

BallAX 4.2

Ballistic Measurement Software



User Manual

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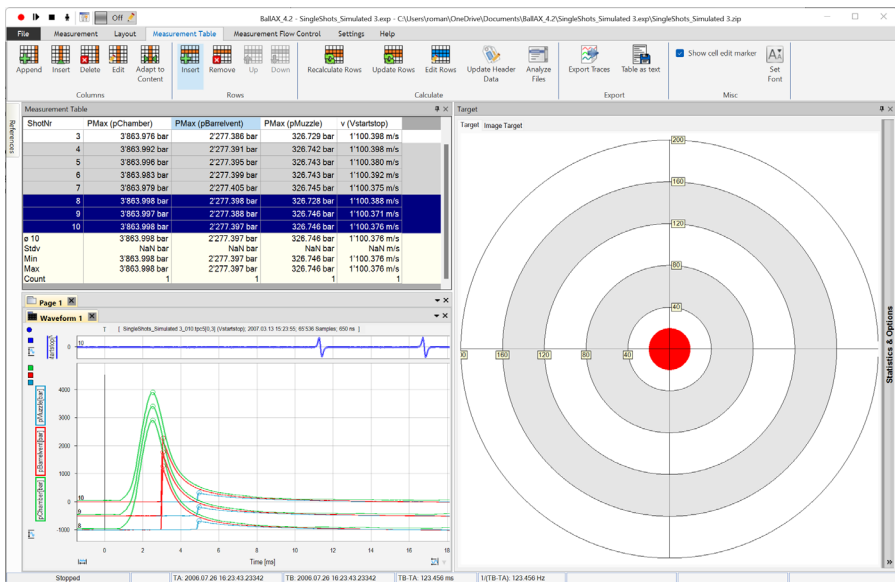
Content

1. Introduction	4	6. Measurement Table	37
1.1 Main Program Parts.....	5	6.1 Table Manipulations.....	37
1.2 Measuring process.....	6	6.2 Scalar Functions.....	39
2. License handling	7	7. Waveform Display	41
2.1 License Activation.....	7	7.1 Block & Cursor Functions.....	42
2.2 Release.....	8	7.2 References.....	43
3. Experiments and Experiment Sets	9	8. Closed Vessel	44
3.1 Startup Page.....	9	9. Formula Editor	45
3.2 Data Structure.....	9	9.1 Controls.....	46
3.3 Write protection.....	10	9.2 Read Header Data.....	47
3.4 Templates.....	10	9.3 Measured curves.....	47
4. Main Configuration	11	10. Report Generator	48
4.1 Overview.....	11	10.1 Keywords.....	48
4.2 Measurement Settings.....	12	11. Measurement Flow Control (MFC)	51
4.3 Mode & Equipment.....	14	11.1 MFC Commands.....	52
4.4 Header Data.....	15	11.2 Remote MFC.....	53
4.5 Plot Settings.....	17	11.3 MFC Examples.....	54
4.6 Continuous Fire.....	18	11.4 Control Elements.....	55
4.7 Target.....	19	12. Global Settings	56
5. Control Panel	20	12.1 Default Paths.....	56
5.1 Device Manager.....	21	12.2 Charge Amplifiers.....	57
5.2 DAQ Operation Modes.....	22	12.3 User Interface.....	58
5.3 ECR Operation Mode.....	25	12.4 Other Settings.....	59
5.4 Channel Configuration.....	28	12.5 Users.....	60
5.5 Trigger.....	32	12.6 Timer.....	61

1. Introduction

BallAX 4 ballistic analysis software is used to acquire and analyze measurement data on firearms, rifles, artillery, bullets and shells with different types of ammunition and explosive propellants, ensuring accurate ballistic measurements.

BallAX 4 is based on modules of the universal data acquisition software TranAX 4. Curve displays and hardware settings in the control panel can be operated in the same way. Measurement data generated in BallAX 4 can be easily opened in TranAX. On the other hand, measurements from TranAX can be imported into BallAX.



Key-Functions

- Quick and easy configuration of many analog input channels
- Data visualization of entire test series
- Sing Shot and Continues Fire Analysis
- More than 30 scalar functions to calculate specific parameters
- Closed vessel Analysis according to TL 1376-0600
- Target Visualization
- Support of Kistler Charge Amplifiers
- English and German version
- Data export to TPC5 and ASCII data format
- Report generator, based on freely editable MS-Excel templates

1.1 Main Program Parts

1.1.1 Graphical display (Waveform)



The measurement data can be displayed graphically in the waveforms.

1.1.2 Measurement table



All measured shots are entered in the measurement table and the configured scalar functions are calculated. Based on the selection the graphical display is updated with the corresponding measurement data.

1.1.3 Scalar Table



Allows individual fields from the measurement table to be displayed individually or other scaling functions to be used.

1.1.4 Target



Hit pattern evaluation. Calculation and analysis can be done with the Formula Editor, additional hardware in the target area will be necessary.

1.1.5 Control Panel



Configuration of the DAQ settings such as input range and type, sampling rate, measurement length or trigger settings.

1.1.6 Reference List



The references are the link between the hardware channels and the measurement fork or waveform displays.

1.1.7 Header Data



Header data for documenting the measurement.

1.1.8 Formula Editor



Additional data processing or scalar calculations can be made using the formula editor.

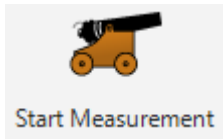
1.1.9 Measurement Flow Control (MFC)



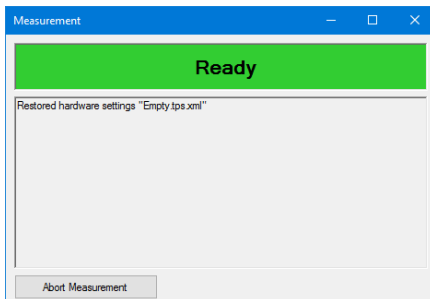
The measurement flow control allows to program a user specific process flow.

1.2 Measuring process

A measurement is started by clicking the button "*Measure*" in the Ribbon Tab "Measurement" in BallAX.



The measurement window is opened, which shows the actual state.



Now BallAX is doing the following:

- Restore the hardware settings
If changes are detected in the Control Panel, the user is asked whether they should be overwritten with the saved settings
- Check Hardware Configuration: This checks whether all references created have also been assigned to a hardware channel
- Configure the charge amplifier (if available)
- Start the measurement
- Wait on the trigger
- Wait on the end of recording
- Saves measured data to a TCP5 file
- Analysis of the measurement data and writes values into the measurement table
- Reset the charge amplifier
- Closes the measurement dialog if successful

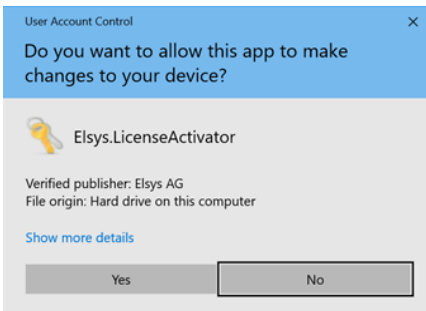
2. License handling

A software activation will be required to use the full potential and all the function of BallAX. Without, the software switches to the LE (Light Edition) mode after a trial period of 30 days. In the LE mode, no new measurement can be started and the software runs as viewer for existing measurements.

For the software activation you need a valid license key. The activation process can be done "online" or "offline". If an activation isn't needed any more on a computer, the key can be released online.

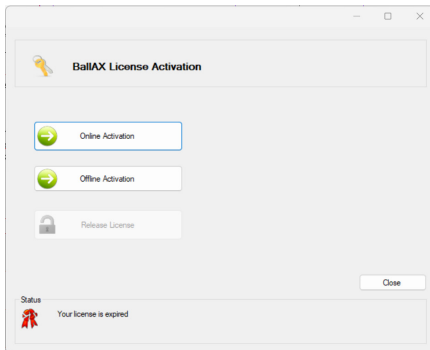
A standard license can be activated twice.

2.1 License Activation



After the first start of BallAX, the Window "BallAX License Activation" appears. The same dialog can also be started under "Settings → Activate License"

The activation needs administration rights as this is done for all users on this computer.



"Online Activation" requires an active Internet connection from the computer to activate BallAX. This is the fastest way to activate the software

"Offline Activation" assumes no active Internet connection. It will need some email interaction with Elsys to activate the software.

2.1.1 Offline Activation

Enter your license code from the manual or the USB stick to the field "Activation Key".

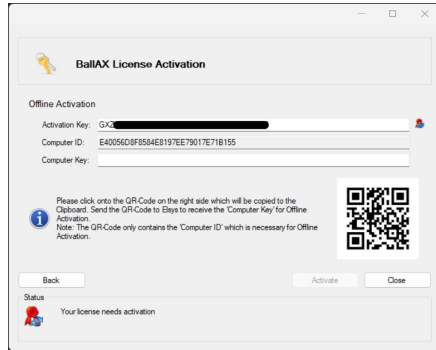
To generate a valid "Computer Key" the "Computer ID" must be sent to Elsys Instruments for the activation.

Please send an Email to info@elsys.ch

It is also possible to just click on the QR code, this will copy the graphics to the Windows clipboard, and can be paste it into an Email.

If it is a valid request for a key, the matching computer key will be sent back per Email and has to be entered into the filed "Computer Key".

Click the button Activate and BallAX will be activated to the full version.

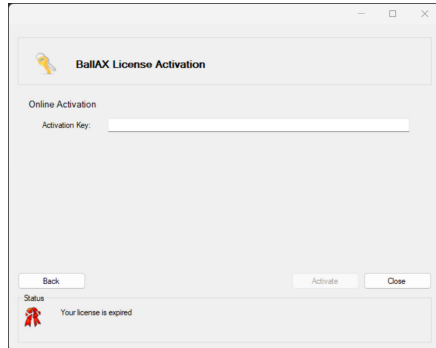


2.1.2 Online Activation

Enter your license code from the manual or the USB stick to the field "Activation Key" and click on Activate.



BallAX requires an Internet connection only for the first online activation. For further usage of BallAX, no active Internet connection is required!



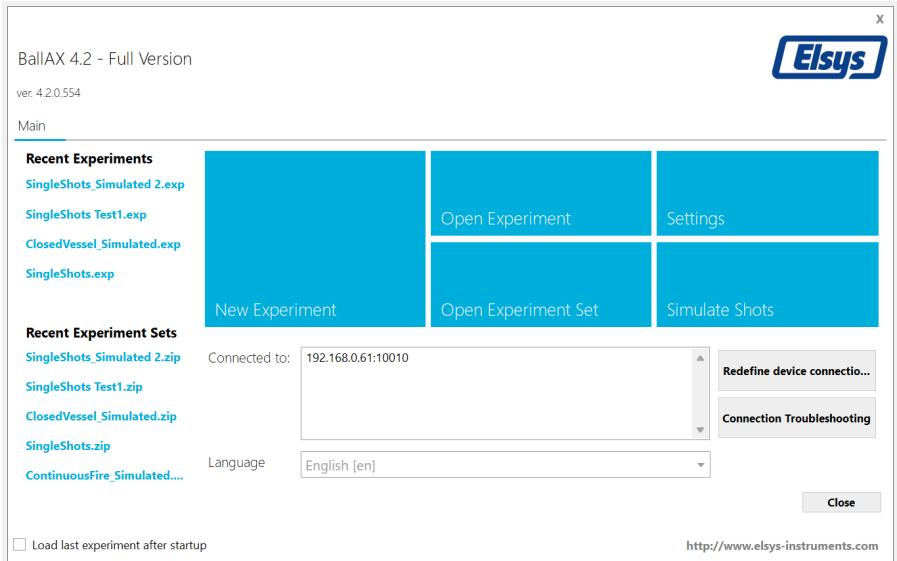
2.2 Release

In case BallAX will be used on several computers, this button can be used to release an active BallAX license for usage on another computer. Internet connection is recommended; else you will have to contact your local distribution partner.



3. Experiments and Experiment Sets

In BallAX the term “Experiment” stands for a measurement project. An Experiment includes all settings such as hardware configuration, the arrangement of the windows, measurement configuration, measurement table settings, formulas etc.



3.1 Startup Page





When starting the software, the startup page appears on which you can load an experiment and experiment sets or create a new one.

If the software should always be started with the last experiment set used, this can also be specified here.

3.2 Data Structure







example.exp

For each experiment, a subdirectory will be created. This usually carries its name plus the extension “.exp”.

-  data
-  expr
-  example.exp
-  example.zip

Inside of the Experiment, there are the sub directories *data* within the measured traces are stored. In *expr* all the calculated traces from the formula editor are stored.

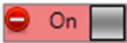
The default root path of a new experiment can be changed in the global settings.

-  example.aut
-  example.ctf
-  example.lay
-  example.tps.xml
-  Settings.xml
-  Snapshot.bmp

An *Experiment Set* is a Zip file, which includes all the settings: Layout, hardware settings, MFC's, formulas, etc.. One Experiment can hold several Experiment Sets which share the same folder.

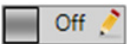
3.3 Write protection

In general, when closing BallAX, all changes in the experiment are stored into the current Experiment Set. For many applications, it may be advantageous that these settings are not changed and no changes in the original Experiment Sets are made.



Write protection is activated. Changes to the layout and settings can be done, but they are discarded when closing.

A corresponding dialog warns against the loss, so that they can still be saved in another experiment set.

