INSTRUCTION MANUAL

Drill & Drop
Soil Moisture Profiler

August 2016

WARRANTY AND ASSISTANCE

This equipment is warranted by CAMPBELL SCIENTIFIC (CANADA) CORP. ("CSC") to be free from defects in materials and workmanship under normal use and service for **twenty-four (24) months** from date of shipment unless specified otherwise. ***** **Batteries are not warranted.** ***** CSC's obligation under this warranty is limited to repairing or replacing (at CSC's option) defective products. The customer shall assume all costs of removing, reinstalling, and shipping defective products to CSC. CSC will return such products by surface carrier prepaid. This warranty shall not apply to any CSC products which have been subjected to modification, misuse, neglect, accidents of nature, or shipping damage. This warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability or fitness for a particular purpose. CSC is not liable for special, indirect, incidental, or consequential damages.

Products may not be returned without prior authorization. To obtain a Return Merchandise Authorization (RMA), contact CAMPBELL SCIENTIFIC (CANADA) CORP., at (780) 454-2505. An RMA number will be issued in order to facilitate Repair Personnel in identifying an instrument upon arrival. Please write this number clearly on the outside of the shipping container. Include description of symptoms and all pertinent details.

CAMPBELL SCIENTIFIC (CANADA) CORP. does not accept collect calls.

Non-warranty products returned for repair should be accompanied by a purchase order to cover repair costs.

CAMPBELL® SCIENTIFIC

Campbell Scientific (Canada) Corp.
14532 131 Avenue NW | Edmonton AB T5L 4X4
780.454.2505 | fax 780.454.2655 | campbellsci.ca

Assistance

Products may not be returned without prior authorization. The following contact information is for Canadian and international clients residing in countries served by Campbell Scientific (Canada) Corp. directly. Affiliate companies handle repairs for clients within their territories. Please visit *www.campbellsci.ca* to determine which Campbell Scientific company serves your country.

To obtain a Returned Materials Authorization (RMA), contact CAMPBELL SCIENTIFIC (CANADA) CORP., phone (780) 454-2505. After a measurement consultant determines the nature of the problem, an RMA number will be issued. Please write this number clearly on the outside of the shipping container. Campbell Scientific's shipping address is:

CAMPBELL SCIENTIFIC (CANADA) CORP.
RMA#_____
14532 131 Avenue NW
Edmonton, Alberta T5L 4X4
Canada

For all returns, the client must fill out a "Statement of Product Cleanliness and Decontamination" form and comply with the requirements specified in it. The form is available from our web site at *www.campbellsci.ca/repair*. A completed form must be either emailed to *repair@campbellsci.ca* or faxed to (780) 454-2655. Campbell Scientific (Canada) Corp. is unable to process any returns until we receive this form. If the form is not received within three days of product receipt or is incomplete, the product will be returned to the client at the client's expense. Campbell Scientific (Canada) Corp.f reserves the right to refuse service on products that were exposed to contaminants that may cause health or safety concerns for our employees.

Precautions

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND **TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC**. FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.ca or by telephoning (780) 454-2505 (Canada). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified personnel (e.g. engineer). If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General

- Prior to performing site or installation work, obtain required approvals and permits.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, 6 meters (20 feet), or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CLIENT ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

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Tables

Sentek Drill & Drop

1. Introduction

The Sentek Drill & Drop uses SDI-12 Digital Technology for simple integration and reliability. The Drill & Drop probe consists of multiple sensors for ease of measuring soil moisture, temperature, and salinity.

Before using the Sentek Drill & Drop, please study

- Section 2 – Cautionary Statements
- Section 7-1 – Wiring
-

2. Cautionary Statements

- Although the Sentek Drill & Drop is designed to be a rugged and reliable device for field use, care should be taken when handling or moving it to avoid damage.
- There are no user-serviceable parts and any attempt to disassemble the device will void the warranty.
- The Sentek Drill & Drop is recommended to be used in conjunction with the SGB3 in order to protect against electrical surge. The SGB3 is available for purchase from Campbell Scientific Canada.

3. Initial Inspection

- Upon receipt of the Sentek Drill & Drop, inspect the packaging and contents for damage. File any damage claims with the shipping company. Immediately check package contents against the shipping documentation. Contact Campbell Scientific about any discrepancies.
- The model number and cable length are printed on a label at the connection end of the cable. Check this information against the shipping documents to ensure the expected product and cable length are received.
- The Sentek Drill & Drop is shipped with sensors installed, a 5 m cable, and a ResourceDVD.

4. Overview

The Sentek Drill & Drop probe possesses multiple sensors. The sensors and cable are encapsulated inside the probe rod. The probes are available with:

- 3, 6, 9, or 12 moisture sensors
- 3, 6, 9, or 12 moisture and salinity sensors

Every sensor has an associated temperature sensor. Sensors are spaced at 10 cm intervals along the probe, with the first sensor centered at 5 cm. Sensor nunbers increase with sensor depth.

Probes are available in 30cm (12 inches), 60 cm (24 inches), 90 cm (32 inches) or 120 cm (48 inches) lengths. All probes are preconfigured with SDI-12 address “0” and all sensors are normalized.

