Particle Analysis and Display System (PADS):

Cloud Droplet Probe with Particle by Particle (CDP_PBP) Module

Operator Manual

DOC-0192, Rev C

PADS 2.8.0, CDP_PBP 2.8.1

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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.

C O N T E N T S

L i s t   o f   F i g u r e s

L i s t   o f   T a b l e s

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 with Particle by Particle (CDP_PBP).

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_PBP module are also described in the *PADS Operator Manual*.

Note that while most of the PADS instrument manuals describe PADS 2.5.1, this manual describes PADS 2.8.0. This is because substantive changes have been made to the CDP-PBP module of the program in version 2.8.0. As a result, the pictures of PADS displays that appear in this manual may differ from those in other instrument manuals. Specifically, PADS charts and histogram displays in this document feature a white rather than black background.

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_PBP

Your CDP_PBP 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_PBP" tab.

2. From the **Configure** menu, select **Configure Instrument.** You will see the following window.
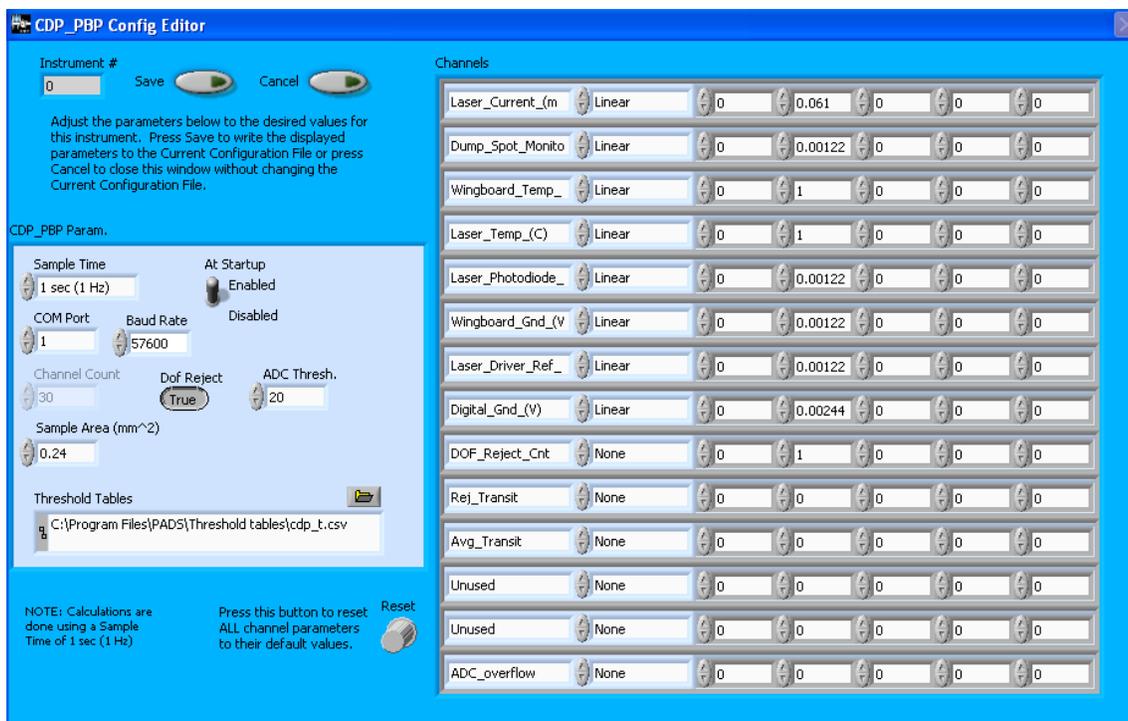
Figure 1: CDP_PBP Configuration Editor Window. The left side of the window contains parameters for the instrument. The tabs on the right side of the window contain information on CDP_PBP channels. (See "Rarely Reconfigured Parameters.")

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_PBP Parameters" and "Rarely Reconfigured CDP_PBP Parameters." If at any time you would like to revert to the previously saved values for the CDP_PBP parameters, press **Cancel** to exit the window without saving changes.

4. When you are done configuring the CDP_PBP 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_PBP Parameters

At Startup Enabled / Disabled: If you want the CDP_PBP to acquire data when PADS begins sampling, make sure this parameter is in the "Enabled" mode. In some cases, such as if the CDP_PBP is inoperative, you may want to use this control to disable the probe. Disabling the CDP_PBP allows data to transmit from other instruments without interference.

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

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.

