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# **Multichannel Frequency Comparator**

## **User Guide**

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# 1 Introduction

Program "Multichannel frequency comparator" (the Program) is designed to control the precision frequency comparator VCH-314 and multichannel frequency comparator of following models: VCH315, VCH-315M. The program provides processing and keeping of the measurement results of the phase difference, frequency difference and frequency instability.

Frequency comparator VCH314, VCH315, VCH-315M (the Comparator) is designed to measure the relative frequency difference and frequency signals instability of the time and frequency standards. It contains identical measuring channels and performs high precision phase and frequency comparison.

## Key applications

- verification of metrological parameters of precision frequency signals sources;
- time and frequency etalon systems;
- automated measurement systems;
- scientific research measurements.

Communication between the IBM / PC-type computer, on which the program is installed, and the Comparator is performed via RS-232C interface, USB or LAN interface (USB and LAN can be unavailable in some models, check the specification).

**Comparator supports only one connection via RS-232C interface, USB interface or LAN interface. Only one connection is available via LAN interface.**

The program requires Windows XP, Vista, 7, 8, 10, 11 or Linux operating system with kernel version 2.6.x or higher.

Implemented features:

- receiving measurement data from the Comparator, automatically saving data in files;
- calculating statistical functions characterizing the frequency difference between two signals;
- displaying measurement results and calculated functions in the form of charts on windows interface;
- printing charts on a printer connected to the computer.

“Frequency comparator measurements processing program” is included with the program.

This manual provides a summary of the basics of the Comparator, as well as the instructions on how to use and configure the Program.

## 2 The working principle of the Comparator

Comparator contains blocks of phase comparators for measuring sinusoidal signals, signal processor unit with RS-232C, USB and LAN interfaces, power supply unit.

Each channel of comparator allows to measure the phase and frequency difference between the measured signal – input  $f_y$  (for VCH315 it is also  $f_z, f_v, f_w$ ) and reference signal – input  $f_x$ . Channel consists of two modules: the relative frequency difference multiplier providing multiplier  $K=10^6$ , and the time stamp counter with 10-nanosecond resolution.

Pulse signal  $F$  is taken from the output of the multiplier unit, its frequency carries information about the frequency difference between the compared signals –  $f_y$  and  $f_x$ :

$$F_{yx} = F_x [1 + K \cdot (f_y - f_x) / f_x]. \quad (2.1.1)$$

$K$  is the coefficient of frequency fluctuations multiplication, equal to  $10^6$ . Typically, the frequency of  $F_x = 100$  Hz, but earlier versions of the VCH315 used a 1Hz signal reduction. For more information, refer to the manual for the comparator model used.

Pulse signals with frequency determined by (2.1.1) are fed to the input of the time interval counter (TIC).

Signal  $t_{yx}$ , that carries information on the phase difference of signals  $f_y$  and  $f_x$ , is taken from the output of the TIC digitized with 10-nanosecond resolution. In other words, the delay between the reference signal synchronous with the  $f_x$  signal and the  $F_{yx}$  signal is measured.

Comparators VCH-315M and VCH030 provide simultaneous measurements of phase differences between the different channels with an accuracy of less than 10 ms.

## 3 The computed functions

The program allows you to process measurement data in real time and calculate the following characteristics:

1) mean relative frequency difference (between the signals fed to the  $f_y$  (measured) and  $f_x$  (reference) inputs of each comparator channel);

2) standard deviation - root mean square deviation of the measured relative frequency value, calculated for the difference between the frequencies of the input signals in each channel of the comparator;

3) Allan deviation - root mean square relative two-sample deviation of the measured frequency value, calculated for the difference between the frequencies of the input signals in each channel of the comparator;

4) assessment of the current relative frequency difference using the Kalman filter.

Standard deviation and Allan deviation are calculated for the measurement time intervals (samplings): 1 s, 10 s, 100 s, 1000 s, 1 h, 10000 s, 1 day.

Standard deviation and Allan deviation are calculated on the entire range of observation time (for all samples from measurement start). In addition, Allan deviation values can also be calculated in observation time intervals  $T$ , fixed for each averaging interval  $\tau_A$  (in the "sliding window" duration  $T = N \tau_A$ , see Section 6.2).

### 3.1 Basic ratios

The source for all the calculated statistical functions are signals of the digitized phase difference  $t_{yx}$ , taken from the inputs of the "Time interval counter" (TIC) blocks, see Section 2.

Initially the phase difference of signal pairs is calculated (based on  $K$  – frequency fluctuations multiplier):

$$\Delta_{yx,i} = -\frac{1}{K} t_{yx,i} \cdot \quad (3.1.1)$$

$i$  – number of intermediate count. **The value  $\Delta_{yx,i}$  should correspond to the difference between the phases of the signals  $f_y$  and  $f_x$ , and the measured value  $t_{yx,i}$  corresponds to the difference between the phases of the signals  $f_x$  and  $f_y$ . Therefore it is a minus sign in the formula (3.1.1). The resulting value  $\Delta_{yx,i}$  can have a constant offset relative to the actual phase difference between the signals  $f_y$  and  $f_x$ .**

Then the relative frequency difference calculated for the pairs of signals, measured on the interval  $\tau_A = M$  seconds:

$$y_{yx,i}^M = \frac{1}{\tau_A} (\Delta_{yx,M(i+1)} - \Delta_{yx,Mi}). \quad (3.1.2)$$

Equation (3.1.2) is the starting point for the calculation of Standard deviation and Allan deviation (formulas (3.2.1) and (3.2.2)), and also used to calculate mean relative frequency difference. The upper index  $M$  is further omitted, since it is everywhere implied that the frequency error is measured on the interval  $M$  seconds.

The Program also calculates the current variations in the relative frequency difference:

$$\delta_{yx,i} = y_{yx,i+1} - y_{yx,i}, \quad (3.1.3)$$

These variations are used to calculate Standard deviation and Allan deviation.

### 3.2 Statistical functions

The mean-square deviation of the measured value of the relative frequency (RMS) is calculated using (3.1.2):

$$\sigma = \sqrt{\frac{1}{N-1} \sum_{i=1}^N (y_{yx,i} - y_{yx}^N)^2} . \quad (3.2.1)$$

$N$  – the number of the frequency difference counts  $y_{yx,i}$  for a certain averaging interval  $\tau_A$ ,  $y_{yx}^N$  – the average value of the relative frequency difference on averaging interval  $N \cdot \tau_A$ .

Root mean square relative two-sample deviation of the measured frequency value (Allan deviation) is calculated on base of (3.1.3):

$$\sigma_y = \sqrt{\frac{1}{2(N-1)} \sum_{i=1}^{N-1} (\delta_{yx,i})^2} . \quad (3.2.2)$$

Mean relative frequency difference is calculated by using the equation (3.1.2), its value is displayed in the main window. In the calculation in (3.1.2) averaging interval coincides with the whole time of observation in the respective channel.

The program evaluates the current relative frequencies difference using the Kalman filter. This estimate, along with mean relative frequency difference estimate is displayed in the main window. The following process model allows to take into account the white noise frequency and frequency random walk:

$$\begin{aligned} \Delta_{i+1} &= \Delta_i + y_i \tau + \xi_i, \\ y_{i+1} &= y_i + \eta_i, \\ \langle \xi_i^2 \rangle &= q_1 \tau, \quad \langle \eta_i^2 \rangle = q_2 \tau, \end{aligned} \quad (3.2.3)$$

where  $\Delta$  corresponds to the phase difference,  $y$  corresponds to the estimated frequency difference,  $\xi, \eta$  – white Gaussian noise,  $\tau$  – interval between counts, equal to 1 s. Measurement model describes the measurement of the phase difference:

$$z_i = \Delta_i + v_i, \quad \langle v_i^2 \rangle = R, \quad (3.2.4)$$

where  $v_i$  – white Gaussian noise,  $z_i$  – measured phase difference.

The filter parameters  $q_1, q_2, R$  are fixed at the moment, their values can be changed in the ini-file of the Program. Default values are  $q_1 = 10^{-26}, q_2 = 0, R = 10^{-24}$ .

According to (3.2.3) and (3.2.4) parameter vector, transition matrix and the measurement matrix have the form of:

$$X_i = \begin{pmatrix} \Delta_i \\ y_i \end{pmatrix}, \quad F = \begin{pmatrix} 1 & \tau \\ 0 & 1 \end{pmatrix}, \quad H = (1 \ 0). \quad (3.2.5)$$

The covariance matrix of the process noise has the form of:

$$Q = \begin{pmatrix} q_1\tau + q_2 \frac{\tau^3}{3} & q_2 \frac{\tau^2}{2} \\ q_2 \frac{\tau^2}{2} & q_2\tau \end{pmatrix}. \quad (3.2.6)$$

During initialization of the Kalman filter assessment of the state vector  $X^+_0$  and estimation error matrix  $P^+_0$  are given. After that filter algorithm starts.

Prediction for the next step is implemented:

$$\hat{X}_i^- = F(\tau)\hat{X}_{i-1}^+ \quad (3.2.7)$$

$$P_i^- = F P_{i-1}^+ F^T + Q \quad (3.2.8)$$

Filter coefficient is calculated:

$$K_i = P_i^- H_i^T [H_i P_i^- H_i^T + R]. \quad (3.2.9)$$

Then the filter state is specified:

$$\hat{X}_i^+ = \hat{X}_i^- + K_i [z_i - H \hat{X}_i^-]. \quad (3.2.10)$$

Error matrix is specified:

$$P_i^+ = [I - K_i H] P_i^-. \quad (3.2.11)$$

The procedure is repeated, starting with the calculation of the formula (3.2.7). The desired estimate of the relative frequency difference at the iteration  $i$  is the value  $y_i$ .

