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Figure 1: Pulse Width Modulated - Constant Temperature Anemometer
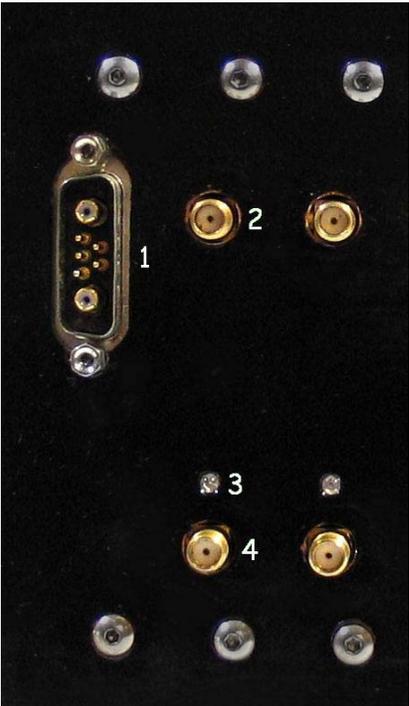

Figure 2: PWM-CTA Front Face (Left)

Figure 3: PWM-CTA Front Face (Right)

Hardware

Pulse Width Modulated – Constant Temperature Anemometer

The Control Unit for the PWM-CTA is a standard 5U rack mount size with dimensions of 17x13x8.75 inches (43.2x33.0x 22.3cm). All connectors with the exception of the power are located on the front of the unit and can be seen in Figure 1. Expansions of the front panel can be seen in Figure 2 and Figure 3 with numbers indicating the unique connection points.

1 Serial & Data Cable

The control and data acquisition from the PWM-CTA is done via a custom RS232 and dual coaxial cable. Serial communication is used for control, while high speed serial data is sent through the two coaxial lines. This cable must connect to the custom connector on the Datel Data Acquisition Board and is approximately 15 ft. long.

2 Sense Connector

The sense connector is a female SMA connector. Both pulse width modulated and analog channels will have this connector. When attaching the hotwire cables, the black grounding wire should lead to this connector. For use as an analog channel, a female BNC to male SMA connector may be used.

3 Status LED

The status LED will light up red when the channel is driving a wire. This means that the channel is set to PWM mode and that the PWM-CTA as a whole is set to run.

4 Power Connector

The bottom row of connectors are also female SMA and provide the power to a hotwire. If the channel is designed to be analog only, this connector will not be present.

5 Power Switch

The rocker switch on the front panel controls the main power of the system.

6 Power LED

The red Power LED will show when the system is powered up.

7 Rackmount Handles

On either side of the PWM-CTA face there are flanges for rack mounting the unit as well as handles for transportation.

Communications Cable

The connector for the PC to PWM-CTA communications cable is shown in Figure 4. It contains both RS232 bidirectional serial lines (the small center pins) and high speed unidirectional serial data lines (coaxial pins on either side). Both ends of the cable are identical and the cable itself is reversible.

Figure 4: PWM-CTA Communications Connector

Probe Cables

The PWM-CTA comes with one custom probe cable and terminator board for each PWM channel ordered. These cables are double shielded and impedance matched to insure the best operating conditions for the hotwire probe.

PWM-CTA Connection

The PWM-CTA connector end of the has two male SMA connections as seen in Figure 6. One of these connections has an additional grounding wire for the cable shield. This should be connected to the sense (top) connector of the channel.

Figure 6: Probe Cable (PWM-CTA end)

Figure 5: Probe Cable (probe end)

Probe Connection

The probe connection as shown in Figure 5 is integrated into the cable. It consists of a 50 ohms termination board and a female SMA connector.

GUI Overview

     Figure 4 shows the PWM Comm Interface for the Pulse Width Modulated – Constant Temperature Anemometer with the various elements numbered for reference.

