
Particle Analysis and Display System (PADS):

Forward-Scattering Spectrometer Probe (FSSP) Module Manual

**DOC-0287, Rev A; PADS 3.5
FSSP Module 3.5**



2545 Central Avenue
Boulder, CO 80301 USA

Copyright © 2011 Droplet Measurement Technologies, Inc.

**2545 CENTRAL AVENUE
BOULDER, COLORADO, USA 80301-5727
TEL: +1 (303) 440-5576
FAX: +1 (303) 440-1965
WWW.DROPLETMEASUREMENT.COM**

All rights reserved. DMT licenses PADS software only upon the condition that you accept all of the terms contained in this license agreement. Each PADS license you purchase allows you to acquire data on one computer only. Data can be viewed in playback mode on an unlimited number of computers.

This software is provided by DMT “as is” and any express or implied warranties, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose are disclaimed. Under no circumstances and under no legal theory, whether in tort, contract, or otherwise, shall DMT or its developers be liable for any direct, indirect, incidental, special, exemplary, or consequential damages (including damages for work stoppage; computer failure or malfunction; loss of goodwill; loss of use, data or profits; or for any and all other damages and losses).

Some states do not allow the limitation or exclusion of implied warranties and you may be entitled to additional rights in those states.

Trademark Information

All Droplet Measurement Technologies, Inc. product names and the Droplet Measurement Technologies, Inc. logo are trademarks of Droplet Measurement Technologies, Inc.

All other brands and product names are trademarks of their respective owners.

Risks of Installing Additional Software

Instrument computers from DMT are configured to acquire data in a reliable, robust manner. Typically, such instruments are either not connected to a network or are connected to a small, local network that is isolated from the internet, reducing the risk of viruses. Since anti-virus programs can cause erratic behavior when run in the background on data acquisition computers, DMT does not install anti-virus, anti-spam, or anti-malware programs. If you choose to install these programs, you accept the risk associated with them in terms of potential performance degradation of the software installed by DMT.

For similar reasons, DMT recommends that you do not install or run other software on the dedicated instrument computer. Although the installation of some software may be unavoidable, it is particularly important not to run other software while the computer is acquiring data.

CONTENTS

1.0	Introduction	4
2.0	Configuration.....	4
2.1	Configuring the FSSP	4
2.1.1	<i>FSSP Parameters</i>	5
2.1.2	<i>Channels Table</i>	8
2.1.3	<i>Tables Tab</i>	10
2.2	Configuring the FSSP Display.....	11
3.0	The FSSP Window	12
3.1	Sub-Tabs	13
3.1.1	<i>Data Tab</i>	13
3.1.2	<i>LWC / # Conc and LWC / MVD Tabs</i>	13
3.1.3	<i>Selectable Charts Tab</i>	14
3.1.4	<i>Tools Tab</i>	14
3.2	Time-Series Chart Displays	14
3.3	Histogram Data Window	14
3.3.1	<i>Normalizing Data</i>	15
4.0	Zooming In and Out	15
	Appendix A: FSSP Channels	16
	Appendix B: Revisions to Manual.....	17

List of Figures

Figure 1:	SPP-100 Configuration Editor Window.....	5
Figure 2:	Example Channel Specifications in the Config Editor Window	9
Figure 3:	FSSP Threshold Tables	10
Figure 4:	FSSP Display Editor Window	11
Figure 5:	FSSP Window	13
Figure 6:	Time-Range Controls	15

1.0 Introduction

The Particle Analysis and Display System (PADS) is a software package that interfaces with instruments produced by Droplet Measurement Technologies (DMT) and other leading instruments used in the atmospheric sciences. This manual describes the PADS Forward-Scattering Spectrometer Probe (FSSP) module version 3.5.0.

For an explanation of the basic PADS setup and instructions on how to acquire data using PADS, consult the *PADS Overview Manual, DOC-0300*. Definitions and calculations used in the FSSP module are also described in the *PADS Overview Manual*.

NOTE: In PADS 2.8, this PADS module was called SPP-100. SPP-100 refers to the electronics system that the FSSP uses. In PADS 3.5, the module was renamed to reflect the name of the instrument rather than the electronics system.

