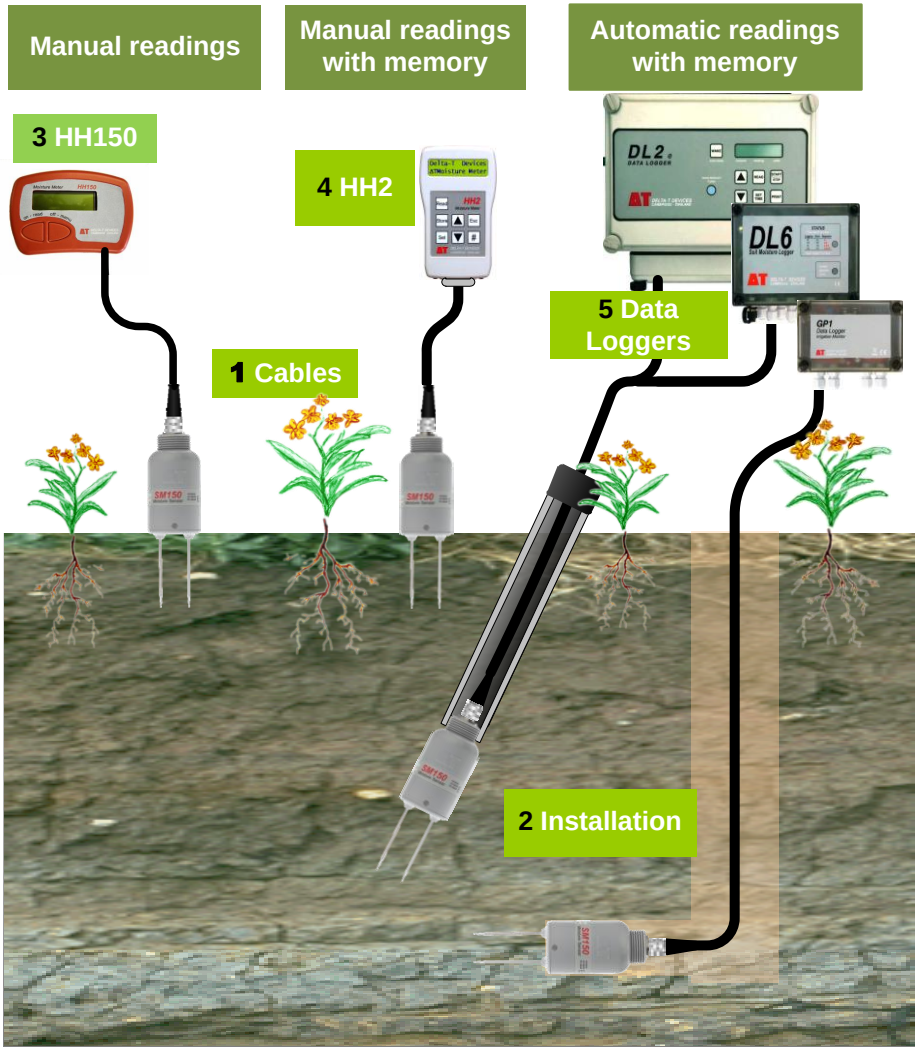
# SM150

## *Soil Moisture Sensor*

# *Quick Start Guide* *Version 1*


**Delta-T Devices Ltd**

# SM150 overview



# 1 *Cables and Accessories*

**HH150** soil moisture sensor

**HH150** +**SM150 Kit**

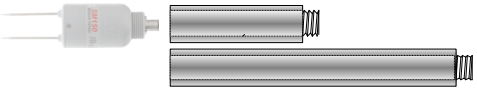
**HH150** includes 1m cable,
Connects to SM150

**SMCS/d-HH2** 1.5m cable
Connects SM150 to HH2

**SMSC/sw-05** 5m cable
100mm flying leads
Connect to GP1 & DL6 loggers

**SMSC/lw-05** 5m cable
200mm flying leads
Connect to DL2 data logger

**L**ogger extension cables
**EXT/5W-05** 5m
**EXT/5W-10** 10m
**EXT/5W-25** 25m



Extension tubes
**ML/EX50** 50cm
**ML/EX100** 100cm

**SM-AUG-100** Spiral Auger 1.2m

Logger Extension cables can be joined up to a maximum length of 50m.
**Align connectors carefully** before pushing parts together.
Screw together firmly to ensure the connection is water-tight.

