rheonics

IO-Link

IO-Link Field Device:
Rheonics, SME

Doc ID: IOL-OP-2411

Covers sensors: Type-SR and Type-DV

GLOBAL SUPPORT

For Support, visit: https://support.rheonics.com

EUROPE HEADQUARTERS
Rheonics GmbH
Klosterstrasse. 19
8406 Winterthur Switzerland

US HEADQUARTERS
Rheonics, Inc.
3 Sugar Creek Center Blvd, Ste 100
Sugar Land, TX 77478
United States of America
Tel: +1 713 364 5427

Website: https://rheonics.com
Support Portal: https://support.rheonics.com
Sales E-Mail: info@rheonics.com
Support E-Mail: support@rheonics.com

Contents

1 Before you begin

1.1 About the manual

This manual provides information on IO-Link support on Rheonics devices. This document specifies all the device-specific features and IO-Link Protocol implementation details.
This manual assumes that the following conditions apply:

- The sensor has been installed correctly and completely according to the installation guidelines.
- The installation complies with all applicable safety requirements.
- The user is trained in relevant safety standards.

1.2 Purpose

This manual is designed to complement the SME Installation Manual by providing a complete, clear description of this field device from an IO-Link Communication perspective.

1.3 Who should use this document?

The specification is designed to be a technical reference for IO-Link end users. This document assumes the reader is familiar with IO-Link protocol requirements and terminology.

1.4 Warning

Before connecting the IO-Link adapter in an explosive atmosphere, make sure instruments are ordered and installed in accordance with intrinsically safe or EX classification-specific field wiring practices. Explosions can cause serious injury or death. Review Rheonics Ex Manual at https://rheonics.com/resources/manuals/.

1.5 Nomenclature

Abbreviation (short form)	Full-term	Meaning
SRV	Symmetric Resonator Viscometer	Viscosity sensor
SRD	Symmetric Resonator Densitometer	Density and Viscosity sensor
DVP	Density Viscosity Probe	HPHT inline probe
DVM	Density Viscosity Module	HPHT inline module
RCP	Rheonics Control Panel	Software for data acquisition and configuration
SME	Smart Module Electronics	Sensor electronics

Table 1. Defined Acronyms

1.6 Related Documentation

You can find all product documentation on the USB storage device that is integrated in the sensor or was shipped with the sensors. You can also find them on the website at: https://rheonics.com/resources

For more information on the sensor, refer to the following documents on Rheonics website. Contact the Rheonics Support Team if you cannot find a document online.

Title	Code	Description
IO-Link Communication Manual	IOL-OP	IO-Link integration with Rheonics sensors
Communication Protocol Manuals	Various	Modbus TCP, Modbus RTU, HART, Profinet, Ethernet/IP, etc.
SME Manual	SME-OP	Sensor Module Electronics Operator Manual
RCP Software Manual	RCP-OM	Rheonics Software Installation and User Manual
EX installation Sensor Manual	EX-IM	Installation of Intrinsically Safe Sensors Manual

Table 2: Related documentation

2 Product overview

2.1 Process Interface

Rheonics SME is the electronics module of Rheonics sensors. The SME, shown in next Figure, is the device that enables integration with industrial communication protocols. This device provides clients the IO-Link adapter interface through Modbus RTU protocol, hence this manual also contains information on Modbus RTU. For further information review Modbus RTU manual on Rheonics web page.

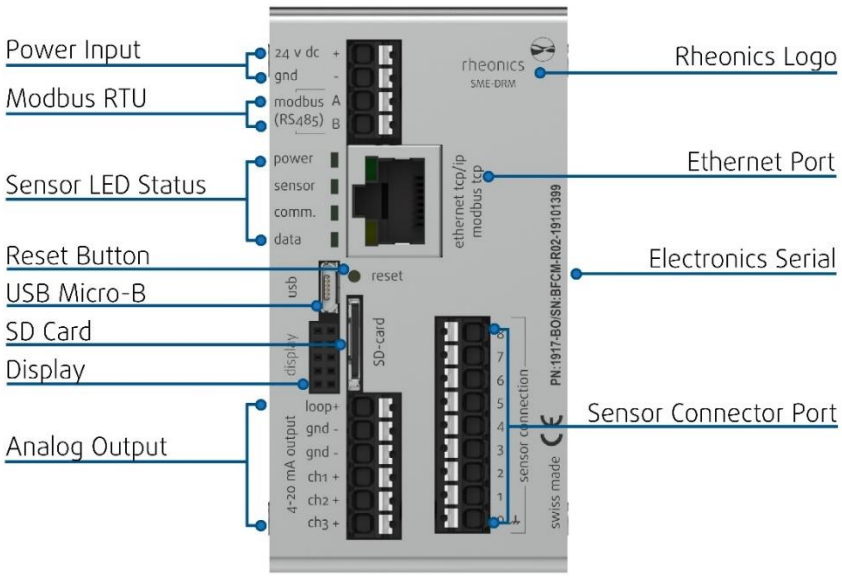

Figure 1. SME sensor electronics unit.

Rheonics SME is used for the Type-SR (SRV & SRD), Type-DV (DVP, DVM) and other sensor types from Rheonics.

Figure 2: Rheonics sensor probes for viscosity and density measurements.

2.2 IO-Link adapter

An IO-Link adapter enables communication between different protocols. To use IO-Link with Rheonics sensors, Modbus signals are converted to IO-Link via an adapter. The IO-Link adapter comes with a fully prepared connector for easy integration.

Figure 3. Banner IO-Link adapter(See Appendix A)

3 IO-Link Wiring

3.1 Instrument overview:

Rheonics has successfully implemented IO-Link communication with its electronics for communication with IO-Link Masters. Depending on the Rheonics sensor type, this allows variables like viscosity, density, temperature, concentration, specific gravity and others to be transmitted in real-time over IO-Link to a device like a PLC or an IO-Link master.
The IO-Link integration with Rheonics is composed and delivered with the following items:

- IO-Link master
  An IO-Link master is a device used in the industrial automation area to connect and manage communication between IO-Link-enabled sensors or actuators and a higher-level control system, such as a PLC or a PC.

- IO-Link Adapter
  An IO-Link adapter or converter is a device that facilitates the conversion between different communication protocols. To use IO-Link protocol on Rheonics sensors, Modbus signals are converted to IO-Link using an adapter. A fully prepared connector is delivered with the sensor.

- IO-Link cable
  Rheonics provides the IO-Link cable that goes from the Rheonics SME to the IO-Link adapter. User must select the length to the IO-Master.

- Rheonics SME
  Rheonics SME is the ultra-fast and robust sensor electronics that includes comprehensive computational models. Depending on the variant, it can be suitable for mounting on DIN rails, inside cabinets, outdoors installations, local display, and laboratory setups. Rheonics SME is powered by 24 DC Volts and is equipped with an Ethernet port, Modbus RTU RS-485 port, and 3 channels for 4-20 mA Analog outputs as detailed in Figure 1.

