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# **Particle Analysis and Display System (PADS): Meteorological Particle Spectrometer (MPS) Module**

## **Operator Manual**

**DOC-0183 Rev A-4**

**PADS 2.5.6, MPS Module 2.5.5**



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## 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 module for the Meteorological Particle Spectrometer (MPS).

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

## 2.0 Configuration

Using PADS, you can configure both the software for the instrument and the instrument's data display in PADS. The following two sections explain how to do this.

### 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.

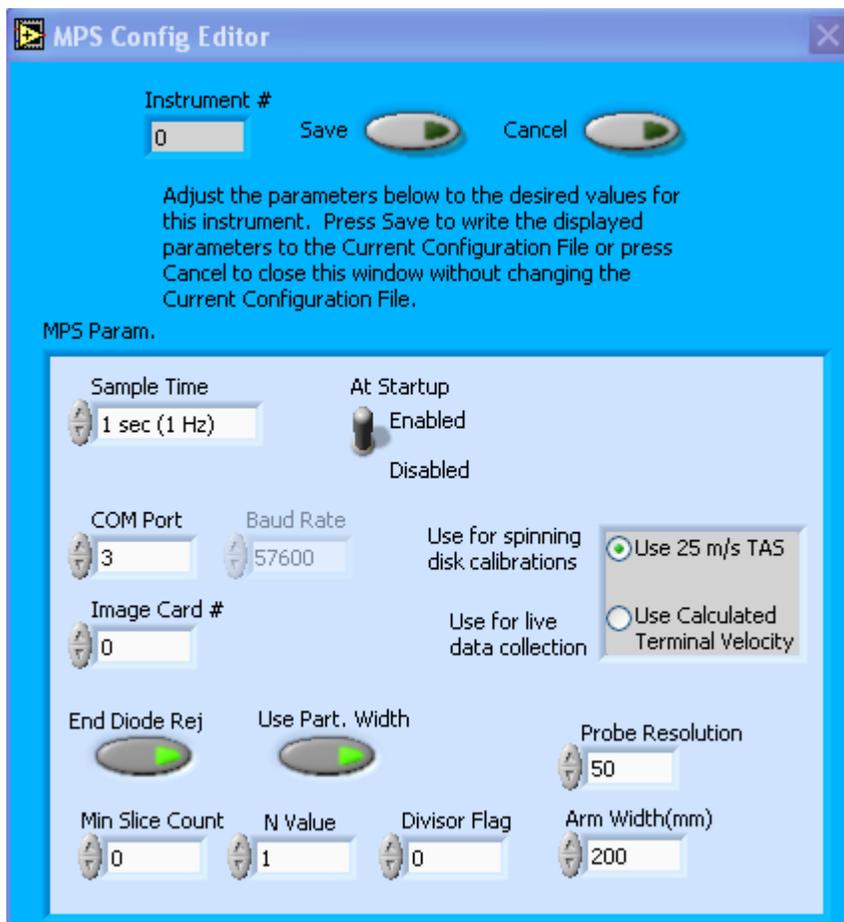


Figure 1: MPS Configuration Editor Window

3. Now you can configure the instrument parameters to your desired specifications. You will find a list of the parameters you may want to reconfigure in the two sections below, “Occasionally Reconfigured MPS Parameters” and “Rarely Reconfigured MPS 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.
4. When you are done configuring the MPS parameters, press **Save** at the top of the Config editor window. (If you would instead like to revert to the previously saved values, click **Cancel**.) 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.

### ***Occasionally Reconfigured MPS Parameters***

**Sample Time:** This parameter shows the time interval you'd like between samples. You can have the probe sample at intervals of .1, .2, .5, 1, 2, 5, or 10 seconds (10, 5, 2, 1, 0.5 or 0.1 Hz). A value of one is recommended, as described in the warning below. 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  $\mu\text{m}$  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  $\mu\text{m}$ .

