WaveGuide - Direction

User Manual

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Applicable for product no.
WG-DR19-SS
WG-DR67-SS

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Preface

This user manual and technical documentation is intended for engineers and technicians involved in the software and hardware setup of the non Ex. certified stainless steel version of the WaveGuide Direction system.

Note

All connections to the instrument must be made with shielded cables with exception of the mains. The shielding must be grounded in the cable gland or in the terminal compartment on both ends of the cable. For more information regarding wiring and cable specifications, please refer to Chapter 2.

Legal aspects

The mechanical and electrical installation shall only be carried out by trained personnel with knowledge of the local requirements and regulations for installation of electronic equipment in hazardous areas.

The information in this installation guide is the copyright property of Radac BV.

Radac BV disclaims any responsibility for personal injury or damage to equipment caused by:

- Deviation from any of the prescribed procedures.

- Execution of activities that are not prescribed.

- Neglect of the general safety precautions for handling tools and use of electricity.

The contents, descriptions and specifications in this installation guide are subject to change without notice. Radac BV accepts no responsibility for any errors that may appear in this installation guide.

Additional information

Please do not hesitate to contact Radac or its representative if you require additional information.

Contents

Introduction

The principle of operation of a WaveGuide Direction system is based on the synchronized measurements of sea elevation (heave) at three different spots on the surface of the water. The slopes around two horizontal and perpendicular axes are calculated using the measured elevations. Then the correlations between the calculated slopes and the measured heave values are used to calculate the wave directional information.

The three radar sensors are standard WaveGuide Height radar sensors that are connected to a WaveGuide Direction server. Each WaveGuide radar sensor measures the distance between the sensor antenna and the water surface. The WaveGuide server takes care of data handling (synchronized measurements, processing, distribution and presentation). The WaveGuide server unit also facilitates commissioning and (remote) servicing of the system. All facilities are accessible via the built in web-server (running on the WaveGuide server).

The WaveGuide radar sensors are available in two versions:

- A standard Ex. certified version.

- A non Ex. certified stainless steel version, where the antenna and electronics are built into one stainless steel compact unit. The antenna and electronics are the same in both versions but the stainless steel version is easier to handle due to its compact size.

This manual describes the non Ex. certified stainless steel version of the WaveGuide Direction system.

Warning
Do not use the instrument for anything else than its intended purpose.

This manual consists of 4 chapters. Chapter 1, specifies the criteria of radar sensor positioning for optimal quality of measurements. Chapter 2, illustrates the mounting and installation procedure. Chapter 3, describes the commissioning of the system via the user interface. Chapter 4, explains data processing, data presentation and data distribution within the system.

Please refer to Appendix 1, for a list of measured and calculated parameters. And to Appendix 2, for specifications, information about certification and environmental conditions applicable to the WaveGuide Direction system.

Chapter 1

Radar positioning and installation

1.1 Safety notes

The personnel installing the WaveGuide system must have basic technical skills to be able to safely install the equipment. When the WaveGuide system is installed in a hazardous area, the personnel must work in accordance with the (local) requirements for electrical equipment in hazardous areas.

Caution
Modification to the instrument may only be carried out by trained personnel that are authorized by Radac BV. Failure to adhere to this will invalidate the approval certificate.

Warning
In hazardous areas it is compulsory to use personal protection and safety gear such as: hard hat, fire-resistive overall, safety shoes, safety glasses and working gloves.
Avoid possible generation of static electricity. Use non-sparking tools and explosion-proof testers.
Make sure no dangerous quantities of combustible gas mixtures are present in the working area.
Never start working before the work permit has been signed by all parties.

Warning
Make sure that all power to the instrument is switched off before opening the covers of the WaveGuide radar. Failure to do so may cause danger to persons or damage the equipment.
All covers of the WaveGuide radar must be closed before switching on the power.

1.2 Positioning

For obtaining the best results from each WaveGuide radar sensor a number of positioning criteria must be taken into account:

- It is advised to choose a mounting position such that the WaveGuide radar beam is free of large reflecting obstacles (the beam of the F08 antenna can be approximated to a conical shape having a 5° [deg] half top angle as shown in Fig. 1.1). The minimum horizontal distance between a radar and any obstacle in the beam's path should be at least 10% of the vertical distance between the radar and the obstacle. This does not only include horizontal objects in the beam's path but also vertical structures.

- Any structure that the WaveGuide radar sensors are mounted to might have some influence on the wave flow around it. Hence, it is advised to mount the radars at a position facing the mean wave direction so that the radars can measure the least disturbed water surface.

- The reference level for the mounting height of the radars is shown in Fig. 1.2.

- A vertically mounted radar (0° [deg] tilt angle) results in optimal performance. But if necessary the WaveGuide radar can be mounted with a maximum tilt angle of 15° [deg] (tilted to face the direction away from the structure it is mounted on).
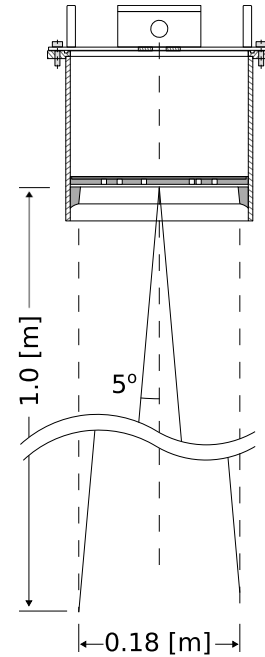

Figure 1.1: The 5° [deg] half top angle of the F08 antenna beam.
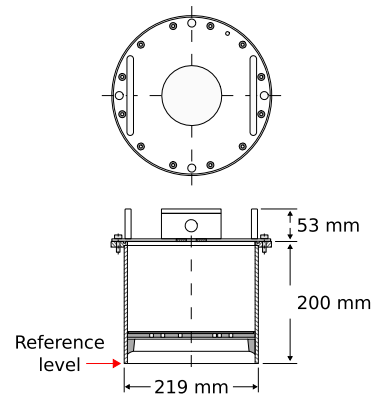

Figure 1.2: The reference level for mounting height measurement.

The working-principle of the WaveGuide Direction system is the measurement of surface elevation at three different positions using an array consisting of three radars. The array design criteria are:

- The footprints (measurement points) of the three radars on the sea surface must form a triangle.

- To obtain directional information of the same quality for all wave directions an equilateral triangle is preferable but not critical.

- The measurement of wave directional parameters is optimal for wave lengths that are 3 to 30 times the array size (distance between the center of two radar footprints). For example, if the dominant wave periods are between 3 and 10 [sec] long (wave lengths from 15 to 150 [m] long). Then for such waves, a radar array size of 5 [m] is optimal.

To allow the WaveGuide Direction system to be installed in various locations it was designed to be mounted in one of three array configurations. All three configurations allow for the radar array footprint to form an equilateral triangle on the sea surface at mean water level.

- The point array, where the three radars are mounted on a single frame. One radar is looking vertically downwards. The two other radars are tilted with an angle between 10 and 15 [deg] from vertical in the direction away from the downward looking radar. In this case the size and position of the array footprints depends on the choice of tilt angle and the vertical position of the radars (height above actual water level).

- The line array, where the mounting positions of the three radars form a straight line. The two outside radars are mounted at zero inclination angles and the middle radar is tilted with an angle between 10 and 15 [deg] in a direction perpendicular to the line the radars are mounted on. In this case the size and position of the array footprints depends on the mounting position, the tilt angle and the vertical position of the radars (height above actual water level).

