RAYLASE

APPLICATION SOFTWARE

Original manual

RAYBOARD

PROCESS DATA ANALYZER

PROCESS DATA ANALYZER

USER MANUAL

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1 INTRODUCTION

1.1 About the PROCESS DATA ANALYZER

The PROCESS DATA ANALYZER (PDA) is an application software for the recording and graphical display of control signals, position data, status information and sensor measured values, which can be managed by the RAYLASE SP-ICE-3 control card.

These are mainly:

- Position data that the control card sends to the deflection unit.
- Control signals for lasers of the control card.
- Sent / Received IO signals.
- Position data measured at the deflection unit.
- Other signals / data recorded at the deflection unit.
- Signals from external sensors that are fed in via the control card interfaces.

Therfore, the data from the *trace buffer* of the control card is read and visualized and/or saved.

- The primary task of the GUI-based PROCESS DATA ANALYZER application is the visualization of the signals / data in order to evaluate them in relation to each other.
- There is also a PROCESS DATA ANALYZER software development kit (SDK), which enables automated data recording.

IMPORTANT: At no time does the PDA software actively intervene in the laser processing or influence it in any way.

1.2 Compatibility

The PDA software is compatible with the RAYLASE SP-ICE-3 control card.

A PDA instance can only connect it with a control card.

In principle, it is possible to have several instances of the PDA software open at the same time.

1.3 Performance features

- Temporal display of all selected signals (comparable to a digital oscilloscope).
- Each selected signal can be displayed spatially resolved in an XY diagram.
- Coupled cursor: The cursor position in the XY diagram follows the cursor in the time diagram.
- Position data of the optical axes can be displayed in both the field and scanner domains.
- Display of actual position data or status information of deflection units.
- Flexible color design of XY diagrams.
- Virtual signals possible for visualising mathematical relationships between signals (e.g. positioning speed).
- MOTF counter-compensation for analysing the vector positions for component reference in MOTF processes.
- Two cursors for measuring times.
- Measurement tools for measuring distances.
- Flexible GUI design thanks to the panel method. This allows, for instance, two XY diagrams to be arranged next to each other.
- Various trigger functions for controlling the start and end of a recording.
- Timer for time-controlled termination of recording to prevent memory overflow.
- Choice between white and dark GUI background color.
- Software development kit (SDK) for carrying out automated data recording or data backups.

1.4 Scope of delivery

The following components are included in the scope of delivery:

- PROCESS DATA ANALYZER software installation file

  Required to install all program and library files needed for the PROCESS DATA ANALYZER application

  NOTE: The installation file (*.msi) can only be downloaded via RAYBOARD PRODUCT INSTALLER
- PROCESS DATA ANALYZER user manual in PDF form (DE, EN)
- License agreement as PDF file (DE, EN)
- Programming manual for PROCESS DATA ANALYZER SDK as CHM file (for programmable interface, EN)
- Optional hardware dongle as license carrier.

Not included in the standard scope of delivery is a ADC Adapter board for converting analog measurement signals to a digital input of the control card.

1.5 About this Manual

This manual describes the entire functionality and performance features of the PROCESS DATA ANALYZER software when used with the graphical user interface (GUI).

Conventions

- Emphasized phrases are printed in **bold**.
- Important notes and remarks are introduced with **NOTE:, RULE:,** etc.
- Folder and file names are printed in *italics*.
- The names of windows, dialogues and tabs are given as normal text: On the Settings tab.
- Menu options are shown in bold and italics: Select ***File > Save as....***
- The names of dialogue options (function buttons, checkboxes) are specified in italics: Select *Fixed*, if you ...
- Buttons are bold and in italics and shown in brackets: Click ***[Apply]***.
- Buttons labelled with graphic icons are described by words.

  Example:  is a ***[Zoom]*** button.
- References to other pages in the manual are indicated by italics: See *page 22, Setup*.
- Links to web addresses are underlined: Visit RAYLASE**.**
- Important technical terms are explained in the glossary, see *page 83, Glossary*.

1.5.1 Version reference

The following table references the manual version of the corresponding software product version.

Manual version	PROCESS DATA ANALYZER version
V1.0	v1.0

1.6 Legal Information

Copyright

RAYLASE reserves the right to make changes to the product described in this manual and to the contents of this manual at any time without notice.

License agreement

The text of the license agreement is delivered as a PDF file together with the software.

Warranty

The rights of the customer in case of material or legal defects of the product are listed in the General Terms and Conditions of RAYLASE. These can be viewed at: https://www.raylase.de/en/terms-and-conditions.html.

No implied warranty or guarantee is given as to fitness for a particular purpose. RAYLASE is not responsible for any damage caused by using the application. Custom assemblies or other assemblies manufactured by RAYLASE may be subject to different warranty terms. Further information can be found in the respective manuals.

1.7 Addresses

Manufacturer

RAYLASE GmbH
Argelsrieder Feld 2+4
D-82234 Wessling
www.raylase.de

Telephone:	+49 8153 9999 699
Fax:	+49 8153 9999 296
E-mail:	info@raylase.de

Customer service

The RAYLASE customer service would be happy to help you at any time if you have any problems with the software or this manual.

Availability:	Monday to Friday, 9:00 am to 7:00 pm
	UTC+1 (April to October: UTC+2)
Telephone:	+49 8153 9999 297
E-mail:	support@raylase.de

2 INSTALLATION AND COMMISSIONING

2.1 Requirements

To successfully install the PROCESS DATA ANALYZER software on a computer, the following requirements have to be met:

Supported operating systems

- Microsoft Windows 10, 64 bit
- Microsoft Windows 11, 64 bit

NOTE: The Linux operating system is not supported

Minimum hardware requirements

- Microsoft .NET Framework version 4.8 or higher
- 8 GB RAM (16 GB recommended)
- 200 MB of free disk space

Scan controller

- A RAYLASE SP-ICE-3 control card is required for recording data.
- A deflection unit, which is controlled by the control card, is required to record actual position data or status information.

NOTES:

- Installation and setup of the control card are described in a separate user manual.
- No control card is required to open data recordings that have already been recorded and saved.

Correction file

For the inverse field correction, it is necessary that a RAYLASE correction file (FC3) is loaded onto the control card.

2.2 Installation process

Double-click on the ProcessDataAnalyzer.exe to start the installation.

For the installation of all RAYLASE software products (and also the PROCESS DATA ANALYZER application), the RAYLASE provides the so-called RAYBOARD PRODUCT INSTALLER (RLPI) free of charge as a central tool on its website.

Using the “Select the targeted software configuration” menu item, select the latest version of PROCESS DATA ANALYZER.

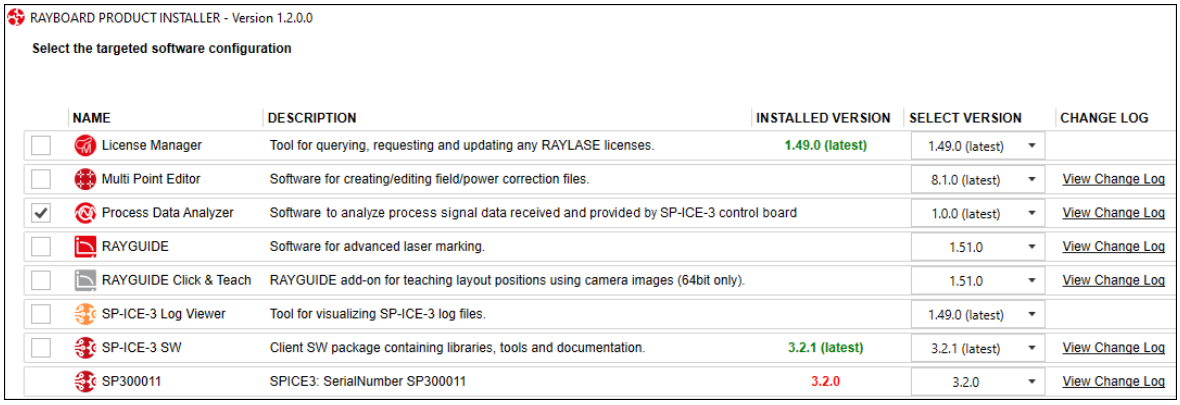


Fig. 2.1: PDA-ABC

Under the installation options, select whether you only want to use the PDA GUI and/or want to install the PDA SDK:

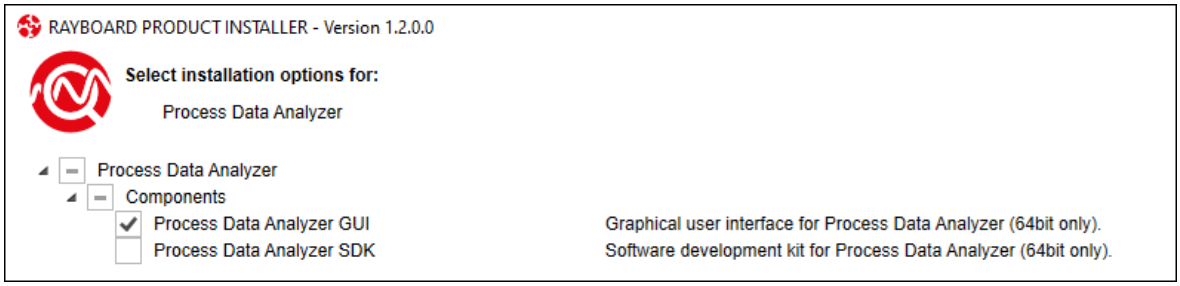


Fig. 2.2: PDA-ABE

Agree to the license agreement.

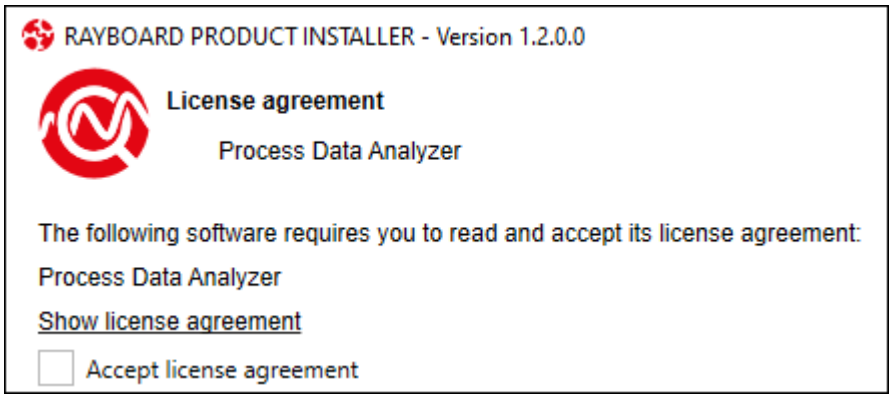


Fig. 2.3: PDA-ABF

After successful installation, you receive the following information in the RAYBOARD PRODUCT INSTALLER.

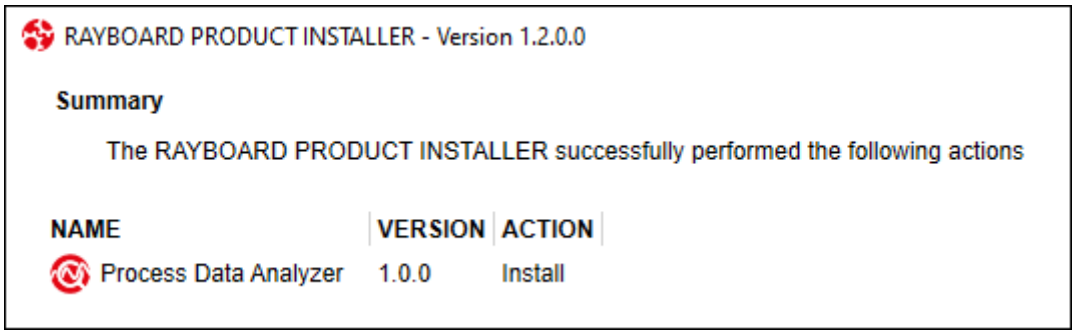


Fig. 2.4: PDA-ABG

The direct link to the change log lets you review the latest changes relative to the predecessor version. The RLPI then downloads the PROCESS DATA ANALYZER installation file and displays the installation options.

By default, the installation process creates the following folders:

- *For the program:*

  C:\Program Files\RAYLASE\PROCESS DATA ANALYZER\
- *To store* configuration files, log files, and other resources:

  C:\ ProgramData\RAYLASE\PROCESS DATA ANALYZER\
- User-specific data is stored in this folder:

  C:\users\Benutzername\AppData\Local\RAYLASE\PROCESS DATA ANALYZER\

The software environment for the license management is also installed.

The installation process creates an icon on the computer's desktop for directly launching the PROCESS DATA ANALYZER application:

Fig. 2.5: PDA-ABB

Starting the software

For example, use the PROCESS DATA ANALYZER desktop icon to start the software.

When the PROCESS DATA ANALYZER application software is started, the first license check also takes place. If no valid license is found, PROCESS DATA ANALYZER starts in demo mode.

NOTE: After starting the software for the first time, a pop-up dialogue with explanations of frequently used mouse function combinations is automatically displayed.

The pop-up dialogue is also available at any time at *Help* > *Show Mouse Controls*.

If necessary, use the checkbox if you do not want the dialogue to be displayed every time you start the application.

3 LICENSES AND UPDATES

3.1 Licenses

3.1.1 Software functional gradations

The PROCESS DATA ANALYZER can be operated in the following variants.

Demo variant

If no valid license is found, PDA starts in demo mode.

It allows the selected signals to be recorded and the recordings to be saved.

However, the demo version does not allow zooming in and therefore no detailed analyses. This version is primarily intended for recording data in support cases.

Basic variant

A license is required for this version.

It allows signals to be recorded and saved. All viewing options and zoom functions are available.

This license is also required to use the SDK interface.

Licensable additional options

The following additional options are also available:

- **Sensor interface version**

  A license is required for this version.

  Compared to the basic version, this license option also allows the recording of signals that come via the ADC Adapter board. These are typically signals from process monitoring sensors.

- **Multi-Card option**

  This additional option allows simultaneous data recording of up to 12 control cards.

3.1.2 Type of provision

The license can be distributed in two ways.

USB dongle (hardware license key)

A USB dongle is connected to a USB port on the computer on which the software is running.

This variant allows you to install the software on more than one computer and use the same dongle on each of them in turn. When the software is installed or started with the dongle attached, the license is found and activated automatically.

NOTE: The dongles are only labelled with RAYLASE as a dongle can contain licenses for various RAYLASE software products.

Activation license file (software license key)

A software license key is only valid for a specific computer.

To use a software key, a "fingerprint" of the designated computer has to be generated.

- In the menu, select *Help* > *License* > *Generate License Request*, and send the generated file to RAYLASE (license@raylase.de).
- RAYLASE then provides you with an activation file which you can import via *Help* > *License* > *Activate License*.

NOTE: A software license key can only be used on the PC where the license request file was generated. It is not possible to move or exchange the license file later.

3.1.3 Displaying current license / version

To view the license and version information for the installed software, in the menu select ***HelpAbout*** > .

Example:

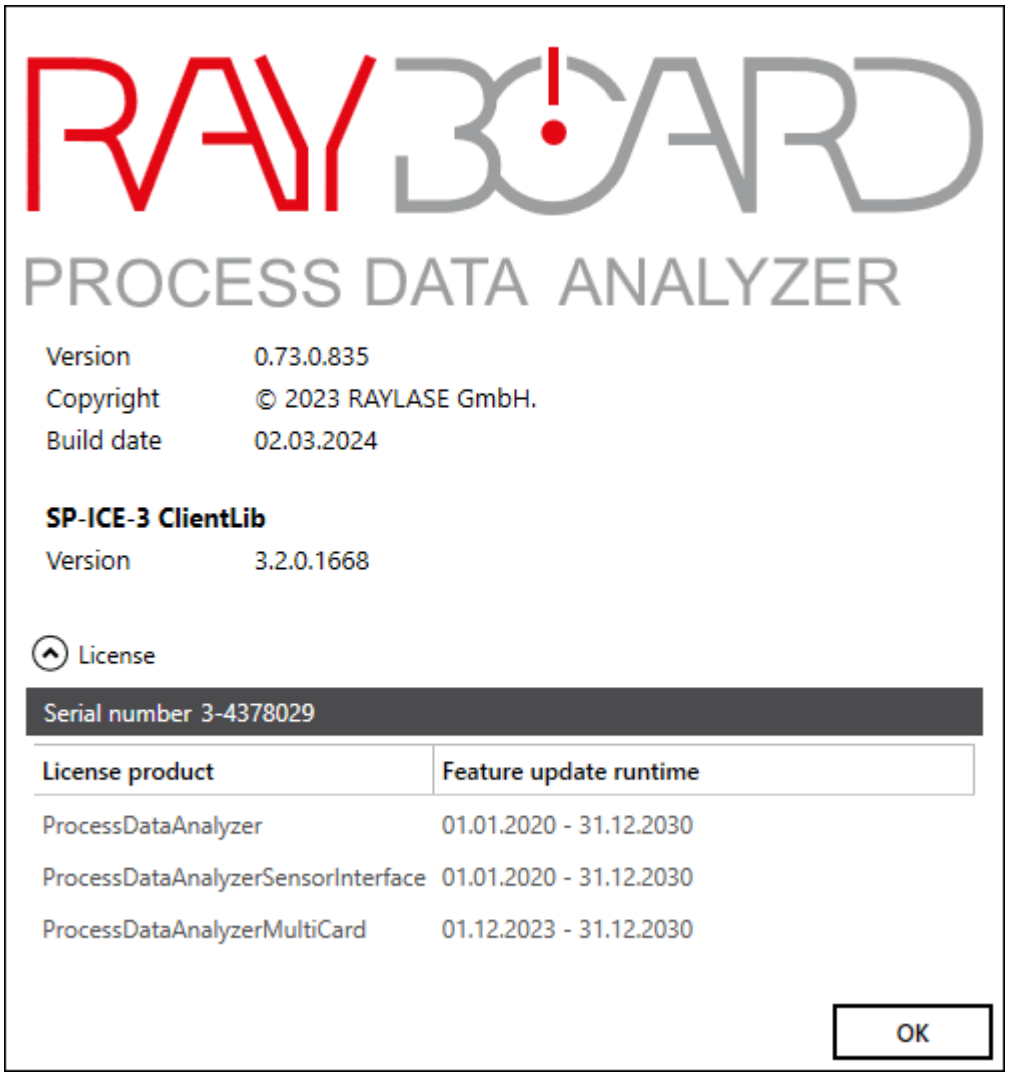


Fig. 3.1: PDA-AAX

3.2 Updates

3.2.1 Feature updates

Each license comes with a predefined runtime for feature updates at the time of purchase. As a rule, this is two years.

After expiration of the runtime, it may happen that new features cannot be used automatically by installing updates. Then it is up to you to purchase a runtime extension.

The update of the feature update runtime is done via license file import, see *page 16, Type of provision*.

NOTE: RAYLASE reserves the right to decide which new features can only be used with the current feature update runtime.

The import of new releases / updates by means of the RAYBOARD PRODUCT INSTALLER is possible independently of this at any time.

3.2.2 Troubleshooting

The import of new software versions for the purpose of troubleshooting is possible at any time and does not require a license update.

Also use the RAYBOARD PRODUCT INSTALLER for this purpose.

4 INTRODUCTION TO THE USER INTERFACE

4.1 Overview

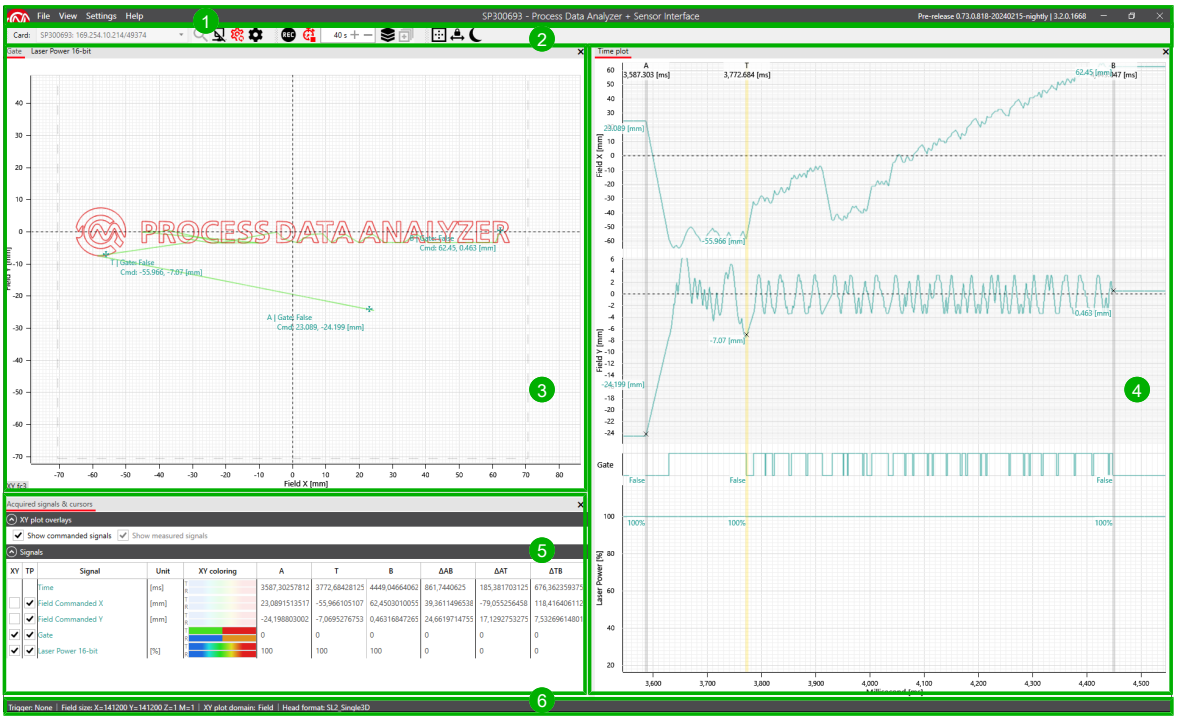


Fig. 4.1: PDA-AAA

No.	Element	Explanation	See ...
1	Menu bar	The main menu provides access to all standard functions.	*page 20, Menu bar*
2	Function bar	The funtion bar contains buttons / functional elements ■ to connect to the control card and ■ for frequently used functions	*page 23, Function bar*

No.	Element	Explanation	See ...
3	Panel: XY Plots	Diagram(s) for displaying the signals in the XY coordinate system.	*page 25, Panels*
4	Panel: Time Plot	Diagrams for visualizing signal progression over time.	
5	Panel: Acquired Signals & Cursors	Display of all currently configured signals and your measured values.	
6	Info bar	Left: Display of important settings (permanent) Right: Display of status messages (dynamic)	

Tab. 4.1: PDA-001

4.2 Menu bar

4.2.1 “File” menu

Menu item	Explanation
Open	A recording that has already been saved in PDA format. **NOTE:** A connection to a control card is not required for this.
Save	Save the current recording in PDA format.
Export	Export the data of the current recording in text-based formats (e.g. *.txt or *.csv). For more details, see *page 75, Saving / Loading data recordings*.
Exit	Close the application.

Tab. 4.2: PDA-002

4.2.2 “View” menu

Menu item	Explanation
XY Plots	Display / Do not display *XY Plots* panel.
Time Plot	Display / Do not display panel *Time Plot*.
Acquired Signals & Cursors	Display / Do not display panel *Acquired Signals & Cursors*.
Reset Layout	Reset the arrangement of the panels to the default layout of the user interface.

