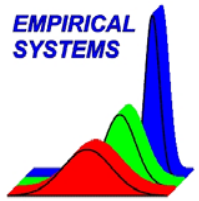
DataWindows Training

Required Tools:

PC or laptop with DataWindowsDemo* software installed

Tutorial 1: Getting Started and Collecting Data
Tutorial 2: Reviewing Data
Tutorial 3: Data Analysis and System Matching
Tutorial 4: New Process Setup
Tutorial 5: Student T Tests

*DataWindowsDemo can be downloaded from
www.empirical-systems.com/support.htm



Tutorial 1: Getting Started and Collecting Data

Tutorial 1: Getting Started and Collecting Data

Overview

- This Tutorial will show you how to load configuration files, specify a System ID for data traces, connect input signals and record data traces.
- DataWindowsDemo.exe is used in the Tutorial as a simulation program that will enable you to collect data from a fictitious process tool.
- For this Tutorial, a DataWindows configuration file has been developed to match the fictitious process tool that you will be monitoring. Configuration file development will be covered in Tutorial 4, New Process Setup

Step 1) Loading a configuration file.

- Find the **DataWindowsDemo** folder in the **Program** folder on the Window's **Start** Menu and select the **DataWindowsDemo** executable.
- After the program loads, select **Read Setup…** from the **File** menu.
- This will display a list of available process configuration files.
- Select **DataWin Demo** from the listed processes and click on **OK**.
- This configuration file was developed to illustrate the functions of DataWindows. In the real world, you would load a configuration file that has been specifically designed by an process applications specialist that is an expert on the process tool you will be monitoring. When you load process configuration files, you are loading much more than channel setup information (as we will soon find out).

Step 2) Edit System ID and Connect input signals.

- From the **Configure** menu, select **System Name** and enter "**W1001**" and select OK. This will identify all future traces with this System ID. This name can be changed at any time to indicate you have moved to a different system.
- Then, select **Channel Setup** from the **Configure** menu. This will display a panel which list each of the 32 input channels.
- For each channels, you can right click on the channel name to get connection instructions. For example, you can right click on Manometer 1 to read how this signal can be connected.
- When you are finished with channel instructions for Manometer 1, click on **Cancel** or **Ok** to save.
- Also, you can change channel colors by clicking on the color box to the right of channel names.
- After you are done with this page, click on **Cancel** to return to the main screen.

Step 3) Collecting Data

- Check to make sure **Toggle Realtime Analysis** is not checked on the Tools menu. If it is, use the mouse to toggle it until it becomes unchecked (this option will be covered in Tutorial 3).
- Click on **Start** to start simulated data collection. A message box will inform you that data collection will start when Trigger 1 is true. Click on **Ok**.
- The simulation will run a short precoat followed by 16, 2 step deposition cycles. Note the data will be identified with System ID, Date and Time. You can add a comment for each run by typing in the comment field. When the run is complete the comment will be saved.
- After the 16 cycles, another precoat will begin followed by another 16 cycles. Until you click on the **Stop** button, this sequence will continue.

Step 4) Changing the view while data collection is active.

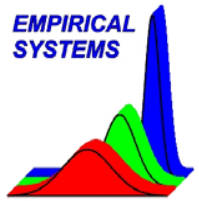
- A Legend is displayed in the top right corner of the display.
- You can toggle visibility of the Legend by selecting or un-selecting **Legend** from the **View** menu or by pressing **Ctrl L**.
- The Legend can be resized by holding down the left mouse button and dragging the left edge of the Legend.
- You can hide channel traces by selecting **Display/Hide Traces** from the **View** menu or pressing **Ctrl T**. Then with the mouse, check only those channels you want to display. Hiding a channel does not inhibit data collection for that channel.
- You can also change the axes' scale by selecting **Change X-Y Scale** from the **View** menu. When scales are changed, the screen will be cleared and new data will be added to the screen.

Step 5) Making sure you can save data at the rate you are collecting it.

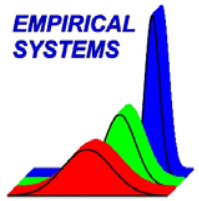
- At high sample rates and/or with many active channels, the PC or laptop that is collecting data has a lot of work to do. Each second, it must transfer data from the data acquisition system, process the data, and save it to disk. This must be done before one second elapses or a buffer over run will occur and the data trace will have a gap in it. A gap in a data trace could produce a very disturbing situation: bad data results in a bad diagnosis of a process tool which results in the tool being needlessly taken off line. DataWindows was designed to prevent this situation.
- A bar graph at the top of the screen labeled **Status** displays the CPU Usage required to transfer data, process it and to save it. 0% is on the left and 100% is on the right. Usually, this graph will display a value which is very near zero.

Step 5) Making sure you can save data at the rate you are collecting it (continued).

- The Status bar graph can be monitored to determined the potential to generate a buffer overrun and produce a gap in data. A bar graph that is constantly displaying a value near zero indicates the potential is low and that no action in needed. A bar graph that is displaying a value near 100% indicates the potential is high and that the user should take steps to reduce CPU Usage. To reduce CPU Usage, the user can exit other applications, reduce the sample rate or reduce the channel count.
- When you are comfortable with the material in this tutorial, leave the simulation program running and continue to Tutorial 2 on the next page.



Tutorial 2: Reviewing Data

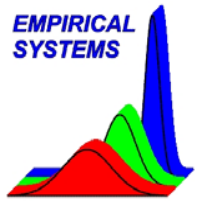


Step 1) Selecting data to review.

- While collecting data, it is possible to review data by starting a special viewer program that was created for this purpose. To do this, find and select **DataWindowsReview** in the **DataWindowsDemo** folder of Window's **Start** menu. This will launch a new program that is identical to DataWindows except data collection is inhibited.

Step 2) Selecting data to review.

- From the DataWindowsReview program, click on the **Playback** button. This will display a list of available data to playback.
- The first entry in the Trace ID listbox is identified as **DataWin Demo POR**. It is not part of the data set you have collected. This entry is part of the configuration file which was loaded when you selected the **DataWin Demo** process in Tutorial 1. Each process configuration file will have is own POR. The POR gives you chance to see how an process expert expects the data to look. We can now compare the data we just collected to the DataWin Demo POR.



Tutorial 2: Reviewing Data

Step 2) Selecting data to review (continued).

- Below the POR entry in the Trace ID listbox, will be displayed a chronological list of collected data.
- As you click on Trace IDs, the fields on the right (System ID, Process, Date, Time, Triggers in the run and Active Channels) will be updated with information from that run.
- Trace Ids that are preceded with a '+' symbol have more than one triggered event. Each triggered event can be replayed individually by double clicking on the Trace ID to display the individual triggers, then select the trigger event of interest.
- If you change your mind and would like to select an entire run, click on the entry preceded with a '-' symbol (the '-' is only visible when a run is expanded).
- Each selected data set will have a check mark preceding it. Many data traces can be selected as a combination of individual triggers and/or complete Trace IDs.

Step 3) Reviewing Data with Auto X Scale

- Data can be replayed to several destinations. For now, select **Strip Chart with Auto X Scale** from the **Playback Destination** list box. This option will display all selected data onto one graph in the chronological order it was collected. The POR, if selected, will be displayed as the last one on the right.
- For this tutorial please limit your selections to less than 20 triggered events. After you have made your data selection and destination selection, click on **Ok** to view the data.

Step 4) Zooming

- Once traces have been replayed, points of interest can be zoomed with a Ctrl left click of the mouse.
- A Ctrl right click will zoom out.
- Further zoom options are available by right clicking on the graph area.

Step 5) View Options and Printing

- If you want to set X-Y scales to specific value, select **Change X-Y Scale** from the **View** menu.
- The visibility of channels can be toggled by selecting **Display/Hide Traces** from the **View** menu or by pressing **Ctrl T**.
- To generate PDF files, click on the **Print to PDF** button. Adobe Reader must be installed to view these files.

