

# Foxcroft Equipment & Service Co. Inc.

## Model FX-300-F

### Ion Selective Electrode Fluoride Analyzer Instruction Manual



**Please Read Carefully and Save.**

The FX-300 analyzer includes an instruction manual that contains important information about its operation. Purchasers who install this product for use by others must leave this instruction manual or a copy with the user.

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# 1 Theory of Operation

The FX-300 series analyzers use ion selective electrodes to directly measure the ion of interest in water without converting the ion to a gaseous form and without the use of reagents. It provides an online continuous measurement for daily monitoring, trending and process control in applications including municipal drinking and waste water, and industrial process water and waste streams.

A complete explanation of ion selective electrode theory and operation is beyond the scope of this manual. A brief general summary is provided below only to distinguish the analytical method used from methods used by other types of instrumentation.

The FX-300 uses an electrochemical potentiometric sensor with a membrane that is selective to, but not exclusive to, the ion of interest. This means that it is possible for other ion types to permeate the membrane and react with the sensor. This presents an interference which is present to some degree in all ion selective electrodes.

When the ions in the fluid being measured reach equilibrium with the internal ion concentration of the sensor an electrical potential difference develops across the membrane between the solution and the sensor's internal reference system. The electrical charge in the sensor is proportional to the ion concentration in the fluid being measured. The relationship between ionic concentration and the electrode potential is governed by the Nernst equation  $E = E_0 + (2.303RT/nF) \times \log(A)$ .

It's important to note the FX-300 ion selective sensors provide a measurement of free ion activity (those ions that are not bound to other ions or molecules), and not the actual total ion concentration. An ion in solution may exist as a free ion, meaning it is not bound to other ions or molecules, or it may interact and bind with other ions or molecules in the solution. The activity of an ion relates to the number of free ions of interest per unit volume of solution. The concentration of the ion of interest refers to the TOTAL number of those ions both free and bound per unit volume of solution

The FX-300 ion selective measurement does not use a method approved for reporting levels to a governing agency since the sample is not conditioned with reagents or buffers to produce a result. It will however provide a status of ion activity in the process stream and indication of actual concentration by using the 1-point offset calibration to concentration standards that is determined by an approved grab sample or laboratory analysis instrument that determines the actual concentration.

The activity of free fluoride ions in solutions is pH and temperature dependent over some pH and temperature ranges. The extent of ionization (HF) conversion to the measurable (F<sup>-</sup>) ion form is also a pH and temperature dependent process.

Temperature dependence is described by the Nernst equation. The effect on a measurement in simple terms means that if the temperature fluctuates or the sensor temperature is not in equilibrium with the solution, the readings will also even if the ion activity remains unchanged.

## 2 Introduction

### 2.0 Fluoride Ion Selective Electrodes



The combination fluoride sensor includes both the measuring and reference electrodes with electrolyte, electronics and a high-impedance PVC organic membrane system in a sealed plastic body. As such there are no replaceable or serviceable items in the sensor. The only service required is occasional cleaning and calibration.

The recommended pH range of the general purpose fluoride sensors is 5.5 to 9.5pH on a continuous basis for optimum sensor lifetime. We recommend a pH less than 9.5 to minimize aging on the crystal. Sensors will start to have some loss of linearity at pH 10. Solutions at pH 11 will destroy the fluoride crystal.

**It is not recommended to operate the general purpose drinking water sensors below 5.5 pH. If the fluoride sensor must operate below 5.5 pH, or above 9.5 pH, you must contact the factory for assistance in selecting a different sensor or sample point for your application.**

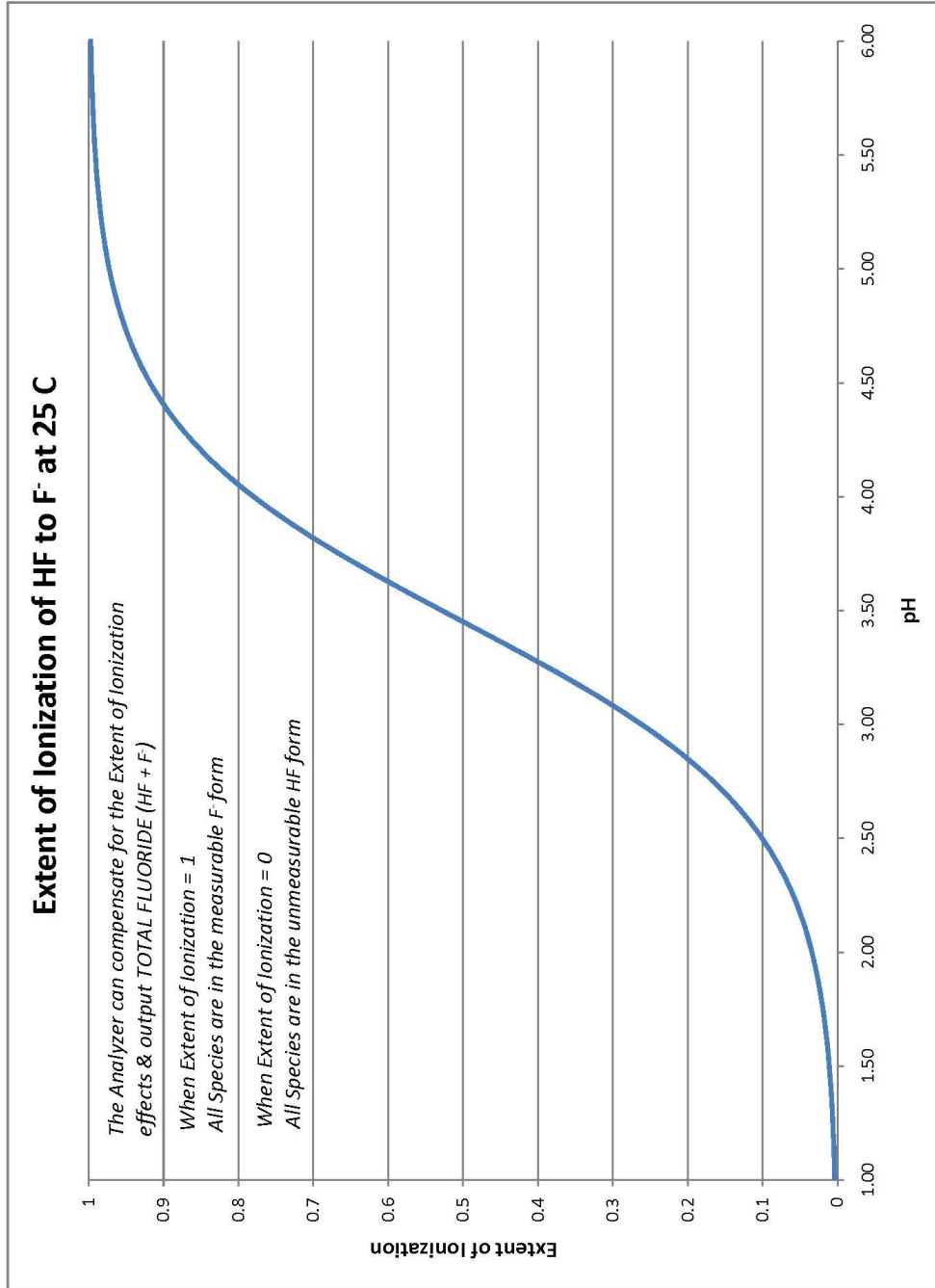
At pH levels below 5.5, the fluoride sensor will not detect the total fluoride content, as some of the fluoride ion will be converted into the form of dissolved HF gas. To convert the measured fluoride ion activity (free fluoride) into a total fluoride reading the free fluoride measurement must be compensated for the effect of pH using the FX-300-TOT module and a pH sensor with FX-300 pH measurement module. See the pH dependent extent of ionization curve for HF dissolved gas and fluoride ions (F) for a graphical representation of this phenomenon.

If you have purchased the FX-300-TOT module, you will be able to compensate for the pH induced effects on the extent of ionization to find the “total unbound free fluoride” as defined by the sum of the free ionized fluoride ion species together with the protonated HF bound form.

Please also note that these pH effects are a temperature dependent phenomenon. The provided extent of ionization curve is only completely valid for pure two component systems with deionized (DI) water. Real world water solutions of a much more complex makeup may vary somewhat from these idealized curves, although the deviation is not expected to be vast for most typical systems.

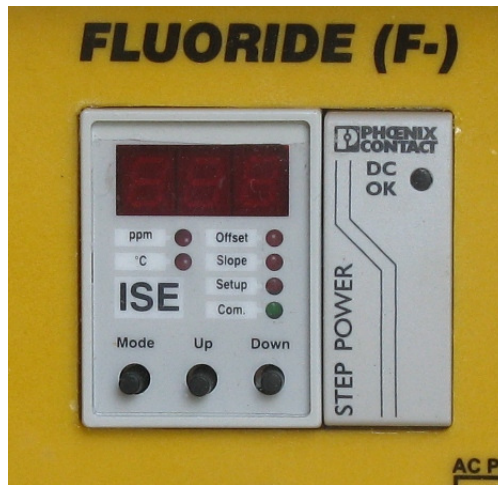
## 2 Introduction

### 2.1 HF Ionization



## 2 Introduction

### 2.2 FX-300 Transmitter Navigation and Operation



Each module has a 3 digit display and LEDs to indicate operating modes. The module is programmed by the use of 3 keys located on the front panel.

- 'Mode' key is used for navigation. The 'Mode' key is used to toggle between operating modes and for selecting a mode.
- "ppm/mV" indicates the run mode.
- °C mode displays the temperature.
- "Offset" is the mode for the 1-point offset calibration
- "Slope" is the mode to modify sensor slope.
- "Setup" mode provides access to program the analyzer.
- "Com" LED is illuminates when the Modbus (if included) is active.

For viewing or changing setup / operating parameters use the Mode key to select SETUP and use the 'Up' and 'Down' keys to scroll through the parameters. Select a parameter by pressing the Mode key.

To make a change you must first unlock the software by selecting parameter P01, then use the 'Up' or 'Down' keys to toggle the lock to "off".

NOTE: The raw uncompensated (a.k.a. "absolute") mV potential of the ISE sensor is displayed by pressing the "Down" key in the main ppm display mode. The display now changes from ppm to absolute mV units. Negative values will be displayed flashing. The temperature can be calibrated pushing the "Up" or "Down" buttons when in the temperature display (°C) mode.



## 2 Introduction

### 2.3 FX-300-ISE Module Function and Programming List of Parameters

**If the software lock (parameter. no.1) is “on” the parameter can only be read. Set software lock P01 to “off” to change values.**

- Par. no.2** sets the module's address for Modbus communication.
- Par. no.3** indicates the type of sensor for the temperature input.
- Par. no.4** If Par no.7 is set to ISE, the signal is temperature compensated. Par. no.4 sets the temperature compensation to either set (manual) or based on the measured temperature.
- Par. no.5** sets the temperature for when temperature compensation of the pH is in fixed (manual) mode.
- Par. no.6** If a long cable is used for the Pt100 sensor the cable impedance should be entered and compensated for this offset.
- Par. no.7** selects the output to be either ISE or temperature.
- Par. no.8** sets the analog output to either 0-20mA or 4-20mA.
- Par. no.9** sets the analog output scaling to either low (0.00-9.99ppm), mid (00.0-99.9ppm) or high (000-999ppm) range.
- Par. no.10 and no.11** are used to set the ppm value that corresponds to 0/4mA output setpoint (**Par. no.10**) and sets the ppm value that corresponds to 20mA output setpoint (**Par no.11**). The difference between Par. no.10 and 11 must be at least 20% of the working output range selected (either low, mid or hgh range). The display and output ranges are altogether decoupled.
- Par no.12** Variable to define the mV change for each “Up” or “Down” button depression when calibration is performed.
- Par. no.13** Displays formula weight of measured ion (next page details how to determine which ion correspond to this value)
- Par. no.14** View and edit the working (effective) sensor offset
- Par. no.15** View and edit the working (effective) sensor slope
- Par. no.16** Offset adjustment for low 0/4mA analog output trim.
- Par. no.17** Gain adjustment for 20mA high analog output trim.
- Par. no.18** If no keys are pressed for 10 min the display will show flashing bar (Energy Save). Press any key to return.
- Par. no.19** The Modbus standard requires a baudrate of 9,600 or 19,200 set in accordance with the Modbus-master.
- Par no.20** Feature to reset the analyzer back to factory default.

**NOTE:** To exit setup mode, press the 'down' button until parameter P00 is displayed, then press 'mode' until PPM (run) mode indicator lights.

## 2 Introduction

### 2.3 FX-300-ISE Module Function and Programming List of Parameters

Note: Values in parameters 13, 14, 15 pertain to Fluoride only. Other ions will have different values in these fields.

No	Parameter	Description	Range	Default
1	Lock	Software lock	On / Off	On
2	Address	Address on Modbus	Off, 1...247	Off
3	Temperature	Type of input	Pt100, Pt1000	Pt1000
4	Compensation	Temp. Comp. of pH	Auto, Set (Manual)	Auto
5	Comp. Temp.	Compensating temperature	0..150	25
6	Cable impedance	Impedance of Pt100 cable	0.0 .. 9.9Ω	0.0
7	Output variable	ISE or temperature	ISE, °C	ISE
8	Analog output range	ISE output range	0-20, 4-20	4-20
9	ISE ppm output range	Low (0-10.0), mid (0-100) and high (0-999)	10.0, 100, 999	10.0
10	0/4mA Set	Low ppm setpoint	0.00 .. 999	0.00
11	20mA set	High ppm setpoint	0.00 .. 999	10.0
12	Step change	mV increment per 'Up' or 'Down' button depression	0=0.02, 1=0.05, 2=0.10, 3=0.20, 4=0.50, 5=1.0, 6=2.0	2 (0.10mV)
13	View formula weight of ion	Grams per mol of ion	XX.XX per ion weight	19 (F only)
14	View current sensor offset	mV at iso-concentration	Per ISE sensor	-47 (F only) <sup>a</sup>
15	View current sensor slope	mV per decade response	Per ISE sensor	-57.2 (F only)
16	0/4mA offset	Trim low	+/-9.99%	0.00
17	20mA gain	Trim high	+/-9.99%	0.00
18	Energy save	Energy save	On/ Off	On
19	Baudrate	Modbus	9,600/19,200	19,200
20	Back to default	Reset to default	Def = reset Par = no reset	Par

<sup>a</sup> On the display this value will be flashing, which indicates a negative value.

## 2 Introduction

### 2.4 FX-300-ISE Module Description

#### 2.41 Sensor Input

The sensor without preamplifier is connected directly to the FX300-pH/ORP/ISE module. The mV signal from the sensor is processed by an integrated high impedance amplifier. The FX300-pH/ORP-X hardware version can support internal or external preamplifiers to enable installations that require long cable lengths or to operate in high interference areas. Temperature measurement with a Pt100/Pt1000 element in the sensor allows automatic temperature compensation to be performed.

#### 2.42 Analog Output

The FX300 transmitters have a single scalable analog output of either 0-20 or 4-20 mA (selectable). The difference required between the minimum (0/4mA) and maximum (20mA) output is 20% of the selected range (low 0-10, mid 0-100 or high 0-1000 ppm). For example, if the low range (0-10) is selected then the output could be as narrow as 0-2 ppm for the 0/4-20 mA scaling. The output is proportional to ISE ppm or temperature and is galvanically insulated from the input.

#### 2.43 Factory Reset

You can use parameter (P20) on the FX-300-ISE transmitter to reset the unit back to the factory dispatched configuration. If you perform a factory reset you will need to re-scale the current output and re-configure alarm settings and limits. You will also need to repeat your 2-point calibration using calibration solutions that are one decade (IOX) apart in value. In addition, you will need to once again place the ISE sensor back into service and allow it to reach equilibrium. You will then also need to repeat your 1-point grab sample offset calibration.

#### 2.44 RS485 Modbus (Optional)

RS485 Modbus output is available in two ways.

1. It can be integrated into the pH or ISE module at time of order only.
2. It is also available in the FX-300-TOT module, which can be added at any time.

Acquired data is transferred using Modbus standard for multi-drop communication and is connected using RS485. The Modbus-master may be the FX300-DAT module or any SCADA system. When units are ordered with Modbus option, the free of charge Windows data logging and graphing software can be used to monitor and record all process and temperature values from up to 247 transmitter simultaneously at distances up to 6500 feet (2 kilometers).

In order to utilize the Modbus interface the FX-300-ISE must be ordered with Modbus. FX-300-ISE may be used as a slave for the 'Dat' - unit FX-300-DAT or as a slave in a SCADA system. The setup / communication for each case will be explained in the following.

#### Modbus With FX-300-DAT

If FX-300-ISE is used together with the FX-300-DAT, the user must pay attention to two things: The baud rate on the Modbus as well as the address of the FX-300-ISE. **The baud rate (P14)** must be set to the baud rate of the FX-300-DAT. Whether a baud rate of 19,200 or 9,600 is used is of no importance, as long as all units on the Modbus are set to the same baud rate.

## 2 Introduction

### FX-300-ISE Module Description

#### 2.44 RS485 Modbus

The address (P02) must be unique in the network; two units are not allowed to have the same address. In a network with the FX-300- DAT as master, all addresses must be assigned without leaving any address out; i.e. if 3 units are connected to a FX-300-DAT, the addresses 1, 2 & 3 must be assigned to the three units. The order of the addresses is of no importance. In a network with an FX-300- DAT, up to 14 slaves may be connected, allowing addresses 1..14.

##### In a SCADA system

Since different SCADA systems may have different restrictions only the general are mentioned here: **The baud rate (P14)** must be set to the baud rate of the SCADA system. **The address (P02)** must be unique in the network; Two units are not allowed to have the same address.

##### Modbus Scaling

The scaling for the ISE output is per parameter no. 9 (low, mid or high) that may differ from the 0/4-20 mA analog output scaling.

##### Modbus

The FX-300-ISE contains 2 measurements (ISE/mV and temperature). Access to these are gained through the function code *Read\_Input\_Registers (04)*. The FX-300-ISE gives access to different diagnostic values via *Diagnostics (08)*, as shown below.

#### Read\_Input\_Registers

Function code	Start address	Number of values
04	1	1 or 2

Value 1 is ISE ppm and value 2 is temperature. The measurements are transmitted in sequence; If 2 values are chosen both ISE ppm and temperature are transmitted. If the value for temperature is wanted, 2 values must be requested. Both values are rated to 0- 1000 corresponding to the range, but the temperature has an offset of 1024; i.e. 0-999 ppm is transmitted as 0-1000 and 0-150°C as 1024-2024. The start address is of no importance but rather only that the number of values determines the returned values.

#### Diagnostics

Function code	Sub code (HEX)	Description
08	00	Return Query Data
	0A	Clear counters and diagnostics register
	0B	Return Bus Message count
	0C	Return Bus Communication Error count
	0D	Return Exception Error count
	0E	Return Slave Message count
	0F	Return Slave No Response count
	12	Return Bus Character Overrun count

## 2 Introduction

### FX-300-ISE Module Description

#### 2.45 Default Ion Settings

Your FX-300-ISE has been preconfigured at the factory for your ion selective measurement requested at the time of order. The ISE measurement type configured for the FX-300-ISE transmitter cannot be modified in the field.

Below are the default nominal values for the parameter P14 and P15 for the fluoride ion selective measurement.

Slope Fluoride Ion (Parameter P15 on FX-300-F): -57.2 mV per decade default value

The slope parameter will only be changed when a 2-point slope calibration is performed. After calibration the slope should be at or very close to the default value. If not this indicates the calibration was not performed properly. Parameter P 15 allows you to both view and manually modify the working slope.

Offset Fluoride Ion (Parameter P14 on FX-300-F): -47 mV default value

Parameter P 14 allows you to both view and manually modify the offset. To modify the slope (or any other parameter) the software lock (PO1) must be disabled.

Formula Weight of Fluoride Ion (parameter P13 on FX-300-F): 19.00 grams per mol. This is a display only value that clearly denotes the ISE measurement type.

#### 2.46 MilliEquivalent (mEq) Mode

The maximum value in ppm that can be displayed and output with the FX-300 ISE transmitter standard configuration is 999ppm. For waste treatment operations that are reducing influent concentrations in the thousands of parts per million there is no way to transmit or display these values in the standard FX-300 configuration.

There is however, another normally undocumented mode in which our ISE transmitters can operate, known as milliEquivalent (mEq) mode. This mode allows greater than 3-digit concentration measurements. We display the higher ppm concentrations by exporting them via 4-20mA output to a remote display with scaled 4-20mA input.

In mEq mode the transmitter maximum operating range is 0-1,000 mEq. 1,000mEq is the same as a 1.000 Molar solution. Each 1mEq unit equates to 19ppm of fluoride since the formula weight of fluoride is 19.00 grams per mol. The fluoride sensor's molar measuring range limit is 19,000.

In this mode the transmitter display will be in mEq units and transmit mEq units via 4-20mA output (or RS485 Modbus if ordered). To get the corresponding ppm units you multiply the mEq units by the formula weight of the ion being measured.

The remote display always receives its 4-20mA input of the pH compensated total ISE from the FX-300-TOT module. Remote display of the free ISE value is normally not necessary in most applications.

## 2.46 MilliEquivalent (mEq) Mode

Following is a conversion of the mEq low, middle and high ranges to their ppm equivalents for fluoride.

### ISE Transmitter Scaling for mEq mode and Parts Per Million (PPM) Equivalent

(Note: The operating range scaling is changed in the ISE transmitter using parameter #9, ISE PPM Output Range. Options are Low (0-10), Middle (0-100) and High (0-999)).

0-10mEq Low Range --> 0 to 190ppm Fluoride Full Scale

Minimum scaling of the 4-20mA output is 20% of full scale, which would be 0-38ppm (4mA setpoint is 0 mEq and the 20mA setpoint is 2 mEq)

0-100mEq Middle Range --> 0 to 1,900ppm Fluoride Full Scale

Minimum scaling of the 4-20mA output is 20% of full scale, which would be 0-380ppm (4mA setpoint is 0 mEq and the 20mA setpoint is 20 mEq)

0-1,000mEq High Range --> 0 to 19,000ppm Fluoride Full Scale

Minimum scaling of the 4-20mA output is 20% of full scale, which would be 0-3,800ppm (4mA setpoint is 0 mEq and the 20mA setpoint is 200 mEq).

To get the best resolution on the 4-20mA output as well as on the remote display, you should trim the range to that portion in which you'll typically be measuring. EXAMPLE: For an intended operating range of 200 to 6,000 ppm, scale the ISE transmitter with mEq mode to the High Range (0-1,000 mEq, which equals 0-19,000 ppm Fluoride). If scaled as 0-315mEq this will correspond to 0-5,985ppm fluoride with a resolution of about 6ppm through the entirety of this range (as configured).

The FX-300- TOT pH compensation module can be used when the ISE transmitter is in mEq mode. When the ISE transmitter feeding the free ISE value in mEq units to the TOT module in mEq mode, the pH compensated "Total ISE" will ALSO be in mEq units (and needs to be scaled accordingly). All calibrations done to the ISE module would then ALSO need to be entered in mEq units.

The ISE transmitter can be operated in mEq mode and communicate with a PLC to operate in ppm mode by applying the proper scaling factor (1mEq = 19ppm fluoride) to go from mEq to ppm in the PLC.

## 2.47 Remote Display Scaling

To scale the 4-20mA input remote display provided with high range mEq mode measurement modules please refer to the separate Precision Digital display documentation included with this manual.