2.0 Configuration

Using PADS, you can configure both the software settings for the instrument and the instrument's data display in PADS. The following two sections explain how to do this. Configuring the instrument's software and display affect the default settings PADS uses when starting up. Some parameters can also be changed while PADS is running, but doing so affects the current session only.

2.1 Configuring the FSSP

Your FSSP and data system should arrive preconfigured from DMT. In some cases, however, you may want to change the software configuration for the instrument. To do this, follow the steps below. *Note: Droplet Measurement Technologies STRONGLY recommends that customers contact our office prior to changing any of the parameters in the instrument configuration. Improper changes can result in communication failure and/or changes in PADS computation algorithms, which can compromise data validity.*

1. Click on the “FSSP” tab.
2. From the **Configure** menu, select **Configure Instrument**. You will see the following window.

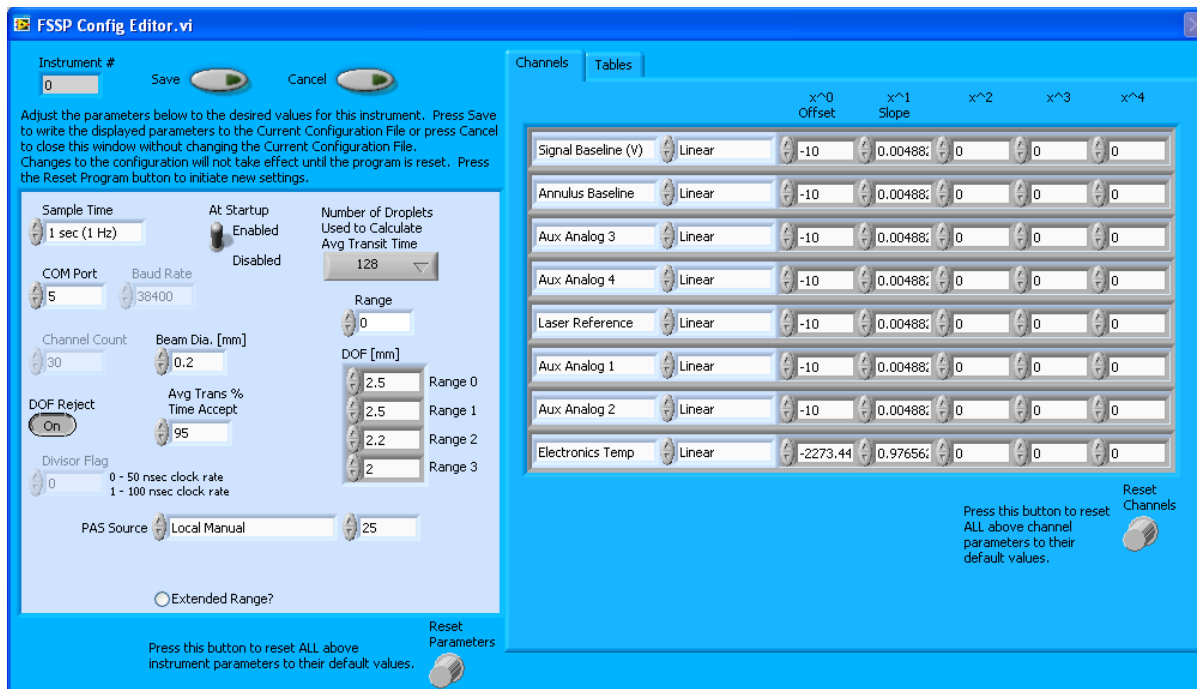


Figure 1: SPP-100 Configuration Editor Window

- Now you can configure the instrument parameters to your desired specifications. See the definitions below for explanations of individual parameters. If at any time you would like to revert to the previously saved values for the FSSP parameters, press **Cancel** to exit the window without saving changes. Pressing **Reset Parameters** reverts parameters to their DMT-supplied default values.
- When you are done configuring the FSSP parameters, press **Save** at the top of the Config editor window. Then press the green **Reset Program** button for the new configuration to take effect. Note that pressing the **Reset Program** button will clear any data currently being displayed.