3.2 Rheonics Modbus to IO-Link Wiring

Connect the IO-Link adapter from the Rheonics sensor to an IO-Link Master device.

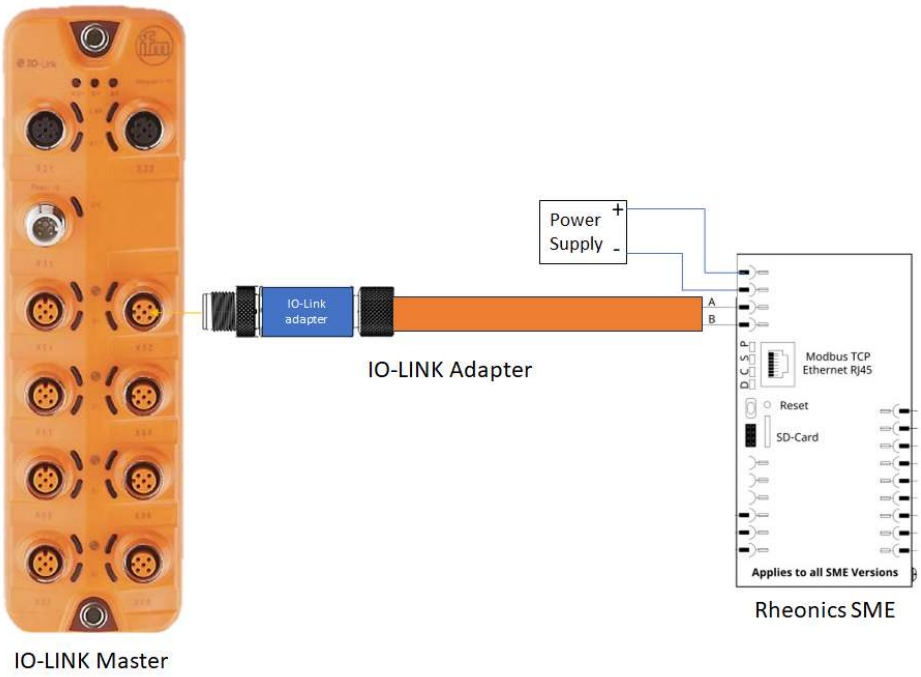

Figure 4. IO-Link wiring diagram

4 Modbus RTU Verification

4.1 Components Used

- Rheonics sensor w/ Firmware V03.30/0 or higher
- Modbus Communication software (e.g. Modbus Poll)
- Rheonics Control Panel (RCP) Software
- Windows 10 or higher - 64 bit
- USB-RS485 2-Wire Converter Terminal Block or adapter

4.2 System Connections

Connect the Rheonics sensor to a PC (with RCP and Modbus communication software installed) using the RS485 pins of the sensor electronics. This can be done with the USB-RS485 or RS232-RS485 adapter. If no communication is established check the RS485 Port and check polarity.

4.3 Configure Rheonics SME

In this section, the SME Ethernet configuration is set. We will use a PC with the RCP software and connect it to the SME using USB. Verify the Address, Baud Rate and Polarity of the device. Figure 6 shows a standard configuration that can be used for the correct performance of the system. See the next steps as guidance.

Note: For IO-Link communication always use the default configuration that comes with the sensor.

- Open the RCP software. On Settings Communication Tab, select USB, identify the COM Port of the desired SME to connect and click Apply. Wait for the Status Led to go green.

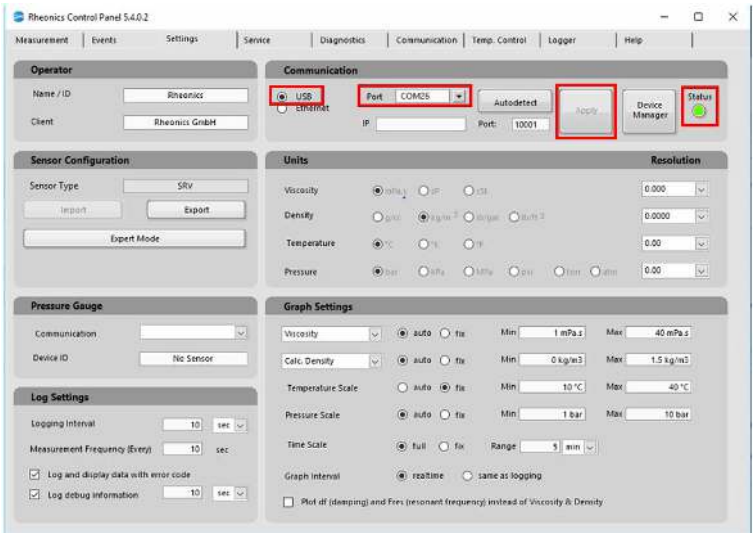

Figure 5: USB connection with SME.

- For the RTU communication, verify the Modbus Address, Baud Rate and Parity.

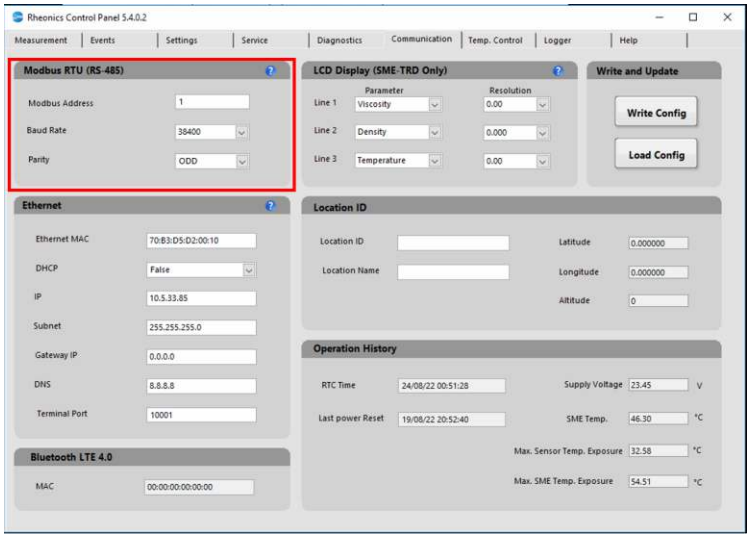

Figure 6: Review Modbus RTU Parameters in RCP.

- Click “Write Config” to ensure this is the configuration in the SME. Wait until the button turns green.

