WLR 8/15/30
Non-Contact Level Meter
User Manual

HyQuest Solutions

-KISTERS Group-

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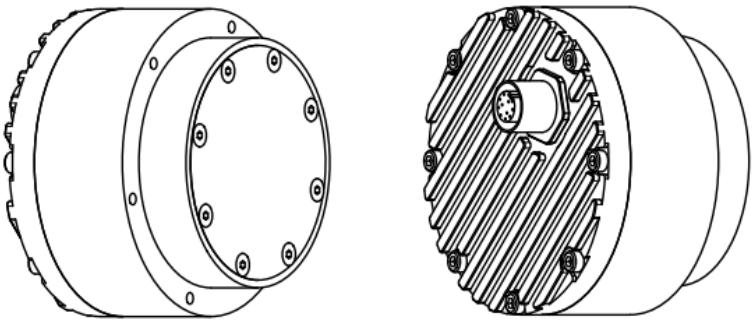

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Glossary

Term	Definition
θ_3	See antenna 3 dB beam width
Antenna 3 dB Beam Width	also known as the half-power; the angle between the half-power of an antenna pattern or beam over which the relative power is at or above 50% of the peak power
bps	bits per second, a measure for data transmission speed
CWFM Radar	continuous-wave frequency-modulated radar
Dead Zone	Equivalent to blocking distance or dead band, defines the minimum distance between water surface and sensor antenna that is needed to measure precisely (a function of the radio wave frequency)
ERP	Effective Radiation Power, IEEE standard definition of directional radiofrequency (RF) power
EIRP	Equivalent Isotropically Radiation Power, hypothetical power of an isotropic antenna with equivalent signal strength of the actual source antenna in the direction of the strongest beam
GHz	See Hz
Hz (GHz)	International Standard System of Units derived unit of frequency, Hertz (symbol: Hz) GHz: a gigahertz is the multiple of the hertz frequency equivalent to 10^9 Hz
GND	Ground, electrical ground or signal ground
Mx, Mxx	ISO standard for metric screw threads w/ M=metric, x or xx = outer diameter in millimeters
RF	Radio Frequency
RxD	Data reception line
TxD	Data transmission line
W Band	Frequency band in the microwave range of the electromagnetic spectrum, typically 75..110 GHz
WLR 8/15/30	Water Level Radar w/ measurement range relative to water surface of • 8 m (26,24 ft) • 15 m (49,2 ft) • 30 m (98,4 ft)

1 INTRODUCTION

WLR 8/15/30 level meters uses radar technology to provide precise contactless measurement of level. The sensor is not in contact with water surface. Therefore, it can be deployed in applications where sensors requiring contact are otherwise prohibited. WLR 8/15/30 sensors have no moving parts making them very reliable, and requiring very little maintenance. Another advantage is fast and simple sensor installation above the water surface. WLR 8/15/30 as a CWFM Radar transmitting an electromagnetic wave in the 77-80 GHz frequency range (W-band) and measuring the frequency shift of the CWFM electromagnetic wave reflected from the water surface.

Measured distance between sensor and target object is proportional to the frequency difference between transmitted CWFM signal and received CWFM signal due to the Doppler Effect. WLR 8/15/30 transmit a linear chirp in the frequency range between 77 GHz and 81 GHz (W-band). As the distance between the radar and water increases, so does the difference between transmitted and received frequency, enabling the level meter to precisely determine the level of sensor in relation to the water. Due to the modulation and detection process in the sensor very precise measurements can be achieved and sensor is not dependent on the air temperature, humidity or other parameters of the environment.

The level meter is available in several models, starting with WLR 8, able to detect water surfaces and waves at distances ranging from 0.1 m (3,28084 feet) to 8.0 m (26,24 ft) with accuracy of 3 mm (0.00984 ft), WLR 15 operating at the range of up to 15 m (49.2 ft) and WLR 30 operating up to 30 m (98.4 ft). The basic model, suitable for most hydrological application on inland waters, measures with a sample frequency of 1 Hz. For Wave Height measurements and other applications requiring fast sample rates, a second version of the sensor sampling at 10 samples per second (10 Hz) is available.

2 ELECTRICAL CHARACTERISTICS

Table 1 provides an overview on the major specifications of the WLR 8/15/30 water level radars.

Table 1. WLR 8/15/30 Specifications

Parameter	MIN	TYP	MAX	Unit
Communication interface: RS-232 interface speed RS-485 interface speed	 9600 9600		 115200 115200	 bps bps
Radar Sensor Frequency Radiated power (EIRP) Beam-width (3dB) – θ_3-Azimuth Beam-width (3dB) – θ_3-Elevation	 77.000	 W-band 12 12	 81.000	 GHz dBm ° °
Power supply voltage	9.0	12.0	27.0	V
Power		1800		mW
Operational temperature range	-40		+85	°C
Measurement range	0.1		8 / 15 / 30	m
Accuracy		3		mm
Resolution			1	mm
Ingress Protection Rating	IP68			---
Mechanical		Ø65 x H55		mm

3 CONNECTOR PIN-OUT

The level meter uses robust IP66 circular M12 connector with 12 positions and the mating cable is also delivered with the level meter. See Figure 1 for connector and cable details.

