RQ-30, RQ-30a

Discharge Measurement System

Manual

Setup version 2.41 (Firmware 3.07)

15.03.2021

Sommer Messtechnik

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Validity

This manual applies to the Discharge Measurement System with the setup version 2.41, including all its subversions.

Created: 04.11.2020 Last update: 15.03.2021

EU conformity

CE

This product is in conformity with the following standards:

EMC	2014/30/EU	EN 61326-1: 2013
LVD	2014/35/EU	EN 62311:2008
		EN 62368-1:2014
RED	2014/53/EU	EN 301 489-1 V2.2.3 EN 300 440-2 V1.4.1
RoHS II	2011/65/EU	
RoHS III	2015/863/EU	

FCC compliance

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.

FCC and IC compliance

This device complies with Part 15 of the FCC Rules and with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions:

1. this device may not cause harmful interference, and
2. this device must accept any interference received, including interference that may cause undesired operation.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

1. l'appareil ne doit pas produire de brouillage, et
2. l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Changes or modifications made to this equipment not expressly approved by Sommer Messtechnik may void the FCC authorization to operate this equipment.

NOTE: 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.

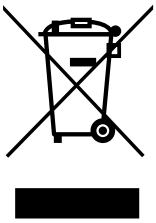
ISED Certification Number: 25742-RGSENS

Safety information

Please read this manual carefully before installing or operating this equipment. Non-compliance with the instructions given in this manual can result in failure or damage of the equipment or may put people at risk by injuries through electrical or mechanic impact.

- Installation and electrical connections must be carried out by qualified personnel familiar with the applicable regulations and standards.
- Installation of equipment on towers, bridges and in discharge channels poses the risk of falling, slipping or dropping of objects. Contact your safety officer or consult applicable safety regulations for precautions and proper personal safety equipment.
- Do not perform any installations in bad weather conditions, e.g. thunderstorms.
- Prior to installation of equipment inform the owner of the measurement site or the authority responsible for it. Upon completion, secure the installation from trespassers.
- Maintenance and repair must be performed by trained personnel or an engineer of Sommer Messtechnik. Only replacement parts supplied by Sommer Messtechnik should be used for repairs.
- Make sure that NO power is connected to the equipment during installation and wiring.
- Only use a power supply that complies with the power rating specified for this equipment.
- Keep equipment dry during wiring and maintenance.
- If applicable, it is recommended to use accessories of Sommer Messtechnik with this equipment.

Disposal



After this device has reached the end of its lifetime, it must not be disposed of with household waste! Instead, dispose of the device by returning it to a designated collection point for the recycling of waste electrical and electronic equipment.

Feedback

Should you come across any error in this manual, or if you miss information to handle and operate the RQ-30 we are pleased to receive your feedback to office@sommer.at.

Content

1 What is the RQ-30?

The exact and real time knowledge of water discharge is of central importance in the fields of hydrography, water storage management, irrigation and for the early detection of floods. It is essential in hydraulic engineering and water resource management and is the basis for hydrological modelling and simulation.

The RQ-30 sensor is a continuous measurement device for the contact-free determination of the water discharge of open rivers and channels. It combines two sensors in one system. The first determines the water level by measuring the transit time of a radar signal. The second simultaneously measures the flow velocity of the water surface by means of the Doppler frequency shift. These two measurements are internally combined and thus provide the water discharge by using a predefined calibration of the measurement site.

Due to the contact-free measurement method the RQ-30 can be installed on extension arms without costly structural measures in the channel or river. This also has the advantage that the sensor is located outside the danger area of flood events and that it requires little maintenance over many years.

Backwater situations caused by inflows, weirs and downstream standing water bodies show no stable relation between water level and discharge. In many situations hysteresis effects with different relations for rising and falling water levels occur. Therefore, the determination of such relations is affected by substantial uncertainty. Only additional information about flow velocity permits the calculation of discharge under these difficult conditions.

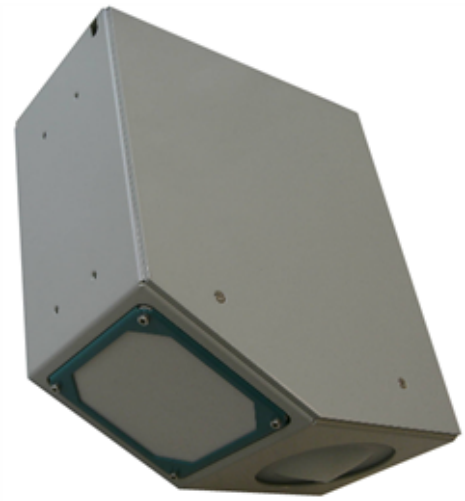


Figure 1 RQ-30

2 Unpacking

When unpacking your RQ-30 sensor box please make sure that the following items are present:

Qty	Art	Item
1	-	RQ-30 in the required version
1	-	Manual and SQ-Commander Software on USB stick

In case of missing or damaged items please contact your Sommer Messtechnik sales partner.

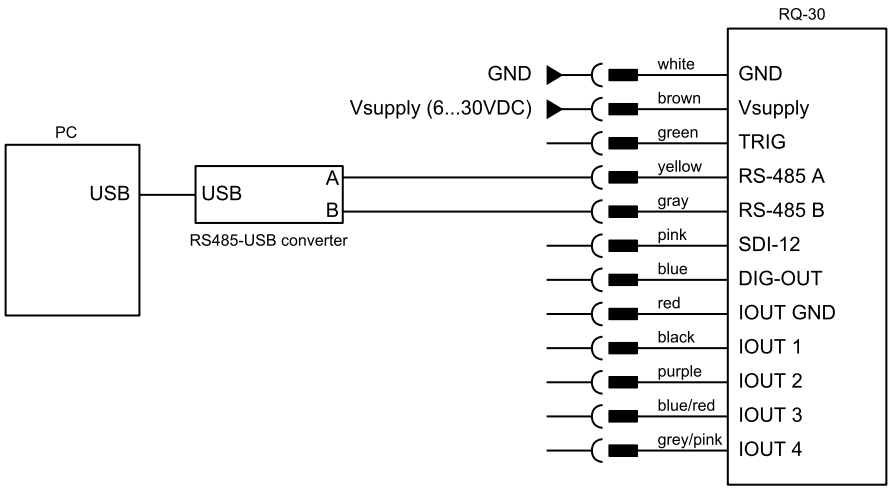
3 Get started

Follow the steps described below to set the basic configurations and to acquire the first measurement results.

NOTE Perform the first start-up in your lab or office before installing the equipment in the field!

3.1 Connect the RQ-30 to your PC

1. Install the SQ-Commander support software (see Installation of SQ-Commander)
2. Connect the yellow and gray wires of the sensor cable to the RS-485 to USB converter cable and plug it into your PC as illustrated in the figure below.
3. Connect the RS-232 to USB converter cable to the RQ-30 and a USB port on your PC.
4. Connect a 6...30 VDC power supply to the RQ-30.
5. Click on Communication assistant on the right-hand side of the SQ-Commander window and follow the instructions. During this procedure the communication assistant will search for connected devices. Upon successful completion, the new connection is added to the connections list (tab Connections (F8)).
6. In the Communication Section at the right-hand side of the SQ-Commander window select Mode Connection and the previously created connection from the drop-down list.
7. Click Connect to establish a connection with the RQ-30. If the connection was successful a green icon is displayed at the top-right corner of the SQ-Commander window.
8. Select the tab Parameters (F2) and click Download parameters from device on the left side of the SQ-Commander window. The complete parameter list is transferred from the sensor to your PC and displayed in the Parameter window.



3.2 Configure the RQ-30

1. Select language, decimal character, units and decimal places (see General settings)
2. Select the measurement trigger (see General settings)
3. Set the parameters of the water level measurement and adjust the measured level (see Water level measurement)
4. Set the parameters of the velocity measurement (see Velocity measurement)
5. Transfer the discharge table from the SQ-Commander to the RQ-30 sensor (see Discharge table)
6. Optional: Configure analog outputs (see Scaling)
7. Send any modifications to the RQ-30 by clicking Upload modified parameters to device.

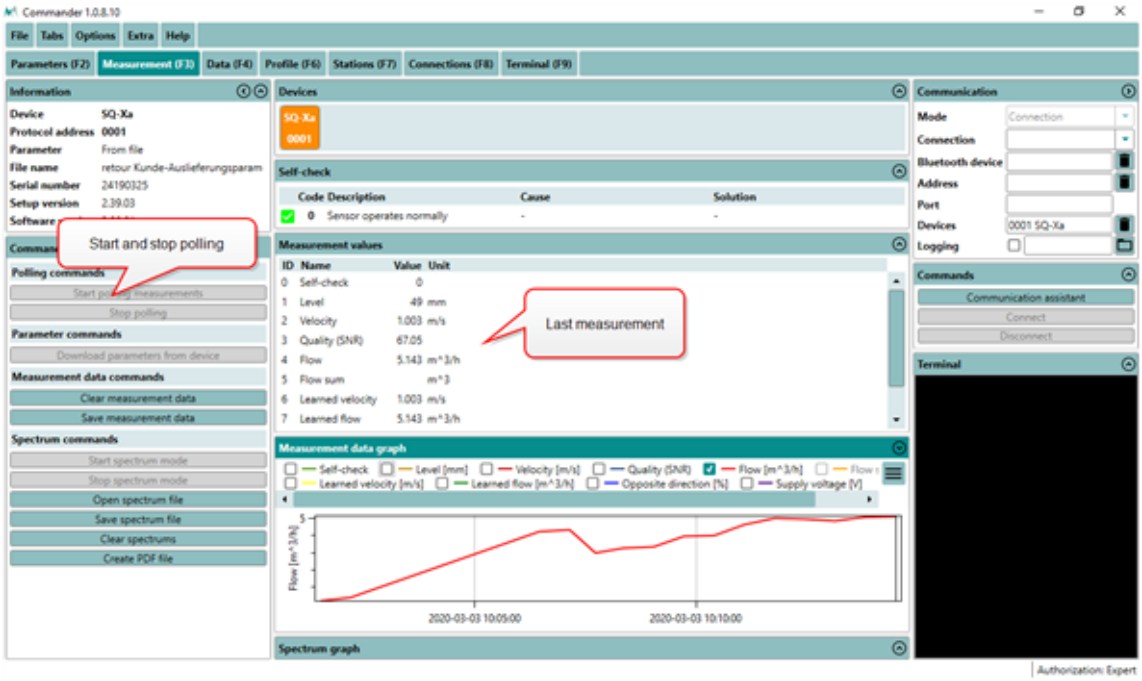
3.3 Adjust the RQ-30 to the current water level

This step needs to be performed as soon as the RQ-30 has been installed at its final location. The respective procedure is described in Adjustment of water level.

3.4 Acquire measurements

1. Establish a connection to your device as described in Working with connections.
2. Download the setup of your device as described in Download setup.
3. Select the Measurement (F3) tab.
4. In the Commandssection click Start polling measurement. Now, the SQ-Commander will trigger measurements of the RQ-30 without any delays between measurements. The results are displayed Measurement values and plotted in the Measurement data graph.

5. To finish polling mode click Stop polling.



4 How the RQ-30 works

The RQ-30 measures the water level contact-free with distance sensor and the flow velocity of the water surface with a Doppler radar sensor and calculates the water discharge.

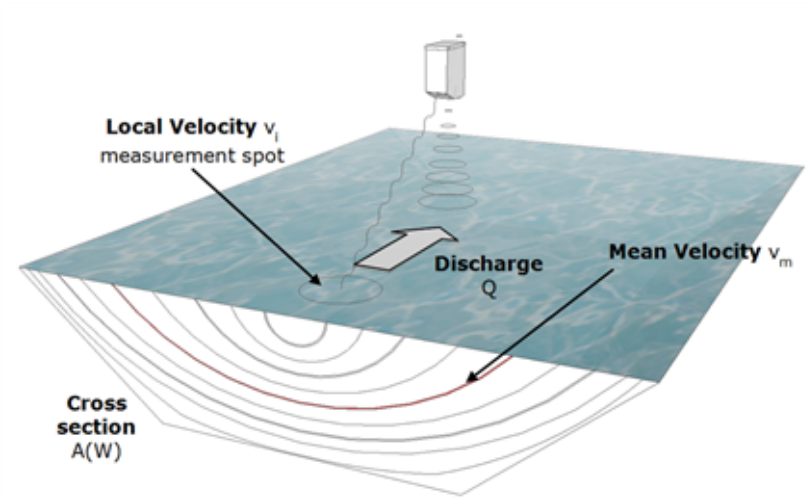


Figure 2 Principle of measurement of the RQ-30 sensor

4.1 Water level

4.1.1 Definition

The water level W is the vertical distance of a point of the water surface above or below a reference level, for example defined by gauge zero GZ.

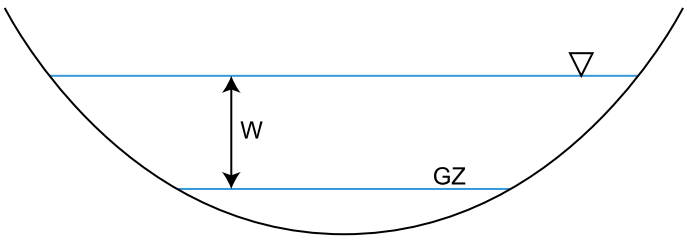


Figure 3 Water level W and gauge zero GZ

4.1.2 Principle of measurement

The water level sensor is installed above a river or channel and transmits a short radar signal towards the water surface. As illustrated in Figure 4 this signal is reflected at the water surface and recorded by the sensor now working as a receiver. The traveling time of the impulse is directly proportional to the distance between the sensor and the water surface.

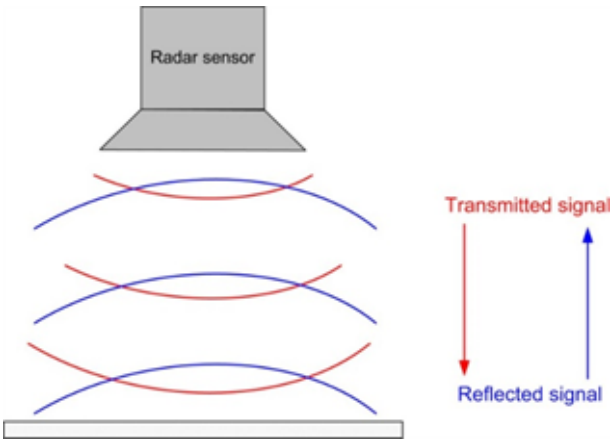


Figure 4 Principle of water level sensor

4.2 Flow velocity

4.2.1 Principle of measurement

The contact-free measurement of the flow velocity is based on the principle of the Doppler Effect. The integrated velocity radar sensor transmits a signal with a constant frequency in a specific angle towards the water surface (see Figure 5). There, the signal is reflected and shifted in frequency due to the movement of the water body. The reflected signal is received by the antenna of the integrated velocity radar sensor. By comparing the emitted frequency to the frequency of the reflected signal from the water surface the local velocity can be determined.

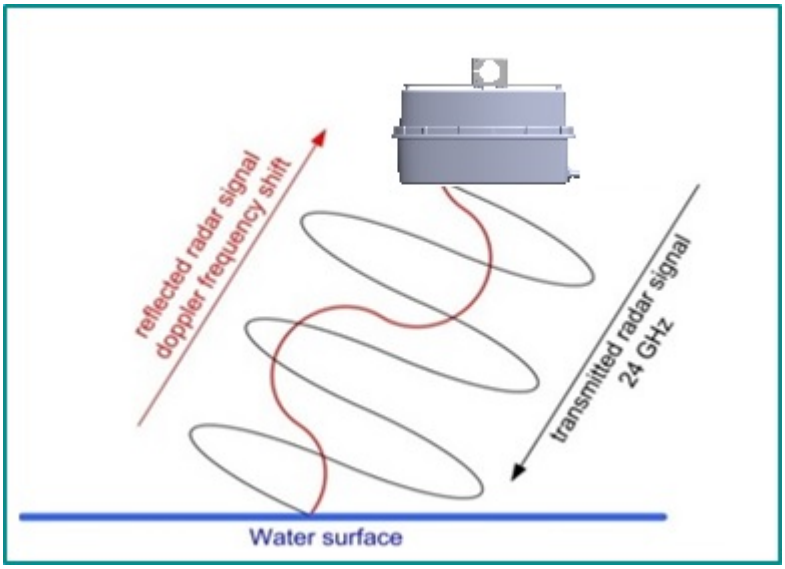


Figure 5 Principle of flow velocity sensor

4.2.2 Flow direction separation

Water can either flow towards or away from the integrated velocity radar sensor. Depending on the flow direction a frequency shift to higher or lower frequencies occurs. This circumstance allows the RQ-30 sensor to separate the water movements by their directions and to separately evaluate the corresponding velocity distribution.

4.2.3 Inclination angle measurement

As the RQ-30 sensor is directed in a specific angle towards the water surface an angle correction has to be applied. The RQ-30 measures its vertical inclination with an internal sensor and applies an automatic angle correction.

4.2.4 Conditions of the water surface

The water surface has to move distinctly and a minimum roughness has to be present to measure a discernible Doppler frequency shift. The more rippled the water surface and the higher the flow velocity is the more reliable the measurements are. The minimum ripple height for a valid analysis is about 2 mm depending on the used frequency. For very slow moving rivers this requirement might not be fulfilled and a continuous and correct velocity measurement cannot be guaranteed.

4.2.5 Radar spectrum

The integrated velocity radar sensor has an opening angle of 12°. Thus, the reflected radar signal of an area is measured. The size of this area depends on the inclination angle and the distance between the sensor and the reflecting water surface.

The velocities appearing in the measured area have a specific distribution depending on the water flow conditions. The velocity distribution is determined with a digital signal processor via spectral analysis, and the dominant velocity in the measurement area is calculated.

As illustrated in Figure 6 the radar spectrum is recorded for water flows up- and downstream. In the lower part of Figure 6 the velocity spectrum of water flowing away from the radar sensor is displayed, in the upper part the spectrum of water flowing towards the sensor. The yellow area is the part of the spectrum used for analysis and the vertical green line indicates the resulting velocity.

By interpreting the radar spectra, velocity measurements can be analyzed in detail. A spectrum can have a narrow or broad peak, one or more maxima or it can identify only one velocity direction. Awareness of this can result in a modification of the settings for the velocity measurement.

For detailed information on how to proceed if more than one peak is visible in the radar spectrum please refer to Appendix B.

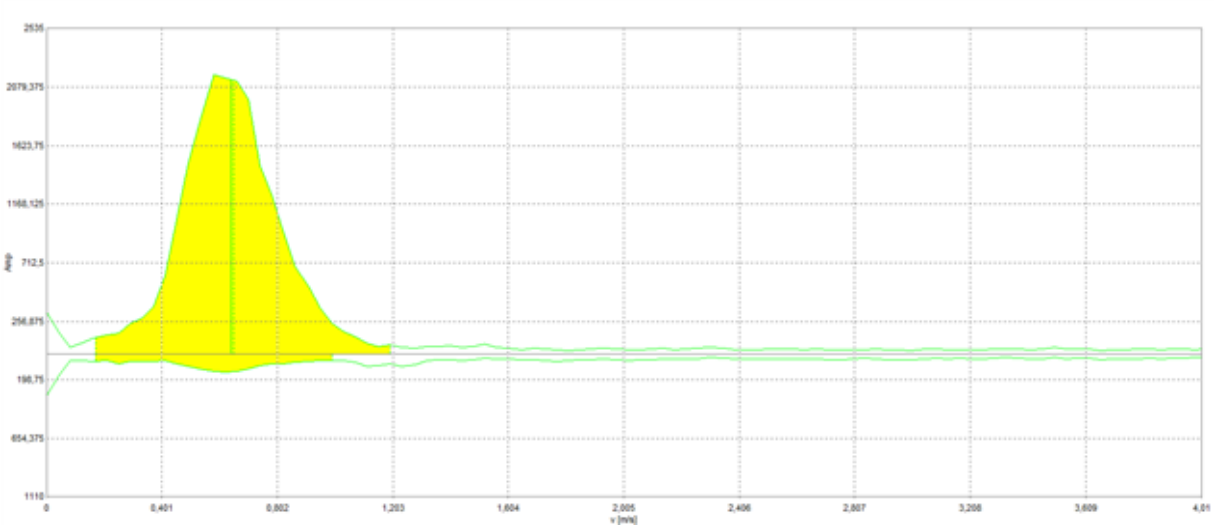


Figure 6 Radar spectrum

4.3 Determination of water discharge

4.3.1 Base equation

The discharge Q is the volume of water V flowing through a cross Section of a river per time unit t. Therefore the dimension is m^3/s, l/s, ft^3/s or m^3/day.

$$Q = \frac{V}{t}$$

By applying the continuity equation the expression above can be transformed into the base equation of the discharge measurement:

$$Q = A \times v_m$$

where A is the wetted cross-Sectional area and vm the mean flow velocity.

The integrated velocity radar sensor measures the local velocity vl at the water surface and not the mean velocity vm. Therefore, a dimensionless correction factor k has to be implemented to calculate the mean velocity from the local velocity:

$$\frac{v_m}{v_l} = k \rightarrow v_m = k \times v_l$$

The k-factor depends on the flow conditions and consequently on the water level W. Its usual range is 60 to 90 % of vl. In combination with the base equation the discharge is calculated:

$$Q = A(W) \times k(W) \times v_l$$

For the RQ-30 a discharge table is generated from the cross-Sectional areas A(W) and the k-factors k (W) for different water levels. This table is stored in the RQ-30 sensor and is the basis for the discharge calculation. It is essential that the water levels of the discharge table correspond to the same reference as the water level measurement of the RQ-30 sensor.

4.3.2 k-Factors

The k-factors are determined by numerical hydraulic modelling. The k-factors mainly depend on the water level, the shape of the channel/river cross-Section, the turbulence of the flowing water and the mounting position of the RQ-30 sensor. By applying a hydraulic model the total water level range can be determined and the discharge calculated from the time of installation. As the k-factors are site-specific they have to be determined for each measurement site.

The PC software SQ-Commander by Sommer Messtechnik can be used to compute k-factors based on hydraulic modelling. Additionally, reference measurements can be used to verify and correct modelled k-factors.

4.3.3 Cross-Sectional area

The cross-Sectional area A(W) as a function of the water level is calculated from the channel/river profile. A(W) values can be computed with the software SQ-Commander by Sommer Messtechnik.

4.3.4 Discharge calculation

The water discharge is calculated from the measured values of W and v_l using the discharge table stored in the RQ-30 sensor. The following scheme illustrates this procedure:

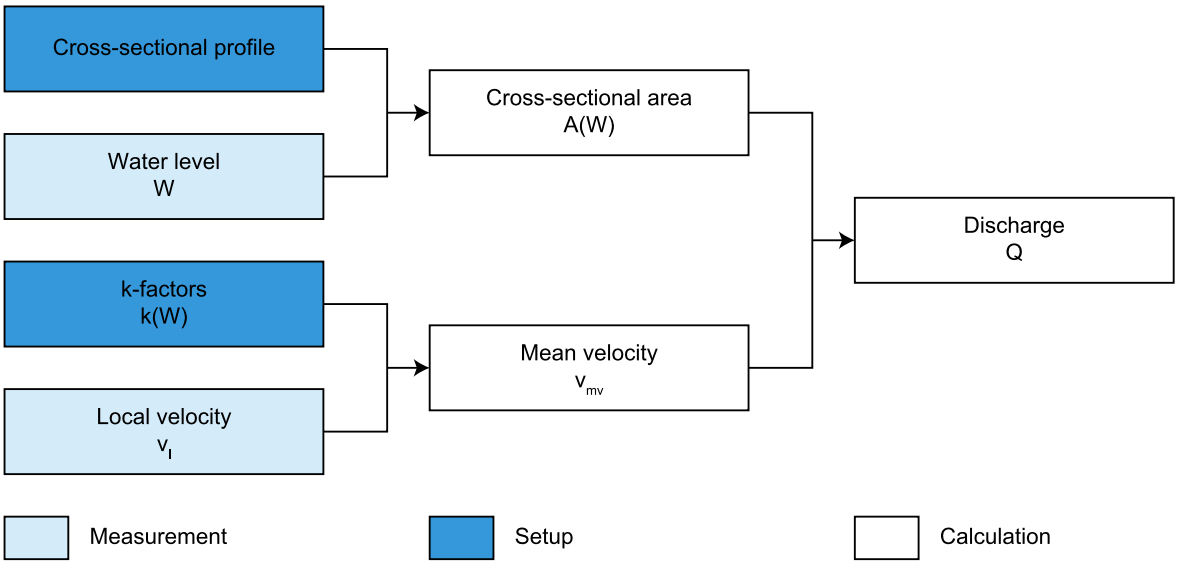


Figure 7 Discharge calculation scheme

5 Components

5.1 Main connector

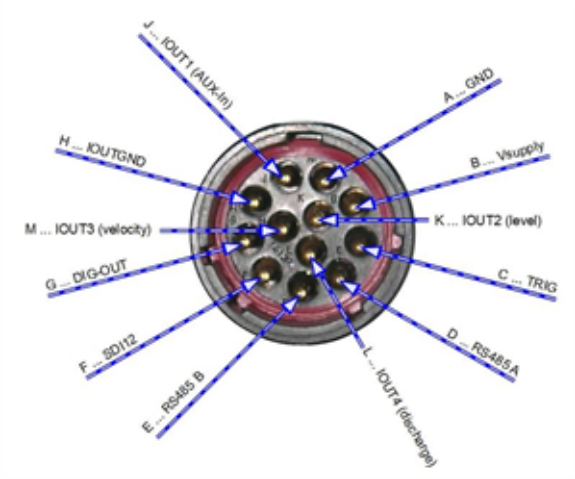


Figure 8 Pin configuration of connector MAIN

	Pin	Function	Description
Power supply	A	GND	Ground
	B	Vsupply	+6...+30 V
Trigger input	C	TRIG	low: 0...0.6 V high: 2...30 V
RS-485 interface	D	RS485 A	1 x RS-485 (1200...115200 Baud)
	E	RS485 B	
SDI-12 interface	F	SDI-12	1 x SDI-12 (1200 Baud)
Switched digital output	G	DIG-OUT	Max. 1.5 A

	Pin	Function	Description
Analog outputs (RQ-30 a only)	H	IOUTGND	Analog ground
	J	IOUT1	Optional sensor (4...20 mA)
	K	IOUT2	Water level (4...20 mA)
	L	IOUT4	Discharge (4...20 mA)
	M	IOUT3	Velocity (4...20 mA)

NOTE The analog outputs and the trigger input are referenced to GND on pin H.

5.2 Connection cable for connector MAIN

The 12-pin connection cable is routed through one of the rubber-sealed holes on the front or back of the metal housing.

Color	Pin	Function	Description
white	A	GND	Ground
brown	B	Vsupply	6...30 VDC
green	C	TRIG	low: 0...0.6 V high: 2...30 V
yellow	D	RS485 A	1 x RS-485 (1200...115200 Baud)
gray	E	RS485 B	
pink	F	SDI12	1 x SDI-12 (1200 Baud)
blue	G	DIG-OUT	Max. 1.5 A
red	H	IOUTGND	Ground for analog outputs
black	J	IOUT1	Optional sensor at AUX
purple	K	IOUT2	Water level
grey/pink	L	IOUT4	Discharge
blue/red	M	IOUT3	Velocity

6 Specifications

Physical and environmental	
Power supply	6...30 VDC; Reverse voltage protection, overvoltage protection
Power consumption at 12 VDC	Standby approx. 1 mA Active measurement approx. 140 mA
Outputs	RS-485 ASCII / Modbus RTU SDI-12 Analog output 4...20 mA (14 bit, max. load 250 Ω) Digital output (low: 0V, high: Vsupply, max. 1.5 A)
Operating temperature	-40...60 °C (-40...140 °F)
Storage temperature	-40...60 °C (-40...140 °F)
Relative humidity	0...100 %
Protection rating	IP 67
Lightning protection	Integrated protection against indirect lightning with a discharge capacity of 0,6 kW Ppp
Housing material	Powder coated aluminum, vandalism-proof Stainless steel option available
Mounting bracket	Ø34...48 mm
Size L x W x H	338 x 154 x 333 mm (13.31 x 6.06 x 13.11 in)
Weight	5.4 kg (11.90 lb)

Velocity	
Detectable measurement range	0.08...15 m/s (depending on waves)
Accuracy	± 0.01 m/s; ± 1 %
Resolution	1 mm/s
Direction recognition	+/-
Measurement duration	5...240 s
Measurement interval	8 s...5 h
Measurement frequency	24 GHz (K-Band)

Radar opening angle	12°
Distance to water surface	0.50...35 m
Vertical inclination	Measured internally

Automatic vertical angle compensation	
Accuracy	± 1 °
Resolution	± 0.1 °

Water level measurement	15 m	35 m	75 m
Measurement range (distance between level sensor and water surface)	0...15 m (0...49.21 ft.)	0...35 m (0...114.83 ft.)	0...75 m (0...246.06 ft.)
Measurement frequency	80 GHz	26 GHz	80 GHz
Resolution	2 mm		
Accuracy	± 0.025 % FS		
Level sensor opening angle	8°	10°	8°

Table 1 Specifications

7 Installation

7.1 Site selection

The selection of a suitable measurement site for the RQ-30 is crucial for the reliability and accuracy of the measurement results. Several aspects related to the hydraulic situation and the mounting of the sensor have to be considered.

7.1.1 Hydraulic requirements

Cross-Sectional velocity distribution

In general, the cross-Sectional velocity distribution at the measurement site must not be changed. For example, fluctuating inflows and regulated weirs can influence the measurements. Therefore a minimum distance to such influences of 5…10x the channel width up- and downstream of the measurement site is recommended. The following drawings illustrate some examples:

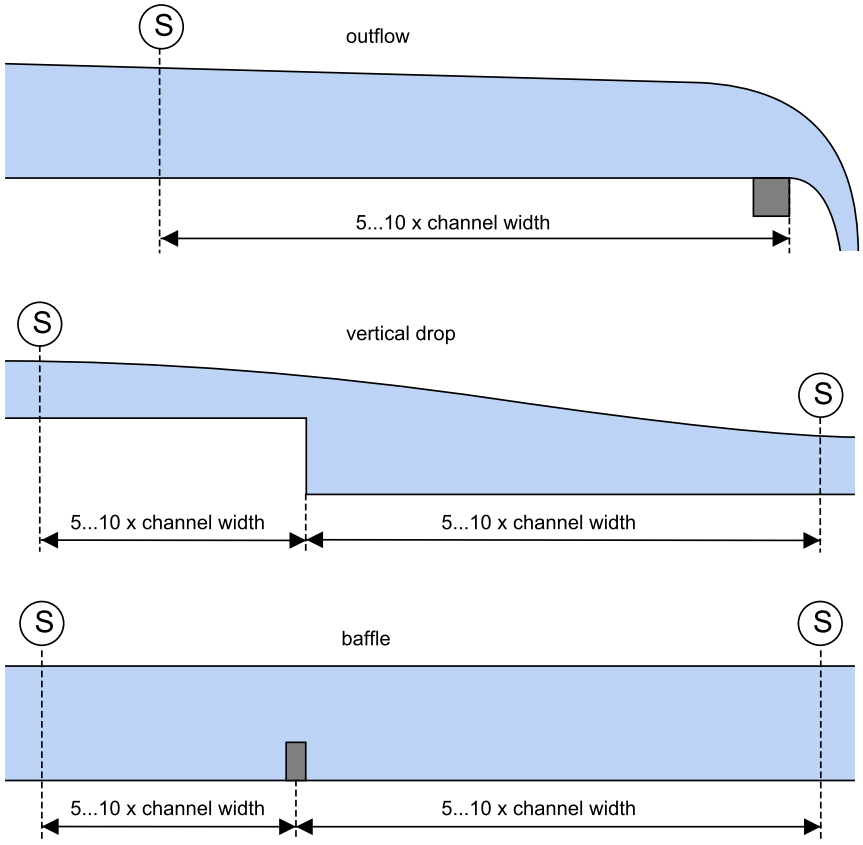


Figure 9 Positioning of RQ-30 sensor under different flow conditions

Stationary waves

There must be no stationary waves present in the field of view of the RQ-30 as they can negatively influence the measurement accuracy. Stationary waves may be caused by big stones and other obstacles; their impact depending on water level. Stationary waves cause errors in angle as the radar impulse is partly reflected from them and not the plane water surface. Also, they may overestimate the water level.

Range with unchanging cross Section

The cross-Section of the channel/river in the vicinity of the flow measurement needs to be stable. Pillars of bridges and bends or corners in the flow channel represent changes of the cross-Section. The minimum distance with a constant cross-Section upstream and downstream of the sensor should be 5…10x the channel width.

Stable cross-Section

The calculation of the discharge requires the cross-Sectional area of the channel/river (see Determination of water discharge). There-fore, the cross Section of the river must not change as this causes the need of a new site calibration. Examples of a changing cross-Section are erosion of the channel bed, deposition of debris or the relocation of sediments. Changes of the cross-Section may be identified by changes in the W-v relation.

Adequate wave movements

Waves or ripples with a height of at least 2 mm have to be present at the water surface over the full expected water level range. Especially very slow flowing rivers often do not meet this requirement (see also Conditions of the water surface).

Influence of wind

For slow moving, deep rivers the flow velocity measurement may be interfered by waves which are caused by wind. If such an influence is observed, the measurement site should be shielded from wind by proper means or an alternative site should be considered.

7.1.2 Installation requirements

Viewing direction

It is recommended to install the RQ-30 with its tip pointing upstream. This has some essential advantages: For installations on bridges the influence of pillars on the water flow conditions are avoided. Addition-ally, the influence of precipitation is eliminated by a direction separation obtained from the velocity spectrum (see Flow direction separation).

Free field of view

The RQ-30 sensor interprets all movements in its field of view. Therefore, no moving objects shall be present in the field of view of the RQ-30. Figure 10 shows the size of the measurement spot and its distance from the RQ-30 sensor for different installation heights. Consider these dimensions when installing the sensor.

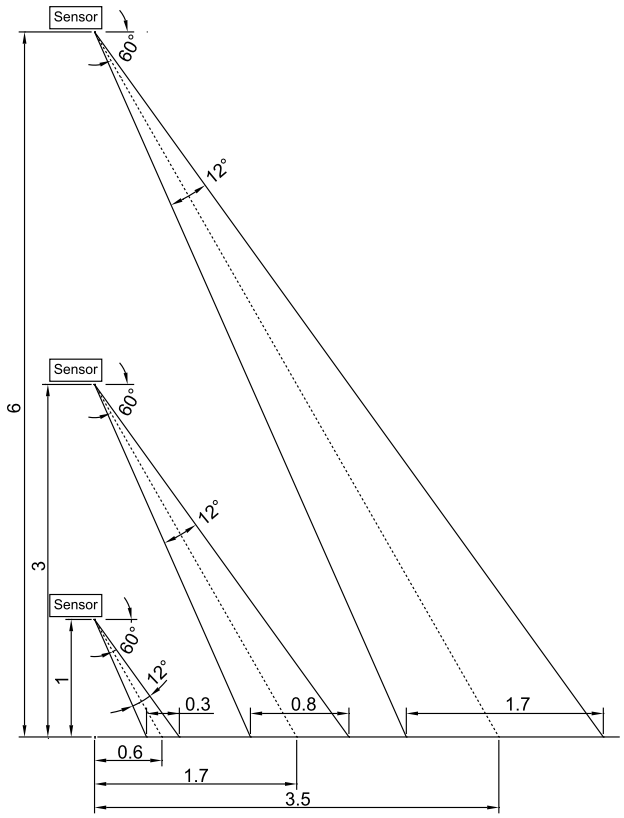


Figure 10 Measurement spot size for different mounting heights (dimensions in m)

Installation underneath bridges

When the RQ-30 is installed underneath a bridge it has to be assured that no rain or melt water is dripping through the field of view of the velocity radar. The occurrence of such events may influence the measurement considerably.