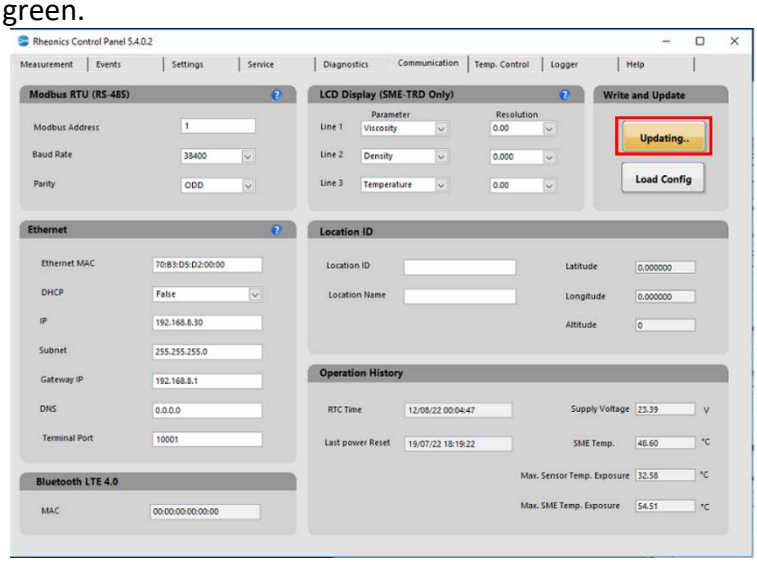

Figure 7. Upload configuration to the SME.

5 Modbus Protocol

The structure of the request and response body in Modbus RTU connections, from the function code to the end of the data portion, has the same layout and meaning as in the other MODBUS variants, such as Modbus TCP or Modbus ASCII. The only differences are the form of any 'framing' sequence, error check pattern, and address interpretation.

5.1 Measured Parameters List

The measured parameters are mapped into the Modbus input registers. There is a total of 23 Parameters available from the SME. Table 3 shows the associated variable, Sensor and Error status.

Parameter	Measurement	Description
Parameter 0	Viscosity median	Takes the median of the last 5 sensor measurements points
Parameter 1	Density median	
Parameter 2	Temperature median	
Parameter 3	Kinematic Viscosity	Measured value divided by density squared
Parameter 4	Density average	Calculates the average of the last 5 measurement points
Parameter 5	Viscosity raw 'process measurement'	Reads the direct measurement taken by the sensor.
Parameter 6	Density raw	
Parameter 7	Temperature raw	
Parameter 8	Resonant Frequency	Measured in Hertz
Parameter 9	Compensated Resonant Frequency	
Parameter 10	Damping	Damping from Measurement
Parameter 11	Coil Temperature	
Parameter 12	Viscosity Last Good	Keeps the last-good median measurement in memory when there is a measurement error
Parameter 13	Density Last Good	
Parameter 14	Displays of mapped value from Modbus register 512	
Parameter 15	Displays of mapped value from Modbus register 514	
Parameter 16	Displays of mapped value from Modbus register 516	
Parameter 17	Estimated Temperature	Calculated from internal temperature Algorithm
Parameter 18	Temperature from PT1000 sensor	Read from internal sensor
Parameter 19	Calculated parameter from viscosity model	Set from Advanced Calculations
Parameter 20	Calculated parameter from density model	
Parameter 21	Calculated parameter from concentration model	
Parameter 22	Sensor Cleanliness Ratio	Used for estimating sensor cleanliness
Sensor Status	Sensor Error Status	Status of the sensor
Error	Error State	Error state of the sensor

Table 3: Measured Parameters List.

6 Data structure

Rheonics devices offer different modules and parameters through IO-Link. Currently, the following parameters are available in Address 0.

Parameter	Data In	Format
Sensor Status	1	Unsigned Int16
Power Supply	2	Float 32
-	3	-
Parameter 12 Viscosity Last Good	4	Float 32
-	5	-
Parameter 12 Viscosity Last Good -Status	6	Unsigned Int16
Parameter 13 Density Last Good	7	Float 32
-	8	-
Parameter 13 Density Last Good - Status	9	Unsigned Int16
Parameter 2 Temperature Median	10	Float 32
-	11	-
Parameter 2 Temperature Median -Status	12	Unsigned Int16
Parameter 4 Kinematic Viscosity	13	Float 32
	14	
Parameter 4 Kinematic Viscosity-Status	15	Unsigned Int16

Table 4. Address 0 data access point

7 Accessing the Data with PACTware

7.1 Reading the IO-Link Data from the Rheonics sensor.

- Open PACTware and select the IO-Link device that is connected
- Scan the devices
  Scan the connected device to display all preconfigured data stored in the Rheonics sensor.
- Access input registers
  In Output (from PLC), select the address 0 to access the preprogrammed data from the adapter. This will provide access to the Input registers from the sensor. Check the Table 3.
- In PACTware to visualize data, go to **"Process data"**, and click the cyclic read button.

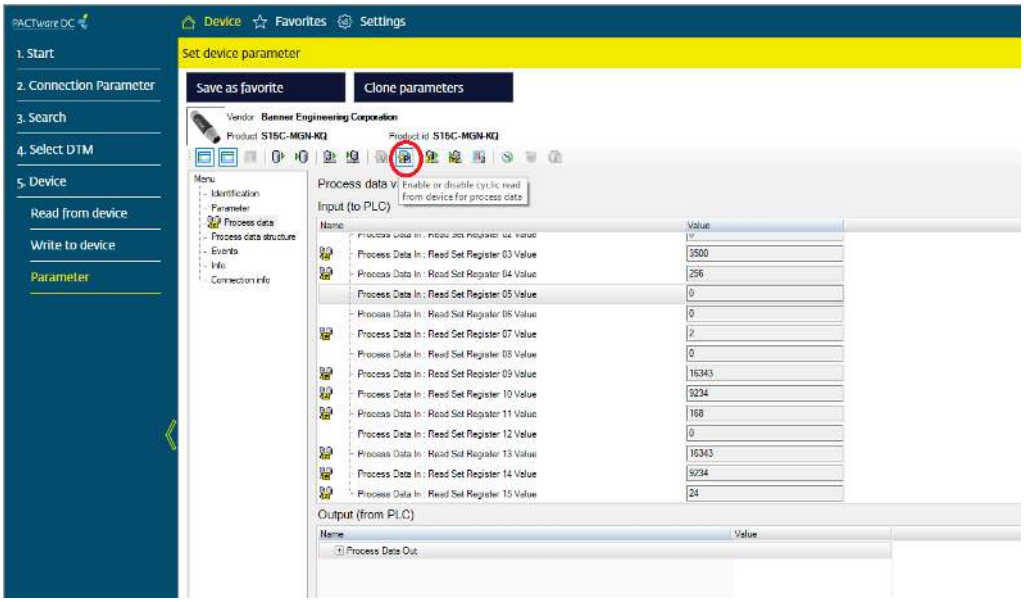

Figure 8. Starting cyclic read with Rheonics sensor

8 IO-Link integration with S7-1200 with IO-Link Master SM 1278

8.1 Components

- Rheonics SME with IO-Link Adapter

  The setup, as covered in Figure 3, consists of an IO-Link adapter that ensures seamless protocol conversion for interoperability between devices in industrial settings, along with the Rheonics SME utilizing the Modbus RTU protocol.

