User Manual

MOP301

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

Modbus

YOUR PARTNER IN SENSOR TECHNOLOGY

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The document may contain technical inaccuracies and typographical errors. The content will be revised on a regular basis. These changes will be implemented in later versions. The described products can be improved and changed at any time without prior notice.

EMC note USA (FCC):

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

EMC note Canada (ICES-003):

CAN ICES-3 (A) / NMB-3 (A)

CONTENT

1 General

This user manual serves for ensuring 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. The user manual may not be used for the purposes of competition without the written consent of E+E Elektronik and may not be forwarded to third parties. Copies may be made for internal purposes. All information, technical data and diagrams included in these instructions are based on the information available at the time of writing.

The manufacturer or his authorized agent can be 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 damages incurred due to failure to comply with the applicable regulations, operating instructions or the specified operating conditions. Consequential damages are excluded from the liability.

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

1.1 Explanation of Symbols

This symbol indicates safety information.
It is essential that all safety information is strictly observed. Failure to comply with this information can lead to personal injuries or damage to property. E+E Elektronik assumes no liability if this happens.

This symbol indicates instructions.
The instructions shall be observed in order to reach optimal performance of the device.

1.2 Safety Instructions

1.2.1 General Safety Instructions

- Avoid any unnecessary mechanical stress and inappropriate use.
- 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 see “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 use MOP301 in explosive atmosphere or for measurement of aggressive gases.
- Do not apply the nominal voltage to the data lines.
- The device is not appropriate for safety, emergency stop or other critical applications where device malfunction or failure could cause injury to human beings.

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.

The manufacturer cannot be held responsible for damages as a result of incorrect handling, installation and maintenance of the device.

Unauthorized modifications of the product lead to loss of all warranty claims. The device may only be powered as described in this manual.

1.2.3 Mounting, Start-up and Operation

The MOP301 moisture in oil probe has been produced under state of the art manufacturing conditions, has been thoroughly tested and has left the factory fulfilling all safety criteria. The manufacturer has taken all precautions to ensure safe operation of the device. The user must ensure that the device is set up and installed in a manner that does not have a negative effect on its safe use. The user is responsible for observing all applicable safety guidelines, local and international, with respect to safe installation and operation on the device. This user manual contains information and warnings that must be observed by the user in order to ensure safe operation.

- Mounting, start-up, operation and maintenance of the device may be performed by qualified staff only. Such staff must be authorized by the plant operator to carry out the mentioned activities.
- The qualified staff must have read and understood this user manual and must follow the instructions contained within.
- All process and electrical connections shall be thoroughly checked by authorized staff before putting the device into operation.
- Do not install or start-up a device supposed to be faulty. Make sure that such devices are not accidentally used by marking them clearly as faulty.
- A faulty device may only be investigated and possibly repaired by qualified, trained and authorized staff. If the fault cannot be fixed, the device shall be removed from the process.
- Service operations other than described in this user manual may only be performed by the manufacturer.

1.3 Environmental Aspects

Products from E+E Elektronik® are developed and manufactured observing of all relevant requirements with respect to environment protection. Please observe local regulations for the device disposal.

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.

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 proprietary sensor leads protection make it ideal for highest requirements. It 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 Type T10, 20 bar (290 psi)

