Particle Analysis and Display System (PADS):

Cloud Imaging Probe (CIP) Module Manual

DOC-0280, Revision A-1

PADS 3.5,

CIP Module 3.5.0

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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.

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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 Cloud Imaging Probe (CIP) 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 CIP *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 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 CIP

Your CIP 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 "CIP" tab.

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

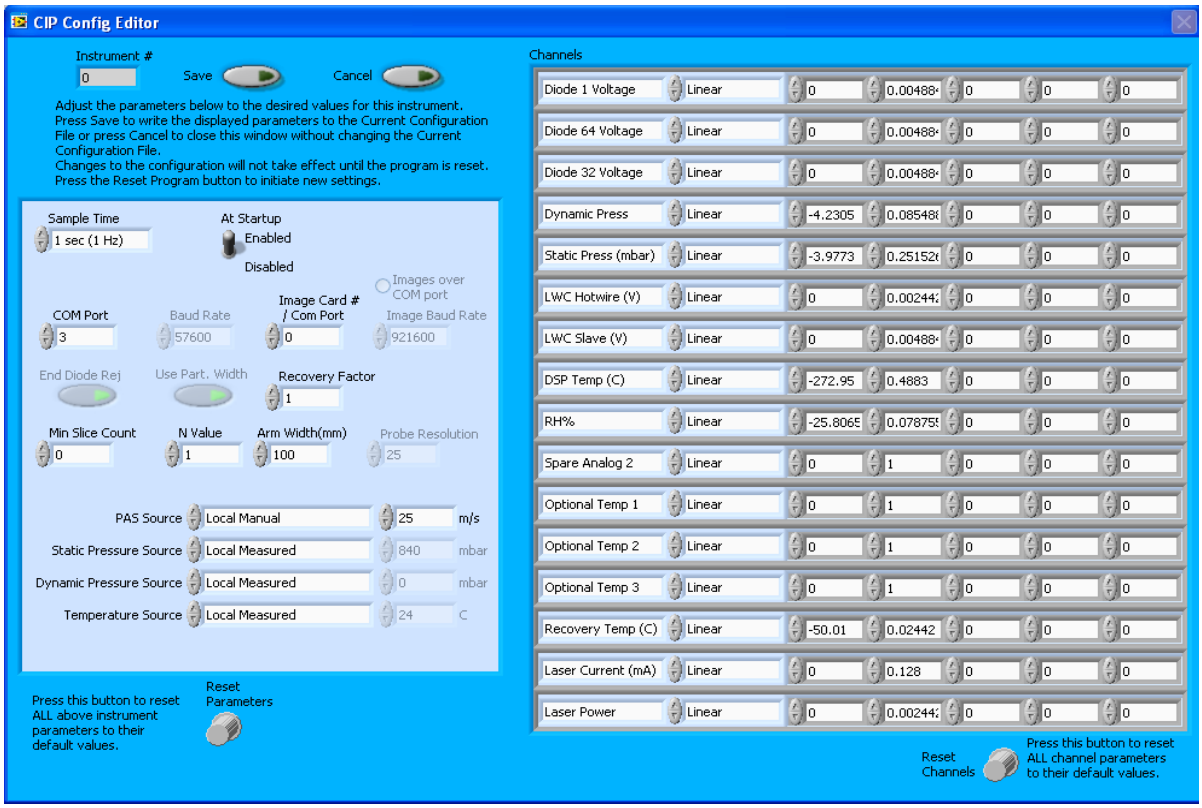

Figure 1: CIP Configuration Editor Window

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 CIP 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 CIP 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 CIP Parameters

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 CIP to acquire data when PADS begins sampling, make sure this parameter is in the "Enabled" mode. In some cases, such as if the CIP is inoperative, you may want to use this control to disable the probe. Disabling the CIP 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 CIP 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, 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.

Image Card # / COM Port: This is the communications port that the CIP 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 CIP. 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 is 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.

Image Baud Rate: This parameter stores the Baud rate for the image data when Images over COM port is true. You should not need to change this rate, and the control has been grayed out.

End Diode Reject: Activating this button instructs the CIP 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.

Note that if you want to measure very large particles, you may want to disable both **End Diode Reject** and **Use Part. Width.** See explanation below.