- SM 1278

  The SM 1278 module allows data exchange with up to four external IO-Link devices, each connected by a single 3-wire cable. Alternatively, it can connect up to four standard actuators or sensors. Its flexible configuration options enable the controller to be easily adapted to different communication partners, ensuring compatibility and smooth operation across various devices.

- TIA Portal

  The Totally Integrated Automation (TIA) Portal is Siemens' comprehensive engineering platform designed to provide a complete suite of automation solutions. It integrates hardware configuration, programming, and diagnostics in a single, user-friendly interface, enabling seamless coordination of devices and systems.

8.2 Hardware connection and block diagram

Connect the IO-Link adapter from the Rheonics sensor to an IO-Link Master device. **Pin 2 on the connector is not used.**

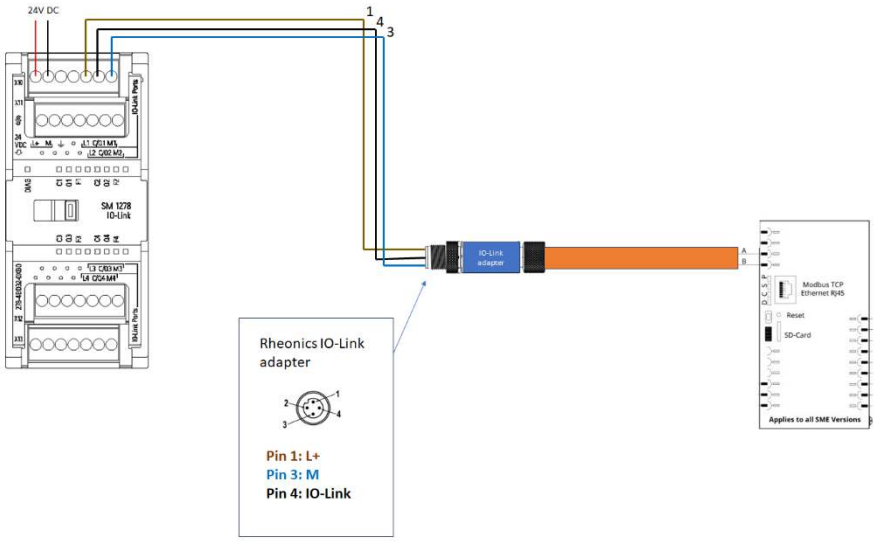

Figure 9. IO-Link Master SM 1278 with Rheonics sensor SME-DRM

8.3 Integration steps

- Add the IO-Link master SM 1278 from the Hardware catalog in TIA PORTAL. The 4-port IO-Link device is added to the project now.

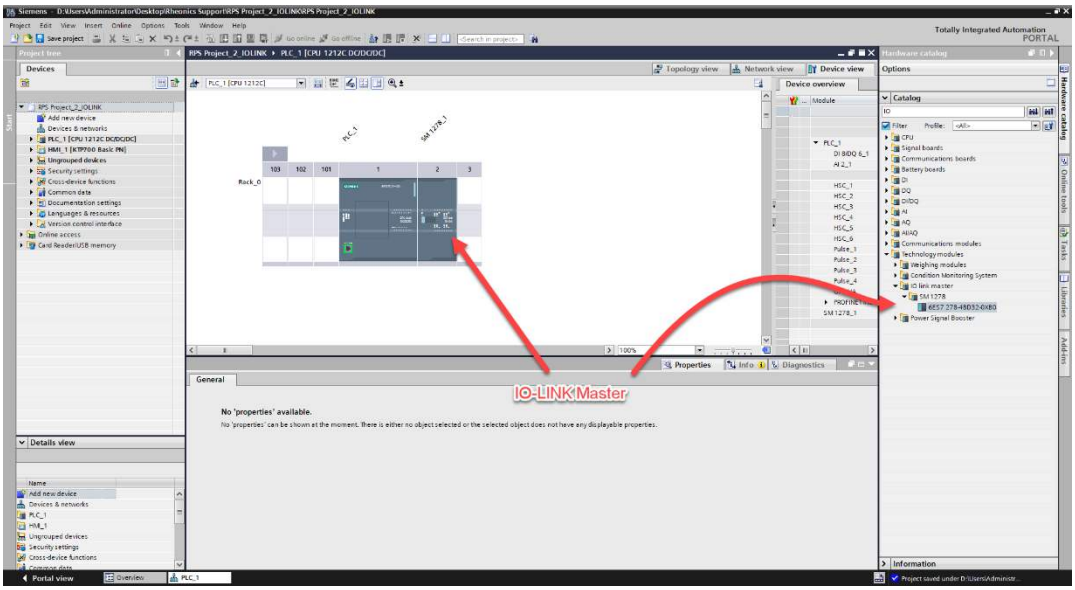

Figure 10. Adding IO-Link Master device SM 1278 to S7-1200 project

- Open the SIMATIC S7 PTC Tool by right-clicking the device just added.

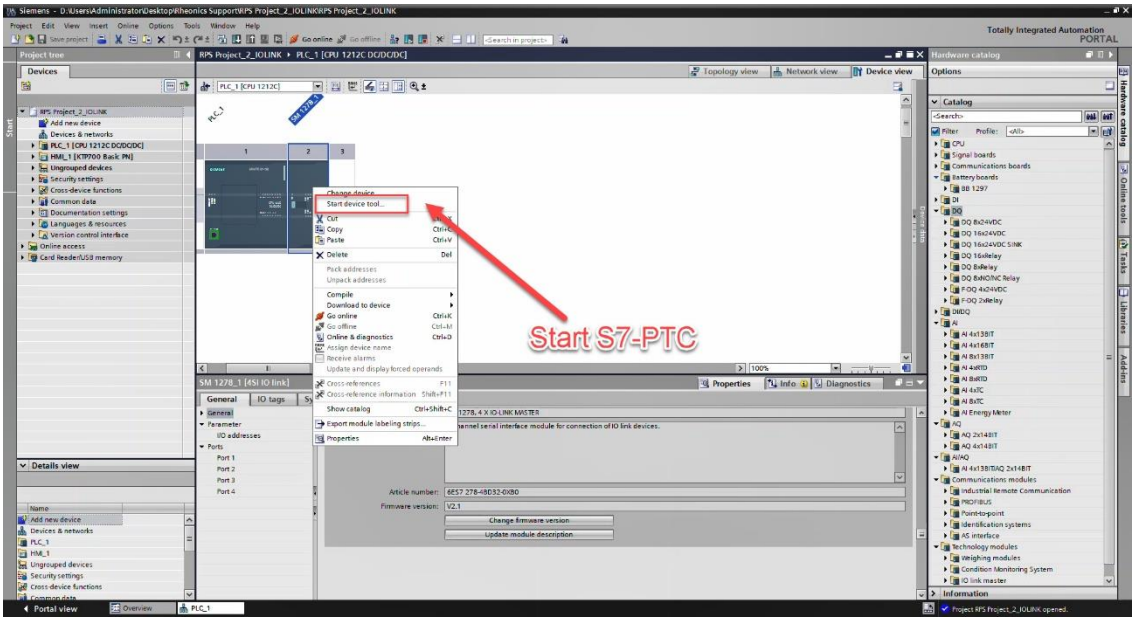

Figure 11. starting the S7-PTC to configure the IO-Link Master device and the IO-Link converter

4

- A prompt message will appear to start the S7-PTC software.