- The triangle array, where the mounting positions of the three radars form a triangle and all three radars are mounted at a zero inclination angle (resulting in optimal performance). In this case the size and orientation of the array footprints are determined only by the horizontal positions of the radars.
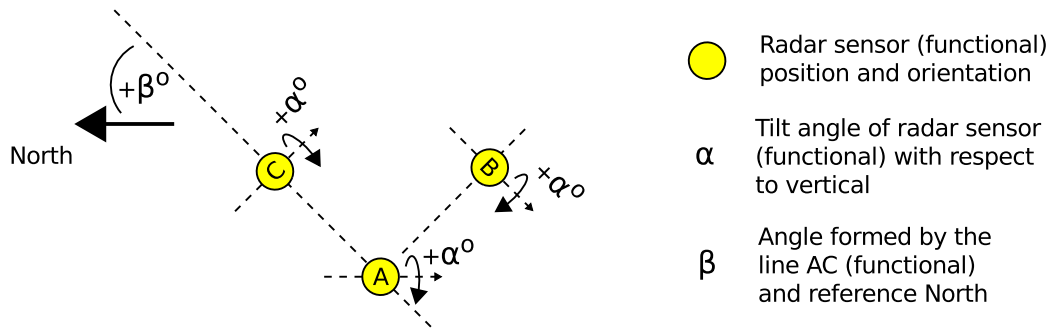
Figure 1.3: Definitions for WaveGuide Direction systems.

The proper installation of a WaveGuide Direction array of radars requires understanding the following naming conventions and standards:

- The labeling of a physical radar (A, B or C) is defined by the connector the radar is connected to on the server. Upon delivery the functional definition of each radar is the same as the physical radar. In certain cases (e.g. when the radars are not installed in counter-clockwise orientation) the function of a radar can be assigned to a different physical radar.

- The positions of the radars A, B and C (functional) must always be in a counter-clockwise orientation

- In a line or a point array radar A (functional) must be the middle radar.

- In a line array radar A (functional) must be radar B physical and vice versa.

- The positions of the radars A and C (functional) define the array orientation with respect to the reference North.

- On the "configure sensor" page of the web-interface the following parameters can be found (more information about accessing and using the web-interface is available in Chapter 3):

  - Distances between radar sensors (functional).
  - Angle between line formed by radars AC (functional) and the reference North.
  - Relation between the radar sensor (functional) and the physical radar sensor (the configuration parameters and reflection diagram of the selected physical radar sensor).

1.3 The point array

The point array has proven to be an easy to install configuration that requires the smallest amount of space on the supporting structure. The correct installation requires the radar sensors to be installed in a counter clockwise manner with radar sensor A installed as the center and vertical radar sensor.

Upon request, Radac can provide a standard mounting frame (product no. WG-MD-SS) that allows for easy and accurate mounting of the system (Fig. 1.6). The mounting frame can be used to mount the three radars together while allowing the vertical mounting of one radar and the tilted mounting of two radars (tilted to 15 [deg] from vertical). This results in an array footprint size that is approximately 25% of the mounting height. Using the array design criteria it can be concluded that this configuration is optimized for measuring directional wave
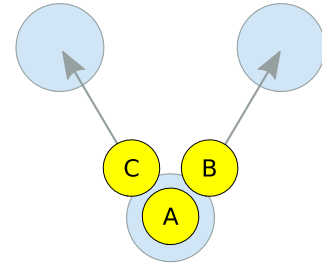
Figure 1.4: Top view of the three radar positions labeled A,B and C in an anticlockwise sequence. In this case the labels apply to the physical radars and their functional definitions.

parameters for wave lengths that are 0.75 to 7.5 times the mounting height. For example, a mounting height of 10 [m] is optimal for wave lengths in the range from 7.5 to 75 [m] (wave periods from 2.2 to 7 [sec]). While a mounting height of 25 [m] is optimal for a wave length range from 18.75 to 187.5 [m] (wave periods from 3.5 to 11 [sec]).

Installation

The optional mounting frame (product no. WG-MD-SS) consists of three parts connected to each other by bolts. The mounting frame should be installed on two horizontal beams (the horizontal beams are not included in the mounting frame package). Figure 1.6 shows the required positions of the mounting holes along the horizontal beams. Note: when designing and producing the horizontal mounting beams, enough horizontal distance should be left between the radars and the structure they are mounted to. That is, to prevent reflections (as explained in the beginning of this chapter). If the customer chooses to design and manufacture a frame, the centers of the mounted radar sensors must form an equilateral triangle. When installing the radar array it is advised to first install the mounting frame on horizontal beams then the three radars.
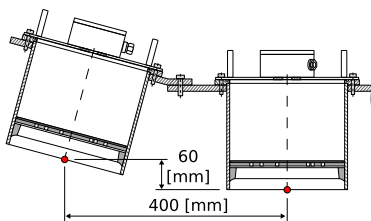
Figure 1.5: Side view of point array mounted on a standard mounting frame (product no. WG-MD-SS).
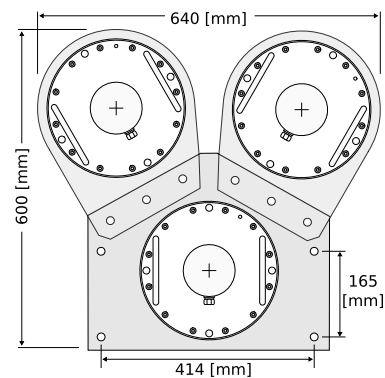
Figure 1.6: Top view of a point array installation mounted on a standard mounting frame (product no. WG-MD-SS).

1.4 The line array

As with other array configurations the labeling of a physical radar sensor (A, B or C) is defined by the connector the radar is connected to on the server. But the Line Array requires that the physical radar sensor A is set using the web-interface as the functional radar B and vice versa. This allows tilting the functional radar A (physical radar B) away from vertical and by doing so forming a triangle with the radar foot prints on the water surface. The conventions for the radar physical definitions, functional definitions and tilt angles are shown in Fig. 1.7.

A mounting plate can be used to fix each radar to two horizontal beams at the desired location (an example sketch of such a plate is given in Fig. 1.8). Upon request, Radac can supply such a mounting plate (product no. WG-MP-SS). During installation it is advised to install the mounting plate first, then install the radar.

Upon request, Radac can supply an optional frame (product no. WG-MH-SS) that allows for mounting a radar at angles 0, 5, 10, 15 and 20 [deg] with the horizontal plane shown in Fig. 1.9). Each frame includes a mounting plate.
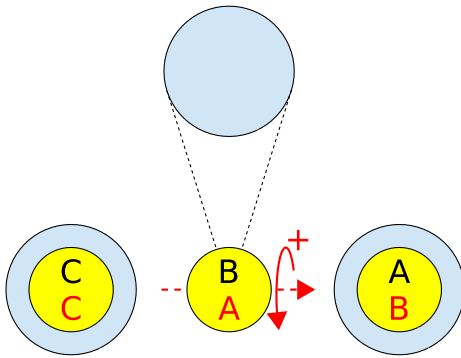

Figure 1.7: Top view of the three physical radars labeled A, B and C. With the functional definitions labeled A, B and C.
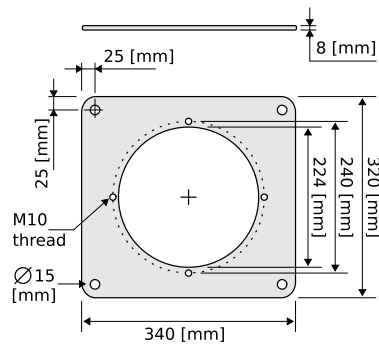

Figure 1.8: Optional mounting plate for an non Ex. certified WaveGuide Radar (product no. WG-MP-SS).
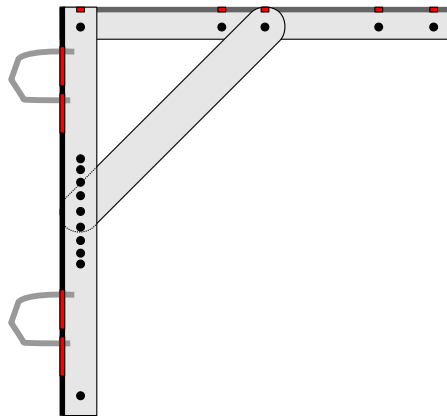

Figure 1.9: Optional frame that allows mounting of the radar at different angles (product no. WG-MH-SS).

