
**Particle Analysis and Display
System (PADS):
Cloud Droplet Probe
with Particle by
Particle (CDP-PBP)
Module Manual**

DOC-0279, Rev B-1

PADS 3.5.0, CDP-PBP Module 3.5.0



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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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 Droplet Probe with Particle by Particle (CDP-PBP) 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 CDP-PBP module are also described in the *PADS Overview Manual*.

2.0 Configuration

Using PADS, you can configure both the software settings for the instrument and the instrument's data display in PADS. The following two sections explain how to do this. Configuring the instrument's software and display affects the default settings PADS uses when starting up. Some parameters can also be changed while PADS is running, but doing so affects the current session only.

2.1 Configuring the 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.

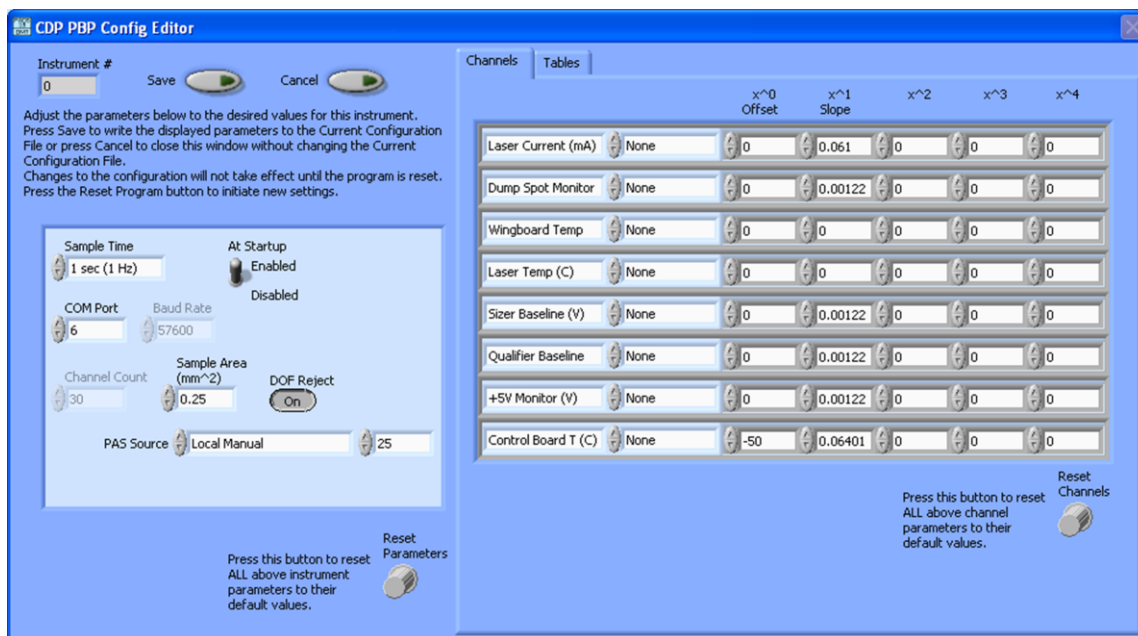


Figure 1: CDP-PBP Configuration Editor Window. The left side of the window contains parameters for the instrument. The table on the right side contains information on CDP-PBP channels and bin thresholds.

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 CDP-PBP 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 CDP-PBP 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 CDP-PBP Parameters

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 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 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. 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 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.

Baud Rate: The baud rate for the probe is defined at manufacture. This parameter has been grayed out and you should not need to change it. If you reconfigure your hardware, however, the baud rate may change. If this occurs, contact DMT for help in changing your baud rate in PADS.

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.

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.

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 ON, 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 of the *PADS Overview Manual*.)

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.

Note: Changing the PAS Source here changes the default used upon start-up. This parameter can be changed during a PADS session by clicking on the **Tools** sub-tab.

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 Tab

The channels listed in the Channels table are configurable. These are A/D housekeeping channels that measure a 0 - 5 V range from one of the instrument's internal sensors, for example a pressure or temperature sensor. A conversion equation converts the A/D counts into other, more meaningful units (e.g., mBar or °C). You can specify this equation in the Channels table.

