User Guide

PSO-200

Optical Modulation Analyzer

www.EXFO.com

Telecom Test and Measurement

EXPERTISE REACHING OUT

EXFO's Commerce And Government Entities (CAGE) code under the North Atlantic Treaty Organization (NATO) is 0L8C3.

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Trademarks

EXFO's trademarks have been identified as such. However, the presence or absence of such identification does not affect the legal status of any trademark.

Units of Measurement

Units of measurement in this publication conform to SI standards and practices.

Patents

EXFO's Universal Interface is protected by US patent 6,612,750.

Version number: 2.0.1

Contents

Certification Information

North America Regulatory Statement

This unit was certified by an agency approved in both Canada and the United States of America. It has been evaluated according to applicable North American approved standards for product safety for use in Canada and the United States.

Electronic test and measurement equipment is exempt from FCC part 15, subpart B compliance in the United States of America and from ICES-003 compliance in Canada. However, EXFO Inc. makes reasonable efforts to ensure compliance to the applicable standards.

The limits set by these standards are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the user guide, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

IMPORTANT

Use of shielded remote I/O cables, with properly grounded shields and metal connectors, is recommended in order to reduce radio frequency interference that may emanate from these cables.

European Community Declaration of Conformity

DECLARATION OF CONFORMITY

Application of Council Directive(s):	2006/95/EC - The Low Voltage Directive 2004/108/EC - The EMC Directive 2006/66/EC - The Battery Directive 93/68/EEC - CE Marking And their amendments
Manufacturer's Name:	EXFO Inc.
Manufacturer's Address:	400 Godin Avenue Quebec, Quebec Canada, G1M 2K2 (418) 683-0211
Equipment Type/Environment:	Test & Measurement / Industrial
Trade Name/Model No.:	PSO-200 / Optical Modulation Analyzer

Standard(s) to which Conformity is Declared:

EN 61010-1:2001 Edition 2.0	**Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements.**
EN 61326-1:2006	**Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements – Part 1: General requirements**
EN 60825-1:2007 Edition 2.0	**Safety of laser products – Part 1: Equipment classification, requirements, and user's guide**
EN 55022: 2006 + A1: 2007	**Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement**

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directive and Standards.

Manufacturer
Signature:

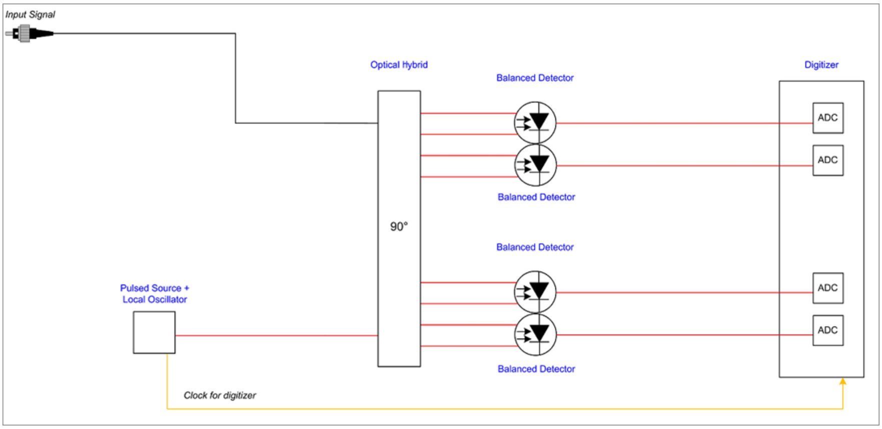
Full Name:	Stephen Bull, E. Eng
Position:	Vice-President Research and Development
Address:	400 Godin Avenue, Quebec (Quebec), Canada, G1M 2K2
Date:	August 17, 2010

1 Introducing the PSO-200 Optical Modulation Analyzer

As new advanced modulation schemes enable the transmission of high-speed optical signals over fiber, research centers, network equipment manufacturers and eventually carriers need new test instruments to properly characterize these signals.

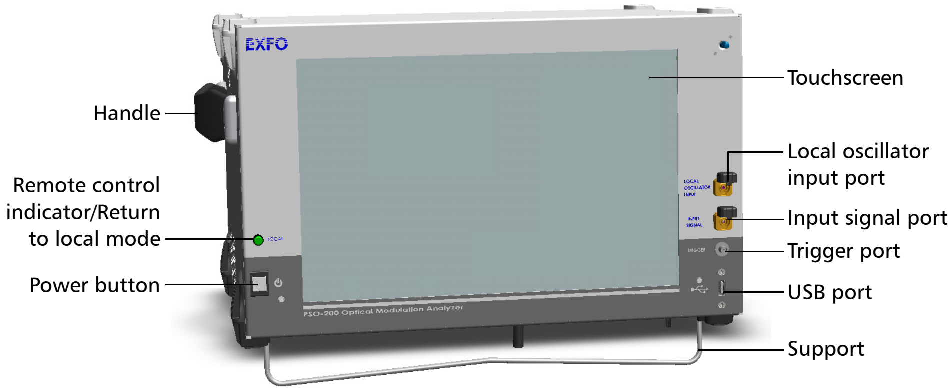
Main Features

The PSO-200 Optical Modulation Analyzer uses equivalent-time optical sampling, allowing the complete characterization of random or repetitive digital signals at 100 Gb/s, 400 Gb/s, 1 Tb/s and beyond.



The PSO-200 displays constellation charts, eye diagrams and patterns with very high temporal resolution. It is a useful tool to study and characterize very high bit-rate systems or very fast events like short pulses, where the bandwidth of ordinary electrical sampling oscilloscopes is not sufficient.

The PSO-200 can measure a number of modulation formats: OOK, BPSK, APSK, QPSK and 16-QAM, all in return-to-zero (RZ) or non-return-to-zero (NRZ) formats.



The PSO-200 Optical Modulation Analyzer has the following features:

- Fully customizable display layout and selection of graphs (intensity, phase, error-vector magnitude) in eye diagram and pattern modes.
- Analysis tools such as averaging, masks, filters and advanced signal processing algorithms.
- Post-processing tools (acquisition import and export, reanalysis with different settings, offline application).
- Bit pattern customization with the Gearbox
- Remote control available (Ethernet TCP/IP with SCPI commands).

Conventions

Before using the product described in this guide, you should understand the following conventions:

WARNING
Indicates a potentially hazardous situation which, if not avoided, could result in *death or serious injury*. Do not proceed unless you understand and meet the required conditions.

CAUTION
Indicates a potentially hazardous situation which, if not avoided, may result in *minor or moderate injury*. Do not proceed unless you understand and meet the required conditions.

CAUTION
Indicates a potentially hazardous situation which, if not avoided, may result in *component damage*. Do not proceed unless you understand and meet the required conditions.

IMPORTANT
Refers to information about this product you should not overlook.

2 Safety Information

Laser Safety Information

WARNING

Do not install or terminate fibers while a light source is active. Never look directly into a live fiber and ensure that your eyes are protected at all times.

WARNING

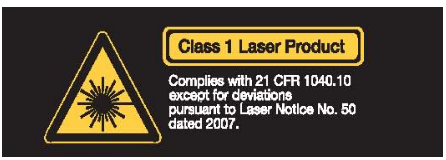
The use of controls, adjustments and procedures other than those specified herein may result in exposure to hazardous situations or impair the protection provided by this unit.

IMPORTANT

When you see the following symbol on your unit **, make sure that you refer to the instructions provided in your user documentation. Ensure that you understand and meet the required conditions before using your product.**

Your instrument is a Class 1 laser product in compliance with standards IEC 60825-1 2007 and 21 CFR 1040.10. Laser radiation may be encountered at the output port.

The following label indicates that a product contains a Class 1 source:



Note: *The label is located at the back of the unit.*

Electrical Safety Information

This unit uses an international safety standard three-wire power cable. This cable serves as a ground when connected to an appropriate AC power outlet.

Note: *To ensure that the unit is completely turned off, disconnect the power cable.*

WARNING

- **Insert the power cable plug into a power outlet with a protective ground contact. Do not use an extension cord without a protective conductor.**
- **Before turning on the unit, connect all grounding terminals, extension cords and devices to a protective ground via a ground socket. Any interruption of the protective grounding is a potential shock hazard and may cause personal injury. Whenever the ground protection is impaired, do not use the unit and secure it against any accidental operation.**
- **Do not tamper with the protective ground terminal.**

The color coding used in the electric cable depends on the cable. New plugs should meet the local safety requirements and include:

➤ adequate load-carrying capacity

➤ ground connection

➤ cable clamp

WARNING

➤ **Use this unit indoors only.**

➤ **Position the unit so that the air can circulate freely around it.**

➤ **Do not remove unit covers during operation.**

➤ **Operation of any electrical instrument around flammable gases or fumes constitutes a major safety hazard.**

➤ **To avoid electrical shock, do not operate the unit if any part of the outer surface (covers, panels, etc.) is damaged.**

➤ **Only authorized personnel should carry out adjustments, maintenance or repair of opened units under voltage. A person qualified in first aid must also be present. Do not replace any components while power cable is connected.**

➤ **Capacitors inside the unit may be charged even if the unit has been disconnected from its electrical supply.**

Equipment Ratings	
Temperature ➤ Operation ➤ Storage	 0 °C to 35 °C (32 °F to 95 °F) -40 °C to 70 °C (-40 °F to 158 °F)
Relative humidity[a]	80 % non-condensing
Maximum operation altitude	2000 m (6562 ft)
Pollution degree	2
Installation category	II
Power supply rating[b]	100 V to 240 V (50 Hz/60 Hz) maximum input power 250 VA

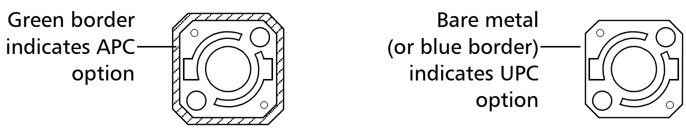
a. Measured in 0 °C to 31 °C (32 °F to 87.8 °F) range, decreasing linearly to 50 % at 40 °C (104 °F).
b. Not exceeding ± 10 % of the nominal voltage.

The following label is located on the back panel of the unit:

3 Getting Started with Your Optical Modulation Analyzer

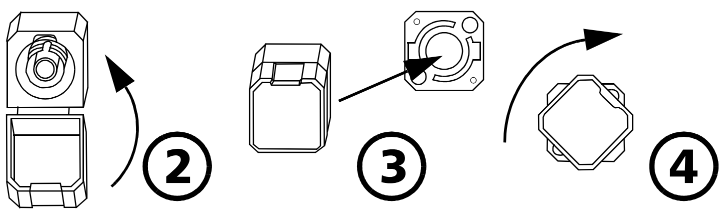
Installing the EXFO Universal Interface (EUI)

The EUI fixed baseplate is available for connectors with angled (APC) or non-angled (UPC) polishing. A green border around the baseplate indicates that it is for APC-type connectors.



To install an EUI connector adapter onto the EUI baseplate:

1. Hold the EUI connector adapter so the dust cap opens downwards.



2. Close the dust cap in order to hold the connector adapter more firmly.
3. Insert the connector adapter into the baseplate.
4. While pushing firmly, turn the connector adapter clockwise on the baseplate to lock it in place.

Cleaning and Connecting Optical Fibers

IMPORTANT

To ensure maximum power and to avoid erroneous readings:

- ➤ **Always inspect fiber ends and make sure that they are clean as explained below before inserting them into the port. EXFO is not responsible for damage or errors caused by bad fiber cleaning or handling.**
- ➤ **Ensure that your patchcord has appropriate connectors. Joining mismatched connectors will damage the ferrules.**

To connect the fiber-optic cable to the port:

1. Inspect the fiber using a fiber inspection microscope. If the fiber is clean, proceed to connecting it to the port. If the fiber is dirty, clean it as explained below.

2. Clean the fiber ends as follows:

2a. Gently wipe the fiber end with a lint-free swab dipped in isopropyl alcohol.

2b. Use compressed air to dry completely.

2c. Visually inspect the fiber end to ensure its cleanliness.

3. Carefully align the connector and port to prevent the fiber end from touching the outside of the port or rubbing against other surfaces.

If your connector features a key, ensure that it is fully fitted into the port's corresponding notch.

4. Push the connector in so that the fiber-optic cable is firmly in place, thus ensuring adequate contact.

If your connector features a screwsleeve, tighten the connector enough to firmly maintain the fiber in place. Do not overtighten, as this will damage the fiber and the port.

Note: *If your fiber-optic cable is not properly aligned and/or connected, you will notice heavy loss and reflection.*

EXFO uses good quality connectors in compliance with EIA-455-21A standards.

To keep connectors clean and in good condition, EXFO strongly recommends inspecting them with a fiber inspection probe before connecting them. Failure to do so will result in permanent damage to the connectors and degradation in measurements.

Starting and Exiting the Optical Modulation Analyzer Application

The PSO-200 Optical Modulation Analyzer runs on a Microsoft Windows environment. When you turn it on, the unit should automatically start the Optical Modulation Analyzer application.

When starting the application, the PSO-200 requires some time to initialize, during which certain features, such as the **Start** button, are not available. A message is displayed in the status bar while initialization is in progress.

To start the application:

- Double-click the shortcut icon on the desktop. 

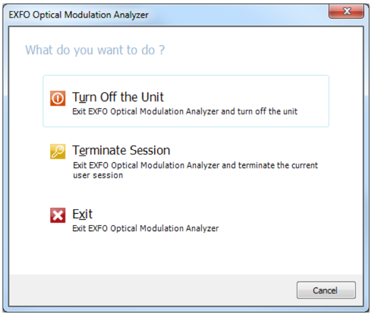
- From the Windows **Start** menu, select **All Programs** > **EXFO** > **Optical Modulation Analyzer**.

To exit the application:

1. From the **File** menu, select **Exit**.

   OR

   Click the  button in the bottom right corner of the main window.
2. Select which shutdown method you want.
   - **Turn off the unit**: closes the application and completely shuts down the PSO-200.
   - **Terminate session**: closes the application and logs off the current Windows session, but does not shut down the PSO-200.
   - **Exit**: closes the application only.



Note: *If there were unsaved acquisitions, you will be prompted to save them when you exit the application.*

4 Setting Up the Optical Modulation Analyzer

You should start by setting parameters on the PSO-200 so that acquisitions are performed according to the signal you are analyzing and that the results meet your needs.

You can also change some settings during an acquisition, or even afterwards to see how it would have affected the results. See *Reanalyzing Acquisitions with New Settings* on page 115.

Note: *Changing settings during an acquisition will not stop it. However, acquired bursts will be cleared and new bursts will be taken using the new settings.*

Configuring the Input Signal

You will need to provide the following information about your input signal, in order to obtain relevant results:

- ITU channel and Offset: this is the signal frequency or wavelength. You can select a channel from the ITU grid (25 GHz spacing), and if needed, indicate an offset value of up to half the channel.

  The signal spectrum needs to be within the receiver spectrum (see *Technical Specifications* on page 131), otherwise the constellation chart might be distorted and noisy, or even not visible at all.

- Local oscillator: you can use the PSO-200's internal pulsed laser source or your own external laser source. For explanations on when and how to use an external source, see *Using an External Local Oscillator* on page 27).

- Modulation scheme (DPSK, QPSK, etc.): select the scheme according to the modulation of your signal under test. Dual-polarization signals are prefixed with "DP" See *Modulation Schemes* on page 247.

  The Free-Run, CW and Intensity Sampling modes allow bypassing some signal processing algorithms for troubleshooting or other analysis purposes. See *Using Special Modulation Modes* on page 24.

- Bit format (RZ or NRZ): this should be used according to the pulse carving status of your signal under test (RZ for pulse-carved signals, NRZ otherwise, as explained in *Modulation Schemes* on page 247). This setting affects measurements associated with the waveform.

- Symbol rate (in GBd): symbol rate of the input signal. An accurate rate (±0.05 GBd or better) is needed to recover the correct waveform (via pattern synchronization) and to get valid time-domain measurements from the time reconstruction algorithms (see *Sampling Methods* on page 240).

- Linewidth: controls the speed of the IF tracking algorithm and should correspond to the signal source's linewidth (approximately ±0.25 MHz).

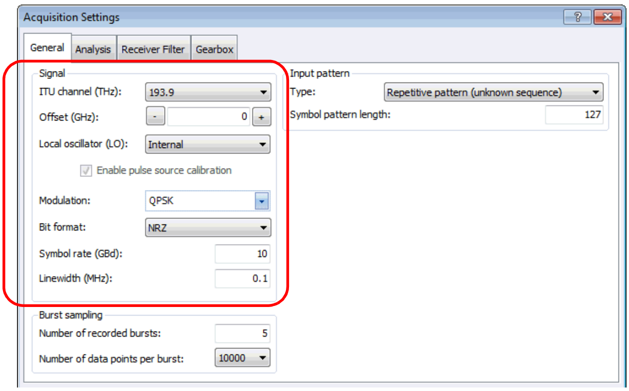
  If it is set too low, there will be remaining phase noise on the captured waveform (constellation symbols spread in the phase direction) or even the phase will not be accurately tracked (cycle slips will occur).

  If it is set too high, the algorithm will remove phase noise not originating from the signal source (constellation symbols will be compressed in the phase direction).

  A proper setting balances these two conditions (equal noise in both amplitude and phase, or a constellation with symmetric points).

To configure the input signal type and properties:

1. From the **Settings** menu, select **Acquisition**.
2. Under the **General** tab, enter the settings in the **Signal** section.



3. Click **Apply** to confirm your settings, or **OK** to also close the window.

Setting Other Acquisition Parameters

Use the following parameters to improve the recovered waveform:

- Burst sampling parameters: you can specify the number of bursts that will be recorded or buffered by the application, as well as the number of data points in each burst. A larger number of points will take more time to process but provide better results.
- Input pattern mode and parameters: available modes depend on the selected modulation scheme.
  - Random – if random signals (live traffic or framed PRBS) or very long patterns (2^{31}-1 PRBS) are used. The constellation chart and eye diagrams of amplitude and phase can be measured, but not the patterns. No filtering, averaging or CD unwrapping possible.
  - Repetitive (unknown pattern) – if your signal under test comprises a repetitive pattern with known word length (for example, PRBS with header data). The pattern can also be recovered.
  - User-defined symbol pattern – if you know exactly the symbol pattern or can extract it from an acquisition (such as in Repetitive mode or if your modulation scheme is not supported by the PSO-200). This mode improves signal processing algorithms and allows the calculation of a symbol error rate (SER). For details, see *Importing User-Defined Symbol Patterns* on page 84.
  - PRBS – if your signal is generated from pseudo-random binary sequences. Since the pattern is known, you can obtain bit error rate (BER) information and you can use the Gearbox to fine-tune the bit alignment of your signal stream.
  - User-defined bit pattern – if you know exactly the sequence of bits in your signal. As for PRBS, you can obtain the BER and are able to use the Gearbox.

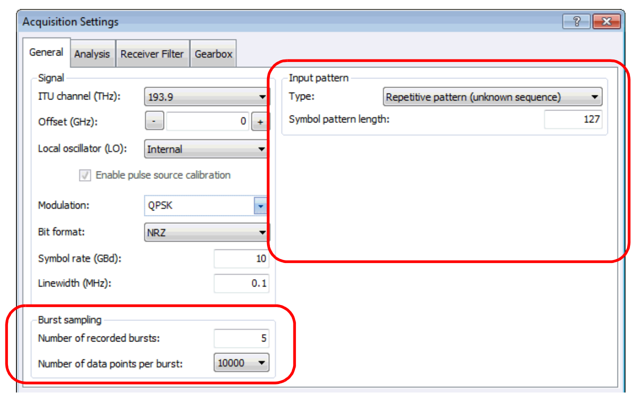
Note: *Free-Run, CW and Intensity Sampling signals do not allow patterns.*

IMPORTANT

Make sure a pattern can be displayed (magnitude graph) in any of the pattern mode acquisitions. If pattern synchronization cannot be achieved, switch the input pattern type to Random.

To set the acquisition parameters:

1. From the **Settings** menu, select **Acquisition**.
2. Under the **General** tab, enter the settings for the burst sampling and input pattern.



3. If you have selected **Repetitive pattern (unknown sequence)**, simply enter the **Symbol pattern length**.

   Otherwise, proceed as explained in *Bit Pattern Analysis and the Gearbox* on page 79.
4. Click **Apply** to confirm your settings, or **OK** to also close the window.

Setting File Autonaming

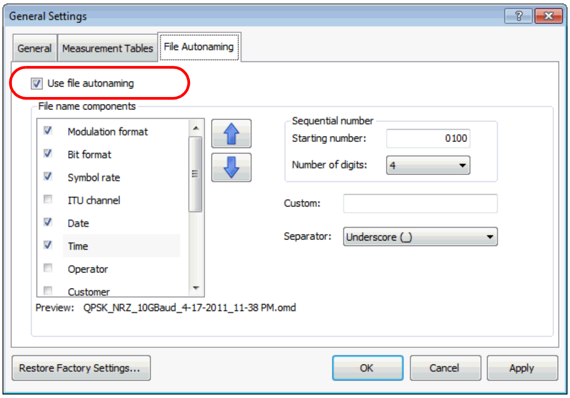
Autonaming helps you create a predefined file naming scheme for *future saved* acquisitions. This can include data components, date/time and sequential numbering. This way you are sure not to overwrite your previous files and always follow a standard that is meaningful to you.

Note: *Characters that cannot be used in a file name are replaced by a tilde "~".*

Note: *Path and file names combined cannot exceed 260 characters. If the items you have selected lead to a name that is too long, it will be truncated.*

To define and activate the autonaming scheme:

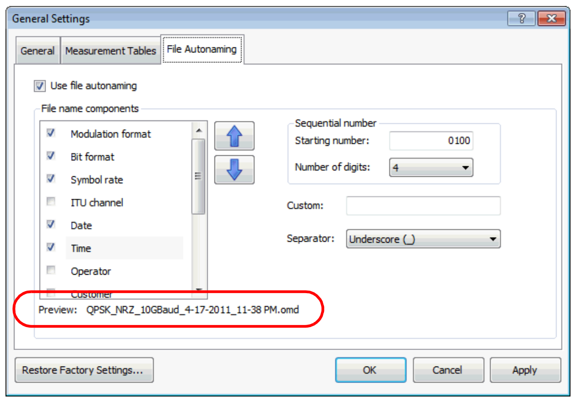
1. From the **Settings** menu, select **General**.
2. Select the **File Autonaming** tab.
3. Check the box to enable the option if you want to use autonaming.



4. Define the autonaming scheme. A sample file name shows you the final output.

➤ Select data components you want to include in the name. You must select at least one item in the list. You can change the order using the up and down arrow buttons.

Note: *The order of the items is kept until you revert to the factory settings.*



➤ Set the sequential number values. You can enter the starting number and select how many digits are to be used. Once the sequence reaches the maximum value (for example, 999 for a 3-digit sequence), the sequence is reset to the first value.

➤ If desired, you can include a comment for your file name in the **Custom** box. The comment contains up to 100 characters.

➤ Select a separator value to place between the selected data components.

5. Click **Apply** to confirm your settings, or **OK** to also close the window.

Identifying Acquisitions

Setting up acquisition information can save you time and work, as your acquisitions will be identified according to your needs each time. You can either set default information for future acquisitions (especially useful in conjunction with file autonaming in automated production environments), or add specific information for the current acquisition.

To enter acquisition identification:

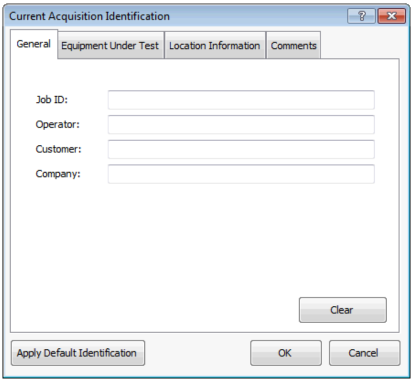
1. If you want to set the *default* information, from the **Settings** menu, select **Default Acquisition Identification**.

   OR

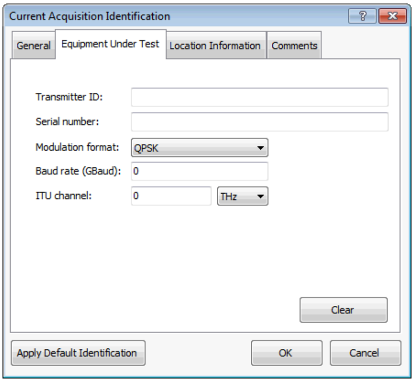
   If you want to identify the *current acquisition* only, from the **File** menu, select **Properties**, then **Current Acquisition Identification**.

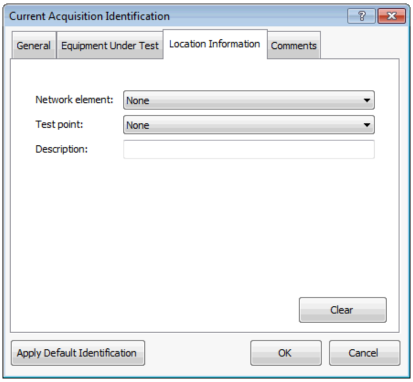
Note: *When editing current acquisition details, you can click **Apply Default Identification** in any tab to insert the default data.*

2. Select the **General** tab, then fill out the basic information for your acquisition, such as the operator or customer name.



3. Select the **Equipment Under Test** and **Location Information** tabs and provide details that pertain to your specific test case.





You can also add a personalized comment in the **Comments** tab.

4. Click **Apply** to confirm your settings, or **OK** to also close the window.

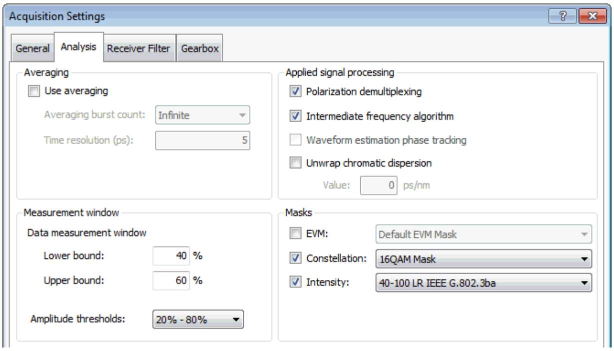
Setting Analysis Parameters

The signal can be analyzed while being acquired or afterwards in reanalysis mode. The following tools are available.

- Burst averaging (see *Using Averaging to Improve Results* on page 70).
- Measurement windows:
  - Data – time range defined as percentages of the symbol period, as explained in *Distinguishing Data Points from Transitions* on page 62.
  - Amplitude – intensity range defined as percentages of the eye amplitude, as explained in *Measurements for Eye Diagrams* on page 258. It is used to compute values like “rise” and “fall” times and provides the eye height.
- Specific optional signal processing algorithms (see *Applying Advanced Signal Processing Algorithms* on page 72). Available algorithms depend on the selected modulation format.
- Pattern masks to test the quality of the signal and perform quick pass/fail analysis (see *Using Pattern Masks* on page 64).

To set the analysis parameters:

1. From the **Settings** menu, select **Acquisition**.
2. Under the **Analysis** tab, select the desired analysis options.



3. Click **Apply** to confirm your settings, or **OK** to also close the window.

Using Special Modulation Modes

In some situations, when the input signal does not represent phase-encoded data, it can be valuable to bypass some of the signal processing algorithms to visualize the signal with a better refresh rate or under different conditions. For example, it may be useful to study just the intensity before a phase-encoding transmitter is set up correctly, for debugging purposes.

You can also export the signal data obtained when bypassing some algorithms to analyze with your own tools (such as MATLAB algorithms).

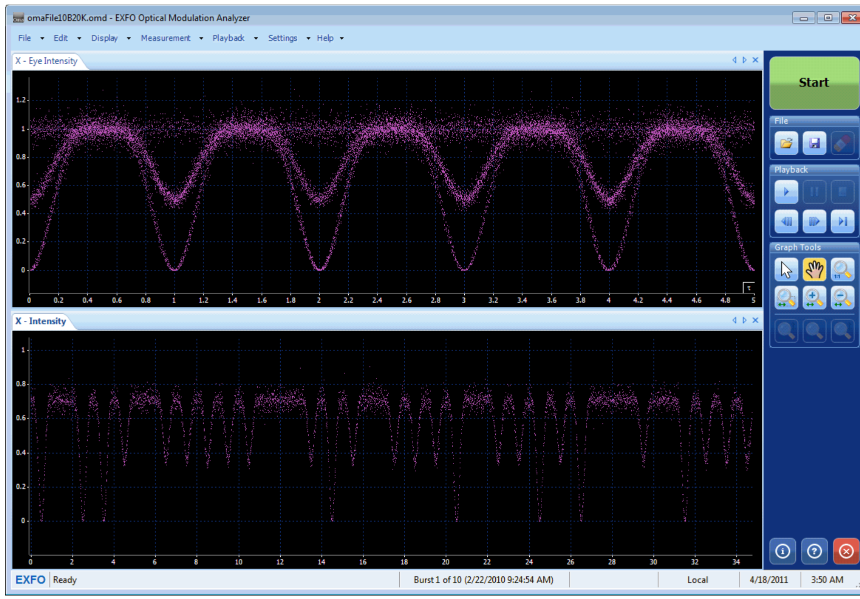
The Optical Modulation Analyzer application offers the following modes:

Mode	Usage
Free-run	General debugging, oscilloscope-like behavior; useful in initial connections to ensure signal input
Continuous wave	CW laser analysis, analyze phase noise
Intensity sampling	Fast, useful for a first tuning of the system under test, shows waveform envelope

Here are the signal processing algorithms (applied or optional) for each mode (for details, see *Signal Processing Algorithms* on page 244):

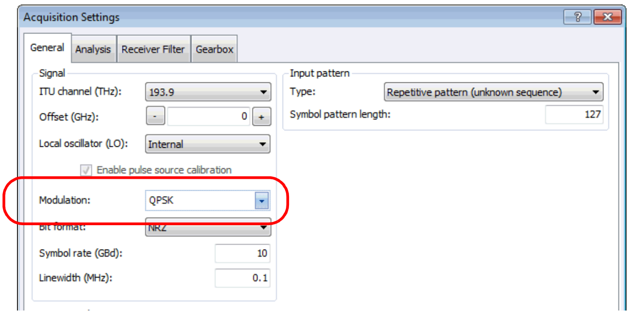
Signal Processing Algorithms (in order)	Free-Run	CW	Intensity Sampling
Polarization demultiplexing	Optional	Optional	Optional
Time reconstruction vector	–	–	Applied
Intermediate frequency recovery	–	Optional	–
Alignment	–	–	–
Other algorithms	–	Applied	–

The figure below shows an example of intensity sampling of 42 GBd QPSK data (top: intensity eye diagram; bottom: corresponding 127 bit pattern). The intermediate frequency recovery algorithm is bypassed so that only intensity is sampled. The phase information is not retrieved.

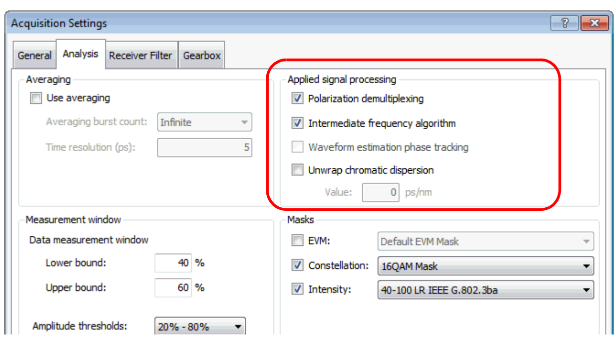


To select a special modulation mode and activate optional algorithms:

1. From the **Settings** menu, select **Acquisition**.
2. Under the **General** tab, select the special mode in the **Modulation** list.



3. Under the **Analysis** tab, select the desired signal processing algorithms to apply.



4. Click **Apply** to confirm your settings, or **OK** to also close the window.

Using an External Local Oscillator

The External local oscillator (LO) option allows you to use your own laser as a source for the local oscillator instead of the PSO-200 internal laser. This is useful in the following cases:

➤ When your signal source has an extremely low phase noise, such that the overall phase noise becomes dominated by the internal LO source.

  If you use as LO a laser source with equivalent (or better) phase noise characteristics, you can reduce the total phase noise in acquisitions.

➤ To accomplish self-homodyne measurements by using the same laser source split between the signal and LO, offering identical phase noise characteristics on both.

  In order to cancel the influence of the source phase noise on the measurements, and thus not requiring phase tracking, you must ensure that the delays of the signal and LO paths will match precisely (even more when your laser source has wider linewidth).

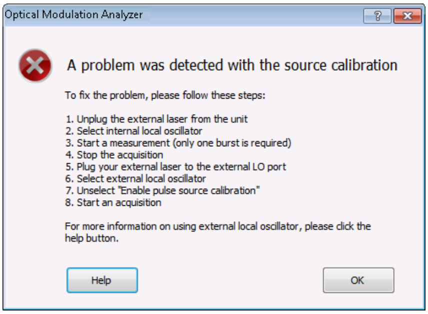
The external laser source must meet the specified power range (see *Technical Specifications* on page 131) and must use polarization-maintaining fiber (PMF).

When the external LO source is distinct from the signal source:

➤ The ITU Channel parameter also applies to the external LO source, so both sources must have the same frequency/wavelength.

➤ The Linewidth parameter should be set to the wider laser source.

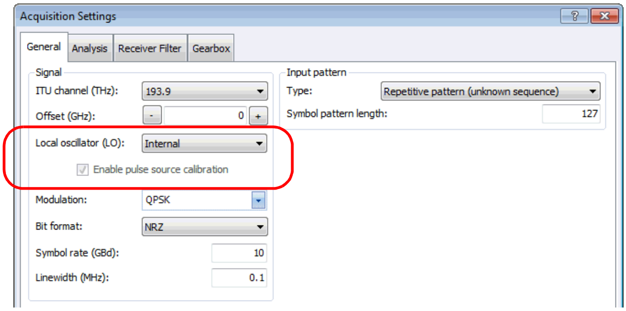
By default, the application automatically calibrates the external LO source during acquisitions. You can disable this option, but you should only do so if the application requires it (see message below), in which case the application will try to use the last calibration values obtained with the internal LO.



Note: *Changing the frequency/wavelength or symbol rate will clear the calibration values, thus requiring the above procedure.*

To enable the external local oscillator:

1. From the **Settings** menu, select **Acquisition**.
2. Under the **General** tab, select **External** in the **Local oscillator** list.



3. If necessary only, disable the automatic calibration by clearing the **Enable pulse source calibration** box.
4. Click **Apply** to confirm your settings, or **OK** to also close the window.
5. Connect your external laser source to the **Local Oscillator Input** port on the PSO-200 front panel.
6. Start an acquisition.

IMPORTANT

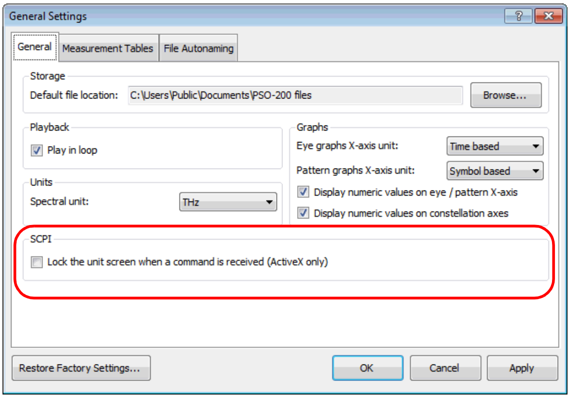
If you revert to Internal LO, ensure your external source is *disconnected* before clicking Start for the next acquisition.