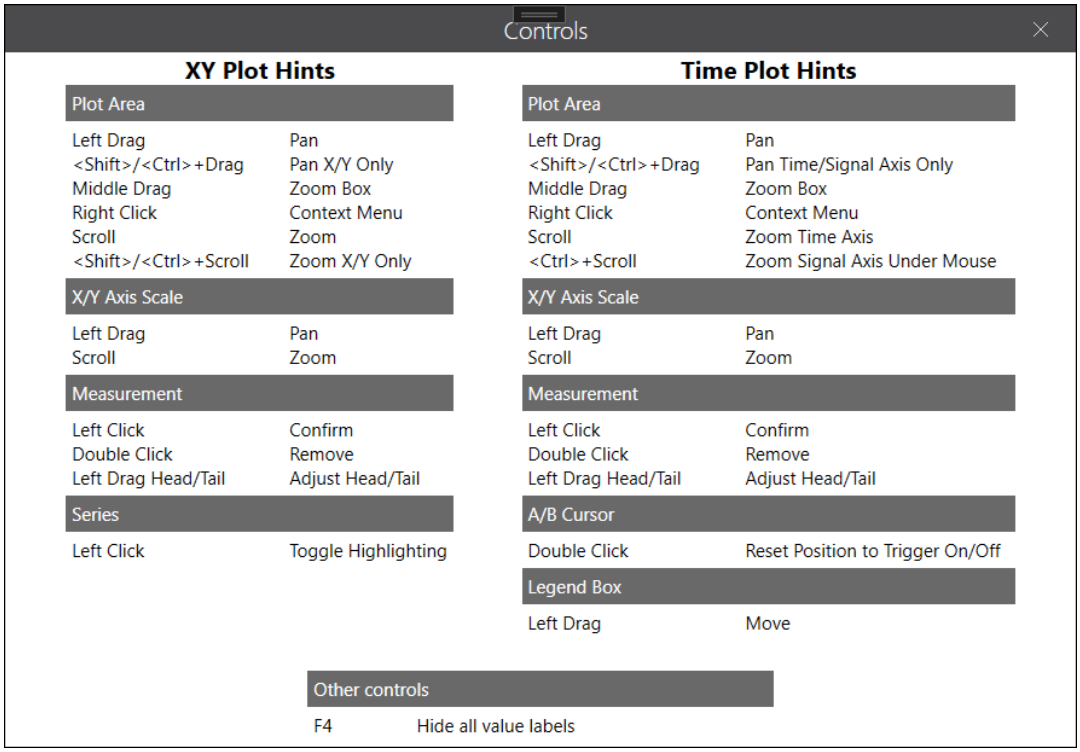
Tab. 4.3: PDA-003

4.2.3 “Settings” menu

Menu item	Explanation
Preferences	Opens the dialogue for defining default settings for the display of the diagrams. For more details, see *page 66, Preferences*. **NOTE:** These settings can also be changed after signal recording. They are immediately applied to the existing diagrams.
Configurations	Opens the signal configuration dialogue. For more details, see *page 28, Configuration of the signal parameters*.

Tab. 4.4: PDA-004

4.2.4 “Help” menu

Menu item	Explanation
Show Mouse Controls	Opens a pop-up dialogue window with an overview of the most important mouse functions for the *XY Plots* and *Time Plot* panels.  For additional details on the mouse functions, *Zoom* and *Pan* (shifting section), see *page 54, Navigation in the diagrams*.
Debug	■ Save Debug Info: Saves all data required for error analysis in a ZIP file.

Menu item	Explanation
	NOTE: In the event of an error, send the file to RAYLASE customer service. ■ Open Log File Location: Opens the storage locations of the PDA log files.
License	■ Generate License Request: Generates a license request file (*.WibuCmRaC). The file is required from RAYLASE to issue your activation license. For more details, see *page 16, Type of provision*. ■ Activate License: Loads an existing license activation file or a file for a license upgrade. (*.WibuCmRaU)
About	Opens an overview of the installed software version and your purchased license products.

Tab. 4.5: PDA-005

4.3 Function bar

Fig. 4.2: PDA-AAB

Element	Explanation
 Card:	Name (serial number) and IP address of the scan controller. Identify the SP-ICE-3 control card by its serial number and select it. **NOTES:** ■ In most cases, each scan controller appears once with its IP4 and once with its IP6 address. ■ Which IP address family is selected for the scan controller does not affect the connection speed to the scan controller.
 ***[Discover]***	Click on the ***[Discover]*** button to search for available control cards on the network.
 ***[Connect]***  ***[Disconnect]***	Click on the ***[Connect]*** or ***[Disconnect]*** button to connect with or disconnect from the control card. An active connection to the control card can be identified by the fact that ■ the serial number of the active control card is also displayed in the header and ■ the button for configuration becomes active.
 ***[Auto-reconnect at startup]***	Toggle button to define if the control card should be connected automatically when PDA starts. The ***[Auto-reconnect at startup]*** button is enabled by default. If you disconnect from the control card and do not want it to reconnect automatically the next time you start the program, you must disable the ***[Auto-reconnect at startup]*** button.
 ***[Configure signal parameters]***	***[Configure signal parameters]*** is used to open the dialogue window for configuring the signals, recording trigger, time behaviour. See *page 28, Configuration of the signal parameters*.

Element	Explanation
 ***[Start acquisition]***  ***[Stop acquisition]***	Use the ***[Start acquisition]*** or ***[Stop acquisition]*** button to start or stop signal recording. Whether the signals are recorded and displayed immediately after starting also depends on the trigger settings. **NOTE:** Depending on the amount of data and the default settings, it may take some time for all signals to be displayed when signal recording is stopped.
 ***[Auto-stop acquisition]***	Enable the ***[Auto-stop acquisition]*** toggle switch to stop signal recording after a predefined time (default = 60 seconds). Use the [+] / [-] buttons to extend or shorten the timer setting in 10-second intervals.
 ***[Open list of triggered segments]***	Use the ***[Open list of triggered segments]*** button to display a list of all recorded segments. For details, see the *page 43, Triggering*, multi-segment trigger option.
 ***[Open the list of position related timestamps]***	Use the ***[Open the list of position related timestamps]*** button to open the list of all points in time associated with the position selected in the XY diagram. For more details, see section *page 64, Determining points in time for a trajectory position*.
 ***[Zoom XY plot to field size]***	Use the ***[Zoom XY plot to field size]*** button to fit the entire scan field in the XY diagram.
 ***[Lock signal auto-resize]***	Enable the segment ***[Lock signal auto-resize]*** toggle button if you always want to have the same time segment in the time diagram by default. If not active, the complete recorded signal curve is always fitted into the time diagram.
 ***[Toggle light or dark background]***	Enable the ***[Toggle light or dark background]*** toggle button to change the background color of the user interface to black. If not enabled, the background is white by default.

Tab. 4.6: PDA-006

4.4 Panels

The user interface basically consists of the three panels ***XY Plots***, ***Time Plot*** and ***Acquired Signals & Cursors*** .

The panels can be freely arranged in relation to each other using the ***panel manager***.

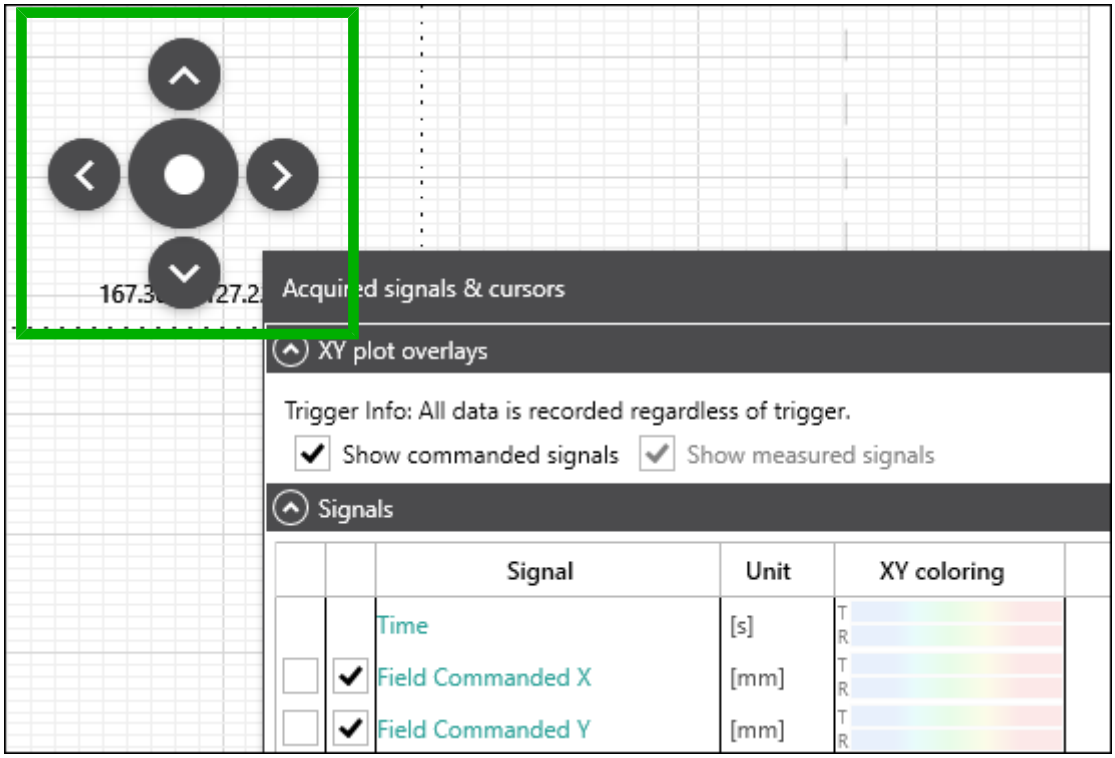


Fig. 4.3: PDA-AAC

Right-click on the tab (underlined in red) to display three options in the context menu:

- Floating: The panel can be freely positioned.
- Dockable: As soon as you move the detached panel, the panel manager appears, which can be used to dock the panel at a different position.
- Tabbed document: The panel is docked.

The XY diagrams are stacked with tabs by default, but can also be arranged next to each other using the panel manager if required.

To do so, grab the diagram by the tab with the mouse and fix it next to the other XY diagram using the panel manager.

Example:

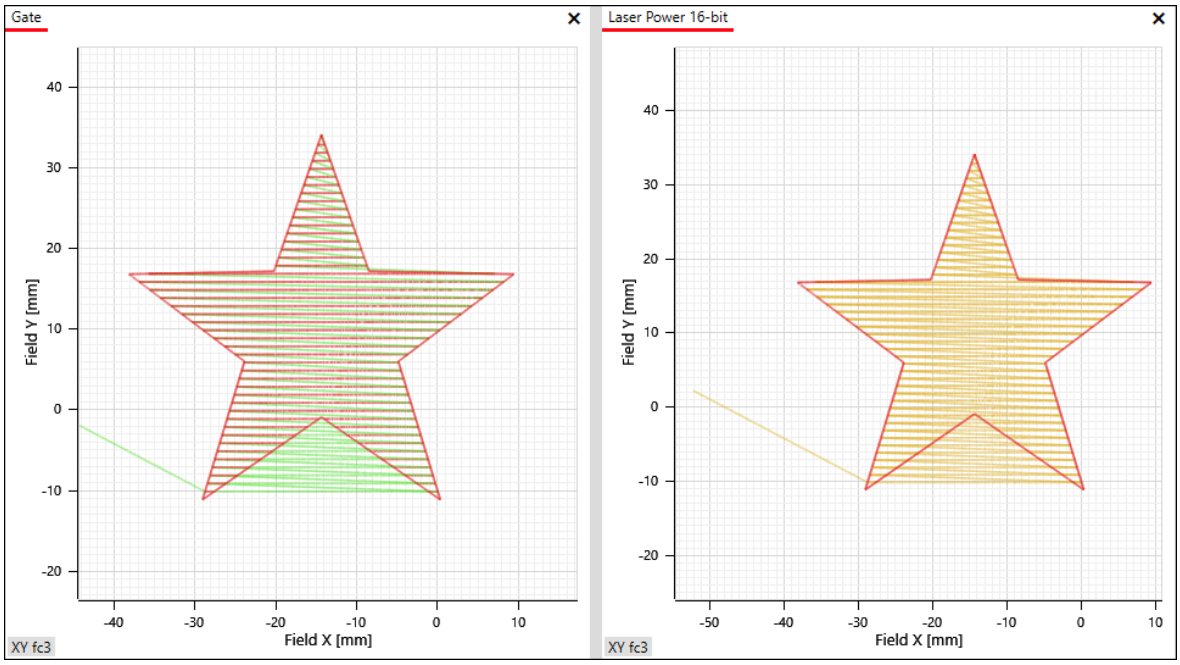


Fig. 4.4: PDA-AAD

In the ***View*** menu, you can enable or disable the display of the three panels and reset the layout of the user view.

See *page 20, "View" menu*.

5 FIRST STEPS

5.1 Connecting control card

In order to be able to record data or signals, the PDA application must be connected to a control card.

NOTE: In principle, a PDA application can only have one connection to a card.

If you want to record signals from several control cards at the same time, you have to start the PDA application several times. Connect each instance to a different control card.

NOTE: Please note that a special license product (PDA Multicard) is required.

… Procedure

The following steps are necessary to establish a connection with a control card:

1. In the function bar, click on ***[Discover]*** to find the available control cards.
2. Identify the desired control card in the results list and select it.

3. Click on ***[Connect]*** to establish the connection to the selected control card.
   - As soon as the connection is established, additional buttons in the function bar become active (the button display changes from grey to black).
   - The serial number of the control card is displayed in the center of the menu bar.

4. Optional: Click on the ***[Auto-reconnect at startup]*** toggle switch to automatically establish the connection to the selected control card when restarting the PDA application.

5.2 Preparing signal recording

Before you start signal recording, certain settings should be made depending on the application.

These basically include

- Selecting the signals or data to be recorded
- Defining trigger events to limit or control the recording range in terms of time
- And ensure that the control card (SP-ICE-3) is correctly configured, in particular
  - That the appropriate correction file has been loaded onto the control card
  - That the appropriate deflection unit is connected
  - That the correct communication protocol is set between the control card and deflection unit and
  - That the tracking error values of the deflection unit are set correctly

5.2.1 Configuration of the signal parameters

The signal parameters are configured using the ***Settings*** > ***Configurations*** menu.

Alternatives:

- Click on the ***[Configure signal parameters]*** button in the function bar
- Use the ***[F3]*** quick access button.

Button	Explanation
	Saves the current configuration.
	Loads a previously saved configuration.
	Reloads the configuration settings from the configuration file.
	Reloads the following parameters of the SP-ICE-3 control card in the PDA application: ■ Inverse field transformation ■ Inverse field correction ■ Tracking error ■ Field size ■ Simulation encoder speed
	Resets the configuration back to the default values. **CAUTION:** ■ All virtual signal configurations are also deleted. ■ The trigger setting is set to “None” mode.

Tab. 5.1: PDA-008

5.2.2 Signals

The ***Signals*** tab is used to select the required signals.

... call up ***Settings*** > ***Configurations*** > ***Signals***.

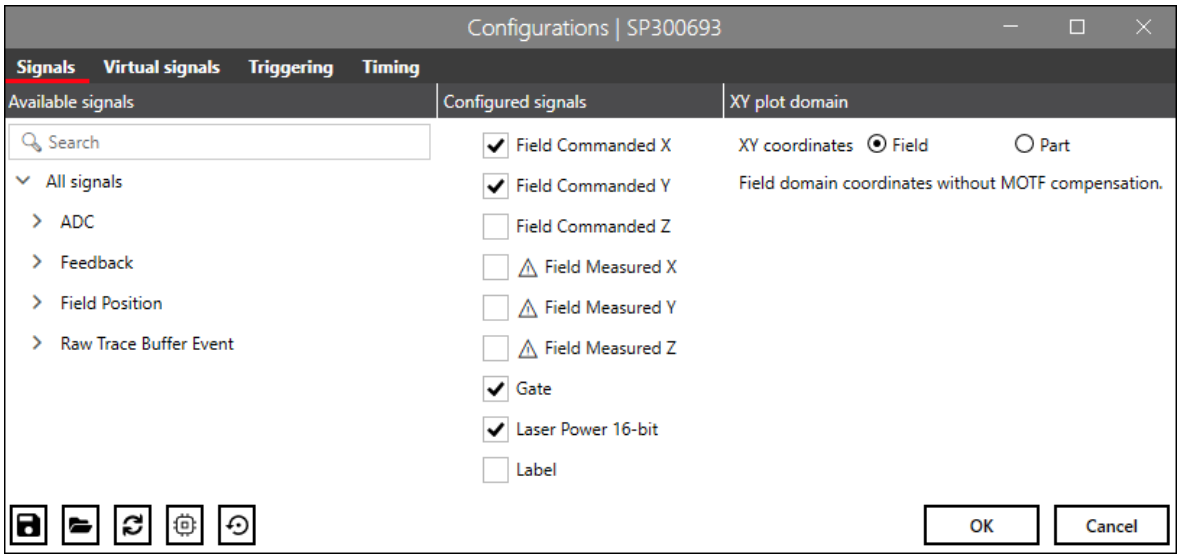


Fig. 5.1: PDA-AAE

The tab ***Signals*** is grouped into three columns:

Column	For explanations, see ...
Available signals	*page 30, Available signals*
Configured signals	*page 39, Configured signals*
XY plot domain	*page 40, XY plot domain*

Tab. 5.2: PDA-012

NOTE: With the initial configuration, the most frequently used signals are already created and you can start right away. Depending on the application, you can select additional signals.

5.2.2.1 Available signals

You will find all available signals in groups in the ***Available signals*** column.

NOTE: Some signals cannot be configured depending on the current settings.

Symbol	Explanation	Cause
	Although this signal can be configured, it will not provide any data.	The connected deflection unit is not equipped with the corresponding optical axis.
	This signal cannot be configured.	The currently set communication protocol (including correction file) does not support data transmission for this signal.

Tab. 5.3: PDA-009

5.2.2.1.1 ADC

In the signal group, ***ADC*** select the configuration of the control card and ADC Adapter.

Then select your signal

- On which port of the SP-ICE-3 control card the ADC Adapter board is connected (port A or B) and
- On which of the four inputs of the ADC Adapter board the analog signal is fed (0 … 3)

Signal: ADC		Port (SP-ICE-3 control card)	Port index differential analog input (ADC Adapter board)
ADC	> ADC A:0	Port A = X903	0
	> ADC A:1		1
	> ADC A:2		2
	> ADC A:3		3
	> ADC B:0	Port B = X901	0
	> ADC B:1		1
	> ADC B:2		2
	> ADC B:3		3

Tab. 5.4: PDA-010

NOTE: Recording the analog signals via the ADC Adapter requires an appropriate license, see *page 15, Software functional gradations*.

For information on the use of the ADC Adapter boards, see *page 78, Notes on using the ADC adapter board*.

5.2.2.1.2 Feedback

Select the ***Feedback*** signal (status information) of the deflection unit that you want to record.

The Feedback signals can be selected for all six conceivable axes.

Signal: Feedback		**In each case for the axes...**
Feedback	> Current Position	> X > Y > Z > ZoomZ > Auxiliary > SensorZ > X (2nd Head) > Y (2nd Head) > Z (2nd Head)
	> Current Velocity	
	> Galvo Temperature	
	> Output Current	
	> Position Error	
	> Relative Output Control	
	> RMS Current	
	> Servo Board Temperature	
	> Target Position	

Tab. 5.5: PDA-011

NOTES:

- Please note that the availability of the Feedback signals depends on the model of the RAYLASE deflection unit and the FPGA version of the DICON eletronic.

  If you have any questions, please contact RAYLASE support.
- Please note that only one of the available feedback signals can be queried per optical axis.
- If two deflection units are controlled by a single control card in master-slave mode, only Feedback signals from a maximum of three axes are available per deflection unit.
- A detailed description of the Feedback signals (status information) can be found in the *Enhanced Protocol* Manual.

CAUTION: If you have connected deflection units of other manufacturers to the SP-ICE-3 control card, RAYLASE itself cannot guarantee the analogy of the status information when using the SL2-100 protocol.

5.2.2.1.3 Field Position

The position data indicate the axis positions in the so-called ***field domain***.

The position data are calculated from the position data of the ***scanner domain*** using an inverse field correction (including inverse field transformation). This applies to both the *Commanded Positions* and the *Measured Positions*. This makes it possible to display the position data in the same coordinate system in which you define your scan geometry.

Signal: Field Position		**Field position**
Field Position	> Commanded Positions	> Field Commanded X
		> Field Commanded Y
		> Field Commanded Z
		> Field Commanded M (magnification)
	> Measured Positions	> Field Measured X
		> Field Measured Y
		> Field Measured Z
		> Field Measured M

Tab. 5.6: PDA-013

NOTES:

- If you want to record position data in the scanner domain, for the Feedback signals, select
  - Target Position or the Tx channel for the TARGET positions
  - Current Position for the ACTUAL positions
- In dual head mode (master-slave control of two 2-axis deflection units), the positions in the field domain can only be generated for the first deflection unit because no inverse field correction can be calculated for the second deflection unit.

5.2.2.1.4 Raw Trace Buffer Event

Unprocessed trace buffer events.

Signal: Raw Trace Buffer Event		For explanations, see ...
Raw Trace Buffer Event	> DAC	*page 33, DAC*
	> Head	*page 34, Head*
	> IO Pin	*page 36, IO Pin*
	> IO Port	*page 37, IO Port*
	> Label	*page 37, Label*
	> Laser	*page 38, Laser*
	> SPI	*page 38, SPI*

Tab. 5.7: PDA-014

5.2.2.1.4.1 DAC

Analog output signals, e.g. for controlling the laser power.

Signal: Raw Trace Buffer Event > DAC		Explanation
DAC	> Dac 0	Primary laser power
	> Dac 1	For example, secondary laser power or simmer current

Tab. 5.8: PDA-015

5.2.2.1.4.2 Head

Deflection units and channels

The signals are displayed in 20-bit decimal format for the forward and return channels.

Signal: **Raw Trace Buffer Event > Head**		
Head	> Head 0	> Head0RxX > Head0RxY > Head0RxZ > Head0TxX > Head0TxY > Head0TxZ
	> Head 1	> Head1RxX > Head1RxY > Head1RxZ > Head1TxX > Head1TxY > Head1TxZ

Tab. 5.9: PDA-017

Tx:
- Channel for sent data
- Generic channel for all commands sent from the control card to the deflection unit (e.g. enhanced commands, target positions in the scanner domain)

Rx:
- Channel for received data
- Which data is received here must be set in advance using an enhanced command.

NOTE: The use of the Rx channel is not recommended. Instead, select the corresponding feedback signal right away. This ensures that the desired data is sent on the feedback channel.

Overview of axis declaration:

Field domain	Scanner domain	Assignment
X	Head0-X	X-mirror – deflection unit 1
y	Head0-Y	Y-mirror – deflection unit 1
Z	Head0-Z	Z-axis (laser focus)
M (magnification)	Head1-X	Zoom axis (AM-MODULE) or X-mirror – deflection unit 2
Auxiliary	Head1-Y	RAYDIME METER or Y mirror – deflection unit 2
SensorZ	Head1-Z	RAYSPECTOR

Tab. 5.10: PDA-035

Relationship between Tx and the feedback signal *Target Position*

The Target Position is the position that is output in the deflection unit to the galvanometer scanners by the electronics.

If the commanded position change (i.e. scan speed) of Tx is too high, the so-called *Slew Rate Limiter* intervenes by reducing the speed. The Target Position is then less steep than Tx (see example).