Note: While it is possible to use the Channels table to rename output channels, in most cases your system is preconfigured so that the channels in the table correctly match output from your instrument(s). While minor rescaling of output channels can improve data accuracy, DMT does not recommend altering your basic channel configuration.

The second column in the table indicates the type of equation that PADS should use—linear, polynomial, or none. (“Thermister D” and “Thermister G” are complicated, pre-set equations used by some instruments, while 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:

$$\text{New_Channel} = 34.01 + 0.061 x + 0.0092 x^2$$

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

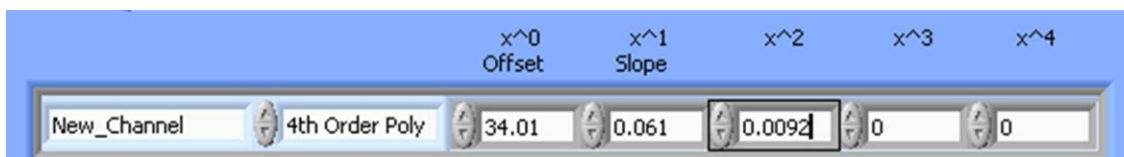


Figure 2: Example Channel Specifications in the Config Editor Window

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 CDP-PBP 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.

2.1.3 Tables Tab

The **Tables** tab lists the threshold tables that allow the CDP-PBP to bin particles according to size. **Bin 1 Lower Thresh.** lists the lower size limit in μm of the smallest bin. **ADC Threshold** indicates the smallest peak A/D 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. Both of these parameters can be changed by typing a new value into the text box or by using the control arrows to the left.

The table below consists of three columns. The left-hand column lists the bin number. The middle column lists the upper size limit in microns for that bin. (Lower size limits are the upper limit of the previous bin, except for bin 1, whose lower boundary is listed above the table.) The right-hand column in the table lists the A/D count that corresponds to this upper size limit. Note that bin numbers are fixed, but you can modify both the upper size boundary and the corresponding A/D count values. To modify a cell, either type in a new value, or use the arrows to the left. The scrollbar to the right allows you to access other rows in the table.

The **Reset Tables** knob restores table values to their DMT-supplied defaults.

After making changes to the Tables 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 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.

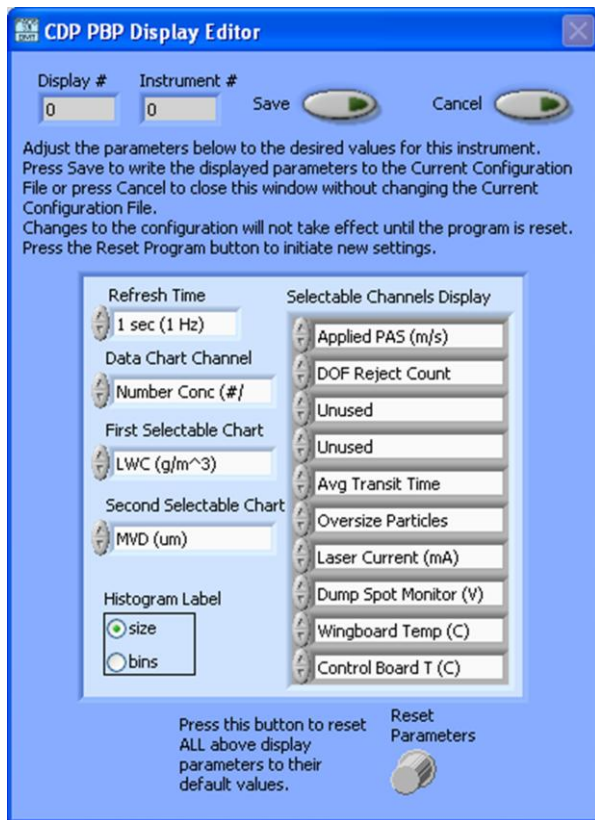


Figure 3: CDP-PBP Display Editor Window

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.)

Data Chart Channel allows you to select a data channel to be displayed in the chart in the upper right of the **Data** tab.

First Selectable Chart and **Second Selectable Chart** allow you to select channels graphed on the **Selectable Charts** tab.

