NeoRec

software for EEG acquisition

USER MANUAL

Please read this user manual before use. The manual contains detailed information and instructions for proper and safe operation.

Manufacturer reserves the right to make refinements and changes to this document for product improvement without prior notification. Misprints which are present in this document will be corrected in subsequent editions.

WARNING

⚠ *Follow the recommendations from the section WARNINGS in USER MANUAL of the amplifier, with which the exploitation of the software is performed.*

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CONTENT

BASIC INFORMATION

NeoRec - software for the acquisition of EEG and other biomedical signals during the process of scientific or medical research. The program records the signals in various file formats and data flows for further analysis and processing by third-party software.

NeoRec is designed to work in conjunction with computer amplifiers and photic stimulators.

Supported amplifiers and stimulators

NVX16	direct current amplifier (direct current – DC) for acquisition up to 10 monopolar EEG channels and up to 6 differential EEG channels (or up to 6 channels of sensors); 4 digital synchronization channels	connection and power supply via USB
NVX24	DC amplifier for acquisition up to 24 EEG channels; 2 digital synchronization channels	connection and power supply via USB
NVX36	DC amplifier for acquisition up to 32 EEG channels and up to 4 channels of sensors; 10 digital synchronization channels	connection and power supply via USB
NVX52	DC amplifier for acquisition up to 48 EEG channels and up to 4 channels of sensors; 10 digital synchronization channels	connection and power supply via USB
NVX136	high speed DC amplifier for acquisition up to 136 EEG channels; possible to connect up to 4 differential channel or channels of sensors; 16 digital synchronization channel	connection by the optical cable to the media converter, then via USB, powered by an external battery pack
FSS4	programmable LED photic stimulator	connection and power supply via USB

Supported file formats and data flows

EDF+	European Data Format (EDF) is a simple 16-bits format for exchange and storage of multichannel biological and physical signals. An extension of EDF, named EDF+, was developed in 2002 and is largely compatible to EDF.	www.edfplus.info
BDF+	BDF+ is the extension of BDF and 24-bits version of EDF+. BDF is the 24-bits version of EDF used by Biosemi, hence the name Biosemi Data Format.	www.teuniz.net/edfbrowser/bdfplus format description.html www.biosemi.com/faq/file_format.htm
GDF	General Data Format for biomedical signals (GDF) is 24/32-bits universal format for various biomedical signals. Was developed Alois Schlögl.	http://arxiv.org/abs/cs/0608052
EEG	Data Exchange format of Brain Vision applications from BrainProducts GmbH	www.brainproducts.com
SM	Proprietary "internal" format of the producer, allowing to provide data storage requirements under conditions of a large input data stream	description may be granted upon the written inquiry to manufacturer

LSL	A data flow for Lab Streaming Layer project provides time-synchronized data transmission over TCP for real-time systems. It provides synchronized data recording with a large number of data sources, such as EEG, video, audio, motion sensors, etc.	https://code.google.com/p/labstreaminglayer/

How to view and process the signal records

For viewing or processing the recorded data, the following third-party programs and software packages are recommended:

EDFbrowser	A free, opensource, multiplatform, universal viewer and toolbox intended for, but not limited to, timeseries storage files like EEG, EMG, ECG, BioImpedance, etc. Supported fileformats: EDF, EDF+, BDF, BDF+	www.teuniz.net/edfbrowser
Polyman	A free, checker/viewer for EDF/EDF+ files. The application can show signals, scorings and other annotations, and any video data. Offers several automatic EEG/EMG analyses and manual sleep scoring. Comes with demo PSG, video and scorings.	www.edfplus.info/downloads/software/polyman.zip
SigViewer	A free, powerful viewing application for biosignals designed to display EEG and other biosignal data. Supported several biosignal data formats through libbiosig (for example GDF, EDF, CNT, EEG, and many more).	www.sigviewer.sourceforge.net
EEGLAB	A free and open source interactive Matlab toolbox for processing continuous and event-related EEG, MEG and other electrophysiological data incorporating independent component analysis, time/frequency analysis, artifact rejection, event-related statistics, and several useful modes of visualization of the averaged and single-trial data.	http://sccn.ucsd.edu/eeglab
ERPLAB	A free, open-source Matlab package for analyzing event-related potentials (ERP) data. It is tightly integrated with EEGLAB Toolbox, extending EEGLAB's capabilities to provide robust, industrial-strength tools for ERP processing, visualization, and analysis.	http://www.erpinfo.org/erplab
OpenViBE	A free and open source software platform dedicated to designing, testing and using brain-computer interfaces. It can be used to acquire, filter, process, classify and visualize brain signals in real time or off line from file.	http://openvibe.inria.fr
BioSig	An open source software library for biomedical signal processing. Major application areas are: neuroinformatics, brain-computer interfaces, neurophysiology, psychology, cardiovascular systems and sleep research.	http://biosig.sourceforge.net
MATLAB Viewer	The MATLAB Viewer is a MATLAB function (vis_stream) that is included with the full LSL distribution. It allows you to view the signal content	https://code.google.com/p/labstreaminglayer/wiki/ViewingStreamsInMatlab

