Particle Analysis and Display System (PADS):

Meteorological Particle Spectrometer (MPS) Module Manual

DOC-0291 Rev A

PADS 3.7.0, MPS Module 3.7.0

2545 Central Avenue
Boulder, CO 80301 USA

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

Trademark Information

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 MPS 4

2.1.1 MPS Parameters 5

2.1.2 Channels Table 9

2.2 Configuring the MPS Display 10

3.0 The MPS Window 11

3.1 Sub-Tabs 11

3.1.1 Data 12

3.1.2 LWC / # Conc and LWC / MVD Tabs 12

3.1.3 Selectable Chart Tab 12

3.1.4 Diode Tab 13

3.1.5 Tools Tab 13

3.2 Histogram Data Window 14

4.0 Zooming 15

5.0 Troubleshooting: Computer Display Issues 15

Appendix A: MPS Channels 16

Appendix B: MPS Image Clock Rate 17

Appendix C: Revisions to Manual 18

List of Figures

Figure 1: MPS Configuration Editor Window 5

Figure 2: Example Channel Specifications in the Config Editor Window 9

Figure 3: MPS Display Editor Window 10

Figure 4: MPS Data Window 12

Figure 5: Diode Tab 13

Figure 6: Time-Range Controls 15

List of Tables

Table 1: Minimum MPS Manual Air Speed Values for MPSs of Different Resolutions 18

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 Meteorological Particle Spectrometer (MPS) module version 3.7.0.

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 MPS module are also described in the PADS Overview Manual.

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 affects 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 MPS

Your MPS 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 "MPS" tab.

2. From the **Configure** menu, select **Configure Instrument.** You will see the following window.

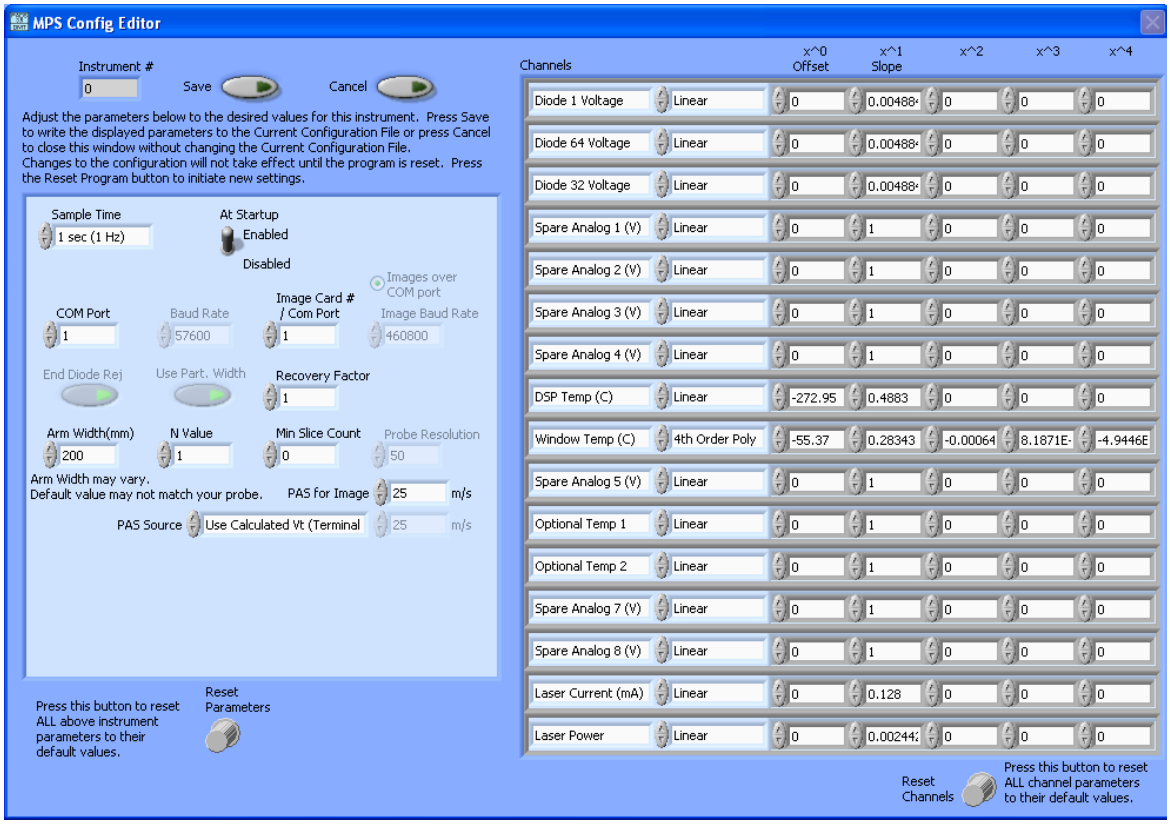

Figure 1: MPS Configuration Editor Window

3. 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 MPS parameters, press **Cancel** to exit the window without saving changes. Pressing **Reset Parameters** reverts parameters to their DMT-supplied default values.

