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User Manual MOP301

Digital Moisture in Oil Immersion Probe up to 120 °C (248 °F)

DNV



Modbus

www.epluse.com

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1 General Information

This user manual is intended to ensure proper handling and optimal functioning of the device. The user manual shall be read before commissioning the equipment and it shall be provided to all staff involved in transport, installation, operation, maintenance and repair. E+E Elektronik Ges.m.b.H. accepts no liability for any warranty or liability claims arising from this publication or improper handling of the product(s) described.

All information, technical data and diagrams included in this document are based on the information available at the time of writing. The document may contain technical inaccuracies and typographical errors. The contents will be revised on a regular basis and changes will be implemented in subsequent versions. The product(s) described and the contents of this document may be changed or improved at any time without prior notice.

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PLEASE NOTE

Find this document and further product information on our website at www.epluse.com/mop301.

1.1 Explanation of Warning Notices and Symbols

Safety precautions

Precautionary statements warn of hazards in handling the device and provide information on their prevention. The safety instruction labeling is classified by hazard severity and is divided into the following groups:

DANGER

Danger indicates hazards for persons. If the safety instruction marked in this way is not followed, the hazard will verly likely result in severe injury or death.

WARNING

Warning indicates hazards for persons. If the safety instruction marked in this way is not followed, there is a risk of injury or death.

CAUTION

Caution indicates hazards for persons. If the safety instruction marked in this way is not followed, minor or moderate injuries may occur.

NOTICE

Notice signals danger to objects or data. If the notice is not observed, damage to property or data may occur.

Informative notes

Informational notes provide important information which stands out due to its relevance.

INFO

The information symbol indicates tips on handling the device or provides additional information on it. This information is useful to achieve optimum performance of the device.

The title field may deviate from “INFO” depending on the context. For instance, it may also read “PLEASE NOTE”.

1.2 Safety Instructions

1.2.1 General Safety Instructions

NOTICE

Improper handling of the device may result in its damage.

- Do not expose the enclosure, sensing probe, or module to unnecessary mechanical stress.
- When replacing the filter cap make sure not to touch the sensing elements.
- The device must be operated with the filter cap on at all times.
- For sensor cleaning and filter cap replacement please refer to “Cleaning Instructions” at www.epluse.com
- Installation, electrical connection, maintenance and commissioning shall be performed by qualified personnel only.
- Use the MOP301 only as intended and observe all technical specifications.
- The device is designed for operation with class III supply (EU) and class 2 supply (NA).
- Do not apply the supply voltage to the RS485 data lines.

1.2.2 Intended Use

The MOP301 is dedicated for reliable and accurate monitoring of lubrication, hydraulic and insulation oils as well as diesel fuel. In addition to highly accurate measurement of water activity (aw) and temperature (T), the MOP301 calculates the absolute water content (x) in ppm.

The probe can be used up to 120 °C (248 °F), 20 bar (290 psi) and is available with either ISO or NPT slide fitting, which allows for variable immersion depth. The mounting and installation methods described in chapter 4 Mounting and Installation shall be used.

⚠ WARNING

Non-compliance with the product documentation may cause safety risks for people and the entire measurement installation.

The manufacturer is not liable for any damage caused by improper handling, installation and maintenance of the device.

- Do not use MOP301 in explosive atmosphere or for measurement of aggressive gases.
- This device is not appropriate for safety, emergency stop or other critical applications where device malfunction or failure could cause injury to human beings.
- The device may not be manipulated with tools other than specifically described in this manual.

NOTICE

Failure to follow the instructions in this user manual may lead to measurement inaccuracy and device failures.

- The MOP301 may only be operated under the conditions described in this user manual and within the specification included in chapter 8 Technical Data.
- Any unauthorised product modification will invalidate all warranty claims. Modifications may only be carried out with the express authorisation of E+E Elektronik Ges.m.b.H.!

1.2.3 Mounting, Start-up and Operation

The MOP301 moisture in oil probe is manufactured to the highest standards and tested to meet all safety requirements before shipping. The manufacturer has taken all precautions to ensure safe operation of the device. The device shall be set up and installed in a way that does not impair its safe use. All applicable local and international safety guidelines for safe installation and operation of the device have to be observed. This user manual contains information and warnings that must be observed in order to ensure safe operation.

PLEASE NOTE

The manufacturer or his authorised agent can only be held liable in case of willful or gross negligence. In any case, the scope of liability is limited to the corresponding amount of the order issued to the manufacturer. The manufacturer assumes no liability for damage caused by non-compliance with the applicable regulations, operating instructions or the specified operating conditions. Any consequential damage is excluded from liability.

WARNING

Non-compliance with the product documentation may cause accidents, personal injury or property damage.

- Mounting, installation, commissioning, start-up, operation and maintenance of the device may only be carried out by qualified staff. Such staff must be authorised by the operator of the facility to carry out the mentioned activities.
- The qualified staff must have read and understood this user manual and must follow the instructions contained within. The manufacturer accepts no responsibility for non-compliance with instructions, recommendations and warnings.
- All process and electrical connections must be thoroughly checked by authorised staff before commissioning the device.
- Do not install or start-up a device suspected to be faulty. Mark it clearly as faulty and remove it from the process.
- Service operations other than described in this user manual may only be performed by the manufacturer. A faulty device may only be investigated and possibly repaired by qualified, trained and authorised staff. If the fault cannot be fixed, the device shall be removed from the process.

1.3 ESD Protection



The sensing elements and the electronics board are ESD (electrostatic discharge) sensitive components of the device and must be handled as such. Failure to do so may damage the device by electrostatic discharge when touching exposed sensitive components.

2 Scope of Supply

- MOP301 – Moisture in Oil Probe with Digital Interface according to ordering code
- Inspection certificate according to DIN EN 10204-3.1
- Quick guide

3 Product Description

3.1 General

The MOP301 is a robust probe for moisture in oil and temperature measurement. Its IP66 rating and the E+E shield technologies make it ideal for highest requirements in terms of maximum service lifetime and measurement performance.

The MOP301 features a moisture in oil measuring range of 0...1 aw, a temperature measuring range of -40...120 °C (-40...248 °F) and a 20 bar (290 psi) pressure rating. Measurement is possible within oil pipes as well as in almost still oil.

The MOP301 is typically deployed in monitoring of lubrication, hydraulic and insulation oils as well as diesel fuel in equipment and machinery. The oil to be monitored may be mineral, synthetic or biodegradable. Installation is simplified by various mounting options which are supported by E+E accessories.

The MOP301 provides the measured data at its digital RS485 interface via Modbus RTU protocol. The M12x1 connector links the probe to the digital infrastructure.