	of any stream on your lab network in real time.	
Lab Recorder	The LabRecorder is the default recording program that comes with LSL. It allows to record all streams on the lab network (or a subset) into a single file, with time synchronization between streams.	https://code.google.com/p/lab streaminglayer/wiki/LabReco rder

CONDUCTING RESEARCH

Run the program NeoRec ![icon]. If the amplifier is connected to the computer and all the necessary drivers are installed, the main window with control elements will appear. Appearance of main window may vary depending on the type of connected amplifier and chosen active profile.

After starting the program, the settings of previous session will be applied. Before the research, it's possible to change the following settings by pressing the button :

- current profile, montage (amount of channels, channel types, references), filters, display settings;
- output file format and destination folder;
- sampling frequency, operating mode and other specific amplifier setting.

Optionally, it's possible to enter information about the patient by pressing . Patient information will remain until exiting the program.

For starting the signal acquisition, press . It is necessary to ensure signal quality and press for start recording. Recording may be paused by pressing the button . For continuation of the recording, press . To stop recording, press .

Recording is always proceed in the SM format. Configured settings (profile, montage, filters, signal types, channel names and their sequence) are applied. The file name is automatically selected and includes the date and time of registration. At the end of the recording, automatic conversion starts into the output file format. The native file in format SM will be removed after successful conversion in case of setting on the selector *Delete SM file after successful conversion*.

Following information may be displayed in the status panel:
- current sampling frequency;
- record duration and amount of recorded data;
- possible recording time, based on available space in the current directory;
- pause duration;
- information about current photic stimulation stage;
- battery status (for some amplifiers);
- amount of missed samples;
- warning of an incorrect internal control parameters of the amplifier.

Important or critical information is displayed in red. Status panel may be moved with mouse. Dimensional bracket for evaluation the signal scale belongs to a particular channel.

An amplitude and time scale for a group of channels may be changed both by arrow buttons on the keyboard ←↑↓→ and by corresponding buttons on the status panel. Keyboard shortcuts Shift + ↑ и Shift + ↓ can change amplitude of the signal, pointed by dimensional bracket of the status panel.

Some amplifiers allow to measure polarization of the electrodes in order to assess the quality of the connection.

Diagram of polarization

Channel name

Polarization % of the worst electrode forming a channel relative to full scale. Minimum polarization 0% - no blue color on the chart.

Electrode impedance control

Before starting the research, it's possible to control the electrode impedance

Impedance (in Ohm) relatively to GND electrode

It's possible to move the border ranges of *desirable, acceptable and unacceptable* impedance by mouse

by pressing the electrode impedance by pressing .

File convertation in manual mode

If the file in SM format have not been deleted after successful convertation, it could be converted to any other output format later. It requires:

1. press ;
2. select desired file with SM extension and click right mouse button;
3. select output file format (e.g. *convert to BDF+*).

Photic stimulation

Photic stimulation (PS) is possible, provided that the photic stimulator was connected to computer before running the program. Only in this case, the button of starting and stopping the *photostimulation script* will appear on the toolbar*.*

Starting the *PS* script is possible only after starting the process of signal acquisition. *PS* stops automatically after the time specified in the script.

PS may be stopped forcibly by pressing the buttons and , or closing the program.

Control panel displays the information about current stage of PS.