***WARNING: One hertz sampling is currently recommended, as choosing other values will invalidate time-dependent PADS calculations like number concentration, volume concentration, and LWC on optical probes. (ED and MVD are not affected.) This is a known bug in PADS that will be fixed in an upcoming version of the program.***

**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.

**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.

**Image Card #:** 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.

**Droplet Speed Radio Button:** This control allows you to select from two possible droplet speeds to be used in concentration calculations, 25 meters/second or calculated

terminal velocity. 25 meters/second is appropriate for spinning disk calibrations. For data acquisition, use the calculated terminal velocity.

The Droplet Speed Radio button does not control the droplet speed used to determine the MPS image clock rate. Rather, the TAS Source controls on the PADS Setup tab determine the droplet speed that in turn sets the image clock rate. For details, see *Appendix B: MPS Image Clock Rate*.

**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.

**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.

**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.

You will notice that there are other parameters listed on the **MPS Config Editor** window. Most of these you should not need to change, and changing them inadvertently may compromise your data. If you are curious about these parameters or think you do need to modify them, see the section titled “Rarely Reconfigured MPS Parameters” below or consult with a DMT technical representative.

### ***Rarely Reconfigured MPS Parameters***

The MPS configuration editor displays several parameters that you will rarely need to modify. The following is a list of these parameters and an explanation of what they do.

**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.

**Baud Rate:** The Baud rate for the probe is defined at manufacture, and you should not need to change it. PADS lists this parameter because some probes can run at different baud rates. So if you reconfigure your hardware, the baud rate may change. In general, a higher baud rate means that the probe can transmit data more quickly to the computer. However, higher baud rates may not work with some computers and can result in unreliable data transmission.

**Probe Resolution:** This parameter indicates your probe's resolution in microns ( $\mu\text{m}$ ). 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.

**Divisor Flag:** This parameter is obsolete.

**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 Operator 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.

After making changes in the instrument configuration window, 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.

## Configuring the MPS Display

To configure the MPS display, go to the **Configure** menu from the MPS tab and select **Configure Display**. This will bring up the following window.

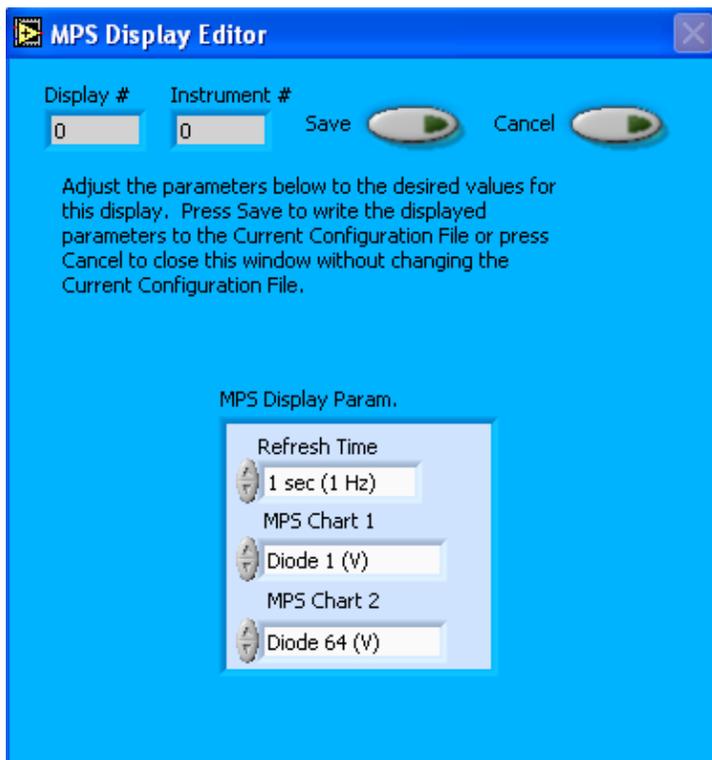


Figure 2: MPS Display Editor Window

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.)

The MPS Display Parameter box at the bottom of the window also allows you to configure the channels on the MPS's selectable graphs. 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.

