AquaCheck

Sub-Surface and Classic series probes

Technical Datasheet and interface manual

Version 1.9
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AquaCheck (Pty) Ltd

STATEMENT OF COMPLIANCY

ELECTRO-MAGNETIC COMPLIANCE

The AquaCheck probe moisture sensor has been tested and found to comply with the limits for this Class digital device, pursuant to the requirements of the CE rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause interference to other radio communications.

EMC APPROVALS

The AquaCheck probe moisture sensor has been tested and found to comply with the following EMC guidelines:

EMISSIONS:
- ✓ ETSI EN 300 220-2 V2.4.1
- ✓ 47 CFR 15C - RSS 210
- ✓ 47 CFR 15C – 15.247 (a)(2), (b)(3), (d), (e)
- ✓ 47 CFR 15C – 15.31(e)
- ✓ 47 CFR 15B – 15.109 (Class B)
- ✓ AS/NZ 4268 (2012)
- ✓ CISPR (Class B) radiated and conducted emissions

IMMUNITY TESTING: ETSI EN 301 489-3 V1.4.1 / ESTI EN 302 489-1 V1.9.2

- ✓ Radiated Immunity   *- EN 61000-4-2/3/4/5/6*

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.

AqauCheck probes are intended to operate buried in the soil, if operated in free air may cause interference to radio communication devices.

This device complies with part 15 of the FCC Rules and Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions:
1. *This device may not cause harmful interference, and*
2. *this device must accept any interference received, including interference that may cause undesired operation.*

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnemen

Changes or modifications made to this equipment not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
—Reorient or relocate the receiving antenna.
—Increase the separation between the equipment and receiver.
—Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
—Consult the dealer or an experienced radio/TV technician for help.

Table of Contents

Foreword - AquaCheck Subsurface and Classic probes

AquaCheck manufacture an extensive range of Subsurface (below ground) and Classic (above ground) Probes. Below shows a table for standard sensor depth and spacing.

#	Probe Length (mm)	Probe Length (Inch)	Sensors (n)	SKU #	100 mm	200 mm	300 mm	400 mm	500 mm	600 mm	700 mm	800 mm	900 mm	1000 mm	1100 mm	1200 mm	1300 mm	1400 mm	1500 mm	1600 mm
1	200mm	8"	2	1120-0202	X	X														
2	400mm	16"	4	1120-0404	X	X	X	X												
3	400mm	16"	2	1120-0204	-	X	-	X												
4	600mm	24"	6	1120-0606	X	X	X	X	X	X										
5	600mm	24"	4	1120-0406	X	X	-	X	-	X										
6	800mm	32"	8	1120-0808	X	X	X	X	X	X	X	X								
7	800mm	32"	6	1120-0608	X	X	X	X	-	X	-	X								
8	800mm	32"	4	1120-0408	-	X	-	X	-	X	-	X								
9	1000mm	40"	10	1120-1010	X	X	X	X	X	X	X	X	X	X						
10	1000mm	40"	8	1120-0810	X	X	X	X	X	X	-	X	-	X						
11	1000mm	40"	6	1120-0610	X	X	-	X	-	X	-	X	-	X						
12	1200mm	48"	12	1120-1212	X	X	X	X	X	X	X	X	X	X	X	X				
13	1200mm	48"	10	1120-1012	X	X	X	X	X	X	X	X	-	X	-	X				
14	1200mm	48"	8	1120-0812	X	X	X	X	-	X	-	X	-	X	-	X				
15	1200mm	48"	6	1120-0612	-	X	-	X	-	X	-	X	-	X	-	X				
16	1400mm	56"	14	1120-1414	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
17	1400mm	56"	12	1120-1214	X	X	X	X	X	X	X	X	X	X	-	X	-	X		
18	1400mm	56"	10	1120-1014	X	X	X	X	X	X	-	X	-	X	-	X	-	X		
19	1400mm	56"	8	1120-0814	X	X	-	X	-	X	-	X	-	X	-	X	-	X		
20	1500mm	60"	15	1120-1515	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
21	1600mm	64"	8	1120-0816	-	X	-	X	-	X	-	X	-	X	-	X	-	X	-	X