The purpose of the SGB3 is to provide adequate surge protection for the Drill & Drop. The case of the SGB3 is suited for mounting to a backplate with 1 inch on center spacing.

5. Specifications

Moisture Sensor Resolution:	1:10000
Moisture Sensor Range:	0 to 100%
Moisture Sensor Precision:	±0.03% vol.
TriScan Sensor Resolution:	1:6000
Temperature Sensor Accuracy:	±2°C @ 25°C
Temperature Sensor Resolution:	0.3 °C
Temperature Range (operating):	-20 °C to +60 °C
Voltage Supply (+Vin):	2.7V to 15Vdc, Nominal 12V

Note When opeating below 5V, the probe will still drive the SDI-12 data line at the 5V specification so the datalogger will also need to be 5V tolerant. Permanent damage may result if the probe is operated above 15V for extended periods of time. Above 15V, the probe will draw higher current (up to about 100 mA).

6. Installation

Tools required:

- Installation Kit (SEN70260) – purchase from Campbell Scientific Canada.
    - Includes installation tripod, swivel auger guide, screw pins (3), toolkit bag
- Tapered Length Auger (SEN71030, SEN71060, SEN71090, or SEN71000) –purchase from Campbell Scientific Canada
- Spray water bottle
- Battery powered drill (most soils)
- AC powered drill (clay soils)
    - Small power generator
    - Electrical extension cord
- Drill socket for screw pins
- 2 sheets of newspaper
- Trowel
- Rubber mallet
- Bucket

The auger is slightly longer than the probe. Therefore, the tapered soil opening created by the auger is deeper compared to the length of the probe body. The resulting soil cavity below the bottom of the probe is designed to accept soil accumulating at the bottom of the cavity during the augering process. Otherwise, soil accumulation could obstruct the insertion probe body to its full length.

6.1 Tripod

1. Place 2 sheets of newspaper beneath the the Stabilization Tripod. This allows easy removal of the augured soil later.
2. To set up the tripod, Prepare screw pins for drilling, place socket into drill and tighten. Drill screw pins straight into the soil. Place one foot onto the centre of the tripod, position the socket onto the screw pin and keep drilling until the head end of the pin comes to rest on top of the tripod. Repeat with the remaining 2 pins and then check the tripod stability.

6.2 Augering

Attach the auger to the drill. Insert the auger into the centre of the tripod keeping it as straight as possible. Start the drill and move the auger constantly and gently 10 – 15 cm up and down during the drilling process. This enables movement of the soil from the auger flight upwards and out of the drilled hole. Wetting the auger in clay soils helps to simplify the drilling process by lubricating the clay ribbons, which allows them to travel up the auger flight and out the hole. In sand, wetting the auger helps to preserve the integrity of the auger hole by preventing wall collapses.

To auger to the proper depth, auger until the end of the auger flight is level with the top of the bush of the tripod, and stop the drill. Carefully remove the auger from the hole and remove all soil from it, placing it in the bucket. Use the auger to measure the depth of the hole before inserting the probe. If you cannot fully insert the auger, then spin the auger to remove the remaining soil at the bottom of the hole, then remove and clean the auger again. Repeat this process as necessary until you can fully insert the auger without spinning it.

Use the drill in reverse mode to remove the screw pins from the installation tripod. Remove the tripod and inspect the quality of the hole. It should be smooth-sided and free of air pockets. Remove the soil from the site using the newspaper, and deposit it in the bucket.

6.3 Probe Installation

Prepare a small trench where the cable should be buried. This will help protect the cable from machinery, or animals chewing. Take caution when digging the trench not to allow soil to fall in the augered hole.

Using water from a spray bottle, wet the entire length of the probe as well as the upper inner walls of the augered hole. This acts as a lubricant for the probe, and is particularly important in clay soils. Insert the probe carefully into the hole pushing it all the way down until the top of the probe is level with the soil surface. The first sensor will now be located at 5cm depth.

Note If the probe protrudes above the soil surface and you cannot push it any further by hand, gently step on it and use your body weight to push it into a final position (level with the ground surface). If this does not work, use a rubber mallet to force penetration of the probe by very gently tapping it with another hammer. Do not use any metal beating implements directly onto probe.

The only required configuration setup is setting the SDI-12 address. This can be done in the field with a Windows laptop or with an office windows computer. Alternatively, it can be done using your SDI-12 datalogger if that capability is available.

6.4 Set Probe Address (if required)

1. Install the USB device driver available for download at https://www.campbellsci.ca/downloads
Note: driver installation is not required if the computer is running Windows 7 or later.

2. Plug in the SDI-12 programming cable into any USB port on your computer.

3. Connect the SDI-12 programming cable to the connector on the probe cable. The probe gets its 5V supply from the USB port.

4. Open Probe Configuration Utility > Baud Rate drop down > 1200.

5. Select the Serial Port drop down on the Serial Port and select the appropriate COM port. Select the Connect button.

6. The probe is now connected. The Probe Info will show the Type, Serial Number and Address (it uses the "?!" SDI-12 address query command to get the probe address).

7. If you need multiple probes on the one SDI-12 datalogger, you should change the probe address(s) from "0" to a unique number (0-9,a-z, or A-Z) for each probe on this datalogger.

