
Particle Analysis and Display System (PADS): Cloud Droplet Probe (CDP) Module

Operator Manual

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PADS 2.5.6

CDP Module 2.5.5



2545 Central Avenue
Boulder, CO 80301 USA

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

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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 module for the Cloud Droplet Probe (CDP).

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 CDP 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 CDP

Your CDP 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 “CDP” tab.
2. From the **Configure** menu, select **Configure Instrument**. You will see the following window.

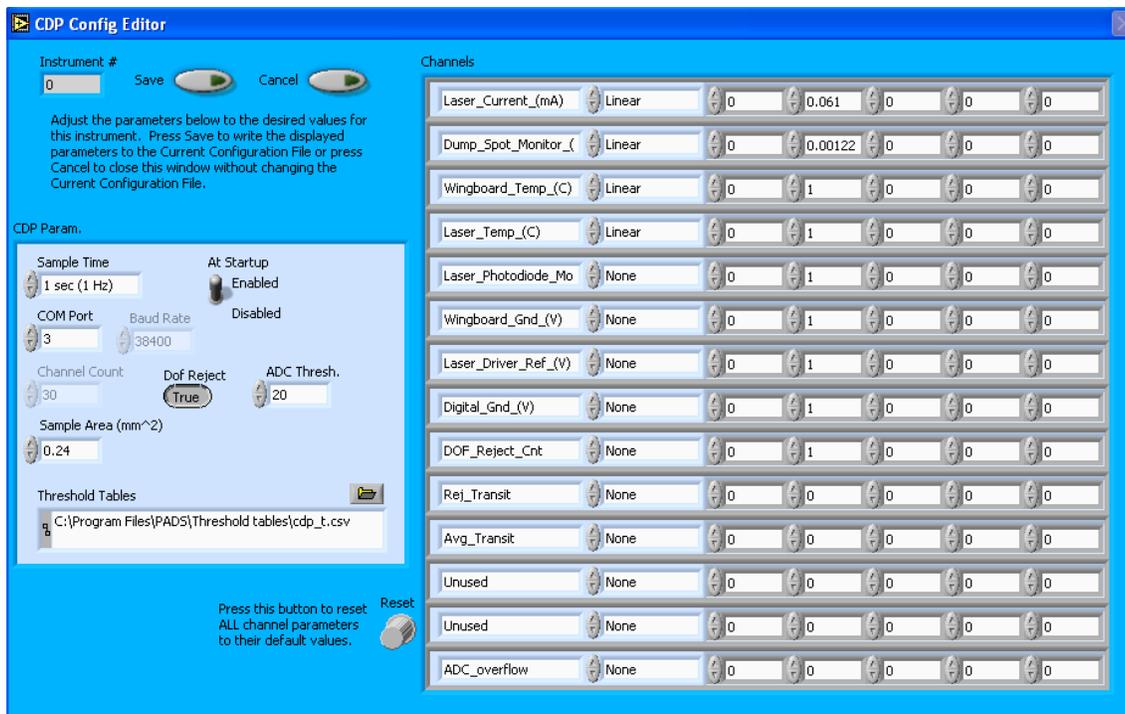


Figure 1: CDP Configuration Editor Window. The left side of the window contains parameters for the instrument. The table on the right side contains information on CDP channels. (See “Rarely Reconfigured Parameters.”)

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 CDP Parameters” and “Rarely Reconfigured CDP Parameters.” If at any time you would like to revert to the previously saved values for the CDP parameters, press **Cancel** to exit the window without saving changes.
4. When you are done configuring the CDP 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 CDP 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 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 .

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 CDP to acquire data when PADS begins sampling, make sure this parameter is in the “Enabled” mode. In some cases, such as if the CDP is inoperative, you may want to use this control to disable the probe. Disabling the CDP allows data to transmit from other instruments without interference.

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

You will notice that there are other parameters listed on the **CDP** 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 CDP Parameters” below or consult with a DMT technical representative.

Rarely Reconfigured CDP Parameters

The CDP 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 CDP. If your CDP 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.

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

DOF Reject: The DOF reject button tells the CDP whether to reject particles that fall outside the CDP's depth of field. The default value is true, 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 Operator Manual.*)

ADC Threshold: The ADC Threshold indicates the smallest peak digital value a particle can have and still be sized by the instrument. Small digital peaks can occasionally occur in the absence of particles, and the ADC Threshold can be used to eliminate such noise.

