



PL Engineering Ltd.

DX5100 Vision Program of DX5100 Controller Configuration

USER GUIDE



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1. PROGRAM OBJECTIVE

The program **DX5100-Config.exe** (hereinafter the Program) is designed to configure the controller DX5100 (hereinafter the Controller). The main goal is to simplify the tuning process of the controller for an end user.

The program applies a standard interface for windows applications.

The program allows performing the following actions with the controller:

- Setting the maximum voltage (for each channel, here and below);
- Setting alarm-limits of temperature;
- Setting the thermistor:
 - Getting the current settings:
 - Type and function of calculating temperature $T = f(R)$;
 - Coefficients of the function of calculating temperature;
 - Nominal value of the thermistor used;
 - Checking the current measurements;
 - Entering new values of the coefficients;
 - Possibility to select from a list of **more than 50 predefined characteristics** of thermistors;
 - Calibration of temperature measurement channel;
 - Starting with Version 334 of the Program:
 - The measuring channel is calibrated by the manufacturer for all possible limits of measurement;
 - A user can simply select a type and size of thermistor. After that the Program will automatically install all the necessary settings of the Controller;
- Configuring the startup mode of the controller after powering up;
- Setting the conditions for signaling that alarm set point is achieved;

- Setting the communication parameters;
- Setting response to signals from digital input and digital output control¹;
- Storage and restoration of controller parameters;
 - The conversion of structures stored in the memory is supported, when taking a new version of the Controller software;
 - A visual preview of all the settings stored in the Controller nonvolatile memory is enabled;
 - The table of thermistor settings can be viewed for all the limits of measurements²;
- Reading and writing of programs of time regulation;
 - Editing the programs in the Controller;
 - Saving into a file, downloading from a file;
- Adjustment of the PID-regulation:
 - Automatic selection of proportional, integral and differential coefficients for each channel;
 - Possibility of manual selection of coefficients;
 - Plotting the setpoint attainment at different coefficients, analysis of results;
 - Saving results to a file, to the clipboard;
 - Printing;
- Terminal:
 - Possibility of communicating with the Controller by a system of commands³;

¹ When using the digital board DX5107.

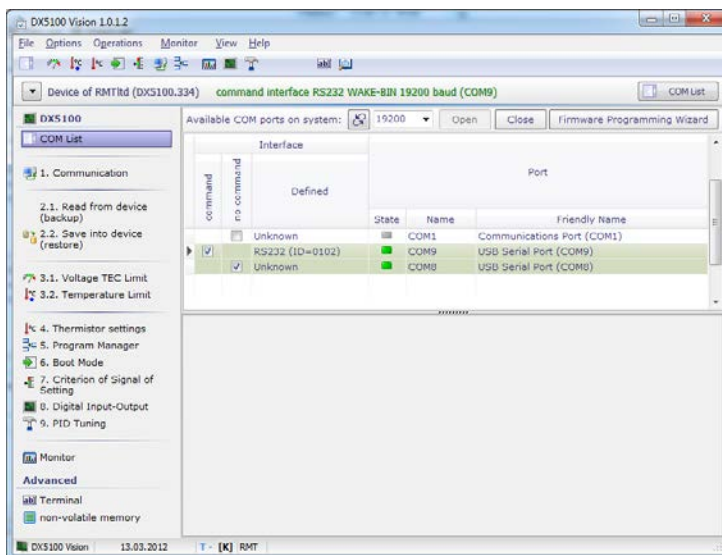
² Starting with Version DX5100.334.

³ See the document «DX5100 Table of Commands v3.5»

- Saving sets of commands in a file;
- Conversion of files with commands from the program "Terminal";
- Usage of a set of commands as macros;
- Loop Macros;
- Upgrading of the Controller programs:
 - Update Wizard;
 - Downloading the update files from the manufacturer's website;
- Monitoring:
 - Using the command/non-command interface;
 - real-time charting of the following telemetry parameters:
 - Total supply voltage of controller;
 - Voltage per channel;
 - Current per channel;
 - Temperature per channel;
 - Displaying controller status (mode, setpoint);
 - Changing the mode during monitoring;
 - Saving of telemetry results in a file;
 - Possibility to change temperature setpoint without restarting PID⁴.

⁴ Starting with the Version DX5100.333.

1.1. Program Main Window



The main window can be divided into several parts:

- Main menu⁵;
- Main toolbar;
- Left toolbar;
- Workspace of window.

In the menu "View" you can enable/disable both the toolbars.

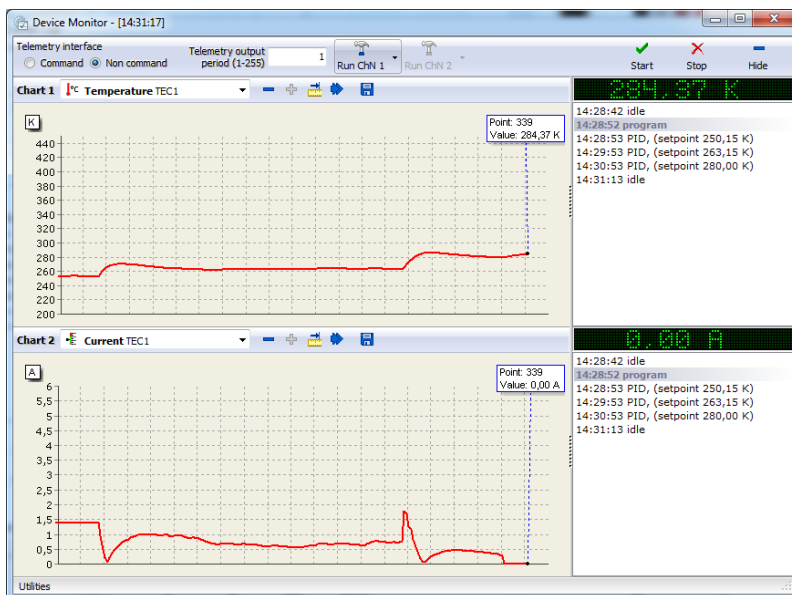
⁵ Numbers of the menu items correspond to the chapters in this document, and determine the desired consistency of the instrument operation.

1.2. Monitor Window

The monitor window allows a user to:

- control the operation of the controller;
- start and stop all the supported modes;
- observe the change of telemetry data in real time;
- store and analyze the data obtained.

In contrast to the main window, there are no settings, only the current management and display of information. For a detailed description, see the chapter "**Monitor**".

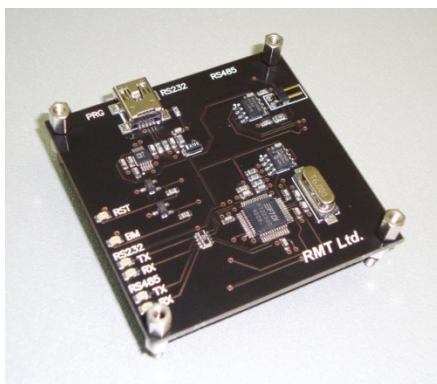


2. DESCRIPTION

3. SETTING PARAMETERS OF COMMUNICATION

3.1. Controller to Computer Connection Options

- Connect the device to the RS-485 and (or) to the COM-port with the RS-232 cable (see the set kit for the digital control board). Connect to the digital board connector XP6 or XP8, respectively.
- Connect the power supply. The power supply must provide $12\text{ V} \pm 10\%$.
- The power supply is connected to the connector XP1 of each power board DX5102, or to the connector XP5 of the power board DX5105.



The controller may be connected to the computer in several ways:

1. Using the RS-232 cable supplied.

Connection is via the connector XP8 of the digital board.

2. With the converter interface DX5106.
 - a. Interface RS485 signals generation
 - b. Interface RS232 signals generation

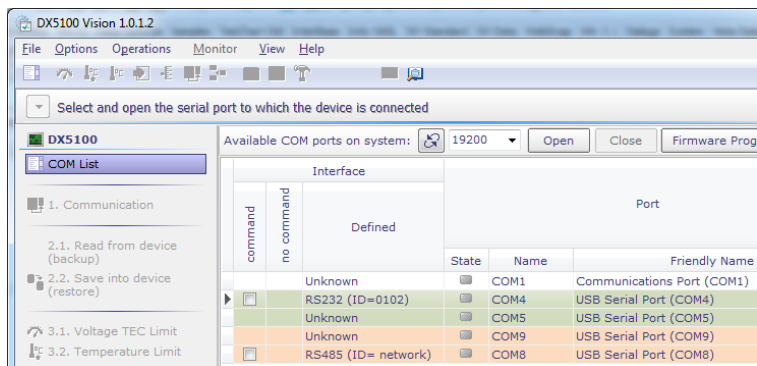
- c. DX5101 programming signals generation
 - d. LED indication of the interfaces status and of programming signals status
 - e. For external commutations there are connectors located on one side of the board.
With the converter interface DX5104.
 - f. Interface RS-485 signals generation
 - g. Galvanic isolation of the interface RS-485 from the computer
 - h. Protection against reverse power
 - i. Functioning without a supply voltage (no galvanic isolation)
3. You can also use other converters of the interface RS-232/RS-485.

The connecting procedure is described in more detail in the paper "DX5100 Technical Manual". In case DX5106 is used, you need to install the drivers from those supplied or from the manufacturer's web site - see "FTDI Drivers Installation Guide for VISTA.pdf" and "FTDI Drivers Installation Guide for WindowsXP.pdf".

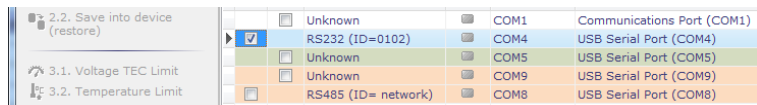
3.2. How to Adjust Computer Serial Ports

By default, the controller is supplied with the settings rate 19200 kbps. When you run the program, it scans the serial ports of the system and determines the connected devices of DX5100.

The scan results can be seen on the tab "**COM List**". When the device is detected, the Program displays the name of the "command" interface and its identifier. When using the interface converter DX5106, the Program will also identify the "non-command" interface, and a pair of interfaces belonging to the same controller will be highlighted by the same color.



Now you must select the device to work with. The logic of the Program involves working with one controller at a time, so flags of the "command" interface choice work like radio buttons.



After the "command" interface selection, there are the following variants:

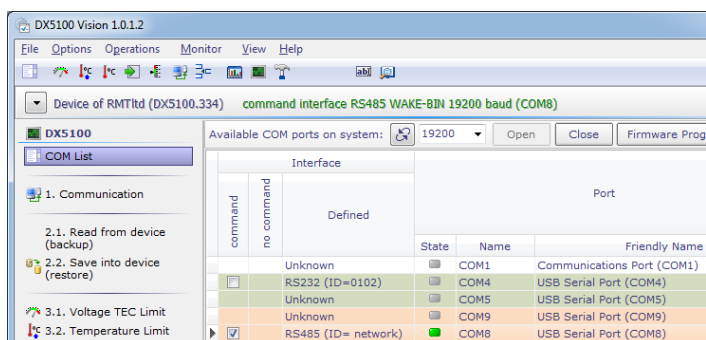
1. If the RS-232 interface is "command", all the free ports defined by the Program as "Unknown" will be available for a "non-command" interface. If you use the interface converter DX5106, you can choose a port highlighted by the same color. Otherwise, you should select the port to which "non-command" interface is connect. You may as well not choose a "non-command" interface.

