PT-1

Temperature Transmitter for Pt100 & NTC Sensors

User's Guide

- o wide temperature range
- o true four-wire measurement with cable and capacitance compensation
- o Platinum sensor's curve is linearized for best accuracy
- o scalable analog output
- o serial port for data transmission and configuration
- o optionally use a standard NTC 100kOhm@25C
- o very stable, no recalibration is required
- o for long-term use
- o temperature controller with an isolated SSR output
- o DIN rail mountable, small size
- o allows for a long cable to be used for the Pt100 sensor
- o low power consumption (20mA from 24V)

VISILAB
SIGNAL TECHNOLOGIES

2010-06

Contents

Visilab Signal Technologies Oy

Address:	Tel.:		e-mail:
Keskustie 15	+358-45-635 4885	+358-45-635 4886	info@visilab.fi
FI-07560 PUKKILA	Y 0631208-0 ALV Rek.		
FINLAND	VAT FI06312080	Helsinki Reg. 365.258	www.visilab.fi

General

This guide contains directions on how to use the PT-1 module together with its specifications. PT-1 is a temperature transmitter designed specifically for preconditioning the common Platinum temperature sensor used in industrial applications. Pt100 is a temperature sensor with a largest number of users in the world. Its use is based mainly on its superior stability, extremely wide temperature range and an excellent tolerance facilitating quick sensor replacement in field conditions. PT-1 finds applications in requiring industrial temperature measurements where the conditions are so harsh that no transmitter electronics can survive. Separating the transmitter from the Pt100 sensor with a cable gives a huge advantage in many cases. Other applications are in many kinds of scientific measurements and laboratory systems. Having the temperature controller feature as standard offers a number of applications in laboratories and in OEM products. PT-1 is based on Visilab's PT-100 and INA-01...5 signal preconditioning products since 1991.

Extra flexibility is offered by the option of being capable of using a standard NTC (negative temperature coefficient resistor) with a limited temperature range and limited accuracy. The use of NTC instead of Pt100 is sensed automatically at the time of connecting power to the module. It has also an LED indicator telling which type of sensor is in use. Settings are saved to a nonvolatile memory by the user with a command through the serial port. The new sensor can be selected also in the menu system without turning the power off.

PT-1 is very stable in all specified environmental conditions and preadjusted at factory. No recalibration is necessary. A temperature offset adjustment is available if required. The sensor is compensated against cable resistance and capacitance and allows the use of ordinary low-cost shielded cable up to 10 meters or more. The sensor's inherent nonlinearity is corrected with the known polynomial to minimize any errors. PT-1 is designed for high reliability and for long-term use. No regular servicing is required. For specifications, refer to Appendix A. The other Appendices contain other useful information.

The module is of very small size and is designed to be installed to a standard DIN rail with a simple click action. The wires are captured with screw terminals. The connection schematic is printed to the side of the module having 12 pins. Although the module is protected against incorrect wiring and ESD, avoid connecting it in the wrong way. The supply voltage to the module is nominally 24V (20mA typically) and allows variation in the range of 23.5V to 25.5V. Overranging the voltage will cause excessive current flow and blowing of the internal fuse. Underranging will keep the module reset with no true actions. The module contains one automatic fuse which requires no servicing and will always restore itself after cooling down.

The Pt100 sensor can be connected to the module with a cable which can be very long and capacitive without any effect on the temperature reading. The measuring principle is true four-point measurement with cable capacitance compensation. Accuracy depends on the Pt100 sensor tolerance used. The delivery does not contain any Platinum sensor and the user should purchase it separately together with a cable suitable for his installation. The cable must have at least four wires plus a shielding to prevent external electrical noise from interfering. The surrounding noise can be excessive in industrial conditions, especially, if heavy electrical motors are used in the vicinity. Avoid using the free wires in the cable for high voltages or noisy signals. For best safety and lowest noise, use the cable only for the sensor.