Locking the Remote Unit

If you control the unit remotely, you can set it so that the keyboard, mouse and touchscreen are inactive. This can be useful when you do not want someone to accidently change your settings.

To lock the unit when using remote control:

1. From the main window, select the **Settings** menu, then **General**.
2. Select the **General** tab.
3. Under **SCPI**, select the option to lock the unit.



The lock takes effect when you start the remote communication. You can unlock the unit via remote control or using the return to local button on the front of the unit.

5 Performing Acquisitions

Starting and Stopping an Acquisition

Once you start an acquisition, it will continue until you stop it. If you had a previous acquisition that you have not saved, you will be prompted to save it before starting a new one.

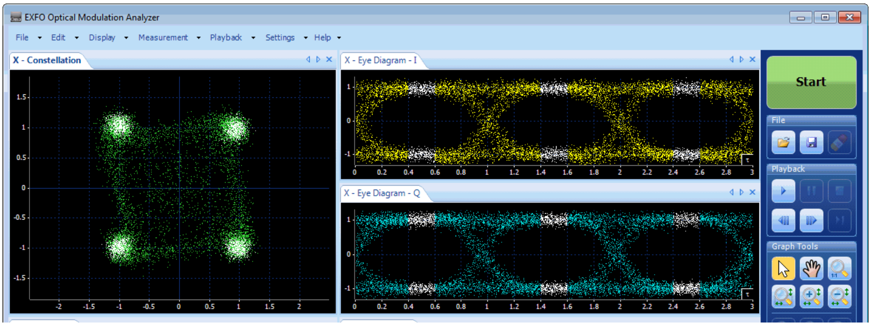
While an acquisition is in progress, the on-screen data and graphs are updated upon each burst, and you can still change the display layout. However, you cannot use the playback controls, or open or save files.

To start an acquisition:

Press the **Start** button.

OR

From the **Measurement** menu, select **Start**.



To stop an acquisition:

While the acquisition is in progress, press the **Stop** button.

OR

From the **Measurement** menu, select **Stop**.

Note: *Closing the application will also stop the acquisition.*

Clearing Data During an Acquisition

While an acquisition is in progress, you can clear the data already acquired at any time in order to capture a clean signal without the glitches that might have been introduced during manipulations.

All graphs and measurement tables are reset, and burst count restarts at 1. The Y axis is re-scaled to a normalized unit.

To clear acquired data:

While an acquisition is in progress, press the (Clear) button.

OR

From the **Measurement** menu, select **Clear Data**.

Saving Acquisitions to a File

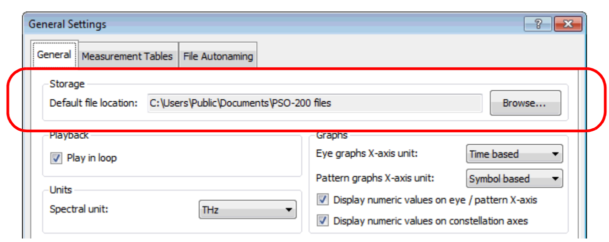
Once an acquisition is completed, you can save it for later analysis and playback.

You can set a *default folder* to use for future acquisitions. The application offers you to save the file in this folder, but you can always select a different location.

Note: *If autonaming was enabled (see* Setting File Autonaming *on page 18), the application will suggest an appropriate name, but you can change it.*

To set a default folder for your saved files:

1. From the **Settings** menu, select **General**.
2. Select the **General** tab.
3. Under **Storage**, locate the folder you want using the **Browse** button.



4. Click **Apply** to confirm your settings, or **OK** to also close the window.

To save an acquisition file:

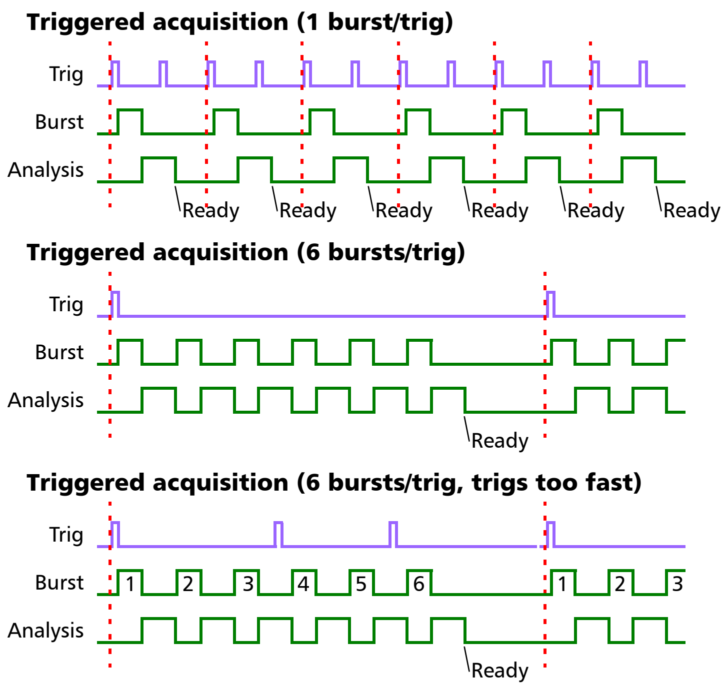
1. From the **File** menu, select **Save As**.
2. Navigate to the folder where you want to save the file.
3. Click **Save**.

If you had previously saved the file, you can use **Save** instead of **Save As** to automatically save it with its current name and location. You can also use the  button on the main window.

Activating Trigger-Based Acquisitions

You could use an external equipment, such as a BER tester, to initiate burst acquisitions on the PSO-200 based on trigger signals. This can be useful in automated long-term tests.

When you start this acquisition process, the application will be on hold, waiting for a trigger signal (which can occur hours later) to acquire new bursts as specified. This process will stop if you press the **Stop** button or when it reaches the specified number of trigs.

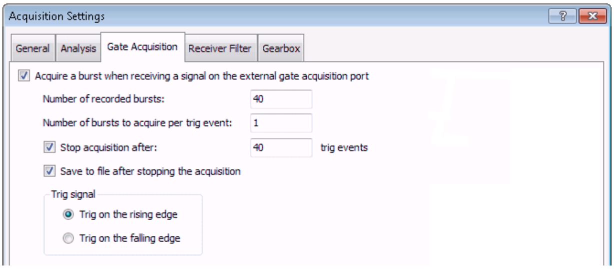


If the external trig signal occurs while the previous burst is still being acquired, the PSO-200 will ignore this trig signal and wait for the next one.

Note: *You must stop the trigger-based acquisition in order to change its settings.*

To activate triggered acquisitions:

1. From the **Settings** menu, select **Acquisition**.
2. Under the **Gate Acquisition** tab, select **Acquire a burst when receiving a signal...**.



3. Select the trigger parameters as follows:
   - Number of recorded bursts: bursts buffered in memory, overriding the equivalent setting in the **General** tab.
   - Number of bursts to acquire per trig event
   - Stop acquisition after N trig events: will stop after this number of “useful” trigs (trigs leading to a burst acquisition, not counting skipped trigs).
   - Save to file after stopping the acquisition: the acquisition will be saved in the location (path) specified in **General Settings**, using autonaming if enabled (or generic names “OMDFileX.omd” otherwise). A file can contain at most 140 bursts.
   - Trig signal: select whether to use the rising signal (reaching 2.5 V upwards) or the falling signal (reaching 2.5 V downwards).
4. Click **Apply** to confirm your settings, or **OK** to also close the window.
5. Connect your external equipment to the **Trigger** port on the PSO-200 front panel.
6. Press the **Start** button. The application will wait for the trigger signal.

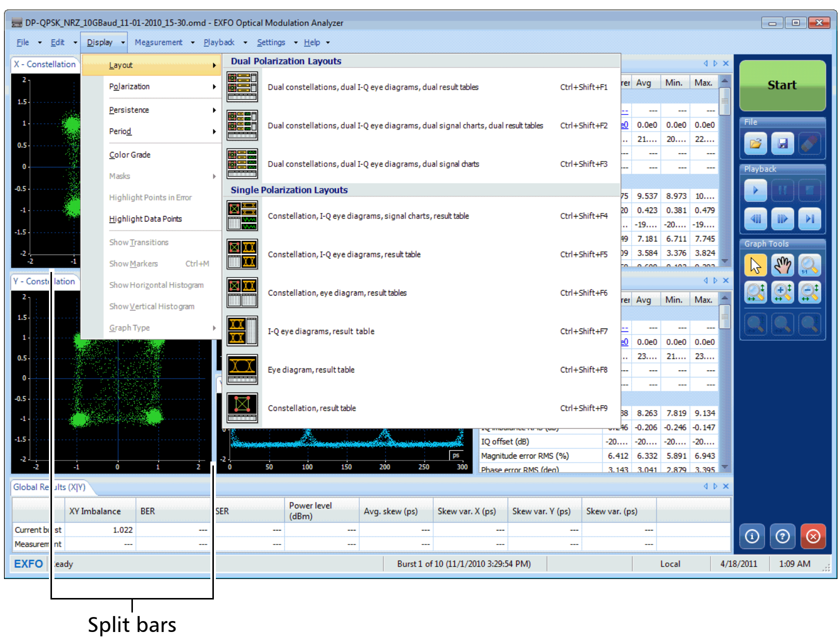
6 Customizing the Graph and Data Layout

Selecting and Customizing the Layout

The application’s main window is fully customizable. You can start with one of the preset single- or dual-polarization layouts that may already suit your needs. Each layout contains a set of graphs and tables.

Note: *Predefined layouts are not editable. Once you close a tab, you can only make it appear again by re-selecting a layout that contains it.*

Note: *Dual-polarization layouts are available even if your unit does not support it, allowing you to open files previously acquired on other units. Polarizations are identified by X and Y.*



At any time during of after acquisitions, you can change the displayed graphs (except the constellation), resize the tabs or close those you do not want to see. The application will remember your layout for your next work session.

Available graphs in the Optical Modulation Analyzer application are described later in this chapter.

To select a predefined layout:

1. From the **Display** menu, select **Layout**.
2. Select which layout better suits your situation. You can also use the keyboard shortcuts.

To change the graph on a tab (eye or pattern):

1. Right-click on the graph tab for which you want to change the content.

   OR

   Select the graph tab, then in the **Display** menu, select **Graph Type**.
2. Select a new type of graph to display.

To resize a tab:

Use the split bars enclosing the tab you want to resize.

To close a tab:

Click the × button in the upper right corner of the tab.

To change the displayed polarization:

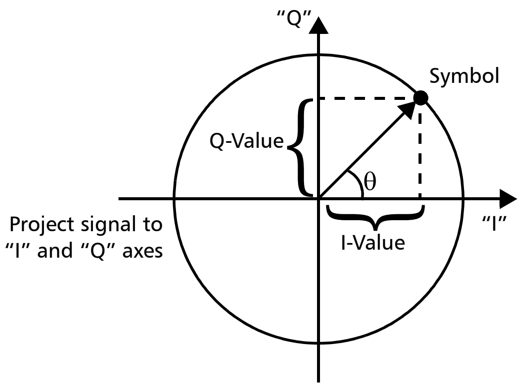
1. From the **Display** menu, select **Polarization**.
2. Select the polarization (**X** or **Y**) to display on all graphs and tables.

Note: *The **Polarization** option is only available if you are viewing a dual-polarization signal on a single-polarization layout.*

Constellation Chart

Useful when characterizing advanced modulation schemes such as DP-QPSK, the constellation chart is a representation of a signal modulated in phase and/or in amplitude.

It shows valid symbols (amplitude and phase relative to the carrier) of a modulation format on a polar graph. Since each symbol is encoded with n bits (depending on the modulation scheme), there will be 2^n permitted symbols.



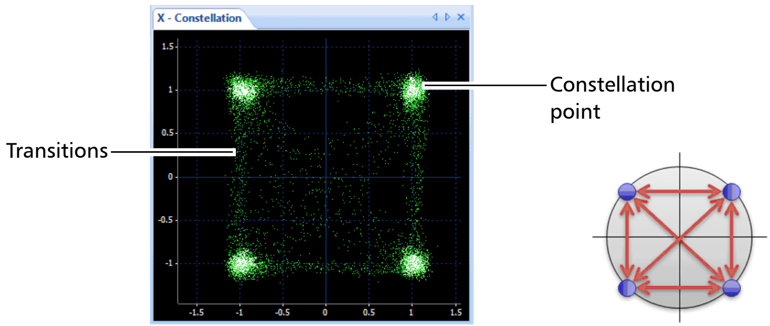
Polar-to-Rectangular Conversion

The "I" axis (in-phase) represents the "real" part of the complex field, while the "Q" axis (quadrature) represents the "imaginary" part.

The length of the vector to the symbol in the chart is the amplitude of the signal (normalized in the Optical Modulation Analyzer application), and its angle from the "I" axis is the phase of the signal.

Note: *There is one constellation chart per polarization state (X and Y).*

The figure below shows an example of a QPSK constellation with four points (2-bit symbols) comprising the data-carrying signal. No time information is given since it would be on the z axis.



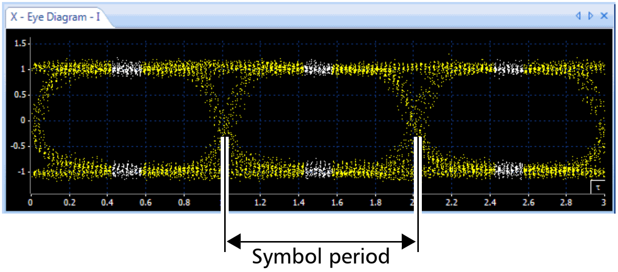
Transitions between constellation points contribute significantly to the spectral content of the input signal, and hence the optimization of these transitions is often the most critical aspect of transmitter operation. Consequently, the PSO-200 is designed to not only display the constellation points, but also visualize these transitions with high accuracy.

If the signal is without error, the ideal symbol would appear as a single point on the constellation. However, signal impairments and modulation errors cause deviations and the symbols will show as a group of points dispersed around the ideal location.

For details about the measurements derived from the constellation chart, see *Measurements for Constellation Charts* on page 252.

Eye Diagrams

An eye diagram is a trace of the intensity, magnitude, or phase, as a function of time, where the corresponding time vector has been “folded” to an integer number of symbol periods (see *Equivalent-Time Sampling* on page 241).



Traditionally, intensity (power) has been shown in eye diagrams, since the power itself contains the information in on-off keying (OOK) data modulation. With more complex phase-encoded signals with coherent detection, I/Q amplitude and phase are also shown in eye diagrams.

To acquire the eye diagram, the PSO-200 relies on a time reconstruction algorithm that works like a software-based clock recovery.

Note: *All eye diagrams are normalized on the Y-axis.*

Several system performance measures can be derived by analyzing the eye diagram. It allows you to determine whether the signal exhibits excessive jitter or noise, or if it is too slow to change, or displays unacceptable overshoot. Distortion of the signal waveform due to inter-symbol interference (ISI) and noise appears as closure of the eye diagram.

For details about the measurements derived from the eye diagrams, see *Measurements for Eye Diagrams* on page 258.

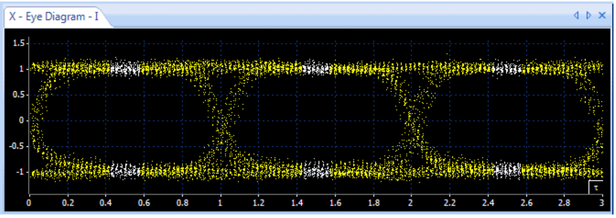
I/Q Eye Diagrams

The I (in-phase) and Q (quadrature) eye diagrams represent the “real” and “imaginary” parts of the complex field as a function of time, respectively.

$$I(t_B) = Re(\boldsymbol{E}(t_B))$$
$$Q(t_B) = Im(\boldsymbol{E}(t_B))$$

where t_B is the remainder after division with the symbol period τ.

The I eye diagram can be seen as the data visible by looking from the right of the constellation chart. Similarly with the Q eye diagram by looking from the top.



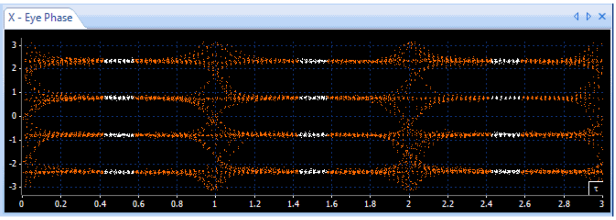
NRZ-QPSK data

Phase Eye Diagram

Eye diagram of arg($\boldsymbol{E}(t_B)$). No amplitude information is provided.

This graph shows the different phases of the signal and the transitions. Its use is to see the phase shifts in PSK and QAM modulations.

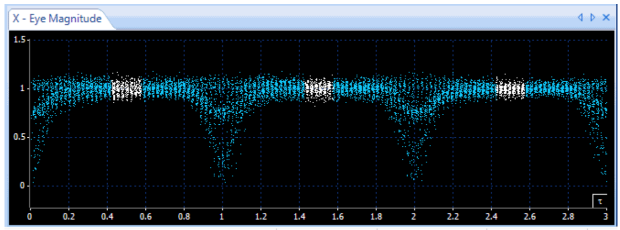
The example below shows four phase levels: $\pi/4$, 3 $\pi/4$, $-\pi/4$, $-3\pi/4$.



QPSK data

Magnitude Eye Diagram

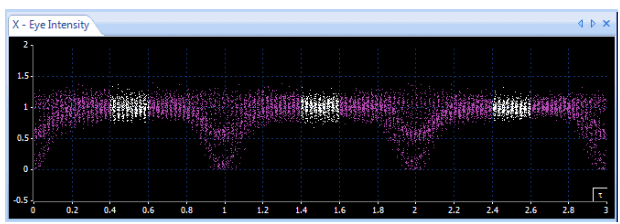
Eye diagram of $P(t_B)^{1/2} = |\boldsymbol{E}(t_B)|$. No phase information is given.



NRZ-QPSK data

Intensity Eye Diagram

Eye diagram of $P(t_B) = |\boldsymbol{E}(t_B)|^2$. No phase information is given.



NRZ-QPSK data

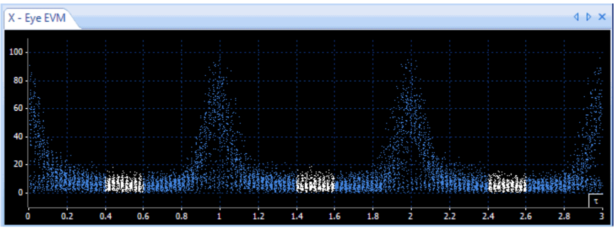
Note: *Intensity = Magnitude*^{2}

Error Vector Magnitude (EVM) Diagram

The quality of the transmitted signal can be established by looking at the error vector, which compares the received signal with an ideal signal, taking into account both phase and magnitude errors.

The error vector magnitude (EVM) value is computed in the data measurement window (excluding measurements from transitions).

When a pattern exists, EVM values are relative to the "expected" reference constellation point. In random mode (no pattern), EVM values are relative to the nearest constellation point.



NRZ-QPSK data

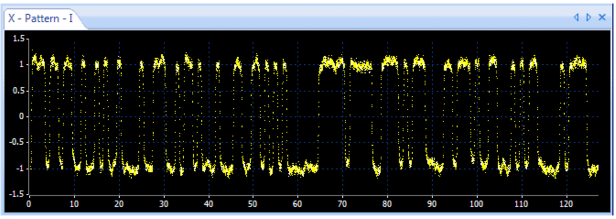
EVM values on the Y axis range from 0 % to 100 %. In some cases, the value can even be above 100 %.

For details about EVM measurements and calculations, see *Measurements for Constellation Charts* on page 252.

Pattern Diagrams

You can view all graphs (I/Q, intensity, magnitude, phase and EVM) as a pattern instead of an eye diagram. The pattern diagram is a continuous curve between different amplitude and/or phase states, as a function of time. It helps viewing the capacity of the system to transmit all signal combinations.

In standard sampling oscilloscopes, a pattern clock (which sends out a pulse synchronized with the periodic pattern) may be used to trigger the scope. In contrast, the PSO-200 uses a software algorithm to reconstruct the pattern.



2^7-1 NRZ-QPSK

On pattern diagrams, the X axis is either symbol- or time-based. At a 100 % zoom value, you can see the entire signal for the symbol pattern.

Y-Axis Auto Scaling (All Graphs)

The unit does not display intensity data (Y axis) in mW, but rather scales it to a normalized unit. Each time you press **Start** (or **Clear Data**), the unit computes a scaling factor based on the first burst, and uses it for subsequent bursts.

Note: *To see the difference in intensity between the X and Y polarizations, compare the Power Level values from both result tables. You can also see the values in the constellation charts.*

7 Viewing and Analyzing Results

Opening an Existing Acquisition File

You can recall previously saved acquisition files on your unit or on another computer for further analysis.

Note: *You cannot open a file while an acquisition is in progress.*

To open an acquisition file:

1. From the **File** menu, select **Open**.
2. Locate the file you want to open.
3. Click **Open**.

You can also open a file directly from the main window by clicking .

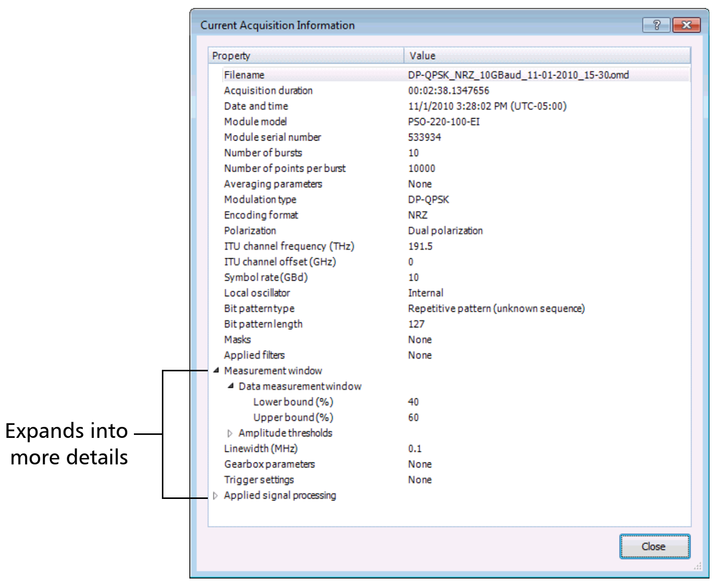
Viewing Acquisition Information

When opening a previously acquired file for analysis, you can view information about the parameters that were used for acquisition.

For details on the parameters displayed, see *Setting Up the Optical Modulation Analyzer* on page 13.

To view data and parameters from the current acquisition:

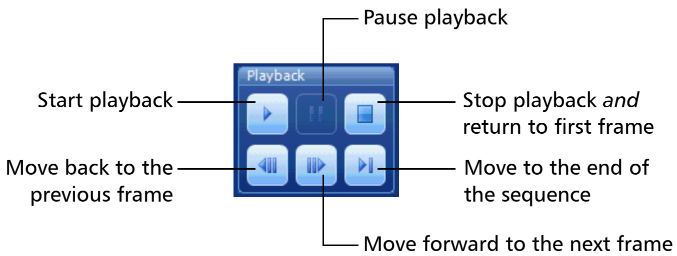
1. From the **File** menu, select **Properties**, then **Current Acquisition Information**.



2. Click **Close** when done.

Playing Back Acquisition Files

Once you have acquired bursts, or after opening a previously saved file, you can use the playback buttons to see the behavior of the acquired signal. All bursts will be played at the same speed as when acquired.



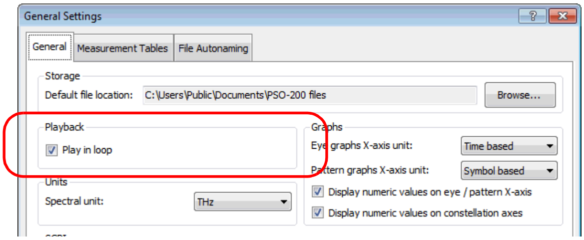
You can also find the playback controls in the **Playback** menu.

Note: *While playing back, the burst number (with its date and time) and total burst count are displayed in the status bar.*

You can set the playback to either stop at the end of the sequence, or loop back to the first frame and continue until you press the **Stop** button.

To set the playback to loop:

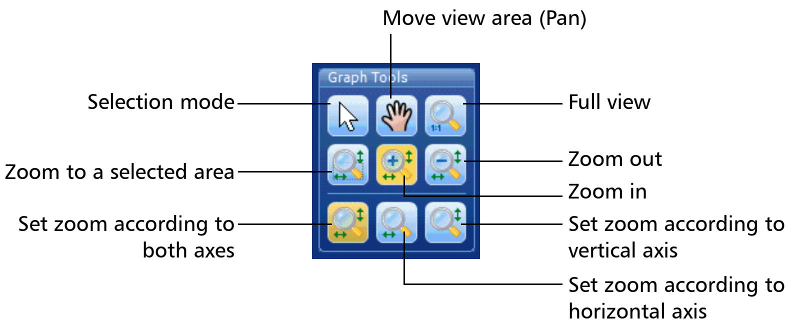
1. From the **Settings** menu, select **General**.
2. Select the **General** tab.
3. Under **Playback**, select the **Play in loop** option.



4. Click **Apply** to confirm your settings, or **OK** to also close the window.

Zooming and Moving Graphs

Once you have acquired data, you can use zoom and pan functions on the graphs to better see the results. The Zoom and Pan buttons are located on the right side of the main window.



➤ When modifying the zoom level of a *pattern diagram*, or if you move its view area, all *pattern diagrams* for the same polarization will adjust to this new zoom level. This allows inter-graph validation and analysis.

➤ Constellation graphs are always zoomed isotropically (same zoom level on both axes) to keep their square appearance.

Displaying and Setting X-Axis Values

For eye and pattern graph types, you can customize the display of the X axis, by selecting the units and by selecting whether values will be shown on the axis or not (if values are not shown, the first and last values are indicated on the sides).

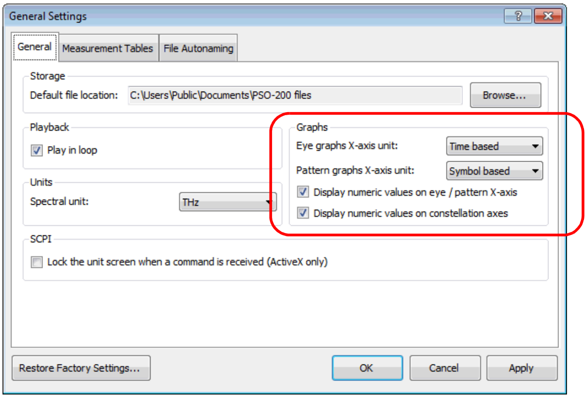
- Eye diagrams: units can be time- or period-based
- Pattern diagrams: units can be time- or symbol-based

Note: *Time unit prefixes will automatically adjust to fit the values (ns, ps, etc.).*

Note: *These features will have an effect on all applicable graphs.*

To customize the display of the X axis:

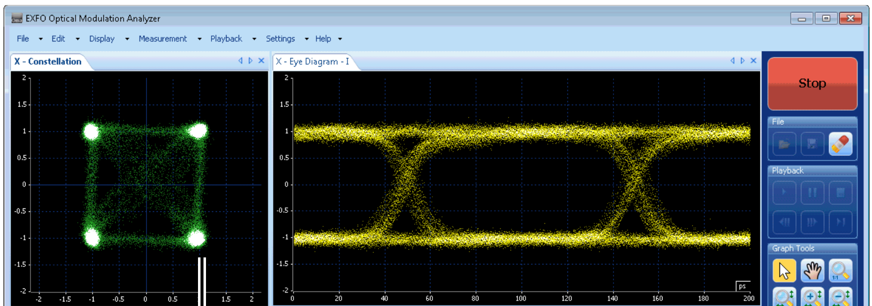
1. From the **Settings** menu, select **General**.
2. Select the **General** tab.
3. In the **Graphs** section, check the boxes to display units on the graphs, and select the appropriate units to use.



4. Click **Apply** to confirm your settings, or **OK** to also close the window.

Displaying Graphs in Color Grade Mode

The Color Grade mode is much like using phosphor persistence on an oscilloscope. The more a specific point is hit, the brighter it is displayed. This quickly gives you a view of the distribution of points on the plots.



Brighter points (almost white)

Color Grade is available during both acquisition and playback, and for the following types of graphs:

➤ Constellation charts

➤ Eye diagrams (I-Q, Phase, Intensity, Magnitude, EVM)

Note: *When going backwards in Playback mode, colors will be reset.*

Note: *Color Grade is applied to all relevant graphs at once. It is not available when Averaging is active.*

To activate Color Grade:

From the **Display** menu, select **Color Grade**. Clear the option to remove the effect.

Displaying Multiple Bursts Simultaneously (Persistence)

With the Persistence mode, charts can display simultaneously the data of up to 5 bursts (layers) to help identifying areas with a high number of points. The “infinite” option accumulates the points from all bursts, which is similar to the Color Grade mode but with a single color.

Note: *Persistence is applied to all relevant graphs at once. It is not available when Color Grade is enabled.*

To set the persistence level:

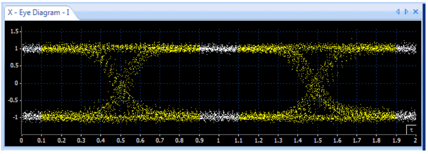
1. From the **Display** menu, select **Persistence**.
2. Select the number of layers (1 to 5 or infinite). The default is 1, which means no persistence.

Setting Number of Symbol Periods for Eye Diagrams

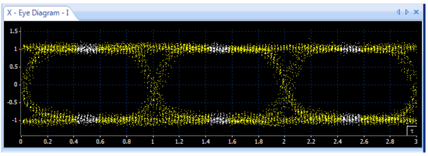
You can display eye diagrams with 1 to 5 symbol periods.

To set the number of symbol periods:

1. From the **Display** menu, select **Periods**.
2. Select the number of periods (1 to 5).



2 periods



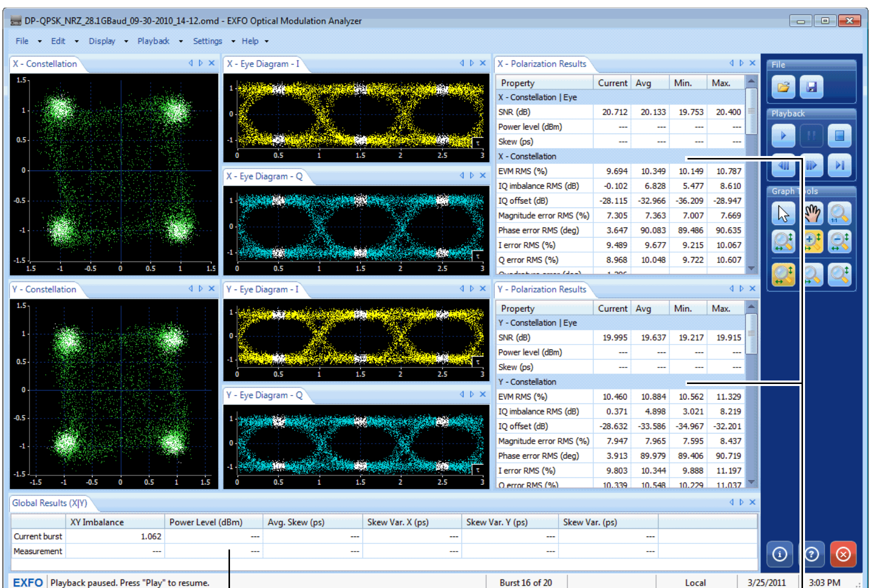
3 periods

Using the Measurement Tables

The measurement table is used to view the calculated results for each axis (I, Q, phase, magnitude). You can decide to display the table or not, and you can customize it to optimize result viewing.

In preset layouts, measurement tables are associated with the corresponding chart. There is also one table per polarization state. However, you can change the layout, or even decide to only display a general table that shows information common to both polarizations.

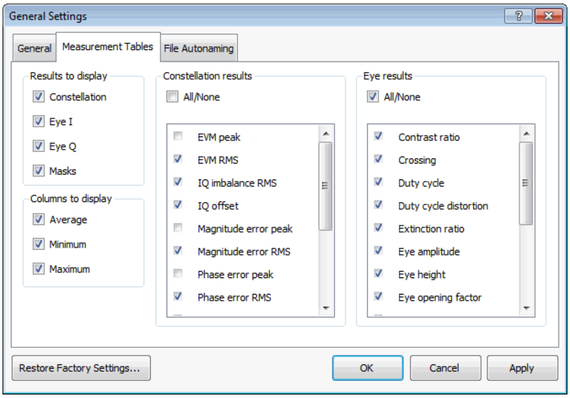
For details on each of the available measurements, see *Measurement Definitions* on page 251.



***Note:** You can copy the contents of the table to the Windows clipboard for use in another application, as explained in* Copying Graph and Measurements to Clipboard *on page 114.*

To customize the measurement table display:

1. From the **Settings** menu, select **General**.
2. Select the **Measurement Tables** tab.
3. Select which items you want to view in the measurement tables.



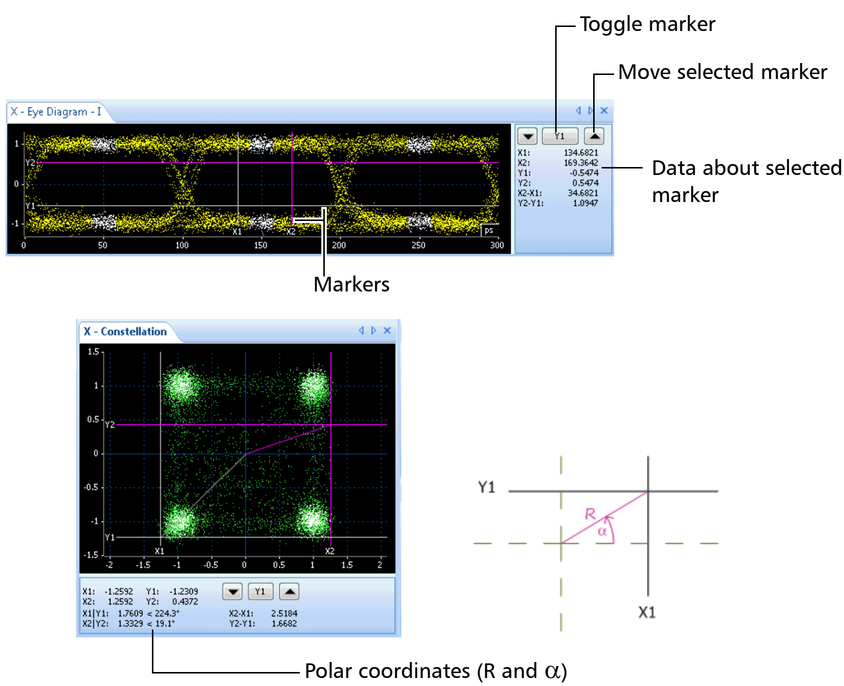
4. Click **Apply** to confirm your settings, or **OK** to also close the window.

Using Graph Markers

To help you evaluate values and differences (deltas) in precise locations of *any graph type*, you can display and position sets of markers on the graph and view corresponding data on a tiny dashboard.

There are two markers for each axis: X1, X2, Y1, Y2. You can move markers from end to end, independently from each other.

Constellation charts also include a diagonal line from the center to crossing pairs of markers (X1|Y1 and X2|Y2), and the dashboard provides corresponding polar coordinates.