The **Histogram Label** radio buttons allow you to select how you would like the x-axis of the histogram labeled - by size (μm) or bin number.

The **Selectable Data Display** controls which channels PADS displays in the upper right of the CDP-PBP window.

Note that many of the settings listed above can also be changed while PADS is acquiring data by using the controls on the main CDP-PBP window. Modifying these parameters on in the Display Editor changes the values used upon start-up.

Reset Parameters reverts the display parameters to their DMT-supplied defaults.

When you are done configuring the CDP-PBP display, 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 you have made. Note that clicking **Reset Program** will clear out any data currently being displayed.

3.0 The CDP-PBP Window

Figure 4 shows the CDP-PBP window.

The different parts of the CDP-PBP 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*.

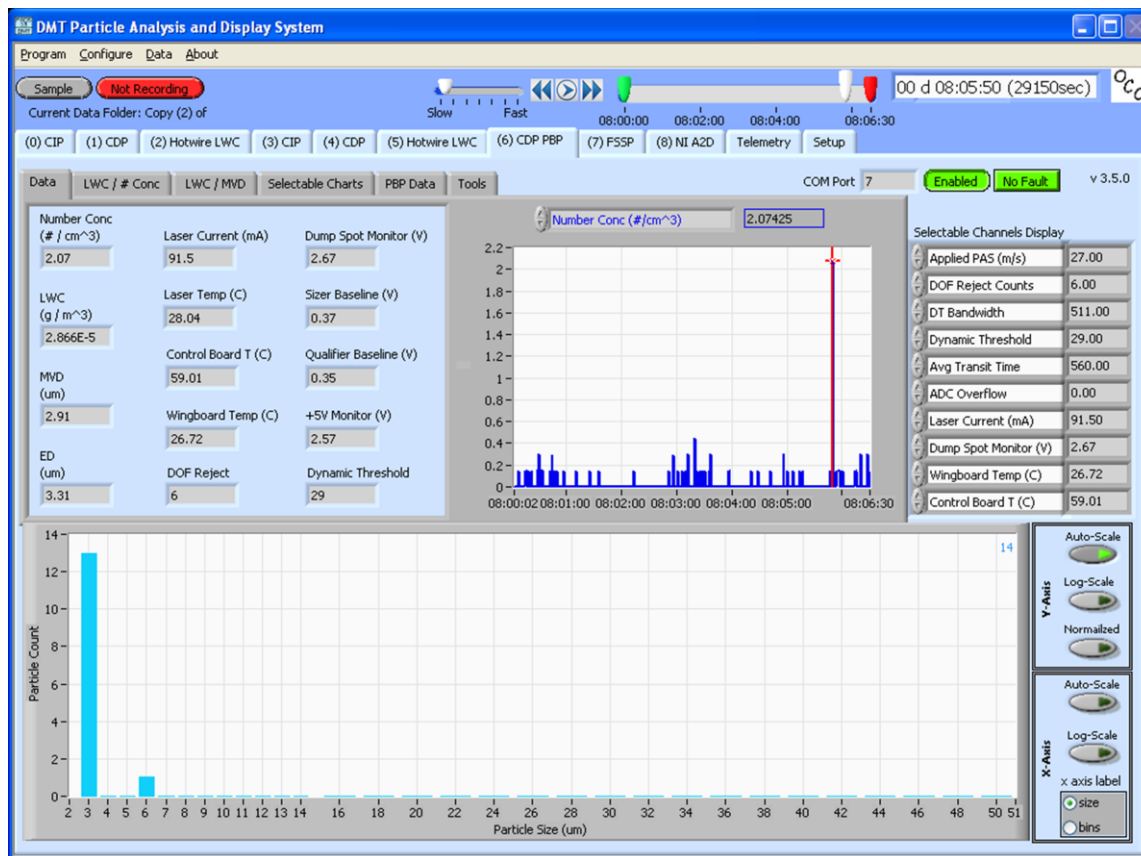


Figure 4: CDP-PBP Window

3.1 CDP-PBP Tabs

The CDP-PBP window has several sub-tabs which are described below.