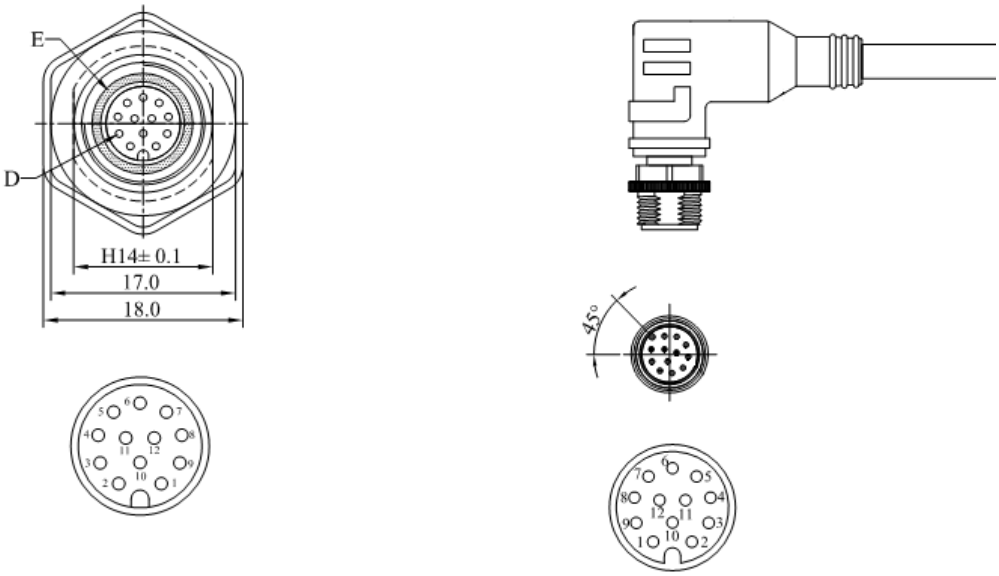

Figure 1 - Level meter connectors

Table 1 shows pin assignments for each single pin of the connector illustrated in Figure 1.

Table 1 - Connector and cable pin-out

Pin No.	Wire Color		Pin Name	Pin Description
1	White		GND	This pin should be connected to the ground (negative) pole of the power supply. *SDI-12 Ground*
2	Brown		+Vin	WLR supply power. Voltage range 9..27 VDC, power supply >= 0.65 W. *SDI-12 Power*
3	Green		RS232 – TxD	RS-232 data transmit signal.
4	Yellow		RS232 – RxD	RS-232 data receive signal.
5	Grey		---	-----
6	Pink		---	-----
7	Blue		---	-----
8	Red		Vout+	Output power supply (=Vin) for supply of external optional equipment and for use with analogue 4-20mA output
9	Orange		RS485 – D-	RS-485 data transmitter/receiver low signal.
10	Dark Red		RS485 – D+	RS-485 data transmitter/receiver high signal.
11	Black		SDI-12 Data	*SDI-12 Data Line*
12	Purple		4-20 mA Output	Analogue 4-20 mA output

3.1 SDI-12 Interface

SDI-12 interface is widely used communication interface in hydrology applications. Such interface is characterized with only one communication wire, slow speed communication and possibility for very long communication cables.

The implemented command set is compliant with SDI-12, Version 1.3 (even though not all commands are fully implemented).

Caution: Differences with SDI-12 sensors

- The Water Level Radar (WLR) is a high-frequency device. The slowest scan rate is 1 sample/sec (1 Hz). A faster version is available with a scan rate of 10 samples/sec (Hz).
- The supply voltage is higher than the standard 5V requirement of the standard.
- The power consumption is higher.

3.2 Serial RS-485 interface

Serial RS-485 interface is implemented as standard industrial half-duplex communication interface. Communication interface is short-circuited and overvoltage internally protected. Depending on the receiving device interface can be used with only two wires (D+ dark red wire & D- orange wire) or in some cases ground connection (signal GND grey wire) is also required. For more details please consult receiver specifications.

Most common communication protocol used with RS-485 interface is Modbus-RTU, but other protocols are also available. Details of communication protocols are described later in this manual.

3.3 Serial RS-232 interface

Serial RS-232 interface is implemented as standard PC full-duplex serial interface with voltage levels adequate for direct connection to PC computer or other embedded device used for serial RS-232 communication.

