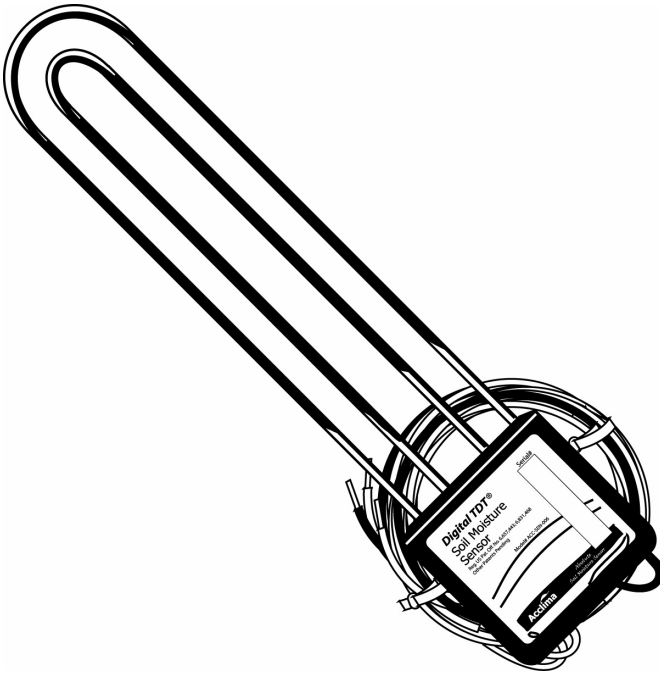


## SDI-12 Soil Moisture Transducer



July 2008  
Rev 6



NOTE: The Acclima Series SDI12 Soil Moisture Transducer uses the industry standard SDI-12 interface for communicating with a Data Recorder or other SDI-12 equipped controlling device. The SDI-12 communications standard is a digital serial data communications hardware and protocol standard based on 1200 baud, ASCII character communications over a three-wire bus. The SDI12 Series is compliant with Version 1.3 of the SDI-12 standard. Version 1.3 is the latest standard at the time of this printing (Sept. 2006).

## Firmware and Manual Disclaimer

This user's manual was prepared for the current transducer firmware release at the time of the manual publication. The manual has been thoroughly edited and is believed to be reliable. Acclima assumes no liability for inaccuracies. Errata may be published on our website if or when deemed necessary by Acclima. Acclima reserves the right to change any specification(s) without notice.

## About Acclima

Acclima is developer and manufacturer of closed-loop irrigation systems based on stable, absolute-reading soil moisture transducers. We manufacture a broad line of automatic irrigation systems and transducers used by thousands of customers in residential and commercial turf irrigation, in agriculture, in environmental data gathering, in soils and horticultural research and in civil engineering.

Typical applications include fully automatic, water-conserving commercial and residential sprinkler irrigation control, sub-surface and center-pivot agricultural irrigation monitoring and control, watershed and dry-land soil moisture monitoring, and structural foundation moisture monitoring.

You can learn more about Acclima's products at [www.acclima.com](http://www.acclima.com) and you can contact us at [sales@acclima.com](mailto:sales@acclima.com).



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Product Introduction and Specifications

Enter topic text here. The Series SDI12 transducer is a Digital Time Domain Transmissometer that measures the permittivity of soils by determining the propagation time of an electromagnetic wave transmitted along a waveguide through the soil. The absolute moisture content of the soil is calculated from the permittivity using the Topp equation. The transducer can be commanded to produce both the bulk permittivity and the moisture content of the soil.

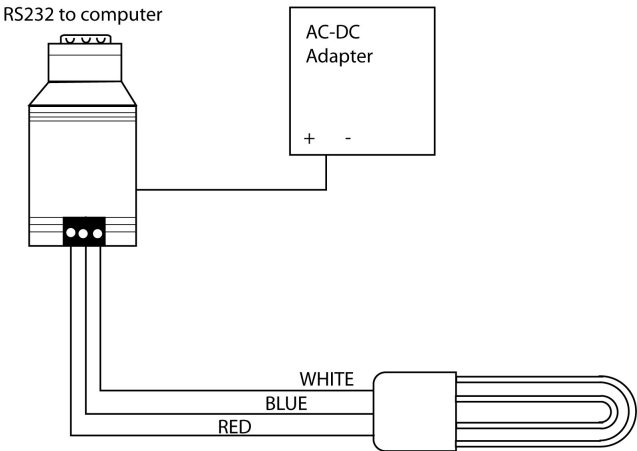
The accuracy and stability of the Series SDI12 is obtained through a patented hardware and firmware system that digitizes the returned waveform and then uses proprietary digital signal analysis algorithms to extract the real propagation time and distortion parameters of the returned wave. High accuracy is achieved over a wide range of soil temperatures and electrical conductivity. In the SDI12 series the resolution of the digitized waveform is 5 picoseconds – permitting a small transducer to report very high resolution data. From the extracted distortion parameters the transducer calculates and reports the electrical conductivity of the soil. The permittivity and soil moisture measurements are compensated for temperature. The transducer also reports soil temperature.