2.1.1 FSSP Parameters

Instrument #: This lists the number corresponding to the instrument you are viewing, in this case the FSSP. If your FSSP has been assigned instrument number one, you will see “1” in this field. You should not need to modify the instrument number, and in fact you are unable to do so from within PADS.

Sample Time: This parameter shows the time interval you'd like between samples. You can have the probe sample at intervals between 0.04 and 20 sec (25 to 0.05 Hz). Note that if you increase the sample time, you will still collect data for the same number of particles. This is because the probe collects data continuously and relays cumulative data at each sampling interval. For example, say you have the sample time set to .5 seconds. You might see four particles of size 25 μm during the first sample, and five particles of this size during the second sample. If you had set your sample time to one second instead of .5 seconds, you would instead get one sample that showed nine particles of size 25 μm . *Note:* Sample Time is most often set to 1 Sec. Higher sample rates may or may not work on a given data system, depending on the computer performance and the number and types of instruments PADS is configured to use.

At Startup Enabled / Disabled: If you want the FSSP to acquire data when PADS begins sampling, make sure this parameter is in the “Enabled” mode. In some cases, such as if the FSSP is inoperative, you may want to use this control to disable the probe. Disabling the FSSP allows data to transmit from other instruments without interference. Data will still be written to the disabled instrument’s output file, but PADS will write “NaN” to all fields.

Number of Droplets Used to Calculate Avg Transit Time This control allows you to specify the number of particle readings that are used to calculate Avg Transit Time, which is the average time it takes for particles to pass through the beam.

COM Port: This is the serial communications port that the FSSP uses to connect with the computer. This number should match the computer hardware configuration for the particular computer you are using. If you are not using multiple computers, this number should not be changed.

Baud Rate: The baud rate for the probe is defined at manufacture. This parameter has been grayed out and you should not need to change it. If you reconfigure your hardware, however, the baud rate may change. If this occurs, contact DMT for help in changing your baud rate in PADS.

Range: The FSSP-100X, as built by the original manufacturer, has 4 size ranges. This setting allows the user to select the particle sensing range. The active range in turn determines which thresholds are used to size particles; see section 2.1.3. Consult your original manual to determine the ranges. There is an “Extended Range” version of the FSSP.

Channel Count: This number indicates how many sizing bins the FSSP uses to categorize particles. This number has been grayed out because it is preconfigured for your instrument and should not change.

Beam Dia. [mm]: The diameter of the instrument's laser beam in mm. This parameter is set at manufacture and should not need to be changed. It is used in sample volume calculations. $\text{Beam Diameter (mm)} * \text{DOF (mm)} * \text{Beam Acceptance} = \text{Sample Area in mm}^2$.

DOF Reject: The DOF reject button tells the FSSP whether to reject particles that fall outside the FSSP's depth of field. The default value is ON, and you should not need to change it. During probe calibration and alignment, DMT sets DOF Reject to false, so that the probe will report all particles it detects. (For a definition of Depth of Field, consult *Appendix A: Definitions* of the PADS Overview Manual.)

Avg Trans % Time Accept: This value sets the percentage of the transit time average that a particle transit must surpass before being accepted for counting.

Transit Reject: If this button is ON, particles with transit times shorter than those specified by **Avg Trans Time Accept** will be excluded from average transit time calculations. This feature is designed to reject particles that may be undersized because they pass through the edge of the laser beam. When Transit Reject is enabled, the instrument measures the transit time of all particles that are accepted within the depth of field, maintains an average of their transit times, and then rejects individual particles whose transit times are less than the accepted percentage of this average. The theory is that if a particle's transit time is too short, the particle must have passed near the beam's edge.

DOF [mm]: The length of the instrument's depth of field in mm. Note that there are four separate DOF fields, one for each of the FSSP's ranges. These parameters are used in sample volume calculations.

Divisor Flag: This selects the PHA divisor of basic clock speed to determine probe sampling speed. 0 is the setting for a 50 nsec clock rate, which is the default. 1 is the setting for a 100 nsec clock rate.