You will notice that there are other parameters listed on the **CDP_PBP Config Editor** window. You should not need to change these, and changing them 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_PBP Parameters" below or consult with a DMT technical representative.

Rarely Reconfigured CDP_PBP Parameters

The CDP_PBP 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_PBP. If your CDP_PBP 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 between samples. It should be set to one Hertz / one second, as choosing other values will invalidate time-dependent PADS calculations. In addition, setting **Sample Time** to a frequency less than one Hertz may invalidate IPT times recorded in the PBP output file, while choosing a time faster than 2 Hertz will exceed the baud rate capacity. See *Appendix B* for details.

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.

Channel Count: This number indicates how many sizing bins the CDP_PBP 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_PBP whether to reject particles that fall outside the CDP_PBP'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.)

Sample Area: This is the physical area in which particles are detected. CDP_PBP 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_PBP 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 0 - 10 Volt range from one of the instrument's internal sensors, for example a pressure or temperature sensor, and then convert this voltage to an 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:

New_Channel = 34.01 + 0.061 x + 0.0092 x^2

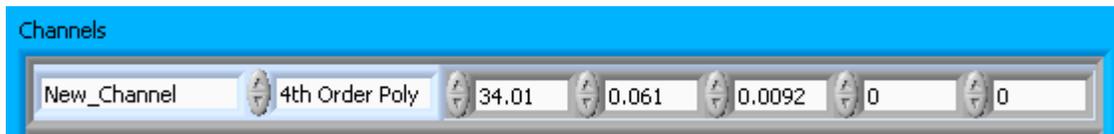where x is the digitized analog value returned by the A/D converter.

Figure 2: Example Channel Specifications in the CDP_PBP 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" knob at the bottom right of the CDP_PBP 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_PBP Display

To configure the CDP_PBP display, click on the CDP_PBP 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.
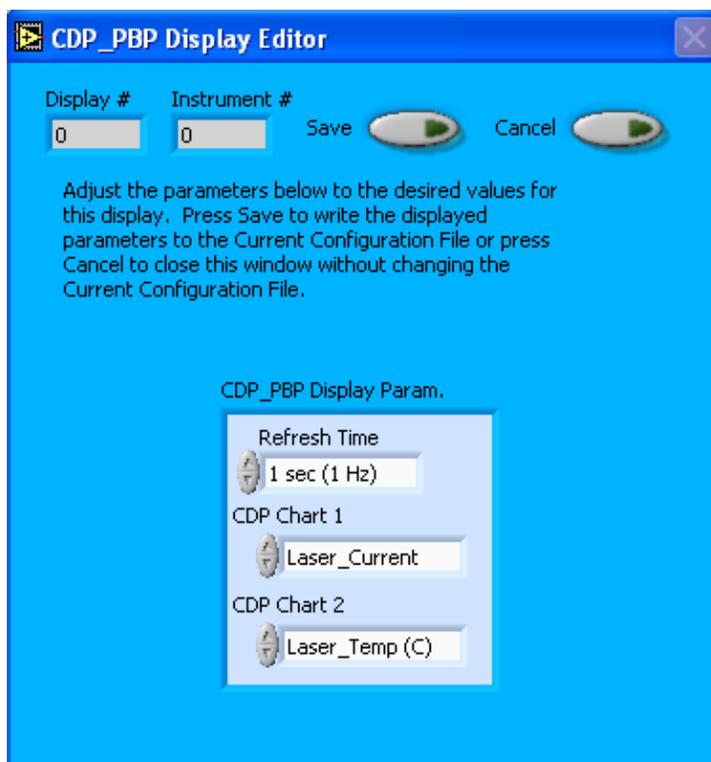
Figure 3: CDP_PBP Display Editor Window