Specifications:

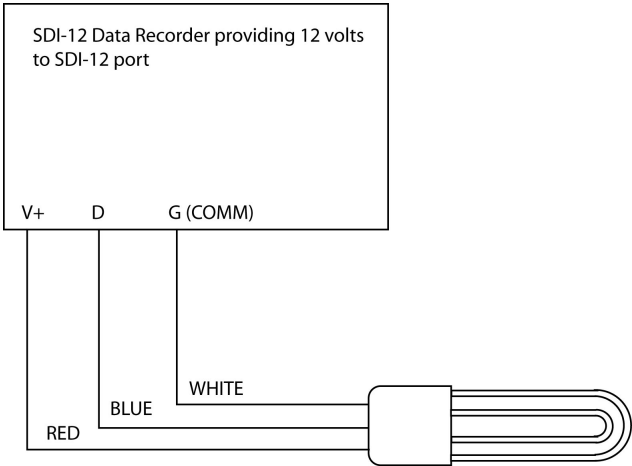
| Parameter                | Accuracy Limits                                      | Conditions                                  |
|--------------------------|------------------------------------------------------|---------------------------------------------|
| Permittivity             | +,- 1% of full scale                                 | 1 to 50 degrees C, 0 to 5.0 dS/m in-soil EC |
| Temperature              | +,- 2.0 degrees C                                    | 1 to 50 degrees C                           |
| Electrical Conductivity  | +,- 0.2dS/m                                          | 1 to 50 degrees C, 0 to 5.0 dS/m in-soil EC |
| Volumetric Water Content | calculated from permittivity using the Topp equation |                                             |

Installation and Wiring

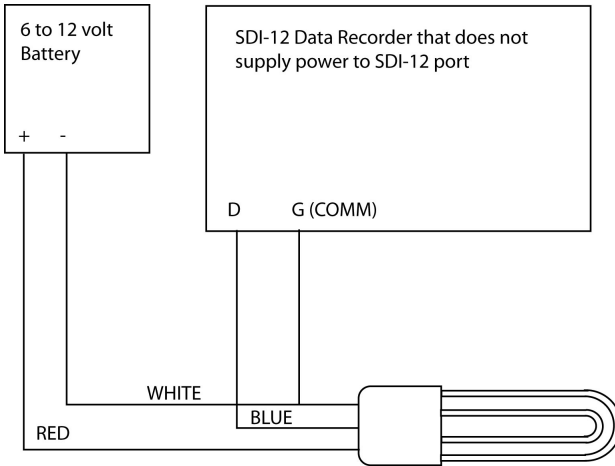
The three wires attached to the transducer are the SDI-12 connections to the data recorder. The white wire is the common return wire for both the power (red) and data (blue) wires. It must attach to the ground terminal on the data recorder SDI-12 connector block. The red wire is the power line and must attach to the power supply line on the data recorder SDI-12 connector block or to the positive side of an external power source. The blue wire is the bidirectional (half-duplex) data line that attaches to the serial data line on the data recorder SDI-12 connector block. If a power supply is used that is external to the data recorder then the negative side of the power supply must be attached to the ground terminal on the data recorder SDI-12 connector block.



**Wiring for RS232 (Serial Port) to PC connection**



**Wiring for a Data Recorder Providing Power to the SDI-12 Port**



### Wiring Diagram for a Data Recorder Using an External Battery

#### Operation

The SDI-12 protocol allows multiple devices to be attached to one SDI-12 port. In order for the data recorder and devices to facilitate unambiguous communications each device on the SDI-12 port is given a unique address. The default address of the Series S100 transducer (as shipped from the factory) is 0 (zero). If this is the only device on the SDI-12 port on your recorder then you may leave the address at 0. If other devices are wired to that port then you will need to insure that they each have unique addresses. Setting address will be discussed later.