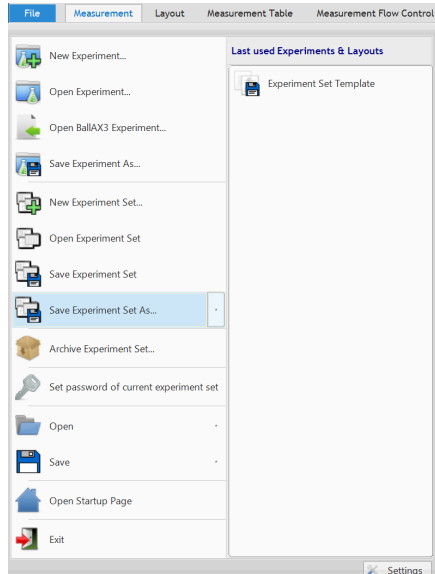


Write protection is turned off. Upon closing of BallAX, any changes in the current experiment set is stored.

Write protection can also be assigned a password: File → "Set password of current experiment set"

3.4 Templates

An "Experiment set" can also be stored as a template. A new experiment can be created based on a template, whereby the corresponding file structure is created and the template set is copied.



Templates are stored in the folder "C:\ProgramData\Elsys\BallAX_4.0\ExperimentTemplates"

If you want to save the currently loaded experiment as a template, this can be done under "File → Save Experiment Set as → Experiment Set Template"

BallAX is installed with a few predefined templates which make it easier to get started with the software.

The default root path of the templates can be adjusted in the global settings.

4.2 Measurement Settings

The Measurement Settings can be found in the Ribbon bar under Measurement → Settings.

4.2.1 Channel Assignment

All signals that are to be recorded in BallAX must be created in the channel assignment dialog and assigned to a hardware channel of the measuring device. The channel name must be unique.

The channel type determines which scalar calculations are possible on a channel when configuring the measurement table. The following channel types are available for selection:

- Pressure
- Velocity
- Temperature
- Any

Charge Amplifier

If an external charge amplifier is used for the pressure channels, the corresponding

amplifier can be selected from a drop down list. If no amplifier is visible in the list, a charge amplifier connection must be first configured in the global settings by clicking on “Charge Amplifier Settings” Button or in File → Settings → Charge Amplifier.

The configuration of the amplifier is done in the lower part of the dialog.

The sensitivity and scale values are then used for configuring the connected charge amplifier.

Sensitivity: is taken from the sensor datasheet.
Scale: defines the input range



The Charge Amplifier input range is calculated based on the fact that the max. output range of $\pm 10V$ of the amplifier should be reached:

$$\text{Range} = 10V * \text{Scale}$$

Nr.	Name	Channel	Type	Charge Amplifier	Filter
1	pChamber	0A1	Pressure	[1] 5018 (SN.1234)	LP Bessel - 10 kHz - 2. Order
2	pBarrelvent	0A2	Pressure	(No Charge Amplifier)	LP Bessel - 10 kHz - 2. Order
3	pMuzzle	0A3	Pressure	(No Charge Amplifier)	LP Butter - 10 kHz - 2. Order
4	Vstartstop	0A4	Velocity	(No Charge Amplifier)	LP Butter - 22 kHz - 2. Order

TO Reference Settings

Hardware Trigger
 Software Trigger

Channel: pChamber Slope: Positive Level: 0

Curve Filtering

Formula:

PZero Calculation

Type: Trigger

Percent [%]: 10

Charge Amplifier

Filter: 10kHz

Zeitkonstante: Low

Sensitivity: 0.01 pC / bar

Scale: 0.1 bar / V

Sensor

Type:

Adapter-No.:

Serial Number:

4.2.2 Software Filter

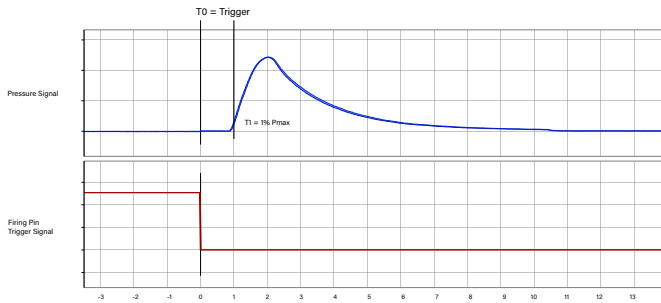
A software filter can be activated on each channel. Some filters are already defined. You can configure additional filters yourself.

4.2.3 T0 Reference Settings

The T0 Reference Settings configures how the T0 time is determined for T1-T5 time calculations.

Hardware Trigger

This is the default setting. The time T0 corresponds to the trigger time at which the device was triggered.



Software Trigger

A pressure channel is used as the trigger channel for which the trigger time is not to be used as the T0 reference.

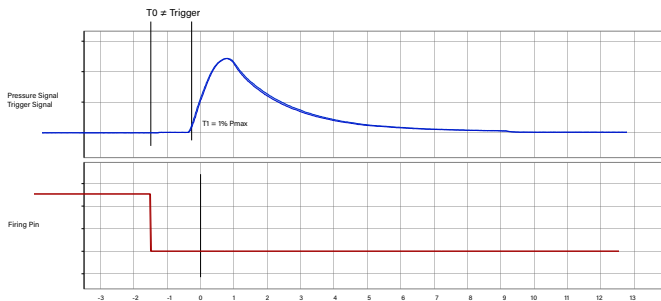
You can now specify a reference channel under Software Trigger on which the time for T0 is to be searched for. A level and positive or negative slope direction can be used as search criteria.

T0 Reference Settings

Hardware Trigger

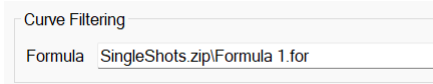
Software Trigger

Channel	Slope	Level
FiringPin	Negative	1

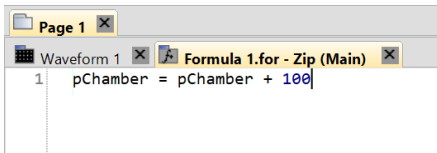


4.2.4 Curve Filtering

If further post-processing of the measurement curves is required, a formula file can be specified which is processed with each measurement.



The measurement curve can be accessed in the formula editor via the reference name. The result of the calculation is also assigned to the reference name:



4.2.5 PZero Calculation

Charge signals can have a DC offset error. To compensate for this in every measurement, the PZero calculation can be activated. There are two possible calculation methods for this:

- Trigger: The offset is calculated from the mean value between the start of the measurement and the trigger time and subtracted from the signal.
- Pmax: The offset is calculated from the mean value between the start of the measurement and the set percentage value of Pmax and subtracted from the signal.



This PZero calculation is only applied to the measurement table and is not visible in the waveform display or in calculations in the formula editor.

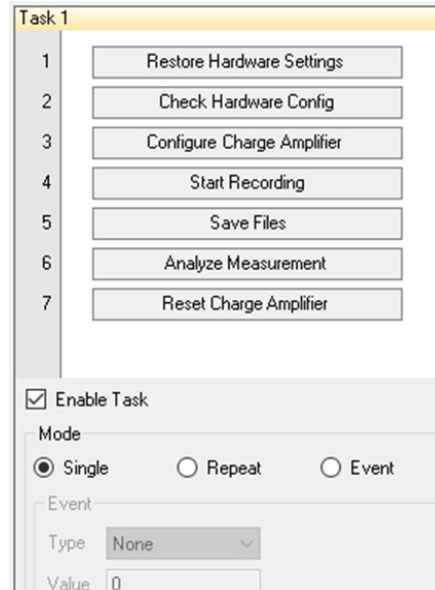
4.3 Mode & Equipment

4.3.1 Mode

By default, the control of the measurement flow (configure the hardware, start measurement, post calculation, etc) is predefined in BallAX. This is called the "Normal Mode". If user specific process should be followed, this can be done by either using the MFC or a formula which executes the corresponding tasks.

MFC

To obtain the same procedure as in the Normal mode, the following steps are necessary. Further functions, formulas and processes can then be supplemented accordingly



Formula

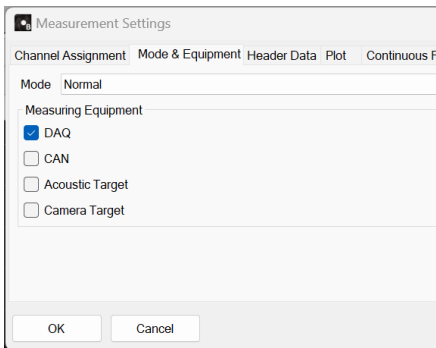
As an alternative to the Measurement Flow Control (MFC), BallAX also offers the possibility of controlling with a formula and also of supplementing it with certain calculations and controls.

The formula code itself is executed in the Main formula. As usual, you can implement your own functions and formula.

```
Measurement.for - Zip (Main)
1 RestoreHardwareSettings()
2 CheckHardwareConfig()
3 ConfigureChargeAmplifier()
4 StartRecording()
5 WaitOnEOR()
6 SaveFiles()
7 AnalyzeFile()
8 ResetChargeAmplifier()
9
--
```

4.3.2 Measuring Equipment

BallAX has built in some hardware specific AddOn's which must be enabled in this settings for being visible in the software.



4.4 Header Data

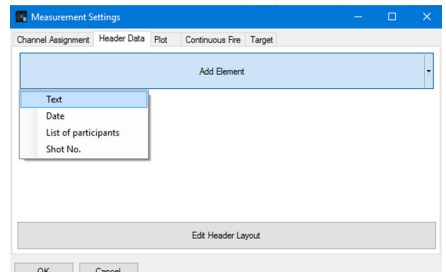
Header data are freely definable fields which can be used for test reports. Under "Settings → Header Data", the fields can be defined and the positioning in the display can be set.

The following text field types are available:

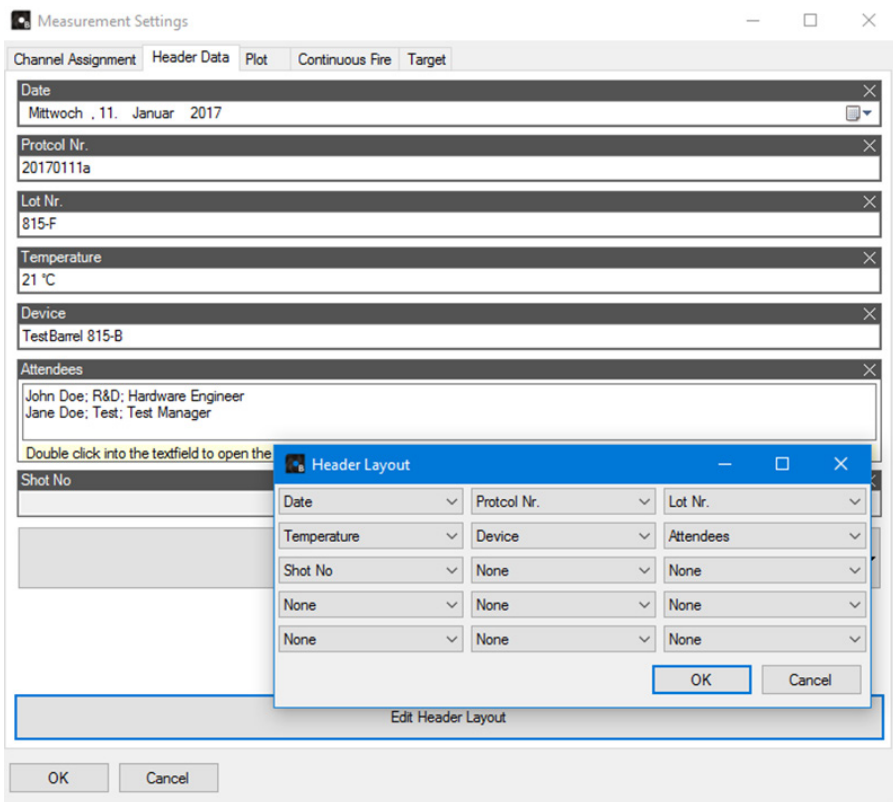
- Text
- Date
- List of participants
- Shot No.

Shot number will be increment automatically, the list of participants can be edited by double clicking on this field.

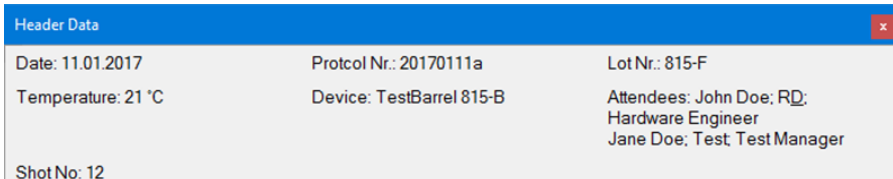
Each element has to be defined first, afterwards it can be located for visualization. Each element has a variable name and its content. The variable name can be used for creating excel based protocols.



Example of a possible configuration:



The final header looks like this:

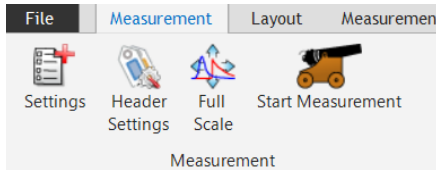


4.5 Plot Settings

Several settings can be made in the plot settings which relate to the signal display in the plot window.

