Application Note – Temperature Monitoring

with a YDOC Data Logger

1 Introduction

A YDOC data logger is provisioned and can be extended with various inputs to connect temperature sensors.

- **Smart temperature sensors**: The SDI-12, RS-232, or RS-485 input can be used to connect (a) smart temperature sensor(s) for hassle-free temperature monitoring. Please consult the documentation of the various brands for more info.

- **Digital thermometers**: An ML-OI-AX-DS18B20 option board can be used to connect up to four DS18B20 factory-calibrated digital thermometers for low-cost, hassle-free temperature monitoring. An ML-OI-AX-RH option board can be used to connect various low cost RH probes with integrated temperature sensor.

- **RTDs**: Low-cost PT1000s can be connected to the standard single-ended voltage inputs, but it's recommended for simplicity and accuracy to use the ML-OI-AD-PT1000 option board with dual PT1000 input.

- **Thermistors**: Low-cost NTC thermistors can be connected to the standard single-ended voltage inputs, but they require some elaboration.

- **Thermocouples**: Thermocouples can be connected to an ML-OI-AD-80MV option board with two high-resolution differential inputs to measure the thermocouple voltage. However, the temperature equation itself is too extensive to be performed in the data logger and must be processed by the data collection system.

Note: To accurately monitor ambient temperatures, you should use a ventilated screen to protect the sensor from direct sunlight and wind.

2 Digital thermometers

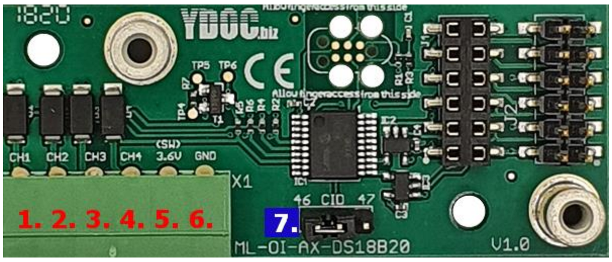
Using simple RTD's or thermistors for temperature monitoring can be cumbersome, as they might require adaptation to specific circumstances, including considerations for impedance, self-heating, and cable resistance.

2.1 ML-OI-AX-DS18B20

A convenient and popular alternative for temperature monitoring is to use low-cost temperature sensors based on factory-calibrated 1-Wire digital thermometer chips from Maxim Integrated, such as the DS18B20, DS1820, DS18S20, DS1822, and DS1920. Up to four of these sensors can be connected and powered via an ML-OI-AX-DS18B20 option board. Each sensor should have 3 wires; signal, power and ground. Up to two AX boards can be installed in a single logger, distinguished from each other by the CID jumper setting,

Connector pinout

1. Input 1
2. Input 2
3. Input 3
4. Input 4
5. 3.6V
6. Ground
7. CID jumper



2.2 ML-OI-AX-RH

Another convenient alternative for temperature monitoring is to use a low-cost RH probe with an I2C interface and an integrated temperature sensor. The ML-OI-AX-RH option board can connect and power one such probe or sensor, automatically detecting which of the following supported chipsets is integrated in the probe: AM2315 (AOSONG), BME280 (Bosch), ChipCap2 (Amphenol), T9602-D-3 (Telaire), and SHT3x/4x (Sensirion). Up to two AX boards can be installed in a single logger, distinguished from each other by the CID jumper setting.

Connector pinout

1. SCL
2. SDA
3. 3.6V
4. Ground
5. CID jumper

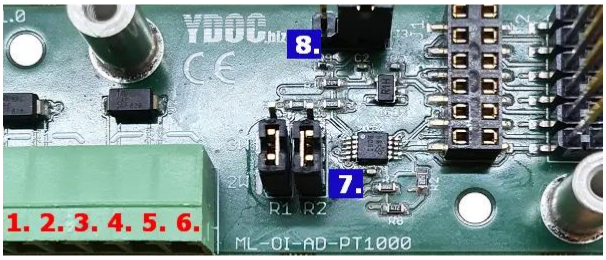
3 RTD's

The PT100 and PT1000 are widely used temperature sensors that operate based on resistance, where temperature is determined by measuring the actual resistance. An RTD can be powered by the logger, and its resistance calculated by measuring the voltage across a divider resistor. However, due to the relatively low resistance of these sensors, issues like cable resistance and self-heating can negatively impact accuracy as well as cause increased power consumption. Therefore, it's not recommended to connect them directly to a standard analog input.

