Agilent 86130A BitAlyzer®
Error Analysis
Getting Started

Agilent Technologies

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The following conventions are used in this book:

Key type for keys or text located on the keyboard or instrument.

Softkey type for key names that are displayed on the instrument's screen.

`Display type` for words or characters displayed on the computer's screen or instrument's display.

User type for words or characters that you type or enter.

Emphasis type for words or characters that emphasize some point or that are used as place holders for text that you type.

Why Use Error Analysis?

Although bit error ratio (BER) is the most fundamental measure of system performance, it may not provide enough information to isolate the cause of bit errors. Error analysis uses bit error measurements and error position information to help you isolate and solve bit error problems quickly.

What this guide contains

- Part 1 is a tutorial that will get you started using error analysis. Each tutorial lesson can be completed in approximately 20 minutes. To get the most from the tutorial, you should complete one lesson at a time in the order presented.
- Part 2 is a reference section that contains more detailed information.

Contents

Part 1: Error Analysis Tutorial

Part 2: Error Analysis Reference

Part 1

Error Analysis Tutorial

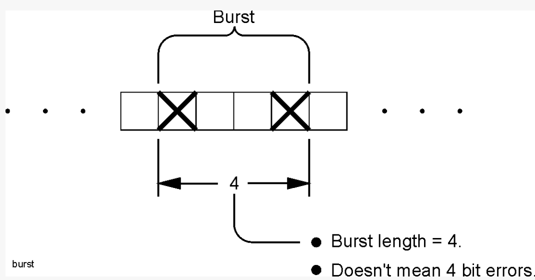
Lesson 1: Strip Chart Analysis

The purpose of strip chart analysis

- To see how BER develops over time. You can identify trends that help you understand how the BER of your system is affected. You can see how BER changes in response to temperature extremes or vibration. You can see if problems are localized to certain times or events.
- To see the proportion of bit vs. burst errors. You can see which type of errors dominate and which should be corrected first. The presence of burst errors indicates that there may be a non-random cause of bit errors that warrants further error analysis.

What is a burst?

A burst is group of errors that are close together and possibly related. The length of a burst does not necessarily correspond to the number of errors within a burst.



NOTE

The absence of burst errors does not rule out non-random causes of bit errors. Further analysis, such as error-free interval analysis, may be necessary.

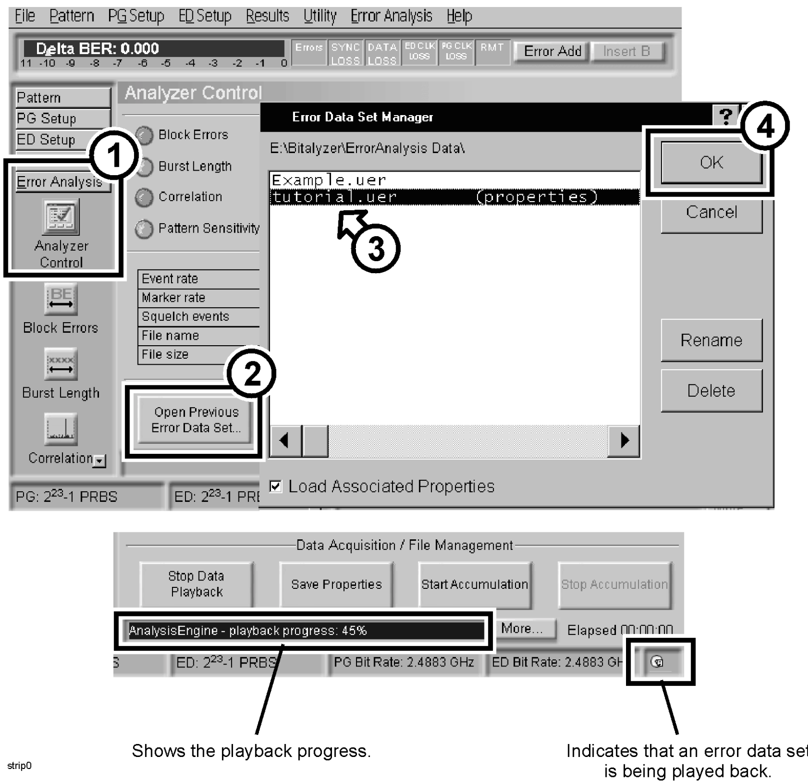
Settings that affect strip chart results

- Integration period (refer to page 1-8)
- Burst criteria (refer to page 1-11 and page 1-46)

How to View Strip Chart Results

1 Press **Preset** ● on the front panel.

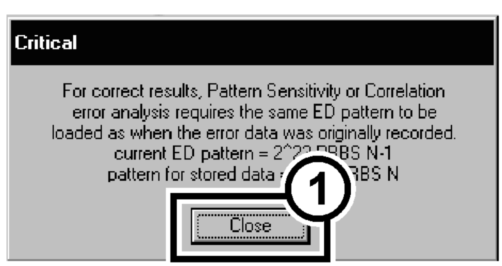
2 Open the data set “tutorial.uer.”



strip0

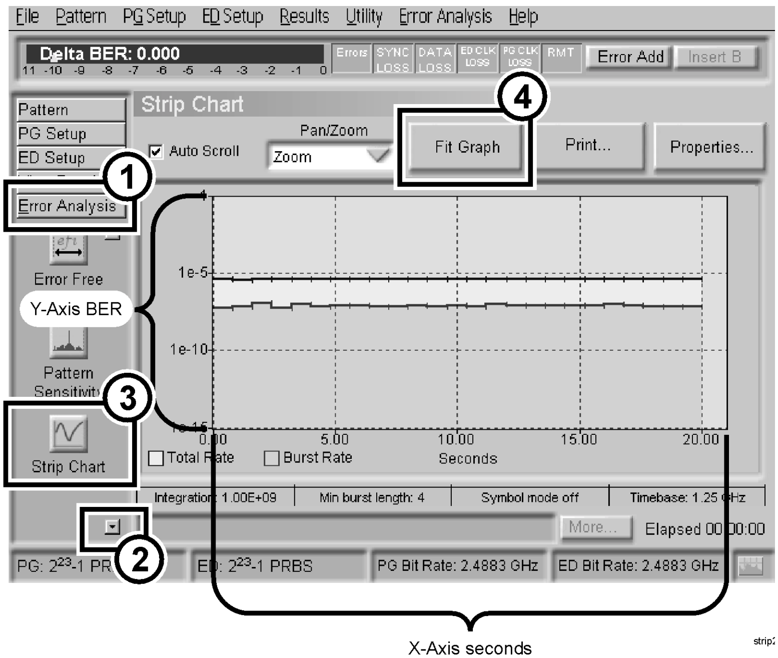
NOTE

The following critical message will also appear. Because this message is not important for strip chart analysis, you can touch **Close**.



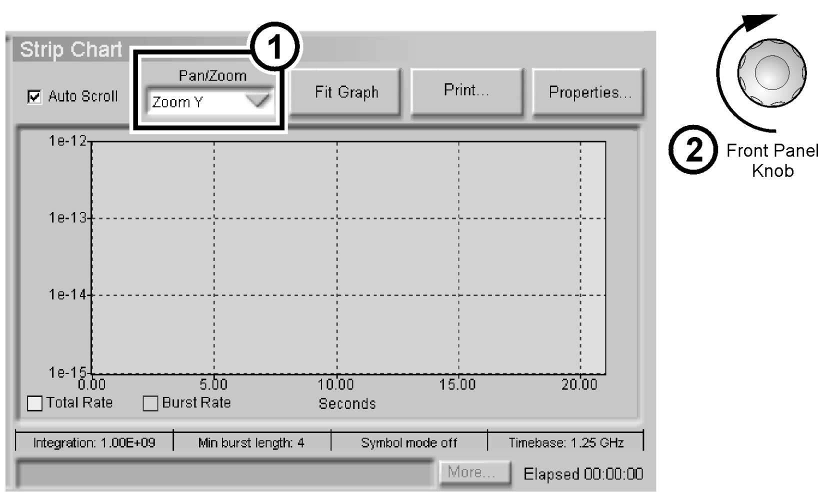
strip1

3 Access the **Strip Chart** results window and touch **Fit Graph**.

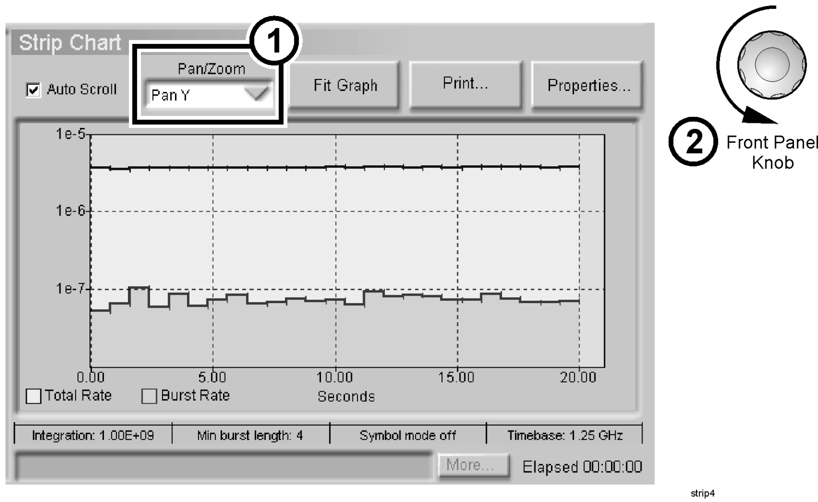


4 Zoom and pan to see more detail.

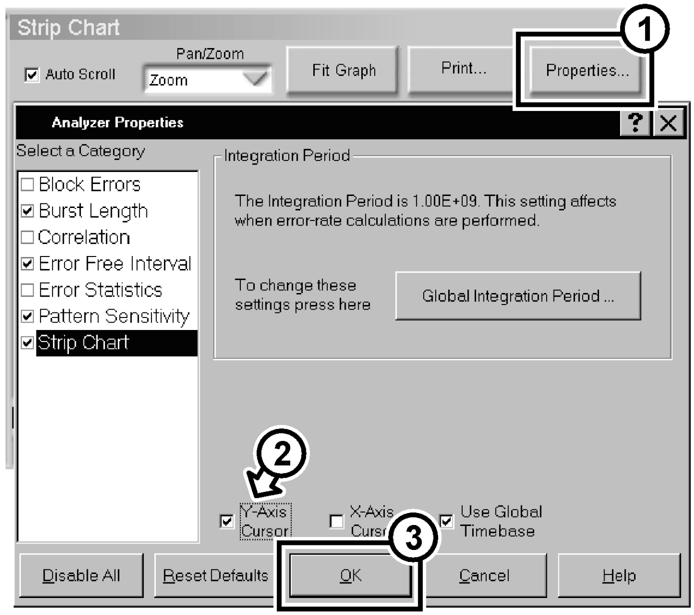
a Select **Zoom Y** from the **Pan/Zoom** list. Touch the display and drag up, or turn the front panel knob clockwise.



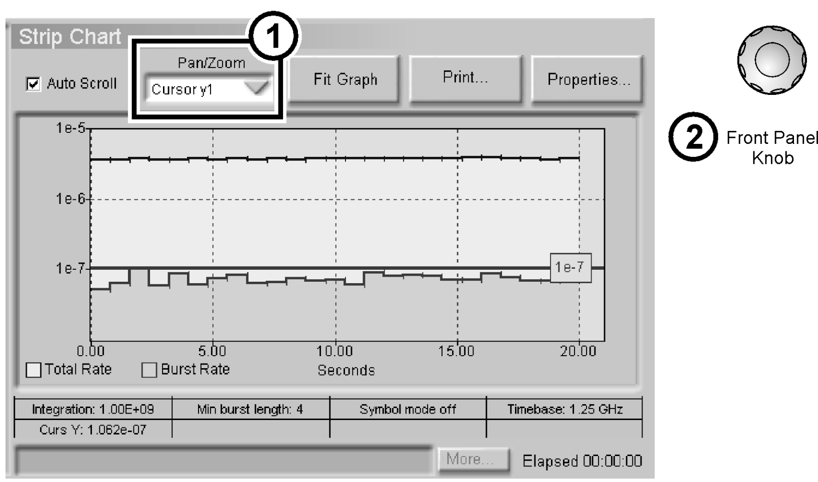
b Select **Pan Y** from the **Pan/Zoom** list. Touch the display and drag down, or turn the front panel knob counter-clockwise.



