3TX-CON-F for Accurate Temperature Compensation of Conductivity in both Negative & Positive Temperature Ranges

Conceptual Background

Measurement near and below zero degrees Celsius requires the use of a special temperature compensation approach by means of a software that allows for entering characteristic experimentally determined temperature coefficients for the given sample to be measured both below and above zero degrees. For such an approach to work, the reference temperature must be changed when the conductivity transmitter operates in this special mode that allows for both measurement in the negative temperature condition and to cross the zero degree threshold into the positive temperature region. The reference temperature must be changed from the ubiquitous 25°C convention to the logical 0°C choice for this special use. The reference temperature must be the intersection between the temperature coefficients to be used for the below zero and above zero condition and this occurs at exactly 0°C.

It is important to bear in mind that the temperature compensation by means of a simple linear correction scheme is really just a reasonably good 1st order linear approximation for the actual more complex temperature dependence of how the raw conductivity changes as a function of temperature. This 1st order approximation break down in particular as we approach and go below zero we must use an altogether different coefficient. The temperature coefficient is an not instrinsic constant but rather dependent upon the reference temperature condition imposed. We need two different temperature coefficient for the positive temperature range: one for the special mode when the reference temp is 0°C and another for the standard mode when the reference temp is 25°C. Note that these two positive temperature coefficients will ALWAYS be different even with the same data set used as the basis because the reference temperature condition imposed is different. We need only a single temperature coefficient for the negative temperature condition since this will only be in use for the special mode where the reference temperature is 0°C. The physical chemistry will limit the actual validity of the lowest temperature condition as defined by the observed freezing point depression.

To visualize how these special temperature compensation modes operate, review the data and curves graphed linked below:

http://www.astisensor.com/3TX-CON-F_negative_and_positive_linear_temperature_compensation_coefficient_for_saturated_sodium_chloride_conductivity.pdf

The 2nd order polynomial fit to the reference data was used to calculate the expected values for the below zero condition. A linear fit was made for the reference data in the 0-36°C for the reference temperatures of 0°C and 25°C. A linear fit was made to these calculated (expected) conductivity values for the below zero conditions and this was the basis of the negative temperature coefficient that was computed (again with a reference temperature of 0°C). There will exist some degree of discontuity for the temperature compensated conductivity value as you cross from the negative to positive temperature region which will be dependent in large part upon how well the two temperature coefficeint were determined for the solution to be measured.

TEMPERATURE OPERATING MODES:

Low Temperature Temp Comp Enabled Mode: When P24 is enabled ("On") the reference temp is 0°C. When the temp is between -40 to 0 °C, the P25 negative temp is used. Once the transmitter is above 0°C the P26 positive temp coefficient is used. The reference temperature is 0°C when P24 is enabled no matter which temperature coefficient is in use to compute the temperature compensation.
Low Temperature Temp Comp Disabled (Standard) Mode: When P24 is disabled ("Off") the reference temperature is the ubiquitous 25°C using P06 temperature coefficient for the 0-210°C range. The transmitter will display and measure down to -40°C, but the temperature compensation will stop at 0°C in this the standard mode (the temperature LED will flash to indicate this situation).

RAW ANALOG OUTPUT MODE:

A raw conductivity output mode is available. The P09 output can be temperature compensated "Con" mode (as before) or the new "Raw" conductivity mode. The raw conductivity output scaling for the 0/4-20mA is set with parameters P26 & P27 (see next page).

MODBUS OUTPUT:

Based upon the CON-E K=20.0/cm specifications as detailed below. The output is compatible with the Windows datalogging software but incompatible with the DAT module. The MODbus scaling is fixed and so decoupled from the adjustable analog scaling.

Nominal Cell Constant	Calibrated Cell Range	Full Range with Temp. Comp.	Full Range Resolution MODBus Value 1 Scaling	Raw Conductivity Input Range	Raw Input Resolution MODBus Value 3 Scaling
K = 20.0/cm	4.00 to 36.0	0-1,000,000 µS (0-1,000mS)	100µS 0-10,000 Steps	0-5,000,000 µS (0-5,000mS)	100µS 0-50,000 Steps

The second MODbus value is the temperature. The scaling is -40 to +210 °C sent as 0-2,500 steps (0.1°C resolution).

