WET150 Sensor

SDI-12 Programmer's Guide

SDI-12

Version 1

Delta-T Devices Ltd

Contents

About this document

The WET150 is an accurate and highly versatile digital multi-parameter sensor for measuring:

- Water content
- Electrical conductivity
- Temperature

in soils, composts and artificial growing media.

The WET150 can be used individually with an SDI-12 meter or as a networked group of sensors using any manufacturer's logger or controller which supports SDI-12 communication. The GP2 logger and controller from Delta-T Devices is ideally suited to networked WET150 applications.

This document is intended as a supplement to the WET150 sensor user manual. It contains technical information on SDI-12 communication commands and responses, plus full details of how the WET150 can be configured to output custom measurements and data formats. It is largely aimed towards system integrators and assumes the reader has some basic familiarity with the SDI-12 communication protocol.

Users of the Delta-T Devices GP2 logger and controller who need to customise the measurement outputs beyond those offered as standard in the DeltaLINK Sensor Library may also find it useful.

SDI-12 commands

The WET150 uses standard basic SDI-12 commands for taking measurements and outputting data in one of several common pre-configured formats.

The WET150 also supports a full set of extended commands to allow custom configuration of output data formats, measurement units and calculations (such as custom soil calibrations for water content). This allows the WET150 to output soil moisture, electrical conductivity and temperature data in a format best suited to your application. This flexibility is particularly useful if your logger or controller does not have the ability to perform conversion calculations, for example to convert from a native permittivity measurement to moisture content in a mineral wool substrate in units of %vol; or the ability to convert from a native Bulk EC measurement in units of $mS.m^{-1}$ to Pore EC in units of $\mu S.cm^{-1}$.

General command and response format

An SDI-12 network can have only one logger or controller (e.g. a Delta-T Devices GP2), but can have up to 62 sensors or devices. The logger sends commands to a specific sensor using an address system. In response, that specific sensor carries out its instruction and responds back to the logger with information.

All SDI-12 commands and responses are made using a defined sequence of letters, numbers and symbols. The meaning and sequence position of them is explained in more detail in the following tables. These human-readable letters, numbers and symbols are converted to binary codes using the ASCII coding scheme to allow them to be transmitted over wires between units.

Fortunately, if you are using DeltaLINK software to configure WET150 measurements and programs for a GP2 logger, the sensor libraries built into DeltaLINK take care of the formatting of commands and handling of the data.

Simplified measurement command sequence example

A simplified typical SDI-12 measurement command sequence between a generic logger and a generic sensor could be illustrated in words as:

Generic Logger	Generic Sensor
Hello sensor at address Z: Take a “measurement set 9” reading. End of command.	
	This is sensor at address Z: In 10 seconds results will be available, consisting of 3 values. End of response.
<Logger waits 10 seconds>	
Hello sensor at address Z: Send the first packet of data. End of command.	
	This is sensor at address Z: Here is a packet of data. End of response.

In this example, the logger requested “measurement set 9” from the WET150 sensor. The WET150 informed the logger that 3 data values would be available. In other words, “measurement set 9” consists of 3 individual measurement parameters grouped together.

The first packet of data in the example contained all 3 values therefore the logger knows the measurement is complete and no further commands are needed to retrieve any outstanding data.

A full list of the pre-configured measurement sets is detailed later in this manual.

Basic commands and responses

All commands and responses start with an address character 0-9, a-z or A-Z, a total of 62 available.
All commands from the logger or controller end in the "!" command termination symbol.
All responses from sensors or devices end in the combination "<CR><LF>" response termination symbols.
<CR> is the ASCII symbol for "carriage return".
<LF> is the ASCII symbol for "line feed".
The <CR><LF> symbols are "non-printable characters" so don't appear on screen in the DeltaLINK terminal mode window, however they are used by the program and the GP2 logger to know when a response has completed.

In the following tables, commands from the logger and responses from a sensor are given in a generic format using placeholder letters, with explanations of the placeholder meanings in the Notes column.

Directly underneath, highlighted and written in italics is a worked example for a logger communicating with a WET150 sensor at address "Z".

Addressing and identification

In an SDI-12 network it is vital to know which sensor is being communicated with. It is common for sensors to be shipped with the address set at 0 (zero), therefore before adding a sensor to a network it must be configured to have a unique address. The commands in the table below show how to set and read an address and how to identify a sensor.

Logger command	Sensor response	Notes
?! *?!*	Query Address a<CR><LF> *Z<CR><LF>*	Sensor responds with its address. ***NOTE: This command can only be used if just one sensor is connected at a time.***
a! *Z!*	Acknowledge Active a<CR><LF> *Z<CR><LF>*	Sensor responds with its address. This command can be used to confirm a specific sensor is active and responding.
aI! *ZI!*	Send Identification allccccccccmmmmmmvvvxxxxxxxxxxxxxx<CR><LF> *Z13Delta-T WET150v01 D1234567<CR><LF>*	Sensor responds with its identification string: **a**: address **ll**: SDI-12 version number **cc...cc**: Company **mm...mm**: Model number **vvv**: Version number of sensor firmware **xx...xx**: Serial number of sensor.
aAb! *ZAY!*	Change Address b<CR><LF> *Y<CR><LF>*	Sensor responds with its new address.

