Guide to multivendor sensors setup using NX controllers.

NX controllers have expanded functionality added on version **3.08.0** to their versatile universal inputs. This document will guide you thru each one of the possibilities of attaching sensors to either the digital or analog side of the universal inputs as well as on the fieldbuses.

From the lists below note that:

- ⊗ Improved range and accuracy sensor types are highlighted in **BLUE**.
- ⊗ Newly added sensor types are highlighted in **GREEN**.

Section 1:

ATTACHING ANALOG SENSORS TO THE UNIVERSAL INPUTS

- ⊗ Raw 12-bit ADC value.
- ⊗ Industrial universal sensors with 0 to 10 Volts output.
- ⊗ Industrial universal Sensors with 2 to 10 Volts output.
- ⊗ Industrial universal Sensors with 0 to 5 Volts output.
- ⊗ Industrial universal Sensors with 1 to 5 Volts output.
- ⊗ Industrial universal Sensors with 4 to 20 mA output.
- ⊗ Industrial universal Sensors with 0 to 20 mA output.
- ⊗ J type thermocouple for high range temperature sensing.
- ⊗ K type thermocouple for high range temperature sensing
- ⊗ Ratiometric pressure sensors for refrigeration use.
- ⊗ Current transformers with 25-500 mA secondary.
- ⊗ Using an analog signal to measure energy consumption in KWh.
- ⊗ Temperature sensor 1000 Ohms Nickel TE-6x00 series by Johnson controls.
- ⊗ Temperature sensor 1000 Ohms Platinum (PT1000) by Dwyer instruments / Johnson Controls.
- ⊗ Temperature sensor 1000 Ohms Silicon TE-6x00, series by Johnson controls.
- ⊗ Temperature sensor 1000 Ohms Silicon KTY-1x0 series by NXP / Digikey.
- ⊗ Temperature sensor 1000 Ohms Silicon A99 series by Johnson Controls / Penn.
- ⊗ Temperature sensor 20K NTC series by Dwyer instruments.
- ⊗ Temperature sensor 10K Type-III by Schneider or Dwyer.
- ⊗ Temperature sensor 10K Type-II by Dwyer instruments.
- ⊗ Temperature sensor 5K by Digikey.
- ⊗ Temperature sensor 3K by Digikey.
- ⊗ Temperature sensor 1K by Digikey.
- ⊗ Temperature sensor using any arbitrary NTC thermistor using Steinhart-Hart calculators from any manufacturer or supplier.
- ⊗ Resistance measuring to obtain ohms value from potentiometers or resistive type sensors.

Section 2:

ATTACHING DIGITAL SENSORS TO THE UNIVERSAL INPUTS

- Dry contact digital sensors with common grounded.
- Dry contact digital sensors with common connected to DC Voltage.
- Connecting NPN type digital sensors.
- Connecting PNP type digital sensors.
- Pulse type sensor to measure water consumption.
- Pulse type sensor to measure gas consumption.
- Pulse type sensor to measure energy consumption in KWh.

Section 3:

ATTACHING DIGITAL SENSORS USING THE FIELDBUSES

- Connecting the environmental corrosion monitor ECM.
- Connecting the NSHF/NSGP digital weight scale.
- Connecting the IQ plus 355 digital weight scale.
- Connecting the OpenBAS-HV-WLSTH temperature and humidity transmitter using Optomux.
- Connecting the OpenBAS-HV-WLSTH temperature and humidity transmitter using Modbus.
- Connecting the BRTH temperature and humidity transmitter using Optomux.
- Connecting the BRTH temperature and humidity transmitter using Modbus.
- Connecting Yaskawa variable frequency drive VFD.
- Connecting Honeywell gas and explosivity sensor using modbus.
- Connecting an Arduino board to send to the NX any kind of digital information.
- Connecting a Raspberry-PI board to send to the NX any kind of digital information.

Revision 0. By: Ricardo Medina -- 22/Jan/2021

Initial release of this document

Revision 1. By: Ricardo Medina -- 22/Jan/2021

Correct selection type for A99 sensors

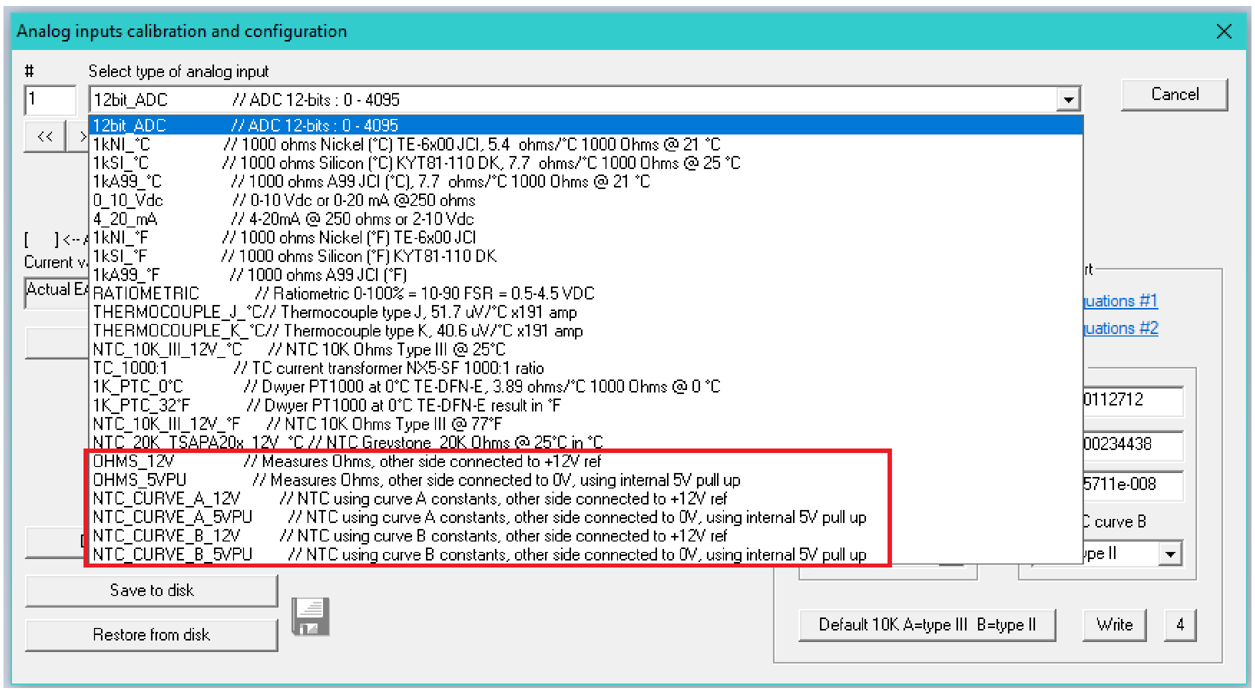
Preface:

Before we go into the details of attaching each one of the sensors the NX controllers can handle, let´s look at the most recently sensor types that were added on version **3.08.0**.

Before moving on I want to deeply thank Chris Lange who produced a large part of the new code and the math behind to get this new sensor types added and pushed me to the limits of what is possible to do on a humble 8-bit Microchip controller with already constrained resources.

In the figure below we can see the newly added sensor types that were added, highlighted in red.

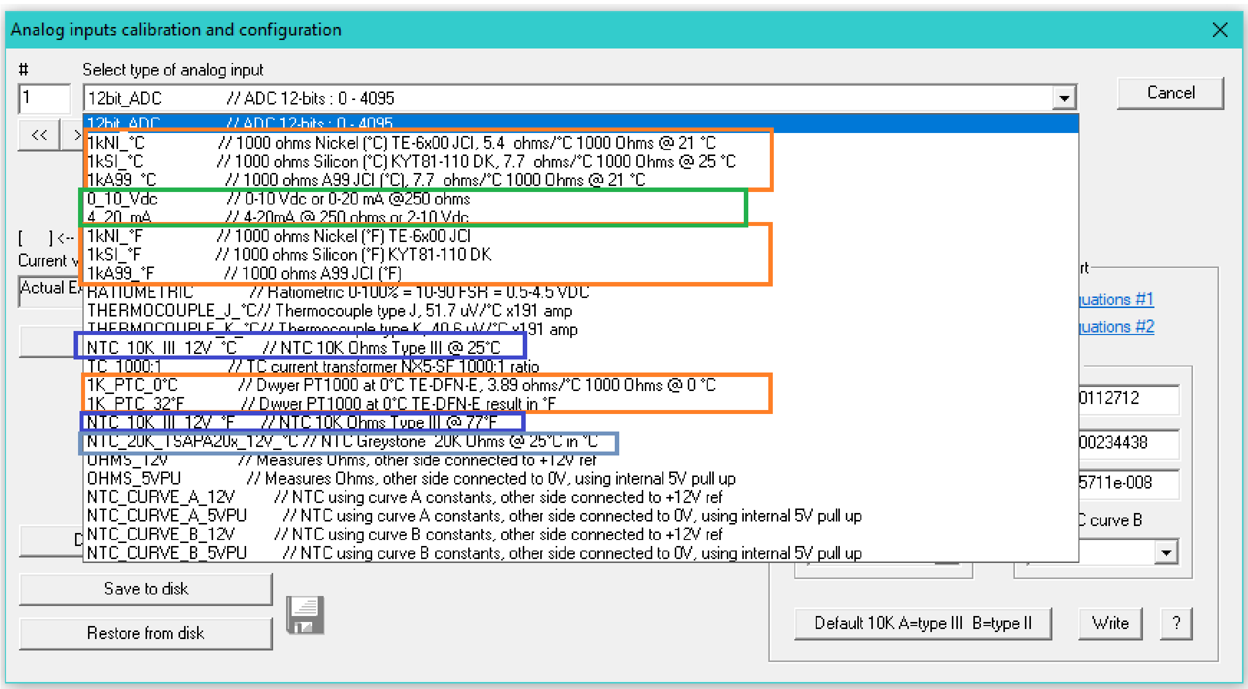
- ⊗ Two resistance measurements were added, with either an internal or external pull ups.
- ⊗ Four thermistor options were added to provide with universal NTC thermistor ranges.



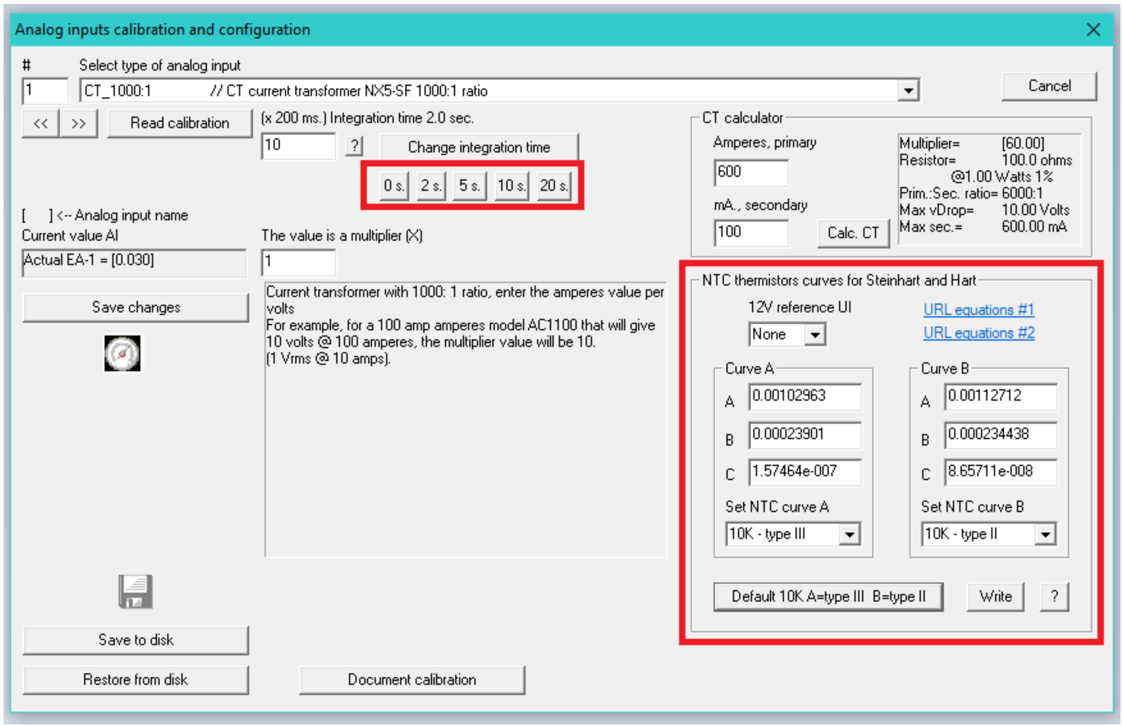
Also following in the figure on the next page is a highlight of the sensor types that were improved.

Figure showing the measurements that were improved.

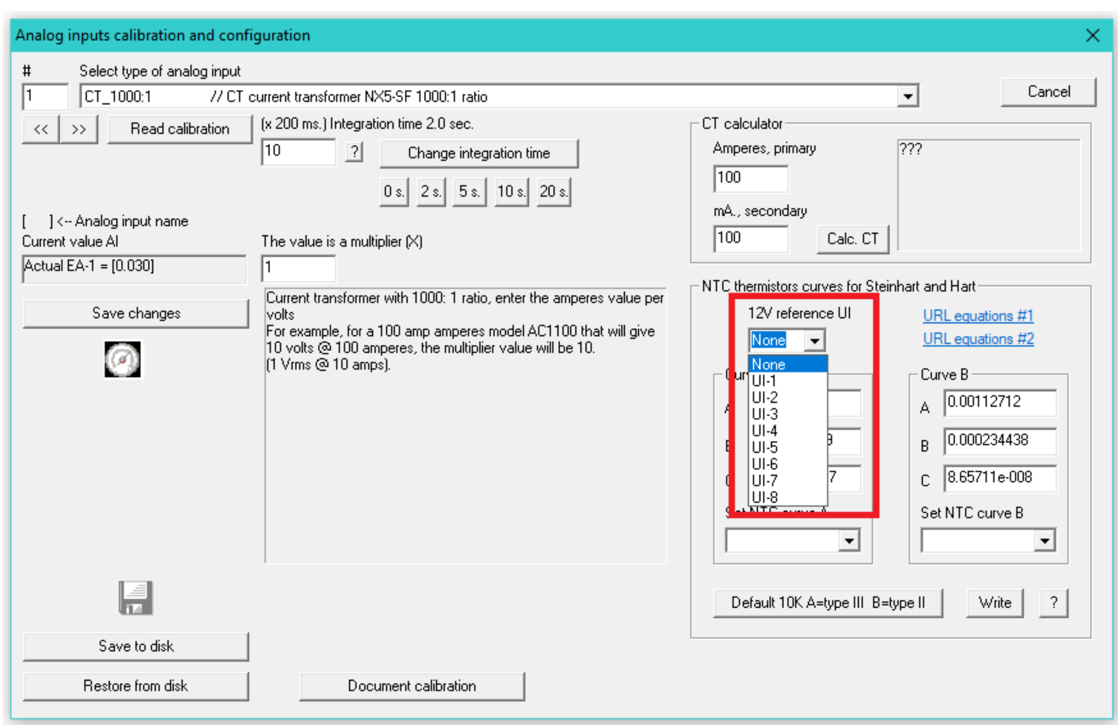
- Eight temperature measurement that previously existed were improved to linearize their readings expanding both the low and high temperature ranges with far better accuracy, they are highlighted in orange.
- Three new modes for using the Voltage and milliampere readings were added to the existing ones, highlighted in green.
- Two existing NTC thermistor types now use the Steinhart-hart equation with a fixed 10K type-III curve highlighted in dark blue.
- The NTC 20K by Greystone or Dwyer was kept for backward compatibility, using the same old formula for existing applications. However, note that a new enhanced version for this thermistor type is also available and will be explained in its own section, shown below highlighted in gray.



Five quick universal input general integration time settings were added, that populate the integration time for new users and avoid confusion or calculation errors. Still the individual integration per analog channel is still available as usual in the INFO button on the main dialog page. Also located in the bottom right corner you will find the newly added options for NTC thermistors.



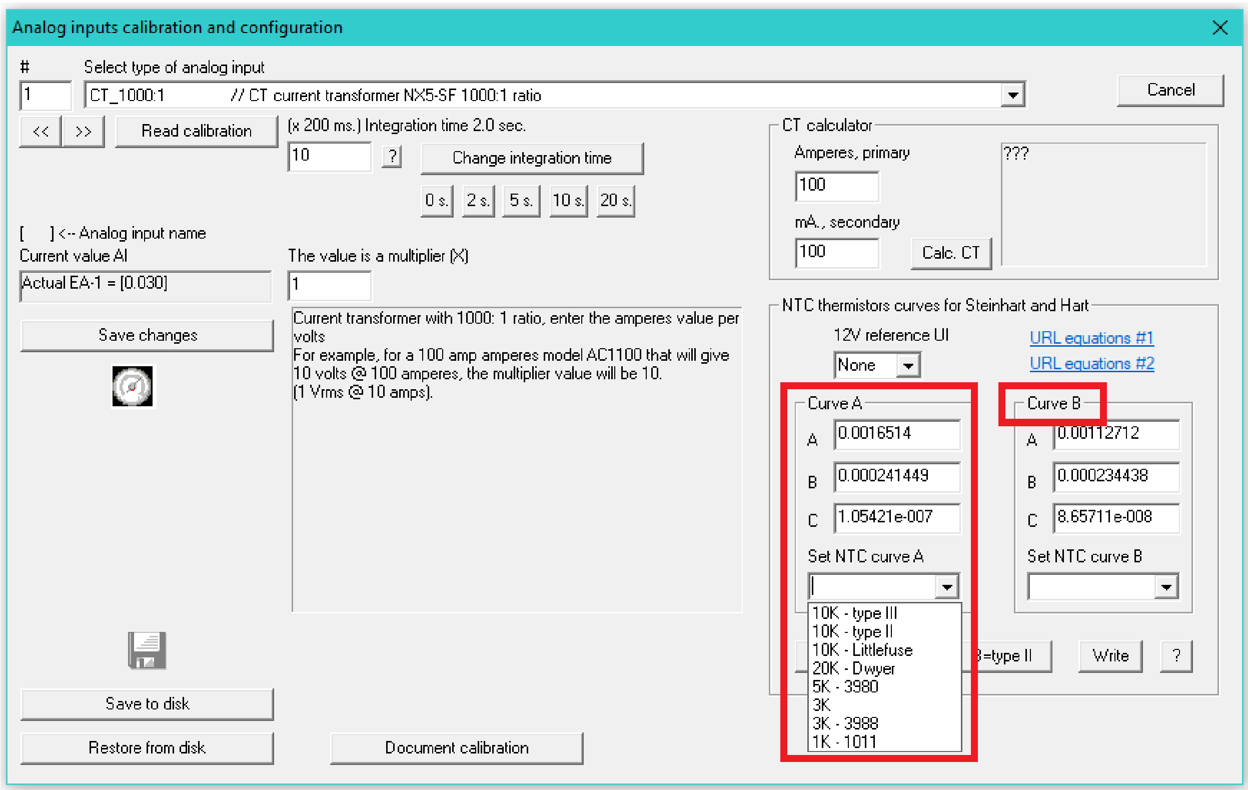
Most OpenBAS-NX controllers have an integrated precision 12 Volts DC internal power supply to be used by analog sensors, the NTC thermistors can use this supply, but if an external 12 Volts supply is used that is not as precise as the internal one, then one of the first eight universal inputs can be used to measure this voltage and use its read value to correct the calculations automatically, by default it is set to none.



Unsurpassed flexibility for using any thermistor from any supplier:

Three different NTC types can be selected at any given time on each NX master out of a pool of nine different types, this capability is further expanded as each slave has the same firmware and thus each slave added, has this same three options.

So, having said this, for a master with four slaves up to 15 different NTC thermistor model types can be used at any given type for the up to 40 universal inputs.

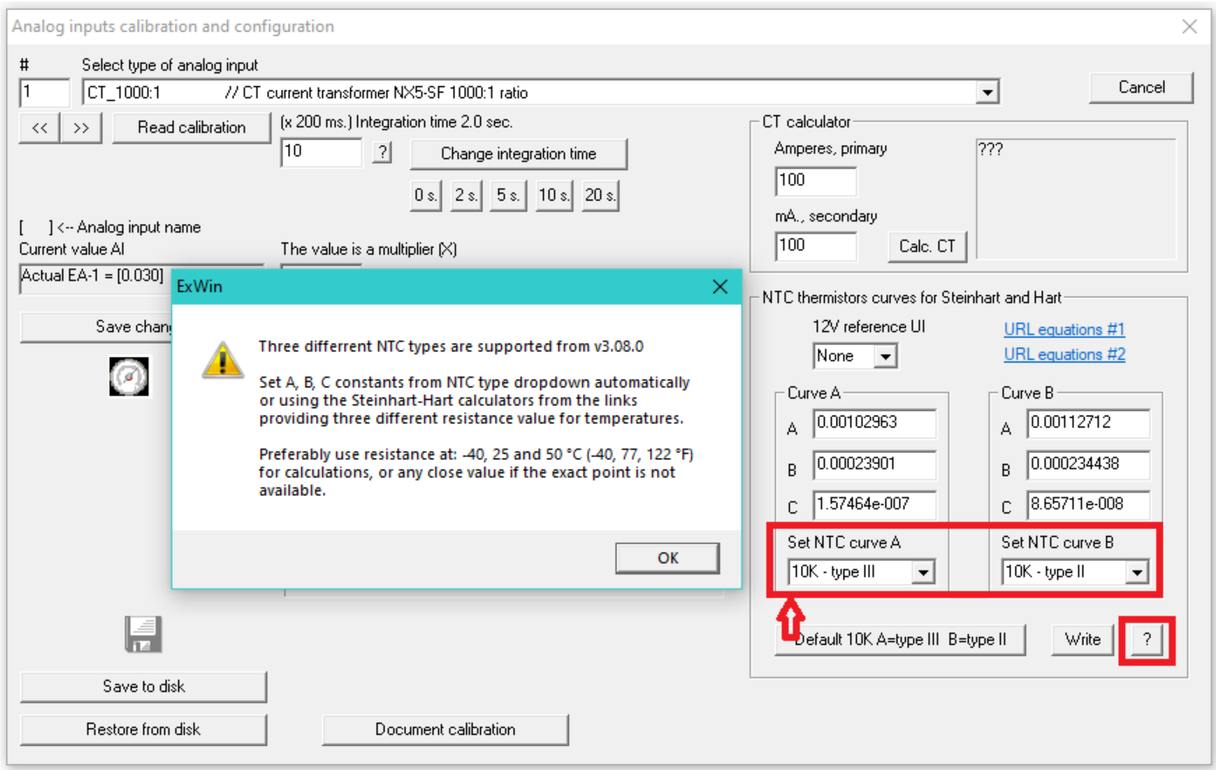


The MFC tool has a raw selection mechanism that has two possible NTC thermistor curve types, herein referred as: **Curve A** and **Curve B** which are additional of the previously existing fixed 10K type III NTC thermistor.

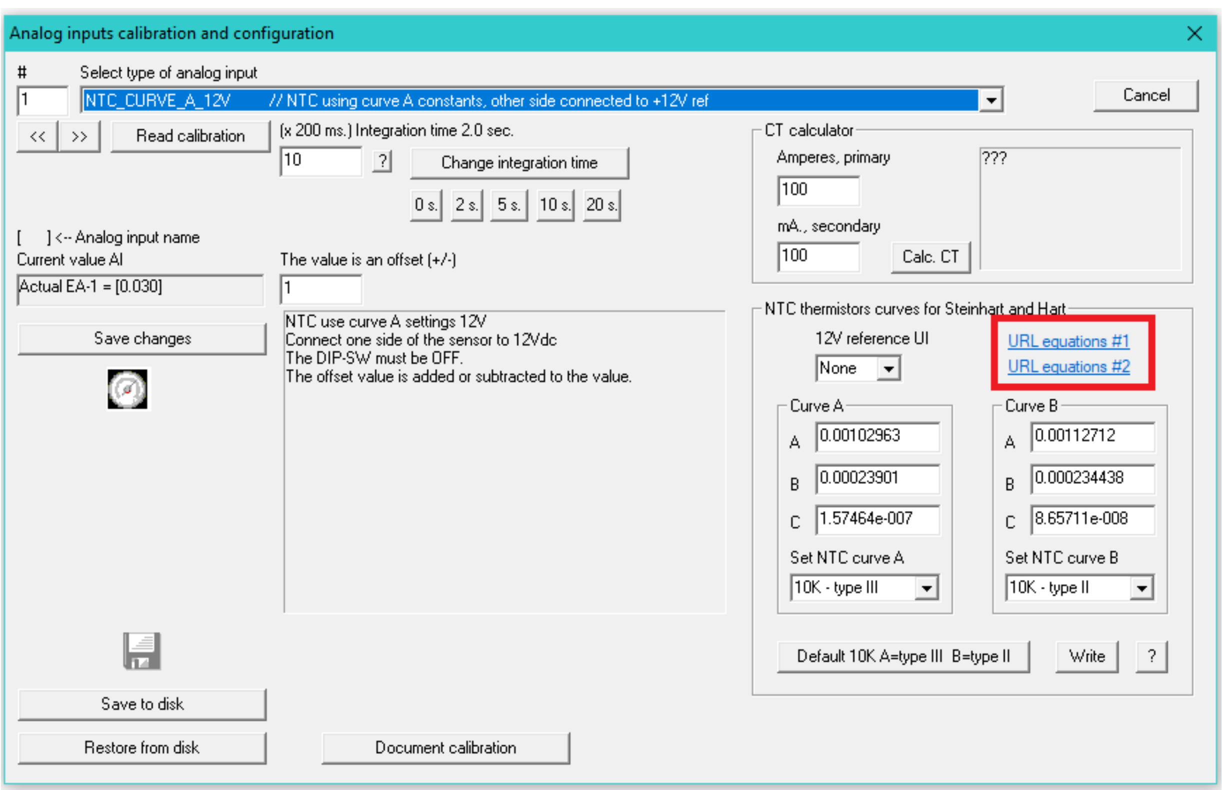
By selecting from the dropdown combo box, any of the eight predefined types shown above can be selected that automatically populate the **A**, **B** and **C** constants needed by the Steinhart-hart equation used.

As the Steinhart-Hart formula is truly universal, on the next page you will learn how to calculate these three constants for any sensor, of any specified resistance, on any range from any manufacturer.

As you will see in the figure below there is a quick online help button to provide basic assistance when calculating the appropriate **A**, **B** and **C** values for each one of the **Curve A** and **Curve B** thermistor types available.

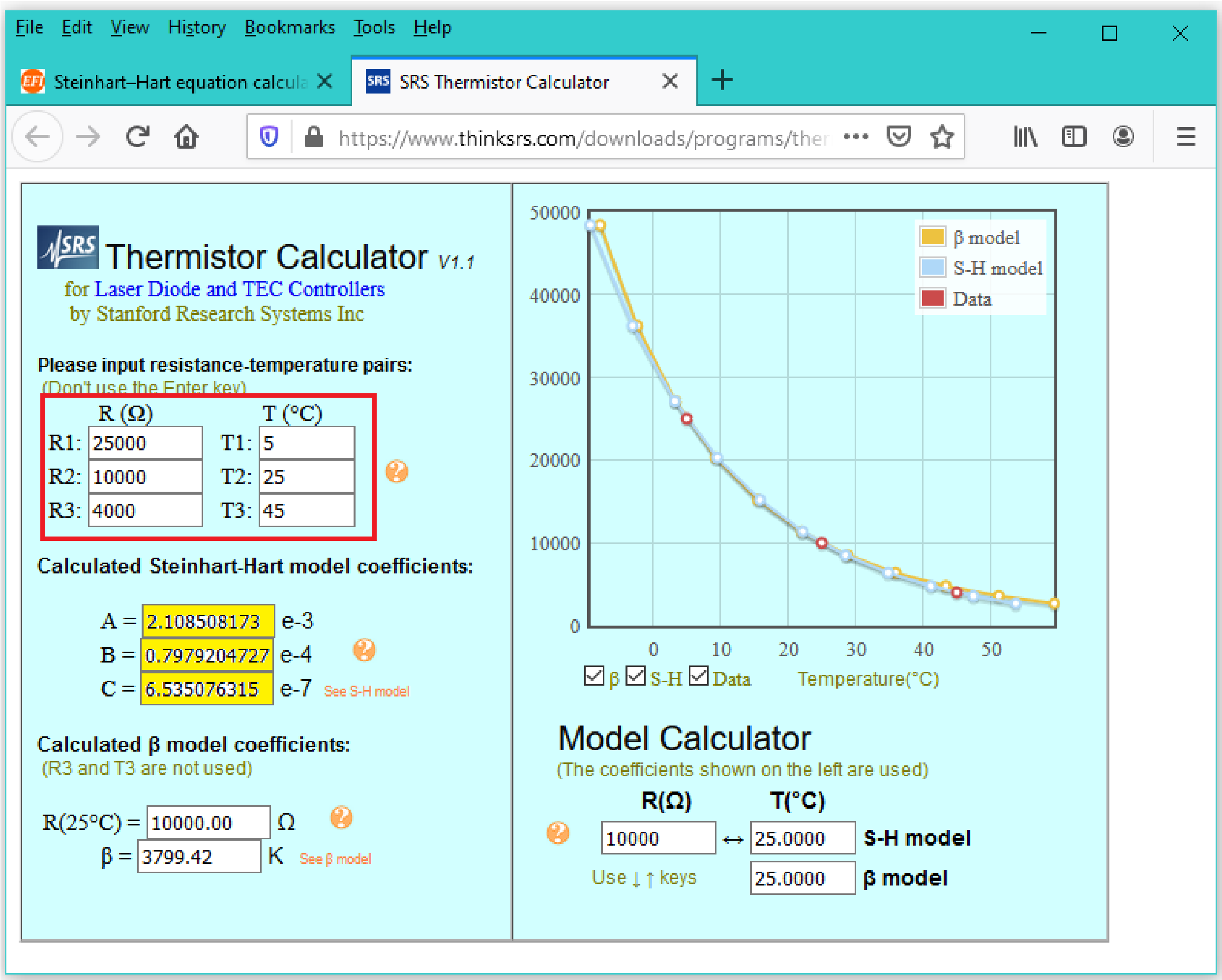


Also, the MFC tool provides two links to two different online calculators that can be seen on the next page. They both provide exactly, the same result, therefore which one you use is just a matter of your own personal taste.

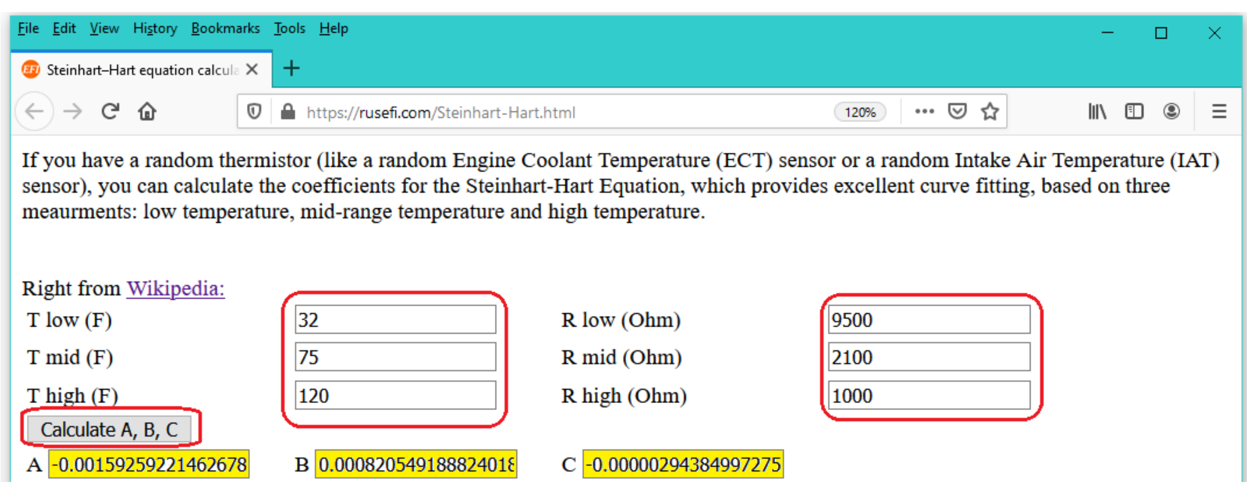


In this one shown first, you must enter the three resistance vs. temperature points in Ohms and °Celsius. It also provides a neat visual representation of the three input points in the graphed curve.

The three **A**, **B** and **C** constants that are highlighted in yellow in the figure below can be simply copied and pasted into the MFC tool using the common **CTRL-C** (copy) and **CTRL-V** (paste) Windows commands.



On this other online calculator option, you must enter the three points in °Fahrenheit and Ohms, respectively. Note that there is nothing stopping you from manually converting the temperatures in the resistance vs. temperature charts from °C to °F and vice versa to use any of these two web sites that you prefer. On the next page a typical resistance vs. temperature NTC thermistor chart is shown.



A typical resistance vs. temperature NTC thermistor chart is shown below obtained from the Dwyer web page.

For typical **HVAC** applications, the resistance values at: **-40, 25 and 50 °Celsius** (or **-40, 77, 122 °Fahrenheit**) are chosen to use in the Steinhart-Hart calculator.