The module has four interfaces. The main interface is a voltage output 0..5V corresponding to 0..500C which can be rescaled to any other temperature range. The second interface consists of two LED indicators. One of them indicates whether the Pt100 is used (off) or the NTC option instead (lit). This LED blinks in normal operation if the module is busy doing some operations commanded by the user. The second LED is lit when the temperature controller is affecting energy flow by closing the isolated switch. When the preset temperature is reached, the LED is turned off. The third interface is the PID controller behind this feature with settable coefficients and an editable setpoint. There is an isolated switch to be connected to some power contactor or a more powerful relay. Small heating/cooling systems can use the switch as such.

The fourth interface is the serial port by which one can configure the module in all possible ways. The module has also a data transmission feature sending regularly temperature values. The data transmission and the temperature controller can be turned on/off via the serial port. The module will save the settings for the future into a nonvolatile memory. The serial port is a standard RS232 with the settings 9600 bauds, no parity, 8 data bits, one stop bit, no handshake. The serial port can be used with any Windows hyperterminal or the ATLINK or MINIATLINK software available from Visilab. The protocol in use is the standard ANSI ESC sequence based VT52 version simplified to a 4x20 character display. In the following, we will describe the menus and commands available. For full data saving features, use our ATLINK/MINIATLINK programs which are capable of saving the data. Note that the data transfer may be invisible when using Visilab's software. In other terminal programs, the data transmissions become visible and may clutter the display.

Installation

PT-1 is taken into use by inspecting for any damage under transport. Report of anything unusual to the retailer from which you purchased the product. If the delivery bundle did not contain the software ATLINK or MINIATLINK, you can download them from the web site of Visilab or from the web sites of our retailers, at no cost. You can also contact the retailer and ask them to send you copies of the programs. Install the programs as demonstrated in its documentation.

Connect the wiring to your sensor, power supply and optional serial port of a computer. You can optionally connect the voltage output to your factory automation system for further processing. The temperature controller output (an isolated SSR switch with a closing action) can be used by your system as well. Avoid switching excessive currents (refer to Appendix A). The guarantee des not cover burnt switches nor damages caused to external devices.

Menu System

Find below the messages sent by the serial port after turning on the power into the module.

The following message is sent to the port at the time of booting up:

```
PT-1 V1.040
(C)Visilab
```

The text will soon go away and is replaced with the run-time menu:

```
R1/0= Start/Stop
D1/0 Data ?=Status
S=Save L=Load Set's
3=SetT 9=Setup
```

By pressing the "?" key one can see the current run status

```
DATA NO
RUN YES
```

The indication may be YES/NO for either one of them depending on user's commands. The menu operates on single keystrokes and Enter is not required. As exceptions are dialogs for adjusting some numeric variables and the turning on/off the data transmission and the temperature controller. The data transmission is turned on by pressing first "D" and then "1". It can be stopped by pressing "D" and "0". There can be a delay of some seconds between these key presses but a too long time will be interpreted as a timeout error and is canceled. The same applies to the temperature controller: "R" "1" and "R" "0" will turn it on and off again. No messages are displayed after these commands. If the serial port is connected to an automation system, it is very simple to use this protocol. Small letters will do as well.

If the settings to be described in this manual are changed by you and you want the module to remember them in the future without your interference, you need to Save the settings. It is done simply by pressing "S". If you have unintentionally made changes you want to cancel, press "L" to load the earlier settings overwriting the current ones.

You can change the temperature controller's set value by pressing "3". A number editing dialog will appear:

```
Control setting(C):
    78.0023C
```

The cursor blinks under one of the digits and you can change that by overwriting with a key press. The cursor then tends to move to the next digit to the right. The decimal part can be reached by pressing the Enter key or the TAB key. Also the arrow keys to the RIGHT and LEFT are in use. When you are happy with the setting, press another Enter or ESC and this finishes the editing and takes the new value into use. The ESC key is also used in all menus as the **only** key with which you can return to the upper level. This control setting is used by the temperature controller when it is turned ON. If it is turned OFF, the setting has no meaning. When control is on, the PID controller reads regularly the temperature sensor and calculates the difference to the set value. The difference drives the SSR output (P-term). The controller has also the capability of correcting a small difference by accumulating them in the I-term (Integration term). It is then able to add some to the difference from this. If the temperature approaches very fast the set value, one can add some braking by slowing it down. This is done by diminishing the difference with the derivative (D-term) of the temperature time series. The user can affect these terms in the PID menu. The user is fully responsible for changing the PID coefficients.