In case RS-232 interface is connected to standard DB-9 PC connector, TxD line (green wire) is connected to pin 2 and RxD (yellow wire) is connected to pin 3. For proper operation of serial interface additional connection of signal GND (grey wire) is required on pin 5 of the DB-9 connector.

The serial RS-232 interface is used as a service port. For more details see 6.2.

Option – on order: HyQuest Solutions can supply cable with DB-9 connector connected to the cable.

3.4 Analogue 4-20 mA Output

Analogue current 4-20 mA output is provided for easier compatibility with older logging and control systems. Output is implemented as current sink architecture with common ground. Maximal voltage applied to the sink can go up to 30 VDC providing greater flexibility in connection of the sensor to PLCs, loggers, or data concentrators.

Signal range and function for 4-20 mA analogue output can be configured in setup application so the sensor will be able to signal best suitable value range with available current range. Current step in the sensor is 0.3 µA limiting resolution possible for the value signalling and care has to be taken in the setup of minimal value to be represented by 4 mA and maximal value to be represented by 20 mA, so the resolution is sufficient for the system requirements.

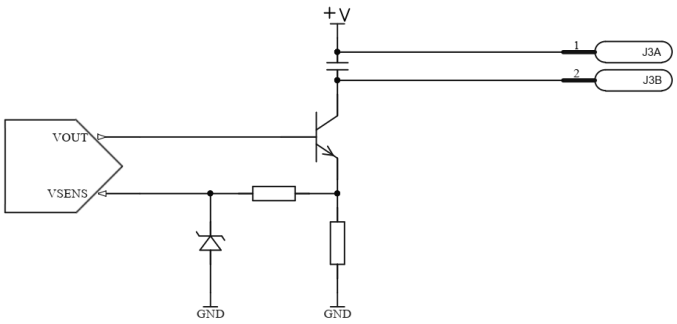

Figure 2 – Schematics 4-20 mA Output

4 Water Level Radar (WLR) Installation

The level meter must be installed above the water surface, pointing directly towards the water surface. Please read the following carefully and respect these instructions and recommendations as much as possible to obtain the best measurement results.

- Minimum Installation Height above Water Surface: 0.1m, recommended > 1 meter
- Maximum Installation Height above Water Surface: <= max measurement range of the device
- Sensor should be directed at a 90° angle towards the water.

Caution:

- Direct non-obstructed line of sight between sensor antenna and the water surface
- Avoid object in the vicinity of the sensor: may reduce accuracy, introduce offsets
- Reduce vibrations of the mounting structure: affects measurements
- Ensure water surface direct below the sensor is clear of: vegetation, rocks, sand deposition, other obstacles.
    - The sensor applies an algorithmic correction to detect and eliminate obstacles from the distance measurement signal spectrum. However, the correction has limits. Vibrations can further limit the effectiveness of the algorithm.

Figure 3 shows how the radar should be positioned relative to the water surface.

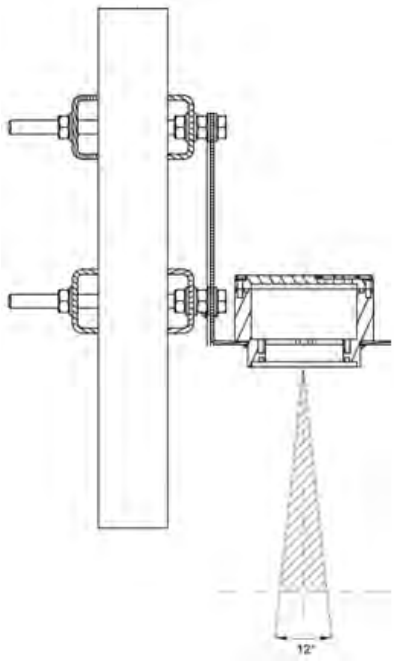

Figure 3 – Water Level Radar (WLR) Installation

The height measurement works best when water surface is calm (not too wavy) as flat surfaces better reflect radar beams. In applications with continuous/frequent highly turbulent water, the length of the radar filter can be adjusted to filter out most, if not all the turbulences.

- Slight up to moderate surface waviness will affect reflected signal level (reducing Signal to Noise Ratio SNR), but is unlikely to affect measurement accuracy.
- Strong turbulent flow with high water waviness will reduce accuracy due the unpredictability of the water surface. The averaging effect across the area covered by the radar beam will reduce oscillations.

Instrument radar beam covers a circular area on the water surface. The radar beam has a 3-dB width angle, subsequently the diameter of the pattern on the water surface depends on the distance of the water surface to the instrument. See Table 2 for pre-calculated pattern dimension.

