Wire Cord Measurement – Rubber Calenders

User Manual

6510020217 Rev 01

Wire Cord Measurement – Rubber Calenders

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Confidentiality Statement

Notice

Trademarks

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Introduction

This manual is provides an introduction to the wire cord measurement in rubber calenders. It provides an overview of measurements, and explains the methods and tools used in MXProLine for digital analysis of a high-frequency sensor signal to produce the wire cord measurements – cord counts, spacing, aperture factor and gum edge distance.

Audience

This manual is intended for use by engineers or process engineers and assumes that the reader has some knowledge of the operation of a paper machine and a basic understanding of mechanical, electrical and computer software concepts.

About This Manual

This manual contains 6 chapters.

Chapter 1, **Measurements**, describes the wire calendar measurement package.

Chapter 2, **Sensors**, describes hopw the measurement package gets signals from the sensors.

Chapter 3, **MSS Data Collection**, describes the data collection done by the MSS and how the profiles are displayed and interpreted.

Chapter 4, **Wire Measurement Processing**, describes the signal conditioning algorithms applied to the data.

Chapter 5, **Operator Displays**, describes visual displays available to the machine operator.

Chapter 6, **Engineering Displays**, describes displays that aid in setting the tuning parameters.

Related Reading

The following documents contain related reading material.

Honeywell P/N	Document Title / Description
MN120505	Balance Gauge Algorithm

Conventions

The following conventions are used in this manual:

> ATTENTION
> Text may appear in uppercase or lowercase except as specified in these conventions.

`Boldface`	Boldface characters in this special type indicate your input.
`Special Type`	Characters in this special type that are not boldfaced indicate system prompts, responses, messages, or characters that appear on displays, keypads, or as menu selections.
Italics	In a command line or error message, words and numbers shown in italics represent filenames, words, or numbers that can vary; for example, filename represents any filename. In text, words shown in italics are manual titles, key terms, notes, cautions, or warnings.
Boldface	Boldface characters in this special type indicate button names, button menus, fields on a display, parameters, or commands that must be entered exactly as they appear.
lowercase	In an error message, words in lowercase are filenames or words that can vary. In a command line, words in lowercase indicate variable input.
Type	Type means to type the text on a keypad or keyboard.
Press	Press means to press a key or a button.

[ENTER] or **[RETURN]**	**[ENTER]** is the key you press to enter characters or commands into the system, or to accept a default option. In a command line, square brackets are included; for example: **SXDEF 1 [ENTER]**
[CTRL]	**[CTRL]** is the key you press simultaneously with another key. This key is called different names on different systems; for example, **[CONTROL]**, or **[CTL]**.
[KEY-1]-KEY-2	Connected keys indicate that you must press the keys simultaneously; for example, **[CTRL]-C**.
Click	Click means to position the mouse pointer on an item, then quickly depress and release the mouse button. This action highlights or “selects,” the item clicked.
Double-click	Double-click means to position the mouse pointer on an item, and then click the item twice in rapid succession. This action selects the item “double-clicked.”
Drag X	Drag X means to move the mouse pointer to X, then press the mouse button and hold it down, while keeping the button down, move the mouse pointer.
Press X	Press X means to move the mouse pointer to the X button, then press the mouse button and hold it down.
ATTENTION	The attention icon appears beside a note box containing information that is important.
CAUTION	The caution icon appears beside a note box containing information that cautions you about potential equipment or material damage.
WARNING	The warning icon appears beside a note box containing information that warns you about potential bodily harm or catastrophic equipment damage.

Honeywell, Vancouver Operations Part Numbers

Honeywell, Vancouver Operations assigns a part number to every manual. Sample part numbers are as follows:

6510020004

6510020048 Rev 02

The first two digits of the part number are the same for all Honeywell, Vancouver Operations products. The next four digits identify part type. Type numbers 1002 designates technical publications. The next four digits identify the manual. These digits remain the same for all rewrites and revision packages of the manual for a particular product. Revision numbers are indicated after the Rev. If no revision numbers follow the part number, then it is the first edition of the manual, Rev 00.

1. Measurements

The wire calender measurement package produces measurements of sheet properties specific to calendered steel fabric. The post-calender scanner measures total sheet weight, gum weight, top and bottom gum weight, and balance for wire calenders. The optional cord sensor package for wire calenders provides measurement of cord count, cord spacing, and spacing faults within the sheet. The measured aperture array is used to correct the gum weight readings (see MN120505 in the related sensor documentation).

The gauging system must differentiate the top and bottom gum plies as they appear in the calendered sheet. Backscatter or Z-Laser measurement of the gum thickness at the calender is likely to be only a rough indicator of the gum thickness on either side of the fabric in the calendered sheet. This occurs because the calender can be configured with varying angles and tensions in the cord as it enters the squeeze (cushion) gap and is embedded into the bottom gum sheet (pressure roll adjustment and fabric tension).

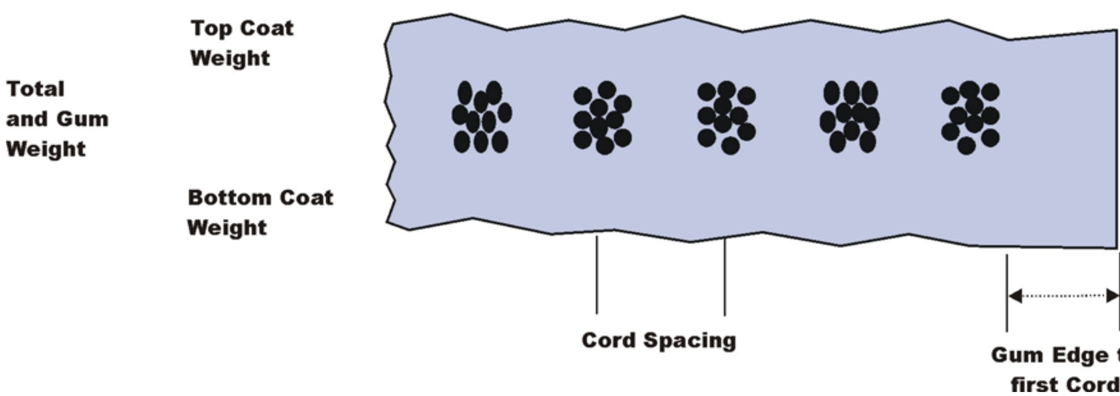


Figure 1-1 Wire Cord Measurements - Cross Section from Machine Direction

Scanning sensor measurements available for wire calenders:

- Total gum weight
- Balance - top/bottom gum weight ratio
- Wire cord counter
- Gum edge – distance from edge to first cord
- Cord spacing and spacing faults
- Aperture factor – fractional open area between cords

The remainder of this document explains the methods and tools used in MXProLine for digital analysis of a high-frequency sensor signal to produce the wire cord measurements – cord counts, spacing, aperture factor and gum edge distance.

2. Sensors

The wire cord measurements use the signal from the slotted x-ray sensor (it has a small aperture covering the receiver). The slot is aligned in the machine direction.

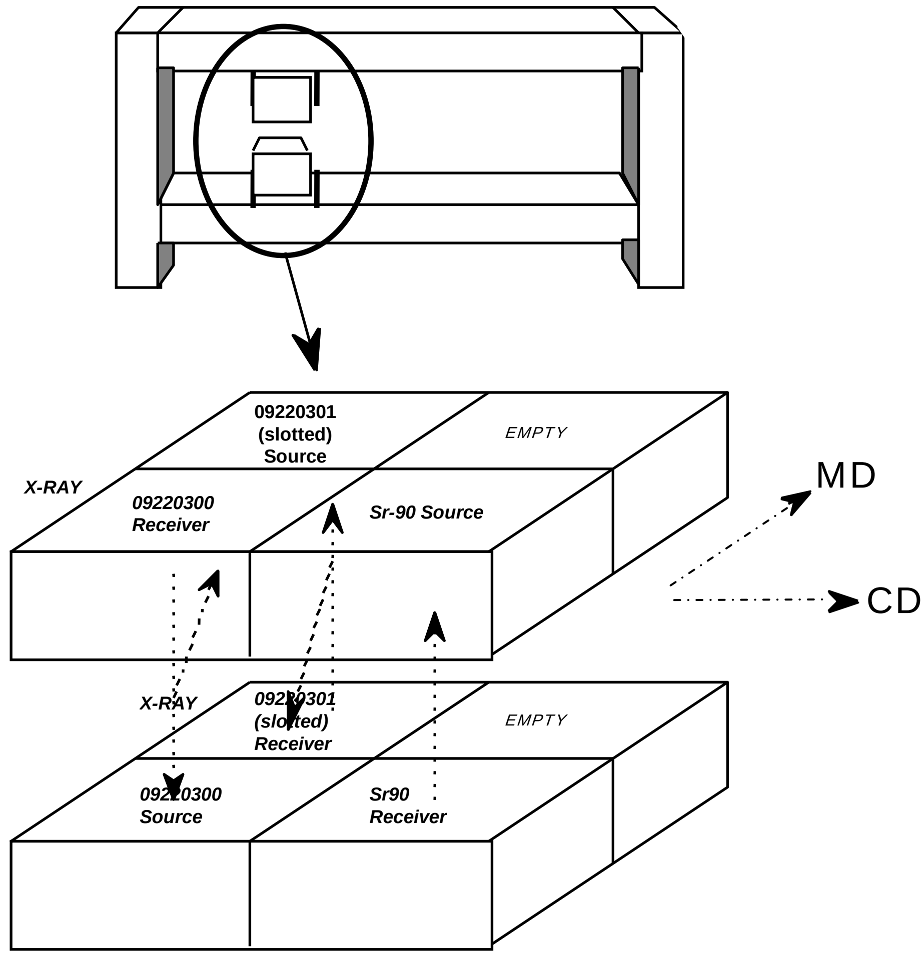


Figure 2-1 Sensor Physical Locations

3. MSS Data Collection

The Measurement SubSystem (MSS) has a special data collection mode available for these systems; it collects the high-frequency signals from the slotted x-ray sensor transmission DAQ channel, assembles the signals sequentially into an array and sends the array to the MXProLine computer's Real-Time Data Repository (RTDR) for additional calculations by the sensor processors. These signals can be 2, 4 or 6 kHz, a rate configurable in the RTDR records for the MSS. The resulting arrays are very large, containing 20,000 to 30,000 elements when scanning a typical sheet at 250 mm per second. Figure 3-1 shows an entire scan profile.

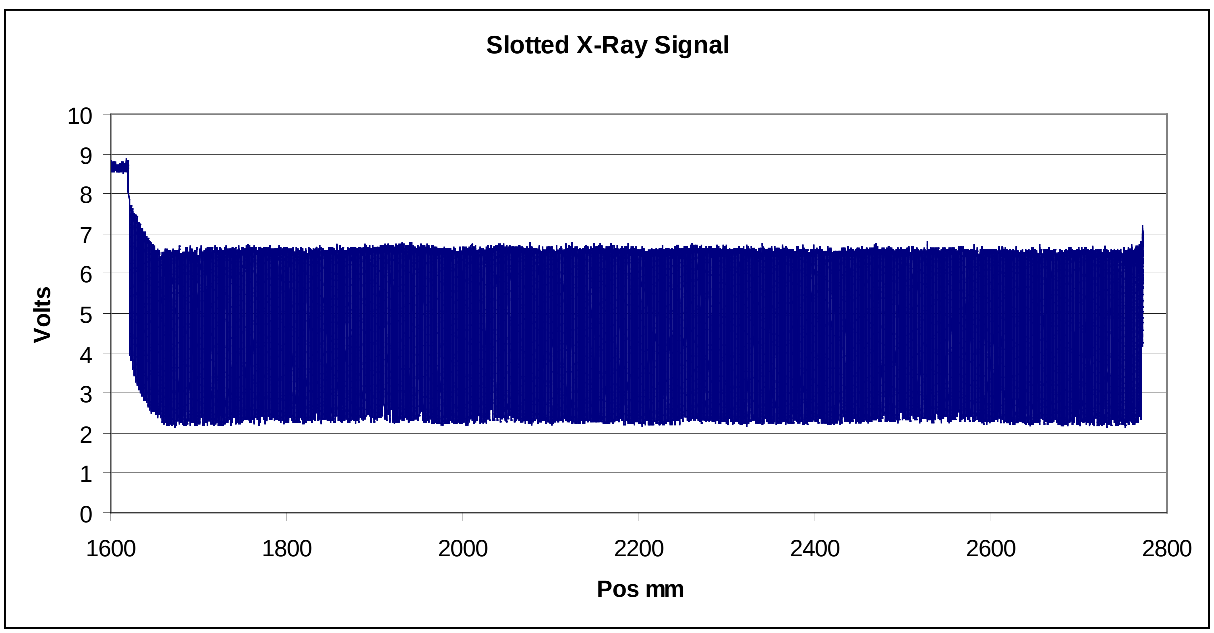


Figure 3-1 Scan Profile

Zooming in to 50 mm (<2 in) of sensor travel gives a clearer picture of the signal. See Figure 3-2. The air (8.7 V), gum (6 - 8 V) and wires (3 - 4 V) are clearly visible. The wire weight is very constant; any longer-term trend in the signal is usually due to changes in the gum weight.