# 4 Installation

## 4.1 Installation in Windows

The program can work under Windows XP, Vista, 7, 8, 10, 11. The software is installed from the CD. Also it is available on the website [www.vremya-ch.com](http://www.vremya-ch.com). Usually the installation program starts automatically. If it does not, run setup.exe from the root directory of the CD-ROM manually. The installer will create shortcut on the desktop and the corresponding item in the "Start" menu. In addition to "Multichannel frequency comparator" a special program "Analyser" is also installed. It allows processing comparator measurement data, generate phase and frequency plots, Allan deviation, Hadamard deviation, etc. (for more details read "Analyser Users Guide").

### **Installing USB driver for comparators with ROM version less than 3.0\***

Before using the USB interface of the Comparator to the computer you need to install device driver that creates a virtual serial port when the Comparator is connected via USB. To install the driver and create a virtual serial port connect the Comparator to the computer USB port and turn it on. If the driver is already installed, the operating system will detect the new "USB Serial Port" device, assign it a number and display a message, such as "USB Serial Port (COM8)", "Your new hardware is installed and ready to use":

If there is no driver, Windows will launch the New Hardware Found Wizard. Decline connection to Windows Update, then click "Next" and select the setting "Install from a list or specific location".

As the directory containing the driver select the folder "Driver" on the CD-ROM with comparator software. If the warning about software compatibility with the operating system "Windows XP" appears, click the Continue Anyway button.

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\* ROM version of the processor can be found in the menu "Help", in the main window of the program. To get this information connection via RS-232 interface can be used.

After the driver installation, click "Finish" button.

After the installation of the driver the device availability message will appear on the screen.

*In some cases, the New Hardware Found Wizard starts again. In this case, you need to go through the installation process again.*

### **Installing USB driver for comparators with ROM version more or equal 3.0**

Standard virtual COM-port driver is used in Windows, no actions needed usually.

If comparator connected via USB is recognized as “Unknown device” in Windows device manager, then update driver and select the folder with drivers on the disk supplied with the comparator.

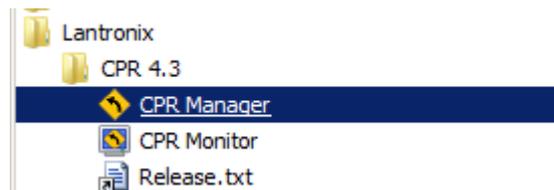
### **Installing the driver to connect the device via LAN interface. Device ROM version less than 3.0**

If ROM version of the device is more or equal to 3.0, then LAN driver is not needed.

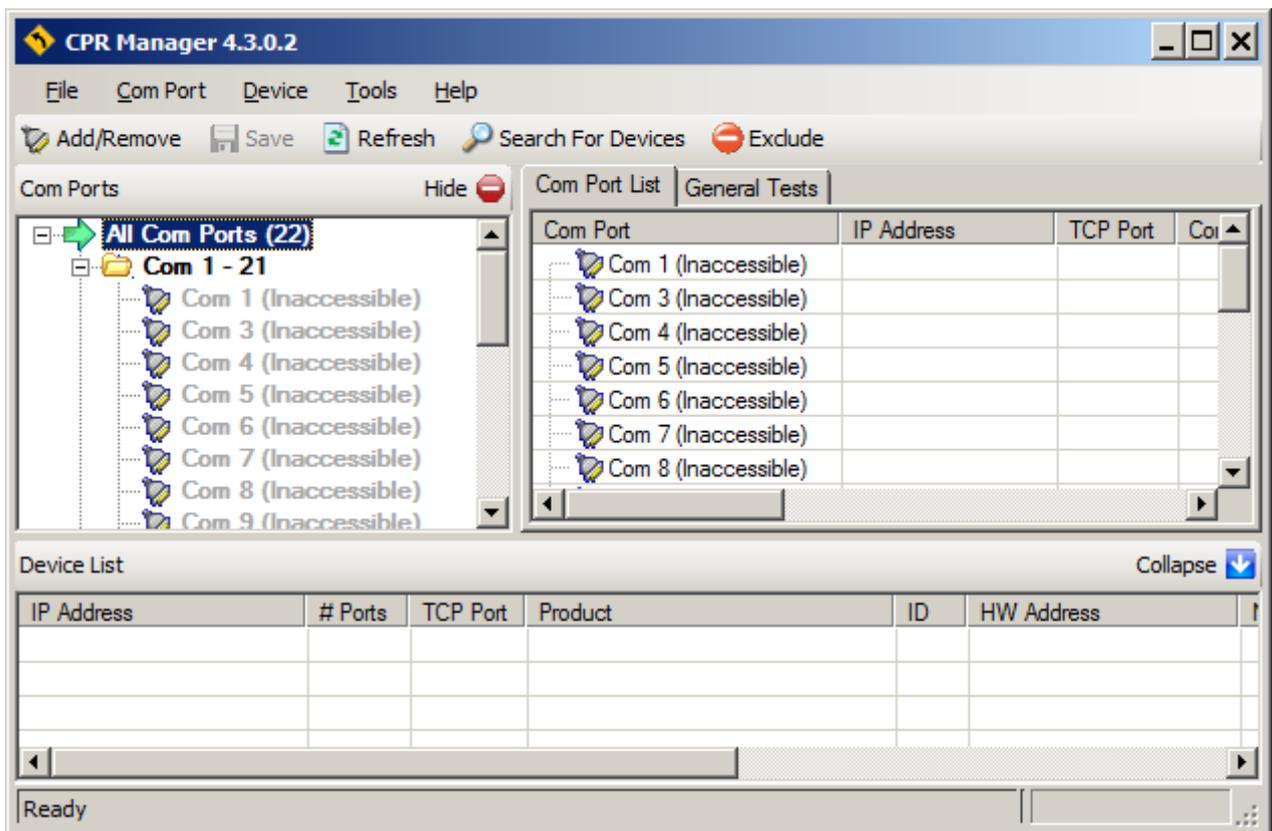
The LAN interface is present in VCH-315M.

By default, the LAN interface of the device is configured to automatically receive an IP address, so the first time you connect to the network, you need to select a local network that has a DHCP server. If you need to set a static IP address, you can do this using the web interface (username: user, no password). To access the web interface, you can find out the dynamically assigned IP address of the device using the "CPR Manager" utility described below.

For remote control via LAN you need to install special software that comes on a disk. This software is also available at the following address: <http://www.lantronix.com/device-networking/utilities-tools/com-port-redirector.html>. To install run `setup_cpr_x86x64cd_4.3.0.2.exe`. After installation, run the "CPR Manager" program (see Figure 4.1).



**Figure 4.1** – Location of the "CPR Manager" shortcut in the "All Programs" menu in Windows 7



**Figure 4.2** – "CPR Manager" main window

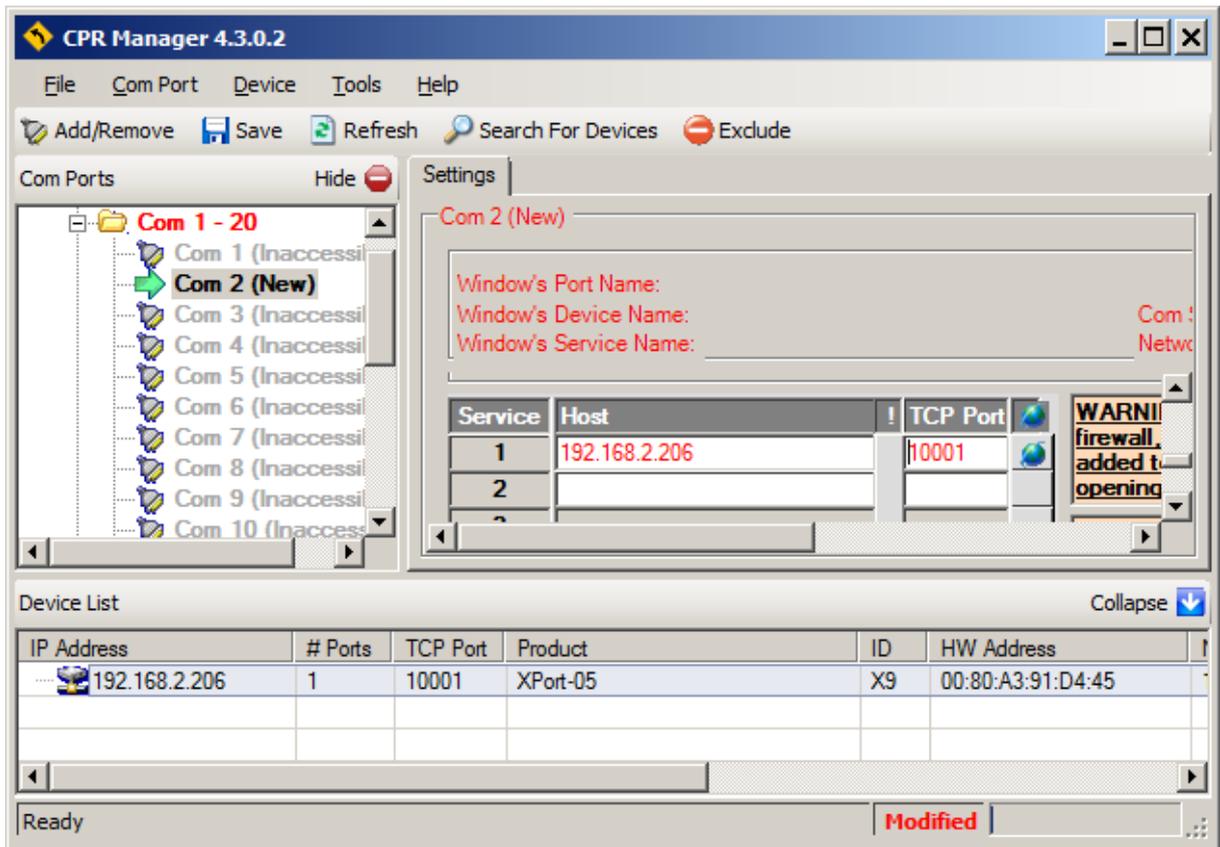
List of the COM-ports will be displayed. If all of them are marked as unavailable (Inaccessible) click the "Add/Remove" and select an available number for the virtual COM-port (Figure 4.3). After that the new COM-port appears in the list labeled "New" (Figure 4.4).

