

# **APROMON™**

Version 3.1

## **PROCESS CONTROL MONITORING SOFTWARE**

### **USER'S MANUAL**

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# APROMON™ USER'S MANUAL

## 1.0 WELCOME TO APROMON™

Dear fellow process control professional, congratulations on your purchase of your Apromon™ process control monitoring software. We at PiControl Company are proud of creating and making available to you the simplest and the most powerful process control-monitoring tool available currently in the marketplace.

Apromon™ is equipped with PiControl Company's proprietary *True Amplitude Detection* (TAD) algorithm that uniquely isolates the true process signal frequency by identifying and isolating the white noise and other non-process signal contributions.

Apromon™ also decomposes the PID controller's action into its independent components to provide unique and useful PID control diagnostics.

Apromon™ provides all the tools you will ever need to quickly and easily monitor all your control loops, both quantitatively and qualitatively with the least effort on configuration and installation.

We pride ourselves for providing the best technical support to all our users and that too, completely free.

Enjoy now as you learn about Apromon™; you will realize that PiControl Company has created a breakthrough in the area of modern process control monitoring.

## 1.1 PROCESS CONTROL MONITORING

Apromon™ is a software product for process control performance monitoring. It analyzes and reports the performance of PID control loops in the DCS or PLC. Apromon™ can also analyze and report the control quality of any process signal including signals that are raw, analog PV

signals, not necessarily part of any control loop or a PID controller.

Apromon™ will improve process control quality, plant stability and push the plant closer to economic constraints resulting in increased production rates and plant profits.

## **1.2 FEATURES AND FUNCTIONS OF APROMON™**

Every plant has tens or hundreds of controllers. Each controller has at least three tuning parameters. No one can watch all controllers carefully every day. A few badly functioning controllers can cause a large section of the plant to cycle (oscillate). Oscillations can propagate or even magnify based on recycle streams and heat integration. Eroded or old valves may be sticking or malfunctioning because of need of newer hardware but could go unnoticed for indefinite periods of time.

Apromon™ identifies the worst performing loops in the plant. It generates a report showing the worst controllers, signals so that the process control engineer or DCS technician can focus on this list of bad controllers and fix them far sooner than before.

Apromon™ provides about twenty control criteria on all controllers. As the end user, you can pick and choose your favorite criteria. We encourage you to see all the criteria in the beginning. With time and experience, you will get skilled in using the right criteria in the best, most powerful way.

Apromon™ comes with a delightfully simple user interface, far easier than any other products out in the marketplace. In just an hour or two, you can install and start using Apromon™ and start improving the plant performance.

## **1.3 SOFTWARE REQUIREMENTS**

Apromon™ runs on Windows XP, Windows NT, or Windows 98/2000 operating systems. Microsoft® Excel is essential for

Apromon to read plant data files in Excel (\*.xls) format. If only files in Comma Separated Values (\*.csv) format are used, Excel is not required.

To install Apromon™, insert Apromon™ installation CD. Installation program will start automatically. (If Autorun is disabled on your PC, open Windows Explorer and double click apromon setup.exe program to start installation.)

Follow the installation instructions on the screen. Follow all screen prompts and answer all the questions on the screen to complete the installation. Apromon™ files will be installed to the specified program folder. A program Group "Apromon" will be created with program icons "Apromon (Offline), Apromon Scheduler, and Help.

#### **1.4 HOW TO USE THIS MANUAL**

This user's manual is written in a sequential manner to aid you to quickly and easily install and use Apromon™. Follow the step-by-step procedure as described below.

#### **2.0 STEP-BY-STEP PROCEDURE TO RUN APROMON™**

We have provided a complete set of all sample files required to configure and run Apromon™. The user has to follow the step-by-step procedure explained below using the sample data sets. Once the user has completed the sample procedure, (s)he will have all the knowledge necessary to configure and run Apromon™ for another plant.

#### **2.1 STEP #1 - START APROMON™**

From Windows bottom Taskbar, click **Start**, point to **Programs**, and then navigate through the menus to the program group "**Apromon**" and then click "**Apromon (Offline)**". This will execute "**Apromon.exe**" file. Wait for a few seconds for the Apromon™ splash screen (showing software name, version number and other information) to close automatically.

## 2.2 STEP #2 – FILE AND FOLDER NAME AND LOCATION

When Apromon™ is installed, it automatically creates various folders. In this step, we ask that the user examine the various folders shown below and the file contents of those folders.

The folder **Apromon** is where the three executable files (Apromon.exe, Apromonsh.exe, ApromonScheduler.exe) are located.

Subfolder **Apromon\Data** is where all plant data files are located. Plant data files are explained in a later section.

Apromon facilitates to analyze as many data file sets as required. Each data files set can be placed in a separate folder. For Example: Data1, Data2, Data3 .... The data folder naming conventions are same as that of Windows folders.

In each Data folder, following subfolders are created.

1. **Detailed Reports**
2. **Error Log Files**
3. **History Apromon**
4. **Summary Reports**

(If any of these subfolders are absent, they are created when Apromon processes the data files)

Subfolder **Detailed Reports** is where all detailed calculation report files are saved. These files are generated automatically by Apromon™ while processing the data files.

A typical detailed report file name is  
**ApromonReport (11.15.06 10.16 AM).xls**  
It contains date and time stamp.

Subfolder **Error Log Files** is where error log files are saved. These files are generated automatically by Apromon™ if bad data (or out-of-range data) are encountered. It contains information about Tag names, total data points found out of

range or have Bad status (Not-a-Number etc.) and their percentages.

A typical error log file name is

**ApromonErrorLog (2006-10-24\_13-54-58).xls**

It contains date and time stamp.

Subfolder **History Apromon** is where all history files are saved. These files are generated automatically by Apromon™ and contain calculation results for every tag.

There is a separate history file created for each tag and then calculation results are appended to those files.

Typical History file names are

FC111.csv

FC222.csv

FC333.csv

Where FC111, FC222, FC333 are tag names.

Subfolder **Summary Reports** is where all summary calculation report files are located. These files are generated automatically by Apromon™ and contain summary reports, summarizing performance criteria for every tag.

A typical summary report file name is

**ApromonSummaryReport\_2006-10-24\_13-55-42.csv**

It contains date and time stamp.

The various files in the above folders are explained in later sections.

### 2.3 STEP #3 - LOAD TUTORIAL EXAMPLE CASE

Start Apromon and from the top toolbar, click OPEN. From the “Open Apromon Configuration File and Run Apromon” dialog, select **Tutorials** folder and then select file **Apromon\_Tutorial\_Original. cfg**.

Apromon will read PV, SP, OP, MODE, DCS and CONFIG files specified in **Apromon\_Tutorial\_Original. cfg**.

You will see the **Data Validation Errors** message. Click OK.

Now you will see **Error Log File** message. It displays the message "**Click on ERRORS tab for more information**". Click OK.

## 2.4 STEP #4 – CHECK BAD DATA

Apromon program windows displays various Tabs. DATA, TREND, DETAIL, SHOW CRITERIA, SELECT CRITERIA, .... The scroll buttons at the rightmost end of the Tabs can be used to scroll between the Tabs. The buttons look as shown below:



Click the right side arrow until ERRORS tab is visible at right. Click this tab. Under PV Violation you will see **FC111::2::0.40%**.

This means that in the PV data file, 2 data points are out of range or have Bad status (Not-a-Number etc.). There are 500 data points in all and 2 out of 500 gives the 0.4%.

To understand and confirm this, click FILES from the top toolbar. This will open "Read APR Data Files and Run Apromon" dialog. The topmost file is the **PV** data file. Scroll inside the PV file field to see the filename with complete path:

**Apromon\_Tutorial\_2006-11-15\_06-19-41\_PV.CSV**

Open this file from the Windows Explorer. One of the values under FC111 PV column is 111.77 and another value is -3.

Click again FILES button from the top toolbar. Under **DCS** see the filename:

**Apromon\_Tutorial\_TAG\_Original.xls**

Click tab APROMON TUTORIAL TAG ORIGINAL. Under FC111 column, notice that PV Hi Range is 100 and PV Lo Range is 0.

Since the two values 111.77 and -3 are outside the PV Hi and Lo Range for FC111, the program reports that 2 values are Bad or out of range.

None of the values in the SP, OP and Mode data files are out of range and hence there are none reported under the ERRORS tab.

Note that the range for checking SP values is the same as for PV (PV Hi and PV Lo Range). OP values for all tags are checked against low and high limits of 0 and 100 (PID output range is 0-100%). A master (cascade) PID may output to a slave PID whose range may be different, but every PID output in % units is 0-100%.

The range for checking Mode values is 0 to 4. In the standard Apromon release, 0 = Manual mode, 1 = Auto mode, 3 and 4 are higher modes (Cascade, Computer, Remote, etc.) depending on the DCS used. If your values are different from these, please contact PiControl and a custom version at no-cost will be sent to you.

Click tab APROMON TUTORIAL CONFIG ORIGINAL. Notice that PERCENT BAD DATA TOLERANCE is 5%. In this example, only 0.4% data are bad. If more than 5% of the data from PV, SP, OP or Mode data files are bad, then all calculations are skipped for that tag completely. In this case, the tag is completely bypassed and the Bypass parameter under the APROMON TUTORIAL TAG ORIGINAL is set to 0 (meaning Inactive). If the user wants to deliberately skip certain tags and take them completely out of all calculations, the user can manually set Bypass = 0.