## 2 Introduction

### FX-300-ISE Module Description

#### 2.48 Transmitter Specifications

Housing	Levan UL94V-0 (Upper part) Noryl UL94V-0 (Lower part)
Mounting	M36 for 35mm DIN rail
Dimensions	D 58 x W 36 x H 86 mm (2.3 x 1.4 x 3.4 in)
Temperature range	-15 to +50°C
Power supply	24VDC +/- 10%
Consumption	60mA max
Sensor type	Combination sensor
ISE/mV range	0-10, 0-100, 0-999 ppm; +/- 1000mV
ISE input	<1pA, >10GΩ
Accuracy	+/- 2%
Temp sensor	Pt100, Pt1000
Temp range	0-150°C +/- 0.3°C
Temperature Compensation	Fixed (manual) or Automatic (using Temperature (TC) measurement)
Analog output	0-20mA or 4-20mA, max 250Ω
Enclosure	Wall mount windowed NEMA 4X reinforced fiberglass

**Table to determine selected ISE transmitter types**

Value of Par. no.13 (formula weight of ion)	Corresponding ion selective analyzer type (fixed)	Value of Par. no.13 (formula weight of ion)	Corresponding ion selective analyzer type (fixed)
18.0	NH <sub>4</sub> <sup>+</sup> (Ammonium)	19.0	F <sup>-</sup> (Fluoride)
40.1	Ca <sup>++</sup> (Calcium)	35.5	Cl <sup>-</sup> (Chloride)
24.3	Mg <sup>++</sup> (Magnesium)	79.9	Br <sup>-</sup> (Bromide)
6.9	Li <sup>+</sup> (Lithium)	126.9	I <sup>-</sup> (Iodide)
23.0	Na <sup>+</sup> (Sodium)	62.0	NO <sub>3</sub> (Nitrate)
107.9	Ag <sup>+</sup> (Silver)	26.0	CN <sup>-</sup> (Cyanide)

*Sign of sensor slope is fixed based upon ion type (anion or cation). Configuration of FX-300-ISE modules is done at Foxcroft factory and cannot be modified in the field. Contact Foxcroft for any values not listed above to determine the measurement type from the parameter 13 (formula weight of ion).*



## 3 Installation

### 3.0 General Information

You should first check that your ISE sensor is properly wired to the FX-300 analyzer according to the schematic for sensors without preamplifiers or sensors with preamplifiers depending on your system configuration.

**CAUTION:** It is altogether critical that the 24VDC power supply used to power the FX-300 transmitters is COMPLETELY separate from all other equipment. This also includes all other instrumentation as well other heavier equipment such as pumps and motors. This is because the FX -300 measurement module is a 3 -wire transmitter. The 3-wire aspect can be explained as follows: the 4-20mA analog current loop output sent from terminal 7 returns back to terminal 8; the +24VDC is connected to terminal 6 while the ground DC common from the power supply is shared with the return of the 4-20mA scalable current loop output on terminal 8.

In this way all of the ground terminals are shared between the current loop output and the DC common amongst all measurement modules energized from a single 24VDC power supply source.

There is 3000V opto-coupler isolation between the inputs and outputs of the measurement transmitter. The outputs are not, however, isolated from each other as the ground terminal is shared in the manner described above. Because of these reasons whatever 24VDC power supply is used to energize the transmitters should be altogether dedicated to only power these modules only.

The isolation on the AC/DC transformer of the FX-300 PS acts to isolate the 24VDC power from any other electrical devices at the installation site ensuring that no potential ground issues occur to the modules themselves nor any devices powered from the FX-300 measurement modules such as preamplifiers and contacting conductivity cells.

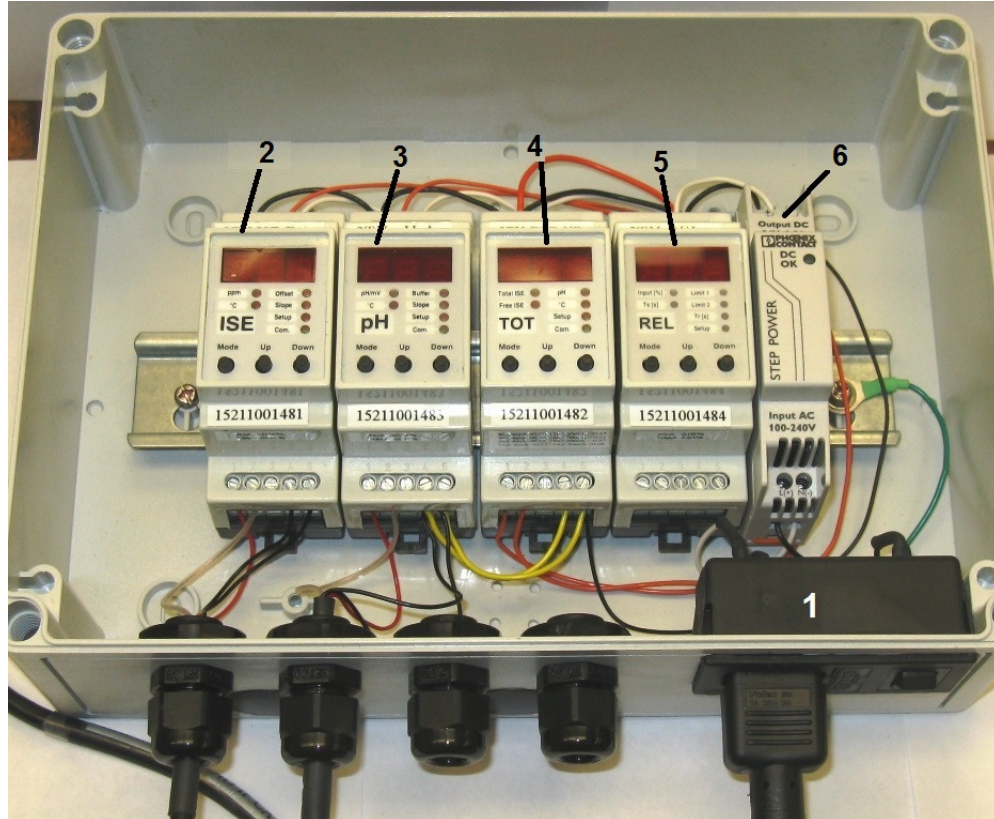
This isolation in the FX-300-PS also ensures that no issues present themselves regarding ground on the analog 4-20mA current loop output or RS485 Modbus outputs emanating from the power supply side of the system. It is still possible to have ground loop and electrical isolation issues that emanate from the process side of the system.

- **CAUTION: IT IS ABOLUTELY CRITICAL TO ENSURE THAT THE ANALOG CURRENT INPUTS OF A PLC OR SCADA ARE ISOLATED.**
- The analyzer is designed for wall mounting. Although the analyzer may be mounted outdoors, do not install it in direct sunlight or in areas of extreme temperatures.
- Install the analyzer in an area where vibration and electromagnetic and radio frequency interference are minimized or absent.
- Keep the analyzer and sensor wiring at least one foot from high voltage conductors. Ensure there is easy access to the analyzer.
- NOTE: Use watertight fittings and hubs that comply with your requirements. Connect the conduit hub to the conduit before attaching the fitting to the analyzer.



## 3 Installation

### 3.1 Component Identification, Standard Configuration



1	Fused Power Entry Module with On/Off Switch
2	ISE (Fluoride) Measurement Module, FX-300-ISE (F)
3	pH Measurement Module, #FX-300-pH
4	pH Compensated Total ISE Module, #FX-300-TOT
5	Relay Control Module, #FX-300-REL
6	24VDC Power Supply, 100-240VAC Input

The FX-300 includes a 3-wire CSA/UL/CE approved universal 100/240 VAC input 24V power supply protected by a 6 amp fuse located in the power entry module.

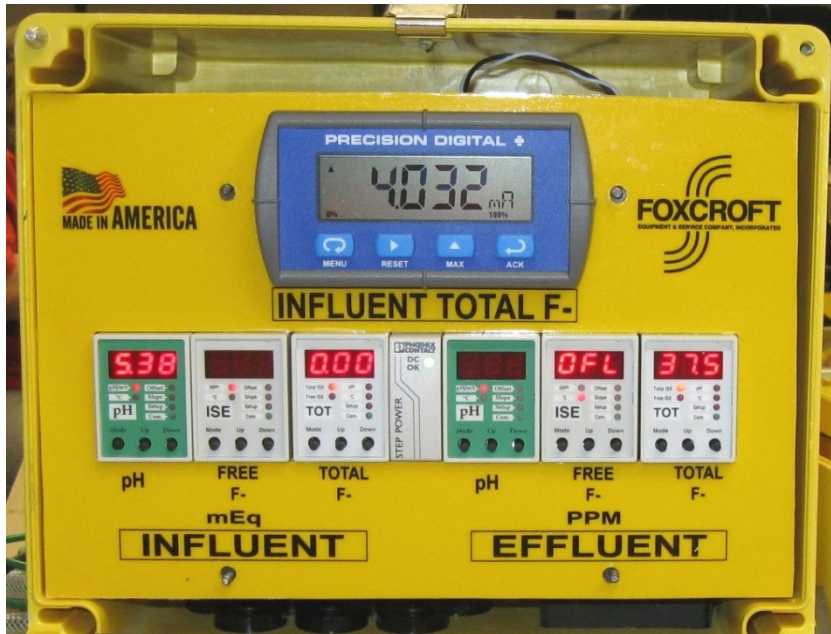
Ensure the instrument is properly grounded.

**CAUTION: THE 24VDC UNIVERSAL POWER SUPPLY CANNOT BE USED TO POWER ANY OTHER DEVICES. IT MUST BE DEDICATED TO POWER THE FX-300 MEASUREMENT MODULES ONLY. THE MEASUREMENT MODULES CANNOT SHARE 24VDC WITH ANY OTHER DEVICES. FAILURE TO DO SO WILL CAUSE GROUND LOOP ISSUES THAT WILL IREPARABLY DAMAGE THE MEASUREMENT MODULES AND ISE SENSOR.**

**NEVER apply voltage across terminals 7 & 8 on any FX-300 transmitter**

### 3 Installation

#### 3.1 Component Identification, High Range mEq Module with Remote Display



Shown: Special multi-channel system; influent treatment with mEq mode ISE module for measurements up to 19,000 ppm, values exported to 4-20mA input 5-digit LCD remote display, pH measurement & pH compensated total free fluoride. Effluent pH, free and total fluoride monitoring with standard local display.

#### Wiring Access

Turn off power to the instrument using the on / off switch on the power entry module. To access the measurement modules for wiring remove the four thumb nuts that retain the instrument cover plate. Lift the plate, and unplug the green wiring connector on the back of the remote display. Each terminal is labeled.

#### 3.1 Component Identification, Power Entry Module with Fuse Holder

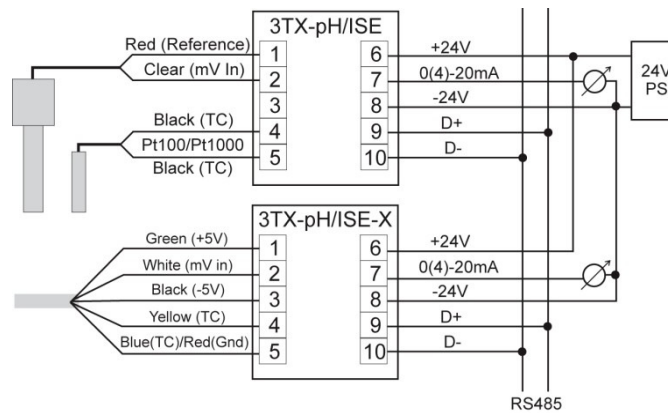


### 3 Installation

#### 3.2 Default Wiring Sensors to the Measurement Modules

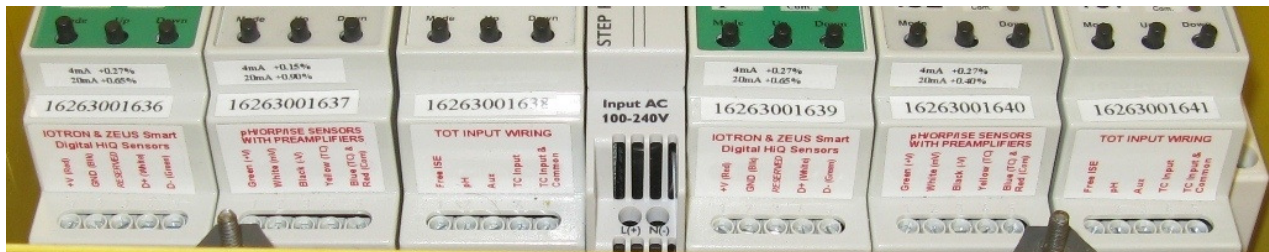
**NEVER apply voltage across terminals 7 & 8 on any 3-wire FX-300 transmitter**

For reference the wiring for ISE sensors with and without preamplifiers is detailed below. These two wiring details represent interface with two altogether different hardware versions which must be selected at time of purchase. The top diagram “FX-300-pH/ISE” is for sensors without internal/ integrated preamplifiers. The bottom diagram “FX-300-pH/ISE-X” is for sensors with internal/integrated preamplifiers.

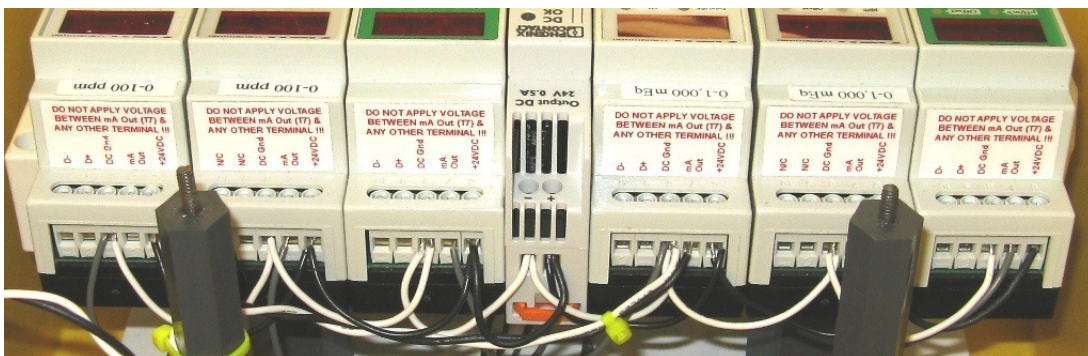


The lead providing +24VDC power always goes to terminal 6 and the 4-20mA current loop output is always sent from terminal 7. The DC common (ground) is shared as terminal 8. The current loop output is sent from terminal 7 and return to terminal 8 (ground / DC common). The FX-300 transmitters are always energized on terminal 6 with the DC ground of the 24VDC power supply (a.k.a. rail) always being the (shared) terminal 8.

#### Sensor Inputs



#### Voltage Inputs, mA & Digital Outputs





## 3 Installation

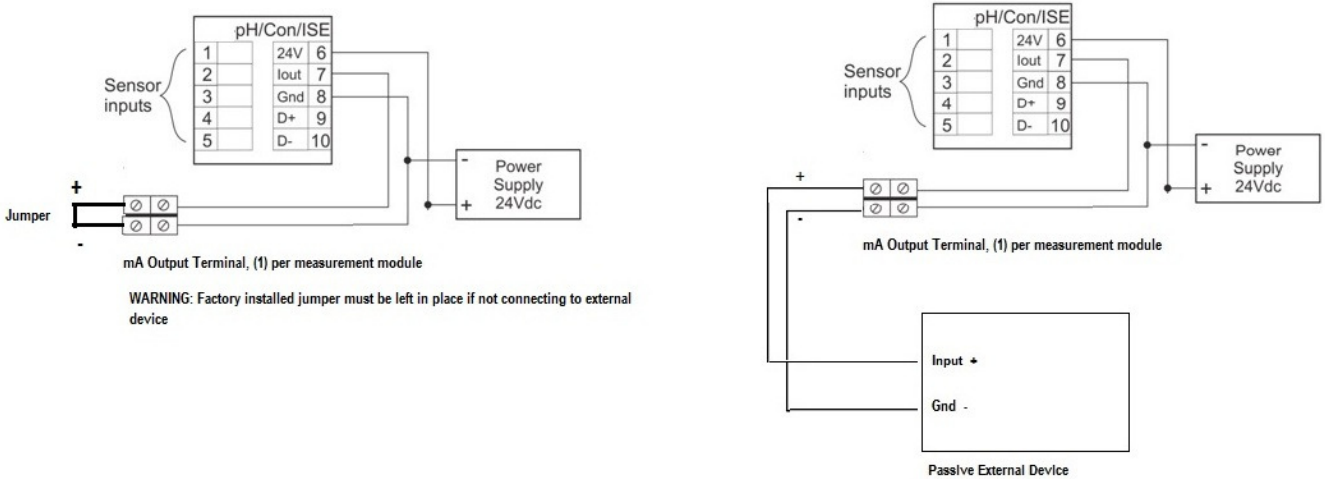
### 3.3 Wiring the 4-20 mA Output

#### Standard Wiring Configuration: 4-20 mA Output

**See the photo on previous page for complete output labeling instructions**

NOTE: Some configurations DO NOT have the 4-20mA bridge terminal block shown below.

Leave the factory installed jumper from the mA output terminal block (if supplied) intact unless you are connecting to an external device that passively measures current. **EXTERNAL DEVICE ANALOG INPUTS MUST BE ISOLATED and must not apply voltage to the active current loop, doing so will damage the transmitter and is not considered a warranty repair issue.**



Keep in mind that all FX-300 transmitters are 3-wire devices. This means they have an ACTIVE 4-20mA analog current loop output, like a 4-wire type device. The data acquisition or control device to which this active 4-20mA output is connected should passively measure the current. Most PLC's have a hardware or software toggle that allows you to select whether the 4-20mA received is from a 4-wire (or 3-wire) active type device or else if it is a 2-wire device which must be energized from the PLC power supply.

**The current output from the FX-300 MUST ALWAYS be connected to isolated analog inputs. If your PLC, SCADA or other external device does not have isolated analog inputs, then you must add an isolator for each current loop to be used.**

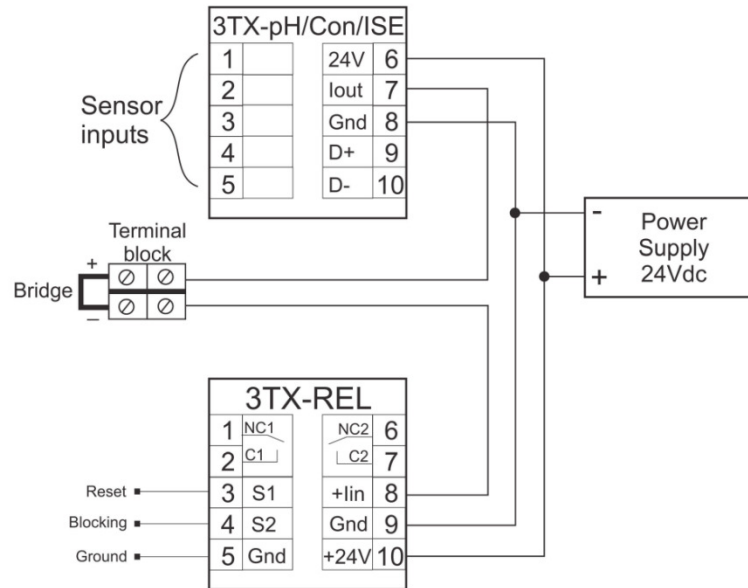
**The ground cannot be shared on both the analog current output from the FX-300 (since it is a 3-wire device) and on the analog input on the PLC. The ground for each analog input on the PLC must then always be isolated.**

### 3 Installation

#### 3.4 Wiring the 4-20 mA Output & FX300-REL Alarm /Relay Control Module

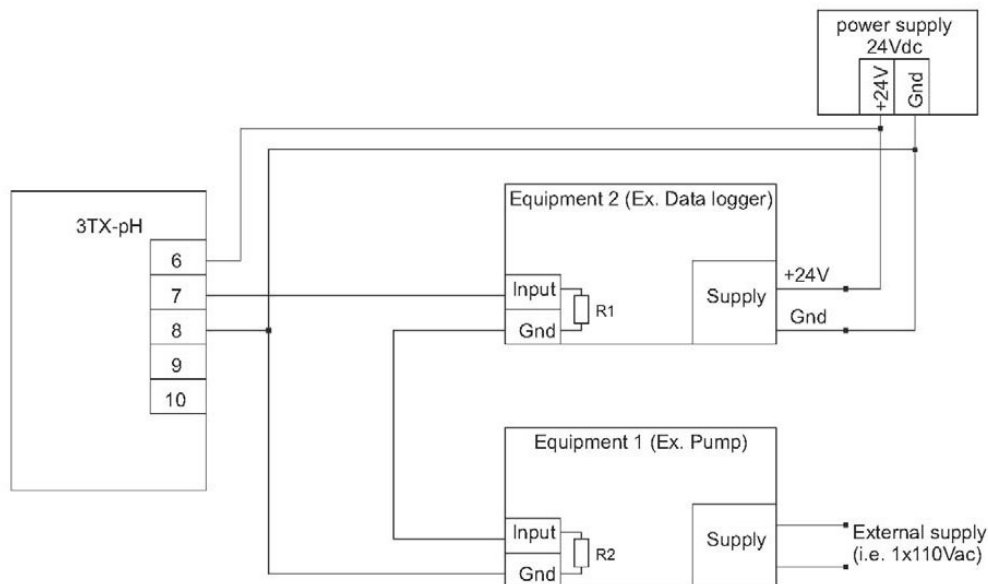
**NEVER apply voltage across terminals 7 & 8 on any FX-300 transmitter**

Standard Factory Default Wiring Configuration: 4-20mA output terminal to FX-300-REL



#### 3.5 Alternate wiring schematic for adding multiple devices to the 4-20mA transmitter output loop.

**EXTERNAL DEVICE ANALOG INPUTS MUST BE ISOLATED** and must not apply voltage to the active current loop, doing so will damage the transmitter and is not considered a warranty repair issue.



Note:  
R1 and R2 are internal resistors.  
 $R1 + R2 < 500\Omega$

## 3 Installation

### 3.6 Wiring the FX-300-TOT Module

**NEVER apply voltage across terminals 7 & 8 on any FX-300 transmitter. EXTERNAL DEVICE ANALOG INPUTS MUST BE ISOLATED and must not apply voltage to the active current loop, doing so will damage the transmitter and is not considered a warranty repair issue.**

#### 3.61 Wiring Approach 1: Spliced Pt100/Pt1000 Temperature Input to FX-300-TOT

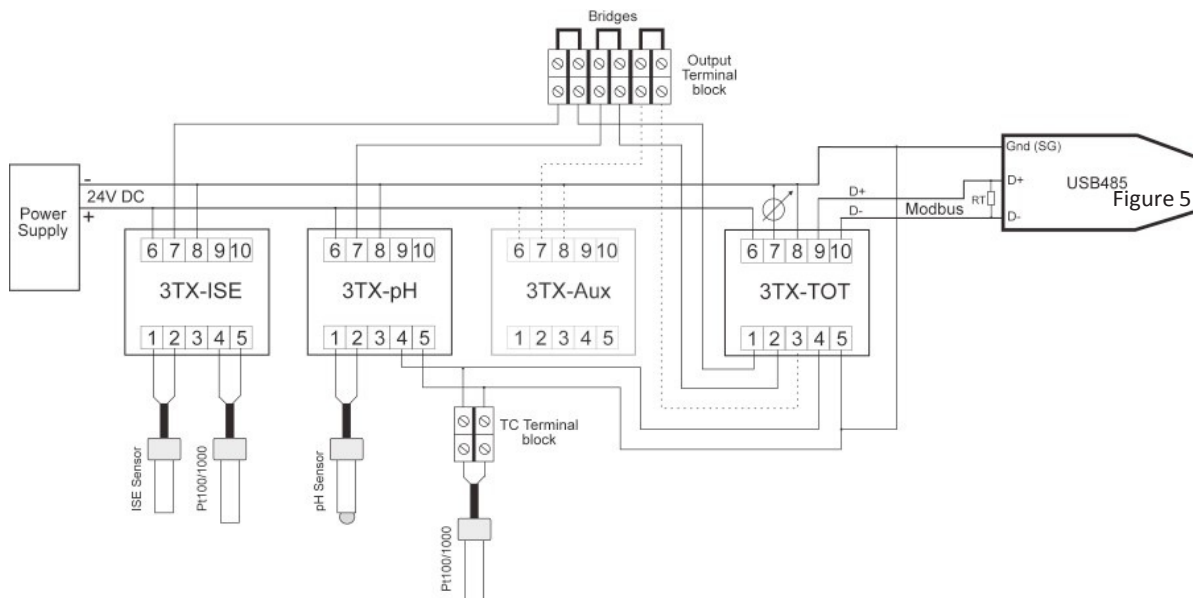
##### NOTES:

The optional FX-300-Aux shown can be any additional measurement transmitter such as FX-300-pH, FX-300-ISE or FX-300-CON

The jumpers from the Output Terminal Block can be removed so that the current loop output can be sent to any data acquisition or control system.

