User Guide

PSO-100

Optical Sampling Oscilloscope Series

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Telecom Test and Measurement

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Units of Measurement

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

Version number: 1.0.0

Contents

Certification Information

FCC Information

Electronic test equipment is exempt from Part 15 compliance (FCC) in the United States. However, compliance verification tests are systematically performed on most EXFO equipment.

CE Information

Electronic test equipment is subject to the EMC Directive in the European Union. The EN61326 standard prescribes both emission and immunity requirements for laboratory, measurement, and control equipment.
This unit has undergone extensive testing according to the European Union Directive and Standards.

DECLARATION OF CONFORMITY

Application of Council Directives:	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
Equipment Type/Environment:	Electrical Equipment for Measurement / Control and Laboratory
Trade Name/Model No.:	Optical Sampling Oscilloscopes / PSO-100 Series

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 Directives and Standards.

Manufacturer

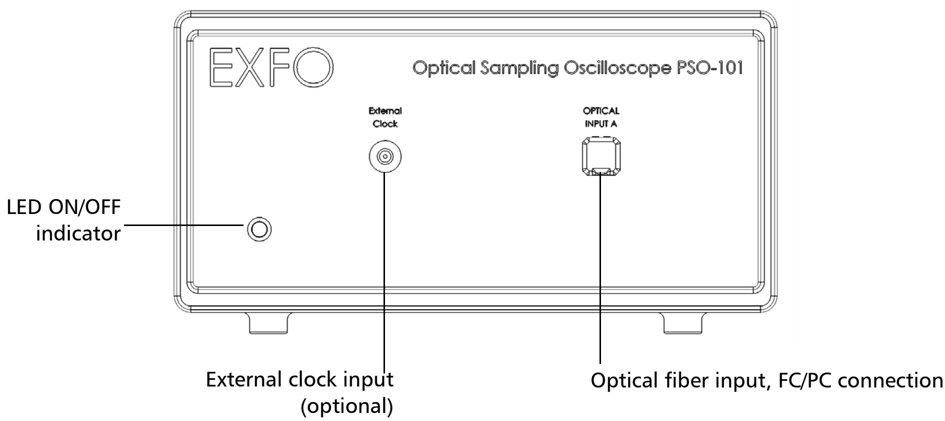
Signature: [signature]

Full Name: Stephen Bull, E. Eng
Position: Vice-President Research and Development
Address: 400 Godin Avenue, Quebec (Quebec), Canada, G1M 2K2
Date: August 11, 2010

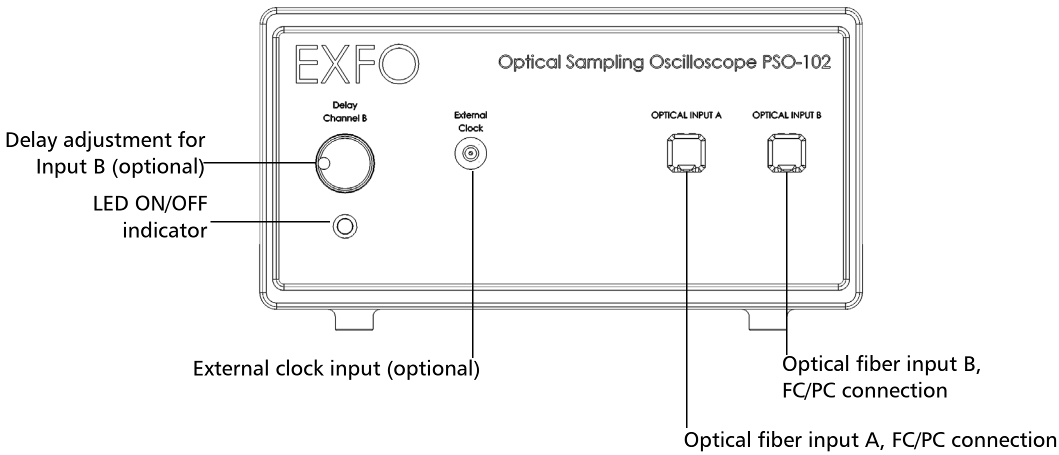
1 Introducing the PSO-100 Optical Sampling Oscilloscope Series

Based on a unique optical sampling approach, the PSO-100 Optical Sampling Oscilloscope Series eliminates almost all the limitations typically found in electrical sampling oscilloscopes. This is done when narrow sampling pulses open a sampling gate that generates a time-stretched version of the measured signal. The optical samples are then converted to electrical signals, which can be easily detected by low-speed electronics and digitally processed.

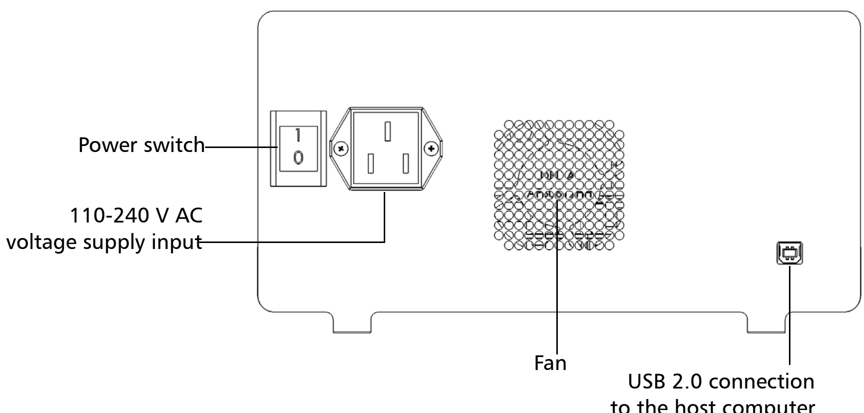
The figures below show the front and rear panels for both models.



Front View (PSO-101)



Front View (PSO-102)



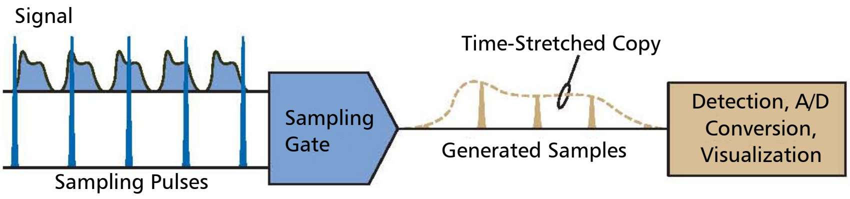
Rear View

IMPORTANT

All instruction or information in this user documentation pertain to both models, unless specified otherwise. The image you see on-screen may be slightly different depending on which model you are using.

PSO-100 Optical Sampling Oscilloscope Series Basic Theory

The theory behind the Optical Sampling Oscilloscope is that the input optical signal is repeatedly sampled in an all-optical gate with high resolution.



The optical samples are detected and then A/D converted and buffered in a data acquisition board. The data is transferred via USB 2.0 to a host computer, where it is processed. An internal software synchronization algorithm calculates the frequency offset between the signal and the sampling frequency. As a result, you can view synchronized eye diagrams, patterns, or pulses without the need for external triggering.

Typical Applications

The Optical Sampling Oscilloscope displays eye-diagrams, patterns, or pulses with very high temporal resolution. It is therefore a useful tool for studying and characterizing very high bit-rate systems or very fast events like short pulses, where the bandwidth of ordinary electrical sampling oscilloscopes is not sufficient.

The instrument can measure a number of amplitude modulation formats, such as:

- non-return-to-zero (NRZ)
- different kinds of return-to-zero (RZ) formats (for example chirped RZ (CRZ) and carrier suppressed RZ (CSRZ))
- other formats, such as duo-binary transmission (DBT).

Since only the amplitude of the signal is measured, the system cannot directly measure the optical phase. By placing a delay interferometer before the scope, you can also handle phase modulated formats like differential phase shift keying (DPSK).

A number of measurement tools are included in the software for characterizing eye-diagrams and waveforms, such as:

- ultra-low timing jitter
- rise and fall times
- extinction ratio (ER)
- and signal-to-noise ratio (SNR), etc.

Functions for waveform averaging, histograms and color grade, are also included.

If the optional external clock input is installed, the internal software synchronization can be performed on the clock signal instead and thereby relaxes the requirements on the signal quality. The external clock is useful in a number of measurement situations where the internal synchronization may fail, such as:

- very noisy or distorted signals
- unconventional modulation formats
- low duty cycle RZ pulses
- sub-optimally multiplexed signals.

If the gated clock mode is installed, the PSO-100 can be used for measuring gated data that come in bursts (for example, circulating loop experiments and optical packet switching).

Conventions

Before using the product described in this manual, 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

CAUTION

Do not open the unit. It contains fragile fiber-optic components, which can be damaged if the unit is opened. There is also a risk for exposure of laser light if the unit is opened. EXFO shall not be liable for any damages resulting from opening the unit.

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

Use of controls, adjustments and procedures for operation and maintenance other than those specified herein may result in hazardous radiation exposure or impair the protection provided by this unit.

Your instrument is a Class 1 laser product in compliance with standards IEC 60825-1 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: *If you need 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.**

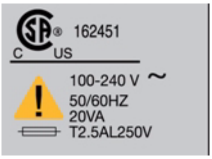
➤ **Only authorized personnel should carry out adjustments, maintenance or repair of opened units under voltage. A person qualified in first aid must also be present. Do not replace any components while power cable is connected.**

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

Equipment Ratings	
Temperature ➤ Operation ➤ Storage	 18 °C to 30 °C (64 °F to 86 °F) 0 °C to 50 °C (32 °F to 122 °F)
Relative humidity[a]	80 % non-condensing
Maximum operation altitude	3000 m (9843 ft)
Pollution degree	2
Installation category	II
Power supply rating[b]	100 V to 240 V (50 Hz/60 Hz) maximum input power 20 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 Sampling Oscilloscope

Host Computer Minimum Requirements

Your host computer must meet the minimum requirements below to display the values properly:

- Microsoft Windows XP, Vista (32 bits), or Windows 7 (32 bits)
- USB 2.0 connection
- CPU: 2 GHz or faster recommended
- 2 Gb of RAM
- 600 Mb of disk space on the host computer

You can use either a desktop or a laptop computer, as long as it meets the requirements.

Note: *The faster the computer, the higher the refresh rate will be on-screen.*

Installing the Matlab Runtime, USB Drivers and Optical Sampling Oscilloscope Software

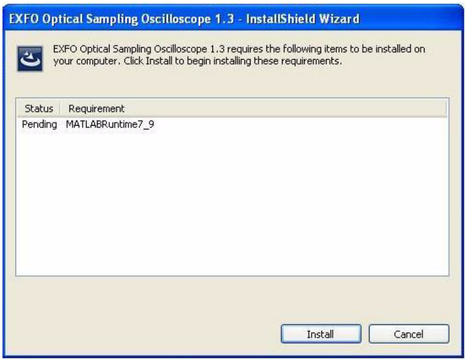
Before using your application, you must install the corresponding Matlab Runtime and USB drivers.

The user software is created in Matlab code, which has been compiled into an executable file. To be able to run this software on your computer, you must install the Matlab Component Runtime software. Afterwards, the installation for the Optical Sampling Oscilloscope application will start by itself.

To install Matlab Runtime and Optical Sampling Oscilloscope software:

1. Make sure that you have Administrator privileges on your computer.
2. Put your CD in the CD ROM drive. If the installation does not start automatically, locate Setup.exe, and double-click it.

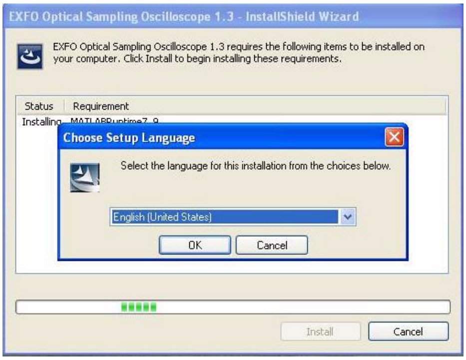
   A list of the components to install appears.

3. Click **Install** to start the process.

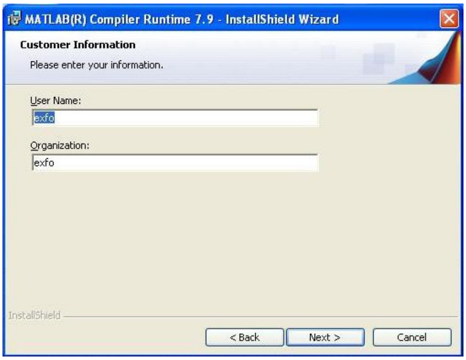
4. Select the language to use for the installation, then click **OK**.

Note: *This setting is for the installation only. The applications themselves are in English only.*



5. When the list of Matlab components appears, click **Install** again, then **Next** to start the installation.

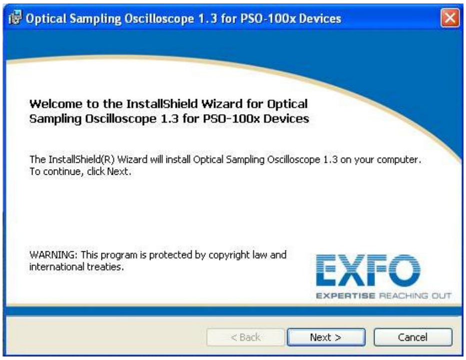
6. Enter your user name and organization information, then click **Next**.



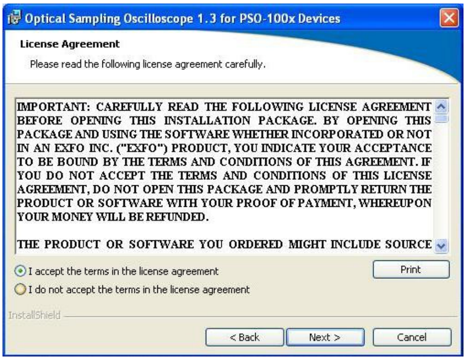
7. Select a destination folder, then click **Next**.

8. You are now ready to install the program. Click **Install**.
9. The installation of the Matlab Compiler Runtime is now complete, click **Finish**.

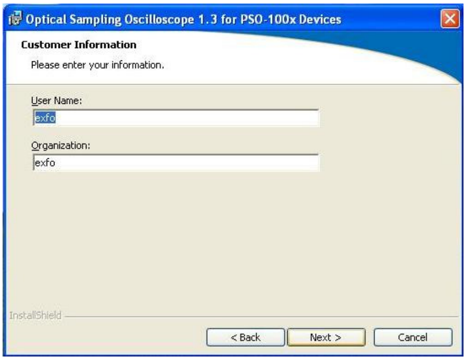
10. When the Optical Sampling Oscilloscope wizard appears, click **Next** to start the installation.



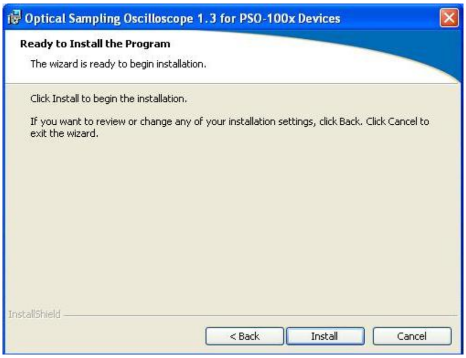
11. Read and accept the licence agreement, then click **Next**.



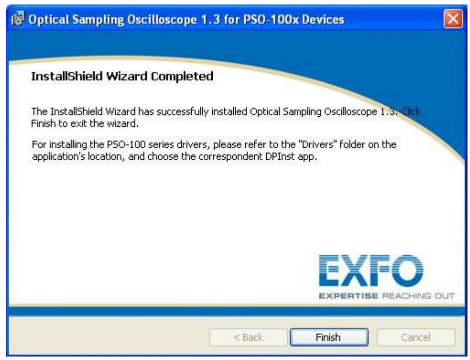
12. Enter your user name and organization information, then click **Next**.



13. You are now ready to install the program. Click **Install**.



14. The installation of the Optical Sampling Oscilloscope is now complete, click **Finish**.



If any version of Matlab is installed on your computer, the system path must be adjusted to prioritize the Runtime over the Matlab software.

Note: *If you have an old version of the* Optical Sampling Oscilloscope *application that was compiled with an old version of Matlab, and you want to update to the* EXFO *application, you need to uninstall the older versions first, then install a new version of MCR (follow the procedure above).*

IMPORTANT

You must remove the HKEY_LOCAL_MACHINE\SOFTWARE\MATLAB registry key after uninstalling the older versions to make sure that the new version is installed correctly.

To install the USB driver on your computer:

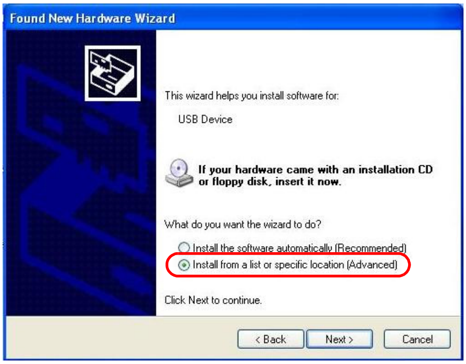
1. Connect the unit using a USB connection. When the instrument is connected to a USB port of the computer for the first time, Windows will find the new hardware and ask you to install the USB driver.

IMPORTANT

Make sure that you use a USB 2.0 port and not a USB 1.1, since this will affect the refresh rate.

2. Windows Update should not search for updates. Select **No, not this time**, and then click **Next** (Windows XP installation only).

3. Select **Install from a specific location**, and then click **Next**.



The USB driver is found in your folder under "…\drivers"; indicate it in the corresponding box. The installation will not pass Windows Logo testing to verify compatibility with Windows XP.

4. Click **Continue anyway** to install the driver and complete the process.

5. Click **Finish**. Windows indicates that it has found new hardware but recognizes the USB device. A loader was installed at step 2. In a second step, the real driver is installed by following step 2 and on once more.

Note: *The exact appearance of the windows differ slightly depending on which version of Windows you are using.*

Installing and Starting the Optical Sampling Oscilloscope

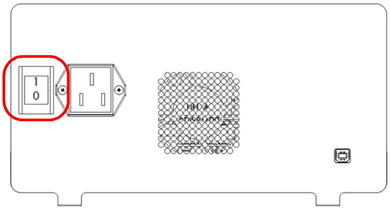
Before you turn on the instrument, follow the procedure below.

To install and start the instrument:

1. Connect the included AC adapter to the input on the rear panel and to the wall socket.
2. If you have not already done so, link the unit and the host computer together using a USB cable.

Note: *The first time you do this you are asked to install the USB driver on your computer. Follow the instructions in* Installing the Matlab Runtime, USB Drivers and Optical Sampling Oscilloscope Software *on page 12. If you are working in Windows XP, make sure that you use the same USB port every time afterwards. If not, you will have to install the USB driver again.*

3. Turn on the instrument using the control on the rear panel. The blue LED indicator on the front panel should be on. Wait 5 minutes and let the instrument warm up.