3.2 Dimensions

Type T4

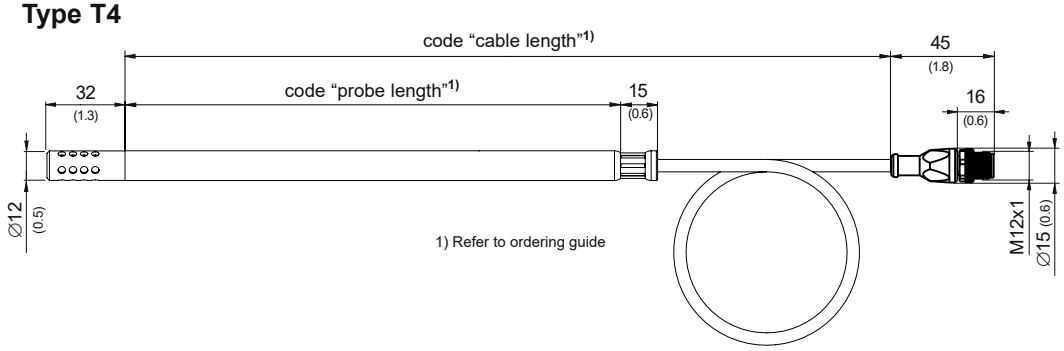
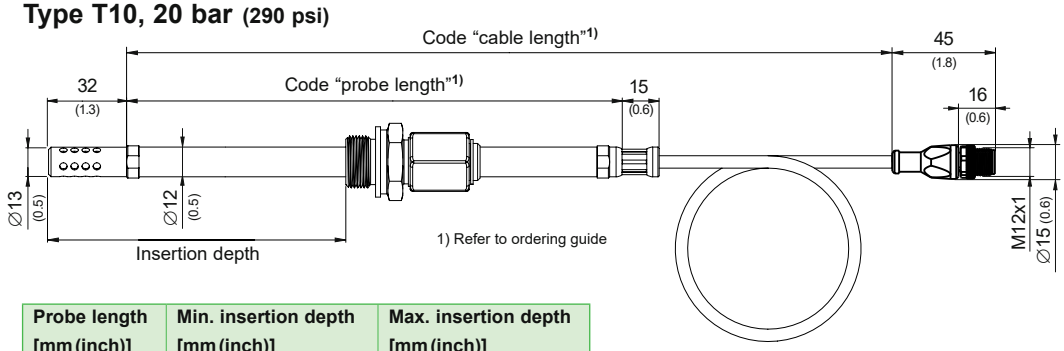


Fig. 2 MOP301 Type T4

Type T10, 20 bar (290 psi)



Probe length [mm (inch)]	Min. insertion depth [mm (inch)]	Max. insertion depth [mm (inch)]
200 (7.9)	23 (0.9)	164 (6.5)
400 (15.7)	23 (0.9)	364 (14.3)

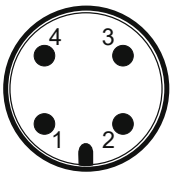
Fig. 3 MOP301 Type T10, pressure tight up to 20 bar (290 psi)

3.3 Electrical Connection

Important note:
The manufacturer cannot be held responsible for personal injuries or damage to property as a result of incorrect handling, installation, wiring, power supply and maintenance of the device.

The relations of electrical potential between a bus system and an MOP301 probe are characterized 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



M12 device plug
front view

Pin number	Function
1	Supply voltage 24 V DC class III ⧏III⧐ (Europe) / class 2 (North America)
2	B RS485 (D-)
3	GND
4	A RS485 (D+)

Tab. 1 MOP301 connection

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.

Please note:
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.
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 minimized 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.

Please note: 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.

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, too).