To achieve desired sensor depths the Subsurface probes are installed about 20mm <u>below</u> ground

Classic probes are to be installed with the lower collar 10-20mm <u>above</u>
 the ground surface
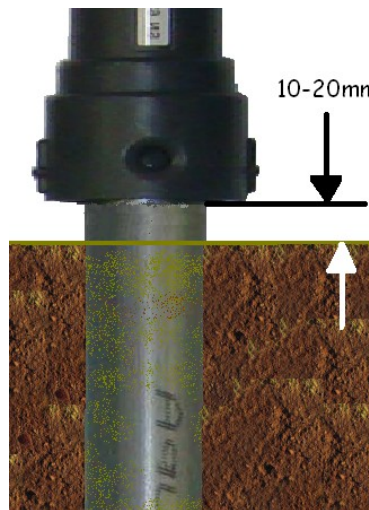
Overview and operational description

The Aquacheck Subsurface and Classic probe range are supplied with wire ends or connector to communicate and power the probe. There are 2 hardware options: SDI and RS485. RS485 is a "special order" and must be specified on the order, it is not field changeable. There are also 2 software "protocols" available, SDI-12 and MODBUS. The possible configurations are thus SDI-12, SDI-12 over RS485, MODBUS over SDI or MODBUS over RS485.

Subsurface probes are provided standard with a 5m cable tail. Classic probes are provided with a friction-lock connector and optionally a cable tail with the female connector fitted.

For proper probe installation refer to the Aquacheck user guide.

Communications interface – SDI-12/RS485

Probes are shipped standard with SDI hardware drivers, RS485 drivers are fitted by "special order". The RS485 drivers are embedded into the probe body, "in-field" changing between RS485 and SDI drivers is not possible. NOTE: The probe "protocol" is different to the hardware drivers: - for example BOTH MODBUS and SDI-12 protocol can operate over the RS485 drivers. Similarly for SDI drivers

Power

Power may be supplied continuously, or as needed. When power is supplied, the controller must wait at least one second before communicating on the bus. It is important that the bus be held in the "idle" state (below 1V for SDI bus and in the "spacing" state for RS485 versions).

If power is removed between readings it is important to remove the power for at least 1 minute so the probe will properly wake on the next power sequence. If communication with the probe is less than one-minute intervals, then keep the power applied. If the controller requests readings at a rate faster than one minute, the probe would return the last valid reading. It is not possible to read the sensors at a rate faster than one minute.

It is important to note that AquaCheck probes support very low power (battery operated) systems. The probe can accept supply voltages as low as 3.3V. The SDI-12 specification requires the data line to operate between 0V and 5V. The user needs to take note that when the probe is supplied with less than 5V the data line will operate at a lower "marking" voltage than 5V. For supplies between 3.3V and 5V the "marking" voltage on the data line will equal the supply voltage less 0.2V. If the RTU expects 5V on the data line, then the probe **must** be powered with at least 5V.

SDI-12 protocol

This section describes the SDI-12 communications protocol. For MODBUS protocol implementation please contact AquaCheck for further information.
AquaCheck SDI-12 probes follow the SDI-12 protocol V1.3. For further information and operation of the SDI-12 specification please download the document at www.sdi-12.org. [It is imperative the any developer follow and implement the specification. SDI commands below illustrate the set of commands used by AquaCheck probes. Exact content may vary, so its important to implement the protocol as laid out in the specification and not rely only on the sample content below.]

In SDI-12 mode the probe follows the communication settings as laid out in the SDI-12 specification: 1200Bd, 7-Bits, EVEN parity and one stop bit. For communication of the RS485 version (SDI-12-over-RS485) the settings/commands are the same.

SDI Break Command

AquaCheck probes implement very low power technology and therefore the internal processor never turns off. The communication port is always "listening" and therefore the "break" command is not required, and will be ignored if supplied. All other behaviour is as set out in the SDI-12 V1.3 spec (including the use of break for aborting a mearurement)

SDI-12 Commands

The following commands are supported by the probes. "a" signifies the address of the probe – the factory default address is 0.