## 2.5 STEP #5 - REVIEW PLANT DATA

Click the left scroll arrow button located near top right until DATA tab is visible at the left.



Click DATA tab. Data sample number is shown in the leftmost column. The next column (first data column) shows data for FC111 PV. The second column shows data for FC111 SP (LSP is displayed on SP; this is explained later in Section 2.11). The third column shows FC111 OP data. The fourth

column shows FC111 Mode data.

Going further right, you see PV, SP, OP and Mode data for all other tags.

Click FILES from the top toolbar. Notice that the data from the PV, SP, OP and Mode files (**Apromon\_Tutorial\_2006-11-15\_06-19-41\_PV.CSV** etc.) is what is displayed under the DATA tab.

Click tab APROMON TUTORIAL TAG ORIGINAL. Notice that the Scan Time (sec) is 5 for all tags except FC222 which has a scan time of 10 sec. (Note that the user must manually specify the Scan Time for every tag). Since the fastest scan time of all tags is 5 sec; each data sample in PV, SP, OP and Mode files is 5 sec apart. Since FC222 has 10 sec. scan time, the values are repeated in all four data files for FC222. Open file **Apromon\_Tutorial\_2006-11-15\_06-19-41\_PV.CSV**

Notice that the first six data points in this file for FC222 are: **45, 45, 45.1, 45.1, 44.65, 44.65**. Also notice that inside Apromon, when you click DATA tab, the first three data values under FC222 PV are **45, 45.1, 44.65**. The first six values from the Excel file are reduced to three values under DATA tab. This is because scan time of FC222 is 10 sec. and the fastest scan time is 5 sec. Every second value from all four files (PV, SP, OP and Mode) is skipped for FC222.

Notice that the number of data samples in all four Excel data files is the same (the last row in the Excel files is #503). Thus, if the scan time of a tag is twice the fastest scan time of all tags, then the every other value from the Excel data files is skipped for tag (it is assumed that the two consecutive values are the same).

Similarly, if the scan time of a tag is three times the fastest scan time of all tags, then two values are skipped. TagA has 5 sec. scan time and TagB has 15 sec. scan time. Let's say the Excel PV data file is as follows:

TagA PV (5 sec scan)	TagB PV (15 sec. scan)
<b>100.1 (kept)</b>	<b>77.1 (kept)</b>
<b>100.2 (kept)</b>	77.1 (skipped)
<b>100.3 (kept)</b>	77.1 (skipped)
<b>100.4 (kept)</b>	<b>88.2 (kept)</b>
<b>100.5 (kept)</b>	88.2 (skipped)
<b>100.6 (kept)</b>	88.2 (skipped)
<b>100.7 (kept)</b>	<b>99.3 (kept)</b>
<b>100.8 (kept)</b>	99.4 (skipped)
<b>100.9 (kept)</b>	99.5 (skipped)

Then, the first three values under DATA tab for TagB would show 77.1, 88.2 and 99.3. The skipped values shown above will not be read. But for TagA, all values will be read (none skipped) since its scan time is 5 seconds (three times as fast as TagB).

Click DATA tab again and using the right side down scroll bar, go about half way down. Notice that FC222 has no data after row #250, but for all other tags, data goes down all the way to #500. The tag FC222, being 10 sec. scan rate has only half the number of data points compared to faster tags at 5 sec. scan rate.

## 2.6 STEP #6 - TREND PLANT DATA

Click TREND tab. Then check one or more checkboxes in the rightmost column. You will see the data trends for the checked variables.

Zoom and Drag Feature: Apromon has powerful zooming and drag feature. To zoom the data trends, follow the procedure below:

1. Check one or more checkboxes to generate trends
2. Inside the trends area, click and hold with the left mouse button.
3. While holding the left mouse button down, move the

mouse diagonally downward and rightward to draw a rectangle.

4. Release the left button to see the zoomed window.
5. Double click anywhere inside the trend box to restore the original window.
6. To drag trends, inside the trend area, press and hold the right mouse button. While holding down the right button, move the mouse up/down/left/right.  
Notice how conveniently you can zoom and move anywhere along the X or Y axis.
7. Double click anywhere inside the trend area to restore the original trends.

**Tags Search Criteria:** This feature facilitates to short list the tags shown in the upper box to trend. Inside the text box (at bottom right side of the screen, below Tags list), type in FC1. Now notice that only the FC111 tags that satisfy the "FC1" wildcard search criteria are displayed above. Type in FC2 to see only the FC222 tags.

The X axis of trends chart shows the total number of data points in the data files (PV, SP, OP and MODE files). All these files have 500 data points. The fastest scan time is 5 seconds. The X axis shows 500 points X 5 seconds = 2500 seconds of data. Since tag FC222 has a slower scan time (10 sec. instead of 5 sec.), the trend is adjusted to fit the 2500 second full window. The X axis always shows the number of data points from the four data files. This number multiplied by the fastest scan time constitutes the length of the X axis in time units. Tags with slower scan times (10 sec., 15 sec., etc. multiples) are adjusted to match the same axis length for faster tags.

## 2.7 STEP #7 - THE DETAIL TAB

The DETAIL tab is used to show diagnostics and tune the Apromon internal tuning parameters related to detecting oscillations in the loop.

Click DETAIL tab, and then click **FC444** in the rightmost

column. See the vertical blue lines in the bottom window. These are called **True Amplitudes**. To understand what they mean, click TREND tab. In the wildcard box located at the bottom, right corner of the screen, type in FC4 and then check the checkboxes for FC444 PV and FC444 LSP. The LSP shows the FC444 SP data and the PV shows the PV data. Section 2.11 explains what is LSP (for now assume that the LSP data are the same as the SP data from the SP data file). Notice there is distinct oscillation. Note the PV-LSP amplitudes (PV deviations from the SP). Now click DETAIL tab and notice that the location and height of the blue bars (true amplitudes) matches with the PV-LSP deviations on the TREND plot.

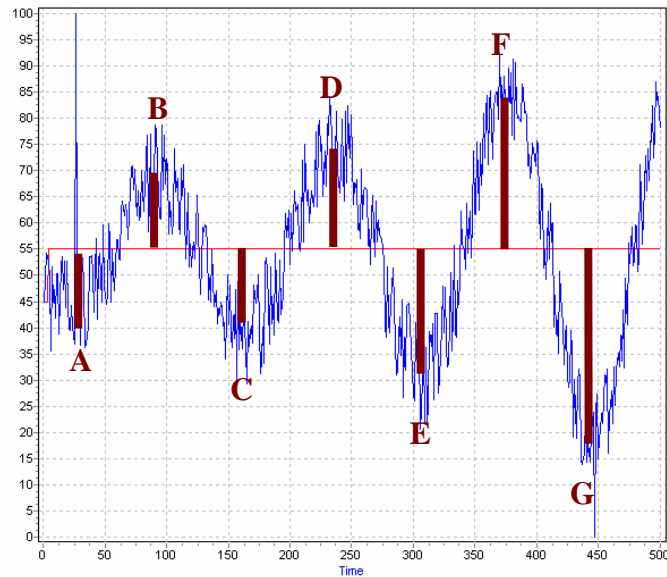
Click DETAIL tab again and this time click FC111. Click TREND tab and bring up trends for FC111 PV and LSP. Study the blue true amplitudes on DETAIL tab with the PV-LSP amplitudes on the TREND plot. Notice that even though the FC111 PV data is noisy, only the meaningful amplitudes that show oscillations are identified and reported. The small squiggles consisting of fast (high frequency) noise are automatically rejected, no matter how much is the noise level.

Study FC222 and FC333 DETAIL and TREND also, to get familiar with the concept of true amplitudes.

On the DETAIL screen, notice that the SPECTRUM value for FC444 is the highest. Higher the SPECTRUM value means higher the extent of oscillations, hunting and/or instability. FC222 has the smallest SPECTRUM value because its true amplitudes are located more randomly. FC444's true amplitudes are located very equidistantly. If true amplitudes are located randomly, then the SPECTRUM value will be smaller and the red bars in the top DETAIL window are widely distributed as in the case of FC222. Notice that the top window under DETAIL tab has various red bars with heights ranging from 19% to much lower. In contrast, FC444 which is noticeably cycling, has one single dominant red bar in the top window. A single top red bar indicates one single dominant frequency, an indication of oscillations.

Oscillations, hunting, instability is undesirable in chemical plants. Using the SPECTRUM and *True Amplitudes*, Apromon reliably identifies the oscillations.

**FIGURE 1. FC111 PV AND SP DATA TREND**



## 2.8 STEP #8 - CHATTER PARAMETER TUNING

Click TREND tab and check the checkboxes for FC111 LSP and FC111 PV. You will see the trends as shown in Figure 1 (note that the brown bars and the A-G labels will not be seen on the Apromon™ screen). The blue trend is the PV and the red is the LSP (setpoint). You can deduce that the real amplitudes (Apromon™'s true amplitudes) are shown by the vertical brown bars labeled by letters A, B, C, D, E, F and G.

