Inertial Measurement Unit

IMU-B, IMU-E, IMU-P

DEMO PROGRAM "IMU DEMO"

User's Manual

Revision 1.4

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Revision history

Revision	Date	Author	Description
1.0	Apr.25, 2016	AK	Released version.
1.1	Mar.17, 2017	AK, MM	1. Added IMU-P figures and its description. 2. Changed figures due to the data format IMU GA Data and new tab Sensors Options. 3. Added section 4.3. Sensors Options. 4. Added data format IMU GA Data and its description (Appendix C). 5. Added ±120°/s and ±450°/s gyro ranges for KG values (see notes to Table C.2 in APPENDIX C). 6. Changed reference to Section for Auto-start from 10.5 to 9.2 on the page 10. 7. Changed reference to IMU firmware version 2.2.0.3 on the pages 21 and 29. 8. Added notes about absence of LED indicator on the IMU-P (pages 32 and 36).
1.2	Jun.16, 2017	PT	1. Added Output variant description within Section 4.3. Sensors options 2. General edits and corrections to Sections 1-4.
1.3	Jul.17, 2017	AK	1. Added IMU Orientation format and its description. 2. Added sections 5.1 - 5.3 due to angles visualization. 3. Corrected scale factors for gyros and accelerometers data for “IMU GA Data” format.
1.4	Nov.21, 2017	AK	1. Added IMU Platform Stabilization format and its description. 2. Added item “Convert log data to bin file” to “Convert” menu and its description.

Table of contents

Introduction

This manual is designed to review the software and uses of the Inertial Labs[tm] IMU.

Use of the IMU should be restricted to only those who have read its user manual and are following the safety measures specified in that user manual.

This document is related to the next Inertial Labs™ models of IMU products:

- **IMU-B and IMU-E** which each use three-axis MEMS angular rate sensors (gyros), three-axis MEMS accelerometers, three-axis MEMS magnetometers, and a piezo-resistive pressure sensor;
- **IMU-P** which is an advanced MEMS sensors based, compact inertial measurement system that uses three-axis high-grade MEMS accelerometers and three-axis tactical grade MEMS gyroscopes.

Fig.1.1. Inertial Labs™ IMU-B, IMU-E

Fig.1.2. Inertial Labs™ IMU-P

1. General information

Operating system. This version of the Demo software is fully compatible with Microsoft XP, Vista, 7, 8.1, and 10.

Working with the software. The "Inertial Labs IMU Demo" software is a Win32 application, and keyboard and mouse are required to use it. The directory structure necessary to store data is created by the user. All necessary configuration and calibration coefficients are stored in the IMU in nonvolatile memory and are automatically loaded into the IMU microprocessor. Calibration coefficients are set by the IMU developer, and should only be changed under the guidance of the IMU developer. When the "Inertial Labs IMU Demo" software is closed, it creates a parameter file (*.prm) which it uses to store the latest parameters of the microprocessor and shell. When working with the IMU, the system will automatically create files with the extensions .prm, .dat, and .bin when saving text or graphical data. Additionally, the operator can create files with the extensions .txt and .rtf.

Requirements to the system resources. The software requires 6 Mbytes of RAM for proper operation. It requires approximately 25 Mbytes of hard drive space for the demo software files, and additional space for files saved during operation (usually no more than 100 Mbytes). The recommended minimum screen resolution is 1280x1024 pixels. The IMU is connected to the PC through either a COM port or a USB port when using the COM-to-USB converter. If using a COM-to-USB converter, reliability of signal reception/transmission between a PC and the IMU can depend greatly on the quality of the COM-to-USB converter and on correct configuration of its driver. The IMU manufacturer guarantees reliable operation of the IMU if it is connected directly to the COM port. Appendix A contains descriptions for installation and configuration of drivers for one of the possible COM-to-USB converters.

Requirements to operators. The IMU Demo software uses a standard Windows operating system. Therefore, operators should know the basic principles of PC operation to use the Demo software, and they should be able to use the Windows operating system.

2. Installation of drivers and configuration of PC parameters

The “Inertial Labs IMU Demo” software does not require any installation. Just copy the software folder to the working directory and launch the application.

If you connect the IMU to a standard computer COM port, drivers are not needed. If the IMU is connected to a USB port with a COM-to-USB converter see “Appendix A. Installation of the COM-to-USB converter drivers and configuration of PC parameters” for more details.

If you use the IMU with an RS-422 interface you need to install the RS422-to-USB converter driver. See “Appendix B. Installation of the MOXA Serial-to-USB converter drivers (for IMU with RS-422 interface)”

To know the numbers of the PC COM ports click “**Device Manager**” in the “**Hardware**” tab of the “System Properties” window (Fig.2.1). In the opened “Device Manager” window (Fig.2.2) you will see the COM ports which will be marked as “**Communications Port (COMN)**” or “**USB Serial Port (COMN)**” or “**MOXA USB Serial Port (COMN)**”. Number N in the port number assigned by the OS.

Fig.2.1

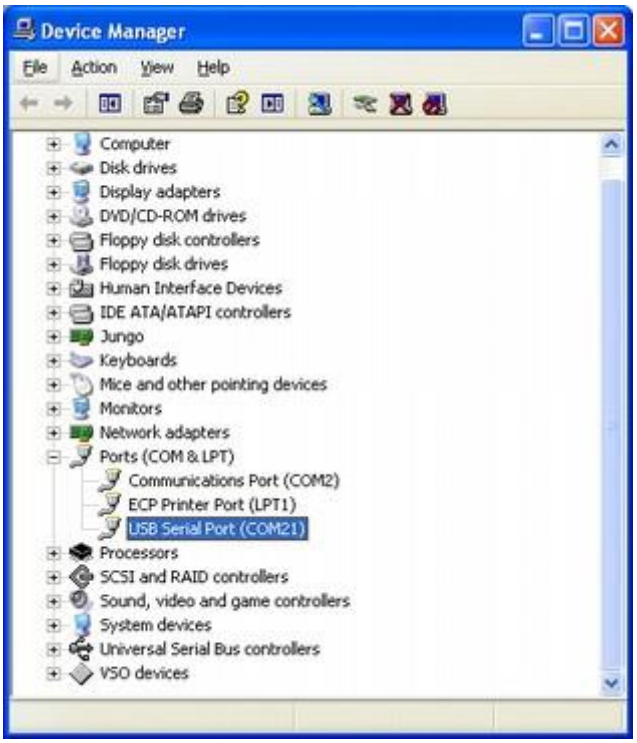


Fig.2.2

3. Main menu of the program

The main menu of the "Inertial Labs IMU Demo" software contains the following items (see Fig.3.1).

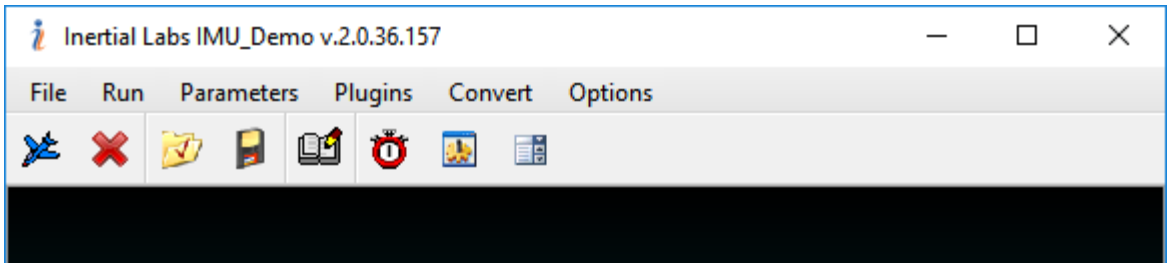


Fig.3.1

File Menu contains standard Windows file management commands (Fig.3.2).

Run Menu contains the IMU control commands (Fig.3.3).

Parameters Menu contains operations with IMU parameters (Fig.3.4).

Plugins Menu of the IMU Demo is empty (reserved for future use).

Convert Menu contains option for conversion of binary data to text format (Fig.3.5).

Options Menu contains the IMU configuration commands (Fig.3.6).

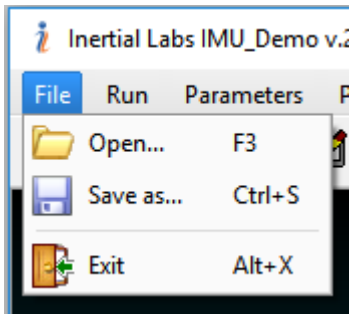


Fig.3.2

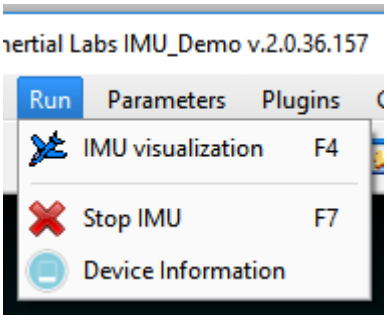


Fig.3.3

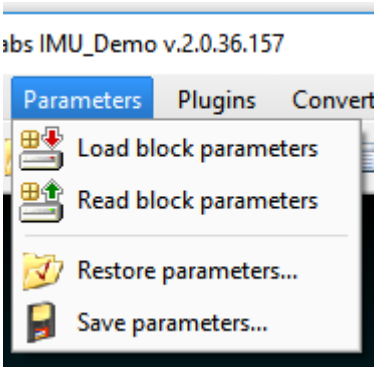


Fig.3.4

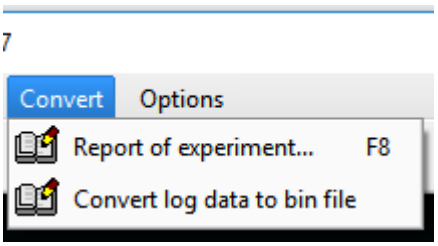


Fig.3.5

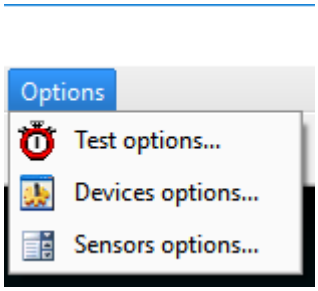


Fig.3.6

Icons for the most often used commands are placed in a toolbar across the top of the interface.

Run: - IMU visualization, F4;
- Stop IMU;

Parameters: - Save parameters;
- Restore parameters;

Convert: - Report of experiment, F8;

Options: - Test options...;
- Device options...;
- Sensors options…

4. Options Menu

4.1. Test options

To set operational parameters of the IMU, COM port, and/or format of output data, select **"Test options…"** (Fig.3.6) from the **"Options"** menu (or click the button).

A **"Test options"** dialog box (Fig.4.1) will be opened.

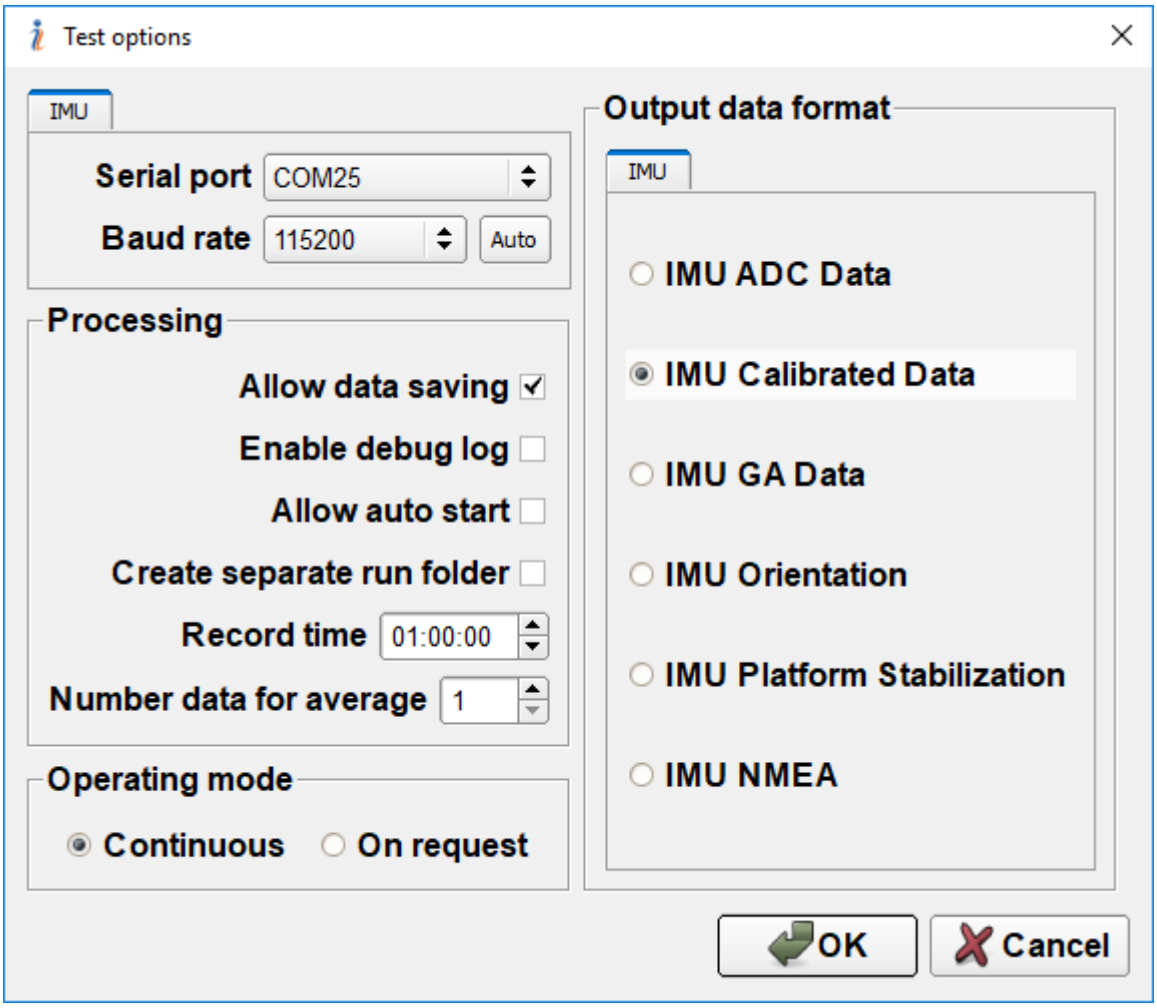


Fig.4.1

You can set the following parameters in the **"Test options"** window:

- Serial port – is the COM port number to which IMU is connected.

- Baud rate – is the set rate for the computer COM port for communication with the IMU unit. To find the value automatically, select the "**Auto**" option and the system will scan the identified COM port and report the current set Baud rate. See section 4.2.1 for details on Baud rate settings.

- Allow data saving checkbox – allows to record the test data to file. If it is unchecked then no file will be created and no message "Data are writing in file" will be displayed.

- Enable debug log – allows recording to the log file of a test run. In the case of an IMU Demo crash it can be used to debug errors. The log file contains information about commands that were sent by the IMU Demo and errors that appeared. In case of errors this file can be sent to Inertial Labs Support with a brief description of user actions to analyze the error.

- Allow auto start checkbox – allows operation with an IMU which was already started before running the IMU Demo software. See section 9.2 for details.

- Create separate run folder – allows automatic creation of a separate data folder for each run. By default this option is disabled.

- Record time – sets data recording time in hours:minutes:seconds format. The parameter is active when data is being saved to file. Values of hours, minutes, and seconds can be changed with the arrows or by entering the required value from a keyboard.

- Number data for average – the quantity of averaged data. This can be used for smoothing of viewed data. Note that averaging relates to the data output on the screen only and is not applied to the data written in a file. The minimal value for the parameter is 1 and changed with the arrows by ±1 or by entering the required value from a keyboard. The default value is 1.

- Operating Mode – defines IMU's output method, Continuous or stepped On Request. The default value is Continuous.

- Output Data Format – sets format of the IMU output data. Select one of the formats: "IMU ADC data", "IMU Calibrated data", "IMU GA data", "IMU Orientation", "IMU Platform Stabilization", "IMU NMEA". For more information on the output data format see Appendix C. The default value is "IMU Calibrated Data".

4.2. Devices options

To set and control IMU operation parameters, select **"Devices options…"** from the **"Options"** menu (Fig.3.6), or click the button (Fig.3.1).

A **"Devices options"** (Fig.4.2) window opens.

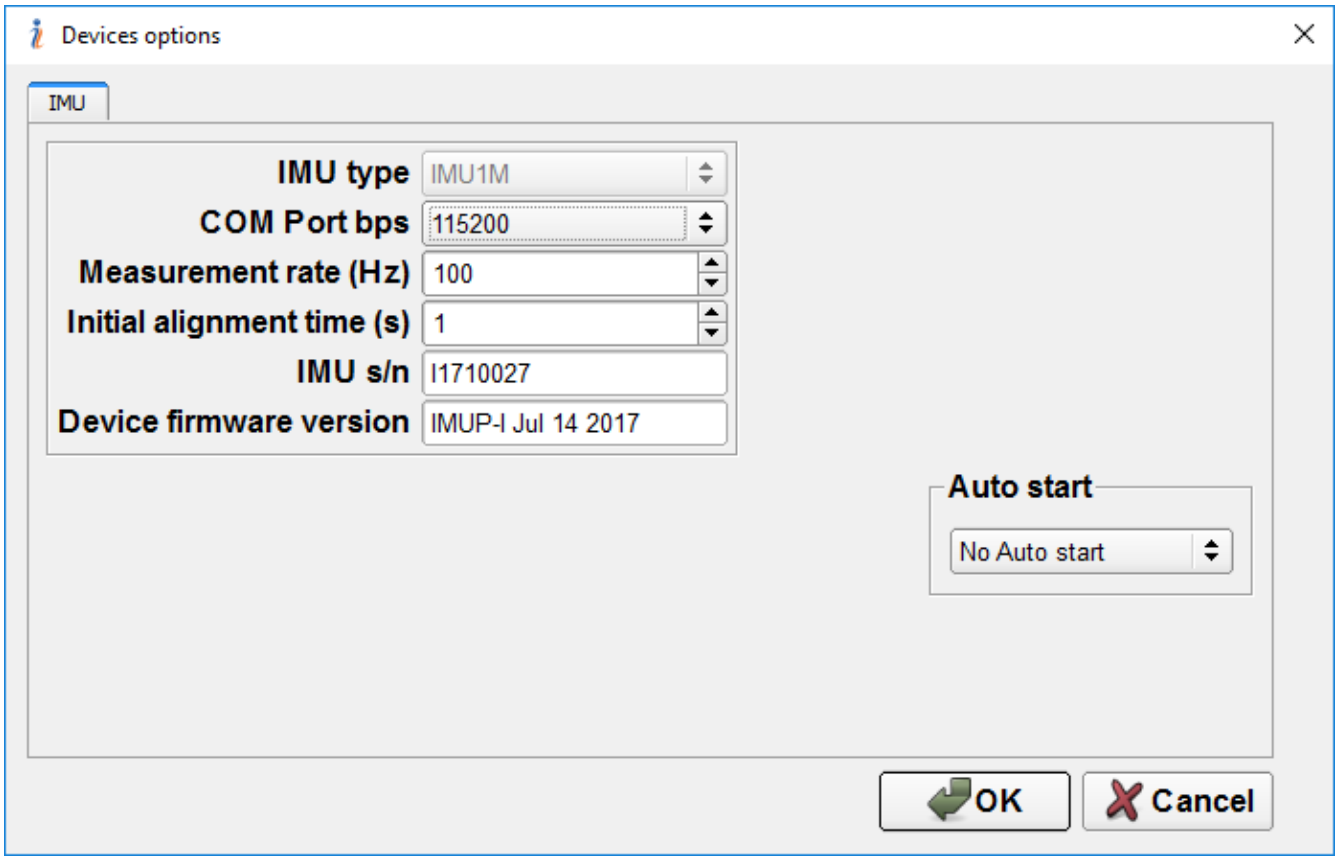


Fig.4.2

You can check or set the following parameters in the "Devices Options" window Fig.4.2:

- **IMU type**. This parameter cannot be changed.
- **COM Port bps** – sets the baud rate of the IMU COM port (see section "4.2.1. Change of the COM port baud rate" for details).
- **Measurement rate** (Hz) – sets data measurement rate in Hertz. Minimal value of the parameter is 1, maximal value is 800; it is changed with the arrows by ±10 or by entering the required value from a keyboard. The

default value is set to 100.

Note: the maximum measurement rate is limited by the chosen baud rate of the COM port which the IMU unit is connected to and the chosen output data format (see Fig.4.1). See section "4.2.2. Limitation of the IMU maximum measurement rate" for full details and Table 4.1 for maximum measurement rate guidelines.

