Delta-T Devices

Leaders in Environmental Measurement

Soil Moisture Measurement

Delta-T Devices Company Profile

Origins

Established in 1971, Cambridge based Delta-T Devices specialises in instruments for environmental science, in particular for soil science, agronomy, plant science, data logging, meteorology and environmental monitoring.

Delta-T is a co-operative company, owned and managed by the members who work within it. Co-operative working creates a highly professional environment in which we all strive to make the business successful. We share a high level of commitment to the company and to our customers.

High Quality Products

Delta-T is a market leader in soil moisture monitoring, with more than 25 years' experience in providing researchers with innovative, dependable soil moisture sensors. We aim to continually improve and extend the capabilities of our products, using the most up-to-date theory and technologies.

In addition to individual instrument sales, we can also supply whole systems, such as a multi-point soil moisture measurement system with a data logger and solar power unit.

Sales and Support

Delta-T has an international network of representatives who can provide local sales and service in most countries. Export sales account for 80% of Delta-T's business.

Delta-T has retained thousands of loyal customers all over the world who value the reliability, performance and long-term service that we provide. Their feedback is incorporated into many of our product designs to create a process of continuous improvement

Policy Statement

"We aim to manufacture and sell instruments for use in work beneficial to the environment and directly related to human and animal welfare. As a matter of conscience, we reserve the right not to sell our instruments to people or institutions involved in military work, tobacco research, environmentally destructive practices and factory farming."

The Delta-T Devices Soil Moisture Range

Delta-T Devices has decades of experience in creating premium-grade equipment for soil moisture measurement and recording. Our instruments are built to exacting standards - ensuring ruggedness, longevity, and optimum performance throughout their life. They are used and trusted by researchers around the world and are suited to a wide variety of applications and budgets.

The Delta-T Devices soil moisture range includes a wide choice of **sensors** and **meters** (pages 1-13) and **data loggers** (pages 14-19). More information can be found online at www.delta-t.co.uk

Overview of Delta-T Soil Moisture Sensors

	Accuracy	% water content	Soil temp	EC	Profiling	Soil water potential
ML3 Page 3 	++++	✓	✓	✗	✗	✗
SM300 Page 4 	+++	✓	✓	✗	✗	✗
SM150 Page 5 	++	✓	✗	✗	✗	✗
WET Page 6 	+++	✓	✓	✓	✗	✗
PR2 Page 10 	++	✓	✗	✗	✓	✗
EQ3 Page 9 	++	✗	✓	✗	✗	✓
SWTs Page 9 	++++	✗	✗	✗	✗	✓

Cable options and accessories for the ML3 ThetaProbe, SM150, SM300 Sensors and EQ3 Equitensiometer

SMSC/sw-05	5m cable terminating in bare wires for connection to GP1, GP2, or DL6 loggers.
SMSC/lw-05	5m cable terminating in bare wires for connection to DL2e.
SMSC/d-HH2	90cm cable, M12 to 25-way D-socket, for connection to an HH2 Meter.

EXT/5W-01 **EXT/5W-05** **EXT/5W-10** **EXT/5W-25**	1m, 5m, 10m, and 25m extension cables, M12 connectors.
ML/EX50	0.5m extension tube.
ML/EX100	1m extension tube.
SM-AUG-100	Spiral auger, 45mm diam. Installs ML3, SM300 or SM150 at depth, length 1.2m.

The **ML3 ThetaProbe** measures soil moisture and temperature with class-leading accuracy

- Soil moisture with ± 1% accuracy
- Built-in temperature measurement
- Simple data logger or meter connection
- Extendable cable system
- Buriable – IP68

Exceptional performance

The ML3 ThetaProbe's class leading ± 1% accuracy, stability, build quality, and reliability have made it the preferred choice of thousands of researchers worldwide.

The ML3 is easy to use. Simply insert the probe into the soil, connect to your data logger or meter, provide 5-14V DC at 18mA and within seconds you can be accurately measuring soil moisture.

A built-in thermistor enables the ML3 to simultaneously measure soil temperature and soil moisture at depth. A new cabling system makes it simple to extend or replace cables, offering a choice of 1m, 5m, 10m and 25m extensions. ML3 cables and connectors are buriable and environmentally protected to IP68.

The salinity response of the ML3 has been improved - its output has been characterised at EC values up to 2000 $mS.m^{-1}$. The temperature range has also been improved with tests demonstrating that the ML3 can operate down to -40 degrees C (non-flexing cables).

Installation

ThetaProbes are robust, buriable and maintenance-free. They can be inserted into augered holes or positioned in the wall of a trench (which is then carefully back-filled). Optional extension tubes assist placement and removal.

Data logging and readout

The ML3 can be logged by any Delta-T data logger, and many loggers from other manufacturers.

For portable applications the ML3 connects to the HH2 Moisture Meter - and these can be ordered together in convenient form as the **ThetaKit** - see image on page 8. (NB: the HH2 does not provide temperature indication from the ML3).

Brief Specification (full spec on page 12)	
Water content	
Accuracy	± 0.01 $m^3.m^{-3}$
Range	0 to 0.5 $m^3.m^{-3}$
Temperature	
Accuracy	± 0.5°C, 0 to +40°C ± 0.75°C, -20 to +60°C [1]
Output	0 to 1.0V differential
Power	5 to 14V, 18mA for 1s
Sample vol.	~60 x 30mm diameter
Size	158 x 40mm diameter
Environmental	IP68, -40 to +70°C

Ordering Information	
ML3	ML3 ThetaProbe Sensor NB: Order cable separately
ML3 ThetaKit	Includes ThetaProbe type ML3, 4 spare rods, HH2 Meter, USB-RS232 adapter cable, insertion kit and case.
ML-RODS-3	Pack of 12 spare rods.
ML/INK 1	Insertion kit for pre-forming holes in hard soils.
See page 2 for cables and accessories	

[1] Figures apply to sensor only and exclude logger or cabling errors

Patents: UK patent 2300485B / US patent 5804976

Feature	Description	Advantage
4-rod arrangement 	3 rods are arranged around a central rod. This creates a defined cylindrical zone of measurement, 60mm long x approximately 30mm diameter.	• Retains soil closer to central rod in case of drying and cracking (other designs, and particularly flat PCB sensors, don't do this) • Measurements can be made close to the soil surface
Replacement rods 	Made of 3mm diameter, resilient, 304 austenitic stainless steel, with sharpened tips. The exposed rod length is 60mm.	• Withstands repeated insertion in soil. Replaced at low cost if bent or damaged • Highly resistant to corrosion • Sharp, narrow rods minimise errors due to soil compaction by the rods
Compact cylindrical shape 	The ThetaProbe has a 40mm diameter body, with threaded end. Extension tubes (0.5 and 1.0m) screw onto this thread. Case sealed to IP68.	• Easy to insert and remove from augered holes • Rapid attachment of extension tubes • Handy size for portable use • Rugged and buriable to 5m

Applications

- **Environmental Research** Soil water is one of the critical components for long-term studies of global climate and local environments. The accuracy and reliability of the ML3 makes it ideally suited to these applications.
- **Sports Turf and Golf** The ML3 ThetaKit is used by sports turf professionals worldwide to spot check soil moisture content and to monitor the performance of automatic sprinklers. (See image on page 8).

The **SM300 Soil Moisture Sensor** measures soil moisture and temperature with research grade accuracy

- Dependable accuracy ± 2.5%
- Soil moisture and temperature
- Good temperature and salinity stability
- Easy data logger or meter connection

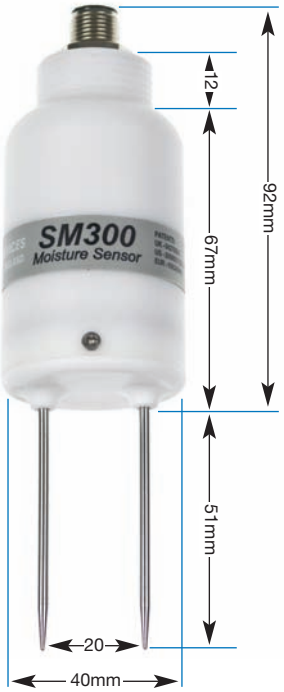
Research grade sensor

The SM300 offers excellent performance in normal and saline soil conditions, and is stable across wide ranges of temperature and salinity. Its construction uses industrial grade connectors and high specification materials throughout to produce a highly dependable soil moisture sensor. The built-in temperature sensor simplifies soil temperature measurement and achieves 0.5°C accuracy.

Applications

- Soil science
- Agronomy
- Horticultural and agricultural research
- Environmental science

The SM300 is only 143mm long, allowing it to be placed in plant pots and other confined spaces. Its accuracy and affordability make it a good choice for vertical soil moisture profiling in situations where Profile Probes (see page 10) would not achieve high enough accuracy or enough depth. The SM300 is ideal for use in situations where temperature profiling is also required.



Calibration

The SM300 is provided with general calibrations for mineral and organic soils. A two-point soil specific calibration can be performed for greater accuracy if required.