Installation on extension arms

The RQ-30 sensor can be mounted on an extension arm protruding from a river bank or channel wall. Sommer Messtechnik suggests installing a rotatable extension arm to facilitate maintenance.

Installation above open channels or rivers

The RQ-30 can be mounted in a range between 0.5 to 15 m above the water surface. With the extended measurement range the RQ-30 can be installed at a height up to 35 m above the water surface.

The sensor has to be mounted on a rigid structure that does not move, e.g. support beams or handrails of a bridge. An exception is the mounting on cable ways, which requires determination of the sensor inclination before each measurement to account for swinging (see parameter definition Inclination measurement).

7.1.3 Documentation

It is recommended to document the measurement site with pictures for future analysis. These may include:

- Measurement site with the installed sensor
- River or channel facing upstream and downstream
- Flow conditions at the measurement site
- Roughness of the river bed or channel walls

7.2 Performing a site survey

Every measurement site requires an individual survey to determine the local hydraulic boundary conditions. These conditions are aggregated the a discharge table, which is used to calculate the discharge based on the measured water level and flow velocity.

Follow the instructions below to perform a complete site survey:

1. Select the reference coordinate system

   The measurements of the water level, the mounting position of the RQ-30 sensor and points in the cross-sectional profile have to relate to each other. Especially the water levels defined in the discharge table and the water levels measured with the RQ-30 sensor have to be consistent. See Map the cross-sectional profile for the available options.

   When selecting the reference system for the measurement site, existing installations for water level measurements should be considered.

   Sites with an existing water level measurement

   If a water level measurement is already present at the measurement site, i.e. gauge plate or gauge sensor, it is recommended to use the gauge zero (GZ) of the existing measurement as the reference level. This level is usually unique and defined permanently. Moreover, consistency in the existing water level measurement and the RQ-30 measurement simplifies interpretation. As illustrated in Figure 11 the level of the gauge zero has to be known in the reference system.

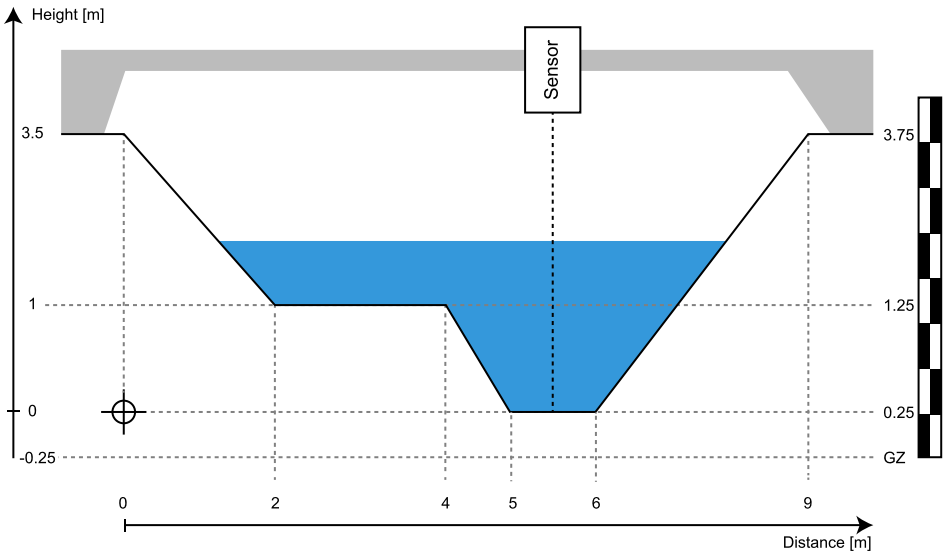


Figure 11 Gauge zero (GZ) of a gauge plate in reference to a channel profile

In the example shown in Figure 11 gauge zero is at -0.25 m in the reference coordinate system of the cross-Section H.

Sites without an existing water level measurement

For measurement sites without an existing water level measurement a new reference has to be defined. It is recommended to select a stable, fixed point as reference for future verification. It is essential to exactly document this point and its relation to the water level W.

For channels with a stable lining a point on the surface can be selected as a reference and gauge zero simultaneously. Thus, the water level can be determined easily and the adjustment procedure for the water level measurement of the RQ-30 sensor is simple.

For all other situations a fixed point has to be selected. Examples are survey points or stable, accessible points on bridges or other structures. This reference point has to be mapped in the coordinates of the cross-Sectional profile. The point does not need to be defined as gauge zero, but needs to relate to it.

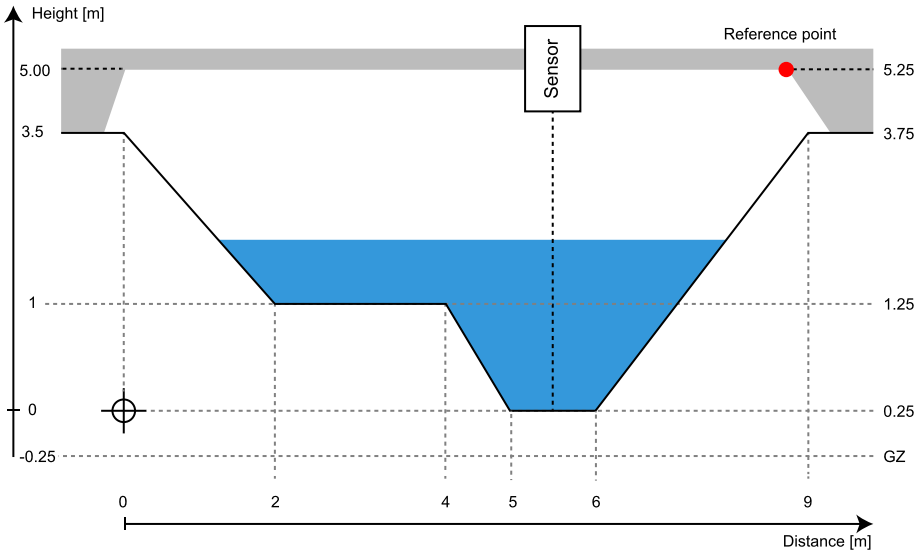


Figure 12 Gauge zero (GZ) with a fixed point referenced to it

In the example of Figure 12 a fixed point was defined on a bridge. The height of the point is 5 m in the reference coordinate system of the cross-Section H. The gauge zero was defined as -0.25 m. Thus, the fixed point is at 5.25 m in the coordinate system of the water level measurement W.

2. Map the cross-sectional profile

   The cross-Sectional profile represents a vertical cut through the channel from the river bed to the maximum expected water level. It is required for the calculation of the wetted cross-Sectional areas A(W) and the modeling of the k-factors k(W) (see Determination of water discharge).

   The cross-Section is usually taken at the position of the water level measurement. A point in the pro-file is specified in one of the following coordinates:

   - height relative to bottom with positive values upwards, see Figure 13
   - absolute height above sea level, see Figure 14
   - height relative to top with positive values downwards, see Figure 15

3. Determine the roughness of the riverbed

   An estimation of the roughness on the edges of the cross-Sectional profile is necessary to model the k-factors. The roughness is specified as absolute roughness k_S, Strickler coefficient k_{St} or Manning co-efficient n. In the SQ-Commander software the roughness is specified in categories, e.g. "Sand bed" or "Brickstone walls".

4. Locate the position of the RQ-30
   The exact position of the RQ-30 in the reference system has to be known (see Figure 16). This information is essential for modelling the k-factors and adjusting the water level measurement.

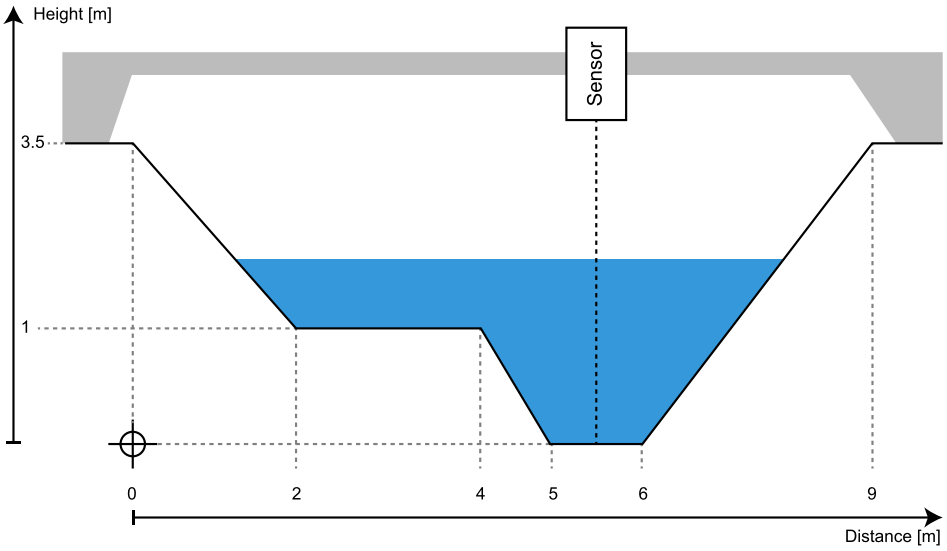


Figure 13 Cross-Sectional profile with height relative to bottom

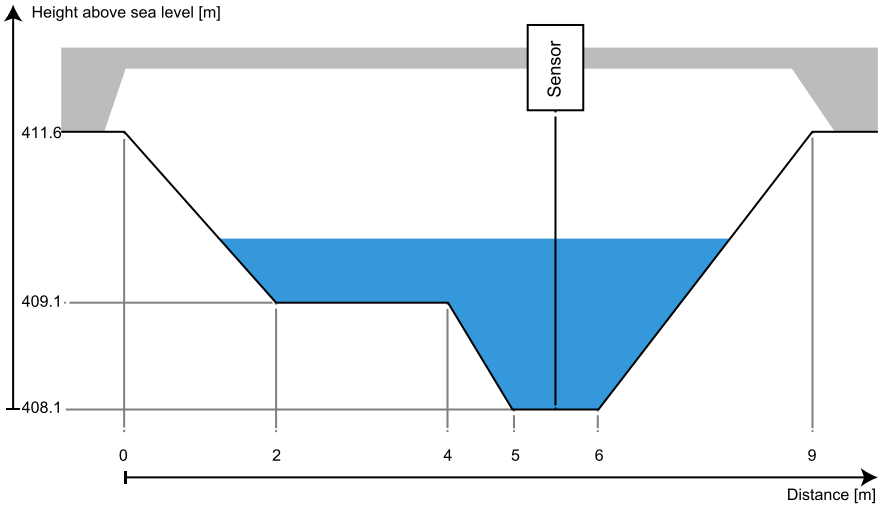


Figure 14 Cross-Sectional profile with absolute heights

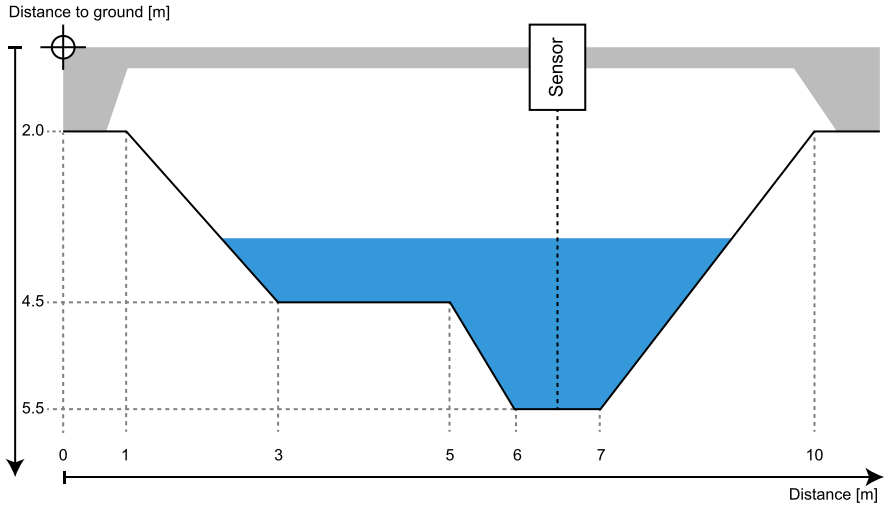


Figure 15 Cross-Sectional profile with heights relative to top

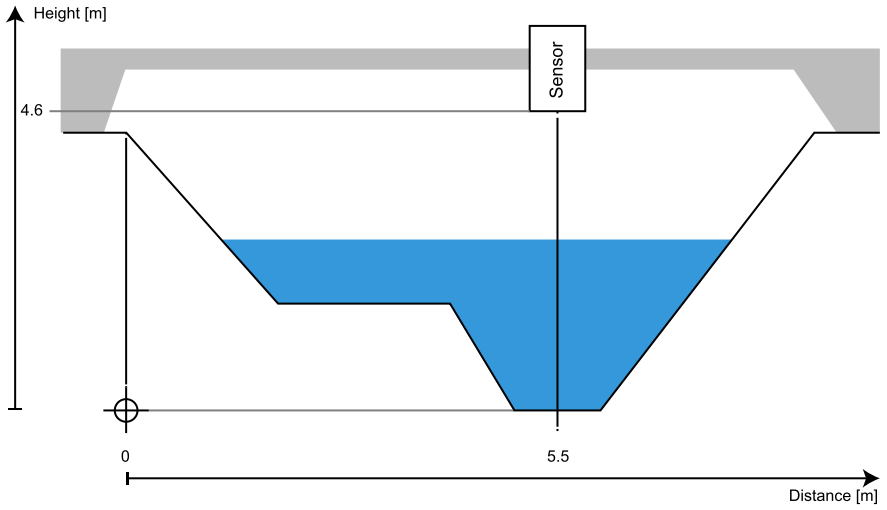


Figure 16 Cross-Sectional profile with RQ-30 position relative to bottom

5. Build the discharge table

   The survey of the measurement site is expressed in the form of a discharge table as shown in Table 2. This table is stored in the RQ-30 sensor and is the basis for the calculation of the discharge as described in Discharge calculation.

   The discharge table contains the cross-Sectional areas A(W) and k-factors k(W) of different water levels W. The areas A(W) are derived from the cross-Sectional profile, k-factors k(W) are determined according to k-Factors.

   The discharge table can contain up to 16 entries which are ordered from low to high water levels. A(W) and k(W) values are interpolated linearly to measured water levels.

The discharge table can be created with the software SQ-Commander by Sommer Messtechnik. After entering the cross- Sectional profile, the channel/river roughness and the sensor position the discharge table is calculated automatically. This table can then be transferred to the RQ-30 sensor.

	Status	Level (W)	K value	Area (A)
		[m]	[ ]	[m^2]
01	on	0.4	64.0	4.7
02	on	0.6	68.7	9.5
03	on	0.8	72.1	14.4
04 … 14	...	...	...	...
15	on	4.9	79.5	141.8
16	on	6.7	80.7	202.4

Table 2 Example of a discharge table

7.3 Things to consider for installation

7.3.1 Power supply

The RQ-30 is designed for extreme environmental conditions at remote sites and with no grid connection. The sensor switches automatically into standby-mode between measurements and thus consumes only approx. 3.5 Ah per day which can be supplied by a 12V-solar-generator mounted to the mast.

7.3.2 Signal cables

Maximum cable length

Please consider the maximum cable lengths for the applied transmission protocol:

Protocol	Max. cable length [m]
SDI-12	60
RS-485	300

Table 3 Maximum cable lengths

NOTE Cable lengths longer than 60 m require a heavier gauge wire if the power supply drops below 11 V.

7.3.3 Lightning protection

If the underground at the measurement site permits sufficient current dissipation it is strongly recommended to equip the sensor support or mast with properly dimensioned lightning protection. Consult an expert for advice.

The RQ-30 is protected against overvoltage. If a data logger is mounted to the mast, its ground lug must be properly connected to earth ground.

7.4 Required tools and equipment

Prepare the following tools and equipment to install the RQ-30:

Qty	Tool
1	Mounting tube Ø34...48 mm
1	Flat spanner 13 mm
1	Cable ties
1	Wire cutter

7.5 Mounting

The RQ-30 is mounted to a tube Ø34…48 mm with the supplied U-bolts. For alternative mounting methods please contact Sommer Messtechnik.

ATTENTION

The RQ-30 must be installed parallel to the water surface! The angle between the water surface and the device must not exceed ±2.5°.

As illustrated in Figure 17 the RQ-30 must be installed parallel to the water surface in both directions: along and perpendicular to the water flow. Additionally, the sloping angle has to be entered in the parameter River inclination. The sloping angle is always entered as a positive value, irrespective of the viewing direction of the sensor.

In tidal situations where both flow directions occur, the RQ-30 should always be mounted horizontally and River inclination should be set to *0*.

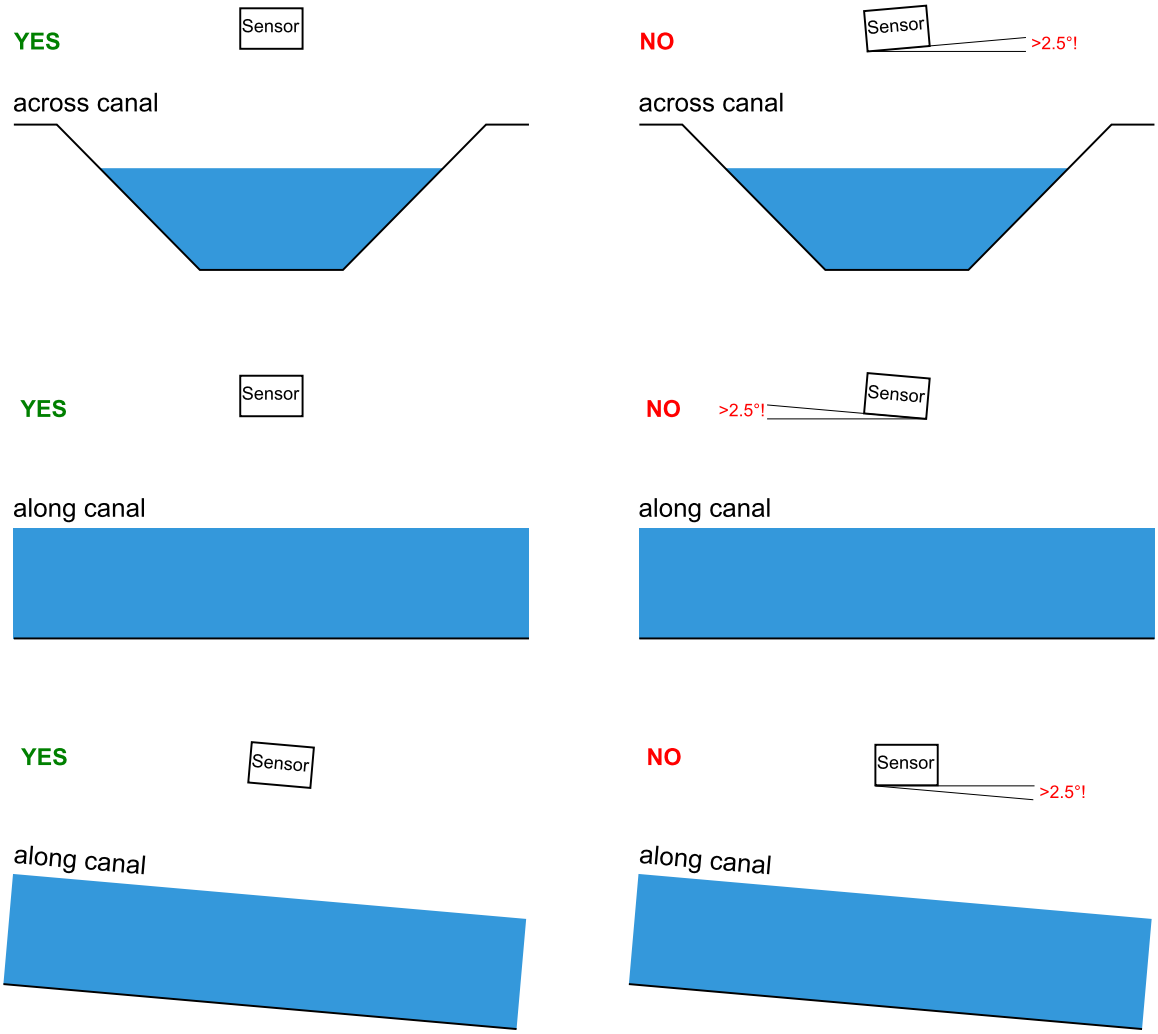


Figure 17 Parallel sensor installation

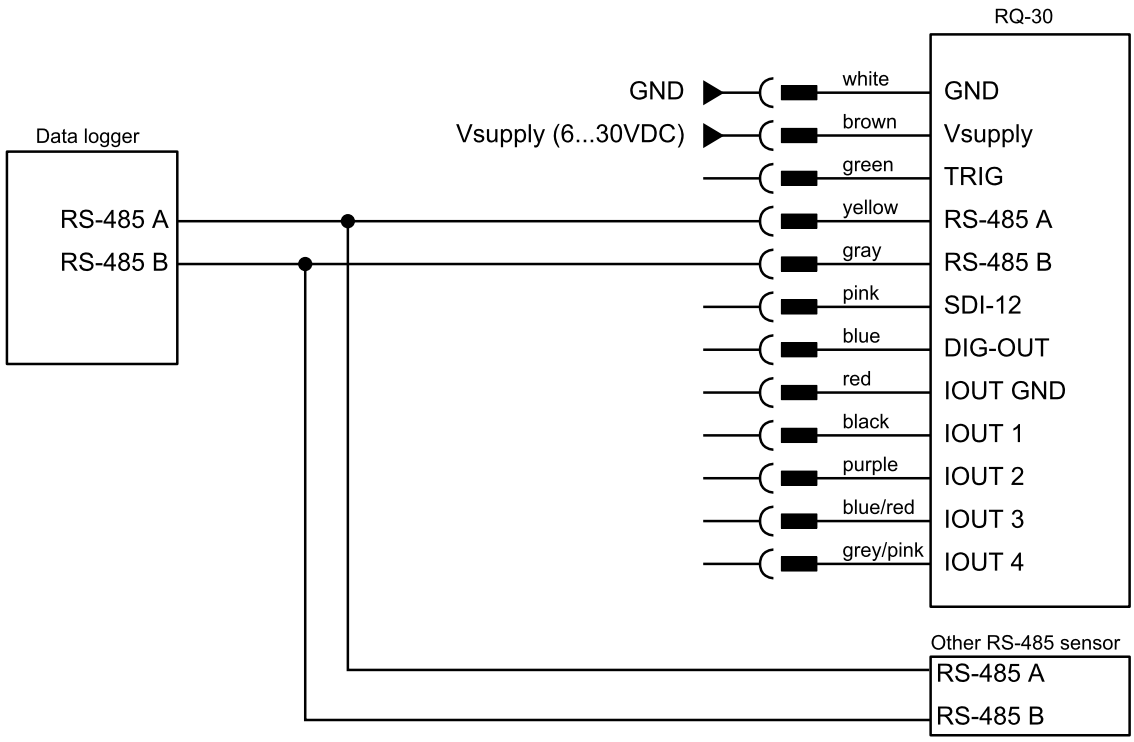
How to install the RQ-30 in a manhole

Sommer Messtechnik offers a versatile mounting accessory suitable for circular manholes which allows for easy and quick installations. With this accessory the RQ-30 mounting position can be adjusted horizontally and vertically. The accessory is suitable for a manhole diameter of 580…690 mm and is provided with an adjustable mounting pole of 0.5…2.5 m length.

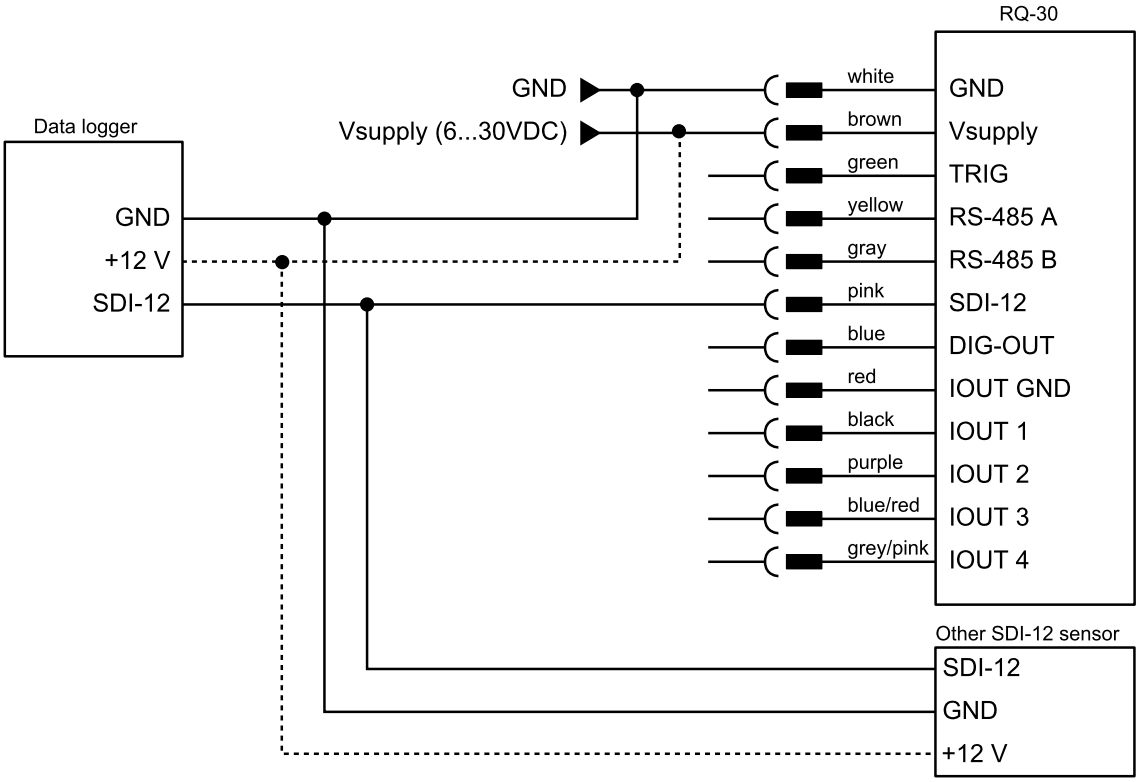
Figure 18 Manhole mounting

7.6 Wiring

7.6.1 RS-485

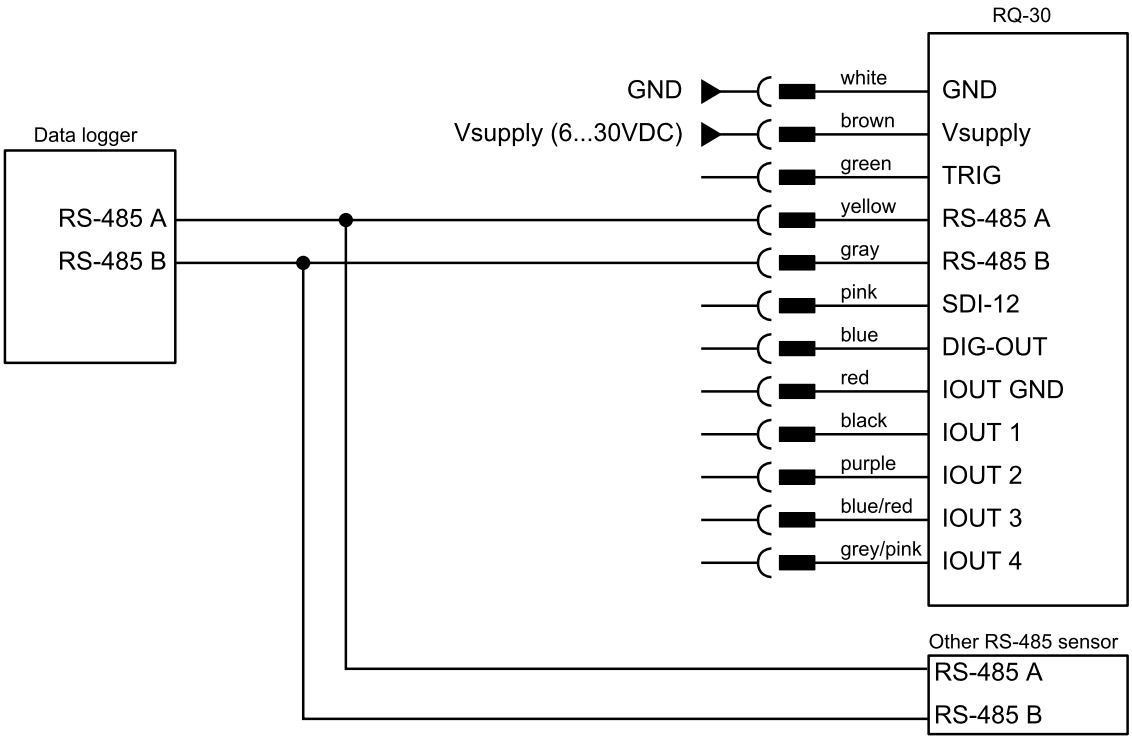


7.6.2 SDI-12



7.6.3 RS-485

Connect the RQ-30 to a data logger or RS-485 network according to the figure below.



7.6.4 SDI-12

Connect the RQ-30 to a data logger by SDI-12 according to the figure below.

SDI-12 uses a shared bus with a ground wire, a data wire (indicated as SDI-12) and an optional +12 V wire.

NOTE The connection with the 12 V power supply is optional and depends on the connected SDI-12 master device (typically a data logger).

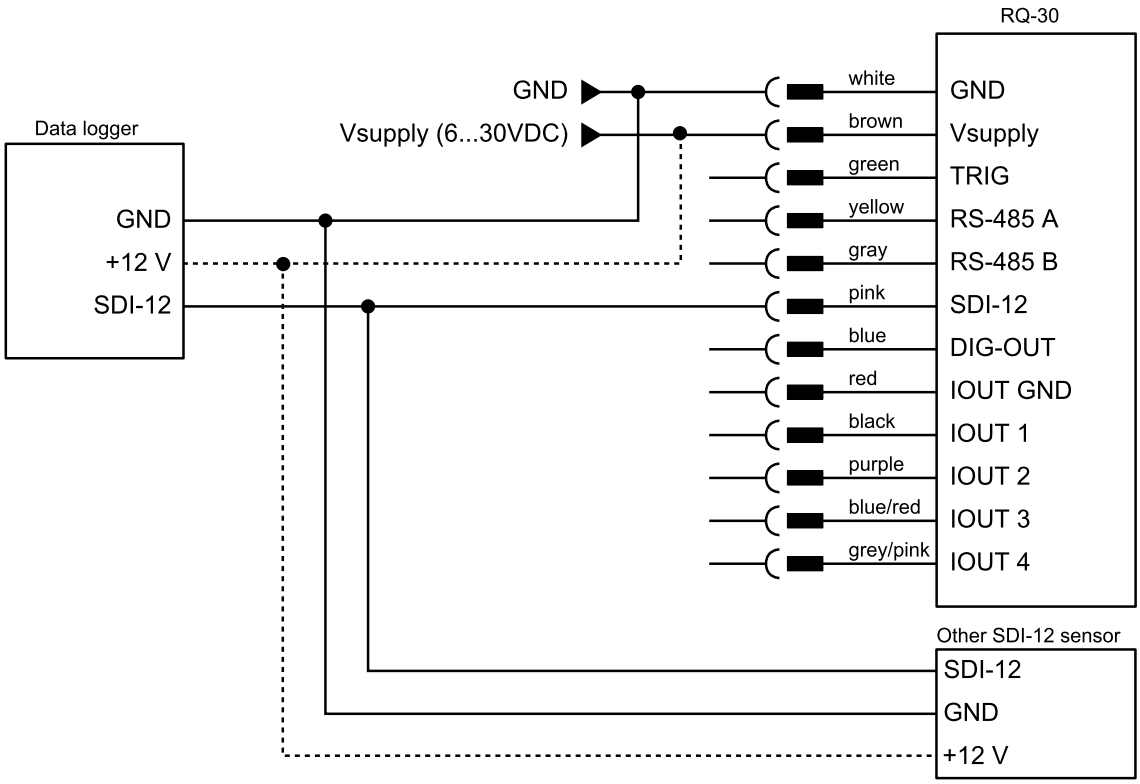
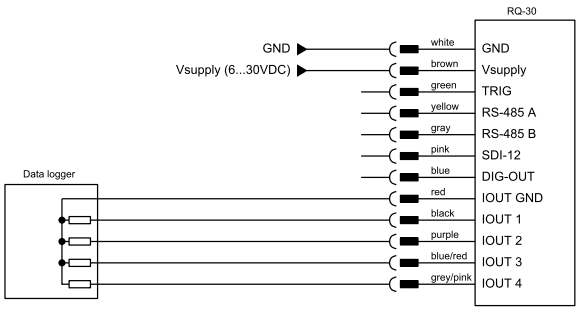


Figure 19 Wiring of the RQ-30 with a data logger via SDI-12

7.6.5 How to wire analog outputs

Connect the analog outputs of the RQ-30 to a data acquisition device according to the figure below.



NOTE If a data logger is connected to the IOUT outputs, the resistance of the logger input(s) must not exceed 470 Ω.

7.7 Adjustment of water level

Once the RQ-30 has been installed at its final location, and has been configured completely, the water level measurement has to be adjusted to the present water level.

Follow the steps below to perform the water level adjustment:

1. Test the water level measurement by clicking Testin the parameter menu Level (W) of the SQ-Commander.
2. If the displayed water level does not match the manually measured level click Adjustment in the parameter menu Level (W).
3. Verify the measured water level by applying the Test function again.

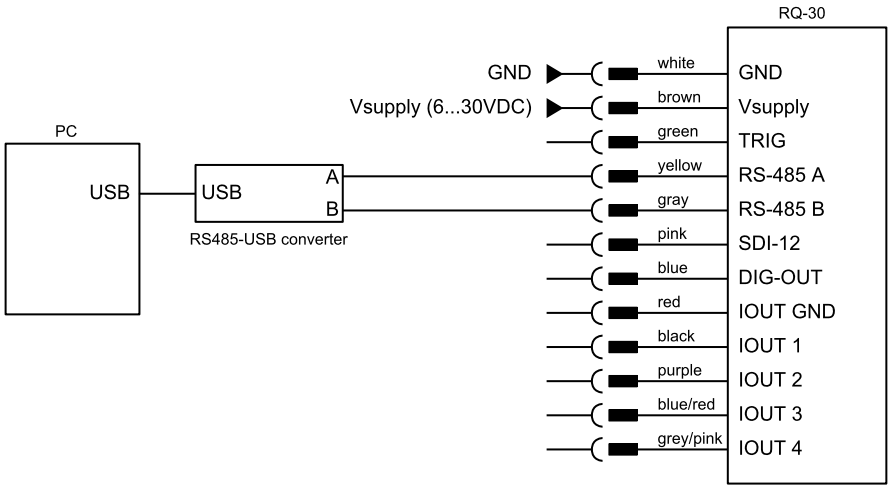
7.8 Start-up

After successful testing, verify that the measurement data are recorded by your data acquisition system and check the data transmission to the remote server if applicable.