4.5.1 X-Axis full View:

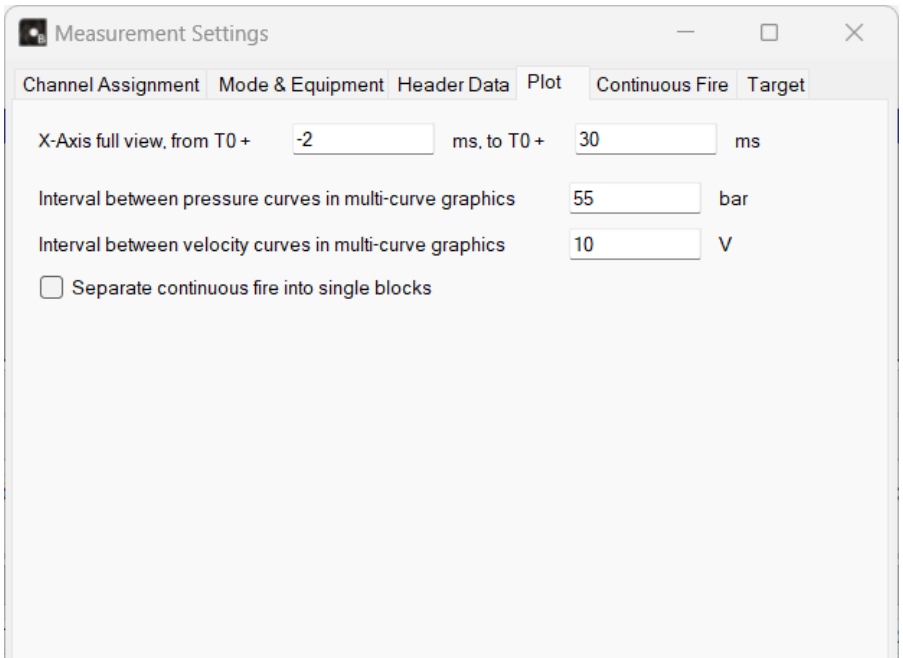
A much larger time window is often recorded than is actually required for the evaluation. This setting is used to set the desired display period, which is taken into account when "Full Scale" is pressed in the measurement ribbon.



This setting only relates to the display and not to calculations.

4.5.2 Interval between

If several shots are selected in the measurement table, they are drawn with a certain offset in the Y-axis so that the curves are better separated from each other. This offset can be set individually for the pressure and velocity curves.



4.6 Continuous Fire

4.6.1 Separation of continuous fire

The measurement curve of a continuous fire measurement contains the pressure curves of several shots one after each other. In order to analyze each shot separately, the shots have to be separated with some certain criteria. This is done by defining a level for a pressure curve or an arbitrary channel. By setting the parameter pretrigger the zero-point $t = 0$ is brought forward.

Example: The level is set to a pressure of 500 bar on the Pmax channel. The pretrigger is set to 2ms. Each shot is separated in the way that the time axis starts with $t=0$ 2ms from the point, where the pressure exceeds 500 bar.

4.6.2 Recording Time Assistant

If number of shots is 1, the program expects a single shot measurement.

If the number of shots is greater than 1, the recording time assistant helps to calculate the required recording time for BallAX. With the expected cadence and the number of shots the minimally required recording time is calculated, in order to be able to record all shots. The current recording time set in BallAX is also displayed and high-lighted in red, if the time is too short.

To change the recording time in BallAX follow the steps below:

- Change the block size and/or the sample rate in the Control Panel.
- Save the system configuration (save Experiment Set)
- Recheck the new settings with the recording time assistant.

The screenshot shows the 'Continuous Fire' configuration window. It has three tabs: 'Channel Assignment', 'Header Data', and 'Continuous Fire'. The 'Continuous Fire' tab is active.

Separation of continuous fire

- Enable Continuous Fire
- Type: Trigger
- Channel: T0
- Comparator: Positive
- Sensitivity: 3 V
- Pretrigger: 2 ms
- Dead time: 50 ms
- Max. count of shots: 10

Continuous fire recording time assistant

- Number of shots: 2
- Minimally expected cadence: 100 Shots/Minute
- Required recording duration: 1200 ms
- Actual setting in TranAX: 2097.152 ms

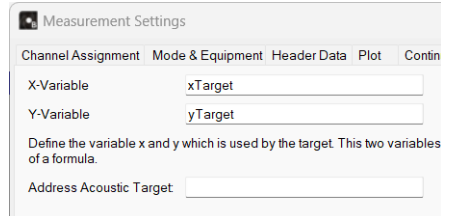
4.6.3 Scalar Function Cad

There are specific functions for continuous fire in the scalar table. The Cad function calculates the shot cadence, with two different calculation types to choose from:

- **Analysis type Level:**
A specific channel and level is defined. The times when the level is exceeded are used as a base to calculate the mean time between the shots and the cadence.
- **Analysis type V-Signal:**
The first of the two V-Signals is taken as a base to calculate the mean time between the shots as well as the cadence.

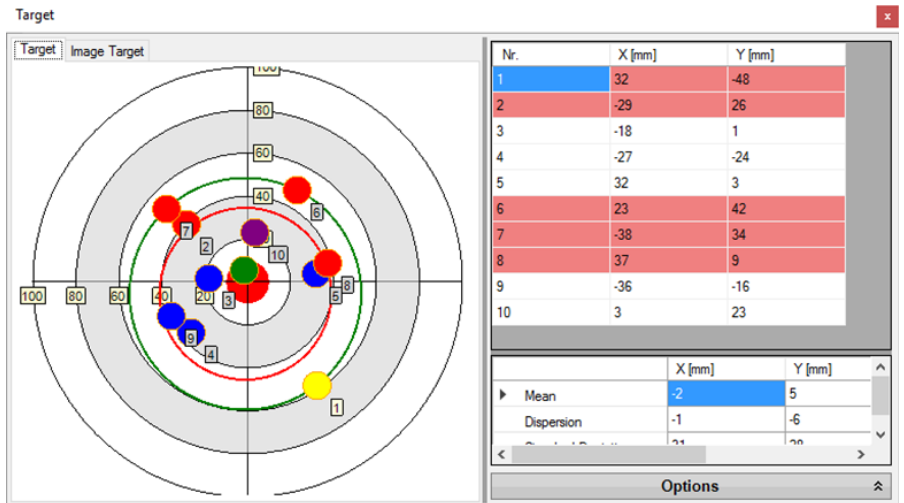
4.7 Target

Target data can be visualised with the built-in Target display. Additional hardware like an optical or acoustical target will be necessary to measure the target data. The calculation of the coordinates can be done with the Formula Editor.

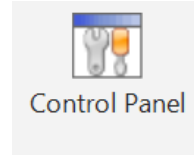


$xTarget = CalcPositionX(xSignal)$
 $yTarget = CalcPositionY(ySignal)$

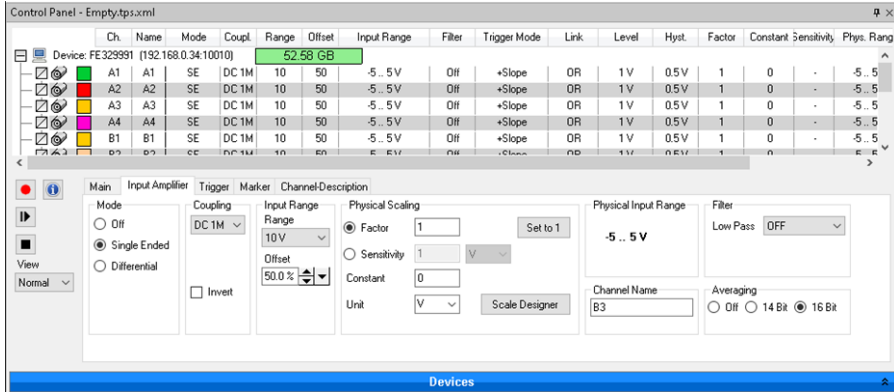
The two functions CalcPositionX() und CalcPositionY() must be created and parameter-



5. Control Panel



The Control Panel is one of the core components of BallAX. It is used to configure the connected DAQ modules and devices. It enables the individual configuration of each channel of the system and settings such as recording mode, sampling rate, block size, trigger settings or signal scaling.



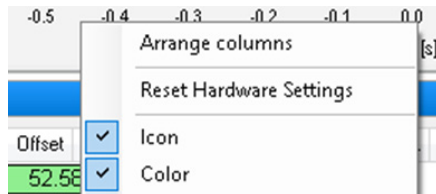
The upper section of the control panel contains a list of all channels and its configuration.

Within this list one or multiple channels can be selected and their settings modified in the section below.

To select multiple channels, press and hold the left mouse button and move over the channels which should be changed. This works in every column except the first two.

Please note the first two columns ("Ch." and "Name") are used to drag & drop the selected channels into a Waveform.

A right click on the header of the table with the channels allows to enable or disable each row, reset the hardware settings to default values and arrange all the columns.



Channel settings can be copied from one channel to another with Ctrl-C and Ctrl-V.

5.1 Device Manager

When starting the software for the first time or if the IP address of the TraNET device has changed, a connection must first be established with the device.

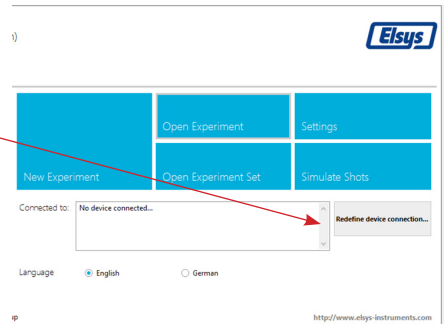
To search for devices, click on the blue "Devices" bar in the Control Panel.



The Device Manager then appears and lists all devices found in the network. If the device does not appear, you can try to enter the IP address of the device manually. If this does not work, consult the device manual regarding network troubleshooting.



The connection can also be created directly from the start screen. It is recommended that the connection is created before an experiment is loaded, as otherwise the hardware settings will not be loaded.



5.2 DAQ Operation Modes

There are four different operation modes in which the data acquisition instrument can be used.

5.2.1 Scope

In Scope mode the device runs like an Oscilloscope. Incoming data from the ADC are written into the on-board memory until a trigger condition occurs. After the trigger condition, the measurement continuous until the post-trigger time is over and stops. The length of the measurement is limited by the maximum memory available on the TPCE board.

Scope Parameters:

- Auto Trigger: If no trigger event occurs BallAX will trigger automatically
- Single Shot: Only one shot will be displayed and the measurement will not be continued
- Sample Rate: Acquisition speed, max speed depends on the installed DAQ board
- Block Size: 1k up to 128 MS per channel, defines the length of the measurement and is limited by the available memory on the DAQ card
- Trigger Delay: specifies the amount of pre- and posttrigger time of the set block length

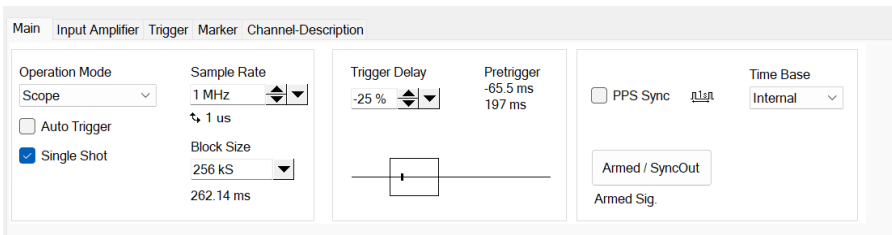
Normally used settings for ballistic application is Scope, Auto Trigger off, Single Shot on!

5.2.2 Multi Block

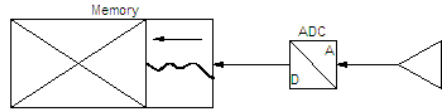
Multi-Block Mode works like the Scope mode but with the addition that the available on-board memory is split up in several blocks. On each trigger, a new part of the memory is used. This way, the on-board memory can be used more effective than in the Scope mode. The maximum number of blocks is limited by the block size and the available memory.

Multi Block Parameters:

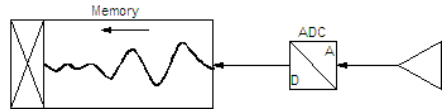
- Number of Blocks
- Block Size
- Trigger Delay



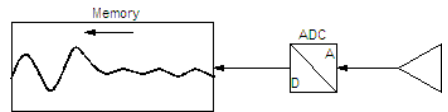
The illustrations on this pages describes the measurement principles in the scope and multi-block mode.



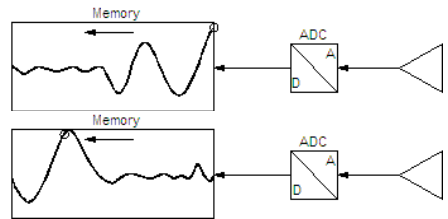
Immediately after measurement start, the DAQ module begins to fill the on-board memory with values digitized by the ADC.



From this point on, the oldest data will be overwritten by new data.



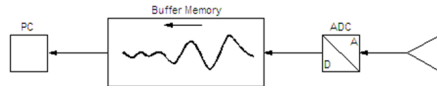
If a trigger event occurs, the post-trigger counter is starting until it reaches the defined post-trigger time and the acquisition is stopped.



In multi-block mode, the acquisition is started again for the next block in the next section of the memory while the computer has access to read the previous block.

5.2.3 Continuous

In the Continuous mode incoming data from the ADC's are buffered on the on-board memory and then transferred immediately to the built-in hard disk of the device. The maximum recording length is only limited by the hard disk size. The amount of data produced per second depend on the used sampling rate and the number of activated channels. If the data rate is higher than the PCIe interface or the hard-disk write throughput, some data from the on-board buffer get lost.



Parameters:

- Sample Rate
- Stop Trigger: The acquisition will stop when a trigger event occurs. Additionally, a trailer length must be set. The measurement will then run after the trigger event for a pre-defined period. The trigger settings are set in the Trigger tab. If not set, the acquisition must be stopped manually (or by a formula or MFC).
- Trailer: post-trigger time if the stop trigger is activated.
- Limit Rec. Size: The acquisition will stop after a predefined time limit. The Maximum Record Length depends on the free hard disc capacity. If the disc capacity is exceeded, no more data will be recorded and the recording is stopped.

Main	Input Amplifier	Trigger	Marker	Channel-Description
Operation Mode Continuous		Sample Rate 1 MHz ↕ 1 us		Trailer 10 MS 10s
		<input type="checkbox"/> Stop Trigger		<input checked="" type="checkbox"/> Limit Rec. Size

5.3 ECR Operation Mode



The ECR mode is an optional feature!

