RP-30 Radar Profiler

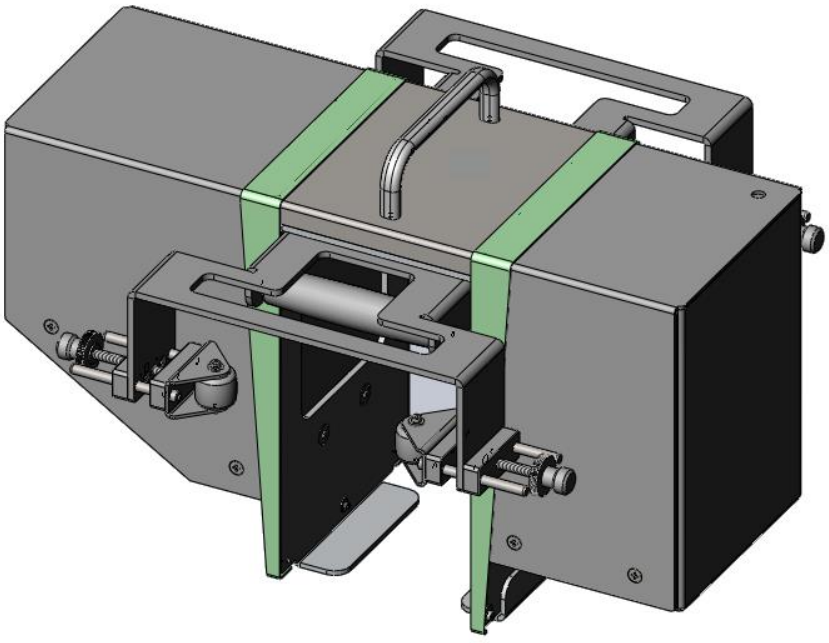
Firmware versions 1.7x and 1.8x

Mobile Discharge Measurement System

User Manual

Manual version: V02

2014-07-29



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Validity

This manual applies to the discharge measurement system RP-30. The manual is valid for the firmware versions 1.8x with all its subversions.

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

CE compliance

This product is in conformity with the following standards

EMI	**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.

FCC compliance

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

FCC ID: **UXSIMS944**

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. Modifications which have not been explicitly authorized by Sommer lead to the expiry of the permission of operation as stated by FCC.

Content

1. Delivery contents

The delivery contents from the RP-30 Radar Profiler includes following articles:

- Carrying case
- RP-30 Radar Profiler
- USB Flash Drive with RPCommander software and user manuals
- USB Bluetooth Dongle
- Surrogate antenna for Bluetooth
- Plastic distance disc
- Traveler for bridge railings and one wing screw
- Two aluminum L-sections and two wing screws for cable ways

2. Introduction

The RP-30 Radar Profiler is a mobile measurement device for the contact-free determination of the discharge of open rivers and channels. Thereby the flow velocity at the surface is measured at defined positions across the cross section by the principle of the Doppler Effect. By knowing the cross section profile and the water level the discharge can be determined. The measurement procedure is performed with the software RPCommander that supports all the necessary measurement steps and post calculations.

Due to the contact-free method the discharge measurements are performed without entering the water body. The RP-30 can be operated on bridge railings, tripods or cable ways. Therefore determinations of the discharge can be performed throughout the complete range of water levels and even under flood conditions, without the danger of damage caused by flotsam and debris.

3. Specifications

3.1. General

General	
Dimensions	445 x 156 x 226 mm
Weight without traveler	6.60 kg
Weight with traveler	8.00 kg
Battery	9 AA Mignon battery pack 10,8V / 2500mAh
Operation time	
Power consumption inactive state	10 mA
Power consumption measurement	110 mA
Storage temperature	-40…60 °C
Operation temperature	-35…60 °C
Data transfer	Bluetooth Class 1 (operating range of up to 200 m)
Protection rating	IP 67
Lightning protection	Integrated lightning protection

Table 1: General specifications

⚠ Attention The RP-30 switches of the Bluetooth module after 15 minutes without using. Restart the RP30 therewith it can be used again.

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 frequency	24 GHz (K-Band)
Radar opening angle	12 °
Distance to water surface	minimum 0.50 m
Necessary minimum ripple height	3 mm
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. Housing

The system housing is manufactured of powder coated aluminum and includes the measurement device, the Bluetooth transmitter and batteries.