Step 6) Reviewing Data with Overlay Charts

- It is often necessary to compare one data trace to another. With the Auto X scale option, it is only possible to do this in a limited manner because traces can only be placed next to each other. In some cases, it is more useful to compare traces with an Overlay Chart.
- An Overlay Chart will align data sets so that their triggers are aligned on the X Scale. This option is very useful for detecting timing problems.
- The Overlay Chart can be selected, after clicking on the **Playback** button, from the **Playback Destination** control.
- Expand one of the data sets in the Trace ID column which is preceded with a '+' to display individual triggers.
- Select one the of the triggers and select **Strip Chart Overlay Chart with Auto X Scale** from the destination control and click on **OK.**

Step 7) Reviewing Data with Overlay Charts (continued)

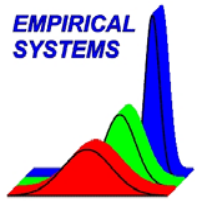
- After selecting **Strip Chart Overlay Chart with Auto X Scale** from the destination control and clicking on **OK,** a popup dialog gives you the option to **Add to current chart** or **Create a new chart**.
- Select **Create a new chart** and observe the displayed data.
- Then click on the **Playback** button again.
- This time select the POR entry from the **Trace ID** listbox.
- Then, make sure **Strip Chart Overlay Chart with Auto X Scale** is selected on the destination control and click on **OK**.
- Select the **Add to current chart option**.
- This will add the new data to the previous chart. The first data set will be displayed with solid lines. All traces after the first will be displayed with dash traces.
- Channel visibility can be toggled by pressing **Ctrl T**.

Step 8) Reviewing Data with Strip Charts

- Often it is useful to playback data in the same manner that it was collected. This can be performed by selecting Strip Chart for the playback destination.
- This method enables the user to playback large amounts of data without worrying about memory limitations.
- Also, when this method is selected, the user is presented with playback controls (shown below) to fast forward, play, step forward, step back, and reverse.
- Click on Playback and replay a few files with this method.

Step 8) Check on Data Collection

- Press **Alt-Tab** to switch back to the **DataWindowsDemo** program to check on data collection. Then switch back to **DataWindowsReview** and Playback a few more traces.



Tutorial 3: Data Analysis and System Matching

Overview

- Now that you are familiar collecting and reviewing data with DataWindows, it is time to learn how to analyze data with statistics, timers and step characterization tools.
- This Tutorial will first show you how to manually analyze data, then it will show you how to do it automatically.
- After this, you will be shown how to generate a system match Summary Report.
- For this Tutorial, we will continue to use the same configuration file as previous Tutorials. This configuration file is similar to what you may be given in the field when you need to match a process tool to a Process of Record.
- We will learn how to analyze data, find out how to view results in SPC Charts and enable Realtime Analysis in this Tutorial.

Overview (continued)

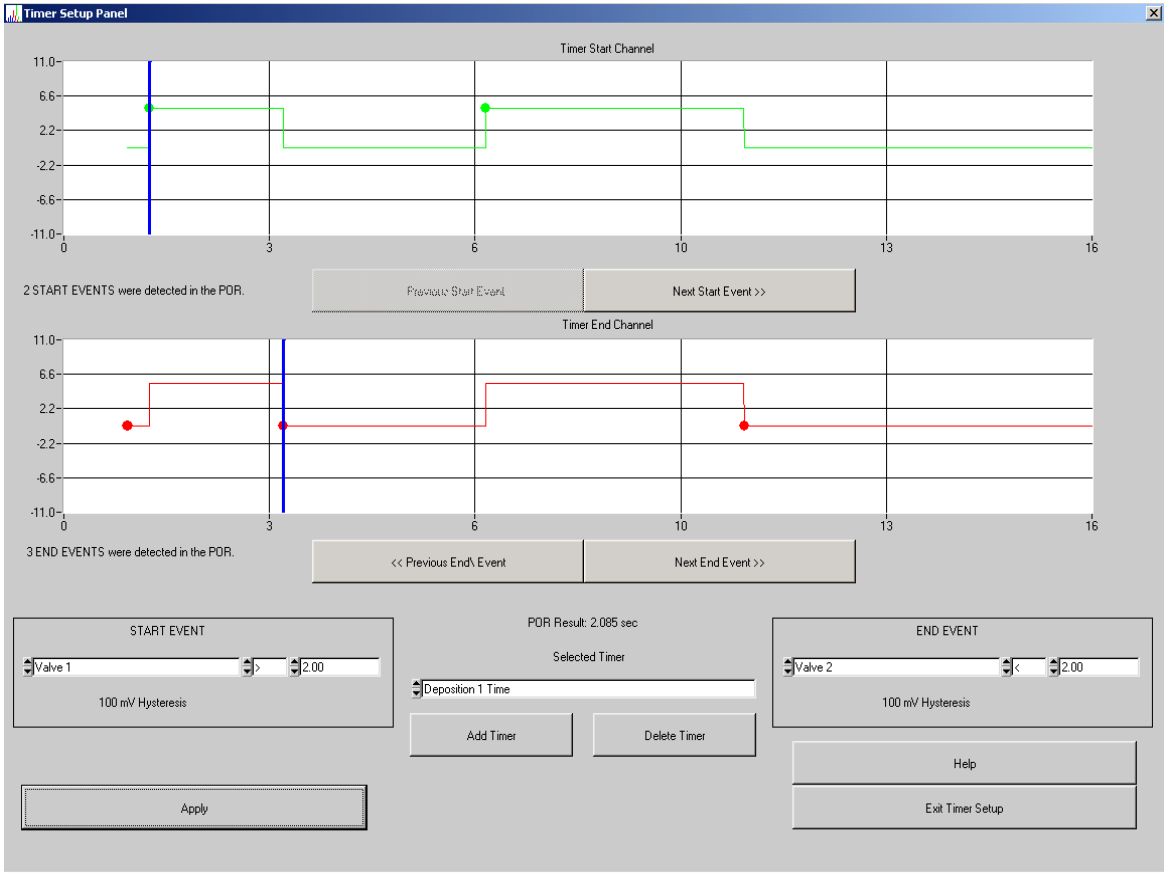
Available Statistics

- Channel Mean
- Channel Standard Deviation
- Channel Maximum
- Channel Minimum
- Typical uses: pressure, temperature, bus current or voltage

Overview (continued)