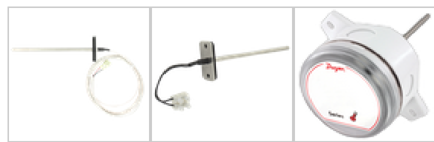
Nothing stops you to use your own selection values, as at the end the result will be the same.

Just make sure the three values chosen are from **LOW → HIGH** temperatures, to obtain a correct result out from the calculator.

Optionally for sensors that have their middle point or reference resistance at 0° instead of at 25°C that point can be used instead as the second point.

Note that the Steinhart-Hart is intended only for **NTC thermistor** type sensors. **RTD** or **PTC** sensors have their own options on the **NX** Universal input calibration types.

Dwyer Manufacturing Excellence Since 1931



	RESISTANCE VS TEMPERATURE TABLE							
	Temperature		Resistance Curves (Ω)					
			A - 10k Ω type III thermistor	B - 10k Ω type II thermistor	C - 3k Ω thermistor	D - PT100 Ω RTD	E - PT1000 Ω RTD	F- 20k Ω thermistor
	°C	°F	Green/Green	Red/Green	Black/Black	Yellow/Yellow	Red/Red	Green/Blue
	-55	-67.0	607800.00	963849.00	289154.70	78.32	783.2	2394000.00
	-50	-58.0	441200.00	670166.00	201049.80	80.31	803.1	1646200.00
	-45	-49.0	323600.00	471985.00	141595.50	82.29	822.9	1145800.00
1st	-40	-40.0	239700.00	336479.00	100943.70	84.27	842.7	806800.00
	-35	-31.0	179200.00	242681.00	72804.30	86.25	862.5	574400.00
	-30	-22.0	135200.00	176974.00	53092.20	88.22	882.2	413400.00
	-25	-13.0	102900.00	130421.00	39126.30	90.19	901.9	300400.00
	-20	-4.0	78910.00	97081.00	29124.30	92.16	921.6	220600.00
	-15	5.0	61020.00	72957.00	21887.10	94.12	941.2	163500.00
	-10	14.0	47540.00	55329.00	16598.70	96.09	960.9	122280.00
	-5	23.0	37310.00	42327.00	12698.10	98.04	980.4	92240.00
	0	32.0	29490.00	32650.00	9795.00	100.00	1000.0	70160.00
	5	41.0	23460.00	25392.00	7617.60	101.95	1019.5	53780.00
	10	50.0	18780.00	19901.00	5970.30	103.90	1039.0	41560.00
	15	59.0	15130.00	15712.00	4713.60	105.85	1058.5	32340.00
	20	68.0	12260.00	12493.00	3747.90	107.79	1077.9	25360.00
2nd	25	77.0	10000.00	10000.00	3000.00	109.74	1097.4	20000.00
	30	86.0	8194.00	8057.00	2417.10	111.67	1116.7	15892.00
	35	95.0	6752.00	6531.00	1959.30	113.61	1136.1	12704.00
	40	104.0	5592.00	5326.00	1597.80	115.54	1155.4	10216.00
	45	113.0	4655.00	4368.00	1310.40	117.47	1174.7	8264.00
3rd	50	122.0	3893.00	3602.00	1080.60	119.40	1194.0	6722.00
	55	131.0	3271.00	2986.00	895.80	121.32	1213.2	5498.00
	60	140.0	2760.00	2488.00	746.40	123.24	1232.4	4520.00
	65	149.0	2339.00	2083.00	624.90	125.16	1251.6	3734.00
	70	158.0	1990.00	1752.00	525.60	127.08	1270.8	3100.00
	75	167.0	1700.00	1480.00	444.00	128.99	1289.9	2586.00
	80	176.0	1458.00	1255.00	376.50	130.90	1309.0	2166.00
	85	185.0	1255.00	1070.00	321.00	132.80	1328.0	1822.60
	90	194.0	1084.00	915.50	274.65	134.71	1347.1	1540.00
	95	203.0	939.30	786.60	235.98	136.61	1366.1	1306.40
	100	212.0	816.80	678.60	203.58	138.51	1385.1	1112.60
	105	221.0	712.60	587.60	176.28	140.40	1404.0	951.00
	110	230.0	623.60	510.60	153.18	142.29	1422.9	815.80
	115	239.0	547.30	445.30	133.59	144.18	1441.8	702.20
	120	248.0	481.80	389.60	116.88	146.07	1460.7	606.40
	125	257.0	425.30	341.90	102.57	147.95	1479.5	525.60
	130	266.0	376.40	301.00	90.30	149.83	1498.3	N/A
	135	275.0	334.00	265.80	79.74	151.71	1517.1	N/A
	140	284.0	297.20	235.30	70.59	153.58	1535.8	N/A
	145	293.0	265.10	208.90	62.67	155.46	1554.6	N/A
	150	302.0	237.00	186.10	55.83	157.33	1573.3	N/A

SECTION 1:

ATTACHING ANALOG SENSORS TO THE UNIVERSAL INPUTS

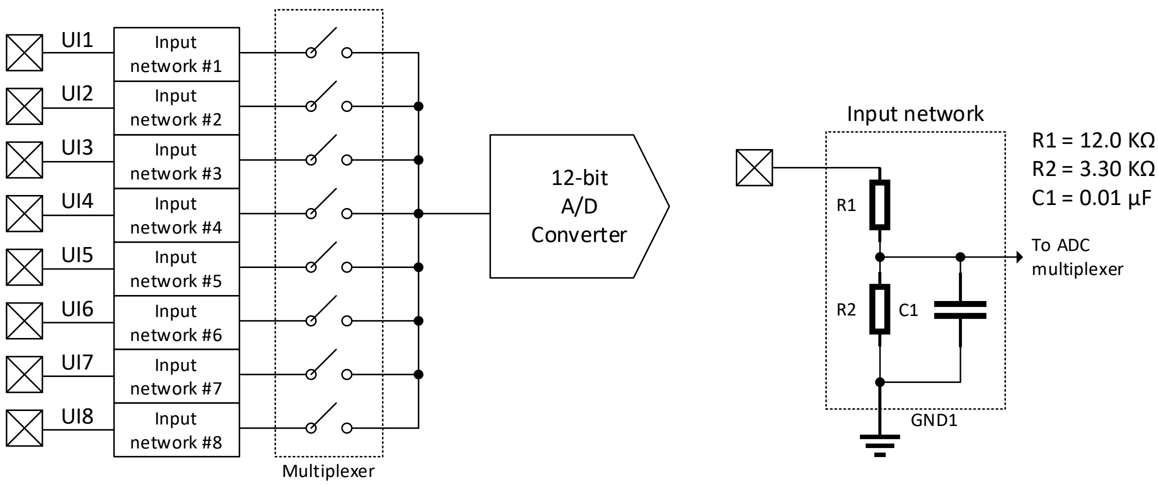
Now that all the features of the MFC tool that were added on v3.08.0 were explained in detail let´s go into how to configure and wire the different sensors to the NX controllers.

⊗ Raw 12-bit ADC value.

All NX controllers’ universal inputs have a high speed accurate 12-bit ADC (Analog to Digital Converter) capable of taking samples in as few as 10 µs. with eight multiplexed terminals available externally.

The sampling rate for the universal inputs is set internally to read all the eight UI channels five times per second, thus having 200 milliseconds of interval between each sample on each individual channel.

The model for the NX universal inputs is as depicted in the figure below:



As shown on the right side of the image above, each of the up to eight universal input channels has an input network (the details shown on the left side) with a total impedance of 15,300 ohms.

Thus, with a **15.3 Volts DC** applied at the input terminal, the voltage present at each multiplexer terminal and at the end via the multiplexed selected channel to the ADC, is in the range of 0 to 3.3 Volts DC with an output code in the range of 0 to 4095.

Further calculations can be done with the PLC to take this reading and scale it up or down and/or adjust it as needed with the PLC´s math instructions.

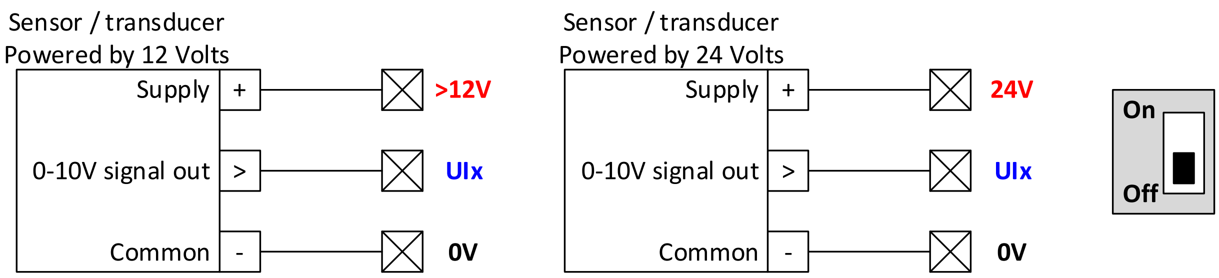
```
12bit_ADC          // ADC 12-bits : 0 - 4095
```

- ➢ Setting the UI channel to this type reads the **RAW 12-bit ADC** value and has no integration whatsoever, except for the **RC** network input hardware filter that limits the input frequency to be below 2 KHz, so whatever value is set in the general integration register or the individual channel will be just ignored.

⊗ Industrial universal sensors with 0 to 10 Volts output.

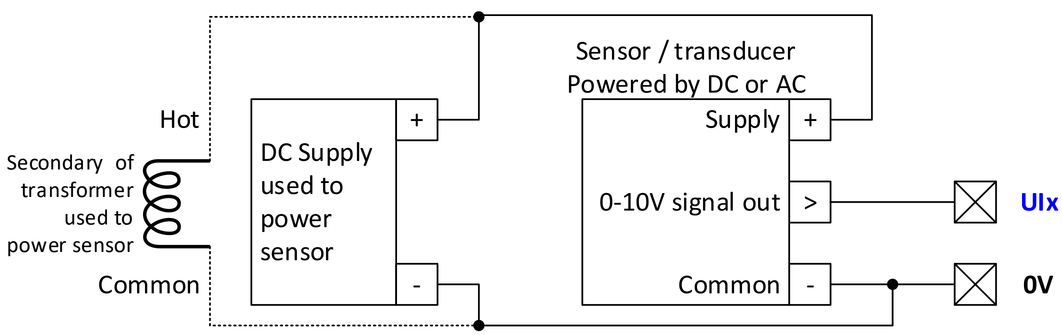
When using sensors or transducers that have a 0-10 Volts output the connection is simple, the common terminal usually goes connected to the 0V terminal, the output signal of the transducer goes directly connected to the universal input and the supply terminal goes connected to either the internal 12 Volts supply or to the 24 Volts terminal, making sure to match if it is AC or DC voltage.

The pull-up DIP-SW for the channel must be set to OFF.



The supply of the sensor / transducer could be independent of the supply powering the controller.

In this case the negative terminal of a DC supply or the common terminal of the secondary of a transformer if the sensor / transducer uses AC Voltage, should be grounded by connecting it to the 0V terminal of the controller.



For setting up the UI channel calibration, select type to 0-10 V:

0_10_Vdc // 0-10 Vdc or 0-20 mA @250 ohms

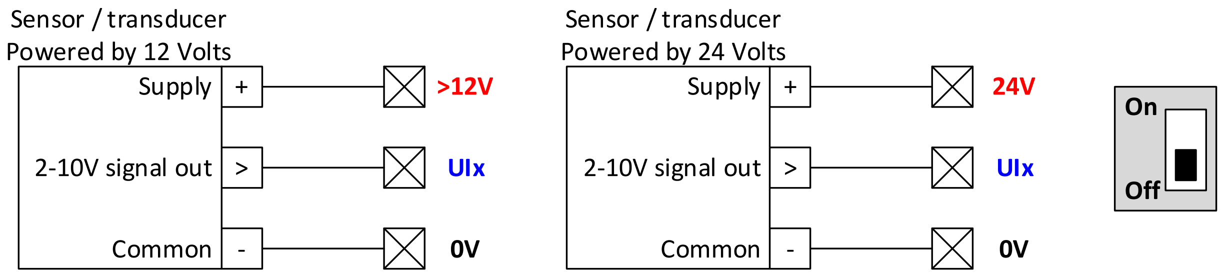
The calibration value will be a multiplier, when set to 1, a 10 Volt signal from the sensor will provide a reading of 10, so to scale it up or down just set the multiplier accordingly.

If for example it were a pressure sensor that measured a 0-100 PSI pressure and the 0-10 V represented this pressure, the multiplier should have to be set to:

- 100 PSI / 10 Volts = **10**, which will do the math that each 1 Volt drop represents 10 PSI.

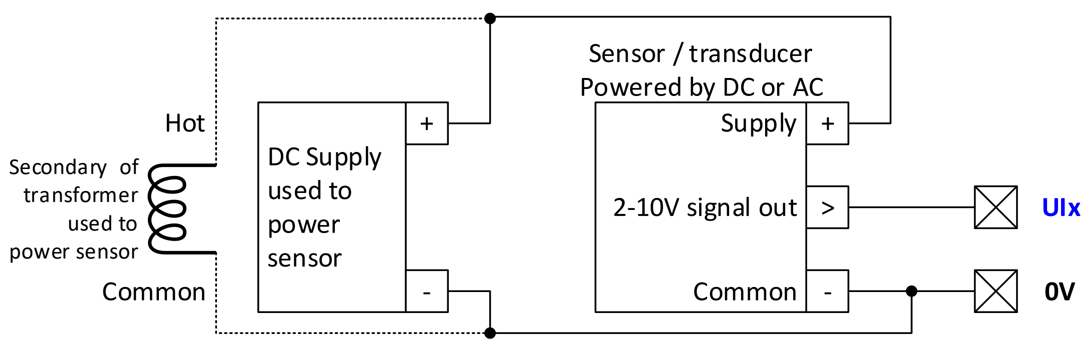
⊗ Industrial universal Sensors with 2 to 10 Volts output.

When using sensors / transducers that output a 2-10 Volt signal output, the connection is similar that when using 0-10 Volt sensors. Also, the pull-up DIP-SW must be off.



The supply of the sensor / transducer could be independent of the supply powering the controller.

In this case the negative terminal of a DC supply or the common terminal of the secondary of a transformer if the sensor / transducer uses AC Voltage, should be grounded by connecting it to the 0V terminal of the controller.



The only thing that must be set different is the sensor type, in this case the 4-20 mA / 2-10 Vdc option must be selected.

```
4_20_mA                // 4-20mA @ 250 ohms or 2-10 Vdc
```

This scales the **2-10 Volt** input signal to represent the full **0-100%** range of the sensor.

As an example, using again the same sensor that gives an output signal of 2-10 Volts with a 100 PSI input pressure, the sensor will output 2 Volts when the pressure is 0 PSI and 10 Volts when the pressure is 100 PSI.

In the case the sensor had no power, or failed or were disconnected, the pressure would read (negative) -25 PSI which would be the representation of the 0V signal at the universal input terminal, thus allowing the detection of a failed sensor input instead of just being stuck with a 0 PSI reading that would be the case when using a 0-10 Volts pressure sensor.

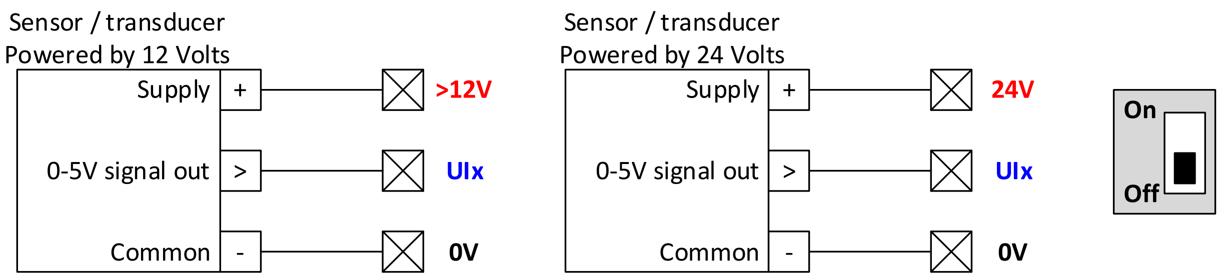
To calculate the multiplier for a 0-100 PSI sensor in this case because the full span of the sensor is 8 Volts only (2-10 Volts) instead of 10, then the multiplier must be set to:

- 100 PSI / 8 Volts = **12.5**, which will do the math that each 1 Volt drop represents 12.5 PSI.

⊗ Industrial universal Sensors with 0 to 5 Volts output.

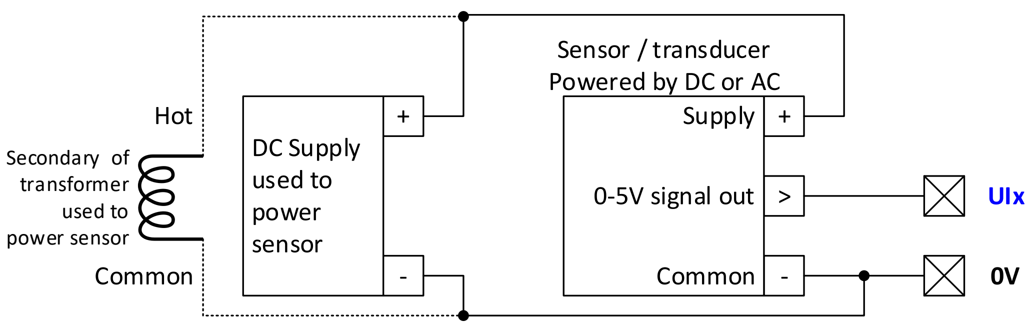
When using sensors or transducers that have a 0-5 Volts output the connection is simple, the common terminal usually goes connected to the 0V terminal, the output signal of the transducer goes directly connected to the universal input and the supply terminal goes connected to either the internal 12 Volts supply or to the 24 Volts terminal, making sure to match if it is AC or DC voltage.

The pull-up DIP-SW for the channel must be set to OFF.



The supply of the sensor / transducer could be independent of the supply powering the controller.

In this case the negative terminal of a DC supply or the common terminal of the secondary of a transformer if the sensor / transducer uses AC Voltage, should be grounded by connecting it to the 0V terminal of the controller.



For setting up the UI channel calibration, select type to 0-10 V:

```
0_10_Vdc            // 0-10 Vdc or 0-20 mA @250 ohms
```

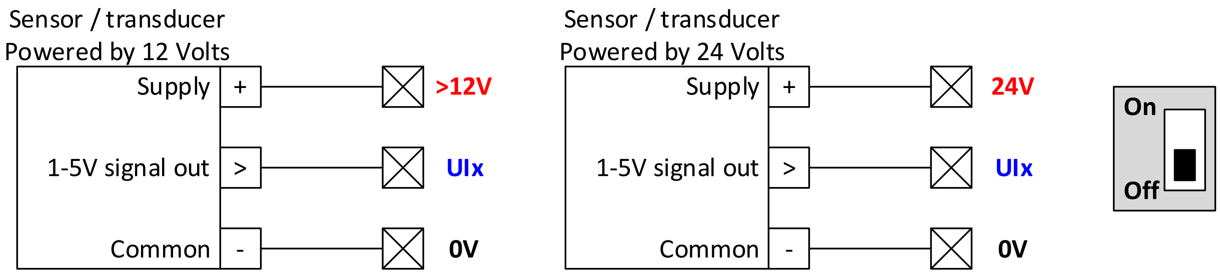
Because in this case the full span is 5 Volts (**0-5 Volts**) instead of 10 Volts, the calibration value will now be a multiplier that is twice of that if you were using a 0-10 V senor.

If for example it were a pressure sensor that measured a 0-100 PSI pressure and the 0-5 V represented this pressure, the multiplier should have to be set to:

- 100 PSI / 5 Volts = **20**, which will do the math that each 1 Volt drop represents 20 PSI.

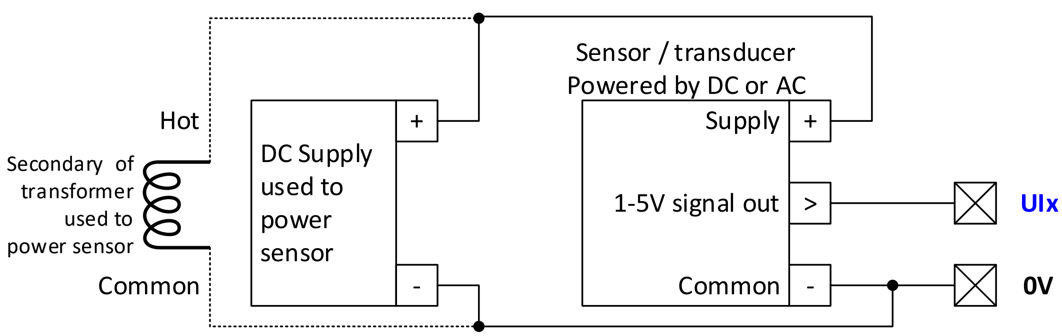
⊗ Industrial universal Sensors with 1 to 5 Volts output.

When using sensors / transducers that output a 1-5 Volt signal output, the connection is similar that when using 0-10 Volt sensors. Also, the pull-up DIP-SW must be off.



The supply of the sensor / transducer could be independent of the supply powering the controller.

In this case the negative terminal of a DC supply or the common terminal of the secondary of a transformer if the sensor / transducer uses AC Voltage, should be grounded by connecting it to the 0V terminal of the controller.



The only thing that must be set different is the sensor type, in this case the 4-20 mA / 2-10 Vdc option must be selected.

```
4_20_mA          // 4-20mA @ 250 ohms or 2-10 Vdc
```

This scales the **1-5 Volt** input signal to represent the full **0-100%** range of the sensor.

As an example, using again the same sensor that gives an output signal of 1-5 Volts with a 100 PSI input pressure, the sensor will output 1 Volts when the pressure is 0 PSI and 5 Volts when the pressure is 100 PSI.

In the case the sensor had no power, or failed or were disconnected, the pressure would read (negative) -25 PSI which would be the representation of the 0V signal at the universal input terminal, thus allowing the detection of a failed sensor input instead of just being stuck with a 0 PSI reading that would be the case when using a 0-5 Volts pressure sensor.

To calculate the multiplier for a 0-100 PSI sensor in this case because the full span of the sensor is 4 Volts only (1-5 Volts) instead of 10, then the multiplier must be set to:

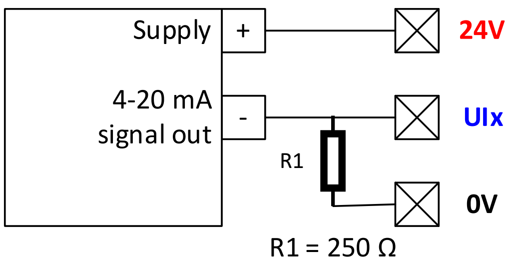
- 100 PSI / 4 Volts = **25**, which will do the math that each 1 Volt represents 25 PSI.

⊗ Industrial universal Sensors with 4 to 20 mA output.

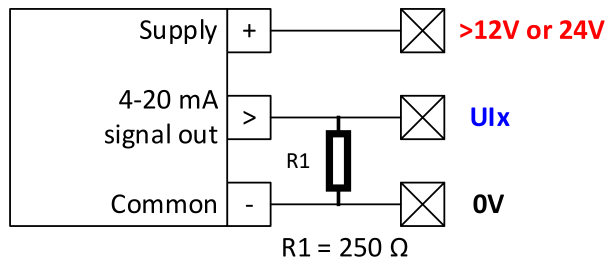
When using sensors / transducers that output a 4-20 mA signal output, there are different types, that use either: **two**, **three** or **four** wires.

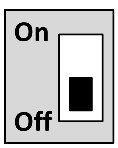
They all should have the pull-up **DIP-SW** in the **OFF** position. Also, a **250 Ω** ½ Watt 1% ballast resistor must be installed between the universal input and the 0V terminals.

Two terminal
Sensor / transducer
Powered by 24 Volts

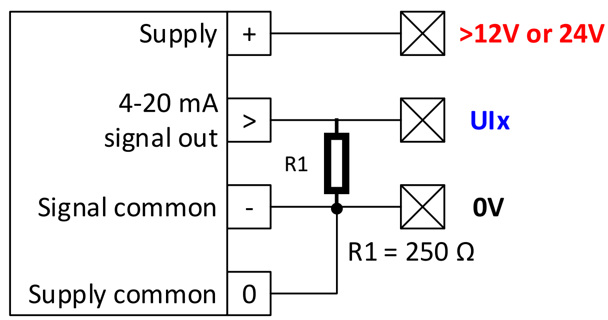


Three terminal
Sensor / transducer
Powered by 12/24 Volts





Four terminal
Sensor / transducer
Powered by 12/24 Volts



Two-wire sensors / transducers have the positive terminal usually connected to the 24 Volts DC supply terminal, as they are self powered by the same current that flows as the signal, hence the 4-20 mA current also powers the sensor and thus needs a higher voltage drop to operate. A **250 Ω** resistor (**R1**) is connected between the universal terminal and the 0V terminal to close the current circuit to ground.

Three-wire sensors / transducers have two terminals for power, as usually their internal current need is higher than the minimum signal current of 4 mA available for self powered sensors, therefore they power the internal circuit of the sensor with the [+] and [–] terminals and the 4-20 mA output signal is connected to the UI terminal, similarly also a **250 Ω** resistor is needed to close the output current circuit to the 0V terminal.

Four-wire sensors / transducers have two terminals for power and two for signal, as opposed to the three-wire type that share the Common terminal for both power and signal. Also, the **250 Ω** resistor is needed to close the output current circuit to the 0V terminal.

The sensor type, in this case the 4-20 mA option must be selected.

```
4_20_mA          // 4-20mA @ 250 ohms or 2-10 Vdc
```

On next page you can see an example of the setting for the calibration value.

Choosing this type scales the **4-20 mA** input signal to represent the full **0-100%** range of the sensor.

The voltage drop across the **250 Ω** ballast resistor with will be 1-5 Volts, which is the signal fed to the universal input terminal and in turn to the ADC converter.

As an example, using again the same sensor that gives an output signal of 4-20 mA with a 100 PSI input pressure, the sensor will output 4 mA when the pressure is 0 PSI and 20 mA when the pressure is 100 PSI.

In the case the sensor had no power, or failed or were disconnected, the pressure would read (negative) -25 PSI which would be the representation of the 0-mA signal at the universal input terminal, thus allowing the detection of a failed sensor input instead of just being stuck with a 0 PSI reading that would be the case when using a 0-20 mA pressure sensor.

To calculate the multiplier for a 0-100 PSI sensor, because the full span seen by the universal input when the 4-20 mA current flows across the **250 Ω** ballast resistor is 4 Volts (1-5 Volts), then the multiplier must be set to:

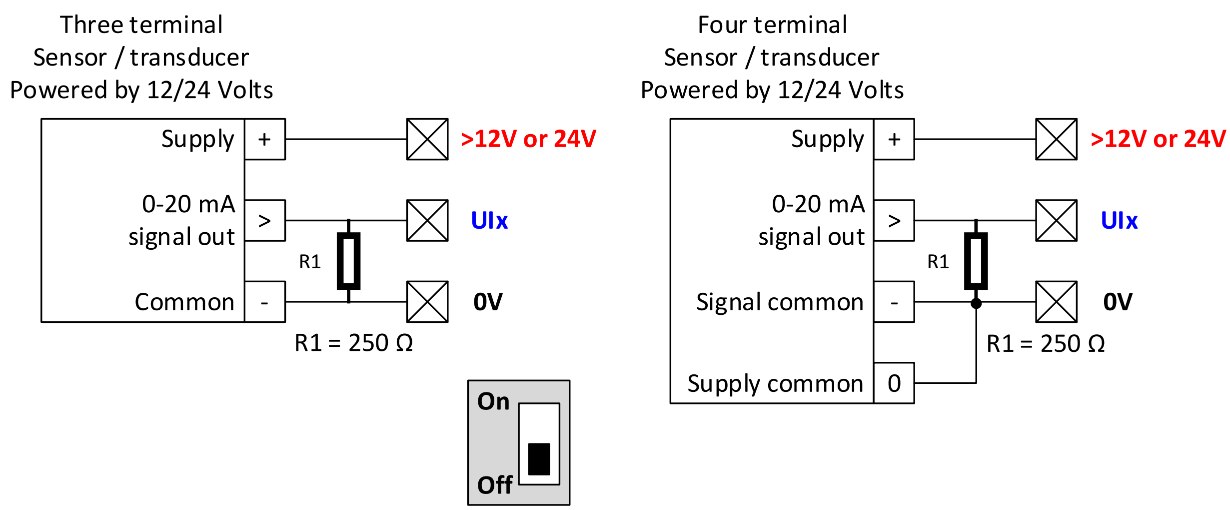
- 100 PSI / 4 Volts span = **25**, which will do the math that each 1 Volt drop across the resistor represents 25 PSI.

⊗ Industrial universal Sensors with 0 to 20 mA output.

When using sensors / transducers that output a 0-20 mA signal output, there are different types, that use either: **three** or **four** wires.

There is no **two-wire** configuration similar as there is in the 4-20 mA sensors, as this would mean the internal circuitry of the sensor should consume zero power, otherwise the minimum current could never reach the 0 mA lower limit.

They all should have the pull-up **DIP-SW** in the **OFF** position. Also, a **250 Ω** ½ Watt 1% ballast resistor must be installed between the universal input and the 0V terminals.



Three-wire sensors / transducers have two terminals for power, as usually their internal current need is higher than the minimum signal current of 4 mA available for self powered sensors, therefore they power the internal circuit of the sensor with the [+] and [–] terminals and the 0-20 mA output signal is connected to the UI terminal, similarly also a **250 Ω** resistor is needed to close the output current circuit to the 0V terminal.

Four-wire sensors / transducers have two terminals for power and two for signal, as opposed to the three-wire type that share the Common terminal for both power and signal. Also, the **250 Ω** resistor is needed to close the output current circuit to the 0V terminal.

The sensor type, in this case the 0-10V + 0-20 mA option must be selected.

```
0_10_Vdc              // 0-10 Vdc or 0-20 mA @250 ohms
```

Choosing this type scales the **0-20 mA** input signal to represent the full **0-100%** range of the sensor.

In the case the sensor had no power, or failed or were disconnected, there is no way to detect this failure, in contrast to the 4-20 mA type that provides a negative signal range for such case.

To calculate the multiplier for a 0-20 mA type for a 0-100 PSI sensor, because the full span seen by the universal input when the 0-20 mA current flows across the **250 Ω** ballast resistor is 5 Volts (0-5 Volts), then the multiplier must be set to:

- 100 PSI / 5 Volts span = **20**, which will do the math that each Volt drop across the resistor represents 20 PSI.

⊗ J type thermocouple for high range temperature sensing.

Type J (iron–constantan) has a more restricted range (−40 °C to +750 °C) than type K but higher sensitivity of about 50 µV/°C. The Curie point of the iron (770 °C) causes a smooth change in the characteristic, which determines the upper temperature limit.

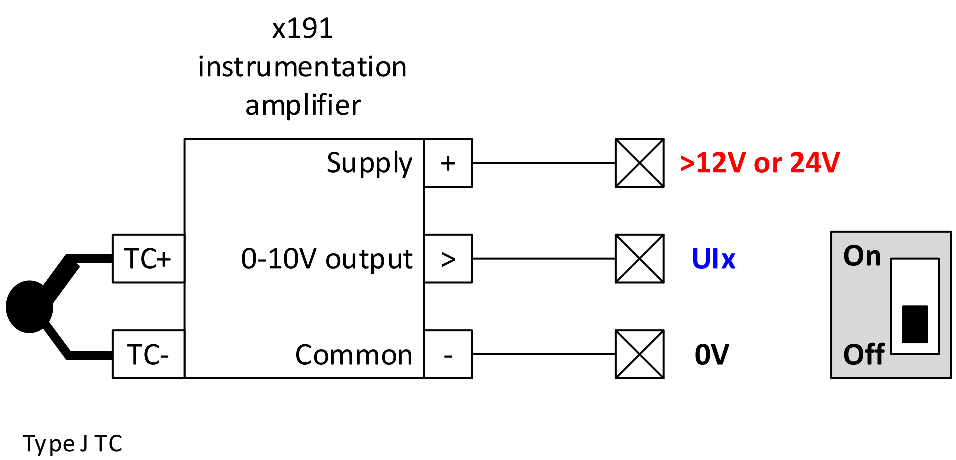
Following this link, you can see the voltage to temperature chart for a typical J type thermocouple.

https://www.pyromation.com/Downloads/Data/emfj_c.pdf

However, their signal is very small, and it is sensitive to drift due to cold junctions, even the wire used to extend a thermocouple must be of the same wire type or secondary cold junctions that are generated induce measurement errors.

Therefore, usually they need special amplifiers that increase their signal range before they can be used.

A type J thermocouple has an output voltage of **51.7 µV/°C** and when using a x191 amplifier you get a signal of **0.0098747 V/°C**, and a 0-10 Volt signal will represent a **0-1012°C** temperature span.



When using a J type thermocouple select this type in the calibration dialog:

THERMOCOUPLE_J °C// Thermocouple type J, 51.7 uV/°C x191 amp

And automatically the correct multiplier will be selected. In this case the calibration value will be an offset in °C that will be added or subtracted from the value read by the A/D converter.