<input type="checkbox"/>	Unknown	<input type="checkbox"/>	COM1	Communications Port (COM1)
<input checked="" type="checkbox"/>	RS232 (ID=0102)	<input type="checkbox"/>	COM4	USB Serial Port (COM4)
<input checked="" type="checkbox"/>	Unknown	<input type="checkbox"/>	COM5	USB Serial Port (COM5)
<input type="checkbox"/>	Unknown	<input type="checkbox"/>	COM9	USB Serial Port (COM9)
<input type="checkbox"/>	RS485 (ID= network)	<input type="checkbox"/>	COM8	USB Serial Port (COM8)

2. If the RS-485 interface is "command", the choice of a "non-command" interface will not be available.

	Unknown		COM1	Communications Port (COM1)
<input type="checkbox"/>	RS232 (ID=0102)		COM4	USB Serial Port (COM4)
	Unknown		COM5	USB Serial Port (COM5)
	Unknown		COM9	USB Serial Port (COM9)
<input checked="" type="checkbox"/>	RS485 (ID= network)		COM8	USB Serial Port (COM8)

Press the button **"Open"**.

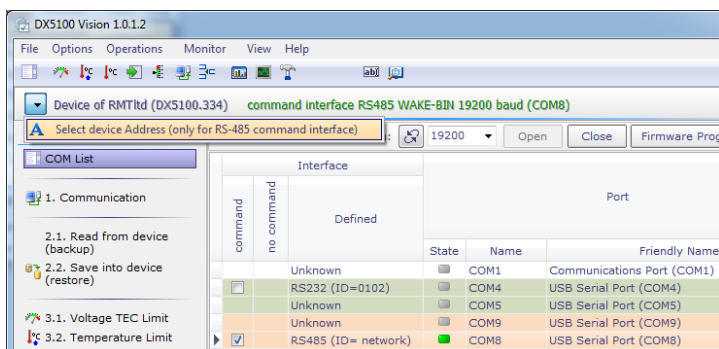


After a successful communication, the program displays information about the controller, a version of the program used, and communication parameters.

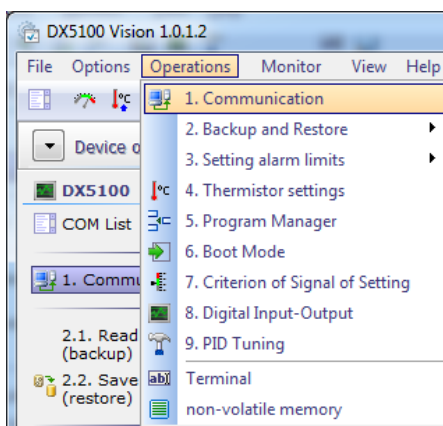
The field **"State"** is an indicator and may have the following values:

- Grey (port available, you can open it);
- Red (port is unavailable, for example, it is opened by another program);
- Green (port is available; it is opened in our program).

For the case when the RS-485 interface is "command", the possibility of selecting a device address in the network is added⁶:



3.3. Setting Communication Parameters of Controller DX5100



⁶ The protocol (WAKE) used to communicate with the Controller, supports addressing of devices from 1 to 127.

To configure the communication settings in the program the tab "**Communication**" is designed.

It can be chosen either from the main menu or clicking the corresponding button in the toolbar.

On this tab there are the controller settings for communication with the computer:

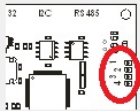
- Address;
- Extended address (not available for editing);
- Selection of the mode WAKE (not available for editing);
- Selection of the command interface;
- Choice of the connection rate;

command interface RS232 WAKE-BIN 19200 baud Apply

Address	<input type="text" value="0x5"/>	Command Interface	RS-232	Wake mode	
Extended Address	<input type="text" value="0200"/>	BaudRate	19200	WAKE mode	BINARY

Connection

The device can be adjusted to different rates of communication. Each of the interfaces available can be command. The WAKE data format may be either symbol or binary. During 1 sec after the Device switched on, the photodiodes indicate the rate of exchange via the interfaces and the mode WAKE as shown below.



There are four LEDs on the Digital Control Board (LED 1...LED 4).

Just after switching ON the Device, during 1 sec LEDs show the exchange rate per interface and the mode WAKE corresponding to the Table below

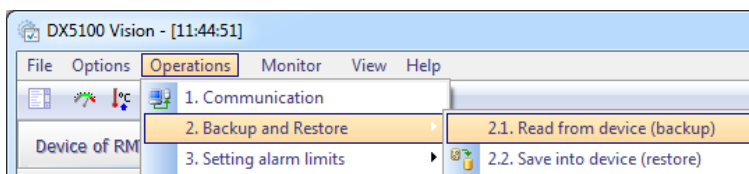


Attention! Take caution when changing the connection parameters. Changes will take effect after rebooting the controller. Next time you connect to the controller you will use the new settings.

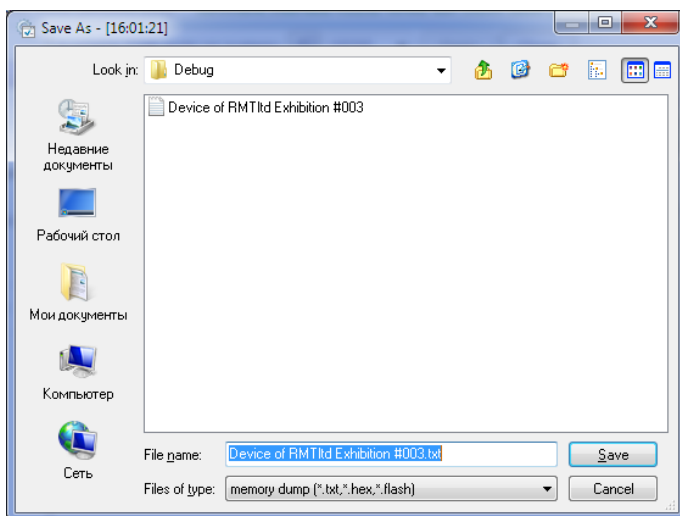
4. HOW TO BACKUP/RESTORE OF PARAMETERS

The operating parameters of the controller, stored in nonvolatile memory of the digital control board, can be provided for the backup (storage) and, if necessary, restore.

It is advisable to save the parameters before the procedures changing them, as well as after their completion. Such procedures, for example are calibration, storage of thermistor polynomial, etc.

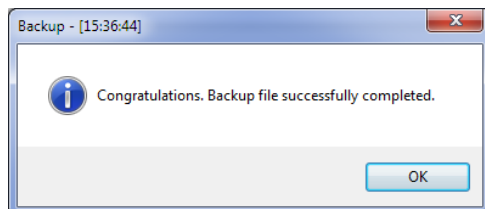


4.1. Backup procedure

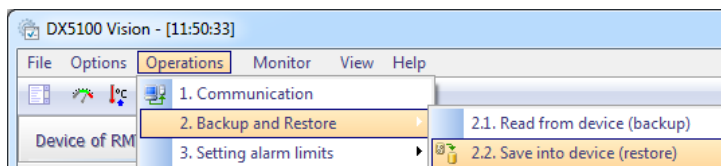


The program suggests that you should save a file with the controller settings. The file name is proposed to be "**Device information**", but you can use another name.

As a result of the procedure, the configuration file will be saved.

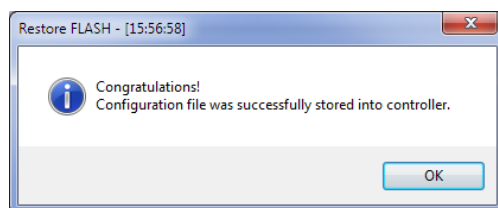
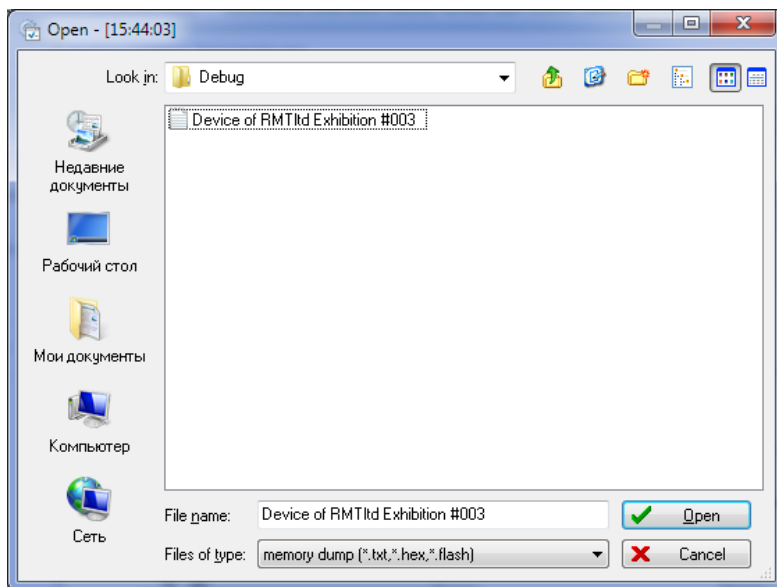


4.2. Procedure of Restoring from Backup






When selecting a relevant item, the program will suggest that you should select a configuration file previously saved.

Here we should bear in mind that if you have a configuration file from another device, i.e., "**Device identifier**" in the file differs from the reading of the controller, the program will notify you and the operation may be aborted.



4.3. Additional Possibilities. Non-Volatile Memory

In order to quickly estimate the Controller parameters that determine the logic of its operation, you can use the tab **"non-volatile memory"**:

non-volatile memory   

☐ <= v.333 ☒ >= v.334 Thermistor table

Address Info #S210 19.01.2012

S/N Fast measurements

DAC calibration coefficients

ADC filters

Registers calibration offset

U TEC Max

PID coefficients

Z-meter (current, R, Z, tau)

Boot (mode, #prg, time)

Temperature Limit (max,min,time)

Criterion of Signal (ON,OFF,Deviation)

PGA

Thermistor settings (degree, current, coef.)

A0	<input type="text" value="3.461840E+01"/>	A0	<input type="text" value="3.461840E+01"/>
A1	<input type="text" value="2.031834E-01"/>	A1	<input type="text" value="2.031834E-01"/>
A2	<input type="text" value="6.715181E-05"/>	A2	<input type="text" value="6.715181E-05"/>
A3	<input type="text" value="-4.899303E-08"/>	A3	<input type="text" value="-4.899303E-08"/>
A4	<input type="text" value="2.056550E-11"/>	A4	<input type="text" value="2.056550E-11"/>
A5	<input type="text" value="-3.376398E-15"/>	A5	<input type="text" value="-3.376398E-15"/>

WAKE (RS232/485, SYM/BIN, BAUD) Digital out Digital PRG#

U T-regulation Checksum

T - [K] RMT

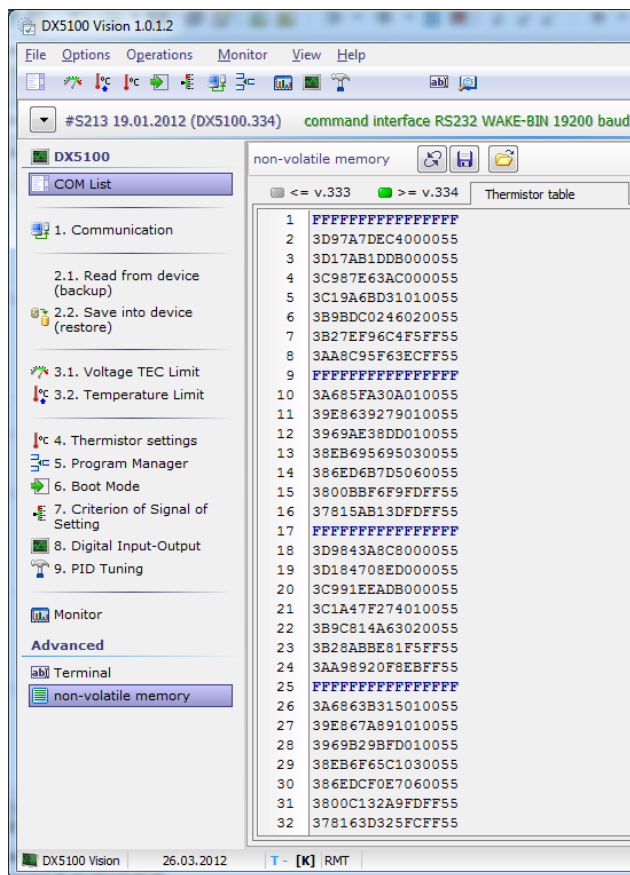
Functions of the buttons:

- **"Reload FLASH"**- read data from the controller;
- **"Save to File"**- save data to disk, with possibility to a later load, see the previous section;
- **"Load from File"**- load the file, for viewing only, without the possibility of storage in the controller. For saving it you have to use the recovery procedure, see the previous section

Tabs functions:

- Tabs with version numbers (versions differ by the structure size and set of parameters).
- The tab **"Thermistor table"**- starting with version 334 of the firmware, the manufacturer provides the controller initial

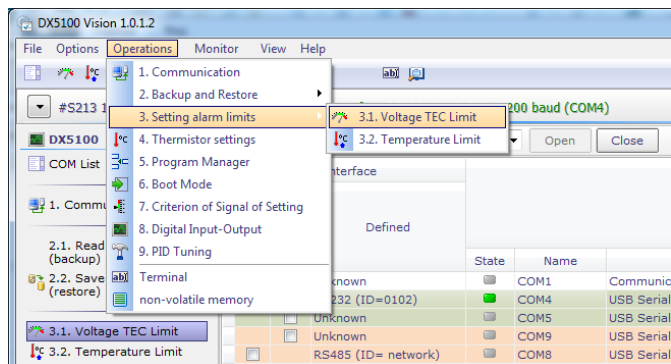
configuration to handle all possible thermistor nominals (see the documentation *TEC Controller DX5100 Technical Manual 2.13 Accuracy*).



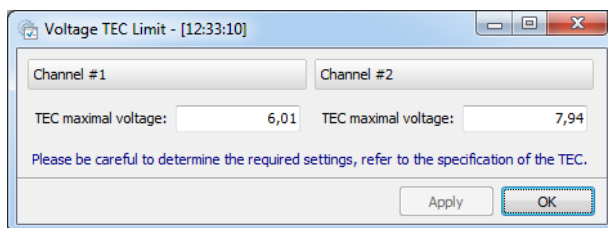
The figure shows the properly filled in structure of thermistor settings. The indication of the correct filling is the last byte in each row: if it is equal to 55h, the setup is made correctly, and you can use the default settings when selecting a thermistor. Details of thermistor configuration procedure are described in Section 4 of this guide.

5. SETTING ALARM LIMITS

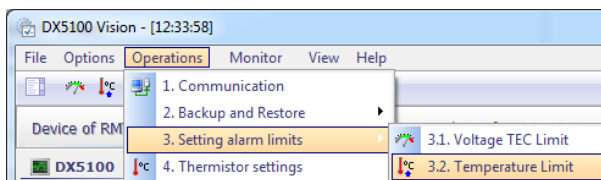
5.1. Setting Limits of TEC Voltage



Important! To prevent a thermoelectric cooler (TEC) failure, it is necessary to set correct limit values of TEC voltage. Refer to the TEC specifications.



5.2. Setting Temperature Limit Values

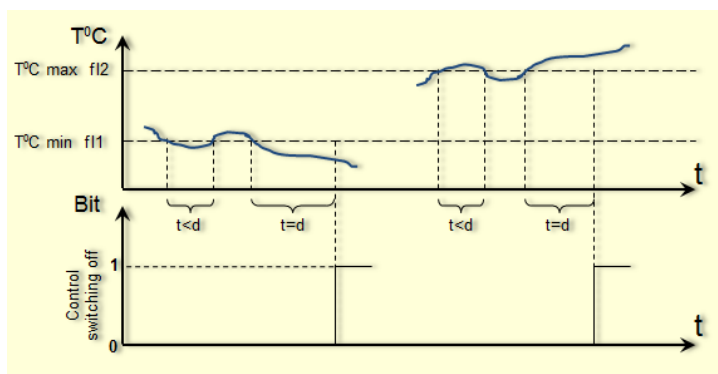


The tab "**Limiting temperatures**" allows you to specify the maximum and minimum temperatures. If temperature is beyond these limits within the time specified, a corresponding alarm is on and PID control is off, - the alarm conditions.

Writing Limiting Temperatures

Channel #1	Channel #2	Description
Min T (f1): 203.00	Min T (f1): 203.00	- Store values of maximal and minimal temperature. Breaking these limitations causes correspondent signal and switching off the PID-Controller – conditions of emergency. Examples: If f1=223.0, f2=363.0, d=10 then: The signal of the temperature limits breaking appears 10 s after temperature drop below 223 K, or 10 s after temperature rise above 363 K
Max T (f2): 403.00	Max T (f2): 403.00	
Time limit (d): 10	Time limit (d): 10	
<input type="button" value="Apply"/>		

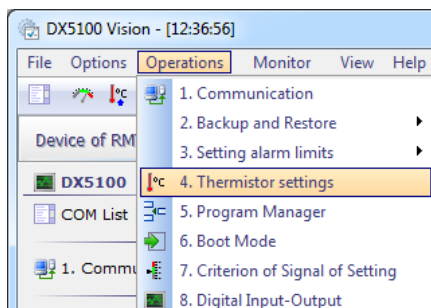
The meaning of the parameters to be set is explained by the following picture:



6. THERMISTOR SETTING



Attention! *It is strongly recommended to back up the parameters of the controller before adjusting the thermistor. See "**Backup/restore of parameters**".*



6.1. Description of Procedure

The procedure consists of finding and storing parameters of the corresponding ADC channels in the non-volatile memory for each temperature sensor.

The procedure for setting a thermistor can be divided into several stages:

- Determination of input data:
 - thermistor type,
 - nominal,
 - choice of function type⁷ to calculate temperature $T = f(R)$,

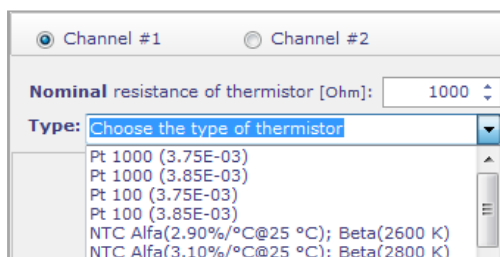
⁷ The controller allows using 2 types of functions for calculating temperature versus resistance:

- • Polynomial 5th order function: $T = A_0 + A_1R + A_2R^2 + A_3R^3 + A_4R^4 + A_5R^5$

- calculation (or entering) coefficients,
- storage of coefficients in controller.
- Calibration of temperature measurement channel:
 - Controller firmware version <= 333
 - calibrating resistors supplied⁸ should be used,
 - cable of four-wire resistance measurement circuit.
 - Controller firmware version >= 334
 - You can choose "automatic" calibration;
 - You can calibrate in the manual mode, as in the version 333;
- Verification of measurement results;

6.2. Determination of Input Data

To ease the setup procedure, the program offers a choice of predefined characteristics of thermistors. The list includes the parameters for 4 platinum thermistors and 47 NTC thermistors with different alpha and beta coefficients.



-
- *Steinhart-Hart equation:* $\frac{1}{T} = A + B \ln(R) + C \ln(R)^3$

⁸ During calibrating, the program will inform you on the required nominal values (depending on thermistor type). You can also use other resistors of similar resistance values.

If you have chosen a thermistor from the list, you can go to the next section, "**Calibration of temperature measurement channel**".

You may check the results of calculations by using the button "**Calc**".

R [Ohm]:	0,00	Calc
T [K]:	273	

If necessary, if your thermistor is not listed, you can use the point "**User defined**".

The program will prompt you to choose a type of function for calculating temperature and operating temperature range⁹.

NTC Alfa(4.70%/°C@25 °C); Beta(4300 K)	
NTC Alfa(4.70%/°C@25 °C); Beta(4450 K)	
NTC Alfa(5.00%/°C@25 °C); Beta(4600 K)	
NTC Alfa(5.20%/°C@25 °C); Beta(4830 K)	
NTC Alfa(5.30%/°C@25 °C); Beta(5000 K)	
User defined	

<input checked="" type="radio"/> Channel #1	<input type="radio"/> Channel #2
Nominal resistance of thermistor [Ohm]: 10000	
Type: User defined	
T = F(R)	
<input type="radio"/> Polynomial <input checked="" type="radio"/> Steinhart and Hart equation	
Select operating temperature range (K)	
From: 273.15	To: 328.15
<input checked="" type="checkbox"/> Include ambient temperature	

When you select the **Steinhart-Hart** equation, you will be asked to enter 3 points of the dependence of temperature on resistance.

R(T)	
T ₁ : 273.15	R ₁ : 35670.00
T ₂ : 298.15	R ₂ : 10000.00
T ₃ : 328.15	R ₃ : 2710.00

This information is usually provided by a thermistor manufacturer. The extreme points should be at the edges of the working range,

⁹ The ambient temperature must fall within the operating temperature range, but if you are sure it does, you can disable the checking of this condition.

while the average - in the middle. The distance between points must be at least 10 degrees.

When choosing a **polynomial** function of temperature calculation you are supposed to enter the coefficients.

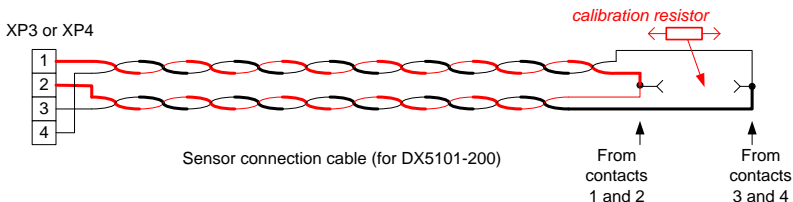
That's enough to start the calibration of temperature measurement channel. You may check the results of calculations of the function of calculating temperature by pressing "**Calc**".

R(T)		Important! The polynomial should be calculated for a needed temperature range. Polynomial factors are to have an exponential form with accuracy 1E-6 (six digits).
A₀:	3.43351e+01	
A₁:	1.854357e-01	
A₂:	1.058491e-04	
A₃:	-8.082131e-08	
A₄:	3.395362e-11	
A₅:	-5.603e-15	

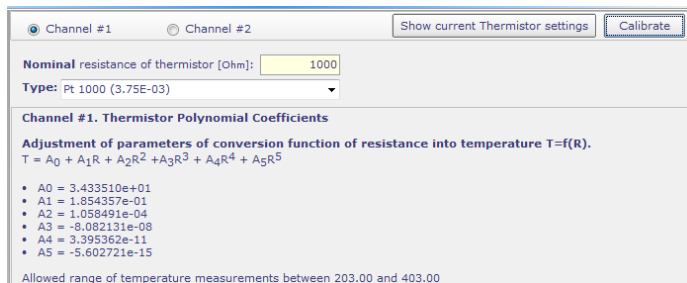
6.3. Calibration of Temperature Measurement Channel

6.3.1. Controller Firmware Version <= 333.

Connect the cable of four-wire resistance measurement circuit to the XP4 connector of the board DX5101-200. At the end of the cable there should be a connector that allows changing quickly the calibration resistors.

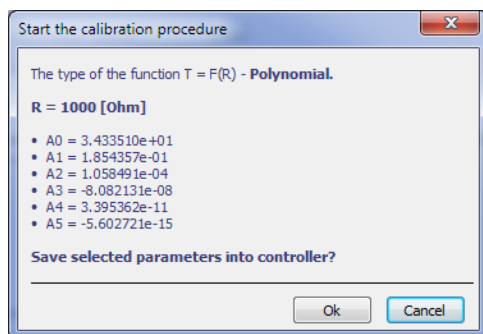


Now we can proceed with the calibration. For example, consider a commonly used platinum thermistor **Pt 1000 (3.75E-03)**.