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 select any channels to be displayed in the selectable charts. See the “Chart Displays” section for more information.

## 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 Operator Manual*.

### Channel Tabs

The MPS channel data section has two tabs at the top, MPS Data and MPS Diagnostics. Figure 3 shows the MPS Data window.

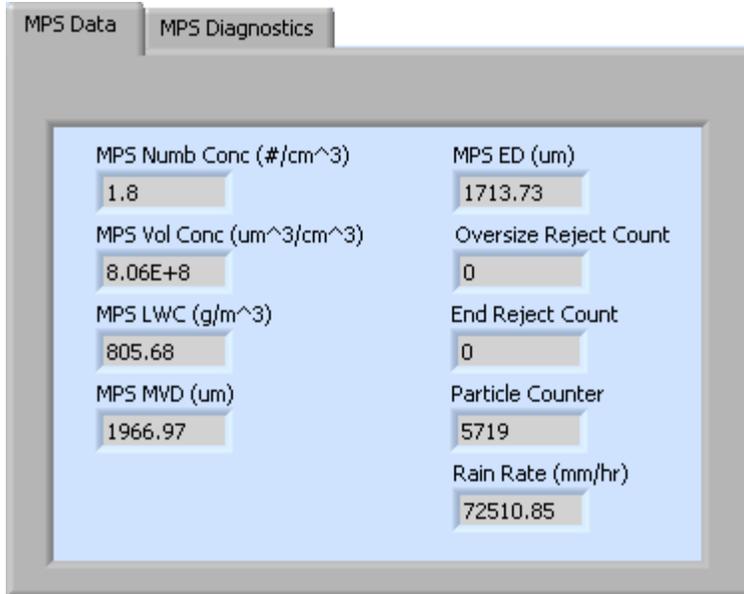


Figure 3: MPS Data Window

The MPS Data tab displays commonly used channels. The MPS Diagnostics tab shows channels that indicate whether the instrument is functioning properly.

For information on specific channels, their definitions, and their acceptable ranges, consult *Appendix A: MPS Channels* and the PADS Operator Manual's *Appendix A: Definitions*.

## Histogram Data Window

Below the channel tabs is the histogram display of MPS-acquired particle data, as shown in Figure 4. Like the channel data display, the histogram shows time-specific data.

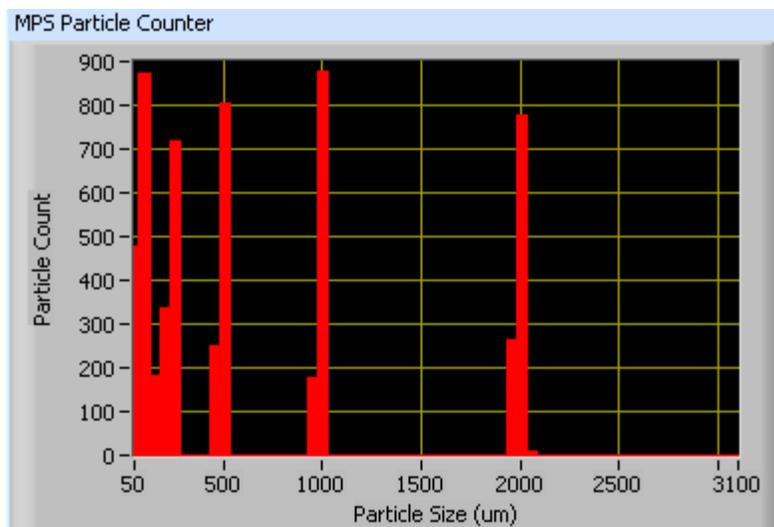


Figure 4: MPS Histogram Window

The histogram shows the number of particles counted in a given size range. In the example above, MPS has detected slightly more than 800 particles of approximate size 500  $\mu\text{m}$  at the time shown. Note that each size shown in the histogram's x-axis actually refers to a size range.