5 Turn on and position the Y-Axis cursor to find the highest burst BER.



strip5

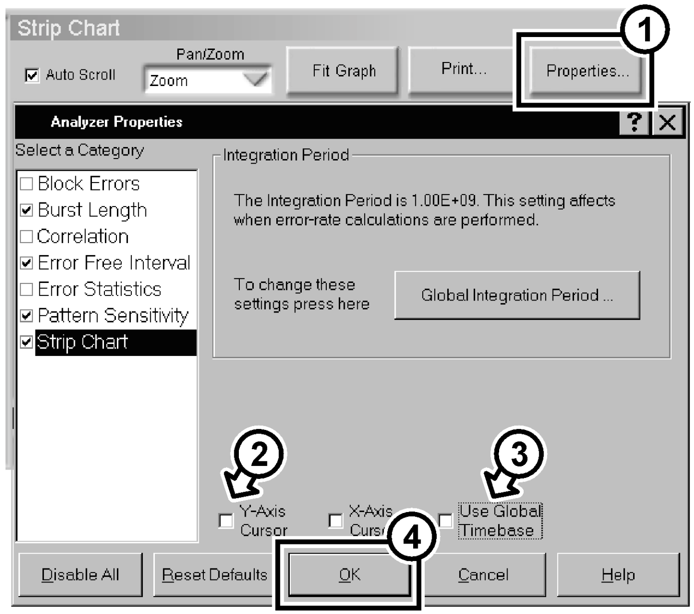


strip6

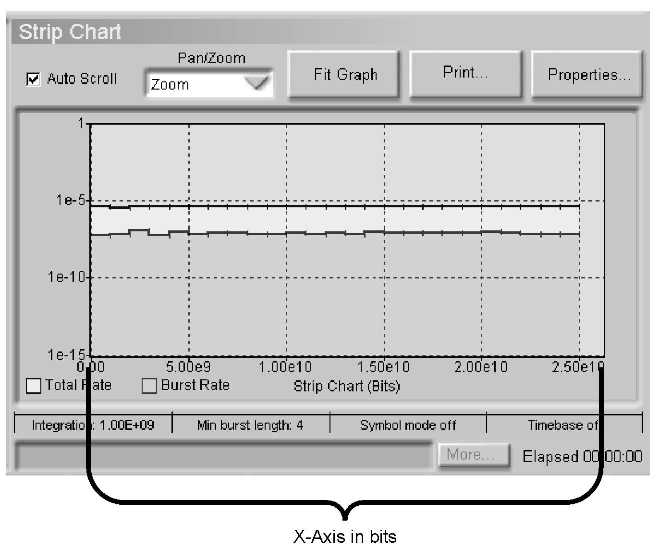
What are the results telling you?

The graph shows that the total BER was consistently high. It also showed that most errors were burst related, meaning that the BER can be improved by removing the non-random cause of errors.

6 Change the X-Axis from time to bits (clear the **Use Global Timebase** checkbox) and turn off the Y-Axis cursor.



strip7

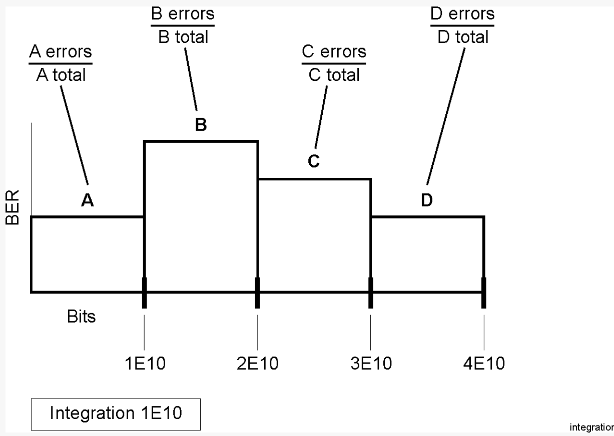


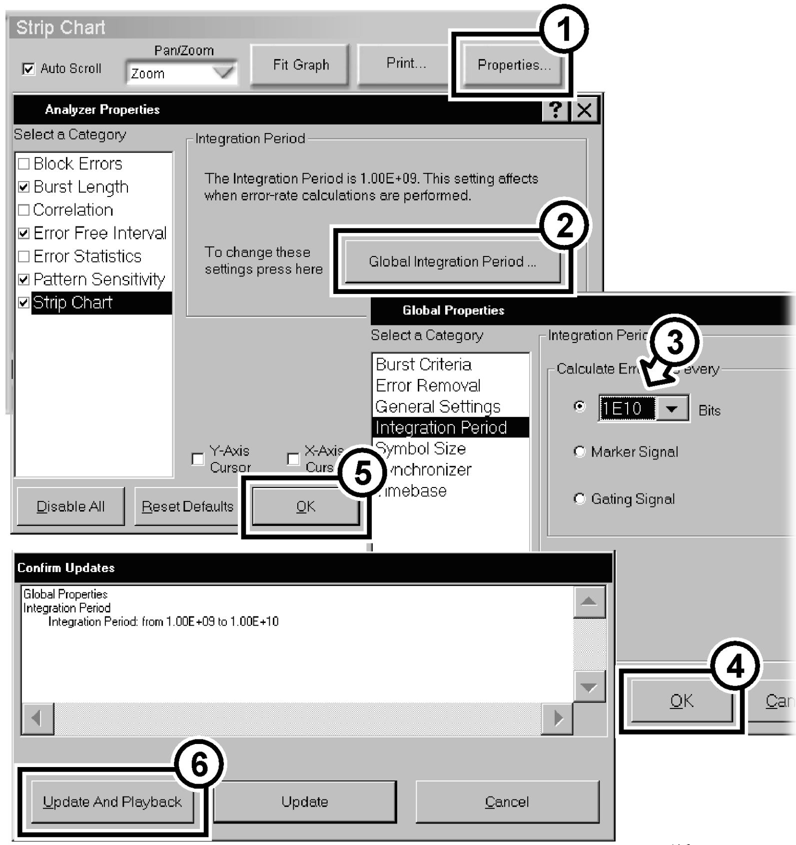
strip8

7 To view a longer-term trend in BER, change the **Integration Period** to 1E10.

What is the integration period?

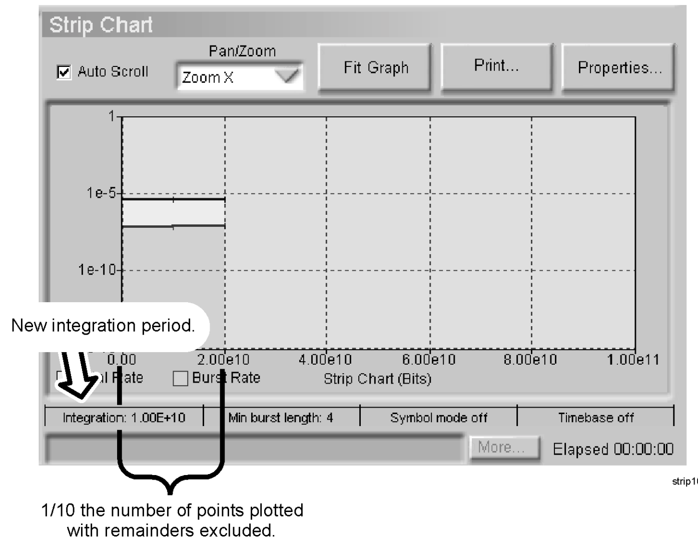
Each measurement point (line segment between tick marks) on the strip chart represents the BER averaged over a specific number of bits. This number of bits is called the integration period, and it affects the total number of points plotted. Smaller integration periods allow you to see short-term trends in BER, while larger periods allow you to see long-term trends.





strip9

NOTE When the critical message box appears, touch **Close**.



What are the results telling you?

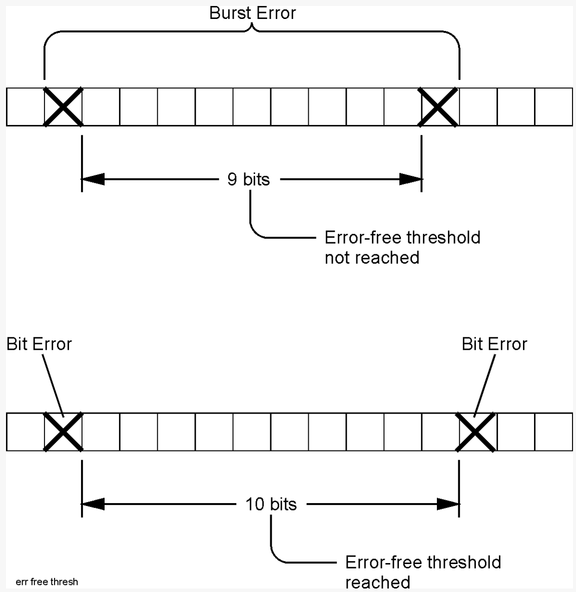
Changing the integration period from 1E9 to 1E10 caused 1/10 the number of points to be plotted. The remaining number of bits that did not equal a multiple of 1E10 were excluded from the results.

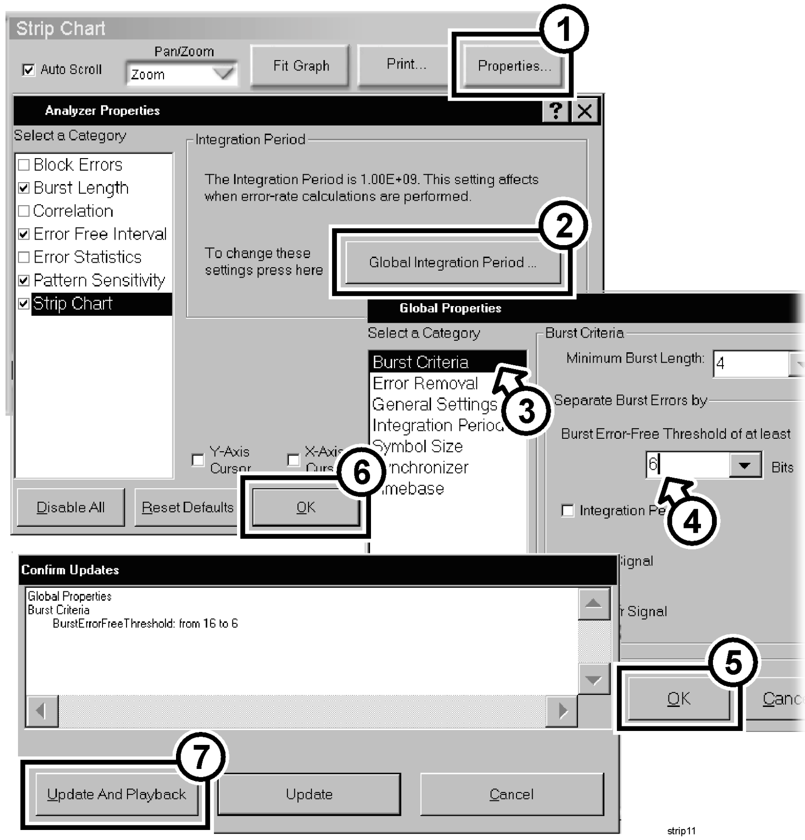
8 Change the **Integration Period** back to 1E9 (refer to the previous step).

9 To see how the burst criteria can affect strip chart results, change the **Burst Error-Free Threshold** to 6.

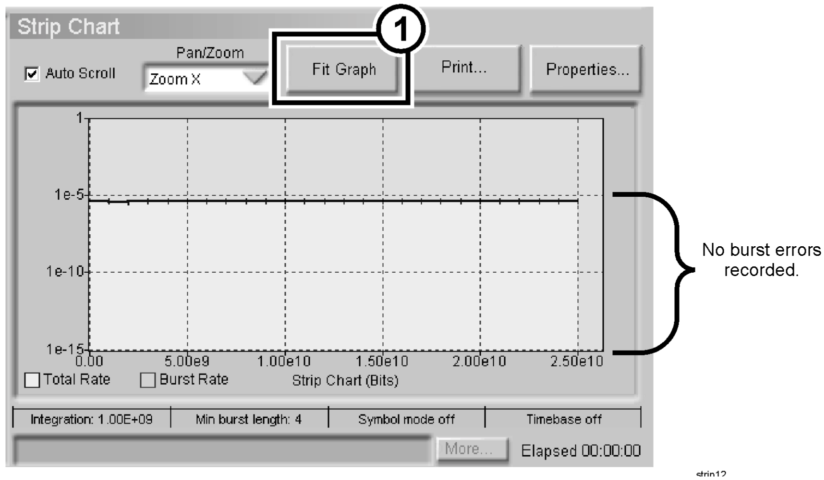
What is the burst error-free threshold?

Groups of errors are only classified as bursts if they meet the user-defined burst criteria. The burst criteria are made up of two components: minimum burst length and burst error-free threshold. For the following example, burst error-free threshold = 10.





NOTE	When the critical message box appears, touch **Close**.



What are the results telling you?

Changing the burst error-free threshold to 6 caused no burst errors to be recorded. Groups of bit errors were no longer classified as bursts because they were all >= 6 bits apart.

10 Change the **Burst Error-Free Threshold** back to 16 (refer to the previous step).

11 To find out the lengths of the burst errors, continue with"Lesson 2: Burst Length Analysis" on page 1-14.

Lesson 2: Burst Length Analysis

The purpose of burst length analysis

- To see if the distribution of burst lengths fits the profile for a specific cause of errors (error mechanism). There are a number of error mechanisms that have specific burst length profiles. You can compare your burst length results with these known profiles to see if there is any relation.

What is burst length?

Burst length is the number of bits from the first error to the last error in a burst. Both the first and last bit error are included in the burst length.

