Manual

pH Probe & Oxidation Reduction Potential Probe

Models 6528A and 6528B

Revision History

File name / Revision	Date	Authors
Previous version BX	2004	RS/ JH
Unidata Manual - 6528 pH and ORP Sensors Issue 2.0	2007	AB/CB/JH/MS/KC
Unidata Manual - 6528 pH and ORP Sensors Issue 3.0 - Format change	11/09/2013	MP
Unidata Manual - 6528 pH and ORP Sensors Issue 4.0.docx	30 01 15	IM,CB

TABLE OF CONTENTS

1.0 INTRODUCTION

This supplement contains information about two probes manufactured for use with Unidata Starlog Dataloggers:

- Model 6528A pH Probe
- Model 6528B ORP Probe

1.1 The pH Probe

The pH probe is a double junction Ag/AgCl gel cell. Because of its unique design the information regarding the use of this specific probe with the logger cannot be applied to another type of pH probe. The information regarding pH theory is of course general to all pH probes unless otherwise stated.

The pH probe consists of conditioning electronics for the Logger enclosed inside the probe head and an epoxy bodied probe filled with a non-refillable buffer gel. The conditioning electronics are powered by an enclosed lithium cell. The probe is designed to connect to the logger through a Field Termination Strip. The signal cable can be extended to a length of 100 metres without affecting the accuracy of the probe.

1.2 The ORP Probe

The plastic body electrodes are rated for a maximum temperature of 80°C though prolonged exposure to elevated temperatures can considerably shorten the life of the electrode.

2.0 pH THEORY

pH is a measure of the acidity or alkalinity of aqueous solutions. The pH is defined as the negative logarithm of the hydrogen ion activity in the solution -

$$pH = -\log a[H^+]$$

Pure water disassociates into hydronium ions (H_3O^+) and hydroxide ions (OH^-) -

$$2H_2O <=> H_3O^+ + OH^- \text{ or } H_2O <=> H^+ + OH^-$$

The disassociation constant of water (Kw) is 10^{-14} and can be equated to the sum of the activities of the [H^+] and [OH^-] ions. That is,

$$K_w = aH+ + aOH- = 10^{-14}$$

for a neutral solution, that is, pure water

$$AH^+ = aOH^- = 10^{-7} \text{ @ } 25°C$$

Therefore,

$$pH = -\log a_{H+} = -\log[10^{-7}] = 7.00$$

pH Scale of Typical Solutions

Concentration of Hydrogen ions compared to distilled water		Examples
10,000,000	pH 0	Battery acid
1,000,000	pH 1	Hydrochloric acid
100,000	pH 2	Lemon juice, vinegar
10,000	pH 3	Grapefruit, soft drink
1,000	pH 4	Tomato juice, acid rain
100	pH 5	Black coffee
10	pH 6	Urine, saliva
1	pH 7	"Pure" water
1/10	pH 8	Sea water
1/100	pH 9	Baking soda,
1/1,000	pH 10	Great Salt Lake
1/10,000	pH 11	Ammonia solution
1/100,000	pH 12	Soapy water
1/1,000,000	pH 13	Bleach
1/10,000,000	pH 14	Liquid drain cleaner

2.1 pH Measurement

The source of the measurement potential is the electrode system. The system consists of a pH sensor whose voltage varies proportionally to the Hydrogen ion activity of the solution and a reference electrode which provides a stable and constant voltage. The result is a voltage equal to the potential difference between the two electrodes.

The voltage source is very weak and requires amplification by a unitary gain buffer amplifier of extremely high input impedance. The Model 6528A pH Probe has an inbuilt self-powered amplifier which eliminates many of the traditional pH measurement problems.

The measured voltage is of the following form:

$$E = E_{Ref} + 1000.N_f.log(a_{H+})\ mV$$

where E_{Ref} = Reference voltage

N_f = Nernstian slope factor

a_{H+} = Hydrogen ion concentration.