Example:

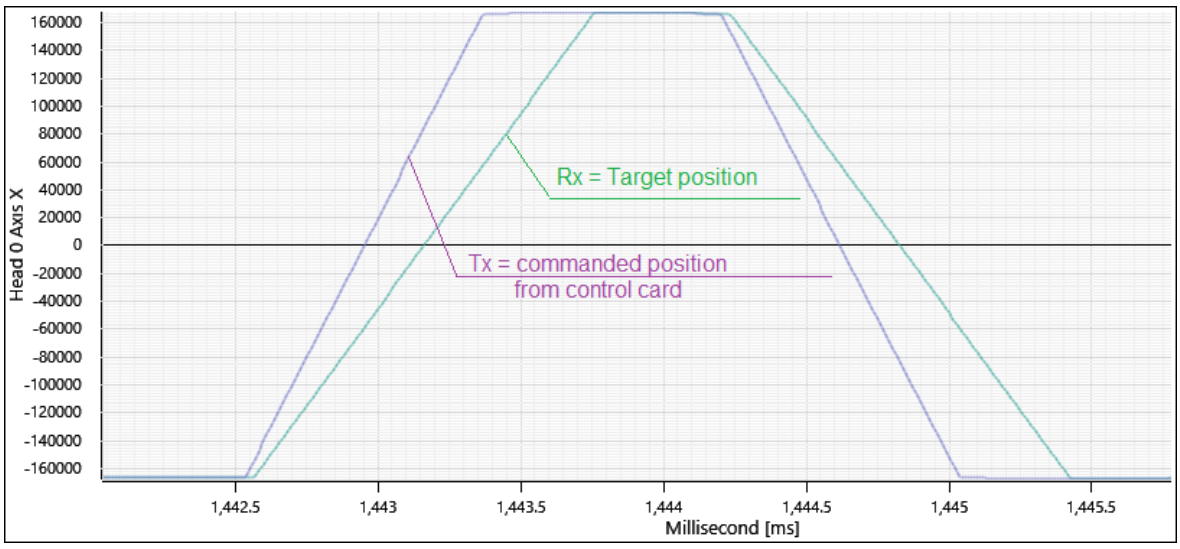


Fig. 5.2: PDA-ABG

5.2.2.1.4.3 IO Pin

Specific input and output pins for signals can be selected here (mostly used for process control).

Signal: **Raw Trace Buffer Event > IO Pin**		**Explanation**
IO Pin	> Abort Mark	Input for signal for list termination.
	> Port Laser In 0	Generic input, depending on the configuration it can be used for laser alarm.
	> Port Laser In 1	Generic input, depending on the configuration it can be used for a MOTF component sensor or as synchronisation with special lasers.
	> Port Laser Out 0	Generic output, depending on the configuration, the “Arm Laser” signal can be output here.
	> Port Laser Out 1	Generic output, depending on the configuration, the signal for the pilot laser can be output here.
	> Port Laser Out 2	Generic output, depending on the configuration, the “Mark Engine Busy” signal can be output here.
	> Start Mark	Input for signal for list start.

Tab. 5.11: PDA-018

5.2.2.1.4.4 IO Port

Specific input and output connections of signals can be selected here (mostly used for process control)

The value is then displayed as a decimal value in the time diagram.

Signal: **Raw Trace Buffer Event > IO Port**		**Explanation**
IO Port	> Port A	Digital, generic IO interface port A with 16-bit input.
	> Port B	Digital, generic IO interface port B with 16-bit input.
	> Port C	Digital, generic IO interface port C with 16-bit input.
	> Port D Low	Digital, reserved interface port D; the lower first 16 bits (of 24 bits).
	> Port D High	Digital, reserved IO interface port E; the upper remaining 8 bits (of 24 bits).
	> Port E Low	Digital, reserved interface port D; the lower first 16 bits (of 24 bits).
	> Port E High	Digital, reserved IO interface port E; the upper remaining 8 bits (of 24 bits).
	> Port Laser In	The 2-bit IO input of the laser control, port X907 of the control card.
	> Port Laser Out	The 3-bit IO output of the laser control, port X907 of the control card.

5.2.2.1.4.5 Label

The values of the so-called trace labels contained in the command list are displayed here.

The trace labels must be set proactively by the application software.

Typical trace labels of the RAYGUIDE application software are:

10 = Start of a list

11 = End of a list

12 = New slice position for deep engraving

5.2.2.1.4.6 Laser

You can select dedicated output signals that are used for laser control here.

Signal: **Raw Trace Buffer Event > Laser**		**Explanation**
Laser	> FPS	First Pulse Suppression
	> Laser Power 16-bit	Laser power specification as 16-bit value (Standard)
	> Laser Power 1-bit	Laser power specification as 1-bit value
	> Laser Power 2-bit	Laser power specification as 2-bit value
	> Laser Power 4-bit	Laser power specification as 4-bit value
	> Laser Power 8-bit	Laser power specification as 8-bit value
	> Laser Triggered	Signal for laser synchronisation (1 bit)
	> Lm	Laser Modulation (Pulse repetition rate or laser frequency)

5.2.2.1.4.7 SPI

Serial Peripheral Interface

Here you can select the data received via the SPI interface.

Signal: **Raw Trace Buffer Event > SPI**		**Explanation**
SPI	> Spi 0 Rx	Data can be recorded via SPI Rx, which an SPI slave device, e.g. a laser adapter board, reports back. **CAUTION:** The selection of these signals in PDA requires correct configuration of the respective SPI module beforehand (either via API commands of the control card or with the *SP-ICE-3 config tool*). For additional details, see *SP-ICE-3 Manual, section 10.3.1*.
	> Spi 1 Rx	
	> Spi 2 Rx	
	> Spi 3 Rx	

5.2.2.2 Configured signals

The ***Configured signals*** displays a list of the signals you have selected from the ***Available signals*** column.

- Only the signals selected using the checkbox are recorded.
- The signal order displayed in the ***Configured signals*** column also defines the order in the ***Time Plot*** panel and the ***Acquired Signals & Cursors*** panel.

  You can use drag & drop to change the sequence as required.

- Clicking on the ***[Remove signal]*** button removes the signal from the ***Configured signals*** column.

  (The button appears as soon as you move the mouse over the signal entry)

- Some signals are not available in the required unit. For these signals, fields for signal conversion are displayed below the list.

  For some signals, the values for scaling are already predefined.

  You can also specify the physical unit of the signal here as an option in order to declare the diagram axis accordingly.

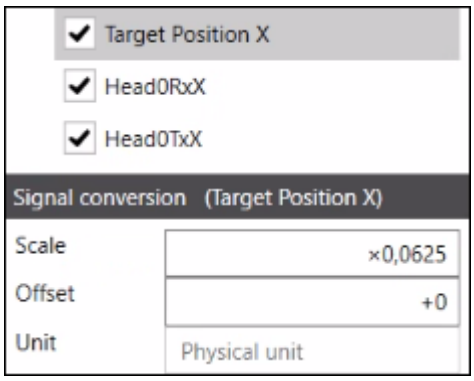


Fig. 5.3: PDA-ABD

5.2.2.3 XY plot domain

For the analysis of laser processes that are run in "***Marking-on-the-fly***" (***MOTF***) mode, it is often interesting to check how the marking would appear on the moving component.

That is why the PDA has the option of displaying the position data edited by the simulated belt movement speed.

To do so, select *Part*. The corresponding signals for the positions, e.g. *Field Commanded X* and *Field Commanded Y* are automatically renamed in *Part Commanded X* and *Part Commanded Y*.

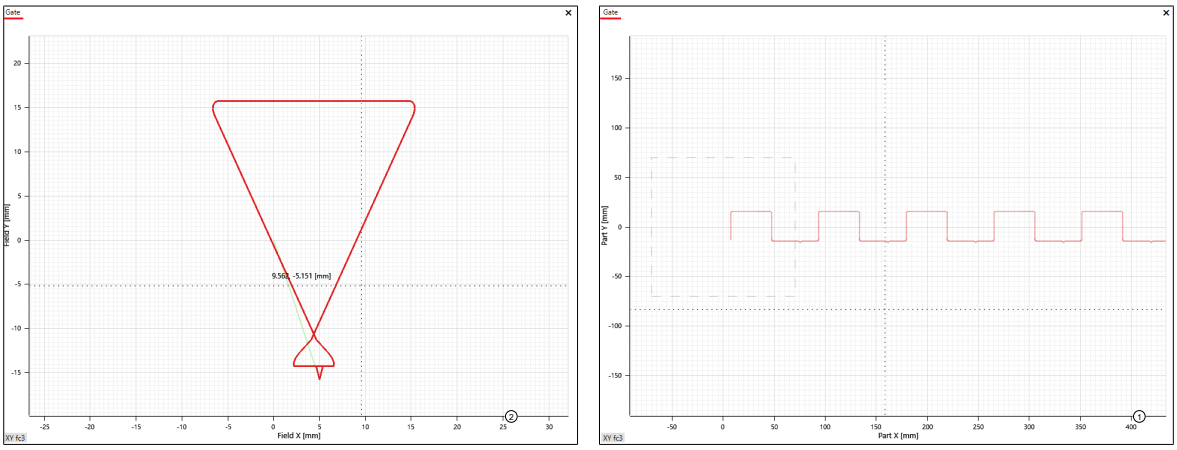


Fig. 5.4: PDA-AAY

1 Static in the field

2 With belt movement (here you can see the contour strung together continuously)

CAUTION: This option only works with the simulation encoder of the SP-ICE-3 control card.

5.2.3 Virtual Signals

The PDA offers the option of configuring so-called virtual signals in addition to the basic signals.

The virtual signals are always calculated mathematically from existing basic signals.

The scan speed is a common example of this. The scan speed is derived from the local change in position over time.

However, it is also possible to duplicate a basic signal. For instance, temperature values can be displayed once as a regular “heat map” and additionally as a “defect map”.

The virtual signals are configured via the ***Settings > Configurations > Virtual Signals*** menu:

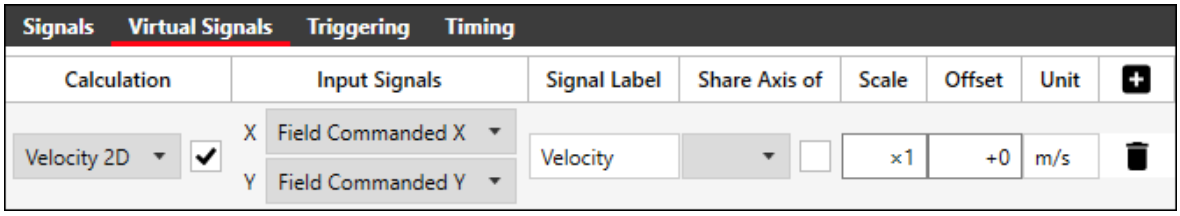


Fig. 5.5: PDA-AAY

Column	Value / Explanation	
Calculation	Drop-down list Select the calculation for the virtual signal here. Use the checkbox to select whether the configured signal should be actively used for signal recording.	
	Velocity2D	Speed in a layer (derivation of the position change over time)
	Velocity3D	Speed in 3-dimensional space
	Substraction	Difference between input signal 1 and input signal 2
	Addition	Sum of input signal 1 and input signal 2
	Multiplication	Product of input signal 1 and input signal 2
	Division	Divider of input signal 1 and input signal 2
	Derivation	Derivation from the selected input signal after time
	Copy	A copy of the selected input signal (useful if two different XY diagrams of the same signal are required) **NOTE:** A copy signal can no longer be used as a base signal for a virtual signal.
Input Signals	Drop-down list All signals that were previously configured and enabled as signals to be recorded on the “Signals” tab are available as input signals. (See section 5.2.1.2)	

Column	Value / Explanation
Signal Label	Input field Enter a useful name for the signal here.
Share Axis of (optional)	Drop-down list Select a signal with which this virtual signal shares the time diagram. This may make it easier to compare two signals. Sharing can be enabled/disabled using the checkbox.
Scale (optional)	Scaling the signal
Offset (optional)	Value offset of the signal
Unit (optional)	Physical unit of the signal
 ***[Add virtual signal]***	Adds a new row for configuration of another virtual signal
 ***[Remove virtual signal]***	Deletes the corresponding row or virtual signal

Tab. 5.12: PDA-022

5.2.4 Triggering

The trigger settings determine when the signal recording starts and stops.

Regardless of the trigger setting, recording must be started with the ***[Start acquisition]*** button.

Recording should also be disabled independently of the trigger settings via the ***[Stop acquisition]*** button.

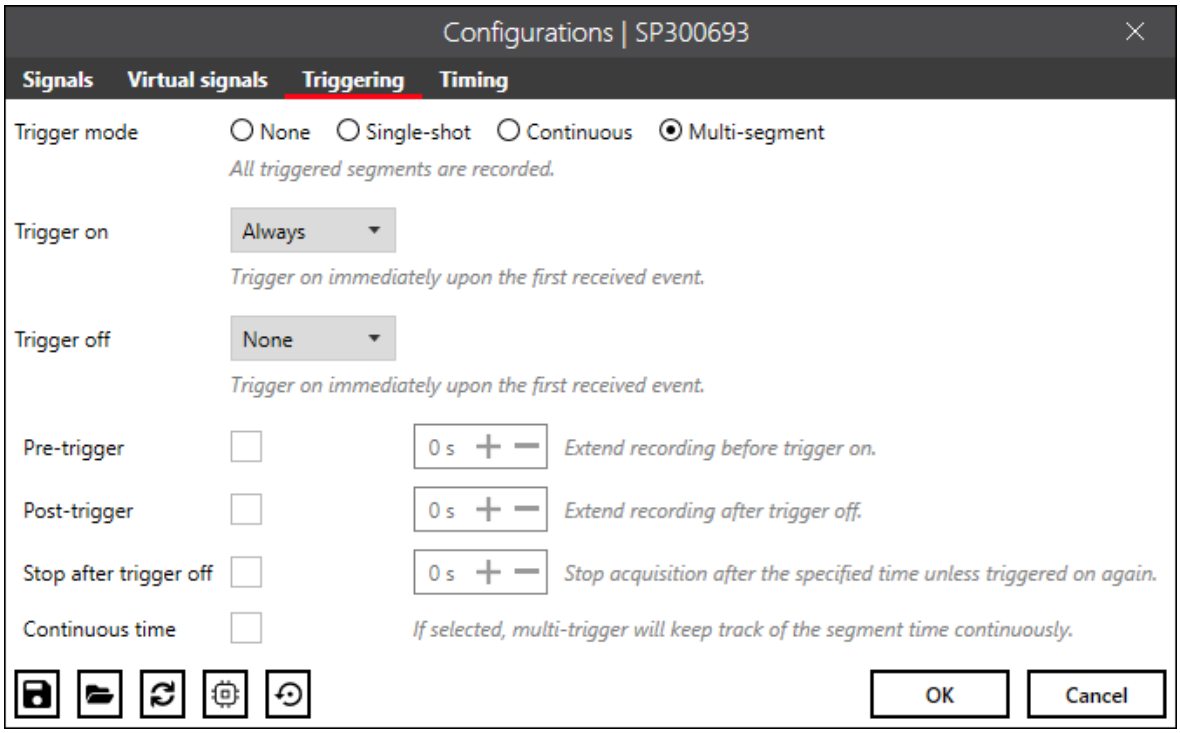


Fig. 5.6: PDA-AAG

In principle, there are four modes to choose from.

Tab **Triggering**	**Explanation**	
Trigger mode	None	In this mode, data recording is not started / stopped by trigger events, but only with the ***[Start acquisition]*** or ***[Stop acquisition]*** buttons. 
	Single Shot	In "Single Shot" mode, only the time segment that starts with the "Trigger-On" event and ends with the "Trigger-Off" event is displayed. See table below for additional settings for this trigger mode.
	Continuous	In "Continuous" mode, all triggered time segments are recorded live, but only the data from the last triggered time segment is retained and displayed. See table below for additional settings for this trigger mode.
	Multi-Segment	In "Multi-Segment" mode, all triggered time segments are not only recorded but also saved. After recording is stopped, the last time segment is displayed. The ***[Open list of triggered segments]*** button is used to individually select all segments for display.  See table below for additional settings for this trigger mode.

Tab. 5.13: PDA-023

The following settings can be made depending on the trigger mode.

Trigger setting	Explanation
Trigger on	Select an event with which the recording of a time segment begins. The choices are: ■ Always ■ Gate on ■ Trace Label
Trigger off	Select an event with which the recording of a time segment ends. The choices are: ■ None ■ Gate off ■ Trace Label ■ Timeout
Pre-Trigger	Select whether a certain time span before the trigger event that starts a period of time to be recorded should also be saved and displayed with the recording. Enter the desired time span.
Post-Trigger	Select whether a certain time span after the trigger event that ends a period of time to be recorded should also be saved and displayed with the recording. Enter the desired time span.
Stop after trigger off	Select whether recording after the *Trigger off* event should be disabled if a new *Trigger on* event does not occur within a certain time span.
Continuous time	Select whether in *Multi-Segment* trigger mode each time segment starts with consecutive time per time segment or whether each time segment starts at t=0.

Tab. 5.14: PDA-036

5.2.5 Timing

On the ***Timing*** tab, time values can be viewed, which synchronise the temporal display of the signals.

These settings ensure, for instance, that the actual position data is offset in relation to the target position data of the deflection unit so that they are synchronised in the temporal display.

By default, the following signals are shifted or time-offset by the following parameters:

1. For positions in the field domain, the measured position is shifted so that it overlaps in time with the commanded position.
2. For raw signals (*Tx* vs. *Rx*), a time offset by the amount of the signal propagation time (control card – deflection unit – control card) can usually be observed. This offset is not automatically equalised.

If there is a need to change the standard time behavior, this can only be done by defining the custom delay.

CAUTION: Changing these values without instruction from RAYLASE is generally not recommended.

6 RECORDING DATA

6.1 Activating / Deactivating signal recording

To record data, signal recording must be enabled in order to react to trigger events if necessary. This is done using the ***[Start acquisition]*** or ***[Stop acquisition]*** buttons in the function bar.

Activation can take place before but also during list execution on the SP-ICE-3 control card.

Recording is stopped at the latest when the timer expires (see function bar) to prevent the recording of too much data from flooding the RAM of the computer.

You can view the data display in the time diagram and XY diagram live. However, in the case of very long recordings with correspondingly large amounts of data, live rendering of data may not be possible. In this case, some time will pass after recording stops until all data has been rendered for display.

NOTE: The XY diagram is automatically fitted to the scan field after signal recording is enabled and any previous trajectories are removed.

The time diagram starts with t=0, at the point in time of the start trigger event.

6.2 Time plot: Temporal display of the signals

All signals configured according to *page 39, Configured signals* and all virtual signals are always displayed over time. All time diagrams have the same X-axis (time), where t=0 is the trigger time. The unit of the time axis (seconds vs. milliseconds vs. microseconds) can be defined in the Preferences (see *page 66, Preferences*).

After signal recording ends, the X-axis is automatically scaled by default so that the complete time span is displayed, taking into account the trigger events.

Alternatively, you can switch off automatic scaling using the ***[Lock signal auto-resize]*** toggle button. The axis range then remains as it was before signal recording was started.

The Y-axis of the signals depends on the signal.

Most signals transmit 20-bit data, which is displayed in the diagram as a decimal value. The scaling of the Y-axis of these signals can be adjusted. For details, see *page 39, Configured signals*.

Some signals are pure Boolean signals (e.g. gate signal). As only the *True* or *False* signal status is displayed here, the Y-axis cannot be scaled.

The data of all signals are displayed below each other in the ***Time Plot*** panel. This means that not only is the X-axis common to all signals, but the cursor also runs vertically through all signal curves.

SPECIAL FEATURE of the diagram sections for the field position of an axis:

The signals for commanded and measured position data of optical axes in the so-called field domain each share a diagram section or the Y-axis so that they can be directly compared to each other. They are displayed in different colors to distinguish them.

As position data can also be sent / received on the Tx and Rx channels of an axis, these two signals also share a diagram section.

NOTES:

- The height dimension of the individual sections of the time diagram is uniform. It can be defined in the ***Preferences*** (in pixels). Diagrams of Boolean signals are an exception.
- If the vertical screen area in the GUI is not sufficient to display all diagram sections one below the other, a scroll bar appears on the right-hand edge.
- Using the checkboxes in the ***Acquired Signals & Cursors*** panel (TP column), you can hide or display individual diagram sections.

- If you want to hide all time diagrams at once, use the ***View*** menu option. Disable ***Time Plot*** here.
- The ***[F4]*** function button can be used to hide the value labels along the cursors if required.

Example:

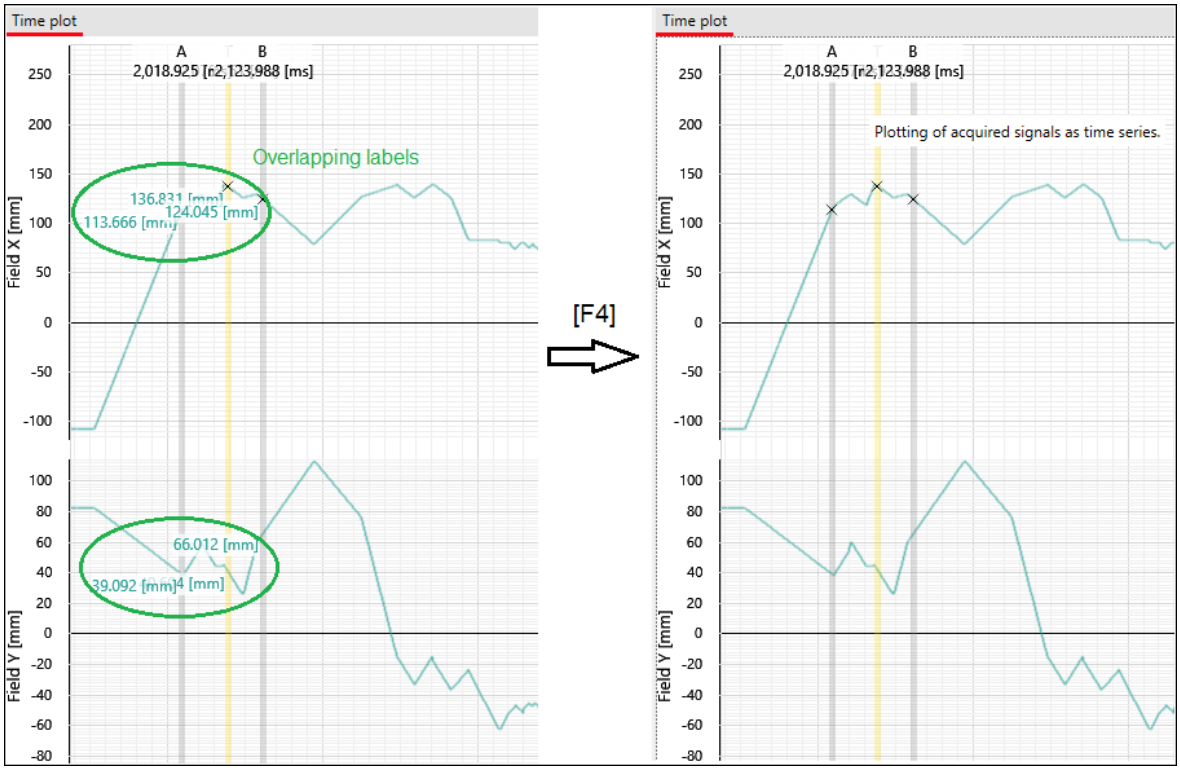


Fig. 6.1: PDA-ABK

Right-click the mouse in the time diagram area to open the **context menu**. You will find additional functions there:

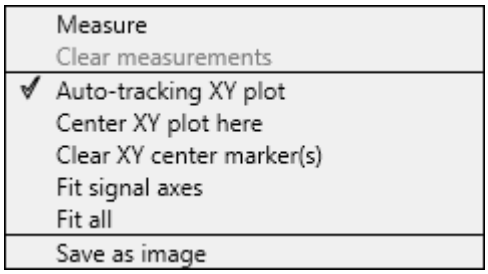


Fig. 6.2: PDA-ABH

Element	Explanation
Measure	Starts the measurement function. See *page 61, Distance measurement tool*.
Clear measurements	Deletes all currently displayed measurement vectors including measured values.
Auto-tracking XY plot	If enabled, the viewport of the XY diagram is automatically fitted to the recorded trajectory after recording is complete.
Center XY plot here	Centers the viewport of the XY diagram around the XY coordinate that belongs to the current point in time of the T cursor, regardless of the zoom level in the XY diagram. See *page 64, Centering XY diagram around a point in time*.
Clear XY center marker(s)	Deletes all vertical auxiliary lines for timestamps that mark an XY position. See *page 64, Determining points in time for a trajectory position*.
Fit signal axis	Scales and shifts the Y-axes of all diagram sections so that all data graphs of the currently displayed time span are visible.
Fit all	Scales and shifts the Y-axes of all diagram sections as well as the time axis so that the complete data graphs are visible.
Save as image	Saves the complete time diagram with the currently displayed time span as a *.png file.

