

# **INSTRUCTION MANUAL**

**Model  
101A**

**DPID  
DigitalPID Data Acquisition and Control Program**

January 18, 2007

Program Version: 1.10

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## 1.0 Introduction

The 101A digitalPID Data Acquisition and Control Program (DPID) controls, calibrates, acquires and displays data from digitalPID model 100A photo ionization sensors. The software connects to the sensors via the PC COM port with a RS-232 to RS-485 converter. Up to 8 sensors can be connected to a single COM port by connecting them in a “daisy chain”.

DPID runs under Linux, a multitasking Unix-like operating system, which allows the acquisition PC to be networked to and controlled from other computers, and lets the operator run other programs while DPID is operating.

The DPID program requires an extended version of the Linux kernel called RTLinux in order to communicate with the digitalPID sensors, i.e., to provide real-time serial communications. Both RTLinux and the DPID program come installed, fully configured and ready to use on the DPID PC.

New program versions can easily be installed on the DPID PC using the installer program present on the PC desktop.

## 2.0 Logon Name and Password

When the 101A DPID PC starts you will be asked for a user name and password. Linux is case sensitive so enter the information as shown below.

User: dpid  
Password: dpid

For specific actions you may need to logon as superuser (this is equivalent to Administrator on a Windows PC). The superuser name and password are listed below.

Superuser: root  
Password: root

You can also become the superuser after logging on as dpid. This is done by opening an xterm and typing the following.

```
su  
Password: root
```

Note: if you change the root password (superuser password) there is no way for us to recover the password if you forget or loose it. Therefore please record the superuser password and store it in a safe place. Many users will elect to connect the DPID PC to a network. Neither the dpid password nor the root password are secure (a secure password should be a minimum of 6 characters containing letters and numbers and one special character (&, ^, \$, #, @, !) and also it should not contain recognizable words). If you intend to connect the DPID PC to a network ensure that you change the passwords to more secure ones.

## 3.0 Quick Start Guide

The software is pre-installed on the DPID PC. Attach the keyboard, mouse (attach the mouse to the PS2 mouse port not to a USB port) and a monitor to the PC. The Linux operating system has been configured for a monitor with a resolution of 1024x768.

Attach the RS-232 to RS-485 converter to COM Port 1 of the DPID PC. Run a single pair cable (22 AWG twisted pair wire is sufficient for runs up to about 4000 feet, Belden 8451 or equivalent) from the converter to the first digitalPID sensor in the line. Connect one conductor of the cable (we suggest using the red wire) to the terminal labeled “B” on both the RS-485 converter and the digitalPID connector. Likewise connect the other conductor (usually the black wire) to the “A” terminal on the converter and on the sensor.

Attach the sensor power wires to a 12 volt battery (we recommend using a sealed lead-acid battery such as a Panasonic LC-RA1212P which has a nominal voltage of 12 VDC and a rated capacity of 12Ah). Connect the red alligator clip to the positive (+) terminal and the black clip to the negative (-) terminal.

## 3.1 Starting the DPID Program

Plug the PC power supply cable into an appropriate AC power source and plug the 12-volt PC power cable into the connector located on the back of the DPID PC. Turn on the PC and login as `dpid` with the password `dpid`. Note: Linux is case-sensitive so ensure you use lowercase when entering the username and password.

```
Username: dpid  
Password: dpid
```

Once you are logged on a Windows-like desktop should appear with a task bar at the bottom of the screen and several icons located on the desktop. A typical desktop is shown in Figure 1. The most frequently used icons will be the *rundpid* icon, the *data* icon, the *Flash* icon, the *Trash* icon and the *xterm* icon. In addition to the icons on the desktop you will also note a series of icons at the bottom of the screen and a taskbar to the right of these icons. The taskbar shows the current Windows that are open and provides a simple method of switching between the Windows. Simply click on the taskbar item that you want to switch to and that Window will become the current and top Window. The most frequently used icon at the bottom of the screen is the *K* icon at the far left of the screen. The *K* icon is similar to the Start button in Windows 9x/2000/XP and provides access to programs and also allows you to shut down the computer properly. Just like Windows, Linux must be shut down properly since the file system is updated during the shutdown procedure.

Once the DPID PC finishes the login process you will see an icon on the Desktop labeled *rundpid* (see Figure 1). This icon executes the command

`/dpid/bin/dpid dpid.cfg dpid.cal dpid.set`

which starts the DPID program using the configuration file `dpid.cfg`, the calibration file `dpid.cal` and the settings file `dpid.set`. All of these files are stored in the `/home/dpid/data` directory.

The software is used to calibrate, control and take data from up to 16 digitalPID gas sensors. Ensure that the sensors are attached and powered before issuing control commands with the DPID program.

The DPID Setup screen is a window that can be repositioned and minimized but its size can not be altered. The DPID screen is set to 800x600 pixels. On higher resolution monitors the DPID setup main screen will appear smaller than on lower resolution monitors. We suggest using a screen resolution of 1024x768. The program can operate at either higher or lower resolutions however the program should not be run at a screen resolution of less than 800x600. The Linux desktop and all program windows use normal Windows-type controls for manipulating the display windows.

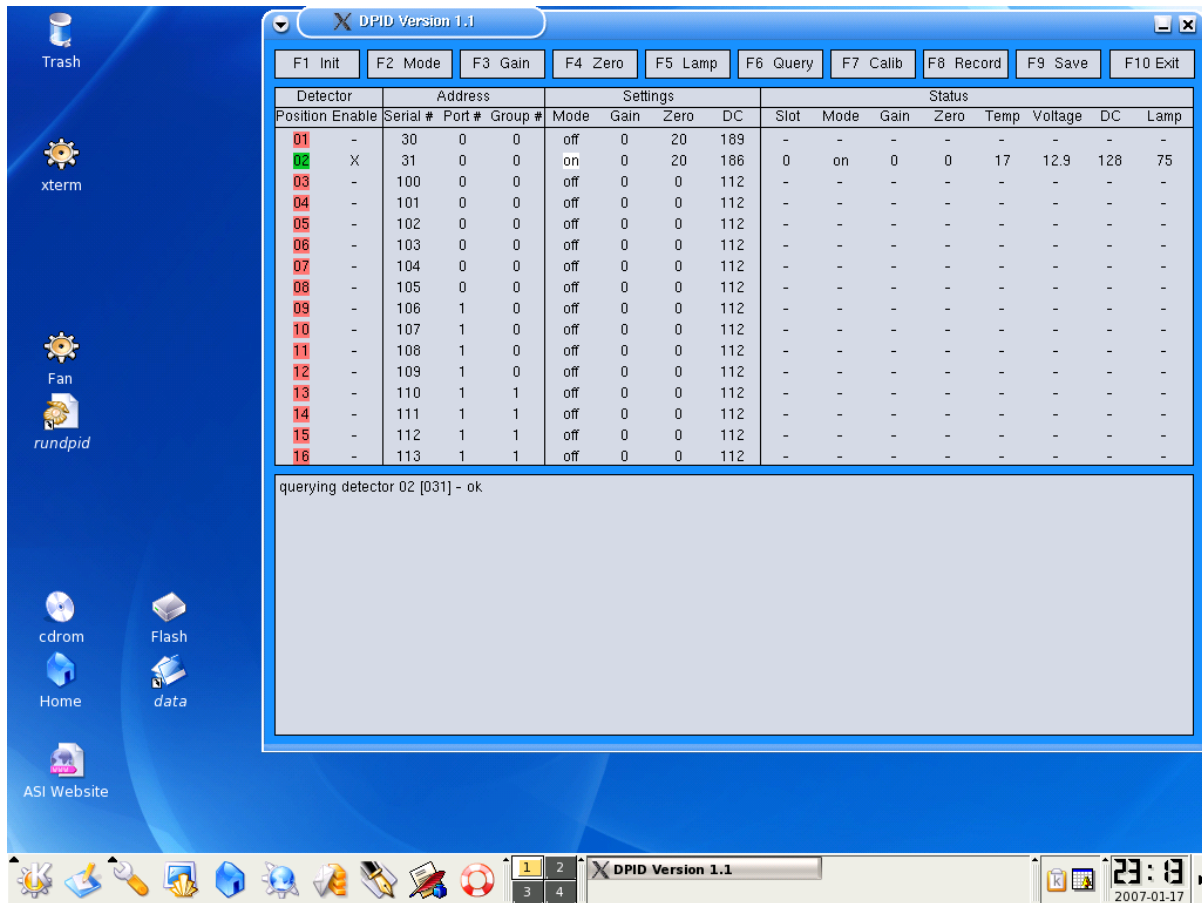


Figure 1 DPID PC Desktop with DPID Setup Screen Open

When the program starts the main window will open showing the DPID Setup screen (Figure 2). This screen can be divided into 3 main areas. The first is the Function key buttons located at the top of the screen. These buttons are used to issue commands to the detectors, switch to the Calibration or Recording Menu, or exit the program. The second area is the parameter array which is located in the middle of the screen. The parameter array is divided into four sections: Detector, Address, Settings, and Status. Parameters are read from the configuration file and are displayed in the first three sections of the array, while the actual status of the detectors is shown in the last section. The final area is at the bottom of the window and it is used for status messages.

To navigate through the array the user can use the mouse or the cursor arrow keys. To modify a parameter in the array the left mouse button will decrease the quantity while the right mouse button will increase the quantity. The keyboard can be used as an alternative to the mouse. When using the keyboard the + and - keys are used to increase or decrease the quantity. The spacebar will cycle through the available options for a quantity or it will increase the selected quantity. The = key will cause the parameter under the cursor to be made equal to the selected value for all detectors.

