: 0 — 999 days (0 = off)

Output signal for conductivity/concentration

0 — 10 V / 10 — 0 V
 2 — 10 V / 10 — 2 V
 0 — 20 mA / 20 — 0 mA
 4 — 20 mA / 20 — 0.4 mA
 The output signal is freely scalable.

Burden

≤ 500Ω for current output
 ≥ 2kΩ for voltage output

Analog output with "Alarm"

Low (0 mA / 0 V / 3.4 mA / 1.4 V)
 or
 High (22.0 mA / 10.7 V)
 or
 a fixed setting

Measuring ranges

Four ranges can be selected. One of these ranges can be activated via an external switch or a PLC.

Temperature transmitter

Temperature acquisition

manually -20.0 to 25.0 to 150°C/°F
 or automatically

Temperature measuring range

-20.0 to 150°C/°F

Characteristic

linear

Accuracy

≤ 0.5% of measuring range

Ambient temperature error

≤ 0.1%/°C

Response time

with exposed temperature sensor
 $t_{99} \leq 6$ sec
 with internal temperature sensor
 $t_{99} \leq 2$ min

Output signal for temperature

0 — 10 V / 10 — 0 V
 2 — 10 V / 10 — 2 V
 0 — 20 mA / 20 — 0 mA
 4 — 20 mA / 20 — 0.4 mA

The output signal is freely scalable within the range -20 to +200°C.

The sensor can be applied within the range -10 to +100°C.

Burden

≤ 500Ω for current output
 ≥ 2kΩ for voltage output

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Analog output for "Alarm"

Low (0 mA / 0 V / 3.4 mA / 1.4 V)
 or
 High (22.0 mA / 10.7 V)
 or
 a fixed setting

Temperature compensation

Reference temperature

15 to 30 °C, adjustable

Temperature coefficient

0.0 to 5.5 %/°C, adjustable

Compensation range

-20 to 150 °C

Function

- linear
- natural water (EN 27 888)
- non-linear (learning function, see special functions)

Sensor

Material

PP (polypropylene), suitable for foodstuffs

Note:

Temperature, pressure and sample medium affect the life of the cell!

Temperature of the sample medium

Process-connection	max. temperature
168	60 °C
169	80 °C
607	short term
617	100 °C
690	

Pressure

10 bar max. at 20 °C
 6 bar max. at 60 °C

Measuring range Sensor	Tolerance (in % of range span)
0 – 500 µS/cm	≤1%
0 – 1000 µS/cm	
0 – 2000 µS/cm	≤0.5%
0 – 5000 µS/cm	
0 – 10 mS/cm	
0 – 20 mS/cm	
0 – 50 mS/cm	
0 – 100 mS/cm	
0 – 200 mS/cm	≤1%
0 – 500 mS/cm	
0 – 1000 mS/cm	
0 – 2000 mS/cm ¹	

¹ not compensated for temperature

Electrical connection - head transmitter (transmitter with cable glands (-82))

Wiring recommendation - head transmitter

Supply and signal output
 (conductivity / concentration and temperature)

Cable gland
 M12 (PA)

Binary input

Cable gland
 M12 (PA)

Switching outputs

Cable gland
 M16 (PA)

Wiring recommendation - with separate sensor

Supply and signal output
 (conductivity / concentration and temperature)

Cable gland
 M12 (PA)

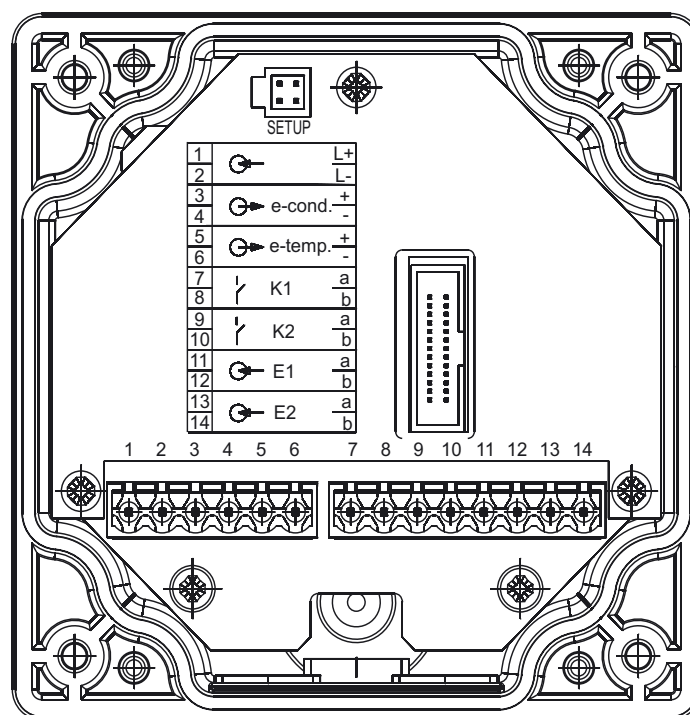
Binary input

Switching outputs

Cable gland
 M12 (PA)

Separate sensor

M12 built-in plug connector



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Supply	Terminal assignment		Symbol
Supply (with reverse-polarity protection)	1 2	L + L -	

Outputs	Terminal assignment		Symbol
Analog signal output: conductivity/ concentration (electrically isolated)	3 4	+ -	
Analog signal output: temperature (electrically isolated)	5 6	+ -	
Switching output K1 (floating)	7 8		
Switching output K2 (floating)	9 10		

Binary inputs	Terminal assignment		Symbol
Binary input E1	11 12		
Binary input E2	13 14		

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Electrical connection (transmitter with M12 connectors (-83))