6.3 XY plot: Locally resolved signal display

The XY diagram is basically used to display the value progression of signals in the scan field using color.

If you only want to view the trajectory of the deflection unit in the scan field, it is enough to display a “simple” signal (such as the laser gate signal) in the XY diagram.

In principle, however, any signal (including the virtual signals) that have been configured according to *page 39, Configured signals* can be displayed in an XY diagram with local resolution along the trajectory. It is always possible to display the trajectory based on the commanded positions. As soon as a RAYLASE deflection unit is connected and switched on, the trajectory can also or alternatively be displayed based on the measured positions.

IMPORTANT: The location or position refers to the coordinate system of the scan field. This is achieved by the PDA application calculating the position in the scanner domain back into the field domain via an inverse field correction and inverse field transformation.

NOTES:

- Basically, the display of signals in the XY diagram only makes sense for signals that change their value depending on their position. This change is then represented in the XY diagram by a change in color. This type of representation is also sometimes referred to as a “heat map”. For more details on the setting options for color coding of the signals, see *page 68, Color settings in the XY diagram*.
- The data in the XY diagram are rendered as vectors by default. This enables very clear display and good resolution even at high zoom levels.
- Alternatively, the data can also be rendered as pixel graphics. This variant is particularly suitable if a large amount of data is recorded, for instance, if laser processes that contain fills or pixel graphics are to be analyzed. For details, see *page 66, Preferences*.
- Basically, multiple XY diagrams are stacked one behind the other in tabs.
- If you move the mouse cursor very close to a trajectory, it will be displayed “thicker” (until you move the mouse cursor away).
- You can also use the panel manager to arrange two or more XY diagrams next to each other to make it easier to compare them.

- Use the checkboxes in the ***Acquired Signals & Cursors*** panel (XY column) to display the XY diagram for a signal. The ***Gate*** and ***Laser Power 16-bit*** signals are set by default.
- If you want to hide all XY diagrams at once, use the ***View*** menu option. Disable ***XY Plots*** here.
- There is a ***[XY fc3]*** label button on the left below the XY diagram. Clicking on this button opens an information window with details about the correction file currently in use or the inverse field correction.

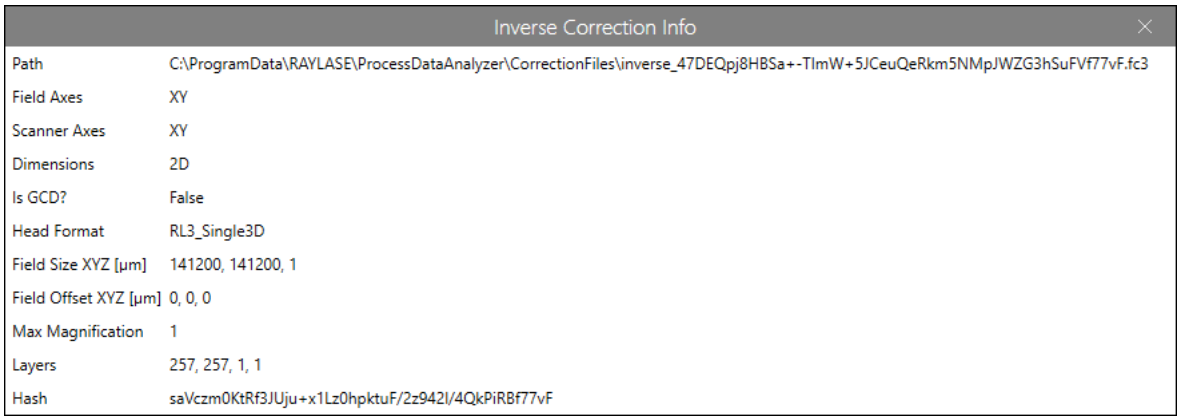


Fig. 6.3: PDA-ABI

Right-click the mouse in the XY diagram area to open the **context menu**. You will find additional functions there:

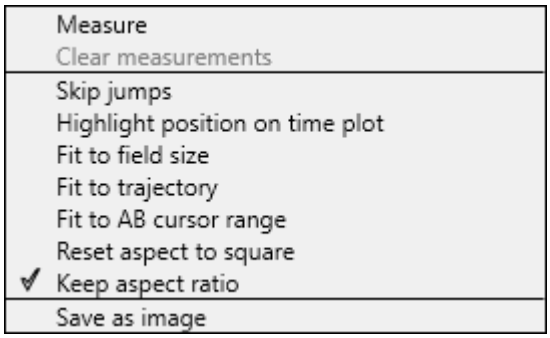


Fig. 6.4: PDA-ABJ

Element	Explanation
Measure	Starts the measurement function. See *page 61, Distance measurement tool*.
Clear measurements	Deletes all currently displayed measurement vectors including measured values.
Skip jumps	Hides / Shows all jump trajectories in all XY diagrams
Highlight position on time plot	Enables the display of all points in time at which the selected coordinate of the trajectory was approached using auxiliary lines in the time diagram. See section 7.4.2
Fit to field size	Fits the viewport to the scan field.
Fit to trajectory	Fits the viewport to the complete trajectory. **NOTE:** This also includes hidden jump vectors.
Fit to AB cursor range	Fits the viewport to the trajectory that was travelled in the time between the two cursors.
Reset aspect to square	Sets the view of the XY diagram to the same scaling of the X and Y axes
Keep aspect ratio	If activated, zoom sections selected with the mouse cursor are always displayed with the same X and Y scaling. Without this function, the axes may be scaled differently according to the selection window.
Save as image	Saves the complete time diagram with the currently displayed time span as a *.png file.

6.4 Navigation in the diagrams

An essential feature of the PDA user interface is that you can view certain temporal or local events of its laser process in great detail.

To do so, you can enlarge and position the image section of the graphs in the diagrams so that you can view the desired detail.

The following section describes some options that can be used to emphasize the desired position of the graph or the desired section of the graph.

6.4.1 Automatic fitting functions

Time diagram

In the time diagram, the X- or time axis is scaled after signal recording stops so that the entire time span of signal recording uses the available diagram area.

The Y- or value axis is also automatically scaled and shifted so that all recorded data can be seen.

The context menu in the time diagram also offers the following two functions:

- ***Fit all***: Fit all graphs completely into the respective screen sections (per diagram section).
- ***Fit signal axis***: Scale the Y- or value axis for all graphs so that all data in the current time range is fitted.

XY diagram

In the XY diagram, the view is automatically fitted to the field size.

The context menu in the XY diagram also offers three functions:

- ***Fit to field size***: Fit the image section back to the field size.
- ***Fit to trajectory***: Fit all recorded trajectories into the image section.
- ***Fit to AB cursor range***: The trajectories resulting from the time span between the two A and B cursors are fitted into the image section.

If you want to fix the scale range predefined for both diagrams for the first view after signal recording has been completed, enable the ***[Lock signal auto-resize]*** toggle button.

6.4.2 Zoom

You can use the mouse wheel to zoom in and out in both the time diagram and the XY diagram. The scale values adjust automatically. The zoom center point corresponds to the current cursor position in the diagram.

In the case of the time diagram, however, only the time axis is stretched/compressed.

To scale the Y- or value axis of the time diagrams, position the mouse cursor directly at the scale of the corresponding diagram section and then use the mouse wheel.

You can also hold down the mouse wheel and drag the mouse cursor to a specific area to be enlarged:

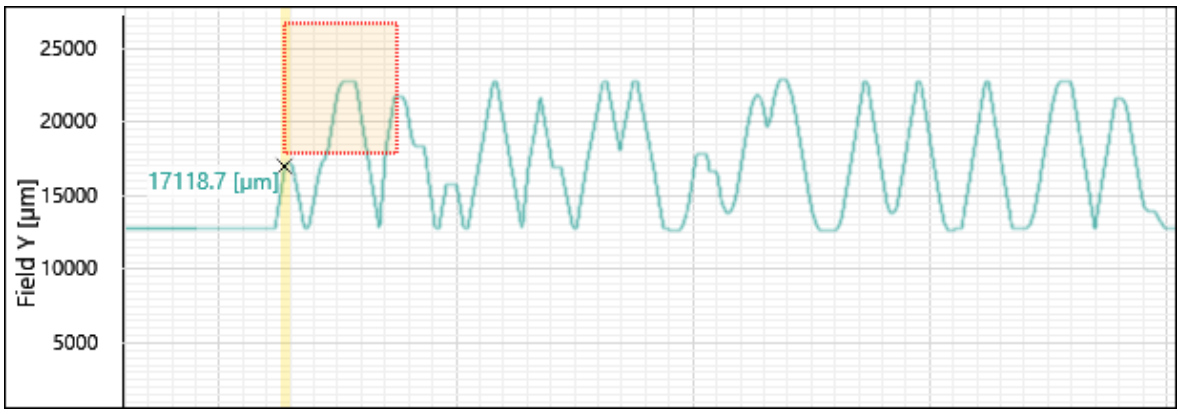


Fig. 6.5: PDA-AGH

6.4.3 Shifting scale range

In both axis directions

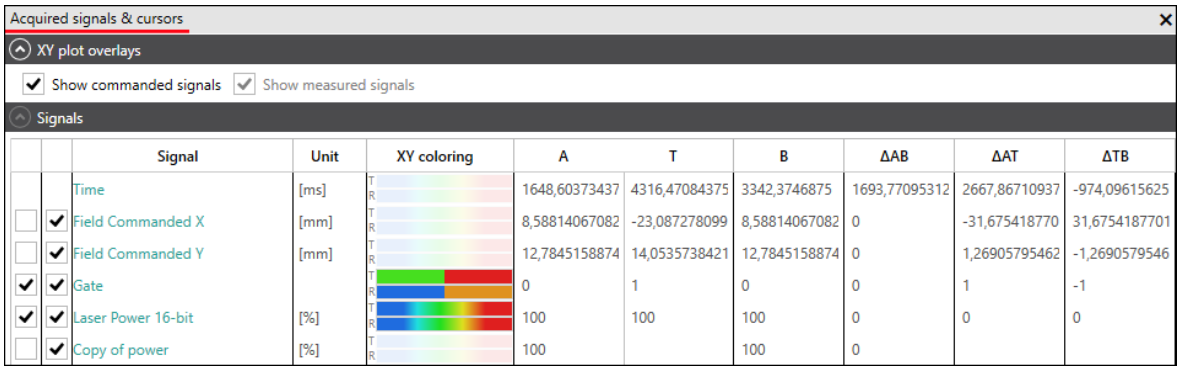
Hold down the left mouse button and shift the image section by moving the mouse until the desired area is in the image.

In just one axis direction

Position the mouse cursor on the corresponding diagram scale (indicator: Mouse pointer changes to hand symbol). Hold down the left mouse button and shift the image section by moving the mouse until the desired area is in the image.

NOTE: An overview of all the functions for zooming and shifting is displayed at *Help > Show Mouse Controls*.

6.5 “Acquired signals & cursors” panel



		Signal	Unit	XY coloring	A	T	B	ΔAB	ΔAT	ΔTB
		Time	[ms]	T R	1648,60373437	4316,47084375	3342,3746875	1693,77095312	2667,86710937	-974,09615625
	☑	Field Commanded X	[mm]	T R	8,58814067082	-23,087278099	8,58814067082	0	-31,675418770	31,6754187701
	☑	Field Commanded Y	[mm]	T R	12,7845158874	14,0535738421	12,7845158874	0	1,26905795462	-1,2690579546
☑	☑	Gate		T R	0	1	0	0	1	-1
☑	☑	Laser Power 16-bit	[%]	T R	100	100	100	0	0	0
	☑	Copy of power	[%]	T R	100		100	0		

Fig. 6.6: PDA-AAI

The ***Acquired Signals & Cursors*** panel is arranged over the ***XY Plots*** panel by default. It is divided up in two sections:

- ***XY plot overlays***, see *page 56, XY plot overlays*.
- ***Signals***, see *page 57, Signals*.

6.5.1 XY plot overlays

Select here whether the trajectories to be displayed in the XY diagram should be based on

- The commanded position data (*Show commanded signals* checkbox) and / or
- The measured position data (*Show measured signals* checkbox).

If you select both, the trajectories for the corresponding signal are displayed superimposed in the same diagram.

The cursor labels on the XY diagram are displayed in different colors for both position data.

NOTE: With the communication protocols currently available, it is not possible to receive measured position data and status information from the deflection unit at the same time.

6.5.2 Signals

The ***Signals*** table lists all actively configured signals and all virtual signals in the order in which they are listed in the ***Configurations > Signals*** menu.

The time is always listed at the top of the table as a separate entity.

Column	Explanation
XY	Use the checkbox to select whether an XY diagram should be generated and displayed for the corresponding signal.
TP	Use the checkbox to select whether a diagram section should be displayed in the time diagram for the corresponding signal.
Signal	Name of the signal.
Unit	Physical unit of the signal, if defined.
XY Coloring	Define the color or color gradient for the display of the signal values along the trajectory here. For details on color selection, see *page 68, Color settings in the XY diagram*.
A	Data value of the respective signal at the position of the A cursor.
T	Data value of the respective signal at the position of the T cursor.
B	Data value of the respective signal at the position of the B cursor.
ΔAB	“Position A cursor” data value minus “Position B cursor” data value.
ΔAT	“Position A cursor” data value minus “Position T cursor” data value.
ΔTB	“Position T cursor” data value minus “Position B cursor” data value.

Tab. 6.1: PDA-024

For more details on the cursor functions and how to use them, see *page 60, Time Plot / XY Plot cursor relationship*.

NOTE: Right-click on the row with the column headings to open the list of all columns. There you can select or deselect the display of the respective column if necessary:

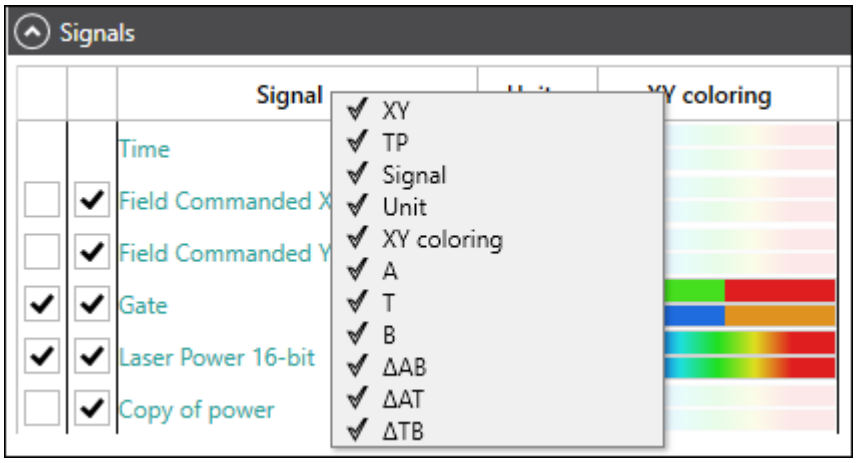


Fig. 6.7: PDA-AAJ

7 EVALUATING DATA

7.1 Measurement cursor

The time diagram offers three measurement cursors (A, B, T).

The labels for the respective measurement cursors are located above the time diagrams.

- You can “pick up” the A/B cursors either at their label or anywhere with the mouse and move them to the desired position.

  When the cursor has been grabbed, the mouse symbol changes to ↔.

  The corresponding time is also displayed in the labels.
- The measurement cursors can be moved very finely using the keyboard. The increment by which a cursor moves when an arrow key is clicked can be specified in the default settings. See also *page 66, Preferences*.

Cursor		Explanations
A cursor B cursor	Static (grey line)	■ If you “grab” the cursor in a diagram section and then move it close to a vertical signal edge or a data point, the cursor is “attached” to this edge. ■ Hold ***[Shift]+[A]*** down to shift the A cursor with the ***[→]*** or ***[←]*** arrow keys. ■ Hold ***[Shift]+[B]*** down to shift the B cursor with the ***[→]*** or ***[←]*** arrow keys.
T cursor	Dynamic (yellow line)	■ The ***[→]*** or ***[←]*** arrow buttons shift the T cursor. **NOTE:** The T cursor is only displayed when the mouse cursor is moving in the time diagram area.

Tab. 7.1: PDA-025

In each diagram section, the value of the signal graph (value label) is displayed for each cursor.

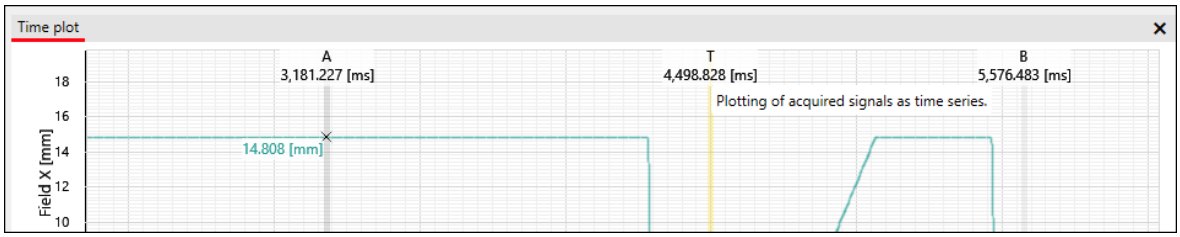


Fig. 7.1: PDA-AAK

The values of the measurement cursors and the time spans between the cursor positions are also listed in the ***Acquired signals and cursors*** panel in the ***Signals*** table. For details, see *page 57, Signals*.

7.2 Time Plot / XY Plot cursor relationship

One of the main functions in the PROCESS DATA ANALYZER is assigning a temporal event to a location or field position.

For this purpose, small crosshairs are displayed for the measurement cursors in the XY plot. Additional information is displayed next to the crosshairs for the respective measurement cursor (so-called cursor labels):

- The signal value (in the example, *Gate* signal [True / False]) and
- The exact position coordinates.

NOTE: The size of the crosshairs can be adjusted. See *page 66, Preferences*.

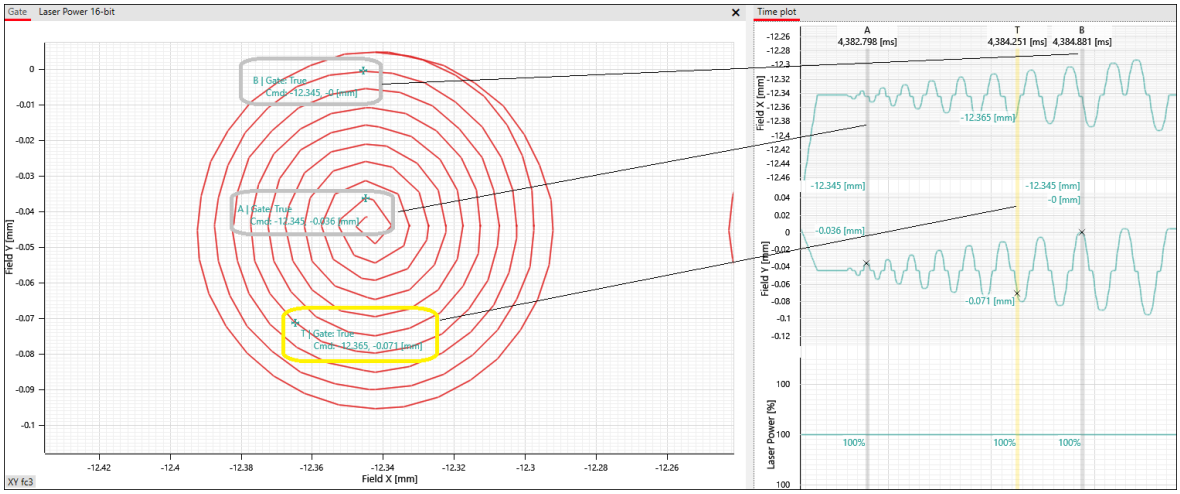


Fig. 7.2: PDA-AAL

7.3 Distance measurement tool

You can use the distance measurement tool to measure distances, times or differences.

Diagram	Measurement of ...
XY diagram	■ Distances between positions or trajectories.
Time diagram	■ Differences in the signal graph (vertical measurement) or ■ Times (horizontal measurement) or ■ Differences and times together.

Tab. 7.2: PDA-026

... Procedure

1. Position the mouse cursor at the starting point for distance measurement.
2. Right-click to open the context menu. Select the ***Measure*** menu item.
3. Move the mouse cursor to the end point of the measurement.
   ✓ As you move the mouse, you will already see the measurement vector.
4. At the end point of the measurement, confirm this by right-clicking the mouse again.

✓ The dimensions are displayed (length of measurement vector, X component, Y component of the measurement vector).

NOTES:

- Both the start and end points of the measurement vector can be moved later with the mouse using drag & drop.
- The measurement vectors remain visible (even with new data recording) until you delete them using the ***Clear measurements*** context menu option.

Example 1: Measurement in the XY diagram: Contour deviation between commanded and measured trajectory

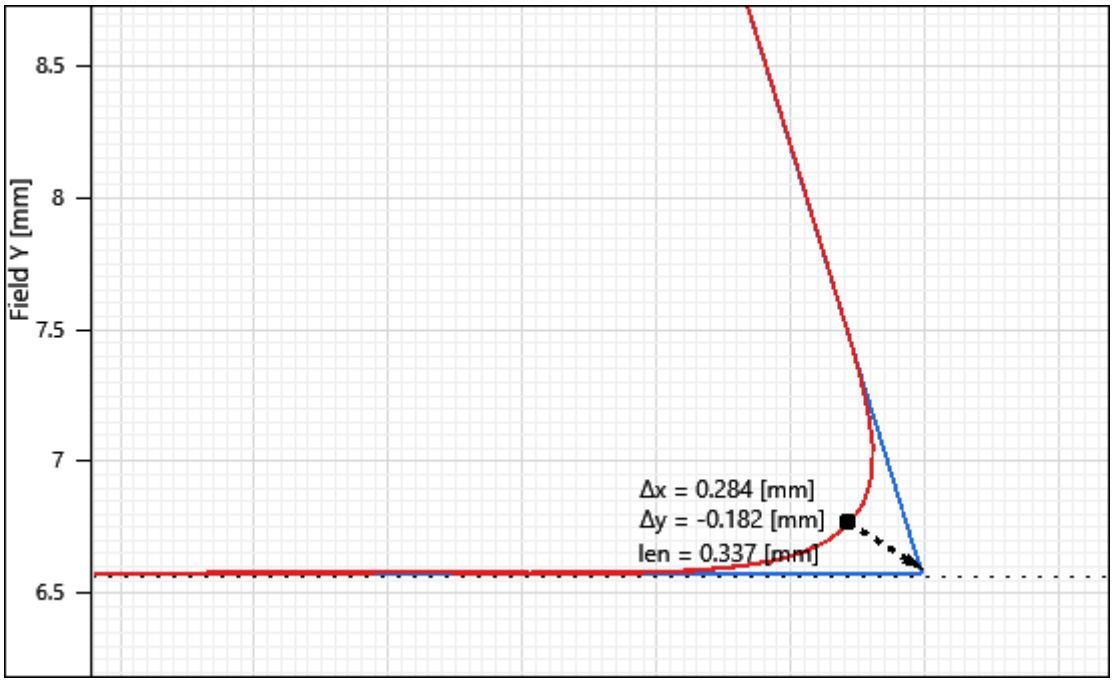


Fig. 7.3: PDA-AAM

Example 2:

Measurement in the time diagram: Comparison of the commanded and measured speed

Measurement is done to determine

- By how much the speed is actually reduced due to a polygon delay, and
- How long it takes until this reduced speed is actually reached at the poly-point.