4. When you are done configuring the MPS 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 MPS Parameters

Instrument #: This lists the number corresponding to the instrument you are viewing, in this case the MPS. If your MPS 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 MPS to acquire data when PADS begins sampling, make sure this parameter is in the "Enabled" mode. In some cases, such as if the MPS is inoperative, you may want to use this control to disable the probe. Disabling the MPS 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.

COM Port: This is the serial communications port that the MPS 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.

Image Card # / COM Port: This is the communications port that the MPS uses to relay image data to the computer. The image card serial port differs from a standard serial port and can communicate data at higher speeds. If you have multiple instruments transmitting image data, the Image Card # tells you which port is being used by the current instrument, in this case the MPS. As with the Com Port parameter, you may need to change this if you are

running PADS in data-acquisition mode on different computers. When **Images over COM port** is true, this parameter applies to the COM port. When **Images over COM port** is false, it is used for the image card.

Images over COM port: When selected, this radio button indicates that the system is using an RS-422 serial port with a DB-9 connection rather than a high-speed serial port with a 25-pin connection. This parameter is set at manufacture and should not be changed.

End Diode Reject: Activating this button instructs the MPS to reject any particles for sizing that obscure an end diode. (Particles that obscure both end diodes are always rejected.) Particles that obscure one end diode usually extend outside the probe area, invalidating any size reading. Thus it often makes sense to exclude them from sizing.

If **End Diode Reject** is enabled, images of these particles are still recorded, and you can still do some sizing of these particles in post-processing. However, they won't be included in the on-board histogram analysis. If **End Diode Reject** is disabled, particles that obscure only one end diode will be sized, albeit incorrectly.

Use Part. Width: Activating this button instructs the MPS to use particle width to size particles for creating the 1D histogram. The default setting for this button is enabled, and in fact the MPS cannot use length as a sizing criterion.

Recovery Factor: This parameter is used in calculating ambient temperature from measured temperature. PADS uses Bernoulli's equation for this calculation. For more information on this equation and the recovery factor, see the "Ambient Temperature" entry in Appendix B of the *PADS Overview Manual*. By default, Recovery Factor is set to 1.0.

Arm Width (mm): The distance between the probe's arms along which the laser travels. This value is used in calculating particle concentrations. (See the "Sample Volume" entry in the *PADS Overview Manual's Appendix A: Definitions* for details.) The arm width of your probe should not change. This parameter is only used in sample volume calculations.

N Value: This parameter determines what fraction of particle images get saved. Its default is one, meaning that all images are saved. Increasing the value decreases the number of images by a factor of N. So if N = 3, PADS will only save every third image. Raising the N value helps conserve disk storage space and limits transmission losses. Unless disk space is an issue, it is recommended that all images are saved.

Min Slice Count: This parameter instructs PADS to store images only of particles that have a minimum slice count. In most instruments, setting a minimum slice count allows you to image only particles that meet a minimum size requirement. On the MPS, however, it is difficult to estimate particle size using slice counts, since smaller particles may have a slower speed than the MPS attributes to them (see *Appendix B*). As a result, it is recommended that you set minimum slice count to zero and not use this parameter to try to eliminate smaller particles from imaging.

Probe Resolution: This parameter indicates your probe's resolution in microns (µm). Because this was set at the time of manufacturing, you should not need to modify this parameter. In fact, doing so may compromise your data. This is because PADS uses the Probe Resolution number specified on the MPS Config Editor window to determine particle size and sample volume.

Particle Speed for Image (m/s): The particle speed used to set the image clock rate in Hz. If images are elongated, try a slower speed. If they are shortened, try a faster speed. For more details on image clock rate and acceptable values for this parameter, see Appendix B of this document.

In practice, particles' terminal velocity will differ depending on their size. However, PADS cannot calculate the terminal velocity until after the particle has been sized, which means this velocity is not available while the particle is being imaged. As a result, the program uses a manual value that works well for most droplets.