Timers

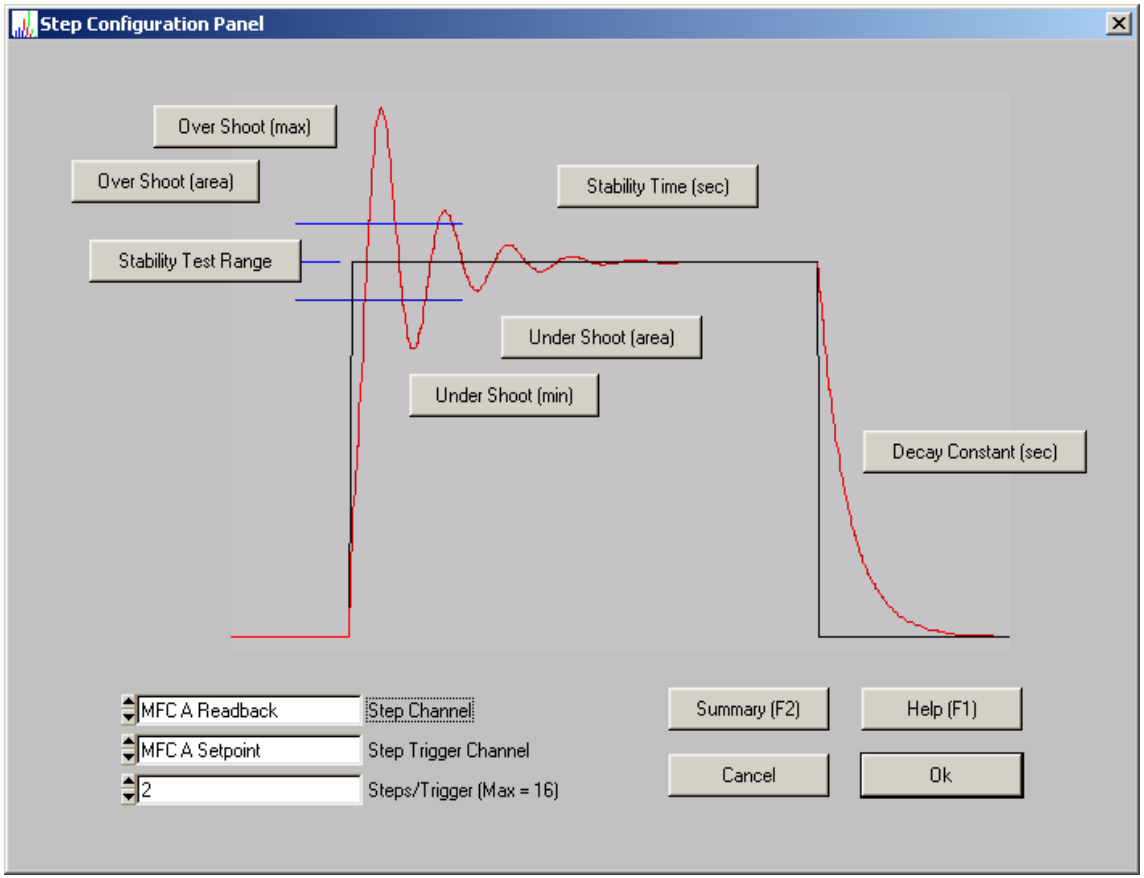
- Independent start and stop events
- Noise tolerant due to 100 mV hysteresis
- Typical uses: software verification, monitor critical valve timing, determine stability time after an event



Overview (continued)

Step Characterization Tests

- Stability Time
- Overshoot Area
- Undershoot Area
- Maximum Overshoot
- Minimum Overshoot
- Decay Constant
- Typical uses: MFC monitoring, control loop testing



Step 1 Manually Analyzing Data

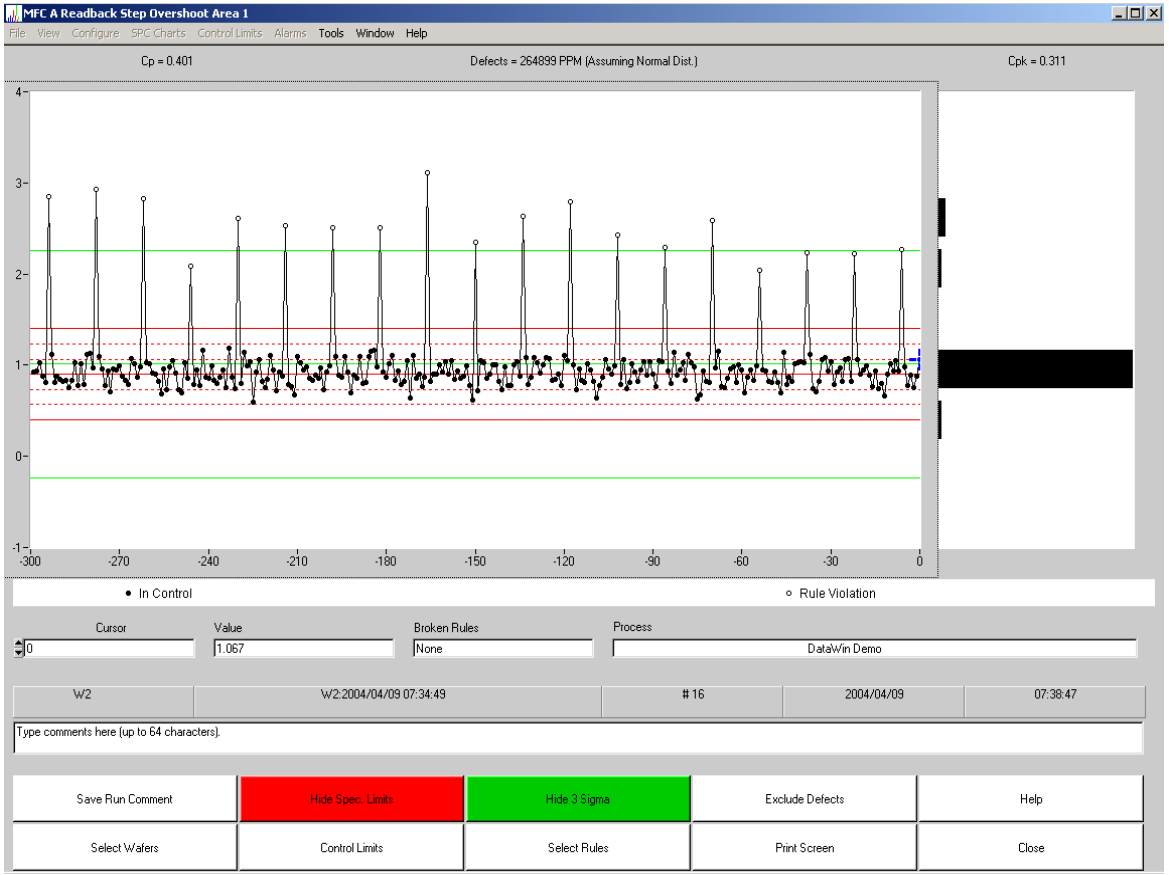
- While you are collecting new data with the DataWindowsDemo program, press Alt Tab to return to DataWindowsReview.
- Click on **Playback**.
- Be sure to select at least 2 data sets with 16 triggers. This will generate the data necessary to complete this Tutorial (please make a note of the data sets that are selected for future reference).
- Select **Strip Chart** from the **Playback Destination**.
- From the **Analyze Option** list box, select **Analyze Data**.
- Click on **OK**.
- Then click on the fast forward button to speed things up.
- During the replay, tests that have been configured in the DataWin Demo setup will be performed and the results of the tests will be compared to specification limits. When violations are detected, alarms will be generated.

Step 2 Reviewing Analysis Results

- **DataWindowsDemo** generates simulated process data with random number generators. To illustrate system matching failures, the simulator will also generate out of family data that will almost certainly generate errors. After completing Step 1, if you don't get an **MFC A Setup Overshoot Area** error, go back and repeat Step 1 with a different Trace ID.
- A popup panel will display error information about the violations. After reviewing error info, click on **OK**.
- You may notice that MFC A data collected for the 10th trigger is out of family. However, it is difficult to assess from a strip chart graph.
- For a definitive answer, select **Step Channel Charts** from the **SPC Charts** menu. Then select **MFC A Readback** followed by **Step 1 Overshoot Area**. This will display a panel which will allow you to select data to review in a SPC Chart. Click on OK to accept the default values.