To display (or hide) markers and dashboard for a graph:

Right-click on a graph, then select **Show Markers** (or **Hide Markers**).

OR:

1. Select a graph.
2. From the **Display** menu, select **Show Markers** (or **Hide Markers**).

To select and move a marker:

In Selection mode, drag the marker on the screen with the mouse or touchscreen.

OR:

1. Click the toggle marker button until you reach the desired marker (indicated on the button).
2. Press or hold the arrow buttons on each side of the marker button in the dashboard unti the marker is correctly positioned.

Note: *If you zoom in on the graph, markers retain their position (thus possibly becoming invisible). If you then move a marker* with an arrow button*, the marker comes back to the visible area, then moves in regular increments.*

Viewing Signal Distribution Using Histograms

In cases where you want to see a more detailed distribution of points in a region, you can display a horizontal or vertical histogram on top of a graph.

- ➤ Horizontal histogram: each bar, displayed vertically from the bottom, represents the number of points for the corresponding value on the *horizontal axis*. For example, in an Intensity-vs.-Time graph, each bar would represent a specific time value.
- ➤ Vertical histogram: each bar, displayed horizontally from the left, represents the number of points for the corresponding value on the *vertical axis*. For example, in an Intensity-vs.-Time graph, each bar would represent a specific intensity value.

The histogram is defined by the enclosed area of markers, so markers must be displayed first. Moving markers or zooming the graph automatically recalculates the histogram values. The histogram is scaled on the graph area so that the highest value is in the middle.

When a histogram is displayed, the following values appear in the graph corner:

- ➤ Mean and standard deviation
- ➤ Total hit count in histogram
- ➤ Peak-to-peak value (max – min)
- ➤ Signal-to-noise ratio (SNR) (for vertical histograms only on eye and pattern graphs, and does not apply to EVM and Phase graphs)

Note: *You cannot display horizontal and vertical histograms simultaneously on a graph.*

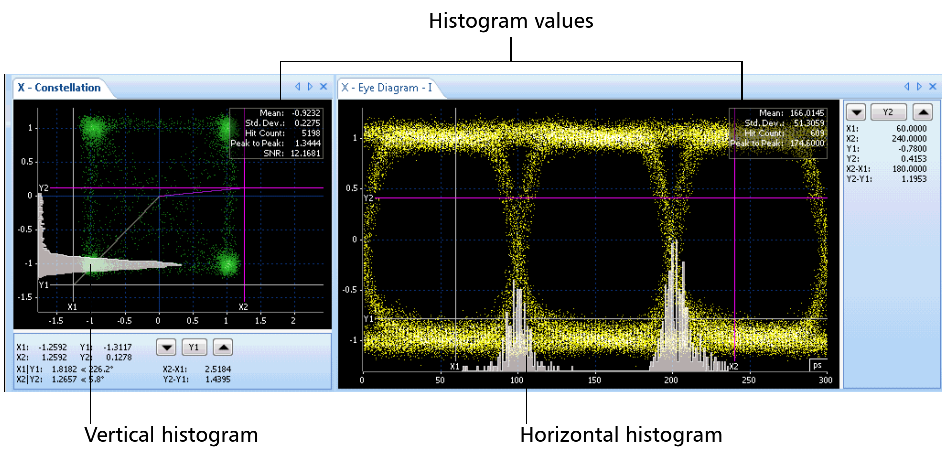
Note: *Histograms are not available when averaging is set, since there are no points to count in this mode (see* Using Averaging to Improve Results *on page 70).*

To display a histogram on a graph:

1. Select a graph.
2. From the **Display** menu, select **Show Markers** (if they are not already displayed), then position them as needed.
3. From the **Display** menu, select **Show Horizontal/Vertical Histogram**. A check mark will appear next to the menu item.

OR:

Right-click on a graph and select **Show Markers**, then right-click on the graph again and select **Horizontal/Vertical Histogram**.



To remove the histogram from a graph:

1. Select a graph.
2. From the **Display** menu, select **Show Horizontal/Vertical Histogram** again to clear the menu item, or select **Hide Markers**.

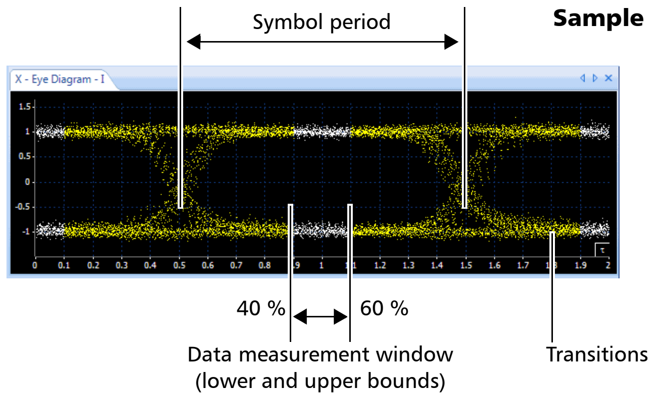
OR:

Right-click on a graph and select **Horizontal/Vertical Histogram** to clear the menu item, or select **Hide Markers**.

Distinguishing Data Points from Transitions

You can display “real data points” in white on all graphs simultaneously to distinguish them from other points, called “transitions”. It allows you to rapidly see if data points are where they should be (a point in the transition path would be considered as an error).

Sample QPSK (NRZ)



Data points are determined using a measurement window, which is a time range that you define as a percentage of the symbol period, as shown above. The following default values are set according to standards:

	Available Range	NRZ Default	RZ Default
Lower bound	0 – 100 %	40 %	47.5 %
Upper bound	0 – 100 %	60 %	52.5 %

With data points highlighted in white, the application allows you to hide (or show) transition points, on the constellation chart only.

Note: *You cannot modify the display of data points and transitions when graphs are shown in Color Grade mode or when averaging is set (see* Using Averaging to Improve Results *on page 70).*

To highlight data points in white:

From the **Display** menu, select **Highlight Data Points**. Clear the option to remove the color.

Note: *This feature will have an effect on all applicable graphs at once.*

To hide or show transitions (constellation chart only):

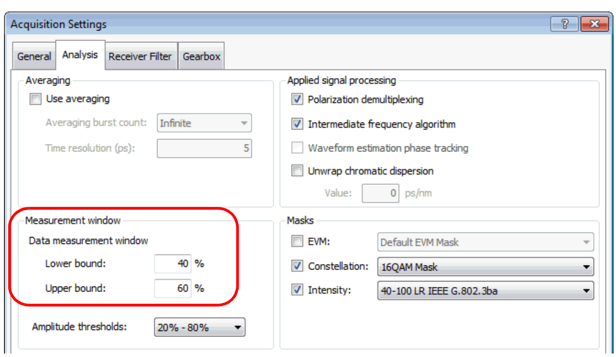
Right-click on the graph, then select **Hide Transitions** (or **Show Transitions**).

OR:

1. Select the constellation chart.
2. From the **Display** menu, select **Hide Transitions** (or **Show Transitions**).

To modify the data measurement window:

1. From the **Settings** menu, select **Acquisition**.
2. Under the **Analysis** tab, set the lower and upper bounds of your measurement window, as a percentage of the bit period.

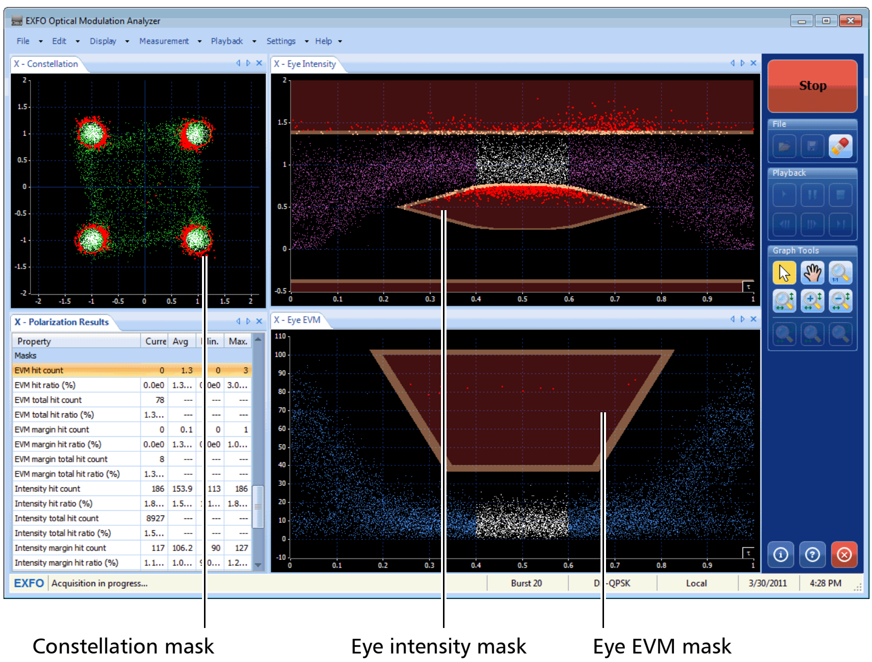


3. Click **Apply** to confirm your settings, or **OK** to also close the window.

Using Pattern Masks

You can display masks on graphs to test signal quality and perform a quick pass/fail verification of signal compliance to applicable standards. Masks are used to determine whether a sampling point fits in the normal pattern or not; points considered “in error” can optionally be highlighted in red.

There are three available mask types, as illustrated below:



➤ Intensity mask: consists of upper and lower zones and a center polygon. *Data points and transition points inside these areas* are considered as errors.

➤ Constellation mask: consists of a circular area around each symbol. *Data points outside the circle* are considered as errors.

➤ EVM mask: consists of a single polygon area. *Data points and transition points inside the polygon* are considered as errors.

The following standard masks are provided with the application:

IEEE G.802.3ba	ITU G.959.1	Other
40-100 LR (large ratio)	NRZ 10G 1310 nm	RZ 40G custom
40-100 SR (small ratio)	NRZ 10G 1550 nm	
	NRZ 40G	

Note: *When an acquisition file contains masks, you can view their settings in the* ***Current Acquisition Information*** *window.*

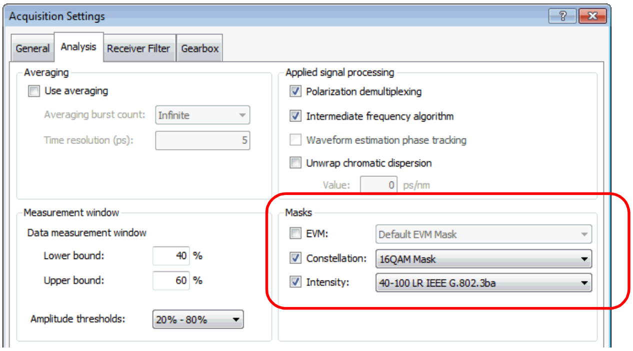
Activating and Displaying Masks

When masks are activated, measurement tables can include hit test results (hit counts and hit ratios). Values are computed the same way as BER/SER (one per polarization, total and per burst). See how to display these results or not in *Using the Measurement Tables* on page 56.

Note: *Masks are not available when Averaging is active and cannot be applied on averaged data.*

To activate and select masks:

1. From the **Settings** menu, select **Acquisition**.
2. Under the **Analysis** tab, select the desired mask types and masks.



The drop-down lists correspond to available mask definition files, either provided with the application or custom-made.

3. Click **Apply** to confirm your settings, or **OK** to also close the window.

Note: *The eye period is automatically set to 1 (and cannot be changed) when an intensity or EVM mask is* active, *no matter if masks are actually shown.*

To show or hide masks on the graphs:

1. From the **Display** menu, select **Masks** > **Show/Hide Masks**.
2. Optionally select **Highlight points in masks** in the same menu. Points in error will be displayed in bright red.

Note: *You can show or hide masks at any time, even while an acquisition is in progress. All masks are shown or hidden at once.*

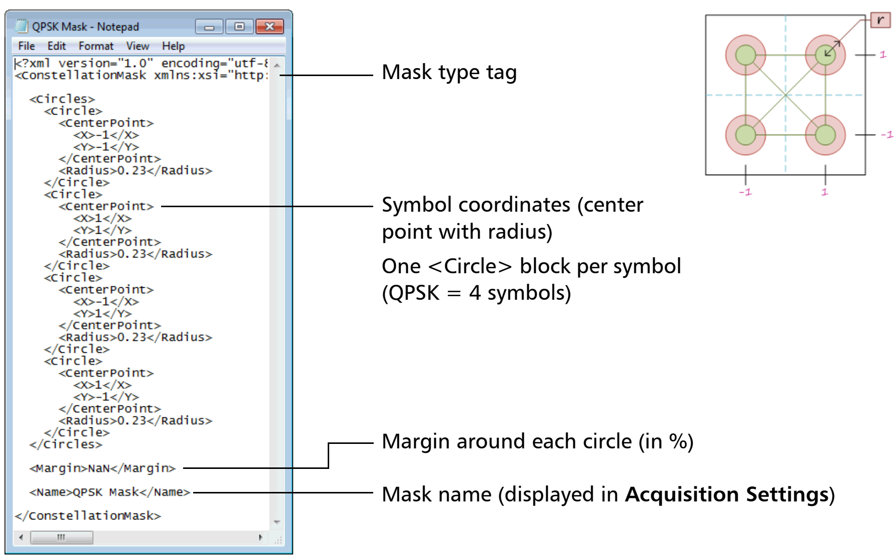
Creating or Editing Mask Definition Files

The Optical Modulation Analyzer does not include a mask editor. However, mask definition files (.maskcfg) are in XML format, allowing you to easily create custom-made masks or edit the ones provided.

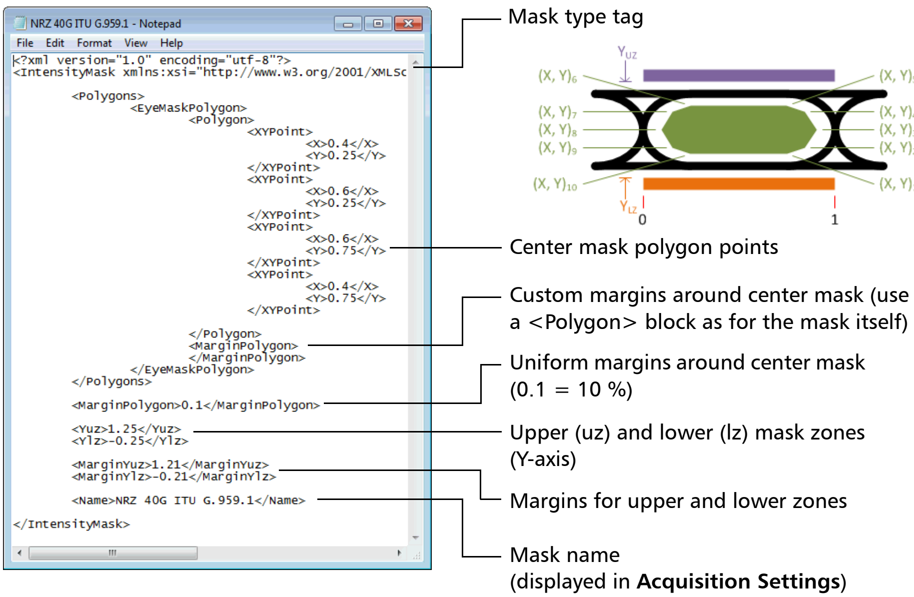
Note: *You can modify mask definition files while the application runs, but you must reopen the* ***Acquisition Settings*** *window to update the list of masks.*

The following examples show the file format for each type of mask:

Constellation Mask (QPSK)



Intensity Mask (NRZ 40G ITU)



Specific requirements for intensity (and EVM) masks:

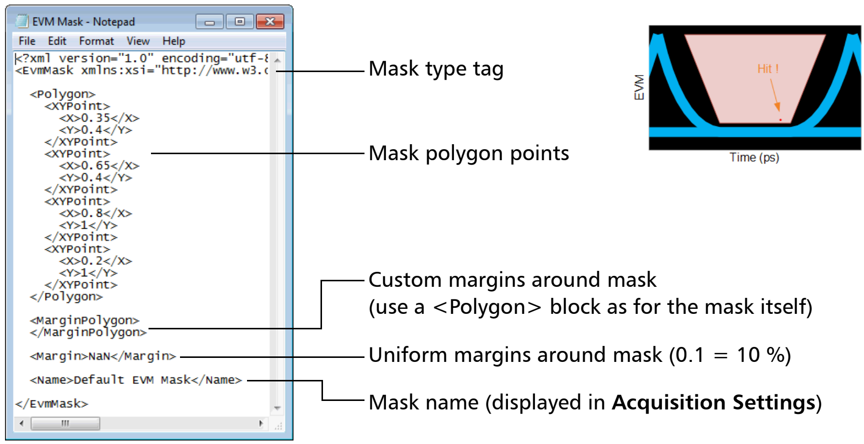
- You can enter as many coordinates (x,y pairs) as needed to form the shape of the center mask.

  Points must be listed in the order one would use when hand drawing the polygon, regardless of the starting point and direction.

- You can apply margins, as zones for points “possibly” in error. Measurements falling in this margin are included in the table.

  You can enter a global margin that will apply around the entire mask, or you can define another *surrounding* custom polygon with a different shape. If you define both, the latter takes precedence.

EVM Mask



EVM masks follow the same requirements and rules as intensity masks, but do not contain upper and lower zones.

To edit mask definition files:

1. Locate the following folder: [application data]\EXFO\PSO-200\Masks. This is where the application looks for mask files. There is a subfolder for each mask type.
2. To keep the provided files intact, make a copy of one of them and open this copy with an XML editor or Notepad.
3. Make the necessary changes, following the guidelines given in the above examples.
4. Save the file in the folder corresponding to its mask type. Use a meaningful name for your needs, as the application does not consider the file name.

Using Averaging to Improve Results

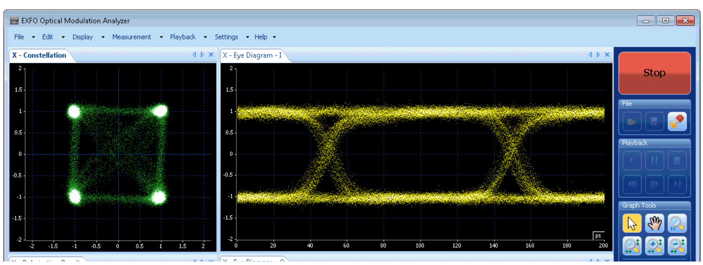
You can improve the signal waveform (and SNR) by averaging subsequent acquisitions and removing noise. When doing so, graphs are plotted using lines between points, so that you can better see the averaged data.

You can set the number of bursts that are averaged, as well as the averaging window (time resolution, the “bin” size in ps into which samples are accumulated).

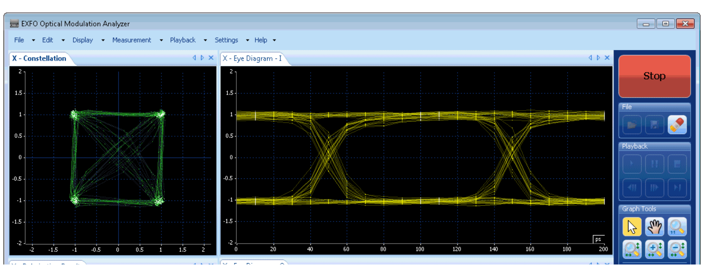
➤ A larger number of bursts improves the SNR but decreases the refresh rate and tracking.

➤ A smaller time resolution improves the SNR.

The figures below illustrate the improvement of results using averaging.



No averaging



Using averaging

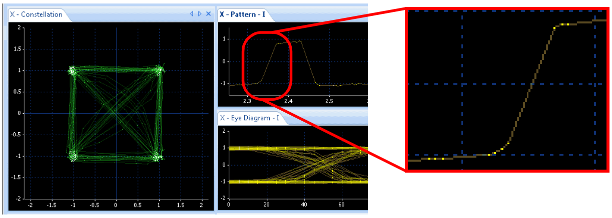
(Infinite, 10 ps)

The averaging mode "fills the holes" by adding more and more points (at intervals defined by the time resolution) to build a complete waveform with all samples from all previous bursts, as shown in the two images below. The average is recalculated after each burst as follows:

$$\text{NewAverage} = \text{PreviousAverage} \cdot \frac{N-1}{N} + \text{NewBurst} \cdot \frac{1}{N}$$

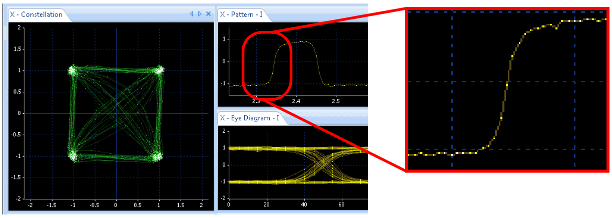
where N is the number of bursts acquired, up to the specified averaging burst count (1 to 64). If Infinite is specified, N will increase infinitely.

For example, if the averaging burst count is 4, N will be 1, 2, 3, 4, 4, 4...



Using averaging

(1 burst, 5 ps)



Using averaging

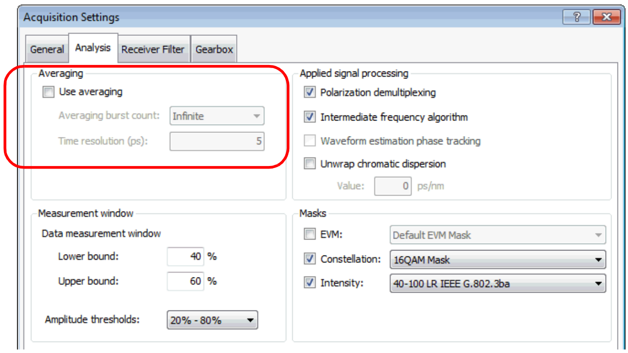
(infinite, 5 ps)

Note: *Averaging is not available in Random input pattern. It requires a pattern (known or unknown) to function properly.*

Note: *Averaging will apply to all relevant graphs at once.*

To activate and configure averaging:

1. From the **Settings** menu, select **Acquisition**.
2. Under the **Analysis** tab, set the averaging parameters.



➤ Select **Use averaging** to activate it (not selected by default).

➤ Select the number of bursts to average on (1 to 64, or Infinite).

➤ Set the averaging window (1 to 10 ps, default = 1 ps).

3. Click **Apply** to confirm your settings, or **OK** to also close the window.

Applying Advanced Signal Processing Algorithms

You can activate or deactivate specific signal processing algorithms before or while acquiring data, or afterwards in reanalysis mode (see *Reanalyzing Acquisitions with New Settings* on page 115). The following algorithms are available, depending on the selected modulation format and input pattern:

➤ Polarization Demultiplexing

For details, see *Polarization Demultiplexing* on page 245.

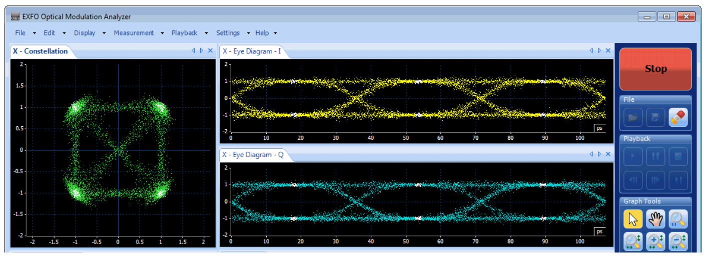
➤ Intermediate Frequency Recovery

For details, see *Intermediate Frequency (IF) Recovery* on page 246.

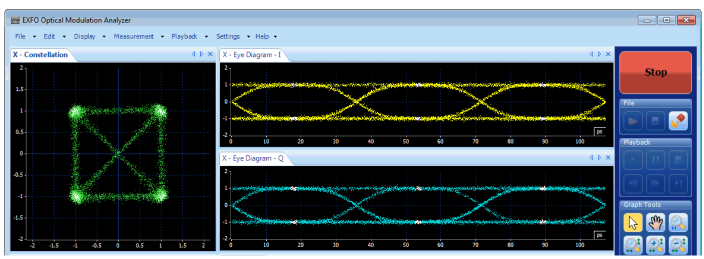
➤ Waveform Estimation Phase Tracking

Increases the PSO-200 phase tracking ability in presence of a large amount of signal phase noise (>1-2 MHz for QPSK). Use when constellation transitions (green samples) suffer from large phase noise whereas symbol center points (white samples) do not spread in phase direction. It utilizes information from the previously acquired waveform to improve the phase tracking of signal transitions.

No Phase Tracking



Using Phase Tracking



Note: *This algorithm slows down the overall performance.*

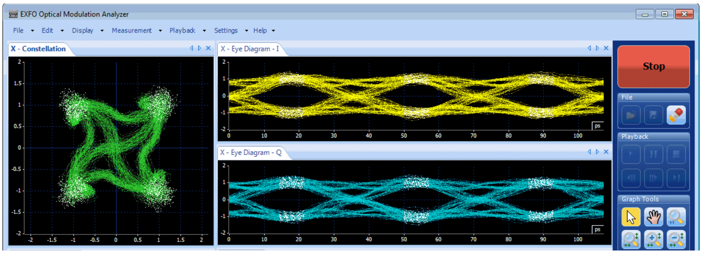
➤ Chromatic Dispersion Unwrapping

Compensates for chromatic dispersion in the signal. You must provide a value (in ps/nm) for use by the algorithm.

Also activates averaging (with the time resolution set based on the signal's symbol rate). If you deactivate averaging, this algorithm is also deactivated.

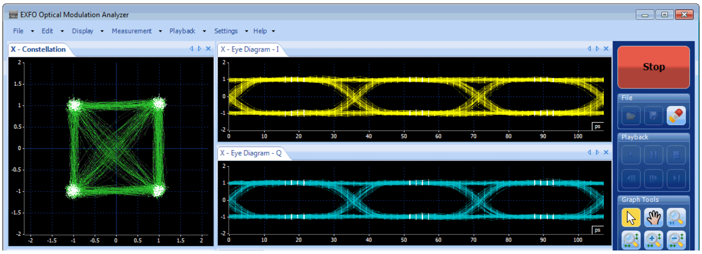
No CD Unwrapping

(after 20 bursts)



Using CD Unwrapping

(after 20 bursts)



The following table shows algorithms available for each input pattern type:

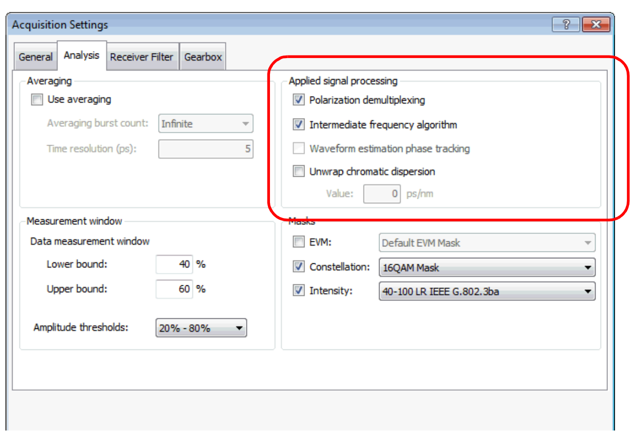
Algorithm	Random	Repetitive (Unknown)	Known Patterns
Polarization demultiplexing	Yes	Yes	Yes
IF recovery	Yes	Yes	Yes
CD unwrapping (as Averaging and Filters)	No	Yes	Yes
Waveform estimation phase tracking	No	No	Yes

To activate signal processing algorithms:

1. From the **Settings** menu, select **Acquisition**.

2. Under the **General** tab, select one of the values in the **Input Pattern Type** list. Then provide the necessary pattern details.

3. Under the **Analysis** tab, select the desired algorithm(s).



4. Click **Apply** to confirm your settings, or **OK** to also close the window.

Applying Data Filtering

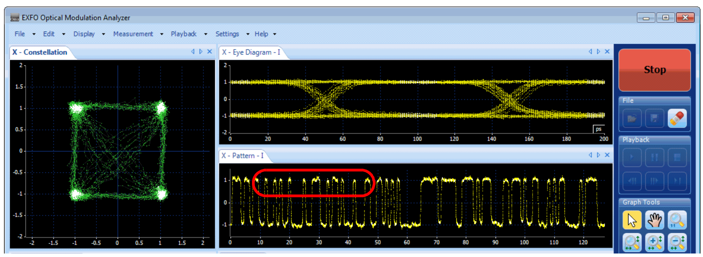
The Optical Modulation Analyzer application allows you to apply the following filters to your acquisition:

➤ Chebyshev (type I only)

➤ Bessel

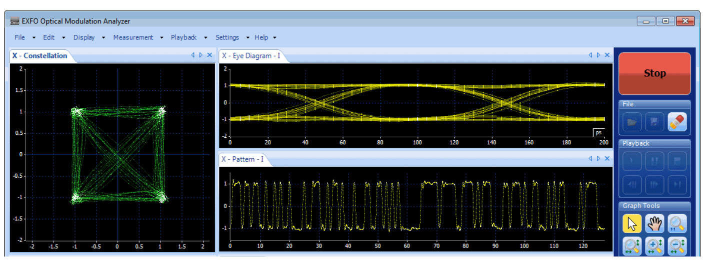
➤ Butterworth

No Filtering



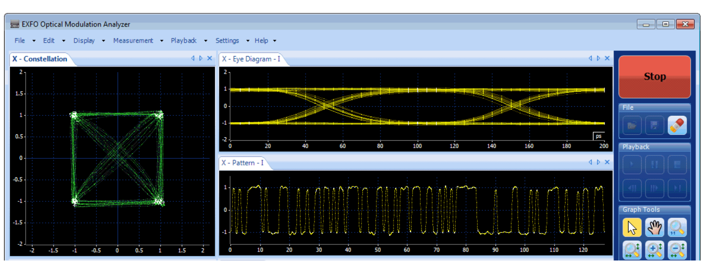
Using Filtering

(Chebyshev)



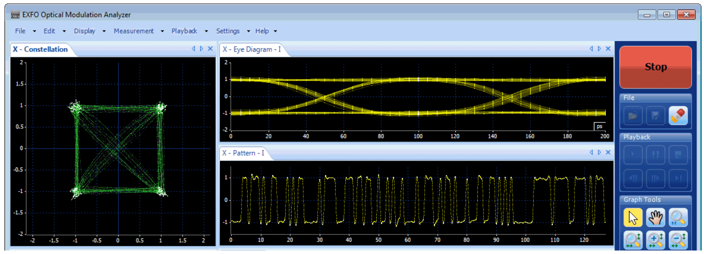
Using Filtering

(Bessel)



Using Filtering

(Butterworth)



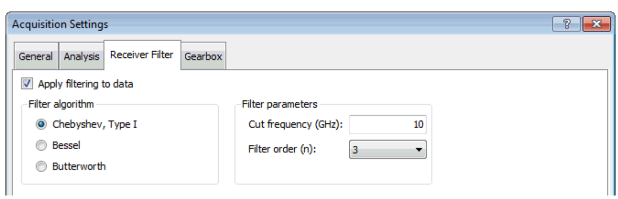
When you select filtering, the application also activates Average mode (the averaging time resolution will be set based on the signal's symbol rate). If you deactivate average mode, filtering is also deactivated.

Note: *Filters are not available in Random input pattern. They require a pattern (known or unknown) to function properly.*

Note: *Filters will not work well with OOK modulation.*

To activate and configure a filter:

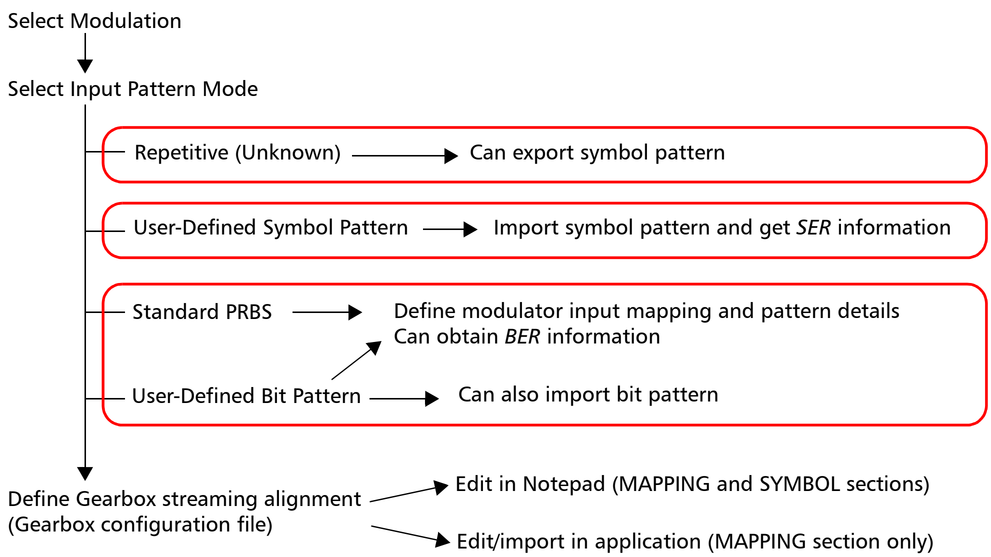
1. From the **Settings** menu, select **Acquisition**.
2. Under the **Receiver Filter** tab, select **Apply filtering to data**.



3. Select the desired filter algorithm and parameters.
   - ➤ Cut frequency (default = signal's symbol rate)
   - ➤ Order of the filter (from 1 to 5, default=3)
4. Click **Apply** to confirm your settings, or **OK** to also close the window.

8 Bit Pattern Analysis and the Gearbox

The following diagram illustrates the main steps and possibilities in bit pattern analysis using the PSO-200 Optical Modulation Analyzer. With compatible pattern modes, the powerful Gearbox tool allows you to define precisely how your data stream is sent to the modulator and to obtain detailed error rates.



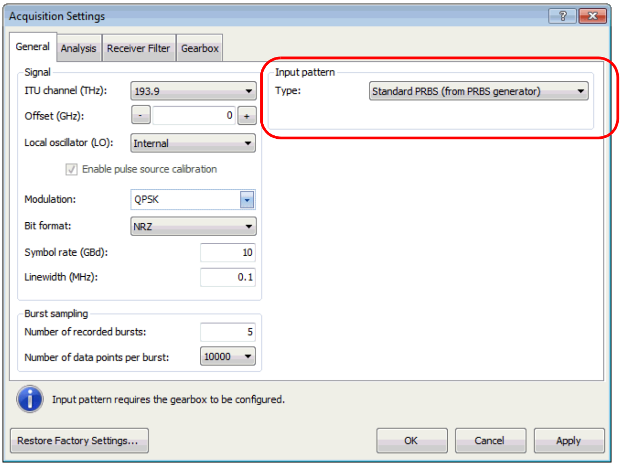
Basic Gearbox Setup Details

Here are the basic instructions to set the Gearbox for testing. The details for each type of setting is explained further in later sections of this chapter.

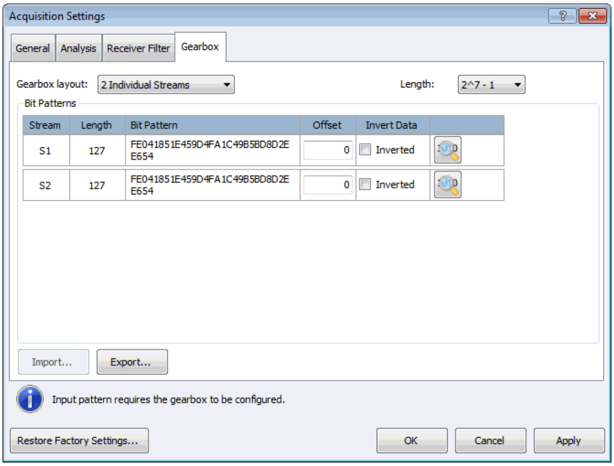
To set the Gearbox:

1. From the main window, select the **Settings** menu, then **Acquisition**.
2. Under the **General** tab, select the input pattern type.