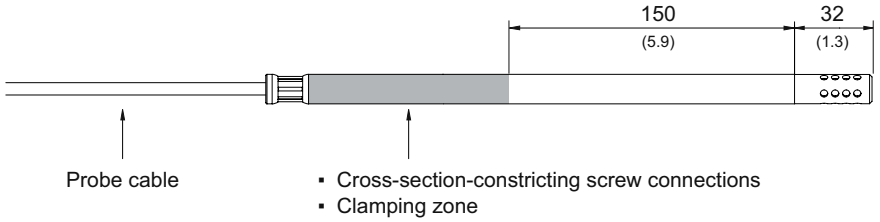


Fig. 4 MOP301 Type T4

4.1 Installation of the Probe Directly in the Process

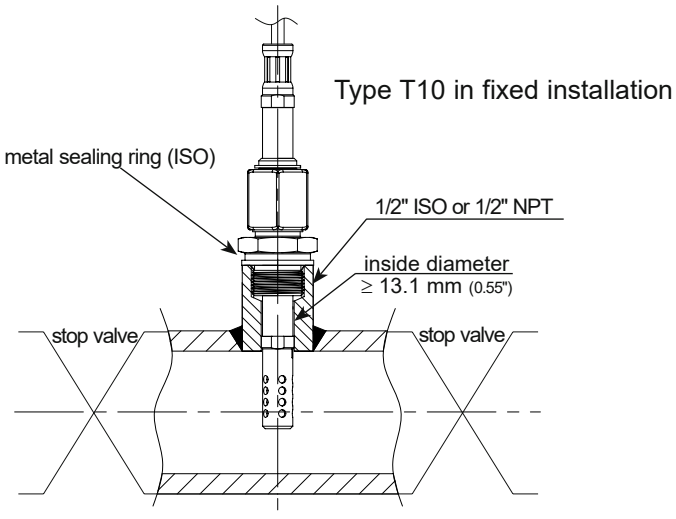


Fig. 5 Installation of the MOP301 probe directly into the process

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.

Replace the metal sealing ring (see Fig. 5) by a new one every time before re-installing the probe.

Probe installation steps

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

Strictly Observe the tightening torque. A torque lower than 30 Nm results in a smaller retention force of the 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

Ball valve HA050101, HA050104
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.

The two metal sealing rings (see Fig. 6) shall be replaced every time prior to 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 (see Fig. 6)

- Install the probe into the ball valve while the ball valve is closed.
- Open the ball valve.
- 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.
- Tighten the lock nut with a torque of 30 Nm.

Strictly observe the tightening torque. A torque lower than 30 Nm results in a smaller retention force of the clamping sleeve. As a result, there is the risk that the sensing probe will suddenly be ejected 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.

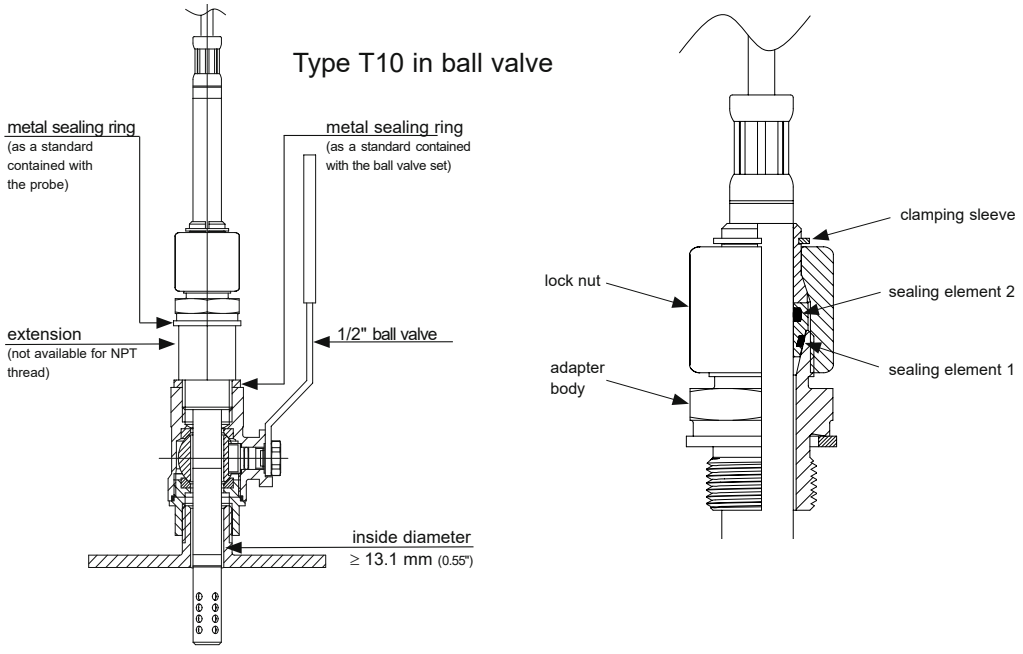


Fig. 6 Installation of the probe by utilizing the ball valve set

Removing the probe

- 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.
- 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.
- After the probe has been pushed out of the process up to the stop, close the ball valve.
- Remove the probe from the ball valve.