Particle Speed Source: The source for the droplet speed used in calculating particle concentrations. This control as allows you to select either a manual speed or a calculated terminal velocity based on particle size. If "Use Manual Vt" is selected, a box will appear that allows you to enter the manual speed. This value is only used in setting the concentration calculations. It does not affect the clock rate, which is determined by the **Particle Speed for Image (m/s)** parameter. However, if the Particle Speed Source is set to "Use Manual Vt," typically the manual value entered in this box should match the value given in Particle Speed for Image.

For details on how PADS calculates sample volume and terminal velocity, see Appendix B of the *PADS Overview Manual*.

2.1.2 Channels Table

The channels listed in the Channels table are configurable. These are A/D housekeeping channels that measure a ± 10V range from one of the instrument's internal sensors, for example a pressure or temperature sensor. A conversion equation converts the A/D counts into other, more meaningful units (e.g., mBar or °C). 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 "Custom" allows users to select an equation they have entered on the **Configure** menu.) "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:

$$New\_Channel = 34.01 + 0.061\ x + 0.0092\ x^2$$

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

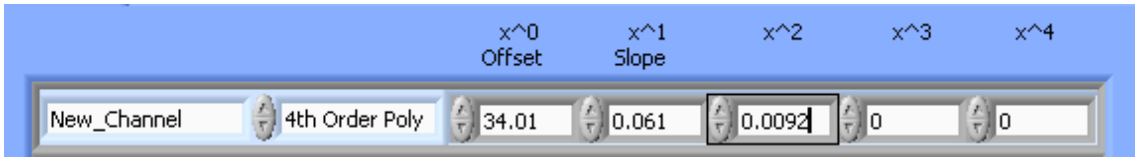

Figure 2: Example Channel Specifications in the Config Editor Window

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 MPS 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.

2.2 Configuring the MPS Display

To configure the MPS display, click on the MPS 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.

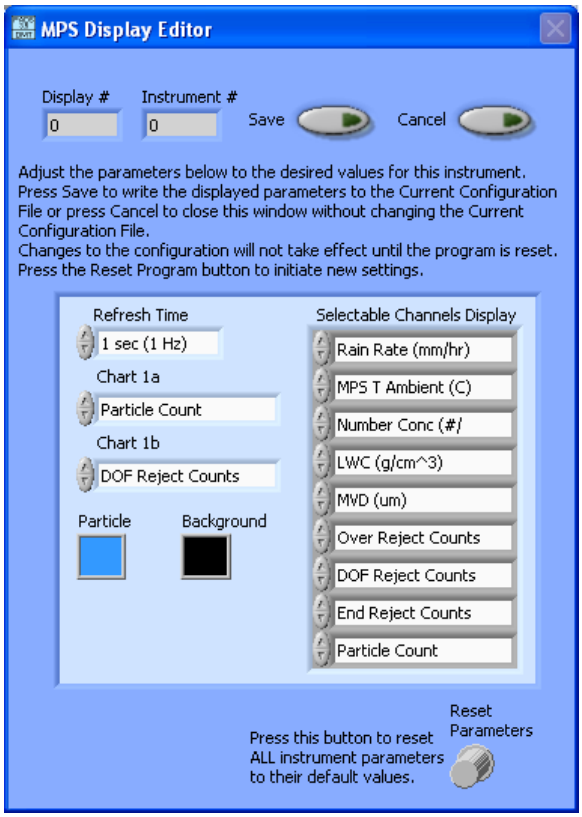

Figure 3: MPS Display Editor Window

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.)

Chart 1a and **Chart 1b** allow you to configure the channels on the MPS's selectable graph. To change these channels, click on the arrow buttons to scroll between available options for the channels. You can also click on the white fields to bring up a list of all the available options, from which you can then choose the channel you want.

The **Particle** and **Background** controls allow you to select colors for the particle image display on the right side of the MPS window.

The **Selectable Channels Display** controls which channels PADS displays in the upper right of the **Data** sub-tab.

When you are done, 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. Note that clicking **Reset Program** will clear out any data currently being displayed.

Configuring channels in the **Display Editor** will change the display upon start-up. Once PADS has started, you can change many of these settings from within the main MPS tab.

3.0 The MPS Window

The following sections describe the different sections of the MPS Window: the channel tabs, the histogram data, and the chart displays.