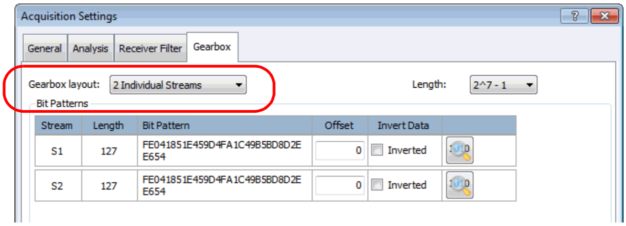
Note: *The Gearbox can only be used with known patterns, such as PRBS, or a user-defined pattern.*



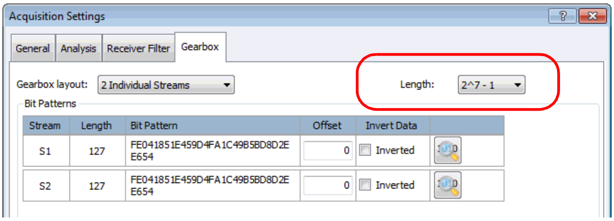
3. Select the **Gearbox** tab.



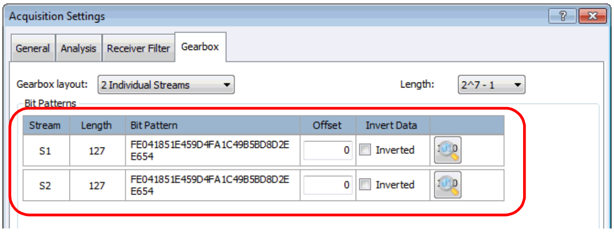
4. Select the Gearbox layout.



5. Select the pattern length.



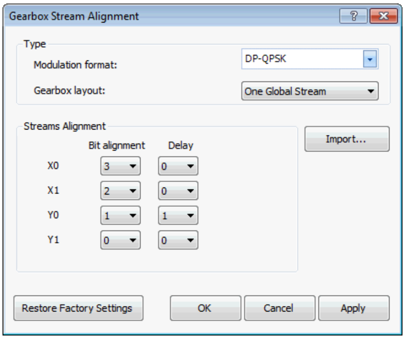
6. Enter the offsets for the bit patterns and indicate whether they are inverted or not. In the case of user-defined patterns, enter the bit stream as well.



To set the bit orders and delays:

1. From the main window, select the **Settings** menu, then **Gearbox Stream Alignment**.

2. In the window, modify the alignments and delays as needed. You can only modify them if you have selected a global or dual X-Y stream.

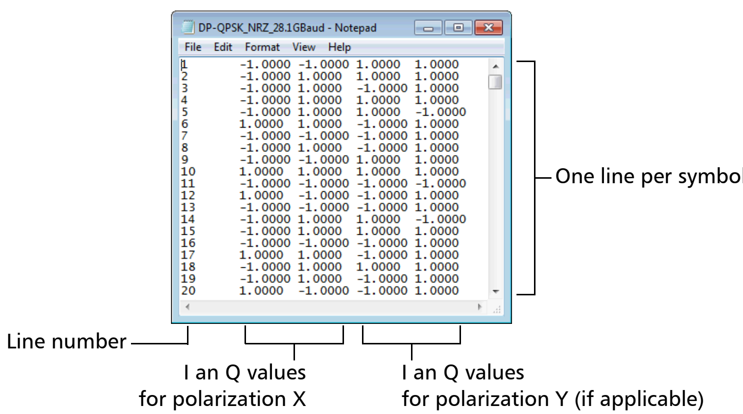


Exporting Symbol Patterns

If the signal data has been acquired with a compatible pattern mode (“Repetitive (unknown)”, “PRBS” or “user-defined”), you can export the actual symbol pattern to a file and reuse it for other acquisitions.

Note: *Exporting the symbol pattern from an acquisition in Repetitive mode is especially useful, since you can reimporting it to obtain better calculations and a symbol error rate. See* Importing User-Defined Symbol Patterns *on page 84.*

The exported file (.osp) is in tab-delimited text format. Here is an example of an exported dual-polarization QPSK symbol pattern, opened in Notepad:



To export a symbol pattern:

1. Select the desired burst (using Playback) from an acquisition made with a compatible input pattern mode.

2. From the **File** menu, select **Export**, then **Symbol Pattern**.

3. Indicate the location where you want to save the file.

Importing User-Defined Symbol Patterns

You can import a known symbol pattern from a file and work directly with the symbols in the constellation without having to know the Gearbox details. This allows you to simulate a modulation scheme implementation that is not supported by the PSO-200 or simply to read back symbols information from a previous export.

In this mode, the IF recovery algorithm takes advantage of the known pattern information, and is therefore more robust towards limitations in the signal laser linewidth (phase noise).

The symbol error rate (SER) can be evaluated, but not the bit error rate (BER), since there is no defined mapping between symbols and bits.

The symbol pattern file must have data for the same polarization(s) as the input signal:

➤ If the signal contains X and Y polarizations and the imported symbol pattern contains only one, the application will automatically duplicate these values for the Y polarization.

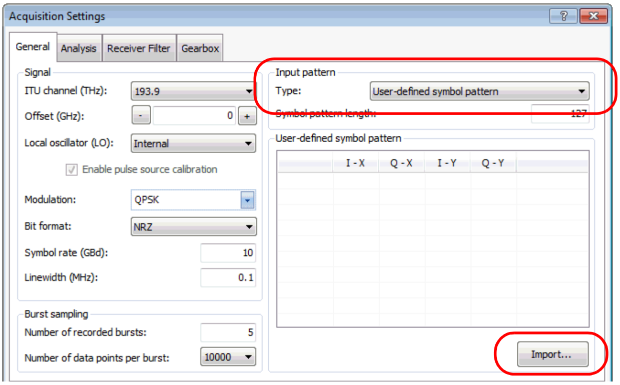
➤ If the signal contains one polarization and the imported symbol pattern contains both, the application will truncate the Y data from the pattern.

Note: *When importing a symbol pattern, the application will normalize any non-normalized value.*

Note: *The Gearbox is not available in this mode.*

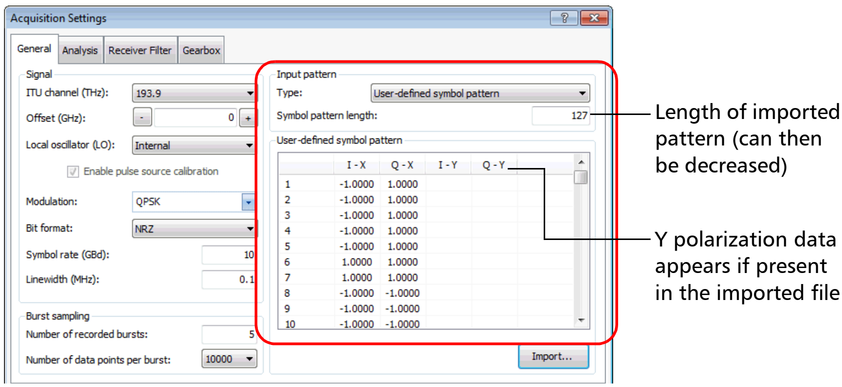
To import a symbol pattern:

1. From the **Settings** menu, select **Acquisition**.
2. Select the **General** tab.



3. In the **Input pattern** section, select **User-defined symbol pattern**.

4. Click **Import**, then select the symbol pattern file (.osp) you want to import and click **Open**.



5. If needed, enter a *smaller* value in the **Symbol pattern length** box. The imported symbol pattern will be truncated when you close the window. The pattern will be unusable if the specified length is larger.

6. Click **Apply** to confirm your settings, or **OK** to also close the window.

Performing Detailed Bit Pattern Analysis with the Gearbox

To obtain information such as the probability of error for each individual bit/byte in a pattern, it is essential to get detailed bit pattern analysis capabilities. The PSO-200 Optical Modulation Analyzer can accurately recover the time-domain information without any signal processing due to the high bandwidth achieved with optical sampling. A detailed analysis of the bit pattern recovered can provide a bit error rate (BER) per polarization or map the error vector magnitude (EVM) per symbol. To achieve this, the PSO-200 must receive information on the pattern and sequences used in the transmitter.

For example, consider the following bytes to transmit: D8 A5 69 FE. We need to go further down to the bits since the transmitter is bit-based:

D8	A5	69	FE
1101 1000	1010 0101	0110 1001	1111 1110

We sequence those bits in time by considering the first one to be transmitted as the farthest one on the left (which is the higher rank bit in binary convention).

A bit-pattern generator *usually* sends bits the way we read them, from left to right. Some may send the bits in reverse order (“0001 1011”), hoping that the receiver will rebuild the sequence correctly.

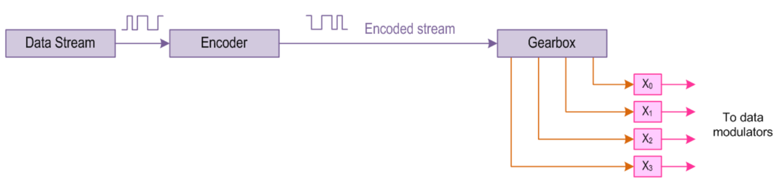
No matter how the generator sends bits, the Optical Modulation Analyzer application needs a way to determine which bit goes to which modulator input of the transmitter, and which symbol in the constellation represents the recomposed bit pattern. This is where the Gearbox is required.

Gearbox Streaming Types

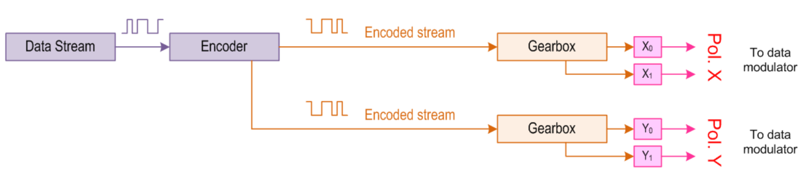
Depending on how the bit pattern is sent to your transmitter, the Gearbox can be configured as follows:

➤ One global stream – a single known encoded data stream is demultiplexed inside the transmitter into several parallel sub-streams sent to the modulator, with delays and inversions (if any).

➤ N individual streams – as many encoded data streams as there are bits per symbol (four in the example diagram) are sent with known delays and inversions, if any, to the same number of modulators.

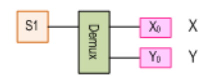
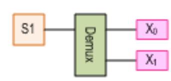
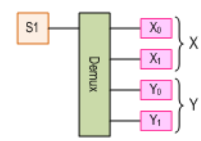
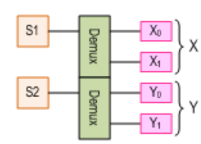
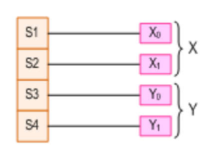


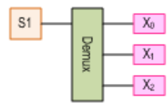
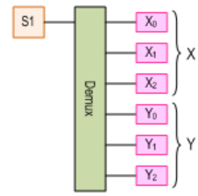
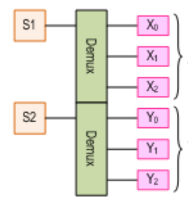
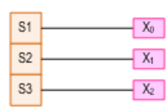
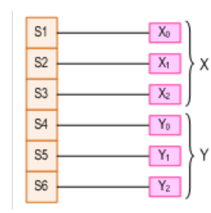
➤ Dual X-Y streams (dual-polarization modulations only) – two known encoded data streams corresponding to the X and Y states of polarization are demultiplexed inside the transmitter into parallel streams sent to the modulators.

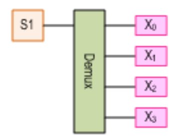
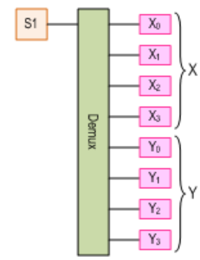
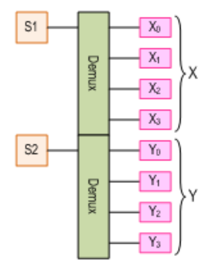
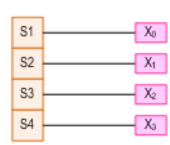
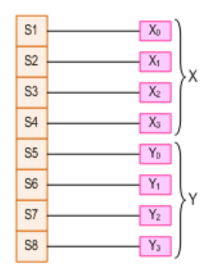


Note: *If the transmitter has an internal encoder, it is the encoded data that must be input to the Gearbox.*

There are several ways to implement a data modulator for a modulation format; with these basic Gearbox settings, you should be able to select a combination that suits your data generation. The table below shows all possible configurations for the supported modulations formats.

Modulation	Single Polarization	Dual Polarization
OOK BPSK	1 global stream 	1 global stream 
		Dual (X-Y) streams 
QPSK	1 global stream 	1 global stream 
		Dual (X-Y) streams 
	2 individual streams 	4 individual streams 

<table>
<tr><th>Modulation</th><th>Single Polarization</th><th>Dual Polarization</th></tr>
<tr><td rowspan="3">APSK</td><td>1 Global stream

</td><td>1 Global stream

</td></tr>
<tr><td></td><td>Dual (X-Y) streams

</td></tr>
<tr><td>3 Individual streams

</td><td>6 individual streams

</td></tr>
</table>

Modulation	Single Polarization	Dual Polarization
16-QAM	1 global stream  	1 global stream 
		Dual (X-Y) streams 
	4 individual streams  	8 individual streams 

Gearbox Configuration File Layout

A Gearbox configuration file is used by the Optical Modulation Analyzer application to properly map the bit pattern provided as the input to the system.This file is divided into three sections:

- Definition
- Bit symbol mapping and delay
- Symbol coordinates

The file is based on Microsoft's information file format (.inf). Sections are represented by an uppercase word enclosed in square brackets. Names should not be modified. Values are represented by a name, followed by "=" and the values. Multiple values are separated by a tab (ASCII 09).

The application provides predefined configuration files for all supported modulation schemes. These files are located in the following folder:

\My Documents\EXFO\PSO-200\GearboxSetups

You can edit the files using any text editor. The Mapping section of the file can also be modified from the Optical Modulation Analyzer application.

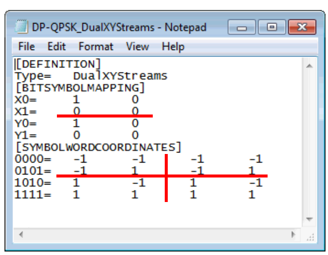
Definition Section

This section describes the type of Gearbox this file addresses. The possible values of the “Type” field are:

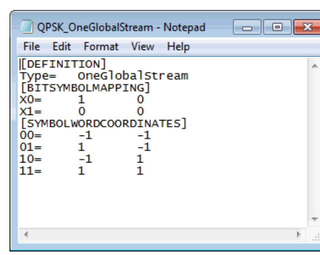
- OneGlobalStream
- NIndividualStreams
- DualXYStreams (only required and supported for dual-polarization modulation schemes)

There is one file per Gearbox streaming type and per modulation scheme. For example, DP-QPSK has three Gearbox configuration files.

The third type (dual X-Y streams) is different from the other two. For a same modulation format, the “SYMBOLWORDCOORDINATES” section content has to be seen as two single-polarization configurations. As an example, see the dual X-Y stream configuration for DP-QPSK (left) compared to the one global stream configuration for QPSK (right).




```
[DEFINITION]
Type=    DualXYStreams
[BITSYMBOLMAPPING]
X0=      1       0
X1=      0       0
Y0=      1       0
Y1=      0       0
[SYMBOLWORDCOORDINATES]
0000=    -1      -1      -1      -1
0101=    -1      1       -1      1
1010=    1       -1      1       -1
1111=    1       1       1       1
```




```
[DEFINITION]
Type=    OneGlobalStream
[BITSYMBOLMAPPING]
X0=      1       0
X1=      0       0
[SYMBOLWORDCOORDINATES]
00=      -1      -1
01=      1       -1
10=      -1      1
11=      1       1
```

As these examples show, the dual X-Y streams configuration represents the same configuration as twice the single-polarization “one global stream”.

In dual X-Y streams, the “SYMBOLWORDCOORDINATES” section does not seem to contain all possible bit combinations, but it does. In the example, the word “0000” is, in fact, “00” of polarization “X” and “00” of polarization “Y”. With two bits per polarization, there are only four possible words.

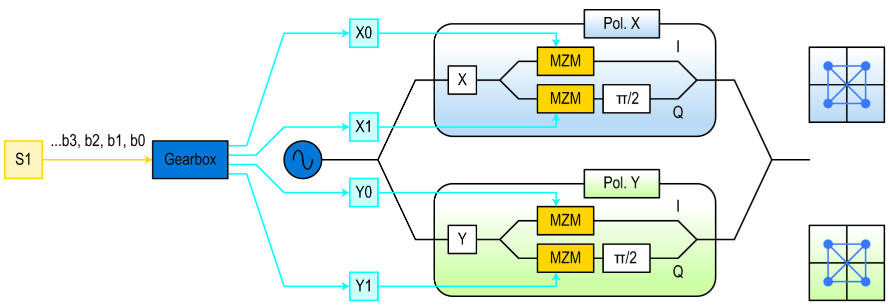
For details about the Gearbox types, see *Gearbox Streaming Types* on page 88.

Bit Symbol Mapping Section

Depending on the modulation scheme, there can be one to four bits per symbol, or even more. This section contains as many lines as there are bits per symbol in the modulation scheme. Each line represents a bit mapping and delay.

Note: *In addition to editing this section of the file with a text editor, you can also modify its values in the Optical Modulation Analyzer application.*

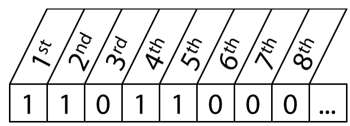
To better understand how this works, here is an example representation of a DP-QPSK transmitter:



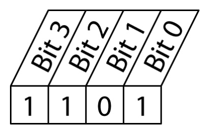
In this image, S1 is the input bit stream, X0 and X1 are the modulator inputs for the X polarization, and Y0 and Y1 are the modulator inputs for the Y polarization. It represents what happens when a single bit stream is split into four modulators. The corresponding configuration file is "DP-QPSK_OneGlobalStream.gearbox".

From the previous example, the following bit stream is sent to the transmitter: 1101 1000 1010 0101 0110 1001 1111 1110.

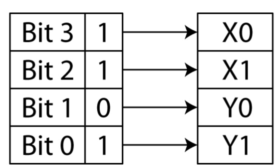
At the transmitter input, the stream looks like this:



The application needs to know which bit goes to which modulator input. This is called *alignment*. The configuration file considers bit naming as follows (by convention, the least significant bit is named "bit 0"):



For example, to indicate to the Gearbox that the bits are aligned this way:



The configuration file should define the inputs as follows (bit name values are in the *first column*):

X0= 3

X1= 2

Y0= 1

Y1= 0

The second column represents the bit delay. In optical systems with ultra-high bit rates, a difference of a few millimeters in fiber length between modulators can lead to bit delays and misalignments. The Gearbox can compensate for these induced delays.

To better understand, here is an example:

Input stream:

1	1	0	1	0	1	1	0	1	0	1	1	1	1	0	0	1	1	1	1	0	0	0	0

As received at modulator inputs (time sliced):

	t=0	t=1	t=2	t=3	t=4	t=5
X0	1	0	1	1	1	0
X1	1	1	0	1	1	0
Y0	0	0	1	1	0	1
Y1	1	0	1	0	1	0

In this example, the Y0 input receives bits with a delay of one “word”. In this case, the second column in the configuration file should be as follows:

X0= 3 0

X1= 2 0

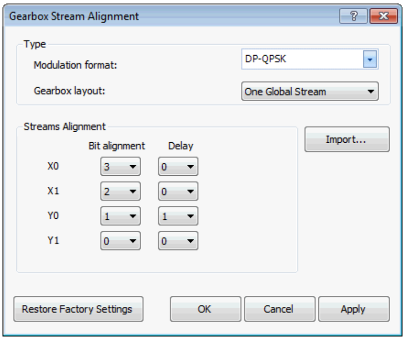
Y0= 1 **1**

Y1= 0 0

Note: *The first symbol identified will be in the time slice corresponding to the greater delay value (t=1 in the above example).*

To set or import the Gearbox stream alignment parameters (Mapping section of the configuration file):

1. From the **Settings** menu, select **Gearbox Stream Alignment**.



2. Select a **Modulation format** and **Gearbox layout**. Each combination corresponds to a configuration file (.gearbox). You can process multiple combinations without exiting this dialog box.

3. Click **Import** to load an existing configuration file (.gearbox). The file must match the selected modulation and layout. The symbol coordinates section is also imported, even if it is not displayed.

4. For each modulator input, select the **Bit alignment** (bit names from 0 to N) and **Delay** (in “block” counts, from 0 to +5).

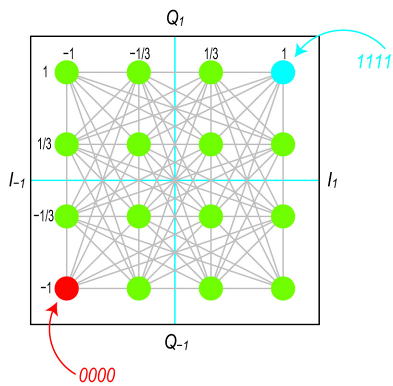
Note: *This step applies to streams that are split into sub-streams. The boxes are disabled (and all fields set to 0) if you select “N individual streams”.*

- For “one global stream”, all bit alignment values must be different.
- For “dual X-Y streams”, bit alignment values for X must be different from each other, and similarly for Y.

5. Click **Apply** to confirm your settings, or **OK** to also close the window.

Symbol Coordinates Section

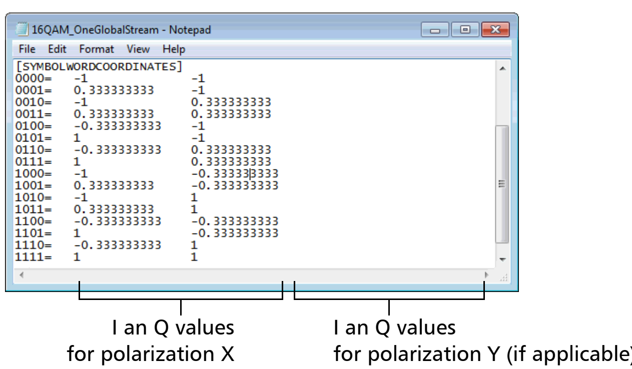
The third section of the Gearbox configuration file is used to tell the application where, in the constellation, a “word” is supposed to be found. This arrangement highly depends of the implementation of the transmitter.



16-QAM constellation example

The configuration file normalizes the constellation on both axes. To indicate where a “word” should appear in the constellation, each line in the file represents a bit pattern and its symbol coordinates:

For example, in a 16-QAM model, we could define that the word “0000” is located at $I_X = -1$, $Q_X = -1$, and “1111” is located at $I_X = 1$, $Q_X = 1$, as shown in the above diagram.



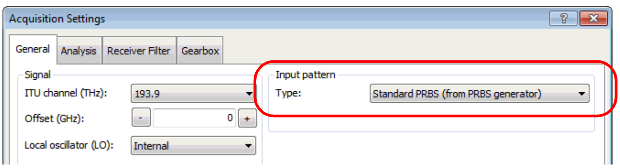
```
[SYMBOLWORDCOORDINATES]
0000=   -1              -1
0001=   0.333333333     -1
0010=   -1              0.333333333
0011=   0.333333333     0.333333333
0100=   -0.333333333    -1
0101=   1               -1
0110=   -0.333333333    0.333333333
0111=   1               0.333333333
1000=   -1              -0.333333333
1001=   0.333333333     -0.333333333
1010=   -1              1
1011=   0.333333333     1
1100=   -0.333333333    -0.333333333
1101=   1               -0.333333333
1110=   -0.333333333    1
1111=   1               1
```

The PSO-200 default implementation and mapping of each modulation is defined in the Gearbox configuration file. If your mapping cannot match this default configuration, you can implement a different mapping, by editing the Gearbox configuration file as explained in *Performing Detailed Bit Pattern Analysis with the Gearbox* on page 87.

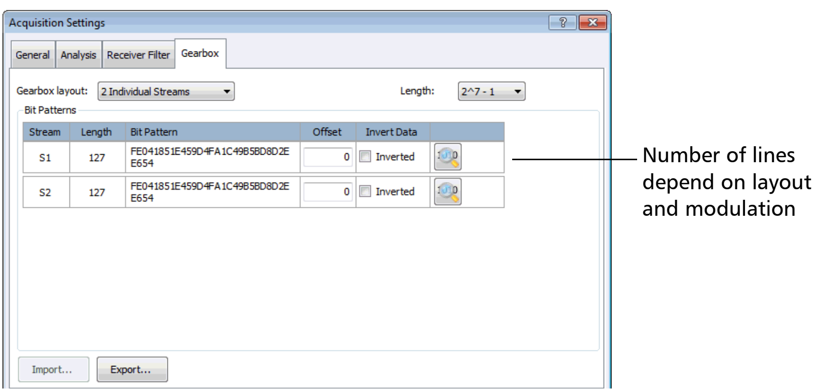
Using PRBS or User-Defined Bit Patterns with the Gearbox

To edit and apply a PRBS:

1. From the **Settings** menu, select **Acquisition**.
2. Select the **General** tab.



3. In the **Input pattern** section, select **Standard PRBS**.
4. Select the **Gearbox** tab. The content fits the PRBS context.



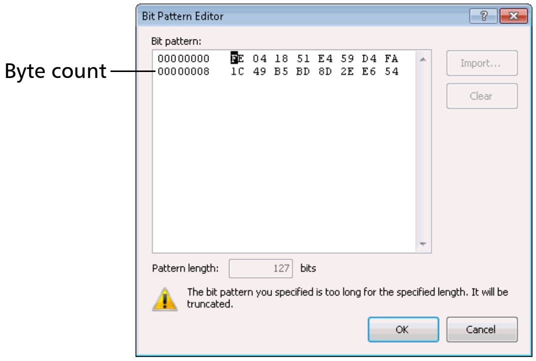
5. Select the **Gearbox layout** corresponding to your data streams. For details see *Gearbox Streaming Types* on page 88. The layout and modulation determine the number of bit streams to configure.

6. Select the **Length** of the PRBS pattern. Available values are all of the form 2^n-1. Each length corresponds to a unique bit sequence, which will be used for all streams.

Note: *Since PRBS sequences are shown in hexadecimal notation, most bit sequences will be truncated to match the selected PRBS bit length.*

7. For each stream listed, perform the following:

7a. Click [icon] to view the entire bit sequence in the **Bit Pattern Editor** window (read-only), then click **OK**.

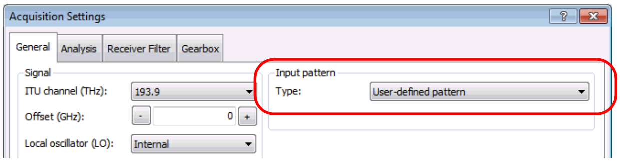


7b. On the **Gearbox** tab, enter an **Offset** value (in bits) if you want the sequence to start at the n^{th} bit/position, and select whether *each bit* in the stream is **inverted** or not (0 becomes 1 and vice-versa).

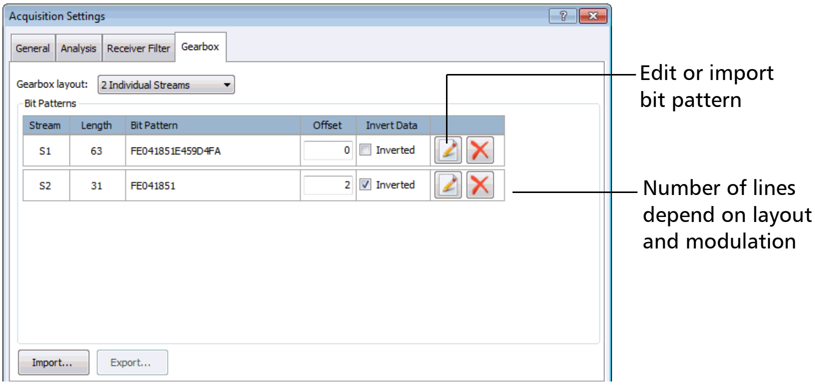
8. Click **Apply** to confirm your settings, or **OK** to also close the window.

To import, edit and apply a custom bit pattern:

1. From the **Settings** menu, select **Acquisition**.
2. Select the **General** tab.



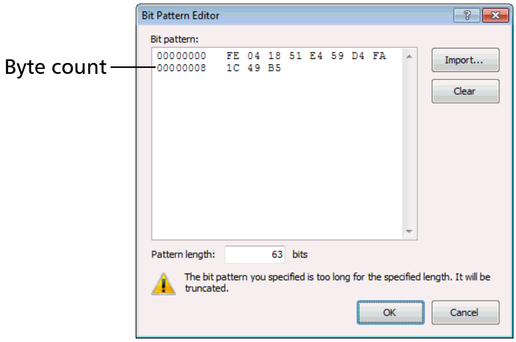
3. In the **Input pattern** section, select **User-defined bit pattern**.
4. Select the **Gearbox** tab. The content fits the user-defined pattern context.



5. As a starting point for the next steps, you can import a Gearbox configuration file (.gboxcfg) by clicking **Import** and selecting the file. See *Exporting Gearbox Setups* on page 104.
6. Select the **Gearbox layout** corresponding to your data streams. For details see *Gearbox Streaming Types* on page 88. The layout and modulation determine the number of bit streams to configure.

7. For each stream listed, perform the following:

7a. Click to open the **Bit Pattern Editor** window.



7b. You can import an existing bit pattern file (plain text with hexadecimal values), then edit values as needed, or you can simply enter the values corresponding to the bit pattern.

Click **Import**, select the file and click **Open**. The imported pattern length is displayed, to save you from counting bytes. You can also click **Clear** to discard the currently displayed values.

7c. Enter a **Pattern length**. The value must be *smaller or equal* to the number of bits in the hexadecimal pattern displayed. The pattern might be truncated to match this length.

7d. Click **OK** to exit the Bit Pattern Editor.

7e. On the **Gearbox** tab, enter an **Offset** value (in bits, from bit 0) if you want the sequence to start at the n^{th} bit/position, and select whether *each bit* in the stream is **inverted** or not (0 becomes 1 and vice-versa).

Note: *When working with delays, the branch that has no delay ends up with the highest offset.*

8. Click **Apply** to confirm your settings, or **OK** to also close the window.

Exporting Gearbox Setups

After you have defined a full Gearbox setup in the Optical Modulation Analyzer application to describe your transmitter's implementation (data stream content and mapping), you can export it to a file for reuse.

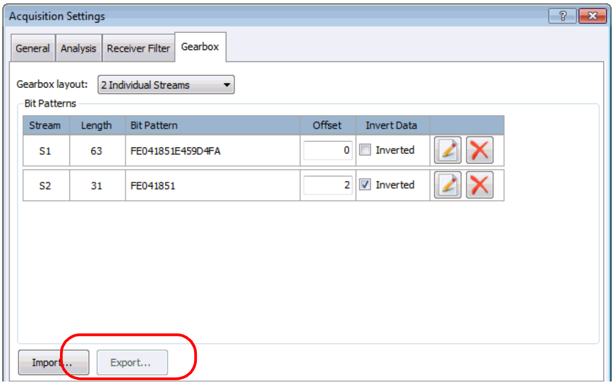
You can export the Gearbox setup of the currently opened file or the one defined in the application settings.

To export the Gearbox setup for the currently opened file:

From the **File** menu, select **Export**, then **Gearbox Setup**.

To export the Gearbox setup of the application settings:

1. From the **Settings** menu, select **Acquisition**.
2. Select the **Gearbox** tab.



3. Click **Export** to save the values of the **Gearbox** tab (layout, length, streams).

Obtaining and Using Bit/Symbol Error Rates

Since the PSO-200 is not a real-time oscilloscope, the sampled symbols will not make a continuous set that can be directly compared with a reference symbol pattern. Even though the symbols are not sampled in order, after time-base reconstruction and constellation sample selection, the symbol error rate (SER) can be evaluated.

To obtain the bit error rate (BER), you have to provide the expected bit pattern (PRBS or user-defined). The BER is a bit-to-bit comparison between the measured and expected patterns, performed on every acquired sample contained in the measurement window.

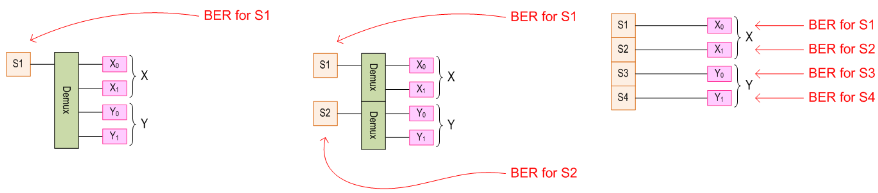
$$\mathrm{BER} = \frac{\text{Total number of non-matching bits}}{\text{Total number of bits verified}}$$

The BER is updated with each new burst processed (current number of errors = previous number + new number). The current burst BER and the total BER (from the start of the acquisition) are both displayed.

Note: *When clicking **Start** or **Clear** in the application, BER results are reset, like all other measurements.*

Note: *BER/SER values cannot be computed in Averaging mode.*

The application displays a BER for *each polarization* of the system, according to the Gearbox configuration, as shown below. The application computes a BER for each input stream.



One global stream   Dual X-Y streams   N individual streams

Similarly, the SER is calculated as the number of error symbols / total number of symbols. A current burst SER and a total SER are measured for each polarization.

The following example shows the difference between BER and SER:

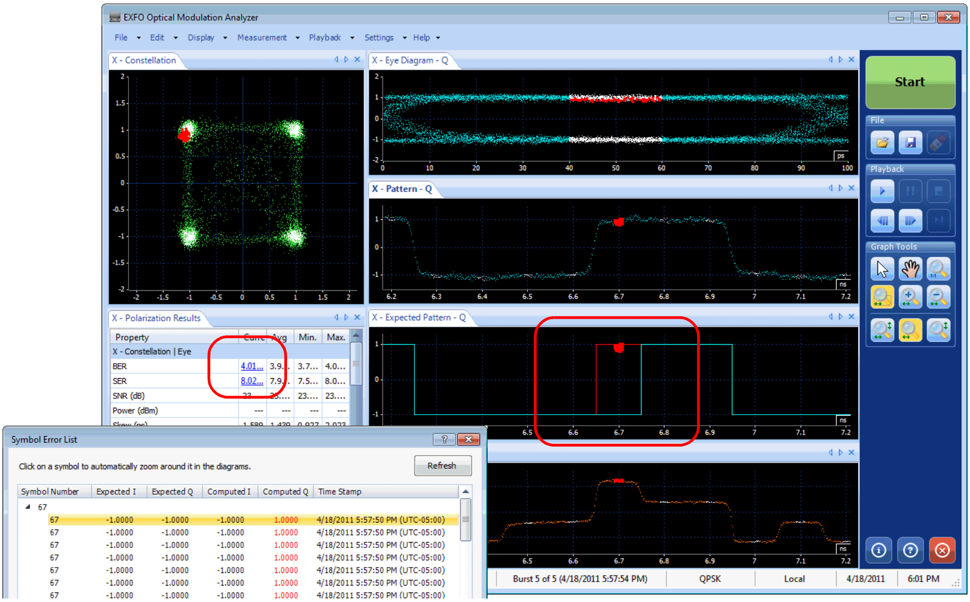
1 symbol = 4 bits (16-QAM)

Provided stream: 0101 1010 0100 1011

Measured stream: 010**0** 1010 01**11** 1011

BER = 3/16 = 0.1875; SER = 2/4 = 0.5

The *expected pattern graph* always overlays the measured pattern (in bright red) and expected pattern. Points in error can also be displayed in bright red on all graph types, as shown below.