Data logging and readout

The SM300 is a dual purpose probe - it can be used with the HH2 Moisture Meter, for instant moisture readings, or left in situ for data logging – to provide moisture and temperature data. (NB the HH2 does not provide temperature indication from the SM300 or ML3 sensors).

The SM300 can be logged by any Delta-T data logger and is compatible with a wide range of loggers, irrigation monitors and controllers from other manufacturers. The GP1 Data Logger offers a particularly competitive logging solution, accepting 4 SM300s or SM150s (moisture measurement only) or 2 SM300s (moisture and temperature). See page 19.

Easy to use

The compact SM300 minimises soil disturbance, preserving the original soil structure. It is easy to insert and install whether at the soil surface or at depth, and is well suited to use in plant pots. The SM300's circular shape allows it to be installed in augered holes - insertion tubes are available.

Convenient interchangeable cables are available for the SM300. The options include bare ends for data logger connection and a dedicated connector for the HH2 Moisture Meter. 5m, 10m and 25m extension cables are available.

Ordering Information

SM300	SM300 Soil Moisture Sensor with built-in temperature sensor. NB cable must be ordered separately.

See page 2 for cable and accessory options

Brief Specification
(full spec on page 12)

Water content	
Range	0 to 1.0 $m^3.m^{-3}$
Accuracy	± 0.025 $m^3.m^{-3}$
Temperature	
Accuracy	± 0.5°C, 0 to +40°C ± 0.75°C, -20 to +60°C [1]
Output	0 to 1.0V
Power	5 to 14V, ~18mA for 1s
Sample volume	~55 x 70mm diameter
Size	see diagram
Environment	IP68, including connector

[1] Figures apply to sensor only and exclude logger or cabling errors

Patents: US7944220 EP1836483

The **SM150 Soil Moisture Sensor** for rapid accurate measurements of substrate moisture content

- ± 3% accuracy
- Good temperature and salinity stability
- Easy data logger connection (0 to 1V DC)

Affordable precision

The SM150 enables growers to monitor the moisture status of 1000's of plants daily. It is particularly easy to insert without damaging roots or disturbing the growing medium, and partnered with the HH150 provides a simple, effective, low-cost solution to checking the uniformity of growing conditions

Applications

- **Horticultural production.** The SM150 is tough enough to be used all day every day in busy growing environments.
- **Landscape.** The SM150 is ideal for sampling the water content of pot-grown plants to detect dry spots and ensure that the benefits of RDI are delivered.
- **Plant nurseries.** With the GP1 or GP2 logger, the SM150 can be used in smart irrigation control systems.

Calibration

The SM150 is provided with general calibrations for mineral and organic soils. A two-point soil specific calibration can be performed for greater accuracy if required.

Data logging and readout

The SM150 Soil Moisture Sensor is compatible with all Delta-T Devices Loggers and its 0 to 1V DC output can be handled by most other types of data logger. The SM150 is compatible with the HH2 Moisture Meter but due to the HH2's higher cost it tends to be used only if PC connectivity is needed.

Monitoring and control

The SM150 is designed for long term burial as well as hand-held use, and can be used with the GP1 or GP2 Data Logger for smart irrigation control. The built-in connector makes it quick and simple to switch between uses.

SM150 Kit

- Complete kit for low cost substrate moisture measurement
- ± 3% accuracy

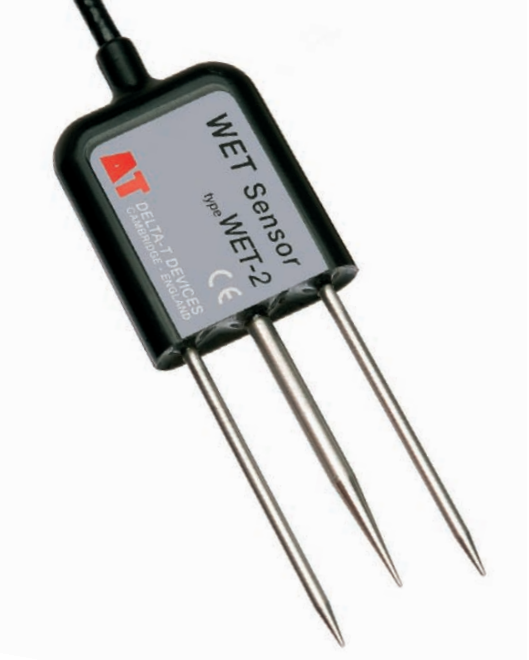
The SM150 Kit provides growers with a very affordable and easy to use tool for obtaining reliable moisture measurements with minimal soil disturbance. The cable and connector are watertight – an essential requirement for potentially wet environments. The kit comprises an SM150 Soil Moisture Sensor, a dedicated HH150 Moisture Meter and a carry case. The HH150 hand held meter is light weight and is very easy to use, being a readout-only device (no data recording or PC complications).

The kit is simple to use - just insert the SM150 into the substrate and press the Read button.

Ordering Information	
SM150	SM150 Soil Moisture Sensor fitted with M12 connector. NB: cable must be ordered separately.
SM150-KIT	Portable soil moisture kit including SM150 Sensor, HH150 Meter, 1m fitted cable, manuals and carrying case.

See page 2 for cable and accessory options (not applicable to SM150 Kit)

Brief Specification (full spec on page 13)	
Range	0 to 1.0 $m^3.m^{-3}$
Accuracy	± 0.03 $m^3.m^{-3}$
Output	0 to 1V
Power	5-14V, ~18mA for 1s
Sample volume	55 x 70mm diameter
Size	143 x 40mm diameter
Environment	IP68 including connector



The **WET Sensor type WET-2** measures three vital soil properties: **W**ater content, **E**lectrical Conductivity (EC) and **T**emperature

- Moisture and nutrient status in the root zone
- Rapid monitoring of growing conditions
- Calibrations for many soils and substrates

Rapid checks on growing conditions

The WET Sensor can easily be inserted into substrates, composts and most soils, enabling growers and researchers to make rapid checks and optimise the uniformity of growing conditions. Each reading takes less than 5 seconds and provides 3 of the most important indicators of root zone health: water content (%), pore water conductivity (ECp) and temperature (°C). The sensor is particularly useful in horticulture for monitoring and correcting for variations when applying fertigation, CRF or organic treatments.

Pore water conductivity

The WET Sensor is able to calculate pore water conductivity (ECp) which is the EC of the water available to plant roots. The ECp calculation is derived from an approximate relationship between dielectric properties. This applies particularly well to WET Sensor readings, which are taken at the same frequency within the same defined region of soil/substrate. The approximation is valid in most soils and is particularly accurate in mineral wool and other artificial substrates media.

Applications

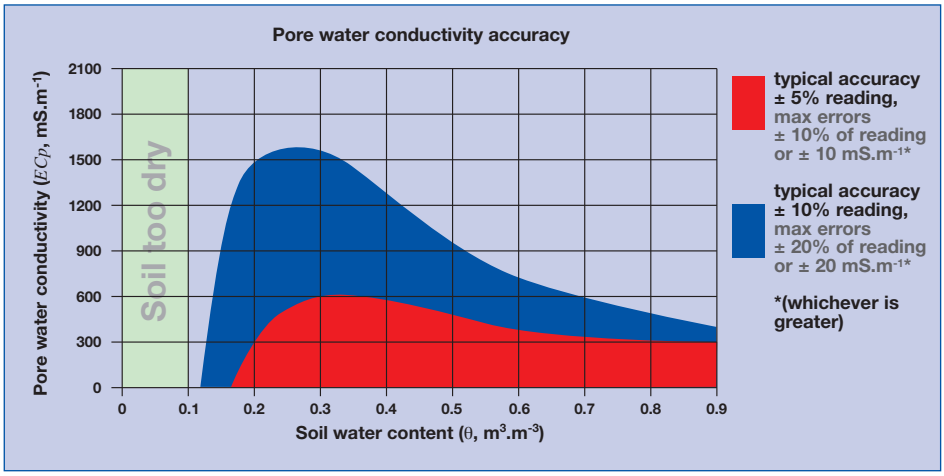
- Horticulture
- Agriculture
- Soil science
- Pollution monitoring

The WET Sensor is used throughout horticulture, especially by soft fruit growers and for crops grown in protected environments, where correct growing conditions are critical to both yield and flavour. The compact sensor can be inserted directly into the growing medium with minimal disturbance to either roots or shoots, and provides information for process optimisation or checking growing condition uniformity.

The WET Sensor can also be used to monitor the build-up of salinity when irrigating with poor quality water, though it should not be used in conditions of high salinity (see graph below).

Horticultural media calibrations

The WET Sensor is supplied with default calibrations for generic mineral, organic, sand and clay soils. Special WET-GH substrate calibrations can be ordered as a set, for a variety of horticultural media including coir, peat-based potting mixes and greenhouse “mineral” soils. Alternatively, WET-ST calibrations can be ordered for mineral wool (vertical and horizontal measurement).