Use Part. Width: Activating this button instructs the CIP to use particle width to size particles for creating the 1D histogram. Particle width is the dimension parallel to the diode array. The other sizing option is to use particle length, which is the dimension perpendicular to the diode array. The default setting for this button is "On," since particle width is generally preferred to particle length as a sizing criterion. This is because length measurements depend on particle velocity and may be distorted if the air speed clock is set incorrectly. However, particles that are wider than the diode array may not be measurable unless the CIP measures their length rather than their width. These particles would block one end of the diode array, making it impossible to estimate their width. However, if you turn off **End Diode Reject** (which means the particle will get sized) and disable **Use Part. Width**, the CIP will record information about the particle's length and the width that was captured by the diode array. You can then use this information in post-processing to estimate the particle's size.

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.

Min Slice Count: By setting the minimum slice count parameter, you can instruct PADS to store images only of larger particles. The probe will not retain any images of particles smaller than the minimum slice count. Each slice has a width of the probe resolution, so a minimum slice count of four on a CIP with 25 µm-resolution means that particles smaller than 100 µm will not be saved as images. Setting the value to zero means that all images will be recorded. Raising the minimum slice count helps conserve storage space on the computer disk and in very high concentrations will also prevent losing information due to limitations related to transmission bandwidth. Note that particles that are not saved as images will still be sized and used to create the 1D size distributions that are transmitted at a constant rate to the computer from the probe. It is recommended that this parameter be set to zero in most cases unless you are operating the system in an environment where concentrations are extremely high, such as in sprays, where the number concentration can exceed several thousand per liter.

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.

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 unless your hardware has been changed (e.g., you have received a Korolev tips upgrade). In this case, you will need to insert the correct new arm width. Korolev tip arm widths are 40 mm or 70 mm; the width is printed on the side of the tip. This parameter is only used in sample volume calculations.

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 CIP Config Editor window to determine particle size and sample volume.

The **Source controls** at the bottom of the parameters box allow you to set the source for airspeed-related parameters that can be measured by instruments or entered manually. For instance, 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.

Similarly, you can instruct the system to use different sources for the static pressure, dynamic pressure, and temperature variables used in calculating air speed. (If the PAS source is a manually entered value, PADS will still calculate air speed and store the result in the CIP PAS (m/s) channel.) For pressure and temperature sources, "Local Measured" uses the instrument's measurement, while "Local Manual" uses manually entered values—initially the ones to the right of the source controls, which can be changed from the instrument display when the program is running.

Pressing the **Reset Parameters** button resets all parameters in the left half of the window to their default values. 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.

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:

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

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

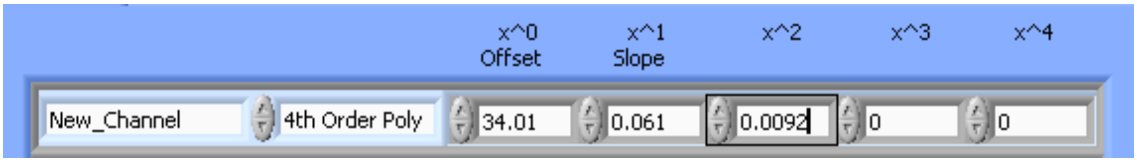

Figure 2: Example Channel Specifications in the Config Editor Window

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 CIP 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 CIP Display

To configure the CIP display, click on the CIP 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.