# 2 Installation

## Surface installation and spot measurements


- Clear away any stones.
  Pre-form holes in very hard soils before insertion.
- Push the SM150 into the soil until the rods are fully inserted. Ensure good soil contact.
- If you feel strong resistance when inserting the SM150, you have probably hit a stone. Stop, and re-insert at a new location.

## Installing at depth

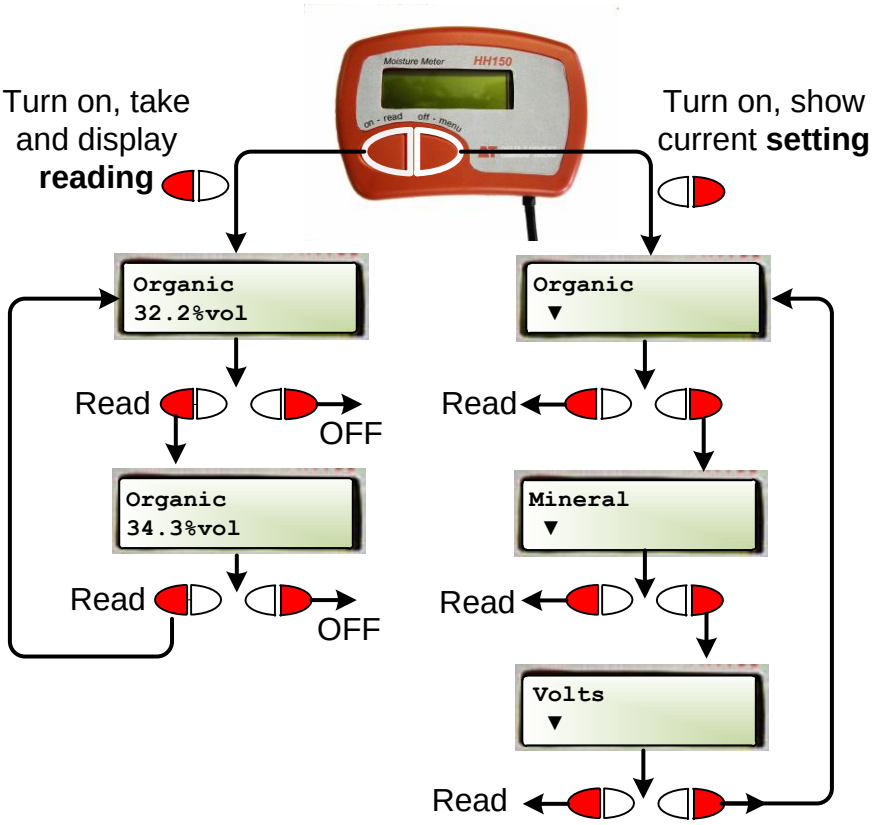
- Auger a 45mm diameter hole. ~10° to vertical is recommended.
- Fit an extension tube to the SM150 – remember to pass the cable through the extension tube and fit the connector first.
- Push the SM150 into the soil until rods are fully inserted. Ensure good soil contact.


## Alternatively

- Dig a trench, and install horizontally.
  (see **Overview** diagram).

Note: Extension tubes are available for installing the SM150 in an augered hole.

# 3 HH150 Meter




- Connect the SM150 to the HH150 meter.
- With the meter OFF, press the right **off – menu** button. This wakes and allows you to set the meter to display readings - either as % volumetric water content of Mineral or Organic soils, or to show the sensor output in Volts.
- Press **off** to save the current Setting and turn the meter off.
- With the meter off, press the left **on – read button** to take a reading. Repeat as required. You may wish to write down the readings.

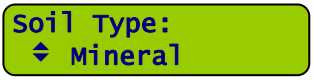
  The meter will sleep after 30 seconds.
  The battery should last for about 10,000 readings.

# 4 HH2 Meter


Use version 2.6 or later of both the PC software HH2Read and the HH2 firmware if possible (or see footnotes).