3.3.1. Standard housing

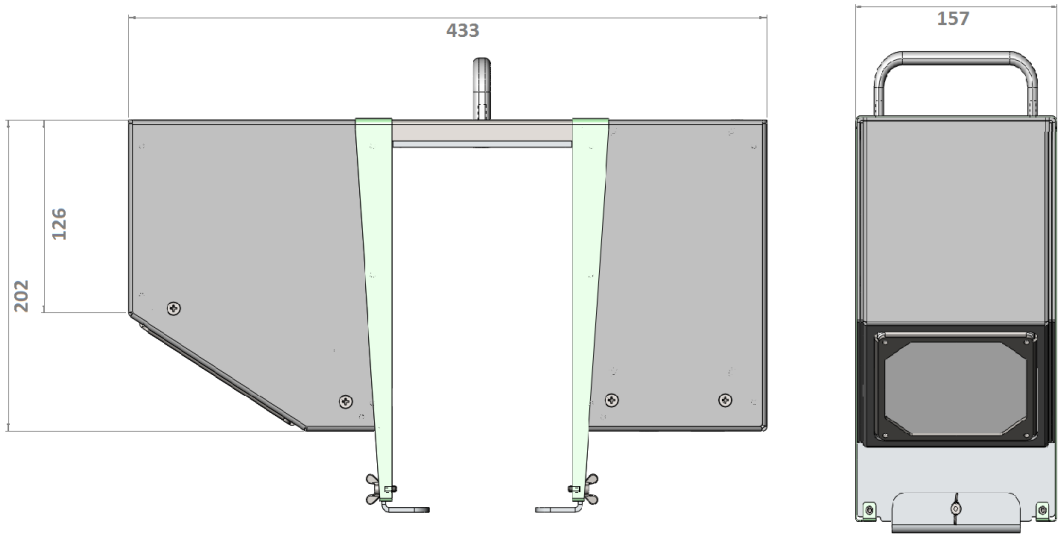
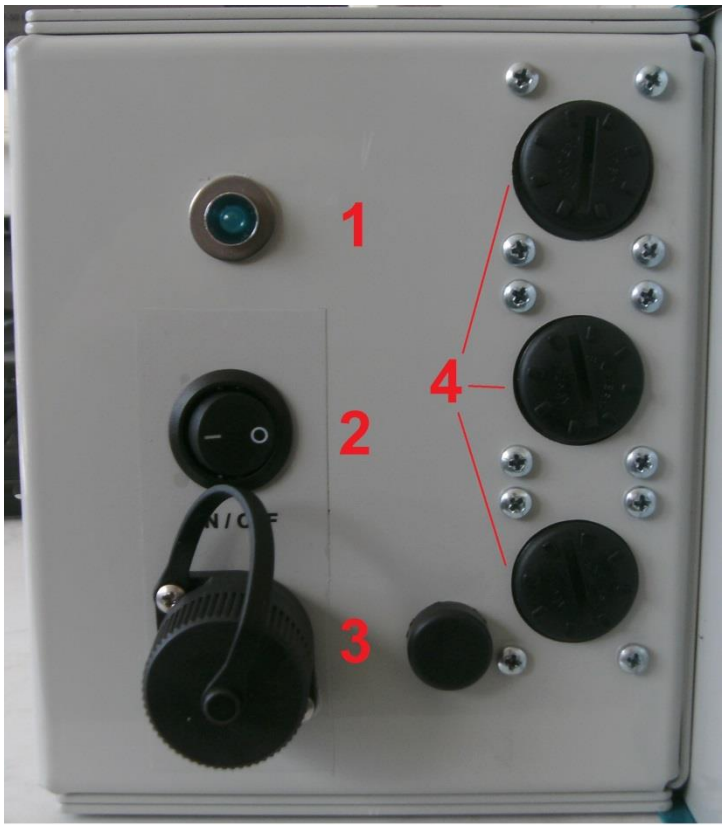


Figure 1: Dimensions of the standard housing in mm

3.4. Controls and sockets



1- Bluetooth state ON/OFF
2- ON / OFF switch
3- Charger socket
4- Battery compartment