- **Initial alignment time** (sec) – sets the initial alignment time in seconds. If nonzero initial alignment time is set, then during this time the IMU averages gyros' data to estimate gyros' biases for their next automatic compensation. In such case don't move the IMU during the initial alignment process otherwise some wrong residual biases may be present in the output gyros' data. Minimum value of the parameter is 0 and it can be changed by ±1 with the arrows or by entering the necessary value from a keyboard. The default value is set to 1.

- **IMU s/n** – specifies the serial number for the IMU in use. This parameter cannot be changed.

- **Device firmware version** – the firmware version of the IMU in use. Its identification code consists of the firmware type, firmware version, and the date of firmware release. This parameter cannot be changed.

- **Auto start** – enables or disables the automatic start of the IMU with a specified data output immediately upon power up (and without the need for any start command from a host computer or application). See section 9.2 for details.

***Notes*:**

1. There must be a properly connected device, with a correctly set COM port and baud rate within the Test options window (see section "4.1 Test options") in order to access the Devices options window. If not, an error window with message "Cannot read parameters!" will appear.
2. It is required for the device to be Stopped while working in the Devices Option window. To stop the IMU select "**Stop IMU"** in the "Run" menu or press **F7** key (Fig.3.3).

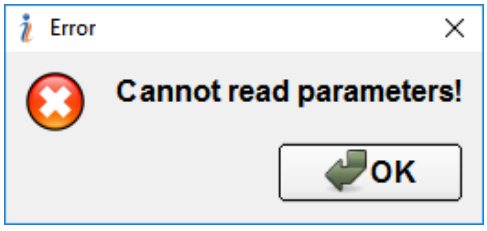


Fig.4.3

4.2.1. Change of the COM port baud rate

The default baud rate for the IMU COM port is set to 115200 bps (this is the maximum rate for native desktop PC COM-ports). If the host computer requires another baud rate for the IMU connection, the user can choose one from the following options: 9600, 14400, 19200, 38400, 57600, 115200, 230400, and 460800 bps.

Notes:

1. The standard baud rate for native COM-ports of desktop PCs cannot support baud rates greater than 115200 bps. For users desiring faster baud rates, a Serial-to-USB adapter should be used for IMU connection to the host computer.
2. Baud rate must be set to the same value in both the "Devices options" and "Test options" windows.

To set the correct COM port baud rate in "**Test options**", go to the "**Test options**" window and click the "**Auto**" button (see Fig.4.4). After several seconds a window with the caption "Serial port baud rate XXXXXX was successfully determined" will appear and the determined baud rate will appear.

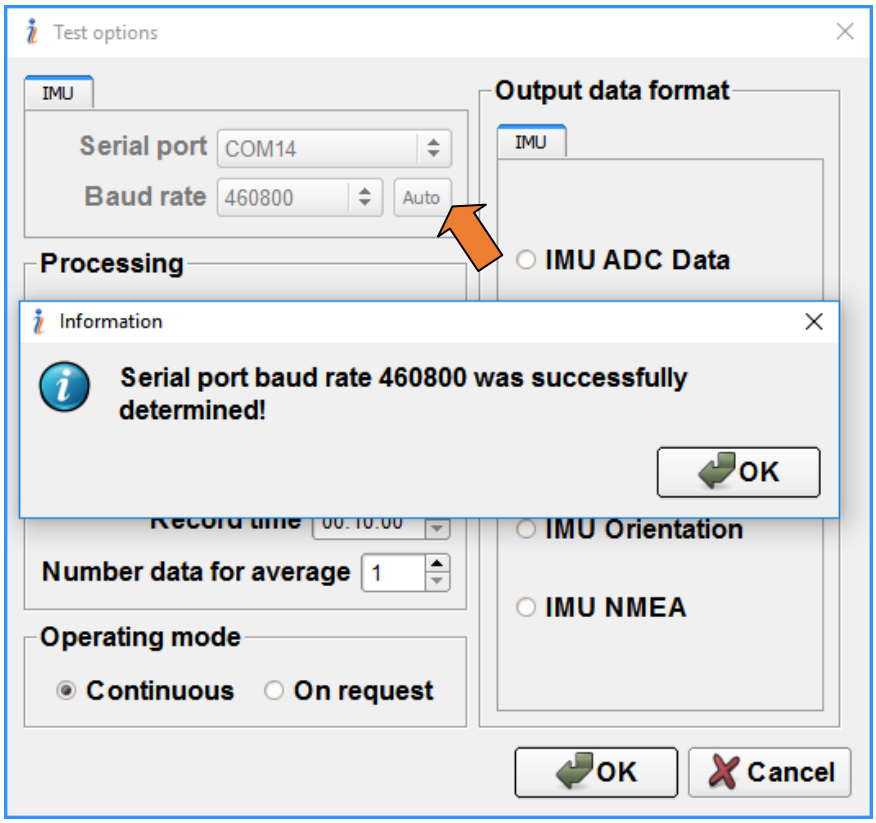


Fig.4.4

To change the COM port baud rate in the IMU unit go to the "**Devices options**", "IMU" tab (see Fig.4.2) and choose the necessary baud rate from the list as Fig.4.5 shows.

After the baud rate choice click the "**OK**" button to load the changed parameter to the IMU nonvolatile memory. Then the information windows shown on the Fig.4.6 and Fig.4.7 appear. Click "**OK**" to close these windows. The COM port baud rate within "**Test options**" will be changed automatically to the chosen value in order to keep communication between the IMU Demo software and the IMU unit.

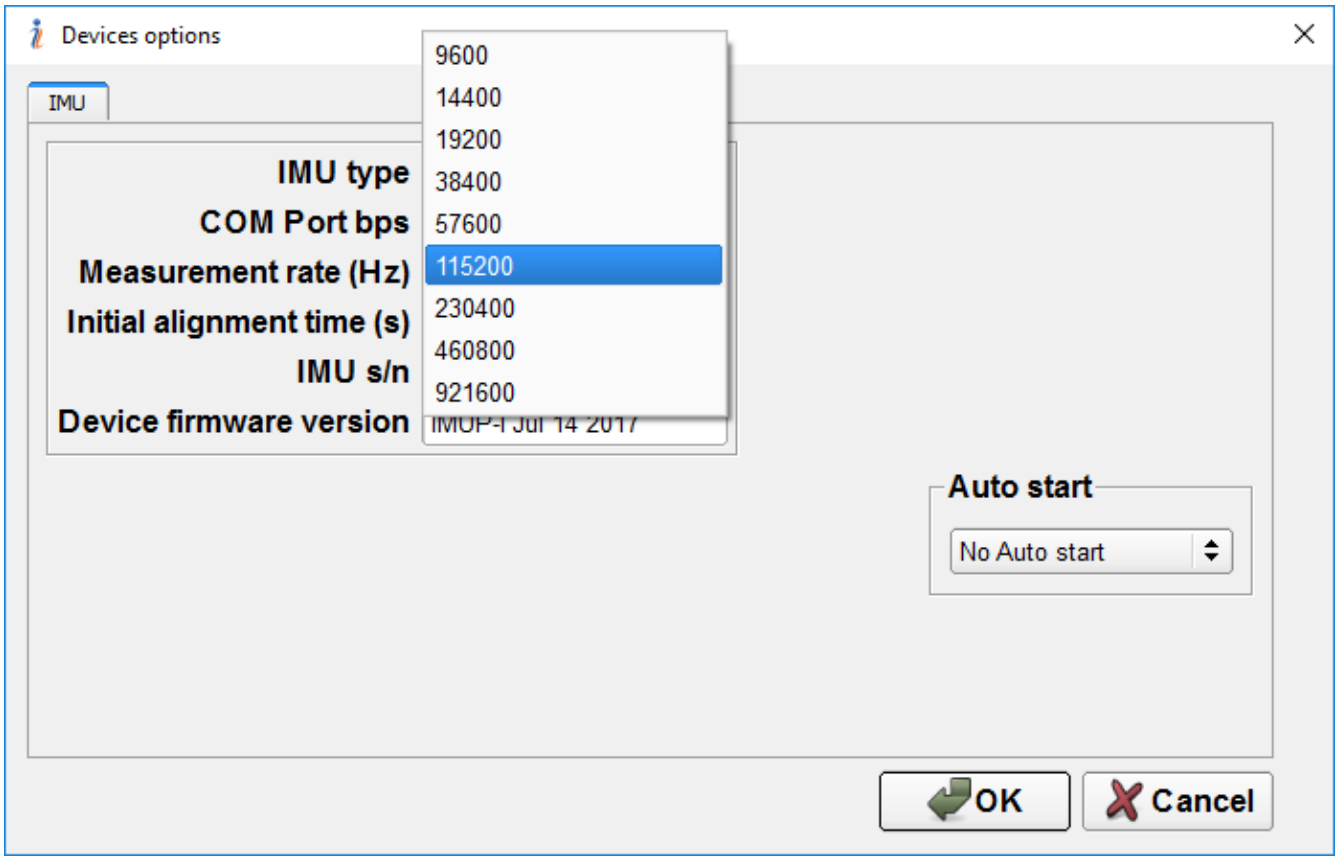


Fig.4.5

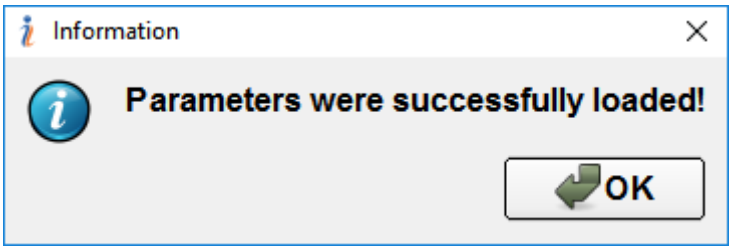


Fig.4.6

Fig.4.7

4.2.2. Limitation of the IMU maximum measurement rate

When setting the measurement rate for the IMU in "**Devices options**" (Fig.4.2) it is essential to ensure the chosen baud rate is capable of handling the data throughput at the desired data rate. The maximum measurement rate (Hz) can be calculated using the baud rate and data package length:

$$\text{max\_meas\_rate} = \frac{\text{COM\_baud\_rate}}{\text{bits\_per\_byte} * \text{package\_length}}, \qquad (4.1)$$

where COM_baud_rate is the COM port baud rate (bps); bits_per_byte = 11 bits per one transferred byte of data; package_length for binary data = payload length plus 8 bytes of overhead. See Appendix C, Table C.2, Table C.4 for payload length of binary output data formats. The package_length of the text output data formats corresponds to their structure shown in Appendix C. Table 4.1 contains data package length for each output data format and also maximum measurement rate calculated using formula (4.1), with some spare. Note that the maximum measurement rate of IMU data is limited to 800 Hz.

Table 4.1. IMU maximum measurement rate for different output data formats

Output data format	Data package length, bytes	COM-port baud rate, bps					
		9600	19200	38400	**115200**	230400	460800
		Maximum data rate, Hz					
IMU Calibrated Data	30+8	20	40	90	**270**	550	800
IMU ADC data	30+8	20	40	90	**270**	550	800
IMU GA Data	32+8	20	40	80	**260**	520	800
IMU Orientation	34+8	20	40	80	**240**	490	800
IMU Platform Stabilization	22+8	20	50	110	**340**	690	800
IMU NMEA	115	7	10	30	**90**	180	360

The IMU Demo Program controls the correctness of the measurement rate setting. If the user sets a measurement rate in "**Devices options**" which exceeds the limits shown in Table 4.1, then a warning window (Fig.4.8) appears.

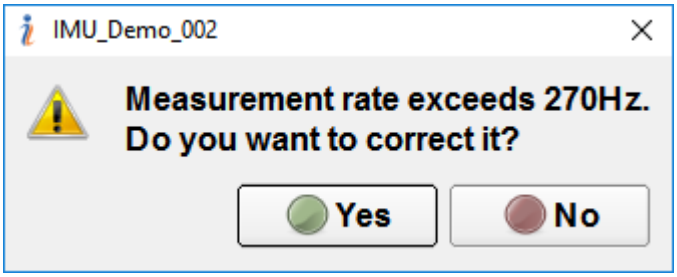


Fig.4.8

Click "Yes" to correct the entered measurement rate or "No" to ignore this warning. The latter case makes sense if the user subsequently chooses another output data format in "**Test options**" with less length of the data package. But in any case, the IMU controls the acceptable measurement rate onboard at the start to not allow the exceeding the maximum value based on the baud rate and output data format.

If the user chooses an output data format in the "**Test options**" window whose data length cannot be selected based on the current set measurement rate then a warning window (Fig.4.9) appears.

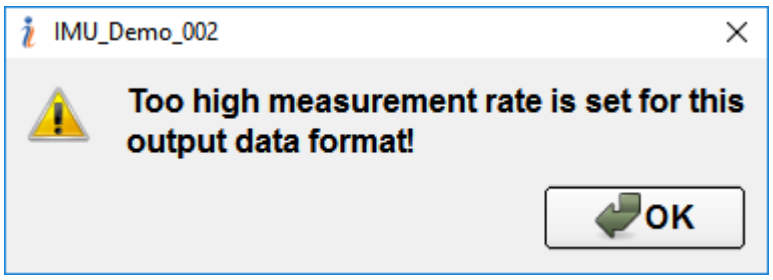


Fig.4.9

4.3. Sensors options

To set and control IMU sensors parameters, select **"Sensors options…"** from the **"Options"** menu (Fig.3.6), or click button (Fig.3.1).

A **"Sensors Options"** (Fig.4.10) window opens.

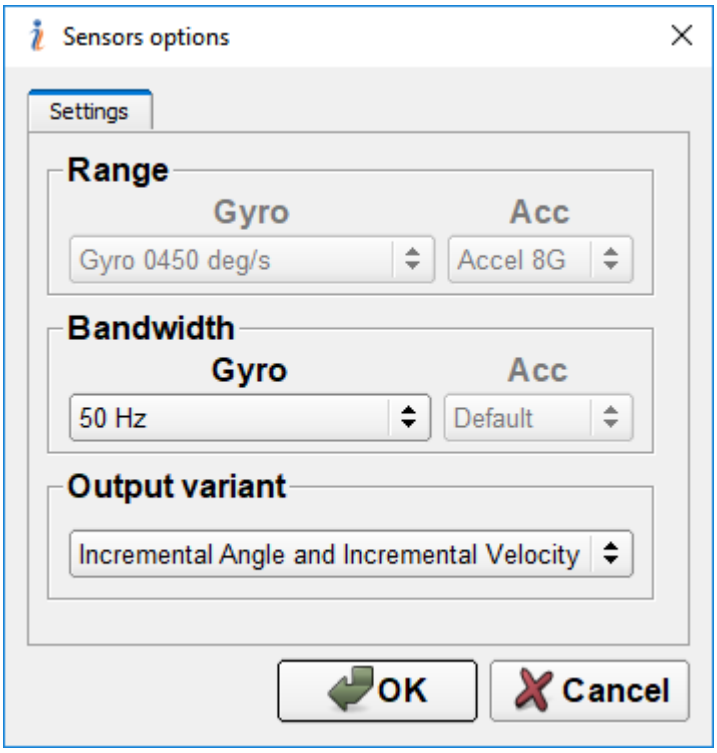


Fig.4.10

There are the following settings for the IMU gyros and accelerometers:

- **Range**
  - **Gyro** – shows the measurement range of gyros. This parameter cannot be changed.
  - **Acc** – shows the measurement range of accelerometers. This parameter cannot be changed.
- **Bandwidth**
  - **Gyro** – specifies the bandwidth of the low-pass filter which is applied to gyro output data. This parameter can be changed by

choosing required value from the drop-down list (see Fig.4.11). The default **Gyro bandwidth** is set to 50 Hz.

- **Acc** – specifies the bandwidth of the low-pass filter which is applied to accelerometers output data. This parameter cannot be changed.

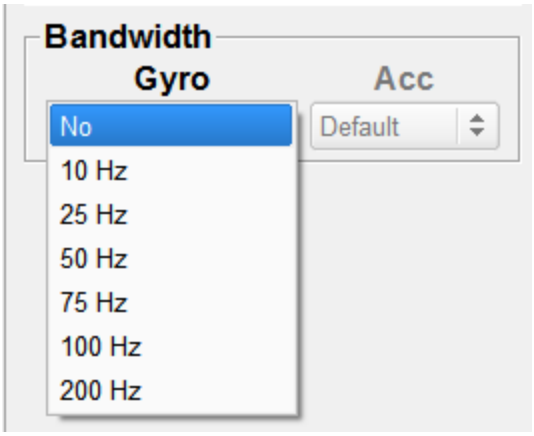


Fig.4.11

- **Output variant**
  - **Instant angular rate and acceleration** – The data of the IMU is sampled at the same rate as the specified messaging rate.
  - **Average angular rate and acceleration** – The data of the IMU is sampled at 800Hz and these data are then averaged according to the messaging rate.
  - **Delta Theta and Delta Velocity** – To be supported in future releases.

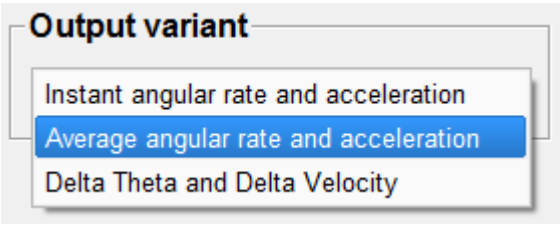


Fig.4.12

5. Run Menu

Control of the IMU is done by the commands in the "**Run**" menu (Fig.3.3). This menu contains next items:

- "IMU visualization" opens appropriate tab with visualization of the IMU operation;
- "Stop IMU" stops the IMU;
- "Device Information" shows main information about connected device;

There are four visualization styles of the IMU Orientation and IMU Platform Stabilization output formats:

- IMU 3D Demo;
- Cockpit;
- Snapshots;
- Data graphs.

For IMU Calibrated Data, IMU GA Data, IMU ADC Data, and IMU NMEA output formats only Data graphs visualization is available.

5.1. IMU 3D Demo

"**IMU 3D Demo**" is default variant of the IMU visualization in which current orientation angles of the IMU are shown as spatial orientation of an airplane (see Fig.5.1). To go to this visualization stile select **"IMU visualization"** from the "**Run**" menu (Fig.3.3), select  on the toolbar, or press **F4** button.

In the opened "IMU visualization" tab, three control buttons (active "Start"  and inactive yet: "Stop"  and "Write" ) appear in the left vertical toolbar. If the "On Request" option is chosen in the "Test Options" menu, then the "Request"  button appears inactive. Two icons appear in the status bar: "Warnings"  and "Failures"  .

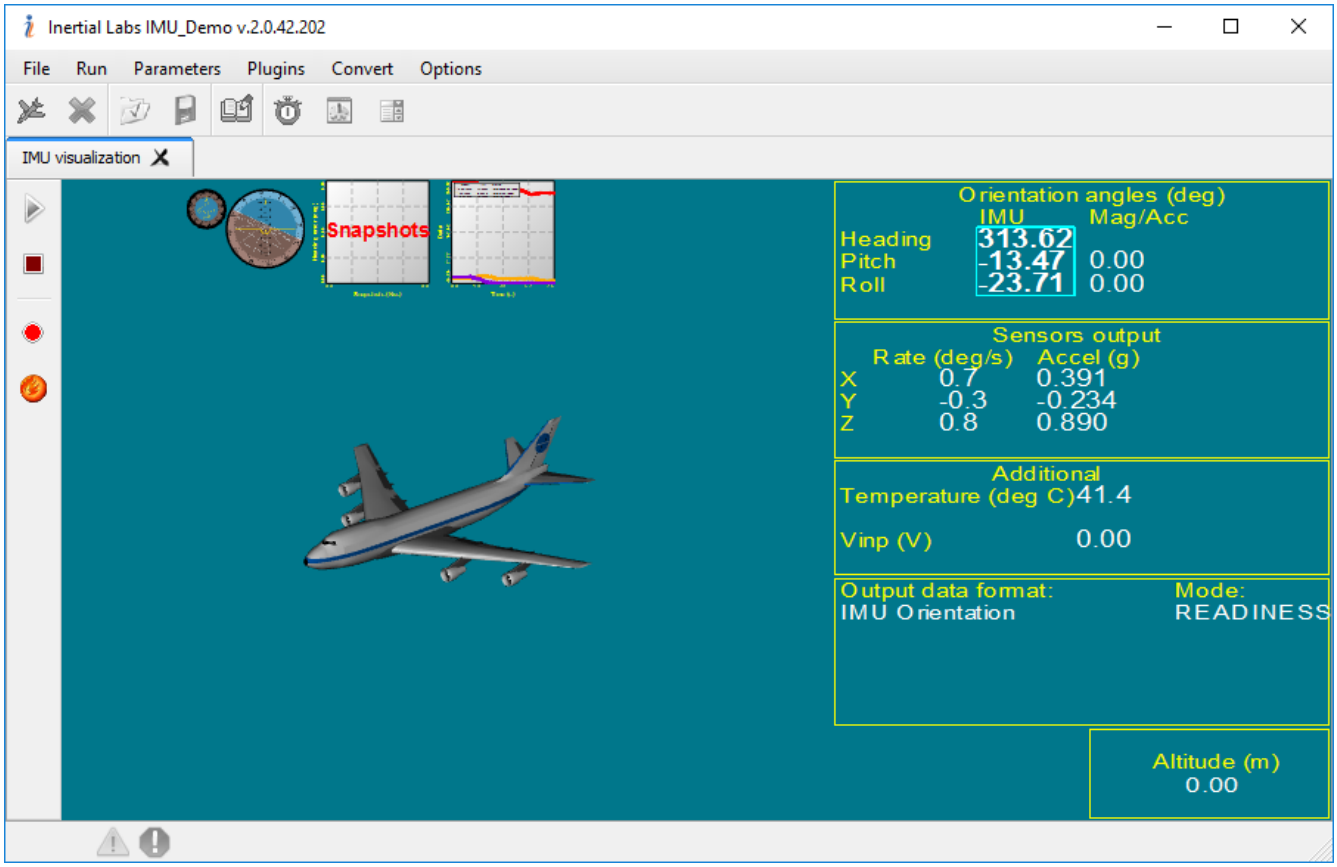


Fig.5.1

Warning and failure messages are generated by IMU in its Unit Status Word (see Appendix D) and appear near  and  icons. You can close these messages by clicking on them.