Click "Search For Devices", after some time the list of available devices will appear in the bottom of the table window (Figure 4.4). Select the device with MAC-address (HW Address) that matches the MAC-address of the device. Double-click the left mouse button on the required row of the table. IP-address of the device will be copied to the table in the Settings tab for the new (selected) COM-port (Figure 4.4).

Click "Save". The device is ready for use via LAN interface.

To ensure the successful setting up of the virtual COM-port you can use the Windows Device Manager, it will show created port, for example: Lantronix CPR Port (COM2), in "Ports (COM & LPT)" tab.





**Figure 4.4** – Selecting device from the list by its MAC-address (only one device shown here)

## 4.2 Installation in Linux

To get the Program for Linux please contact us: [admin@vremya-ch.com](mailto:admin@vremya-ch.com). The compressed file will be sent.

FTDI-driver for virtual COM-port VCP is needed to work with a comparator via USB. Most Linux distributions with kernel version 2.6 and above have this driver, so no setup is required. Otherwise, the driver is available for download on the web-address: <http://www.ftdichip.com/Drivers/VCP.htm>.

**For RS-232 interface connection it is recommended to use the computer COM-port integrated on the motherboard, or use a special USB-RS232 adapter from FTDI company. Otherwise operation via COM-port to Linux is not guaranteed.**

## 5 Connecting the Comparator and starting to work with the Program

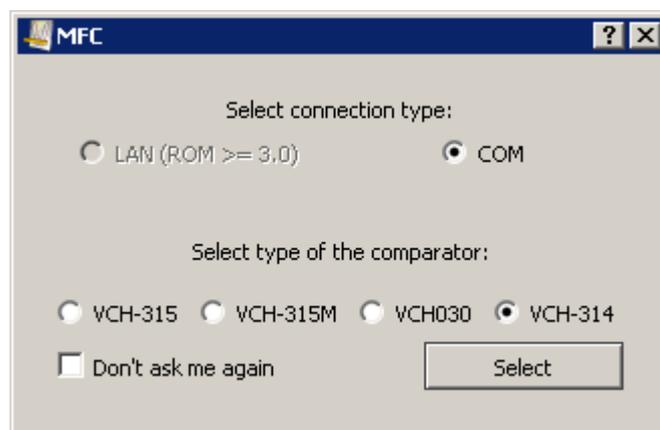
If the comparator is connected via RS-232 interface, then before connecting the device to the computer it is recommended to turn off the device. If a USB interface or LAN interface are used, the Comparator can be connected in the ON state.

After connecting the device to a computer, you can turn the device on. When you first connect the device via USB, you may need to install a driver (see Section 4).

In MFC since ROM version 3.0 the LAN communication between PC and comparator is provided by UDP-protocol. For previous versions special LAN driver creating virtual COM-port is needed (Section 4.1), select COM to connect comparator via LAN in this case.

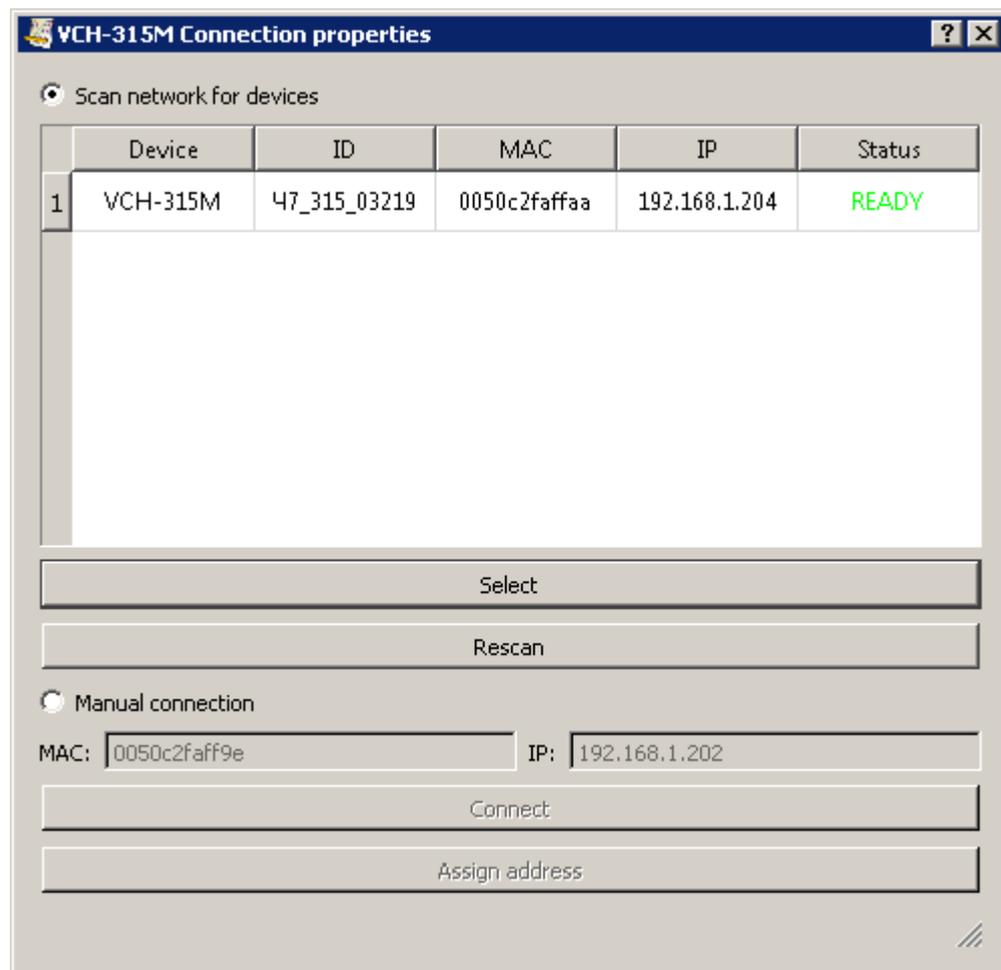
Currently LAN is supported only by VCH-315M model. Every comparator has its own MAC-address, and IP-address is automatically assigned to a comparator if there is DHCP-server on the local network. There is also an option to set IP manually if there is no DHCP-server available.

After the Program launch, there are options to choose LAN or COM connection and the specific comparator model (Figure 5.1).



**Figure 5.1** – Window for selecting the Comparator type

After choosing LAN-connection and comparator's model, "Connection properties" window pops up (Figure 5.2). In that window you can scan your network to get the list of comparators ("Scan network for devices"). After setting it, there is a special broadcast message sent from your PC, and in response it gets address information from all comparators available on your network which includes IP, MAC and ID info. Based on the info, the table is formed where every row corresponds to a single comparator on your network.