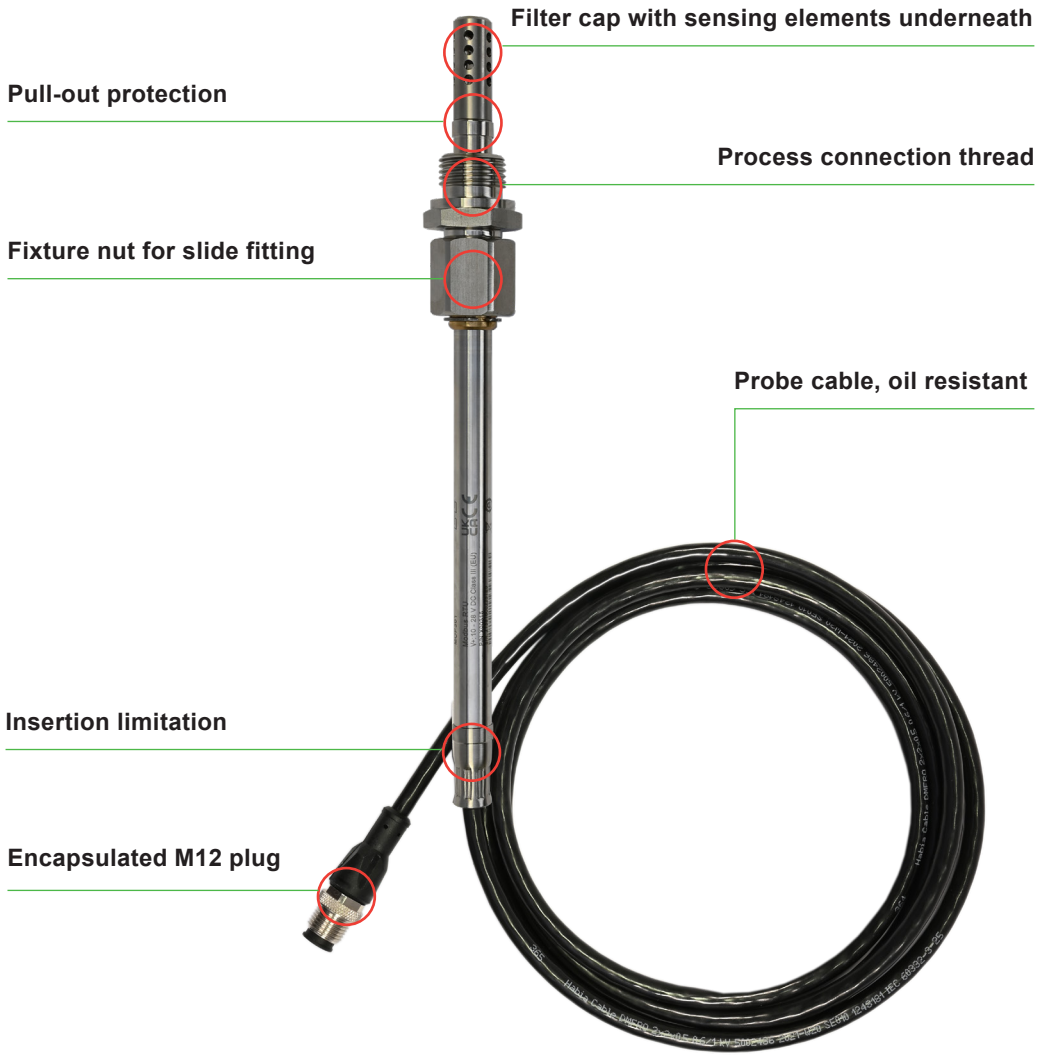


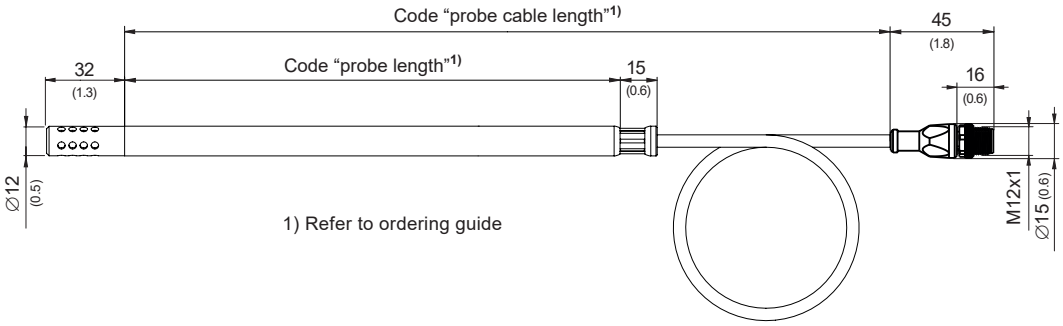
Fig. 1 MOP301 probe, Type T10, 20 bar (290 psi)

3.2 Dimensions

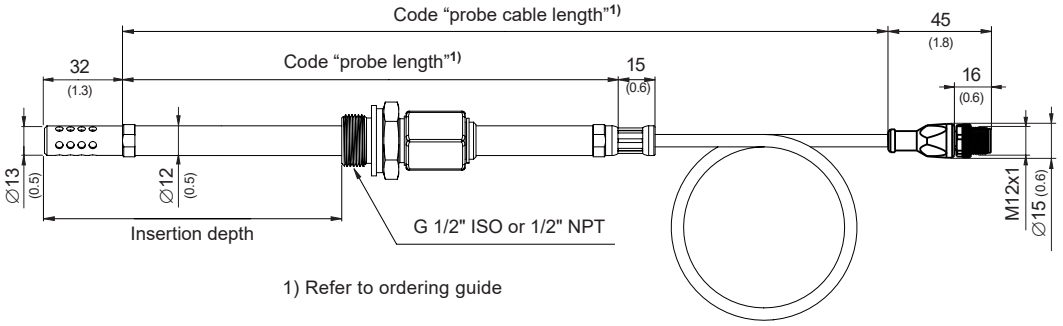
Values in mm (inch)

Types

Type T4



Type T10, 20 bar



Probe length [mm (inch)]	Min. insertion depth [mm (inch)]	Max. insertion depth [mm (inch)]
200 (7.9)	23 (0.9)	167 (6.6)
400 (15.7)	23 (0.9)	367 (14.4)

3.3 Effect of Oil Viscosity and Flow on Response Time

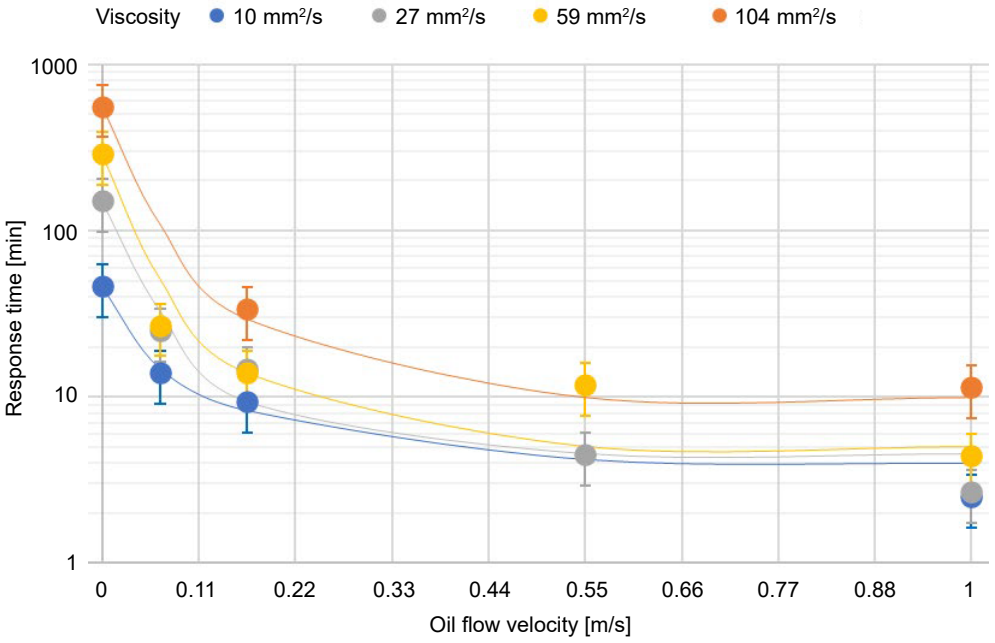
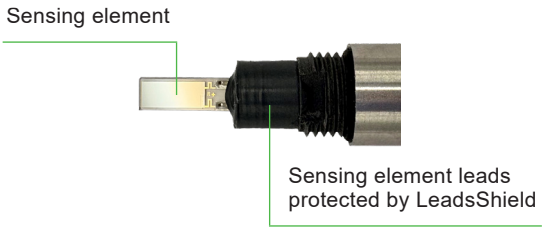