"IMU visualization" tab consists from two vertical parts. Visualization panel of the IMU outputs is situated on the left part of the tab. The right part displays text data from IMU and additional information

"**Start**" button  starts the IMU with parameters saved in the IMU's microprocessor.

Notes:

1. If nonzero initial alignment time was set then during this time the IMU averages gyros data to estimate gyros biases for their next automatic compensation. In such case don't move the IMU during the initial alignment procedure otherwise some wrong residual biases may be present in output gyros data.

2. In the IMU-B and IMU-E with firmware version before 2.2.0.3 the initial alignment procedure is obligatory even if zero initial alignment time is set.

If initial alignment time is set other than 0 second then process of the initial alignment of the IMU is performed with displayed message “Initial alignment. Please wait”. Also a progress bar of initial alignment will appear in the status line of the main window. Once the initial alignment time is over, observe changes in numeric data and plots. If initial alignment time is set to 0 and initial alignment process is skipped.

Once the “**Start**” button is pressed, buttons “Stop”  and “Write”  become active. If the “On Request” option was chosen in the “Test Options” menu, then the button “Request”  becomes active too.

Upon clicking the “**Write**” button  the measured data is saved, which is signified by the message “Data are writing in file!” in the text part of the window. Note that the data are saved in binary file and can be used in two ways:

- visualization through opening the file in “**File**” menu (see item 10.1.1. Data viewer);
- conversion to text file using “**Report of experiment**” from “**Convert**” menu item.

The “**Stop**” button  stops data output to the screen and data saving procedure with no data losses.

If in the menu “Options” the data output method “On Request” is chosen, then getting data from the IMU is performed by clicking the button  . In case of data saving (if the “Write” button  is pressed), the measured data are written in one file sequentially.

Displayed data depend on selected output data format (see Appendix B for details). If the “IMU Orientation data“ format is chosen then next data are displayed in the right part of the tab (Fig.5.1):

a) Orientation angles “Heading”, “Pitch” and “Roll”. In the “IMU” column, angles calculated in the IMU’s microprocessor using the embedded main algorithm are output.

b) Output signals of the IMU sensors: “Rate (deg/sec) “ – angular rate values in deg/sec measured by angular rate sensors, “Accel (g) “ – linear acceleration values in g measured by accelerometers.

c) Current temperature “Temperature (degC)“ inside the IMU.

d) Input supply voltage of the IMU in VDC “Vinp (V)“.

e) Format of output data “Output Data Format: …“. This format is set by operator in the «**Test Option**» window (Fig.4.1).

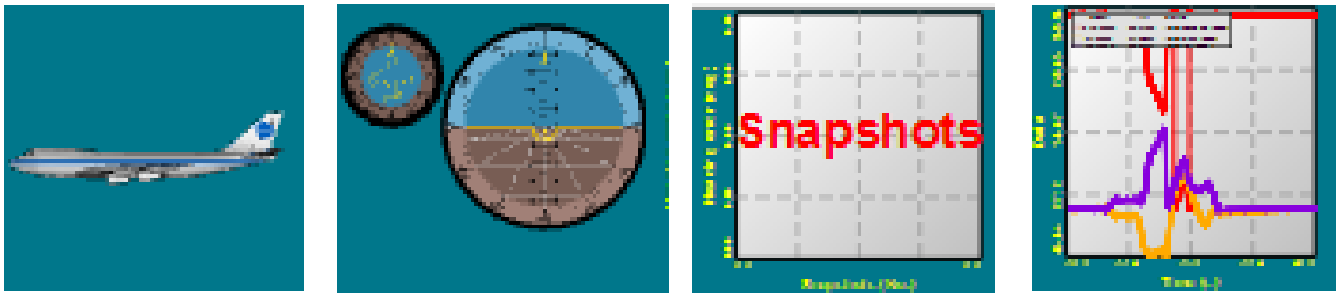
f) Current mode of the IMU operation (Readiness or Sleep).

g) Current altitude “Altitude” in meters.

To stop data output from the IMU click the “**Stop**“ button .

To leave the IMU visualization mode click the in the title of current tab.

For other styles of visualization of the IMU outputs there are clickable previews in the upper part of the “IMU visualization” tab (Fig.5.2). It is possible to switch between visualization styles at any time of the IMU operation by simple clicking on its preview.



a) b) c) d)

Fig.5.2

5.2. Cockpit style of visualization

“Cockpit” window allows showing current attitude of the IMU in “Cockpit display” style (see Fig.5.3). To switch visualization to this mode click on preview shown in the Fig.5.2b and window shown in the Fig.5.3 will appear.

There is heading indicator in the upper left corner of the tab. In the center part of the tab an attitude indicator (artificial horizon) is shown. Its vertical scale corresponds to pitch, limb corresponds to roll.

To switch to other than “Cockpit” style click on appropriate preview in the upper part of the “IMU visualization” tab (Fig.5.2).

To stop data output from the IMU click the “**Stop”** button .

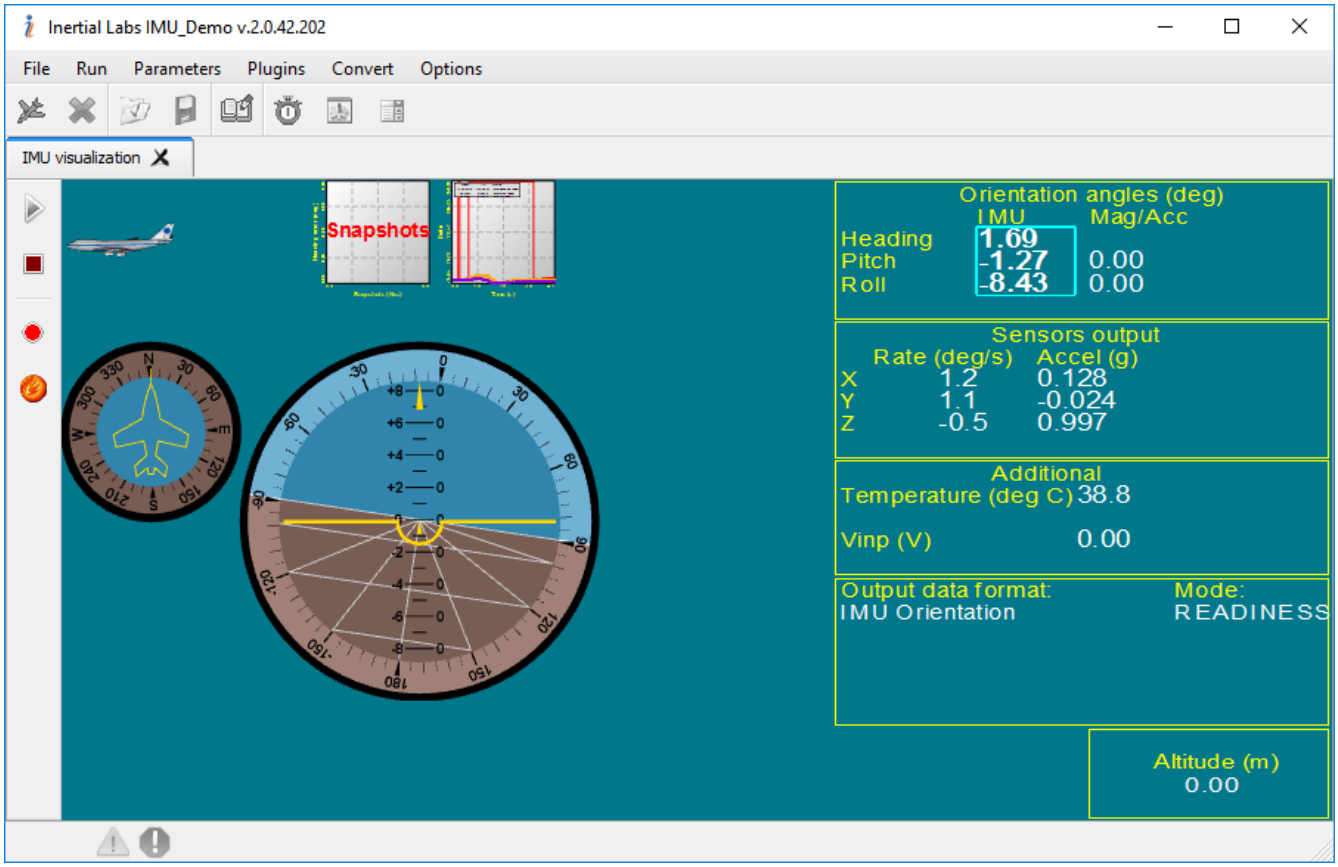


Fig.5.3

5.3. On-the-fly accuracy style of visualization

“On-the-fly accuracy” feature is designed for checking the IMU accuracy during its ordinary operation when the IMU can be directed to points with known orientation.

To switch visualization to this mode click on preview shown in the Fig.5.2c and window shown in the Fig.5.4 will appear.

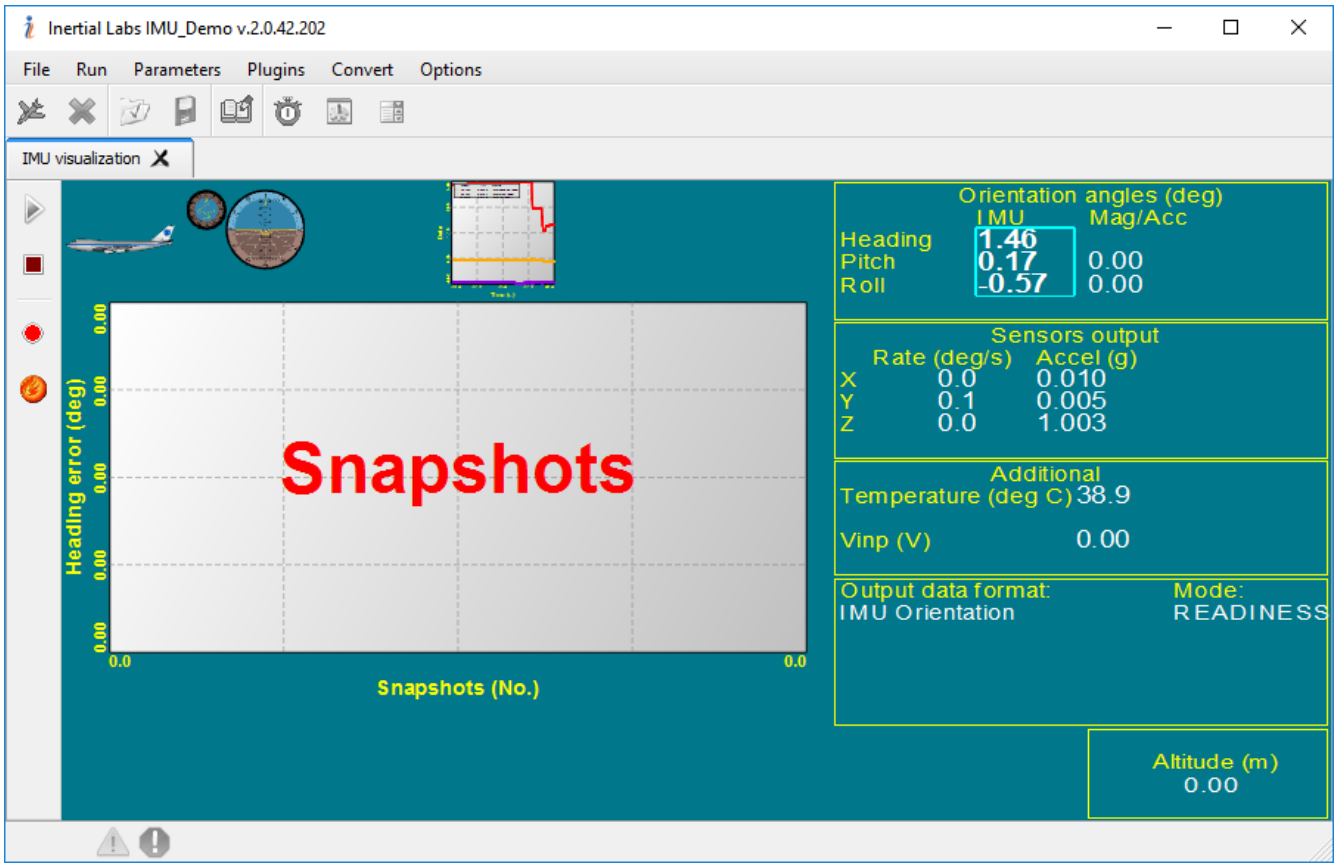


Fig.5.4

5.4. Data graphs style of visualization

"Data graphs" window allows showing graphs of current IMU outputs (see Fig.5.5). To switch visualization to this mode click on preview shown in the Fig.5.2d and window shown in the Fig.5.5 will appear.

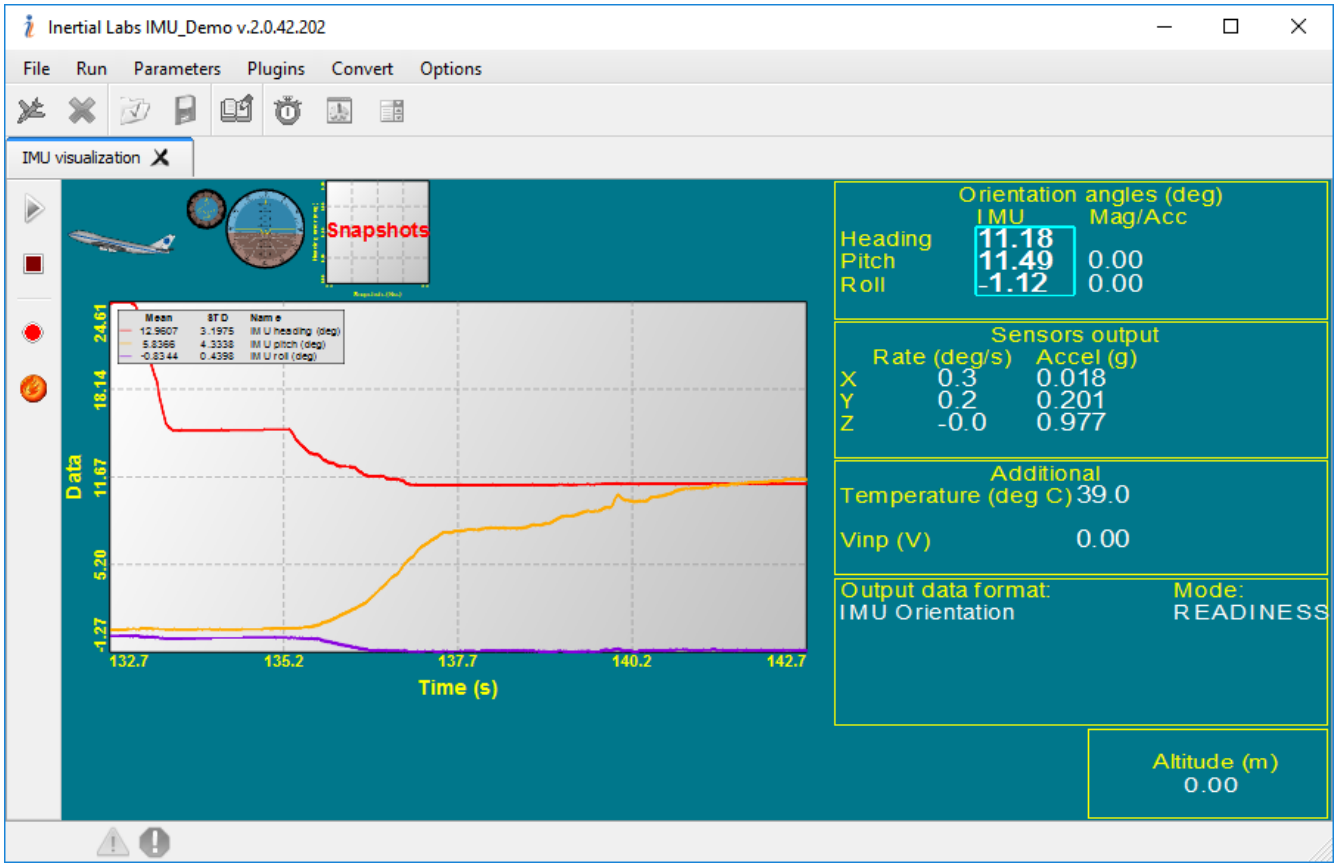


Fig.5.5

It is possible to select the signals you want to display by right-click on the graphs area. As a result window shown in the Fig.5.6 will appear.

Plotted graphs are scalable. To zoom in click and hold the left button on the mouse and drag mouse in down-right direction. Click and hold right button on mouse to shift plot. To zoom out click and hold the left button and drag mouse in up-left direction. The legend is located in the upper left corner of the tab. This legend shows mean value, STD and the names of displayed signals.

You can select or deselect signals by clicking on their titles:

- IMU heading (deg) – plots heading angles in deg;
- IMU pitch (deg) – plots pitch angle in deg;
- IMU roll (deg) – plots roll angle in deg;
- Accel pitch (deg) – plots pitch angle calculated by accelerometer data in deg;
- Accel roll (deg) – plots pitch angle calculated by accelerometer data in deg;
- Gyro X (deg/sec) – plots output signal of the gyro X in deg/sec;
- Gyro Y (deg/sec) – plots output signal of the gyro Y in deg/sec;
- Gyro Z (deg/sec) – plots output signal of the gyro Z in deg/sec;
- Accelerometer X (g) – plots output data of the accelerometer X in g;
- Accelerometer Y (g) – plots output data of the accelerometer Y in g;
- Accelerometer Z (g) – plots output data of the accelerometer Z in g;
- Temperature (deg C) – plots current temperature inside the IMU in Celsius degrees.

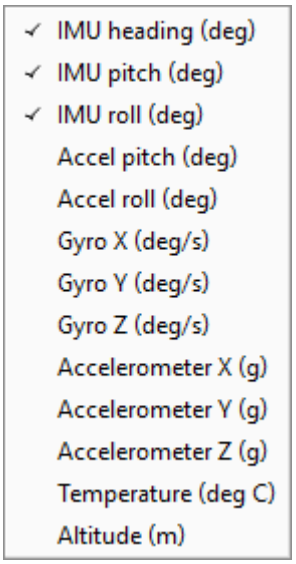


Fig.5.6

Altitude (m) – plots altitude in meters.

5.5. Other items of the Run menu

- **Stop IMU** – stops the IMU. In most cases it is used for correct termination of completed operations. For this command the hot key **F7** can be also pressed or the button can be clicked.

- **Device Information** – opens tab with the IMU main information: integrated device (IMU) serial number and firmware version; IMU1 serial number and firmware version; parameters of GNSS receiver; GPS reference week number; pressure sensor type (see Fig.5.7).

Note the Inertial Labs™ IMU does not include GNSS receiver, so related fields in the Device Information on Fig.5.7 are empty, and GPS reference week number = 0. If you need in IMU with GNSS receiver please contact the Inertial Labs.