Table 2 – Approximated Height-Dependent Circular Radar Beam Pattern Dimension (Water Surface)

Height [H]	R		Height [H]	R
0.3 m (0.33 ft)	0.06 m (0.2 ft)		9 m (29.52 ft)	1.89 m (6.2 ft)
0.5 m (1.64 ft)	0.11 m (0.36 ft)		10 m (32.8 ft)	2.10 m (6.89 ft)
1 m (3.28 ft)	0.21 m (0.69 ft)		11 m (36.08 ft)	2.31 m (7.58 ft)
2 m (6.56 ft)	0.42 m (1.38 ft)		12 m (39.36 ft)	2.52 m (8.27 ft)
3 m (9.84 ft)	0.63 m (2.07 ft)		13 m (42.64 ft)	2.73 m (8.95 ft)
4 m (13.12 ft)	0.84 m (2.76 ft)		14 m (45.92 ft)	2.94 m (9.64 ft)
5 m (16.4 ft)	1.05 m (3.44 ft)		15 m (49.2 ft)	3.15 m (10.33 ft)
6 m (19.68 ft)	1.26 m (4.13 ft)		20 m (65.6 ft)	4.20 m (13.78 ft)
7 m (22.96 ft)	1.47 m (4.82 ft)		25 m (82 ft)	5.25 m (17.22 ft)
8 m (26.24 ft)	1.68 m (5.51 ft)		30 m (98.4 ft)	6.30 m (20.66 ft)

4.1 Rain and wind

WLR 8/15/30 instruments has integrated internal software filters to filter out effects of rain, fog or wind for radar distance sensor. These filters however have some limitations. Majority of measurement inaccuracies caused by environmental factors can be solved by proper sensor installation.

For rain and snow suppression, the most effective solution is to mount the radar so that it points directly at water. As rain or snow fall, they affect the water surface, so it isn't as reflective as usually, thus reducing the SNR. However, our devices are tested and calibrated in a way, so they detect the surface even under heavy rainfall.

Influence of the wind on the accuracy is in most cases small and can be neglected. The only exception is strong wind as it will create surface waves and turbulences which can be detected as a shift in level. As mentioned above, length of radar filter can be adjusted to compensate for this.

4.2 Interference and multiple radars

Distance measurement radar is operating in W-band from 77 GHz to 81 GHz with linear frequency modulation, modulating signal continuously in the mentioned frequency range. To get interference between two or more sensors it will be required to keep central frequencies very precise just like in surface velocity radar and additionally timing synchronization of radar should be kept in range of 25 ns to each other. Such

synchronization is very complex to achieve so the interference probability between several radars on the same location is very small.

It is possible that some wideband radiation sources can introduce small and impulse interference for the short period of time, but this should not, or it is very unlikely to affect measurements reported by radar sensor.

4.3 Interference with Fog and Evaporation

Generally, radar sensors are not affected by fog or evaporation of water unless very heavy evaporation is present and water density in the air is very high.

The best solution for the distance measurement is in most cases to increase average period to get better average distance value. As evaporation is naturally very turbulent event with significant difference in density over the surface area and in time, averaging of the distance measurement spectrum is solving the problem of accuracy in such conditions.

4.4 Reflections

Water is very reflective medium for the radar waves and most of the power transmitted from radar transmitter will be reflected from the water surface. Reflections of the radar transmitted power beam follow the same physical laws as in optics and every time radar beam hits the surface part of the power is reflected away from the radar, part of the power is reflected towards the radar and only a small part of power is absorbed by the water. Depending on the surface roughness and incident angle ratio between power reflected in the direction away from the radar and direction back towards the radar can significantly vary. As incident angle for radars in fixed, only the roughness is determining the ration in our case.

In the case of level meter where incident angle of transmitted radar beam to the water is around 90° most of the power is reflected to the sensor and only small portion of the transmitter power will be dispersed in all directions. Ratio between power reflected to the sensor and power dispersed in all directions is dependent on the surface roughness but in general it is very small amount of the energy that is dispersed, and it is very unlikely that dispersed energy will cause additional multipath problems due to the more reflections from surrounding objects.

5 DATA INTERFACE

WLR 8/15/30 Water Level Radars are equipped with serial data interfaces.

Interfaces available on WLR Water Level Radars are compatible with HyQuest Solutions iRIS Data Loggers, and many third-party data loggers.

5.1 SDI-12

Serial SDI-12 is the preferred interface in many hydrometeorological applications. Multiple Water Level Radars can be connected via SDI-12 to a single data logger. Level measurements are not reported automatically, but are reported only after being requested by the master device (data logger unit). WLR 8/15/30 implements a sub-set of the SDI-12 Version 1.3 command set. Detailed description of the protocol is given in the Chapter 6 of this User manual.

Default communication parameters are:

- Bitrate: 1200 bps
- Start bits: 1
- Data bits: 7
- Stop bits: 1
- Parity: Even

5.2 Serial RS-485 Interface

Serial RS-485 interface is used for connecting multiple level meters to a single data logger. RS-485 allows to connect multiple level meters on a single bus. Level measurements are not reported automatically, but are reported only after being requested by the master device (data logger unit). WLR 8/15/30 supports Modbus RTU over RS-485 bus. Detailed description of the protocol is given in the Chapter 6 of this User manual.

