RP Metrix

LASOM1 Performance Data

Overview

This document describes measurements of the LASOM1 olfactometer. Some tests were made on the olfactometer alone while others added an external timing valve - a situation more typical of real-life situations.

Data Acquisition and analysis

Several techniques have been used to characterize olfactometer output, some of these include measuring the temperature change in a carrier when a cold or warm olfactant is added, mass spectrometry, flame ionization detection and photo ionization detection.

For all of the experiments we describe here we chose to use a Photo Ionization Detector (PID) made by Aurora Scientific[1] for several reasons: a) it has a wide, 330 Hz, bandwidth and correspondingly fast response time of ~ 0.5 ms, b) it has a $>10^4$ dynamic range, c) it's compact sensor head. We found the Aurora Scientific minPID to be reliable and repeatable during the course of many experiments. In the tests described in this document amyl acetate was used as an odorant. Amyl acetate has an ionization energy of ~9.9 eV and is easily detectable by the miniPID[2].

Data was acquired using a Tektronix oscilloscope, and was analyzed using Matlab v2008a (7.6)

Dilution measurements

By changing the relative flow rates of the two Mass Flow Controllers (MFC) on an olfactometer different odorant dilutions can be realized. This is done using the control software on the host computer.

The MFC low rates were adjusted so that the carrier flow was a given percentage of the total flow (carrier flow + dilution flow) while keeping the total flow at a constant 1000 cm^3 min^{-1}. Odor pulses of several seconds were given and the PID response was then measured after reaching a steady state. The maximum deliverable odor concentration of 100% was at carrier flow rate of 900 cm^3 min^{-1} and odorant flow rate of 100 cm^3 min^{-1}. Results from this test are shown in Fig 1.

To prevent introducing errors in the measurements the PID gain was not adjusted during these measurements. Thus, it is conceivable that further dilutions can be achieved and measured by increasing the PID gain at high dilutions but these measurements were not performed.

1 www.aurorascientific.com/product/fr_minipid.asp?frm=
2 http://www.raesystems.com/~raedocs/App_Tech_Notes/Tech_Notes/TN-106_Correction_Factors.pdf

Nevertheless, it is clear from this set of measurements that an olfactometer can be reliably used to dilute olfactants by one order of magnitude at least.