The ECR mode allows targeted acquisition of cyclic or sporadically arising events. This implies that the registration of measuring data only occurs if certain signal conditions (trigger, time window, repetitions, etc.) are fulfilled. Thus, many unwanted and unneeded signal data will not be stored.

Nevertheless, it can be guaranteed that no dead times arise and therefore no events will be lost. This even applies if many channels at maximum sample rate have to be supervised over a long period of time. Since each channel possesses its own signal buffer (up to 64M samples), only the average number of events per second may not exceed a certain value. This value depends on the adjustable block length per event and furthermore it is defined by the maximum possible transfer rate to the hard disk (approx. 200M samples per second, depending upon CPU/Disk systems).



Compared to the block mode, with ECR mode it is guaranteed to have no dead times between adjacent blocks. Note that, if in block mode a trigger event occurs at the end of the block, the event might not be recorded.

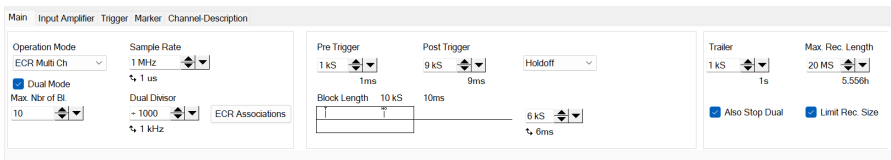
In the ECR-mode it is guaranteed that there is no dead-time between adjacent blocks. The overlapping data-area depends on the event-rate and it can be controlled within certain

limits with the Holdoff function. In Block Mode on the other hand, the blocks are strictly sequential data acquisitions with a gap between blocks.

In the ECR mode the block size is determined explicitly by pre- and post-trigger settings. As with the multi block mode you also can set the maximum number of blocks that will be recorded. Furthermore, there is a Retrigger (RT) marker in the illustration below the settings or a Holdoff (HO) marker shown, depending on the settings made in the ECR tab. There are two different ECR modes, the single and multi-channel mode. Both modes support a Dual mode option.

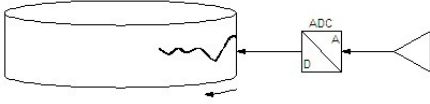


If the trigger conditions are set very uncritically, then in ECR Mode the CPU could easily be overloaded by fast periodically signals. The CPU might seem to be blocked.

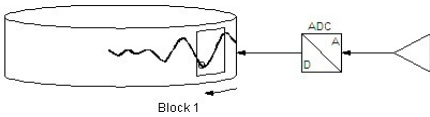


5.3.1 Basic Sequence

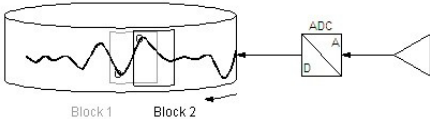
The ECR mode runs as follows: The digitalized signal will be stored to the on-board memory which acts as a ring buffer.



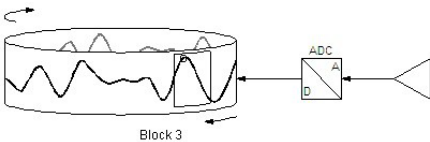
As soon as the trigger is released, a block of samples will be read from the ring buffer and will be saved to the hard disk.



If a new trigger event within the actual block occurs, a new overlapping block will be saved.



If the ring buffer is full, the oldest measurement data will be overwritten with new incoming data. Usually, the overwritten data would be transferred to the hard disk before this happens. If too many events occur in a period of time, the ring buffer may overflow. TranAX will display a message according to the status.



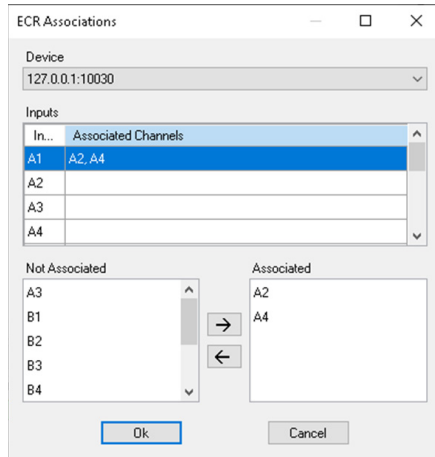
After the predefined number of saved blocks is reached (in this example 3), the recording stops.

5.3.2 Single vs Multi-Channel Mode

The ECR multi-channel and single-channel modes differ in the way the triggers are processed. In multi-channel mode, each channel also triggers the other active channels. In terms of function, this is the same as in scope and multi-block mode.

In ECR Single Channel, each channel triggers only the channel by itself. If you still want to connect individual channels to the trigger logic, this can be done via the ECR associations.

To associate a channel, press the button „ECR Associations“ and a window as shown below will appear:



Simply select the desired input channel from the Input-field, choose not yet associated channels and press the right arrow.

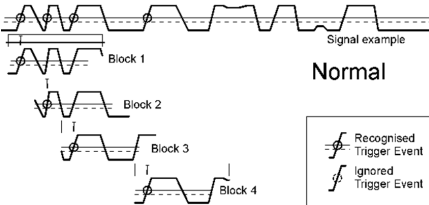
5.3.3 Dual mode

An other feature of ECR is the "Dual Mode". It allows to store a continuous measurement at a slower sampling rate than the captured blocks. For example fast transient can be captured at 10 MS/s by the triggered blocks while storing slower signals at 100 kHz over a long period of time.

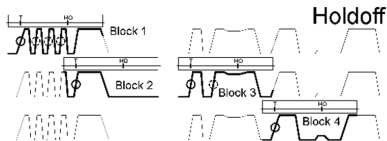
5.3.4 ECR Trigger option

The Trigger option Normal, Retrigger and Holdoff controls the overlapping of multi blocks and can help to prevent multi-event generation on bouncing signals.

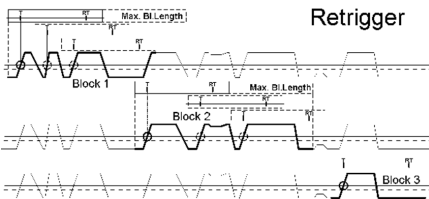
Normal: Any detected trigger condition will generate a new block



Holdoff: you instruct the software to ignore all additional trigger events until to the Holdoff marker HO.



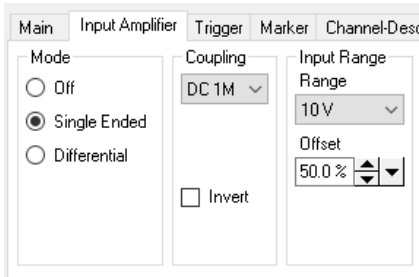
Retrigger: In this mode, the block is extended by a defined additional time with each trigger that occurs within a certain time. However, as soon as the maximum block length is reached, the block is nevertheless completed and another trigger event will generate a new block.



5.4 Channel Configuration

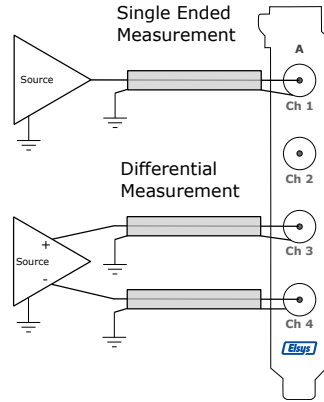
5.4.1 Input Configuration

The input configuration of the measurement channel has a significant influence on correct and accurate measurement results. The possible settings depend on the measurement hardware used. Depending on the type of measuring card, additional setting options are available. Unless otherwise specified, the settings here always apply per channel.



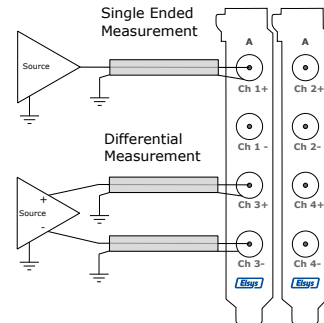
Mode:

- Single Ended: default setting
- Differential: Two neighboring channels are combined to form a differential channel. (for differential DAQ cards, each channel can be set to differential as these inputs have a + and - Input BNC.
- Off: the channel is turn off an no data are acquired. Always switch off all unnecessary channels to avoid producing unnecessary data, especially in Continuous mode.



Single Ended boards have one BNC connector per channel where the outside shielding is connected to chassis/protective Ground.

Two neighboring channel can be configured per software as differential input stage. In this case the signal must be connected as shown above.



Differential boards have two BNC connector per channel where the outside shielding is connected to chassis/protective Ground.

Single ended measurement can be performed by just using the + input of the BNC pair

Coupling:

- DC, AC or ICP/IEPE (Integrated Current Power for Piezo sensors), Charge.
- For the modules 120MS and 240MS modules, the input impedance can be set to 50Ω. For all other modules, this value is set to 1MΩ.
- For TraNET 408 DP, the current for the IEPE power source can be configured from 4 to 20 mA.

Input Range:

- The input range must be set as close to the maxim input signal level for having best signal to noise ratio and ADC resolution.
- The input range is either in Volt or in pC.
- An offset can be set for the voltage inputs for having unsymmetric input ranges. (e.g. 10V with 50% means from -5V to +5V, 10 Range with 20% means from -2V to +8V)

Physical Scaling:

- Depending on the connected sensors, the measured value can be converted to its defined value. Either by using a Factor and a constant or Sensitivity and a constant. Please note the that Sensitivity is 1/Factor and vice versa. Unit can be entered as a text or selected with the dropdown menu.
- In case of neither Factor nor Sensitivity is given use the Scale Designer to calculate these values
- Physical Input Range: Overview of the possible measurement range with the actual used settings
- Scale Designer: To set scale and factor from two reference points,

Channel Name:

- Text field for giving a name to a channel. This name will be used in the Measurement settings for configuring the measurement chain (charge amplifier, software filtering, etc.)

The screenshot shows a configuration window titled "Physical Scaling". It contains several input fields and buttons:

- Physical Scaling:**
 - Factor: 1 (with a "Set to 1" button)
 - Sensitivity: 1 (with a "V" dropdown menu)
 - Constant: 0
 - Unit: V (with a dropdown menu and a "Scale Designer" button)
- Physical Input Range:** -5 .. 5 V
- Channel Name:** A3

Filter:

- Allows to set a Low Pass Filter 1st order: Off, 100kHz, 1MHz
- With an option built-in Anti-Aliasing filter, more frequencies will be available

5.4.2 Averaging

The ADC of a Elsys DAQ module always runs with its maximum possible sample rate. If the used sample rate is less than the maximum rate, then the excess samples will be averaged. This process is reducing dramatically the noise at lower sample rates. At sample rates lower than $\frac{1}{4}$ off the maximum sample rate, this way two additional bit will be added for having a 16 bit ADC resolution.

In 16 bit mode, no digital marker bit can be used as they share the same bit in the data stream.

The image shows two control panels. The top panel is titled 'Filter' and contains a 'Low Pass' dropdown menu currently set to 'OFF'. The bottom panel is titled 'Averaging' and contains three radio button options: 'Off', '14 Bit', and '16 Bit'. The '16 Bit' option is selected, indicated by a filled circle.



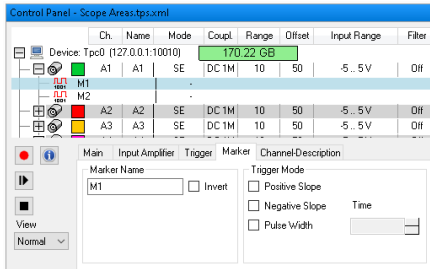
The parameter **"Averaging"** will be set for **all channels** within a module.



In some cases, averaging should not be used, e.g. for **under sampling** (sampling with a lower frequency than the measured signal). In this case, averaging has to be set to "off".

5.4.3 Markers (Digital Inputs)

(this is an optional feature)



Every data acquisition channel has two digital inputs called Markers. Marker signals are digital signals with values 0 or 1 and they can be displayed in the dedicated Marker Waveform Display

In the Tab "Marker", the name of each Marker Input can be changed, per default they are called M1 and M2 for each channel. With the check box "Invert" the signals can be inverted. E.g. in combination with an opto-coupler, default signal is On = 5V = 1. In this case, this should be visualized as status Off = 0V = 0, this means Off, so the signal can be inverted to visualize it more understandable.



Marker inversion will be marked with a "\" (Backslash) at the end of the name. "M1\" means the inverted Marker 1.



In case the TPCX/TPCPE digitizer module is set to 16-bit mode, there are no Markers (digital inputs) available.



These settings are always visible in the Control Panel, even when there is no Marker option installed.

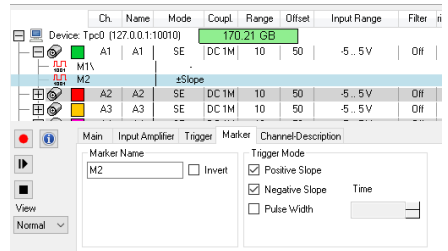


The corresponding analog channel must be switched **ON** (tab "Input Amplifier" in the Control Panel) to record the Marker signals.

Trigger settings for Markers

Each Marker input can be used for triggering measurements. It is possible to trigger on a Positive Slope, Negative slope or a combination from both.

For some customized applications on modules, Pulse Width Trigger can be selected.



The settings for the calculation must be made before the data capture starts.

5.5 Trigger

5.5.1 General Information

Each channel can be used as a trigger source. If the trigger is activated on several channels, the first trigger detected triggers the recording.