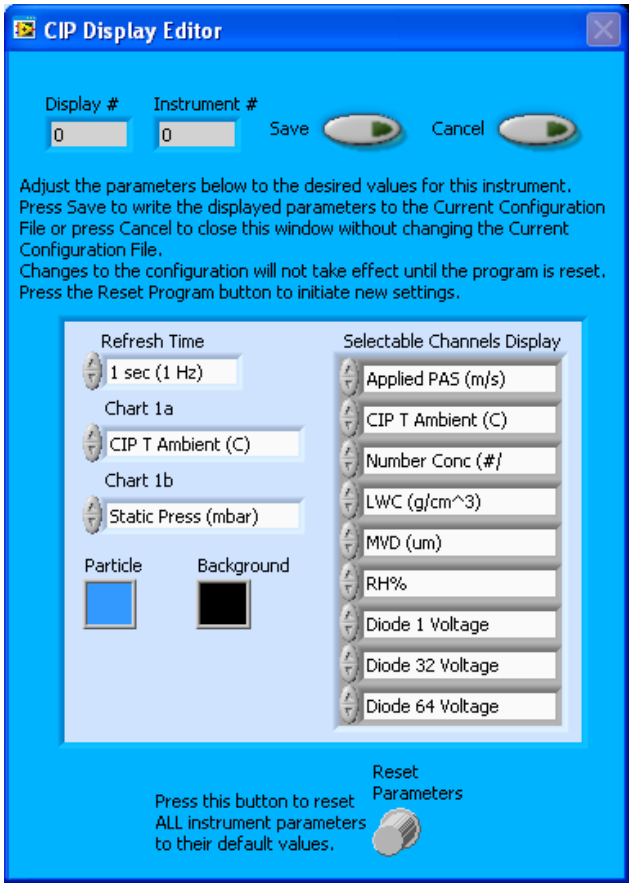

Figure 3: CIP Display Editor Window

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 **Chart 1a** and **1b** controls allow you to configure the channels on the CIP's selectable graphs (on the **Selectable Chart** tab). To change these settings, 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** color boxes control the colors for the particle images displayed to the right of the CIP tabs. Clicking on a box brings up a palette that allows you to select new colors.

The **Selectable Channels Display** control allows you to select CIP channels whose current-time values will appear on the **Data** tab.

Reset Parameters restores all the fields to their DMT-supplied default values.

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 CIP Window

The different parts of the CIP Window are discussed below. For explanations of the **Enabled** button, **COM Port** indicator, and **Fault/No Fault** button, see the "Instrument Tabs" section of the *PADS Overview Manual*.

3.1 Tabs

There are five CIP tabs: Data, LWC / # Conc, LWC / MVD, Selectable Chart, and Tools. The CIP Data window is shown below.

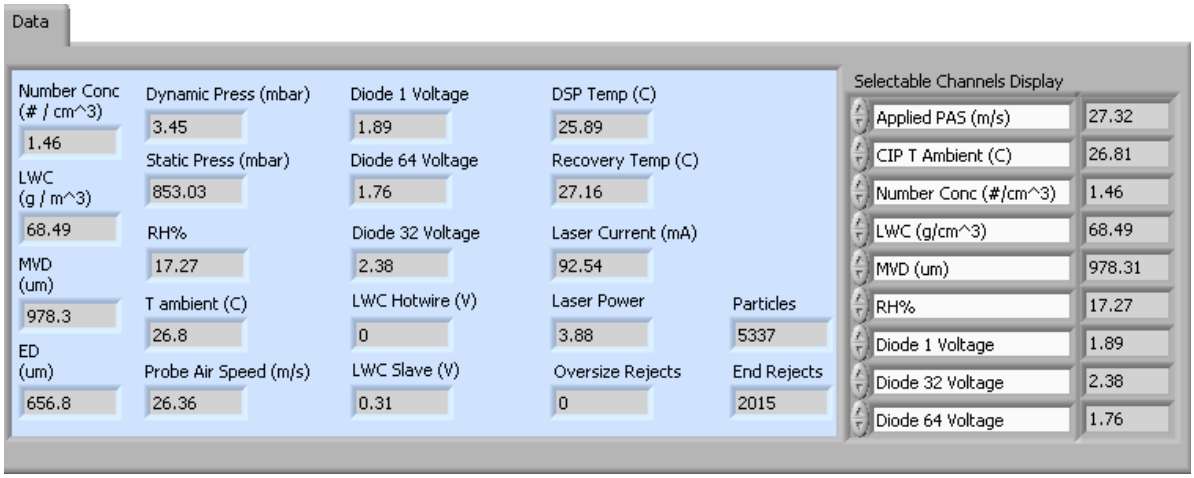

Figure 4: CIP Data Window

3.1.1 Data Tab

The **Data** tab displays many of the CIP output channels. For a complete list of channels, consult *Appendix A: CIP 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 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*.