In the Send Identification command above, the worked example response can be broken down as:
Z = SDI-12 address of the sensor
13 = SDI-12 specification version the sensor conforms to (version 1.3 in this example)
Delta-T = Manufacturer
WET150 = Product model number
v01 = Firmware version (version 01 in this example)
D1234567 = WET150 serial number

Default (sequential) measurement instruction and data response

All logger measurement commands and sensor responses follow the same structure. The default "start measurement" and "send data" commands are shown below, along with the sensor's response to each command. The data values in the sensor response are always prefixed with a plus (+) or minus (-) sign which acts as a value separator.

Logger command	Sensor response	Notes
aM! *ZM!*	Start Measurement atttn<CR><LF> *Z0013<CR><LF>*	Sensor responds with: **a**: address **ttt**: time in seconds until measurement data ready. **n**: number of values to be returned
aD0! *ZD0!*	Send Data a<values><CR><LF> *Z+36.54+284.5+18.66<CR><LF>*	Sensor responds with a packet of data. In this case, the default aM! measurement returns 3 values corresponding with Permittivity, Bulk EC (in $mS.m^{-1}$) and Temperature (in °C).

Additional (sequential) measurements

In addition to the default measurement aM!, there are 9 other pre-set measurements aM1! ... aM9! The SDI-12 commands related to these additional measurements is almost identical to the basic measurement commands above.

Logger command	Sensor response	Notes
aM1! ... aM9 ZM1!	Start Measurement atttn<CR><LF> *Z0013<CR><LF>*	Sensor responds with: **a**: address **ttt**: time in seconds until measurement data ready. **n**: number of values to be returned
aD0! *ZD0!*	Send Data a<values><CR><LF> *Z+36.54+284.5+18.66<CR><LF>*	Sensor responds with a packet of data. NOTE: Regardless of which number measurement is invoked, the first packet of data to be returned is always requested with command aD0!

A list of the default configurations for how the WET150 responds to these additional measurements is detailed later in section: Pre-configured measurement sets.

Concurrent measurements

The way in which the WET150 can be instructed to perform concurrent measurements is almost identical to the default and additional sequential measurements above. Instead of using the command letter M, letter C is used instead. Also, the response from the sensor to a concurrent measurement command uses two digits for the number of values to be returned (instead of one with a sequential measurement).

Logger command	Sensor response	Notes
aC! or aC1! ... aC9! *ZC1!*	Start Measurement atttnn<CR><LF> *Z00103<CR><LF>*	Sensor responds with: **a**: address **ttt**: time in seconds until measurement data ready. **nn**: number of values to be returned
aD0! *ZD0!*	Send Data a<values><CR><LF> *Z+36.54+284.5+18.66<CR><LF>*	Sensor responds with a packet of data. NOTE: Regardless of which number measurement is invoked, the first packet of data to be returned is always requested with command aD0!

Checking transmitted data integrity

The SDI-12 communications protocol is robust in most situations. However in electrically noisy environments (radio or mains interference nearby) or with particularly large SDI-12 networks the data received at the logger may become corrupted.

Major data corruption in the form of a garbled command or response is easily spotted by the logger. In such a situation the SDI-12 specification requires the logger to retry by sending the command to the sensor again.

Some minor data corruption can also be spotted by the logger through basic error checking, again resulting in command retries. However, in some rare circumstances other minor data corruption may go unnoticed by the logger due to the limitations of the SDI-12 basic error detection system.

Fortunately the SDI-12 specification also includes provision for a comprehensive error check on any measurement data the logger receives. This is at the cost of slightly longer data transmission times as extra checksum data is sent by the sensor. The logger uses the checksum data to verify the measurement is received without corruption. In the SDI-12 specification, this checksum is referred to as a Cyclic Redundancy Check (CRC). The CRC data is 3 non-numeric characters long and is appended directly after the measurement data .

Only sensors designed to SDI-12 specification version 1.3 or later support this CRC error checking feature – this includes all Delta-T Devices SDI-12 loggers and sensors.

All previously described measurement commands can have the comprehensive CRC error checking applied to them by appending the letter C to the measurement type, as follows:

Standard measurement	Measurement with CRC error checking
aM!	aMC!
aM1! ... aM9!	aMC1! ... aMC9!
aC!	aCC!
aC1! ... aC9!	aCC1! ... aCC9!

The sequential measurement command and data response format when using CRC error checking is shown below, using just the aMC1! command as an example. Again, commands from the logger and responses from a sensor are given in a generic format, and directly underneath as a worked example for a WET150 at address "Z" written *in italics*.

Logger command	Sensor response	Notes
aMC1! *ZMC1!*	Start_Measurement atttn<CR><LF> *Z0013<CR><LF>*	Sensor responds with: **a**: address **ttt**: time in seconds until measurement data ready. **n**: number of values to be returned
aD0! *ZD0!*	Send_Data a<values><CRCdata><CR><LF> *Z+36.54+284.5+18.66VhT<CR><LF>*	Sensor responds with a packet of data with 3 CRC error check characters appended. NOTE: Regardless of which number measurement is invoked, the first packet of data to be returned is always requested with command aD0!

As with a standard concurrent measurement command, the response from the sensor to a concurrent measurement command with CRC error checking uses two digits for the number of values to be returned (instead of one for a sequential measurement). The aCC1! command is used below as an example.

Logger command	Sensor response	Notes
aCC1! *ZCC1!*	Start_Measurement atttnn<CR><LF> *Z00103<CR><LF>*	Sensor responds with: **a**: address **ttt**: time in seconds until measurement data ready. **nn**: number of values to be returned
aD0! *ZD0!*	Send_Data a<values><CRCdata><CR><LF> *Z+36.54+284.5+18.66VhT<CR><LF>*	Sensor responds with a packet of data with 3 CRC error check characters appended. NOTE: Regardless of which number measurement is invoked, the first packet of data to be returned is always requested with command aD0!