2.2 Temperature Effects

The voltage produced by the probe is dependent upon temperature. This variation is accounted for in the Nernst slope factor (N_f).

$$N_f = \frac{2.3RT}{nF}$$

where R = gas constant (8.314 J/Kmol)

T = temperature in Kelvin

F = Faraday constant (9.65 x 10^{4} C/mol)

n = valence factor (“1” for hydrogen)

Therefore,

$$N_f = 1.982\, x10^{-4}\, T$$

For example, at	0°C (273K),	N_f = 0.0541
	10°C (283K),	N_f = 0.0561
	20°C (293K),	N_f = 0.0581
	30°C (303K),	N_f = 0.0615
	40°C (313K),	N_f = 0.0621
	60°C (333K),	N_f = 0.0661
	80°C (353K),	N_f = 0.0701

3.0 OXIDATION REDUCTION POTENTIAL (ORP) THEORY

Similar to the manner in which acidic or basic solutions are quantified by pH measurements, solutions can also be graded as oxidising or reducing based on measurement of ORP values.

Oxidation is a process during which a molecule or ion loses electrons. However, oxidation is always coupled together with reduction so that as one element gets oxidised, the other automatically is reduced.

Redox Process: $2Fe^{3+}+2l \rightarrow 2Fe^{2+}+l^{2}$

Oxidation: $2l \rightarrow l_2+2e$

Reduction: $2Fe^{3+}+2e \rightarrow 2Fe^{2+}$

This complementary oxidation-reduction process is known as a redox reaction system and the ORP value is a measure of the electron activity as compared to the hydrogen activity in the case of pH measurements.

Redox potentials are measured by an electrode normally made of an inert metal and are capable of absorbing or releasing electrons. The common metals used are platinum and gold.

When the redox electrode is immersed in a solution containing a reversible chemical reaction system, a migration of electrons is established between the electrode and the system. This electron flow can be construed as an exchange current density and is of paramount importance for accurate, fast and reproducible redox potential measurement.

3.1 ORP Measurements

ORP measurements are based on the potential difference measured between the platinum or gold electrode and a reference electrode. The identical reference system utilised for the pH electrode (e.g., Ag/AgCl) can also be used for redox measurements.

Redox electrodes are used to monitor many chemical processes especially those involving reaction. Common applications include:

Water treatment The redox systems used in water treatment are the reduction of chromates and oxidation of cyanides.

Pool sanitation ORP measurements are being increasingly used as an effective measure of the sanitizer activity in pool and spa waters. Pool water, having an ORP value equal to or higher than 650mV, is well within accepted bacterial parameters.

4.0 CONNECTING PH PROBE TO UNIDATA LOGGER

1. To connect 6528A pH probe to the Starlogger modified Isolation module Model 6141A has to be installed on to Starlogger FTS Model 6103E.
2. For example 6141A is to be installed in to A1 (Analog 1) mounting holes
3. Modify isolation module 6141A by removeing Pin 2 Signal Ground

8 +5V   6 Out   5+IN   4   3 –IN   2   1 Pwr GND
SIG GND

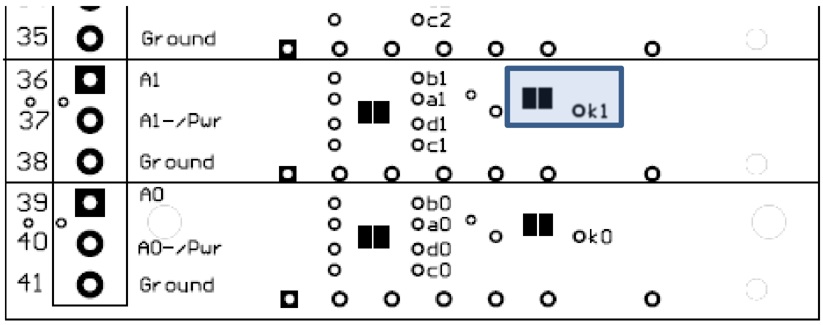
4. Remove links on Starlogger FTS 6103E for A1 connections as:

   Link k1 out (no link)