Step 3 Viewing SPC Charts

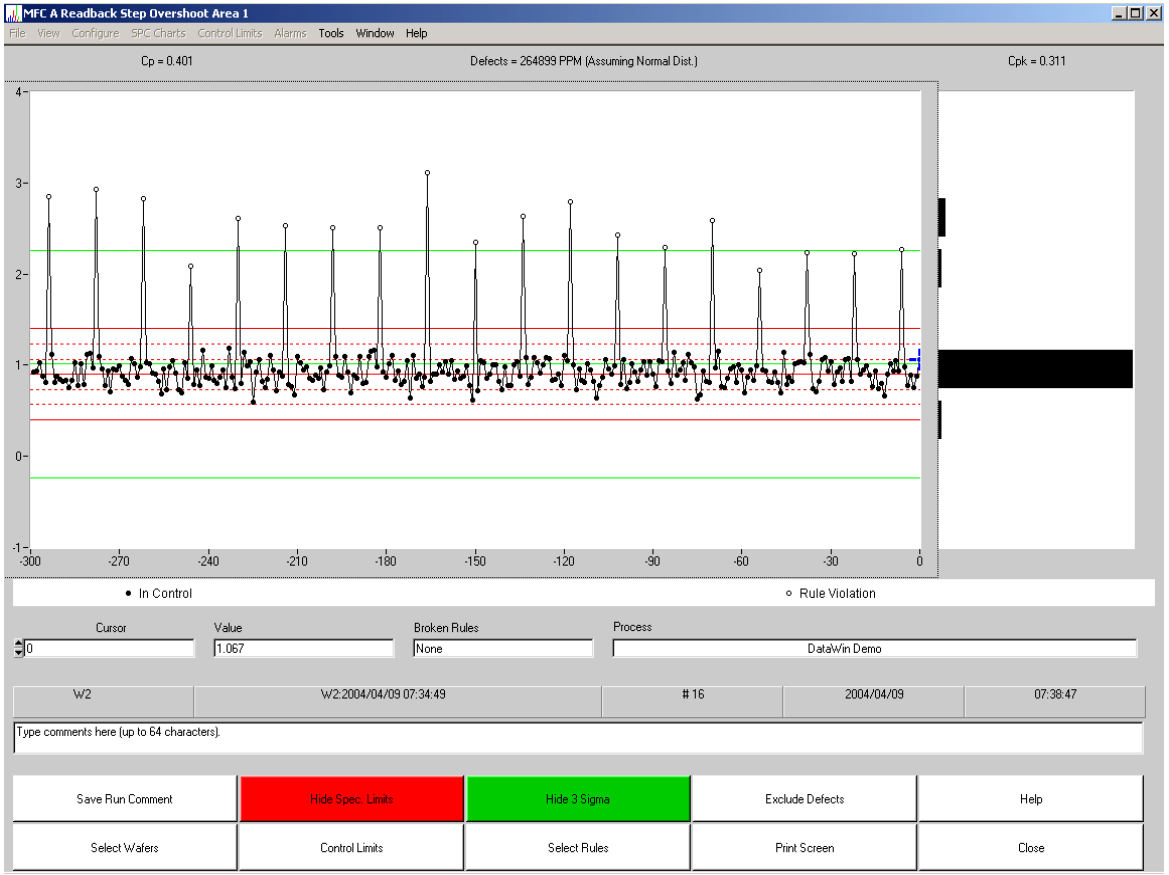
- SPC Charts display processed data in a chronological order.
- Each point is the result of the calculation that was done on the raw data.
- You can click on each point to display System ID, Trace ID, Trigger Number, Date and Time.
- Spec limits are charted in red and 3 sigma limits are in green.



SPC Chart

Step 4 Displaying raw data from SPC Charts

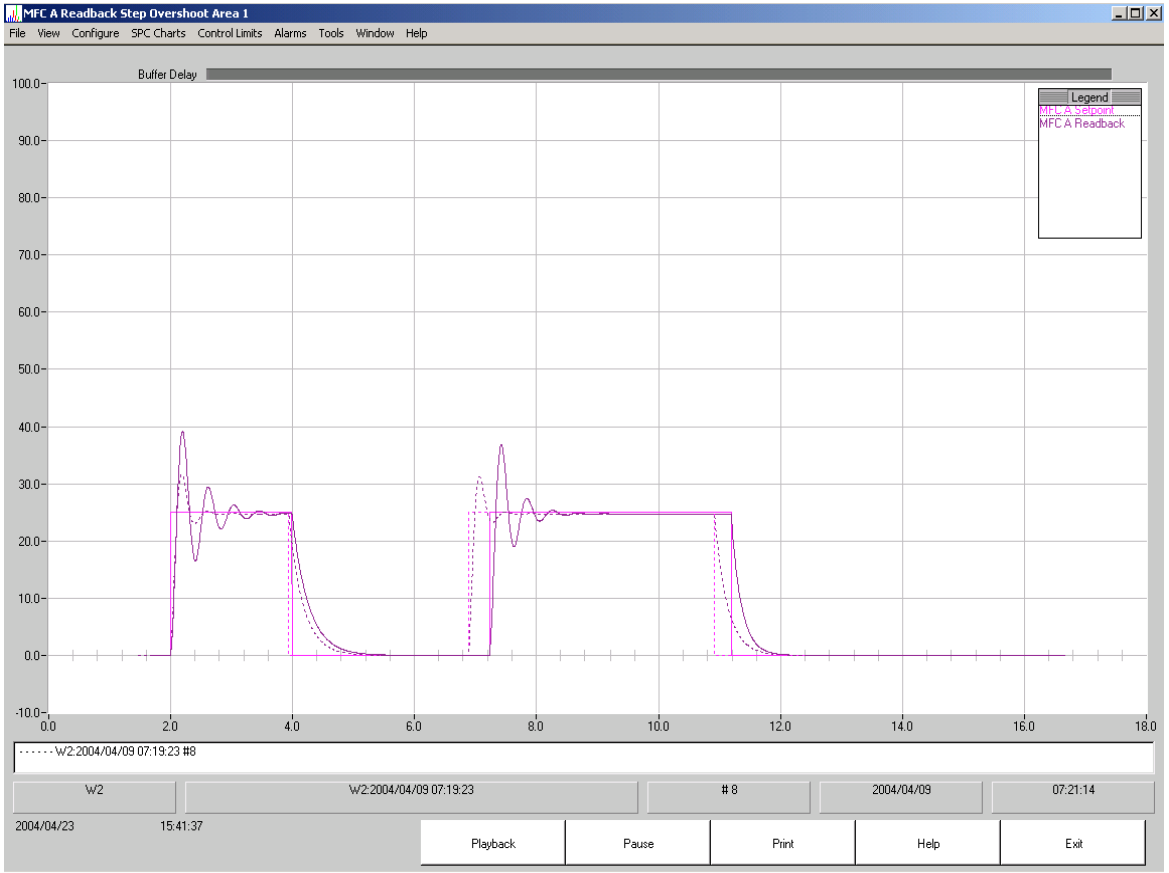
- From the SPC Chart, it is obvious that trigger 10 is out of family.
- To further investigate, double click on one of the out of spec points.
- Click Yes, to confirm your intention to view a strip chart for that point.
- Then select channels MFC A Setpoint and MFC A Readback from the popup panel.



SPC Chart

Step 4 Displaying raw data from SPC Charts (continued).

- Select **Create a new chart** option.
- Now, double click on one of the in spec data points on the SPC Chart.
- Click on **Yes** to confirm.
- Select channels MFC A Setpoint and MFC A Readback and hit **Ok**.
- Click on **Add to current chart** (new data will be overlaid with dashes).



Overlay Chart

Step 5 Generating System Matching Report

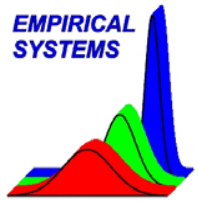
- Select **Generate System Matching Report** from the **Tools** menu.
- Then select from the Trace ID list box the runs that you manually analyzed.
- Click on OK.
- A popup panel will tell you if any violations occurred on those runs.
- Then, text will be displayed in Notepad.
- For each critical process parameter, an entry in the text file will tell you whether the test passed or failed.
- You can save the file, print it or cut and paste it into another document.

Step 6 Further Investigation

- For further investigation, see if you can use the skills that you have learned to first display the SPC Charts for each of the errors that were generated.
- Then from the SPC charts, display the strip chart data and determine why the error was generated.
- For example, you can investigate the cause of Deposition 1 Timer errors, by reviewing the Deposition 1 Time SPC Chart.

Step 7 Activating Realtime Analysis

- Press Alt Tab to return to DataWindowsDemo.
- Click on **Stop** to halt data collection.
- From the **Tools** menu, select **Toggle Realtime Analysis**.
- Verify a check mark appears next to Toggle Realtime Analysis.
- Then click on **Start**.
- Data collection will begin and data analysis will be performed on traces as they are collected.
- After a few minutes, the screen will turn yellow to indicate an error has occurred and a popup panel will inform you of violation details.
- Alarms can be viewed and cleared from the DataWindowsReview application by selecting **Clear Current Alarms** from the **Alarms** menu.



