STARLOG

pH Probe
Oxidation Reduction Potential (ORP) Probe

Model 6528A
Model 6528B

CE

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1. INTRODUCTION

This supplement contains information about two probes manufactured for use with UNIDATA STARLOG Data Loggers:

- *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 either directly or through a Field Termination Strip. The probe is supplied with spade connectors. 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. 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,

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

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

$2H_2O \iff H_3O^+ + OH^-$

or $H_2O \iff H^+ + OH^-$

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

i.e., $K_W = a_{H+} + a_{OH-}$

$= 10^{-14}$

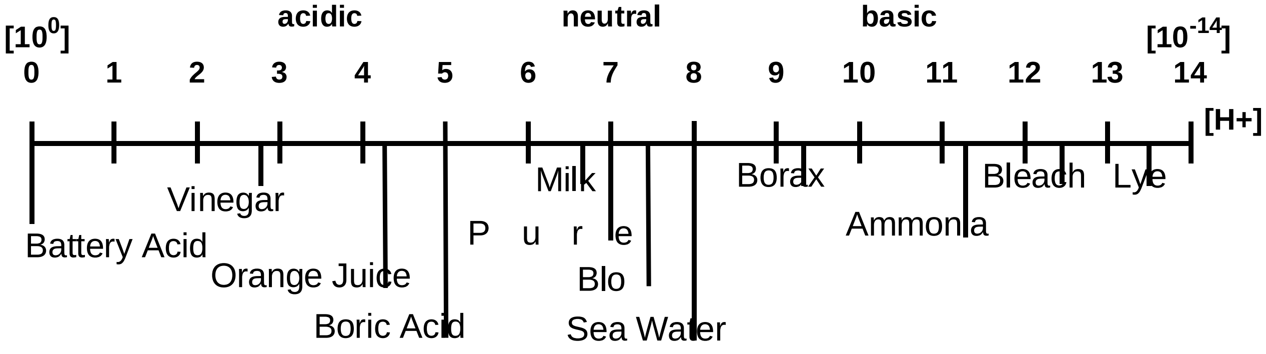
for a neutral solution, i.e., pure water

$A_H + = a_{OH-} = 10^{-7}$ @ 25°C

Therefore,

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

pH Scale of Typical Solutions



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 (= 8.313)
T = temperature in Kelvin
F = Faraday constant (= 9.648×10^4)
n = valence factor (=1 for hydrogen)

Therefore,

$N_f = 1.982 \times 10^{-4}T$

E.g., 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. OXIDATION REDUCTION POTENTIAL (ORP)

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:	$2Fe^{3+}+2I\rightarrow 2Fe^{2+}+I^{2}$
Oxidation:	$2I\rightarrow I_2+2e$
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 is 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.

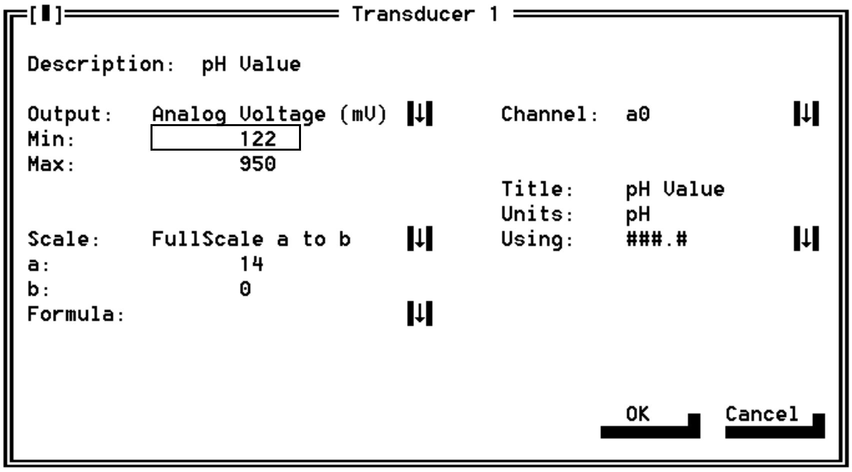
3.1. Measurements

ORP measurements are based on the potental 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.