8. If the address was changed, select Write to Probe > OK to Confirm writing to the probe.

9. Select Backup Configuration and save the file in an appropriate folder.

Note You must not restore a configuration saved from a different Probe because the normalization values will not be appropriate.

10. You can verify that the sensors are operational by selecting the Sensor Test tab > Query All Sensors.

11. Select Disconnect and unplug probe.

Connect probe to your SDI-12 Datalogger

12. Wire your SDI-12 datalogger to the Sentek SDI-12 datalogger cable.

13. Plug the SDI-12 probe cable connector to the SDI-12 datalogger cable.

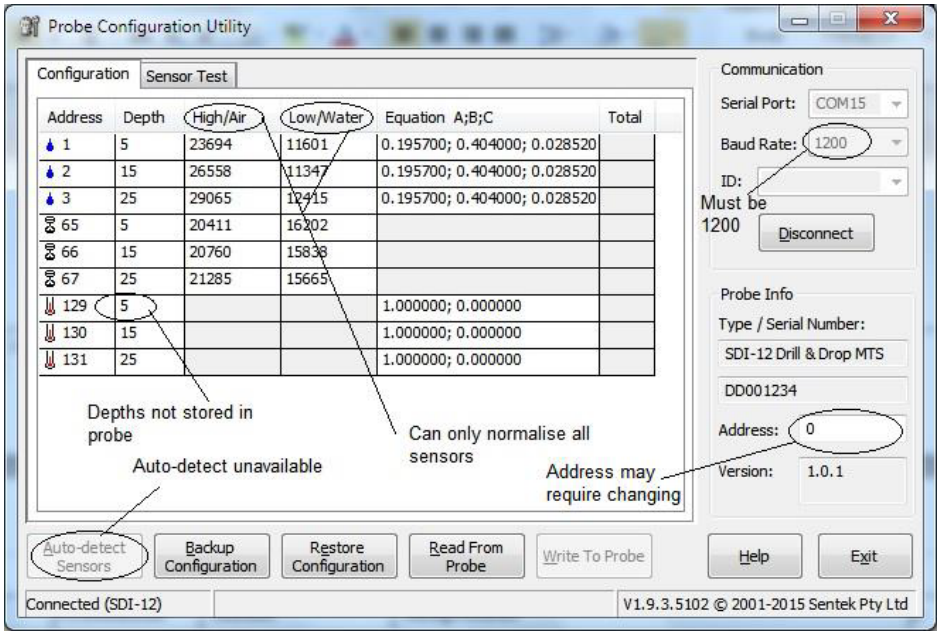
The probe is now ready for logging readings.

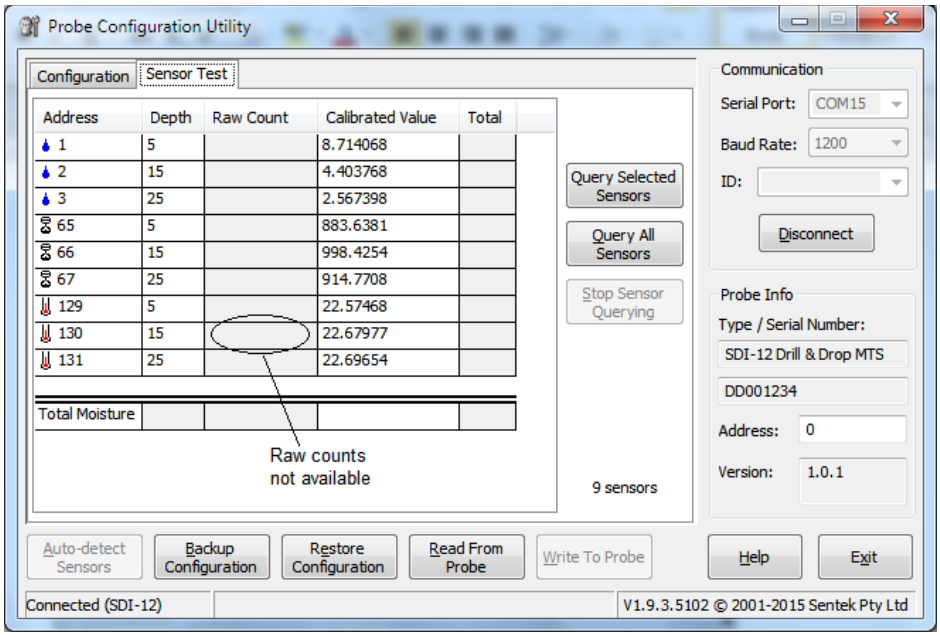
6.5 Sentek Probe Configuration Utility (PConfig)

Note Probes are supplied preconfigured and normalized. Modifying information stored in the Drill & Drop probe may result in incorrect readings being reported to the controlling device.

The Probe Configuration Utility (PConfig) is used to configure probe interfaces with depth location, normalization values (air and water counts) and calibration information for each sensor installed on the probe. This information is stored in non-volatile memory and is used to produce the calculated value (value that has been processed via the interfaces calibration formule) for each sensor on the probe.