IMPORTANT

Do not turn off the instrument unnecessarily, for example if you change the host computer. If the instrument is turned off, it may need to cool down for five minutes before it can be started again.

4. Start the application on your computer by selectin the **start** menu, then **Programs > EXFO > Optical Sampling Oscilloscope**.

IMPORTANT

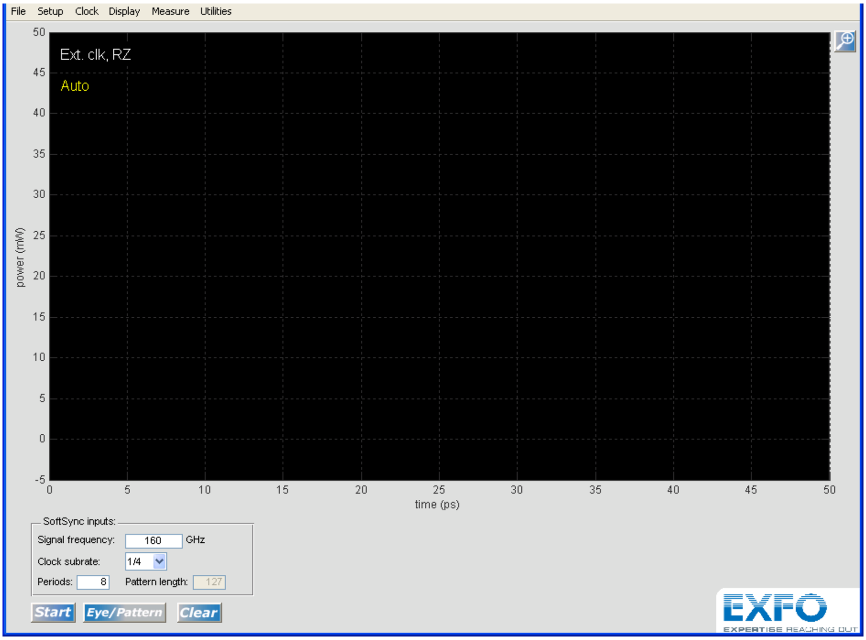
The Optical Sampling Oscilloscope must be turned on before starting the application.

IMPORTANT

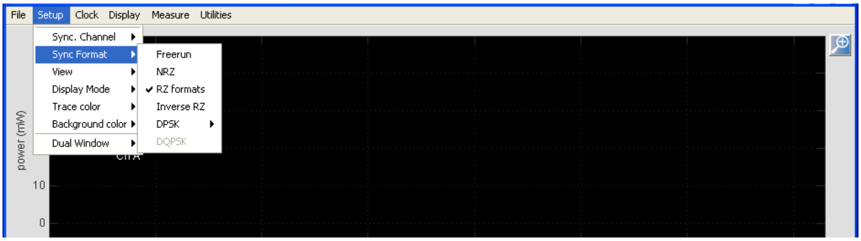
EXFO recommends that you put the synchronization type to Freerun before starting your tests. This ensures that you have an adequate signal with an appropriate amplitude.

First a DOS window opens where the version number is shown. Then the **USB connection OK** message should appear. If it does not, the USB communication with the instrument is not functioning properly. If the initial test is passed the application appears on-screen.

The first time you start the application, the screen will show the default setting. However, if you make changes to these settings while working, the unit will retain those changes and display them again the next time you start the application.



5. From the **Setup** menu, select **Sync Format**, then **Freerun**, and click the **Start** button at the left bottom corner to check for the signal quality.

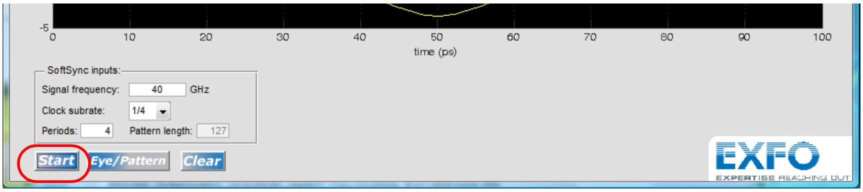


The instrument should now start to measure and samples should appear at the zero level. The instrument will need some time to warm up before the samples attain the correct DC level. The DC level is somewhat temperature dependent.

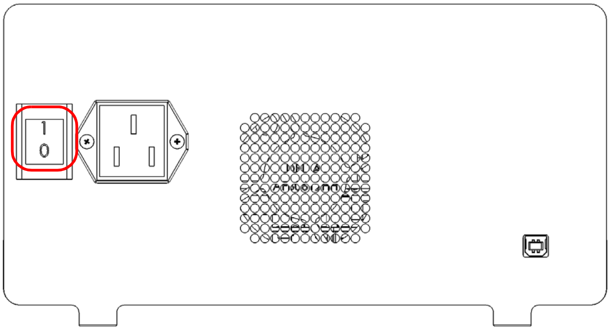
Turning off the Optical Sampling Oscilloscope

To turn off the instrument:

1. Stop the sampling with the **Stop** button in the application.



2. Turn off the instrument using the control on the rear panel.



Note: *If you do the opposite, the application may freeze.*

IMPORTANT

Do not turn off the instrument unnecessarily, for example if you change the host computer. If the instrument is turned off, it may need to cool down for five minutes before it can be started again.

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.

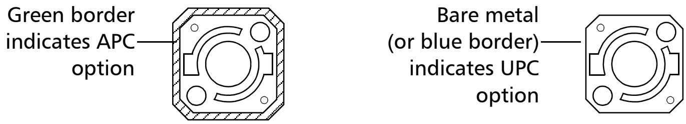
4. Push the connector in so that the fiber-optic cable is firmly in place, thus ensuring adequate contact.

   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.*

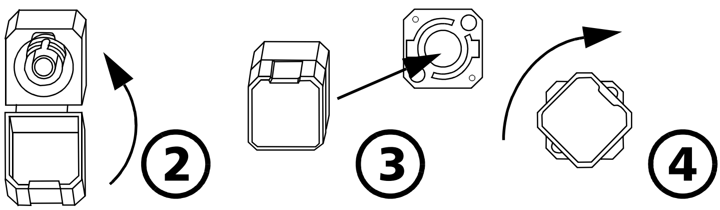
Installing the EXFO Universal Interface (EUI)

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:

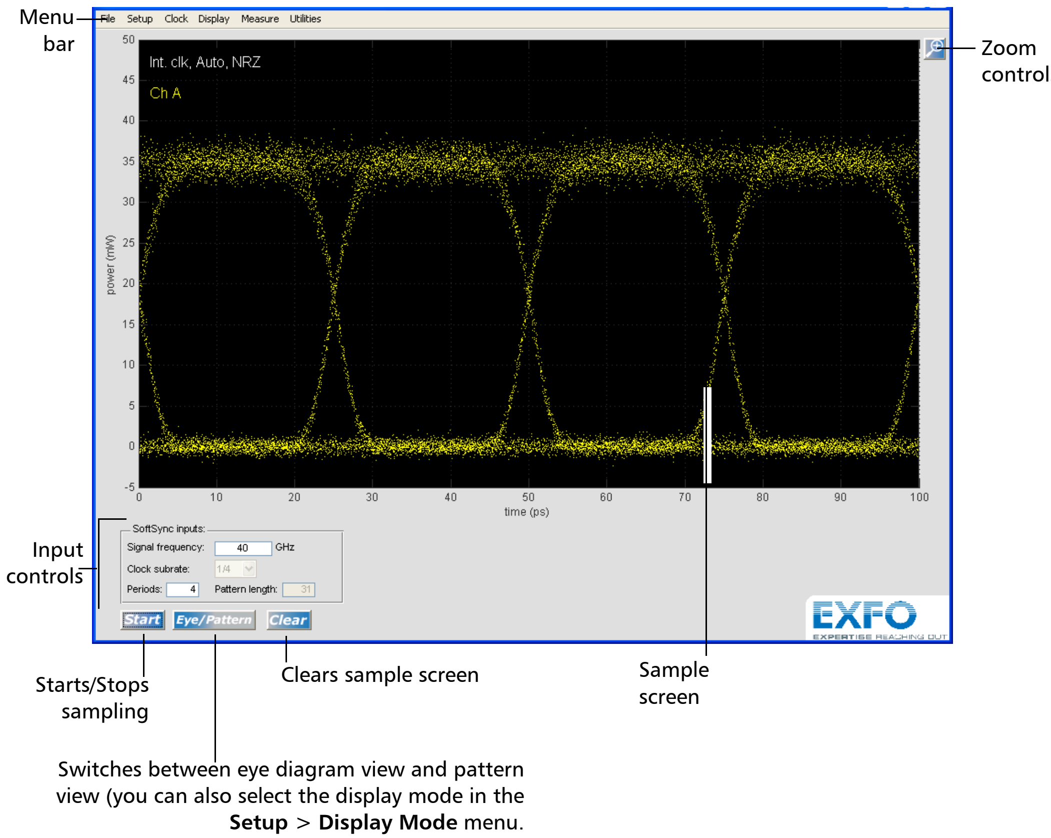
1. Hold the EUI connector adapter so the dust cap opens downwards.



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.

4 Setting up and Using the Optical Sampling Oscilloscope

Once the unit and application are started, you can begin using the Optical Sampling Oscilloscope.

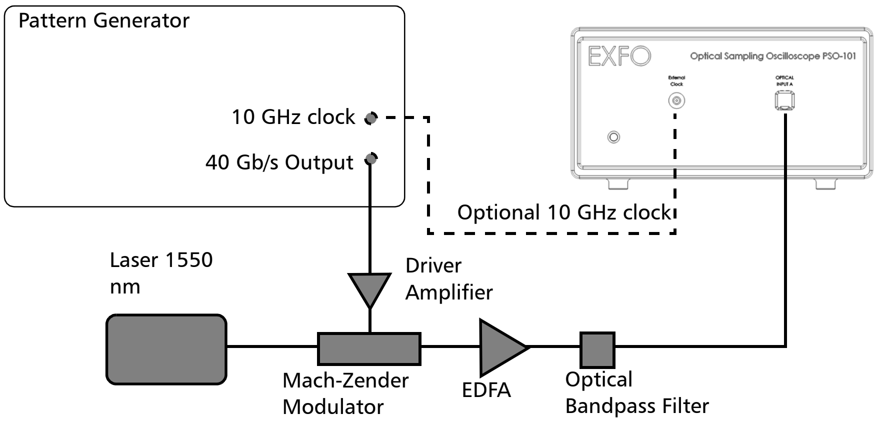


- From the menu bar you can select different functions, for example to save samples, to select the waveform format, and clock settings.
- From the **Setup** menu, you can select the method used to synchronize the channel(s), the synchronization format, as well as the color settings and the display modes. This is also where you will set the dual window settings.
- The **Clock** menu allows you to enable the optional external and gated clocks.
- From the **Display** menu you can select the number of samples, persistence layers, averaging, histograms, and color grade, etc.
- In the **Measure** menu, you can select a number of parameters to measure in eye diagrams or waveforms.
- In the **Utilities** menu, you can perform actions such as synchronizing the signals, adjusting the zero level (nulling the signal) or find a pattern for your sampling.
- Under **SoftSync inputs** you can insert the signal frequency, how many periods/eye-diagrams to visualize on the sample screen, pattern length, and clock sub rate if the external clock option is used.
- The zoom controls feature functions for zooming in x- or y directions. You can also use the pan function to view a particular part of the time or power scales.
- At the bottom there are three buttons: **Start**/**Stop**, a switch button between eye-diagram and pattern, and a **Clear** button for clearing measurements, histograms, averaging and color grades.

By clicking the right mouse button you can place markers and introduce a time delay between the data and the external clock.

Note: *The controls for the dual window display function exactly in the same way as their single-window counterparts. For details on the features you can use in the dual display, please see the corresponding section for single display.*

For the examples in this documentation, we have tested an optical 40 Gb/s NRZ transmitter, which consists of a laser source modulated by a pattern generator and a Mach-Zender modulator according to the figure below.



The average input power to the sampling oscilloscope was approximately 15 mW after amplification and filtering. Since the signal sensitivity that is the peak power required to get 20 dB SNR $(= 10\log_{10}(P^2/\sigma^2))$, is approximately 1 mW, you may need to amplify an NRZ signal to measure a clear eye diagram. Short RZ pulses on the other hand, for example from a ring laser with comparable average power, and hence high peak power, do not need amplification. An optical band-pass filter is recommended to filter out ASE noise from the EDFA. The input signal could, of course, be of various types of optical amplitude modulated signals at any bit rate from DC to 1.28 Tb/s or short pulses without data.

Adjusting the Zero Level (Nulling Offsets)

Temperature and humidity variations affect the performance of electronic circuits and optical detectors, which can offset measurement results. To compensate for this offset, the PSO-100 is equipped with an offset nulling function.

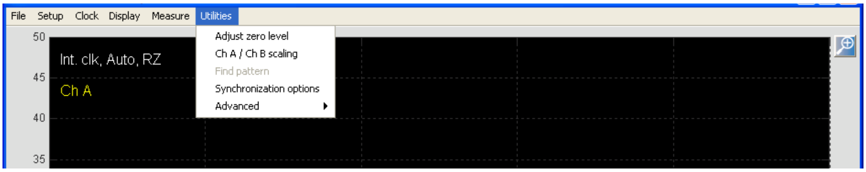
EXFO recommends performing a nulling of the electrical offsets whenever environmental conditions change.

IMPORTANT

Light must not reach the detector when nulling offsets.

To adjust the zero level:

1. From the main window, select the **Utilities** menu, then **Adjust Zero Level**.



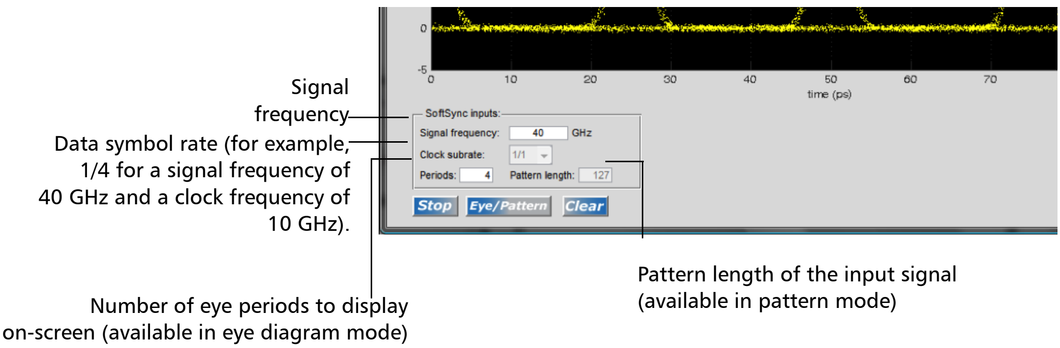
2. Remove the input signals from the unit, then click on the screen to start the process.

   The unit will set the average level to zero, then continue to measure.

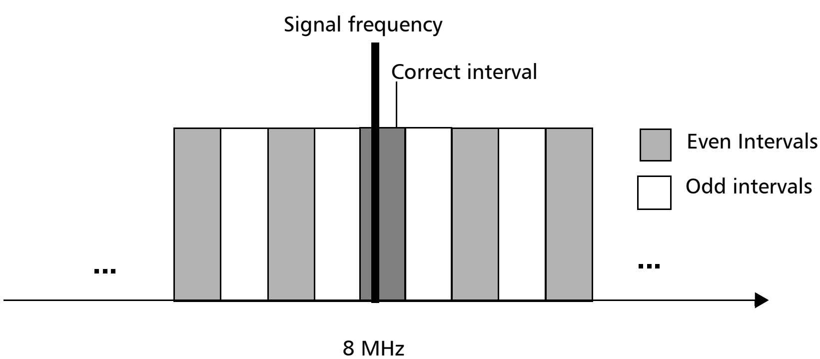
Once the process is complete, you can turn on the input signal again and continue the measurements.

Managing SoftSync Input

The **SoftSync inputs** section the bottom left is used for input of parameters important for the software synchronization algorithm to correctly synchronize the data.



In order to obtain the correct time scale, an estimate of the signal frequency should be inserted since there is no other way for the software to know the bit rate. The signal frequency should be accurate within the correct 8 MHz (sampling frequency divided by two) interval, according to the figure below.



Ensuring that the correct values are entered ensures appropriate measurements.

➤ If you select an incorrect interval, you will still see an eye-diagram, but with an incorrect time scale; it will actually show a reversed time scale for odd intervals.

➤ If you select an incorrect interval in pattern mode, you will notice that you see numerous eye diagrams instead of a pattern. Although this is not the expected result, this can be used to determine the correct interval or signal frequency by selecting a value untils you see a pattern.

IMPORTANT

Different signal generators may have different calibrations. The sampling frequency also drifts slightly with temperature. Therefore, a 40 GHz setting in SoftSync inputs is not guaranteed to fully match a signal generator set to 40.000 GHz. You may have to tune the signal frequency in SoftSync to find the correct interval.

You can also calibrate the sampling frequency in the Utilities menu,, using the Find pattern feature.

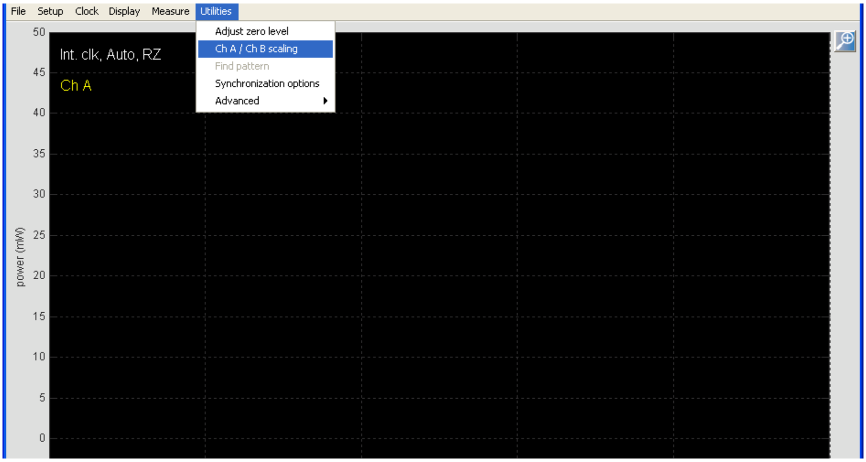
➤ When the external clock (option) is selected from the Clock menu, **Clock subrate** becomes active. You can then select the correct clock sub rate from the list. For example, if a 10 GHz clock and 40 Gb/s data is used, a ¼ sub rate clock should be used. If an incorrect value is chosen from the list, the time scale will be incorrect.

Scaling Channel 1 to Channel 2 (PSO-102 Models)

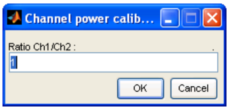
If, for some reason, the power calibration has shifted (the signal is not of the same value on both channels), you can re-calibrate this ratio. for the two channels.