**3.62 IMPORTANT NOTE:** For systems that include the FX-300-TOT and a pH sensor with integrated preamplifier, the pH sensor wires are connected as follows (this is not shown in the diagram below):

pH module Terminal #1: Green (+5V)  
pH module Terminal #2: White (Signal)  
pH module Terminal #3: Black (-5V)  
pH module Terminal #5: Red (Common/Reference)  
TC terminal Blue: Blue (PT1000), factory bridged internally to the FX-300-TOT  
TC terminal Yellow: Yellow (PT1000), factory bridged internally to the FX-300-TOT



##### CAUTION:

The output terminal block provides connections to external devices of output measurements via analog 0/4-20mA and RS485 Modbus (if Modbus is available). **If readings will not be sent to an external device the factory installed jumpers must be left in place to avoid the possibility of disabling the unit and burning out one or more of the transmitters.**

## 3 Installation

### Wiring the FX-300-TOT Module

#### 3.63 Wiring: 4-20mA Temperature Input to FX-300-TOT

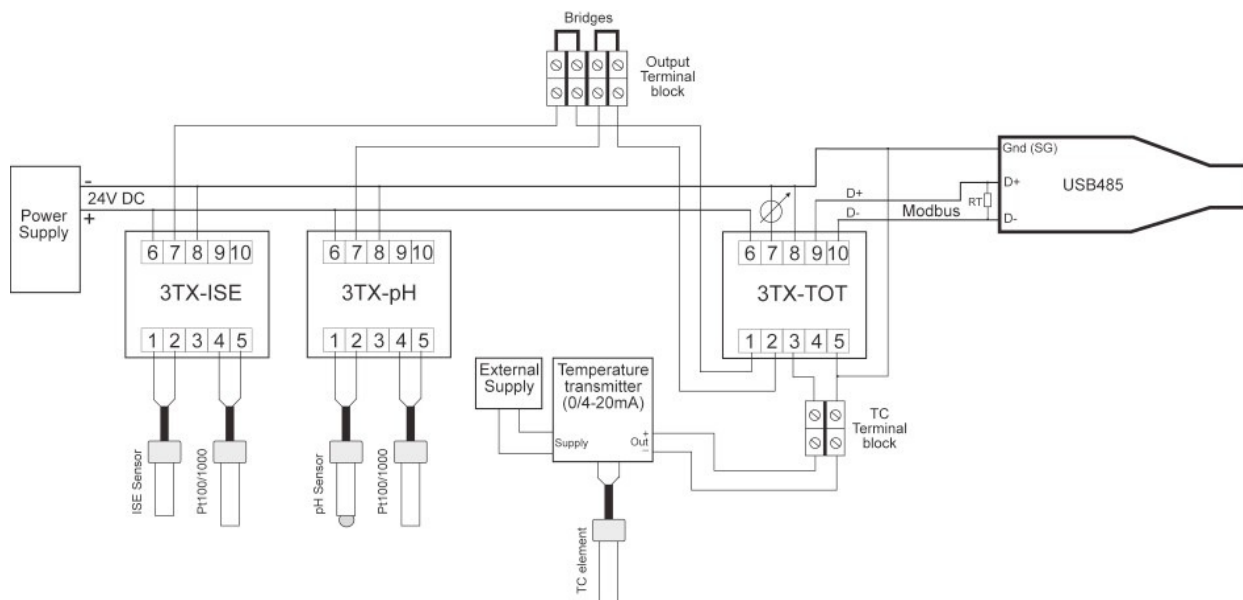
**NEVER** apply voltage across terminals 7 & 8 on any FX-300 transmitter. **EXTERNAL DEVICE ANALOG INPUTS MUST BE ISOLATED** and must not apply voltage to the active current loop, doing so will damage the transmitter and is not considered a warranty repair issue.

#### NOTES:

*In wiring Approach 3, it is not possible to have a third measurement transmitter (shown on Approach 1 & 2 as FX-300-Aux). The TC terminal block shown is optional.*

*The jumpers from the Output Terminal Block can be removed so that the current loop outputs can be sent to any data acquisition or control system.*

*When purchased as a complete assembly, specify your desired wiring approach and all units will be pre-wired at the factory prior to dispatch.*



## 3 Installation

### 3.7 New Sensor Installation

The industrial ISE sensor can be installed into service by use of an inline installation (in a pipe tee or flow cell), by immersion or submersion into a tank or basin.

For any installation, be sure not exceed the flow and pressure rating of a given sensor. Optimal performance and sensor lifetime will be achieved by having a slow continuous flow past the sensor. Maximum continuous flow rate of 2 GPH In 1" schedule 40 or 80 pipe.

Do not allow air bubbles to get trapped near the fluoride ion selective organic membrane. This will cause erroneous readings and drift. This potential problem is alleviated by installing the ISE sensor at between 45 - 80 degrees above the horizontal (whether inline or in a tank).

Ion Selective sensors should NEVER be installed in a horizontal or inverted configuration as this may lead to erratic and unreliable reading.

In addition, most industrial ISE sensors are liquid or semi-liquid filled and as such may have a small air pocket inside the sensing element. To ensure that there is not an air pocket caught inside the sensing element, shake the ISE sensor firmly downward. The small capillary force holding the air bubble in place inside the sensing element will be overcome by a firm downward shake.

Thermal equilibrium between the sensor and process solutions at elevated or depressed temperature (not at 25 degrees Celsius) is generally better achieved via immersion or submersion installation styles. Submersion style sensors do require sensor cable waterproofing.

Approximate Time to Allow Sensor to Reach Process Equilibrium	
pH	1/2 hour maximum
Ammonium	4 - 24 hours
Nitrate	1 - 2 days
Nitrite	1 - 2 days
Fluoride	4 - 24 hours
Conductivity	1/2 hour maximum
Ultralow Ammonium, Nitrate, Nitrite	Several days to weeks in wastewater

#### 3.7.1 Submersible Sensor Installation

The sensor can be submerged into an aeration basin if it has been supplied with cable waterproofing. Do not simply submerge the sensor into the water by the cable. Use the rear mounting threads on the sensor body to attach a pipe or other device to secure the sensor.

The sensor should be mounted at a 15-45 degree angle to prevent an internal air pocket from contacting the sensor tip resulting in erratic and unreliable readings.

The sensor should be placed at least 2 feet from the wall or side of the basin, and completely submerged at least below the surface.

You may need to install the sensor into a stilling well in order to meet the less than 0.5 ft/sec. flow velocity requirement of the sensor for stable readings and to extend sensor life.

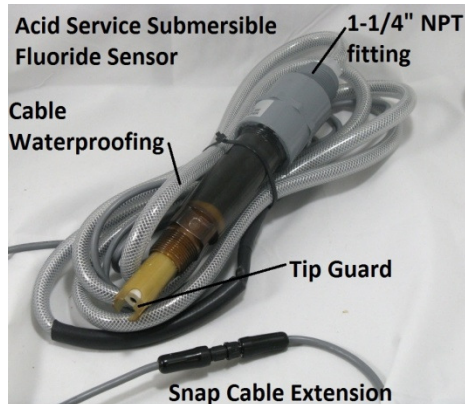
Sensor cables should be installed in conduit to avoid interference of low level sensor signals.



## 3 Installation

### 3.71 Submersible Sensor Installation

The sensor can be submerged into an aeration basin if it has been supplied with cable waterproofing. Do not simply submerge the sensor into the water by the cable. Use the rear mounting threads on the sensor body to attach a pipe or other device to secure the sensor.



The sensor should be mounted at a 15-45 degree angle to prevent an internal air pocket from contacting the sensor tip resulting in erratic and unreliable readings.

The sensor should be placed at least 2 feet from the wall or side of the basin, and completely submerged at least below the surface.

You may need to install the sensor into a stilling well in order to meet the less than 0.5 ft/sec. flow velocity requirement of the sensor for stable readings and to extend sensor life.

Sensor cables should be installed in conduit to avoid interference of low level sensor signals.

**Snap cable extensions** are available for cable runs longer than 20-feet. One cable half remains permanently wired to the fluoride transmitter, the other half is permanently attached to the sensor and sealed. The two cables are joined with a pin connector.

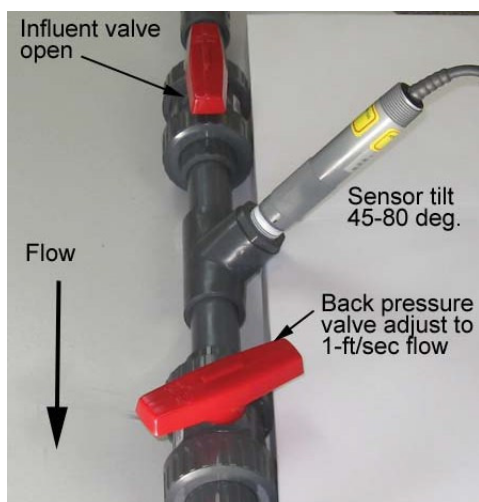
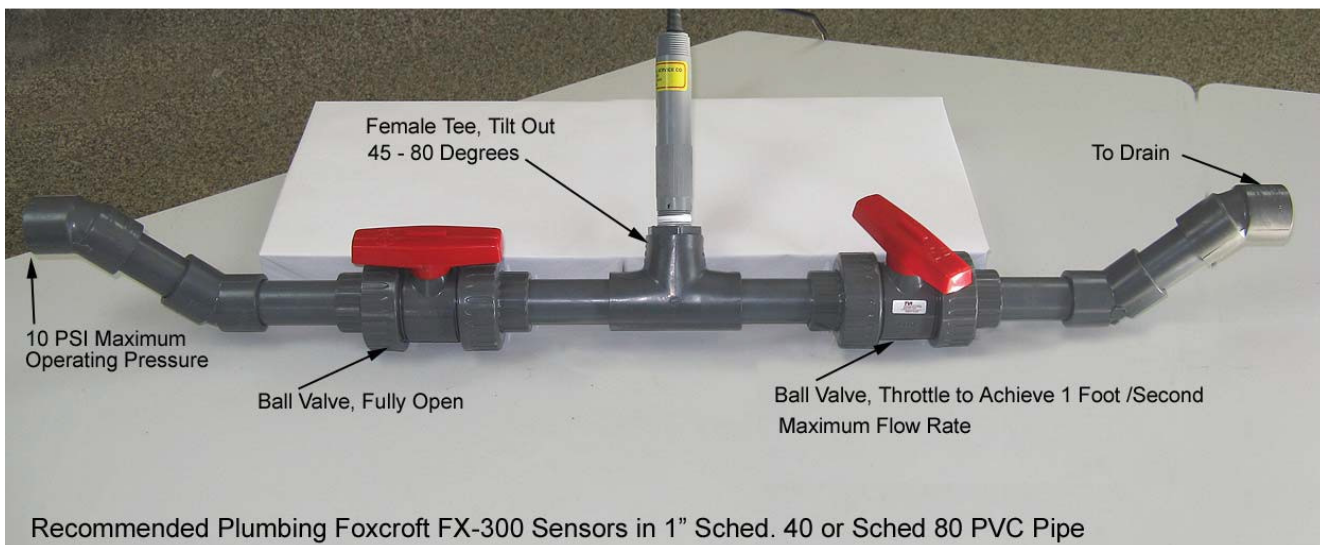
To disconnect, turn the lock collar counterclockwise to unlock, then pull the connectors apart. To connect, push the connectors together lightly while rotating them slowly until the internal pins align and the connectors snap together. Rotate the lock collar clockwise to seal and lock the connector halves.



### 3 Installation

#### 3.72 Installation (Inline Sensor Plumbing)

Please refer to the photos below which illustrate the recommended inline sensor plumbing installation using 1" Schedule 40 or 80 PVC pipe. The exact layout is determined by site requirements or limitations. However, the layout shown will ensure the electrode tip stays submerged and minimizes the opportunity for bubbles to collect at the electrode tip. Flow is from left to right.



The sensor orientation should be between 45 and 80 degrees above horizontal to prevent air bubbles becoming trapped near the ion selective membrane or on the sensor tip. Sensors should NEVER be mounted with the sensor tip pointing straight down, horizontally, or pointing up as this may cause a bubble on the sensor tip and lead to erratic or unreliable readings.

**DO NOT OVERTIGHTEN THE SENSOR AS THIS MAY CRACK THE FLUORIDE ISE CRYSTAL**

Pressure must be stable and should not exceed 20 PSIG, if needed install a pressure reducing regulator.

Recommend flow rate is about 2-3 GPH in 1" schedule 80 PVC pipe, or 1-foot /sec. velocity. Flow rate must be stable. Open the influent ball valve on the left fully, and use the backpressure valve on the right to control flow and provide back pressure. Optionally a flow rotometer can be substituted for the flow control valve to more easily set the flow to the desired rate.

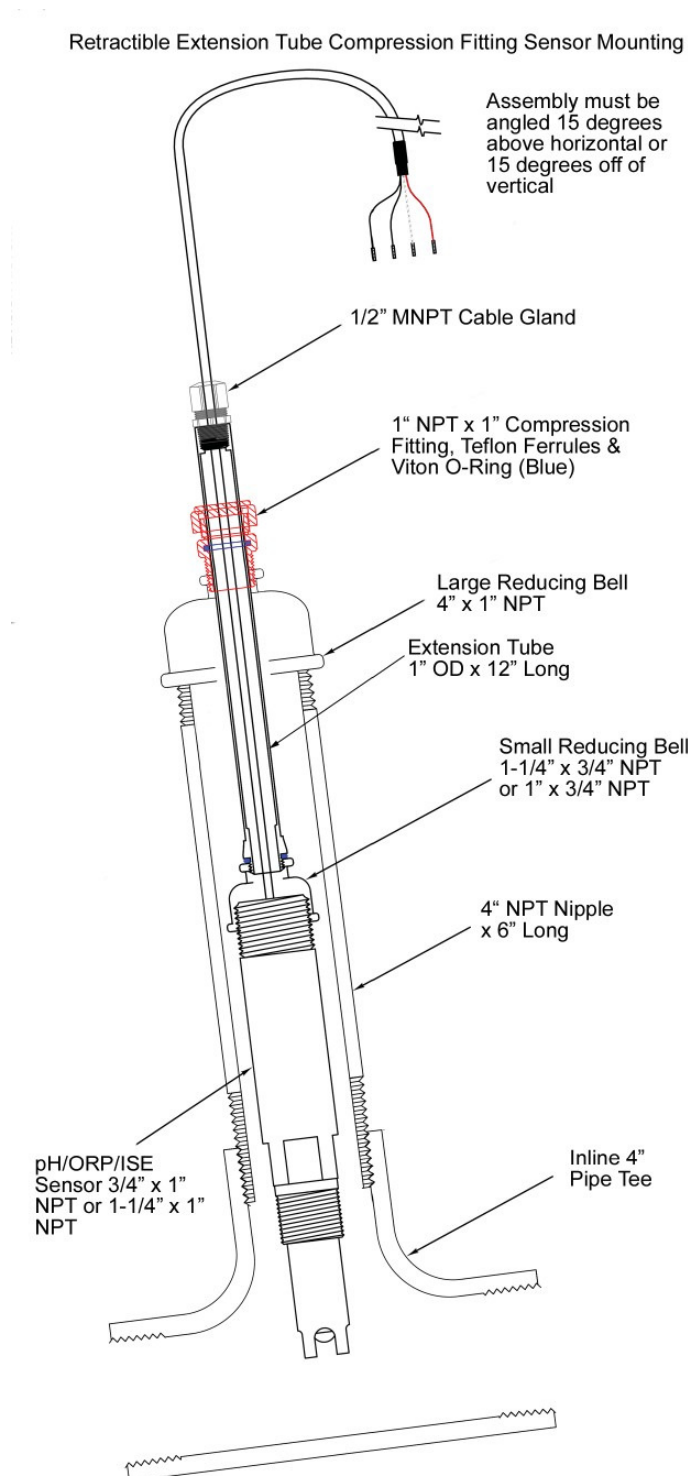
### 3.73 Installation (FX-300-FP Inline Flow Panel)



### 3 Installation

#### 3.74 Installation (Inline Compression Fitting Sensor Plumbing)

The retractable extension tube compression fitting mounting style is used to provide the proper sensor insertion depth into a 3" or larger pipe tee, similar to a full hot tap insertion mounting. Required components are shown below; pipe size is minimum 3".





### 3.74 Installation (Inline Compression Fitting Sensor Plumbing)

#### Sensor Extension Tube Assembly and Insertion

**NOTE: The inline compression fitting assembly must be installed at an angle as shown (Min 15 degrees above horizontal or 15 degrees off of the vertical)**

1. Keep the sensor tip protective cap on the sensor until ready to insert into the process.
2. Use Teflon tape to seal all NPT threads; do not seal the straight compression threads.
3. Assemble the extension tube to the 1-1/4" x 3/4" NPT small reducing bell, tighten firmly to compress the O-ring.
4. Slide the large reducing bell over the extension tube and against the small reducing bell.
5. Slide the stainless steel compression fitting onto the extension tube, tighten the 1" NPT threads into the large reducing bell and tighten the compression nut to keep the extension tube from slipping through the reducer bell during assembly.
6. Thread the sensor cable through the reducing bell and extension tube.
7. Thread the sensor cable through the cable gland, tighten the 1/2" NPT threads into the end of the extension tube and tighten. Tighten the compression cap with cord grip.
8. Connect the sensor cable to the transmitter in the main control unit per the appropriate wiring diagram for the sensor being used.
  - 8a. Note that wiring will vary depending on whether the sensor has an integral preamplifier, an external preamplifier, or no preamplifier.
9. Remove the sensor tip protective cap, and carefully insert the assembly into the pipe nipple and inline tee.
10. Tighten the large reducing bell onto the pipe nipple.
11. Loosen the compression cap on the extension tube, and slide the extension tube until the sensor tip is in the center of the inline tee.
12. Tighten the compression fitting cap on the extension tube.
13. Open the isolation / flow control valves to achieve 2 GPH flow rate.

## **3 Installation**

### 3.74 Installation (Inline Compression Fitting Sensor Plumbing)

#### **Sensor Extension Tube Assembly and Insertion**

14. Allow the sensor to reach electrochemical and thermal equilibrium.
15. Perform the 1-point offset calibration with a photometer or other analysis instrument.

#### **Sensor Removal:**

1. Close the isolation valves to prevent process fluoride from leaking after the large reducing bell is removed.
2. Loosen the nut on the compression fitting. This will reduce the compression from the ferrules. The special sealing O-Ring installed in the compression fitting will prevent any liquid from flowing back through during this step.
3. Slide back the extension tube until the small reducing bell stops against the large reducing bell. Tighten the nut on the compression fitting. This prevents the extension tube from moving accidentally. Failure to tighten the nut on the compression fitting (to reapply pressure from the ferrules) can result in the extension tube dropping and damaging the sensor.
4. Loosen the larger reducing bell from the process.
5. Clean, calibrate and/or replace the sensor that is installed onto the small reducing bell as may be required.

## 4 Start Up

### 4.0 Startup Overview

1. Mount the analyzer on the wall.
2. Install the sensor into the process fluid measuring tee/cell with water flow off.
3. Connect the sensor wires to the transmitter input terminals. Make sure that your ISE sensor is properly wired according to the schematic for "Sensors Without Preamplifiers" or "Sensors With Preamplifiers" depending the sensor type ordered.
4. Secure the signal wire to the wall or mounting panel with cable ties or in conduit to prevent movement which can affect readings.
5. Make electrical connections for current output and or alarm relays if needed.
6. Connect 3-wire 100 to 240 VAC 50/60 Hz power to the analyzer.
  - i) You may also connect to 3-wire 24VDC power if you have a dedicated (i.e. not shared with other equipment) 24VDC power supply available.
7. Verify electrical connections and apply power to the analyzer.
8. Verify the analyzer operating parameters have been set at the factory to suit your application. If needed configure the analyzer module(s)

### 4.1 Settings to check for systems with ISE modules only

- i) **For systems supplied with ISE measurement module (transmitter) only:**
  - (1) Make sure the operating range matches the needs of your process: Low (0-9.99 ppm); Mid (0-99.9) or High (0-999)
  - (2) Make sure the mA input of an external device you connect to matches the scaling of the transmitter's mA output.

### Startup Overview continued

#### 4.2 Settings to check for systems with alarm relay modules

##### ii) For systems supplied with the FX-300-REL alarm relay & control module:

- (1) Make sure the analog input (P03) on the REL module matches the analog output of the ISE module (P08). Selections are 0-20mA or 4-20 mA.
- (2) Make sure display mode (P06) on the REL module matches the output variable (P07) on the ISE module (factory set to ISE).
- (3) Make sure the ISE Output (operating) range (P09) of the ISE module matches the ISE input range (P07) of the REL module.
- (4) Enter the value for the 0/4mA input (P09) on the REL module to match the 0/4 mA output (P10) of the ISE module.
- (5) Enter the value for the 20mA input (P09) on the REL module to match the 20 mA output (P11) of the ISE module.
- (6) On the REL module set the type of limit for alarm limit 1: Hi (max), Lo (min). Default is Hi.
- (7) On the REL module set the type of limit for alarm limit 2: off, Hi (max), Lo (min). Default is Lo
- (8) On the REL module set the alarm trip point for each limit by using the limit buttons on the face of the module. First unlock the software. Return to run (input) mode, press the Mode button until Limit 1 LED lights, and use the up/down keys until the set point is displayed. Press Mode button to light the Limit 2 LED, and use the up/down keys to enter the set point. Press the Mode button to return to run mode. The software will lock automatically after 10 minutes.



## 4 Start Up

### Startup Overview continued

#### 4.2 Settings to check for systems with pH compensation module

##### iii) For systems supplied with the FX-300-TOT pH compensation and FX-300-pH modules:

The analyzer is preconfigured as much as possible in the factory and requires little field configuration. Make sure the following parameters match between the ISE, pH and TOT modules for them to work in unison. Note that this is not a complete list of parameters, other parameters may need configuration in each module. Refer to the section of this manual that pertains to the module of interest for a complete listing and description of configurations.

Parameter	ISE Par. No.	pH Par. No.	TOT Par. No.
ISE analog output (0-20mA, 4-20 mA) / TOT input	08		03
Free ISE range (Hi, Mi, Lo)	09		04
Scale 0/4 mA Free ISE output / TOT input	10		05
Scale 20 mA Free ISE output / TOT input	11		06
pH analog output (0-20mA, 4-20 mA) / TOT input		11	07
Scale 0/4 mA pH output / TOT input		13	08
Scale 20 mA pH output / TOT input		14	09
Temp. Compensation Mode (Default Auto / Man)	04	05	10
Temp. Compensation input (PT100, Default PT1000)	03	04	13
If a <u>2nd</u> pH, or ISE module installed, match its 0/40-20 mA analog output to	08	11	14
If a <u>2nd</u> pH or ISE module installed, match its measurement type (pH, ISE) to	07	10	15
If a <u>2nd</u> ISE module installed, match its operating range (Hi, Mi, Lo) to	09		16
If a <u>2nd</u> pH module installed, match its operating range (Hi, Mi, Lo) to		09	18
If a <u>2nd</u> pH or ISE module installed, scale 0/4mA output / TOT input	10	13	19
If a <u>2nd</u> pH or ISE module installed, scale 0/20mA output / TOT input	11	14	20
Type of TOTAL ISE output (0/4-20mA)	08	11	23
Scaling for 0/4-20mA TOTAL ISE output working range (Hi, Mi, Lo)	09		24
Scale TOTAL ISE 0/4mA output	10		25
Scale TOTAL ISE 20 mA output	11		26
Set pH Compensation mode (Default Auto)	04		27

**NOTE:** Additional settings may be required for the TOT module, see parameter list in the FX-300-TOT section of this manual

## 4 Start Up

### Startup Overview continued

9. Verify that water pressure will remain steady and not exceed 20 psig, and open the flow control valve or rotometer to start flow to the sensor.
10. Use both the flow control valve or rotometer and the backpressure valve to achieve a slow steady flow of about 2 GPH. The flow rate must not fluctuate to achieve valid results.
11. With the sensor in the process fluid, allow the sensor to reach electrochemical and thermal equilibrium. The time required varies by sensor and by application.
12. After the sensor has reached equilibrium and the readings have stabilized, perform the 1-point offset calibration to standardize the sensor with an approved grab sample analysis result. **DO NOT PERFORM A TWO POINT CALIBRATION WITH STANDARD SOLUTIONS FOR A NEW SENSOR INSTALLATION.**

**NOTE:** If no keys are pressed for 10 minutes the display will show a flashing bar indicating it is in Energy Save mode. Press any key to return normal display mode. To turn off energy saving mode and show a display continuously, go to parameter 18 and toggle to off.