Fig. 2 Response time as a function of viscosity and flow

3.4 E+E Shield Technologies

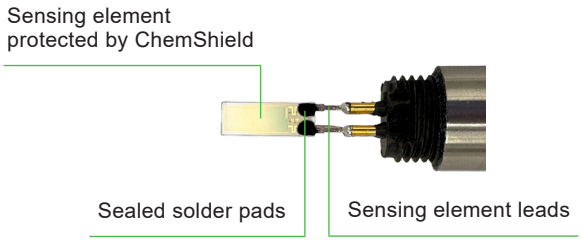
LeadsShield – Protective Sensor Leads Encapsulation

In certain applications, the oil can become corrosive over time, for example due to continuous contamination of lubricating oils by salt water in the maritime environment. In such demanding applications, the E+E LeadsShield sensor leads encapsulation can significantly extend the sensor lifetime.



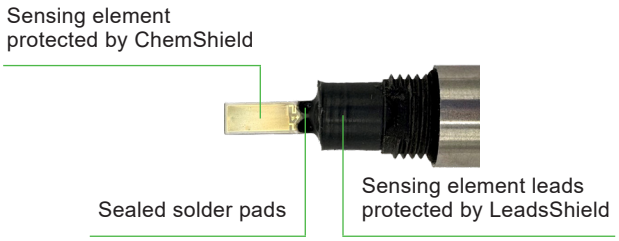
ChemShield – Protection Against Chemical Contamination

The E+E ChemShield protects the sensing element in MIO applications against the harmful effects of oil ageing, oxidation and aggressive changes to the oil (e.g. in natural ester oils). This improves the long-term stability of the sensors in these critical applications.



LeadsShield + ChemShield

This option combines the protection concepts of shielding both, the sensing element and its leads. ChemShield and LeadsShield protect against the short- and long-term effects of contaminated, ageing and deteriorating oil. The measures significantly improve the sensor's long-term stability and extend its service life.



3.5 Electrical Connection

⚠ WARNING

Incorrect installation, wiring or power supply may cause overheating and result in personal injury or property damage.

For correct cabling, always observe the presented wiring diagram for the product version used.

The manufacturer cannot be held responsible for personal injury or damage to property caused by incorrect handling, installation, wiring, power supply or maintenance of the device.

The relations of electrical potential between a bus system and an MOP301 probe are characterised by the following properties:

- The bus connection is not electrically isolated from the supply connection
- The MOP301 is not electrically isolated from the supply voltage
- Each MOP301 can be supplied separately

Plug for supply and analogue output



M12 device plug
front view

Pin	Assignment
1	Supply voltage 8 - 35 V DC class III ⧈ (Europe) / class 2 (North America)
2	B RS485 (D-)
3	GND
4	A RS485 (D+)

ⓘ PLEASE NOTE

The sensor tube must always be earthed for DNV EMC.

4 Mounting and Installation

The probe can be installed in applications such as oil storages with almost non-moving oil or as well in circulation pipes with moving oil.

⚠ WARNING

Incorrect installation, wiring or power supply may cause overheating or electrical shock and therefore personal injuries or damage to property.

For installation in high voltage equipment, e.g. in power transformers, there may be the danger of electrical shock. Always chose the installation depth so that the required safety distances between the MOP301 probe and any electrically live parts are respected.

NOTICE

- If the MOP301 is installed in equipment with moving parts, e.g. in gears, it has to be ensured that the probe does not touch any of these parts.
- In moving oil, the mechanical stress on the probe is minimised by placing only the filter cap into the flow. In systems with mechanical oil contaminants, the sensor may get installed only behind an appropiate filter.
- To maintain its integrity, the probe cable must not be routed over sharp edges. The cable's minimum bend radius is 5x the cable diameter in fixed installations and 10x the cable diameter when occasionally flexing the cable.

⚠ WARNING

Working with pressurised pipes poses a considerable risk of injury and damage to property.

When mounting an MOP301-T4 by means of ducts, make sure that precautions are taken to prevent the sensor from shooting out. The internal ducting (to the electronics) is suitable for up to 20 bar (290 psi). The respective feedthrough determines the actual working pressure (<20 bar (<290 psi)). As a rule, non cross-section-constricting and cross-section-constricting (cut-in) screw connections may be used; cross-section-constricting screw connections are only permitted in the rear part as shown in the sketch below (grey area from 32 + 150 mm from the probe tip; clamping is permitted in the grey marked area only). Please refer to Fig. 3.

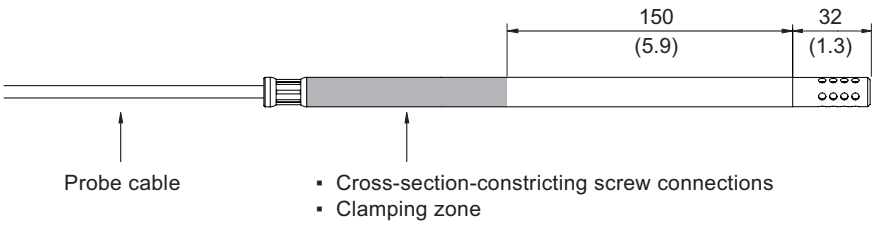


Fig. 3 MOP301 Type T4 fastening zone

ⓘ INFO

Optionally, there is a SWAGElok fitting available for type T4.

Order code:

- ISO HA011102
- NPT HA011103

4.1 Installation of the Probe Directly in the Process

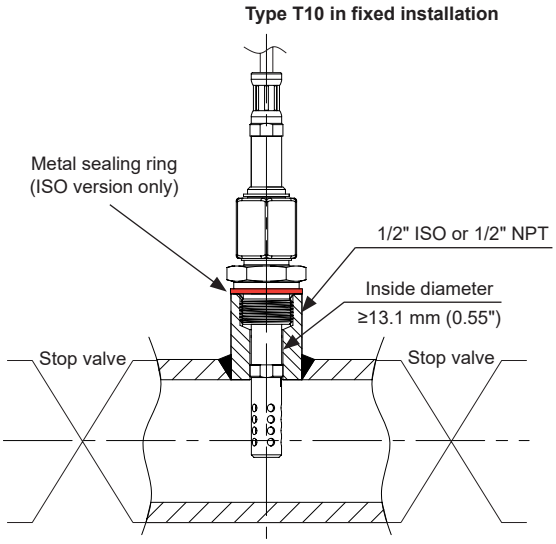


Fig. 4 Installation of the MOP301 probe directly into the process

For direct probe installation, shut-off valves shall be placed on both sides of the probe insert. This allows the sensor probe to be easily removed for maintenance and calibration.