Settings that affect burst length results

- Burst error-free threshold (refer to page 1-8)
- Chart range and bin resolution (refer to page 1-27)

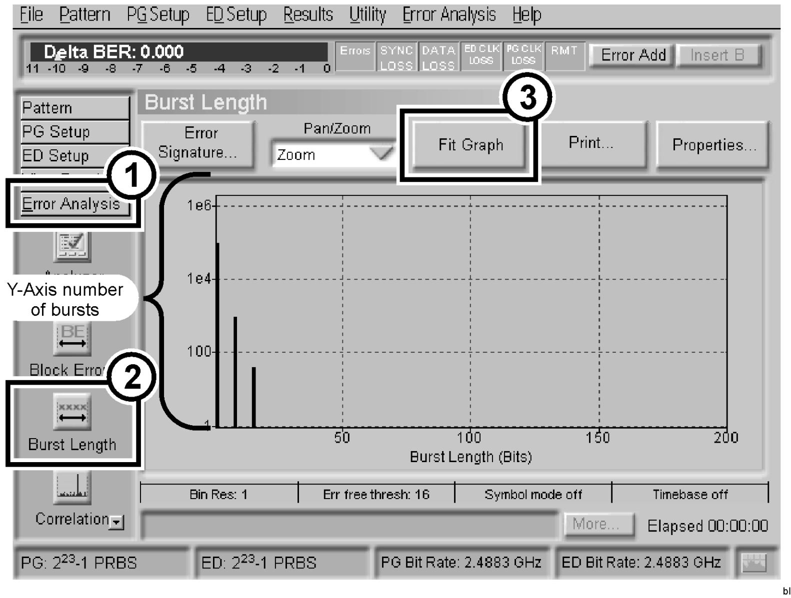
How to View Burst Length Results

1 Press **Preset** ● on the front panel.

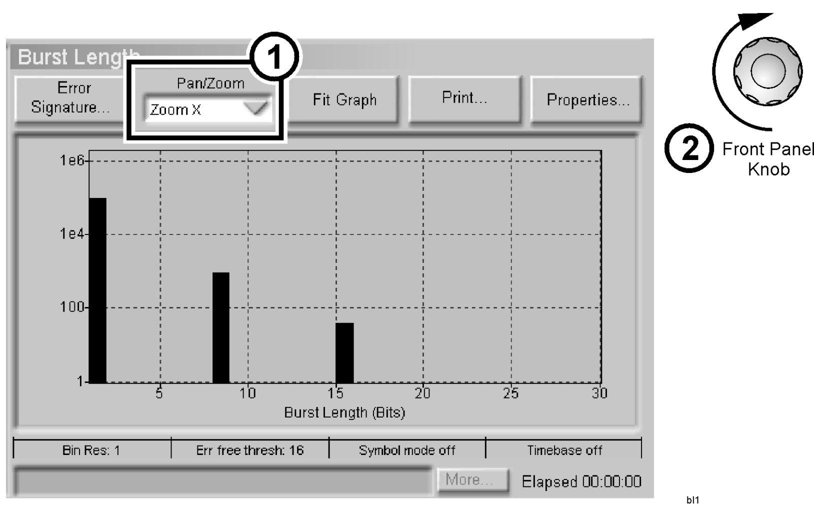
2 Open the previous data set “tutorial.uer” as shown on page 1-3.

NOTE When the critical message box appears, touch **Close**.

3 Access the **Burst Length** results window and touch **Fit Graph.**

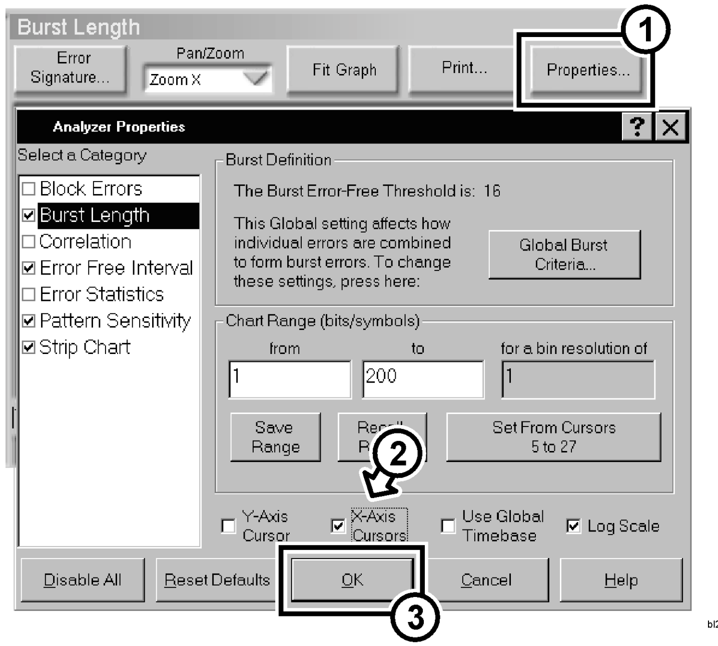


4 Use **Zoom X** to zoom in to the 1-to-30 burst length range.



5 Turn on and position X-Axis cursors on the burst length results.

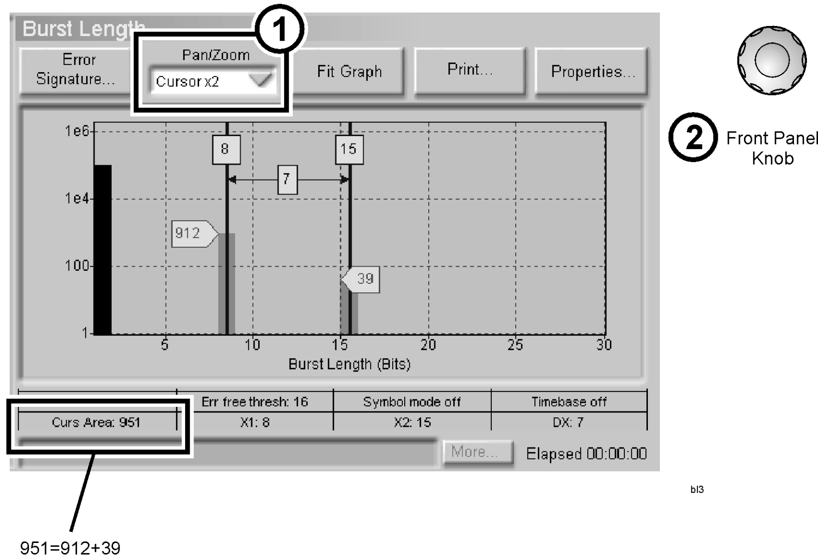
a In the **Properties** dialog box, select the **X-Axis Cursors** checkbox and touch **OK**.



b Select **Cursor x1** from the **Pan/Zoom** list. Touch and drag the cursor, or use the front panel knob to move the cursor to the desired position. Select **Cursor x2** and repeat.

NOTE

For rough or large changes in cursor position, it may be faster to touch and drag cursors. For fine adjustments of cursor position, it's best to use the front panel knob. If cursors do not respond to the front panel knob, touch any point on the graph and try again.



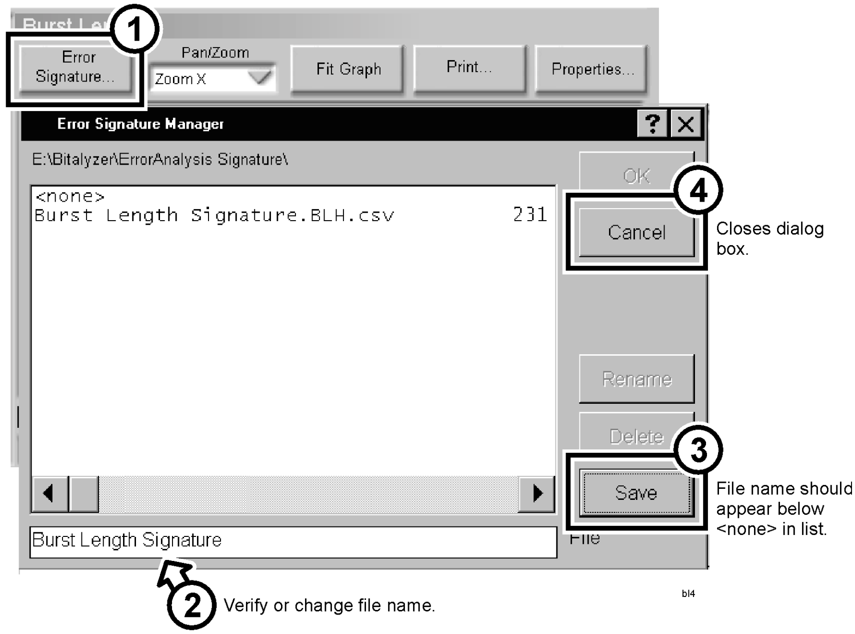
NOTE

Notice that the “Cursor Area” indicator adds up the occurrences of error bursts within the cursor range. The cursor range includes the position of x1 and x2.

What are the results telling you?

Burst errors occur at two specific burst lengths (8 and 15). Perfect “spikes” such as these often come from problems inside the signal processing core of a system. Other types of analysis, such as correlation or pattern sensitivity, may provide more information.

6 Save the error signature of the recorded burst length results.



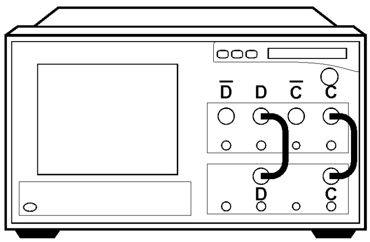
7 To compare these recorded results with live results, continue with "How to View Live Burst Length Results."

How to View Live Burst Length Results

NOTE

You cannot change settings and use **Update And Playback** while in live mode. For example, you cannot change the burst criteria or chart range without losing your results. For information on recording error data sets, refer to “How to Set up a Record File” on page 2-6.

1 Connect the PG clock and data ports directly to the ED clock and data ports.



2 Press 

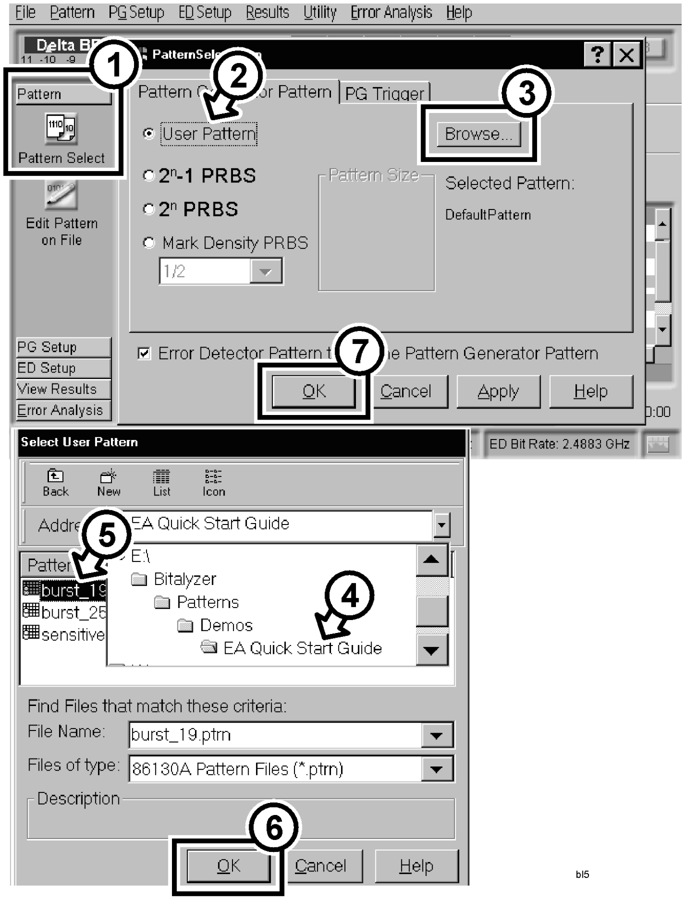
and select 

.

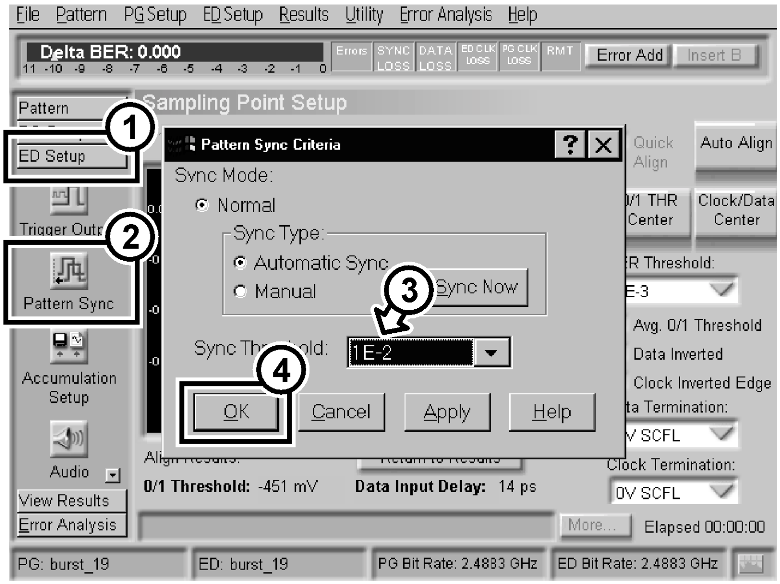
3 Press 

to optimize the sampling point.