Sample Area: This is the physical area in which particles are detected. CDP sample area is a constant regardless of particle size. This value is preconfigured to match your instrument, so it is strongly suggested that you do not change it.

Threshold Tables: This field lists the path to the threshold table files. These files are used in sizing particles, and the CDP has two threshold tables associated with it. (PADS only lists one of these tables in the Threshold Tables field, but both are in the directory.) `CDP_t.csv` tells PADS the correct sizing bin for a particle given the peak digital value converted from the light scattered by the particle. `CDP_p.csv` tells PADS the upper size boundary in microns for each sizing bin. Note that the Thresholds Tables field should always be set to the `CDP_t.csv` file, and PADS finds the `CDP_p.csv` file automatically using the same path.

While CDP threshold tables have multiple rows, PADS only uses one row from each table. This data row has been chosen to work with your specific CDP.

Channels: The first eight channels listed in the channels table are configurable. These are A/D housekeeping channels that measure a 0-5 V value from one of the instrument's internal

sensors, for example a pressure or temperature sensor, and then convert this voltage to a integer value from 0 to 4095.

The integer values returned by the first eight channels can 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.

The second column in the table indicates the type of equation that PADS should use—linear, polynomial, or none. (Do not use the “CAS Temp.” option, which is reserved for internal 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 CDP 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.

The first eight table rows, which encompass Laser_Current_(mA) through Digital_Gnd_(V) on the default settings, are the channels that you may want to modify this way. The remaining channels, DOF_Reject_Cnt through ADC_Overflow, should not be modified.

Clicking the “Reset” knob at the bottom right of the CDP Parameter window will reset all the channel parameters to their DMT-supplied 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.

Configuring the CDP Display

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

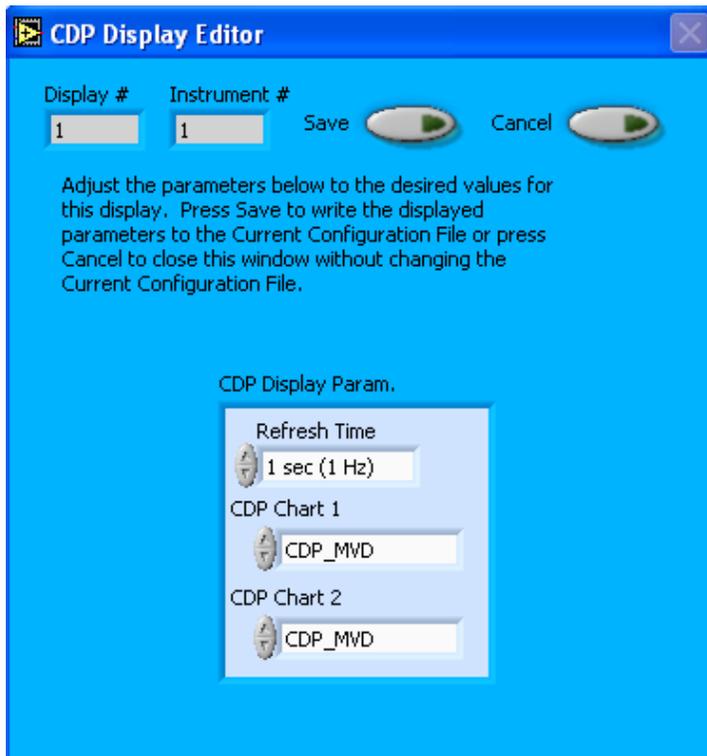


Figure 3: CDP Display Editor Window

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 CDP Display Parameter box at the bottom of the window also allows you to configure the channels on the CDP'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 CDP Window

The different parts of the CDP Window are discussed below. 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 CDP channels are displayed in the data window at the upper left of the CDP tab. These data are specific to the time listed in the upper-right of the PADS window.