### 4.3 OFL and UFL Error Codes

The flashing “OFL” means that an overflow issue exists on the input while a flashing “UFL” means that an underflow issue exists on the input. When this error exists you will not be able to perform any programming or configuration of the transmitter until the issue is resolved. The “OFL” or “UFL” condition can be due to a variety of possible causes which are summarized below:

#### POTENTIAL TEMPERATURE INPUT RELATED PROBLEMS

- A temperature element is not properly connected to the transmitter input board. Most electrochemical transmitters require a valid temperature input in order to operate properly.
  - Check that each of leads are firmly connected to the proper terminals per the wiring schematic
  - If no sensor is available or the sensor employed does not have a temperature compensation element, please use a 110 Ohm axial resistor to simulate a P100 TC input @ 25°C or a 1100 Ohm axial resistor to simulate a Pt1000TC input @ 25°C.
  - Check that the transmitter setting for the Pt100 or Pt1000 TC type matches the temperature element in the sensor.

#### POTENTIAL SIGNAL INPUT RELATED PROBLEMS

- The input signal value obtained from the connected sensor exceeds the lower or upper boundary limits possible for the input circuit. There are a variety of potential causes itemized below:
- Confirm that the proper type of sensor is being connected to the correct type of mating transmitter. For example: transmitters come in separate versions that are for use with sensors without integral preamplifiers and sensors that have integral preamplifiers.
- Leads are not secure or the color coding is not correct. Please refer to the documentation supplied in documentation with your shipment or contact the factory for assistance.
- The connected sensor is either damaged or expired. Connect a different known working sensor on the same transmitter to determine if the issue is with the input board or to the connected sensor.
- If you have gone through all of the troubleshooting steps and are still receiving the “OFL” or “UFL” error then most likely your input board has stopped working properly. Contact the factory.

## 5 Calibration

### 5.0 Calibration Notes

#### **DO NOT PERFORM A TWO POINT CALIBRATION WITH STANDARD SOLUTIONS FOR A NEW SENSOR INSTALLATION.**

All calibration solutions and process grab samples should be calibrated and tested at temperatures identical to the process temperature for optimal results. The actual temperature of the process solution (and thereby the calibrating solutions as well) is not as critical as the fact that they are calibrated at the same temperature to eliminate all potential sources of uncertainty.

For greatest overall accuracy of the fluoride (F-) measurement, however, all tests should be performed as close to 25 degrees Celsius (room temperature process solutions) as possible. The valid (permissible) temperature range for all fluoride ion selective sensors is five to fifty (5-50) degrees Celsius (41 to 122 degrees Fahrenheit).

Please note that accuracy is a function of the uncertainty of the instrument being used or compared to, the accuracy of standard solutions, and accuracy of the procedure used by the calibration technician.

A 1-point offset calibration will only be as accurate as the instrument used to analyze the grab sample and if performed promptly after making a grab sample determination.

Calibration solutions should be kept clean and out of direct sunlight and/or other high-energy radiation sources to maximize accuracy of their ppm values.

In 2-point calibration, Calibration Point 1 (always the lower concentration value and calibration solution) and Calibration Point 2 (always the higher concentration value and calibration solution) determines the response curve of a given fluoride ion selective sensor.

Before purchasing any commercial calibration solutions, be sure that they have a TISAB- II background and that their values will bracket your desired measurement range.

Since the fluoride transmitter has a 3-digit display, a 1,000 mg/L (ppm) calibration solution will only display as "999". It's suggested to use a "non-standard" solution of lower concentration in order to display 3 significant digits during calibration.

Many fluoride calibration solutions are commercially available from a variety of chemical supply houses. Be sure the solution is mixed or purchased premixed with TISAB II ionic strength adjusting buffer because it is more stable than TISAB III.

**NOTE:** *Be sure to rinse the sensor tip with distilled or deionized water and blot dry before placing the sensor into a different calibration standard.*

## 5 Calibration

### 5.0 Calibration Notes

There is a time averaging (dampen) function that is set in the FX-300-ISE at the factory. This value is configurable for both the extent of time averaging for the measure and calibrate modes separately. If you find that you wish to have more or less time averaging than what is provided on your unit at present, contact the factory for assistance with this. These values cannot be modified in the field but rather need to be changed at the factory. The preset values are fine for the vast majority of users and applications although they can be modified upon request without incurring any cost.

You can view the sensor slope resulting from a 2-point calibration with parameter P15 and the sensor offset resulting from a 2-point calibration with parameter P14. If you perform a 1-point grab sample offset subsequently the offset (P14) will change whereas the sensor slope (P15) will remain from your 2-point slope calibration.

All settings are stored in EEPROM so the unit can be powered down without loss of configuration or calibration. The 'hold' feature is automatically activated each time any 2-point or 1-point calibration is performed. This means that the last process value will continue to be sent via the analog 4-20mA and Modbus digital output before entering the calibration mode. This is the default behavior and can only be modified at the Foxcroft factory if this is not desired.

The decimal place on the display will automatically move as appropriate based upon the ppm value of the sensor reading. Note that the display will always auto-range from 0.00 to 9.99, 00.0 to 99.9 and 000 to 999 ppm. Your analog and digital Modbus output will, however, be defined as selected in parameter P09. This means that your output may be maxed out and not reflect the exact process reading if you selected too low a range for your output scaling in P09.

### 5.1 One-Point Offset Calibration

The 1-Point offset calibration is used to bring the ISE sensor into agreement with a grab sample analysis obtained by an alternate method to determine fluoride ion concentration. It is also used to adjust for occasional sensor drift.

It is not necessary to remove the sensor from service to perform a 1-point grab sample offset “Standardize” calibration.

Offset calibration simply requires the use of the Offset and UP / Down buttons only (after the software is unlocked), to enter the calibration result. It can be performed as often as desired. This is in most cases the only calibration required.

Please note that a 1-point offset calibration will only be as accurate as the instrument used to analyze the grab sample and if performed promptly after making a grab sample determination.

The grab sample should be analyzed in as timely a manner as possible for best results.

There are a variety of methods to perform the grab sample analysis. This includes portable photometers and laboratory fluoride ion selective electrode methods with the addition of TISAB-II to the unknown sample to adjust for all background ion effects.

When this method is used, it is typical to add the TISAB-II on a one to one volume basis to the unknown, and then to determine the fluoride concentration of this diluted sample. The actual fluoride concentration will then just simply be double the TISAB-II diluted unknown sample.

This grab sample determined concentration of the process sample (by whatever method employed) will then be entered into the analyzer as described below.

#### 1-point offset calibration procedure

1. With the sensor installed in service, allow at minimum 3-5 minutes for the sensor to display a stable reading with the process.
2. On the ISE module enter Setup and press the UP button to Parameter No. 01, which is a “software lock”. Toggle to ‘Off’ using the up or down key.
3. Exit Setup by pressing the down button to parameter P00, then press Mode.
4. Use the ‘Mode’ key to select ‘OFFSET’.
5. Use the Up/Down keys to adjust the displayed reading until the display shows the correct value in accordance with the concentration determined by the grab sample analysis.

**NOTE:** If your system includes the FX-300-TOT module that provides a pH compensated total unbound ion measurement, enter the calibration value by pressing the keys on the ISE module until the display on the FX-300-TOT module displays the correct reading.

6. Press the “Mode” button to return to PPM (run) mode.

### 5.2 First Time Calibration for Systems with pH Compensation

If your system includes the FX-300-TOT module that provides a pH compensated total unbound ion measurement, you must first ensure the temperature displayed on the ISE, pH and TOT modules are the same.

To check simply press the Mode button on each module to display the temperature measured by the sensor's integral temperature element.

#### 1 - Point offset calibration procedure for Systems with pH Compensation

1. If you need to calibrate the temperature you should start with the module that shares its temperature input with the FX-300-TOT module. As standard the temperature input to the pH module is shared or spliced with the TOT module.
2. To calibrate the temperature:
  - a. Unlock the software: Use the Mode button to enter Setup, press the Up button to parameter P01, press Mode, and press the Up button to unlock the software.
  - b. Press the down button to parameter P01 and press Mode to return to Run mode.
  - c. Press the Mode button again enter temperature display the "°C" LED will light.
  - d. Use the up / down keys to enter the desired temperature value.
  - e. Press the Mode button until ppm LED is lit indicating run mode.
3. Calibrate the temperature in the remaining measurement module(s).
4. You must also make sure your pH sensor responds properly or has been calibrated before calibrating the ISE sensor.
5. To enter the calibration value from your grab sample determination use the keys on the ISE module until the display on the FX-300-TOT module displays the correct reading.

See the notes on pH sensor calibration and solutions after the calibration instructions below. For complete details refer to the FX-300-pH section later in this manual

### 5.3 Two-Point Slope Calibration

**We do not recommend 2-point slope field calibration for new sensor installations; for most if not all applications the factory set slope will provide the best results.**

**The 2-point calibration should only be done when the sensor begins to lose response or sensitivity. The 1-point offset is the only calibration required on a regular basis.**

**Performing calibration with fluoride standards will not get the inline installation dialed-in. This can only be done with a proper grab sample offset calibration.**

The 2-point calibration determines the sensitivity or slope of each sensor, which is then stored in the analyzer.

The 'hold' feature is automatically activated each time any 2-point or 1-point calibration is performed. This means that the last process value will continue to be sent via the analog 4-20mA and Modbus digital output before entering the calibration mode. This is the default behavior and can only be modified at the Foxcroft factory if this is not desired.

For a 2-point calibration you will need:

- A clean sensor. Please refer to the cleaning procedure in the previous section.
- A 250 ml glass or plastic beaker that is heavy enough to prevent the sensor from tipping the beaker over.
- Low Fluoride Standard Solution (low ppm) mixed with TISAB II total ionic strength adjusting buffer
- High Fluoride Standard Solution (high ppm) mixed with TISAB II total ionic strength adjusting buffer

**NOTE:**

- *The calibration solutions need to be at least 1 decade (10 times) apart.*
- *Always use the more stable TISAB II rather than TISAB III total ionic strength adjusting buffer for both self prepared and premixed solutions purchased from a lab supply company.*
- *Since the fluoride transmitter has a 3-digit display, a 1,000 mg/L (ppm) calibration solution will only display as "999". It's suggested to use a "non-standard" solution of lower concentration in order to display 3 significant digits during calibration.*

If you wish to make your own calibration solutions instructions to do so are below.

**NOTE:** If your system includes the FX-300-TOT module that provides a pH compensated total unbound ion measurement, you must first ensure the temperature matches between the ISE, pH and TOT modules, and you must also calibrate your pH sensor if needed. To enter the calibration value use the keys on the ISE module until the display on the FX-300-TOT module displays the correct reading.

## 5 Calibration

### 5.4 2-point slope calibration procedure

We do not recommend 2-point slope field calibration for new sensor installations; for most if not all applications the factory set slope will provide the best results.

The 2-point calibration should only be done when the sensor begins to lose response or sensitivity. The 1-point offset is the only calibration required on a regular basis.

Performing calibration with fluoride standards will not get the inline installation dialed-in. This can only be done with a proper grab sample offset calibration.

**NOTE:** Always use the more stable TISAB II rather than TISAB III total ionic strength adjusting buffer for both self prepared and premixed solutions purchased from a lab supply company.

1. Fill a 250 ml beaker with enough standardization solution so that the entire tip of the Fluoride sensor will be submersed.
2. Place the sensor into the first low ppm ISE standard solution.
3. Allow a minimum of 3 – 5 minutes for the sensor to stabilize once it has been removed from the process and placed into the low standard solution (low ppm).
4. Parameter No. 01 is a “lock” that must be set to ‘Off’ to change ANY parameter, including the temperature, offset and slope calibrations.
5. Press the ‘Mode’ key to select ‘Offset’.
6. Adjust the reading using the Up/Down keys until the display shows the correct value for the first low ppm ISE solution standard.
7. When done press the “Mode” key until the PPM (Run) mode indicator lights, indicating the run mode.
8. Rinse the sensor in distilled or deionized water, blot dry with a paper towel and place the sensor into the second high ppm ISE standard solution.
9. Allow a minimum of 3 – 5 minutes for the sensor to stabilize between the low and high Calibration Solutions (low ppm to high ppm).
10. Press the “Mode” key to select SLOPE.
11. Use the Up/Down keys until the display reads the second desired value for the second high ppm ISE solution standard.
12. Press the “Mode” key until the PPM (Run) mode indicator lights, indicating the run mode.
13. **CAUTION:** When finished you must verify that your calibration has resulted in a slope (parameter #15) that is at or near the default fluoride slope of -57.2. If it is not the calibration was not performed correctly; either re-calibrate or re-set the transmitter back to the default slope of negative 57.2 using parameter #15.
14. **CAUTION:** Before returning the calibrated sensor into service you must perform the 1-point offset calibration to ensure agreement with grab sample analysis.



## 5 Calibration

### 5.5 How to prepare a fluoride standard solution

We do not recommend 2-point slope field calibration for new sensor installations; for most if not all applications the factory set slope will provide the best results.

The 2-point calibration should only be done when the sensor begins to lose response or sensitivity. The 1-point offset is the only calibration required on a regular basis.

Performing calibration with fluoride standards will not get the inline installation dialed-in. This can only be done with a proper grab sample offset calibration.

#### Materials

- Sodium fluoride (Analytical or ACS Reagent Grade or better, brand new sealed dry bottle preferred)
- TISABII (Total Ionic Strength Adjustor Buffer)
- 1L volumetric flask (one each minimum, four each recommended)
- 5L volumetric flask (one each) or 2L volumetric flask (two each)
- 1ml volumetric pipette
- 10ml volumetric pipette
- 1L opaque plastic bottles with air-tight sealing cap (five each)
- DI water (15mΩ or higher resistivity grade recommended but not critical)

**NOTES:** *Ensure that all glassware is clean and dry before proceeding.*

- *Thoroughly clean volumetric flasks after preparing any solution with distilled or deionized water.*
- *Solution prepared from this procedure will stay good for 1 year from date of manufacture if stored in a sealed, opaque plastic bottle in a cool, dry location.*
- *Always use the more stable TISAB II rather than TISAB III total ionic strength adjusting buffer for both self prepared and premixed solutions purchased from a lab supply company.*
- *Since the fluoride transmitter has a 3-digit display, a 1,000 mg/L (ppm) calibration solution will only display as “999”. It’s suggested to use a “non-standard” solution of lower concentration in order to display 3 significant digits during calibration.*

#### Stock solution preparation procedures

Preparation of diluted TISAB II background stock solution (DO THIS FIRST)

1. Measure out 2L of TISAB II solution and pour into a 5L volumetric flask.
2. Dilute with distilled or deionized water to 5L mark. Mix solution well until all the two solutions are completely miscible and the resulting solution is homogenous.
3. Seal 5L volumetric flask with glass stopper.

Preparation of 10,000ppm fluoride stock solution (DO THIS FIRST)

1. Measure out 22.101g of sodium fluoride salt.
2. Place this sodium chloride salt into 1L volumetric flask.
3. Dilute with distilled or deionized water to 1L mark. Mix solution well until it is completely homogenous (dissolved).
4. Transfer this 10,000ppm fluoride stock solution to a 1L plastic bottle and label appropriately.

## 5 Calibration

### 5.5 How to Prepare a Fluoride Standard Solution

Fluoride calibration solution preparation procedures

#### Preparation of 10ppm sodium fluoride standard ion solution

1. Draw 1ml of 10,000ppm fluoride stock solution and transfer to a 1L volumetric flask.
2. Dilute with TISAB II diluted background solution to 1L mark. Mix solution well until completely homogenous.
3. Transfer this 10ppm fluoride calibration solution to a 1L plastic bottle and label appropriately.

#### Preparation of 100ppm sodium fluoride standard ion solution

1. Draw 10ml of 10,000ppm fluoride stock solution and transfer to a 1L volumetric flask.
2. Dilute with TISAB II diluted background solution to 1L mark. Mix solution well until completely homogenous.
3. Transfer this 100ppm fluoride calibration solution to a 1L plastic bottle and label appropriately.

#### Preparation of 20ppm sodium fluoride standard ion solution

1. Draw 2ml of 10,000ppm fluoride stock solution and transfer to a 1L volumetric flask.
2. Dilute with TISAB II diluted background solution to 1L mark. Mix solution well until completely homogenous.
3. Transfer this 20ppm fluoride calibration solution to a 1L plastic bottle and label appropriately.

#### Preparation of 200ppm sodium fluoride standard ion solution

1. Draw 20ml of 10,000ppm fluoride stock solution and transfer to a 1L volumetric flask.
2. Dilute with TISAB II diluted background solution to 1L mark. Mix solution well until completely homogenous.
3. Transfer this 200ppm fluoride calibration solution to a 1L plastic bottle and label appropriately.

### 5.6 Notes on pH Sensor Calibration

**NOTE:** Calibrating a pH sensor when it is not at thermal equilibrium is a very common cause of calibration error. The temperature indicated for the sensor (press Mode button on the pH transmitter until °C LED is lit) can be used as a gauge of when it is ready to proceed with a calibration having reached a thermal equilibrium.

#### pH Buffer Accuracy & Stability Issues

Some pH buffers degrade in quality quite quickly when left open to air, or else with exposure to heat and/or light. In particular, both pH buffer 7.00 and 10.00 are notorious about losing their values when exposed to the air, sunlight or just simply degrade with time. One simple procedure is to be sure to check whether your buffers employed are still within the expiry period. In contrast, the 4.01 pH buffer is a well known VERY stable pH buffer and so is the industry default standard for conditioning and 1-point tests for pH sensors.

The 6.86 and 9.18 pH buffers are amongst the most stable high pH buffers available. We strongly recommend purchasing colorless pH buffers. In particular, if colored pH buffers are used for calibrations, please be sure that they are NOT also used as the conditioning solution in which pH sensors are stored. For higher value pH buffers (10+) buy in small amounts (to ensure that they stay in code) and keep them stored in a sealed container (make sure that the cap is on tight) in a cool, dry place. These higher value pH buffers are notoriously very unstable, much as the low pH buffers also tend to be rather unstable. For your reference, the MOST stable pH buffers are 4.01 and 6.86 and to a lesser degree 9.18. These are the typical pH buffers used in Europe and by research chemists here in the US.

pH BUFFER DURING CALIBRATION NOTE: Since the pH transmitter does not automatically correct for the temperature effects on your particular pH buffer, you will need to manually enter the correct buffer pH value at your particular temperature manually to ensure optimum accuracy during the calibration step. Each pH buffer solution is always labeled with the pH value at various temperatures so that you can adjust the pH value to the appropriate number. Please note that temperature compensation does NOT account for the change in the pH buffer values with temperature (this must be done manually).

#### 1-Point Offset Calibration:

1. First unlock the software.
  - a. Press MODE button until the "Setup" LED is lit to enter "Setup".
  - b. Press the Up button to parameter P01, press Up button until OFF is displayed to unlock the software and permit changes
2. Return to Run mode by pressing MODE button, then press the down button until parameter P00 is displayed, press Mode again to return to PPM (Run) mode.
3. Perform offset calibration (enter the grab sample reading promptly):
  - a. Press MODE until Offset LED is illuminated.
  - b. Use the up down keys to enter the grab sample value.
  - c. Press MODE until the PPM (run mode) LED is illuminated to display the readings being monitored and or recorded.
4. The software will lock automatically after several minutes.

### 5.6 Notes on pH Sensor Calibration

#### Performing the Two Point Slope Calibration

For optimal results all calibration solutions and process grab samples should be calibrated and tested at temperatures identical to the process temperature. The actual temperature of the process solution (and thereby the calibrating solutions as well) is not as critical as the fact that they are calibrated at the same temperature to eliminate all potential sources of uncertainty.

Calibration solutions should be fresh, kept clean, and stored in a cool, dry place out of direct sunlight and/or other high-energy radiation sources to maximize accuracy of their values.

Always rinse the sensor with distilled or deionized water and gently blot dry with a soft lint free cloth before placing the sensor into a different buffer solution during calibration.

To calibrate you will need:

A *clean* sensor. Please refer to the cleaning procedure in the previous section.  
A 250 ml glass or plastic beaker that is heavy enough to prevent the sensor from tipping the beaker.

High pH buffer solution  
Low pH buffer solution  
Distilled or deionized water  
A soft lint free cloth

1. Fill a 250 ml beaker with enough high buffer solution so that the entire tip of the pH sensor will be submersed.
  - i. **NOTE: For 2-point calibration always start with the high buffer solution first.**
2. Allow a minimum of 3 – 5 minutes for the sensor to stabilize in the high buffer solution. The time to reach electrochemical and thermal equilibrium may take several hours in some cases.
  - i. **NOTE:** Do not to move or touch the cable while a value is being stabilized.  
Touching the sensor cable can cause a noisy signal that may result in erroneous values and calibrations.
3. With a stable reading displayed, press the “Mode” key until the SETUP indicator lights.
4. Press the Down key to select parameter P01, LOCK. Use the Up/Down key to turn software lock to “OFF”. Select by pressing the Mode key.
5. Press the Down key until P00 is displayed, pres Mode to exit SETUP.
6. Press the Mode key until the BUFFER indicator lights. This is the high buffer calibration mode. Press the Up/Down key as required to enter the calibration solution pH value.
7. Rinse the sensor with distilled or deionized water and blot dry with a soft lint free cloth before placing it into the low buffer solution.
8. Press the Mode key until the SLOPE indicator lights. This is the low buffer calibration mode. Press the Up/Down key as required to enter the calibration solution pH value.
9. Press the Mode key until the pH indicator lights. This is the run mode.

NOTE: There is no need to go back and turn the software lock to ON, it will revert to this mode automatically after a period of time.

## 6 Sensor Maintenance & Cleaning

### 6.0 Fluoride Sensor Maintenance & Cleaning

No maintenance is required other than cleaning the sensor. The sensor is sealed, as such there is no need or means to add electrolyte.

For the best lifetime possible you will need to perform regular periodic cleaning and maintenance. The frequency of cleaning will depend on the quality of the process water and the buildup of process deposits on the probe tip.

The fluoride ( $F^-$ ) sensor should also be cleaned when transferring a sensor in or out of solution; before being placed into standard solutions with different concentrations, or before a 2-point calibration is performed.

If no contamination or buildup is evident the simple rinsing procedure can be used. Cleaning is only required if the ISE membrane or reference junction appears to be fouled.

**NOTE:** *Any noticeable deposits on the tip of the sensor will result in a less accurate calibration and measurement.*

#### **CAUTION: DO NOT SCRATCH THE SENSING ELEMENT**

#### **6.1 Cleaning Procedure for High pH & Drinking Water Applications**

##### Rinsing Only Procedure

1. Thoroughly rinse the sensor tip with distilled or deionized (DI) water. Gently blot the sensor tip dry. Be careful not to scratch or damage the sensitive fluoride ion selective membrane.