4 Select alternate pattern “burst_19.ptrn” as the PG and ED pattern.

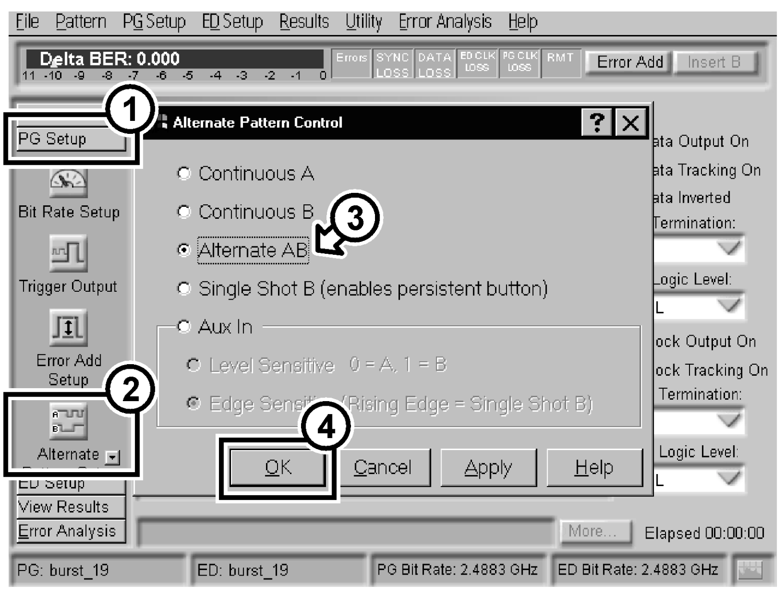


5 Change the **Sync Threshold** to 1E-2.



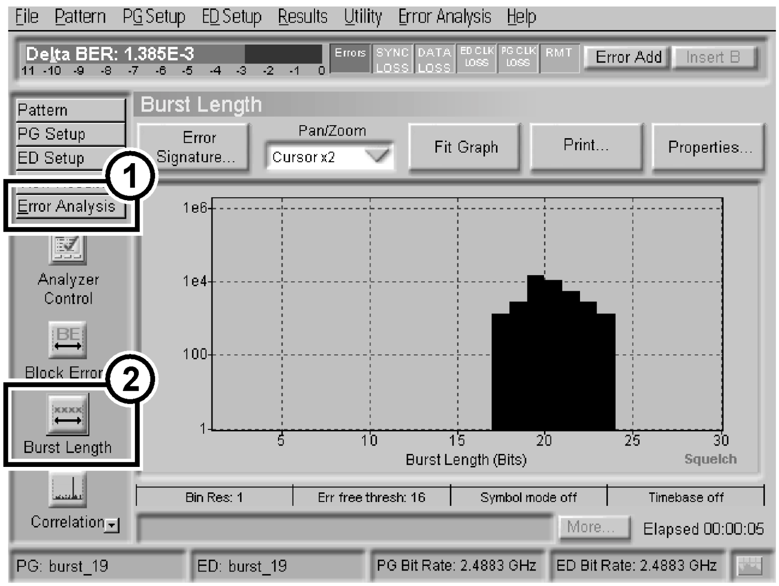
bl6

6 Select the **Alternate AB** alternate pattern control.



bl7

7 Access the **Burst Length** results window and accumulate for 5 to 10 seconds. (Press [Start Accum], wait 5 to 10 seconds, and press [Stop Accum].)



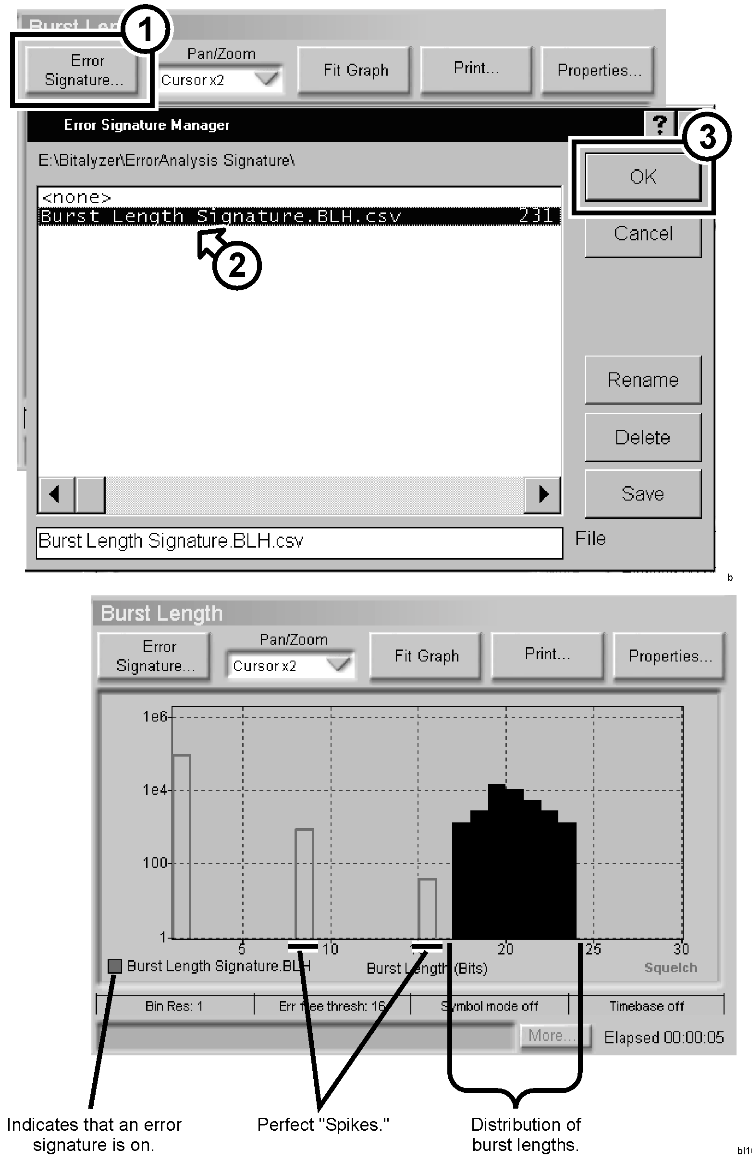
bl8

What does squelch mean?

Notice that the squelch indicator appeared on the lower right corner of the chart. This means that the error event rate was so high that there were periods when the analysis software was not able to process the number of errors that occurred.

Error analysis results are no longer accurate after squelching occurs. However, they are still useful in indicating that there is some type of non-random error mechanism.

8 Overlay the error signature of the recorded results.



NOTE Overlaying signatures is a quick way of matching or excluding known error mechanisms. To turn off the error signature, select “<none>” in the **Error Signature Manager** (refer to the previous step).

What are the results telling you?

There is a definite contrast between the live and recorded results. For the live results, there was a distribution of burst lengths (17 to 23) that centered around a peak (19). This fits the profile for a problem that is outside the signal processing core of a system.

9 For recorded results: to find out if there are signal processing errors related to the test pattern, continue with “Lesson 3: Pattern Sensitivity Analysis” on page 1-25.

Lesson 3: Pattern Sensitivity Analysis

The purpose of pattern sensitivity analysis

To find out if a specific bit sequence in a pattern causes errors. Pattern sensitivity is a very common source of bit errors in communications systems. This often happens because of bandwidth limited channels.

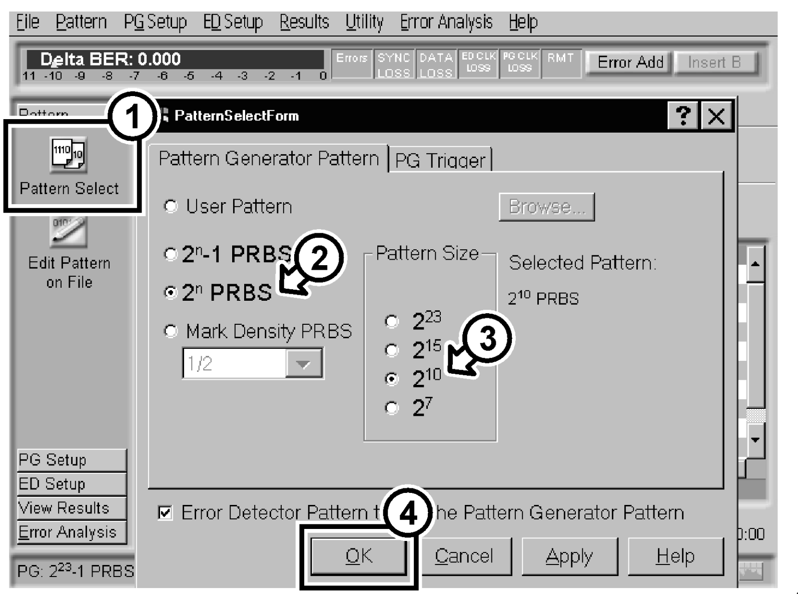
Settings that affect pattern sensitivity results

- ED pattern
- Chart range and bin resolution (refer to page 1-27)

How to View Pattern Sensitivity Results

1 Press **Preset** ● on the front panel.

2 Select 2^{10} PRBS as the PG and ED pattern.

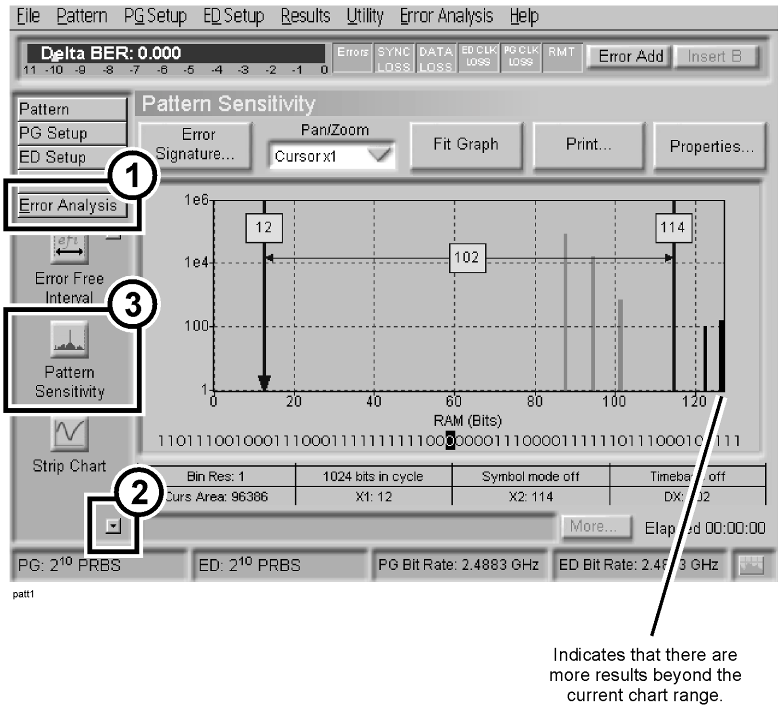


3 Open the previous data set “tutorial.uer” as shown on page 1-3.

NOTE

Because the correct pattern has been selected, the critical message box should not appear.

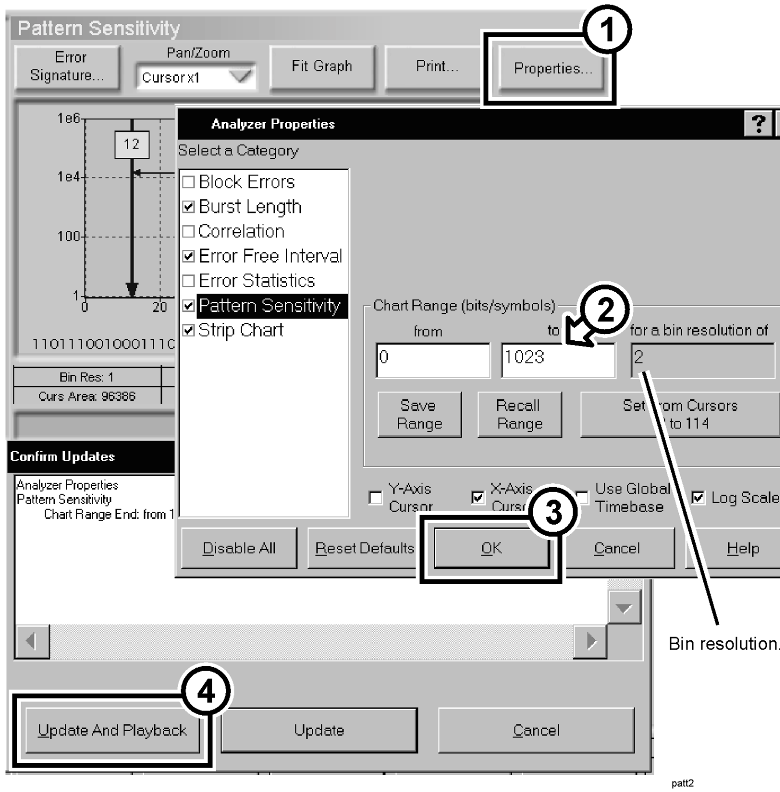
4 Access the **Pattern Sensitivity** results window.