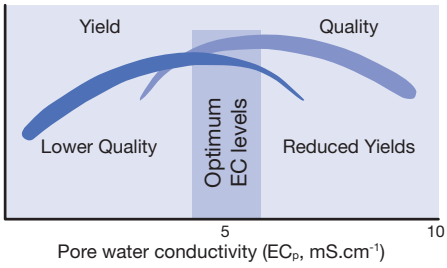
Logging option

The WET Sensor can be connected to the GP2 or GP1 Data Logger in order to monitor fluctuations in growing conditions over time. The smart control relay capability of the GP2 and GP1 are fully enabled for the WET Sensor, so the system may be configured to control water content and/or EC or temperature using powerful built-in control capabilities.

Brief Specification (full spec on page 12)	
Measured parameters	
Permittivity, ε′	1 to 80 ± 2.5 [1]
Bulk conductivity	0 to 300 mS.m^{-1} ± 10 (ECb)
Temperature	-5 to 50°C ± 1.5°C
Calculated parameters	
Volumetric Soil Moisture, θ	0 to 100% ± 3% [2]
Pore water conductivity	see graph below (ECp)
Other specifications	
Calibration	Individual sensor calibrations stored within sensor EEPROM
Output	Serial data (TTL)
Environmental	IP68, 0 to 50°C
Power	6 to 10V, ~38mA for 2.5s
Dimensions	~120 x 45 x 13mm
Rods	~68mm long
Sample volume	~500ml

[1] Permittivity is a measure of the dielectric properties of materials, e.g. soils and substrates.
[2] Soil moisture accuracy refers to errors after applying a soil-specific calibration, within 10°C of calibration temperature.

Yield and Quality of Tomatoes v ECp



WET Kit

For portable applications the WET Sensor is used with an HH2 Moisture Meter and is normally supplied as a complete kit - see Ordering information.

WET KIT

Ordering Information			
WET-2/d	Sensor with 1m cable and 25-way D-socket for use with HH2		
WET-2/w	Sensor with 5m cable terminating in bare wires for use with GP1 or GP2		
WET-2-K1	WET Kit including WET-2/d, HH2 Moisture Meter, manuals and carrying case		
WET-2-K4	As WET-2-K1 Kit plus WET-GH1 substrate calibration upgrade		
Calibration sales codes (dependent on WET partnering equipment)			
Substrate calibration upgrades If additional horticultural substrate calibrations are required, they should be ordered at the time of purchase of the HH2, GP2 or GP1. Substrate calibrations are factory installed at Delta-T's premises.			
HH2	GP2	GP1	Substrate calibration upgrade
WET-GH-1	**WET-GH-1G2**	**WET-GH-1G**	Horticultural media including coir, peat-based potting mixes and greenhouse 'mineral' soils
WET-ST-1	**WET-ST-1G2**	**WET-ST-1G**	Mineral wools (vertical and horizontal measurement)

Horticultural Applications

Fertigation and hydroponics Where plants are grown in artificial substrates, nutrients are routinely supplied in irrigation water - "fertigation".

Nutrient levels are controlled by monitoring the water content and conductivity (EC) and adjusting the injection of liquid fertiliser into the irrigation water. The Delta-T WET Sensor excels in monitoring this crucial information.

Soil salinity If the irrigation water is recycled or abstracted from rivers with high levels of dissolved salts, over time there can be a build-up of soil salinity. Soil salinisation will eventually reduce crop yields. The WET Sensor is fast and efficient for sampling soil salinity, ensuring that growers have the essential information they need to take remedial action.

Container-grown shrubs and trees Nutrients may also be provided by Controlled Release Fertilisers. The rate at which these are taken up depends on the weather conditions. The WET Sensor can be used to measure EC within the growing media, removing much of the guesswork from this procedure.

Acknowledgements

WET Sensors have been developed in co-operation with:

PLANT RESEARCH INTERNATIONAL WAGENINGEN UR

Plant Research International (formerly IMAG-BV), P.O. Box 16, 6700 AA Wageningen, The Netherlands.
Web site: www.pri.wur.nl

Designers of the WET Sensor & the ASIC which enables accurate measurement of permittivity and conductivity of the bulk soil or media

Cultilène® SAINT-GOBAIN CULTILENE

Saint-Gobain Cultilène B.V. Zeusstraat 2, 5048 CA TILBURG, The Netherlands.
Web site: www.cultilene.com

Sponsors of research into horticultural media applications & suppliers of horticultural media calibrations

The **HH2 Moisture Meter** provides instant readout from most Delta-T soil moisture sensors

- Immediate display of water content
- Store up to 1500 readings
- Reads ML3, SM300, SM150, PR2 or WET Sensor

Overview

The HH2 offers impressive functionality in a compact hand-held unit designed for field use. Readings are displayed on the LCD and can be stored to memory for later download to a PC. Up to 1500 time-stamped readings can be stored.

Applications

- Reads ML3*, SM150, SM300* and WET Sensors
- Reads PR2/6 and PR2/4 Profile Probes

Simple versatile operation

The HH2 can be operated with one hand for convenience in the field. Each time-stamped reading includes a unique sample number, a plot identification letter (A to Z) and a sensor location number (1 to 255).

Data is transferred to a PC using the RS232 cable provided with each unit. See ordering information for USB connection. The HH2Read software provides a Dataset Import Wizard for direct download into Excel. Data can also be downloaded in comma-separated ASCII (.csv) format.

Reading Profile Probes

The HH2 Moisture Meter can take readings from a PR2 Profile Probe wherever access tubes have been installed. With an installed array of access tubes, one HH2/PR2 combination can profile large areas quickly. The HH2 auto-detects the number of sensors in each Profile Probe.

ML3 ThetaKit

Reading WET Sensors

The HH2 is able to display the 3 outputs produced by the WET Sensor and store them until downloaded to a PC. Standard calibrations for Mineral, Organic, Clay, or Sand media can be selected. In addition, user-defined custom calibrations can be entered for soils and other substrates.

User-selectable options allow pore water and/or bulk conductivity to be displayed, and also the permittivity. The HH2 provides user-selectable temperature compensation.

Horticultural media calibrations

The WET Sensor is supplied with default calibrations for generic mineral, organic, sand and clay soils. WET-GH-1 substrate calibrations can be ordered as a set, for a variety of horticultural media including coir, peat-based potting mixes and greenhouse "mineral" soils. WET-ST-1 substrate calibrations can be ordered for mineral wool (vertical and horizontal). See page 7 for calibrations ordering information.

Water deficit

This reading indicates the amount of water needed (in mm) to restore the soil to field capacity, down to a user-defined rooting depth. The HH2 calculates water deficit from the user-defined field capacity and from readings taken either from a single sensor or the individual sensors of a Profile Probe. The HH2 User Manual contains tables of standard soil classifications and their associated field capacities.

Soil types

Standard calibrations for generalised mineral and organic soils are supplied with the HH2 for use with the ML3*, Profile Probe and SM300* Sensors. The HH2 also enables up to 5 extra user-defined soil calibrations to be characterised and stored. The soil calibration can be switched at any time during the collection of data, and can be specified separately for each sensor position on a single Profile Probe. The unconverted mV readings can be stored alongside the soil water readings.

Ordering Information

Moisture Meter type HH2 with integral 25-pin D-connector, battery, RS232 cable and 25 to 9 pin adapter.

If the HH2 is intended for use with a single ML3 ThetaProbe or a single WET Sensor it can be ordered as part of a convenient kit – see pages 3 or 7.

USB to RS232 Adapter Cable type USB-RS232. 100cm cable, connects 9 pin RS232 to USB (for connection to PC).

Brief Specification

(further specs on page 19)

Range	Zero to saturation (soil water content) 0 to 1.5V (voltage range)
Accuracy	± 0.13% of mV reading ± 1mV
Resolution	1mV
Reading storage	Typically 500 to 1500 readings (depends on sensor and settings)
Connection	1 x male 25-pin D-connector used for sensor and RS232 communications
Environmental	IP54, 0 to 40°C (operating)
Size, weight	125 x 80 x 40mm, 450g
Battery type, life	9V alkaline 6LR61 (PP3), ~ 5,000 readings

*NB The ML3 or SM300 can be used as a portable moisture probe with the HH2 Meter but the HH2 does not provide temperature indication from the SM300 or ML3

Soil Water Potential
(matric potential)

- Loggable water-filled pressure transducer tensiometers
- Maintenance-free wide range Equitensiometers

EQ3 Equitensiometer

Tensiometers type SWT4, SWT4R and SWT5

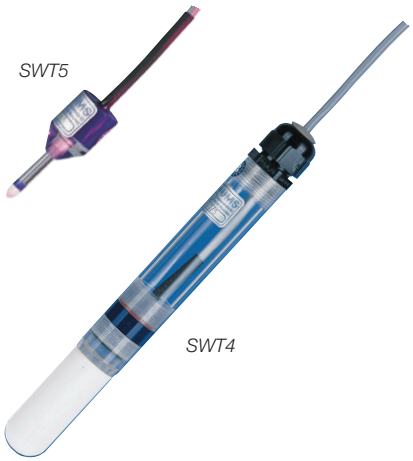
These precision, water-filled ceramic cup tensiometers have good accuracy (± 0.5 kPa) over the range +100 to -85 kPa (+100 to -160 kPa for SWT5X).