- Connect the SM150 to the HH2 meter.
- Press **Esc** to turn the meter on, and if necessary press again until the HH2 displays the start-up screen.
- Set the meter to read from an SM150:
  - Press **Set** and scroll down to the **Device** option.
  - Press **Set** again and scroll down to select SM150.
  - Press **Set** to confirm this choice.


- Make sure the HH2 is correctly configured for your soil type:
  - At the start-up screen, press **Set** and scroll down to the **Soil Type** option.
  - Press **Set** again and scroll down to the appropriate soil type (use **Mineral** for sand, silt or clay soils or **Organic** for peaty soils)
  - Press **Set** to confirm this choice.




- Choose the units you want for displaying readings:
  - At the start-up screen, press **Set** and scroll down to the **Display** option.
  - Press **Set** again and scroll down to select units.
  - Press **Set** to confirm this choice.
- Press **Read** to take a reading.


- Press **Store** to save or **Esc** to discard the reading.
- Remove the SM150 from the soil and move to a new location...
- If you have saved data, connect your HH2 to a PC and run ***HH2Read*** to retrieve the readings.


Note: For an upgrade contact Delta-T.
See also: **HH2 User Manual** and
**HH2 User Manual Addendum to V4 – SM150 Support**

# 5 Data Loggers

- Connect the SM150 soil moisture output as a differential powered sensor.
- Configure the logger input as a voltage sensor, using the look-up tables or polynomial coefficients as shown on page 9

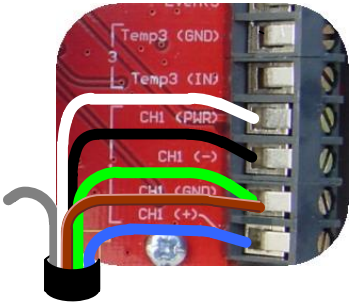
  Note: The SM150 has been optimised for a 0.5 to 1 second warm-up period. Do not power the sensor continuously.

## GP1


- Up to 4 SM150s can connect to a GP1.
  Channels 1 & 2 are wired as differential powered sensors.
  Channels 3 & 4 are wired as single-ended powered sensors*.

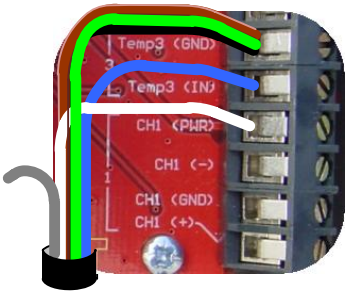
Channel 1 wiring connections (channel 2 is similar):

| *SM150 wiring* | *Colour* | *GP1 terminal* |
|---|---|---|
| Power 0V | brown | **CH1 (GND)** |
| Power V+ | white | **CH1 (PWR)** |
| Signal HI | blue | **CH1 (+)** |
| Signal LO | black | **CH1 (-)** |
| Cable shield | green | **CH1 (GND)** |
| Not used | grey | Not connected |




Channel 3 wiring connections* (channel 4 is similar):

| *SM150 wiring* | *Colour* | *GP1 terminal* |
|---|---|---|
| Power 0V | brown | **Temp3 (GND)** |
| Power V+ | white | **CH1 (PWR)** |
| Signal HI | blue | **Temp3 (IN)** |
| Signal LO | black | **Temp3 (GND)** |
| Cable shield | green | **Temp3 (GND)** |
| Not used | grey | Not connected |




- Using DeltaLINK logger software (version 2.6* or later) configure each channel by choosing Sensor Type **SM150** from the sensor menu.

* Note: Reading accuracy on channels 3 and 4 is reduced by long sensor cables.

For configuration details see the ***GP1 Quick Start Guide***.

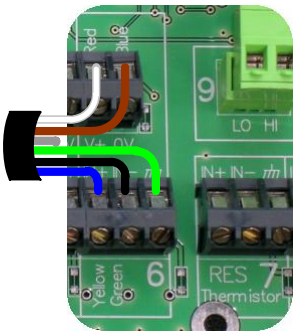
* Download the latest version of the DeltaLINK logger software from www.delta-t.co.uk or from our **Softaware and Manuals CD** issue 3 or later

# DL6


- Up to 6 SM150s can connect to a DL6 logger.
- Each is wired as a differential, powered sensor.