Head transmitter

Connector I

Supply and
signal output for conductivity /
concentration

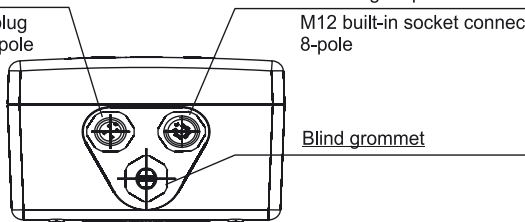
M12 built-in plug
connector, 5-pole

Connector II

Signal output for temperature
and binary input
Switching outputs

M12 built-in socket connector
8-pole

Blind grommet



Transmitter with separate sensor

Connector I

Supply and
signal output for conductivity /
concentration

M12 built-in plug
connector, 5-pole

Connector II

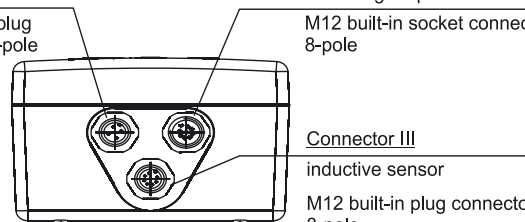
Signal output for temperature
and binary input
Switching outputs

M12 built-in socket connector
8-pole

Connector III

inductive sensor

M12 built-in plug connector
8-pole



Supply	Connector	Assignment	Symbol
Supply (with reverse-polarity protection)	I	L + L -	

Outputs	Connector	Assignment	Symbol
Analog signal output: conductivity/ concentration (electrically isolated)	I		
Analog signal output: temperature (electrically isolated)	II		
Switching output K1 (floating)	II		
Switching output K2 (floating)	II		

Binary inputs	Connector	Assignment	Symbol
Binary input E1	I II		
Binary input E2	I II		

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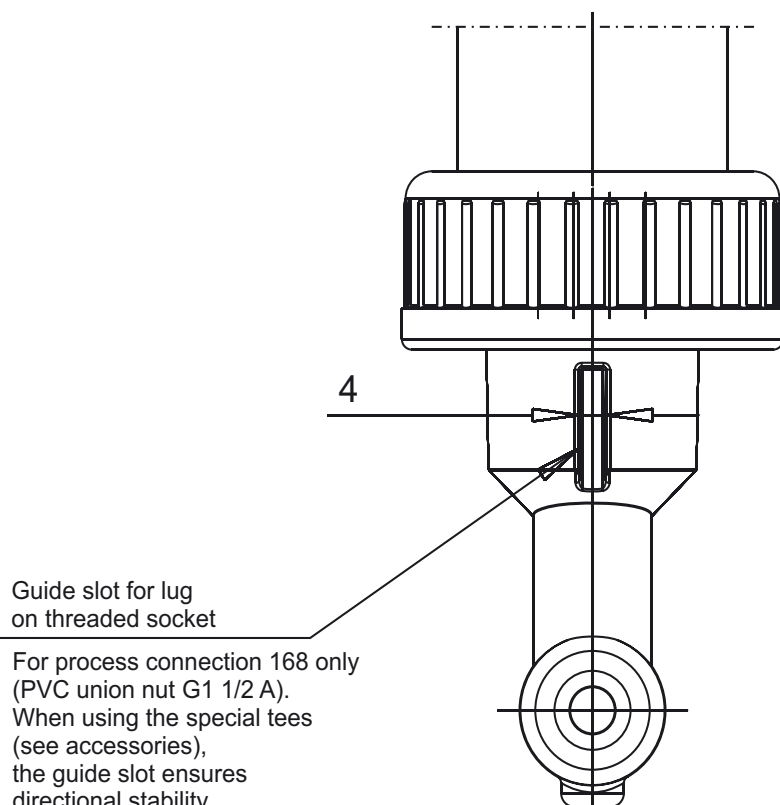
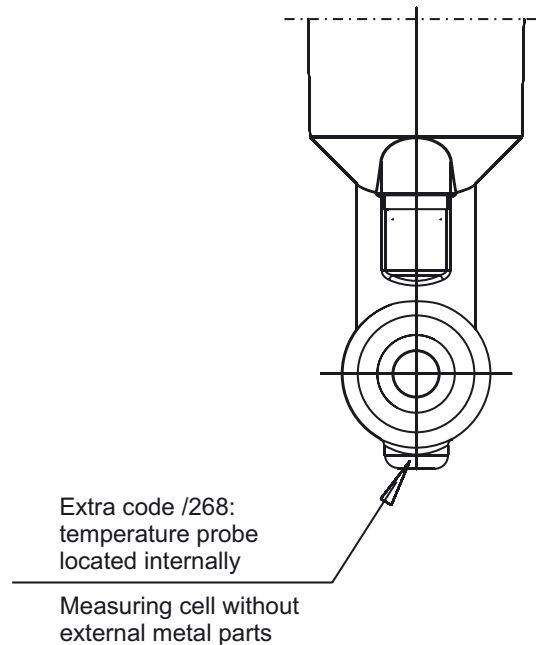
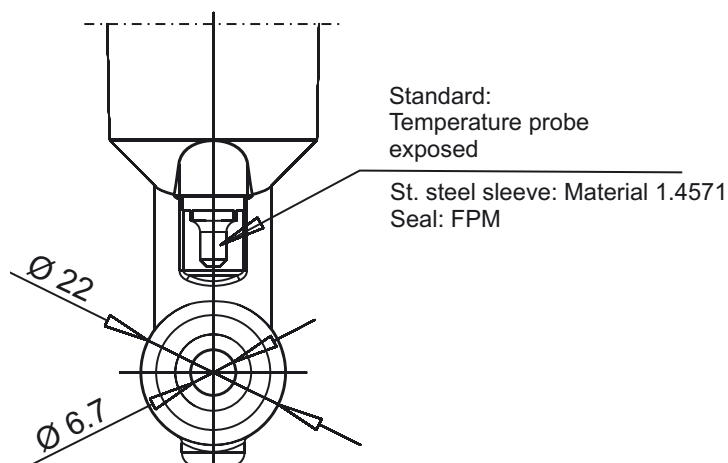
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Dimensions

Sensor (detail)



For process connection 168 only
 (PVC union nut G1 1/2 A).
 When using the special tees
 (see accessories),
 the guide slot ensures
 directional stability.
 The cell can only be installed
 in the correct orientation.