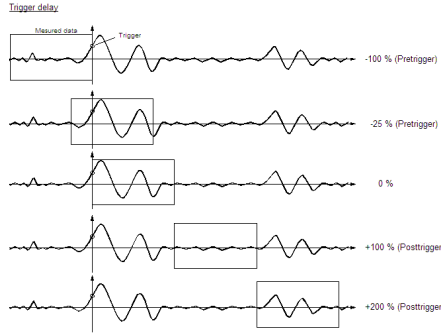
A distinction is made between the standard triggers and the advanced triggers. The advanced triggers are optional and must be purchased separately and activated on the measuring card.

Trigger levels can be defined either in the scaled physical unit or in the effective input voltage (or charge for charge inputs). It is recommended to set the trigger level in the physical unit (default)

5.5.2 Pre- and Post-Trigger

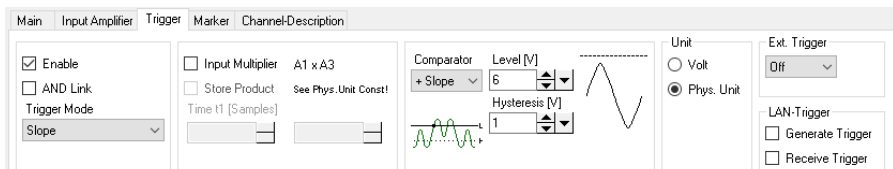
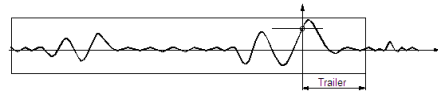
For all triggered measuring modes, the pre- and post-trigger time can be set relative to the trigger time. This setting always applies to all channels and cannot be set individually for each channel.

These trigger delays (-% for pre; +% for post) are defined in terms of percent of the total block period. The hardware allows a trigger delay between -100% and +200%.



Trigger delay (trailer) in Continuous mode:

There is no pre/post trigger in Continuous mode. In this mode the stop trigger and **trailer** are utilized. The stop trigger is used to determine the end of the measurement i.e. data acquisition stops at trigger. However, sometimes it is required that the measurement continues for a predetermined time after the stop trigger - this is called the trailer. The trailer is defined in number of samples after stop trigger. The TPCX/TPCE hardware allows settings from 0 (no trailer) to 16 MSamples. This option is also included in the ECR dual mode.



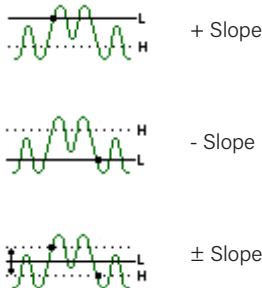
5.5.3 Standard Trigger

The following trigger types can be set on any analogue channel. On the illustration, “L” is the **trigger level** and “H” the configurable **hysteresis level**.

The hysteresis is required to trigger on the correct edge in the event of noisy signals. It should therefore never be set to 0. 1% of the input range is often a good value for the hysteresis.

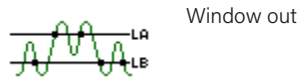
Slope Trigger

With the slope trigger settings, you can select the positive, negative or both slopes of the trigger signal. A trigger will be generated when the hysteresis level has been passed and subsequently the slope level has been reached.



Window Trigger

Selecting the “window in” trigger, triggering occurs when the signal enters the window. With the “window out” trigger, triggering occurs when the signal leaves the window. It does not matter whether this happens at the lower or upper limit.



5.5.4 External Trigger

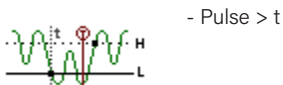
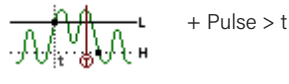
In addition, each device has an external trigger input available (TTL). Triggering can be enabled or inhibited using a second external input (TTL) called disarms. For more information about the pin layout of the external digital I/O connector please see the hardware manual.

5.5.5 Advanced Triggers

All of the following trigger settings are only available with the Advance Trigger option.

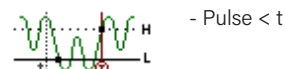
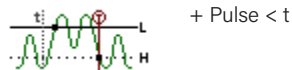
Pulse > Time

As soon as a positive or negative pulse is recognized, a trigger is generated if the pulse width is greater than the specified time, respectively if the signal doesn't reach the hysteresis level within the defined time domain. Please note: To determine the end of a pulse it must be considered to set the trigger hysteresis.



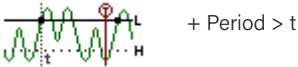
Pulse < Time

A trigger is generated as soon as a pulse width is smaller than the specified time.



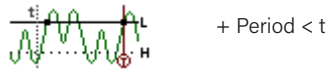
Period > Time

A trigger is generated if the period is greater than the defined time. Also, the hysteresis will be considered to detect level crossing of periods. The hysteresis allows suppression of illegal periods (e.g. high frequency noise).



Period < Time

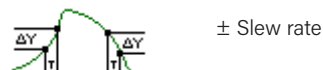
A trigger is generated as soon as a period width is smaller than the specified time.



Slew rate

With the slew rate trigger you can generate triggers on specified positive or negative slew rates. It's mainly used to detect fast parasites or spikes on slower periodic signals. It actually works like a trigger generator's low frequency suppression.

The slew rate has to be defined by Delta Samples (Delta times) and Delta-Y (Delta amplitude). Delta-Y should be set to a value at least twice the expected noise on the signal. The Delta-Time parameter is limited to 1024 samples. The resulting slew rate value can be examined in the column Trigger Mode of the channel list in the Control Panel.



Pulse inside t1 .. t2

Triggering will take place, when a pulse length is detected which is longer than t1 but shorter than t2.

Pulse outside t1 .. t2

Triggering will take place, when a pulse appears outside the time limits t1 and t2. This means that the pulse width has to be shorter than t1 or longer than t2 to meet the trigger condition (pulse width < t1 or pulse width > t2).

Delay > t

This trigger mode uses the signals of channel 1 and 3 (respectively 2 and 4). It captures when the time between trigger condition of **channel 1** and the condition of **channel 3 is longer** than the pre-set time t. In this case, the system generates a trigger.

In addition to the time t, the comparator settings (edge, level, and hysteresis) for the two channels 1 and 3 must be set.



For this trigger mode, channel 1 and 3 as well as channel 2 and 4 are combined. Other combinations of channels are not possible.

Delay < t

A trigger is signaled, when the delay is shorter than the time t. In addition to the time t, the comparator settings for the channels 1 and 3 (respectively 2 and 4) can be set individually (Level, Hysteresis, Slope).

Delay inside t1 .. t2

This trigger mode uses the signals of channel 1 and 3 (respectively 2 and 4). It captures when the **Time between** trigger condition of channel 1 and the condition of channel 3 is **within** the pre-set time limits t1 and t2. In this case, the system generates a trigger.

In addition to the times t1 and t2, the comparator settings (edge, level, and hysteresis) for the two channels 1 and 3 must be set.

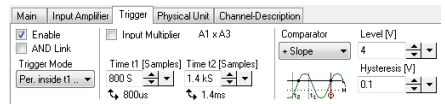
Delay outside t1 .. t2

This trigger mode uses the signals of channel 1 and 3 (respectively 2 and 4). It captures when the **Time between** trigger condition of channel 1 and the condition of channel 3 is **outside** the pre-set time limits t1 and t2. In this case, the system generates a trigger.

In addition to the times t1 and t2, the comparator settings (edge, level, and hysteresis) for the two channels 1 and 3 must be set.

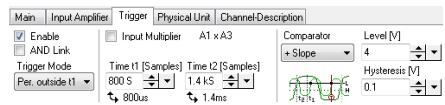
Period inside t1 .. t2

A trigger event is caused when the period is within the pre-set time limits t1 and t2.



Period outside t1 .. t2

A trigger event is caused when the period is outside the pre-set time limits t1 and t2.



5.5.6 Input Multiplier

The function Input Multiplier multiplies the currently digitized signals of two channels (e.g. A1 and A3 or A2 and A4). The resulting signal (a product) will then be passed to the trigger discriminator instead of the original signal from channel A1 resp. A2, on which the module will trigger. The range and resolution of the products depend on the settings (range, offset, physical scaling factor and physical unit) of the two channels.

The full range and full resolution can only be exhausted to half. This will be the case if both channels are set to 0% or 100%. The multiplied product curve will then have a range from 0 to +Max or to -Max. There will never be a multiplied product in a range from -Max to +Max. **Having the offsets set to 50%, only one fourth of the maximum possible resolution is achieved.**



Note that the hardware multiplier doesn't take the constant of the Physical Scaling into account. It should therefore be set to 0 for both channels.

The checkbox "Store product" only visible when "Input Multiplier" is activated will replace the recording of one channel (e.g. A1) with the result of the multiplied two channels. The second channel (e.g. A3) will contain the normal recording (unchanged).

The amplitude resolution of the product signal is also 14-bit resp. 16-bit. If the original signals don't use the full dynamic range of the amplifier and the ADC, the resolution of the output signal can be strongly minimized. It's recommended to choose for both signals, measurement ranges that optimize the dynamic range of the input stages.

5.5.7 AND Link (logic AND operation)

By default, all active trigger sources are combined in an OR-logic. This means, any enabled trigger source can trigger all the channels simultaneously of a TraNET instrument or a TraNET system synchronized with SyncLink. In cases where AND-logic is required, all trigger sources of a 4-ch or 8-ch DAQ module, e.g. A1 - A8, can be combined in an AND-logic. Therefore, the AND Link needs to be activated on those channels of a module that need to form the desired AND combination.

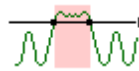
The AND-logic trigger allows to combine all trigger modes, including the AND Link dedi-

cated State trigger mode, across all channels of one module. This enables the user to trigger on complex signals.

State

If AND Link is activated, the trigger mode "State" becomes available. "State" can be used as a **qualifier** for another trigger source. Only if the State of a trigger source is met AND when the conditions of another trigger source are met, it will be triggered.

The State trigger mode is only available when the AND Link is activated. State trigger is used in an AND combination to qualify another trigger source or several trigger sources of one and the same 4-ch or 8-ch module.



State Above



State Below

5.5.8 LAN-Trigger:

In combination with multiple DAQ devices, GPS and network synchronization, this allows to send trigger messages over network and receive trigger messages from other devices.



The reliability and delay of the LAN trigger depends on the network infrastructure.

6. Measurement Table

All measured shots are listed in tabular form in the measurement table. The columns in the table show the calculated data from the scalar functions set in the table header. The corresponding scaling functions can be selected by double-clicking on the header cell of the corresponding column.

The measurement curve of the selected row is displayed in the waveform. If several lines are selected, the curves are displayed with an offset to each other. This offset can be adjusted in the measurement settings.





If changes have been made to the scalar functions or new columns have been added, the tabs must be recalculated using the "Update Row" function.

The table can also be expanded with comment lines or statistical evaluations. It is also possible to add shots manually as "Simulated shots". This can be useful if not all shots are measured but the shot number is still to be continued.





Measurement Table					
ShotNr	Filepath	PMax (pChamber)	PMax (pBarrelvent)	PMax (pMuzzle)	v (Vstartstop)
1	data\SingleShots...	3'864.003 bar	2'277.408 bar	326.746 bar	1'100.381 m/s
2	data\SingleShots...	3'863.995 bar	2'277.413 bar	326.744 bar	1'100.359 m/s
3	data\SingleShots...	3'863.973 bar	2'277.411 bar	326.740 bar	1'100.392 m/s
4	data\SingleShots...	3'863.985 bar	2'277.418 bar	326.746 bar	1'100.354 m/s
5	data\SingleShots...	3'863.976 bar	2'277.410 bar	326.731 bar	1'100.357 m/s

6.1 Table Manipulations


6.1.1 Columns

	Appends a Column at the right end of the measurement table
	Inserts a column on the left side of the selected column
	Removes the selected column
	Opens the Scalar Table window of the selected column. Alternatively, the header of this column can be double clicked.


6.1.2 Rows

	Inserts a new row with the following options: <ul style="list-style-type: none"> • Comment, as an information text • Statistic, analysis of the selected rows • Closed Vessel, statistic data • Simulated shots
	Removes the selected row
	Moves a comment up one line. This works only with comments!
	Moves a comment down one line. This only works with comments!

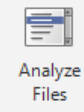
6.1.3 Calculate



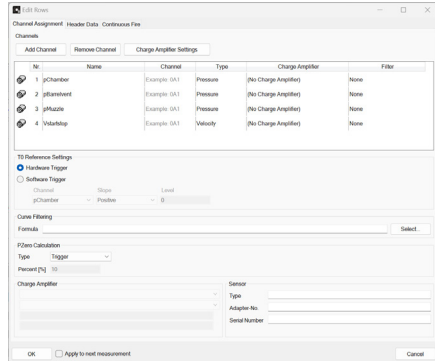
Recalculates the selected rows. This can be used, if Scalar functions or formulas have changed or additional columns are added to the table.



Settings can be modified subsequently for individual shots, e.g. software filter or T0 reference settings or header data. The line is automatically recalculated.




Provides the ability to import and analyze TPC5 files. This means that old series of measurements or recordings with TranAX can be imported, analyzed and printed into a report in BallAX.




The Edit Row dialog is almost identical to the measurement settings for new measurements. If you want to apply the settings of the row to new measurements, the option “Apply to next measurement” must be selected.

6.1.4 Export



Exports the selected measurement rows in the table to a specific format (Ascii, Krenz, Tpc2, Wave, Segy, Awt, Diadem).



Export measurement table and header data as a text file which is tab separated. You can choose if you want to export header data, statistical rows and the units. It also offers you to choose the number of digits and the format.