1.5 The triangle array

As with other array configurations the labeling of a physical radar sensor (A, B or C) is defined by the connector the radar is connected to on the server. The mounting positions of radars A, B and C must be anticlockwise when looking from above (as shown in Fig.1.10).

A mounting plate can be used to fix each radar to two horizontal beams at the desired location (an example sketch of such a plate is given in Fig. 1.11). Upon request, Radac can supply such a mounting plate (product no. WG-MP-SS). During installation it is advised to install the mounting plate first, then install the radar antenna and then install the radar.
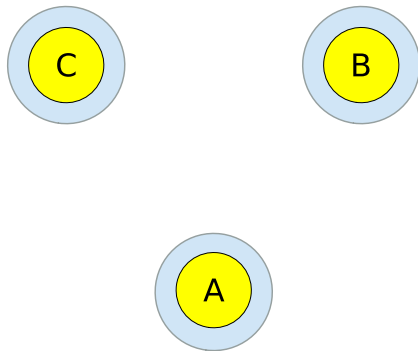

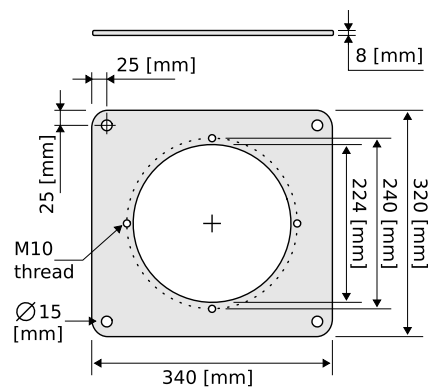Figure 1.10: The three radar positions are numbered A,B and C in an anticlockwise sequence.

Figure 1.11: Optional mounting plate for a non Ex. certified WaveGuide Radar (product no. WG-MP-SS).

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Chapter 2

Wiring

2.1   WaveGuide radar

A cable gland (IP68-10bar and IP69K certified) is supplied with each WaveGuide radar for use on the terminal compartment as a watertight cable entry point. The supplied gland allows the installation of non-armoured elastomer and plastic insulated cables from 8 to 15 [mm] in diameter.

In the terminal compartment there is one five pole connector as shown in Fig. 2.1. The connector is used to connect the RS485 data wires (poles labeled 1, 2 and 3) and supply power to the radar (poles labeled + and -).

It is advised to use three separate cables to connect the radar sensors to the server (one cable per sensor). But it is also possible to use one cable to connect all three radar sensors to the server. Both methods are explained in the following sections.
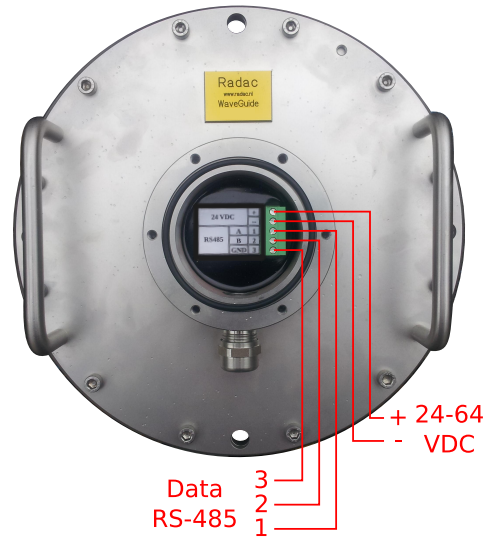
Figure 2.1: Terminal compartment and connections.

Warning
Improper installation of cable glands will invalidate the IP67 approval of the WaveGuide radar.

Warning
Safety depends on proper grounding of the radar sesnor case. Check the resistance of the ground connection directly after installation. The measured ground resistance shall be below the maximum prescribed by local grounding requirements.

2.2 WaveGuide server

For ease of use, the connector poles common between the WaveGuide server and radars are marked using the same labeling symbols.

Warning

It is of utmost importance to keep in mind the positions of the installed WaveGuide radars with respect to the chosen array type when connecting the radars to the server.
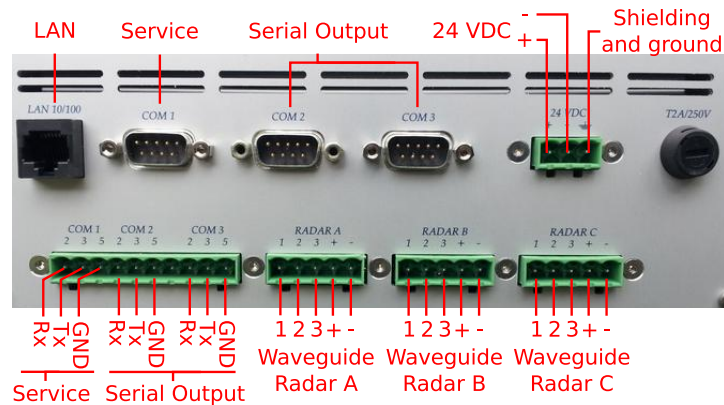
Figure 2.2: Connector panel on the WaveGuide server.

In addition to the connectors used for connecting the WaveGuide radar, the connector panel of the WaveGuide server includes the following connectors,

- COM1: Reserved service port.

- COM2: Serial port for RS-232 data output.

- COM3: Serial port for RS-232 data output.

- LAN port: Ethernet access to the server.

Note

Each COM port is connected in parallel to both the DE-9 connector and the terminal block connector. Hence, only one of the two types of connectors needs to be used per COM port.

When the radar is powered through the server, then the power supply for the server must be 24-36 [VDC]. Please do take care of the voltage drop due to wire resistance between the server and the radar. The power supply to the WaveGuide radar is controlled by the power switch on the WaveGuide server.

2.3 Three cable connection

Each cable between the server and a radar sensor, must be a shielded five wire cable with at least one twisted-wire-pair. The length of each cable can not exceed 1200 [m]. The cable shielding must be connected to ground at both ends of the cable. Since there can be a potential difference between the ground at the radar sensor side and the ground at the server side, a capacitor (10 to 100 [nF]) should be used on one side of the cable between its shield and the ground.

The twisted-wire-pair is used for the RS-485 communication link (pins labeled 1 and 2). RS-485 transceivers use differential signals and need a third wire to provide a reference common voltage to allow for the interpretation of the differential signal (pin labeled 3). Without this common reference, a set of transceivers may incorrectly interpret the differential signal.