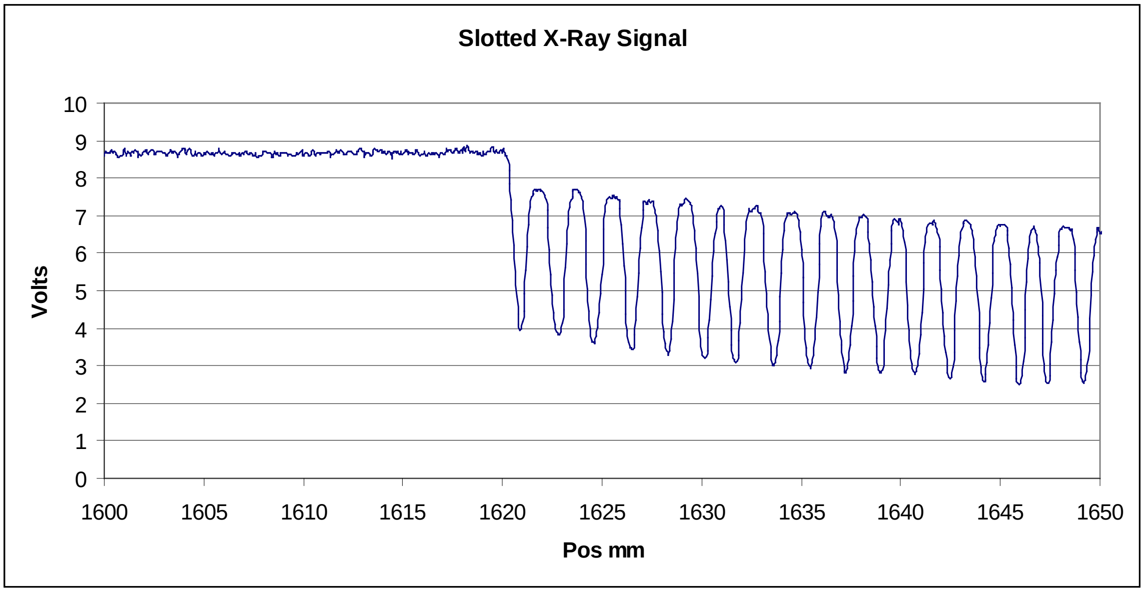


Figure 3-2 Scan Profile – 50mm Sensor Travel

Zooming in some more and showing the individual points in the graph as in Figure 3-3 demonstrates the sample rate relative to the wires.

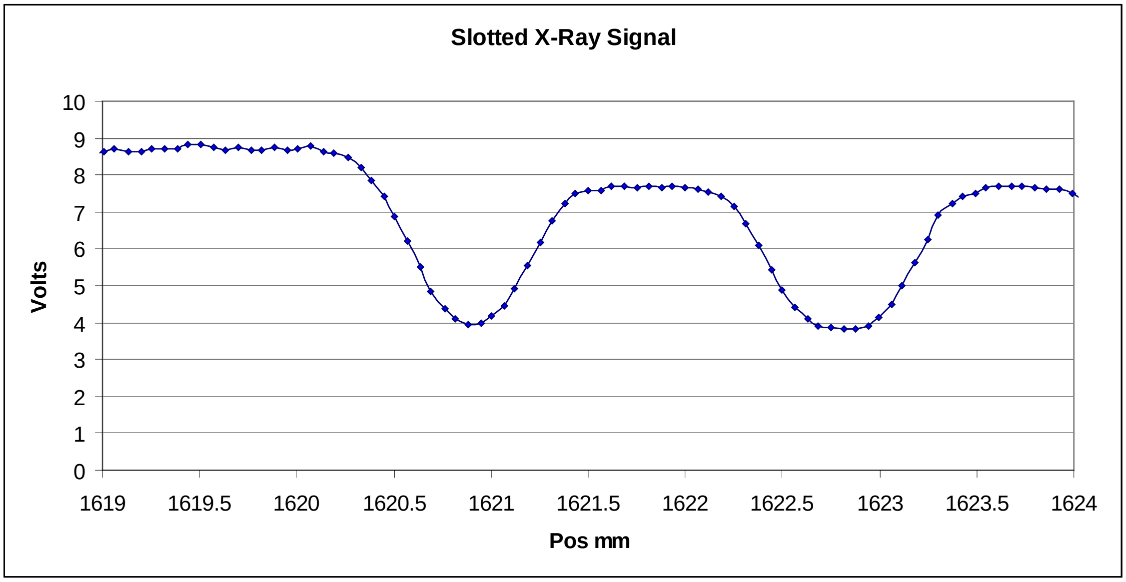


Figure 3-3 Scan Profile - Individual Points in Graph Profile

The Cord Counting processor in the MXProLine Server will condition and analyze this waveform to compute the aperture factor, cord count, gum edge distance and locate any cord spacing faults. This subsequent processing is designed to locate the positions of each valley in the voltage array – these valleys represent the positions of the steel cords in the sheet.

3.1. Abnormal cord spacing conditions

When cords (the low points in the voltage graph) are too closely spaced, they may in fact block enough of the x-ray signal to reduce the voltage shown in the gum spacing between cords. This is clear in Figure 3-4, where no cords are missing but there are very large spacing irregularities:

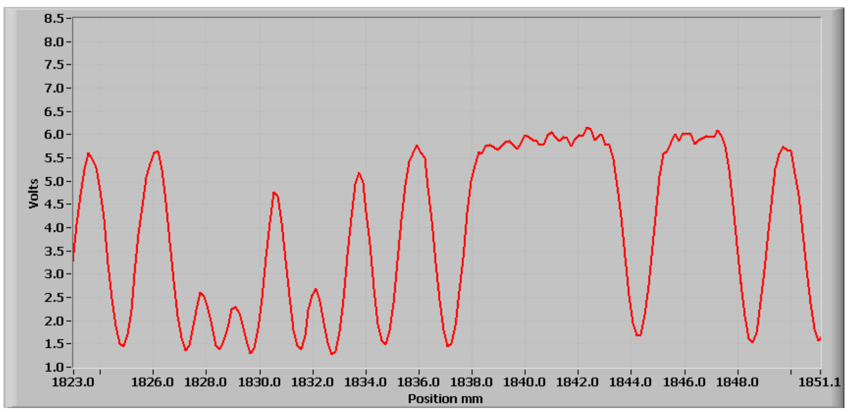


Figure 3-4 Abnormal Cord Spacing Condition: Large Spacing Irregularities

In extreme cases, cords that are contacting each other or perhaps crossed can look like single large valleys:

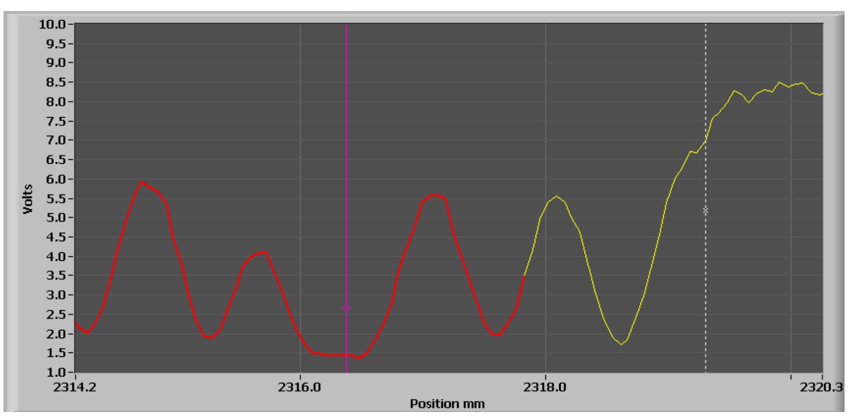


Figure 3-5 Abnormal Cord Spacing Condition: Contacting or Crossed Cords

4. Wire Measurement Processing

4.1. Signal conditioning

The raw signal from the slotted sensor is conditioned prior to cord detection. The signal conditioning methods are derived from profile streak analysis.

The purpose of signal conditioning is to isolate only the valleys (cord locations) in the raw voltage profile and level the high and low areas that are present in the raw voltage profile. Various tools are employed to remove longer-term trends in the profile (usually due to changing gum weight), transition effects at or near the edge of the sheet and any variations in the gum weight between cords.

4.1.1. Cuts – profile (amplitude) and derivative

The purpose of this phase of wire sensor signal processing is to remove points from the input data array that are out of range or whose derivative is out of range – out of range is defined by use of histograms – to form a mask array that is used to form a background profile that is subtracted from the raw data to isolate the valleys (cord positions). We impose cuts on a profile based on profile amplitude, derivative and if between negative and positive derivatives. The algorithm output is a set of masks (0, 1) for each element of the raw array for each of the cut types.

4.1.1.1. Derivative cut processing

1. Amplitude cut using median filter.

2. Compute derivative at each point.

3. Compute a histogram of the derivatives with a defined number of bins, for example, 200. The histogram number of bins defines the degree to which the raw array values can be resolved (for example, 1/200 = 0.005 = 0.5%).

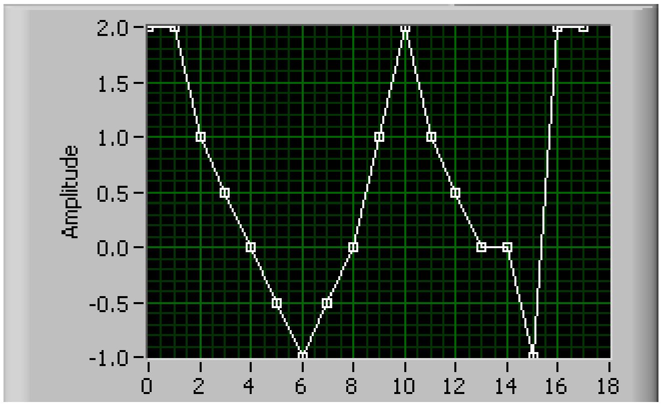
4. Compute cut limits based on the defined cut number of bins from the histogram, for example, +/- 30.

5. Compute a *cut mask* array containing ones and zeroes, with zeroes indicating elements to be removed from the source array. Zeroes indicate points where the derivative is outside the defined cut limits.