Tutorial 4 New Process Setup

Overview

- The previous Tutorials have utilized a predefined configuration file. It was assumed this file was correctly setup to not only collect data but also to process the data and to determine when data meets specifications.
- This Tutorial will demonstrate how to generate a configuration file if one is not available.

Step 1 Saving a new configuration file.

- Switch to the DataWindowsDemo application and click on **Stop** (if necessary).
- Select **Save Process As…** from the **File** menu and enter a descriptive name to identify the new process setup file.
- Click on **Ok**.

Step 2 Channel Setup

- Select **Channel Setup** from the **Configure** menu.
- As you connect each channel to the MX32USB data acquisition board, toggle each channel **Status** button to **On** and enter a descriptive text name in the **Channel Name** field.
- Then, right click on the channel name and enter connection instructions.
- To calculate channel mean, standard deviation, maximum and minimum set the **Data Type** to **Static**.
- To characterize MFCs, channel **Data Type** should be set to **Step**.
- For all other channels select **Valve** as the **Data Type** (this reduces the number of calculations the software has to do).
- A linear transformation will be preformed on each channel, Y = A * X + B. If you would like to convert voltage to engineering units, enter the appropriate values. Otherwise, set A = 1 and B = 0.
- Click on **Ok**, when finished.

Step 3 Selecting a sample rate.

- Select **Daq Setup** from the **Configure** menu.
- From the **Sample Rate** listbox, select a sample rate that will meet your requirements.
- Click on **Ok**.

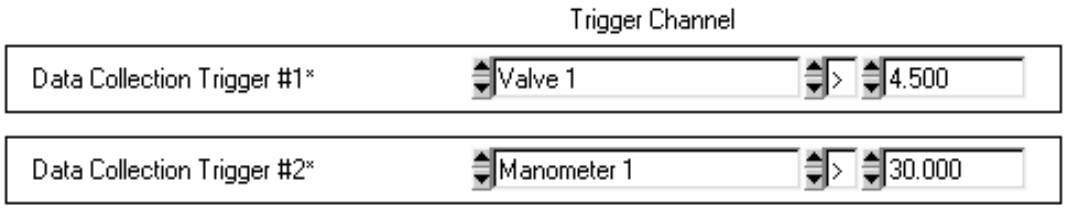
Step 4 Trigger Setup

- Data triggers are required to collect data when data of interest is available.
- Select **Trigger Setup** from the **Configure** menu to display the trigger setup panel.
- Up to 2 logical conditions can be activated to generate a data trigger.
- To activate Trigger #1, select a trigger channel from Trigger #1, Trigger Channel listbox. Then specify a greater than or less than condition and a trigger value.
- Trigger #2 can be deactivated by selecting Disable from Trigger #2 Trigger Channel listbox. To activate Trigger #2, select a trigger channel from Trigger #2, Trigger Channel listbox. Then specify a greater than or less than condition and trigger value.

Step 4 Trigger Setup (continued)

Example:

You may want to collect data when Valve 1 signal goes above 1.0, but only during a deposition cycle (not during a gas box flush). During a fictitious deposition cycle Manometer 1 is > 30.0 while during a gas box flush Manometer 1 is < 10.0. Below, it is shown how to enter this information.



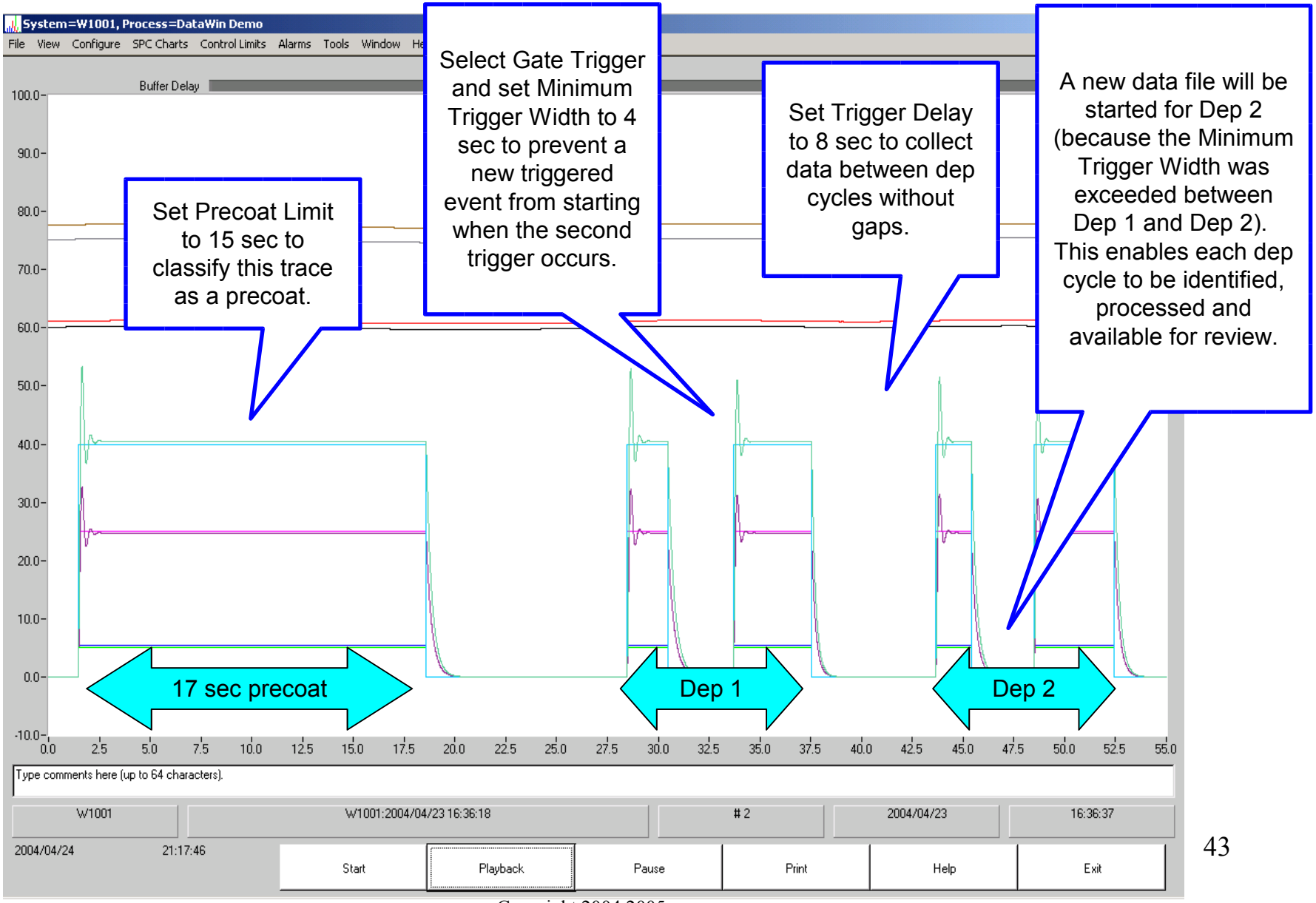
Step 4 Trigger Setup (continued)

- 1 to 2 seconds of data prior to a true data collection trigger will be saved in data files. This ensures the user will not miss transient activity when the trigger occurs.
- The **Trigger Delay** parameter is used to determine when data collection ends. To stop collecting data 10 sec after a trigger condition, set the Trigger Delay to 10.
- The end of the data file also depends on whether the trigger is set to a gate or an edge trigger. For a gate trigger, data collection will end when the Trigger Delay expires after the trigger becomes false. For a edge trigger, data collection will end when the Trigger Delay expires after the trigger becomes true.
- The Minimum Trigger Width can be used to ignore triggers that occur before the Trigger Delay transpires. This useful when a process sequence has several conditions that meet trigger conditions, but you don't want to start another trace.