The remaining two wires out of the five wires in a cable are used for supplying power to the radar sensor (pins labeled + and -).
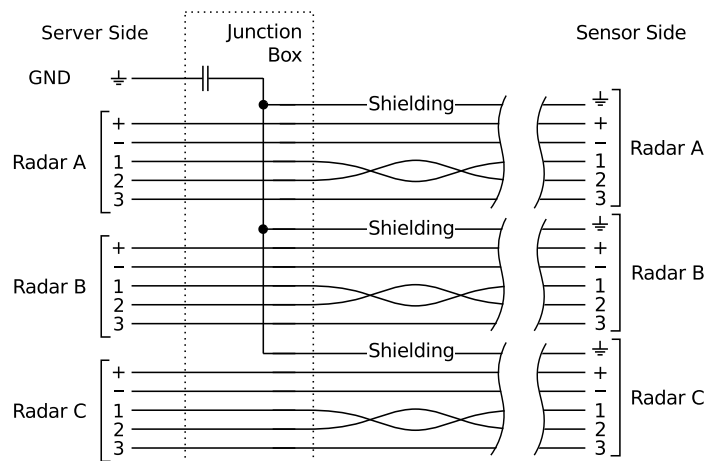

Figure 2.3: The three cable connection diagram between the WaveGuide server and radars when the radars are powered from server.

2.4   One cable connection

When it is more convenient to use one cable to connect all three radars to the server (for example, when the one-point array configuration is used). The cable used must be a shielded, nine wire cable with at least three twisted-wire-pairs. The length of the cable can not exceed 1200 [m]. The cable shielding must be connected to ground at both ends of the cable. Since there can be a potential difference between the ground at the radar sensor side and the ground at the server side. A capacitor (10 to 100 [nF]) should be used on one side of the cable between its shield and the ground.

The twisted-wire-pairs are used for the RS-485 communication links (pins labeled 1 and 2). RS-485 transceivers use differential signals and need a third wire to provide a reference common voltage to allow for the interpretation of the differential signal (pin labeled 3). Without this common reference, a set of transceivers may incorrectly interpret the differential signal. It is sufficient to use one wire to connect the reference common voltage pins (labeled 3) of all three radar sensors to the reference common voltage pins (labeled 3) of the three connectors on the server side (please note that all reference common voltage pins on the server side and on the radar sensor side must be connected to the reference common voltage wire).

The remaining two wires are used for power and those can be connected to any of the radar sensor connectors (+ and - pins) on the WaveGuide server side. On the Side of the radar sensors an Ex. certified terminal box must be used to split the two power wires, the reference common voltage wire and the cable shielding to connect the 3 radars.

Figure 2.4: The one cable connection diagram between the WaveGuide server and radars when the radars are powered from server.

2.5   Separate sensor power supply

In some cases it is more convenient to use a separate power supply to power the radar sensors rather than supplying them with power from the server side. In that case a 24-64 [VDC] power supply can be used on the radar sensor side to supply them with a total of 18 [Watt] of power.

If a separate power supply is used for the radar sensors, then the one cable or three cables used to connect the server to the radar sensors do not need the extra two wires per cable for power. Hence, in the one cable solution seven wires will be sufficient and in the three cable solution three wires per cable will be sufficient.

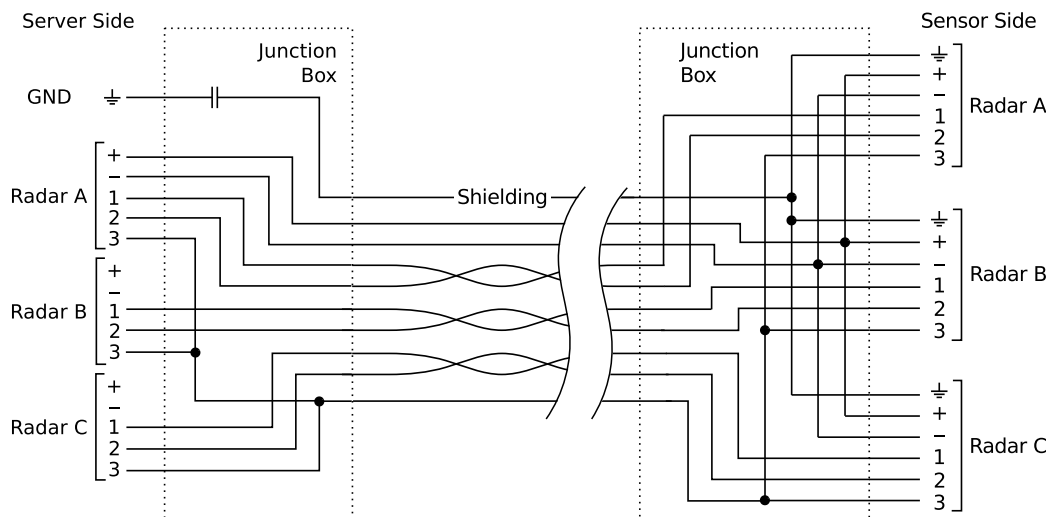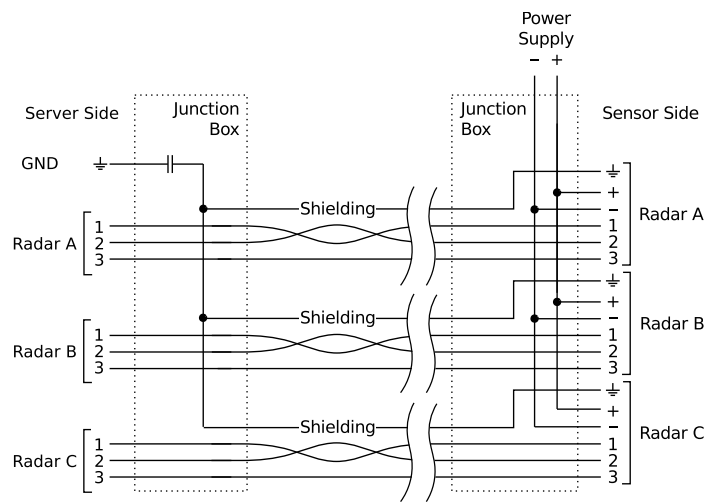Figure 2.5: The three cable connection diagram between the WaveGuide server and radars when the radars are powered from a separate source.
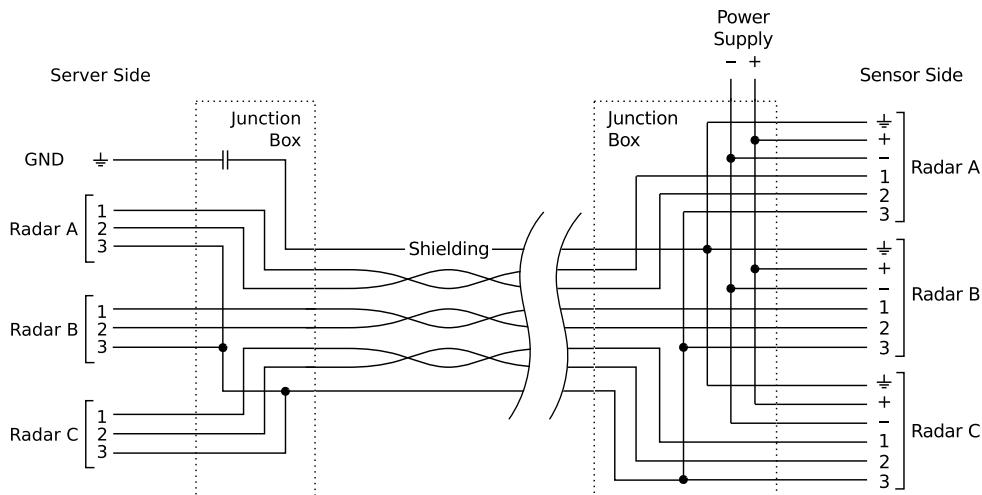
Figure 2.6: The one cable connection diagram between the WaveGuide server and radars when the radars are powered from a separate source.