3.1 ML-OI-AD-PT1000

For connecting a PT1000, it is recommended to use the ML-OI-AD-PT1000 option board, which features two 16-bit differential AD converters and Wheatstone bridge circuits to accurately measure the resistance of up to two PT1000 sensors. The sensors are excited briefly to eliminate self-heating, and a 3-wire configuration can be used to minimize the effects of cable resistance. Up to two AD boards can be installed in a single logger, distinguished from each other by the CID jumper setting.

Connector pinout



1. Excitation wire sensor R1
2. Return wire sensor R1
3. Second return wire sensor R1
4. Excitation wire sensor R2
5. Return wire sensor R2
6. Second return wire sensor R2
7. CID jumper
8. 2 or 3 wire configuration jumpers

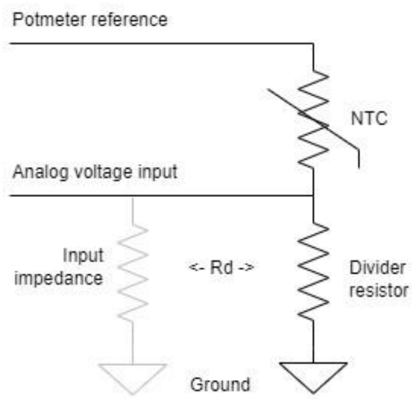
Note: This board is specifically designed for PT1000 sensors and therefore not suitable for connecting PT100 or other RTD sensors.

4 Thermistors

NTC thermistors (Negative Temperature Coefficient) are temperature-sensitive resistors whose resistance decreases as temperature increases. The temperature can be calculated from the voltage drop measured across a divider resistance in a voltage divider configuration with an NTC thermistor.

The thermistor should be connected between the 3.3V potentiometer reference output and an analog voltage input, preferably the potentiometer input. Set the potmeter parmeter to 0 .. 3.3V instead of 0..100%

A divider resistor should be connected between the analog voltage input and ground. It is recommended that this resistor has approximately the same resistance as the NTC thermistor.

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Analog input

[0] Exit
[1] Name                      >> PM
[-] Sensor power              >> N/A
[3] Sample interval           >> Data log interval
[-] Port mode                 >> Port 5; 0-3.3 V
[5] Parameter settings        >> Divider
[6] Parameter value at 0 V    >> 0 V
[7] Parameter value at 3.3 V >> 3.3 V
[8] Determine linear offset only (1 calibration point)
[9] Determine linear conversion function (2 calibration points)
[A] Burst mode                >> Disabled
[R] Remove
[T] Test measurement
>|
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4.1 NTC formula

You can use a calculated channel to calculate the temperature from the measured voltage drop across the divider resistance with the following formula:

`ntc(Vin[;R0[;Rd[;B[;D]]]])`

The formula accepts 1 to 5 arguments.

Vin, the measured voltage drop across the divider resistance.
R0, the nominal resistance of the NTC (default 10kohm).
Rd, the value of the divider resistance (default 10kohm).
B, the so called B-Value of the used thermistor (default 3950).
D, the self heating dissipation constant of the used thermistor in mW/°C (default 2).

Example: `ntc(:Vin;10;9.77;3892)`

4.2 Tips to increase the accuracy of NTC temperature measurements

1) Choose a high-accuracy NTC thermistor, ideally with 0.1% tolerance.

2) Enter the exact divider resistance: Calculate the exact divider resistance, taking into account the input impedance of the system. If the input impedance of the measurement circuit is high (e.g., the potentiometer input), it can often be neglected. However, this is not true for lower impedance analog inputs, which need to be considered. To measure the divider resistance accurately, temporarily replace the NTC with a precise resistor (0.1% tolerance, labeled R1) and measure the voltage across the divider resistor.

The formula to calculate divider resistance Rd is:

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(VRd * (R1 + 150Ω)) / (3.3V – VRd)
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where 150 Ω is the internal protection resistor in series with the potmeter reference voltage.

The voltage can be measured with the data logger [T] test function.

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3) Optionally optimize the divider resistance: Select a divider resistor value so that the divider resistance corresponds to the value of the NTC thermistor at the midpoint of the temperature range of interest.

4) Enter the correct B-Value as provided by the manufacturer.

5) Enter the correct dissipation factor as provided by the manufacturer**.**