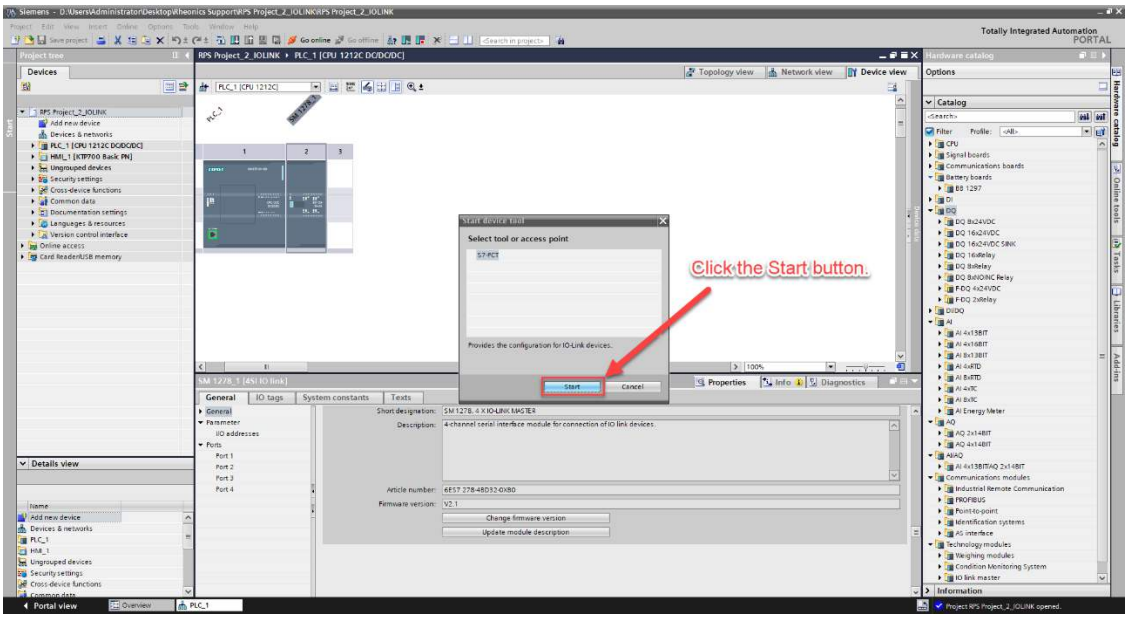

Figure 12. Starting the S7-PTC

- Download the IODD file for the IO-Link converter which can be found at https://www.bannerengineering.com/us/en/products/part.809836.html and import this file in S7-PCT.

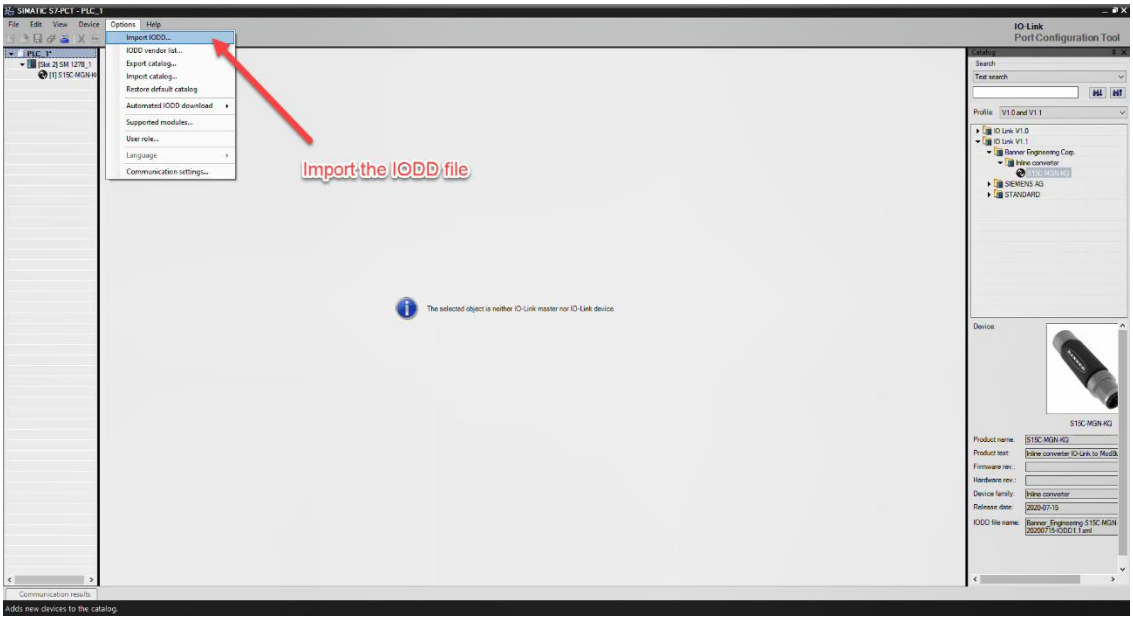

Figure 13. Installing the IODD file.

- Drag and drop the IO-Link converter to the IO-Link Master.