Parameters & Setup

The parameter setup is accessed via "Setup" on faceplate and functions in typical manner as for all other 3TX-CON transmitters.

No	Parameter	Description	Range	Default
01	Lock	Software Lock	On / Off	On
02	Address	Address on MODbus	Off, 1…247	Off
03	Temperature	Type of Input	Pt100, Pt1000	Pt1000
04	Compensation	Temp. Comp. Conductivity	Auto, Fixed (Manual / Set)	Auto
05	Manual. Comp. Temp.	Fixed Temperature Value	-40 to +210 °C *	25
06	Temp. Comp. 0-210°C	Coefficient for 0-210°C Range	0.00 – 6.00 %/°C	2.10
07	Wire Gauge	Sensor AWG	20, 22, 24	22
08	Cable Length	Length in feet	1…999 feet	10
09	Input for Analog Out	Input for the analog output	**Temperature Compensated "*Con*" or Raw Conductivity "Raw"**	Con
10	Analog Output Mode	Type of Output	4-20mA, 0-20mA	4-20
11	0/4mA Low Output	Low Output (Cond Units)	0%-90% of Full Range	0%
12	20mA High Output	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%**	1
14	Offset Adjustment	Zero Calibration	Increments per P13 *	N/A
15	Working Gain (Slope)	Gain on Cell Constant	±80%	1.00
16	0/4mA Offset	Trim Low	±9.99% *	Factory
17	20mA Gain	Trim High	±9.99% *	Factory
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	1,000mS	999mS
22	Nominal Cell Constant	Cell constant a.k.a. "K"	K=20.0/cm	20.0
23	Output mode	Type of output mode	Non-inverted, Inverted	n.inv
24	Low Temperature Compensation Mode	Enable or Disable Low Temp Compensation Mode	Off (0-210°C) or On (-40 to +210°C) **	On **
25	Temp Comp -40 to 0°C	Coefficient for -40 to 0°C Range	-6.00 to +6.00 %/°C *	2.85
26	0-210°C Temp Coefficient - Low Range	Coefficient for 0-210°C Range Low Range Mode Enabled	-6.00 to +6.00 %/°C *	3.75
27	Raw Low Setpoint	Sets 0/4mA for Raw Mode	0%-90% of Full Range	0mS
28	Raw High Setpoint	Sets 20mA for Raw Mode	10%-100% of Full Range	2,000mS
29	Reset Calibrations Only	Reset P14 & P15 back to factory	Def=Reset, Par=NoReset	Par

** Negative values will be shown as flashing* *** When P24 is "On" the reference temperature is 0℃. When P24 is "Off" the standard 25℃ reference temp is used.*

Adjustment

Besides the setup parameters the user will be able to adjust the gain (cell constant) of the conductivity measurement as well as offset on the temperature measurement. Gain adjustment is accessible via the menu point "Gain" on the faceplate. Offset on the temperature is done by pressing the "Up" / "Down" while displaying temperature.

- Gain on conductivity (P15): Range = ±80% in steps of parameter P13
- Offset on conductivity (P14): Range = -50% in steps of parameter P13. Adjustment is only possible in negative direction ("Down"-button); "Zeroing" a displayed positive value.
- Offset on Temperature: Range = ±25°C in steps of 0.2°C. Negative temperature will be shown as flashing.

Display features

- Raw conductivity is shown when pressing the "Down" key in the main conductivity display. Values larger than 999mS will be show with mS LED flashing (i.e. if the mS LED is flashing with 1.23 displayed, this means 1,230mS raw conductivity).
- The mA output for the current configuration is displayed by pressing the "Up" key in the main conductivity display mode.
- Production date (yy.m) is displayed by pressing the "Down" & "Mode"-key simultaneously in main conductivity display mode. The month shows as 1..9 and A for October, B for November and C for December (i.e. October 2011 will display as "11.A")
- Software revision is displayed by pressing the "Up" & "Mode"-key simultaneously in the main conductivity mode.

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