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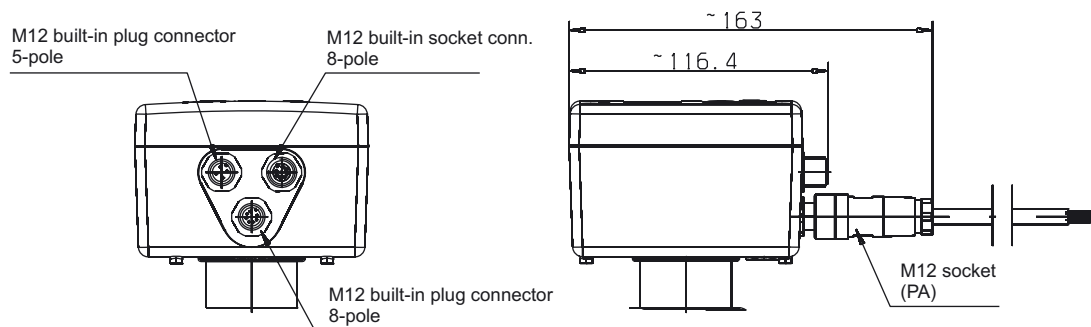
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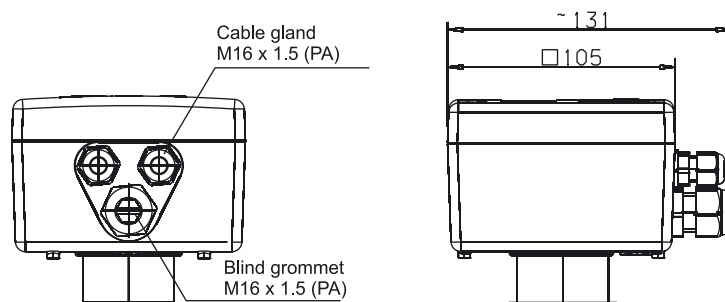
Dimensions

Transmitter with M12 plug connectors and M12 socket connectors



Transmitter with M16 cable gland

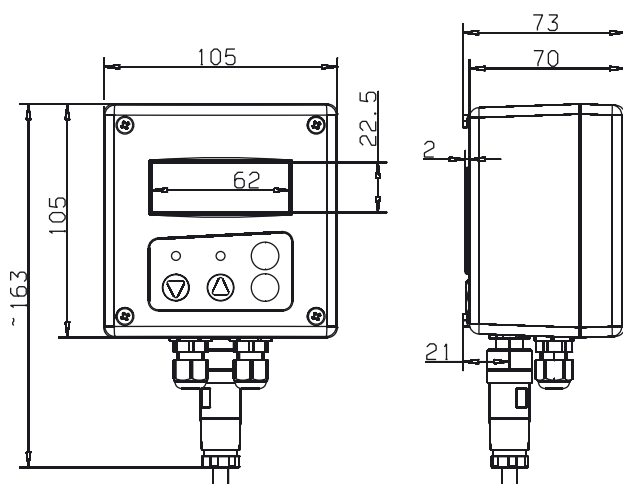
(only for the "head transmitter" model)



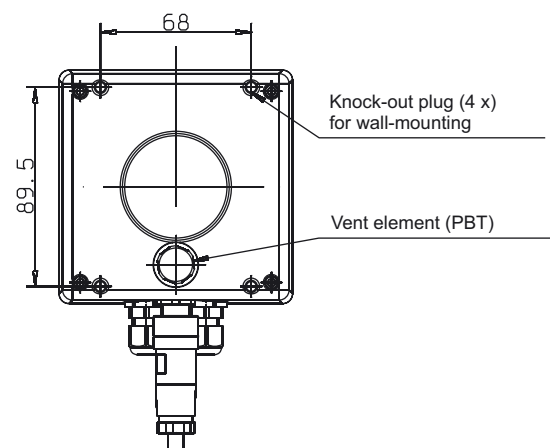
Version:

Transmitter with separate sensor (split version)

(basic type extensions /20, /25, /60 or /65)



Drilling diagram



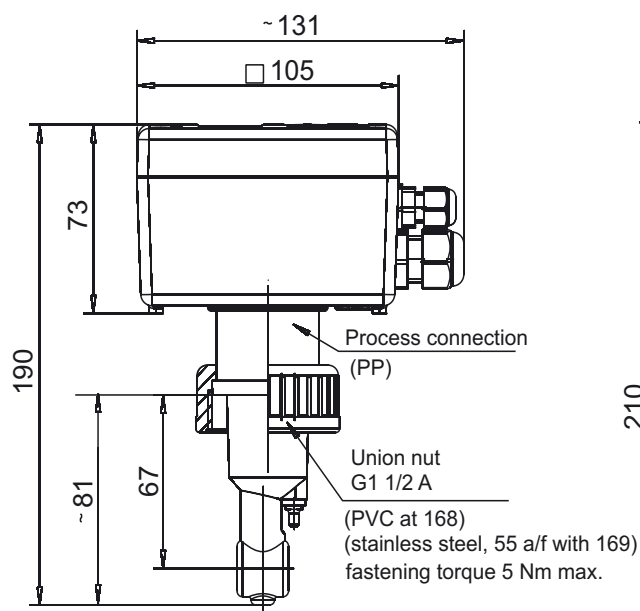
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 Phone: +44 1279 635533
 Fax: +44 1279 635262
 e-mail: sales@jumo.co.uk
 Internet: www.jumo.co.uk