##### Cleaning Procedure

1. Thoroughly rinse the sensor tip with distilled or deionized water. Gently blot the sensor tip dry. Be careful not to scratch or damage the sensitive fluoride ion selective membrane.
2. The fluoride sensor tip can be cleaned with isopropyl alcohol to remove any oily or waxy build-up. No other solvents or reagents should be used without contacting the factory to ensure that it is suitable.
3. Scrape the entire reference area clean with a sharp blade or Stanley knife. This reference is solid-state and cannot be damaged with ordinary cleaning techniques.
4. Once the reference junction has been cleaned the entire sensor tip can be soaked in either the low or high standardization solution. Allow about 5 minutes for conditioning before performing a 2-point calibration.

**NOTE:** *Do not allow the sensor to be exposed to air for prolonged periods of time, this will cause the reference junction to become dehydrated. Always store the sensor in standardization solution when the sensor is not in service.*

## 6 Sensor Maintenance & Cleaning

### 6.2 Cleaning Procedure for Low pH Applications, Etching Baths and First-Stage and Batch Wastewater Fluoride Treatment Systems

**CAUTION:** The following procedure applies only to Foxcroft series “SFL” fluoride sensors that are designed to operate in 0-6 pH solutions and to withstand acid cleaning. Cleaning any other fluoride sensor with this procedure will destroy the sensor and will not be replaceable under warranty. If you are unsure of the correct cleaning procedure to follow for your sensor please contact the factory for assistance.

Due to the nature of treating acid fluoride waste (often with calcium chloride –  $\text{CaCl}_2$  – or calcium hydroxide –  $\text{Ca}(\text{OH})_2$  –) there can be a rather substantial build-up of insoluble solids that must be removed from the sensor. This is only possible by performing strong acid cleaning and also possibly by mechanically cleaning, depending on the thickness of the build-up. A typical example is the removal of calcium fluoride ( $\text{CaF}_2$ ) or fluorosilicates by means of strong hydrochloric acid ( $\text{HCl}$ ) cleaning media.

To achieve the best sensor lifetime possible it is necessary to perform regular periodic cleaning and maintenance. The frequency will be defined by the nature of the installation and operations at the site. You can never let an installation go too long without any maintenance or with very infrequent cleaning and expect good results.

For mechanical cleaning, care must always be taken not to damage the measurement elements (be it the pH glass or the fluoride ISE crystal).

#### **Cleaning Procedure for Low pH Applications**

1. Begin by soaking the sensor in a hydrochloric acid ( $\text{HCl}$ ) solution. The strength of the solution required will vary with the degree of build-up. Start with a 5%  $\text{HCl}$  solution, and increase up to 15% if necessary.
2. If the deposit is removed successfully, rinse with deionized water and gently blot dry.
3. If the deposit remains, rinse with deionized water and gently blot dry.
4. Scrape the entire reference area clean with a sharp razor blade or Stanley knife. The reference is the surface surrounding the fluoride crystal/membrane, it is solid-state and cannot be damaged with ordinary cleaning techniques. **Do not scratch the membrane.**
5. Once the reference junction has been cleaned, rinse with deionized water. The entire sensor tip should then be soaked for about 5 minutes in either the low or high standardization solution before proceeding to perform a 2-point calibration.

If the deposits cannot be removed by soaking or mechanical cleaning the sensor must be replaced.



## 7 Sensor Specifications

### Fluoride Sensor Specifications

#### FX-300 Integrated Fluoride Ion Selective Sensor Specifications For High pH Service

**Part number:** SF-66-CP-10

3/4"- 3/4" MNPT Integrated, Fluoride Ion Selective Sensor for use in high pH Applications

**Recommended Applications:** Fluoride ion concentration in aqueous solution from drinking water through waste water. Not suitable for use in etching solutions. See Acceptable pH Range

**Special Features:** Crosslinked polymer in the reference system is resistant to heat, solvents and to most chemicals. Sensor holds an excess of KCl, assuring saturation at all temperatures and extending the life of the sensor.

The ion sensitive part of the sensor is designed to resist the attack of acids, typically used in fluoride etching processes.

The construction of the sensor permits easy access to the sensing and reference surfaces for cleaning or inspection.

**General Specifications:**

Concentration Range: 1 to  $10^{-6}$  Molar, 19,000 to 0.019 ppm

Lowest Limit of Detection:  $5 \times 10^{-8}$  Molar, .001 ppm

pH Range: 5.5 to 9.5 pH (continuous)

Temperature Range: 5 to 50° C

Pressure Range: 1 to 20 psig (6.9 to 138 kPag)

Body Material: CPVC (Chlorinated-Polyvinyl-Chloride)

Junction Material: Kynar (Poly-Vinylidene-Fluoride)

Cable: RG 174/U Coaxial (without preamplifier)

Connector: BNC (unless otherwise specified)

**Ion Sensor Specifications:**

Measuring Membrane: Selective Fluoride Sensitive Membrane (solid state)

Dimensions: 0.310, (7.8 mm)

DIA

Initial Impedance: Less than 100 M Ohms @ 25° C

Interfering Ions:

Given in Ratios of Permissible Excess:

OH-  
above  
12.0 pH

Interfering Ion / Measured Ion (in Molarity):

**Reference System Specifications:**

Type:

Double

Junction

Reference Half Cell: Ag/AgCl, Saturated

KCl

Primary Junction: Porous Ceramic, Saturated KCl in crosslinked polymer

Secondary Junction: Porous Kynar, Saturated with KCl in crosslinked polymer

Surface Area: 366,000 mil<sup>2</sup>, (236 mm<sup>2</sup>)

Storage and Shelf Life: At room temperature with closed protector cap, 1 year from date of manufacture.

Standard Hook-Up Options:

No Preamp - BNC Connector + TC lead wires

With Preamp – Multiconductor Lead Wires – See Hook Up Schematics

## 7 Sensor Specifications

### Fluoride Sensor Specifications

#### FX-300 Integrated Fluoride Ion Selective Sensor Specifications Twist Lock Mounting

**Part**

**Number:** SF-8T-UL-10

1" MNPT Twist Lock Immersion Integrated, Fluoride Ion Selective Sensor for use in high pH Applications

**Recommended Applications:** Fluoride ion concentration in aqueous solution from drinking water through waste water. Not suitable for use in etching solutions.

**Special Features:** Crosslinked polymer in the reference system is resistant to heat, solvents and to most chemicals. Sensor holds an excess of KCl, assuring saturation at all temperatures and extending the life of the sensor.

The construction of the sensor permits easy access to the sensing and reference surfaces for cleaning or inspection.

**General Specifications:**

Concentration 1 to  $10^{-6}$  Molar, 19,000 to

Range: 0.019 ppm

Lowest Limit of Detection  $5 \times 10^{-8}$  Molar, .001 ppm

pH Range: 5.5 to 9.5 pH (continuous), intermittent up to 11 pH with measuring crystal degradation

Temperature

Range: 5 to 50 °C

Fast Temp PT1000 for  
variable temperature  
conditions

Temperature Compensation:

Pressure

Range: 1 to 20 psig (6.9 to 138 kPag)

Body

Material: Ultem (Poly-Ether-Imide)

Junction

Material: Kynar (Poly-Vinylidene-Fluoride)

Cable: RG 174/U Coaxial (without preamplifier)

Connector: BNC (unless otherwise  
specified)

**Ion Sensor Specifications:**

Measuring Membrane: Selective Fluoride Sensitive  
Membrane (solid state)

Dimensions: 0.310", (7.8 mm) DIA

Initial

Impedance: Less than 100 M Ohms @ 25 °C

Interfering Ions in Ratios of Permissible Excess:

Interfering Ion / Measured Ion (in OH- above 12.0  
Molarity): pH

**Reference System Specifications:**

Type: Double

Junction

Reference Half Cell: Ag/AgCl, Saturated  
KCl

Primary Junction: Porous Ceramic, Saturated KCl in  
crosslinked polymer

Secondary Junction: Porous Kynar, Saturated with KCl  
in crosslinked polymer

Surface Area: 366,000 mil<sup>2</sup>, (236 mm<sup>2</sup>)

Storage and Shelf Life: 1 year from date of manufacture at room temperature with protective cap on

## 7 Sensor Specifications

### Fluoride Sensor Specifications

#### FX-300 Integrated Fluoride Ion Selective Sensor Specifications For Low pH Service Applications & Acid Cleaning

**Part number:** SFL-8U-UL-G-10

1" x 1-1/4" MNPT Integrated, Fluoride Ion Selective Sensor for use in low pH applications, submersible or insertion mounting recommended. Not for inline mounting.

**Recommended Applications:** Specially designed for Fluoride ion concentration in continuous low pH solutions from 0.0 - 11pH. Wastewater treatment of acid fluoride solutions for etching metal, glass, and silicon wafers. Applications requiring strong acid cleaning for  $\text{CaF}_2$  buildup removal

**Special Features:** Crosslinked polymer in the reference system is resistant to heat, solvents and to most chemicals. Sensor holds an excess of KCl, assuring saturation at all temperatures and extending the life of the sensor.

The ion sensitive part of the sensor is designed to resist the attack of acids, typically used in fluoride etching processes.

The construction of the sensor permits easy access to the sensing and reference surfaces for cleaning or inspection.

**General Specifications:**

Concentration Range: 1 to  $10^{-6}$  Molar, 19,000 to 0.019 ppm

Lowest Limit of Detection  $5 \times 10^{-8}$  Molar, .001 ppm

pH Range: 0 to 11 pH (continuous)

Temperature Range: 5 to 50 ° C

Pressure Range: 1 to 20 psig (6.9 to 138 kPag)

Body Material: CPVC (Chlorinated-Polyvinyl-Chloride)

Junction Material: Kynar (Poly-Vinylidene-Fluoride)

Cable: RG 174/U Coaxial (without preamplifier)

Connector: BNC (unless otherwise specified)

**Ion Sensor Specifications:**

Measuring Membrane: Selective Fluoride Sensitive Membrane (solid state)

Dimensions: 0.310, (7.8 mm) DIA

Initial Impedance: Less than 100 M Ohms @ 25 ° C

Interfering Ions:

Given in Ratios of Permissible Excess:

OH-  
above  
12.0 pH

Interfering Ion / Measured Ion (in Molarity):

**Reference System Specifications:**

Type: Double  
Junction

Reference Half Cell: Ag/AgCl,  
Saturated KCl

Primary Junction: Porous Ceramic, Saturated KCl in crosslinked polymer

Secondary Junction: Porous Kynar, Saturated with KCl in crosslinked polymer

Surface Area: 400,000  $\text{mil}^2$ , (236  
 $\text{mm}^2$ )

Storage and Shelf Life: At room temperature with closed protector cap, 1 year from date of manufacture

## 8 Additional Measurement & Function Modules

If you wish to install additional measurement modules or modules to provide additional function, please refer to the following guides on the product information and wiring schematics of these modules.

Additional modules include:

**Section 8 FX-300-pH/ORP:** pH, ORP/mV and Temperature Transmitter with fully scalable 0/4-20mA output and Modbus (optional)

**Section 9 FX-300-CON:** Contacting Conductivity Transmitter with fully scalable 0/4-20mA output and Modbus (optional)

**Section 10 FX-300-REL:** Alarm & relay controller (On/Off, TPC, PFC) for pH/ORP, ISE & Conductivity measurement modules

**Section 11 FX-300-TOT:** Computes pH compensated “Total ISE” from ISE, temperature & pH analog inputs. It provides 0/4- 20mA analog output of the total ISE measurement and digital RS485 Modbus output of all sensor inputs and outputs.

#### 8 FX-300-pH/ORP 3-Wire pH/ORP/mV/Temperature Transmitter

- The FX-300-pH/ORP is an analyzer for pH, ORP, mV and Temperature Measurement
- Data Ranges: 0-14pH,  $\pm 1000$ mV, 0-210 °C
- pH/ORP sensor with or without preamplifier support (300 feet max w/preamp)
- 2-Point Slope calibrations use the same slope in acidic and alkaline ranges
- When 3-Point Slope Calibration Configuration is enabled a separate slope can be calibrated for acidic ranges (0-7 pH) and alkaline ranges (7-14 pH) for the utmost accuracy
- 1-Point Offset Calibration provides a quick calibration with single pH buffer or to allow for agreement between laboratory pH measurements
- Temperature compensation via Platinum 100 or 1000 Ohm element
- 3-Digit display of pH/mV or temperature
- Fully Scalable Analog Output 0-20 mA or 4-20 mA for pH/mV or temperature
- Galvanic isolation between sensor input, power & analog output (3000V rating)
- Optional: Serial communication via RS-485 Modbus digital output
- NEMA 4X enclosures supporting up to 4 or 8 each pH/ORP/ISE or conductivity transmitters

#### Programming

The module is programmed by use of 3 keys located on the front panel. The 'Mode' key is used for selecting setup and the 'Up' or 'Down' keys are used to scroll through the parameters. The parameter to be altered is selected with the 'Mode' key and the value is changed using the 'Up' or 'Down' keys. **Parameter No. 01 is a "lock" which must be set to 'Off' to change ANY parameter, including the temperature, offset and slope calibrations.**

To exit the SETUP mode, press the 'down' button until parameter P00 is displayed, then press 'mode' to return to the pH (run) mode.

#### Input

The pH/ORP sensor without a preamplifier is connected directly to FX-300-pH transmitter. The mV signal from these sensors are processed by an integrated high impedance amplifier before entering the microprocessor. Alternatively, the FX-300-pH-X hardware version can support external preamplifiers to enable installations that require long cable lengths or to operate in very high interference areas. Temperature measurement is accomplished with a 2-wire Pt100/Pt1000 temperature sensor and then temperature compensation performed by the built-in microprocessor.

#### Analog Output

The FX-300-pH transmitter (module) has a scalable analog output of either 0-20 mA or 4-20 mA (selectable). The minimum pH range between the low (0mA or 4mA) and high (20mA) output is 1 pH unit with the default as 0 pH at 0mA or 4mA and 14pH at 20 mA. The output is proportional to pH/mV or Temperature and is galvanic insulated from the inputs.

**pH Module Function and Programming****Modbus (Optional)**

Acquired data is transferred using the Modbus standard for multidrop communication. The units are connected using the RS485 system. The Modbus-master may be the FX-300- DAT 'Dat' module or a SCADA system with installed software for Modbus. Parameter 02 is used to set the address of the module to 'Off' or 1 to 247.

**Transmitter Specifications****Mechanical**

Housing	Lexan UL94V-0 (Upper Part) Noryl UL94V-0
Mounting	M36 for 35mm DIN rail
IP Class	Housing IP40. Connector IP20
Connector	Max 16A. Max 2.5mm <sup>2</sup> . Max torque 0.6 Nm
Temperature	-15 to +50 °C
Weight	75 grams (2.64 ounces)
Dimensions	D 58 x W36 x H86 mm (2.3" x 1.4" x 3.4")
CE mark	EN61326A

**Electrical**

Power supply	24VDC +/- 10%
Consumption	60mA max
Sensor	Combination sensor
pH/mV range	0-14pH, +/-1000mV
ph input accuracy	< 1pA, >10GΩ
Temperature sensor	Pt100, Pt1000
Temperature range	0-210°C +/- 0.3°C
Compensation	Fixed (Manual) or Automatic using Temperature (TC) Measurement
Analog output	0-20mA or 4-20mA, max 250Ω



## pH Module Function and Programming

The 23 programmable parameters are shown to the right. For access see the programming section of this manual. If the software lock (Par. no. 1, below) is “On” the parameter can only be read. Set Software Lock to “Off” to change values.

- Par. no. 2** sets the module's address for Modbus communication.
- Par. no. 3** indicates the type of input for the pH/mV input.
- Par. no. 4** indicates the type of input for the temperature input.
- Par. no. 5** If Par. no. 3 is set to pH, the signal is temperature compensated. Par. no. 5 sets the temperature compensation to either set (manual) or based on the measured temperature.
- Par. no. 6** sets the temperature for when temperature compensation of the pH measurement is in set (manual mode).
- Par. no. 7** If a long cable is used for the Pt100 sensor the cable impedance should be entered and compensated for this offset.
- Par. no. 8** is used to set how the pH sensor slope is calibrated. If 3-Point Slope Option is (On), the sensor is calibrated to have two different slope for the acidic pH range (i.e. between 6.86/7.00 and 4.01 buffers) and the alkaline pH range (i.e. between 6.86/7.00 and 9.18/10.00). If 3-Point Slope Option is (Off), the slope from a single slope calibration will be used in all pH ranges (0-14).
- Par. no. 9** If Par.no. 3 is set to mV, the range is set using this parameter. It is possible to select the whole range ( $\pm 1000\text{mV}$ ), the negative range ( $-1000\text{--}0\text{mV}$ ) or the positive range ( $0\text{--}1000\text{mV}$ ). This setting impacts the analog output and transferred data.
- Par. no. 10** is used to set the analog output proportional to either the pH/mV signal or the temperature signal.
- Par. no. 11** sets the analog output to either 0-20 mA or 4-20 mA.
- Par. no. 12** allows setting the output to be inverted (i.e. for use in control) with the output corresponding to 20-0mA or 20-4mA.
- Par. no. 13** are used to set the pH value that corresponds to 0/4mA output setpoint (Par
- and 14** no. 13) and sets the pH value that corresponds to 20mA output setpoint (Par no. 14). The minimum difference between Par no. 13 and 14 must be at least 1.0 pH unit although it is fully scalable without the ranges specified.
- Par. no. 15** Variable to define the mV change for each “Up” or “Down” button depression when calibration is performed.
- Par. no. 16** View & edit working sensor offset (Abs mV at pH 7)
- Par. no. 17** View & edit working sensor slope 1. If P08 is OFF (default) then slope for full 0-14 range. If P08 is ON (3-Point Cal / Dual Slope mode) then this is the slope for 0-7 pH range.
- Par. no. 18** View & edit working sensor slope 2 for 7-14 pH range. This is valid only if P08 is ON, or else just blank “---” no value.
- Par. no. 19** Offset adjustment for 0/4mA low analog output trim.
- Par. no. 20** Gain adjustment for 20mA high analog output trim.
- Par. no. 21** If no keys are pressed for 10 minutes the display will show a flashing bar (Energy Save). Pressing any key to return.
- Par. no. 22** The Modbus standard requires a baudrate of 9,600 or 19,200 set in accordance with the Modbus-master.
- Par no. 23** Feature to reset the analyzer back to factory default.

## 8 Additional Measurement & Function Modules

FX-300-pH / ORP

### pH Module Function and Programming

No	Parameter	Description	Range	Default
1	Lock	Software lock	On / Off	On
2	Address	Modbus	Off, 1...247	Off
3	pH/mV	Type of input	pH, mV	pH
4	Temperature	Type of input	<b>Pt100, Pt1000</b>	Pt1000
5	Compensation	Temp Comp	Auto, Set	Auto
6	Manual Temp	Fixed Temp	0...210	25
7	Cable impedance	Impedance of Pt100 Cable	0.0...9.9Ω	0.0
8	3-point slope option	Calibration of sensor slope option	Off (2-point) On (3-point)	Off
9	Range mV	Range for mV	+/-1000, -1000 to 0, 0 to +1000	+/-1000
10	Input for lout	Input used for output	pH or temperature	pH
11	Lout	Type of output	4-20mA, 0-20mA	4-20
12	Lout mode	Lout mode	Noninverter, inverted	noninverted
13	0/4mA set	Low setpoint	0.0-13.0 pH	0.0
14	20mA set	<b>High setpoint</b>	1.0-14.0 pH	14.0
15	Step change	<b>mV increment for calibration</b>	<b>0=0.2, 1=0.5, 2=1.0, 3=2.0</b>	<b>1 (0.5mV)</b>
16	Offset	mV @ pH7	+/-250mV	0
17	Slope 1	mV per pH	30 to 90	59.2
18	Slope 2	mV per pH	30 to 90	---
19	0/4mA offset	Trim low	+/-9.99%	0.00
20	20mA gain	Trim high	+/-9.99%	0.00
21	Energy save	Energy save	On/off	On
22	Baudrate	Modbus	9,600/19,200	19,200
23	<b>Back to default</b>	<b>Reset to default</b>	<b>Def=Reset, Par=NoReset</b>	<b>Par</b>

#### pH Module Buffer/Slope Adjustment

Calibration of the pH electrode is done via the Up/Down keys on the front. Using the 'Mode' key select 'Buffer' and calibrate the pH high (typically 7pH) calibration standard until the display reads the standard's value. Rinse the sensor in distilled water, and place into the low (typically 4pH) pH standard solution. Next select 'Slope' and use the Up/Down keys until the display reads the desired value.

If dual-slope mode is enabled (Parameter 8) the electrode must be calibrated at a total of three points - one at pH 7 (in the 'Buffer' cal mode) then in a pH buffer above pH7 (in the 'Slope' cal mode) and then in a pH buffer below pH7 (in the 'Slope' cal mode). You must exit the 'Slope' mode after completing the acidic slope calibration before entering the alkaline slope calibration.

The 'Buffer' calibration mode can also achieve a process offset calibration where the online reading can be made to agree with any grab sample analysis.

It is possible to manually enter the sensor offset and slope(s) values using P16, P17 & P18 respectively. All settings are stored in EEPROM so unit can be powered down without loss of configuration or calibration.

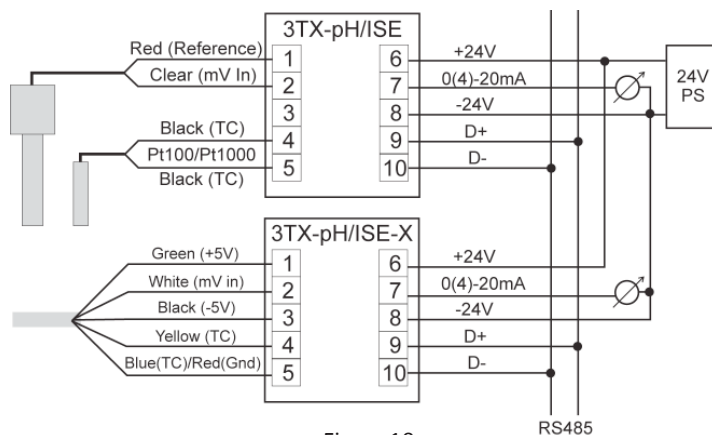


Figure 10

#### Typical installation

The wiring for sensors with and without preamplifiers are detailed above. Note that these two wiring details represent interface with two altogether different hardware versions which must be selected at time of purchase.

**NOTE:** The raw uncompensated (a.k.a. "absolute") mV potential of the pH sensor is displayed by pressing the "Down" key in the main pH/mV display mode. The display now changes from pH to absolute mV units. Negative values will be displayed flashing. The temperature can be calibrated pushing the "Up" or "Down" buttons when in the temperature display (°C) mode.

## **9 Additional Measurement & Function Modules**

### **FX-300-CON Contacting Conductivity**

#### **FX-300-CON 3-Wire Contacting Conductivity Transmitter**

- FX-300-CON is a transmitter for Conductivity & Temperature Measurement
- Measurement Ranges: 0.05 – 500,000  $\mu\text{S}$  | 0.00005 – 500 mS (par no. 21), 0-210  $^{\circ}\text{C}$
- Cell Constants Supported: 0.01-10.0 (par no. 22) - custom cell constants available
- The full scale measurement range and nominal cell constant must be defined at the time of order and cannot be changed after dispatch from factory
- Production Calibration a.k.a. Single (1-Point Offset) Calibration supported for quick calibration to allow for agreement with laboratory conductance analysis
- Temperature compensation via Platinum 100 or 1000 Ohm element
- Display Conductivity (in  $\mu\text{S}$  or mS) or Temperature
- Scalable Analog Output 0-20 mA or 4-20 mA for Conductivity or Temperature
- Galvanic isolation between sensor input and analog output (3000V rating)
- Automatic correction for resistance and capacitance of sensor cable
- Optional: Serial communication via RS-485 Modbus Digital Output
- Field installations supported using weatherproof IP65 enclosures
- Up to 6 measurement modules can be used in a single enclosure assembly
- Optional 115/230 VAC power supply, relay/controller & datalogger modules

#### **Programming**

The module is programmed by use of 3 keys located on the front panel. The 'Mode' key is used for selecting setup and the 'Up' or 'Down' keys are used to scroll through the parameters. The parameter to be altered is selected with the 'Mode' key and the value is changed using the 'Up' or 'Down' keys. Parameter No. 01 is a "lock" which must be set to 'Off' to change ANY parameter, including the temperature and gain calibrations.