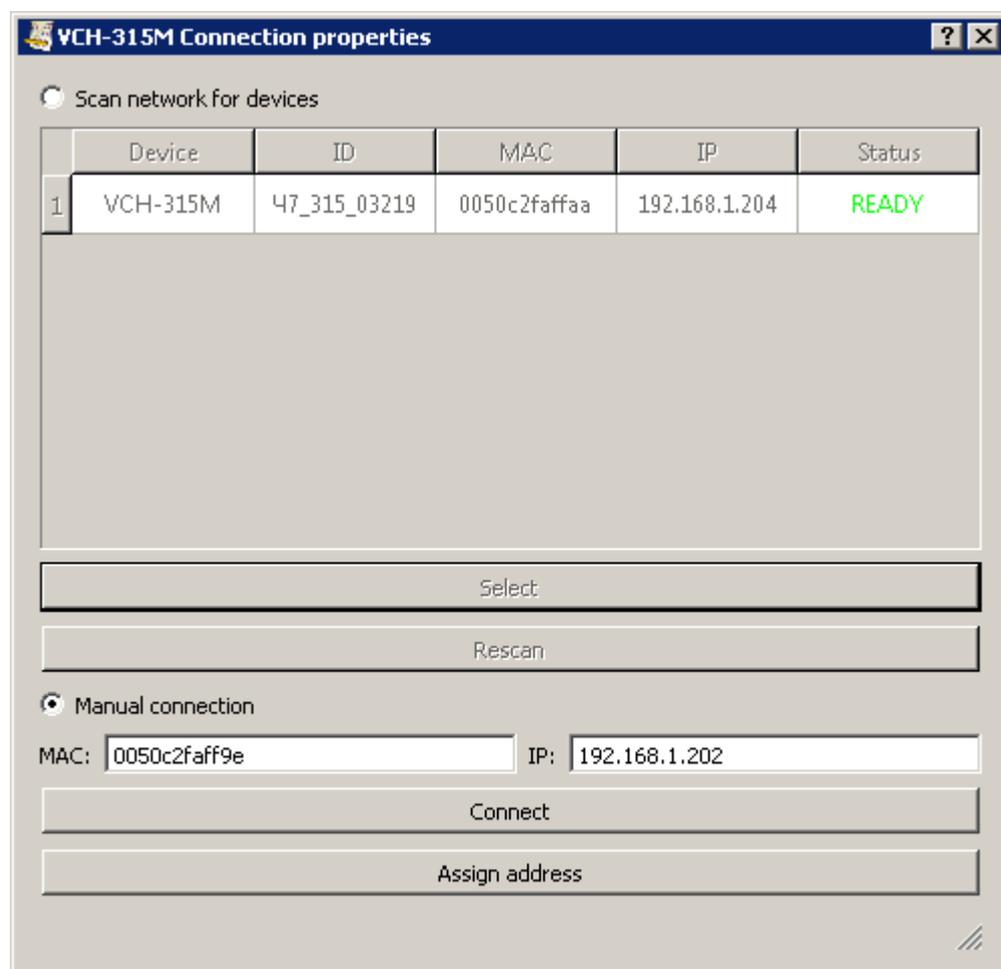


**Figure 5.2** – Window "Connection properties"

Besides the address info, there is also a "Status" column in the table which can be used to determine the accessibility state of the device. To connect with a comparator, one needs the status of the device to be "READY" with the font color set to green (the " \* " sign near the status means that the type of the device in the row doesn't correspond to the type of the device chosen on MFC launch, so you can't

choose that device unless you restart the MFC and set the corresponding device type). If the conditions above are satisfied, you can launch the measurements by clicking the necessary row of the table and pressing “Select” button below it. There is also an option to rescan the network by pressing “Rescan” button.

Besides, in the “Connection properties window” you can choose connection parameters manually (“Manual connection”) or assign the IP address to a device if there is no DHCP-server on the network. The latter turns off DHCP support of the device.



**Figure 5.3** – Window “Connection properties”. Manual connection

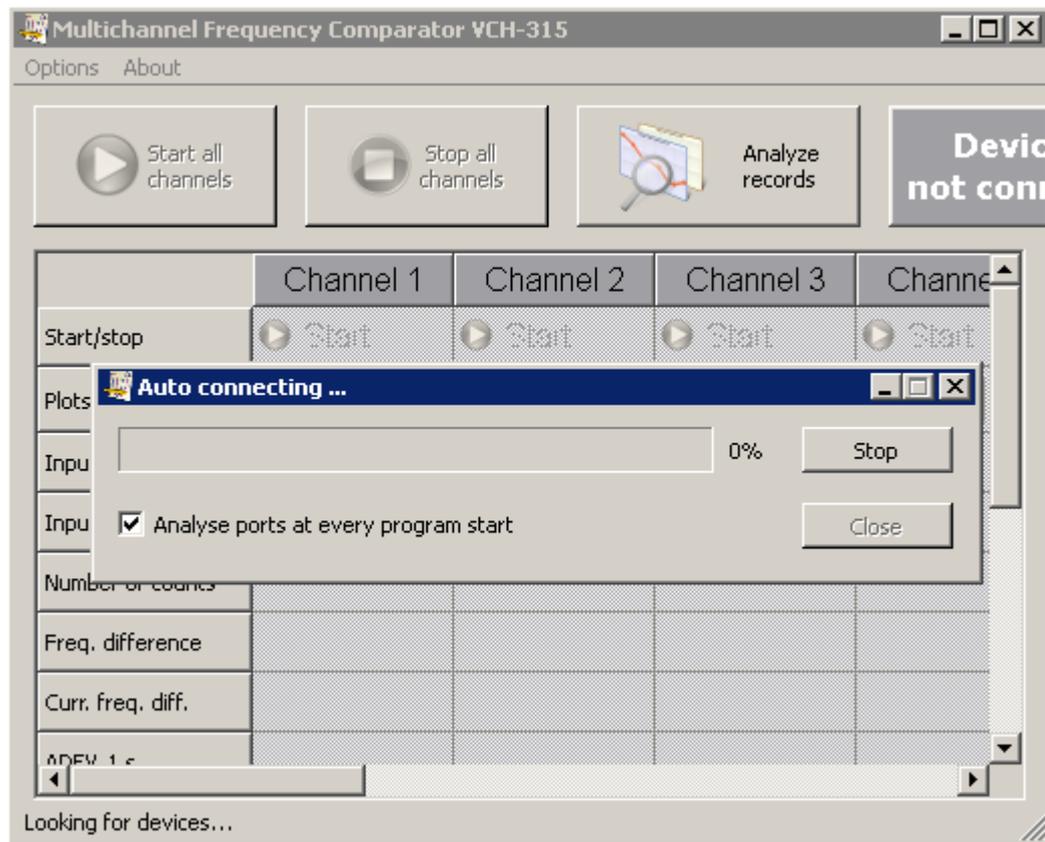
After choosing a device type, the main window pops up. In that window in the “Options” section one can see the same connection parameters window with the additional button “Use DHCP” which you can find useful if the DHCP-server shows up

in your network and therefore the IP address can be set automatically. The DHCP-server support can also be reset by restarting a comparator.

If COM connection type was selected (Figure 5.1), then after choosing a device type, the window "Auto Connect ..." showing the process of connecting with the device (see Figure 5.4) will appear. The "Auto connect ..." window is displayed and the ports analysis process and device connection begin at startup if you select the "Analyse ports at every program start" item in the "Auto connect ..." or in the "Connecting to the device" (menu item "Options> Connection", refer to Section 6.2).

The Program automatically searches for COM ports available to the operating system (including virtual USB and LAN ports) to which Comparators are connected. If no comparator is not found, the Program displays a message asking you to retry the connection.

If "Analyse ports at every program start" is not checked, then when you run the Program it will attempt to connect using COM-port number from the previous program run, the number is stored in the ini-file in the Program directory.



**Figure 5.4** – Main window at startup

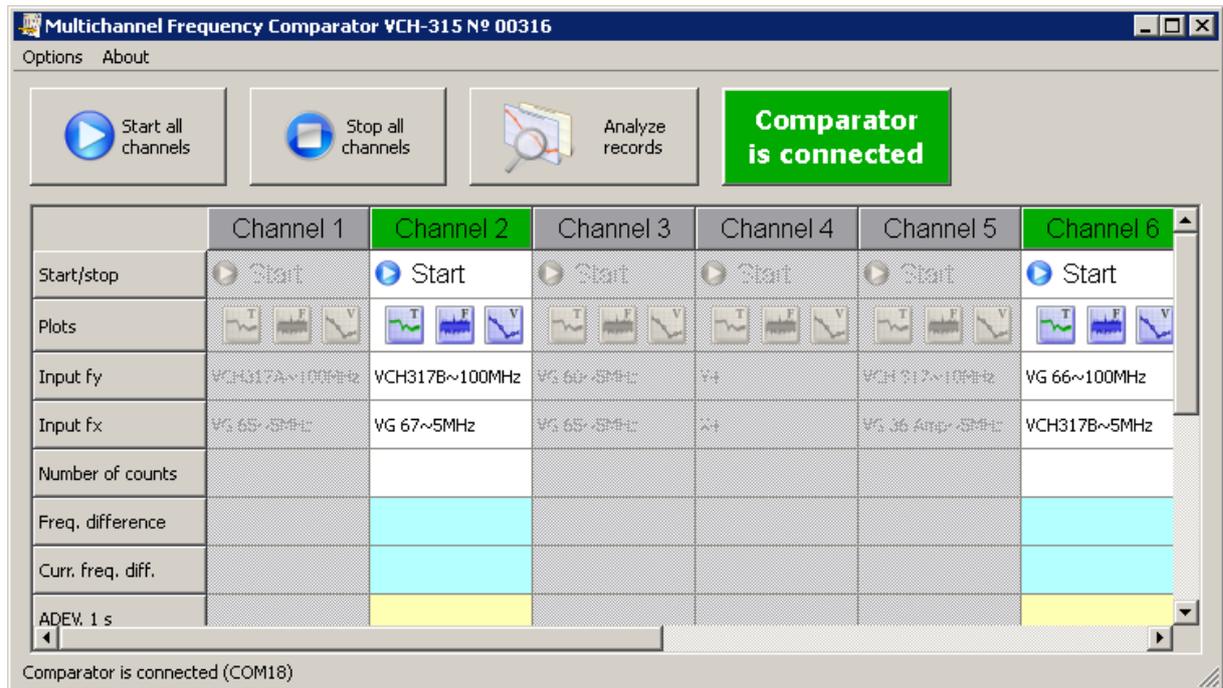
Name of the main program window contains the name of the comparator and its serial number (the serial number is not displayed when connecting to VCH315 or VCH-314).

You can turn on the Comparator after the launch of the Program.