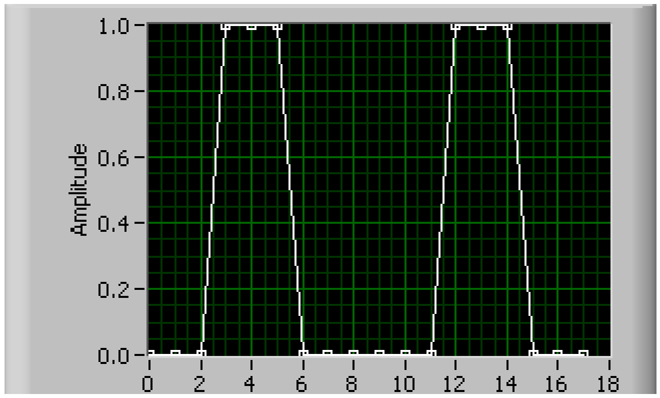
4.1.1.2. Inter-derivative cut processing (also called between derivatives cut)

1. Collect the derivative array and the derivative cut limits for the next steps.

2. Compute a *cut mask* array containing ones and zeroes, with zeroes indicating elements to be removed from the source array. This masks out (zero) any array data on the trailing edge of a transition from high to low derivative. For example, a derivative array that looks like



If there are cut mask limits at 0.99 and –0.99, the derivative mask looks like



4.1.1.3. Profile (amplitude) cut processing

1. Amplitude cut using median filter.

2. Compute a histogram of the filtered array values with a defined number of bins, for example, 200.

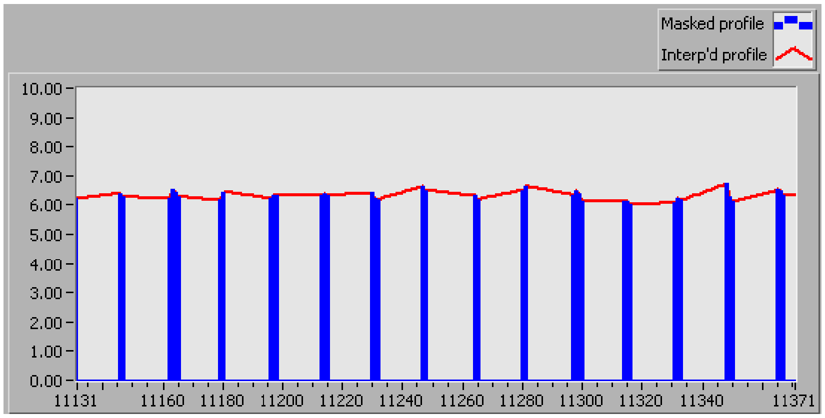
3. Compute cut limits based on the defined cut number of bins from the histogram, for example, +/- 30 from the histogram max value.

4. Compute a cut mask array containing ones and zeroes, zeroes indicate elements to be removed from the source array. Zeroes indicate points where the raw array value is outside the defined cut limits.

4.1.1.4. Background profile and subtraction

1. Multiply the derivative and inter-derivative cut masks together, add the result to the profile cut, and create an array with ones for resulting points > zero, zeroes otherwise. This step effectively adds back points that are on the plateaus.

   This resulting mask profile is multiplied times the filtered voltage profile (using the profile cut median filter result). This masked profile enters an interpolation algorithm that produces an array interpolating between mask points (ones):



2. This array is subtracted from the median filtered raw array to form a *subtracted profile* that is used in the subsequent cord identification and spacing algorithms. If done correctly, it will have no long-term drift and the maximum value will be zero (flattened in the areas between cords).

   This completes the transformation from a noisy array with drift into an array that lends itself to cord detection and analysis.

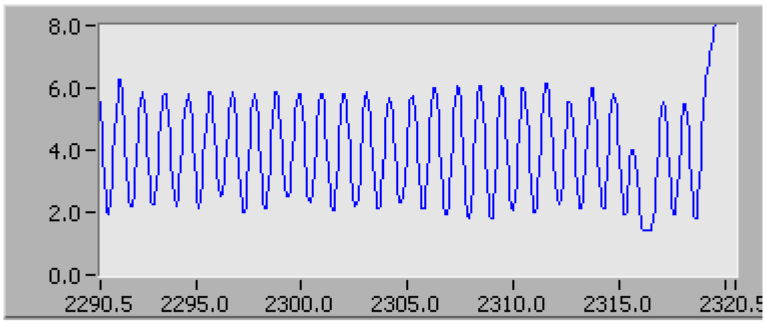


Figure 4-1 Raw Array

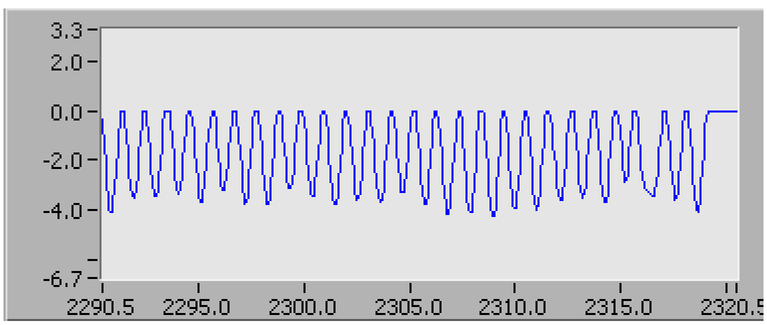


Figure 4-2 Subtracted profile

4.2. Cord identification

To analyze the remaining valleys for average depth and full width half max (FWHM).

1. Find the valley locations.

   The tuning constant minimum depth is used to eliminate false detection of valleys that aren't deep enough. Use this value sparingly (default is zero – most products should function well with this default setting). The valleys are identified by their low and high boundary positions and by their depth.

2. Find **Full Width Half Max** for each valley – this is the width of a valley at the midpoint between the valley's high and low values. This is normally a repeatable indication of the relative width of each cord that forms a valley.

3. Choose one of three methods to determine the cord diameters:

   a. Use nominal cord diameter – this option is provided for circumstances where very small wires or irregularly shaped wires might make cord width detection difficult or noisy.

   b. Use the **FWHM** values - **RECOMMENDED**

   c. Use the valley boundaries – should be reliable indicator for larger diameter wire, but may prove challenging to adjust for smaller wires.

4. The results of the cord finding are arrays of the low edge, center and high edge (in mm) for each cord found in the array.

4.2.1. Spacing and Fault Identification

1. Compute spacing – spacing is measured as the distance from cord center to cord center. Nominal spacing is 1 / nominal ends per distance unit (ends/mm, ends/inch, etc.).

2. Compute spacing faults – a spacing fault is declared when a cord-to-cord distance exceeds the nominal spacing times the **Maximum Deviation Proportion**, which is a fractional spacing limit. If the **Maximum Deviation Proportion** is 0.3, then the spacing needs to be within +/- 30% of the nominal spacing to avoid a fault condition.

Let

S = Nominal Spacing

s = spacing

A = Nominal aperture factor

p = Maximum Deviation Proportion

Then for any cord space, the following must be true or a spacing fault is declared for that cord:

$|(s-S)/S| <= pA$

3. Compute aperture factors (fractional open space between cords). This is equal to the distance between two cords' adjacent edges (gum distance) divided by the cord spacing distance.

4. Find sheet edge positions. This is done by testing the raw voltage array from each side toward the center to find the point where the voltage drops below a threshold. The threshold is defined as a *threshold proportion* (fraction) times air volts (the off sheet voltage). The raw voltage array is passed through an exponential filter before testing the threshold (note: excessive filtering can lead to a lag (offset to the inside) in the edge position result – this in turn can lead to a misleading low value in the gum edge distance (distance from sheet edge to edge of first cord).

5. Compute gum edge raw and average values – The gum edge raw values are the distances from the computed sheet edge position to the computed position of the outside edge of the first cord in the sheet. To provide a more stable measurement (there is some degree of signal shift in the scanner direction of travel, depending on mechanical characteristics of the scanner and accuracy of scanner and sensor tuning), the last two gum edge raw values are averaged to produce a final gum edge measurement.

5. Operator Displays

5.1. Wire cord display

The wire cord display is used by calender operators to easily identify cord count and spacing measurements and to quickly navigate to any spacing fault areas in the sheet for analysis and correction of the defects. It is normally available on the **Home** (**Favorites**) navigation menu as well as on the Analysis menu.

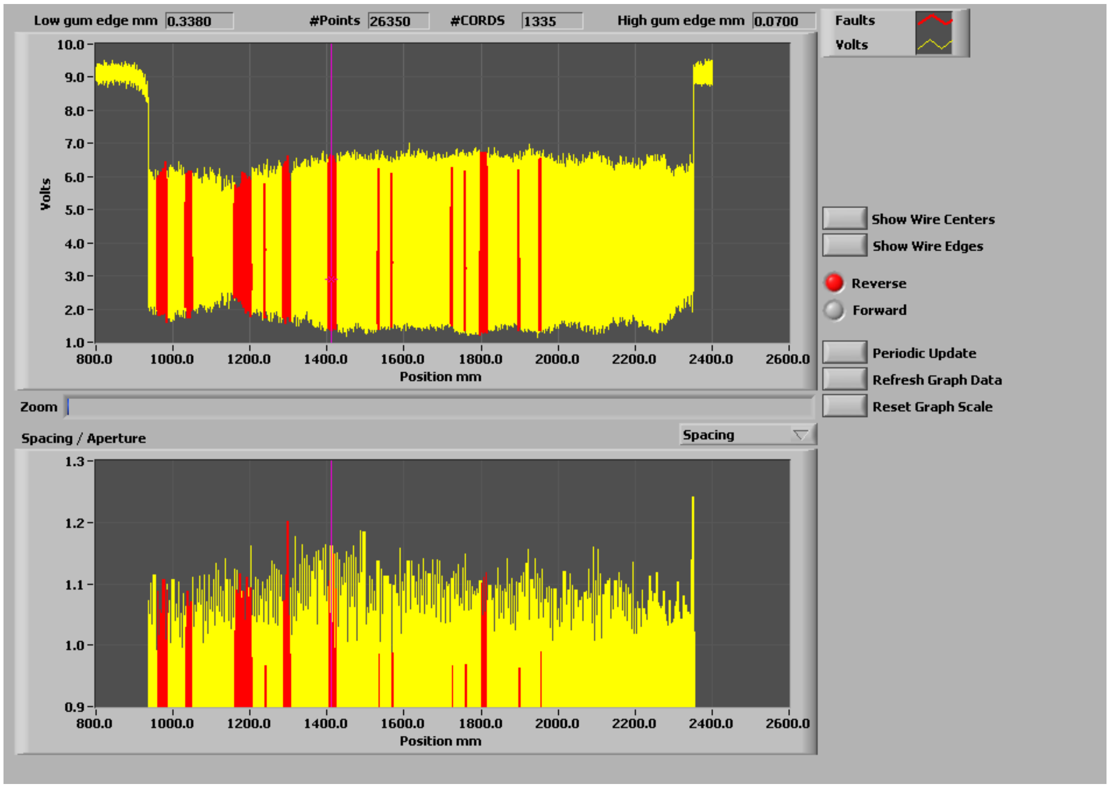
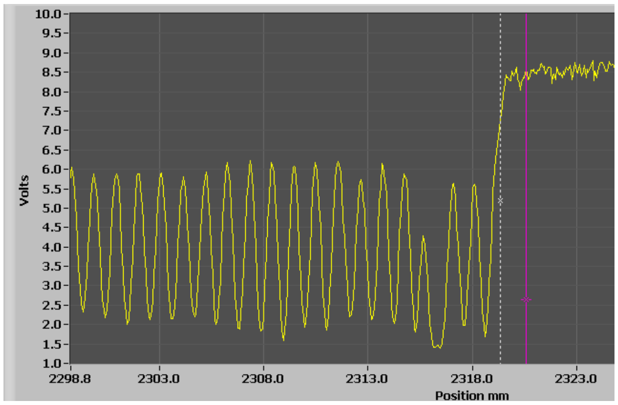


Figure 5-1 Wire Cord Display

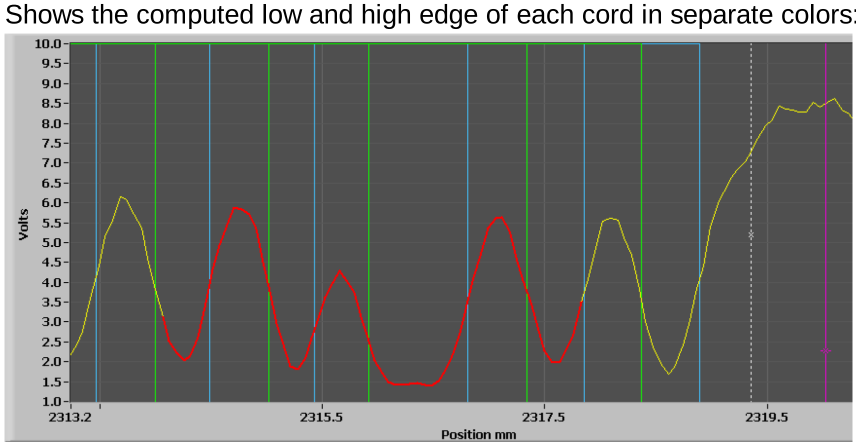
The upper graph in Figure 5-1 shows the raw slotted sensor voltage array, yellow where the spacing is within limits, red where the spacing is out of limit. The x-axis shows the position in mm within the scanner frame where the measurement was taken during the previous scan. The cursor (purple) can be moved to any location in the graph –move the Zoom slider control to the right (shown just below the top graph), and the graph zooms in proportionally, staying centered at the current cursor location. Move the top graph cursor, and the bottom graph cursor moves to the same location.