#### **Input**

The conductivity cell outer and inner electrodes are connected to terminals 1 and 2, respectively. The current through the cell is proportional to the conductivity of the solution and measurement of the current is the basis of the readout, the analog output as well as the value sent over the Modbus. The Pt100/Pt1000 temperature sensor is connected to terminals 4 and 5 and the measured value is the basis of the temperature correction, which is performed by the built-in microprocessor. Terminal 3 is the ground terminal and should be connected to sensor wire shield.

#### **Analog Output**

The FX-300-CON transmitter (module) has a scalable analog output of either 0-20 mA or 4-20 mA (selectable) and can be standard or inverted. The conductivity scaling between the minimum (0mA or 4mA) and maximum (20mA) output is 10% to 100% of the full range scale specified where the low and high outputs can be otherwise arbitrarily defined in conductivity units. The output is galvanically isolated from inputs and proportional to conductivity or temperature.

## 9 Additional Measurement & Function Modules

### FX-300-CON Contacting Conductivity

FX-300-CON

#### Modbus (Optional)

Data is transferred using Modbus standard for multidrop communication and connected using RS485. The Modbus master may be the FX-300-DAT or any SCADA system. When units are ordered with Modbus, a Windows datalogging software is freely provided that can be used to monitor and record all process and temperature values from up to 247 transmitters simultaneously at distances to 6500 feet (2 km).

#### Specifications

##### Mechanical

Housing	Lexan UL94V-0 (Upper Part) Noryl UL94V-0
Mounting	M36 for 35mm DIN rail
IP Class	Housing IP40. Connector IP20
Connector	Max 16A. Max 2.5mm <sup>2</sup> . Max torque 0.6 Nm
Temperature	-15 to +50 °C
Weight	75 grams (2.64 ounces)
Dimensions	D 58 x W36 x H86 mm (2.3" x 1.4" x 3.4")
CE mark	EN61326A

##### Electrical

Power supply	24VDC +/- 10%
Consumption	60mA max
Sensor	2-wire contacting cell
Measuring range	See par. 21 for Max Full Range
Cell constant	Se par. 22 (nominal) and 15 (gain)
Accuracy	Class 2 excluding sensor
Temperature sensor	Pt100, Pt1000
Temperature range	0-210°C +/- 0.3°C
Temperature Compensation	Fixed (Manual) or Automatic using Temperature (TC) Measurement
Analog output	0-20mA or 4-20mA, max 250Ω

## 9 Additional Measurement & Function Modules

### FX-300-CON Contacting Conductivity

#### Function and Programming Parameters

The 22 programmable parameters are shown to the right. If the software lock (Par. no. 1) is "On" the parameter can only be read. Set Software Lock to "Off" to change values.

- Par. no. 2** sets module's address for Modbus communication.
- Par. no. 3** indicates the type temperature input (Pt100 or Pt1000).
- Par. no. 4** sets the temperature compensation to be either fixed (manual/set) or automatic from measured temperature.
- Par. no. 5** sets the value for when temperature compensation of the conductivity measurement is in fixed (manual/set mode).
- Par no. 6** is the temperature compensation coefficient used, expressed in %/°C units (valid for auto or manual TC mode)
- Par. no. 7** the wire gauge (AWG) for the sensor cable used
- Par. no. 8** the length of sensor cable in units of feet.
- Par. no. 9** select the conductivity measurement (S) or temperature measurement (°C) signal to be used for the analog output.
- Par. no. 10** sets the analog output to either 0-20 mA or 4-20 mA.
- Par. no. 11** sets low 0/4mA output scaling (in conductivity units).
- Par. no. 12** sets high 20mA output scaling (in conductivity units). The difference between low & high output setpoints (P11 & P12) must be at least 10% of full range scaling per parameter P21.
- Par. no. 13** Step change for up or down button during calibration.
- Par. no. 14** Zero offset calibration done when sensor is dry in air.
- Par. no. 15** Set/display the gain on cell constant. The effective cell constant is the product of P18 (gain) and P22 (nominal cell).
- Par. no. 16** Offset adjustment for 0/4mA low analog output trim. \*
- Par. no. 17** Gain adjustment for 20mA high analog output trim. \*
- Par. no. 18** If no keys are pressed for 10 minutes, display will show flashing bar (Energy Save Mode). Pressing any key to exit
- Par. no. 19** sets baudrate of 9,600 or 19,200 per Modbus master.
- Par. no. 20** Feature to reset the analyzer back to factory default.
- Par. no. 21** is the full range of the particular FX-300-CON module/transmitter. This is a display (read-only) parameter.
- Par no. 22** is the nominal conductivity cell constant. This is a display (read-only) parameter. Both P21 and P22 have been set at the factory prior to dispatch and cannot be changed in the field.
- Par. no. 23** allows setting the output to be inverted (i.e. for use in control) with the output corresponding to 20-0mA or 20-4mA.

\*negative trim adjustments will be shown as flashing



## 9 Additional Measurement & Function Modules

### FX-300-CON Contacting Conductivity

#### Function and Programming Parameters

No	Parameter	Description	Range	Default
1	Lock	Software lock	On / Off	On
2	Address	Address on Modbus	Off, 1...247	Off
3	Temperature	Type of input	Pt100, Pt1000	Pt1000
4	Compensation	Temp Comp. Conductivity	Auto, Set (Manual/ Set)	Auto
5	Compensating	Compensating Temperature	0...210	25
6	Temp Comp Factor	Compensation Factor	0.50 - 5.00 %/°C	2.10
7	Wire Gauge	Sensor AWG	20, 22, 24	22
8	Cable Length	Length in feet	1...999 feet	10
9	Input for lout	Input for the analog output	Conductivity Con or Temp °C	Con
10	Lout	Type of output	4-20mA, 0-20mA	4-20
11	0/4mA Low Output Scale	Low output (Cond units)	0%-90% of full range	0%
12	20mA High Output Scale	High output (Cond units)	10%-100% of full range	100%
13	Step change	Increments for calibration	0=0.1%, 1=0.2%, 2=0.5%, 3=1.0%	2
14	Offset adjustment	Zero calibration	Increments per P13	n/a
15	Working gain (slope)	Gain on cell constant	+/-50% from nominal	1.00
16	0/4mA offset	Trim low	+/-9.99% *	0.00
17	20mA gain	Trim high	+/-9.99% *	0.00
18	Energy save	Energy save	On/off	On
19	Baudrate	Modbus	9,600/19,200	19,200
20	Back to default	Reset to default	Def=Reset, Par=NoReset	Par
21	Full range	Max range	Per cell K	n/a
22	Nominal cell constant	Cell constant aka 'K'	As defined on order	n/a
23	Lout mode	Lout mode	Noninverted, inverted	Noninverted

## 9 Additional Measurement & Function Modules

### FX-300-CON Contacting Conductivity

#### Calibration

Use the 'Mode' key to select 'Gain', followed by 'Up' or 'Down' to adjust the readout corresponding to the expected value. The adjustment may be  $\pm 50\%$  from nominal value, and may be entered manually using Par no. 15. The readout is the basis for the analog & Modbus outputs. It is possible to also perform a zero calibration when the sensor is clean and dry and exposed to only air with Par no. 14, with the steps determined by Par no. 13. The effective cell constant is found by multiplying the nominal cell constant (P22) with effective gain (P15).

**NOTE:** The temperature can be calibrated pushing the "Up" or "Down" buttons when in the temperature display ( $^{\circ}\text{C}$ ) mode.

Cell Constant	Full Scale Maximum Conductivity Range (Nominal)	Minimum Range at 10%
10.0 (5.0-15.0)	0 to 500,000 microSiemens ( $\mu\text{S}$ ) /cm 0 to 500mS/cm	0 to 50,000 microSiemens ( $\mu\text{S}$ )/cm 0-50 mS/cm
2.0 (1.0-3.0)	0 to 100,000 microSiemens ( $\mu\text{S}$ ) /cm 0 to 50mS/cm	0 to 10,000 microSiemens ( $\mu\text{S}$ )/cm 0-10 mS/cm
1.0 (0.5-1.5)	0 to 50,000 microSiemens ( $\mu\text{S}$ ) /cm 0 to 50mS/cm	0 to 5,000 microSiemens ( $\mu\text{S}$ )/cm 0-5 mS/cm
0.1 (0.05-0.015)	0 to 5,000 microSiemens ( $\mu\text{S}$ ) /cm 0 to 5mS/cm	0 to 500 microSiemens ( $\mu\text{S}$ )/cm 0-0.5 mS/cm
0.01 (0.005-0.015)	0 to 500 microSiemens ( $\mu\text{S}$ ) /cm 0 to 0.5mS/cm	0 to 50 microSiemens ( $\mu\text{S}$ )/cm 0-0.05 mS/cm
0.01 (0.005-0.015)	0 to 50 microSiemens ( $\mu\text{S}$ ) /cm 0 to 0.05mS/cm	0 to 5 microSiemens ( $\mu\text{S}$ )/cm 0-0.005 mS/cm

**NOTES:** Many alternate cell constants and ranges can also be supported (inquire to factory). The ranges shown above are a guideline for full range scaling of common cell constants for illustrative purposes. The full scale measurement range and nominal cell constant must be defined at the time of order and cannot be changed after dispatch. The effective cell constant can be modified with the gain calibration function such that it is  $\pm 50\%$  of the nominal cell constant value. Displayed next to the nominal cell constant above is the possible effective cell constant after a -50% or +50% gain (slope) adjustment has been done in calibration or manually entered.

#### Modbus

In order to utilize the Modbus interface the FX-300-CON must be ordered with Modbus. FX-300-CON may be used as a slave for the 'Dat' - unit FX-300-DAT or as a slave in a SCADA system or with the free of charge Windows datalogging and graphing software.

#### With FX-300-DAT

If FX-300-CON is used together with the FX-300-DAT, the user must pay attention to two things: The baud rate on the Modbus as well as the address of the FX-300-CON. The baud rate (P19) must be set to the baud rate of the FX-300-DAT. Whether a baud rate of 19,200 or 9,600 is used is of no importance, as long as all units on the RS-485 Modbus network are set to the same baud rate.

## 9 Additional Measurement & Function Modules

### FX-300-CON Contacting Conductivity

#### Modbus

The address (P02) must be unique in the network; Two units are not allowed to have the same address. In a network with the FX-300-DAT as the master, all addresses must be assigned without leaving any address out; i.e. if 3 units are connected to a FX-300-DAT, the addresses 01, 02 & 03 must be assigned to the three units. The order of the addresses is of no importance. In a network with a FX-300-DAT, up to 14 Modbus slaves may be connected, allowing only the addresses 01 to 14.

#### In a SCADA system or with Windows software

Since different SCADA systems may have different restrictions only the general are mentioned here: The baud rate (P19) must be set to the baud rate of the SCADA system. The address (P02) must be unique in the network; Two units are not allowed to have the same address. Up to 247 FX-300 transmitters may be connected on a single network, although repeaters may be required if more than 32 nodes are used and/or for long cable distances.

#### Modbus Scaling

The Modbus scaling for the conductivity process measurement output is the same as the analog output range as defined by P11 (low 0/4mA setpoint) and P12 (high 20mA setpoint).

The FX-300-CON contains 2 measurements (Conductivity and temperature). Access to these measurements are gained through the function code Read\_Input\_Registers (04).

#### Read Input Registers

Function code	Start address	Number of values
<b>04</b>	<b>1</b>	<b>1 or 2</b>

Value 1 is Conductivity and value 2 is Temperature. Please note that the measurements are transmitted in sequence; If 2 values are chosen both conductivity and temperature are transmitted. If, for instance, the value for temperature is wanted, 2 values must be requested. Both values are rated to 0-1000 corresponding to the effective range, but the temperature has an offset of 1024; i.e. the effective conductivity range is transmitted as 0-1000 and the full scale temperature range (0-210°C) is transmitted as 1024- 2024.

The FX-300-CON gives access to different diagnostic values via Diagnostics (08), as shown in the following.

#### Diagnostics

Function code	Sub code (HEX)	Description
08	00	Return query data
	0A	Clear counters and diagnostics register
	0B	Return bus message count
	0C	Return bus communication error count
	0D	Return exception error count
	0E	Return slave message count
	0F	Return slave no response count
	12	Return bus character overrun count

#### ***FX-300-REL Alarm Relay and Controller Module***

- FX-300-REL is a versatile controller and alarm module with 2 independent limits
- Performs alarm relay and/or controller function for FX-300-pH, FX-300-ISE or FX-300-CON measurement modules
- Offering Simple On/Off as well as more sophisticated Time Proportional Control (TPC) and Proportional Frequency Control (PFC) a.k.a. Variable Pulse
- One FX-300-REL module is required for control and/or alarm function for each FX-300 measuring module (i.e., 1 each analog input per FX-300-REL module)
- Analog input: 0-20mA or 4-20mA
- Maximum or minimum limits can be configured for each of the 2 relays
- Configurable start timer and reaction timers
- 24VDC power operation, 5A max load/rating for each dry contact relay
- Hold function to disable relays during calibration and maintenance of measuring transmitters and sensors
- Scaling in native measurement units (pH, ppm,  $\mu\text{S}/\text{mS}$ ) for all configurable parameters for ease of use and programming
- DIN rail mountable; small form factor for tight space installations
- Field installations using NEMA 4X enclosures, supporting up to a total of 8ea FX-300 transmitter modules in a single enclosure.

#### **Application**

FX-300-REL modules are ideal for supervising mA signals. This unit is fully compatible with the output provided by all of our FX-300 measuring transmitters (FX-300-pH, FX-300-ISE, and FX-300-CON). Simple On/Off as well as programmable control functionality is possible with the FX-300-REL module.

#### **Analog Input**

The analog input is a current input, and may be set up to either 0-20mA or 4-20mA. The FX-300-REL can be scaled so as to match exactly the 0-20mA or 4-20mA analog output from the FX-300-pH, FX-300-ISE & FX-300-CON measurement modules.

#### **Digital Input**

The FX-300-REL may be configured to both positive and negative logic on the digital inputs. Using parameter no. 21, the input may be set to either active high or active low. With positive logic, the accepted input voltage range is 5- 30VDC. Negative logic is achieved by connecting the input to ground; for example by using a switch. The supervision may be blocked by activating the S2 input.

#### **Relay Output**

The unit contains two relays, one for each limit. The relays are both connection relays, but the polarity may be inverted independently using parameters no. 19 and 20 when in simple supervision and On/Off control mode.

## 10 Additional Measurement & Function Modules

### FX-300-REL Relay & Control

#### FX-300-REL

##### Alarm Limits

The FX-300-REL integrates two limits. All settings for one limit may be altered independently of the other. Each limit may be set up as a Max. or Min. limit. All limits can be entered in the native unit of the measurement module to which it is connected (pH, ppm,  $\mu\text{S/mS}$ ).

##### Start Timer (Ts)

The start timer may be used to avoid alarms during startup of an unstable process. It is activated when the input reaches 5%. If the timer is set to 0, supervision is performed without using the start timer.

##### Reaction Timers (Tr)

Each limit has a corresponding reaction timer used to avoid alarms if the limits are exceeded for short periods of time.

##### Control Modes

The FX-300-REL module can operate in four modes: 1) Simple supervision (alarm function only); 2) On/Off control with deadband; 3) Time Proportional Control (TPC) or 4) Proportional Frequency Control (PFC a.k.a. Variable Pulse).

##### Reset

During simple supervision (i.e. control mode is "Off") an alarm may be reset in two ways: 1) by activating the external reset input (S1 – terminal 3) or 2) by pressing the 'Mode' key in the "input" display mode. A reset requires the alarm condition to be cleared.

#### Specifications

##### Mechanical

Housing	Lexan UL94V-0 (Upper Part) Noryl UL94V-0 (Lower Part)
Mounting	M36 for 35mm DIN rail
IP Class	Housing IP40. Connector IP20
Connector	Max 16A. Max $2.5\text{mm}^2$ . Max torque 0.6 Nm
Temperature	-15 to +50 °C
Weight	200 grams (7.04 ounces)
Dimensions	D 58 x W36 x H86 mm (2.3" x 1.4" x 3.4")
CE mark	EN61326A

##### Electrical

Power supply	24VDC +/- 10%
Consumption	60mA max
Input current range	(0)4-20mA, 70 $\Omega$
Digital input	Pos. logic: 5-30VDC; Neg. logic: 0V
Input S1	External reset
Input S2	Alarm block
Relay spec	250VAC/5A

## 10 Additional Measurement & Function Modules

### FX-300-REL Relay & Control

#### Function and Settings

If the software block (par. no.1) is “on” the parameter can only be read. Set software lock to “off” to change values. To access parameters, press ‘Mode’ key until ‘Setup’ LED is lit and displays ‘P00’. Use ‘Up’ and ‘Down’ keys to scroll through the parameters. Select parameter with ‘Mode’ key, and change value using ‘Up’ or ‘Down’ keys. To exit, select ‘Par. no. 00’ and press ‘Mode’ key.

- Par. no.2** Hold (Relay condition held – signaled by flashing input LED)
- Par. no.3** Type of input is selected - 0-20mA or 4-20mA.
- Par. no.4** Indicates the type of limit 1: Min. or Max.
- Par. no.5** Indicates the type of limit 2: Off, Min. or Max.
- Par. no.6** Select if display will show % (4mA=0%, 20mA=100%), pH units, Conductivity Units (either  $\mu\text{S}$  or mS), or ISE units (ppm)
- Par. no.7** When P05 is ISE, selects full scale range on FX-300-ISE module’s 4-20mA output. ‘Lo’ is 0-10 ppm, ‘Mi’ is 0-100 ppm & ‘Hi’ is 0-999 ppm.
- Par. no.8** When P05 is set to CON, this selects the full scale range on the corresponding FX-300-CON measurement module 4-20mA. Each cell constant will define the full range scale. For K=0.01, Max=0.5mS; K=0.1, Max=5mS; K=1.0, Max=50mS; K=2.0, Max=100mS, K=10.0, Max=500mS
- Par. no.9** \* This defines the value of the 4mA input. When P06 is % there are no adjustments possible. When P06 is ISE the value should match P10 on the FX-300-ISE module to which is it connected. When P06 is CON, then this will always be 0mS (no matter what the cell constant). When P06 is pH, the value should be match P13 on the FX-300-pH module.
- Par. no.10** \* This defines the value of the 20mA input. When in P06 is % there are no adjustments possible. When P06 is ISE the value should be adjusted to match P11 on the FX-300-ISE to which is it connected. The difference between P09 and P10 when P06 is ISE must be at least 20% of the operating range (P09 on the FX-300-ISE). When P06 is CON then this will by default be the maximum full range scale associated with the conductivity cell constant selected. This value should match value of P12 on the FX-300-CON. The minimum value is 10% of full range. When P06 is pH, the value should match P14 on the FX-300-pH module. The minimum difference between P09 & P10 when P06 is pH is 3 pH units.
- Par. no.11 and no.12** Off means simple supervision with alarm relays set to limits only. If 1, then On/Off Control is enabled. If 2, then time proportional control (TPC) is enabled. If 3, then proportional frequency control (PFC) is enabled (a.k.a. variable pulse control).
- Par. no.13** Sets basic time for limit 1 when in TPC mode (P11=2)
- Par. no.14** Sets basic time for limit 2 when in TPC mode (P12=2)
- Par. no.15** Sets basic pulse rate for limit 1 when in PFC mode (P11=3)
- Par. no.16** Sets basic pulse rate for limit 2 when in PFC mode (P12=3)
- Par. no.17** Common parameter - If On/Off mode (P11=1) then hysteresis (dead band) - If TPC or PFC (P11=2/3) then proportional band – For Limit 1
- Par. no.18** Common parameter - If On/Off mode (P12=1) then hysteresis (dead band) - If TPC or PFC (P12=2/3) then proportional band – For Limit 2
- Par. no.19** Polarity of relay 1: Non inverted/ Inverted \*\*\*
- Par. no.20** Polarity of relay 2: Non inverted/ Inverted \*\*\*
- Par. no.21** Digital input configured to be active high (Hi) or low (Lo).



## 10 Additional Measurement & Function Modules

### FX-300-REL Relay & Control

#### Function and Settings

**Par. no.22** Allows calibration offset of 0mA or 4mA current signal input.

**Par. no.23** Allows calibration gain adjustment of 20mA current signal

input. **Par. no.24** Displays result of 0/4mA trim offset calibration (P22) in

% units **Par. no.25** Displays result of 20mA trim gain calibration (P23) in %

units **Par. no.26** Feature to reset the analyzer back to factory default.

\*\* Value is 50% of range determined by Display mode (P06) and scale parameters P09 & P10

\*\*\* Relay polarity does not apply when in TPC mode (P11/P12=2) or PFC mode (P11/P12=3)

\*\*\*\* Default values will depend upon 4mA and 20mA calibration performed at THE factory.

#### List of Parameters

No	Parameter	Description	Range	Default
1	Lock	Software lock	On / Off	On
2	Hold	Relay on hold	On / Off	Off
3	Input	Analog input	0-20mA, 4-20mA	0-20
4	Limit 1	Type of limit	Min (Lo), Max (Hi)	Hi
5	Limit 2	Type of limit	Off, Min (Lo), Max (Hi)	Lo
6	Display mode	Type of input measurement	%, pH, CON, USE	%
7	ISE range	ISE range input	Lo, Mid, Hi	Lo
8	Con range	Conductivity Cell Constant	0.01, 0.1, 1.0, 2.0, 10.0	1.0
9	4mA scale	Reading @ 4mA	*	*
10	20mA scale	Reading @ 20mA	*	*
11	Mode Lim1	Control mode limit 1	Off, 1, 2, 3	Off
12	Mode Lim 2	Control mode limit 2	Off, 1, 2, 3	Off
13	Time Lim1	Time for limit 1	1...250s	10
14	Time Lim2	Time for limit 2	1...250s	10
15	Pulse Lim1	Pulse rate for limit 1	1...250 pulse/min	60
16	Pulse Lim2	Pulse rate for limit 2	1...250 pulse/min	60
17	Hysteresis 1	Dead band limit 1	1...50% **	10%
18	Hysteresis 2	Dead band limit 2	1...50% **	10%
19	Polarity 1	Polarity for relay 1 <i>Non-inverted, inverted</i>	n.inverted, inverted	n.inv
20	Polarity 2	Polarity for relay 1 <i>Non-inverted, inverted</i>	n.inverted, inverted	n.inv
21	Logic	Logic for digital inputs	Neg (Lo), Pos (Hi)	Lo
22	Trim Low	Calibrate 4mA input	As defined	-
23	Trim High	Calibrate 20mA input	As defined	-
24	% trim low	Display 4mA offset	+/- 9.99%	****
25	% trim low	Display 20mA gain	+/- 9.99%	****
26	Back to default	Reset to default	Def=Reset, Par=NoReset	Par

## 10 Additional Measurement & Function Modules

### FX-300-REL Relay & Control

#### Control Functions and Modes

The unit contains two relays, one for each limit. The relays are both connection relays, but the polarity may be inverted independently using parameters no. 19 and 20 when in simple supervision and On/Off control mode.

##### On/Off Control

When the measurement crosses the chosen setpoint, the relay will open and not close again until the measurement exceeds the hysteresis band.

##### Hysteresis Band

A hysteresis band (a.k.a. dead band) always lies above a Min & below a Max limit. This is P17 for Limit 1 & P18 for Limit 2 in On/Off mode.

##### Proportional Band

The proportional band is a range where a variable control is performed. A proportion band lies above a minimum and below a maximum limit. This is P17 for Limit 1 & P18 for Limit 2 in TPC control mode.

##### Basic Frequency

The basic frequencies for Limit 1 & 2 may be set from 1 to 250 pulse per minute (default 60). This is valid in the PFC control mode only.

##### Proportional Frequency Control (PFC a.k.a. Variable Pulse)

If the measurement lies outside the proportional band the relay will pulsate with the basic frequency. Inside the proportional band the frequency is changed linearly towards zero as the measurement approaches the setpoint.