For direct installation into a pressure chamber, make sure that the pressure in the chamber and the ambient pressure are equal before removing the probe. The temperature during probe installation may deviate by max. ±40 °C (±72 °F) from the regular temperature during normal operation.

NOTICE

Replace the metal sealing ring (refer to Fig. 4 Installation of the MOP301 probe directly into the process) by a new one every time before re-installing the probe.

Probe installation steps

1. Close both shut-off valves.
2. Place the sensor probe into the probe insert and adjust the immersion depth.
3. Tighten the lock nut with a torque of 30 Nm.
4. Open the valves.

⚠ WARNING

Working with pressurised pipes poses a considerable risk of injury and damage to property.

Strictly observe the tightening torque. A torque lower than 30 Nm results in a smaller retention force ofthe clamping sleeve. This leads the risk of sudden expulsion of the sensing probe due to the pressure. A torque higher than 30 Nm may lead to permanent deformation of the clamping sleeve and the sensing probe. This would make the removal and re-installation of the probe difficult or even impossible.

4.2 Probe Installation with Ball Valve

The ball valve allows for installation and removal of the probe without process interruption. For mounting into the pipe, the ball valve shall be installed perpendicular to the flow direction.

INFO

There are ball valves available as accessory with G 1/2" thread (order code HA050101) and with 1/2" NPT thread (order code HA050104).

NOTICE

The two metal sealing rings (refer to Fig. 5 Installation of the probe by utilising the ball valve set) shall be replaced every time prior to re-installing the probe.

PLEASE NOTE

The temperature during probe installation may deviate by max. ±40 °C (±72 °F) from the regular temperature during normal operation.

Probe installation steps (refer to Fig. 5 Installation of the probe by utilising the ball valve set)

1. Install the probe into the ball valve while the ball valve is closed.
2. Open the ball valve.
3. Slide the probe through the ball valve to the desired immersion depth. Depending on the process pressure additional tools may be necessary for pushing the probe into the process. Make sure not to damage the probe and the cable.
4. Tighten the lock nut with a torque of 30 Nm.

WARNING

Strictly observe the tightening torque. A torque lower than 30 Nm results in a smaller retention force ofthe clamping sleeve. This leads the risk of sudden expulsion of the sensing probe due to the pressure. A torque higher than 30 Nm may lead to permanent deformation of the clamping sleeve and the sensing probe. This would make the removal and re-installation of the probe difficult or even impossible.

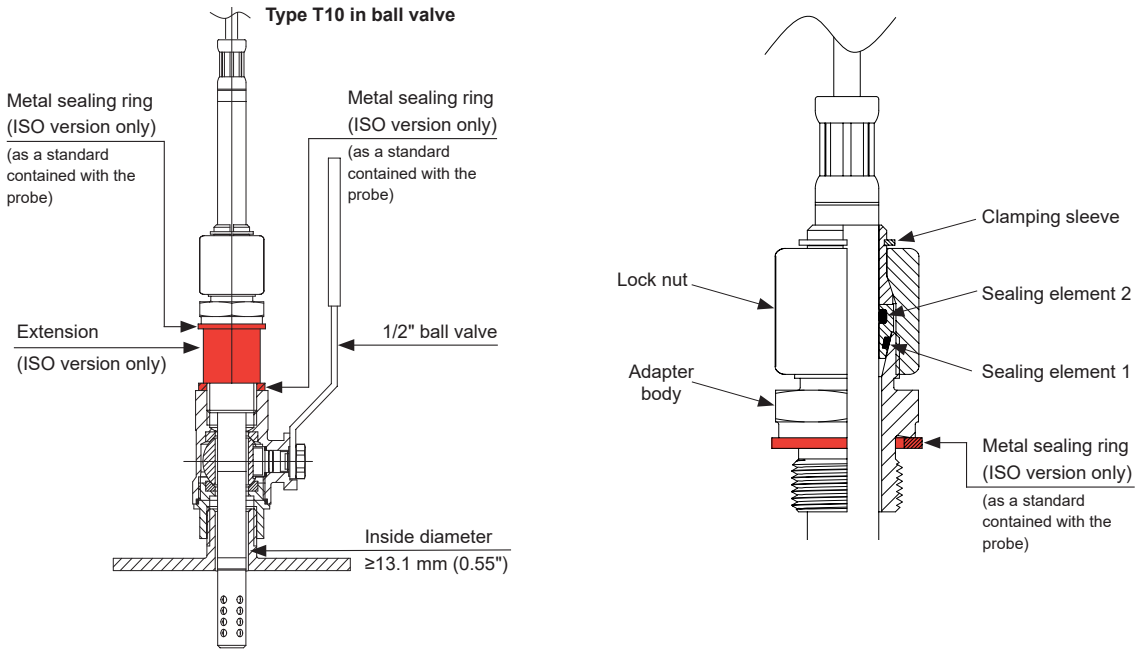


Fig. 5 Installation of the probe by utilising the ball valve set

Removing the probe

1. Hold the probe firmly so that it is not suddenly ejected when the lock nut is released. Make sure not to bend and damage the probe cable.
2. Loosen the lock nut slowly with a spanner (spanner size 24) until the probe is pushed out by the system pressure. Do not loosen the lock nut completely, but only until the probe slides out by itself. If the system is almost pressureless, pull out the sensor slightly.
3. After the probe has been pushed out of the process up to the stop, close the ball valve.
4. Remove the probe from the ball valve.

NOTICE

Observe the correct positioning of the sealing element 1 before reinstalling the probe.

Replacement of the sealing element

In case of repeated installations and removals the sealing element 1 might be damaged. It can be replaced by the user.

4.3 Sampling Cell with Shut-off Function

The sampling cell with shut-off function is designed for placing a MOP301 in a bypass oil sampling or as well directly into the process. In both cases, the sampling cell could be moved into the oil flow or in service position by interrupting the oil flow. When closing the G 1/2” ISO sensor port with a sealing plug, the sampling cell with shut-off function works like a ball valve. Using the sampling cell with shut-off function works like the method described in chapter 4.1 Installation of the Probe Directly in the Process, however without the need of stop valves in the upstream and downstream of the measurement point.

INFO

The sampling cell with shut-off function is available with PN40 and DN25 as an accessory (order code HA050109).

Technical data of the sampling cell[1)]

Pipe thread	Rp / Whitworth thread according to EN 10226 (old DIN 2999)
Senor port thread	G 1/2" ISO
Operating pressure	40 bar (at max. 80 °C) / 580 psi (at max. 176 °F)
Temperature range	-20...+180 °C (-4...+356 °F)
Wetted parts	Stainless steel 1.4408 and PTFE

1) Please note that specifications of probe and sampling cell may restrict each other in terms of temperature and pressure application range.

Replace the metal sealing ring (refer to Fig. 5 Installation of the probe by utilising the ball valve set) by a new one every time before re-installing the probe. The temperature during probe installation may deviate by max. ±40 °C (±72 °F) from the regular temperature during normal operation.

Probe installation steps

1. Shut off the valve
2. Place the sensor probe into the probe insert and adjust the immersion depth
3. Tighten the lock nut with a torque of 30 Nm
4. Open the valve

WARNING

Strictly observe the tightening torque. A torque lower than 30 Nm results in a smaller retention force ofthe clamping sleeve. This leads the risk of sudden expulsion of the sensing probe due to the pressure. A torque higher than 30 Nm may lead to permanent deformation of the clamping sleeve and the sensingprobe. This would make the removal and re-installation of the probe difficult or even impossible.