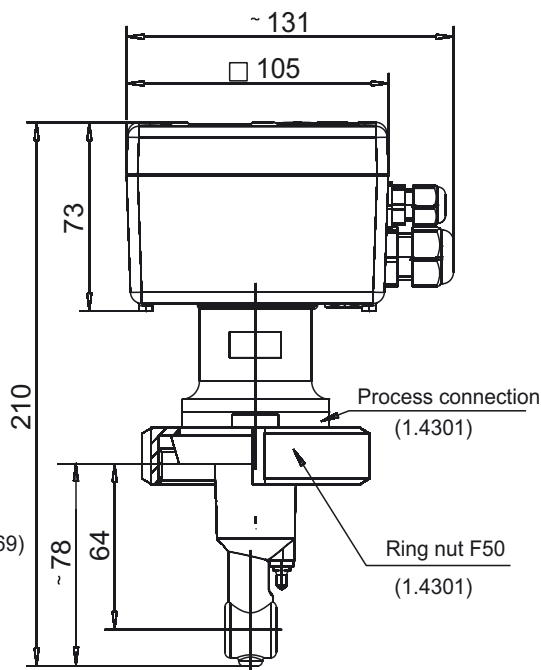
JUMO Process Control, Inc.
 8 Technology Boulevard
 Canastota, NY 13032, USA
 Phone: 315-697-JUMO
 1-800-554-JUMO
 Fax: 315-697-5867
 e-mail: info@jumo.us
 Internet: www.jumo.us



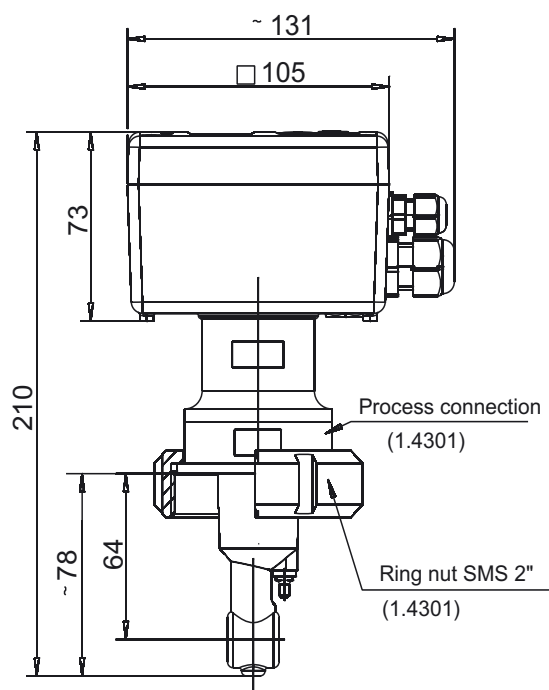
Dimensions / Process connections (head transmitter)



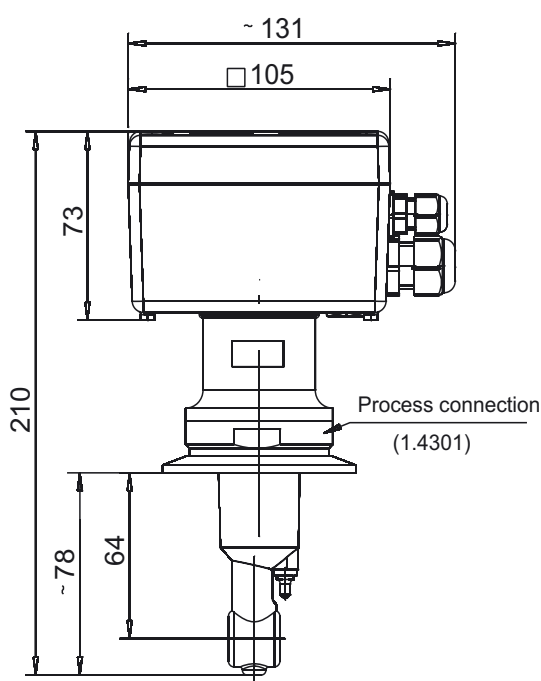
Version with
process connection 168
DN32 and DN40



Version with
process connection 607
MK DN40



Version with
process connection 690
SMS 2"



Version with
process connection 617
Clamp 2 1/2"
(retaining clip is not included
in delivery)