Default communication parameters are:

- Bitrate: 9600 bps
- Data bits: 8
- Stop bits: 1
- Parity: Even

6 DATA PROTOCOLS

WLR 8/15/30 level meters supports the following data protocols:

- SDI-12 Version 1.3 (sub-set), multiple devices on a single SDI-12 bus
- Servicing protocol on RS-232 interface for configuring the unit, one device per connection
- Modbus RTU on RS-485 interface, multiple devices on a single RS-485 bus

Support for additional protocols is available upon customer request.

6.1 SDI-12 Protocol

WLR Water Level Radars will respond to all SDI-12 v1.3 commands. However, the core functionality is assured by means of using the commands referenced in Table 3.

Note:

- 'a' represents the device address.
- Active commands to set/change parameters are highlighted in Table 3.

Table 3 - SDI-12 commands

Command	Data Length	Response	Details
?!	3 bytes	a<CR><LF>	Device will identify using its SDI-12 address, default address is 0
a!	3 bytes	a<CR><LF>	Device will respond if its address is 'a'
aAb!	3 bytes	b<CR><LF>	Device will respond if its address is 'a' with its new address 'b'
aM!	7 bytes	a0007<CR><LF>	Device has 2 measured values available immediately
aMC!	10 bytes	a0007<crc><CR><LF>	Device has 2 measured values available immediately, along with 3 bytes of calculated CRC
aC!	7 bytes	a0007<CR><LF>	Device has 2 measured values available immediately
aCC!	10 bytes	a0007<crc><CR><LF>	Device has 2 measured values available immediately, along with 3 bytes of calculated CRC
aR0!	10 bytes	a0007<crc><CR><LF>	Device has 2 measured values available immediately
aV!	5 bytes	a0001<CR><LF>	Device verification is 1 value, available immediately
aD0!	variable	a+f+f+d+d+d+d+f<CR><LF>	+f – measured relative level depending on sensor height +f – measured distance from sensor to water +d – measured temperature inside device +d – measured water temperature (on request only) +d – measured accelerometer angle of device in x direction (on request only) +d – measured accelerometer angle of device in y direction (on request only) +f – SNR of latest measurement

		in case of verification command only: a±1<CR><LF>	in case of verification: +1 - everything in order -1 - error

aXPR0!	variable	aI0I0A0A0??????<CR><LF>	Measurement unit, according to SDI-12 requirements: I0 – level in meters A0 – temperature in °C
aXGU0!	variable	a+d<CR><LF>	+d – measurement unit for level 0 – m 1 – cm 2 – mm 3 – in 4 – ft
aXGU0+d!	variable	a+d<CR><LF>	+d – measurement unit for level 0 – m 1 – cm 2 – mm 3 – in 4 – ft
aXGP0!	variable	a+f<CR><LF>	+f – Dead zone minimum value, sensor will not report measurement lower than this
aXGP0+f!	variable	a+f<CR><LF>	+f – Dead zone minimum value, sensor will not report measurement lower than this
aXGP1!	variable	a+f<CR><LF>	+f – Dead zone maximum value, sensor will not report measurement lower than this
aXGP1+f!	variable	a+f<CR><LF>	+f – Dead zone maximum value, sensor will not report measurement lower than this
aXGP2!	variable	a+f<CR><LF>	+f – sensor height above riverbed
aXGP2+f!	variable	a+f<CR><LF>	+f – sensor height above riverbed
aXGP3+f!	variable	a+f<CR><LF>	+f – current staff gauge reading, device will calculate sensor height above riverbed as: staff gauge reading + distance from sensor to water
aXGP4!	variable	a+f<CR><LF>	+f – averaging time in seconds
aXGP4+f!	variable	a+f<CR><LF>	+f – averaging time in seconds

6.2 Servicing protocol (RS-232)

The servicing protocol is used to retrieve and modify device operating parameters. Various device settings, such as unit system and filtering parameters are configured using this protocol. The servicing protocol is always active.

To make radar configuration easy, HyQuest Solutions provides a Configurator utility application. Regular users do not need to be concerned about the servicing protocol used between the Configurator utility and the level meter device. The Configurator utility is described in the Chapter 7 of this manual.

The servicing protocol listens on RS-232 serial port for incoming requests, and on each received request, it will answer back.