To enter a ratio for channel 1 vs. channel 2:

1. From the main window, select the **Utilities** menu.
2. Select **Ch A / Ch B scaling**.



3. Enter the ratio you want to use for channel A compared to channel B.



4. Click **OK** to close the window.

Finding a Pattern in a Sampling

If for some reason the pattern does not show up in your measurement, but numerous eye diagrams instead, you can find the pattern using your unit.

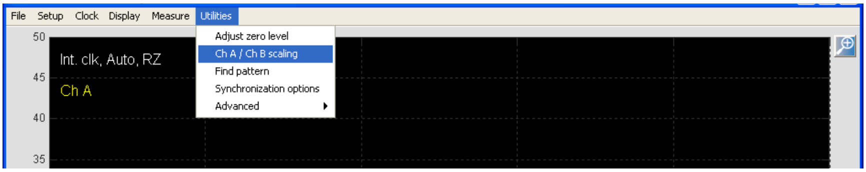
Note: *It will only work if you have a repetitive pattern, not random data or SONET/SDH framed data.*

Before you do this, make sure that you have inserted the correct pattern length. Also insert the approximate signal frequency (and clock subrate if using the external clock). For example you may not know the signal frequency exactly, which results in incorrect time scale. But if you still want to see the pattern use the find pattern function.

To find the pattern in your sampling:

1. Make sure that you are in pattern display mode, and that the sampling is running.
2. From the main window, select the **Utilities** menu, then **Find pattern**.

   The pattern is displayed automatically.

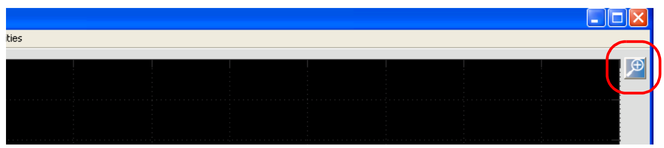


Using the Zoom Functions

The zoom functions are located on the right hand side of the window. You can decide to show or hide the zoom menu at any time.

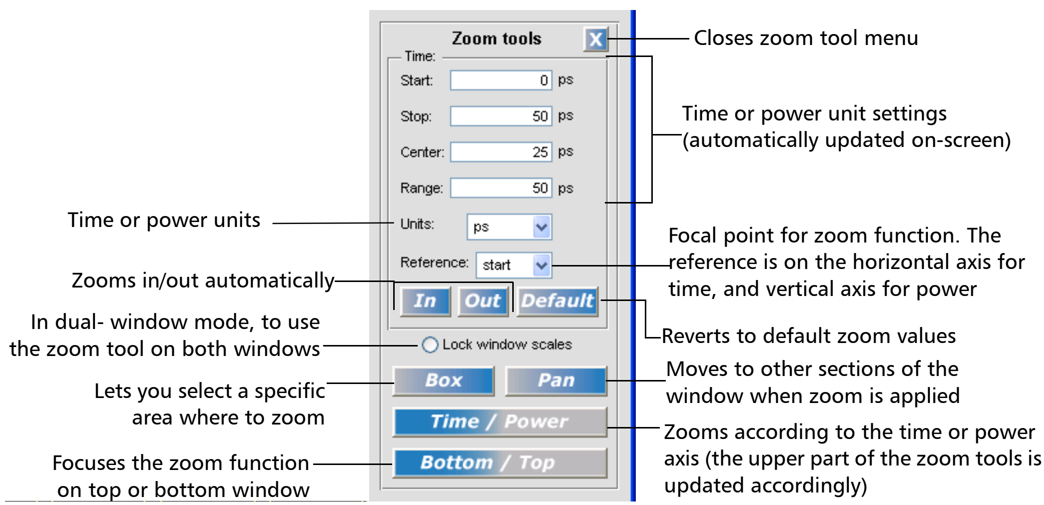
To display the zoom controls:

Click  at the top right hand corner of the window.



To use the zoom controls:

Once you have activated the zoom tools, use the feature that suits your situation best:



Note: *The blue portion of the button indicates which option is currently selected.*

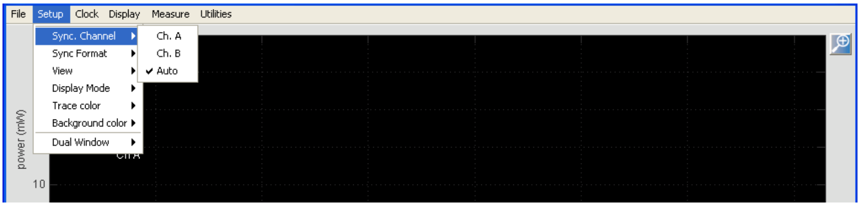
Note: *Each time that you change the view type for a window, the zoom factor reverts to the default value.*

Synchronizing the Input to a Specific Channel

You might want to synchronize your input signal with a specific channel (A or B), or let the Optical Sampling Oscilloscope pick the best signal automatically.

To select a channel for input synchronization:

1. From the main window, select the **Setup** menu, then **Sync. Channel**.



2. Select which channel you want to use, or select the automatic mode.

Your choice will be indicated on the top lefthand part of the screen.

Selecting Sync Format

The Optical Sampling Oscilloscope features several synchronization formats so that the software and data are correctly matched. If you use an unconventional data format, the existing format selections may fail to provide you with an accurate measurement. For testing unconventional data formats, EXFO recommends using the optional external clock.

- In Freerun mode, the raw data is shown without synchronization.
- The NRZ mode is optimized for NRZ, but can also be used, for example, in duo-binary transmission.
- The RZ mode is preferable for all RZ formats (for example RZ, chirped RZ (CRZ), carrier suppressed RZ (CSRZ), etc.). It also works for RZ pulses (no data). There is also a selection for inverse RZ data, which can be used for example in NRZ-DPSK or NRZ-DQPSK data, before demodulation..

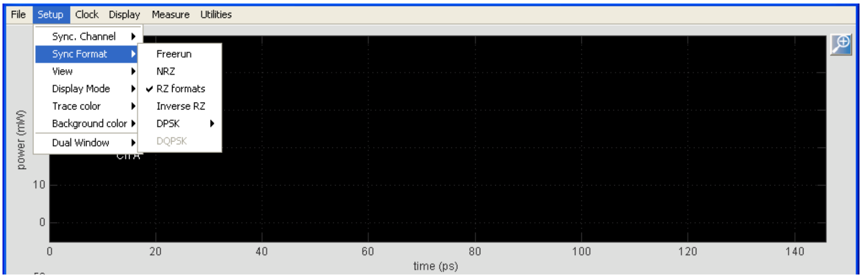
➤ The DPSK (differential phase-shift keying) formats selection (PSO-102 model only) allow you to measure either RZ-DPSK or NRZ-DPSK formats after a delay interferometer that is used to demodulate the phase encoded data.

You can also select the balanced detection type for the two outputs from the delay interferometer, with a manual delay on channel B to make sure that the sampling occurs simultaneously on both channels. This selection also applies to NRZ-DQPSK and RZ-DQPSK.

Note: *In the case of the PSO-101, it is of course possible to look at a single-ended detection of DPSK and DQPSK by measuring one output from the demodulator, and then use the NRZ format for NRZ-DPSK (and NRZ-DQPSK) and the RZ format for RZ-DPSK (and RZ-DQPSK).*

To select a data format:

1. From the main window, select the **Setup** menu, then **Sync Format**.
2. From the list, select the desired format.

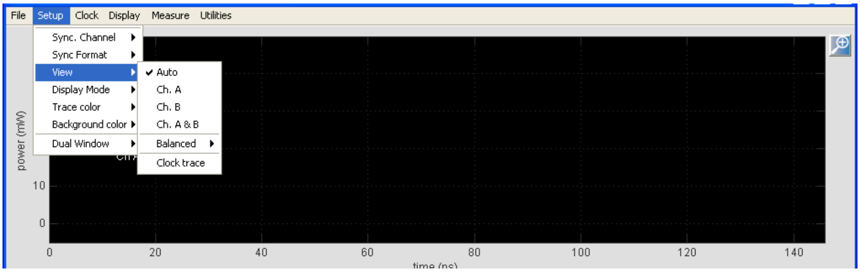


Selecting the Channels (PSO-102 Only)

You can view either channel A, B, or both in either the top or bottom window. You can also set your Optical Sampling Oscilloscope to automatically detect which channel is active and display it accordingly.

To select the channel to display:

1. From the main window, select the **Setup** menu, then **View**.



2. Select which channel configuration you want to view.

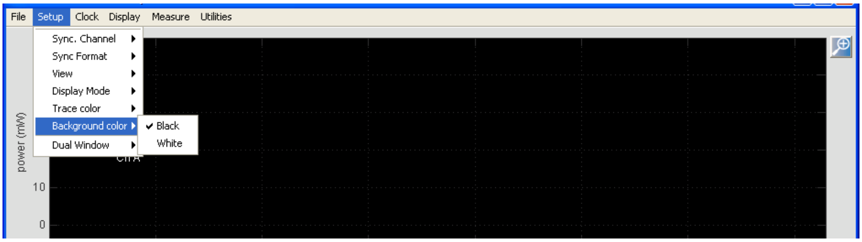
   You can also display a balanced signal, A-B or B-A. It is almost mandatory in DPSK and DQPSK receivers to perform balanced detection. Here we can do the balanced detection in software and visualize a balanced detected eye diagram with very high bandwidth.

Selecting Trace and Background Colors

Depending on your work environment, you may find that some display colors are better to view the samplings. You can change the background color, and the sampling trace color for each viewing window.

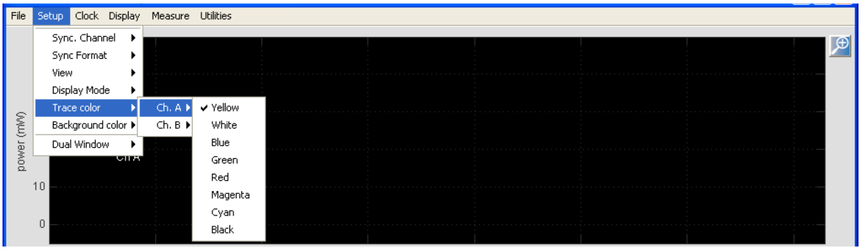
To change the background color:

From the **Setup** menu, select **Background Color**, then select either black or white.



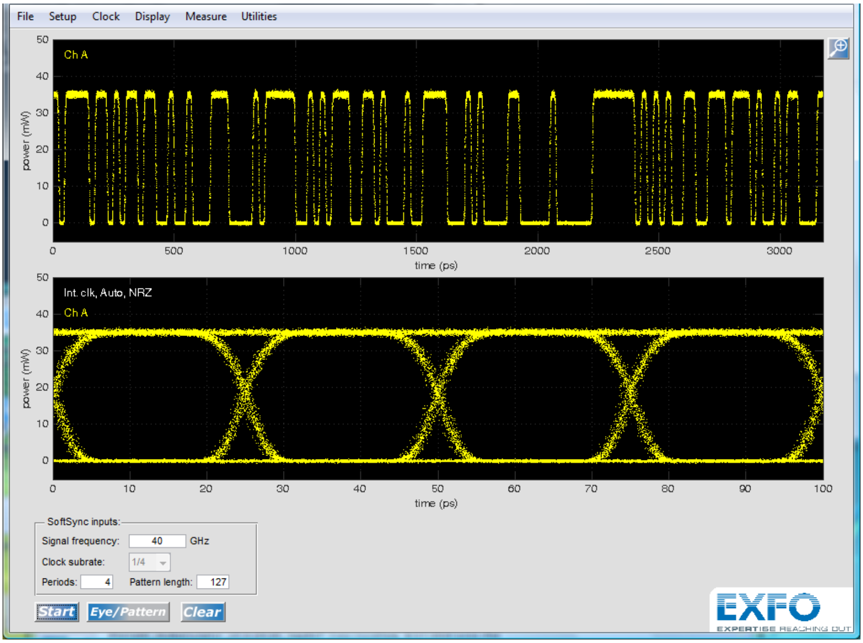
To select a trace color:

1. From the **Setup** menu, select **Trace Color**.
2. Select the channel for which you want to change the color, then select a color in the list.



Using the Dual Window View

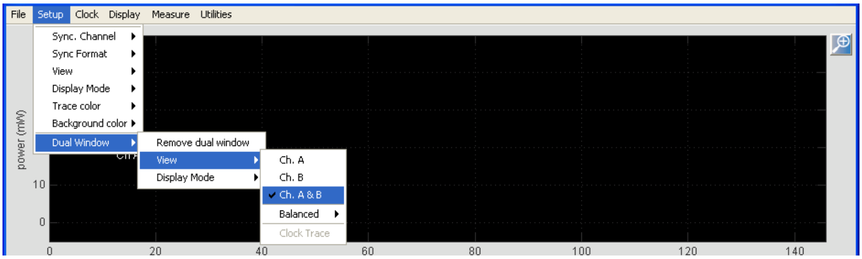
The dual window view allows you to open a second window to simultaneously visualize the eye, the pattern, or the Freerun trace.



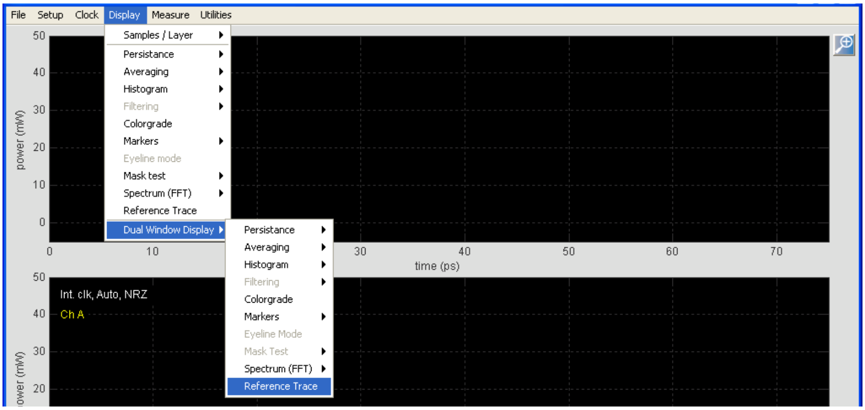
Note: *The controls for the dual window display function exactly in the same way as their single-window counterparts. For details on the features you can use in the dual display, please see the corresponding section for single display.*

To select the dual view and its options:

1. From the main window, select the **Setup** menu, then **Dual Window**.
2. Select the channel to display in the window under **View**, and the type of display (eye diagram or pattern) for it.



3. From the main window select the **Display** menu.
4. Select **Dual window**, then select which option you wish to view.



Using the Clock Input

In some situations, you cannot fully rely on the software synchronization of the input signal alone, for example when sampling very noisy or distorted signals, or when using unconventional data formats or setting up OTDM data. In such situations, the external clock option is very useful.

You can work using different types of clocks for your testing.

- Internal clock (default): the signal is software synchronized without an external clock.
- External clock (optional): the clock signal determines the time scale, which should be synchronous with the signal.

  The external clock is useful in a number of measurement situations where the internal synchronization may fail, for example with very noisy or distorted signals, unconventional modulation formats, and sub-optimally multiplexed signals. In the external clock selection you can select either an absolute or adaptive time scale, where the absolute time scale is the standard selection and the adaptive is recommended for an external clock with large timing jitter.
- Gated clock (optional): for burst measurements, for example in circulating loop- or packet- switching experiments, you can use the gated clock mode. A window then opens where you can customize parameters such as the burst period and duty cycle.

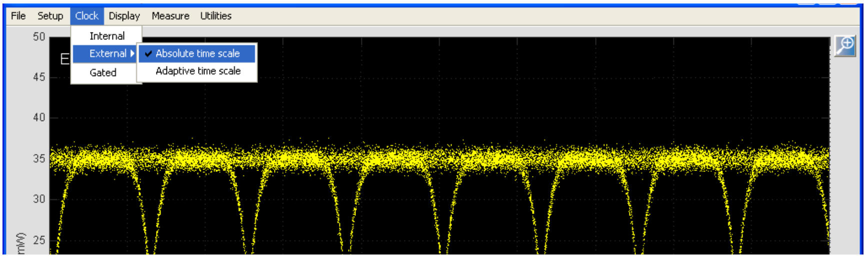
Note: *The external clock option must be installed for the gated clock to be available.*

To activate the internal clock:

1. From the main window, select the **Clock** menu.
2. Select **Internal**.

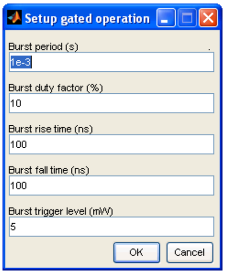
To activate the external clock:

1. From the main window, select the **Clock** menu.
2. Select **External**, then select either the absolute or adaptive time scale.



To activate the gated clock:

1. From the main window, select the **Clock** menu.
2. Select **Gated**.
3. Enter the settings for using the gated clock in the corresponding boxes.



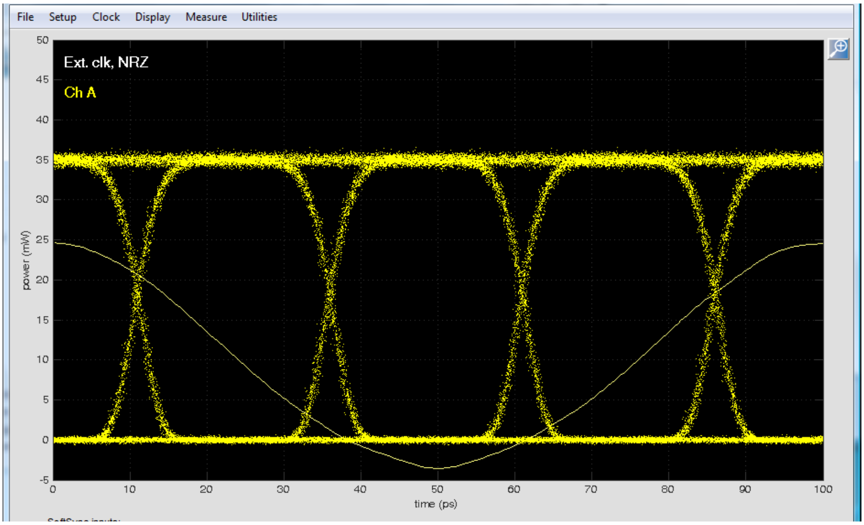
4. Click **OK** to confirm your choice and close the window.

To use the external clock input:

1. Connect an external electrical clock to the front panel.

The clock should have a peak-to-peak voltage between 0.8 and 2 volts for clock frequencies up to 12.5 GHz. It will work also for lower voltages, but with a slightly worse timing jitter. For clock frequencies up to 25 GHz, higher voltages are required, between 1.5 and 3 V.

2. Select **External** from the **Clock** menu (constant time scale is recommended for a high quality clock with low timing jitter). The figure below shows an example using a 10 GHz sub-rate clock and a 40 Gb/s NRZ data signal, that is a ¼ clock sub-rate.



The clock signal itself is shown above the data signal.