Figure 2: Control RP-30 Radar Profiler

3.4.1. Pin out socket charger

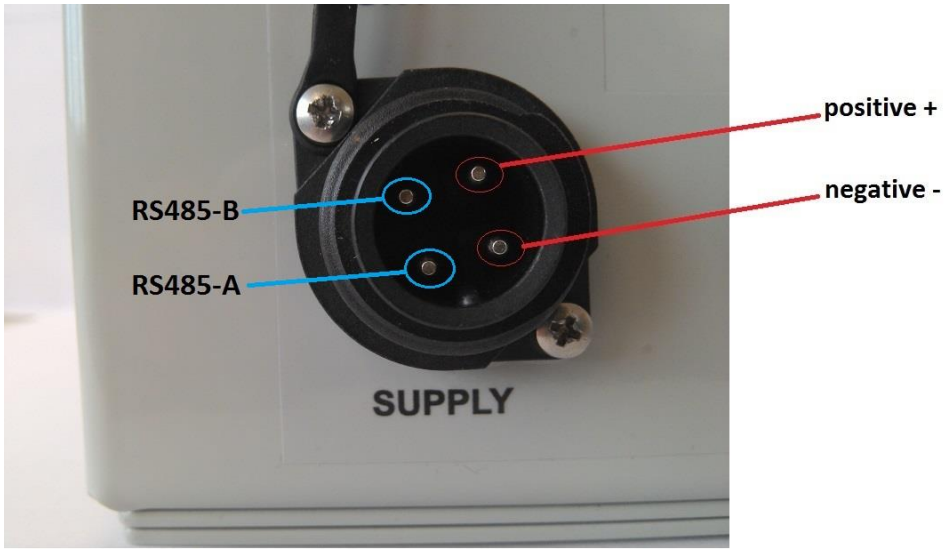


Figure 3: Socket charger

3.5. Connection

The connection between RP-30 and Laptop is done with Bluetooth. The Bluetooth module in the RP-30 is supplied with the radar. The LED at the control panel indicates this. Five seconds after switching on the RP-30 the Bluetooth module and the LED turns on. If the RP-30 is not used for 15 minutes in the switched-on state the Bluetooth module and subsequently the LED are automatically switched off. This is done to save power. Restart the RP-30 and the Bluetooth module is working again.

To parameterize the RP-30 a connection with RS485 is also possible. Plug in a jack with the right pin allocation (see Figure 1) at the charger socket and connect it with the Laptop.

4. Principle of measurement

The RP-30 measures the flow velocity at the water surface at predefined positions. The RPCommander is able to calculate the discharge if the water level and the cross section profile are known.

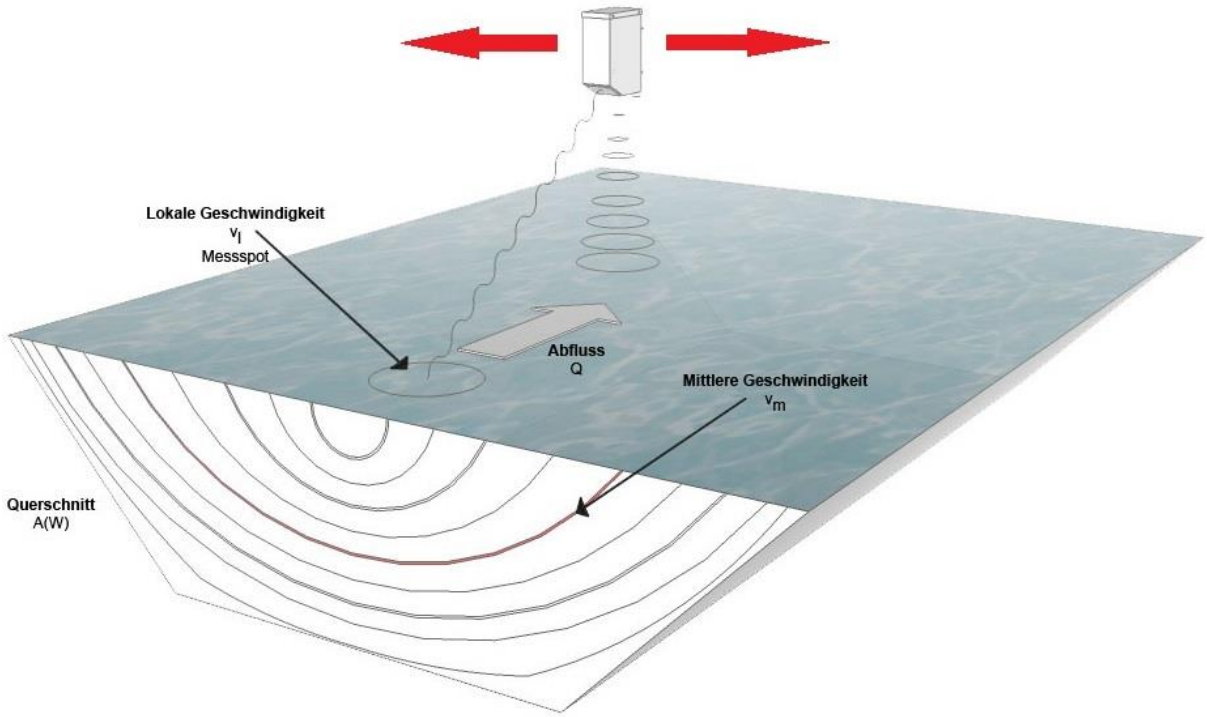


Figure 4: Principle of measurement of the RP-30 radar profiler

4.1. Flow velocity

4.1.1. Principle of measurement

The contact-free measurement of the flow velocity is based on the principle of 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.

4.1.2. Measurement spot

The radar sensor has an opening angle of 12°. Therefore the signals of an area are measured. The size of this measurement spot 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.