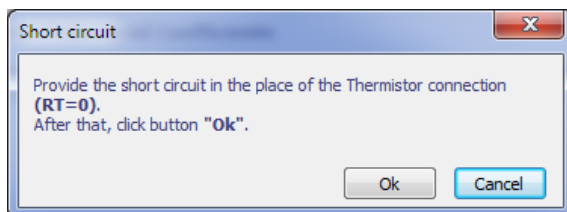


Click the button "**Calibrate**".

The program will ask for the confirmation.



After the positive answer the calibration procedure is started. The program asks to connect the jumper in the place of the thermistor (the connector of the cable of the four-wire resistance measurement circuit).

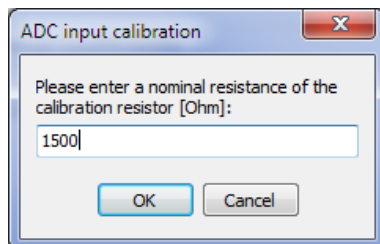


Set the jumper, click "**Ok**". The program will do the zero calibration and ask you to connect the calibration resistance of the closest nominal, but not greater than the value calculated.



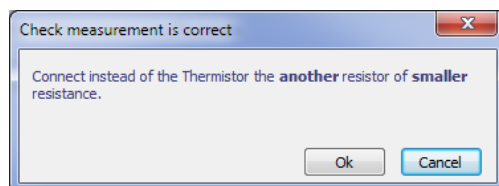
Connect the resistance 1500 Ohm (supplied). Click "**Ok**".

The program will ask for the nominal value of the resistor connected (Ohm).



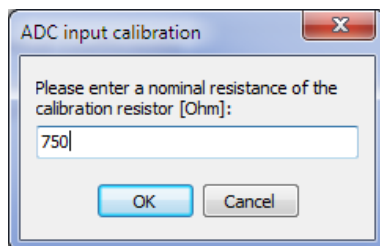
Write 1500 and click "**Ok**".

The program prompts you to connect another resistor of a smaller value.



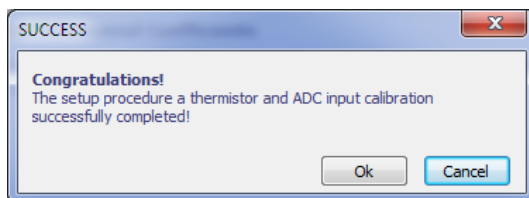
Connect the resistor 750 Ohm.

Click **"Ok"**.



The program will ask for the nominal value of the resistor connected again (Ohm).

Write 750. Click **"Ok"**.

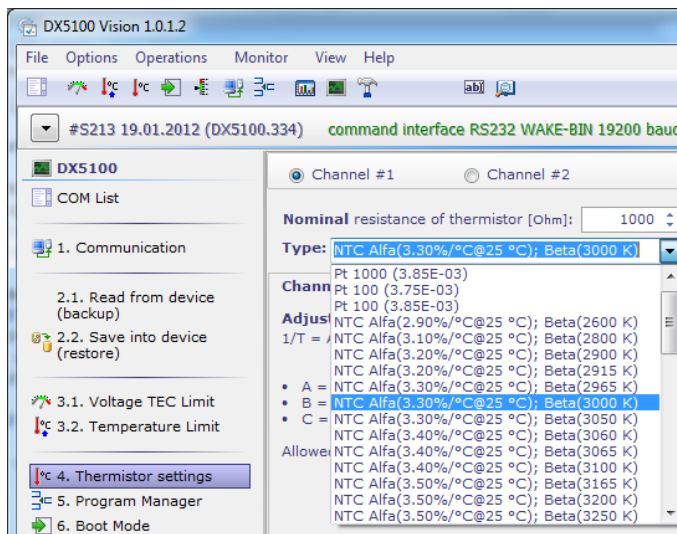


The procedure of setting the thermistor parameters and calibrating temperature measurement channel is completed¹⁰.

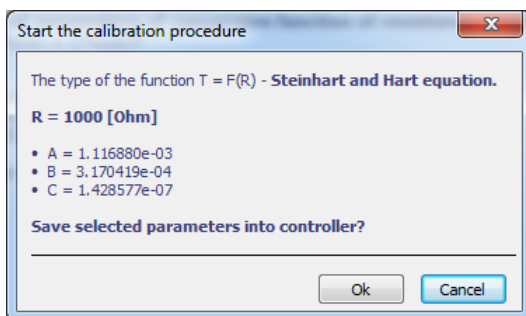
¹⁰ If you failed to do something, you can always carry out the calibration procedure again, or reset the controller parameters from the backup file, see Chapter **"Procedure of Restoring from Backup"**.

6.3.2. Controller Firmware Version >= 334

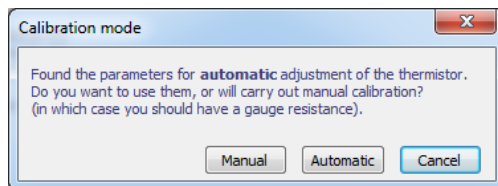
Since the calibration procedure of the measurement channel has been carried out by the manufacturer, you need only select your thermistor type and value:



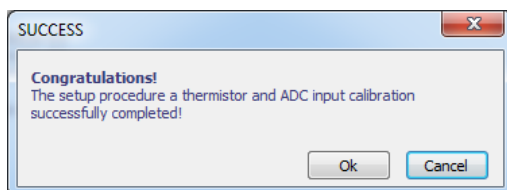
After clicking the "Calibrate" button and confirming the start of the calibration procedure:



You will be prompted to select a mode:



- The manual mode is described in Section 4.3.1
- In the automatic mode, the parameters set in the controller will match your thermistor.



6.4. Viewing Current Settings of Thermistor. Checking Measurements.

If necessary, you can get the current thermistor settings and assess the accuracy of measurements. Click the button "**Show current Thermistor settings**".



The program will read from the controller a type of the function used and its coefficients, and try to identify a thermistor connected. In the case of coincidence of the coefficients with those predefined, on the following information will be displayed the screen:

☒ Channel #1
 ☐ Channel #2

Show current Thermistor settings

Calibrate

Nominal resistance of thermistor [Ohm]:

Type:

Channel #1. Thermistor Polynomial Coefficients
Adjustment of parameters of conversion function of resistance into temperature
 $T=f(R)$.
 $T = A_0 + A_1R + A_2R^2 + A_3R^3 + A_4R^4 + A_5R^5$

- $A_0 = 3,433510e+01$
- $A_1 = 1,854357e-01$
- $A_2 = 1,058491e-04$
- $A_3 = -8,082131e-08$
- $A_4 = 3,395362e-11$
- $A_5 = -5,602721e-15$

 Allowed range of temperature measurements between 203,00 and 403,15

Pt 1000 (3.75E-03)

Check function of approximation

R [Ohm]:

T [K]:

Calc

Measurement of the resistance of the thermistor

ADC [hex]:

R [Ohm]:

T [K]:

Measurement

If the coefficients are not identical (an unknown thermistor), the program will build a graph of temperature versus resistance, and determine the thermistor nominal by the obtained coefficients (for platinum thermistors at $T = 0^\circ\text{C}$, for NTC thermistors at $T = 25^\circ\text{C}$).

☒ Channel #1
 ☐ Channel #2
 Show current Thermistor settings
Calibrate

Nominal resistance of thermistor [Ohm]: 1000

 Type: User defined

Channel #1. Steinhart and Hart equation

Adjustment of parameters of conversion function of resistance into temperature $T=f(R)$.

$$1/T = A + B \cdot \ln(R) + C \cdot \ln(R)^3$$

NTC 10000 [Ohm] A = ?.% / °C @ 25 °C; B = ? K

- A = 1,305440e-03
- B = 2,146278e-04
- C = 9,187203e-08

NTC 10000 [Ohm] A = ?.% / °C @ 25 °C; B = ? K

 Check function of approximation

R [Ohm]: 0,00

 T [K]: 0,00

Calc

Measurement of the resistance of the thermistor

 ADC [hex]:

 R [Ohm]:

 T [K]:

Measurement

6.4.1. Verification of the function of temperature calculation

Using the input field for temperature or resistance in the block **"Check function of approximation"** you can verify if the calculated values agree with the experimental ones.

For illustration we use an example from the document

"Thermoelectric Cooler Controller DX5100. Quick Start Instruction".

R(T)

T ₁ :	273.00	R ₁ :	35670.00
T ₂ :	298.00	R ₂ :	10000.00
T ₃ :	328.00	R ₃ :	2710.00

Choose item **"User defined" → "Steinhart and Hart equation"**, set the nominal value 10,000 Ohm.

Enter three points from the table:

In the field **"R[Ohm]:"** enter the

R [Ohm]: 35670

 T [°K]: 0.00

Calc

resistance values from the table, click the button "**Calc**". Repeat the calculation for each point of the original table.

Obtain the results of temperature calculation:

Initial data		→	Calculated $T = f(R)$	
$R[\text{Ohm}]$	$T[\text{K}]$		$R[\text{Ohm}]$	$T[\text{K}]$
35670	273		35670	273
27230	278		27230	278
20960	283		20960	283
16260	288		16260	288
12710	293		12710	293
10000	298		10000	298
7920	303		7920	303
6320	308		6320	308
5070	313		5070	313
4090	318		4090	318
3320	323		3320	323
2710	328		2710	328

It is also possible to carry out a reverse calculation: enter temperature, and calculate resistance.

R [Ohm]:	<input type="text" value="0.00"/>	<input type="button" value="Calc"/>
T [°K]:	<input type="text" value="273"/>	

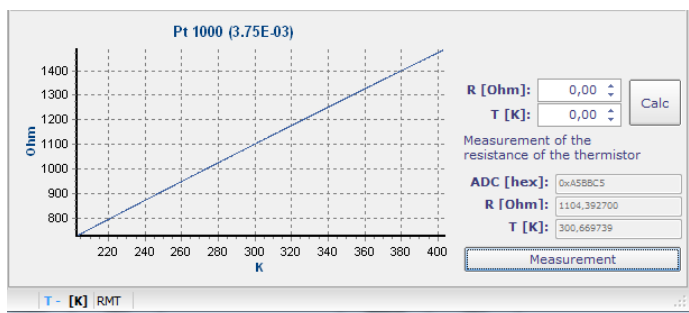
In the field "**T[K]:**" enter the temperature from the table, click the button "**Calc**". Repeat the calculation for each point of the original table.

Initial Data		→	Inverse Calculation of R	
$R[\text{Ohm}]$	$T[\text{K}]$		$R[\text{Ohm}]$	$T[\text{K}]$

35670	273	35670	273
27230	278	27242	278
20960	283	20970	283
16260	288	16266	288
12710	293	12709	293
10000	298	10000	298
7920	303	7922	308
6320	308	6316	308
5070	313	5067	313
4090	318	4090	318
3320	323	3320	323
2710	328	2710	328

6.4.2. Checking Temperature Measurement Channel

The block "**Measurement of the resistance of the thermistor**" allows checking the temperature measurement channel.



Connect the resistor with which the calibration was done.

Click "**Measurement**", as a result we obtain the current values for checking.

The main field here is "**ADC [hex]**".

The controller applies a 24-bit ADC. Hence, the full scale (the nominal value of the resistance, which we entered in the calibration) corresponds to the value FFFFFFFh. It should be close to this value, but not equal, otherwise it will be perceived as an overflow.

For checking, we carry out the measurements about 10 times and observe this parameter.