For example, move the cursor near the high edge of sheet and zoom almost to maximum, the display responds with



This is a good time to note that the computed sheet edge positions are shown on the graph as dotted white lines (see zoomed picture above). Only by zooming in to the edges can you evaluate the validity of the edge measurement and the gum edge measurement.

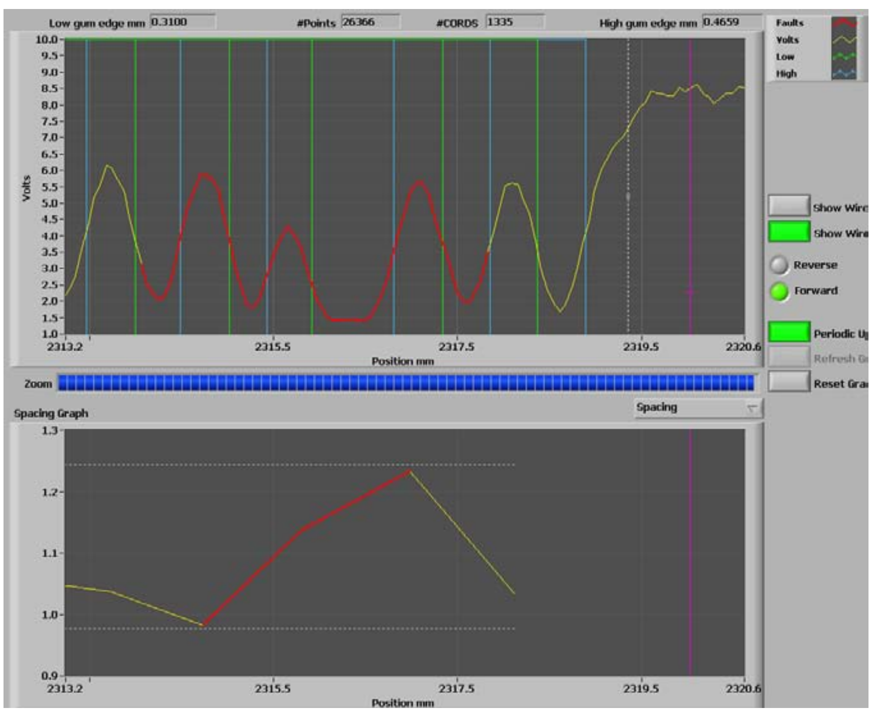
Table 5-1 Wire Cord Display Controls

Button	Description
Show Wire Centers	Causes wire centers to appear as vertical lines in the graph (green in this example)  This display option makes it easy to see if the cord detection software has correctly identified all of the wires, especially in a fault area where cords may be too close together for the software to separate them. This picture is a good example – we either have a very thick cord (with larger than normal spacing) at the third position from the edge (causing the fault) or we have two cords so close together that they are effectively blocking the sensor from seeing the gum between them.
Show Wire Edges	Shows the computed low and high edge of each cord in separate colors:  In this example, the low edges are green and the high edges are blue. The distance from the last cord's high edge to the dotted white line (sheet edge) is the gum edge distance. This form of display makes obvious the location of the spacing fault, note the excessive width of the third valley in from the edge and its neighbors.
Periodic Update	Enable the periodic update option if you want each new scan to update the data on the display. Turn this option **OFF** if you want to examine a particular scan's data for faults or other problems. The first time you navigate to this display, this option defaults to **OFF**.

Button	Description
Refresh Graph data	Available if you are **NOT** using the **Periodic Update** mode. Press this button to update the graph information after you have completed your examination of the previous data.
Reset Graph Scale	Press this button if you have zoomed in or moved to a location in the graph but want to quickly return to a view of the full graph, perhaps to move the cursor to a different location or fault location in the sheet. The bottom graph shows either cord spacing or aperture factor (it defaults to spacing unless the selector is changed). The spacing graph also shows the spacing limits that can cause spacing fault alarms if the spacing for any cord exceeds the limits. You can easily see how close any part of the sheet is to an out-of-limit condition.

Other information:

1. The low and high gum edge readings are shown above the top graph.
2. The total number of points in the graph is shown next to the total number of cords, also above the top graph.
3. The scan direction for the data you are currently seeing is displayed to the right of the top graph. This is useful information if you are concerned that the sensors are not set up correctly – you can use this display to observe scan-to-scan differences in the cord locations and gum edge readings.



5.2. Profile displays

The standard profile displays make the final cord spacing measurements (aperture, spacing and fault count) available in this display format, but without a view of the high frequency raw voltage arrays.

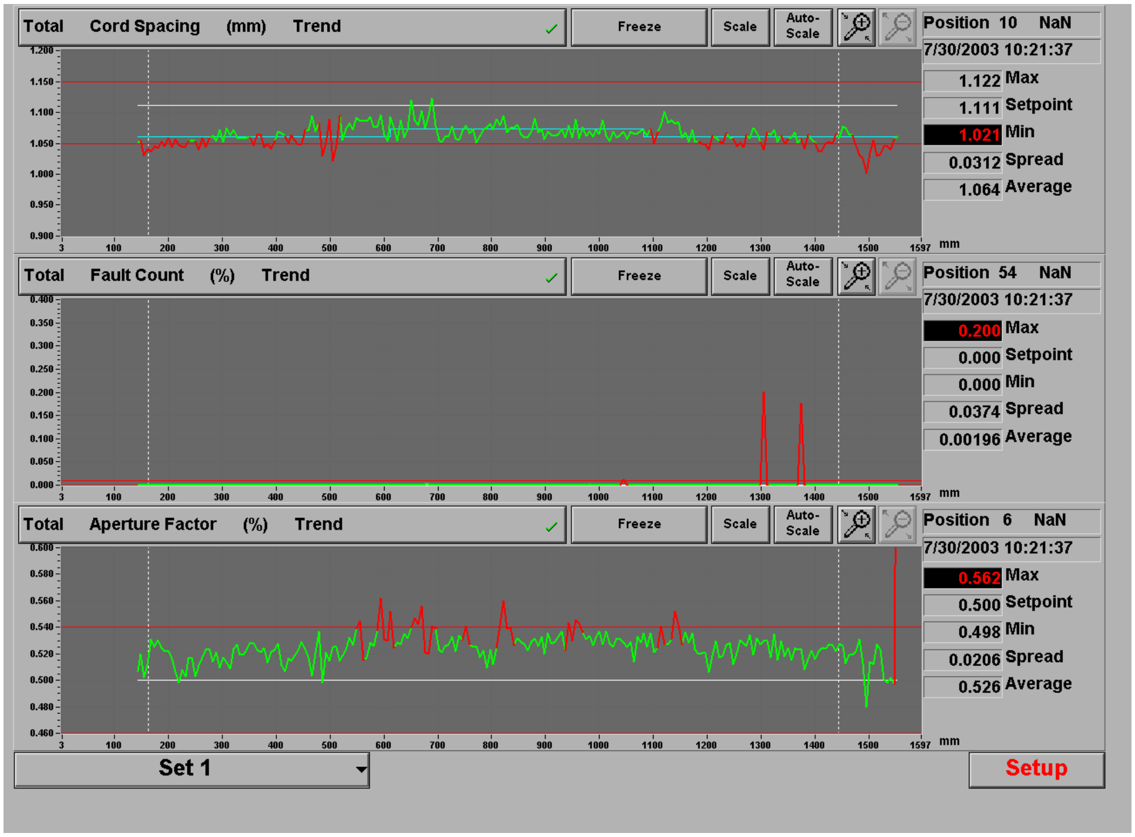


Figure 5-2 Standard Profile Displays

Standard profile displays are good summary views of the wire measurements and quick indicators of problem areas in the sheet. The arrays shown in Figure 5-2 are averaged into the same bins as the other profile measurements (gum weight, total weight, and others) for easy comparison of the relationships between measurements as they interact in the calender.

6. Engineering Displays

6.1. Tuning Constants

Table 6-1 Tuning Parameters

Parameter	Also Known As	Display	Recipe?
Max Sample Size		Recipe maintenance	CordCP Configuration Table
Max Sample Position		Recipe maintenance	CordCP Configuration Table
Min Sample Position		Recipe maintenance	CordCP Configuration Table
Wire diameter	Wire diameter in mm	Maintain Data for Analysis	Fabric table
Ends per width unit	Ends per mm	Maintain Data for Analysis	Fabric table
Data units	Width units	Maintain Data for Analysis	
Air volts		Maintain Data for Analysis	
Edge Prop	CordCP Edge Proportion	Maintain Data for Analysis	CordCP Limits Table
Edge FF	CordCP Edge FF	Maintain Data for Analysis	CordCP Calibration Table
Prof Hist Max	CordCP Air Cutoff	Tune Background Profile	CordCP Calibration Table
Prof Hist Min	CordCP Cord Cutoff	Tune Background Profile	CordCP Calibration Table
#Profile Bins		Tune Background Profile	
Profile Cut bin width		Tune Background Profile	
Rank for Profile Filter		Tune Background Profile	

Parameter	Also Known As	Display	Recipe?
Stretch fraction		Tune Background Profile	
#Deriv bins		Tune Background Profile	
Deriv cut bin width		Tune Background Profile	
Rank for Deriv filter		Tune Background Profile	
Cut Widening #bins		Tune Background Profile	
Use Deriv Cut?		Tune Background Profile	
Use Btwn Deriv Cut?		Tune Background Profile	
Use Profile Cut?		Tune Background Profile	
Use Nominal Diameter?	CordCP Use Nom Wire Diam	Tune Cord Identification	CordCP Configuration Table
Use FWHM?		Tune Cord Identification	
Width Multiplier		Tune Cord Identification	
Minimum Depth	CordCP Min Depth	Tune Cord Identification	CordCP Calibration Table
Maximum Deviation Proportion	CordCP Max Deviation	Tune Fault Identification	CordCP Limits Table
Minimum Width for Acceptable Zone	CordCP Belt Min mm	Tune Fault Identification	CordCP Limits Table

6.2. Cord Counting display

This display (available on the **Scanner**/**Sensor** navigation menu) provides an overview of the current cord measurements and some navigation buttons to the more detailed setup displays that are used to configure the wire cord detection software.