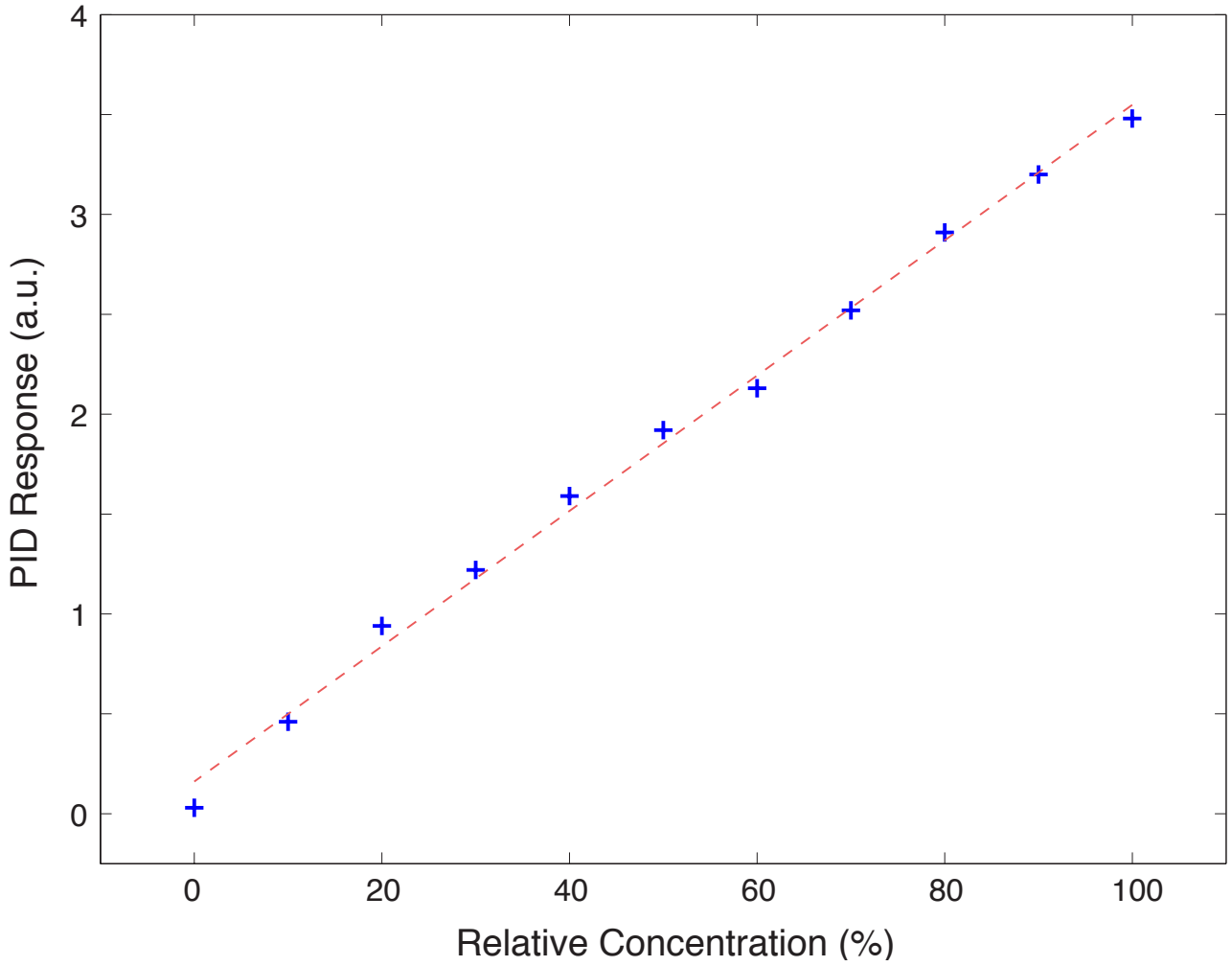

Fig.1 - Dilution measurements of amyl acetate. Dilutions were achieved by adjusting the relative flow rates of the carrier and dilution gases while keeping the total flow constant. The dashed red line is a best fit to the data.

Cross contamination measurements

An important measure of the performance of the olfactometer is the degree to which a particular odor will contaminate the other odors in the olfactometer - the concern being that presenting an odor might contaminate the odorant in a downstream vial.

A test was designed to measure the degree to which this occurs. Amyl acetate was loaded in six vials including in the first vial closest to the mass flow controller. Downstream at position 10 (farthest from the MFC), a new, clean, empty vial was installed. Attempts to induce cross contamination were performed over the course of approximately 15 minutes by repeatedly activating the vials containing amyl acetate.

Fig. 2 shows the PID response to opening the first and last vial. First, a very large PID response is seen when amyl acetate from vial 1 is presented. At 15 seconds, the contents of vial 10 were released. Pressure measurements (not shown here) proved that the empty vial was indeed being pressurized. It is clear that if amyl acetate was released from the downstream vial it was below the detection limit of the PID.