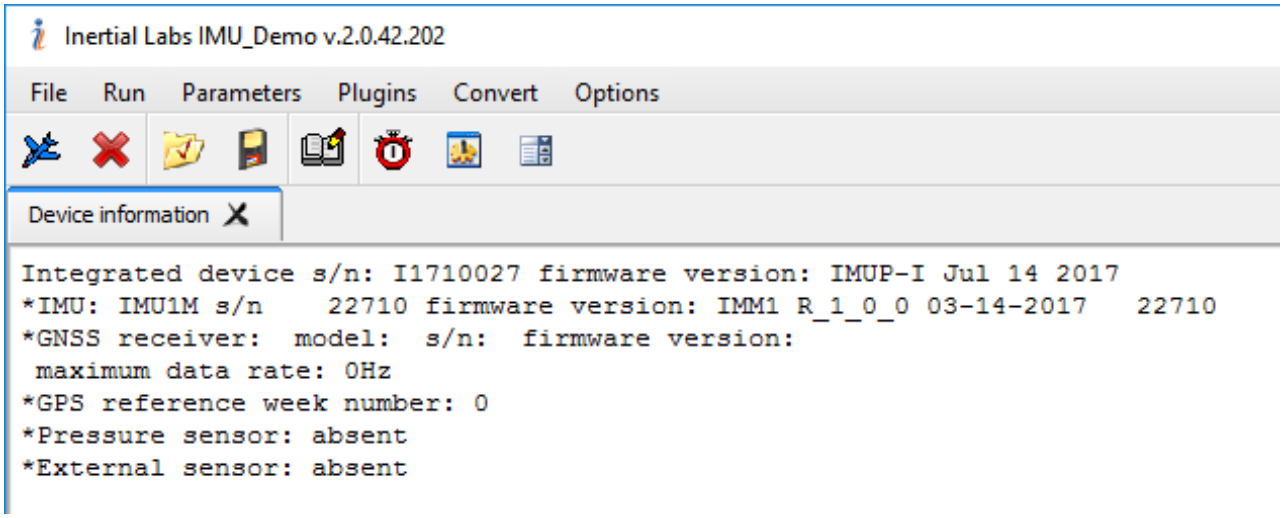


Fig.5.7

6. File Menu

"File" menu enable to work with already saved tests results. There are such items in the "File" menu:

- "Open";
- "Save as";
- "Exit".

6.1. "Open" item

You can visualize data saved to files during an IMU run. To open the saved *.bin file choose the "Open" option (Fig.3.2) or press **F3**. The standard window Windows "Open…" will appear, in which it is necessary to choose needed *.bin file saved previously when the IMU was operating in its standard mode. After selection of file, data are read from it and new tab **"Data viewer"** shown in the Fig.6.1 will open. It is possible to select the data you want to display by right-click on the graphs area. As a result window shown in the Fig.5.6 will appear where you can select or deselect showed data by clicking on their titles.

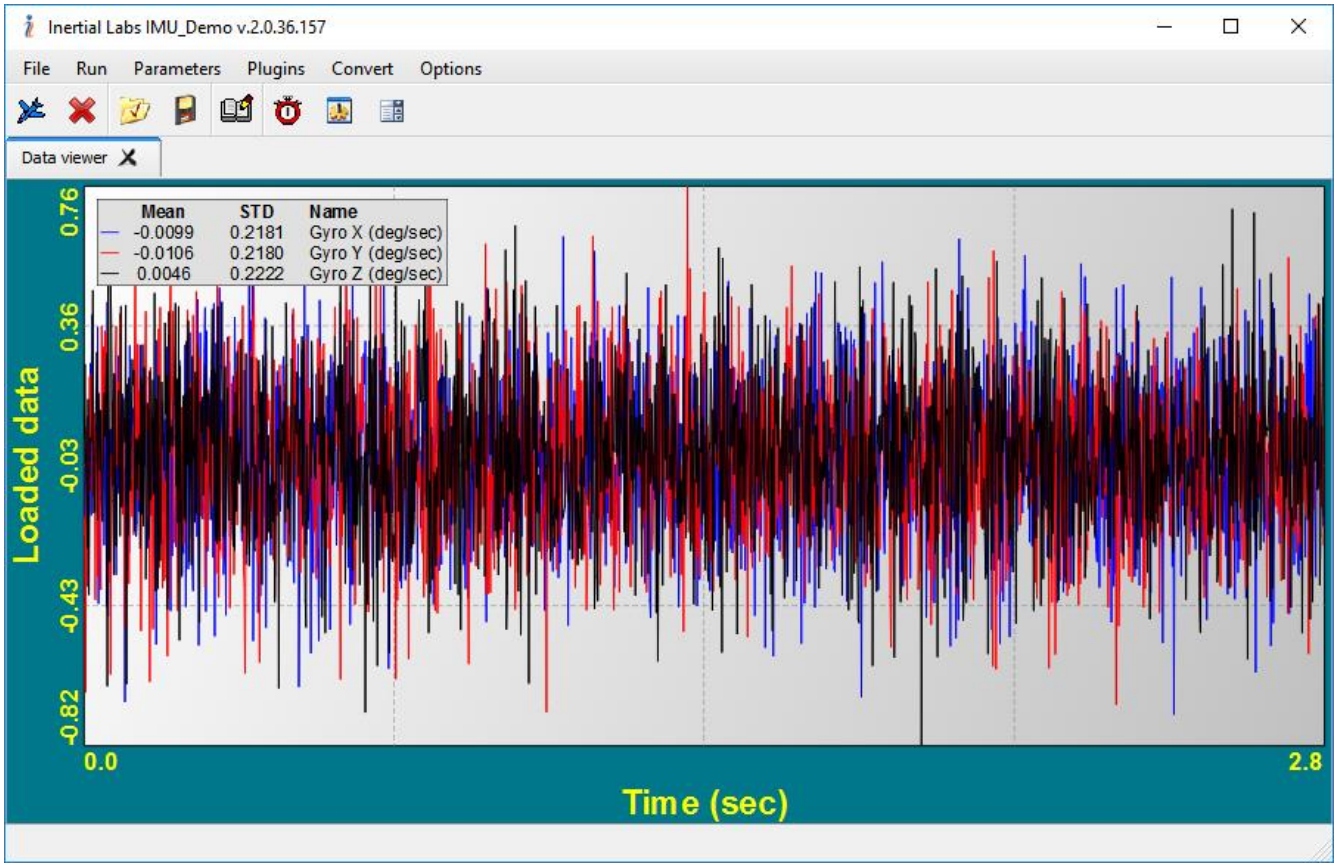


Fig.6.1

Plotted graphs are scalable. To zoom in please click and hold left button on mouse and drag mouse in down-right direction. To zoom out please click and hold left button on mouse and drag mouse in up-left direction. Click and hold right button on mouse to drag the plot.

Legend is located at the left upper corner of the tab. This legend shows mean value, STD (standard deviation) and name of displayed data.

To close graphs please click the  icon in the title of current tab.

6.2. "Save as" item

You can preset the name of the file for data writing. For this select the **"Save as"** item (Fig.3.2) and enter a desirable file name.

7. Parameters menu

"Parameters" menu enables working with the IMU parameters. There are the following items in the **"Parameters"** menu:

- Load block parameters;
- Read block parameters;
- Restore parameters;
- Save parameters;

7.1. "Load block parameters" and "Read block parameters" items

These items are used to check operation of appropriate commands of the IMU. IMU Demo software allows more convenient means to load the IMU parameters to the IMU nonvolatile memory.

7.2. Restore parameters

"Restore parameters" command (see Fig.3.4) is used to quickly load the IMU parameters to the IMU nonvolatile memory. When **"Restore parameters"** command is selected, or  button is clicked, a standard Windows "Open" window opens; in this window operator selects one of the previously saved files with .prm extension. Consequently, the parameters are automatically saved to the IMU nonvolatile memory and to the Demo-Program shell. The same way is used to restore the factory settings of the IMU parameters. In this case you should select original file with .prm extension that comes on CD with Inertial Labs IMU.

7.3. Save parameters

If you have changed some parameters of the IMU (in "**Device options…**" window from the "**Options**" menu or other menus), and you want to save these parameters as variant for future work, you can save the IMU current parameters in binary file with .prm extension. For this use "**Save parameters**" command (see Fig.3.4) or click  button. After that a standard Windows "Save as …" window is opened; in this window operator is suggested to save current parameters of the IMU to a "File of parameters" with .prm extension.

8. Convert Menu

There are two items "**Report of experiment**" and "**Convert log data to bin file**".

"Report of experiment" item is used to convert saved binary data (pair of files *.bin, *.prm) to text file. When the **"**Report of experiment" item is selected, or button  is clicked, or **F8** button is pressed (see Fig.3.5), a standard Windows "Open" window is opened. In this window operator selects one of the *.bin files saved previously when the IMU was operating in its ordinary mode. Consequently, a report file with same name but with .txt extension is created. Note that file with an extension .prm and the same name as .bin should be present as well.

The "Report of experiment" creates text file according to the output data format of data in the binary *.bin file. The necessary data format is set by user in the "Test Options" window. A description of the text file is done in the "Appendix C.2. Text presentation of output data formats".

"**Convert log data to bin file**" is useful if data were saved directly to a log file as output from the IMU COM port, without use of IMU Demo software. In this case saved log contains also headers, check sum and other service data according to the IMU message structure. Use «Convert log data to bin file» to convert log file to binary files *.bin, *.prm which can be processed by IMU Demo software.

After select the "Convert log data to bin file" item a standard Windows "Open" window appears. In this window please select parameters file *.prm with current parameters of the IMU unit. Then new Windows "Open" window is opened where user is asked to select the log file. After this the pair *.bin, *.prm files will be created with the same name as log file plus "_Converted" text.

9. The IMU operation

9.1. The main operation modes of the IMU

Step 1. Connect a power cable and data transfer cable to the IMU. Connect the other end of the data transfer cable to either COM port or USB port of the host computer. If connection between the computer and the IMU is done through a USB port, a driver for a COM-to-USB converter needs to be installed. See Appendix A 'Installation of the COM-to-USB converter drivers and configuration of PC parameters' for details on the installation procedure. If it is connected to a standard PC COM port, then there are no needs to install any drivers. Note that IMU manufacturer guarantees reliable operation of the IMU if it is connected directly to the COM port.

Step 2. Start IMU_Demo.exe file to begin working with the Demo software. The main menu will appear (Fig.3.1).

Step 3. Select **"Test options…"** from the **"Options"** menu (see Fig.3.7) or click  button. "Test option" window (Fig.4.1) will open.

Step 4. Set the correct COM port number in the **"Serial port"** field and its baud rate as Fig.4.1 shows.

Step 5. (Not obligatory) In "Test option" window (Fig.4.1), if you need, you can set **"Record time"** of data writing when data is being saved to file and **"Number data for average"** (the quantity of averaged data) that can be used for smoothing of viewed data. Note that averaging relates to the data output on the screen only and is not applied to the data written in a file.

Note: For the number of the COM port to which the IMU is connected, see 2. "Installation of drivers and configuration of the PC parameters" and Appendix A. "Installation of the COM-to-USB converter drivers and configuration of the PC parameters".

Step 6. In "Test option" window (Fig.4.1) set (check) data output mode in the "**Operating Mode**" group, and also **"Output Data Format"** (see Appendix C for more information on the output data format). Click **"OK"**.

Step 7. (Not obligatory) If you want to change some parameters of the IMU or its operation select **"Device options…"** from the **"Options"** menu –

see Fig.3.6. Appropriate window Fig.4.2 will open. Set the necessary IMU operation parameters. Click "**OK**".

Step 8. Select "**IMU Visualization**" from the "**Run**" menu (Fig.3.3) or click  button on the toolbar, or press **F4**. The window shown in Fig.5.1 will appear.

Step 9. Click the "**Start**"  button. If initial alignment time is set other than 0 second then process of the initial alignment of the IMU is performed with displayed message "Initial alignment. Please wait". Also a progress bar of initial alignment will appear in the status line of the main window. Once the initial alignment time is over, observe changes in numeric data and plots. If initial alignment time is set to 0 and initial alignment process is skipped.

Notes:

1. If nonzero initial alignment time was set then during this time the IMU averages gyros data to estimate gyros biases for their next automatic compensation. In such case don't move the IMU during the initial alignment procedure otherwise some wrong residual biases may be present in output gyros data.

2. In the IMU-B and IMU-E with firmware version before 2.2.0.3 the initial alignment procedure is obligatory even if zero initial alignment time is set.

Step 10. If you have selected the "On Request" operating mode, click the "**Request**"  button to get data from the IMU each time if you want. Observe changes in numeric data and graphical evolutions of the object.

Step 11. To save data click "**Write**"  button. Caption "Data are writing in file!" will appear. Also a progress bar of data writing and timer will appear in the status line of the main window.

In the "On Request" operating mode data is written in a file sequentially with the each click of the "**Request**"  button.

Note: To allow data sawing the appropriate checkbox should be set in the **"Test Options"** window (see Fig.4.1).

Step 12. To stop the IMU click the "**Stop**"  button. If the data were being written to a file then the writing is stopped too.

The default directory for saved files is the "data" subdirectory placed in the directory where the file IMU_Demo_*.exe is located. The default name of the file with saved data is generated automatically and consists of the IMU serial

number, date and time digits separated by dash symbols where the first 4 digits are the year, the next 2 digits are the month, then 2 digits of day, next digits are hours, minutes and seconds of operation start. When saving the data, two files of the same name with .bin and .prm extensions are saved in the specified folder. In .bin files the measured data is saved, and in .prm files the IMU microprocessor parameters, at which this data was obtained, are saved. For example, F15A0025-2016-04-04-12-14-26.bin corresponds to data saved from the IMU s/n A1240013 on 2016, April 4th, at 12:14:26.

Note. You can preset name of file for data writing. For this select item **"Save as"** in the **"File"** menu and enter desirable file name.

Step 13. Repeat Step 9 – Step 12 as many times as you need.

Step 14. To close standard operation mode window (Fig.5.1) click the  icon in the title of current tab.

Step 15. Select **"Stop IMU" (**Fig.3.3) from the **"Run"** menu, or click  button.

To get the saved data as text file, do the following:

Step 16. Select "**Report of experiment**" from the "**Convert**" menu (Fig.3.5) or press **F8** in the main menu or click  button (Fig.3.1). A standard Windows "Open" window will open.

Step 17. Select the necessary file with extension .bin. Click "**OK**". A .txt file will be created with the same name and in the same folder as the selected .bin file, with format set in Step 6.

Note. When large file data is processed then some time is necessary for text file saving. If you will start new operations with Demo software before end of text file saving, then Demo software will appear as not responding or locked. Just wait some time for saving end, after that Demo software will be unlocked.

Also you can plot saved IMU binary data using **"File"** menu. See section 6.1 for more details.

9.2. IMU automatic start

The Inertial Labs™ IMU has ability to start operation automatically after power on, with continuous output data in desirable output data format. See Appendix C for more details about data formats.

The auto start option can be enabled or disabled in the drop-down list “Auto start” in the “IMU” tab of the “Devices Options” window – see Fig.4.2. To allow this option the IMU should be connected to PC and powered.

The drop-down list “Auto start” contains list of all available output data formats, see Fig.9.1. Please choose desirable output data format for the IMU auto start. Default is “No Auto start” option that disables automatic start.

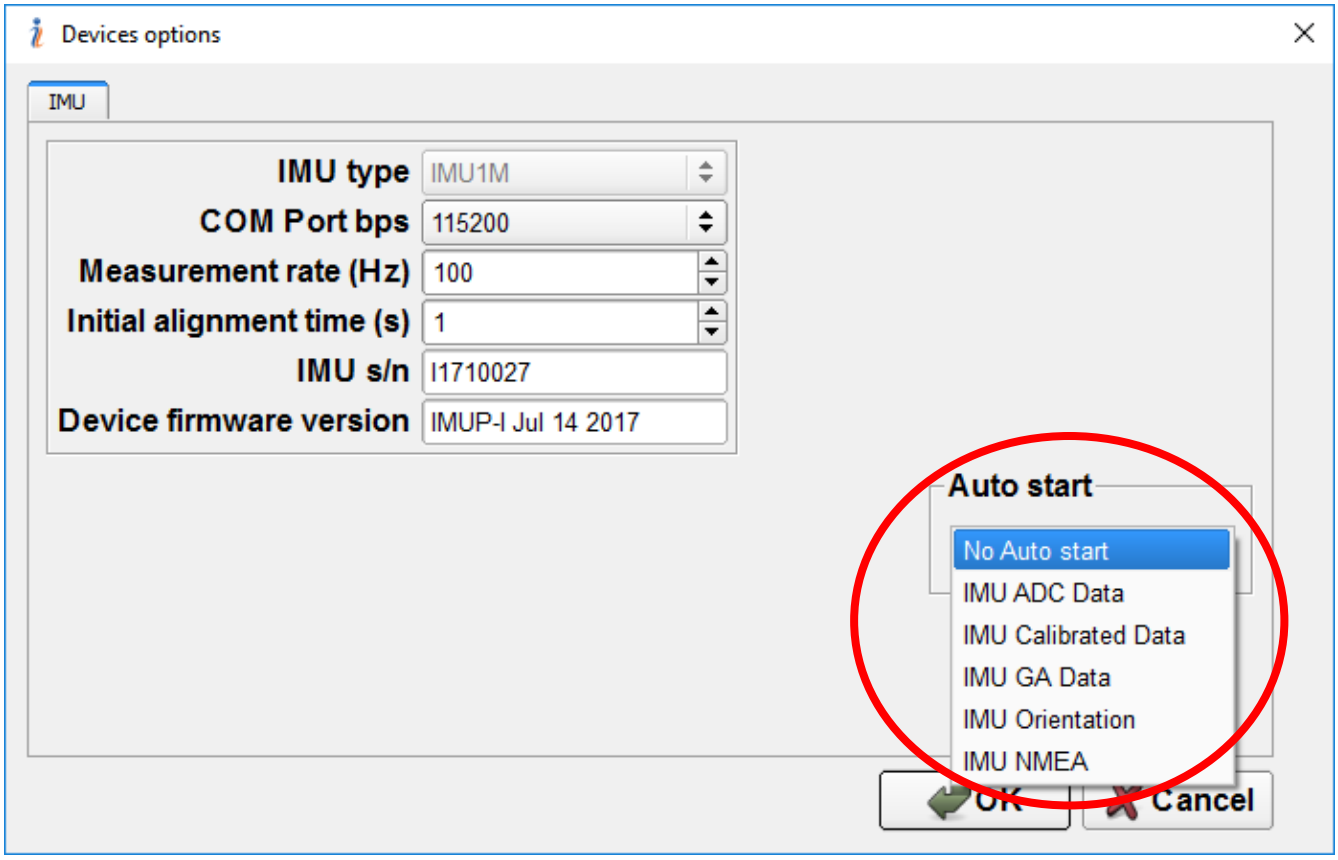


Fig.9.1

Usually just IMU Demo software is used to start and stop the IMU operation. To allow the IMU Demo to receive data from the IMU that was started

automatically, it is necessary to select the “Allow auto start” checkbox in the “Test options” window – see Fig.4.1. After the “Allow auto start” checkbox is selected, it is necessary to close the IMU Demo and start it again to apply this setting.

Operation with automatically started IMU is close to those described in the section 9.1, with a little difference.

Step 1. Connect the IMU to PC and power on. LED indicator of the IMU will light yellow during less than 1 second until the primary initialization of the IMU microprocessor is completed. After that the IMU starts calculations and its LED indicator changes color to green.

Note: IMU-P does not have LED indicator.

Step 2. Wait not less than set time for the initial alignment (if it is set other than 0 second) and run the IMU Demo program. If the COM port number was set correctly and “Allow auto start” checkbox was selected then IMU Demo will show the IMU continuous data in chosen output data format.

The next possible steps are the same as described in section 9.1, steps 11 – 17. For example, you can:

Step 3. To save data to file please click the “Write”  button.

Step 4. To stop the IMU click “Stop”  button. If the data were being written in a file then the writing is stopped too.

10. Continuous self-monitoring of the IMU health

The Inertial Labs IMU has continuous built-in monitoring of the IMU health. In the main mode the IMU sends out Unit Status Word (USW) in each data block (see also Appendix C).

The low byte (bits 0-7) of USW indicates failure of the IMU. If this byte is 0 then the IMU operates correctly, if it is not 0, see “Appendix D. The Unit Status Word definition” for type of failure or contact the developers directly.

The high byte (bits 8-15) contains a warning or is informative for the user. Status of each bit of the USW warning byte is specified in the “Appendix D. The Unit Status Word definition”.

11. Control of compatibility between the IMU firmware and IMU Demo versions

Firmware of the Inertial Labs IMU is developing continuously. The IMU hardware also can be changed. Sometimes the IMU features are so new that are not supported by old versions of the IMU Demo software. On the other hand, some functions of the old IMU Demo software were deleted from the new software versions.

