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

**DOC-0278, Rev A-1**

**PADS 3.5.0, CDP Module 3.5.0**



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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 (CDP) 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 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 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.

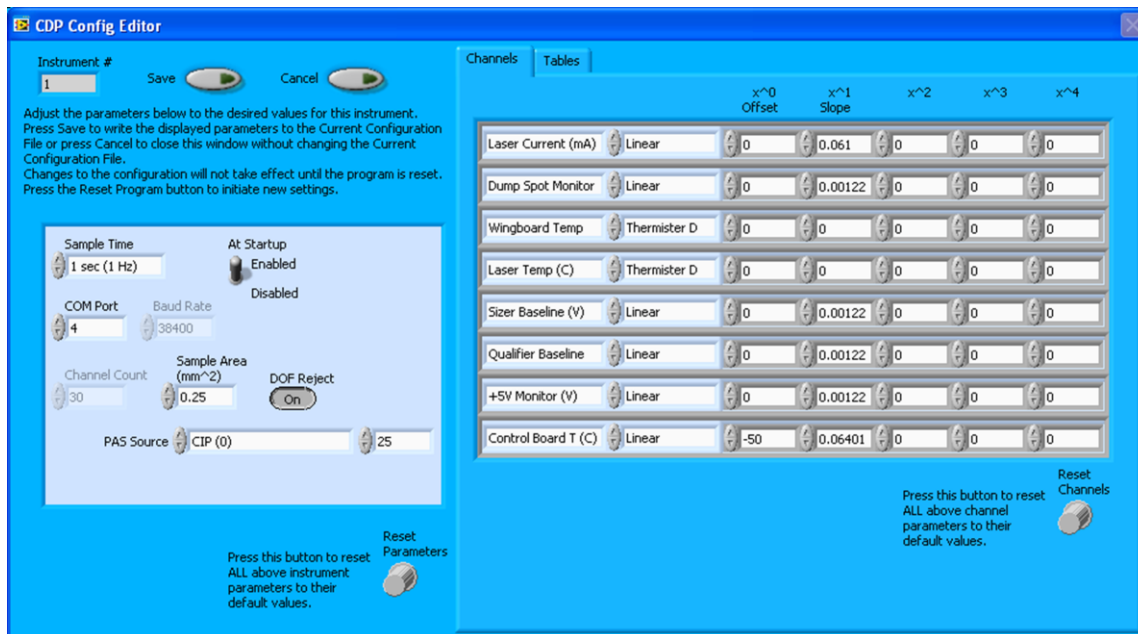


Figure 1: CDP Configuration Editor Window. The left side of the window contains parameters for the instrument. The tables on the right side contains information on CDP channels and bin thresholds.

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 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 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 Parameters

**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.

**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  $\mu\text{m}$  during the first sample, and five particles of this size during the second sample. If you had set your sample time to one second instead of .5 seconds, you would instead get one sample that showed nine particles of size 25  $\mu\text{m}$ . *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 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. 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 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 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 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 whether to reject particles that fall outside the CDP’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: Definitions* 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, 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 “4<sup>th</sup> 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. “4<sup>th</sup> 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 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 to bin particles according to size. **Bin 1 Lower Thresh.** lists the lower size limit in  $\mu\text{m}$  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 Display

To configure the CDP display, click on the CDP 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.

