Measuring Temperature and Resistance

Abstract

The application note deals with methods of temperature and resistance measurement by means of analogue inputs of control systems by the company AMiT.

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File: ap0015_en_02.pdf

Attachment

File content: ap0015_en_01.zip

temper_p1_en_01.dso	Measuring temperature by means of Ni1000 and Pt1000
Ni1000_5000.pdf	Characteristics of the sensor Ni1000/5000
Ni1000_6180.pdf	Characteristics of the sensor Ni1000/6180
Pt1000_3850.pdf	Characteristics of the sensor Pt1000/3850

Contents

Revision history

Version	Date	Changes
001	14. 08. 2008	New document
002	29. 07. 2014	The second chart in Chapter 6 modified, proofreading

Related documents

1. Help section for DetStudio development environment
   File: DetStudioHelp.chm
2. CSN IEC 751 Standard for industrial platinum resistance sensors
3. CSN IEC 584-2 Standard for thermoelectric cells
4. www.sensit.cz – resistance sensors manufacturer
5. Characteristics of the sensor Ni1000/5000
   file: Ni1000_5000.pdf
6. Characteristics of the sensor Ni1000/6180
   file: Ni1000_6180.pdf
7. Characteristics of the sensor Pt1000/3850
   file: Pt1000_3850.pdf

1 Temperature Measurement Options

There are various types of resistance temperature sensors that can be connected to control systems by the company AMiT. This application note explains connection procedure for the following types:

- **Ni1000/6180** – range of temperature measured -60 °C to +146 °C.
- **Ni1000/5000** – range of temperature measured -60 °C to +174 °C.
- **Pt1000** – range of temperature measured -50 °C to +250 °C.
- **Pt100** – range depends on the sensor applied, on the converter and on parameters of the control system analogue input.
- **Thermocouple** – range depends on the sensor applied, on the converter and on parameters of the control system analogue input.
- **Resistance sensor** – values measured range from 0 Ω to 1960 Ω (analogue input in the mode Ni1000).

2 Sensor Ni1000

This type of sensor can be connected directly to analogue inputs of any control system produced by AMiT that can be set to the mode Ni1000.

Measurement range Ni1000/6180	-60 °C to +146 °C
Measurement range Ni1000/5000	-60 °C to +174 °C
AD converter interface (LSB)	0.3 °C

The measurement accuracy depends on the value measured.

Temperature [°C]	Accuracy [°C]
-50	0.8
0	0.9
150	1.2

The resistance value in Ni1000 on temperature is determined directly by the manufacturer (see e.g. www.sensit.cz).

Note:
The value 6180 ppm (5000 ppm) indicates the mean relative change of resistance to degrees Celsius between temperatures 0 °C to 100 °C (more information is available for example at www.sensit.cz).

In order for inputs with sensors Ni1000 to work properly, most control systems need to have the appropriate HW connections set into the Ni1000 mode in the control system, according to technical documents. After setting this mode, an unconnected sensor on the AIx input will have voltage of approx. 12 V. The voltage is switched on for 20 ms in intervals of 220 ms (an ordinary voltmeter only measures the mean value); therefore, the sensor does not get overheated due to permanent power supply.

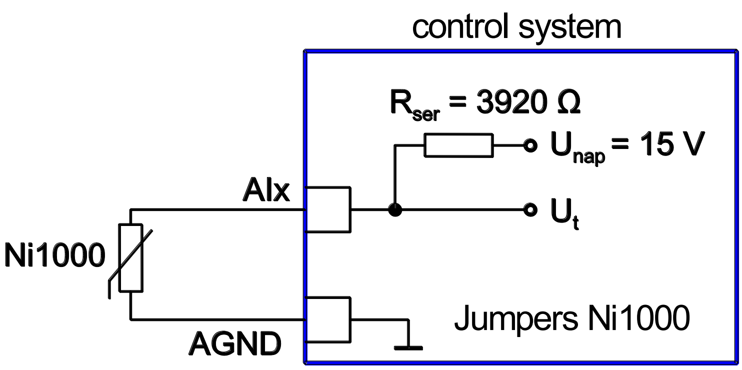

Fig. 1 – Input technical design

In the application, inputs with sensors Ni1000 load up using the `Ni1000` module. It is adapted for sensors with sensitivity of 6180 ppm a 5000 ppm.

Fig. 2 – Connecting a Ni1000 sensor to the control system

Application with an example of reading the value from the Ni1000 sensor is included in the attachment ap0015_en_01.zip. It is a sample project called temper_p1_en_01.dso created in the DetStudio development environment. This project is created for the control system **StartKit**. However, it can be changed for any control system that allows connection of Ni1000 sensor, by means of a DetStudio menu "Tools/Change Station".