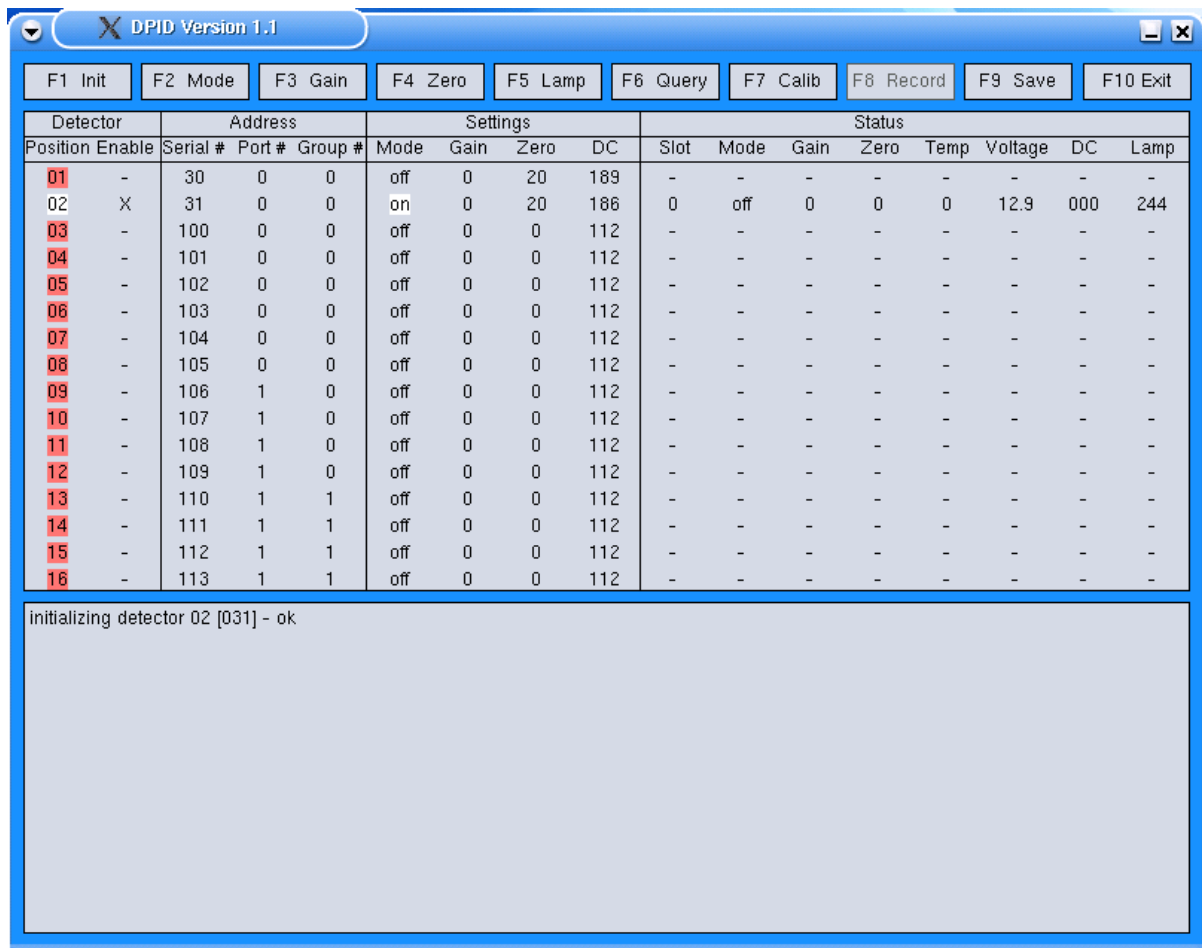


Figure 2 DPID Setup Screen



## 3.2 Step by Step Quick Start Guide

The following is a condensed description of the program's use and is intended only to give the user an idea of the order of operations required when controlling a digitalPID sensor.

- 1) Start the DPID control program. The cursor control keys or the mouse are used to move the cursor throughout each menu and the + and - keys or the mouse left and right buttons are used to change the settings.
- 2) Enable the sensors that you want to use. Serial numbers are used for identifying each sensor. If the correct serial numbers are not present in the Serial # column under the Address heading then use the arrow keys to highlight the serial number entry of interest and then use the + or - keys to change the number.
- 3) Set the operating mode of the sensors. The options for operating mode are off, idle and on. Off powers off the pump, lamp and the analog to digital (A/D) converter but leaves the micro on in a low-power state. The idle setting turns on everything but the pump. This setting is useful if the sampling pump needs to be shut off due to the temporary presence of a dust cloud or a strong contaminant cloud that you don't want to be drawn into the sensor. The On setting turns everything on in the sensor.
- 4) Set the gain for the sensors. The possible gain settings are 0, 1, 2, and 3. Note: in most cases the lowest gain setting is the best one to use as it provides the lowest noise setting and because we use an 18-bit A/D converter this means that the sensor's background noise can be resolved even on this lowest gain setting.
- 5) Issue an Init command (F1). This command initializes the sensors and places them in a known state. This command must be the first command issued to the sensors after they are powered.
- 6) Set the mode parameter to on and then issue a mode command (F2) to turn the sensors on. This will light the UV lamp and start the sample pump. Note it may take up to 2 minutes for the lamp to light and then a further minute or so for the lamp brightness to be adjusted. If the lamp does not light within several minutes then the software will automatically shut the sensor off. This feature is included to prevent damage to the lamp circuitry. Note: sometimes it can take two or three "on" commands before the lamp lights.
- 7) Issue a gain command (F3) to set the gain.
- 8) Allow the sensor to warm up for at least 30 minutes before taking data.
- 9) After warm up ensure that the sensors are drawing clean air and then issue a zero command (F4) to zero the sensor. The zero command is intended to drive the output of the sensor to a pre-set "offset" level. Since the sensor's output tends to drift down over time, the offset ensures that the sensor output remains above zero. The number under the ZERO column of the SETTINGS section of the SETUP menu controls the amount that the signal is offset above zero. The valid range is from 0 to 255 where the sensor offset (in A/D levels) will be 64 times the number listed in the ZERO column. Typical offset values range from 50 to 100 (3,200 to 6,400 A/D levels). Note: the full-scale range of the sensor (measured in A/D levels) is 262,144 so an offset of 10,000 A/D levels or less doesn't represent a significant portion of the sensor's range.
- 10) At any time the operational status of the sensor can be determined by issuing a Query command (F6).

- 11) To view the sensor output and record data press the Record function key (F8).
- 12) The main function keys used in the Recording Menu (Figure 3) are: Enable (F2), Disable (F3) and Record (F4). Sensor output can be viewed in semi real-time (delayed by 4 seconds) by enabling the sensors. However this function only starts the transmission of data from the sensors to the computer and the plotting of that data on the screen, it does not record any data to disk.
- 13) In order to record data first enable the sensors (F2) then type in a data filename, the recording duration, and, if desired, a recording start time. Then press the F4 key to start logging data to disk. Note: if the Duration is set to 00:00:00 then the recording will run until the Abort key (F5) is pressed.
- 14) Recording will automatically finish when the recording duration is over or it can be terminated at any time by pressing the Abort key (F5). This key stops data recording and closes the data file. All data recorded up to the time of pressing the Abort key is saved.
- 15) To stop data transmission and plotting on the screen, press the Disable key (F3). If data logging is underway then the data logging must first be Aborted (F5) before disabling data transmission. To exit the Record menu press the Exit key (F11); note that the data transmission must be disabled before the Exit key will function.

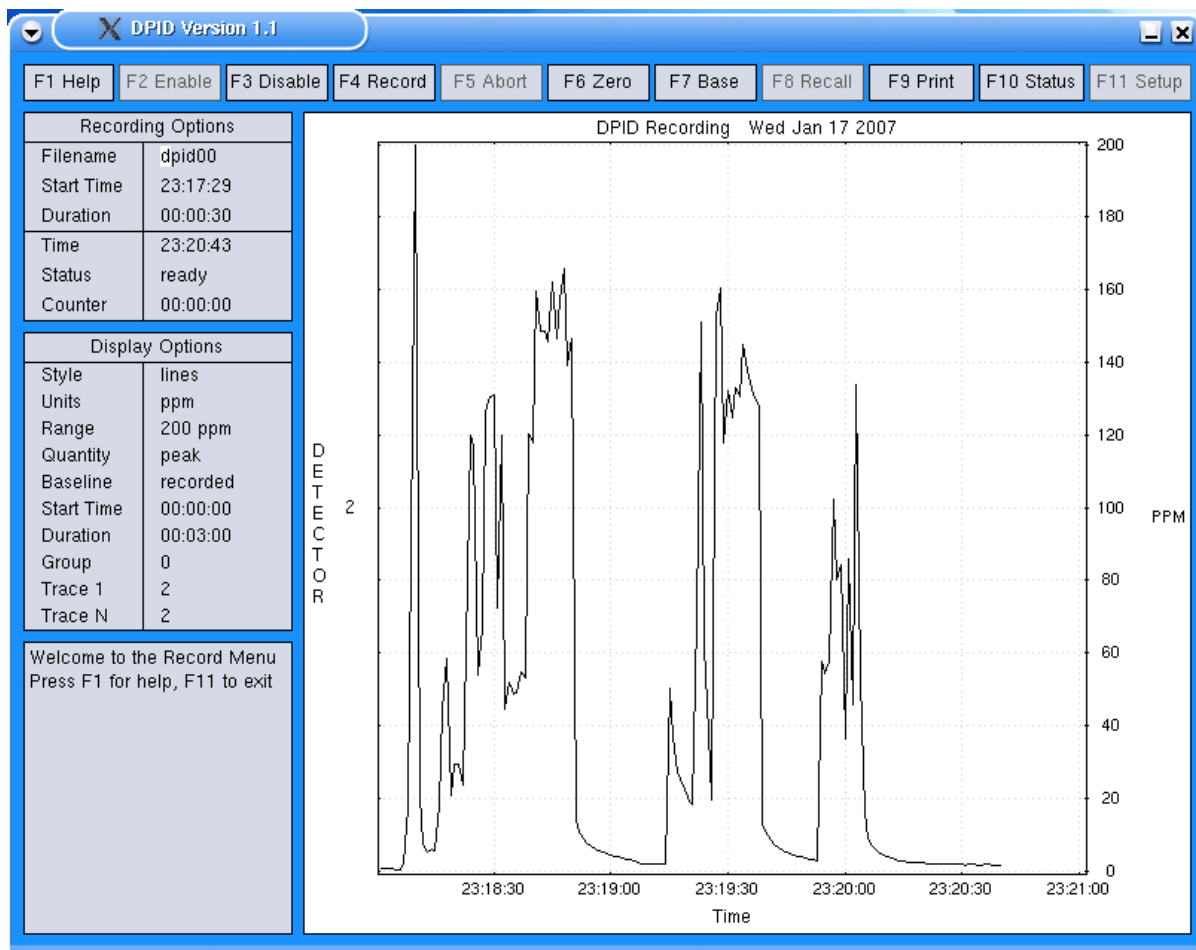


Figure 3 DPID Recording Screen

## 4.0 DPID Program

The DPID program consists of a Setup screen, a Data Recording screen and a Calibration screen. Section 4.1 describes the Setup screen, section 4.2 the Data Recording screen and section 4.3 the Calibration screen.