By removing the probe, close first the shut-off valve. Before openening the valve, ensure that the sensor port contains a sensor or is closed by a sealing plug.

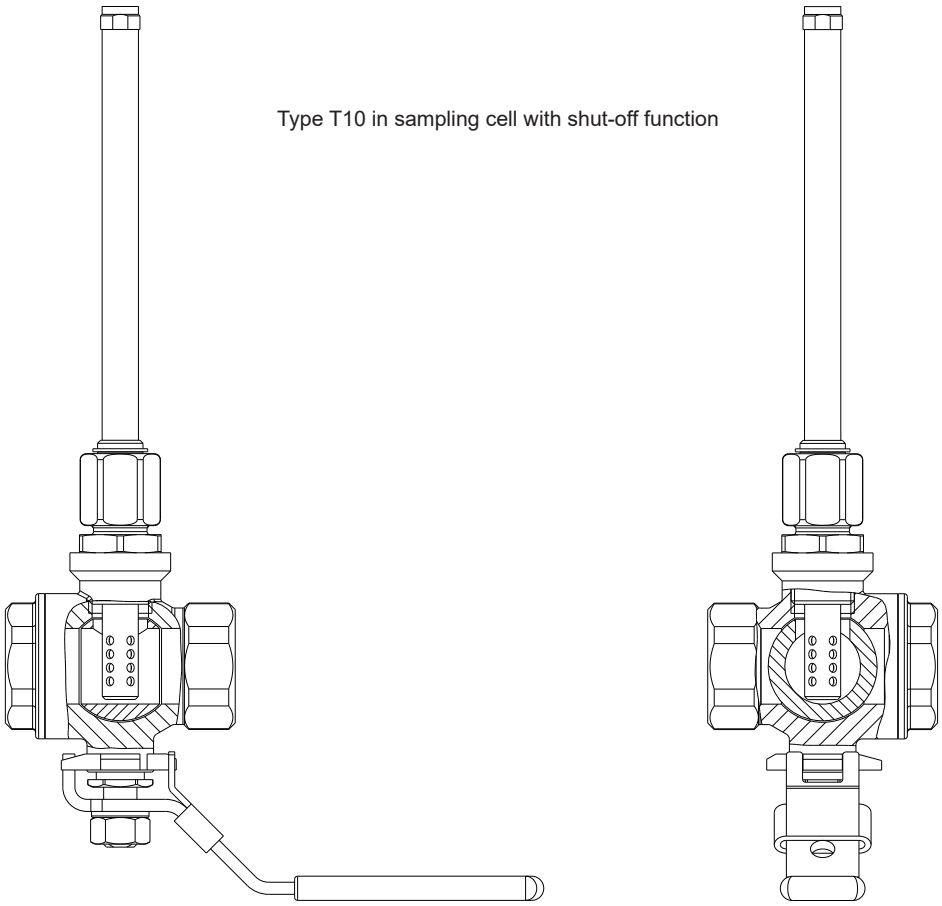


Fig. 6 Sampling cell with shut-off function position “open” (left) and position “closed” (right)

5 Setup and Adjustment

The MOP301 is ready to use and does not require any configuration by the user. The factory setup of MOP301 corresponds to the type number ordered. Please refer to the data sheet at www.epluse.com/mop301. If needed, the factory setup can be changed with the help of the PCS10 Product Configuration Software and the Modbus configuration adapter (order code HA011018). Refer to chapter 5.1 below.

The user can change the display settings and the output configuration. Refer to chapter 5.1 for details.

5.1 PCS10 Product Configuration Software

The PCS10 provides a convenient graphical user interface to the MOP301. To use the software for performing adjustments and changes in settings, please proceed as follows:

1. Download the PCS10 Product Configuration Software from www.epluse.com/pcs10 and install it on a PC.
1. Connect the MOP301 to the PC using the Modbus configuration adapter.
2. Start the PCS10 software.
2. Follow the instructions on the PCS10 opening page to scan the ports and to identify the connected device.
3. Click on the desired setup or adjustment mode from the main PCS10 menu on the left. Follow the PCS10 online instructions that are displayed when clicking on the “Tutorial” button.
4. Upload changes to the probe by pressing the “Sync” button.

NOTICE

The MOP301 may not be connected to any additional power supply when using the Modbus configuration adapter HA011018.

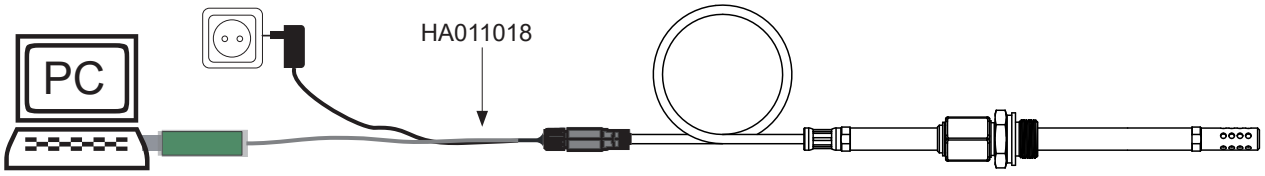


Fig. 7 MOP301 connected to a PC running PCS10

Besides an individual probe naming, the communication parameters may be changed and the custom Modbus map can be configured. Refer to chapter 5.4 Configurable Custom Modbus Map.

There is a separate menu item for setting the oil parameters. An oil library with up to 50 entries may be created. The library may be exported and imported and an appropriate parameter set may be uploaded to the probe.

A 1- and 2-point adjustment may be carried out and the factory setup may be restored again. Refer to chapter 6.2 Moisture and Temperature Adjustment and Calibration.

The configuration of an individual probe may be exported and imported.

5.2 Modbus Setup

	Factory settings	Selectable values (via PCS10)
Baud rate	9600	9 600, 19 200, 38 400, 57 600, 76 800, 115 200
Data bits	8	8
Parity	Even	None, odd, even
Stop bits	1	1, 2
Modbus address	70	1...247

Tab. 1 Modbus RTU protocol settings

PLEASE NOTE

- The recommended settings for multiple devices in a Modbus RTU network are 9600, 8, even, 1.
- The MOP301 represents 1 unit load on an RS485 network.

Device address, baud rate, parity and stop bits can be set via:

- PCS10 Product Configuration Software and the Modbus configuration adapter HA011018.
  The PCS10 can be downloaded free of charge from www.epluse.com/pcs10.
- Modbus protocol in the register 1 (0x00) and 2 (0x01).
  Refer to Application Note Modbus AN0103 (available at www.epluse.com/mop301).

The serial number as ASCII-code is located in read-only registers 1 - 8 (0x00 - 0x07).
The firmware version is located in read-only register 9 (0x08) (bit 15...8 = major release; bit 7...0 = minor release).
The sensor name as ASCII-code is located in read-only registers 10 - 17 (0x09 - 0x10).

NOTICE

When reading information that spans multiple registers, it is always necessary to read all registers, even if the desired information requires less.

NOTICE

To obtain the correct floating point values, both registers have to be read within the same reading cycle. The measured value may change between two Modbus requests. This can cause inconsistencies in the exponent and mantissa.

