RQ-30, RQ-30a

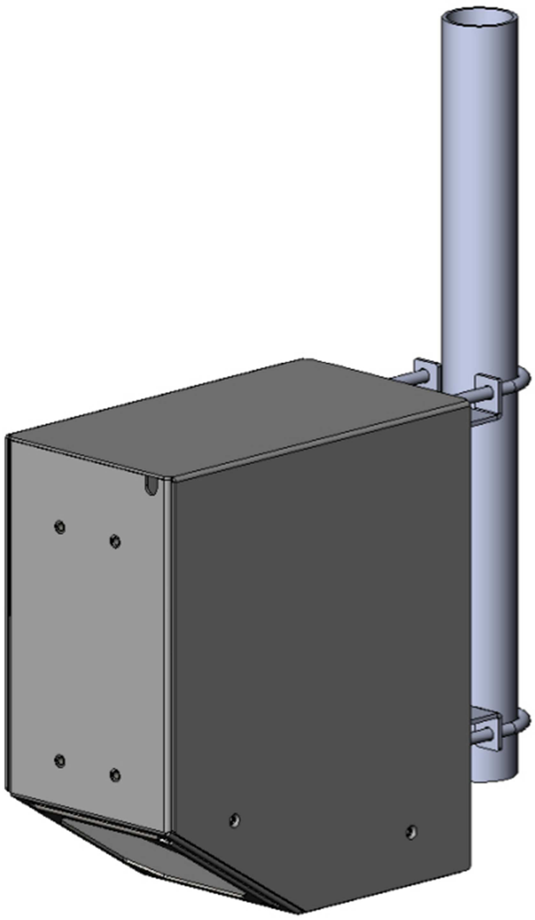
Firmware version 1.8x

Discharge Measurement System

User Manual

Manual version: V02

2014-07-29



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Validity

This manual applies to the discharge measurement systems RQ-30 and RQ-30a. The RQ-30a is an extended version with analog outputs. In this manual RQ-30 is generally used for both versions if not mentioned otherwise.

The manual is valid for the firmware version 1.7x with all its subversions.

The firmware version is listed in the menu "I Special functions" under the menu item "I-E Device status" or in the boot message.

CE compliance

This product is in conformity with the following standards

EMV	**EN 301 489 - 1 - 3; V 1.6.1**
Safety	**EN 60950 - 1**
Health	**EN 62311**
R&TTE	**EN 300 440 - 2; V 1.2.1**

following the provision of directive R&TTE 1999/5/EC.

Safety Information

Please read this entire manual before setting up or operating this equipment. The non-compliance of this manual could result in damage to the equipment. Also in the case of non-compliance injuries of individuals cannot be excluded totally.

To make sure that the protection provided of and by this equipment is not impaired, do not use or install this equipment in any manner other than that specified in this manual.

Contents

1. Introduction

The exact and real-time knowledge of the discharge is an important task in the fields of hydrography, water storage management, irrigation and prevention of natural hazards. It is the requirement to calculate water structures and for an economical management of water resources and is the base for simulations of hydrological processes with mathematical-physical models.

The RQ-30 radar sensor is a continuous measurement device for the contact-free determination of the discharge of open rivers and channels. It combines two contact-free radar methods in one system. On one hand the water level is measured by a transit time measurement of a radar signal. On the other hand the flow velocity at the surface is simultaneously determined by the principle of Doppler frequency shift. These two measurements are internally combined and provide the discharge using a predefined calibration of the measurement site.

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 a substantial uncertainty. Only the additional information of flow velocity allows the calculation of the discharge under these difficult conditions.

Due to the contact-free measurement methods the radar sensor usually can be installed on bridges or extension arms without expensive structural measures in the river or channel. The radar sensor is located outside the danger area of flood events and allows a low maintenance operation over many years.

2. Overview of the installation steps

The following overview lists the most important steps for a full installation of the RQ-30 radar sensor at a measurement site. The installation is divided in the calibration of the measurement site, the establishing of a connection to the radar sensor and the parameterization of the radar sensor.

Calibration of the measurement site

The result of the calibration of the measurement site is the discharge table. This table is the basis for the calculation of the discharge out of the water level and velocity measurement.

1. Selection of the measurement site (chapter 5.1)
2. Selection of the mounting position and direction of the radar sensor (chapter 5.2)
3. Collection of information of the measurement site (chapter 5.3.1)
    a. Determination or provision of the cross section profile
    b. Determination of the roughnesses in the cross section of the river
    c. Exact determination of the mounting position of the radar sensor
    d. Information about existing water level measurements (gauge plates…)
    e. Documentation of the measurement site with photographs
4. Selection of a reference system for the water level (chapter 5.3.2)
5. Calibration of the measurement site and provision of the discharge table (chapter 5.3.3)

Establishing of the connection to the radar sensor

1. Installation of the "RQCommander" or usage of a terminal program
2. Installation of the interface converter (chapters 6.1.1 and 10.5)
3. Connecting and supplying the radar sensor (chapter 3.5)
4. Setting of the connection parameters (chapter 6.1.2)
5. Establishing the connection (chapter 6.1.3)

Parameterization of the radar sensor

1. Setting of language, decimal character, units and decimal places (chapter 6.2)
2. Defining of the trigger for the measurements (chapter 6.3.1)
3. Setting and adjusting of the water level measurement (chapter 6.3.2)
4. Setting the parameters of the velocity measurement (chapter 6.3.3)
5. Transferring of the discharge table (chapter 6.4)
6. Defining and setting of the data output (chapters 7 and 7.4)
7. Connection of a data logger (chapters 7.2.8, 7.3.4 and 8.3)

3. Specifications

3.1. General

General	
Power supply	6…30 V; Reverse voltage protection, overvoltage protection
Consumption at 12 V	Standby approx. 1 mA Active measurement approx. 140 mA
Operating temperature	-35…60 °C (-31…140 °F)
Storage temperature	-40…60 °C (-40…140 °F)
Protection rating	IP 67
Lightning protection	Integrated protection against indirect lightnings with a discharge capacity of 0,6 kW Ppp

Table 1: General specifications

3.2. Velocity measurement

Velocity measurement	
Detectable measurement range	0.10…15 m/s (depending on the flow conditions)
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

Table 2: Specifications of the velocity measurement

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

Table 3: Specifications of the internal angle measurement

3.3. Water level measurement

Water level measurement	
Measurement range (from radar transmitter to water surface)	0…15 m (0…49.21 ft.) - standard version
	0…35 m (0…114.83 ft.) - extended measurement range (optional)
Resolution	1 mm
Accuracy	± 2 mm; ± 0.025 % FS (15 m)
Radar frequency	26 GHz (K-Band)
Radar opening angle	10 °

Table 4: Specifications of the water level measurement

3.4. Housing

The system housing is manufactured out of powder coated aluminum. The mounting from the RQ-30 is designed for a pipe diameter 34 – 48mm.

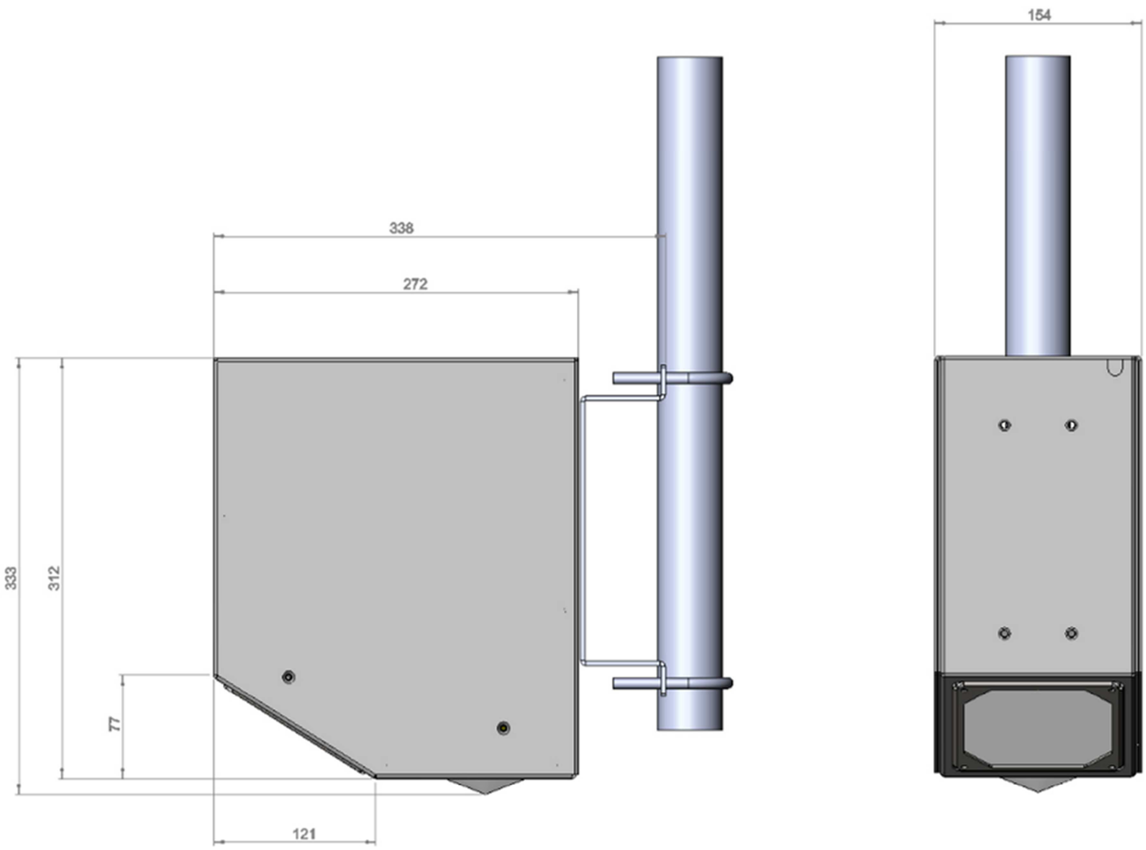


Figure 1: Dimensions of the housing in mm

3.5. Pin configurations

3.5.1. Connector MAIN

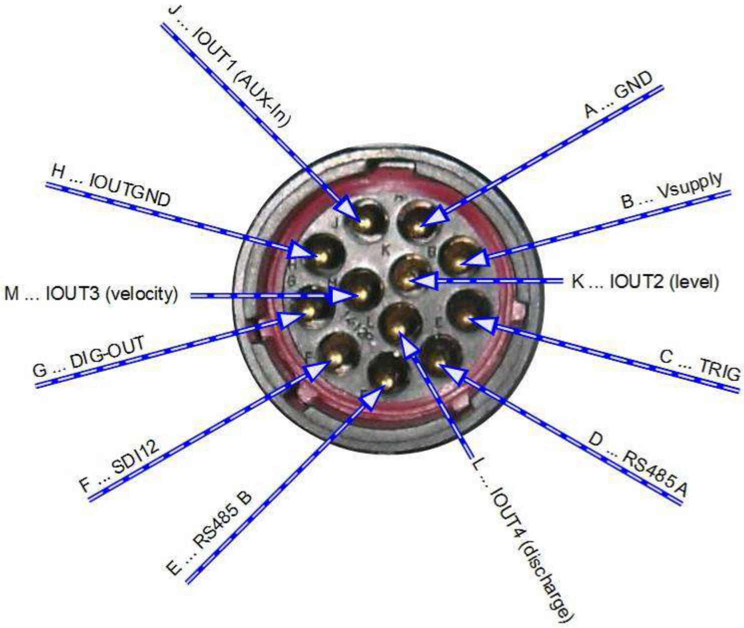


Figure 2: Pin configuration of the connector MAIN

MAIN (12 Pins)			
Power supply	A	GND	Ground
	B	Vsupply	+6…+30 V
Trigger input	C	TRIG	Low level: 0…0.6 V High level: 2…30 V
RS-485 interface	D	RS485 A[1]	1 x RS-485 (1200…115200 Baud)
	E	RS485 B[1]	
SDI-12 interface	F	SDI12	1 x SDI-12 (1200 Baud)
Digital switching output	G	DIG-OUT	Max. 1.5 A
Analog outputs (RQ-30a only)	H	IOUTGND	Ground for analog outputs
	J	IOUT1	Optional sensor at AUX
	K	IOUT2	Water level
	L	IOUT4	Discharge
	M	IOUT3	Velocity

Table 5: Configuration of the connector MAIN

⚠ Attention For the analog outputs the IOUT4 relates to pin L and IOUT3 to pin M.

[1] According to the TI notation and differs from the standard EIA notation

3.5.2. Connection wire for connector MAIN

Connection wire			
white	A	GND	Ground
brow	B	Vsupply	+6…+30 V
green	C	TRIG	Low level: 0…0.6 V High level: 2…30 V
yellow	D	RS485 A[2]	1 x RS-485 (1200…115200 Baud)
gray	E	RS485 B[2]	
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
violet	K	IOUT2	Water level
gray/pink	L	IOUT4	Discharge
blue/red	M	IOUT3	Velocity

Table 6: Configuration of the connection cable for the connector MAIN

3.5.3. Connector LEVEL

The female connector LEVEL connects the water level sensor with a 4 to 20 mA input. The connected sensor is supplied with 12 VDC.

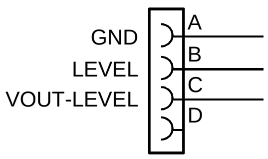


Figure 3: Configuration of the connector LEVEL

LEVEL			
Ground	A	GND	Ground
Input 4…20 mA	B	LEVEL	4…20 mA
Supply	C	VOUT-LEVEL	12 VDC
-	D	-	-

Table 7: Pin configuration of the connector LEVEL

[2] According to the TI notation and differs from the standard EIA notation

3.5.4. Connector AUX

At the male connector AUX an optional sensor can be connected to the RQ-30 (i.e. Temperature sensor). The input is for 0 to 2.5 V signals. The connected sensor can be supplied with the supply voltage of the RQ-30 minus 1 V.

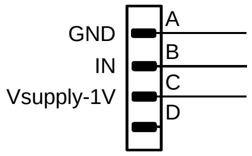


Figure 4: Configuration of the connector AUX

AUX			
Ground	A	GND	Ground
Input 0 to 2.5 V	B	IN	0…2.5 V
Supply	C	Vsupply - 1 V	Supply voltage of the RQ-30 minus 1V
-	D	-	-

Table 8: Pin configuration of the connector AUX

4. Principle of measurement

The RQ-30 radar sensor measures contact-free the water level and the flow velocity at the water surface and calculates the discharge.

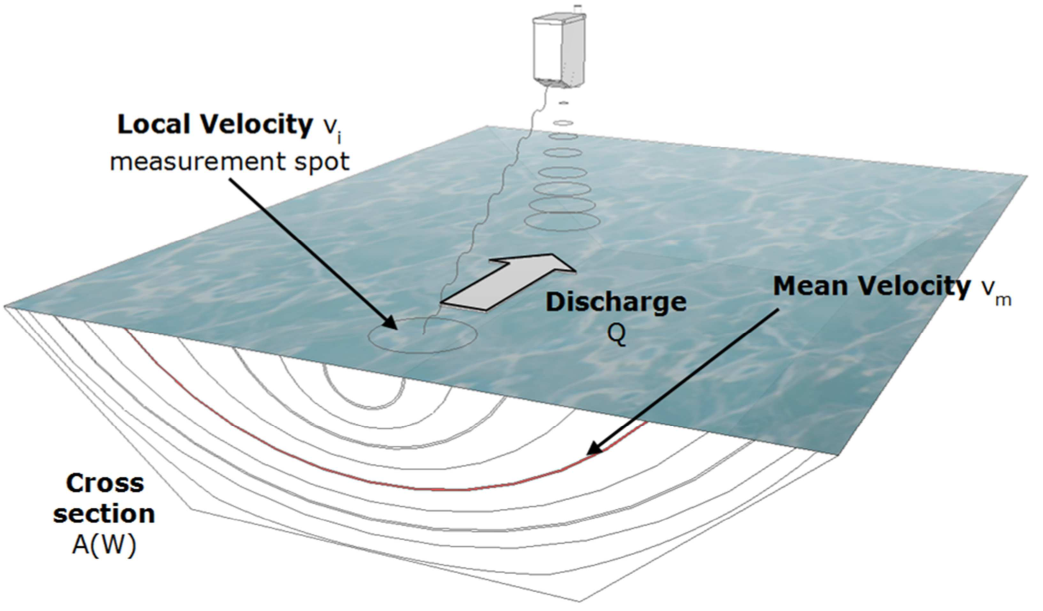


Figure 5: Principle of measurement of the RQ-30 radar sensor

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 relation datum, for example defined by gauge zero GZ.

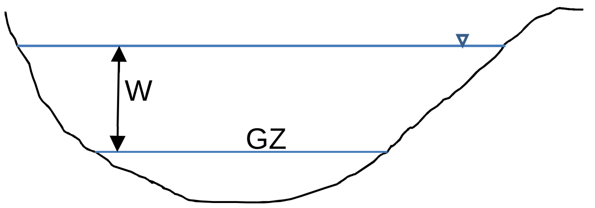


Figure 6: Water level W and gauge zero GZ

4.1.2. Principle of measurement

The water level is measured contact-free using the principle of transit time measurements of reflected signals. The radar sensor is installed above a river and transmits a short micro wave impulse in the direction of the water surface. This impulse is reflected at the water surface and is recorded by the same sensor now working as receiver. The time between transmitting and receiving the impulse is directly proportional to the distance from sensor to water surface.

4.2. Flow velocity

4.2.1. Principle of measurement

The contact-free measurement of the flow velocity is based on the principle if the Doppler effect. The radar sensor transmits a signal with a constant frequency in a specific angle to the water surface. There the signal is reflected and shifted in frequency due to the Doppler Effect by movements of the water surface. The reflected signal is received by the antenna of the radar sensor. By comparing the transmitted frequency to the frequency of the reflected signal from the water surface the local velocity can be determined.

4.2.2. Radar spectrum

The radar sensor has an opening angle of 12°. Therefore the signals of an area are measured. The size of the area depends on the inclination angle and the distance from the sensor to the reflecting water surface. The velocities appearing in this area have a specific distribution depending on the current conditions. The velocity distribution is determined with a digital signal processor via spectral analysis and the dominant velocity in the measurement area is calculated. Spectra can be output and used to evaluate measurements at measurement sites.

4.2.3. Direction separation

Movements can either appear in direction to or from the radar sensor. Depending on the direction a frequency shift to higher or lower frequencies occurs. This circumstance allows the radar sensor to separate the movements by their directions and to separately evaluate the corresponding velocity distributions.