NOTE

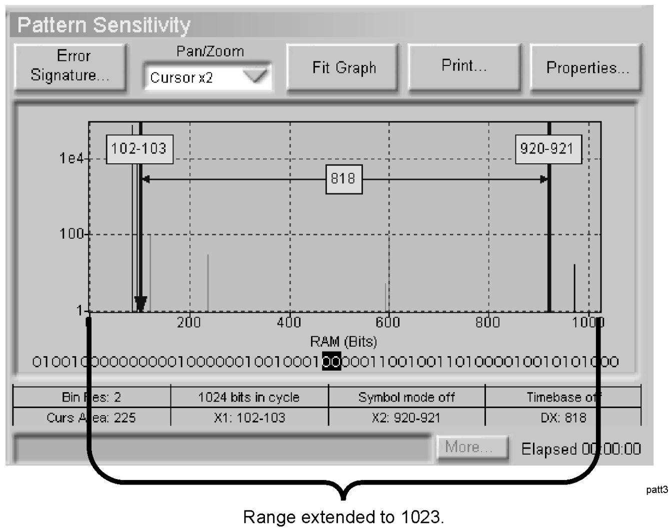
Notice that the peak on the right-most side of the chart is thicker in appearance. A peak such as this can appear on the left-most or right-most side of any analyzer chart, indicating that there are more results beyond the current chart range.

5 To see results for all bit positions in the pattern, change the chart end range to 1023. Notice that the bin resolution changed to 2.

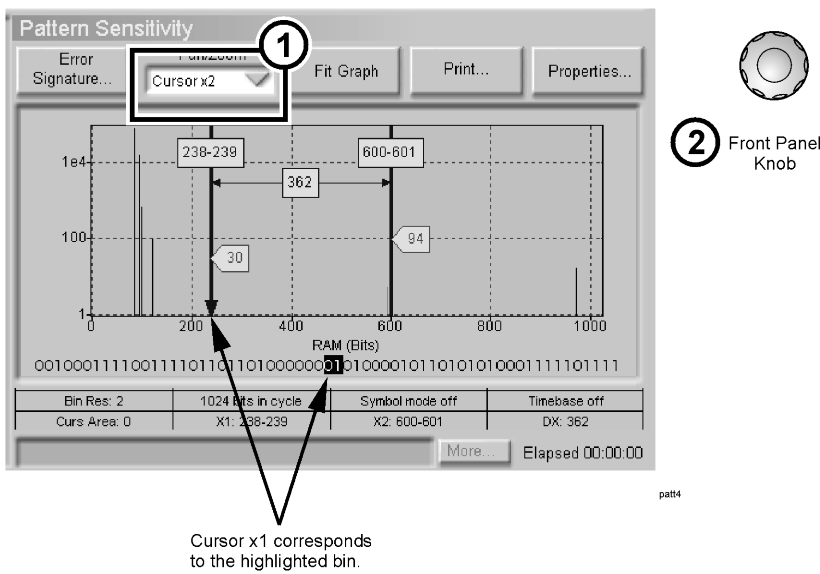


What is bin resolution?

Each point on the x-axis of a results graph is called a bin, and there are a maximum of 1000 bins available. The bin resolution for pattern sensitivity indicates how many bits are represented by one bin. Chart ranges greater than 1000 cause bin resolutions to be greater than 1.



6 Position the X-Axis cursors on two of the smaller results (refer to page 1-16).



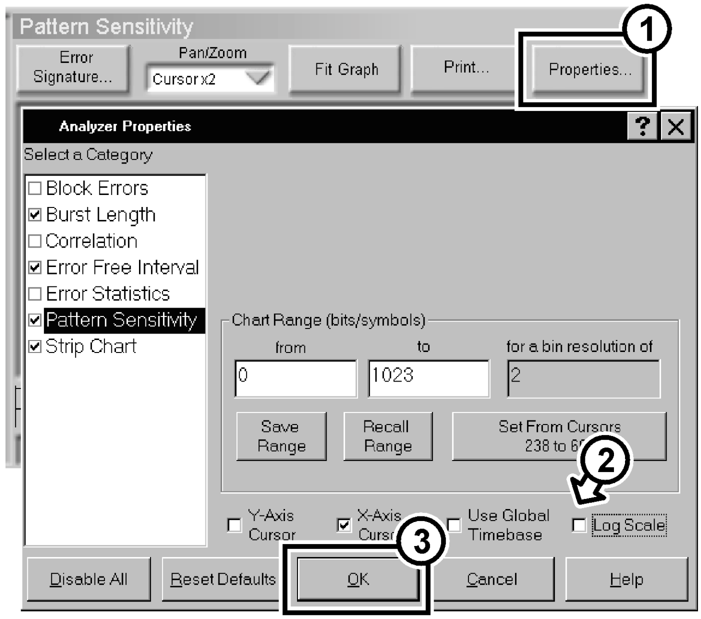
NOTE The position of cursor x1 corresponds to the highlighted bin (containing one or more bits) below the chart. This allows you to see where bits are located in the pattern.

What are the results telling you?

Because bin resolution is 2, the highlighted bin contains 2 bits. This means that one or both of the highlighted bits is errored.

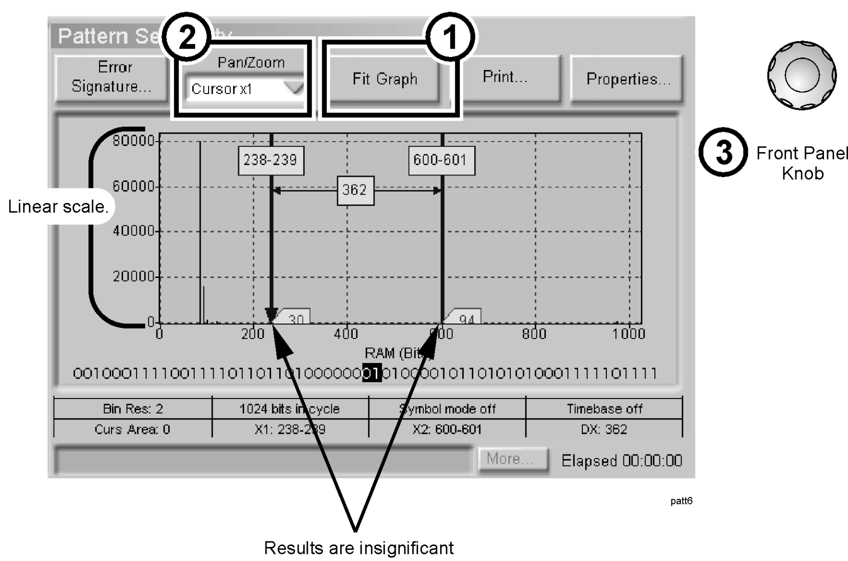
Notice that the results beyond position 127 (the default chart range) are insignificant in comparison with the larger results. To illustrate this further, continue with step 7.

7 To view results in a different way, change the chart scale from log to linear.



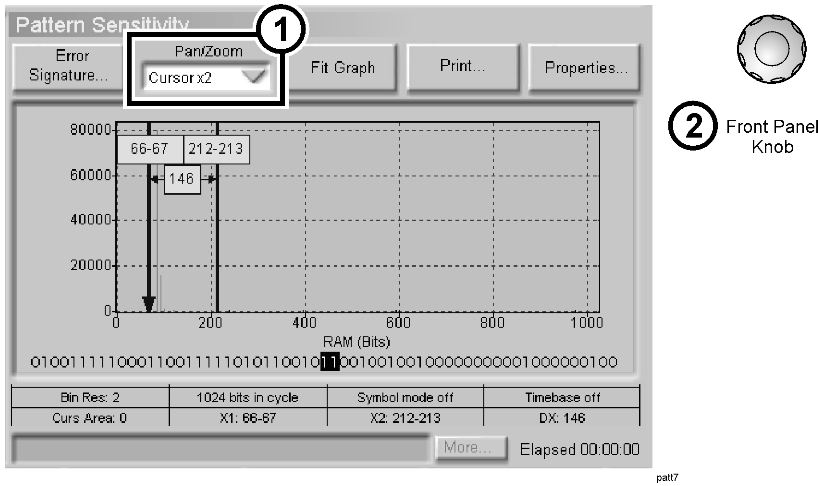
patt5

8 Touch **Fit Graph** and position the cursors to their previous locations. (X1 cursor: 238-239. X2 cursor: 600-601.)

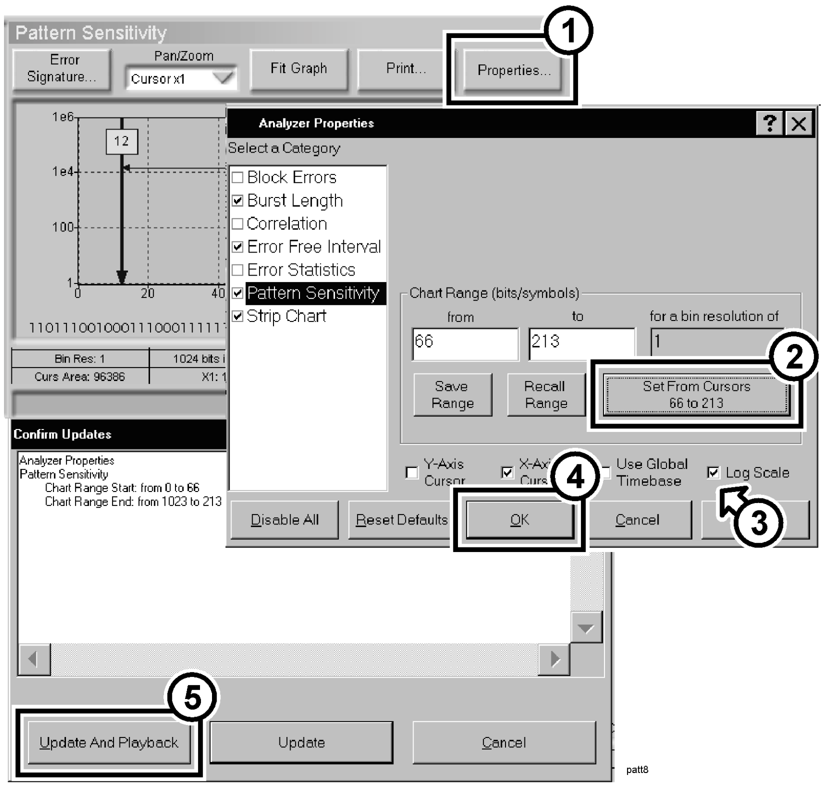


patt6

9 Position X-Axis cursors to "surround" the larger results (refer to page 1-16).

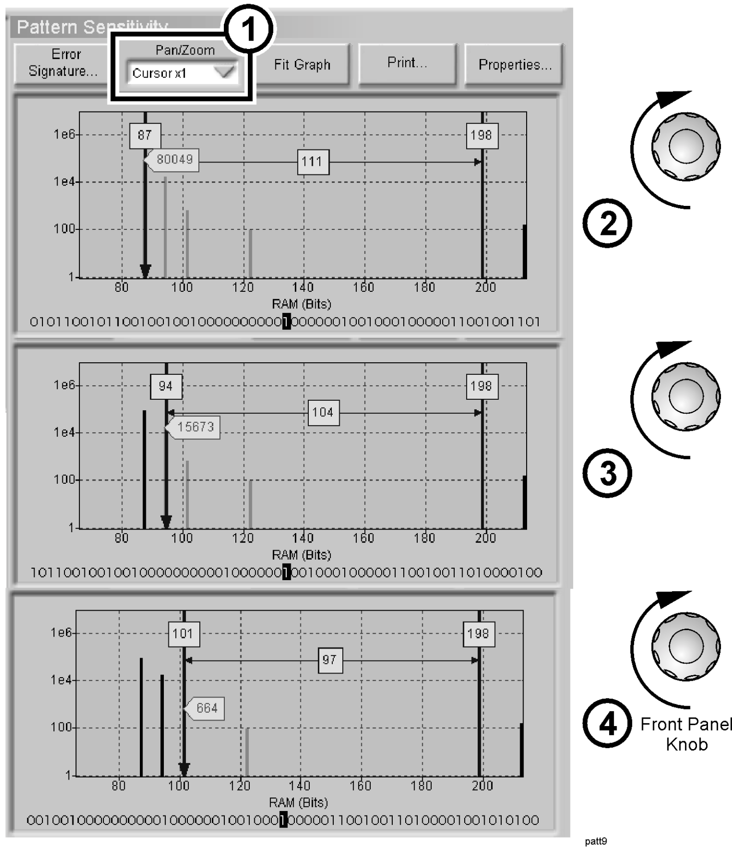


10 Set the chart range to the cursor range, and change the chart scale back to log.



11 Position cursor x1 on the 3 largest peaks and make note of the results.

NOTE To see the results more clearly, decrease the zoom of the y-axis. The quickest way to do this is to touch the display and drag down.



What are the results telling you?

The results indicate a high occurrence of pattern sensitivity to isolated 1’s among long strings of 0’s.

The results also indicate that pattern sensitivity is the origin of the burst length results as seen on page 1-15. If bit errors occurred simultaneously in positions 87 and 94, a burst length of 8 would result. If bit errors occurred simultaneously in positions 87 and 101, a burst length of 15 would result.

To find out what caused this pattern sensitivity, continue with “Lesson 4: Error-Free Interval Analysis” on page 1-34.

Lesson 4: Error-Free Interval Analysis

What is an error-free interval?

An error-free interval is an error-free gap between errors. An error-free interval distance is measured in bits or time.