Step 4 Trigger Setup (continued)

- The Precoat Limit can be used to classify traces as precoats. For example, set the Precoat Limit to to 80 to identify traces longer than 80 seconds as precoat traces. When a trace is identified as a precoat, the data will be identified with a precoat suffix
- After you have finished trigger configuration, click on **OK**.
- Then Click on Start to test the trigger. If the trigger operates correctly, proceed to the next step. Otherwise, repeat Step 4 until the trigger functions as desired.

Tutorial 4: New Process Setup
Step 4 Trigger Setup (example)

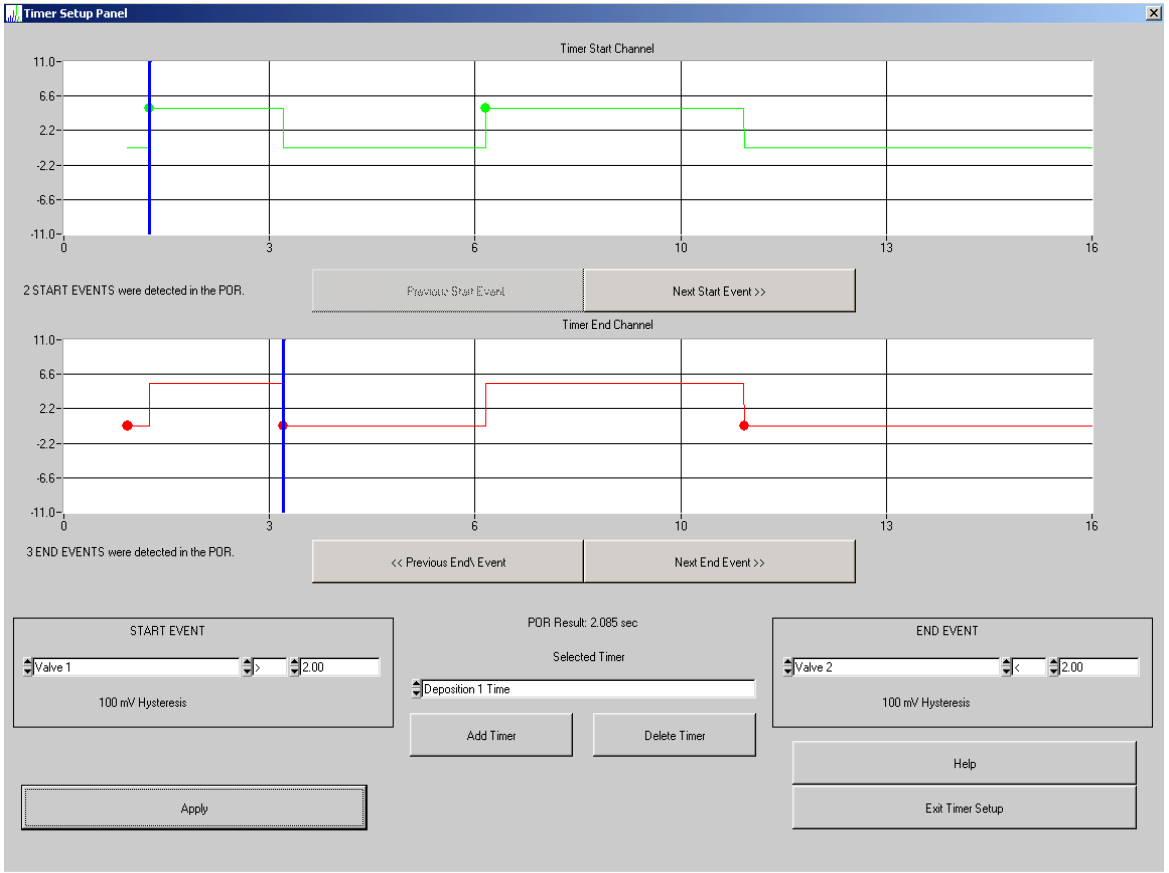


Step 5 Selecting a Process of Record (POR)

- After Trigger Setup has been completed, collect several sets of data to verify the trigger and to generate a data set from which a Process of Record can be selected from.
- The selected POR will serve as a model for all other traces and will enable timers to be setup. Data should be reviewed to determine the Trace ID and the Trigger number which would be most appropriate for the POR.
- After a trace has been selected to be the POR, select **Choose the Process of Record from…** from the **File** menu.
- Then select the Trace ID from the Trace ID listbox and the Trigger number from the Trigger listbox to create a new POR.
- Once the process of record has been selected, it will become part of the process setup. When you export a process and send it to the field, DataWindows will make a copy of the POR and save it with the exported process. In this way, users in the field will also be able to review and compare their data to the same POR you have identified.

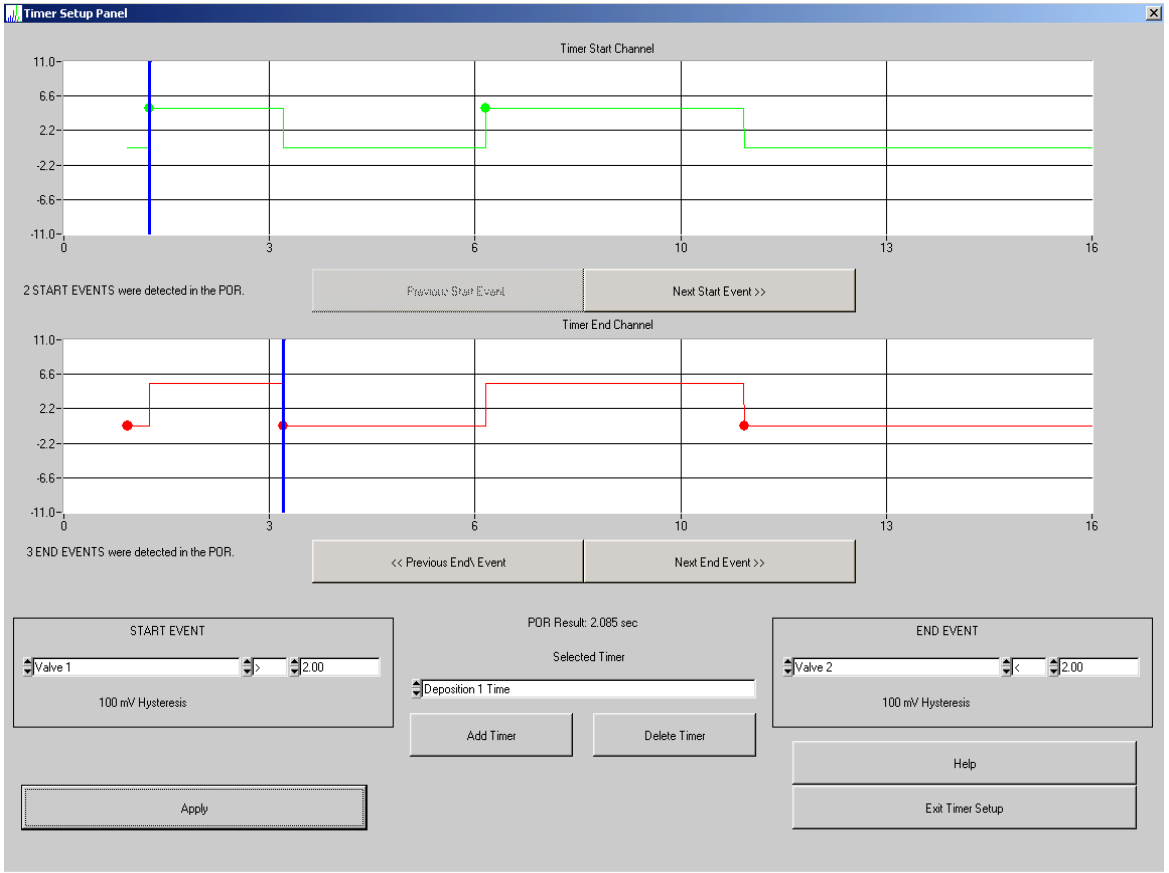
Step 6 Configuring timers

- To configure timers, select **Timer Setup** from the **Configure** menu.
- If necessary, delete unwanted timers by selecting them from the **Selected Timer** listbox and clicking on **Delete Timer**.
- Then click on Add Timer and enter start and finish conditions as prompted.