The following requests are recognized by the servicing protocol:

Change serial baud rate

Changes the device serial baud rate.
#set_baud_rate=9600
#set_baud_rate=38400
#set_baud_rate=57600
#set_baud_rate=115200

Change Modbus ID

Changes the Modbus ID of the device. Accepts integer values.
#set_Modbus_id=<1-255>

Change SDI-12 ID

Changes the SDI-12 ID of the device. Accepts integer values.
#set_sdi_id=<1-255>

Change Modbus baud rate

Changes the baud rate for Modbus RTU communication with the device.
#set_Modbus_baud_rate=9600
#set_Modbus_baud_rate=19200
#set_Modbus_baud_rate=38400
#set_Modbus_baud_rate=57600
#set_Modbus_baud_rate=115200

Change Modbus parity

Changes Modbus RTU parity setting. 0=no parity, 1=odd parity, 2=even parity.
#set_Modbus_parity=0
#set_Modbus_parity=1
#set_Modbus_parity=2

Change Modbus stop bits

Changes the number of stop bits for Modbus RTU communication with the device.
#set_Modbus_stop bits=1
#set_Modbus_stop bits=2

Change moving average filter

Changes the window length (i.e. the number of samples samples) that are taken into account by thr moving average filter. Accepts integer values.

#set_frame_number=<1-1000>

Change IR filter

XXX Changes the constant used by IR filter. Accepted values are floating point using decimal point between 0 and 1.

#set_IR_constant=<0-1>

Change measurement offset

Changes level offset. Accepted values are floating point using decimal point in meters. The pre-set value results from factory calibration and should not be changed unless necessary.

#set_level_offset=<0->

Change amplitude threshold

Changes the minimum spectrum amplitude threshold for peak detection. Peaks below the threshold will not be detected. Accepts integer values.

#set_amplitude_threshold=<0->

Change Dead zone settings

Changes the dead zone of the radar sensor. Objects below '*Dead zone min*' and beyond '*Dead zone max*' will not be recorded. Accepted values are floating point using decimal point in millimetres.

#set_Dead zone_min=<0->

#set_Dead zone_max=<0->

Change 4-20mA settings

Sets the range for the 4-20mA output. 'analogue min' is reported as 4 mA. 'analogue max' is reported as 20 mA. Both values are accepted as floating point, in millimetres.

#set_analogue_min=<0->

#set_analogue_max=<0->

Change sensor height

Sets the sensor height relative to the bottom of the riverbed. The sensor will output relative measurement of the actual water level based on its height above the riverbed.

#set_sensor_height=<0->

Retrieve current device status

#get_info

Requests the current device status. Here is an example status output:

 # device_type:999

 # firmware:16
 # serial_number:000000
 # Modbus_id:2
 # baud_rate:115200
 # rs485_baud_rate:9600
 # rs485_parity:2
 # rs485_stop bits:1
 # level_range:15360.000000
 # level_resolution:7.500000
 # level_offset:0.100000
 # Dead zone min:0.200000
 # Dead zone max:15.360000
 # averaging_frame_number:24
 # spectrum_amplitude_threshold:15
 # IR_constant:0.250000
 # FFT_size:4096
 # chirp_slope_rate:40
 # ramp_duration:100
 # sampling_rate:8191
 # number_of_samples:777
 # RX_gain:34
 # active_TX_antenna:1

6.3 Modbus RTU Protocol (RS-485)

The unit responds to Modbus requests over RS-485 dana line. The baud rate is configured through the PC application, and 1 stop bit, even parity, 8 data bits configuration is used.

Modbus registers that are accessed by Modbus protocol are 16-bit (2-byte) registers. Any number of registers can be read or written over Modbus.

Modbus is a request-response protocol where a master (such as datalogger) sends out requests, and slave devices (such as WLR 8/15/30 sensors) responds. The request and response format, with example is given in tables 3-6.

In each request, the master can either ask the slave to retrieve value of one or more registers, or the master can set the value of one or more registers. Each register holds one 16-bit value.

Table 4 - Master request format

Name	Addr	Fun	Data start Addr		Data#of regs		CRC16	
Length	1 byte	1 byte	2 bytes (H,L)		2 bytes (H,L)		2 bytes (L,H)	
Example	0X01	0X03	0X00	0X00	0X00	0X01	0X84	0X0A

Table 5 - Request example

Name	Content	Detail
Address	0X01	Slave address (Sensor id)
Function	0X03	Read slave info
Data start Addr	0X00	The address of the first register to read (HIGH)
	0X00	The address of the first register to read (LOW) – Sensor ID reg

Data of regs	0X00	High
	0X01	Low (read only 1 register)
CRC16	0X84	CRC Low
	0X0A	CRC High

Table 6 - Slave (sensor) response format

Name	Addr	Fun	Byte count	Data		CRC16	
Length	1 byte	1 byte	1 byte	2 bytes(H,L)		2 bytes(L,H)	
Example	0X01	0X03	0X02	0X00	0X01	0X79	0X84

Table 7 - Response example

Name	Content	Detail
Address	0X01	Slave address (Sensor id)
Function	0X03	Read slave info
Data length	0X02	Data length is 2 bytes
Data	0X00	Data high byte
	0X01	Data low byte, means ID is 1
CRC16	0X79	CRC Low
	0X84	CRC High

The table 7 defines the data returned by the unit when the master requests register read. The table 8 defines how to write device configuration. Rows highlighted in blue denote the important values measured by the sensor. Rows highlighted in green denote operating parameters that could be changed in the field.