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

The different parts of the CDP_PBP 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_PBP Data tab is displayed in upper left of the CDP tab, as shown in Figure 4. The information PADS displays in these tabs is specific to the time listed in the upper-right of the PADS window.
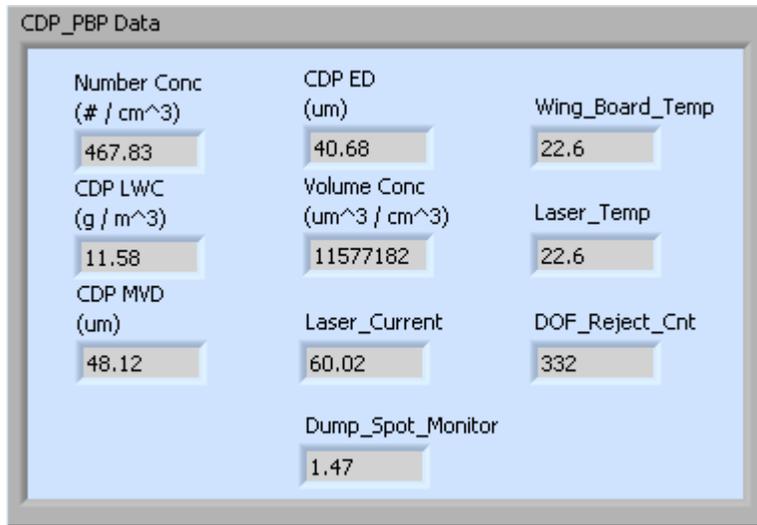
Figure 4: CDP_PBP Calc Data Window

Note that some field names may vary depending on the housekeeping channels you have selected for the instrument on the Config Editor screen.

Histogram Data Window

Below the CDP_PBP Data tab is the histogram display of acquired particle data, as shown in Figure 5. 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.
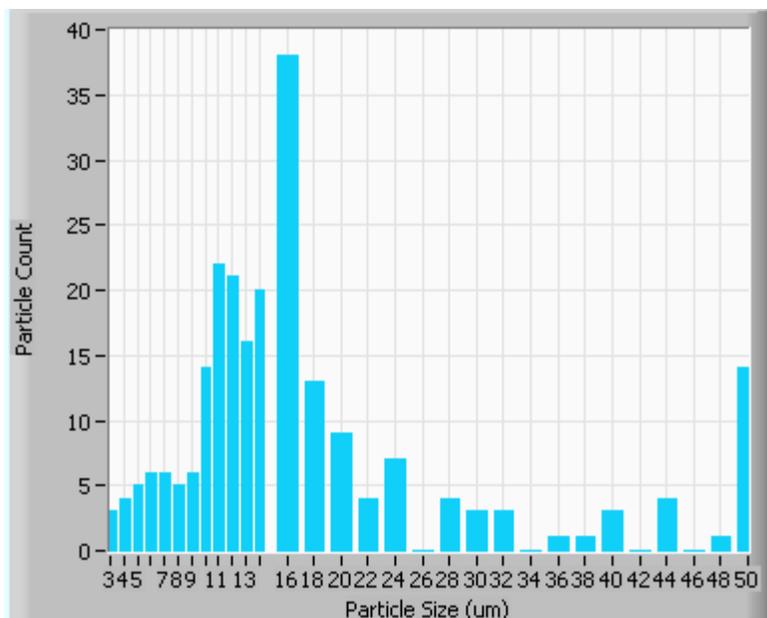
Figure 5: CDP_PBP Histogram Display

On CDP-PBPs 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-PBP to detect a wide range of particles yet still provide nuanced sizing for smaller particles.