As a warning, if you apply a nonzero coefficient for the I-term and your system has a tendency of being sluggish in responding to heating, be careful! There is the possibility of a large amount of history from the I-term accumulated into the controller and the system might overheat as it is not able to slow down when it finally gets heated up close to the setting value. That poses a risk of danger. With such systems it is recommended to use ramp heating controllers having a tight control but being slower in response. They are, however, inherently much safer than a simple PID controller.

If you press "9" you will enter another menu, the Setup menu, looking like this:

```
2=PID 3=Tlimit                    Setup menu
5=Delimiter:
7=Pt100 4=Scales
6=DataFile 8=Fact.
```

Pressing "2" will lead to a menu for setting the PID coefficients of the controller. The PID controller coefficients have already been preset for regular operation, with I and D terms turned off (=zero). The P-term is 1000 being the nominal value for normal operation. If you modify it to 100, the controller becomes less responsive and will have a difference to the set value. Using too high values may lead to control system oscillation. The I-term is for removing differences by accumulating the difference and feeding it back to the controller. The D-term is a braking feature slowing down too rapid rising/ falling of temperature. Note that using the controller and adjusting the coefficients usually requires some understanding of control systems to keep the system safe. The responsibility for adjusting the coefficients is fully on the user's desk. You will see the following menu.

```
T1                    PID menu
1=P 2=I 3=D
```

Pressing "1" leads to a dialog:

```
P-term: 1000
```

and you can now do the editing as before. There is no decimal part. Pressing "2" leads to a dialog:

```
I-term:     0
```

Pressing "3" leads to a dialog:

```
D-term:    0
```

Back in the Setup menu, if you press "3" you will se the following dialog for setting the overtemperature limit:

```
100.0000C
```

If temperature exceeds this limit at any time while the controller is running, it will cause the controller to be turned off and there will be a message to the display:

```
OVERHEATING!
```

If you press "5" in the Setup menu, you will see the following dialog for setting a delimiter character between data entries:

```
ASCII#:  9
```

Edit the ASCII code (default = 9 = TAB). The delimiter separates the data fields making it easier to interpret the data files with e.g. any spreadsheet programs. The delimiter is not always visible on the screen but the corresponding ASCII character is used. You could have something different,like 13 (CR) or 10 (LF) depending on the settings of your spreadsheet program. Check the ASCII table for available codes.

If you press "7" in the Setup menu, you will see the following:

```
7=Pt100
```

or

```
7=NTC
```

You can select the temperature sensor as Pt100 or NTC by pressing "7" repeatedly. The Pt100 used is any regular device. If high accuracy or tolerance for replacement is required, use one of proper category. Always use the Pt100 as a four-wire element, never buy Pt100 sensors prewired to three-wire systems. Else you will lose the accuracy. The NTC is an "industry standard" 100kOhm @25C type made by Betatherm and optionally by other manufacturers. The current product code is 100k6A372I and the beta value is 4143. The temperature range for best accuracy with this type of sensor is very limited (0 to 50C). The module will automatically sense replacing the Pt100 with an NTC and the opposite. Just turn the power off momentarily.

Pressing "4" in the Setup menu will lead to:

```
Analog output
1=Low 2=High 5=Set
9=Test 0=Offset
```

This is the voltage scaling menu for adjusting the temperature range corresponding to the voltage range 0..5V. The low end is set by pressing "1" and the high end by pressing "2". The new range is taken into use by pressing "5". When you exit this menu the new scaling is used in the analog output. The default values are Low=0.0C and High=500.0C, corresponding to voltages 0V and 5V. You could for example, use the range -100.0C, 400C to shift the focus to the lower temperatures or the range 0.0C, 100.0C for enlarging the lower end. If you use funny values here, you will end up with funny voltages as well. The DAC producing the analog signal is limited always to 0-5V and attempts to exceed these limits will drive the signal to either end value. You can test the result without the control system interfering in this menu by pressing "9" and editing a test temperature to be output as analog signal. When you return to the higher levels, the analog signal is overridden by the current temperature reading.