Using Version 3 Software to describe a pH Probe used with a STARLOGGER

```
                     Edit a Transducer

Transducer Description        pH Value

Input Channel                 a0     analog 0 (8 bit)
Input Channel Range mV        0 to 2550

Transducer Range mV           122 to 950
Transducer Scaling / Formula  14 to 0

Title for Reports             pH Value
Units of Result               pH
Using String                  ###.#
```

Using Version 2 Software to describe a pH Probe used with a STARLOGGER

4. USING THE PROBES & STARLOG SOFTWARE

```
[■]                     Transducer 1

Description:  pH Value

Output:   Analog Voltage (mV)  ↓     Channel:  A0        ↓
Min:             -414.17
Max:              414.17
                                     Title:    pH Value
                                     Units:    pH
Scale:    FullScale a to b     ↓     Using:    ###.#     ↓
a:                14
b:                0
Formula:                       ↓

                                           OK     Cancel
```

Using Version 3 Software to describe a pH Probe used with a MACRO Data Logger

UNIDATA's instruments are designed for automatic monitoring and collection of data in a STARLOG Data Logging System. When the instruments are connected to a STARLOGGER, MACRO or Portable Data Logger, data sensed by the instruments is logged and stored according to a program you define using the STARLOG Software Package.

```
                     Edit a Transducer

Transducer Description        pH Value

Input Channel                 h0     analog 0 (16 bit)
Input Channel Range mV        -500 to 500

Transducer Range mV           -414.17 to 414.17
Transducer Scaling / Formula  14 to 0

Title for Reports             pH Value
Units of Result               pH
Using String                  ###.#
```

Using Version 2 Software to describe a pH Probe used with a MACRO Logger

The STARLOG Software Package runs on a computer compatible with IBM systems (PC/XT/AT, PS/2). This package includes a menu-driven program so that you can easily generate a data logging program – called a Scheme – then load the Scheme into a Data Logger. To discover how to use this program see the STARLOG Users Manual.

```
[■]==================== Transducer 1 ====================

Description:  Oxidation-Reduction Potential

Output:   Analog Voltage (mV)  ↓      Channel:  a0          ↓
Min:             0
Max:             2550
                                      Title:    ORP
                                      Units:    mV
Scale:    FullScale a to b     ↓      Using:    ####        ↓
a:               0
b:               2550
Formula:                       ↓

                                               OK      Cancel
```

Using Version 3 Software to describe an ORP Probe
used with a STARLOGGER

```
----------------------- Edit a Transducer -----------------------

  Transducer Description        Oxidation-Reduction Potential

  Input Channel                 a0     analog 0 (8 bit)
  Input Channel Range mV        0 to 2550

  Transducer Range mV           0 to 2550
  Transducer Scaling / Formula  0 to 2550

  Title for Reports             ORP
  Units of Result               mV
  Using String                  ####
```

Using Version 2 Software to describe an ORP Probe
used with a STARLOGGER

There are two versions of STARLOG Software:

– for faster computers (386 and above) Version 3
– for older systems (80x86, XT computers) Version 2

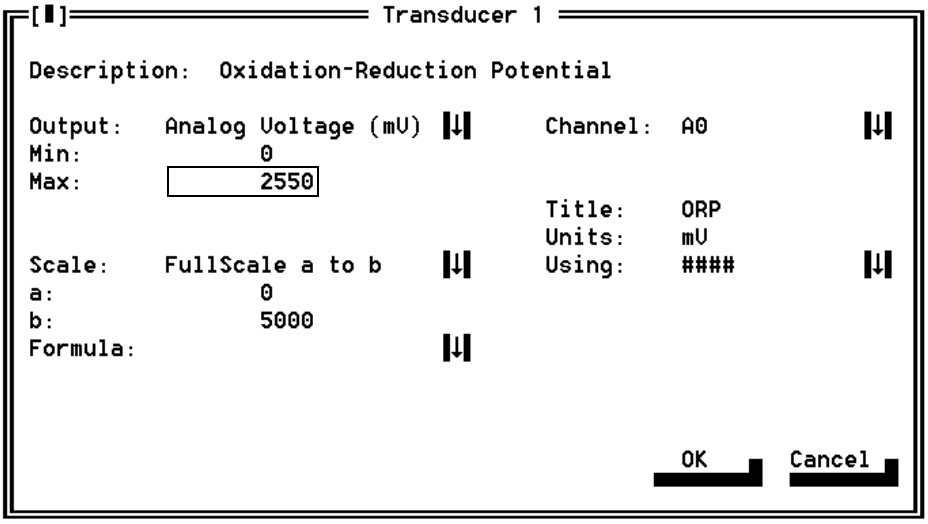
This section provides you with information you will find helpful in creating and executing a pH or ORP Monitoring Scheme.