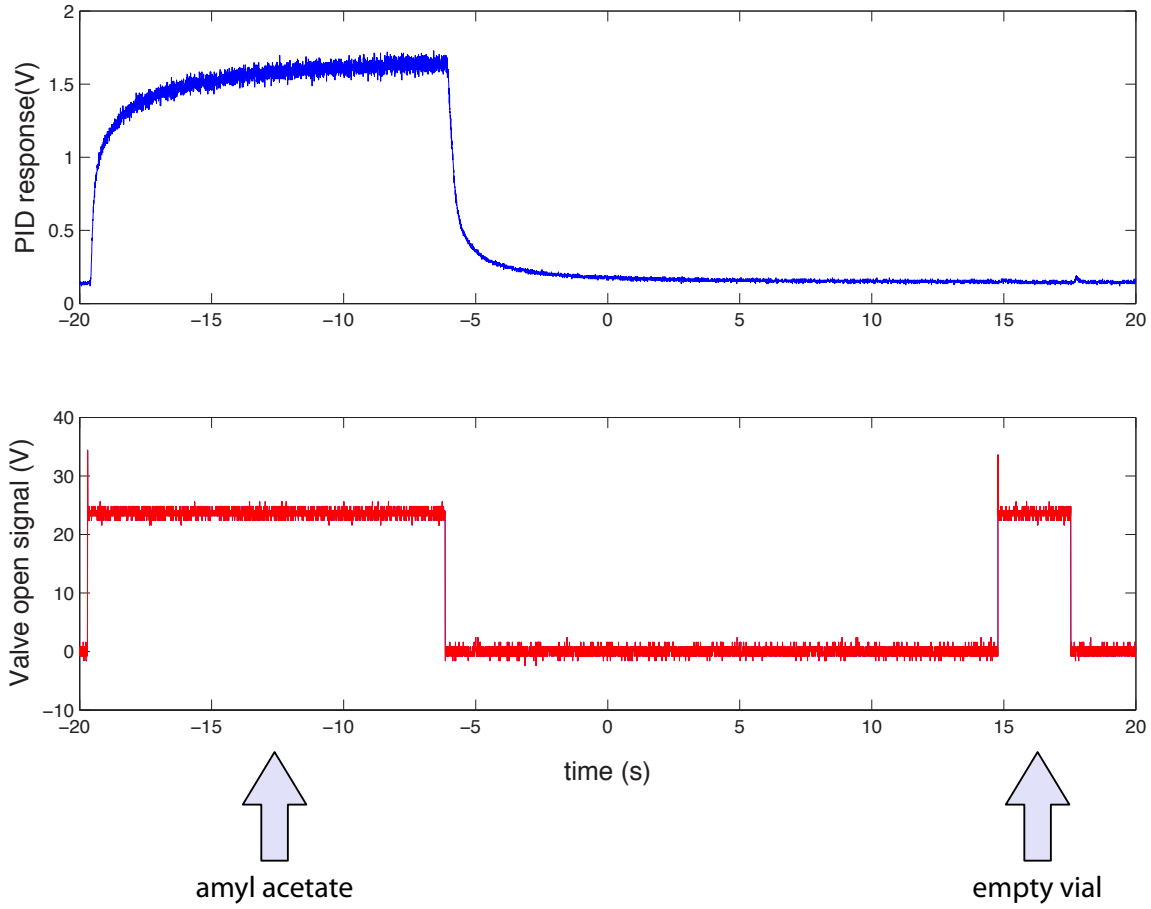

Fig. 2 - Cross contamination measurements. The PID response to the downstream clean vial contents shows that very little if any cross contamination occurs. The tiny artifact that appears when the vial 10 valve was closed was most likely induced electrical noise from the valve driver.

Repeatability

This study was aimed at determining the repeatability of the odor presentation. Due to the radially nonuniform velocity of gas flow in tubing even a very short pulse of odorant will emerge from the tubing smeared out in time. A timing valve is commonly used in an experiment configuration to ensure a fast rise time at the final output.

This test shows the ability of the olfactometer to control external valves as well as the repeatability of

the sequencer. The configuration of the system that included a fast external valve[3] as is shown in Fig. 3. This was done to more closely approximate a realistic (albeit simple) setup. The external valve was driven by one of the external valve drivers on the olfactometer.

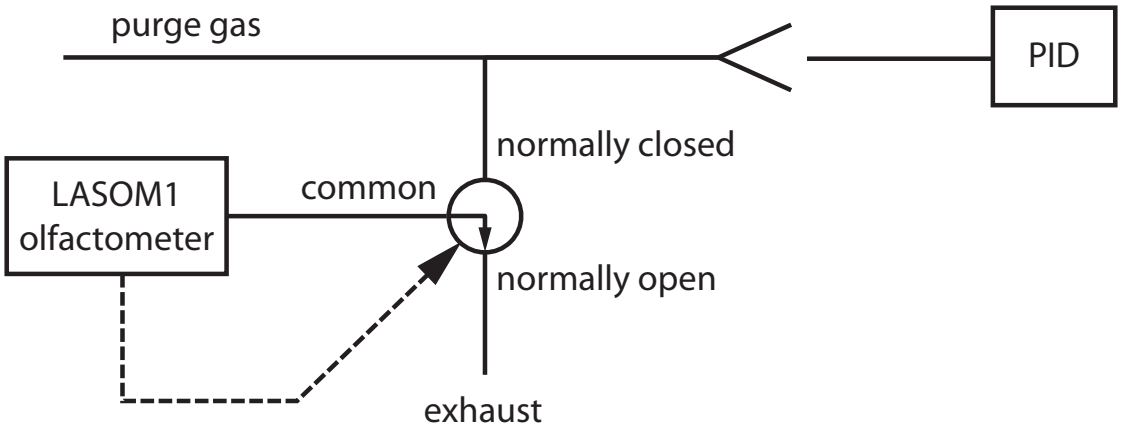

Fig. 3 - Experimental setup for repeatability and jitter measurements. The olfactometer controlled (dashed line) an external 3-way Teflon solenoid valve that was used to create an odor event with precise timing. The PID itself has a pump that is used to bring gases into the instrument.

For these experiments nitrogen was used as a purge gas because air contains oxygen that absorbs UV. This increases the noise and background in the PID signal. One vial of the olfactometer was loaded with amyl acetate. A LASOM1 sequencer script was written in a Matlab environment that was being used at the time. Python, LabView and direct text editing were used in other experiments. This script produced repeated stimuli.