The **PAS Source** control specifies from which of the following sources the system should obtain the applied probe air speed (PAS):

- 1.) A specific instrument in the system (this can be any instrument capable of measuring air speed)
- 2.) A manually entered value:
 - a. A “Local” value, which at start-up is the value entered in the box to the right of the source control. This number can be changed from the instrument display while the program is running.
 - b. A “Global” value entered on the **Setup** tab

Applied PAS is used to calculate sample volume. In flight conditions, you will typically want to select an instrument as the air speed source. However, you will need to enter manual air speed values during probe calibration.

Extended Range?: This parameter indicates whether the FSSP is an “extended range” version. The range type is determined at manufacture, and this parameter should not change.

Pressing the **Reset Parameters** button resets all parameters to their DMT-supplied default values. After making changes to the parameters, you will need to press the **Save** button and then click the green **Reset Program** to activate these changes. Clicking **Reset Program** will clear any data PADS is currently displaying.

2.1.2 Channels Table

The channels listed in the Channels table are configurable. These are A/D housekeeping channels that measure a 0 - 10 V range from one of the instrument’s internal sensors, for example a pressure or temperature sensor, and then convert this voltage to a binary value from 0 to 4095. These binary values can then be turned into other, more meaningful units (e.g., mBar or °C) by using a conversion equation. You can specify this equation in the Channels table.

Note: *While it is possible to use the Channels table to rename output channels, in most cases your system is preconfigured so that the channels in the table correctly match*

output from your instrument(s). While minor rescaling of output channels can improve data accuracy, DMT does not recommend altering your basic channel configuration.

The second column in the table indicates the type of equation that PADS should use—linear, polynomial, or none. (“Thermister D” and “Thermister G” are complicated, pre-set equations used by some instruments, while the “Custom” options are reserved for future use.) “Linear” indicates a linear equation, while “4th Order Poly” indicates a higher order polynomial equation with up to five terms. “None” means the digital value (between 0 and 4095) will be returned without any scaling.

The right-hand fields in the channels table indicate the coefficients to be used in the conversion equation. Figure 2 shows the setup for a hypothetical channel with the second-order polynomial conversion equation, as follows:

$$\text{New_Channel} = 34.01 + 0.061 x + 0.0092 x^2$$

where x is the digitized analog value returned by the A/D converter.



Figure 2: Example Channel Specifications in the Config Editor Window

The number of coefficients that PADS uses depends on the equation type. “None” does not use any coefficients. “Linear” uses the first two coefficients, which are listed in the first two table cells after the equation type. “4th Order Poly” uses one to five coefficients.

In cases where there are non-zero numbers in cells that are not used in the function, PADS ignores these numbers. For instance, if you specify “Linear” as your function and have .32 in the farthest right cell, the program will just ignore this value.

Clicking the **Reset Channels** knob at the bottom of the FSSP Parameter window will reset all the channel parameters to their DMT-supplied default values.

After making changes to the Channels tab, you will need to press the **Save** button and then click the green **Reset Program** to activate these changes. Clicking **Reset Program** will clear any data PADS is currently displaying.

2.1.3 Tables Tab

The **Tables** tab lists the threshold tables that allow the FSSP to bin particles according to size. The top half of the table lists the bin boundaries in μm , while the lower half of the table lists the corresponding digital peaks. The bin numbers are listed in the middle.

Note that each half of the table has four rows, one for each range of the FSSP.

The bin sizes and digital counts listed the Upper Bin Sizes and Upper Thresholds tables represent each bin’s *upper* boundaries. Lower boundaries are the upper boundaries of the previous bin, except for bin 1. Bin 1’s lower particle-size boundaries are listed in the **Bin 1 Lower Thresh.** column. The corresponding lower digital count boundaries are listed in the **ADC Lower Thresh.** column.

The scrollbar at the bottom of the tables allows access to boundaries for higher bin numbers.

Example: Say PADS is configured to use the threshold tables listed in Figure 3. The instrument, which is currently set to use Range 2, detects a particle with a 400 digital-count peak. The particle would fall in Bin 4, which contains particles that generated a peak digital count of 326 - 453. The corresponding size range would be 2.5 - 3 μm .