There is also a possibility of adjusting an optional temperature reading offset by pressing "0" with a similar dialog as before. The default value is 0.0 but if you for some reason, insist on having an offset in the reading, you can do it here. It does not matter which type of sensor you use, the offset value is added to the current temperature as a base value. The dialog looks like this:

```
Offset of temp.(C)
for Pt100&NTC:
   0.0000C
```

When you return back to the run-time menu by pressing the ESC key a few times, you should decide whether you like to save the current settings (see above). The module itself will refresh its nonvolatile memory every year itself as long as it is powered up. This will prevent it from losing its data if it is unused for a long time (more than 10 years). The saving takes a few seconds and the BUSY LED will blink during this time but the control is not lost.

The option "6" is for toggling between the possible selections for data transmission:

```
6=DataFile 8=Fact
```

or

```
6=Display 8=Fact
```

or

```
6=File&Displ 8=Fact
```

The first case means that the data is hidden and sent to a file (if a file is opened in ATLINK for that purpose). The data items are simple text formatted floating numbers. The data items are marked with ASCII 2 and ASCII 3 as simple packets and the ATLINK interprets them as hidden data and does not show them. The second case shows the data on the fourth line only and no data is sent away. The third case causes the data to be both displayed on the fourth line and sent as hidden packets. Note that if all data sent to the serial port is saved, the data display on the fourth line will eventually make a data flow with lots of ESC characters. To simplify, if all you need is data packets and your terminal program can handle the data packets without cluttering the display, use option **DataFile**. If all you need is data display on the screen, use option **Ddisplay**. If you need both data packets to be saved and data displayed on the fourth line (your terminal program can handle the data packets without cluttering the display), use option **File&Displ**. Try out the options if uncertain of the result.

If you need to clear all user-definable settings and start from scratch, press "8" to initialiaze all settings. All scalings and settings are restored to sensible working values. The internal calibrations are not touched.

Appendix A. Specifications of PT-1 Rev 2.0

o a true four-wire platinum temperature sensor temperature transmitter with process and user interfaces
o small size, attachable to a standard DIN rail
o simple to use, configuration by serial port, nonvolatile memory for settings
o supports both regular Pt100 Platinum sensors and standard NTC 100kOhm @25C
o Pt100 response curve is linearized
o small excitation (1 mA ==> 100 uW) to avoid self-heating
o automatic selection between Pt100 and NTC at power-up
o accuracy +/-0.3C in the range 0..200C, +/-0.4C in range 200...500C, +/-0.5C in range -200..0C
o has a temperature controller and an isolated solid-state relay (SSR) for controlling low-power devices directly or contactors for high-power applications
o interfaces:
  o voltage output 0..5V 12 bits, temperature range is scalable, maximum output current 5mA
  o serial port (9600 bauds, no parity, 8 data bits, 1 stop bit, no handshake) and a simple ANSI ESC sequence protocol for configuration and commands. Start/Stop commands for the controller, Save/Load commands for the nonvolatile memory, status information commands and a simple menu system. The serial port can be configured as RS485.
  o two LED indicators:
    o indication of Pt100 or NTC selected, used also as a BUSY signal
    o SSR switch closing action indicator
  o a PID temperature controller with adjustable setvalue and settable PID coefficients
o input power requirement 24V 20mA typically (<30mA in all cases), operating range 23.5 to 25.5V
o ESD protected input lines
o power input protected against overvoltage and polarity reversion, filtered for EMC
o SSR max 200 mA and 24 - 350VAC, isolation to 3000VAC or better
o the Pt100 signal is preprocessed with high-stability circuits and converted to digital form with a 16 bit ADC
o sampling interval 1/sec
o control interval 1/sec
o extremely stable, no recalibration is required
o designed for long-term use in industrial conditions
o allows for a long capacitive cable to Pt100 (up to 200 pF/m or more). 10 m cables have been used with success. Cable shielding is recommended for best results.
o NTC is not recommended to be used with long cables (max 1000 mm), only for rather local measurements due to its high impedance and noise sensitivity. The NTC is measured with a two-wire method
o operating temperature -20 to +60C
o built into a grey polycarbonate housing, size 22x75x100 mm, has 12 screw terminals 2.5 mm^2, flammability rating UL94V-1/2
o RS232 cable maximum length 40 m, RS485 maximum 1200 m (with a termination resistor)