For explanations of the **Enable** button, **COM Port** indicator, and **Fault/No Fault** button, see the "Instrument Tabs" section of the *PADS Overview Manual*.

The **Rain Rate** displays the rain rate in mm/hr. For information on how PADS calculates the Rain Rate, see *Appendix B* of the *PADS Overview Manual*.

3.1 Sub-Tabs

The MPS channel data section has six sub-tabs, which are described below.

3.1.1 Data

The MPS Data sub-tab (Figure 3) displays commonly used channels.

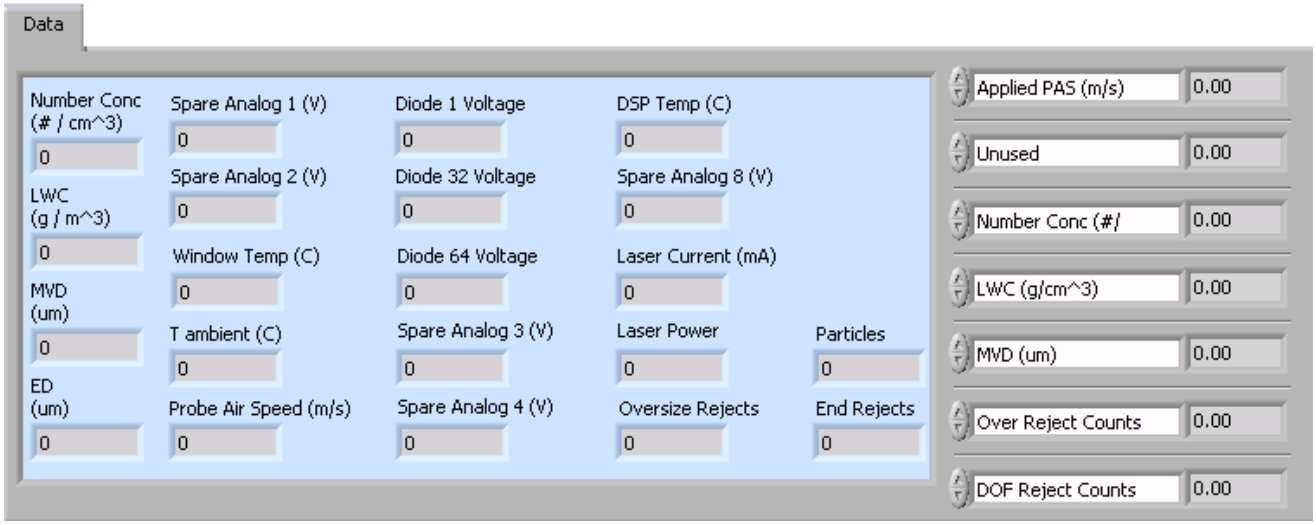

Figure 4: MPS Data Window

For information on specific channels, their definitions, and their acceptable ranges, consult *Appendix A: MPS Channels* and 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 (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 Chart 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 Diode Tab

The Diode tab, shown below, shows a time-series chart of Diode 1, 32, and 64 voltages. This chart can be used to indicate potential problems with failing lasers or blocked diodes. For more information, see the entry for "Diode 1, 32 and 64 Voltages" in Appendix A of the *PADS Overview Manual*.