8 Operation

8.1 Connect device to PC

1. Install the SQ-Commander support software (see Installation of SQ-Commander)
2. Connect the yellow and gray wires of the sensor cable to the RS-485 to USB converter cable and plug it into your PC as illustrated in the figure below.
3. Connect the RS-232 to USB converter cable to the RQ-30 and a USB port on your PC.
4. Connect a 6...30 VDC power supply to the RQ-30.
5. Click on Communication assistant on the right-hand side of the SQ-Commander window and follow the instructions. During this procedure the communication assistant will search for connected devices. Upon successful completion, the new connection is added to the connections list (tab Connections (F8)).
6. In the Communication Section at the right-hand side of the SQ-Commander window select Mode Connection and the previously created connection from the drop-down list.
7. Click Connect to establish a connection with the RQ-30. If the connection was successful a green icon is displayed at the top-right corner of the SQ-Commander window.
8. Select the tab Parameters (F2) and click Download parameters from device on the left side of the SQ-Commander window. The complete parameter list is transferred from the sensor to your PC and displayed in the Parameter window.



To activate the communication between your device and the SQ-Commander software follow the steps described in Working with connections.

9 Maintenance

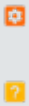
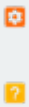
The RQ-30 generally does not require any special maintenance. However, the device should be inspected occasionally for damage and a dirty sensor surface. To remove dirt use a wet cloth with little force. Do not use any abrasive detergent or scraping tool!

9.1 Device status

During operation the RQ-30 continuously performs a self-check to identify any abnormal system behavior or device failure. This self-check is returned by the RQ-30 as a code (SFCH-code) with a value of 1 to 16. In the table below the SFCH-code together with their cause and solution. An icon as specified in the legend below is linked to each SFCH-code to indicate the significance of a detected abnormality.

To view the self-check message open the SQ-Commander, connect to the RQ-30 and open the tab Measurements (F3). In the main window a section named Self-check opens and displays the current device status.

NOTE The parameter Status must be set to *off = SFCH (self-check, default)* in order to activate the self-check feature.

Symbol	SFCH-Code	Description	Cause	Solution
	16	Sensor returns 999997, i.e., level can not be measured or measurement value has not been returned.	● Sensor connected incorrectly. ● Sensor has just been powered. ● Sensor is malfunctioning.	1. Check correct sensor installation (facing water surface). 2. Check wire connections. 3. Wait until the sensor has acquired its first measurements. 4. Re-power the sensor and start Spectrum mode to trigger measurements.
	15	Sensor Inclination angle is outside the range ±2.5° (only applicable if Inclination measurement is set to *every measurement*).	● Sensor mounted improperly. ● River inclination set inadequately.	1. Check setting of Inclination measurement. 2. Check mounting position of sensor. 3. If sensor is installed with an inclination, adjust River inclination.
	14	Velocity sensor returns excessive values.	● Sensor may be mounted improperly or velocity settings are configured incorrectly.	1. Check/adjust sensor position 2. Check/adapt settings in menus Velocity and Tech. velocity (v).

Symbol	SFCH-Code	Description	Cause	Solution
	13	Velocity cannot be determined.	● Water flows very slowly and/or river has high waves. This may lead to overlapping velocity peaks.	1. Rivers with high waves should flow reasonably fast; change measurement site if this is not the case. 2. If waves are small, reduce Minimum velocity und reduce the range between Minimum velocity and Maximum velocity. 3. Check opposite direction content and increase Stop, max. opp. direction. 4. Change the distance to the water surface. 5. Mount the sensor in the reverse direction 6. Create artificial surface waves. 7. If error persists, change measurement spot to one with higher flow velocities.
	12	Only applicable to RQ-30L. Water level is above W_Q, fixation level.	● Level sensor may be configured incorrectly, e.g., sign of water level range may be inverted.	1. Check/adapt settings of water level sensor.
	11	Not specified	-	-

Symbol	SFCH-Code	Description	Cause	Solution
	10	Velocity indicates wrong flow direction.	● Sensor may not be properly configured. ● Insufficient waves on the water surface. ● Strong winds.	1. Check parameter Viewing direction. 2. Mount the sensor in the reverse direction
 	9	Velocity cannot be determined.	● Flow conditions may be outside the range of detection. ● Sensor may be configured incorrectly or is malfunctioning.	1. Check/adapt settings in menus Velocity. 2. Check opposite direction content and increase Stop, max. opp. direction. 3. Change the distance to the water surface. 4. Mount the sensor in the reverse direction 5. Create artificial surface waves. 6. If error persists, change measurement site.

Symbol	SFCH-Code	Description	Cause	Solution
	8	Opposite direction content is too high.	● Sensor may not be properly configured or is malfunctioning.	1. Check/adapt settings in menus Velocity. 2. Check opposite direction content and increase Stop, max. opp. direction. 3. Change the distance to the water surface. 4. Mount the sensor in the reverse direction 5. Create artificial surface waves. 6. If error persists, change measurement site.
	7	Quality (SNR) is insufficient	● Sensor may not be properly configured or is malfunctioning. ● Insufficient waves on the water surface.	1. Check/adapt settings in menus Velocity. 2. Check opposite direction content and increase Stop, max. opp. direction. 3. Change the distance to the water surface. 4. Mount the sensor in the reverse direction 5. Create artificial surface waves. 6. If error persists, change measurement site.

Symbol	SFCH-Code	Description	Cause	Solution
	6	No discharge values	● Sensor cannot determine the cross-sectional area	1. Check/adapt settings in menu Level (W) and perform a level adjustment with Adjustment. 2. Verify that the profile is correct and check it the water level is within the range of the profile. 3. Verify that the sensor returns velocity values.
	5	Sensor did not measure flow velocity.	● Water level below WLL, low level border ● Insufficient waves on the water surface. ● Water level has not been adjusted ● WLL,low level border is set too high.	1. Check/adapt settings in menus Velocity 2. Check Quality (SNR) and opposite direction content and increase Stop, max. opp. direction. 3. Change the distance to the water surface. 4. Mount the sensor in the reverse direction 5. Create artificial surface waves. 6. If error persists, change measurement site.

Symbol	SFCH-Code	Description	Cause	Solution
	4	Water level is above WMA, maximum level	● May occur if W-v learning has been optimized for low water levels (high water levels are extrapolated). ● Water level adjustment has not been performed. ● Sensor has been improperly positioned. ● An obstacle may protrude into the field of view of the sensor.	1. OK if acceptable. 2. Check/adapt settings in menu Level (W) and perform a level adjustment with Adjustment. 3. Verify that the profile is correct and match it to the water level settings. 4. Check that the field of view is free of any obstacles.
	3	Water level is below WCF, cease to flow level.	● May occur during low water levels. ● Water level adjustment has not been performed. ● Sensor has been improperly positioned. ● An obstacle may protrude into the field of view of the sensor.	1. OK if WCF value >0 is required. 2. Set WCF to 0. 3. Check/adapt settings in menu Level (W) and perform a level adjustment with Adjustment. 4. Verify that the profile is correct and match it to the water level settings. 5. Check that the field of view is free of any obstacles.

Symbol	SFCH-Code	Description	Cause	Solution
 	2	Values of WCF, cease to flow level, WLL, low level border and WMA, maximum level are equal.	● Wrong operator input.	1. OK if acceptable. 2. Check/adapt settings in menu Level (W) 3. Set the values of WCF, cease to flow level, WLL, low level border and WMA, maximum level correctly. WMA > WLL > WCF
	1	No discharge table available.	● Discharge table has not been uploaded. ● Discharge table has only one entry.	1. Upload discharge table. 2. Check entries of discharge table.
	0	Sensor operates normally	-	-

Device status codes

Symbol	Status
	Device failure
	Function check
	Out of range
	Normal operation with optimized setup
	Normal operation

Device status symbols

10 Support software SQ-Commander

10.1 Software features

The SQ-Commander is a multipurpose software tool to configure and operate any Sommer Messtechnik device. It offers the following functions:

- Communication with Sommer Messtechnik sensors and data loggers via serial connection, modem, socket, IP-call and Bluetooth®
- Management of connections and stations
- Configurations of sensors and data loggers
- Live data monitoring and storage
- Data management including download from data loggers and transmission to MDS (Measurement Data server)
- Terminal window to check data transfer and to access device settings directly

10.2 System requirements

The SQ-Commander software supports 32- and 64-bit versions of Windows 7 SP1, Windows 8, Windows 8.1 and Windows 10.

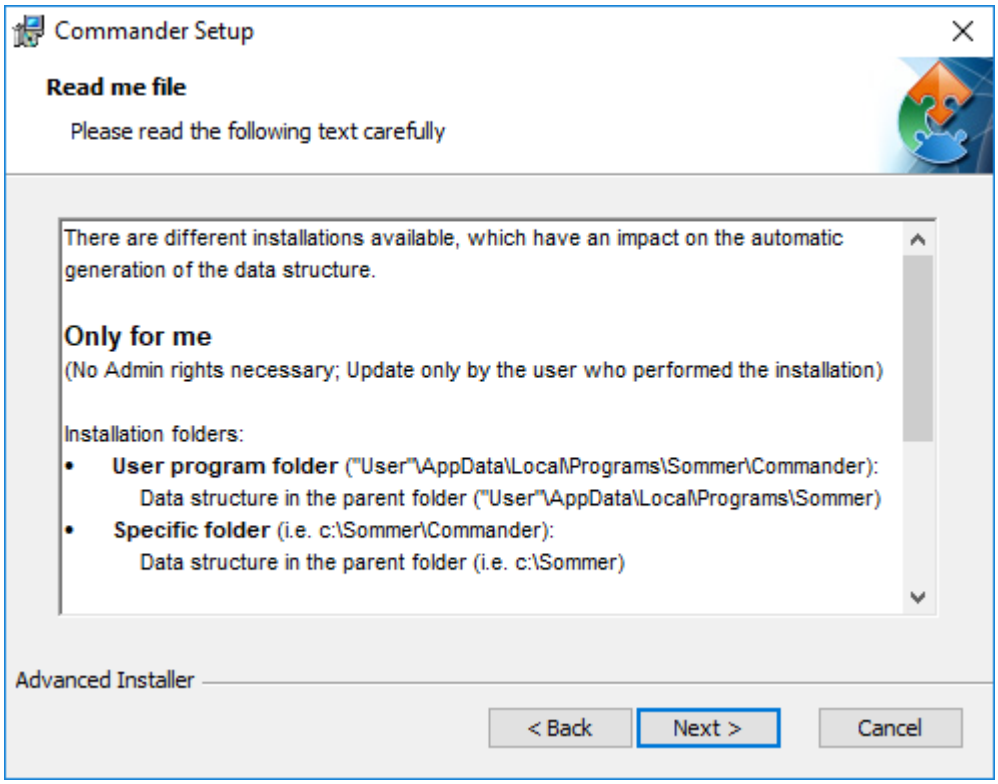
For correct operation Microsoft® .NET Framework 4.5 or later must be installed.

10.3 Installation of SQ-Commander

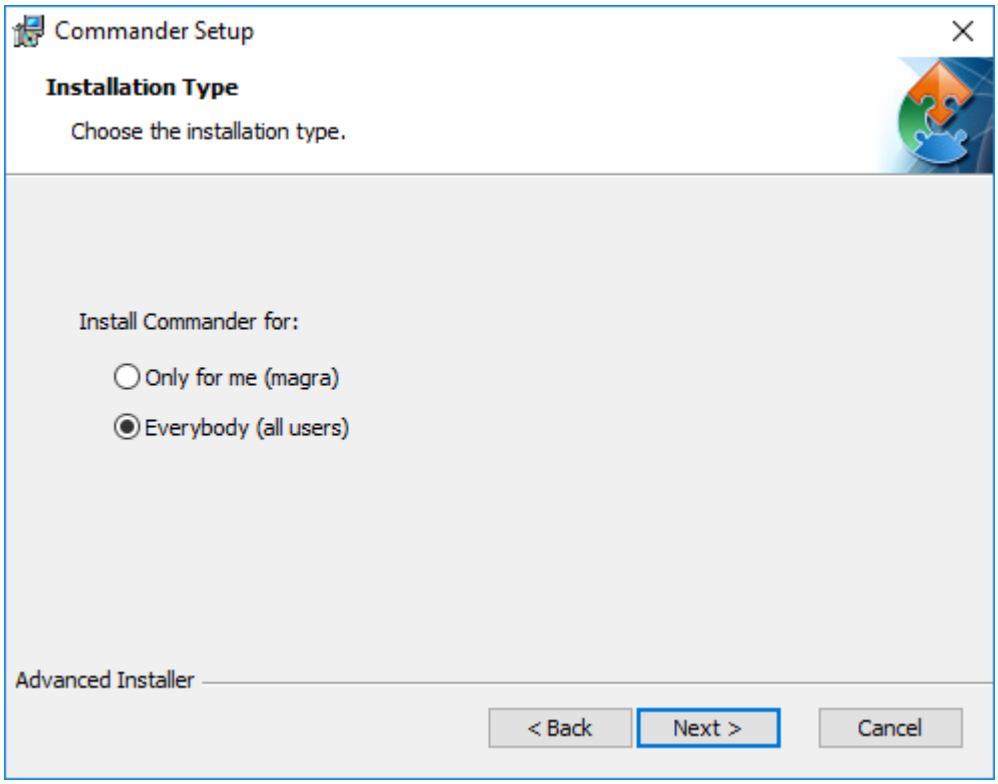
Follow the steps below to install the SQ-Commander software:

1. Plug the USB stick shipped with the device into your PC.
2. Double-click the commander.msi installer file on the USB drive.
3. Click Next on the pop-up window

4. Read the instructions and click Next



5. Select the installation type and click Next



NOTE

Two installation types are available. Depending on the selection, the access rights and the folder structure differ:

Only for me

No admin rights are required. Updates are only available to the user who installed the software.

Installation folders:

- User program folder:
  Users\User\AppData\Local\Programs\Sommer\Commander
  Data structure:
  Users\User\AppData\Local\Programs\Sommer
- Specific folder (default):
  C:\Sommer\Commander
  Data structure (default):
  C:\Sommer

Everybody

Admin rights are required. Updates may only be performed by system administrators.

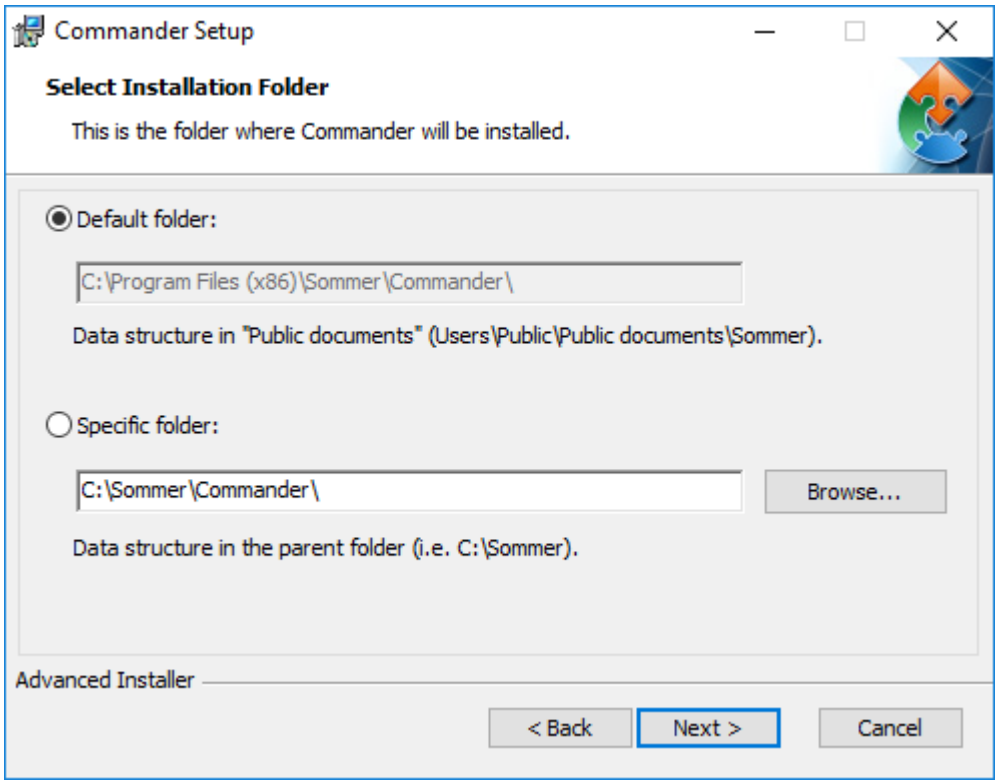
Installation folders:

- Standard program folder:
  Program Files (x86)\Sommer\Commander

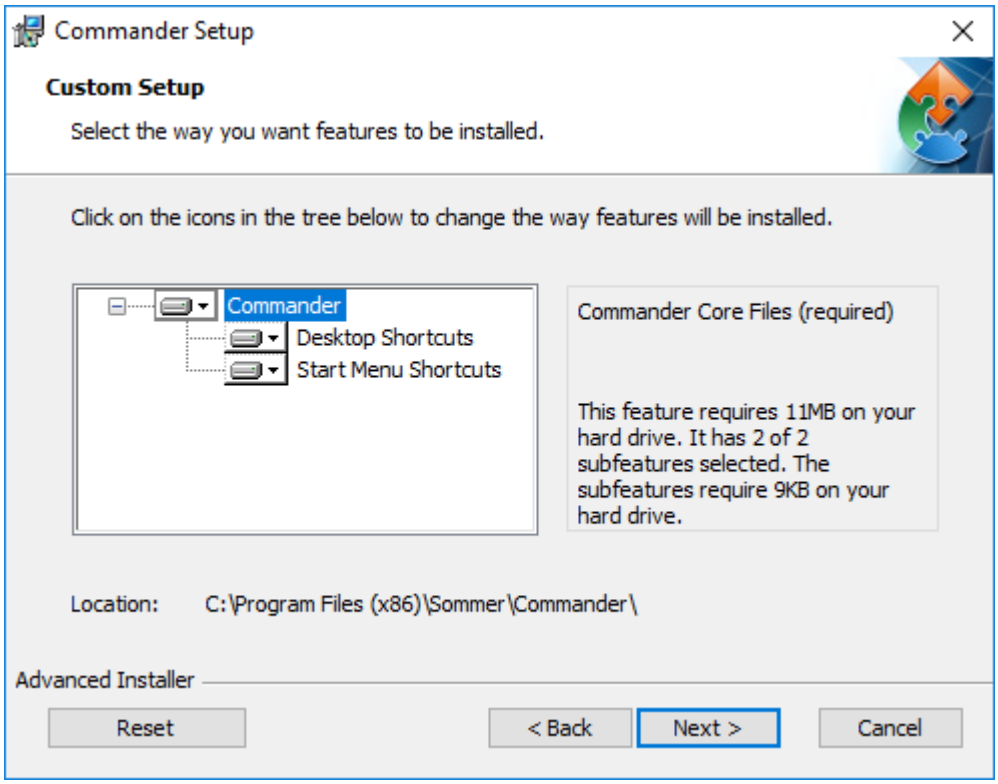
Data structure:
Users\Public\Public documents\Sommer

- Specific folder (default):
  C:\Sommer\Commander
  Data structure (default):
  C:\Sommer

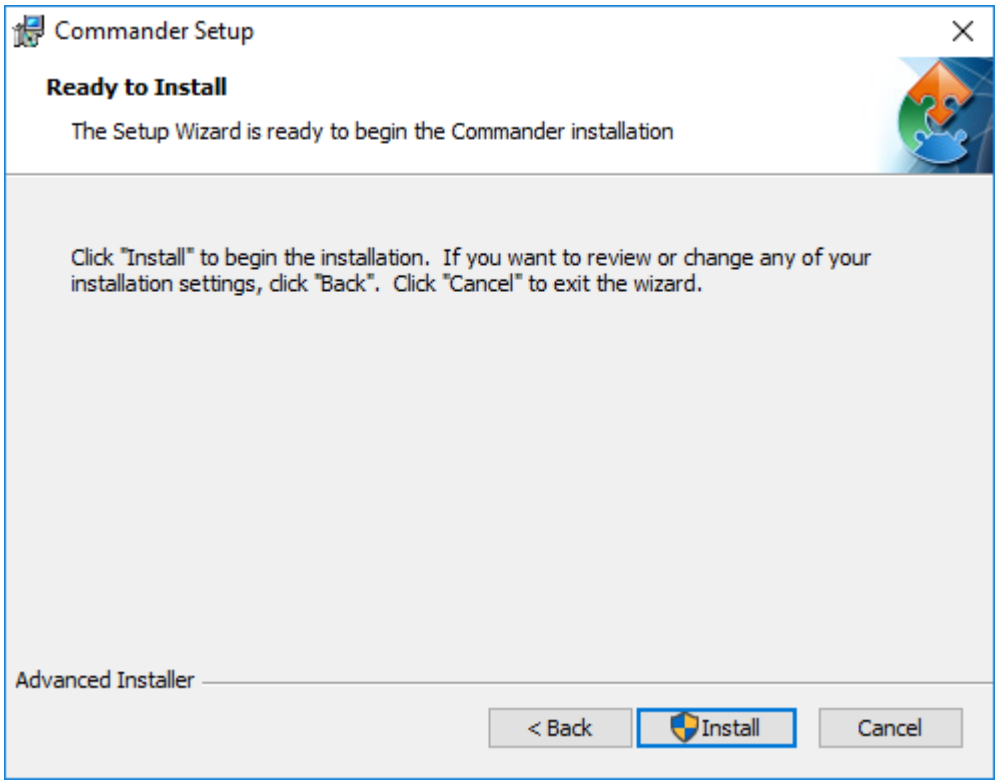
6. Select the installation directory and click Next.



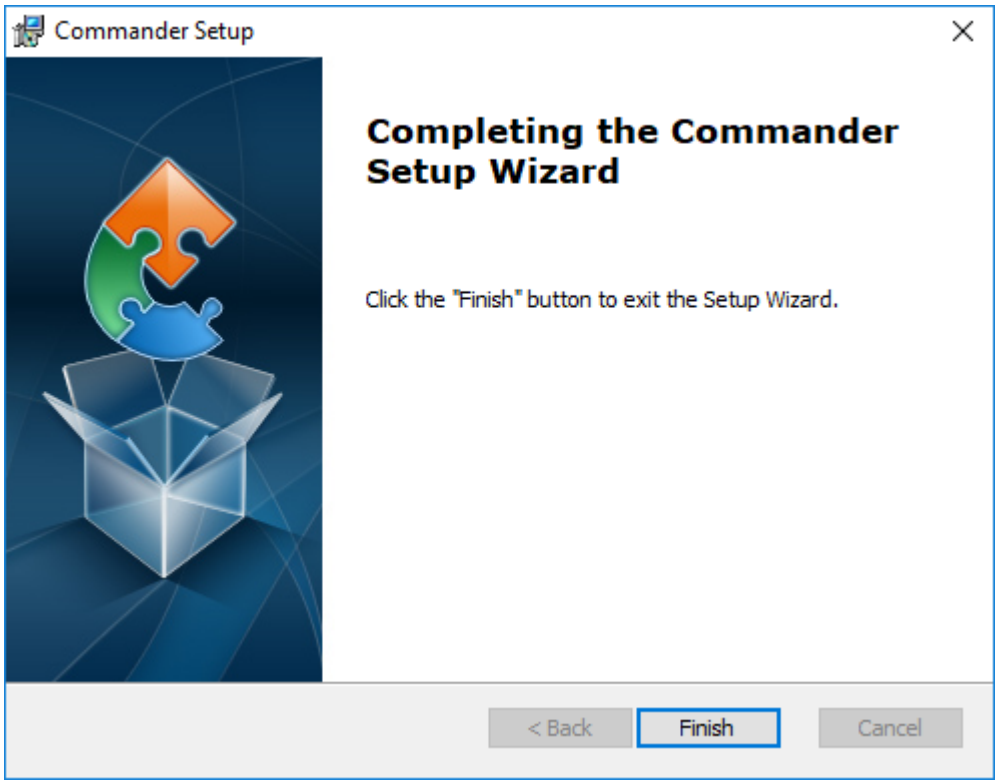
7. Select the features to be installed and click Next.



8. Click Install to start the installation.



9. Click Finish to complete the installation.



10.4 Working with connections

10.4.1 Establish a connection with the Communication assistant

1. Install the SQ-Commander support software as described in Installation of SQ-Commander.
2. Connect the device to your PC according to Connect the RQ-30 to your PC.
3. Start the SQ-Commander software on your PC.
4. Click on Communication assistant on the right-hand side of the SQ-Commander window and follow the instructions. During this procedure the communication assistant will search for connected devices. Upon successful completion, the new connection is added to the connections list (tab Connections (F8)).
5. In the Communication Section at the right-hand side of the SQ-Commander window select Mode Connection and the previously created connection from the drop-down list.
6. Click Connect to establish a connection with the RQ-30. If the connection was successful a green icon is displayed at the top-right corner of the SQ-Commander window.

To view the settings of the connected device or to read the current measurements, follow the steps described in Download setup and Record measurements.

10.4.2 Establish a connection manually

1. Install the SQ-Commander support software as described in Installation of SQ-Commander.
2. Connect the device to your PC according to Connect the RQ-30 to your PC.
3. Start the SQ-Commander software on your PC.
4. Select the required connection in the Connections list of the Connections (F8) tab and click Connect. If the connection was successful a green icon is displayed at the top-right corner of the SQ-Commander window.
   If you don't have the required connection available in the Connections list, create a new connection as described in Create a new connection.

To view the settings of the connected device or to read the current measurements, follow the steps described in Download setup and Record measurements.

10.4.3 Create a new connection

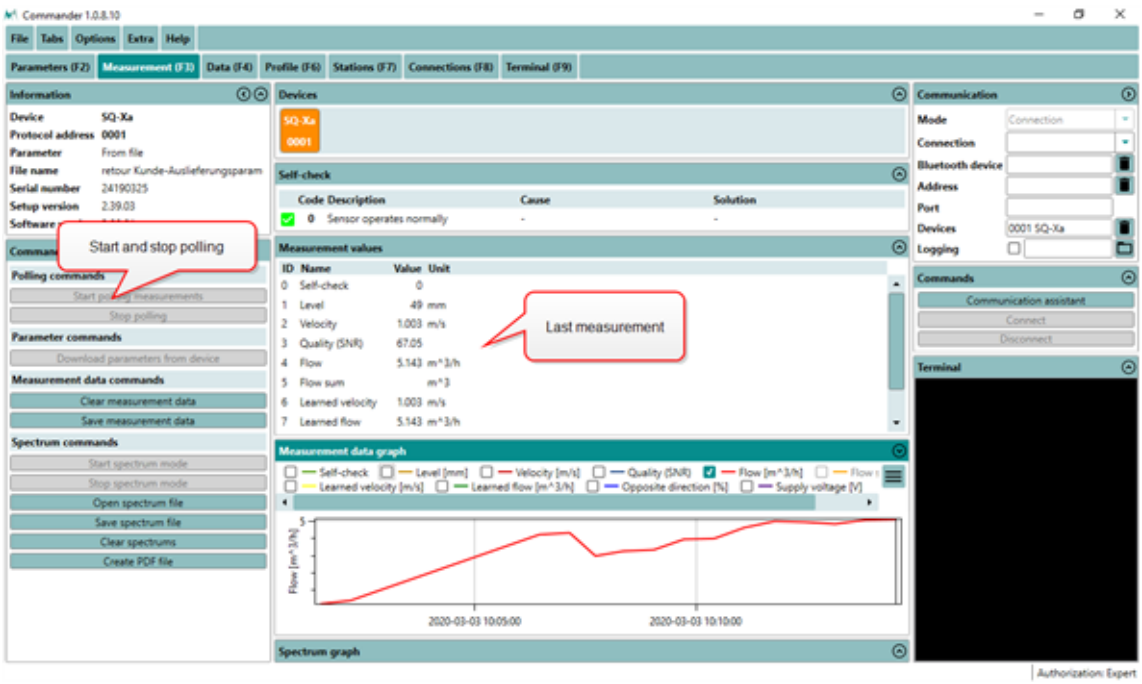
1. Select the Connections (F8) tab in the SQ-Commander.
2. Click New connection.
3. In the section Connection settings enter a name of the new connection, e.g. *Serial-com1-9600*, and the connection type, e.g. *Serial connection*.
4. Enter the required information for the selected connection type.
   If your RQ-30 is wired to your PC with a RS-485 to USB converter cable, select the port where the device is connected and select a Baud rate of 9800.

10.5 Working with measurements

10.5.1 Poll continuous measurements

1. Establish a connection to your device as described in Working with connections.
2. Download the setup of your device as described in Download setup.
3. Select the Measurement (F3) tab.
4. In the Commandssection click Start polling measurement. Now, the SQ-Commander will trigger measurements of the RQ-30 without any delays between measurements. The results are displayed Measurement values and plotted in the Measurement data graph.

5. To finish polling mode click Stop polling.



NOTE The polling mode stops automatically after 30 minutes.

10.5.2 Record measurements

1. Establish a connection to your device as described in Working with connections.
2. Download the setup of your device as described in Download setup.
3. Select the Measurement (F3) tab.
4. If the connection with your device is active, the data will now be displayed in the measurement table and updated at the interval specified in the setup. Also, the incoming data strings are displayed in the Terminal.
5. Click Save measurement data in the Commands section to save the recorded measurements. The data are saved as a *.csv file in the SommerXF format.

NOTE You can change the scope of the data output in the setup OP, information.

10.6 Working with data

10.6.1 View live data

Follow the steps below to view live data acquired from your device:

1. Establish a direct or remote connection with the RQ-30 using the SQ-Commander. Use an existing SQ-Commander-connection or -station if available.
2. In the Parameters (F2) tab download the parameters of the RQ-30.
3. Now, there are two options to view the measurement data:
    1. If OP, measurement output is set to *measured automatic*, data are displayed in the Measurement (F3) tab in the specified measurement interval.
    2. Open the Measurement (F3) tab and click Start polling measurements. With this option measurements are triggered in the fastest possible sequence and the results are displayed instantly. This measurement mode can be stopped by clicking Stop polling, or it is finished automatically after 30 minutes.

10.7 Working with spectra

10.7.1 Record spectrum

1. Establish a connection to your device as described in Working with connections.
2. Download the setup of your device as described in Download setup.
3. Select the Measurement (F3) tab.
4. Click Start spectrum mode in the Commands section. Now the SQ-Commander collects the spectrum data and displays them in Spectrum graph.

NOTE The collection of the spectrum data may require some time.

5. Click Save spectrum file in the Commands section to save the recorded spectra. The data are saved as a *.xlms file.

NOTE The number of acquired spectra is displayed at the bottom of the Spectrum graph. You can navigate through the spectra by clicking the nav-

igation buttons.

6. Click Stop spectrum mode to quit recording spectra.

10.7.2 Read spectrum file

1. Open the SQ-Commander.
2. Click Open spectrum file in the Commands section.
3. Select the desired spectrum file (*.xmls) and click Open. The spectra are now opened and displayed in the Spectrum graph.

NOTE The number of acquired spectra is displayed at the bottom of the Spectrum graph. You can navigate through the spectra by clicking the navigation buttons.

10.8 Working with parameter (setup) files

10.8.1 Download setup

1. Establish a connection to your device as described in Working with connections.
2. Select the Parameters (F2) tab in the SQ-Commander software.
3. In the Commands section click Download parameters from device.
   The SQ-Commander now downloads the setup currently active on the RQ-30. This may take some time if you are downloading the setup for the first time to your PC. Consecutive downloads of a setup with the same version number are usually faster.

You can now save the setup file by clicking Save parameter file, or edit the settings as described in Edit setup.

TIP Save the setup on your PC before you make any changes!

10.8.2 Open a setup file

1. Start the SQ-Commander on your PC and connect to your RQ-30 either directly with the USB to RS485 isolated converter cable or, if available, the optional Bluetooth connection.

2. Open the Parameters (F2) tab and click Open parameter file. Select the required file (extension .xmld or .xmla).
3. Verify the new settings and click Upload all parameters to device. After completion the new settings are active on your data logger.

10.8.3 Edit setup

1. Open the setup file as described in Open a setup file or download it from your device as described in Download setup.
2. Adapt the values of the settings in question and press Enter after each. After you have changed a value, its text box will turn red.

> **NOTE** If you have entered a value outside the data range of the setting, it will be forced to the next valid value! The valid range of each setting is listed in the Parameter definitions.

3. After you have adapted all required settings save the setup file and/or upload the setup to your device by clicking Upload modified parameters to device.
   Once the setup has been saved or uploaded, the modified red text boxes will turn white again, indicating that the settings have been saved/applied.

10.8.4 Upload new setup file

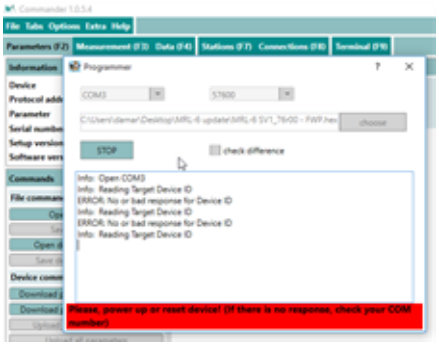
1. Establish a connection to your device as described in Working with connections.
2. Select the Parameters (F2) tab.
3. Download the setup currently on the RQ-30 as described in Download setup and save it by clicking Save parameter file. This step is recommended to have the latest setup available for documentation.
4. Click Open parameter file and select the required setup file (*.xlmp) on your PC.
5. Click Upload all parameters to device. This transfers the current setup to the RQ-30.
6. To verify the correct upload click Dowanload parameters from device. This will display the present setup of the RQ-30.

10.9 Update firmware

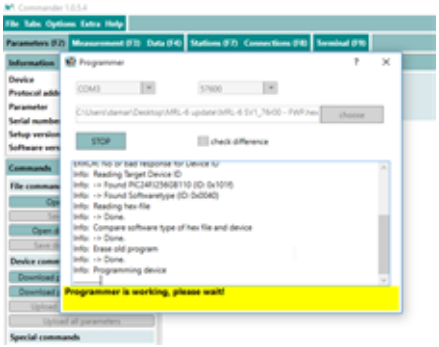
1. Connect the RQ-30 to your PC with the USB to RS485 isolated converter cable and make sure the device is powered.
2. Click on the menu item Extra and select Start Programmer.

3. Select the firmware file (*.hex) provided by SOMMER Messtechnik. Make sure the file is stored on your PC and not on a USB or network drive.
4. Choose the COM-port the data logger is connected to and a Baud-rate of 57'600.
5. Perform the following three steps in short sequence:
   - Click Program
   - Unpower the data logger
   - Wait 3…5 seconds
   - Repower the data logger

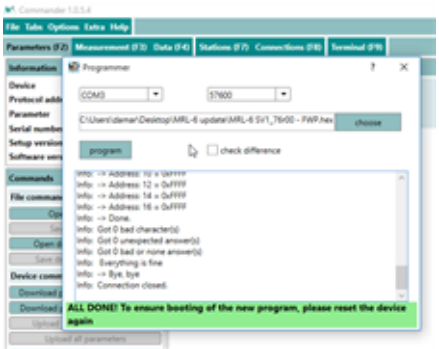
   The firmware currently present on the data logger is now erased and the new one copied to the data logger. During the update process the pop-up window may show the following messages:



The programmer is not ready; power needs to be on.