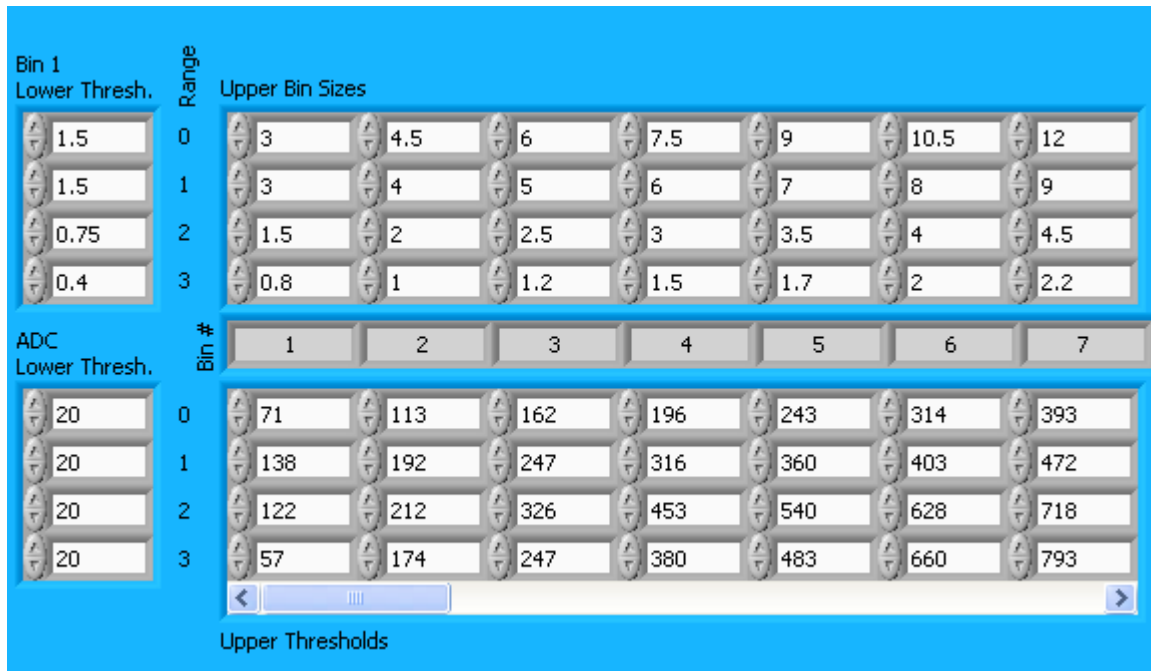


Figure 3: FSSP Threshold Tables

The **Reset Tables** knob restores table values to their DMT-supplied defaults.

After making changes to the Tables tab, you will need to press the **Save** button and then click the green **Reset Program** to activate these changes. Clicking **Reset Program** will clear any data PADS is currently displaying.

2.2 Configuring the FSSP Display

To configure the FSSP display, click on the FSSP tab if you have not already done so. Then select **Configure** from the menu bar and click on **Configure Display**. This will bring up the following window.