SWT tensiometers require refilling and degassing after dry periods, and must be protected from frost. SWT4 and SWT4R have improved performance and better frost resistance. The SWT4R refillable version can be filled and emptied in situ. The SWT5 is a miniature version that can be used for plant pots, etc.

The tensiometers require a stabilised 10.6V DC 1.3mA power source. A GP2 Data Logger can power and log up to 12 tensiometers. Alternatively, a GP1 fitted with 1 or 2 GP-PBA-X50 boards can log 1 or 2 tensiometers.

When more than 12 tensiometers need to be connected to a single data logger, the DL2e Logger is available (see page 18).

For use in drier soils (< -160 kPa) or at remote sites, the Equitensiometer should be considered.



EQ3 Equitensiometer

- Convenient, accurate, reliable alternative to water-filled tensiometers
- Excellent range 0 to -1000 kPa
- Maintenance-free - no refilling or degassing
- New built-in temperature measurement
- New extendable cable system

The EQ3 next generation equitensiometer has extra features and a new look. With maintenance-free operation and a wide measurement range it continues to be an excellent choice for reliable matric potential measurement, but now also measures soil temperature.

The EQ3 uses class leading ThetaProbe technology to avoid the many problems of water-filled tensiometers. It provides an accurate loggable output, making it suitable for environmental monitoring, particularly in dry soils. The EQ3 incorporates soil temperature measurement. It also features a detachable cable system - enabling easy changing of cable length.

The EQ3 is ideally suited to static long term monitoring of matric potential and soil temperature. It can even be left installed in frozen soils. Typical areas of use include environmental, plant, soil, ecology and geo-sciences research, as well as civil engineering and agricultural engineering applications.

Applications

- Soil science
- Agronomy
- Horticultural and agricultural research
- Civil engineering

The EQ3's full range is 0 to -1000 kPa but best accuracy is achieved between -100 and -500 kPa. This makes it well suited to plant water stress studies - even in very dry soils.

Please note that despite its many strengths (and advantages over water-filled tensiometers), the EQ3 should not be seen as a rapid response sensor that covers the full range of matric potentials at high accuracy. Such a sensor does not yet exist. EQ3 equilibration time is typically several hours.

As the EQ3 is maintenance-free (no refilling, degassing, or topping up required) frost resistant and low powered, it can be conveniently used at remote sites over long periods of time. In such instances it is possible to access sensor data wirelessly via a GPRS enabled data logger such as the GP2.

Ordering Information
(full specs on page 13)

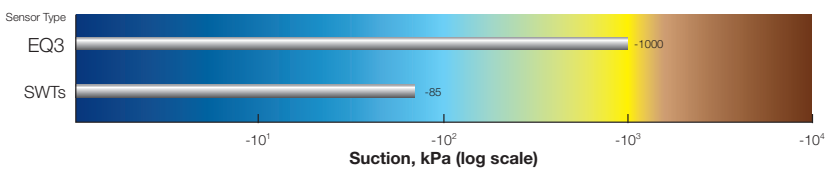
EQ3	EQ3 Equitensiometer. See page 2 for cable and accessory options.
SWT4-t40	Water-filled tensiometer with 40cm shaft [1]
SWT4R-t40	Refillable version of SWT4 [1]
SWT5-s07	Miniature water-filled tensiometer with 7cm shaft [2]

All SWTs are fitted with a 1.5m cable and connector. A connecting cable must be ordered with each SWT. Lengths of 5, 10 and 20m are available.

[1] SWT4 tensiometers can be fitted with other shaft lengths, minimum 20cm up to 211cm max.

[2] SWT5 can be fitted with shaft lengths 2 to 20cm.

Comparison of matric potential ranges



The **PR2 Profile Probe** provides easy and accurate soil moisture profiles

- Soil moisture content - not just trends
- Low salinity and temperature sensitivity
- Portable meter option for multi-site measurement
- GP2 and DL6 Logger options for continuous monitoring

Dual purpose

The unique PR2 Profile Probe can be installed for continuous data logging and can also be used for multi-site, portable measurements with an HH2 hand-held readout unit.

The PR2 uses patented* sensing technology, making it possible to measure soil moisture content in a range of soil types and across a wide range of nutrient levels, including saline soil conditions.

Applications

- Soil moisture profiles
- Agriculture
- Hydrology
- Civil engineering

Installation and connection

Users can choose between the PR2/4, measuring at 4 depths down to 40cm, or the PR2/6, measuring at 6 depths down to 100cm. The nominal sensing depths are 10, 20, 30, 40, 60 and 100cm.

Profile probes are used in access tubes inserted into augered holes in the soil. Access tubes require an installation hole only 27mm in diameter, allowing easy installation and minimal soil disturbance. They are manufactured to strict tolerances and are exceptionally strong and durable in the soil. Correct installation is essential and we recommend the use of our specially designed augering equipment (see next page).

Robust

The PR2 is constructed from the highest grade components and materials to ensure robustness in harsh environments. Reliable, environmentally sealed IP68 connectors provide a wide range of cable length and connectivity options. This flexibility makes sensor connection and disconnection quick and easy.

Data logging

The DL6 is a dedicated logger optimised for use with Profile Probes and other Delta-T Moisture Sensors (see opposite).

For multi-probe applications, the DL2e Logger is ideal (see page 16).

Brief Specification (full spec on page 13)	
Range	0 to 0.4 $m^3.m^{-3}$ [1]
Accuracy	± 0.04 $m^3.m^{-3}$
Output	**PR2/6:** 6 x 0 to 1.0V [2] **PR2/4:** 4 x 0 to 1.0V
Power	5.5 to 15V [3] **PR2/6:** ~120mA for 1s **PR2/4:** ~80mA for 1s
Sensing depths (nominal)	**PR2/6:** 10, 20, 30, 40, 60, 100cm **PR2/4:** 10, 20, 30, 40cm
Sampling volume	**Vertically:** ~95% sensitivity within ± 50mm of upper rings **Horizontally:** ~95% sensitivity within 200mm diameter
Size (length x diam)	**PR2/6:** 1350 x 25.4mm **PR2/4:** 750 x 25.4mm
Sealing	IP68
Access tubes	
Size (length x diam)	**ATL1:** 1154mm x 28mm **ATS1:** 554mm x 28mm

[1] Measures full range up to 1.0 $m^3.m^{-3}$ with reduced accuracy
[2] Corresponding to 0 to 0.6 $m^3.m^{-3}$
[3] 5.5V DC with 2m cable, 7.5V with 100m

HH2 Moisture Meter

The HH2 is a versatile readout unit that provides an easy and convenient way to display and store readings from Profile Probes. With the HH2 and PR2 combination, a Probe can be moved from access tube to access tube, enabling large amounts of soil moisture data to be collected at multiple sites. (see page 8)

(Above) PR2/6 Profile Probe with HH2 Moisture Meter.
(Right) PR2/4 Profile Probe

Ordering Information	
PR2/4	Profile Probe, 40cm (no cable)
PR2/6	Profile Probe, 100cm (no cable)
All Profile Probes are fitted with an IP68 connector and come with a protective tube. **Cable must be ordered separately.**	
Standard cables	
PRC/d-HH2	1.5m cable, IP68 M12 connector to 25-way D-socket. Connects PR2 to HH2 Moisture Meter
PRC/M12-05	5m cable, IP68 M12 connectors. Connects PR2 to GP2 or DL6 Logger
PRC/w-05	5m cable, IP68 M12 connector to bare wire. Connects PR2 to data loggers
Extension cables	
EXT/8W-05	5m extension cable, M12
EXT/8W-10	10m extension cable, M12
EXT/8w-25	25m extension cable, M12
The EXT/8W - xx cables can be connected together to create custom lengths – then fitted to a PRC/M12-05 or PRC/w-05 cable for data logger connection.	
Access tubes and PR2 accessories	
ATS1	Short access tube, includes cap, bung and collar. For use with PR2/4
ATL1	Long access tube, includes cap, bung and collar. For use with PR2/6
PR2-SP	Profile Probe spares kit
PR-CB2	Protective carrying bag suitable for PR2 and HH2 Moisture Meter

* Patents: US7944220 EP1836483

Augering and Extraction Kits
for optimal Access Tube installation

Finishing auger

Profile Probes are used within access tubes inserted into augered holes in the soil - correct installation is vital for accurate measurement of soil moisture profiles. The goal of installation is to produce optimal contact between the soil and the wall of the access tube. The augered holes should be straight, smooth sided and the correct diameter.

Delta-T augering kits help you achieve the best possible access tube installation in virtually any soil. However it may not be possible to install an access tube successfully in very stony soils, or where a site features compaction, voids, foreign bodies, or soil instability.

Three types of augering kit are available (a PR-AUG2 25mm spiral auger should be ordered in addition to the selected kit for dry sandy soils).

Augering Kit features

The key components are:

Stabilisation plate to keep the auger vertical. Reading errors can arise from conical enlargement of the hole (funnelling) during augering, especially in the top 30cm. This results in poor contact between the surface of the access tube and the surrounding soil. The stabilisation plate minimises this effect.