If the program was able to detect connected Comparator, message "Connecting the comparator" is displayed in the status bar.

If communication with the comparator was successful status bar will show message containing the connection port number, for example: "The comparator is connected (COM1)". The field in the upper right corner of the main window changes colour to green, the label changes to "The comparator is connected". The comparator channels that contain measured ("Input  $f_y$ ") and reference ("Input  $f_x$ ") signals are

marked green in the table in the main window, the corresponding table columns become active (Figure 5.5).

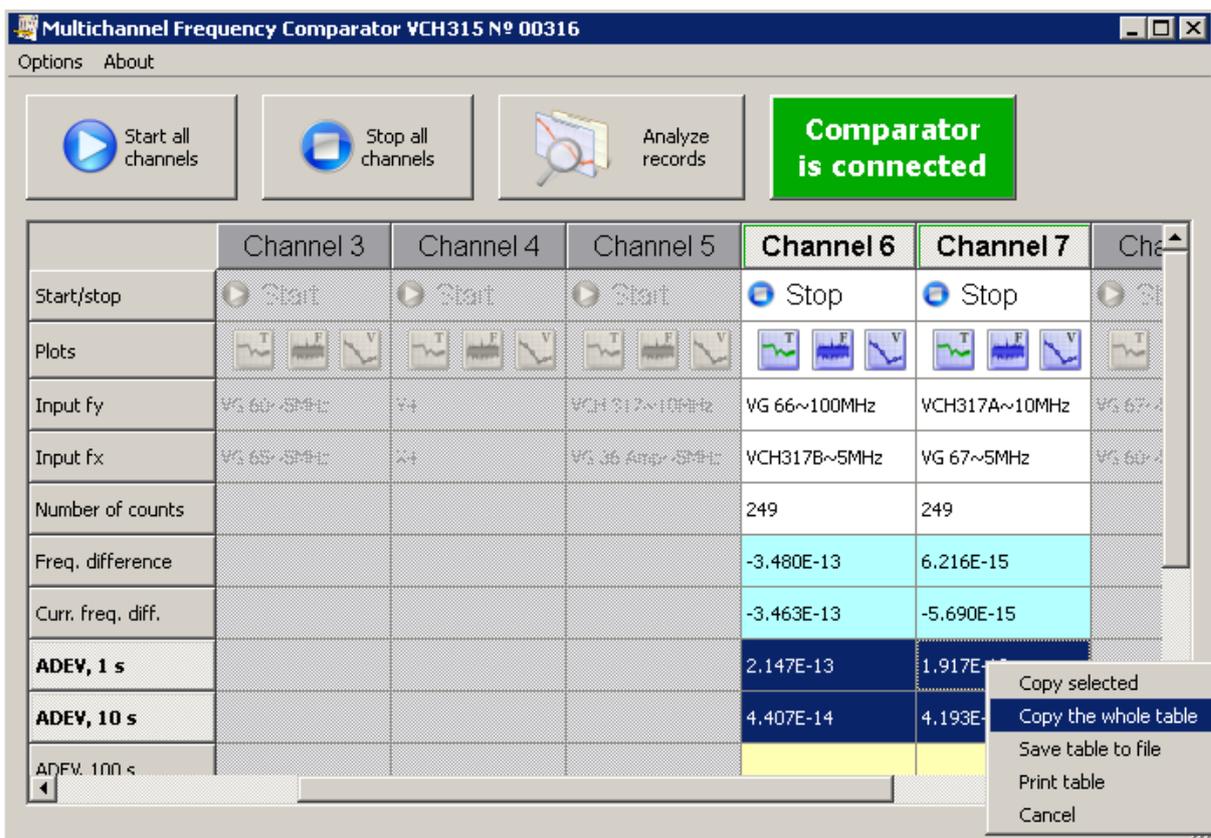


**Figure 5.5** – Main window after connection is established

If multiple comparators are connected, you need to choose the comparator from the list in the "Options" menu under "Connection" item (see Section 6.2). Next time you start the Program connection is established with the comparator selected earlier.

## 6 Interface

Program interface is standard for Windows applications (Figure 6.1). Appearance of the program may differ from shown in this manual depending on the user's individual settings. The main element of the Program window is a table containing information on the signal in each channel, the number of counts obtained, the average relative frequency difference, assessment of the current relative frequency difference, value of the frequency instability (standard deviation or Allan deviation). You can choose between showing either standard deviation or Allan deviation in the table and graphs performed in "Setting calculations" item in "Options" menu (see Section 6.2).

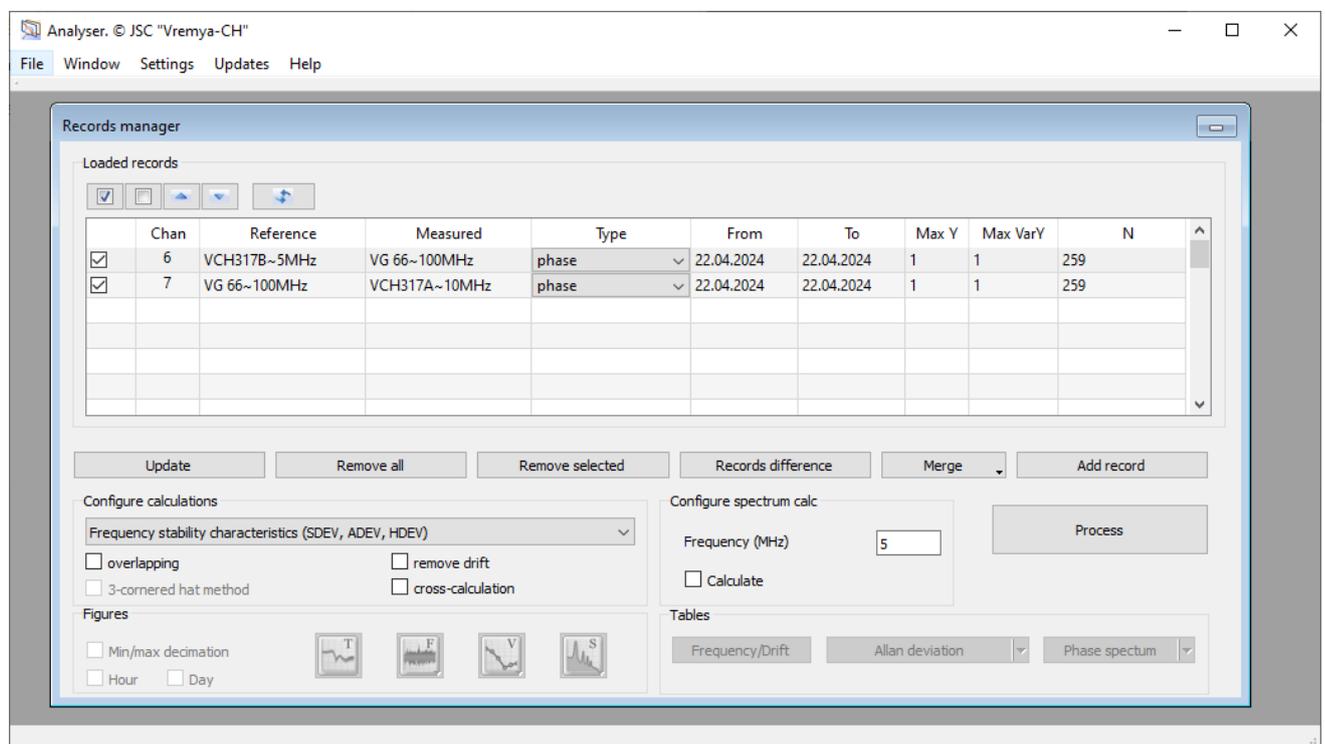


**Figure 6.1** – Main Window

To start or stop measurements in the required channel click on the corresponding field in the "Start/Stop" row. If you want to start or stop measurements simultaneously

on all channels that contain signals use the buttons: "Start all channels", "Stop all channels." When you try to stop the measurement in one or all channels window appears, asking whether this operation should continue.

When you click "Analyze records" then "Analyser" program is launched. Current measurement data are automatically uploaded into "Analyser" program (Figure 6.2). It allows processing current data or open previous data records, display phase and frequency plots for different averaging times, generate statistical functions: Allan deviation, Hadamard deviation, etc. (for more details read "Analyser User Guide").