We recommend strongly to use version of the IMU Demo software that comes on CD with the IMU until the IMU firmware is updated.

If the IMU has too old firmware version then before execution of any command sent from the Demo Software to the IMU the warning window appears (see Fig.11.1) that informs about incompatible version of the IMU firmware. Click “OK” and continue work.

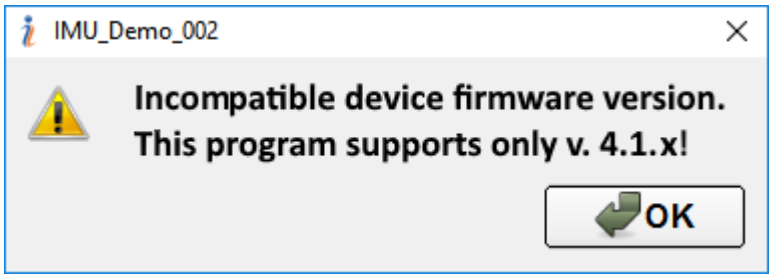


Fig.11.1

12. Troubleshooting

12.1. How to repair the IMU parameters

Need to repair of the IMU parameters appears in some cases, for example at incorrect loading of parameters into the IMU memory.

You can use original file with .prm extension that comes on CD with the Inertial Labs IMU, or use own files created by "**Save parameters**" command (if these files contain valid data of course).

Follow next steps to restore IMU parameters.

1. Connect the IMU to PC and power it.

2. Start the IMU Demo software. The main menu will appear (see Fig.3.1).

3. Select **"Test options…"** from the **"Options"** menu (or click  button) – see Fig.3.7. "Test options" window (Fig.4.1) will open.

4. Select the correct COM port number and its rate. Click "**OK**".

Note. For the number of the COM port to which the IMU is connected, see items 2. "Installation of drivers and configuration of the PC parameters" and Appendix A. "Installation of the COM-to-USB converter drivers and configuration of the PC parameters."

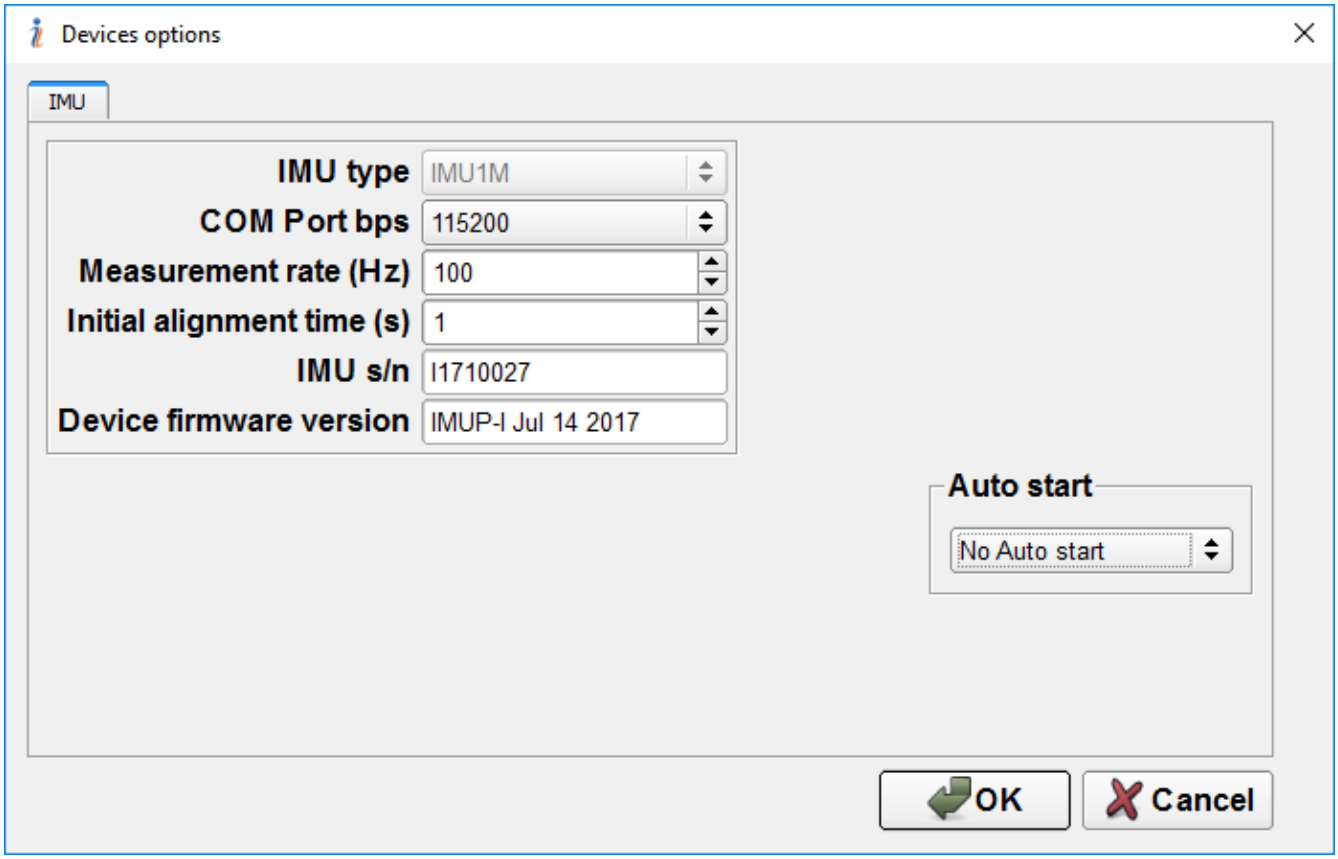
5. Select **"Restore parameters"** in the **"Parameters"** menu (see Fig.3.4) or click  button. A standard Windows "Open" window will open.

6. Select file with extension .prm containing the factory settings of the IMU parameters or own file created by "**Save parameters**" command (if this file contains valid data of course). Click "**OK**". These parameters will be loaded into IMU memory automatically.

12.2. What do you have to do at strange behavior of the IMU

If you see strange behavior of the IMU, first check whose parameters are loaded in the connected IMU. This may occur, for example, if you have restored parameters that corresponds to another IMU with an improper serial number. Please use **"Restore parameters…"** command accurately to avoid wrong parameters loading into the IMU's memory.

To check whose parameters are loaded in the connected IMU please select "**Device options …**" from the **"Options"** menu (or click button) – see Fig.3.7. "Device options" window will open:



In the field **"IMU name"** you will see serial number of the IMU. It must correspond to serial number that is placed on label on IMU's nose.

If **"IMU name"** doesn't correspond to serial number of the connected IMU then you must restore original parameters as that described in section 12.1.

12.3. What do you have to do if messages "Cannot read parameters!", "Cannot load parameters!", or "Cannot start IMU" appear

When you use Inertial Labs IMU Demo Software, the most of operations are started with reading data from the IMU nonvolatile memory to control correct IMU status. For this purpose the IMU should be powered and connected to COM-port or USB-port using COM-to-USB adapter.

When you see one of messages that Fig.14.1 shows, then you should check the next items:

- The IMU is powered (LED indicator in IMU-B, IMU-E lights red).
- The IMU is connected to COM-port or USB-port using COM-to-USB adapter.
- The COM-port number and its baud rate are set correctly in the **"Serial port"** field in **"Test options…"** window from the **"Options"** menu as Fig.4.1 shows.

Then simply click the "**OK**" button and repeat your operation.

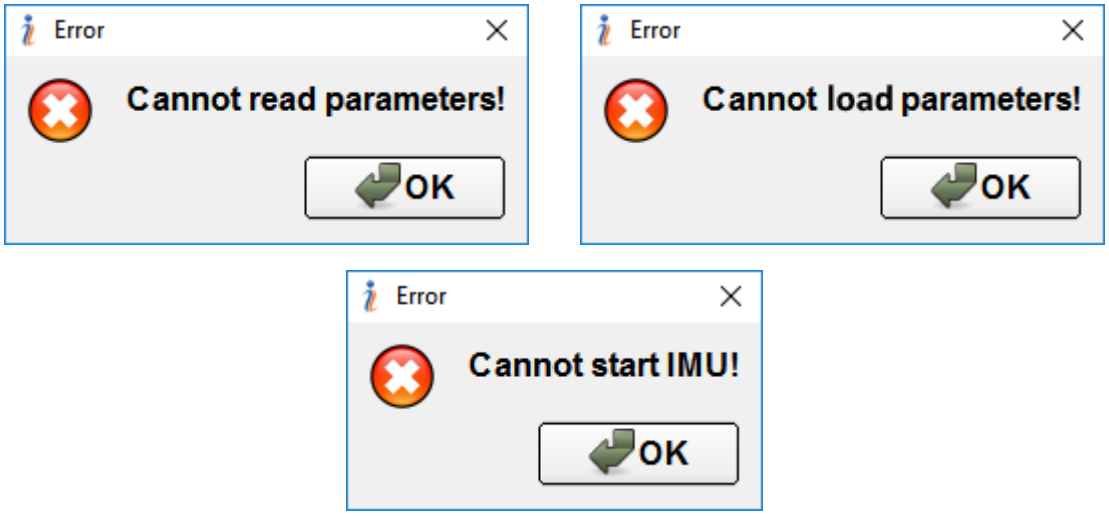


Fig.14.1

APPENDIX A.
Installation of the COM-to-USB converter drivers and configuration of PC parameters

Inertial Labs IMU developer highly recommends connection of the IMU with RS-232 interface to a computer through a standard COM-port for guaranteed reliable operation of the IMU. If connection of the IMU to a computer is done through a USB port, it is necessary to install a COM-to-USB converter driver. The converter driver is in the folder COM_to_USB_Driver placed on the CD provided with the IMU. Sequence of the converter driver installation is as follows:

– Connect the converter to a computer. The computer automatically starts a search and installation program for the necessary drivers of the connected device. A window (Fig.A.1) opens. Select “No, not this time” from the menu and click on the “Next” button.

Fig.A.1

– Window (Fig.A.2) will appear on the display. Select “Install from a list or specific location (Advanced)” from the menu and click on the “Next” button.

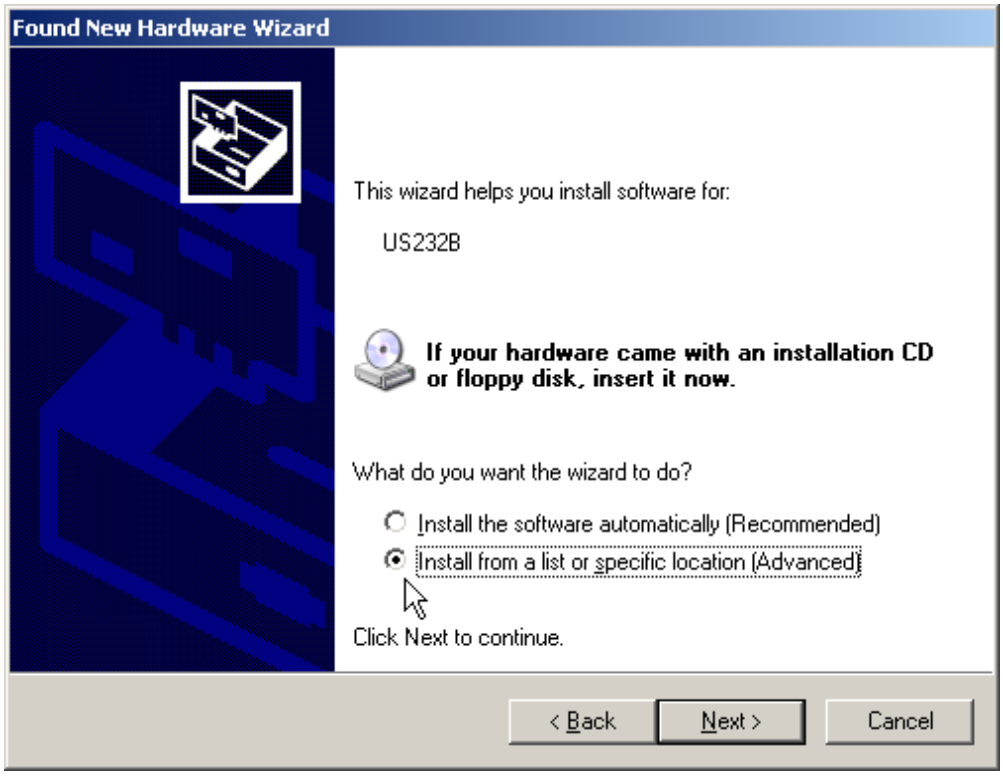


Fig.A.2

– Window (Fig.A.3) will appear on the display. Check “Include this location in the search:” and click on “Browse”. Show the path to the converter drivers folder in the window (Fig.A.4) which appears on the top of the previous one (folder name may differ from the name in Fig.A.4) and click “OK” (if a folder containing no driver files is selected, “OK” button will remain inactive). Next, in the window Fig.A.3, which will be looking like the window in Fig.A.5, a path will be defined. Using this path the installation program will search for the necessary converter driver. Press “Next” to continue installation.

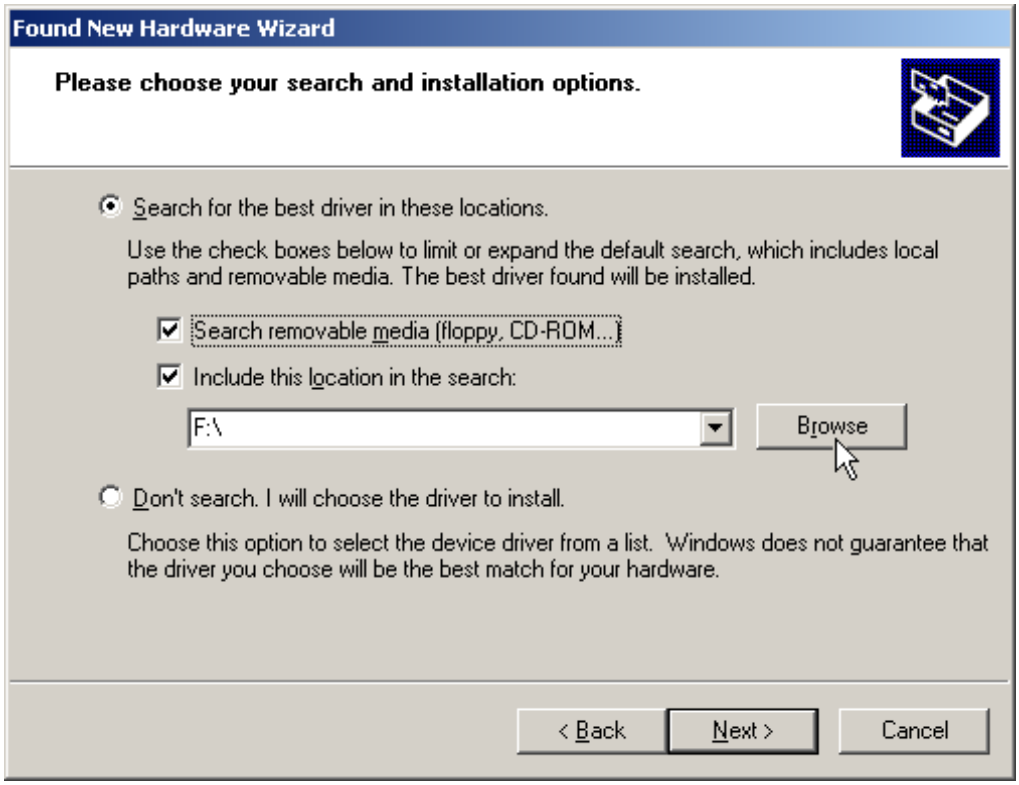

Found New Hardware Wizard
Please choose your search and installation options.
Search for the best driver in these locations.
Use the check boxes below to limit or expand the default search, which includes local paths and removable media. The best driver found will be installed.
Search removable media (floppy, CD-ROM...)
Include this location in the search:
F:\
Browse
Don't search. I will choose the driver to install.
Choose this option to select the device driver from a list. Windows does not guarantee that the driver you choose will be the best match for your hardware.
< Back
Next >
Cancel

Fig.A.3

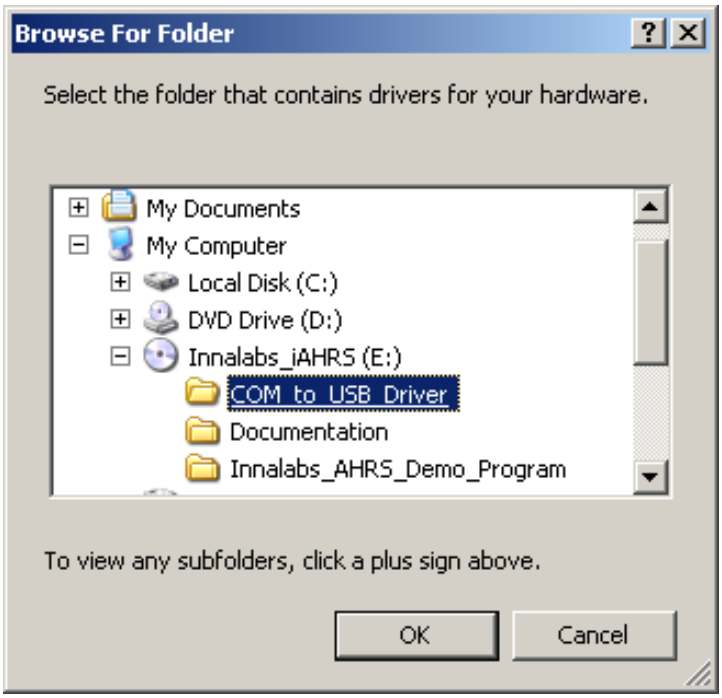

Browse For Folder
Select the folder that contains drivers for your hardware.
My Documents
My Computer
Local Disk (C:)
DVD Drive (D:)
Innalabs_iAHRS (E:)
COM_to_USB_Driver
Documentation
Innalabs_AHRS_Demo_Program
To view any subfolders, click a plus sign above.
OK
Cancel

Fig.A.4

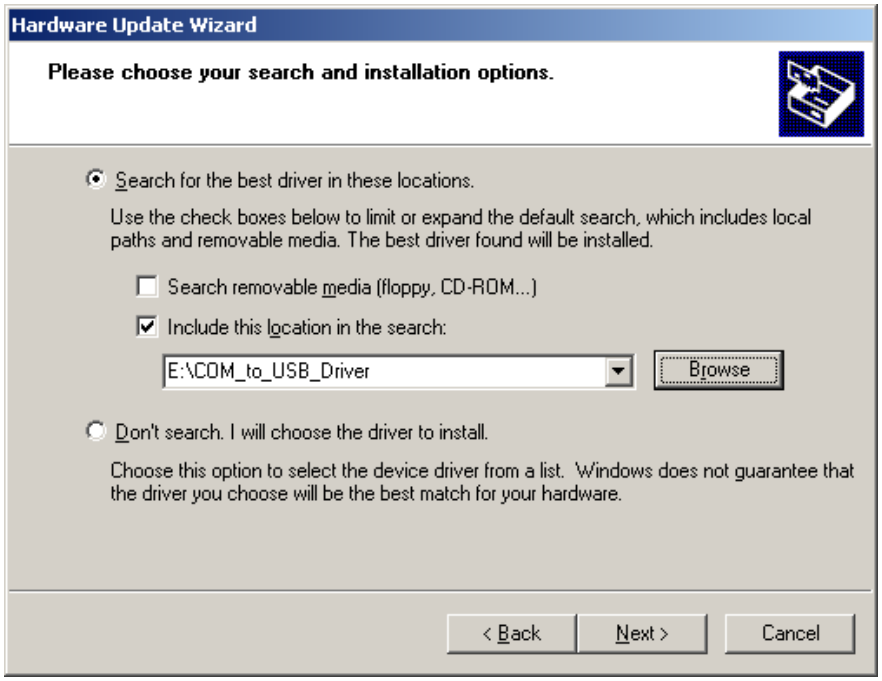


Fig.A.5

– If the program finds the necessary files, it will automatically start the driver installation. If installation is completed successfully, the window in Fig.A.6 will appear on the screen. Press “Finish” to complete installation procedure for the COM-to-USB converter driver.