Note: *If the clock signal on the sample screen turns red, this indicates that the clock signal is too low, and should be increased; or it may happen in a measurement situation with frequency holes. It goes away after a while (read more about frequency holes in Frequency Holes* on page 120*).*

In this example, we have chosen to view two clock periods at 10 GHz, which makes eight eyes at 40 Gb/s. You can also view patterns in external clock mode, just switch to **Pattern**. Again, make sure that the pattern length, the signal frequency, and also the sub-rate clock are correct. By clicking the right button and select **Signal/clock delay,** you can introduce a delay between the data and the clock, which is useful for centering eye diagrams on the screen and perform measurements on a specific eye diagram, since all measurements are performed on the first eye diagram as shown in *Eye Mode Measurement Example* on page 73.

To display the clock trace on-screen:

1. From the main window, select the **Setup** menu, then **View.**
2. Select **Clock trace**.

To introduce a time delay between the data and the external clock:

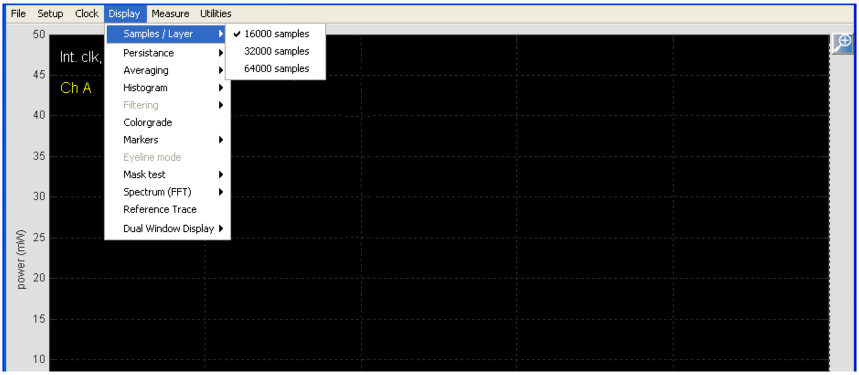
Right-click when in the main window, then select **Signal/Clock delay**.

Selecting the Number of Samples per Layer of Display

You can choose to have more or less samples per layer of display. More samples will make a more precise measurement, but it takes longer to achieve. The refresh rate will change depending on the number of samples selected.

To select the number of samples:

1. From the main window, select the **Display** menu, then **Samples / Layer**.
2. Select the number of samples to use.

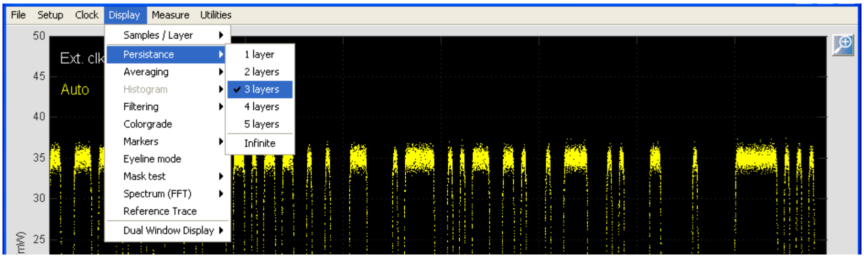


Changing the Persistence Time

In the **Display** menu you can change the persistence time by choosing a number of layers and the number of samples per layer. In this way you can determine the total number of samples on the screen. Since the persistence time depends on the speed of the host computer, this allows for a selection better adapted for each user.

To change the persistence time:

1. From the main window, select the **Display** menu.
2. Select **Persistence**, then select the number of layers to use.

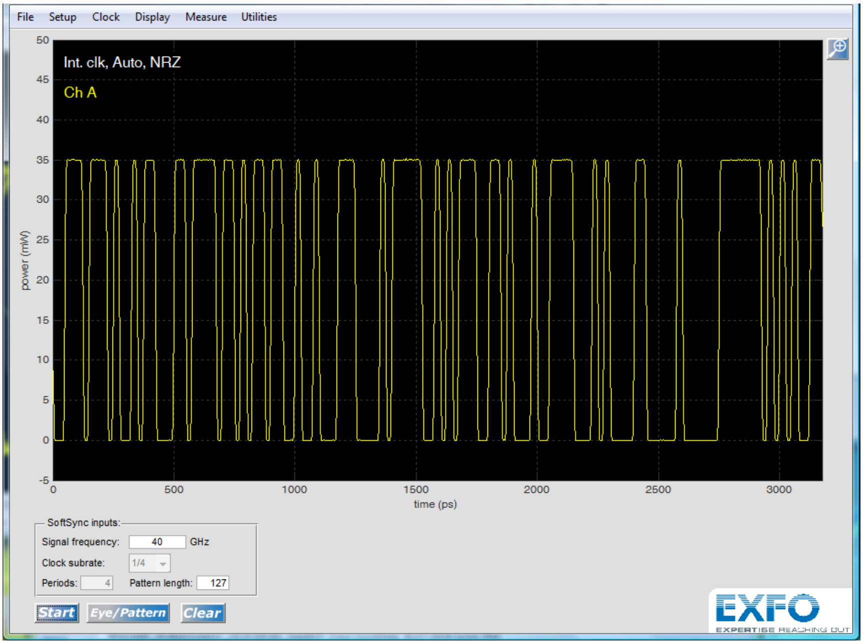


Changing the Averaging Value

The averaging value is where noise can be averaged out from a waveform, pulse or pattern. The number of averages can be between 1 and 64, and infinite.

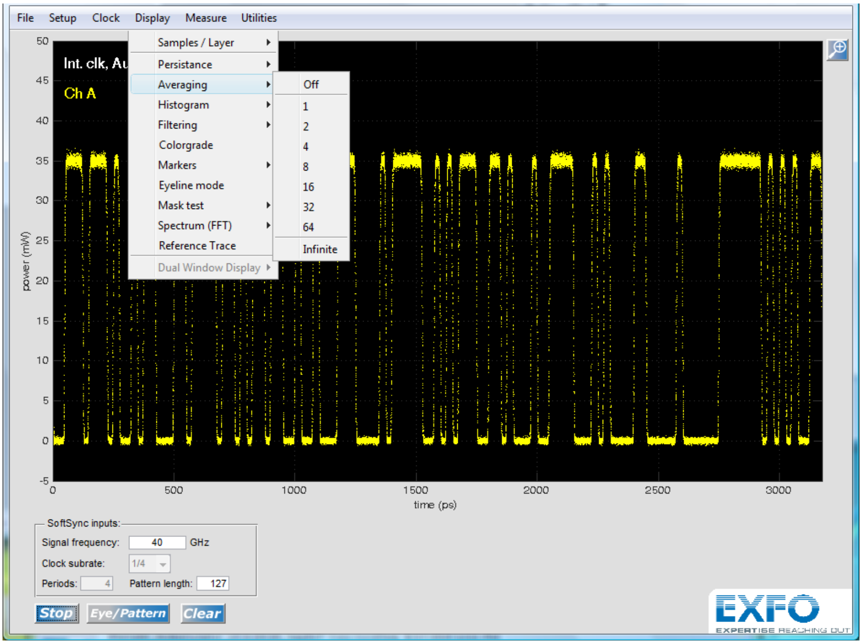
In the figure below, the 127-bit pattern is averaged and the noise is removed. Note that this works for patterns, pulses and waveforms, not eye-diagrams, since it does not represent a continuous curve. The number of averages can be set from 1 to 64 and infinite.

The averaging function uses the pixel information to calculate the average. This means that a higher resolution in pixels/ps is achieved in a zoomed window compared to the default window.



To change the averaging value:

1. From the main window, select the **Display** menu.
2. Select **Averaging**, then select the number of averages to use.



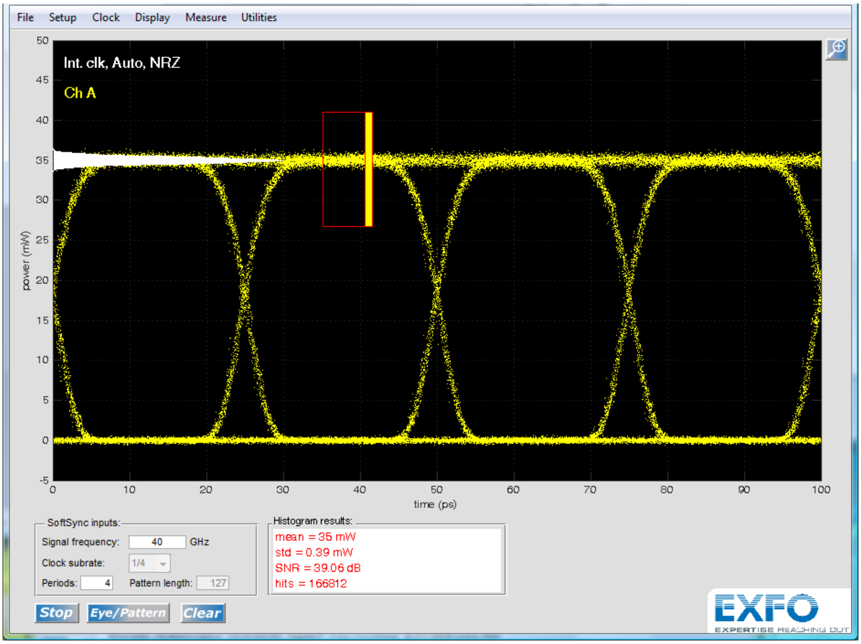
To average from the beginning:

From the main window, click **Clear**.

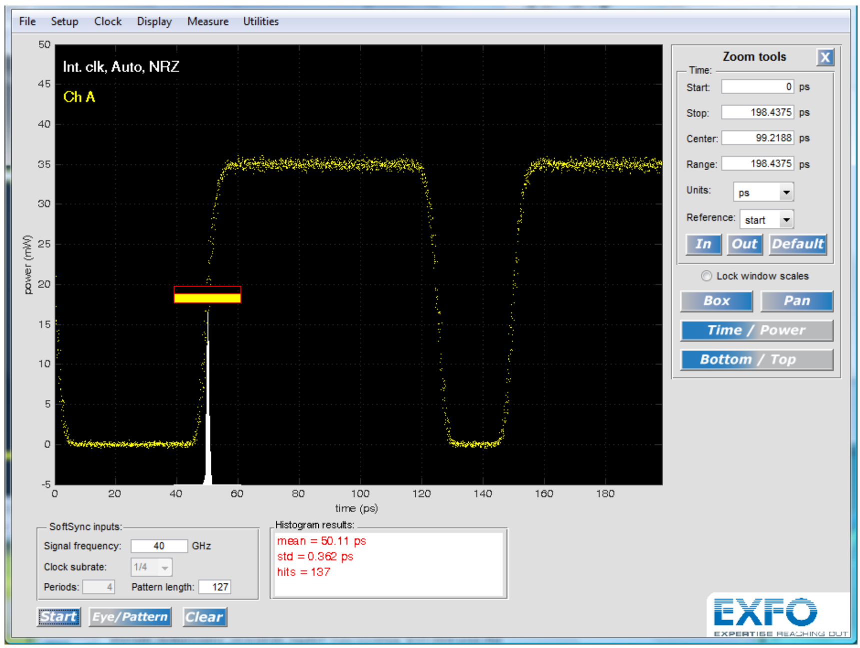
Displaying Histograms

You can view either a horizontal or a vertical histogram of the data to help you better see the distributions in the time or power direction. For example, you can select a vertical histogram to measure the SNR, or a horizontal histogram to measure the RMS timing jitter.

In the figure below, we have selected a vertical histogram, and selected a window using the mouse. A red square shows the histogram window. The histogram is shown to the left and the mean, the standard deviation, the SNR $(= 10*\log_{10}(\text{mean}^2/\text{std}^2))$ values, and the number of histogram hits are shown in the measurement box at the bottom of the application.

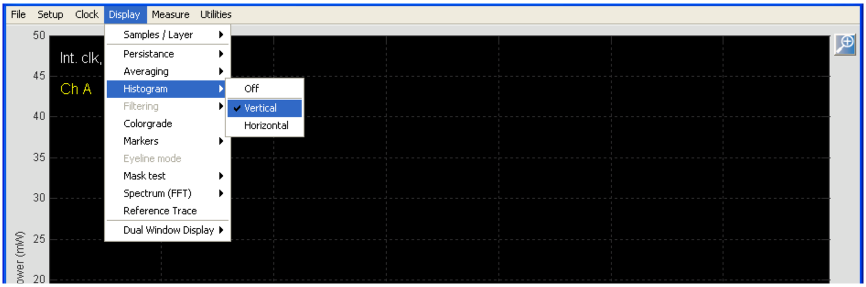


In the figure below, we have instead selected a horizontal histogram at a rising slope in the pattern. The histogram is shown at the bottom of the sample screen. The mean time in the histogram window, the standard deviation, and the number of histogram hits are shown under **Histogram results**.



To display a histogram of the data:

1. From the main window, select the **Display** menu, then **Histogram**.
2. Select the type of histogram to view (horizontal or vertical).



3. Select a histogram window using the mouse by clicking-dragging the mouse cursor to select the desired area.

Note: *You can clear the histogram by clicking the* ***Clear*** *button at the bottom of the application.*

If you want to select a new histogram window, first deselect the present window in the histogram menu.

Managing Filters

Software defined filters can be applied to emulate a measurement situation with lower bandwidth, or to obtain filter characteristics that are theoretically perfect instead of hardware filters that change with time and from unit to unit. On the Optical Sampling Oscilloscope, you can use the following filters:

- Bessel
- Butterworth
- Chebychev

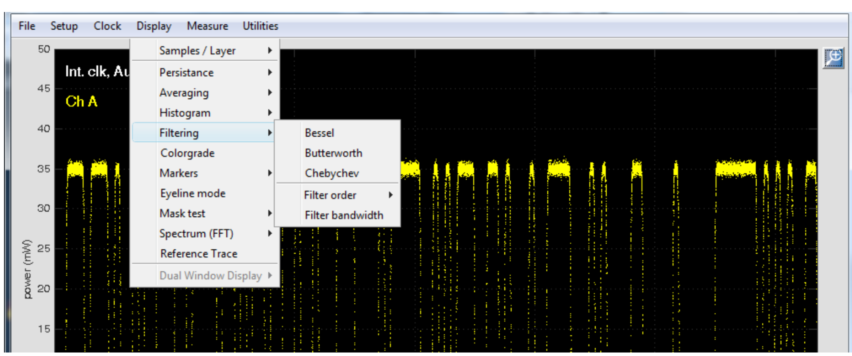
You can set the order of the filter, and customize a bandwith over which the filter is applied.

Note: *The Chebychev filter is of Type 1, with a 1-dB ripple in the passband.*

Note: *You must be in pattern mode and use a repetitive sequence to use filters.*

To add a filter to the sampling:

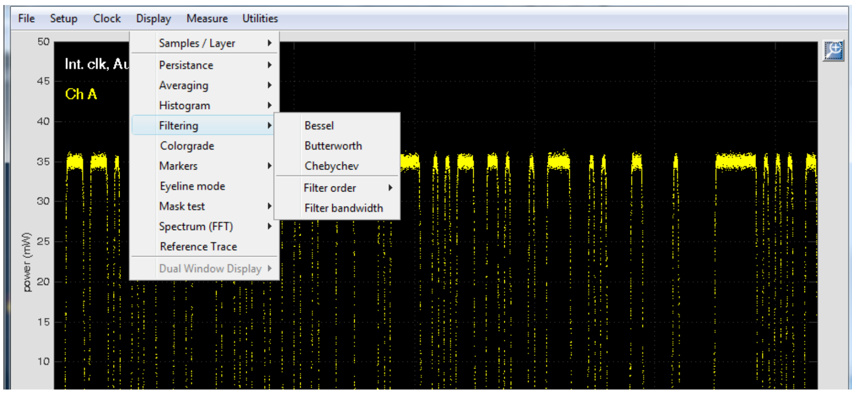
1. From the main window, select the **Display** menu, then **Filtering**.



2. Select the type of filter to apply. You can select only one type at a time.

To set the order for the filter:

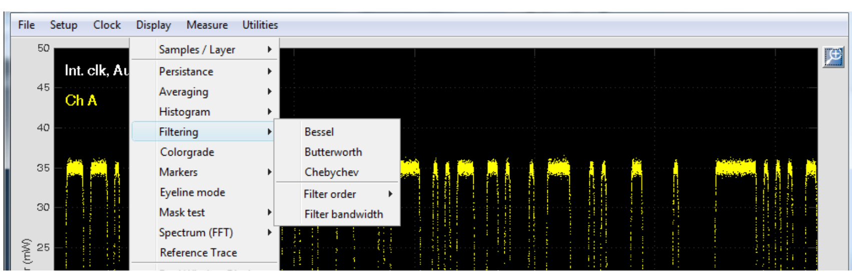
1. From the main window, select the **Display** menu, then **Filtering**.



2. Under **Filter order**, select the rank for your filter.

To set the bandwidth for the filter:

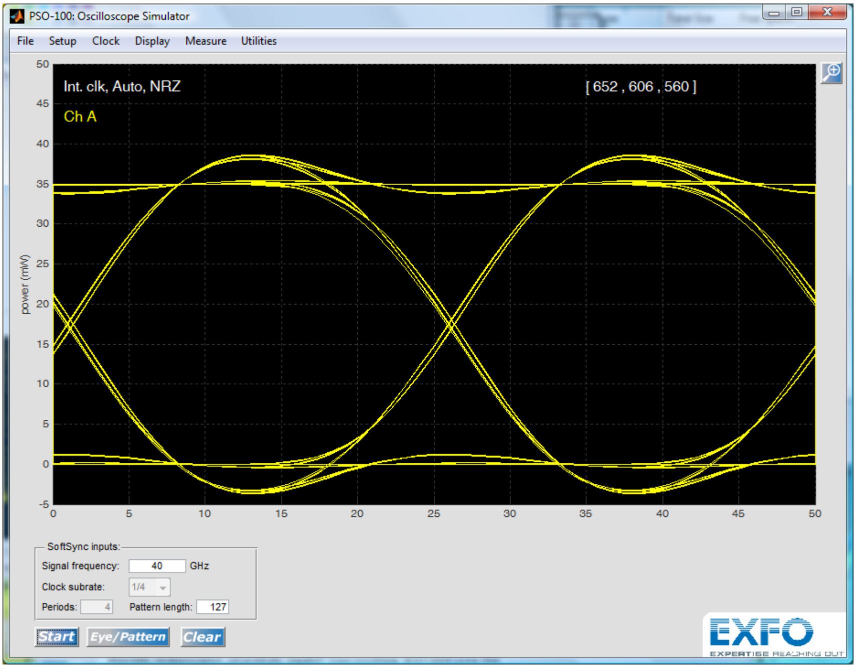
1. From the main window, select the **Display** menu, then **Filtering**.



2. Select **Filter bandwidth**.
3. Enter a value in GHz for the bandwidth.

4. Click **OK** to confirm your choice.

The figure below shows an example of a filtered 127-bit, 40 Gb/s, NRZ signal with a 40 GHz, 5th order Butterworth filter.