1. Oscilloscope – shows a real time view of the data being returned by one or all active channels.
2. Statistics – if a single channel is selected, the mean, standard deviation, and range of the data will be shown in the statistics area.
3. Channel Selection – selects the channel to be shown in the oscilloscope and for real time adjustment using the available controls below.
4. All Check Box – if checked all channels are shown in the scope. In this case, the channel select list only affects the real time adjustments.
5. Start / Stop Graph Button – enables or disables the real time data display. This does not affect the function of any of the adjustment or data acquisition buttons below.
6. Gain-Bandwidth Controls – allows the user to adjust the gain-bandwidth or slew rate of a wire. Generally the gain-bandwidth will only be lowered if there is substantial noise on the channel. Similarly, the slew rate will only be lowered if there is significant cross talk between two channels.
7. Eref Adjustment – with the four buttons, the reference voltage for a given wire can be adjusted. The reference voltage proportional to the maximum overheat of the wire and changing the voltage will result in an inversely proportional change in the average pulse width.
8. Run / Stop Active Channels – Running active channels will cause any wire that is in PWM mode to start driving a wire. The red LED's on the system should light up and the red button in the software will turn green until the until the system is stopped.
9. Acquire / Stop Acquire Data – Causes PWM Comm to temporarily leave the real time interface and store data to disk. Acquire will run for the time period set unless it is interrupted mid cycle.
10. Acquire Time – sets the desired time for acquisition, PWM Comm will automatically calculate the number of samples needed based on the system frequency.
11. Status Bar – status messages for PWM Comm will be displayed here.
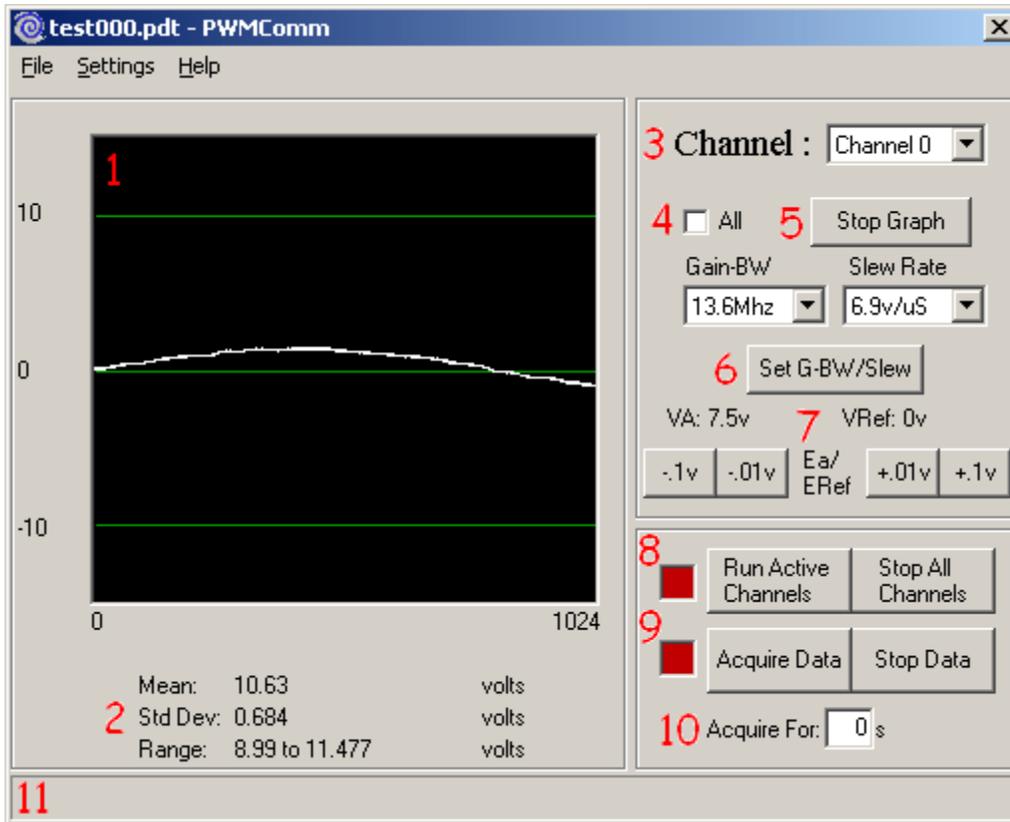
Figure 5: PWM Comm Elements

Menus

File Menu

- Channel Setup – Stops the PWM-CTA from running if necessary, then opens the experiment setup windows in which all channels can be configured.
- File Numer – Sets the file numbering scheme for subsequent data files based on a start value and number of digits to be used. The file number will default to start as 001 and increment every time data is saved to a file.
- Open – Opens a pre-made experiment file without going into the experiment setup window.
- Reset Communications – Sends a reset string across the RS232 connection to the PWM-CTA flushing the command buffer.
- Reset PWM – sends the experiment data currently stored in PWM Comm to the PWM-CTA. This is useful if the PWM-CTA has been turned off while the software remained open.
- Exit – Exits the PWM Comm GUI. The GUI will wait stop the oscilloscope or current acquisition prior to exiting.
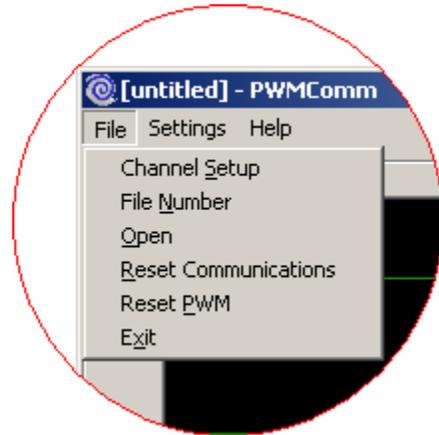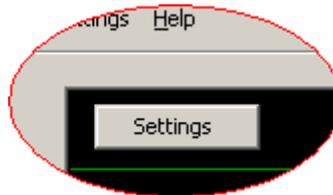
Settings Menu