As a result of the CDP-PBP'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-PBP window. Then press "Normalized." 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_PBP chart displays consist of tabs with standard charts, selectable charts, particle by particle (PBP) data, and larger version of the histogram that appears in the bottom left of the instrument window. 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.
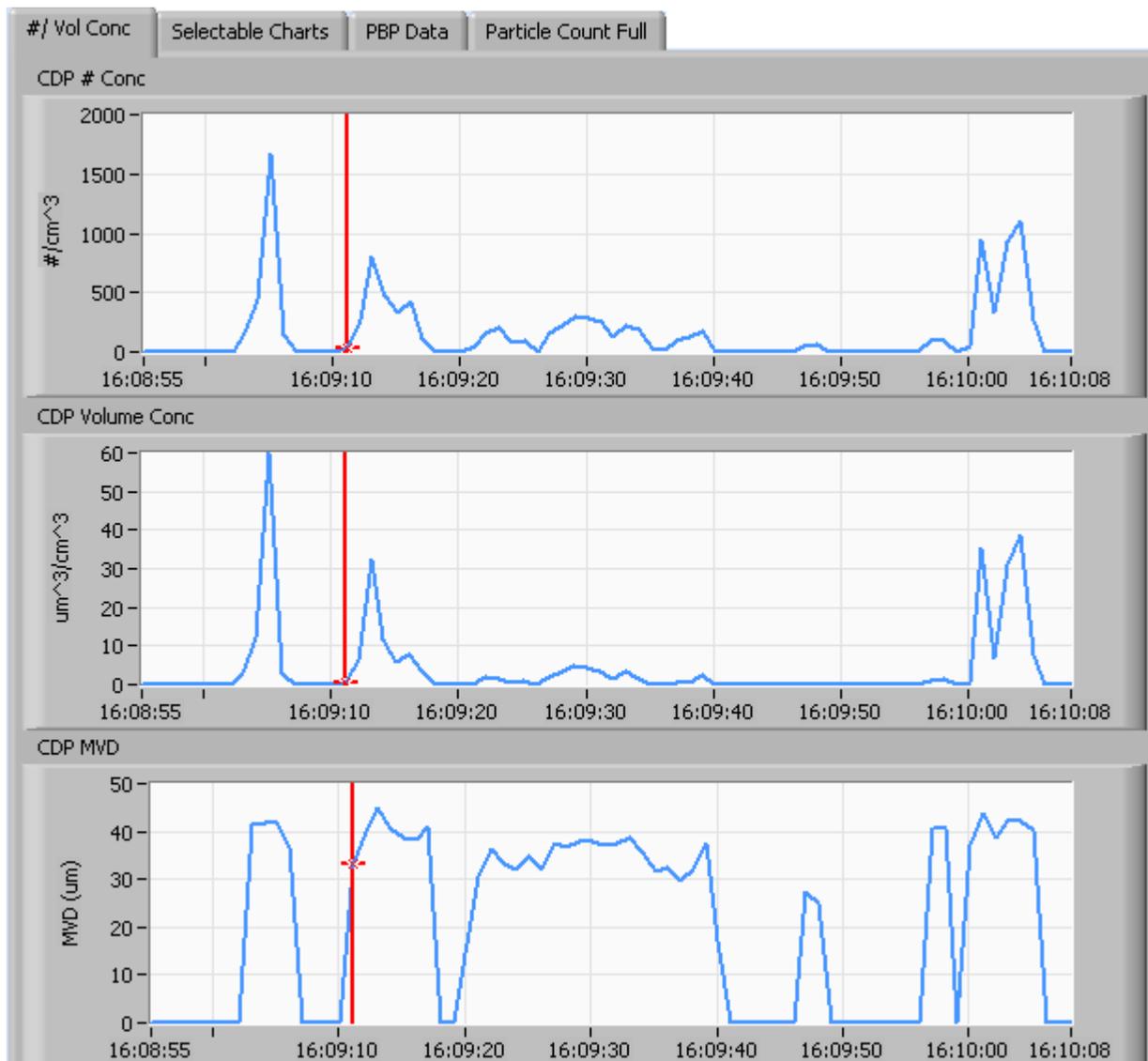
Figure 6: CDP_PBP Time-Series Charts

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 16:09:30, you simply select the field that currently says 16:10:08, type in 16:09:30, 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, which brings up a drop-down menu. 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. Standard Charts (the #/Vol Conc Tab)

The three graphs on the first tab display particle number concentration ($\#/cm^3$), volume concentration ($\mu m^3/m^3$) and MVD (μm).

In playback mode, you can zoom in or out on the charts by using the time controls. In acquisition mode, use the "Display Range" control to zoom in or out.

2. Selectable Charts

The **CDP_PBP 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_PBP 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. PBP Data

The PBP Data tab displays particle-by-particle data for the sample time listed in the upper right of the CDP_PBP window. The histogram displays particle counts as a function of inter-particle time (IPT) in milliseconds. The fields above the histogram display the average IPT time and the standard deviation from the mean. Below and to the right of these fields are radio buttons that allow you to display the data linearly or logarithmically.

Note that average IPT time and standard deviation from the mean may be inaccurate if the CDP-PBP Sample Time is set to a frequency of lower than 1 Hz. The histogram will still be accurate in this case. See Appendix B for details.

The IPT histogram displays data collected in the 28 CDP_PBP_IPT_Bin channels. IPT Time ranges for each bin are given in Table 1.

Bin	IPT (msec)	Bin	IPT (msec)	Bin	IPT (msec)	Bin	IPT (msec)
1	0 - 1	8	7 - 8	15	50 - 60	22	300 - 400
2	1 - 2	9	8 - 9	16	60 - 70	23	400 - 500
3	2 - 3	10	9 - 10	17	70 - 80	24	500 - 600
4	3 - 4	11	10 - 20	18	80 - 90	25	600 - 700
5	4 - 5	12	20 - 30	19	90 - 100	26	700 - 800
6	5 - 6	13	30 - 40	20	100 - 200	27	800 - 900
7	6 - 7	14	40 - 50	21	200 - 300	28	900+

Table 1: IPT Time Ranges for CDP_PBP_IPT Bins

4. 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 wide 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.