3.1.1 Data Tab

The **Data** tab displays the current values for many of the CDP-PBP data channels. For more information on these channels, see the *PADS Overview Manual*. On the right side of the tab is a time-trace chart of a user-selectable channel. This channel can be changed by clicking on the name of the currently displayed channel, which will bring up a list of options.

3.1.2 LWC, # Conc, and MVD Tabs

The **LWC / # Conc** tab displays a time-trace chart of calculated liquid water content in g/m^3 (shown in green) and **# Conc** in particles/ cm^3 (shown in blue). The **LWC /# MVD** tab displays a time-trace chart of calculated liquid water content in g/m^3 (green) and MVD in μm (blue).

3.1.3 Selectable Charts Tab

This tab displays time-trace charts of two user-selectable channels. The charts are overlaid on each other, with the left axis (in black) corresponding to the channel listed in the above left of the chart, and the right axis (in blue) applying to the channel listed in the above right. To change these channels, click on the names of the currently displayed channels, which will bring up a list of options. If you would like to permanently change the **Selectable Charts** channels, as opposed to simply changing them for the current session, you can do so by selecting **Configure > Configure Display** and making the desired changes.

3.1.4 PBP Data Tab

The **PBP Data** tab displays a histogram of inter-particle times (IPT) in milliseconds. IPT ranges for each bin are given in Table 1. The x-axis label on the chart is the upper boundary of the bin. However, Bin 28's upper boundary is really 1677.72, as shown in the

chart below, not the 1000 that PADS displays. This is the longest inter-particle time that the CDP-PBP can detect.

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 - 1678

Table 1: IPT Time Ranges for CDP-PBP IPT Bins

The Y-scale button allows you to scale histogram data linearly or logarithmically.

In addition, the PBP Data tab displays the **Avg Inter-Particle Time** and **IPT Standard Deviation** for the sampling period, both in milliseconds.

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.

3.1.5 Tools Tab

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.

The **PAS Source** on the tools tab modifies the source for the current PADS session only. To change this source permanently, select **Configure > Configure Instrument** and update the PAS Source on the Configuration Editor. *Note:* the PAS source can be changed during

acquisition, but if data are reprocessed, the source may change; see the “Configure Menu” section of *DOC-0300, the PADS Overview Manual*.

3.2 Histogram Data Window

Below the CDP-PBP sub-tabs is the histogram display of CDP-PBP-acquired particle data for the current time. The x-axis labels indicate either the upper boundary of each size bin or the bin number, depending on the **x-axis label** setting (in the bottom right). Bin boundaries are determined by the threshold tables described in section 2.1.3. If PADS is displaying the x-axis as bin numbers, the size in μm for each bin is displayed at the top of the histogram bars.

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.

If you want to see a normalized histogram curve, click on the **Normalized** button in the Y-axis controls to right of the histogram itself. The normalization will take effect and you will see each bin of data divided by the width of that bin in μm .

The y-axis and x-axis controls to the right of the histogram also allow log scaling and autoscaling. By default, both axes are scaled linearly and the y-axis is autoscaled. If autoscaling is enabled, 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.

3.3 Selectable Data Display

The upper right of the CDP-PBP window displays current data for ten user-selectable channels. New channels can be selected by clicking on the name of a current channel and selecting a replacement from the drop-down list. To make permanent changes to this list, edit the settings on the CDP-PBP Display Editor (select **Configure > Configure Display**).

Appendix A: CDP-PBP Channels

CDPs with the particle-by-particle feature generate a raw and scaled output file, just as a regular CDP does. However, there are two differences with CDP-PBPs: first, the raw and scaled output files contain several additional channels, second, the PBP instrument generates an entirely new file, in .csv form, that contains particle-by-particle information.

Main Output File (0XCDP PBPYYYYMMDDhhmmss.csv)

DMT revised the CDP-PBP firmware in 2010 to implement a dynamic threshold feature in the instrument’s sizer signal. As a result of this modification, instruments manufactured after mid-2010 have two additional output channels, DT Bandwidth and Dynamic Threshold. In instruments without the dynamic threshold feature, these channels are spares. In addition, another update to the CDP-PBP hardware resulted in changes to the CDP-PBP default housekeeping channels. Thus different CDP-PBPs may have different standard output channels.