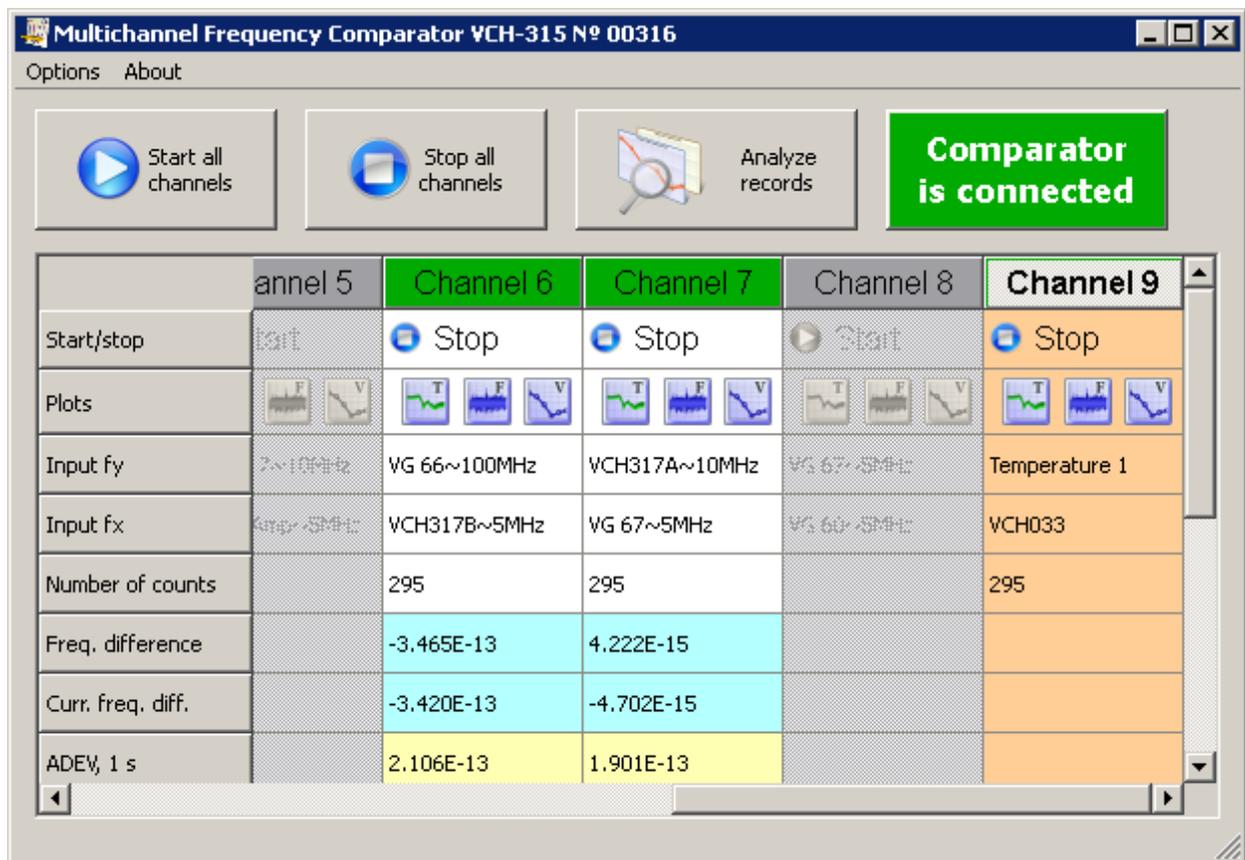
**Figure 6.2** – "Analyser" program opened with current measurement records

The program ("Multichannel frequency comparator") allows you to specify names for the reference ("Input  $f_x$ ") and measured ("Input  $f_y$ ") signals of each channel in the appropriate fields in the "reference signal" and "measured signal" rows. The names of the signals must be assigned before the measurements start, after that editing fields of the table with the names of the signals will not be possible. The names of the

signals will be displayed when working with the entries in the time-frequency measurements data processing program.

The text of the entire table or only the selection can be copied to the clipboard, saved to a file or printed out. To do this, press the right mouse button on the table field and select the required option in the pop-up menu (see Figure 6.1).

**If the device contains one or more temperature sensors, additional channels for measuring temperature, highlighted in orange, are available in the table of the main window (see Figure 6.3).**



**Figure 6.3** – Main window. Temperature measurement channel (optional)

Measurements in channel for temperature recording start and stop same way as in the other channels. When you press the "Start all channels" / "Stop all channels" on available channels for temperature recording the measures will also the start (stop). You can change the name in the temperature fields of the channel. By default, the

"Input  $f_x$ " contains the string "FMC" and the "Input  $f_y$ " - the string "Temperature N", where N is the number of the sensor. When measurements are running the field "Number of counts" displays the number of obtained temperature counts. The rest of the fields in the table for the channel remain empty.

Similarly to the phase difference measurement the Program creates the current temperature graphs, as well as temperature variations and the average temperature variation dependence from the averaging interval. The formulas for the calculations are the same as in the phase measurements processing, but temperature is used instead of the phase difference.

### 6.1 Current measurement graphs

In "Plots" row of the table of the main window you can open the graphs of phase difference, relative frequency difference, Standard deviation or Allan deviation by pressing the corresponding button.

The program can show the decimated phase difference values, and average values of the relative frequency difference on averaging intervals of 1 s, 10 s, 100 s, 1000 s and 3600 s. To select the averaging interval for the frequency or the decimation factor for phase you need to press the right mouse button in the required channel field in the "Plots" row, and select the time interval (see Figure 6.4).

Figures 6.5 and 6.5 show examples of phase difference and relative frequency difference graphs for averaging intervals of 100 s and 1 s respectively. Graphs show up to 1000 last entries for any averaging interval.

Line of mean relative frequency difference can be displayed on the frequency graph (Figure 6.5).

**The average value is calculated by formula (3.1.2) for the current graph. This value may vary significantly for frequency graphs with different averaging**

intervals, and can also be different from the value obtained by the Kalman filter and shown in the table.

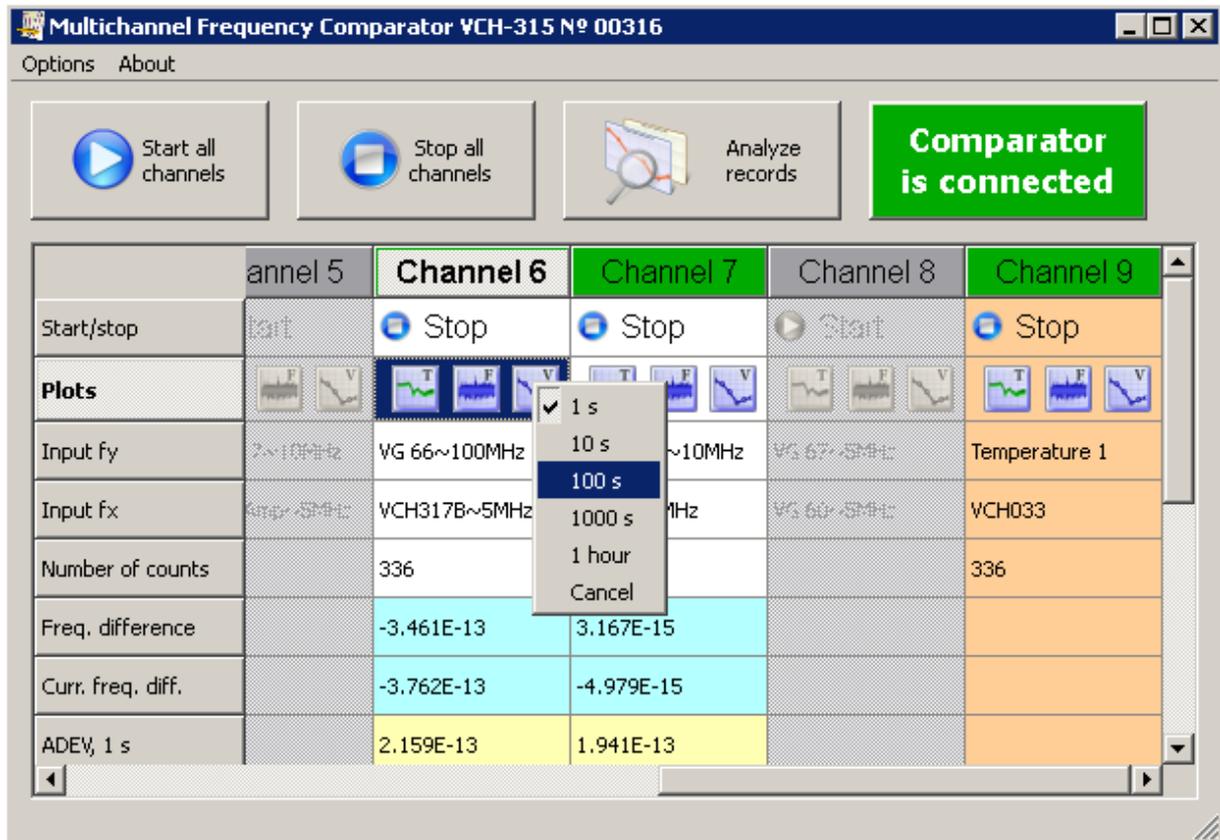
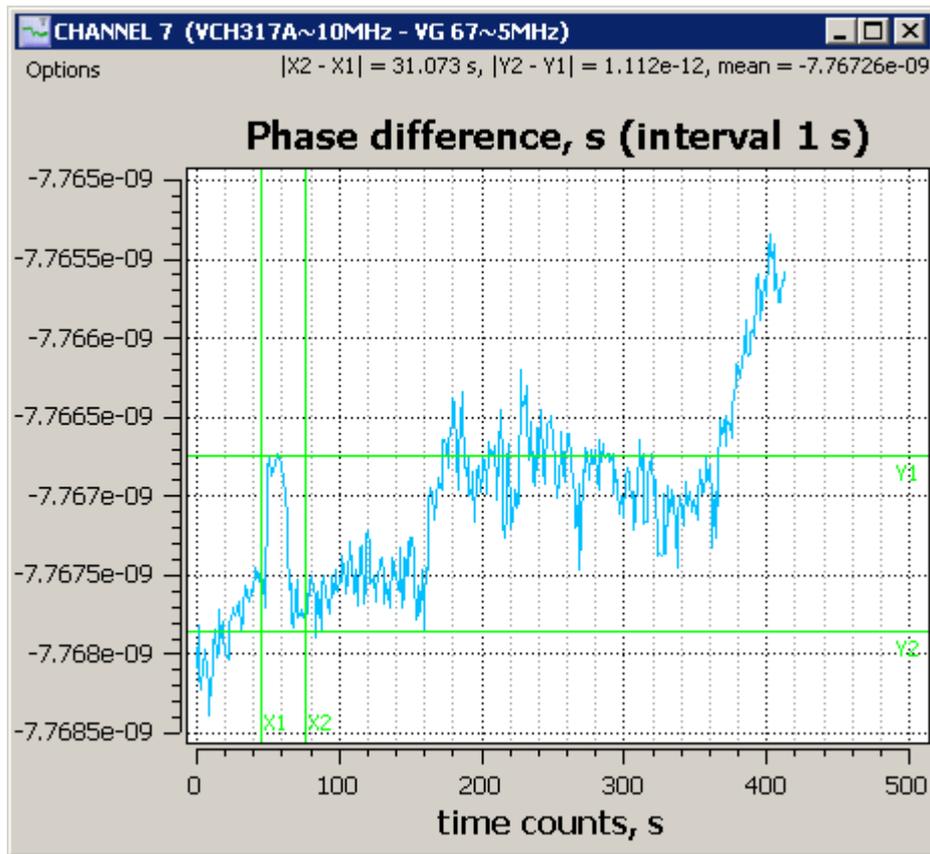
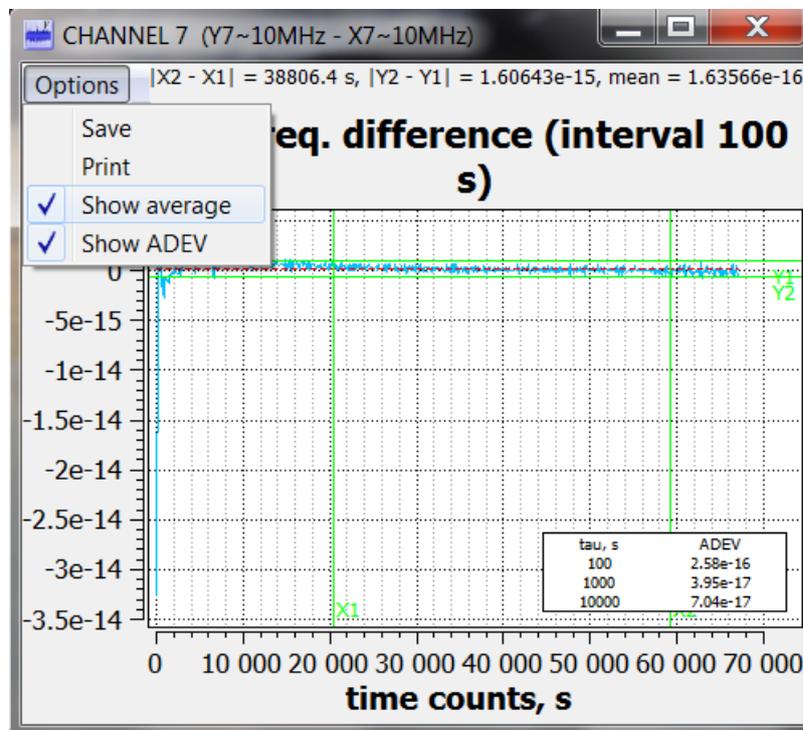