Pre-configured measurement sets

As shown in the previous command and response formatting tables, the SDI-12 specification allows for ten pre-configured multi-parameter measurement sets.

The WET150 can use any of these measurement sets (shown in detail on the next page) as sequential or concurrent measurements, either with or without CRC error checking.

In summary, these measurement commands are:

Measurement type	Commands
Standard sequential	aM! and aM1! ... aM9!
Standard concurrent	aC! and aC1! ... aC9!
Sequential with CRC error checking	aMC! and aMC1! ... aMC9!
Concurrent with CRC error checking	aCC! and aCC1! ... aCC9!

where a is the address of the sensor.

All measurements sets other than aM9! can be customised. See the following sections for customisation details.

The factory defaults for the ten pre-configured measurement sets (shown only using the M command for clarity) are:

Command	Response parameters	Units	Notes
aM!	ε_r (permittivity)	(none)	
	EC_p (pore water EC)	$mS.m^{-1}$	Compensated to 25°C linearly at 2%/°C, soil parameter= 4.1
	T	°C	
aM1!	Water content	%vol	Using **Mineral** soil-type calibration
	EC_p (pore water EC)	$mS.m^{-1}$	Compensated to 25°C linearly at 2%/°C, soil parameter= 4.1
	T	°C	
	ε_r (permittivity)	(none)	
	EC_b (bulk EC)	$mS.m^{-1}$	
aM2!	Water content	%vol	Using **Organic** soil-type calibration
	EC_p (pore water EC)	$mS.m^{-1}$	Compensated to 25°C linearly at 2%/°C, soil parameter= 4.1
	T	°C	
	ε_r (permittivity)	(none)	
	EC_b (bulk EC)	$mS.m^{-1}$	
aM3!	Water content	%vol	Using **PeatMix** soil-type calibration
	EC_p (pore water EC)	$mS.m^{-1}$	Compensated to 25°C linearly at 2%/°C, soil parameter= 4.1
	T	°C	
	ε_r (permittivity)	(none)	
	EC_b (bulk EC)	$mS.m^{-1}$	
aM4!	Water content	%vol	Using **Coir** soil-type calibration
	EC_p (pore water EC)	$mS.m^{-1}$	Compensated to 25°C linearly at 2%/°C, soil parameter= 4.1
	T	°C	
	ε_r (permittivity)	(none)	
	EC_b (bulk EC)	$mS.m^{-1}$	
aM5!	Water content	%vol	Using **MinWool** soil-type calibration
	EC_p (pore water EC)	$mS.m^{-1}$	Compensated to 25°C linearly at 2%/°C, soil parameter= 4.1
	T	°C	
	ε_r (permittivity)	(none)	
	EC_b (bulk EC)	$mS.m^{-1}$	
aM6!	Water content	%vol	Using **Perlite** soil-type calibration
	EC_p (pore water EC)	$mS.m^{-1}$	Compensated to 25°C linearly at 2%/°C, soil parameter= 4.1
	T	°C	
	ε_r (permittivity)	(none)	
	EC_b (bulk EC)	$mS.m^{-1}$	
aM7!			Blank
aM8!			Blank
aM9!	ε_r (permittivity)	(none)	
	EC_b (bulk EC)	$mS.m^{-1}$	
	T	°C	

Customising measurement sets

When operating the WET150 in an SDI-12 network with a Delta-T Devices logger (e.g. GP2), the preferred measurement set uses the native parameters of the sensor: ε_r (real relative permittivity), EC_b (bulk EC) in units $mS.m^{-1}$ and Temperature in units °C. This is done using measurement command aM9! (or its concurrent equivalent, both with or without CRC error checking). Conversions to water content and pore water EC (in any soil type and in any units) are easily configured in the logger program, along with any compensations relating to soil temperature.

However, some third-party loggers and irrigation controllers may not have the flexibility of the Delta-T Devices GP2 logger and require measurement data to be presented in a specific compatible format. Measurement sets aM! and aM1! ... aM8! in the WET150 can be customised to return measurements with:

- different parameters in a different order
- more or fewer parameters
- different units
- custom soil calibrations
- different soil temperature compensations

This also applies to concurrent measurements, both with and without CRC error checking.

Note that measurement set aM9! is fixed in format for use with Delta-T Devices loggers and hand-held meters and cannot be customised.

The WET150 measurement sets are customised by sending the sensor special SDI-12 commands. These "extended" SDI-12 commands are similar in form to the previously described measurement commands which the logger transmits to the WET150 to take measurements. Each WET150 measurement set customisation only needs to be performed once as the settings are retained in memory when power is lost.

It is also possible to read back the current parameters which define the operation of measurement sets aM! and aM1! ... aM8! in the WET150. Details of each of the measurement set parameters, along with how they can be configured and read back are given in the following sections.

Parameter sequence / parameter types (Customisation function "A")

Up to nine parameters can be sequenced together in any order to form a measurement set, but a parameter ID can only be used once in the sequence. Parameters may further be configured for soil type (general or custom soil-calibrations), EC temperature compensation rate/reference and EC output units.