6.1.5 Misc

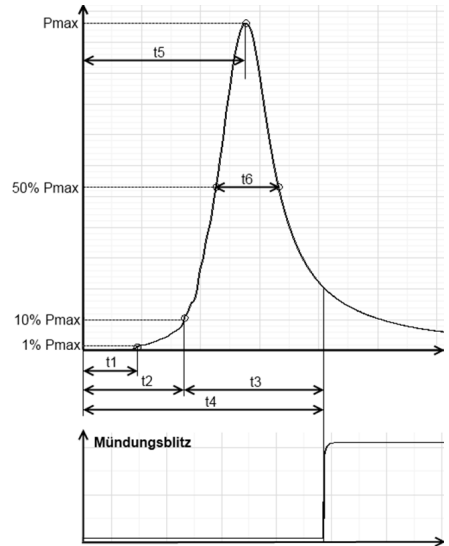
Show cell edit marker

If a calculated cell is double-clicked, the value can be overwritten manually. The cell is marked as modified accordingly. If this marking is not desired, it can be switched off here.

6.2 Scalar Functions

6.2.1 Pressure Channels

Value	Definition
t0x	Absolute time of the start of the measurement process (trigger time for single shot measurements).
t1	Time between t0 and 1% P _{max}
t2	Shot Ignition delay time. Time between t0 and 10% P _{max} .
t3	t3 = t4 - t2
t4	Shot time. Time between t0 and the muzzle exit time of the shot.
t5	Time of P _{max}
t6	Difference between the two points in time with a gas pressure of 50%.
t1x, t2x, t4x	Absolute times of the according points.
t6.1, t6.2	Absolute times of both points at 50% P _{max}
P _{Zero}	Zero point of the pressure measurement
P _{Max}	Maximum gas pressure



6.2.2 Further Functions

Value	Definition
va, vb	Velocity
v0a, v0b	Muzzle velocity. Is calculated from va respectively vb with the air resistance and the distance to the middle of the measurement base.
vm	Mean value of both velocities va and vb
v0m	Mean value of both muzzle velocities v0a and v0b.

tv1a, tv1b, tv2a, tv2b	Absolute times of the impulses/zero-crossings, which are used to calculate the velocities.
TA, TB	Temperature
Min.DiffA, Min.DiffB	Minimum value of the difference curve
Max.DiffA, Max.DiffB	Maximum value of the difference curve

Continuous Fire

Value	Definition
DeltaT	Time difference to the previous shot
Cad	Cadence (Shots per minute), calculated from DeltaT
tCadx	Absolute time of the shot

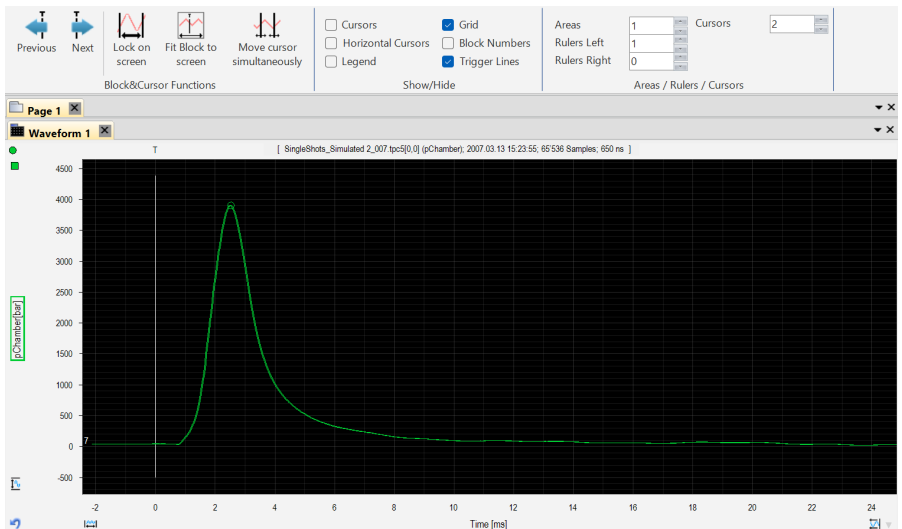
6.2.3 Closed Vessel

Value	Definition
Lot	Lot assignment (Inspection or reference lot)
P_{max}	Maximum gas pressure
tp_{max}	Time of the maximum gas pressure
t1	Time of 3% pmax
PA_old	Rise in pressure according to "old" calculations. A regression line is built over 450µs for all points of the curve. The rise in pressure is the maximum slope of the regression lines.
PA_avg	Rise in pressure according to TL 1376-0600. Average of all PA@xy.
PA@xy	Rise in pressure according to TL 1376-0600 at the point $xy * P_{max}$.
L@xy	Dynamic volatility according to TL 1376-0600 at the point $p / P_{max} = xy$.

7. Waveform Display

The waveform display visualizes the recorded pressure and velocity curves. By simply dragging a channel from the reference panel or from the control panel into a waveform window, it is displayed as a signal curve. If several signals are superimposed in a waveform display, the signals are differentiated by different colors and displayed by small colored boxes on the left side of the waveform display.

Several waveforms can be organized in pages. Within a page, the waveforms can be arranged next to or below each other.



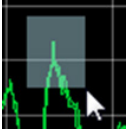
If you open more and more waveforms, keep your workspace well arranged by right clicking on the page or waveform tab to open a context menu. Here you can close your displays, set the title or arrange your waveform windows vertically or horizontally.

Close	Ctrl+Shift+C
Prominent	Ctrl+Shift+T
Rebalance	Ctrl+Shift+R
Set Title..	
Duplicate Waveform Display	
Create documentation page	

Navigating in the Waveform

7.2.1 Zooming

You can zoom into an area simply by pulling a box with the mouse pointer over the area. Click on the upper left corner of the visible section, move with pressed mouse button to the lower right corner and release the mouse button.




By pressing Shift + y, only the Y-axis will be zoomable. The same for pressing Shift + x, only the X-axis will be zoomed in.



Or clicking with the left mouse button on the axis labelling. A zoom pointer will then appear and by moving up/down and left/right respectively you may zoom in or out. You also may use the mouse wheel for this.

7.2.2 Moving traces

To move within the waveform just press and hold your right mouse button and move into the desired direction. Secondary, you can move your mouse pointer over the axis units

and a double-sided arrow  will appear. Click and hold your mouse pointer and move as long as required. Again, while your mouse pointer is on the axis units you may use your mouse wheel to move the traces.

Time range shifting of the traces (X-axis) with the mouse wheel is also possible with the

mouse cursor in the waveform display window while simultaneously pressing the shift key.

7.2.3 Set to full scale

There are two buttons for this function:



Switch Y axis to vertical full scale (for each axis individual)





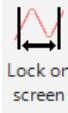
Switch X axis to horizontal full scale







Auto scroll: Enabled, the waveform display will automatically scroll horizontally with the signal while recording in continuous mode (or ECR with dual mode).

Disabled, it will pause the scrolling but not the acquisition!

7.1 Block & Cursor Functions

 Previous	Previous Block, time window moves to previous block. Mostly used for Multi block and ECR recordings.
 Next	Next Block, time window moves to next block. Mostly used for Multi block and ECR recordings.
 Lock on screen	Lock Cursors on display. Cursors are locked to display, also during zooming and moving of curves, i.e. are not locked to the Traces!

	<p>Lock Time Window. Time window marker on the main waveform, are locked to display, also during zooming and moving of curves, i.e. are not locked to Traces!</p>
	<p>Fit Time Window to Block. Set time window marker at the border of a block.</p>
	<p>Start and stop of a recorded block will be fit into the time borders of the waveform.</p>
	<p>Move Cursors A and B simultaneously. Cursors (normally A and B) will be moved together.</p>

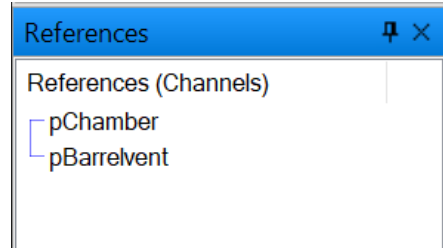
7.1.1 Show / Hide

<input checked="" type="checkbox"/> Cursors <input type="checkbox"/> Horizontal Cursors <input checked="" type="checkbox"/> Legend	<ul style="list-style-type: none"> • Cursors visible / hidden • Horizontal Cursors visible / hidden • Legend visible / hidden
<input checked="" type="checkbox"/> Grid <input type="checkbox"/> Block Numbers <input checked="" type="checkbox"/> Trigger Lines	<ul style="list-style-type: none"> • Waveform grids visible / hidden • Block numbers visible / hidden • Trigger lines visible / hidden

7.1.2 Areas / Rulers / Cursors

<p>Areas <input type="text" value="1"/></p> <p>Rulers Left <input type="text" value="1"/></p> <p>Rulers Right <input type="text" value="0"/></p>	<ul style="list-style-type: none"> • Number of Areas • Number of Y-axis on the left side • Number of Y-axis on the right side
<p>Cursors <input type="text" value="0"/></p>	<ul style="list-style-type: none"> • Number of additional Cursors (C-Z)

7.2 References

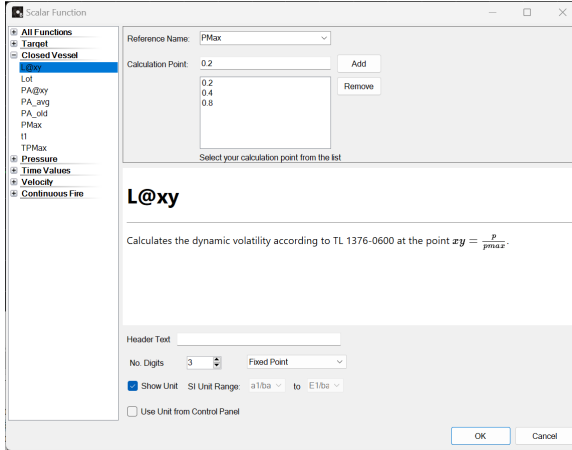


In BallAX, it is important to use the references as the signal source in the waveform display and not the channels from the control panel. Only then will the curves be updated accordingly depending on the selected shot in the measurement table.

To display the curves, the reference window must be opened. The available references are listed based on the channels from the measurement settings dialog. The references can be dragged and dropped into the waveform.

8. Closed Vessel

BallAX is able to analyze the pressure curve of a Closed Vessel measurement according to the regulations in the document TL 1376-0600.



The settings for the Closed Vessel analysis always apply to the whole measurement run; they cannot be defined for each shot separately. If a change is made, the result values of all shots are recalculated.

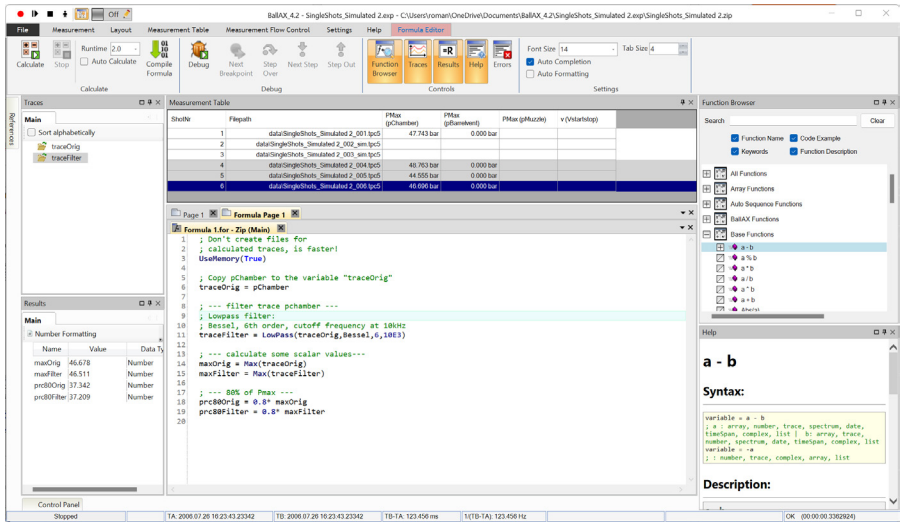
The points p / p_{max} , at which the rise in pressure and the volatility are calculated, can be defined freely. The average of the rises in pressure (PA_avg) is calculated over all defined points.

9. Formula Editor

BallAX contains a powerful formula editor with a variety of useful functions for analyzing measured signal curves.

With more than 350 mathematical functions and commands, almost any practical calculation can be performed.

This is only a quick guide. Further information can be found in the TranAX software manual.



The Formula Editor offers the convenience of current programming environments: syntax highlighting, auto completion, scalable font size, etc.

The formula editor consists of the following components:

- The formulas for the calculations are entered in the text box in the middle labeled "Main Formula". Each line represents a function and normally each function is separated by a line break.
- To the left on the image above is the column for Results, with scalar values at the bottom and the calculated signal curves at the top. The signal curves can be drawn using drag & drop into the waveform display.



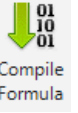
- Scalar-values in "Results" also can be made visible in the Text-Boxes of the waveform display.
- Top right is a list of all available channels and instructions. They can be added by double clicking on the text box. The help section for each function is at the bottom of the right hand column.



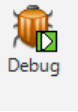


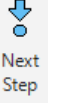
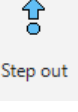
By pressing the button F10, formals will be calculated even the formula page or the formula window is not activated or visible.

9.1 Controls

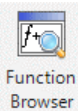

9.1.1 Calculate




 Calculate	With the Calculate button, calculations can be started manually. Calculation can also be initiated by the command „Calculate“ in an MFC or by pressing F10.
 Stop	By pressing the Stop button, a running calculation will be canceled.
<input type="checkbox"/> Auto Calculate	When the option auto calculate is checked, all calculations are performed immediately after recording of a signal.
 Compile Formula	Creates a DLL file out of the formula code. Depending on the code, this can accelerate the execution speed by up to 50 times. This feature is also usefully for code protection; no plain text of the source code will be visible.