4.1.3. Character 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 may not be fulfilled and a continuous velocity measurement cannot be guaranteed.

4.1.4. Flow direction determination

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. Therefore the orientation of the RP-30 according to the flow direction has to be set prior to any measurement.

4.1.5. 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 automatic angle correction. The RP-30 determines the inclination angle during every measurement, as especially when mounted on cable ways the inclination may vary.

4.2. Determination of the discharge

4.2.1. Base equation

The base of the discharge calculation is the general equation for discharge measurements:

$$(1)\quad Q = A \cdot v_m$$

Q = discharge [m³/s]

A = cross section area [m²]

v_m = mean flow velocity [m/s]

4.2.2. Cross section

Cross section profile

The precondition for the determination of the discharge is the cross section profile. Either the cross section is known due to topographical survey or it has to be determined in advance. This can be performed with staging in different verticals or by measurements with an ADCP boat.

The cross section profile is entered prior to the measurement in the profile mode. It is also possible to perform the measurement and enter the profile after the velocity measurements have been completed. If this method is chosen a reference point must be defined so that the measured velocities can be linked to the corresponding cross section.

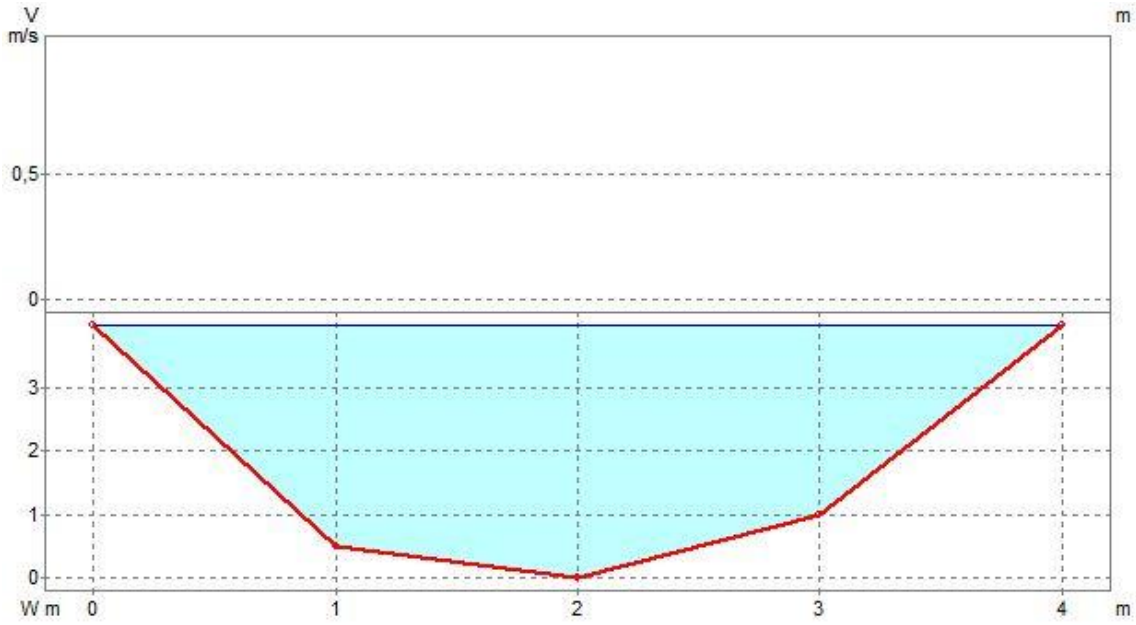


Figure 5: Cross section profile

Sectors and positions

Before the measurement the cross section is divided into different sectors. The individual sectors are defined by a position, where the measurement of the surface velocity is performed. The margins of the sectors to each other are set to the middle to the adjoining positions.