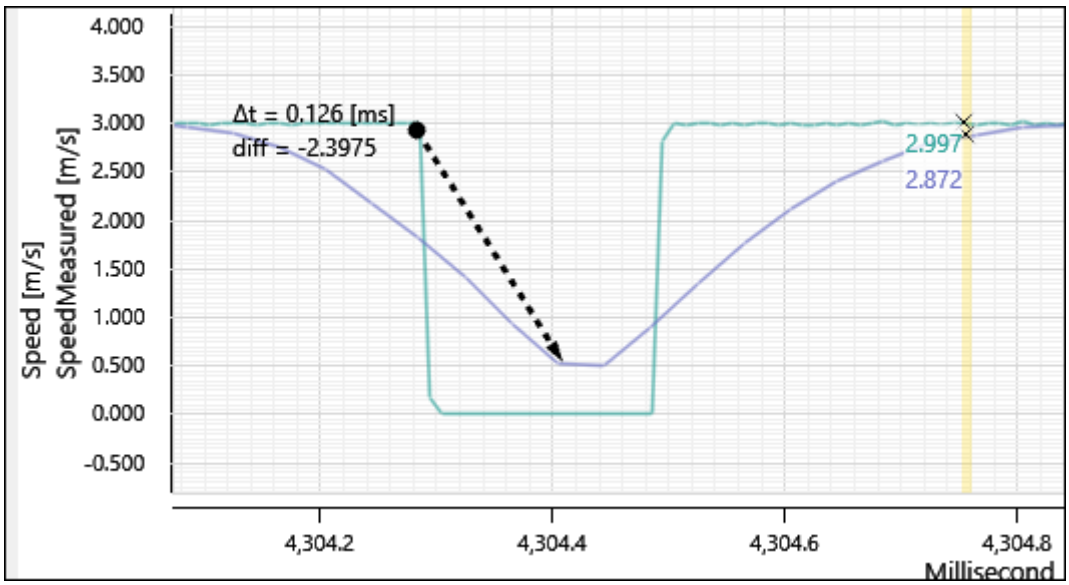


Fig. 7.4: PDA-AAN

7.4 Functions for dynamic correlation between time diagram and XY diagram

7.4.1 Centering XY diagram around a point in time

If you can only see a limited section of the trajectory in the XY diagram because the zoom level is high, you can use this function

- to center this section on an event (position of the T cursor in the time diagram)
- without having to change the zoom level.

... Procedure

1. To do this, position the T cursor at the desired event or point in time.
2. Right-click to open the context menu of the time diagram. Select the ***Center XY plot here*** menu item.

✔ The XY diagram is centerd.

7.4.2 Determining points in time for a trajectory position

If a point of a trajectory has been “approached” several times (i.e. at different times), you can use this function to determine all the points in time associated with this trajectory position.

You can then analyze the individual points in time in the time diagram.

... Procedure

1. Position the mouse cursor at the desired position of the trajectory in the XY diagram.
2. Right-click to open the context menu of the XY diagram. Select the ***Highlight position on time plot*** menu item.

✔ Vertical auxiliary lines are displayed in the time diagram at these points in time to mark them.

You can use the button in the ***[Open the list of position related timestamps]*** function bar to open a list with all time stamps and corresponding position.

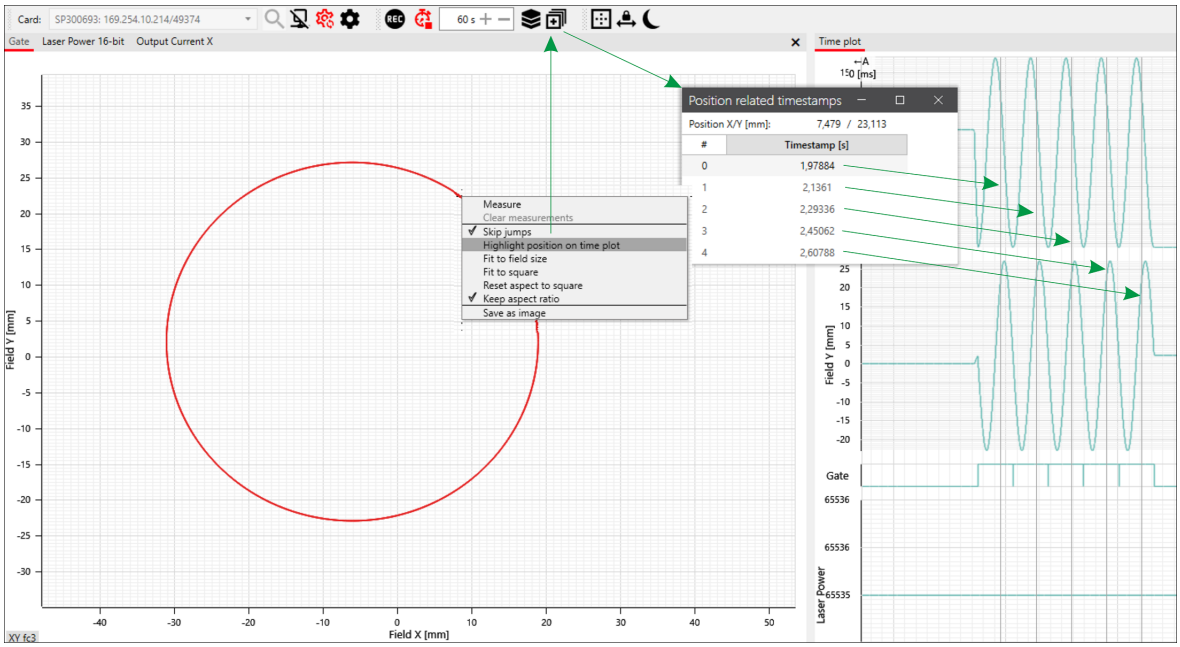


Fig. 7.5: PDA-AAO

You can remove the auxiliary lines in the time diagram via the ***Clear XY center marker(s)*** context menu option.

8 PREFERENCES

You can open the dialogue with ***Settings > Preferences*** or using the ***[F2]*** quick access button.

It is divided up in two areas:

- Charts and
- Units.

NOTE: You can change all settings in Preferences, even after recording data. The changes are also applied directly to existing records.

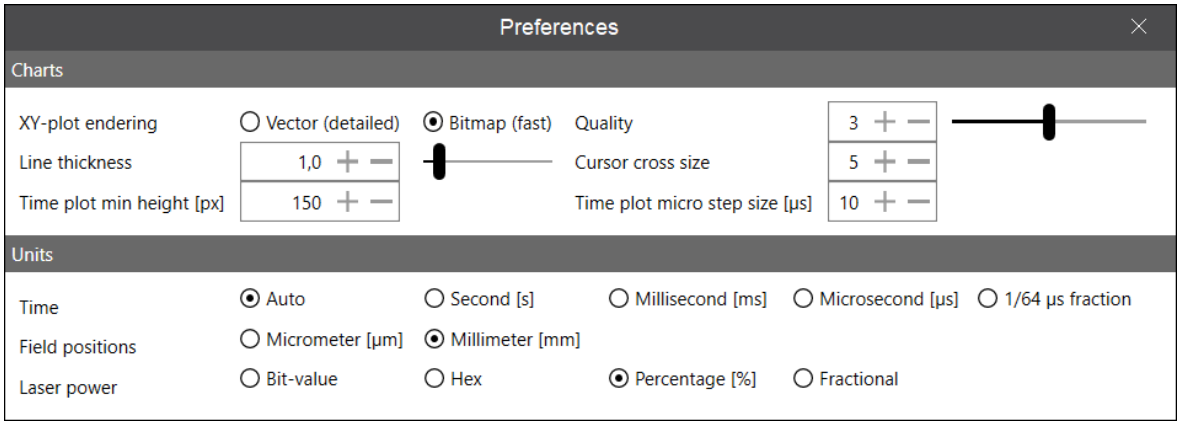


Fig. 8.1: PDA-AAP

Value	Explanations
Charts	
XY-plot rendering	Select whether the trajectories in the XY diagram are rendered as vector or raster graphics (pixel graphics). ■ *Vectors (detailed)* Rendering as a vector graphic results in a higher level of detail, but requires more computing power. For laser processes with a high number of trajectories (e.g. bitmap, fills, etc.), this rendering variant can result in some time elapsing after the end of the recording until all data has been completely rendered. Any shifting or zooming of an image section is then also very slow. ■ *Bitmap (fast)* Rendering as a raster graphic requires much less computing time, but the data resolution is less detailed. The quality of the rendered raster graphic can be set in levels from 1 to 5 (1 = high resolution ... 5 = low resolution).

Value	Explanations
Line thickness	Define the displayed line width for vector rendering in pixels. The setting range is from 0.1 to 10.
Cursor cross size	Define the size of the crosshairs here that show the position of the cursors of the time diagram in the XY diagram. The default value is 5 pixels
Time plot min height [px]	Define the minimum height of the individual diagram sections in the time diagram in pixels here. Default value: 150 Pixel.
Time plot micro step size [µs]	Define the time span by which a cursor is moved with the arrow keys per button click.
Units Define the units or the order of magnitude of the most important parameters here.	
Time	You can choose from the following options for the time units: ■ *Auto*: Automatic unit ■ *Second [s]* ■ *Millisecond [ms]* ■ *Microsecond [µs]* ■ *1/64 µs fraction*
Field positions	You can choose from the following options for the units of the field positions or the distances in the field domain: ■ *Micrometer [µm]* ■ *Millimeter [mm]*
Laser power	The laser power can alternatively be specified in the following units: ■ *Bit-value* ■ *Hex* ■ *Percentage [%]* ■ *Fractional*

Tab. 8.1: PDA-027

9 COLOR SETTINGS IN THE XY DIAGRAM

9.1 Color spectrum

The colors in the PROCESS DATA ANALYZER change the HSL color spectrum.

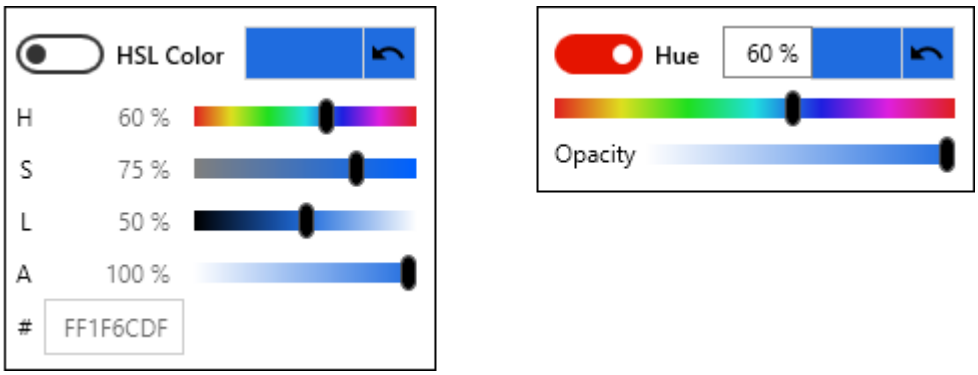


Fig. 9.1: PDA-AAS

Coding	Explanation
H	Hue (color value)
S	Saturation (saturation)
L	Lumination (brightness)
A	Transparency (transparency)
#	Color code

Tab. 9.1: PDA-031

9.2 Assigning colors

In the XY diagram, the data values are displayed over the course of the trajectory using the color or color gradient.

You can open the color settings in the ***Acquired signals and cursors*** panel by clicking on the color bars in the ***XY Coloring*** column.

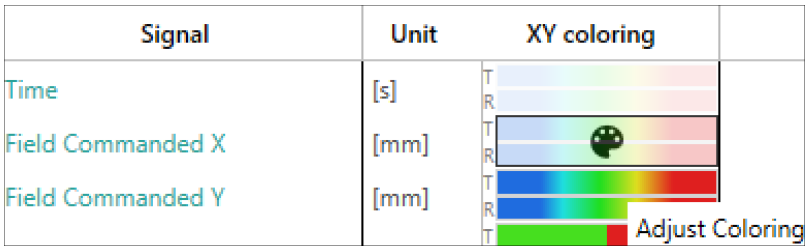


Fig. 9.2: PDA-AAV

A dialogue opens that you can use to make color settings on two tabs:

- *Commanded XY*:

  Color settings for the data points of the commanded trajectory.
- *Measured XY*:

  Color settings for the data points of the measured trajectory.

9.2.1 Boolean data

For boolean data (e.g *Gate* signal) which only have two states, one color is sufficient for each state.

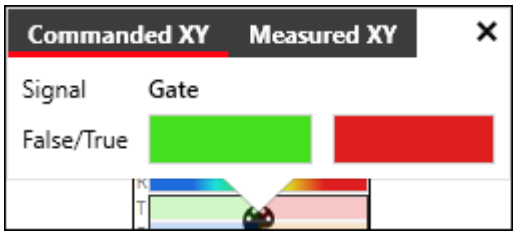


Fig. 9.3: PDA-AAR

9.2.2 Data with continuous progression

9.2.2.1 Settings

The following color settings can be made for data with a continuous gradient.

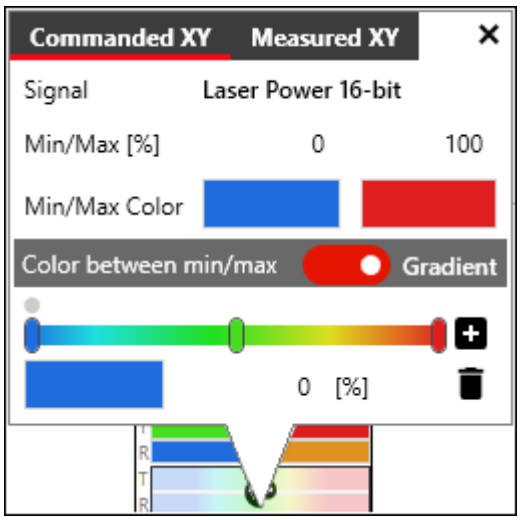


Fig. 9.4: PDA-AAQ

Value	Explanation
Signal	
Min/Max [%]	Min. and max. data value Specify the upper and lower limit value between which the data is either displayed with a color gradient or a fixed color. ■ *Min*: All data positions with a *value* ≤ *min* are displayed in the min. color. ■ *Max*: All data positions with a *value*> *max* are displayed in the max. color.
Min/Max Color	Color selection For all data points with *value* ≤ *min* and *value* > *max*.

Value	Explanation
Color between min/max ↔ ***Gradient*** Slider for selecting the type of coloring	
Slider to the right = *Gradient*	The data points between the min. and max. values are displayed with a color gradient. The settings for the color gradient appear at the bottom of the dialogue. Color gradient: Slider for the color gradient settings The default setting of the slider contains three support points (“gradient stops”) ■ Left = Basic color blue ■ Center = Basic color green ■ Right = Basic color red  adds another support point for the color gradient.  deletes a support point.
Slider to the left = *Color between min/max*	The data points between the min. and max. values are displayed with only one color without a color gradient. Fixed Color Select a color (or transparent) for all data points.

Tab. 9.2: PDA-029

9.2.2.2 Signal range: Assigning a color gradient

1. Open the color settings for the selected signal.
2. Make sure that the slider is set to the right to the *Gradient* setting.
3. In the *Color gradient* slider, click on the respective support point and then on the color field at the bottom left.

   The following dialogue opens:

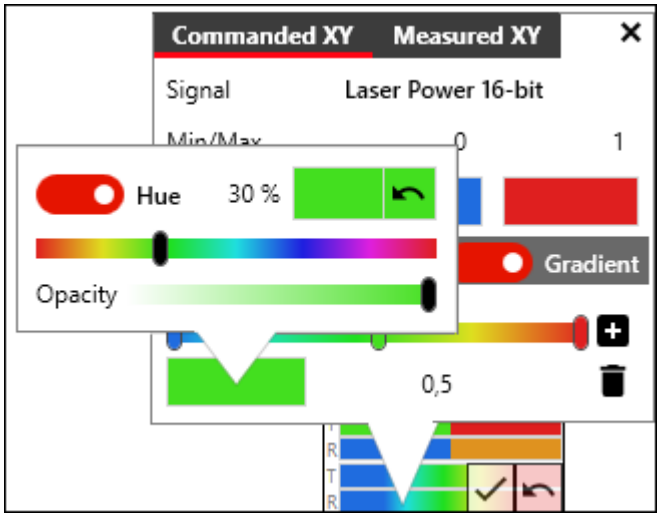


Fig. 9.5: PDA-AAT

4. Select the desired color for this support point.
5. If needed, add support points  or remove undesired support points  .
6. Click on  to apply the colur scheme.

NOTE: If you want to enter specific values for the HSL color spectrum, move the slider for the color value (Hue) to the left .

9.2.2.3 Signal range: Assigning a fixed color

1. Open the color settings for the selected signal.
2. Make sure that the slider is set to the right to the *Color between min/max* setting.
3. Then click on the *Fixed Color* color field.
   The following dialogue opens:

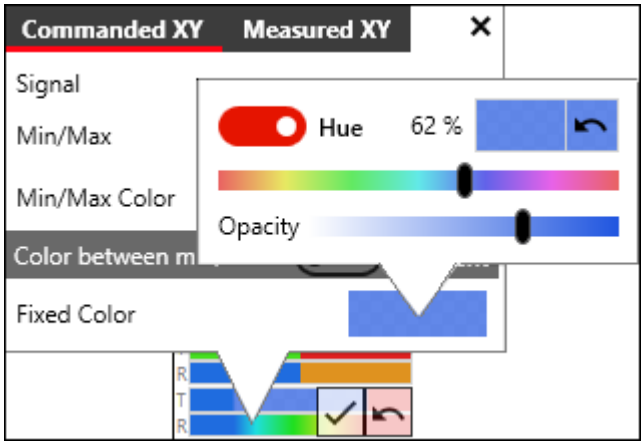
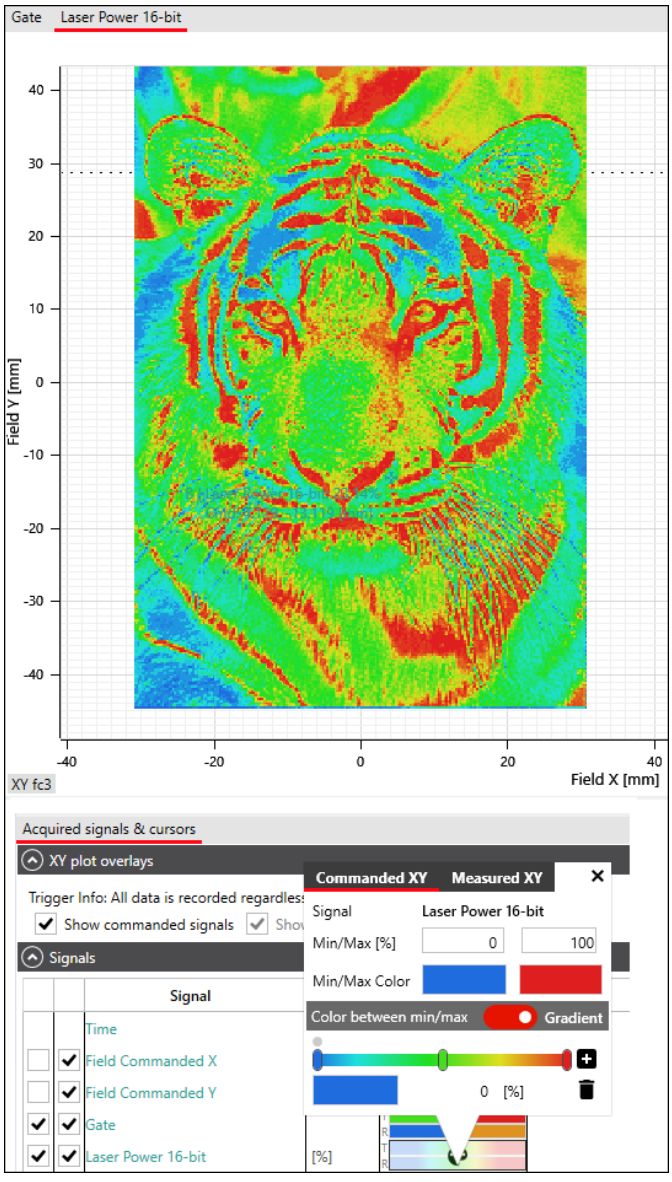
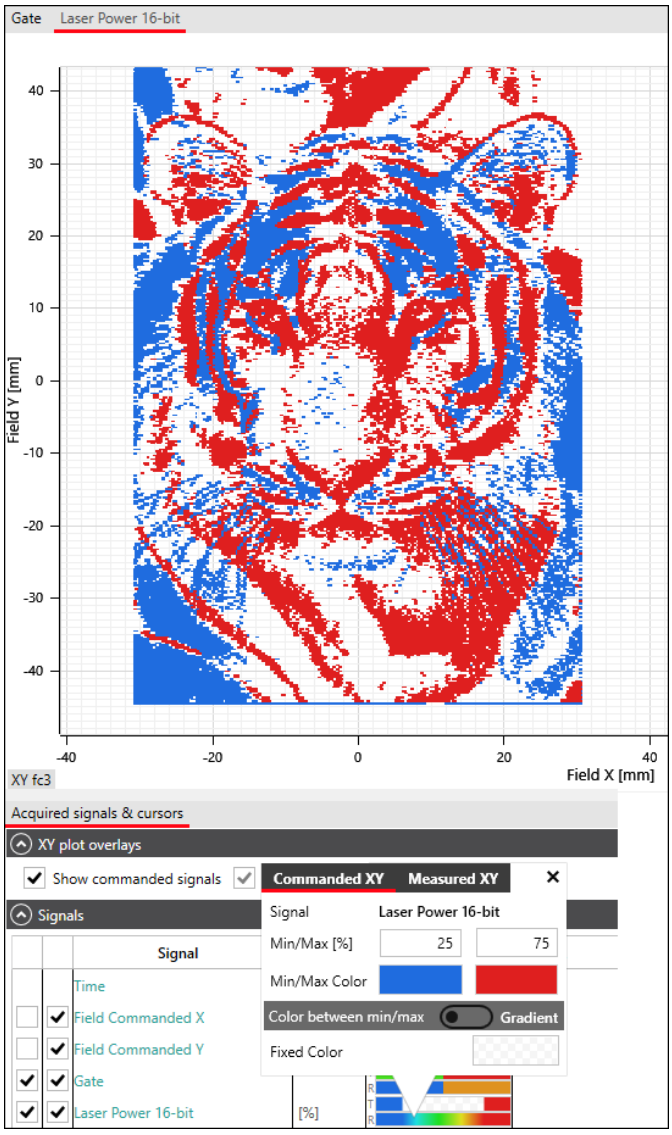


Fig. 9.6: PDA-AAU

4. Select the desired color.
5. Click on  to apply the colur scheme.

NOTE: If you want to enter specific values for the HSL color spectrum, move the slider for the color value (Hue) to the left .

9.2.2.4 Examples

Heat map	Defect map
With color gradient over the entire value range	With fixed (transparent) color between min. value and max. value
	

Tab. 9.3: PDA-030

10 SAVING / LOADING DATA RECORDINGS

The PDA application saves the data recordings in its own data format ("*.pdatrace*", PDA Trace File).

These files can also be loaded in other PDA applications.

The menu options are available for this purpose: ***File > Open*** or ***File > Save***.

NOTES:

- It is also possible to simply record and save the data without a license, e.g. for general fault analyses.
- The PDA application does not need a control card to load a data recording in order to analyze it.
- When a data recording is loaded, an existing connection to the control card is automatically disconnected.
- At the same time, the data recording configuration is loaded.
  - This makes it possible to see which signals, trigger settings etc. were set up in the configuration dialogue.
  - Parameters such as field size are also obtained from the file.
- Additional XY diagrams can also be generated after loading, provided that the basic signals have been recorded.
- To record new data again, reconnect to the control card using the ***[Connect]*** button.

11 DATA EXPORT

To continue to process the data recorded with PROCESS DATA ANALYZER in other programs, you can also export this data in generic data formats (*.csv or *.txt).

To do this, use the export dialogue via the ***File > Export*** menu option or the ***[Ctrl]+[E]*** quick access buttons.