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

Sampling cell with shut-off function, PN40, DN25 HA050109

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 interupting 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.

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)
Wettet parts:	Stainless steel 1.4408 & 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 (see Fig. 6) 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

- Shut off the valve
- Place the sensor probe into the probe insert and adjust the immersion depth
- Tighten the lock nut with a torque of 30 Nm
- Open the valve

Strictly observe the tightening torque. A torque lower than 30 Nm results in a smaller retention force of the 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.

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.

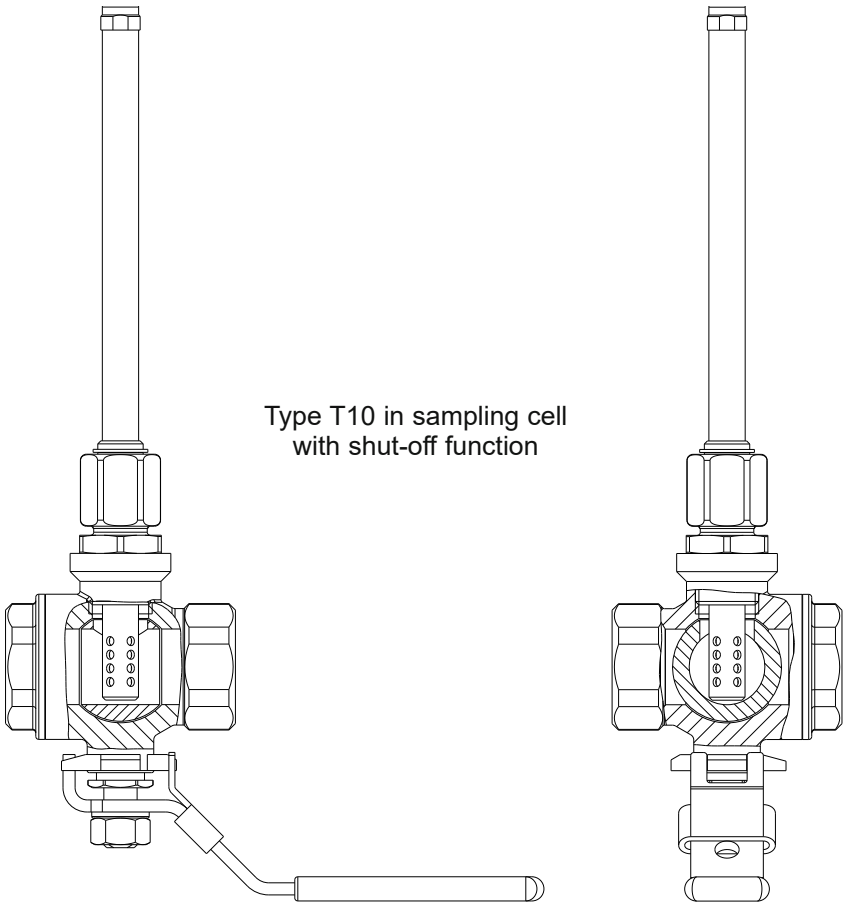


Fig. 7 Sampling cell with shut-off function position “open” (left) and position “closed” (right)

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. The user can change the factory setup with the help the PCS10 Product Configuration Software and the Modbus configuration adapter (order code HA011018). Refer to chapter 5.1 below.