These details illustrate connection to channel 6:

| SM150 wiring | Colour | DL6 terminal |
|---|---|---|
| Power 0V | brown | **0V** |
| Power V+ | white | **V+** |
| Signal HI | blue | **IN+** |
| Signal LO | black | **IN-** |
| Cable shield | green | ⏚ |
| Not used | grey | Not connected |




- Use DeltaLINK logger software (version 2.6* or later).

For configuration details see the ***DL6 User Manual.pdf****

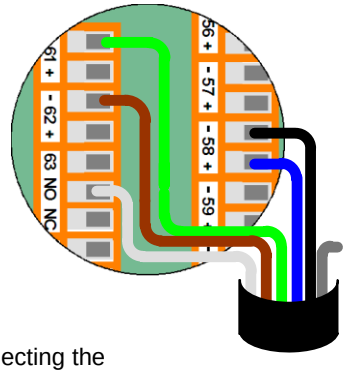
* Download the latest version of the DeltaLINK logger software from www.delta-t.co.uk or from our **Softaware and Manuals CD** issue 3 or later

# DL2e


- Up to 60 SM150s may be connected.
- Each is connected as a differential, powered sensor.

These details illustrate connection to Channel 58 using a LAC1 input card configured in 15-channel mode, and warm-up channel 63:

| SM150 wiring | Colour | DL2e terminal |
|---|---|---|
| Power 0V | brown | **CH62- or 61-** |
| Power V+ | white | **CH63 NO** |
| Signal HI | blue | **CH58+** |
| Signal LO | black | **CH58-** |
| Cable shield | green | **CH61- or 62-** |
| Not used | grey | Not connected |




- Configure the chosen DL2e logger channels by selecting the appropriate **SM150** sensor types from the LS2Win sensor library. You need Ls2Win version 1.0 SR8 or later*.

For configuration details see the ***DL2e User Manual*** or ***LS2Win Help***.

* Download the latest version of the Ls2Win logger software from www.delta-t.co.uk or from our **Softaware and Manuals CD** issue 3 or later

# 6 How to calculate soil moisture

| | Example |
|---|---|
| ■ Take a reading with the SM150 | V = 0.294 volts |
| *either* | |
| ■ Convert the reading to $\sqrt{\varepsilon}$ using equation 1 or the linearisation table below. | $\sqrt{\varepsilon}$ = 3.52 |
| ■ Then convert $\sqrt{\varepsilon}$ to soil moisture, $\theta$, using the soil calibration values ($a_0$, $a_1$). | $\theta$ = 22.9% for mineral soil |
| *or* | |
| ■ Convert directly for mineral or organic soils using equations 2 or 3 | $\theta$ = 22.9% |

## Conversion to √ε

***Polynomial*** *(for use over the full range of SM150 readings)*

$$\sqrt{\epsilon} = 1.0 + 14.4396V - 31.2587V^2 + 49.0575V^3 - 36.5575V^4 + 10.7117V^5 \text{.....(1)}$$

*where V is the SM150 output in volts*

***Linearisation table*** *(for use over the full range of SM150 readings)*

| V | √ε | V | √ε | V | √ε | V | √ε | V | √ε |
|---|---|---|---|---|---|---|---|---|---|
| 0.000 | 1.000 | 0.300 | 3.576 | 0.600 | 5.101 | 0.900 | 6.778 | 1.200 | 8.924 |
| 0.075 | 1.942 | 0.375 | 3.964 | 0.675 | 5.503 | 0.975 | 7.232 | 1.275 | 9.743 |
| 0.150 | 2.620 | 0.450 | 4.337 | 0.750 | 5.917 | 1.050 | 7.720 | 1.350 | 10.808 |
| 0.225 | 3.144 | 0.525 | 4.713 | 0.825 | 6.342 | 1.125 | 8.270 | 1.425 | 12.242 |

## Conversion from $\sqrt{\varepsilon}$ to Soil Moisture

■ Soil moisture $\theta = (\sqrt{\varepsilon} - a_0)/a_1$

■ Use these generalised soil calibration values for mineral and organic soil types, or carry out a soil-specific calibration to derive your own values
See ***SM150 User Manual***.

| | $a_0$ | $a_1$ |
|---|---|---|
| Mineral | 1.6 | 8.4 |
| Organic | 1.3 | 7.7 |

■ Multiply x100 to convert soil moisture from $m^3.m^{-3}$ to % volumetric.