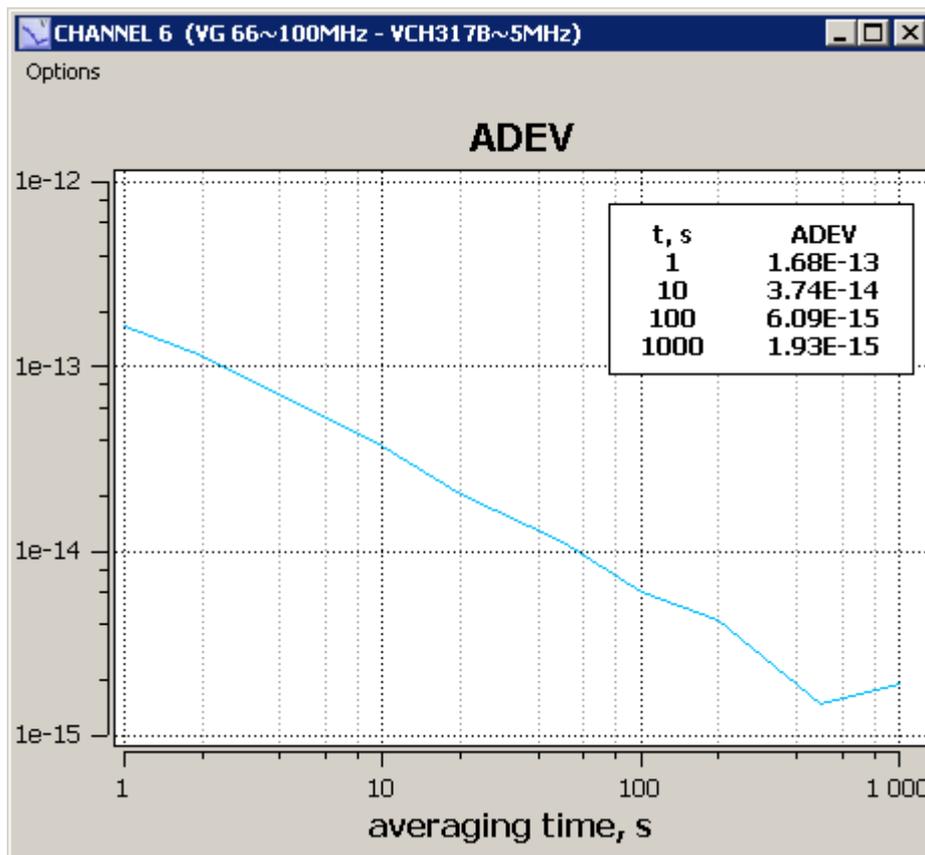
Figure 6.4 – Main window. Selecting averaging interval for the phase and frequency graphs



**Figure 6.5** – Phase difference graph for averaging interval of 1 s



**Figure 6.6** – Relative frequency difference graph for averaging interval of 100 s



**Figure 6.7** – Standard deviation graph

Figure 6.7 is an example of Allan deviation (ADEV) graph, that also contains a table of ADEV values.

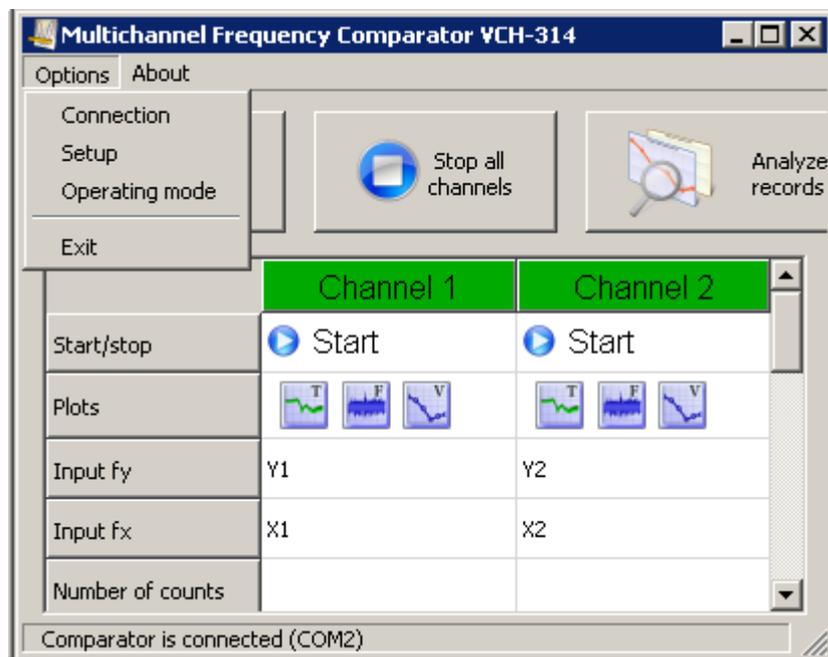
All graphs have a marker that appears when you click left mouse button in the graph field. Horizontal and vertical values for the selected point are shown in the upper right corner of the window (Figure 6.6). With a marker you can measure the distance between two points on the graph, to do that select the first point by clicking left mouse button, then hold down the button, move cursor to the second point and release mouse button. The measured horizontal and vertical difference values will be displayed in the upper right corner of the window (Figure 6.5). In addition, the relative frequency difference graph in the upper-right corner shows the average value for the selected interval, and a table with the ADEV values for this interval will appear in the graph

field (figure 6.6). Each graph window has the "Options" menu, where you can save the graph to a "bmp" or "jpg" file or print it out.

## 6.2 Main window menu

Figure 6.8 shows the "Options" menu of the main window.

The "Connection" item opens a "Connect device" (Figure 6.8) window. This window shows the list of available COM-ports (including virtual COM-ports) of the computer. If the connection to the device is found in the list, the corresponding COM-port will be highlighted and the serial number of the connected comparator is shown (the serial number may not be shown for VCH315 and VCH-314).