If PConfig is not installed on your computer, it is available for download at www.campbellsci.ca/downloads





Note

Not all capabilities of Probe Configuration Utility can be utilized on the SDI-12 Drill & Drop probe.

- Depths (5, 15, 25, etc) are shown on the Configuration tab, but are not stored in the probe, consequently the SDI-12 datalogger must setup appropriate depths if required.
- Configuration cannot change so Auto-Detect Sensors is not available
- Air and water normalization is performed for all sensors at one time (not individually)
- Salinity sensor calibration coefficients (ABC) cannot be changed

Note

After updating the probe firmware, if you cannot restore the configuration for a previously saved backup Configuration, you must use a water container long enough to fully cover all the sensors at one time in order to normalize the sensors.

- Raw values are not shown on the Sensor Test tab
- Query Selected sensors must read all sensors, but only displays selected sensors
- The Probe configuration is fixed so Auto-detect Sensors in not required and is not available.

7. Operation

7.1 Wiring

Table 7-1. Drill & Drop Connection to SGB3		
Colour	**Function**	**Drill & Drop**
Red	Power	L1
White	SDI-12	L2
	Not used	L3
Green	Power Ground	G

Table 7-2. Connection to Campbell Scientific Dataloggers			
Colour	**SGB3 Description**	**CR1000**	**CR6**
Red	L1	12V or SW12V	12V or SW12V
White	L2	C1, C2, C3, C7	C or U Terminal
	L3	Not Used	Not Used
Green	G	G	G

7.1.1 Wiring the Probe Cable

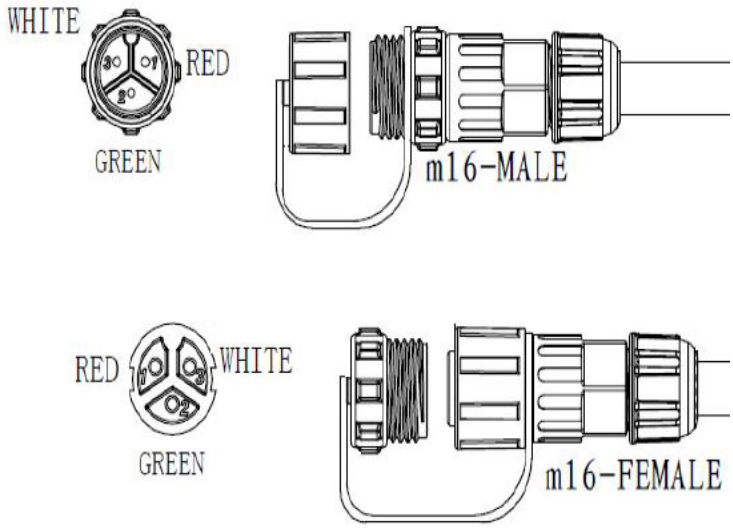
Note Damage to the Drill & Drop cable or loose connectors may result in moisture entering the cable, resulting in corrosion and cable failure.

The SDI-12 Drill & Drop probe is supplied with a 5 m cable terminated with a 3-pin water proof M16 male connector and a companion 40 cm SDI-12 datalogger cable with female M16 connector and 3 bare wires to connect into your SDI-12 datalogger. The probe cable has an attached label showing the probe Serial Number. This number matches the number stored in the probe (SDI-12 command0I! and shown in PConfig Probe Info Serial Number).

The 5 m cable is integrated into the probe and cannot be removed. The M16 connectors must be (with fingers) tightly screwed together to prevent the entry

of moisture. If preferred, the connector can be removed and the cable wired directly to the SDI-12 datalogger.

Please contact Campbell Scientific Canada if you require connectors that extend the cable beyond 5 m.



M16, 3-pin, Rigoal connectors

7.1.2 SDI-12 Probe Programming Cable

This cable's female M16 connector is compatible with the male M16 connector on the SDI-12 probe cable. The cable is not waterproof.

7.2 Normalizing Sensors

Note Probes are supplied pre-normalized, so normalization is not required. If the firmware needs updating, you must Backup Configuration and Restore Configuration after the new firmware has been loaded.

Normalization is the setting of the range over which the sensor is effective. For example, soil moisture sensors have a range bounded by 2 extremes – air and water. The normalization process is necessary to adjust for any variance that may occur during the production of the sensor. Sentek supplies the SDI-12 probes preconfigured, so normalization values should not be changed.

The Sentek Nornalization container does not support Drill & Drop probes.

7.3 Setting the SDI-12 Address

Drill & Drop SDI-12 probes are preconfigured to SDI-12 address 0.

If multiple probes are on the one SDI-12 but it will be necessary to use either your SDI-12 logger or PConfig to change the SDI-12 address of the probe in the range “0” to “9”, “A’ to “Z” and “a” to “z”.

7.4 Sensor Test

After setup in the field, the Query All Sensors function can be used to confirm all sensors are operational.

7.5 SDI-12 Communication

This section provides information about the SDI-12 communication protocol version 1.3 used by the SDI-12 Drill & Drop probe interfaces.

Note Protocol version 1.3 is compatible with version 1.2 with the addition of checksum commands and responses.

For more information on SDI-12 operation and the SDI-12 specificaiton, visit www.sdi-12.org.