4.2.4. Inclination angle measurement

As the radar sensor is directed in a specific angle to the water surface an angle correction has to be applied. The radar sensor internally measures its vertical inclination and uses this value for the automatically angle correction.

4.2.5. Conditions of the water surface

The water surface has to move observably and a minimum roughness has to be present to measure an interpretable Doppler frequency. The more rippled the water surface and the higher the flow velocity is the more reliable the measurement results are. The minimum ripple height for a valid analysis is about 3 mm depending on the used frequency. For very slow moving rivers this requirement must not be fulfilled and a continuous velocity measurement cannot be guaranteed.

4.3. Determination of the 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 or ft^3/s.

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

By using the continuity equation the equation can be transformed in the base equation of the discharge measurement.

$$Q = A \cdot v_m$$

A is the wetted cross sectional area and v_m is the mean flow velocity

The radar sensor measures the local velocity v_l at the water surface and not the mean velocity v_m. Therefore a dimensionless correction factor k has to be implemented to recalculate the local velocity into the mean velocity.

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

The k-factor depends on the flow conditions and consequently on the water level. Usually it is in the range of 60 to 90 %. In combination with the base equation the equation for the calculation of the discharge in the radar sensor is derived.

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

For the RQ-30 radar sensor a discharge table is generated out of the cross section areas A (W) and the k-factors k (W) in relation to the water level W. This table is deposited in the radar sensor and is the basis for the discharge calculation. It is essential that the water levels of the discharge table correspond to the same datum as the level measurement of the radar sensor "Level (W)".

4.3.2. k-Factors

The k-factors depend on the conditions of the measurement site and have to be determined individually for every measurement site.

The k-factors are determined by modeling with a numeric hydraulic model. The k-factors depend in common on the water level, the shape of the cross section, the roughness of the river and the position of the radar sensor. The advantage of modeling is the instant calculation of the discharge from the time of the installation and the covering of the complete water level range.

Modeling can for example be performed with the PC software "RQCommander Modelling" of Sommer GmbH. Additionally reference measurements can be used to verify existing k-factors from models and allow a manual correction.

4.3.3. Cross section area

The cross section area A (W) as a function of the water level is calculated from the cross section profile. Software for this procedure is for example the software "RQCommander Modelling" of Sommer GmbH.

4.3.4. Calculation

In the radar sensors the cross section area and the k-factors are deposited in a discharge table. This discharge table is the base for the discharge calculation using linear interpolation.

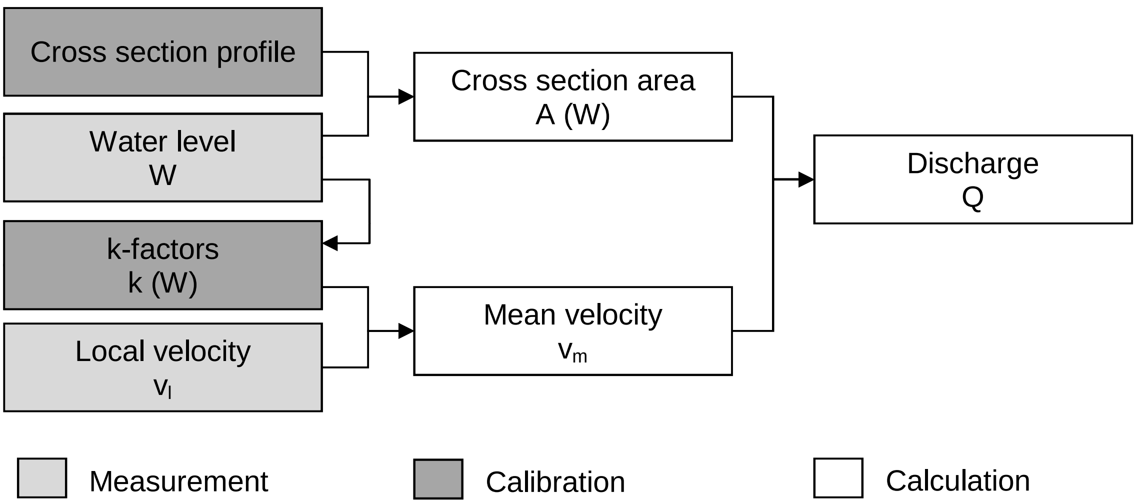


Figure 7: Calculation scheme for the discharge

5. Measurement site

5.1. Selection and evaluation

The selection of a suitable measurement site for the radar sensor is crucial for the reliability and the accuracy of the measurement results. Requirements related to the hydraulic situation and the mounting of the sensor have to be fulfilled.

5.1.1. Hydraulic requirements

Velocity distribution in the cross section

In general the velocity distribution at the measurement site must not be changed by time variable influences like fluctuating inflows and regulated weirs. Therefore a minimal distance to such influences of the fivefold to tenfold of the river width upstream and downstream of the measurement site is recommended.

Avoiding of stationary waves

In the viewing range of the radar sensor no stationary waves may occur as they may influence the velocity and water level measurement strongly. Stationary waves are caused by pillars of bridges, sharp edges in the bed or big stones and their appearance is moreover depending on the water level. On one hand stationary waves cause errors in angle as the radar impulse is reflected from the stationary wave and not the plane water surface. On the other hand they may influence the gauge measurement as stationary waves at the water surface are interpreted as higher water levels.

Range with unchanging cross section

Especially when modeling measurement sites the cross section in the range of the complete measurement has to be consistent. Changes are for example caused by widenings or narrowings of the river bed. Also pillars of bridges and curves in the river may change the cross section. The range with unchanging cross section should be the twofold of the distance between the mounting height of the radar sensor and the minimum water level upstream and half the distance downstream of the measurement.

Stable cross section

The calculation of the discharge uses the cross section area (see 4.3). Therefor the cross section of the river must not change as this causes the need of a new site calibration. Examples for changes of the cross section are abrasion of the channel bed, the agglomeration of bed loads or the relocation of sand banks. 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 3 mm have to be present at the water surface over the full gauge range. Especially for slow moving rivers this requirement is not fulfilled (see 4.2.5).

Influence of wind

For slow moving, deep rivers the velocity measurement may be distorted by waves caused by wind. Therefore measurements at sites with wind influence should be protected as much as possible against the wind.

5.1.2. Mounting requirements

Height of mounting

The radar sensor can be mounted in a range from 0.5 to15 m above the water surface or river bed.

⚠	Attention	The default operation range of the water level sensor is 15 m. The operation range can be optionally extended to 35 m, which needs a special sensor version.

Stable sensor mounting

The sensor has to be mounted stable and the installation rig may not swing. An exception is the mounting on cables, which needs a new determination of the inclination angle during every measurement (see chapter 6.3.3.2).

Free view field

The radar sensor interprets all movements in its view field. Therefore no moving objects may be present in the view field of the radar. Examples are trees, bushes or grass moving in the wind.

View direction

The radar sensor can either be mounted in or against the flow direction. The view direction against the flow direction has essential advantages and is strongly recommended. For installation on bridges the influence of pillars on the flow conditions are avoided. Additional the influences of rain and snow fall can be eliminated by a direction separation of the velocity measurement (see 4.2.3). The radar sensor can differ if movements occur in direction to the radar sensor or from the sensor away. As rainfall usually moves downwards and therefor from the radar sensor away, these parts of the velocities can be blanked out.

Mounting bellow bridges or in closed channels

It has to be assured that no rain or melt water from the bridge or ceiling is drained through the view field of the radar. The appearance of such events may influence the measurement strongly during rain fall.

Especially in situations with ceilings multiple reflections may occur. Thereby the radar signal may not only be reflected back to the sensor by the water surface but through multiple reflections from the bridge or the ceiling. This may influence the received signals and the measurement results. Multiple reflections are minimized by as smooth as possible ceilings and the avoiding of rectangular edges.

5.2. Mounting of the sensor

The radar sensor can be mounted in different ways.

Bridges

The mounting on bridges is a simple cost-efficient variant as an existing building is used. The radar sensor is either installed on the structure itself or on the railing of the bridge. In many cases the radar sensor can be protected against rain fall

The following points have to be accounted for:

- Preferred viewing direction upstream
- Avoiding of drainages of water in view field
- Avoiding of multiple reflections
- Protections against vandalism

Extension arms

If no bridges are available the sensor can be mounted on extension arms protruding from one bank into the river. It is suggested to install rotatable attachments to simplify the maintenance.

The following points have to be accounted for:

- Representative position in the main current
- No swinging of the assembly

Cable ways

The radar sensor can be mounted on a cable way or ropes crossing the river.

The following points have to be accounted for:

- Performing of inclination measurement prior to every measurement
- Minimize the swinging of the sensor
- Avoid changes in the height position

5.3. Site Calibration

Every measurement site demands its individual calibration. The calibration is deposited in the form of the discharge table in the radar sensor. It is used to calculate the discharge out of the measured water level and velocity.

5.3.1. Necessary Information

Cross section profile

The cross section profile is a vertical section through the channel from the river bed to the maximum expected water level. It is necessary for the calculation of the cross section areas A (W) and the modeling of the k-factors k (W) (see chapter 4.3).

The cross section is usually taken at the position of the water level measurement. The height information is either in local height coordinates, in absolute height above the sea level or as distance from a point at the top downwards.

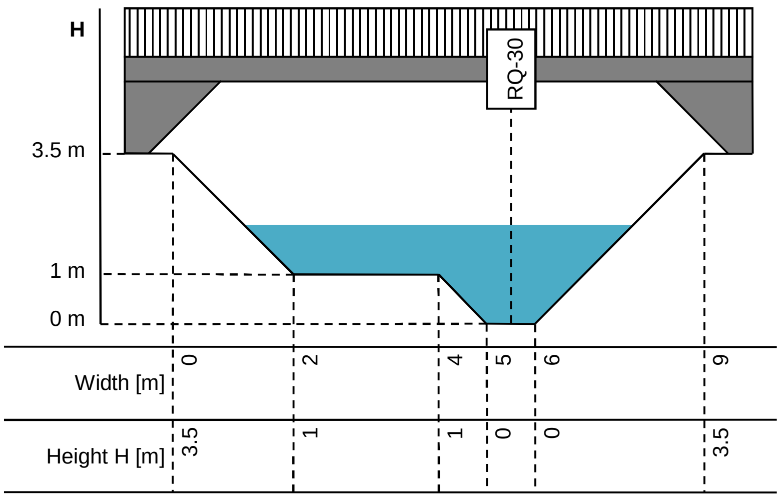


Figure 8: Cross section profile in local height H

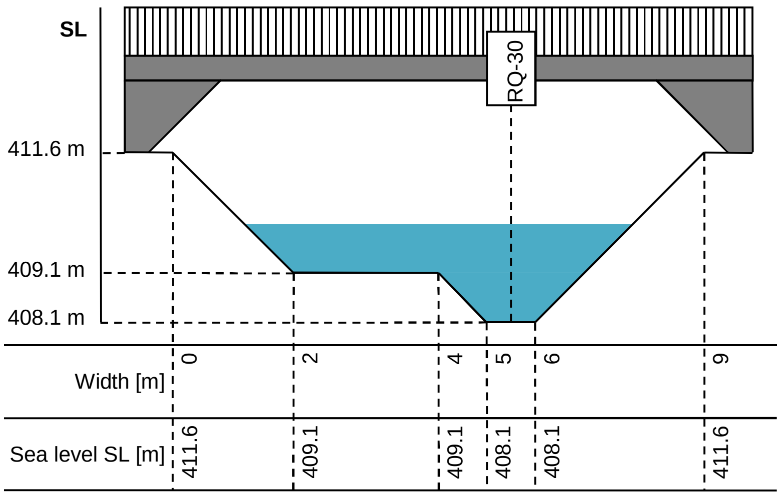


Figure 9: Cross section profile in sea level SL

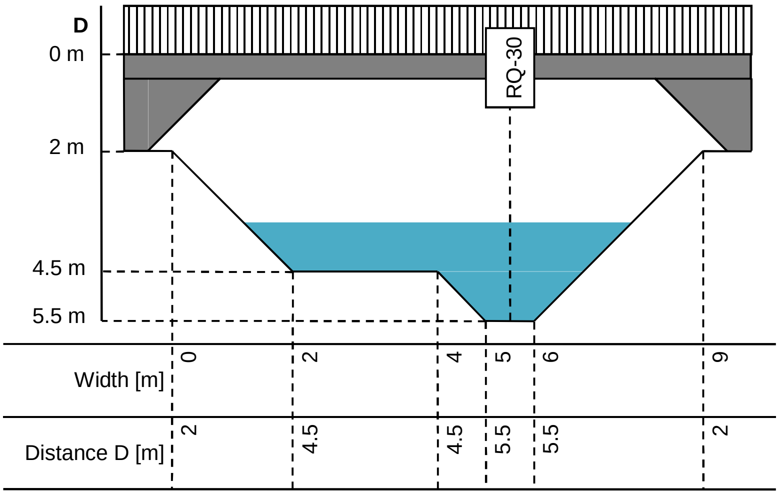


Figure 10: Cross section profile in distance downwards D

Roughnesses

An estimation of the roughnesses in the cross section profile is necessary to model the k-factors. The roughness is specified as absolute roughness k_S, Strickler coefficient k_{St} or Manning coefficient n. For the software "RQCommander" a description of the condition at the border in the form "Bed of sand" or "Brick stone walls" is sufficient to constitute the roughness coefficients.

Radar position

The exact position of the radar in the reference system has to be known. This information is essential for the modeling of the k-factors and the adjusting of the water level measurement.

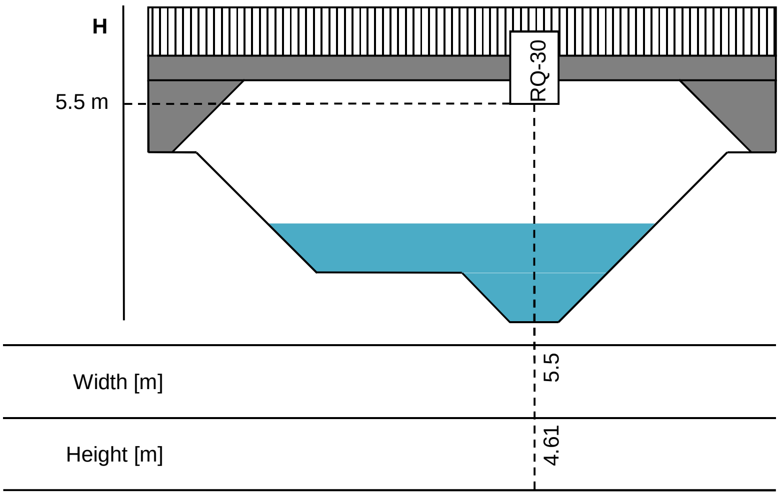


Figure 11: Cross section profile with radar position in local height

Pictures

It is recommended to document the measurement site with pictures. These help to understand the situation at the measurement site and are useful for a post processing.

Adequate motives are:

- Measurement site with the installation position of the sensor
- Situation of the river in viewing direction upstream and downstream
- Flow conditions at the measurement site
- Information to the roughnesses in the cross section

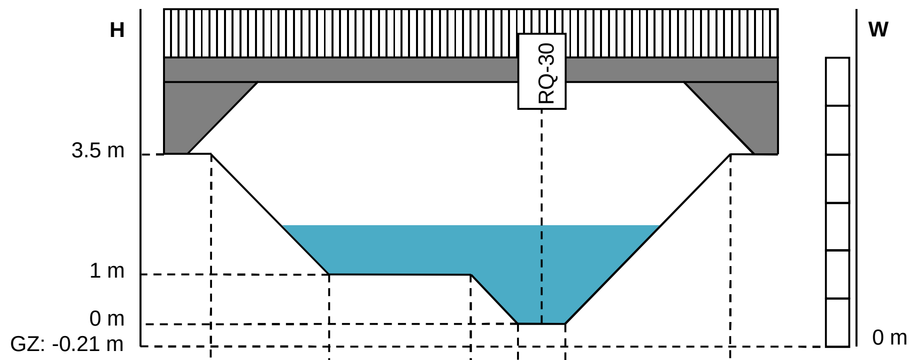
5.3.2. Selection of a reference system

The requirement for a correct usage of the calibration in form of the discharge table is a unique reference system "Level (W)" for the measurement site. The measurements of the water level, the mounting position of the radar sensor and the cross section profile have to relate to each other. Especially the water level in the discharge table and the water level measurement in the radar sensor have to be consistent with each other.

To select the reference system for a measurement site, situations with an existing water level measurement and without a water level measurement have to be differed.

Sites with an existing water level measurement

If a water level measurement is already present at the measurement site (i.e. a gauge plate or a gauge sensor) it is recommended to use the gauge zero of the existing measurement as the reference point. The point of the gauge zero is usually unique and defined permanently. Moreover the consistency of the existing water level measurement and the radar measurement simplifies the interpretation. The height position of the gauge zero (GZ) has to be known in the reference system of the cross section.



Width [m]	0	2	4	5	6	9
Height H [m]	3.5	1	1	0	0	3.5
Water level W [m]	3.71	1.21	1.21	0.21	0.21	3.71

Figure 12: Gauge zero GZ of a gauge plate for a cross section in local height H

In the example the gauge zero GZ at -0.21 m is the reference point for the cross section identified by local height H and width. With the reference point the profile is transferred into the water level.

Sites without an existing water level measurement

For measurement sites without an existing water level measurement a new reference system has to be defined. It is recommended to select a fixed-point as reference point to allow a later reproduction of the definition of the reference system. It is essential to document the reference point and its relation to the water level W properly.

For channels with a stable river bed a point on the bed can be selected as reference point and gauge zero simultaneously. The advantage is the usually simple determination of the actual water level and therefore an easy adjusting procedure of the water level measurement in the radar sensor.

For all other measurement sites a fixed point has to be selected. Examples are survey points or unique points on bridges or assemblies. This point has to be known in the coordinates of the cross section. It is not necessary that the height position of the reference point has to be selected as gauge zero. But the relation of the height of the reference point has to be related absolutely to the gauge zero.