Appendix B. EMC Compatibility

EC Declaration of Conformity

We

Visilab Signal Technologies Oy
Keskustie 15
FI-07560 Pukkila
FINLAND

declare that the

PT-1 Pt100 temperature transmitter

meets the intent of the EMC directive 89/336/EEC. Compliance is based on the following harmonized standards:

Emissions:

EN 50 081 part 2 (industrial environment):1993 referring to :
EN 55 011 radiated, Class A, Group 1
EN 55 011 conducted, Class A, Group 1

Immunity:

EN 50 082 part 2 (industrial environment):1992 referring to (both radiated and conducted fields):
EN 61000-4
IEC 1000-4
ENV 50140
ENV 50141
ENV 50204

I certify that the apparatus identified above conforms to the requirements of Council Directive 89/336/EEC.

Henrik Stenlund
managing director
31st August 2007

CE

Note for users:
When the apparatus identified above is connected by someone to become a part of an industrial control system, he is also responsible for the EMC compatibility of the resulting system. He is also liable of providing the necessary optical or galvanic isolations for signals and transient absorbers for other lines to conform to the EMC directives.

Appendix C. Connections

Apply the schematics below for connecting the PT-1 to your Pt100 sensor and control system. When using the NTC option, observe the screw terminals into which it is to be connected.