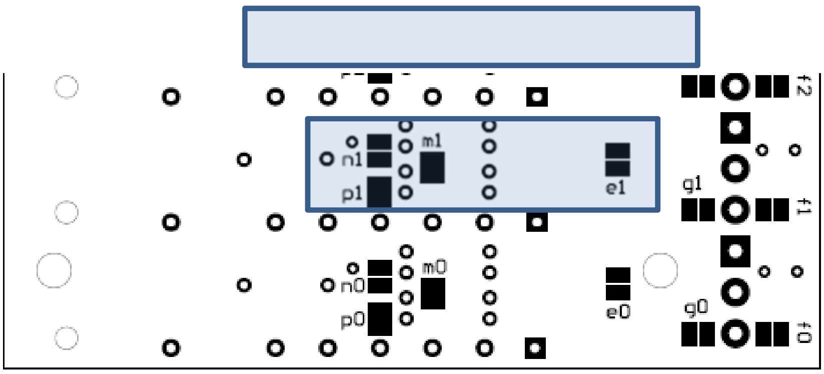
   Link m1 in

   Link n1, p1 and e1 out

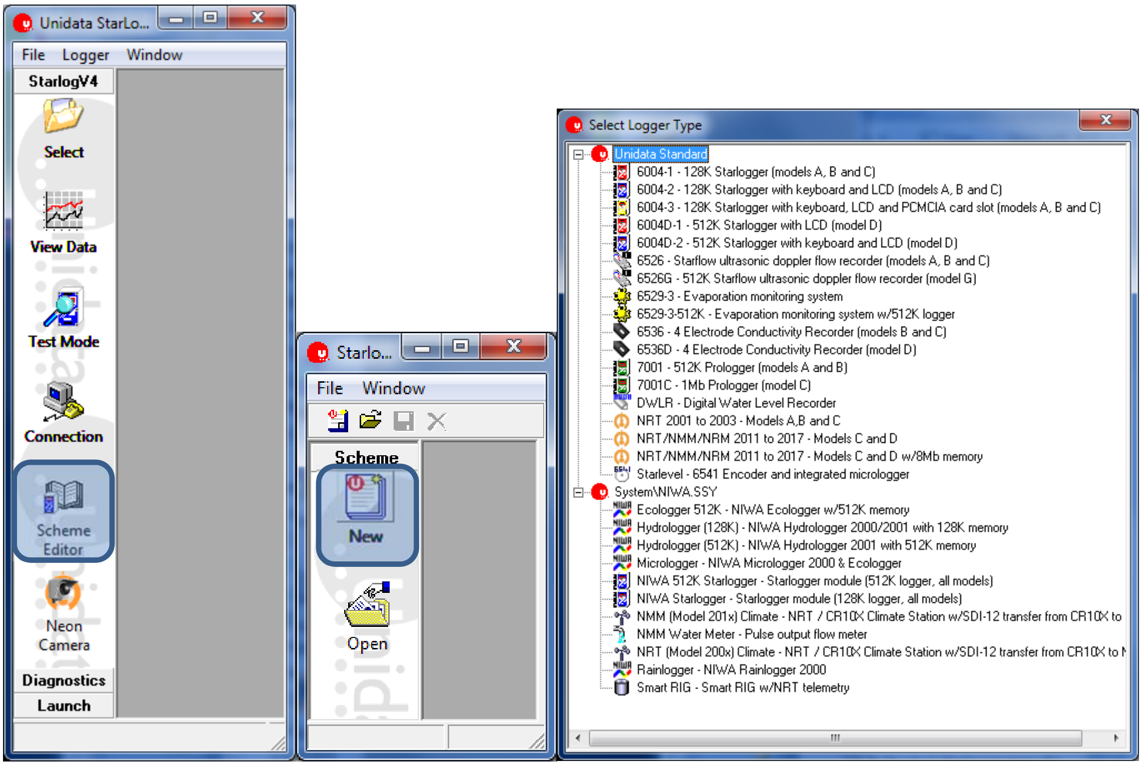
Front of the 6103E FTS PCB