Chapter 3

WaveGuide system commissioning

With all the wiring in place as described in the previous chapter, the server can be configured using the following steps (explained in the current chapter):

1. Connect the WaveGuide server to a computer.

2. Become an authorized user.

3. Configure the system.

4. Set sensor parameters

5. Perform a system check.

6. Set system date/time.

7. Configure the distribution of data.

The display on the server shows system information and measured parameters and is controlled using,

- Button 1: To switch between groups.

- Button 2: To switch between items within each group.

- Button 5: To confirm mounting and unmounting of USB data storage.

The server display contains the following groups and items:

- Parameters
  - Scrolls through selected parameters (Appendix 1, Table 1)
- Network
  - Host name
  - IP address
- System information
  - Date and time
  - Uptime
  - Software version
- USB storage (only appears when USB device is connected)
  - State
  - Mount USB disk?/ Unmount USB disk?

Step 1. Connect the WaveGuide server to a computer

Once the WaveGuide server is connected to a Local-Area-Network, communication with the WaveGuide server can be done via the available web-interface (Fig. 3.1). For this purpose any web browser with JavaScript enabled can be used.

Figure 3.1: The web interface of the WaveGuide server.

Note
A computer can be connected to the WaveGuide server directly using a network cable (a crossover cable is not required).

By default, during startup the WaveGuide server tries to obtain an IP-address by searching the Local-Area-Network for a DHCP server. If a DHCP server is not found, the WaveGuide server will use the default IP-address 192.168.111.71.

When the WaveGuide server completes the startup process, its IP-address can be found via the LCD display (it can take up to 10 minutes for the IP-address to appear). To view the IP-address, scroll through the menu using button 1 until network information is displayed and then use button 2 to switch between displaying the Host-Name and the IP-address.

The default IP-address can be modified via the web interface. To access the web-interface, type the IP-address indicated on the LCD display (e.g. http://192.168.111.71) in the address line of your Internet browser. Note, that your computer must be on the same IP-address subnet as the WaveGuide server that you are trying to connect to.

The WaveGuide server homepage contains 10 links in the menu bar on the left side (Fig. 3.1). Those links are described in Table 3.1.

Link	Description
Measurements	Measured data plots.
Parameters	Calculated parameter plots.
Spectra	Spectral plots of energy density, mean direction and spreading.
Data logger	Access to data logger files.
Sensor raw data	Preview of raw data required for data processing routines.
Configure Sensor	For defining the array and sensor configuration.
Subscriptions	Settings for data distribution.
Configure Network	Allows the user to change the network settings.
Set Date/Time	WaveGuide server date and time settings.
Expert Mode	Allows for editing more settings.
System Info	System state overview.

Table 3.1: Description of server links.

Step 2. Become an authorized user

To modify the WaveGuide system configuration you need to be an authorized user. Therefore, an authorization dialogue will appear when the user tries to change a configuration item.

The authorization will become invalid after 5 minutes of inactivity. However, the web browser may store the login name and password. In that case, the authorization data will be submitted automatically by the browser without a pop-up dialog. The default login name and password are both "radac".

After successful authorization, the changed settings will be stored and a reboot dialog will appear. The settings will not be effective until the WaveGuide server is rebooted.

Step 3. Configure the sensors

The "Configure Sensor" page will display a sensor drop-down menu. Choose "dirA" and click the "edit" button. This will display the configuration page for the directional array (Fig. 3.2).

Sensor names in the "port RADAR #" drop-down menu (sensor0, sensor1 and sensor2) should not be altered unless the functions of the radar sensors need to be switched as in the case of a line array. The physical radar sensors are called RADAR A, RADAR B and RADAR C according to the connector they are connected to on the server side. The actual radars must be mounted at positions A, B and C (depending on the chosen array as explained in Chapter 1). If the radar sensor functionality is switched then the sensor properties set using the web interface relate to the functional radar sensor A, B or C not the physical radar sensor A, B or C.

Figure 3.2: The "configure sensor" page will display a sensor drop-down menu. Choose "dirA" and click "edit". This will display the configuration page for the WaveGuide Direction radar sensors.

Fill in the distances between the radar mounting points (as defined by their functional labels). Next fill in the "Angle-North-AC (deg)". This is the angle between the line formed by functional radars A and C and the reference North direction. The "preview geometry" button, generates an illustration of the array configuration based on the parameters provided (see Fig. 3.3).
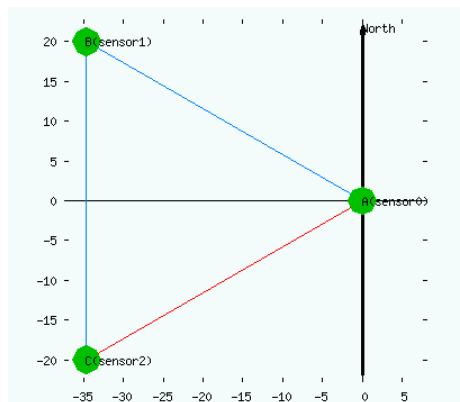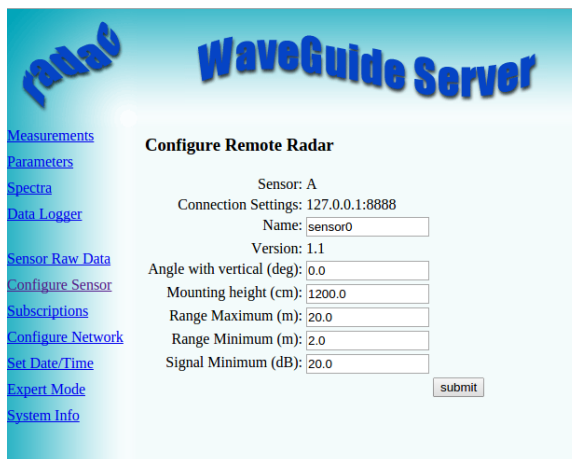

Figure 3.3: Preview of the array orientation based on user input.

Step 4. Set sensor parameters

The mounting height and tilt angle (angle with vertical) for each radar sensor must be set, even if all three mounting heights and tilt angles are equal. This can be done by clicking the "configure" button for each sensor respectively (see Fig. 3.2 and 3.4).

Figure 3.4: Setting sensor parameters (changes only take effect after the system is rebooted).

The tilt angle or the angle with vertical is measured in [deg]. For the Point Array, only radars B and C will have a tilt angle larger than 0 [deg]. In the triangular array, all 3 radars have a tilt angle of 0 [deg]. While for the in-line array, only radar C will have a tilt angle larger than 0 [deg] (as explained in Chapter 1).

The "Mounting height" is defined as the height of a radar above the reference water level in [cm]. The reference point for measuring the height of each radar is the lower-side of the radar sensor case (as shown in Fig. 1.2). By default, the mounting height is set to zero [cm].

The "Range Maximum" is the maximum distance (in [m]) at which the sensor will detect the water level. It is advised to set this parameter to a value lower than two times the distance from the radar to the lowest expected water level. That is to avoid detecting multiple echoes of the same measurement sweep.