To highlight error points in red:

From the **Display** menu, select **Highlight Points in Error**. Clear the option to remove the color.

Note: *This feature will have an effect on all applicable graphs at once.*

To view details about erroneous symbols:

1. In the measurement table, click on the link in BER or SER cells. It will display symbol numbers with expected and measured I/Q values.
2. Click on any symbol number to zoom on this symbol in pattern graphs.

9 Post-Processing and Reanalyzing Data

Installing and Using the Application on a Computer

You can install the application on a computer for data analysis purposes. The application will have the same features, except the **Start**/**Stop** button for acquisitions and related settings.

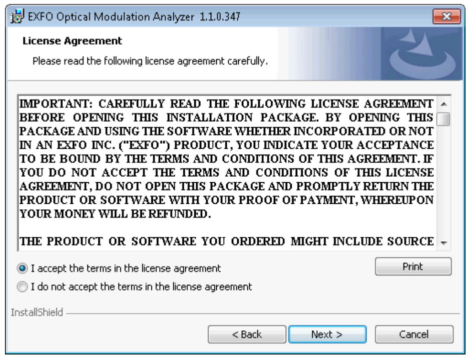
The computer must meet the following minimum requirements:

System Element	Windows XP / Vista / 7
Processor	Intel Core 2 Duo 2.53 GHz
RAM	2 Gb
Disk Space	10 Gb
Screen Resolution	1024 x 768
Other	Microsoft .NET 2.0 Framework SP2

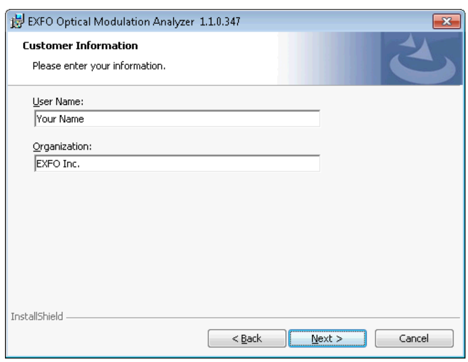
To install or update the Optical Modulation Analyzer application:

1. Insert the installation disk into your DVD-ROM drive.
2. If the installation does not start automatically, open Windows Explorer, select the DVD-ROM drive and double-click on the *Setup.exe* file.
3. From the welcome dialog box, click **Next**.

4. Read and accept the licence agreement, then click **Next**.



5. Enter your customer information, then click **Next**.



6. Click **Install** to begin the process.

7. When the installation is complete, click **Finish** to exit the wizard.

To start the application:

➤ Double-click the shortcut icon on the desktop.

➤ From the Windows **Start** menu, select **All Programs** > **EXFO** > **Optical Modulation Analyzer**.

Installing and Activating Software Options

Some options available for your unit are available through the purchase of a .key file. Such a file unlocks the options you have purchased on the unit.

If you have purchased your unit with the options already selected, the key files will have been activated for you. However, if you purchase an option afterwards, you will have to activate it on your unit yourself.

To activate options, you need to contact EXFO with the following information close at hand:

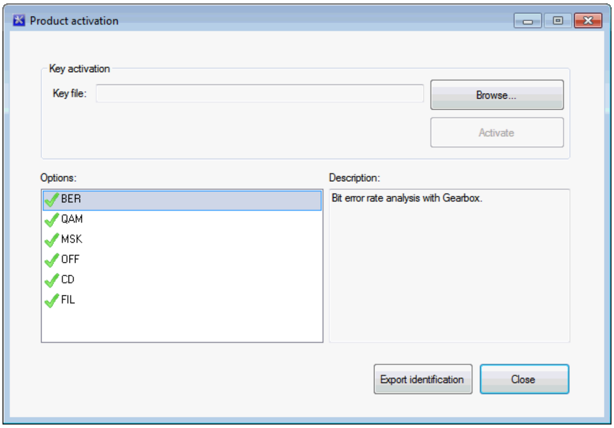
➤ Purchase order number

➤ Product serial number

➤ Customer name

➤ Unique identification file generated from your computer (see below)

You will receive an option key file (.key) that you can use on your unit. This file contains all of the options that you have activated.



To generate the Identification file for your unit or computer:

1. From the Windows **Start** menu, select **All Programs** > **EXFO** > **Optical Modulation Analyzer** > **Software Options Product Activation**.
2. Click **Export Identification** to generate an XML file identifying your unit or computer uniquely.
3. Save the file.
4. Click **Close** to exit the **Product Activation** window.

To activate the options for your unit:

1. From the Windows **Start** menu, select **All Programs** > **EXFO** > **Optical Modulation Analyzer** > **Software Options Product Activation**.
2. Click **Browse** to locate the .key file that you have received.
3. Click **Activate**.

   The option indicator will turn into a green check mark to confirm that the option is now active.
4. Click **Close** to exit the **Product Activation** window.

To view currently activated options:

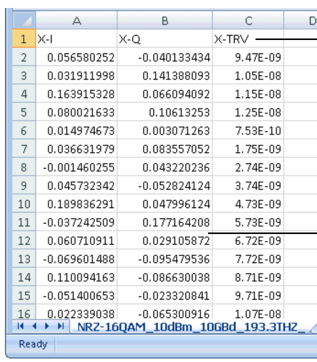
1. From the main window, click  (or select the **Help** menu, then **About**).
2. Select the **Software Options** tab.

Exporting Data

You can export PSO-200 data and results to comma-separated values (.csv) text files, to use in a spreadsheet or text editor, or for reprocessing in MATLAB or other tools. The data available for export is the current data in memory.

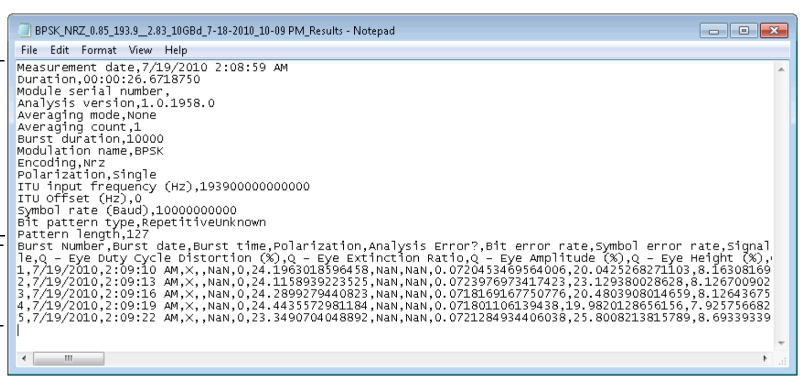
Note: *Each burst will generate a separate* data *file, but all results will be saved in a single* result *file.*

Here is an example of a data file (one burst), opened in Microsoft Excel:



	A	B	C	D
1	X-I	X-Q	X-TRV	
2	0.056580252	-0.040133434	9.47E-09	
3	0.031911998	0.141388093	1.05E-08	
4	0.163915328	0.066094092	1.15E-08	
5	0.080021633	0.10613253	1.25E-08	
6	0.014974673	0.003071263	7.53E-10	
7	0.036631979	0.083557052	1.75E-09	
8	-0.001460255	0.043220236	2.74E-09	
9	0.045732342	-0.052824124	3.74E-09	
10	0.189836291	0.047996124	4.73E-09	
11	-0.037242509	0.177164208	5.73E-09	
12	0.060710911	0.029105872	6.72E-09	
13	-0.069601488	-0.095479536	7.72E-09	
14	0.110094163	-0.086630038	8.71E-09	
15	-0.051400653	-0.023320841	9.71E-09	
16	0.022339038	-0.065300916	1.07E-08	

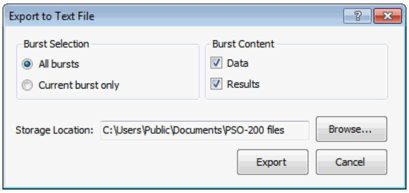
Here is an example of a results file (all bursts), opened in Notepad:




```
Measurement date,7/19/2010 2:08:59 AM
Duration,00:00:26.6718750
Module serial number,
Analysis version,1.0.1958.0
Averaging mode,None
Averaging count,1
Burst duration,10000
Modulation name,BPSK
Encoding,Nrz
Polarization,Single
ITU input frequency (Hz),193900000000000
ITU offset (Hz),0
Symbol rate (Baud),10000000000
Bit pattern type,RepetitiveUnknown
Pattern length,127
Burst Number,Burst date,Burst time,Polarization,Analysis Error?,Bit error rate,Symbol error rate,Signal
le,Q - Eye Duty Cycle Distortion (%),Q - Eye Extinction Ratio,Q - Eye Amplitude (%),Q - Eye Height (%),
1,7/19/2010,2:09:10 AM,X,,NaN,0,24.1963018596458,NaN,NaN,0.0720453469564006,20.0425268271103,8.16308169
2,7/19/2010,2:09:13 AM,X,,NaN,0,24.1158939223525,NaN,NaN,0.0723976973417423,23.129380028628,8.126700902
3,7/19/2010,2:09:16 AM,X,,NaN,0,24.2899279440823,NaN,NaN,0.0718169167750776,20.4803908014659,8.12643675
4,7/19/2010,2:09:19 AM,X,,NaN,0,24.4435572981184,NaN,NaN,0.0718011061394 38,19.9820128656156,7.925756682
5,7/19/2010,2:09:22 AM,X,,NaN,0,23.3490704048892,NaN,NaN,0.0721284934406038,25.8008213815789,8.69339339
```

To export the data:

1. From the **File** menu, select **Export**, then **Acquisition to Text File**.



2. Select which items you want in your export file (data, results, or both).

3. Indicate the location where you want to save the file.

Copying Graph and Measurements to Clipboard

You can copy the content of any graph or measurement table displayed on your screen to the Windows clipboard, and then paste it into a drawing, spreadsheet, or other application to include in reports or for subsequent viewing or processing.

- Graphs are copied exactly as displayed, with current zoom level, markers and histograms. They are in bitmap (.bmp) format.
- Tables are copied exactly as displayed, with the same data selected in the Settings window. They are in tab-delimited text format.

To copy a graph or measurement table to the clipboard:

1. Right-click on the tab containing the item, then select **Copy**.

   OR

   Click on the tab, then from the **Edit** menu, select **Copy**.

2. Paste the copied content into the application of your choice (some applications will only allow pasting of compatible content).

Reanalyzing Acquisitions with New Settings

You can see the effect of applying new settings on previously acquired data with the Reanalyze feature. You can use this feature on the PSO-200 Optical Modulation Analyzer or with a file opened on a separate computer.

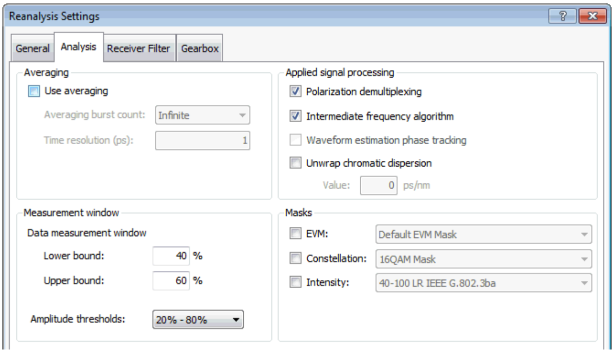
Most acquisition and analysis settings can be modified, but not those related to the input signal itself. Unavailable settings are grayed out in the application.

Masks and Gearbox settings contained in the original file will be discarded.

Note: *You can undo your changes at any time as explained in* Reverting to Original File *on page 116.*

To reanalyze acquisition data:

1. From the **File** menu, select **Reanalyze**.
2. Under all tabs, select the new settings.



3. Click **Analyze** to confirm your settings and start the process. This will take a few seconds.
4. Save the acquisition in a new file or export the data as needed (see *Exporting Data* on page 113).

Reverting to Original File

When working on a file, you might want to discard your changes and retrieve the file's last saved state. The following changes can be "undone":

- Information changed in the **Current Acquisition Identification** window (available from the **Properties** menu).
- Settings changed for the acquisition reanalysis (available from the **File** > **Reanalyze** menu option).

This feature is available as long as you have not saved your work. When you save, the application now considers this as the "original" file.

To revert to the original file:

From the **File** menu, select **Revert to Original File**.

10 Maintenance

To help ensure long, trouble-free operation:

- Always inspect fiber-optic connectors before using them and clean them if necessary.
- Keep the unit free of dust.
- Clean the unit casing and front panel with a cloth slightly dampened with water.
- Store unit at room temperature in a clean and dry area. Keep the unit out of direct sunlight.
- Avoid high humidity or significant temperature fluctuations.
- Avoid unnecessary shocks and vibrations.
- If any liquids are spilled on or into the unit, turn off the power immediately, disconnect from any external power source, remove the batteries and let the unit dry completely.

WARNING

The use of controls, adjustments and procedures other than those specified herein may result in exposure to hazardous situations or impair the protection provided by this unit.

Cleaning EUI Connectors

Regular cleaning of EUI connectors will help maintain optimum performance. There is no need to disassemble the unit.

IMPORTANT

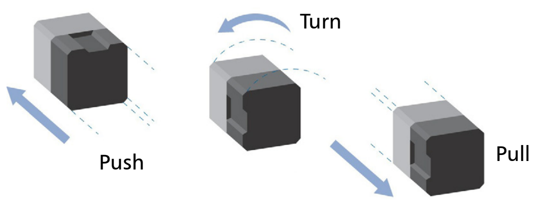
If any damage occurs to internal connectors, the module casing will have to be opened and a new calibration will be required.

WARNING

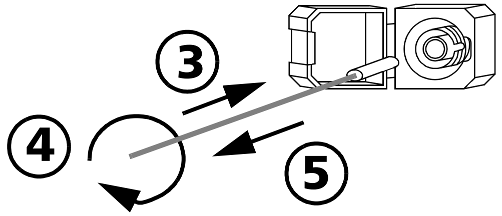
Looking into the optical connector while the light source is active WILL result in permanent eye damage. EXFO strongly recommends to TURN OFF the unit before proceeding with the cleaning procedure.

To clean EUI connectors:

1. Remove the EUI from the instrument to expose the connector baseplate and ferrule.



2. Moisten a 2.5 mm cleaning tip with *one drop* of isopropyl alcohol (alcohol may leave traces if used abundantly).
3. Slowly insert the cleaning tip into the EUI adapter until it comes out on the other side (a slow clockwise rotating movement may help).



4. Gently turn the cleaning tip one full turn, then continue to turn as you withdraw it.
5. Repeat steps 3 to 4 with a dry cleaning tip.

Note: *Make sure you don't touch the soft end of the cleaning tip.*

6. Clean the ferrule in the connector port as follows:

   6a. Deposit *one drop* of isopropyl alcohol on a lint-free wiping cloth.

IMPORTANT

Isopropyl alcohol may leave residues if used abundantly or left to evaporate (about 10 seconds).

Avoid contact between the tip of the bottle and the wiping cloth, and dry the surface quickly.

   6b. Gently wipe the connector and ferrule.

   6c. With a dry lint-free wiping cloth, gently wipe the same surfaces to ensure that the connector and ferrule are perfectly dry.

   6d. Verify connector surface with a portable fiber-optic microscope (for example, EXFO's FOMS) or fiber inspection probe (for example, EXFO's FIP).

7. Put the EUI back onto the instrument (push and turn clockwise).

8. Throw out cleaning tips and wiping cloths after one use.

Recycling and Disposal (Applies to European Union Only)

For complete recycling/disposal information as per European Directive WEEE 2002/96/EC, visit the EXFO Web site at www.exfo.com/recycle.

11 Troubleshooting

Solving Common Problems

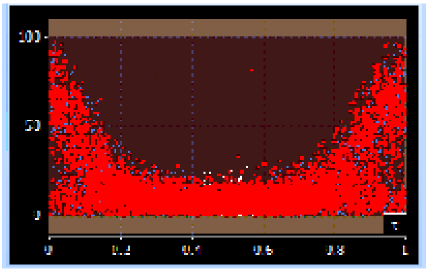
Here are a few common situations you might have to deal with:

- The burst number appears in red in the status bar. This is caused by a malfunction in processing data.

  You can do one of the following:

  - Save acquisition and send the .omd file to EXFO.
  - Click on the red burst number. Some debugging information will be displayed. Paste content of this dialog box in an e-mail to EXFO.

- Masks: the application limits the number of points considered “in error” to 5000, so it is possible that more points in error then look normal, as shown below:



Solving Phase Tracking Issues

Phase tracking issues (cycle slips) typically occur for the following reasons:

Cause	Solution
Pattern synchronization not succeeded	➤ Check if a pattern is visible on the magnitude pattern graph. Magnitude/intensity information is not dependent on successful phase recovery. ➤ If no pattern synchronization occurs, verify **Modulation**, **Symbol rate** and **Symbol pattern length** values (Acquisition Settings).
Bandwidth of phase tracking set too low to match signal source	➤ If magnitude graph shows synchronized pattern, but no pattern appears in phase pattern graph, verify **Linewidth** value (Acquisition Settings) corresponds precisely to the signal source.
Signal source linewidth too large or non-Lorentzian phase noise characterisitcs	➤ For signal source phase noise exceeding ~1 MHz (QPSK), move to one of the known pattern modes. ➤ If laser source can be temporary replaced, export then import symbol pattern is the most convienient way to accomplish improved phase noise tolerance. ➤ Alternatively, set up the Gearbox according to transmitter realization.

Viewing Online Help

An online version of this documentation is available from within the Optical Modulation Analyzer application.

To view the online help:

From the main window, click .

OR

From the **Help** menu, select **Help Topics**.

Contacting the Technical Support Group

To obtain after-sales service or technical support for this product, contact EXFO at one of the following numbers. The Technical Support Group is available to take your calls from Monday to Friday, 8:00 a.m. to 7:00 p.m. (Eastern Time in North America).

Technical Support Group
400 Godin Avenue
Quebec (Quebec) G1M 2K2
CANADA

1 866 683-0155 (USA and Canada)
Tel.: 1 418 683-5498
Fax: 1 418 683-9224
support@exfo.com

For detailed information about technical support, and for a list of other worldwide locations, visit the EXFO Web site at www.exfo.com.

To accelerate the process, please have information such as the name and the serial number (see the product identification label), as well as a description of your problem, close at hand.

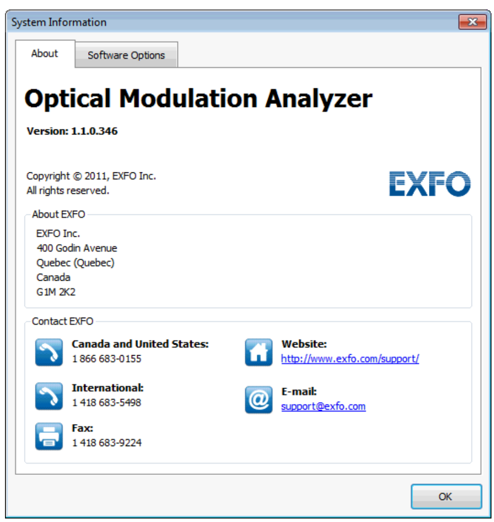
Viewing System Information

When contacting EXFO's technical support, you might be asked to provide some information regarding the version of your application, or any other detail that can help solving your problem.

Note: *The* ***Software Options*** *tab lists the optional features that you have purchased and activated.*

To view system information:

1. From the main window, click  (or select the **Help** menu, then **About**).
2. Select one of the available tabs.



Transportation

Maintain a temperature range within specifications when transporting the unit. Transportation damage can occur from improper handling. The following steps are recommended to minimize the possibility of damage:

➤ Pack the unit in its original packing material when shipping.

➤ Avoid high humidity or large temperature fluctuations.

➤ Keep the unit out of direct sunlight.

➤ Avoid unnecessary shocks and vibrations.

12 Warranty

General Information

EXFO Inc. (EXFO) warrants this equipment against defects in material and workmanship for a period of one year from the date of original shipment. EXFO also warrants that this equipment will meet applicable specifications under normal use.

During the warranty period, EXFO will, at its discretion, repair, replace, or issue credit for any defective product, as well as verify and adjust the product free of charge should the equipment need to be repaired or if the original calibration is erroneous. If the equipment is sent back for verification of calibration during the warranty period and found to meet all published specifications, EXFO will charge standard calibration fees.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL EXFO BE LIABLE FOR SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Liability

EXFO shall not be liable for damages resulting from the use of the product, nor shall be responsible for any failure in the performance of other items to which the product is connected or the operation of any system of which the product may be a part.

EXFO shall not be liable for damages resulting from improper usage or unauthorized modification of the product, its accompanying accessories and software.

Exclusions

EXFO reserves the right to make changes in the design or construction of any of its products at any time without incurring obligation to make any changes whatsoever on units purchased. Accessories, including but not limited to fuses, pilot lamps, batteries and universal interfaces (EUI) used with EXFO products are not covered by this warranty.

This warranty excludes failure resulting from: improper use or installation, normal wear and tear, accident, abuse, neglect, fire, water, lightning or other acts of nature, causes external to the product or other factors beyond the control of EXFO.

Certification

EXFO certifies that this equipment met its published specifications at the time of shipment from the factory.

Service and Repairs

EXFO commits to providing product service and repair for five years following the date of purchase.

To send any equipment for service or repair:

1. Call one of EXFO's authorized service centers (see *EXFO Service Centers Worldwide* on page 130). Support personnel will determine if the equipment requires service, repair, or calibration.
2. If equipment must be returned to EXFO or an authorized service center, support personnel will issue a Return Merchandise Authorization (RMA) number and provide an address for return.
3. If possible, back up your data before sending the unit for repair.
4. Pack the equipment in its original shipping material. Be sure to include a statement or report fully detailing the defect and the conditions under which it was observed.
5. Return the equipment, prepaid, to the address given to you by support personnel. Be sure to write the RMA number on the shipping slip. *EXFO will refuse and return any package that does not bear an RMA number.*

Note: *A test setup fee will apply to any returned unit that, after test, is found to meet the applicable specifications.*

After repair, the equipment will be returned with a repair report. If the equipment is not under warranty, you will be invoiced for the cost appearing on this report. EXFO will pay return-to-customer shipping costs for equipment under warranty. Shipping insurance is at your expense.

Routine recalibration is not included in any of the warranty plans. Since calibrations/verifications are not covered by the basic or extended warranties, you may elect to purchase FlexCare Calibration/Verification Packages for a definite period of time. Contact an authorized service center (see *EXFO Service Centers Worldwide* on page 130).

EXFO Service Centers Worldwide

If your product requires servicing, contact your nearest authorized service center.

EXFO Headquarters Service Center
400 Godin Avenue
Quebec (Quebec) G1M 2K2
CANADA

1 866 683-0155 (USA and Canada)
Tel.: 1 418 683-5498
Fax: 1 418 683-9224
support@exfo.com

EXFO Europe Service Center
Winchester House, School Lane
Chandlers Ford, Hampshire S053 4DG
ENGLAND

Tel.: +44 2380 246800
Fax: +44 2380 246801
support.europe@exfo.com

EXFO Telecom Equipment (Shenzhen) Ltd.
3rd Floor, Building 10,
Yu Sheng Industrial Park (Gu Shu Crossing), No. 467,
National Highway 107,
Xixiang, Bao An District,
Shenzhen, China, 518126

Tel: +86 (755) 2955 3100
Fax: +86 (755) 2955 3101
support.asia@exfo.com

A Technical Specifications

IMPORTANT

The following technical specifications can change without notice. The information presented in this section is provided as a reference only. To obtain this product's most recent technical specifications, visit the EXFO Web site at *www.exfo.com*.

SPECIFICATIONS [a]	
Optical	
Wavelength range	1530 nm to 1565 nm (C band)
Line-coding schemes	OOK, BPSK, PSK, QPSK, DPSK, DQPSK, APSK and 16-QAM, as well as all dual-polarization, RZ or NRZ versions of these schemes
Transmission rates	Transmission rate independent; any rate up to 75 GBd (gigabaud)
Pattern length supported	< 2^{16} (including PRBS) in Pattern mode Unlimited (random data) in Constellation or Eye mode
Sensitivity	−13 dBm
User interfaces	
Display	15.4 in TFT touchscreen
Ports	LAN and USB (3)
Operating system	Windows 7 ™

GENERAL SPECIFICATIONS	
Weight	23 kg (51 lb)
Size (H x W x D)	288 mm x 439 mm x 380 mm (11 5/16 in x 17 5/16 in x 14 5/16 in)
Temperature operating	 0 °C to 35 °C (32 °F to 95 °F)
Relative humidity	80 % non-condensing

SAFETY
21 CFR 1040.10 and IEC 60825-1:2007 CLASS 1 LASER PRODUCT

B SCPI Commands Reference

This appendix presents detailed information on the commands and queries supplied with your PSO-200 Optical Modulation Analyzer.

IMPORTANT

You must add the following mnemonic *at the beginning of any command or query* that you send to the instrument:

LINStrument<LogicalInstrumentPos>:

where *<LogicalInstrumentPos>* corresponds to the identification number of the instrument. In the PSO-200, its value is 1.

Quick Reference Command Tree

Command						Parameter(s)	P.
MMEMory	LOAD	TRACe				<Filename>	138
	STORe	TRACe				<Filename>	139
			DATA			<Path>	140
SENSe	DDEMod	AVERage	STATe			<Mode>	141
			STATe?				142
			COUNt			<Count>	143
			COUNt?				144
			TCONtrol			EXPonential|LAST	145
			TCONtrol?				147
		MODulation				"APSK|BPSK|CW|DP-APSK|DP-BPSK|DP-CW|DP-FreeRun|"DP-Intensity Sampling"|DP-OOK|DP-16QAM|DP-QPSK|FREERUN|"Intensity Sampling"|OOK|16QAM|QPSK|"	148
		MODulation?					151
		SRATe				<Rate>	154

Command						Parameter(s)	P.
		SRATe?					155
		BDURation				<Integer>,POI	156
			VALue?				157
			UNIT?				158
	RECording	LENGth				<Length>,BUR	159
			VALue?				160
			UNIT?				161
INITiate							162
ABORt							163
READ	DDEMod?						164
	DDEMod	DATA[n]?					165
		AVERage?					166
CALCulate	DDEMod	DATA[n]	TABLe	NAMes?			167
			TABLe?			X|Y|XY,<Name>	168
		AVERage	TABLe?			X|Y|XY,<Name>	170
		MINimum	TABLe?			X|Y|XY,<Name>	172
		MAXimum	TABLe?			X|Y|XY,<Name>	174
		DATA[n]	VECTor?			XI|XQ|XM|XP|YI|YQ|YM|YP|TRV	176
			VECTor	POINts?		XI|XQ|XM|XP|YI|YQ|YM|YP|TRV	178
			RAW[c]?				180
		ERRor	VECTor?			XSymbolError|YSymbolError	181
			VECTor	INDex?		<Error Index>,XSymbolError|YSymbolError	182

Command						Parameter(s)	P.
SENSe	ROSCillator	SOURce	TYPe			INTernal|EXTernal	184
			TYPe?				185
	DDEMod	MASK	NAMe			EVM|Constellation|Intensity,<Mask Name>	186
			NAMe?			EVM|Constellation|Intensity	187
			STATe			EVM|Constellation|Intensity,<enable>	188
			STATe?			EVM|Constellation|Intensity	189
		FILTer	TYPe			Chebyshev1|Bessel|Butterworth|None	190
			TYPe?				191
			CUTFrequency			<frequency>	192
			CUTFrequency?				193
			ORDer			<order >	194
			ORDer?				195
		WINDow	UPPerbound			<percent>	196
			UPPerbound?				197
			LOWerbound			<percent>	198
			LOWerbound?				199
			AMPLitude			10-90|20-80	200
			AMPLitude?				201
MMEMory	LOAD	GEARbox	SETup			<Filename>	202
	STORe	GEARbox				<Filename>	203

Command						Parameter(s)	P.
	LOAD	GEARbox	STReam			16QAM|APSK|BPSK|DP-16QAM|DP-APSK|DP-BPSK|DP-OOK|DP-QPSK|OOK|QPSK,OneGlobalStream|DualXYStreams|nIndividualStreams,<Filename>	204
	STORe	GEARbox				16QAM|APSK|BPSK|DP-16QAM|DP-APSK|DP-BPSK|DP-OOK|DP-QPSK|OOK|QPSK,OneGlobalStream|DualXYStreams|nIndividualStreams,<Filename>	207
SENSe	DDEMod	SYNC	SWORd	PTYPe		Prbs|Random|RepetitiveUnknown|UserDefinedBitPattern|UserDefinedSymbolPattern	210
				PTYPe?			212
				PLENgth		<pattern length>	213
				PLENgth?			214
MMEMory	LOAD	PATTern				<Filename>	215
	STORe	PATTern					216
SENSe	DDEMod	LEARnpattern					217
		LEARnpattern?					218
	ROSCillator	SOURce	PHASecalibration				219
			PHASecalibration?				220
	DDEMod	SIGNal	FREQuency				221
			FREQuency?				222
			OFFSet				223
			OFFSet?				224
			WIDTh				225
			WIDTh?				226
		AVERage	RES				227

Command						Parameter(s)	P.
			RES?				228
		CDIS	ENABle				229
			ENABle?				230
			VAL				231
			VAL?				232
		SIGNal	ENCoding				233
			ENCoding?				234
		DEMX					235
		DEMX?					236
		IFAL					237
		IFAL?					238

Product-Specific Commands—Description

:MMEMory:LOAD:TRACe

Description	This command loads a measurement in the memory. This command is not associated with *RST.
Syntax	:MMEMory:LOAD:TRACe<wsp><Filename>
Parameter(s)	*Filename:* The program data syntax for <Filename> is defined as a <STRING PROGRAM DATA> element. Selects the valid path of the file.
Example(s)	LINS1:MMEM:LOAD:TRAC "C:\OMATRACES\myMeasurement.omd"
Notes	If no path is specified, only a file name, the default path is used. If the file doesn't exist, is not readable, is not the right format, an error is generated.
See Also	MMEMory:STORe:TRACe "C:\OMATRACES\myMeasurement.omd"

:MMEMory:STORe:TRACe

Description	This command saves a measurement on the disk. This command is not associated with *RST.
Syntax	:MMEMory:STORe:TRACe<wsp><Filename>
Parameter(s)	*Filename:* The program data syntax for <Filename> is defined as a <STRING PROGRAM DATA> element. Selects the valid path of the file.
Example(s)	LINS1:MMEM:STORe:TRAC "C:\OMATRACES\myMeasurement.omd"
Notes	If no path is specified, only a file name, the default path is used. If the file doesn't exist, is not readable, is not the right format… an error is generated.
See Also	MMEM:LOAD:TRAC "C:\OMATRACES\myMeasurement.omd"

:MMEMory:STORe:TRACe:DATA

Description	This command exports a measurement in the CSV format. This command is not associated with *RST.
Syntax	:MMEMory:STORe:TRACe:DATA<wsp><Path>
Parameter(s)	➤ *Path:* The program data syntax for <Path> is defined as a <STRING PROGRAM DATA> element. Selects the valid path of the file. ➤ *Format:*
Example(s)	LINS1:MMEM:STOR:TRAC:DATA "C:\OMATRACES\" ,CSV
Notes	If no path is specified, only a file name, the default path is used. Only CSV format is supported. If the path is not accessible, if there is not enough space available … an error is generated.
See Also	MMEMory:LOAD:TRACe "C:\OMATRACES\myMeasurement.omd"

:SENSe:DDEMod:AVERage:STATe

Description	This command sets the average mode status. At *RST, this value is set to OFF.
Syntax	:SENSe:DDEMod:AVERage:STATe<wsp><Mode >
Parameter(s)	*Mode:* The program data syntax for <Mode> is defined as a <Boolean Program Data> element. The <Mode> special forms ON and OFF are accepted on input for increased readability. ON corresponds to 1 and OFF corresponds to 0. Enables or disables the average Mode state. ON, enables the average Mode state. OFF, disables the average Mode state.
Example(s)	SENSe:DDEMod:AVERage:STATe ON
See Also	SENS:ROSC:SOUR:PHAS ON

:SENSe:DDEMod:AVERage:STATe?

Description	This query returns the average mode status. At *RST, this value is set to OFF.
Syntax	:SENSe:DDEMod:AVERage:STATe?
Parameter(s)	None
Response Syntax	<Status>
Response(s)	*Status:* The response data syntax for <Status> is defined as a <NR1 NUMERIC RESPONSE DATA> element. Returns the average mode status. 1, average Mode state is enabled. 0, average Mode state is disabled.
Example(s)	SENSe:DDEMod:AVERage:STATe ON SENSe:DDEMod:AVERage:STATe? Returns 1
See Also	SENS:ROSC:SOUR:PHAS ON SENS:ROSC:SOUR:PHAS?

:SENSe:DDEMod:AVERage:COUNt

Description	This command sets the number of bursts used to calculate average results. At *RST, this value is 0.
Syntax	:SENSe:DDEMod:AVERage:COUNt<wsp><Count>
Parameter(s)	*Count:* The program data syntax for <Count> is defined as a <DECIMAL NUMERIC PROGRAM DATA> element. Returns the number of bursts used to calculate average results.
Example(s)	SENSe:DDEMod:AVERage:COUNt 64 SENSe:DDEMod:AVERage:COUNt? Returns 64
See Also	SENSe:DDEMod:AVERage:STATe?

:SENSe:DDEMod:AVERage:COUNt?

Description	This query returns the number of bursts used to calculate average results. At *RST, this value is 0.
Syntax	:SENSe:DDEMod:AVERage:COUNt?
Parameter(s)	None
Response Syntax	<Average Count>
Response(s)	*Average Count:* The response data syntax for <Average Count> is defined as a <NR1 NUMERIC RESPONSE DATA> element. Returns the number of bursts used to calculate average results.
Example(s)	SENSe:DDEMod:AVERage:COUNt 20 SENSe:DDEMod:AVERage:COUNt? Returns 20
See Also	SENSe:DDEMod:AVERage:TCONtrol?

:SENSe:DDEMod:AVERage:TCONtrol

Description	This command sets the average mode that is to be managed, when the number of scans processed exceeds the Average Number of bursts. At *RST, this value is LAS.
Syntax	:SENSe:DDEMod:AVERage:TCONtrol<wsp>EXPonential|LAST
Parameter(s)	*Avg:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: EXPonential|LAST. Selects the average mode to be set. EXPonential, new results are averaged exponentially. LAST, last N bursts will be used to compute the average.
Example(s)	SENSe:DDEMod:AVERage:TCONtrol LAS

:SENSe:DDEMod:AVERage:TCONtrol

Notes	When averaging is on and the number of scans is less than or equal to the Avg Number setting, a linear average is calculated. After the scan count exceeds the Avg Number setting, if more burst has to be acquired. If Average Mode is Exponential then new results are averaged in exponentially. In other words, each succeeding average will be the weighted sum of the previous average, weighted by (N–1)/N, and the new measurement, weighted by 1/N, where N is the Average Number setting. If Average Mode is Last, then average values will be computed when the acquisition will stop. The last N bursts will be used to compute the averages. State is saved in instrument.
See Also	SENSe:DDEMod:AVERage:COUNt 10

:SENSe:DDEMod:AVERage:TCONtrol?