Command	Function	Example response and notes
?!	Call any probe on the bus	a<cr><lf> find the address of a probe – only use this command with one probe connected on the bus
a!	Ack active	a<cr><lf> Acknowledge probe is present
aI!	Identification	013AquaChckACHSDI041ssssssssss<cr><lf> See command detail explination
aM! (or aM0!)	Start measurement	atttn<cr><lf> (ttt=delay and n=number of values) followed by Attention response: a<cr><lf> after ttt second (see detail below)
aMn!	Start measurement on subsequent channels	atttn<cr><lf> (ttt=delay and n=number of values) here ttt is usually 0 and the Attention response does not follow (see detail below)
aDn!	Read data	addddddddd<cr><lf> refer below for details

aC! (or aC0!)	Concurrent measurement	atttnn<cr><lf> Same as M command except n can be greater than 9 and there is no Attention responce
aAb!	Change Addr	Change the bus address from a to b
aX#!	Read Config	Read the probe configuration.
aMC! Or aCC!	Checksum	Supported in firmware V43.0 and later
aR0!	R0 (info)	(V43.0+) a0003<cr><lf> (see below, probe identification)
aRn!	aR1 to aR9	a0000<cr><lf>

There are no user settable values within the SDI-12 communication for the probes. All calibration information if factory programmed into the probe. Only the SDI address can be changed.

Sensor map

Command	Meaning
aM!, aM0!, aC! Or aC0!	Start a reading and return the soil moisture values
aM1! or aC1!	Read the temperature values (will not start a new reading if this command is given directly after the moisture reading)
aD! or aDn!	Return the values – see below for details

Reading data from the probe (aM or aC command)

Reading of moisture data will commence with the issuing of the aM! (or aM0!) command. Use of this command is as follows:

Issue the aM! command.
The probe replies with atttn<cr><lf> where ttt is the delay time in seconds and n is the number of sensors.

Note this response can only report a maximum of 9 sensors (*).

Just less than ttt seconds the probe gives the attention response a<cr><lf>. The controller can now fetch the data.

Issue the aDn! command (aD0! aD1! aD2! etc). Each command responds with data in the format:

asiii.dddsiii.dddsiii.ddd<cr><lf>
where s is a sign "+" or "-", iii is the integer value and ddd is the decimal value

example : a+123.45-4.689+100.234<cr><lf> This response has 3 values of 123.45 -4.689 and +100.234

Now keep issuing further aDn! commands until all the data values are finished. If you read more values than exist then the probe will respond with a<cr><lf> indicating there are no more values.

(*) Note for probes with >9 sensors the aM! will respond with n=9. To get all the sensors data keep giving aDn! commands until there are no more values

Note also that currently the probe gives 3 readings per D command with a fixed format, but the controller must not rely on this as the number of values in one D command may change as well as the decimal format may vary in the number of decimals after the ".".

Reading of moisture data will commence with the issuing of the aC! (or aC0!) command. Use of this command is as follows:

Issue a aC! command.
The probe replies with atttnn<cr><lf> where ttt is the delay time in seconds and nn is the number of sensors. n can be 0 to 99.

This command does **not** give the attention response; the controller must wait for ttt seconds before fetching the data.

Note on reading temperature:

The temperature is read with the aM1! (or aC1!) command. There are the same number of temperature sensors as moisture sensors. The temperature is measured at the same time as the moisture, so it is more efficient to start with the moisture reading, then there will be no wait to fetch the temperature data.

Fetch the temperature data in the same manner as the moisture data.

Note: the controller MUST NOT access the SDI-12 bus while the probe is taking a reading. Sending a "break" or any command to the probe will interrupt the read cycle, and the probe will listen to the bus for new commands.

Interpretation of data value

The values returned in the D command are signed decimal values.

For moisture sensors the return value has a possible range of -5 to +120. The probe sensor is calibrated to return 0.000SFU to 100.000SFU for air and water readings (see specifications of calibrated values). A return value of less than -4% will indicate a sensor problem, and a return value of -5% (exactly) will indicate sensor failure.

Please note that the probe can under certain conditions return valid moisture reading above 100. The 100 value is calibrated in water and under certain soil/water conditions the reading can exceed 100, for example in heavy saturated clay we have found readings of up to 106.