2.1 Using the Ni1000 Sensor to Measure Temperature up to 200 °C

If you need to use the Ni1000 sensor connected to a control system made by AMiT to measure temperature higher than the ones stated in Chapter 1 (e.g. up to 200 °C), you will be able to realize this by connecting a parallel resistor (10 kΩ) to the Ni1000 sensor. The appropriate input is set into the Ni1000 mode by means of a HW connector. The appropriate channel has to be read by means of the module `AnIn` with the following parameters

```
AnIn #Nixx, U1, 5V, 0V/0mA, 5V, 0.0, 5.0
```

where

- **Nixx** – reference to the used signal of channel type Ni1000.
- **U1** – voltage measured at the input with a connected sensor and parallel resistor.

It is necessary to recalculate the measured voltage value U1 using the following formula

U2 = U1 × Rp × Un / (Un × Rp - U1 × Rser)

where

- **U1** – voltage measured by the modul AnIn (0 V to 5 V).
- **Rp** – parallel resistance (10 kΩ).
- **Un** – power divider voltage (15 V).
- **Rser** – power divider series resistance (3.92 kΩ).

The calculated value U2 needs to be converted into temperature in °C using the module `Ni1000U2T`.

Attention
You must bear in mind that the measurement will be influenced by parameters of resistors connected in parallel (accuracy, temperature stability, etc.). We recommend you select a resistor with accuracy 0.1 % or more accurate.

3 Pt1000 Sensor

This type of sensor can be connected directly to analogue inputs of any control system produced by AMiT that can be set to the mode Ni1000.

Pt1000 measurement range	-50 °C to +250 °C
AD converter interface (LSB)	1 °C

The measurement accuracy depends on the value measured.

Temperature [°C]	Accuracy [°C]
-50	1.0
0	1.3
150	2.6

Dependence of PT1000 resistor value on temperature is described by the CSN IEC 751 standard.

In order for inputs with Pt1000 sensors to work properly, most control systems need to have the appropriate HW connections set into the Pt1000 mode in the control system, according to technical documents. After setting this mode, an unconnected sensor on the AIx input will have voltage of approx. 12 V. The voltage is switched on for 20 ms in intervals of 220 ms (an ordinary voltmeter only measures the mean value); therefore, the sensor does not get overheated due to permanent power supply.

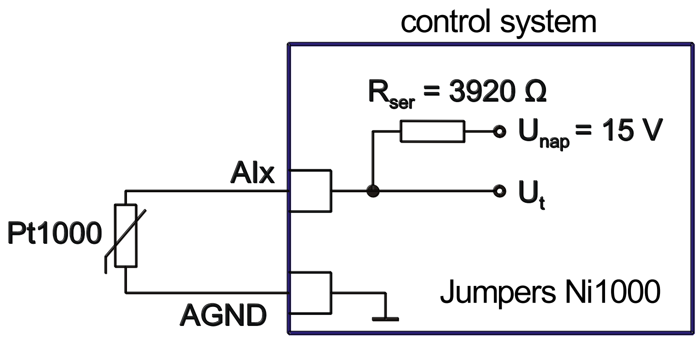

Fig. 3 – Input technical design

In DetStudio development, we do not use the module`Ni1000`, but the module `AnIn` instead.

```
AnIn #Nixx, U_Pt1000, 5V, 0V/0mA, 5V, 0.0, 5.0
```

where

- **Nixx** – reference to the used signal of channel type Ni1000.
- **U_Pt1000** – voltage on Pt1000 sensor proportional to temperature.

Voltage measured can then be converted to temperature (e.g. by using the module `Interpol` or a mathematical equation) according to the sensor resistance characteristics.

Fig. 4 – Connecting a Pt1000 Sensor to the control system

Application with an example of reading the value from the Pt000 sensor is included in the attachment ap0015_en_01.zip. It is a sample project called temper_p1_en_01.dso created in the DetStudio development environment. This project is created for the control system **StartKit**. However, it can be changed for any control system equipped with analogue inputs by means of a DetStudio menu “Tools/Change Station”.

4 Pt100 Sensor

In order to measure temperature using the Pt100 Sensor, we need to use an external converter that converts the resistance value to a current or voltage range. Output of this converter is then directly connected to the current or voltage input of the control system (of the extending I/O module).