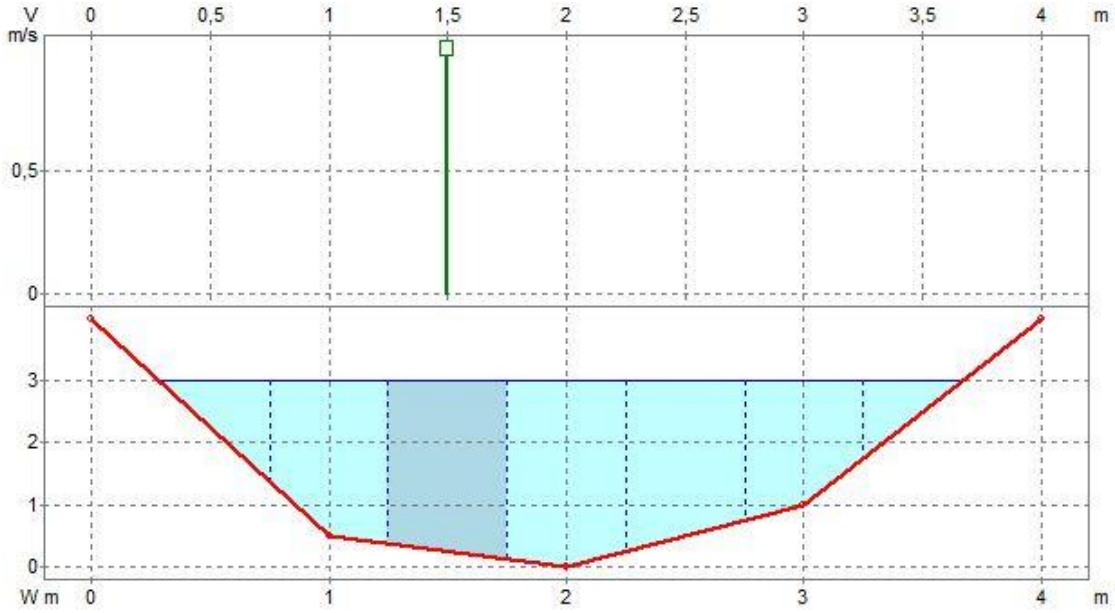


Figure 6: sectors and positions

In figure 6 a sector is marked which is defined by the position 1.5 m. The margins of the sector are 1.25 and 1.75 m

4.2.3. Discharge Calculation

The discharge is determined for every sector individually.

$$(2)\quad Q_i = A_i \cdot v_{m,i}$$

Q_i = discharge of sector i [m³/s]

A_i = cross section area of the sector i [m²]

$v_{m,I}$ = mean flow velocity of sector i [m/s]

Cross section area

The cross section area of a sector is determined from the cross section and the water level.

In the example the cross section is 1.375 m² for a water level of 3 m

Flow velocity

In the next step at every position a flow velocity measurement is performed and so the velocity profile is determined.

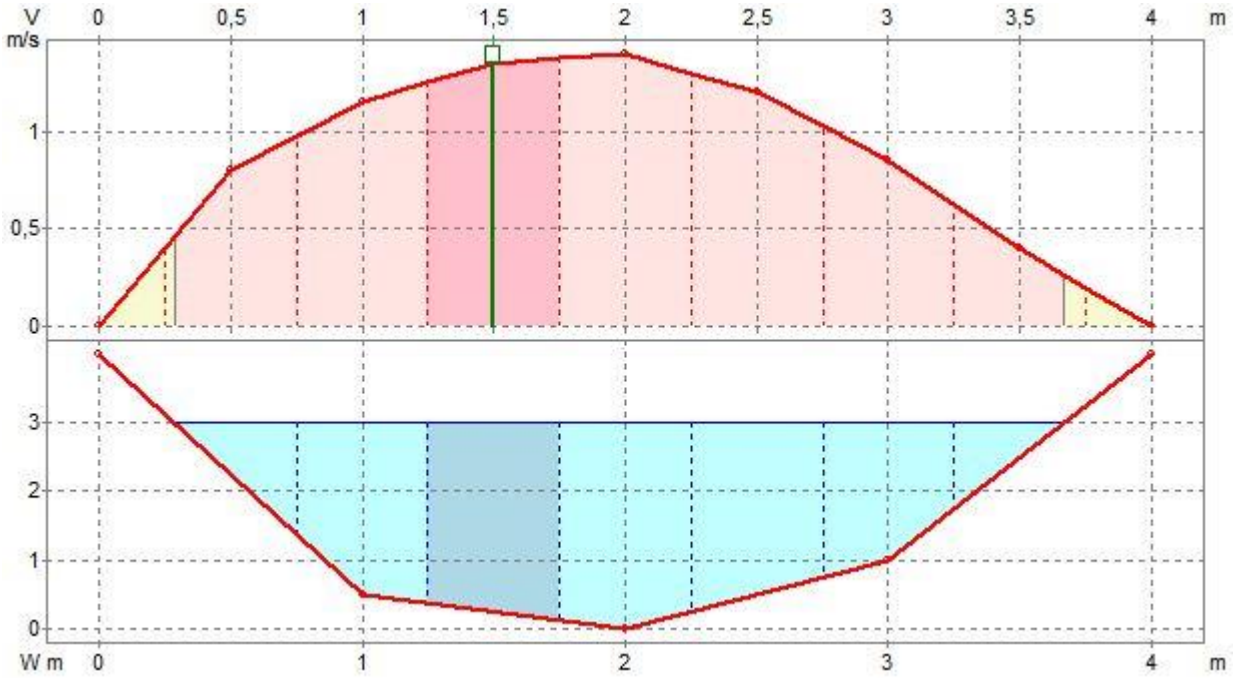


Figure 7: Flow velocity and cross section area

4.2.4. K-factor

In the sectors the flow velocity at the water surface is measured. This velocity is not the mean velocity. Therefore a correction factor has to be implemented to calculate the mean velocity from the surface velocity.

$$(3)\quad v_m = k \cdot v_l$$

k = k-factor, dimensionless correction factor

v_m = mean flow velocity [m/s]

v_l = local flow velocity at the water surface [m/s]

The k-factor is either a fixed percentage value (i.e. 85 %) or it is modeled from the cross section profile.