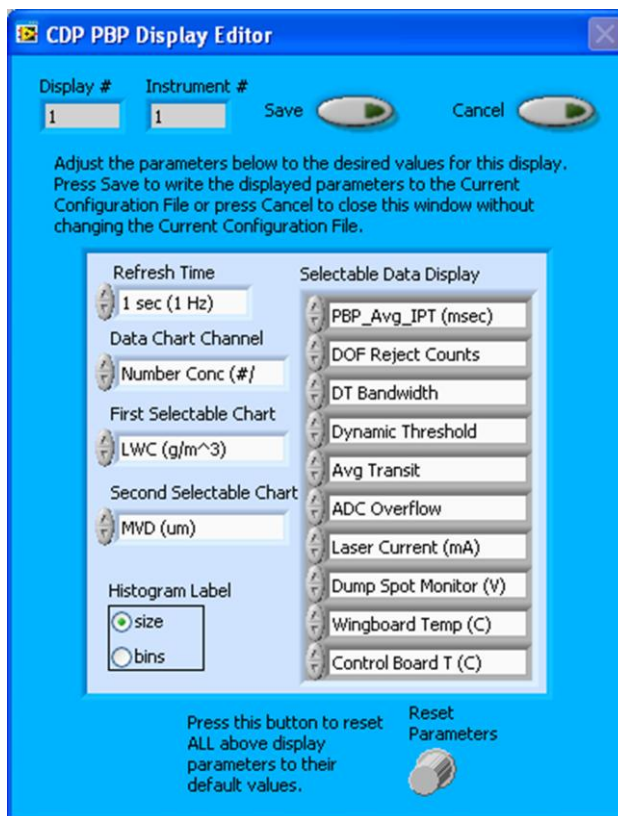


Figure 3: CDP Display Editor Window

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 ( $\mu\text{m}$ ) or bin number.

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

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

When you are done configuring the CDP 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 Window

Figure 4 shows the CDP window.

The different parts of the CDP 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*.