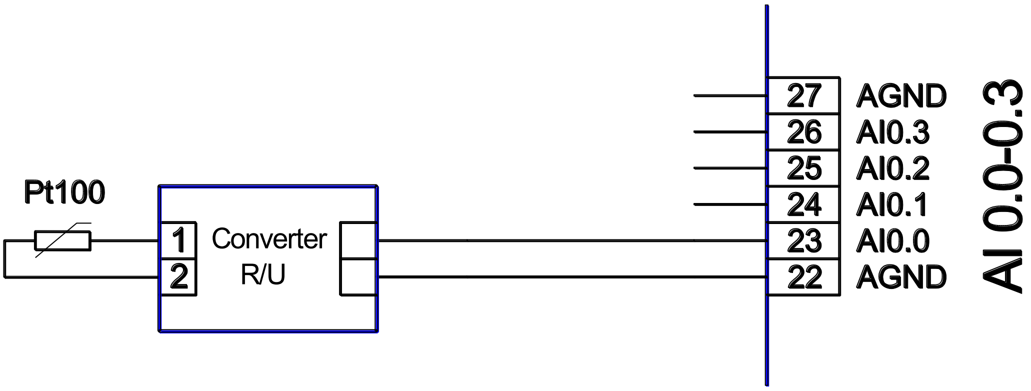

Fig. 5 – Connecting the Pt100 Sensor using the resistance/voltage converter

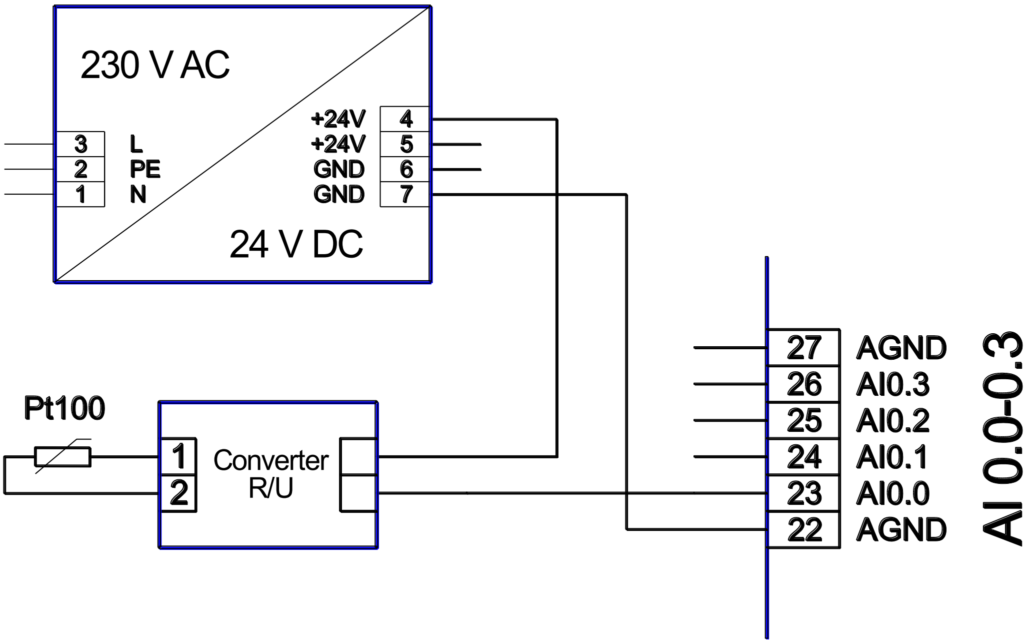

Fig. 6 – Connecting the Pt100 Sensor using the resistance/current converter

The value of voltage/current from the converter is obtained in the control system by means of the module `AnIn` with suitable parameters (depending on the converter type). Voltage/current measured can then be converted to temperature (e.g. by using the module `Interpol` or a mathematical equation) according to the sensor resistance characteristics.

Note:
One of the options is also the use of an extending module 6AR produced by the company SMARIS, which communicates with control systems by means of the ARION protocol (see AP0005 – Communication in the ARION network); up to 6 Pt100 sensors can be connected to it.

5 Thermocouple

In order to measure temperature using a thermocouple, we need to use an external thermocouple amplifier (e.g. by the company Analog Devices). We may connect the amplifier directly or by means of a voltage/current converter to the voltage or current input of the control system (of the extending I/O module).