INFO

The Modbus function codes mentioned throughout this document shall be used as described in chapter 6 of MODBUS APPLICATION PROTOCOL SPECIFICATION V1.1b3, available at https://www.modbus.org/.

Communication settings (INT16)

Parameter	Register number[1] [Dec]	Register address[2] [Hex]	Size[3]
Write register: function code 0x06			
Modbus address[4]	1	00	1
Modbus protocol settings[4]	2	01	1

Device information (INT16)

Parameter	Register number[1] [Dec]	Register address[2] [Hex]	Size[3]
Read register: function code 0x03 / 0x04			
Serial number (as ASCII)	1	00	8
Firmware version	9	08	1
Sensor name (as ASCII)	10	09	8
Device status (bit decoded)[5]	602	0x259	1

1) Register number (decimal) starts from 1.
2) Register address (hexadecimal) starts from 0.
3) Number of registers
4) For Modbus protocol settings see Application Note Modbus AN0103 (available on www.epluse.com/mop301).
5) Please refer to chapter 5.5 Device Status Indication.

Tab. 2 MOP301 device information registers

5.3 Modbus Register Map

The measurement data is saved as 32 bit floating point values (data type FLOAT32) and as 16 bit signed integer values (data type INT16).

FLOAT32

Parameter	Unit	Register number[1] [DEC]	Register address[2] [HEX]
Read register: function code 0x03 / 0x04			
Water activity aw	-	1135	46E
Water content x	ppm	1141	474
Temperature	°C	1003	3EA
	°F	1005	3EC
Saturation	%	1137	470
Oil parameter A	-	0224	DF
Oil parameter B	-	0226	E1
Oil parameter C[3]	-	0228	E3
Oil parameter D[3]	-	0230	E5
Oil parameter E[3]	-	0232	E7
Write register: function code 0x10			
Oil parameter A[4]	-	0101	64
Oil parameter B[4]	-	0103	66
Write register: function code 0x10 (with firmware V1.3.3 or higher)			
Oil parameter A[5]	-	0224	DF
Oil parameter B[5]	-	0226	E1
Oil parameter C[5]	-	0228	E3
Oil parameter D[5]	-	0230	E5
Oil parameter E[5]	-	0232	E7

INT16

Parameter	Unit	Scale[6]	Register number[1] [DEC]	Register address[2] [HEX]
Read register: function code 0x03 / 0x04				
Water activity aw	-	100	4068	FE3
Water content x	ppm	0.1	4071	FE6
Temperature T	°C	100	4002	FA1
	°F	50	4003	FA2
	K	50	4005	FA4
Saturation	%	10	4069	FE4

1) Register number starts from 1
2) Register address starts from 0
3) New register in device with firmware version 1.3.3 or higher.
4) If parameters A and B are written with these addresses, parameters C, D and E will be automatically set to 0.
   Example: Writing Parameter A -2663.30005 decimal: 46 10 00 64 00 02 04 74 CD C5 26 E3 44
   Writing Parameters A and B -1663.30005 and 7.3705 decimal: 46 10 00 64 00 04 08 E9 9A C4 CF DB 23 40 EB CA 19
   If two parameters are to be uploaded, it is recommended to write them with a single command.
5) Example: A= -100, B=10, C=-110, D=11, E=1
   46 10 00 DF 00 0A 14 00 00 C2 C8 00 00 41 20 00 00 C2 DC 00 00 41 30 00 00 3F 80 DF CC.
6) Examples: For scale 100, the reading of 2550 means a value of 25.5. For scale 50, the reading of 2550 means a value of 51.

Tab. 3 MOP301 FLOAT32 and INT16 measured data registers

5.4 Configurable Custom Modbus Map

It is possible to map measured value/status registers arbitrarily in a block with up to 20 registers provided for this purpose. This means that registers of interest may be mapped in an area with consecutive registers, so that important values can be queried with a single command in one block.

The register block for the configuration of the customisable Modbus map consists of the registers 6001 (0x1770) to 6010 (0x1779). For the blockwise query of the measured values behind Modbus registers 3001 (0xBB8) to 3020 (0xBCB), the firmware accesses this configuration area and thus gets the information which measured value/status registers are to be output. A maximum of 10 user-defined registers can be mapped. The table below shows an example:

Registers ...		**... with these assigned measurands ...**			**... map to registers ...**		**... mirrored from source registers**	
Dec	**Hex**	**Meas.**	**Unit**	**Type**	**Dec**	**Hex**	**Dec**	**Hex**
Function code 0x10					*Function code 0x03/0x04*			
6001	1770	Status	-	INT16	3001	BB8	602	259
6002	1771	T	°C	FLOAT32	3002	BB9	1003	3EA
			°C	FLOAT32	3003	BBA	1004	3EB
6003	1772	T	°F	FLOAT32	3004	BBB	1005	3EC
			°F	FLOAT32	3005	BBC	1006	3ED
6004	1773	T	T	INT16	3006	BBD	4002	FA1
6005	1774	aw	-	FLOAT32	3007	BBE	1035	46E
			-	FLOAT32	3008	BBF	1036	46F
6006	1775	x	ppm	FLOAT32	3009	BC0	1141	474
			ppm	FLOAT32	3010	BC1	1142	475
6007	1776	Saturation	%	FLOAT32	3011	BC2	1137	470
			%	FLOAT32	3012	BC3	1138	471
6008	1777	aw	-	INT16	3013	BC4	4068	FE3
6009	1778	x	ppm	INT16	3014	BC5	4071	FE6
60110	1779	Saturation	%	INT16	3015	BC6	4069	FE4
					3016	BC7	65536	FFFF
					3017	BC8	65536	FFFF
					3018	BC9	65536	FFFF
					3019	BCA	65536	FFFF
					3020	BCB	65536	FFFF

Tab. 4 Custom Modbus map example

The custom map can be configured via:

- PCS10 Product Configuration Software and the Modbus configuration adapter HA010018. The PCS10 can be downloaded free of charge from www.epluse.com/pcs10.
- Modbus protocol commands, refer to the example in chapter 5.6 Modbus RTU Examples.

5.5 Device Status Indication

The MOP301 features a status register that contains all status and error information. The status information can be read from Modbus register 602 (0x259). Errors are displayed in bit-coded form. If an event is present, the corresponding bit is set to 1.

If a critical error occurs, all Modbus values are set to NaN (according to IEEE754 for data type FLOAT32) or to 0x8000 (INT16).

Measured values out of range are limited by the corresponding limit value.

Error Bits	Description	Recommended action
Bit 0	Error: Hardware T sensing	Return the faulty unit to E+E for service.
Bit 1	Error: Short circuit of T sensing element	1. Clean sensing head acc. to cleaning instructions. 2. Return the faulty unit to E+E for service.
Bit 2	Error: Open loop of T sensing element	Return the faulty unit to E+E for service.
Bit 3	Error: Short circuit of moisture sensing element	1. Clean sensing head acc. to cleaning instructions. 2. Return the faulty unit to E+E for service.
Bit 4	Error: Open loop of moisture sensing element or heavy pollution	1. Clean sensing head acc. to cleaning instructions. 2. Return the faulty unit to E+E for service.
Bit 5	Warning: Polluted moisture sensing element or highly conductive oil	Clean sensing head or oil is incompatible.
Bit 6	Warning: Temperature below allowed working range	Observe the lower working range limit.
Bit 7	Warning: Temperature above allowed working range	Observe the upper working range limit.
Bit 8	Error: T sensing element defective	Return the faulty unit to E+E for service.
Bit 9	Warning: Moisture below allowed working range	Observe the lower working range limit.
Bit 10	Warning: Moisture above allowed working range	Observe the upper working range limit.
Bit 11	Error: Moisture sensing element defective	Return the faulty unit to E+E for service.
Bit 12	Error: Hardware moisture sensing	Return the faulty unit to E+E for service.