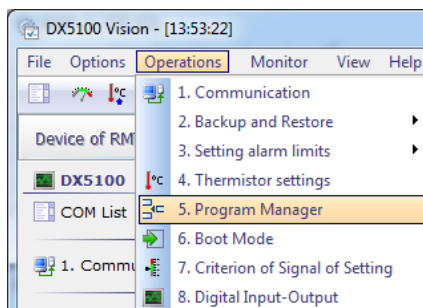
7. PROGRAM MANAGER

The Controller implements the operational mode **"Program"**. It allows a various control (stop of regulation, T-regulation, PID control, maintaining a constant voltage) in time. Programs are stored in the controller nonvolatile memory.

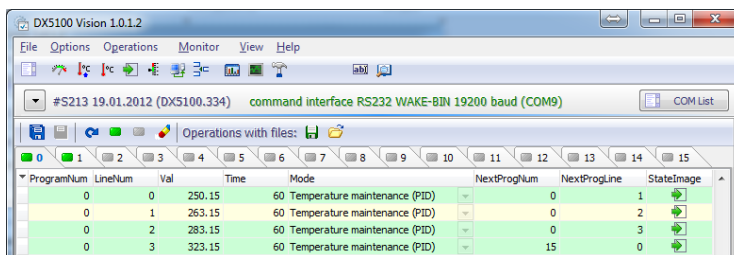
In addition to direct control by the program (here we mean the launch of the program from your computer), the controller will also enter this mode when:

1. Autostart after power up, see the Chapter **"Autostart adjustment"**;
2. Upon receiving the signal from the outside, see the Chapter **"Digital Input Control. DX5107"**.

To edit a program of regulation in time there is a tab **"Program manager"**.

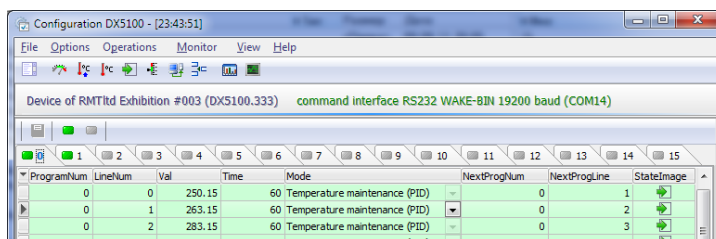


The controller supports 16 programs, 50 lines each:

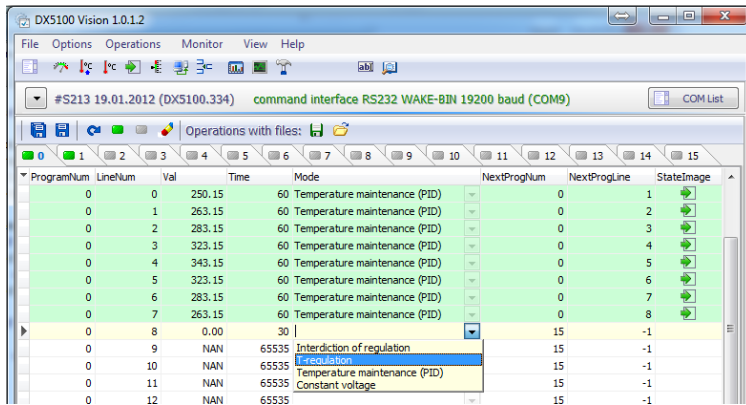


The tabs from 0 to 15 correspond to the programs in the controller, the green indicator on the tab of the program indicates that the program is available. The controller can auto-switch to this program on the signal from the digital board¹¹.

You can edit lines of the program:



¹¹ For more details see "**Termoelectric Cooler Controller DX5100 Technical Manual**"



The first two fields "**ProgramNum**" and "**LineNum**" cannot be edited.

The field "**Val**" is a field of the type float and stores the setpoint for the control command.

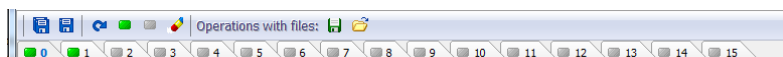
The next field "**Time**" is the time, in seconds, during which the mode given in the line of the program will run.

The field "**Mode**" actually is a mode (stop of regulation, T-regulation, PID control, maintaining a constant voltage).

The fields "**NextProgNum**" and "**NextProgLine**" contain the number of a program and of a line, to which the control will pass after the period "**Time**".

The field "**StateImage**" is a reference one and marks the lines of the program, whose addresses of transitions to the next line are correct.

If the address to the next line is not correct, the controller stops control and passes to the mode "**IDLE**".

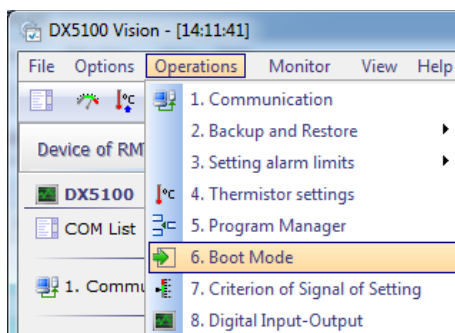


The tab has its own toolbar, which contains buttons, [as follows](#):

- The button "**Save All**" saves all the edited lines of the current program in the controller;
- The button "**Save current line**" changes the current line in the controller. The edited lines are highlighted in yellow. The button is only available on the line changed.
- The button "**Refresh**" updates a current program by data from the controller;
- Two buttons of changing the program status, change the controller status - a criterion of the program validity;
- The button "**Clear program line**" cleans a current line of the program;
- File operations:
 - Save a current program to a file, the file extension is *.csv;
 - Read a previously saved program from a file.

8. AUTOSTART CONFIGURATION

The controller can be configured into various operational modes of after powered.



1. Regulation disabled
2. Operation by program

3. Temperature control
4. PID-control
5. Maintaining of constant voltage

To select autostart, use the tab "**Boot Mode**". You can set necessary parameters for the different modes. The links provide reference information on possible modes of operation.

Start of regulation after restarting

Channel #1	Channel #2
Mode: Idle	Mode: Idle
Programm Start with program #: <input type="text" value="0"/> Delay before start (sec): <input type="text" value="0"/> <input type="button" value="Show prog"/>	Programm Start with program #: <input type="text" value="0"/> Delay before start (sec): <input type="text" value="0"/> <input type="button" value="Show prog"/>
T-Regulation T [K]: <input type="text" value="293.00"/>	T-Regulation T [K]: <input type="text" value="293.00"/>
PID Regulation T [K]: <input type="text" value="293.00"/>	PID Regulation T [K]: <input type="text" value="293.00"/>
Constant Voltage U [V]: <input type="text" value="0.00"/>	Constant Voltage U [V]: <input type="text" value="0.00"/>
<input type="button" value="Apply"/>	

Operation modes:

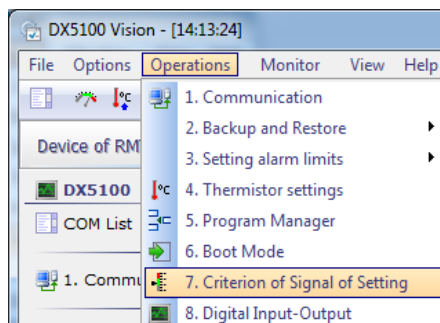
- [Constant Temperature \(PID-Regulation\)](#)
- [Constant Voltage](#)
- [Regulation according to program](#)
- [T-Regulation \(Relay\)](#)

9. CONDITIONS OF SIGNALING OF SETPOINT ATTAINMENT

The device implements PID temperature control. See Section 9. "PID Tuning".

It is necessary to establish criteria for setting and resetting signalization on reaching the desired temperature.

In addition to maintaining temperature constant, the device supports the temperature changing in time - cycling. This function is performed by automatically changing the setpoint in time in accordance with the program by a customer.



One can control and, if necessary, change the criteria for the set point achieved, by the tab "**Criterion of Signal of Setting**".

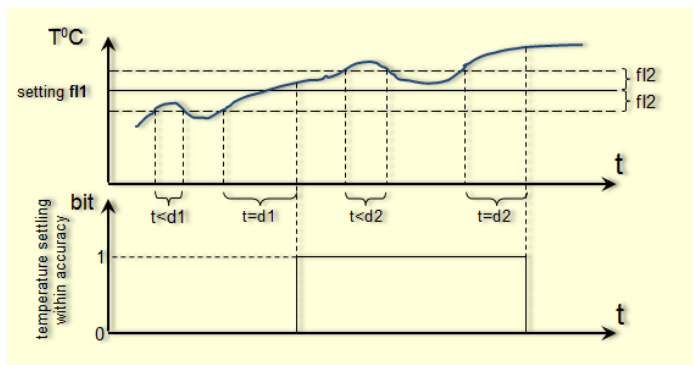
The parameters to be entered:

d1 - 2...255 - number of periods of PID, after which, if the temperature exceeded the set limits, the corresponding status signal is removed

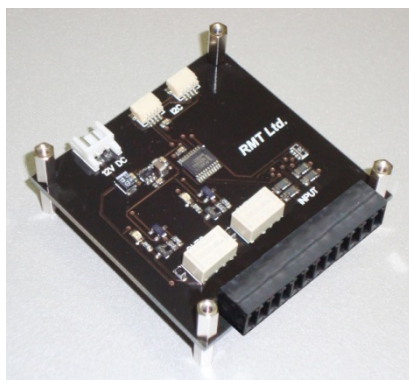
d2 - 2...255 - number of periods of PID, after which, if the temperature is within limits, a corresponding status signal is generated

The parameter **d2** should not exceed **d1**. Both the parameters must not be less than "2".

The meaning of the parameters set and of the status of digital outputs is displayed on the chart.



10. DIGITAL INPUT CONTROL (DX5107)

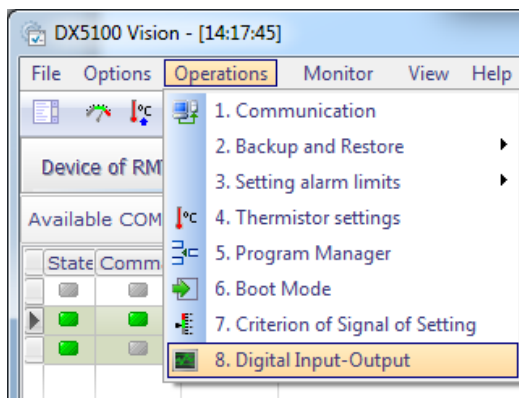


The board DX5107

When using the board DX5107 the controller can carry out the following:

- Control of digital outputs, depending on temperature of the channel (each channel). The board has a relay that triggers after a certain period of time after reaching the desired temperature.
- LED indication of digital output status.

- Transition to programs of channel control by signals arriving at the digital input. That is, using an external influence the controller can be transferred into different modes of regulation.
- Synchronization of the controller with the work of external devices, and external events processing.



Activating the settings tab, digital input-output

Digital Input-Output Board DX5107

Channel #1		Channel #2	
<input checked="" type="checkbox"/> Digital Input	<input type="checkbox"/> Digital Input	<input checked="" type="checkbox"/> Digital Input	<input type="checkbox"/> Digital Input
Program on falling Start with program # <input type="text" value="1"/>	Program on rising Start with program # <input type="text" value="0"/>	Program on falling Start with program # <input type="text" value="15"/>	Program on rising Start with program # <input type="text" value="15"/>
<input type="button" value="Show prog"/>	<input type="button" value="Show prog"/>	<input type="button" value="Show prog"/>	<input type="button" value="Show prog"/>
<input type="checkbox"/> Digital Output		<input type="button" value="Apply"/>	

By the board DX5107 the controller can carry out:

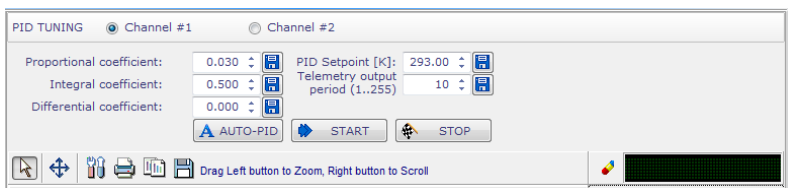
- Control of a digital output depending on temperature of a channel (for each channel). On the circuit board there is a relay which responds a certain period after of the set temperature is achieved.
- LED indication of the status of the digital output
- Transition to the programs of control of channels by the signals entering the digital input. I.e. manipulating from the outside, for example by buttons, it is possible to transfer the controller to various modes of regulation.
- Synchronization of work of the controller with work of external devices and with external events
- For external commutations there are connectors located on two sides of the board.