### 4.1 DPID Setup Screen

When the DPID program starts it:

- reads the configuration and calibration files;
- opens an 800x600 window for the Setup screen;
- opens the FIFOs (first in, first out) used to communicate with the RT serial driver;
- allocates a block of memory for internal data storage.

If an error occurs during initialization, the program issues an error message and aborts. Otherwise, it displays the Setup screen, as shown in Figure 4 below.

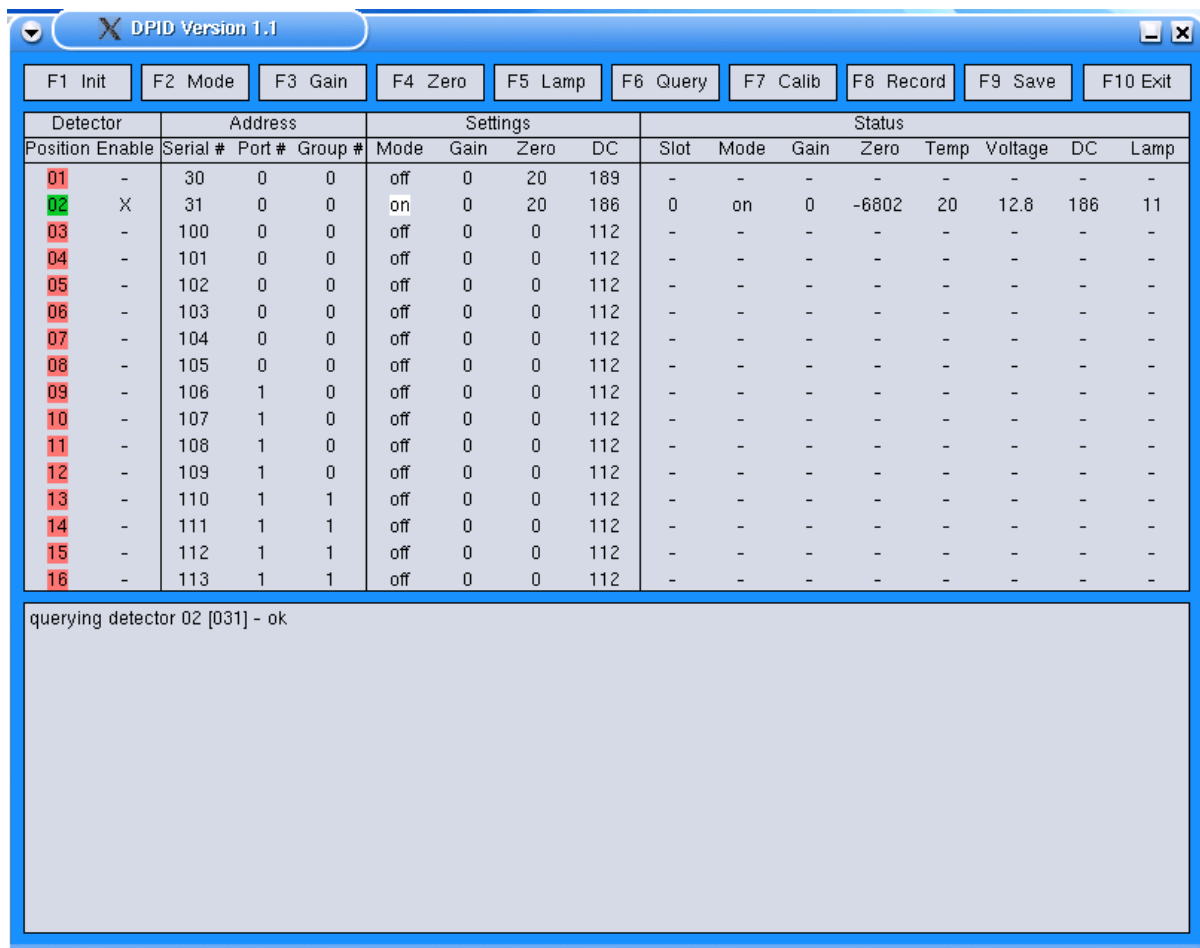


Figure 4 DPID Setup Screen

Function keys (shown at the top of the Setup screen) are used to issue commands to the detectors, switch to the Calibration or Recording Menu, or exit the program.

The parameter array in the middle of the screen is divided into four sections: Detector, Address, Settings, and Status. Parameters read from the configuration file are displayed in the first three sections of the array, while the actual status of the detectors is shown in the last section.

To navigate through the array the user can use the mouse or the cursor arrow keys. To modify a parameter in the array the left mouse button will decrease the quantity while the right mouse button will increase the quantity. The keyboard can be used as an alternative to the mouse. When using the keyboard the – and + keys are used to decrease or increase the quantity. The spacebar will cycle through the available options for a quantity or increase the parameter depending on which parameter is highlighted. The = key will cause the highlighted parameter to be set equal to the selected value for all detectors.

#### **4.1.1 Function Key Control Buttons**

The first six functions in the Setup Menu are used to issue commands to enabled detectors, while the last four are used to switch to a different menu, save the current settings, or exit the program.

When a command such as Init or Mode is issued, the program sends the command to each enabled detector, and waits for a response. If the program receives a valid reply, a query command is issued, and the status of the detector is displayed. If the program receives no response or an invalid response to the command or query, the detector's position number is drawn on a red background, and the numbers in the Status section are replaced by '-'.

##### **F1 Init**

Initialize all enabled detectors, place them in a known state (off), and assign transmission slot numbers. This command must be issued before others commands, apart from Quit, will operate.

##### **F2 Mode**

Turn the detectors off, on, or to idle (all system on except the sample pump).

##### **F3 Gain**

Set the gain, or full-scale range of the detectors.

##### **F4 Zero**

Zero the sensor output, and then offset the output by the specified number of D/A levels (number of D/A levels of offset are equal to the Zero parameter x 64).

##### **F5 Lamp**

Maximize the brightness of the detector's lamp, and hence the sensitivity of the detector, by adjusting the duty cycle of the lamp's power supply. If the DC parameter is set

to 0 then an automatic lamp brightness routine will execute. This routine sweeps the lamp control voltage throughout its possible range and monitors the lamp output looking for the brightest lamp output. The DC value is then set to the value that results in the brightest lamp output. If the DC parameter is set to a specific, non-zero, number then the lamp control voltage will be set to this level regardless of the lamp sensor output.

### **F6 Query**

Query each detector and display the returned status (i.e., Slot, Mode, Gain, Zero, Temp, Voltage, DC and Lamp).

### **F7 Calib**

Switch to the Calibration Menu.

### **F8 Record**

Switch to the Record Menu.

### **F9 Save**

Write the current setup parameters to file dpid.cfg, or the configuration file used to start the program, overwriting the previous file contents.

### **F10 Quit**

Exit the program and return to the command prompt.

## **4.1.2 Control Parameter Information**

The parameter array in the middle of the screen is divided into four sections: Detector, Address, Settings, and Status. Parameters read from the configuration file are displayed in the first three sections of the array, while the actual status of the detectors is shown in the last section.

### **Position**

The position is a number from 1-16 which normally corresponds to the location of the sensor on the test grid, and is used in most files and drawings created by the program. The state of each detector is indicated by the background color of the position number, where:

- Red = disabled (i.e., unused) or unknown
- White = off
- Yellow = idle (i.e., in standby mode)
- Green = on (i.e., ready for recording, see Figure 4)

### **Enable**

This switch indicates if the detector is disabled (-) or enabled (x). Commands are only sent to enabled detectors; any unused detectors should be disabled.

### **Serial**

The detector serial number in the range from 1-254. The serial number is located on the back panel of the sensor.

**Port**

The serial port (0-7) the detector is connected to.

**Group**

The group number (0-7) assigned to the detector, used to control how channels are displayed.

**Mode**

The mode of the detector, i.e., off, idle, or on. The Mode, Gain, and Zero values are used when the corresponding command is issued, but do not necessarily represent the actual state of the sensor. The actual sensor state should be read from the Status area of the screen.

**Gain**

The gain setting of the detector, where 0=1000 ppm, 1=250 ppm, 2=62.5 ppm, 3=31.25 ppm full-scale range.

**Zero**

The desired sensor offset (0-255) after a zero command. The actual offset in D/A values is the zero value x 64.