##### Time Proportional Control (TPC)

The time is constant and equal to the basic time. Instead the duty cycle is changed according to the same principle as for PFC control. If the measurement lies outside the proportional band the relay is closed permanently and open permanently if limit is exceeded.

##### Control examples

On/Off control may be used for alarms and simple control of pumps. Proportional frequency control is primarily designed for the control of dosing pumps. Proportional time control may be used for control where more fine approach is required than simple on/off control offers.

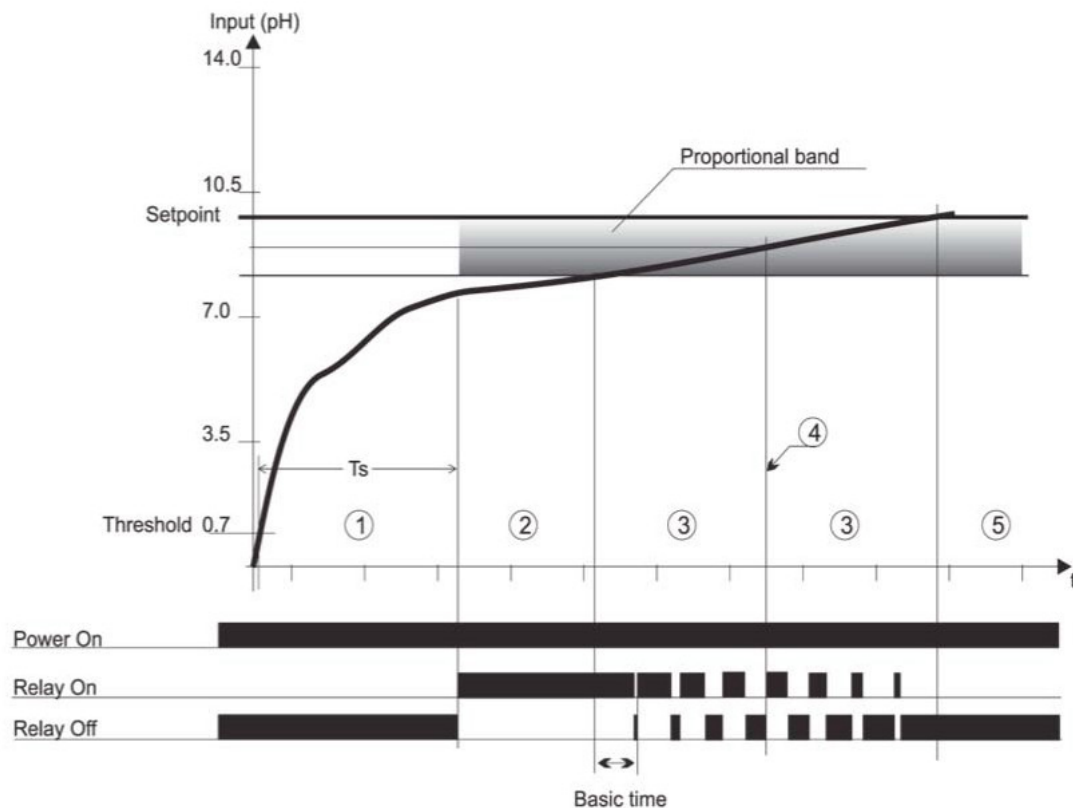
##### Parameters Accessible from LED Menu

In addition to the parameters in the setup menu, the FX-300-REL also features parameters directly accessible from the main LED menu (see next column top). The parameters are accessible by pressing the 'Mode' key until the LED for the parameter to be altered is lit. Use the 'Up' and 'Down' keys to alter the parameter. These parameters and their functions are shown in the table below. Par No. 01 is a "lock" which must be 'Off' to change ANY parameter at all.

## 10 Additional Measurement & Function Modules

### FX-300-REL Relay & Control

The figure below shows in principle how the TPC algorithm works. The curve depicts a process where a certain pH value (setpoint) is required. This example is taken from conditioning of heating water from a district heating plant, where the required pH value lies on 9.8 pH



Parameter	Description	Range	Default
Ts [s]	Start up - timer	0.0 to 999s	10.0
Limit 1	Setpoint for limit 1 * Display mode % Display mode pH Display mode Con Display mode ISE	5.0 - 99.9% 0.1 - 14.0pH 1 - 500 ** 1 - 999 ***	80.0 11.2 400 ** 800 ***
Limit 2	Setpoint for limit 2 * Display mode % Display mode pH Display mode Con Display mode ISE	5.0 - 99.9% 0.1 - 14.0pH 1 - 500 ** 1 - 999 ***	20.0 2.8 100 ** 200 ***
Tr [s] (limit 1)	Reaction time limit 1 ^	00.0 to 99.9s	10.0
Tr [s] (limit 2)	Reaction time limit 2 ^	00.0 to 99.9s	10.0

\*\*

Values depend on display mode and range selected with P06, P07 and P08

\*\*\*

Decimal point depends on selected range for conductivity

\*\*\*\*

Decimal point depends on selected range for ISE

^

During this time period, no relay action will be undertaken when P06 is set to Off (supervision/alarm function only) or On/Off Relay control mode

## 10 Additional Measurement & Function Modules

### FX-300-REL Relay & Control

#### Typical Installation Wiring

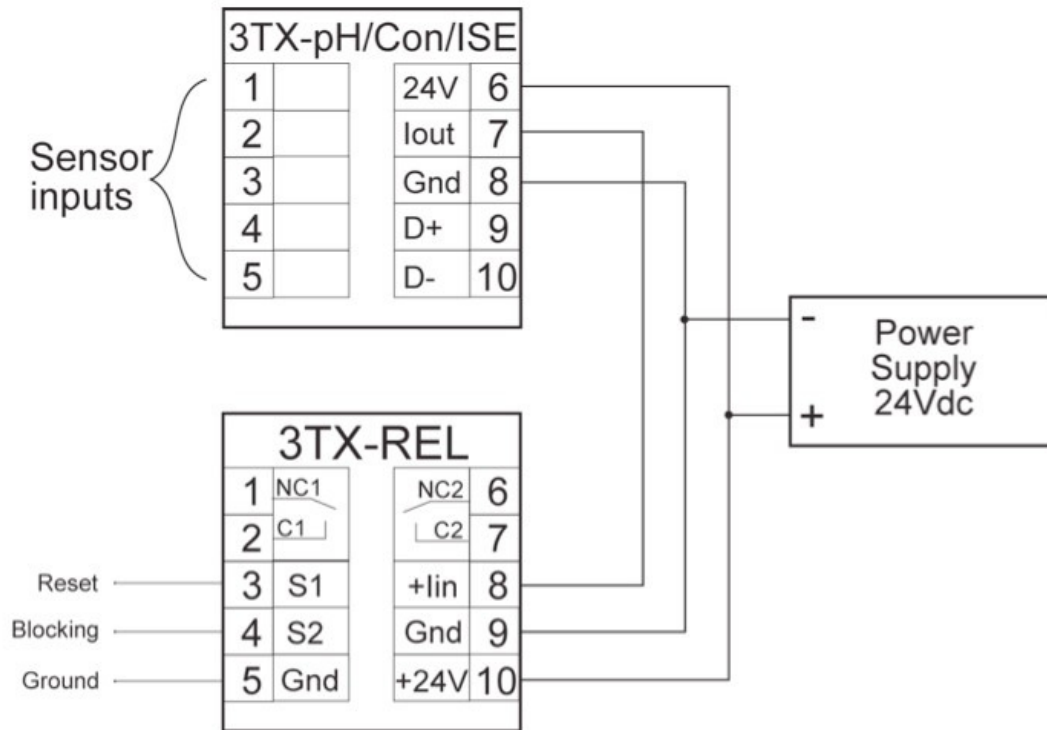


Figure 12

**Note:** An alternate wiring configuration is required if the 0/4-20mA transmitter output is to be first (also) sent to another data acquisition or control device.

#### Example of pH Control Application using TPC Mode

The required settings needed for this TPC implementation are:

Limit: Hi (Max limit) or Lo (Min limit); Here a max limit is needed.

Control mode: TPC

Setpoint: Requested pH value; here 9.8pH

Proportional band: Band where the actual regulation is performed; here 1pH

Unit Basic time: "Cycle time" for the TPC algorithm

Start timer: Startup time for the sensor to settle

When the measured value crosses 5% of the measuring range (here corresponding to 0.7pH) the startup timer is activated to avoid false readings during settling time of the sensor. This time should be selected large enough to give the sensor time to settle, but not much longer than this, since the supervision and control will be disabled in this period. The relay is off in this condition (see period 1 on figure).

After expiration of the startup timer the FX-300-REL starts to control. In the example, the measured value lies below the setpoint minus the proportional band (Period 2) and the relay will be continuously on to use maximum conditioning fluid.

When the measured value exceeds the setpoint minus the proportional band the values is said to lie

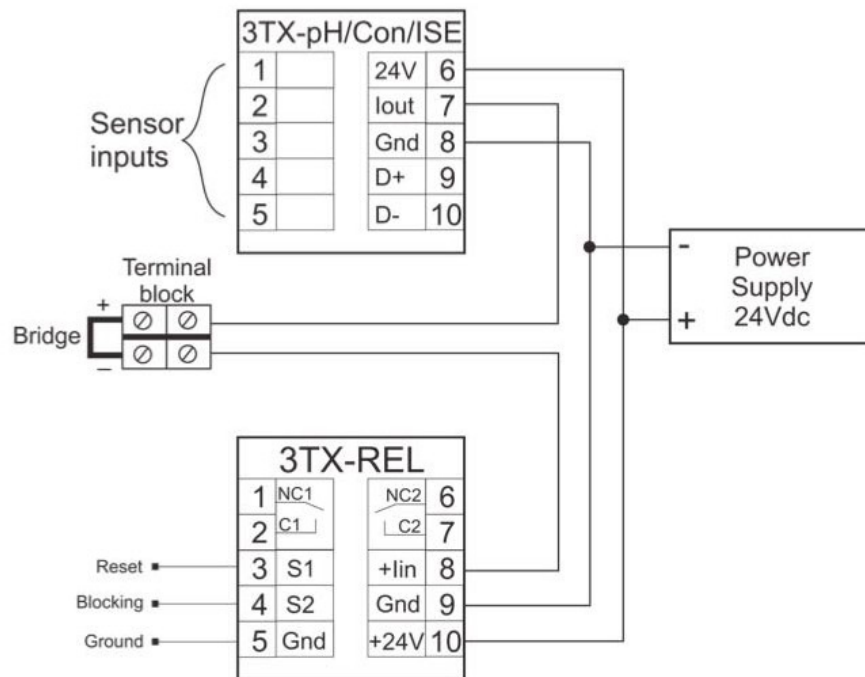
## 10 Additional Measurement & Function Modules

### FX-300-REL Relay & Control

within the proportional band (Period 3) and the on-time of the relay is regulated proportional to the distance up to the setpoint. This is illustrated with the two “bars” below the curve, where it is shown that the on-time drops as the value comes closer to the setpoint. At the point (4) the value is exactly in the middle of the proportional band where the on-time and off-time of the relay are equal (The relay is on half the time).

Finally when the setpoint is reached the relay is kept off and will not be set on again until the measured value drops below the setpoint. This is illustrated with period (5)

**Wiring Schematic for FX-300 Measurement Transmitters (FX-300-pH, FX-300-CON or FX-300-ISE) when used together with FX-300-REL Relay Module and a 4-20mA Output is Required to connect with additional Data Acquisition or Control Devices**



If you wish to “insert” an external device into the current loop, it can be done by removing the bridge jumper and connecting the two terminals to the external device (“+” to device input and “-” to device output, which may also be device ground). If no external device is to be connected, the bridge jumper must be in place to ensure normal operation of the FX-300-REL relay module.

## 11 Additional Measurement & Function Modules

### FX-300-TOT pH Compensation Total ISE

#### ***FX-300-TOT Total ISE pH Compensation Module***

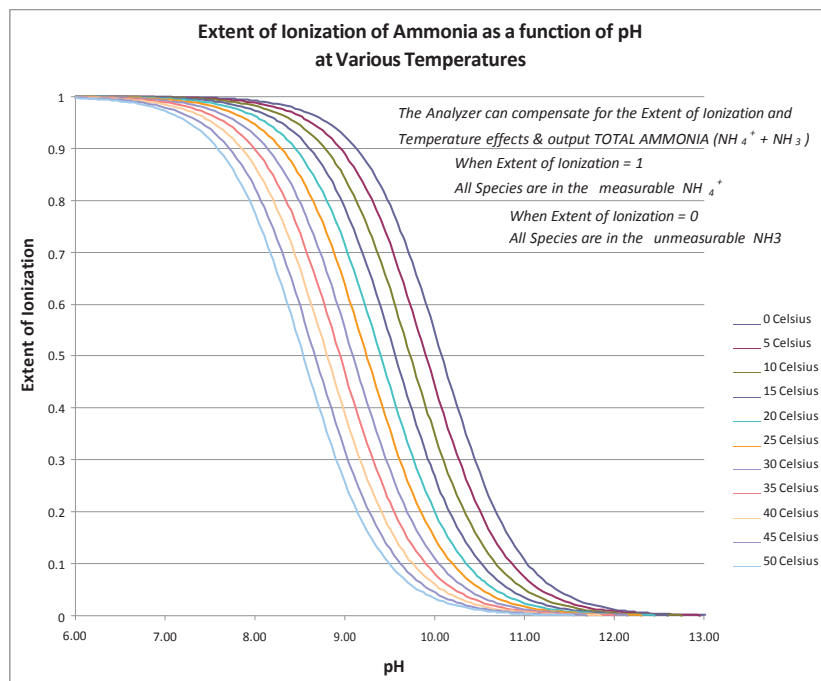
- The FX-300-TOT module determines the total free unbound ion concentration by a compensation algorithm using Free ISE, pH and temperature as the primary process inputs
- Total ISE can at present be found for Ammonia ( $\text{NH}_3 + \text{NH}_4^+$ ), Fluoride ( $\text{HF} + \text{F}^-$ ), Cyanide ( $\text{HCN} + \text{CN}^-$ ) and Sulfide ( $\text{HS}^- + \text{S}_2^-$ )
- Total ISE computed is sent via 0/4-20mA analog output which is galvanically isolated from sensor inputs for use with mating data acquisition or controls
- Input 1 is always Free ISE and Input 2 is always pH
- Input 3 can be supported for any pH, ORP/mV, ISE, Conductivity measurement
- All inputs and the computed total ISE are sent RS-485 Modbus digital outputs
- The analog inputs can be sent on to other data acquisition and control devices
- Highly configurable set of user parameters always almost any input configuration to be supported and the total ISE output to be highly customized
- Temperature input can be obtained from splicing P100/Pt1000 TC input from ISE or pH sensor, from a separate Pt100/Pt1000 temperature sensor, or else from a scaled 4-20mA signal from a separate transmitter

#### **Programming**

The module is programmed by use of 3 keys located on the front panel. The 'Mode' key is used for selecting setup and the 'Up' or 'Down' keys are used to scroll through the parameters. The parameter to be altered is selected with the 'Mode' key and the value is changed using the 'Up' or 'Down' keys. Parameter No. 01 is a "lock" which must be set to 'Off' to change ANY parameter, including the temperature, buffer and slope calibrations.

## 11 Additional Measurement & Function Modules

### FX-300-TOT pH Compensation Total ISE



The graph above shows the effects of pH and temperature on the extent of ionization for the weak base, ammonia. The dissolved ammonia gas is converted into the ionized ammonium ion, which is measured by the ISE sensor. The extent of ionization reveals the percent of the weak base which can be measured. When the extent of ionization is 1.00, then 100% is in the measurable form. When the extent of ionization is 0.00, then 0% is in the measurable form. The FX-300-TOT module is able to compute, display and transmit what would be 100% of the weak acid or base activity, even if only a small fraction is actually in the measurable form.



# 11 Additional Measurement & Function Modules

## FX-300-TOT pH Compensation Total ISE

### Transmitter Specifications

#### Mechanical

Housing	Lexan UL94V-0 (Upper Part) Noryl
Mounting	M36 for 35mm DIN rail
IP Class	Housing IP40. Connector IP20
Connector	Max 16A. Max 2.5mm <sup>2</sup> . Max torque 0.6 Nm
Temperature	-15 to +50 °C
Weight	200 grams (7.04 ounces)
Dimensions	D 58 x W36 x H86 mm (2.3" x 1.4" x 3.4")
CE mark	EN61326A

#### Electrical

Power supply	24VDC +/- 10%
Consumption	60mA max
Input current range	(0)4-20mA, 70Ω
Digital input	Pos. logic: 5-30VDC; Neg. logic: 0V
Input S1	External reset
Input S2	Alarm block
Relay spec	250VAC/5A

# 11 Additional Measurement & Function Modules

## FX-300-TOT pH Compensation Total ISE

The graphs to the right show the impact of pH on the extent of ionization of various weak acids as a function of pH. Unlike the graph for the conversion of the weak base ammonia to ammonium ion as function of pH shown at various temperatures, all of the graphs to the right are shown at a single temperature for a more simple visualization of these effects at the common 25 degrees Celsius condition. As short explanation of the chemistry behind the pH compensation to compute total ISE that the FX-300-TOT performs is below to understand the conditions under which this module should be used in conjunction with the FX-300-ISE and FX-300-pH transmitters.

The extent of ionization defines the percent of the species of interest for the weak base (typically ammonia) or the weak acid (typically HF, HCN or HS-) is converted into the form which the ion selective sensor can detect, which is the free ionized species. On the vertical axes this extent of ionization is 0.00 when none of the species is in the measurable form for the ion selective sensor. In such cases, it is not possible to use pH compensation is not possible since none of the species can be measured by the ISE sensor at all. When the extent of ionization is 1.00 then all of the weak base or weak acid is in the ionized form that can be detect by the ISE sensor and so not pH compensation is required. For example, all of the NH<sub>3</sub> gas is in the NH<sub>4</sub><sup>+</sup> ion form all of the HF gas is in the F<sup>-</sup> ion form, all of the HCN gas is in the CN<sup>-</sup> ion form and all of the HS<sup>-</sup> ions is in the measurable S<sup>2-</sup> ion form.

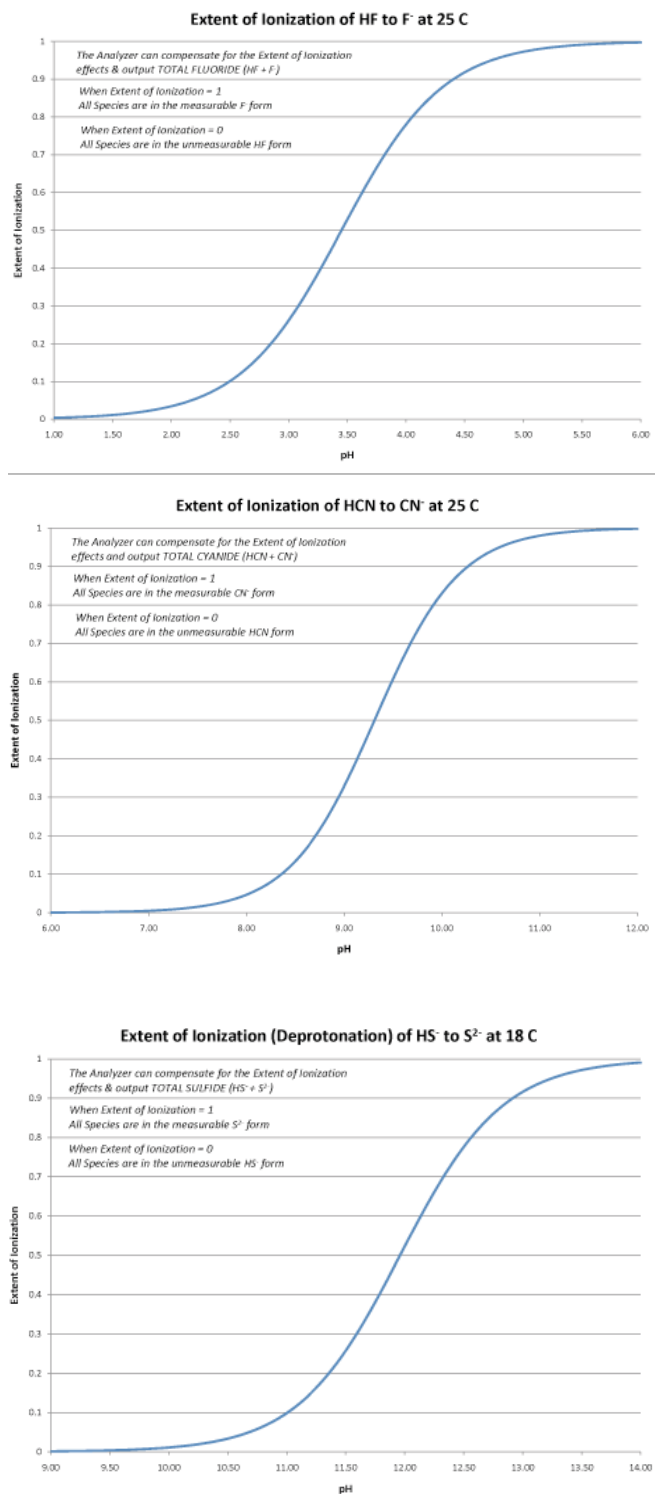


Figure 15

The portion which is in the measurable form at that given pH and temperature (the extent of ionization) is called the "Free ISE". The "Total ISE" computed by the FX-300-TOT module is the value computed as though all 100% were in the measurable form. An simple example is given below for the purposes of illustration:

Samples conditions are Temp: 25.0 °C, pH: 3.45

The extent of Ionization at this pH and temperature for the HF/F<sup>-</sup> system is 0.50 Free ISE: 35.0 ppm Fluoride (F<sup>-</sup>), Computed Total ISE: 70.0 ppm Fluoride (F<sup>-</sup>)

## 11 Additional Measurement & Function Modules

### FX-300-TOT pH Compensation Total ISE

The FX-300-TOT module uses built-in algorithms to compute the extent of ionization for the system of interest (NH<sub>3</sub>, HF, HF or HS) at the current pH and temperature. The Total ISE is found by simply taking the Free ISE and dividing it by this computed extent of ionization. The resulting Total ISE shows what would be the ion activity detected if all of the species were at a condition such that they were in the measurable form.

For the FX-300-TOT module, Input 1 shall always be the Free ISE and Input 2 shall always be the pH to be used for compensation (analog input from FX-300-pH transmitter). If the pH input is not available or constant, the pH value used can be entered manually in parameter P28, when P27 is set to manual (Set) pH mode. The temperature input used for the pH compensation algorithm can be obtained from a spliced Pt100 or Pt1000 TC element (obtained from the ISE or pH sensor), a separate Pt100/Pt1000 temp. probe, or else a 4-20mA signal from a temperature transmitter. In all cases the temperature input is always connected as Input 3. There is an optional support for a fourth input on the FX-300-TOT module. This is often an ion selective measurement that does not require pH compensation, an additional pH/ORP measurement, or else a conductivity measurement. All input measurements as well as the computed Total ISE value can be sent for further use in other data acquisition or control devices via analog 0/4-20mA outputs and Modbus RS-485 digital output.

If the FX-300-TOT module was purchased part of a complete FX-300 field assembly, then the user parameters will have been preconfigured at the factory in the most suitable manner possible based upon the information provided. As such, quite often very few of the parameters may need to be modified to begin using your FX-300-TOT module.