The programmer is active.



The firmware update has finished.

6. Close the programmer-window as soon as the firmware update has finished.
7. Switch off and repower the data logger again.

8. Open the Parameters (F2) tab.
9. Click Download parameters from device. The download of the new parameter list might take a few minutes. After completion the new firmware and setup versions will be displayed in the Information section.

11 Configuration of the RQ-30

11.1 Software tools

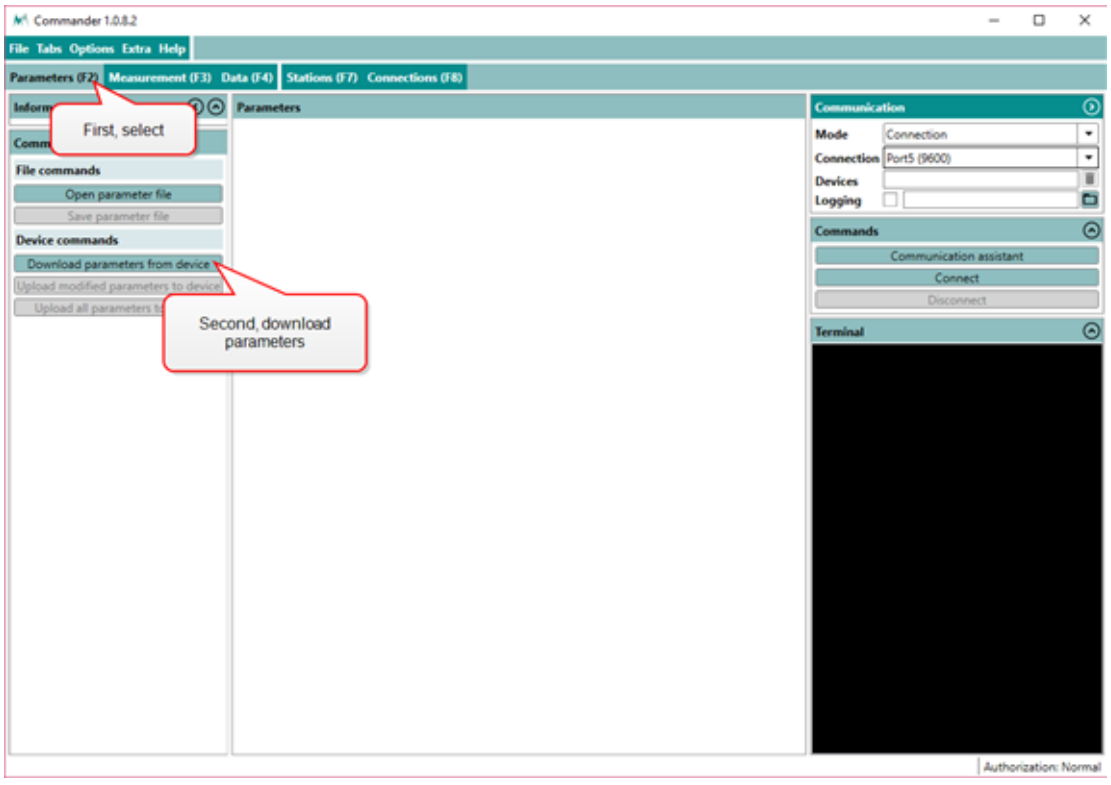
The RQ-30 can be configured with one of the following tools:

- Configuration with SQ-Commander support software
- Configuration with a terminal program

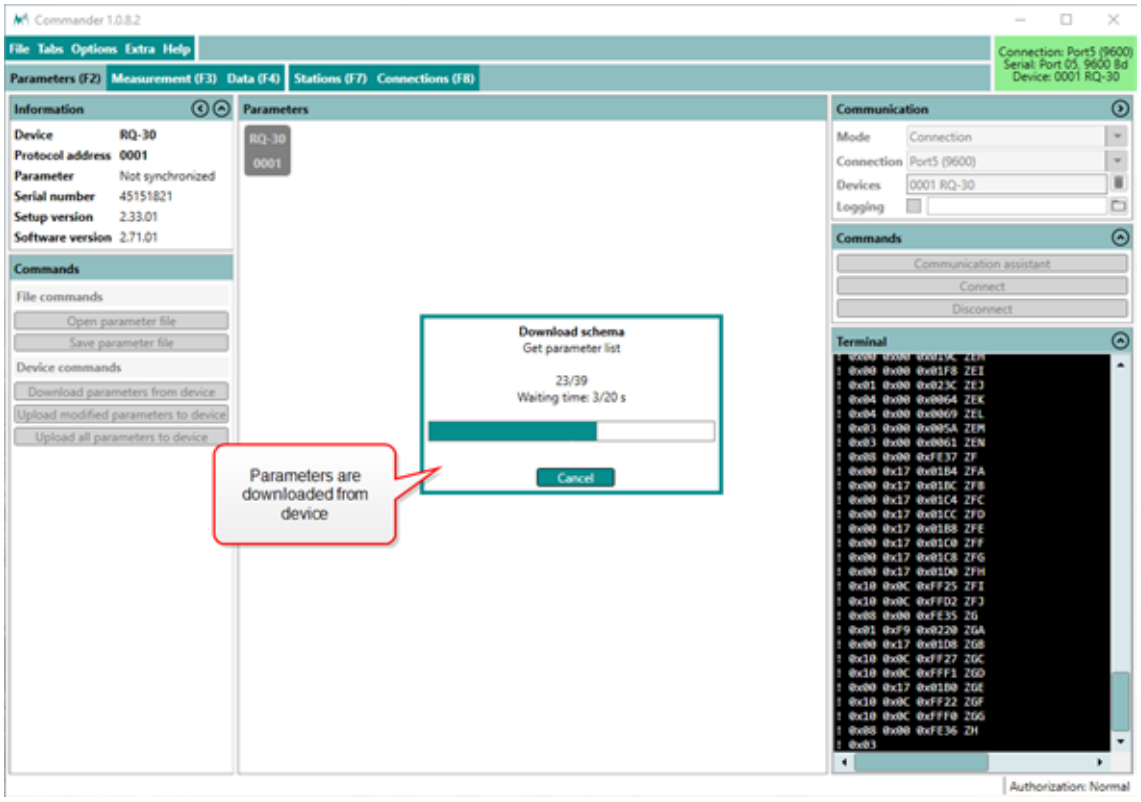
11.2 Configuration with SQ-Commander support software

Follow the steps below to modify the configuration parameters of the RQ-30:

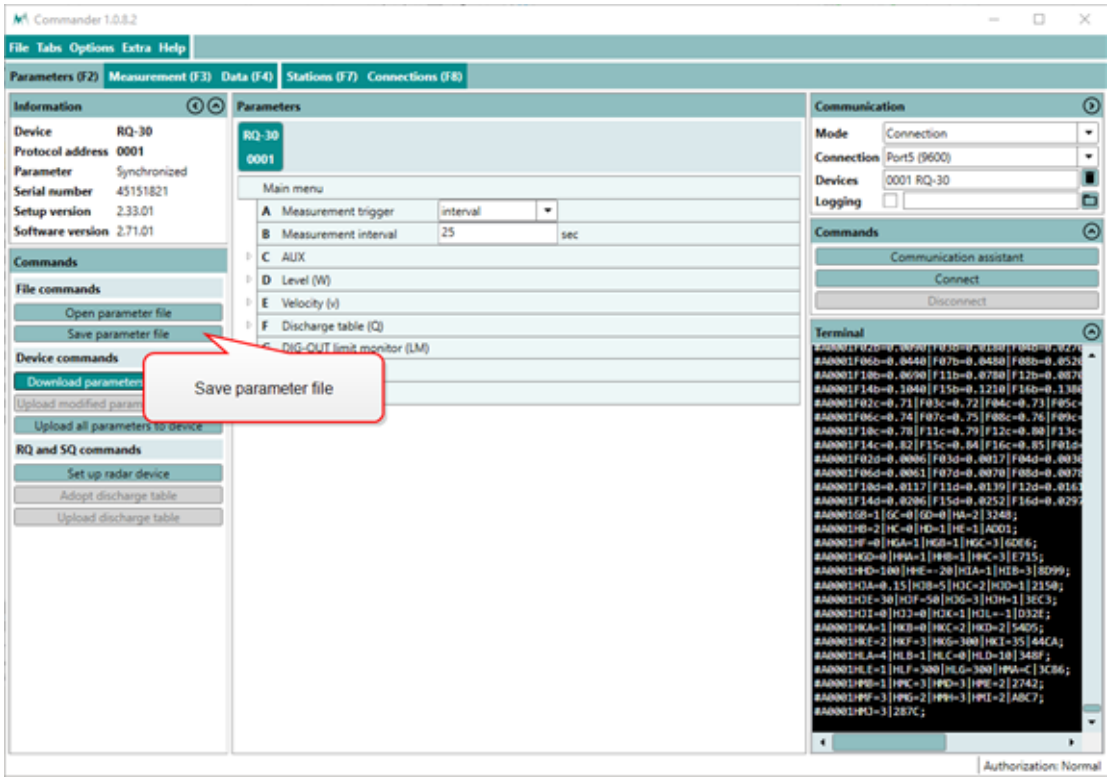
1. Establish a connection between your PC and the RQ-30 as described in Connect the RQ-30 to your PC.
2. Select the tab Parameters (F2) and click Download parameters from device. The complete parameter list is transferred from the sensor to your PC and displayed in the Parameter window.



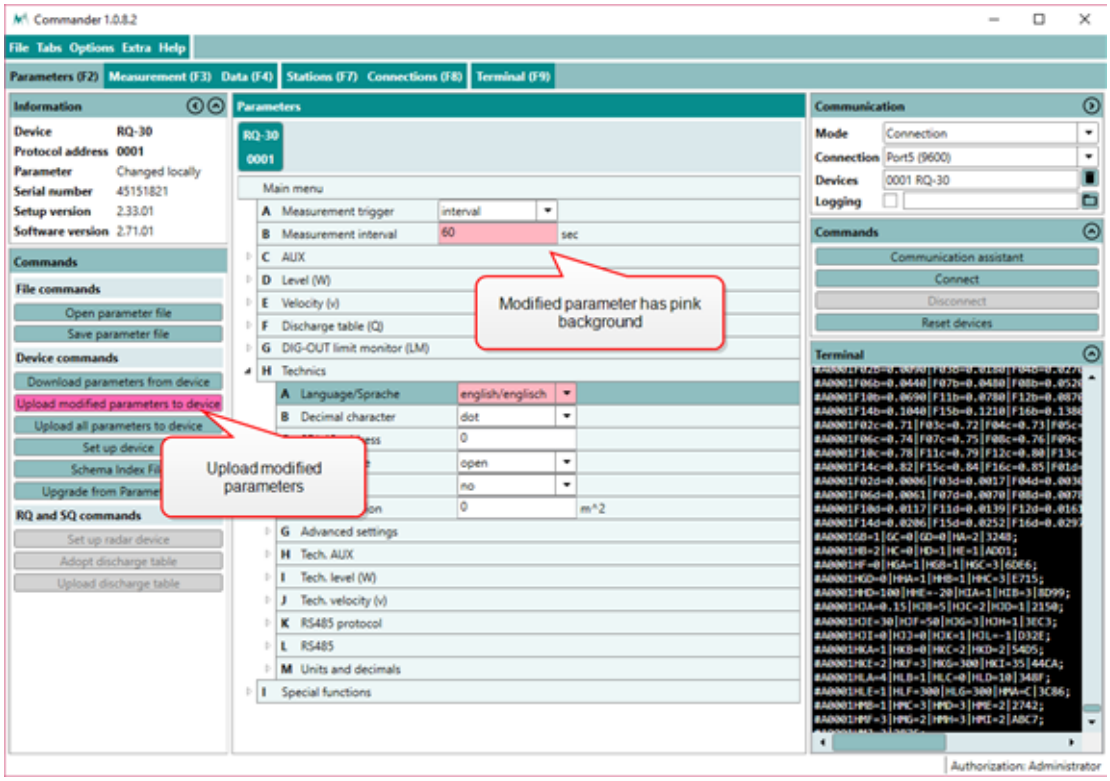
NOTE The first download of the parameter list may take a few minutes. After that the device is known to the PC and consecutive downloads are much faster.



3. Save the parameter file to your PC by clicking Save parameter file. This step is recommended to track any configuration changes.



4. Adapt the parameters required for your application. Changed values are displayed with a pink background.



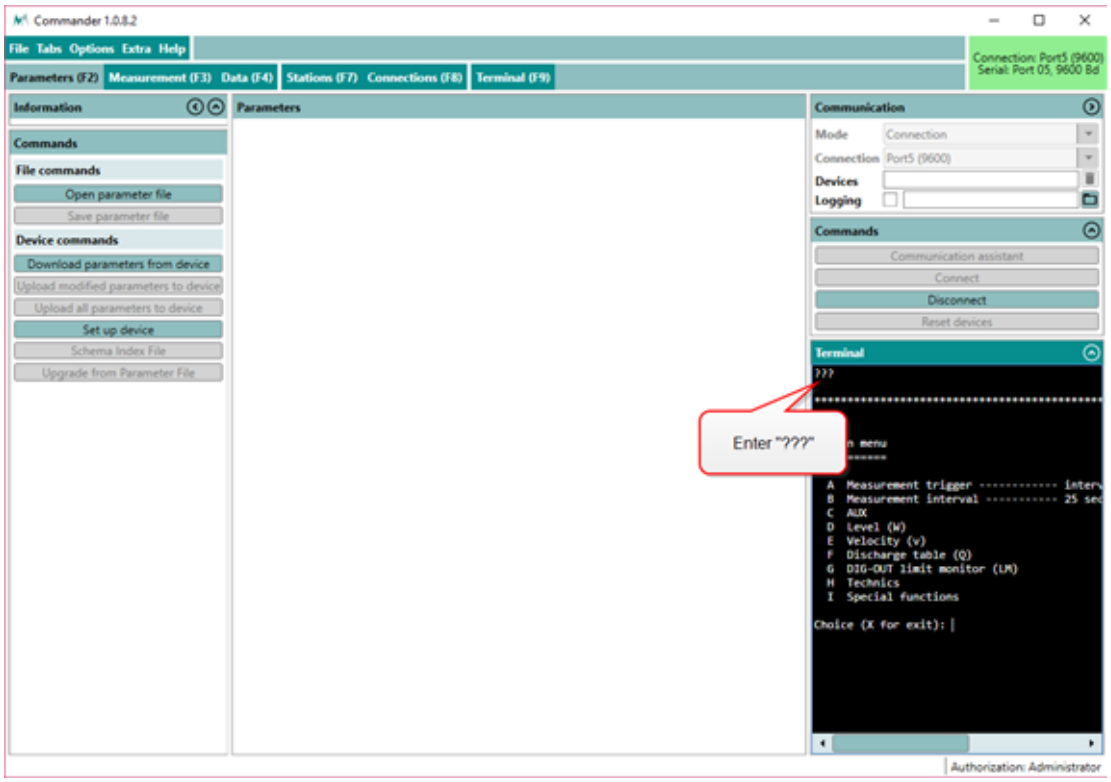
5. Send the modifications to the RQ-30 by clicking Upload modified parameters to device. Upon successful upload the pink backgrounds disappear again.

11.3 Configuration with a terminal program

The SQ-Commander software ships with an integrated terminal program. However, communication with the RQ-30 can be performed with any terminal program.

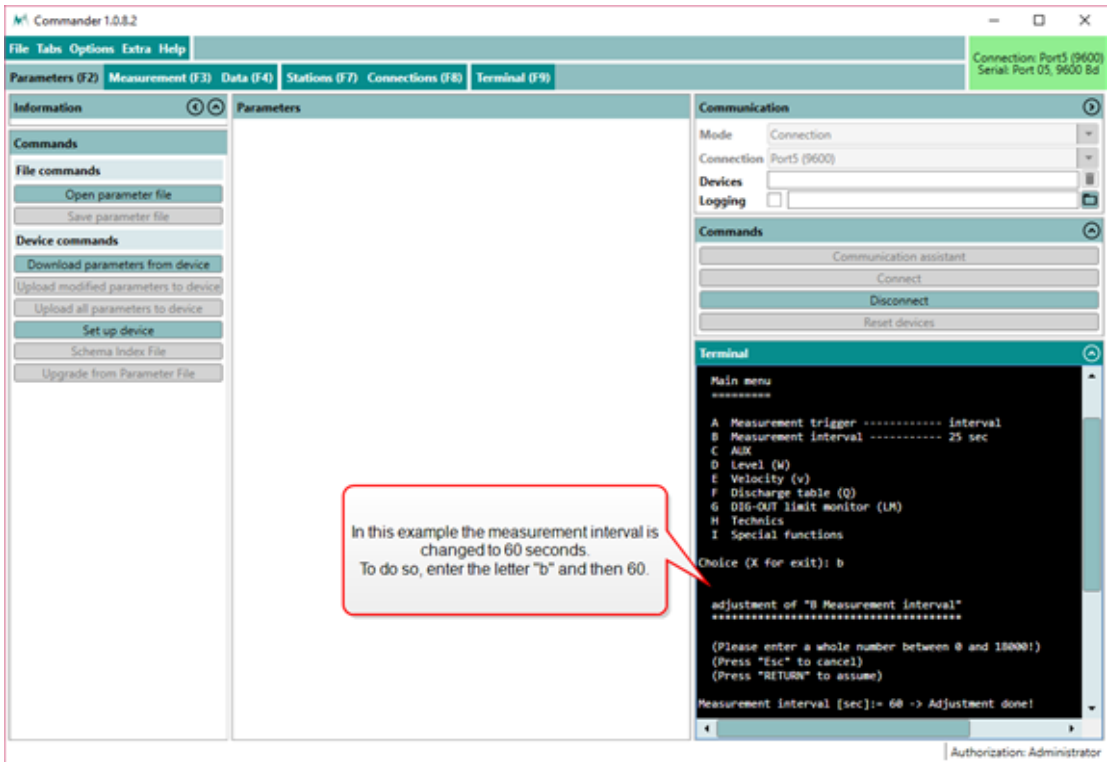
Follow the steps below to modify the configuration parameters of the RQ-30:

1. Establish a connection between your PC and the RQ-30.
2. In the terminal window enter three question marks (???) in quick succession. The main parameter menu is displayed in response.



NOTE As an unwanted switching into the menu mode has to be avoided the timing of the three question marks ??? is very restrictive and must never be finished with Return/Enter. This is especially important for command line tools, which may automatically send a closing "Carriage return".

3. Read or modify the required parameters: The menu items can be selected by entering the letter assigned to each item. Upon selection a submenu is opened or the selected parameter is displayed with its unit. Changes to values are confirmed with Return/Enter or discarded with Esc. Menus are closed with X. After closing the main menu with X the sensor performs an initialization.



11.4 Conflict messages

During configuration via RS-485, the RQ-30 may return conflict messages after one or more parameters have been changed and uploaded to the device. An example is shown in Figure 20.

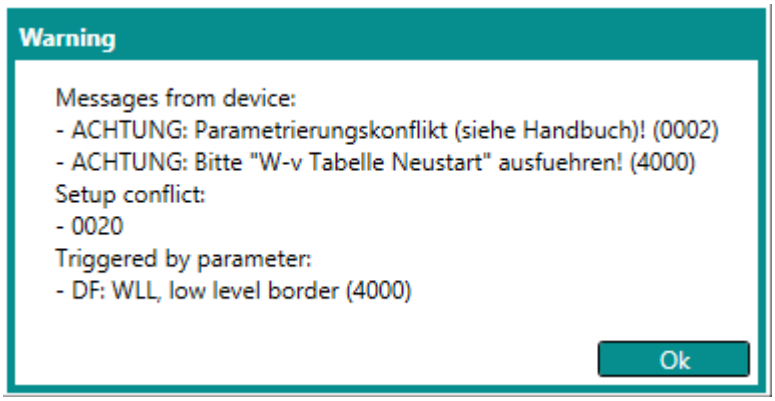


Figure 20 Conflict message

ATTENTION If a conflict occurs, invalid settings are replaced automatically with valid values. Verify the values of the conflicting parameters and adapt them if needed!

11.4.1 Setup conflict

A setup conflict message as listed below is returned if a modified setup with conflicting parameters is loaded onto the RQ-30.

Conflict code	Parameter	Comment
0001	AUX, Status	Conflict with a hidden parameter. Please contact Sommer Messtechnik for advice.
0002	OP, measurement output	Set to *just per command* if Output protocol (OP) is set to *Modbus*.
0010	River inclination	Set to *0* if Possible flow directions is set to *two (tide)*.
0020	WLL, low level border WCF, cease to flow level	The water level parameters should respect the rule: WMA > WLL > WCF. If the specified levels violate this rule, they are adapted to the next valid value.
0040	Maximum velocity	Set to 5 m/s if value is ≥30 m/s or <1.5 m/s.
0080	Minimum velocity	Set to 25% of Maximum velocity if >25% of Maximum velocity. Set to 0.01 m/s if Maximum velocity is below 0.01 m/s.

Table 4 Setup conflict messages

11.5 General settings

When first setting-up a RQ-30 at a measurement site, the parameters described below may need to be adapted.

11.5.1 Measurement trigger

Measurements are initiated by one of the options listed in the table below.

The commands to trigger measurements via RS-485 and SDI-12 are described in Communication.

Measured data are either returned directly after the measurement or can be requested by commands via the RS-485 or SDI-12 interface. The format of the returned data can be configured in the sub-menu Output protocol (OP).

ID	Option	Description
1	Interval (default)	Measurements are initiated in a specified interval.
2	TRIG input	Measurements are triggered by the positive edge of a DC-voltage signal applied to the TRIG input (low: 0 ... 0.6 V, high: 2.2 ... 28 V, pulse duration must be ≥500 ms, delay between pulses must be ≥500 ms)
3	SDI-12/RS-485	Measurements are externally triggered by commands via RS-485 or SDI-12 from ,e.g. a data logger.
4	all allowed	Measurement is triggered by all options mentioned above.

An internal measurement interval can be set for the RQ-30. If selected in menu item Measurement trigger, measurements are performed in the defined interval. However, a measurement is always completed before a new one is initiated.

11.5.2 Language/Sprache

The menu language.

11.5.3 Decimal character

The character used as decimal separator in the values of the settings and in serial data strings.

11.5.4 Units and decimals

The units and number of decimal digits. These have to be set prior to all other settings as all values are saved internally in this format. They are set in the parameter menu Units and decimals.

ATTENTION If units or decimals are changed, related parameters may need to be adjusted.

The available units for the discharge rate cover a large range and have to be selected carefully to avoid data overflow. The table below lists the available units and their conversion factors.

Unit discharge rate	Factor [l/s]	Factor [ft^3/s]
l/s	1.00	0.04
m^3/s	1'000.00	35.31
m^3/h	0.28	0.01
ft^3/s	28.32	1.00
ac-ft/h	342.63	12.10
us. gal/s	3.79	0.13
en. gal/s	4.55	0.16
Ml/d	11.57	0.41

11.5.5 Output protocol (OP)

The type of the serial output protocol. The following options are available:

ID	Option	Description
1	Sommer (default)	Sommer protocol; data values are returned with an index starting at 1
2	Standard	Standard protocol; data values are returned without an index
3	MODBUS	Modbus protocol

11.5.6 OP, information

The main measurement values are always included in the data output string. Additionally, special and analysis values can be included.

ID	Option	Description
1	main values	Only the main values are returned.
2	& special values (default)	Main values and special values are returned.
3	& analysis values	Main, special and analysis values are returned.

11.6 Water level measurement

The settings for the water level measurement are defined under Level (W) and Tech. level (W).

11.6.1 WMA, maximum level

The maximum expected water level (see Figure 21). It represents the upper limit of the W-v relation and is required for W-v learning.

11.6.2 WLL, low level border

The water level below which velocity measurements are not feasible (see Figure 21). It represents the lower limit of the W-v relation. A guidance value is 5 cm above the river bed or any protruding stones in the measurement area.

ATTENTION Below the low level border no velocity measurement is performed any more.

11.6.3 WCF, cease to flow level

The water level at which the flow velocity is always zero (see Figure 21).

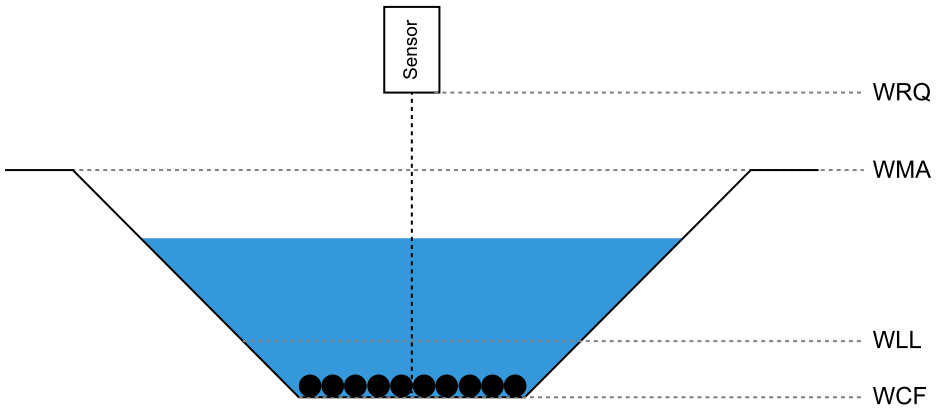


Figure 21 Designation of water levels

In general, the predefined water levels respect the rule: W_Q, Q-30 > WMA > WLL > WCF

11.6.4 Adjustment

The most important setting for water level and discharge measurements is the level adjustment. It is essential that the measured water level W is referenced to the levels in the cross-Sectional profile and the discharge table (see Section Performing a site survey).

The procedure to adjust the level is different for sites with and without existing water level measurements.

Adjustment with known water level

The adjustment with an existing water level measurement is simple as the actual water level is known. However, it is essential that the gauge zero GZ of the existing water level measurement is defined as the reference level for the discharge table.

The water level measurement of the RQ-30 sensor is set to the known value by the following steps:

1. Click the button Adjustment in the parameters list. This initiates a water level measurement and the measured level is displayed.
2. Enter the water level of the existing measurement. After confirmation the water level measurement of the RQ-30 sensor is adjusted to the given value and the entry for the mounting height W_Q is updated.

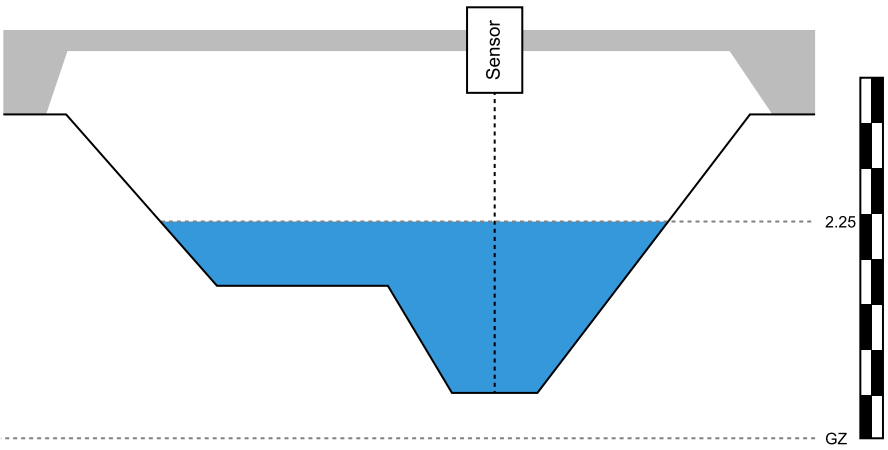


Figure 22 Water level adjustment with known water level

Adjustment with unknown water level

If the water level at the measurement site is not known, the mounting height of the RQ-30 sensor W_Q can be set directly. To do this, the exact vertical position of the RQ-30 sensor in the reference coordinate system must be determined.

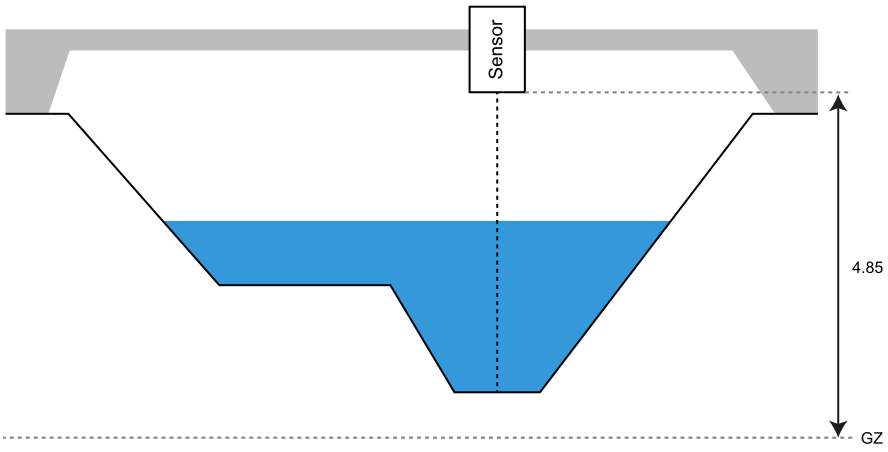


Figure 23 Water level adjustment by setting of the mounting level W_Q of the RQ-30

Setting of the special water levels

The velocity measurement might be obstructed at low water levels. If the level drops below WLL, the velocity measurement is stopped to avoid erroneous measurements. However, the water level

measurement is still performed and the discharge is determined by interpolating the velocity between WLL and WCF. The velocity at WLL is calculated from the W-v relation.

11.7 Velocity measurement

The measurement of the flow velocity depends on the mounting position of the RQ-30 sensor and the water flow conditions at the site. These conditions are defined by the settings under Velocity and Tech. velocity (v)

11.7.1 Viewing direction

The viewing direction of the RQ-30 sensor in relation to the flow direction of the river, either *upstream* or *downstream*.

11.7.2 Possible flow directions

The setting to define if the river only flows in one direction or if two flow directions can occur, e.g. under tidal influence (see also Flow direction separation).

11.7.3 Measurement duration

The duration of a single measurement. During this time the velocity radar signal is recorded and the radar spectrum is calculated. Generally, a measurement duration of 30 s is recommended. For very calm rivers a longer measurement duration should be selected.

11.7.4 Minimum velocity

The minimum expected velocity. No lower velocities are considered.

11.7.5 Maximum velocity

The maximum expected velocity. The velocity measurement is optimized for this setting. Usually a value of 5 m/s is adequate.

11.7.6 Meas. spot optimization

The expected velocity distribution in the measurement spot. The more irregular the distribution, the wider the selected spectral band width used for the velocity measurement.

For the first measurements at a new site the option *standard* is recommended. Later on, the measurement may be optimized by selecting another option.

11.7.7 Measurement type

The velocity measurement can either be performed continuously in one block, or in a sequence of five consecutive blocks with breaks in between. The sequenced method is more representative but slower. By default the selection should be set to *continuous*.

11.7.8 Criteria for invalid measurements and their handling

Velocity measurements can be defined as invalid by the criteria quality (SNR) and opposite direction content (Stop, min. quality (SNR) to Stop, replace value). These criteria and the handling of invalid measurements are controlled with these settings. Please refer to Tech. velocity (v) for details.

11.7.9 Inclination measurement

As described in Inclination angle measurement each velocity measurement has to be corrected for sensor inclination. If the RQ-30 sensor is mounted stably it is sufficient to measure the installation angle with the first measurement after a sensor restart. If the sensor can move it is recommended to perform an inclination measurement with each velocity measurement.

11.7.10 View spectral distribution

With this function the RQ-30 radar sensor is switched into spectrum mode and the spectra are recorded by the SQ-Commander and displayed in the Measurement tab. Please refer to Radar spectrum for more details on velocity radar spectra.

11.8 Discharge table

To calculate the discharge from water level and velocity measurements, a discharge table is required. This table is generated during the site survey as described inPerforming a site survey .

The discharge table can be edited directly in the parameter menu Discharge table or uploaded to the RQ-30 sensor via the Profile tab of the SQ-Commander software.

11.9 Total discharge volume

The RQ-30 offers the function to totalize the measured discharge rate and return it as a discharge sum.

The totalizer function is activated by setting Status to *on*. The discharge sum is then returned by the RQ-30 with the main values (see Data output).

The discharge sum can be reset to a user defined value, usually zero, with the SQ-Commander function Set total discharge volume.

11.10 W-v relation

Generally, water level W and flow velocity v are related. If this relationship is assumed to be stable discharge rates can be deduced from water level measurements only. This functionality is implemented in the RQ-30 sensor as W-v learning, which means that the sensor continuously adjusts an internally stored W-v curve with each new measurement.

11.10.1 Usage

The W-v relation can be used to smooth velocity measurements and discharge rates. Generally, the water level fluctuates only slightly while the flow velocity can vary considerably depending on the flow conditions. By applying the learned W-v relation to the water level measurements velocity and discharge data can be smoothed.

Additionally, the W-v relation is used to interpolate flow velocities for water levels between the low level border WLL and the cease to flow level WCF as shown in Figure 24. Such conditions occur if stones impair the velocity measurement or if the sensor points to dry areas. For these low water levels the velocities can be interpolated from the W-v relation and thus provide valid velocity and discharge values.

ATTENTION If no stable W-v relation is present at the measurement site the learned W-v relation will provide unstable results as well.

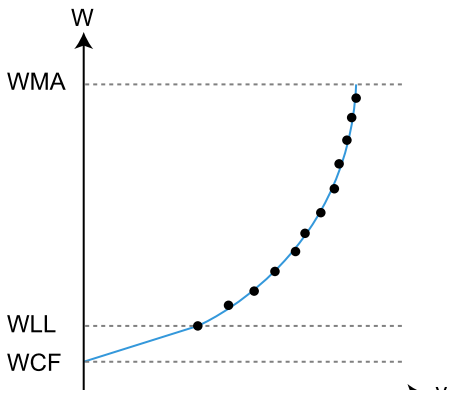


Figure 24 Interpolation of the flow velocity between WLL and WCF

11.10.2Learning of the W-v relation

For the water level range between the maximum level WMA and the low level border WLL a table with 16 value pairs consisting of water levels and learned velocities is created. The learned velocities in the table are continuously adjusted with each new measurement. With time, the complete water level range is covered with learned velocities and a relatively stable relation between water level and velocity is generated, provided the measurement site allows this. Consequently, for each measured water level a learned velocity and a learned discharge can be assigned by linear interpolation.

ATTENTION The time needed to generate a complete W-v learning curve strongly depends on the fluctuations of the water level at the measurement site.

11.10.3Water levels for the W-v relation

The range of water level, in which the W-v relation is learned, is defined by the special water levels WMA, WLL and WCF (see Water level measurement).

11.10.4Activation

Usage of the W-v relation is activated as soon as one of the special water levels WMA, WLL or WCF is different from zero.

11.10.5 W-v priority

By default the W-v priority is set to *no* and the measured velocity and discharge are returned as main values. The learned velocity and discharge are returned as special values.