Now click DETAIL tab and click **FC111**. The blue vertical bars are the true amplitudes as identified by Apromon™. Notice that the presence of noise in the PV data shown in Figure 1 results in the tiny true-amplitudes shown in the DETAIL plot for

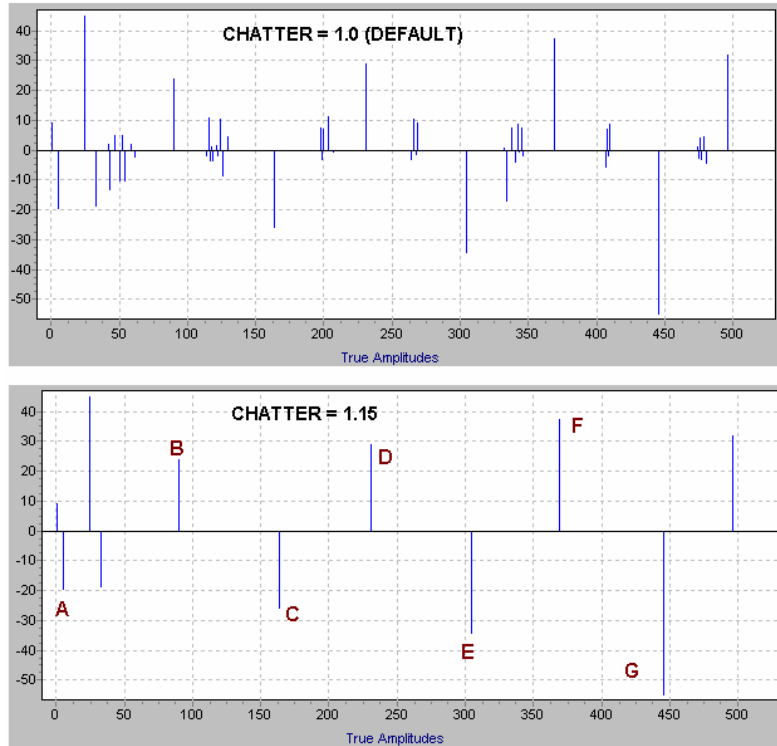
FC111 (also shown in the top trend in Figure 2). We want to get rid of the tiny true-amplitudes and retain only the larger ones representative of the real process (the small amplitudes are because of random white noise, present in most signals in chemical plants).

To eliminate the tiny amplitudes, click APROMON TUTORIAL TAG ORIGINAL tab and under the **FC111** column, change the CHATTER from 1 to 1.15. Now click RUN from the top toolbar to run calculations. Now click DETAIL tab and click **FC111**. Now, all the tiny vertical blue true-amplitude bars are eliminated. What we are left with are the true amplitudes as shown in the bottom trend plot in Figure 2.

Note that the A-G labels shown in Figure 2 for true amplitudes match with those in Figure 1 showing the raw PV data. Mission accomplished! We have processed the raw data and identified the genuine (true) amplitudes.

The default value of CHATTER is 1 for all tags. For noisy signals, the user needs to tune the chatter parameter as illustrated in the above example. In most cases, leaving the default parameters will give meaningful results; but it is recommended to check the noise level and tune the chatter parameter for important tags.

## **FIGURE 2. TUNING THE CHATTER PARAMETER**



## 2.9 STEP #9 - EXAMINE THE SPECTRUM VALUE

Click DETAIL tab and examine the values under SPECTRUM tab.

Click **FC444**. Notice that FC444's true amplitudes (vertical blue bars) in the bottom window are very much equally spaced. The more equidistant the true amplitudes, the higher the SPECTRUM value. FC444 oscillates at a single dominant frequency and hence the top-trend under the DETAIL tab shows a single tall red bar (93%).

Click **FC111** - this tag has the second highest SPECTRUM value. FC111 has fewer amplitudes; also with a strong dominant frequency, though not as strong as FC444. Hence

its tallest red bar in the top window is 67% tall, it has three more small red bars showing presence of some other less dominant signal frequency.

Click **FC333** and then **FC222**. Both these have true amplitudes that are much more randomly spaced. There is no clear-cut single dominant frequency. Their SPECTRUM values are lower and they have many tall red bars in the top window indicative of the presence of various signal frequencies and no single dominant frequency like in the case of FC444.

## 2.10 STEP #10 - EXAMINE PID CONTRIBUTION AND PID EQUATION

Click DETAIL tab and then click **FC111**. See the blue, red and purple horizontal bars near the bottom right corner of the screen. These bars show the percent of total PID control action coming from the three controller contributions - **Proportional**, **Integral** and **Derivative**. The three values will always add to 100%.

Note the P, I and D values. Now click APROMON TUTORIAL TAG ORIGINAL tab and under the **FC111** column, change the Derivative from initial value of 0.2 to 2.0. Click **RUN** from the top toolbar and then click DETAIL tab. Click **FC111** and notice that the D value (derivative contribution) is much larger than before.

Click APROMON TUTORIAL TAG ORIGINAL tab and click inside any of the checkboxes for PID Equation for any of the tags. You will see 24 types of PID equations. In our example, we have equation #2. If your PID equation from your plant DCS or PLC is not listed here, contact PiControl for a free software update (info@picontrolsolutions.com).

This current version of Apromon™ requires the PID tuning parameters to be manually specified by the user under the APROMON TUTORIAL TAG ORIGINAL tab page. The next software release of Apromon™ will automatically read the current DCS/PLC PID settings.

## 2.11 STEP #11 - SP OPTIONS

Click APROMON TUTORIAL TAG ORIGINAL tab. Notice the SP Options row. All tags have the value 1. Click the SP Options for any tag. Notice there are four options:

- 1=LSP (lagged SP)
- 2=ASP (average SP)
- 3=LPV (lagged PV)
- 4=APV (average PV)

Notice the fields SP Lag and PV Lag under the SP Options field. Note that all SP Lag and PV Lag are zero for all four tags.

### LSP OPTION (LAGGED SP OPTION)

With LSP option selected (option 1 for SP Options) and SP Lag = 0, click TREND tab and check the **FC222 LSP** and **FC222 PV** boxes. Notice the LSP trend shows the SP trend, going from 45 to 55 at time = 4 on the X axis. Now click APROMON TUTORIAL TAG ORIGINAL tab and set SP Lag for **FC222** to 35. Click TREND tab and then click RUN from the top toolbar. Now notice that the LSP trend is lagged with a time constant of 35 minutes specified for SP Lag. Since many chemical processes are slow, the LSP + SP Lag feature allows us to lag the SP changes. The SPECTRUM values, true amplitudes are affected by the SP Lag values. The Error performance criteria (explained in a later section) also are affected by the SP Lag values.

### ASP OPTION (AVERAGE SP OPTION)

Select the ASP option (option 2 for SP Options). With this option, the SP Lag value is not used and disregarded. Click RUN from the top toolbar. Click TREND tab and check the **FC222 LSP** and **FC222 PV** boxes. Notice now that the trend is labeled ASP. The ASP trend is the average of the raw SP data and will always be a straight line.

### LPV OPTION (LAGGED PV OPTION)

With LPV option selected (option 3 for SP Options) and PV Lag = 0, click TREND tab and check the **FC222 LPV** and **FC222 PV** boxes. Notice the LPV trend is the same as the raw PV trend. Now instead of using the SP in the SPECTRUM and true amplitude calculations, this LPV value is used. With LP Lag =0, this is neither useful nor meaningful. But now click APROMON TUTORIAL TAG ORIGINAL tab and set PV Lag for **FC222** to 60. Click TREND tab and then click RUN from the top toolbar. Now notice that the LPV trend is the PV trend lagged with a time constant of 60 minutes specified for PV Lag. Depending on signal characteristics, using the lagged PV (LPV) trend instead of the SP is more appropriate in some cases.

#### **APV OPTION (AVERAGE PV OPTION)**

Select the APV option (option 4 for SP Options). With this option, the PV Lag value is not used and disregarded. Click RUN from the top toolbar. Click TREND tab and check the **FC222 APV** and **FC222 PV** boxes. Notice now that the trend is labeled APV. The APV trend is the average of the raw PV data and will always be a straight line.

#### **WHEN TO USE LSP, ASP, LPV OR APV?**

In most cases, use the default LSP option with SP Lag = 0. In some cases other options may give better results by identifying the true amplitudes and detecting oscillations more accurately. Cases where other options (ASP, LPV or APV) may benefit for detecting oscillations are on:

- Pure analog signals not used in a PID controllers where there is no setpoint to work with. Here use LPV.
- Slave loops may work better also with LPV option and an appropriate PV Lag parameter.

Determining appropriate values for SP Lag and PV Lag is purely based on trial-error, by examining the PV, SP on the TREND plot and trying different SP Lag or PV Lag parameters.

Note that with LSP option, SP Lag is used and PV Lag is not important. With LPV option, PV Lag is used and SP Lag is not important. For the ASP and APV options, neither SP Lag nor PV Lag values are used.

## 2.12 STEP #12 - SELECT CRITERIA

Click SELECT CRITERIA tab. You will see all the control performance criteria. SELECT ALL selects all criteria to display. SELECT NONE cancels selection of all criteria. Clicking on each of the criteria buttons selects each individual criterion. Click SELECT ALL. Now click SHOW CRITERIA and proceed to the next step below.

## 2.13 STEP #13 - SHOW CRITERIA

Apromon™ calculates and displays several control performance criteria for every tag. This section describes all the criteria. **Note that you must click RUN button on the top toolbar after making changes to any of the parameters and options for the effect to be seen.**

- **CRITERIA #1: ERROR**

This is the Integrated Absolute Error, called IAE. Error is calculated as PV minus SP. IAE is the absolute value of the error, integrated over the full time period.

Click tab:

APROMON TUTORIAL CONFIG ORIGINAL. See the variable called EU/PCT. The default value is 1; this means that the error is calculated as the percent of scale. If EU/PCT is set to 0, then the error is calculated in engineering units.