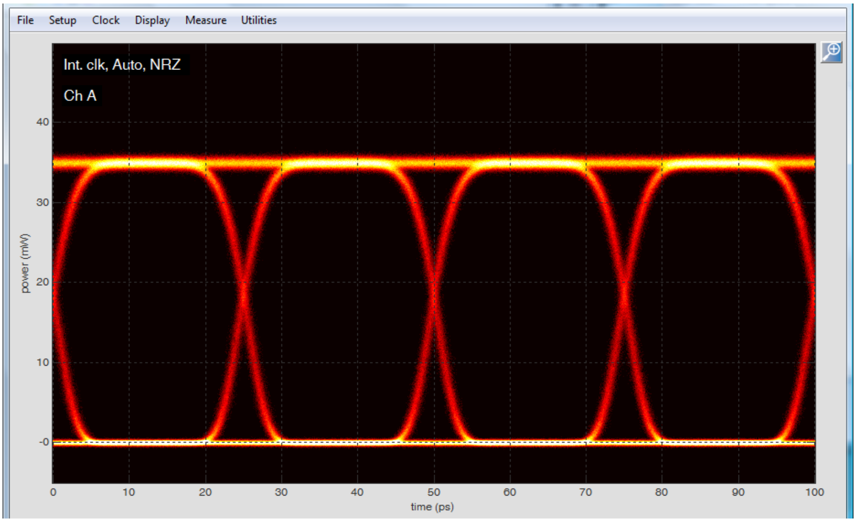


Using Colorgrade

Colorgrading the sampling can let you see which parts of the graph are displayed more often and which are displayed less often. The more often the parts are displayed, the brighter the corresponding color will be. The longer you let the sampling run, the more data is accumulated and the more precise the results.

The color grade function uses the pixel information to calculate the 2-D histogram. This means that a higher resolution in pixels/ps is achieved in a zoomed window compared to the default window.

In the figure below you can see colorgrade in eye-mode.



To activate the color grade mode:

In the **Display** menu, select **Colorgrade**.

To restart the color grade accumulation:

Click **Clear**.

Using Markers

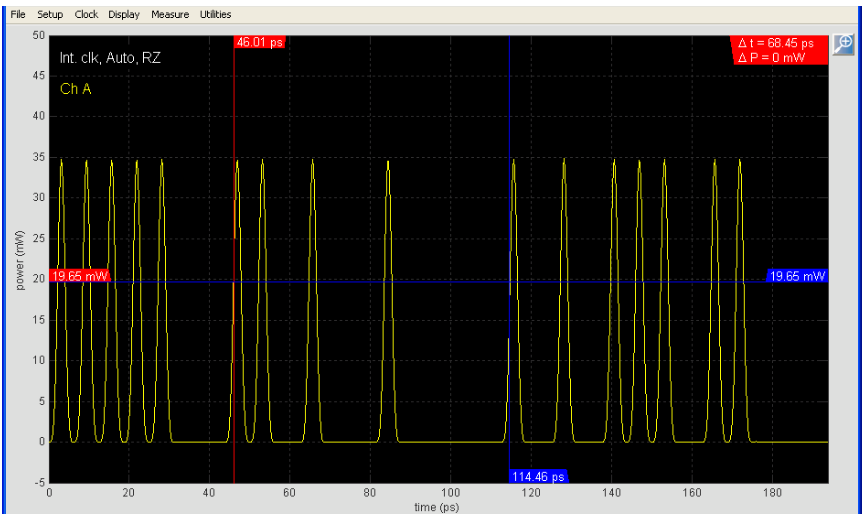
Markers are quick and easy ways to take precise measurements.

To place markers:

1. Make sure that the sampling is running.
2. Right-click on the sample screen, then select **Marker 1**.
3. Click on the location where you want to put the marker.
4. Repeat steps 2 and 3 for the other marker.

Note: *You can also select the markers from the* ***Display*** *menu.*

The figure below shows an example where we have placed two markers in a 160 Gb/s pattern to measure the spacing between two slopes. The difference in time and power is shown at the top right corner of the sample screen. The red and blue indicators will give you the power and time values for each marker.



To move markers:

When the appropriate marker is selected, click on the screen where you want to put it.

To switch between the markers:

Right-click on the screen and select **Toggle marker**.

OR

Select the **Display** menu, then **Markers**.

To remove the markers:

Right-click on the screen, then click on the marker to remove the check mark.

OR

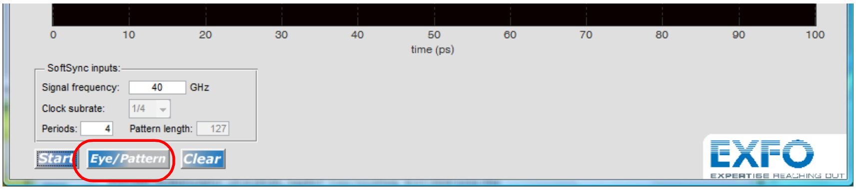
Select the **Display** menu, then **Markers** to select the marker and remove the check mark.

Using the Eyeline Mode

The eyeline mode is mainly used for noise reduction in eye diagrams. When a periodic pattern is sampled it is possible to average over several patterns in a similar way as in normal averaging mode. An eyeline trace is obtained when the averaged pattern is folded back into an eye diagram. In order to produce a full eyeline trace several samples must be recorded from all bits in the pattern. Hence, the longer the pattern the more time it will take to acquire all samples.

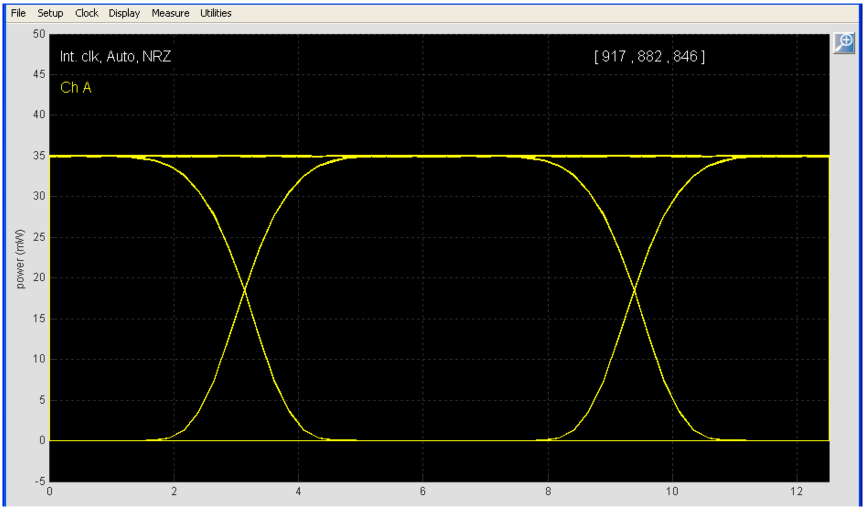
To use the eyeline mode:

1. Select the pattern view mode using the button at the bottom of the screen.



2. In the **Display** menu, select **Eyeline mode**.

The figure below shows an eyeline trace from a normal 40 Gb/s, NRZ 127, bit pattern. Before the eyeline trace appears all bins (separated with 1 ps) must be filled with at least one sample. During this process, the maximum number of samples in any bin, the average number of samples per bin, and the minimum number of samples in any bin are shown in the sample window. This will be noticed first when the pattern is relatively long.



Using Masks

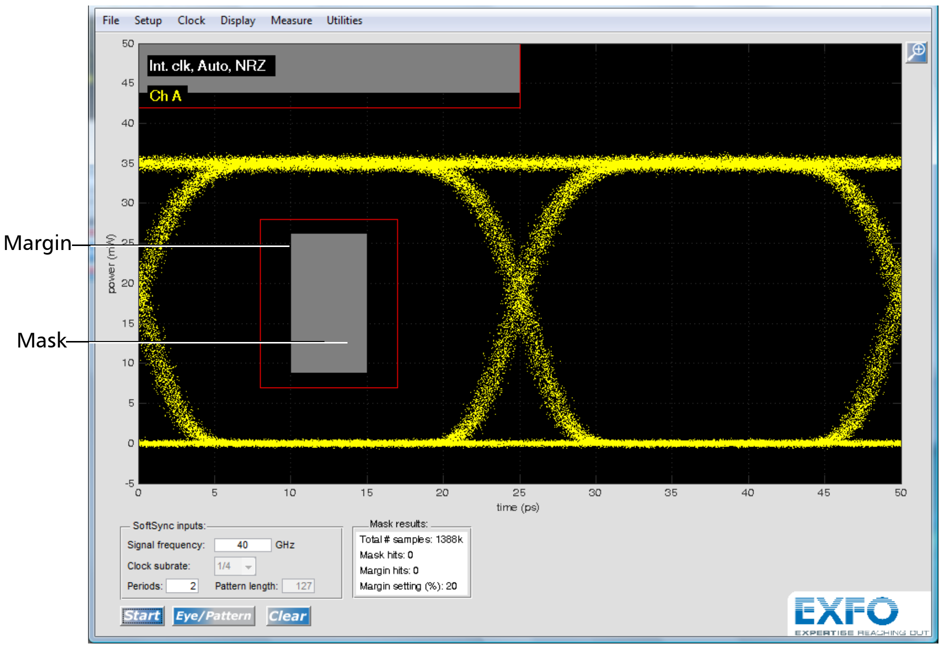
Mask testing is a procedure commonly used to verify that a transmitter complies with certain standards. The test is done in an eye diagram, where masks are placed in three regions: in the center of the eye, above the logic one, and below the logic zero level. Samples in these regions are unacceptable and referred to as mask hits or mask violations.

You can also activate a mask margin, which is slightly larger (a certain percentage) than the original mask to see the tolerance area within the eye diagram.

You can see at the bottom of the application the results from the mask test, including the total number of samples, the number of hits in the mask and in the margin, etc.

The mask is only placed in one eye period, so if for example four eyes periods are shown in the application, it will take longer time to acquire a certain number of samples in the mask test. Therefore, EXFO recommends to visualize one eye period.

The figure below shows the result from a mask test on 40 Gb/s NRZ data. The mask that is centered to the eye diagram is a standard square shaped mask with a height of 50 % of the eye amplitude (P_{one}-P_{zero}), and a width of 20 % of the eye period.

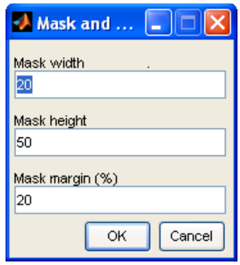


To set up the mask parameters:

1. From the main window, select the **Display** menu.

2. Select **Mask test**, then **Settings**.

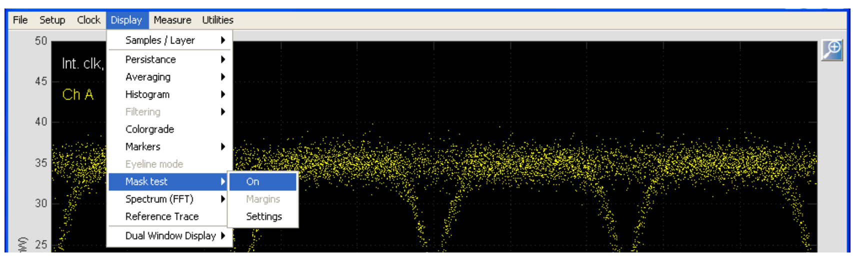
3. Enter values for the width, the height and the margin value of the mask.



4. Click **OK** to close the window.

To activate the mask testing option:

From the main window, select the **Display** menu, then **Mask test** and **On**.



The mask is automatically aligned and shown as grey areas that appear in the eye diagram.

To view the margins of the mask:

When the mask mode is activated, go in the **Display** menu, then select **Mask test** and **Margins**.

The margin will appear as a red outline arount the mask.

Displaying the FFT Spectrum of a Sampled Signal

Your Optical Sampling Oscilloscope can be used as an FFT spectrum viewer as well.

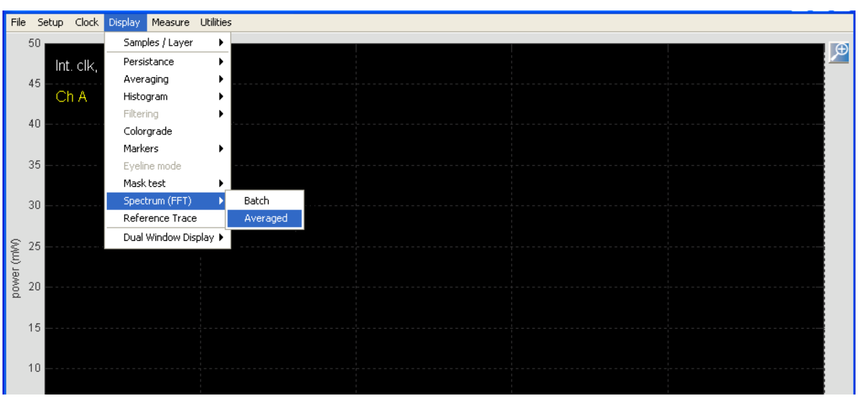
To look at the spectral content of a signal is useful in many situations. For example, you might want to see the bandwidth of the signal, or look at specific frequency harmonics that you want to maximize or minimize.

You can choose between two spectrum types:

- Batch: The FFT of each batch is taken separately.
- Averaged: Several batches are taken together to accumulate an averaged FFT.

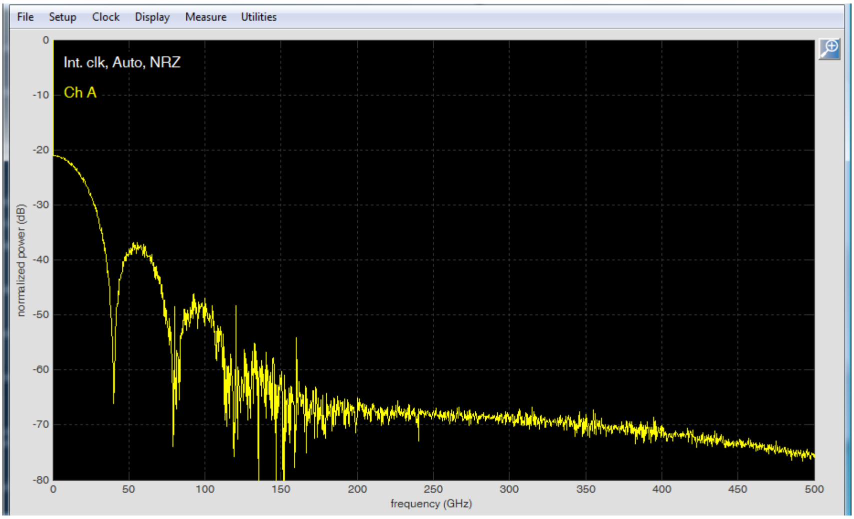
To display an FFT spectrum:

1. From the main window, select the **Display** menu, then **Spectrum (FFT)**.
2. Select which type of spectrum to view.



3. Start the sampling session.

Here is an example of a spectrum of an NRZ 40Gb/s signal. You can see the characteristic dips in the spectrum at 40 GHz, 80 GHz, and so forth.

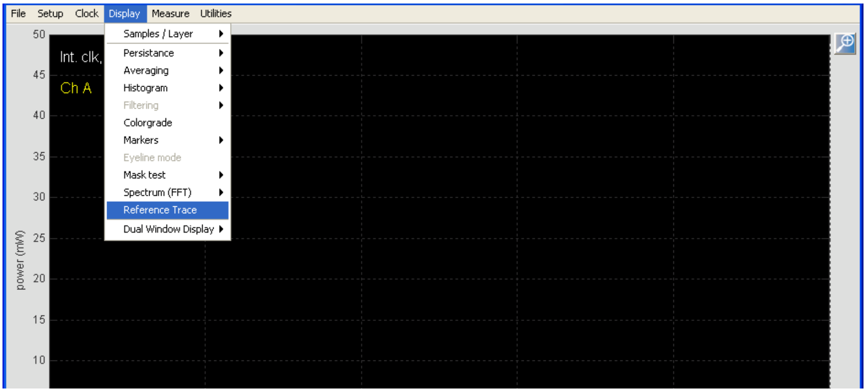


Displaying a Reference Trace for your Measurements

You can display a reference trace for your sampling to better see how your sampling relates to the desired result. The reference trace will appear in white on the display as you activate the sampling.

To display the reference trace:

From the main window, select the **Display** menu, then **Reference Trace**.



To save the reference trace and display it on-screen for the current session:

While the reference trace is activated, select the **File** menu, then **Save data > Save setup > Bottom**, then select the reference trace.

The reference trace appears in the background of the window in white.

Managing Measurement Parameters

In the **Measurement** menu you can select one or more parameters to measure from an eye diagram, pattern or waveform.

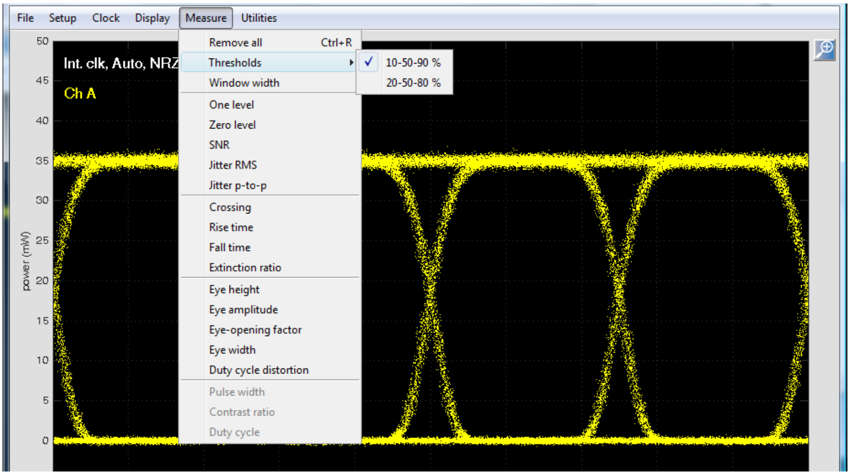
You can display up to three measured parameters simultaneously in the sample screen. When a fourth parameter is selected, the first one is automatically deselected. The indicators on-screen always pertain to the most recent measurement type you have selected.

The measurements are based on a number of histograms, so the longer time you wait, the more accurate the parameters will become. As long as at least one parameter is selected, all histograms are accumulated and all parameters are measured even though not shown. By removing all measurements, the histograms are cleared.

If you want to clear the histograms without removing the measurements, use the **Clear** button in the main window.

To select a measurement type:

From the main window, select the **Measure** menu, then the measurement type you want.