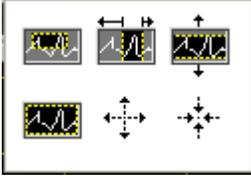**The Graph Tools Buttons**

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_PBP Channels

The CDP_PBP generates two output files. These will be named something like the following:

- 01CDP_PBP20081022110533.csv
- 01CDP_PBP20081022110533_PBP.csv

The first file contains CDP_PBP output gathered over each sampling instance. This file contains data on all the particles the probe has detected. The second file, which has "PBP" appended to its name, contains particle-by-particle data. PADS collects particle-by-particle data only for the first 256 particles detected in each sampling instance. If more than 256 particles arrive in the sampling interval, they are ignored in the second file but included in calculations of concentration, LWC, and MVD that are recorded in the first file. If no qualified particles are detected during a given sampling instance, the PBP file will not store any data. More information about these two files is given below.

For definitions of the channels, consult *Appendix A: Definitions* in the *PADS Operator Manual*. For channels that start with "CDP" or "CDP_PBP," look under the more general term in the *PADS Operator Manual*. For instance, for the definition of CDP_MVD, see "MVD" in the main manual.

1.) Main CDP_PBP file

For an instrument with 30 bins, the main file will typically have the channels listed below. The channels in italics are configurable housekeeping channels that may be different on your instrument. Channels will also differ for CDPs with fewer than or more than 30 bins. In cases where two names are given for one channel, for instance "Dump_Spot_Monitor / Laser_Monitor," current versions of PADS have the first name as the default channel label and older versions have the second name. You can plot any CDP_PBP channel with respect to time using the CDP_PBP Selectable Charts tab.

Time	Rej_Trans	CDP_PBP_Bin_6
Laser_Current	Avg_Transit	CDP_PBP_Bin_7
Dump_Spot_Monitor/Laser Monitor	Unused *(see note below)*	CDP_PBP_Bin_8
Wing_Board_Temp	Unused *(see note below)*	CDP_PBP_Bin_9
Laser_Temp	ADC_Overflow	CDP_PBP_Bin_10
Laser_Ref/CDP_HK4	CDP_PBP_Bin_1	CDP_PBP_Bin_11
GND/CDP_HK5	CDP_PBP_Bin_2	CDP_PBP_Bin_12
Digital_V_Ref/CDP_HK6	CDP_PBP_Bin_3	CDP_PBP_Bin_13
Digital_GND/CDP_HK7	CDP_PBP_Bin_4	CDP_PBP_Bin_14
DOF_Reject_Cnt	CDP_PBP_Bin_5	CDP_PBP_Bin_15

CDP_PBP_Bin_16	CDP_MVD (um)	CDP_PBP_IPT_Bin_14
CDP_PBP_Bin_17	CDP_ED (um)	CDP_PBP_IPT_Bin_15
CDP_PBP_Bin_18	PBP_Avg_IPT (msec)	CDP_PBP_IPT_Bin_16
CDP_PBP_Bin_19	PBP_IPT_STD (msec)	CDP_PBP_IPT_Bin_17
CDP_PBP_Bin_20	CDP_PBP_IPT_Bin_1	CDP_PBP_IPT_Bin_18
CDP_PBP_Bin_21	CDP_PBP_IPT_Bin_2	CDP_PBP_IPT_Bin_19
CDP_PBP_Bin_22	CDP_PBP_IPT_Bin_3	CDP_PBP_IPT_Bin_20
CDP_PBP_Bin_23	CDP_PBP_IPT_Bin_4	CDP_PBP_IPT_Bin_21
CDP_PBP_Bin_24	CDP_PBP_IPT_Bin_5	CDP_PBP_IPT_Bin_22
CDP_PBP_Bin_25	CDP_PBP_IPT_Bin_6	CDP_PBP_IPT_Bin_23
CDP_PBP_Bin_26	CDP_PBP_IPT_Bin_7	CDP_PBP_IPT_Bin_24
CDP_PBP_Bin_27	CDP_PBP_IPT_Bin_8	CDP_PBP_IPT_Bin_25
CDP_PBP_Bin_28	CDP_PBP_IPT_Bin_9	CDP_PBP_IPT_Bin_26
CDP_PBP_Bin_29	CDP_PBP_IPT_Bin_10	CDP_PBP_IPT_Bin_27
CDP_PBP_Bin_30	CDP_PBP_IPT_Bin_11	CDP_PBP_IPT_Bin_28
Number_Conc (#/cm^3)	CDP_PBP_IPT_Bin_12	Status
CDP_LWC (g/m^3)	CDP_PBP_IPT_Bin_13	GPS Time

NOTE: 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.