The "Range Minimum" is the minimum distance (in [m]) at which the sensor will detect the water level. This parameter is used to avoid spurious measurements and should be set depending on the installation location. If there are any nearby surfaces that can reflect the radar signal the "Range Minimum" should be set to a value higher than the distance to those reflecting surfaces. The "Range Minimum" parameter should not be lower than 2 [m] to avoid interference with the internal reflection in the radar antenna.

The "Signal Minimum" is the lower limit for the signal power that will be considered in water level measurements. This parameter should be set to 20 [dB] in the case of a vertically mounted radar sensor and set to 5 [dB] in the case of a tilted radar sensor.

After changing the sensor parameters for the three radar sensors, rebooting the system is required for the changes to take effect. The reflection diagram of each sensor should be checked to ensure that the water level measurement is within the defined limits (More information can be found in "Step 5.1: Check the Reflection Diagrams").

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Step 5: Perform a system check

This section explains how to inspect the quality of measurements after configuring and rebooting the WaveGuide server (the start-up process can take up to 5 minutes):

Step 5.1: Check the System Info page

The bottom most table on the system info page, displays the sensor status (as shown in Fig. 3.5). The communication status "INIT" indicates that the WaveGuide server is initiating the communication process with the radar sensors. Once the communication process is initiated (a process that can take up to five minutes after reboot) the displayed status becomes "OK".
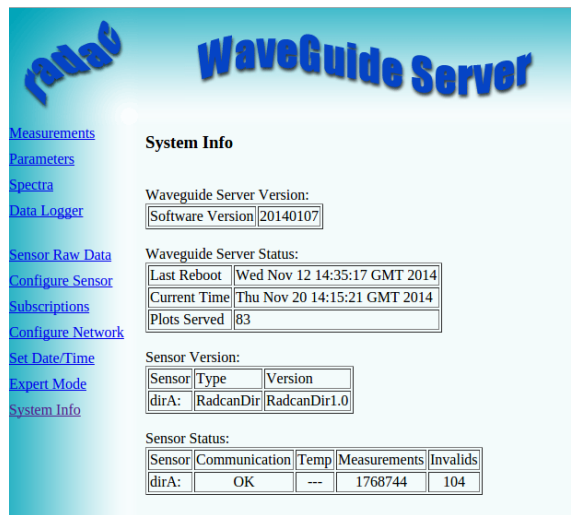
Figure 3.5: System information.

In the same table, the ratio between the number of performed and invalid measurements gives an indication of the system performance. When the system is setup in a correct manner, the number of invalid measurements should be below 10% of the number of performed measurements. However, during the startup and communication initiation processes the number of invalid measurements can grow to over 1000 (temporarily increasing the ratio between invalid measurements and performed measurements). The number of invalid measurement will show a slow increase after the initial invalid measurements.

Step 5.2: Check the reflection diagrams

The reflection diagram for each radar sensor can be accessed via the sensor configuration page by clicking on the corresponding "reflection" button (Fig. 3.2). Please note, that each reflection diagram is displayed in a new window.

A reflection diagram is a graphic representation of a 25 [ms] scan, where the signal strength [dB] is plotted against the measured distance [m]. A scan consists of one up-sweep (increasing frequency, red curve) and one down-sweep (decreasing frequency, blue curve).

Often several peaks are visible in a reflection diagram as shown in Fig. 3.6. This is caused by the multiple signal reflections between radar, water surface and any objects within the radar foot-print.
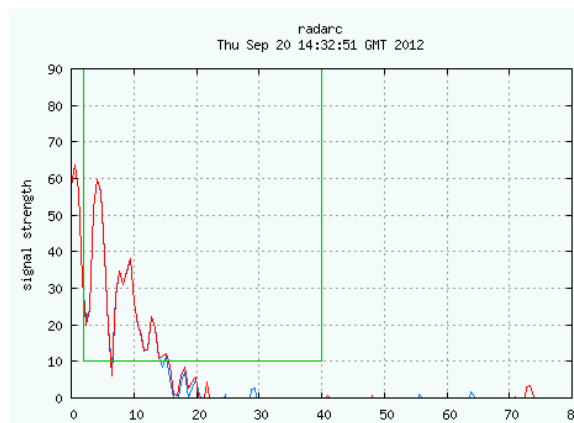
Figure 3.6: The reflection diagram of one of the three sensors.

Based on a one minute history of measured distance, the WaveGuide system calculates an expected minimum and maximum distance for the next measurement. The values for the expected minimum and maximum distance are shown on the reflection diagram using vertical green lines. A horizontal green line shows the minimum expected reflection strength (the value set as the Signal Minimum [dB] parameter).

The three green lines together form a region of acceptable values for the current measurement and any values outside of it are ignored. The highest peak in the region bounded by the green lines, is considered to represent the distance to the water surface. The region of acceptable values is automatically updated when persistent reflections occur outside this region.

Step 5.3: Check measurements

On the "Measurements" page, the data measured during the last 1, 3 or 10 minutes can be viewed. Please inspect the available graphs to visually confirm measured heave data.

Step 6: Set system date and time.

Some customers choose to use their own facilities to log the time at which data points are collected. However, for the highest level of accuracy the WaveGuide server is capable of adding time stamps to measured data points.

The current date and time can be set using the "Set Date/Time" page (Fig. 3.7). The date and time are kept by an on-board clock (with battery back-up). Please be aware that such on-board clocks are not very accurate and can drift over the years while the system is used.

If the system is connected to a network and has access to the Internet, then it will automatically synchronize the time and date with an Internet time server. Even then it is advised to set the initial date and time as accurately as possible because the synchronization of date and time when there is a large difference takes a long time due to the small incremental changes. After changing the system time or date, the WaveGuide server must be rebooted.

Figure 3.7: Setting the system time and date.

If the WaveGuide system is not connected to the Internet but instead connected to a local network that includes a time server, then the server can be adjusted to synchronize time and date with the local time server. For more information regarding such an adjustment please contact Radac.

Step 7: Configure the distribution of data

The WaveGuide server can transmit measured and calculated data via its serial ports (COM2 & COM3) and via its network link to several network addresses. In the "Subscriptions" page (Fig. 3.8), the existing subscriptions can be removed or modified and new ones can be added. Simultaneous subscriptions are possible.

Figure 3.8: List of defined subscriptions.

The address for a serial port subscription should have the following format: "port", "baudrate", "number of data bits", "number of stop bits", "parity", "handshake". For example, COM2,9600,7,1,EVEN,NONE.

If the address string is not complete the default values will be used. For example, COM2,9600 will be interpreted as COM2,9600,8,1,NONE,NONE.

The format for the network message is: "http://ip address:port". For example, http://192.168.111.103:8032.

The format of the output string can be chosen from the drop-down menu. Four message format options are available, Radac (default), KMA, SESAM and FGTI.

After modifying or creating a new subscription, click the "update" button and authorize the changes. This will change and store the settings and implement the subscription (no system reboot is required).