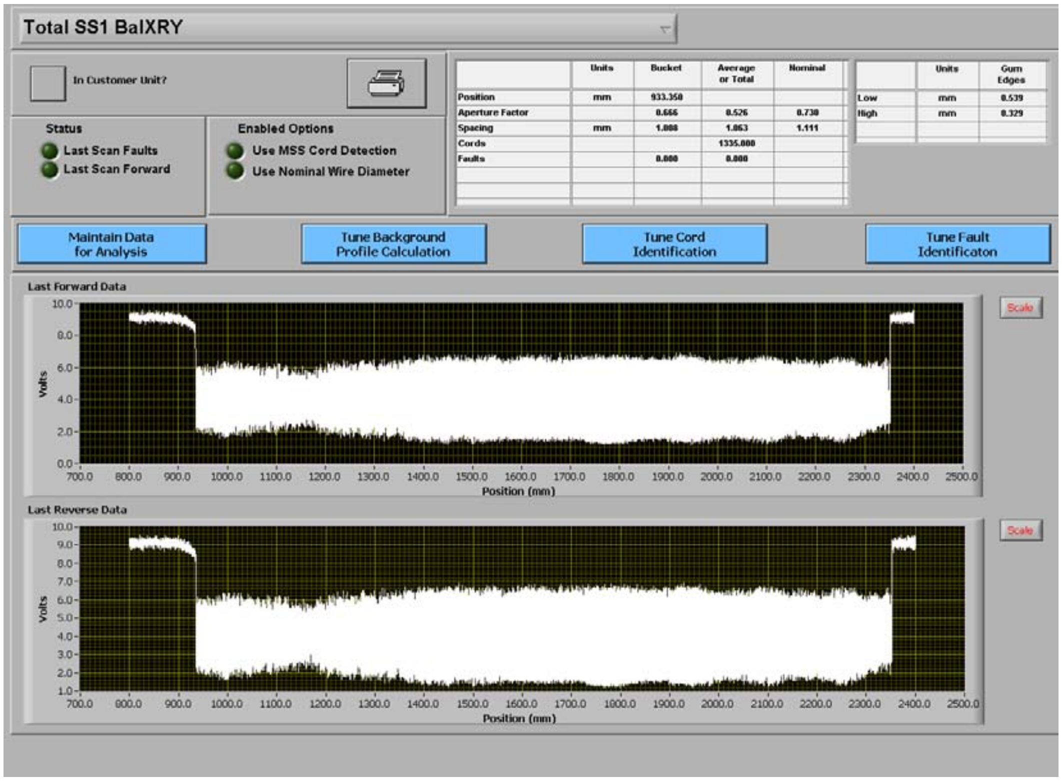


Figure 6-1 Cord Counting Display

The cord counting display and the detailed setup displays have a feature that permits the horizontal scale (x-axis) to be manually adjusted – and this scaling information is retained until the system is restarted or until the next time it is changed manually or the auto-scaling is re-enabled. This makes it easy to navigate from one display to another, examining a section of the sheet in detail, without having to deal with scaling adjustments to see enough information in the areas of concern.

To use the scaling

1. Press the **Scale** button next to each graph. A dialog box appears asking if you want to enable or disable the **X-axis** auto-scaling.

2. Press **YES**, and the dialog box prompts for scale entries (low and high). This is repeated then for the **Y-axis**.

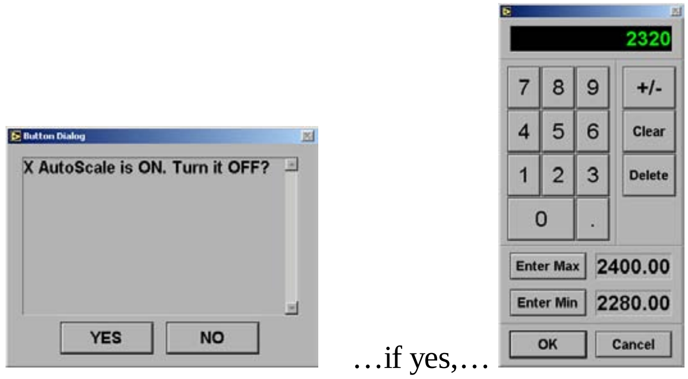


Figure 6-2 Scaling Dialog Prompts

6.3. Maintain data for analysis display

This is a versatile display with many functions, most of them designed to read or write data to and from files or the sensor processor. This is used to generate simulation data, save data for offline analysis and to adjust a few parameters related to wire cord data and edge detection.

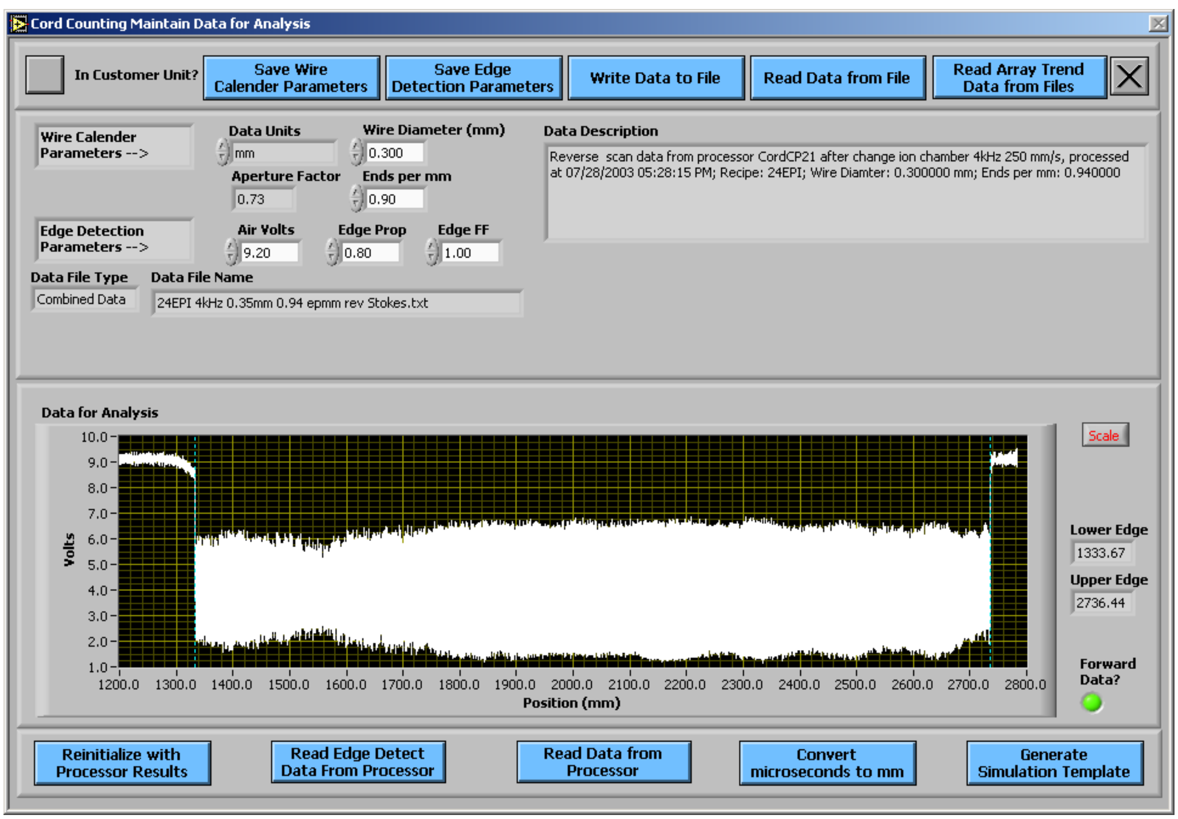
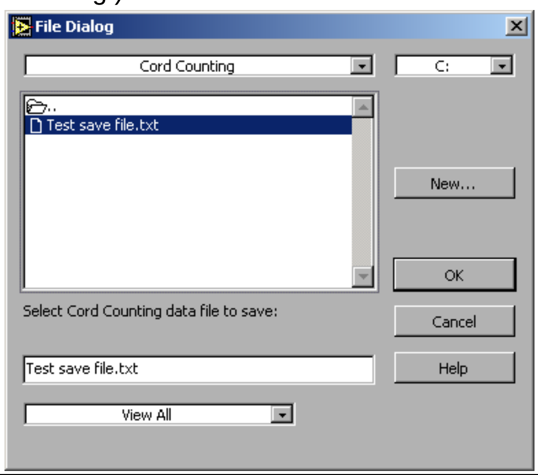
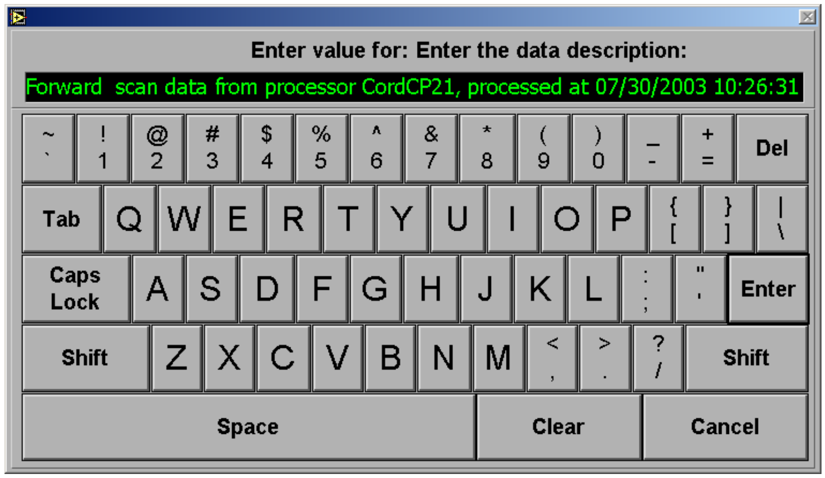
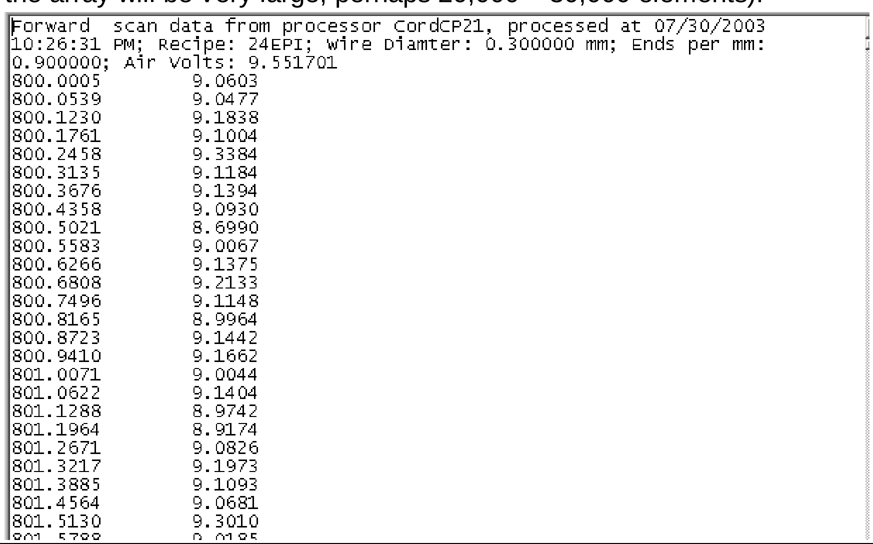


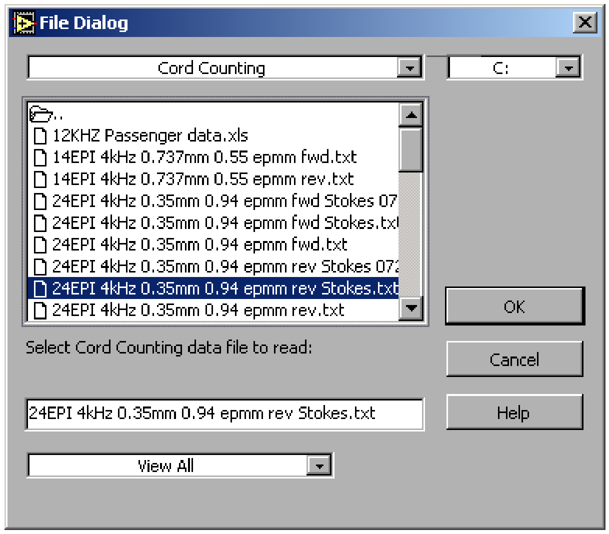
Figure 6-3 Maintain Data for Analysis Display