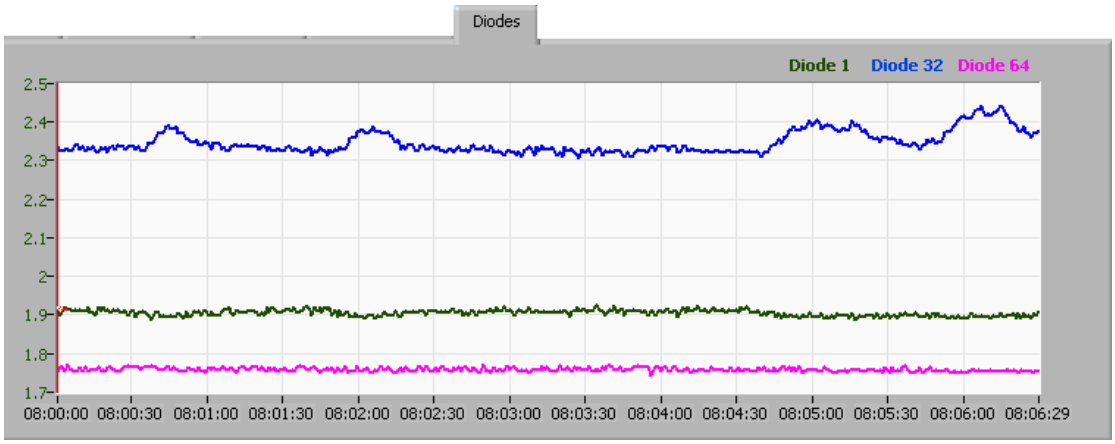

Figure 5: Diode Tab

3.1.5 Tools Tab

On the left side of the **Tools** tab are two controls for setting the source for airspeed-related parameters. **Particle Speed for Image (m/s)** is the speed used to set the image clock rate.[1] **Particle Speed Source** determines the droplet speed source used in calculating concentrations. This control as allows you to select either a manual speed (the value entered in the box to the right) or a calculated terminal velocity based on particle size. Note that a manual value entered under **Particle Speed Source** is used only for concentration calculations. It does not affect the clock rate, which is determined by the **Particle Speed for Image (m/s)** parameter. However, if the Particle Speed Source is set to "Use Manual Vt," typically the manual value entered in this box should match the value given in **Particle Speed for Image (m/s)**.

For details on how PADS calculates sample volume and terminal velocity, see Appendix B of the *PADS Overview Manual*.

[1] If images are elongated, try a slower speed. If they are shortened, try a faster speed. For more details on image clock rate and acceptable values for this parameter, see Appendix B of this document. Note that in practice, particles' terminal velocity will differ depending on their size. However, PADS cannot calculate the terminal velocity until after the particle has been

These two parameters are identical to the controls on the Configuration Editor except that any changes made here affect the current session only. (Changes made in the Configuration Editor affect the settings upon PADS start-up.)

Particle time lists the time of the first slice of particle data. PADS reads this time from the particle image header.

Probe Time lists the probe time as reported by the MPS. PADS reads this time from the regular, 1D data stream.

Playback Mode Features

In playback mode, PADS displays the following additional features on the **Tools** tab:

The **Current Image** box displays the current image, i.e. the one stored in the current particle index and image buffer. (Image files consist of sequential 4096-byte buffers, and each buffer contains data on multiple particles.)

Image Filename lists the name of the file from which PADS is reading image data.

The **Image data found** indicator is lit when the MPS has imaged particles.

Slices/Particle lists the number of data slices per particle image. A slice is the state of the MPS's 64-element linear array at a given moment in time. A slice must be stored each time interval that the particle advances through the beam a distance equal to the resolution of the probe.

Particle Size (µm) lists the approximate diameter of the current particle in microns.

 # images lists the number of particles in the current image data buffer.

3.2 Histogram Data Window

Below the channel tabs is the histogram display of MPS-acquired particle data. The histogram shows the number of particles counted in a given size range. Note that each size shown in the histogram's x-axis actually refers to a size range.

---

sized, which means this velocity is not available while the particle is being imaged. As a result, the program uses a manual value that works well for most droplets.

4.0 Zooming

There are several ways to zoom in or out on MPS 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.

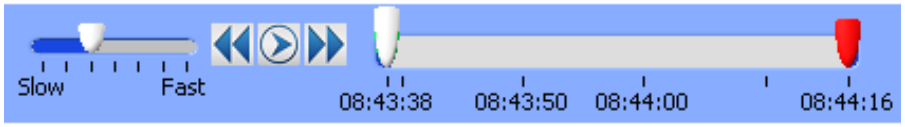

Figure 6: Time-Range Controls

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.

5.0 Troubleshooting: Computer Display Issues

If the computer attached to the MPS is displaying information chaotically, turn off both the instrument and the computer. Then turn the computer back on and allow it to boot before turning the instrument on again. This should resolve the display issues. The computer must always be allowed to boot up before power is applied to the instrument.

Appendix A: MPS Channels

A list of MPS channels appears below. The MPS output file will contain data values for each channel for each sampling instance. For definitions of the channels, consult *Appendix A: Definitions* in the *PADS Overview Manual*.