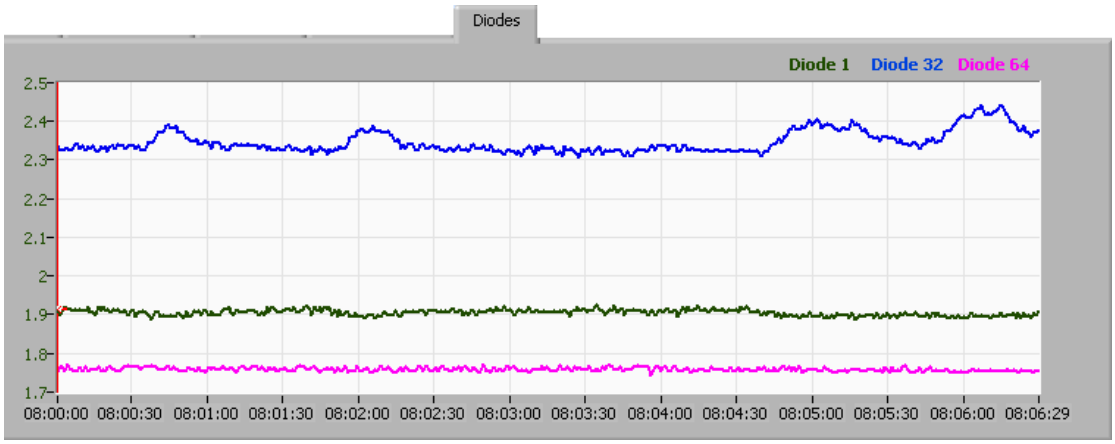

Figure 5: Diode Tab

3.1.5 Tools Tab

The **Tools** tab has several functions. On the left side are controls for setting the source for airspeed-related parameters. These 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.)

The right side of the **Tools** tab displays data related to particle images. These fields are only visible in playback mode. The **Pause Display** button allows you to pause the image display to examine an image of interest in more detail. The histogram display will continue to update during this time. To resume the image display, click on the Pause Display button again.

Particle time lists the time of the first slice of particle data. PADS reads this time from the particle image header. (For more details about the particle image header, see "Host Computer - CIP Communications for 2D Image Data" in DOC-0201, the *Image Probe Data Reference Manual*.

CIP Probe Time lists the probe time as reported by the CIP. 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 CIP has imaged particles.

Slices/Particle lists the number of data slices per particle image. A slice is the state of the CIP'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 CIP-acquired particle data, as shown below. Like the channel data display, the histogram shows time-specific data.

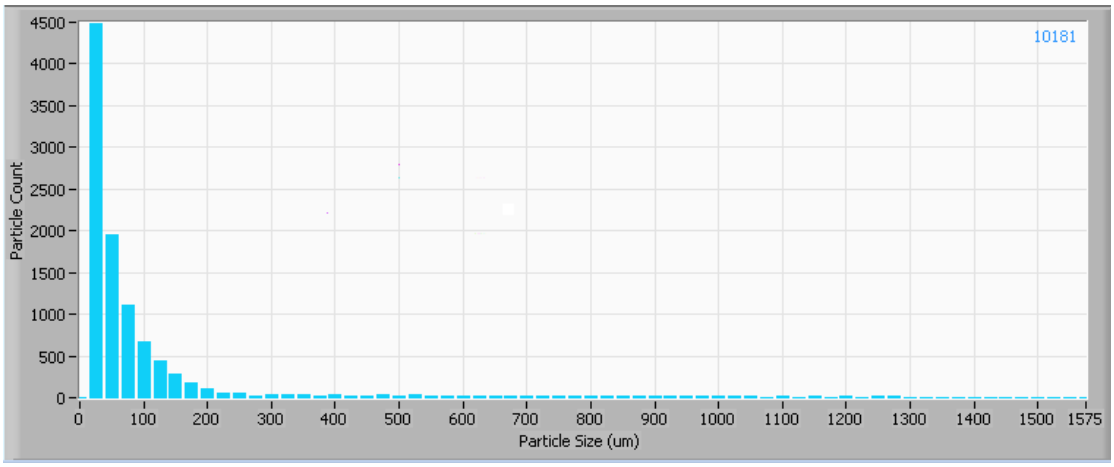

Figure 6: CIP Histogram Window

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. For instance, for a 25 µm-resolution instrument, the particles listed of size 200 µm refer to those sized 188.5 – 212.5 µm. Particles trigger the diodes when they cover more than 50% of the diode—in this case, if particles are wider than 12.5 µm. So particle size is measured ±12.5 µm. For more information on particle sizing with the CIP, refer to the *DMT Data Analysis User's Guide*.