PS stage with 2 Hz flashing frequency. 8 sec. of total 1 min. passed
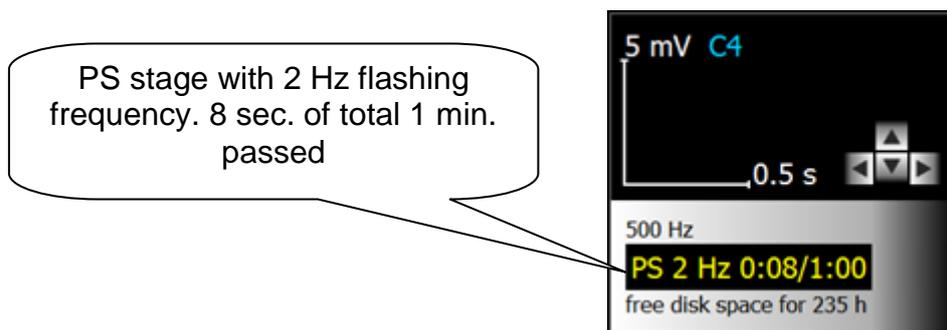
A special event with information about the frequency and duration of current PS stage generates at the start of each stage of PS. Also a single event is formed after the end of PS.

CONFIGURING PROFILES

Default profiles

Program installer automatically creates multiple profiles specific to each available amplifier. Usually it is the following profiles:

- **monopolar** – profile, where all channels are formed monopolarly, respect to GND electrode or hardware REF electrode (if present in the amplifier); for amplifiers without hardware REF electrode this profile has technological and test purpose; not recommended for conducting the research due to a low degree of common-mode signal suppression; can be used as a basis for creation of new profiles with a real referent;
- **refA1A2** – profile with popular montage, when for channels of left hemisphere A1 referent is used, for right - A2, and for the central sagittal line channels - (A1+A2)/2.
- **refT3T4** – profile similar to *refA1A2*, but instead of A1 and A2 channels, T3 and T4 are used.

Default profile cannot be removed. When trying to change the basic parameters of the default profile, such as montage or filter settings, the program prompt you to create a new profile.

Common settings for all profiles

- output file format *Format* and folder *Record path*;
- selector *Delete SM file after successful conversion*.

Basic parameters (Main)

Profile of the research:
selection, creation, removal

Accessories scheme – accordance of amplifier
electrodes to channel labels:
selection, creation, editing, removal

Information about the
amplifier

Assignment of destination folder
and format of output file;
assignment of the selector of SM
file removal

Assignment of
sampling frequency,
operating mode and
other device settings

Reference channels

List of reference
channels

Switched electrodes form
a mean value of reference
channel

Creation or
removal of
reference
channel

The reference channel is formed by averaging of potentials of all the channels that forms the reference channel.

$$V_{ref_k}(t) = \frac{1}{n} \sum_{i=1}^{n} V_{channel_i}(t)$$

Channels

Callout labels in the figure:
- Input line for synchronous modifying of dedicated channels
- Choosing the type of channel and electrodes of amplifier
- Filters
- Color of channel, background, channel label and second grid
- Title of the channel group
- Amplification
- Scroll mode
- Expand or collapse the group
- Signal type
- Channel label
- Create group <Shift+Ins>
- Delete group or channel <Del>
- Create channel <Ins>
- Move in the list <Alt> + ← →

Select:
- Ctrl + <A> all channels
- Ctrl + <G> all channels in a group
- Ctrl+"left button" channel
- Shift+" left button " a range of channels
"drag and drop" by mouse

Channels grouped together only for the convenience to display on the screen.

Type of the channel may be monopolar *mono*, repeating the amplifier signal, or differential *diff*, calculated as the difference between two amplifier signals (or signal and reference).

Filters are implemented in software and can be set *separately for each channel*. The program does not provide a full analysis of the stability of the filter, so user need to be careful about setting the cutoff frequency limits and to take into account current *sampling rate*.

Highpass filter *HPF* is selected from a list or set arbitrarily in the range from 0 to 10 Hz for border level -3dB (-30%). Type – recursive Butterworth of 2nd order.

Lowpass filter *LPF* is selected from a list or set arbitrarily in the range from 1 to 500 Hz for border level -3dB (-30%). Type – recursive Butterworth of 2nd order.

Bandpass filter *ADF* is selected from the list: *off*, *50 Hz*, *60 Hz*. Type - recursive adaptive.

Signal Type is selected from the list and used to write it into some file formats, and also for correct display the amplitude.