End Seconds
Day of Year
Year
Status
Over Reject Counts
DOF Reject Counts
End Reject Counts
Particle Count
Probe Hours
Probe Minutes
Probe Seconds
Probe Milliseconds
Host Sync Counter
Reset Flag
Diode 1 Voltage
Diode 64 Voltage
Diode 32 Voltage
Spare Analog 1 -4 (V)
DSP Temp (C)
Window Temp (C)
Spare Analog 5 (V)
Optional Temp 1 and 2
Spare Analog 7 and 8 (V)
Laser Current (mA)
Laser Power
Spare 1 - 8
Unused
Rain Rate (mm/hr)
Number Conc (#/cm^3)
LWC (g/cm^3)
MVD (um)
ED (um)
Applied PAS (m/s)
Bin 1 – 62
UTC Seconds / GPS Time
Date
Time

If there is no instrument in the system that reports **GPS Time**, or if such an instrument exists but the user has selected on the MPS Config Editor to show UTC Seconds, the output channel file will contain **UTC Seconds**. Otherwise, it will report **GPS Time**.

The last two channels, **Date** and **Time**, will be listed after **GPS Time/ UTC Seconds** only if **Write Date & Time Stamp** is enabled on the **Setup** tab.

MPS channels fall into several broad categories:

- Time Channels
- Bin Channels
- Statistical Data—data returned from the probe, e.g. counts of rejected particles
- Calculated Channels—channels calculated by PADS, e.g. Numb Conc
- Spare channels and channels reserved for internal use

- Housekeeping channels: The MPS has 16 A/D housekeeping channels that have a ±10 V range measured by a 12-bit A/D converter that gives integer values from 0 to 4095. The channels displayed in italics in the list above are housekeeping channels.

Appendix B: MPS Image Clock Rate

On aspirated or airborne instruments the particles all move with the same velocity, regardless of size. For such instruments, PADS calculates the sample volume used in particle concentration calculations by multiplying three factors: 1) the probe sample area 2) the air flow velocity, and 3) the sample time. On the MPS, flow equates to the calculated terminal velocity of the particles. Terminal velocity varies with particle size, so sample volume varies as well. For details, see the "Sample Volume" entry in the PADS Overview Manual's *Appendix B: Calculations for Derived Channels*.

While it is straightforward to compute sample volume from calculated terminal velocity, it is impossible to use calculated terminal velocity to set the probe's image clock rate. This is because the calculated terminal velocity cannot be known until after the particle is imaged and sized.

To circumvent this problem, PADS uses a fixed clock rate that optimizes the images of the largest and fastest particles. This results in smaller particles being oversampled, which causes them to appear elongated. However, the fast rate enables the MPS to accurately size all particles. This would not be the case if the clock rate were set to the median terminal velocity for all particles. In this situation, the biggest and fastest particles would travel through the probe so quickly that they might not be imaged at their greatest width, leading them to be undersized.

The artificial elongation of particle images does not present a problem for drizzle and rain drop sizing, since it is the width and not the length of an image that is used to derive the diameter. There will be a larger uncertainty, however, when irregular snowflakes are falling through the instrument.

Adjusting the Image Clock Rate for Probe Resolution

As stated above, PADS uses an MPS clock rate that optimizes the images of the largest and fastest particles. It uses the velocity specified by the **Particle Speed for Image (m/s)** field to determine this clock rate. In contrast, the **Particle Speed Source** parameter only influences the sample volume used in various particle concentration calculations. This control does not affect the clock rate. Both **Particle Speed for Image (m/s)** and **Particle Speed Source** can be set on the **Tools** tab or in the Configuration Editor. Changing these

parameters on the **Tools** tab changes them for the current session only. Setting them on the Configuration Editor changes the values used each time the program is started.

Table 1 shows the values to enter in the **Particle Speed for Image (m/s)** field during live data collection. These are the minimum air speeds required to accurately size all particles. Entering higher numbers will still result in all particles being sized accurately, but smaller particles may appear more elongated.

Probe Resolution (µm)	Particle Speed for Image (m/sec)
25	5.6
50	8.2
75	9.0
100	9.3

Table 1: Minimum MPS Manual Air Speed Values for MPSs of Different Resolutions

Calculating the Values in Table 1

The values in Table 1 were calculated as follows. The diameter, *d*, of the largest particle detectable by an MPS is (62 * *p*), where *p* is the probe resolution (µm). The terminal velocity (vt) in m/sec of this particle is then calculated using the following equation:

$$vt = -0.19305 + 0.0049631\ d - 9.0457*10^{-7}\ d^2 + 5.6597*10^{-11}\ d^3$$

For more details, see "Terminal Velocity" in the *PADS Overview Manual's Appendix B: Calculations for Derived Channels*.

Appendix C: Revisions to Manual

This document replaces DOC-0182, the *PADS MPS Operator Manual* for PADS version 2.X. All sections have been updated.