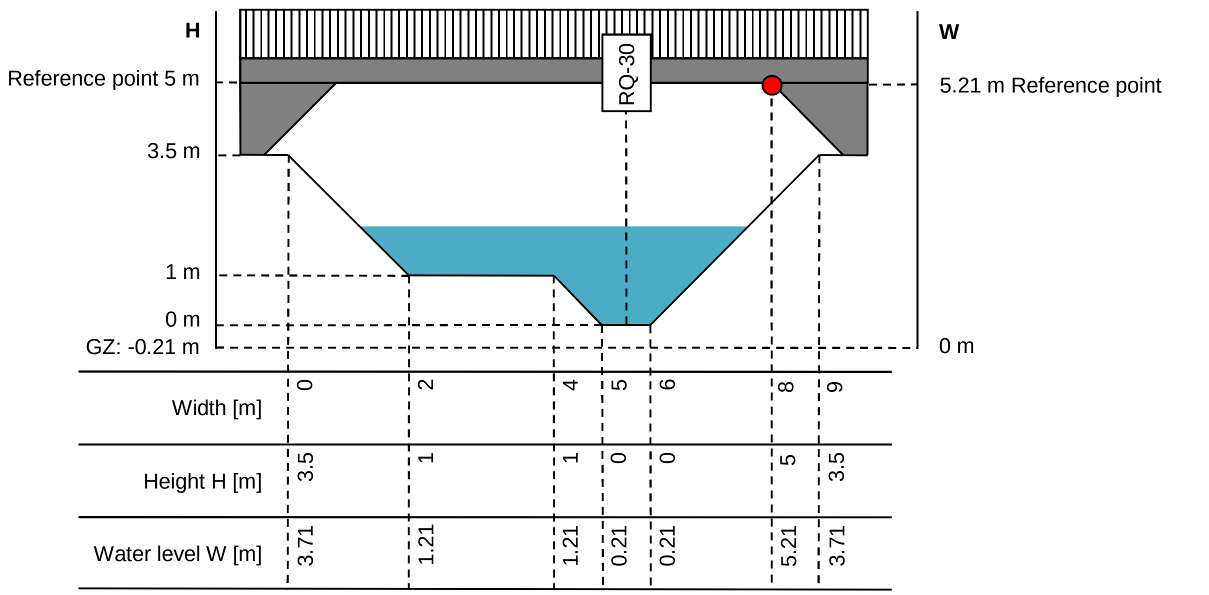


Figure 13: Gauge zero GZ with fixed point for a cross section in local height H

In the following example a fixed-point was defined at a unique point on the bridge. The height of the point is 5 m in the reference system of the cross section H. The gauge zero was defined as -0.21 m in the system of the cross section H. So the fixed point is at 5.21 m in the system of the water level measurement W and the cross section can be transferred into the reference system of the water level W.

5.3.3. Creating the discharge table

The calibration of the measurement site is expressed in the form of the discharge table. This table is stored in the radar sensor and is the base for the calculation of the discharge out of the water level and velocity measurements described in chapter 4.3 and in the following figure.

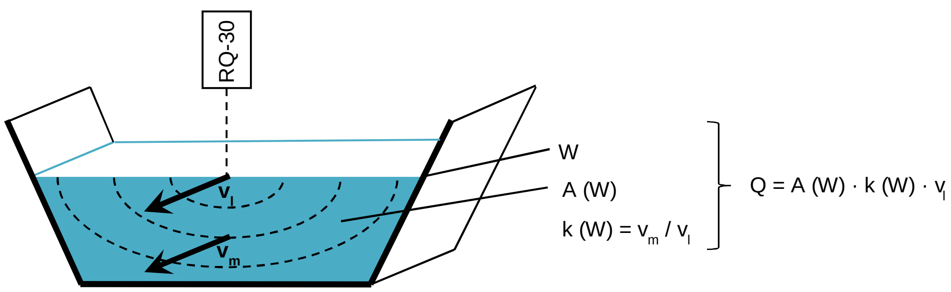


Figure 14: Meaning of the values of a line in the discharge table

The discharge table consists of the cross section area A (W) and the k-factor k (W) in dependence of the water level W. The area of the cross section is derived from the cross section profile. The k-factor, used to calculate the measured local velocity at the water surface into the mean velocity, is determined according to chapter 4.3.2. The water levels in the discharge table have to correlate exactly with the water level measurement of the radar sensor.

In the discharge table up to 16 lines can be edited. The sequence is from low to high water levels. Values between two water levels are linear interpolated in the radar sensor.

Number	Gauge [m]	k-value [%]	Area [m²]
01	0,4	64,0	4,7
02	0,6	68,7	9,5
03	0,8	72,1	14,4
04	1,08	74,2	21,5
05	1,6	74,7	35,7
06	2,12	75,0	51,5
07	3,16	77,7	84,0
08	4,9	79,5	141,8
09	6,7	80,7	202,4
10			
11			
12			
13			
14			
15			
16			

Figure 15: Example of a discharge table

An appropriate and relatively simple possibility to create the discharge table is the software "RQCommander Modelling" of Sommer GmbH. The cross section profile, the roughnesses and the sensor position can be entered and the discharge table is calculated automatically. It then simply can be transferred to the radar sensor. Alternative procedures are described in chapter 4.3.2.

6. Radar sensor

6.1. Direct connection

In this section the establishing of a direct connection from a PC or a laptop to the radar sensor is described.

6.1.1. Converter

The radar sensor has a RS-485 interface. To establish a direct connection to a computer a converter is necessary.

Converter USB to RS-485

The first possibility is the connection with a USB interface. The usage of any converter from USB to RS-485 is possible. Sommer GmbH uses the converter "USB-Nano 485".

The converter is connected to a free USB interface and the drivers have to be installed. This supplies a COM port that is used for the connection.

ⓘ	Note	The installation of the converter "USB-Nano 485" is described in the appendix 10.5.

The radar sensor is connected following the schema bellow and the supply is provided.

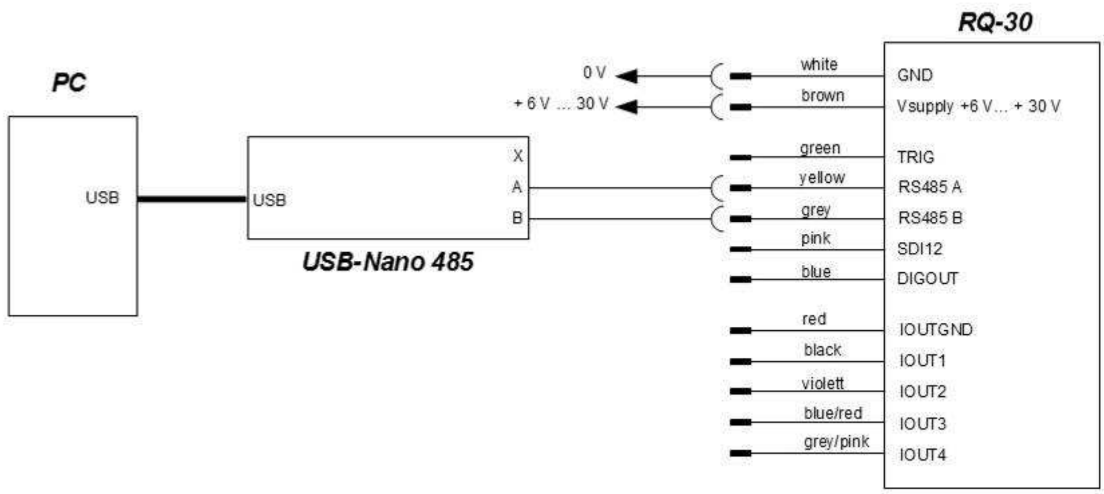


Figure 16: Connection details for the converter "USB-Nano-485"

Converter RS232 to RS485

The second possibility is the connection with a RS-232 interface of the computer. For that the converter "IFD RS232-485" of Sommer GmbH has to be used.

The converter and the radar sensor are connected following the schema bellow and the supply is provided for the converter and the radar sensor.

⚠	Attention	The interface converter "IFD RS232-485" of Sommer GmbH can only be operated with maximal 15 VDC.

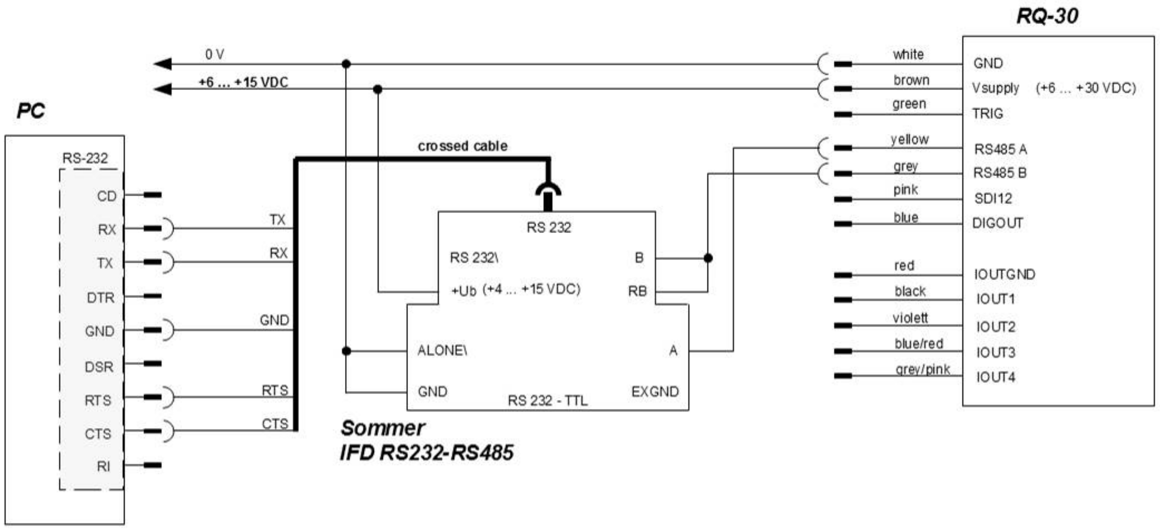


Figure 17: Connection details for the converter "IFD RS232-485"

6.1.2. Connection settings

The communication settings by factory default are listed below and have to be set for the COM port on the first connection.

Baud rate	9600
Data bits	8
Parity	none
Stop bits	1
Flow control	none

Table 9: Default connection settings

6.1.3. Communication

The communication with the sensor is performed either with a terminal program using the sensor menu or with the PC software "RQCommander" with automatic communication using sensor commands.

6.1.3.1. Terminal program and sensor menu

The communication with a radar sensor can be performed with any terminal program. For example the "HyperTerminal" can be used that is included by default in Microsoft Windows (Start → Programs → Accessories → Communications → HyperTerminal). In the software "RQCommander" a terminal program is included too.

In a first step the COM port has to be selected and the connection settings have to be set in the terminal program.

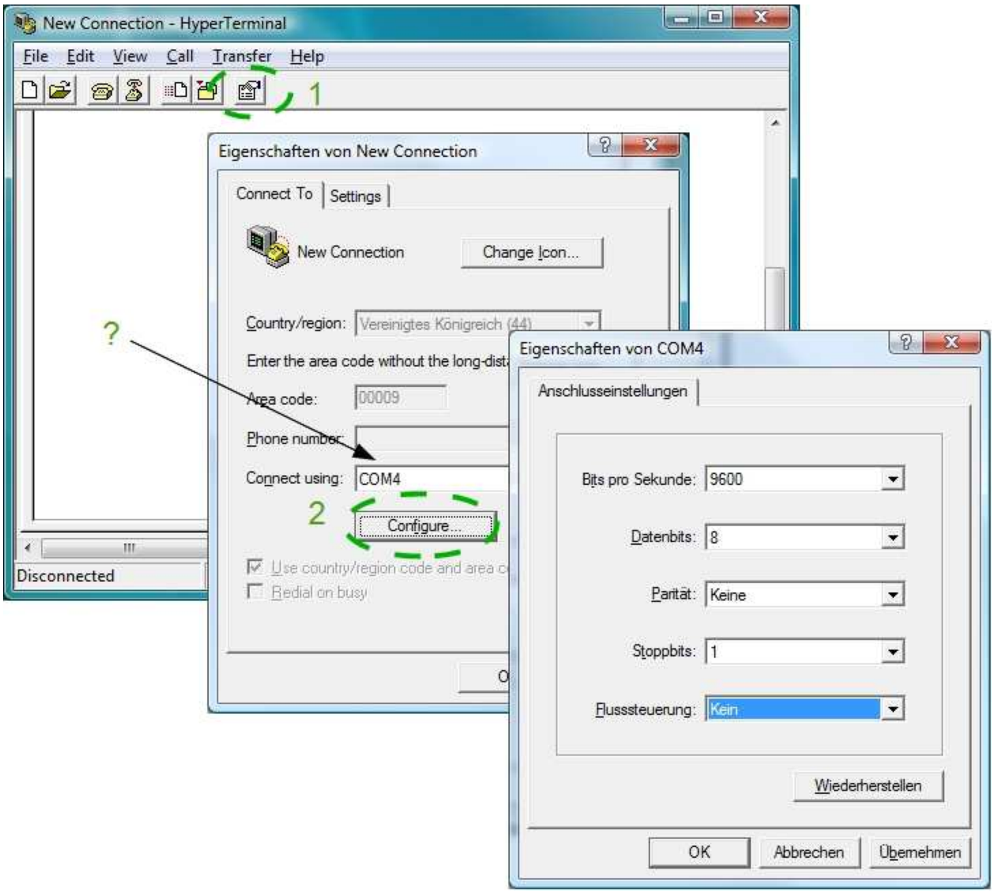


Figure 18: Setting of the COM port and the connection settings

In the next step the connection can be established. If the power supply of the sensor is switched on a boot message is output.

```
Boot RQ-30a 1_70r00 S00 D01!
```

Figure 19: Boot message and initialization message

In the boot message the RQ-30 radar sensor is identified with its firmware version and the address in the RS-485 bus (S…system key; D…device number)

The sensor menu can be opened by quickly entering three question marks "???".

ⓘ	Hint	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 an "Enter". This is especially important for command line tools, which may automatically send a closing "Carriage return”.

```
Main menu
=========


A  Measurement trigger ------------ interval
B  Measurement interval ----------- 600 sec
C  AUX
D  Level (W)
E  Velocity (v)
F  Discharge table
G  DIG-OUT output
H  Technics
I  Special functions

Choice (X for exit):
```

Figure 20: Main menu

The menu items are selected by entering the letter left of the label. Either submenus are opened or the selected parameter is displayed with its unit. Changes are confirmed with "Enter" or discarded with "Esc". Menus are closed with "X".

ⓘ	Hint	All parameters of the menu are described in detail in chapter 9.

After closing the main menu with "X" the sensor performs an initialization. The beginning and the end of the initialization procedure is displayed by the initialization message.

```
Start init!
Init done!
```

Figure 21: Initialization message

6.1.3.2. RQCommander

A simple and comfortable way to communicate with the radar sensor is the PC software "RQCommander" of Sommer GmbH. The communication with the radar sensor is operated by commands.

After editing the communication settings, the communication to the sensor is established. At first the all parameters are transferred from the sensor to the PC and are displayed in a local menu structure according to the sensor menu.

⚠	Attention	At the first communication with a new sensor version the parameter schema of the sensor has to be transferred. Only then the menu structure is known in the "RQCommander".

All parameter can be saved locally in files and can be edited. Modified or all parameters can be uploaded to the sensor.

Further functions of the "RQCommander" are:

- Profile-Mode for site calibrations with entering of cross sections and creation of discharge tables (see 5.3) (only "RQCommander Modelling")
- Transferring of discharge tables to radar sensors (only "RQCommander Modelling")
- Spectrum-Mode to visualize radar spectra (see 4.2.2)
- Time Series-Mode to recalculate data (only "RQCommander Modelling")
- Terminal-Mode to check data transfer strings and for direct call of the sensor menu.

ⓘ	Hints	All parameters of the menu are described in detail in chapter 9. A detailed description of the "RQCommander" can be found in the online help or the manual of the "RQCommander".

6.2. Basic settings

The basic settings have to be set at the first setting-up of the radar sensor at a measurement site. They are located in the menu "H Technics" and the submenu "0 Units and decimals" of the radar sensor (see chapter 9).

6.2.1. Language

This setting defines the language of the menu.

6.2.2. Decimal character

The setting defines the character for the decimal separator in the menu, the serial output strings and the commands.

6.2.3. Units and decimals

The units and number of decimals have to be defined for all measured and calculated values. The settings have to be set prior to all other settings as all values are saved internally in this format. Therefore all related parameters must be reedited elaborately after a later change of any of these settings.

6.3. Measurement settings

6.3.1. Timely triggering of measurements

In the RQ-30 radar sensor measurements can be triggered differently. Either they are started internally by an interval or they are triggered externally by the TRIG input or by RS-485/SDI-12 commands. The type of trigger is set in the menu item "A Measurement trigger".

⚠	Attention	The outputs of the measurement values are independent from the performing of the measurements and have to be set separately.

Internal measurement interval

The measurements are started by the radar sensor in a defined interval. The interval is set in the menu item "B Measurement interval".

External trigger

The measurements are started externally by a rising flank of the signal at the TRIG-input.

External command

The measurements are triggered by commands via the RS-485 or SDI-12 interface.

6.3.2. Water level measurement

6.3.2.1. Adjustment

The most important setting for the water level and discharge measurement is the adjusting of the level. It is essential that the measured water level W is related to the reference system and respectively the discharge table (see chapter 5.3.2).

The procedure of the water level adjustment is different for sites with and without existing water level measurements.

Adjustment with known water level

The adjustment with existing water level measurements is very simple as the actual water level is known. It is essential that the gauge zero GZ of the existing water level measurement is defined as the reference point for the discharge table.

The water level measurement of the radar sensor is simply set to the known value of the existing water level measurement. This is done with the menu item "D-C Adjustment" in the menu "D Level (W)". Thereby first a water level measurement of the radar sensor is performed and the actual value is output. In the next step the target value of the water level is entered as "Set point level". It has to be the actual water level known from the existing water level measurement. After confirming the input the water level measurement of the radar sensor is automatically adjusted to the given value and the mounting height of the radar sensor WRQ in the reference system W is calculated.