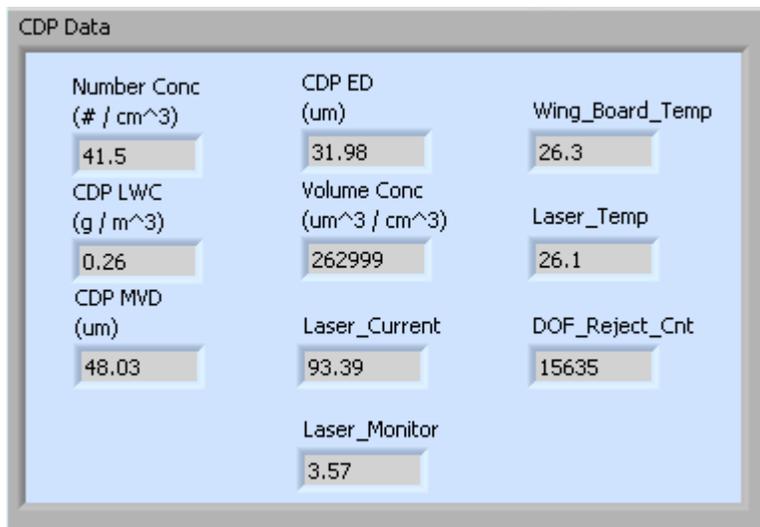


Figure 4: The CDP Data Window

Note that the channels on the CDP Data window may vary from the ones depicted above if you have changed them in the Config Instrument window. The preconfigured channels are described in Appendices A and B of the PADS operator manual.

Histogram Data Window

Below the CDP Data window is the histogram display of CDP-acquired particle data. Like the channel data display, the histogram shows time-specific data. The x-axis labels indicate the upper boundary of each size bin, which PADS reads from the `CDP_p.csv` threshold table. A bin's lower boundary is the upper boundary of the previous bin, except for the first bin, which has a lower boundary of 2 μm .

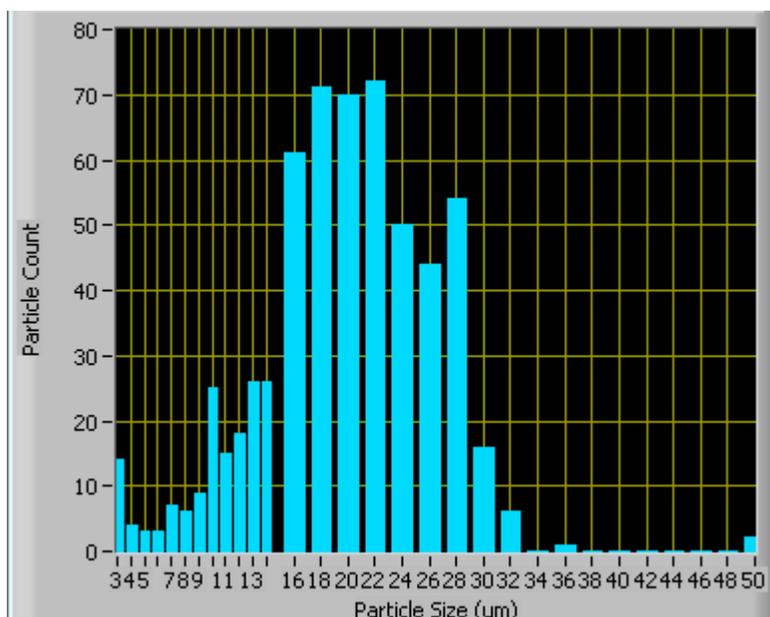


Figure 5: CDP Histogram Display

On CDPs with thirty bins, the first sizing bin typically includes all detected particles 2-3 μm in size. The next bin holds particles of size 3-4 μm , the next bin particles 4-5 μm , and so on, until particles reach 13 μm . At this point, the width of the bin doubles, so that bin 14 holds particles of size 16-18 μm , bin 15 holds particles 18-20 μm , and so on. This sizing system enables the CDP to detect a wide range of particles yet still provide nuanced sizing for smaller particles.

As a result of the CDP's uneven bin widths, the histogram distribution may not be a smooth curve. When the bin width changes from one to two μm , the bins capture many more particles. Figure 5 above, for instance, shows a jump in detected particles starting with the 16-18 μm bin.

If you want to see a normalized histogram curve, click on the "Particle Count Full" tab on the right side of the CDP window. Then press "Normalized." When new data are displayed, either by acquiring a new sample or by stepping through data in playback

mode, the normalization will take effect and you will see each bin of data divided by the width of that bin in μm .

Chart Displays

The CDP chart displays consist of a tab with three standard charts, a tab with two selectable charts, and a tab with a real-time large histogram (the “Particle Count Full” tab, shown below). You can access any of these charts by selecting the tabs in the upper part of the chart display window. Figure 6 shows these tabs and the standard time-series charts.