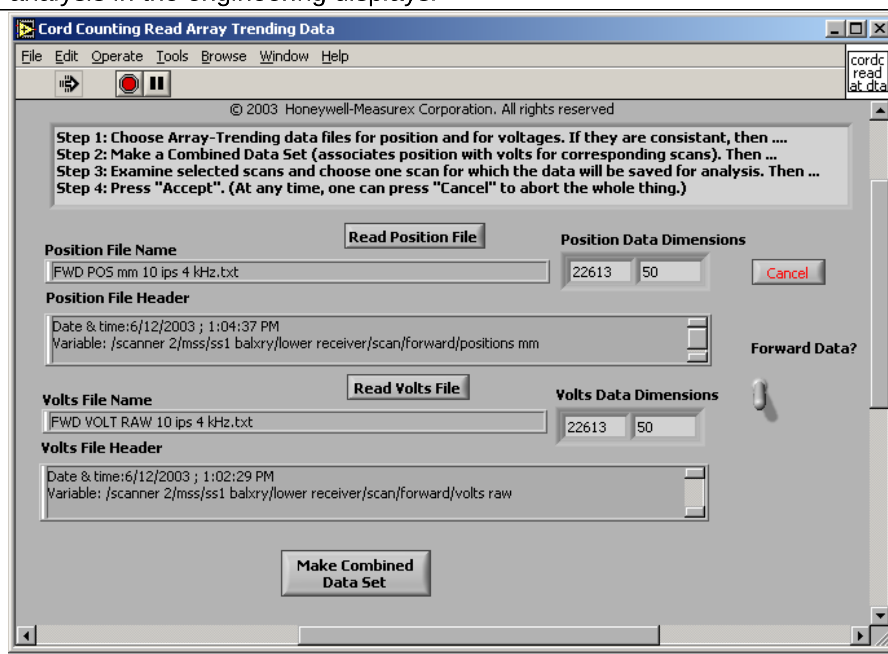
Table 6-2 Maintain Data for Analysis - Display Function Buttons

Button	Description
Upper Display Buttons	
Save Wire Calender Parameters	Prompts to save the units (yes / no) and then the diameter and ends per unit (yes / no).
Save Edge Detection Parameters	Prompts to **Save to Recipe** (yes / no) – saving the air volts, edge proportion and edge **FF**.
Write Data to File	Writes the position and voltage high frequency arrays to a tab-delimited text file that can be read offline by some other program or used to import for analysis or use as a simulation template. The first prompt requests a file name and location (default location is \database\calibration\cord counting\ - many files are stored for testing purposes in \hmx\gauging\test data\cord counting\): 

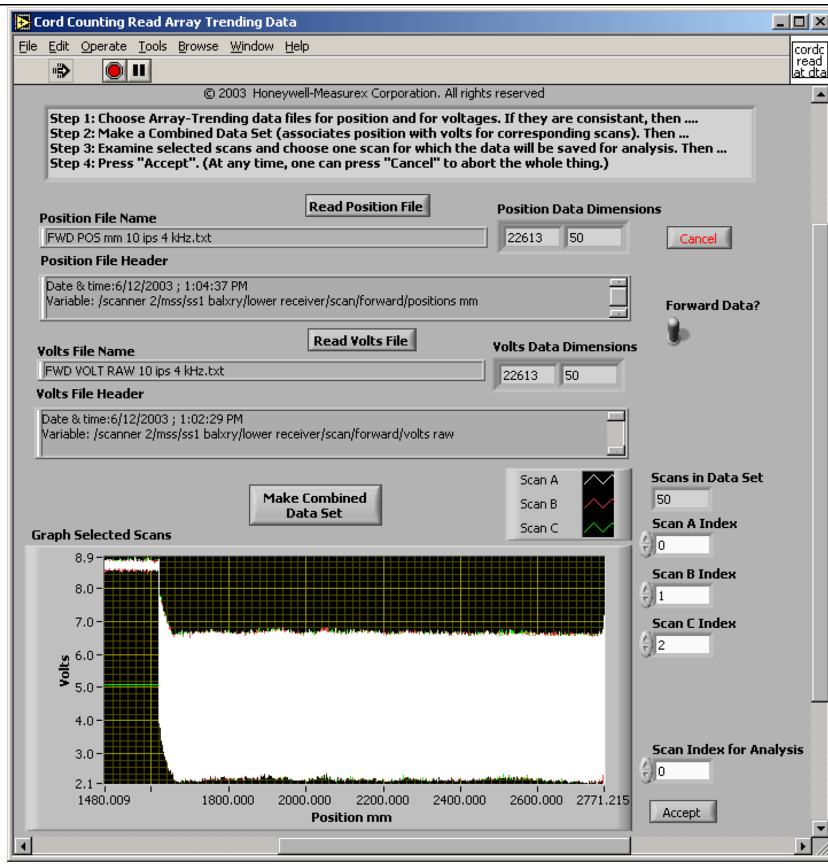
Button	Description
	Next dialog is for entering descriptive text that will be inserted in the first line of the file, which would include useful reference information like scan speed, data acquisition rate, wire diameter, ends per width unit, and other relevant information.  The saved file looks something like the next image (the first column is position (mm), the second column is the measured voltage at that position – the array will be very large, perhaps 20,000 – 30,000 elements):  Forward scan data from processor CordCP21, processed at 07/30/2003 10:26:31 PM; Recipe: 24EPI; Wire Diamter: 0.300000 mm; Ends per mm: 0.900000; Air Volts: 9.551701 800.0005 9.0603 800.0539 9.0477 800.1230 9.1838 800.1761 9.1004 800.2458 9.3384 800.3135 9.1184 800.3676 9.1394 800.4358 9.0930 800.5021 8.6990 800.5583 9.0067 800.6266 9.1375 800.6808 9.2133 800.7496 9.1148 800.8165 8.9964 800.8723 9.1442 800.9410 9.1662 801.0071 9.0044 801.0622 9.1404 801.1288 8.9742 801.1964 8.9174 801.2671 9.0826 801.3217 9.1973 801.3885 9.1093 801.4564 9.0681 801.5130 9.3010

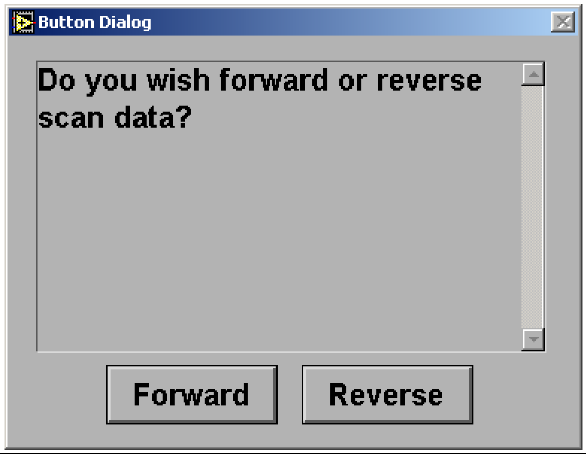
<table>
<tr><th>Button</th><th>Description</th></tr>
<tr><td>Read Data from File</td><td>Prompts for a file to read that will contain position and voltage arrays in a format like the Write Data to File function (refer to previous button description):

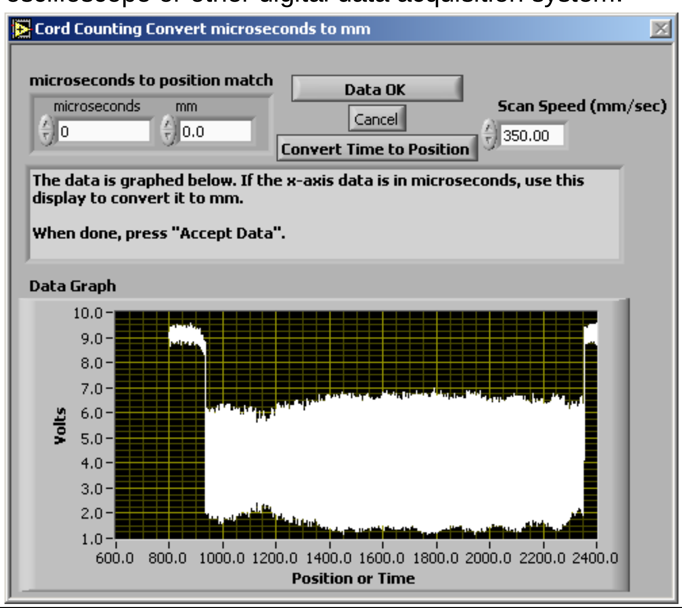


If the read file contents are okay, the data will be displayed and used for analysis in the engineering displays.</td></tr>
<tr><td>Read Array Trend Data from Files</td><td>

Press Make Combined Data Set and this dialog box appears:</td></tr>
</table>

Button	Description
	 Adjust scan A, scan B and scan C indices (to the right of the graph) to view comparisons between adjacent scans in the data. Select a **Scan Index** for **Analysis** value to select from the available data an array to export for the engineering analysis displays.
Lower Display Buttons	
Reinitialize with Processor Results	Reads the last scan data from the processor.
Read Edge Detect Data from Processor	Reads current edge position and calibration information from the processor.

<table>
<tr><th>Button</th><th>Description</th></tr>
<tr><td>Read Data from Processor</td><td>Reads either the last forward or reverse scan from the processor.


</td></tr>
<tr><td>Convert microseconds to mm</td><td>If you have imported data where the x-axis (position) date are not in distance units but rather in units of time, use this function to convert to position in mm. You'll be prompted for conversion factors. Press "Convert Time to Position" after entering conversion factors, then press "Data OK" to accept the results. This is useful if you have offline data collected by an oscilloscope or other digital data acquisition system.


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

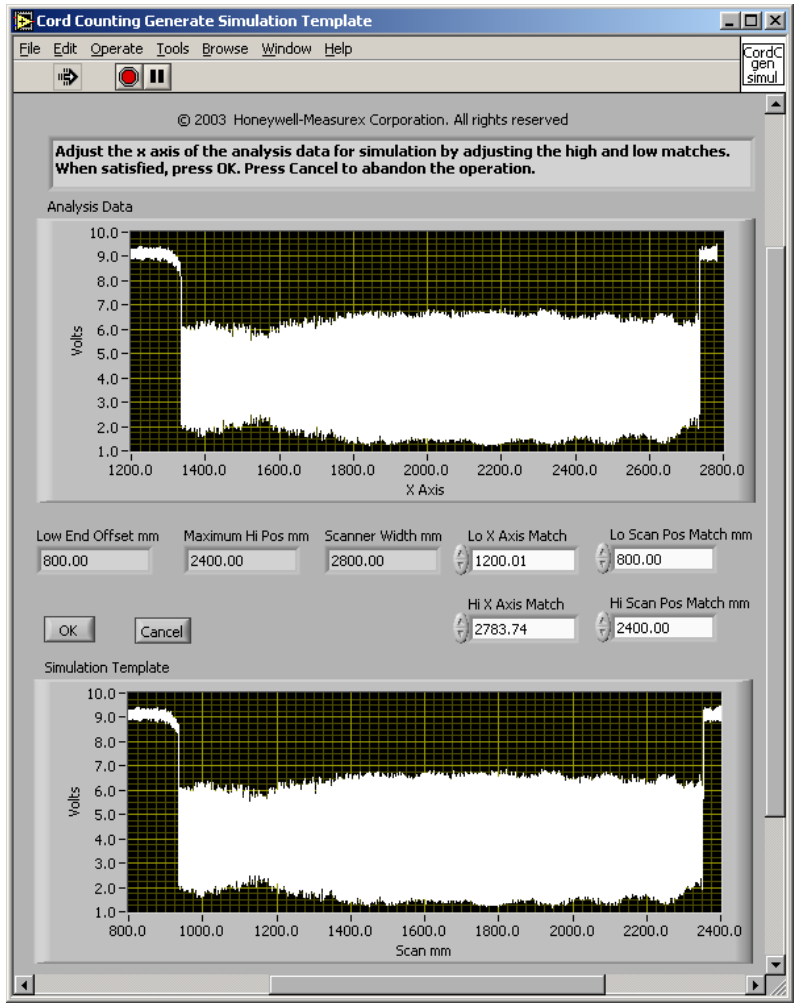
Button	Description
Generate Simulation Template	Creates a sensor signal array (volts vs. position) that is exported to the scanner simulator to generate cord voltage profiles when in simulation. This is good for offline analysis of saved data or remote analysis of saved data by persons not at the site where the system is installed. It can also be used to generate realistic data for tuning or training when the system or calender are in a state where the scanner can not be operated on calendered steel fabric (leader threaded, running textile codes, etc.). To complete the export to a simulation template, the display requests any necessary adjustments in the scan positions to align the imported data with the simulated edge positions and sheet width. 