SDI-12 commands are a concatenation of three fields. The first is the device address. This is a single character – typically in the range 0 to 9 but can also use the characters a to z and A to Z. The second is the command which may consist of several characters. The command characters are always upper case. The last is the command terminator which is always an exclamation point (!).

#### Setting the Address

If more than one device is wired to the SDI-12 port you will need to assure that they all are set up with unique addresses. If you are not sure you can connect them one at a time and use the “**Address Query**” command “**?!**” to read the addresses. Only one device can be connected to the SDI-12 port when using this command. The device will respond with its address.

To change the address of a device use the “**Change Address**” command. The syntax is “**aAn!**”, where ‘a’ is the present address ‘A’ is the Set Sensor Address command and ‘n’ is the new address. The device will return the new address. For example, if **0A4!** is transmitted, the sensor address will be re-programmed to 4 and the sensor will return ‘4’.

To verify that the SDI12 sensor is responding on its address use the “**Send Identification**” command “**ai!**”. The SDI12 sensor will respond with “**a13Acclima SDI12 1.0**”. In the response the “a” is the device address, “13”

represents Version 1.3 of the SDI-12 standard, and the “1.0” is the version of the SDI12 sensor.

| Command Name        | Syntax | Device Response      |
|---------------------|--------|----------------------|
| Address Query       | ?!     | a                    |
| Change Address      | aAb!   | b                    |
| Send Identification | a!     | a13Acclima SDI12 1.0 |

Command Summary

The SDI12 sensor implements commands that comply with versions 1.0, 1.1, 1.2 and 1.3 of the SDI-12 specifications. All commands required for full compliance to the version 1.3 specifications are implemented in the SDI12 sensor. However the ‘additional measurements’ commands in the SDI-12 specification are meaningless to the Acclima SDI12 sensor, since the permittivity, moisture, conductivity and temperature measurements are all required and all made with every single measurement. Hence the response for all of these additional measurements commands is “a<CR><LF>” as required by the SDI-12 specification. The sensor ignores unimplemented commands outside those required by the SDI-12 spec. There is no response to them.

Additional ‘Extended Commands’ are incorporated by Acclima for digitized waveform dumps and factory calibration settings and readings.

Command Reference

The table below documents all commands supported by the SDI12 transducer in alphabetical order:

| Command                | Function                                                                     | Transducer Response                                                                           |
|------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| ?!                     | Address Query                                                                | <b>a</b> Note: only one device can be connected to the SDI-12 port when this command is used. |
| a!                     | Acknowledge Active                                                           | <b>a</b>                                                                                      |
| aAb!                   | Change Address                                                               | <b>b</b>                                                                                      |
| aC!<br><br>aCC!        | Start Concurrent Measurement<br><br>Start Concurrent Measurement-Request CRC | <b>a00109</b><br>Measurement takes 1 second.<br>Nine values are returned.                     |
| aC1!<br>.<br>.<br>aC9! | Start Additional Concurrent Measurement                                      | <b>a00000</b><br>No data to be provided                                                       |