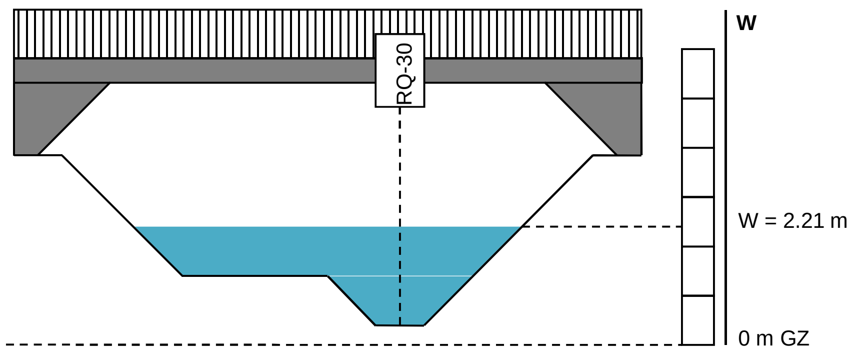


Figure 22: Water level adjustment with known water level

Adjustment with unknown water level

If no water level of an existing water level measurement is known, the mounting height of the radar sensor WRQ can be set directly. The requirement for this procedure is knowledge of the exact vertical position of the radar sensor WRQ in the reference system W. The value of WRQ is entered in the menu item "D-D WRQ, RQ-30 fixation level".

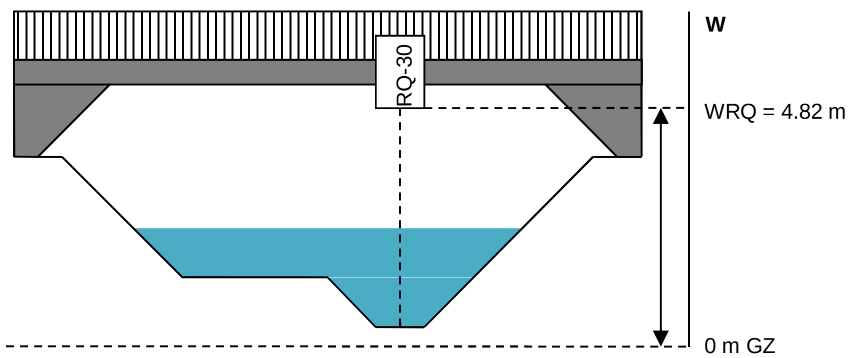


Figure 23: Water level adjustment by setting of the mounting level WRQ

6.3.2.2. Setting of the special water levels

The velocity measurement might be obstructed at low water levels. Therefore the radar sensor offers the possibility to set low level border WLL. If the water level drops below the WLL, the velocity measurement is stopped to avoid wrong measurements. The water level measurement is still performed and the discharge is calculated by extrapolating the velocity from the WLL downwards. The zero point for the extrapolation of the velocity is the flow stop level WFS. The velocity at the low level border WLL is calculated by the W-v relation, which needs the maximum level WMA to define the learning range (see chapter 6.5). If during the installation water level is below the WLL the W-v relation has not been learned yet. Therefore a temporary velocity can be set in the menu item "H-K-K Start veloc. at WLL" to get calculated values for the discharge during installation.

In general the special water levels respect the rule: WRQ > WMA > WLL > WFS

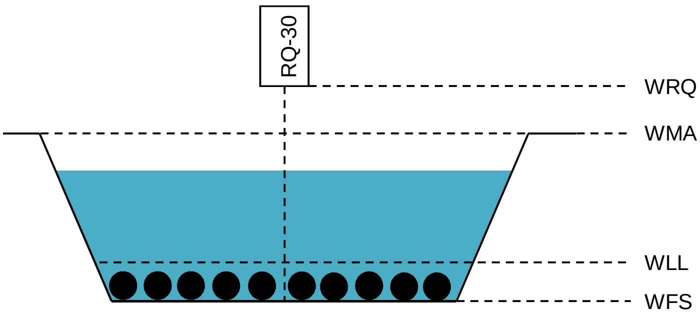


Figure 24: Special water levels

WRQ, RQ-30 fixation level

The RQ-30 fixation level is the mounting height of the radar sensors in the reference system W. It is either entered directly or is automatically calculated when performing an adjustment of the water level. The height of the radar sensor is measured from the lower edge of the plate at the water level sensor.

WMA, maximum level

The maximum level is the upper limit of the range for the W-v relation.

WLL, low level border

The low level border is the water level, from which on the velocity measurement is sufficient enough. A guidance value is 5 cm above the river bed or poking out stones in the measurement area.

The low level border is the lower limit of the range for the W-v relation.

⚠ Attention	Bellow the low level border no velocity measurement is performed any more.

WFS, flow stop level

The flow stop level is the water level down to that the velocities are linear extrapolated from the low level border. The velocity at the flow stop level is always 0.

6.3.3. Velocity measurement

6.3.3.1. Settings

The measurement of the velocity depends on the mounting position of the radar sensor and the flow conditions at the site. Therefor specific settings have to be defined to describe the local situation at the measurement site. All the settings are located in the menus "E Velocity (v)" and "H-K Tech. velocity (v)".

Viewing direction

The viewing direction describes the orientation of the radar sensor in relation to the flowing direction of the river. Either the radar sensor is mounted against the flow direction looking "upstream" or it is installed in flow direction looking "downstream".

Possible flow direction

Due to the direction separation (see chapter 4.2.3) the radar sensor can identify the flow direction. Therefore it has to be defined, if the river only flows in one direction or if two flow directions can occur as for example under tidal influences.

Maximal and minimal velocity

The maximum velocity defines the maximum expected velocity. The velocity measurement is optimized for this setting. Usually a value of 5 m/s is sufficient. For this value no security has to be accounted for as the radar sensor already includes one.

The minimal velocity defines the minimal velocity for the determination. No lower velocities are considered.

Measurement spot optimization

The measurement spot optimization describes the expected velocity distribution in the measurement spot. The irregular the distribution is, the wider the spectral band width has to be selected. The analysis algorithm for the velocity is optimized for this setting by the radar sensor.

For the first measurements at a new measurement site the selection “standard” is recommended. Later on the measurement may be optimized by selecting another river type.

Measurement duration

The measurement duration defines the duration of a single measurement. During this time the radar signal is recorded and the radar spectrum is calculated. Usually measurement durations of 60 s are recommended. For very regularly flowing rivers a lower measurement duration can be selected.

Measurement type

The measurement type describes if the measurement is either performed continuously over the complete measurement time, or if the measurement time is divided in five parts by systematic time breaks. The sequenced method is more representative but the processing is slower. By default the selection should be set to "continuous".

Criteria and behavior for invalid measurements

Measurements of the velocity can be defined as invalid with the criteria quality (SNR) and opposite direction content (Stop measurements). The criteria and the behavior if such invalid measurements occur can be controlled in multiple parameters.

6.3.3.2. Inclination measurement

As described in chapter 4.2.4 for every velocity measurement an angle correction has to be applied. This is done using an internal inclination measurement of the radar sensor. If the sensor is mounted stable it is sufficient to measure the installation angle only on the first measurement after the restart of the radar sensor. If the sensor can swing it is recommended to perform an inclination measurement during every velocity measurement. This setting is set with the menu item "H-E Inclination measurement".

6.3.3.3. Radar spectrum

With the software "RQCommander" radar spectra from radar sensors can be received and visualized. The radar sensor is switched into spectrum mode and the spectra are output cyclical.

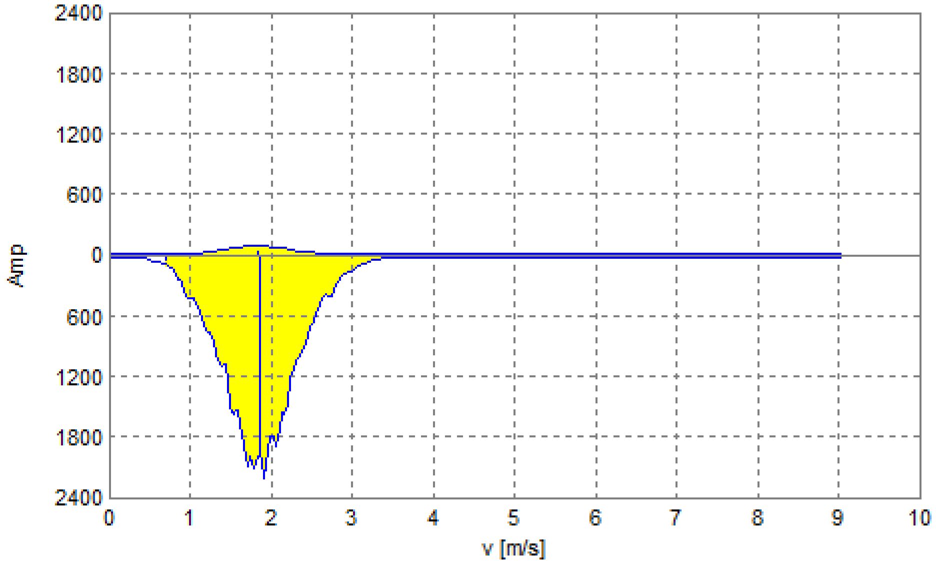


Figure 25: Radar spectrum

The radar spectrum is displayed for both movement directions. In the lower half of the graphic the spectrum of movements in direction away from the radar sensor are displayed, in the upper half movements in direction to the radar sensor are displayed. The calculated velocity is identified with a line. The yellow marked area is used for the calculation.

By interpreting the radar spectra a detailed analysis of the velocity measurement at the measurement site is possible. Spectra can be narrow or wide, one or more maxima can occur and only one or both velocity directions can be identified. This awareness can result in a modification of the settings for the velocity measurement.

6.4. Discharge table

To calculate the discharge from the measurements of the water level and the velocity, a discharge table is needed. This table is the result of a site calibration as described in chapter 5.3.

The discharge table is deposited in the radar sensor. It is either edited directly in the menu "F Discharge table" or the discharge table is uploaded to the radar sensor with the PC software "RQCommander Modelling".

6.5. W-v relation

The RQ-30 radar sensor supports the functionality of W-v learning. Thereby a stable relation between water level W and the flow velocity is assumed. This relation is generated internally in the radar sensor and is adjusted continuously. The usage of the W-v relation results in additional measurement values for the velocity and the discharge.

6.5.1. Usage

The W-v relation can be used to smooth velocity measurements and consequently the discharge. The water level fluctuates in general only minimal, while the velocity depending on the flow conditions can show strong fluctuations. The usage of the learned velocities from the W-v relation according to the measured water level therefore results in smoother measurement values.

Additionally the W-v relation is used to extrapolate velocities for water levels below the low level border WLL. At low water levels for examples stones can influence the flow condition in a way that the velocity measurement is invalid. Or velocity measurements cannot be possible as the sensor is directed on dry areas. For these low water levels the velocities can be extrapolated from the W-v relation and therefore provide valid values for the velocity and the discharge (see chapter 6.3.2.2).

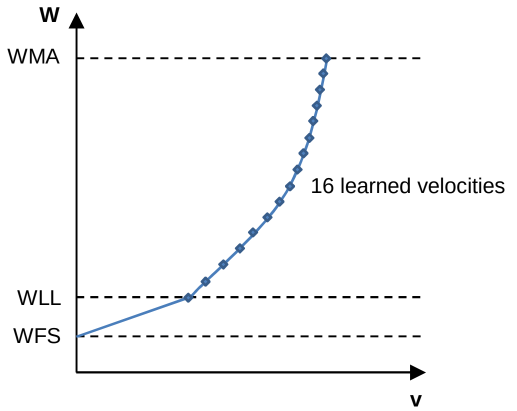


Figure 26: Extrapolation of the velocity below the low level border WLL

⚠	Attention	If no stable W-v relation is present at the measurement site the learning of the W-v relation will provide instable results as well.

6.5.2. Learning of the W-v relation

For the range between the two water levels "WMA maximum level" and "WLL low level border" internally a table with 16 value pairs is created consisting out of water levels and learned velocities. These learned velocities of the table are now continuously adjusted with every measurement. By and by the complete range of the water level is passed through and a relatively stable relation between water level and velocity is formed, if the measurement site allows this. Consequently for every measured water level a learned velocity and respectively a learned discharge can be assigned by linear interpolation.

⚠	Attention	The duration for the learning of the W-v relation is influenced by the fluctuation of the water level at the measurement site.

6.5.3. Settings

Water 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 described in chapter 6.3.2.2.

Activation

The usage of the W-v relation is activated as soon as one of the special water levels WMA, WLL or WFS is different from 0.

W-v priority

By default the W-v priority is deactivated and the measured velocity and discharge are output in the serial and analog outputs. In the serial outputs the learned velocity and learned discharge are output as special values.

By activation the W-v priority the output of the measurement values is switched. The learned velocity and discharge are now in the main values and the measured velocity and discharge are in the special values. This selection is performed with the menu item "H-G W-v priority"

Resetting the learned W-v relation

With the menu items "D-H W-v table reset" and "I-G W-v table reset" the W-v table is deleted and the W-v learning starts from scratch. This is especially necessary if water levels for the W-v relation are changed or the radar sensor is installed at a new measurement site.

7. Serial data output

The radar sensor includes a RS-485 and a SDI-12 interface for data output and communication.

7.1. Measurement values

The measurement values of the radar sensor are arranged in a fixed sequence. Every value is identified with an increasing index. The measurement values are divided in groups.

Main values

The main values contain the most important measurement values. These values are always included data output. The units and decimal places are depending on the settings in the submenu "H-O Units and decimals".

Index	Measurement value	Description
00	AUX	Measurement value of the optional sensor at AUX
01	Water level	Measured water level
02	Velocity[3]	Measured velocity
03	Quality (SNR)	Quality value with SNR (see appendix 10.1.2)
04	Discharge[3]	Discharge of the measured velocity
05	Cross section area	Cross section area according to water level and discharge table

Table 10: Main values

Special values

The special values are usually the learned velocity and the learned discharge. By activating the W-v priority with the menu item "H-G W-v priority" the measured velocity and measured discharge are output instead. The learned velocity and the learned discharge then are output in the main values. The output of the special values has to be activated in the menu item "H-M-E MO information".

Index	Measurement value	Unit	Description
06	Learned Velocity[3]		Learned velocity from the W-v relation
07	Learned Discharge[3]		Discharge of the learned velocity
08	Opposite direction content	%	Relation between the velocity distributions in analysis direction and opposite direction
09	Supply voltage	V	Voltage at the supply input

Table 11: Special values

[3] The positions of the measured and learned velocities and discharges can be switched with the menu item "H-G W-v priority".

Analysis values

The 11 analysis values provide information to the velocity measurement and can be interpreted by experts. . The output of the analysis values has to be activated in the menu item "H-M-E MO information".

Index	Measurement value	Unit	Description
10	Peak width	mm/s	Band width of the signal
11	CSR	%	Corrected intensity
12	Area of the peak		
13	RMS at the PIC	mV	
14	Amplification		Value of the amplification regulation
15	Amplification relation	%	
16	Signal relation	%	
17	Error code		
18	not used		
19	not used		
20	not used		

Table 12: Analysis values

7.2. RS-485 Interface

The settings for the output of the measurement data via the RS-485 interface are in the submenu "H-M RS-485 protocol".

7.2.1. System key and device number

The system key and the device number are used to identify a radar sensor in serial output protocols and commands. This is essential if multiple devices (radar sensors and data loggers) are operated within a bus system.

System key

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

Device number

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

7.2.2. Output time point

The serial data output can be triggered in different ways. The selection is in submenu "H-M RS-485 protocol".

Just per command

The serial data output is controlled by commands via the RS-485 interface.

After measurement

The serial data output is performed automatically right after every measurement. The starting points for measurements are described in chapter 6.3.1.

Per TRIG input

The serial data output is triggered by an increasing slope on the TRIG input.

If additionally the measurement is triggered by the TRIG input too, a measurement is started simultaneously with the output of the last measurement values.

7.2.3. Operation modes

Out of the combination of triggering the measurements (see chapter 6.3.1) and the data output (see chapter 7.2.2) the following operation modes are derived.

Pushing mode

This is the default operation mode. The measurements are triggered internally by the measurement interval and the data output is performed automatically after the finishing of a measurement. So the measurements and data outputs are controlled completely by the internal interval. No external trigger is needed.

Polling mode

A connected data logger triggers the measurements and the output of the data individually either by external commands or by the TRIG input.

Apparent polling

A connected data logger triggers only the measurements. The data output is performed automatically after the measurement. The triggering of the measurement is performed either by external commands or the TRIG input.

7.2.4. Additional output strings

The output protocols have separate output strings for the main values, the special values and the analysis values (see chapter 7.1). Only the main values are always output. The output strings of the special values and the analysis values can additionally be activated with the setting "H-M-E MO Information".

7.2.5. Waking-up of a connected data logger

The radar sensor supports the waking-up of connected data loggers independent of the protocol. Normally this feature is only used in pushing mode. The settings are in the submenu "H-M RS-485 protocol".

Sync sequence

The sync sequence consists out of "UU~?~?" and is sent directly before a command. The aim is to synchronize the receiving UART.

Prefix

The prefix is an arbitrary character; the radar sensor uses a blank. The character is sent prior to any communication. Then the time of the "H-M-G MO prefix holdback" is waited and the command is sent afterwards. With this procedure the receiving device has time to wake-up.

7.2.6. Output protocols

For the output of measurement values via the RS-485 interface different protocols are available. They are selected with the menu item "H-M-C Output protocol type".

7.2.6.1. Sommer protocol

The data strings of the Sommer protocol consist out of a header with the system key, device number and a string number, multiple measurement values with the measurement index according to chapter 7.1 and a closing sequence. The format of header, measurement values and closing sequence is described in detail in appendix 10.2.1.1.

Main values

The main values are identified by the string number 00 right after G.

Protocol string
#M0001G00se00 -17.4|01 8806|02 0.433|03 40.93|04 0.00|0599999.98|59DF;

Table 13: Example of protocol string with main values in Sommer protocol

`#M0001G00se`	Header with system key 00, device number 01 and string number 00
`00 -17.4|`	AUX
`01 8806|`	Water level
`02 0.433|`	Velocity[4]
`03 40.93|`	Quality (SNR) (see appendix 10.1.2)
`04 0.00|`	Discharge[4]
`0599999.98|`	Cross section area
`59DF;`	Closing sequence

Table 14: Main values in Sommer protocol

Special values

The special values are identified by the string number 01 right after G.

Protocol string
#M0001G01se06 0.000|07 0.00|08 46|09 15.13|E30C;

Table 15: Example of protocol string with special values in Sommer protocol

`#M0001G01se`	Header with system key 00, device number 01 and string number 01
`06 0.000|`	Learned velocity[4]
`07 0.00|`	Learned discharge[4]
`08 46|`	Opposite direction content
`09 15.13|`	Supply voltage
`E30C;`	Closing sequence

Table 16: Special values in Sommer protocol

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

Analysis values

The Analysis values are identified by the string numbers 02 and 03 right after G.