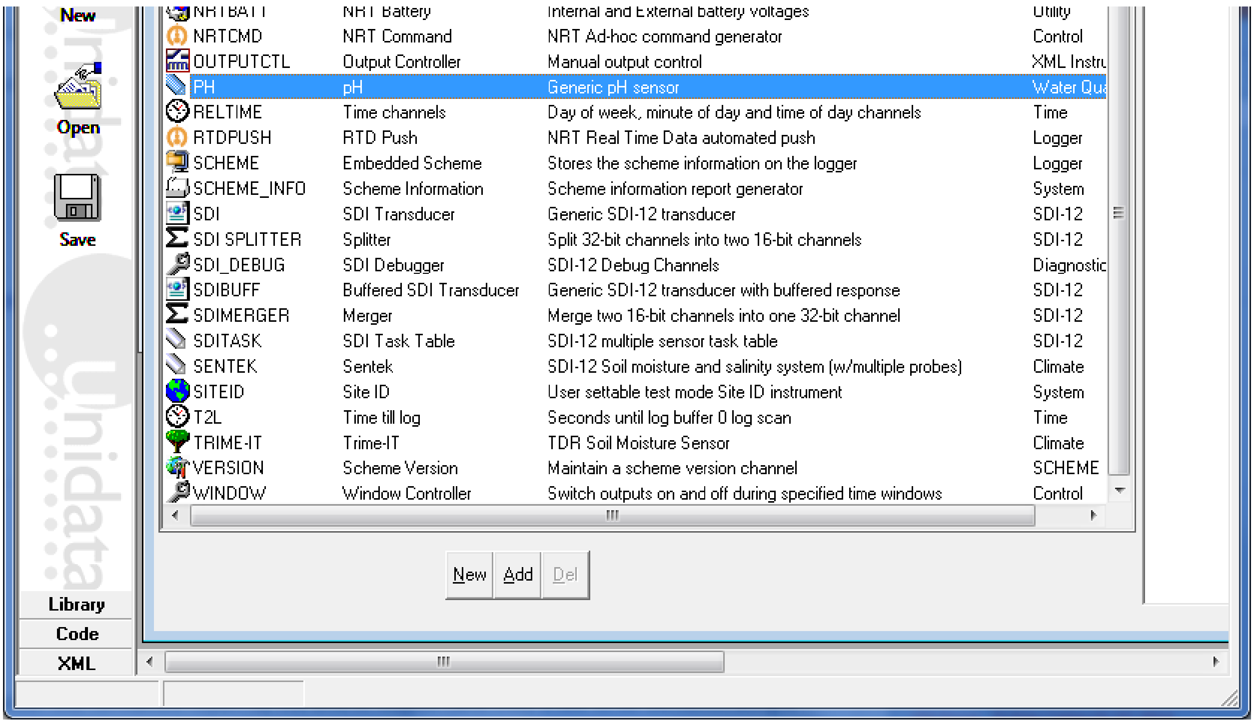
Back of the 6103E FTS PCB



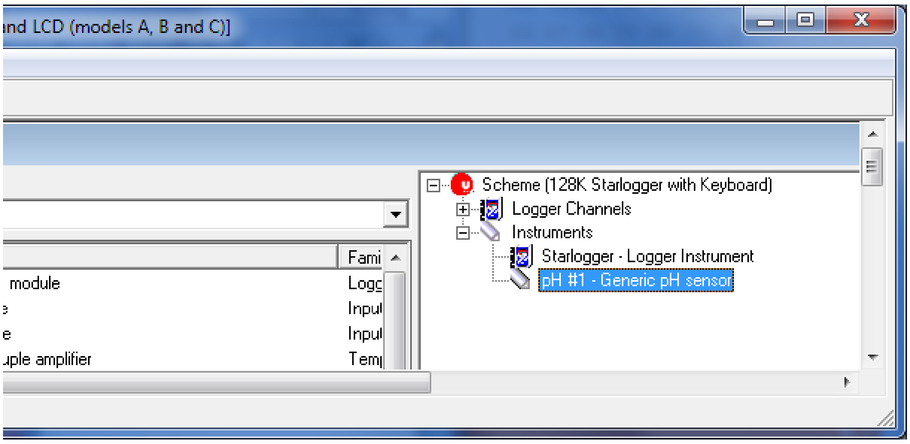
5. Open the **Scheme Editor**, **New** and **Select Logger Type** (Starlogger)