**4.1.3 Status Information**

The Status area of the Setup screen shows the actual status of each enabled sensor. This information is automatically requested after the sensor commands Init, Mode, Gain, Zero, and Lamp. The information can also be obtained at any time by pressing the Query button.

**Slot**

The transmission slot number (0:7) of the detector.

**Mode**

The mode of the detector (off, idle, or on).

**Gain**

The gain of the detector (0:3).

**Zero**

The desired offset of the sensor's output.

**Temp**

The temperature within the detector measured in degrees C.

**Voltage**

Battery voltage measured in volts.

## DC

The duty cycle (0-255) of the circuitry that drives the lamp. In order to ensure accurate conversion of A/D levels to ppm it is important that the lamp duty cycle is set to the same value as used during the calibration. In addition the Lamp output (see next item) should be close or equal to the lamp output observed during calibration.

## Lamp

The detector's lamp output (0-255) measured in arbitrary units where the lower the number the brighter the lamp. Normally the lamp parameter should be less than 20 when the sensor is working correctly. Typical levels are 8 to 14. In order to ensure accurate conversion of A/D levels to ppm it is important that the lamp output be close to the same value during a test as it was during calibration. Therefore it is useful to record the Lamp output during calibration and compare it to this value before starting a data recording.

## 4.2 Data Recording Screen

The Data Recording screen consists of Function key buttons at the top of the screen, Recording Options and Display Options sections on the left side of the screen and a large graphing area on the rest of the screen (see Figure 5).

Function keys F1-F11 are used to enable or disable data transmission from the sensors, start or stop logging data, redraw the acquired data, etc.

The Recording Options window shows the name of the file data is logged to, the start time and duration of the recording, as well as the current time and program status.

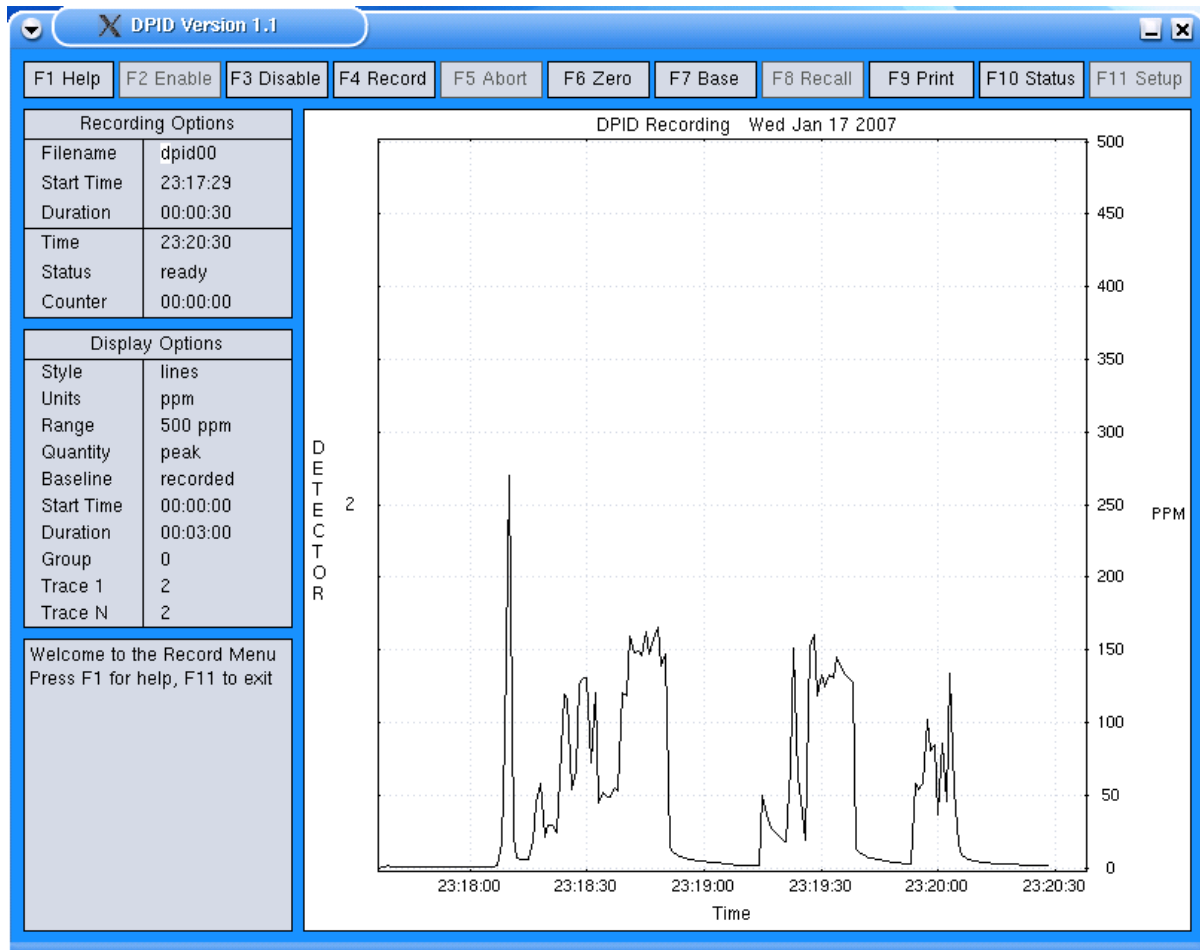
The Display Options window shows the settings used to display the data. Options include the style, range, and display units, the start time and duration, and the range of detectors to display.

The Message window shows the program's response or progress when a function-key is pressed. When tracing equipment problems, the Setup Menu should be used, as error messages in the Record Menu are rather terse.

The Display window shows a graph of the recorded data based on the settings in the Display Options window.

The program uses the same key strokes and mouse controls to move around and modify items in the Recording and Display Option windows as used in the Setup screen. In addition to the normal controls the Recording screen also uses:

[Delete]	delete the character under the cursor.
[A-Z, 0-9]	replace the character under the cursor.
[Enter]	redraw the data using the current Display Options.



**Figure 5 DPID Data Recording Screen**

## Overview of the Recording Process

When data transmission is enabled, measurements are transferred from the detectors to the PC at a rate of 50 samples per second. The data stream is block-averaged to 1 sample/second and stored in memory. The peak-value obtained during each 1 second interval of the data is also stored in memory. This allows the user to display either the 1 second average of the data or the peak value obtained each second.

Once the peak-value/block-averaged data is stored, it can be displayed on screen, in real or nominal time, and plotted. Missing or corrupt data is represented by red markers when displayed, as well as underflow or overflow data.

When data is logged to disk, it is recorded at the natural sampling rate of the detectors, i.e., at 50 samples per second. Two files are created when logging data: an ASCII header file and a binary data file. Data file format is described in section 5.4.

Recorded data (i.e., A/D levels versus time) are stored in the binary data file as signed 32-bit integers, in time-multiplexed order. Note that only the sensor output is stored not the



time. The header file contains the start time of the recording and data is stored at a rate of 50 samples per second per sensor. Missing or corrupt data is represented by negative A/D values, where:

- 1 = data overflow,
- 2 = data underflow,
- 3 = checksum error in the transmitted packet, and
- 4 = missing packet.

### **4.2.1 Function Key Control Buttons**

The Recording screen has eleven function keys at the top of the screen. These are used to control recording, zero, baseline offset control, reading stored files, printing, status and exiting to the Setup screen.

#### **F1 Help**

The Help function displays a basic help message in the Message window.

#### **F2 Enable**

The Enable function places the program in sampling mode, i.e., the program starts sending sync commands to the detectors at 4 second intervals and enables data transmission. When data starts arriving at the PC, the Status field in the Recording Options window changes from “idle” to “ready”. Note that the Enable function must be executed before any other functions, apart from Help, Recall and Setup, will operate.

#### **F3 Disable**

The Disable function is the complement of Enable; the program disables data transmission and stops issuing sync commands.

#### **F4 Record**

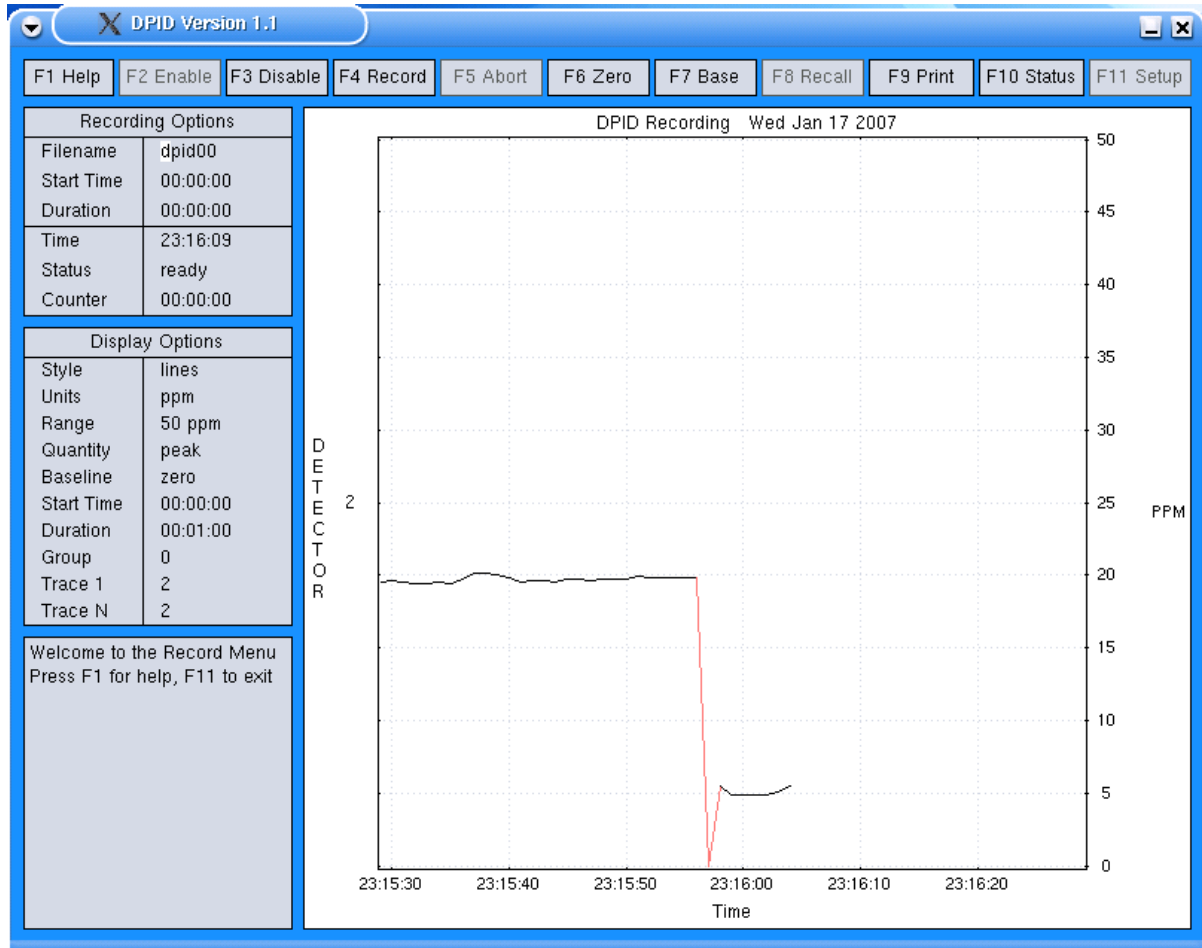
The Record function logs data to disk at the specified time.