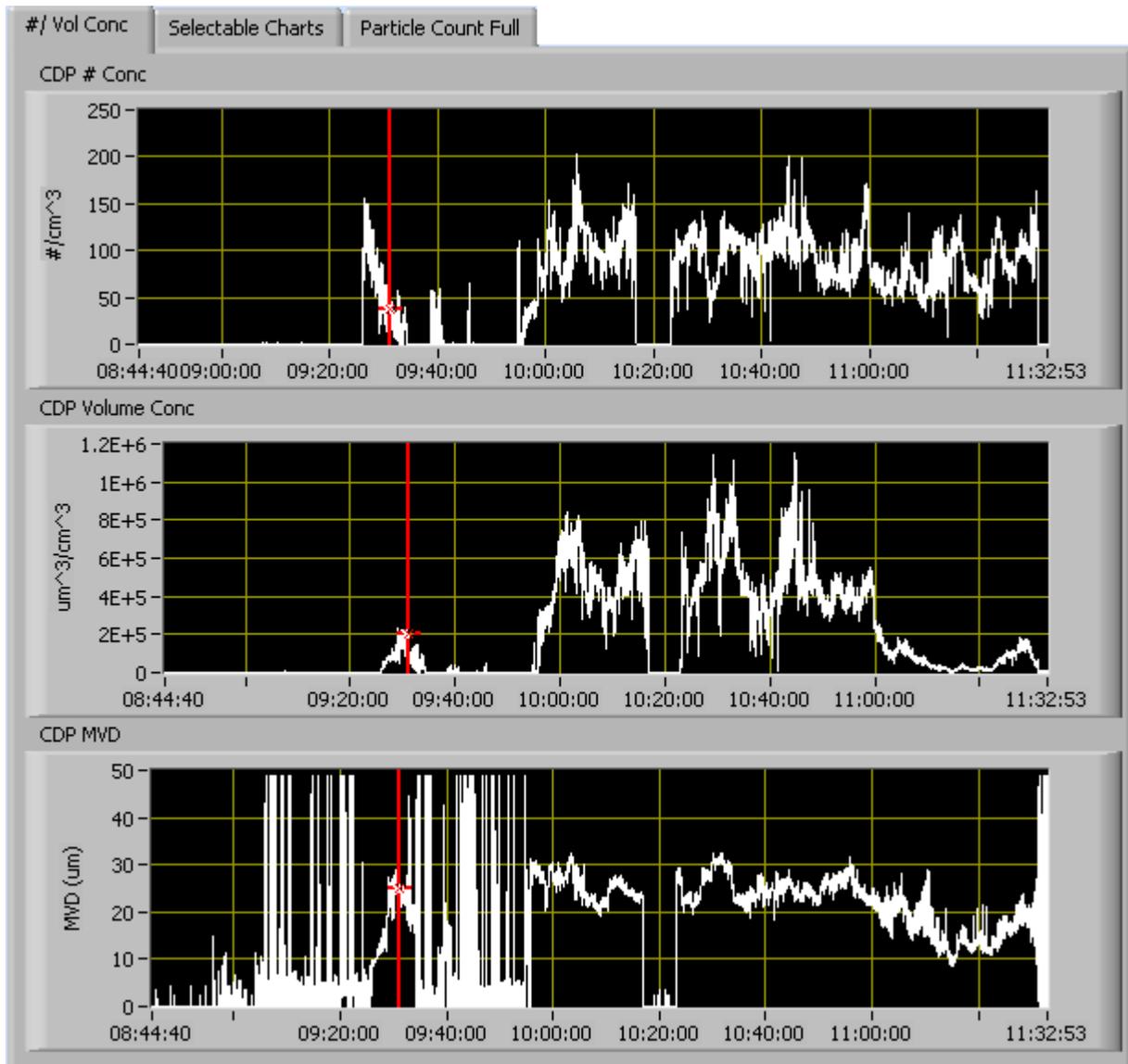


Figure 6: CDP Standard Time-Series Charts

When you access time-series charts in playback mode, the currently selected moment in time is indicated by a red 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 10:00:00, you simply select the field that currently says 11:32:53, type in 10:00:00, 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. # / Vol Conc

The three graphs on the first tab display particle number concentration ($\#/cm^3$), volume concentration ($\mu m^3/cm^3$), and MVD (μm) with respect to time. In playback mode, you can zoom in or out by using the time controls. In acquisition mode, use the “Display Range” control to zoom in or out.

2. Selectable Charts

The **CDP 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 **CDP 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.

3. Particle Count Full

The **Particle Count Full** tab shows a larger version of the histogram that appears in the bottom left of the CDP 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.