The nine parameters are each represented by an ID letter in the following table:

ID	Parameter type	Further configuration required
A	ε_r (permittivity)	
B	Water content in %	Soil type (generic type or soil-specific calibration values)
C	Water content in volumetric $m^3.m^{-3}$	Soil type (generic type or soil-specific calibration values)
D	EC_b (bulk EC)	EC units
E	EC_p (pore water EC, at soil temperature)	EC soil parameter, EC units
F	EC_p (pore water EC, compensated to a reference temperature)	EC soil parameter, EC compensation temperature, EC temperature coefficient, EC units
G	Temperature in °C	
H	Temperature in °F	
I	Square root permittivity (refractive index)	

The generalised extended SDI-12 command for applying a custom sequence of parameters to a WET150 measurement set is:

aXU<measurement_set>A=<ID_1><ID_2>...<ID_n>!

Command element	Notes
a	Sensor address.
X	SDI-12 specified symbol for extended command.
U	WET150 configuration symbol.
<measurement_set> 0 → M / C / MC / CC 1 → M1 / C1 / MC1 / CC1 2 → M2 / C2 / MC2 / CC2 3 → M3 / C3 / MC3 / CC3 4 → M4 / C4 / MC4 / CC4 5 → M5 / C5 / MC5 / CC5 6 → M6 / C6 / MC6 / CC6 7 → M7 / C7 / MC7 / CC7 8 → M8 / C8 / MC8 / CC8 9 → (invalid, fixed form)	Measurement set which the customisation applies to. *For example, if <measurement_set> value is "4", the customised measurement parameter sequence defined here applies equally to:* *M4 (Sequential measurement set 4)* *C4 (Concurrent measurement set 4)* *MC4 (Sequential measurement set 4 with CRC error checking)* *CC4 (Concurrent measurement set 4 with CRC error checking)*
A	Customisation function letter for "parameter sequence".
=	Customisation command separator.
<ID_1><ID_2>...<ID_n>	Sequence of capital ID letters from the parameter types table representing the order in which measurement data will be reported back to the logger. Parameters can be in any order. Minimum one parameter. Maximum nine parameters. A parameter may only appear once in the sequence.
!	Command termination.

Example: "Configure WET150 at address Z to output for measurement set M4: Temperature °F / EC_b / EC_p (compensated to a reference temperature) / water content in %."

ZXU4A=HDFB!

After a parameter sequence configuration command, the WET150 responds with either a confirmation or an error. The response always starts with the WET150's address and always terminates with the non-printable characters <CR><LF>.

Pass:

Sensor response	Notes
a OK <ID_1><ID_2>...<ID_n>	"a" is the WET150 address. <ID_1><ID_2>...<ID_n> is a sequence of capital ID letters from the parameter types table representing the order in which measurement data will be reported back to the logger.

Fail:

Sensor response	Notes
a ERROR, Invalid measurement	"a" is the WET150 address. The <measurement_set> number in the command string must be 0-8.
a ERROR, Invalid parameter	More than 9 parameter IDs. Invalid ID letter used.
a ERROR, Invalid command	Invalid customisation function letter or formatting error.
a ERROR, Duplicate parameter	ID letter appears more than once in the sequence.
a ERROR, measurement M9 is not editable	Measurement set M9/C9/MC9/CC9 is a fixed format.

To read back the sequence of parameters settings in a WET150 measurement set, use the generalised extended SDI-12 command:

aXU<measurement_set>A?!

This read command is similar in structure as for applying a sequence of parameters and uses the same command elements.

Example: "What parameter sequence order is WET150 at address Z configured to output for measurement set M4?":

ZXU4A?!

The response from the WET150 to the above read command is:

Sensor response	Notes
a <ID_1><ID_2>...<ID_n>	"a" is the WET150 address. <ID_1><ID_2>...<ID_n> is a sequence of capital ID letters from the parameter types table representing the order in which measurement data will be reported back to the logger.

The response always starts with the WET150's address and always terminates with the non-printable characters <CR><LF>.

Soil calibration / generic soil type configuration (customisation function "B")

If the WET150 has been custom configured to output data in water content in % or $m^3.m^{-3}$, then soil calibration should be configured to best match the soil / substrate in which it is used. Failure to set the correct soil calibration will result in incorrect water content readings.

The WET150 has several pre-defined generic soil calibration types which can be selected. See the "Calibration" section of the manual for how these are derived and how to calculate your own soil-specific calibration values.

The pre-defined generic soil calibrations and values are:

ID	Soil type	a0	a1
A	Mineral	1.6	8.4
B	Organic	1.3	7.7
C	PeatMix	1.16	7.09
D	Coir	1.16	7.41
E	MinWool	1.04	7.58
F	Perlite	1.06	6.53
Z	Custom **	n/a	n/a

The generalised extended SDI-12 command for applying a soil calibration to WET150 measurements is:

aXU<measurement_set>B=<soil_ID>!

** To use a soil-specific calibration, set <soil_ID> to Z and see the next section for how to apply your own soil-specific a0 and a1 values.

Command element	Notes
a	Sensor address.
X	SDI-12 specified symbol for extended command.
U	WET150 configuration symbol.
<measurement_set> 0 → M / C / MC / CC 1 → M1 / C1 / MC1 / CC1 2 → M2 / C2 / MC2 / CC2 3 → M3 / C3 / MC3 / CC3 4 → M4 / C4 / MC4 / CC4 5 → M5 / C5 / MC5 / CC5 6 → M6 / C6 / MC6 / CC6 7 → M7 / C7 / MC7 / CC7 8 → M8 / C8 / MC8 / CC8 9 → (invalid, fixed form)	Measurement set which the customisation applies to. *For example, if <measurement_set> value is "4", the customised soil calibration configuration defined here applies equally to:* *M4 (Sequential measurement set 4)* *C4 (Concurrent measurement set 4)* *MC4 (Sequential measurement set 4 with CRC error checking)* *CC4 (Concurrent measurement set 4 with CRC error checking)*
B	Custom function letter for "soil calibration".
=	Customisation command separator.
<soil_ID>	Single capital ID letter from the soil type table representing the generic soil calibrations used in water content calculations. Maximum one parameter.
!	Command termination.