You can zoom in or out by typing new values on the ends of the histogram axes. For instance, if you only want to view particles that are 50-425  $\mu\text{m}$ , you would type "425" into the label that currently displays 3100. You can also access graphing options by right-clicking on the histogram window; see the "Chart Displays" section for details.

To view a larger and more detailed histogram, click on the **Full Hist.** tab in the Chart displays described below.

## Chart Displays

PADS organizes the MPS chart displays using four tabs. You can access the charts by selecting these tabs, which are shown in Figure 5.

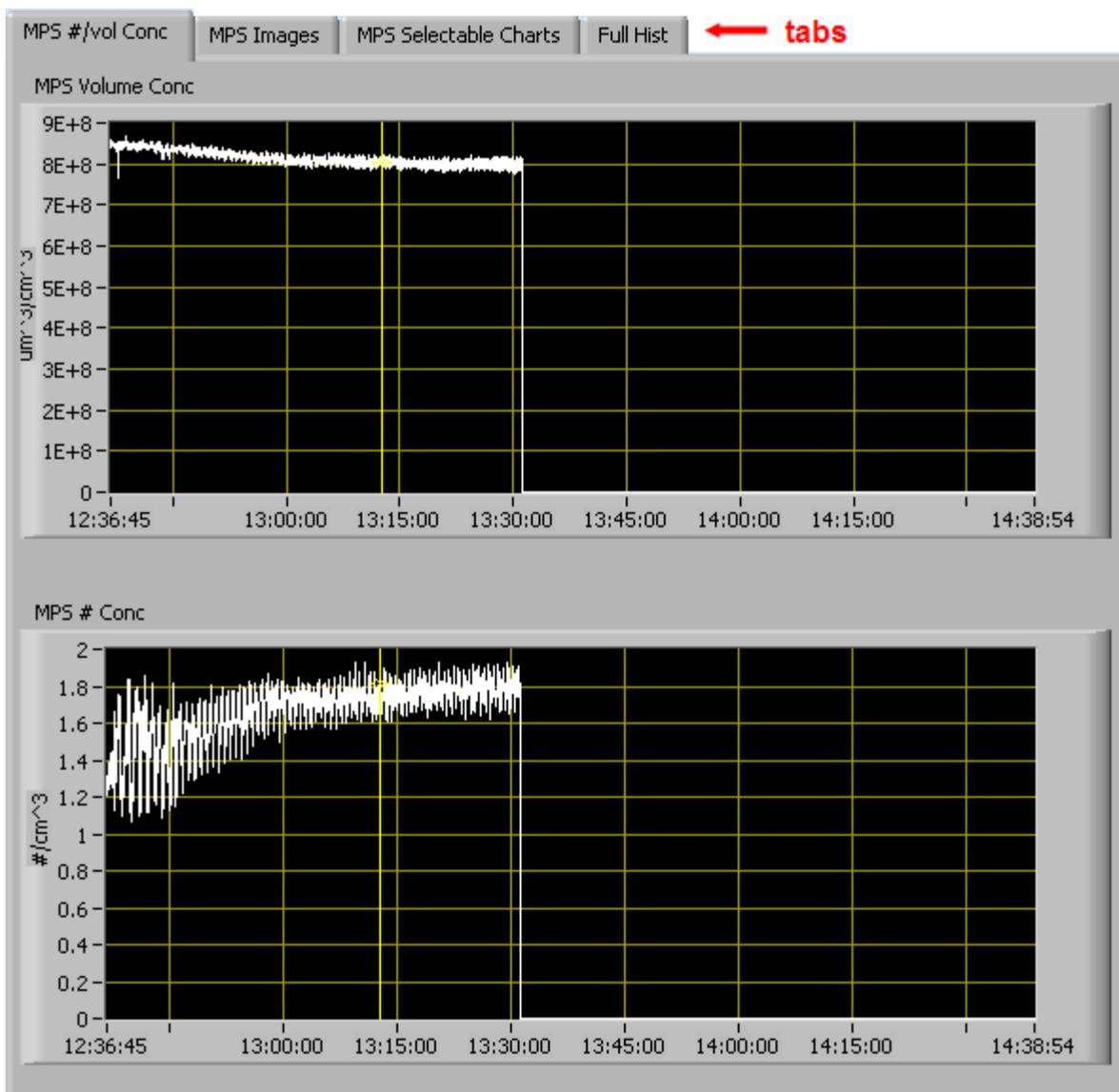


Figure 5: MPS Chart Tabs

When you access time-series charts in playback mode, the currently selected moment in time is indicated by a yellow cursor, as shown above. The y-axis value for this time is indicated by cross (+) on this cursor. Note that when you display a large range of time-series data, the chart display does not have sufficient resolution to display each individual time point. To increase resolution, zoom in on the data by changing the time interval to a smaller range.

On all the charts with x and y axes, you can change the scale by typing a different number into the starting and ending values on each axis. For instance, if you want to change the time period in one of the graphs above to end at 13:00:00, you simply select the field that currently says 14:38:54, type in 13:00:00, and hit the <Enter> key. In

acquisition mode, you must disable autoscaling (see below) before you modify fields in this way.

Many charts also show you options for scaling and copying the data when you right-click on them. These options are as follows:

**Autoscale** This autoscales the relevant axis. In autoscaling mode, the minimum and maximum values of the axis are set automatically so that all data points can be seen in the display. Note that on charts that have autoscale buttons, like the large histogram chart on some instrument tabs, the buttons override the Autoscale options in the drop-down menu. To see autoscaling options in the drop-down menu, position the cursor over the relevant axis before right-clicking. Note that you may not always be able to autoscale the x-axis.

**Copy Data** This copies the chart to the clipboard using a screen capture. This chart can then be pasted into other documents like Word or PowerPoint presentations.

**Export Simplified Image** This copies a simplified image of the data to the clipboard or an output file. You can choose the format you desire—bitmap (.bmp), encapsulated postscript (.eps), or enhanced metafile (.emf). Note that when you select the .eps option, you must copy the data to a file. Unless you specify otherwise, output files will be saved in the time-and-date-specific output file directory for the current session.