Protocol string
#M0001G02se10   430|11   293|12   78|13   116|14   11075|15   -40|E08D;
#M0001G03se16   0|17   0|18 9999998|19 9999998|20 9999998|3827;

Table 17: Example of protocol strings with analysis values in Sommer protocol

`#M0001G02se`	Header with system key 00, device number 01 and string number 02 for the analysis values 08 to 13
`10      430|`	Peak width [mm/s]
`11      293|`	CSR [%]
`12       78|`	Area of the peak
`13      116|`	RMS at the PIC
`14    11075|`	Amplification
`15      -40|`	Amplification relation [%]
`E08D;`	Closing sequence

Table 18: Analysis values 1 in Sommer protocol

`#M0001G03se`	Header with system key 00, device number 01 and string number 03 for the analysis values 14 to 19
`16        0|`	Signal relation [%]
`17        0|`	Error code
`18 9999998|`	not used
`19 9999998|`	not used
`20 9999998|`	not used
`3827;`	Closing sequence

Table 19: Analysis values 2 in Sommer protocol

7.2.6.2. Standard protocol

The Standard protocol is similar to the Sommer protocol. But the output is simplified and eventually easier to interpret. The format is described in 10.2.1.2 in detail.

Measurement values

The measurement values are output with the identifier "M_". In the measurement values the main values and the special values are included according to the sequence from chapter 10.2.1.2.

Protocol string
M_0001   -17.3   6458   0.679   35.93   0.00 99999.98   0.679   0.00   46   15.13

Table 20: Example of protocol string with measurement values in Standard protocol

`M_0001`	Header with identifier for measurement values

-17.3	AUX
6458	Water level
0.679	Velocity [5]
35.93	Quality (SNR) (see appendix 10.1.2)
0.00	Discharge[5]
99999.98	Cross section area
0.679	learned velocity[5]
0.00	learned discharge[5]
46	Opposite direction content
15.13	Supply voltage

Table 21: Measurement values in Standard protocol

Analysis values

The measurement values are output with the identifier "Z_".

Protocol string
Z_0001 664 239 61 91 11075 47 0 200 9999998 9999998 9999998

Table 22: Example of protocol string with analysis values in Standard protocol

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 23: Analysis values in Standard protocol

7.2.6.3. Modbus

The measurement values can be read out via the Modbus protocol by a Modbus master (see description in chapter 7.4)

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

7.2.6.4. Compatibility protocols

To simplify the replacing of existing RQ-24 radar sensors with new RQ-30 radar sensors the old protocols of the RQ-24 are still available. So the receiver of the measurement data does not have to be parameterized new.

The protocols are described in the manual of the RQ-24. It is recommended not to use these protocols any more.

7.2.7. Commands

Commands can be sent via the RS-485 interface to the radar sensor to start measurements, request output strings, request measurement values and to parameterize the radar sensor. A more detailed description is provided in appendix 10.2.2.

7.2.7.1. Types of commands

Writing command with receiving confirmation

The identifier is "W". The command demands a closing sequence with a valid CRC-16. The receiving radar sensor returns a receiving confirmation.

Writing command without receiving confirmation

The identifier is "S". The command demands no closing sequence and therefore no CRC-16. The receiving radar sensor does not acknowledge the receiving of the command

Reading command

The identifier is "R". The command demands a closing sequence with a valid CRC-16. The receiving radar sensor returns the requested measurement value or parameter.

7.2.7.2. Triggering of measurements

The command "$mt" triggers a complete measurement sequence (velocity, water level and AUX measurement).

Command	Answer
#W0001$mt|BE85;	#A0001ok$mt|4FA9;
#S0001$mt|7F43;	none

Table 24: Triggering a measurement

7.2.7.3. Requesting of output string

The command "$pt" requests the output strings.

Command	Answer
#W0001$pt|EE20;	#A0001ok$mt|8C35;
#S0001$pt|	none

Table 25: Requesting the output strings

7.2.7.4. Requesting of single measurement values

The reading command "R" with the index of the requested measurement values according to chapter 7.1 requests single measurement values. A detailed description is in appendix 10.2.2.

Command	Answer

#R0001_010cv|EA62;	#A0001ok_010cv874,9 |5997;

Table 26: Requesting of the water level with index 01

7.2.8. Connection to a data logger

A data logger to receive measurement values via the RS-485 interface is connected according to the following schema.

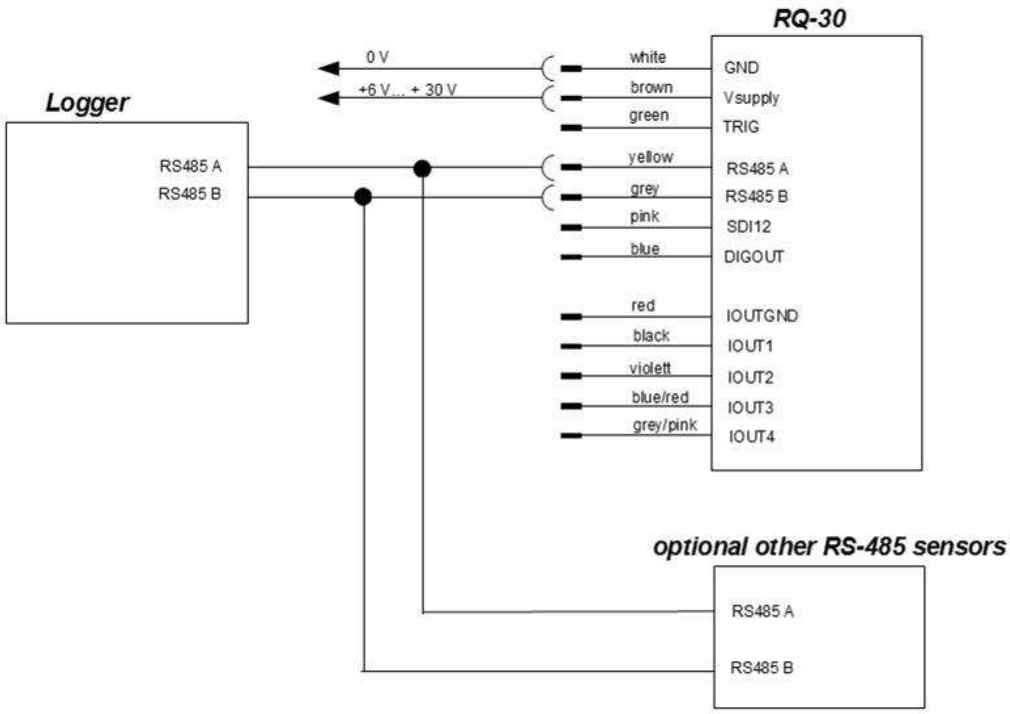


Figure 27: Connection schema for a data logger with RS-485 interface

7.3. SDI-12 interface

SDI-12 (Serial Data Interface at 1200 Baud) is a serial data communication standard for interfacing multiple sensors with a single data recorder. SDI-12 uses a shared bus with a ground wire, a data wire (indicated as SDI-12) and an optional +12 V wire. A detailed description to the usage of the SDI-12 interface is in the appendix 10.3 and on http://www.sdi-12.org.

7.3.1. SDI-12 address

The radar sensor is identified with a unique address in the SDI-12 bus system. The address can be changed in the menu item "H-C SDI-12 address" or by the SDI-12 command class "A". The default address is 0.

7.3.2. Measurement values of the main cycle

The sequence of the main, special and analysis values is according to the description in chapter 7.1. These values can be requested by the command groups "aM!", "aMC!", "aC!" and "aCC!" and by the command classes "R" and "RC" in interval mode.

7.3.3. Operation modes of the radar sensor

Out of the combination of triggering the measurements (see chapter 6.3.1) the following operation modes for the radar sensor are possible.

Interval mode

This is the default operation mode. The measurements are triggered internally by the measurement interval. So the measurement values are available anytime to the SDI-12 BUS. Therefore the measurement values only have to be requested by class "R" (SDI-12 version > 1.2 necessary). For commands of the command groups "aM!", "aMC!", "aC!" and "aCC!" a virtual measurement time of 1 s is specified.

Polling mode

A connected SDI-12 data logger triggers and controls the output of data autonomous by commands of the command groups "aM!", "aMC!", "aC!" and "aCC!". For this mode the measurements of the radar sensor have to be triggered by external commands (see chapter 6.3.1 or the menu item "A Measurement trigger" in chapter 9)

7.3.4. Connection to a data logger

SDI-12 uses a shared bus with a ground wire, a data wire (indicated as SDI-12) and an optional +12 V wire. A data logger is connected according to the following schema

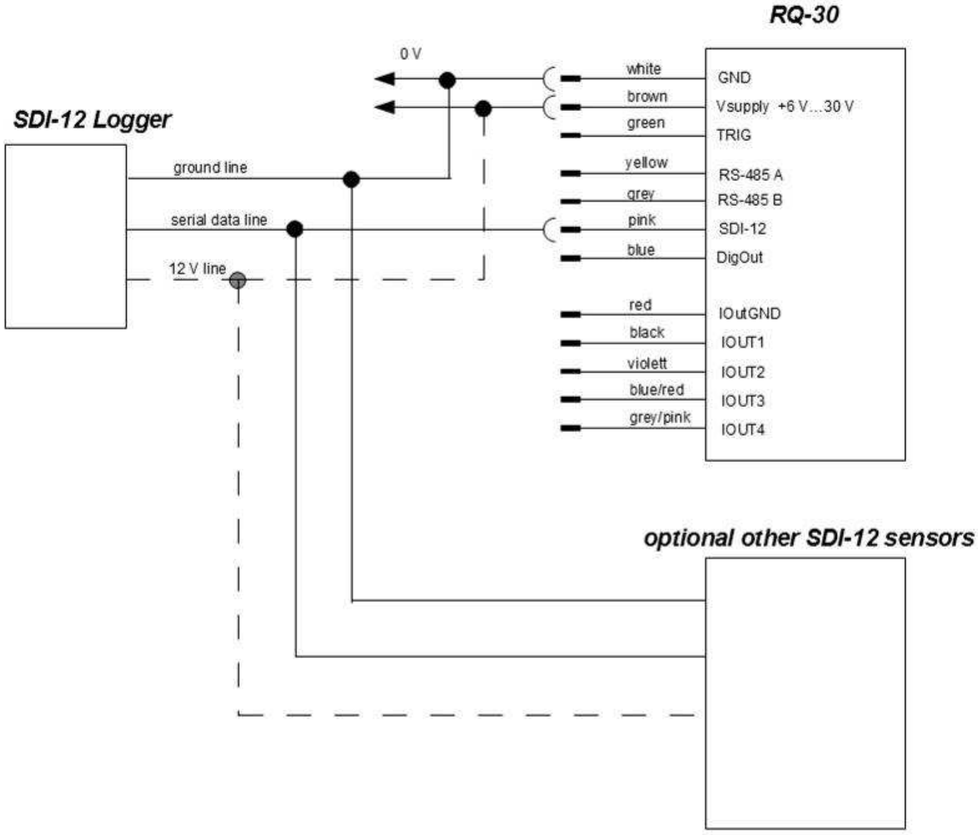


Figure 28: Connection schema for a data logger with SDI-12-485 interface

⚠	Comment	The connection with the 12 V wire for power supply is optional.

7.4. Modbus

The measurement values can be read out via the Modbus protocol by a Modbus master. In the radar sensor the Modbus protocol is not fully implemented for parameterization and controlling of the Sensor. Therefor the radar sensor has to be parameterized by the menu parameters.

With the delivery settings of the radar sensor an operation with the Modbus protocol is not possible. Therefore the sensor has to be set to Modbus compatible.

All supported Modbus functions and the register assignment are described in appendix 10.4.

7.4.1. Output protocol type Modbus

The output in the Modbus protocol is activated with the menu item "H-M-C Output protocol type" and the selection "Modbus".

7.4.2. Modbus default settings

The radar sensor can be simply set to Modbus compatible settings with the command "H-M-I MODBUS, set default". The settings include multiple parameters described in appendix 10.4.1.

If the settings of the Modbus master do not match the Modbus default settings of the radar sensor, the adoption of these parameters may only be performed after setting the radar sensor into Modbus default settings.

⚠	Attention	After performing the command "H-M-I MODBUS, set default" the connection settings of a local terminal or the software "RQCommander" have to be adjusted.

7.4.3. Modbus device address

The device address for the Modbus protocol can be changed with the menu item "H-M-J MODBUS, device address". The device address is predefined with 35 out of compatibility reasons.

7.4.4. Connection to a Modbus

The radar sensor is connected to a Modbus according to the following table. The labels correspond to the connector MAIN (see chapter 3.5.1) and the connection wire for the connector MAIN (see chapter 3.5.2).

Modbus	Connector MAIN	Connection wire	Description
Common	Pin A	White	GND
D1 - B/B	Pin D	Yellow	RS-485 A
D0 - A/A	Pin E	Grey	RS-485 B

Table 27: Connection to a Modbus

The radar sensor does not have termination resistors and does not need BUS polarization resistors. Therefor a RS-485 BUS termination has to be implemented extern.

⚠	Attention	The converter "USB-Nano 485" and the Modbus must never be connected simultaneously to the radar sensor.

8. Analog data output

⚠	Attention	The analog data output via the 4…20 mA outputs is only possible with the version RQ-30a.

Measurement values can be output via analog outputs. The settings for the analog outputs are located in the submenu "H-L 4-20 mA outputs". The pin configuration for the analog 4…20 mA outputs is described in chapter 3.5.

8.1. Analog outputs

IOUT1 – AUX

Output IOUT1 is reserved for the measurement values of optional sensors connected to the AUX input. The output corresponds to a linear equation defined by the span between 4 and 20 mA and the value of the 4 mA signal.

IOUT2 – level

At output IOUT2 the water level is output. The output corresponds to a linear equation defined by the span between 4 and 20 mA and the value of the 4 mA signal.

IOUT3 - velocity

Output IOUT3 is used for the velocity measurement. Only the 20 mA value for the maximum velocity can be set.

If only the flow direction downstream is allowed the 4 mA value corresponds to the velocity of 0. If both flow directions are possible the velocity of 0 is the half scale at 12 mA. The maximal negative velocity corresponds to 4 mA and the maximal positive velocity 20 mA.

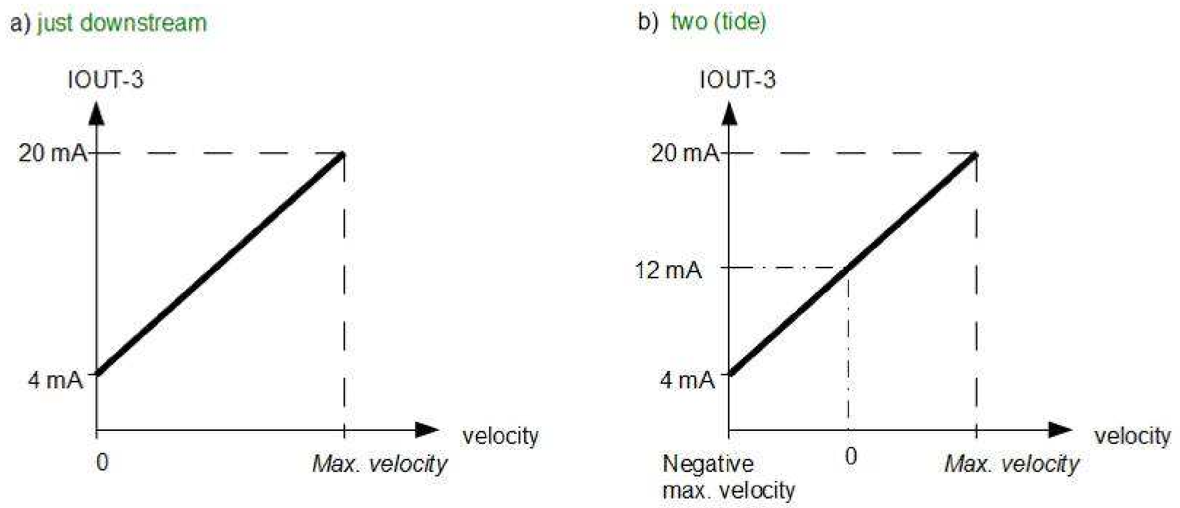


Figure 29: Definition of the 4 to20 mA signal with "E-B possible flow directions" (a) "just downstream" and (b) "two (tide)"

IOUT4 - discharge

Output IOUT4 is used for the discharge. The output is used according to the description of output IOUT3.

8.2. Status

The selection defines if and when the analog outputs are activated.

Off

The analog outputs are deactivated and are not used.

Just during TRIG

The analog outputs are only active, if an external signal is present at the TRIG input. The last measurement values are output.

Always on

The analog outputs are permanently active. The last measurement values are output.

8.3. Connection of a data logger

Data logger with analog inputs can be connected according to the following schema.

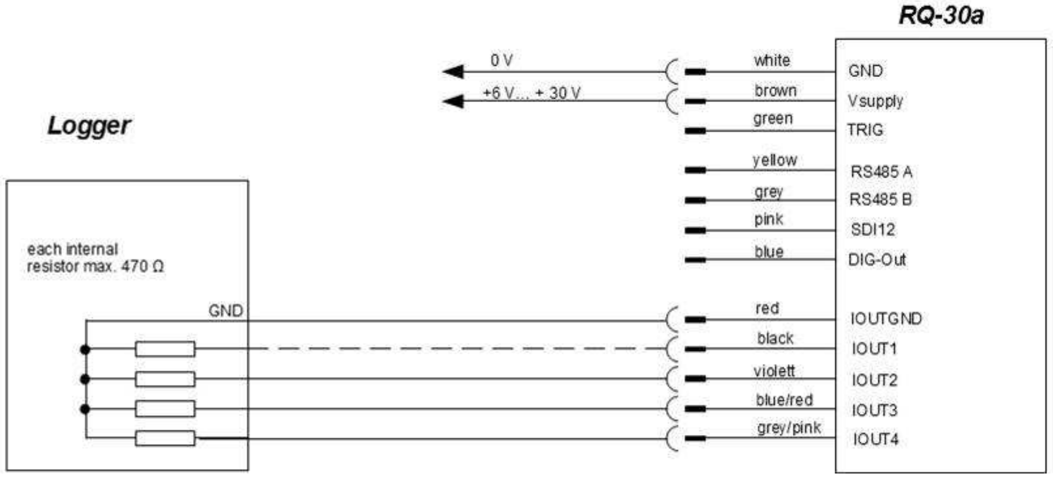


Figure 30: Connection schema for a data logger with analog inputs

⚠	Important	If a logger is connected to the IOUT outputs the resistance of the logger input should not exceed 470 Ω.