Description	This query returns, the average mode that is to be managed, when the number of scans processed exceeds the Average Number of bursts. At *RST, this value is LAS.
Syntax	:SENSe:DDEMod:AVERage:TCONtrol?
Parameter(s)	None
Response Syntax	<Average>
Response(s)	*Average:* The response data syntax for <Average> is defined as a <CHARACTER RESPONSE DATA> element. Returns the average mode that is to be managed, when the number of scans processed exceeds the Average Number of bursts. EXPonential, new results are averaged exponentially. LAST, last N bursts will be used to compute the average.
Example(s)	SENSe:DDEMod:AVERage:TCONtrol EXP SENSe:DDEMod:AVERage:TCONtrol? Returns EXP
Notes	See DDEMod:AVERage:TControl for more details.
See Also	SENSe:DDEMod:AVERage:COUNt?

:SENSe:DDEMod:MODulation

Description	This command sets the digital communication format used by the demodulator. At *RST, this value is set to DP-QPSK or QPSK. It's device dependent.
Syntax	:SENSe:DDEMod:MODulation<wsp>"APSK|BPSK|CW|DP-APSK|DP-BPSK|DP-CW|DP-FreeRun|"DP-Intensity Sampling"|DP-OOK|DP-16QAM|DP-QPSK|FREE RUN|"Intensity Sampling"|OOK|16QAM|QPSK|"
Parameter(s)	*Modulation:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: "APSK|BPSK|CW|DP-APSK|DP-BPSK|DP-CW|DP-FreeRun|"DP-Intensity Sampling"|DP-OOK|DP-16QAM|DP-QPSK|FREE RUN|"Intensity Sampling"|OOK|16QAM|QPSK|". Selects the modulation for digital communication format used by demodulator. APSK, selects Amplitude and Phase-shift keying as the modulation for the digital communication format.

:SENSe:DDEMod:MODulation

BPSK, selects Binary phase-shift keying (BPSK) as the modulation for the digital communication format.
DP-CW, selects Differential Quadrature keying (CW) as the modulation for the digital communication format.

DP-APSK, selects Differential Quadrature Phase-shift keying (DPSK) as the modulation for the digital communication format.
DP-BPSK, selects Differential Quadrature Binary phase-shift keying (BPSK) as the modulation for the digital communication format.

DP-FreeRun, selects Differential Quadrature Phase-shift keying (FreeRun) as the modulation for the digital communication format.
DP-Intensity Sampling, selects Differential Quadrature Phase-shift keying (Intensity Sampling) as the modulation for the digital communication format.

DP-OOK, selects Differential Quadrature On-off Keying as the modulation for the digital communication format.
DP-16QAM, selects Differential Quadrature Amplitude Modulation (QAM16) as the modulation for the digital communication format.

:SENSe:DDEMod:MODulation

DP-QPSK, selects Differential Quadrature phase-shift keying (QPSK) as the modulation for the digital communication format.
FREERUN, selects FreeRun as the modulation for the digital communication format.
Intensity Sampling, selects Intensity Sampling as the modulation for the digital communication format.

OOK, selects On-off Keying as the modulation for the digital communication format.
16QAM, selects Quadrature Amplitude Modulation (QAM16) as the modulation for the digital communication format.

QPSK, selects Quadrature phase-shift keying (QPSK) as the modulation for the digital communication format.

Example(s)	SENSe:DDEM:MOD QPSK SENSe:DDEM:MOD? Returns QPSK
Notes	State is saved in instrument. Default modulation is QPSK.
See Also	SENS:DDEM:SYNC:SWOR:PTYP Prbs SENS:DDEM:SYNC:SWOR:PTYP?

:SENSe:DDEMod:MODulation?

Description	This query returns the digital communication format used by the demodulator. At *RST, this value is set to DP-QPSK or QPSK. It's device dependent.
Syntax	:SENSe:DDEMod:MODulation?
Parameter(s)	None
Response Syntax	<Modulation>
Response(s)	*Modulation:* The response data syntax for <Modulation> is defined as a <CHARACTER RESPONSE DATA> element. Returns the modulation that is set. APSK, Amplitude and Phase-shift keying as the modulation for the digital communication format is selected. BPSK, Binary phase-shift keying (BPSK) as the modulation for the digital communication formatis selected. DP-CW, Differential Quadrature keying (CW) as the modulation for the digital communication formatis selected. DP-APSK, Differential Quadrature Phase-shift keying (DPSK) as the modulation for the digital communication formatis selected.

:SENSe:DDEMod:MODulation?

DP-BPSK, Differential Quadrature Binary phase-shift keying (BPSK) as the modulation for the digital communication formatis selected.
DP-FreeRun, Differential Quadrature Phase-shift keying (FreeRun) as the modulation for the digital communication formatis selected.

DP-Intensity Sampling, Differential Quadrature Phase-shift keying (Intensity Sampling) as the modulation for the digital communication formatis selected.
DP-OOK, Differential Quadrature On-off Keying as the modulation for the digital communication formatis selected.

DP-16QAM, Differential Quadrature Amplitude Modulation (QAM16) as the modulation for the digital communication formatis selected.
DP-QPSK, Differential Quadrature phase-shift keying (QPSK) as the modulation for the digital communication formatis selected.

FREERUN, FreeRun as the modulation for the digital communication formatis selected.
Intensity Sampling, Intensity Sampling as the modulation for the digital communication formatis selected.
OOK, On-off Keying as the modulation for the digital communication formatis selected.

:SENSe:DDEMod:MODulation?

	16QAM, Quadrature Amplitude Modulation (QAM16) as the modulation for the digital communication formatis selected. QPSK, Quadrature phase-shift keying (QPSK) as the modulation for the digital communication formatis selected.
Example(s)	SENSe:DDEM:MOD QPSK SENSe:DDEM:MOD? Returns QPSK
Notes	Default modulation is QPSK.
See Also	SENSe:DDEMod:AVERage:TCONtrol EXP

:SENSe:DDEMod:SRATe

Description	This command sets the symbol rate (symbols per second) for the analyzer's digital demodulator. At *RST, this value is set to 28 Gbaud or 20 Gbaud. It’s device dependent.
Syntax	:SENSe:DDEMod:SRATe<wsp><Rate>
Parameter(s)	*Rate:* The program data syntax for <Rate> is defined as a <DECIMAL NUMERIC PROGRAM DATA> element. Selects the symbol rate to be set for the analyzers digital demodulator.
Example(s)	SENSe:DDEM:SRAT 25.3 SENSe:DDEM:SRAT? Returns: 25.3
Notes	State is saved in instrument.
See Also	SENSe:DDEMod:SRATe?

:SENSe:DDEMod:SRATe?

Description	This query returns the symbol rate (symbols per second) for the analyzer's digital demodulator. At *RST, this value is set to 28 Gbaud or 20 Gbaud. It’s device dependent.
Syntax	:SENSe:DDEMod:SRATe?
Parameter(s)	None
Response Syntax	<Rate>
Response(s)	*Rate:* The response data syntax for <Rate> is defined as a <NR2 NUMERIC RESPONSE DATA> element. Returns the symbol Rate for the analyzers digital demodulator.
Example(s)	SENSe:DDEM:SRAT 25.3 SENSe:DDEM:SRAT? Returns: 25.3
Notes	Default frequency is 10.0 GBaud.
See Also	SENSe:DDEMod:AVERage:COUNt 10

:SENSe:DDEMod:BDURation

Description	This command sets the burst duration in terms of time or symbol length. At *RST, this value is 10000.
Syntax	:SENSe:DDEMod:BDURation<wsp><Integer>,POI
Parameter(s)	➤ *Integer:* The program data syntax for <Integer> is defined as a <DECIMAL NUMERIC PROGRAM DATA> element. Sets the burst duration in terms of time or symbol length. ➤ *Units:* The program data syntax for the second parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> element for this parameter is POI. POI, selects points as unit.
Example(s)	SENSe:DDEMod:BDURation 10000,POI
Notes	State is saved in instrument. This is command only, there is no query. Possible Values: 10000 | 20000 | 30000 | 40000 | 50000 | 60000 | 70000 | 80000 | 90000 | 100000 | 110000 | 120000
See Also	SENSe:DDEMod:BDURation:VALue?

:SENSe:DDEMod:BDURation:VALue?

Description	This query returns the integer value of the burst duration. At *RST, this value is 10000.
Syntax	:SENSe:DDEMod:BDURation:VALue?
Parameter(s)	None
Response Syntax	<Value>
Response(s)	*Value:* The response data syntax for <Value> is defined as a <NR1 NUMERIC RESPONSE DATA> element. Returns the integer value of the burst duration.
Example(s)	SENSe:DDEMod:BDURation 10000,POI SENSe:DDEMod:BDURation:VALue? It returns 10000
See Also	SENSe:DDEMod:BDURation:UNIT?

:SENSe:DDEMod:BDURation:UNIT?

Description	This query returns the unit of the burst duration. At *RST, this value is POI.
Syntax	:SENSe:DDEMod:BDURation:UNIT?
Parameter(s)	None
Response Syntax	<Unit>
Response(s)	*Unit:* The response data syntax for <Unit> is defined as a <CHARACTER RESPONSE DATA> element. Returns the unit of the burst duration. POI, returns points as unit.
Example(s)	SENSe:DDEMod:BDURation 10000,POI SENSe:DDEMod:BDURation:UNIT? ItreturnsPOI
See Also	SENSe:DDEMod:BDURation:VALue?

:SENSe:RECording:LENGth

Description

This command sets the amount of bursts to be recorded.
At *RST, this value is 20.

Syntax

:SENSe:RECording:LENGth<wsp><Length>,BUR

Parameter(s)

➤ *Length:*

The program data syntax for <Length> is defined as a <DECIMAL NUMERIC PROGRAM DATA> element.

Number of bursts to record.Value between 1 and 140. Default value is 20.

➤ *Burst:*

The program data syntax for the second parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> element for this parameter is BUR.

Sets the amount of bursts to be recorded.

Example(s)

SENSe:REC:LENG 20,BUR

See Also

SENSe:RECording:LENGth:VALUe?
SENSe:RECording:LENGth:UNIT?

:SENSe:RECording:LENGth:VALue?

Description	This query returns the integer value of the burst duration. At *RST, this value is 10.
Syntax	:SENSe:RECording:LENGth:VALue?
Parameter(s)	None
Response Syntax	<Value>
Response(s)	*Value:* The response data syntax for <Value> is defined as a <NR1 NUMERIC RESPONSE DATA> element. Returns the integer value of the burst duration. POI, returns points as unit.
Example(s)	SENSe:REC:LENG 20,BUR SENSe:REC:LENG:VAL? Returns: 20
Notes	Returns the first (numeric) parameter of the most recent :SENSe:RECording:LENGth command.
See Also	SENSe:RECording:LENGth:UNIT?

:SENSe:RECording:LENGth:UNIT?

Description	This query returns the unit of the burst duration. At *RST, this value is BUR.
Syntax	:SENSe:RECording:LENGth:UNIT?
Parameter(s)	None
Response Syntax	<Unit>
Response(s)	*Unit:* The response data syntax for <Unit> is defined as a <CHARACTER RESPONSE DATA> element. Returns the unit of the burst duration.
Example(s)	*REC:LENG 140,BUR *REC:LENG:VAL? Returns: 140 *REC:LENG:UNIT? Returns: BUR
Notes	Returns the second parameter of the most recent recording length command. Since the only supported value is BURst, it always returns BURst.
See Also	SENSe:RECording:LENGth:VALUe?

:INITiate

Description	This command starts recording the bursts. This command is not associated with *RST condition.
Syntax	:INITiate
Parameter(s)	None
Example(s)	LINS1:INIT
Notes	State is saved in instrument. This is command only, there is no query. See the Recall functionality to access previously saved data.
See Also	ABORT

:ABORt

Description	This command stops recording the bursts. This command is not associated with *RST condition.
Syntax	:ABORt
Parameter(s)	None
Example(s)	LINS1:ABOR
Notes	State is saved in instrument. This is command only, there is no query. See the Recall functionality to access previously saved data.
See Also	INITiate

:READ:DDEMod?

Description	This query reads the entire (current) measurement and returns it in the output buffer in the CSV format. This command is not associated with *RST.
Syntax	:READ:DDEMod?
Parameter(s)	None
Response Syntax	<List>
Response(s)	*List:* The response data syntax for <List> is defined as a <STRING RESPONSE DATA> element. Returns the entire measurement that is streamed in the output buffer, in the CSV format.
Example(s)	LINS1:READ:DDEM?
See Also	READ:DDEMod:DATA2?

:READ:DDEMod:DATA[n]?

Description	This query reads a burst (index n) and returns it in the output buffer in the CSV format. This command is not associated with *RST.
Syntax	:READ:DDEMod:DATA[n]?
Parameter(s)	None
Response Syntax	<List>
Response(s)	*List:* The response data syntax for <List> is defined as a <STRING RESPONSE DATA> element. Returns the specified burst that is streamed in the output buffer, in the CSV format.
Example(s)	LINS1:READ:DDEM:DATA2?
See Also	READ:DDEMod?

:READ:DDEMod:AVERage?

Description	This query reads the average results and returns them in the output buffer in CSV format. Maximum, Minimum and Average are returned in a CSV table. This command is not associated with *RST.
Syntax	:READ:DDEMod:AVERage?
Parameter(s)	None
Response Syntax	<List>
Response(s)	*List:* The response data syntax for <List> is defined as a <STRING RESPONSE DATA> element. Reads the average results and returns them in the output buffer in CSV format. Maximum, Minimum and Average are returned in a CSV table.
Example(s)	LINS1:READ:DDEM:AVER?
See Also	READ:DDEMod?

:CALCulate:DDEMod:DATA[n]:TABLe:NAMes?

Description	This query displays the table entries associated with the specified polarization. This command is not associated with *RST.
Syntax	:CALCulate:DDEMod:DATA[n]:TABLe:NAMes?
Parameter(s)	None
Response Syntax	<List>
Response(s)	*List:* The response data syntax for <List> is defined as a <STRING RESPONSE DATA> element. Returns a comma-separated list of names for a specific polarization (X or Y) or global to both polarization (XY). X, table entries associated with the X polarization are displayed. Y, table entries associated with the Y polarization are displayed. XY, table entries associated with the XY polarization are displayed.
Example(s)	LINS1:CALC:DDEM:DATA1:TABL:NAM?
See Also	CALC:DDEM:DATA2:TABL? X, "IQ imbalance RMS (dB)"

:CALCulate:DDEMod:DATA[n]:TABLe?

Description	This query reads the entire table or a table entry from a specific burst identified by index n. This command is not associated with *RST.
Syntax	:CALCulate:DDEMod:DATA[n]:TABLe?<wsp>X|Y|XY,<Name>
Parameter(s)	➤ *Polarization:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: X|Y|XY. Reads the entire table or a table entry from a specific burst identified by index n. X, reads the entire table or a table entry associated with the X burst. Y, reads the entire table or a table entry associated with the y burst. XY, reads the entire table or a table entry associated with the XY burst. ➤ *Name:* The program data syntax for <Name> is defined as a <STRING PROGRAM DATA> element. Reads Specific table entry name.
Response Syntax	<List>

:CALCulate:DDEMod:DATA[n]:TABLe?

Response(s)	*List:* The response data syntax for <List> is defined as a <STRING RESPONSE DATA> element. Reads the entire table or a table entry from a specific burst identified by index n. X, entire table or a table entry associated with the X burst is read. Y, entire table or a table entry associated with the y burst is read. XY, entire table or a table entry associated with the XY burst is read.
Example(s)	LINS1:CALC:DDEM:DATA2:TABL? X,"IqImbalancePeak"
See Also	CALC:DDEM:AVER:TABL? Y,"Rise time (ps)"

:CALCulate:DDEMod:AVERage:TABLe?

Description	This query reads the average entries and returns them in the output buffer. This command is not associated with *RST.
Syntax	:CALCulate:DDEMod:AVERage:TABLe?<wsp>X|Y|XY,<Name>
Parameter(s)	➤ *Polarization:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: X|Y|XY. Reads average entries and return in the output buffer. X, reads average entries and return in the X buffer. Y, reads average entries and return in the Y buffer. XY, reads average entries and return in the XY buffer. ➤ *Name:* The program data syntax for <Name> is defined as a <STRING PROGRAM DATA> element. Reads Specific table entry name.
Response Syntax	<List>

:CALCulate:DDEMod:AVERage:TABLe?

Response(s)	*List:* The response data syntax for <List> is defined as a <STRING RESPONSE DATA> element. Reads average entries and returns in the output buffer. X, average entries are read and returned in the X buffer. Y, average entries are read and returned in the Y buffer. XY, average entries are read and returned in the XY buffer.
Example(s)	LINS1:CALC:DDEM:AVER:TABL? Y,"Rise time (ps)"
Notes	Query only. This retrieves the names of the table entries. Each of these names may be used in these commands to access a single entry in the designated table: CALC:DDEM:DATA[n]:TABL? X|Y|XY , '< CALC:DDEM:AVER:TABL? X|Y|XY , '< CALC:DDEM:MIN:TABL? X|Y|XY , '< CALC:DDEM:MAX:TABL? X|Y|XY , '< If polarization Y is requested but the selected modulation does not support dual polarization an error will be generated
See Also	CALC:DDEM:MIN:TABL? Y,"Eye amplitude (%)"

:CALCulate:DDEMod:MINimum:TABLe?

Description	This query reads the minimum entries and returns them in the output buffer. This command is not associated with *RST.
Syntax	:CALCulate:DDEMod:MINimum:TABLe?<wsp>X|Y|XY,<Name>
Parameter(s)	➤ *Polarization:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: X|Y|XY. Reads the minimum entries and return them in the output buffer. X, reads the minimum entries and return them in the X buffer. Y, reads the minimum entries and return them in the Y buffer. XY, reads the minimum entries and return them in the XY buffer. ➤ *Name:* The program data syntax for <Name> is defined as a <STRING PROGRAM DATA> element. Reads Specific table entry name.
Response Syntax	<List>

:CALCulate:DDEMod:MINimum:TABLe?

Response(s)	*List:* The response data syntax for <List> is defined as a <STRING RESPONSE DATA> element. Reads the Minimum entries and returns them in the output buffer. X, Minimum entries are read and returned in the X buffer. Y, Minimum entries are read and returned in the Y buffer. XY,Minimum entries are read and returned in the XY buffer.
Example(s)	LINS1:CALC:DDEM:MIN:TABL? Y,"Eye amplitude (%)"
See Also	:CALCulate:DDEMod:MAXimum:TABLe? X, "I - eye zero level"

:CALCulate:DDEMod:MAXimum:TABLe?

Description	This query reads the maximum entries and returns them in the output buffer. At *RST, this value is device dependent.
Syntax	:CALCulate:DDEMod:MAXimum:TABLe?<wsp>X|Y|XY,<Name>
Parameter(s)	➤ *Polarization:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: X|Y|XY. Reads the MAXimum entries and return them in the output buffer. X, reads the MAXimum entries and return them in the X buffer. Y, reads the MAXimum entries and return them in the Y buffer. XY, reads the MAXimum entries and return them in the XY buffer. ➤ *Name:* The program data syntax for <Name> is defined as a <STRING PROGRAM DATA> element. Reads Specific table entry name.
Response Syntax	<List>

:CALCulate:DDEMod:MAXimum:TABLe?

Response(s)	*List:* The response data syntax for <List> is defined as a <STRING RESPONSE DATA> element. Reads the MAXimum entries and returns them in the output buffer. X, Maximum entries are read and returned in the X buffer. Y, Maximum entries are read and returned in the Y buffer. XY,Maximum entries are read and returned in the XY buffer.
Example(s)	LINS1:CALCulate:DDEMod:MAXimum:TABLe? X, "I - eye zero level"
See Also	CALC:DDEM:DATA5:VECT? TRV

:CALCulate:DDEMod:DATA[n]:VECTor?

Description	This query returns the output buffer and the Specified Vector for a specific burst identified by n. At *RST, this value is device dependent.
Syntax	:CALCulate:DDEMod:DATA[n]:VECTor?<wsp>XI |XQ|XM|XP|YI|YQ|YM|YP|TRV
Parameter(s)	*Vector:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: XI|XQ|XM|XP|YI|YQ|YM|YP|TRV. Returns the output buffer and the Specified Vector for a specific burst identified by n. XI and YI, returns the output buffer and the Specified Vector forI vector on polarization. XQ and YQ, returns the output buffer and the Specified Vector for Q vector on polarization. XM and YM, returns the output buffer and the Specified Vector for magnitude vector on polarization. XP and YP, returns the output buffer and the Specified Vector for phase vector on polarization. TRV, returns the output buffer and the Specified Vector for the Time Reconstructed Vector.
Response Syntax	<List>

:CALCulate:DDEMod:DATA[n]:VECTor?

Response(s)

List:

The response data syntax for <List> is defined as a <STRING RESPONSE DATA> element.

Returns the output buffer and the Specified Vector for a specific burst identified by n.

XI and YI, output buffer and the Specified Vector forI vector on polarization is returned.
XQ and YQ, output buffer and the Specified Vector for Q vector on polarization is returned.
XM and YM, output buffer and the Specified Vector for magnitude vector on polarization is returned.

XP and YP, output buffer and the Specified Vector for phase vector on polarization is returned.
TRV,output buffer and the Specified Vector for the Time Reconstructed Vector is returned.
TRV refers to the Time Reconstructed Vector.

Example(s)

LINS1:CALC:DDEM:DATA5:VECT? TRV

See Also

CALC:DDEM:DATA2:VECT:POIN? XM

:CALCulate:DDEMod:DATA[n]:VECTor:POINts?

Description	This query returns the number of points by the command:CALCulate:DDEMod:DATA[n]:VECTor? . This command is not associated with *RST.
Syntax	:CALCulate:DDEMod:DATA[n]:VECTor:POINts?<wsp>XI|XQ|XM|XP|YI|YQ|YM|YP|TRV
Parameter(s)	*Vector:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: XI|XQ|XM|XP|YI|YQ|YM|YP|TRV. Returns the number of points by the command :CALCulate:DDEMod:DATA[n]:VECTor?. XI and YI, returns the number of points forI vector on polarization. XQ and YQ, returns the number of points for Q vector on polarization. XM and YM, returns the number of points for magnitude vector on polarization. XP and YP, returns the number of points for phase vector on polarization. TRV, returns the number of points for the Time Reconstructed Vector.
Response Syntax	<List>

:CALCulate:DDEMod:DATA[n]:VECTor:POINts?

Response(s)	*List:* The response data syntax for <List> is defined as a <STRING RESPONSE DATA> element. Returns the number of points by the command :CALCulate:DDEMod:DATA[n]:VECTor?. XI and YI, number of points forI vector on polarization are returned. XQ and YQ, number of points for Q vector on polarization are returned. XM and YM, number of points for magnitude vector on polarization are returned. XP and YP, number of points for phase vector on polarization are returned. TRV, number of points for the Time Reconstructed Vector are returned. TRV,output buffer and the Specified Vector for the Time Reconstructed Vector is returned.
Example(s)	LINS1:CALC:DDEM:DATA2:VECT:POIN? XM
See Also	CALC:DDEM:DATA5:RAW1?

:CALCulate:DDEMod:DATA[n]:RAW[c]?

Description	Return in the output buffer the Raw Data for a specific burst identified by n and a specific channel identified by c. At *RST, this value is device dependent.
Syntax	:CALCulate:DDEMod:DATA[n]:RAW[c]?
Parameter(s)	None
Response Syntax	<List>
Response(s)	*List:* The response data syntax for <List> is defined as a <STRING RESPONSE DATA> element. Returns the Raw Data for a specific burst in the output buffer, in the CSV format.
Example(s)	LINS1:CALC:DDEM:DATA5:RAW1?
See Also	CALC:DDEM:DATA2:VECT:POIN? XM

:CALCulate:DDEMod:ERRor:VECTor?

Description	This query returns the Errors. This query is not associated with any *RST value.
Syntax	:CALCulate:DDEMod:ERRor:VECTor?<wsp>XSymbolError|YSymbolError
Parameter(s)	*Vector Name:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: XSymbolError|YSymbolError. Selects the Error. XSymbolError, selects XSymbolError as the error. YSymbolError, selects YSymbolError as the error.
Response Syntax	<Error List>
Response(s)	*Error List:* The response data syntax for <Error List> is defined as a <STRING RESPONSE DATA> element. Returns the Errors.
Example(s)	LINS1:CALC:DDEM:ERR:VECT? XSymbolError LINS1:CALC:DDEM:ERR:VECT? YSymbolError
See Also	CALC:DDEM:ERR:VECT? XSymbolError CALC:DDEM:ERR:VECT:IND? 0,XSymbolError

:CALCulate:DDEMod:ERRor:VECTor:INDex?

Description	This query returns the Error list. This query is not associated with the *RST value.
Syntax	:CALCulate:DDEMod:ERRor:VECTor:INDex?<wsp><Error Index>,XSymbolError|YSymbolError
Parameter(s)	➤ *Error Index:* The program data syntax for <Error Index> is defined as a <DECIMAL NUMERIC PROGRAM DATA> element. Selects the Error list. ➤ *Vector Name:* The program data syntax for the second parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: XSymbolError|YSymbolError. Selects the Error. XSymbolError, selects XSymbolError as the error. YSymbolError, selects YSymbolError as the error.
Response Syntax	<Error List>

:CALCulate:DDEMod:ERRor:VECTor:INDex?

Response(s)	*Error List:* The response data syntax for <Error List> is defined as a <STRING RESPONSE DATA> element. Returns the Error list.
Example(s)	LINS1:CALC:DDEM:ERR:VECT:IND? 0,XSymbolError
See Also	CALC:DDEM:ERR:VECT? XSymbolError

:SENSe:ROSCillator:SOURce:TYPe

Description	This command sets the frequency reference. At *RST value, it is set to Internal.
Syntax	:SENSe:ROSCillator:SOURce:TYPe<wsp>INTernal|EXTernal
Parameter(s)	*Source Type:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: INTernal|EXTernal. Sets the frequency reference. INTernal, sets the frequency reference as Internal. EXTernal, sets the frequency reference as External.
Example(s)	LINS1:SENS:ROSC:SOUR:TYP INTernal LINS1:SENS:ROSC:SOUR:TYP EXTernal
See Also	SENS:ROSC:SOUR:TYP INTernal SENS:ROSC:SOUR:TYP?

:SENSe:ROSCillator:SOURce:TYPe?

Description	This query returns the frequency reference. At *RST value, it is set to Internal.
Syntax	:SENSe:ROSCillator:SOURce:TYPe?
Parameter(s)	None
Response Syntax	<Source Type>
Response(s)	*Source Type:* The response data syntax for <Source Type> is defined as a <CHARACTER RESPONSE DATA> element. Returns the frequency reference. INTernal, Internal is selected as the frequency reference. EXTernal, External is selected as the frequency reference.
Example(s)	LINS1:SENS:ROSC:SOUR:TYP?
See Also	SENS:ROSC:SOUR:TYP INTernal SENS:ROSC:SOUR:TYP?

:SENSe:DDEMod:MASK:NAMe

Description	This command sets the Mask Name of the digital demodulator. This command is not associated with *RST.
Syntax	:SENSe:DDEMod:MASK:NAMe<wsp>EVM|Constellation|Intensity,<Mask Name>
Parameter(s)	➤ *Mask Type:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: EVM|Constellation|Intensity. Sets the Mask Type. EVM, set the mask type. Constellation, set the mask type. Intensity, set the mask type. ➤ *Mask Name:* The program data syntax for <Mask Name> is defined as a <STRING PROGRAM DATA> element. Sets the Mask Name.
Example(s)	LINS1:SENS:DDEM:MASK:NAM EVM,"MyTest"
See Also	MMEMory:LOAD:TRACe "C:\OMATRACES\myMeasurement.omd"

:SENSe:DDEMod:MASK:NAMe?

Description	This query returns the Mask name of the digital demodulator. This command is not associated with *RST.
Syntax	:SENSe:DDEMod:MASK:NAMe?<wsp>EVM|Constellation|Intensity
Parameter(s)	*Mask Type:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: EVM|Constellation|Intensity. Sets the Mask Type. EVM, set the mask type. Constellation, set the mask type. Intensity, set the mask type.
Response Syntax	<Mask Name>
Response(s)	*Mask Name:* The response data syntax for <Mask Name> is defined as a <STRING RESPONSE DATA> element. Returns the Mask name.
Example(s)	LINS1:SENS:DDEM:MASK:NAM EVM,"MyTest" LINS1:SENS:DDEM:MASK:NAM? EVM Returns MyTest
See Also	CALC:DDEM:ERR:VECT? XSymbolError

:SENSe:DDEMod:MASK:STATe

Description	This command enables and disables the Mask state of the digital demodulator. At *RST value, it is disabled.
Syntax	:SENSe:DDEMod:MASK:STATe<wsp>EVM|Constellation|Intensity,<enable>
Parameter(s)	➤ *Mask Type:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: EVM|Constellation|Intensity. Sets the Mask Type. EVM, set the mask type. Constellation, set the mask type. Intensity, set the mask type. ➤ *enable:* The program data syntax for <enable> is defined as a <Boolean Program Data> element. The <enable> special forms ON and OFF are accepted on input for increased readability. ON corresponds to 1 and OFF corresponds to 0. Enable the Mask Type.
Example(s)	LINS1:SENS:DDEM:MASK:STAT EVM,1
See Also	SENS:ROSC:SOUR:PHAS ON SENS:ROSC:SOUR:PHAS?

:SENSe:DDEMod:MASK:STATe?

Description

This query returns the Mask state of the digital demodulator.
At *RST value, it is disabled.

Syntax

:SENSe:DDEMod:MASK:STATe?<wsp>EVM|Constellation|Intensity

Parameter(s)

Mask Type:

The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: EVM|Constellation|Intensity.

Sets the Mask Type.
EVM, set the mask type.
Constellation, set the mask type.
Intensity, set the mask type.

Response Syntax

<Status>

Response(s)

Status:

The response data syntax for <Status> is defined as a <NR1 NUMERIC RESPONSE DATA> element.

Returns the selected Mask state.

Example(s)

LINS1:SENS:DDEM:MASK:STAT EVM,1
LINS1:SENS:DDEM:MASK:STAT? EVM Returns 1

See Also

SENS:ROSC:SOUR:PHAS ON
SENS:ROSC:SOUR:PHAS?

:SENSe:DDEMod:FILTer:TYPe

Description	This command sets the filter Type of the of the digital demodulator. At *RST value, it is None .
Syntax	:SENSe:DDEMod:FILTer:TYPe<wsp>Chebyshev1 |Bessel|Butterworth|None
Parameter(s)	*filter:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: Chebyshev1|Bessel|Butterworth|None. Sets the filter type. Chebyshev1, sets Chebyshev1 as the filter type. Bessel, sets Bessel as the filter type. Butterworth, sets Butterworth as the filter type. None, sets None as the filter type.
Example(s)	LINS1:SENS:DDEM:FILT:TYP Chebyshev1 LINS1:SENS:DDEM:FILT:TYP Bessel LINS1:SENS:DDEM:FILT:TYP Butterworth LINS1:SENS:DDEM:FILT:TYP None
See Also	SENS:DDEM:SYNC:SWOR:PTYP Prbs SENS:DDEM:SYNC:SWOR:PTYP?

:SENSe:DDEMod:FILTer:TYPe?

Description	This query returns the filter Type of the of the digital demodulator. At *RST value, it is None .
Syntax	:SENSe:DDEMod:FILTer:TYPe?
Parameter(s)	None
Response Syntax	<Type>
Response(s)	*Type:* The response data syntax for <Type> is defined as a <CHARACTER RESPONSE DATA> element. Returns the Filter type. Chebyshev1, CHEBYSHEV1 is selected as Filter type. Bessel, BESSEL is selected as Filter type. Butterworth, BUTTERWORTH is selected as Filter type. None, NONE is selected as Filter type.
Example(s)	LINS1:SENS:DDEM:FILT:TYP?
See Also	SENS:DDEM:SYNC:SWOR:PTYP Prbs SENS:DDEM:SYNC:SWOR:PTYP?

:SENSe:DDEMod:FILTer:CUTFrequency

Description	This command sets the FilterCutFrequency. At *RST, this value is set to 28 Gbaud or 20 Gbaud. It’s device dependent.
Syntax	:SENSe:DDEMod:FILTer:CUTFrequency<wsp><frequency>
Parameter(s)	*frequency:* The program data syntax for <frequency> is defined as a <DECIMAL NUMERIC PROGRAM DATA> element. Sets the FilterCutFrequency.
Example(s)	LINS1:SENS:DDEM:FILT:CUTF 2
See Also	SENS:DDEM:FILT:ORD 1

:SENSe:DDEMod:FILTer:CUTFrequency?

Description	This query returns the FilterCutFrequency. At *RST, this value is set to 28 Gbaud or 20 Gbaud. It’s device dependent.
Syntax	:SENSe:DDEMod:FILTer:CUTFrequency?
Parameter(s)	None
Response Syntax	<frequency>
Response(s)	*frequency:* The response data syntax for <frequency> is defined as a <NR2 NUMERIC RESPONSE DATA> element. Returns the FilterCutFrequency.
Example(s)	LINS1:SENS:DDEM:FILT:CUTF 2 LINS1:SENS:DDEM:FILT:CUTF? Returns 2
See Also	SENS:DDEM:FILT:ORD?

:SENSe:DDEMod:FILTer:ORDer

Description	This command sets the Filter order of the demodulator. At *RST value, it is set to 3.
Syntax	:SENSe:DDEMod:FILTer:ORDer<wsp><order >
Parameter(s)	*order :* The program data syntax for <order > is defined as a <DECIMAL NUMERIC PROGRAM DATA> element. Sets the filter order.
Example(s)	LINS1:SENS:DDEM:FILT:ORD 1
See Also	SENS:DDEM:WIND:UPP 55

:SENSe:DDEMod:FILTer:ORDer?

Description	This query returns the Filter order of the demodulator. At *RST value, it is set to 3
Syntax	:SENSe:DDEMod:FILTer:ORDer?
Parameter(s)	None
Response Syntax	<order >
Response(s)	*order :* The response data syntax for <order > is defined as a <NR1 NUMERIC RESPONSE DATA> element. Returns the filter order.
Example(s)	LINS1:SENS:DDEM:FILT:ORD 1 LINS1:SENS:DDEM:FILT:ORD? Returns 1
See Also	SENS:DDEM:WIND:UPP 55 SENS:DDEM:WIND:UPP?

:SENSe:DDEMod:WINDow:UPPerbound

Description	This command sets the measurement for Window Upper bound. At *RST value, it is set to 60 %.
Syntax	:SENSe:DDEMod:WINDow:UPPerbound<wsp> <percent>
Parameter(s)	*percent:* The program data syntax for <percent> is defined as a <DECIMAL NUMERIC PROGRAM DATA> element. Sets the measurement for Window Upper bound in %.
Example(s)	LINS1:SENS:DDEM:WIND:UPP 55
See Also	SENS:DDEM:WIND:LOW 1 SENS:DDEM:WIND:LOW?

:SENSe:DDEMod:WINDow:UPPerbound?