The marks **"Digital Input"** and **"Digital Output"** allow or prohibit the use of the digital input-output. For each channel, you can enter the program number to control the operation whenever the input signal changes.

The button **"Show program"** will switch you to the program manager tab and load the program the appropriate number.

11. PID TUNING

To fine-tune the PID controller the tab is provided:



Here you can set the PID controller coefficients, plot the setpoint attaining curve at different values of the coefficients. The controller has a built-in function **"AUTO-PID"**. When using it, you may get the initial values of the coefficients.

11.1. AUTO-PID FUNCTION

11.1.1. Introduction

The finding of optimum parameters of regulation of the given object is quite a delicate and long procedure. It is a consecutive experimental choice of parameters.

At the same time the quality of regulation of temperature depends on the optimality of the set parameters.

Attention! The parameters preset at the device delivery are formal and do not concern a real controlled object.

With the purpose of simplification of the PID controller optimum parameters choice in the TEC Controller DX5100 the function auto-PID is realized.

This function realizes the known Ziegler-Nichols algorithm. The user applying this function can use the obtained PID controller parameters for the subsequent accurate adjustment or apply the given parameters directly to the control of the object.

Attention! Before starting the auto-PID function it is necessary to set thermoelectric module maximal allowable voltage.

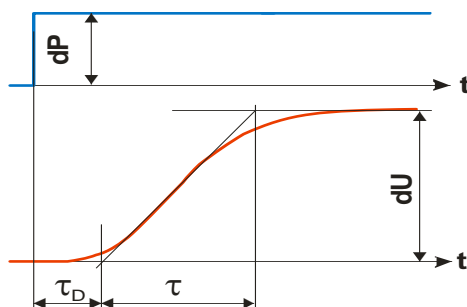
Attention! Nevertheless the manufacturer regards the parameters obtained with the help of the built-in auto-PID function as estimated and not quite optimum. It is recommended to check up the obtained parameters and if necessary to carry out a more accurate tuning of the PID parameters depending on the required quality of the thermal regulation.

11.1.2. Ziegler-Nichols Algorithm

In the Controller DX5100 one of the known algorithms of an automatic finding of the PID parameters is realized.

When the object of regulation is exposed to voltage (current) of a certain value the dynamic characteristic of the object of regulation is obtained as the parameters of its transition into a stationary condition at a given influence.

The figure below illustrates the dynamics of the process and the required parameters.



The required parameters are:

- Deadtime τ_D
- Process gain $K = \frac{\tau}{\frac{dU}{dP} \tau_D}$

The found values of the specified parameters by the Ziegler-Nichols method enable to estimate the PID parameters as:

Proportional coefficient	$1,2 \times K$
Integral coefficient	$2 \times \tau_D$
Differential coefficient	$0,5 \times \tau_D$

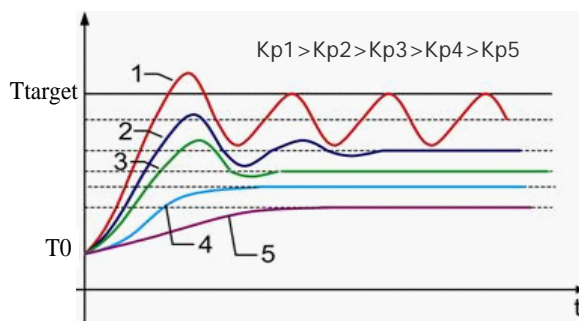
11.2. PID TUNING TIPS

The tuning quality can be estimated by different criteria: by the rate of achieving the setpoint, by the minimal overshoot, by accuracy of setpoint maintenance. The tuning quality can also be estimation by the transient process of achieving the setpoint. Recommendations for PID tuning by the form of the starting curve are given below.

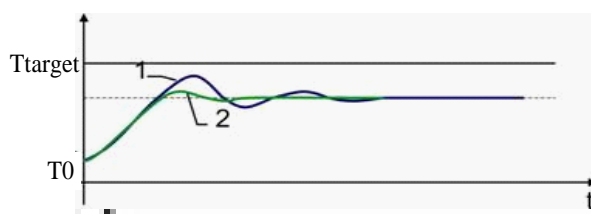
1. Set values of integrated and differential components equal to zero:

$$K_i=0; K_d=0$$

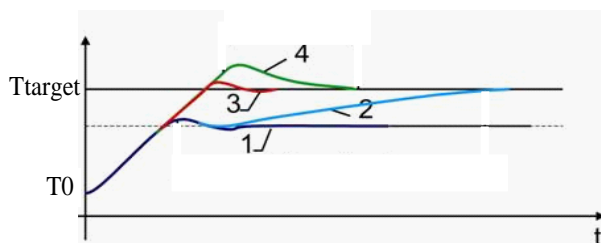
Modify the value of the proportional component factor so that the form of the transitive characteristic correspond that of curve 2 or 3.

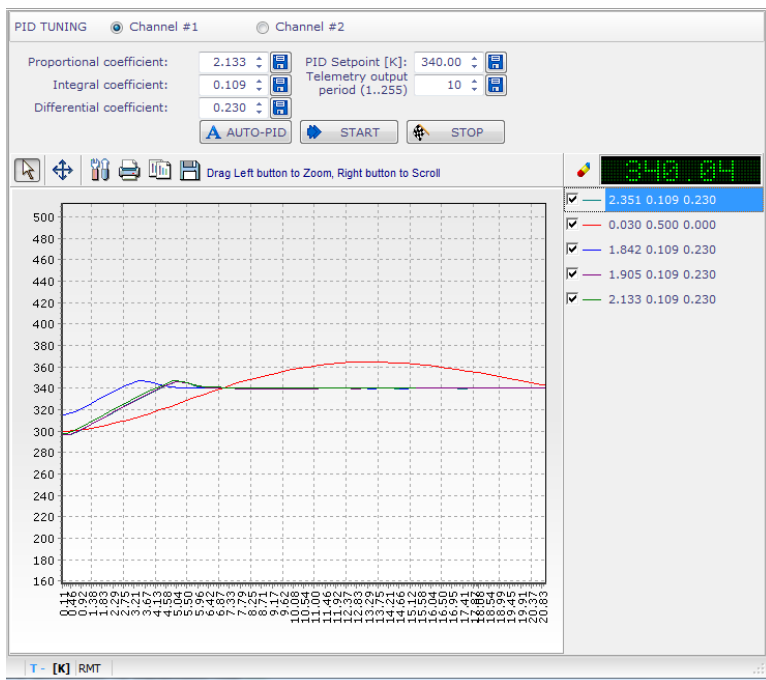


2. Modify the value of the differential component factor so that the form of the transitive characteristic correspond that of curve 2.



3. The integrated component is intended to remove a residual mismatch between the temperature value achieved in the system and the setpoint. Modify the value of the proportional component factor so that the form of the transitive characteristic correspond that of curve 3.





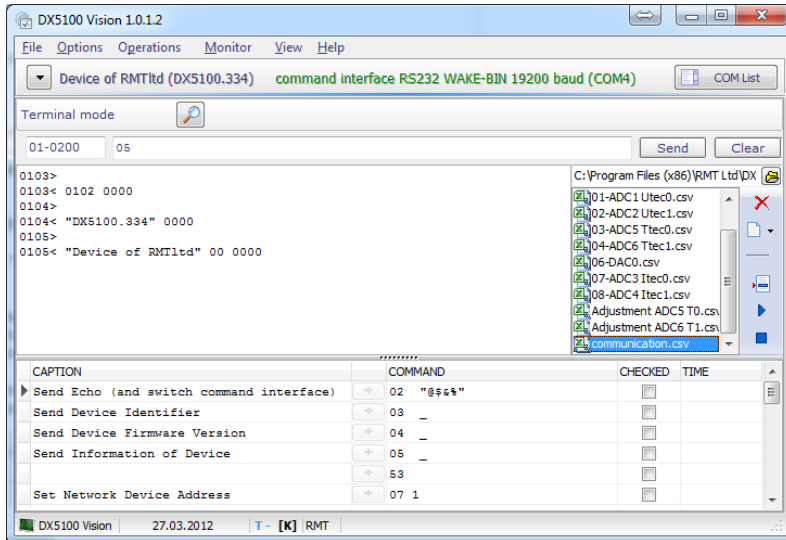
12. TERMINAL

12.1. How to Communicate with Controller via System of Commands¹²

For a maximum flexibility, the controller gives an opportunity of communicating in the terminal mode. For example, you can develop your own model of the controller behavior, regulation using various input parameters; you can change settings and coefficients affecting the controller logic, etc.

¹² See the documentation "DX5100 Table of Commands V320"

In the upper right window of the edit box specify the address of the controller and the extended address. The controller DX5100 extended address is always 0200.

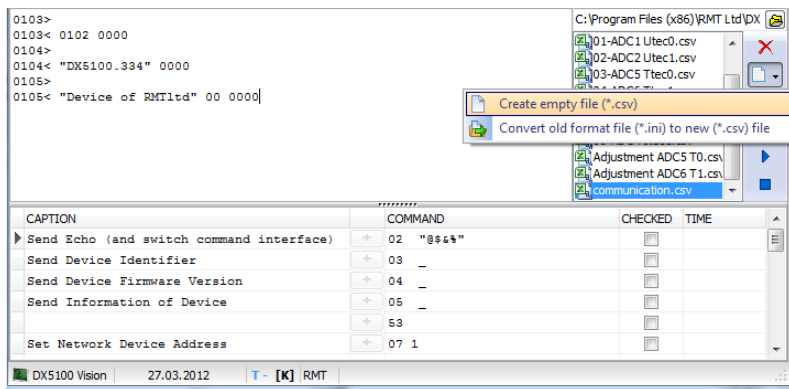


In the next entry field you can enter commands sent to the controller (in an appropriate format described in the controller documentation¹².

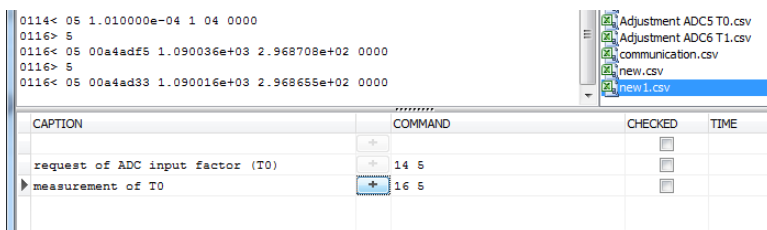
The output window displays information received from the controller in response to the command.

12.2. How to Save Sets of Commands in File

You can create new sets of commands and save them for later use. To do this, use the toolbar located to the right. The **"New"** button causes a pop-up menu:



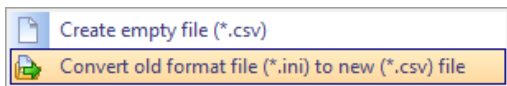
When creating a new file, you will be prompted for a filename. Then you can start typing commands line by line in the table.