7.5.1 Power Sequence

The SDI-12 can either be continuously powered or powered when needed. When continuously powered the probe responds as specified in the SDI-12 protocol specification. The probe requires about 1 second to power up before it will respond to SDI-12 commands.

An SDI-12 compatible device (datalogger) will send a break to wake all SDI-12 probe interfaces on the SDI-12 bus before a command is sent. When this break is received, the SDI-12 probe interface will then be placed in idle mode, ready to communicate with the controlling device. The probe interface will

remain in idle mode while the command is being processed. If a break (and valid communication) is not received within 150 milliseconds of the last command, the SDI-12 probe interface will be placed in low power standby.

7.5.2 Basic Commands Supported

The following commands are supported by the SDI-12 Drill & Drop probes.

Table 7-3. Commands Supported by Drill & Drop Probes

Command	Name	Response
?!	Address Query	a<CR><LF> The probe interface address (not suitable in a multi-drop situation)
a!	Acknowledge Active	a<CR><LF> The probe interface address
aI!	Send Identification	allccccccccmmmmmmvvvxxxxxxxxxxxx <CR><LF> Identification information
aAb!	Change Address	a<CR><LF> The probe interface address
aM! and aMC!	Start Measurement	atttn<CR><LF> Delay (ttt) in seconds and number of values (n) up to 9
aMn! and aMCn!	Start Measurement N = 1 to 5 and 9	atttn<CR><LF> Delay (ttt) in seconds and number of values (n) up to 9 Note: A response of a0000<CR><LF> is provided indicating all values are served by previous Start Measurement commands (aMn!)
aC! And aCC!	Concurrent Measurement	atttn<CR><LF> Delay (ttt) in seconds and number of values (nn) up to 12
aCn! And aCCn!	Concurrent Measurement N = 1 to 2 and 9	atttn<CR><LF> Delay (ttt) in seconds and number of values (nn) up to 12 Note: A response of a0000<CR><LF> is provided indicating all values are served by previous Start Concurrent Measurement (aCn!) commands
aDn!	Send Data n = 0 to 9	Apd.dapd.d … (etc.) <CR><LF> Refer to “Data Reading” section
aV!	Start Verification	a0000<CR><LF> Not supported Probe interface will respond with its address

aRn!	Continous Measurement	a<CR><LF> Not supported Probe interface will respond with its address

7.5.3 Extended Commands Supported

These commands are not in the standard SDI-12 basic commands, but are compatible with SDI-12. Extend commands. They all start with the letter “X”. These commands are used by PConfig 1.9.3 later.

Table 7-4. Extended Commands

Command	Name	Response
aXA!	Air normalization	Perform air normalization of moisture and salinity measurements – measures all sensors and stores the results as air normalization values. Response: ann <CR><LF> (for success) Response: a <CR><LF> (for failure) Where nn is the number of sensors normalized
aXAnnddddsssss!	Store Air normalization value sensor nn	Write air normalization moisture value ddddd and salinity value sssss for sensor nn Response: ann <CR><LF> (for success) Response: a <CR><LF> (for failure)
aXAnnddddd!	Store Air normalization value sensor nn	Write air normalization moisture value ddddd for sensor nn Response: ann <CR><LF> (for success) Response: a <CR><LF> (for failure)
aXAnn!	Read Air normalization value sensor nn	Read air normalization for sensor nn Response: annddddd <CR><LF> (for moisture only probe) Response: annddddsssss <CR><LF> (for salinity probe)
aXW!	Water normalization	Perform water/base normalization of moisture and salinity measurements –

		measures all sensors and stores the results as water/base normalization values. Response: ann <CR><LF> Where nn is the number of sensors normalized
aXWnnddddddssss!	Store water normalization value sensor nn	Write water normalization moisture value ddddd and salinity value sssss for sensor nn Response: ann <CR><LF> (for success) Response: a <CR><LF> (for failure)
aXWnnddddd!	Store water normalization value sensor nn	Write water normalization for sensor nn Response: ann <CR><LF> (for success) Response: a <CR><LF> (for failure)
aXWnn!	Read water normalization value sensor nn	Read water normalization value sensor nn Response: annddddd <CR><LF> (for moisture only probe) Response: annddddddssss <CR><LF> (for salinity probe)
aXEnnpd.dpd.dpd.d!	Set ABC for moisture sensor nn	Set moisture sensor equation for sensor nn Equation is formed by 3 coefficients, A, B, and C, which are of the form pd.d as per SDI-12 and! Results. Response: ann <CR><LF> (for success) Response: a <CR><LF> (for failure or invalid sensor number)
aXEnn!	Read ABC for moisture sensor nn	Read moisture equation for sensor nn Response: annpd.dpd.dpd.d <CR><LF> Response data is as per set data
aXTnnpd.dp.d.d!	Set linear calibration constants for temperature sensor nn to the supplied constants	First constant is slope (A, unitless) and second constant is offset (B, in °C) such that: T-cal = A * T-measured + B Note: Linear calibration can be used to convert result into

		Fahrenheit if values used are 1.8 and 32.0 Response: ann <CR><LF> (for success) Response: a <CR><LF> (for failure)
aXTnn!	Read linear calibration constants for temperature sensor nn	Response: annpd.dpd.d <CR><LF>

7.5.4 Data Reading

The SDI-12 probe interfaces accept the Start Measurement command (aM! or aMn!) and Start Concurrent Measurement command (aC! or aCn!) for obtaining calibrated values from the probe's sensors.