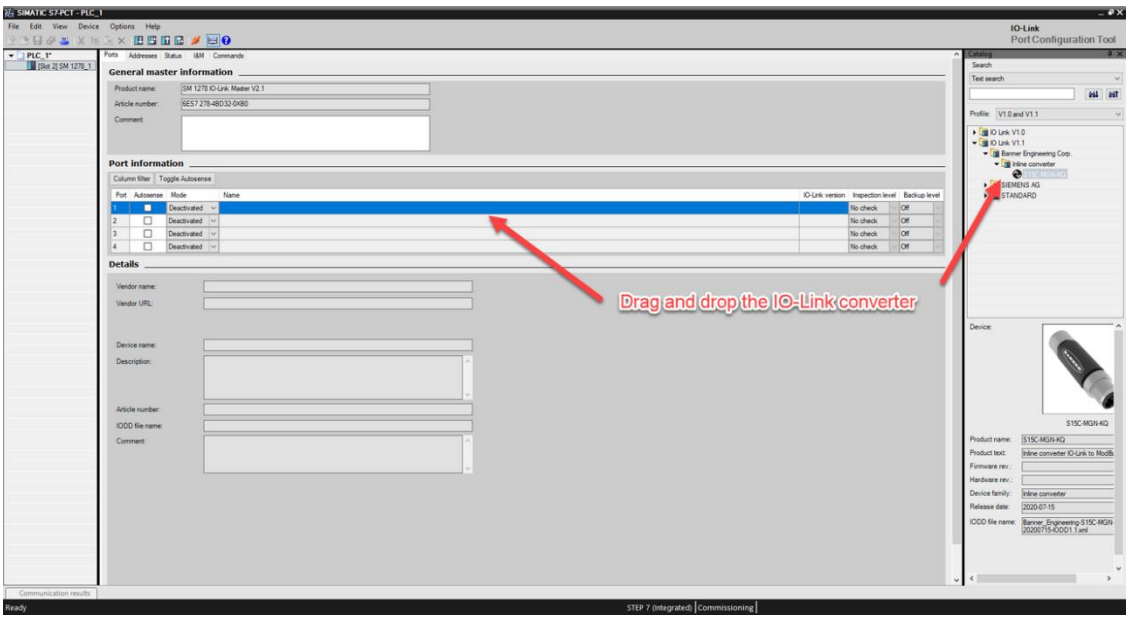

Figure 14. Adding IO-Link converter for configuration

- Go to the Addresses tab to verify which PLC address was assigned to the data in IO-Link.

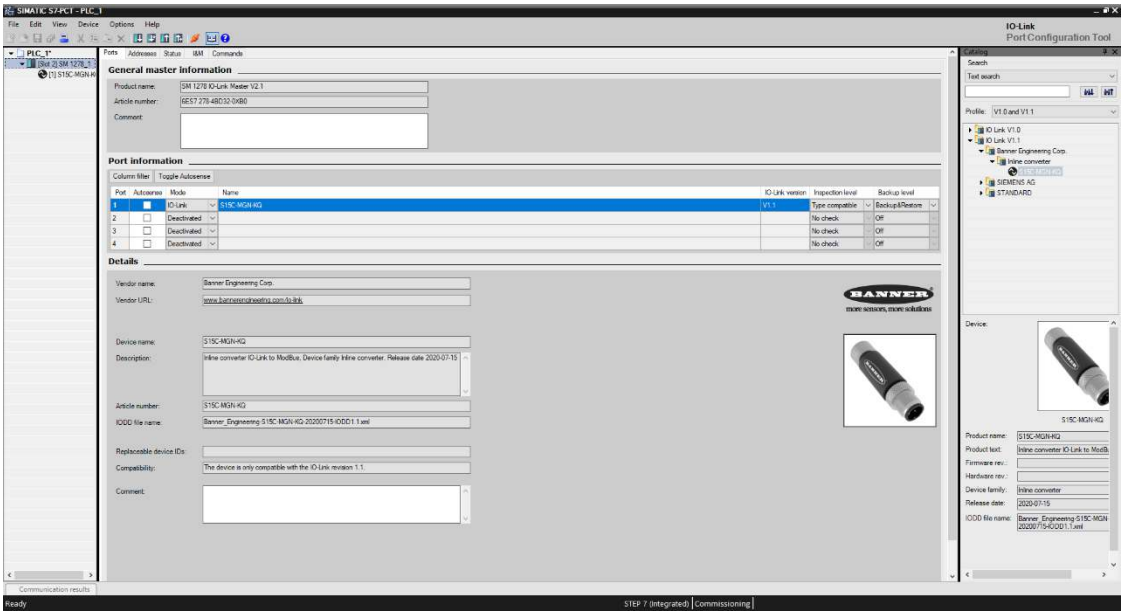

Figure 15. IO-Link Master configuration in Ch1

- Click the show addresses button to check the assigned address on the PLC.

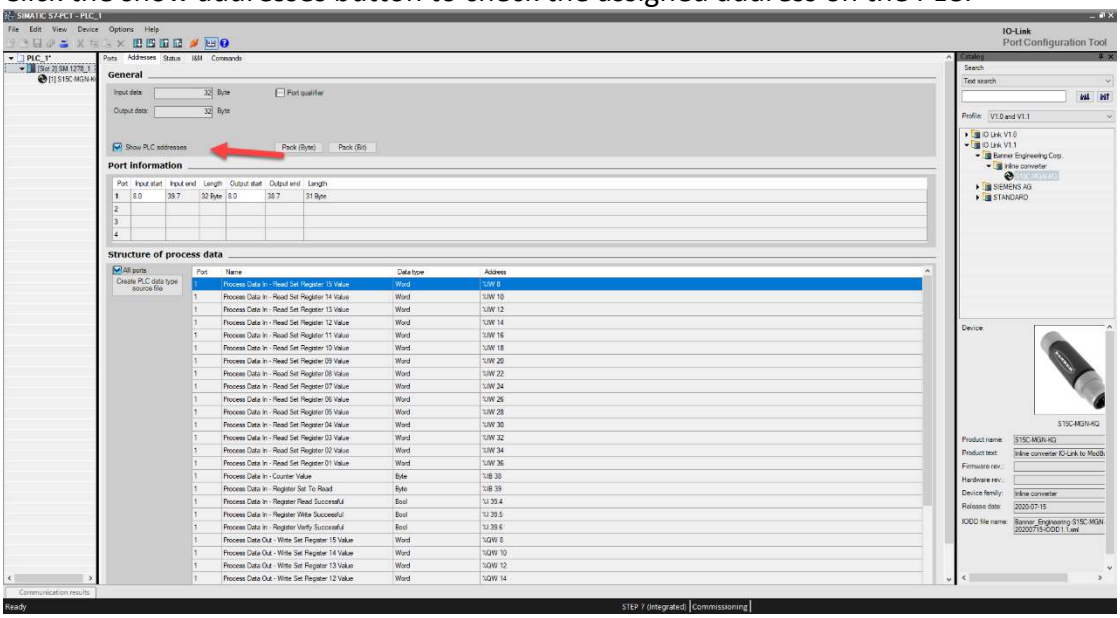

Figure 16. IO-Link Master mapping in S7-PTC

- Table 5 below presents in S7-PTC will show a format like this one.

