1 Hardware

1.1 Photoacoustic Spectrometer

1.1.1 Housekeeping

The PAS maintains an array of housekeeping data associated with each cell. Each signal originates as an analog signal The thermistors not associated with the Wavelength TECs (WCT3243) use a 10 V voltage divider with a 10 kΩ reference resistor (R_{ref}). All thermistors in the system are flag mounted series ON-930-44000 resistors which register a 10 kΩ resistance at 25°C. The signal in is an anlog voltage. The voltage is converted to a thermistor resistance R_t using the following equation:

$$R_t = R_{ref}(\frac{V_source}{V_meas} - 1) \tag{1}$$

The thermistor resistance is then converted to a temperature using the Steinhart-Hart equation:

$$\frac{1}{T} = A + B \ln R + C(\ln R)^3 \tag{2}$$

where A, B, and C are the Steinhart-Hart coefficients. The coefficients for the thermistor are defined by the thermistor model itself and can be solved for using the resistance as a function of temperature tables provided by the manufacturer; this results an a linear equation where $|\mathbf{1} \ln \mathbf{R} (\ln \mathbf{R})^3| \mathbf{X} = (\mathbf{T})^{-1}$ and $\mathbf{X}$ is a vector representing the coefficients. For the series used in the PAS, the coefficients are 2.72e-3, 2.68e-4 and 6.17e-7 for A, B and C respectively.

An additional thermistor is provided for monitoring the temperature recorded by the Wavelength TECs. The output of this TEC is filtered through the TEC electronics and is returned as a factor of the thermistor resistance. So, if the thermistor is registering a temperature of 10°C, the voltage observed from the TEC eletronics will be 1. This value is readily converted to a temperature using Eq. 2.

Each cell in the PAS monitors the relative humidity RH as well as the air temperture T_{RH} using a Vaisala HMP50 humidity probe located near the outlet of the cell. The probe provides two 0 to 5 V signals. The conversion of these signals to real physical data is performed via the following two equations:

$$T_{RH} = 20 \times V - 40 \tag{3}$$

and

$$RH = 20 \times V \tag{4}$$

1.2 Cavity Ring Down Spectrometer

2 Software Overview

Most software described herein is object-oriented. All instruments are built off of a single parent called the **Instrument** class.

3 Instrument Class

The Instrument class is the top-level class for most instrument acquisition applications. The Instrument class is, for all purposes, a virtual class which only functions after instantiation. The Instrument class is a simple class which contains a set of must-override routines as well as some static VIs that provide soem generic functionality, particularly if the class will be used in a state-machine setup.

Each instrument is assumed to do the following:

- **Configure** at startup. The process of configuring an instrument is specific to the implementation, but all instruments require it in order to make measurements, return data, produce signals, etc. Some instruments will have a configuration file that may be read in at startup while others may simply need to specify pre-defined tasks and scales.

- Get Data during operation. This may require communication with serial ports or calling DAQmx routines to read data off of data acquisition cards.

- Analyze Data at some point during operation. While this function may be combined with the **Get Data**

4 Photoacoustic Spectrometer

Every photoacoustic spectrometer (PAS) encompasses only two things:

- A cell through in which the bean and aerosol interact.

- The data produced by this interaction.

Signal	Range		Card	Channel	Scale
	High	Low			
Cell 1 Thermistor A	0	5	6229	ai0	N/A
Cell 2 Thermistor A	0	5	6229	ai5	N/A
Cell 3 Thermistor A	0	5	6229	ai10	N/A
Cell 4 Thermistor A	0	5	6229	ai16	N/A
Cell 5 Thermistor A	0	5	6229	ai21	N/A
Cell 1 Thermistor B	0	5	6229	ai1	N/A
Cell 2 Thermistor B	0	5	6229	ai6	N/A
Cell 3 Thermistor B	0	5	6229	ai11	N/A
Cell 4 Thermistor B	0	5	6229	ai17	N/A
Cell 5 Thermistor B	0	5	6229	ai22	N/A
Cell 1 TRH	0	5	6229	ai3	3
Cell 2 TRH	0	5	6229	ai8	3
Cell 3 TRH	0	5	6229	ai13	3
Cell 4 TRH	0	5	6229	ai19	3
Cell 5 TRH	0	5	6229	24	3
Cell 1 RH	0	5	6229	ai2	4
Cell 2 RH	0	5	6229	ai7	4
Cell 3 RH	0	5	6229	ai12	4
Cell 4 RH	0	5	6229	ai18	4
Cell 5 RH	0	5	6229	ai23	4
Cell 1 LRMS	0	5	6229	ai4	N/A
Cell 2 LRMS	0	5	6229	ai9	N/A
Cell 3 LRMS	0	5	6229	ai14	N/A
Cell 4 LRMS	0	5	6229	ai20	N/A
Cell 5 LRMS	0	5	6229	ai25	N/A

Table 1: Low frequency signal layout. Scales specified above are applied through the DAQmx functionality. Thermistors are scaled in the software. **LRMS** refers to the laser RMS and this value is not scaled. The laser RMS provides an indication of the laser power that the photodiodes are seeing (which should be minimally effected by interference of aerosol with the beam).

5 Cavity Ring Down

The CRDS fires three different lasers at a rate of 1000 shots per second into eight different cells. Each shot results in a single decay on each channel. Data is collected at a rate up to 2.5 mega-samples a second using a PXI S-series 6133 from the point of the shot being fired until the smaller of 500 μs or 5x the previous decay constant τ. The data is aggregated on a 1 second basis and then the 1000 individual traces on each channel are analyzed using a routine defined by .

5.1 Fitting Taus

Signal	Range		Card	Channel
	High	Low		
Cell 1 Microphone	5	-5	6259	ai0
Cell 2 Microphone	5	-5	6259	ai2
Cell 3 Microphone	5	-5	6259	ai4
Cell 4 Microphone	5	-5	6259	ai6
Cell 5 Microphone	5	-5	6259	ai16
Cell 1 Photodiode	5	-5	6259	ai1
Cell 2 Photodiode	5	-5	6259	ai3
Cell 3 Photodiode	5	-5	6259	ai5
Cell 4 Photodiode	5	-5	6259	ai7
Cell 5 Photodiode	5	-5	6259	ai17

Table 2: High frequency signal layout.