Please note the value returned IS NOT a % of soil moisture, but simply a **scaled frequency unit** (SFU). It is also not linear with moisture. If the user has a requirement to read volumetric water content, then please refer to a separate document "AquaCheck soil calibrations". Take special note that soil-and-site specific calibrations are advised when using these equations.

Temperature values are returned in absolute value degrees centigrade. The range for temperature values is -20 to +50 Degrees centigrade.

Probe identification (aI! command)

Send the aI! command to fetch the probe identification. This responds with:
Allcccccccccmmmmmmvvvxxxxxxxxxxxx<CR><LF>
a = Probe address
l ="13" SDI-12 protocol version 1.3
c = "AquaChck" company name
m = "ACCSDI" or "ACHSDI" – probe type model;

Note:
- ACCSDI will have probe calibrations of 6% to 94% (legacy controllers that could not handle <0 and > 100 value (typically probes V32)
- ACHSDI will have probe calibrations of 0% to 100% (+- 1% accuracy calibration) (typically probes V39 up)
- Probe V39 up have improved temperature correction algorithms.

v = firmware version number (eg 032)
x = Serial number (Only available from firmware V39 onwards, Always begins with "S")

Read Probe Configuration (aX#! command) (V40 firmware or later ONLY) – note when designing with V43 and later rather use the aR0! Command.

Send the "extended" command aX#! to fetch the probe Configuration. This responds with:

a#nLx<CR><LF>

#n = number of sensors (Only available from firmware V40)
Lx = probe length identifier

where x=
0   Not Set
1   10cm
2   20cm
3   30cm
4   40cm
5   60cm
6   80cm
7   100cm
8   120cm
9   140cm
10   150cm
11   160cm   (example a#6L6 is a 6 sensor 80cm probe)

Note: versions 40 upward will no longer implement the #L in the info string. Consult AquaCheck for further advice on older versions.

Read Probe Configuration (aR0! command) (V43 firmware or later ONLY)

Send command aR0!

Replies with a0003<cr><lf>, meaning there are 3 values to read

Send aD0! command
Replies:
a+vvv.v+#+L<cr><lf> where vvv.v is the version (eg 43.0), # is the number of sensors and L is the probe length (cm) (example a+43.0+06+100<cr><lf> means V43.0 firmware, 6 sensor 100cm probe)

About the calibration process

AquaCheck factory calibrates the probes in controlled air bath and water bath. This ensures all probes have the same performance under the same conditions.

For V39 onwards the sensors are calibrated to read 0 in air and 100 in water. At calibration time this is done within +- 1%. This means a sensor may read -1 to +1 post calibration. (the controller needs to cope with values less than 0 and greater than 100)

If conversion is required to read moisture in volumetric units, then a "soil calibration formula" will need to be used. User must note that soil calibrations are very specific to the particular soil type. If the user requires very accurate volumetric readings, then an "in-filed" calibration would be highly advised. A 2-point calibration for each sensor may be required (near dry or WP, and near field capacity). The method of calibration would depend on the soil consistency at the installed profile. Due to the variability that capacitance technology exhibits in different soil textures it is not possible to specify an

absolute accuracy for volumetric readings. However, the repeatability and resolution will follow those in the specifications. Typically, one can expect a 5% to 7% overall accuracy without further calibration provided the calibration equation accurately reflects the soil type and the recommended installation is followed. A further caution must be added in the case where either the soil type differs down the profile, or a different slurry is used – the slurry will affect the overall soil texture and cause the calibration function to be inaccurate. Using a different slurry will however NOT affect the performance of the probe, but keep in mind the composition of the slurry could change over time if it is significantly different in texture to the soil around it. In this case a follow-up re-evaluation of the management lines may be needed once the soil has settled.