Example: "Configure WET150 at address Z to use Organic soil calibration in calculations for measurement set M4."

ZXU4B=B!

After a soil calibration configuration command, the WET150 responds with either a confirmation or an error. The response always starts with the WET150's address and always terminates with the non-printable characters <CR><LF>.

Pass:

Sensor response	Notes
a OK	"a" is the WET150 address.

Fail:

Sensor response	Notes
a ERROR, Invalid measurement	"a" is the WET150 address. The <measurement_set> number in the command string must be 0-8.
a ERROR, Invalid soil type	Invalid ID letter used.
a ERROR, Invalid command	Invalid customisation function letter or formatting error.
a ERROR, measurement M9 is not editable	Measurement set M9/C9/MC9/CC9 is a fixed format.

To read back the pre-defined generic soil calibration settings in a WET150 measurement set, use the generalised extended SDI-12 command:

aXU<measurement_set>B?!

This read command is similar in structure as for applying a pre-defined generic soil calibration and uses the same command elements.

Example: "What soil calibration is WET150 at address Z configured to use for calculations in measurement set M4?":

ZXU4B?!

The response from the WET150 to the above read command is:

Sensor response	Notes
a <ID>	"a" is the WET150 address. <ID> is a capital ID letter representing the soil type from the pre-defined generic soil calibrations table.

The response always starts with the WET150's address and always terminates with the non-printable characters <CR><LF>.

Soil-specific calibration configuration (customisation function "C")

If the soil calibration (soil type) in the previous section is set to Custom, i.e. <soil_ID> is set to Z, then your own soil-specific calibration a0,a1 values should be applied using the commands below.

Note: The entered custom a0,a1 values are ignored in calculations if <soil_ID> is not set to Z in the soil calibration configuration of section 0. The use of pre-defined generic soil types over-rides any custom a0,a1 values entered here.

The generalised extended SDI-12 command for entering soil-specific calibration a0,a1 values into the WET150 is:

aXU<measurement_set>C=<a0>,<a1>!

Note that the numeric values of <a0> and <a1> must be in decimal point format not decimal comma:

1.23 ✓
1,23 ✗

Command element	Notes
a	Sensor address.
X	SDI-12 specified symbol for extended command.
U	WET150 configuration symbol.
<measurement_set> 0 → M / C / MC / CC 1 → M1 / C1 / MC1 / CC1 2 → M2 / C2 / MC2 / CC2 3 → M3 / C3 / MC3 / CC3 4 → M4 / C4 / MC4 / CC4 5 → M5 / C5 / MC5 / CC5 6 → M6 / C6 / MC6 / CC6 7 → M7 / C7 / MC7 / CC7 8 → M8 / C8 / MC8 / CC8 9 → (invalid, fixed form)	Measurement set which the customisation applies to. *For example, if <measurement_set> value is "4", the customised soil-specific calibration defined here applies equally to:* *M4 (Sequential measurement set 4)* *C4 (Concurrent measurement set 4)* *MC4 (Sequential measurement set 4 with CRC error checking)* *CC4 (Concurrent measurement set 4 with CRC error checking)*
C	Custom function letter for "soil-specific calibration".
=	Customisation command separator.
<a0>,<a1>	Your soil-specific calibration values of a0,a1. Numbers are unsigned decimal, up to 2 decimal places. Valid ranges a0: 1.00 to 5.00 a1: 3.00 to 15.00
!	Command termination.

Example: "Configure WET150 at address Z to use soil-specific calibration values of a0 = 2 and a1 = 9.42 in calculations for measurement set M4."

ZXU4C=2,9.42!

After a soil calibration configuration command, the WET150 responds with either a confirmation or an error. The response always starts with the WET150's address and always terminates with the non-printable characters <CR><LF>.

Pass:

Sensor response	Notes
a OK <a0>,<a1>	"a" is the WET150 address. <a0> is the entered value of a0 to 2 decimal places <a1> is the entered value of a1 to 2 decimal places

Fail:

Sensor response	Notes
a ERROR, Invalid measurement	"a" is the WET150 address. The <measurement_set> number in the command string must be 0-8.
a ERROR, Invalid a0 value <a0_value>	The entered value for a0 is outside the valid range.
a ERROR, Invalid a1 value <a1_value>	The entered value for a1 is outside the valid range.
a ERROR, Invalid command	Invalid customisation function letter or formatting error.
a ERROR, measurement M9 is not editable	Measurement set M9/C9/MC9/CC9 is a fixed format.

To read back the soil-specific calibration values in a WET150 measurement set, use the generalised extended SDI-12 command:

aXU<measurement_set>C?!

This read command is similar in structure as for applying a soil-specific calibration and uses the same command elements.

Example: "What soil-specific calibration a0 and a1 values is WET150 at address Z configured to use for calculations in measurement set M4?":

ZXU4C?!

The response from the WET150 to the above read command is:

Sensor response	Notes
a <a0>,<a1>	"a" is the WET150 address. <a0>,<a1> are the soil-specific calibration values.