8.4. Simulate current output

This function allows the testing of the analog outputs. First a value between 4 and 20 mA is entered. After confirmation the corresponding simulated values for the analog outputs are displayed. Additionally the defined current value is output at the analog outputs. A connected data logger should now receive the simulated values. By another confirmation the simulation of the current output is finished.

9. Description of the parameter

The settings of the radar sensor are opened and changed either with a terminal program or the PC software "RQCommander" (see chapter 6.1.3).

Main menu			
A	Measurement trigger	interval	
B	Measurement interval	20	sec
C	AUX		
D	Level (W)		
E	Velocity (v)		
F	Discharge table (Q)		
G	DIG-OUT output		
H	Technics		
I	Special functions		
X	Exit		

Figure 31: Main menu

The parameters are arranged in a main menu with submenus. The menu items are selected by the entering the letter left to the label. Either submenus are opened or the selected parameter is displayed with its unit. Changes are confirmed with "Enter" or discarded with "Esc". Menus are closed with "X".

A Measurement trigger

Measurements are either started in an internal adjustable interval. Or they are externally triggered with the TRIG input or by commands via the RS-485 or SDI-12 interface.

Values	Parameter	Description
1 (default)	interval	Measurements are internally started in an interval.
2	TRIG input	Measurements are externally triggered with the TRIG input.
3	SDI-12/RS-485	Measurements are externally triggered by commands via the RS-485 or SDI-12 interface.

With the TRIG input measurements are started when the signal rises from low level (0...0.6 V) to high level (2...30 V).

The commands to trigger measurements with the RS-485 and SDI-12 interface are described in chapters 7.2.7 and 7.3.3.

The outputs of the measurement values are independent from the performing of measurements and are explicit set in the submenu "H-M RS-485 protocol". Outputs of measurement values are either performed directly after a measurement or they are requested by the TRIG input or by commands via the RS-485 or SDI-12 interface.

B Measurement Interval

The radar sensor has an internal measurement interval to start measurements activated by the menu item "A Measurement trigger". Measurements are automatically performed in the defined interval. However a measurement is always performed completely before a new one is started.

Unit	sec	seconds
Value range	1…18000	20 sec (default)

C AUX

AUX is the 0 to 2.5 V input for external measurements that can be used for different sensors. By default a contact-free temperature sensors is parameterized. The menu supports the start-up of the connected sensor. The parameterization of the input is in the submenu "H-I Tech. AUX".

AUX		
A	Mean value, no. of values	1
B	Test…	
C	Adjustment…	

Figure 32: Menu AUX

C-A Mean value, no. of values

The mean value of the external measurement can be calculated in the form of a moving average. The number of values defines how many measurement values are kept in the memory and are used for the calculation of the mean value.

Value range	2…120	Number of values for the calculation of the mean value.
Special function	1 (default)	No mean value is calculated.

C-B Test

A measurement at the input AUX is performed and the measurement result is displayed.

C-C Adjustment

A procedure to adjust the measurement value is started. First a measurement is performed and displayed. Afterwards a target value is set and confirmed. The measurement is then adjusted to exactly measure the target value.

D Level (W)

In the menu the parameter concerning the water level measurement at the measurement site are listed. The water level measurement itself is parameterized in the submenu "H-J Tech. level (W)".

Level (W)			
A	Mean value, no. of values	1	
B	Test…		
C	Adjustment…		
D	WRQ, RQ-30 fixation level	3351	cm
E	WMA, maximum level	0	cm
F	WLL, low level border	0	cm
G	WFS, flow stop level	0	cm
H	W-v table reset…		

Figure 33: Menu Level (W)

The menu items from "E" to "H" are related to the W-v relation (see chapter 6.5). If all these values are set to 0 no W-v relation is calculated.

D-A Mean value, no. of values

A mean value in the form of a moving average can be calculated for the water level. The number of values defines how many measurement values are kept in the memory and are used for the calculation of the mean value.

Value range	2…120	Number of values for the calculation of the mean value.
Special function	1 (default)	No mean value is calculated.

D-B Test

A measurement of the water level is performed and the measurement result is displayed.

D-C Adjustment

A procedure to adjust the measurement value is started. First a measurement is performed and displayed. Afterwards a target value is set and confirmed. The measurement is then adjusted to exactly measure the target value. The adjusting of the water level is described in chapter 6.3.2.1 in detail.

D-D WRQ, RQ-30 fixation level

The fixation level WRQ is the vertical position of the radar sensor in the reference system of the water level measurement. On the radar sensor it is the tip of the water level sensor. The setting of the fixation level is described in chapter 6.3.2.1 in detail.

Unit		Unit of the level (W)
Value range	-9999.99…99999.99	0 (default)

D-E WMA, maximum level

The maximum level WMA is the upper limit of the water level range for the calculation of the W-v-relation.

Unit		Unit of the level (W)
Value range	-9999.99…99999.99	0 (default)

D-F WLL, low level border

The low level border is the water level below that no valid velocity measurements are possible. The measurements of the water level are still possible and are performed.

It is the lower limit of the water level range for the calculation of the W-v-relation.

Unit		Unit of the level (W)
Value range	-9999.99…99999.99	0 (default)

D-G WFS, flow stop level

The flow stop level is the water level where the river ceases to flow. This does not have to be the river bed (see chapter 6.5.3).

For the water levels between the flow stop level and the low level border the velocities and discharges are extrapolated from the W-v relation.

Unit		Unit of the level (W)
Value range	-9999.99…99999.99	0 (default)

D-H W-v table reset

The W-v table is deleted and the W-v learning starts from scratch. This is especially necessary if water levels for the W-v relation are changed.

E Velocity (v)

In the menu the settings for the velocity measurement are parameterized.

Velocity (v)			
A	Viewing direction	upstream	
B	Possible flow directions	just downstream	
C	River inclination	0	deg
D	Pivot angle	0	deg
E	Measurement duration	20	sec
F	Filter, no. of values	1	
G	Filter, type	moving average	

Figure 34: Menu Velocity (v)

E-A Viewing direction

The setting defines the viewing direction of the radar sensor in relation to the flow direction of the river. The advantages of the different viewing directions are described in chapter 5.1.2.

Values	Parameter	Description
1	downstream	The radar sensor is directed in flow direction.
2 (default)	upstream	The radar sensor is directed against the flow direction.

E-B Possible flow directions

Due to the direction separation (see chapter 4.2.3) the radar sensor can identify the flow direction. Therefore it has to be defined, if the river only flows in one direction or if two flow directions can occur as for example under tidal influences.

Values	Parameter	Description
1 (default)	just downstream	Only downstream flowing velocities are output.
2	two (tide)	Down- and upstream flowing velocities are output. Upstream flowing velocities are indicated with a negative sign.

E-C River inclination

The radar sensor only measures its own vertical inclination. To compensate the influence of an inclination of the river surface an additional correction inclination can be set. It is either added or removed depending on the flow direction. Usually 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.

Unit	Degree	
Value range	0…90	0 (default)

E-D Pivot angle

Usually the main flow is normal to the cross section of a river and the radar sensor is mounted so as well. But if the radar sensor has to be directed in a horizontal angle, this angle can be considered for by adjusting this setting. It is recommended to not select an angle greater than 30° to ensure a reliable and accurate velocity measurement.

Unit	Degree	
Value range	0…60	0 (default)

E-E Measurement duration

The measurement duration defines the duration of a single measurement. During this time the radar signal is recorded and the radar spectrum is calculated.

Usually measurement durations of about 60 s are recommended. It should be at least 10 s. A long measurement time has influence on the power consumption.

Unit	sec	Seconds
Value range	5…240	20 sec (default)

E-F Filter, no. of values

Every single velocity measurement is saved internally in a buffer to use them for filtering. The setting defines the number of measurement values in the buffer. If the buffer is full the last value is replaced by the new value.

The number of values in the buffer depends on the dynamic of the water surface. Fast changing rivers have a high dynamic and demand a small buffer, smooth rivers or irrigation channels have a low dynamic and can use a large buffer.

Value range	1…120	
Special function	1 (default)	no filtering

E-G Filter, type

The velocity values in the buffer are filtered in the following ways.

Values	Parameter	Description
1 (default)	moving average	The mean value is calculated with all values in the buffer.
2	eliminate spikes	The mean value is calculated with all values in the buffer without the 5 highest values to eliminate upward spikes. If the buffer size is smaller than 10 half of the values are eliminated.
3	minimum value	The smallest value from the buffer is output.
4	medium value	All values of the buffer are sorted by size. The value in the middle is output.

F Discharge table

As described in chapter 4.3 the discharge is calculated from the measured water level and the measured velocity in consideration of the cross section area and the k-factors. The information of the cross section areas and the k-factor is edited in the discharge table.

Discharge table (Q)

	Status	Level (W)	K value	Area (A)
		[m]	[ ]	[m^2]
01	theor.	4,1	0,881	76,58
02	theor.	4,6	0,86	113,38
03	theor.	8,6	0,849	444,42
04	theor.	9,1	0,811	492,38
05	theor.	9,7	0,805	553,99
06	theor.	10	0,778	586,56
07	theor.	11,3	0,748	743,89
08	off	0	1	0
09	off	0	1	0
10	off	0	1	0
11	off	0	1	0
12	off	0	1	0
13	off	0	1	0
14	off	0	1	0
15	off	0	1	0
16	off	0	1	0

Figure 35: Menu Discharge table (Q)

The information is arranged in 16 lines in order from low to high water levels. The values for water level in between of two lines are linear interpolated. The determination of the discharge table is described in chapters 4.3 and 5.3.3. A simple possibility is to use the software "RQCommander Modelling" of Sommer GmbH. This program supports the calculation of the discharge table from a cross section profile and addition information and the simple transfer from the discharge table to the radar sensor.

⚠ Important In the sensor menu a leading 0 has to be entered when accessing a line by the line number.

F-A Status

The status describes the activity and priority of lines.

Values	Parameter	Description
1 (default)	off	The line is inactive.
2	theor.	The line is active with theoretical values from a model.
3	calib.	The line is active with calibrated values from reference measurements. These values have high priority.

Calibrated values dominate over theoretical values. If the measured water level lies between two calibrated lines the theoretical lines are ignored.

F-B Level (W)

The water levels are edited with increasing order from low to high water levels. The unit is defined in the submenu "H-O Units and decimals".

Unit		Unit of the level (W)
Value range	-9999.99…99999.99	0 (default)

F-C k value

The k-factor is the relation between the mean and the measured local velocity at the defined water level (see chapter 4.3.2). The value is absolute, i.e. a k-factor of 70 % is entered as 0.700.

Value range	0…99999.999	1 (default)

F-D Area (A)

The area corresponds to the filled part of the cross section area depending on the water level.

Unit		Unit of the area (A)
Value range	-9999.99…99999.99	0 (default)

G DIG-OUT output

The RQ-30 radar sensor supports the surveillance of discharges. The discharge is checked using a threshold value. A violation of the threshold causes the digital output to be set.

DIG-OUT output			
A	Trigger via	off	
B	Threshold type	threshold overrun	
C	Discharge threshold value	100	m^3/s
D	Discharge hysteresis	2	m^3/s

Figure 36: Menu DIG-OUT output

G-A Trigger via

The parameter activates the discharge surveillance and defines if the discharge of the device or a combined discharge of multiple devices is checked.

Values	Parameter	Description
1 (default)	off	Surveillance deactivated
2	discharge	Surveillance of the discharge of the device
3	multi-point discharge	Surveillance of the combined discharge

G-B Threshold type

The parameter defines the orientation of the threshold and if it is violated by an overrun or an underrun of the threshold.

Values	Parameter	Description
1 (default)	threshold overrun	Violation when overrunning the threshold
2	threshold underrun	Violation when underrunning the threshold

G-C Discharge threshold value

Unit		Unit of the discharge (Q)
Value range	-99999.99…999999.99	100 (default)

G-D Discharge hysteresis

The definition of a hysteresis suppresses multiple violations if the measurement value fluctuates in the range of the threshold. After a violation the hysteresis has to be overrun or underrun to cause a new violation. The hysteresis is an absolute value and is added in the correct orientation to the threshold.

Unit		Unit of the discharge (Q)
Value range	0…999999.99	2 (default)

H Technics

Technics			
A	Language/Sprache	english/englisch	
B	Decimal character	dot	
C	SDI-12 address	0	
D	Reset behavior	hard reset	
E	Inclination measurement	first measurement	
F	Sleep mode	idle	
G	W-v priority	no	
H	Area correction	0	m^2
I	Tech. AUX		
J	Tech. level (W)		
K	Tech. velocity (v)		
L	4-20 mA outputs		
M	RS-485 protocol		
N	RS-485		
O	Units and decimals		

Figure 37: Menu Technics

H-A Language/Sprache

The language of the sensor can be changed.

Values	Parameter	Description
1	german/deutsch	German language
2 (default)	english/englisch	English language

H-B Decimal character

The decimal separator is set for the complete sensor including output values and menu parameters.

Values	Parameter	Description
1	comma	
2 (default)	dot	

H-C SDI-12 address

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

Value Range	0…9	0 (default)

H-D Reset behavior

The radar sensor keeps some information in its memory as for example the inclination of the sensor, the last amplification and values for the calculation of mean values. This setting defines if this information is deleted on a sensor rest or not. During the installation a hard reset is recommended. After finishing the installation a soft reset should be selected to minimize the start-up time and suppress multiple adjustment of the inclination.

Values	Parameter	Description
1 (default)	hard reset	A reset deletes the complete historic information and determines it new.
2	soft reset	All historic information is kept and used for measurements and calculations.

H-E Inclination measurement

The measurement of the velocity has to be corrected with the inclination angle in which the radar sensor is directed to the water surface (see chapter 4.2.4). The inclination angle is measured by the internal inclination sensor of the radar sensor and stored in the memory. Every velocity measurement is automatically corrected with this inclination. The setting controls, when measurements of the inclination are performed.

Values	Parameter	Description
1 (default)	first measurement	The inclination is only measured prior to the first measurement after the initialization process (after switching on and after changes of parameters)
2	every measurement	The inclination is measured during every velocity measurement.

⚠ Important If the inclination of the radar sensor can change (i.e. if mounted on a cable way), the inclination has to be measured new for every velocity measurement.

H-F Sleep mode

The parameter defines the behavior of the radar sensor in the pause between measurements. Thereto the measurement interval has to be higher than the duration of a complete measurement cycle.

Values	Parameter	Description
1	MODBUS, fast	The radar sensor stays in normal mode.
2(default)	MODBUS, slow	The radar sensor stops its program and can be woken up by the RS-485 interface.
3	standard	The radar sensor stops its program and can be woken up by the RS-485 interface only with time delay.

H-G W-v priority

The setting defines if the measured or learned values of the velocity and the discharge are output (see chapter 6.5). The output includes values in the serial output strings (see chapter 7.2.6 and 7.3) and the analog outputs (see chapter 8.1).

Values	Parameter	Description
1 (default)	no	The measured velocities and discharges are output in the main values and the learned velocities and discharges are output in the special values.
2	yes	The learned velocities and discharges are output in the main values and the measured velocities and discharges are output in the special values.

⚠	Important	For water levels below the low level border always the learned velocities and discharges are output.

H-H Area correction

In case of slight changes of the river bed and consequently the cross section area a positive or negative correction value can be applied to adjust the discharge table to the new situation.

Unit		Unit of the area (A)
Value range	-99999.99…999999.99	0 (default)

H-I Tech. AUX

This submenu contains all technical parameters for the AUX input. This is the 0 to 2.5 V input for an optional sensor.

Tech. AUX			
A	Status	off	
B	Supply	switched	
C	Hold-back time	3	sec
D	0-2.5 V input span	100	C
E	0 V input value	-20	C

Figure 38: Submenu Tech. AUX

H-I-A Status

The setting controls if the AUX input is used. If no sensor is connected it is recommended to set the status to "off" to minimize power consumption.

Values	Parameter	Description
1 (default)	off	The AUX input is switched off.
2	on	The AUX input is switched on.

H-I-B Supply

For an efficient energy management the supply of the optional sensor connected to the AUX input can be switched.

Values	Parameter	Description
1 (default)	switched	The supply is only switched on for measurements.
2	always on	The supply is always on.
3	always off	The supply is always off.

H-I-C Warm-up time

Sensors usually demand a specific time between the switching on of the sensor and the provision of valid measurement. Therefore the sensor waits the defined hold-back time span after switching on the power supply and performing a measurement of the AUX input.

Unit	sec	seconds
Value range	0…255	3 (default)

H-I-D 0-2.5 V input span

The AUX input is a 0 to 2.5 V input. The span defines the range from 0 to 2.5 V for the selected unit.

Unit		Unit of AUX
Value range	-99999.99…999999.99	100 (default)

H-I-E 0V input value

The input value defines the value at 0 V in the selected unit.

Unit		Unit of AUX
Value range	-99999.9…999999.99	-20 (default)

H-J Tech. level (W)

In this submenu contains the technical parameters for the water level measurement.

Tech. level (W)			
A	Supply	always on	
B	Hold-back time	60	sec
C	Input span	-15000	mm

Figure 39: Submenu Tech. Level (W)

H-J-A Supply

For an efficient energy management the supply of the water level sensor can be switched.

Values	Parameter	Description
1	switched	The supply is only switched on for measurements.
2 (default)	always on	The supply is always on.
3	always off	The supply is always off.

H-J-B Warm-up time

The hold-back time is the time the sensor waits between switching on the supply and performing a measurement. The water level sensor demands 60 s before valid measurements are available. So for switched power supply the hold-back time has to be at least 60 seconds. If the supply is not switched the hold-back time can be set to 0.

Unit	sec	Seconds
Value range	0…255	60 (default)

H-J-C Input span

The water level sensor provides a signal of 4 to 20 mA. The span defines the range from 4 to 20 mA in the selected unit of the water level.

Unit		Unit of the level (W)
Value range	-9999999…99999999	-15000 (default for standard range of 15 m) -35000 (default for extended range of 35 m)

Usually the default value should not be changed as the parameter has to correspond to the settings in the water level sensor.

H-K Tech. velocity (v)

In this submenu contains the technical parameters for the velocity measurement.

Tech. velocity (v)			
A	Minimum velocity	150	mm/s
B	Maximum velocity	5000	mm/s
C	Spectral trap, veloc. rise	200	mm/s
D	Meas. spot optimization	standard	
E	Measurement type	continuous	
F	Stop, min. quality (SNR)	30	
G	Stop, max. opp. direction	50	%
H	Stop, number of valid meas.	3	
I	Stop. behavior	use replace value	
J	Stop, replace value	0	m/s
K	Start veloc. at WLL	0	m/s
L	Velocity output	surface velocity	

Figure 40: Submenu Tech. velocity (v)

H-K-A Minimum velocity

The minimum velocity defines the starting velocity of the spectral analysis. No lower velocities can be measured.