If the W-v priority is set to *yes* the learned velocity and discharge are returned as main values. The measured velocity and discharge are returned as special values.

11.10.6 W-v table reset

With this function the existing W-v table is deleted and the W-v learning starts anew. This is required if any of the special water levels WMA, WLL or WCF have changed or if the RQ-30 sensor is moved to another measurement site.

12 Communication

12.1 Communication protocols

The RQ-30 provides the following communication protocols:

- RS-485
- Modbus
- SDI-12

12.2 Data output

The measurement values returned by the RQ-30 are arranged in a fixed sequence and identified by an index. They are divided into three groups and can be selected in OP, information.

12.2.1 Main values

The main values comprise the primary measurement values as listed below and are always returned with the data string. Units and decimal places can be set in Units and decimals.

Index	Measurement value	Unit	Description
01	AUX	-	Only if Status of Tech. AUXis *on*. Measurement value of the auxiliary sensor
01	Self-check	-	Only if Status of Tech. AUXis *off*. ID of self-check function (see Device status)
02	Water level	[2]	Measured water level
03	Velocity[1].	[2]	Measured velocity
04	Quality (SNR)	-	Quality value containing SNR
05	Discharge[1]	[2]	Measured discharge

[1] The location of the measured and learned velocities and discharges in the output can be switched with the menu item W-v priority

[2] Unit according to sub-menu Units and decimals

Index	Measurement value	Unit	Description
06	Area	^{2}	Cross sectional area
09	Opposite direction	%	Only if Status of Total discharge volume is *off* (default)
09	Discharge sum	^{2}	Only if Status of Total discharge volume is *on*

Table 5 Main values

12.2.2 Special values

The special values comprise the learned velocity and discharge as well as some diagnostic values (see 12.2.2). By activating the W-v priority with the menu itemW-v priority the measured velocity and discharge are returned instead (The learned velocity and discharge are then returned with the main values).

Index	Measurement value	Unit	Description
07	Learned Velocity^2	1	Learned velocity of W-v relation
08	Learned Discharge^2	1	Discharge calculated from learned velocity
10	Supply voltage	V	Voltage of the power supply input

Table 6 Special values

12.2.3 Analysis values

The analysis values as listed in 12.2.3 comprise diagnostic information of the velocity measurement.

Index	Measurement value	Unit	Description
11	Peak width	mm/s	Band width of the signal
12	CSR	%	Corrected intensity
13	Area of the peak	-	-

Index	Measurement value	Unit	Description
14	RMS at the PIC	mV	Diagnostic variable
15	Amplification	-	Value of the amplification regulation
16	Amplification relation	%	Diagnostic variable
17	Signal relation	%	Diagnostic variable
18	Error code	-	for diagnostic use of Sommer Messtechnik only
19	not used	-	-
20	not used	-	-
21	not used	-	-

Table 7 Analysis values

12.2.4 Quality value

The quality value provides information about the velocity measurement and distribution and has the format: `-21.89`

	Description
-	Validity of the measurement
21	SNR in dB
8	Amplification, 0...9
9	Band width class, 0...9

Validity of the measurement

Measurements with a negative quality value have been identified as invalid (so-called stop measurements).

A velocity measurement is flagged invalid if the opposite direction content exceeds the threshold defined in Stop, max. opp. direction or if the quality value is below the Stop, min. quality (SNR) limit.

SNR

The Signal-to-Noise Ratio contains the most important information of the quality value. Generally, a SNR lower than 30 indicates an insufficient flow velocity measurement.

Amplification

Depending on the condition of the water surface, e.g. waves, and the distance between water surface and sensor the received radar signals may fluctuate considerably. To compensate for these fluctuations the radar signal is amplified accordingly.

A high amplification value indicates a weak radar signal; a value of 0 is optimal.

Band width class

The band width class depends on the spectral velocity distribution. Generally, a high band width corresponds to a turbulent river, i.e. *Splash water*, a low band width to a calm river, i.e. *consistent*. This classification may not be very accurate. Observations of the flow conditions at the measurement site always have to be considered.

12.2.5 Exception values

Measurement data may be returned with the following exception values:

Value	Description
9999.998	Initial value: No measurement has been performed yet (position of decimal character is irrelevant).
9999.997	Conversion error: Caused by a technical problem (position of decimal character is irrelevant)
9999999	Positive overflow
-9999999	Negative overflow

Table 8 Exception values

12.3 RS-485

12.3.1 What is RS-485?

RS-485 is a serial communication method for computers and devices. It is currently a widely used communication interface in data acquisition and control applications where multiple nodes communicate with each other.[1]

12.3.2 What can I do with it?

RS-485 communication is primarily used to trigger measurements and read their results. It also permits to change parameters of the RQ-30.

12.3.3 Configuration

The RQ-30 has serial RS-485 communication enabled by default. If the device is integrated into a RS-485 network or connected to a stand-alone data acquisition system, e.g. a data logger, the parameters listed in RS-485 Protocol may need to be adapted.

System key and device number

The system key and device number are used to identify a RQ-30 in a bus system. This is essential if multiple devices (RQ-30 and data loggers) are operated within the same system.

System key

The system key separates different conceptual bus systems. This may be necessary if the remote radio coverage of two measurement systems overlap. In general, the system key should be set to *00*.

Device number

The device number is a unique number that identifies a device in a bus system.

OP, measurement output

The serial data output can be triggered in the following ways:

[1]https://www.lammertbies.nl/comm/info/RS-485.html

ID	Option	Description
1	just per command	The output is only requested by commands via the RS-485 or SDI-12 interface.
2	after measurement (default)	The serial data output is performed automatically right after each measurement.
3	pos. TRIG slope	The output is triggered by a positive edge of a control signal applied to the trigger input.

NOTE If OP, measurement output is set to *pos. TRIG slope*, the data are returned with a delay of 200 ms after the trigger has been set. Make sure that your data acquisition system takes account of this lag to ensure that it receives the most recent data.

Operation modes

The selected combination of measurement trigger and output time determines the following operation modes:

	Mode		
Parameter	**Pushing**	**Polling**	**Apparent polling**
Measurement trigger	internal	TRIG input SDI-12/RS485	TRIG input SDI-12/RS485
OP, measurement output	after measurement	just per command	after measurement

Waking-up a connected data logger

The RQ-30 supports wake-up of a connected data logger that is in standby mode. Generally, this feature is only used in pushing mode and can be set under OP, wake-up sequence.

Sync sequence

The sync sequence is the string `UU~?~?` and is sent directly before a command. It is used to synchronize the receiving UART.

Prefix

The prefix is an arbitrary character; the RQ-30 uses a blank. This character is sent prior to any communication. Then the time of the OP, prefix holdback is waited and the command is sent afterwards. With this procedure the receiving device has time to wake-up.

Output protocols

For data output via RS-485 different protocols are available, which can be selected under Output protocol (OP).

12.3.4 Data output options

Data are returned in two different formats, selectable in Output protocol (OP):

- Sommer protocol
- Standard protocol
- Sommer old protocol

12.3.5 Sommer protocol

The data string of the Sommer protocol has the following format:

EXAMPLE

```
#M0001G01se01      1461|02      1539|03
25.25|04      0|3883;
```

Header

The header (`#M0001G00se`) identifies the data by system key, device number and string number.

Parameter	Format	Description
Start character	#	
Identifier	M	M identifies an output string
System key	dd	
Device number	dd	

Parameter	Format	Description
Command ID	G	G defines an output string with string number
String number	dd	01 Main values 03 Special values 05 Analysis values 06 Analysis values
Command	se	se identifies automatically sent values

Table 9 Header of the Sommer protocol

Measurement value

A measurement value (02 1539|) has a length of 8 digits and is returned together with its index. If the measurement value is a decimal number, one digit is reserved for the decimal character. Values are returned right-aligned, so blanks may occur between index and value.

Parameter	Format	Description
Index	dd	2 numbers
Value	xxxxxxxx	8 character right-aligned
Separator	|	

Table 10 Values in Sommer protocol

End sequence

The data string is terminated with a CRC-16 in hex format (3883) followed by an end character and <CR><LF>. The CRC-16 is described in Sommer CRC-16.

Parameter	Format	Description
CRC-16	Hhhh	4-digit hex number
End character	;	
Control characters	<CR><LF>	Carriage return and Line feed

Table 11 End sequence of the Sommer protocol

Example Sommer protocol

Main values

Main values are returned as in the following example:

EXAMPLE #M0001G00se01 - 17.4|02 8806|03 0.433|04 40.93|05 0.00|06 5.36|59DF;

#M0001G00se	Header with system key 00, device number 01 and string number 00
01 -17.4|	AUX
02 8806|	Water level
03 0.433|	Flow Velocity[1]
04 40.93|	Quality (SNR) (see Quality value)
05 0.00|	Discharge[1]
06 5.36|	Area
59DF;	Closing sequence

Table 12 Main values in Sommer protocol

Special values

Special values are returned as in the following example:

EXAMPLE #M0001G01se07 0.000|08 0.00|09 46|10 15.13|E30C;

#M0001G01se	Header with system key 00, device number 01 and string number 01

[1] The positions of the measured and learned velocity and discharge can be switched with the menu item W-v priority.

07 0.000|	Learned velocity[1]
08 0.00|	Learned discharge[1]
09 46|	Opposite direction content
10 15.13|	Supply voltage
E30C;	Closing sequence

Table 13 Special values in Sommer protocol

Analyis values

Analysis values are returned as in the following example:

EXAMPLE

```
#M0001G02se11        430|12        293|13         78|14
116|15   11075|16     -40|E08D;

#M0001G03se17          0|18          0|19   9999998|20
9999998|21 9999998|3827;
```

#M0001G02se	Header with system key 00, device number 01 and string number 02 for the analysis values 11 to 16
11 430|	Peak width [mm/s]
12 293|	CSR [%]
13 78|	Area of the peak
14 116|	RMS at the PIC
15 11075|	Amplification
16 -40|	Amplification relation [%]
E08D;	Closing sequence
#M0001G03se	Header with system key 00, device number 01 and string number 03 for the analysis values 17 to 21
17 0|	Signal relation [%]

18 0|	Error code
19 9999998|	not used
20 9999998|	not used
21 9999998|	not used
3827;	Closing sequence

Table 14 Analysis values in Sommer protocol

12.3.6 Standard protocol

The data string of the Standard protocol has the following format:

EXAMPLE `M_0001 1461 1359 25.38 0`

Header

The header (`M_0001`) identifies the data by system key and device number.

Parameter	Format	Description
Identifier	`X_`	`M_` Measurement values `S_` Special values `V_` Analysis values
System key	`Dd`	
Device number	`Dd`	

Table 15 Header of the Standard protocol

Measurement values

Measurement values are returned in sequence and are separated by a blank. A measurement value has a length of 8 digits. If the measurement value is a decimal number, one digit is reserved for the decimal character. Values are returned right-aligned, so additional blanks may be returned between values.

Parameter	Format	Description
Separator	[blank]	blank
Value	xxxxxxxx	8 character right-aligned

Table 16 Values in Standard protocol

End sequence

The data string is terminated with <CR><LF>.

Example Standard protocol

Main and special values

Main and special values are returned as in the following example:

EXAMPLE

```
M_ 0001      - 17.4   6458      0.679      35.93
0.00     5.36     0.679      0.00        46     15.13
```

M_0001	Header with identifier for measurement values
-17.4	No value assigned, always 99999998
6458	Water level
0.679	Velocity[1]
35.93	Quality (SNR) (see Quality value)
0.00	Discharge1
5.36	Area
0.679	learned velocity[1]
0.00	learned discharge[1]

[1] The positions of the measured and learned velocity and discharge can be switched with the menu item W-v priority.

46	Opposite direction content
15.13	Supply voltage

Table 17 Main and Special values in Standard protocol

Analyis values

Analysis values are returned as in the following example:

EXAMPLE

```
Z_0001      664      239       61       91
11075        47        0      200  9999998  9999998
9999998;
```

Z_0001	Header with identifier for analysis values
664	Peak width [mm/s]
239	CSR [%]
61	Area of the peak
91	RMS at the PIC
11075	Amplification
47	Amplification relation [%]
0	Signal relation [%]
200	Error code
9999998	not used
9999998	not used
9999998	not used

Table 18 Analysis values in Standard protocol

12.3.7 Sommer old protocol

The data string of the Sommer old protocol has the following format:

EXAMPLE `#M0001G00se00 -17.4|01 0.535|02 0.000|03 -1.89|04 0.0|05 0|B11D;`

This protocol is identical with the Sommer protocol except that the index of the measurement values starts at 0 instead of 1.

This protocol has been implemented for compatibility reasons: When a Sommer device with firmware < 2.0 is updated to version 2.x the protocol is automatically set to Sommer old. Thus, the setup of a connected data logger does not have to be adjusted.

12.3.8 RS-485 commands

Command structure

The structure of serial commands and answers (`#W0001$mt|BE85;`) is described in the following table:

Parameter	Format	Description
Start character	#	
Identifier	X	W RQ-30 returns a confirmation on receipt. This command type demands a closing sequence with a valid CRC-16. S RQ-30 does not acknowledge the receipt of the command. This command type demands no closing sequence and therefore no CRC-16. R RQ-30 returns the requested measurement value or parameter. This command type demands a closing sequence with a valid CRC-16. T Write a volatile setting and receive a confirmation A Answer of device to read or write command
System key	dd	
Device number	dd	
Command	xxx	See RS-485 commands
Separator	|	
CRC-16	hhhh	4-digit hex number
End character	;	

Table 19 Structure of Sommer bus commands and answers

Commands

The following commands can be used with the RQ-30:

Command	Description
`$mt`	Trigger a measurement
`$pt`	Return measurement values
`XX`	Read a parameter with identifier XX
`XX=xxxx`	Write a parameter with identifier XX and the value xxx

Table 20 List of Sommer bus commands

Trigger a measurement

The command `$mt` triggers a complete measurement sequence as in the following example:

EXAMPLE `#W0001$mt|BE85;` Answer: `#A0001ok$mt|4FA9;`

Read a parameter value

Read measurement interval (in the example below the menu item `B`):

EXAMPLE `#R0001B|228E;` Answer: `#A0001B=300|F8B3;`

Request a complete data string

The command `$pt` requests a data string as in the following example:

EXAMPLE `#S0001$pt|` Answer: none

The data string is returned as soon as the RQ-30 has processed the command.

Request a single measurement value

The reading command `R` together with the index of the requested measurement returns a single measurement value. In the following example the measurement value with index `01` (in this example a water level) is requested:

EXAMPLE

```
#R0001_010cv|EA62;
```

Answer: `#A0001ok_010cv1461     |07EB;`

12.3.9 Sommer CRC-16

The CRC-16 (cyclic redundancy check) used in data transmission of Sommer devices is based on the ZMODEM protocol. When data are exchanged between two devices the receiving device calculates the CRC-value. This value is compared to the CRC value sent by the other device to check if the data were transmitted correctly. Please refer to technical literature or contact Sommer for calculation of CRC-16 values.

You can here calculate the CRC of a command online .

If you need to compute CRCs automatically, you can implement the following script in your data logger or controller software:

Computation CRC-16 in C/C++

```
1  crc16 = crc16tab[(unsigned char)(crc16>>8)] ^ (crc16<<8) ^ (unsigned int)(c);
```

The `crc16tab` array is listed in CRC-16 array.

12.4 SDI-12

12.4.1 What is SDI-12?

SDI-12 (Serial Data Interface at 1200 Baud) is a serial data communication standard for interfacing multiple sensors with a single data recorder. For a detailed description on SDI-12 communication please refer to www.sdi-12.org.

12.4.2 What can I do with it?

The RQ-30 listens to standard SDI-12 commands as listed in the SDI-12 specifications of version 1.3, e.g., to trigger a measurement or retrieve measurement results. Additionally, a set of extended SDI-12 commands is implemented in all SOMMER sensors for instrument configuration.

12.4.3 Configuration

The RQ-30 has SDI-12 communication enabled by default. When setting up a SDI-12 network take the following considerations into account:

- Each device in the SDI-12 network must have a unique address, e.g. data logger address *0*, RQ-30 address *1*.
- If the RQ-30 operates in polling mode (Measurement trigger set to *SDI-12/RS-485*), measurements are triggered by `M!` commands and data are retrieved by `D!` commands.
- If the RQ-30 operates in pushing mode (Measurement trigger set to *interval*), data are retrieved by the `R!` commands.
- When multiple sensors are connected to the same network, data acquisition should be done in sequence, i.e., data should have been received from the first sensor before triggering the measurement of the second sensor.
- Most data loggers control the timing of messages (marking and spacing) automatically. If this is not the case, please refer to www.sdi-12.org.

12.4.4 Data structure

The answer from the SDI-12 device is a string containing the sensor address, the requested data and a terminating carriage return/line feed.

In a string containing measurement data, the measurements are returned in the same order as listed by the index in Data output.

EXAMPLE

`0+2591+706+25.53+62<CR><LF>`

Value	Content
0	Sensor address
2591	Measurement with index 01
706	Measurement with index 02

Value	Content
25.53	Measurement with index 03
62	Measurement with index 04

If a device returns more than 9 measurement values, or if the values are returned in groups (see also Request results) the measurement index increments in the next group.

EXAMPLE

`0D0!` Answer: `0+2591+706+25.53+62<CR><LF>`

`0D0!` Answer: `0+56.2+125+12.32<CR><LF>`

Value	Content
0	Sensor address
2591	Measurement with index 01
706	Measurement with index 02
25.53	Measurement with index 03
62	Measurement with index 04
0	Sensor address
56.2	Measurement with index 05
125	Measurement with index 06
12.32	Measurement with index 07

12.4.5 SDI-12 commands

The following tasks can be performed with standard and extended SDI-12 commands.

Extended SDI-12 commands are non-standard commands implemented by SOMMER to enable device configuration via SDI-12.

NOTE After any changes, the settings have to be adopted with the command `aXW_ts|!`, with `a` the sensor address.

Command structure

A standard SDI-12 command starts with the sensor address and ends with an exclamation mark, e.g., `0M!` to trigger a measurement.

Configuration commands contain additional information; see the sections below for details.

Identify device

The identification of a SDI-12 device is requested with the command `aI!`, with `a` the sensor address.

EXAMPLE

`0I!` Answer `013Sommer  USH  140r90 USH-9  <CR><LF>`

The answer contains the following information:

`0`	SDI-12 address
`1`	SDI-12 version prior to the point
`3`	SDI-12 version after the point
`Sommer`	Description of the company (6 characters and 2 blanks)
`USH`	Description of the firmware (5 characters and 2 blanks)
`140r90`	Firmware version (6 characters and 2 blanks)
`RQ-30`	Device designation (max. 13 characters)

Acquire measurements

To acquire a measurement from a sensor, two individual SDI-12 commands – trigger a measurement and request measurement values – need to be sent.

EXAMPLE

`0M!` Answer: `00084<CR><LF>` and `0<CR><LF>` after 8 seconds

`0D0!` Answer: `0+2591+706+25.53+0<CR><LF>`

The first values in the response to the `aDn!` command is the sensor address.

Trigger measurement

The command aM! with sensor address a triggers a measurement as in the example below.

The response states the measurement duration and the number of measurement values (see example below). After completion of the measurement, the device will return an additional a<CR><LF>, with a the sensor address.

EXAMPLE

0M! Answer: 00084<CR><LF> and 0<CR><LF> after 8 seconds

The answer contains the following information:

0 SDI-12 address

008 Duration of the measurement in seconds

4 Number of measurement values

Request results

After each measurement, results are requested with the command aDn!, with a the sensor address and n the index of the returned data string.

EXAMPLE 0D0! Answer: 0+2591+706+25.53+0<CR><LF>

The leading 0 of the response is the sensor address.

Generally, the command aD0! is sufficient to request up to 9 measurement values. If more than 9 values need to be read, or if the values are returned in groups, the commands aD1!, aD2!,… may need to be issued after aD0!. For example, if a measurement returns 8 values in two groups of 4, the commands aD0! and aD1! need to be issued to receive all values.

Acquire continuous measurements

If the SDI-12 device is operating in continuous measurement mode (not polled by SDI-12), the command aR0! will request and return the current reading of the sensor. The values within the data string follow the order listed in the measurement table. The first values in the response to the aRn! command is the sensor address.

EXAMPLE

`0R0!` Answer: `0+2591+706+25.53+0<CR><LF>`

If more than 9 values need to be read, or if the values are returned in groups, the commands `aR1!`, `aR2!`,... may need to be issued after `aR0!`. For example, if a measurement returns 8 values in two groups of 4, the commands `aR0!` and `aR1!` need to be issued to receive all values.

Configure parameter

The configuration parameters of a SOMMER sensor are read with the command `aXRpp!` and written with the command `aXWpp=vvv!`, with `a` the sensor address, `pp` the parameter identifier and `vvv` the value of the parameter.

Read and write a parameter

EXAMPLE

Reading of measurement interval (in this example menu item B)

`0XRB|!` Answer: `0B=300|<CR><LF>`

Setting of measurement interval to 60 s (in this example menu item B)

`0XWB=60|!` Answer: `0B=60|<CR><LF>`

Read and write a selector-parameter

Changing the measurement trigger (in the following example menu item A) from *interval* to *SDI-12/RS485*:

EXAMPLE

`0XRA|!` Answer: `0A=1|<CR><LF>`

`0XWA=3|!` Answer: `0A=3|<CR><LF>`

Read and write a parameters of a table

Some SOMMER sensors are equipped with multiple transducers and their settings are listed in a table (see example below). A value within such a table is addressed by its row-index (01, 02 …) and column-index (A, B …). A corresponding SDI-command has the following format:

EXAMPLE

In this example of a snow scale the value in row 01 and column B of the parameter D-D-E is changed to -1.4.

`0XWDDE01B=-1.4|!` Answer: `0DDE01b=-1.4|<CR><LF>`

	Identifier	offset zero kg	gain	zero default kg	gain default
01	Load Cell 1	-1.4	0,997787	0,000	0,997787
02	Load Cell 2	0,000	0,997787	0,000	0,997787
03	Load Cell 3	0,000	0,997787	0,000	0,997787
04	Load Cell 4	0,000	0,997787	0,000	0,997787

Adopt settings

Some settings need to be adopted with the command `aXW_ts|!`, with `a` the sensor address. It is recommended to issue `aXW_ts|!` after each configuration change.

12.5 Modbus

12.5.1 What is Modbus?

Modbus is a serial communication protocol used for transmitting information over serial lines between electronic devices. The device requesting the information is called the Modbus Master and the devices supplying information are Modbus Slaves. In a standard Modbus network, there is one Master and up to 247 Slaves, each with a unique Slave Address from 1 to 247. The Master can also write information to Slaves.

Modbus has become a standard communication protocol in industry, and is now the most commonly available means of connecting industrial electronic devices. It is often used to connect a supervisory

computer with a remote terminal unit (RTU) in supervisory control and data acquisition (SCADA) systems. Versions of the Modbus protocol exist for serial lines (Modbus RTU and Modbus ASCII) and for Ethernet (Modbus TCP).[1]

12.5.2 What can I do with it?

Modbus-communication with RQ-30 allows reading of measurement values and device information by a Modbus master. Additionally, the basic RS-485 port settings can be written to the RQ-30.

12.5.3 Wiring

For Modbus communication the RQ-30 is wired according to the table below.

Modbus	Connector MAIN	Connection wire	Description
Common	A	White	GND
Vsupply	B	Brown	6...30 VDC
D1 - B/B	D	Yellow	RS-485 A
D0 - A/A	E	Grey	RS-485 B

Table 21 Modbus wiring

NOTE If the RQ-30 is operated with multiple Modbus devices within the same network, termination resistors may be required. Please contact Sommer Messtechnik for details.

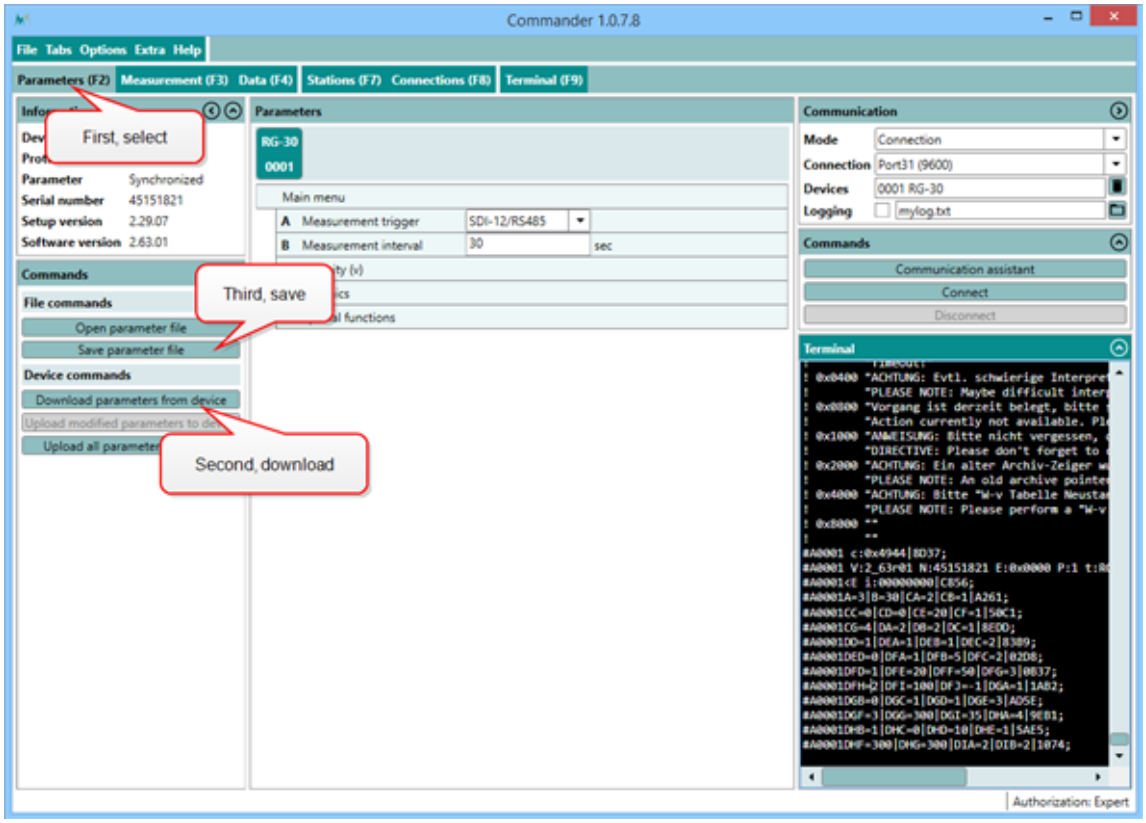
12.5.4 Configuration

Follow the instructions below to change the communication of a Sommer-device (in this example a RG-30) to Modbus:

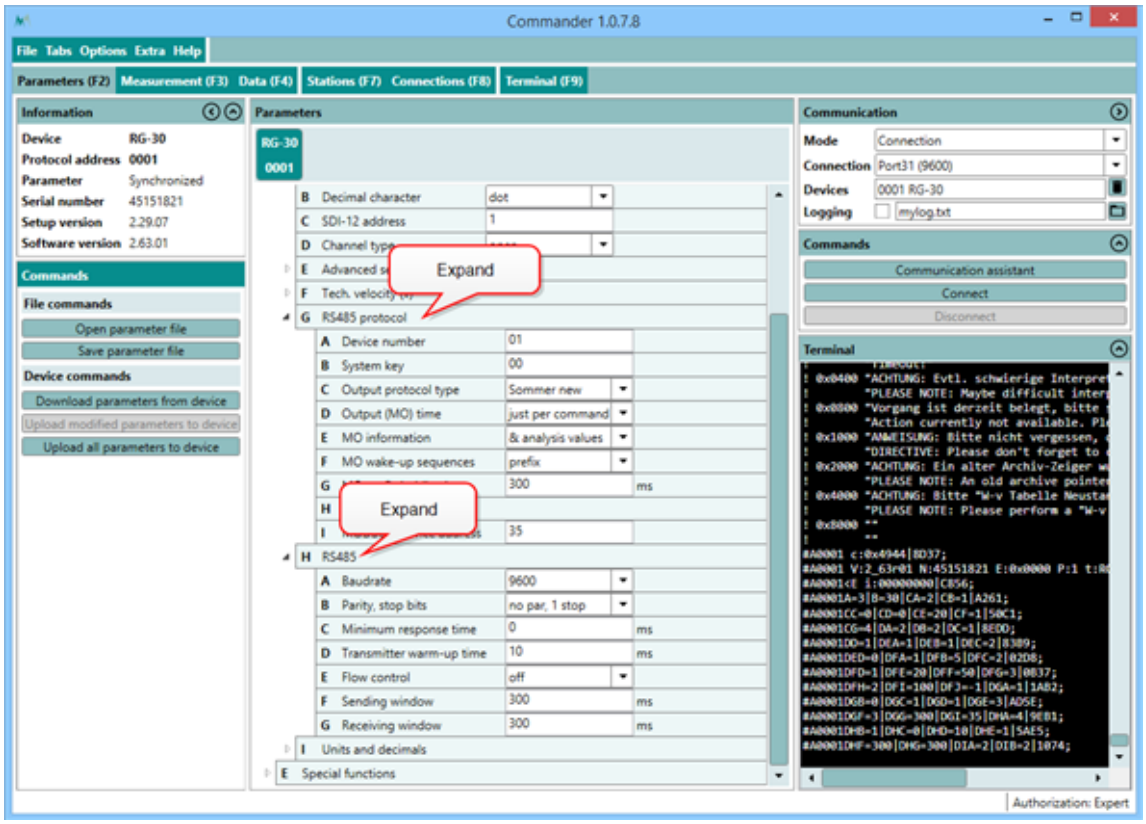
1. Connect the USB to RS-485 converter to the data cable of the Sommer-device and a USB port on your PC.
2. Connect the sensor to a power supply with the specified rating.
3. Start the SQ-Commander software on your PC.
4. Establish a connection to the Sommer-device.

[1] http://www.simplymodbus.ca/FAQ.htm

5. Download the sensor's parameters in the Parameters (F2) tab and save the parameter list on your PC.



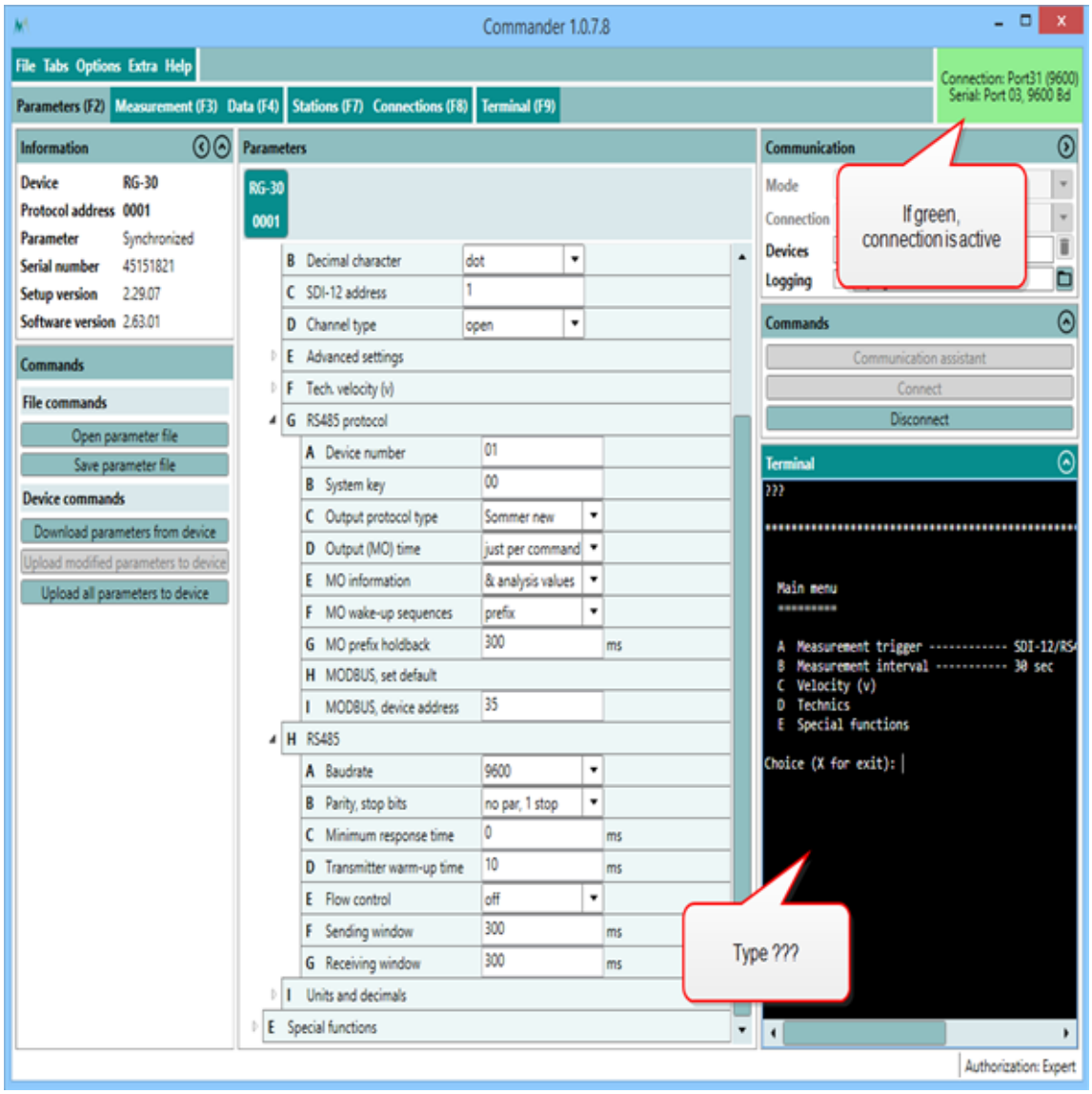
6. In the parameter list navigate to Technics and open the menus RS-485 protocol and RS485 and take a screenshot of the associated parameters. This and the previous step are helpful if you need to switch back to the standard communication mode at a later time.



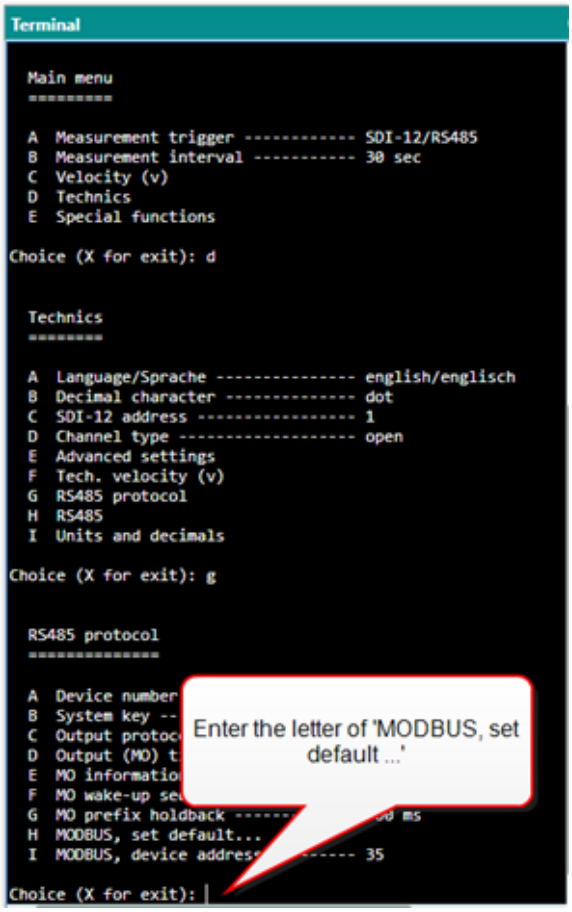
7. Set Measurement trigger to one of the following options:
   A. *Interval*, if measurements are triggered internally by the device.
   B. *SDI-12/RS-485*, if measurements are triggered by SDI-12.
   C. *TRIG input*, if measurements are triggered by a trigger input.
   D. *all allowed*, if measurements are triggered by one of the previous options.