Note The SDI-12 probe interfaces do not support the Continuous Measurement command (aRn!). The probe will respond with its address followed by <CR><LF> in response to this command.

The SDI-12 probe interface returns sensor values in sensor depth order, starting at the shallowest depth (i.e. 5 cm)).

As the Start Measurement command (aM! or aMn!) reports how many sensor readings to expect, the controlling device should issue Send Data commands (aDn!) until it either receives a reply with no data (a<CR><LF>, indicating that the probe abandoned sampling or that all data has been received) or until it has received all of the specified number of sensor values.

Note:

1. The controlling device may choose not to issue all Send Data commands (aDn!) when retrieving the data.
2. The SDI-12 probe for moisture, salinity, and temperature values "pd.d" currently uses a fixed nine character format of "sign followed by three digits, followed by the decimal point, followed by four decimal digits" (±nnn.nnnn) to return readings. This may change in future issues of the SDI-12 probe firmware (software should not rely on this fixed format).
3. Valid soil moisture values will always be in the range +000.0000 to +101.0000. Soil moisture data which would result in values in the range -0.1 to 0.0 will be returned as +000.0000. Any soil moisture values outside of this range (caused by faulty sensors, incorrect probe installation or configuration) will be

returned as -999.9999. A failed sensor will also return a value of -999.9999.

4. Some third party SDI-12 dataloggers cannot represent full 7-digit accuracy, so convert -999.9999 to -1000.000.

7.5.4.1 Data Reading Using the Start Measurement Command (aMn! Or aMCn!)

Table 7-5 shows the allocation of the Start Measurement commands (aM!, aMn!, aMC!, or aMCn!). The (aMCn!) commands are the SDI-12 version 1.3 commands that have a CRC checksum in their response.

Note Although the commands support up to 16 sensors, SDI-12 Drill & Drop probes have 3, 6, 9, or 12 sensors.

Table 7-5. Start Measurement Commands

Command	
aM! (aMC!)	Read Soil Moisture values 1 – 9
aM1! (aMC1!)	Read Soil Moisture values 10 – 12
aM2! (aMC2!)	Read Salinity values 1 – 9
aM3! (aMC3!)	Read Salinity values 10 – 12
aM4! (aMC4!)	Read Temperature values 1 – 9
aM5! (aMC5!)	Read Temperature values 10-12
aM9! (aMC9!)	Read Supply Voltage

Other Start Measurement commands will result in a response of “a <CR><LF>”.

7.5.4.2 Soil Moisture, Salinity, and Temperature Values (aM! through aM5!)

The Start Measurement command (aM! or aMn!) allows up to nine (9) values to be returned. As it is possible to have up to twelve (12) values from the SDI-12 probe interface, two (2) Start Measurement commands (aM! or aMn!) are required. The Send Data command (aDn!) may return up to three (3) values.

Command	Response
aMn!	a0029<CR><LF>
	a<CR><LF> Service request response

The response indicates that 9 values will be available within a time of 2 seconds. After approximately 2 seconds the probe will issue a Service Request (a<CR><LF>, where “a” is the probe address). The controlling device will then issue Send Data commands (aDn!) to read the values.

Command	Response
aD0!	a+001.0000+001.1234+000.0200<CR><LF>
aD1!	a+000.1234+000.0000+123.1234<CR><LF>
aD2!	a+010.1200+000.1234+044.8750<CR><LF>

If there are more than 9 values, a further Start Measurement command (aM! Or aMn!) must be issued.

Command	Response
aM1!	A0023<CR><LF>
	a<CR><LF> Service request response

The response indicates that another 3 values will be available within a time of 2 seconds. After approximately 2 seconds, the probe will issue a Service Request (a<CR><LF>, where “a” is the probe address) and the controlling device will then issue Send Data commands (aDn!) to read the values.

Command	Response
aD0!	a+002.0010+003.1234+001.0200<CR><LF>
aD1!	a<CR><LF>

The aMCn! Commands perform the same function as the aMn! Command, but the aDn! response includes a CRC checksum. The 16 bit CRC is encoded as three ASCII characters appended before the <CR><LF> characters. For example:

Command	Response
0MC!	00023<CR><LF>
	a<CR><LF> Service request response
aD0!	0D0!0+0.155954+0.008233+0.033187@BQ<CR><LF>
aD1!	0AP@ <CR><LF>

7.5.4.3 Data Reading Using Concurrent Measurement Command (aCn! Or aCCn!)

Table 7-6 shows the allocation of sensors for the Start Concurrent Measurement commands (aC! Or aCn!). The (aCCn!) commands are the SDI-12 version 1.3 commands that have a CRC checksum in their response.