The response always starts with the WET150's address and always terminates with the non-printable characters <CR><LF>.

EC soil-parameter configuration (customisation function "D")

Any measurement set which outputs a data in terms of EC_p (pore water EC) requires an EC soil-parameter value in order to calculate EC_p from internally measured parameters of Permittivity and EC_b (bulk EC). This applies to the pre-configured measurement sets as well as any custom measurement sets.

The default value is 4.1 and it is suitable for a range of both organic and mineral agricultural soils. However measurements in sand, heavy clay, glass beads or some other unusual media may require a value specific to that medium to be calculated. See the Soil Parameter section of the main WET150 manual for an explanation of the EC soil-parameter value and how it can be calculated for specific soils and media.

Failure to set the correct EC soil-parameter value will result in incorrect measurement results, particularly as soils become drier. Note that in very dry soils it is not possible to calculate EC_p reliably, therefore an error code value of -8020 is returned instead. Using the default soil-parameter value of 4.1 and the generic soil type calibrations, the lower soil moisture limit for EC_p calculations are:

Soil calibration / generic soil type	Lower limit soil moisture content for ECp calculation
Mineral	12.67%
Organic	17.72%
PeatMix	21.22%
Coir	20.30%
MinWool	21.43%
Perlite	24.57%

The generalised extended SDI-12 command for changing the EC soil-parameter in the WET150 is:

aXU<measurement_set>D=<soil_param>!

Note that the numeric value of <soil_param> must be in decimal point format not decimal comma:

1.23 ✓

1,23 ✗

Command element	Notes
a	Sensor address.
X	SDI-12 specified symbol for extended command.
U	WET150 configuration symbol.
<measurement_set> 0 → M / C / MC / CC 1 → M1 / C1 / MC1 / CC1 2 → M2 / C2 / MC2 / CC2 3 → M3 / C3 / MC3 / CC3 4 → M4 / C4 / MC4 / CC4 5 → M5 / C5 / MC5 / CC5 6 → M6 / C6 / MC6 / CC6 7 → M7 / C7 / MC7 / CC7 8 → M8 / C8 / MC8 / CC8 9 → (invalid, fixed form)	Measurement set which the customisation applies to. *For example, if <measurement_set> value is "4", the customised EC soil-parameter configuration defined here applies equally to:* *M4 (Sequential measurement set 4)* *C4 (Concurrent measurement set 4)* *MC4 (Sequential measurement set 4 with CRC error checking)* *CC4 (Concurrent measurement set 4 with CRC error checking)*
D	Custom function letter for "EC soil-parameter configuration".
=	Customisation command separator.
<soil_param>	Your EC soil-parameter values. Numbers are unsigned decimal, up to 2 decimal places. Valid ranges: 0.00 to 10.00
!	Command termination.

Example: "Configure WET150 at address Z to use EC soil-parameter value 7.6 in EC_p calculations for measurement set M4."

ZXU4D=7.6!

After an EC soil-parameter configuration command, the WET150 responds with either a confirmation or an error. The response always starts with the WET150's address and always terminates with the non-printable characters <CR><LF>.

Pass:

Sensor response	Notes
a OK <soil_param>	"a" is the WET150 address. <soil_param> is the entered value of EC soil-parameter rounded to 2 decimal places.

Fail:

Sensor response	Notes
a ERROR, Invalid measurement	"a" is the WET150 address. The <measurement_set> number in the command string must be 0-8.
a ERROR, Invalid number <soil_param>	The entered value for <soil_param> is outside the valid range.
a ERROR, Invalid command	Invalid customisation function letter or formatting error.
a ERROR, measurement M9 is not editable	Measurement set M9/C9/MC9/CC9 is a fixed format.

To read back the EC soil-parameter value used in a WET150 measurement set calculation, use the generalised extended SDI-12 command:

aXU<measurement_set>D?!

This read command is similar in structure as for applying an EC soil-parameter value and uses the same command elements.

Example: "What EC soil-parameter value is WET150 at address Z configured to use for calculations in measurement set M4?":

ZXU4D?!

The response from the WET150 to the above read command is:

Sensor response	Notes
a <soil_param>	"a" is the WET150 address. <soil_param> is the EC soil-parameter value.

The response always starts with the WET150's address and always terminates with the non-printable characters <CR><LF>.

EC compensation temperature configuration (customisation function "E")

Any measurement set which outputs data in terms of EC_p (pore water EC) with temperature compensation requires a EC compensation temperature reference value. This applies to the pre-configured measurement sets as well as any customised measurement sets.

The purpose of temperature compensating Pore EC measurements is to allow measurements taken at different soil temperatures to be compared on a like-for-like basis, as if they were all taken at a common reference temperature. This is necessary because Pore EC measurements are highly temperature dependent.

The default reference temperature is 25°C. Another common reference temperature is 20°C, but other values can be used. See the "Temperature compensation" section of the main WET150 manual for further information.

Note that is it not possible to set EC compensation temperature in °F. Please convert °F to °C before entering the value.

Note also that in very dry soils it is not possible to calculate ECp reliably, therefore an error code value of -8020 is returned instead. See section 0 (EC soil-parameter configuration) for details of the lower limit of soil moisture content for EC_p calculations.

The generalised extended SDI-12 command for changing the EC compensation temperature reference value in the WET150 is:

aXU<measurement_set>E=<degC>!