A list of CDP-PBP default channels for a 30-bin CDP-PBP appears below. In cases where default channels may differ, the channels appear in italics and both options are listed. Since it is possible to rename channels in the Configuration Editor, your list may look different from either of the lists.

The CDP-PBP 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-PBP Selectable Charts tab.

For definitions of the channels, consult *Appendix A: Definitions* in the *PADS Overview Manual*.

End Seconds	<i>Sizer Baseline (V) / Laser Photodiode Monitor</i>
Day of Year	<i>Qualifier Baseline (V) / Wingboard Ground</i>
Year	+5V Monitor (V)
Status	<i>Control Board T (C) / Digital Ground (V)</i>
DOF Reject Counts	Spare 1 - 8
Avg Transit Reject	Number Conc (#/cm ³)
Avg Transit	LWC (g/m ³)
<i>DT Bandwidth / unused</i>	MVD (um)
<i>Dynamic Threshold / unused</i>	ED (um)
ADC Overflow	PBP_Avg_IPT (msec)
Laser Current (mA)	PBP_IPT_STD (msec)

Dump Spot Monitor (V)	Applied PAS (m/s)
Wingboard Temp (C)	CDP Bin 1 - 30
Laser Temp (C)	CDP IPT Bin 1 - 28
	GPS Time / UTC Seconds

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

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

CDP-PBP channels fall into several broad categories:

- Time channels
- Bin channels, which store data on the number of particles of different sizes that the CDP-PBP has detected
- Housekeeping channels (see below)
- Particle statistics such as the number of rejected particles, the particle number concentration, etc.
- Probe statistics
- Unused channels (e.g., Spare 1 - 8)

Housekeeping Channels:

Many of the probe statistics are stored in “housekeeping channels,” a term that refers to sensor data gathered by the A/D. The CDP-PBP has 8 A/D housekeeping channels that have a 0-5 V range measured by a 12-bit A/D converter that gives integer values from 0 to 4095. Several of these channels store data that indicate whether the probe is functioning properly. A complete list of default housekeeping channels is given below. In cases where channels differ for different versions of the instrument, the defaults for the current version are presented first. Default channels can be changed from the Config Editor screen, although it is recommended you contact DMT before doing so.

Laser Current (mA)	Sizer Baseline (V) / Laser Photodiode Monitor
Dump Spot Monitor (V)	Qualifier Baseline (V) / Wingboard Ground
Wingboard Temp (C)	+5V Monitor (V)
Laser Temp (C)	Control Board T (C) / Digital Ground (V)

PBP Output File (0XCDP PBPYYYYMMDDhhmmss_PBP.csv)

The PBP output file contains six channels for every particle observed in the particle-by-particle analysis:

Time Stamp
Size [counts]
IPT [msec]
PADS Time
Time Counter
raw ipt

Two additional channels, **Date** and **Time**, may be listed after **GPS Time/ UTC Seconds** if **Write Date & Time Stamp** is enabled on the **Setup** tab. See the previous section for details.

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: Inter-Particle Time (IPT) Calculations

The CDP-PBP instrument does not return IPTs 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 IPTs from these times as follows. For each particle, the program first calculates the **Time Stamp** 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. (The **Time Stamp** channel is stored in the PBP file, not in the main output file.) **IPT** is then derived by subtracting the **Time Stamp** of the previous particle from that of the current particle.

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

3.1 Sample Time Settings that Ensure Correct IPTs

The 20-bit serial-data times have a resolution of 1 μsec , so a maximum time of $2^{20} * .001 \text{ msec} = 1049 \text{ msec}$ 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.)

3.2 NaN Results in IPT Channel

If one sampling instance has more than 256 observed particles, the **IPT** 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** for the first particle in the first data packet can be a valid **IPT** 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** 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 IPTSTD (msec)**.

Appendix C: Revisions to Manual

This document replaces DOC-0192, the *CDP-PBP PADS Operator Manual* for PADS version 2.X.

Rev. Date	Rev. No.	Summary	Section
3-13-11	B	Added Table 1	1.3.4
10-13-11	B-1	Changed “DT Noise Band” channel to “DT Bandwidth”	Appendix A