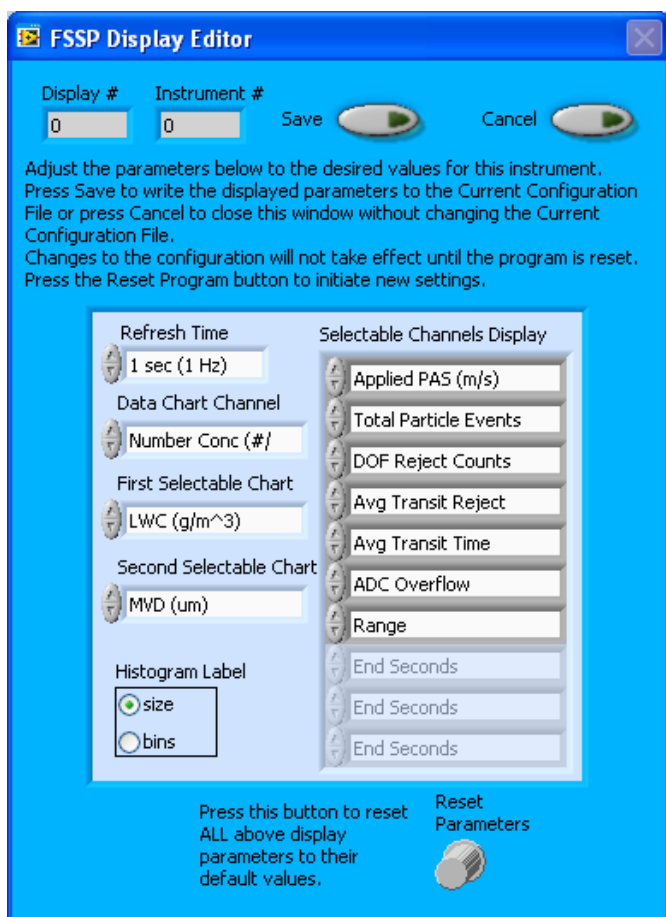


Figure 4: FSSP Display Editor Window

You do not need to modify the **Display #** or **Instrument #**. Changing the **Refresh Time** allows you to set the time intervals for data display during acquisition mode; you can choose any time that is equal to or greater than the sample time. (Choosing a time less than the sample time is not useful, since the same data will be displayed multiple times.)

Data Chart Channel allows you to select a data channel to be displayed in the chart in the upper right of the **Data** tab.

First Selectable Chart and **Second Selectable Chart** allow you to select channels graphed on the **Selectable Charts** tab.

The **Histogram Label** radio buttons allow you to select how you would like the x-axis of the histogram labeled - by size (μm) or bin number.

The **Selectable Channels Display** controls which channels PADS displays in the upper right of the FSSP window.

Note that many of the settings listed above can also be changed while PADS is acquiring data by using the controls on the main FSSP window. Modifying these parameters on in the Display Editor changes the values used upon start-up.

Reset Parameters reverts the display parameters to their DMT-supplied defaults.

When you are done configuring the FSSP display, click on **Save** to update the configurations or **Cancel** to revert to the previous configuration. After you reset PADS, you will be able to see any changes you have made. Note that clicking **Reset Program** will clear out any data currently being displayed.

3.0 The FSSP Window

The different parts of the FSSP Window are discussed below. For explanations of the **Enable** button, **COM Port** indicator, and **Fault/No Fault** button, see the *PADS Overview Manual*.

The upper portion of the FSSP window displays five sub-tabs: **Data**, **LWC/# Conc**, **LWC MVD**, **Selectable Charts**, and **Tools**. More about each of these sub-tabs is given in the following sections. In addition to these sub-tabs, the FSSP window features a **Selectable Channels Display** in the upper right and a histogram of particle counts.

Figure 5 displays the FSSP window with the **Data** sub-tab active.