One example of these repeated stimuli is shown in Fig. 4. First, the odor valve on the olfactometer was activated for enough time to achieve a steady state in our particular setup. The timing details will vary between different setups due to different tubing lengths, tubing diameters, washing flows, etc. The lower trace (green) shows the voltage on the vial valve. This valve is onboard the olfactometer. After 0.5 s the external valve is opened (middle trace in red). The top trace (blue) shows the PID response.

The process shown in Fig. 4 was repeated 50 times and the results are shown in the form of a heat map in Fig. 5. It is clear from this figure that the odor signal as measured by the PID is repeatable and that the odor signal is stable over the course of an odor event.

Timing - onset and decay jitter

Finally, the onset and decay jitter of the odor signal was extracted from the same data set represented in Fig.5. This gives an idea of the jitter of the olfactory signal. The onset of the PID response was

3 3-Way Teflon Solenoid Valve , part number 001-0028-900, www.parker.com/pneutronics

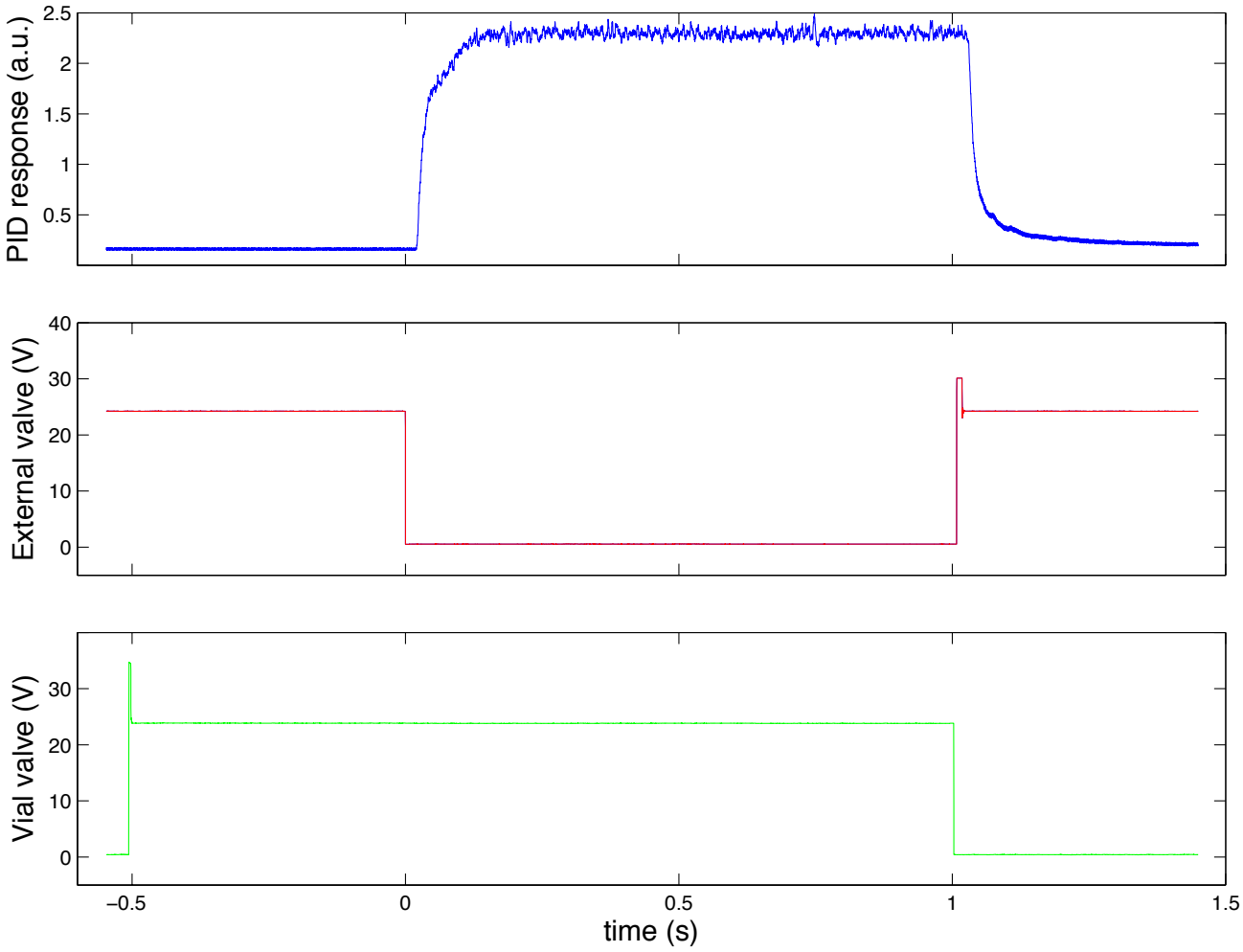

Fig. 4 - Example of the PID response (top trace) to a pulse of an amyl acetate. An external valve was used for this measurement (see Fig. 3). First, a steady state of odor output from the olfactometer is prepared. Then, the external valve is used to present the odor to the PID. This arrangement allows for more precise timing of the olfactory signal.

captured around 3 s and decay was captured around 8 s. All 50 of the onset and decay signals are plotted in Fig. 6.