Table 7-6. Concurrent Measurement Commands	
Command	**Response**
aC! (aCC!)	Read Soil Moisture values 1 – 12
aC1! (aCC1!)	Read Salinity values 1 – 12
aC2! (aCC2!)	Read Temperature values 1 – 12
aC9! (aCC9!)	Read Supply voltage

Note Other Start Concurrent Measurement commands will result in a response of "a0000 <CR><LF>".

The aCCn! Commands performes the same function as the aCn! Command, but the aDn! response includes a CRC checksum. The 16 bit CRC is encoded as three ASCII characters appended before the <CR><LF> characters. For example:

Command	Response
0CC!	000203<CR><LF>
0D0!	00+0.174914+0.008619+0.03419HNs<CR><LF>
0D1!	0AP@<CR><LF>

7.5.4.1 Soil Moisture, Salinity, and Temperature Values (aCn! Or aCCn!)

The Start Concurrent Measurement commands (aCn! Or aCCn!) "allows values to be sampled with a single command. Values are gathered in the same way as for the Start Measurement command (aMn! Or aMCn!), but the Send Data command (aDn!) may return up to eight (8) values.

Command	Response
aC!	a00312 <CR><LF>

The response indicates that 12 soil moisture values will be available after a time of 3 seconds. The contolling device will then issue Send Data commands (aDn!) to read the values.

Command	Response
aD0!	a+001.0000+001.1234+000.0200+000.1234+000.0000+123.1234 +010.1200+000.1243<CR><LF>
aD1!	a+044.8750+002.0010+003.1234+001.0200<CR><LF>

Note The SDI-12 probe interface *will not* issue a service request for this command.

Refer to notes on Start Measurement (aM! or aMn!) command above.

The supply voltage commands returns the value of the supply voltage to the probe.

Command	Response
aM9!	a0001 <CR><LF>

The response contains one value which is the supply voltage detected within the probe. This may be slightly less than the supplied voltage due to cable and component voltage drops. The controlling device will then issue Send Data commands (aDn!) to read the values.

Command	Response
aD0!	a+4.966250<CR><LF>

7.5.4.2 Send Identification Command (aI!)

The SDI-12 probe interface will respond with a string of the following format when sent the Send Identification command (aI!):

allccccccccmmmmmmvvvxxxxxxxxxxxx <CR><LF>

a = probe address

l = “13” SDI-12 protocol version 1.3

c = “SENTEK” – company name

m = “DD MT” – probe type Moisture & Temperature

m = “DD MTS” – probe type Moisture, Temperature & Salinity

v = firmware version number

x = serial number (reported by PConfig, present on cable label)