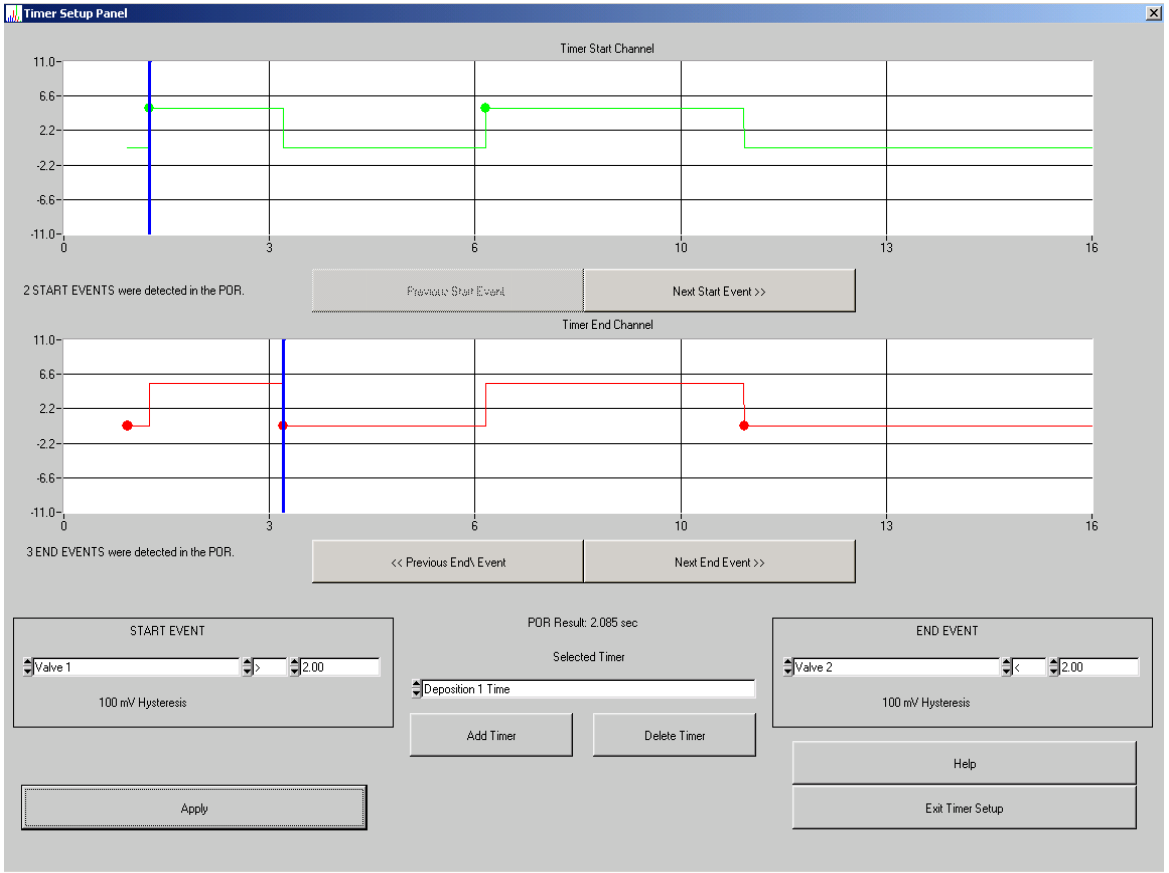
Step 6 Configuring timers (continued)

- The start channel will be displayed in green and the stop channel will be displayed in red.
- If necessary, adjust the start or stop conditions until the desired conditions are specified, then click on the **Apply** button.
- Each event will be highlighted with a dot.



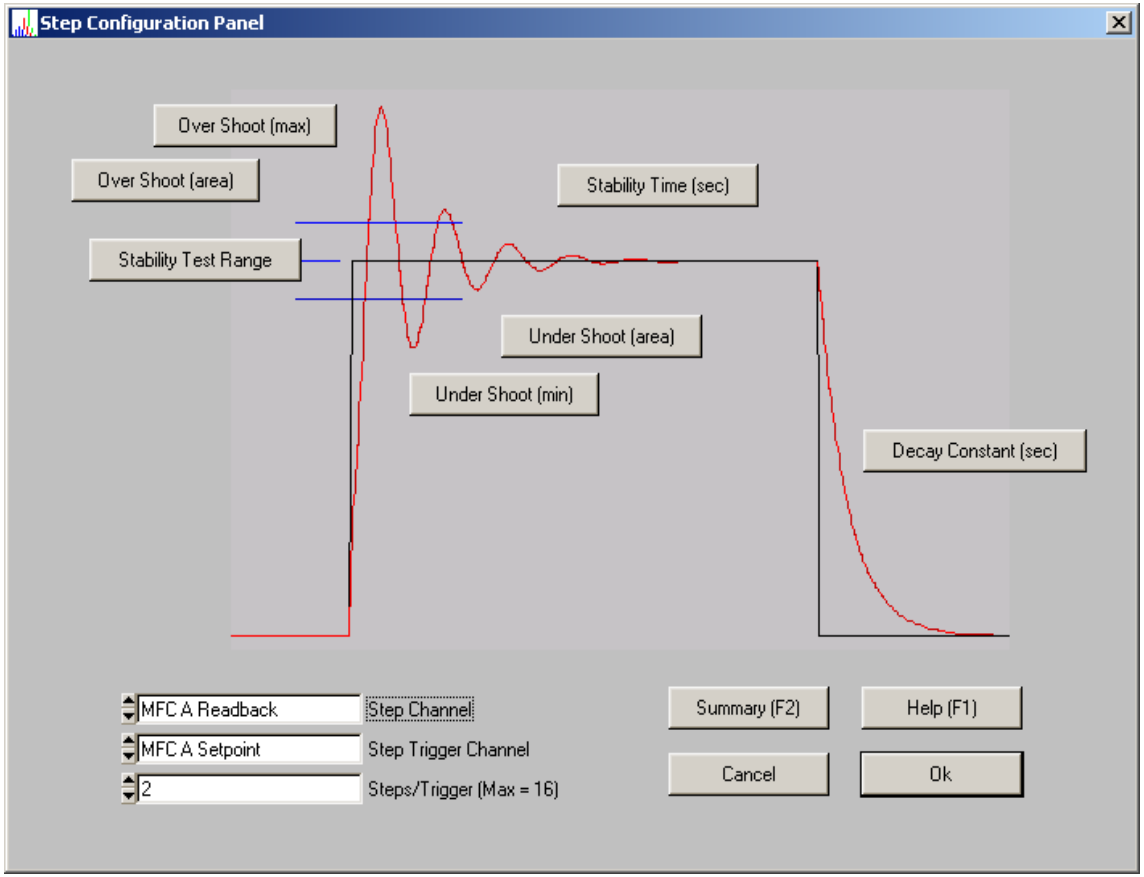
Step 6 Configuring timers (continued)

- If necessary, click on the Next Start Event or the Previous Start Event until the correct start event is specified.
- If necessary, click on the Next End Event or the Previous End Event until the correct end event is specified.
- To add another timer, click on **Add Timer**.
- When finished, click on **Exit Timer Setup**.