9.1.2 Debug

 Debug	The Button „Start Debug“ starts to calculate the formula until the first break point. The calculation will stop at this point and the just calculated values (traces and results) can be analyzed.
 Next Breakpoint	„Next Breakpoint“ will execute the rest of the code until the next breakpoint or until the end.
 Step Over	Calculating a program line, without jumping into any sub-functions.
 Next Step	Go to next line in the formula.
 Step out	Will finish the calculation of a loop function (for, loop etc.) and will stop at the next line after the loop has been completed.

9.1.3 Display

 Function Browser	Displays the „Function Browser“. All available functions, instructions and channels can be selected in this window.
 Traces	Displays the window „Traces“. The calculated signal curves are listed in this window. These curves may be placed via Drag & Drop into a waveform window.

 Results	<p>Displays the window „Results“. The calculated scalar values (numbers, no signal curves) are listed in this window.</p>
 Help	<p>Displays the window „Help“. This window displays a brief description for each selected function in the „Function Browser“.</p>
 Errors	<p>Additional window with debug outputs and error messages from calculated formulas.</p>
<h3>9.1.4 Settings</h3>	
<p>Font Size <input type="text" value="13"/></p>	<p>The font size in the window „Formula“ can be set individually and will be stored with the layout settings.</p>
<p>Tab Size <input type="text" value="4"/></p>	<p>Number of spaces that will be inserted while pressing the Tab key.</p>
<p><input checked="" type="checkbox"/> Auto Completion</p>	<p>When this check-box is selected, suggestions for auto completion will appear as you type the formula. Using the arrow keys up and down, the appropriate proposal can be selected and adopted by pressing the „TAB“ or space key. By pressing „ESC“, auto competitions will be canceled.</p>
<p><input type="checkbox"/> Auto Formatting</p>	<p>Rearranges the written code according „Tab Size“. Nested for loops will be reformatted correctly.</p>

9.2 Read Header Data

Values form the variables of the Header Data can also be read from in the Formula Editor. The function `GetHeaderValue()` returns the value of its variable as type string.

Example:

There is the text variable "Lot No." with the value "815-F" in the Header Data.

```
Lot No.
815-F
```

The code below returns the value:
`LotNo = GetHeaderValue("Lot No.")`



The replacement is not case sensitive. and spaces will be removed
E.g. "Lot No." has the same meaning as "lotno."

9.3 Measured curves

A measurement curve is addressed in the formula editor via the reference name from the measurement settings:

`trace = pChamber`



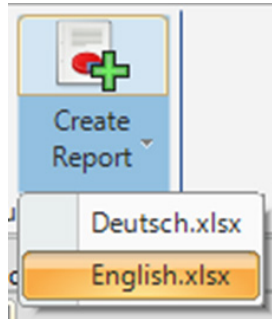
The formula editor will use the original curve without any offset compensation (pZero) but after any filter and TRef0 calculation.

10. Report Generator

Measurement reports are generated in BallAX based on Excel or RTF (Rich Text Format) templates. The templates can be freely designed. The measurement data and graphics are placed at the appropriate position in the sheet using keywords. The keywords have the form "%xxxx%"

The templates must be placed in the folder default Document folder, normally: "C:\Users\NAME\Documents\BallAX_4.2\ReportTemplates". This folder can be changed in the global settings.

To generate a report, select the corresponding template and then click on the report icon.



10.1 Keywords

10.1.1 Predefined Keywords

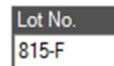
Variable	Replaced by
%ShotNo%	"Shot-No." from the header data
%ImageTopLeft%	Marks the top left corner where the image (Waveform) has to be placed (%ImageTopLeft% must be used with %Image-Bottom-Right%).
%ImageBottom-Right%	Marks the bottom right corner where the image has to end (%ImageBottomRight% must be used with %Image-TopLeft%).

10.1.2 User Variables

All user specific parameters from the Header Data can be used in the reports. The name of the variable has to be written between two percentage signs. Spaces will be removed during parsing.

Example:

There is the text variable "Lot No." with the value "815-F" in the Header Data.



Write the keyword %Lot No.% or also without space %LotNo.% into the report template:

"Lot No" with space	%Lot No.%
"Lot No" without space	%LotNo.%

This keyword will be replaced with the value (in this case "815-F") for the created report:

"Lot No" with space	815-F
"Lot No" without space	815-F

10.1.3 Measurement Table

The variable `%Table%` marks the upper-left corner of the measurement table. The formatting of this cell is applied for all cells of the table.

To set a different formatting in Excel for certain table row types, add the following variables to the cells to the right of the `%table%`-cell:

Variable	Formatting of this cell is applied to
<code>%HeaderFormat%</code>	first row of the table (column headers)
<code>%CommentFormat%</code>	comment rows
<code>%StatFormat%</code>	statistic rows

	A	B	C	D	E
1	Measurement results				
2					
3	<code>%Table%</code>	<code>%HeaderFormat%</code>	<code>%CommentFormat%</code>	<code>%StatFormat%</code>	
4					
5					

The column widths set in BallAX are applied accordingly to the excel columns.

10.1.4 Charge Amplifier Settings

The following parameters of the individual charge amplifiers can be used in the reports. All values are related to the respective channel. In this example, the "pChamber" channel is used:

Variable	Replaced by
%pChamber.caLpFilter%	Low-pass filter settings
%pChamber.caHpFilter%	High-pass filter settings
%pChamber.caSensitivity%	Sensitivity [pC / bar]
%pChamber.caMeasurementRange%	Measurement range [bar]
%pChamber.caType%	Typ of charge amplifier and interface
%pChamber.caSerialNumber%	Serial number of the charge amplifier
%pChamber.caDescription%	Description of the charge amplifier
%pChamber.senType%	Sensor Type
%pChamber.senAdapterNumber%	Sensor Adapter Number
%pChamber.senSerialNumber%	Sensor Serial Number

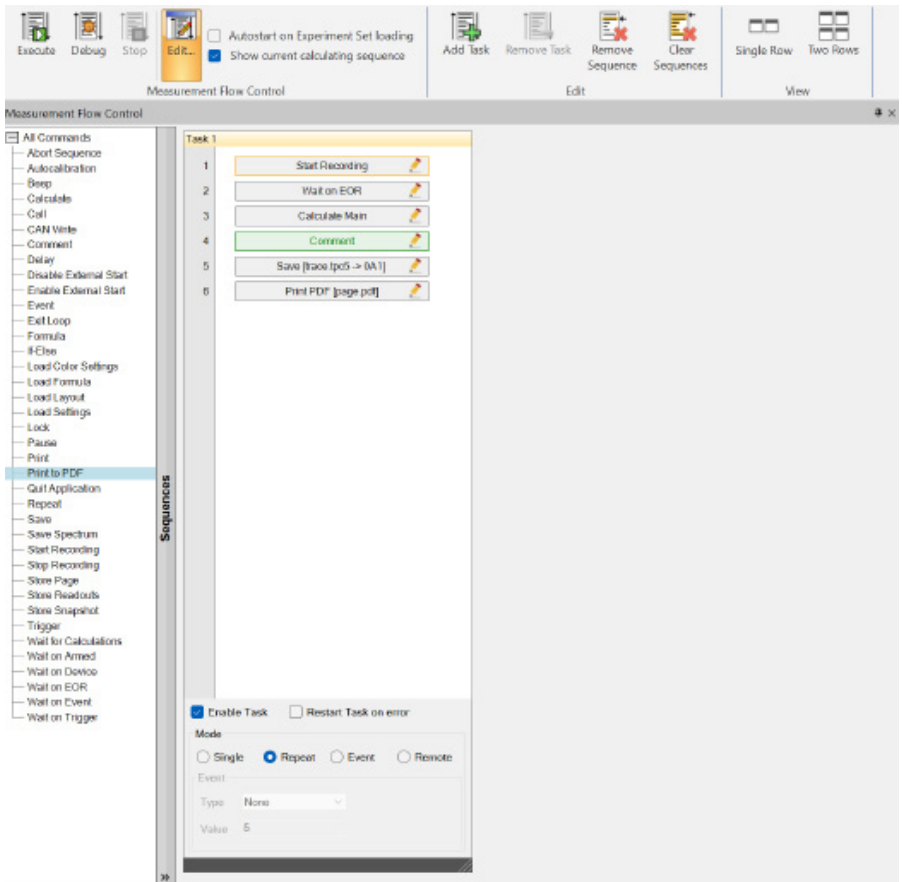
11. Measurement Flow Control (MFC)

The MFC is a powerful tool for measurement automation. (The MFC replaces the well-known Auto Sequences from the previous versions but with many new functionalities.)

A measurement sequence (task) can be defined from a list of functions. This can be executed once or repeatedly. Several tasks can run in parallel or be controlled interdependently via event controls.

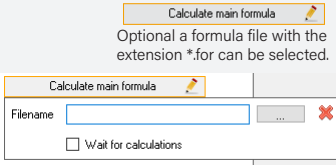
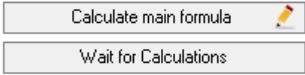
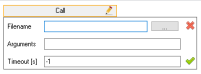

Possible scenario:

- Automatic saving
- Automatic form execution
- Automatic report generation
- Display of comments and instructions
- Execution of third-party commands



11.1 MFC Commands

The following commands can be used in the MFC:

Abort Sequence	Stops the Measurement Flow, same function as pressing the Stop button or button „F8“.
Autocalibration	Starts an Autocalibration of the connected devices.
Beep	Activates the Windows system sound.
Calculate	<p>Calculates the Main formula in the Formula Editor.</p>  <p>Optional a formula file with the extension *.for can be selected.</p> <p>If "Wait on calculation" is enabled, this command will wait until the calculation of the formula is done. This has the same effect as "Calculate" in combination with "Wait for Calculations".</p> 
Call	<p>Calls an external application or batch file.</p> <p>Filename defines the name of the application, Arguments the console parameters or arguments. In case of the application doesn't close, there is a possibility to define a timeout.</p> 
Comment	<p>As it says, just a comment field for some additional information for the sequence or Task. Documentation inside a Task or information about date and author of this Measurement Flow Task.</p> 
Delay	<p>Waits the defined time in seconds. Allowed are integer and float number. Long delays will be visualized with a countdown in remaining seconds.</p>

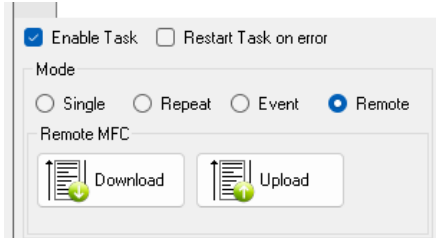
Disable External Start	<p>TranET device have an External Start input on its 25pin D-sub connector of the Starhub. This command disables the External Start function.</p> <p>See also „Enable External Start“</p>
Enable External Start	<p>Enables the External Start input. See also „Disable External Start“</p>
Event	<p>Creates an event, which can be used in another Task to start</p>
Exit Loop	<p>Quits a running loop, mostly used in combination with an If Else statement, e.g. to check the status or value of a formula</p>
Formula	<p>Formula calculates the formula in its sliding window.</p> <p>See also Calculate, which calculates the main formula tab of the Formula Editor</p>
If-Else	<p>If-Else statement, check a variable value form a formula and decide how to proceed. Please note that each Task runs independent, formula values, traces etc. have to be transferred with WriteforNext and ReadofPrevious command.</p>
Load Formula	<p>Loads a Formula file to the main formula Tab</p>
Load Layout	<p>Load a saved Layout file</p>
Load Settings	<p>Loads a hardware settings file</p>
Pause	<p>Shows an information dialog, which has to be confirmed.</p>
Print	<p>Printout a Page or Waveform to the defined default printer (the curves will be updated automatically after each measurement). The layout can be defined with the print preview option. Please use the name of the Page or Waveform which will be printed.</p>
Quit Application	<p>Closes TranAX. In case of changes and activated write protection, a dialog will appear first. Without write protection, settings will be saved and TranAX closed.</p>
Repeat	<p>Used in Combination with Next. Number of repetitions can be defined, Repeat Forever is possible to. Please note that every Task has the possibility to for Repeat Forever in its mode settings in the bottom section of the Task window. Also available options are Singe and Interval.</p>
Save	<p>Save recorded traces to a file, *.tpc5</p>

Save spectrum	Save a calculated FFT traces to a file, *.tps5
Start Recording	Starts a new recording, often used in combination with Wait on EOR, this can also be activated directly in this function. It also allows to save recorded traces directly to a reference.
Stop Recording	Stops a running recording
Store Page	Saves a whole page to a *.tpd file
Store Readout	Stores the Scalar tabled data to a text file.
Store Snapshots	Save a screenshot of the defined Page or Waveform. File format and resolution can be defined in the TranAX settings.
Trigger	Raises a Trigger Event
Wait for Calculations	Waits until the calculation of the main formula, Scalar table A and B and Harmonics Table is done. Used in combination with Calculate.
Wait on Armed	Wait until the System is armed
Wait on Device	Waits until the device is online, in case of a disconnected TraNET device
Wait on EOR	Waits until the Recording is done (End Of Record, EOR), used in combination with Start Recording
Wait on Event	Wait on an Event. An Event can be raised in another task
Wait on Trigger	Wait until the system has triggered. Manual or a trigger event.

11.2 Remote MFC

A task can also be executed directly on a TraNET device and not as usual in the application software.

This can be used for autonomous measurement and monitoring of systems. Measurement data can be saved directly to the internal SSD. Not all MFC functions are supported as autonomous tasks.



- Download the Measurement Flow from a TraNET FE device

TraNET FE → TranAX/BallAX

- Upload the Measurement Flow to a TraNET FE device

TranAX/BallAX → TraNET FE

11.3 MFC Examples

11.3.1 Simple Example:

Measuring of data, calculation of main formula in Formula Editor and finally save some traces to a file.