⊗ K type thermocouple for high range temperature sensing

Type K (chromel–alumel) is the most common general-purpose thermocouple with a sensitivity of approximately 41 µV/°C. It is inexpensive, and a wide variety of probes are available in its −200 °C to +1350 °C (−330 °F to +2460 °F) range.

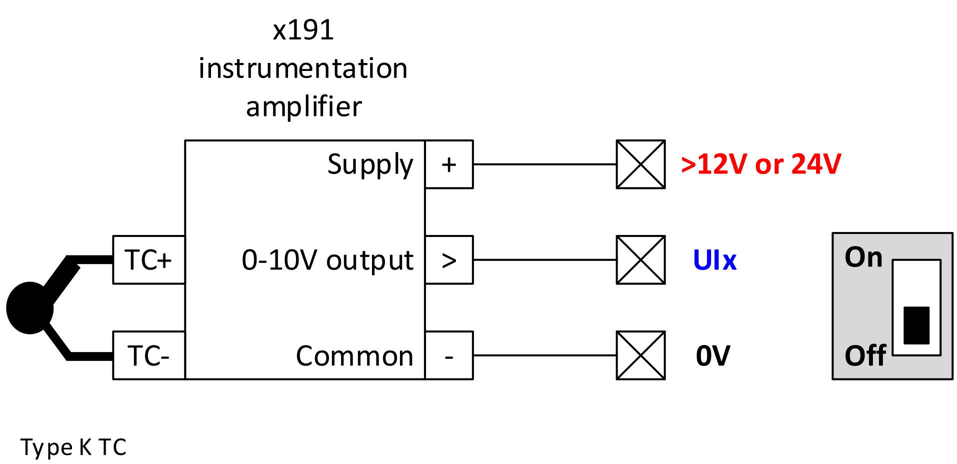
Following this link, you can see the voltage to temperature chart for a typical K type thermocouple.

https://www.pyromation.com/Downloads/Data/emfk_c.pdf

However, their signal is very small, and it is sensitive to drift due to cold junctions, even the wire used to extend a thermocouple must be of the same wire type or secondary cold junctions that are generated induce measurement errors.

Therefore, usually they need special amplifiers that increase their signal range before they can be used.

A type K thermocouple has an output voltage of **40.6 µV/°C** and when using a x191 amplifier you get a signal of **0.0077546 V/°C**, and a 0-10 Volt signal will represent a **0-1289°C** temperature span.



When using a K type thermocouple select this type in the calibration dialog:

THERMOCOUPLE_K_°C// Thermocouple type K, 40.6 uV/°C x191 amp

And automatically the correct multiplier will be selected. In this case the calibration value will be an offset in °C that will be added or subtracted from the value read by the A/D converter.

⊗ Ratiometric pressure sensors for refrigeration use.

The **ratiometric measurement principle** is an often-used **concept** that eliminates interference in the power supply. In **ratiometric measurements**, the **measured** quantity sought after is the ratio of two quantities that typically exhibit interference.

In refrigeration it is very typical to use ratiometric pressure sensors to measure the condenser and evaporator pressures.

Their output range is usually in the 0.5 to 4.5 Volt range for a 0-100% of the span value, thus allowing easily to detect sensors that are either:

- Failed
- Un-powered
- Disconnected
- Shorted

To use this type of sensors usually requires having a 5 Volt power supply, some of them can be powered with higher voltages such as 12- or 24-Volts DC as well.

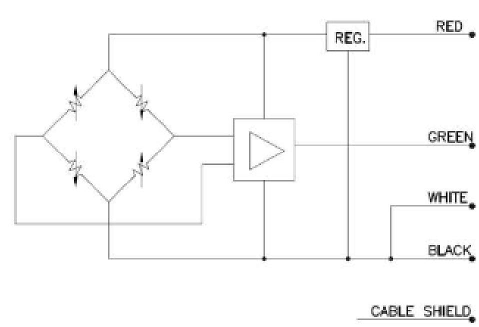
Please carefully review the wiring diagram of the sensor you are planning to use as there is no standard in color coding or supply voltages, this is a typical example of wiring information on the datasheet of a ratiometric pressure sensor:

https://www.te.com/commerce/DocumentDelivery/DDEController?Action=srchrtrv&DocNm=EB100&DocType=DS&DocLang=English

WIRING: SHIELDED CABLE 4 LEADS AWG26

RED	+SUPPLY
GREEN	+OUTPUT
WHITE	-OUTPUT
BLACK	-SUPPLY

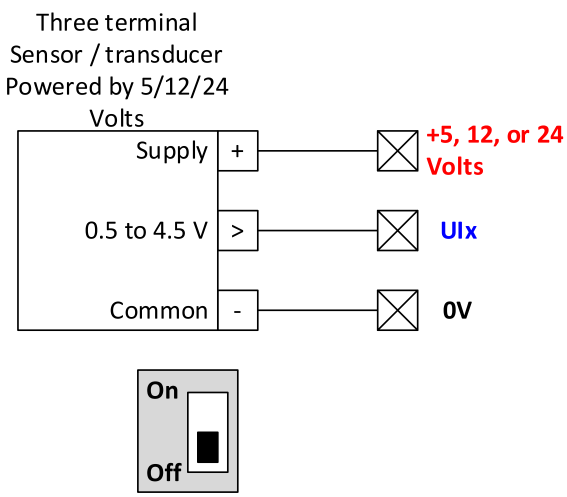
The shield is not connected to sensor's body.

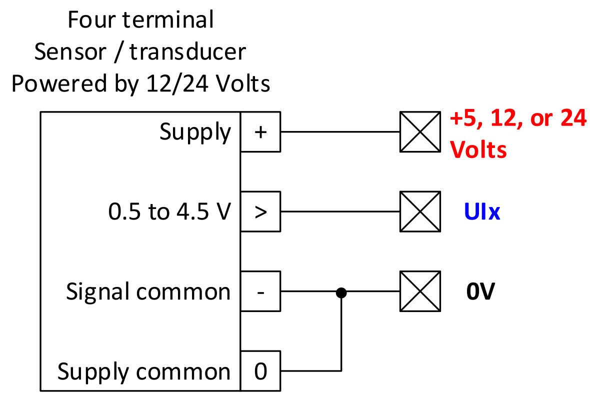


On the next page some additional typical wiring diagrams are shown.

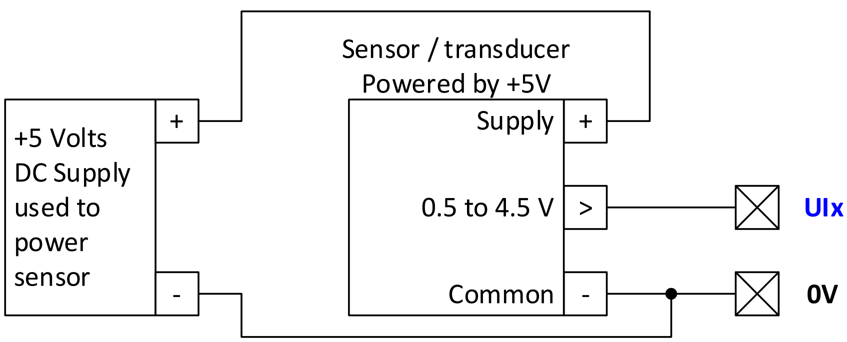
Typical ratiometric wiring diagrams, in all cases the pull-up DIP-SW must be in the **OFF** position:

If a shield terminal exists it is always a good practice to connect it to either the 0V terminal of the controller and also this same 0V terminal should be connected to the metallic chassis or earth terminal to reduce electrical interference to reach the measured signal.





When using an external power supply to power the sensor(s) transducer(s) make sure that the negative side of the power supply is always connected to the 0V terminal of the controller to provide a solid reference.



When using this type of sensors select the ratiometric type option:

```
RATIOMETRIC          // Ratiometric 0-100% = 10-90 FSR = 0.5-4.5 VDC
```

If for example it were a pressure sensor that measured a 0-100 PSI pressure and the 0.5 to 4.5 Volts represented this pressure, the multiplier should have to be set to:

- 100 PSI / 4 Volts span = **25**, which will do the math that each Volt drop output from the transducer represents 25 PSI.

⊗ Current transformers with 25-500 mA secondary.

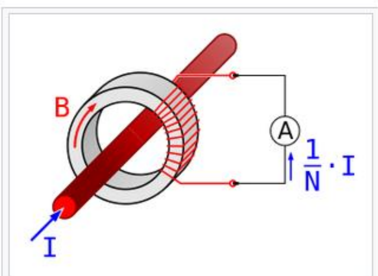
Only the **NXSF** and the **NG** controllers can measure AC current directly out of a **current transformer** which outputs an AC signal into a ballast resistor that is then measured by sampling the sinewave at 1,200 samples per second and reconstructing the **RMS** (Root Mean Square) component to be able to read real current and later use it to calculate power.

All other controllers must use instead **current transducers** that convert the AC current to a DC signal that is either a 0-10V or 4-20mA representation of the measured current.

The main difference is cost, while **current transformers** are cheap and cost usually between $1 to $10 USD depending on their range, size and construction, **current transducers** on the other side cost anywhere between $50 to $200 USD thus making them too expensive for price sensitive applications.

There are almost as many **current transformers** (referred as only **CT** hereon) as there are grains of sand on the beach, so it pays to put attention to their specifications.

By definition, a **CT** is a type of transformer that is used to reduce or divide an alternating current (AC). It produces a current in its secondary which is proportional to the current in its primary according to its turn ratio.



Before we continue it is important to understand some basic definitions that will help us to properly select an appropriate **CT** for our application:

Construction:

Current transformers typically consist of a silicon steel ring core wound with many turns of copper wire as shown in the illustration above. The conductor carrying the primary current is passed through the ring. The CT's primary, therefore, consists of a single 'turn'. The primary 'winding' may be a permanent part of the current transformer. **"Split core"** style **CT**s are also available that ease installation as shown in the image below.

Current Ratio:

CTs are specified by their current ratio from primary to secondary. The rated secondary current is normally standardized at 100 mA, 250 mA, 500 mA, 1 or 5 amperes. For example, a 4000:5 **CT** secondary winding will supply an output current of 5 amperes when the primary winding current is 4000 amperes.

Burden:

The secondary load of a current transformer is termed the "burden" to distinguish it from the primary load. The burden in a CT metering electrical network is largely resistive impedance presented to its secondary winding. Typical burden ratings of **CT**s are: 1.5 VA, 3 VA, 5 VA, 10 VA, 15 VA, 20 VA, 30 VA, 45 VA and 60 VA. ANSI/IEEE burden ratings are B-0.1, B-0.2, B-0.5, B-1.0, B-2.0 and B-4.0. This means a CT with a burden rating of B-0.2 will maintain its stated accuracy with up to 0.2 Ω on the secondary circuit.

Knee-point core-saturation voltage:

The magnitude of the secondary voltage above which the output current ceases to linearly follow the input current within declared accuracy. It is defined as the voltage at which a 10% increase in applied voltage increases the magnetizing current by 50%. The knee-point is generally constrained typically 1.2 to 1.5 times rated current.

Magnetic hysteresis:

Occurs when an external magnetic field is applied to a ferromagnet such as iron and the atomic dipoles align themselves with it. Even when the field is removed, part of the alignment will be retained: the material has become magnetized. Once magnetized, the magnet will stay magnetized indefinitely. To demagnetize it requires heat or a magnetic field in the opposite direction.

These last two terms are important! as you must always select a **CT** that is fit for your application. If for example the current you expect to measure is 200 Amperes, selecting a too small **CT** of only 150A will provide wrong readings in the high end of the range. But also selecting a too large **CT** for example of 500A will increase the error in the 10% lower range.

Having clarified the most important terms it is now time to go into the nitty gritty of selecting a **CT** and after that connecting it to the NX terminal and configuring it.

Following is a link to a typical **CT** manufacturer: https://www.zntar.com/ and expecting to measure a current of maximum 100 Amperes on a conductor that is 10 mm thick, we will then choose a split-core **CT** from the **SCTK681** series as shown below, following on the next page are the detailed selection criteria.

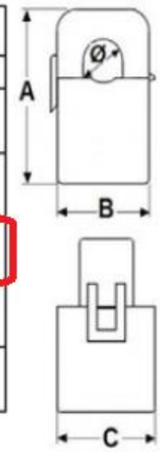
SCTK681A Split Core CT Current Transformer

SCTK681A **Split Core current Transformer**	
Input	0-630A
Output	As per your request
Φ	5/10/16/25/36mm
Email: **sales@zntar.com**	

More details | **Inquiry**

Split Core Current Transformers Type Selection (Output: mA/V)

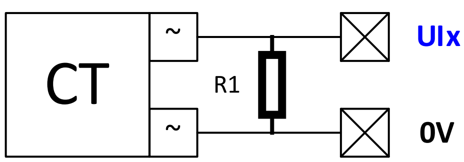
Mfg P/N	Rated Input (A)	Output (mA/V)	Accuracy	Dimensions(mm/inch)			
				Ø	A	B	C
SCTK681A-005	5-20A (5、8A、10、15、20)	0-25mA 0.333V	0.5、1.0、3.0	5.0 (0.20)	31.5 (1.24)	19.5 (0.77)	21.0 (0.83)
SCTK681A-010	5-75A (5、10、20、50、75)	0-50mA 0.333V	0.5、1.0、3.0	10.0 (0.39)	41.0 (1.61)	24.0 (0.94)	26.5 (1.04)
SCTK681A-016	5-150A (5、10、50、100、150)	0-100mA 0.333V	0.5、1.0、3.0	16.0 (0.63)	45.5 (0.22)	29.0 (1.14)	31.5 (1.24)
SCTK681A-024	10-250A (10、50、100、200、250)	0-200mA 0.333V	0.5、1.0、3.0	24.5 (0.96)	65.0 (2.56)	45.0 (1.77)	40.0 (1.57)
SCTK681A-035	10-630A (20、100、250、400、600)	0-500mA 0.333V	0.5、1.0、3.0	35.7 (1.41)	81.5 (3.21)	57.0 (2.24)	51.0 (2.01)

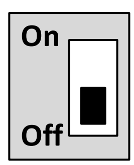


From the chart above we have selected the **SCTK681A-016-100-100mA** that has the following features:

- **16 mm inner diameter** to comfortably fit into our selected with thickness of 10 mm, selecting a bigger diameter is allowed but there could be too much slack and it also becomes bulkier and more expensive.
- **100 Amperes** primary current.
- **100 mA (0.1A)** secondary current, hence we have a 1000:1 ratio.

The **CT** is connected between the universal input and the 0V terminals, in all cases the pull-up DIP-SW must be in the **OFF** position. Also, a burden resistor must be installed also between the **UI** and **0V** terminals. The value of this resistor must be calculated using the **CT calculator** shown on the next page as well as the multiplier to use.





R1 = Burden resistor
See text for value

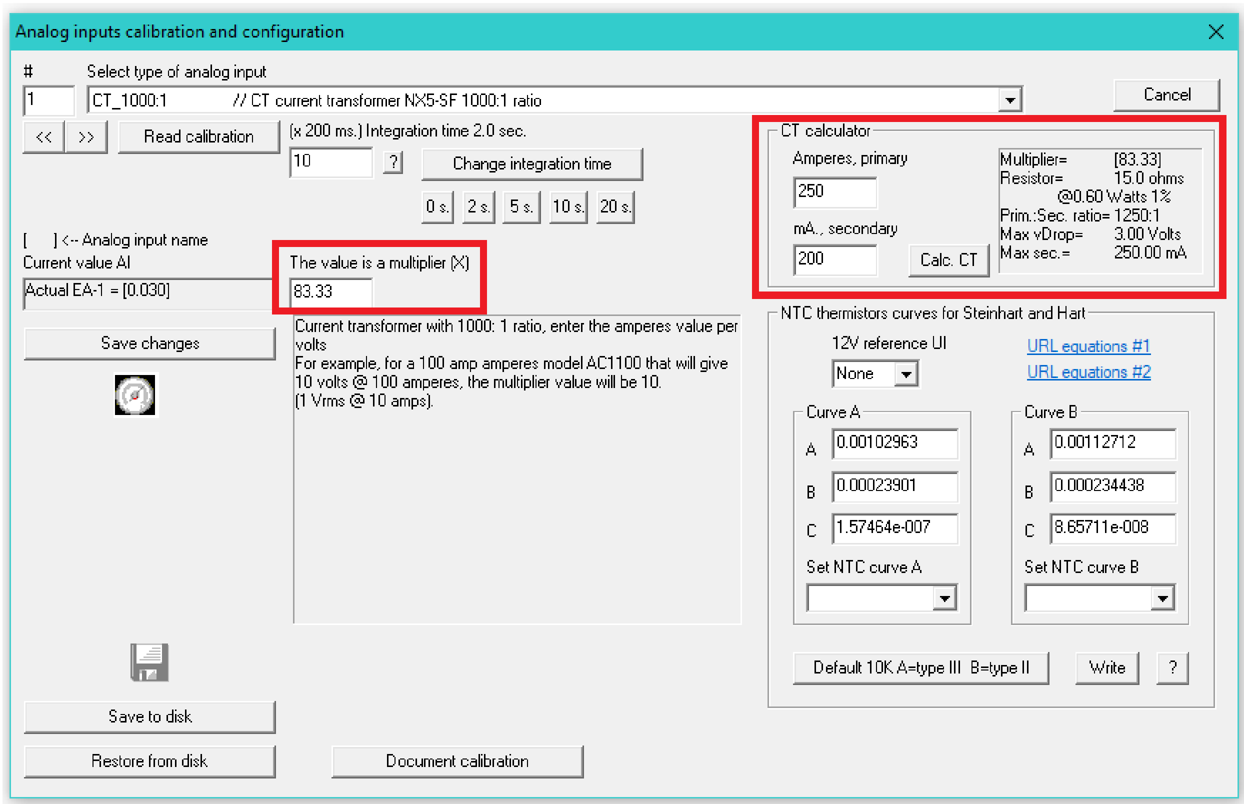
NOTE: The **100 Ω** resistor is already installed internally in the NXSF controller and can be switched ON by its own DIP-SW that so there is no need to install it externally when using CT's that are 100 mA or less.

The following table lists the suggested burden resistor value depending on the current of the secondary of the **CT** in milliamperes.

mA. secondary	Burden resistor		
	Ω	W	Integrated with a DIP-SW option on the NXSF
25	100	0.5	**
50	100	0.5	**
100	100	1	**
200	15	1	
250	15	1	
500	3.9	1	

To use a **CT** in the **NXSF** or **NG**, select the following type:

Us the CT calculator to find out the exact burden resistor value and multiplier to use based on the primary and secondary currents as shown below.



For this example, we have selected a **SCTK681A-024-250-200mA** that has:

- **24 mm** inner diameter.
- **250 Amperes** primary current.
- **200 mA** secondary current.

With this data using the **CT** calculator we can see the result is:

- Multiplier: **83.33**
- Resistor value: **15 Ω** at **0.6 Watts** 1%, therefore a 1-Watt commercial value can be used.
- Ratio of primary to secondary is: **1250:1**

A list of commercially available burden resistors from various suppliers is available on the next page. A tolerance of 1% or 2% is usually preferred to get a precision reading and flame-retardant coating for safety.

Can be used for **25**, **50** mA **CT** secondaries:

100 Ohms ±1% 0.5W, 1/2W Through Hole Resistor Axial Flame-Retardant Coating.

- https://www.digikey.com/en/products/detail/vishay-dale/CMF55100R00FHEB/1553910
- https://www.mouser.mx/ProductDetail/KOA-Speer/MFS1-2DCT52R1000F/?qs=sGAEpiMZZMsPqMdJzcrNwuBnmYaxrx0HGIhLooCfRXE%3D

Can be used for **25**, **50** and **100** mA **CT** secondaries:

100 Ohms ±1% 1W Through Hole Resistor Axial Flame-Retardant Coating.

- https://www.digikey.com/en/products/detail/vishay-beyschlag-draloric-bc-components/PAC100001000FA1000/596473
- https://www.mouser.mx/ProductDetail/Vishay-Draloric/PAC100001000FA1000/?qs=sGAEpiMZZMsPqMdJzcrNwl5vxkMOsrq%2FGBgHut%2F9O84%3D

Can be used for **200**, and **250** mA **CT** secondaries:

15 Ohms ±1% 1W Through Hole Resistor Axial Flame-Retardant Coating.

- https://www.digikey.com/en/products/detail/vishay-beyschlag-draloric-bc-components/PAC100001509FA1000/596488
- https://www.mouser.mx/ProductDetail/Vishay-Dale/CPF115R000FKB14/?qs=sGAEpiMZZMsPqMdJzcrNwgEVHw%2FvMBeIXh8Ri6GIrpI%3D

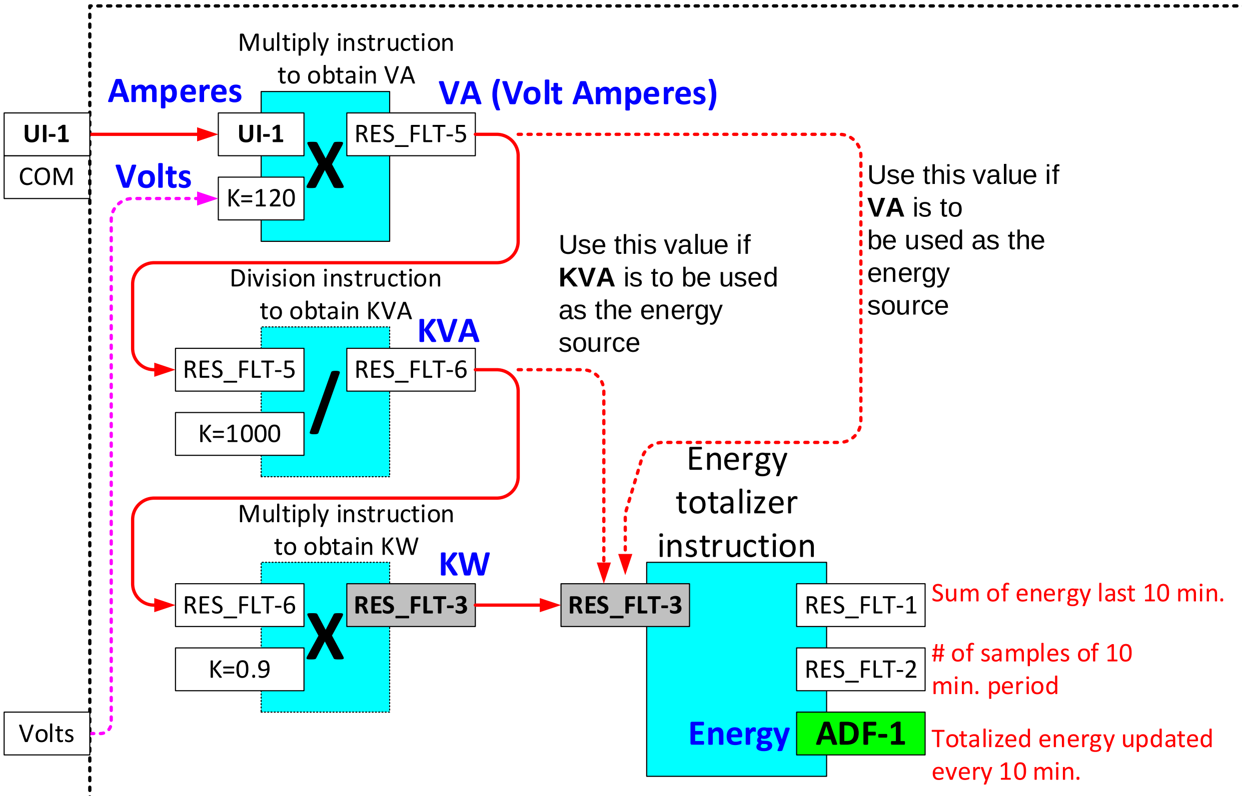
Can be used for **500** mA **CT** secondaries:

3.9 Ohms ±1% 1W Through Hole Resistor Axial Flame-Retardant Coating

- https://www.digikey.com/en/products/detail/vishay-beyschlag-draloric-bc-components/PAC100003908FA1000/596516?s=N4IgjCBcoExaBjKAzAhgGwM4FMA0IB7KAbXBjHIE4QBdfABwBcoQBlRgJwEsA7AcxABffAGZ4IJJDRY8hEuDAiIdEExbtu-IfhgAGABwBWcWsggAqjy6MA8sgCy2VJgCuHbCHwuWNgBYBbTE8Qf14WEQA6anx-VAAPcKjtEABaOGgJKE4XWSJIUmMVUxAhYRB00ndMLkxGAg5aQSA
- https://www.mouser.mx/ProductDetail/Vishay-Draloric/PAC100003908FA1000/?qs=gQQ%2FpDEpiRJ6qADCpT5xQQ%3D%3D

⊗ Using an analog signal to measure energy consumption in KWh.

Following the diagram below, using a current signal coming from either a current transformer (**CT)** or a current transducer that provides a 0-10 or 4-20 DC signal energy can be tracked.



- The voltage reading can be external from any remote controller measuring AC Voltage such as a power meter.
- Or fed into a Universal Input if a 0-10 Vdc or 4-20 mA. transducer that measures AC Voltage is available.
- Or it can simply be a constant

If only **VA** will be used to get **VA/h** energy just one multiply instruction is needed to multiply Volts x Amperes to obtain VAs.

If the measurement is to be in **KVA/h**, then a second division instruction is needed to convert the previous VA into a KVA reading by dividing VA / 1000.

If the measurement is to be in **KW/h**, then a third multiplier instruction is needed to multiply KVA by the power factor (PF) and obtain KW.

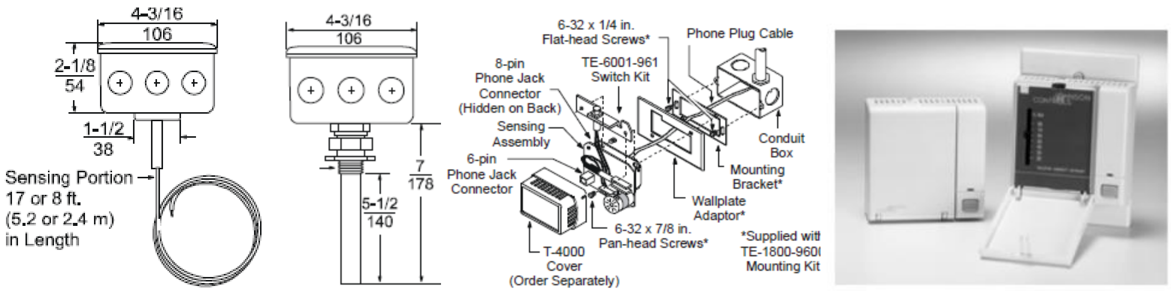
Finally, whatever unit of energy you use, using an "**Energy Totalizer instruction**" the readings are taken and added to the current energy reading.

The values are updated continuously, and every 10 minutes the "**Total Energy**" register that is stored on EEPROM is updated so that the energy readings are not lost even if power is lost.

⊗ Temperature sensor 1000 Ohms Nickel TE-6x00 series by Johnson controls.

The following temperature sensors from Johnson controls that have Nickel temperature sensors with a temperature coefficient of **5.4 Ω/°C** and a temperature reference at **21°C** can be used from the following series:

- **TE-6100** types **1** through **12**.
- **TE-6400** with the '**N**' model specified for the sensor type.
- **TE-6700** with the '**N**' model specified for the sensor type.

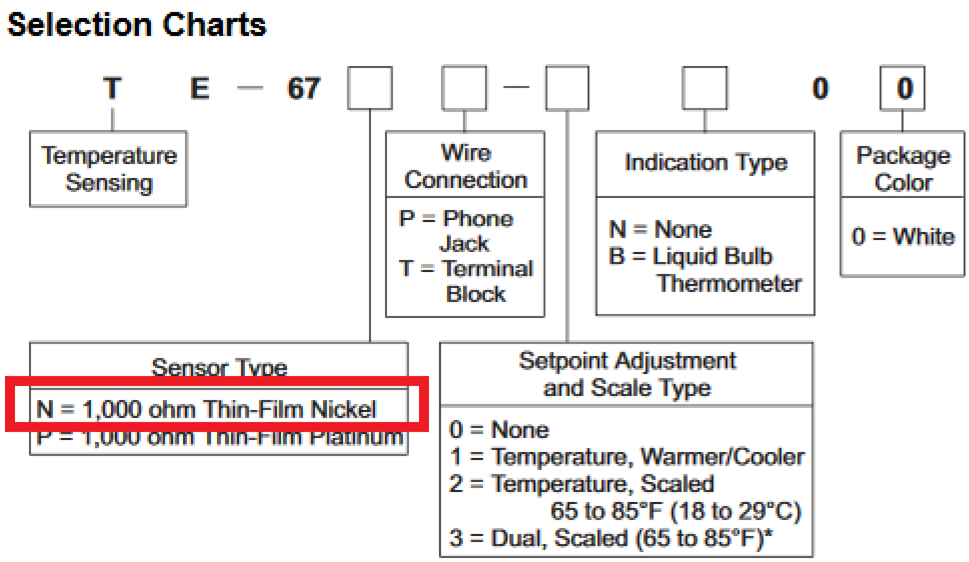


TE-6100 Series Temperature Sensors and Completed Sensor/Hardware Assemblies

Specification	Model	Description
Elements	TE-6100-1 through -12	Nickel Resistance Type
	TE-6100-960, -961, -962	PTC Silicon
Reference Resistances	TE-6100-1 through -12	1,000 Ohms at 70°F (21°C)
	TE-6100-960, -961, -962	1,035 Ohms at 77°F (25°C)
Temperature Coefficient	TE-6100-1 through -12	Positive, Approximately 3 ohms/°F (5.4 ohms/°C)
	TE-6100-960, -961, -962	Positive, Approximately 4.3 ohms/°F (7.7 ohms/°C)
Resistance Tolerances	TE-6100-1, -2, -3, -8	±1.0% at 70°F (21°C)
	TE-6100-960, -961, -962	Calibrated for 1,035 Ohms ±0.5/-0.15 ohms at 77°F (25°C)
Ambient Operating Environment	TE-6100-1, -2, -3	-50 to 250°F (-46 to 121°C)
	TE-6100-8	0 to 130°F (-18 to 54°C), 10 to 90% RH, Noncondensing
	TE-6100-11, -12, 960, -961	32 to 104°F (0 to 40°C), 10 to 90% RH, Noncondensing, Limited by an 85°F (29°C) Maximum Dew Point
	TE-6100-962	-40 to 212°F (-40 to 100°C), 10 to 90% RH, Noncondensing
Set Point Range	TE-6100-8	55 to 85°F (13 to 29°C), °F and °C Scales Furnished
	TE-6100-12	Warmer/Cooler Scale
	TE-6100-960	50 to 85°F (10 to 29°C), °F and °C Scales Furnished

There is a great variety of sensors available. For the Silicon or Platinum use, types refer to their respective sections on this manual.

Next page shows wiring diagram to the universal inputs and general settings.

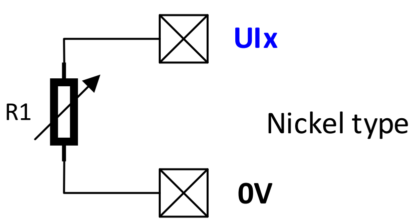


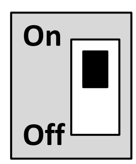
For selecting this sensor types, both **°Celsius** and **°Fahrenheit** options are available when selecting the sensor type as shown below:

1kNI_°C // 1000 ohms Nickel (°C) TE-6x00 JCI, 5.4 ohms/°C 1000 Ohms @ 21 °C

1kNI_°F // 1000 ohms Nickel (°F) TE-6x00 JCI

The sensors must be wired to the universal input on one side and the other one to 0V. The pull-up selector DIP-SW for the channel must be in the **ON** position.





The multiplier is an offset that will be added or subtracted to the current reading.

Wiring should be kept short with no more than 50 metres or 150 feet roundtrip as any added resistance added to the sensor will modify the temperature reading and must be compensated with the calibration value.

Recommended wiring is #18 - #22 wire gauge braided copper shielded or unshielded. If shielded wire is used, the shield must be connected to earth on a single point to avoid parasitic currents that might affect the reading.

The general or per channel integration time can be increased to remove unwanted noise being picked up by the field wiring to eliminate temperature reading variance.

The calibration field is an offset that is added or subtracted (if negative) from the reading.

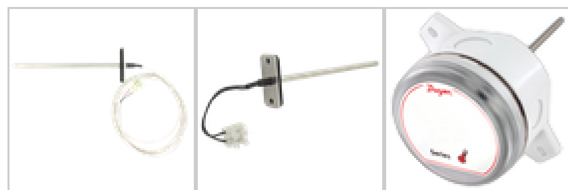
⊗ Temperature sensor 1000 Ohms Platinum (PT1000) by Dwyer instruments / Johnson Controls.

Platinum sensors are by far the best of linear sensors, they have a temperature coefficient of **3.89 Ω/°C** and a temperature reference at **0°C,** they tend to be more expensive than Nickel or Silicon but offer an excellent long-term stability.

The following sensor types are available from either Dwyer or Johnson Controls

- **TE-DFx-E** Duct type sensors from Dwyer.
- **TE-Bx-E** Immersion type probes from Dwyer.
- **TE-6700** Space sensors with the 'P' model specified for the sensor type by JCI.