**Clear Graph** This erases the currently displayed data points from the graph.

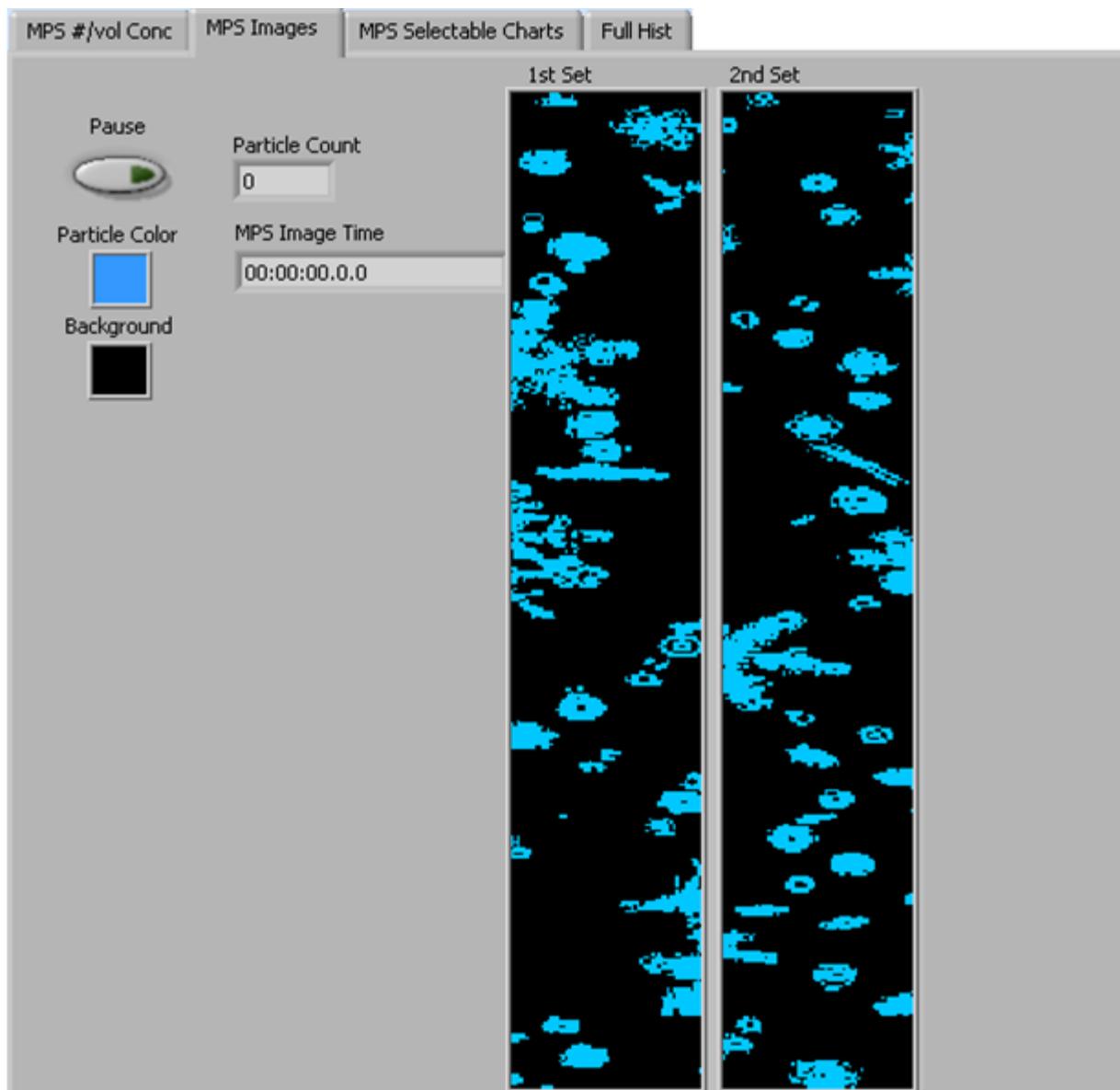
More information about each of the tabs on the chart displays section is given below.

### **1. MPS #/Vol Conc**

The two graphs on the first tab, **MPS # / Vol Conc**, plot volume concentration ( $\mu\text{m}^3/\text{cm}^3$ ) and particle concentration ( $\#/\text{cm}^3$ ) as a function of time. In playback mode, you can zoom in or out by using the time controls.

### **2. MPS Realtime Images**

The **MPS Images** tab shows two-dimensional images of particles, as shown in Figure 6. Images are only available during acquisition mode. The Images tab is inactive in playback mode. For viewing particles in playback mode, use the PADS Integrated Image Playback System.



*Note: Images generated by the MPS may differ significantly from the ones shown above.*

Images are shown for the current point in time unless you press pause, at which point the images freeze. The **Particle Count** reflects the cumulative number of particles PADS has counted in the current session. This number may be larger than the number of particles that have been imaged, depending on your *N* parameter. Particle count rolls over to zero when it hits 65,000. **MPS Image Time** indicates the time at which the particles were imaged.

Note that smaller particles imaged by the MPS may appear elongated. This is because of issues with the clock rate. See *Appendix B: MPS Image Clock Rate* for details.

### 3. MPS Selectable Charts

The **MPS Selectable Charts** tab displays two charts with user-specified channels plotted as a function of time. To change the channels plotted in the selectable charts, you have two options:

- 1.) To change the charts for the current session only, click on the **MPS Selectable Charts** tab and use the control in the upper left of the chart to select the channel you desire. You can either click on the text control to the right, which brings up a selectable list of channels, or you can use the button on the left to scroll between channels.
- 2.) To change the channels shown in the chart's display when PADS starts, go to the **Configure** menu, select **Configure Display**, and choose the desired channel. Then press the **Reset Changes** button to apply this configuration.