Tab. 5 Device status indication

5.6 Modbus RTU Examples

The MOP301's Modbus address is 70 [0x46].

Please refer to

- Chapter 6 of MODBUS APPLICATION PROTOCOL SPECIFICATION V1.1b3, available at https://www.modbus.org/.
- E+E Application Note Modbus AN0103 (available at www.epluse.com/mop301)

Read the temperature (FLOAT32) T = 26.66048812866211 °C from register address 0x3EA:

Master (e.g. PLC) → **MOP301**

Request [Hex]:

Modbus address	Function code	Starting address Hi	Starting address Lo	Qty. of registers Hi	Qty. of registers Lo	CRC
46	03	03	EA	00	02	EA CC

Response [Hex]:

Modbus address	Function code	Byte count	Register 1 value Hi	Register 1 value Lo	Register 2 value Hi	Register 2 value Lo	CRC
46	03	04	48	AE	41	D5	4A B9

Floating point values are decoded according to IEEE754, please refer to the example at the end of this chapter.

Read register from custom modbus map

address 0x0BB8-0x0BB9, unconfigured

Request [Hex]:

Modbus address	Function code	Starting address Hi	Starting address Lo	Qty. of registers Hi	Qty. of registers Lo	CRC	
46	03	0B	B8	00	02	49	7D

Response [Hex]:

Modbus address	Function code	Byte count	Register 1 value Hi	Register 1 value Lo	Register 2 value Hi	Register 2 value Lo	CRC	
46	03	04	FF	FF	FF	FF	CC	A3

Mapping custom Modbus map

assign T (register address 0xEA) and aw (register address 0x46E) to the custom Modbus map, starting address 0xBB8

Request [Hex]:

Modbus address	Function code	Starting address Hi	Starting address Lo	Qty. of registers Hi	Qty. of registers Lo	Byte count		
46	10	17	70	00	02	04		
			Register 1 value Hi	Register 1 value Lo	Register 2 value Hi	Register 2 value Lo	CRC	
			03	EA	04	6E	F2	52
			T [°C]		aw			

Response [Hex]:

Modbus address	Function code	Byte count	Register 1 value Hi	Register 1 value Lo	Register 2 value Hi	Register 2 value Lo	CRC	
46	10	17	70	00	02	--	4A	D0

Poll register address 0xBB8

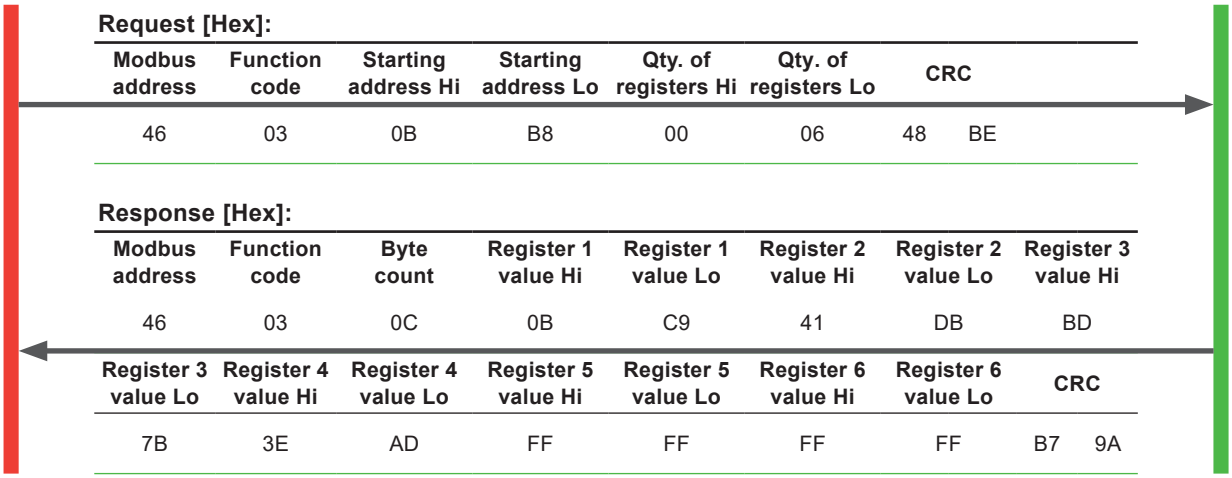
Request [Hex]:

Modbus address	Function code	Starting address Hi	Starting address Lo	Qty. of registers Hi	Qty. of registers Lo	CRC	
46	03	0B	B8	00	02	49	7D

Response [Hex]:

Modbus address	Function code	Byte count	Register 1 value Hi	Register 1 value Lo	Register 2 value Hi	Register 2 value Lo	CRC	
46	03	04	E6	F1	41	DA	1A	47

Poll register address 0xBB8-0xBBE



Decoding of floating point values:

Floating point values are stored according to IEEE754. The byte pairs [1], [2] and [3], [4] are transformed as follows (register contents taken from the T reading Modbus request/response example above):

Modbus response [Hex]

Register 1 Hi [3]	Register 1 Lo [4]	Register 2 Hi [1]	Register 2 Lo [2]
48	AE	41	D5
MMMM MMMM	MMMM MMMM	SEEE EEEE	EMMM MMMM

Tab. 6 Modbus response

IEEE754 representation [Hex, Bin]

Register 2 Hi [1]	Register 2 Lo [2]	Register 1 Hi [3]	Register 1 Lo [4]
41	D5	48	AE
0100 0001	1101 0101	0100 1000	1010 1110
SEEE EEEE	EMMM MMMM	MMMM MMMM	MMMM MMMM
Decimal value: 26.66048812866211			

Tab. 7 Data representation according to IEEE754

6 Maintenance and Service

The MOP301 does not require any special maintenance, nevertheless for high accurate measurements especially over wide aw and T ranges it is recommended to calibrate the probe every 12 months. If needed, the enclosure may be cleaned and the device may be re-adjusted as described below.

6.1 Cleaning

If required, the sensing head can be cleaned. Please find the E+E cleaning instructions at www.epluse.com/cleaning-instructions.

6.2 Moisture and Temperature Adjustment and Calibration

Depending on the application and the requirements of certain industries, there might arise the need for periodical calibration (comparison with a reference) or adjustment (bringing the device in line with a reference).

The MOP301 can be calibrated / adjusted with the help of the PCS10. For this purpose, the probe needs to be connected to a PC via a Modbus configuration adapter.

Definitions

- **Calibration** documents the accuracy of a measurement device. The device under test (specimen) is compared with the reference and the deviations are documented in a calibration certificate. During the calibration, the specimen is not changed or improved in any way.
- **Adjustment** improves the measurement accuracy of a device. The specimen is compared with the reference and brought in line with it. An adjustment can be followed by a calibration which documents the accuracy of the adjusted specimen.