Calculation

The calculation of the partial discharge with a k-factor is determined from equations (2) and (3):

$$(4)\quad Q_i = A_i \cdot k_i \cdot v_{l,i}$$

Q_i = discharge of sectors i [m³/s]

A_i = cross section area of sector i [m²]

K_i = k-factor of sectors i

$v_{l,I}$ = local velocity at the water surface of sector i [m/s]

In the example the cross section area of 1.375 m², the k-factor of 85 % and the velocity of 1.35 m/s result in a discharge for the sector of 1.578 m³/s.

Total discharge

The total discharge is the sum of the partial discharges of the individual sectors.

$$(5)\quad Q = \sum Q_{i\ \mathrm{i}}$$

Q = discharge [m³/s]

Q_i = discharge of the individual sectors i [m³/s]

Modeling of the k-factor

The k-factor is a dimensionless correction factor to calculate the mean velocity from the measured surface velocity. Usually the k-factor is in the range of 70 to 90 % but can deviate strongly due to geometrical influences.

The modeling of the k-factor is performed for each sector individually.

Determination of the mean velocity

The mean velocity is determined theoretically using the flow formula by Darcy-Weisbach. The necessary geometrical information and the roughnesses are extracted from the cross section profile in combination with the water level.

Determination of the surface velocity

The velocity at the water surface is calculated using the logarithmic law for the velocity distribution and the mean velocity.

Calculation of the k-factor

The k-factor is calculated from the two determined velocities using equation (3).

$$(6)\ \mathrm{k} = \frac{v_m}{v_l}$$

k = k-factor

v_m = mean velocity [m/s]

v_l = local flow velocity at the water surface [m/s]

5. First use

The first steps are carried out in the office to make the basic settings.

5.1. Delivery completeness

Check the completeness of the delivered contents.

5.2. Insert battery / replace battery

The supply from the RP-30 consists of 9 AA Mignon batteries divided in 3 battery packs.

When delivered the RP-30 housing contains the battery. It is in the part of the case with the control module.

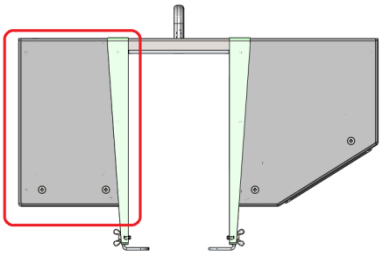


Figure 8: RP-30 Radar Profiler

The following steps explain the battery integration and replacement

1. Battery compartment

The aperture from the battery compartments are at the control panel. (See Figure 2)

Figure 9: First four screws to open

Turn the cap at anti-clockwise direction to open the battery compartment.

2. Remove battery

After opening the cap remove the batteries

Figure 10: opened battery compartment

3. Insert battery

After remove the old batteries, new batteries are inserted with the negative polarity first.

The cap is been closed and the RP-30 is ready for work.

5.3. Charging theRP-30 Radar Profiler

Connect the charger to the RP-30 at the socket (see 3.4 Control) Connect the charger with the main supply.

The charging starts automatically when the charger is connected. At first the red LED blinks for 10 seconds after that it lit continuously.

Meaning from the charger LED lights

RED	The battery is charging
GREEN	The RP-30 is fully charged and is ready for use (trickle charge)

5.4. RPCommander installation

Take the included USB Flash Drive and install the RPCommander on the laptop (follow the installation steps).

5.5. Bluetooth connection (Laptop – RP 30)

Insert the delivered USB Bluetooth dongle in an USB port of the laptop. The laptop automatically installs the driver for the Bluetooth USB dongle. For this installation a connection with the internet is necessary.

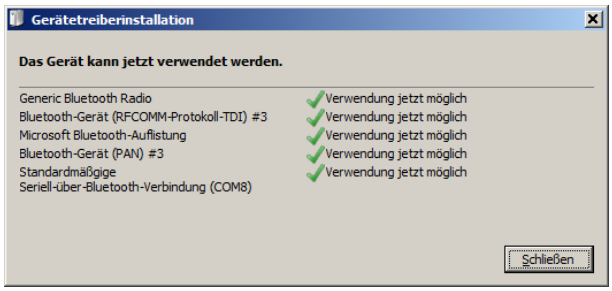
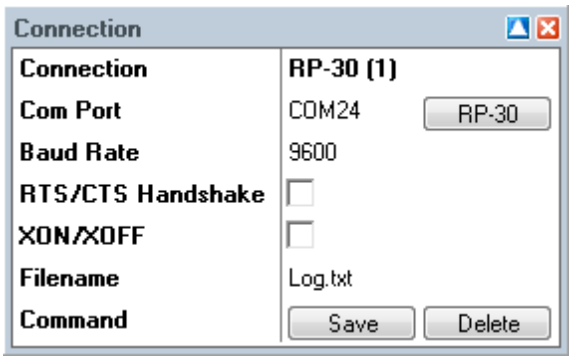