Description	This query returns the measurement value for Window Upper bound. At *RST value, it is set to 60 %.
Syntax	:SENSe:DDEMod:WINDow:UPPerbound?
Parameter(s)	None
Response Syntax	<percent>
Response(s)	*percent:* The response data syntax for <percent> is defined as a <NR2 NUMERIC RESPONSE DATA> element. Returns the measurement value for Window Upper bound.
Example(s)	LINS1:SENS:DDEM:WIND:UPP 55 LINS1:SENS:DDEM:WIND:UPP? Returns 55
See Also	SENS:DDEM:WIND:LOW 1 SENS:DDEM:WIND:LOW?

:SENSe:DDEMod:WINDow:LOWerbound

Description	This command sets the measurement for Window Lower bound value in %. At *RST value, it is set to 40 %.
Syntax	:SENSe:DDEMod:WINDow:LOWerbound<wsp> <percent>
Parameter(s)	*percent:* The program data syntax for <percent> is defined as a <DECIMAL NUMERIC PROGRAM DATA> element. Sets the measurement for Window Lower bound value in %.
Example(s)	LINS1:SENS:DDEM:WIND:LOW 1 LINS1:SENS:DDEM:WIND:LOW 2
See Also	SENS:DDEM:WIND:UPP 55 SENS:DDEM:WIND:UPP?

:SENSe:DDEMod:WINDow:LOWerbound?

Description	This query returns the measurement for Window Lower bound value in %. At *RST value, it is set to 40%.
Syntax	:SENSe:DDEMod:WINDow:LOWerbound?
Parameter(s)	None
Response Syntax	<percent>
Response(s)	*percent:* The response data syntax for <percent> is defined as a <NR2 NUMERIC RESPONSE DATA> element. Returns the measurement for Window Lower bound value in %.
Example(s)	LINS1:SENS:DDEM:WIND:LOW 1 LINS1:SENS:DDEM:WIND:LOW? Returns 1
See Also	SENS:DDEM:WIND:UPP 55 SENS:DDEM:WIND:UPP?

:SENSe:DDEMod:WINDow:AMPLitude

Description	This command sets the measurement value for amplitude thresholds. At *RST value, it is set to 20%-80%.
Syntax	:SENSe:DDEMod:WINDow:AMPLitude<wsp>10-90|20-80
Parameter(s)	*value:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: 10-90|20-80. Sets the measurement value for amplitude thresholds. 20-80,selects 20%-80% as the measurement value for amplitude thresholds. 10-90 ,selects 10%-90% as the measurement value for amplitude thresholds.
Example(s)	LINS1:SENS:DDEM:WIND:AMPL 20-80
See Also	SENS:DDEM:WIND:LOW 1 SENS:DDEM:WIND:LOW 2

:SENSe:DDEMod:WINDow:AMPLitude?

Description	This query returns the measurement value for amplitude thresholds. At *RST value, it is set to 20%-80%.
Syntax	:SENSe:DDEMod:WINDow:AMPLitude?
Parameter(s)	None
Response Syntax	<amplitude>
Response(s)	*amplitude:* The response data syntax for <amplitude> is defined as a <CHARACTER RESPONSE DATA> element. Returns the measurement value for amplitude thresholds. 20-80, 20%-80% is selected as the measurement value for amplitude thresholds. 10-90, 10%-90% is selected as the measurement value for amplitude thresholds.
Example(s)	LINS1:SENS:DDEM:WIND:AMPL?
See Also	SENS:DDEM:WIND:LOW?

:MMEMory:LOAD:GEARbox:SETup

Description	This command sets the file for the GearBox setup. This command is not associated with the *RST value.
Syntax	:MMEMory:LOAD:GEARbox:SETup<wsp><Filename>
Parameter(s)	*Filename:* The program data syntax for <Filename> is defined as a <STRING PROGRAM DATA> element. Sets the file for the GearBox setup.
Example(s)	LINS1:MMEMory:LOAD:GEARbox:SETup "C:\Gearbox\TEST1.gboxcfg"
See Also	MMEM:LOAD:GEAR:STR 16QAM,OneGlobalStream,"C:\Gearbox\TEST1.gearbox" MMEM:LOAD:GEAR:STR APSK,OneGlobalStream,"C:\Gearbox\TEST1.gearbox"

:MMEMory:STORe:GEARbox:SETup

Description	This command sets the file destination for the Gear Box Setup. This command is not associated with the *RST value.
Syntax	:MMEMory:STORe:GEARbox:SETup<wsp><File name>
Parameter(s)	*Filename:* The program data syntax for <Filename> is defined as a <STRING PROGRAM DATA> element. This command sets the file destination for the Gear Box Setup.
Example(s)	LINS1:MMEMory:STORE:GEARbox:SETup "C:\Gearbox\TEST1.gboxcfg" LINS1:MMEMory:LOAD:GEARbox:SETup "C:\Gearbox\TEST1.gboxcfg"
See Also	MMEMory:LOAD:GEARbox:SETup "C:\Gearbox\TEST1.gboxcfg"

:MMEMory:LOAD:GEARbox:STReam

Description	This command sets the GearBox Stream Alignment Setup (string modulation, string gearboxLayout, string fileDestination). This command is not associated with the *RST value.
Syntax	:MMEMory:LOAD:GEARbox:STReam<wsp>16QAM|APSK|BPSK|DP-16QAM|DP-APSK|DP-BPSK|DP-OOK|DP-QPSK|OOK|QPSK,OneGlobalStream|DualXYStreams|nIndividualStreams,<Filename>
Parameter(s)	➤ *modulation:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: 16QAM|APSK|BPSK|DP-16QAM|DP-APSK|DP-BPSK|DP-OOK|DP-QPSK|OOK|QPSK. Sets the string modulation format for the GearBox Stream Alignment Setup. 16QAM , selects 16QAM as the string modulation format for the GearBox Stream Alignment Setup. APSK, selects APSK as the string modulation format for the GearBox Stream Alignment Setup. BPSK, selects BPSK as the string modulation format for the GearBox Stream Alignment Setup. DP-16QAM , selects 16QAM as the string modulation format for the GearBox Stream Alignment Setup.

:MMEMory:LOAD:GEARbox:STReam

DP-APSK, selects DP-APSK as the string modulation format for the GearBox Stream Alignment Setup.
DP-BPSK, selects DP-BPSKas the string modulation format for the GearBox Stream Alignment Setup.
DP-OOK, selects DP-OOK as the string modulation format for the GearBox Stream Alignment Setup.

DP-QPSK , selects DP-QPSK as the string modulation format for the GearBox Stream Alignment Setup.
OOK , selects OOK as the string modulation format for the GearBox Stream Alignment Setup.
QPSK, selects QPSK as the string modulation format for the GearBox Stream Alignment Setup.

➤ *gearboxLayout:*

The program data syntax for the second parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: OneGlobalStream|DualXYStreams|nIndividualStreams.

Sets the Gear box layout for the GearBox Stream Alignment Setup.
OneGlobalStream, selects OneGlobalStream as the Gear box layout for the GearBox Stream Alignment Setup.

:MMEMory:LOAD:GEARbox:STReam

DualXYStreams, selects DualXYStreams as the Gear box layout for the GearBox Stream Alignment Setup.
nIndividualStreams, selects nIndividualStreams as the Gear box layout for the GearBox Stream Alignment Setup.

➤ *Filename:*

The program data syntax for <Filename> is defined as a <STRING PROGRAM DATA> element.

Sets the file name for the GearBox Stream Alignment Setup.

Example(s)

LINS1:MMEM:LOAD:GEAR:STR 16QAM,OneGlobalStream,"C:\Gearbox\TEST1.gearbox"
LINS1:MMEM:LOAD:GEAR:STR APSK,OneGlobalStream,"C:\Gearbox\TEST1.gearbox"

LINS1:MMEM:LOAD:GEAR:STR BPSK,OneGlobalStream,"C:\Gearbox\TEST1.gearbox"
LINS1:MMEM:LOAD:GEAR:STR DP-16QAM,OneGlobalStream,"C:\Gearbox\TEST1.gearbox"

See Also

MMEM:LOAD:GEAR:SET "C:\Gearbox\TEST1.gboxcfg"

:MMEMory:STORe:GEARbox:STReam

Description

This command sets the GearBox Stream Alignment Setup(string modulation, string gearboxLayout, string fileDestination).
This command is not associated with the *RST value.

Syntax

:MMEMory:STORe:GEARbox:STReam<wsp>16QAM|APSK|BPSK|DP-16QAM|DP-APSK|DP-BPSK|DP-OOK|DP-QPSK|OOK|QPSK,OneGlobalStream|DualXYStreams|nIndividualStreams,<Filename>

Parameter(s)

➤ *modulation:*

The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: 16QAM|APSK|BPSK|DP-16QAM|DP-APSK|DP-BPSK|DP-OOK|DP-QPSK|OOK|QPSK.

Sets the string modulation format for the GearBox Stream Alignment Setup.
16QAM , selects 16QAM as the string modulation format for the GearBox Stream Alignment Setup.

APSK, selects APSK as the string modulation format for the GearBox Stream Alignment Setup.
BPSK, selects BPSK as the string modulation format for the GearBox Stream Alignment Setup.
DP-16QAM , selects 16QAM as the string modulation format for the GearBox Stream Alignment Setup.

:MMEMory:STORe:GEARbox:STReam

DP-APSK, selects DP-APSK as the string modulation format for the GearBox Stream Alignment Setup.
DP-BPSK, selects DP-BPSKas the string modulation format for the GearBox Stream Alignment Setup.
DP-OOK, selects DP-OOK as the string modulation format for the GearBox Stream Alignment Setup.

DP-QPSK , selects DP-QPSK as the string modulation format for the GearBox Stream Alignment Setup.
OOK , selects OOK as the string modulation format for the GearBox Stream Alignment Setup.
QPSK, selects QPSK as the string modulation format for the GearBox Stream Alignment Setup.

➤ *gearboxLayout:*

The program data syntax for the second parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: OneGlobalStream|DualXYStreams|nIndividualStreams.

Sets the Gear box layout for the GearBox Stream Alignment Setup.
OneGlobalStream, selects OneGlobalStream as the Gear box layout for the GearBox Stream Alignment Setup.

:MMEMory:STORe:GEARbox:STReam

	DualXYStreams, selects DualXYStreams as the Gear box layout for the GearBox Stream Alignment Setup. nIndividualStreams, selects nIndividualStreams as the Gear box layout for the GearBox Stream Alignment Setup. ➤ *Filename:* The program data syntax for <Filename> is defined as a <STRING PROGRAM DATA> element. Sets the file name for the GearBox Stream Alignment Setup.
Example(s)	LINS1:MMEM:STOR:GEAR:STR 16QAM,OneGlobalStream,"C:\Gearbox\TEST1.gearbox" LINS1:MMEM:STOR:GEAR:STR APSK,OneGlobalStream,"C:\Gearbox\TEST1.gearbox" LINS1:MMEM:STOR:GEAR:STR BPSK,OneGlobalStream,"C:\Gearbox\TEST1.gearbox" LINS1:MMEM:STOR:GEAR:STR DP-16QAM,OneGlobalStream,"C:\Gearbox\TEST1.gearbox"
See Also	MMEM:STORE:GEAR:SET "C:\Gearbox\TEST1.gboxcfg" MMEM:LOAD:GEAR:SET "C:\Gearbox\TEST1.gboxcfg"

:SENSe:DDEMod:SYNC:SWORd:PTYPe

Description	This command sets the BitPatternType. *RST it is set to Repetitive Unknown sequence.
Syntax	:SENSe:DDEMod:SYNC:SWORd:PTYPe<wsp>Prbs|Random|RepetitiveUnknown|UserDefinedBitPattern|UserDefinedSymbolPattern
Parameter(s)	*Bit pattern type:* The program data syntax for the first parameter is defined as a <CHARACTER PROGRAM DATA> element. The allowed <CHARACTER PROGRAM DATA> elements for this parameter are: Prbs|Random|RepetitiveUnknown|UserDefinedBitPattern|UserDefinedSymbolPattern. Sets the BitPatternType. Prbs, selects Stabdard PRBS (From PRBS generator) as BitPatternType. Random, selects Random as BitPatternType. RepetitiveUnknown, selects RepetitiveUnknown as BitPatternType.

:SENSe:DDEMod:SYNC:SWORd:PTYPe

	UserDefinedBitPattern, selects UserDefinedBitPattern as BitPatternType. UserDefinedSymbolPattern, selects UserDefinedSymbolPattern as BitPatternType.
Example(s)	LINS1:SENS:DDEM:SYNC:SWOR:PTYP Prbs LINS1:SENS:DDEM:SYNC:SWOR:PTYP Random LINS1:SENS:DDEM:SYNC:SWOR:PTYP RepetitiveUnknown LINS1:SENS:DDEM:SYNC:SWOR:PTYP UserDefinedBitPattern LINS1:SENS:DDEM:SYNC:SWOR:PTYP UserDefinedSymbolPattern
See Also	SENS:DDEM:SYNC:SWOR:PLEN 1 SENS:DDEM:SYNC:SWOR:PLEN?

:SENSe:DDEMod:SYNC:SWORd:PTYPe?

Description	This query returns the BitPatternType. At *RST it is set to Repetitive Unknown sequence.
Syntax	:SENSe:DDEMod:SYNC:SWORd:PTYPe?
Parameter(s)	None
Response Syntax	<Bit pattern type>
Response(s)	*Bit pattern type:* The response data syntax for <Bit pattern type> is defined as a <CHARACTER RESPONSE DATA> element. Returns, the BitPatternType. Prbs,Prbs is selected as BitPatternType. Random, Random is selected as BitPatternType. RepetitiveUnknown, RepetitiveUnknown is selected as BitPatternType. UserDefinedBitPattern, UserDefinedBitPattern is selected as BitPatternType. UserDefinedSymbolPattern, UserDefinedSymbolPattern is selected as BitPatternType.
Example(s)	LINS1:SENS:DDEM:SYNC:SWOR:PTYP Prbs LINS1:SENS:DDEM:SYNC:SWOR:PTYP? Returns Prbs
See Also	SENS:DDEM:SYNC:SWOR:PLEN 1 SENS:DDEM:SYNC:SWOR:PLEN?

:SENSe:DDEMod:SYNC:SWORd:PLENgth

Description	This command sets the BitPattern Length. At *RST it is set to 127.
Syntax	:SENSe:DDEMod:SYNC:SWORd:PLENgth<wsp> <pattern length>
Parameter(s)	*pattern length:* The program data syntax for <pattern length> is defined as a <DECIMAL NUMERIC PROGRAM DATA> element. Sets the BitPattern Length.
Example(s)	LINS1:SENS:DDEM:SYNC:SWOR:PLEN 1
See Also	SENS:DDEM:SYNC:SWOR:PTYP Prbs SENS:DDEM:SYNC:SWOR:PTYP?

:SENSe:DDEMod:SYNC:SWORd:PLENgth?

Description	This query returns the BitPattern Length. At *RST it is set to 127.
Syntax	:SENSe:DDEMod:SYNC:SWORd:PLENgth?
Parameter(s)	None
Response Syntax	<pattern length>
Response(s)	*pattern length:* The response data syntax for <pattern length> is defined as a <NR1 NUMERIC RESPONSE DATA> element. Returns the BitPattern Length.
Example(s)	LINS1:SENS:DDEM:SYNC:SWOR:PLEN 1 LINS1:SENS:DDEM:SYNC:SWOR:PLEN? Returns 1
See Also	SENS:DDEM:SYNC:SWOR:PTYP Prbs SENS:DDEM:SYNC:SWOR:PTYP?

:MMEMory:LOAD:PATTern

Description	This command sets the Bit Pattern. This command is not associated with the *RST value.
Syntax	:MMEMory:LOAD:PATTern<wsp><Filename>
Parameter(s)	*Filename:* The program data syntax for <Filename> is defined as a <STRING PROGRAM DATA> element. Sets the file path for Bit Pattern.
Example(s)	LINS1:MMEM:LOAD:PATT "D:\EXFO\PSO-200\test1.osp"
See Also	MMEM:LOAD:PATT "D:\EXFO\PSO-200\test1.osp" MMEM:STOR:PATT "D:\EXFO\PSO-200\test1.osp"

:MMEMory:STORe:PATTern

Description	This command sets the Bit Pattern. This command is not associated with the *RST value.
Syntax	
Parameter(s)	*Filename:*
Example(s)	LINS1:MMEM:STOR:PATT "D:\EXFO\PSO-200\test1.osp"
See Also	MMEM:LOAD:PATT "D:\EXFO\PSO-200\test1.osp" MMEM:STOR:PATT "D:\EXFO\PSO-200\test1.osp"

:SENSe:DDEMod:LEARnpattern

Description	This command enables the "Waveform estimation phase tracking" signal processing algorithm (as in the Analysis tab of the Acquisition Settings dialog box). At *RST the value is set to OFF.
Syntax	
Parameter(s)	*Learn Pattern:*
Example(s)	LINS1:SENS:DDEM:LEAR OFF
See Also	SENS:ROSC:SOUR:PHAS ON SENS:ROSC:SOUR:PHAS?

:SENSe:DDEMod:LEARnpattern?

Description	This query enables the "Waveform estimation phase tracking" signal processing algorithm (as in the Analysis tab of the Acquisition Settings dialog box). At *RST the value is set to OFF.
Syntax	
Parameter(s)	None
Response Syntax	
Response(s)	*Status:*
Example(s)	LINS1:SENS:DDEM:LEAR OFF LINS1:SENS:DDEM:LEAR? Returns 0
See Also	SENS:ROSC:SOUR:PHAS ON SENS:ROSC:SOUR:PHAS?

:SENSe:ROSCillator:SOURce:PHASecalibration

Description	This command sets the "Enable pulse source calibration" option (as in the General tab of the Acquisition Settings dialog box). This option is available when an external source is used as local oscillator. It attempts to adjust the source's phase shift. At *RST it is set to ON.
Syntax	
Parameter(s)	*Phase Calibration:*
Example(s)	LINS1:SENS:ROSC:SOUR:PHAS OFF
See Also	SENS:DDEM:LEAR ON SENS:DDEM:LEAR?

:SENSe:ROSCillator:SOURce:PHASecalibration?

Description	This query returns the value of “Enable pulse source calibration” option (as in the General tab of the Acquisition Settings dialog box). This option is available when an external source is used as local oscillator. It attempts to adjust the source’s phase shift. At *RST it is set to ON.
Syntax	
Parameter(s)	None
Response Syntax	
Response(s)	*Status:*
Example(s)	LINS1:SENS:ROSC:SOUR:PHAS ON LINS1:SENS:ROSC:SOUR:PHAS? Returns 1
See Also	SENS:DDEM:LEAR ON SENS:DDEM:LEAR?

:SENSe:DDEMod:SIGNal:FREQuency

Description	.This command sets the signal frequency or wavelength. The signal spectrum needs to be within the receiver spectrum, otherwise the constellation chart might be distorted and noisy, or even not visible at all. The range is from 191.5 to 196.25. At *RST this value is set to 193.1.
Syntax	
Parameter(s)	*Frequency:*
Example(s)	LINS1:SENSe:DDEMod:SIGNal:FREQuency 192
See Also	SENSe:DDEMod:SIGNal:OFFSet 10

:SENSe:DDEMod:SIGNal:FREQuency?

Description	This query returns the signal frequency or wavelength. The signal spectrum needs to be within the receiver spectrum, otherwise the constellation chart might be distorted and noisy, or even not visible at all. he range is from 191.5 to 196.25. At *RST this value is set to 193.1.
Syntax	
Parameter(s)	None
Response Syntax	
Response(s)	*Frequency:*
Example(s)	LINS1:SENSe:DDEMod:SIGNal:FREQuency 192 LINS1:SENSe:DDEMod:SIGNal:FREQuency? Returns 192
See Also	SENSe:DDEMod:SIGNal:OFFSet 10 SENSe:DDEMod:SIGNal:OFFSet?

:SENSe:DDEMod:SIGNal:OFFSet

Description	This command sets an offset value of up to half the channel. The range is from -12 GHZ to 12 GHZ. At *RST this value is set to 0.
Syntax	
Parameter(s)	*Offset:*
Example(s)	LINS1:SENSe:DDEMod:SIGNal:OFFSet 10
See Also	SENSe:DDEMod:SIGNal:FREQuency 192

:SENSe:DDEMod:SIGNal:OFFSet?

Description	This query returns an offset value of up to half the channel. The range is from -12 GHZ to 12 GHZ. At *RST this value is set to 0.
Syntax	
Parameter(s)	None
Response Syntax	
Response(s)	*Offset:*
Example(s)	LINS1:SENSe:DDEMod:SIGNal:OFFSet 10 LINS1:SENSe:DDEMod:SIGNal:OFFSet? Returns 10
See Also	SENSe:DDEMod:SIGNal:FREQuency 192 SENSe:DDEMod:SIGNal:FREQuency?

:SENSe:DDEMod:SIGNal:WIDTh

Description	This command controls the speed of the IF tracking algorithm and corresponds to the signal source's linewidth. The range is from 0.1 MHz to 5 MHz. At *RST this value is set to 0.1.
Syntax	
Parameter(s)	*Width:*
Example(s)	LINS1:SENSe:DDEMod:SIGNal:WIDTh 2
See Also	SENSe:DDEMod:CDIS:VAL 10.21

:SENSe:DDEMod:SIGNal:WIDTh?

Description	This query returns the speed of the IF tracking algorithm and corresponds to the signal source's linewidth. The range is from 0.1 MHz to 5 MHz. At *RST this value is set to 0.1
Syntax	
Parameter(s)	None
Response Syntax	
Response(s)	*Width:*
Example(s)	LINS1:SENSe:DDEMod:SIGNal:WIDTh 2 LINS1:SENSe:DDEMod:SIGNal:WIDTh? Returns 2
See Also	SENSe:DDEMod:CDIS:VAL 10.21 SENSe:DDEMod:CDIS:VAL?

:SENSe:DDEMod:AVERage:RES

Description	This command sets time resolution. The range is from 1 ps to 10 ps. At *RST this value is set to 1.
Syntax	
Parameter(s)	*Value:*
Example(s)	LINS1:SENSe:DDEMod:AVERage:RES 1.2
See Also	SENSe:DDEMod:SIGNal:WIDTh 2

:SENSe:DDEMod:AVERage:RES?

Description	This query returns the time resolution. The range is from 1 ps to 10 ps. At *RST this value is set to 1.
Syntax	
Parameter(s)	None
Response Syntax	
Response(s)	*Value:*
Example(s)	LINS1:SENSe:DDEMod:AVERage:RES 1.2 LINS1:SENSe:DDEMod:AVERage:RES? Returns 1.2
See Also	SENSe:DDEMod:SIGNal:WIDTh 2 SENSe:DDEMod:SIGNal:WIDTh?

:SENSe:DDEMod:CDIS:ENABle

Description	This command sets the chromatic dispersion in the signal. This command also activates the averaging. If averaging is deactivated, this algorithm is also deactivated. At *RST this value is set to OFF.
Syntax	
Parameter(s)	*Status:*
Example(s)	LINS1:SENSe:DDEMod:CDIS:ENABle 1
See Also	SENSe:DDEMod:DEMX ON

:SENSe:DDEMod:CDIS:ENABle?

Description	This query returns the chromatic dispersion in the signal. This command also activates the averaging. If averaging is deactivated, this algorithm is also deactivated. At *RST this value is set to OFF.
Syntax	
Parameter(s)	None
Response Syntax	
Response(s)	*Status:*
Example(s)	LINS1:SENSe:DDEMod:CDIS:ENABle 1 LINS1:SENSe:DDEMod:CDIS:ENABle? Returns 1 LINS1:SENSe:DDEMod:CDIS:ENABle OFF LINS1:SENSe:DDEMod:CDIS:ENABle? Returns 0
See Also	SENSe:DDEMod:DEMX ON SENSe:DDEMod:DEMX?

:SENSe:DDEMod:CDIS:VAL

Description	This command sets the chromatic dispersion value. The range is from -999 ps/nm to 999 ps/nm. At *RST this value is set to 0.
Syntax	
Parameter(s)	*Value:*
Example(s)	LINS1:SENSe:DDEMod:CDIS:VAL 10.21
See Also	SENS:DDEM:WIND:UPP 55

:SENSe:DDEMod:CDIS:VAL?

Description	This query returns the chromatic dispersion value. The range is from -999 ps/nm to 999 ps/nm. At *RST this value is set to 0.
Syntax	
Parameter(s)	None
Response Syntax	
Response(s)	*Value:*
Example(s)	LINS1:SENSe:DDEMod:CDIS:VAL 10.21 LINS1:SENSe:DDEMod:CDIS:VAL? Returns 10.21
See Also	SENS:DDEM:WIND:UPP 55 SENS:DDEM:WIND:UPP?

:SENSe:DDEMod:SIGNal:ENCoding

Description	This command sets the format of the bit. At *RST this value is set to NRZ
Syntax	
Parameter(s)	*Format:*
Example(s)	LINS1:SENSe:DDEMod:SIGNal:ENCoding NRZ
See Also	SENS:DDEM:SYNC:SWOR:PTYP Prbs

:SENSe:DDEMod:SIGNal:ENCoding?

Description	This query returns the format of the bit. At *RST this value is set to NRZ
Syntax	
Parameter(s)	None
Response Syntax	
Response(s)	*Format:*
Example(s)	LINS1:SENSe:DDEMod:SIGNal:ENCoding NRZ LINS1:SENSe:DDEMod:SIGNal:ENCoding? Returns NRZ
See Also	SENS:DDEM:SYNC:SWOR:PTYP Prbs SENS:DDEM:SYNC:SWOR:PTYP?

:SENSe:DDEMod:DEMX

Description	This command sets the status of Polarization demultiplexing algorithm. At *RST this value is set to ON.
Syntax	
Parameter(s)	*Status:*
Example(s)	LINS1:SENSe:DDEMod:DEMX ON
See Also	SENSe:DDEMod:IFAL OFF

:SENSe:DDEMod:DEMX?

Description	This query returns the status of Polarization demultiplexing algorithm. At *RST this value is set to ON.
Syntax	
Parameter(s)	None
Response Syntax	
Response(s)	*Status:*
Example(s)	LINS1:SENSe:DDEMod:DEMX ON LINS1:SENSe:DDEMod:DEMX? Returns 1
See Also	SENSe:DDEMod:IFAL OFF SENSe:DDEMod:IFAL?

:SENSe:DDEMod:IFAL

Description	This command sets the Intermediate Frequency Recovery. At *RST this value is set to Enabled.
Syntax	
Parameter(s)	*Status:*
Example(s)	LINS1:SENSe:DDEMod:IFAL ON
See Also	SENSe:DDEMod:CDIS:ENABle OFF

:SENSe:DDEMod:IFAL?

Description	This query returns the Intermediate Frequency Recovery. At *RST this value is set to Enabled.
Syntax	
Parameter(s)	None
Response Syntax	
Response(s)	*Status:*
Example(s)	LINS1:SENSe:DDEMod:IFAL OFF LINS1:SENSe:DDEMod:IFAL? Returns 0
See Also	SENSe:DDEMod:CDIS:ENABle OFF SENSe:DDEMod:CDIS:ENABle?

C Coherent Detection and Sampling Methods

Coherent Detection

Coherent receivers are sensitive to the optical field of the detected (data) signal, and hence can be utilized to receive signals modulated in amplitude, phase, and/or frequency. Coherent receivers include a local oscillator (LO), which is a CW reference signal that beats with the data signal on the photodetector.

The LO can either have the same frequency as the optical carrier, known as *homodyne detection*, or a frequency offset from the carrier. If the frequency offset is less than the signal bandwidth, it is known as *intradyne detection*, whereas a frequency offset larger than the signal bandwidth is referred to as *heterodyne detection*. In the PSO-200, an internal LO is set near the signal carrier, resulting in intradyne detection.

By using an optical 90° hybrid, where the signal and LO are mixed, together with balanced detectors, the in-phase (I) and quadrature-phase (Q) components are given directly by

$$I(t) = 4 \cdot |E_s(t)| \cdot |E_{LO}| \cdot \cos[\omega_{IF}t + \phi_s(t) - \phi_{LO}(t)]$$
$$Q(t) = 4 \cdot |E_s(t)| \cdot |E_{LO}| \cdot \sin[\omega_{IF}t + \phi_s(t) - \phi_{LO}(t)]$$

where:

$E_s(t)$ and E_{LO} are the signal and LO optical fields

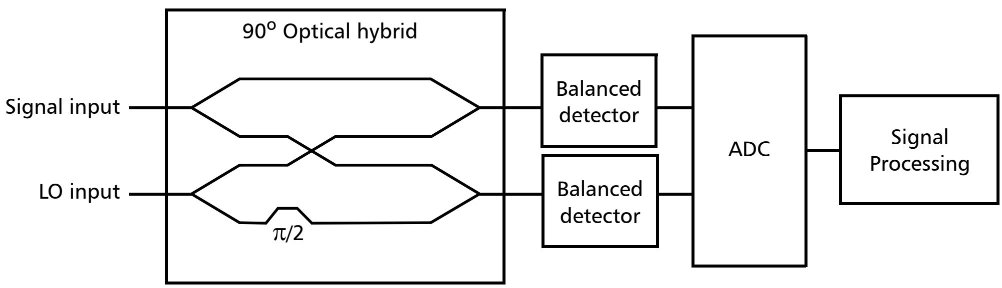
$\omega_{IF} = \omega_s - \omega_{LO}$ is the signal and LO intermediate frequency (IF)

$\phi_s(t)$ is the modulated signal phase

ϕ_{LO} is the relative phase of the LO

Thus, the detected signals correspond to the I and Q axes in the signal space. The equation above is valid for co-polarized signal and LO. In order for the coherent receiver to be polarization independent, a second (identical) branch handles the orthogonal state of polarization (SOP). In order to retrieve $E_S(t)$ and $\phi_S(t)$, the IF must be tracked and removed from the measured signal, which is carried out with advanced signal processing.

The diagram below shows a coherent receiver for a single SOP:



Sampling Methods

Digital sampling is used to visualize time-varying signals. The basic principle is that a snapshot of the signal is acquired by a sampling gate. The gate opens for a small fraction of a second and the signal is quantized by analog-to-digital conversion (ADC).

In general, electronic sampling gates are used. However, for optical measurements, it is preferable to implement optical sampling gates. The benefit is that the sampling bandwidth can be significantly increased; optical sampling systems with >500 GHz bandwidth exist.

Optical sampling gates can be implemented by exploiting nonlinearities in optical fibers or crystals to create an ultra-high-speed optical switch, or, as an alternative, via linear optical sampling. The latter method is unique in that it obtains the optical field in the sampling process itself.

Digital sampling can be implemented as real-time sampling or equivalent-time sampling. The PSO-200 uses the latter.

Real-Time Sampling

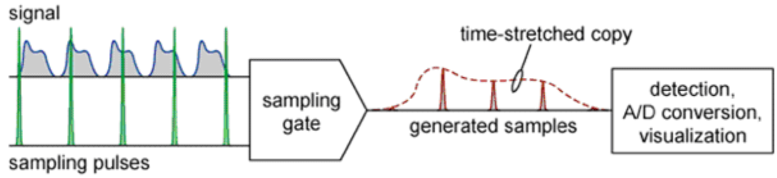
Real-time sampling means that a signal is acquired with high-speed sampling in order to track the instantaneous amplitude variations. Real-time sampling enables measurements of single events and transitions, but requires high-speed electronics, since accurate reconstruction of a digitized signal requires a sampling rate that exceeds twice the signal bandwidth, as dictated by the Nyquist criterion.

An insufficient sampling rate gives rise to the “aliasing” phenomenon, that is, high-frequency components are misinterpreted as lower frequency components and corrupt the reconstruction of the signal. It is therefore common practice to implement anti-aliasing filters to limit the analog bandwidth of the sampling to below half the sampling rate. To this date, commercially available electric real-time sampling systems have analog bandwidths typically less than 20 GHz and sampling rates up to around 50 samples per second.

Equivalent-Time Sampling

The PSO-200 Optical Modulation Analyzer uses equivalent-time sampling, which is the most common technique to achieve sampling with high bandwidth. The sampling rate is lower than in real-time sampling, which eliminates the need for high-speed acquisition electronics.

The signal waveform is built-up by sweeping the sampling point over the signal; hence signal reconstruction using equivalent-time sampling is restricted to measurements of periodic signals and studies of deterministic events. Constellation and eye diagrams of random pattern data sequences with fixed symbol rate can also be acquired.

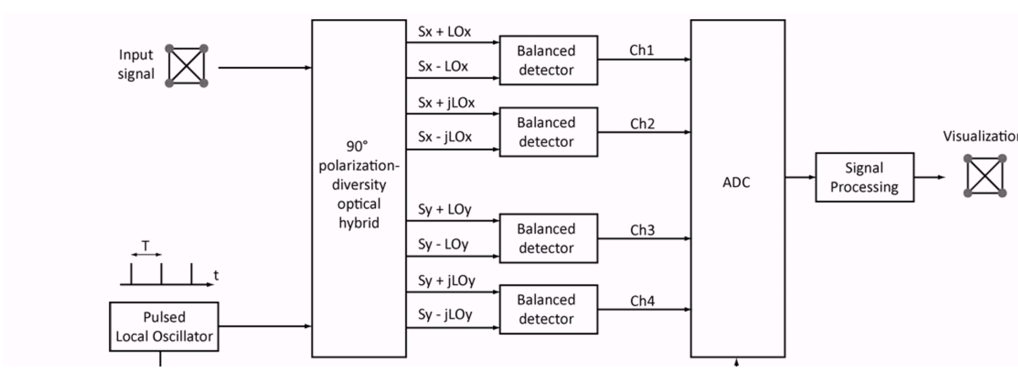


The sampling is usually conducted by sequential sampling with precise control of the sampling instant, or by random sampling that builds up the measured signal from the asynchronous relation between the signal and sampling frequency. The signal is reconstructed by repositioning the time-stamped samples on a correct (equivalent-) time position. The visualization of a time-varying signal in an eye diagram (superimposing the signal to a limited time frame) provides information on the signal and its impairments (symbol rate, rise time, timing jitter, intensity noise...).

The PSO-200 is designed to provide the constellation chart, including transitions, of advanced modulation formats, such as BPSK, QPSK, APSK, and 16-QAM. In order to achieve distortion-free measurements of the phase-encoded data, the PSO-200 relies on a pulsed LO with short, clean, and chirp-free pulses. The sampling frequency is lower than the symbol rate but is sufficient to track the IF in real time.

PSO-200 Principles of Operation

Coherent detection with receiver phase diversity is required to obtain the optical field, that is, retrieve the complete optical carrier phase information. The PSO-200 is based on linear equivalent-time optical sampling, where the input signal field is mixed with a pulsed LO in a dual-polarization 90° optical hybrid, as illustrated below.



When the LO pulses overlap the input signal, mixing occurs, and optical samples are generated. These samples are detected, captured in an ADC in long batches, processed, and finally displayed, for example in the form of a constellation chart.