## Direct conversion for Mineral and Organic soils

$$\theta_{mineral} = -0.0714 + 1.7190V - 3.7213V^2 + 5.8402V^3 - 4.3521V^4 + 1.2752V^5 \text{ ... (2)}$$

$$\theta_{organic} = -0.0390 + 1.8753V - 4.0596V^2 + 6.3711V^3 - 4.7477V^4 + 1.3911V^5 \text{ ... (3)}$$

# 7 Check Sensor is working

### *Air reading*

- Hold the SM150 in air and away from other objects and take a reading using an HH150 meter, or an HH2 meter or voltmeter or a logger with no more than 5m of cable. In air the reading should be 0 ±4mV
  (Note: the HH150 reports *under-range* if the reading is less than zero *)*

Warning: Do not touch the pins

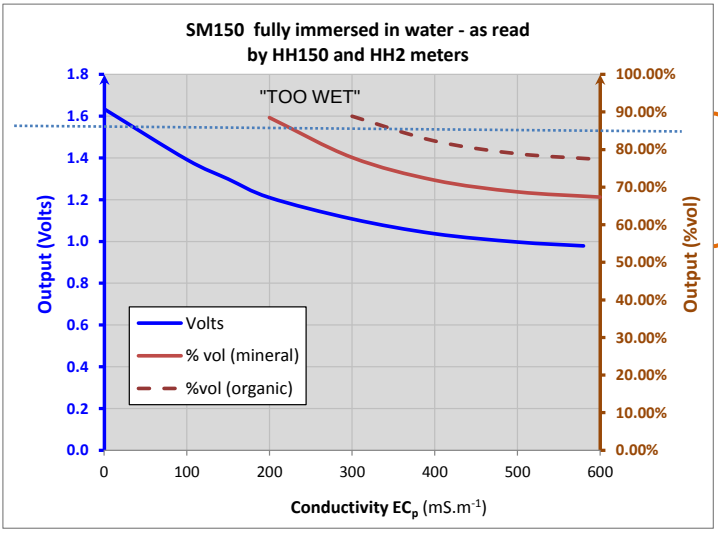
Try not to touch the pins. A typical electrostatic discharge from your body can create a temporary offset in sensor readings for up to one hour.

### *Water reading*

- Measure the output in voltage.

In the UK the sensor will typically read about 1.5 volts in tap water (because the salinity is typically 50mS.m-1).
The "water reading" you get will depend on the salinity of your local water.

Note: HH150 meter indicates "TOO WET" above 1.5V or 85% vol.




*Soil moisture readings are not correct when no soil is present i.e. at 100% vol.*

*SM150 tables and polynomial constants are optimised at 220 mS.m$^{-1}$ for soil moisture values below 70%vol*

**Graph: showing the effect of salinity on SM150 sensor output when fully immersed in water with no soil present.**

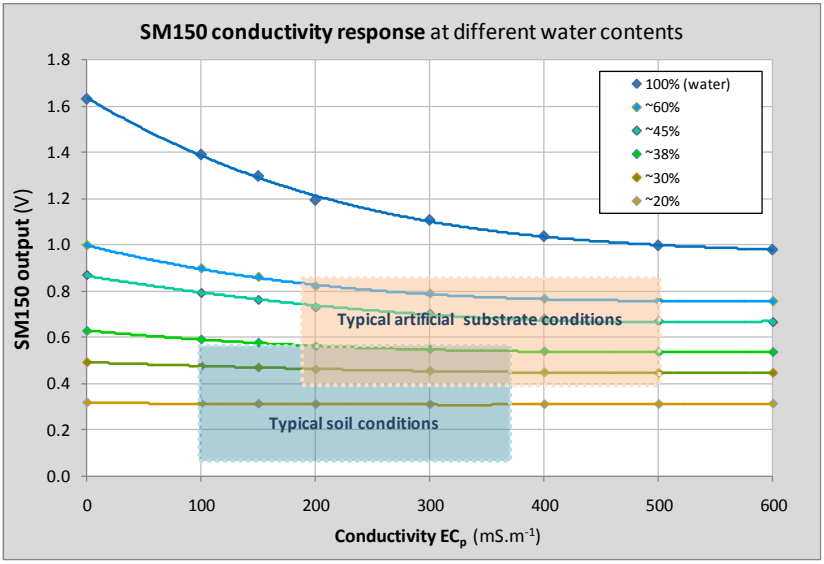
# 8 Specifications *(for full specification see SM150 User Manual)*