> **NOTE** Modbus cannot trigger measurements! Make sure to use the trigger option suitable for your application!

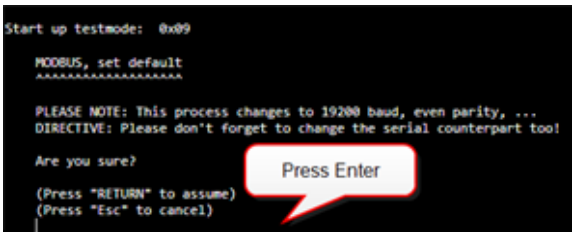
8. Verify that the connection to the Sommer-device is active and click into the Terminal window. Type ??? to enter the sensor-menu.



9. Navigate to *RS485 protocol* and select *MODBUS, set default…* Please note, that the index-letters might be different for your Sommer-device!

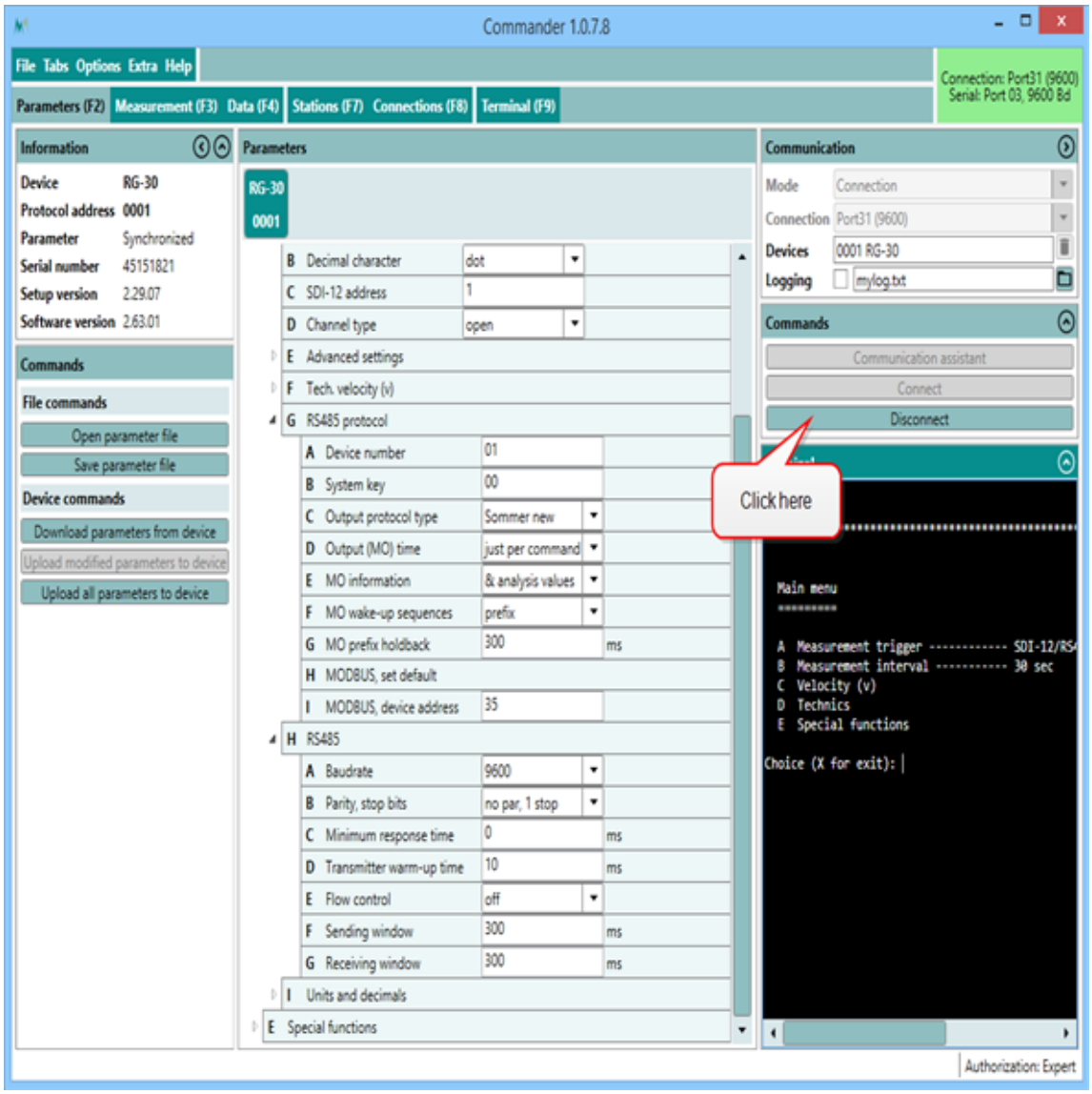


10. Acknowledge the safety-note.



11. After completion the following message will be displayed:

12. Enter X until you get back to the main menu. The Sommer-device is now restarted and available for Modbus-communication. As the connection-parameters have been changed to Modbus, the connection to the sensor is lost. Press Disconnect for completion.



NOTE

By switching communication to Modbus with MODBUS, set default the following parameters are changed:

Parameter	Modbus setting
OP, measurement output	just per command
Output protocol (OP)	Modbus
MODBUS, device address	35
Sleep mode	Modbus, slow
Parity, stop bits	even par, 1 stop
Baud rate	19200
Flow control	off
Transmitter warm-up time	10 ms

Parameter	Modbus setting
Minimum response time	30 ms

12.5.5 Modbus commands and registers

Read input registers

Input registers contain measurement values. The content of these registers is updated after each measurement.

	Register address	Variable	Unit / value	Bytes	Format
Test value	0	Hard coded test value	2.7519...	4	float
Main values	2	AUX	[2]	4	float
	4	Water level	[2]		
	6	Velocity[1]	[2]		
	8	Quality (SNR)	-		
	10	Discharge[1]	[2]		
	12	Area	[2]		
Special values	14	Learned velocity[1]	[2]	4	float
	16	Learned discharge[1]	[2]		
	18	Opposite direction content	%		
	20	Supply voltage	V		

[1] The positions of the measured and learned velocity and discharge can be switched with the setting W-v priority.

[2] Unit according to submenu Units and decimals.

	Register address	Variable	Unit / value	Bytes	Format
Analysis values	22	Peak width	mm/s	4	float
	24	CSR	%		
	26	Area of the peak	-		
	28	RMS at the PIC	mV		
	30	Amplification	-		
	32	Amplification relation	%		
	34	Signal relation	%		
	36	Error code	-		
	38	not used	-		
	40	not used	-		
	42	not used	-		
Device info	65533	Device type and configuration	320X	2	unsigned int
	65534	Software version	XYYZZ	2	unsigned int
	65535	Modbus implementation version	10100	2	unsigned int

Table 22 Input registers

Read and write holding registers

Holding resisters are mainly used to configure the Modbus adapter communication. Configuration settings are read with function 03 (read holding registers) and written with function 06 (write single registers).

NOTE Restart the Modbus adapter after changing the configuration!

	Register address	Variable	Range	Bytes	Format
Config values	0	Modbus default[1]	0 - 1...read 1...write	2	unsigned int
	1	Modbus device address	1 to 247		
	2	RS-485 baud rate	1...1200 baud 2...2400 baud 3...4800 baud 4...9600 baud 5...19200 baud 6...38400 baud 7...57600 baud 8...115200 baud		
	3	RS-485 parity/ stop bits	1...no parity, 1 stop bit 2...no parity, 2 stop bits 3...even parity, 1 stop bit 4...odd parity, 1 stop bit		

Table 23 Holding registers

Report slave ID

The Modbus function 17 (report slave ID, read only) can be used to read basic information of the RQ-30. The following example shows the response of function 17 of a RG-30 sensor, which is received in hex-format:

EXAMPLE 23 11 26 53 FF 27 74 20 53 6F 6D 6D 65 72 20
20 52 47 2D 33 30 20 20 20 32 5F 37 31 72 30 31 20
34 35 31 35 31 38 32 31 00 BB D4

[1]Writing "1" sets the Modbus default settings.

			Example	
	Content	**Length (Bytes)**	**HEX-value**	**Decimal, ASCII**
PDU* response	Slave address	1	23	35
	Function code	1	11	17
	Number of bytes (excl. slave-address, function code, NUL and CRC)	1	26	38
	Slave ID	1	53	"S"
	Run status (0=inactive; FF=active)	1	FF	255
	Modbus implementation version	2	27 74	10100
	Separator	1	20	" "
	Vendor string	7	53 6F 6D 6D 65 72 20	"Sommer "
	Separator	1	20	" "
	Device configuration	7	52 47 2D 33 30 20 20	“RG-30 “
	Separator	1	20	" "
	Software version	7	32 5F 37 31 72 30 31	2_71r01
	Separator	1	20	" "
	Serial number	8	34 35 31 35 31 38 32 31	45151821
	NUL	1	00	
	CRC	2	BB D4	

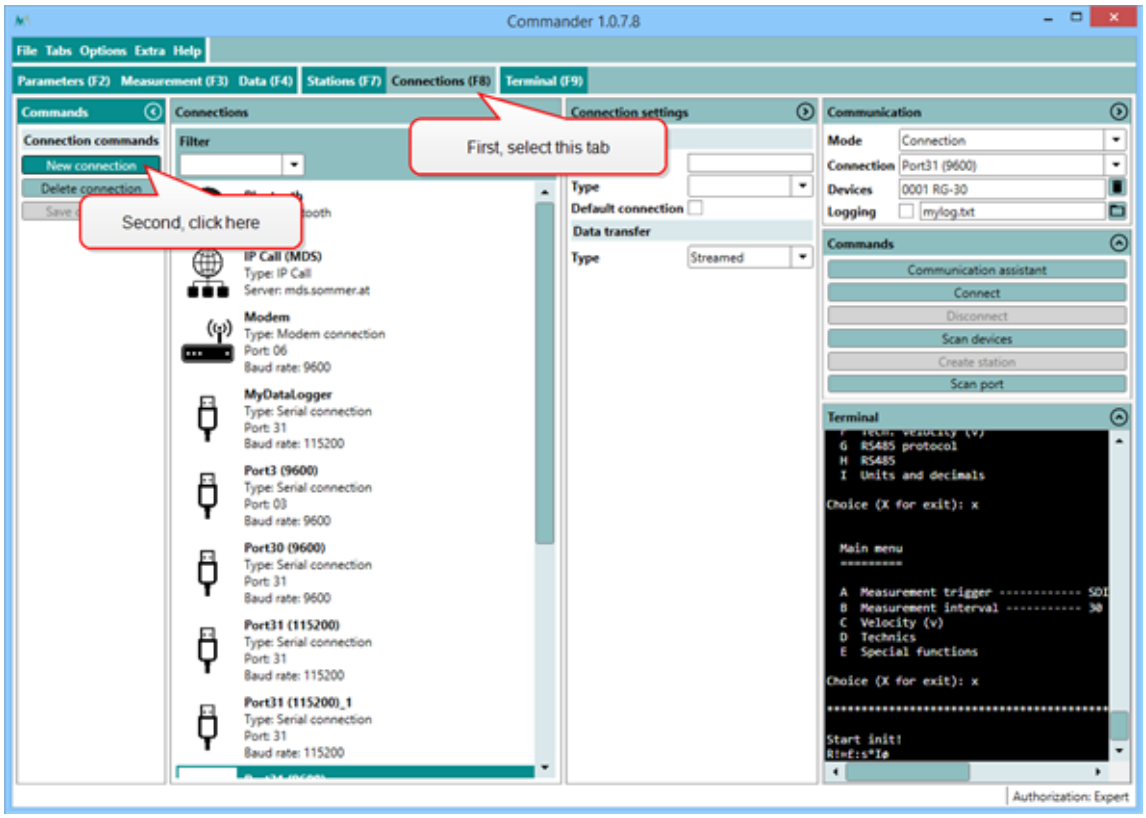
*Protocol Data Unit

Table 24 Slave ID

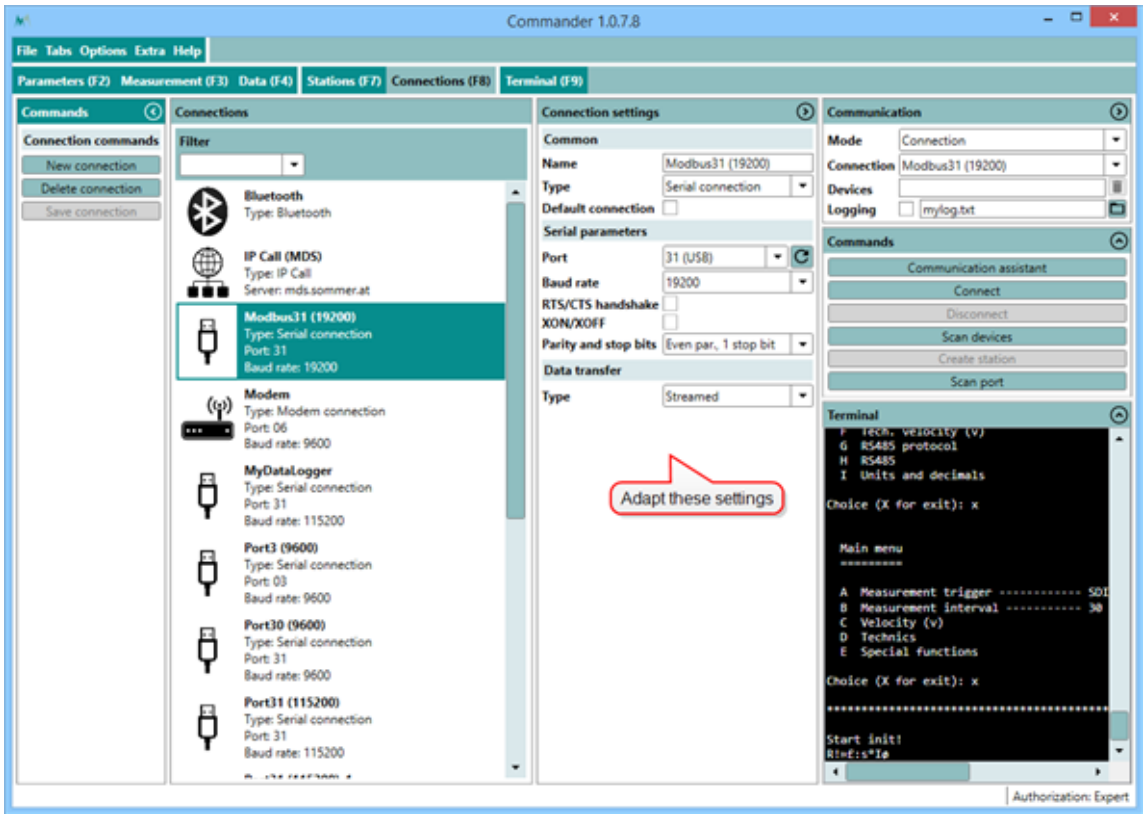
12.5.6 Reactivate Sommer protocol

Follow the instructions below to change the data output back to Sommer-protocol:

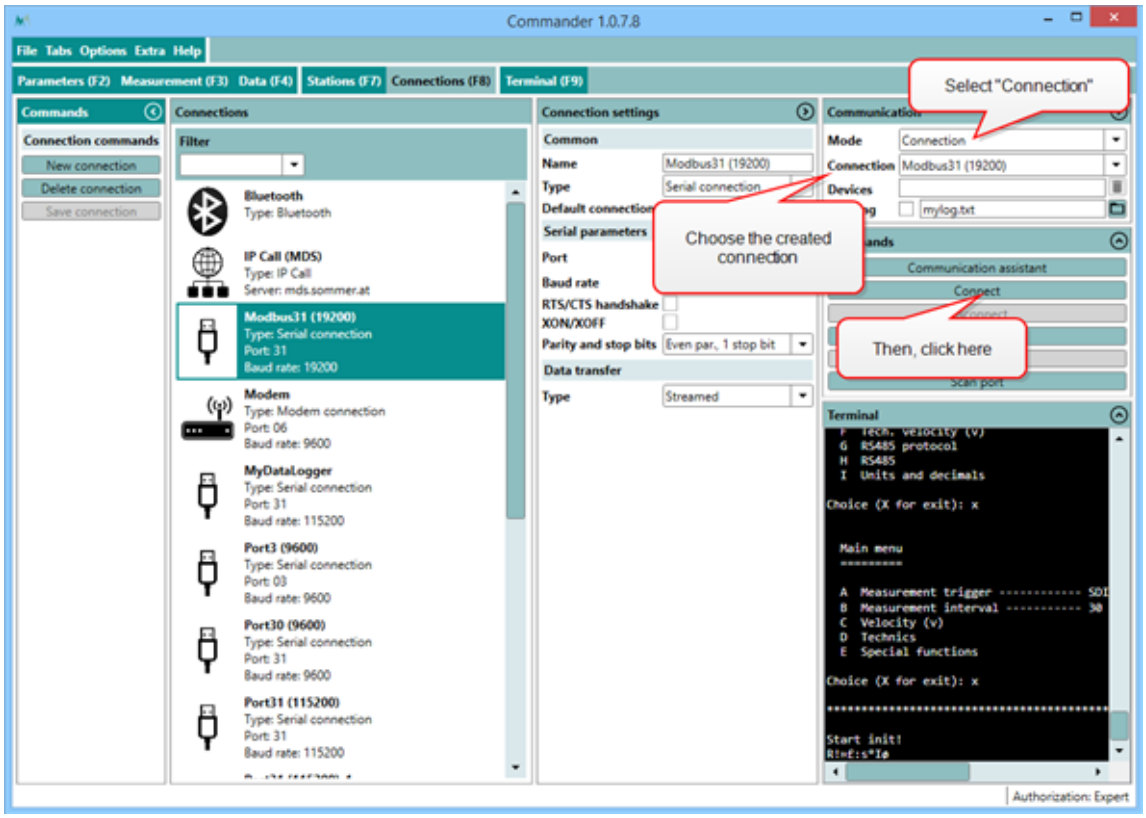
1. Open the Connections (F8) tab and click New connection.



2. Enter the Name of the new connection. We recommend to use a meaningful name for later recognition, e.g. Modbus31 (19200) to indicate port 31 and Baud-rate 19200. Select the Type Serial connection and choose the Port your sensor is connected to, set the Baud-rate to *19200* and the Parity/stop bits to *Even par., 1 stop bit*.



3. Click Save connection.
4. In the Communication window select Mode Connection and choose the Connection you have created. Then click Connect.

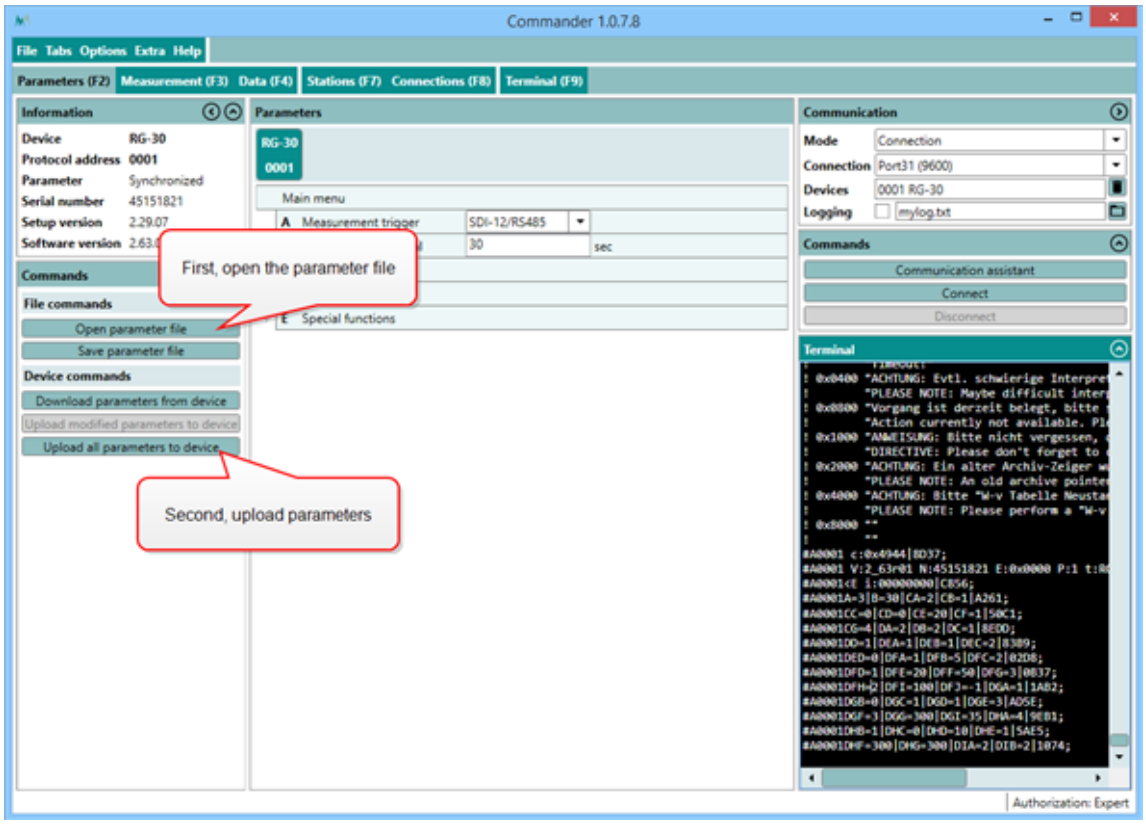


5. Download the parameters and save the parameter file as described in Configuration.

> **TIP** Save the parameter file for future use and to document configuration changes!

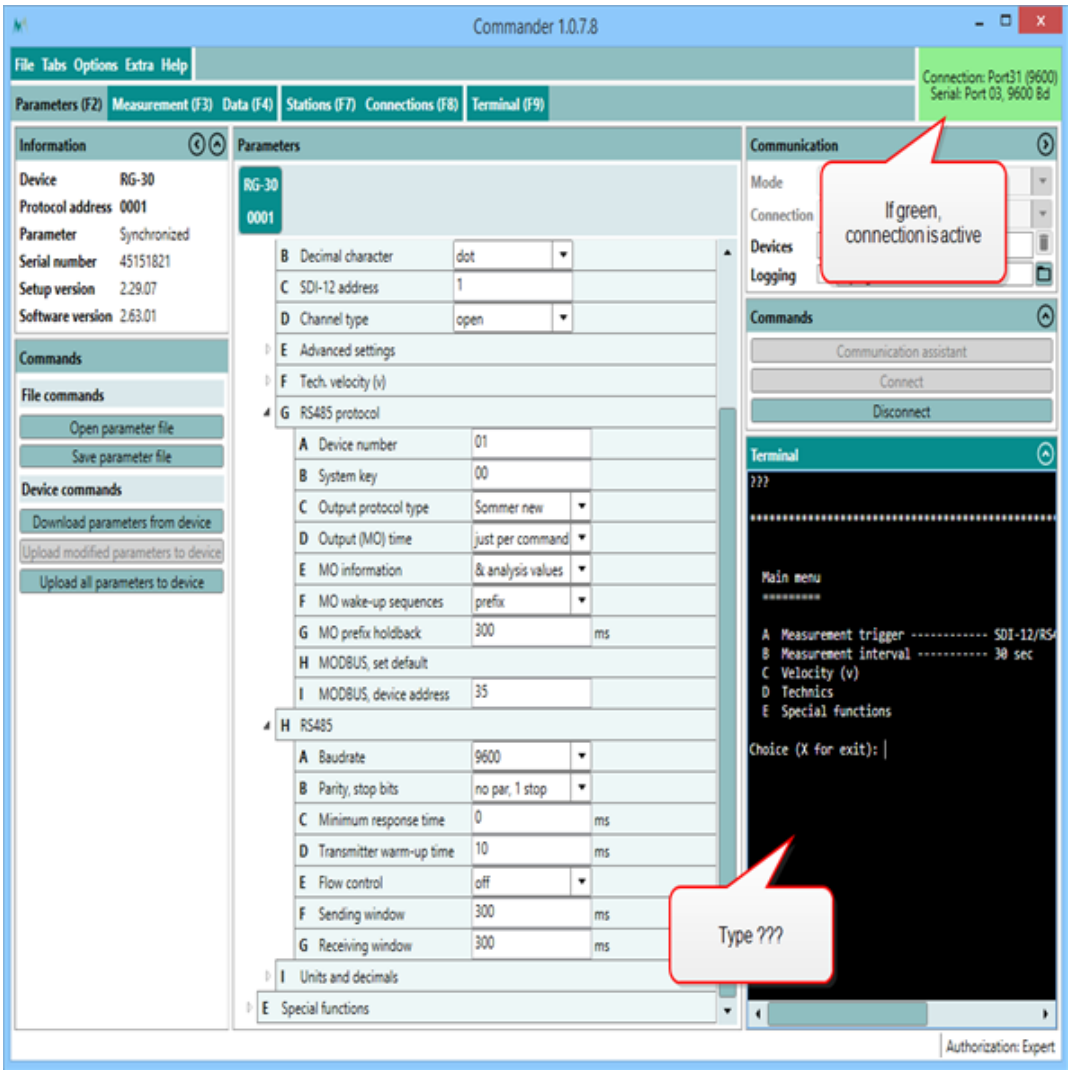
6. Now, two options are available to revert communication back to the Sommer-protocol:

A. If a parameter file is available that has the Sommer-protocol enabled, the file can be loaded by clicking Open parameter file, selecting the respective file and uploading the parameters to the device by clicking Upload all parameters to device.

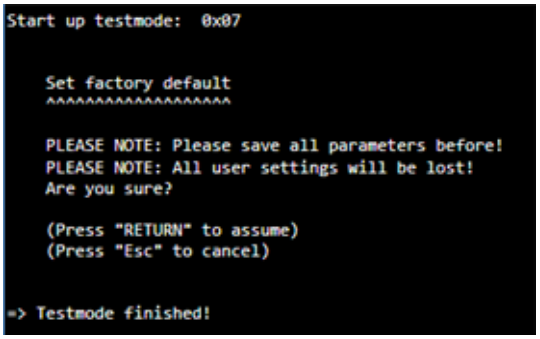


B. If no parameter file is available, the device has to be reset to its default configuration:

1. Click into the Terminal window and type ??? to enter the sensor-menu.



2. Navigate to Special functions and select Set factory default…
3. Acknowledge the safety-note.



4. Enter X until you get back to the main menu. The Sommer-sensor is now restarted and available in its initial configuration. As the connection-parameters have been changed to the default settings, the connection to the sensor is lost. Press Disconnect for

completion.

7. Establish the original connection to the Sommer-sensor as described in Configuration.
8. Download the sensor's parameters in the Parameters (F2) tab, adapt the required parameters, or upload your originally saved parameter file to the RQ-30.

12.5.7 PLC integration

The RQ-30 can be integrated into a PLC system as a slave device. It supports the PROFIBUS, PROFINET, EtherCAT and CANopen protocols. This requires an additional serial converter, e.g. Anybus Communicator.

13 Analog output

13.1 What can I do with it?

Only available with RQ-30a. Measurement values of water level, flow velocity, discharge and the auxiliary analog input can be returned by analog 4...20 mA signals. These can be configured in 4-20 mA outputs.

13.2 Activation

In the setting Status the state of the analog output can be set to on of the following options:

ID	Option	Description
1	off (default)	Analog outputs are inactive.
2	just during TRIG	Analog outputs are only active, if an external signal is present at the TRIG input. The outputs are high as long as the signal at the TRIG input is high.
3	always on	Analog outputs are permanently active.

NOTE The RQ-30 delays analog data acquisition by 200 ms. If Status is set to *just during TRIG* , the analog output must be read with a delay of min. 200 ms after the trigger has been sent. This ensures that the analog measurement has sufficiently stabilized. As the analog measurement itself requires some time, the result should be read with a delay of *measurement duration + min. 1 second*.

13.3 Scaling

The variables and their analog output range are configured as described below.

NOTE
The analog outputs may return currents between 0 and 21 mA. However, the accuracies stated in the specifications are only valid for signals within 4 to 20 mA!

If the measured value falls below or exceeds the 3.9…21 mA range, 3.9 mA and 21 mA, respectively, are returned. An exception are the measurement values `99999998` and `99999997`, which return a 3.8-mA and 3.7-mA signal, respectively.

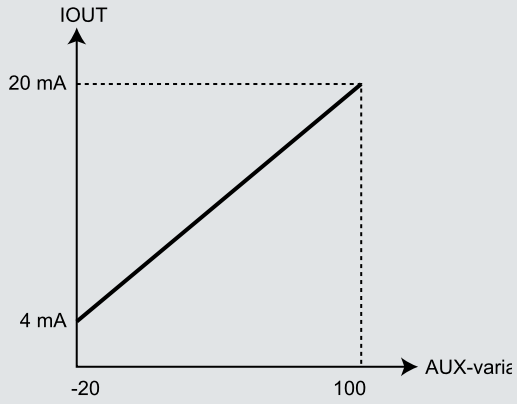
ATTENTION The 4-mA output should correspond to a measurement value at or below the expected minimum! With low current output the accuracy tends to decrease and cross-talk with other analog channels may occur.

13.4 IOUT1 – AUX

The analog output IOUT1 returns the measured auxiliary quantity, by default a temperature. The output corresponds to a linear equation defined by the span between 4 and 20 mA and an offset at 4 mA.

EXAMPLE

In the default configuration the parameter IOUT1, AUX 4 mA value is set to *-20* and IOUT1, AUX 4-20 mA span to *100*, as illustrated below.



13.5 IOUT2 – water level

The analog output IOUT2 returns the water level. The output corresponds to a linear equation defined by the span between 4 and 20 mA and an offset at 4 mA. See IOUT2, level 4-20 mA span for an example.

13.6 IOUT3 – flow velocity

The analog output IOUT3 returns the water flow velocity. Only the maximum velocity at 20 mA has to be set; a velocity of zero is assumed at 4 mA.

If only uni-directional water flow is allowed (this option is set in Possible flow directions), the 4 mA signal corresponds to a velocity of 0 m/s. If two-directional flow is selected, a 12 mA signal corresponds to a velocity of 0 m/s. In this case the maximum negative velocity corresponds to 4 mA and the maximum positive velocity to 20 mA. See Figure 25 for an illustration of these two situations.

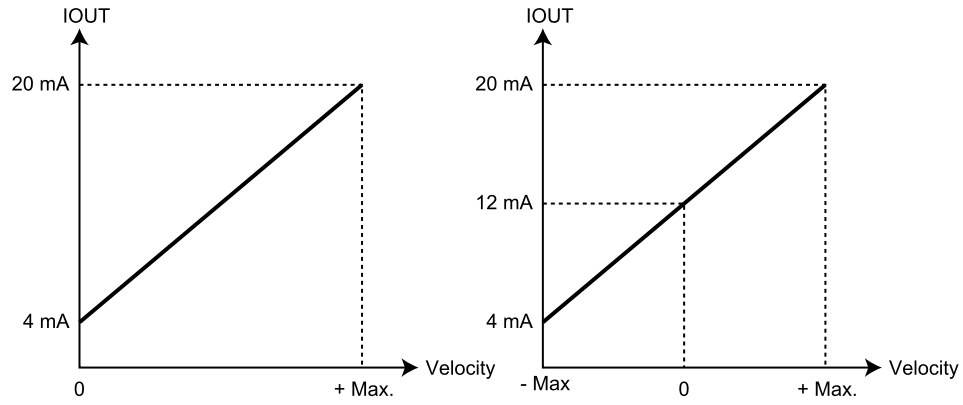


Figure 25 Definition of the 4 to20 mA signal with uni- and two-directional water flow

13.7 IOUT4 – discharge

The analog output IOUT4 returns the water discharge. Only the maximum velocity at 20 mA has to be set; a discharge of zero is assumed at 4 mA.

If only uni-directional water flow is allowed (this option is set in Possible flow directions), the 4 mA signal corresponds to a discharge of zero. If two-directional flow is selected, a 12 mA signal corresponds to a discharge of zero. In this case the maximum negative discharge corresponds to 4 mA and the maximum positive discharge to 20 mA. See 13.7 for an illustration of these two situations.

13.8 Simulate current output

With this function the analog outputs can be simulated. A user-defined current value between 4 and 20 mA is applied to the analog output pins, which can be read with a connected data logger or multimeter. By pressing Return/Enter again the simulation stops.

14 Parameter definitions

A Measurement trigger

generic-measurement-trigger

Measurements are initiated by one of the options listed in the table below.

The commands to trigger measurements via RS-485 and SDI-12 are described in Communication.

Measured data are either returned directly after the measurement or can be requested by commands via the RS-485 or SDI-12 interface. The format of the returned data can be configured in the sub-menu Output protocol (OP).

ID	Option	Description
1	Interval (default)	Measurements are initiated in a specified interval.
2	TRIG input	Measurements are triggered by the positive edge of a DC-voltage signal applied to the TRIG input (low: 0 ... 0.6 V, high: 2.2 ... 28 V, pulse duration must be ≥500 ms, delay between pulses must be ≥500 ms)
3	SDI-12/RS-485	Measurements are externally triggered by commands via RS-485 or SDI-12 from ,e.g. a data logger.
4	all allowed	Measurement is triggered by all options mentioned above.

B Measurement Interval

generic-measurement-interval

An internal measurement interval can be set for the RQ-30. If selected in menu item Measurement trigger, measurements are performed in the defined interval. However, a measurement is always completed before a new one is initiated.

Value range	Default	Units
20...18'000	60	s

C AUX

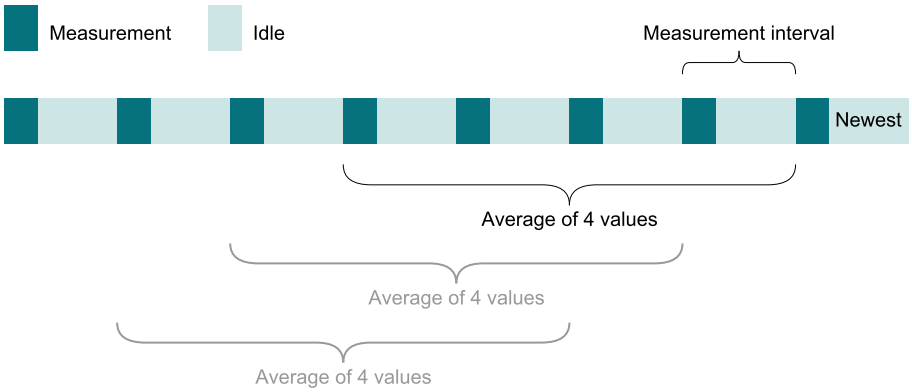
Specifies the auxiliary 0...2.5 V analog input. Usually, a temperature sensor is connected, but any analog sensor may be used. Additional configurations can be set in Tech. AUX.