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 the PC.
2. Connect the MOP301 to the PC using the Modbus configuration adapter.
3. Start the PCS10 software.
4. Follow the instructions on the PCS10 opening page for scanning the ports and identifying the connected device.
5. Click on the desired setup or adjustment mode from the main PCS10 menu on the left. Follow the online instructions of the PCS10 which are displayed when clicking the “Tutorial” button.
6. Changes are uploaded to the probe by pressing the “Sync” button.

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

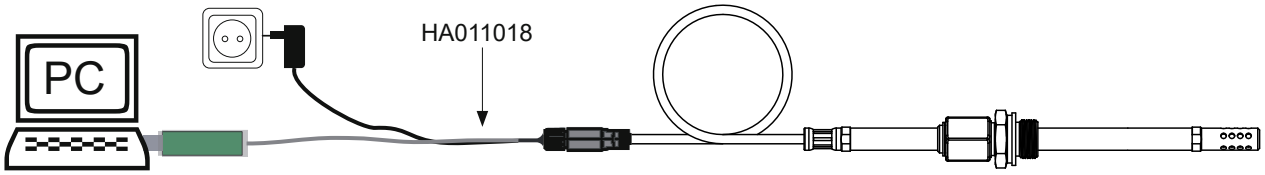


Fig. 8 Configuration

Besides an individual probe naming, the communication parameters may be changed and the custom Modbus map can be configured. Refer to chapter 5.4 Freely 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. See chapter 6.3 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	9600, 19200, 38400, 57600, 76800, 115200
Data bits	8	8
Parity	Even	None, odd, even
Stop bits	1	1, 2
Modbus address	70	1...247

Tab. 2 Modbus default settings

Device address, baud rate, parity and stop bits can be set via:
1. PCS10 Product Configuration Software and the Modbus configuration adapter HA011018.
   The PCS10 can be downloaded free of charge from www.epluse.com/pcs10.
2. Modbus protocol in the register 1 (0x00) and 2 (0x01).
   See 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, 16 bits per address). The firmware version is located in register 9 (0x08) (bit 15...8 = major release; bit 7...0 = minor release). The sensor name is located in register address 10 (0x09).

Please note: When reading the serial number or the sensor name, it is always necessary to read all 8 registers, even if the desired information requires less.

Please note: For obtaining the correct floating point values, both registers have to be read within the same reading cycle. The measured value can change between two Modbus requests, therefore exponent and mantissa may get inconsistent.

Communication settings (INT16)		
Parameter	**Register number[1] [Dec]**	**Register address[2] [Hex]**
Write register: function code 0x06		
Modbus address	1	0x00
Modbus protocol settings[3]	2	0x01

1) Register number starts from 1.
2) Protocol address starts from 0.
3) For Modbus protocol settings see Application Note Modbus AN0103 (available at www.epluse.com/mop301).

Tab. 3 MOP301 communication settings registers

Device information (INT16)		
Parameter	**Register number[1] [Dec]**	**Register address[2] [Hex]**
Read register: function code 0x03 / 0x04		
Serial number (as ASCII)	1	0x00
Firmware version	9	0x08
Sensor name	10	0x09
Device status (bit decoded)[3]	602	0x259

1) Register number starts from 1.
2) Protocol address starts from 0.
3) See chapter 5.5 Device Status Indication.

Tab. 4 MOP301 device information registers

5.3 Modbus Register Map

The measured data is saved as a 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	0x46E
Water content x	ppm	1141	0x474
Temperature T	°C	1003	0x3EA
	°F	1005	0x3EC
Saturation	%	1137	0x470
Oil parameter A	-	0224	0xDF
Oil parameter B	-	0226	0xE1
Write register: function code 0x10			
Oil parameter A[3]	-	0101	0x64
Oil parameter B[3]	-	0103	0x66

1) Register number starts from 1
2) Register address starts from 0
3) Examples: 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.