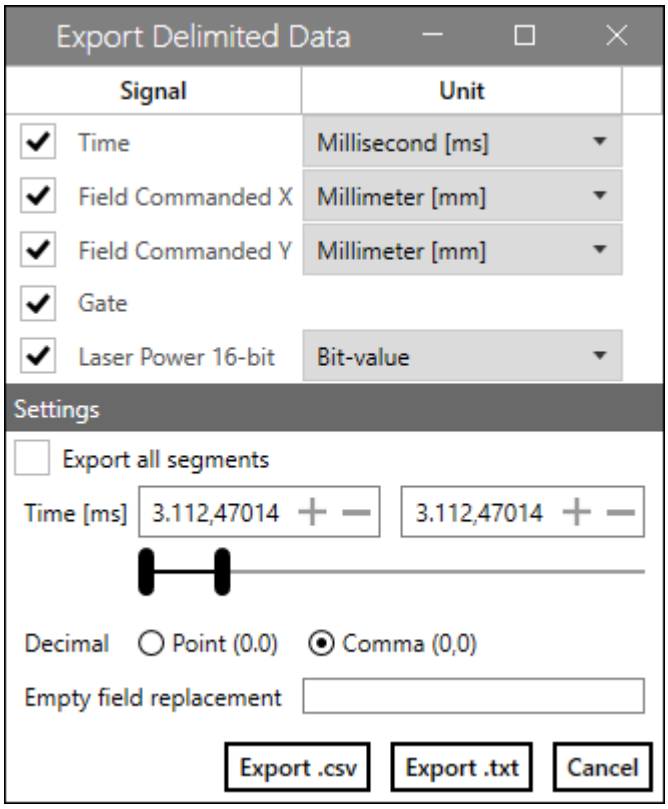


Fig. 11.1: PDA-AAZ

Value	Explanation
Signal list	
Signal	Selection of all signal data to be included in the export.
Unit	If necessary, the unit for export can be changed from the display unit.
Settings	
Export all segments	If enabled: In the case of multi-segment triggered data recording, the data from all segments is exported.
Time	Option to limit the time span for data export.
Decimal	Define whether a period or a comma should be used as a decimal separator for the exported data.
Empty field replacements	Specify a substitution character for empty fields.
[Export .csv] ***[Export .txt]***	Buttons for exporting the data of the last recording in the respective format.

Tab. 11.1: PDA-032

Data recording or data export

- *Data recording:*

  Data recording saves the complete signal and trigger configuration as well as the inverse field correction. It can be opened and analyzed again in PDA. Transferring to another PDA user is possible.

- *Data export:*

  Exported data can never be imported back into the PDA. Export the data if it is to be used in other applications.

12 NOTES ON USING THE ADC ADAPTER BOARD

The PDA application can also be used to display data from external sensors with position resolution. Sensors that obtain light for analyzis from the deflection mirrors are particularly well suited to this purpose. For example, temperatures of a melt can be measured using pyrometers or similar sensors.

Any analog output signals from these sensors can be converted into digital signals (16-bit resolution) using the ADC Adapter boards. The digital signals can be fed in at the SP-ICE-3 control card either at input slots A or B (port A, port B). With the *trace buffer* function of the control card, PROCESS DATA ANALYZER can then read out and display the measurement data of the external sensors.

When connecting the ADC Adapter boards to the SP-ICE-3 control card, please note that the corresponding input slot still needs to be configured. Use the SP-ICE-3 configuration tool to do so (component of the SP-ICE-3 software tools).

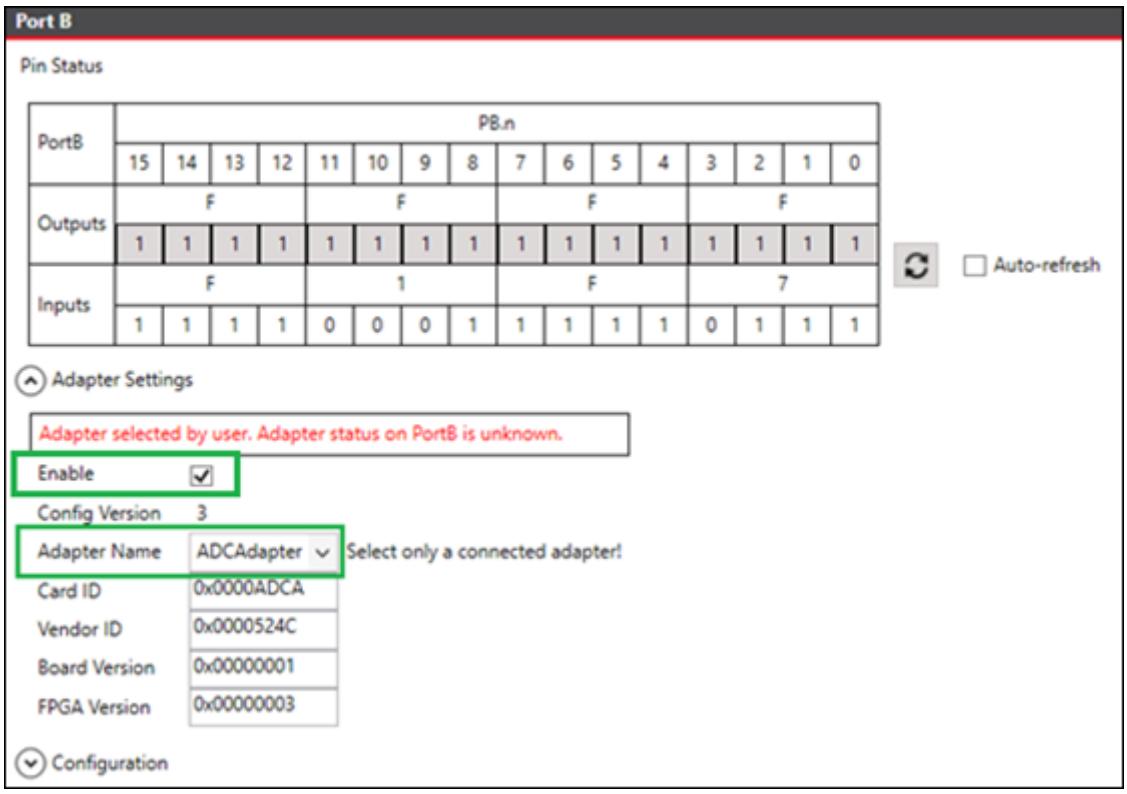


Fig. 12.1: PDA-ABA

… Procedure

1. Connect to the control card using the SP-ICE-3 configuration tool.
2. Change to the ***I/O tab***.
3. Expand the adapter settings for the corresponding slot (port A / port B).
4. In the ***Adapter Name*** field, select the *ADCAdapter* entry.
5. Enable the ***Enable*** checkbox.
   ✓ The *CardID*, *VendorID*, *Board Version* and *FPGA Version* fields are automatically filled with the data from the EEPROM of the adapter card.
6. Click on the ***[Upload to card]*** button to apply the changes.

NOTES:

- For details on the ADC Adapter board and its plug connections and circuits, see *SP-ICE-3 Manual, section 4.4*.
- Recording the data of these channels requires a separate license.
- The analog inputs of the ADC Adapter boards cover a voltage range from -5V to +5V, which corresponds to a bit range from -32768 bits to +32768 bits.

  If the sensor only uses a real range of 0V to +5V, the scale factor is calculated as follows:

  5 : 32768 = 0.00015259.

13 NOTES ON API INTERFACE

The graphical user interface of the PROCESS DATA ANALYZER only allows the data to be recorded and analyzed manually.

In order to record, save or export data automatically, there is an optional .NET library for the programmatic use of some PDA functions.

These basically include:

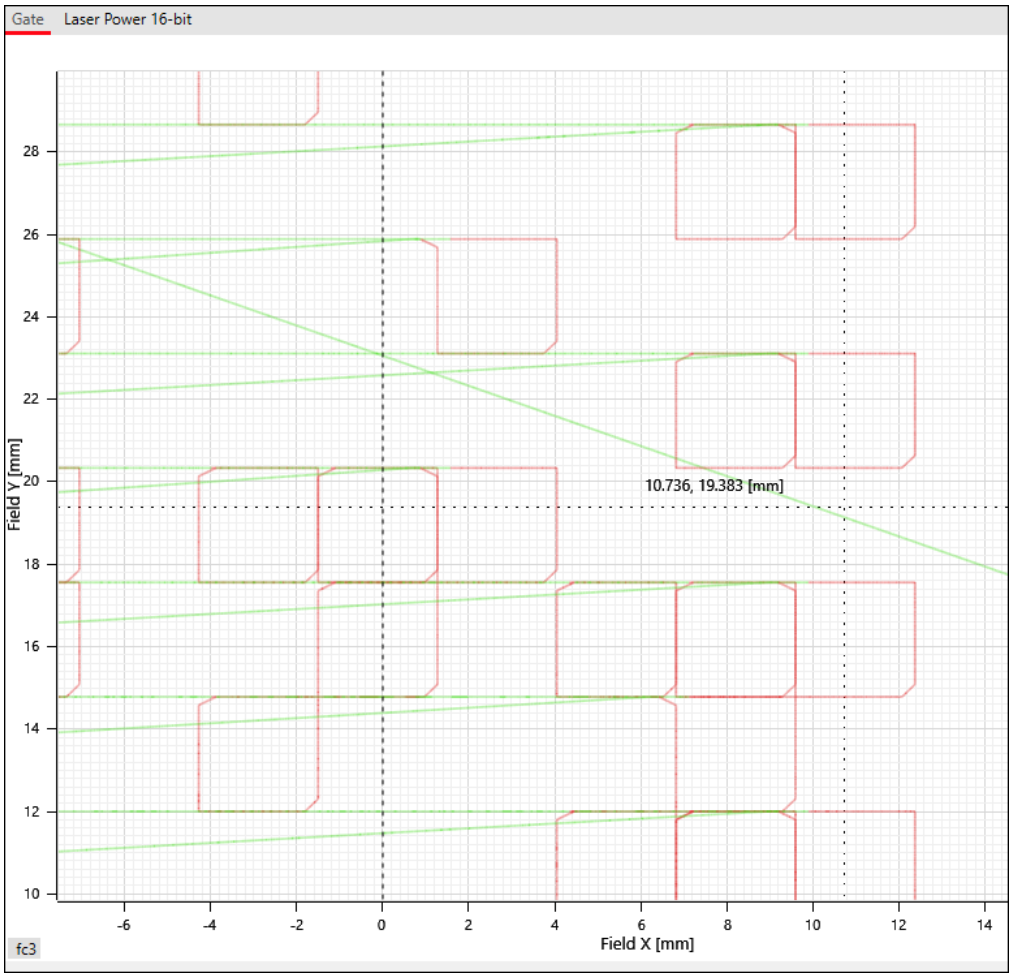
- Configuration of signals
- Configuration of trigger options
- Starting and stopping of data recording and
- Saving or exporting of data

Data can also be transmitted to a corresponding client counterpart via the streaming server while recording is in progress.

For more details, see the *ProcessDataAnalyzer API Manual.chm* .

14 TROUBLESHOOTING

Error	Measure
No connection to the control card possible.	Check ■ Whether the firmware version of the control card and the PDA program version are compatible. ■ On the web interface of the control card, check whether the number of authorised connections of the control card is set to the value “-1” = infinite. ■ Whether another application is accessing the trace buffer of the control card (e.g. SP-ICE-3 tool *Virtual Pointer*). The trace buffer only grants exclusive access to one application at a time.
No inverse field correction possible.	Make sure that a compliant *.FC3 correction file is loaded on the SP-ICE-3 control card.
No live data in the time diagram.	Recording does not start. Check your trigger settings, especially the default for the start trigger.
Signals can be seen in the time diagram, but XY diagrams show nothing.	Check whether ■ At least one of the two checkboxes for commanded or measured trajectories is checked in the Acquired signals and cursors panel. ■ The positions of both the X- and Y-axes were selected at least as the commanded position for recording. ■ The position signals of the X- and Y-axes were only recorded in the scanner domain.

Error	Measure
Systematic errors in the display of the data in the XY diagram	Example: Bevelled 90° corners that were not commanded in this way.  It is very likely that the tracking error value for one of the two mirror axes is incorrect. To verify this, check the tracking error values at *Configurations* > *Timing*. Check whether the tracking error values are correct on the control card. If necessary, reload the values from the control card into the PDA application.

Tab. 14.1: PDA-033

NOTE: If you encounter exception errors when using the PDA software, we ask you to provide RAYLASE with this information for error analysis.

To do so, use the *Help* > *Save Debug Info* menu option. Please send the zip folder created in the process to *support@raylase.de*.

15 GLOSSARY

Current Position	Status information of the deflection unit that provides the actual position of the optical axis (deflection mirror, lens) in the scanner domain.
Defect map	A defect map is a two-dimensional representation of data where deviations are displayed with local resolution. All data that is outside defined limits (i.e. below and above two limit values) is displayed in one color. This makes it possible to visualize where values of relevant measured variables have occurred outside the corresponding limits (e.g. temperatures).
Diagram section	Section of the time diagram with its own Y- (value) axis for the temporal representation of a signal.
Heat map	A heat map is a two-dimensional, locally resolved representation of all data over the entire value range. This data can be visualized using a color index, for example.
Output Current	Status information of the deflection unit that provides the galvanometer scanner current consumption.
Position Error	Since the actual position values of the optical axes always lag behind their target position, the position error is never zero. The difference between the internal target position and the current position is defined as a signed integer. This measured value can overflow, e.g. if a target jump is made from one end of the axis to the other. The value is then saturated at -32768 or +32767. The internal target position does not necessarily correspond to the commanded position. That is why it cannot be guaranteed that the axis is at a certain expected position, even if the position error is at or near zero. This is the case, for instance, if the axis has not yet started up or if an internal error or a transmission error of the target position has occurred. With the SL2-100 or RL3-100 protocol, this value is supplied with 20-bit resolution. For more details, see *Enhanced Protocol Manual*.

RMS Current	Status information of the deflection unit, which provides the galvanometer scanner current consumption averaged over a time of 1 s.
Slew Rate Limiter	Software function module on the control electronics of the deflection unit that limits the maximum target speed.
Target Position	Status information of the deflection unit that provides the target position of the optical axis (deflection mirror, lens) in the scanner domain.
Trace buffer	Ring buffer of the SP-ICE-3 control card. The configured signals are temporarily saved here so that they can then be provided to the PDA software, e.g. for graphical display. More details on the trace buffer can be found in the *SP-ICE-3 Control Card Manual, section 15*.

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ENHANCED PROTOCOL

SUPPORTED BY DIGITAL DEFLECTION UNITS

USER MANUAL

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6	27.05.2022	Correction Relative Output Control / State Flags Low / Loop Transfer Delay; New Layout	JVI, INA

CONTENTS

1 OVERVIEW

SS-IV und SS-V deflection units provide the SL2-100 interface as standard.
The XY2-100 interface can be ordered as an option in addition to the SL2-100 interface.
Digital three-, four- and five-axis system may support the RL3-100-interface.
Using each of these three interfaces the Enhanced Protocol can be used to transmit commands to and receive extended status information from the deflection unit.
XY2-100 provides 16-bit resolution; SL2-100 and RL3-100 provide 20-bit resolution.
This document describes all supported Enhanced Commands.

2 XY2-100-E

The XY2-100-E interface provides
A COMMAND channel for each axis (X, Y, Z), transmitting reference positions, occasionally interspersed with control commands, from the control card to the deflection unit.
A RETURN channel for each axis (X, Y, Z), for data sent back from the deflection unit to the control card.
Common CLK and SYNC signals.
All signals are differential without galvanic isolation.

2.1 Electrical Connection

A standard 25-pin-DSUB female connector is used for data transfer on both deflection unit and control card.
The corresponding cable has all used pins connected one-to-one.
Twisted-pairs are recommended for the differential signals.
Some deflection units (DIG1) have reserved pins for connecting the power supply: these must not be connected to the control card.

2.2 Pinout

Pin	Direction	Signal Name
1	to deflection unit	CLK-
14	to deflection unit	CLK+
2	to deflection unit	SYNC-
15	to deflection unit	SYNC+
3	to deflection unit	X COMMAND- (small mirror)
16	to deflection unit	X COMMAND+ (small mirror)
4	to deflection unit	Y COMMAND- (large mirror)
17	to deflection unit	Y COMMAND+ (large mirror)
5	to deflection unit	Z COMMAND- (focus axis)
18	to deflection unit	Z COMMAND+ (focus axis)
6	to control card	Y RETURN-
19	to control card	Y RETURN+
7	to control card	Z RETURN-
20	to control card	Z RETURN+
8	to control card	X RETURN-
21	to control card	X RETURN+
9	power supply on deflection unit	Optional +15 V for Head (not used for standard SS-IV/V)
22		
10		
23	deflection unit ↔ control card	Signal GND
11		
24		
12	power supply on deflection unit	Optional -15 V for Head (not used for standard SS-IV/V)
25		
13		
shield		GND

2.3 Differences from other suppliers

In RAYLASE deflection units, the X-axis (smaller) mirror is defined as the one, which the laser beam hits first.
Some other suppliers define this to be the Y-axis.
Note that the pinout of the XY2-100-E interface on RAYLASE deflection units swaps the positions of the X- and Y channels compared to the pinout used by other manufacturers.
Consequently, RAYLASE SS-IV/V deflection units can be used immediately as drop-in re-placements for units from such manufacturers: it is not necessary to swap the X- and Y channels physically at the connector.

2.4 Components

The maximum frequency of the CLK signal is 4 MHz.
2 MHz is recommended.
Recommended line driver is UA9638CD.
Recommended line receiver is MAX3096, UA9637, or AM26LV32.

3 SL2-100

SL2-100 carries both X- and Y command channels over a single differential wire pair, and both X- and Y return channels over a second differential pair.
Additional wires are not required for clock or synchronisation.
Return channel synchronisation is independent of the command channel.
SL2-100 is galvanically isolated by transformers. The maximum cable length is 20m.
SL2-100 supports 20-bit resolution.
Enhanced Commands use only the upper 16 bits, and are transmitted in payload bits 19 to 4, with the 4 LSBs set to 0.

3.1 Electrical Connection

Both ends of the cable use a male D-SUB connector. Pins 1 and 6 are cross-connected to pins 5 and 9 of the other end, and vice versa.
All other pins must be N/C.
The casing of both connectors must be connected to the cable shield.

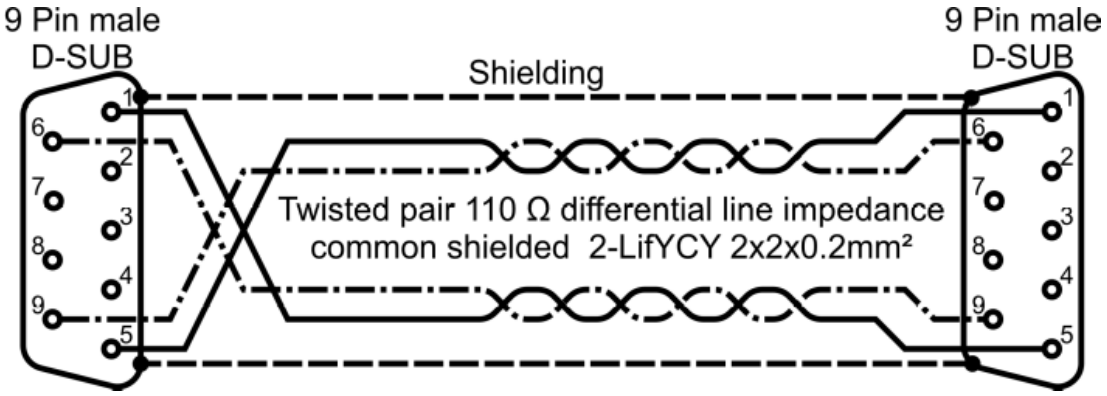


Figure 1: Electrical connection SL2-100

3.2 Pinout

Deflection Unit Pin	Direction	Signal Name	Control Card Pin
1	to deflection unit	COMMAND+	5
6	to deflection unit	COMMAND-	9
5	to control card	RETURN+	1
9	to control card	RETURN-	6
7,8	GND	GND	NC
2	output	3.3 V	NC
case			case

4 RL3-100

RL3-100 uses the SL2-100 electrical connection with a higher data rate and a more efficient protocol to transfer up to five axes over the SL2-100 cable.
RL3-100 also supports 20-bit resolution.

5 XY2-100-E FRAME FORMAT

5.1 Frame Timing

A frame consists of 20 bits.
A '0' on the SYNC signal indicates the last bit of a frame.
On the command channels, state changes occur with the rising edge of the CLK signal.
On the return channels, state changes occur with the falling edge of the CLK signal.
This means that the return channels are delayed by half a clock period compared to the command channels.

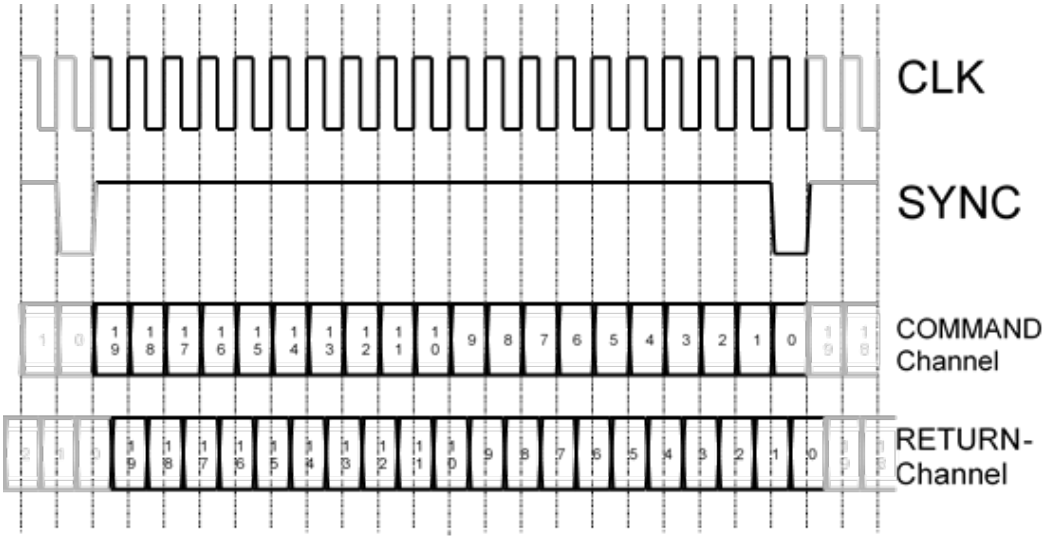


Figure 2: XY2-100-E Frame Timing

5.2 Frame Structure

Depending on data to be transmitted, the XY2-100-E Protocol defines differently structured frames.
The frames on the command channels can be distinguished from each other clearly due to static definition of certain header bit-patterns.
The frames on the return channels cannot be distinguished from each other by their header bit-patterns.
However, since the controller card specifies the data type present on each return channel at any given time, the data format of these frames is also known by the controller card.

5.2.1 Command Channel Frame Types

There are three different command channel frame types:
16 bit position (inherited from XY2-100 without -E)
18 bit position (inherited from XY2-100 without -E, RAYLASE SuperScan and SS-II deflection units)
Command frame (according XY2-100-E specification 8 bit command and 8 bit parameter)
The deflection unit can clearly distinguished between these three frame types due to their differing ID Byte patterns (I2, I1, I0), as illustrated in Figure 3.
The various frame types can appear in any arbitrary order.
The distinction between an 18-bit position frame and a command frame is determined by the differing parity. This means that under certain circumstances the deflection unit cannot identify parity errors.
The position (D15 - D0 or D17 - D0) is interpreted as unsigned integer where D0 is the least significant bit, and D15 or D17 the most significant bit.
A command frame transports a command byte (C7 - C0) and a related parameter byte (P7 - P0). The meaning of the parameter byte varies according to the command byte.