Channels in this file 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_PBP 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 will be collected from an instrument other than the CDP_PBP, even though it appears as a channel in the CDP_PBP output file. *Note that these Time channels—i.e., the ones in the main output file—differ from those in the PBP output file. PBP file channels are described below.*

Bin Channels: Channels labeled CDP_PBP_Bin_[*i*] and CDP_PBP_IPT_Bin_[*i*] categorize particles by size and inter-particle times. These data are used in the histogram displays. Note that CDP_PBP_IPT_Bin channels only store data on particles observed during the particle-by particle analysis.

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

Housekeeping Channels: The CDP_PBP has 8 A/D housekeeping channels that have a 0-10 V range measured by a 12-bit A/D converter that gives integer values from 0 to 4095. Several of the housekeeping channels store data that indicate whether the probe is functioning properly. The housekeeping channels are denoted by italics in channels list given above.

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

Channels that are Currently Nonfunctional or Reserved for Internal Use: These channels are labeled "Unused."

2.) The CDP_PBP Particle-by-Particle File

The output second file has PBP appended to its name and contains particle-by-particle data. The file lists four channels:

Time
Size [counts]
IPT [msec]
PADS Time

These channels get reported for the first 256 particles that the CDP_PBP detects in each sampling instance. Size is given in A/D counts and needs to be converted to a size in µm during post-processing using the appropriate conversion factors.

Appendix B: IPT Time Calculations

The CDP-PBP instrument does not return IPT times in the serial stream data. Rather, during each sampling instance, the CDP-PBP returns a 48-bit number indicating the time that elapsed from probe initialization to the observation of the first particle in the sampling instance. For each PBP particle in the sampling instance, the probe also returns a 20-bit number indicating the time between the first observed particle and the current particle. PADS then calculates IPT times from these times as follows. For each particle, the program first calculates the **Time** for each particle by adding three factors: 1.) the 20-bit particle time, 2.) the 48-bit time stamp of the first particle and 3.) the time in seconds after midnight at which the probe was initialized. (This **Time** channel is the one stored in the PBP file, not the one in the main output file.) **IPT Time** is then derived by subtracting the **Time** of the previous particle from that of the current particle.

This method economizes data packet space while simultaneously allowing for large IPT times. Assuming that the **Sample Time** parameter is set properly (see below), PADS can accurately calculate IPT times even for particles that are observed over a week apart.

Sample Time Settings that Ensure Correct IPTs

The 20-bit serial-data times have a resolution of 1 μsec, so a maximum time of 2^{20} * .001 msec = 1049 msec or 1.05 seconds. As a result, if Sample Time is set to longer than one second, the 20-bit number may not accurately reflect the time elapsed between the current particle and the first particle. As a result, both the **IPT** channel in the PBP data file and the **PBP_Avg_IPT (msec)** and **PBP_IPT_STD (msec)** channels in the main data file may be inaccurate. To avoid this problem, make sure that the **Sample Time** is set to 1 or 0.5 seconds (i.e., one or two Hertz). (While choosing an even faster **Sample Time** would in theory also allow for accurate reporting, doing so exceeds the baud rate capacity, so it is not recommended either.) Note that while selecting a two Hertz rate will increase the number of particles reported in the PBP data, it may invalidate time-dependent PADS calculations such as particle concentration.

NaN Results in IPT Channel

If one sampling instance has more than 256 observed particles, the **IPT Time** for the first particle in the next sampling instance will be NaN. This is because the CDP-PBP only collects particle-by-particle data for up to 256 particles, so PADS cannot know the time of the previous particle for the first particle of the next sampling instance.

The IPT time for the first particle in the first data packet can be a valid IPT time or NaN. If the probe has been sampling (but not recording) data up to this point, the time of the

previous particle will be known. Thus the IPT time of the first recorded particle can be calculated. However, if the user starts recording and sampling data simultaneously, there will be no data available for the particle before the first recorded particle. Thus the IPT for this particle will be NaN.

Particles with IPTs of NaN are not included in PADS calculations for **PBP_Avg_IPT (msec)** and **PBP_IPT_STD (msec).**

Appendix C: Revisions to Manual

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