Normalized Button

If you enable normalization, PADS will scale the particle data so that each bin of data is divided by the width of that bin in μm . Normalization is useful when the widths of the size bins are not constant, as is often the case when an optical spectrometer has to cover a large size range or if some size bins are made larger to decrease uncertainty due to operational limitations. Without normalization, the concentrations from one size bin cannot be compared quantitatively from those in another size bin of different width. For example, if 8 particles are counted in a size bin that is 2 μm wide and 8 particles are counted in the next larger channel that is 4 μm wide, the size distribution would appear flat and we would assume that it was equally probable to measure particles of either size. This is a biased sample, however, since the larger size bin is twice as large as the smaller. If we normalize by the width, however, we find that the smaller size category has 4 particles per μm and the larger size bin only has 2 particles per μm . This is now an unbiased sample.

The Graph Tools Buttons

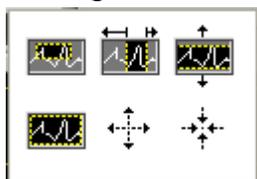
The graph tools buttons look like this:



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.

Appendix A: CDP Channels

A list of CDP channels for a 30-bin CDP appears below. (Since it is possible to rename some channels, your list may look different. Channels will also differ for CDPs with fewer than or more than 30 bins.) The CDP output file will contain data values for each channel for each sampling instance. You can also plot each of these channels with respect to time using the CDP Selectable Charts tab.

For definitions of the channels, consult *Appendix A: Definitions* in the *PADS Operator Manual*. Channels that start with “CDP” are the CDP’s results for channels that are often stored or calculated by several instruments. For these definitions, look under the more general term in the *PADS Operator Manual*. For instance, for the definition of CDP_ED, see “ED” in the main manual.

Configurable Channels <i>(measured voltages converted to integer values, then scaled)</i>	}	Time	CDP_Bin_3	CDP_Bin_21
		Laser_Current_(mA)	CDP_Bin_4	CDP_Bin_22
		Dump_Spot_Monitor_(V)	CDP_Bin_5	CDP_Bin_23
		Wingboard_Temp_(C)	CDP_Bin_6	CDP_Bin_24
		Laser_Temp_(C)	CDP_Bin_7	CDP_Bin_25
		Laser_Photodiode_Monitor_(V)	CDP_Bin_8	CDP_Bin_26
		Wingboard_Gnd_(V)	CDP_Bin_9	CDP_Bin_27
		Laser_Driver_Ref_(V)	CDP_Bin_10	CDP_Bin_28
		Digital_Gnd_(V)	CDP_Bin_11	CDP_Bin_29
		DOF_Reject_Cnt	CDP_Bin_12	CDP_Bin_30
		Rej_Transit	CDP_Bin_13	Number_Conc
		Avg_Transit	CDP_Bin_14	CDP_LWC
		Unused ¹	CDP_Bin_15	CDP_MVD
		Unused	CDP_Bin_16	CDP_ED
		ADC_overflow	CDP_Bin_17	Status
		CDP_Bin_1	CDP_Bin_18	GPS Time
		CDP_Bin_2	CDP_Bin_19	
			CDP_Bin_20	

¹ If your CPD has a dynamic threshold feature (only available in instruments manufactured after mid-2010), the two channels listed as “unused” will store DT Bandwidth and Dynamic Threshold. For more information, see DOC-0258, the DMT Technical Note on the Dynamic Threshold Feature for CDPs. The most recent version of this document is available online if you go to dropletmeasurement.com, select Resources > Technical Bulletins, and then click on the “CDP Dynamic Threshold Feature for Cloud Droplet Probes” link.

CDP channels fall into several broad categories:

Time Channels: The time channels store time data. Time is generated by the PADS computer clock and is the time when the program receives the CDP data. It is given in seconds after midnight on the day the program was started. 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 CDP, even though it appears as a channel in the CDP output file.

Configurable Channels: The first eight channels after Time are A/D housekeeping channels. These channels have a 0-5 V scale measured by a 12-bit A/D converter that gives integer values from 0 to 4095. If you would like to configure these channels, please contact DMT.

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

Channels for Other Statistical Data: DOF_Reject_Cnt, Rej_Transit, Avg_Transit, and ADC_overflow store particle statistics collected by the CDP. Status stores statistical data the CDP has gathered on the communication between PADS and the probe.

CDP Calculated Channels: Number_Conc, CDP_LWC, CDP_MVD, and CDP_ED store the results of calculations PADS has performed on CDP particle data.

Unused Channels: Channels marked "Unused" currently do not store any data.

Appendix B: Revisions to Manual

Rev. Date	Rev. No.	Summary	Section
9/27/10	A-6	Added footnote on dynamic threshold channels	Appendix A