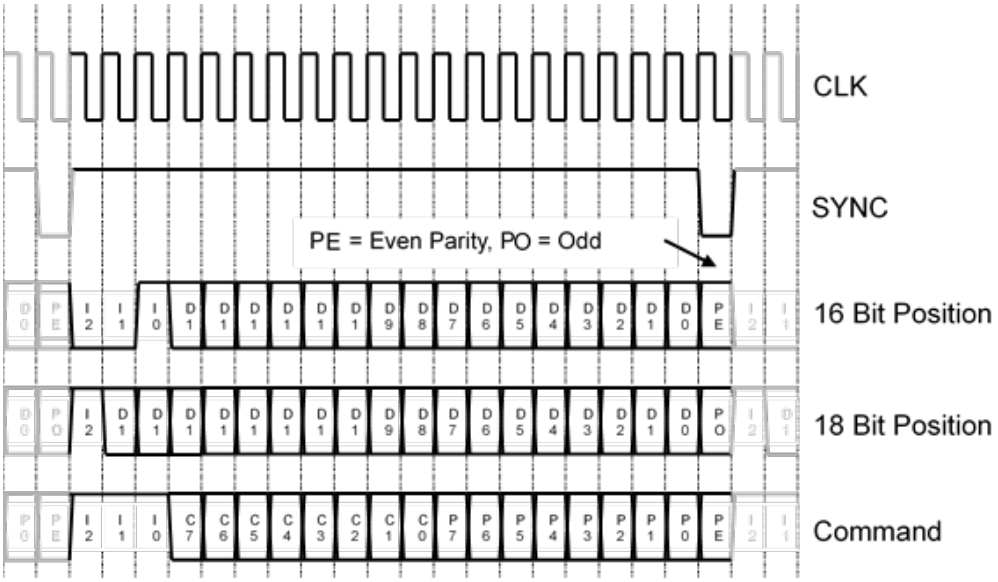


Figure 3: XY2-100-E Command Channel Frame Types

5.2.2 Return Channel Frame Types

The return channels carry various data for each deflection unit axis, as requested from time to time by the control card.
For reasons of backward-compatibility, there are three different frame types, which are not immediately distinguishable from each other by their structure alone.
Instead, interpretation of the received data frame must be based on the expected format due to the last sent command.
Figure 4illustrates the three possible return channel frame types.

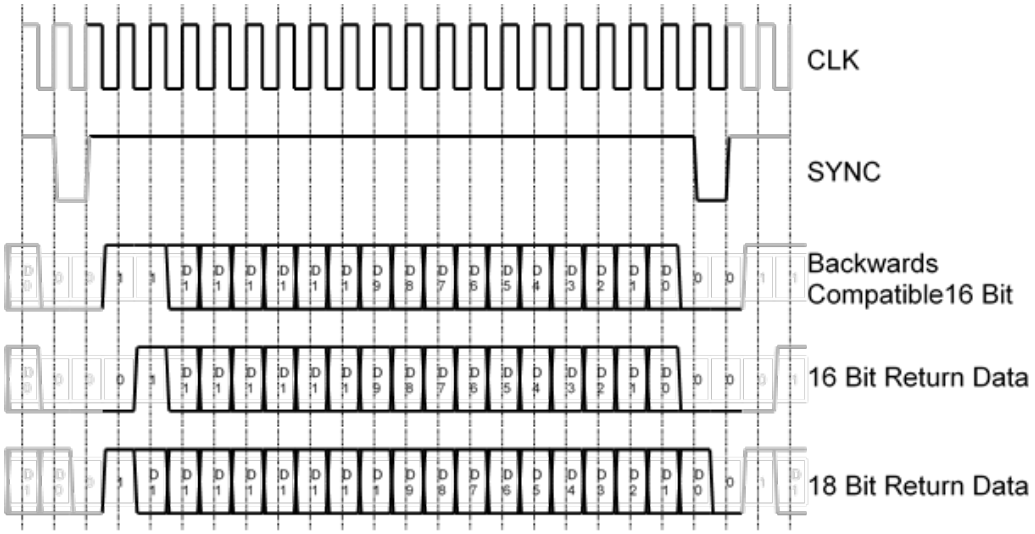


Figure 4: XY2-100-E Return Channel Frame Types

5.2.2.1 16 Bit Backward-Compatible Return Data

This differs from the standard 16 Bit Return Data by one control bit at the beginning of the frame.
This frame type is the same as used in RAYLASE analogue deflection units (e.g. SS-II series).

5.2.2.2 16 Bit Return Data

This is the standard return channel frame type.

5.2.2.3 18 Bit Return Data

This offers a four times higher resolution than the 16-bit frame types.

5.3 Mixing of Command Channel Frame Types

Normally, a 16- or 18-bit reference position is sent in each frame to each axis of the deflection unit.
By inserting individual command frames into the data stream, it is possible to influence the behaviour of the deflection unit.
During the 10 µs period in which the command frame is being transmitted, no reference position can be sent to the deflection unit. The latter therefore interpolates the missing position in-formation from the two nearest neighbouring positions sent by the control card.

6 SL2 AND RL3 RETURN CHANNEL FRAME FORMAT

Because SL2-100 and RL3-100 offer 20 bit resolution the returned 16-bit values are left-aligned to the 20-bit field by shifting them 4 bit to the left.
The lowest 4 bits are set to 0 in most cases. However, some returned values benefit from the increased resolution (e.g. Current Position). In that case, those 4 lower bits contain the least significant bits of the 20-bit value, which would get striped in XY2-100.
In contrast to XY2-100-E, SL2-100 and RL3-100 employ only one return channel frame type.

7 ENHANCED COMMANDS

This chapter describes how the behaviour of the deflection unit can be influenced and how various status data can be requested using appropriate commands.

7.1 Structure of a command

A command consists of two Bytes:

1. Command-Code
2. Parameter

These two Bytes are sent to the deflection unit within a command frame with D15-D8 as command code and D7-D0 as parameter.
Up to 256 different command codes are available, but SS-IV/V does not use all of them.
The meaning of the parameter varies depending on the command code.

7.2 Overview of all Commands

Command Code	Description	Details
0x05	**Set Data Source** Selects the data source for the return channel.	7.3.1 page 15
0x0A	**Save Settings** Saves current settings so that they persist after rebooting the deflection unit. Affected settings are: - Selected return data source (Set Data Source) - Selected tuning (- Select Tuning) - Position scale factor (- Set Position Scale Factor) - Tracking error range (Set Position Acknowledge Level) - Interpolation time (- Set Interpolation Time) - Mirror Tilt Angle (Set Mirror Tilt Angle)	7.3.2 page 36
0x11	**Select Tuning** Selects the current tuning parameters. The command allows selection from up to three preconfigured tunings. **Note: the axis is briefly in an undefined state until the selected tuning takes effect.**	7.3.3 page 36
0x12	**Set Position Scale Factor** Defines the mechanical deflection of the axis. This command is not supported by SS-IV/V.	7.3.4 page 36
0x15	**Set Position Acknowledge Level** Defines the tracking error limit. If the current tracking error exceeds this value, the PosAck bit in the status word is cleared.	7.3.5 page 37
0x17	**Data Source Storage** Parameter == 0xFF: temporarily save the currently selected return data source. Parameter == 0x00: the previously saved return data source will be restored.	7.3.6 page 37

Command Code	Description	Details
0x21	**Set Echo Data** Defines the return data statically based on the given parameter byte. The parameter byte is copied unaltered into the upper 8 bits of return data. The inverted parameter byte is copied into the lower 8 bits of return data.	7.3.7 page 37
0x90	**Set Interpolation Time** Defines the interpolation mode and interpolation time.	7.3.8 page 38
0x93	**Set Mirror Tilt Angle** Tilts the mirror so that an off-axis laser pointer or camera can cover the whole field.	7.3.9 page 39

7.3 Description of Commands

7.3.1 Set Data Source

This command selects the data source for the return channel.
Except as noted otherwise, all data sources employ 16 Bit Return Data.

Parameter Byte	Data Source Name	Details
0x00	Status Word	7.3.1.1 page 17
0x01	Current Position	7.3.1.2 page 18
0x02	Target Position	7.3.1.3 page 18
0x03	Position Error	7.3.1.4 page 19
0x04	Output Current	7.3.1.5 page 19
0x05	Relative Output Control	7.3.1.6 page 20
0x06	Current Velocity	7.3.1.7 page 20
0x14	Galvanometer Temperature	7.3.1.8 page 20
0x15	Servo Board Temperature	7.3.1.9 page 21
0x17	DSP Core Voltage	7.3.1.10 page 21
0x18	DSP IO Voltage	7.3.1.11 page 21
0x19	Analog Supply Voltage	7.3.1.12 page 22
0x1A	Main Supply Voltage	7.3.1.13 page 22
0x1E	Serial Number Low	7.3.1.14 page 22
0x1F	Serial Number High	7.3.1.15 page 23
0x20	Article Number Low	7.3.1.16 page 23
0x21	Article Number High	7.3.1.17 page 23
0x22	Firmware Version Number	7.3.1.18 page 24
0x24	Aperture	7.3.1.19 page 24
0x25	Wavelength	7.3.1.20 page 24
0x26	Tuning Selectors	7.3.1.21 page 25
0x27	Data Source Selectors	7.3.1.22 page 25

Parameter Byte	Data Source Name	Details
0x28	State Flags Low	7.3.1.23 page 26
0x29	State Flags High	7.3.1.24 page 27
0x2A	Stop Event Code	7.3.1.25 page 28
0x2B	Stop Flags Low	7.3.1.26 page 28
0x2C	Stop Flags High	7.3.1.27 page 29
0x2F	Running Time Seconds	7.3.1.28 page 29
0x30	Running Time Minutes	7.3.1.29 page 29
0x31	Running Time Hours	7.3.1.30 page 30
0x32	Running Time Days	7.3.1.31 page 30
0x3F	Position Scale	7.3.1.32 page 30
0x40	Position Acknowledge Level	7.3.1.33 page 31
0x50	Loop Control Tracking Error	7.3.1.34 page 31
0x51	Slew Rate Limit	7.3.1.35 page 32
0x55	Root-mean-square Current	7.3.1.36 page 32
0x56	Transfer Delay	7.3.1.37 page 32
0x57	Loop Transfer Delay	7.3.1.38 page 33
0x80	Compatible Status Word **Non-standard!** **16 Bit Backward-Compatible Return Data**	7.3.1.39 page 33
0x90	Interpolation Time Configuration	7.3.1.40 page 34
0x93	Mirror Tilt Angle	7.3.1.41 page 34
0x98	Auxiliary Temperature Sensor 1	7.3.1.42 page 35
0x99	Auxiliary Temperature Sensor 2	7.3.1.43 page 35
0x9A	Auxiliary Temperature Sensor 3	7.3.1.44 page 35

7.3.1.1 Status Word

Identifier			SetDataSource Parameter	
StatusWord			0x00	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	2x unsigned 8 bit	-

Description

Equivalent to the status word of the standard XY2-100 (without -E)

The status word consists of 8 bit, which are repeated, in upper and lower Byte.

Bit 15 and bit 7	= 1 : axis operational; = 0 : error
Bit 14 and bit 6	= 1: galvo temperature normal; = 0: galvo temperature error. (SS-IV/V always OK, as this temperature is not measured)
Bit 13 and bit 5	= 1: like bit 12 and bit 4, but for the Z-axis.
Bit 12 and bit 4	= 1: X-axis position within tracking error limit. Both bits are also reset when the axis is tilted (see 7.3.9 Set Mirror Tilt Angle, page 41)
Bit 11 and bit 3	= 1: like bit 12 and bit 4, but for the Y-axis.
Bit 10 and bit 2	= 1: auto calibration sensor inactive (always 1 if no sensor is installed)
Bit 9 and 1	= always 0
Bit 8 and 0	= always 1

7.3.1.2 Current Position

Identifier			SetDataSource Parameter	
CurrentPosition			0x01	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-32768	-	32767	Signed 16 bit	-
Description				
Current measured position of the mirror as 16 bit signed integer. 0 means that the axis is in the middle of the field. Provides the current position referenced to the non-tilted centre – even when the axis is tilted (see 7.3.9 Set Mirror Tilt Angle, page 39) Due to noise, it is possible for the measured value to exceed the available data range. In this case, the returned value saturates at the minimum or maximum possible value. When using SL2-100 this value has 20-bit resolution.				

7.3.1.3 Target Position

Identifier			SetDataSource Parameter	
TargetPosition			0x02	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-32768	-	32767	Signed 16 bit	-
Description				
Internal command position of the mirror as 16 bit signed integer. 0 means that the axis should be in the middle of the field. Provides the target position referenced to the non-tilted centre – even when the axis is tilted (see 7.3.9 Set Mirror Tilt Angle, page 39) Under certain circumstances (error condition, or shortly after switching on the supply voltage) the internal target position within the deflection unit may not be equal to the position commanded via XY2-100-E interface. When using SL2-100 this value has 20-bit resolution.				

7.3.1.4 Position Error

Identifier			SetDataSource Parameter	
PositionError			0x03	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-32768	-	32767	Signed 16 bit	-
Description				
A signed integer calculated from Target Position - Current Position. This value can overflow (e.g. when a jump from one extreme of axis travel to the other is requested), in which case the value saturates at -32768 or +32767. Even if this value is close to zero, there is no guarantee that the axis is at the commanded target position since the internal target position may not conform to the commanded position. This can occur, for instance, when the axis has not booted yet, or when an internal or transmission error occurs. When using SL2-100 this value offers 20-bit resolution.				

7.3.1.5 Output Current

Identifier			SetDataSource Parameter	
OutputCurrent			0x04	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-32768	-	32767	Signed 16 bit	mA
Description				
The measured galvo current in mA as signed integer. The maximum current can be +-10 A approximately. This value can be read starting with firmware Rev. 4977.				

7.3.1.6 Relative Output Control

Identifier			SetDataSource Parameter	
RelativeOutputControl			0x05	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-32767	-	32767	Signed 16 bit	1 / 32768
Description				
The relative output control level in 1 / 32768 parts of full scale. For example a value of 3267 corresponds to (3267 / 32678) = 10%. This value can be read starting with firmware Rev. 4977.				

7.3.1.7 Current Velocity

Identifier			SetDataSource Parameter	
CurrentVelocity			0x06	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-32768	-	32767	Signed 16 bit	bit/ms
Description				
The current angular speed of the axis in bit/ms. In case of under- or overflow, the value will be saturated at -32768 or +32767.				

7.3.1.8 Galvanometer Temperature

Identifier			SetDataSource Parameter	
GalvanometerTemperature			0x14	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
0 (0 °C)	-	1500 (150 °C)	Signed 16 bit	1/10 °C
Description				
The current temperature of the galvanometer scanner as signed integer in 1/10 °C. Values lower than zero indicate that there is not sensor present. This value can be read starting with firmware Rev. 6972.				

7.3.1.9 Servo Board Temperature

Identifier			SetDataSource Parameter	
ServoBoardTemperature			0x15	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-400 (-40 °C)	-	1200 (120 °C)	Signed 16 bit	1/10 °C
Description				
The current temperature of the servo board as signed integer in 1/10 °C.				

7.3.1.10 DSP Core Voltage

Identifier			SetDataSource Parameter	
DSPCoreVoltage			0x17	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
1.15 V (115)	1.2 V (120)	1.25 V (125)	Signed 16 bit	1/100 V
Description				
The current core voltage of the processor as signed integer in 1/100 V. The nominal value is 1.2 V.				

7.3.1.11 DSP IO Voltage

Identifier			SetDataSource Parameter	
DSPIOVoltage			0x18	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
3.1 V (310)	3.3 V (330)	3.5 V (350)	Signed 16 bit	1/100 V
Description				
The DSP IO voltage as signed integer in 1/100 V. The nominal value is 3.3 V.				

7.3.1.12 Analog Supply Voltage

Identifier			SetDataSource Parameter	
AnalogSupplyVoltage			0x19	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
8 V (800)	10 V (1000)	15 V (1500)	Signed 16 bit	1/100 V
Description				
The analog supply voltage as signed integer in 1/100 V. The nominal value is 10 V.				

7.3.1.13 Main Supply Voltage

Identifier			SetDataSource Parameter	
MainSupplyVoltage			0x1A	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
28 V (2800)	33 V (3300) or 48 V (4800)	50 V (5000)	Signed 16 bit	1/100 V
Description				
The input supply voltage as signed integer in 1/100 V. The nominal value is 33 V or 48 V. If the limits are exceeded, the axis is deactivated.				

7.3.1.14 Serial Number Low

Identifier			SetDataSource Parameter	
SerialNumberLow			0x1E	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	Unsigned 16 bit	-
Description				
The lower 16-bit word of the deflection unit's 32-bit serial number. The whole 32 bit serial number may be obtained from: **(65536 * Serial Number High) + Serial Number Low**				

7.3.1.15 Serial Number High

Identifier			SetDataSource Parameter	
SerialNumberHigh			0x1F	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	Unsigned 16 bit	-
Description				
The upper 16-bit word of the deflection unit's 32 bit serial number. The whole 32 bit serial number may be obtained from: **(65536 * Serial Number High) + Serial Number Low**				

7.3.1.16 Article Number Low

Identifier			SetDataSource Parameter	
ArticleNumberLow			0x20	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	Unsigned 16 bit	-
Description				
The lower 16-bit word of the deflection unit's 32-bit article number. The whole 32 bit article number may be obtained from: **(65536 * Article Number High) + Article Number Low**				

7.3.1.17 Article Number High

Identifier			SetDataSource Parameter	
ArticleNumberHigh			0x21	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	Unsigned 16 bit	-
Description				
The upper 16-bit word of the deflection unit's 32-bit article number. The 32 bit article number may be obtained from: **(65536 * Serial Number High) + Article Number Low**				

7.3.1.18 Firmware Version Number

Identifier			SetDataSource Parameter	
FirmwareVersionNumber			0x22	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	Unsigned 16 bit	-
Description				
The version of the firmware of the axis.				

7.3.1.19 Aperture

Identifier			SetDataSource Parameter	
Aperture			0x24	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	Signed 16 bit	mm
Description				
The aperture of the mirror on the axis in mm.				

7.3.1.20 Wavelength

Identifier			SetDataSource Parameter	
Wavelength			0x25	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	Signed 16 bit	nm
Description				
The design wavelength of the mirror coating in nm.				

7.3.1.21 Tuning Selectors

Identifier			SetDataSource Parameter	
TuningSelectors			0x26	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	2x unsigned 8 bit	-
Description				
The lower 8 bits (D7 to D0) hold the selector for the currently active tuning. The active tuning can be selected by the command 7.3.3 Select Tuning, page 36. The upper 8 bits (D15 to D8) hold the selector for the default tuning which is loaded automatically after booting. The command Save Settings, 7.3.2 page 36, can be used to make the currently active tuning become the default tuning.				

7.3.1.22 Data Source Selectors

Identifier			SetDataSource Parameter	
DataSourceSelectors			0x27	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	2x unsigned 8 bit	-
Description				
The lower 8 bits (D7 to D0) hold the number of the currently selected return data source. Consequently, the lower 8 bits are always 0x27. The upper 8 bits (D15 to D8) hold the selector for the default return data source, which is loaded automatically after booting. The command Save Settings,7.3.2 page 36, can be used to make the currently selected data source become the default.				

7.3.1.23 State Flags Low

Identifier			SetDataSource Parameter	
StateFlagsLow			0x28	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	Flags 16 bit	-

Description

Bit 15	= 1: Output stage active.
Bit 14	= 0: Galvo heating inactive (SS-IV/V has no galvo heating).
Bit 13	= 1: All voltages (including internally generated) within allowed range.
Bit 12	= 1: Tracking error is within the tracking error window (adjustable via 7.3.5 Set Position Acknowledge Level, page 37)
Bit 11	= 1: Servo board temperature normal (i.e. under 80°C)
Bit 10	= 1: Boot process finished.
Bit 9	= 1: No permanent errors.
Bit 8	= 1: External supply voltages OK.
Bit 7	= 1: Servo board temperature normal (i.e. under 80°C).
Bit 6	= 1: ADC initialized.
Bit 5	= 1: Axis is not in a critical position.
Bit 4	= 1: Controller parameters OK.
Bit 3	= 1: Mirror is not tilted (see command 7.3.9 Set Mirror Tilt Angle, page 39).
Bit 2	= 1: Axis in standard control mode
Bit 1	= 1: unused
Bit 0	= 0: Position control of the axis is active.

7.3.1.24 State Flags High

Identifier			SetDataSource Parameter	
StateFlagsHigh			0x29	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	Flags 16 bit	-

Description

Bit 15	= 1: AGC of position detector within allowed range.
Bit 14	= 1: Analog supply voltages OK.
Bit 13	= 1: ADC supply voltage OK (2.5 V)
Bit 12	= 1: DSP supply voltage OK (3.3 V)
Bit 11	= 1: DSP core voltage OK (1.2 V)
Bit 10	= 1: Servo board temperature okay
Bit 9	= 1: Galvo temperature okay
Bit 8	= 1: Measured current of the output stage is in the allowed range.
Bit 7	= 1: Target value of the current of the output stage okay
Bit 6	= 1: unused
Bit 5	= 1: unused
Bit 4	= 1: unused
Bit 3	= 1: unused
Bit 2	= 1: unused
Bit 1	= 1: unused
Bit 0	= 1: unused

7.3.1.25 Stop Event Code

Identifier			SetDataSource Parameter	
StopEventCode			0x2A	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	0	-	Unsigned 16 bit	-
Description				

The cause of the latest error

0x0000	no error
0x0001	Galvanometer reached a critical edge position (unused)
0x0002	ADC error (unused)
0x0003	Temperature too high.
0x0004	External supply voltage outside allowed range.
0x0005	Invalid flags (unused).
0x0006 – 0x000C	Reserved (unused).
0x000D	Watchdog (unused)
0x000E	Position error excessively high for too long a time (unused)
0x000F	Reserved (unused)
0x0010	Error in the current controller of the output stage (transient load too high)
0x0011 – 0xFFFF	Unused

7.3.1.26 Stop Flags Low

Identifier			SetDataSource Parameter	
StopFlagsLow			0x2B	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	Flags 16 bit	-
Description				

The state of the flags (State Flags Low) at the time of the last triggered error state.

7.3.1.27 Stop Flags High

Identifier			SetDataSource Parameter	
StopFlagsHigh			0x2C	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	Flags 16 bit	-
Description				
The state of flags (State Flags High) at the time of the last triggered error state.				

7.3.1.28 Running Time Seconds

Identifier			SetDataSource Parameter	
RunningTimeSeconds			0x2F	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
0	-	59	Signed 16 bit	seconds
Description				
The seconds part of the total running time of the axis. This value is incremented once per second up to 59, at which point a carry over to Running Time Minutes occurs, and the value is reset to 0. The total running time of the axis is persistent over power cycles.				

7.3.1.29 Running Time Minutes

Identifier			SetDataSource Parameter	
RunningTimeMinutes			0x30	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
0	-	59	Signed 16 bit	minutes
Description				
The minutes part of the total running time of the axis. This value is incremented once per minute up to 59, at which point a carry over to Running Time Hours, page 30, occurs, and the value is reset to 0. The total running time of the axis is persistent over power cycles.				

7.3.1.30 Running Time Hours

Identifier			SetDataSource Parameter	
RunningTimeHours			0x31	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
0	-	23	Signed 16 bit	hours
Description				
The hours part of the total running time of the axis. This value is incremented once per hour up to 23, at which point a carry over to 7.3.1.31 Running Time Days, page 30, occurs - and the value is reset to 0. The total running time of the axis is persistent over power cycles.				

7.3.1.31 Running Time Days

Identifier			SetDataSource Parameter	
RunningTimeDays			0x32	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
0	-	32767	Signed 16 bit	days
Description				
The days part of the total running time of the axis. This value is incremented once per day. The total running time of the axis is persistent over power cycles.				

7.3.1.32 Position Scale

Identifier			SetDataSource Parameter	
Position Scale			0x3F	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	0	-	Signed 16 bit	-
Description				
Not supported				

7.3.1.33 Position Acknowledge Level

Identifier			SetDataSource Parameter	
PositionAcknowledgeLevel			0x40	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	2x unsigned 8 bit	-
Description				
The lower 8 bits (D7 to D0) hold the currently set Position Acknowledge Level. The configuration of the Position Acknowledge Level is described in 7.3.5 Set Position Acknowledge Level, page 37. The upper 8 bits (D15 to D8) reflect the default Position Acknowledge Level that is automatically loaded after switching on the supply voltage of the axis. The command 7.3.2, Save Settings, page 36, can be used to store the currently set Position Acknowledge Level as the default to be loaded automatically after booting.				