Dwyer® Manufacturing Excellence Since 1931



Home / Products / Temperature / Sensors / **Series TE**

Series TE Duct and Immersion Building Automation Temperature Sensor

Available up to 18" Probe Length, Thermistor or RTD Outputs

Model Chart

EXAMPLE	TE	IBN	A	04	4	4	12	Series TE-IBN-A0444-12 Immersion Probe, 10K type 3 thermistor, 4" probe length, 1/4" probe diameter, 4" flying leads, with 1/2" NPT connection.
SERIES	TE							Duct and Immersion Building Automation Temperature Sensor
MOUNTING CONFIGURATION		DFN						Duct Flange Probe Only (not w/ Connection 12,14)
		DFG						Duct Flange In Housing (not w/ Connection 12,14)
		DFW						Duct Flange NEMA 4X Housing (not w/ Connection 12,14)
		IBN						Immersion Probe Only
		IBG						Immersion in Housing (not w/ Connection 00)
		IBW						Immersion NEMA 4X Housing (not w/ Connection 00)
SENSOR TYPE			A					10K Type III Thermistor
			B					10K Type II Thermistor
			C					3K Ohm Thermistor
			D					PT100 Ohm RTD
			E					PT1000 Ohm RTD
			F					20K Thermistor
			G					1.8K Thermistor
			H					5K Thermistor
			I					100K Thermistor
			J					2.252 Thermistor
			K					NI 1000 Ohm RTD
			L					Balco NI 1000 Ohm RTD
			M					PT100 Ohm RTD 1/10 DIN (3-wire)
			P					PT1000 Ohm RTD 1/10 DIN (3-wire)
			Q					10k Ohm Type 3 Thermistor w/11K Ohm Shunt

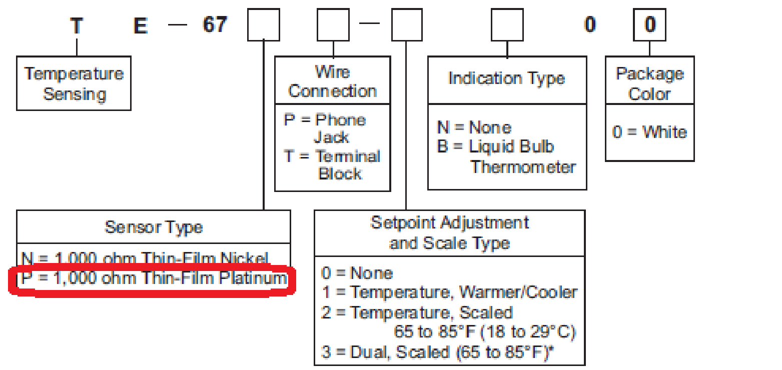
Also, from Johnson controls a great variety of sensors is available, the table on next page will help you to select from the different models available.

Johnson Controls

Code No. LIT-1900055
Issued December 6, 2013

TE-6700 2nd Generation Temperature Elements

Selection Charts



* These models do not have a functioning LED, but all models have the manual override PB.

Example 1: To order a nickel sensor with a phone jack, a warmer/cooler temperature setpoint, and a liquid bulb thermometer, specify Product Code Number TE-67NP-1B00.

Example 2: To order a platinum sensor with a terminal block, a scaled temperature setpoint, and no indication, specify Product Code Number TE-67PT-2N00.

Accessories for TE-6700 Series

Code Number	Description
ACC-DWCLIP-0	Drywall Clip Mounting Kit (10 per bag)
ACC-INSL-0 [1]	Foam Pad Kit for Wallbox Mounting (10 per package)
ACC-INSL-1 [1]	Foam Pad Kit for Surface Mounting (10 per package)
GRD10A-608	Plastic Guard with Baseplate and Mounting Ring
T-4000-119	Allen-Head Adjustment Tool (30 per bag)
TE-67L-600	Fahrenheit Label Replacement Kit
TE-67L-601	Celsius Label Replacement Kit
TE-67MB-600	Mounting Base Kit
TE-67D0-601 [2]	Door Replacement Kit with a Johnson Controls Logo (10 per box)
TE-67D0-602 [2]	Door Replacement Kit without a Logo (10 per box)

1. These foam pads prevent drafts from entering the unit through the wall, and make installation easier when mounting on an uneven surface.
2. Contains 10 original style and 10 new style doors

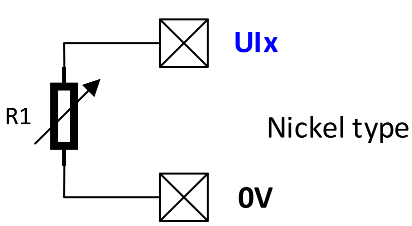
Technical Specifications

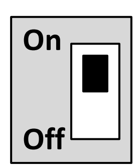
TE-6700 2nd Generation Temperature Elements (Part 1 of 2)		
Nickel Sensor	Temperature Sensor	1,000 ohm thin-film nickel
	Temperature Coefficient	Approximately 3 ohm per F° (5.4 ohm per C°)
	Reference Resistance	1,000 ohm at 70°F (21°C)
	Accuracy	±0.34F° at 70°F (±0.18C° at 21°C)
Platinum Sensor	Temperature Sensor	1,000 ohm thin-film platinum
	Temperature Coefficient	Approximately 2 ohm per F° (3.9 ohm per C°)
	Reference Resistance	1,000 ohm at 32°F (0°C)
	Accuracy	±0.65F° at 70°F (±0.36C° at 21°C)

For selecting this sensor types, both **°Celsius** and **°Fahrenheit** options are available when selecting the sensor type as shown below:

```
1K PTC 0°C     // Dwyer PT1000 at 0°C TE-DFN-E, 3.89 ohms/°C 1000 Ohms @ 0 °C
1K PTC 32°F    // Dwyer PT1000 at 0°C TE-DFN-E result in °F
```

The sensors must be wired to the universal input on one side and the other one to 0V. The pull-up selector DIP-SW for the channel must be in the **ON** position.





The multiplier is an offset that will be added or subtracted to the current reading.

Wiring should be kept short with no more than 50 metres or 150 feet roundtrip as any added resistance added to the sensor will modify the temperature reading and must be compensated with the calibration value.

Recommended wiring is #18 - #22 wire gauge braided copper shielded or unshielded. If shielded wire is used, the shield must be connected to earth on a single point to avoid parasitic currents that might affect the reading.

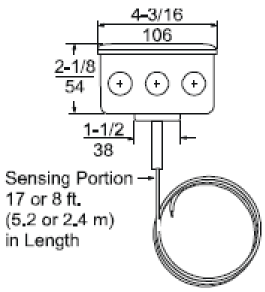
The general or per channel integration time can be increased to remove unwanted noise being picked up by the field wiring to eliminate temperature reading variance.

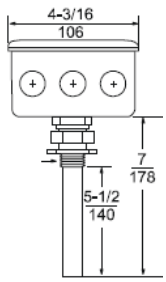
The calibration field is an offset that is added or subtracted (if negative) from the reading.

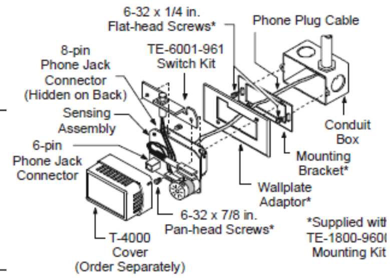
⊗ Temperature sensor 1000 Ohms Silicon TE-6x00, series by Johnson controls.

The following temperature sensors from Johnson controls that have Silicon temperature sensors with a temperature coefficient of **7.7 Ω/°C** and a temperature reference at **25°C** can be used from the following series:

- **TE-6100** types 960, 961, 962.







TE-6100 Series Temperature Sensors and Completed Sensor/Hardware Assemblies

Specification	Model	Description
Elements	TE-6100-1 through -12	Nickel Resistance Type
	TE-6100-960, -961, -962	PTC Silicon
Reference Resistances	TE-6100-1 through -12	1,000 Ohms at 70°F (21°C)
	TE-6100-960, -961, -962	1,035 Ohms at 77°F (25°C)
Temperature Coefficient	TE-6100-1 through -12	Positive, Approximately 3 ohms/°F (5.4 ohms/°C)
	TE-6100-960, -961, -962	Positive, Approximately 4.3 ohms/°F (7.7 ohms/°C)
Resistance Tolerances	TE-6100-1, -2, -3, -8	±1.0% at 70°F (21°C)
	TE-6100-960, -961, -962	Calibrated for 1,035 Ohms ±0.5/-0.15 ohms at 77°F (25°C)
Ambient Operating Environment	TE-6100-1, -2, -3	-50 to 250°F (-46 to 121°C)
	TE-6100-8	0 to 130°F (-18 to 54°C), 10 to 90% RH, Noncondensing
	TE-6100-11, -12, 960, -961	32 to 104°F (0 to 40°C), 10 to 90% RH, Noncondensing, Limited by an 85°F (29°C) Maximum Dew Point
	TE-6100-962	-40 to 212°F (-40 to 100°C), 10 to 90% RH, Noncondensing
Set Point Range	TE-6100-8	55 to 85°F (13 to 29°C), °F and °C Scales Furnished
	TE-6100-12	Warmer/Cooler Scale
	TE-6100-960	50 to 85°F (10 to 29°C), °F and °C Scales Furnished

There is a great variety of sensors available. For the Nickel or Platinum use, types refer to their respective sections on this manual.

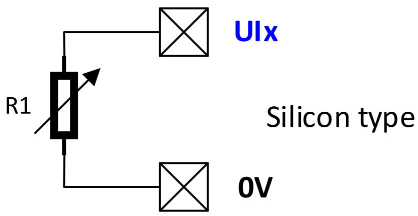
Next page shows wiring diagram to the universal inputs and general settings.

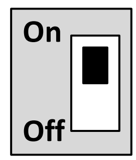
For selecting this sensor types, both a **°Celsius** and **°Fahrenheit** options are available when selecting the sensor type as shown below:

1kSI °C // 1000 ohms Silicon (°C) KYT81-110 DK, 7.7 ohms/°C 1000 Ohms @ 25 °C

1kSI °F // 1000 ohms Silicon (°F) KYT81-110 DK

The sensors must be wired to the universal input on one side and the other one to 0V. The pull-up selector DIP-SW for the channel must be in the **ON** position.





The multiplier is an offset that will be added or subtracted to the current reading.

Wiring should be kept short with no more than 50 metres or 150 feet roundtrip as any added resistance added to the sensor will modify the temperature reading and must be compensated with the calibration value.

Recommended wiring is #18 - #22 wire gauge braided copper shielded or unshielded. If shielded wire is used, the shield must be connected to earth on a single point to avoid parasitic currents that might affect the reading.

The general or per channel integration time can be increased to remove unwanted noise being picked up by the field wiring to eliminate temperature reading variance.

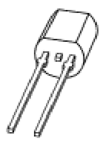
The calibration field is an offset that is added or subtracted (if negative) from the reading.

⊗ Temperature sensor 1000 Ohms Silicon KTY-1x0 series by NXP / Digikey.

The following temperature sensors from NXP and distributed by Digikey that have Silicon temperature sensors with a temperature coefficient of **7.7 Ω/°C** and a temperature reference at **25°C** can be used from the following series:

https://www.digikey.com/en/products/detail/nxp-usa-inc/KTY81-110112/735617

There is a great variety of sensors available. For the Nickel or Platinum use, types refer to their respective sections on this manual.



KTY81 series

Silicon temperature sensors

Rev. 05 — 25 April 2008 **Product data sheet**

1.2 Features

- High accuracy and reliability
- Positive temperature coefficient; fail-safe behavior
- Long-term stability
- Virtually linear characteristics

1.3 Quick reference data

Table 1. Quick reference data

T_{amb} = 25 °C; in liquid; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
R_{25}	sensor resistance	$I_{sen(cont)}$ = 1 mA				
		KTY81/110	990	-	1010	Ω
		KTY81/120	980	-	1020	Ω
		KTY81/121	980	-	1000	Ω
		KTY81/122	1000	-	1020	Ω

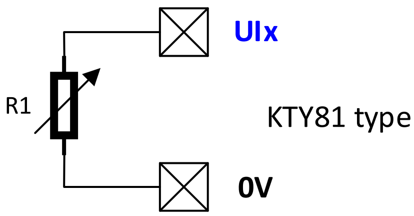
Next page shows wiring diagram to the universal inputs and general settings.

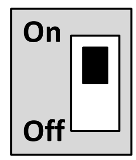
For selecting this sensor types, both a **°Celsius** and **°Fahrenheit** options are available when selecting the sensor type as shown below:

1kSI °C // 1000 ohms Silicon (°C) KYT81-110 DK, 7.7 ohms/°C 1000 Ohms @ 25 °C

1kSI °F // 1000 ohms Silicon (°F) KYT81-110 DK

The sensors must be wired to the universal input on one side and the other one to 0V. The pull-up selector DIP-SW for the channel must be in the **ON** position.





The multiplier is an offset that will be added or subtracted to the current reading.

Wiring should be kept short with no more than 50 metres or 150 feet roundtrip as any added resistance added to the sensor will modify the temperature reading and must be compensated with the calibration value.

Recommended wiring is #18 - #22 wire gauge braided copper shielded or unshielded. If shielded wire is used, the shield must be connected to earth on a single point to avoid parasitic currents that might affect the reading.

The general or per channel integration time can be increased to remove unwanted noise being picked up by the field wiring to eliminate temperature reading variance.

The calibration field is an offset that is added or subtracted (if negative) from the reading.

⊗ Temperature sensor 1000 Ohms Silicon A99 series by Johnson Controls / Penn.

The following **A99** temperature sensors from Johnson Controls / Penn that have a Silicon temperature sensor with a temperature coefficient of **7.7 Ω/°C** and a temperature reference at **25°C** can be used:

PENN

FANs 125, 121, 930, 930.5
Product/Technical Bulletin A99
Issue Date 1118

A99B Series Temperature Sensors

The A99B Series Temperature Sensors are passive PTC (Positive Temperature Coefficient) sensors. The A99B sensors are splashproof and are designed to measure temperature in a variety of refrigeration applications. Several accessories allow easy tailoring of the temperature sensor to various mounting configurations.

Applications include temperature sensing for freezers and coolers, as well as in defrost termination sensing, space and return air temperature sensing, and condenser fan cycling.

Figure 1: A99B Temperature Sensors

Table 3: Sensors

Product Code Number	Description
A99BA-200C	PTC Silicon Sensor with Shielded Cable; Cable length 6-1/2 ft (2 m); Range: -40 to 212°F (-40 to 100°C)
A99BB-25C	PTC Silicon Sensor with PVC Cable; Cable length 9-3/4 in. (0.25 m); Range: -40 to 212°F (-40 to 100°C)
A99BB-200C	PTC Silicon Sensor with PVC Cable; Cable length 6-1/2 ft (2 m); Range: -40 to 212°F (-40 to 100°C)
A99BB-200D	PTC Silicon Sensor with PVC Cable Bulk Pack; contains 100 A99BB-200 sensors. Individual sensor cable length 6-1/2 ft (2 m); Range: -40 to 212°F (-40 to 100°C)
A99BB-300C	PTC Silicon Sensor with PVC Cable; Cable length 9-3/4 ft (3 m); Range: -40 to 212°F (-40 to 100°C)
A99BB-500C	PTC Silicon Sensor with PVC Cable; Cable length 16-3/8 ft (5 m); Range: -40 to 212°F (-40 to 100°C)
A99BB-600C	PTC Silicon Sensor with PVC Cable; Cable length 19-1/2 ft (6 m); Range: -40 to 212°F (-40 to 100°C)
A99BC-25C	PTC Silicon Sensor with High Temperature Silicon Cable Cable length 9-3/4 in. (0.25 m); Range: -40 to 248°F (-40 to 120°C)
A99BC-300C	PTC Silicon Sensor with High Temperature Silicon Cable Cable length 9-3/4 ft (3 m); Range: -40 to 248°F (-40 to 120°C)
A99BC-1500C	PTC Silicon Sensor with High Temperature Silicon Cable Cable length 49 ft (15 m); Range: -40 to 248°F (-40 to 120°C)

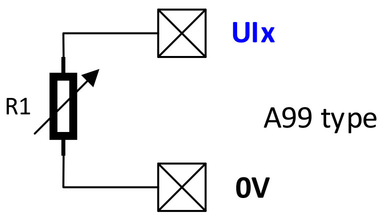
There is a great variety of models available. For the Nickel or Platinum use, types refer to their respective sections on this manual.

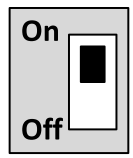
For selecting this sensor types, both **°Celsius** and **°Fahrenheit** options are available when selecting the sensor type as shown below:

1kA99_°C // 1000 ohms A99 JCI (°C), 7.7 ohms/°C 1000 Ohms @ 21 °C

1kA99_°F // 1000 ohms A99 JCI (°F)

The sensors must be wired to the universal input on one side and the other one to 0V. The pull-up selector DIP-SW for the channel must be in the **ON** position.





The multiplier is an offset that will be added or subtracted to the current reading.

Wiring should be kept short with no more than 50 metres or 150 feet roundtrip as any added resistance added to the sensor will modify the temperature reading and must be compensated with the calibration value.

Recommended wiring is #18 - #22 wire gauge braided copper shielded or unshielded. If shielded wire is used, the shield must be connected to earth on a single point to avoid parasitic currents that might affect the reading.

The following wire table could also be used for these sensors:

For wiring, follow the instructions below:

- Make sure all wiring conforms to the National Electric Code and local regulations.
- Run high and low voltage wiring in separate conduits. For applications in critical industrial environments, use a sensor with a shielded cable (A99BA).
- If wire is added to the sensor leads, additional resistance may affect the sensor reading. Longer wires increase resistance, which causes a shift in the sensor temperature reading.

  Note: At the wire lengths listed in Table 1, the error in the sensed temperature is less than 1°F (0.5°C).

Table 1: Maximum Sensor Wire Lengths (for less than 1°F error)

Wire Gauge	Wire Length	
AWG	Feet	Meters
14 AWG	800	244
16 AWG)	500	152
18 AWG	310	94
20 AWG	200	61
22 AWG	124	38

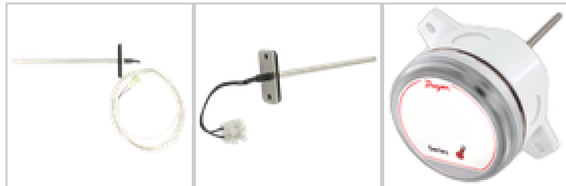
- Shielded Cable Models (A99BA) Only: For all controls, including the Johnson Controls/PENN System 350, MR, MS, and A419, connect the sensor cable shield to the controller per the controller's instructions.

The general or per channel integration time can be increased to remove unwanted noise being picked up by the field wiring to eliminate temperature reading variance.

The calibration field is an offset that is added or subtracted (if negative) from the reading.

⊗ Temperature sensor 20K NTC series by Dwyer instruments.

Dwyer® Manufacturing Excellence Since 1931



Home / Products / Temperature / Sensors / **Series TE**

Series TE Duct and Immersion Building Automation Temperature Sensor

Available up to 18" Probe Length, Thermistor or RTD Outputs

Model Chart

EXAMPLE	TE	IBN	A	04	4	4	12	Series TE-IBN-A0444-12 Immersion Probe, 10K type 3 thermistor, 4" probe length, 1/4" probe diameter, 4" flying leads, with 1/2" NPT connection.
SERIES	TE							Duct and Immersion Building Automation Temperature Sensor
MOUNTING CONFIGURATION		DFN						Duct Flange Probe Only (not w/ Connection 12,14)
		DFG						Duct Flange In Housing (not w/ Connection 12,14)
		DFW						Duct Flange NEMA 4X Housing (not w/ Connection 12,14)
		IBN						Immersion Probe Only
		IBG						Immersion in Housing (not w/ Connection 00)
		IBW						Immersion NEMA 4X Housing (not w/ Connection 00)
SENSOR TYPE			A					10K Type III Thermistor
			B					10K Type II Thermistor
			C					3K Ohm Thermistor
			D					PT100 Ohm RTD
			E					PT1000 Ohm RTD
			F					20K Thermistor
			G					1.8K Thermistor
			H					5K Thermistor
			I					100K Thermistor
			J					2.252 Thermistor
			K					NI 1000 Ohm RTD
			L					Balco NI 1000 Ohm RTD
			M					PT100 Ohm RTD 1/10 DIN (3-wire)
			P					PT1000 Ohm RTD 1/10 DIN (3-wire)
			Q					10k Ohm Type 3 Thermistor w/11K Ohm Shunt

For selecting this sensor types, a **°Celsius** option is only available, you can easily convert using the PLC or the script by multiplying the °C reading by 1.8 and adding then 32. A subroutine can easily be added to do all °C to °F conversions for any variable this way.

For compatibility, a legacy selection is available, however for better accuracy, it is recommended to use one of the new types available which use the Curve A or Curve B types with the 20K curve setting selected.

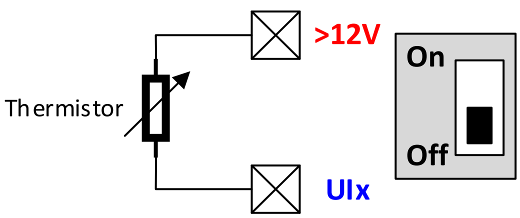
On next page all the options for connecting and configuring are shown.

From UI type selection, the **legacy 20K** model can be selected, however the last four options highlighted using **Curve A** or **Curve B** are preferred to obtain the best accuracy.

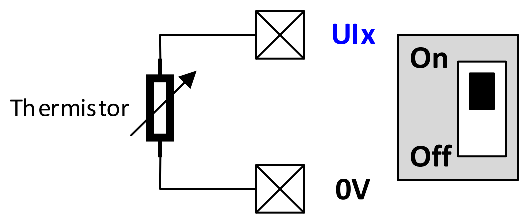
```
12bit_ADC          // ADC 12-bits : 0 - 4095
1kNI_°C            // 1000 ohms Nickel (°C) TE-6x00 JCI, 5.4  ohms/°C 1000 Ohms @ 21 °C
1kSI_°C            // 1000 ohms Silicon (°C) KYT81-110 DK, 7.7  ohms/°C 1000 Ohms @ 25 °C
1kA99_°C           // 1000 ohms A99 JCI (°C), 7.7  ohms/°C 1000 Ohms @ 21 °C
0_10_Vdc           // 0-10 Vdc or 0-20 mA @250 ohms
4_20_mA            // 4-20mA @ 250 ohms or 2-10 Vdc
1kNI_°F            // 1000 ohms Nickel (°F) TE-6x00 JCI
1kSI_°F            // 1000 ohms Silicon (°F) KYT81-110 DK
1kA99_°F           // 1000 ohms A99 JCI (°F)
RATIOMETRIC        // Ratiometric 0-100% = 10-90 FSR = 0.5-4.5 VDC
THERMOCOUPLE_J_°C// Thermocouple type J, 51.7 uV/°C x191 amp
THERMOCOUPLE_K_°C// Thermocouple type K, 40.6 uV/°C x191 amp
NTC_10K_III_12V_°C    // NTC 10K Ohms Type III @ 25°C
CT_1000:1          // CT current transformer NX5-SF 1000:1 ratio
1K_PTC_0°C         // Dwyer PT1000 at 0°C TE-DFN-E, 3.89 ohms/°C 1000 Ohms @ 0 °C
1K_PTC_32°F        // Dwyer PT1000 at 0°C TE-DFN-E result in °F
NTC_10K_III_12V_°F    // NTC 10K Ohms Type III @ 77°F
NTC_20K_TSAPA20x_12V_°C // NTC Greystone  20K Ohms @ 25°C in °C
OHMS_12V           // Measures Ohms, other side connected to +12V ref
OHMS_5VPU          // Measures Ohms, other side connected to 0V, using internal 5V pull up
NTC_CURVE_A_12V       // NTC using curve A constants, other side connected to +12V ref
NTC_CURVE_A_5VPU      // NTC using curve A constants, other side connected to 0V, using internal 5V pull up
NTC_CURVE_B_12V       // NTC using curve B constants, other side connected to +12V ref
NTC_CURVE_B_5VPU      // NTC using curve B constants, other side connected to 0V, using internal 5V pull up
```

For NTC thermistors, two wiring options are available when selecting either the **Curve A** or **Curve B** types:

***** Using built in or external **12V** reference supply



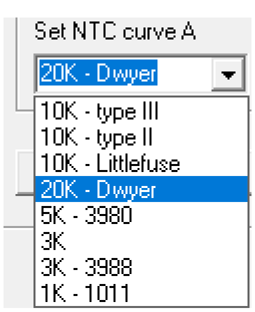
***** Using the internal **5V** Pull-Up.

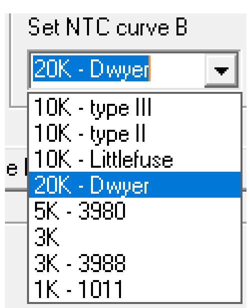


The **12V** is preferred wiring method as it gives the better bit per °C reading, also low range temperatures below -5°are better measured with this method.

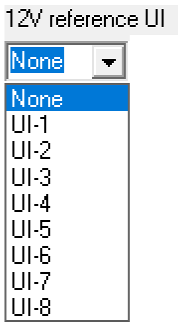
The **5V** wiring type offers a grounded common terminal that in some cases improves accuracy for noisy environments.

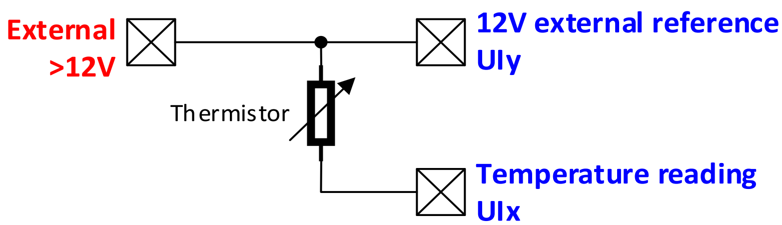
When selecting the 12V or 5V for either **Curve A** or **Curve B** use either the following corresponding options to fill in the three constants:





When using the 12V wiring option and instead of using the internal 12V reference supply which is highly accurate you instead use an external supply that can be as much as ±1V off, it is highly recommended to use the option to compensate for this variation, by attaching the 12V external voltage to an additional universal input, and use this measurement to compensate the reading, by selecting the appropriate UI channel that this voltage is fed to:





If the same external 12V supply is used for more than one thermistor, the reference voltage reading can be the same to all thermistors used, so it only needs to be measured once.

The general or per channel integration time can be increased to remove unwanted noise being picked up by the field wiring to eliminate temperature reading variance.

The calibration field is an offset that is added or subtracted (if negative) from the reading.

⊗ Temperature sensor 10K Type-III by Schneider or Dwyer.

10K type III thermistors are available from mostly any manufacturer.

Schneider Electric offers the ET Series of temperature sensors that have the 10K NTC thermistors as one of their element options. Platinum and Silicon options are also available that could be used as described on that type sections elsewhere on this manual.

Schneider Electric

ET Series

Temperature Sensors

General Instructions

APPLICATION

Thermistors offer high accuracy and interchangeability over a wide temperature range. The ET series can be used in the following applications:

- Space
- Duct
- Immersion
- Averaging
- Strap-On
- Bead/Bullet
- Outdoor Air

ET Series Photo

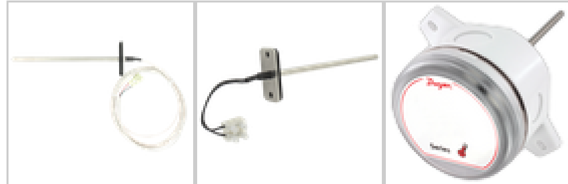
FEATURES

- Offer high accuracy and interchangeability over a wide temperature range.
- Non-polarity sensitive

SPECIFICATIONS

	For TAC Vista, I/NET, Continuum, and I/A	1000 Ohm Platinum	1000 Ohm BALCO
Output	1.8K Ohms @ 77° F (25° C) Vista 10K Ohms @ 77° F (25° C) I/Net 10K Ohms @ 77° F (25° C) Continuum 10K Ohms @ 77° F (25° C) with 11K Ohms shunt resistor I/A	1K Ohms @ 32°F (0°C)	1000 Ohms @ 70°F (21°C)

Next page offers selection options for Dwyer sensors as well.



Home / Products / Temperature / Sensors / **Series TE**

Series TE Duct and Immersion Building Automation Temperature Sensor

Available up to 18" Probe Length, Thermistor or RTD Outputs

Model Chart

EXAMPLE	TE	IBN	A	04	4	4	12	Series TE-IBN-A0444-12 Immersion Probe, 10K type 3 thermistor, 4" probe length, 1/4" probe diameter, 4" flying leads, with 1/2" NPT connection.
SERIES	TE							Duct and Immersion Building Automation Temperature Sensor
MOUNTING CONFIGURATION		DFN DFG DFW IBN IBG IBW						Duct Flange Probe Only (not w/ Connection 12,14) Duct Flange In Housing (not w/ Connection 12,14) Duct Flange NEMA 4X Housing (not w/ Connection 12,14) Immersion Probe Only Immersion in Housing (not w/ Connection 00) Immersion NEMA 4X Housing (not w/ Connection 00)
SENSOR TYPE			A					10K Type III Thermistor

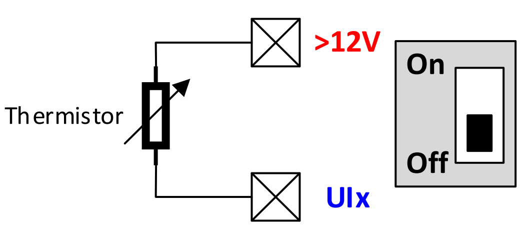
For selecting this sensor types, a **°Celsius** option is only available, you can easily convert using the PLC or the script by multiplying the °C reading by 1.8 and adding then 32. A subroutine can easily be added to do all °C to °F conversions for any variable this way.

From UI type selection use any of the two wiring options for either **Curve A** or **Curve B** options.

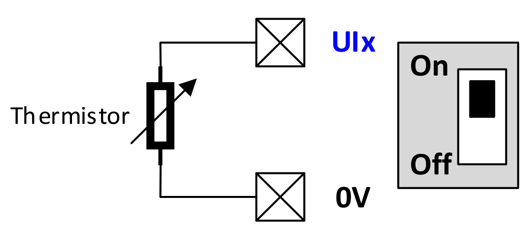
```
NTC_CURVE_A_12V      // NTC using curve A constants, other side connected to +12V ref
NTC_CURVE_A_5VPU     // NTC using curve A constants, other side connected to 0V, using internal 5V pull up
NTC_CURVE_B_12V      // NTC using curve B constants, other side connected to +12V ref
NTC_CURVE_B_5VPU     // NTC using curve B constants, other side connected to 0V, using internal 5V pull up
```

For 10K type III NTC thermistors, two wiring options are available when selecting either the **Curve A** or **Curve B** types:

***** Using built in or external **12V** reference supply



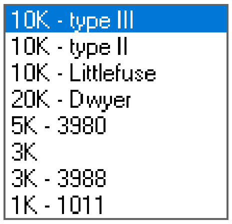
***** Using the internal **5V** Pull-Up.



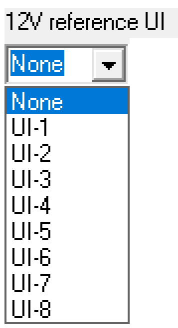
The **12V** is preferred wiring method as it gives the better bit per °C reading, also low range temperatures below -5°are better measured with this method.

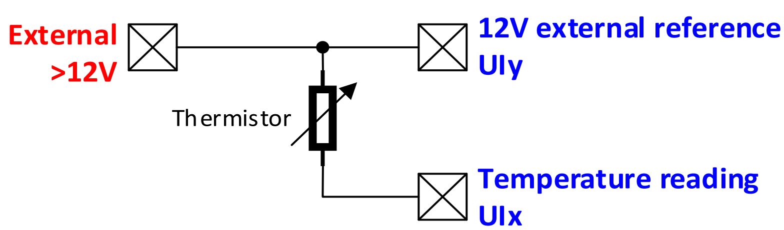
The **5V** wiring type offers a grounded common terminal that in some cases improves accuracy for noisy environments.

When selecting the 12V or 5V for either **Curve A** or **Curve B** use the following corresponding option to fill in the three constants:



When using the 12V wiring option and instead of using the internal 12V reference supply which is highly accurate you instead use an external supply that can be as much as ±1V off, it is highly recommended to use the option to compensate for this variation, by attaching the 12V external voltage to an additional universal input, and use this measurement to compensate the reading, by selecting the appropriate UI channel that this voltage is fed to:





If the same external 12V supply is used for more than one thermistor, the reference voltage reading can be the same to all thermistors used, so it only needs to be measured once.

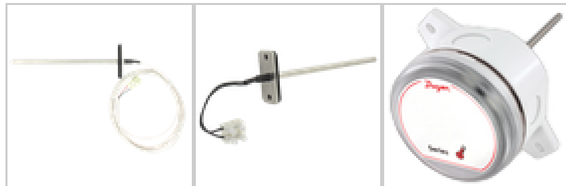
The general or per channel integration time can be increased to remove unwanted noise being picked up by the field wiring to eliminate temperature reading variance.

The calibration field is an offset that is added or subtracted (if negative) from the reading.

⊗ Temperature sensor 10K Type-II by Dwyer instruments.

10K type II thermistors are available from Dwyer instruments.