Table 8 - Retrieving data from the sensor

Fun	Data Addr	Data Length	Data Range	Details
0X03	0x0001	2 bytes	0 – device range[mm]	Current level measurement
	0x0002	2 bytes	0 – device range[mm]	Average level measurement
	0x0003	2 bytes	0 → 9600 1 → 38400 2 → 57600 3 → 115200 0xFF → other/error	RS-232 baud rate
	0x0004	2 bytes	1 - 255	Modbus ID
	0x0005	2 bytes	0 → 9600 1 → 19200 2 → 38400 3 → 57600 4 → 115200 0xFF → other/error	RS-485 baud rate (Modbus)

Fun	Data Addr	Data Length	Data Range	Details

0X03	0x0006	2 bytes	0 → no parity 1 stopbit 1 → no parity 2 stop bits 2 → odd parity 1 stopbit 3 → odd parity 2 stop bits 4 → even parity 1 stopbit 5 → even parity 2 stop bits default → even parity 1 stopbit	RS-485 parity and stop bits
	0x0007	2 bytes	1-65535	SDI-12 ID
	0x000A	2 bytes	900 - 65535	Device type; WLR X → 999, 998
	0x000B	2 bytes	1 – 32 default: 24	Number of frames for average measurement
	0x000C	2 bytes	1 – 65535 default: 0	Minimum spectrum amplitude threshold, used for detecting peaks
	0x000D	2 bytes	0 – device range [mm] default → 0	Dead zone minimum in mm
	0x000E	2 bytes	0 – device range[mm] default → device range [mm]	Dead zone maximum in mm
	0x000F	2 bytes	0 – device range[mm] default → device range [mm]	4-20mA minimum value in mm
	0x0010	2 bytes	0 – device range[mm] default → device range [mm]	4-20mA maximum value in mm
	0x0011	2 bytes	0 – device range [mm]	Level measurement offset
	0x0012	2 bytes	0 – 1000	IR filter constant $IR_{const} = \frac{value_{int}}{1000}$
	0x0013	2 bytes	0 – 34	RX gain
	0x0014	2 bytes	1 – 3	Active TX antenna
	0x0015	2 bytes	2 printable characters	Serial number[0-1]
	0x0016	2 bytes	2 printable characters	Serial number[2-3]
	0x0017	2 bytes	2 printable characters	Serial number[4-5]
	0x0018	2 bytes		FW version
	0x0019	2 bytes	4096,8192	Number of FFT samples

Fun	Data Addr	Data Length	Data Range	Details
0X03	0x001A	2 bytes	0-255	Temperature of electronics inside the case
	0x001B	2 bytes	0+	SNR of the current measurement
	0x0020	2 bytes	Current relative level	Current level measured depending on the sensor height; Calculated as sensor height – current level measurement
	0x0021	2 bytes	Average relative	Average level measured depending on the sensor height; Calculated as sensor height – average level measurement
	0x0022	2 bytes	Sensor height	Sensor height in mm above the riverbed

Table 9 - Writing data to the sensor

Fun	Data Addr	Data Length	Data Range	Details
0x06	0x0003	2 bytes	0 → 9600 1 → 38400 2 → 57600 3 → 115200 0xFF → other/error	RS-232 baud rate
	0x0004	2 bytes	1 - 255	Modbus ID
	0x0005	2 bytes	0 → 9600 1 → 19200 2 → 38400 3 → 57600 4 → 115200 0xFF → other/error	RS-485 baud rate (Modbus)
	0x0006	2 bytes	0 → no parity 1 stopbit 1 → no parity 2 stop bits 2 → odd parity 1 stopbit 3 → odd parity 2 stop bits 4 → even parity 1 stopbit 5 → even parity 2 stop bits default → even parity 1 stopbit	RS-485 parity and stop bits

Table 10 – SDI-12

Fun	Data Addr	Data Length	Data Range	Details
0x06	0x0007	2 bytes	1 – 65535	SDI-12 ID