Radac message format

The Radac format starts a new line for each parameter in the subscription. The time used in the Radac format is Unix Epoch time in milliseconds (UTC time in milliseconds since 00:00:00 on the 1st of January 1970). Each line in the Radac format ends with a Line-Feed character (char10). When a parameter is disapproved or not available the string "NaN" is inserted instead of the actual value (NaN stands for Not a Number). An example of the output strings in the Radac format is,

time=1157359800206;sensor=radcan;H1=-319.9429cm;
time=1157359259847;sensor=radcan;Hm0=1.2517135cm;
time=1157359860268;sensor=radcan;H1=NaNcm;

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KMA message format

Modifications can be made upon request. For example, the Korean Meteorological Administration (KMA format) preferred a readable time format in the Korean time zone. An example of the output strings in the KMA format is,

time=2006/09/04 17:58:00;H1=-319.70026cm;
time=2006/09/04 17:48:59;Hm0=1.3314528cm;
time=2006/09/04 17:59:00;H1=NaNcm;

SESAM message format

The SESAM format, used by the Dutch Ministry of Infrastructure and the Environment (Rijkswaterstaat), is only defined for the heave and the 10 second mean (H parameter). It consists of 8 character lines (Line-Feed character + status character + sign character + 4 character value in cm + Carriage-Return character). For a regular message the status character is a space. If an error occurs the status character becomes a letter A. An example of the output strings in the RWS format is,

 +0001
 - 0004
A+9999

FGTI message format

The FGTI format used by the Belgium government. Where one string is used for all required information (parameters + spectrum) per processing interval. The chosen parameters are separated by a semicolon (;) and the 51 spectrum values (czz10) are included. The "NaN" string is replaced with a "-9999" string. An example of the output string in the FGTI format is,

time=1159898219628;sensor=radcan;H1/3=0.101608045cm;Hm0=0.070818946cm;Czz10=0.0,5.0869432E-5,
1.3970293E-4,4.7124052E-4,7.1615004E-4,7.975558E-4,7.6214876E-4,7.1647903E-4,7.6107396E-4,6.847791E-
4,6.6441507E-4,4.567583E-4,7.3393347E-4,8.3342794E-4,7.177321E-4,8.320104E-4,9.631133E-4,4.7024636E-
4,5.479116E-4,7.0798665E-4,7.973897E-4,8.964213E-4,0.0010354978,5.15721E-4,8.0113555E-4,8.009798E-4,
8.0272334E-4,8.0752687E-4,6.5126666E-4,8.172201E-4,5.1516114E-4,6.2683446E-4,5.63858E-4,3.5074513E-4,
6.5980386E-4,5.53472E-4,7.269641E-4,6.289437E-4,6.156702E-4,5.8503065E-4,6.2185246E-4,5.5198127E-4,
4.41777E-4,2.7770927E-4,3.3221033E-4,7.5746316E-4,6.8937184E-4,6.167301E-4,7.730603E-4,6.513776E-4,
5.5705215E-4cm2/Hz;

Chapter 4

Using the system

4.1 Calculated parameters

Once the system is commissioned the facilities of raw data presentation, reflection diagram, system info etc. can be used to monitor the proper operation of the system.

Water level and wave height information are calculated using the measurements of one radar (physical RADAR A). For directional information the measurements of all three radars are analyzed and the directional parameters are calculated. There are two analysis routines:

Wave Analysis
The Standard Wave Processing Package (SWAP) is used in performing time and frequency domain analysis on the measured data to calculate wave parameters. This package is the standard processing package used by the Dutch government for wave height analysis. It also meets the standards set by The International Association of Oil & Gas Producers (OGP). A detailed description of the SWAP package is available on the Radac website (http://www.radac.nl).

The SWAP parameters are calculated every minute using 20 minute data blocks. The 20 minute observation block is chosen as a compromise between short enough to obtain "small" variance in the statistical parameters and long enough to assume it to be a stationary process. The time stamp used on SWAP parameters is the mean between the start and end time of the 20 minute data block.

Tide Analysis
The tide parameters are calculated by averaging measured data over 10 [min] periods by default. Other averaging periods can be set upon request.

Parameters that are calculated over a time period get a time stamp that is in the center of the time period used to calculate them. The spectra and parameters that can be calculated by the WaveGuide system are described in Appendix 1. Due to the large number of parameters, only a selection of the most commonly used ones is displayed on the user interface. This selection can be modified by Radac upon request.

4.2 Data logging

A USB storage device can be easily mounted to the WaveGuide server for data logging. But without taking additional precautions, USB storage is not a safe method for archiving data. Since power failures can damage USB devices, it is advised to use an Uninterrupted Power Supply (UPS) together with a high quality USB device.

The WaveGuide server supports FAT32 , Ext2 and Ext3 formats. The majority of USB devices are delivered with FAT32 format.

Note
The USB device used must not be formatted using NTFS.

A USB drive must be manually mounted when first used, and will be automatically re-mounted on system reboot. Mounting a USB drive can be done via the push buttons on the front panel of the WaveGuide server. Using button "1" scroll to the storage menu. If the message" Disk not mounted" is displayed click button "2". If the message "Mount USB disk? OK" is displayed. Click button "5" to mount the device.

To unmount or remove the disk safely, use button "1" to scroll to the storage menu. Then click button "2" to arrive at the "Safely remove? OK" option. Then Click button "5" to unmount the device.

The "Data Logger" page in the web user interface (Fig. 4.1) gives access to the stored data. Also the data can be transferred easily to other computers using an FTP program. Login name and password for FTP file transfers are the same as the user-name and password for modifying settings (by default both user-name and password are "radac")
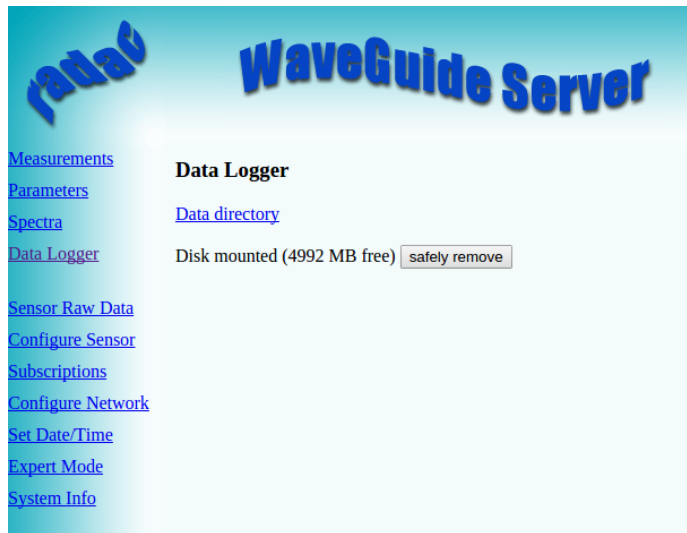

Figure 4.1: Data logger page.

The folder structure used is one directory per system. In this directory, sub-directories are created that contain the raw data and parameter files (one file per day per parameter).

If the drive is full a delete mechanism starts. This allows the system to store the most recent parameters at the expense of the oldest data.

Appendix 1: System parameters

Default parameters

In the web user interface and the physical display, a selection of the raw and processed parameters is made available to the user (Table 1).

Name	Description	Unit
heave	Instantaneous water level	*cm*
S0bh	Average directional spreading in the frequency band 30-500mHz	*deg*
Th0	Average mean direction in the frequency band 30-500mHz	*deg*
Th010	10 mHz spectrum of mean direction	*deg*
S0bh10	10 mHz spectrum of directional spreading	*deg*
Hm0	Significant wave height from M0	*cm*
Ngd_zP	Percentage of datap oints that do not contain error code before pre-processing	*%*
Tm02	Average period from M0 and M2 in the range f=[30-500] mHz	*s*
Czz10	10 mHz energy density spectrum	*cm*
Tmax	Period of longest wave in the last 20 [min]	*s*
Hmax	Height of highest wave in the last 20 [min]	*cm*
Fp	Frequency f where Czz10(f) has its maximum in the range f =[30-500]	*mHz*
H10	Average height over last 10 minutes	*cm*

Table 1: Default parameters

All possible parameters

Tables 2 to 11, describe all the parameters measured and calculated by the WaveGuide Direction system.