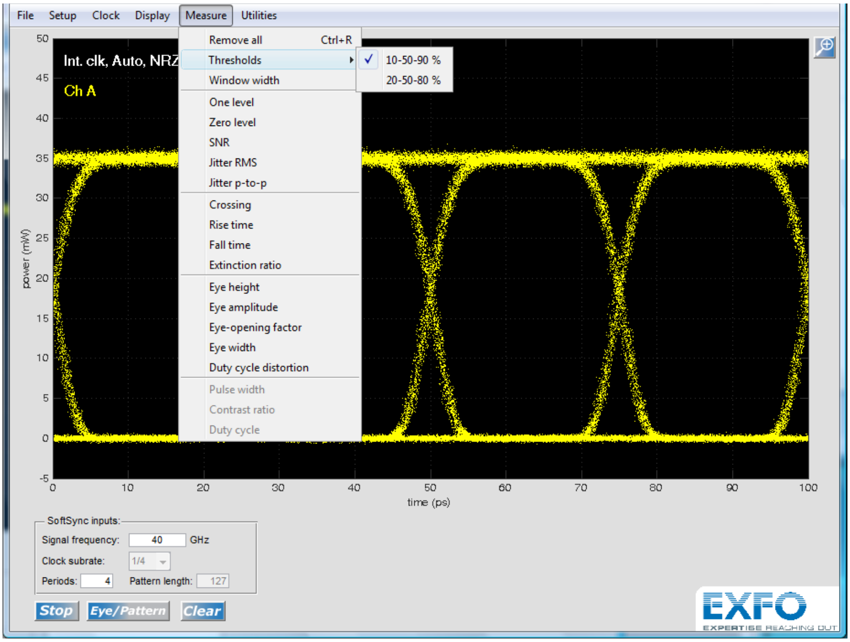


Note: *For more details, see* Measurement Definitions *on page 109.*

To set the thresholds for rise and fall times:

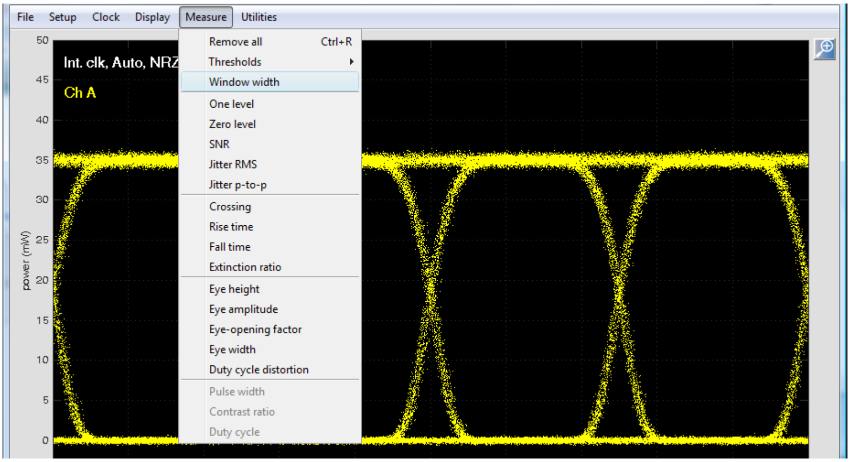
1. From the main window, select the **Measure** menu.

2. Select **Thresholds**, then the desired value (10-90 % or 20-80 %).

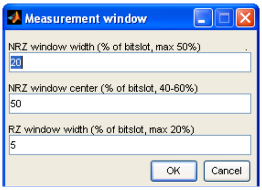


To set the histogram window width for NRZ and RZ formats:

1. From the main window, select the **Measure** menu.
2. Select **Window width**.



3. Enter the desired values for the window.



Note: *In the case of short RZ pulses with a low duty cycle, you must decrease the RZ window width to a small value. For example, if the duty cycle is only 10%, EXFO recommends that the window width is set to 1 %; if the duty cycle is only 1 %, the window width should be set to 0.1%.*

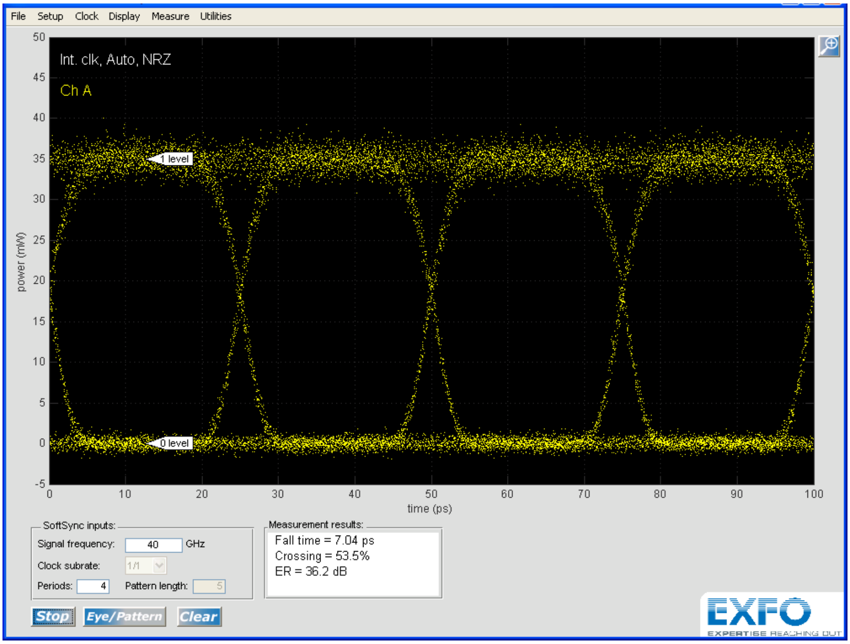
4. Click **OK** to close the window.

To remove all measurements from the window:

From the main window, select the **Measure** menu, then **Remove all**.

Eye Mode Measurement Example

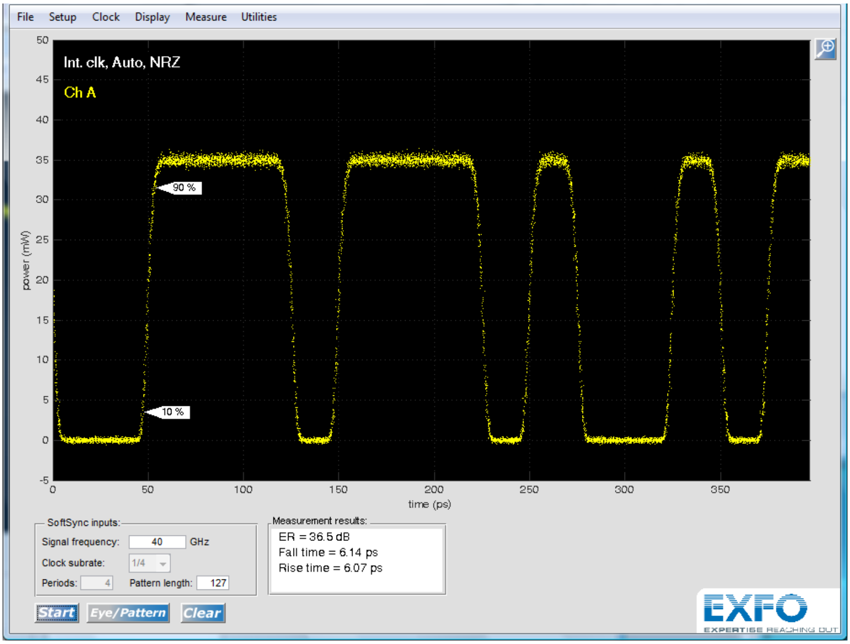
In the figure below, we have selected to show the measures of fall time, crossing and extinction ratio, which are shown under **Measurement results** at the bottom of the application. Markers associated with the parameter that was chosen last (here the 3rd in the list - the ER) indicate where the measurement was taken and what were the one and zero levels from which the ER was calculated.



Note: *You can also use the dual window function in the display menu to view both the eye and pattern simultaneously.*

Pattern Measurement Example

Instead of an eye diagram you can choose to visualize the pattern procedure. Switch from **Eye** to **Pattern** at the bottom left. The figure below shows a part of a 127 bit, 40 Gb/s, NRZ pattern with measurements of ER, fall time and rise time..



Managing Synchronization

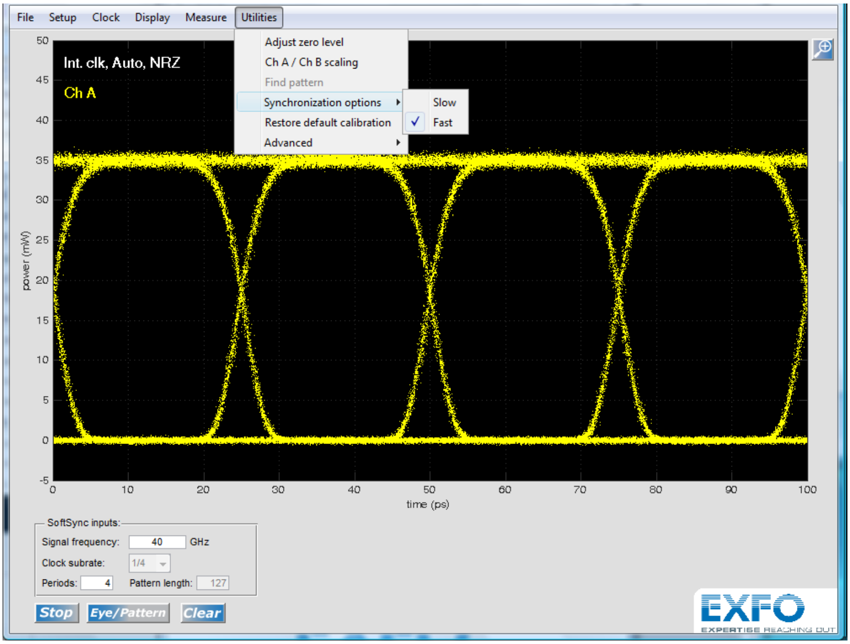
There are two synchronization methods used for measurements:

➤ The fast sync, which implies that only a fine-tuning is done from the last measurement. This is the default method.

➤ If the fast sync is switched off, the software performs a coarse sync every time, which takes more time, but is convenient when tuning the signal frequency continuously during the measurement, for example when optimizing the signal frequency of a ring laser.

To activate the fast sync option:

1. From the main window, select the **Utilities** menu.
2. Select **Synchronization options**.



3. Specify whether you want fast or slow sync.

Setting the Data Phase Tracking Algorithm

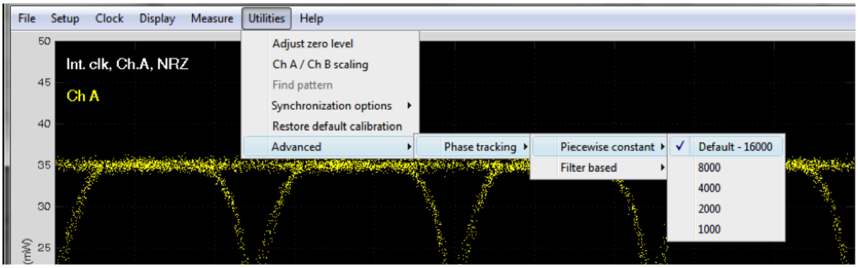
Data phase noise lead to timing jitter. To counter this, you can optimize the phase tracking algorithm settings. There are two different algorithms; piece wise constant, or filter-based. In the piece wise constant setting, you can shorten the batch length from the default value of 16000 to a smaller value. This will divide the whole batch into smaller subbatches, and since the synchronization is performed on each of the batches, the data phase is tracked in a faster manner.

For high performance signal generators, there is usually no need to reduce the batch length at all. For line card transmitters however, there is sometimes needed to reduce the batch length. Use the highest batch length possible, since a short batch length normally leads to larger problems with frequency holes.

In some cases, there may be even more phase noise and the algorithm must be faster. If the eye diagram looks jittery even with a batch length of 1000, EXFO recommends to select the filter-based phase tracking algorithm.

To set the phase tracking value:

1. From the main window, select the **Utilities** menu, then **Advanced > Phase tracking**.



2. Under **Piecewise constant**, select the value you want to use.

   The rate is updated automatically.

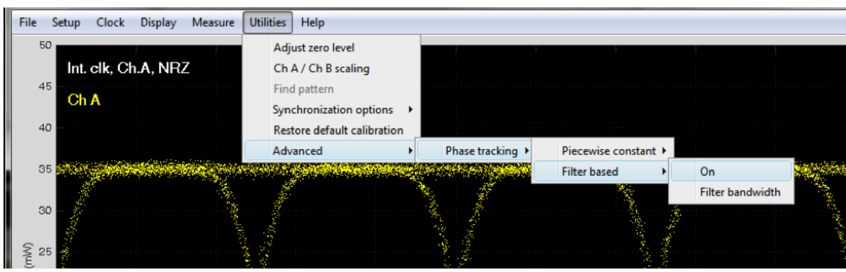
Filter-Based Phase Tracking

If the piecewise constant algorithm cannot handle the timing jitter, and a faster algorithm is required in order to track the phase, use the Filter based phase tracking algorithm. It is typically needed in some transponder line cards with relatively large phase noise.

You can set a software-defined filter bandwidth, which corresponds to a hardware clock recovery circuit with the same bandwidth.

To activate the filter-based phase tracking:

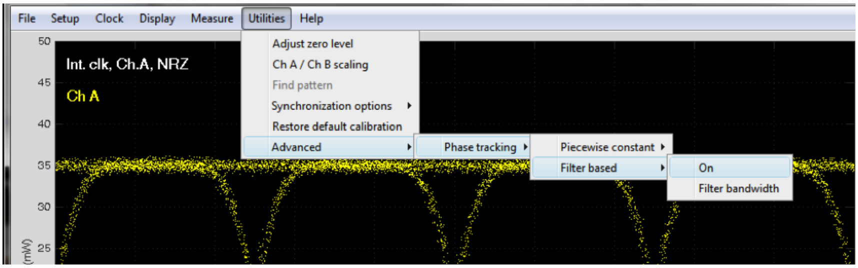
1. From the main window, select the **Utilities** menu, then **Advanced > Phase tracking**.



2. Select **Filter based**, then **On**.

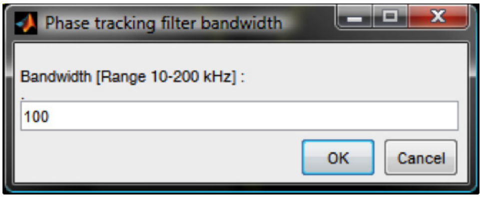
To set the filter bandwidth:

1. From the main window, select the **Utilities** menu, then **Advanced > Phase tracking**.



2. In **Filter based**, select **Filter bandwidth**.

3. Enter the bandwidth value to use, in kHz.



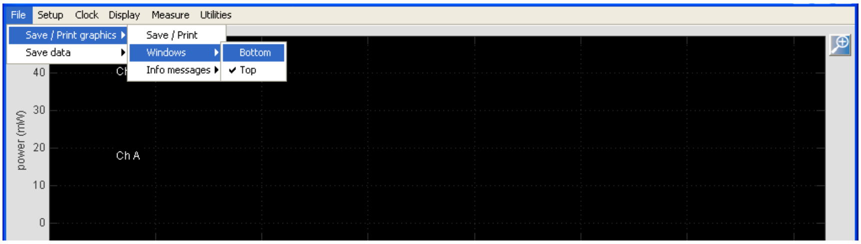
4. Click **OK** to validate your choice.

Saving Sample Files

You can save the samples on the screen in a number of different formats, as a picture or as data samples. The saved pictures only show the sample screen with the same axis proportions as in the application.

To save or print a sample as a graph:

1. From the main window, select the **File** menu, then **Save / Print graphics**.

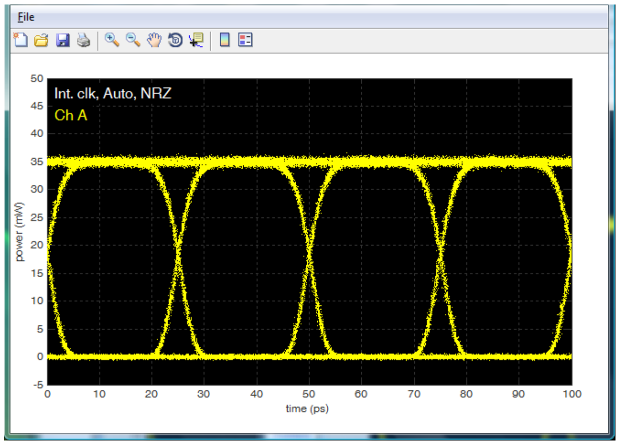


2. In the **Windows** submenu, select whether you want to save or print the top or the bottom window.

3. In the **Info messages** submenu, select whether you want the messages displayed in the graph or not.

Note: *These settings will remain as you have selected them until you change them again.*

4. Click **Save / print**.



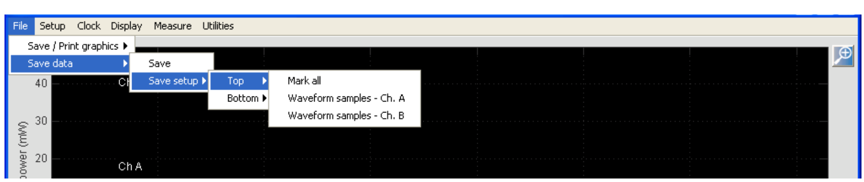
5. Select [save icon] to save the file to the desired folder, or [print icon] to print it.

To save the sample as data:

1. From the main window, select **File**, then **Save data**.

2. Under the **Save setup** menu, select if you want to include the waveform samples for channel A and/or B for the top and bottom window

Note: *If you are not using the dual window setting, or if only channel A or B are active, you will have fewer choices.*



3. Click **Save**. Confirm the location and format for the resulting file (.csv for Excel format, or .mat for Matlab format).

5 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 and let the unit dry completely.

WARNING

Use of controls, adjustments, and procedures for operation and maintenance other than those specified herein may result in hazardous radiation exposure.

There are no operator serviceable parts inside the unit. Please refer all servicing to EXFO personnel.

- The unit has a fan for active cooling. Make sure there is sufficient airflow to cool the device, any objects that cover the ventilation holes must be removed.
- Do not apply too large torque when connecting the clock input. Use a torque wrench.
- The instrument is somewhat temperature sensitive during the start procedure. Avoid placing the unit in a hot cabinet.

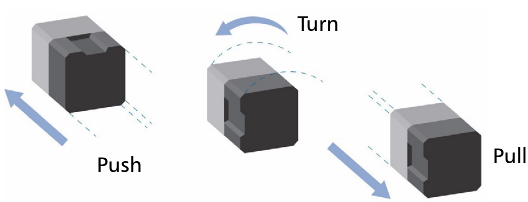
Cleaning EUI Connectors

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

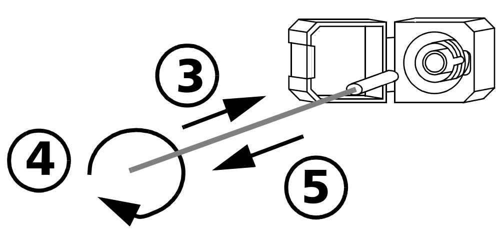
> **IMPORTANT**
>
> **If any damage occurs to internal connectors, the module casing will have to be opened and a new calibration will be required.**

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).