Tab. 5 MOP301 FLOAT32 measured data registers

INT16 (read register):				
Parameter	**Unit**	**Scale[3]**	**Register number[1] [Dec]**	**Register address[2] [Hex]**
Read register: function code 0x03 / 0x04				
Water activity aw	-	1000	4068	0xFE3
Water content x	ppm	0.1	4071	0xFE6
Temperature T	°C	100	4002	0xFA1
	°F	50	4003	0xFA2
	°K	50	4005	0xFA4
Saturation	%	10	4069	0xFE4

1) Register number starts from 1
2) Register address starts from 0
3) 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. 6 MOP301 INT16 measured data registers

5.4 Freely 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 custom map can be configured via:
1. PCS10 Product Configuration Software and the Modbus configuration adapter HA011018.
   The PCS10 can be downloaded free of charge from www.epluse.com/pcs10.
2. Modbus protocol commands, refer to the example in chapter 5.6 Modbus RTU Examples.

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	0x1770	Status	-	INT16	3001	0xBB8	602	0x259
6002	0x1771	T	°C	FLOAT32	3002	0xBB9	1003	0x3EA
			°C	FLOAT32	3003	0xBBA	1004	0x3EB
6003	0x1772	T	°F	FLOAT32	3004	0xBBB	1005	0x3EC
			°F	FLOAT32	3005	0xBBC	1006	0x3ED
6004	0x1773	T	°C	INT16	3006	0xBBD	4002	0xFA1
6005	0x1774	aw	-	FLOAT32	3007	0xBBE	1035	0x46E
			-	FLOAT32	3008	0xBBF	1036	0x46F
6006	0x1775	x	ppm	FLOAT32	3009	0xBC0	1141	0x474
			ppm	FLOAT32	3010	0xBC1	1142	0x475
6007	0x1776	Saturation	%	FLOAT32	3011	0xBC2	1137	0x470
			%	FLOAT32	3012	0xBC3	1138	0x471
6008	0x1777	aw	-	INT16	3013	0xBC4	4068	0xFE3
6009	0x1778	x	ppm	INT16	3014	0xBC5	4071	0xFE6
6010	0x1779	Saturation	%	INT16	3015	0xBC6	4069	0xFE4
					3016	0xBC7	65536	0xFFFF
					3017	0xBC8	65536	0xFFFF
					3018	0xBC9	65536	0xFFFF
					3019	0xBCA	65536	0xFFFF
					3020	0xBCB	65536	0xFFFF

Tab. 7 Custom Modbus map example

5.5 Device Status Indication

If a critical error occurs, all Modbus values are set to NaN (according to IEEE754 for data type FLOAT32) or to 0x8000 (INT16). It is possible to read out all status and error information via Modbus register 602 (0x259). Errors are displayed in bit-coded form. If an event is present, the corresponding bit is set to 1.

Measured values outside the measureing range are limited with 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

5.6 Modbus RTU Examples

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

Please refer to

- MODBUS APPLICATION PROTOCOL SPECIFICATION V1.1b3, chapter 6: www.modbus.org/docs/Modbus_Application_Protocol_V1_1b3.pdf
- 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, 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

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	06	48	BE

Response [Hex]:

Modbus address	Function code	Byte count	Register 1 value Hi	Register 1 value Lo	Register 2 value Hi	Register 2 value Lo	Register 3 value Hi
46	03	0C	0B	C9	41	DB	BD

Register 3 value Lo	Register 4 value Hi	Register 4 value Lo	Register 5 value HI	Register 5 value Lo	Register 6 value Hi	Register 6 value Lo	CRC	
7B	3E	AD	FF	FF	FF	FF	B7	9A

Decoding of floating point values:
Floating point values are stored according IEEE754. The byte pairs 1, 2 and 3, 4 are reorganised as follows:

MMMMMMMM	MMMMMMMM	SEEEEEEE	EMMMMMMM
Byte 3	Byte 4	Byte 1	Byte 2

Example (numbers taken from T reading in first Modbus request/response example in this chapter):

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

6 Maintenance and Service

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 Repairs

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

6.3 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 see www.eplusecal.com.