#### List of Parameters for Function and Programming FX-300-TOT

- |                    |  |
|--------------------|--|
| <b>Par. no. 1</b>  | is a "lock" which must 'Off' to change ANY parameter.  |
| <b>Par. no. 2</b>  | sets module's address for Modbus communication.  |
| <b>Par. no. 3</b>  | sets Free ISE input to be 0-20mA or 4-20mA (P08 on FX-300-ISE).  |
| <b>Par. no. 4</b>  | sets Free ISE input to low, mid or high. This should match P09 on the FX-300-ISE transmitter that is used for the Free ISE input.  |
| <b>Par. no. 5</b>  | defines value of 0/4mA input for free ISE. This value should be adjusted to match P10 on FX-300-ISE module to which is it connected.   |
| <b>Par. no. 6</b>  | defines value of 20mA input for free ISE. This should match P11 on FX-300-ISE. P05 & P06 must be at least 20% of the operating range (P09 on the FX-300-ISE).  |
| <b>Par. no. 7</b>  | sets pH input to be 0-20mA or 4-20mA (P11 on FX-300-pH).   |
| <b>Par. no. 8</b>  | defines the value of 0/4mA input for pH. This value should be adjusted to match P13 on FX-300-pH module to which is it connected.  |
| <b>Par. no. 9</b>  | defines the value of 20mA input for pH. This value should be adjusted to match P14 on FX-300-pH module to which is it connected. The minimum difference between P08 and P09 when is at least 3 pH units.   |
| <b>Par. no. 10</b> | sets temperature for pH compensation in auto or manual mode.   |
| <b>Par. no. 11</b> | defines temperature when P10 is set (in manual mode).  |
| <b>Par. no. 12</b> | sets temperature input mode when P10 is Auto. When in Splice or Raw Pt100/Pt1000 mode, this signal is gained from Input 3/Ground. When in 0/4-20mA temperature input mode, this signal is gained from Input 3/Ground and P13 must be set to Temperature. If P10 is manual, all temperature inputs are ignored. |
| <b>Par. no. 13</b> | sets Pt100 or Pt1000 TC input (if P12 is Splice or Raw mode).  |
| <b>Par. no. 14</b> | sets 0-20mA or 4-20mA mode for Input 3.  |
| <b>Par. no. 15</b> | sets types of signal to be provided on Input 3 to Temp, pH, ORP/mV, CON, or ISE. If P12 is 4-20mA then this must be set to Temp.   |

<h2 style="text-align: center;">11 Additional Measurement &amp; Function Modules</h2> <h3 style="text-align: center;">FX-300-TOT pH Compensation Total ISE</h3>
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#### List of Parameters for Function and Programming FX-300-TOT

- |                    |  |
|--------------------|--|
| <b>Par. no. 16</b> | selects ISE Input 3 to low, mid or high when P15 is set to ISE. This should match P09 on the FX-300-ISE transmitter that is used as Input 3.   |
| <b>Par. no. 17</b> | selects cell constant used on sensor for FX-300-CON Input 3 when P15 is set to CON (Conductivity).   |
| <b>Par. no. 18</b> | selects range for Input 3 when P15 is set to ORP/mV mode.  |
| <b>Par. no. 19</b> | defines the value of the 4mA input. When P15 is ORP/mV the minimum value of P18 range selected is set. When P15 is ISE the value should be adjusted to match P10 on mating FX-300-ISE. When P12 is CON, then this will always be 0mS. When P13 is pH, the value should match P13 on the mating FX-300-pH.  |
| <b>Par. no. 20</b> | value of the 20mA input. When P15 is ORP/mV the maximum value of P18 range selected is set. When P13 is ISE the value should match P11 on FX-300-ISE. P19 and P20 when P15 is ISE must be at least 20% of the operating range (P09 on FX-300-ISE same as P16 on the FX-300-TOT). When P15 is CON should match P13 on FX-300-CON. When P15 is pH, the value should match P14 on the mating FX-300-pH. |
| <b>Par. no. 21</b> | displays the real time reading of Input 3.   |
| <b>Par. no. 22</b> | selects the type of pH compensation being performed.   |
| <b>Par. no. 23</b> | sets the Total ISE input to 0-20mA or 4-20mA.  |
| <b>Par. no. 24</b> | sets Total ISE output to be low, mid or high.  |
| <b>Par. no. 25</b> | sets Total ISE output at 0/4mA.  |
| <b>Par. no. 26</b> | sets Total ISE output at 20mA. The difference between P25 and P26 should be at least 20% of the range selected by P24.   |
| <b>Par. no. 27</b> | selects pH to be gained from Input 2 (Auto) or user defined (Manual)   |
| <b>Par. no. 28</b> | sets the pH value when in P27 is in Manual mode  |
| <b>Par. no. 29</b> | offset calibration of 0mA or 4mA current signal input 1 (Free ISE)   |
| <b>Par. no. 30</b> | gain calibration adjustment of 20mA current signal input 1 (Free ISE)  |
| <b>Par. no. 31</b> | offset calibration of 0mA or 4mA current signal input 2 (pH)   |
| <b>Par. no. 32</b> | gain calibration adjustment of 20mA current signal input 2 (pH)  |
| <b>Par. no. 33</b> | offset calibration of 0mA or 4mA current signal Input 3  |
| <b>Par. no. 34</b> | gain calibration adjustment of 20mA current signal Input 3   |
| <b>Par. no. 35</b> | offset calibration of 0mA or 4mA current signal Output (Total ISE)   |
| <b>Par. no. 36</b> | gain calibration adjustment of 20mA current signal Output (Total ISE)  |
| <b>Par. no. 37</b> | sets the baudrate in accordance with the Modbus-master.  |
| <b>Par. no. 38</b> | Feature to reset the analyzer back to factory default.   |

## 11 Additional Measurement & Function Modules

### FX-300-TOT pH Compensation Total ISE

**List of FX-300-TOT Parameters**

No	Parameter	Description	Range	Default
1	Lock	Software Lock	On / Off	On
2	Address	Address on Modbus	Off, 1...247	Off
3	Input 1 - free ISE	Free ISE analog input	Off, 4-20mA, 0-20mA	4-20mA
4	Free ISE range	Select FX-300-ISE free ISE input	Lo (0-10), Mi (0-100), Hi (0-999)	Lo
5	0/4mA Scale - Free ISE	Reading @ 0/4mA	-	-
6	20mA Scale	Reading @ 20mA	-	-
7	Input 2 - pH	pH for compensation	Off, 4-20mA, 0-20mA	4-20mA
8	0/4mA scale	Reading at 4mA	-	-
9		Reading at 20mA	-	-
10	Input 3 - Temp	Temperature mode	Manual (set) or automatic (aut)	Set
11	Manual Temp	Sets the operating temp if P10 is set	0...105	25
12	Temp mode	Sets the temperature input mode	Splice, raw, 4-20mA	Splice
13	TC input select	Temp input if P12 is splice or raw	Pt100 or Pt1000	Pt1000
14	Input 3 - configure	Select analog input 3	Off, 4-20mA, 0-20mA	Off
15	Input 3 - variable	Type of input measurement	Temp, pH, ORP/mV, CON, ISE	ISE
16	Input 3 - ISE range (if P15 is ISE)	Select working input range on FX-300-ISE input 3	Lo (0-10), Mi (1-100), Hi (0-999)	Lo
17	Input 3 - conductivity cell constant	Select conductivity cell constant and associated full scale range	0.01, 0.1, 1.0, 2.0, 10.0 (If P15 is CON)	1.0
18	Input 3 - ORP/mV	Set ORP/mV scaling (if P15 is ORP)	+/-1000, -1000 to 0, or 0 to +100	+/-1000
19	Input 3 - 0/4mA scale	Reading @ 0/4mA	-	-
20	Input 3 - 20mA scale	Reading @ 20mA	-	-
21	Display input 3	Displays real-time input 3 reading	Temp, pH, ORP/mV, CON or ISE	Off (none)
22	Type of pH compensation	Select the type of pH compensation to be performed	Total Ammonia (NH3), Total Fluoride (HF), Total Cyanide (HCN) and Total Sulfide (HS)	Depends on request at time of order

# 11 Additional Measurement & Function Modules

## FX-300-TOT pH Compensation Total ISE

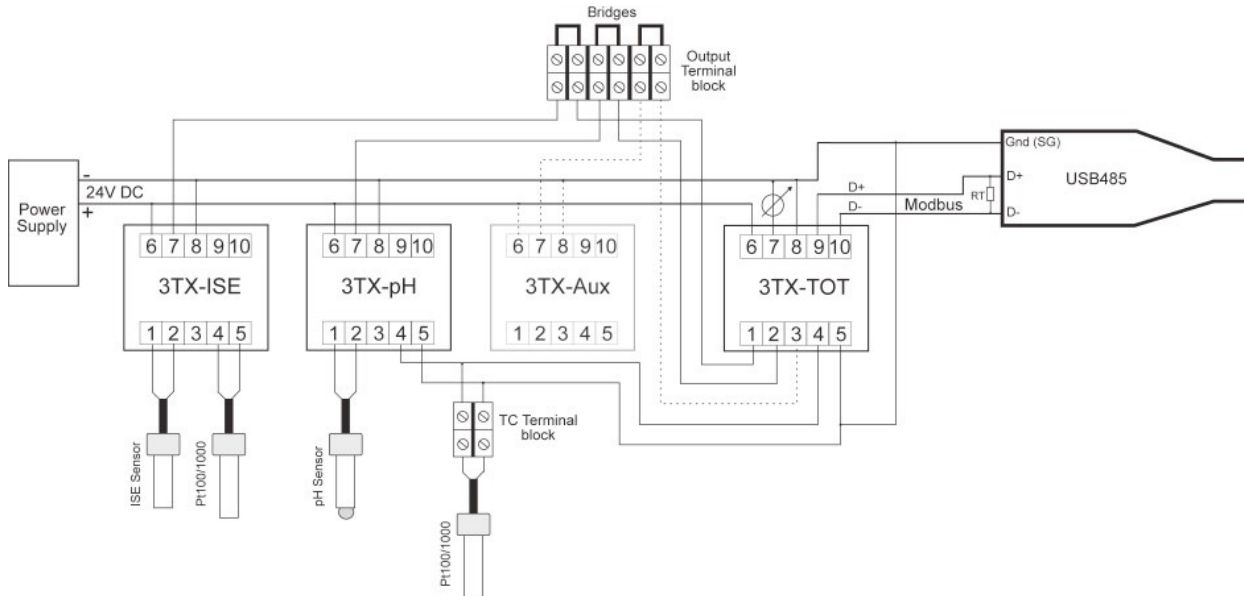
### List of FX-300-TOT Parameters

23	Type of total ISE output	Select 0-20mA or 4-20mA output	4-20mA, 0-20mA	4-20mA
24	Scaling for 0/4-20mA Total ISE Output	Select working output range on computed total ISE output	Lo (0-10), Mi (0-100), Hi (0-999)	Hi
25	0/4mA scale-total ISE	Reading @ 0/4mA	-	-
26	20mA scale - total ISE	Reading @ 20 mA	-	-
27	Set pH compensation mode	Set automatic or manual pH input mode	Automatic (aut) or manual (set)	Automatic
28	Manual pH value	User entry of pH value in manual mode	0.00-14.00	-
29	Trim low input 1	0/4mA offset calibration for input 1	As defined by free ISE measurement	-
30	Trim high input 1	20mA gain calibration for input 1	As defined by free ISE measurement	-
31	Trim low input 2	0/4mA offset calibration for input 2	As defined by pH measurement	-
32	Trim high input 2	20mA gain calibration for input 2	As defined by pH measurement	-
33	Trim low input 3	0/4mA offset calibration for input 3	As defined by input 3 configuration	-
34	Trim high input 3	20mA gain calibration for input 3	As defined by input 3 calibration	-
35	Trim low output	0/4mA offset calibration for output (total ISE)	As defined by P23, P24, P25 and P26	-
36	Trim high output	20mA gain calibration for output (total ISE)	As defined by P23, P24, P25 and P26	-
37	Baudrate	Modbus	9,600/19,200	19,200
38	Back to default	Reset to default	Def=reset, Par=no reset	Par

# 11 Additional Measurement & Function Modules

## FX-300-TOT pH Compensation Total ISE

### Wiring Approach 1: Spliced Pt100/Pt1000 Temperature Input to FX-300-TOT



**NOTES:** The optional FX-300-Aux shown can be any additional measurement transmitter such as FX-300-pH, FX-300-ISE or FX-300-CON

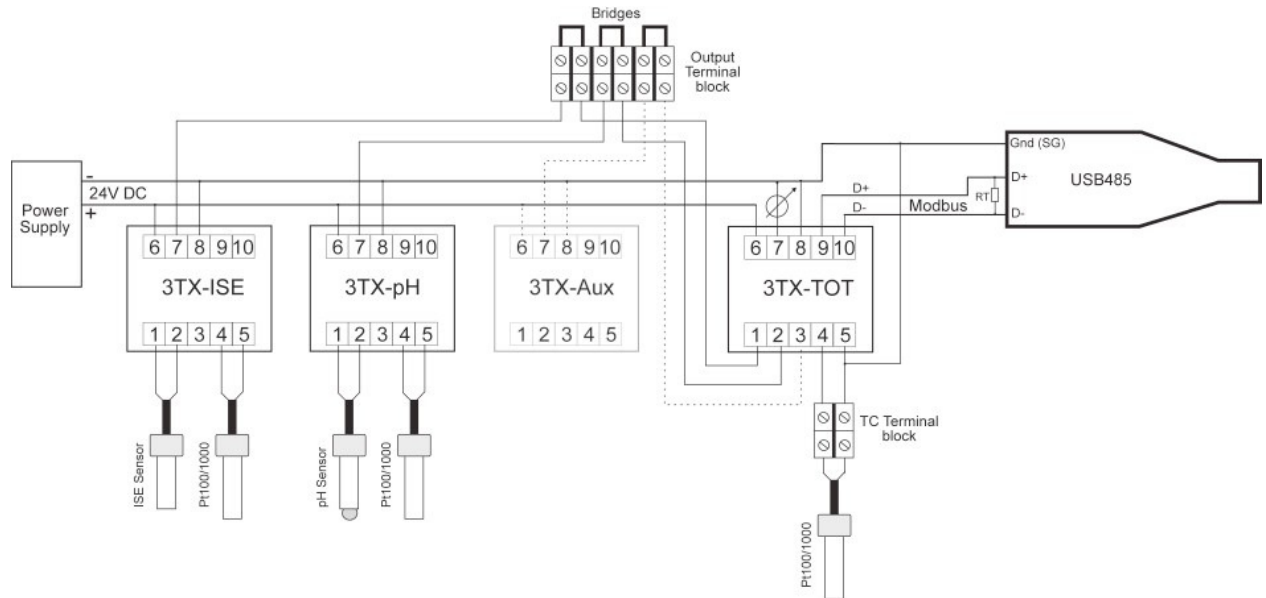
The jumpers from the Output Terminal Block can be removed so that the current loop output can be sent to any data acquisition or control system.

When purchased as a complete assembly, specify your desired wiring approach and all units will be pre-wired at the factory prior to dispatch.



# 11 Additional Measurement & Function Modules FX-300-TOT pH Compensation Total ISE

## Wiring Approach 2: Raw Pt100/Pt1000 Temperature Input to FX-300TOT



**NOTES:** The optional FX-300-Aux shown can be any additional measurement transmitter such as FX-300-pH, FX-300-ISE or FX-300-CON.

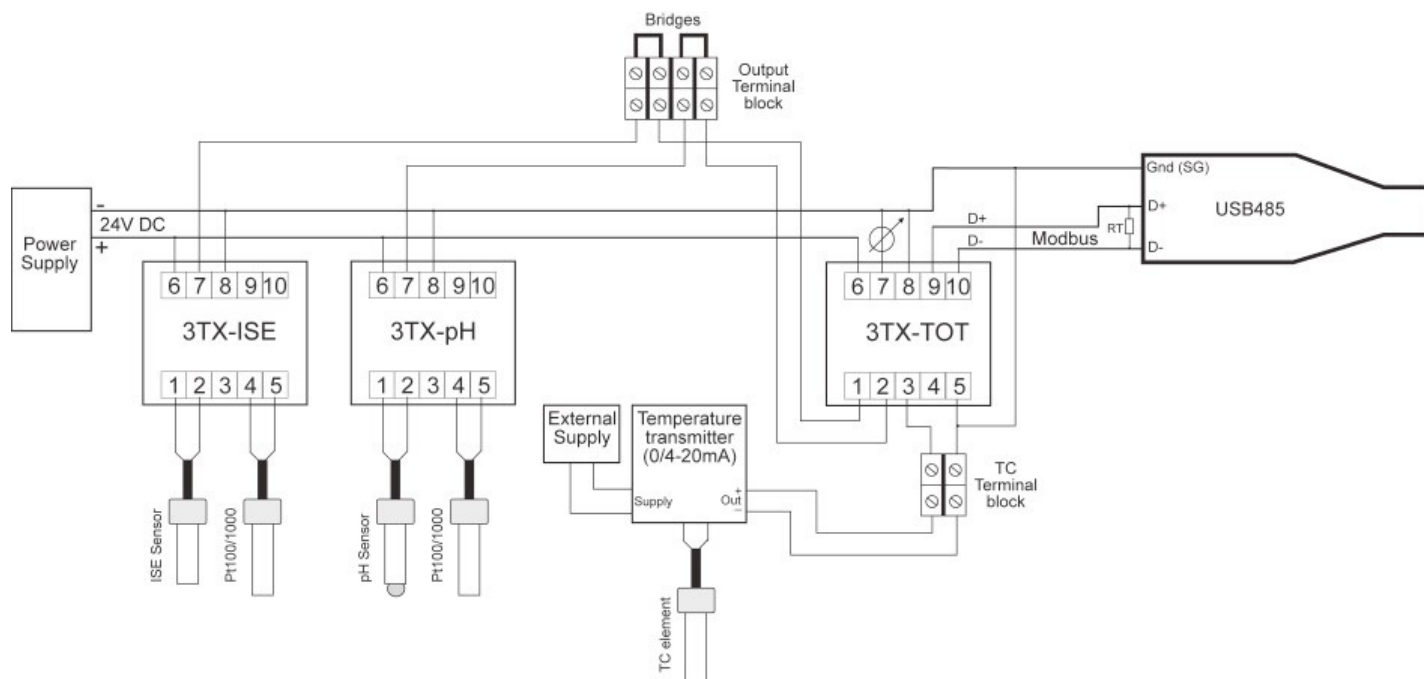
The jumpers from the Output Terminal Block can be removed so that the current loop outputs can be sent to any data acquisition or control system.

The TC terminal block shown is optional (can be wired directly into terminals 4 & 5 on FX-300-TOT module if desired).

# 11 Additional Measurement & Function Modules

## FX-300-TOT pH Compensation Total ISE

### Wiring Approach 3: 4-20mA Temperature Input to FX-300-TOT



**NOTES:** In wiring Approach 3, it is not possible to have a third measurement transmitter (shown on Approach 1 & 2 as FX-300-Aux). The TC terminal block shown is optional.

The jumpers from the Output Terminal Block can be removed so that the current loop outputs can be sent to any data acquisition or control system.

When purchased as a complete assembly, specify your desired wiring approach and all units will be pre-wired at the factory prior to dispatch.

**NOTES on display options and temperature calibration:** The temperature is calibrated by pushing the “Up” or “Down” buttons when in the temperature display (°C) mode.

The effective real-time pK (at the current temperature) is displayed by pressing the “Down”-key in main “TOTAL ISE” display mode.

The effective real-time extent of ionization is displayed by pressing the “Up”-key in the main “TOTAL ISE” display mode.

# 11 Additional Measurement & Function Modules

## FX-300-TOT pH Compensation Total ISE

### Modbus

In order to utilize the Modbus interface the FX-300-CON must be ordered with Modbus. FX-300-CON may be used as a slave for the 'Dat' - unit FX-300-DAT or as a slave in a SCADA system. The setup / communication for each case will be explained in the following.

#### With FX-300-TOT

If FX-300-TOT is used together with the FX-300-DAT, the user must pay attention to two things: The baud rate on the Modbus as well as the address of the FX-300-TOT. **The baud rate (P27)** must be set to the baud rate of the FX-300-DAT. Whether a baud rate of 19,200 or 9,600 is used is of no importance, as long as all units on the Modbus are the same baud rate.

**The address (P02)** must be unique in the network; two units are not allowed to have the same address. In a network with the FX-300-DAT as the master, all addresses must be assigned without leaving any address out; The order of the addresses is of no importance. In a network with an FX-300-DAT, up to 14 slaves may be connected, allowing only the addresses 1..14.

#### In a SCADA system

Since different SCADA systems may have different restrictions only the general are mentioned here: **The baud rate (P27)** must be set to the baud rate of the SCADA system. **The address (P02)** must be unique in the network; Two units are not allowed to have the same address.

#### Modbus Scaling

The scaling for the computed Total ISE output is defined by the range selected in P24 (low 0-10ppm, mid 0-100ppm or high 0-999ppm). This Modbus output for the computed Total ISE may differ from the analog 0/4-20mA scaling defined by P25 & P26.

The FX-300-TOT contains a maximum of 4 input measurements (Free ISE, pH, Temp and Auxiliary) and a fifth value for the computed Total ISE as the output. All five of these can be transmitted on the Modbus. Access to these are gained through the function code Read\_Input\_Registers (04). The FX-300-TOT gives access via Diagnostics (08), as shown in the following.

#### **Read Input Registers**

Function code	Start address	Number of values
<b>04</b>	<b>1</b>	<b>1 or 2</b>

Measurements are transmitted in sequence; All values are rated to 0-1000 corresponding to the range, Output (Total ISE – 1st value) has no offset, Input 1 (Free ISE – 2nd value) an offset of 1024, Input 2 (pH – 3rd value) an offset of 2048, Input 3 (Temp – 4th value) an offset of 3072 and Auxiliary has no offset (5th value); Total ISE is sent as 0-1000, Free ISE as 1024-2024, pH as 2048-3048, Temp as 3072-4072, and Aux (when present) as 0-1000.

#### **Diagnostics**

Function code	Sub code (HEX)	Description
08	00	Return query data
	0A	Clear counters and diagnostics register
	0B	Return bus message count
	0C	Return bus communication error count
	0D	Return exception error count
	0E	Return slave message count
	0F	Return slave no response count
	12	Return bus character overrun count

### Customer Service Department

If you need spare parts, assistance in troubleshooting, or repair service, please contact Foxcroft Customer Service at:

**Foxcroft Equipment and Service, Co. Inc.**  
**2101 Creek Road, P.O. Box 39**  
**Glenmoore, PA 19343**

**Tel: (800) 874-0590**  
**(610) 942-2888**  
**Fax: (610) 942-2769**  
**Email: [service@foxcroft.com](mailto:service@foxcroft.com)**  
**[www.foxcroft.com](http://www.foxcroft.com)**

### Customer Repair / Returns Policy

All systems returned for repair or replacement must be freight prepaid and include the following information:

1. A clearly written description of the malfunction.
2. Name of person to contact and the phone number where they can be reached.
3. Proper return address for shipping system back. Include preferred shipping method.
4. A purchase order if the system is out of warranty to cover costs of repair.
5. A Return Material Authorization Number (RMA) is required before shipping any products for service. Call telephone number above to receive a RMA number.

**NOTE:** *Returns will only be held at Foxcroft for 90 days. If a decision is not made regarding the repair, the product will be returned.*

Foxcroft Equipment & Service warrants all products obtained hereunder to be free from defects in material and workmanship for a period of one year from the date of shipment. In the event of a product failure or defect requiring warranty repair, the customer must obtain an RMA number by calling 1-800- 874-0590, before returning the product, at the customer's expense to Foxcroft for repair. Warrantor (Foxcroft Equipment and Service) will repair the unit, without charges for parts, labor and return freight.

Foxcroft Equipment & Service is not responsible for damage to its products through improper installation, maintenance, act of God, use or attempts to operate such products beyond their functional capacity, intentionally or otherwise, or for any unauthorized repair.

Buyer agrees to hold Foxcroft Equipment & Service harmless from all claims for damages arising out of injury or death to any person or damage to any facility, or any other property, or loss of use of any such property, whether such person or property is on or off the installation or activity site for which the equipment or material furnished hereunder is destined and whether such damage, loss destruction or loss of use, injury or death results directly or indirectly from a nuclear incident or for any other cause.

Statements and instructions set forth herein are based upon the best information and practices known to Foxcroft Equipment & Service but it should be assumed that every acceptable safety procedure is contained herein. Of necessity this company cannot guarantee that actions in accordance with such statements and instructions will result in the complete elimination of hazards and it assumes no liability for accidents that may occur.



**Serial Number Label of FX-300 Series Analyzer:**

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