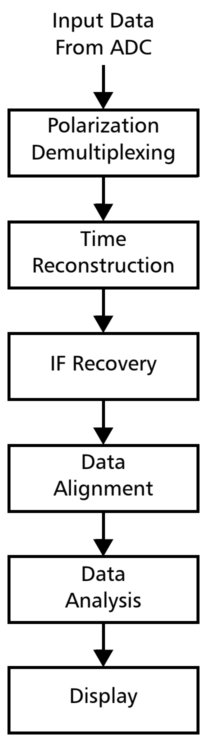
The sampling frequency is determined by the pulse repetition frequency ($f_s = 1/T$) of the LO pulse source, whereas the resolution of the sampling gate is determined by the LO pulse width (Δt). If the bandwidth of the sampling gate is much larger than the symbol rate (that is, the signal phase and amplitude are approximately constant over the LO pulse duration t), the set of optical samples are given by the equations below.

$$Ch1[n] = I_x(nT) = 4 \cdot |E_{s,x}(nT)| \cdot |E_{LO,x}| \cdot \cos[\omega_{IF,x} nT + \phi_{s,x}(nT) - \phi_{LO,x}(nT)]$$
$$Ch2[n] = Q_x(nT) = 4 \cdot |E_{s,x}(nT)| \cdot |E_{LO,x}| \cdot \sin[\omega_{IF,x} nT + \phi_{s,x}(nT) - \phi_{LO,x}(nT)]$$
$$Ch3[n] = I_y(nT) = 4 \cdot |E_{s,y}(nT)| \cdot |E_{LO,y}| \cdot \cos[\omega_{IF,y} nT + \phi_{s,y}(nT) - \phi_{LO,y}(nT)]$$
$$Ch4[n] = Q_y(nT) = 4 \cdot |E_{s,y}(nT)| \cdot |E_{LO,y}| \cdot \sin[\omega_{IF,y} nT + \phi_{s,y}(nT) - \phi_{LO,y}(nT)]$$
$$n = 0, 1, 2, \ldots, N$$

In order to achieve undistorted constellation charts, the pulses should be characterized by low noise, low timing jitter, short temporal duration, and be chirp-free. The sampling frequency f_s is independent of the symbol rate B, however, advantageously, f_s can be tuned to scan over the signal.

Signal Processing Algorithms

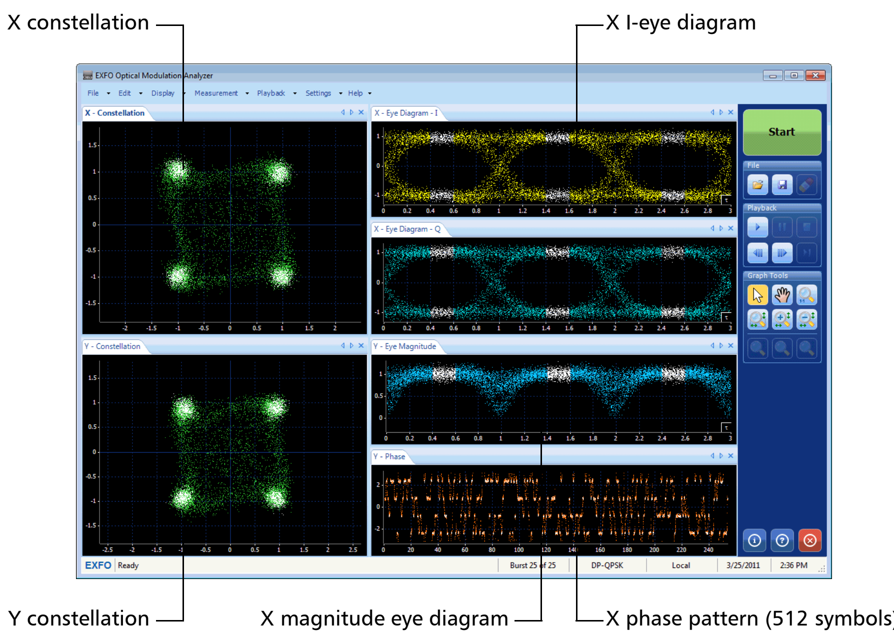
The signal processing algorithms of the PSO-200 reconstruct the waveform of the signal under test from the set of four parallel data streams acquired by the data acquisition card. The main processing steps are shown and explained below:



Polarization Demultiplexing

The polarization-diversity scheme employed in the PSO-200 makes it polarization independent for single-polarization transmission (even if the SOP of the signal varies in time), but it may also be applied to polarization-multiplexed (also referred to as “dual polarization” - DP) transmission, where the software can separate the two orthogonal SOPs (X and Y) and display the corresponding two constellation charts.

The figure below shows typical results from a 28 GBd DP-QPSK signal.



Time-Base Reconstruction

The PSO-200 is not a real-time sampling scope, hence the time base is unknown, especially since the sampling frequency and symbol rate are independent and essentially considered as free-running.

To reconstruct the correct time base, you must input the symbol rate to the system. A software-based clock recovery algorithm then “time stamps” each of the acquired optical samples. In this way, amplitude and phase eye diagrams having very low timing jitter are measured.

Intermediate Frequency (IF) Recovery

The detected signal can conveniently be visualized in a constellation chart via the I and Q signals. However, we only want to visualize the modulation information (that is, data signal plus possible distortions, etc.).

In an intradyne detection scheme, the signal modulation is corrupted by the superimposed IF, so the influence of $\omega_{IF}t$ must be removed. The IF is retrieved by digital signal processing, which enables the LO laser to be free-running in relation to the signal laser. This approach requires high-speed sampling to accurately acquire the variations of the IF phase.

IF recovery can be performed as follows:

1. Detected I and Q signals are combined to form a complex signal, ***E***.

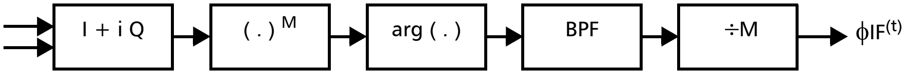
2. The phase modulation of the signal is removed by raising ***E*** to the M^{th} power, where M is the number of phase levels of the modulation (M=4 for QPSK), in order that all modulation phases be multiples of 2π.

3. The signal phase is calculated and corresponds to $M\varphi_{IF}(t)$.

4. The continuously varying phase is bandpass-filtered and divided by M.

5. The retrieved φ_{IF} is subtracted from the received signal phase.

The result is a signal with data modulation only, that can be visualized in the constellation chart.

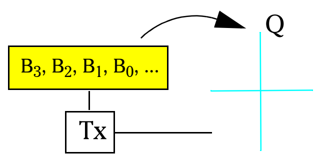


D Modulation Schemes

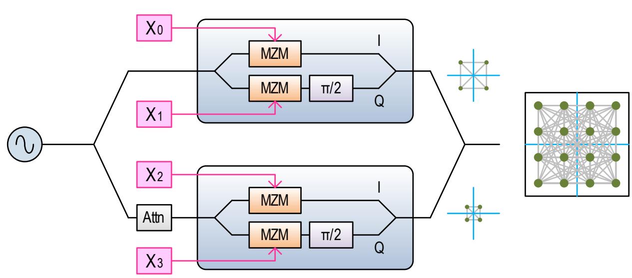
This appendix describes modulation schemes supported by the PSO-200. All formats can be RZ (pulse carved) or NRZ. The pulse carver is usually placed after the data modulator, and synchronized with the symbol rate. Hence, when a pulse carver is used, it does not affect the constellation points, but only the transitions, since the power goes down to zero between each symbol.

As an example, the table in this section shows QPSK with (RZ) and without (NRZ) pulse carving. Your pulse carver can be operated in different modes depending on your transmitter and signal, for example, 33 % RZ, 50 % RZ, or 66 % RZ (carrier suppressed), which affects the optical spectral content.

A general transmitter may be considered as a “black box” that only describes the mapping, as shown below.



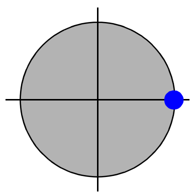
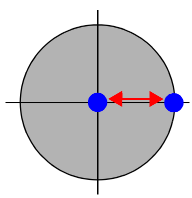
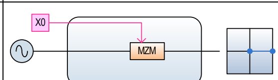
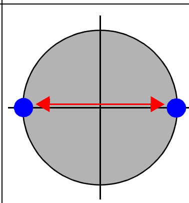
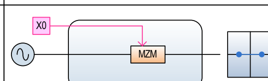
The mapping concept must be understood in order to specify a mapping for a specific transmitter. As an example, consider the 16-QAM default implementation below.



The X_0-X_1 arm has an I/Q modulator that generates a QPSK constellation, whereas the X_2-X_3 arm generates a smaller QPSK constellation (since it has an attenuator included). Hence, the X_0-X_1 arm determines the quadrant in the 16-QAM constellation, whereas the X_2-X_3 arm determines the symbol in each quadrant, as illustrated.

For simplicity purposes, transitions corresponding to higher-order formats are not illustrated here. The symbol mapping, $\{B_3,B_2,B_1,B_0\}'\{I,Q\}$), depends on the specific implementation, and there are several possible implementations for most modulation formats.

The PSO-200 default implementation and mapping of each modulation is shown in the table below. To implement a different mapping, you must edit the Gearbox configuration file as explained in *Performing Detailed Bit Pattern Analysis with the Gearbox* on page 87.

<table>
<tr><th>Modulation Format</th><th>Bits/ Symbol</th><th>Constellation Chart</th><th>Default Implementation</th><th>Mapping</th></tr>
<tr><td>CW</td><td>–</td><td></td><td>
No modulation</td><td>–</td></tr>
<tr><td>OOK</td><td>1</td><td></td><td>
Remark: M = x-cut or z-cut MZ biased at $\pi/4$</td><td><table><tr><th>B_0</th><th>I</th><th>Q</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table></td></tr>
<tr><td>BPSK</td><td>1</td><td></td><td>
Remark: M = x-cut MZ biased at 0</td><td><table><tr><th>B_0</th><th>I</th><th>Q</th></tr><tr><td>0</td><td>-1</td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table></td></tr>
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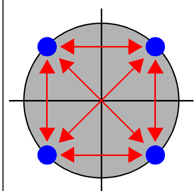
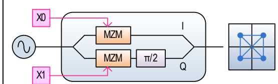
</td><td>NRZ:

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<tr><td>0</td><td>1</td><td>1</td><td>-1</td></tr>
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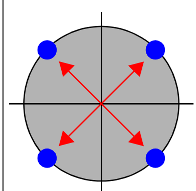
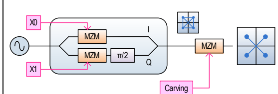
</td><td>RZ:

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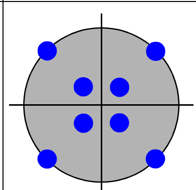
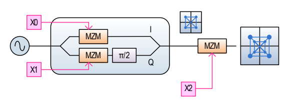
<tr><td>APSK</td><td>3</td><td></td><td>
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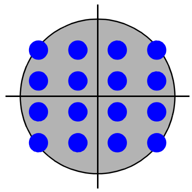
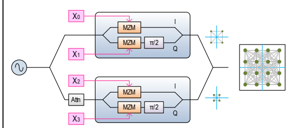
<tr><td>16-QAM</td><td>4</td><td></td><td>
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<tr><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
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</td></tr>
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E Measurement Definitions

Measurements follow the conventional measurement definitions from the telecommunications industry. They are based on different histograms obtained from the acquired samples of the signal under test.

For "constellation" measurements, the measurement procedure is conducted on the time-less constellation graph, whereas for "Eye" measurements, it is conducted on graphs displaying the acquired signal vs. time, and is always conducted based on eye diagrams of the signal.

Data Used for Measurements

Both constellation and eye measurements rely on a selected portion of the signal considered as the *symbol center*, which is defined in the Optical Modulation Analyzer application using the data measurement window, as explained in *Distinguishing Data Points from Transitions* on page 62. For reliable measurements it is important to ensure a proper position and width of this region.

The default center region is:

- For NRZ data: between 40 % and 60 % of the symbol period
- For RZ data: between 47.5 % and 52.5 % of the symbol period

All measurements are separately conducted on X and Y polarizations tributaries of the signal under test.

Note: *Statistical measurement of pattern-synchronized waveforms can be obtained using the user-defined vertical/horizontal histograms. For details see* Viewing Signal Distribution Using Histograms *on page 60.*

Note: *Some of the measurements are not performed in averaging mode.*

Note: *All X/Y polarization results come with average, minimum and maximum values.*

Measurements for Constellation Charts

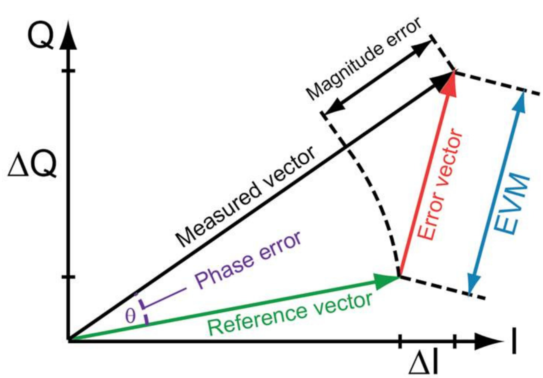
Constellation chart measurements refer to parameters based on signal properties associated with the time-less vector analysis in I and Q space. The constellation vector analysis is described below, where measured samples of the symbol center are assigned a vector.

$$\mathbf{S}_{\text{meas}}(n) = \begin{pmatrix} I_{\text{meas}}(n) \\ Q_{\text{meas}}(n) \end{pmatrix}$$

Each modulation format is also associated with an ideal symbol constellation denoted

$$\mathbf{S}^r_{\text{ref}} = \begin{pmatrix} I^r_{\text{ref}} \\ Q^r_{\text{ref}} \end{pmatrix} \qquad r = 1 \ldots M$$

where M is the number of symbols in the M-ary level modulation format. The measured samples S_{meas} are normalized to minimize the deviation from the reference constellation symbols. The figure below illustrates an example of a measured vector S_{meas} (black) and its corresponding ideal reference vector S_{ref} (green).



The analysis of the deviation of the measured samples relative to the reference symbols is conducted by the parameters defined in this section.

Error Vector Magnitude

The deviation of an acquired signal sample and its ideal position[1] in the constellation chart according to the modulation format can be computed as the magnitude of the corresponding error vector (red), and referred to as the error vector magnitude (EVM):

$$\mathrm{EVM(n)} = \left|\mathbf{S}_{\mathrm{meas}}(n) - \mathbf{S}_{\mathrm{ref}}^{r(n)}\right|$$

where n is the sample index of the N symbol center samples from the acquired waveform. Consequently, there is one EVM value associated to each sample (this is what is displayed in the EVM graphs, as explained in *Error Vector Magnitude (EVM) Diagram* on page 46).

To provide a compact single number figure of merit, the root mean square (rms) value of these EVMs is computed:

$$\mathrm{EVM_{rms}} = \sqrt{\frac{1}{N}\sum_{n=1}^{N} \mathrm{EVM}(n)^2} \times 100[\%\mathrm{rms}]$$

given in percent to the magnitude of the longest reference vector.

Magnitude Error

The magnitude error (EM) is the deviation in magnitude between the sampled signal and the ideal reference constellation, as illustrated in the graph on page 252. It is calculated as:

$$\mathrm{EM_{rms}} = \sqrt{\frac{1}{N}\sum_{n=1}^{N} \left(\left|\mathbf{S}_{\mathrm{meas}}(n)\right| - \left|\mathbf{S}_{\mathrm{ref}}^{\mathrm{r}(n)}\right|\right)^2} \times 100[\%\mathrm{rms}]$$

given in percent to the magnitude of the longest reference vector.

1. For input pattern types 'Random' and 'Repetitive pattern' the ideal position refers to the closest symbol of the ideal reference constellation. For 'Standard PRBS' and 'User-defined pattern' the ideal position is the expected constellation symbol associated with each sample, based on your input signal.

Phase Error

The phase error (EP) describes the deviation of phase from the ideal reference vector, illustrated in the graph. It is computed according to:

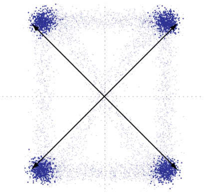
$$EP_{rms} = \sqrt{\frac{1}{N}\sum_{n=1}^{N}\left(\operatorname{atan}\left(\frac{I_{meas}(n)}{Q_{meas}(n)}\right) - \operatorname{atan}\left(\frac{I_{ref}^{r(n)}}{Q_{ref}^{r(n)}}\right)\right)^2}\,[\mathrm{deg}]$$

IQ Gain Imbalance

The gain imbalance describes the ratio between the I and Q part of the signal and is computed according to:

$$GI = 20\log\sqrt{\frac{1}{N}\sum_{n=1}^{N}\left(\frac{I_{meas}(n)/I_{ref}^{r(n)}}{Q_{meas}(n)/Q_{ref}^{r(n)}}\right)^2}\,[\mathrm{dB}]$$

The diagram below illustrates a signal with IQ gain imbalance and the corresponding ideal reference vectors.



In-Phase Error

The in-phase error (EI) is the rms deviation of the I component of the error vectors, denoted ΔI in the graph. It is calculated according to:

$$EI_{rms} = \sqrt{\frac{1}{N}\sum_{n=1}^{N}(I_{meas}(n) - I_{ref}^{r(n)})^2} \times 100[\%\mathrm{rms}]$$

given in percent to the magnitude of the longest reference vector.

Quadrature-Phase Error

The quadrature-phase error (EQ) is the rms deviation of the Q component of the error vector, denoted ΔQ in the graph. It is calculated according to:

$$EQ_{rms} = \sqrt{\frac{1}{N}\sum_{n=1}^{N}(Q_{meas}(n) - Q_{ref}^{r(n)})^2} \times 100[\%rms]$$

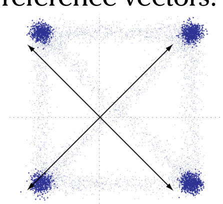
given in percent to the magnitude of the longest reference vector.

IQ Offset

The IQ offset measures the signal constellation DC offset from origin of the constellation chart. Its value is given in dB units according to:

$$IQ_{offset} = 20\log\sqrt{\frac{1}{N}\sum_{n=1}^{N} I_{meas}(n)^2 + \frac{1}{N}\sum_{n=1}^{N} Q_{meas}(n)^2}[dB]$$

The following diagram illustrates a signal with IQ offset and the corresponding ideal reference vectors.



Quadrature Error

Quadrature error appears when the I and Q channels are not operating precisely at 90 degrees relative to each other. The quadrature error is referenced to the average vector of the demodulated symbols:

$$\mathbf{S}^{\mathrm{r}}_{\mathrm{avg}} = \begin{pmatrix} I^{r}_{\mathrm{avg}} \\ Q^{r}_{\mathrm{avg}} \end{pmatrix} = \begin{pmatrix} \frac{1}{N}\sum_{n=1}^{N} I_{\mathrm{meas}}(n) \\ \frac{1}{N}\sum_{n=1}^{N} Q_{\mathrm{meas}}(n) \end{pmatrix}$$

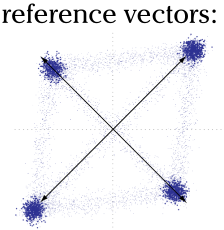
where $r = 1..M$ (for M level signals) refers to the related symbol of the normalized measured I and Q component. The quadrature error is computed as the rms for all constellation symbols and expressed as the angular deviation from the ideal 90 degrees, according to:

$$QE^{r} = 90 - \operatorname{acos}\left(\frac{1}{2} \cdot \frac{([I^{r}_{avg}]^{2} - I^{2}_{\mathrm{ref}}) + ([Q^{r}_{avg}]^{2} - Q^{2}_{\mathrm{ref}})}{I_{\mathrm{ref}} \cdot Q_{\mathrm{ref}}}\right)$$

$$\mathrm{QE}_{\mathrm{rms}} = \sqrt{\frac{1}{M}\sum_{r=1}^{M} (QE^{r})^{2}}\,[\mathrm{deg}]$$

Quadrature error is not computed for binary modulation formats.

The following diagram illustrates a signal with quadrature error and the corresponding ideal reference vectors:



Signal-To-Noise Ratio

The signal-to-noise ratio (SNR) computed in the constellation is the ratio of the symbol amplitudes over the two-dimensional noise distribution. The presented value is the average SNR of all symbols, $r = 1..M$, according to

$$\mathrm{SNR} = 10\log\left[\frac{1}{M}\sum_{r=1}^{M}\left(\frac{\left|I_{avg}^{r}\right|^{2}+\left|Q_{avg}^{r}\right|^{2}}{\sigma_{I}^{2}+\sigma_{Q}^{2}}\right)\right][\mathrm{dB}]$$

where $\sigma_{I,Q}$ is the standard deviation of the I_{meas} and Q_{meas}, respectively.

XY Imbalance

The XY imbalance measurement is the ratio of the amplitudes of the X and Y polarization tributaries of the signal:

$$\mathrm{XYimbal} = \frac{\left|S_{avg,X}\right|}{\left|S_{avg,Y}\right|}$$

Power Level

The power level is an approximation of the power level on polarization X, Y and global.

$$\mathrm{Power}_{\mathrm{TOT}} = \mathrm{Power}_{\mathrm{X}} + \mathrm{Power}_{\mathrm{Y}}$$

$$\mathrm{Power}_{\mathrm{X}} = \frac{1}{K}\sum_{k=1}^{K}\left|S_{X}(k)\right|^{2} \qquad \mathrm{Power}_{\mathrm{Y}} = \frac{1}{K}\sum_{k=1}^{K}\left|S_{\mathrm{Y}}(k)\right|^{2}$$

where K is the total number of acquired samples of the waveform (transitions and center points).

Measurements for Eye Diagrams

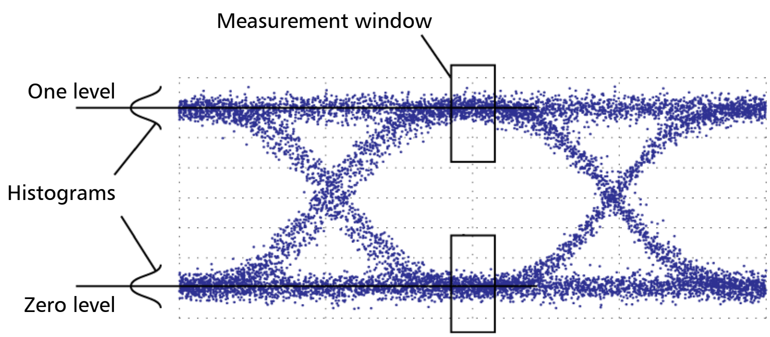
Eye diagram measurements refer to measurements conducted in time-domain graphs primarily on I, Q tributaries (when measurements are conducted on the magnitude or intensity of the signal, this is specified in the definitions).

Some measurement parameters are only defined for specific modulation formats and signals utilizing pulse carving, hence the composition of measurements depends on the user input signal parameters (Modulation and Bit Format, see *Configuring the Input Signal* on page 13).

Since the PSO-200 is a coherent optical modulation analyzer, it measures the field of the signal, so all eye diagram measurements are computed on field (for example, I, Q, and Magnitude graphs).

One and Zero Levels

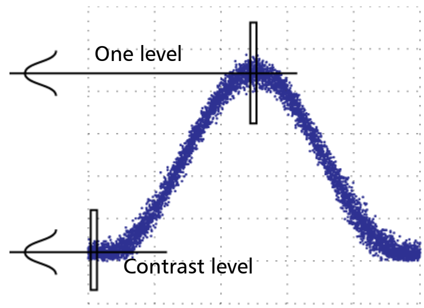
The eye-mode measurements start out by measuring the one and zero levels, since many other measurements depend on these values.



- The one level, E_{one}, represents the logic one level in the eye diagram, determined by the mean level within the data measurement window.
- The zero level, P_{zero}, represents the logic zero level in the eye diagram, determined by the mean level within the data measurement window.

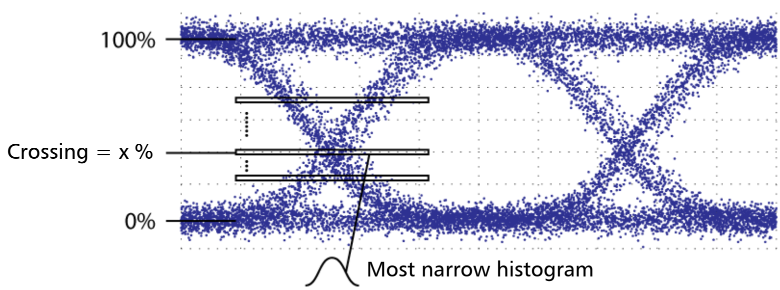
Contrast Ratio

The contrast ratio (CR) is only defined for RZ formats as the ratio between the one level and the level between the pulses in the magnitude graph, that is $CR = E_{one}/E_{contrast}$.



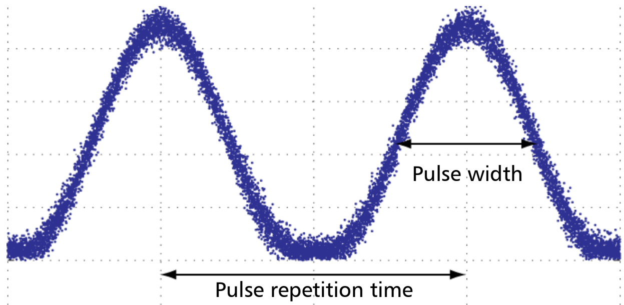
Crossing

The crossing percentage (NRZ formats only) is a measure of the location of the eye crossing points relative to the separation between the one and zero levels. Horizontal time histograms are constructed, and the histogram having the smallest variance determines the crossing point.



Duty Cycle

The duty cycle is defined only for RZ formats as the ratio between the pulse width (read at 50 % of the one level) and the pulse repetition time.

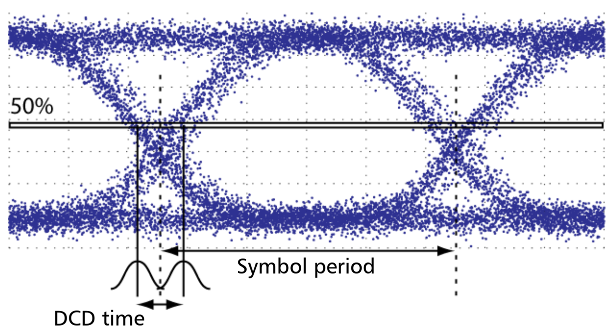


Duty Cycle Distortion

The duty cycle distortion (DCD) is a measurement of the time separation of the rising and falling edge of the eye at the center (50 %) level. It is defined in percentage of the symbol period as:

$$DCD = 100\% \frac{|T_{rise,center} - T_{fall,center}|}{symbol\ period}$$

In a “perfect” eye with no timing and amplitude jitter, and a 50 % crossing, the DCD is zero.



Extinction Ratio

The extinction ratio (ER) of an eye diagram is only defined for NRZ (OOK) signals and is the ratio between the one level and the zero level in magnitude. It is defined as:

$$ER = \left(\frac{E_{one} - E_{dark}}{E_{zero} - E_{dark}}\right)$$

Eye Amplitude

The eye amplitude (EA) is defined as the difference between the one and zero levels according to:

$$EA = E_{one} - E_{zero}$$

given in percent to the highest level in the eye diagram.

Eye Height

The eye height (EH) measures the vertical opening of an eye diagram and is defined as:

$$EH = (E_{one} - 3\sigma_{one}) - (E_{zero} + 3\sigma_{zero})$$

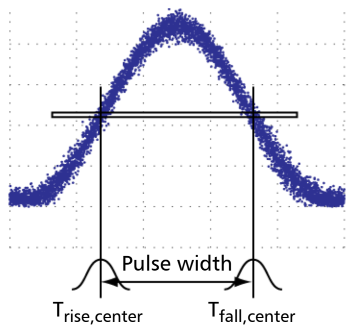
Eye-Opening Factor

The eye-opening factor is a measurement of the vertical eye opening according to:

$$EOF = \frac{(E_{one} - \sigma_{one}) - (E_{zero} + \sigma_{zero})}{E_{one} - E_{zero}}$$

Pulse Width

The pulse width measurement only applies to RZ formats. From a thin horizontal histogram at the 50 % threshold between the one and zero levels the mean crossing points determine the pulse width. It is measured in the magnitude graph of the signal.

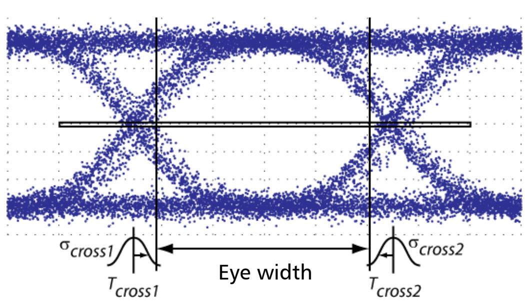


Eye Width

The eye width is a measurement of the horizontal opening of the eye. It is defined as:

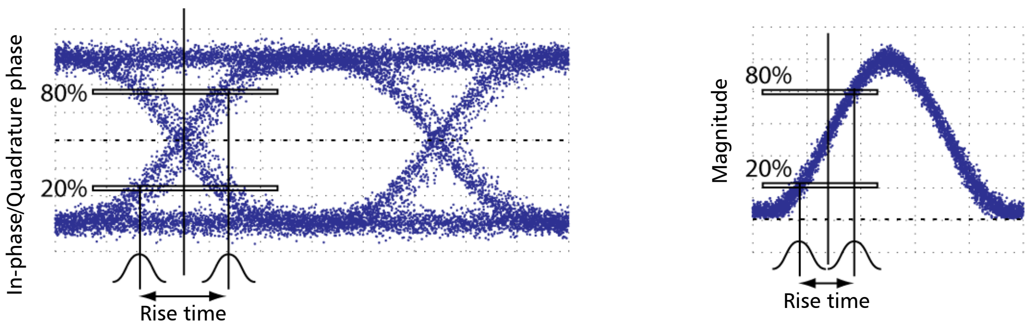
$$EW = (T_{cross2} - 3\sigma_{cross2}) - (T_{cross1} + 3\sigma_{cross1})$$

where the mean crossing points, T_{cross}, and horizontal standard deviations σ_{cross} are measured from the histograms in the eye diagram.



Rise Time and Fall Time

- Rise time: delay between the times where the slope transits through the 20 % and up to the 80 % thresholds.
- Fall time: delay between the transit times through the 80 % level down to the 20 % level.

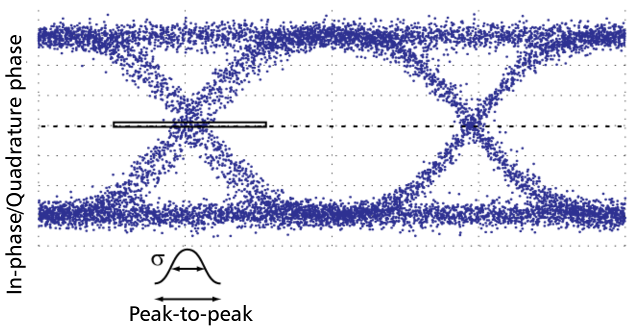


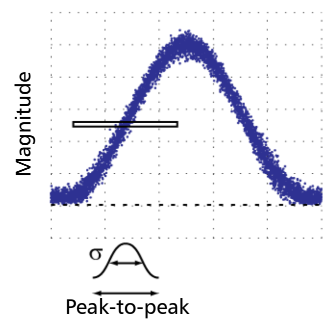
Note: *The 20-80 % thresholds can be changed in the Optical Modulation Analyzer application (see* Setting Analysis Parameters *on page 22).*

Rise and fall time are applied to the magnitude of the signal for RZ formats.

Timing Jitter

The timing jitter of an eye diagram is a measurement of the variance in time locations of the crossing point. Horizontal time histograms are constructed, and the histogram having the smallest variance determines the crossing point. The standard deviation of this histogram determines the RMS timing jitter and the extreme points (largest and smallest time values) in the histogram determine the peak-to-peak timing jitter.



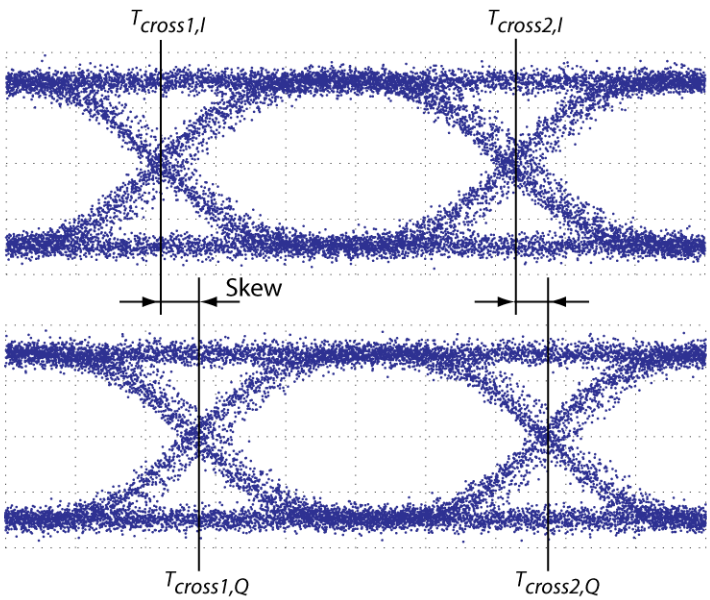


Timing jitter is applied to the magnitude of the signal.

IQ Skew

The IQ skew is the time difference between I and Q tributaries of the signal for each polarization. It is defined from the mean crossing points T_{cross} of I and Q, respectively, according to

$$\text{IQSkew} = \frac{|T_{cross1,\,Q} - T_{cross1,\,I}| + |T_{cross2,\,Q} - T_{cross2,\,I}|}{2}$$



The global skew takes both polarizations into account, according to

$$\text{GlobalSkew} = \frac{\text{Max}(T_{cross1}) - \text{Min}(T_{cross1}) + \text{Max}(T_{cross2}) - \text{Min}(T_{cross2})}{2}$$

$$T_{cross1} = T_{cross1,\,I,\,X}, T_{cross1,\,Q,\,X}, T_{cross1,\,I,\,Y}, T_{cross1,\,Q,\,Y}$$
$$T_{cross2} = T_{cross2,\,I,\,X}, T_{cross2,\,Q,\,X}, T_{cross2,\,I,\,Y}, T_{cross2,\,Q,\,Y}$$

where X and Y indexes refer to X and Y polarization states.

IQ skew is not applicable to binary modulation formats (BPSK, OOK).

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NOTICE
通告

CHINESE REGULATION ON RESTRICTION OF HAZARDOUS SUBSTANCES
中国关于危害物质限制的规定

NAMES AND CONTENTS OF THE TOXIC OR HAZARDOUS SUBSTANCES OR ELEMENTS CONTAINED IN THIS EXFO PRODUCT
包含在本 EXFO 产品中的有毒有害物质或元素的名称和含量

O	Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in SJ/T11363-2006 表示该有毒有害物质在该部件所有均质材料中的含量均在 SJ/T11363-2006 标准规定的限量要求以下。
X	Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in SJ/T11363-2006 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出 SJ/T11363-2006 标准规定的限量要求。

Part Name 部件名称	Toxic or hazardous Substances and Elements 有毒有害物质和元素					
	Lead 铅 (Pb)	Mercury 汞 (Hg)	Cadmium 隔 (Cd)	Hexavalent Chromium 六价铬 (Cr VI)	Polybrominated biphenyls 多溴联苯 (PBB)	Polybrominated diphenyl ethers 多溴二苯醚 (PBDE)
Enclosure 外壳	O	O	O	O	O	O
Electronic and electrical sub-assembly 电子和电子组件	X	O	X	O	X	X
Optical sub-assembly[a] 光学组件 [a]	X	O	O	O	O	O
Mechanical sub-assembly[a] 机械组件 [a]	O	O	O	O	O	O

a. If applicable.
如果适用。

MARKING REQUIREMENTS
标注要求

Product 产品	Environmental protection use period (years) 环境保护使用期限 (年)	Logo 标志
This Exfo product 本 EXFO 产品	10	
Battery[a] 电池 [a]	5	

a. If applicable.
如果适用。

P/N: 1064467

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