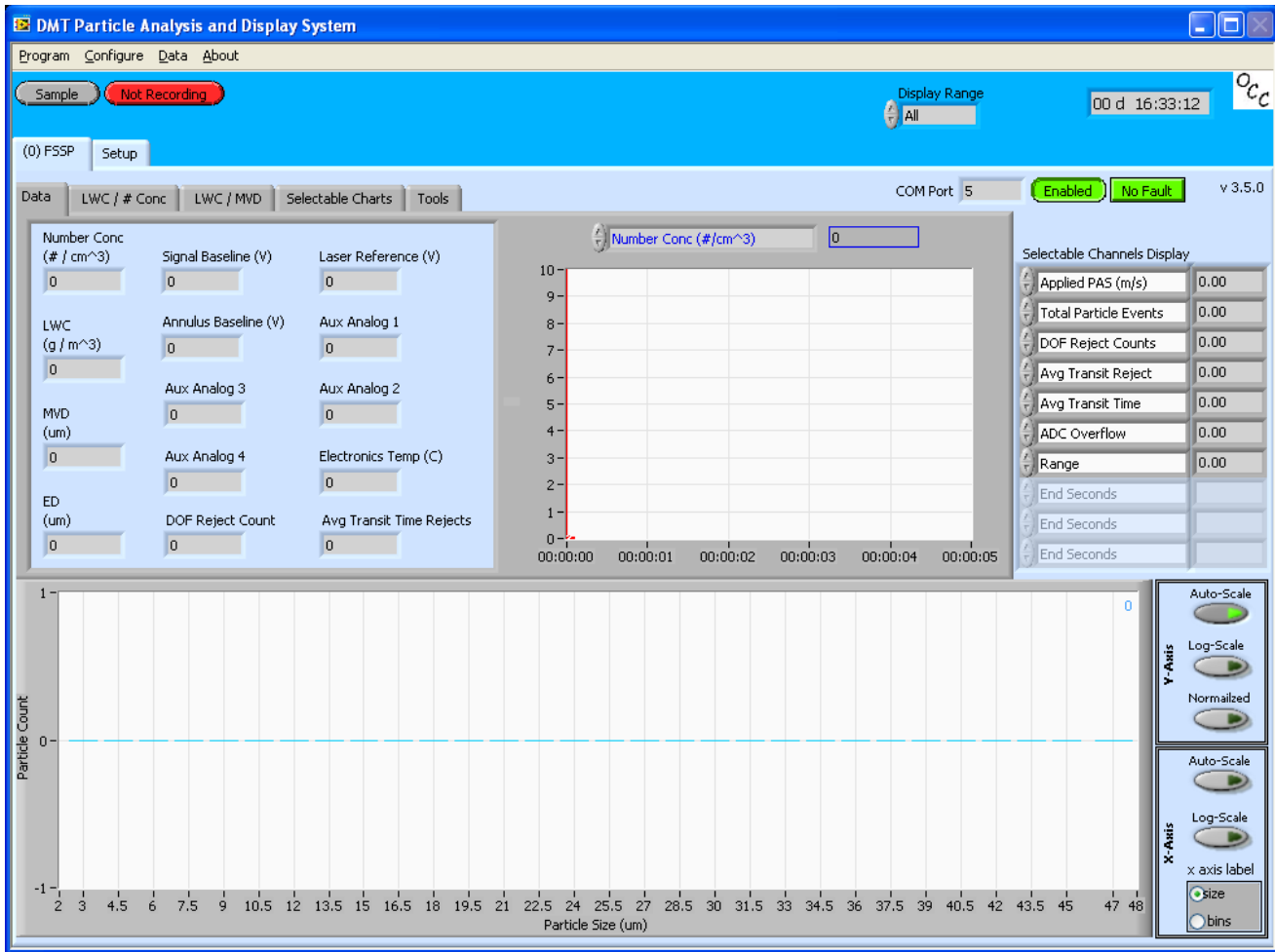


Figure 5: FSSP Window

3.1 Sub-Tabs

3.1.1 Data Tab

The **Data** tab displays standard FSSP output channels. For channel definitions and acceptable ranges, consult the PADS Overview Manual’s *Appendix A: Definitions*.

3.1.2 LWC / # Conc and LWC / MVD Tabs

The **LWC / # Conc** tab graphs liquid water content (g/m^3) and # Conc (particle counts/ cm^3) with respect to time. The two graphs are overlaid, with the LWC axis on the left and the # Concentration axis on the right.

The **LWC / MVD** tab graphs liquid water content (g/m^3) and median volume diameter (MVD, in μm) with respect to time. The two graphs are overlaid, with the LWC axis on the left and the MVD axis on the right.

3.1.3 Selectable Charts Tab

The **Selectable Chart** tab displays two user-selectable time-trace charts overlaid upon each other. You can select the channels that are displayed in these charts by clicking on the controls in the upper left and right-hand corners of the tab. If you click on the name of the channel that is currently displayed, a list of available channels will pop up, from which you can select a channel to view.

3.1.4 Tools Tab

The **PAS Source** control sets the source for probe air speed.

The **Range** control allows you to select the range of the FSSP that is currently active.

Both these controls are identical to their counterparts on the Configuration Editor except that any changes made here affect the current session only. Changes made in the Configuration Editor, in contrast, affect the settings upon PADS start-up.

3.2 Time-Series Chart Displays

The FSSP chart displays are located on the top right of the window. Three tabs display number concentration ($\#/ \text{cm}^3$), volume concentration ($\mu\text{m}^3/\text{cm}^3$), and total particle count.