To execute a command, you must click on the button "+" in the appropriate row of the table. When working with the table, you can use the context menu:

12.3. Conversion of Files with Commands from Program "Terminal"

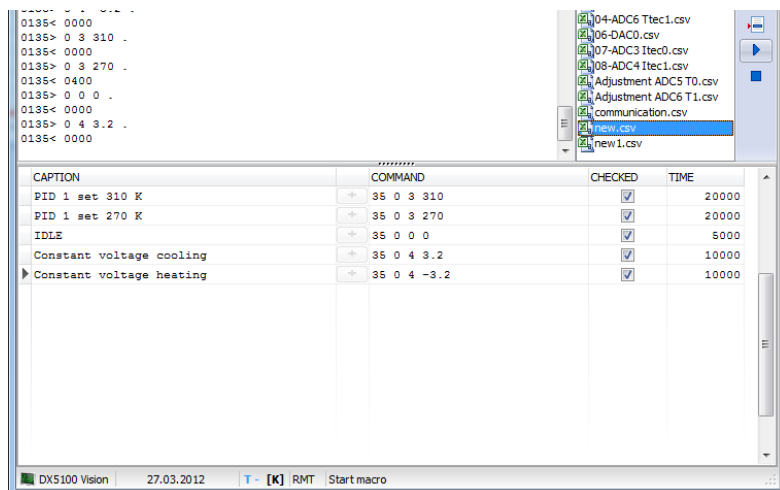
If you previously used the program "Terminal" you may have saved command files of the old format (*.ini). In this case, you can convert them for the use in DX5100 Vision.



12.4. Usage of Set of Commands as Macros



You can execute single commands, and can mark necessary commands, set the delay time (duration in milliseconds after the command execution) and click on the Start button on the right toolbar.



The commands will be executed sequentially from top to bottom.

12.5. Cyclic execution of Macros.

You can also perform sets of commands in cycle. To do it, it is necessary to click the button **"Run macro as cycle"** and then **"Start macro"**.

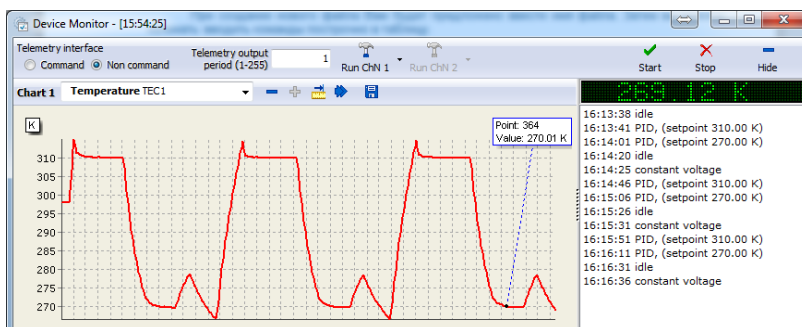
The button **"Stop"** interrupts the execution.

You can use the cyclic execution of macros, simultaneously viewing charts in the window "Monitor" (see the next section).



CAPTION		COMMAND	CHECKED	TIME
PID 1 set 310 K	+	35 0 3 310	<input checked="" type="checkbox"/>	20000
PID 1 set 270 K	+	35 0 3 270	<input checked="" type="checkbox"/>	20000
IDLE	+	35 0 0 0	<input checked="" type="checkbox"/>	5000
Constant voltage cooling	+	35 0 4 3.2	<input checked="" type="checkbox"/>	10000
▶ Constant voltage heating	+	35 0 4 -3.2	<input checked="" type="checkbox"/>	10000

For example, the result of looping of this commands set will be the following graph of the temperature of the cold side of thermoelectric module connected to the controller first channel:



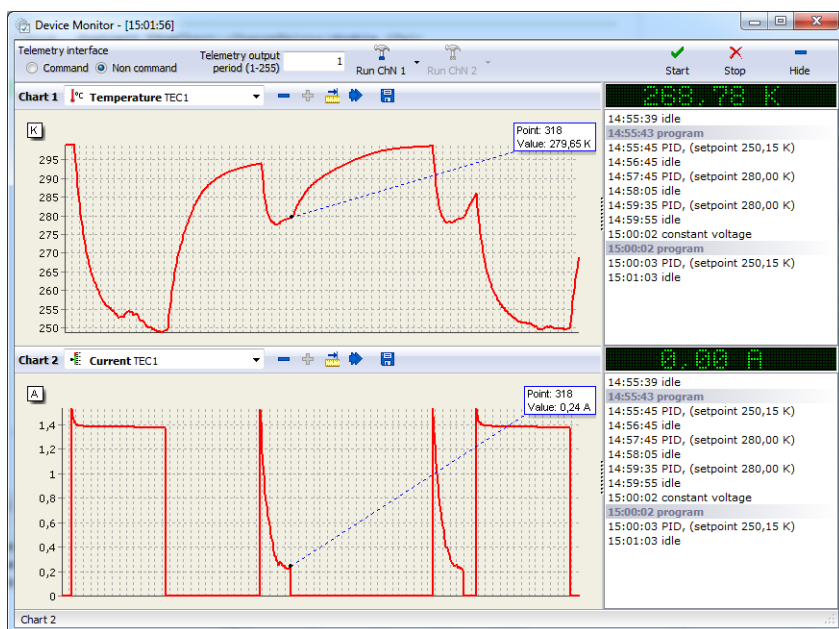
13. MONITOR

13.1. Telemetry Start

The program has the following modes: monitoring the current status of the controller, telemetry by a user's choice, charting, data storage for later analysis.

The monitor window is not for parameters setting. You can only receive information from the controller and control the current behavior and regulation by one or two channels.

Window of monitor:



The group of radio buttons **"Telemetry interface"** allows selecting an interface for sending telemetry data. If you do not use the

command interface ¹³, the choice is not available and the telemetry speed will be lower.

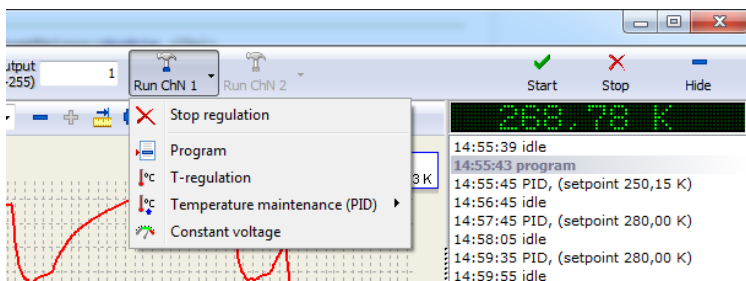
The telemetry period is the interval at which the controller will generate telemetry data. It can take the values from 1 to 255, 1 corresponds to 10 ms.

For the command interface we recommend to choose this value not less than 50, you can determine the optimal value experimentally.

The buttons «**Start**» and «**Stop**» start and stop telemetry. Pay attention to the fact that they do not affect the regulation, i.e. if you switch on the telemetry, choose and run the regulation mode, and then turn off the telemetry by clicking on the stop button, the controller will continue to regulate in the mode selected.

13.2. Choice of Regulation Mode

The regulation mode can be chosen from the dropdown menu of the corresponding channel:

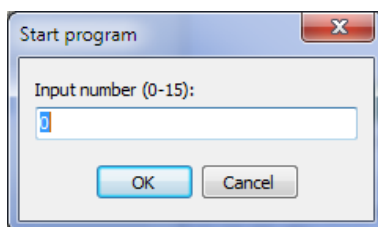


If the channel is not available, the menu of this channel will not be available either.

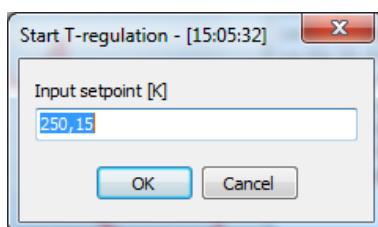
When selecting a regulation mode, the program will prompt you for the necessary data:

¹³ See Sections "**3.1 Controller to Computer Connection Options**" and "**1.2. How to Adjust Computer Serial Port**"

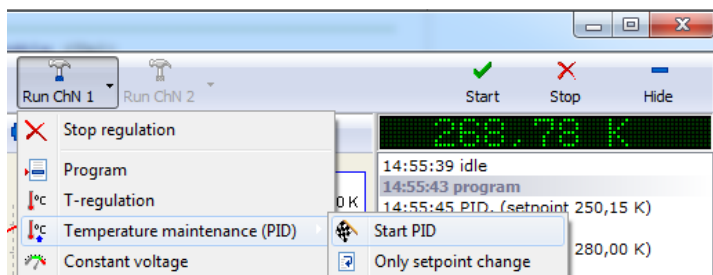
- Mode "**Program**":



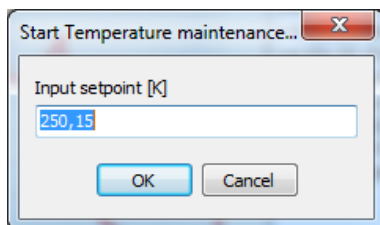
- Mode "**T-regulation**":



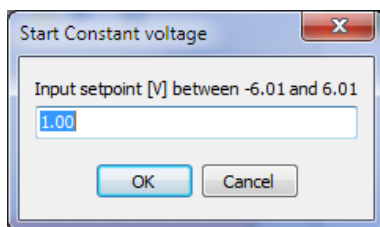
- Mode of PID temperature control:
 - Starting with the controller version **DX5100.333** it is possible to change a temperature setpoint without restarting PID:



- Request for setpoint:



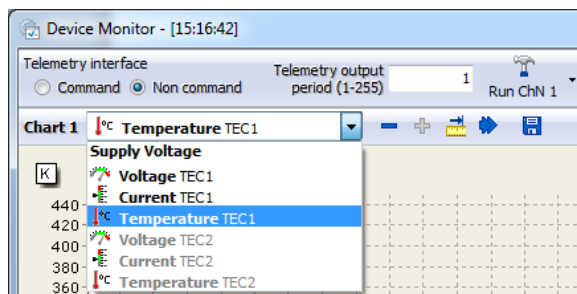
- Mode "**Constant voltage**":



- See the Chapter "**5.1 Setting Limits of TEC Voltage**"

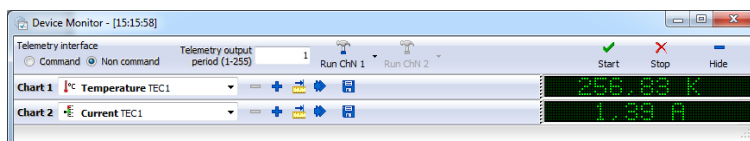
13.3. Charts

It is possible to build two graphs simultaneously; the choice of parameters for each graph is done from the drop-down list:

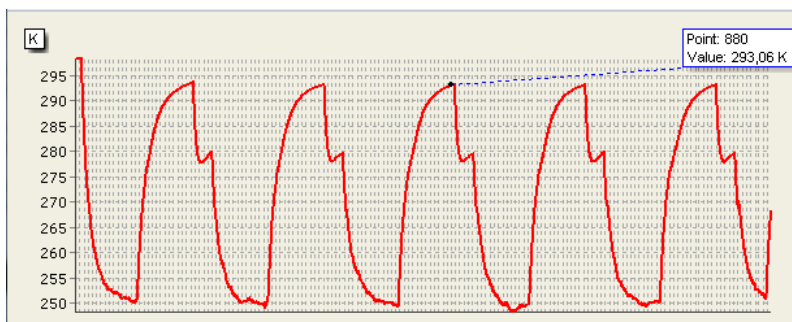


Each chart has its own toolbar:

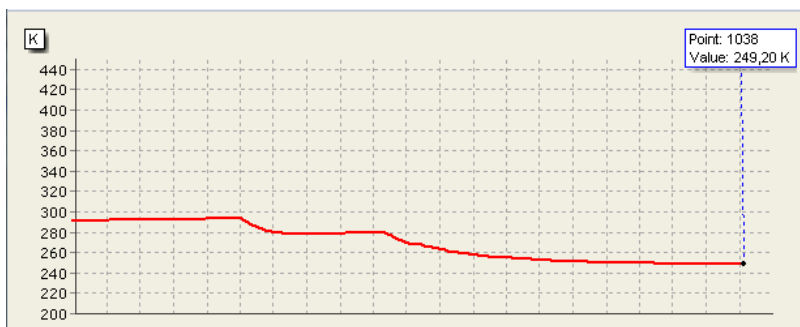
- The buttons "+" and "-" allow minimizing/maximizing the chart window:



- Next button is zooming (the default chart width is 200 pixels):



- Button of scale recovery (200 pixels):



- Storage button saves the data to an Excel file:

250.12 K	
15:10:58 idle	
15:11:05 PID, (setpoint 250,15 K)	
15:12:05 idle	
15:13:05 PID, (setpoint 280,00 K)	
15:13:25 PID, (setpoint 250,15 K)	
15:14:25 idle	
15:15:25 PID, (setpoint 280,00 K)	
15:15:45 PID, (setpoint 250,15 K)	
15:16:45 idle	
15:17:45 PID, (setpoint 280,00 K)	
15:18:05 PID, (setpoint 250,15 K)	
15:19:05 idle	
15:20:05 PID, (setpoint 280,00 K)	
15:20:25 PID, (setpoint 250,15 K)	
1.38 A	

	A	B
1	Index	Y
2	0	299.46
3	1	299.46
4	2	299.46
5	3	299.46
6	4	299.46
7	5	299.47
8	6	299.46
9	7	299.46
10	8	299.46
11	9	299.46
12	10	299.46
13	11	299.47
14	12	299.46
15	13	299.46
16	14	299.46
17	15	299.46

13.4. Status Bar

On the right side of each graph there is a status bar that displays the controller current mode and the telemetry value:

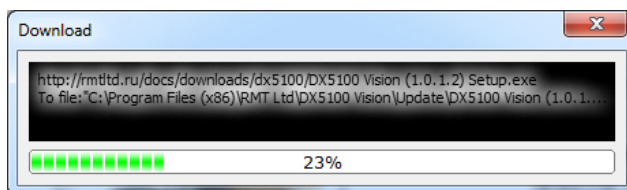
14. UPDATE

Our company is eager to provide you with the most suitable mechanisms to solve your tasks. The sphere of these tasks is constantly growing - there are new problems, new options for using the equipment. For feedback you can use the form "**About**".

We are always glad to offer you all the possible assistance.

14.1. Software Update

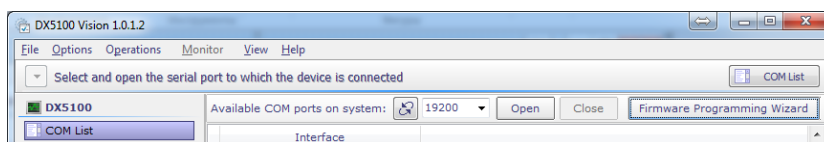
The update of DX5100 Vision program is available in the window "**About**".



Or on our web: <http://www.promln.ru/downloads/>

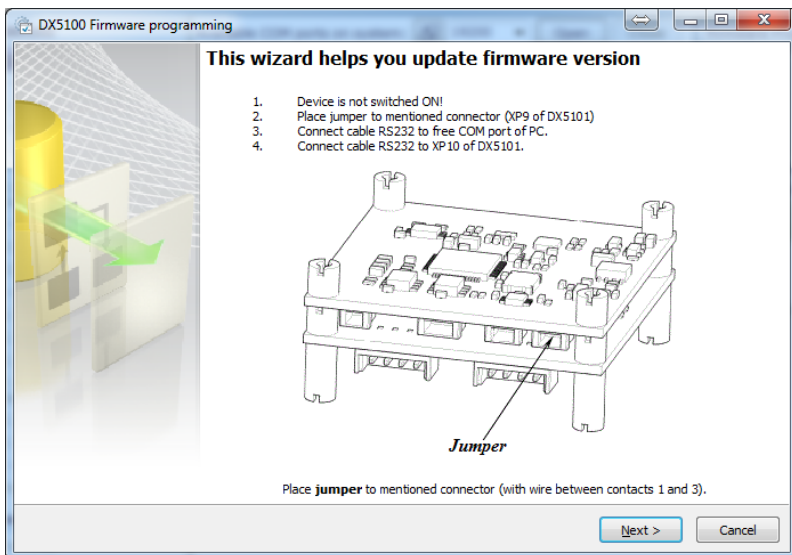
14.2. Firmware Update

To update the firmware of the controller you can use the master "**Firmware Programming Wizard**" on the starting tab of the program.



Here are the steps that are necessary for the successful programming of the controller:

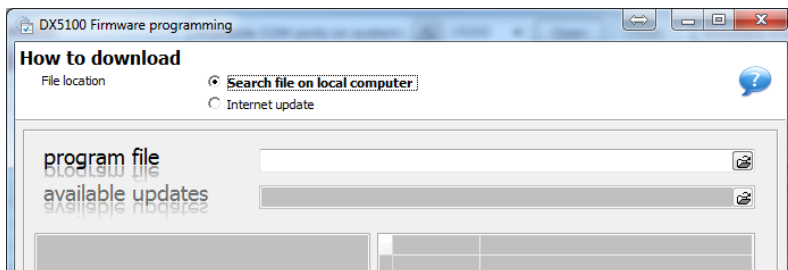
14.2.1. How to Prepare for Controller Programming



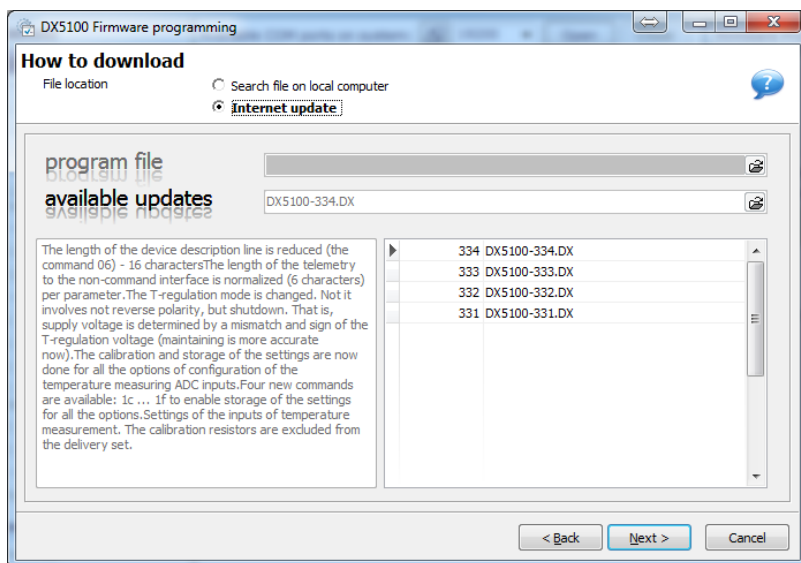
- Turn off the controller power;
- Set the jumper supplied to the connector "PRG";
- Proceed to the next page of the wizard;

14.2.2. Selection of Firmware File

Select the file location: "Internet update";



Select the version of the file;



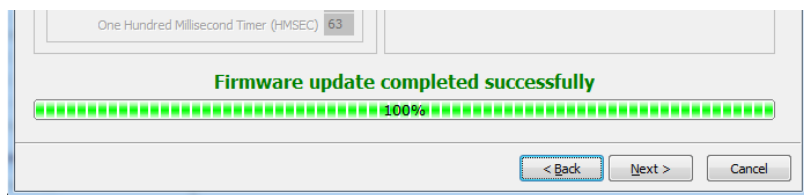
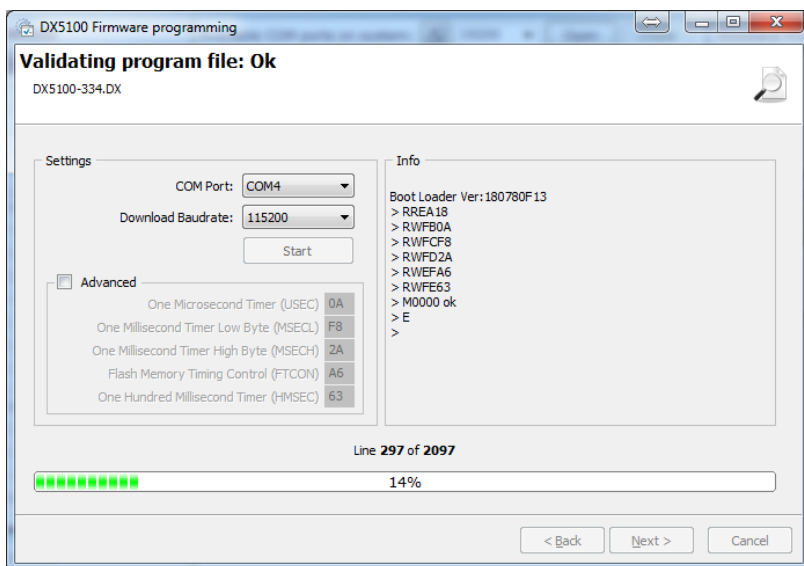
Proceed to the next page of the wizard;

14.2.3. Programming



Attention! Turn on the controller power

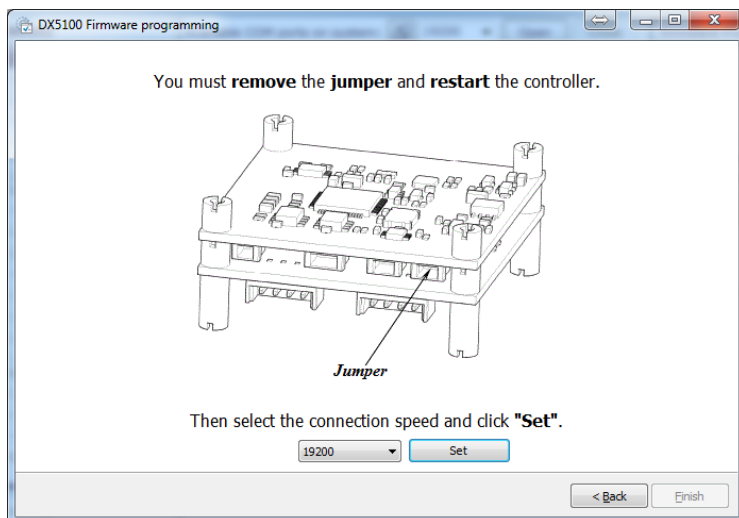
If you want to change the serial port number and speed of programming, press the button **"Start"**.



Proceed to the next page of the wizard;

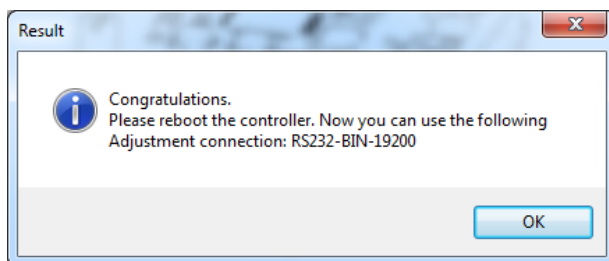
14.2.4. How to Set Connection Rate in Controller after Programming

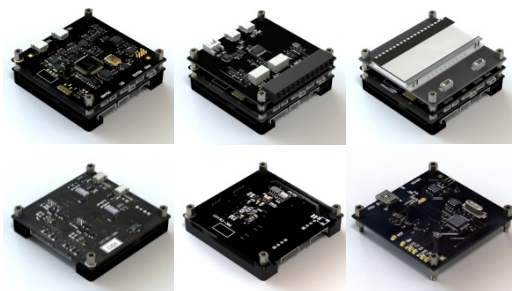
After programming the controller, the setting of the connection rate may have changed. There is a special procedure of setting new parameters:



Remove the jumper, reset the controller, select the speed you are going to use in future to work with the controller.

Press the button **"Set"**.





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