Example: 013SENTEK DD MTS101DD001000 <CR><LF>

7.6 Example Program – CR1000

```
'Title of Program:
'Sentek Drill and Drop Example Program

'Created for:
'Campbell Scientific Canada Reference

'Created By: Campbell Scientific (Canada) Corp.
'Website: www.campbellsci.ca
'Address: 14532 - 131 Ave NW Edmonton, Alberta T5L 4X4
'General Phone Number: 780-454-2505
'Author: Laura Blazejewski
'E-mail: dataloggers@campbellsci.ca

'Created on:
'Jan 5, 2016
'====================Revision History=======================
'Revision number:
'Revision Date:
'Author:
'Description:
'==================Program Description=====================
'This program will measure a 60cm TriSCAN Drill and Drop probe
'The probe measures soil temperature, moisture, and electrical conductivity
'depths 5,15,25,35,45,55cm

'==================Sensors and Peripherals=================
'Datalogger, Serial Number: **** , PakBus Address: ****
'Communication peripheral, Serial Number: ***, Pakbus Address: *** (if applicable)
'I.P. Address:
'Phone number: (if applicable)
'Physical connection to datalogger:
'Other peripherals: , Serial Number: ***
'Physical connection to datalogger: enter DESCRIPTIVE instructions

'Sensor: , SN: ***, Output type, Address:

'Wiring:
'Red - 12V
'Green - Ground
'White - C1 (SDI-12)
'======================Constants=========================
'Example of Customized constant table:
'To change constants go to TOOLS --> CUSTOMIZED CONSTANTS

'Start of Constants Customization Section
'Program Scan Rate
Const Scan_Rate = 10  'units secs
'End of Constants Customization Section

'====================== Declarations=====================
'Diagnostic Parameters
Public Battery_Voltage_Logger
Units Battery_Voltage_Logger = Volts
Public Battery_Voltage_Probe
Units Battery_Voltage_Probe = Volts
Public Panel_Temperature
Units Panel_Temperature  =Deg C

'Measurement Parameters
Public WaterContent(6) 'Soil Moisture
Alias WaterContent(1)= Moisture_5cm
Alias WaterContent(2)=Moisture_15cm
Alias WaterContent(3)=Moisture_25cm
Alias WaterContent(4)=Moisture_35cm
Alias WaterContent(5)=Moisture_45cm
Alias WaterContent(6)=Moisture_55cm
```

```
Units WaterContent() = %

Public Salinity(6) 'Salinity
Alias Salinity(1)=Salinity_5cm
Alias Salinity(2)=Salinity_15cm
Alias Salinity(3)=Salinity_25cm
Alias Salinity(4)=Salinity_35cm
Alias Salinity(5)=Salinity_45cm
Alias Salinity(6)=Salinity_55cm
Units Salinity = VIC

Public Temperature_Soil(6)
Alias Temperature_Soil(1)=Temp_5cm
Alias Temperature_Soil(2)=Temp_15cm
Alias Temperature_Soil(3)=Temp_25cm
Alias Temperature_Soil(4)=Temp_35cm
Alias Temperature_Soil(5)=Temp_45cm
Alias Temperature_Soil(6)=Temp_55cm
Units Temperature_Soil = Deg C

'====================== Data Tables=========================
'Diagnostics Data Table (should be collected on a daily basis)
DataTable(Diagnostics,True,365)
  DataInterval(0,1440,Min,0)
  'CardOut(0,365)
  Maximum(1,Battery_Voltage_Logger,FP2,False,False)
  Minimum(1,Battery_Voltage_Logger,FP2,False,False)
  Maximum(1,Panel_Temperature,FP2,False,False)
  Minimum(1,Panel_Temperature,FP2,False,False)
  Sample(1,Status.OSVersion,IEEE4)
  Sample(1,Status.SerialNumber,IEEE4)
  Sample(1,Status.StartTime,IEEE4)
  Sample(1,Status.StationName,IEEE4)
  Sample(1,Status.RunSignature,IEEE4)
  Sample(1,Status.ProgSignature,IEEE4)
  Sample(1,Status.LithiumBattery,IEEE4)
  Sample(1,Status.Low12VCount,IEEE4)
  Sample(1,Status.SkippedScan,IEEE4)
  Sample(1,Status.CPUDriveFree,IEEE4)
  Sample(1,Status.USRDriveFree,IEEE4)
  Sample(1,Status.CardBytesFree,IEEE4)
EndTable

DataTable (Hourly,True,-1)
  DataInterval (0,1,Hr,10)
  Average (1,WaterContent(),FP2,False)
  Average (1,Salinity(),FP2,False)
  Average (1,Temperature_Soil,FP2,False)
EndTable

DataTable (Test_5min,True,-1)
  DataInterval (0,5,Min,10)
  Average (1,WaterContent(),FP2,False)
  Average (1,Salinity(),FP2,False)
  Average (1,Temperature_Soil,FP2,False)
EndTable
'======================Main Program======================
BeginProg
  '==================Subroutines and Functions==================
  '======================Main Scan=========================

  Scan(Scan_Rate,Sec,1,0) 'scan rate is set as a constant
    SDI12Recorder (WaterContent,1,0,"M!",1.0,0) 'Measure the soil moisture values 1-
9
    ' SDI12Recorder (WaterContent,1,0,"M1!",1.0,0) 'Measure the soil moisture values
10-12
    SDI12Recorder (Salinity,1,0,"M2!",1.0,0) 'Measure the Salinity Values 1-9
    ' SDI12Recorder (Salinity,1,0,"M3!",1.0,0) 'Measure the salinity values 10-12
```

```
    SDI12Recorder (Temperature_Soil,1,0,"M4!",1.0,0) 'Measure the temperature values
1-9
    ' SDI12Recorder (Temperature_Soil,1,0,"M5!",1.0,0) 'Measure the temperature
values 10-12
    SDI12Recorder (Battery_Voltage_Probe,1,0,"M9!",1.0,0) 'Measure the probe supply
voltage

    '=======================Slow Sequence=======================
    '===================Diagnostics Information====================
    'Datalogger Battery Voltage measurement
    Battery(Battery_Voltage_Logger)
    'Wiring Panel Temperature measurement
    PanelTemp(Panel_Temperature,_60Hz)
    '==============Modem Power Control and Configuration==============
    '====================Call Data Tables=======================
    CallTable (Diagnostics)
    CallTable (Hourly)
    CallTable Test_5min
  NextScan
EndProg
```

8. Troubleshooting

This section assumes that the person is trained in installation and configuring Sentek probes.

Table 8-1 Troubleshooting

Symptom or error message	Possible cause	Possible solution
PConfig – Timeout while connecting to the probe	The wrong COM port has been selected	Try every COM port in the PConfig list
	Attempt to connect at 9600 baud	Set Baud rate to 1200 or Auto
	Interface incorrectly powered	3V to 15V DC must be supplied through the SDI-12 cable
	The PConfig version in use does not support SDI-12 protocol	Update to PConfig 1.9.3 or later
Salinity sensor data not present in SDI-12 data	Non-Salinity probe type	Check PConfig Probe info Type: SENTEK MTS
SDI-12 data is -999.9999	Sensor not detected	Check cables and connectors
	Normalization values are incorrect	Restore the configuration from the saved Backup configuration. If a backup is not available, water normalization must be done in a

		water container long enough to cover all sensors at the same time
SDI012 data is -1000.000		Some third party dataloggers cannot handle full 7-digit accuracy and round -999.9999 to -1000.000
PConfig or SDI-12 datalogger Sensor missed	Probe failure	Contact your Distributor or Sentek Technical support
SDI-12 data not recorded or intermittent	Possible SDI-12 message clashing	Ensure that probes on the one SDI-12 cable have different addresses
	Supply voltage out of range	The probe will not operate if voltage is below about 3V or above 15V

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