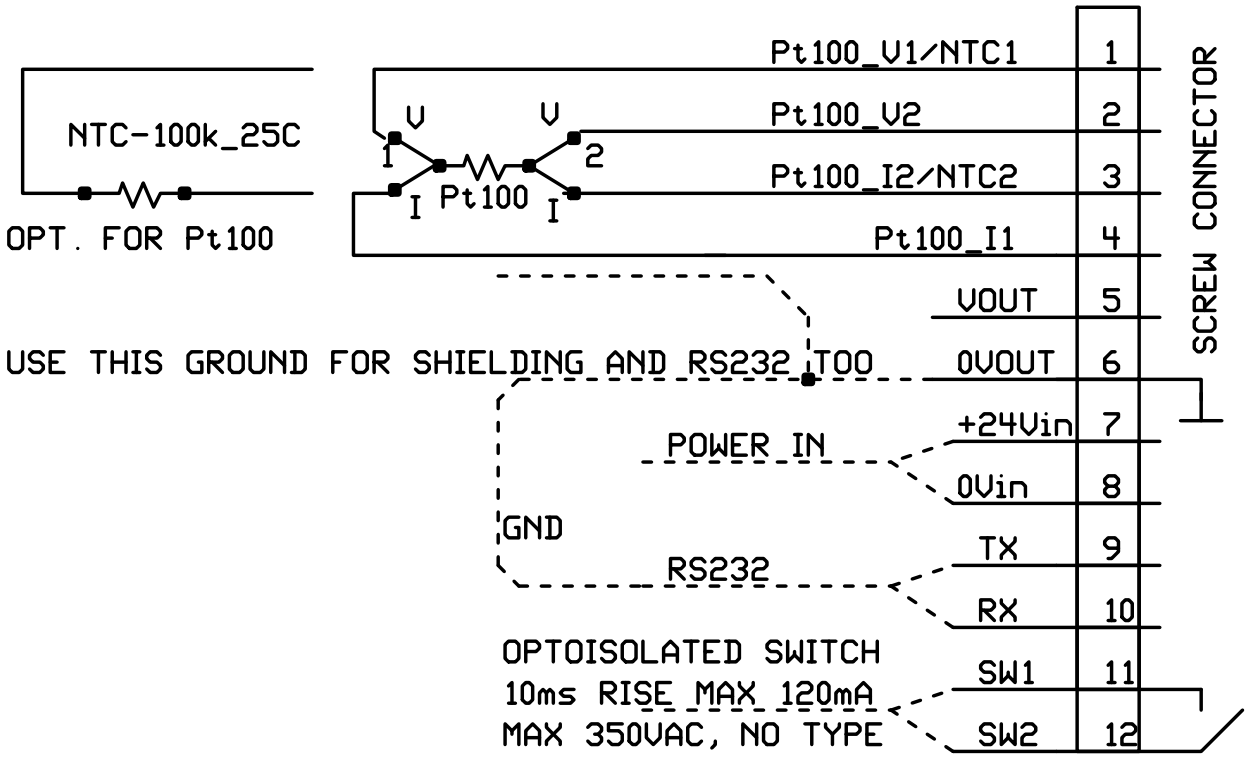

Figure C-1. Schematics for the PT-1 connections to the external world. The SSR has a capacity of 200mA of DC/AC loading. Do not exceed that.

Appendix D. Panel Items

Find below an image of the panel sticker (Figure D-1).

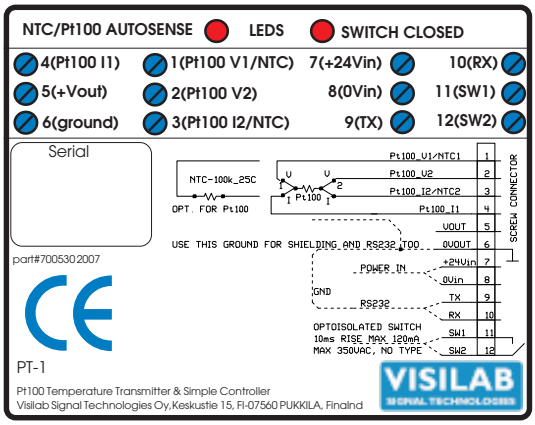

Figure D-1. Panel sticker for the PT-1.

The screw terminals are located at the front end of the PT-1 module for easy access when it is mounted onto a DIN rail with other modules. See the figure D-2 below.

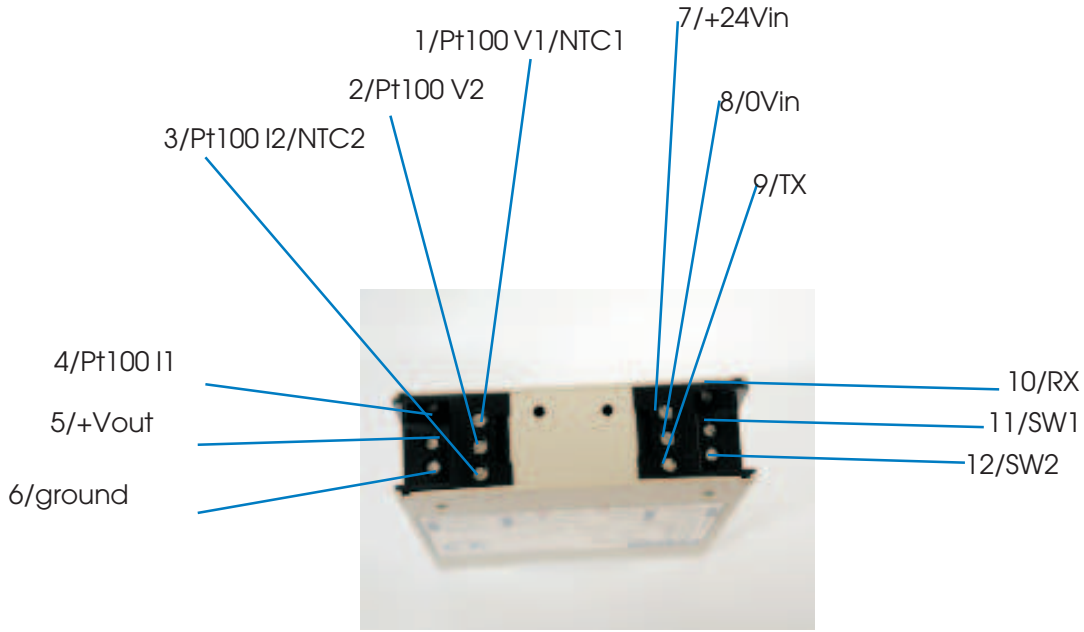

Figure D-2. Location of screw connectors for PT-1.