Calibration and adjustment at E+E Elektronik

Calibration and/or adjustment can be performed in the E+E Elektronik calibration laboratory. For information on the E+E capabilities in ISO or accredited calibration please refer to www.eplusecal.com.

Calibration and adjustment by the user

PLEASE NOTE

Moisture calibration and adjustment is to be carried out for the measurand “relative humidity” and shall be performed in air.

Depending on the level of accuracy required, the humidity reference can be:

- Humidity calibrator (e.g. Humor 20), please refer to www.epluse.com/humor20.
- Hand-held Meter (e.g. Omniport 40), please refer to www.epluse.com/omniport40.
- Humidity Calibration Kit (e.g. E+E Humidity Standards), please refer to www.epluse.com/mop301.

6.3 Repairs

PLEASE NOTE

Repairs may only be carried out by the manufacturer. The attempt of unauthorised repair excludes any warranty claims.

6.4 Spare Parts

Description	Code
Stainless steel filter cap for flow <1 m/s (<3.3 ft/s)	**HA010110**
Stainless steel filter cap for flow >1 m/s (>3.3 ft/s)	**HA010111**

7 Accessories

For further information please refer to the Accessories datasheet.

Accessories	Code
Modbus configuration adapter, M12 4 poles ←→ USB	**HA011018**
E+E Product Configuration Software (Free download: www.epluse.com/pcs10)	**PCS10**
Humidity calibration kit	**See data sheet** Humidity Calibration Kit
Y-style splitter, M12x1, 1 plug ←→ 2 sockets, 5 poles	**HA030204**
Protection cap for M12 socket	**HA010781**
Protection cap for M12 plug	**HA010782**
Ball valve G 1/2" ISO	**HA050101**
Ball valve 1/2" NPT	**HA050104**
Sampling cell with shut-off function, PN40, DN25	**HA050109**
SWAGElok fitting for type T4 **Pressure-tight feed-hrough, Ø12 mm (0.47")** For probe assembly up to 20 bar (290 psi) **G 1/2" ISO** **1/2" NPT**	 **HA011102** **HA011103**

8 Technical Data

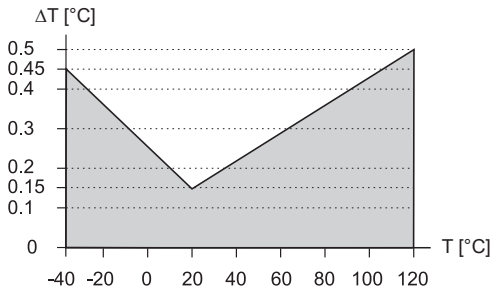
Measurands

Water activity (aw) / water content (x)

Measuring range	0...1 aw 0...100 000 ppm; actual range depends on the oil type, for non-mineral transformer oil, specific solubility parameters are needed (ppm output is valid in the range 0...100 °C (32...212 °F))
Accuracy1[1)] including hysteresis, non-linearity and repeatability **0...40 °C (32...104 °F) (0...0.9 aw)** **(0.9...1 aw)** **-40...+120 °C (-40...+356 °F) (0...1 aw)**	 ±0.02 aw ±0.025 aw ±0.03 aw
Response time t_{63}	Highly dependent on the properties of the oil, such as viscosity and flow[2)].
Resolution	0.0001 aw

1) Traceable to international standards, administrated by NIST, PTB, BEV...
The accuracy statement includes the uncertainty of the factory calibration with a coverage factor k=2 (2-times standard deviation). The accuracy was calculated in accordance with EA-4/02 and with regard to GUM (Guide to the Expression of Uncertainty in Measurement).
2) Please refer to Fig. 2 Response time as a function of viscosity and flow in the user manual at www.epluse.com/mop301.

Temperature (T)

Measuring range	-40...+120 °C (-40...+212 °F)
Accuracy[1)]	
Resolution	0.01 °C

1) Traceable to international standards, administrated by NIST, PTB, BEV,...
The accuracy statement includes the uncertainty of the factory calibration with a coverage factor k=2 (2-times standard deviation).
The accuracy was calculated in accordance with EA-4/02 and with regard to GUM (Guide to the Expression of Uncertainty in Measurement).

Output

Digital

Digital interface	RS485 (MOP301 = 1 unit load)
Protocol **Factory settings** **Supported Baud rates** **Measured data types**	Modbus RTU 9 600 Baud, parity even, 1 stop bit, Modbus address 70 9 600, 19 200, 38 400, 57 600, 76 800 und 115 200 FLOAT32 and INT16

General

Power supply class III USA & Canada: Class 2 supply necessary, max. voltage 30 V DC	8 - 35 V DC
Power consumption, typ. without termination resistor	40 mW
Electrical connection	M12x1, 4 poles
Pressure rating	20 bar (290 psi)
Temperature working range **Sensing element + filter cap** **Probe** **Cable** **M12 connector**	 -40...+125 °C (-40...+257 °F) -40...+120 °C (-40...+248 °F) -40...+120 °C (-40...+248 °F) -25.....+90 °C (-13...+194 °F)
Storage conditions	-40...+80 °C (-40...+176 °F) 0...95 %RH, non-condensing
Material **Cable jacket**[1)] **Probe**	 HFS 125XL, black, oil and fuel resistant Stainless steel 1.4404
Protection rating	IP66
Electromagnetic compatibility	EN 61326-1:2013 — EN 61326-2-3:2013 — Industrial Environment EN IEC 61326-1:2021 — EN IEC 61326-2-3:2021 — Industrial Environment FCC Part15 Class B — ICES-003 Class B — DNV-CG-0339
Shock and vibration	Tested acc. to EN 60068-2-6, EN 60068-2-27 and DNV-CG-0339
Conformity	CE UKCA DNV [2)]
Type approval	DNV Certificate No. TAA00003FA
Configuration and adjustment	PCS10 Product Configuration Software (free download) and configuration adapter

1) Please mind the mounting and installing instructions included in the user manual.
2) DNV scope of approval: please refer to ordering guide.

9 Conformity

9.1 Declarations of Conformity

E+E Elektronik Ges.m.b.H. hereby declares that the product complies with the respective regulations listed below:

CE European directives and standards.

and

UKCA UK statutory instruments and designated standards.

DNV DNV (Det Norske Veritas) maritime type approval.

Please refer to the product page at www.epluse.com/mop301 for the Declarations of Conformity.

9.2 Electromagnetic Compatibility

EMC for industrial environment.
The probe is a group 1 device and corresponds to class B.

9.3 FCC Part 15 Compliance Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the installation manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

9.4 ICES-003 Compliance Statement

This Class B digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

9.5 DNV Type Approval

Approval standard DNV-CG-0339:2021

Location Classes	
Temperature	D
Humidity	B
Vibration	B
EMC	B
Enclosure	B / IP66

10 Recycling of the Device

PLEASE NOTE

Products from E+E Elektronik Ges.m.b.H. are developed and manufactured in compliance with relevant environmental protection requirements. Please observe local regulations for the disposal of the device.

For disposal, the individual components of the device must be separated according to local recycling regulations. The electronics shall be disposed of correctly as electronics waste.



Fig. 8 MOP301

No.	Part	Material	Recycling Type
1	Probe	Various materials	Electrical and Electronics waste

Tab. 8 Recycling of the MOP301 probe

Company Headquarters &
Production Site

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your partner
in sensor
technology.

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