Unit	mm/s	
Value range	0…1500	150 (default)

H-K-B Maximum velocity

The maximum velocity defines the maximum expected velocity. The velocity measurement is optimized for this setting. Usually a value of 5000 mm/s (5 m/s) is sufficient. No security has to be accounted for as it is automatically included in the radar sensor.

Unit	mm/s	
Value range	2500…30000	5000 (default)

H-K-C Spectral trap, veloc. Rise???

The radar sensor has the possibility to save spectra of special events. The output of these spectra can be requested. The parameter defines the velocity increase between to measurements from that on the spectra are saved.

Unit	mm/s	
Value range	16…30000	200 (default)

H-K-D Meas. spot optimization

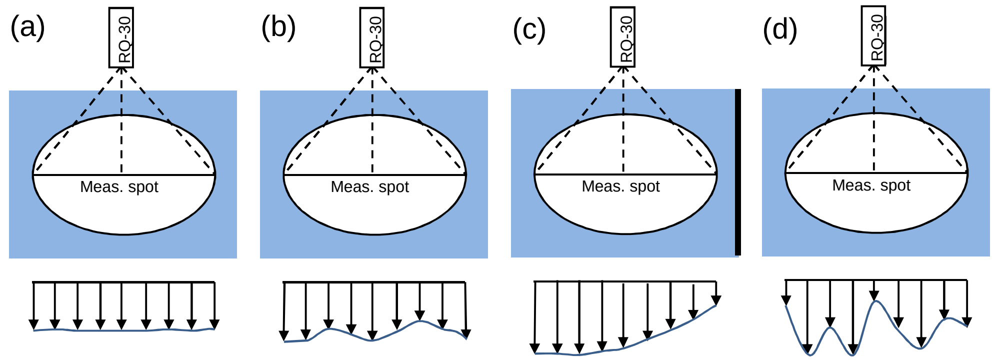


Figure 41: Measurement spot optimization: (a) very constant veloc. (b) standard (b) bank area (d) splash water

The parameter describes the expected velocity distribution in the measurement spot. The irregular the distribution is, the wider the spectral band width has to be selected. The analysis algorithm for the velocity is optimized for this setting by the radar sensor.

For the first measurements at a new measurement site the selection "standard" is recommended. Later on the measurement may be optimized by selecting another river type.

Values	**Parameter**	**Description**
1	very constant veloc.	homogenous water surface, small bandwidth
2 (default)	standard	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

H-K-E Measurement type

The measurement with the length of the measurement duration can be measured continuously in one piece or divided in parts.

Values	Parameter	Description
1 (default)	continuous	The measurement is measured in one piece.
2	sequenced	The measurement is measured divided into five parts.

Continuous measurement type

The complete measurement duration is measured continuously in one piece. This has the advantage of a fast measurement using little energy. But for high fluctuations of the velocity the measurement time has to be selected very long to receive representative results.

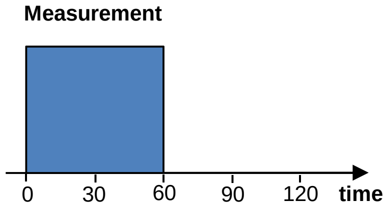


Figure 42: Continuous measurement type

Sequenced measurement type

The measurement duration is divided randomly in five parts and is measure with randomly distributed breaks. This increases the complete measurement duration but the energy consumption stays equal. This has the advantage that with the same measurement time a longer time range can be observed without increasing the energy consumption. Especially for high fluctuations of the velocity this method provides better results.

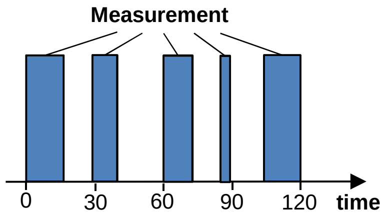


Figure 43: Sequenced measurement type in five blocks

H-K-F Stop, min. quality (SNR)

The parameter defines a lower limit for the value of the quality (SNR), below that measurements are identified as invalid. Invalid measurements are handled according to the menu item "H-K-I Stop, behavior".

A low quality (SNR) occurs if the velocity is below a measureable value. Especially measurement site in tidal influences or with back-water and where the velocity can decrease to 0 the usage of this parameter is recommended.

Unit	??	
Value range	7…100	30 (default)

H-K-G Stop, max. opp. direction

The opposite direction content is the relation between the velocity distributions in analysis direction and opposite direction. The parameter defines an upper limit for the opposite direction content, above that measurements are identified as invalid. Invalid measurements are handled according to the menu item "H-K-I Stop, behavior".

Unit	%	
Value range	10…1000	
Application area	30…100	50 (default)

H-K-H Stop, number of valid meas.

After invalid measurements this number of valid measurements has to occur, to identify the measurement as valid again.

Value range	1…20	3 (default)

H-K-I Stop, behavior

The parameter defines the handling of invalid measurements (stop measurements).

Values	Parameter	Description
1	hold value	The last valid value is output.
2 (default)	use replace value	The replace value is output (see "H-K-J Stop, replace value")
3	use learn value	The learned value from the W-v relation is output according to the water level.

H-K-J Stop, replace value

The parameter is the replace value for invalid measurements (stop measurements)

Unit	m/s	
Value range	-9999.999…99999.999	0 (default)

H-K-K Start veloc. at WLL

During the installation this parameter can be set, if the water level is between the low level border WLL and the flow stop level WFS). So discharge values can instantly be output. As soon as the water level is above the low level border WLL this parameter is not relevant any more.

Unit	m/s	
Value range	-9999.999…99999.999	0 (default)

H-K-L Velocity output

The setting defines the type of velocity for all output values (see chapter 4.3.1).

Values	Parameter	Description
1 (default)	surface velocity	The velocity is output as local surface velocity v_l.
2	mean profile veloc.	The velocity is output as mean velocity v_m

		($v_m = k\ (W) \cdot v_l$).

H-L 4-20 mA outputs

⚠ Attention	The submenu is only available in the version RQ-30a.

The settings control the 4 to 20 mA outputs for measurement values (see chapter 8.1)

4-20 mA outputs			
A	Status	always on	
B	IOUT1, AUX 4-20 mA span	100	C
C	IOUT1, AUX 4 mA value	-20	C
D	IOUT2, level 4-20 mA span	2000	cm
E	IOUT2, level 4 mA value	-1000	cm
F	IOUT3, Max. velocity	10	m/s
G	IOUT4, Max. discharge	100	m^3/s
H	Simulate current output		

Figure 44: Submenu 4-20 mA outputs

H-L-A Status

The selection defines, if and when the analog outputs are activated.

Values	Parameter	Description
1	off	The analog outputs are deactivated and are not used.
2	just during TRIG	The analog outputs are only active, if an external signal is present at the TRIG input.
3 (default)	always on	The analog outputs are permanently active.

H-L-B IOUT1, AUX-IN 4-20 mA span

The span defines the output range from 4 to 20 mA for the sensor connected to the AUX input.

Unit		Unit of AUX
Value range	-99999.99…999999.99	100 (default)

H-L-C IOUT1, AUX-IN 4 mA value

The value is the 4 mA output value for the sensor connected to the AUX input.

Unit		Unit of AUX
Value range	-99999.99…999999.99	-20 (default)

H-L-D IOUT2, level 4-20 mA span

The span defines the output range from 4 to 20 mA for the water level. The span should be selected to cover the complete expected water level range. Additionally the span should be a whole number and simple.

Example

Minimum:	120 cm
Maximum:	1450 cm
Difference:	1330 cm
4-20 mA span:	1600 (100 cm corresponds to1 mA)
4 mA value	0

Unit		Unit of the level (W)
Value range	-9999999…99999999	2000 (default)

H-L-E IOUT2, level 4 mA value

The value is the 4 mA output value for the water level. The value should be below the minimal expected water level and should be simple.

Unit		Unit of the level (W)
Value range	-9999999…99999999	-1000 (default)

H-L-F IOUT3, Max. velocity

The velocity range for the output is defined from 0 to a maximal velocity. Therefor the 4 mA value is predefined at 0 and only the 20 mA value is set as maximal velocity.

Unit		Unit of the velocity (v)
Value range	-9999.999…99999.999	10 (default)

H-L-G IOUT4, Max. discharge

The discharge range for the output is defined from 0 to a maximal discharge. Therefor the 4 mA value is predefined at 0 and only the 20 mA value is set as maximal discharge.

Unit		Unit of the discharge (Q)
Value range	-99999.99…999999.99	100 (default)

H-L-H Simulate current output

This function allows the testing of the analog outputs. First a value between 4 and 20 mA is entered. After confirmation the corresponding simulated values for the analog outputs are displayed. Additionally the defined current value is output at the analog outputs. A connected data logger should now receive the simulated values. By another confirmation the simulation of the current output is finished.

H-M RS-485 protocol

In this submenu the data output via the RS-485 interface is defined.

RS-485 protocol			
A	Device number	1	
B	System key	0	
C	Output protocol type	Sommer	
D	Measurement-Output (MO) time	after measurement	
E	MO information	& special values	
F	MO wake-up sequence	prefix	
G	MO prefix hold-back	300	ms
H	MO inact. timeout for prefix	19	sec
I	MODBUS, set default		
J	MODBUS, device address	35	

Figure 45: Submenu RS-485 protocol

H-M-A Device number

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

Value range	0…98	1 (default)

H-M-B System key

The system key defines the own bus system. Thereby different conceptual bus systems can be separated. These occur if remote radio coverages of two measurement systems overlap. In general the setting should be set to 00.

Value range	0…99	0 (default)

H-M-C Output protocol type

The type of the serial output protocol is set. The protocols are described in chapter 7.2.6.

Values	Parameter	Description
1 (default)	Sommer	Sommer protocol
2	standard	Standard protocol
3	compatible A	MIO protocol with checksum (comp. RQ-24)
4	compatible B	MIO protocol with CRC-16 (comp. RQ-24)
5	compatible C	Standard protocol (comp. RQ-24)
6	MODBUS	Modbus protocol

H-M-D Measurement Output (MO) time

The type of triggering the serial data outputs is defined.

Values	Parameter	Description
1	just per command	The output is only requested by commands via the RS-485or SDI-12 interface.
2 (default)	after measurement	The serial data output is performed automatically right after every measurement.
3	pos. TRIG slope	The serial data output is triggered by an increasing slope on the TRIG input.

H-M-E MO information

The main values are always included in a data output. Additional special values and analysis values can be output (see chapter 7.1).

Values	Parameter	Description
1	main values	Only the main values are output
2 (default)	& special values.	Main values and special values are output.
3	& analysis values	Main, special and analysis values are output

H-M-F MO wake-up sequence

If output data is transmitted automatically without requesting the data to a recording device, many devices demand a wake-up sequence before the data can be received and processed. The radar sensor has the possibility of a sync sequence and a prefix (see chapter 7.2.5). The sync sequence is "UU~?~?" and is sent directly before the output string. The prefix is a blank sent with a time delay before the output string.

Values	Parameter	Description
1	off	No wake-up sequence
2	sync	"UU~?~?" directly before the output string
3 (default)	prefix	a blank with time delay before the output string
4	prefix & sync	a blank with time delay and "UU~?~?" directly before the output string

H-M-G MO prefix holdback

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

Unit	ms	Milliseconds
Value range	0…5000	300 (default)

H-M-H MO inact. timeout for prefix

A prefix is used to wake-up receiving devices. These are usually kept awake for a specific time. Therefore no new prefix is necessary in this time. The parameter defines the time the output has to be inactive before a new prefix is sent.

Unit	sec	Seconds
Value range	0…60	19 (default)

H-M-I MODBUS, set default

The specification of the Modbus demands a defined default setting including multiple parameters. This command sets all these parameters (see appendix 10.4.1).

H-M-J MODBUS, device address

The setting is the unique device address for the Modbus protocol.

Value range	1…247	35 (default)

H-N RS-485

In this submenu the connection settings for the RS-485 interface are defined (see chapter 6.1.2).

RS-485			
A	Baud rate	9600	
B	Parity, stop bits	no par., 1 stop	
C	Minimum response time	0	ms
D	Transmitter hold-back	20	ms
E	Flow control	off	
F	Sending window	500	ms
G	Receiving window	400	ms

Figure 46: Submenu RS-485

H-N-A Baud rate

The transmission rate in bps is selected.

Values	Parameter
1	1200
2	2400
3	4800
4 (default)	9600
5	19200
6	38400
7	57600
8	115200

H-N-B Parity, stop bits

The parameter sets the RS-485 settings for parity and stop bits together.

Values	Parameter	Description
1 (default)	no par, 1 stop	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

H-N-C Minimum response time

The parameter makes sure that no interferences of commands and answers at the RS-485 interface occur. Thereto the answers are delayed by the selected time. Additional the parameter can guarantee that the answer is kept compact.

Unit	ms	Milliseconds
Value range	0…2000	0 (default)

H-N-D Transmitter warm-up time

The interface waits the defined time before data is sent.

Unit	ms	Milliseconds
Value range	0…2000	20 (default)

H-N-E Flow control

The XOFF-XON flow control can be activated for the communication.

Values	Parameter	Description
1 (default)	off	no flow control
2	XOFF-XON blocking	XOFF-XON flow control, especially adapted for half-duplex systems

H-N-F Sending window

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

Unit	ms	Milliseconds
Value range	200…5000	500 (default)

H-N-G Receiving window

If the XON-XOFF flow control is activated a break is performed between the transmissions of the blocks. The length of these breaks in ms is set.

Unit	ms	Milliseconds
Value range	200…5000	400 (default)

H-O Units and decimals

Units and decimals		
A	AUX unit	C
B	AUX decimals	1
C	Level (W) unit	cm
D	Level (W) decimals	1
E	Velocity (v) unit	m/s
F	Velocity (v) decimals	3
G	Discharge (Q) unit	m^3/s
H	Discharge (Q) decimals	2
I	Area (A) unit	m^2
J	Area (A) decimals	2

Figure 47: Submenu Units and decimals

⚠	Important	These settings have to be defined prior to all following settings as internal information is saved in the defined formats. After a later adjustment all settings in the menu have to be checked and adjusted.

H-O-A AUX unit

The unit for the measurement of the optional sensor at the input AUX is set as a text.

Value range	8 characters	C (default)

H-O-B AUX decimals

The number of the places after the decimal character is defined for the measurement values of the optional sensor at the AUX input.

Value range	0…6	1 (default)

H-O-C Level (W) unit

The unit of the water level is selected.

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

H-O-D Level (W) decimals

The number of the places after the decimal character is defined for the water level.

Value range	0…6	1 (default)

H-O-E Velocity (v) unit

The unit of the velocity is selected.

Values	Parameter	Description
1	mm/s	Millimeter per second
2 (default)	m/s	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

H-O-F Velocity (v) decimals

The number of the places after the decimal character is defined for the velocity.

Value range	0…6	3 (default)

H-O-G Discharge (Q) unit

The unit of the discharge is selected.

Values	Parameter	Description
1	l/s	Liter per second
2 (default)	m^3/s	Cubic meter per second
3	ft^3/s	Cubic feet per second
4	yd^3/s	Cubic yard per second
5	us. Gal/s	US gallons per second
6	en. Gal/s	English gallons per second
7	Ml/d	Megaliter per day

H-O-H Discharge (Q) decimals

The number of the places after the decimal character is defined for the discharge.

Value range	0…6	3 (default)

H-O-I Area (A) unit

The unit of the area is selected.

Values	Parameter	Description
1	dm^2	Square decimeter
2 (default)	m^2	Square meter
3	ft^2	Square feet

4	yd^2	Square yard

H-O-J Area (A) decimals

The number of the places after the decimal character is defined for the area.

Value range	0…6	2 (default)

I Special functions

Special functions	
A	View spectral distribution
B	Veloc. radar inspection
C	View spectral trap
D	View setup
E	Device status
F	W-v table view
G	W-v table reset
H	Set factory default
I	Temp load factory default
J	Relaunch program
	Replace program

Figure 48: Menu Special functions

I-A View spectral distribution

With this command the radar sensor is set into spectral mode. After every measurement the spectral velocity distribution for both movement directions is output in a table. Subsequent additional information is output. The spectral mode is automatically closed after 30 minutes.

With the software "RQCommander" the spectra can be received, visualized and stored. So experts can analyze the velocity measurement at a measurement site (see chapter 6.3.3.3).

I-B Veloc. radar inspection

With this command the radar sensor is set into the inspection mode. This means that the radar accuracy with the calibration box is checked.

I-C View spectral trap

The radar sensor has to possibility to save spectra of special events. This command outputs these spectra. One output includes four spectra.

Index	Spectrum	Description
1	**Stop**	Spectrum of the last invalid measurement caused by a Stop event
2	**Reference**	Spectrum of the measurement directly prior to the last event with the velocity increase according to menu item "H-K-C Spectral trap,

		veloc. rise".
3	**Trap**	Spectrum of the measurement of the last event with the velocity increase according to menu item "H-K-C Spectral trap, veloc. rise".
4	**Normal**	Actual spectrum

Table 28: Spectra in the spectral trap results

I-D View setup

All parameters of the radar sensor are output sequentially as text.

I-E Device status

Displays information about the sensor, version and status

I-F I-DW-v table view

The learned W-v table is output as a table.

I-G W-v table reset

The learned W-v table is complete deleted and is generated new.

I-H Set factory default

All parameters are set to the default values predefined by the manufacturer.

I-I Temp. load factory default

In a temporary mode all default values are loaded. The settings cannot be edited but they can be checked. The temporary mode is terminated when closing the main menu.

I-J Relaunch program

The sensor is restarted. The procedure is equivalent to switching the supply off and on.

I-K Replace program

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

10. Appendix

10.1. Measurement values

10.1.1. Special values and error values

Measurement values can have special values or error values.

Value	Description
9999.998	Initial value: No measurement was performed yet.
9999.997	Converting error
9999999	Positive overflow
-9999999	Negative overflow

Table 29: Special values and error values

10.1.2. Quality value

The quality value provides information to the velocity measurement and distribution. The parameter is a decimal number consisting out of the following parameters.