Firmware Upgrade

From time-to-time it may be required to upgrade the firmware to take advantage of new feature that may be implemented.
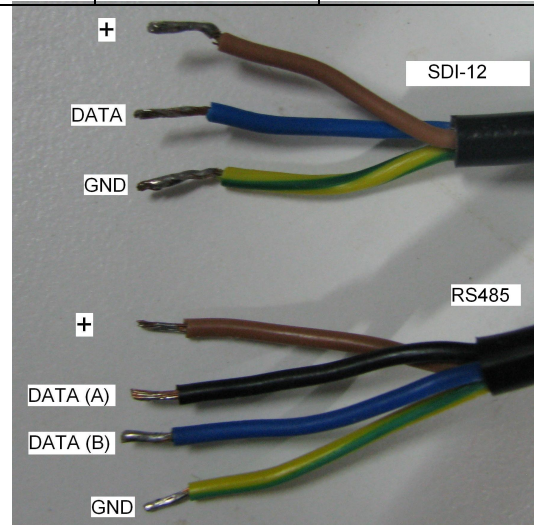
AquaCheck supplies a utility tool and PC program to upgrade firmware.
Follow the instructions for upgrading as supplied with the firmware file, or as supplied or directed by your AquaCheck representative.

Specifications

| Parameter	Value or Meaning
Supply Voltage (absolute maximum)	3.3V to 14V (5V to 14V for RS485, Note RS485 will function properly between 3.3V and 5V, but the driver may not achieve the EIA standard of 4000ft)
Cable or connector	(Sub surface probes supplied std with 5M cable 3-core/4-core)
SDI communication port	ESD protection fitted
RS485 Communication port (Order option)	ESD Protection / TIA/EIA485 compliant
Baud rate SDI-12 mode	1200 7-bit Even parity, one stop bit
Supply Current Active Read (about 2 seconds for 6 sensor probe)	23mA
Supply Current idle	<0.1mA for SDI, <0.3mA for RS485
Temperature measurement	-20 to +50 degrees centigrade
Sensor calibration	AIR (RH less than 75%) and distilled water Calibrated to read 0 (+-1) in air and 100 (+-1) in water
Sensor stability	Maximum drift of 3% over the warranty period as measured under that same calibration conditions
Sensor Resolution	Moisture 0.01 & Temp 0.1
Repeatability	Moisture 0.05 & Temp 0.2
Sensor drift with temperature	Less than 0.1% per degree Centigrade over the range +5 C to +40C

Connections

Signal (PVC – Cabtyre/Alvern)		SDI-12 open ended	RS485 open ended	Classic male plug SDI	Classic male plug RS485
Supply Voltage	B	Brown	Brown	1	1
Data (or Data B)	B	Blue	Blue	2	3
Data A		-	Black	-	2
Ground		Green/Yellow	Green/Yellow	3	4

Halogen-free type communication cable:

Switch -craft		AQUACHECK Signal	4-CORE Helukabel
1		+V OUT	BROWN
2		DATA (RS485-B)	BLUE
3		COUNTER (RS485-A)	WHITE
4		GND	BLACK

TELEMETRY	PROBE	
	SDI	RS485
+ OUT	+ supply to probe	
SDI-12 DATA	DATA	DATA-B
COUNTER	N/C	DATA-A
GND		
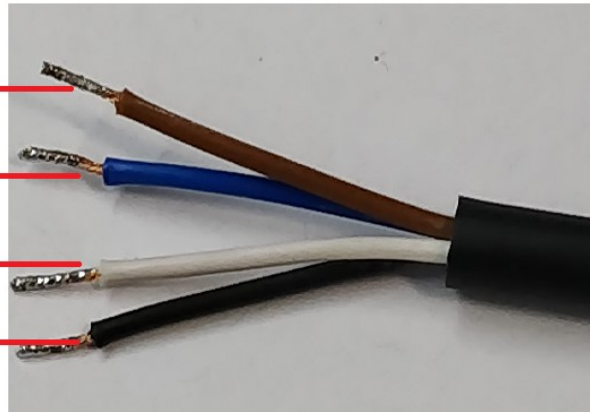
Cable Part numbers:
- HELUKABEL Sensor-Aktor: 7023341
- HELUKABEL Sensorflex-H: 76285 or 76301
- LAPP UNITRONIC SENSOR FD: 7038884

Please note: Asof April-2019 Aquacheck Subsurface probes will be phasing to the abovementioned cable; the PVC cable will no longer be used. These cables are halogen-free (PUR) – for datasheets please contact Aquacheck.

Example of probe connection to 4-pin Switchcraft (EN3C4M):