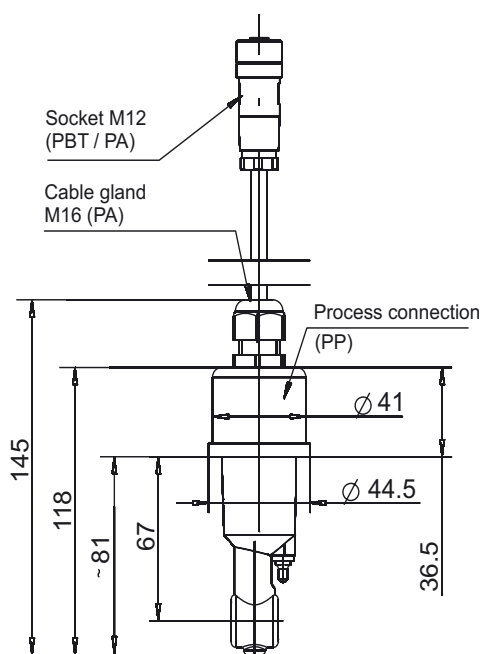
JUMO GmbH & Co. KG
 Delivery address: Mackenrodtstraße 14,
 36039 Fulda, Germany
 Postal address: 36035 Fulda, Germany
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 Fax: +49 661 6003-607
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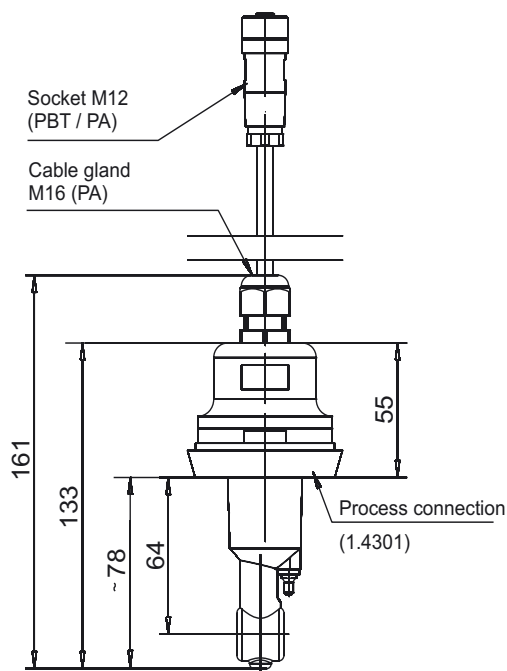
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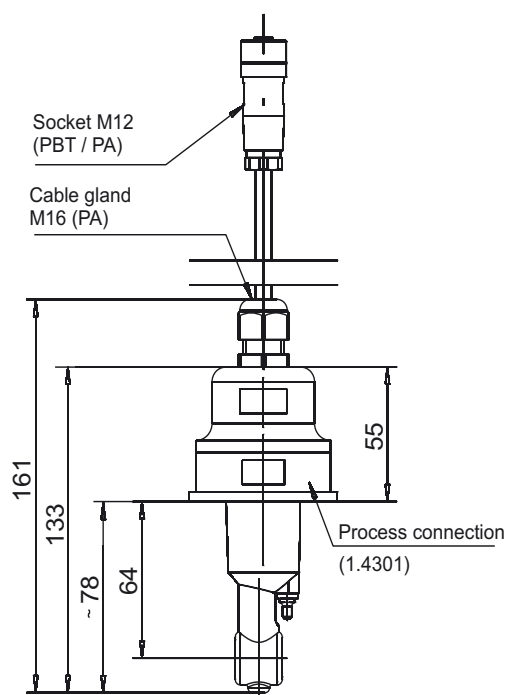
Dimensions / Process connections (separate sensor)



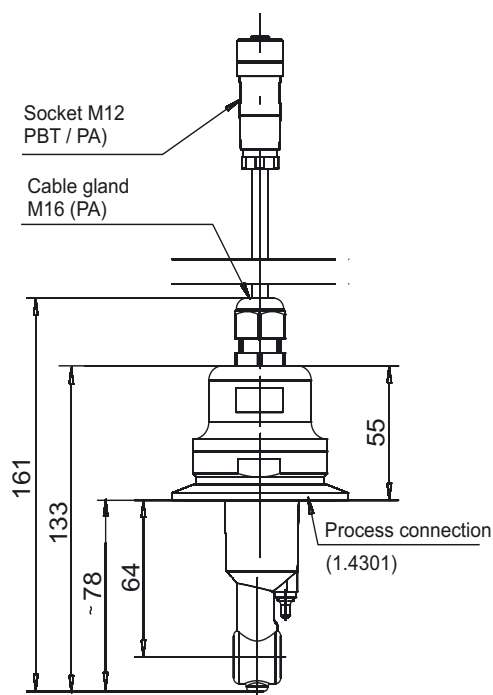
Split version
 for process connection 168 and 169
 DN32 and DN40
 (union nut not included
 in delivery)



Split version
 for process connection 607
 MK DN50
 (union nut not included
 in delivery)



Split version
 for process connection 690
 SMS 2"
 (union nut not included
 in delivery)



Split version
 for process connection 617
 Clamp 2 1/2"
 (retaining clip not included
 in delivery)