Insertion rod to drive the access tube into an augered hole by applying force to the bottom of the tube (normally by hammering). This new technique reduces the flexing that can produce air gaps around the access tube and minimises soil displacement.

Finishing auger to expand augered pilot holes to the exact diameter required for an access tube. This specially designed adjustable finishing auger produces straight, smooth-sided holes in most soil types.

Extraction Kit

The optional PR-EXK1 is a heavy duty system for removing installed access tubes from the ground. The kit includes a cast iron jack, chains, jack foot and a tube clamp.

Data logger options for Profile Probes

The DL6, GP2 and DL2e are versatile loggers that can be connected to many types of soil moisture sensor and other environmental sensors. See page 19 for further information.

	PR2/4	PR2/6	Notes
DL6 Logger 	1	1	Profile probe can be instantly connected with dedicated cable and input socket.
GP2 Logger 	3	2	With the GP2-P2-LID option, up to 2 profile probes can be instantly connected to the dedicated input sockets. A third probe can be connected using screw terminals.
DL2e Logger 	3 to 15*	2 to 10*	Basic DL2e logs 3 PR2/4s or 2 PR2/6s. Analog expansion cards allow larger numbers to be connected.

* Subject to power switching requirements

Ordering Information

PR-ASK1-S	Augering starter kit (short). For short access tube installation only, includes 24mm pilot auger, stabilisation plate and access tube insertion rod
PR-ASK1-L	Augering starter kit (long). For access tube installation (long or short tubes), includes all items in PR-ASK1-S Kit, plus finishing auger and mallet
PR-AKC1	Augering kit (complete). For access tube installation (long or short tubes), includes all items in PR-ASK1-L Kit, plus flexicanes, carrying bag and cleaning rod
PR-AUG2	25mm spiral auger, for dry sandy soils
PR-EXK1	Access tube extraction kit

Augering kit selection

Soil type and depth (normal soils)	PR-ASK1-S Starter Kit (short)	PR-ASK1-L Starter Kit (long)	PR-AKC1 Complete Kit
Up to 40cm depth	✔	✔✔	✔✔✔
Up to 1m depth	✗	✔✔	✔✔✔

- For dry, sandy soils the PR-AUG2 25mm spiral auger should be ordered in addition to the selected augering kit
- Only the complete kit includes a carrying bag
- All items can be ordered individually

Key:

✔ = Meets basic need
✔✔ = Well suited
✔✔✔ = Well suited & includes items for extra convenience
✗ = Unsuitable

Soil Moisture Sensor Specifications

	Multi-parameter				
Sensor	**ML3 ThetaProbe** 	**SM300** 	**WET Sensor** 		
Measurement	Volumetric water content and soil temperature	Volumetric water content and soil temperature	Volumetric water content	Pore water conductivity (ECp)	Temperature
Accuracy	**± 0.01 $m^3.m^{-3}$ (1%)** With soil-specific calibration **± 0.5°C**, 0 to 40°C for temp sensor	**± 0.025 $m^3.m^{-3}$ (2.5%)** With soil-specific calibration **± 0.5°C**, 0 to 40°C for temp sensor	**± 0.03 $m^3.m^{-3}$ (3%)**	See graph on page 6	**± 1.5°C**
Soil moisture measurement range	Full accuracy over: **0 to 0.5 $m^3.m^{-3}$** Full range: 0 to 1.0 $m^3.m^{-3}$	Full accuracy over: **0 to 0.5 $m^3.m^{-3}$** Full range: 0 to 1.0 $m^3.m^{-3}$	Full accuracy over: **0 to 1.0 $m^3.m^{-3}$**	See graph on page 6	**0 to 50°C**
Salinity range	**50 to 500 $mS.m^{-1}$** Salinity errors < 0.035 $m^3.m^{-3}$ from 0.05 to 0.4 $m^3.m^{-3}$. Can be calibrated up to 2,000 $mS.m^{-1}$	**50 to 1000 $mS.m^{-1}$** Salinity errors < 0.035 $m^3.m^{-3}$ from 0 to 0.4 $m^3.m^{-1}$	**0 to 300 $mS.m^{-1}$** Supplied with extended range calibrations which should be used for readings between 300 to 500 $mS.m^{-1}$		
Temperature range	Full accuracy over: **0 to 40°C** **± 0.75°C**, -20 to +60°C for temp sensor. Figures exclude logger or cabling errors	Full accuracy over: **0 to 60°C** **± 0.75°C**, -20 to +60°C for temp sensor. Figures exclude logger or cabling errors	**-5 to 50°C**		
Output	**0 to 1.0V** differential Corresponding to 0 to ~0.6 $m^3.m^{-3}$	**0 to 1.0V** differential Corresponding to 0 to ~0.6 $m^3.m^{-3}$	**Serial TTL data** providing permittivity, bulk conductivity and temperature, from which water content and pore water conductivity are calculated		
Power requirement	**5 to 14V, ~18mA for 1s** Minimum 5.5V with 100m cable	**5 to 14V, ~18mA for 1s** Minimum 5V with 100m cable	**6 to 10V, ~38mA for 2.5s**		
Environmental	**IP68,** -40 to +70°C	**IP68**	**IP68**		
Sample volume	**~60 x 30mm diameter** Sample volume is weighted towards soil immediately surrounding the rods	**~55 x 70mm diameter** Sample volume is weighted towards soil immediately surrounding the rods	**~500ml** Sample volume is weighted towards soil immediately surrounding the rods		
Dimensions and weight	Overall: **158 x 40mm dia**. Rods: 60mm x 3.2mm dia. Weight: 0.1 kg (excl. cable)	Overall: **143 x 40mm dia**. Rods: 51mm x 2.5mm dia. Weight: 0.1 kg (excl. cable)	Overall: **~120 x 45 x 13mm** Rods: 68mm x 3.0mm dia. Weight: 0.1 kg		
Sensor calibrations	Individual sensors are interchangeable Recalibration advised every 3 years (depending on use)		Sensor calibrations supplied in WET Sensor EEPROM Recalibration advised every 3 years (depending on use)		
Soil calibrations	Generalised **Mineral** and **Organic** soil calibrations are supplied		Generalised **Mineral**, **Organic**, **Sand** and **Clay** calibrations are supplied, specialist calibrations are available for horticultural substrates (see page 9)		
Applications	Versatile, high accuracy sensor recognized as the "gold standard" for the precise determination of soil moisture content. Also provides soil temperature when fully buried.	High quality sensor suited to research, and a cost effective alternative where ML3 accuracy is not required, It combines soil moisture and temperature measurement (when fully buried).	Measures pore water conductivity, moisture content and temperature directly within soils and substrates. It has crucial applications in precision horticulture and soil science research.		

Sensor Specifications

Soil water content			Soil water potential	
SM150 	**PR2** 		**SWT4, 4R & 5** 	**EQ3** 
Volumetric water content	Volumetric water content		Soil water potential (matric potential)	Soil water potential (matric potential) and soil temperature
± 0.03 $m^3.m^{-3}$ (3%) With soil-specific calibration	**± 0.04 $m^3.m^{-3}$ (4%)**		**± 0.5 kPa**	**± 10kPa over 0 to -100kPa,** 10% of reading over -100 to -1000kPa **± 0.5°C**, 0 to 40°C for temp sensor
0 to 1.0 $m^3.m^{-3}$ but less accurate above 70% vol	Full accuracy over: **0 to 0.4 $m^3.m^{-3}$** Full range: 0 to 0.6 $m^3.m^{-3}$		SWT4, SWT4R and SWT5: **+100 to -85 kPa** SWT5x: **+100 to -160kPa**	**0 to -1000kPa** (-10bar)
50 to 1000 $mS.m^{-1}$ ± 5% vol over 100 to 1000 $mS.m^{-1}$ and 0-60% vol	**50 to 400 $mS.m^{-1}$** Salinity errors included in specification		No significant effect	Suitable for all non-saline soils.
Full accuracy over: **0 to 60°C**	Full accuracy over: **0 to 40°C**		**0 to 50°C**	**0 to 40°C** **± 0.75°C**, -20 to +60°C for temp sensor. Figures exclude logger or cabling errors
0 to 1.0V differential Corresponding to 0 to ~0.6 $m^3.m^{-3}$	**0 to 1.0V** differential PR2/6: x6 outputs, PR2/4: x4		**1mV / kPa**	**0-1.0V** differential, non-linear. (Calibration data and graph supplied with each sensor) Resistance 5.8Ω to 28kΩ for temp sensor
5-14V, ~18mA for 1s Minimum 5V with 100m cable	**5.5 to 15V** PR2/6: **~120mA for 1s** PR2/4: **~80mA for 1s** Minimum 7.5V with 100m cable		**Precision 10.6V, ~1.3mA**	**5 to 14V, 18mA for 1s**
IP68 with Delta-T supplied cables	**IP67** (handle) **IP68** (PR2 rod when installed in access tube)		**IP68**	**IP68**
~55x70mm diameter Sample volume is weighted towards soil immediately surrounding the rods or rings	~95% sensitivity within a cylinder of **diameter 200mm**		**N/A**	**N/A**
Overall: **143 x 40mm dia**. Rods: 51mm x 2.5 mm dia. Weight: 0.1 kg (excl. cable)	PR2/6: **length 1350mm** PR2/4: **length 750mm** Both: **25.4mm diameter** PR2/6: 1.2 kg, PR2/4: 0.8 kg		Depends on model and shaft length	**181 mm x 40.5 mm** diameter Weight: 0.3 kg (excl. cable)
Individual sensors are interchangeable Recalibration advised every 3 years (depending on use)			Interchangeable sensors Recalibration advised every 2 years (depending on use)	Individual sensor calibrations supplied
Generalised **Mineral** and **Organic** soil calibrations are supplied			No soil calibrations required	No soil calibrations required
Entry level sensor - providing a reliable, low cost option for making soil and substrate moisture measurements. It measures volumetric soil moisture content with 3% accuracy - offering precision and ruggedness at an affordable price.	Provides rapid moisture content readings in a vertical soil profile. Used in access tubes for easy insertion and removal. Can be left installed for data logging or used with the HH2 for multi-site portable readings.		Precision, trusted range of tensiometers for use in wetter soils – well suited to the study of water uptake/movement. They require regular maintenance.	Maintenance-free dielectric tensiometer with soil temp measurement. Can be left installed even in frozen soils. Best results in dry soils. Readings are lower accuracy than water-filled tensiometers.