Different from one *Gain* is set if there was a preliminary signal conversion (e.g. by an external preamp, sensor or a voltage divider).

Events
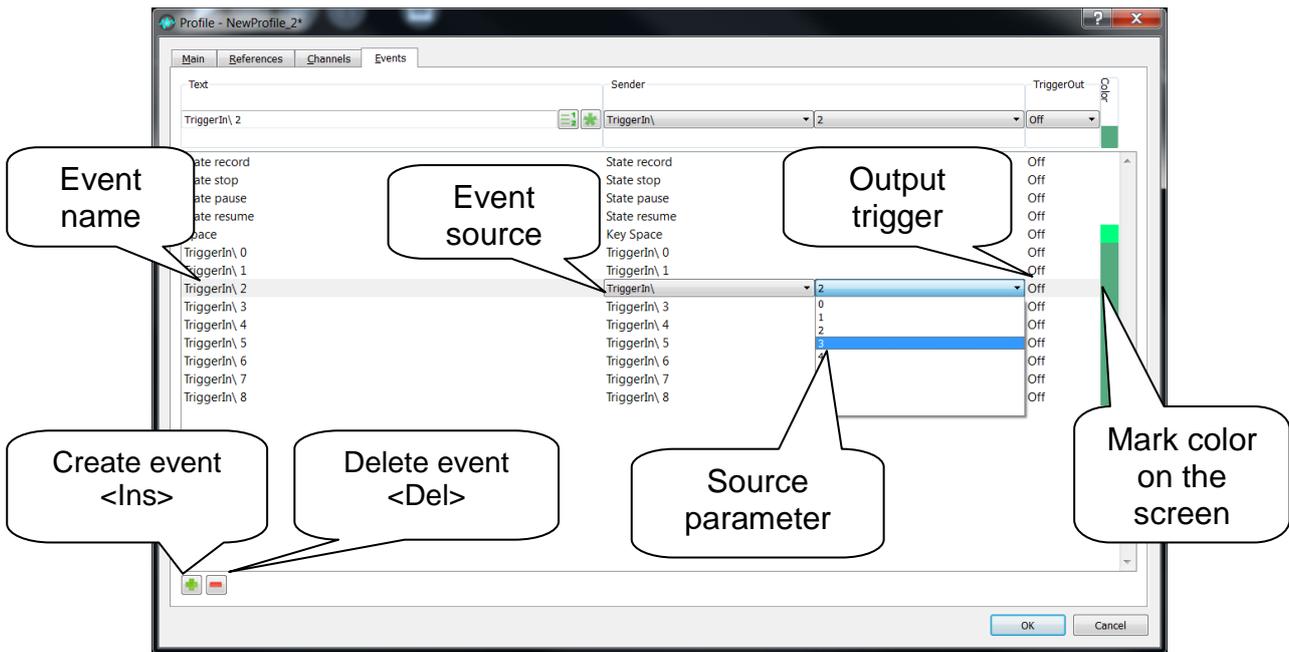
Event may be initialised by one of the:

- pressing the key on the keyboard *Key*;
- changing the program *State* (e.g. beginning of *record*, *pause, resume, stop, etc.*);
- edge *TriggerIn/* or decline *TriggerIn* signal of synchronization, applied to the corresponding digital input of the amplifier;
- changing PS mode

Setting up of output trigger *TriggerOut* allows to form additional reaction at the time of event occurrence (e.g. to form an impulse on certain digital output of the amplifier).

Photic stimulation stages (Photic stimulation)

This tab is available only if the photic stimulator was connected to the computer before running the program.

INSTALLATION AND MAINTENANCE

Computer requirements

Computer requirements are defined the *Operation Manual* of the amplifier, which will be operated by the program. These requirements must correspond or exceed the following minimum recommended requirements: Microsoft Windows 7 32 or 64 bit; processor is not slower than Intel Core i3 1.7 GHz, RAM at least 4 GB, display resolution not less than 1366 x 768.

Installation and removal of the program

For installation and removal of the program, administrative access is required.

It's desirable to install the software before the first amplifier connection to the computer.

Connect the media containing the distribution package to the computer and wait for the automatic start of the installation process, or run the *setup.exe*. Follow the guidelines of the program installer. 64-bit or 32-bit version of the program will be installed, depending on the operating system architecture.