Which Data Logger To Use – The pH and ORP Probes may be used with a STARLOGGER, Portable or MACRO Data Logger. You will want to select a correct scaling formula.

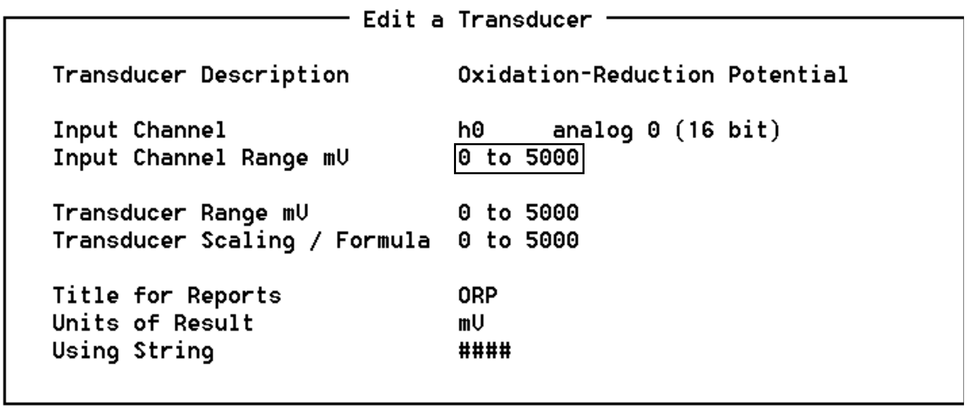
4.1. Adding the pH Probe to a Scheme

When using a STARLOGGER or Portable Data Logger with a pH probe connected as shown in section 5.1, the transducer has the attributes shown here:

Using a MACRO Data Logger, it is possible to define a transducer for



Using Version 3 Software to describe an ORP Probe used with a MACRO Logger



Using Version 2 Software to describe an ORP Probe used with a MACRO Logger

STARLOG software straight from the measurements taken for calibration.

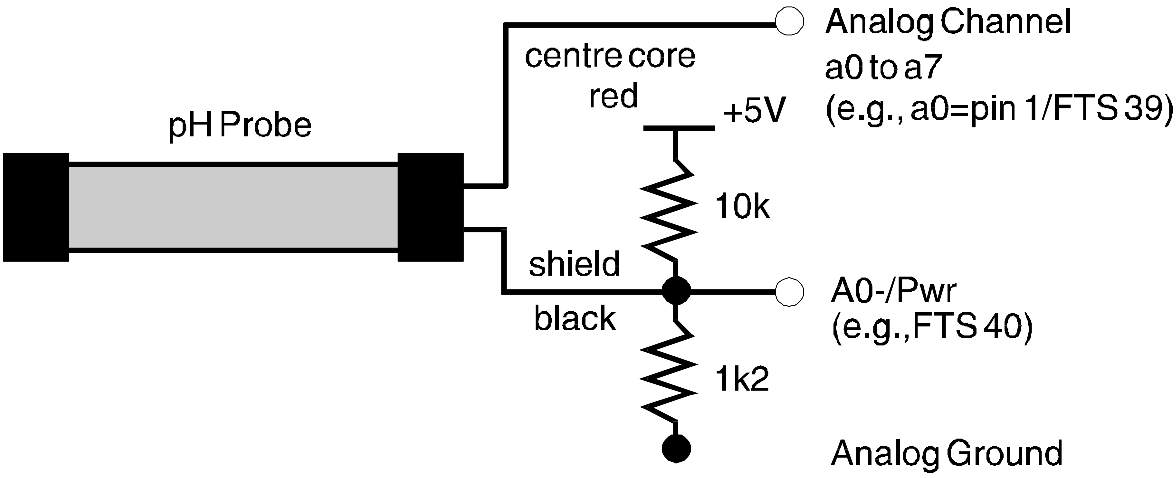
Transducer Range (mV) and **Scaling** must be defined.