Dwyer® Manufacturing Excellence Since 1931



Home / Products / Temperature / Sensors / **Series TE**

Series TE Duct and Immersion Building Automation Temperature Sensor

Available up to 18" Probe Length, Thermistor or RTD Outputs

Model Chart

EXAMPLE	TE	IBN	A	04	4	4	12	Series TE-IBN-A0444-12 Immersion Probe, 10K type 3 thermistor, 4" probe length, 1/4" probe diameter, 4" flying leads, with 1/2" NPT connection.
SERIES	TE							Duct and Immersion Building Automation Temperature Sensor
MOUNTING CONFIGURATION		DFN						Duct Flange Probe Only (not w/ Connection 12,14)
		DFG						Duct Flange In Housing (not w/ Connection 12,14)
		DFW						Duct Flange NEMA 4X Housing (not w/ Connection 12,14)
		IBN						Immersion Probe Only
		IBG						Immersion in Housing (not w/ Connection 00)
		IBW						Immersion NEMA 4X Housing (not w/ Connection 00)
SENSOR TYPE			A					10K Type III Thermistor
			B					10K Type II Thermistor

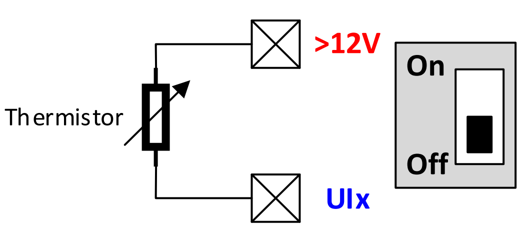
For selecting this sensor types, a **°Celsius** option is only available, you can easily convert using the PLC or the script by multiplying the °C reading by 1.8 and adding then 32. A subroutine can easily be added to do all °C to °F conversions for any variable this way.

From UI type selection use any of the two wiring options for either **Curve A** or **Curve B** options.

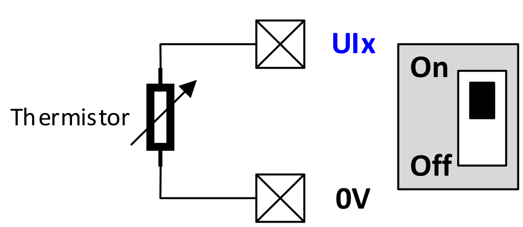
```
NTC_CURVE_A_12V     // NTC using curve A constants, other side connected to +12V ref
NTC_CURVE_A_5VPU    // NTC using curve A constants, other side connected to 0V, using internal 5V pull up
NTC_CURVE_B_12V     // NTC using curve B constants, other side connected to +12V ref
NTC_CURVE_B_5VPU    // NTC using curve B constants, other side connected to 0V, using internal 5V pull up
```

For 10K type II NTC thermistors, two wiring options are available when selecting either the **Curve A** or **Curve B** types:

***** Using built in or external **12V** reference supply



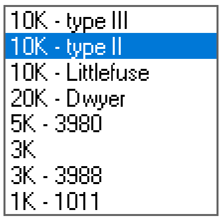
***** Using the internal **5V** Pull-Up.



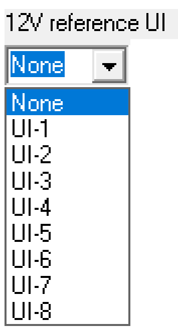
The **12V** is preferred wiring method as it gives the better bit per °C reading, also low range temperatures below -5°are better measured with this method.

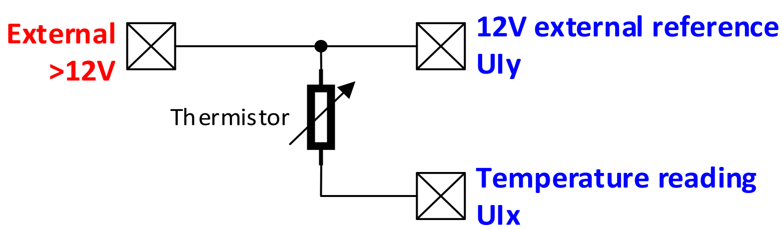
The **5V** wiring type offers a grounded common terminal that in some cases improves accuracy for noisy environments.

When selecting the 12V or 5V for either **Curve A** or **Curve B** use the following corresponding option to fill in the three constants:



When using the 12V wiring option and instead of using the internal 12V reference supply which is highly accurate you instead use an external supply that can be as much as ±1V off, it is highly recommended to use the option to compensate for this variation, by attaching the 12V external voltage to an additional universal input, and use this measurement to compensate the reading, by selecting the appropriate UI channel that this voltage is fed to:





If the same external 12V supply is used for more than one thermistor, the reference voltage reading can be the same to all thermistors used, so it only needs to be measured once.

The general or per channel integration time can be increased to remove unwanted noise being picked up by the field wiring to eliminate temperature reading variance.

The calibration field is an offset that is added or subtracted (if negative) from the reading.

⊗ Temperature sensor 5K by Digikey.

5K thermistors are available from Digikey manufactured by **TDK** for cabinet and evaporator in refrigerators and deep freezers applications: https://www.digikey.com/en/products/detail/epcos-tdk-electronics/B57020M2502A017/739845?s=N4IgTCBcDaICwE4CsBaMAGA7KgcgERAF0BfIA

B57020M2502A017 Datasheet

Digi-Key Part Number	495-2075-ND
Manufacturer	EPCOS - TDK Electronics
Manufacturer Product Number	B57020M2502A017
Supplier	EPCOS - TDK Electronics
Description	THERMISTOR NTC 5KOHM 3980K PROBE
Manufacturer Standard Lead Time	30 Weeks
Detailed Description	NTC Thermistor 5k Cylindrical Probe, Plastic

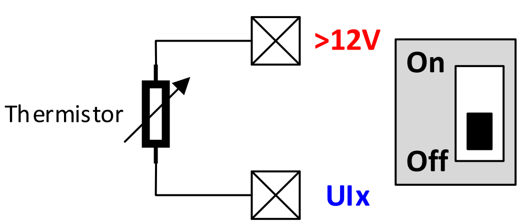
For selecting this sensor types, a **°Celsius** option is only available, you can easily convert using the PLC or the script by multiplying the °C reading by 1.8 and adding then 32. A subroutine can easily be added to do all °C to °F conversions for any variable this way.

From UI type selection use any of the two wiring options for either **Curve A** or **Curve B** options.

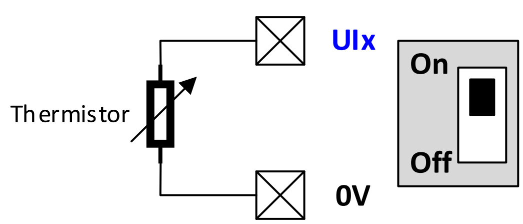
```
NTC_CURVE_A_12V     // NTC using curve A constants, other side connected to +12V ref
NTC_CURVE_A_5VPU     // NTC using curve A constants, other side connected to 0V, using internal 5V pull up
NTC_CURVE_B_12V     // NTC using curve B constants, other side connected to +12V ref
NTC_CURVE_B_5VPU     // NTC using curve B constants, other side connected to 0V, using internal 5V pull up
```

For 5K thermistors, two wiring options are available when selecting either the **Curve A** or **Curve B** types:

***** Using built in or external **12V** reference supply



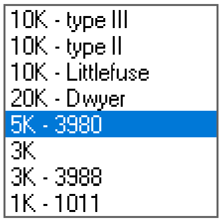
***** Using the internal **5V** Pull-Up.



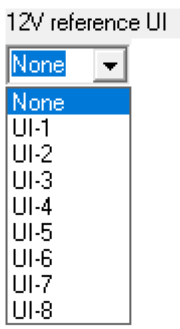
The **12V** is preferred wiring method as it gives the better bit per °C reading, also low range temperatures below -5°are better measured with this method.

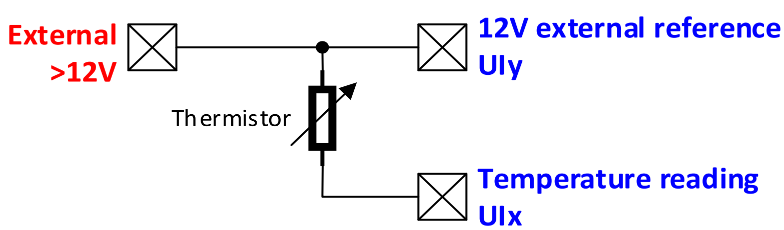
The **5V** wiring type offers a grounded common terminal that in some cases improves accuracy for noisy environments.

When selecting the 12V or 5V for either **Curve A** or **Curve B** use the following corresponding option to fill in the three constants:



When using the 12V wiring option and instead of using the internal 12V reference supply which is highly accurate you instead use an external supply that can be as much as ±1V off, it is highly recommended to use the option to compensate for this variation, by attaching the 12V external voltage to an additional universal input, and use this measurement to compensate the reading, by selecting the appropriate UI channel that this voltage is fed to:





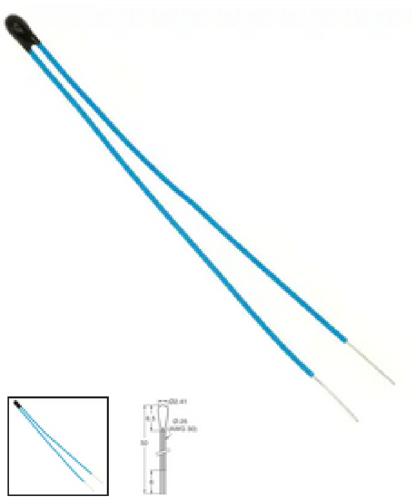
If the same external 12V supply is used for more than one thermistor, the reference voltage reading can be the same to all thermistors used, so it only needs to be measured once.

The general or per channel integration time can be increased to remove unwanted noise being picked up by the field wiring to eliminate temperature reading variance.

The calibration field is an offset that is added or subtracted (if negative) from the reading.

⊗ Temperature sensor 3K by Digikey.

3K thermistors are available from Digikey manufactured by **TDK** for short response and low cost applications: https://www.digikey.com/en/products/detail/epcos-tdk-electronics/B57863S0302F040/739900?s=N4IgTCBcDaICwE4CsBaMBGJAGFA5AIiALoC%2BQA



B57863S0302F040 Datasheet

Digi-Key Part Number	495-2150-ND
Manufacturer	EPCOS - TDK Electronics
Manufacturer Product Number	B57863S0302F040
Supplier	EPCOS - TDK Electronics
Description	THERMISTOR NTC 3KOHM 3988K BEAD
Manufacturer Standard Lead Time	16 Weeks
Detailed Description	NTC Thermistor 3k Bead

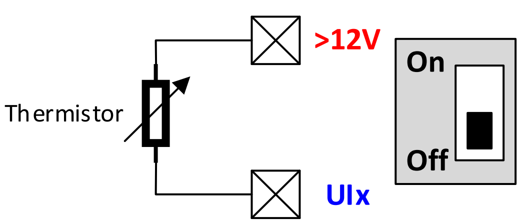
For selecting this sensor types, a **°Celsius** option is only available, you can easily convert using the PLC or the script by multiplying the °C reading by 1.8 and adding then 32. A subroutine can easily be added to do all °C to °F conversions for any variable this way.

From UI type selection use any of the two wiring options for either **Curve A** or **Curve B** options.

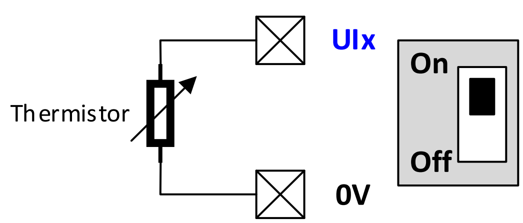
```
NTC_CURVE_A_12V     // NTC using curve A constants, other side connected to +12V ref
NTC_CURVE_A_5VPU    // NTC using curve A constants, other side connected to 0V, using internal 5V pull up
NTC_CURVE_B_12V     // NTC using curve B constants, other side connected to +12V ref
NTC_CURVE_B_5VPU    // NTC using curve B constants, other side connected to 0V, using internal 5V pull up
```

For 3K thermistors, two wiring options are available when selecting either the **Curve A** or **Curve B** types:

***** Using built in or external **12V** reference supply



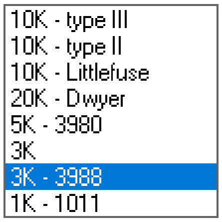
***** Using the internal **5V** Pull-Up.



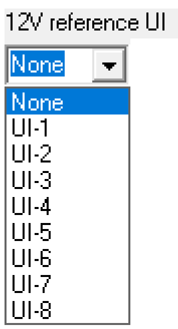
The **12V** is preferred wiring method as it gives the better bit per °C reading, also low range temperatures below -5°are better measured with this method.

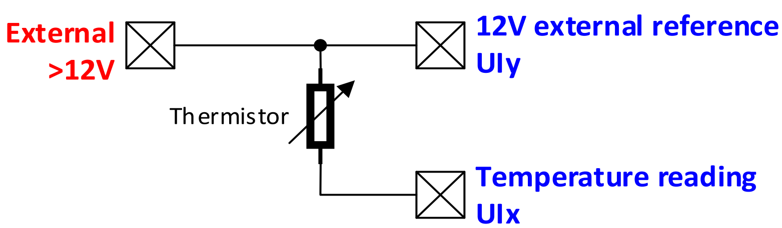
The **5V** wiring type offers a grounded common terminal that in some cases improves accuracy for noisy environments.

When selecting the 12V or 5V for either **Curve A** or **Curve B** use the following corresponding option to fill in the three constants:



When using the 12V wiring option and instead of using the internal 12V reference supply which is highly accurate you instead use an external supply that can be as much as ±1V off, it is highly recommended to use the option to compensate for this variation, by attaching the 12V external voltage to an additional universal input, and use this measurement to compensate the reading, by selecting the appropriate UI channel that this voltage is fed to:





If the same external 12V supply is used for more than one thermistor, the reference voltage reading can be the same to all thermistors used, so it only needs to be measured once.

The general or per channel integration time can be increased to remove unwanted noise being picked up by the field wiring to eliminate temperature reading variance.

The calibration field is an offset that is added or subtracted (if negative) from the reading.

⊗ Temperature sensor 1K by Digikey.

1K thermistors are available from Digikey manufactured by **TDK** for temperature compensation, measurement and control (chassis mounting) with good thermal coupling through screw-typecase https://www.digikey.com/en/products/detail/epcos-tdk-electronics/B57045K0102K000/3500200?s=N4IgTCBcDaICwE4CsBaA7ABgGwJQOQBEQBdAXyA

B57045K0102K000 Datasheet

Digi-Key Part Number	495-7069-ND
Manufacturer	EPCOS - TDK Electronics
Manufacturer Product Number	B57045K0102K000
Supplier	EPCOS - TDK Electronics
Description	THERMISTOR NTC 1KOHM 3730K STUD
Manufacturer Standard Lead Time	10 Weeks
Detailed Description	NTC Thermistor 1k Nonstandard, Threaded Stud

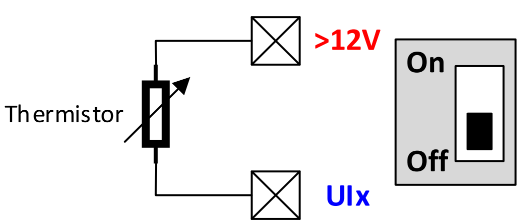
For selecting this sensor types, a **°Celsius** option is only available, you can easily convert using the PLC or the script by multiplying the °C reading by 1.8 and adding then 32. A subroutine can easily be added to do all °C to °F conversions for any variable this way.

From UI type selection use any of the two wiring options for either **Curve A** or **Curve B** options.

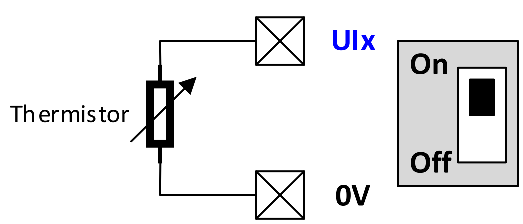
```
NTC_CURVE_A_12V     // NTC using curve A constants, other side connected to +12V ref
NTC_CURVE_A_5VPU    // NTC using curve A constants, other side connected to 0V, using internal 5V pull up
NTC_CURVE_B_12V     // NTC using curve B constants, other side connected to +12V ref
NTC_CURVE_B_5VPU    // NTC using curve B constants, other side connected to 0V, using internal 5V pull up
```

For 1K thermistors, two wiring options are available when selecting either the **Curve A** or **Curve B** types:

* Using built in or external **12V** reference supply



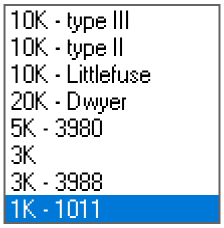
* Using the internal **5V** Pull-Up.



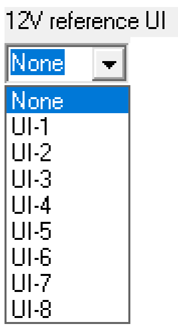
The **12V** is preferred wiring method as it gives the better bit per °C reading, also low range temperatures below -5°are better measured with this method.

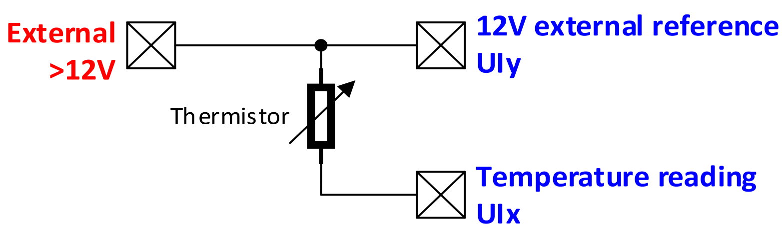
The **5V** wiring type offers a grounded common terminal that in some cases improves accuracy for noisy environments.

When selecting the 12V or 5V for either **Curve A** or **Curve B** use the following corresponding option to fill in the three constants:



When using the 12V wiring option and instead of using the internal 12V reference supply which is highly accurate you instead use an external supply that can be as much as ±1V off, it is highly recommended to use the option to compensate for this variation, by attaching the 12V external voltage to an additional universal input, and use this measurement to compensate the reading, by selecting the appropriate UI channel that this voltage is fed to:





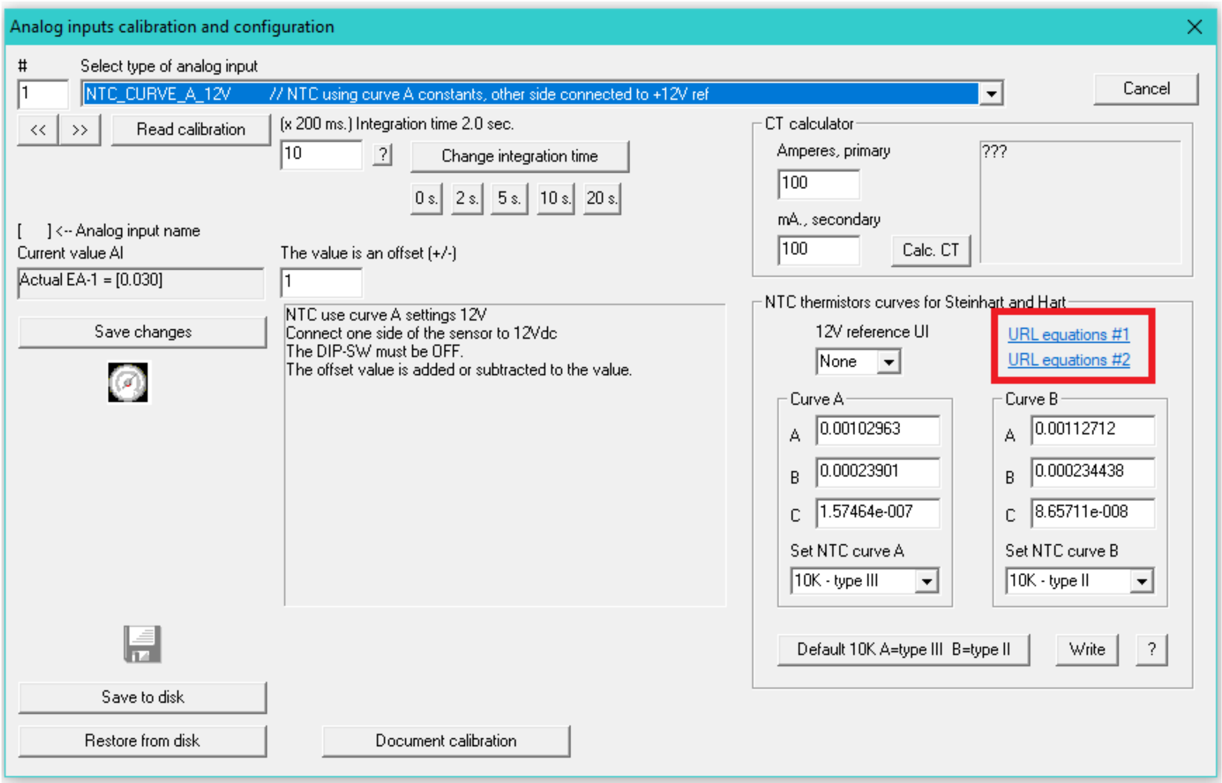
If the same external 12V supply is used for more than one thermistor, the reference voltage reading can be the same to all thermistors used, so it only needs to be measured once.

The general or per channel integration time can be increased to remove unwanted noise being picked up by the field wiring to eliminate temperature reading variance.

The calibration field is an offset that is added or subtracted (if negative) from the reading.

⊗ Temperature sensor using any arbitrary NTC thermistor using Steinhart-Hart calculators from any manufacturer or supplier.

The MFC tool provides two links to two different online calculators. They both provide exactly, the same result, therefore which one you use is just a matter of your own personal taste.



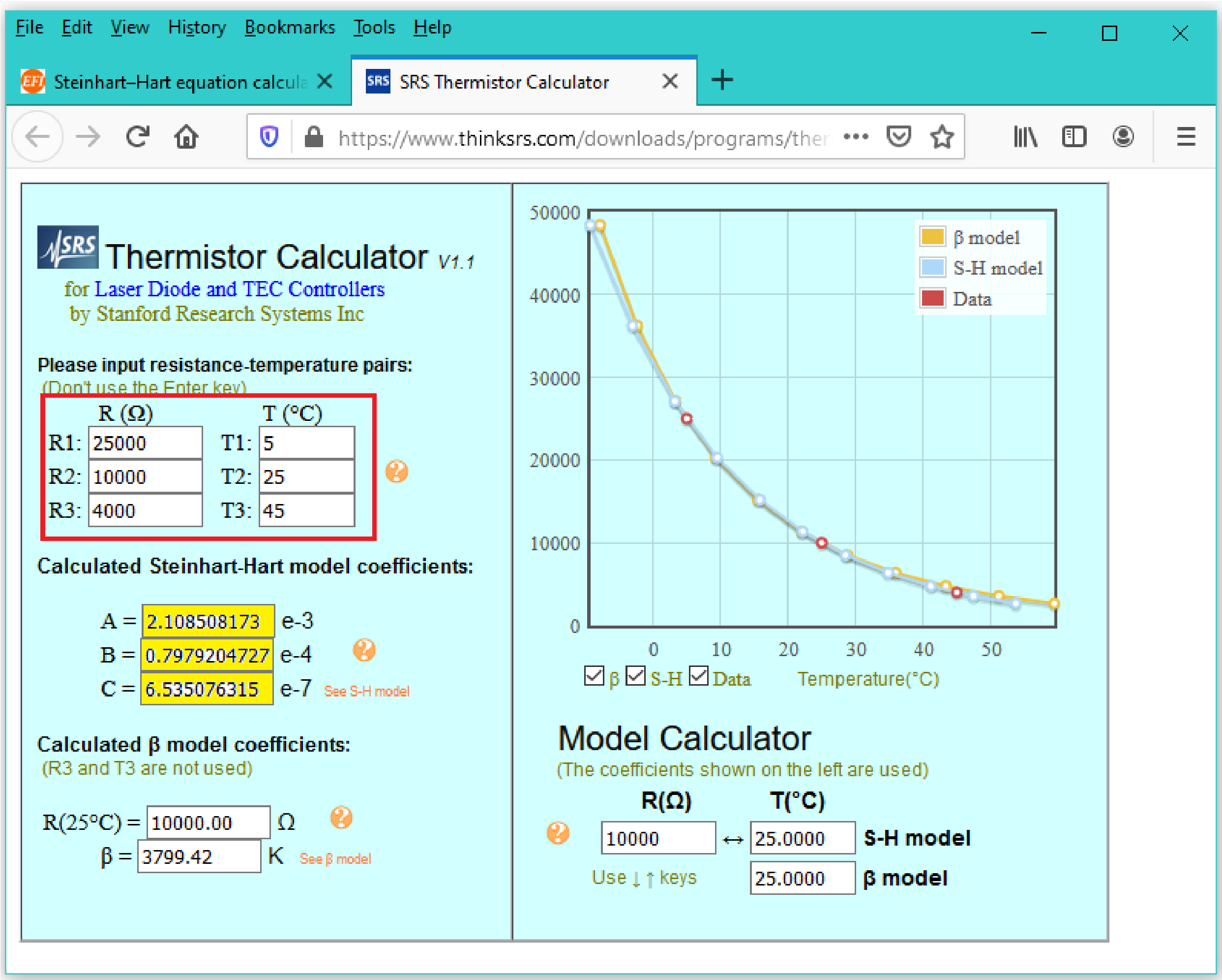
Using the thermistor's temperature to resistance charts usually available from the manufacturer you can easily calculate the three constants needed by the Steinhart-Hart equation using the online calculators.

A typical chart or table is shown to the right for different NTC thermistors:

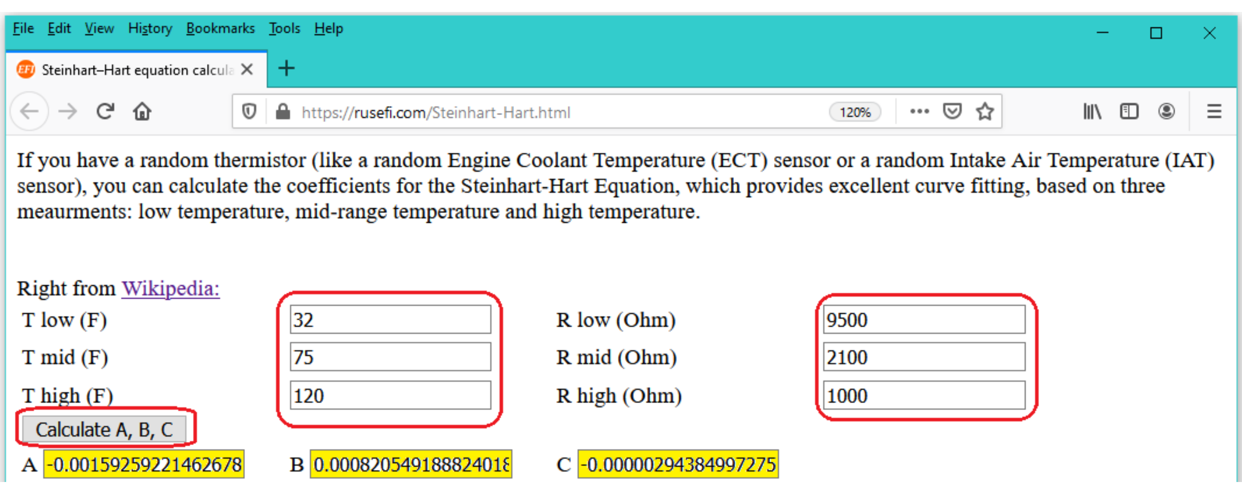
R/T No.	1011		1012		1013	
T (°C)	$B_{25/100}$ = 3730 K		$B_{25/100}$ = 4300 K		$B_{25/100}$ = 3900 K	
	R_T/R_{25}	α (%/K)	R_T/R_{25}	α (%/K)	R_T/R_{25}	α (%/K)
−55.0	70.014	6.9	87.237	6.8	77.285	7.0
−50.0	49.906	6.7	62.264	6.7	54.938	6.7
−45.0	36.015	6.4	44.854	6.5	39.507	6.5
−40.0	26.296	6.2	32.599	6.3	28.722	6.3
−35.0	19.411	6.0	23.893	6.1	21.099	6.1
−30.0	14.479	5.8	17.654	6.0	15.652	5.9
−25.0	10.903	5.6	13.098	5.8	11.715	5.7
−20.0	8.2923	5.4	9.8059	5.7	8.8541	5.6
−15.0	6.3591	5.2	7.4266	5.5	6.7433	5.4
−10.0	4.9204	5.1	5.6677	5.4	5.1815	5.2
−5.0	3.8279	4.9	4.3213	5.3	4.0099	5.1
0.0	3.0029	4.8	3.3208	5.1	3.1283	4.9
5.0	2.3773	4.6	2.5842	5.0	2.4569	4.8
10.0	1.8959	4.5	2.0238	4.9	1.9438	4.6
15.0	1.5207	4.3	1.5858	4.8	1.5475	4.5
20.0	1.228	4.2	1.2507	4.7	1.2403	4.4
25.0	1.0000	4.1	1.0000	4.5	1.0000	4.3
30.0	0.81779	3.9	0.7964	4.4	0.81104	4.1
35.0	0.67341	3.8	0.64053	4.3	0.66146	4.0
40.0	0.55747	3.7	0.51772	4.2	0.54254	3.9
45.0	0.46357	3.6	0.41958	4.1	0.44727	3.8
50.0	0.3874	3.6	0.34172	4.1	0.37067	3.7
55.0	0.32368	3.5	0.27877	4.0	0.30865	3.6
60.0	0.272	3.4	0.22861	3.9	0.25825	3.5
65.0	0.23041	3.3	0.18872	3.8	0.21707	3.4
70.0	0.19604	3.2	0.15645	3.7	0.18323	3.3
75.0	0.16735	3.1	0.13012	3.6	0.15535	3.3
80.0	0.14342	3.0	0.10863	3.6	0.13223	3.2
85.0	0.12347	3.0	0.091115	3.5	0.11302	3.1
90.0	0.10668	2.8	0.0767	3.4	0.096951	3.0
95.0	0.092734	2.8	0.064867	3.3	0.083487	3.0
100.0	0.080903	2.8	0.055047	3.3	0.072139	2.9
105.0	0.070616	2.7	0.046797	3.2	0.062559	2.8
110.0	0.061826	2.6	0.039904	3.1	0.054425	2.8
115.0	0.054282	2.6	0.034255	3.1	0.047508	2.7
120.0	0.047793	2.5	0.029498	3.0	0.041594	2.6
125.0	0.042249	2.4	0.025448	3.0	0.036532	2.6

In this one shown first, you must enter the three resistance / temperature points in **Ohms and °Celsius**. It also provides a neat visual representation of the three input points in the graphed curve.

The three **A**, **B** and **C** constants that are highlighted in yellow in the figure below can be simply copied and pasted into the MFC tool using the common **CTRL-C** (copy) and **CTRL-V** (paste) Windows commands.



On this other online calculator option, you must enter the three points in **°Fahrenheit and Ohms**, respectively. Note that there is nothing stopping you from manually converting the temperatures in the resistance vs. temperature charts from °C to °F and vice versa to use any of these two web sites that you prefer. On the next page a typical resistance vs. temperature NTC thermistor chart is shown.

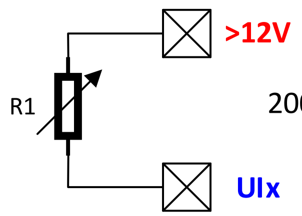


⊗ Resistance measuring to obtain ohms value from potentiometers or resistive type sensors.

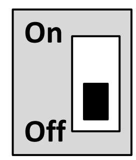
There are two methods of connecting resistive sensors such as:

- **PTC** temperature sensors.
- **NTC** thermistors
- Potentiometers
- Any kind of resistive sensor.

The first option is to connect one side of the resistive element to the **+12V** DC voltage reference terminal and the other side to the universal input terminal, in this case the **DIP-SW** for that channel must be in the **OFF** position.



200 Ω < **R1** < 1 MΩ



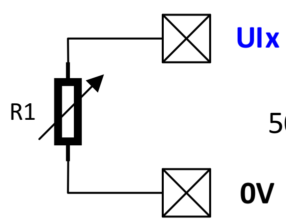
This setup has the following **advantages:**

- Higher resistance range.
- Better bit per ohm resolution.

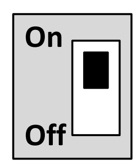
disadvantages:

* Uses a higher voltage.

The second option is to connect one side of the resistive element to the **0V** terminal also called **Ground** and the other side to the universal input terminal, in this case the **DIP-SW** for that channel must be in the **ON** position and applies an internal 5V reference voltage across a 1 Kilo ohm impedance resistor.



500 Ω < **R1** < 40 KΩ



This setup has the following **advantages:**

- One side is grounded.
- Uses a smaller voltage.

disadvantages:

* Reduced bit per ohm resolution.
* Reduced resistance range.

Use either option as needed when selecting from the calibration type:

OHMS_12V // Measures Ohms, other side connected to +12V ref
OHMS_5VPU // Measures Ohms, other side connected to 0V, using internal 5V pull up

The value read will be in ohms and can be scaled and or adjusted using the math instructions of the PLC as needed.

The integration is applied, and the calibration value is an offset added or subtracted to the ohm value.