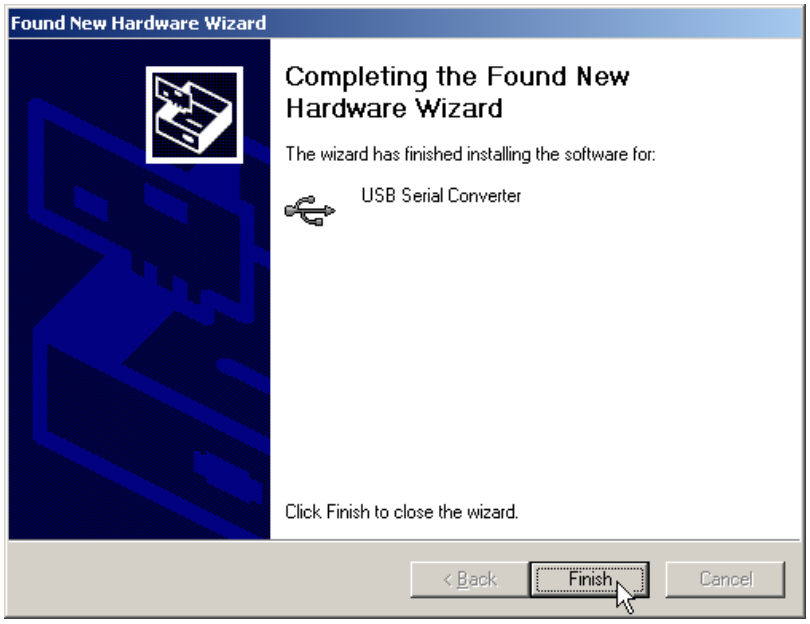


Fig.A.6

If the necessary drivers are not installed, an error message (Fig.A.7) will appear. In this case, click "**Back**" and set the correct path to the driver files in the window in Fig.A.3.

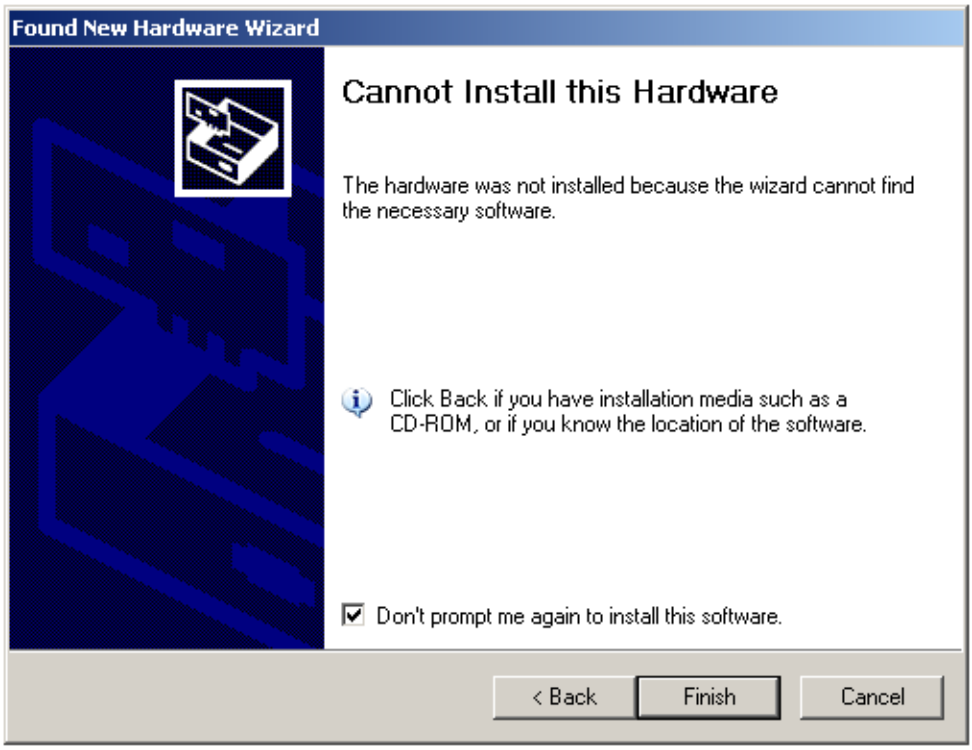


Fig.A.7

Once the converter driver is installed, you will need to know the number of the additional COM-port set by the system and configure parameters of this port for correct operation of the IMU. To do this, press the "**Device Manager**" button in the "System Properties" window, in the "**Hardware**" page. In the opened "Device Manager" window (Fig.A.8) the additionally set COM-port will be marked as "**USB serial port (COMN)**". Number N in the port name will be assigned by the computer.

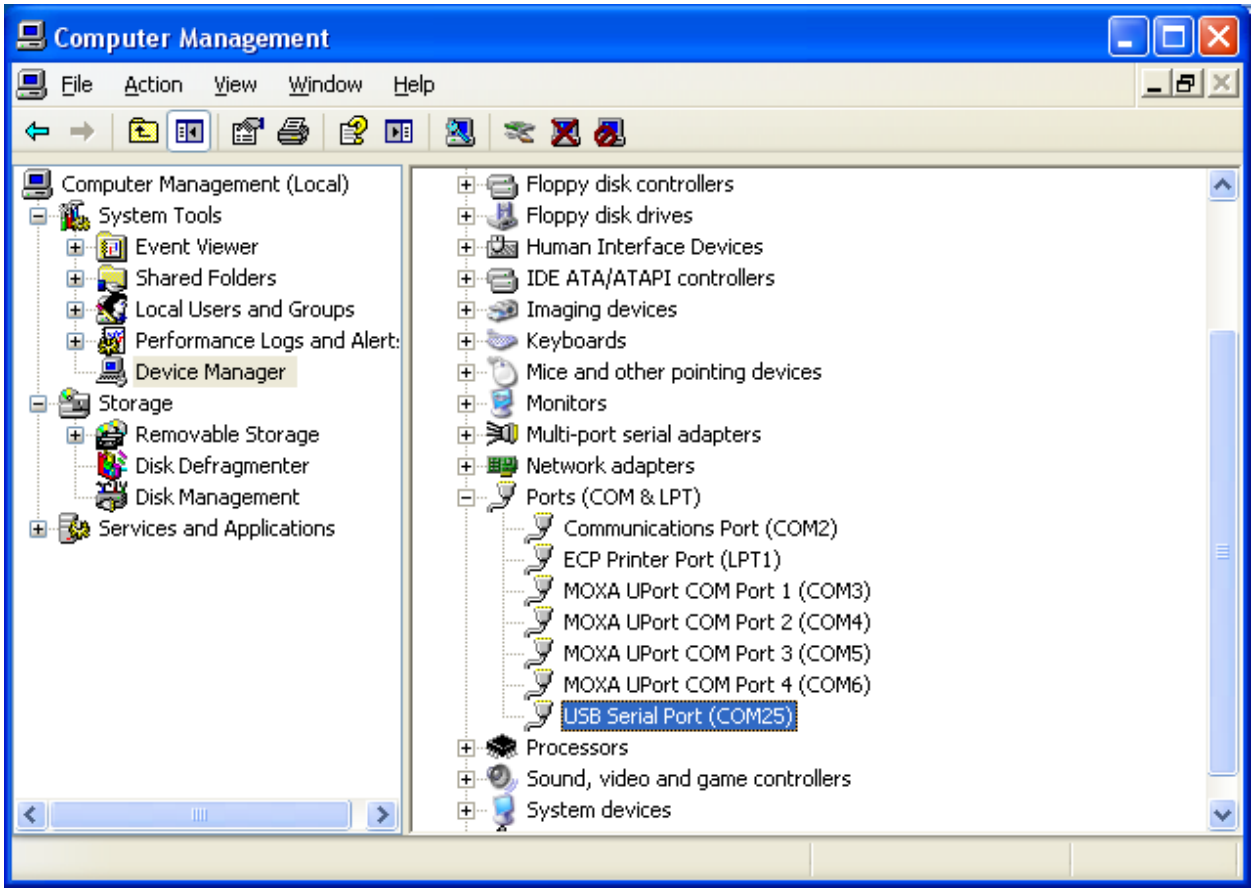


Fig.A.8

Next, open the Properties window of this port "USB serial port (COMN) Properties" (Fig.A.9) and press the "**Advanced**" button. In the opened "Advanced Settings for COMN" window set the parameters:

- Latency Timer (msec) to **1**;
- Minimum Read Timeout (msec) to **100**;
- Minimum Write Timeout (msec) to **100**;

as it is shown in Fig.A.10, and click "OK".

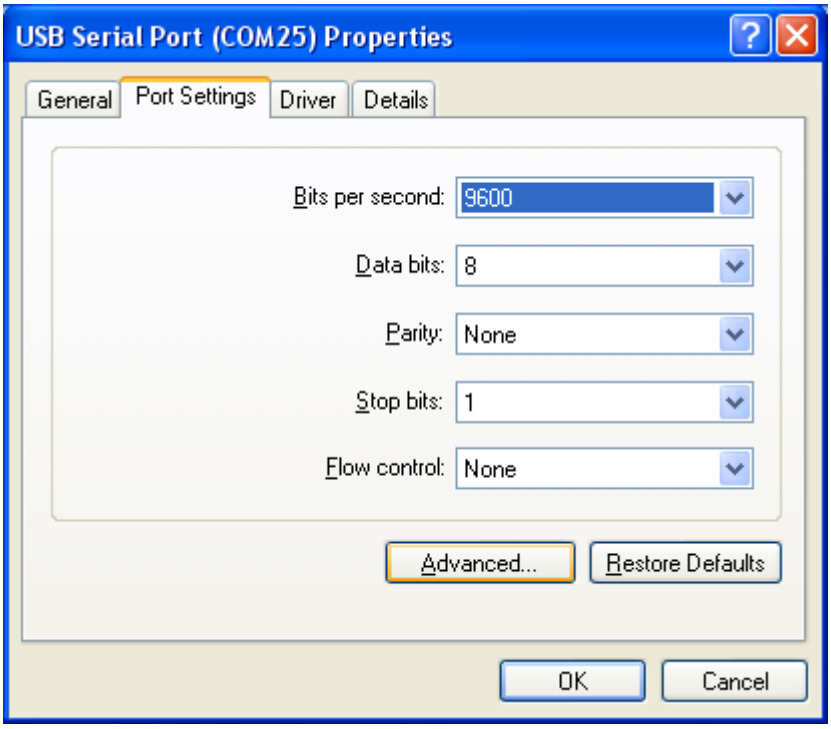


Fig.A.9

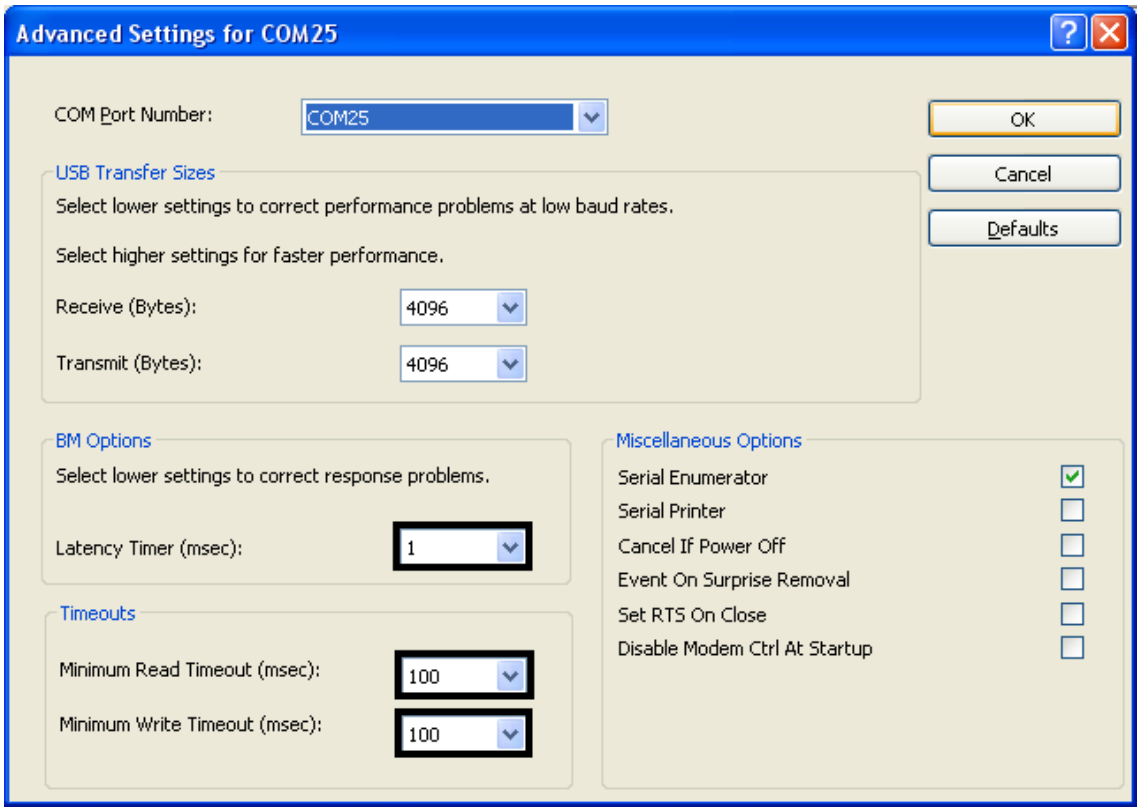


Fig.A.10

In the case of problems in COM-to-USB driver operation please make one more adjustment of the driver. In the “Device Manager” window (see Fig.A.9) go to the “Universal Serial Bus controllers” section, item “USB Serial Controller” (see Fig.A.11). Twice click on this item to set its properties. The window “USB Serial Controller Properties” will be opened where go to “Advanced” tab and check “Load VCP” box (see Fig.A.12).

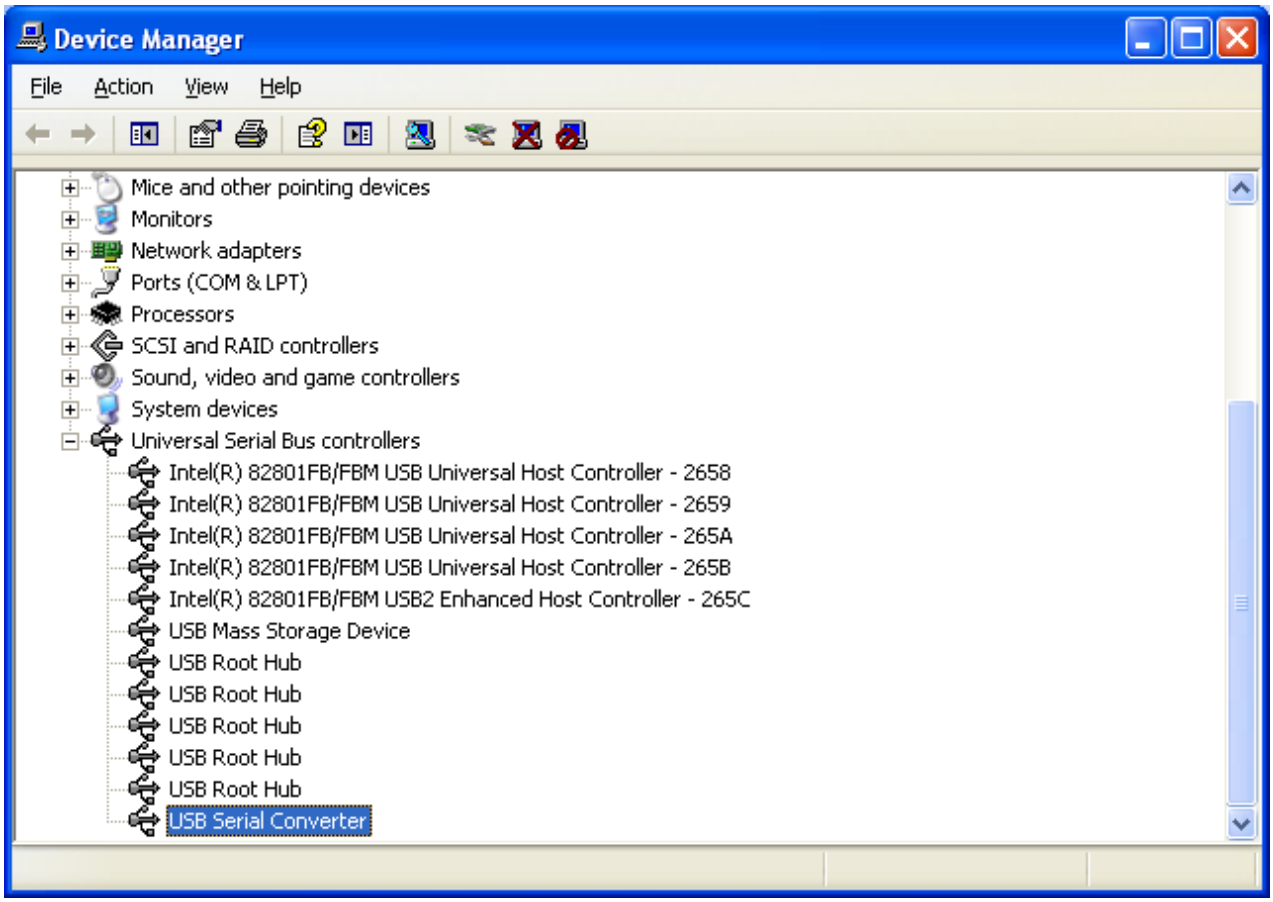


Fig.A.11

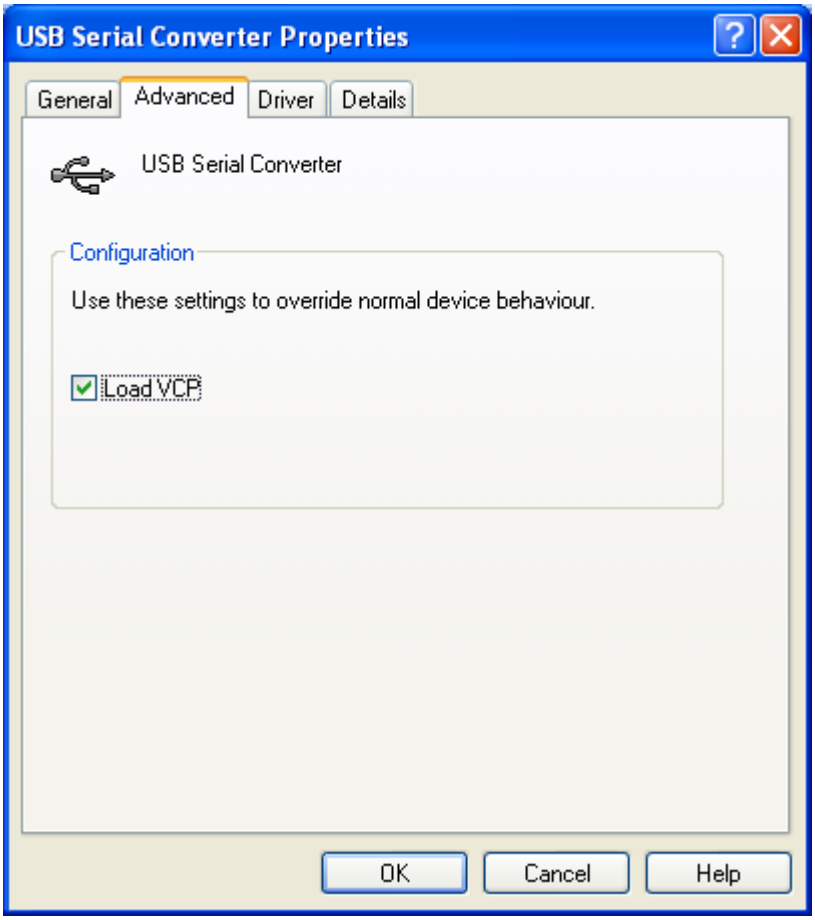

USB Serial Converter Properties
General
Advanced
Driver
Details
USB Serial Converter
Configuration
Use these settings to override normal device behaviour.
Load VCP
OK
Cancel
Help

Fig.A.12

APPENDIX B.
Installation of the MOXA Serial-to-USB converter drivers (for IMU with RS-422 interface)

The Inertial Labs™ IMU with RS-422 interface can be connected to PC USB port using Serial-to-USB MOXA 1130 converter, which is supplied with the IMU unit by the Inertial Labs. In this case it is necessary to install appropriate driver which can be downloaded from the official MOXA site. Make sure that driver completely suits your operating system.

Sequence of the MOXA 1130 converter driver installation is as follows:

Click twice on icon of downloaded driver window shown on the Fig.B.1 will appear.