The default option (1 = percent of scale) is recommended since this shows all values in percent-of-scale in which case, the values are directly comparable and more meaningful. The percent of scale is based on the PV Hi Range and PV Lo Range specified in the tag configuration screen under the APROMON TUTORIAL CONFIG ORIGINAL tab.

- **CRITERIA #2: ERROR SQUARED**

This is the Integrated Square of the Error (ISE). Error is calculated as PV minus SP. ISE is the square of the error, integrated over the full time period.

Click tab:

APROMON TUTORIAL CONFIG ORIGINAL. See the variable called EU/PCT. The default value is 1; this means that the error is calculated as the percent of scale. If EU/PCT is set to 0, then the error is calculated in engineering units.

The default option (1 = percent of scale) is recommended since this shows all values in percent-of-scale in which case, the values are directly comparable and more meaningful. The percent of scale is based on the PV Hi Range and PV Lo Range specified in the tag configuration screen under the APROMON TUTORIAL CONFIG ORIGINAL tab.

The results from criterion are similar to the ERROR criteria. You can closely examine both the ERROR and ERROR SQUARED criteria, but using one of them only will be found to be sufficient.

- **CRITERIA #3: ERROR DEVIATION**

This is the average error between the PV and SP.

Click tab:

APROMON TUTORIAL CONFIG ORIGINAL. See the variable called EU/PCT. The default value is 1; this means that the error is calculated as the percent of scale. If EU/PCT is set to 0, then the error is calculated in engineering units.

The default option (1 = percent of scale) is recommended since this shows all values in percent-of-scale in which case, the values are directly comparable and more meaningful. The percent of scale is based on the PV Hi Range and PV Lo Range specified in the tag configuration screen under the

APROMON TUTORIAL CONFIG ORIGINAL tab.

This criterion is similar to the ERROR and ERROR SQUARED criteria, but is less commonly used. If you have decided to use either the ERROR or ERROR SQUARED criteria or both, this criteria could be ignored. Apromon™ provides the three error criteria for the sake of completion; the user can use any or all of the three criteria.

- **CRITERIA #4: CONTROL TIGHTNESS**

This criterion is a function of how often the PV crosses the SP. High numbers for this criterion means that the control is tight and crisp. Low numbers indicate potentially sluggish control. Sluggish control may be caused by weak integral action. Excessively high derivative action also can potentially cause this criterion to show high values.

Click tab APROMON TUTORIAL TAG ORIGINAL and set the Steady State Time (minutes) correctly for each tag. The steady state time is the time required for the PV to reach the new steady state after a bump in the OP (valve position). Typical values of steady state time are as follows:

- Flow PID 2 minutes
- Pressure PID 5 minutes
- Temperature PID 20 minutes
- Level PID 30 minutes
- Online Analyzer PID 120 minutes
- Motor KW or Amps control 3 minutes

- **CRITERIA #5: IMBALANCE**

The imbalance criterion looks at the ratio of the time spent by the PV on any one side of the SP. A value of 1.0 is the highest (best) rating for this criterion. Higher values indicate that the PV spends more time on one side of the SP (higher or lower than the SP) and this is not desirable. Higher values can be indicative of weak control action, possibly large external disturbances or control valve problems.

This criterion is in some ways analogous to the skew criterion

(explained later below). The difference is that the imbalance criterion looks at the ratio of the time spent on one side of the SP whereas the skew criterion looks at the ratio of the integrated positive and negative errors.

- **CRITERIA #6: UNSTABLE**

The Unstable criterion shows how many times the PV signal became unstable during the time window. "*Becoming-Unstable*" is defined as when the PV signal starts oscillating with increasing amplitudes.

Zero is the desired value (no unstable oscillations). Any positive number indicates the number of times this signal became unstable. Non-zero value is indicative of aggressive tuning, most likely excessively high proportional and/or integral action.

- **CRITERIA #7: HUNTING**

The Hunting criterion shows how many times the PV signal was hunting during the time window. "*Hunting*" is defined as when the PV signal is oscillating with large amplitudes with fairly constant heights. Hunting can also be defined as when the signal oscillates at larger than desirable amplitudes.

Hunting is what happens first before the signal goes to "Unstable".

Zero is the desired value (no hunting). Any positive number indicates the number of times the signal was hunting. Non-zero value is indicative of aggressive tuning, most likely excessively high proportional and/or integral action.

Zero is the desired value. Any positive number indicates the number of times this signal began to "hunt". Non-zero value is indicative of aggressive tuning, most likely excessively high proportional and/or integral action.

- **CRITERIA #8: SPECTRUM**

The spectrum criterion indicates whether the signal comprises of many signal frequencies or comprises of a few dominant frequencies.

Lower values (values under 4 or 5) indicate that the signal has many frequencies and no single dominant frequency. Lower values are desirable.

Higher values (more than 10) mean there are some noticeably dominant frequencies and this can indicate cycling. Higher values could be because of aggressive PID tuning (aggressive control action) or also because of oscillatory external disturbances causing the signal to oscillate.

The range of spectrum can extend from around 2 (no cycling or oscillations) to over 200 (strong symptoms of cycling and oscillations).

- **CRITERIA #9: SATURATION OP**

This criterion shows the percent of time when the controller output was over 90% or less than 10% and when the controller was not in manual mode. Low values are desirable. Zero means the output was never saturated.

- **CRITERIA #10: SATURATION PV**

This criterion shows the percent of time when the PV (process value) was within 3% of either the high or low PV range (instrument range) and when the controller was not in manual mode. Low values are desirable. Zero means the PV was never close to the instrument range units.

- **CRITERIA #11: SPIKE OP**

This criterion shows the largest change in the output (OP) value during 3 consecutive scans over the entire data set. This value can capture proportional kick on a SP change and flag excessive proportional action. Also, this value can

capture excessive derivative action if the PV signal is noisy and derivative action is excessive. Larger values of this criterion are not necessarily bad or show poor performance. The purpose of the criterion to flag excessive movement in the OP that can possibly help to alert excessive control aggression or also show the need for more PV filtering.

- **CRITERIA #12: SPIKE PV**

This shows the largest change in the PV value over the entire data set. Larger values of this criterion are not necessarily bad or show poor performance. But they warn that the PV is changing suddenly by a large value. If this PV is used for closed-loop control action, then large PV changes could possibly cause excessive, potentially undesirable control action. It may be desirable to validate this spiky signal with a spike rejection functionality that freezes the signal or changes it based on the maximum rate of change limit.

- **CRITERIA #13: ONSTREAM FACTOR**

This criterion shows the fraction of the time the controller is in automatic or cascade modes (not in manual mode). 100% indicates the controller is never in manual mode. 0% indicates that the controller is always in manual mode.

The criterion not only looks at the Mode value (showing controller mode - manual, auto, cascade, etc.), but also examines the OP, PV and SP values from the entire data set.

If OP values are frozen (fixed at some constant value), then the criterion knows that the controller is in manual even though the Mode values may show non-manual. Also, if the PV and SP are exactly equal, then the criterion also knows that the controller was PV-tracking and hence in manual mode, even though the Mode values may show a non-manual state.

- **CRITERIA #14: CHEAT**

When an advanced control scheme is not working well,

experienced operators often help it by flipping one or more PIDs either from auto to manual or from cascade to auto/manual and then bumping the SP or OP and then flipping it back to their normal mode. This action is caused "cheating" because the operator is helping the control scheme. The time during which the mode change is made is typically under a minute. The cheat value is incremented by one each time the mode changes from normal mode to a temporary abnormal mode (lasting less than a minute) and then back to the normal mode.

- **CRITERIA #15: INTERVENE**

This shows the number of times the PID underwent a mode change. There are three common modes - manual, auto and cascade. Each time the mode is changed, this criterion value is incremented by unity.

- **CRITERIA #16: ROPE LENGTH**

This criterion displays the total control valve movement during the entire data set. High value indicates excessive control valve movement and can cause control valve damage and premature replacement. In certain control schemes, large control valve movement is unavoidable, so high values are not necessarily bad. But this could be reflective of possibly excessive aggressive tuning.

- **CRITERIA #17: VACILLATION**

This criterion indicates the number of times the control valve changes the direction of travel. If the control valve was opening from 10% to 11% and then goes to 5%; this is considered as one change in travel direction (valve position changes direction from increase to decrease). Excessive number of valve direction change can wear out the valve prematurely. In certain control schemes, frequent valve travel directional changes are unavoidable; so high values are not necessarily bad. But this could be reflective of more than needed aggressive tuning.

- **CRITERIA #18: NOISE LEVEL**

This criterion indicates the amount of random noise (white noise) component in the PV signal. The more the random noise level, higher the Noise Level value. On tags with high Noise Level values (Noise Level equal to or greater than 5), adding some PV filtering at the DCS level could potentially improve the signal quality and hence the control action.

Click tab SHOW CRITERIA and use the left/right arrow buttons at the bottom to scroll to see the Noise Level criterion. Note that FC111 has the highest Noise Level (5) and FC444 has the lowest (2). Click tab TREND and examine all the four PV signals. You can visually see that FC444 PV is very smooth (hardly any noise) and FC111 PV is very noisy (many random fast spiky signals).

- **CRITERIA #19: MATCH**

This criterion shows tags that have the same dominant frequency. Tags with the same match value have similar signal frequencies. Apromon categorizes all tags into 14 categories based on their frequency distribution. Tags with fast dominant frequencies are likely to have similar or identical match values (lower values). Tags with slower dominant frequencies are likely to have higher values.