#### **F5 Abort**

The Abort function terminates the data logging process and closes the data files. No data is lost when the Abort key is pressed.

#### **F6 Zero**

The Zero function zeroes the output of the sensors while data transmission is enabled. This function is similar to the Zero function in the Setup Menu, but it uses the offset value of the first enabled detector for all enabled detectors. Figure 6 shows the Data Recording display after the F6 Zero function key is pressed. The zero function works by first driving the A/D converter into an underflow state and then ramping up the output of the D/A converter until the desired A/D level is reached. During the Zero function the sensor output is monitored and the D/A output is steadily increased until the sensor output reaches 64 x specified Zero value. The red line corresponds to when the sensor output is driven to an A/D underflow and then ramped up to the desired offset.



**Figure 6 Data Recording Screen after F6 Zero Function**

### **F7 Base**

The Base function takes the last data packet, and records the mean A/D value for each channel. This baseline (or background) value can be removed from the displayed data using the Baseline setting in the Display Options menu, as described in section 4.2.3. This is useful for displaying small signals on a large baseline. Note this Baseline function is for display purposes only; it has no effect on the recorded data.

### **F8 Recall**

The Recall function reads and displays an existing data file (see Filename in section 4.2.3). In order to use this function, data transmission must be disabled.

### **F9 Print**

The Print function dumps an image of the display to the Postscript file ddd\_nnn.ps, where ddd is the name of the data file, and nnn is the plot number (000-999).

## **F10 Status**

The Status function displays recording statistics, such as the number of expected packets. A packet is a 4-second block of data, or 200 samples, the number of missing or corrupt packets, the number of A/D underflows and overflows, etc. The recording statistics are reset when data transmission is enabled or when data is logged to file.

## **F11 Setup**

The Setup function leaves the Record Menu and returns to the Setup Menu. Data transmission must be disabled before leaving the Record Menu.

## **4.2.2 Recording Options**

There are six fields in the Recording Options window: the first three, Filename, Start Time, and Duration, are set by the operator, while the remaining fields, Time, Status, and Counter, are generated by the program.

### **Filename**

The name of the file data will be logged to when Record (F4) is pressed; or the name of the file read and displayed when Recall (F8) is pressed. A unique filename must be entered in order to log data to disk, as the program will refuse to overwrite existing files. Do not use spaces or other special characters in filenames. Header information is written to (or read from) ddd.hdr, and sensor measurements (A/D values) are written to (or read from) ddd.bin, where ddd is the entered filename.

### **Start Time**

The time (hh:mm:ss) to start logging data to disk. If the Start Time equals 00:00:00 when Record (F4) is pressed, or if the Start Time is less than the current time, data logging begins immediately. Otherwise, the program waits until the specified time before logging data.

### **Duration**

The desired duration (hh:mm:ss) of the recording. If the Duration equals 00:00:00 when Record is pressed, data will be logged to disk until the Abort (F5) is pressed. Otherwise, data will be logged to disk for the specified time.

### **Time**

The current time, obtained from the system clock.

### **Status**

The current status of the program, that is:

- idle - the program is idle and data transmission is disabled.
- ready - the program is collecting data and is ready to record.
- waiting - the program is ready to record but is waiting for the specified Start Time.
- recording - the program is logging data to disk.
- flushing - the program has finished recording and is flushing the data buffers.

## **Counter**

The counter indicates the time remaining before recording begins, or the time since the recording began.

### **4.2.3 Display Options**

The settings in the Display Options window control the way that data is displayed. As noted earlier, the arrow keys, or mouse, are used to move around and modify the settings, while the Enter key redraws the data using the current settings.

#### **Style**

The drawing style, i.e., points, lines, bars, or contours. The first three styles are useful when displaying a few channels, while the last style is more appropriate for a large number of channels (see Trace 1 and Trace N below).

#### **Units**

The desired display units, available units are: A/D levels, voltage, or ppm. Data is converted from A/D levels to ppm using the calibration constants, as described in section 5.2, and from A/D levels to voltage assuming 262,144 A/D levels equal 10 volts.

#### **Range**

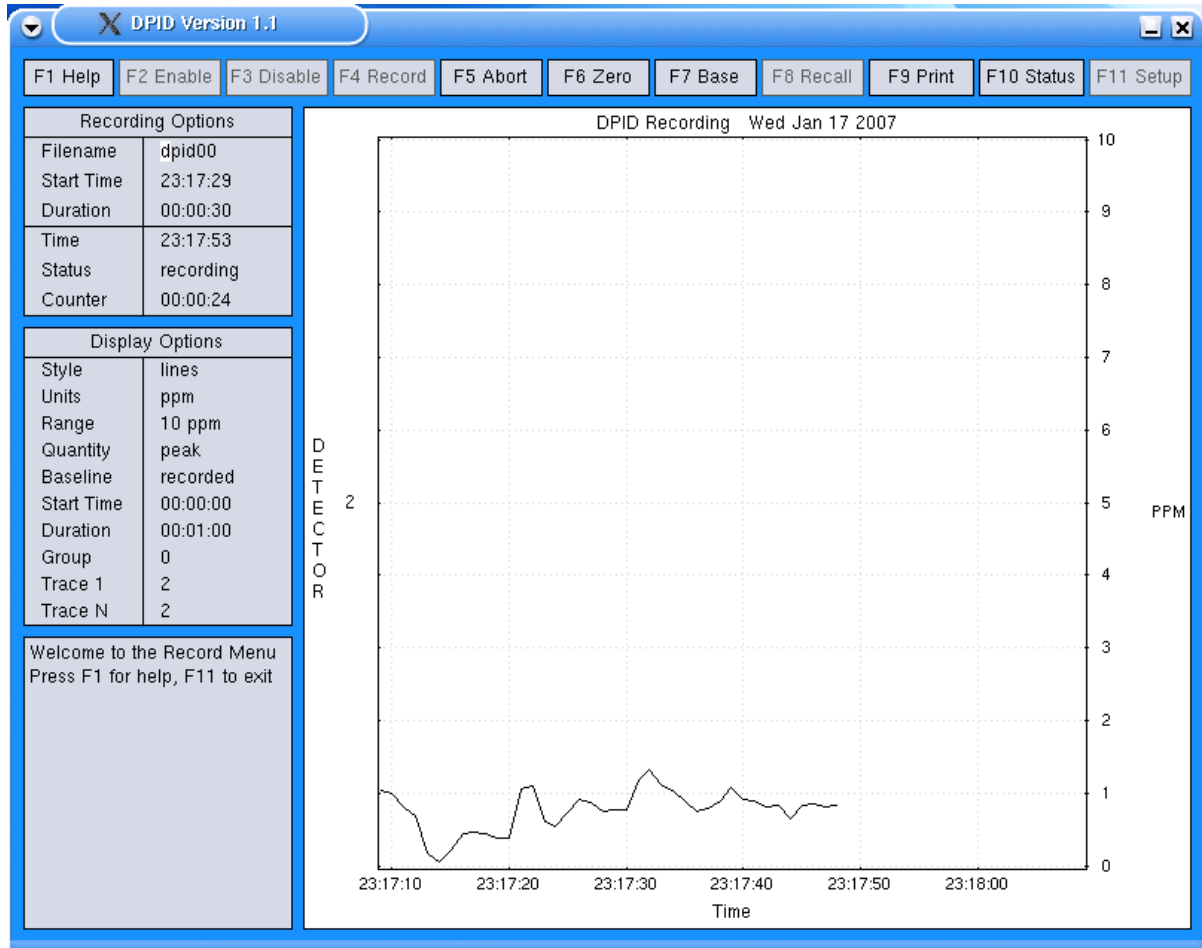
The full-scale range of the displayed data.

#### **Quantity**

The quantity to display, choices are: peak or block-averaged values.

#### **Baseline**

The baseline value subtracted from all measurements before they are displayed, choices are: zero (i.e., no baseline correction) or recorded (baseline correction is applied before displaying the data). If the baseline A/D values of the sensors were previously recorded using the Base command, they are subtracted from the displayed data when Baseline is set to recorded. Comparison of Figures 6 and 7 show the effect of the Baseline function. In Figure 6 the output is seen to be about 5 ppm after the zero function and the Baseline value is set to zero. In Figure 7 the Baseline value is set to recorded and the 5 ppm offset is subtracted from the signal to yield a signal that is plotted as less than 1 ppm.