Changing the parameters available by default on the web interface is possible. It is strongly recommended that the user requests the changes when the WaveGuide Direction system is ordered so that all necessary tests can be performed at Radac. Post-installation adjustments to the available parameters are also possible upon request.

Name	Description	Unit
heave	Instantaneous water level	*cm*
slope	Water surface slopes	*−*

Table 2: Raw data at 2 or 2.56 [Hz]

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Name	Description	Unit
Czz5	5 mHz energy density spectrum	mHz
WTBH	Table of wave heights	cm
WTBT	Table of wave periods	s
Czz10	10 mHz energy density spectrum	mHz

Table 3: Spectra and wave tables

Name	Description	Unit
Hm0	Significant wave height from M0	cm
M0	Band energy from Czz10(f) in the range f =[30-500] mHz	cm^2
M0_M	Band energy from Czz10(f) in the range f =[30-1000] mHz	cm^2
Hm0_M	Significant wave height from M0_M	cm
Tm02	Average period from M0 and M2 in the range f=[30-500] mHz	s
Tm02_M	Average period from M0 and M2 in the range f =[30-1000] mHz	s
TE0	Band energy from Czz10(f) in the range f =[500-1000] mHz	cm^2
TE1	Band energy from Czz10(f) in the range f =[200-500] mHz	cm^2
TE1_M	Band energy from Czz10(f) in the range f =[200-1000] mHz	cm^2
TE2	Band energy from Czz10(f) in the range f =[100-200] mHz	cm^2
HTE3	Wave height from TE3 (band energy from Czz10(f) where f =[30-100] mHz)	cm
Fp	Frequency f where Czz10(f) has its maximum in the range f =[30-500] mHz	mHz
Fp_M	Frequency f where Czz10(f) has its maximum in the range f =[30-1000] mHz	mHz
AV10_H	Theoretical number of degrees of freedom of the energy density spectrum (= 4 * Ndlr_H) 20 HS7 Wave height from band energy from Czz5(f) in the range f =[30-142.5] mHz	cm
Tm0_1	Minus first moment period from M-1 and M0 in the range f =[30-500] mHz	s
Tm0_1_M	Minus first moment period from M-1 and M0 in the range f =[30-1000] mHz	s

Table 4: Parameters of spectral processing

Name	Description	Unit
H1/3	Average height of the highest 1/3 of the waves	cm
TH1/3	Average period of the highest 1/3 of the waves	s
H1/10	Average height of the highest 1/10 of the waves	cm
H1/50	Average height of the highest 1/50 of the waves	cm
T1/3	Average period of the longest 1/3 of the periods	s
GGH	Average height of all waves	cm
GGT	Average period of all waves	s
AG2	Number of waves	$-$
SPGH	Standard deviation of the wave height	cm
SPGT	Standard deviation of the wave period	s
Hmax	Height of highest wave	cm
Tmax	Period of longest wave	s
THmax	Period of highest wave	s
HCM	Crest height, maximum positive value of all data within one analysis period	cm

Table 5: Parameters from time domain processing of data collected in the last 20 [min]

Name	Description	Unit
Nwt_zP	Sum of periods of waves divided by analysis period	—
Ndlr_H	Number of valid sub-series of the signal in the vertical direction	—
Ngd_zP	Percentage of data-points that do not contain error code before pre-processing	—
Nu_z	Number of valid data-points that are rejected because of 0-sigma errors	—
Nv_z	number of valid data-points that are rejected because of 4-sigma errors	—
Nd_z	number of valid data-points that are rejected because of 4-delta errors	—
Ni_z	number of interpolated or extrapolated vertical wave motion datapoints	—

Table 6: Quality parameters

Name	Description	Unit
H	Average height over last 10 seconds	*cm*
H1	Average height over last 1 minute	*cm*
H5	Average height over last 5 minutes	*cm*
H10	Average height over last 10 minutes	*cm*

Table 7: parameters from tide processing

Name	Description	Unit
Th010	10 mHz spectrum of mean direction deg	*deg*
S0bh10	10 mHz spectrum of directional spreading deg	*deg*

Table 8: Directional spectra

Name	Description	Unit
Th0	Average mean direction in the frequency band 30-500mHz	*deg*
S0bh	Average directional spreading in the frequency band 30-500mHz	*deg*
Th3	Average mean direction in the frequency band 30-100mHz	*deg*

Table 9: Directional parameters

In the directional spectral analysis the frequency range from 30-500mHz is divided in 15 separate frequency bands. These frequency bands are given in the Table 10.

Name	Description	Unit
B0	30-500	mHz
B1	200-500	mHz
B2	100-200	mHz
B3	30-100	mHz
B4	Peak frequency band (fmax-Δ f to fmax+Δ f)	mHz
G1	30-45	mHz
G2	45-60	mHz
G3	60-85	mHz
G4	85-100	mHz
G5	100-125	mHz
G6	125-165	mHz
G7	165-200	mHz
G8	200-250	mHz
G9	250-335	mHz
G10	335-500	mHz

Table 10: Frequency bands from 5 [mHz] spectra

Per frequency band 7 parameters are calculated. These parameters are given in Table 11.

Name	Description	Unit
Hm0_	Average wave height in the frequency band	m
Ndfe_	Number of degrees in the frequency band	deg
Th0_	Mean direction of the directional distribution in the frequency band	deg
S0bh_	Average width of the directional distribution in the frequency band	deg
G1_	Average asymmetry of the directional distribution in the frequency band	$-$
G2_	Average flatness of the directional distribution in the frequency band	$-$
Fm01_	Average frequency in the frequency band	mHz

Table 11: Parameters in each of the 15 frequency bands

Appendix 2: System specifications

WaveGuide radar

Mechanical

Dimensions	26.5 x 26 [cm] (diameter, height)
Weight	$\approx$ 12 [kg]
Casing material	Stainless Steel

Electrical

Radar frequency	9.9 – 10.2 [GHz]
Modulation	Triangular FMCW
Emission	The emitted microwave energy is far below acceptable limits for exposure of the human body. Depending on the type of antenna, a maximum radiation of 0.1 [mW] is generated.
Power requirements	24-64 [VDC] and 6 [Watt] (when powered separately from server).

Environmental conditions

Ambient temperature	-40 to 60 [^oC]
Relative humidity	0 – 100 %
Ingress protection	IP67

WaveGuide server

Dimensions	48 x 9 x 28 [cm] (width, height and depth)
Computer boards	AAEON, GENE-TC05
Processor	Intel® Atom™E620T 600MHz
COM ports	3 x RS485 (used to connect the radar).
	3 x RS232.
Network	Ethernet
Power requirements	24-36 [VDC] and 12 [Watt] if radar is powered via server.
	9-36 [VDC] and 6 [Watt] if radar is powered separately.
Operating temperature	-40 to 85 [^oC]
Cooling	No fan required
Display	2 x 20 characters
Memory	On board flash

General system specifications

sampling rate	5 [Hz]
wave heights	0 – 60 [m]
wave periods	0 – 1 [Hz]
accuracy water level	< 1 [cm]
processing period:	
wave height	20 [min] (SWAP standard)
wave direction	20 [min] (SWAP standard)
tide	can be changed upon request (default is 10 [min])
processing interval:	
wave height	can be changed upon request (default is 1 [min])
wave direction	can be changed upon request (default is 1 [min])
tide	can be changed upon request (default is 1 [min])