- **CRITERIA #20: SKEW**

The skew criterion shows the ratio of the positive and negative integrated errors. Higher values are undesirable and indicate that the integrated error on one side of the SP is more than the other side. Higher error on one side of the SP can be indicative of weak control action, possibly large external disturbances or control valve problems.

This criterion is in some ways analogous to the imbalance criteria. The difference is that the skew criterion looks at error ratio whereas the imbalance criterion looks at the ratio of the

time spent on one side of the SP.

- **CRITERIA #21: CRIMP**

This is the ratio of accumulated changes in SP to the accumulated changes in PV. Lower values up to the value of 1.0 are good. Values over 1.0 warn one of two possibilities:

- Controller tuning is so sluggish that the new SPs are not reached in a timely manner. May be desirable to make the controller tuning more aggressive.
- If the controller is of slave type in a cascade loop, then the master controller's tuning is so aggressive that the slave is unable to keep up with the SP changes caused by the master. In this case, may be desirable to make the master controller less aggressive and/or the slave more aggressive.

- **CRITERIA #22: PROPORTIONAL**

Apromon™ is equipped with the PDA algorithm (PID Component Decomposition Algorithm) that looks at the full PID control action and then decomposes it into the individual Proportional, Integral and Derivative components. This value shows the percent of the total PID action that is because of the Proportional action only.

- **CRITERIA #23: INTEGRAL**

Apromon™ is equipped with the PDA algorithm (PID Component Decomposition Algorithm) that looks at the full PID control action and then decomposes it into the individual Proportional, Integral and Derivative components. This value shows the percent of the total PID action that is because of the Integral action only.

- **CRITERIA #24: DERIVATIVE**

Apromon™ is equipped with the PDA algorithm (PID

Component Decomposition Algorithm) that looks at the full PID control action and then decomposes it into the individual Proportional, Integral and Derivative components. This value shows the percent of the total PID action that is because of the Derivative action only.

- **CRITERIA #25: GRADE**

Apromon™ calculates an overall "grade" value based on some of the above criteria. The grade is calculated based on various criteria explained above:

- Error criteria
- Onstream factor
- Extent of cycling (oscillations) as determined by the spectrum, hunting and unstable criteria
- Combination of other criteria

The grade calculation algorithm is "smart". It does not double-penalize the score because of overlapping criteria.

- **CRITERIA #26: DIAGNOSTICS**

The diagnostics criterion displays a text message describing the overall performance of each tag. If the control performance is good, the diagnostic displays "Control Performance is Satisfactory". Various other messages are generated based on the values of the various criteria.

## 2.14 STEP #14 - SHOW CRITERIA

Click tab SHOW CRITERIA and click Change Criteria for Sort Order. You will see that the first option (ERROR) is selected. Notice that under the ERROR column, the highest value (FC111) is at the top and the lowest value is at the bottom (tag FC333). Notice also the button with the label Sort Ascending. Click this button and notice that it toggles to display the label Sort Descending. And now, the ERROR column is flipped from top to bottom - now FC333 (with the lowest value) is at the top and FC111 (with the highest value) is at the bottom. Thus, with ERROR selected on the menu under Change

Criteria for Sort Order, all tags are sorted based on the ERROR values.

Now click again Change Criteria for Sort Order. Click Control Tightness. Now notice that all tags are sorted based on the values of the Control Tightness criterion.

This feature allows you to sort based on any user-desired criteria and also in either ascending or descending orders.

See CRITERIA button on top toolbar. Click this button. You will see a list of all selected and unselected criteria. Click tab SHOW CRITERIA and then click CRITERIA button. Now while examining the criteria, you can select or deselect one or more of the criteria conveniently.

## 2.15 STEP #15 - CREATE AND EXAMINE HISTORY FILES

Apromon™ saves the results of all 26 criteria in historical files for future retrieval and analysis.

Click tab APROMON TUTORIAL CONFIG ORIGINAL and see the two fields called SAVE HISTORY FILES - INTERACTIVE and SAVE HISTORY FILES - SCHEDULED.

Notice that both have values of 1 (which means save files on exit). This means that every time the program exits, all 26 criteria are saved into historical files. The tutorial example that you are running is the **interactive** version of running Apromon™. Apromon™ can also be run in an automatic mode; where it runs by itself automatically at predetermined (pre-configured) times. The automatic mode is also called the **scheduled** mode.

It is recommended that you always save files for the SCHEDULED mode. This is because the scheduled mode runs automatically every scan time and saves all performance criteria for later use. You want all the data to be saved obviously for the future.

In case of INTERACTIVE mode, save history files while you are configuring Apromon™. in the early stages and tuning the

various tuning parameters. After you are satisfied with the tuning and you have completed running the scheduled mode automatically, you will not need to run the interactive mode too often and then it is better not to save the history files from the interactive mode.

Note that both the interactive and scheduled versions are two separate, totally independent pieces of software that share the configuration data specified under tabs APROMON TUTORIAL CONFIG ORIGINAL and APROMON TUTORIAL TAG ORIGINAL.

Both the interactive and scheduled versions write historical data to the same set of files. The historical files are located in subfolder **History Apromon**. If you have run the tutorial example only once and have not yet exited, there will not be in any files in this folder. Exit the program and restart a few times with the interactive save option set to 1 (as is the default above) and then you will see Excel CSV files generated in the above specified folder.

## 2.16 STEP #16 - EXAMINE HISTORY PLOTS

Apromon™ plots history data from the historical data files described above. Click HISTORY button and near bottom left of the screen, select subfolder **History Apromon**. Now under SELECT TAG you will see the four tags (FC111 to FC444). Select the desired criteria to display in the rightmost column (all criteria are provided including the Select-none and Select-all options). Double click any tag to see the historical performance.

## 2.17 STEP #17 - VIEW SUMMARY REPORT AND CONFIGURE SUMMARY REPORT LIMITS

Click tab SUMMARY REPORT. (If you cannot see this tab, then use the left and right scroll arrow buttons located near the top right corner of the screen to get to this tab). Notice that the summary report looks like the SHOW CRITERIA data. The difference is that the summary report has less data to make it

more concise and show limited information.

Now click tab SUMMARY REPORT LIMITS. Notice that each criterion has a LOW LIMIT, HIGH LIMIT and a SELECT (Yes/No) option. If "No" is selected, then the criterion is not displayed under the summary report. Tagnames shown for a given criterion show up in the summary report only if the criterion value happens to lie within the low limit and high limit.

The summary report is a nice feature to short list only those tags which fall within the user specified range. Tags that are performing well with small error values, tags that are not oscillating etc., can be kept out of the summary report so that the focus is only on the poorly performing tags with high errors etc.

## 2.18 STEP #18 - TUNE HUNTING AND UNSTABLE CRITERIA

Apromon™ is equipped with a powerful and novel algorithm called TAD (True Amplitude Detection) to detect unstable and hunting characteristics in a process signal. This step shows how to tune parameters related to the hunting and unstable criteria.

We are at step #18 and you may have changed some parameters while trying to study and learn the various steps. To make sure we have the same parameter values, let us reload the original case file that will upload all the example values. To do this, click OPEN from the top toolbar. If a Confirm dialog window is seen with message "TAG/CONFIG file is changed, Save Changes?", click "No". Select file Apromon Tutorial Original.cfg. Click OK twice and we have the original case with all the values.

Click tab APROMON TUTORIAL TAG ORIGINAL and set Chatter for **FC111** to 1.15 as was done in Step #8. Click RUN from the top toolbar.

Click tab SELECT CRITERIA and click buttons UNSTABLE and HUNTING. Click tab SHOW CRITERIA. Notice that

**FC111** has UNSTABLE = 2 and HUNTING = 2. Click tab TREND and check the **FC111** PV and LSP boxes. The PV trend for FC111 is increasing both on the positive and negative side of the SP. Click tab APROMON TUTORIAL TAG ORIGINAL and notice that the **FC111** PV High Limit is 100, Unstable Limit = 0.03 and Hunting Limit = 0.04. Notice that on TREND tab, the amplitudes of FC111 are more than 3% of the PV High Range.

The 0.04 Hunting Limit means that if the signal amplitude (ABS(PV-SP)) is more than 4% of the PV High minus PV Low Range, then the signal is considered to be **hunting**.

The 0.03 Unstable Limit means that if the signal amplitude (ABS(PV-SP)) is more than 3% of the PV High minus PV Low Range, then the signal is considered to be **unstable**.

For **FC111**, both the 3% and 4% limits are satisfied and hence it is flagged as unstable and hunting.

Now let's examine **FC444**. Click tab SHOW CRITERIA. Both Unstable and Hunting are 0. Click tab TREND and check the **FC444** PV and LSP boxes. Notice that the signal is distinctly oscillatory. The PV goes only + or - 3 around the LSP. **FC444** PV High Range is 700 and the + and - 3 variation around the LSP is less than the 3% and 4% limits for satisfying the unstable and hunting criteria.

Click tab APROMON TUTORIAL TAG ORIGINAL and for **FC444**, change UNSTABLE LIMIT and HUNTING LIMIT to 0.005. Now, if the amplitudes exceed 0.5%, they will be flagged as unstable and/or hunting. Click RUN from the top toolbar. Click tab SHOW CRITERIA.