|                                  |                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                    |
|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>aCC1!</b><br><br><b>aCC9!</b> | Start Additional Concurrent Measurement – Request CRC                                                                                                                 | <b>a00000</b><br>No data to be provided                                                                                                                                                                                                                                                            |
| <b>aD0!</b>                      | Get First 4 Data Items in response to a <b>Measurement</b> command: VWC, Soil Temp., Soil Permittivity, Soil EC<br><br>Get the response from a <b>Verify</b> command. | <b>asppp.ppsTT.TTskk.kksss.s</b><br>ppp.pp is the water content (%)<br>TT.TT is the soil temperature (C)<br>kk.kk is the soil relative permittivity<br>ss.s is the soil electrical conductivity (dS/m)<br><br><b>a+ppp.pp&lt;CR&gt;&lt;LF&gt;</b><br>Mean value of 3 VWC readings                  |
| <b>aD1!</b>                      | Get Remaining 6 Data Items in response to a <b>Measurement</b> command:                                                                                               | <b>asrrr.rsvvv.vsttttstttstttstttt</b><br>rrr.r is the maximum rise time (mv/ns)<br>vvv.v is the amplitude at max rt (mv)<br>tttt is the propagation time at mrt (ps)<br>tttt is the waveform prop time (ps)<br>tttt is the compensated prop time (ps)<br>tttt is the waveform measurement span ps |
| <b>aD2!</b>                      | No data for this command                                                                                                                                              | <b>a</b>                                                                                                                                                                                                                                                                                           |
| <b>aD3!</b>                      | No data for this command                                                                                                                                              | <b>a</b>                                                                                                                                                                                                                                                                                           |
| <b>aD4!</b>                      | No data for this command                                                                                                                                              | <b>a</b>                                                                                                                                                                                                                                                                                           |
| <b>aD5!</b>                      | No data for this command                                                                                                                                              | <b>a</b>                                                                                                                                                                                                                                                                                           |
| <b>aD6!</b>                      | No data for this command                                                                                                                                              | <b>a</b>                                                                                                                                                                                                                                                                                           |
| <b>aD7!</b>                      | No data for this command                                                                                                                                              | <b>a</b>                                                                                                                                                                                                                                                                                           |
| <b>aD8!</b>                      | No data for this command                                                                                                                                              | <b>a.</b>                                                                                                                                                                                                                                                                                          |
| <b>aD9!</b>                      | No data for this command                                                                                                                                              | <b>a</b>                                                                                                                                                                                                                                                                                           |
| <b>al!</b>                       | Send Identification                                                                                                                                                   | <b>a13Acclima SDI12 1.0</b>                                                                                                                                                                                                                                                                        |

|                                                                                |                                                                      |                                                                                                                                                                                                                                                                                                                                              |
|--------------------------------------------------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>aM!</b>                                                                     | Start Non-Concurrent Measurement                                     | <b>a0019</b><br>Measurement takes 1 second and returns nine values.                                                                                                                                                                                                                                                                          |
| <b>aMC!</b>                                                                    | Start Non-Concurrent Measurement – Request CRC                       | <b>a</b><br>Sensor returns a <b>Service Request</b> after measurement is made.                                                                                                                                                                                                                                                               |
| <b>aM1!</b><br>.<br>.<br><b>aM9!</b><br><b>aMC1!</b><br>.<br>.<br><b>aMC9!</b> | Additional Measurements<br><br>Additional Measurements – Request CRC | <b>a0000</b><br>The SDI12 sensor does not require the use of this command. If the command is received the sensor reports 'no data' to be returned.                                                                                                                                                                                           |
| <b>aR0!</b><br>.<br>.<br><b>aR9!</b>                                           | Continuous Measurement                                               | <b>a0000</b><br>The SDI12 sensor does not use this command but responds with no data.                                                                                                                                                                                                                                                        |
| <b>aRC0!</b><br>.<br>.<br><b>aRC9!</b>                                         | Continuous Measurement – Request CRC                                 | <b>a0000</b><br>The SDI12 sensor does not use this command but responds with no data.                                                                                                                                                                                                                                                        |
| <b>aV!</b>                                                                     | Start Verification                                                   | <b>a0031</b><br>One data item will be returned after 3 seconds. The data item will be the mean of 3 water content readings or it will be 'fail' if the sensor is not working properly.<br><b>a</b><br>The sensor returns a <b>service request</b> after the measurement is made.<br>The data can be retrieved using the <b>aD0!</b> command. |
| <b>aXAtttt!</b>                                                                | Get Waveform Amplitude at tttt picoseconds                           | <b>vvvv</b><br>vvvv is waveform amplitude                                                                                                                                                                                                                                                                                                    |
| <b>aXR34!</b><br>.<br>.<br><b>aXR42!</b>                                       | Read Conductivity Compensation Threshold for Segment x               | <b>atttt</b><br>tttt is the threshold for segment x in mv/ns                                                                                                                                                                                                                                                                                 |
| <b>aXR44!</b><br>.<br>.<br><b>aXR52!</b>                                       | Read Conductivity Compensation Multiplier for Segment x              | <b>ammm</b><br>mmm is the multiplier for segment x                                                                                                                                                                                                                                                                                           |