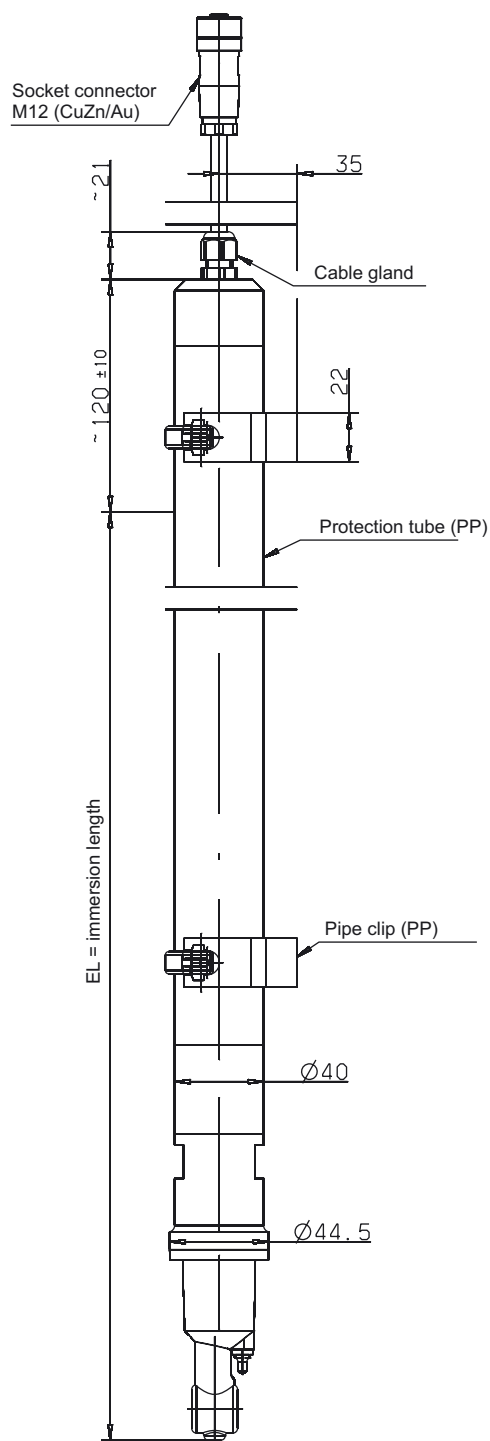
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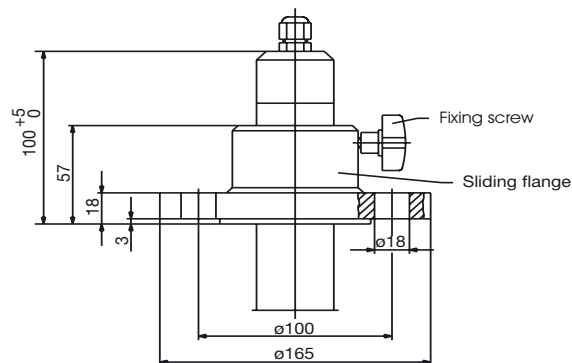
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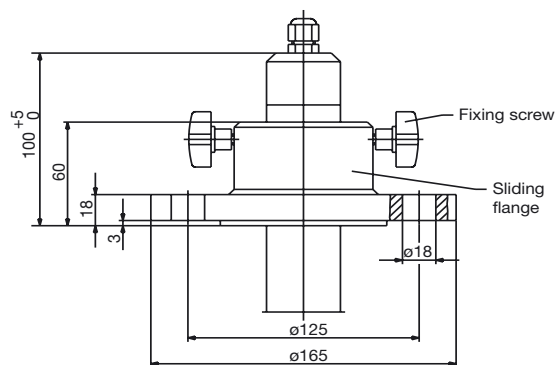
Dimensions (separate sensor as immersion model)



Split version
 for process connection 706
 immersion model
 (pipe clips included in delivery)



Optional accessory:
 flange DN32, Sales No. 20/00083375



Optional accessory:
 flange DN50, Sales No. 20/00083376

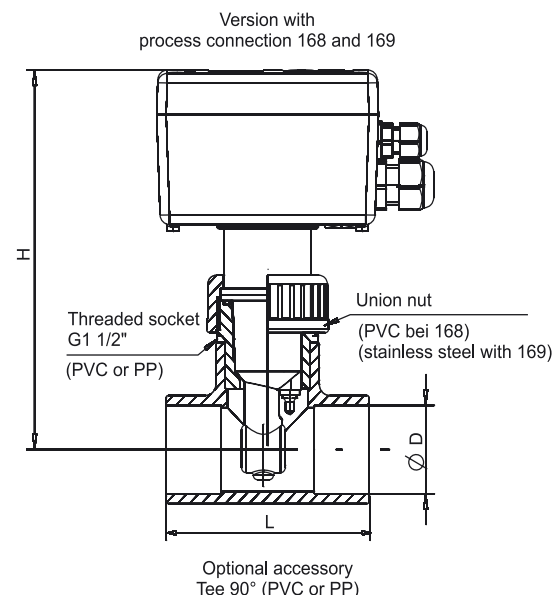
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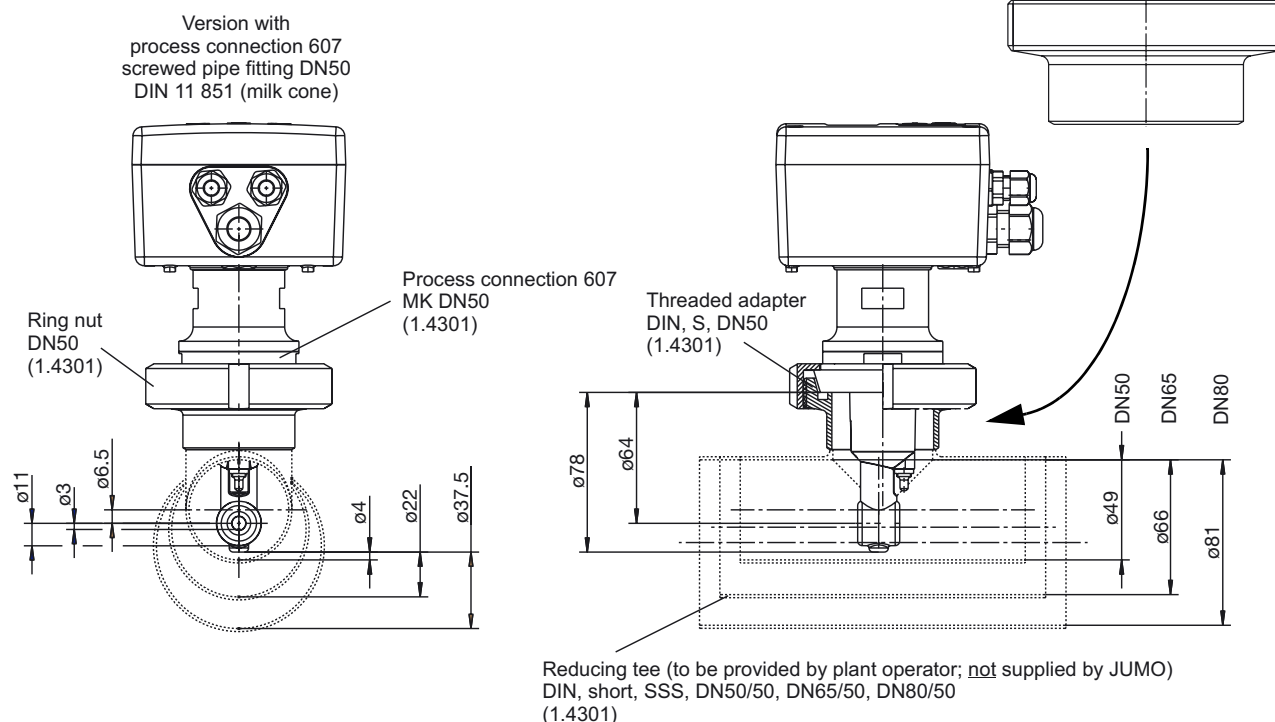