WARNING

Verifying the surface of the connector WHILE THE UNIT IS ACTIVE WILL result in permanent eye damage.

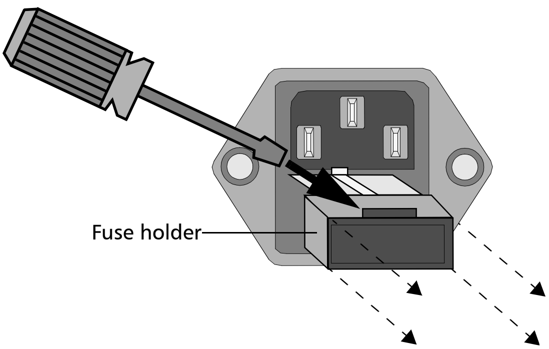
7. Put the EUI back onto the instrument (push and turn clockwise).
8. Throw out cleaning tips and wiping cloths after one use.

Replacing Fuses

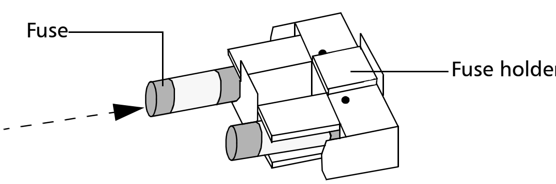
The unit contains two fuses (T2.5A L, 5 mm x 20 mm (0.197 in x 0.787 in), slow-blow, low-breaking capacity, 250 V). The fuse holder is located at the back of the unit, just below the power inlet.

To replace a fuse:

1. Turn off the unit and unplug the power cord.
2. Using a flat-head screwdriver as a lever, pull the fuse holder out of the unit.

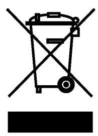


3. Check and replace the fuses, if necessary.
4. Insert the new fuse into the fuse holder.



5. Make sure the fuses are placed firmly in the holder prior to reinsertion.
6. Firmly push the fuse holder into place.

Recycling and Disposal (Applies to European Union Only)



Recycle or dispose of your product (including electric and electronic accessories) properly, in accordance with local regulations. Do not dispose of it in ordinary garbage receptacles.

This equipment was sold after August 13, 2005 (as identified by the black rectangle).

- ➤ Unless otherwise noted in a separate agreement between EXFO and a customer, distributor, or commercial partner, EXFO will cover costs related to the collection, treatment, recovery, and disposal of end-of-lifecycle waste generated by electronic equipment introduced after August 13, 2005 to an European Union member state with legislation regarding Directive 2002/96/EC.
- ➤ Except for reasons of safety or environmental benefit, equipment manufactured by EXFO, under its brand name, is generally designed to facilitate dismantling and reclamation.

For complete recycling/disposal procedures and contact information, visit the EXFO Web site at www.exfo.com/recycle.

6 Troubleshooting

Solving Common Problems

Problem	Cause	Possible Solution
Nothing happens when you start sampling, but you can use the **Start/Stop** button.	➤ The samples are outside the sampling screen. ➤ The input power is too high.	➤ Zoom out or pan to find the samples. ➤ Reduce input power.
The application freezes and you cannot use the **Start/Stop** button.	➤ The unit was turned off while the application was sampling.	➤ Turn on the unit again, then restart the application on the host computer.
The application does not start at all	➤ The MCR is not installed ➤ The system path is incorrect ➤ The MCR version is incorrect	➤ Install the MCR using the MCRinstaller ➤ See *Installing the Matlab Runtime, USB Drivers and Optical Sampling Oscilloscope Software* on page 12. ➤ When receiving a new software update from EXFO, make sure that you use the correct MCR version.

Problem	Cause	Possible Solution
The application was just started, but you can see a message that indicates "USB connection failed" .	➤ The USB cable is not connected.	➤ Connect the USB cable to the computer in the correct USB port, and restart the application.
	➤ The USB communication is broken and does not resume in a hot-swap situation.	➤ Disconnect the USB cable and connect it again. Restart the application.
	➤ The USB driver is not correctly installed.	➤ Install the USB driver.

Problem	Cause	Possible Solution
The application was just started. In the DOS window "USB connection OK" is shown. When you click **Start** in the application nothing happens and in the DOS window TriggerTest is not passed.	USB connection is up, but the instrument is not triggering.	➤ Make sure the unit is turned on. ➤ If it does not help, the internal pulse source has not started correctly. Make sure that the surrounding temperature is within specifications. ➤ If the unit was recently turned off, let it cool down for a few minutes before you turn it on again. ➤ If the problem persists, contact EXFO.

Problem	Cause	Possible Solution
No signal is shown in the application, only samples at the zero level.	➤ Power is too low. ➤ Wavelength is not appropriate. ➤ Dirty contacts.	➤ Increase signal power. ➤ Use the 1520-1565 nm wavelength region. ➤ Clean the input contacts. If you send in a lot of power and the contacts are dirty, the input contact may be damaged and must be repaired.
Windows indocates that it found new hardware when you insert the USB cable	➤ You are using a new USB port (Windows XP). ➤ The USB driver is not installed.	➤ Use the correct USB port (the one you used when the USB driver was installed) or install the driver on the new port. ➤ Install the USB driver.

Problem	Cause	Possible Solution
The update rate is very slow, even in Freerun mode and with 16 k samples.	➤ You are using a USB 1.1 port. ➤ Your computer is slow . ➤ You have several other applications running.	➤ If you have a USB 2.0 port on your computer connect the USB cable to that port and reinstall the USB driver. ➤ Install the application on a faster computer. ➤ Close some applications, restart the computer if necessary.
The power level shown in the application is much lower than expected.	➤ Signal wavelength is outside the 1525-1565 nm span. ➤ Dirty contacts.	➤ Use the 1525-1565 nm span. ➤ Clean the contacts.

Problem	Cause	Possible Solution
The sampled data looks very noisy, jittery or distorted. The software does not seem to be able to synchronize the data.	➤ The input signal is too low. ➤ The signal has very poor OSNR or suffers from dispersion. ➤ The waveform format is incorrect. ➤ There are frequency holes. ➤ The data signal suffers from large phase noise. ➤ The signal wavelength is in the 1567-1570 nm span. ➤ The internal sampling pulse source has not locked yet.	➤ Increase the signal power ➤ Try to use the external clock ➤ Set the appropriate waveform format or use the external clock. ➤ Click clear. ➤ Change the phase tracking algorithm (**Utilities** > **Advanced** menu), or use the external clock in adaptive mode. ➤ Use 1525-1565 nm. ➤ Turn off the optical input signal. Wait and let the unit warm up until it locks.
My OTDM data jumps around on the screen.	It is difficult to synchronize a sub-optimally multiplexed data signal.	Use the external clock with a subrate clock.

Problem	Cause	Possible Solution
My short RZ pulses look like an eye diagram.	It is difficult to correctly synchronize very low duty cycle pulses <1 %.	Start and stop the sampling to resynchronize the pulses, until it looks like short pulses. If it does not work, use the external clock.
The eye diagram looks jittery even if you use an external clock	The clock signal may suffer from large phase noise.	Change the phase tracking algorithm (**Utilities** > **Advanced** menu), or use the adaptive clock mode.
The DC level is not zero even if the input signal is off.	The DC level drifts slightly with temperature.	Adjust the zero level from the **Utilities** menu.
The samples are unevenly distributed or appear at discrete points in the signal. When you start and stop the sampling the data may be incorrectly synchronized.	Frequency holes.	Wait and see if it disappears. Increase the number of layers and/or the number of samples/layer. Tune the signal frequency a few 100 Hz if possible.
The application crashes. Error messages appear in the DOS window.	Software bug.	Click **Start** again. If that does not help, restart the application. Contact EXFO.

Problem	Cause	Possible Solution
The LED indicator on the front panel is off even if the unit is turned on.	AC adapter is not plugged in correctly.	Plug in the AC adapter.
The instrument chassis is warm.	The fan is off.	Contact EXFO.

Contacting the Technical Support Group

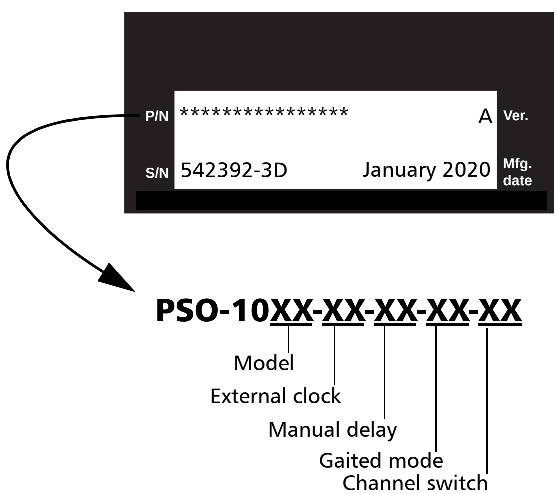
To obtain after-sales service or technical support for this product, contact EXFO at one of the following numbers. The Technical Support Group is available to take your calls from Monday to Friday, 8:00 a.m. to 7:00 p.m. (Eastern Time in North America).

For detailed information about technical support, visit the EXFO Web site at www.exfo.comwww.exfo.com.

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

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



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.

7 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.

IMPORTANT

The warranty can become null and void if:

- **unit has been tampered with, repaired, or worked upon by unauthorized individuals or non-EXFO personnel.**
- **warranty sticker has been removed.**
- **case screws, other than those specified in this guide, have been removed.**
- **case has been opened, other than as explained in this guide.**
- **unit serial number has been altered, erased, or removed.**
- **unit has been misused, neglected, or damaged by accident.**

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.

IMPORTANT

EXFO will charge a fee for replacing optical connectors that were damaged due to misuse or bad cleaning.

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 101). 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 101).

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
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quebec.service@exfo.com

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ENGLAND

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Tel: +86 (755) 2955 3100
Fax: +86 (755) 2955 3101
beijing.service@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*.

	PSO-101	PSO-102
Number of channels	1	2
Wavelength range (nm) [b]	C: 1525/1563 L: 1575/1608	
Optical bandwidth (GHz)	≥500	
Polarization dependence (dB)	≤1	
Timing jitter (fs) [c]	≤100, 50 [b]	
Signal sensitivity (mW) [b, d]	2	
Power uncertainty (dB)	1	
Maximum input peak power without damage (mW)	200	
Maximum input average power without damage (mW) [e]	100	
Minimum signal duty cycle without external clock (%)	1	
Frequency holes due to asynchronous sampling (%)	≤1	
External clock frequency range (GHz)	0.001 to 12.5	
External clock input level at 10 GHz (V)	0.8 to 2	
External clock duty cycle (%)	≥10, ≤90	
Connectors		
fiber input	FC/PC	
external clock	SMA	

GENERAL SPECIFICATIONS

Weight	4.7 kg (10.3 lb)	5.5 kg (12.1 lb)
Size (H x W x D)	128 mm x 238 mm x 373 mm (5 in x 9.4 in x 14.7 in)	
Temperature		
operating	18 °C to 28 °C (64 °F to 82 °F)	
storage	0 °C to 50 °C (32 °F to 122 °F)	
Power consumption (V4)	20	

SAFETY

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

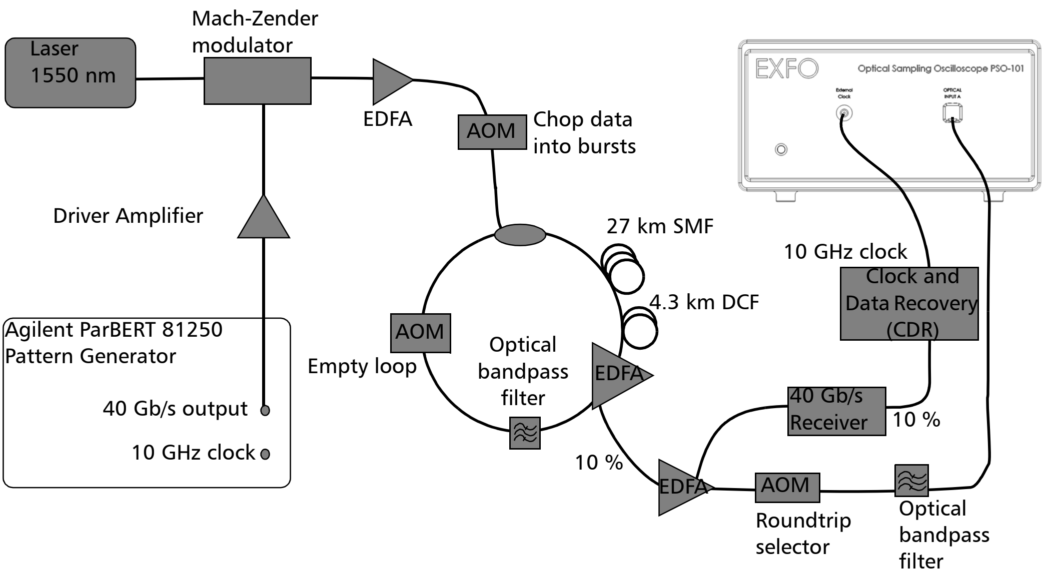
Notes

a. At 1550 nm.
b. Typical.
c. Timing jitter measurement depends on the signal SNR and slope rise time.
d. Peak power required to obtain 10 dB OSNR.
e. Input contact may be damaged if contacts are dirty.

B Burst Mode Measurements

The burst mode is very useful for example in circulating loop experiments. For this function to work, you must have the external clock option.

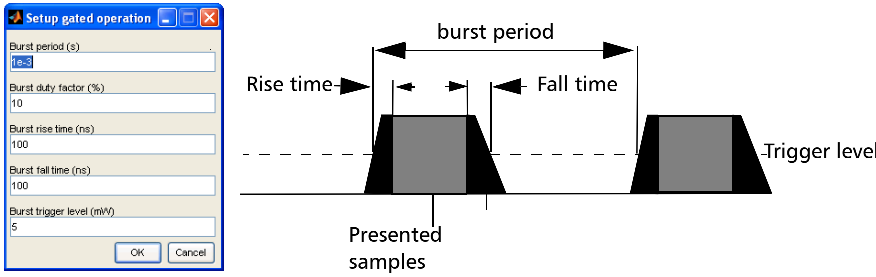
In the figure below, we see an example with 42.3 Gb/s NRZ data modulation that come in bursts from a circulating loop.



The first acousto-optic modulator (AOM) chops the data into bursts with a duration to exactly fill the loop (in this case 31.3 km of fiber). The AOM inside the loop is used for emptying the loop after N circulations, when a new burst is injected into the loop.

In this way, a near continuous data stream is circulating in the loop. The output signal from the loop constitutes of bursts originating from circulation number 1,2,…,N. With the last AOM, you select which circulation to monitor. The signal frequency (or sub-rate) clock (in this case from the clock recovery circuit) is inserted on the external clock input and the optical signal from the loop is inserted to the sampler.

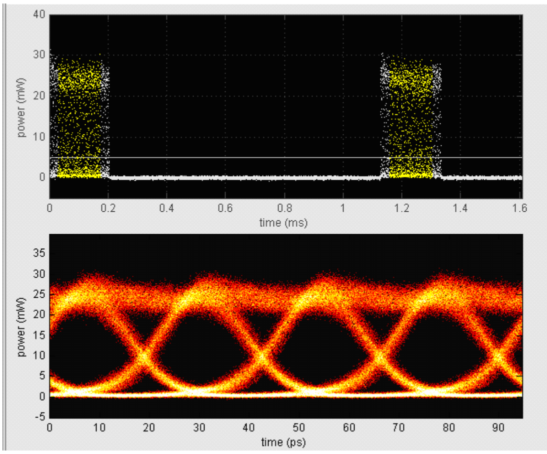
Then, select **Gated** from the **Clock** menu. A window pops up, according to the figure below.



Insert the burst period, duty factor, rise- and fall times, and the burst trigger level. In this case, the burst period is 0.775 ms, the burst duration is 155 μs, that is, a 20 % duty factor. The AOM have rise and fall times of 100 ns. If there is a distinct peak in the beginning of each burst originating from gain variation in an EDFA in the loop, the rise time can be adjusted to remove this peak. The trigger level should be set between zero and the signal peak power, in this case, 5 mW.

Initially, only the recovered eye diagram is shown in the application, but by selecting **Display>Dual window>Gated**, you can observe the bursts in Freerun mode together with the trigger level in the upper window.

The yellow samples are then visualized in an eye diagram in the lower window, while the white samples are removed, according to the figure below.



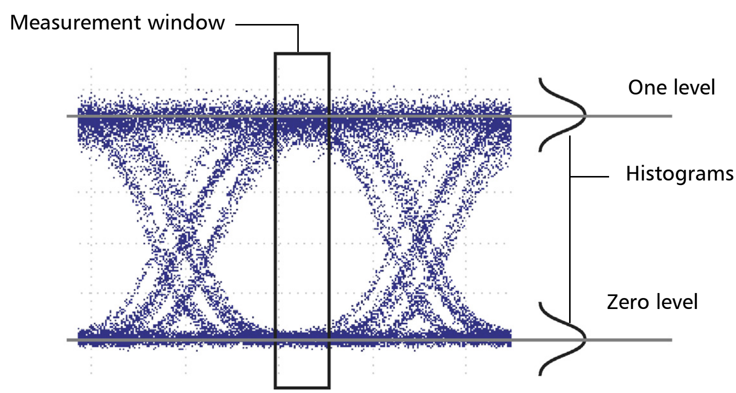
In this way, you can determine whether the burst parameters are set correctly or not. For example, if the rise time parameter is too low, you will observe samples in the middle of the eye, and if the trigger level is too high, the refresh rate will become very low since it does not trig until the trigger timeout value is reached. Depending on the burst period, you may need to increase the number of samples/layers in the **Display** menu.

If the loop length is much longer, that is if the burst is longer than 1 ms, and fills a whole batch entirely, you can use the internal clock instead of the external clock to make measurements.

C Measurement Definitions

The measurement definitions essentially follow the conventional standard from electrical sampling oscilloscopes. All measurements are based on histograms taken over samples that build up the signal. The measurement procedure is somewhat different if you are analyzing an eye diagram or waveform. In eye-mode, the histograms are placed at the same eye in time, where both a one level and a zero level are present. This is not possible if a pattern is analyzed. The software then identifies the first rising and trailing slopes in the window. All parameters (except the fall time) are then calculated from the rising slope area.

The eye-mode measurements start out by measuring the one and zero levels since many of the measurement parameters depend on these values. The one and zero levels are measured according to the figure below.