|                                                    |                                                          |                                                                             |
|----------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------------------------|
| <b>aXR54!</b><br>.<br>.<br><b>aXR62!</b>           | Read Conductivity Compensation Offset for Segment x      | <b>aooo</b><br>ooo is the offset for segment x                              |
| <b>aXR14!</b>                                      | Read Manufacturing week and year                         | <b>awwyy</b><br>ww is the manufacturing week. yy is the manufacturing year. |
| <b>aXRF!</b>                                       | Read Firmware Revision                                   | <b>ar.rr</b><br>r.rr is the firmware revision                               |
| <b>aXR12!</b>                                      | Read Hardware Revision                                   | <b>ar</b><br>r is the hardware revision                                     |
| <b>aXR18!</b>                                      | Read Propagation Time Full-Scale Multiplier              | <b>a±p.ppp</b><br>Percent increase or decrease to full-scale value.         |
| <b>aXR16!</b>                                      | Read Propagation Time Offset                             | <b>a±t.ttt</b><br>±t.ttt is the offset in ns                                |
| <b>aXR22!</b>                                      | Read Temperature Compensation Multiplier                 | <b>amm</b><br>mm is the multiplier                                          |
| <b>aXR24!</b>                                      | Read Temperature Compensation Threshold                  | <b>att</b><br>tt is the threshold value                                     |
| <b>aXW34stttt!</b><br>.<br>.<br><b>aXW42stttt!</b> | Write Conductivity Compensation Threshold for Segment x  | <b>attt</b><br>ttt is the threshold for segment x in mv/ns                  |
| <b>aXW44mmm!</b><br>.<br>.<br><b>aXW52mmm!</b>     | Write Conductivity Compensation Multiplier for Segment x | <b>ammm</b><br>mmm is the multiplier for segment x                          |
| <b>aXW54ooo!</b><br>.<br>.<br><b>aXW62ooo!</b>     | Write Conductivity Compensation Offset for Segment x     | <b>aooo</b><br>ooo is the offset for segment x                              |
| <b>aXW14dddd!</b>                                  | Write Manufacturing Week and Year                        | <b>awwyy</b><br>ww is the manufacturing week. yy is the manufacturing year. |
| <b>aXW10srrrr!</b>                                 | Write Firmware Revision                                  | <b>ar.rr</b><br>r.rr is the firmware revision                               |
| <b>aXW12srrrr!</b>                                 | Write Hardware Revision                                  | <b>ar</b><br>r is the hardware revision                                     |
| <b>aXW18spppp!</b>                                 | Write Full-scale                                         | <b>a±p.ppp</b>                                                              |

|              | Propagation Time Multiplier               | Percent increase or decrease to full-scale value. |
|--------------|-------------------------------------------|---------------------------------------------------|
| aXW16stttt!  | Write Propagation Time Offset             | a±t.ttt<br>±t.ttt is the offset in ns             |
| aXW22smmm m! | Write Temperature Compensation Multiplier | amm<br>mm is the multiplier                       |
| aXW24stttt!  | Write Temperature Compensation Threshold  | att<br>tt is the threshold value                  |

Making Measurements with the SDI-12 Sensor

There are two commands that cause the SDI12 sensor to take measurements and store them for subsequent retrieval. The first is the **“Non-concurrent Measurement Command” ‘M’**. The second is the **“Concurrent Measurement Command” ‘C’**. The sensor responds to both of the commands with **“atttn”** where **“a”** is the sensor address, **“ttt”** is the number of seconds before the data will be ready, and **“n”** is the number of data items that will have been prepared. For the Acclima SDI12 sensor the number of data items is 9.

Non-Concurrent Measurement

When using the non-concurrent command, the recorder waits for the sensor to complete its measurement and then retrieves the result. The sensor sends a “Service Request” code to the recorder after preparing the data so that the recorder will retrieve the data at the appearance of the Service Request or after the indicated time has expired, whichever occurs first. The Service Request code is simply the address of the sensor **“a”**, followed by carriage return and line feed characters.

Concurrent Measuremet

When using the concurrent measurement command the sensor does not return a service request when the data is ready for retrieval. The recorder is allowed to perform other communications to other devices while the sensor is making the measurement and preparing the data. Then when the recorder is available and the indicated measurement time has elapsed the recorder retrieves the data.