Note that the numeric values of <degC> must be in decimal point format not decimal comma:

1.23 ✓

1,23 ✗

Command element	Notes
a	Sensor address.
X	SDI-12 specified symbol for extended command.
U	WET150 configuration symbol.
<measurement_set> 0 → M / C / MC / CC 1 → M1 / C1 / MC1 / CC1 2 → M2 / C2 / MC2 / CC2 3 → M3 / C3 / MC3 / CC3 4 → M4 / C4 / MC4 / CC4 5 → M5 / C5 / MC5 / CC5 6 → M6 / C6 / MC6 / CC6 7 → M7 / C7 / MC7 / CC7 8 → M8 / C8 / MC8 / CC8 9 → (invalid, fixed form)	Measurement set which the customisation applies to. *For example, if <measurement_set> value is "4", the customised EC compensation temperature defined here applies equally to:* *M4 (Sequential measurement set 4)* *C4 (Concurrent measurement set 4)* *MC4 (Sequential measurement set 4 with CRC error checking)* *CC4 (Concurrent measurement set 4 with CRC error checking)*
E	Custom function letter for "EC compensation temperature".
=	Customisation command separator.
<degC>	Your preferred EC compensation temperature in °C. Numbers are unsigned decimal, up to 2 decimal places. Valid range 0.00 to 100.00 °C
!	Command termination.

Example: "Configure WET150 at address Z to use an EC compensation temperature of 16°C in calculations for measurement set M4."

ZXU4E=16!

After an EC compensation temperature configuration command, the WET150 responds with either a confirmation or an error. The response always starts with the WET150's address and always terminates with the non-printable characters <CR><LF>.

Pass:

Sensor response	Notes
a OK <degC>	"a" is the WET150 address. <degC> is the entered value of EC compensation temperature rounded to 2 decimal places.

Fail:

Sensor response	Notes
a ERROR, Invalid measurement	"a" is the WET150 address. The <measurement_set> number in the command string must be 0-8.
a ERROR, Invalid number <degC>	The entered value for <degC> is outside the valid range.
a ERROR, Invalid command	Invalid customisation function letter or formatting error.
a ERROR, measurement M9 is not editable	Measurement set M9/C9/MC9/CC9 is a fixed format.

To read back the EC compensation temperature value in a WET150 measurement set, use the generalised extended SDI-12 command:

aXU<measurement_set>E?!

This read command is similar in structure as for applying an EC compensation temperature value and uses the same command elements.

Example: "What EC compensation temperature value is WET150 at address Z configured to use for calculations in measurement set M4?":

ZXU4E?!

The response from the WET150 to the above read command is:

Sensor response	Notes
a <degC>	"a" is the WET150 address. <degC> is the EC compensation temperature in °C.

The response always starts with the WET150's address and always terminates with the non-printable characters <CR><LF>.

EC temperature coefficient configuration (customisation function "F")

Any measurement set which outputs data in terms of EC_p (pore water EC) with temperature compensation requires a EC temperature coefficient value. This applies to the pre-configured measurement sets as well as any custom measurement sets.

The default value is a compensation of 2%/°C (linear), but other values can be used if the specific ion composition of your soil is known. See the "Temperature compensation" section of the manual for further information.

Note that in very dry soils it is not possible to calculate ECp reliably, therefore an error code value of -8020 is returned instead. See section 0 (EC soil-parameter configuration) for details of the lower limit of soil moisture content for EC_p calculations.

The generalised extended SDI-12 command for changing the EC compensation temperature reference value in the WET150 is:

aXU<measurement_set>F=<tempco>!

Note that the numeric values of <tempco> must be in decimal point format not decimal comma:

1.23 ✓
1,23 ✗

Command element	Notes
a	Sensor address.
X	SDI-12 specified symbol for extended command.
U	WET150 configuration symbol.
<measurement_set> 0 → M / C / MC / CC 1 → M1 / C1 / MC1 / CC1 2 → M2 / C2 / MC2 / CC2 3 → M3 / C3 / MC3 / CC3 4 → M4 / C4 / MC4 / CC4 5 → M5 / C5 / MC5 / CC5 6 → M6 / C6 / MC6 / CC6 7 → M7 / C7 / MC7 / CC7 8 → M8 / C8 / MC8 / CC8 9 → (invalid, fixed form)	Measurement set which the customisation applies to. *For example, if <measurement_set> value is "4", the customised EC temperature coefficient defined here applies equally to:* *M4 (Sequential measurement set 4)* *C4 (Concurrent measurement set 4)* *MC4 (Sequential measurement set 4 with CRC error checking)* *CC4 (Concurrent measurement set 4 with CRC error checking)*
F	Custom function letter for "EC temperature coefficient".
=	Customisation command separator.
<tempco>	Your preferred EC temperature coefficient in %/°C. Numbers are unsigned decimal, up to 2 decimal places. Valid range 0.00 to 10.00 %/°C
!	Command termination.

Example: "Configure WET150 at address Z to use an EC temperature coefficient of 1.8%/°C (linear) in calculations for measurement set M4."

ZXU4F=1.8!

After an EC temperature coefficient configuration command, the WET150 responds with either a confirmation or an error. The response always starts with the WET150's address and always terminates with the non-printable characters <CR><LF>.

Pass:

Sensor response	Notes
a OK <tempco>	"a" is the WET150 address. <tempco> is the entered value of EC temperature coefficient rounded to 2 decimal places.