Rheonics Data-Address	Parameter	PLC Address
Process Data In - Read Set Register 15 Value	Parameter 4 Kinematic Viscosity-Status	%IW 8
Process Data In - Read Set Register 14 Value		%IW 10
Process Data In - Read Set Register 13 Value	Parameter 4 Kinematic Viscosity	%IW 12
Process Data In - Read Set Register 12 Value	Parameter 2 Temperature Median - Status	%IW 14
Process Data In - Read Set Register 11 Value		%IW 16
Process Data In - Read Set Register 10 Value	Parameter 2 Temperature Median	%IW 18
Process Data In - Read Set Register 09 Value	Parameter 13 Density Last Good - Status	%IW 20
Process Data In - Read Set Register 08 Value		%IW 22

Process Data In - Read Set Register 07 Value	Parameter 13 Density Last Good	%IW 24
Process Data In - Read Set Register 06 Value	Parameter 12 Viscosity Last Good - Status	%IW 26
Process Data In - Read Set Register 05 Value		%IW 28
Process Data In - Read Set Register 04 Value	Parameter 12 Viscosity Last Good	%IW 30
Process Data In - Read Set Register 03 Value		%IW 32
Process Data In - Read Set Register 02 Value	Power Supply	%IW 34
Process Data In - Read Set Register 01 Value	Sensor Status	%IW 36

Table 5. Variable mapping in TIA PORTAL

- The next step is to map all the variables to the PLC

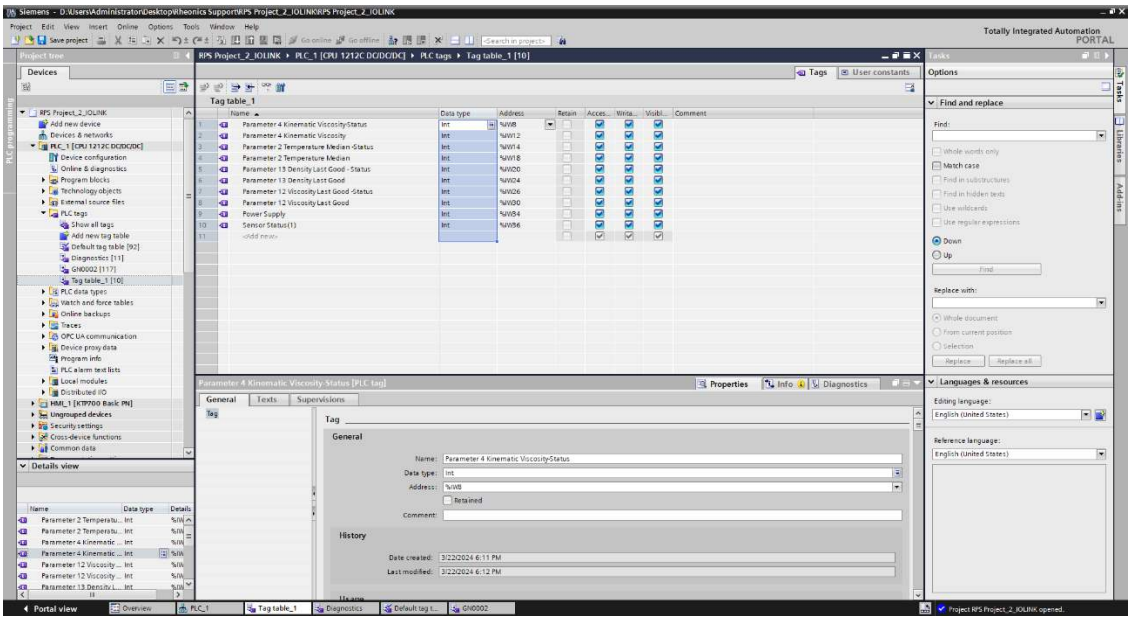

Figure 17. Added tags for IO-Link communication

- Finally convert the data to correct format.

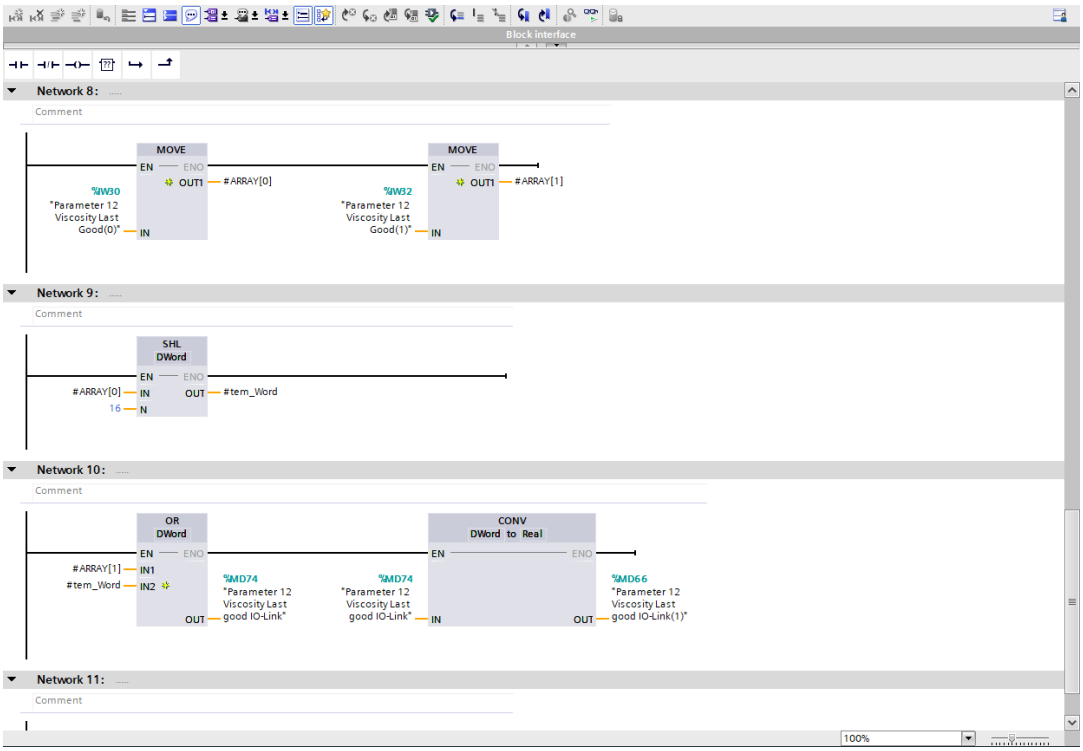

Figure 18. Data conversion for Rheonics sensor reading

9 Sensor status and parameter status

All Rheonics sensors for inline viscosity and density monitoring have sensor status The sensor status which is read at Register 01(See Table 4) will display the following information.