Data Retrieval

To retrieve the requested measurement data the recorder sends a **“Dx”** command to the sensor, where **‘x’** is **0 or 1**. . The **D0** command returns the basic 4 measurement items: Volumetric Water Content, Soil Temperature, Soil Relative Permittivity, and Soil Electrical Conductivity. The **D1** Command returns: Waveform Maximum Risetime, Waveform Amplitude at Maximum Risetime, Waveform Propagation Time at Maximum Risetime, Uncompensated Waveform Propagation Time, Compensated Waveform Propagation Time and the Waveform Measurement Span. The syntax for the command is: **“aDx!”**, where **“a”** is the sensor address and **x** is the data item number that is requested. Below is a table showing the data available from the SDI12 sensor and the

commands used to retrieve them.

| Data Item Requested              | Command | Response Example | Units |
|----------------------------------|---------|------------------|-------|
| Volumetric Water Content         | aD0!    | +25.03           | %     |
| Soil Temperature                 | aD0!    | ±32.16           | C     |
| Bulk Relative Permittivity       | aD0!    | +32.13           | --    |
| Soil Electrical Conductivity     | aD0!    | +1.6             | dS/m  |
| Waveform Max. Risetime           | aD1!    | +342             | mv/ns |
| Amplitude at Max. Risetime       | aD1!    | +271             | mv    |
| Propagation Time at Max Risetime | aD1!    | +5705            | ps    |
| Waveform Propagation Time        | aD1!    | +5325            | ps    |
| Compensated Propagation Time     | aD1!    | +5340            | ps    |
| Waveform Measurement Span        | aD1!    | +320             | ps    |

Multiple values are returned with the **aDx!** command. The format of the returned data is:

**a+25.03+32.16+32.13+1.6<CR><LF>**

Note that the returned data is always preceded by the device address **a**. Each data value is preceded by a sign. No units are returned but are assumed known by the user. The units are as shown in the table above. Each return data string is terminated by carriage return and line feed characters.

Examples of Using the Sensor

Example 1: Reading four basic data items using non-concurrent commands:

This first example shows how a data recorder would obtain 4 data items from a sensor that has address **5**: (1) Volumetric Water Content, (2) Soil Temperature, (3) Soil Permittivity or Dielectric Constant and (4) Soil Electrical Conductivity. In this example the data recorder will operate in the non-concurrent mode – that is, it will not spend any time with other sensors until this sensor has completed its measurements and has reported them.

The first command from the data recorder is:

**5M!**

This command is called the “Start Measurement” command. The ‘**5**’ in this command is the address of the sensor you wish to respond to the command. It will cause the SDI12 sensor to begin the process of taking a set of

measurements. The sensor will immediately respond to this command as follows:

**50019<CR><LF>**

This response starts with the address of the sensor (**5**), then continues with the number of seconds that are required to take the readings, **001** (1 second), then finishes with the number of data items that will be returned with each measurement request (**9**). Every response from the sensor is terminated with a carriage return and a line feed character. After the sensor has finished its measurements it transmits a **service request** to the recorder:

**5<CR><LF>**

The **service request** is just the address of the sensor. The recorder then sends a command to get the first set of data items:

**5D0!**

The items requested are: volumetric water content, soil temperature, soil permittivity and soil electrical conductivity. Upon receiving this command the sensor responds with:

**5+25.03+32.16+32.13+1.6<CR><LF>**

The first **5** is the sensor address. The remaining string contains the requested data items – each preceded by a ‘+’ or a ‘-’ sign.

This completes the four basic readings from the sensor. If the user desires the additional 5 data items from the sensor he would program the data recorder to issue the 2<sup>nd</sup> data retrieval command, **aD1!**

**aD1!**

The sensor responds with:

**a+342.0+271.0+5405+5325+5340+320<CR><LF>**

Here again the leading **5** is the address of the sensor. The remaining string contains the data items: waveform maximum rise time, waveform amplitude at maximum rise time, waveform propagation time at maximum rise time, uncompensated propagation time, compensated propagation time, and waveform measurement span.

| Recorder Command                 | Syntax     | Sensor Response                       |
|----------------------------------|------------|---------------------------------------|
| Start Non-Concurrent Measurement | <b>5M!</b> | <b>50019</b> (addr., time, #readings) |

|                              |      |                                          |
|------------------------------|------|------------------------------------------|
|                              |      | 5 (Service Request)                      |
| Get First 4 Basic Data Items | 5D0! | 5+25.03+32.16+32.13+1.6<CR><LF>          |
| Get Remaining 6 Data Items   | 5D1! | a+342.0+271.0+5405+5325+5340+320<CR><LF> |

**Example 2: Reading four basic data items using concurrent commands:**

This second example shows how a data recorder would obtain the same 4 basic data items from a sensor using concurrent commands. In this example the data recorder will operate in the concurrent mode – that is, it will be free to service other sensors while the sensor with address 5 is making its measurements. Concurrent measurement commands use **C** instead of **M** in the command. Thus the command to **start concurrent measurement** is:

**5C!**

The sensor immediately responds with:

**500109**

With concurrent commands the sensor does not provide a **service request** after the measurements have been made. The recorder relies on the timing information provided by the sensor and will not request data until the time interval has expired – in this case 1 second.