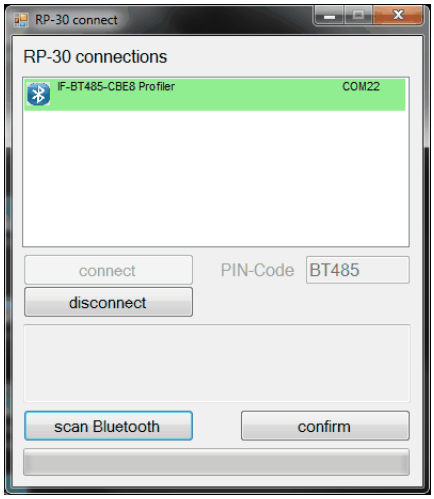
Figure 19: Automatical Bluetooth install

Open the RPCommander software. Switch ON the RP-30 Radar Profiler



The communication with the RP-30 uses Bluetooth-transmission. By clicking the button "RP-30" in the window "Connection" a dialog is opened. During the startup of the dialog a procedure is started that searches automatically for RP-30 devices.

Figure 20: Bluetooth connection window



All found RP-30 are displayed in a list. The device for the connection is selected from the list and confirmed with the button "Confirm". The COM-port for the device is selected automatically and is displayed in the window "Connection"

On the first connection with the RP-30, the device and its COM-port have to be installed by windows. This procedure may take a few minutes and is visualized in standard Windows dialogs.

Figure 21: opened dialog window

5.5.1. Trouble Shooting

The Bluetooth connection with the RP-30 demands the “Microsoft Bluetooth Stack”. If other Bluetooth drivers are installed on the laptop, they may be selected instead of this standard driver.

It is nearly always possible to disable any third-party stack and replace it with the Microsoft stack. In Device Manager select the adapter/device for the Bluetooth Radio (see e.g. in Stack Identification), select "Update Driver ...", then "Browse ...", "Let me pick ..." and choose "Generic Bluetooth Adapter" if offered. (Some dongles have drivers with different names, e.g. "Belkin Bluetooth Adapter", "IBM Integrated Bluetooth". etc.) At that point the Microsoft Bluetooth stack should become active.

It may be preferable in all cases however to actually uninstall the other stack software.

6. Operating methods

The RP-30 can basically be operated in three different methods.

6.1. Bridge Railing

To operate the RP-30 on bridge railings the included traveler is used.

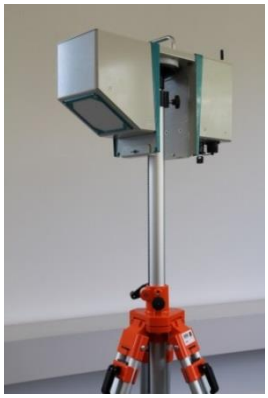
Fix the RP-30 on the traveler with the bigger wing screw facing upwards.

Place the traveler on the railing and adjust it to the railing with the four manual screws.

Now the RP-30 can simply be moved along the railing.

Figure 22: RP-30 mounting on a rail

6.2. Tripod



The RP-30 can be operated on a tripod.

For the installation the distance disc must be used between the top mounting table and the RP-30 for more stability.

For the measurement the complete tripod is moved across the river and is relocated for every measurement at the specific position.

Figure 23: RP-30 mounting on a tripod

6.3. Cable way

The RP-30 can be operated on cable ways. It is especially designed for cable ways of SEBA.

The RP-30 is placed on the cable way. With the two aluminum L-sections the device is fixed and prevented from gliding off the cable way. The two aluminum L-sections are fixed with the little screws at the bottom side of the RP-30.

The cable way with the mounted RP-30 is moved to the measurement positions in the usual way.

Figure 24: RP-30 mounting on a cable way

7. Measurement procedure

The basis for discharge measurements is the cross section profile. If the profile is known it is entered in the RPCommander. Then the measurement positions across the profile are defined. If the profile is not available, the profiler measurement can still be performed and the profile is entered afterwards.

The key point for profiler measurements is the presence of a unique reference system for the width position. Only then the profile and the measurement positions can be related to each other and the discharge can be calculated. Usually a zero point is given; otherwise it has to be defined.