- Comm 1 – Comm 4 – allow the selection of the serisl port being used.
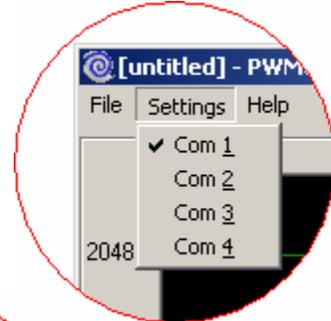
Graph Setup Right Click Menu

- Settings –launches the graph settings window from which the axes of the oscilloscope can be adjusted

Configuration Windows

Channel Setup

The channel setup window can be opened by selecting Channel Setup from the File Menu in PWM Comm. The window is shown in Figure 8. Since the PWM-CTA chassis can hold up to 18 channels, the channel setup pane will show 18 lines. The channels in a PWM-CTA are sequentially numbered from left to right with the first channel being closest to the PC connector.

1. Experiment Description – any text describing the experiment being set up can be placed here, the description is not used other than as a reminder to the user.
2. Frequency – allows the user to set the frequency at which the PWM-CTA will run. Frequencies available are integer divisions of 100kHz.
3. Data Order Marker – inserts an artificial channel of data into the sequence. Since the PWM-CTA is constantly running when data is acquired, it is impossible to know exactly what channel will be sampled first. This marker is used to sort the data.
4. OK / Undo / Cancel / Apply Buttons – The function buttons follow the same conventions as most Windows programs. The only variation is the Undo button, which undoes all changes back to the last save. It should also be noted that the OK and Apply buttons write the experiment to a file.
5. Title- allows the user to give channels a meaningful title.
6. Function – this is where the function of each channel is set. Analog channels will return null data if set to a non-A/D mode, while non-existent channels will return bad data if not left off.
7. Ea – This is the voltage being used to drive the wire. In the setup panel, it is not a user adjustable option.
8. ERef – This is the voltage which signifies that the wire has reached the proper overheat. It is automatically calculated based on Ea and the Overheat ratio.
9. Gain – sets the gain of the sense input when driving a hot wire. Generally this does not need adjustment, but allows for use of a greater range of wires and cables.
10. Slew Rate – Adjusts the rate at which the driving pulse can rise and fall between 0 volts and Ea.
11. A/D Range – defines the range of the A/D converter which can be reduced in order to increase resolution.
12. Bandwidth – adjusts the gain bandwidth of a channel, the higher gain bandwidth settings will allow more sensitivity. This should only be turned down if wire noise becomes an issue.
13. Characteristic Impedance – must match the cable and termination resistor value. This will not need to be changed unless non DFTI probe cables are used.
14. Overheat – sets the ratio of the wire's hot resistance to cold resistance.
15. RCold – displays the cold resistance of the wire currently attached to the channel.
16. Update – checks the cold resistance of the wire and updates the RCold, ERef and Ea boxes accordingly.
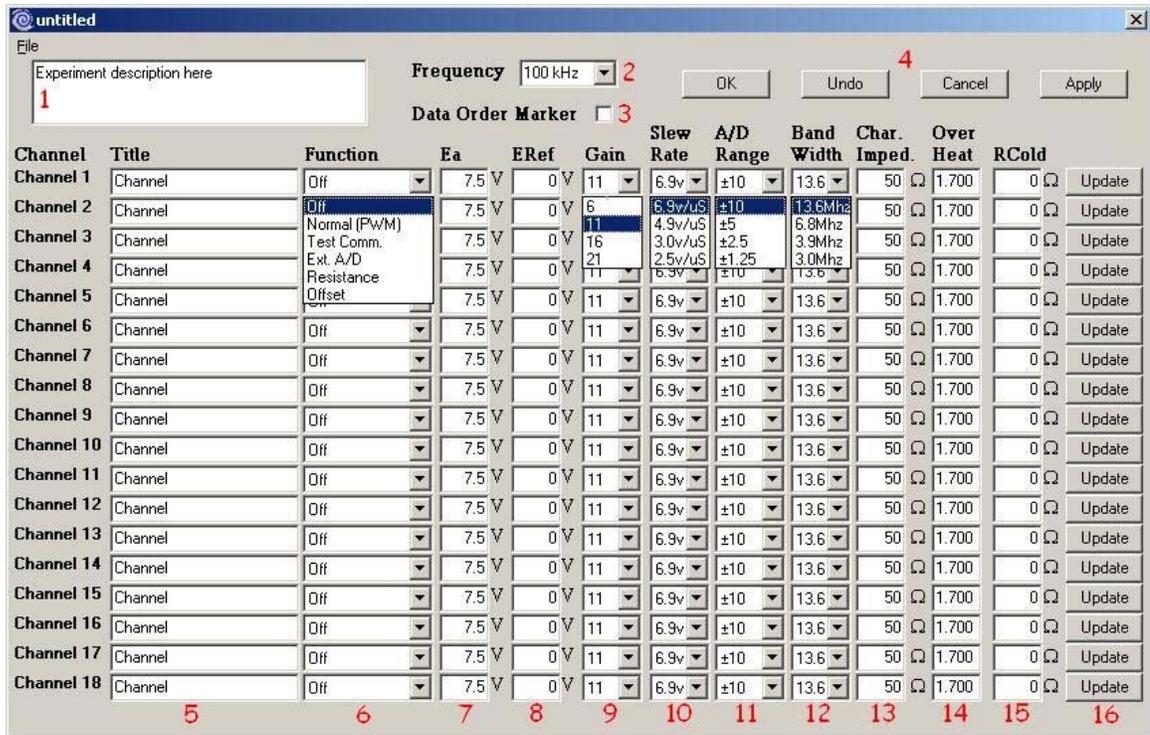
Figure 6: PWM Comm Channel Setup Window