C-A Mean value, no. of values

`rq-discharge-mean-value-no`

Every water level measurement is stored internally in a buffer to compute a moving average. This setting defines the number of measurement values in the buffer. If the buffer is full the oldest value is replaced by the most recently recorded value.

ATTENTION If the measurement interval is long, the measurement data may lag behind! For example, if the measurement interval is 5 min and the filter is applied over 10 measurements, it may take up to 50 min until the full scale of a measurement shift is observed.



Value range	Default	Units
1...120	1	-

C-B Test

`rq-discharge-test-aux`

A measurement of the auxiliary input is performed and after completion the result is displayed.

C-C Adjustment

`rq-discharge-adjustment`

Function to adjust the measurement value. First, a measurement is performed and the result displayed. Afterwards, a target value is set and confirmed. The measurement is then adjusted to exactly match the target value. The adjustment of the water level measurement is described in detail in Section Water level measurement.

D Level (W)

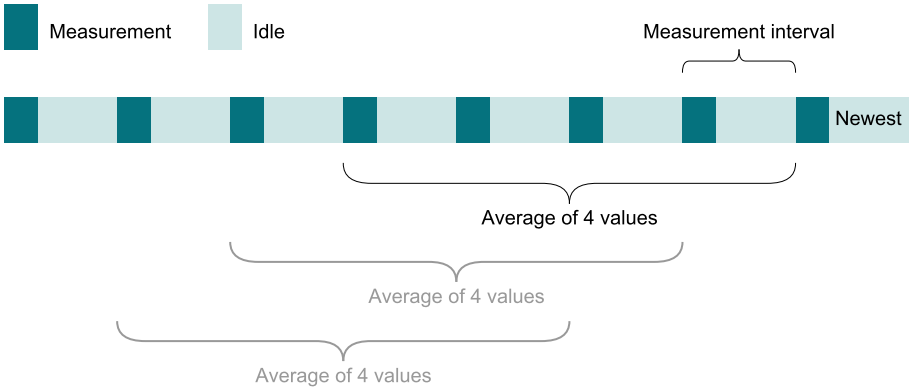
D-A Mean value, no. of values

`rq-discharge-mean-value-no`

Every water level measurement is stored internally in a buffer to compute a moving average. This setting defines the number of measurement values in the buffer. If the buffer is full the oldest value is replaced by the most recently recorded value.

ATTENTION If the measurement interval is long, the measurement data may lag behind! For example, if the measurement interval is 5 min and the filter is

applied over 10 measurements, it may take up to 50 min until the full scale of a measurement shift is observed.



Value range	Default	Units
1...120	1	-

D-B Test

`rq-discharge-test-level`

A level measurement is performed and after completion the result is displayed.

D-C Adjustment

`rq-discharge-adjustment`

Function to adjust the measurement value. First, a measurement is performed and the result displayed. Afterwards, a target value is set and confirmed. The measurement is then adjusted to exactly match the target value. The adjustment of the water level measurement is described in detail in Section Water level measurement.

D-D W_Q, fixation level

`rq-discharge-fixation-level`

The fixation level W_Q ist the vertical distance between the deepest point in the cross-sectional profile and the bottom surface of the RQ-30.

ATTENTION Use the Adjustment button to set the fixation level W_Q automatically!

Value range	Default	Units
-9999.99...99999.99	0	Unit of level

D-E WMA, maximum level

`rq-discharge-maximum-level`

The maximum possible water level. This value should be smaller as or equal to the fixation level W_Q.

NOTE If set to *0* the machine learning function is deactivated.

Value range	Default	Units
-9999.99...99999.99	0	Unit of level

D-F WLL, low level border

`rq-discharge-low-level-border`

The low level border is the water level below which velocity measurements are not feasible. However, the RQ-30 calculates the velocity below WLL with its learning function.

The low level border constitutes the lower limit of the water level range for the calculation of the learning function (continuously updated relation between water level and flow velocity).

Value range	Default	Units
-9999.99...99999.99	0	Unit of level

D-G WCF, cease to flow level

`rq-discharge-cease-to-flow-level`

The cease to flow level is the water level at which there is no water flow in the channel. This may or may not be the river bed (see also W-v relation).

For water levels between the cease to flow level and the low level border velocities and discharges are extrapolated from the W-v relation. At water levels below WCF no velocities are returned.

Value range	Default	Units
-9999.99...99999.99	0	Unit of level

D-H W-v table reset

`rq-discharge-w-v-table-reset`

The stored W-v table is deleted and the W-v learning starts anew. This is especially required if the water flow regime and thus the W-v relation have changed, e.g. new channel profile.

E Velocity

E-A Viewing direction

`rq-discharge-viewing-direction`

This setting defines the viewing direction of the RQ-30 sensor in relation to the flow direction of the river. The advantages of the different viewing directions are described in Installation requirements.

ID	Option	Description
1	downstream	The RQ-30 sensor is directed in flow direction.
2	upstream (default)	The RQ-30 sensor is directed against the flow direction.

E-B Possible flow directions

`rq-discharge-possible-flow-directions`

Due to the direction separation (see Flow direction separation) the RQ-30 sensor can identify the flow direction. Therefore it has to be defined if the river only flows in one direction or if bi-directional flow can occur as for example under tidal influence.

ID	Option	Description
1	just downstream (default)	Only downstream flow is recorded.
2	two (tide)	Down- and upstream flow is recorded. Upstream flow is indicated by a negative sign.

E-C River inclination

`rq-discharge-river-inclination`

The RQ-30 sensor only measures its own vertical inclination. To compensate for the influence of a sloping river surface an additional correction can be set. It is either added or subtracted depending on the flow direction. Generally, rivers do not show an appreciable inclination of the water surface. For the possible flow direction *two (tide)* an inclination of *0* has to be set.

Value range	Default	Units
0...90	0	-

E-D Yaw angle

`rq-discharge-yaw-angle`

Usually the main water flow is perpendicular to the cross Section of a river and the RQ-30 sensor is mounted in the same way. However, if the RQ-30 sensor has to be rotated horizontally, the rotation angle can be considered for by adjusting this setting. To ensure a reliable and accurate velocity measurement it is recommended to select a yaw angle smaller than 30°.

Value range	Default	Units
0...60	0	Degree

E-E Measurement duration

`rq-discharge-measurement-duration`

The measurement duration defines the duration of a single measurement. During this time the RQ-30 signal is recorded and the velocity radar spectrum is analyzed.

Generally, a measurement duration of 30 ... 60 s is recommended. It should be at least 10 s. A long measurement time increases power consumption.

Please see Warm-up time for an illustration of the measurement duration in relation to the Measurement Interval and the level measurement.

Value range	Default	Units
5...240	30	Seconds

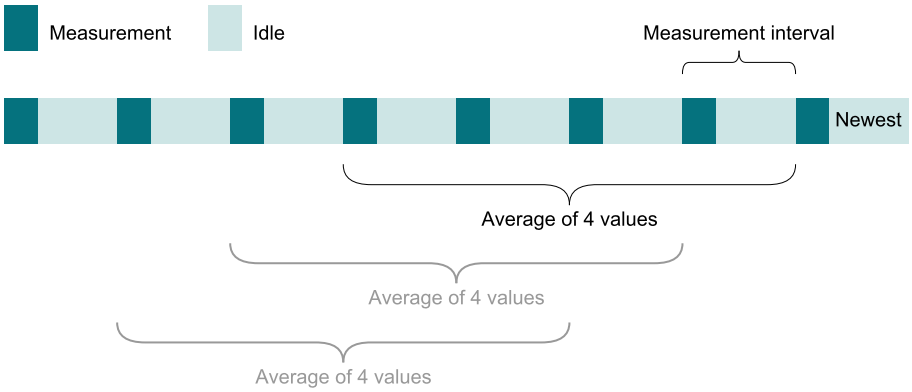
E-F Filter, no. of values

`rq-discharge-filter-values`

Every velocity measurement is stored internally in a buffer for filtering. This setting defines the number of measurement values in the buffer. If the buffer is full the oldest value is replaced by the most recently recorded value.

The number of buffered values depends on the turbulence of the water surface. Highly turbulent rivers demand a small buffer, rivers or irrigation channels with low turbulence require a larger buffer.

ATTENTION If the measurement interval is long, the measurement data may lag behind! For example, if the measurement interval is 5 min and the filter is applied over 10 measurements, it may take up to 50 min until the full scale of a measurement shift is observed.



Value range	Default	Units
1...120	1	-

E-G Filter, type

`rq-discharge-filter-type-velocity`

The velocity values in the buffer can be filtered by one of the following options:

ID	Option	Description
1	moving average (default)	The mean value of all buffered values is calculated.
2	eliminate spikes	To eliminate spikes the mean value is calculated without the 5 highest and 5 lowest buffered values. If the buffer size is smaller than 15 two third of the values are eliminated.
3	minimum value	The smallest value from the buffer is returned.
4	median value	The median value of the buffered data is returned.

F Discharge table

`rq-discharge-table`

As described in Section Determination of water discharge the discharge is calculated from the measured water level and the measured velocity considering the cross-Sectional area and the k-factors. The values of the cross-Sectional areas and the k-factors are set in the discharge table.

The information is arranged in 16 lines ordered from low to high water levels. The values for water levels between two lines are interpolated linearly.

The discharge table can be generated with the software SQ-Commander of Sommer GmbH. This program calculates areas and k-factors from a cross-Sectional profile and additional characteristics of the water channel. It also provides functionality to transfer the discharge table to the memory of the RQ-30 sensor. See Sections Determination of water discharge and Performing a site survey for more details on discharge tables and their generation.

	Status	Level (W)	K value	Area (A)
		[m]	[ ]	[m^2]
01	on	0.4	64.0	4.7
02	on	0.6	68.7	9.5
03	on	0.8	72.1	14.4

	Status	Level (W)	K value	Area (A)
04 ... 14	...	...	...	...
15	on	4.9	79.5	141.8
16	on	6.7	80.7	202.4

F-A Status

`rq-discharge-status-discharge-table`

The status describes the activity and priority of a data line within the discharge table. The following options are available:

ID	Option	Description
1	Off (default)	The line is inactive.
2	theor.	The line is active with theoretical values from a numerical hydraulic model.
3	calib.	The line is active with calibrated values from a reference measurement. These values have high priority.

F-B Level (W)

`rq-discharge-level`

The entries of the discharge table are ordered from low to high water levels. The unit of the water level is defined in the submenu Units and decimals.

Value range	Default	Units
-9999.99...99999.99	0	Unit of level

F-C k value

`rq-discharge-k-value`

The k-factor is the ratio between the mean and the measured local velocities at the defined water level (see k-Factors). The value is scaled to 1, i.e. a k-factor of 70 % is entered as 0.700.

Value range	Default	Units
0...99999.999	1	-

F-D Area (A)

rq-discharge-area

The area is the cross-Sectional area of the water filled part of the river or flow channel.

Value range	Default	Units
-9999.99...999999.99	0	Unit of area

G Total discharge volume

G-A Status

rq-discharge-status-discharge-volume

The status of the total discharge volume function. The following options are available:

ID	Option	Description
1	Off (default)	The volume totalizer function is inactive.
2	on	The volume totalizer function is active. The discharge sum is returned with the main measurement values (see Data output)

G-B Simulation discharge volume

rq-discharge-simulation-RQ

With this function the daily discharge volume can be simulated. This allows to estimate the maximum discharge rate before data overflow of the totalized discharge volume occurs.

EXAMPLE

The following RQ-30 settings are assumed:

Measurement trigger internal

Measurement Interval 60 s

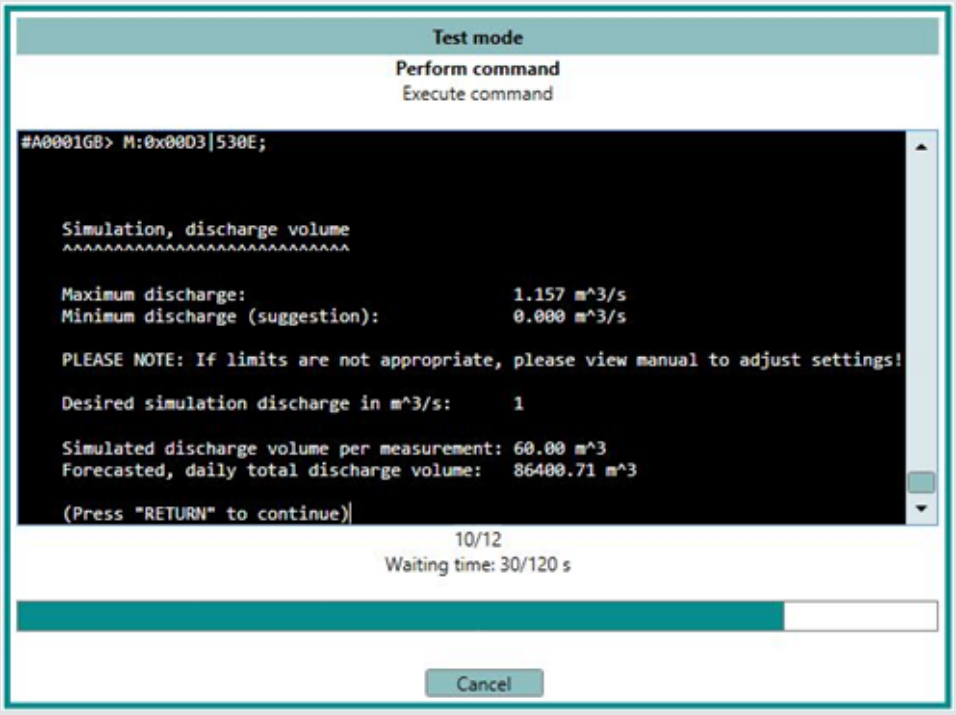
Discharge (Q), unit m^3/s

Discharge (Q) decimals 3

Total discharge volume unit* m^3

Total discharge volume decimal 2

After pressing the buttonSimulation discharge volume in SQ-Commander a window will pop up:



Enter the discharge rate you want to simulate, e.g. *1 m^3/s*, and press Enter. The result shows the discharge volume per measurement interval and the total daily discharge volume.

Notice: The simulated maximum discharge depends on Units and decimals. Furthermore, the RQ-30 sensor provides 8 characters to display the total daily discharge. Thus, the maximum discharge rate is restricted either by the total daily discharge – in the current example *99999.99 m3*.

G-C Set total discharge volume

rq-discharge-set-total-volume

With this function the total discharge volume can be set to a defined value, e.g. a reset to zero.

H DIG OUT

H-A LM, trigger via

rq-discharge-lm-trigger-via

This parameter defines the method by which the discharge is monitored. One of the following options can be selected:

ID	Option	Description
1	Off (default)	Surveillance deactivated
2	discharge	Surveillance of the discharge of the device
3	multi-point discharge	Same as option discharge
4	level	Surveillance of the level
5	velocity	Surveillance of the velocity
6	AUX	Surveillance of the AUX input

H-B LM, limit type

rq-discharge-lm-limit-type

This parameter defines the orientation of the threshold. The following options are available:

ID	Option	Description
1	limit overrun (default)	Violation when the defined value exceeds the limit
2	limit underrun	Violation when the defined value drops below the limit

H-C LM, limit value

`rq-discharge-lm-limit-value`

This parameter specifies the magnitude of the limit value.

Value range	Default	Units
-99999.99...999999.99	0	Unit of selected parameter (level, velocity,...)

H-D LM, hysteresis

`rq-discharge-lm-hysteresis`

The specification of a hysteresis value suppresses multiple violations if the measurement value closely fluctuates around the threshold. After a violation the hysteresis value has to be exceeded to cause a new violation. The hysteresis is an absolute value and is added with the correct sign to the threshold. Figure 26 illustrates an example.

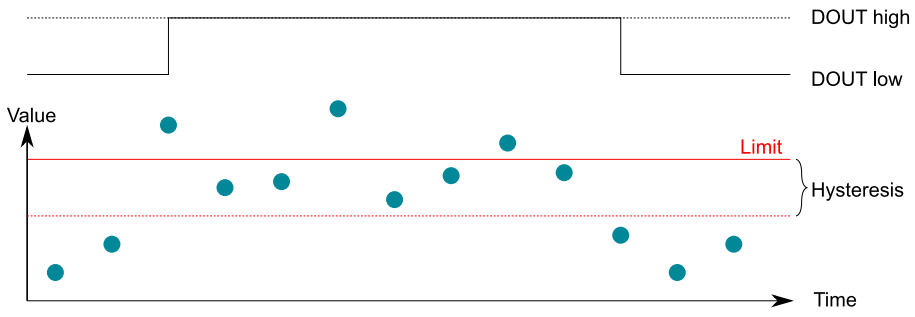


Figure 26 Hysteresis in monitoring of water level W

Value range	Default	Units
0...999999.99	0	Unit of selected parameter (level, velocity,...)

I Technics

I-A Language/Sprache

`generic-language`

The menu language.

ID	Option	Description
1	german/deutsch	German language
2	english/englisch (default)	English language

I-B Decimal character

`generic-decimals-character`

The character used as decimal separator in the values of the settings and in serial data strings.

ID	Option	Description
1	comma	-
2	dot (default)	-

I-C SDI-12 address

`generic-sdi-12-address`

The address is a unique identifier of the sensor within a SDI-12 bus system.

Value range	Default	Units
0...9, a...z, A...Z	0	-

I-D Channel type

`rq-discharge-channel-type`

This parameter specifies the type of flow channel where the RQ-30 sensor is installed. The selection determines how the flow velocity is calculated from the velocity spectrum (see Channel type for details). One of the following options can be selected:

ID	Option	Description
1	open (default)	Open flow channel.
2	covered	Closed or covered flow channel, e.g. discharge pipe.

I-E W-v priority

`rq-discharge-w-v-priority`

The W-v priority determines if the measured or learned values of the velocity and discharge are returned (see W-v priority).

ATTENTION For water levels below the low level border WLL the learned velocity and dis-charge are returned.

ID	Option	Description
1	no (default)	The measured velocity and discharge are returned as part of the main values. The learned velocity and discharge are returned as part of the special values.
2	yes	The learned velocity and discharge are returned as part of the main values. The measured velocity and discharge are returned as part of the special values.

I-F Area correction

`rq-discharge-area-correction`

In case of small changes of the river bed, and consequently the cross-sectional area, the discharge table can be adjusted by an offset. It is recommended to avoid larger corrections with this parameter.

Value range	Default	Units
-99999.99...999999.99	0	Unit of area

I-G Advanced settings

I-G-A Reset general behavior

`generic-reset-behavior`

The RQ-30 keeps certain sensor data in its memory, e.g. the measured data for calculation of the moving average. This setting defines whether the acquired sensor data are deleted upon a sensor reset or not.

ID	Option	Description
1	hard reset	A reset deletes all acquired and stored sensor data.
2	soft reset (default)	All acquired and stored sensor data are kept for measurements and calculations.

NOTE During the installation a hard reset is recommended. After finishing the installation a soft reset should be selected. This shortens start-up time.

I-G-B Reset total discharge volume

`rq-discharge-reset-total-discharge`

The value of the total discharge volume when the RQ-30 is restarted (either by re-powering the RQ-30 or by the function Relaunch program). By interrupting the power supply of the RQ-30 this function can be used to reset the total discharge volume in a specified interval.

ID	Option	Description
1	hold value (default)	The last value of the total discharge is set.
2	set to zero	The total discharge is set to zero.

I-G-C Inclination measurement

`rq-discharge-inclination-measurement`

The measurement of the flow velocity has to be corrected for the inclination of the RQ-30 sensor as described in Inclination angle measurement. The following angle corrections are available:

ID	Option	Description
1	first measurement (default)	The inclination is only measured prior to the first measurement after the initialization process (after powering up and after parameter updates)
2	every measurement	The inclination is measured during each velocity measurement.

ATTENTION If the inclination of the RQ-30 sensor can change, i.e. if mounted on a cable way, the inclination should be measured along each velocity measurement.

I-G-D Sleep mode

`generic-sleep-mode`

Defines the behavior of the RQ-30 between two measurements, provided the measurement interval is longer than the time of the measurement itself. The following options are available:

ID	Option	Description
1	MODBUS, fast	For MODBUS applications. The RQ-30 stays in normal mode. This option permits high data transmission rates, but increases power consumption.
2	MODBUS, slow	For MODBUS applications. The RQ-30 goes into idle mode and can be woken up by a command via the RS-485 interface with a low baud rate. This option reduces power consumption at lower data transmission rates.
3	Standard (default)	The RQ-30 goes into sleep mode and can be woken up by a command via the RS-485 interface only with a time delay. Option with the lowest power consumption.

I-G-E Sommer ID

`generic-sommer-id`

The Sommer ID is used to define stations within the SQ-Commander software. The ID is preset in the device and corresponds to its serial number.SOMMER suggests not to change the ID, except if a RQ-30 device is replaced. In such a case it can be practical to change the ID of the new device to the ID of the replaced device to guarantee data consistency.

I-H Tech. AUX

I-H-A Status

`rq-analog-in-status`

Activity status of the auxiliary analog sensor input. If no sensor is connected set to off.

ID	Option	Description
1	off = SFCH (self-check, default)	AUX input is off and the RQ-30 returns the self-check value.
2	on = AUX	AUX input is on.

I-H-B Supply

`rq-analog-in-supply`

Configuration of the sensor power supply.

ID	Option	Description
1	switched (default)	Sensor power supply is only switched on for measurements. Recommended to minimize power consumption.
2	always on	Sensor power supply is always on.
3	always off	Sensor power supply is always off.

I-H-C Warm-up time

`rq-analog-in-warm-up-time`

Delay between power-up of the sensor supply and the return of the measurement.

Value range	Default	Units
0...255	3	Seconds

I-H-D 0-2.5 V input span

`rq-analog-in-2.5v-input-span`

The value range of the measured quantity that corresponds to the 0...2.5 V input.

Value range	Default	Units
-99999.99...999999.99	100	Unit of auxiliary sensor quantity

I-H-E 0 V input value

`rq-analog-in-input-value-0v`

This value of the measured quantity that corresponds to the 0 V input.

Value range	Default	Units
-99999.99...999999.99	-20	Unit of auxiliary sensor quantity

I-I Tech. level (W)

This submenu contains the technical parameters for the water level measurement.

I-I-A Supply

`rq-discharge-supply`

For an efficient energy management the power supply mode of the water level sensor can be set to one of the following options:

ID	Option	Description
1	switched	Sensor power supply is only switched on for measurements.
2	always on (default)	Sensor power supply is always on.
3	always off	Sensor power supply is always off. **ATTENTION** This option deactivates the level sensor! Only use it if the level sensor is supplied by an external power source!

I-I-B Warm-up time

`rq-discharge-warm-up-time`

The time between power-up of the sensor and the first measurement. The water level sensor re-quires 60 s before valid measurements are returned. Thus, for the switched power supply mode the warm-up time has to be at least 60 seconds.

The figure below illustrates the measurement sequence of the RQ-30 including the warm-up time of the level sensor.

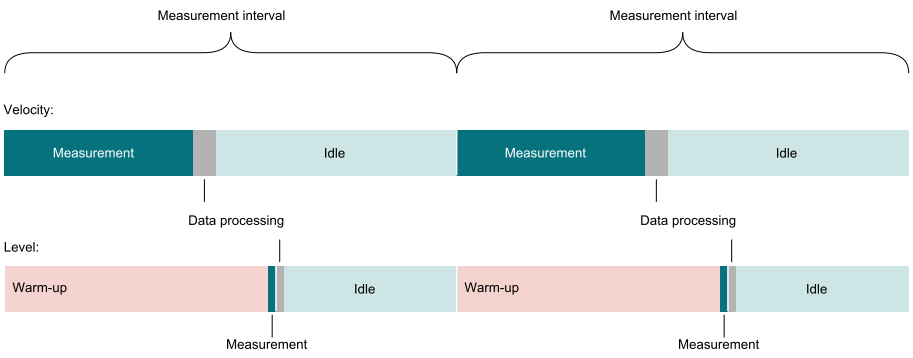


Figure 27 Measurement sequence of the RQ-30.

Value range	Default	Units
0...255	60	Seconds

I-J Tech. velocity (v)

This submenu contains the technical parameters for the velocity measurement.

I-J-A Minimum velocity

`rq-discharge-minimum-velocity`

The minimum velocity defines the lower limit for the velocity determination by spectral analysis.

Value range	Default	Units
0...1.5	0.08	m/s

I-J-B Maximum velocity

`rq-discharge-maximum-velocity`

The maximum velocity defines the upper limit of expected velocities. The velocity measurement is optimized for this setting. Usually a value of 5000 mm/s (5 m/s) is adequate. No extra margin has to be accounted for as this is included in the RQ-30 sensor by default.

Value range	Default	Units
0...15	5	m/s

I-J-C Meas. spot optimization

`rq-discharge-meas-spot-optimization`

Inactive if parameter Channel type Channel type is set to covered.

This parameter describes the expected flow velocity distribution within the measurement spot as illustrated in Figure 28. For a more heterogeneous flow distribution a wider spectral band width has to be selected. The options are as follows:

ID	Option	Description
1	very constant veloc.	homogenous water surface, small bandwidth
2	standard (default)	heterogeneous water surface, wide bandwidth
3	bank area	heterogeneous water surface with very different velocities, very wide bandwidth
4	splash water	Splashing water surface, full bandwidth

For the initial measurements at a new site the option *standard* is recommended. Later on the measurement may be improved by selecting another optimization option.

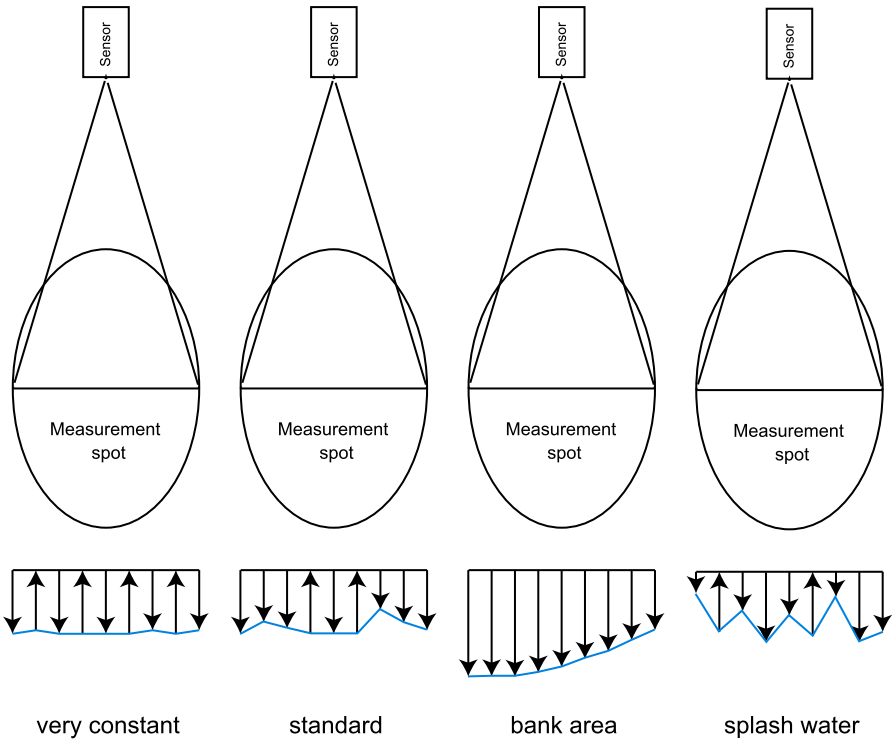


Figure 28 Measurement spot optimization concepts

I-J-D Measurement type

`rq-discharge-measurement-type`

The flow velocity can be measured by two different methods:

ID	Option	Description
1	continuous (default)	The measurement is performed in one piece.
2	sequenced	The measurement is split into five parts.

Continuous measurement type

The flow velocity measurement is performed continuously in one piece. This has the advantage of a fast measurement with little energy consumption. However, for highly fluctuating velocities the measurement time has to be increased considerably to gain accurate results.

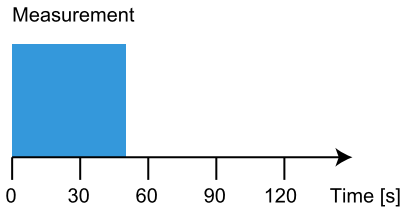


Figure 29 Continuous measurement type

Sequenced measurement type

The flow velocity measurement is divided into five sub-intervals of random length summing up to the specified measurement duration. This increases the complete measurement duration without increasing energy consumption. Thus, this method provides more accurate results for highly fluctuating velocities.

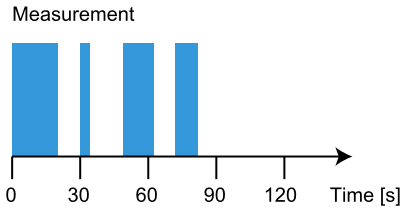


Figure 30 Sequenced measurement type

I-J-E Stop, min. quality (SNR)

`rq-discharge-stop-min-quality`

This parameter defines the lower limit of the quality value, expressed by SNR. Flow velocities below this quality value are identified as invalid. Invalid measurements are handled according to the behavior set in Stop, behavior.

A measurement with a low SNR occurs if the velocity is below the detection limit. It is recommended to set this parameter at measurement sites with tidal influence or with back-water and where the velocity can drop to zero.

Value range	Default	Units
7...100	30	-

I-J-F Stop, max. opp. direction

`rq-discharge-stop-max-opp-direction`

The opposite direction content is the fraction of counter-flow in measurement direction. The parameter defines an upper limit for counter-flow, above which measurements are identified as invalid. Invalid measurements are handled according to the behavior set in Stop, behavior.

Value range	Default	Units
10...1000	200	%

I-J-G Stop, number of valid meas.

`rq-discharge-stop-number-valid-meas`

After an invalid measurement has occurred the selected number of valid measurements has to be returned before the measurements are tagged as valid again.

Value range	Default	Units
1...20	3	-

I-J-H Stop, behavior

`rq-discharge-stop-behaviour`

This parameter defines the handling of invalid measurements. The following options can be set:

ID	Option	Description
1	hold value	The last valid value is returned.
2	use replace value (default)	The replacement value set in Stop, replace value is returned.
3	use learn value	The learned value according to the water level of the W-v relation is returned.

I-J-I Stop, replace value

`rq-discharge-stop-replace-value`

An invalid measurement is replaced by this value if option 2 in Stop, behavior is selected.

Value range	Default	Units
-9.999...9.999	0	m/s

I-J-J Stop velocity at WLL

`rq-discharge-stop-velocity-wll`

If the water level during installation is between the low level border WLL and the flow stop level WCF), the flow velocity can be set with this parameter in order to instantly record discharge values. As soon as the water level is above the low level border WLL this parameter is not relevant any more.

Value range	Default	Units
-9.999...9.999	0	m/s

I-J-K Velocity output

`rq-discharge-velocity-output`

The type of velocity returned by the sensor.

ID	Option	Description
1	surface velocity (default)	The velocity is returned as local surface velocity v_l.
2	mean profile veloc.	The velocity is returned as mean velocity v_m ($v_m = k\,(W) \cdot v_l$).

I-J-L Meas. spot weighting

`rq-discharge-meas-spot-weighting`

Weighting factor used to adjust the flow velocity measurement to specific wave characteristics. For most applications the default of zero is applicable. Positive values reduce the flow velocity, negative values increase the velocity. For a river with a rough water surface, a value of 17 may be applied.

Value range	Default	Units
-100...100	0	-

I-K 4-20 mA outputs

I-K-A Status

`generic-analog-out-status`

The status defines the behavior of the analog outputs.

ID	Option	Description
1	off (default)	Analog outputs are inactive.
2	just during TRIG	Analog outputs are only active, if an external signal is present at the TRIG input. The outputs are high as long as the signal at the TRIG input is high.
3	always on	Analog outputs are permanently active.

I-K-B IOUT1, AUX 4 mA value

`rq-analog-out-iout1-aux-4ma-value`

This value of the measured quantity that corresponds to the 4 mA output.

Value range	Default	Units
-99999.99...999999.99	-20	Unit of auxiliary sensor quantity

I-K-C IOUT1, AUX 4-20 mA span

`rq-analog-out-iout1-aux-span`

The output range of the 4-20 mA signal for the measured quantity.

Value range	Default	Units
-99999.99...999999.99	100	Unit of auxiliary sensor quantity

I-K-D IOUT2, level 4-20 mA span

`rq-analog-out-iout2-level-span`

The output range of the 4-20 mA signal for the water level. The span should cover the complete water level range that is expected.

Value range	Default	Units
-9999999...99999999	35	Unit of water level

EXAMPLE

Minimum expected water level: 120 mm

Maximum expected water level: 1450 mm

Water level span: 1330 mm

IOUT2, level 4-20 mA span: 1600 (a change of 100 mm corresponds to a change of 1 mA)

IOUT2, level 4 mA value: 0

In some cases it may be required to report the distance to the water surface instead of the water level. This can be achieved with the following settings:

IOUT2, level 4-20 mA span: -1600 mm

IOUT2, level 4 mA value: 1600 mm

I-K-E IOUT2, level 4 mA value

`rq-analog-out-iout2-level-4ma-value`

This minimum water level that corresponds to the 4 mA current output. The value should be below the lowest expected water level and should be easily interpretable.

Value range	Default	Units
-99999.99...999999.99	0	Unit of water level

I-K-F IOUT3, Max. velocity

`rq-analog-out-iout3-max-velocity`

The maximum velocity that corresponds to the 20 mA current output. The 4 mA output is predefined to correspond to a velocity of 0.

Value range	Default	Units
-99999.99...999999.99	10	Unit of velocity

I-K-G IOUT4, max. discharge

`rq-analog-out-iout4-max-discharge`

This maximum discharge that corresponds to the 20 mA current output. The 4 mA output is predefined to correspond to a discharge of 0.

Value range	Default	Units
-99999.99...999999.99	100	Unit of discharge

I-K-H Simulate current output

`generic-analog-out-simulate-current`

With this function the analog outputs can be simulated. Upon submission of a current value between 4 and 20 mA the corresponding values of the selected variable are displayed. The selected current is also applied to the analog outputs and can be read with a connected data logger or multimeter. By pressing Return/Enter again the simulation stops.

NOTE

If Status is deactivated, no current output can be simulated.

If Status is set to just during TRIG, the trigger must be set prior to simulation. Additionally, the trigger must be reset before each simulation.

I-L RS-485 Protocol

I-L-A Device number

`generic-rs-485-protocol-device-number`

The device number is used for the unique identification of the device in a bus system.

Value range	Default	Units
0...98	1 (default)	-

I-L-B System key

`generic-rs-485-protocol-system-key`

The system key defines the bus system of the device. Thus, different conceptual bus systems can be separated. Interfering bus systems occur if the remote radio coverage of two measurement systems overlap. In general, the system key should be set to 00.

Value range	Default	Units
0...99	0	-

I-L-C Output protocol (OP)

`generic-rs-485-protocol-output-protocol`

The type of the serial output protocol. The following options are available:

ID	Option	Description
1	Sommer (default)	Sommer protocol; data values are returned with an index starting at 1
2	Standard	Standard protocol; data values are returned without an index
3	MODBUS	Modbus protocol

NOTE For MODBUS applications run MODBUS, set default to get the appropriate communication settings.