The **GP2 Data Logger and Controller** is a powerful, weatherproof, research grade data logger with unique features for recording and controlling field experiments

- 12 differential channels
- High performance microvolt sensitivity
- Easy to set up and select sensors
- Versatile communication options

GP2 with Expansion Lid type GP2-G5-LID fitted

The GP2 is a 12 channel field data logger with advanced control capabilities – ideal for demanding research applications and field work. It is weatherproof, rugged, battery powered and comes with 12 differential analog inputs and 2 relays as standard. It can log most sensor types and accepts voltage, resistance, current, potentiometer, counter, bridge, frequency and digital state inputs.

Sensors / Inputs

- 12 differential (or 24 single-ended) analog inputs configurable as:
  - Voltage
  - Resistance (2-wire or 3-wire)
  - Bridge
  - Potentiometer
  - Thermistor (3-wire)
- 4 digital inputs as:
  - Counters, 2 fast + 2 slow
  - Frequency
  - Digital state
- 1 Delta-T WET sensor channel

The GP2 provides a versatile solution for both simple and complex recording and control applications. Simple point and click software makes it easy to set-up logging parameters. Delta-T sensors can be selected from a menu.

Flexibility and customisation

The GP2's analog inputs can be fully customised. Each channel can have its own input type and recording parameters. DeltaLINK software gives the user control over reading frequency, thresholds and units, and provides recording options for average, min and max, plus specialised wind options. Users can add their own custom sensor types to the sensor library, exploiting the GP2's detailed configuration options. The GP2 provides 4 analog input ranges down to microvolt resolution with adaptive auto-ranging, excellent analog accuracy, and configurable sensor excitation - enabling it to support nearly all analog sensors.

Calculations based on the measurements from several input channels can be recorded and displayed as additional virtual channels (calculated measurements).

A range of expansion lids is available with additional cable entry points and configurations, including dedicated connectors for Delta-T Profile Probes and wider diameter cable entry glands.

Application Areas

- Demanding research projects
- Environmental monitoring
- Irrigation control
- PID control applications
- Soil moisture recording - simple connection to Profile Probes

GP2 Data Logger & Controller

Advanced Features

- Flexible control outputs
- Powerful Script Editor
- Virtual Channels
- Unique program Simulator

The GP2 is a flexible and powerful research and control tool, enabling model implementation, simulation and evaluation.

Script Editor

The Script Editor creates step by step operations to control simple or complex processes or recording requirements. The sophistication it offers opens up a huge number of potential applications.

- Sophisticated control algorithms - create complex and powerful models such as PID (proportional-integral-derivative). Control via simple step-by step operation.
- No programming language skills are needed - only a reasonable knowledge of (Excel spreadsheet-level) algebraic expressions is required.
- Custom in-line data processing - implement real-time data driven calculations such as dew-point, wind chill factor and evapotranspiration calculation and analysis.

Virtual Channels

Data can be processed to obtain max, min, sum etc. and the results logged to a virtual channel. Calculations can be made using any channel combination. Calculated measurements also allow implementation of custom formulas - including trig functions, common math functions and more.

Simulator

- Implement simple or complex conditions, algebraic expressions and record result values
- Create and manipulate variables e.g. for disease risk factor

This unique software feature allows logging programs to be tested before real-world activation. For applications involving weather data, irrigation or soil moisture recording, the environmental variables can be changed to test how the program responds.

Running the GP2 Simulator generates years of data displayed almost instantly.

Dependable quality

The GP2 is a rugged, sealed and completely dependable. Its program editor has built-in error checking, and enables the full logger configuration (including advanced features) to be road-tested before activation. Sensor integrity, set-up and connections can also be checked before or during logging by viewing real-time measurements.

Fault tolerance is provided by intelligent statistics (rejecting erroneous sensor measurements), and safety conditions (upper and lower limits on active and rest periods). The relay outputs can be configured as intelligent alarm outputs, and LEDs on the front panel provide a quick visual reassurance that logging is proceeding correctly.

Data storage and power options

Up to 2.5 million readings (typical) can be stored in internal FLASH memory (4 Mb).

The GP2's 6 internal AA batteries are sufficient for ~300k readings. External power (10 - 15V DC, 2A) can be connected if required. Delta-T can provide complete systems including enclosures, batteries and solar power (see page 17). An optional mains adapter is also available (type GP2-PSU).

Data collection, logger networks and GPRS communications

Data can be collected on-site by laptop via USB/RS232, or remotely using the GPRS modem options (see page 17 for further details). Up to 7 GP2 loggers can be networked to create efficient and flexible monitoring and control systems. Networked GP2s share communications and power via an M12 cabling network (see Ordering Information).

Specifications

See page 19

GPRS-BX1/SP modern box (solar panel not shown)

Control

Up to 6 independent experiments or zones can be controlled and monitored concurrently. Control conditions can range from simple thresholding to sophisticated calculations using the Script Editor. Control parameters (e.g. target soil moisture level) can be adjusted throughout an experiment without interrupting data logging. The number of control relay outputs can be increased from 2 to 6 using the optional Relay Expansion Module.

Ordering Information

GP2 Data Logger Advanced Data Logger and Controller with 12 analog, 4 event, and 2 relay channels, plus 1 WET Sensor channel. Includes DeltaLINK PC Software, USB cable and Quick Start Guide.

Expansion Lid with 5 cable glands type GP2-G5-LID GP2 lid with 5 general purpose cable glands. Each gland accepts either a single cable of 3mm to 10mm diam, or 2 cables of 4.5mm to 3mm diam (using gland insert).

Expansion Lid with 2 Profile Probe connectors type GP2-P2-LID GP2 lid with 2 sockets for connection to Profile Probe cables (PRC/M12-05).

Relay Expansion Module type GP2-RLY Provides 4 extra relay outputs. Increases number of relay channels from 2 to 6.

GP2 Network Power Cable type GP2-NPC For use with GP2-NTP Network T-Piece. Connects to EXT/5W-xx cables to provide power and communications to one or more GP2 Loggers.

Network T-Piece type GP2-NTP Enables GP2 Data Logger to use M12 network cabling. Connects to EXT/5W-xx M12 cables and to GP2-USB cable.

Mains Power Supply type GP2-PSU For GP2 Data Logger. Input: 100 - 240V AC, 50 - 60Hz. Output: 2.5A, 12V via screw terminals (requires minimum 2A, 2-core wire). Must be protected from weather. Suitable for powering GP2 directly, or via GP2-NPC Network Power Cable. Requires correct IEC mains lead, (see below).

Mains lead, national plug to IEC connector types PC-UK, PC-EU, PC-US, PC-IN, PC-CN Connects to GP2-PSU and LBC4.

Service Pack type GP2-SER Contains battery holder, cable gland bungs and a selection of other spares.

Mounting Plate type DL-MKT Suitable for GP1, GP2 and DL6.

Modem Box with GPRS, Solar Power and Battery type GPRS-BX1/SP See page 17 for description.

Modem Box with GPRS and Battery type GPRS-BX1/B See page 17 for description.

The **GP1 Data Logger** is a compact research grade data logger

- High accuracy 7-channel data logging
- 600,000 readings

Overview

Depending on the combination of sensors and accessories used, the GP1 can take readings from:

- 2 ML3, SM300 or SM150 soil moisture sensors (or other voltages)
- 2 Pressure transducer tensiometers
- 2 Temperature sensors (or 2 x SM300s or 2 x SM150s)
- 2 Pulse counters (for rainfall or water meter)
- 1 Delta-T WET sensor

The GP1 provides 2 differential voltage channels that are ideal for connecting ML3, SM300 or SM150 soil moisture sensors.