Fail:

Sensor response	Notes
a ERROR, Invalid measurement	"a" is the WET150 address. The <measurement_set> number in the command string must be 0-8.
a ERROR, Invalid number <tempco>	The entered value for <tempco> is outside the valid range.
a ERROR, Invalid command	Invalid customisation function letter or formatting error.
a ERROR, measurement M9 is not editable	Measurement set M9/C9/MC9/CC9 is a fixed format.

To read back the EC temperature coefficient value in a WET150 measurement set, use the generalised extended SDI-12 command:

aXU<measurement_set>F?!

This read command is similar in structure as for applying an EC temperature coefficient value and uses the same command elements.

Example: "What EC temperature coefficient value is WET150 at address Z configured to use for calculations in measurement set M4?":

ZXU4F?!

The response from the WET150 to the above read command is:

Sensor response	Notes
a <tempco>	"a" is the WET150 address. <tempco> is the EC temperature coefficient value.

The response always starts with the WET150's address and always terminates with the non-printable characters <CR><LF>.

EC measurement units configuration (customisation function "H")

Any measurement set which outputs data in terms of EC_b (bulk EC) or EC_p (pore water EC) either with or without temperature compensation can be configured to scale numeric values to output in different EC measurement units.

The available EC measurement units are:

ID	EC units (symbols)	Description	100 mS.m^{-1} equivalent	Notes
A	S.m^{-1}	Siemens per metre	0.1 S.m^{-1}	
B	dS.m^{-1}	Deci-Siemens per metre	1 dS.m^{-1}	
C	mS.cm^{-1}	Milli-Siemens per centimetre	1 mS.cm^{-1}	
D	mS.m^{-1}	Milli-Siemens per metre	100 mS.m^{-1}	Default
E	µS.cm^{-1}	Micro-Siemens per centimetre	1000 µS.cm^{-1}	

The default EC measurement units are mS.m^{-1}. The table also shows equivalence comparisons for 100 mS.m^{-1} which have been scaled to match the alternate output units.

The generalised extended SDI-12 command for changing the EC measurement units in the WET150 is:

aXU<measurement_set>H=<units_ID>!

Command element	Notes
a	Sensor address.
X	SDI-12 specified symbol for extended command.
U	WET150 configuration symbol.
<measurement_set> 0 → M / C / MC / CC 1 → M1 / C1 / MC1 / CC1 2 → M2 / C2 / MC2 / CC2 3 → M3 / C3 / MC3 / CC3 4 → M4 / C4 / MC4 / CC4 5 → M5 / C5 / MC5 / CC5 6 → M6 / C6 / MC6 / CC6 7 → M7 / C7 / MC7 / CC7 8 → M8 / C8 / MC8 / CC8 9 → (invalid, fixed form)	Measurement set which the customisation applies to. *For example, if <measurement_set> value is "4", the customised EC measurement units defined here applies equally to:* *M4 (Sequential measurement set 4)* *C4 (Concurrent measurement set 4)* *MC4 (Sequential measurement set 4 with CRC error checking)* *CC4 (Concurrent measurement set 4 with CRC error checking)*
H	Custom function letter for "EC measurement units".
=	Customisation command separator.
<units_ID>	Single capital ID letter from the EC measurement units table representing the required output units. Maximum one parameter.
!	Command termination.

Example: "Configure WET150 at address Z to use EC measurement units of dS.m^{-1} for measurement set M4."

ZXU4H=B!

After an EC measurement units configuration command, the WET150 responds with either a confirmation or an error. The response always starts with the WET150's address and always terminates with the non-printable characters <CR><LF>.

Pass:

Sensor response	Notes
a OK	"a" is the WET150 address.

Fail:

Sensor response	Notes
a ERROR, Invalid measurement	"a" is the WET150 address. The <measurement_set> number in the command string must be 0-8.
a ERROR, Invalid soil type	Invalid ID letter used.
a ERROR, Invalid command	Invalid customisation function letter or formatting error.
a ERROR, measurement M9 is not editable	Measurement set M9/C9/MC9/CC9 is a fixed format.

To read back the EC measurement units setting in a WET150 measurement set, use the generalised extended SDI-12 command:

aXU<measurement_set>H?!

This read command is similar in structure as for applying an EC measurement units setting and uses the same command elements.

Example: "What EC measurement units is WET150 at address Z configured to use for EC values in measurement set M4?":

ZXU4H?!

The response from the WET150 to the above read command is:

Sensor response	Notes
a <units_ID>	"a" is the WET150 address. <units_ID> is a capital ID letter representing the EC output units from the EC measurement units table.

The response always starts with the WET150's address and always terminates with the non-printable characters <CR><LF>.

Factory reset

A factory reset reverts all WET150 measurement sets to their default configurations. It does not change the SDI-12 address and it does not delete sensor factory calibration information.

To reset the WET150 back to its factory default measurement set configuration, use the following generalised extended SDI-12 command:

aXUG!

Note that as the reset applies to all measurement set configurations, no <measurement_set> number is included in this command.

Command element	Notes
a	Sensor address.
X	SDI-12 specified symbol for extended command.
U	WET150 configuration symbol.
G	Custom function letter for reset to factory defaults.
!	Command termination.

Example: "Reset WET150 at address Z back to factory defaults."

ZXUG!

After a factory reset command, the WET150 responds with either a confirmation or an error. The response always starts with the WET150's address and always terminates with the non-printable characters <CR><LF>.

Pass:

Sensor response	Notes
a OK	"a" is the WET150 address.

Fail:

Sensor response	Notes
a ERROR, Invalid command	"a" is the WET150 address. Invalid customisation function letter or formatting error.

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