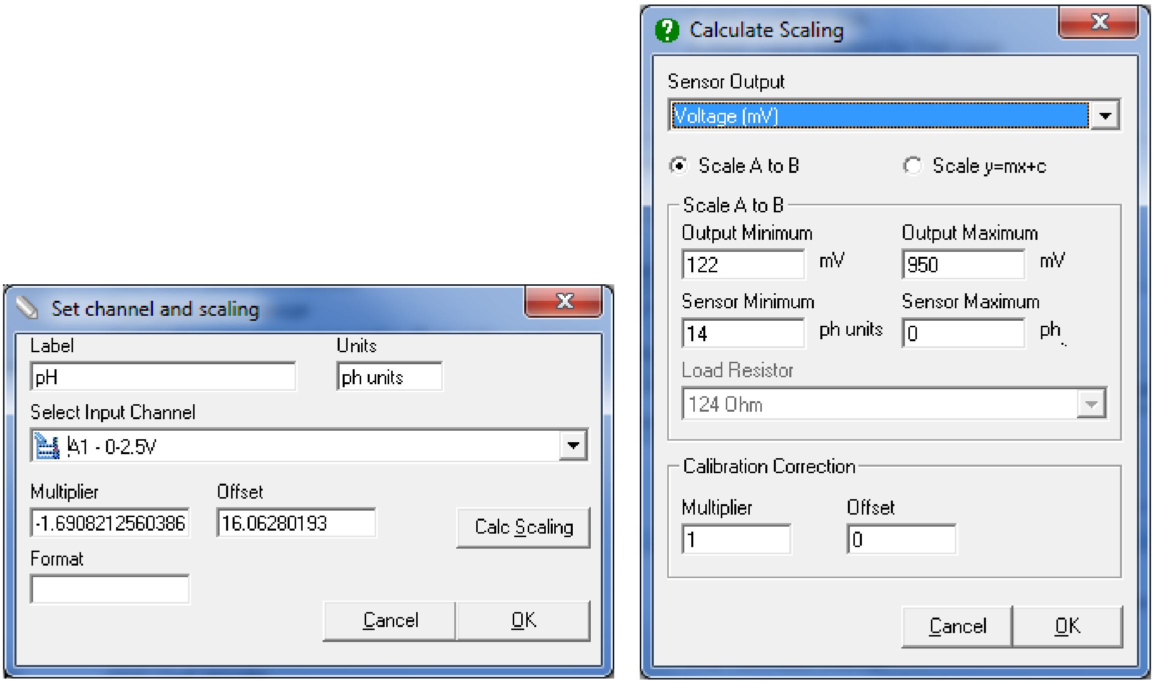
6. Select the **Instruments** menu, then Instrument **(PH)** and **Add** Instrument



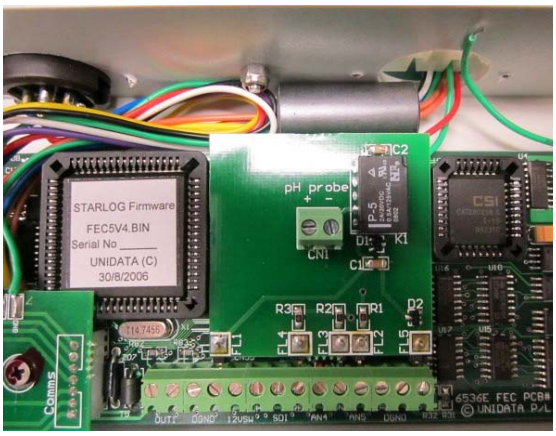
7. Mouse right click on the added scheme (Voltage #1)
Select **Edit**

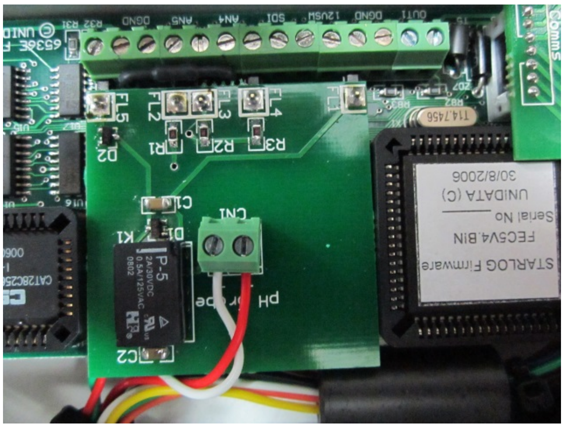


8. Select **Input Channel** and **Calc Scaling**



Please note to use pH probe with the conductivity instrument 6536E or any module from NRT range additional PCB Model 6536E-PCP-PH is required.

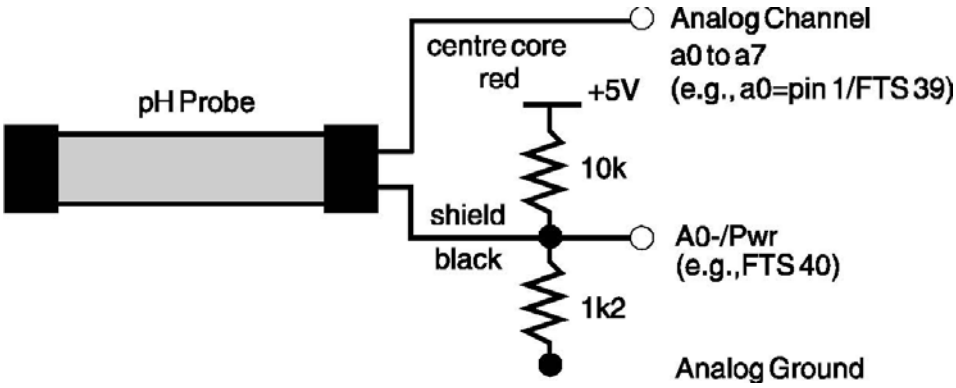




These wiring modifications should be performed by Unidata.