Of equal importance is the knowledge of the water level during the time of measurement. It is entered as start and end level in RPCommander.

Prior to every measurement some parameters have to be set on the RP-30. The parameters are the viewing direction (upstream, downstream) and measurement duration (for detailed information see RPCommander manual).

For the measurement move the RP-30 to the first valid measurement position. The single measurement is started with the RPCommander. It takes at least the defined measurement duration. When the measurement results are present they are automatically accepted and displayed by the RPCommander.

Repeat the procedure for every measurement position.

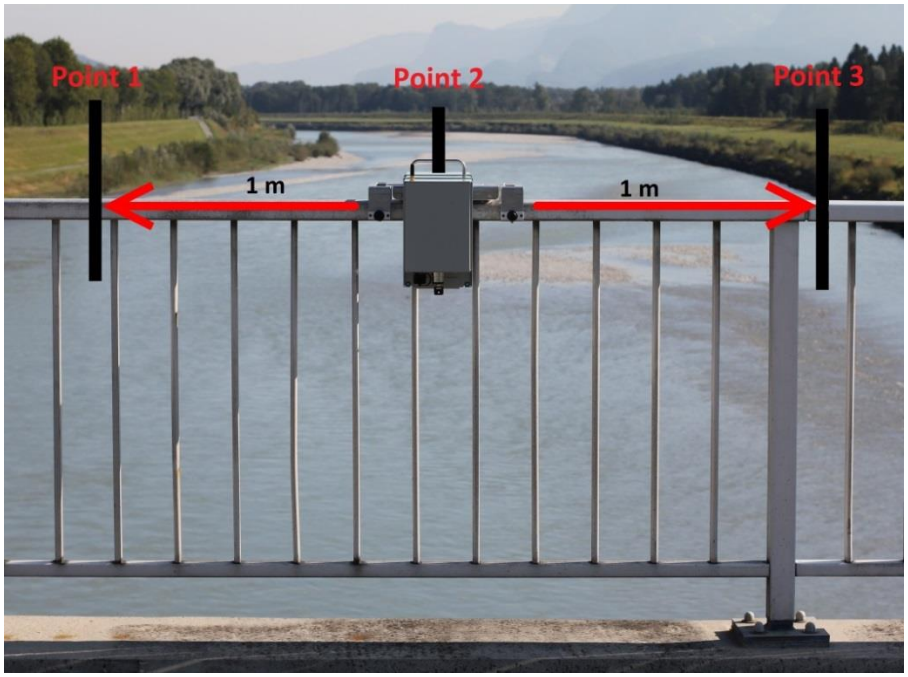


Figure 25: RP-30 with the traveller mounting on a rail

After all measurement positions have been measured the resulting discharge is displayed in the RPCommander. An additional measurement moving across in the opposite direction can be performed.

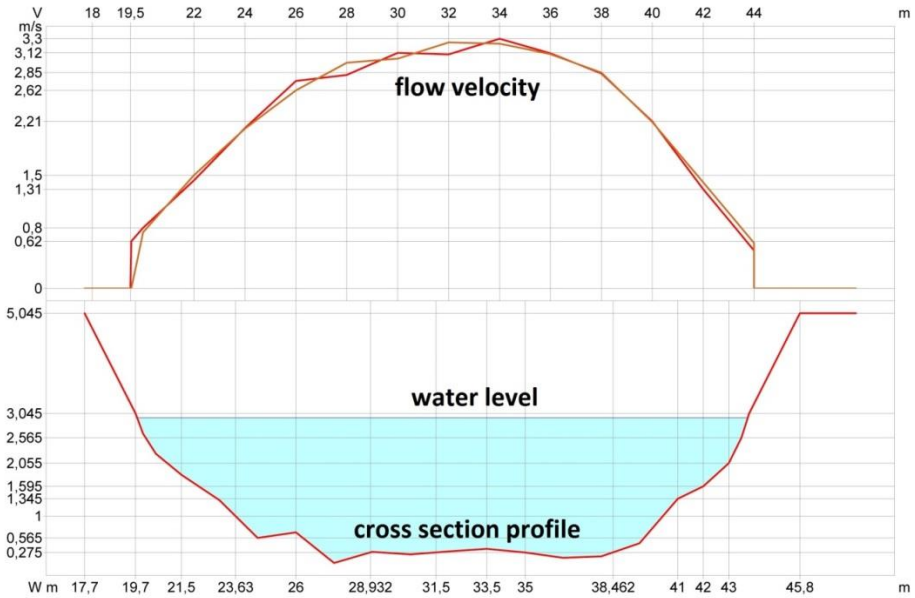


Figure 26: RPCommander generated diagram

8. RPCommander

The RPCommander is the appropriate software program for the RP-30 radar profiler. More information about this SW is described in the User Manual_RPCommander_V2.3.0_EN.