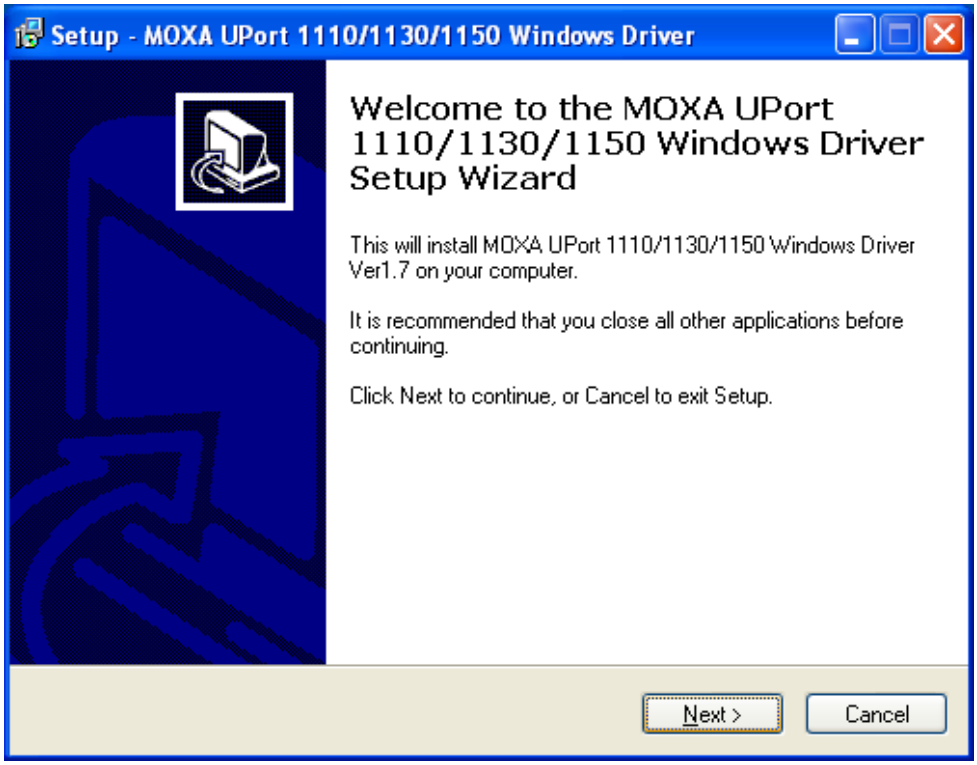


Fig.B.1

Click "**Next**" button and window shown on the Fig.B.2 will appear. In the address box put the exact location where the drivers have been installed to.

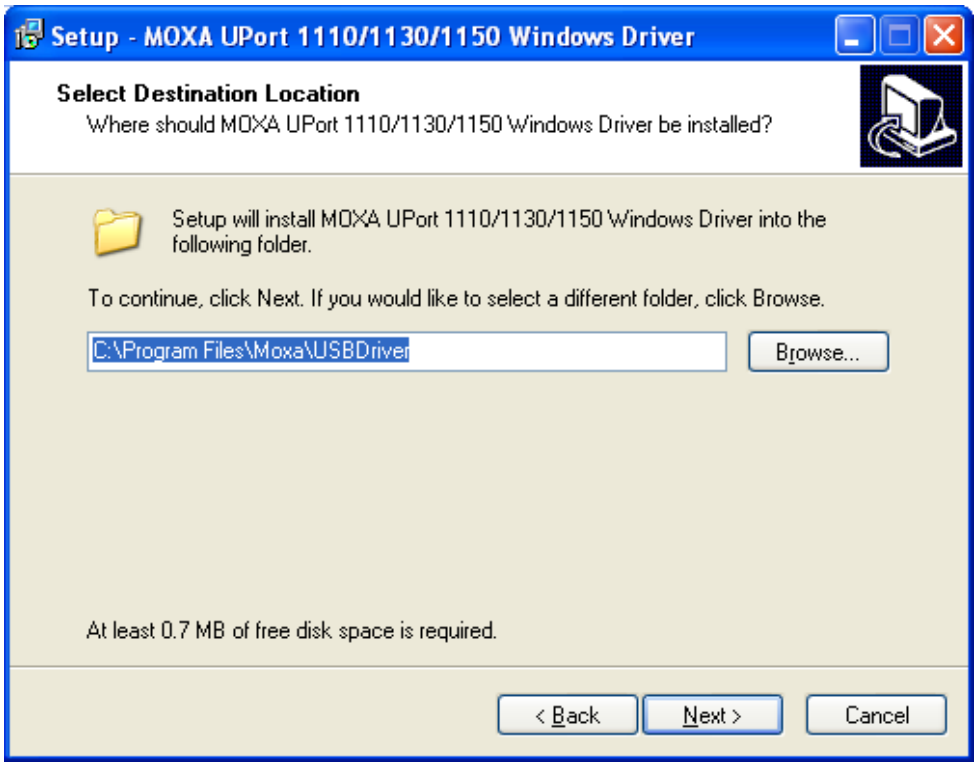


Fig.B.2

Click "**Next**" to continue installation. Then window shown on the Fig.B.3 will appear. In the address box put location and name of the program's shortcuts and click "**Next**" button.

Window Fig.B.4. will appear where you can check the correctness of settings. If data are correct click "**Install**" button. In the other case click "**Back**" button to review and change any settings. If installation completed successfully window shown on the Fig.B.5 will appear. Click "**Finish**" button to close installation window.

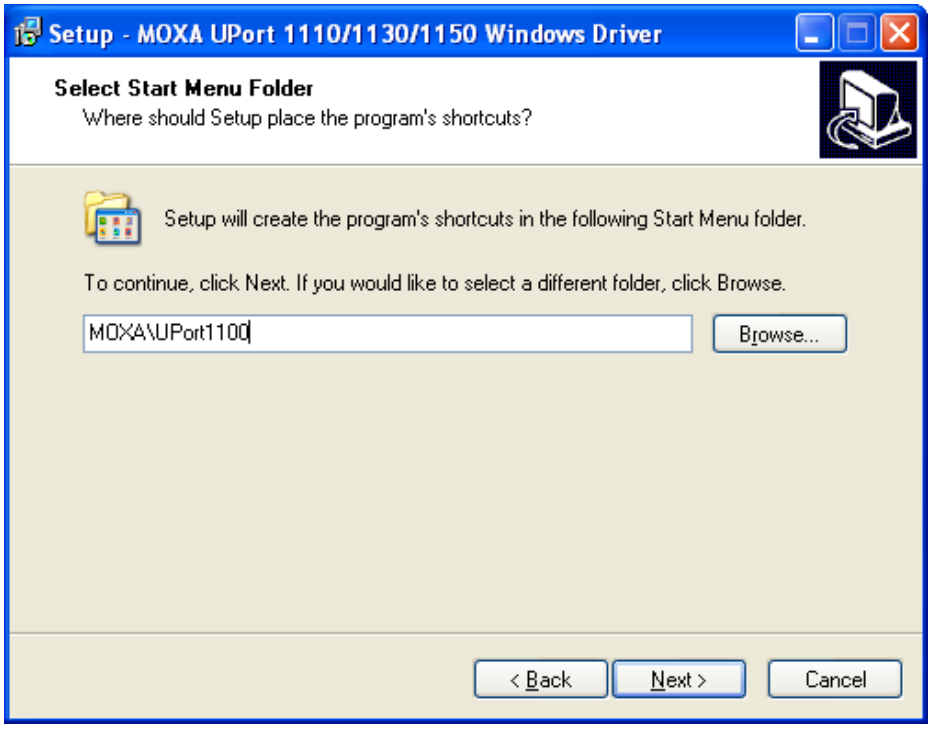

Setup - MOXA UPort 1110/1130/1150 Windows Driver
Select Start Menu Folder
Where should Setup place the program's shortcuts?
Setup will create the program's shortcuts in the following Start Menu folder.
To continue, click Next. If you would like to select a different folder, click Browse.
MOXA\UPort1100
Browse...
< Back
Next >
Cancel

Fig.B.3

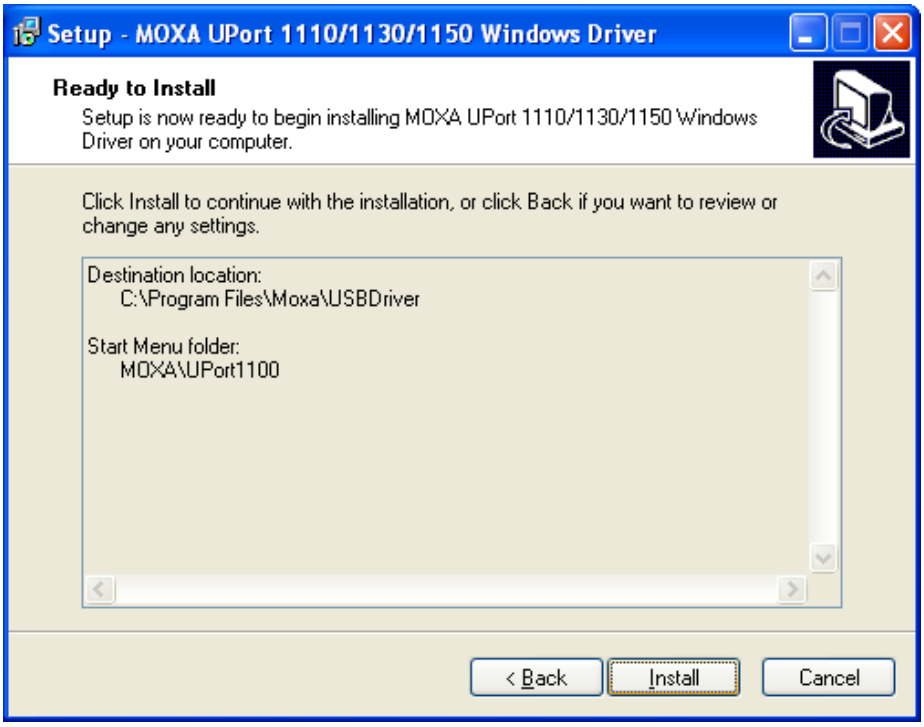

Setup - MOXA UPort 1110/1130/1150 Windows Driver
Ready to Install
Setup is now ready to begin installing MOXA UPort 1110/1130/1150 Windows Driver on your computer.
Click Install to continue with the installation, or click Back if you want to review or change any settings.
Destination location:
C:\Program Files\Moxa\USBDriver
Start Menu folder:
MOXA\UPort1100
< Back
Install
Cancel

Fig.B.4

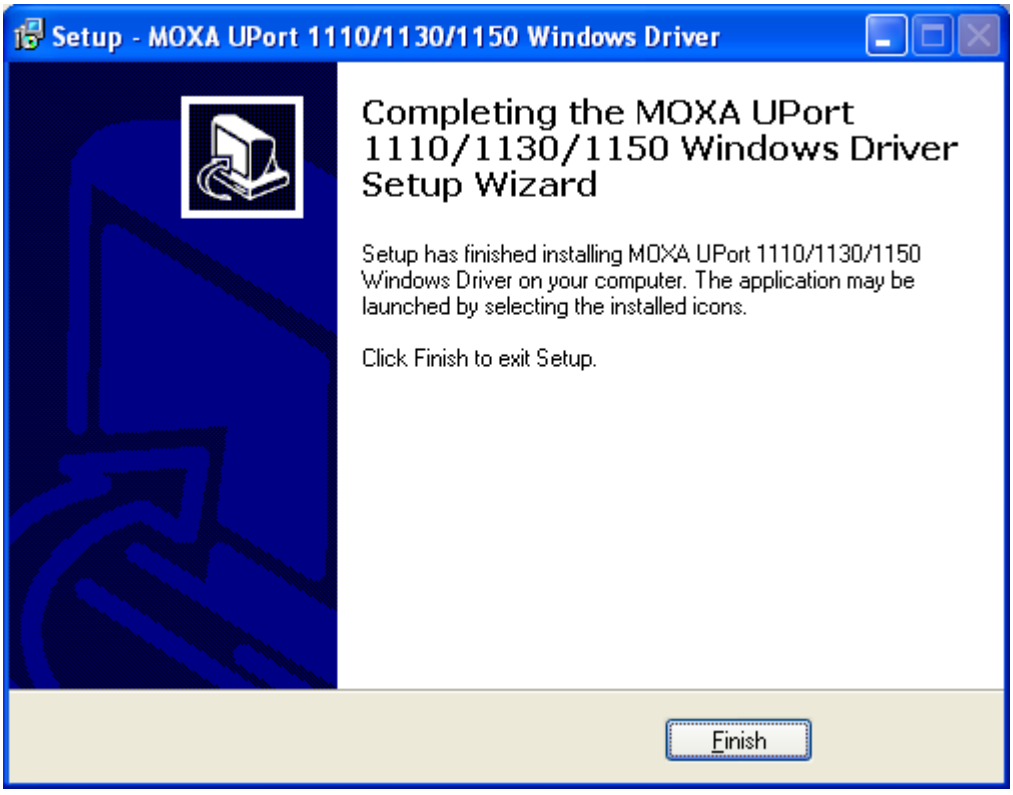


Fig.B.5

The next step is configuration of the installed driver. To do this, press the "**Device Manager**" button in the "System Properties" window, in the "**Hardware**" page. In the opened "Device Manager" window (see Fig.B.6) select device "**Uport 1130**" in the "**Multiport serial adapters**" group.

Double click on this device to show its properties where go to the "**Ports Configuration**" tab (see Fig.B.7). Please check that there is set **RS-422** interface as Fig.B.7 shows. If other interface is set then click on the "**Port Setting**" button, and in opened window Fig.B.8 select just **RS-422** interface. Click "**OK**" button to accept configuration.

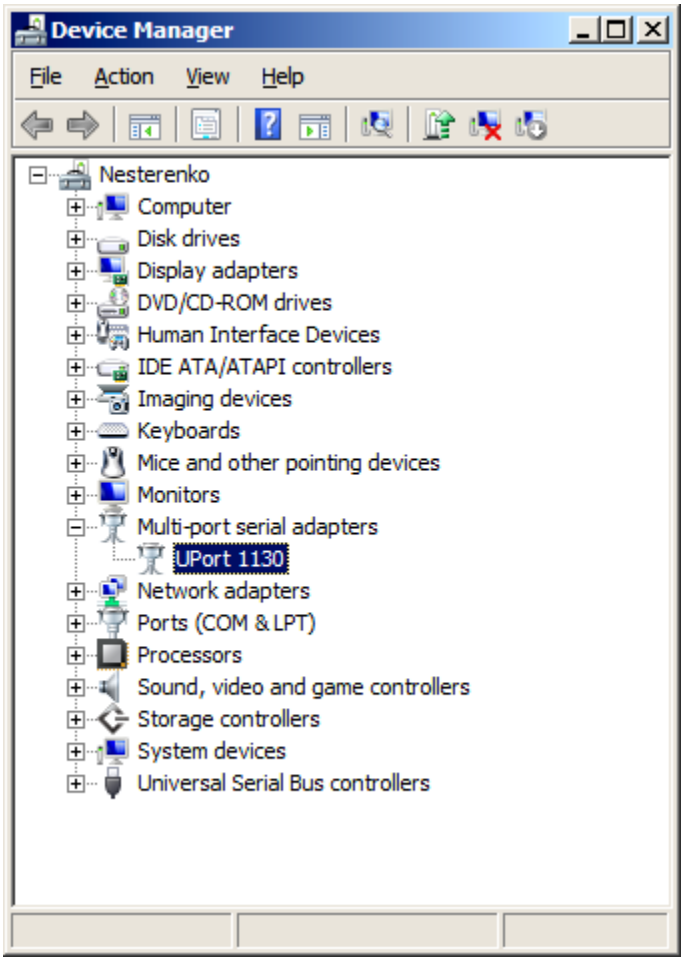

Device Manager
File
Action
View
Help
Nesterenko
Computer
Disk drives
Display adapters
DVD/CD-ROM drives
Human Interface Devices
IDE ATA/ATAPI controllers
Imaging devices
Keyboards
Mice and other pointing devices
Monitors
Multi-port serial adapters
UPort 1130
Network adapters
Ports (COM & LPT)
Processors
Sound, video and game controllers
Storage controllers
System devices
Universal Serial Bus controllers

Fig.B.6

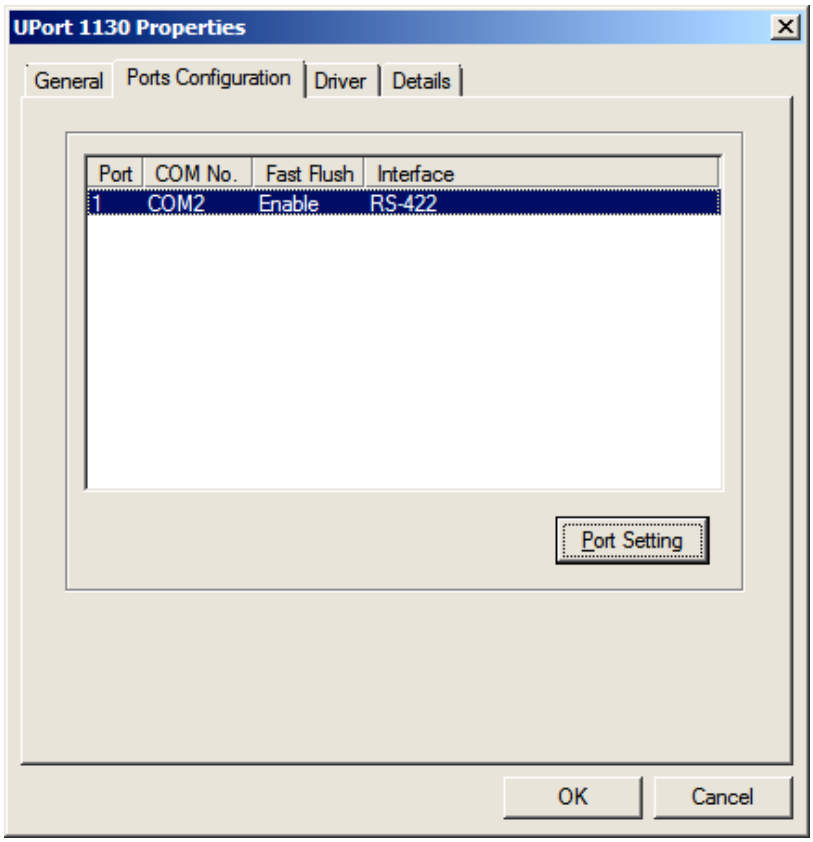

UPort 1130 Properties
General
Ports Configuration
Driver
Details
Port
COM No.
Fast Flush
Interface
1
COM2
Enable
RS-422
Port Setting
OK
Cancel

Fig.B.7

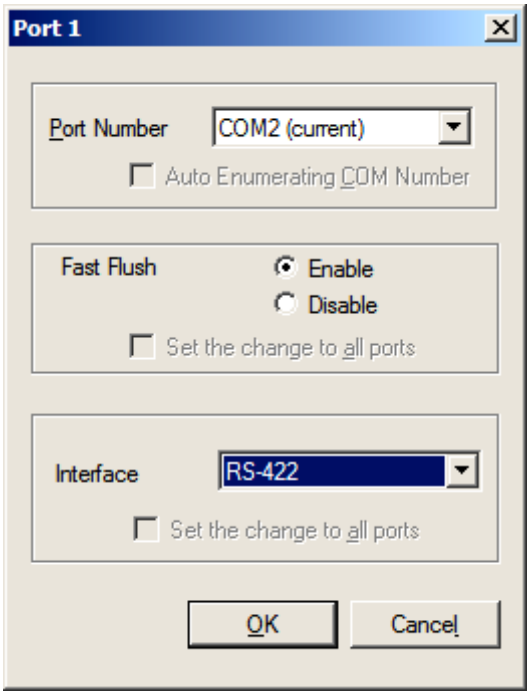

Port 1
Port Number
COM2 (current)
Auto Enumerating COM Number
Fast Flush
Enable
Disable
Set the change to all ports
Interface
RS-422
Set the change to all ports
OK
Cancel

Fig.B.8

Once the converter driver is installed and configured, you will need to know the number of the additional COM-port set by the system and configure parameters of this port for correct operation of the IMU. To do this, go again to the "**Device Manager**" window Fig.B.6 and look the "**Ports (COM & LPT)**" list. There additional COM-port is appeared, "**MOXA USB serial port (COMN)**" (see Fig.B.9). Number N in the port name is the necessary port number assigned by the computer.