### 4. Full Histogram

The **Full Hist** tab shows a larger version of the histogram in the bottom left of the MPS screen. This histogram also allows you to manipulate the display using the controls and features described below.

#### Autoscale Buttons

The Autoscale controls, Autoscale X and Autoscale Y, let you control how the x and y scales are set. If you enable autoscaling, PADS will automatically select an appropriate scale with which to display the current data. For instance, if the probe is not currently detecting many particles, the y-axis range will decrease. On the other hand, if you disable autoscaling, the scale of the axes will remain constant. In this case, the range will always be the same as it was when autoscaling was disabled. The minimum and maximum Y values can then be changed manually by typing new numbers into these fields. *In playback mode, autoscaling will not take effect until you change the time using the time controls.*

Note that the Autoscale Y button overrides the Autoscale Y option in the drop-down menu that appears when you right-click on the chart.

#### Log-Scale Button

When you turn on the Log-Scale button, PADS scales the y-axis logarithmically rather than linearly. Autoscaling can be enabled or disabled with this option.

## The Graph Tools Buttons

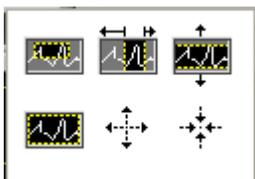
The graph tools buttons look like this:



The left button currently does not have functionality.

The right button allows you to move the histogram display around in the window.

Clicking on the middle button brings up the zoom window, which looks like this:



Before using the zoom controls, turn off autoscaling so your scaling changes stay in effect when new data are displayed.

Selecting the icon on the upper left  allows you to select data on the histogram screen and magnify it. This changes both the x and y axes.

Selecting the button on the upper middle  allows you to select a horizontal range of data you'd like magnified. This will change the x axis but not the y axis.

Selecting the button on the upper right  allows you to select a vertical range of data you'd like to see magnified. This will change the y axis but not the x axis.

Selecting the button on the bottom left  sets the axis to the same limit autoscaling would use. Autoscaling is not enabled, however, so when the data change, the axis limit stays constant.

Selecting the button on the bottom middle  allows you to zoom in on a target.

Selecting the button on the bottom right  allows you to zoom out on a target.

## **4.0 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 Operator Manual*. For channels that start with “MPS,” look under the general term in the *Operator Manual* (e.g., “ED” for “MPS\_ED”).

Time	Bin_34	Spare Analog 2 (V)
Over Rej Count	Bin_35	Spare Analog 3 (V)
Bin_1	Bin_36	Spare Analog 4 (V)
Bin_2	Bin_37	DSP Board Temp (C)
Bin_3	Bin_38	Control Board Temp (C)
Bin_4	Bin_39	Spare Analog 5 (V)
Bin_5	Bin_40	Window Temp (V)
Bin_6	Bin_41	Spare Analog 6 (V)
Bin_7	Bin_42	Spare Analog 7 (V)
Bin_8	Bin_43	Spare Analog 8 (V)
Bin_9	Bin_44	Laser Current (mA)
Bin_10	Bin_45	Laser Power (V)
Bin_11	Bin_46	Particle Counter
Bin_12	Bin_47	Seconds
Bin_13	Bin_48	Milliseconds
Bin_14	Bin_49	Hours
Bin_15	Bin_50	Minutes
Bin_16	Bin_51	Host Sync Counter
Bin_17	Bin_52	Reset Flag
Bin_18	Bin_53	True Air Speed (m/s)
Bin_19	Bin_54	MPS Numb Conc (ct/cc)
Bin_20	Bin_55	MPS Vol ( $\mu\text{m}^3/\text{cm}^3$ )
Bin_21	Bin_56	MPS LWC ( $\text{g}/\text{m}^3$ )
Bin_22	Bin_57	MPS MVD ( $\mu\text{m}$ )
Bin_23	Bin_58	MPS ED ( $\mu\text{m}$ )
Bin_24	Bin_59	Rain Rate (mm/hr)
Bin_25	Bin_60	Optional (X Position)
Bin_26	Bin_61	Optional (Y Position)
Bin_27	Bin_62	Optional (Pressure 1)
Bin_28	DOF Rej Counts	Optional (Pressure 2)
Bin_29	End Rej Counts	Optional (Pressure 3)
Bin_30	Diode 1 (V)	Optional (Temperature)
Bin_31	Diode 64 (V)	Optional (Flow)
Bin_32	Diode 32 (V)	Optional (Density)
Bin_33	Spare Analog 1 (V)	Status