Mounting examples



DN	ø D	L	H	Material	Maximum temperature	Sales No.
32	40	98	172	PVC	+60°C	20/00439247
40	50	118	177			20/00439249
32	40	88	179	PP	+80°C	20/00449511
40	50	102	181			20/00449514
50	63	124	181			20/00449516

Weld-on threaded pipe adapter
 DN50, DIN 11 851
 (mating component for proc. connection 607),
 Sales No. 20/00085020



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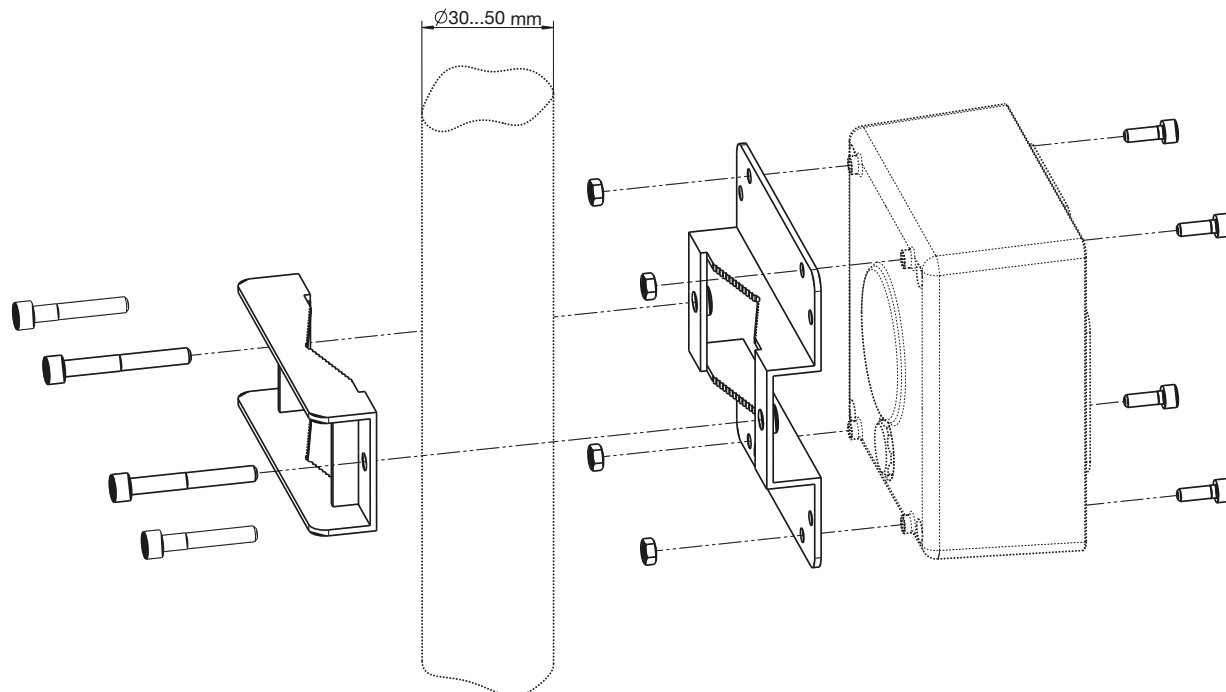
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**Kit for pipe mounting**

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Order details: CTI-500 as "Head transmitter"

202755 (1) **Basic type**
 JUMO CTI-500
 Inductive transmitter/ switching device for conductivity/
 concentration and temperature

(2) Basic type extensions

10 head transmitter without display/keypad ¹
 15 head transmitter with display/keypad

(3) Process connection

o o 168 PVC union nut G1¹/₂A ^{2,6}
 o o 169 stainless steel union nut G1¹/₂A ²
 o o 607 screwed pipe fitting DN50, DIN 11 851(MK DN50, milk cone)
 o o 617 clamp connection 2¹/₂"
 o o 690 SMS 2"

(4) Immersion length

o o 000 see dimensions

(5) Electrical connection

o o 82 cable glands
 o o 83 M12 plug/socket connectors (instead of the cable glands) ³
 o o 84 two M16 cable glands and one blind grommet

(6) Extra codes⁴

x x 000 no extra code
 o o 268 internal temperature sensor
 o o 580 1 set M12 plug/socket connectors
 o o 844 supply voltage 24 V AC
 o o 768 cell material PVDF⁵
 o o 844 supply 24 AC V ±10%

x = standard

o = available as an option

	(1)	(2)	(3)	(4)	(5)	(6)	(6)
Order code		/	-	-	-	/	, ...
Order example	202755	/ 10	- 108	- 000	- 82	/ 000	