Appendix E. Terms for Guarantee

The manufacturer (Visilab Signal Technologies Oy) grants a guarantee of two years for the buyer of PT-1 temperature transmitter from the date of purchase. The guarantee covers all faults and misalignments which are in the equipment at the moment of purchase including those which appear during the guarantee period. The manufacturer is liable of repairing the instrument without cost to the buyer. The manufacturer can ship a new instrument of equivalent value and status if considered as a better solution than repairing. The buyer is liable of paying the freight costs to the factory of the faulty unit. The unit must not be sent to the manufacturer without a permission from the manufacturer. Units sent without a permission will be repaired at the cost of the buyer.

The guarantee does not cover wearing parts, like batteries, lamps, cables or motors or screw terminals. The guarantee does not cover faults caused by errors or neglects of the user nor those faults which are caused by deliberate breaking. The guarantee does not cover faults caused by incorrectly installed cables or conductors. The guarantee does not cover any damages to the user or to any third party independently of the way how the instrument has been used. The guarantee does not cover faults caused by natural phenomena like lightnings or floods, nor user errors like dropping the unit. The guarantee is void if the unit is sold to any third party. All faults which are not covered will be repaired at the cost of the buyer.

If opening of the instrument has been attempted at those parts which are not intended for the user, the manufacturer can refuse to repair or service the instrument. Then the instrument will be shipped back to the buyer at the cost of the buyer. Such parts are the housing and the electronics board. The instrument can not be opened and should not be disassembled unnecessarily.

Visilab Oy reserves all rights to changes and modifications in the looks, specifications, electronic design, electronic and software interfaces and computer programs, and also the right to change the retail prices of the instrument or its parts without any notice to present or potential customers. All copyrights and design rights belong to Visilab Oy. The PC programs, which have been sold to the buyer, can be used and copied freely for his own use but can not be sold to any third party.

The manufacturer is not responsible for any casualties, damages or accidents which the user has caused directly or indirectly with this PT-1 instrument, either to himself or to any third party.

Appendix F. Approximation used with NTC

The NTC option is measured as a two-wire element and the resulting highly nonlinear response curve is partly linearized. It is done by replacing the curve with a straight line. See the curve below indicating the range of validity of this arrangement. You can, of course, do measurements in a wider temperature scale but the error may be significant and, besides, the voltage range 0...5V will be the limiting factor anyhow. The ADC used for the NTC is 8 bits.