The screenshot shows a task sequence for 'Task 1' with five steps:

- 1 Start Recording
- 2 Wait on EDR
- 3 Calculate main formula
- 4 Wait for Calculations
- 5 Save [myData_# ->]

Below the task list is an 'Enable Task' dialog box with the following settings:

- Enable Task
- Mode: Single, Repeat, Interval
- Interval: Type: None, Value: 5

11.3.2 Example with two MFC Tasks:

Controller checks for the TraNET device to be ready (powered on and connected), then starts recording, does some calculation with the Formula Editor and finally saves a snapshot of the waveform.

The screenshot shows two task sequences in the 'Measurement Flow Control' window:

Controller Sequence:

- 1 Pause
- 2 Formula [Formula]
- 3 Repeat [100]
- 4 Delay [5 s]
- 5 Wait on Device
- 6 Event [Measure]
- 7 Delay [220 s]
- 8 Next

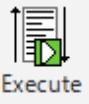
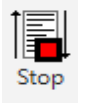
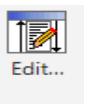
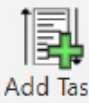
Measurement Sequence:

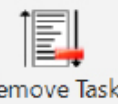
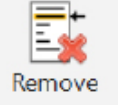
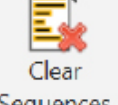
- 1 Wait on Event [Measure]
- 2 Stop Recording
- 3 Start Recording
- 4 Delay [1 s]
- 5 Trigger
- 6 Delay [1 s]
- 7 Stop Recording
- 8 Wait on EDR
- 9 Calculate main formula
- 10 Store Snapshot

Below each sequence is an 'Enable Task' dialog box with the following settings:

- Enable Task
- Mode: Single, Repeat, Event
- Event: Type: None, Value: 5

11.4 Control Elements

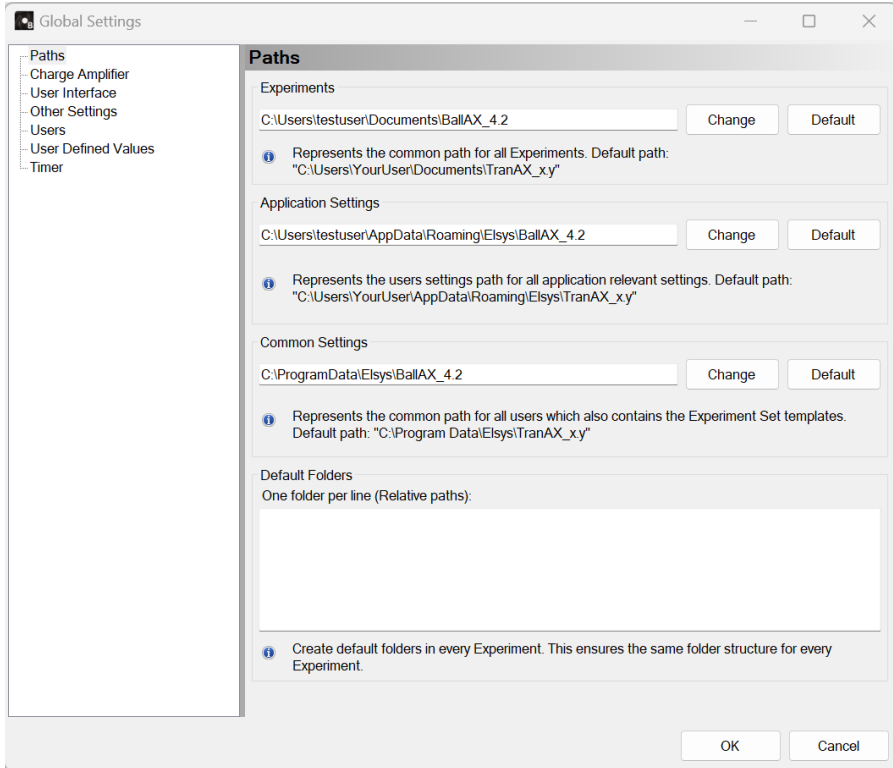
 <p>Execute</p>	<p>Starts the defined and enabled tasks. You will have to define the tasks according your application.</p> <p>Short-Cut: F4</p>
 <p>Stop</p>	<p>Stops the Measurement Flow and its defined tasks.</p> <p>Short-Cut: F8</p>
 <p>Edit...</p>	<p>Opens the Measurement Flow Control editor window.</p>
<input checked="" type="checkbox"/> Show current calculating sequence	<p>Visual feedback of the current status of the Tasks. Needs some additional performance, can be used during development of Task, afterward disabled to increase the performance and speed.</p>
 <p>Add Task</p>	<p>Adds a new Task to the Measurement Flow. Each Task can run independent from each other or connected through events. Also, Formulas will be handled independent in each Task. To Transfer results from one Task to another, the known functions WriteforNext and ReadofPrevious will be used.</p>

 <p>Remove Task</p>	<p>Removes the selected Task. Please note that „Task 1“ is always present and cannot be deleted. Renaming is possible.</p>
 <p>Remove Sequence</p>	<p>Removes the selected items in a Task, alternatively, the button delete can be pressed.</p>
 <p>Clear Sequences</p>	<p>Clears an entire Task. The same as select all items in a Task and pressing the button delete.</p>

12. Global Settings

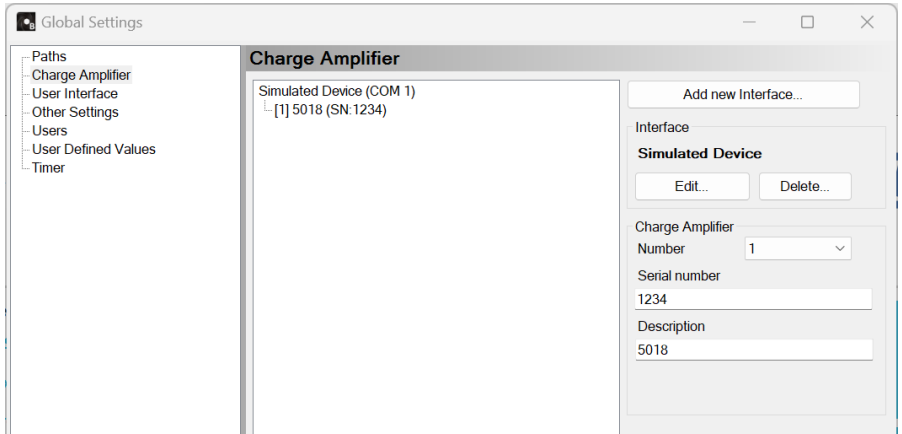
Some settings are global and apply to all measurement runs. In order to change these settings, go to the menu "File → Settings"

12.1 Default Paths



The default paths that are created during installation can be customized in the global settings.

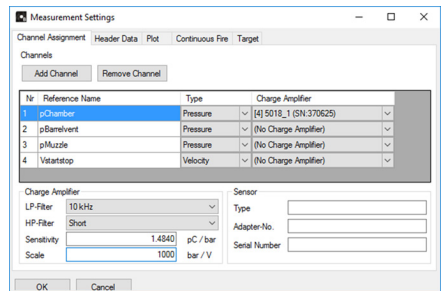
12.2 Charge Amplifiers



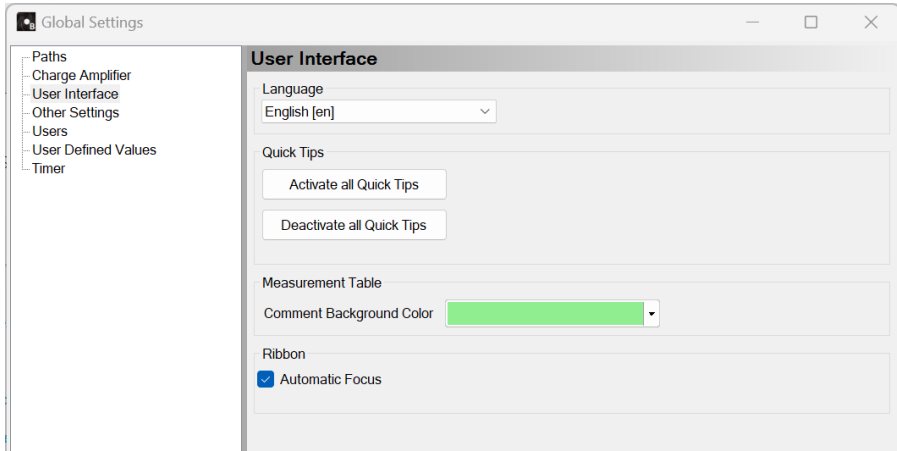
External charge amplifiers must first be created and configured here in the global settings on each computer. This setting is not saved in the experiments themselves as this setting can be different on each system, even though the same experiment template is used.

The charge amplifiers created here are then available for selection in the Measurement Settings table.

The effective amplifier setting then also takes place in the measurement settings.



12.3 User Interface



12.3.1 Language

The language of the GUI can be set to English or German. A restart of the application software is required in order to change the language.

12.3.2 Quick Tips

Quick Tips are displayed when the software is started. Quick Tips can be enabled or disabled.

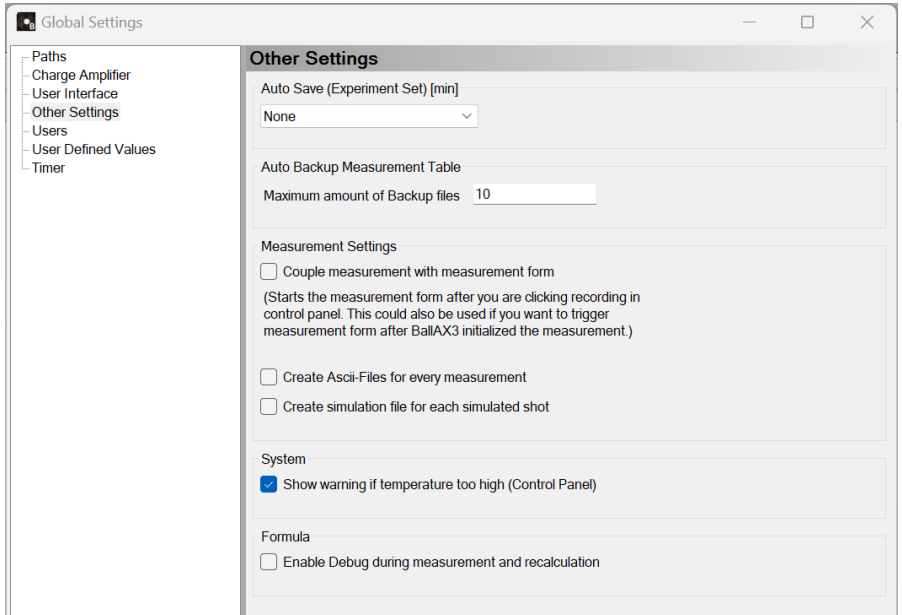
12.3.3 Measurement Table

The background color for comment lines in the measurement table can be set here.

12.3.4 Ribbon

By default, the ribbon bar automatically switches to the corresponding tab when a specific program section is clicked in the software interface. This behavior can be switched off here.

12.4 Other Settings



12.4.1 Auto Save

Define the time interval for automatically saving the Experiment Set.

12.4.2 Auto Backup Measurement Table

A backup of the measurement table is created after each shot. The number of backups to be kept on the disk can be set here.

12.4.3 Couple Measurement

Normally, the measurement must be started via the "Start Measurement" button, the measurement is automatically entered in the measurement table and the calculations are applied.

However, if the measurement is started from another software instance or other device, this option can be used to perform the analysis automatically after the measurement.

12.4.4 Create ASCII-Files

In addition to the TPC5 format, the measurement data is also saved in ASCII format.

12.4.5 Create simulation file

By default, no TPC5 is generated if simulated shots are inserted into the measurement table. In order to have consistent file names that match the shot number, the creation of a file can be activated here.

12.4.6 System Temperature Warning

All TPC5 boards as TraNET FE devices have a built-in temperature sensor. If the temperature is too high, a warning is displayed in the software. This can be deactivated here (not recommended).

12.4.7 Formula Debugging

To ensure that the breakpoints in the formula editor work when executing a measurement or recalculating the measurement table, this must be activated here.

12.5 Users

Here you can create a list of users/participants which can later be used in the header data.

These data are stored in the directory

C:\Users\YourName\AppData\Roaming\

Elsys\BallAX_xx (as a shortcut in the File

Explorer of Windows% appdata% -> Elsys ->

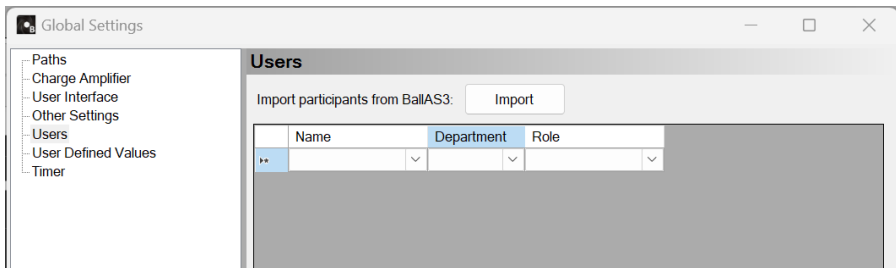
BallAX_xx) in the file participant.xml This file

and can be easily copied to other systems and

computers. This dialog also offers the possi-

bility to import the user configuration of older

BallAS/BallAX versions.



12.6 Timer

The timer function allows a timer to be displayed in the ribbon bar which is re-initialized with each shot. This can be used, for example, to ensure that preset cooling times are respected.

The timer can run forwards and backwards or display the current time or the time of the last shot.