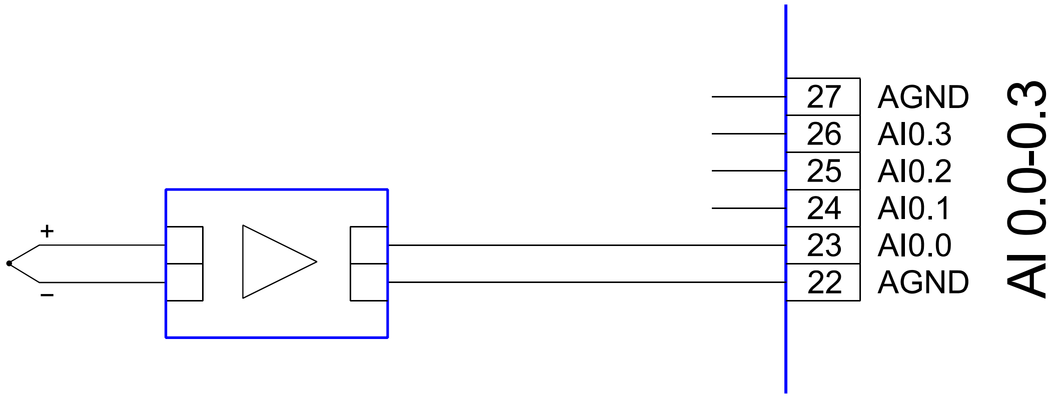

Fig. 7 – Connecting the thermocouple using an amplifier

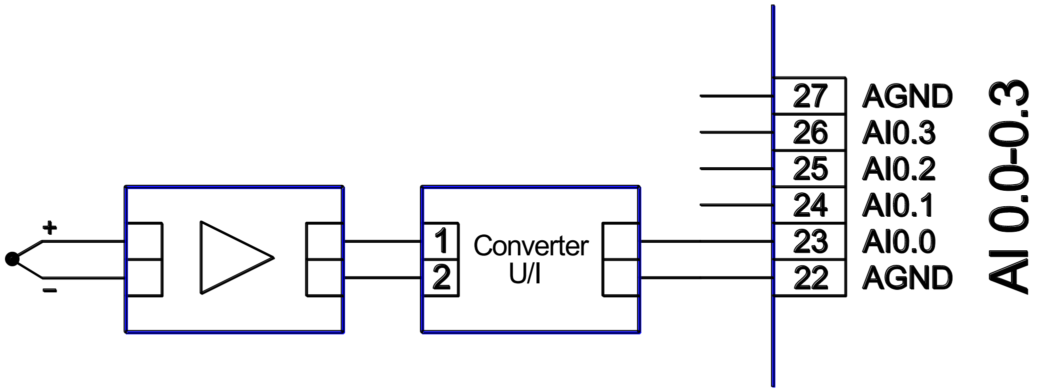

Fig. 8 – Connecting the thermocouple using a voltage/current converter

The value of voltage/current from the converter is obtained in the control system by means of the module `AnIn` with suitable parameters (depending on the type of amplifier or converter). Voltage/current measured can then be converted to temperature (e.g. by using the module `Interpol` or a mathematical equation) according to the thermocouple characteristics.

6 A General Resistance Sensor

In general, resistance sensors can be connected directly to analogue inputs of any control system produced by AMiT that can be set to the mode Ni1000.

R measurement range	0 Ω to 1960 Ω
AD converter interface (LSB)	2 Ω

The measurement accuracy depends on the value measured.

Resistance [Ω]	**Accuracy [Ω]**
0	1.5
1000	2.0
1960	3.0

In order for inputs with resistance sensors to work properly, most control systems need to have the appropriate HW connections set into the Ni1000 mode in the control system, according to technical documents. After setting this mode, an unconnected sensor on the AIx input will have voltage of approx. 12 V. The voltage is switched on for 20 ms in intervals of 220 ms (an ordinary voltmeter only measures the mean value); therefore, the sensor does not get overheated due to permanent power supply.

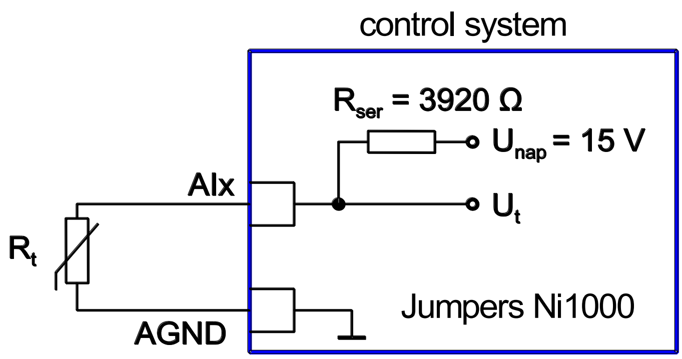

Fig. 9 – Input technical design

In DetStudio development environment, we refer to such an input as voltage input, using the modul `AnIn` with the following parameters

```
AnIn #Nixx, U_Rt, 5V, 0V/0mA, 5V, 0.0, 5.0
```

where

- **Nixx** – reference to the used signal of channel type Ni1000.
- **U_Rt** – voltage on resistance sensor proportional to temperature.

We obtain the sensor resistance from the voltage measured by using the following formula:

Rt = 3920 × U_Rt / (15 - U_Rt) [Ω].

The resistance calculated can then be converted to temperature (e.g. by using the module `Interpol` or a mathematical equation) according to the sensor resistance characteristics.

7 Technical Support

All information on connection possibilities of resistance temperature sensors will be provided by the technical support department of the company AMiT. Do not hesitate to contact the technical support via e-mail using the following address: **support@amit.cz**.

8 Warning