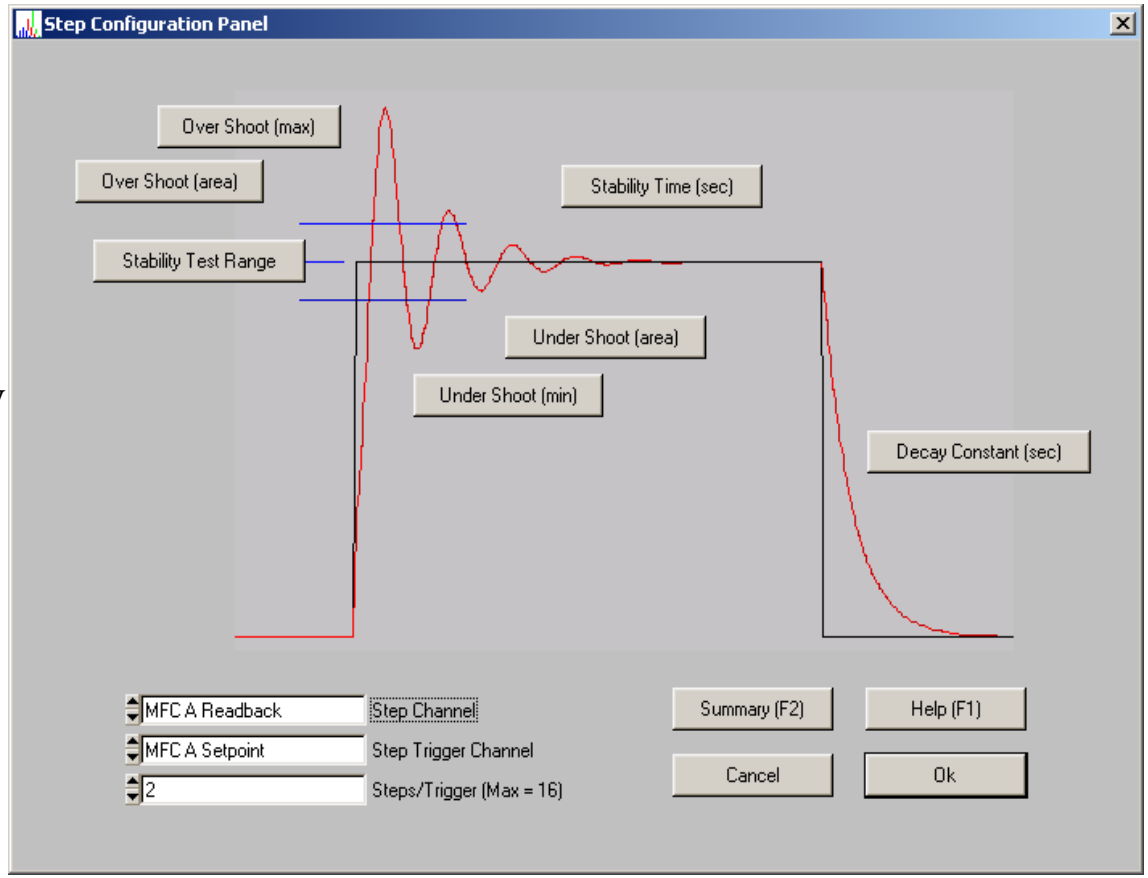
Step 7 Configuring step channels

- Select Step Channel Setup from the Configure menu.
- Select each step channel in the Step Channel listbox.
- For each step channel, specify a **Step Trigger Channel**. A Step Trigger Channel is used to start step testing. For MFCs, setpoint makes an excellent Step Trigger Channel.



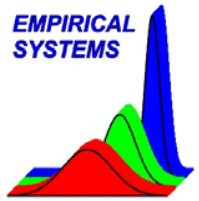
Step 7 Configuring step channels (continued)

- Also, for each step channel, specify the number of **Steps/Trigger**.
- The Stability Test Range will default to 90 to 110% of setpoint. If you would like to alter this, click on the Stability Test Range button.
- Click on **Ok**.



Step 8 Setting up Spec Limits

- After completing timer and step setup. Turn Realtime Analysis on (by selecting Realtime Analysis from the Tools menu), then click on **Start** to collect data.
- After collecting at least 16 triggered events, switch to the DataWindowsReview application and click on the **SPC Charts** menu and select a SPC Chart of interest.
- Select the new data from the Batch Selection listbox then click on **Ok**.
- The displayed SPC Chart will show both 3 sigma limits and specification limits (if specified).
- To change spec limits, click on the **Control Limits** button, adjust the limits and click on **Ok**.
- Click on **Ok** and repeat for each SPC Chart of interest.



Tutorial 5 Student T Test

Overview

A Student T Test is a statistical test that can be used to compare two data sets. Specifically, it will tell you the probability of a difference between them. This Tutorial will show you how to perform these tests and how to generate a test report. It is assumed by this time that you are familiar the subjects covered in the previous Tutorials and that you can successfully simulate deposition cycles with the Realtime Analysis enabled.

Tutorial 5: Student T Tests

Situations to use a Student T Tests:

- New software has be installed on your process tool and you want to know it the change affected process performance.
- Or, you may want to know if the new MFC you have installed is statistically different than the old one.
- Or, you may want to compare field data to final test data.
- Or, you may want to compare deposition cycle 1 to deposition cycle 10.

Data Preparation

- Load the **DataWin Demo** process.
- Make sure **Toggle Realtime Analysis** on the **Tools** menu has a check mark next to it.
- Change the system name to W100 (select **System Name** from the **Configure** menu). Then simulate 16 deposition cycles by clicking on **Start**. After 16 cycles have completed, click on **Stop**.
- Now change the system name to W101 and simulate another 16 cycle run. We will begin this tutorial by comparing system W100 to system W101 to see if there is a difference between them.

Step 1 Select Process of Record Data

- From DataWindowsDemo or DataWindowsReview, select **Compare Data Sets** from the **Tools** menu. This will display a panel that will guide you through the 5 steps of this Tutorial.
- Click on the first button, **Select Process of Record Batches**. Do not confuse Process of Record Batches with the POR data file. In this context, the Process of Record refers to a collection of data collected before a change, or a suspected change, has been made to the system. If were evaluating new process tool software, the Process of Record Batches would be the data that was collected before the change was made.

Step 1 Selecting Process of Record Data (continued)

- Select the W100 Trace ID (not the W100 Precoat) in the **Batch Selection** listbox.
- Leave default values on all other controls.
- Then click on **Ok**.

Step 2 Selecting Test Data

- Click on the next button, **Select Test Batches**.
- Select the W101 Trace ID (not the W101 Precoat) in the **Batch Selection** listbox.
- Leave default values on all other controls.
- Then click on **Ok**.

Step 3 Select Confidence Level

- Click on the next button, **Select Confidence Level**.
- Select the confidence level you would like to use for the test. The higher the confidence level the greater confidence you can have in your test report conclusions.
- Recommendation:

  Select 99.9%
- Click on **OK**.

Step 4 Select SPC Charts

- Click on **Select SPC Charts/View Dual SPC Charts**.
- Select SPC Charts of interest from the listbox and click on **View Chart** to display a Dual SPC Chart. For Dual SPC Charts, Test data is displayed in black while Process of Record data is displayed in blue.
- Make sure a check mark is placed next to the SPC Charts you would like to test from the list.
- Recommendation:

  Select **MFC A Readback Overshoot Area Step 1**.

  Select **Deposition 1 Time**.

  Select **Deposition 2 Time**.

Step 5 Perform Student T Test

- Then click on **Perform Comparison**.
- Test results will be displayed on screen.
- For each selected parameter, if there is no statistical difference between the 2 data sets, a Pass result will be generated.
- If a statistical difference is detected or if there is not enough data points to perform the test, a Fail result will be generated.
- Use the File menu to print the test report or to save it as a text file.

Extra Credit

- Start deposition simulation by clicking on the **Start** button. Take a lunch and collect at least 5 sets of 16 deposition cycles (more is better, run it over night if you can).
- Perform a Student T test to determine if **MFC A Readback Overshoot Area Step 1** has a difference between trigger 1 and trigger 10.