I-L-D OP, measurement output

`generic-rs-485-protocol-measurement-output`

Specifies the timing of the serial data output.

ID	Option	Description
1	just per command	The output is only requested by commands via the RS-485 or SDI-12 interface.
2	after measurement (default)	The serial data output is performed automatically right after each measurement.
3	pos. TRIG slope	The output is triggered by a positive edge of a control signal applied to the trigger input.

I-L-E OP, information

`generic-rs-485-protocol-information`

The main measurement values are always included in the data output string. Additionally, special and analysis values can be included.

ID	Option	Description
1	main values	Only the main values are returned.
2	& special values (default)	Main values and special values are returned.
3	& analysis values	Main, special and analysis values are returned.

I-L-F OP, wake-up sequence

`generic-rs-485-protocol-wake-up-sequence`

Serial data can be transmitted to a recording device automatically without a request. However, many devices demand a wake-up sequence before they can receive and process data. The RQ-30 has the option to send a sync sequence and a prefix before data are transmitted (see Waking-up a connected data logger). The following options are available:

ID	Option	Description
1	off	No wake-up sequence
2	sync	The sync sequence UU~?~? is sent before the output string.
3	prefix (default)	A blank with a time delay is sent before the output string.
4	prefix & sync	A blank with a time delay and the sync sequence UU~?~? is sent before the output string.

I-L-G OP, prefix holdback

`generic-rs-485-protocol-prefix-holdback`

The hold-back time defines the time delay between the prefix and the data string.

Value range	Default	Units
0...5'000	300	ms

I-L-H MODBUS, set default

`generic-rs-485-protocol-modbus-set-default`

Only available in terminal mode. The Modbus protocol demands a defined setting, including multiple parameters. This command sets all these parameters automatically (see Modbus).

I-L-I MODBUS, device address

`generic-rs-485-protocol-modbus-device-address`

Unique device address for the Modbus protocol.

Value range	Default	Units
1...247	35	-

I-M RS-485 Port

I-M-A Baud rate

`generic-rs-485-port-baud-rate`

The following transmission rates in bps (baud) can be selected:

ID	Option	Description
1	1'200	-
2	2'400	-
3	4'800	-
4	9'600 (default)	-
5	19'200	-
6	38'400	-
7	57'600	-
8	115'200	-

I-M-B Parity, stop bits

`generic-rs-485-port-parity-stop-bits`

The following combinations of parity and stop bits can be selected:

ID	Option	Description
1	no par, 1 stop (default)	No parity and 1 stop bit
2	no par, 2 stop	No parity and 2 stop bits
3	even par, 1 stop	Even parity and 1 stop bit
4	odd par, 1 stop	Odd parity and 1 stop bit

I-M-C Minimum response time

`generic-rs-485-port-minimum-response-time`

Setting of this parameter avoids interference of communication at the RS-485 interface. For this purpose the response to a command is delayed by the selected time. Additionally, the response is kept compact.

Value range	Default	Units
0...2'000	0	ms

I-M-D Transmitter warm-up time

`generic-rs-485-port-transmitter-warm-up-time`

The transmitter warm-up time defines the time before data is sent.

Value range	Default	Units
0...2'000	10	ms

I-M-E Flow control

`generic-rs-485-port-flow-control`

The XOFF-XON flow control can be activated with this setting.

ID	Option	Description
1	Off	no flow control
2	XOFF-XON blocking (default)	XOFF-XON flow control, especially adapted for half-duplex systems

ATTENTION To use spectrum mode (View spectral distribution) set Flow control to *XOFF-XON blocking*. This enables a return to normal mode at any time.

I-M-F Sending window

`generic-rs-485-port-sending-window`

If XON-XOFF flow control is activated data are transmitted in blocks with the defined length.

Value range	Default	Units
200...5'000	300	ms

I-M-G Receiving window

`generic-rs-485-port-receiving-window`

If XON-XOFF flow control is activated transmission of blocks is delayed by the specified time.

Value range	Default	Units
200...5'000	300	ms

I-N Units and decimals

I-N-A AUX unit

`generic-units-aux`

The unit of the quantity measured on the auxiliary input. Default is °C.

I-N-B AUX decimals

`generic-decimals-aux`

The number of decimal places of the quantity measured on the auxiliary input.

Value range	Default	Units
0...6	0	-

I-N-C Level, unit

`generic-units-level`

The following units of the level/distance can be selected:

ID	Option	Description
1	mm (default)	Millimeter
2	cm	Centimeter
3	m	Meter
4	in	Inch
5	ft	Feet
6	yd	Yard

I-N-D Level, decimals

`generic-decimals-level`

The number of decimal places for the measured level/distance.

Value range	Default	Units
0...6	0	-

I-N-E Velocity, unit

`generic-units-velocity`

The following units of the flow velocity can be selected:

ID	Option	Description
1	mm/s	Millimeter per second
2	m/s (default)	Meter per second
3	km/h	Kilometer per hour
4	ft/s	Feet per second
5	in/s	Inch per second
6	mph	Miles per hour
7	kn	Knots

I-N-F Velocity decimals

`generic-decimals-velocity`

The number of decimal places for the measured velocity.

Value range	Default	Units
0…6	2	-

I-N-G Discharge (Q), unit

`generic-units-discharge`

The following units of the water discharge can be selected:

ID	Option	Description
1	l/s	Liter per second
2	m^3/s (default)	Cubic meter per second
3	ft^3/s	Cubic feet per second
4	ac-ft/h	Acre-feet per hour
5	us. gal/s	US gallons per second
6	en. gal/s	English gallons per second
7	Ml/d	Megaliter per day
8	m^3/h	Cubic meter per hour

ATTENTION When the discharge unit is changed the internal discharge volume counter is reset to 0!

I-N-H Discharge (Q) decimals

`generic-decimals-discharge`

This parameter sets the number of decimal places for the water discharge.

Value range	Default	Units
0...6	0	-

I-N-I Total discharge volume unit*

`generic-units-total-discharge`

The following units of the total water discharge can be selected:

ID	Option	Description
1	l	Liter
2	m^3 (default)	Cubic meter
3	ft	Cubic feet

ID	Option	Description
4	ac-ft	Acre-feet
5	us. gal	US gallons
6	en. gal	English gallons
7	Ml	Megaliter

I-N-J Total discharge volume decimal

`generic-decimals-total-discharge`

This parameter sets the number of decimal places for the total water discharge.

Value range	Default	Units
0...6	0	-

I-N-K Simulation, discharge volume

`rq-discharge-simulation-SQ`

With this function a user defined discharge volume can be simulated. This simulation is based on the settings in menus Measurement trigger and Units and decimals.

EXAMPLE

The following RQ-30 settings are assumed:

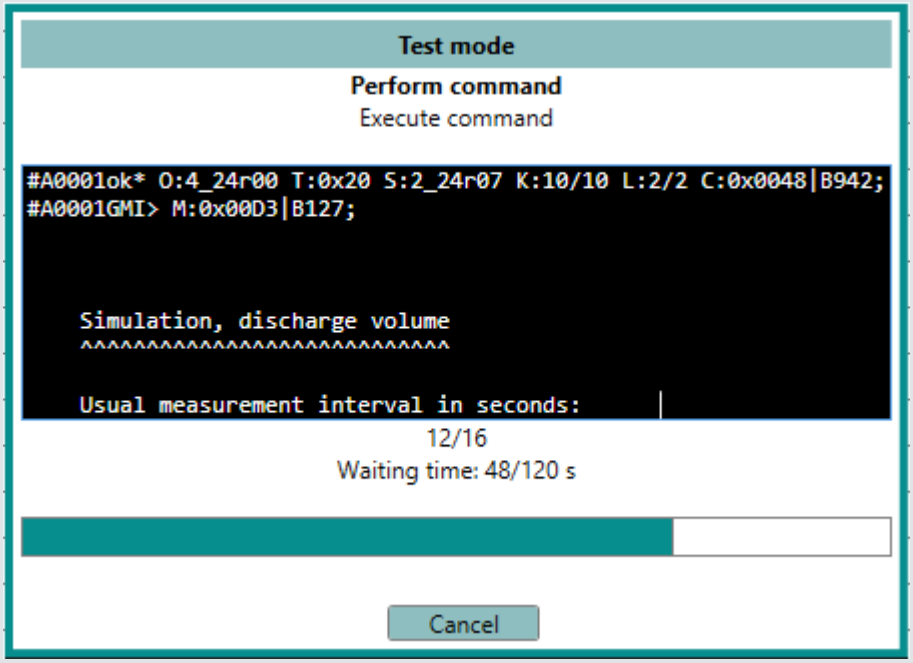
Discharge (Q), unit l/s

Discharge (Q) decimals 1

Total discharge volume unit* m^3

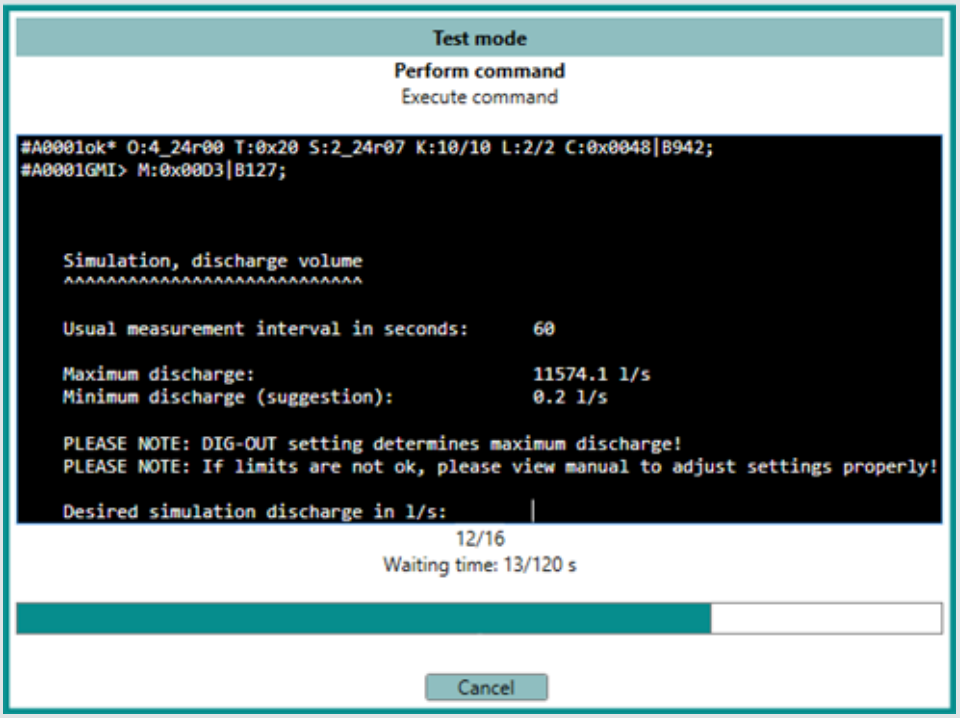
Total discharge volume decimal 1

After pressing the button in SQ-Commander a window will pop up:



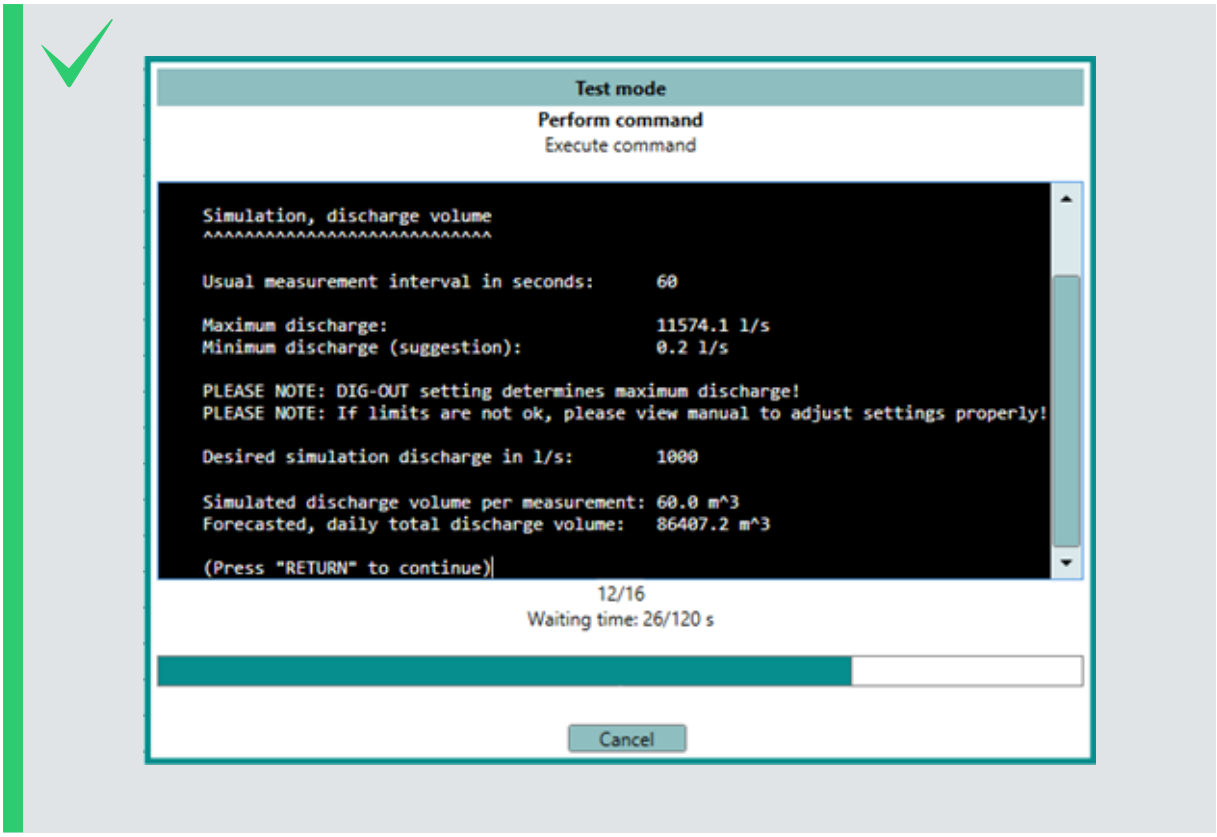
This dialog will only be displayed if the measurement trigger is set to *SDI 12/RS485*! If the measurement trigger is set to *interval* the defined measurement interval will be adopted.

Enter the interval by which measurements are triggered externally (usually a data logger) and confirm with Enter. Maximum and minimum discharge rates are calculated:



Notice: Simulated minimum and maximum discharges are dependent on the settings in Units and decimals. Furthermore, the RQ-30 sensor provides 8 characters to display the total daily discharge. Thus, in the current example a maximum daily discharge of *999'999.9 m3* can be displayed before data overflow occurs. This corresponds to a maximum discharge rate of 11'574.1 l/s.

Enter the discharge rate you want to simulate, e.g. *1'000 l/s*, and press Enter. The result lists the simulated discharge volume per measurement and a forecasted, daily discharge volume:



I-N-L Area (A), unit

`generic-units-area`

The following units of the cross-Sectional area can be selected:

ID	Option	Description
1	dm^2	Square decimeter
2	m^2 (default)	Square meter
3	ft^2	Square feet
4	yd^2	Square yard

I-N-M Area (A) decimals

`generic-decimals-area`

This parameter sets the number of decimal places for the cross-Sectional area.

Value range	Default	Units
0...6	2	-

J Special functions

J-A View spectral distribution

`generic-special-functions-view-spectral-distribution`

With this command the sensor is set into spectral mode. After 30 minutes the spectral mode is switched off automatically.

With the SQ-Commander software the spectra can be recorded, visualized and stored for expert analysis of the sensor signal, e.g. additional reflections.

J-B Veloc. radar inspection

`rq-discharge-veloc-radar-inspection`

Diagnostic tool for in-depth device analysis. Inactive, for in-house use only.

J-C Continuous meas. mode (temp).

`generic-special-functions-continuous-meas-mode`

Inactive in the SQ-Commander menu. This feature can be triggered under the Measurement (F3) tab with the command Start polling measurements. When active, measurements are performed continuously, ignoring the specified measurement interval.

J-D View spectral trap

`rq-discharge-view-spectral-trap`

For expert use only! Inactive in the SQ-Commander menu.

The integrated velocity radar sensor has the option to save the spectra of special events. This command returns these spectra. One output contains four spectra.

Index	Option	Description
1	Stop	Spectrum of the last invalid measurement caused by a Stop event.
2	Reference	Spectrum of the measurement performed before the last event.
3	Trap	Spectrum of the measurement of the last event with the velocity increase according to menu item Spectral trap, veloc. rise.
4	Normal	Actual spectrum

J-E Set total discharge volume

`rq-discharge-set-total-volume`

With this function the total discharge volume can be set to a defined value, e.g. a reset to zero.

J-F View setup

`generic-special-functions-view-setup`

All parameters of the RQ-30 are listed in the terminal window.

J-G Device status

`generic-special-functions-device-status`

Displays information about the sensor and the software version.

J-H W-v table view

`rq-discharge-w-v-table-view`

The learned W-v table is listed in the terminal window. Only available in terminal mode.

J-I W-v table reset

`rq-discharge-w-v-table-reset`

The learned W-v table is completely deleted and re-initiated.

J-J Set factory default

`generic-special-functions-set-factory-default`

All parameters are reset to factory defaults. Only available in terminal-mode.

J-K Temp. load factory default

`generic-special-functions-temp-load-factory-default`

Loads factory default values temporarily. Only available in terminal mode.

J-L Relaunch program

`generic-special-functions-relaunch-program`

The device is restarted. Powering the sensor off and on again is equivalent.

J-M Replace program

`generic-special-functions-replace-program`

The sensor is set into a "Boot Loader" mode for three minutes to upload new software.

Appendix A Troubleshooting

A.1 Devices

A.1.1 The RQ-30 is not responding

Reason	Solution
The power supply is not connected or turned off.	Check if the power supply is connected and on.
The polarity of connected power supply wires is wrong.	Check the polarity of connected wires.
Wrong sensor cable.	Use the original sensor cable configured by Sommer Messtechnik (only applicable to Sommer Messtechnik cables).

Reason	Solution
Power supply is insufficient. The RQ-30 requires a certain inrush-current that the power supply is not able to provide.	1. Use a power supply providing >0.5 A at 12 VDC or a fully charged battery. 2. In case of long sensor cables (>50 m) use a 24-VDC power supply. **NOTE** Please note that power supplied by the USB-port is insufficient to power the RQ-30!
The power supply voltage is out of range.	Adjust the power supply to match the specified voltage range.
The port settings of the RQ-30 and the data acquisition system do not match.	Use the SQ-CommanderCommunication assistant or adapt port settings on your device. **NOTE** Sommer Messtechnik devices require the following Baud rates: ● Sensor: 9600 ● Data logger: 115200 ● Modbus: 19200 In case of doubt use the function Check port in the Communication assistant.
The COM-port has not assigned correctly to the USB converter.	1. Make sure to use a Sommer Messtechnik USB converter. Third party converters are not supported. 2. Check the COM-port number using Windows Device Manager. 3. Plug in the USB converter first, then start SQ-Commander.
A sensor wire is not connected firmly to the terminal of the data acquisition device.	Check the firm connection of the sensor wires.
A pin of the connector plug is bent or broken.	Verify that all connector pins are straight.

A.1.2 The RQ-30 reboots repeatedly

Reason	Solution
The power supply has not enough current to start the RQ-30.	Verify that the power supply provides enough current. A RQ-30 consumes up to 140 mA @ 12 V. If required, power the RQ-30 by an additional or alternative supply.

A.2 Measurement data

A.2.1 Measurement data are not updated

The device is connected to the SQ-Commander, but the data are not updated.

Cause	Solution
Data traffic conflict	Reboot the device by interrupting the power supply.

A.2.2 The RQ-30 returns no or zero velocity

Reason	Solution
Water level has not been adjusted.	Perform a water level adjustment.
WLL, low level border is too high.	Verify correct setting of WLL, low level border.
RQ-30 position and/or sensor settings do not match water flow conditions.	1. Check settings in menu Velocity. 2. Check value of *Quality (SNR)* returned by the RQ-30. 3. Check value of *Opposite direction* returned by the RQ-30. Increase Stop, max. opp. direction. 4. Increase or decrease the vertical mounting position of the RQ-30. 5. Reverse the viewing direction of the RQ-30 and adapt the setting Viewing direction.

Reason	Solution
Waves on water surface are insufficient	1. Create surface waves using a chain, rope or other means upstream of the measurement spot. 2. If waves on the water surface look sufficient, toggle Channel type to open or vice versa. 3. Increase Measurement duration up to 60 s.

1.2.3 The RQ-30 returns the wrong water level

Reason	Solution
Water level is not adjusted properly.	Perform a water level adjustment. **NOTE** The water level is the vertical distance between the deepest point of canal/river and the water surface.
The RQ-30 is installed improperly and/or water level settings are inappropriate.	1. Verify that the RQ-30 is mounted within its measurement range (see Specifications). 2. Verify that the RQ-30 is installed parallel to the water surface. 3. Make sure that no obstacles extend into the measurement beam. 4. Deactivate the moving data filter (Filter, no. of values). 5. Perform a level test and verify the correct reading. 6. Switch Supply to *always on*. 7. Verify units and decimals of water level.

A.2.4 The RQ-30 continuously returns the same water level

Reason	Solution
Supply in setup menu Tech. level (W) is set to *always on*.	Change setting to *switched*. If set to *always on*, the level sensor of the RQ-30 does not receive the measurement trigger.
The water level is outside the measurement range of the RQ-30.	Check the water level with the function Test in setup menu Level (W). Check the values of WCF, cease to flow level and WMA, maximum level. If these levels are different from *0*, the measured water level must be within the range of these two settings. Otherwise, the RQ-30 returns the hold value.

1.2.5 The RQ-30 returns no water discharge

Reason	Solution
The RQ-30 does not have the correct cross-sectional profile available.	1. Verify that the measured water level is within the range covered by the cross sectional profile. 2. Upload the cross-sectional profile again.
Water level has not been adjusted.	Perform a water level adjustment.
WLL, low level border is set too high.	Verify that WLL, low level border is correct.
The RQ-30 does not detect the flow velocity.	1. Verify that the flow velocity reading is correct. 2. Check Velocity settings. 3. Check Quality (SNR) returned by the RQ-30. 4. Check Opposite direction and increase Stop, max. opp. direction.
Units and decimals of water discharge are inappropriate	Verify that units and decimals of water discharge are suitable.

1.2.6 Velocity/level data show spikes

Reason	Solution
Water surface is rough.	1. Verify if spikes are plausible. If a single spike extends over multiple measurements, the observed shift may be real. 2. Apply a moving data filter (see Velocity and Level (W)). 3. Switch Supply to *always on*. 4. Increase Measurement duration up to 60 s.

A.3 Firmware & software

A.3.1 Commander loads wrong setup

If the setup is reloaded from the device the SQ-Commander seems to display an old version.

Cause	Solution
The device has been connected to the same PC before and several different setup files have been loaded.	Delete the setup files of the device that have been downloaded by SQ-Commander to the folder *C:\Users\Public\Documents\Sommer\Setup*. The respective files can be identified by the serial number in the file name and the file date.

A.3.2 Firmware update via RS-485 is aborted

Reason	Solution
USB to RS-485 converter cable is damaged or can only operate on 9600 baud.	Replace USB to RS-485 converter cable. The programmer requires 57600 baud.

A.4 SDI-12

A.4.1 The RQ-30 is not detected by a SDI-12 master device

Reason	Solution
The RQ-30 and the SDI-12 master have different grounds.	Verify that the RQ-30 and the SDI-12 master are connected by a ground (GND) wire.

A.5 Analog output

A.5.1 The 4-20 mA output is wrong

Reason	Solution
Analog output settings incorrect.	1. Check analog output settings. 2. Run Simulate current output and verify correct output.
Sensor and data acquisition system have different grounds.	Verify that sensor and data acquisition system have the same ground.
The 4-20 mA output is delayed by approx. 150 ms. If the output is read before, a wrong value is acquired.	Sample the 4-20 mA output with a delay of more than 150 ms.

Appendix B Unwanted reflections

B.1 Open channel

Depending on the dimensions of the water channel in which the RQ-30 sensor is installed in, unwanted reflections may occur and distort the velocity spectrum. Such reflections can be detected by looking at a recorded velocity spectrum as shown in the following example:

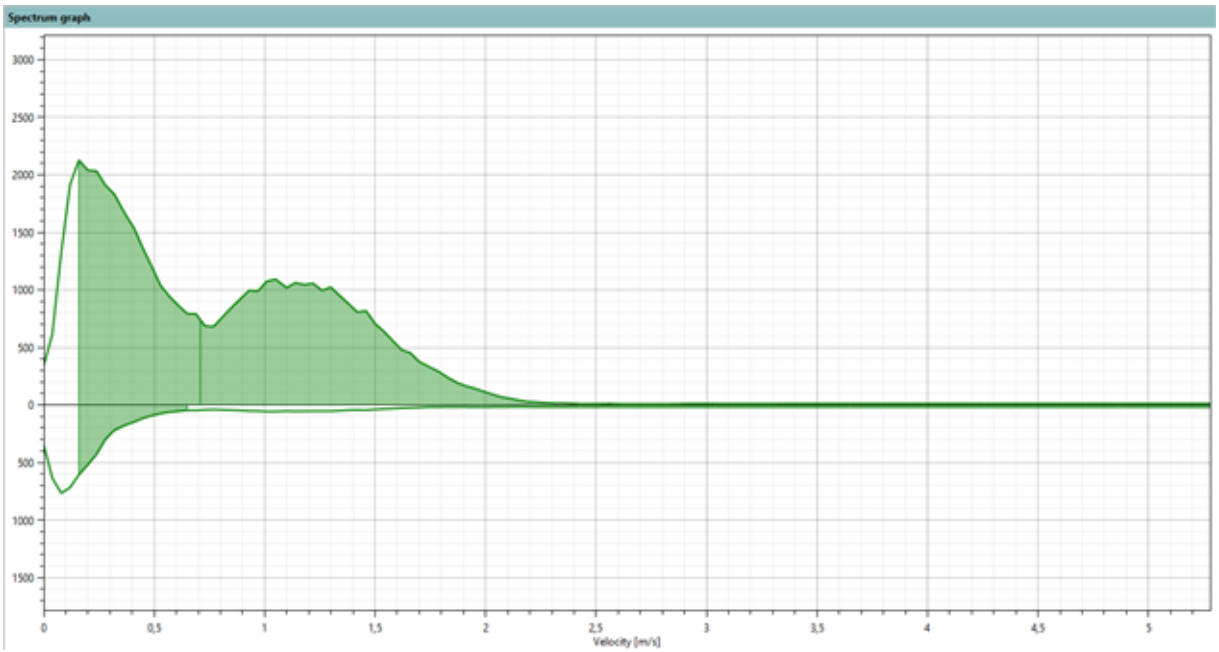


Figure 1 Velocity spectrum containing unwanted reflections

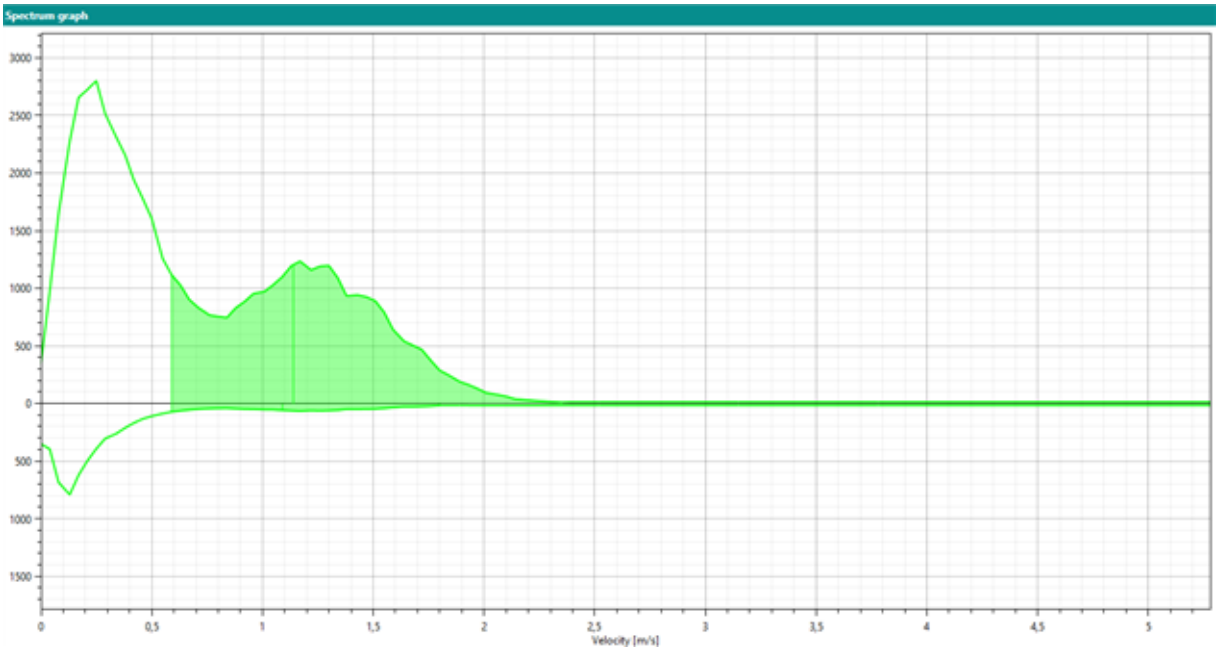


Figure 2 Velocity spectrum with adjusted minimum velocity

In the spectrum of Figure 1 two peaks can be observed: The first at approximately 0.15 m/s and the second at approx. 1.2 m/s. The shaded area is considered by the implemented algorithm to calculate the flow velocity. In this example the sensor determined a velocity of 0.71 m/s.

A second, independent measurement at the site revealed a flow velocity of 1.1 … 1.2 m/s. The discrepancy between these two results can be attributed to reflections on the channel wall, which caused a secondary peak in the spectrum at 0.15 m/s.

This means the first peak in the spectrum (at 0.15 m/s) is caused by an unwanted reflection in the channel where the RQ-30 is installed. The result is that the algorithm implemented in the RQ-30 is not able to determine the correct velocity. Due to the low velocity of the first peak the determined (and output-ted) velocity is lower than the real velocity:

To suppress this undesired behavior the setting Minimum velocity has to be set to a velocity higher than that of the first peak. Appendix B shows the result of this procedure: The first peak is not shaded anymore, meaning it is not considered for the velocity calculation. Only the second peak is used by the algorithm and the calculated flow velocity of 1.15 m/s is in agreement with the velocity of the comparison measurement.

B.2 Closed channel

The example described above is valid for open channels only. If the RQ-30 sensor is applied in a closed channel and the configuration Channel type is set to closed the first peak in the velocity spectrum is

ignored. This peak results from reflections at the channel wall is removed before the velocity calculation.

Appendix C CRC-16 array

CRC-16 array

```
crc16tab[] =
{
0x0000, 0x1021, 0x2042, 0x3063, 0x4084, 0x50A5, 0x60C6, 0x70E7,
0x8108, 0x9129, 0xA14A, 0xB16B, 0xC18C, 0xD1AD, 0xE1CE, 0xF1EF,
0x1231, 0x0210, 0x3273, 0x2252, 0x52B5, 0x4294, 0x72F7, 0x62D6,
0x9339, 0x8318, 0xB37B, 0xA35A, 0xD3BD, 0xC39C, 0xF3FF, 0xE3DE,
0x2462, 0x3443, 0x0420, 0x1401, 0x64E6, 0x74C7, 0x44A4, 0x5485,
0xA56A, 0xB54B, 0x8528, 0x9509, 0xE5EE, 0xF5CF, 0xC5AC, 0xD58D,
0x3653, 0x2672, 0x1611, 0x0630, 0x76D7, 0x66F6, 0x5695, 0x46B4,
0xB75B, 0xA77A, 0x9719, 0x8738, 0xF7DF, 0xE7FE, 0xD79D, 0xC7BC,
0x48C4, 0x58E5, 0x6886, 0x78A7, 0x0840, 0x1861, 0x2802, 0x3823,
0xC9CC, 0xD9ED, 0xE98E, 0xF9AF, 0x8948, 0x9969, 0xA90A, 0xB92B,
0x5AF5, 0x4AD4, 0x7AB7, 0x6A96, 0x1A71, 0x0A50, 0x3A33, 0x2A12,
0xDBFD, 0xCBDC, 0xFBBF, 0xEB9E, 0x9B79, 0x8B58, 0xBB3B, 0xAB1A,
0x6CA6, 0x7C87, 0x4CE4, 0x5CC5, 0x2C22, 0x3C03, 0x0C60, 0x1C41,
0xEDAE, 0xFD8F, 0xCDEC, 0xDDCD, 0xAD2A, 0xBD0B, 0x8D68, 0x9D49,
0x7E97, 0x6EB6, 0x5ED5, 0x4EF4, 0x3E13, 0x2E32, 0x1E51, 0x0E70,
0xFF9F, 0xEFBE, 0xDFDD, 0xCFFC, 0xBF1B, 0xAF3A, 0x9F59, 0x8F78,
0x9188, 0x81A9, 0xB1CA, 0xA1EB, 0xD10C, 0xC12D, 0xF14E, 0xE16F,
0x1080, 0x00A1, 0x30C2, 0x20E3, 0x5004, 0x4025, 0x7046, 0x6067,
0x83B9, 0x9398, 0xA3FB, 0xB3DA, 0xC33D, 0xD31C, 0xE37F, 0xF35E,
0x02B1, 0x1290, 0x22F3, 0x32D2, 0x4235, 0x5214, 0x6277, 0x7256,
0xB5EA, 0xA5CB, 0x95A8, 0x8589, 0xF56E, 0xE54F, 0xD52C, 0xC50D,
0x34E2, 0x24C3, 0x14A0, 0x0481, 0x7466, 0x6447, 0x5424, 0x4405,
0xA7DB, 0xB7FA, 0x8799, 0x97B8, 0xE75F, 0xF77E, 0xC71D, 0xD73C,
0x26D3, 0x36F2, 0x0691, 0x16B0, 0x6657, 0x7676, 0x4615, 0x5634,
0xD94C, 0xC96D, 0xF90E, 0xE92F, 0x99C8, 0x89E9, 0xB98A, 0xA9AB,
0x5844, 0x4865, 0x7806, 0x6827, 0x18C0, 0x08E1, 0x3882, 0x28A3,
0xCB7D, 0xDB5C, 0xEB3F, 0xFB1E, 0x8BF9, 0x9BD8, 0xABBB, 0xBB9A,
0x4A75, 0x5A54, 0x6A37, 0x7A16, 0x0AF1, 0x1AD0, 0x2AB3, 0x3A92,
0xFD2E, 0xED0F, 0xDD6C, 0xCD4D, 0xBDAA, 0xAD8B, 0x9DE8, 0x8DC9,
0x7C26, 0x6C07, 0x5C64, 0x4C45, 0x3CA2, 0x2C83, 0x1CE0, 0x0CC1,
0xEF1F, 0xFF3E, 0xCF5D, 0xDF7C, 0xAF9B, 0xBFBA, 0x8FD9, 0x9FF8,
0x6E17, 0x7E36, 0x4E55, 0x5E74, 0x2E93, 0x3EB2, 0x0ED1, 0x1EF0
}
```

Glossary

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