9.1 Sensor Error Status

The sensor status can take any of the following values OR a combination of them:

Bit	Hex	Name	Comment
Bit 0	0x0001	PLL frequency mismatch	The PLL frequency does not match the sensor frequency. Derived from the ASB string (E10)
Bit 1	0x0002	PLL not locked	The PLL is not locked. Derived from the ASB string (E01)
Bit 2	0x0004	PLL lock incorrect	The PLL has locked on a wrong frequency. Derived from the ASB string (E02)
Bit 3	0x0008	ASB communication error	Issues with sensor electronics
Bit 4	0x0010	Temperature sensor failed	The temperature sensor has failed. Derived from the ASB string if temperature is -273.0
Bit 5	0x0020	Sensor too hot	If temperature is above the hardcoded physical temperature limit.
Bit 6	0x0040	ASB communication error	Communication issue between two electronics boards in the SME
Bit 7	0x0080	Serial Changed	
Bit 8	0x0100	Status not clean	Sensor is not clean (only SRV)
Bit 9	0x0200	Status in Air	Determines if sensor is in air
Bit 10 -15	Unused		

Table 6: Sensor error status bit code and description.

9.2 Parameter Status

The Parameter Status can take any of the following values, OR a combination of these states.
For example: If there is a config error, the status value will be 0x0003
If there is a config error and an internal error, the status will take a value of 0x0023.

Bit	Hex	Name	Comment
Bit 0	0x0001	General error	This bit is always set in case there is an issue with the parameter. It can be used by the general user or application programmer to alert an issue with that parameter output. For details check the other bits
Bit 1	0x0002	Config error	The parameter is not configured or there exists a configuration error.
Bit 2	0x0004	Hardware error	The parameter cannot be calculated as the hardware failed. Example: Temperature sensor has failed.
Bit 3	0x0008	Dependent error	A parameter source for a dependent parameter is not available. Example: In case of a free formula a referenced parameter is NAN.
Bit 4	0x0010	Not ready	No result is yet available. Example: No measurement has been taken yet. The algorithm requires a run-in time

Bit 5	0x0020	Internal error	Internal error - Report to Rheonics
Bit 6	0x0040	Calibration Error	Diagnostics
Bit 7	0x0080	Further use	
Bit 8	0x0100	Parameter Calibrated	Triggered when parameter has a calibration/scale factor/coefficient applied to it.
Bit 9	0x0200	Model Loaded	Active when a model has been loaded in script parameters. Only valid for parameters 19,20,21
Bit 10	0x0400	Filtering Active	Active when there is a filter loaded for that parameter
Bit 11	0x0800	Not stable	Parameter result not yet stable Example: Set for example on viscosity if sensor status is not okay.
Bit 12	0x1000	Warning lower	Below lower warning limit (if configured for parameter)
Bit 13	0x2000	Warning upper	Above upper warning limit (if configured for parameter)
Bit 14	0x4000	Alarm lower	Below alarm limit (Hardcoded depending on parameter type)
Bit 15	0x8000	Alarm upper	Above alarm limit (Hardcoded depending on parameter type)

Table 7: Parameter Status bit code and description.

9.3 Which parameters should I read?

Each of the 23 parameters from Rheonics sensor are shown in Section **Error! Reference source not found.** and can be programmed if requested to the Rheonics sales team.

For up-to-date parameters information, please check the pages:

https://support.rheonics.com/support/solutions/articles/81000393235-parameter-list-access-for-field-devices	

https://support.rheonics.com/support/solutions/articles/81000393237-units-translation-table-for-field-devices	

10 Units table

Unit Index	Unit Display	Unit Index	Unit Display
0		**35**	°Baumé
1	mPa.s	**36**	°Brix
2	cP	**37**	%wt/v
3	Pa.s	**38**	%v/v
4	Poise	**39**	%vol
5	Reyn	**40**	Bar
6	mm^2/s	**41**	psi
7	cSt	**42**	m^3/s
8	St	**43**	sccm
9	m^2/s	**44**	gpm
10	in^2/s	**45**	pH
11	SUS	**46**	m^3
12	VI	**47**	gal
13	AV	**48**	STP
14	PV	**49**	Tref
15	YP	**50**	n_D
16	sec	**51**	%wt
17	µ	**52**	%Vol
18	η	**53**	mol/m^3
19	ν	**54**	alcohol
20	°C	**55**	ethanol
21	°F	**56**	Hz
22	°K	**57**	rhe
23	$ref_{XX^{\circ}Y}$	**58**	°P
24	g/cc		
25	Kg/m^3		
26	lb/ft^3		
27	lbm/gal		
28	lbs/gal		
29	ppg		
30	pptf		
31	$slug/ft^3$		
32	SG		
33	ρ		
34	°API		

Table 8. Units translation table.

11 Troubleshooting

Electronics Issues	
Red or no LED lights in SME, error in display or output signals	1. Check power supply and cabling 2. Check Rheonics SME-OP manual online for information
SME does not power up	1. Check power supply and cabling 2. Try with a different power supply
Sensor Probe Issues	
NaN values are displayed on the display, RCP software or PLC	1. Check wiring from the probe to SME is correct 2. Check the probe visually, this may require disassembly from the process 3. Contact Rheonics Support Team
Converter issues	
No data is visible	1. Check the Power led is green on the SME and IO-Link adapter. 2. Check Modbus port is properly wired 3. Try swapping wire A and B from RS485 lines
Data issues	
Measured value is different from my reference standards	1. Viscosity is shear-dependent for non-Newtonian fluids, which means readings differ between sensor technologies 2. Density should be the same under equal temperature and pressure conditions. Contact Rheonics Support Team 3. To verify Rheonics sensors' accuracy,

	calibration fluids and correct setup should be used. Contact Rheonics Support Team
Wrong readings for each parameter	1. Verify each parameter is correctly mapped, some bytes may be swapped 2. Try swapping wire A and B from RS485 lines 3. Verify readings on the RCP software with the sensor connected to the PC via Ethernet or USB
Sensor Status does not match any bit from the sensor status table	1. Sensor status byte is swapped

https://support.rheonics.com/support/solutions/articles/81000397717-modbus-rtu-troubleshooting	

- Contact Rheonics Support Team at
  - support@rheonics.com
  - https://support.rheonics.com

https://support.rheonics.com/support/home	

12 Appendix A: IO-Link converter

The S15C-MGN-KQ is a compact Modbus master to IO-Link converter that allows user configuration for reading up to 60 registers and writing up to 15. It automatically transmits predefined Modbus registers over IO-Link. Its flexible design enables direct connection to a sensor or in-line installation, providing both ease of use and versatility.

https://www.bannerengineering.com/us/en/products/part.809836.html

DISCLAIMER

Rheonics is not endorsing this product, users should use it at their own risk, and it merely serves for informational and illustration purposes; no rights can be derived from its contents.

13 Reviews and approvals

Version	Nature of changes	Approval	Doc. Id	FW version	Date
1	Original	C. Arroyo	IOL-OP-2411	3.30/15	14.11.2024

14 Notes/Errata

Contact Rheonics support for customization of system settings.

Notes