Oscilloscope Setup

The oscilloscope setup panel can be accessed by right clicking anywhere on the oscilloscope screen. In the Y Axis Scale, the standard scale corresponds to the scope setting the minimum at 25% duty cycle and the maximum at 50%. The user range can be used for finer focus or to adjust for analog channels, however, since every analog channel can have an independent range, the oscilloscope range must be set in counts. Zero and 65535 counts correspond to the minimum and maximum voltages respectively.
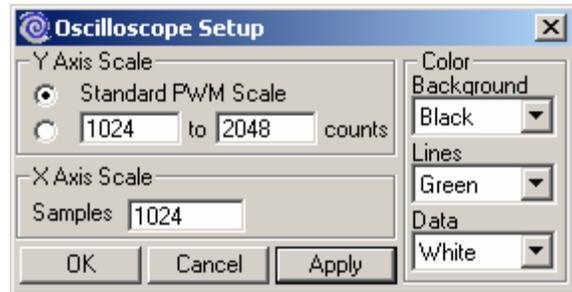

Figure 7: Oscilloscope Setup Window

The X Axis Scale sets the number of samples displayed on the graph. It should be noted that the time required to analyze and plot the points is noticeably greater than the time take to acquire the data, so very large sample numbers should be avoided (limit to about 10,000) although they are not prevented.

The color of the display can also be adjusted, but will be reset each time PWM Comm is started. Also worth noting is that these settings change only how the data is displayed and have no effect on the operation of the PWM-CTA.

Data Acquisition

Whenever the oscilloscope is running, the PWM-CTA is actively acquiring data. The data acquisition buttons allow the user to save this data to a file for later processing. The data acquisition section of the GUI is shown in Figure 10.

The top pair of buttons controls the run status of the channels. The run status applies only to hotwire channels, and has no effect on the operation of analog channels. If hotwire channels are being used, active channels must be set to run by clicking the "Run Active Channels" button prior to acquiring data.
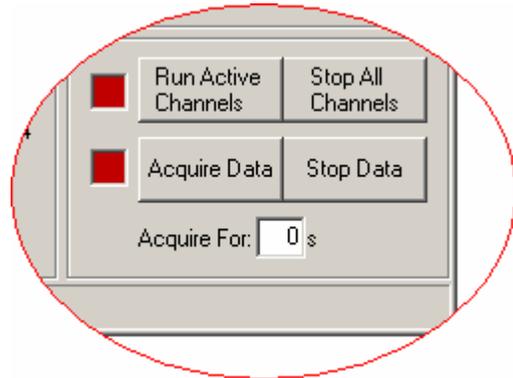

Figure 8: Data Acquisition Buttons

Data is saved to a file for a set amount of time as indicated in the "Acquire For:" box. PWM Comm automatically calculates the number of data points taken based on the time. Due to the limitations of the Datel card, the data must be taken in blocks of a fixed size. For this reason, the actual file may contain slightly more data than fits the entered time period.

The data file will be named the same as the experiment file along with an incrementing counter and a .pdt extension. This counter will start at 001 and increment through 999. The counter settings can be adjusted through the File menu in the main GUI window. The file is written in binary format and contains a 64 bit header followed by the acquired data saved as 16 bit unsigned integers. Functions have been included to load the .pdt files into Matlab.