¹ The PC setup program is required for programming the instrument, see accessories

² Special tee is not included in delivery, see accessories

³ If required, order extra code /580

⁴ List extra codes in sequence, separated by commas

⁵ Only with process connections 168 and 169, in combination with extra code 268

⁶ Maximum temperature of medium: 60°C

⁷ Mounting items (mounting brackets) do not come with delivery. If required, please include in your order (accessories)

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Order details: CTI-500 as "Transmitter with separate sensor"

					(1) Basic type	
					JUMO CTI-500 Inductive transmitter/switching device for conductivity/	
					concentration and temperature	
					(2) Basic type extensions	
					transmitter without display/keypad	
					(without sensor) ¹	
					transmitter with display/keypad	
					(without sensor) ⁷	
					transmitter without display/keypad	
					including sensor (cable length: 10 m) ¹	
					transmitter with display/keypad	
					including sensor (cable length: 10 m)	
					replacement sensor with a 10 m long cable	
					without transmitter ^{3, 7}	
					(3) Process connection	
					not available	
					PVC union nut G1 ¹ / ₂ A (media temperature: 60°C max.) ^{2, 8}	
					stainless steel union nut G1 ¹ / ₂ A ²	
					screwed pipe fitting DN50, DIN 11 851(MK DN50, milk cone)	
					clamp connection 2 ¹ / ₂ " ³	
					SMS 2" ³	
					immersion model	
					(4) Immersion length	
					not available	
					500 mm	
					1000 mm	
					1500 mm	
					2000 mm (max. length)	
					special length (in 250 mm steps; e.g. 0250; 0750; 1250; 1750)	
					(5) Electrical connection	
					attached cable with M12 socket connector on separate sensor	
					cable glands on the operating unit	
					M12 plug/socket connectors on operating unit ⁴	
					two cable glands and one blind grommet	
					(6) Extra codes⁵	
					no extra code	
					internal temperature sensor	
					1 set M12 plug/socket connectors	
					cell material PVDF ⁶	
					supply voltage 24 V AC	

x = standard

0 = available as an option

	(1)	(2)	(3)	(4)	(5)	(6)	(6)
Order code	202755	/		-		-	
Order example	202755	/	65	-	108	-	1000 - 21 / 000

¹ The PC setup program is required for programming the instrument, see accessories

² Special tee is not included in delivery

³ Mounting items (union/ring nuts, mounting brackets) do not come with delivery. If required, please include in your order (accessories)

⁴ If required, order extra code /580

⁵ List extra codes in sequence, separated by commas

⁶ Only with process connections 168 and 169, in combination with extra code 268

⁷ A calibration kit is absolutely essential for commissioning. If required, please include in your order (accessories)

⁸ Maximum temperature of medium: 60°C

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Stock items (shipment: 3 days after receipt of order)

Type

202755/15-168-0000-82/000
 202755/15-607-0000-82/000

Sales No.

20/00445843
 20/00445845

Production items (shipment: 10 days after receipt of order)

Type

202755/65-607-0000-82/000

Sales No.

20/00445840

Accessories

Type

Weld-on threaded adapter DN50, DIN 11 851
 (mating component for process connection -607)
 Special tee¹ DN32, PVC, including threaded socket (60°C max.)
 (mating component for process connection -168)
 Special tee¹ DN40, PVC, including threaded socket (60°C max.)
 (mating component for process connection -168)
 Special tee¹ DN32, PP, including threaded socket (100°C max.)
 (mating component for process connection -169)
 Special tee¹ DN40, PP, including threaded socket (100°C max.)
 (mating component for process connection -169)
 Special tee¹ DN50, PP, including threaded socket (100°C max.)
 (mating component for process connection -169)
 Union nut G1 1/2, PVC
 Union nut G1 1/2, stainless steel
 Ring nut DN50, DIN 11 851
 Ring nut SMS DN2"
 Flange DN32², material: PP
 Flange DN50², material: PP
 Kit for pipe mounting
 M12 socket connector, 5-pole, straight, for assembly by user
 M12 plug connector, 8-pole, straight, for assembly by user
 M12 socket connector, 8-pole, straight, for assembly by user
 PC setup software for JUMO CTI-500
 PC interface cable with TTL / RS232 converter and adapter (serial connection cable)
 PC interface cable with USB / TTL converter and two adapters (USB connection cable)
 Switched-mode power supply,
 Type PS5R-A24
 Cover with LC display and keypad

Sales No.

20/00085020
 20/00439247
 20/00439249
 20/00449511
 20/00449514
 20/00449516
 20/00439199
 20/00452039
 20/00343368
 20/00345162
 20/00083375
 20/00083376
 20/00459189
 20/00444313
 20/00444307
 20/00444312
 20/00447634
 70/00350260
 70/00456352
 20/00374661
 20/00443725

necessary for versions 202755/xx-xxx-xxxx-83/xxx³

necessary for versions 202755/xx-xxx-xxxx-83/xxx³

replacement part for sensor 202755/80...

SMPS for DIN rail mounting
 input voltage 100 — 240 VAC / 50 — 60 Hz
 output voltage 0.3 A 24 VDC

facilitates the programming of transmitters without display and without keypad

¹ with anti-rotation lug - the cell can only be installed in the correct orientation

² only in conjunction with a separate sensor in the immersion version 202755/60-706-... or 202755/65-706-... or 202755/80-706-...

³ not required if extra code 580 is ordered