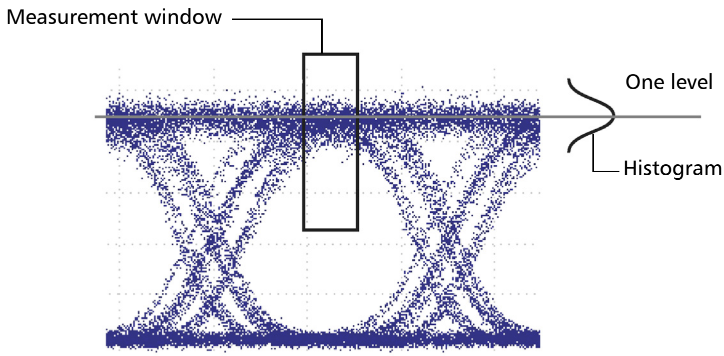


The default histogram window width for NRZ data is between 40 % and 60 % of the eye. For RZ, the default window is between 47.5 % and 52.5 %. These parameters can be changed in the **Measure** menu, under **Window width**.

Note: *If you measure on short RZ pulses for example from a ring laser, the 5 % window width will probably be too wide, and you would need to decrease the window width.*

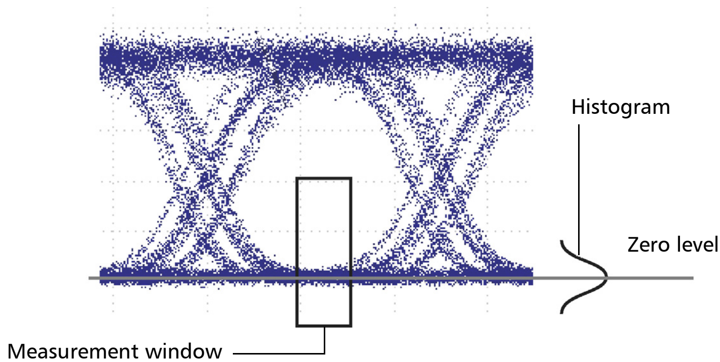
One Level

The one level, P_{one}, is the logic one level in the eye diagram. The mean level within the histogram window determines the one level.



Zero Level

The zero level, P_{zero}, is the logic zero level in the eye diagram. The mean level within the histogram window determines the zero level.



Signal-to-Noise Ratio

The eye signal-to-noise ratio (SNR) is a figure of merit of an eye diagram indicating the eye opening relative to the noise in both the one and zero levels. The eye SNR is defined as:

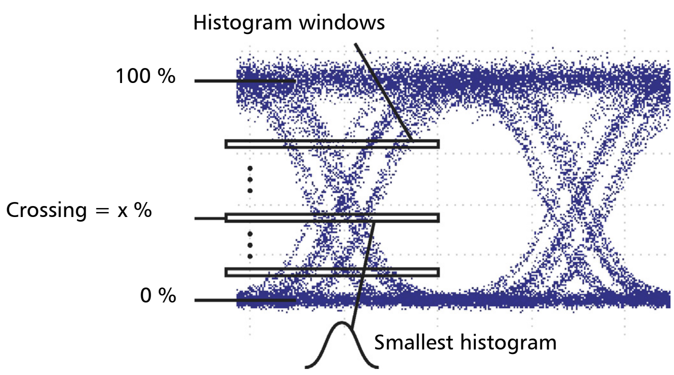
$$\text{EyeSNR} = 20\log_{10}\frac{(P_{one} - P_{zero})}{(\sigma_{one} + \sigma_{zero})}$$

The noise in the one and zero levels, σ_{one} and σ_{zero}, are the standard deviations of the histogram at each level.

Note: *The eye SNR, sometimes referred to as Q-value, is different from the SNR used in vertical histograms and the definition of signal sensitivity (that is* P^2_{one}/σ^2_{one}*).*

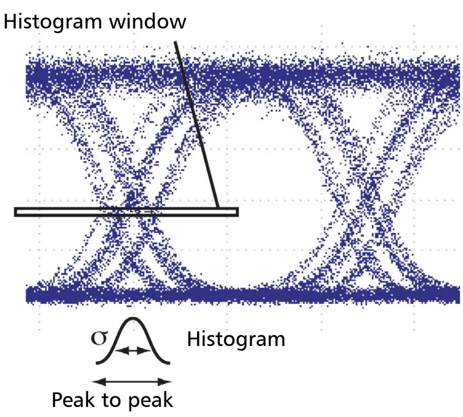
Crossing

The crossing percentage 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.



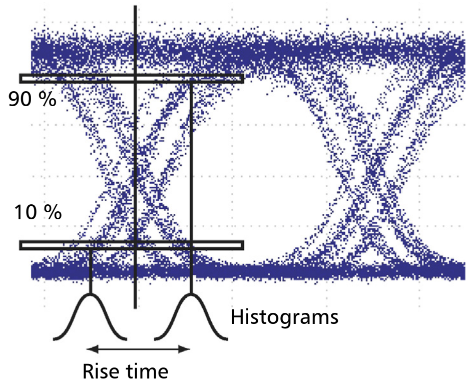
Timing Jitter

The timing jitter of an NRZ 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 (the largest and the smallest time value) in the histogram determine the peak-to-peak timing jitter.



Rise Time and Fall Time

The rise time is calculated from horizontal histograms according to the figure below.



The time delay between the times where the slope transits through the 10 % and up to the 90 % thresholds determines the rise time. In the same way, the fall time is calculated as the time delay between the transit times through the 90 % level down to the 10 % level. The 10-50-90 % thresholds can be changed to 20-50-80 % in the **Measure** menu under **Thresholds**.

Extinction Ratio

The extinction ratio (ER) of an eye diagram is simply the ratio between the one level and the zero level. The accuracy of the ER can be dominated by with which the zero level is measured. The DC offset in the instrument electronics in turn can affect this. It is therefore important that the dark level (P_{dark}) is calibrated before the ER measurement. Calibrating the dark level is done in the **Utilities** menu. The ER is defined as:

$$ER = \left(\frac{P_{one} - P_{dark}}{P_{zero} - P_{dark}}\right)$$

Eye Height

The eye height (EH) is a measurement of the vertical opening of an eye diagram and it is defined as:

$$EH = (P_{one} - 3\sigma_{one}) - (P_{zero} + 3\sigma_{zero})$$

Eye Amplitude

The eye amplitude (EA) is simply defined as the difference between the one and zero levels according to:

$$EA = P_{one} - P_{zero}$$

Eye Opening Factor

The eye-opening factor is a measurement of the vertical eye opening according to:

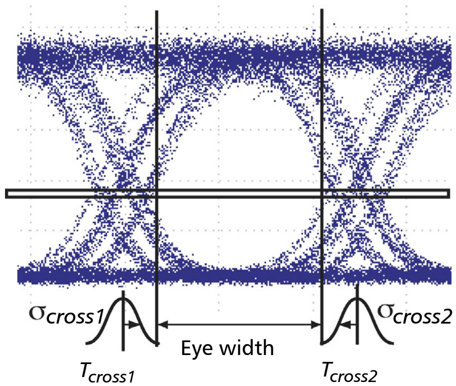
$$EOF = \frac{(P_{one} - \sigma_{one}) - (P_{zero} + \sigma_{zero})}{P_{one} - P_{zero}}$$

Eye Width

The eye width is a measurement of the horizontal opening of the eye. The eye width 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.

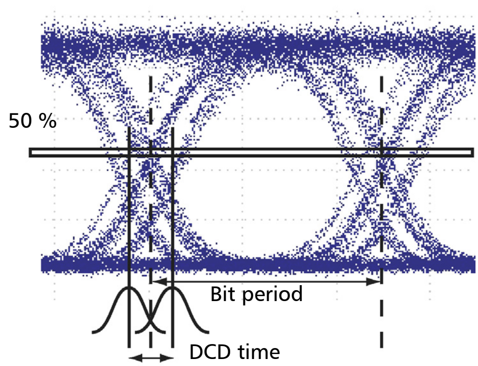


Duty Cycle Distortion

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. The DCD is defined in percentage of the bit period as:

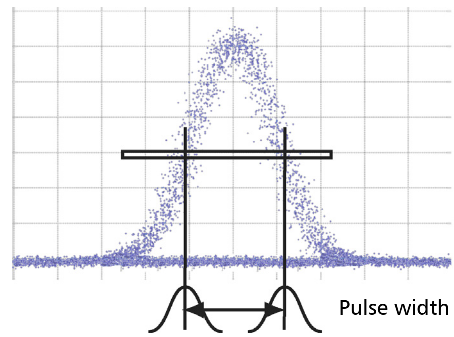
$$\mathrm{DCD} = 100\% \frac{|T_{\mathrm{rise,center}} - T_{\mathrm{fall,center}}|}{\mathrm{bit\ period}}$$

In a "perfect" eye with no timing- and amplitude jitter, and a 50 % crossing, the DCD is zero.



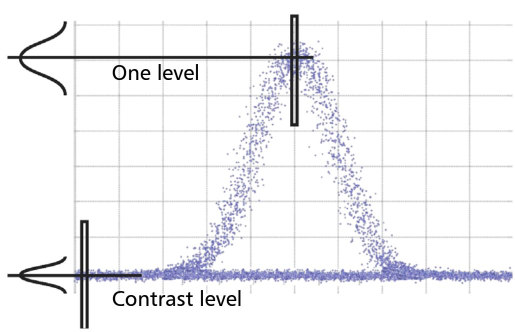
Pulse Width

The pulse width measurement is only possible for RZ pulses. It can be used both for eye diagrams and pulses without data modulation. From a thin horizontal histogram at the 50 % threshold between the one and zero levels the mean crossing points determine the pulse width.



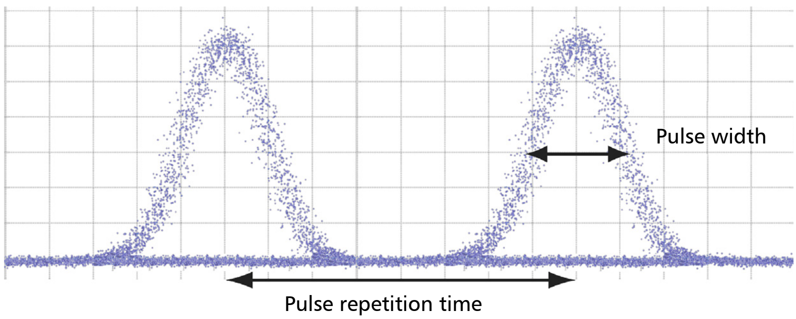
Contrast Ratio

The contrast ratio (CR) is only defined for RZ data as the ratio between the one level and the level between the pulses, that is $CR = P_{one}/P_{contrast}$. Similarly as for the ER, the CR depends on the accuracy of the DC offset level. It is therefore important to calibrate the dark level before measurement.



Duty Cycle

The duty cycle is only defined for RZ pulses or data as the ratio between the pulse width and the pulse repetition time.

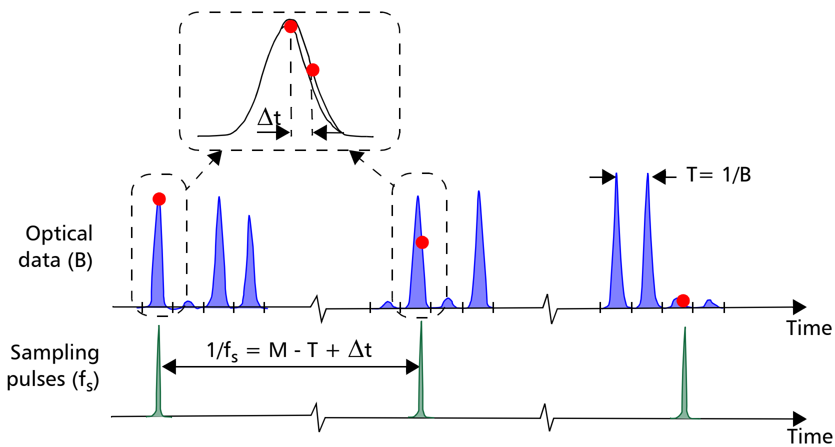


D Asynchronous Sampling Principle

Since the instrument has no hardware trigger, there is no way for the system to control the sampling frequency relative to the signal frequency, that is, the frequencies are asynchronous, and the sampling points will appear at seemingly random positions in time. In order to synchronize the data, the instrument relies on software synchronization. As a consequence, there are some forbidden signal frequencies that will be sampled at the same position of the eye, referred to as *frequency holes*.

Trigger-Free Synchronization

The figure below illustrates the optical data at bit rate B sampled at a sampling frequency of f_s. Samples of the signal with energy proportional to the signal power at the overlap with the sampling pulses are taken.



Eye diagram synchronization requires that the offset frequency, Δf, between the signal bit-rate, B, and the sampling frequency, f_s, related by $B=Mf_s+\Delta f$, is known. Assuming that the bit-rate is known within the correct $f_s/2$ interval, then the integer M, which is the number of bit slots between the samples, is well defined.

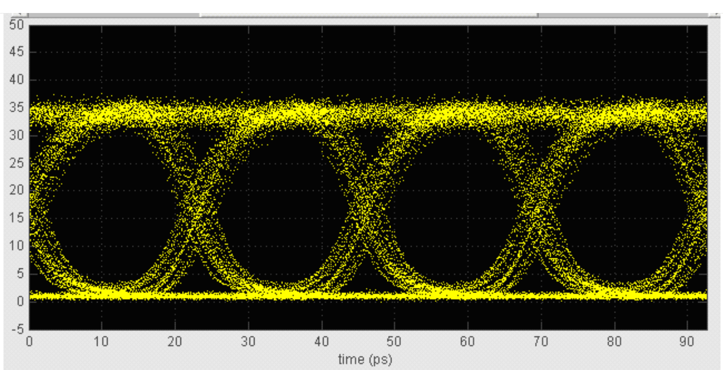
The offset frequency Δf is more conveniently expressed in terms of a corresponding time step, Δt (ps/sample), given by

$$\Delta t = \frac{1}{f_s} - \frac{M}{B}$$

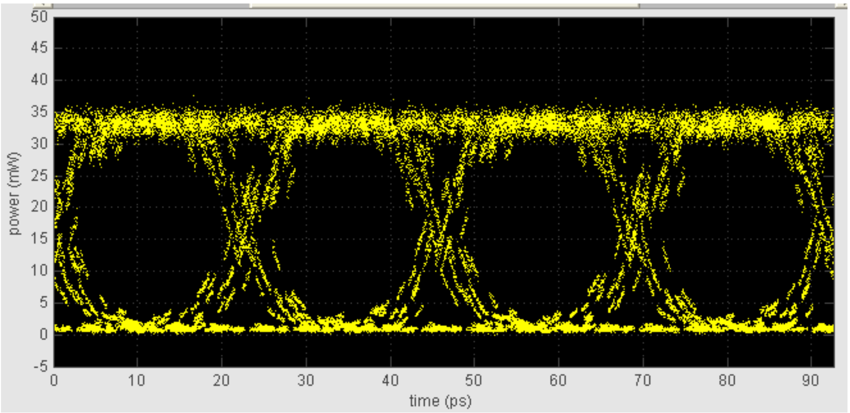
and referred to as the bit-slot scanning step. For correct synchronization you provide an estimate of the bit rate (in correct $f_s/2$ interval) and then the software computes Δt.

Frequency Holes

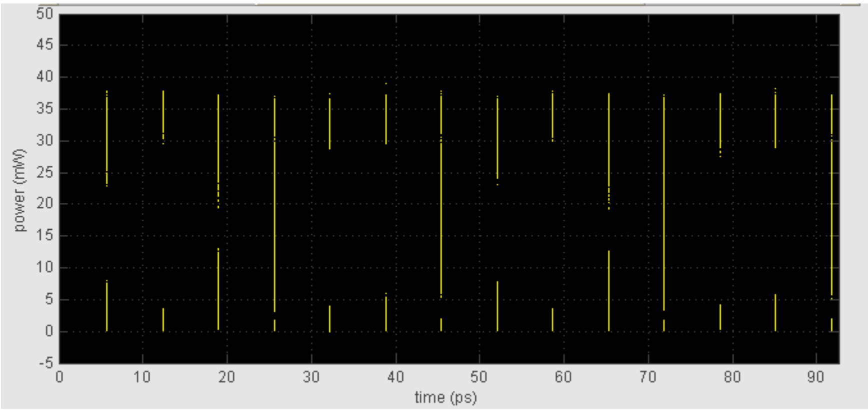
Due to the asynchronous sampling principle the system has no control over where the samples are taken relative to the input signal time position. This is generally not a problem since dramatic effects do not occur with large probability. A normal sampled 43.2 Gb/s eye diagram with 32 k samples and one layer is shown.



The samples are evenly distributed, but sometimes the samples could be unevenly distributed.



In rare cases, the samples could originate from just a few points in the eye diagram.



We call this phenomenon *frequency holes*, since there are certain distinct offsets between the signal frequency and the sample frequency that give rise to this effect. Since both the signal frequency and the sampling frequency drifts slightly with time, this effect may come and go in a random manner.

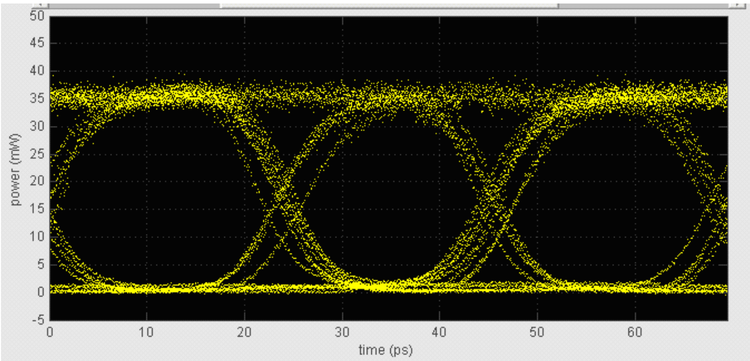
Directly after startup of the instrument the sampling frequency drifts relatively fast until it settles. During this time, you may pass a number of frequency holes. If you still have ended up in a situation with recurrent frequency holes, a possibility is to tune the signal frequency by only a few 100 Hz to jump out of the frequency hole. To reduce the probability for frequency holes, you can increase the number of samples/layers and the number of accumulated layers in the **Display** menu. We have calculated that the probability for frequency holes is less than 0.1 % for 128 k samples, if you characterize a frequency hole event by having less than 100 distinct points over one bit period.

Note: *If we visualize patterns instead, these events become more frequent as you increase the total time window.*

Pattern Effects

The software synchronization principle also results in another phenomenon. If there is no external clock present and you must rely on the internal signal synchronization, there may be pattern depending effects in some situations.

For example if you sample a 2^6-1 = 63 bit PRBS eye diagram and chose to visualize 3 eyes. Since 63 is evenly divisible by 3 you would see that not all combinations of transitions occur for every eye.



Besides, there is no way for the software to discriminate between different eyes from layer to layer. As a result, the eyes may jump around and look different from layer to layer. This may look strange the first time you see it, but now when you are aware of it, you know where it comes from. A way to get rid of this effect is of course to visualize for example 4 eyes instead of the 3 eyes shown here.

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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: 1056317

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ISO 9001

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