Now notice that HUNTING = 4 for **FC444** but UNSTABLE is still 0. Click tab TREND and see **FC444** PV and LSP. Notice that **FC444** cycles (oscillates) with constant amplitudes (not growing amplitudes) and this is called **hunting**.

In case of **FC111**, the amplitudes were increasing and this

phenomenon is called **unstable**.

Click tab APROMON TUTORIAL TAG ORIGINAL and notice that Unstable Rise = 1.15 for all tags. This means that if the ratio of the heights of three or more consecutive positive or negative amplitudes is 1.15 or more, then the signal is flagged as **unstable**. This means that newer amplitudes must be larger than the most recent one by 15%. In most cases, this default 1.15 value will be suitable and there will be no need for a change.

The Oscillation Distance is set to 0.275 and there will be no need to change this default. The oscillation distance checks to make sure that consecutive hunting or unstable amplitudes are equidistant. If three consecutive amplitudes pass the amplitude (height) criteria but are spaced too far differently, then the signal is not oscillating and both the unstable and hunting criteria will report a zero.

## 2.19 STEP #19 - STEADY STATE TIME

Click tab APROMON TUTORIAL TAG ORIGINAL and at the bottom see the Steady State Time parameter. This is the time required for the PV to reach a new steady state after a change in the PID OP (or valve position). Normally, the steady state time is set to about 3 or 4 times the first order time-constant of the process. Typical values for Steady State Time are as follows:

<u>Signal Type</u>	<u>Steady State Time (minutes)</u>
Flow signals	3
Pressure signals	7
Temperature signals	20
Level signals	30

Set your best guess for this parameter. Apromon™ is equipped with auto self detection of this parameter and hence approximate or even somewhat inaccurate setting of this parameter will not seriously impact any of the performance calculations.

## 2.20 STEP #20 - APROMON\_TUTORIAL\_CONFIG\_ORIGINAL

Here we will describe all remaining parameters not described yet in the above steps.

Click tab APROMON TUTORIAL CONFIG ORIGINAL.

GRADE LIMIT: Default is 85. Based on various criteria, Apromon™ calculates an overall GRADE; value which is reported under tab SHOW CRITERIA. If the grade is more than this limit, then the DIAGNOSTICS message (also displayed under SHOW CRITERIA) will display "Control performance is Satisfactory". Otherwise, a diagnostic message indicative of the tag's control performance deficiency will be displayed.

CRITERION FOR SORT is the criteria used to sort all tags. E.g., if ERROR is selected, then all tags are sorted based on the ERROR.

SORT ORDER: The sorting above can be set to ascending or descending.

SAVE ERROR LOG: If value is set to 1, then the program saves the error log file if bad data (or out-of-range data) are encountered.

ERROR SCALE: The default value is 1. This is a pure multiplier for the ERROR, ERROR SQUARED and ERROR DEVIATION criteria. In most cases, this is always set to 1, but may be used to scale if necessary to compare errors from different plants with different PV High and Low Ranges.

SPECTRUM 1-14 LIMITS: If you click DETAIL tab and then click any tag on the right, you see the frequency distribution in the top window. There are up to 15 vertical red bars. The spectrum limit values are used to adjust spacing if your plant data dynamics are uncommonly fast or slow. Click Default Spectrum Limits button for some good starting default settings.

On the DETAIL tab, if you see most tags with a single tall bar on the right (bar #15), then increase the Spectrum Limits by 3-5 and click RUN from the top toolbar. Try a few times with increased limits (raise all limits by 3-5). Conversely, if you see most tags with a single tall bar on the left (bar #1); then reduce the Spectrum Limits by 3-5 and click button RUN. Try a few times with increased limits (reduce all limits by 3-5). PiControl will provide you free email assistance to optimize your Spectrum Limits if you feel you need some expert assistance.

ALL OTHER PARAMETERS: Leave them at their default values.

Congratulations! You have successfully completed and studied the tutorial example. Pat yourself on the back for your hard work and dedication. The reward is that now you have the knowledge necessary to configure and implement the Apromon™ software at your plant. Now proceed to Section 3.

### **3.0 CONFIGURING APROMON™ FOR YOUR PLANT**

So far we explained all Apromon™ features by using an illustrative example to make it easier to understand. Now we will explain how to install Apromon™ at your plant.

#### **3.1 PREPARING PLANT DATA FILES**

Your plant most likely has a data historian like OSI's PI/Process-Book, Honeywell's PHD or similar. Wonderware, Intellution-Fix and similar PC-based systems also can be made to generate plant data files with some additional utility programs. Apromon™ needs plant data files containing plant data at some scan time - 5 sec, 10 sec, etc. These files must be in Microsoft® Excel (xls) or comma separated values (.csv) format. Apromon™ reads plant data from xls/csv format files and then performs all calculations. Apromon™ requires four plant data files to run:

- PV Data File (contains PID controller's PV data)
- SP Data File (contains PID controller's SP data)
- OP Data File (contains PID controller's OP data)

- Mode Data File (contains PID controller's MODE data)

These four files: PV, SP, OP and MODE all have similar file structure. These are four independent files with unique filenames. These files contain historical plant data. The fastest scan time allowed is 5 seconds. Scan times supported are: 5, 10, 30, 60, 90, 120, 150, 180, 210, 240, 270 and 300 (all in seconds). Tags with 5 seconds scan time will have a new value in each row in the file. Tags with 10 seconds scan time will have one repeated value in every row. Tags with 30 seconds scan time will have six repeat values in the rows. With this format, the total number of rows in all columns will be identical. To understand this, refer to Figure 3 showing a sample PV data file. Scan time of tags FC101, FC103, FC104 and FC106 is 5 seconds; scan time of tags FC102 and FC105 is 10 seconds. Notice that the 5 seconds tags have a new value in each row (at each scan time) whereas the 10 seconds tags have a value repeated as shown highlighted in gray.

These four data files (PV, SP, OP and Mode) are typically automatically generated every periodic interval. Typical intervals are 6, 8, 12 or 24 hours. Apromon™ reads these files at the same interval, performs all calculations and then deletes these files automatically.

Typically, both the four-file creation process and the automatic running of Apromon™ at the desired sample time are set to happen automatically. Procedure on how to run Apromon™ automatically is explained in a later section.

## PLANT DATA FILE NAME FORMATS

The PV, SP, OP, and MODE data file name **must** follow the following format:

**XXXX\_XXXX\_YYYY-MM-DD\_HH-MM-SS\_ZZ.CSV**

Where

- **XXXX** can be any string **not** containing character “\_”
- **YYYY-MM-DD** is the date stamp

- **HH-MM-SS** is the time stamp
- **ZZ** can be **PV**, **SP**, **OP** or **MODE** depending on the file it represents.
- **XXXX** can be any number of characters provided complete file name does not exceed number of characters allowed by Windows.

If your plant data file names follow different name format, please contact PiControl Solutions. We can then provide support for this new file name format in the Apromon program.

### **PV DATA FILE**

The PV data file contains PV (process variable) data for the PID controller tag. The PV data file must have the string "PV" embedded anywhere inside the filename. Example PV data File Name:

Apromon\_Tutorial\_2006-02-17\_06-19-41\_PV.CSV

### **SP DATA FILE**

The SP data file contains SP (setpoint) data for the PID controller tag. The SP data file must have the string "SP" embedded anywhere inside the filename. Example SP data File Name:

Apromon\_Tutorial\_2006-02-17\_06-19-41\_SP.CSV

### **OP DATA FILE**

The OP data file contains OP (controller output) data for the PID controller tag. The OP data file must have the string "OP" embedded anywhere inside the filename. Example OP data File Name:

Apromon\_Tutorial\_2006-02-17\_06-19-41\_OP.CSV

### **MODE DATA FILE**

The MODE data file contains controller mode (manual, auto, cascade etc.) data for the PID tag. This file must have the string "MODE" embedded anywhere inside the filename. An

example File Name is:  
Apromon\_Tutorial\_2006-02-17\_06-19-41\_MODE.CSV.

The data in the file should be:  
1 = Manual  
2 = Auto  
3 = Cascade  
4 = Computer, Remote etc.

### **FILE STRUCTURE AND CONTENTS**

All four files (PV, SP, OP and Mode) have the same file structure. A sample PV data file is shown below in Figure 3. The SP file looks the same as in Figure 3, but carries SP data instead of PV data. The OP and Mode files also are similar.

For all four files, the first row has the "TIME" label followed by tagnames. A maximum of 255 tagnames are allowed. If your plant has more than 256 tags to be monitored, then you can divide the plant into groups or areas and run multiple instances of Apromon™.

The second and third rows show tagname descriptor and engineering units.

The first column in each of the four files contains the time stamp. Apromon™ does not really read this column but still, the column cannot be left blank.