The purpose of error-free interval analysis

- To find out if there are repetitive errors in your system by viewing the number of occurrences of error-free intervals. If certain error-free intervals occur more often than others, then your errors are not random. The error-free interval distance in bits can also be translated into a time period.

Settings that affect error-free interval results

- Chart range and bin resolution (refer to page 1-27)

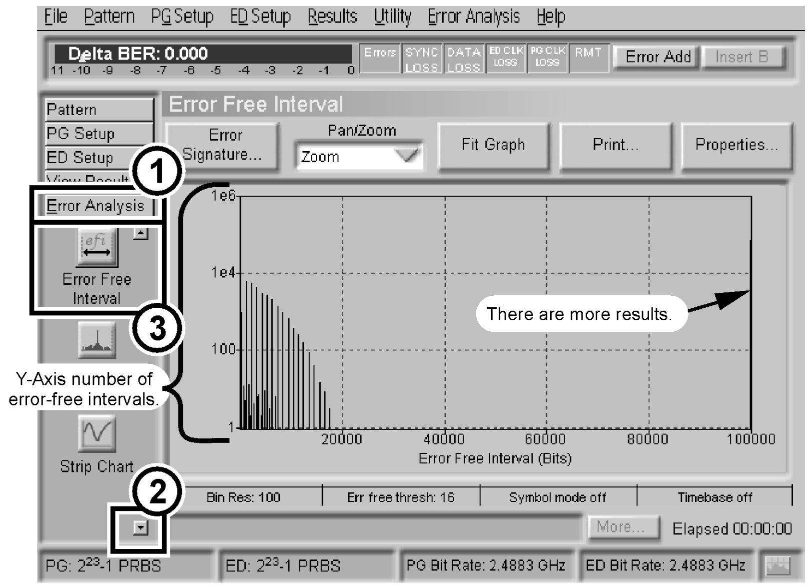
How to View Error-Free Interval Results

1 Press **Preset** ● on the front panel.

2 Open the previous data set “tutorial.uer” as shown on page 1-3.

NOTE When the critical message box appears, touch **Close**.

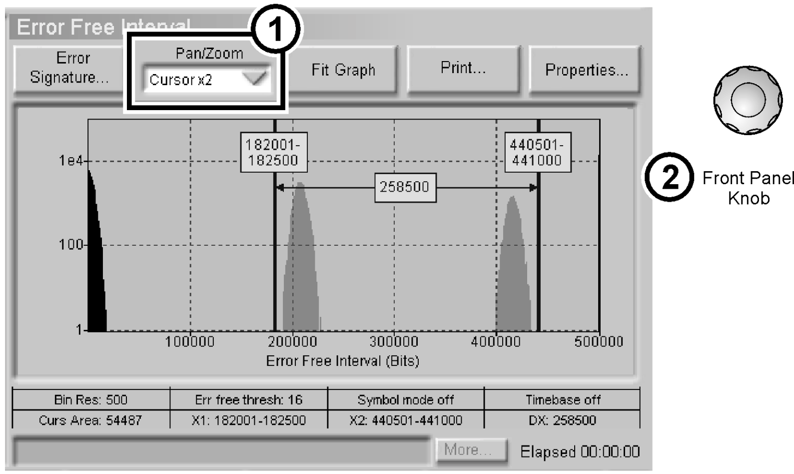
3 Access the **Error-Free Interval** results window.



efi0

4 To see more data, change the chart range to 500,000 (refer to page 1-27).

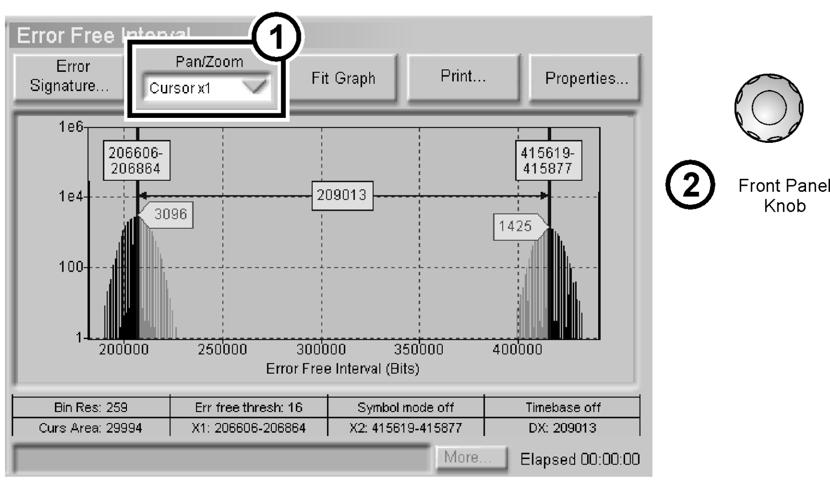
5 Turn on and position X-Axis cursors to surround two peaks (refer to page 1-16).



efi1

> **What are the results telling you?**
>
> The distribution of error-free intervals indicates that there is repetitive, external interference. The interference is inducing pattern sensitivity in the test device.

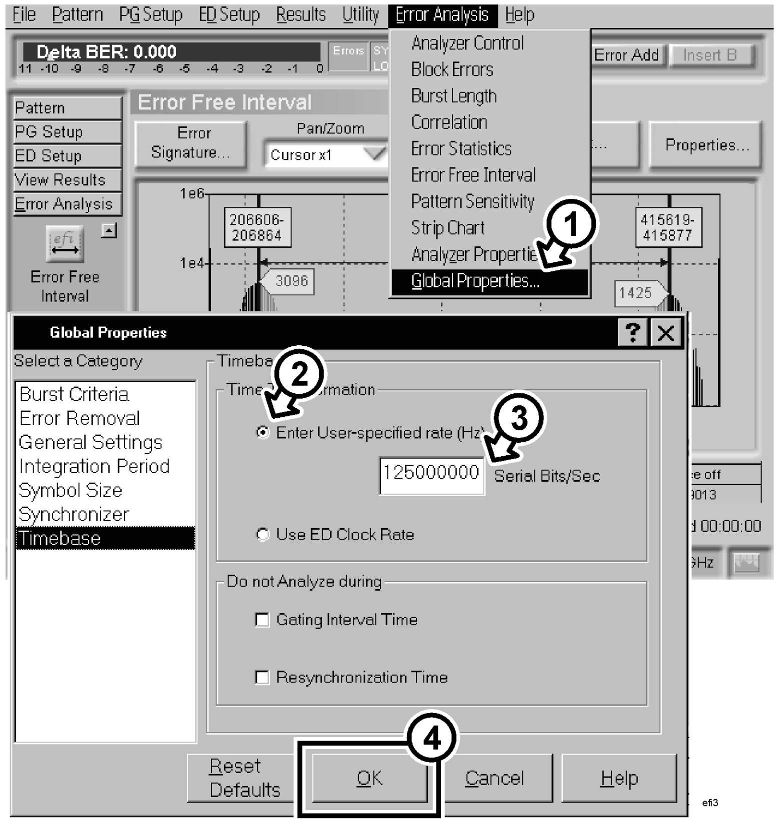
6 Set the chart range to the cursor range (refer to page 1-32) and position the cursors on the two peaks.



efi2

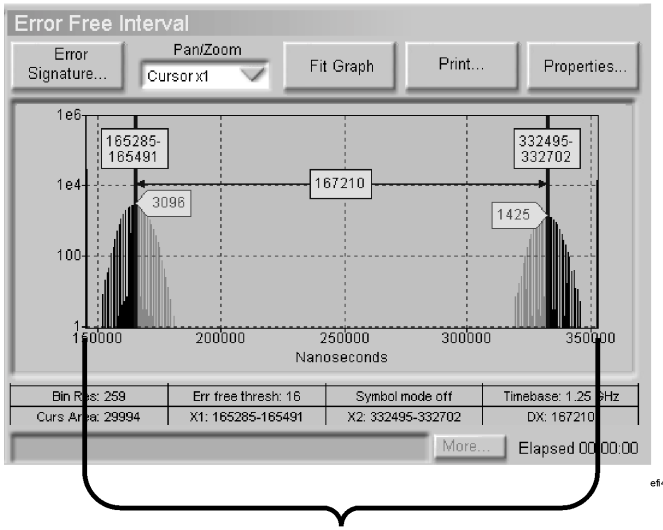
7 Change the X-Axis from bits to time.

a Make sure that the global timebase is set to 1.25 GHz (this was the bit rate used while recording “tutorial.uer”).



NOTE	To ensure accurate results, the global timebase must be set to the bit rate used during your measurement.

b In the **Properties** dialog box, select the **Use Global Timebase** checkbox (refer to page 1-7).



8 Invert the time period between peaks to find the frequency of the interference.

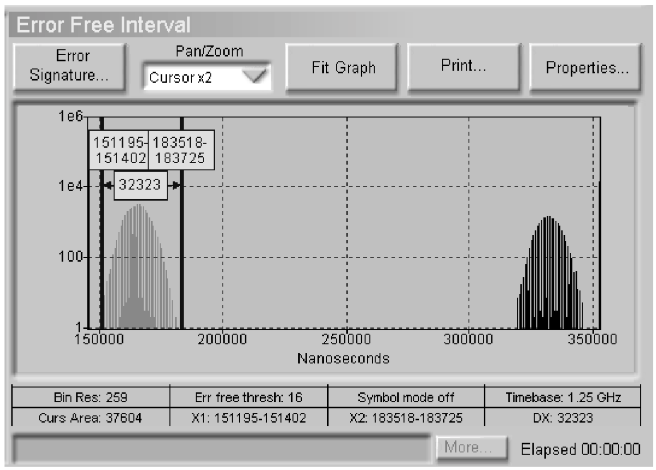
What are the results telling you?

The inverse of 167,210 ns is 5.98 kHz. Knowing the frequency of interference may help you isolate the cause of errors in your system.

How to Save and Recall Chart Ranges

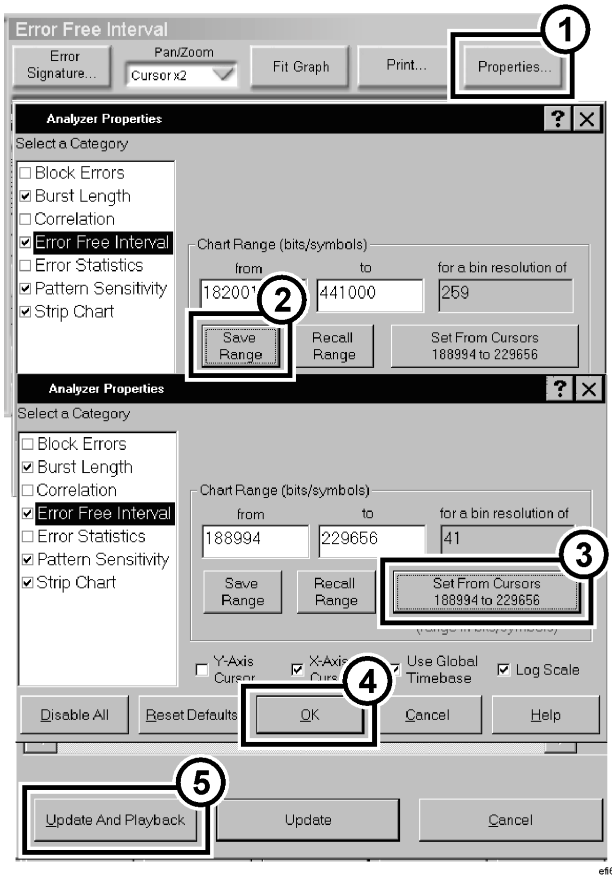
If you don't want to lose your current range settings, you can use the save and recall range functions.