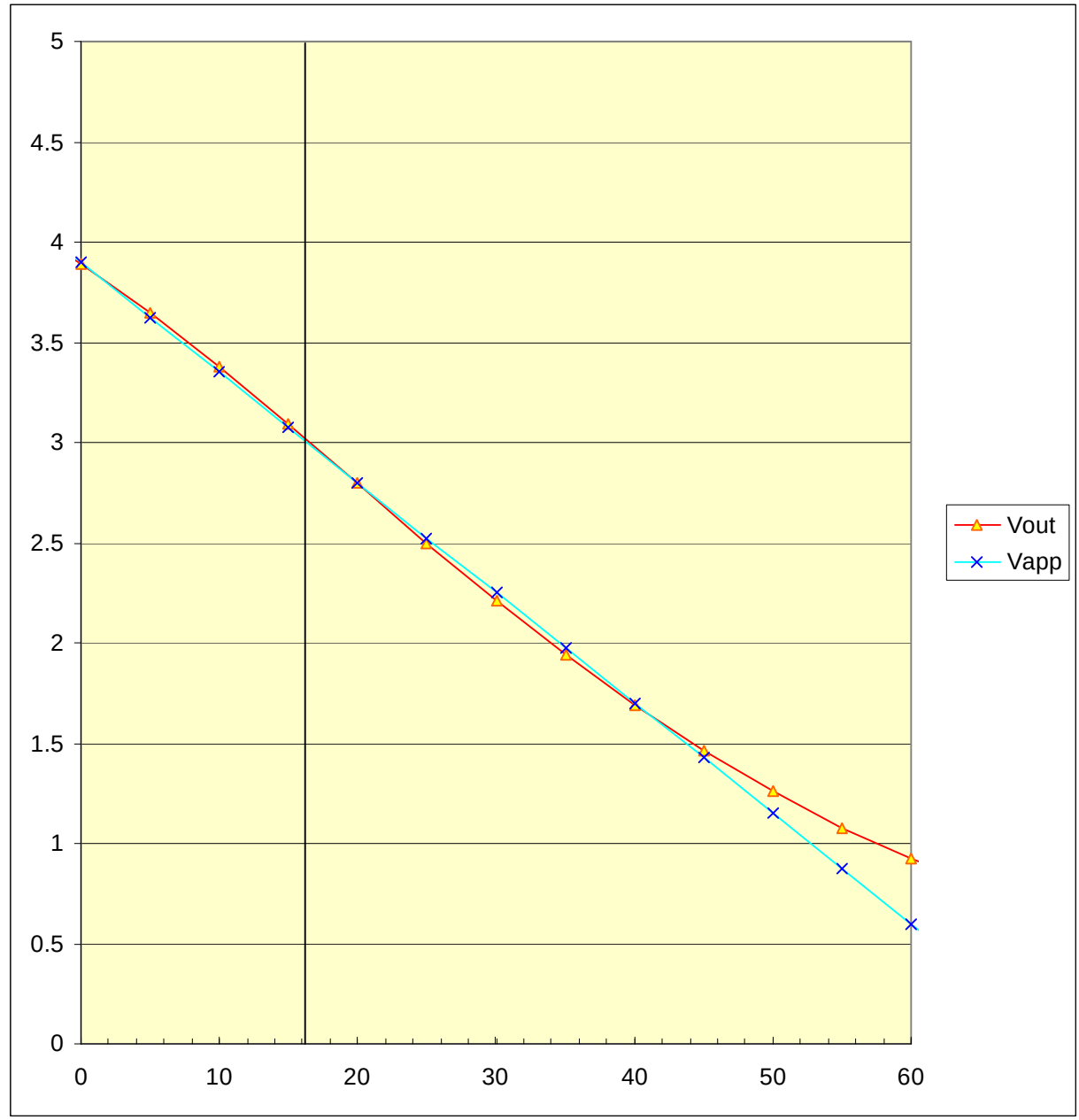

Figure F-1. NTC curve for PT-1.

Appendix G. Serial Port Configuration

PT-1 is by default set up as RS232 for PC communication. However, it can be configured as RS485 to be used in environments with lots of electrical interference. This option also allows for very long cable legs between a PC and PT-1. The only requirement is that the PC end has an RS485 to RS232 converter.

The configuration is done by opening the small top cover between the screw terminal groups having two openings for the LEDs. Twist it carefully open with a small screwdriver. Below the cover you will find a set of jumper plugs. The RS232 settings is for having them to the right (if you look from the sticker side) and the RS485 setting is the opposite (marked on the printed circuit board). You need to have pliers with a long nose to pick up each plug and push it into the other position. It would be recommended to disconnect the +24V power feed to the module for safety. Do not lose the plug inside the module. You need to set all of the three plugs to make the selection effective. Replace the top cover and reconnect the power.

The RS485 A-B lines use the same TX-RX lines as RS232. If they are crossed, it may happen that the receiver sees the signal polarity incorrectly. In that case, swap the wires. The basic baud rate is 9600 bauds and that enables long distance operation up to 1200 meters. If strange errors are met or corrupted data is received, that may be caused by electrical reflections in the cable. In that case, one might need a termination resistor to match the cable impedance. The resistor would be 120 to 400 Ohms and be connected directly between the screw terminals TX - RX. The termination resistor is usually needed at the ends of a long cable but not in between.

If you lost a plug inside the module, you need to open up the PT-1 case by opening the plastic locking and sliding out the circuit board. Avoid touching any components on the board.Do not use too much force at any time. The guarantee does not cover damage caused by opening the case. Replace the cover and apply the locking in the original way.

Index