Parameter	Position
Validity of the measurement	Sign
SNR	Number before the decimal character
Amplification	First figure after the decimal character
Band width class	Second figure after the decimal character

Table 30: Parameters of the quality value

Validity of the measurement

Measurements with a negative sign have been identified as invalid (stop measurements). The criterion for the invalidity is an opposite direction content above the threshold of menu item "H-K-G Stop, max. opp. direction". The quality of measurements, that are declared as invalid by a quality (SNR) below the threshold of menu item "H-K-F Stop, min. quality (SNR)", are not signed negative.

SNR

The Signal-to-Noise Ratio is the most important parameter in the quality value. The SNR is the positive number before the decimal character and is output in dB. Usually a SNR lower than 30 refers to an insufficient velocity measurement.

Amplification

Received radar signal can be variably strong. Reasons are beneath others the condition of the water surface, the presence of waves and the distance to the reflector.

The amplification of the radar sensor is automatically adjusted for the measured signal. The lowest amplification is 0, the highest is 9. If the amplification is high, the echo of the radar signal is weak. So amplifications with the value 0 are optimal and with the value 9 they are bad.

Band width class

The band width class depends on the spectral velocity distribution. A high band width corresponds usually with a turbulent river type (i.e. "Splash water"), a low band width with a smooth river type (i.e. "consistent"). This assignment is not very accurate. Observations of the flow conditions at the measurement site always have to be considered.

Band width class	Quotient of width over velocity
0	< 0.25
1	> 0.25
2	> 0.5
3	> 0.75
4	> 1
5	> 1.25
6	> 1.5
7	> 1.75
8	> 2

Table 31: Definition of band with classes

10.2. RS-485 interface

10.2.1. Protocols

10.2.1.1. Sommer protocol

Header

The header of output strings in Sommer protocol is used to identify the data by the system key, the device number and the string number.

Parameter	Format	Description
Start character	#	
Identifier	M	"M" identifies an output string
System key	dd	2 numbers
Device number	dd	2 numbers
Command ID	G	"G" defines an output string with string number
String number	dd	00 Main values 01 Special values 02 Analysis values 1 03 Analysis values 2
Command	se	"se" identifies automatically sent values
Example	**#M0001G00se**	

Table 32: Header of the Sommer protocol

Measurement value

Output strings in Sommer protocol contain multiple measurement values. The values are output sequenced. For a value 8 characters are reserved. A decimal number may contain maximal 7 numbers; the 8 character is reserved for the decimal character. The values are output right-aligned, so blanks may occur between index and value.

Parameter	Format	Description
Index	dd	2 numbers
Value	xxxxxxxx	8 character right-aligned
Separator	|	
Example	**00 9.15|**	

Table 33: Values in Sommer protocol

End sequence

The output string is finished with a CRC-16 and an end character. The CRC-16 is described in chapter 10.2.4. After the output string the control characters "Carriage return" and "Line feed" are output.

Parameter	Format	Description
CRC-16	hhhh	4 hex characters
End character	;	
Control characters	[CR][LF]	"Carriage return" and "Line feed"
Example	**9E31;[CR][LF]**	

Table 34: End sequence of the Sommer protocol

10.2.1.2. Standard protocol

Header

In the header auf output strings in Standard protocol measurement values and analysis values are differed. The radar sensor is identified by the system key and device number.

Parameter	Format	Description
Identifier	X_	"M_" Measurement values "Z_" Analysis values
System key	dd	2 numbers
Device number	dd	2 numbers
Example	**M_0001**	

Table 35: Header of the Standard protocol

Measurement values

Output strings in Standard protocol contain multiple values. The measurement values are output sequenced and are separated by a blank. For a value 8 characters are reserved. A decimal number may contain maximal 7 numbers; the 8 character is reserved for the decimal character. The values are output right-aligned, so additional blanks may occur.

Parameter	Format	Description
Separator	[blank]	blank
Value	xxxxxxxx	8 character right-aligned
Example	**9.15**	

Table 36: Values in Standard protocol

End sequence

The output string is finished with the control characters "Carriage return" and "Line feed".

Parameter	Format	Description
Control characters	[CR][LF]	"Carriage return" and "Line feed"

Table 37: End sequence the Standard protocol

10.2.2. Commands and answers

The structure of commands and answers is described in the table below.

Parameter	Format	Description
Start character	#	
Identifier	X	Capital letter
System key	dd	2 numbers
Device number	dd	2 numbers
Command	xxx	Command
Separator	|	
CRC-16	hhhh	4 hex characters (only W commands)
End character	;	
Example	**#W0001$mt|BE85;**	

Table 38: Structure of commands and answers

Identifier

The following identifiers are available. "A" is returned from the receiving device.

Identifier	Description
W	Request or write command with receiving confirmation
S	Request command without receiving confirmation
R	Read command
A	Answer/ receiving confirmation

Table 39: Identifier

Commands

The following commands can be used with the radar sensor.

Command	Description
$mt	Triggering of a complete measurement
$pt	Requesting of output strings
_dd0cv	Requesting of single measurement values "dd"…measurement index according to chapter 7.1
XX	Reading of a parameter of the sensor menu "XX"…Identifier of the parameter in the sensor menu
XX=xxxx	Setting of a parameter of the sensor menu "XX"…Identifier of the parameter in the sensor menu "xxx"…new value for the parameter

Table 40: List of commands

Examples

Command	Answer	Description
#W0001$mt|BE85;	#A0001ok$mt|4FA9;	Triggering of a measurement
#S0001$pt|	none	Requesting of output strings
#R0001_010cv|EA62;	#A0001ok_010cv874,9 |5997;	Requesting the water level with 01
#R0001B|228E;<	#A0001B=10|0D03;	Reading the measurement interval (menu item B)
#W0001B=15|B57C;	#A0001B=15|0803;	Setting the interval to 15 s (menu item B)

Table 41: Examples of RS-485 commands

10.2.3. Error codes

During the communication via the RS-485 interface the following errors can occur. The error code is bit coded. The single errors are in hex format. If multiple errors are present the error numbers are summed.

Error number	Description
0x0001	"Mistake: please just enter valid values!"
0x0002	"Mistake: please just enter menue choice characters!"
0x0004	"Abortion!"
0x0008	"Timeout!"
0x0010	"Adjustment done!"
0x0020	"Testmode finished!"
0x0040	"ATTENTION: parameter conflict (view manual)!"
0x0080	"Testmode back to menu!"
0x0100	"Denied, due to temporarily loaded menu!"
0x0200	"Testmode aborted!"
0x0400	"Error: CRC failure!"
0x0800	"Restarted testmode!"
0x1000	"ATTENTION: Please make a "W-v table reset"!

Table 42: Error numbers

10.2.4. Sommer CRC-16

The CRC-16 (cyclic redundancy check) of the Sommer protocol is based in the following CRC table, a fixed one-dimensional field with 256 unsigned values in 16 bit hex format. When receiving data the receiving device calculates the CRC value. This value is compared with the received CRC value to check if the data has string been transferred accurate.

```
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
}
```

Table 43: CRC-16 table

The CRC-16 value is calculated stepwise character by character. When the CRC of the complete string is calculated, it is added at the ending of the string and finished with a semicolon.

When calculating the CRC of an existing string, the calculation of the CRC is stopped at the fifth character before the ending semicolon right before the CRC. The calculated CRC then is compared to the received one. If they are identical the string was sent correctly.

The start value for the initial CRC-16 calculation is always 0. The CRC-16 of a single character is calculated according to the following procedure.

Parameter	**remark**
byte1 = Crc16 right shift by 8 bits	(Upper byte vanishes)
uint1 = c	(new character, Upper byte = 0)
uint2 = Crc16 left shift by 8 bits	(Lower byte = 0)
uint3 = crc16tab[byte1]	Table value from the CRC-16 table
Crc16 = uint3 (excl. Or) uint2 (excl. Or) uint1	

Figure 49: Procedure of CRC-16 calculation

The same procedure expressed in C code:

```
Crc16 = crc16tab[(unsigned char)(Crc16>>8)] ^ (Crc16<<8) ^ (unsigned int)(c);
```

Figure 50: Procedure of CRC-16 calculation in C

Example

String with CRC-16
#M0001G00se00   9,15|01   1,075|02   1,347|03   8,91|04   1,61|0599999,98|3FF7;

Figure 51: Example of a string with CRC-16

The first character is "#", the last character for the CRC-16 calculation is the separator "|". The CRC-16 of the string is 3FF7. The end character is ";". The CRC-16 is calculated sequentially with the start value 0 for the initial CRC-16 calculation.

Position	**String**	**CRC-16**
Start		0000
0	#	0023
1	#M	234D
2	#M0	5931
3	#M00	FAEC
4	#M000	A265
5	#M0001	F099
….	….	….

Figure 52: Example of a CRC-16 calculation

10.3. SDI-12 interface

In this manual only the most important aspects corresponding to the RQ-30 are mentioned. A detailed description of SDI-12 standards can be accessed by the following link:

http://www.sdi-12.org

10.3.1. Structure of SDI-12 commands

Parameter	Format	Description
SDI-12 address	d	1 number
Command	Xxxxx	Capital letter, letters and numbers
End character	!	
Example	**0XWA=0!**	

Table 44: Structure of SDI-12 commands

10.3.2. Sensor identification

The requesting of the sensor identification is performed with the SDI-12 command "aI!" with "a" standing for the SDI-12 address of the device.

Command	Answer
0I!	013Sommer RX-30 170r00 RQ-30a[CR][LF]

Table 45: Example of a sensor identification request

In the answer the following information is included.

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)
RX-30	Description of the firmware (5 characters and 2 blanks)
170r00	Firmware version (6 characters and 2 blanks)
RQ-30a	Comment (max. 13 characters)

Table 46: Answer to a sensor identification request

10.3.3. Requesting of measurement values

The requesting of the complete measurement values is performed with the SDI-12 commands "aR0!" and "aR1!" with "a" standing for the SDI-12 address of the device.

Command	Answer
0R0!	0-16.5+8964+2.452+29.93+0.00+99999.98+2.444+0.00[CR][LF]
0R1!	0+46+15.13[CR][LF]

Table 47: Example of a measurement values request

In the answer string the main values and the special values are included according to the sequence from chapter 7.1.

0	SDI-12 address
-16.5	AUX
+8964	Water level
+2.452	Velocity[6]
+29.93	Quality (SNR) (see appendix 10.1.2)
+0.00	Discharge[6]
+99999.98	Cross section area
+2.444	learned velocity[6]
+0.00	learned discharge[6]
+46	Opposite direction content
+15.13	Supply voltage

Table 48: Answer to a measurement values request

10.3.4. Requesting of measurement values measured before

Measurement values are requested with the SDI-12 command "aDn!" with "a" standing for the SDI-12 address of the device and "n" for the index of the data strings.

The maximal number of characters is usually 35. So the data output has to be stacked from longer data strings. With every stack the data index is increased. The measurement values follow the sequence from chapter 7.1 but the supply voltage is not output.

Command	Answer
0M!	00649[CR][LF]
0D0!	0+999999.8+99999998+0.683+3.02[CR][LF]
0D1!	0+99999.98+99999.98+9999.998[CR][LF]
0D2!	0+99999.98+99999.98[CR][LF]

Table 49: Process with triggering a measurement and requesting the data

10.3.5. Triggering of measurements

Measurements are triggered with the SDI-12 commands "aM!" and "aC!" with "a" standing for the SDI-12 address of the device. "aC!" is only used for simultaneous measurements of multiple sensors.

Command	Answer
0M!	00649[CR][LF]

Table 50: Example of a measurement triggering

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

The answer returns information to the measurement duration and the numbers of measurement values.

0	SDI-12 address
064	Duration of the measurement in seconds
9	Number of measurement values

Table 51: Answer to triggering a measurement command

After the measurement duration the measurement values are requested with the commands "aDn!".

Additionally single measurement cycles can be triggered with the SDI-12 commands "aMn!" and "aCn!" more accurate. The meaning of "n" is shown in the table below.

	SDI-12 command:	**aM0! aC0!**	**aM1! aC1!**	**aM2! aC2!**	**aM3! aC3!**	**aM4! aC4!**	**aM5! aC5!**	**aM6! aC6!**	**aM7! aC7!**
Main values	AUX	1	1			1			
	Water level	2	2				1	1	1
	Velocity[7]	3	3	1	1			2	2
	Quality (SNR)	4	4	2	2			3	3
	Discharge[7]	5	5	3				4	4
	Cross section area	6	6	4				5	5
Special values	Learned velocity[7]	7	7	5				6	6
	Learned discharge[7]	8	8	6				7	7
	Opposite direction content	9	9	7				8	8
	Supply voltage	10[8]	10[8]	8				9	9
Analysis values	Peak width		11	9				10	
	CSR		12	10				11	
	Area of the peak		13	11				12	
	RMS at the PIC		14	12				13	
	Amplification		15	13				14	
	Amplification relation		16	14				15	
	Signal relation		17	15				16	
	Error code		18	16				17	
	not used		19	17				18	
	not used		20	18				19	
	not used		21	19				20	

Table 52: Triggering of measurements with "aMn!" and "aCn!"

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

[8] The value cannot be output with commands of the class "M"

The radar sensor confirms the receiving by returning an answer with information to the measurement duration and the number of measurement values. These are then requested with the commands "aDn!".

10.3.6. Parameterization commands

The SDI-12 commands for the parameterization are the reading command "aXRXX|!" and the writing command "aXWXX=xxx|!" with "a" standing for the SDI-12 address of the device, "XX" for the identifier of the parameter in the sensor menu and "xxx" for the value of the parameter.

Command	Answer
0XRB|!	0B=30|[CR][LF]

Table 53: Reading of the measurement interval (menu item B)

Command	Answer
0XWB=60|!	0B=60|[CR][LF]

Table 54: Setting of the measurement interval to 60 s (menu item B)

After changing parameters the radar sensor has to be restarted with the SDI-12 command "aXW_ts|!".

10.3.7. Adoption of the settings

The SDI-12 command to adopt the settings is "aXW_ts|!" with "a" standing for the SDI-12 address of the device.

Command	Answer
0XW_ts|!	0ok_ts|[CR][LF]

Table 55: Adoption of the settings

10.4. Modbus

10.4.1. Modbus default settings

The default settings are set by the command "H-M-I MODBUS, set default"

Baud rate	19200
Data bits	8
Parity	even
Stop bits	1
Flow control	none

Table 56: Default settings for the Modbus

10.4.2. Modbus Configuration

Function 04: Read input registers (read only)

The measurement values are in a sequence according to chapter 7.1.

	Index	Register address	Description	Unit / value	Bytes	Format
Test value		0	Hardcoded test value	2.7519…	4	float
Main values	00	2	AUX	[9]	4	float
	01	4	Water level	[9]		
	02	6	Velocity[10]	[9]		
	03	8	Quality (SNR)			
	04	10	Discharge[10]	[9]		
	05	12	Cross section area	[9]		
Special values	06	14	Learned velocity[10]	[9]	4	float
	07	16	Learned discharge[10]	[9]		
	08	18	Opposite direction content	%		
	09	20	Supply voltage	V		
Analysis values	10	22	Peak width	mm/s	4	unsigned int
	11	24	CSR	%		
	12	26	Area of the peak			
	13	28	RMS at the PIC	mV		
	14	30	Amplification			
	15	32	Amplification relation	%		
	16	34	Signal relation	%		
	17	36	Error code			
	18	38	not used			
	19	40	not used			
	20	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 57: Function 04 to request measurement values

Function 06: Write single registers and Function 03: Read holding registers

[9] Unit from the submenu "H-O Units and decimals".

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

	Register address	Description	Range	Bytes	Format
Config values	0	Modbus default[11]	0 - 1…read 1…write	2	unsigned int
	1	Modbus device address	1 to 247		
	2	RS-485 baud rate	0…1200 baud 1…2400 baud 2…4800 baud 3…9600 baud 4…19200 baud 5…38400 baud 6…57600 baud 7…115200 baud		
	3	RS-485 parity/stop bits	0…no parity, 1 stop bit 1…no parity, 2 stop bits 2…even parity, 1 stop bit 3…odd parity, 1 stop bit		

Table 58: Function 06 and Function 03 to read and write configuration values

Function 17: Report server ID response format (read only)

	Register address	Description	Format	Dec. values / ASCII	HEX values
PDU response	0	Byte count	char	38	26
	1	Server ID	char	"S"	53
	2	Run indicator status	char	255	FF
	3 - 4	Modbus implementation version	unsigned int	10100	27 74
	5	Separator	char	" "	20
	6 - 12	Vendor string	7 chars	"Sommer "	53 6F 6D 6D 65 72 20
	13	Separator	char	" "	20
	14 - 20	Device configuration	7 chars	variable	variable
	21	Separator	char	" "	20
	22 - 29	Software version	7 chars	X_YYrZZ	variable
	30	Separator	char	" "	20
	32 - 38	Serial number	8 chars	XXXXXXXX	variable

Table 59: Function 17 to report sever ID response format

[11] Writing "1" sets the Modbus default settings (see chapter 10.4.1).

10.5. Installation of the converter "USB-Nano-485"

For the installation of the converters "USB-nano-485" two drivers have to be installed. First the USB-controller "USB-nano-485" and second a COM port "USB Serial Port" is installed.

In the following steps the installation procedure is described in detail:

1. Connect the converter to an USB interface at your computer. Usually Windows identifies the new USB device and starts the installation of the driver "USB-nano-485". Otherwise make sure you have administration rights on your computer and open the Device Manager ("Start -> Control Panel (-> System and Security) -> System --> Device Manager"). Look for the "USB-nano-485" under "Other Devices" and start the installation from there.
2. In the dialog you are asked to confirm if you want to search for the most actual driver. If you have an open internet connection let Windows search for the driver. Otherwise or if the search was not successful select the option to browse for a local driver software. Insert the Installation CD and select the CD-ROM path.
3. In the next window Windows informs you that the driver has no valid signature. Accept this circumstance and proceed. The installation is performed and the dialog can be closed.
4. In the next step the installation is started automatically once again to install the second driver for the COM port "USB Serial Port". Pleas follow the procedure as before.
5. After finishing the installation a new COM port "USB Serial Port" is available. In the Device Manager ("Start -> Control Panel (-> System and Security) -> System --> Device Manager") you can check or edit the number of the new COM port. If you are not sure which COM port belongs to the new converter, plug the converter off and on. This causes the related COM port to disappear and reappear after the reconnection.
6. Memorize or document the number of the COM port fort he further use.
7. The installation procedure in finished and has not to be repeated any more for the converter. For any new converter the procedure has to be repeated.

Attention	It is not necessary to change settings for the converter in the Device Manager.