1 Position the X-Axis cursors to surround one peak.

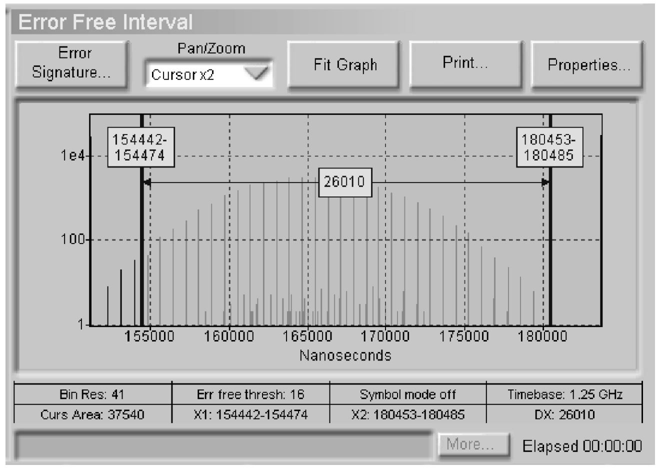


efi5

2 In the **Properties** dialog box, save your current chart range, then set the chart range to the cursor range.

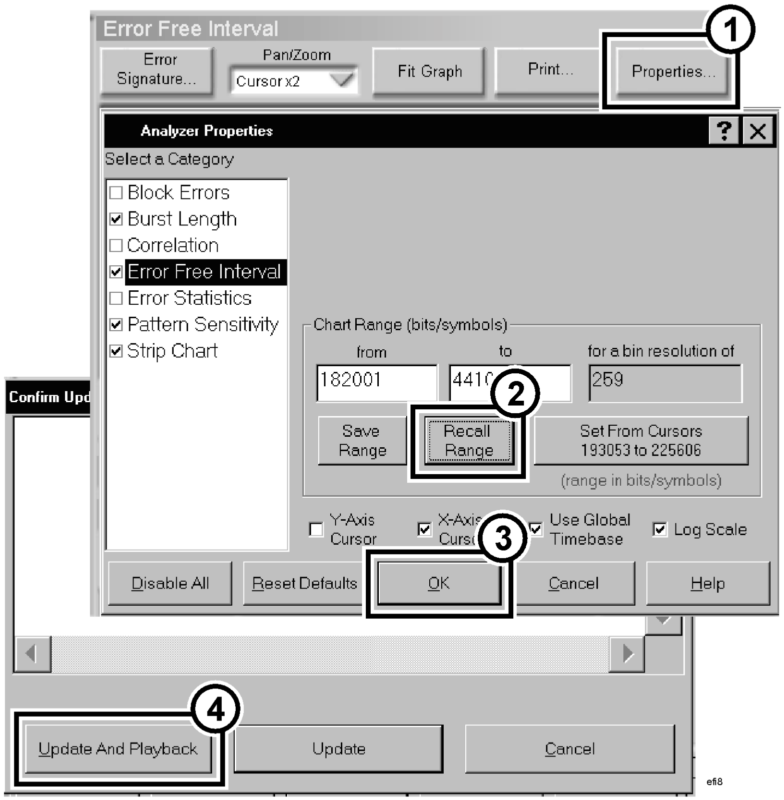


NOTE When the critical message box appears, touch **Close**.


Error Free Interval
Error Signature...
Pan/Zoom
Cursor x2
Fit Graph
Print...
Properties...
154442-
154474
180453-
180485
26010
1e4
100
1
155000
160000
165000
170000
175000
180000
Nanoseconds
Bin Res: 41
Err free thresh: 16
Symbol mode off
Timebase: 1.25 GHz
Curs Area: 37540
X1: 154442-154474
X2: 180453-180485
DX: 26010
More...
Elapsed 00:00:00

efi7

3 You can go back to your saved chart range at any time: Open the **Properties** dialog box and and touch **Recall Range**.



NOTE When the critical message box appears, touch **Close**.

Lesson 5: Error Statistics Analysis

Error statistics can be used as a numeric summary of the total, burst, and non-burst related errors covering your entire experiment. Error counts and ratios are included. In addition, the key settings that effect statistics results are shown.

You can use error statistics to separate out burst and non-burst related errors, and to nominally check the overall BER of your measurement.

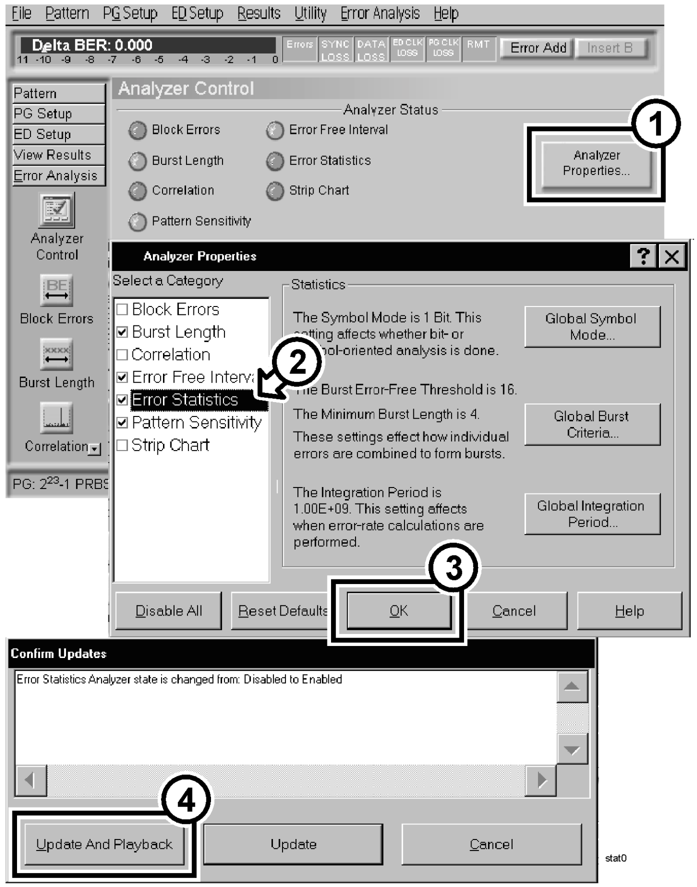
How to View Error Statistics

1 Press **Preset** ● on the front panel.

2 Open the previous data set “tutorial.uer” as shown on page 1-3.

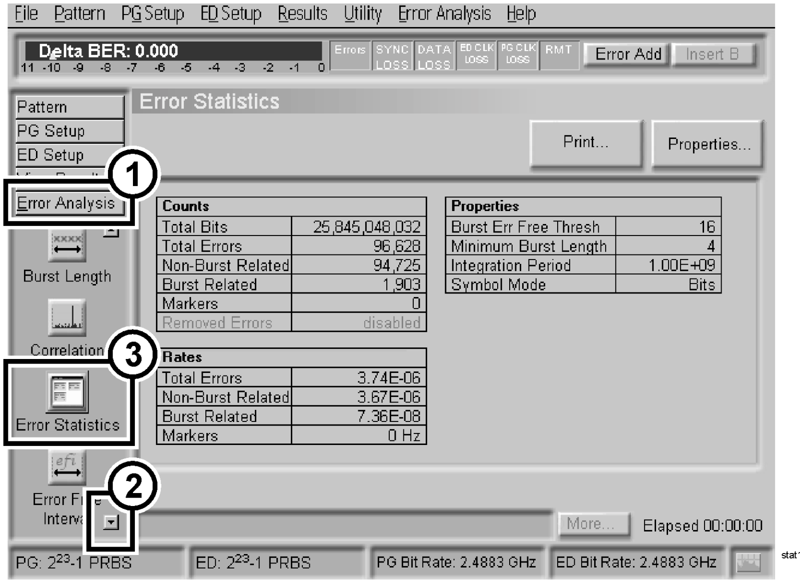
NOTE When the critical message box appears, touch **Close**.

3 Enable the error statistics analyzer.



NOTE	When the critical message box appears, touch **Close**.

4 Access the **Error Statistics** results window.

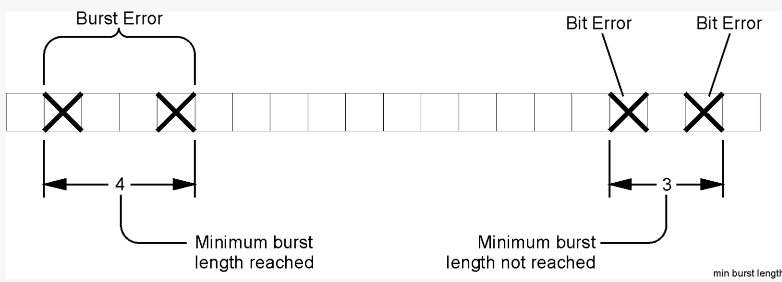


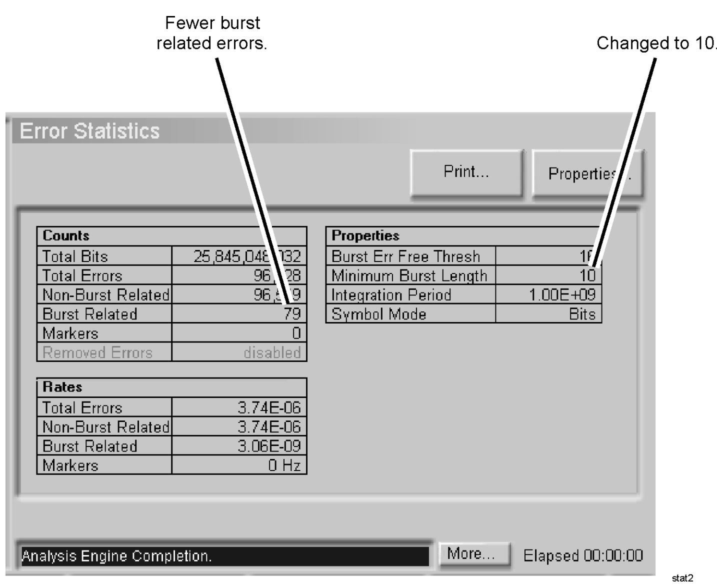
NOTE	The **Total Bits** count will vary slightly from the accumulated results **Bit Count**. This is due to differences in hardware and software accumulation startup times. The hardware responds immediately when **Start Accumulation** is pressed, whereas software startup procedures introduce a small indeterminate lag time before software accumulation begins.

5 To see how the burst criteria can change error statistics results, change the **Minimum Burst Length** to 10 (refer to page 1-11).

What is the minimum burst length?

Groups of errors are only classified as bursts if they meet the user-defined burst criteria. The burst criteria are made up two components: minimum burst length and burst error-free threshold. For the following example, minimum burst length = 4.





What are the results telling you?

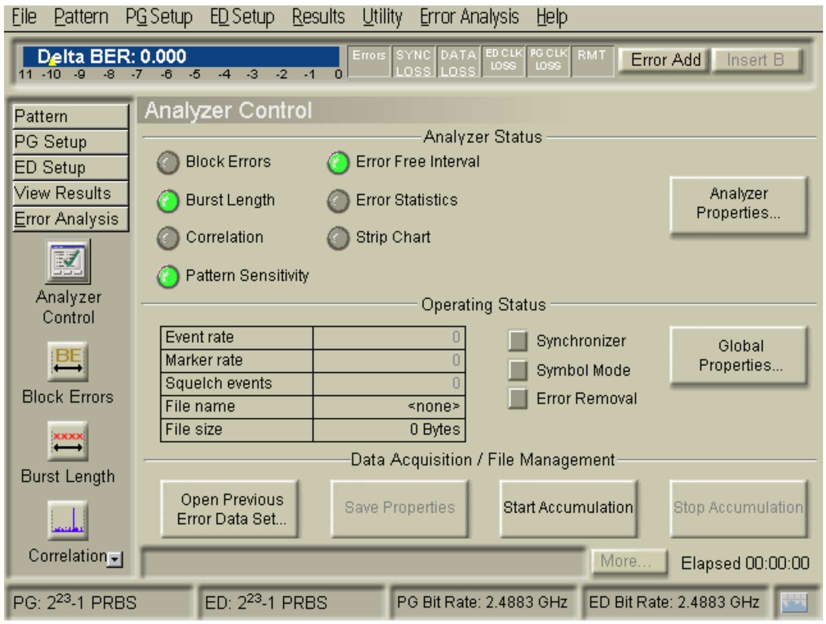
Changing the minimum burst length to 10 caused fewer burst errors to be recorded.

Part 2

Error Analysis Reference

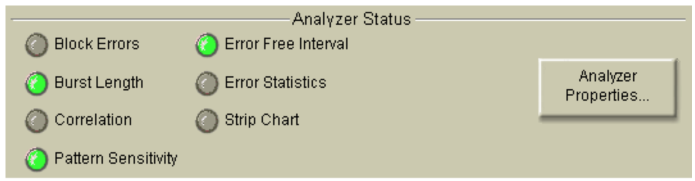
Analyzer Control

The **Analyzer Control** window gives you an overall view of error analysis settings. It also provides access to analyzer and global properties, where you can view more settings and make changes.



Analyzer Status

The **Analyzer Status** area contains a status indicator for each analyzer. A green indicator means that an analyzer is on; a gray indicator means that an analyzer is off.

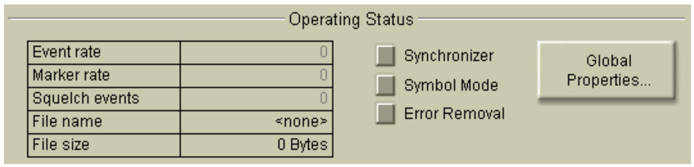


The **Analyzer Properties** button/dialog box provides access to all the settings used by the individual analyzers. For example, some analyzer properties are chart range, chart scale, and cursors. In this dialog box, you can also enable or disable analyzers.

NOTE Each analyzer requires processing time from the computer system, which impacts overall performance. If you are not using an analyzer, it is best to disable it.

Operating Status

The **Operating Status** area displays information about the current analysis, and displays the status of error filters.



Analysis information

- **Event rate**: The number of error events per second being analyzed.
- **Marker rate**: The measured frequency of the marker signal.
- **Squelch events**: The number of times that the event rate was too high for the software to process the number of errors. Error analysis results are no longer accurate after squelching occurs.
- **File name**: The filename associated with the present error data set file operation.
- **File size**: The size of the error data set file associated with the present file operation.

Error filter status

- **Synchronizer**: If this filter is on, all error events are removed until the analyzer receives a marker signal, gating signal, or PRBS trigger signal. Once this starting signal is received, all errors are counted. This allows error analysis to begin precisely in alignment with a data sequence or external input.
- **Symbol Mode**: If this filter is on, the interpretation of error data is changed from single-bit error statistics to symbol-wide error statistics.
- **Error Removal**: If this filter is on, errors will be removed that belong to bursts with lengths above or below a user-defined threshold. In this way, you can analyze error statistics from errors that come from bursts of particular lengths or within a range of lengths.