Section 2:

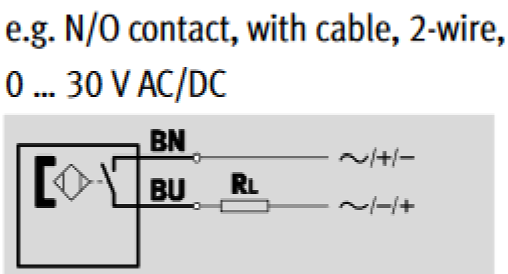
ATTACHING DIGITAL SENSORS TO THE UNIVERSAL INPUTS

⊗ Dry contact digital sensors with common grounded.

When using dry contact sensors, there are two connection types available to either **0V** or grounded or applying an external **12 Volts** to one of the terminals.

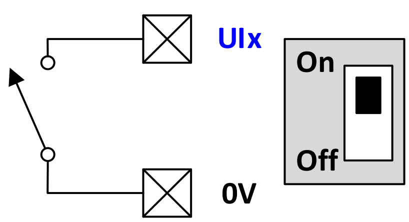
Here we will first see how to connect the grounded type.

Dry contact sensors are usually mechanical type where two metal contacts close or open and can have applied on them AC or DC voltages without regard to polarity as shown below.

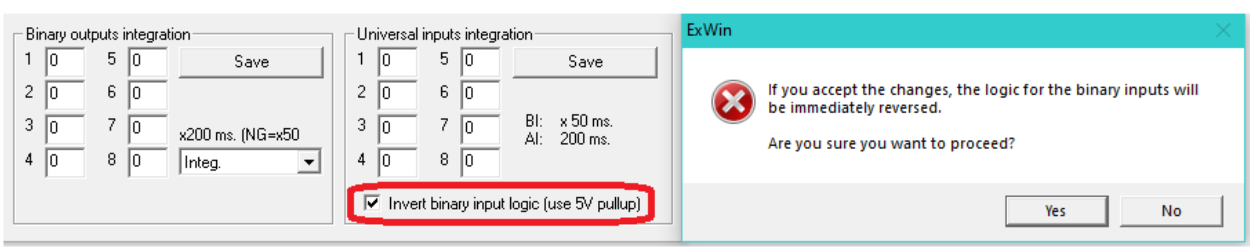


The wiring diagram is as follows; one terminal connected to the universal input while the other one is connected to 0V.

The Pull-Up DIP-SW for that channel must be in the **ON** position.



For this option to work correctly in the Expanded INFO dialog **select** the: "**Inverted BI logic**" checkbox.

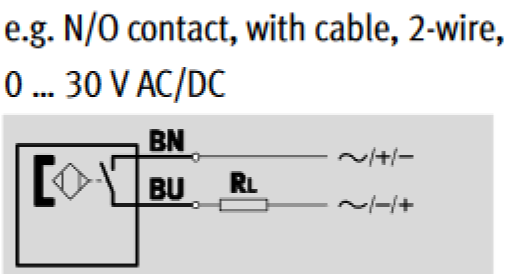


⊗ Dry contact digital sensors with common connected to DC Voltage.

When using dry contact sensors, there are two connection types available to either **0V** or grounded or applying an external **12 Volts** to one of the terminals.

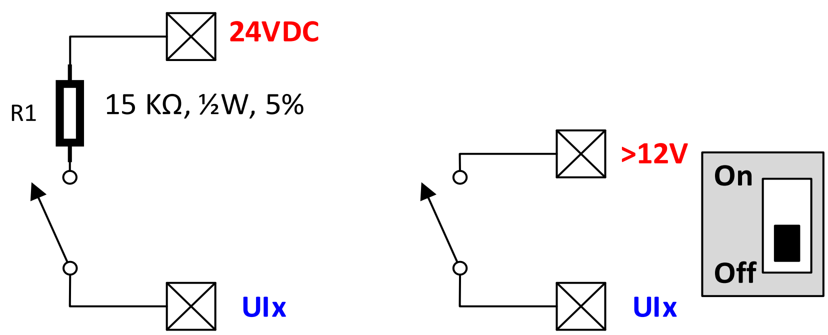
Here we will now see how to connect the type that has a DC voltage applied across.

Dry contact sensors are usually mechanical type where two metal contacts close or open and can have applied on them **AC** or **DC** voltages without regard to polarity as shown below.

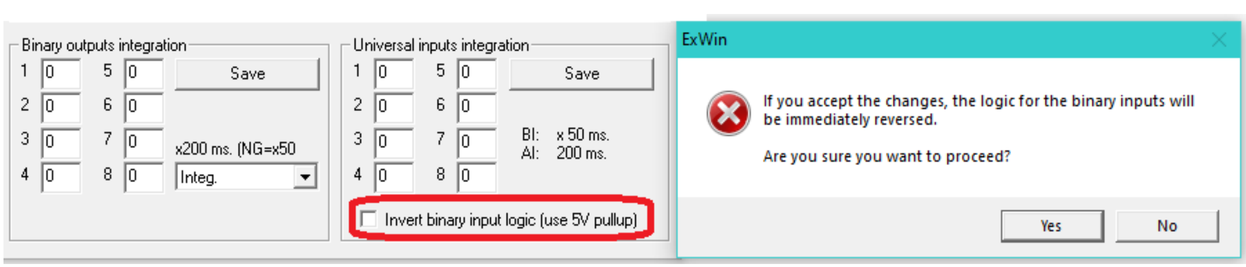


The wiring diagram is as follows; one terminal connected to the external reference voltage of **12 Volts** DC or using a **15KΩ** resistor in series if using **24 VDC**.

The Pull-Up DIP-SW for that channel must be in the **OFF** position.



For this option to work correctly in the Expanded INFO dialog **unselect** the: "**Inverted BI logic**" checkbox,



⊗ Connecting NPN type digital sensors.

NPN sensors come in many different forms, shapes, construction, and types such as:

- Inductive
- Magnetic
- Capacitive
- Proximity
- Optical
- And many more

They distinguish themselves from “dry contact” sensors because instead of a mechanical contact they have an electronic transistor as the output.

Following is a typical table for proximity sensors, in where it can be seen that the **NPN switching output** is one of the available options.

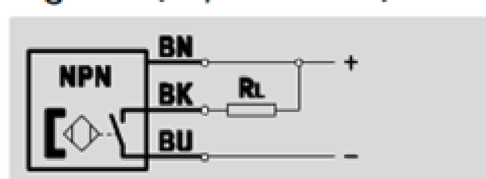
Proximity sensors SMT/SME FESTO

Product range overview

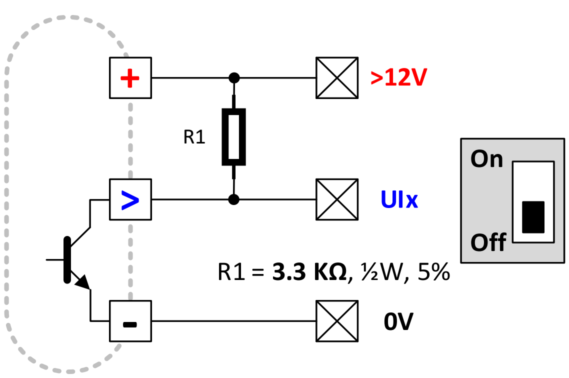
Design	Type of mounting	Measuring principle	Type	Operating voltage range	Switching output	Switching element function	→ Page/ Internet
For C-slot	Standard						
	Insertable in the slot from above, flush with the cylinder profile	Magneto-resistive	SMT-10M	10 ... 30 V DC	PNP	N/O contact	C-slot
					NPN		
					Non-contacting, 2-wire		
		Magnetic reed	SME-10M	5 ... 30 V AC/DC	Contacting, bipolar	N/O contact	
	Insertable in the slot lengthwise	Magneto-resistive	SMT-10G	10 ... 30 V DC	PNP	N/O contact	
		Magnetic reed	SME-10	12 ... 27 V AC/DC	Contacting	N/O contact	

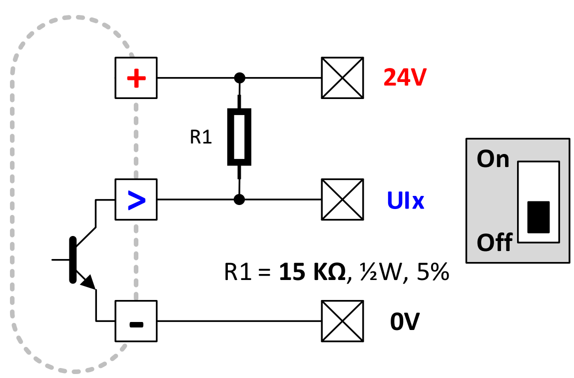
To the right is a typical installation diagram for an **NPN output sensor**, a load resistance **RL** is usually connected to the positive supply side. Take note that the colors and identification of the terminals very and are different according to the manufacturer or specific part number.

e.g. NPN, N/O contact, with cable



A typical wiring diagram for either **12V** or **24V** supply is shown below, the Pull-Up DIP-SW for the channel should be **OFF.** Typical load resistors for a **~2-4 mA** load for both DC supplies are shown.





⊗ Connecting PNP type digital sensors.

PNP sensors come in many different forms, shapes, construction, and types such as:

- Inductive
- Magnetic
- Capacitive
- Proximity
- Optical
- And many more

They distinguish themselves from "dry contact" sensors because instead of a mechanical contact they have an electronic transistor as the output.

Following is a typical table for proximity sensors, in where it can be seen that the **NPN switching output** is one of the available options.

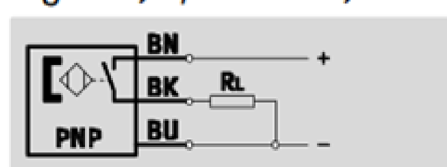
Proximity sensors SMT/SME FESTO

Product range overview

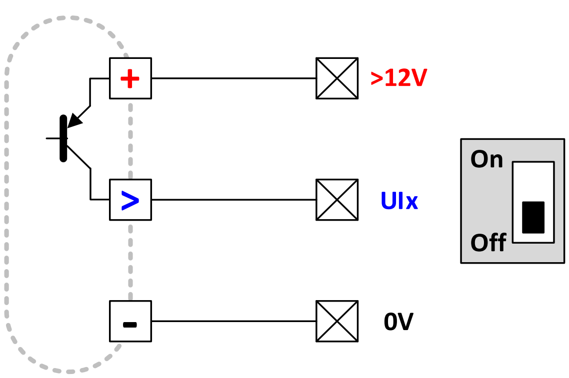
Design	Type of mounting	Measuring principle	Type	Operating voltage range	Switching output	Switching element function	→ Page/ Internet
For C-slot	Standard						
	Insertable in the slot from above, flush with the cylinder profile	Magneto-resistive	SMT-10M	10 ... 30 V DC	PNP	N/O contact	C-slot
					NPN		
					Non-contacting, 2-wire		
		Magnetic reed	SME-10M	5 ... 30 V AC/DC	Contacting, bipolar	N/O contact	
	Insertable in the slot lengthwise	Magneto-resistive	SMT-10G	10 ... 30 V DC	PNP	N/O contact	
		Magnetic reed	SME-10	12 ... 27 V AC/DC	Contacting	N/O contact	

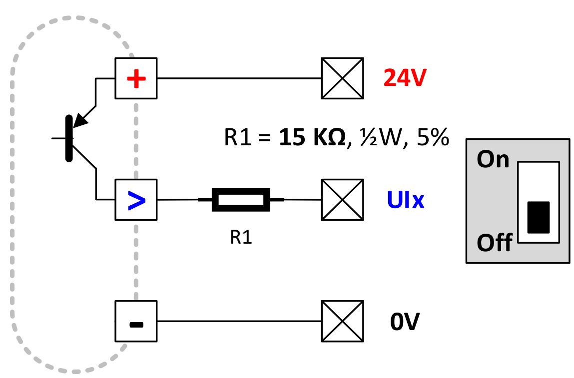
To the right is a typical installation diagram for a **PNP output sensor**, a load resistance **RL** is usually connected to the ground or 0Vterminal. Take note that the colors and identification of the terminals very and are different according to the manufacturer or specific part number.

e.g. PNP, N/O contact, with cable



A typical wiring diagram for either **12V** or **24V** supply is shown below, the Pull-Up DIP-SW for the channel should be **OFF.** Typical load resistors for a ~1 mA load for both DC supplies are also shown.





NOTE 1: Universal Inputs have a **15.3KΩ** internal network resistor connected to 0V, which is used as the **RL** load resistor for a load current of approximately **~1 mA**.

NOTE 2: The external resistor is only needed for operation with a **24V** supply to protect the UI from overvoltage.

⊗ Pulse type sensor to measure water consumption.

Water meter is something that usually needs to be measured on **BAS systems**. Many types and technologies are offered by insurmountable number of suppliers.

Below are images of typical flow sensors used measure water consumption from the online supplier:

https://www.omega.com/en-us/flow-instruments/flow-meters/c/paddlewheel-flow-meters

Low Flow Polypropylene & TFE Liquid Flow Meters

General Purpose Paddlewheel Flow Meter

Low Flow Indicating Paddlewheel Flow Meter

Low Cost Paddlewheel Flow Meter

Low Velocity Paddlewheel Flow Meter

All Metal Hot Tap Option Paddlewheel Flow Meter

Stainless Steel Paddlewheel Flow Meter

Adjustable Length Insertation Paddlewheel Flow Meter

PVDF Flow Monitoring System for Corrosive Fluids

Flow Sensor with Visual Indication and Switch or Pulse Output

Paddlewheel Flow & Temperature Meter

Fixed Length Inseration Paddlewheel Flow & Temperature Meter

As usually the output type of this sensors is either a: **Dry-Contact** or **PNP** or **NPN** output, please refer for the previous two sections on connecting this type of sensors.

Some sensors have electronic pulse dividers that provide a scaled version of the reading, while other ones are straight pulses coming out of the magnetic pickup sensor.

You must read the manual to know how use and connect the sensors. On next page is a typical calculation to obtain water consumption in either **m³** or **feet³** units.

For our example we will use a water flow sensor from: https://www.omega.com/en-us/flow-instruments/flow-meters/paddlewheel-flow-meters/p/FPB100-Series

This type of sensors have an electronic built board that is used to match the sensor to the pipe being installed into, at the end the board provides pulsed outputs that can be fed to a universal input set as a pulse counter.

Mode

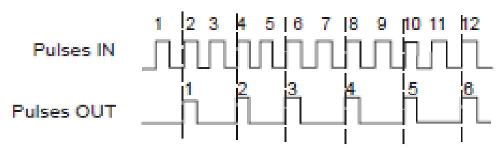
Select DIVIDER or TOTAL operation.
The factory setting is TOTAL.

PULSE DIVIDER Output = Input pulses ÷ P-Factor

DIVIDER allows you to set a scaling value (P-Factor) from 1.0000 to 99999.

Example: If the P-Factor is set for 2, then the FPB will output one pulse for every 2 pulses received from the sensor.
This selection enables the output frequency to be scaled down to match associated equipment capabilities.

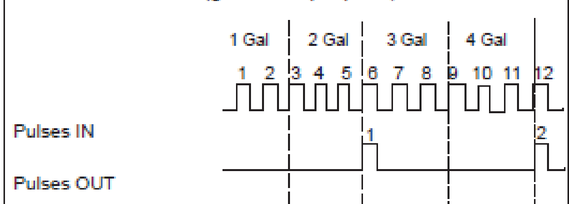
When using the PULSE DIVIDER output, associated equipment must divide the K-Factors in this manual by the P-Factor for correct calibration.



PULSE TOTAL Output = Input pulses ÷ (K-Factor × P-Factor)
TOTAL is a traditional pump pulser function. This selection will allow the entry of a K-Factor to define a volumetric unit, then set a P-Factor to define the number of volumetric units required to generate one pulse out.

Example:
Set the Total Pulse output so there is one pulse out for each 2 gallons that passes the sensor if the K-Factor is 3.0.

1. K-Factor = 3.0 (pulses in per gallon)
2. P-Factor = 2 (gallons out per pulse)

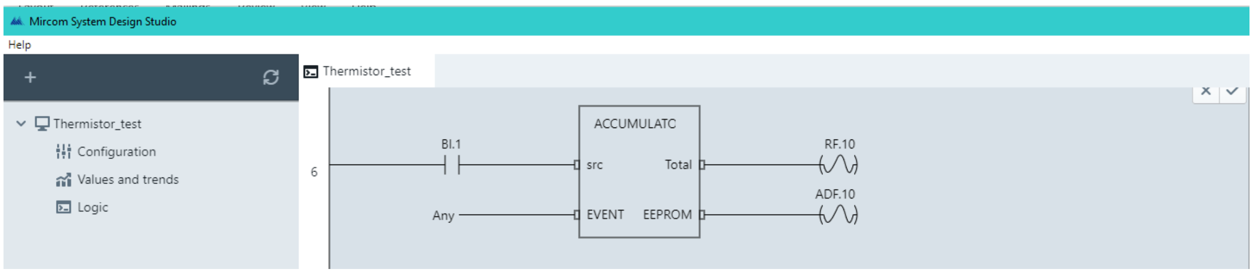


The **UI-1** and **UI-2** each master or slave are high speed pulse inputs and can take a pulse frequency up to 250 pulses per second or 15,000 pulses per minute.

The **UI-3** thru **UI-8** can only take up to 10 pulses per second or 600 pulses per minute. If your signal is less than 10 pulses per second, it is recommended to use UI-3 thru UI-8 as they have an additional software filter that eliminates noise.

Once you have the pulse signal connected either as **NPN** or **PNP** types as described on the sections above, all you need to do is to set up a **TOTALIZER** instruction.

Below is the setup of the "Totalizer Instruction" using System Design Studio.



After we have the reading in Gallons it is easy using the PLC with the math instructions to convert it to:

- **Liters.**

  Multiply US Gallons by **3.785412** to obtain **litres**.

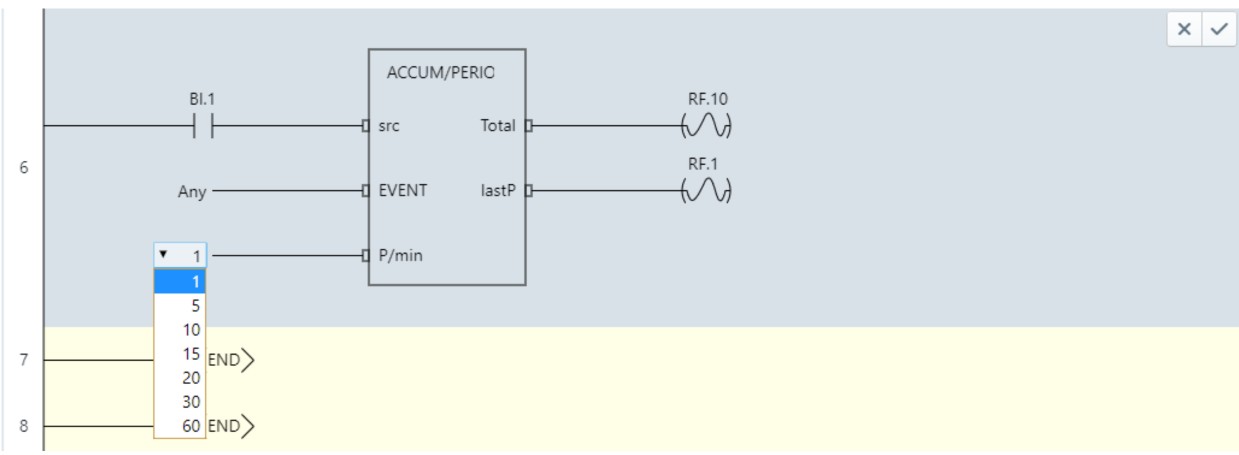
- **Cubic metres.**

  Multiply US Gallons by **0.003785** to obtain **m**^{3}.

- **Cubic feet.**

  Multiply US Gallons by **0.133681** to obtain **feet**^{3}.

Also, if you want periodic measurements such a **Litres/hour** instead / or in addition to the accumulated readings, an additional accumulator per period can also be added.



⊗ Pulse type sensor to measure gas.

Gas measurement is another typical requirement of a **BAS system** is shown below from:
https://www.elster-americanmeter.com/assets/products/products_elster_files/EAM-DS3537.pdf

The output type of this meters is either a: **Dry-Contact** or **PNP** or **NPN** output, please refer for the previous sections on connecting this type of sensors.

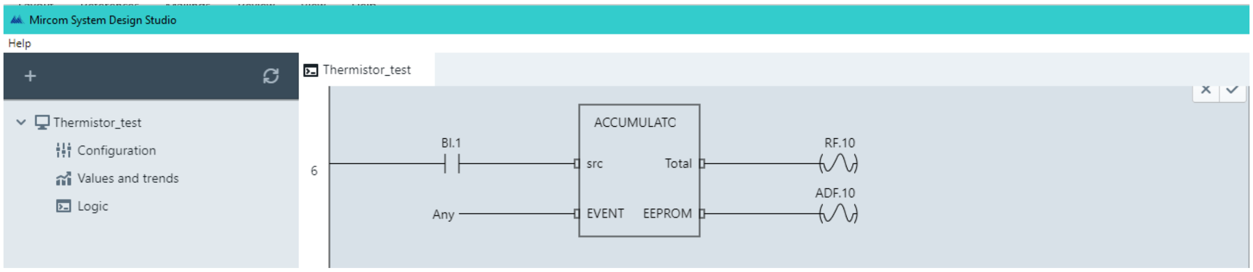
Usually, this type of meters provide a pulse output per every unit or fraction of unis consumed, therefore similarly as with water meters, the pulsed output representing a unit of gas, which is typically **1 cubic foot** can be fed directly to an accumulator.

The **UI-1** and **UI-2** each master or slave are high speed pulse inputs and can take a pulse frequency up to 250 pulses per second or 15,000 pulses per minute.

The **UI-3** thru **UI-8** can only take up to 10 pulses per second or 600 pulses per minute. If your signal is less than 10 pulses per second, it is recommended to use UI-3 thru UI-8 as they have an additional software filter that eliminates noise.

Once you have the pulse signal connected either as **NPN** or **PNP** types as described on the sections above, all you need to do is to set up a **TOTALIZER** instruction.

Below is the setup of the "Totalizer Instruction" using System Design Studio.

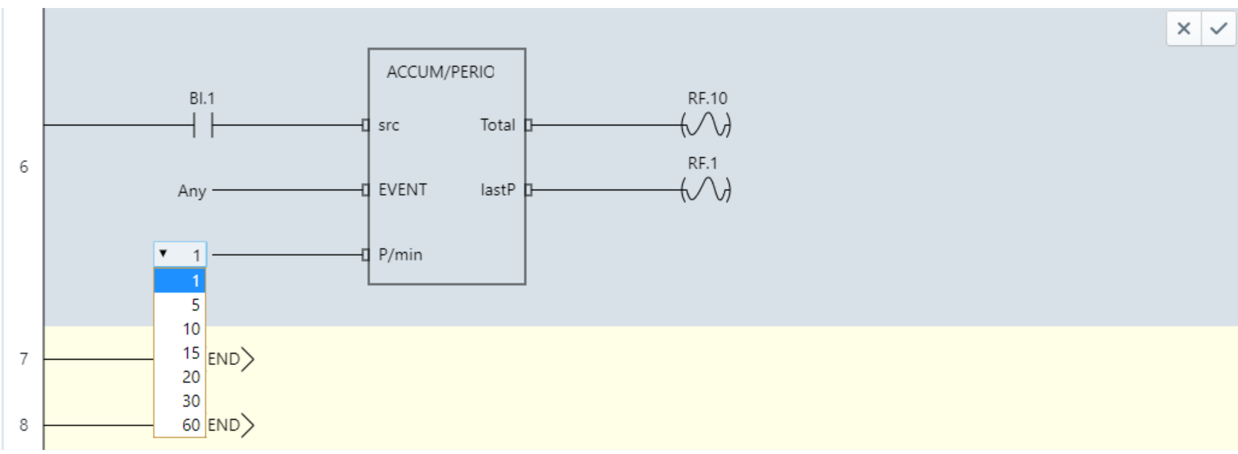


After we have the reading in **feet^3** it is easy using the PLC with the math instructions to convert it to:

- **Cubic metres.**

  Multiply cubic feet by **0.028317** to obtain **m^3**.

Also, if you want periodic measurements such a **ft^3/hour** instead / or in addition to the accumulated readings, an additional accumulator per period can also be added.



⊗ Pulse type sensor to measure energy consumption in KWh.

Energy meters that provide a pulse output per every KWh of energy can be connected to NX controllers to keep track and optionally trend the energy information.

One of such meters is the PM3210 meter from Schneider Electric:
https://www.se.com/ww/en/product/METSEPM3210/pm3210-power-meter---output-digital-and-pulse/

PM3200 series User manual
DOCA0006EN-06
08/2016

Pulse Output (PM3210)

Pulse output is used for active energy pulse output only. You can configure the pulse frequency (pulse/kWh) and the pulse width. The minimum pulse width is 50 ms. The pulse stop is equal or longer than the pulse width. The pulse output indicates the primary energy consumption considering transformer ratios. You should set a proper value of pulse frequency and pulse width to avoid pulse missing due to over-counting.

The output type of this meters is either a: **Dry-Contact** or **PNP** or **NPN** output, please refer for the previous sections on connecting this type of sensors.

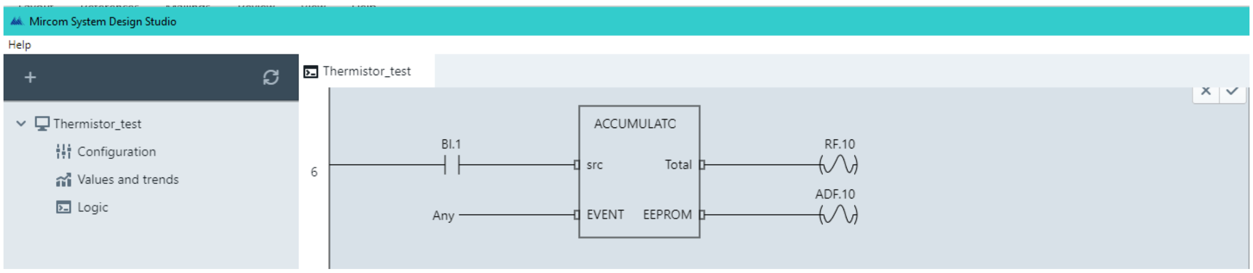
Usually, this type of meters provide a pulse output per every unit or fraction of unis consumed, therefore similarly as with water and gas meters, the pulsed output representing a unit of energy which is typically (KWh – Kilo Watt per hour), which can be fed directly to an accumulator.

The **UI-1** and **UI-2** each master or slave are high speed pulse inputs and can take a pulse frequency up to 250 pulses per second or 15,000 pulses per minute.

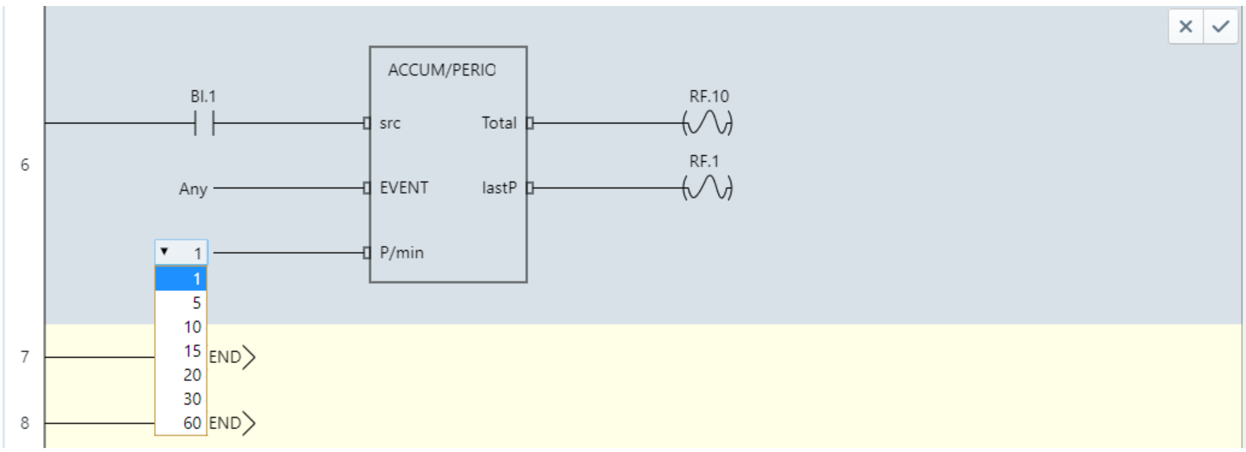
The **UI-3** thru **UI-8** can only take up to 10 pulses per second or 600 pulses per minute. If your signal is less than 10 pulses per second, it is recommended to use UI-3 thru UI-8 as they have an additional software filter that eliminates noise.

Once you have the pulse signal connected either as **NPN** or **PNP** types as described on the sections above, all you need to do is to set up a **TOTALIZER** instruction.

Below is the setup of the "Totalizer Instruction" using System Design Studio.



Also, if you want periodic measurements such as **KWh/hour** instead / or in addition to the accumulated readings, an additional accumulator per period can also be added.



Section 3:

ATTACHING DIGITAL SENSORS USING THE FIELDBUSES

⊗ Connecting the environmental corrosion monitor ECM.

One of the protocols supported by NX controllers is that one for the Environmental Corrosion Monitor which is a widely used solution in the oil and mining industry.

https://www.cosasco.com/product/ecm-environmental-condition-monitoring-system

Features

- **Digital and Analog Outputs**
- **Optional Datalogging**
- **High-Sensitivity Corrosion Rate Measurement**
- **Corrosion Rate, Relative Humidity, Monitors Temperature, and Differential Pressure**
- **Corrosion Rate of Copper and Silver Sensors Corresponds to ISA Standard S71.04-2 2013**

By loading any standard **OpenBAS-HV-NX10** controller with the dual core version of the firmware, this protocol is loaded into COM2 when set for the ASCII protocol.

It must be set to 9,600 baud no parity as well.

On the next page the jumper setting of the internal main PCB of the ECM is highlighted to use either an RS232 or a RS485 connection between the ECM and the NX10P.

Select the jumpers as needed for **RS232** or **RS485** operation. As described on the manual the RS232 is the standard and preferred connection method, on the next page the wiring diagram is shown.

Chapter 6
Data Logger Operation/RS 232 Communication

General

The data logger and RS 232 communication is accessed through a 9 pin D sub connector on the bottom of the ECM.