**Figure 7 DPID Recording Showing the Effects of F7 Base and Baseline = Recorded**

### Start Time

The time of the first sample to display, this is the origin of the time-axis. If the Start Time equals 00:00:00, then the time axis scrolls, i.e., only the most recent data is displayed. All data from the time when data transmission was enabled can be viewed by setting the Start Time and Duration appropriately.

### Duration

The amount of data to display, i.e., the length of the time-axis.

### Group

The group number (0-7) to display. Each detector is assigned a group number in the Setup Menu and when the group number is non-zero then only the detectors in the selected group are displayed.

### Trace 1

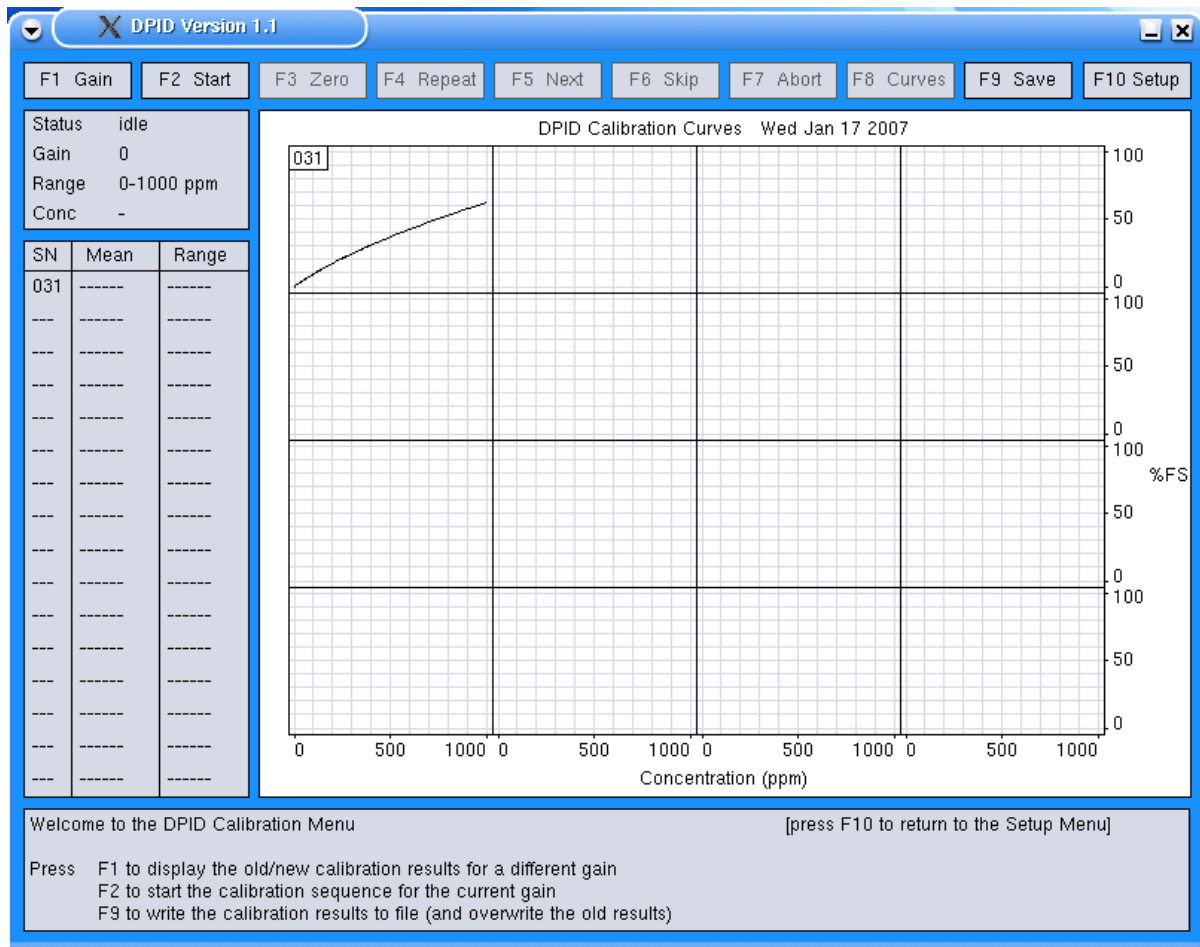
The first detector number (1-16) in the current group to display.

## Trace N

The last detector number (1-16) in the current group to display. The Trace commands allow the data from any number of sensors to be shown regardless of the number of sensors enabled. For instance if 16 sensors are enabled then if Trace 1 is set to 1 and Trace N is set to 16 all 16 sensors will be plotted. However if Trace 1 is set to 2 and Trace N is also set to 2 then only the second sensor will be plotted.

## 4.3 Calibration Screen

The Calibration screen consists of Function key buttons at the top of the screen, status information in the top left corner, sensor serial number, mean and range data table on the left side and calibration curves on the right. At the bottom of the screen is information on how to use the calibration menu (see Figure 8).



**Figure 8 DPID Calibration Screen**

Function keys F1-F10 are used to select the gain, start a series of calibration measurements, display and save the results, etc. The Status window at the top-left corner of

the screen shows the program status, the current gain setting and range, and the current calibration-gas concentration. The Mean/Range window displays the mean-value and range, in A/D levels, of the last measurement obtained during a calibration sequence. The Message window at the bottom of the screen shows the program's response or progress when commands are executed. It also displays prompts to assist the user as the calibration measurements are made. The Main window is a 16-channel display of either the last calibration measurement (i.e., A/D level vs. time) or the derived calibration curves (i.e., A/D level vs. concentration).

As noted in Sections 5.2 and 5.3, calibration information is stored in two files: `dpid.set`, which describes the calibration unit and type of measurements to perform, and `dpid.cal`, which contains the calibration constants and the measurement error.

The assumed relationship between sensor output and concentration is:

$$C_{\text{ppm}} = A_g * \text{ADU} + B_g * \text{ADU}^2$$

where ADU is the sensor output (or A/D level) after the baseline signal is removed,  $A_g$  and  $B_g$  are the calibration constants of the sensor at gain setting  $g$ , and  $C_{\text{ppm}}$  is the estimated concentration.

For practical reasons, the program uses the approximation

$$C_{\text{ppm}} = A_g * \text{ADU}$$

for displaying data on screen in ppm units (Section 4.2.3).

To determine  $A_g$  and  $B_g$  at a particular gain setting, the program measures the output of each sensor ( $C_{\text{adi}}$ ) over a range of concentrations ( $C_i = C_1, C_2 \dots C_N$ ), removes the baseline signal ( $C_{\text{ad0}}$ ), then finds the best-fit quadratic to the measurements, from which  $A_g$  and  $B_g$  are derived.

The mean-absolute error (labeled  $E_g$  in the calibration file) is found by comparing the predicted concentration ( $C_{\text{ppm}}$ ) with the actual concentrations ( $C_1, C_2 \dots C_N$ ), i.e.,

$$EI = \frac{1}{N} \sum_{i=1}^N |A_g \cdot C_{\text{adi}} + B_g \cdot C_{\text{adi}}^2 - C_i|$$

When the calibration constants at one gain are found, the program also calculates the corresponding constants at higher gains, using the relative gains in the calibration file. This shortcut should be accurate, since the relative detector gains (1, 4, 16, and 32) are digitally controlled. However, the user has the option of performing the measurements at each and every gain setting, or of letting the program estimate the results at higher gains.

### 4.3.1 Function Key Control Buttons

When the Calibration Menu is first displayed, the only enabled functions are Gain, Start, Save and Setup. The remaining functions (Zero through Curves) are only enabled during or after a calibration measurement starts.

#### **F1 Gain**

The Gain function selects the gain setting (0-3) for the next set of measurements, and displays the calibration curves for the selected gain.

#### **F2 Start**

The Start function begins a calibration sequence at the selected gain. This function is fairly automated; the program takes care of most details, and only prompts the user when necessary. In more detail, the Start function:

1. Sets the gain of the detectors to the desired level, and purges the calibration unit for  $t_{\text{purge}}$  seconds
2. Sets the calibration-gas concentration to 0 ppm
3. Records for  $t_{\text{rec}}$  seconds, then computes and displays the mean and range of a/d levels for each detector
4. Enables the relevant function keys and prompts the user to accept the measurement, repeat or skip it, etc. If the measurement is accepted or skipped, the program moves on to the next concentration in the sequence and repeats step 3.

When the sequence is finished or aborted, the program purges the calibration unit and re-enables the Start function-key. As measurements are taken, the F8 key can be used to show the raw data (A/D level versus time) or the results (relative sensor output versus concentration). After 3 or more complete measurements, the program also computes the best-fit quadratic to the measurements and displays the resulting curves (red) along with the point measurements (red markers) and original curves (black).

For manual calibrations where an automated calibrator is not being used then the user can disregard the purge commands. In addition the gas concentrations will need to be manually set by the user. Since the program will automatically take data for each concentration setting it is important that this first measurement be ignored and the measurement repeated after the concentration flow has been set and then has stabilized. In practice this means that after the user issues a F5 Next command the F4 Repeat command will need to be issued several times until the sensor output stabilizes. Once a stable reading has been obtained then the user can press F5 Next to continue to the next concentration. The program will display this concentration and then the user can adjust the manual calibrator to deliver the required concentration. Then the measurement will need to be repeated several times until a steady reading is once again achieved.

#### **F3 Zero**

The Zero function issues a zero command to all enabled detectors. This function is only enabled when the gas concentration equals 0 ppm.