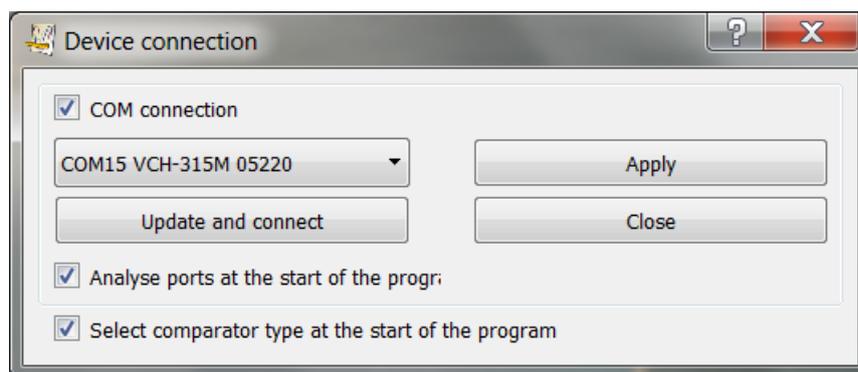
**Figure 6.8** – "Options" menu of the main window

When you click "Refresh and connect" button, if measurements are stopped the current device connection (if established) breaks and port analysis begins in order to find and connect to Comparator. If measurements are going on this option is not available.

When you click "Apply" the Program will try to connect to COM-port selected in the list, if the number of the selected port is different from the current one.

Option "Analyse ports at every program start" means that the analysis of ports and connection to the device, if it is detected (Section 5), will be made again at the next program start. If this option is selected, next time you start connection attempt will be made at the previously selected COM-port specified in the ini-file. Similarly, if the "Select comparator type at the start of the program" option is not selected, the next time the Program starts, it will establish a connection with the comparator type that was previously used, information about the comparator type is saved in the ini-file.

If PC running the program is connected to multiple Comparators VCH315 you can select the required COM-port from the list. Click "Apply" to connect to the Comparator via the selected port. When you click "Update and connect" current connection to the device (if it has been established) is broken, ports analysis and connection to the previously selected Comparator will start.



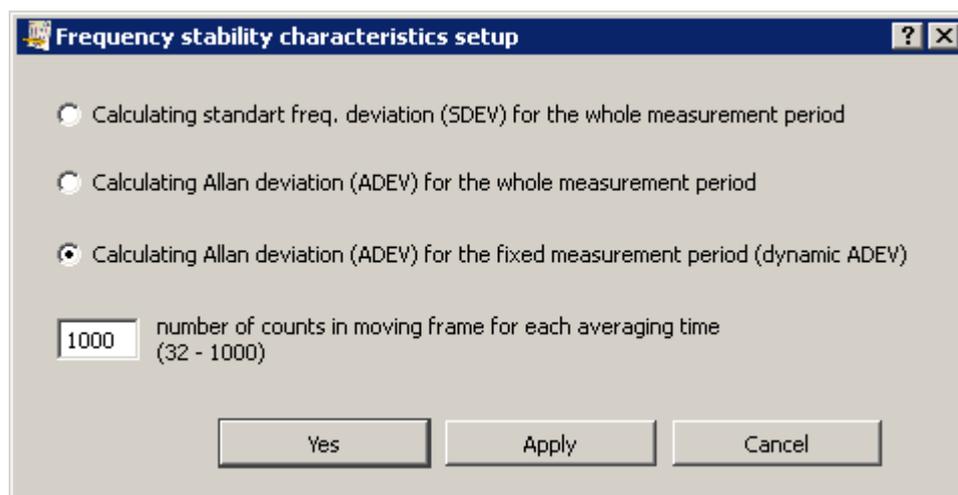
**Figure 6.9** – "Device connection" window

Menu item "Setup" (Figure 6.8) opens a window "Frequency stability characteristics setup" (Figure 6.10). You can select statistical functions: SDEV (root mean square relative deviation of the results of pairs of signals frequency difference measurements) and ADEV (root mean square relative random two-sample deviation of the results of pairs of signals frequency difference measurements). SDEV (standard deviation) is always calculated at the entire interval of observation time (since start of measurements). ADEV (Allan deviation) can be calculated at the entire interval of observation time or at a fixed interval preceding the current moment (in a sliding window). If you select a fixed interval you need to set the number of averages, i.e. the

length of the sliding window. The number of averages can be set from 32 to 1000. For example, if you select 100 averages the ADEV observation time at averaging interval  $\tau_A = 1$  will be  $T = 100$  s, and for  $\tau_A = 3600$  s will be  $T = 360000$  s.

Note. If frequency jump occurred with 100 averages selected then after 101 seconds ADEV value for  $\tau_A = 1$  s will not contain any information about this jump

Note that the number of averages can be changed only when measurements on all channels are stopped. You can change the type of calculated function during measurements. After selecting the necessary statistical function press "Yes" or "Apply", then the changes will take effect, the table and graphs will show the values of selected characteristic.



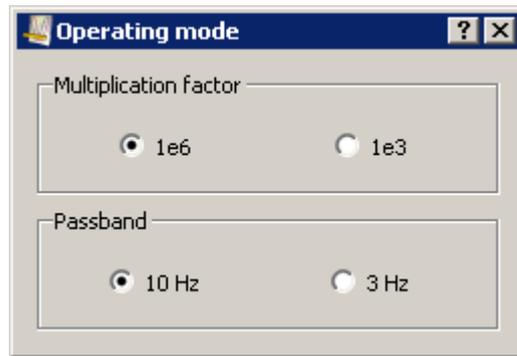
**Figure 6.10** – "Frequency stability characteristics setup" window

Menu item "Operating Mode" (Figure 6.8) is available for VCH-314 only. It opens a window "Operating Mode" (Figure 6.11).

The multiplication factor for the frequency noise can take two meanings:  $1 \cdot 10^6$  (1e6) and  $1 \cdot 10^3$  (1e3).

The set of available meanings of the passband for measured frequency noise is present in the "Passband" panel. It is determined by the chosen multiplication factor value. If it is equal to  $1 \cdot 10^6$ , then this passband can take two meanings: 3Hz, or 10Hz.

For the multiplication factor equal to  $1 \cdot 10^3$  the meaning of the passband is automatically set to 10kHz.



**Figure 6.11** – "Operating mode" window

"Help" menu provides information about the program version and firmware version of the connected comparator.

### 6.3 Records files

Program saves phase differences samples measurement data.  $t_{yx,i}$  in two catalogs "samples" and "ASCII" in its root folder.

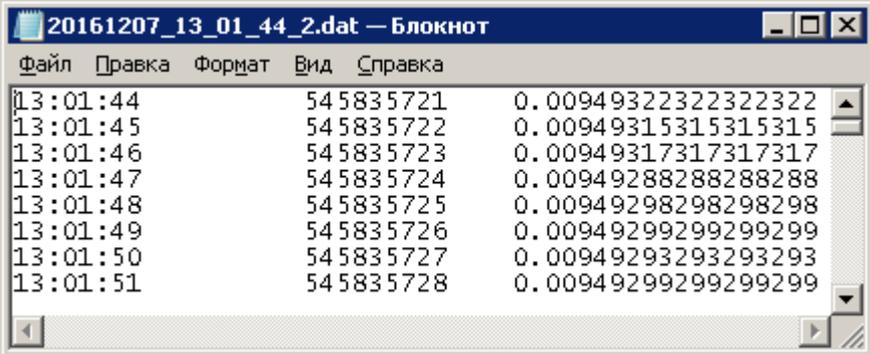
In the "samples" catalog data is stored in a format designed for time-frequency measurements data processing program Analyser. For each channel, two files are created with "\*.inf" and "\*.dat" extensions and named in YYMMDD\_n format where YY - year, MM - month, DD - day, n - channel number. If there were no measurements in a day, then files for this day are not created.

**Data processing program can be started by pressing the "Analyse" button in the main window (see Section 6). In addition, the processing program can be run on another computer connected via LAN to the computer running the "Multichannel Frequency Comparator" program. In the processing program you need to specify the path to the "samples" directory to work with records.**

"ASCII" catalog contains measurement data records in ASCII format for each channel separately. **Writing in this format can be turned off if the ini-file is set to ASCII=0 in Settings.** The file name includes date and time of recording start: YYYYMMDD\_hh\_mm\_ss\_n, where YYYY - year, MM - month, DD - day, hh - hours, mm - minutes, ss - seconds, n - channel number.

Records are divided into files for days. If recording is continued on the following day, a new file with name that includes the date of the next day and time 00:00:00 (eg 20150601\_00\_00\_00\_1) will be created.

The image below shows an example of a file in ASCII-format. The first column contains time of measurement corresponding to the time of the computer that is running the program. The second column contains comparator time counts in seconds. The third column contains comparator  $t_{yx,i}$  counts. For phase difference samples in seconds, you must divide  $t_{yx,i}$  by fluctuations of the comparator frequency multiplication coefficient  $K$ , equal to  $10^6$ , and change the sign (3.1.1)



The screenshot shows a Notepad window titled "20161207\_13\_01\_44\_2.dat - Блокнот". The window contains a table of data records with three columns: time, comparator time counts, and comparator counts. The data is as follows:

Time	Comparator time counts (s)	Comparator counts
13:01:44	545835721	0.00949322322322322
13:01:45	545835722	0.00949315315315315
13:01:46	545835723	0.00949317317317317
13:01:47	545835724	0.00949288288288288
13:01:48	545835725	0.00949298298298298
13:01:49	545835726	0.00949299299299299
13:01:50	545835727	0.00949293293293293
13:01:51	545835728	0.00949299299299299

**Figure 6.12** – Example of the records stored in ASCII-format