7.3.1.34 Loop Control Tracking Error

Identifier			SetDataSource Parameter	
CtrlTrackingError			0x50	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
Range				
Description				
Returns the tracking error of the position loop controller in microseconds. It only reports the tracking error of the loop controller itself and does not include the transfer delay of the position demand to the loop controller. This value can be read starting with firmware Rev. 6972.				

7.3.1.35 Slew Rate Limit

Identifier			SetDataSource Parameter	
SlewRateLimit			0x51	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	Unsigned 16 bit	increments / ms
Description				
Returns the maximum velocity in position increments per millisecond. If the velocity of the commanded position is larger that this value the velocity gets limited to this value. When interpreted as a 16 bit value the maximum velocity is 65535 (2^16-1) increments / ms which corresponds to a full field per millisecond. When interpreted as a 20 bit value the maximum velocity is 1048575 (2^20-1) increments / ms which also corresponds to a full field per millisecond. This value can be read starting with firmware Rev. 6972.				

7.3.1.36 Root-mean-square Current

Identifier			SetDataSource Parameter	
RmsCurrent			0x55	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	Unsigned 16 bit	mA
Description				
Returns the measured root mean square galvo current of the last second in milliampere. This value can be read starting with firmware Rev. 6972.				

7.3.1.37 Transfer Delay

Identifier			SetDataSource Parameter	
TransferDelay			0x56	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	Unsigned 16 bit	µs
Description				
Returns the XY2-, SL2- and RL3-protocol position transfer delay between the control card and the loop controller in microseconds. This value can be read starting with firmware Rev. 6972.				

7.3.1.38 Loop Transfer Delay

Identifier			SetDataSource Parameter	
LoopTransferDelay			0x57	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	Unsigned 16 bit	µs
Description				
Returns XY2, SL2 and RL3 protocol delay that elapses between the moment when position command is sent to the loop controller and the moment when this position command is received by the controller card via feedback channel. This value can be read starting with firmware Rev. 6972.				

7.3.1.39 Compatible Status Word

Identifier			SetDataSource Parameter	
Compatible Status Word			0x80	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	2x unsigned 8 bit, SS-II compatible frame format	-
Description				
Conforms to the status word of the standard XY2-100 (without -E). The only difference from Status Word is that the 16 Bit Backward-Compatible Return Data frame is used instead of 16 Bit Return Data frame. The return data are identical to those of the SS-II. The meaning and the function of the data bits are identical to those provided by 7.3.1.1 Status Word, page 17.				

7.3.1.40 Interpolation Time Configuration

Identifier			SetDataSource Parameter	
InterpolationTimeConfiguration			0x90	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
-	-	-	2x Unsigned 8 bit	
Description				
The lower 8 bits (D7 to D0) hold the currently set interpolation time. The upper 8 bits (D15 to D8) hold the default interpolation time, which is loaded automatically after booting. The command 7.3.2 Save Settings, page 36, can be used to store the current interpolation time as the default. The current interpolation time can be set with the command 7.3.8 Set Interpolation Time, page 38. The significance of the bits in both returned bytes is also described there.				

7.3.1.41 Mirror Tilt Angle

Identifier			SetDataSource Parameter	
MirrorTiltAngle			0x93	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
Dependent on axis and scan head type	High Byte: 0 Low Byte: dependent on scan head type	Dependent on axis and scan head type	2 x signed 8 bit	1/128 of total deflection
Description				
The lower 8 bits (D7 to D0) contain the current tilt angle of the axis. The tilt angle can be set with the command 7.3.9 Set Mirror Tilt Angle, page 39. The upper 8 bits (D15 to D8) are reserved. After booting, the axis is not tilted.				

7.3.1.42 Auxiliary Temperature Sensor 1

Identifier			SetDataSource Parameter	
AuxTemp1			0x98	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
0 (0 °C)	-	1200 (120 °C)	Signed 16 bit	1/10 °C
Description				
The current temperature of the first auxiliary temperature sensor as signed integer in 1/10 °C. Values lower than zero indicate that there is not sensor present.				

7.3.1.43 Auxiliary Temperature Sensor 2

Identifier			SetDataSource Parameter	
AuxTemp2			0x99	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
0 (0 °C)	-	1200 (120 °C)	Signed 16 bit	1/10 °C
Description				
The current temperature of the second auxiliary temperature sensor as signed integer in 1/10 °C. Values lower than zero indicate that there is not sensor present.				

7.3.1.44 Auxiliary Temperature Sensor 3

Identifier			SetDataSource Parameter	
AuxTemp3			0x9A	
Range				
Minimum	**Nominal**	**Maximum**	**Data type**	**Unit**
0 (0 °C)	-	1200 (120 °C)	Signed 16 bit	1/10 °C
Description				
The current temperature of the third auxiliary temperature sensor as signed integer in 1/10 °C. Values lower than zero indicate that there is not sensor present.				

7.3.2 Save Settings

Identifier	Command Code
SaveSettings	0x0A
Description	
Saves the current settings as defaults in order to make them available after re-booting the deflection unit. Following settings are saved: - Selected data source return channel 7.3.1 Set Data Source, page 15) - Selected tuning set (7.3.3 Select Tuning, page 36) - Current position scaling factor (7.3.4 Set Position Scale Factor, page 36) - Limit of the tracking error (7.3.5 Set Position Acknowledge Level, page 37) - Interpolation time (7.3.8 Set Interpolation Time, page 38) - Mirror Tilt Angle (7.3.9 Set Mirror Tilt Angle, page 39) In order to execute this command, 0x00 must be sent as parameter. Thus, the 16 bit payload of the command frame must be exactly 0x0A00. This command can be executed during normal operating mode without interrupting the axis movement.	

7.3.3 Select Tuning

Identifier	Command Code
SelectTuning	0x11
Description	
This command allows different tuning sets to be selected. The tuning sets are optionally pre-configured by RAYLASE. The goal of different tuning sets is to adjust the dynamic behaviour of the deflection unit during operation. The SS-IV/V series can support up to three different tuning sets. The selector for the desired tuning set should be passed in the parameter. Valid parameter values are 0, 1 and 2. All the other parameter values are ignored. Tunings cannot be switched dynamically: when Select Tuning is received, the servo controller is stopped and then restarted with the new parameters. The return data source 7.3.1.21 Tuning Selectors, page 25, provides the currently set tuning and the default tuning, which is loaded automatically after booting. 7.3.2 Save Settings, page 36, can be used to make the currently selected tuning become the default.	

7.3.4 Set Position Scale Factor

This command is not supported by SS-IV/V.

7.3.5 Set Position Acknowledge Level

Identifier	Command Code
SetPositionAcknowledgeLevel	0x15
Description	
This command specifies the tracking error window. The default value is 183 (equal to 0.28% of the axis range). If the position error exceeds the tracking error window, PosAck bits are reset to 0 in the return data sources - 7.3.1.1 Status Word, page 17, - 7.3.1.23 State Flags Low, page 26, and - 7.3.1.39 Compatible Status Word, page 33. The current position error can be requested from the return data source 7.3.1.4 Position Error, page 19.	

7.3.6 Data Source Storage

Identifier	Command Code
DataSourceStorage	0x17
Description	
The action performed by this command depends on the parameter:	

Parameter	Action
0x00	Saves the current return channel data source temporarily. (NB: only until the axis is rebooted)
0xFF	Restores the return channel data source, which was previously saved.

7.3.7 Set Echo Data

Identifier	Command Code
SetEchoData	0x21
Description	
This command specifies the returned data directly. The upper 8 bits of the returned data are set equal to the parameter byte. The lower 8 bits of the returned data are set equal to the complement of the parameter byte. With this command, the XY2-100-E interface can be tested for transmission errors.	

7.3.8 Set Interpolation Time

Identifier	Command Code
SetInterpolationTime	0x90

Description

This command sets the configuration of the interpolation of target positions for the axes. The meaning of the individual bits of the parameter byte is described in the table below.

The current interpolation configuration can be obtained from the return data source 7.3.1.40 Interpolation Time Configuration, page 34.

The configuration can be saved permanently with the command Save Settings, page 36.

IMPORTANT NOTE for SS-IV/V:

- **The configuration sent to the Y-axis is used for both X and Y-axes.**
- **Any separate configuration sent to the X-axis will be ignored.**

Bit 7 down to 1	Interpolation time in steps of 2 micro seconds (0 => 0us, 1 => 2us, …, 127 => 254µs) When target positions are sent via XY2-100-E at shorter intervals than specified here, linear interpolation between neighbouring target positions is performed. Note, however, that all movements of the axis are delayed by the specified interpolation time. The total tracking delay time is increased by this amount. The effective tracking delay of the position controller itself does not change. Corners of marked objects, for instance, do not become rounded; they are simply marked slightly later. If necessary, the laser delay times should be adjusted. Default: 120us (60)
Bit 0	If this bit is set to '1', single repetitions of target positions are ignored. This is necessary when using SP-ICE-1 PCI PRO or SP-ICE-2 control cards with SS-IV/V, since these cards transmit each target position twice consecutively. If both identical target positions were considered in the interpolation, the interpolated positions would proceed in steps rather than smoothly. For control cards, which do not send double position data it does not matter, if this mode is active (bit set to '1') as the second target position is ignored only if it is identical to the previous one. Default: '1' (active)

7.3.9 Set Mirror Tilt Angle

Identifier	Command Code
SetMirrorTiltAngle	0x93

Description

This command allows compensation of the position offset resulting from an off-axis laser pointer or camera.

The 8-bit parameter of this command is signed integer. The value range is -128 to +127. The unit is 1/128 of the complete deflection range, which for RAYLASE heads usually is +/- 22.5 ° optical. However, in order to avoid mirror collisions the possible tilt range is limited dependent on the deflection unit type.

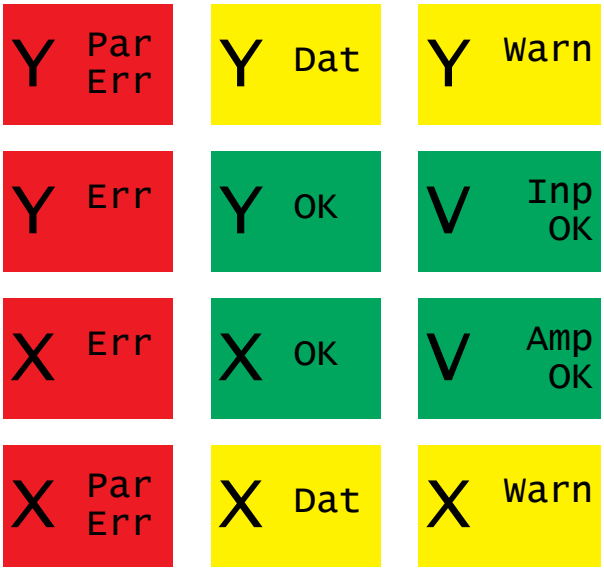
The currently set tilt angle can be retrieved from the return data source 7.3.1.41 Mirror Tilt Angle, page 34.

After booting the scan head, the axis is not tilted.

Concerning tilt angle the following return data sources are of interest:

Data Source	Section	Page	Effect
Status Word	7.3.1.1	17	Tracking error bit will be reset if the axis is tilted.
Compatible Status Word	7.3.1.39	33	
State Flags Low	7.3.1.23	26	Bit 3 will be reset if the axis is tilted. The tracking error bit (bit 12) is not affected.
Mirror Tilt Angle	7.3.1.41	34	Returns currently effective tilt angle
Current Position	7.3.1.2	18	Provides the current position referenced to the non-tilted centre – even when the axis is tilted. Therefore, this signal can be used for position verification. At the edge of the field, the signal will be saturated.
Target Position	7.3.1.3	18	Provides the target position referenced to the non-tilted centre – even when the axis is tilted. At the edge of the field, the signal will be saturated.
Position Error	7.3.1.4	19	Provides the tracking error of the controller always. This signal is therefore not suitable for position verification.

8 STATUS-LEDS (SS-IV ONLY)



LED Label	Description
Y Par Err **X Par Err**	Flashes red if a parity error on the Y or X channel of the XY2-100-E or SL2-100 is detected. The flash duration is extended so that even single frame errors are visible. Both LEDs light continuously if no correct frames are received on either XY2-100-E or SL2-100 interface. If frames are received on both XY2-100-E and SL2-100 interfaces, both LEDs blink alternately with a half second period.
Y Dat **X Dat**	Flashes yellow when the frame content on the Y or X channel of the XY2-100-E or SL2-100 interface changes. The flash duration is extended so that even single frame changes are visible.
Y Err **X Err**	Lights red if the Y or X-axis reports an error and while the scan head is booting. If X/Y OK and X/Y Err LEDs light both at the same time an internal error has occurred.
Y OK **X OK**	Lights green if the Y or X-axis is operational. If X/Y OK and X/Y Err LEDs light both at the same time an internal error has occurred.
Y Warn **X Warn**	Lights yellow if the Y or X amplifier reaches the maximum duty cycle. This means that the marking job is too demanding for the deflection unit at the supplied operating voltage. To solve the problem, either increase the supplied voltage to 48 V, reduce the marking velocity, or accept inferior marking quality.
V In OK	Lights green when the power supply is connected (30 V or 48 V)
V Amp OK	Lights green if output stage supply voltage is OK.

9 USAGE OF THE PILOT LASER

A SS-IV with the option Mirror Tilt, combined with a digital LTM (Linear Translator Module) with the optional Laser Pointer, allows the laser pointer to be coupled into the optical path without additional optics.

In order to use this feature, a sequence of commands must be sent to the X, Y, and Z-axes.

9.1 Activation sequence for the laser pointer

<table>
<tr><th colspan="2">Command or
Return Data Source</th><th>Description</th></tr>
<tr><td>1</td><td>Status Word
(7.3.1.1 page 17)</td><td>Verify that X, Y, and Z axes are error free.
The retrieved status for all three axes must match the bit pattern in the following table.
Bits marked with “X” can be ignored.
<table>
<tr><th>Bit</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><th></th><th>E</th><th>T</th><th>Z</th><th>X</th><th>Y</th><th>F</th><th>0</th><th>1</th><th>E</th><th>T</th><th>Z</th><th>X</th><th>Y</th><th>F</th><th>0</th><th>1</th></tr>
<tr><th>X</th><td>1</td><td>1</td><td>X</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td><td>1</td><td>1</td><td>X</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td></tr>
<tr><th>Y</th><td>1</td><td>1</td><td>X</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td><td>1</td><td>1</td><td>X</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td></tr>
<tr><th>Z</th><td>1</td><td>1</td><td>X</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td><td>1</td><td>1</td><td>X</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td></tr>
</table>
</td></tr>
<tr><td>2</td><td>Set Mirror Tilt Angle
(7.3.9 page 39)</td><td>Set tilt angle for X- and Y-axes.</td></tr>
<tr><td>3</td><td>Mirror Tilt Angle
(7.3.1.41 page 34)</td><td>Verify that axes have accepted the tilt command.
Wait until the low bytes of the X- and Y-axes show the requested tilt angle.
<table>
<tr><th></th><th>High-Byte</th><th>Low-Byte</th></tr>
<tr><th>X-axis</th><td>To be ignored</td><td>X tilt angle</td></tr>
<tr><th>Y-axis</th><td>To be ignored</td><td>Y tilt angle</td></tr>
</table>
</td></tr>
<tr><td>4</td><td>Position Error
(7.3.1.4 page 19)19</td><td>Verify that the axes have reached the tilted position.
The absolute value of the position error of the X- and Y-axes must be smaller than the expected maximum error.
The retrieved values are 16 bit signed integers.</td></tr>
</table>

<table>
<tr><th colspan="2">Command or
Return Data Source</th><th>Description</th></tr>
<tr><td>5</td><td>Status Word
(7.3.1.1 page 17)</td><td>Verify that X, Y, and Z axes are error free.
The retrieved status for all three axes must match the bit pattern in the following table.
Bits marked with “X” can be ignored.
<table>
<tr><th>Bit</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><th></th><th>E</th><th>T</th><th>Z</th><th>X</th><th>Y</th><th>F</th><th>0</th><th>1</th><th>E</th><th>T</th><th>Z</th><th>X</th><th>Y</th><th>F</th><th>0</th><th>1</th></tr>
<tr><th>X</th><td>1</td><td>1</td><td>X</td><td>0</td><td>X</td><td>X</td><td>0</td><td>1</td><td>1</td><td>1</td><td>X</td><td>0</td><td>X</td><td>X</td><td>0</td><td>1</td></tr>
<tr><th>Y</th><td>1</td><td>1</td><td>X</td><td>X</td><td>0</td><td>X</td><td>0</td><td>1</td><td>1</td><td>1</td><td>X</td><td>X</td><td>0</td><td>X</td><td>0</td><td>1</td></tr>
</table></td></tr>
<tr><td>6</td><td>Set Mirror Tilt Angle
(7.3.9 page 39)</td><td>Activate the laser pointer by sending command Set Mirror Tilt Angle with parameter 0x01 to the Z-axis.</td></tr>
<tr><td>7</td><td>Mirror Tilt Angle
(7.3.1.41 page 34)</td><td>Verify that the laser pointer activation command has been accepted by the Z-axis.
Wait until the low-byte of the return data of the Z-axis provides the value 0x01.
<table>
<tr><th></th><th>High-Byte</th><th>Low-Byte</th></tr>
<tr><th>Z-axis</th><td>To be ignored</td><td>0x01</td></tr>
</table></td></tr>
<tr><td>8</td><td>Status Word
(7.3.1.1 page 17)</td><td>Verify that X, Y, and Z axes are error free.
The retrieved status for all three axes must match the bit pattern in the following table.
Bits marked with “X” can be ignored.
<table>
<tr><th>Bit</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><th></th><th>E</th><th>T</th><th>Z</th><th>X</th><th>Y</th><th>F</th><th>0</th><th>1</th><th>E</th><th>T</th><th>Z</th><th>X</th><th>Y</th><th>F</th><th>0</th><th>1</th></tr>
<tr><th>X</th><td>1</td><td>1</td><td>X</td><td>0</td><td>X</td><td>X</td><td>0</td><td>1</td><td>1</td><td>1</td><td>X</td><td>0</td><td>X</td><td>X</td><td>0</td><td>1</td></tr>
<tr><th>Y</th><td>1</td><td>1</td><td>X</td><td>X</td><td>0</td><td>X</td><td>0</td><td>1</td><td>1</td><td>1</td><td>X</td><td>X</td><td>0</td><td>X</td><td>0</td><td>1</td></tr>
<tr><th>Z</th><td>1</td><td>1</td><td>0</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td></tr>
</table></td></tr>
</table>

9.2 Deactivation sequence for the laser pointer

<table>
<tr><th colspan="2">Command or
Return Data Source</th><th>Description</th></tr>
<tr><td>1</td><td>Status Word
(7.3.1.1 page 17)</td><td>Check that X, Y, and Z axes are error free.
The retrieved status for all three axes must match the bit pattern in the following table.
Bits marked with “X” can be ignored.
<table>
<tr><th>Bit</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><th></th><th>E</th><th>T</th><th>Z</th><th>X</th><th>Y</th><th>F</th><th>0</th><th>1</th><th>E</th><th>T</th><th>Z</th><th>X</th><th>Y</th><th>F</th><th>0</th><th>1</th></tr>
<tr><td>X</td><td>1</td><td>1</td><td>X</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td><td>1</td><td>1</td><td>X</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td></tr>
<tr><td>Y</td><td>1</td><td>1</td><td>X</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td><td>1</td><td>1</td><td>X</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td></tr>
<tr><td>Z</td><td>1</td><td>1</td><td>X</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td><td>1</td><td>1</td><td>X</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td></tr>
</table></td></tr>
<tr><td>2</td><td>Set Mirror Tilt Angle
(7.3.9 page 39)</td><td>Deactivate the laser pointer by sending command Set Mirror Tilt Angle with parameter 0x00 to the Z-axis.</td></tr>
<tr><td>3</td><td>Mirror Tilt Angle
(7.3.1.41 page 34)</td><td>Verify that the laser pointer has been deactivated.
Wait until the low-byte of the return channel of the Z-axis provides the value 0.
<table>
<tr><th>High-Byte</th><th>Low-Byte</th></tr>
<tr><td>To be ignored</td><td>0x00</td></tr>
</table></td></tr>
<tr><td>4</td><td>Set Mirror Tilt Angle
(7.3.9 page 39)</td><td>Reset the tilt angle for X- and Y-axes to zero.</td></tr>
<tr><td>5</td><td>Mirror Tilt Angle
(7.3.1.41 page 34)</td><td>Verify that the tilt command has been accepted by the axes.
Wait until the Low-Bytes of the X- and Y-axes show the value zero.
<table>
<tr><th>High-Byte</th><th>Low-Byte</th></tr>
<tr><td>To be ignored</td><td>0x00</td></tr>
</table></td></tr>
</table>

<table>
<tr><th colspan="2">Command or
Return Data Source</th><th>Description</th></tr>
<tr><td>6</td><td>Status Word
(7.3.1.1 page 17)</td><td>
Check that X, Y, and Z axes are error free.
The retrieved status for all three axes must match the bit pattern in the following table.
Bits marked with “X” can be ignored.
<table>
<tr><th>Bit</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>9</th><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><th></th><th>E</th><th>T</th><th>Z</th><th>X</th><th>Y</th><th>F</th><th>0</th><th>1</th><th>E</th><th>T</th><th>Z</th><th>X</th><th>Y</th><th>F</th><th>0</th><th>1</th></tr>
<tr><td>X</td><td>1</td><td>1</td><td>X</td><td>1</td><td>X</td><td>X</td><td>0</td><td>1</td><td>1</td><td>1</td><td>X</td><td>1</td><td>X</td><td>X</td><td>0</td><td>1</td></tr>
<tr><td>Y</td><td>1</td><td>1</td><td>X</td><td>X</td><td>1</td><td>X</td><td>0</td><td>1</td><td>1</td><td>1</td><td>X</td><td>X</td><td>1</td><td>X</td><td>0</td><td>1</td></tr>
<tr><td>Z</td><td>1</td><td>1</td><td>X</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td><td>1</td><td>1</td><td>X</td><td>X</td><td>X</td><td>X</td><td>0</td><td>1</td></tr>
</table>
Explanation:
The X- and Y-axes must reach the correct “non-tilted” position.
Therefore, the PosAck bits for X- and Y-axes must be “1”.
The PosAck bit for the Z-axis may stay at “0” since the Z-axis has a larger tracking error.
</td></tr>
</table>

10 COMMAND LOCKING

If certain enhanced-commands are executed accidentally, the marking result may well be adversely affected.
To help prevent accidental execution, a locking mechanism is supported, starting with firmware version 5726.
This requires that a specific unlock sequence is executed before any of the protected commands can be executed. After this, a lock sequence should be executed to protect against accidental execution again.

10.1 Protected Commands

1. Save Settings, chapter 7.3.2 on page 36
2. Select Tuning, chapter 7.3.3 on page 36
3. Set Position Scale Factor, chapter 7.3.4 on page 36
4. Set Interpolation Time, chapter 7.3.8 on page 38
5. Set Mirror Tilt Angle, chapter 7.3.9 on page 39

10.2 Unlock Sequence

The following enhanced-commands must be executed in the exact order shown:

0x1C10, 0x02D5, 0x03A2, 0x0458, 0x1300

Repetition of individual commands is permitted as long as the order is kept.

10.3 Lock Sequence

The following enhanced-commands must be executed in the exact order shown:

0x0100, 0x1300

Repetition of individual commands is permitted as long as the order is kept.

10.4 Example (Tuning Switch)

1. 0x1C10 (Unlock Sequence part 1)
2. 0x02D5 (Unlock Sequence part 2)
3. 0x03A2 (Unlock Sequence part 3)
4. 0x0458 (Unlock Sequence part 4)
5. 0x1300 (Unlock Sequence part 5)
6. 0x1101 (Switch to Tuning 1; Select Tuning, chapter 7.3.3 on page 36)
7. 0x0100 (Lock Sequence part 1)
8. 0x1300 (Lock Sequence part 2)

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