The number in the upper right of the histogram shows the total particle count across the entire histogram (10181 in Figure 6).

3.2.1.1 Changing Scaling

The AutoScale and Logscale buttons are located to the lower right of the histogram.

Autoscale Buttons

The Y-axis and X-axis autoscale controls 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.

Log-Scale Buttons

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.

3.3 Image Data Display

CIP images are displayed on the far right of the CIP window. The **Tools** sub-tab displays additional information about images.

PADS displays image data in two columns, with the second column being a continuation of the first. You can change the colors of particles and the background by selecting **Configure > Configure Display.**

The two scrollbars to the left of the image data allow you to move around in the image data. The top scrollbar selects which image in the current image buffer to display on top. The bottom scrollbar selects which buffer of data is currently active.

Images are shown for the current point in time unless you press **Pause Display**, at which point the images freeze.

4.0 Zooming In and Out

There are several ways to zoom in or out on CIP charts and the histogram. As described in the *PADS Overview Manual*, you can use the time-range controls (Figure 7) 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.

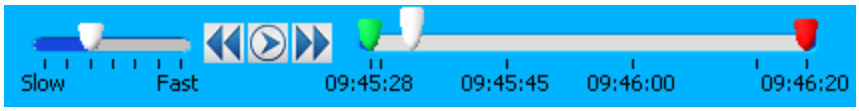

Figure 7: Time-Range Controls

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: CIP Channels

A complete list of CIP default data channels appears below. (Since it is possible to rename channels in the Configuration Editor, your list may look different.) The CIP output file will contain data values for each channel for each sampling instance. You can also plot each of these channels as a function of time using the CIP Selectable Charts tab. For definitions of the channels, see *Appendix A* in the *PADS Overview Manual*

End Seconds	LWC Hotwire (V)
Day of Year	LWC Slave (V)
Year	DSP Temp (C)
Status	RH%
Over Reject Counts	Spare Analog 2
DOF Reject Counts	Optional Temp 1 - 3
End Reject Counts	Recovery Temp (C)
Particle Count	Laser Current (mA)
Probe Hours	Laser Power
Probe Minutes	Spare 1 – 8
Probe Seconds	CIP T Ambient (C)*
Probe Milliseconds	CIP PAS (m/s)*
Host Sync Counter	Number Conc (#/cm^3)
Reset Flag	LWC (g/cm^3)
Diode 1 Voltage	MVD (um)
Diode 64 Voltage	ED (um)
Diode 32 Voltage	Applied PAS (m/s)
Dynamic Press (mbar)	Bin 1-62
Static Press (mbar)	GPS Time / UTC Seconds

Two additional channels, **Date** and **Time**, may be listed before **GPS Time/ UTC Seconds** if **Write Date & Time Stamp** is enabled on the **Setup** tab. GPS Time is reported if there is an instrument on the system that reports GPS Time; otherwise, this channel is UTC Seconds.

* For **CIP T Ambient (C)** and **CIP PAS (m/s)**, see the definitions for **T Ambient (C)** and **PAS (m/s)**.

CIP Channels fall into several broad categories:

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

- Channels reserved for internal use (e.g., Host Sync Counter and Reset Flag)

Many of the probe statistics are stored in "housekeeping channels," a term that refers to data gathered with A/D sensors. The CIP has 16 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. Several of these channels indicate whether the probe is functioning properly. A complete list of housekeeping channels is given below.

Diode 1 Voltage	*Static Press*	*RH%*	*Optional Temp 3*
Diode 64 Voltage	*LWC Hotwire (V)*	*Spare Analog 2*	*Recovery Temp*
Diode 32 Voltage	*LWC Slave (V)*	*Optional Temp 1*	*Laser Current (mA)*
Dynamic Press	*DSP Temp*	*Optional Temp 2*	*Laser Power*

Appendix B: Revisions to Manual

Rev. Date	Rev. No.	Summary	Section
6/6/2011	A-1	Updated reference document for host-computer/CIP communications	3.1.5
		Removed **Write OSDS?** parameter definition	2.1.1

This manual replaces DOC-0180, the *CIP PADS Operator Manual* for PADS version 2.X. All sections have been updated.