	0x000B	2 bytes	1 – 1000 default: 100	Number of frames for average measurement
	0x000C	2 bytes	1 – 65535 default: 0	Minimum spectrum amplitude threshold, used for detecting peaks
	0x000D	2 bytes	0 – device range [mm] default → 0	Dead zone minimum in mm
	0x000E	2 bytes	0 – device range[mm] default → device range [mm]	Dead zone maximum in mm
	0x000F	2 bytes	0 – device range[mm] default → device range [mm]	4-20mA minimum value in mm
	0x0010	2 bytes	0 – device range[mm] default → device range [mm]	4-20mA maximum value in mm
	0x0011	2 bytes	0 – device range [mm]	Level measurement offset
	0x0012	2 bytes	0 – 1	IR filter constant $IR_{const} = \frac{value_{int}}{1000}$
	0x0015	2 bytes	2 printable characters	Serial number[0-1]
	0x0016	2 bytes	2 printable characters	Serial number[2-3]
	0x0017	2 bytes	2 printable characters	Serial number[4-5]
	0x0022	2 bytes	Sensor height	Sensor height in mm above the riverbed

7 RADAR CONFIGURATOR UTILITY

HyQuest Solutions provides a user-friendly PC application to configure WLR Water Level Radars. Additionally, the Configurator Utility displays current level readings.

When started, the Configurator Utility displays its main window. Initially, no level data is displayed, as the connection to the level meter device is not established.

Figure 4 - Level Meter Configurator main window

To connect the Configurator utility with the level meter, connect your PC to the radar using an RS-232 serial cable connection. Then, select the *Radar → Connect* menu option in the Configurator Utility, and choose the appropriate COM port number. The Configurator will try to establish a data link between your PC and the level meter device. After the data link is established, active device parameters will be displayed, and the level measurements will be displayed:

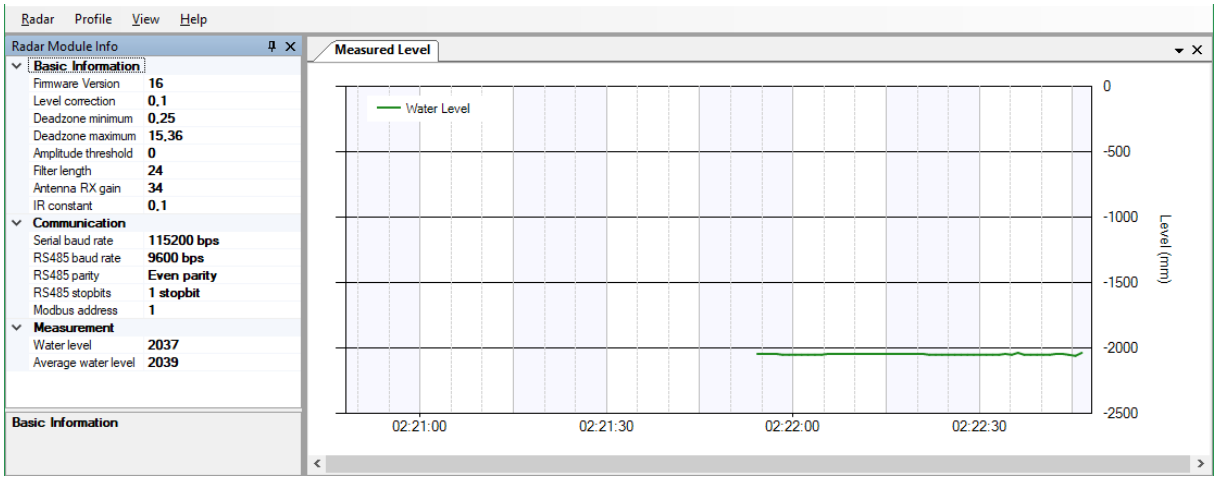

Figure 5 - Configurator main window with device connected

The utility window is divided into two panes, that can be manually re-arranged. The first panel (at the left part of the screen) is the Radar Module Info pane that displays the radar level meter information and operating parameters. Some of these parameters can be changed by editing the values directly inside the Radar Module Info pane. The following information is displayed:

Firmware version	*the version of the firmware running in the radar sensor device*

Level correction	*correction in meters to be added to the detected level*
Dead zone minimum	*minimum detected distance*
Dead zone maximum	*maximum detected distance*
Filter length	*if moving average filter is used, select the averaging window length*
Amplitude threshold	*minimum spectrum amplitude necessary for peak detection*
RX gain	*the current gain value of the radar signal amplifier*
IR constant	*if IR is used, this value is used for the IR filter*
Serial baud rate	*the communication baud rate used for serial communication*
RS485 baud rate	*the communication baud rate used for RS485 communication*
RS485 parity	*parity used on the RS485 bus*
RS485 stop bits	*stop bits used on the RS485 bus*
Modbus address	*device address on the RS485 bus*
Water level	*water level in meters*
Average water level	*average water level in meters, using filter length*

The second pane (in the right part of the window) displays the history graph showing the measured level in the last 30 minutes.

8 MECHANICAL DRAWING

For mechanical dimensions of the Water Level Radar (WLR), please refer to Figure 6.

Figure 6 – HS Water Level Radar (WLR): Mechanical Drawing, all dimensions in mm (1 mm = 0,00328 ft)