The recorder then requests the four data items exactly in the same manner as with non-concurrent readings. If the remaining 6 data items are desired the recorder issues the **ad1!** command to get them. The commands and responses are summarized in the table below:

| Recorder Command                 | Syntax | Sensor Response                          |
|----------------------------------|--------|------------------------------------------|
| Start Non-Concurrent Measurement | 5C!    | 500109 (addr., time, #readings)          |
| Get First Four Data Items        | 5D0!   | 5+25.03+32.16+32.13+1.6<CR><LF>          |
| Get Remaining 6 Data Items       | 5D1!   | a+342.0+271.0+5405+5325+5340+320<CR><LF> |

**Note the difference between the two tables: The concurrent command uses 'C' instead of 'M', and there is no service request from the sensor. Also the initial sensor response allows for 99 readings instead of 9 readings.**

### Data Communications Error Checking

So far, all **Start Measurement** Commands that we have discussed have requested data wherein no error checking is done to verify the correct reception of the data by the recorder. The SDI-12 specification provides for error checking by using an additional command character '**C**' with the Start Measurement command. Thus when the commands

**aMC!** or **aCC!**

are transmitted to the sensor, the sensor appends a CRC code to the end of the returned data. This code is generated from the data in such a manner that if the data changes in the transmission the change can be detected in the recorder. If the recorder experiences such corruption in the data it will repeat the data request automatically.

#### 3.3.6 Verify Command

The SDI-12 specification requires a special command for the purpose of verifying that the sensor is working properly. Acclima's implementation of that command is as follows:

1. The recorder sends out the **verify command**:

**aV!**

2. Upon receiving the verify command the sensor will respond with:

**atttn**

where **a** is the sensor address, **ttt** is the time required to make verification readings, and **n** is the number of data items that will be returned. For this command **ttt = 003** and **n = 1**.

3. The sensor takes 3 full sets of readings. The corrected propagation times from the three readings are saved and compared. If any of these propagation times are out range or if they differ by an unacceptable amount an error is acknowledged. Next the volumetric water content is calculated from the mean of the three readings. The sensor then sends out a **service request**:

**a**

4. The recorder issues a **read data** command **D0**:

**aD0!**

The sensor responds with the volumetric water content or, if an error occurred in the reading, the returned data field will contain **E** (for Error)..

### Verify Command

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**a**

4. The recorder issues a **read data** command **D0**:

**aD0!**

The sensor responds with the volumetric water content or, if an error occurred in the reading, the returned data field will contain **E** (for Error)..

### Special Acclima-Proprietary Commands

The SDI-12 specification allows the use of proprietary commands for use by manufacturers and users in calibrating sensors or implementing special features available in the sensor. Acclima takes advantage of this allowance in providing access to calibration constants and waveform downloads.

#### Reading and Setting calibration constants:

The **calibration constants** stored in the SDI12 series sensors are used in setting the zero and full scale readings and for temperature compensation of the readings. The sensor toleration to electrical conductivity can also be extended to about 10 dS/m by setting **conductivity compensation** factors. The zero, full scale and temperature compensation factors are set in the factory and should not be changed. You may read them if you wish using the commands given below. The **conductivity compensation** numbers that are shipped in the sensor are default numbers only and do not guarantee accurate operation in environments where the soil conductivity exceeds 5 dS/m. Below 5dS/m no compensation is necessary. If you wish to work in very high salinity soils you can place a sensor order with the factory and ask to have those constants set

for an additional cost.