In some cases, in the absence of setup.exe, it is necessary run the file *NeoRec-xyzzzz-x64.exe* for installation 64-bit or *NeoRec-xyzzzz-x64.exe* for 32-bit program, where *xyzzzz* - software version. Uninstalling of the application is made by standard means of the operating system through the *Control Panel*.

Manual installation of the amplifier driver

The amplifier and stimulator driver will automatically be installed during the main program installation. Correctly installed driver is displayed in the list of the *Windows Device Manager* as ready to work.

During the first connection of the amplifier or mediaconverter to the USB port, operating system will automatically start the installation of the device driver, unless driver has not been installed yet.

There is an opportunity for manual starting the installation procedure, reinstall or update the driver from the *Windows Device Manager*.

During the installation, it is necessary to cancel the automatic driver search on the Internet and specify the path to the amplifier driver. Actual version of the driver may be downloaded from the manufacturer's website.

Selecting program language

Press , choose *Language.*

Information about program version, components, licenses, supported amplifiers and stimulators

Press , choose *About.*

Feedback

The *NeoRec* program provides an opportunity of error logging that occur during the program operation. In case of malfunctions of software or hardware, it is necessary to archive the content of the folder %localappdata%\MCS\NeoRec\logs\ and send it at the address mks@mks.ru with a description of occurred problem.

APPENDICES

LSL (Lab Streaming Layer) data flow

Program maintains an opportunity of sending data through LSL protocol. For starting the process of data sending, user needs to select an item *Lab Streaming Layer (LSL)* in a *Format* field of *Profile* dialog box, start signal acquisition and press the *Record* button (as in a standard signal recording to the file). In case of successful initialisation of LSL flow and starting of data sending, a status panel will show a flashing line *LSL out* with information about sending duration and size of send data. *DataStreamLatency* parameter was entered in order to regulate a period of data sending to LSL flow. An *Optimal* value is set by the default, which provides a stable data transfer. In case of necessity of high frequency polling delay, user may set a *High* mode, which send the data more often but less stable.

⚠ *LSL flows is initialized in the moment of pressing the Record button and become visible in LSL space by third party applications.*

For online viewing of the data flow, a MATLAB Viewer plugin may be used. The following dialog box will appear after the starting of *vis_stream()*:
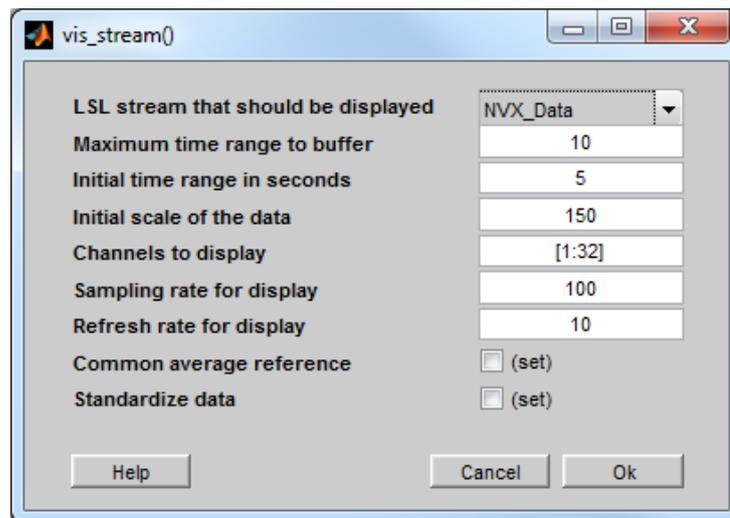

At least two streams will be present in the list of available flows: *NVX_Data* – a flow contains a time series of physiological channels, described in a profile settings; *NVX_Events* – a flow, contains a series of event points described in *Events* list. For viewing of physiological channels, user need to choose *NVX_Data* flow and specify advanced settings of display (channels, scale, refresh rate etc.) and press *Ok*.