Table 6-3 Maintain Data for Analysis - Display Data Entry Fields for Cord and Edge Detection Parameters

Field	Data Description
Data units	Selects the width units to be used for width, diameter and spacing measurements. Default is mm. The list of standard available units is: 
Aperture factor	Compute this value from the wire diameter and ends per unit = 1 - (ends per unit * wire diameter). This is the fractional open space between wires (fraction of the sheet that is gum between wires).
Wire diameter	Specifies the nominal diameter of the wires in whatever units are selected. Comes from the fabric table in the recipe database.
Ends per unit	Nominal number of wires per distance unit.
Air volts	Nominal sensor voltage when entirely off sheet. Should be something near 9 volts, should match the air volts shown in the standardization reports
Edge prop	Proportion (fraction) of the air volts used to detect the edge of sheet.
Edge FF	Filter factor (FF) used to filter the voltages when looking through the voltage array for the sheet edge. This is used in an exponential filter, so the filtered voltage (FV) will be FV = [FF * raw volts + (1 – FF) * previous raw volts]

6.4. Tune background profile calculations display

This display is used to tune the signal conditioning (including the amplitude, derivative and inter-derivative cuts) that are done prior to cord finding and spacing calculations. Press the Scale button to zoom the graph scales to view in detail any area of the array that has particular interest.

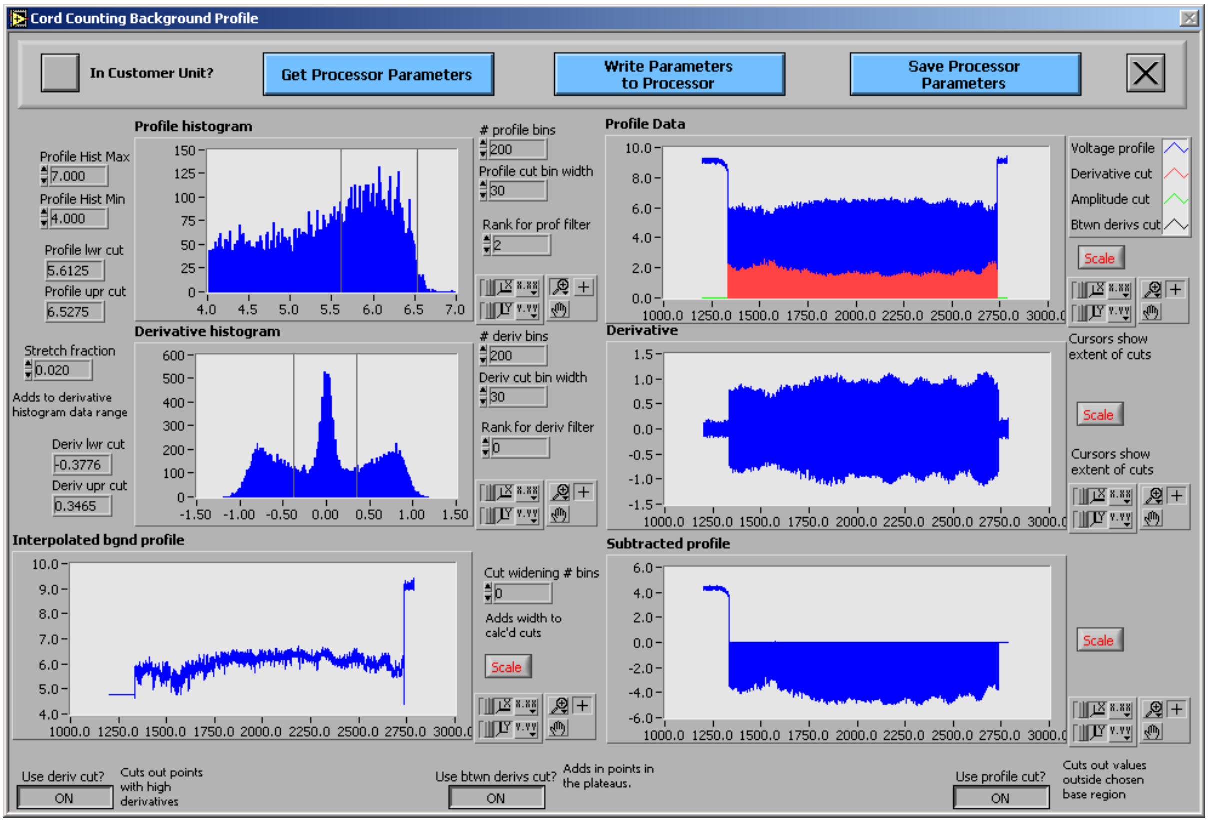


Figure 6-4 Background Profile Display

The zoomed graph shows the raw voltage (after median filter) and the affected areas due to the various masking algorithms:

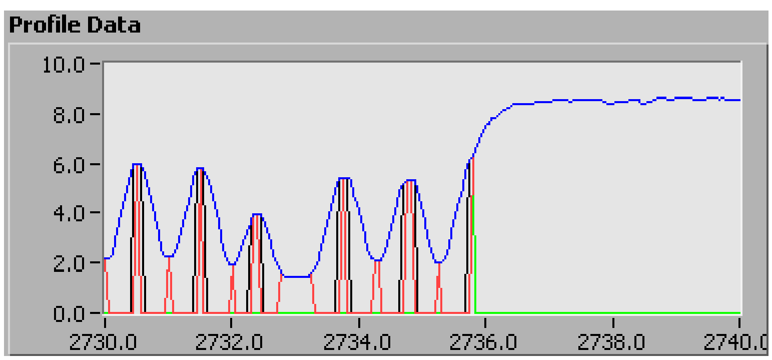


Figure 6-5 Sample Scaled Graph Detail

Figure 6-6 is the same data set showing the derivative at each point:

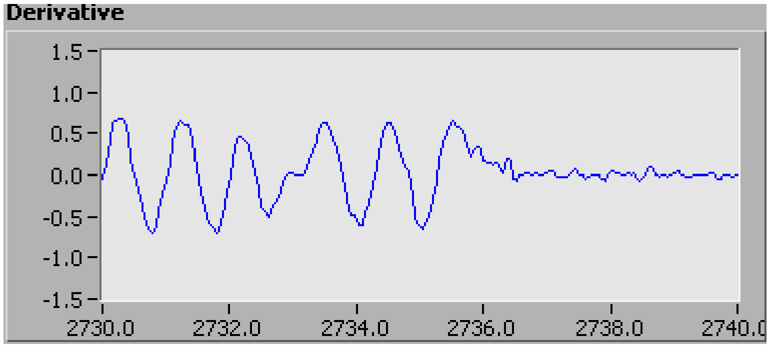


Figure 6-6 Zoomed Graph Showing Derivative

Figure 6-7 shows the subtracted profile at each point after interpolation and calculation of each of the masks:

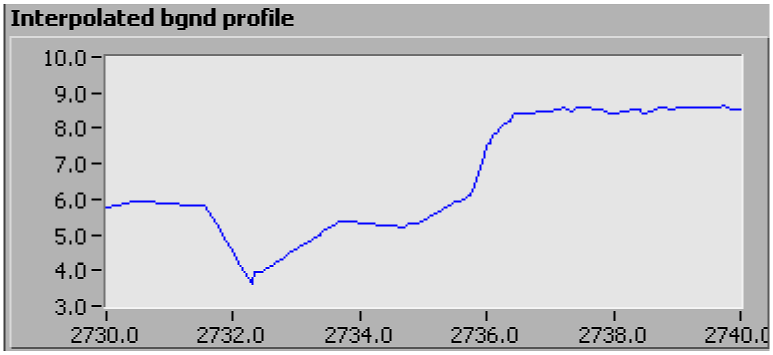


Figure 6-7 Zoomed Graph Showing Subtracted Profile

Finally, Figure 6-8 shows the subtracted result (raw filtered voltages minus the background):

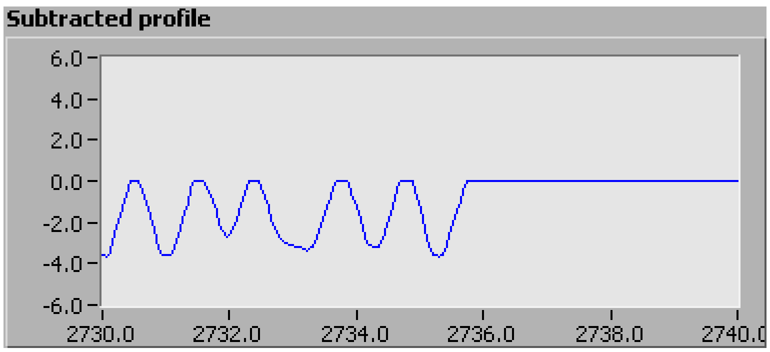


Figure 6-8 Zoomed Graph Showing Subtracted Result

Table 6-4 Tune Background Profile Calculations - Display Data Entry Fields for Adjustable Parameters

Field	Data Description
Profile Histogram Max	Defines the high end of the histogram. This histogram is not concerned with masking air or cord voltages, so only voltage between the air cutoff and the cord cutoff are considered. Also known as air cutoff voltage.
Profile Histogram Min	Defines the low end of the histogram. This histogram is not concerned with masking air or cord voltages, so only voltage between the air cutoff and the cord cutoff are considered. Also known as the cord cutoff.
#Profile Bins	Number of bins into which the histogram algorithm will divide the profile data. Adjust this value under very exceptional circumstances. The default value of 200 is okay for most applications.
Profile Cut Bin Width	Number of bins to exclude in the mask array to either side of the peak in the histogram.
Rank for Profile Filter	A median filter is used to smooth the array data before the histogram. The amount of smoothing from this filter is defined by the rank (number of elements to include when computing a median value). Zero rank produces no filtering, higher numbers produce more smoothing. A rank of two or less is okay.
Stretch fraction	Fraction by which the max and min of the derivative array is extended to compute the deivative histogram limits. It should be a small number that stretches at least one bin so that the histogram captures the full range of the derivatives. A value at least 1/#derivative bins is okay.
#Derivative Bins	The number of bins in the derivative histogram. The higher this number, the better the resolution of the histogram, but the more likely that the max (peak) value in the histogram will vary due to noise in the voltage array. The default value of 200 is okay for most applications.
Derivative Cut Bin Width	Number of bins to exclude in the mask array to either side of the peak in the histogram.
Rank for Derivative Filter	A median filter is used to smooth the array data before the histogram. The amount of smoothing from this filter is defined by the “rank” (number of elements to include when computing a median value). Zero rank will produce no filtering, higher numbers will produce more smoothing. A rank of two or less is okay for this application.
Cut Widening #Bins	Extends the cuts by that number of elements. Another tuning factor if needed.
Use Derivative Cut?	Enables the derivative cut.
Use Between Derivatives Cut?	Enables the inter-derivative cut.
Use Profile Cut?	Enables the amplitude cut. Recommended to use all three of the cut types, tuning them according to need. Each is designed to remove a particular feature from the raw profile to produce the desired result in the mask and resulting background profiles, none of them are adequate on their own.

6.5. Cord identification display

Cord identification is the process of searching the subtracted array for valleys (cords) and finding the low, center and high positions for each valley. If the background profile is tuned well, the valleys are very easy to find, so the cord center is easy to find. The cord count and cord spacing are then very accurate, even if the tuning is not optimal. It is quite another matter to accurately identify the high and low edges of each cord – the cords are small, even compared to the small slot size of the sensor.