<u>THE RS 485 COMMUNICATION IS FOR SPECIALTY OPERATION. PLEASE CONTACT THE FACTORY FOR INFORMATION ON ON-LINE MULTI-DROP APPLICATIONS.</u>

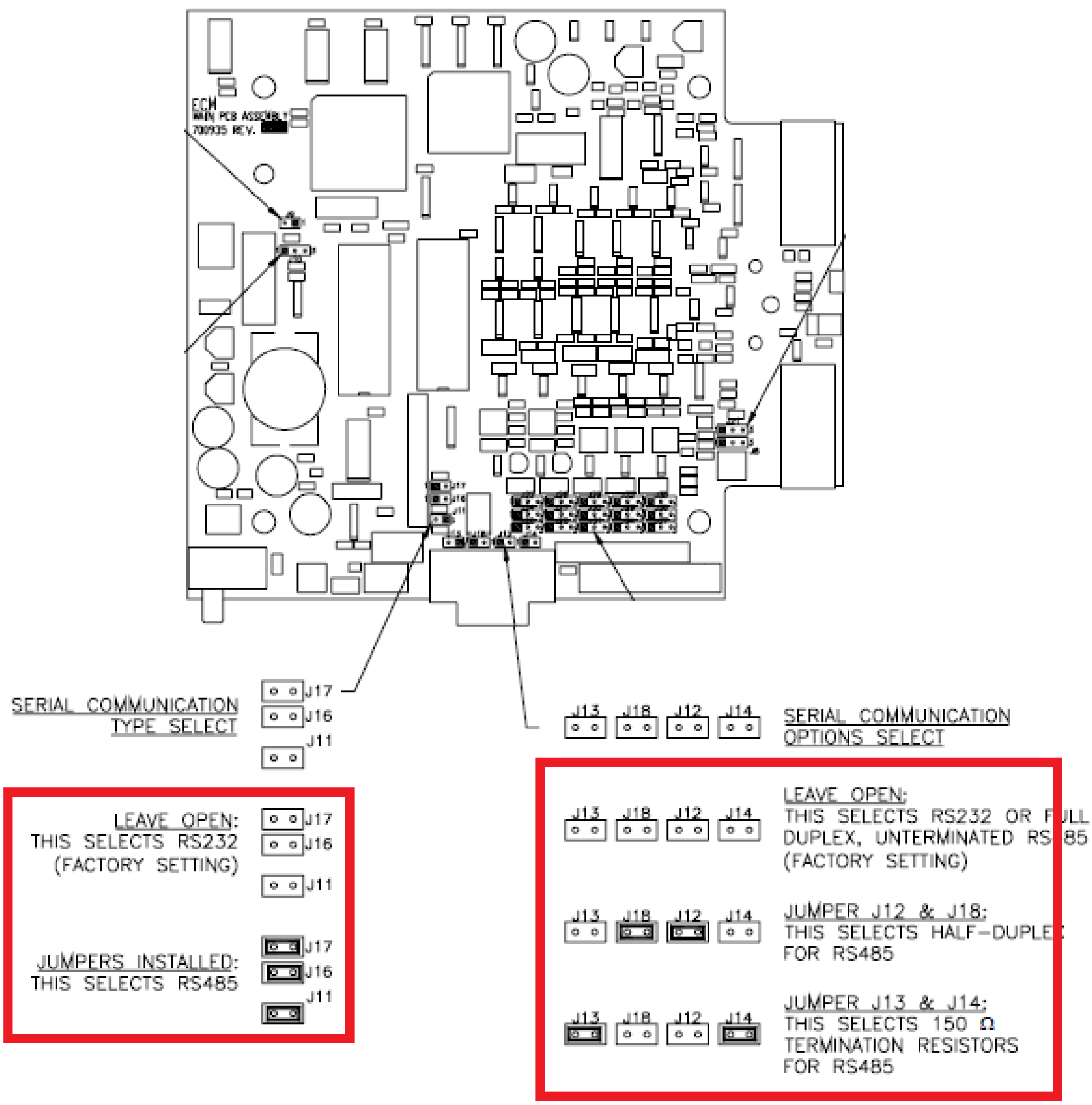
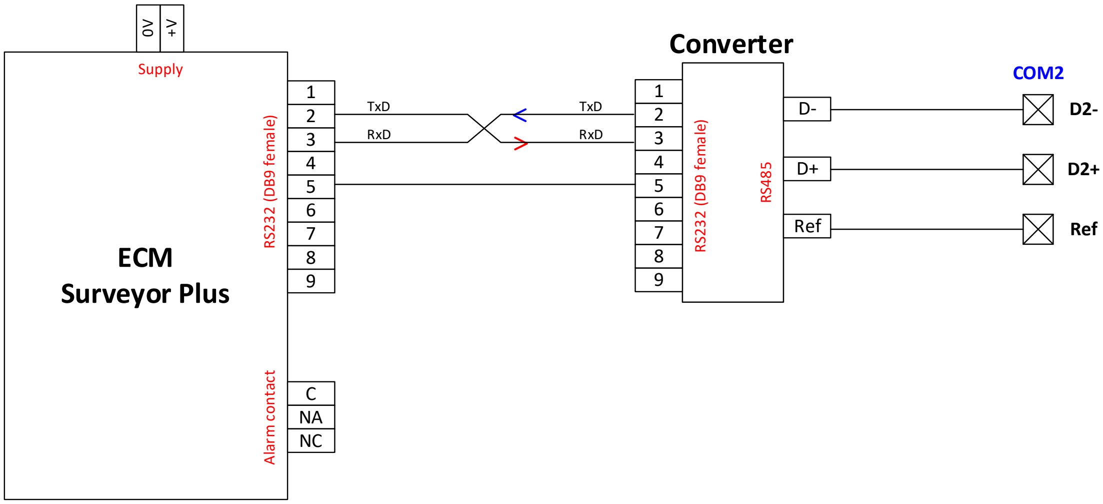
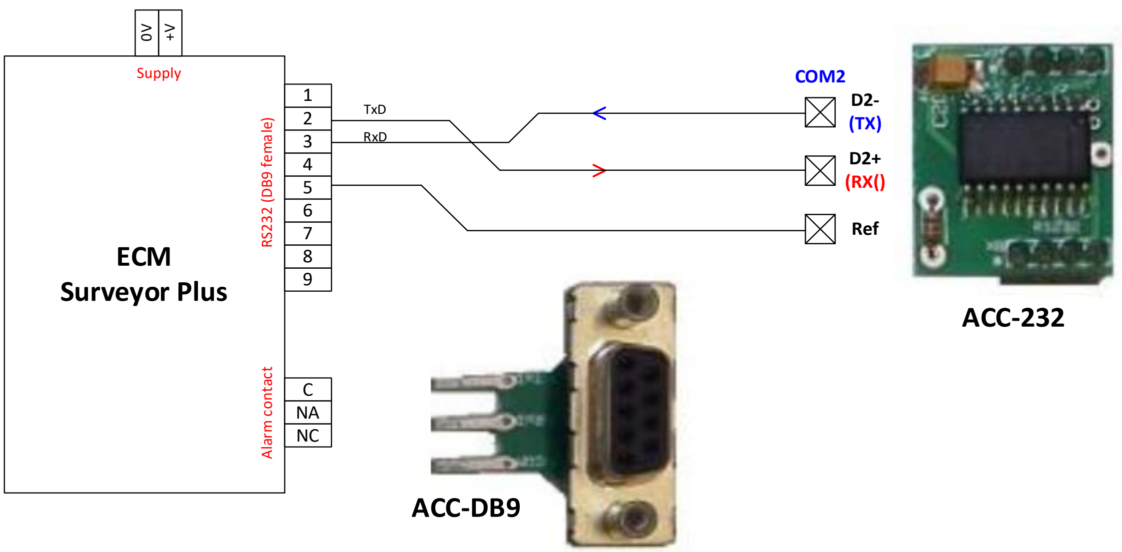


Diagram for connecting the **ECM** to the **NX** using an external **RS232** to **RS485** converter.



Also, by installing an accessory **RS232** board on the **NX** instead of the standard **RS485** driver, a direct connection can be done instead as shown below. Optionally also if you already have an **RS232 crossover cable** with **DB9-M** connectors on both ends, a **DB9 to 3** pin terminal connectors is also available.



Mapping table for ECM:

When using this protocol, the following points get automatically mapped into the remote points and regularly updated every minute for your use.

You can also use the NX's PLC to do math on them or set alarms based on ranges, or anything else you need.

Mnemonic	RES_FLT	Description
GL1	RES_FLT-11:	G LEVEL 1; G1, G2, G3, G4, GX
GL2	RES_FLT-12:	G LEVEL 2; G1, G2, G3, G4, GX
CR1	RES_FLT-13:	CORROSION RATE A° / PER MONTH Cu
CR2	RES_FLT-14:	CORROSION RATE A° / PER MONTH Ag
ML1	RES_FLT-15:	METAL LOSS A° Cu
ML2	RES_FLT-16:	METAL LOSS A° Ag
TEMP	RES_FLT-17:	TEMPERATURE °C x 10
RH	RES_FLT-18:	RELATIVE HUMIDITY % x 10
DPT	RES_FLT-19:	DIFFERENTIAL PRESSURE TRANSMITTER inWG

⊗ Connecting the NSHF/NSGP digital weight scale.

When you are in the need of precisely measure weight, rather than using an analog reading that will lose precision, it is better to attach the digital weight to the serial port on an NX and have the full resolution that a digital scale offers.

Most of the **NSHF/NSGP** digital weight scales from this link come with a built-in serial port that can be attached directly to an NX to get the weight reading.

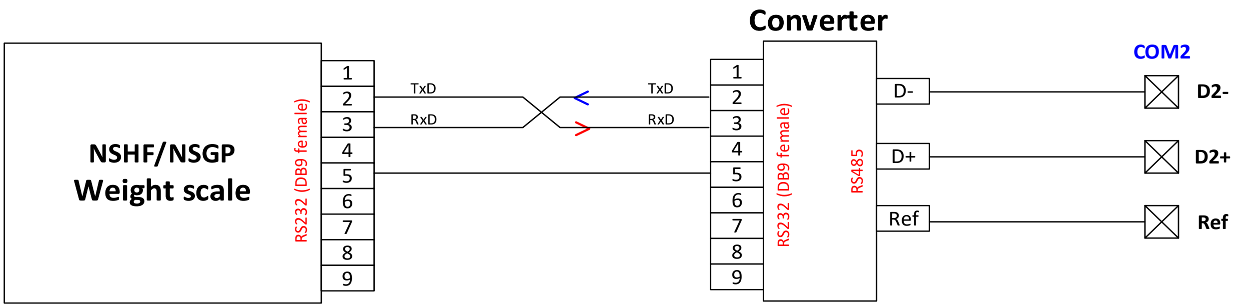
https://mx.nsglobaltrade.com/

Refer to the specific model for the terminals and settings needed, use a **9,600 baud, no parity** communication on **COM2**.

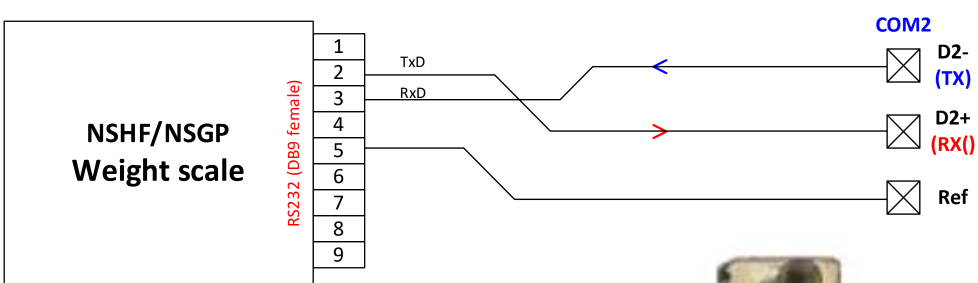
By loading any standard **OpenBAS-HV-NX10** controller with the dual core version of the firmware, this protocol is loaded into COM2 when set for as shown to the right:

On the next page typical wiring connections are shown.

Diagram for connecting a digital weight scale to the **NX** using an external **RS232** to **RS485** converter.



Also, by installing an accessory **RS232** board on the **NX** instead of the standard **RS485** driver, a direct connection can be done instead as shown below. Optionally also if you already have an **RS232 crossover cable** with **DB9-M** connectors on both ends, a **DB9 to 3** pin terminal connectors is also available.



ACC-232

ACC-DB9

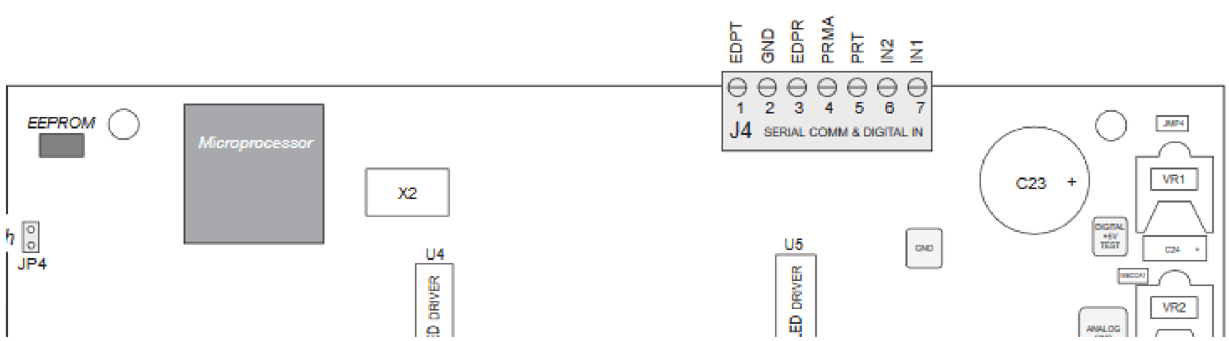
⊗ Connecting the IQ plus 355 digital weight scale.

When you are in the need of precisely measure weight, rather than using an analog reading that will lose precision, it is better to attach the digital weight to the serial port on an NX and have the full resolution that a digital scale offers.

The **IQ plus 355** digital weight scale from this link come with a built-in serial port that can be attached directly to an NX to get the weight reading.

https://www.cisco-eagle.com/uploads/Rice-Lake-Manuals/IQ-plus-355-Installation-Manual.pdf

As shown on the image below, the **J4** connector on the weight scale has the **EDP** port that when set to output the weight being measured at a **9,600 baud, no parity** can be attached to the **COM2** of an **NX** controller



These three wires need to be connected as shown on the next page:

Port	J4 Pin	Label	Function
EDP Port	1	EDPT	RS-232 TxD
	2	GND	RS-232 Ground / -20 mA OUT
	3	EDPR	RS-232 RxD
Printer Port	4	PRMA	+20 mA OUT
	5	PRT	RS-232 TxD
Digital Inputs	6	IN2	Digital Input 2
	7	IN1	Digital Input 1

Table 2-2. J4 Pin Assignments

By loading any standard **OpenBAS-HV-NX10** controller with the dual core version of the firmware, this protocol is loaded into COM2 when set for as shown to the right:

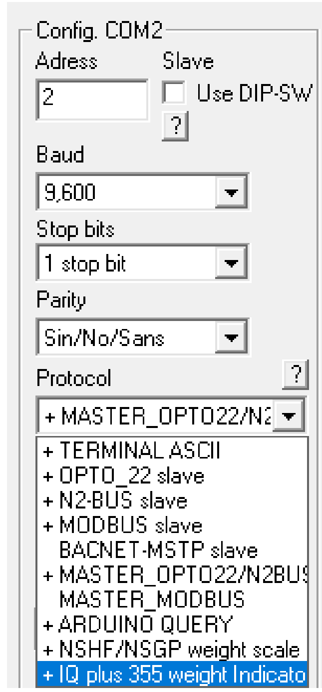
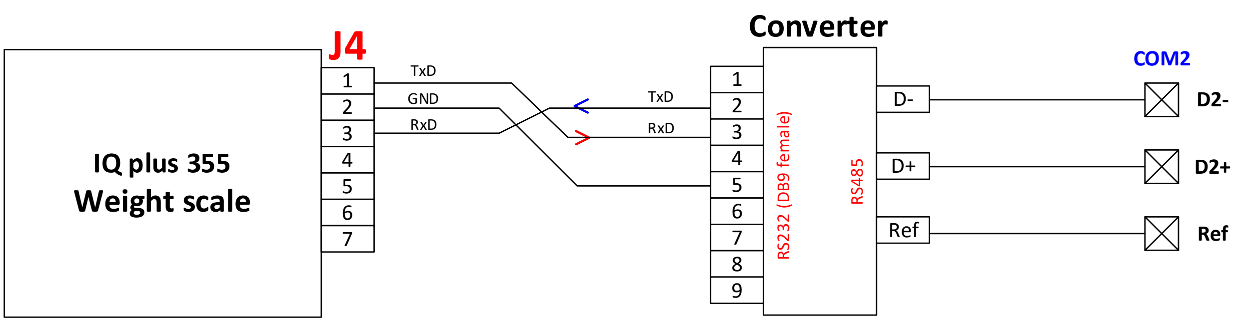
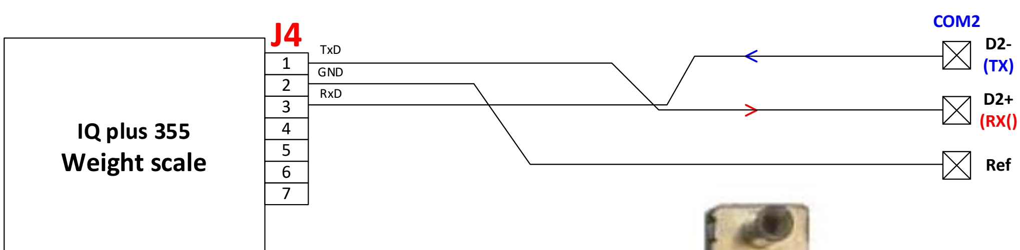


Diagram for connecting a digital weight scale to the **NX** using an external **RS232** to **RS485** converter.



Also, by installing an accessory **RS232** board on the **NX** instead of the standard **RS485** driver, a direct connection can be done instead as shown below. Optionally also if you already have an **RS232 crossover cable** with **DB9-M** connectors on both ends, a **DB9 to 3** pin terminal connectors is also available.



ACC-232

ACC-DB9

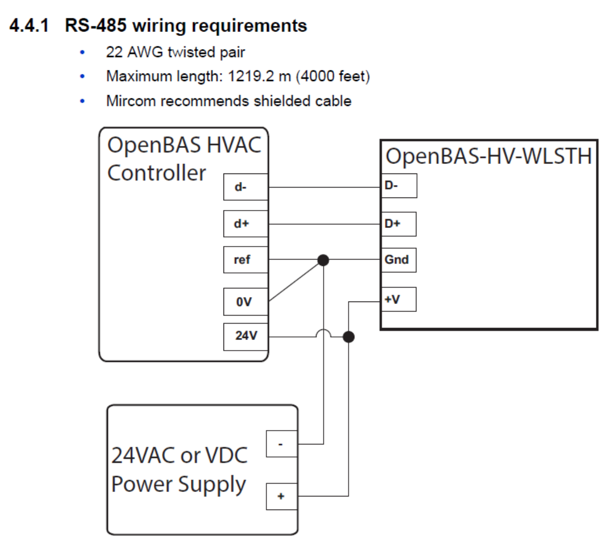
⊗ Connecting the OpenBAS-HV-WLSTH temperature and humidity transmitter using Optomux.

When there is the need to measure temperature and humidity over an **RS485** bus, as many **OpenBAS-HV-WLSTH** transmitters can be attached to the bus as needed. The fieldbuses on an NX controller can have up to 32 controllers can be attached on a typical bus without needing bus extenders using this connection method.

https://mircom.com/product-listing/smart-buildings/building-automation-systems/hvac/wireless-transmitter-temperature-humidity/

The **OpenBAS-HV-WLSTH** comes from the factory set to wireless mode, to change it to **RS485** using Optomux follow the instructions on the user guide described on the next page.

For wiring refer to Mircom document **LT-6131** on page 16, The mapping point for Optomux is also shown below.



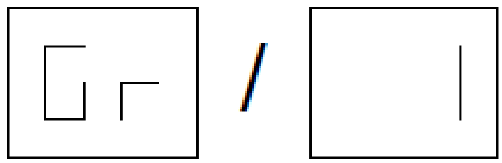
Mapping table

Opto-22/N2-Open	Variable
ADF-1	Temperature °C
ADF-2	Humidity %HR
ADF-3	Modo, 0=OFF, 1=Auto, 2=Manual
ADF-4	Program type
ADF-5	Fan speed
ADF-6	Temperature setpoint
ADF-7	Unoccupied setpoint
ADF-8	Humidity setpoint
ADF-9	Timer T1
ADF-10	Proportional band
ADF-11	Temperature calibration +/-°C
ADF-12	Humidity calibration +/-%HR

Select the wireless group or wired protocol

For wireless operation a group must be selected between values of 1 to 10, each wireless group can have up to 199 addresses.

If instead a value between 11 to 15 is selected, the wired interface will be used instead, and the address will represent the address of the RS485 interface on the bus.



Group/Prortocol	Protocol	Address range
1 to 10.	Wireless group	1 to 199.
11.	ASCII terminal protocol	No addressing possible on this protocol.
12.	Optomux protocol	1 to 199.
13.	N2-Open protocol	1 to 199.
14.	Modbus RTU protocol	1 to 199.
15.	BACnet/MST protocol	5 to 127.

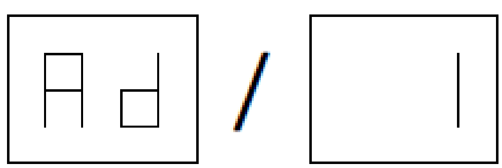
Select the desired group or protocol using the INC and DEC buttons.

To jump to the next parameter press the ON/OFF button. If no button activity is detected within 20 seconds the thermostat will revert automatically to normal operation mode.

Wired or Wireless address

The address for either the wired or Wireless interface depending on the setup of the previous group / protocol setting can be set on this screen,

.



Select the desired address using the INC and DEC buttons.

To jump to the next parameter press the ON/OFF button. If no button activity is detected within 20 seconds the thermostat will revert automatically to normal operation mode.

⊗ Connecting the OpenBAS-HV-WLSTH temperature and humidity transmitter using Modbus.

When there is the need to measure temperature and humidity over an **RS485** bus, as many **OpenBAS-HV-WLSTH** transmitters can be attached to the bus as needed. The fieldbuses on an NX controller can have up to 32 controllers can be attached on a typical bus without needing bus extenders using this connection method.

https://mircom.com/product-listing/smart-buildings/building-automation-systems/hvac/wireless-transmitter-temperature-humidity/

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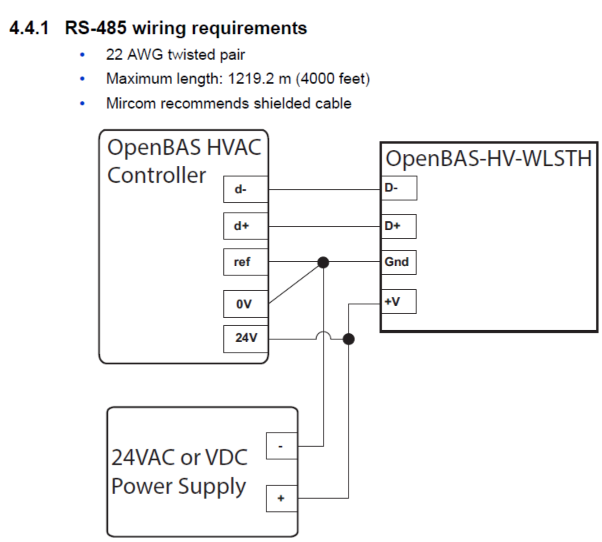

Modbus	Notes
HR-1	Temp x10
HR-2	Humidity X10
HR-3	
HR-4	
HR-5	
HR-6	
HR-7	
HR-8	
HR-9	
HR-10	
HR-11	
HR-12	

Select the wireless group or wired protocol

For wireless operation a group must be selected between values of 1 to 10, each wireless group can have up to 199 addresses.

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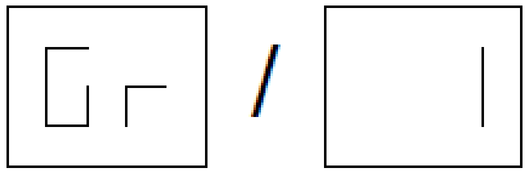

Group/Prortocol	Protocol	Address range
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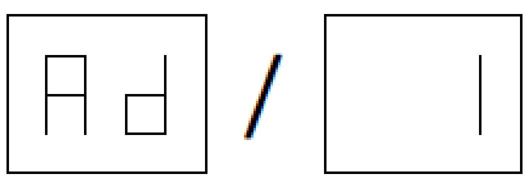


Select the desired address using the INC and DEC buttons.

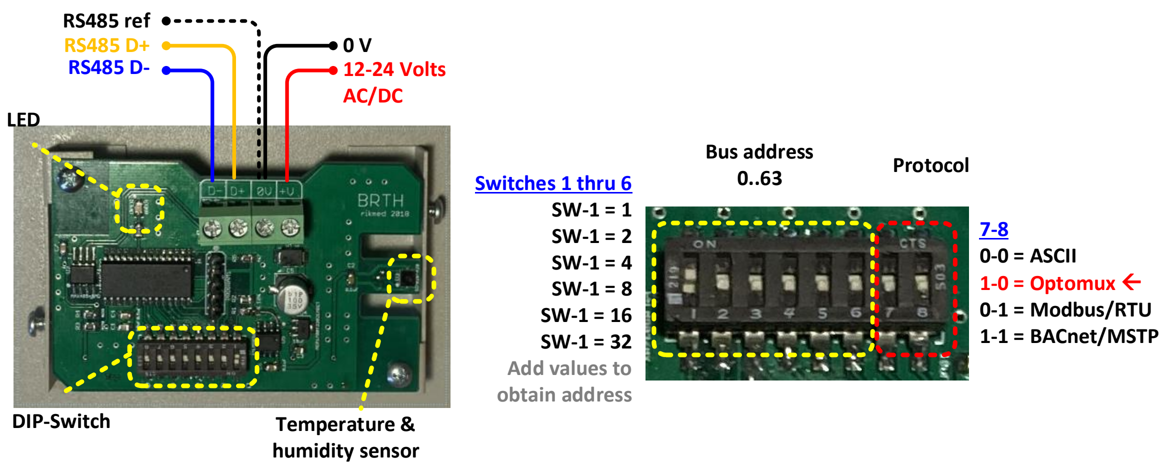
To jump to the next parameter press the ON/OFF button. If no button activity is detected within 20 seconds the thermostat will revert automatically to normal operation mode.

⊗ Connecting the BRTH temperature and humidity transmitter using Optomux.

When there is the need to measure temperature and humidity over an **RS485** bus, as many **OpenBAS-HV-WLSTH** transmitters can be attached to the bus as needed. The fieldbuses on an NX controller can have up to 32 controllers can be attached on a typical bus without needing bus extenders using this connection method.

http://www.rikmed.com/OpenBAS/Spanish/BRTH_SP.pdf

Wiring the senor to the RS485 bus is straightforward, Also the protocol and address selection is simply done by setting a DIP-SW as shown below. Baud is set to **9,600** no stop bit.



The following points can be mapped in Optomux:

Points for remote communications RMT-1.50 (OPTOMUX/N2-BUS)

#	Address	Type/Nr.	Status	Curr. value	Name
1	3	ADF-001	OK	24.13	Temp GC
2	3	ADF-002	OK	75.43	Temp_GF
3	3	ADF-003	OK	37.14	Rel. Humidity
4	3	ADF-004	OK	0.00	Cal._Temp.
5	3	ADF-005	OK	0.00	Cal._Rel.Hum.

⊗ Connecting the BRTH temperature and humidity transmitter using Modbus.

When there is the need to measure temperature and humidity over an **RS485** bus, as many **OpenBAS-HV-WLSTH** transmitters can be attached to the bus as needed. The fieldbuses on an NX controller can have up to 32 controllers can be attached on a typical bus without needing bus extenders using this connection method.

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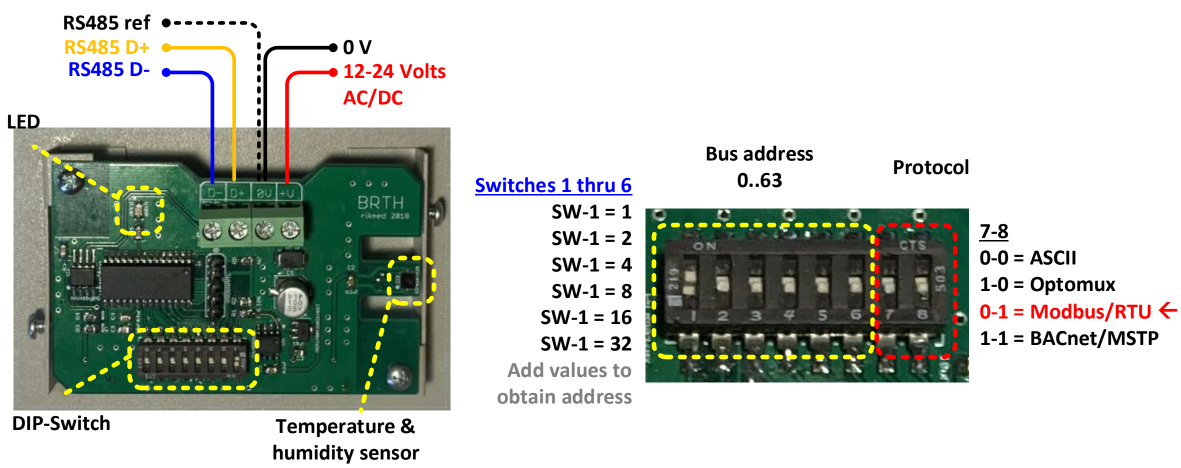
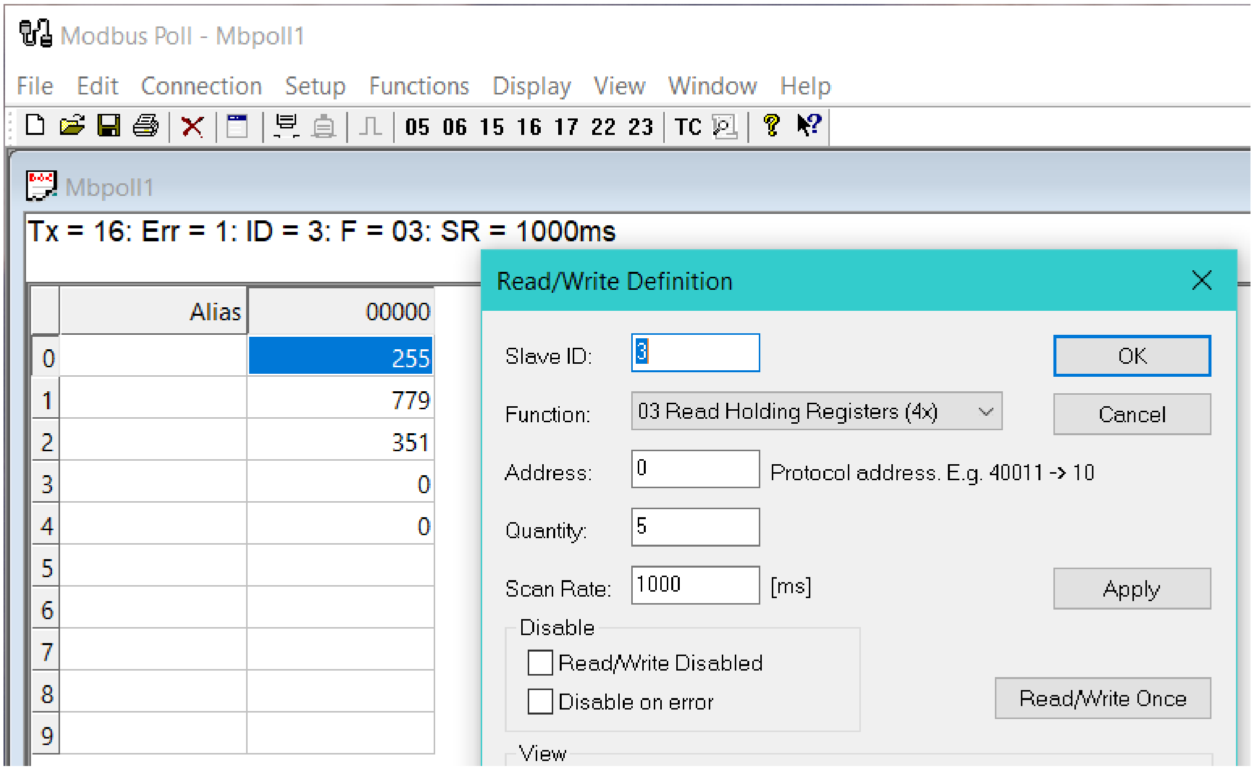


On the next page you can review the Modbus-RTU mapping:

The following points can be mapped in Modbus-RTU:



- Holding register 1 Temperature °C x10 Read only.
- Holding register 2 Humidity %RH x10 Read only.
- Holding register 3 Temperature °F x10 Read only.
- Holding register 4 Calibrate temperature °C X10 Read / Write.
- Holding register 5 Calibrate humidity x10 Read / Write.

⊗ Connecting Yaskawa variable frequency drive VFD.

Most VFD´s that have a modbus interface can be attached to the NX con COM1 set as master. With that all the points that are accessible over the modbus interface can be read and written easily.

On this example we will show you how to connect and control a V1000 VFD from Yaskawa.

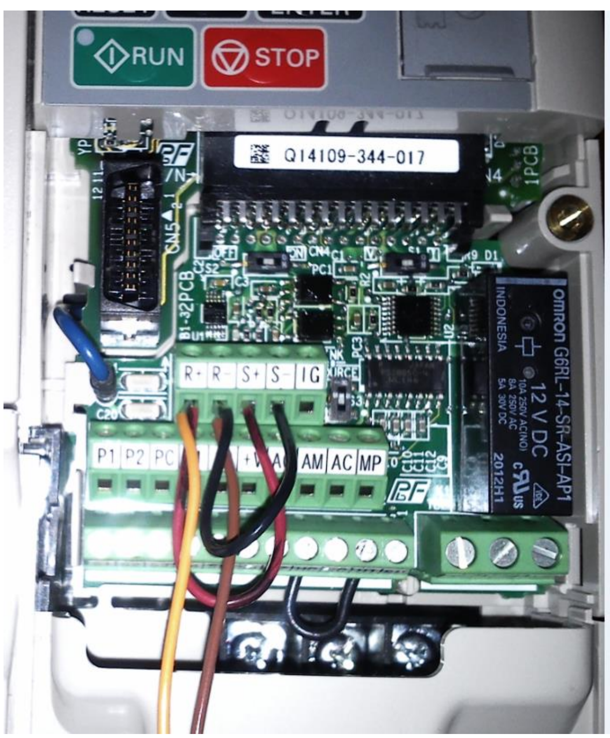
https://www.yaskawa.com/products/drives/industrial-ac-drives/microdrives/v1000-drive

◆ **H5: MEMOBUS/Modbus Serial Communication**

Through the drives built in RS-422/485 port (terminals R+, R-, S+, S-), serial communication can be performed with programmable logic controllers (PLCs) or similar devices using the MEMOBUS/Modbus protocol.

The H5-□□ parameters are used to set up the drive for MEMOBUS/Modbus Communications. *Refer to MEMOBUS/Modbus Serial Communication on page 439* for detailed descriptions of the H5-□□ parameters.

210 **YASKAWA ELECTRIC** SIEP C710606 18F YASKAWA AC Drive – V1000 Technical Manual



As shown on the image to the right, the modbus cards that all **V1001** VFD drives have, have five terminals labeled:

R+ and S+ must be shorted together = **D+**

R- and S- must be shorted together = **D-**

G is the reference terminal = **REF**

These should be connected on the **RS485** bus.

As many as 32 VFD's can be connected to the RS485 bus and controlled by an NX.

All the points mapped as remote points.