The table below shows the proprietary commands that are used to read and write these calibration constants:

| Command                          | Read Syntax | Write Syntax |
|----------------------------------|-------------|--------------|
| Firmware Revision                | aXR10!      | aXW10srrrr!  |
| Hardware Revision                | aXR12!      | aXW12srrrr!  |
| Manufacturing Date               | aXR14!      | aXW14sdddd!  |
| Zero Offset                      | aXR16!      | aXW16szzzz!  |
| Full Scale Multiplier            | aXR18!      | aXW18stttt!  |
| Sensor Address                   | AXR20!      | aXW20saaaa!  |
| Temp. Compensation Factor        | aXR22!      | aXW22sffff!  |
| Temp. Compensation Threshold     | aXR24!      | aXW24stttt!  |
| Temp. Sensor Compensation        | aXR26!      | aXW26stttt!  |
| <b>Conductivity Compensation</b> |             |              |
| Segment 0 Threshold              | aXR34!      | aXW34stttt!  |
| Segment 1 Threshold              | aXR36!      | aXW36stttt!  |
| Segment 2 Threshold              | aXR38!      | aXW38stttt!  |
| Segment 3 Threshold              | aXR40!      | aXW40stttt!  |
| Segment 4 Threshold              | aXR42!      | aXW42stttt!  |
| Segment 0 Multiplier             | aXR44!      | aXW44smmmm!  |
| Segment 1 Multiplier             | aXR46!      | aXW46smmmm!  |
| Segment 2 Multiplier             | aXR48!      | aXW48smmmm!  |
| Segment 3 Multiplier             | aXR50!      | aXW50smmmm!  |
| Segment 4 Multiplier             | aXR52!      | aXW52smmmm!  |
| Segment 0 Offset                 | aXR54!      | aXW54soooo!  |
| Segment 1 Offset                 | aXR56!      | aXW56soooo!  |
| Segment 2 Offset                 | aXR58!      | aXW58soooo!  |
| Segment 3 Offset                 | aXR60!      | aXW60soooo!  |
| Segment 4 Offset                 | aXR62!      | aXW62soooo!  |

|                    |      |  |
|--------------------|------|--|
| Flash Write Lock   | aXL! |  |
| Flash Write Unlock | aXU! |  |

**Write Protection:**

The SDI12 sensor will not respond to write commands unless an “UNLOCK” command has been issues previous to the write attempt. After the write command has been completed a “LOCK” command must be issued. This practice will prevent accidental modification of sensor timing and compensation factors. The “UNLOCK” command is:

**aXU!** with the response **aU<CR><LF>**

and the “LOCK” command is:

**aXL!** with the response **aL<CR><LF>**

**Waveform Download:**

A single point on the received waveform can be acquired by sending the command:

**aXAtttt!**

where tttt is the time from the beginning of the waveform where an amplitude value is to be acquired. The time is entered in picoseconds to the nearest 5 picoseconds. The sensor returns the amplitude (in millivolts) of the waveform at that ordinate:

**avvv.v**

If this command is used repeatedly, with pppp incrementing with each use, a graphical representation of the waveform (or a portion thereof) can be constructed.

The proprietary commands all use the **X** character to identify them. The data recorder may or may not allow the use of these commands. If the data recorder conforms to version 1.2 or later of the SDI-12 specification, then it will support these commands in the **Transparent Mode**. In this mode a PC or modem is connected to the recorder serial port and issues the commands **through** the recorder and receives the response **through** the recorder, using the recorder only as a buffering device.

**Troubleshooting**  
**No Data Return by the SDI-12 Transducer**

Check the sensor connections to the data recorder. The white wire connects to the SDI-12 port GROUND terminal. The blue wire connects to the SDI-12 port DATA terminal. The red wire connects to the SDI-12 port V+ terminal or to the

positive terminal of an external battery. If an external battery is used the negative terminal of the battery connects to the GROUND terminal of the SDI-12 port.

Measure the voltage between the black wire and the red wire. It must be between 6volts and 12 volts.

Check the sensor address using the **?!** command with no other devices connected to the recorder. Insure that the sensor address is used in the commands you are using.

Review the command syntax you are using. Insure that all commands are upper case.

### **Unreadable Data**

Insure that there are no address conflicts. Disconnect all other devices and try the read again.

Insure that the cable length to the sensor does not exceed 200 feet.

**NOTES**

**Warranty****LIMITED PRODUCT WARRANTY**

Congratulations on your recent purchase of an Acclima product. You are among a growing force of those interested in conserving water – earth's most important resource.

Your Acclima product is warranted for two years from date of purchase to be free of defective materials and workmanship, provided it is used within the working specifications for which the product was designed, and under normal use and service. Unless installed by an authorized Acclima trained technician, Acclima assumes no responsibility for installation. Acclima also assumes no responsibility for removal or unauthorized repair. Acclima's liability under this warranty is limited solely to replacement or repair of defective parts. Acclima will not be liable for any crop or other consequential damages resulting from any defects in design or breach of this warranty.

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