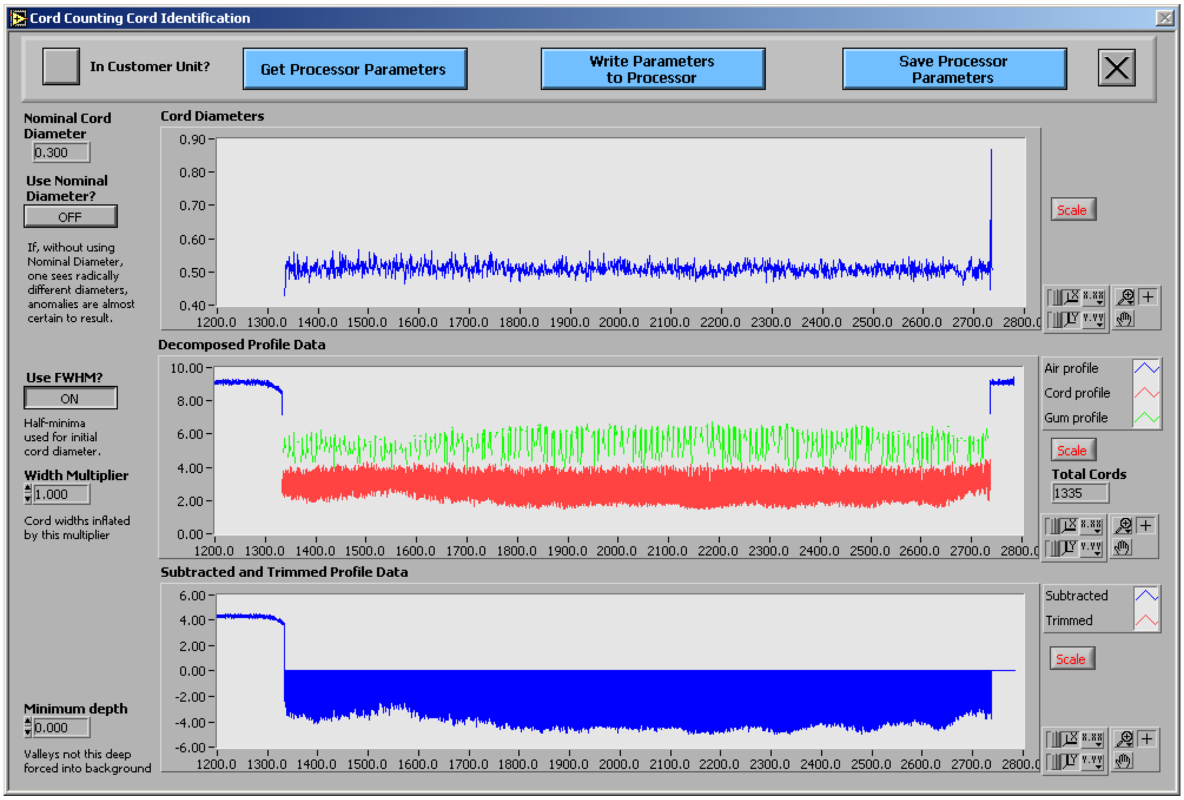


Figure 6-9 Cord Identification Display

The graphs can be zoomed to provide more detailed information. Of particular interest is the middle graph showing air, gum and cord locations using different colors in the graph of the raw sensor voltage (see Figure 6-10).

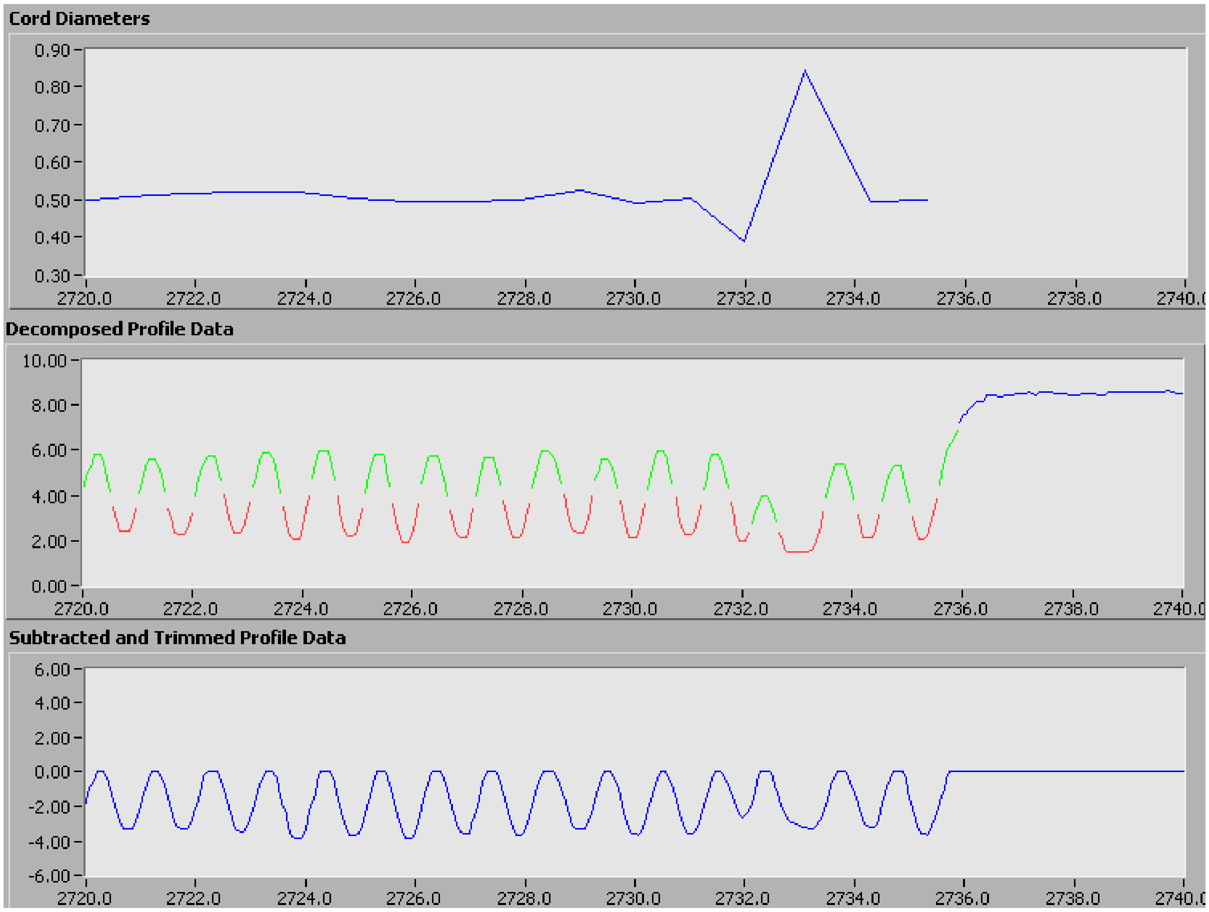


Figure 6-10 Cord Identification Display - Zoomed Graph

Table 6-5 Cord Identification - Display Data Entry Fields for Tuning Parameters

Field	Data Description
Use FWHM	Uses full width half-max algorithm to determine the cord low and high edges (and thus the diameters). Recommended for most wire, as it produces repeatable results in a wide range of conditions.
Use Nominal Diameter	Uses the cord centers (valley centers) to compute spacing, but assumes wires are at their nominal (recipe – see fabric table) diameters. Useful for very small or irregularly shaped wire.
Width Multiplier	Multiplier that artificially inflates the wire diameters by this multiplier. Use as a correction factor for fine tuning only after you are satisfied with the other tuning.
Minimum Depth	Minimum depth of a valley. The default is zero, leaving the algorithm free to find valleys on its own (a good option if the raw array is fairly clean and if the other tuning constants are known to be accurate). If you have a noisy profile and the median filter is not doing enough to smooth things, this might be a useful parameter to adjust to avoid finding false wires.

6.6. Tune fault identification display

This display shows details about the computed aperture factor and cord spacing, as well as highlighting any areas of the sheet with out-of-limits spacing (spacing faults). Once we've found the cords, it's a simple matter to compute the spacing and test against alarm limits. There are only two setup parameters on this display:

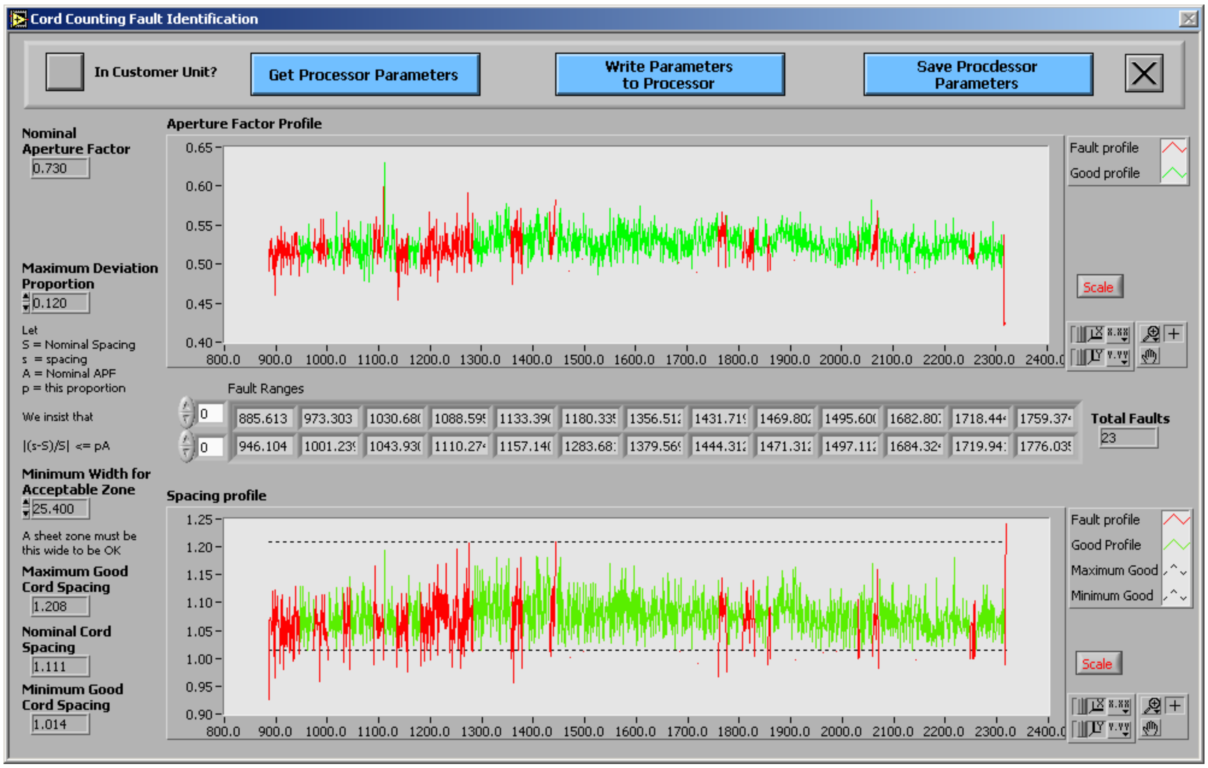


Figure 6-11 Tune Fault Identification Display

Table 6-6 Tune Fault Identification - Display Data Entry Fields for Tuning Parameters

Field	Data Description
Maximum Deviation Proportion	Fractional allowable deviation from nominal spacing – any wire with spacing greater than the nominal spacing * (1 + / - this fraction) will be in a spacing fault area.
Minimum Width for Acceptable Zone	Minimum distance between faults before a part of the sheet is declared good. In other words, if two spacing faults are 10 mm apart and the minimum good zone width is 25.4, the entire 10 mm distance will be declared as a fault area. This serves to prevent an excessive number of faults from confusing the situation, making true fault areas more visible to the operator.