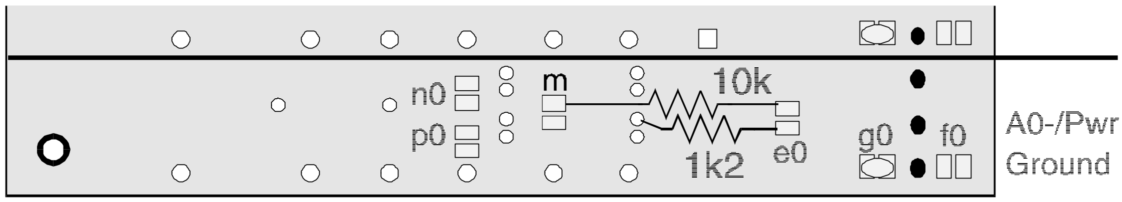
e.g., if	E = 185mV @ pH = 4	
&	E = 4.2mV @ pH = 7	
then,	the range is	**4.2 to 185**
	and scaling is	**7 to 4**

» NOTE: Using Version 2 Software, the Analog Channel in the MACRO Logger must be configured (using the **MACRO Configuration** menus) to a range of -500 to 500 mV to register pH values.

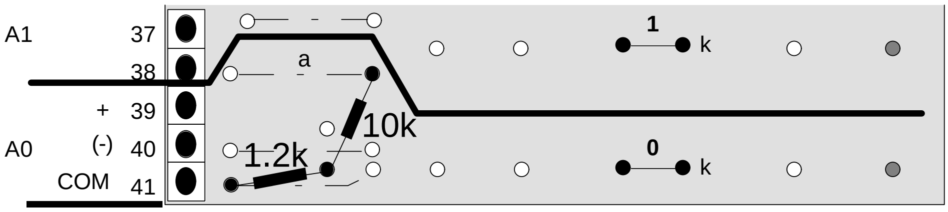
4.2. Adding the ORP Probe to a Scheme

The output of the ORP Probe is mV. Connected to a STARLOGGER or Portable Data Logger, no conversion is required. Therefore, the ORP's attributes are:





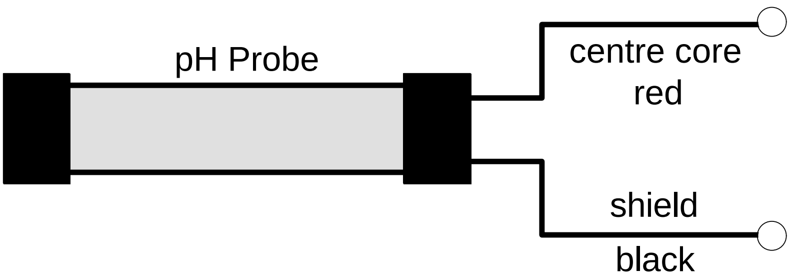
Model 6103D Field Termination Strip (back)



Model 6103B Field Termination Strip

Using a MACRO Data Logger, it is possible to define a transducer for STARLOG software straight from the measurements taken for calibration.

Again, with the ORP no conversion is required. When using a MACRO Data Logger with an ORP probe connected as shown in section 5.2, the transducer



has the following attributes:

4.3. 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. CONNECTIONS

The pH probe must be connected to an analog channel and configured as a single ended input. A connection diagram is shown below.

pH Probe		STARLOGGER & PDL		MACRO	
Colour	**Function**	**Pin**	**FTS**	**Pin**	**FTS**
red	+	1	39	20	39
black	–	23	41	1	40

5.1. STARLOGGER and Portable Data Logger

Connect the two resisters provided as shown in these diagrams onto the Field Termination Strip.

5.2. MACRO Data Logger

The probe may be connected directly to a MACRO Field Termination Strip (Model 7100) or to an input signal connector (Model 7101A).

6. SPECIFICATIONS

6.1. 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

6.2. 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

7. CALIBRATION

7.1. 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.

i.e 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)

7.2. 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.

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

2.- $185 = [1000 . 1.982 \times 10-4 . 293(7 – 4)][1 + S] + 4.2$
   $1 + S = \frac{185 – 4.2}{174.218}$
   $S = 0.0378$ (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.

8. MAINTENANCE

8.1. Cleaning Electrode

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.

8.2. Storing Electrode

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).

Never store the electrode in distilled water.