MPS channels fall into several broad categories:

*Time Channels:* Time, Hours, Minutes, Seconds, Milliseconds, and GPS Time store time data. Time is generated by the PADS computer clock and is the time when the program receives the MPS data. It is given in seconds after midnight on the day the program was started. Hours, Minutes, Seconds, and Milliseconds are times that the MPS clock generates when the probe collects data. (PADS sets the MPS clock, so although times are not perfectly synchronized, they are very close.) GPS Time is included in every instrument’s list of channels whenever a GPS is included as one of the PADS instruments. GPS Time may be collected from an instrument other than the MPS, even though it appears as a channel in the MPS output file.

*Bin Channels:* Channels labeled Bin\_[i] store data on the number of particles of different sizes that the MPS has detected. These data are used in the histogram display.

*Channels for Other Statistical Data:* Over Rej Count, DOF Rej Counts, End Rej Counts, and Particle Counter store particle statistics collected by the MPS. Status stores statistical data the MPS has gathered on the communication between PADS and the probe.

*Housekeeping Channels:* The MPS has 16 A/D housekeeping channels that have a  $\pm 10$  V range measured by a 12-bit A/D converter that gives integer values from 0 to 4095. Several of the housekeeping channels store data that indicate whether the probe is functioning properly. A list of these housekeeping channels is given below.

<i>Diode 1 (V)</i>	<i>Spare Analog 2 (V)</i>	<i>Control Board Temp (C)</i>	<i>Spare Analog 7 (V)</i>
<i>Diode 64 (V)</i>	<i>Spare Analog 3 (V)</i>	<i>Spare Analog 5 (V)</i>	<i>Spare Analog 8 (V)</i>
<i>Diode 32 (V)</i>	<i>Spare Analog 4 (V)</i>	<i>Window Temp (V)</i>	<i>Laser Current (mA)</i>
<i>Spare Analog 1 (V)</i>	<i>DSP Board Temp (C)</i>	<i>Spare Analog 6 (V)</i>	<i>Laser Power (V)</i>

*Calculated Channels:* MPS Numb Conc, MPS Vol, MPS\_LWC, MPS\_MVD, and MPS\_ED store the results of calculations PADS has performed on MPS particle data. True Air Speed stores the true air speed collected by the master TAS source designated on the PADS Setup screen.

*Channels Reserved for Internal Use:* The channels marked “Optional” are reserved.

## 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 that varies with particle size. Terminal velocity varies with particle size, so sample volume varies as well. For details, see the “Sample Volume” entry in the PADS Operator 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 on the PADS Setup window’s **Manual Air Speed (m/s)** field to determine this clock rate. In contrast, the **droplet speed radio button** on the MPS instrument configuration editor window only influences the sample volume used in various particle concentration calculations. This control does not affect the clock rate.

Table 1 shows the True Air Speed values to enter in the Setup screen’s **Manual Air Speed (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)	Manual Air Speed (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 ( $v_t$ ) in m/sec of this particle is then calculated using the following equation:

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

For more details, see “Terminal Velocity” in the *PADS Operator Manual’s Appendix B: Calculations for Derived Channels*.

## Appendix C: Revisions to Manual

Rev. Date	Rev. No.	Summary	Section
1-19-10	A-4	Added information on troubleshooting problems with the computer display	4.0