The two temperature channels are optimised for 10k thermistor probes and provide accurate temperature readings over the range -20 to +60°C. They can be used to log the temperature outputs from ML3 or SM300 sensors. Either channel can alternatively be used to log the soil moisture output from additional SM300 or SM150 sensors. [2]

Ease of use

The GP1 is very simple to set up and maintain, particularly for outdoor data logging applications. Its small size and waterproofing (IP67) allow it to be fitted wherever is most convenient, and no secondary enclosures are required. The internal alkaline battery lasts for >1 year (when taking hourly readings from 2 moisture sensors, 2 temperatures and a raingauge).

The GP1 can be fully configured, connections checked, data collected and readings displayed in the field using a notebook PC.

The WS-GP1, a complete GP1-based weather station, is also available.

Versatile and dependable

The GP1 is well suited to logging ML3, SM300, SM150 and WET sensors. It is also compatible with other analog environmental sensors including: RH, temperature, light and sunshine duration, rainfall and flow rate. In addition tensiometer and bridge sensors can be logged using the optional GP-PBA-X50 bridge adapter board.

Application Areas

- Monitoring soil moisture
- General data logging
- Controlling irrigation

Accessories

The GP1 is available with a wide range of accessories and communication (see page 17) options including GPRS modem systems and cable network options.

WET Sensors & tensiometers

The GP1 can take readings from a WET Sensor, recording water content, EC and temperature.

The GP1's voltage input channels can read 1 or 2 pressure transducer tensiometers using 1 or 2 optional GP-PBA-X50 bridge adapter boards.

Ordering Information	
GP1	Data Logger including DeltaLINK-PC software and RS232 cable
GP1-MP1	Mounting Kit with fittings for 51mm tube or flat surface
GP1-LID2	Expansion Lid providing 4 further cable glands
GP1-EPC1	External power cable
GP-PBA-X50	Precision bridge adapter board
USB-RS232	USB to RS232 Adapter Cable. 100cm cable, connects 9 pin RS232 to USB (for connection to PC).

Smart irrigation control

The GP1 enables smart irrigation control using any combination of soil water content, matric potential, rainfall, temperature, etc. It can be configured simply to inhibit irrigation while the soil moisture is above a threshold value, but full logic control is also available - including a pulse option for matching the rate of irrigation to the absorption dynamics of the soil.

Brief Specification (further specs on page 19)	
Voltage range	-0.2 to +2.7V differential
Accuracy [1]	± (1.6mV + 0.05% of reading)
Resolution	0.1mV
Temperatures [2]	± 0.07°C, typical at 20°C (10k thermistor)
Pulse counters	1 x 50Hz, 1 x 33kHz max
Relay output	<30V DC or <24V AC, 1A fuse (resettable)
Sensor excitation	Switched battery 5 to 9V, 120mA max or precision 5V, 50mA max
Reading storage	600,000 readings, typical
Connections	4 cable glands 5-way RS232 / external power connector
Environmental	Waterproof (IP67) -20 to +60°C
Size, weight	140 x 105 x 45mm 280g
Battery type, life	9V 6LR61 (PP3), alkaline, ~1 year

[1] Accuracy applies over full -20 to 60°C

[2] The 2 temperature channels can be configured as SM150 or SM300 soil moisture inputs, but they provide only single-ended inputs so should not be used with long cables or in noisy environments. The accuracy figures quoted for GP1 soil moisture readings do not apply to these resistance channels when configured as soil moisture inputs.

The **DL6 Data Logger** is optimised for use with Delta-T soil moisture sensors

- High accuracy 8 channel data logging
- Ideal for Profile Probes, ThetaProbes, SM300s, and SM150s

Overview

The DL6 can record data from:

- 6 Soil water content sensors (or other analog voltages)
- 1 Temperature sensor
- 1 Pulse counter (e.g. rainfall)

The DL6 can be used with combinations of ThetaProbes, SM300s, SM150s and Profile Probes as well as a temperature sensor and raingauge. It is well suited to both research applications and environmental monitoring.

Application Areas

- Monitoring soil moisture
- Dedicated Profile Probe connector

Brief Specification (further specs on page 19)	
Voltage range	-0.01 to +1.15V differential voltage
Accuracy	± 0.3% ± 0.3mV
Resolution	0.2mV
Temperature	± 0.4°C
Pulse counter	50Hz max
Relay output	<25V DC/AC, 1A fuse
Sensor excitation	Switched battery 5 to 9V, 120mA max
Reading storage	16,000 readings, non-volatile
Connections	8 cable glands 8-way PR2 connector RS232 connector
Environmental	Waterproof (IP67) -10 to +50°C
Size, weight	180 x 160 x 70mm, 830g
Battery type, life	6 alkaline AA cells, ~1 year

Ordering Information	
DL6	Data Logger with DeltaLINK-PC software and RS232 cable
DL6-MKT1	Mounting Kit with 1m ground stake, brackets, clamps and fixings
USB-RS232	As page 16

GPRS Modem Systems for GP2, GP1 and DL6 Data Loggers

Users have a choice of two modem box solutions for GPRS communications - one with battery and solar power, the other with just a battery. These are complete systems - only the data logger has to be ordered separately.

NB: customers need to provide their own SIM card and make arrangements with a network provider. The SIM must have a fixed IP address and be GPRS enabled.

Ordering Information

Modem Box with GPRS and Battery type GPRS-BX1/B*. For use with GP2, GP1 and DL6 Loggers. Includes quad band GPRS modem, 10Ah sealed lead acid battery and 1m comms and power extension cable, antenna and 5m coaxial cable. Supplied with mounting kit for fixing to tubular masts or poles (42-51 mm dia).

Modem Box with GPRS, Solar Power and Battery type GPRS-BX1/SP*. For use with GP2, GP1 and DL6 Loggers. Includes all items supplied with GPRS-BX1/B plus solar regulator, 30W solar panel (2m cable) and mounting bracket for solar panel.

GP2 to Modem Box Cable, M12 to M8 type GP2/GP1-M8. M12 (f) to M8 (m) 0.9m cable. Connects GP2 Data Logger to GPRS Modem Boxes. Also directly links GP2 and GP1 cable networks.

DL6 to Modem Box Cable, M12 to M8 type GP1/DL6-M8. M12 (f) to M8 (m) 1.5m cable. Connects DL6 Data Logger to GPRS Modem Boxes. Also directly links DL6 and GP1 cable networks.

*Modem Boxes for use with a GP2 or DL6 logger require an additional cable to be ordered. For GP2, order GP2/GP1-M8 cable. For DL6, order GP1/DL6-M8 cable.

The logger has to be situated outside the modem box e.g. mounted on a mast pole.

Enclosure, Power and GPRS Modem options for GP2 Data Logger (individual items)

When a lockable enclosure is required, for example to provide security, environmental protection or easier cable routing and connection, the M2-ENCL Enclosure is available. The M2-ENCL-B2 can be combined with a GP2 Logger, battery, solar panel and modem to create a complete system.

NB: customers need to provide their own SIM card and make arrangements with a network provider. The SIM must have a fixed IP address and be GPRS enabled.

Ordering Information

GPRS Modem for GP2 Logger type MD-GPRS-1. Includes quad band GPRS modem and 3db antenna with cable and power cable (fits into M-ENCL-B2 Enclosure for weather protection).

Enclosure and 12V wiring kit for GP2 type M-ENCL-B2. For mounting onto Delta-T masts. Backplate-mounted 12V battery wiring system with protected input power terminals. Comprises lockable IP53 steel enclosure, cable glands (supplied with 12 glands as standard) and trunking. Suits GP2 Logger and MD-GPRS-1 Modem. The cost of the enclosure includes the fitting and partial pre-wiring of any logger power supplies and modem ordered at the same time. Dimensions: 500 (h) x 400 (w) x 250 (d) cms NB: Does not include battery, charger or solar panel.

Rechargeable battery type LBAT4. 12V 10Ah sealed lead acid battery spade terminals.

Solar Powered Charging System for GP2 Logger type SOL4-KIT2. 30W solar panel with mounting kit, including U-clamps, regulator/charger and cabling. NB: does not include enclosure, mounting mast or battery. Must be used with a suitable enclosure; when ordered for use with a GP2 Logger, an M-ENCL-B2 Enclosure must be ordered at the same time.

Battery charger for LBAT4 type LBC4. Mains battery charger for 10Ah lead acid battery. Input voltage range 100-240V AC 3A. For indoor use only. Requires correct IEC mains lead, ordered separately - see below.

Mains lead type PC-xx. Connects national plug to IEC connector to LBC4 Battery charger. See page 15 for details.

The **DL2e Data Logger** is a weatherproof field data logger with a versatile range of expansion options

- Battery powered, weatherproof and rugged
- User expandable from 15 up to 62 input channels
- Easy configuration, data collection and display

Overview

The DL2e is a versatile field logger, able to read a wide range of sensors.

- 15 differential or 30 single-ended analog channels (voltage or resistance)
- 2 counters
- 2 relay outputs (or sensor excitation)

+ optional analog expansion cards (up to 64 channel limit)

Applications

- **General data logging for moderate to complex systems**

The DL2e is well suited to projects requiring large scale soil moisture records. When fully expanded it can read 30 ThetaProbes, or 10 PR2/6 Profile Probes, or 30 SM300s or 60 SM150 sensors, or up to 15 tensiometers.