Below is a list of the VFD settings for controlling them via the RS485 bus as taken from Yaskawa's user guide:

Settings of the V-1000 for being driven by modbus:

```
b1-01 FreqRef = 2              // Modbus, 0=OP, 1=Trm, 3=OptPCB, 4=PulseInp
b1-02 RunComand = 2            // Modbus, 0=OP, 1=Trm, 3=OptPCB
b1-03 StopMeth = 1             // Coast to stop
b1-04 reverse = 1              // reverse disabled
b1-15 Freqref2 = 2             // Modbus, 0=OP, 1=Trm, 3=OptPCB, 4=PulseInp
b1-16 RunComand2 = 2           // Modbus, 0=OP, 1=Trm, 3=OptPCB, 4=PulseInp
H5-01 Address = 0x00..0x20     // Default 31 = 0x1F (Rango válido 1..32)
H5-02 Speed = 3                // 9,600 baud
H5-03 Parity = 0               // No parity
H5-04 StopMthd = 1             // Coast to stop
H5-05 CommFaultEn = 1 (0)      // Enable fault detection = 1, disabled = 0
H5-06 WaitTx = 5               // ms wait for transmit
H5-07 RTS = 1                  // Set a 1 para RS485
H5-09 CTS = 10                 // Default seconds to alarm no COMM modbus RTU
H5-10 unitVoltageMon = 0       // .1 (X10)
H5-11 CommEnterFnct = 1        // Default
H5-12 RunComand = 0            // Bit.0 reg 0001 start FWD, Bit.1 reg 0001 start REV
```

This is the list of some of the modbus registers used for this application.

modbus registers read & write:

```
Holding_Register[ 2 ]          // 0/1 to start and stop the motor
Holding_Register[ 3 ]          // Frequency reference in Hz x100
                               // Units depend on setting of: o1-03 x100-Hz (default = 0)
                               // x100-% = 1, x1 RPM/min = 2)
```

modbus registers read only:

```
Holding_Register[ 33 ]         // Status: bit0=run, bit1=reverse, bit2=ready, bit3=fault...
Holding_Register[ 34 ]         // fault code: bit0=overCurr, bit1=OverVlt, 2=Overload,
                               // bit3=Overheat...
Holding_Register[ 36 ]         // Frequency reference (Units are determined by parameter o1-03)
Holding_Register[ 37 ]         // Output frequency (Units are determined by parameter o1-03)
Holding_Register[ 38 ]         // Output voltage reference x10 (units determined by H5-10)
Holding_Register[ 39 ]         // Output current x100 (0.01 A units for drives set to 11 kW in
                               // Heavy or normal Duty and 0.1 A units for drives set to >= 15 kW
Holding_Register[ 40 ]         // Output power
Holding_Register[ 41 ]         // Output Torque reference (OLV only)
```

On next page you can see the typical labels of a system to drive the VFD:

NX5 labels:

```
====================================================
Controller name [Yaskawa]
Address: [USB]
=====================================================
-----------------------------------------------------
ADF eeprom
-----------------------------------------------------
ADF -1 [Frequency VFDx100] = 400.000000
-----------------------------------------------------
ADI eeprom
-----------------------------------------------------
ADI -1 [Mask drive run FWD] = 1 (hex=0x0001)
ADI -2 [Mask_drive_run_REV] = 2 (hex=0x0002)
ADI -3 [Mask_drive_ready] = 4 (hex=0x0004)
ADI -4 [Mask_fault] = 8 (hex=0x0008)
-----------------------------------------------------
RES_BIT in RAM
-----------------------------------------------------
RES_BIT-40 [Run FWD]
RES_BIT-41 [Run_REV]
RES_BIT-42 [Drive ready]
RES_BIT-43 [Fault active]
-----------------------------------------------------
RES_FLT in RAM
-----------------------------------------------------
RES_FLT-1 [Frequency /Hz]
RES_FLT-2 [Motor voltage]
RES_FLT-3 [Current_Amps]
RES_FLT-4 [Energy_Watts]
RES_FLT-5 [Status bits]
-----------------------------------------------------
Remote points
-----------------------------------------------------
REMT_PT-1 [Start/Stop RD]
REMT_PT-2 [Start/Stop_WR]
REMT_PT-3 [Freq Ref WR x100]
REMT_PT-4 [Freq_Ref_RD_x100]
REMT_PT-5 [Status bits]
REMT_PT-6 [Fault codes]
REMT_PT-7 [Freq_ref_x100]
REMT_PT-8 [Output_F.Ref_x100]
REMT_PT-9 [Output Voltage x10]
REMT_PT-10 [Output_Curr_x10]
REMT_PT-11 [Output_Power /10]
REMT_PT-12 [Output_Torque (OLV]
```

⊗ Connecting Honeywell gas and explosivity sensor using modbus.

The oil and mining industries are always high risk, and therefore the use of gas sensors for explosivity levels or detection of harmful gases is mandatory.

Most sensors besides having the industry standard 4-20 mA analog interface, also use the Hart protocol, and for SCADA systems they all use modbus.

As the COM1 of all NX controllers can be set to modbus master, it is possible to attach the readings of these sensors to be directly read by the NX controller to avoid losing accuracy or resolution.

The link below provides access to such a gas sensor:

https://sps.honeywell.com/us/en/products/safety/gas-and-flame-detection/industrial-fixed/xnx-universal-transmitter

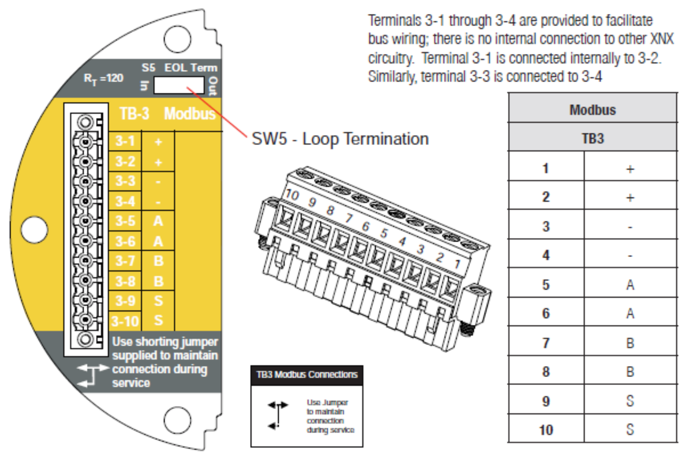


Figure 60. XNX Modbus Option Board Terminal Block / Jumper Switch

The connection of this sensor uses typical industrial modbus labeling A & B for the terminals in where:

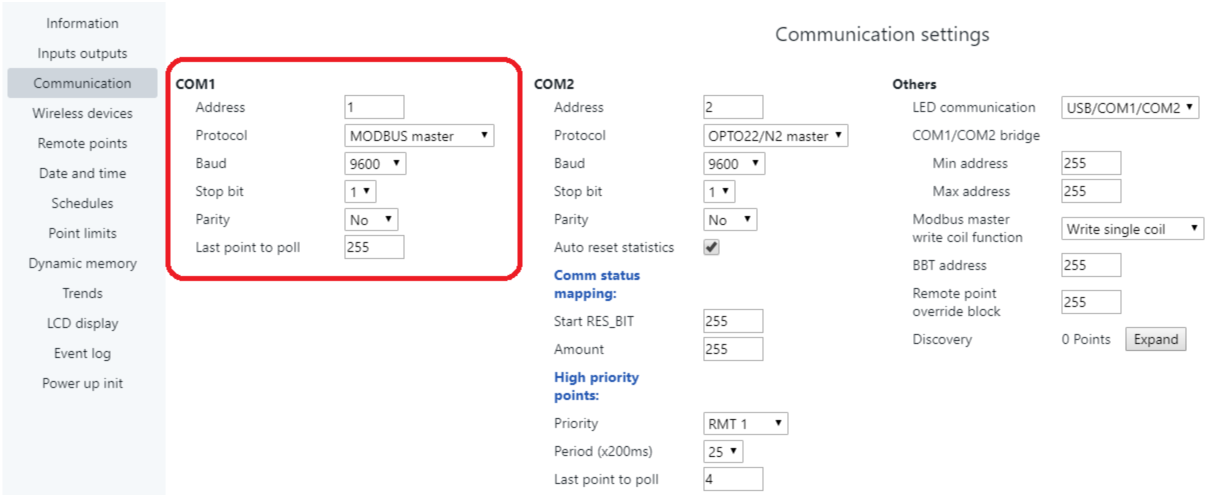
Most manufacturers are all incorrect (but consistent), and their practice is in widespread use. The issue also exists in programmable logic controller applications. Care must be taken when using A/B naming. Alternate nomenclature is often used to avoid confusion surrounding the A/B naming:

- TX+/RX+ or **D+** as alternative for **B ,** (high for mark i.e. idle)
- TX−/RX− or **D−** as alternative for **A**, (low for mark i.e., idle)

In addition to the A and B connections, an optional, third connection may be present (the TIA standard requires the presence of a common return path between all circuit grounds along the balanced line for proper operation) called **SC**, **G** or **reference**.

Most systems are set up at 9,600 baud no parity, but some use either odd or even parity, so be sure the sensor setting with that of COM1.

On the next page a typical setting for COM1 using modbus is depicted.



As mostly these sensors are set up and commissioned by certified technicians, you must ask them to provide you with the specific mapping of the modbus registers, and whether they are mapped as either input registers for read only or holding registers if any parameter is intended to also be able to be written.

Also, any multiplication factor and should be provided by the installer for you to map on the NX remote points.

This is a typical list of gases that can be measured by industrial gas sensors:

- Table 1 lists the gases according to the reaction they produce at a given detector.
- An eight star (8*) gas produces the highest output, while a one star (1*) gas produces the lowest output. (These are not applicable at ppm levels.)

Gas	Star Rating	Gas	Star Rating
Acetone	4*	Hexane	3*
Ammonia	7*	Hydrogen	6*
Benzene	3*	Methane	6*
Butanone	3*	Methanol	5*
Butane	4*	Nonane	2*
Butyl acetate	1*	MIBK	3*
Butyl acrylate	1*	Octane	3*
Cyclohexane	3*	Pentane	4*
Cyclohexanone	1*	Propane	5*
Diethyl ether	4*	Propan-2-ol	4*
Ethane	6*	Styrene	2*
Ethanol	5*	Tetra hydrafuran	4*
Ethyl acetate	3*	Toluene	3*
Ethylene	5*	Triethylamine	3*
Heptane	3*	Xylene	2*

Table 1. Star Rating of Gases

⊗ Connecting an Arduino board to send to the NX any kind of digital information.

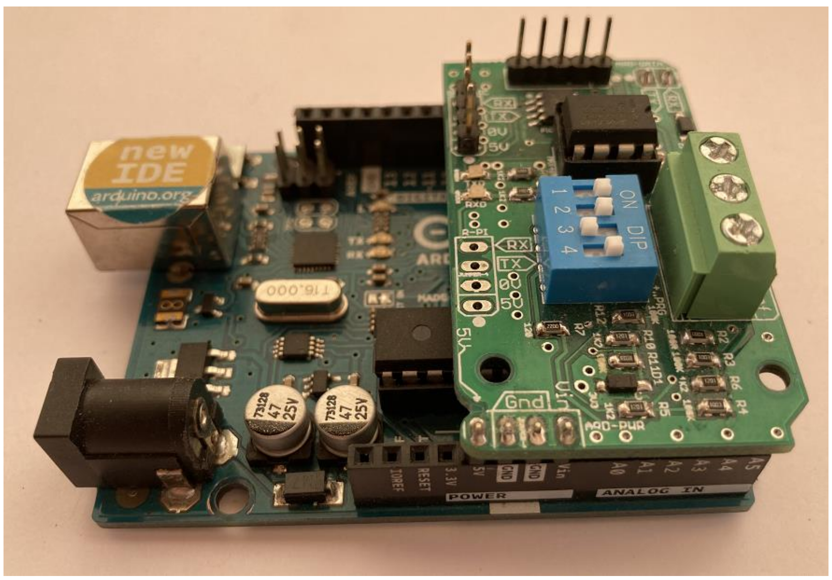
Arduino boards are nowadays used by many engineers doing BAS installations; however, the limited input range and resolution of Arduino's boards limit their applications.

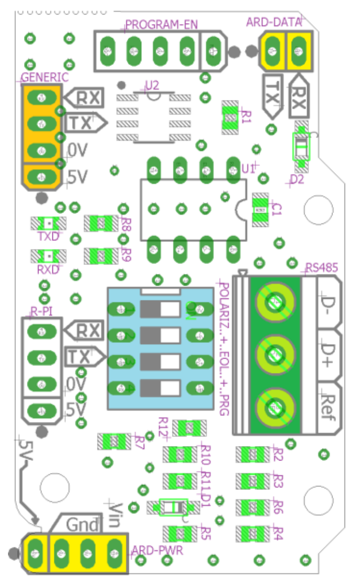
https://www.arduino.cc/

When you want to use an **NX** as the **analog front end** and read the **universal inputs** from an Arduino and optionally control the NX's outputs you have two options.

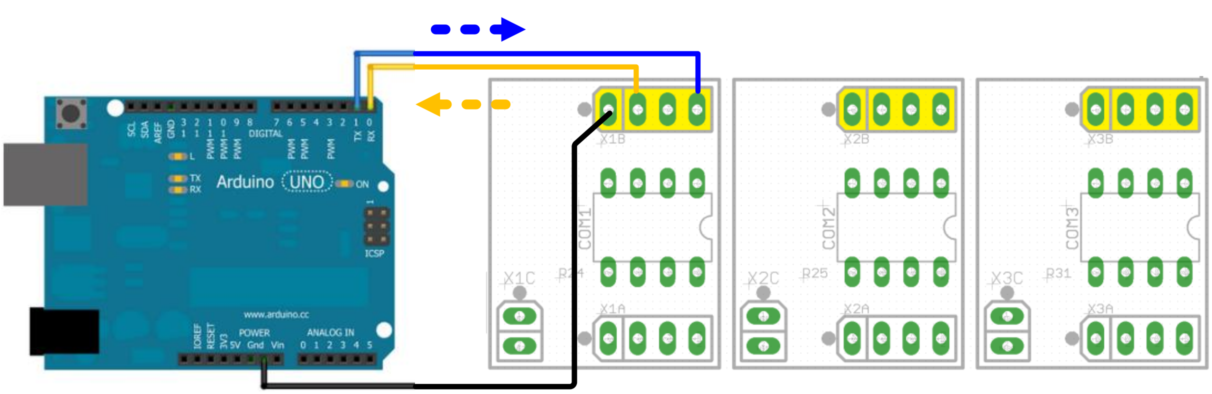
- One is to use TTL signals of the UART that is what the Arduino boards use. That however limits you to no more than 30 cm. between the Arduino board and the NX, also only one NX can be attached per Arduino.
- The other one is to add an RS485 driver to the Arduino to extend the range up to 1,200 metres and also to network up to 32 NX controllers on the bus.

On the image below you can see how a typical RS485 network card can be plugged on top of an Arduino board, and the details of the network card terminals on the right.



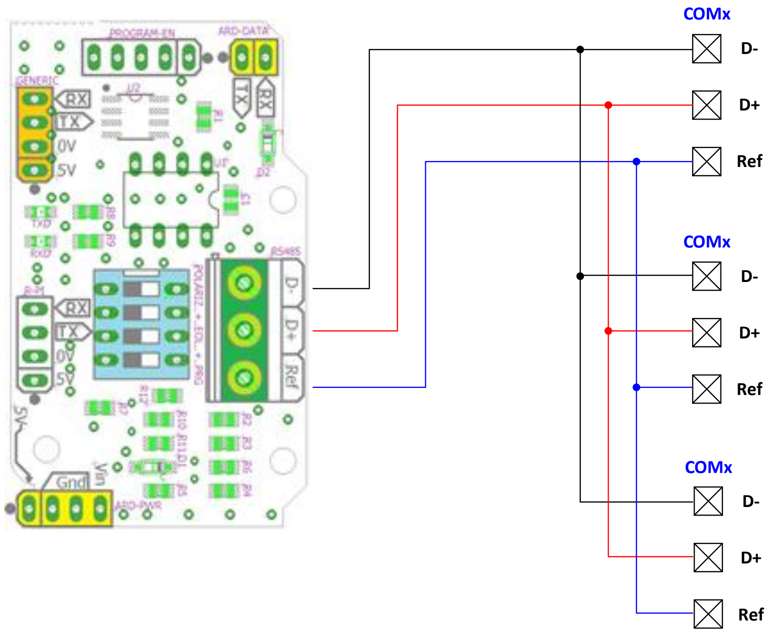


The wiring diagram for using TTL is as follows, you can connect any of COM1, COM2 or COM3 of the NX to the UART of the Arduino, make sure to connect the TX → RX in both cases (crossover) and the GND of both systems together:



When using networked controllers connected to an Arduino use typical RS485 wiring guidelines, such as:

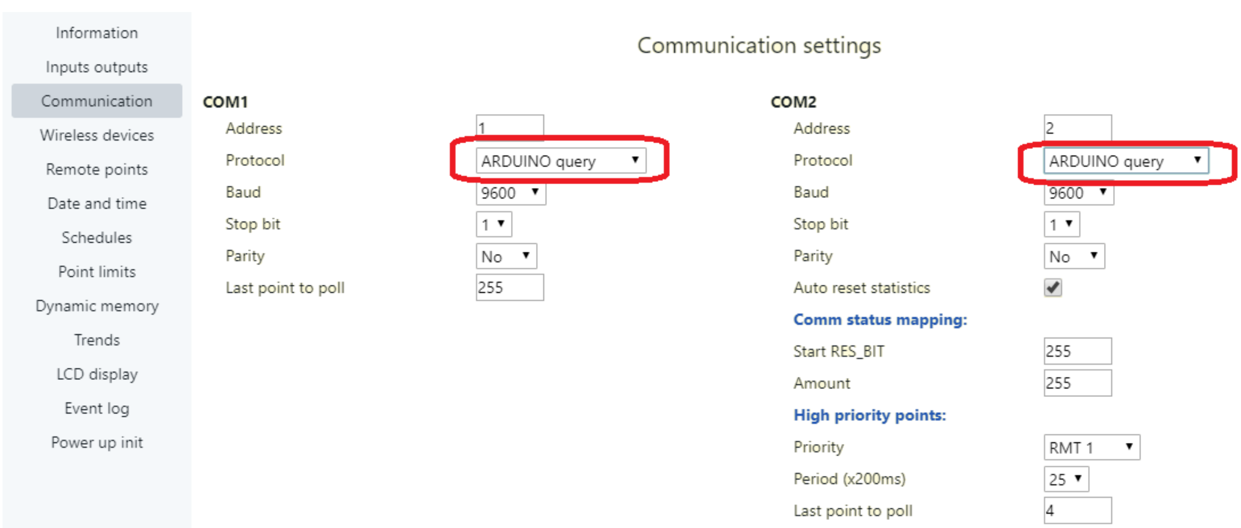
- Use daisy chain bus style, no T´s allowed.
- Properly terminate and bias the bus.
- Use appropriate three wire bus to connect the reference terminal.



For using the SQL Arduino protocol, select the following options from the communication setting on the COM port of your choosing.

Also make sure that the baud rate, and stop bits match on all controllers.

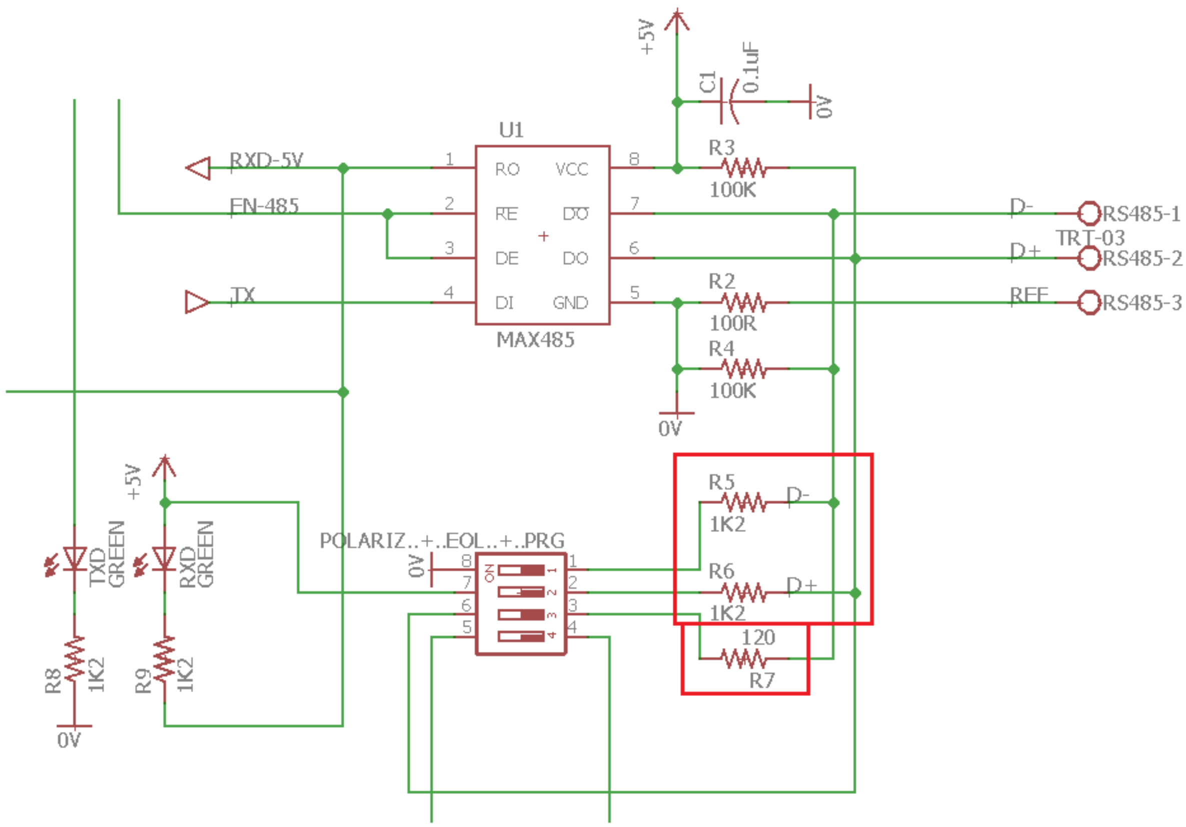
If using networked devices, it is important to assign a unique address to each NX device on the bus to avoid collisions due to a repeated address.



Refer to the **Arduino SQL language reference** for creating your sketches by referring to this user guide: http://www.rikmed.com/OpenBAS/Programming/NX%20modbus%20on%20Raspberry%20PI%20with%20Python.pdf

The **DIP-SW** on the Network board has the following usage:

- Pins **1** and **2** enable the bus polarization (BIAS) **1.2K Ω** resistors when set to **ON**.
- Pin **3** enables the **120Ω** end of line (EOL) resistor when set to **ON**.
- Pin **4** is for Arduino programming, set to **OFF** for loading your sketch using the USB connector, set to **ON** for normal operation.



⊗ Connecting a Raspberry-PI board to send to the NX any kind of digital information.

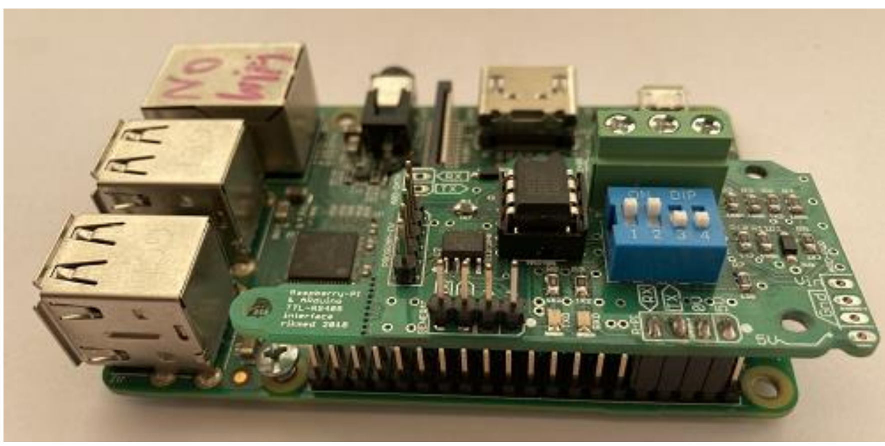
Raspberry-PI board boards are nowadays used by many engineers doing BAS installations; however, the limited input range and resolution of Raspberry-PI boards limit their applications.

https://www.raspberrypi.org/

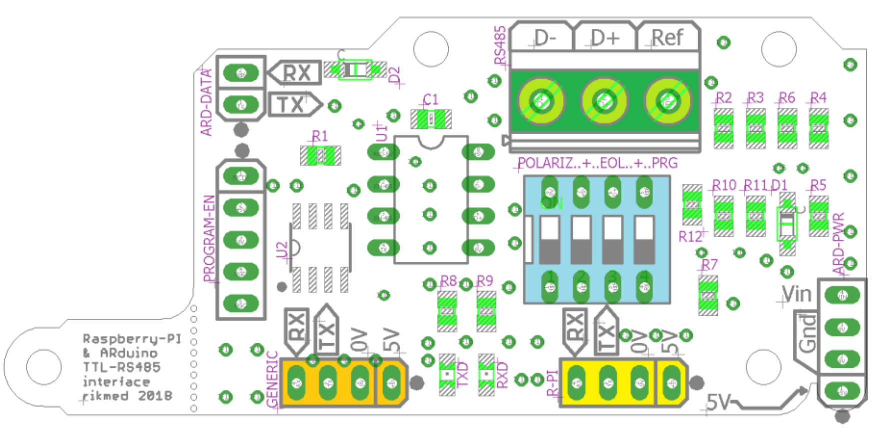
When you want to use an **NX** as the **analog front end** and read the **universal inputs** from a Raspberry-PI and optionally control the NX's outputs you have three options.

- One is to use TTL signals of the UART that is what the Raspberry-PI boards use. That however limits you to no more than 30 cm. between the Raspberry-PI board and the NX, also only one NX can be attached per Raspberry-PI.
- The other one is to add an RS485 driver to the Raspberry-PI to extend the range up to 1,200 metres and also to network up to 32 NX controllers on the bus.
- The last is to use an ETH3 with Ethernet and access the NX over IP using Raspberry-PI's Ethernet or Wi-Fi interfaces,
- this last option is not covered here.

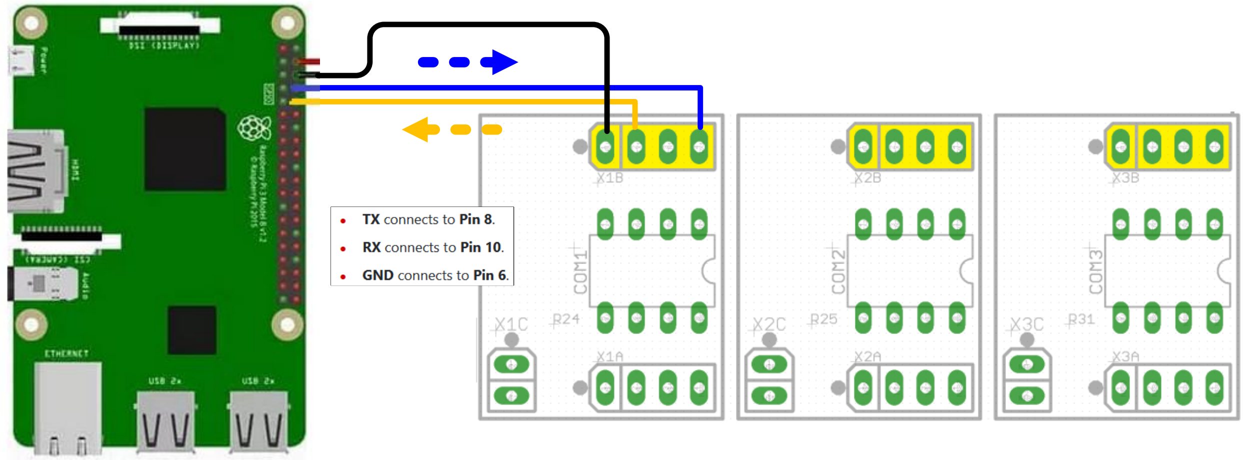
On the image below you can see how a typical RS485 network card can be plugged on a Raspberry-PI.



Here are the details of the network card when used for the Raspberry-PI.



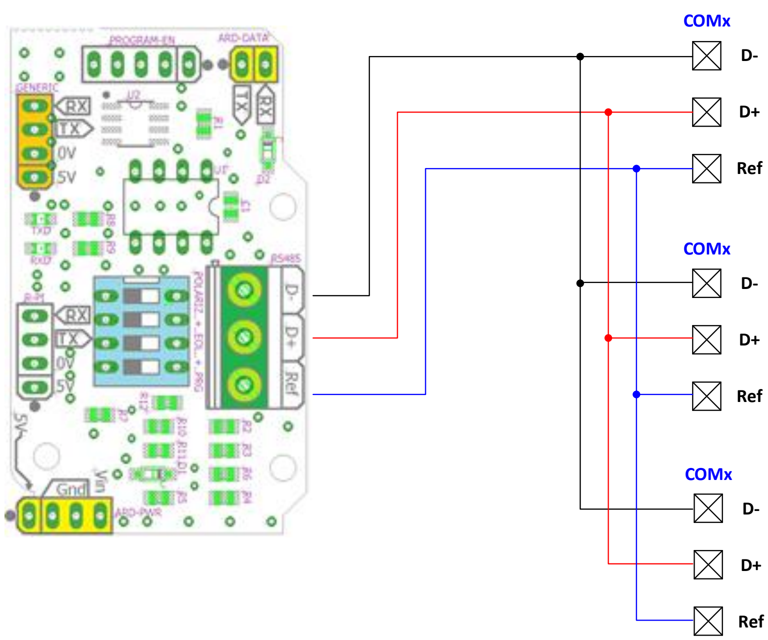
The wiring diagram for using TTL is as follows, you can connect any of COM1, COM2 or COM3 of the NX to the UART of the Raspbery-PI, make sure to connect the TX → RX in both cases (crossover) and the GND of both systems together:



NOTE: The Raspberry-PI uses 3.3V logic, do not connect the RX or TX pins to any 5V terminal. Doing so will damage your board, The NX uses 3.3V logic but is 5V tolerant and does not get damaged by 5V signals.

When using networked controllers connected to a Raspberry-PI use typical RS485 wiring guidelines, such as:

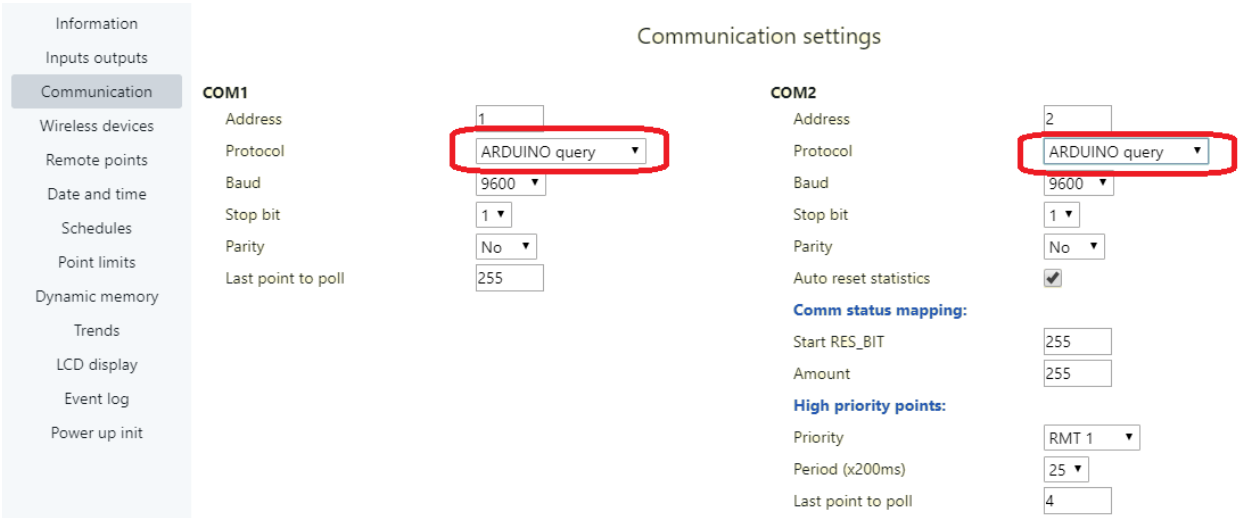
- Use daisy chain bus style, no T´s allowed.
- Properly terminate and bias the bus.
- Use appropriate three wire bus to connect the reference terminal.



For using the SQL Arduino protocol, select the following options from the communication setting on the COM port of your choosing.

Also make sure that the baud rate, and stop bits match on all controllers.

If using networked devices, it is important to assign a unique address to each NX device on the bus to avoid collisions due to a repeated address.



Refer to the **Raspberry-PI SQL language reference** when writing your programs:
http://www.rikmed.com/OpenBAS/Programming/NX%20modbus%20on%20Raspberry%20PI%20with%20Python.pdf

The **DIP-SW** on the Network board has the following usage:

- Pins **1** and **2** enable the bus polarization (BIAS) **1.2K Ω** resistors when set to **ON**.
- Pin **3** enables the **120Ω** end of line (EOL) resistor when set to **ON**.
- Pin **4** is not used for Raspberry-PI operation.