#### **F4 Repeat**

The Repeat function repeats the measurement at the current concentration, and discards the previous measurement. The Space key can be used in place of F4 to repeat a measurement.

#### **F5 Next**

The Next function saves the last measurement, and moves on to the next concentration in the sequence. The Enter key can be used in place of F5 to save a measurement.

#### **F6 Skip**

The Skip function discards the last measurement, and moves on to the next concentration in the sequence. Note that all measurements in the sequence will be discarded if there are less than 3 complete measurements when the sequence is complete.

#### **F7 Abort**

The Abort function discards the last measurement, purges the calibration unit, and terminates the calibration sequence. If there are 3 or more complete measurements at the time, the program finds the best-fit curve to the measurements.

#### **F8 Curves**

The Curves function toggles the main display between calibration measurements (A/D level versus time) and calibration curves (relative A/D level versus concentration). Graphs of the calibration curves contain:

- a black curve showing the detector response (relative A/D level versus concentration) using the calibration constants stored in file dpid.cal
- a red curve showing the detector response using the constants derived from the latest set of measurements (i.e., since entering the Calibration Menu).
- red markers showing the latest set of measurements.

#### **F9 Save**

The Save function writes the calibration results to file dpid.cal, or the calibration results file used to start the program, overwriting the previous contents of the file. It is a good idea to copy the current dpid.cal file to another file name prior to commencing a calibration.

#### **F10 Setup**

The Setup function leaves the Calibration Menu and returns to the Setup Menu. Note that the new set of calibration constants, if any, will be discarded unless the results are saved (F9) before pressing the F10 Setup key.

## 5.0 DPID Files

### 5.1 DPID Configuration File

The DPID program uses a configuration file to store sensor settings. These settings are automatically recovered the next time the program starts. The configuration file is stored in the /home/dpid/data directory and it is called dpid.cfg. The contents of a typical configuration file are shown below.

```
/******
```

```
DPID Configuration File  
Created Tue Jan 16 17:09:52 2007
```

```
D    detector number (1:64)  
E    enable switch (0:off 1:on)  
SN   serial number (0:255)  
GN   group number (0:7)  
P    serial port number (0:7)  
G    initial gain (0:3)  
Z    initial zero offset (0:255)  
DC   initial lamp duty cycle (0:255)
```

```
D      E      SN      GN      P      G      Z      DC
```

```
*****/
```

```
1      1      29      0      0      0      20     189  
2      1      30      0      0      0      20     186  
3      0      100     0      0      0      0      112  
4      0      101     0      0      0      0      112  
5      0      102     0      0      0      0      112  
6      0      103     0      0      0      0      112  
7      0      104     0      0      0      0      112  
8      0      105     0      0      0      0      112  
9      0      106     0      1      0      0      112  
10     0      107     0      1      0      0      112  
11     0      108     0      1      0      0      112  
12     0      109     0      1      0      0      112  
13     0      110     1      1      0      0      112  
14     0      111     1      1      0      0      112  
15     0      112     1      1      0      0      112  
16     0      113     1      1      0      0      112
```

The dpid.cfg configuration file is an ASCII text file. The file may be edited to change configuration data but it must be saved as a text file and not as a word processor file. If the configuration file is to be edited on a Windows PC then use the Notepad program to do the editing, do not use Word to edit this file. The configuration file is only read by the program

on startup. Editing the file after the DPID program starts will have no effect on the DPID program until the next time the program is started.

The contents of the dpid.cfg file are as follows.

### **Header Information**

The header consists of the first seventeen lines. The first line identifies the file and the second provides the creation date and time. The rest of the lines in the configuration header are information lines explaining what the column headings mean.

### **Sensor Setup Table**

The sensor setup table is the remaining 16 lines in the file with one line per sensor. Each line consists of the following information.

#### **Detector Number (D)**

This is a simple sequential number of the sensors from 1 to 16.

#### **Enable Switch (E)**

This indicates whether this sensor should be enabled upon program startup or not. 1 = enable, 0 = disable. Enabling sensors that are not connected will result in very slow program operation as the communications functions will repeatedly attempt to contact all enabled sensors and will not continue with program execution until after the communications routine has timed out.

#### **Sensor Serial Number (SN)**

This is the serial number of the sensor as found on the sensor's back panel. The serial number is an integer value ranging from 1 to 254.

#### **Group Number (GN)**

This column determines which group each sensor should be placed in for plotting purposes. Different sensors can be placed in different groups and then the data from the sensors contained in a particular group can be displayed together.

#### **Serial Port Number (P)**

The serial port that each sensor is connected to must be specified under this heading. The legal range of serial ports ranges from 0 to 7 which corresponds to COM1 through COM8. (Version 1.10 of the DPID program has been configured to only connect to serial ports COM1 and COM2. Therefore the only available port numbers are 0 and 1). A maximum of 8 sensors can be connected to a single serial port.

#### **Initial Gain Setting (G)**

This is the sensor gain setting that the sensor will be switched to upon startup. The range is from 0 to 3 which corresponds to gain settings 1 through 4.

#### **Initial Zero Offset (Z)**

The initial zero offset is a number in the range of 0 to 255 which corresponds to the amount of zero offset that the sensor will be set to after issuing a Zero command.

### **Initial Lamp Duty Cycle (DC)**

This controls the brightness of the UV lamp inside the sensor. The duty cycle corresponds to the control voltage to the lamp circuit. The range is 0 to 255 and typical duty cycles for running a lamp are in the 180 to 210 range. When the sensor is turned on it will auto tune the lamp to the brightest setting. However since the calibration is affected by lamp brightness it is a good idea to record the lamp duty cycle that was set during calibration and then set the lamp to this value before running a test.

## **5.2 DPID Calibration File**

The DPID program uses a calibration file to store sensor calibration results that are used to convert digital data to standard units (i.e., A/D levels to parts per million (ppm)). The calibration file is stored in the /home/dpid/data directory and it is called dpid.cal. The dpid.cal file contains the calibration data for all possible sensors (254 different sets of calibration data). Ensure that you do not delete any lines from the calibration file. The contents of a typical calibration file are shown on the next page.

/\*\*\*\*\*

DPID Calibration File  
Created Tue Jan 16 17:09:28 2007

SN DPID serial number (1:254)  
Ag Bg Eg calibration constants/error at gain g

$$\text{Cppm} = \text{A[g]} * \text{ADU} + \text{B[g]} * \text{ADU}^2$$

SN A0 B0 E0 A1 B1 E1 A2 B2 E2 A3 B3 E3

\*\*\*\*\*/

001	3.815e-03	1.455e-08	1.000e-09	9.537e-04	9.095e-10	1.000e-10	2.384e-04	5.684e-11	1.000e-11	1.192e-04	1.421e-11	1.000e-12
002	3.815e-03	1.455e-08	1.000e-09	9.537e-04	9.095e-10	1.000e-10	2.384e-04	5.684e-11	1.000e-11	1.192e-04	1.421e-11	1.000e-12
003	3.815e-03	1.455e-08	1.000e-09	9.537e-04	9.095e-10	1.000e-10	2.384e-04	5.684e-11	1.000e-11	1.192e-04	1.421e-11	1.000e-12
.												
.												
.												
029	3.241e-03	8.372e-09	5.286e-01	8.104e-04	5.233e-10	0.000e+00	2.026e-04	3.270e-11	0.000e+00	1.013e-04	8.176e-12	0.000e+00
030	3.046e-03	7.099e-09	8.449e-01	7.615e-04	4.437e-10	0.000e+00	1.904e-04	2.773e-11	0.000e+00	9.519e-05	6.933e-12	0.000e+00
.												
.												
.												
253	3.815e-03	1.455e-08	1.000e-09	9.537e-04	9.095e-10	1.000e-10	2.384e-04	5.684e-11	1.000e-11	1.192e-04	1.421e-11	1.000e-12
254	3.815e-03	1.455e-08	1.000e-09	9.537e-04	9.095e-10	1.000e-10	2.384e-04	5.684e-11	1.000e-11	1.192e-04	1.421e-11	1.000e-12

The calibration file consists of a header followed by a line for each possible serial number (001 – 254). Each calibration line contains 13 columns, first is the detector serial number, which ranges sequentially 1 to 254, followed by the calibration constants, Ag and Bg, and the measurement error, Eg, for the gain settings 0, 1, 2 and 3. Note: if Eg is 0.000e+00 then this indicates that the higher gain calibration constants for this sensor were calculated from a lower gain calibration using the relative detector gains.

### 5.3 DPID Set File

The DPID program uses a settings file to store sensor calibration setup information. The settings file is stored in the /home/dpid/data directory and it is called dpid.set. A typical settings file is shown below.

```

/*****
DPID Calibration Setup File
Tue Jan 16 15:06:01 2007
*****/

0          /* calibration serial port (0-7)    */

20.00     /* overall flowrate (liters/minute) */
20.00     /* maximum flowrate of the air mfc */
20.00     /* maximum flowrate of the gas mfc */

1         /* purge-air time (seconds)        */
8         /* recording time (seconds)          */

1.00     /* relative detector gain (g=0)      */
4.00     /* relative detector gain (g=1)      */
16.00    /* relative detector gain (g=2)     */
32.00    /* relative detector gain (g=3)     */

1000.00  /* full-scale range in ppm (g=0)      */
250.00   /* full-scale range in ppm (g=1)      */
60.00    /* full-scale range in ppm (g=2)     */
30.00    /* full-scale range in ppm (g=3)     */

1.00     /* concentration (ppm) of gas #1     */
10.00    /* concentration (ppm) of gas #2     */
100.00   /* concentration (ppm) of gas #3     */
1072.00  /* concentration (ppm) of gas #4     */

          /* calibration sequences for g=0:3 */
          /* N C1 C2 ... CN                */

6        0.00 10.00 50.00 100.00 500.00 1000.0
4        0.00 10.00 100.00 225.00
4        0.00 2.00 25.00 50.00
4        0.00 1.00 10.00 25.00

```

The DPID program is capable of controlling an automatic calibrator and many of the settings in this file pertain to the automatic system. After the header information the settings are shown with one setting per line of the file. A description of each setting is given below. If the researcher is using a manual calibrator then only the settings that are indicated with a \* need to be entered.