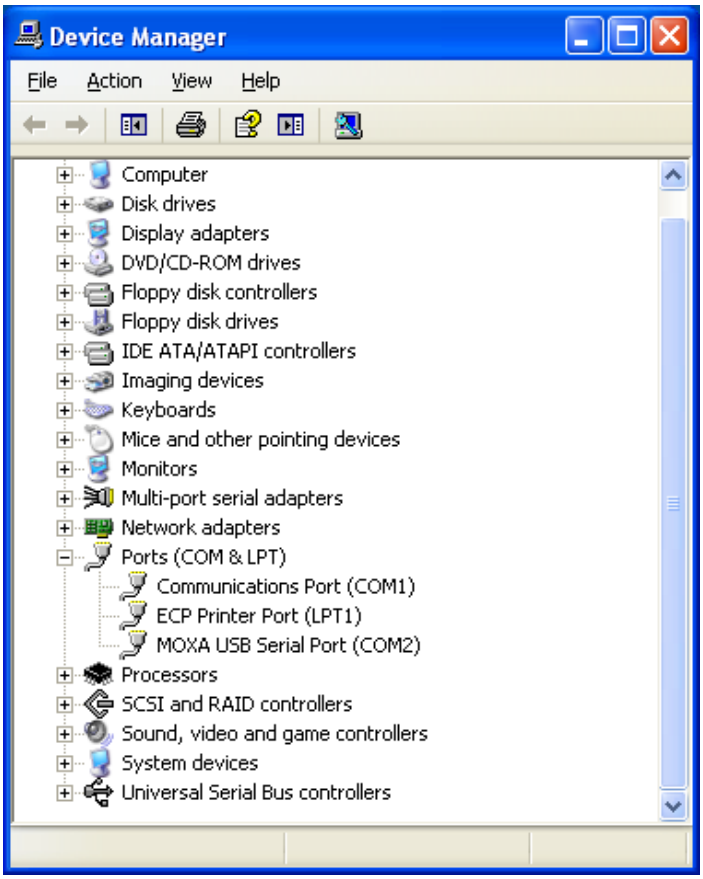


Fig.B.9

APPENDIX C.
Description of data files

The Inertial Labs IMU Demo software creates data files if "**Write**" button is pressed after IMU start. These are two binary files with the same name and extensions .prm and .bin, where .prm file contains the IMU parameters, and .bin file contains the IMU outputs. Select "**Report of experiment**" from the "**Convert**" menu of the IMU Demo or press F8 or click  button to convert these binary data to text file (see section 8 for more details).

Structure of binary and text files is described below. Note that text file is more convenient for analysis.

C.1. Structure of binary file

If user has possibility to work with binary file directly, below is description of the binary .bin file. This file structure copies structure of the IMU output data that is described in the Inertial Labs IMU Interface Control Document (ICD).

The first 50 bytes of the *.bin file are results of the IMU initial alignment, see Table C.1.

Table C.1. Structure of the first 50 bytes of *.bin file (block of initial alignment data)

Byte	Parameter	Format	Length	*Note*
0-11	Gyros bias	float	3*4	3 numbers in ADC codes
12-23	Average acceleration	float	3*4	3 numbers in ADC codes
24-35	Average magn. field	float	3*4	3 numbers in ADC codes
36-47	Reserved	float	3*4	Used in other Inertial Labs™ products
48-49	USW	word	2	0 – successful initial alignment; ≠0 – unsuccessful

Notes:

1. USW is Unit Status Word (see Appendix D. The Unit Status Word definition, for details).
2. In the Table C.1 and in all next there is denoted:
word = unsigned 2 byte integer;
sword = signed 2 byte integer.
3. The low byte is the first.

All the remaining data in the *.bin file are blocks of the IMU output data written at IMU operation with set data rate (100 Hz default). Each data block has structure according to the chosen output format – IMU Calibrated Data, IMU ADC data, IMU GA data, IMU Orientation, IMU Platform Stabilization, IMU NMEA. Structure of data block is described in Tables C.2 – C.6 for each output data format.

Table C.2. The message payload at IMU Calibrated Data format

Byte number	0 – 5	6 – 11	12 – 17	18 – 19	20 – 21	22 – 23	24 – 25	26 – 27	28 – 29
Parameter	GyroX, GyroY, GyroZ	AccX, AccY, AccZ	MagX, MagY, MagZ	Pressure	Reserved	Reserved	USW	Vinp	Temper
Length	3× 2 byte sword	3× 2 byte sword	3× 2 byte sword	2 byte word	2 byte sword	2 byte sword	2 byte word	2 byte word	2 byte sword
Note	Angular rates, deg/s *KG	Accele-rations,g* KA	Magnetic fields, nT/10	Pa/2				Supply voltage, VDC* 100	Temperature, ºC*10

Notes

1. Values of KG, KA are scale factors depending on gyro and accelerometer range:

Gyro range, deg/sec	120	250 or 300	450 or 500	950 or 1000
KG	200	100	50	20

Accelerometer range, g	2	6	8	10	15
KA	10000	5000	4000	2000	1000

2. MagX, MagY, MagZ parameters are zero for IMU-P.
3. Pressure is zero for IMU-P.
4. g = 9.8106 m/s^2.
5. USW is unit status word (see Appendix D for details).
6. Vinp is input voltage of the IMU (for IMU-P is zero).
7. The low byte is transmitted by first.

Table C.3. The message payload at IMU GA Data format

Byte number	0 – 11	12 – 23	24 – 25	26 – 27	28 – 29	30 – 31
Parameter	GyroX, GyroY, GyroZ	AccX, AccY, AccZ	Reserved	USW	Vinp	Temper
Length	3×4 byte integer	3×4 byte integer	2 byte word	2 byte word	2 byte word	2 byte sword
Note	Angular rates, deg/s *1e5	Accelerations, g*1e6			Supply voltage, VDC* 100	Temperature, ºC*10

Notes

1. g = 9.8106 m/s^2.
2. USW is unit status word (see Appendix D for details).
3. Vinp is input voltage of the IMU (for IMU-P is zero).
4. The low byte is transmitted by first.

Table C.4. The message payload at IMU ADC data format

Byte number	0 – 5	6 – 11	12 – 17	18 – 19	20 – 21	22 – 23	24 – 25	26 – 27	28 – 29
Parameter	UgyroX, UgyroY, UgyroZ	UaccX, UaccY, UaccZ	UmagX, UmagY, UmagZ	UP	UT	Reserved	USW	Vdd	Utermo
Length	3× 2 byte sword	3× 2 byte sword	3× 2 byte sword	2 byte word	2 byte word	2 byte sword	2 byte word	2 byte word	2 byte sword
Note	Gyros data, ADC code	Accelerometers data, ADC code	Magnetometers data, ADC code	Pressure data, ADC code	Pressure temperature data, ADC code			Combined voltage	Temperature, ADC code

Notes

1. USW is unit status word (see Appendix D for details).
2. The following data are recorded in the field Vdd sequentially (for IMU-P are zero):
   - the IMU input voltage, Vinp, VDC*100;
   - stabilized voltage supplied to the IMU sensors, Vdd, VDC*1000;
3. In the Utermo field ADC codes are recorded sequentially from 7 temperature sensors inside gyros, accelerometers and magnetometers.
4. UP and UT are raw data from the pressure sensor – pressure and temperature (for IMU-P are zero).

5. The low byte is transmitted by first.

At the “NMEA Output” the IMU data are transmitted in the form of sentences with printable ASCII characters like the NMEA 0183 format. Each sentence starts with a “$” sign and ends with <CR><LF> (carriage return 0xD and line feed 0xA symbols). All data fields are separated by commas. The general form of the “NMEA Output” sentence is the next

$PGAM, GGGG.xx, GGGG.yy, GGGG.zz, AA.xxxx, AA.yyyy, AA.zzzz, MXXXXXX, MYYYYYY, MZZZZZZ, PPPPPP, tttttttt,TTT.t,VV.v,SSSS*CC<CR><LF>

where PGAM is identifier and other fields are listed in the Table C.5.

Table C.5. The IMU message in NMEA format

Field	Parameter	*Note*
GGGG.xx	GyroX	deg/s
GGGG.yy	GyroY	deg/s
GGGG.zz	GyroZ	deg/s
AA.xxxx	AccX	g
AA.yyyy	AccY	g
AA.zzzz	AccZ	g
MXXXXXX	MagX	nT
MYYYYYY	MagY	nT
MZZZZZZ	MagZ	nT
PPPPPP	Pressure	Pa
tttttttt	Timestamp	ms
TTT.t	Temperature	ºC
VV.v	Vinp	VDC
SSSS	USW	hex written with ASCII
CC	Check sum	

Notes

1. g = 9.8106 m/s^2.
2. USW is unit status word (see Appendix D for details).
3. MagX, MagY, MagZ parameters are zero for IMU-P.
4. Timestamp is time in milliseconds from the beginning of IMU start.
5. Vinp is input voltage of the IMU (for IMU-P is zero).
6. Check sum consists of a "*" and two hex digits representing XOR of all characters between, but not including "$" and "*".

Table C.6. The message payload at IMU Orientation data format

Byte number	0 – 1	2 – 3	4 – 5	6 – 11	12 – 17	18 – 23	24–27	28 – 29	30 – 31	32 – 33
Parameter	Yaw	Pitch	Roll	GyroX, GyroY, GyroZ	AccX, AccY, AccZ	MagX, MagY, MagZ	Reserved	USW	Vinp	Temper
Length	2 byte word	2 byte sword	2 byte sword	3× 2 byte sword	3× 2 byte sword	3× 2 byte sword	4 bytes integer	2 byte word	2 byte word	2 byte sword
Note	Orientation angles, deg*100			Angular rates, deg/s *KG	Accele-rations,g *4000	Magne tic fields, nT/10			Supply voltage, VDC* 100	Temper ature, ºC*10

Notes

1. KG is scale factor which value depends on gyro range:

Gyro range, deg/sec	120	240	450	950
KG	200	100	50	20

2. g = 9.8106 m/s^2.
3. MagX, MagY, MagZ parameters are zero (not measured in IMU-P).
4. Vinp parameter is zero (not measured in IMU-P).
5. USW is unit status word (see Appendix D for details).
6. The low byte is transmitted by first.

Table C.7. The message payload at IMU Platform Stabilization data format

Byte number	0 – 11	12 – 13	14 – 15	16 – 17	18 – 19	20 – 21
Parameter	GyroX, GyroY, GyroZ	Yaw	Pitch	Roll	Temper	USW
Length	3×4 byte integer	2 byte word	2 byte sword	2 byte sword	2 byte sword	2 byte word
Note	Angular rates, deg/s *1e5	Orientation angles, deg*100			Temperature, ºC*10	

Notes

1. USW is unit status word (see section 5.4 for details).
2. The low byte is transmitted by first.

C.2. Text presentation of output data formats

User can choose one of the formats to view and save IMU data depending on the necessary information (see Fig.4.1). In the beginning of each file, after the text "Test report", serial number of the tested IMU is specified, and next are the IMU firmware version, date and time of file saving. Below are examples of the saved data in each of available data formats.

IMU ADC Data

P26 Test report Date\Time 15.03.2017 17:33:38
Integrated device s/n: I1710003 firmware version: IMUp v1.0.1.4 15.03.17
*Pressure sensor: absent
Measurement rate, Hz _____ 100

Gyro_X	Gyro_Y	Gyro_Z	Acc_X	Acc_Y	Acc_Z	Magn_X	Magn_Y	Magn_Z	UP	UT
-2	1	0	5	-17	2005	1280	-3827	-4164	41760	23112
0	-1	1	0	-19	2008	1285	-3812	-4166	41760	23112

(continuation)

Reserv	Temperature	Vdd	USW (L/H)
0	11264	12.310	00000000 0000000
0	11265	32.980	00000000 00000000

Note: saved data units

Gyro_X	Gyro_Y	Gyro_Z	Acc_X	Acc_Y	Acc_Z	Magn_X	Magn_Y	Magn_Z	UP	UT
ADC code	ADC code	ADC code	ADC code	ADC code	ADC code	ADC code	ADC code	ADC code	ADC code	ADC code

(continuation)

Reserv	Temperature	Vdd	USW (L/H)
–	ADC code	VDC	– –

In the Temperature column ADC codes are recorded sequentially from 7 temperature sensors of the gyros, accelerometers, magnetometers.
In the Vdd column the INS input voltage and stabilized voltage supplied to the IMU sensors are recorded sequentially.
USW (Unit Status Word) is in binary form with low and high bytes listed in the last two columns.
Status of each bit of the USW is specified in the Appendix D.

IMU Calibrated data

P27 Test report Date\Time 12.04.2016 17:14:38
Integrated device s/n: I1650001 firmware version: A2IMU v1.0.0.3 11.04.16
*Pressure sensor: present
Measurement rate, Hz _____ 100

Rate_X	Rate_Y	Rate_Z	AccX	AccY	AccZ	Magn_X	Magn_Y	Magn_Z	P_Bar	Reserved1	Reserved2	Temperature	Vdd	USW (L/H)
0.00	0.08	0.02	0.0025	-0.009	1.0055	13120.0	-37970.0	-42560.0	99730	0	0	28.1	12.34	0000000 00000000
0.08	0.04	0.08	-0.0015	-0.010	1.0040	13230.0	-38190.0	-42590.0	99728	0	0	28.1	12.34	0000000 00000000

Note: saved data units

Rate_X	Rate_Y	Rate_Z	AccX	AccY	AccZ	Magn_X	Magn_Y	Magn_Z	P_Bar	Reserved1	Reserved2	Temperature	Vdd	USW (L/H)
deg/s	deg/s	deg/s	deg/s^2	deg/s^2	deg/s^2	nT	nT	nT	Pa	–	–	deg C	VDC	– –

In the Vdd column the IMU input voltage and stabilized voltage supplied to the IMU sensors are recorded sequentially.
USW (Unit Status Word) is in binary form with low and high bytes listed in the last two columns.
Status of each bit of the USW is specified in the Appendix D.

IMU GA Data

P35 Test report Date\Time 15.03.2017 17:33:38
Integrated device s/n: I1710003 firmware version: IMUp v1.0.1.4 15.03.17
*Pressure sensor: absent
Measurement rate, Hz _____ 100

Rate_X	Rate_Y	Rate_Z	Acc_X	Acc_Y	Acc_Z	Reserv	Temperature	Vinp	USW (L/H)
-0.2246	0.0452	-0.1869	-0.159428	0.006134	-0.989320	0	45.7	12.16	00000000 0000000
-0.1758	0.2537	-0.1737	-0.159430	0.006369	-0.989074	0	45.7	12.19	00000000 00000000

Note: saved data units

Rate_X	Rate_Y	Rate_Z	Acc_X	Acc_Y	Acc_Z	Reserv	Temperature	Vinp	USW (L/H)
deg/s	deg/s	deg/s	deg/s^2	deg/s^2	deg/s^2	–	°C	VDC	– –

USW (Unit Status Word) is in binary form with low and high bytes listed in the last two columns.
Status of each bit of the USW is specified in the Appendix D.

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Tel: +1 (703) 880-4222, Fax: +1 (703) 935-8377 Website: www.inertiallabs.com

IMU NMEA

Example of the IMU message in NMEA format:

```
$PGAM,-000.24,-000.11,0000.01,00.0593,00.0100,01.0075,-005820,-018391,-039272,099762,000000010,022.7,15.0,0000*3D
$PGAM,-000.08,-000.12,-000.08,00.0594,00.0105,01.0059,-005845,-018400,-039287,099759,000000020,022.7,15.0,0000*25
```

See Appendix B "Description of data files" for details of the IMU message in NMEA format.

NMEA data message can be converted to more convenient text form using "Report of experiment" item from the "Convert" menu. Example of converted NMEA messages to *.txt file is shown below:

P28 Test report Date\Time 18.04.2016 11:37:42
Integrated device s/n: F1550000 firmware version: A2IMU v2.2.0.3 15.04.16
*Pressure sensor: present
Measurement rate, Hz _____ 100

Gyro_X	Gyro_Y	Gyro_Z	Acc_X	Acc_Y	Acc_Z	Magn_X	Magn_Y	Magn_Z	Pressure	Timestamp	Temperature	Vinp	USW (L/H)
-0.24	-0.11	0.01	0.0593	0.0100	1.0075	-5820.00	-18391.00	-39272.00	99730	10	22.70	15.00	0000000 00000000
-0.08	-0.12	-0.08	0.0594	0.0105	1.0059	-5845.00	-18400.00	-39287.00	99728	20	22.70	15.00	0000000 00000000

Note: saved data units

Gyro_X	Gyro_Y	Gyro_Z	Acc_X	Acc_Y	Acc_Z	Magn_X	Magn_Y	Magn_Z	Pressure	Timestamp	Temperature	Vinp	USW (L/H)
deg/s	deg/s	deg/s	deg/s²	deg/s²	deg/s²	nT	nT	nT	Pa	ms	deg C	VDC	– –

USW (Unit Status Word) is in binary form with low and high bytes listed in the last two columns.
Status of each bit of the USW is specified in the Appendix D

IMU Orientaion

P17 Test report Date\Time 12.07.2017 20:55:10, GPS reference week number 0
Integrated device s/n: F17I0027 firmware version: A2IMU v2.8.4.8 07.06.17
*IMU: IMU1M s/n 20819 firmware version: IMME R.1.0.4 03.21.2016
*GNSS receiver: model: s/n: firmware version: maximum data rate: 20Hz
*Pressure sensor: type1
*External sensor: absent
Measurement rate, Hz _____ 100
Magnetic declination _____ Mdec= -10.5 Latitude= 39.04 Longitude= -77.39 Altitude= 0.00 Date= 2015.4128
Initial alignment _____ Heading = 278.016 Roll = -1.416 Pitch = 0.318

Heading	Pitch	Roll	Rate_X	Rate_Y	Rate_Z	Acc_X	Acc_Y	Acc_Z	Magn _X	Magn _Y	Magn _Z	Altitude	Temp	Vinp	USW
278.01	0.32	-1.41	51.02	-16.06	16.62	0.022	0.142	0.915	0	0	0	0	34.1	0	00000000 00000000
278.00	0.32	-1.41	50.10	-22.64	9.96	0.005	0.128	0.908	0	0	0	0	34.1	0	

Note: saved data units

Heading	Pitch	Roll	Rate_X	Rate_Y	Rate_Z	Acc_X	Acc_Y	Acc_Z	Magn _X	Magn _Y	Magn _Z	Altitude	Temp	Vinp	USW
deg	deg	deg	deg/s	deg/s	deg/s	deg/s^2	deg/s^2	deg/s^2	_T	_T	_T	m	°C	VDC	– –

In the Vinp column the IMU input voltage and stabilized voltage supplied to the IMU sensors are recorded sequentially.
USW (Unit Status Word) is in binary form with low and high bytes listed in the last two columns.
Status of each bit of the USW is specified in the Appendix D.

IMU Platform Stabilization

P44 Test report Date\Time 21.11.2017 12:57:30
Integrated device s/n: I1710017 firmware version: IMUPI-2.1.1.10 Nov 17 2017
*Pressure sensor: absent
Measurement rate, Hz _____ 100

Gyro_X	Gyro_Y	Gyro_Z	Yaw	Pitch	Roll	Temperature	USW (L/H)
0.1185	-0.0295	0.0773	0.01	1.56	0.56	43.1	00000000 00000000
-0.0165	0.2988	0.0473	0.01	1.56	0.56	43.1	00000000 00000000

Note: saved data units

Gyro_X	Gyro_Y	Gyro_Z	Yaw	Pitch	Roll	Temperature	USW (L/H)
deg/s	deg/s	deg/s	deg	deg	deg	deg C	– –

USW (Unit Status Word) is in binary form with low and high bytes listed in two columns. Each bit of the USW is specified in Appendix D.

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APPENDIX D.
The Unit Status Word definition

	Bit	Parameter	Performance
Low (failure) byte	0	Initial Alignment	0 – Successful initial alignment 1 – Unsuccessful initial alignment due to IMU moving or large changing of outer magnetic field
	1	IMU Parameters	0 – Parameters are correct 1 – Parameters are incorrect
	2	Gyroscope Unit	0 – No failure 1 – Failure is detected
	3	Accelerometer Unit	0 – No failure 1 – Failure is detected
	4	Magnetometer Unit	0 – No failure 1 – Failure is detected
	5	Electronics	0 – No failure 1 – Failure is detected
	6	GNSS receiver	0 – No failure 1 – Failure is detected
	7	Reserved	–
High (warning) byte	8	Incorrect Power Supply	0 – Supply voltage is not less than minimum level 1 – Low supply voltage is detected
	9		0 – Supply voltage is not higher than maximum level 1 – High supply voltage is detected
	10	Angular Rate Exceeding Detect	0 – X-angular rate is within the range 1 – X-angular rate is outrange
	11		0 – Y-angular rate is within the range 1 – Y-angular rate is outrange
	12		0 – Z-angular rate is within the range 1 – Z-angular rate is outrange
	13	Large Magnetic Field Detect	0 – Total magnetic field within the normal range 1 – Total magnetic field limit is exceeded
	14	Environmental Temperature	0 – Temperature is within the operating range 1 – Temperature is out of the operating range
	15	Reserved	–