**Figure 3. Sample PV Data File**

TIME	FC101	FC102	FC103	FC104	FC105	FC106
	string	string	string	string	string	string
	string	string	string	string	string	string
02/02/05 16:30:00	48	48	50	50	50	50
02/02/05 16:30:05	47	48	52	50.5	50	52
02/02/05 16:30:10	45	43	48	49	49	48
02/02/05 16:30:15	43	43	54	52	49	54
02/02/05 16:30:20	55	59	46	47	47	46
02/02/05 16:30:25	59	59	56	54.5	47	56
02/02/05 16:30:30	41	34	44	44	44	44
02/02/05 16:30:35	34	34	58	58	44	58
02/02/05 16:30:40	41	54	42	40	40	42
02/02/05 16:30:45	54	54	60	62.5	40	60
02/02/05 16:30:50	60	70	40	35	35	40
02/02/05 16:30:55	70	70	40	68	35	40
02/02/05 16:31:05	65	58	62	29	29	62
02/02/05 16:31:10	58	58	62	74.5	29	62
02/02/05 16:31:15	52	47	37	22	22	37
02/02/05 16:31:20	47	47	37	82	22	37
02/02/05 16:31:25	42	35	65	14	14	65
02/02/05 16:31:30	35	35	65	90.5	14	65
02/02/05 16:31:35	39	49	33	5	5	33
02/02/05 16:31:40	49	49	33	50	5	33
02/02/05 16:31:45	58	59	33	55	55	33
02/02/05 16:31:50	59	59	33	45	55	33
02/02/05 16:31:55	40	40	33	199	100	150
02/02/05 16:32:00	40	40	33	199	100	177

All other columns show the data for each of the tags in the columns. (PV data in PV file, SP data in SP file, OP data in OP file and MODE data in MODE file).

Sample data files used in the example (see sections 2.4 and

2.5) illustrate the file structure and naming convention. The four data files provided with the Apromon™ software are:

**Apromon\_Tutorial\_2006-11-15\_06-19-41\_PV.CSV**

**Apromon\_Tutorial\_2006-11-15\_06-19-41\_SP.CSV**

**Apromon\_Tutorial\_2006-11-15\_06-19-41\_OP.CSV**

**Apromon\_Tutorial\_2006-11-15\_06-19-41\_MODE.CSV**

### 3.2 TAG DATA FILE

Tag data file is also required to run Apromon™. The example illustrated in Section 2 above uses the supplied file called ***Apromon\_Tutorial\_Tag\_Original.xls***. The content of this file was explained in detail in Section 2.

Note that tab APROMON TUTORIAL TAG ORIGINAL, actually shows the contents of the TAG file ***Apromon\_Tutorial\_Tag\_Original.xls***.

This file specifies various DCS-related PID configuration parameters and also tag-process related configuration parameters.

The scan time for each tag is specified in this file. The scan time (seconds) specified in this file must match (agree) with the scan time (specified indirectly in how many consecutive values are repeated) in the PV, SP, OP and Mode data files.

The Tag File contains tuning and configuration information. Once configured the first time, the data does not need frequent changes. To change the content of this file, you can directly modify the Excel file ***Apromon\_Tutorial\_Tag\_Original.xls*** or click the tab APROMON TUTORIAL TAG ORIGINAL and modify the fields. Program prompts for saving changes made to TAG files before exit or opening another configuration file.

In the example illustrated in Section 2, we supplied the TAG file to the run the program. But how about a new configuration case, where a new TAG file has to be created for the first time with no existing file?

A brand-new TAG file for a particular plant data files set can be created by use of TAG FILE button provided on the top toolbar.

Click button TAG FILE from the top toolbar. A window “**Default values for TAG file**” is shown. All the TAG file parameters are seen with some default values. These values will be written for each Tag.

Click button “Create Tag File”.

To create TAG file, program needs to first read all the Tag names from one of the plant data file (PV/SP/OP/MODE). A “**Select Data File**” dialog is shown. Select appropriate data files folder and select one of the PV, SP, OP, MODE files and click “Open”. (**Note:** Data file can be in Excel (xls) or Comma Separated Values (csv) format. Select appropriate option from “Files of type” list shown at the bottom of the dialog)

Another dialog is seen with a title “**Enter name for TAG file**”. Type name for the new TAG file to be created and click “Save”. (Note: TAG file to be created can be in Excel (xls) or Comma Separated Values (csv) format. Select an appropriate option from “Save as type” list shown at the bottom of the dialog).

“Tag File Created successfully” message is shown with the tag file name with its complete path.

Click “Close” button.

The TAG file such created can then be edited to change values individually for all tags and set the right values for each tag. But creation of the initial tag file with the help for this feature is a nice convenience for creating some initial file conveniently.

### 3.3 CONFIGURATION DATA FILE

This file contains various parameters, such as calculation tuning parameters, option to generate history files, and various other software configuration parameters required to run Apromon™.

A sample illustrative file is supplied with the Apromon™ software product and was used in the example described in Section 2. Many of the parameter settings in this file may be left at their default values with rare need for a change. However, for special cases, some changes may be necessary as explained in Section 2. The name of the sample configuration data file used in the tutorial example in Section 2 is ***Apromon\_Tutorial\_Config\_Original.xls***.

Note that the tab APROMON\_TUTORIAL\_CONFIG\_ORIGINAL, actually shows the contents of the CONFIG file ***Apromon\_Tutorial\_Config\_Original.xls***.

To change the content of this file, you can directly modify the CONFIG file ***Apromon\_Tutorial\_Config\_Original.xls*** or click the tab APROMON\_TUTORIAL\_CONFIG\_ORIGINAL and modify the fields.

### 3.4 SPECIFY PLANT DATA FILE STRUCTURE (FILE ***APRODEFA.INI***)

In the plant data files (PV, SP, OP and Mode files) explained above, the actual plant data starts in row #3 and column #2. Row #s 1, 2 and column #1 do not contain any plant data. Apromon™ needs to be told in which column and row the plant data starts.

This information is specified in the file ***aprodefa.ini***. Look for this file in the Apromon folder and open it with Notepad editor. The bottom of this file has two lines: Row=4 Col=2. This tells

Apromon™ that data starts in row #4 and column #2.

If your plant data as generated by your plant data generating software starts in another row or column, you can just modify the Row and Col numbers in the **aprodefa.ini** file to specify the appropriate row and column location.

Note that when you started Apromon™ and loaded the tutorial example in Section 2.3, the file **aprodefa.ini** already existed in the Apromon folder (this file is supplied with the Apromon™ software). If this file is deleted and does not exist in the Apromon folder, then if you start Apromon™ program, the program will ask the user to specify the row and column information.

For an illustration, close the Apromon™ program (if running) and then delete the **aprodefa.ini** file in the Apromon folder. Start **Apromon** program or double click **apromon.exe** from the folder to re-start Apromon™. The program asks two questions: "**Data starts in which row?**" and "**Data starts in which column?**" Specify 4 for row and 2 for column to re-create the deleted **aprodefa.ini** file, or specify different numbers to match your plant data file structure. A new **aprodefa.ini** file is now created.

### 3.5 INTERACTIVE AND SCHEDULED MODES

Apromon™ can run in two modes: interactive mode and scheduled mode.

The **interactive mode** is run interactively by the user. The example illustrated in Section 2 shows the interactive mode. In this mode, Apromon™ reads plant data and then performs all the control monitoring calculations. In the interactive mode, the user can conduct various what-ifs studied with different windows of data and sets of conditions as was shown in the various steps in Section 2.

This mode is required for tuning the various configurations and tuning parameters in the TAG and CONFIG files, also

explained in Section 2 (the files ***Apromon\_Tutorial\_TAG\_Original.xls*** and ***Apromon\_Tutorial\_TAG\_Original.xls***). The interactive mode runs the program file ***apromon.exe***.

The ***scheduled mode*** is also called the automatic mode. The scheduled mode reads the same TAG and CONFIG files from the interactive version and also same plant data files (the PV, SP, OP and Mode files) but has no user interface.

The scheduled mode runs the file ***apromonsh.exe***. The scheduled mode has no user interface. It reads the plant, TAG and CONFIG files and runs all calculations and then creates Error Log Files, History Files, Detailed Report and Summary Report files.

For running the scheduled mode, some configuration is necessary. The scheduled mode configuration parameters are specified in a file called ***ApromonDefault.cfg***. The tutorial example came equipped with this file. You can open this file from the Apromon folder and examine its content. If this file is missing, then, when the interactive Apromon program is run, it will ask information to specify the scheduled mode configuration parameters.

To show how to configure the scheduled mode, close the Apromon™ program (if running) and then delete the ***ApromonDefault.cfg*** file in the Apromon folder. Start ***Apromon*** program or double click file ***apromon.exe*** from the Apromon folder to re-start the interactive Apromon™ program. The program asks question: "***For Apromon Scheduled program, configuration file ApromonDefault.cfg is required. Do you wish to create this file now?***"

Click Yes if you plan to run the scheduled (automatic) mode. For industrial plants monitoring real-time plant data, the choice will be most likely "yes" since you want Apromon™ to run automatically at a set period to monitor, calculate and save the historical performance. Proceed to the next section to create the ***ApromonDefault.cfg*** file.

Click No if you want to use the interactive mode only as was

illustrated in the various steps in Section 2 and do not need to run automatically. If you are in academics or a student and wish to run the interactive mode only for Apromon™ on-demand, then your choice may be a "no" and you can skip the next section.

### 3.6 CONFIGURE APROMONDEFAULT.CFG FILE

If you selected "Yes" from the above section, then you will see a dialog titled "**Enter Defaults for Apromon Scheduled Version**". Select the data folder (directory) on the left side to select the folder where all the data files are located. For now, select folder "Tutorials".

The plant data files, TAG and CONFIG files can be specified as shown below:

#### SPECIFY PV DATA FILE

On right hand side, click the button for PV. "**Select PV Data File**" dialog is seen. To select csv, xls or xlr file type, select appropriate option from "Files of type" list shown at the bottom of the dialog. For now, select csv option.