### **Calibration Serial Port**

This is the serial port number (0-7) that the automatic calibration unit is attached to.

### **Flowrates**

The next three lines set the flowrates for the desired overall flowrate in standard liters/minute (slpm) of the air/gas mixture, the maximum flowrate of the air and the maximum flowrate of the gas. These settings are used to control the mass flow controllers that control the concentration of gas delivered to the sensors. The overall flowrate shouldn't exceed the maximum flowrates of the air or gas. The maximum flowrate should be set to be greater than or equal to  $1.1 \times \text{sensor flowrate} \times \text{total number of sensors}$ , e.g., assuming 16 sensors with a sensor flowrate of 1.12 slpm then maximum flowrate =  $1.1 \times 1.12 \times 16 = 19.7$  slpm. Therefore a maximum of 20 slpm is a reasonable value to use.

### **Purge Time**

The next line sets the purge-time in seconds. The calibration unit is purged for this many seconds at the beginning and end of each calibration sequence.

### **\*Recording Time**

This line sets the data recording time in seconds used for each measurement of sensor output versus concentration. The recording time should be long enough for a good average but short enough that it doesn't take an excessive amount of time to collect data. It is best to select a recording time that is an integer multiple of 4 seconds. A recording time of 8, 12 or 16 seconds is usually sufficient.

### **\*Relative Detector Gain**

The relative gains of the detectors at the four gain settings (0-3). These numbers are used to convert the calibration results for one gain setting (say,  $g=0$ ) to another setting. These numbers should never change as the relative gains are fixed inside the sensor.

### **\*Full Scale Range**

These four lines set the full-scale range, in ppm, for the plotting of calibration data from the detectors at the four gain settings. These numbers should be multiples of 10, and are used to set the axes when graphing the calibration results. These numbers should never be changed unless the sensor will be calibrated over a smaller range than the normal full scale range of the sensor for the given gain.

### **\*Calibration Gas Concentrations**

These four lines are the actual concentrations, in ppm, of the calibration gases, lowest to highest. Note: there is provision for up to four calibration gases but there is no requirement to use this many different concentrations. If the calibration is to be performed over a small range of the detector then you may only use 2 or 3 of the concentrations instead

of all four. In practice there is not much difference between the 1 ppm readings and the zero air reading. This means that good calibrations can be performed using zero air, 10, 100 and 1000 ppm gases only. However if you elect to use less than the maximum number of calibration concentrations then ensure that there are four entries in the file even if a particular gas concentration is not being used. An example follows. Assume three calibration gases were purchased that are nominally 10, 100 and 1000 ppm propylene in zero air. When the gases are delivered the actual concentrations are found to be 9.8, 104 and 1052 ppm. Therefore the gas concentration lines should be changed to read.

```
1.00          /* concentration (ppm) of gas #1    */
9.8           /* concentration (ppm) of gas #2    */
104.00        /* concentration (ppm) of gas #3    */
1052.00       /* concentration (ppm) of gas #4    */
```

### \*Calibration Sequence

The last four lines set the number of points in a calibration and the concentrations to use in each calibration sequence for each gain setting. There must be 3-10 points in each sequence, with the concentrations listed in increasing order and the first concentration equal to 0.0 ppm. Calibrations are performed at the pre-determined concentrations that are set by these lines. If performing a manual calibration it is easiest to calibrate at concentrations equal to the gas bottle concentrations and at 50% of these concentrations. Therefore if the gas concentrations are 1, 10, 100 and 1000 ppm then normally a calibration would be performed at 0, 1, 5, 10, 50, 100, 500 and 1000 ppm. There is nothing to stop the user from picking any concentration of interest, for example 35 ppm but it must be realized that with manual calibrations the gas flowrates must be set to produce this concentration. Also when doing manual calibrations it is best to set the concentrations in the calibration sequence equal to the actual concentrations of the calibration gas bottles and not to the nominal values. Using the example from the Calibration Gas Concentrations description this would mean that a possible Calibration Sequence is as follows.

```
6      0.00  9.80  52.00 104.00 526.00 1052.0
4      0.00  9.80  104.00 200.00
4      0.00  4.90  9.80  52.00
4      0.00  1.00  9.80  26.00
```

Note: some sensors will go offscale before 1000 ppm is reached. Therefore it is wise to first use the Record Screen to measure the sensor output at the maximum concentration you want to calibrate at. If the sensor goes offscale then reduce the maximum concentration until the sensor stays on scale and ensure that this value is used as the maximum calibration concentration. If a given concentration in a calibration sequence is found to cause the sensor to go offscale then the user can issue an F6 Skip function, as described in section 4.3.1, to skip this offscale measurement.



## 5.4 DPID Data Files

When DPID stores data to a file it actually creates two files, one is an ASCII text file with the extension .hdr that stores header information and the other is a binary data file with the extension .bin. By default data files are stored in the /home/dpid/data directory. A typical ASCII header data file is shown below.

```
DPID Recording
Wed Jan 17 23:17:29 2007
Channels 1
Channel   Sensor   Serial   Gain
1        2        31      0
```

The header file contains the date and time that the recording was started, the number of channels recorded (number of sensors enabled) and a list of the channel number, sensor number, serial number and gain setting for each sensor used in the recording. This information is required in order to correctly extract data from the binary data file and also to later apply the correct calibration conversions to the data.

Data is stored in the binary data files as signed 32-bit integers with the first number corresponding to the first data point of the first sensor, the second number corresponding to the first data point of the second sensor and so on.

Only the sensor output is stored in the binary data, the time when each data point was collected is not stored. Since the header file contains the start time of the recording and data is stored at a rate of 50 samples per second per sensor the time series can easily be calculated from the start time, acquisition rate and the number of the particular measurement.

Legitimate measurements will always be positive integers. Missing or corrupt data is represented by negative integers, where:

- 1 = data overflow (sensor output offscale),
- 2 = data underflow (sensor output less than zero),
- 3 = checksum error in the transmitted packet (corrupt data),
- 4 = missing packet (missing data).

## 6.0 Installation of a New Version of the DPID Program

This chapter provides a brief description of the procedure required to update to a newer version of the DPID program.

Aurora Scientific Inc. has a policy of continual product improvement. We are pleased to receive user comments about the program including suggestions for new functions.

### Updating DPID Program

Note: Linux is case sensitive; ensure that you type the commands as shown below.

1. If the DPID program is running then exit the program.
2. Copy the update file to the USB Memory stick supplied with the DPID PC.
3. Put the memory stick in the DPID PC.
4. Click on the Flash icon on the desktop to open a directory window. Also click on the Home icon to open the home directory window.
5. Drag and drop the update file from the Flash to the /home/dpid directory.
6. Close the Flash and Home directory windows.
7. Click on the *install* icon on the desktop.
8. Browse and select the upgrade file.
9. Press start and the installer will install the file. You may be asked to log in as root during the installation phase. If so then type the current root password and press enter. The root password was set to “root” when the system was shipped.
10. After the installation is complete you may be asked to reboot the PC. If so please do this before running the new version of the program.

This completes the update procedure. If you experience any difficulties while updating your system please contact Aurora Scientific Inc.

## 7.0 Warranty

The 101A DPID PC system is warranted to be free of defects in materials and workmanship for one year from the date of shipment. Aurora Scientific Inc. will repair or replace, at our option, any part of the 101A system that upon our examination is found to be defective while under warranty. Obligations under this warranty are limited to repair or replacement of the instrument. Aurora Scientific Inc. shall not be liable for any other damages of any kind, including consequential damages, personal injury, or the like. Damage to the system through misuse will void this warranty. Aurora Scientific Inc. pursues a policy of continual product development and improvement therefore we reserve the right to change published specifications without prior notice.

## 7.1 Contacting Aurora Scientific Inc.

Technical assistance is available by regular mail, email, phone, or fax. Use the information below to contact Aurora Scientific Inc.

Address: Aurora Scientific Inc.  
DPID Technical Assistance  
P.O. Box 2724  
Richmond Hill, Ontario, CANADA  
L4E 1A7

Phone: 1 905 727-5161  
Toll Free: 1 877 878-4784 (North America)  
FAX: 1 905 713-6882  
E-mail: [questions@AuroraScientific.com](mailto:questions@AuroraScientific.com)  
Web site: [www.AuroraScientific.com](http://www.AuroraScientific.com)

## 8.0 Terms and Conditions for Returning Equipment

1. Aurora Scientific Inc. **will not** accept any equipment returned without prior authorization in the form of a return material authorization number.
1. **Please call Customer Service at (905) 727-5161 or toll free at 1-877-878-4784 to obtain an RMA number. Please be prepared to supply the model and serial number, these can be found on the ASI tag affixed to the DPID PC.**
2. Please package equipment properly. Goods that are damaged in shipment are the responsibility of the shipper.
3. **Aurora Scientific, Inc. withholds the right to assess charges for the repair or replacement of such damaged goods, regardless of warranty status.**
4. Warranty repairs will be shipped back to the customer via FedEx. If you require or request another form of shipment, the cost of such service is your full responsibility.
5. Aurora Scientific, Inc. **will not** be responsible for any return or replacement **shipping charges** incurred due to an incorrect order placed by the customer.

### Return Shipping Address:

Aurora Scientific Inc.  
360 Industrial Pkwy. S., Unit 4  
Aurora, ON, Canada  
L4G 3V7  
Attn: RMA Returns