| | |
|---|---|
| Accuracy | ±3.0% vol over 0 to 70 % vol and 0-60°C * |
| Measurement range | 0 to 100% vol but less accurate above 70%vol** |
| Salinity error | ±5% vol over 100 to 1000 mS.m$^{-1}$ and 0-60% vol |
| Conductivity response | See SM150 User Manual |
| Temperature sensitivity | See SM150 User Manual |
| Sampling volume | See SM150 User Manual |
| Output signal | 0-1 V differential ≈ 0 to 60% nominal |
| Output compatible with | HH150, HH2, GP1, DL6, DL2e |
| Maximum cable length | 1m (HH150 meter)<br>100m (GP1, DL6 and DL2e data loggers) |
| Power requirement | 5-14VDC, 18mA for 1s |
| Operating range | -20 to +60°C |
| Environment | IP68 *** |
| Sample volume | 55 x 70mm diameter |
| Dimensions/Weight | 143 x 40 mm diameter/ 0.1 kg |

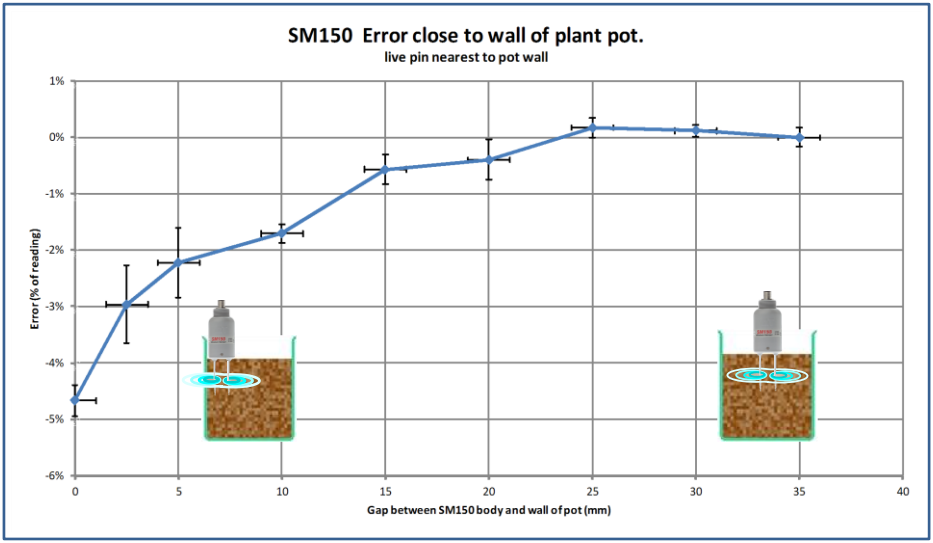
***** Note: See full specification in **SM150 User Manual**

****** In water (no soil present) the reading may not be 100% vol.
It depends on a0 and a1 but can still be used as a quick check that the unit is working.

*** With Delta-T supplied cables



## Field of sensitivity




This graph shows the effect of being too close to the wall of a plant pot and gives a partial indication of the shape of the field of sensitivity around the pins

# 9 Care and Safety

- Do not touch the rods or expose them to other sources of static damage, particularly when powered up.
- Keep the SM150 in its protective tube when not in use.
- Ensure that the connectors are clean, undamaged and properly aligned *before* pushing the parts together. Screw together firmly for water-tight seal.
- Do not pull the sensor out of the soil by its cable.
- If you feel strong resistance when inserting into soil, it is likely you have encountered a stone. Stop pushing and re-insert at a new location.

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