4.1 Connecting ORP Probe to Unidata Logger

The output of the ORP Probe is mV. Connected to a Starlogger no conversion is required. Therefore, the ORP's attributes are:



4.2 Temperature Calibration

It is possible to use a temperature probe in conjunction with the pH probe to obtain a temperature corrected value of pH. This is done by defining a new formula which takes readings from both probes and evaluates them to the value of pH.

5.0 CALIBRATION

5.1 pH Probe

The ideal probe will produce a voltage of 0mV at a pH of 7 and a voltage proportional to the Nernst factor over a range of pH. That is, the formula is -

$E = -1000N_f \log[10^{-7}] + 1000N_f \log[a_{H+}]$

$E = 1000N_f (-\log[10^{-7}] + \log[a_{H+}])$

$= 1000N_f (7- pH)$

and if the temperature is assumed to be 20°C, the formula is -

$E = 58.1 (7 - pH)$

$E = 406.7 - 58.1pH$ (mV)

5.2 Errors

Some variation in the offset potential and slope characteristics will occur between probes from manufacture. Added to this is the aging effect of the electrode and a degree of contamination which is unavoidable. If these factors produce an unacceptable error level then the calibration formula must be adjusted.

This is achieved through the accurate measurement of two solutions whose pH levels are known. Powders for making such solutions are readily available from a range of suppliers including Radio Spares. The first should be a pH of 7.00 and the second is normally 4.00 or 10.00 depending on whether the anticipated operating range is basic (ph10) or acidic (ph4).

The temperature should also be measured accurately.

For example:

pH = 7 E=4.2mV T = 20°C = 293K

pH = 4 E=185mV T=20°C = 293K

$E = [1000N_f (7 - pH)][1 + S] + O$

1. $4.2 = [1000 . 1.982 \times 10\text{-}4. 293(7 - 7)][1 + S]+ O$
   $4.2 = 0 + O$
   $O = 4.2$ (offset)

2. $-185 = [1000 . 1.982 \times 10\text{-}4 . 293(7 - 4)][1 + S] + 4.2$ 185 − 4.2

   $1 + S = \frac{185 - 4.2}{174.218}$

   $S = 0.0378$ (slope)

i.e. $E = 1.0378 [1000N_f(7 - pH)] + 4.2$

This new formula corrects the slope and offset errors associated with an individual probe's characteristics.

6.0 MAINTENANCE

Cleaning Electrodes

1. General - Soak in 0.1M HCl solution for 1.5 hour, then rinse in distilled water.
2. Specific solutions are available from suppliers for cleaning probes which have been immersed in organic, petroleum and inorganic solutions for long periods of time.

Storing Electrodes

1. To ensure a free flowing liquid junction and quick response, the reference junction and sensing element MUST NOT be allowed to dry out.
2. Short Term Storage (between measurements/up to one week): Soak and store electrode in 0.1M KCl solution.
3. Long Term Storage (More than week): Cover the sensing element with its protective cap containing a few drops of storage solution (0.1M KCl solution).

Note: Never store the electrode in distilled water.

7.0 SPECIFICATIONS

Model 6528A pH Probe

Range:	0 to 14 pH
Temperature Range:	0 to 80°C
Impedance:	10Ω
Internal reference:	Ag/AgCl
Reference junction:	Double junction
Reference electrolyte:	Gel
Housing:	Epoxy
Size:	12mm diameter, 150mm long
Weight:	50g

Model 6528B ORP Probe

Range:	±700mV
Temperature Range:	0 to 80°C
Impedance:	10Ω
Type of sensor:	Platinum
Internal reference:	Ag/AgCl
Reference junction:	Double junction
Reference electrolyte:	Gel
Housing:	Epoxy
Size:	12mm diameter, 150mm long
Weight:	50g