From the files list, select file

***Apromon\_Tutorial\_2006-11-15\_06-19-41\_PV.CSV***  
and click "Open".

#### SPECIFY SP DATA FILE

On right hand side, click the button for SP. "**Select SP Data File**" dialog is seen. Follow the procedure described in SPECIFY PV DATA FILE section and select file

***Apromon\_Tutorial\_2006-11-15\_06-19-41\_SP.CSV***  
and click "Open".

#### SPECIFY OP DATA FILE

On right hand side, click the button for OP. "**Select OP Data File**" dialog is seen. Follow the procedure described in SPECIFY PV DATA FILE section and select file:

***Apromon\_Tutorial\_2006-11-15\_06-19-41\_OP.CSV***  
and click "Open".

#### SPECIFY MODE DATA FILE

On right hand side, click the button for MODE. “**Select MODE Data File**” dialog is seen. Follow the procedure described in SPECIFY PV DATA FILE section and select file:

***Apromon\_Tutorial\_2006-11-15\_06-19-41\_MODE.CSV***  
and click “Open”.

#### SPECIFY DCS (TAG) FILE

On right hand side, click the button for DCS. This is to specify the TAG file, which contains some DCS-related tag information. “**Open**” dialog is seen. Select option “Apromon Excel Data Files (\*.xlr;\*.xls)” from “Files of type” list shown at the bottom of the dialog and select file

***Apromon\_Tutorial\_TAG\_Original.xls***  
and click “Open”.

#### SPECIFY CONFIG FILE

On right hand side, click the button for CONFIG. This is to specify software configuration data. “**Open**” dialog is seen. Select option “Apromon Excel Data Files (\*.xlr;\*.xls)” from “Files of type” list shown at the bottom of the dialog and select file

***Apromon\_Tutorial\_Config\_Original.xls***  
and click “Open”.

(Note: In the example illustrated in Section 2, the plant data files (PV, SP, OP and Mode data files) are in CSV format and the TAG and CONFIG files are in XLS format.)

In “Specify Output Files Folder” section, select the Drive and the Folder where you wish to generate Apromon output files. For now, select “Tutorials” subfolder from Apromon folder.

Click button Save ApromonDefault.cfg File. Message “*ApromonDefault.cfg created successfully*” is seen. Click OK. The information from this file is used by the Apromon scheduled mode (***apromonsh.exe***) program.

**Note: If Apromon Scheduled version is to be run, delete**

**the ApromonDefault.cfg file provided with the program and create a new file specifying correct data files as explained above.**

Note that the scheduled program reads the plant data file names from the **ApromonDefault.cfg** and then from the file name format, determines today's (current date's) data file names. The filename specifications below tell the scheduled program the format of the filenames to look for. The time stamp in the filenames shown below is ignored. Based on the filename structure, the scheduled program looks for files with today's date for a new automatic run. If there are multiple files with the same date, then the most recent time stamp is used. If data files with today's date are missing, then the scheduled program will report an error.

### **3.7 AUTOMATIC (SCHEDULED) RUNNING OF APROMON™**

As described earlier, the **apromon.exe** file invokes the interactive mode and the **apromonsh.exe** file invokes the scheduled (automatic).

If you double click the **apromon.exe** file, you invoke the interactive mode.

If you double click the **apromonsh.exe** file, you invoke the scheduled mode. In this case, the program will run, read data, perform all calculations and then write data to the respective files and then will exit. To use the **apromonsh.exe** file, user has to invoke the file and this is a manual step.

To make the process of triggering the scheduled program (**apromonsh.exe**) automatic, we have provided scheduler software included in the supplied software. This program is the file **ApromonScheduler.exe**. This scheduler, triggers the scheduled mode to run automatically at preset times.

Double click the file **ApromonScheduler.exe**. Now you will see the scheduler window. Scheduler window immediately minimizes to the Windows Taskbar at right hand side near the clock. Double click the Apromon Scheduler icon or right click

Apromon Scheduler icon and click Show on the popup menu. Right hand side of the Apromon Scheduler window shows content of file ApromonScheduleder.INI. This INI file stores timings set by the user to run Apromon Scheduled version. Apromon Scheduler reads this file and invokes Apromon Scheduled version at these specified times.

A typical content of ApromonScheduleder.INI set to run every 4 hours would look as below:

Apromon Scheduled Time (HH:MM)

00:30  
04:30  
08:30  
12:30  
16:30  
20:30

Click Edit button to specify the times you want the scheduled program to run automatically. After entering the correct timings, click Save button to save the scheduler trigger times to the INI file. Make sure that each time Apromon Scheduled version is run, it gets latest generated data files. Set the timings accordingly.

**Notes:**

1. Never delete/modify first header line “Apromon Scheduled Time (HH:MM)” from the file while editing.)
2. Apromon Scheduler will process INI files only if it is running. Start Apromon Scheduler program every time windows start. To read more about how to start a program when Windows restart, read Windows Help under topic “Start a program each time you start Windows”.
3. To disable the scheduler, just keep the timings empty (without removing first header line). Program shows message “Scheduler Disabled”. Otherwise program shows next scheduled time and time remaining to start the Apromon Scheduler version.

The "Show Grade Trends" button displays the historic

performance of the tags.

The "Show Summary Reports" button displays the latest summary report.

The trends and reports displayed are automatically refreshed to show the latest results.

Hide button minimizes the program on Windows Taskbar.

Close button closes Apromon Scheduler program and unloads from memory. After closing, program will not start Apromon Scheduled version.

To restart Scheduler, from Windows Taskbar, click **Start**, point to **Programs**, and then navigate through the menus to the program group "**Apromon**" and then click "**Apromon Scheduler**" or open Windows Explorer, navigate to Apromon folder and double click **ApromonScheduler.exe** file.

### **3.8 FILES TO RUN INTERACTIVE MODE**

In the previous section, we specified the filenames and locations for the scheduled mode.

Remember that the Section 2 example ran the interactive mode. We clicked on FILES as shown in Section 2.4. When you click FILES button. You are seeing the files specified for the interactive mode.

### **3.9 EDITING THE TAG FILE**

Click EDIT TAG FILE button from the top toolbar and then click the button next to the "Select Tag File" Textbox. In the "Open" Dialog, select the folder containing TAG file and select TAG file to be modified. (**Note:** TAG file can be in Excel (xls) or Comma Separated Values (csv) format. Select appropriate option from "Files of type" list shown at the bottom of the dialog)

Now you can convenient modify any TAG file.

### 3.10 EDITING THE CONFIG FILE

Click button EDIT CONFIG FILE from the top toolbar and then click the button next to the "Select CONFIG File" Textbox. In the "Open" Dialog, select the folder containing CONFIG file and select CONFIG file to be modified. (Note: CONFIG file can be in Excel (xls) or Comma Separated Values (csv) format. Select appropriate option from "Files of type" list shown at the bottom of the dialog)  
Now you can convenient modify a CONFIG file.

### 3.11 FILE OPERATIONS- OPEN, FILES, SAVE

OPEN button from the top toolbar allows user to read and process Apromon Configuration (cfg) file. User can build a configuration file for each data files set and then use it every time in the Apromon interactive mode version to process data files.

Contents of a typical configuration (cfg) file are as follows:

[Header]

ID=Apromon Config File

[TagNames]

NoTags=2

0=FC104.SP LAGGED

1=FC104.PV

[Files]

PV=C:\Apromon\Small Data Set\Small\_PV.xls

SP= C:\Apromon\Small Data Set\Small\_SP.xls

OP= C:\Apromon\Small Data Set\Small\_OP.xls

MODE=C:\Apromon\Small Data Set\Small\_MODE.xls

DCS= C:\Apromon\Small Data Set\Small\_TAG.xls

CONFIG=C:\Apromon\Small Data Set\Small\_CONFIG.xls

[Criteria]

NoCriteria=2

0=ERROR

1=ERROR SQUARED

The sections in the file can be described as follows.

1. Header section is used to verify that the file is a valid Apromon configuration file.
2. TagNames section stores number of tags and their names which are selected by the user.
3. Files section contains file names of PV, SP, OP, MODE and CONFIG files. Files will contain full path.
4. Criteria section contains criteria currently selected by the user.

TagNames and Criteria section

If a configuration file is open, click FILES button from the top toolbar to see the data files used in that configuration file.

SAVE button from the top toolbar can be used to save changes to currently opened Apromon configuration file or to create a new Apromon configuration file.

#### **How to create a new Apromon Configuration file?**

1. Start Apromon.
2. Click FILES button from the top toolbar.
3. "Read APR Data Files and Run Apromon" dialog is seen. Select and Specify all the (PV, SP, OP, MODE DCS and CONFIG) files.
4. In "Specify Output Files Folder" section, select the Drive and the Folder where you wish to generate Apromon output files.
5. Click button "Read Data Files and Run Apromon".
6. Click SAVE button from the top toolbar.
7. "Save Apromon Configuration File" Dialog is seen.
8. Enter name for the new configuration file and click "Save" button. Apromon configuration file with .cfg extension is created.
9. List of tag names selected for Trending and Criteria selected to display are also saved in the configuration file. This is useful while using same configuration file to monitor some particular Tags. Every time this configuration file is opened by Apromon, these Trends and selected Criteria can be seen immediately without need of reselecting.

Click SAVE button from the top toolbar to save the list of tag names and criteria selected before exiting Apromon or opening another Apromon configuration file.

10. Now from Windows Explorer, go to the folder where new configuration file is saved and open it in any text editor like Notepad. Examine the file contents. (See section 3.11 for more details)

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