NOTE

A green indicator means that a filter is on; a gray indicator means that a filter is off. These filter settings can be accessed within the **Global Properties** dialog box.

Global Properties

This button/dialog box provides access to the following global settings that can affect all analyzers:

- Burst Criteria (Burst Error-Free Threshold and Minimum Burst Length)
- Error Removal
- General Settings (Record File)
- Integration Period
- Symbol Size
- Synchronizer
- Timebase

NOTE An important step before starting error analysis is to set up a record file. Refer to “How to Set up a Record File” on page 2-6

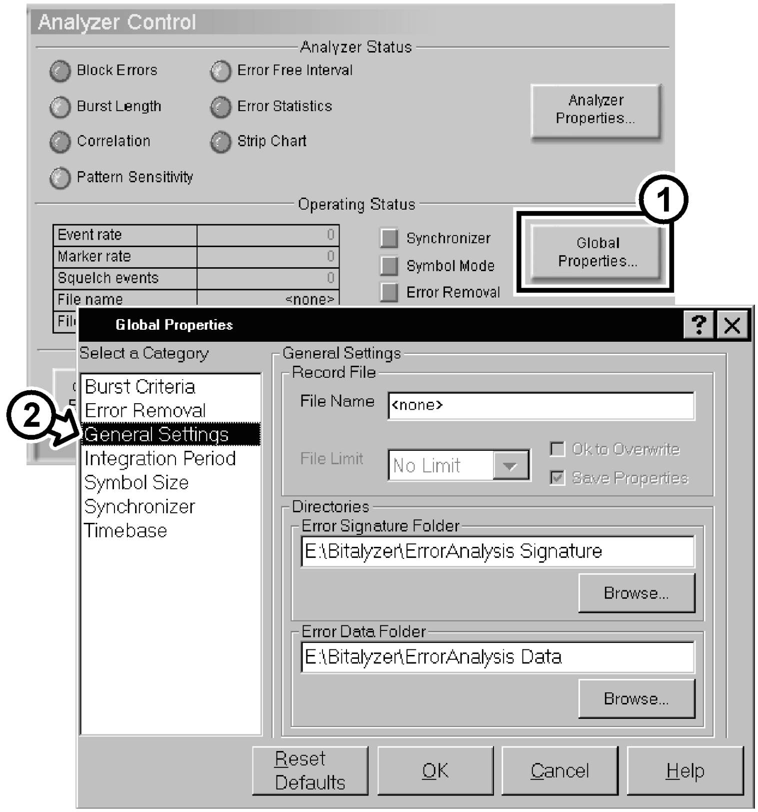
How to Set up a Record File

Before you can use error analysis, you must first accumulate measurement data. By default, the measurement data for error analysis is temporary, being overwritten at the start of the next accumulation. In addition, this temporary data can only be analyzed with the current analyzer and global property settings.

If you would like to save error analysis data, and have the option to re-analyze it with different properties settings, then you must set up a record file before accumulating.

Recording an error data set records the raw error position information directly and is not affected by the settings of any given error analysis view. You can change analysis settings and use the same captured error data set to view the results. This is very useful when you capture long measurements and want to examine “what if?” scenarios using the different analysis techniques. Recorded error data sets can also be used as documentation that defines precisely how and where errors happened during your measurement.

1 Touch **Global Properties** and **General Settings**.



record_file

2 In the **File Name** box, enter a file name.

3 Optional: Choose other record file settings.

a From the **File Limit** list, select a file limit.

b Select or clear the **OK to Overwrite** checkbox.

CAUTION

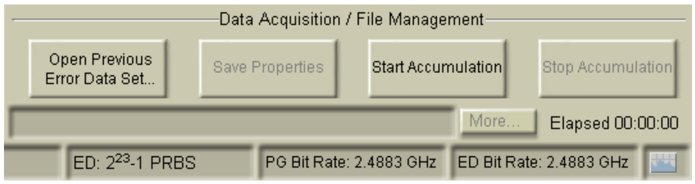
If **OK to Overwrite** is selected, the record file name can be overwritten, with measurement results lost.

c Select or clear the **Save Properties** checkbox.

4 Touch **OK**.

Data Acquisition/File Management

The **Data Acquisition/File Management** area allows you to accumulate measurement data, save properties settings, or open previously recorded error data sets.



CAUTION

If **Prompt for Filename** is selected in **Accumulation Setup** (located in the **ED Setup** active list), touching the **Start/Stop Accumulation** softkeys on the touchscreen will not provide a filename prompt. This may result in writing over a previous file.

To avoid this, use 

and 

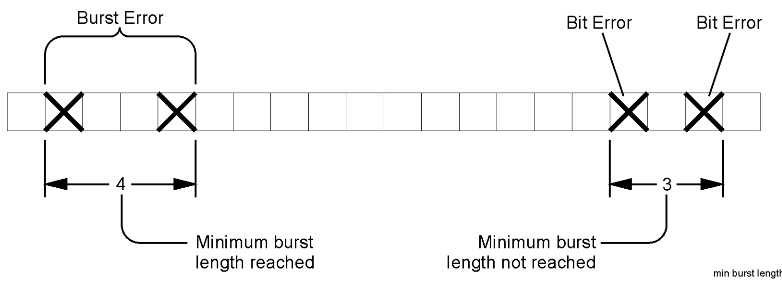
on the front panel.

Applications for Burst Criteria

In the tutorial, you learned how burst criteria settings affects analysis results. This section explains how these settings may be useful for specific applications.

Minimum Burst Length

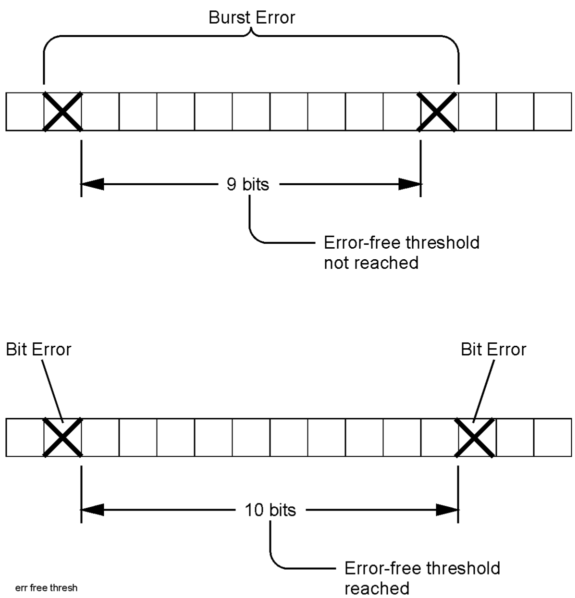
Example: Minimum burst length = 4.



Different physical phenomena cause different concentrations of errors. For instance, if a channel is affected by small amounts of noise, it generally experiences very small errors that are randomly distributed. The same channel may also be affected by interferences from strong electromagnetic fields pulsating at characteristic interference frequencies. These errors typically cause a greater number of neighboring bits to be in error every so often. By setting the **Minimum Burst Length** to be somewhere above the 1- or 2-bit burst lengths produced by the random error noise phenomena, and somewhere below the typical burst length produced by the interference phenomena, then the non-burst error rates will represent the errors from the noise and the burst error rates will represent the errors from the interference. This is a good example of error analysis providing the ability to further diagnose errors, and to distinguish their source.

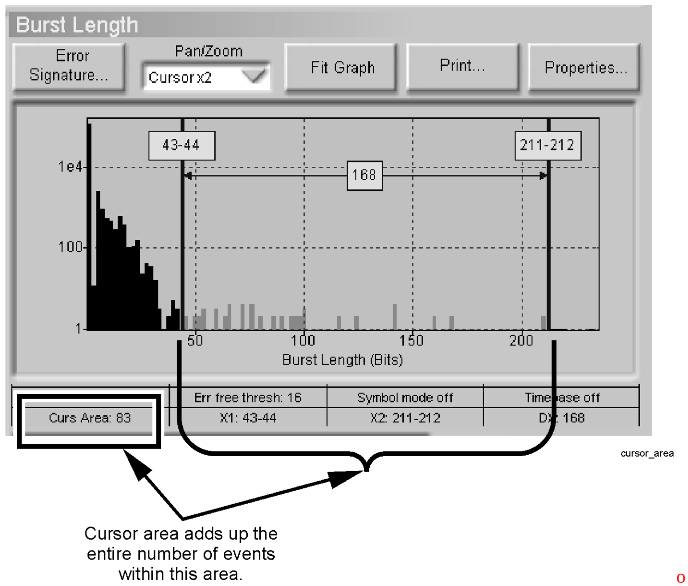
Burst Error Free Threshold

Example: Burst error-free threshold = 10.



The **Burst Error Free Threshold** setting is used to customize how closely consecutive errors have to follow one another in order to be included in one burst. This is useful because measurements are often made on the output of a particular communication system architecture that may be built to concentrate errors using particular factors. For instance, if a forward error correction system is being used and a particular error correction block is saturated with too many incoming errors to be corrected, the results may be a complete error correction block containing garbage. In this case, if you set the **Burst Error Free Threshold** to be the length of the error correction block, individual errors from one garbage block will be grouped together and reported as a single burst representing an FEC block failure. On the burst length view, this configuration would clearly show a distribution of error bursts centered roughly at the size of the error correction block. Interestingly, you would also see a second, less-populated distribution centered at roughly two times the size of the error correction block - resulting from occurrences of two consecutive uncorrectable error correction blocks.

Applications for Cursor Area



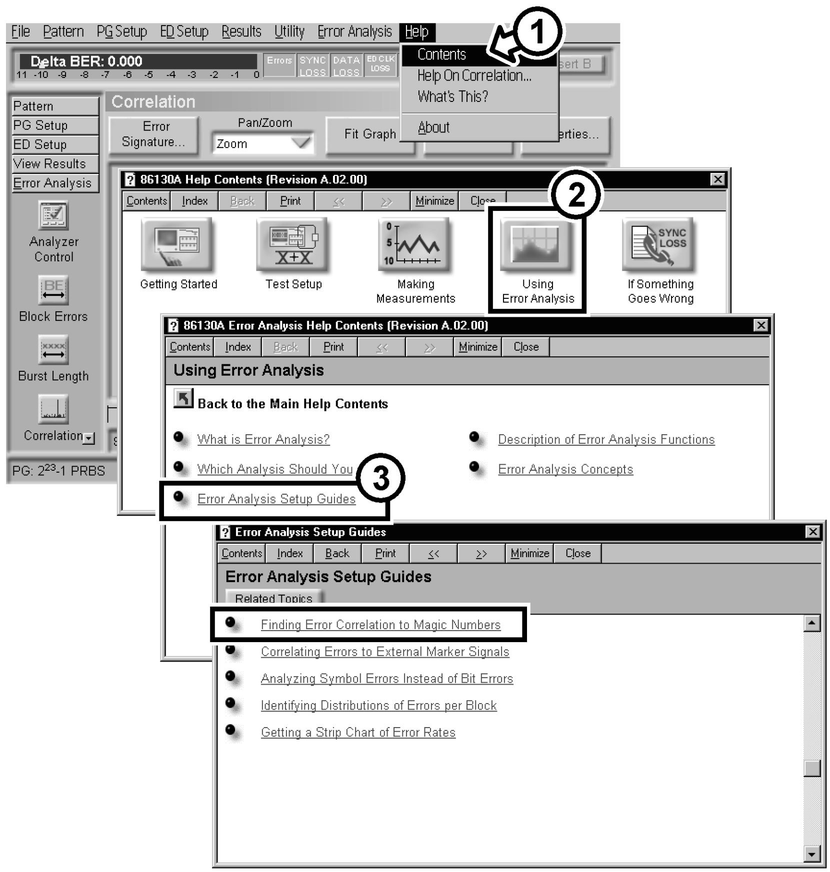
Histograms distinguish event occurrences by some metric. Cursor area measurements allow further quantifications of how many occurrences fall within some range of that metric. This is especially important when histogram entries may be shaped as a distribution of events, centered about some value, rather than one single, precise spike. Using the cursor area function, it is easy to "add-up" all the entries in a distribution surrounded by the cursors.

One example of using the cursor area function is to quantify different populations of histogram entries. In the Burst Length view, for instance, a particular communications channel may have been built to withstand bursts of a given length by adding interleaving circuitry. Typically, bursts of the specified length or below would be corrected without problems, whereas bursts beyond that length would trigger another sort of error protection strategy, for instance, retransmission of a packet. By using the cursor area on the Burst Length view, one might distinguish the number of bursts that are within the protected range, and the number that are not. This can shed light on the amount of retransmissions that would be required under those circumstances. What's better, is the original designer of such a system might make these measurements on a typical physical-layer and specifically design the length of the interleaver to achieve a certain ratio of re-transmissions.

Where to Go for More Information

There are more error analysis techniques to learn, such as block error analysis and correlation analysis. You can refer to the online Help for more information – it explains error analysis concepts and includes step-by-step instructions.

You can also use the context-sensitive **Help On ...** or **What's This?** Help to get help on any item in a dialog box or window.



help_access

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