Calibration and adjustment by the user

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 see www.epluse.com/humor20.
- Handheld device (e.g. Oilport 30), please see www.epluse.com/oilport30.
- Humidity standards (e.g. Humidity Calibration Kit), please see www.epluse.com/mop301.

6.4 Spare Parts

Description	Order code
Stainless steel filter cap for flow < 1 m/s	HA010110
Stainless steel filter cap for flow > 1 m/s	HA010111

7 Accessories

Item	Order code
E+E Product Configuration Software (Free download: www.epluse.com/pcs10)	**PCS10**
Modbus configuration adapter	**HA011018**
Stainless steel filter cap for flow < 1 m/s	**HA010110**
Stainless steel filter cap for flow > 1 m/s	**HA010111**
Protection cap for M12 socket	**HA010781**
Protection cap for M12 plug	**HA010782**
T wcoupler M12 - M12	**HA030204**
Ball valve G 1/2" ISO	**HA050101**
Ball valve 1/2" NPT	**HA050104**
Sampling cell with shut-off function, PN40, DN25	**HA050109**

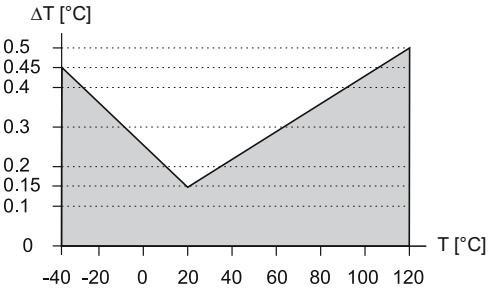
8 Technical Data

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))
Response time t_{90}, typ. *@ 20 °C (68 °F)*	10 min. in still oil
Accuracy[1)] *Including hysteresis, non-linearity and repeatability*	
0...40 °C (32...104 °F) (0...0.9 aw)	±0.02 aw
(0.9...1 aw)	±0.025 aw
-40...120 °C (-40...356 °F) (0...1 aw)	±0.03 aw
Resolution	0.0001 aw

Temperature (T)

Measuring range	-40...120 °C (-40...248 °F)
Accuracy[1)]	
Resolution	0.01 °C

Output

Digital interface	RS485 (MOP301 = 1 unit load)
Protocol	Modbus RTU
Factory settings	9600 Baud, parity even, 1 stop bit, Modbus address 70
Supported baud rates	9600, 19200, 38400, 57600, 76800 and 115200
Data types for measured values	FLOAT32 and INT16 registers

General

Power supply class III ⧫ (EU) / class 2 (NA)	8 - 35 V DC[2)]
Power consumption, typ.	40 mW (without termination resistor)
Electrical connection	M12x1, 4 poles
Protection rating	IP66 / NEMA 4X
Pressure rating	20 bar (290 psi)
Probe material	Stainless steel 1.4404
Cable jacket[3)]	HFS 125XL, black, oil and fuel resistant
Temperature working range	Sensing element + filter cap: -40...125 °C (-40...257 °F) Probe: -40...120 °C (-40...248 °F) Cable: -40...120 °C (-40...248 °F) M12 connector: -25...90 °C (-13...194 °F)
Storage conditions	-40...80 °C (-40...176 °F) 0...95 %RH, non-condensing
Electromagnetic compatibility	EN 61326-1 EN 61326-2-3 ICES-003 ClassA Industrial Environment FCC Part15 ClassA
Shock and vibration	Tested acc. to EN 60068-2-6 and EN 60068-2-27
Configuration and adjustment	PCS10 Product Configuration Software (free download) and configuration adapter

1) Valid in fluids.
Traceable to international standards, administrated by NIST, PTB, BEV...
The accuracy statement includes the uncertainty of the factory calibration with an enhancement 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) USA & Canada class 2 supply required, max. supply voltage 30 V DC.
3) Please mind the mounting and installing instructions included in the user manual.

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