3.3 Histogram Data Window

Below the FSSP chart displays is the histogram display of FSSP-acquired particle data. Like the channel data display, the histogram shows time-specific data.

Clicking on the X and Y-axis **Log-Scale** buttons instructs PADS to display data logarithmically. The **Autoscale** buttons autoscale the relevant axis.

The x-axis labels can display either particle sizes or bin numbers, depending on which radio button is selected in the **x-axis label** control. If the x-axis labels display bin numbers, the corresponding particle sizes appear above the data bars.

3.3.1 Normalizing Data

On instruments with thirty bins, bins have a width ranging from 0.01 μm for small bins to 0.2 for large bins. This system enables the instrument to detect a wide size range of particles yet still provide nuanced sizing for smaller particles.

As a result of the instrument's uneven bin sizes, the histogram distribution may not be a smooth curve. When the bin range increases, the bins capture many more particles.

If you want to see a normalized histogram curve, click on the “Normalized” button in the **Y-Axis** controls. The normalization will take effect and you will see the distribution normalized by bin width. To normalize the data, PADS divides each bin count by the bin width in microns.

4.0 Zooming In and Out

There are several ways to zoom in or out on FSSP charts and the histogram. As described in the *PADS Overview Manual*, you can use the time-range controls (Figure 6) to zoom. To zoom in on the data, move the green and red controls close to the white control, which will narrow the range of displayed data. To zoom out, move the two colored controls away from the white control.

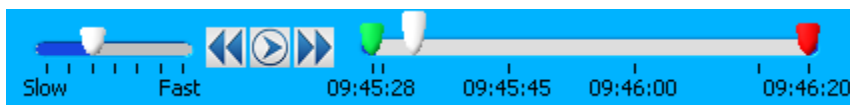


Figure 6: Time-Range Controls

On the chart itself, you can also type numbers directly into the first and last labels on the x and y axis to change the scaling.

Note: Do not right-click on chart and change the auto-scaling using the drop-down menu. This can interfere with the chart display. PADS autoscales most charts automatically. You can turn off autoscaling on the histogram using the buttons in the lower right of the window.

Appendix A: FSSP Channels

A list of channels for a 30-bin instrument appears below. The FSSP output file will contain data values for each channel for each sampling instance. You can also plot each of these channels against time using the FSSP Selectable Charts tab. For definitions of the channels, consult *Appendix A: Definitions* in the *PADS Overview Manual*.

End Seconds	<i>Aux Analog 2</i>
Day of Year	<i>Electronics Temp (C)</i>
Year	Spare 1 - 8
Status	Number Conc (#/cm ³)
DOF Reject Counts	LWC (g/m ³)
Avg Transit Reject	MVD (um)
Avg Transit Time	ED (um)
FIFO Full	Total Particle Events
Reset Flag	Beam Acceptance
ADC Overflow	Range
<i>Sizer Baseline (V)</i>	Applied PAS (m/s)
<i>Qualifier Baseline (V)</i>	FSSP Bin 1 - 30
<i>Aux Analog 3</i>	UTC Seconds
<i>Aux Analog 4</i>	Date*
<i>Laser Reference (V)</i>	Time*
<i>Aux Analog 1</i>	GPS Time /UTC Seconds **

* These are optional channels that will appear if **Write Date & Time Stamp** is enabled on the **Setup** tab.

** GPS Time appears if one of the instruments in the system has GPS time available. Otherwise, this channel is UTC Seconds.

FSSP Channels fall into several broad categories:

- Time channels
- Bin channels, which store data on the number of particles of different sizes that the FSSP has detected
- Particle statistics (e.g., rejected particles, number concentration, etc.)
- Probe statistics
- Spare or unused channels

Some probe statistics are stored in “housekeeping channels,” a term that refers to data gathered with A/D sensors. The FSSP has 8 A/D housekeeping channels that have a 0-10 V range measured by a 12-bit A/D converter that gives integer values from 0 to 4095. Housekeeping channels are denoted by italics in the list above.

Appendix B: Revisions to Manual

This manual replaces DOC-0199, the *PADS SPP-100 Manual for Use with the FSSP*.