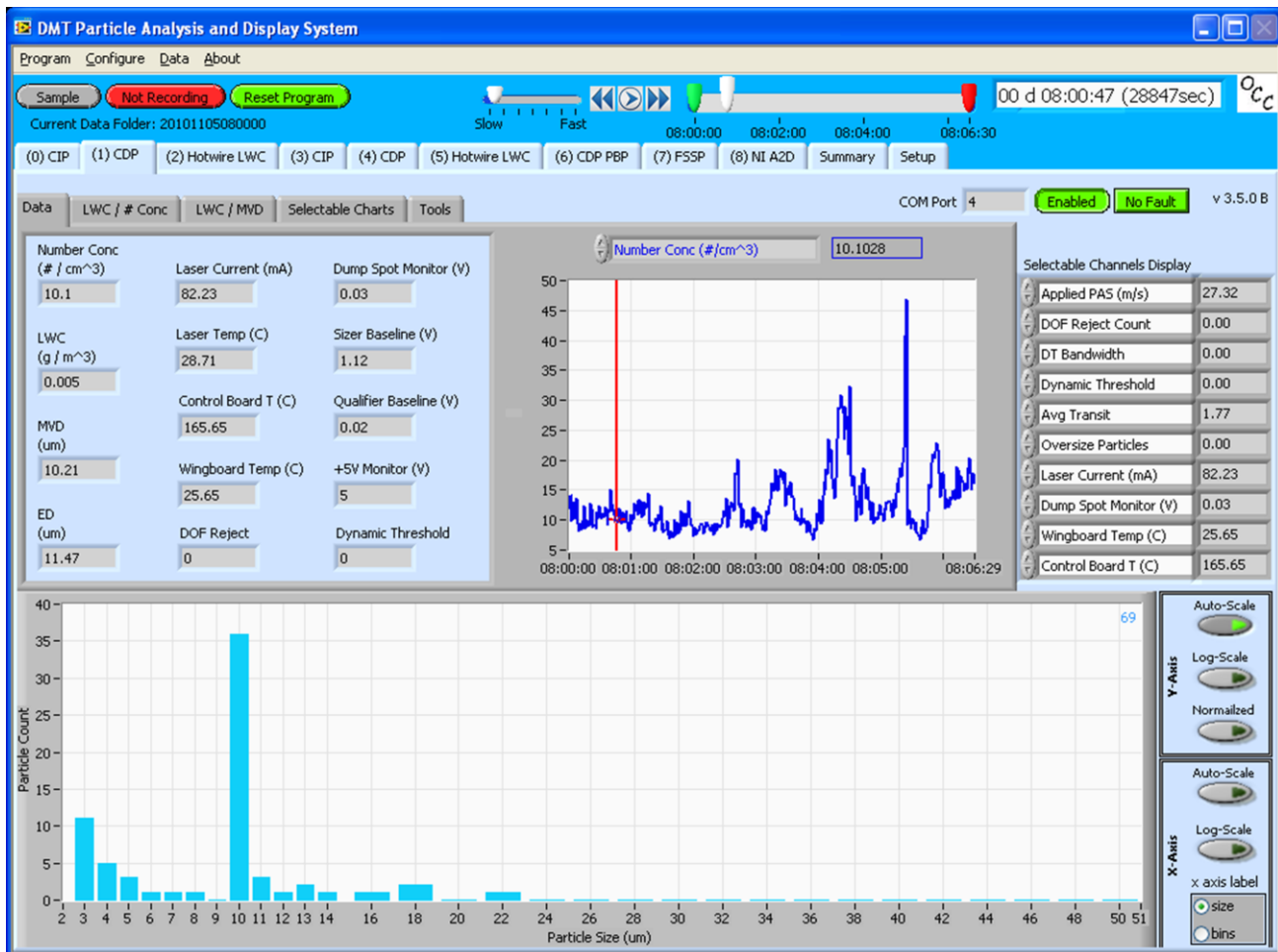


Figure 4: CDP Window

## 2.3 CDP Tabs

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

### 2.3.1 Data Tab

The **Data** tab displays the current values for many of the CDP 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.

### 2.3.2 LWC / # Conc and LWC / MVD Tabs

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

### 2.3.3 Selectable Charts

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.

### 2.3.4 Tools Tab

The **PAS Source** control specifies from which of the following sources the system should obtain the applied probe air speed (PAS):

- 3.) A specific instrument in the system (this can be any instrument capable of measuring air speed)

- 4.) A manually entered value:
  - c. 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.
  - d. 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 3 Overview Manual*.

## 2.4 Histogram Data Window

Below the CDP sub-tabs is the histogram display of CDP-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  $\mu\text{m}$  for each bin is displayed at the top of the histogram bars.

On CDPs with thirty bins, the first sizing bin typically includes all detected particles 2-3  $\mu\text{m}$  in size. The next bin holds particles of size 3-4  $\mu\text{m}$ , the next bin particles 4-5  $\mu\text{m}$ , and so on, until particles reach 13  $\mu\text{m}$ . At this point, the width of the bin doubles, so that bin 14 holds particles of size 16-18  $\mu\text{m}$ , bin 15 holds particles 18-20  $\mu\text{m}$ , 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  $\mu\text{m}$ , 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  $\mu\text{m}$ .

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 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.

## 2.5 Selectable Data Display

The upper right of the CDP 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 Display Editor (select **Configure > Configure Display**).

## Appendix A: CDP Channels

DMT revised the CDP 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 hardware resulted in changes to the CDP default housekeeping channels. Thus different CDPs may have different standard output channels.

A list of CDP default channels for a 30-bin CDP 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 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 Overview Manual*.

End Seconds	Laser Temp (C)
Day of Year	<i>Sizer Baseline (V) / Laser Photodiode Monitor</i>
Year	<i>Qualifier Baseline (V) / Wingboard Ground</i>
Status	+5V Monitor (V)
DOF Reject Counts	<i>Control Board T (C) / Digital Ground (V)</i>
Avg Transit Reject	Spare 1 - 8
Avg Transit	Number Conc (#/cm <sup>3</sup> )
<i>DT Bandwidth / unused</i>	LWC (g/m <sup>3</sup> )
<i>Dynamic Threshold / unused</i>	MVD (um)
ADC Overflow	ED (um)
Laser Current (mA)	Applied PAS (m/s)
Dump Spot Monitor (V)	CDP Bin 1 - 30
Wingboard Temp (C)	GPS Time / UTC Seconds

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. GPS Time is reported if there is an instrument on the system that reports GPS Time; otherwise, this channel is UTC Seconds.

CDP channels fall into several broad categories:

- Time channels
- Bin channels, which store data on the number of particles of different sizes that the CDP 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 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)

## Appendix B: Revisions to Manual

Rev. Date	Rev No.	Summary	Section
10-10-11	A-1	Specified that optional Date and Time channels appear after, not before, UTC Seconds/GPS Time channel	Appendix A
		Changed DT Noise Band channel to DT Bandwidth	Appendix A

This document replaces DOC-0177, the *CDP PADS Operator Manual* for PADS version 2.X.