⚠ *For providing of unified output data, data points have dimension of volts for EEG, ECG channels etc. Event data points in NVX_Events flow have values corresponding to the serial number in the list of Events.*

After pressing the *Ok* button, the following window will appear:
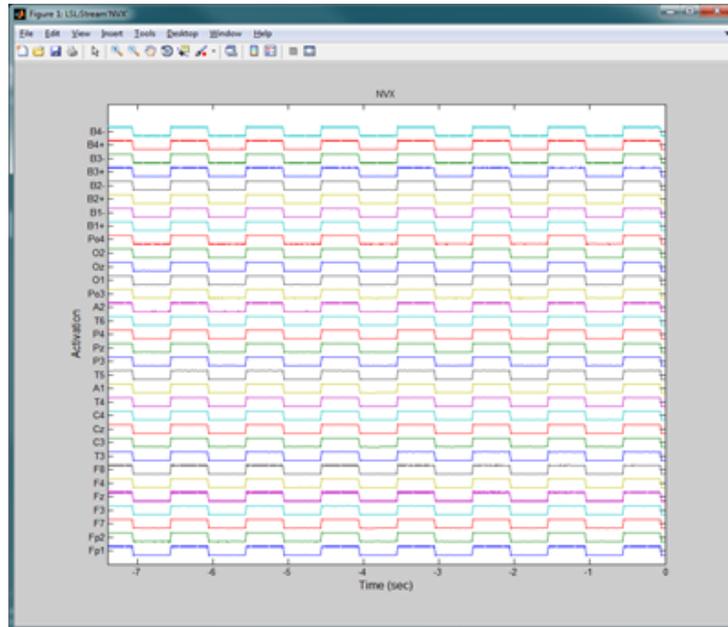
As an application of signal writing to the file may be a program *LabRecorder*, which allow to connect to LSL flow and write the data in XDF format.
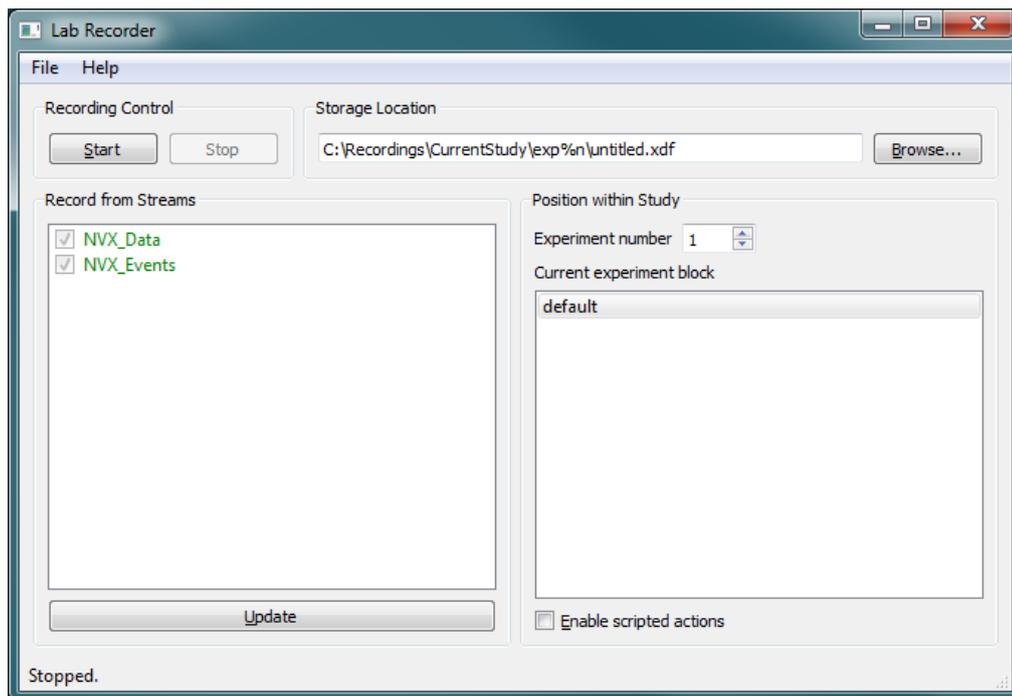
For reading the XDF file, a MATLAB Importer plugin may be used.

https://code.google.com/p/labstreaminglayer/wiki/ImportingRecordingsInMatlab

Passing the path to the XDF file as a function parameter of *load_xdf()*, user is allowed to get a data structure containing information about the recorded stream and the time series of data channels and events.

⚠ *When using the function load_xdf(),user is recommended to disable parameter HandleClockSynchronization for providing synchronization between flows of Data and Events. E.g. streams = load_xdf(filename, 'HandleClockSynchronization', false)*