Expandable platform

The minimum DL2e system can be quickly adapted by adding extra cards that expand the capacity of the basic logger.

The SWT range of tensiometers (see page 9) can be used with the DL2e if it is fitted with a TVB1 or TVB-M Voltage Regulator.

There is a wide range of mounting options, power supplies, communication systems and enclosures available for creating complex logging systems. The DL2e Data Logger is also portable, weatherproof, battery-powered and very easy to set up, so it makes an excellent choice for quick-and-simple logging tasks.

Easy software

The DL2e is supplied with the Ls2Win software for configuring logging sessions, managing sensor libraries, graphing real-time readings and collecting stored data.

The built-in DL2e keypad and display can be used to test sensor connections in the field and to check logging status.

NB The DL2e is not compatible with DeltaLINK software.

Ordering Information	
DL2e	Data Logger including 15/30 analog channels, 128k readings memory, Ls2Win software and RS232 cable
LAC1	15/30 Channel Analog Input Card
TVB1	Voltage Regulator, provides stabilised 10.6V DC
TVB-M	As TVB1 but requires environmental protection such as M2-ENCL enclosure
USB-RS232	USB to RS232 Adapter Cable type USB-RS232. 100cm cable, connects 9 pin RS232 to USB (for connection to PC).

PLEASE NOTE: For many applications the GP2 Data Logger will provide a better solution than the DL2e Data Logger. Please see pages 14 & 15. However, for customers who wish to log larger numbers of analog inputs using a single data logger, the DL2e is still an excellent choice.

Brief Specification (further specs on page 19)	
Voltage range	± 4mV, ± 32mV, ± 262mV, ± 2.097V
Accuracy [1]	± 0.02%
Resolution	1µV, 8µV, 64µV, 0.5mV
Resistance ranges	1kΩ, 10kΩ,100kΩ, 1MΩ
Accuracy	± 0.1% (± 0.6% to 50°C, on lowest range)
Resolution	0.01Ω (lowest range)
Counters	100Hz max
Relay outputs	2 relays switching 1A, 24V
Sensor excitation	2 relays switching battery or external power
Reading storage	128,000 readings
Connections	13 pluggable screw connector blocks, + RS232 and external power
Display	2-line LCD
Environmental	Weatherproof (IP65) -20 to +60°C
Size, weight	280 x 220 x 140mm, 2.7kg
Battery type, life	6 alkaline AA batteries, ~1 year quiescent

[1] Accuracy applies over full -20 to 60°C

Logger comparison table

	GP2 	DL2e 	DL6 	GP1 	HH2 Meter 
Input connections	12 differential (or 24 single-ended) analog inputs configurable as: Voltage, Resistance (12 3-wire or 24 2-wire), Bridge (12), Potentiometer (12)	15 analog channels expandable to 30, 45, or 60	6 voltage channels	2 voltage channels	1 water content sensor or 1 WET Sensor
			1 temperature	2 temperatures or 2 additional SM150 or SM300 Sensors [3]	
	4 digital inputs as: Counters, (2 fast + 2 slow), Frequency, Digital state	2 counters	1 counter	2 counters (33kHz & 50Hz)	
	1 Delta-T WET sensor channel Unlimited virtual channels	-	-	1 WET Sensor	-
Control outputs	2 relay outputs expandable to 6 (1A)	2 relays (1A)	1 relay (2A)	1 relay (1A)	-
Readings stored	2.5 Million	128,000	16,000	600,000	1,500
Recording rate	1 second to 24 hours	1 second to 24 hours	1 second to 24 hours	1 second to 24 hours	-
Configuration	DeltaLINK	Ls2Win	DeltaLINK	DeltaLINK	By keypad
Communication options	USB/RS232 or modem	RS232, USB [1]	RS232, USB [1] or modem	RS232 USB [1] or modem	RS232 / USB [1]
Sensor excitation	Calibrated 3V reference, +5V and +12V regulated, or 5 to 10.5V (battery or external power), user selectable.	2 relay switched logger or external power	1 switched logger power	1 switched logger power 1 5V precision reference	1 switched battery
Power	6 AA alkaline batteries or external power 10-15V DC	6 AA alkaline batteries or external power 7-15V	6 AA alkaline batteries	1 9V 6LR61 (PP3) alkaline or external power 11-24V	1 9V 6LR61 (PP3) alkaline
Battery life (dependent on usage)	~ 300K readings	~ 6 months	~ 1 year	~ 1 year	~ 5,000 readings
Enclosure rating	IP65	IP65	IP67	IP67	IP54
Temperature range	-20 to +60°C	-20 to +60°C	-10 to +50°C	-20 to +60°C	0 to +40°C
Display	-	2 line x 16 character	-	-	2 line x 16 character
Size	225 x 185 x 75mm	280 x 220 x 140mm	180 x 160 x 70mm	140 x 105 x 45mm	125 x 80 x 45mm
Typical applications	• Demanding research projects • Environmental monitoring • PID control applications	• General data logging for moderate to complex systems	• Monitoring soil moisture profiles • Controlling irrigation	• Monitoring soil moisture • General data logging • Controlling irrigation	• Instantaneous reading of soil moisture / profiles / WET Sensor

Sensor compatibility (maximum number of sensors that could be connected[2])

	GP2	DL2e	DL6	GP1	HH2 Meter
ML3	✓ (6) with temp / (12) without temp	✓ (30) with temp / (60) without temp	✓ (1) with temp (5) excl. temp	✓ (2) with temp ✓ (4) excl. temp [3]	✓ without temp
SM300	✓ (6) with temp / (12) without temp	✓ (30) with temp / (60) without temp	✓ (1) with temp (5) excl. temp	✓ (2) with temp ✓ (4) excl. temp [3]	✓ without temp
SM150	✓ (12)	✓ (60)	✓ (6)	✓ (4) [3]	✓
PR2	✓ (2 PR2/6 with expansion lid) (3 PR2/4 with expansion lid)	✓ (10 PR2/6) (15 PR2/4)	✓ (1)	-	✓
WET Sensor	✓ (1)	-	-	✓ (1)	✓
EQ3	✓ 6 with temp / 12 without temp	✓ (30) with temp / (60) without temp	✓ (6 as mV only)	✓ (2 as mV only)	✓ (mV only)
Temperature	✓ (12)	✓ (60)	✓ (1)	✓ (2)	-
Tensiometers	✓ (12)	✓ (60), requires TVB1s)	-	✓ (2) each requires GP-PBA-X50	-
Counters or Events	✓ (4) 2 fast 2 slow	✓ (2)	✓ (1)	✓ (2) 1 fast 1 slow	-
Relay output	✓ (2) expandable to (6)	✓ (2)	✓ (1)	✓ (1)	-

[1] With USB to RS232 Adapter Cable type USB-RS232
[2] With appropriate expansion cards and power supply arrangements
[3] Temp channels provide only single-ended inputs so should not be used with long cables or in noisy environments when used with soil moisture sensors. The accuracy figures quoted for GP1 soil moisture readings do not apply to these resistance channels when configured as soil moisture inputs.

Ordering Information

UK customers

SALES AND TECHNICAL ENQUIRIES: should be made directly to Delta-T in the UK.
sales@delta-t.co.uk

PRICES: are available on request, and a detailed quotation can be provided if required.

PAYMENT: for new customers, we usually ask for payment in advance. Account facilities are available for customers placing regular orders. Details can be obtained from Delta-T.

Customers outside the UK

OVERSEAS REPRESENTATION: Delta-T has an extensive network of representatives. A list is available on our website. In these countries, all sales and technical enquiries should be directed to our representatives.

DIRECT SUPPLY: if there is no Delta-T representative in your country, we will supply you directly from the UK. Export sales account for 80% of our business and we have many years' experience of dealing with enquiries from overseas clients.

PRICES: are available on request from your local representative or Delta-T. Detailed quotations can also be provided when needed, including costs for freight, insurance and documentation.

PAYMENT: our normal terms are payment in advance of shipment, or by irrevocable documentary credit. Account facilities may be available for customers placing regular orders. Details of these facilities and documentary credit conditions can be obtained from Delta-T.

GUARANTEE AND SERVICE: Delta-T guarantees its products against defects in manufacture or materials for a period of 24 months from the date of delivery. Full details including terms and conditions of sale, and arrangements for servicing and recalibration are available on our website.

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Co-operatively owned and managed

Other Delta-T Products

As well as sensors for soil moisture measurement, Delta-T specialises in instruments for:

- **Meteorology**
- **Solar radiation studies**
- **Canopy analysis**
- **Leaf area index**
- **Plant physiology**
- **Environmental monitoring**

...and our products include:

- **Weather stations**
- **Sunshine Pyranometers**
- **Data loggers**
- **Porometers**
- **Canopy analysers**
- **Image analysers for leaves**

GP1 Data Logger controlling precision gantry irrigation within a glasshouse at Hillier Nurseries.

Representative

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