The standard deviation, of the rise time was calculated using the time that the rising signal reached a threshold value of 0.25 This threshold is indicated in Fig. 6a by a red line. This calculation yielded 50 numbers, one for each trial. This threshold value was chosen as about ⅒ of the saturation value of 2.5 (the red region in Fig. 5). The standard deviation was found to be ~0.3 ms. Similarly, for the decay a threshold value of 2.2, shown as a green line in fig. 6b, was chosen. This data yielded a standard deviation of ~3.6 ms - about 10 times the onset jitter. The reason for this is not certain but is most likely due to the time it takes to purge the tubing of any odorant.

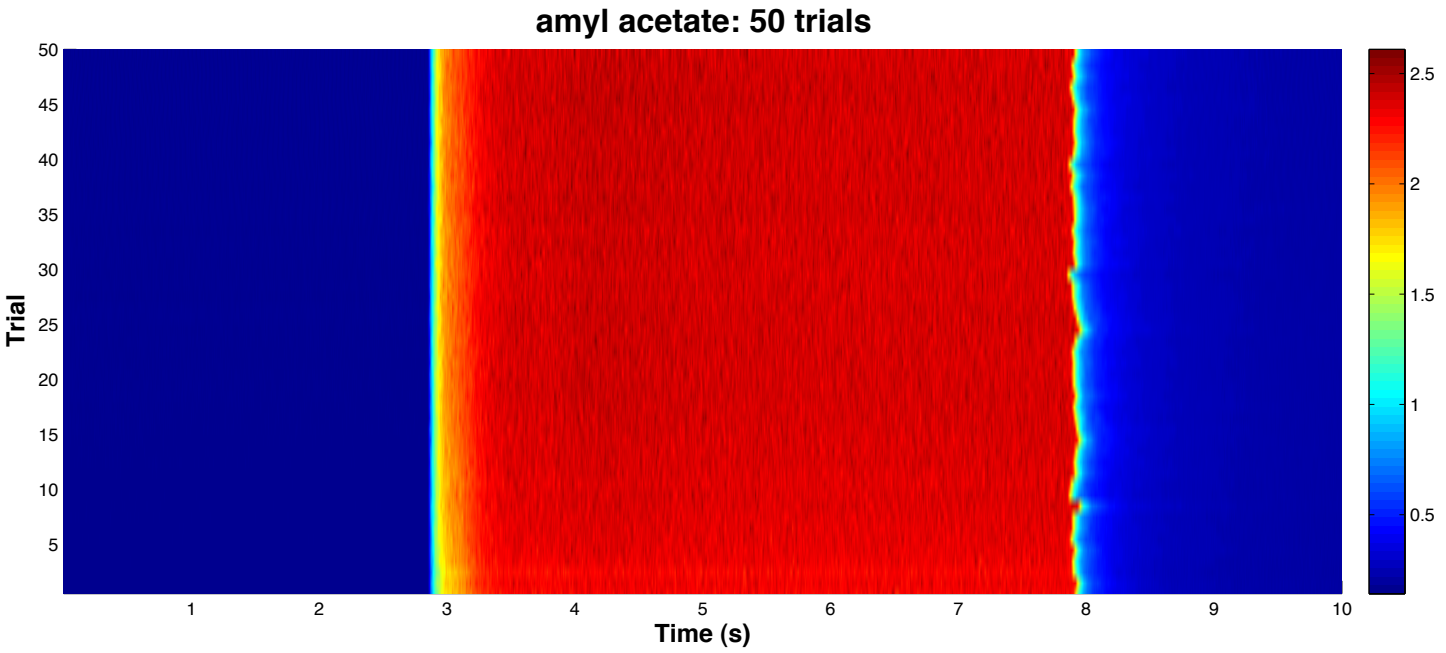

Fig. 5 - 50 repeats of the PID response to amyl acetate using the experimental setup shown in Fig. 3. One of these repeats is shown in Fig.4. Here the 50 repeats are stacked on each other to form a heat map. Each trial is represented as a horizontal bar where the color of the bar is at any given point corresponds to the amplitude of the PID response signal. The amplitude of the signal is coded according to the color key on the right.

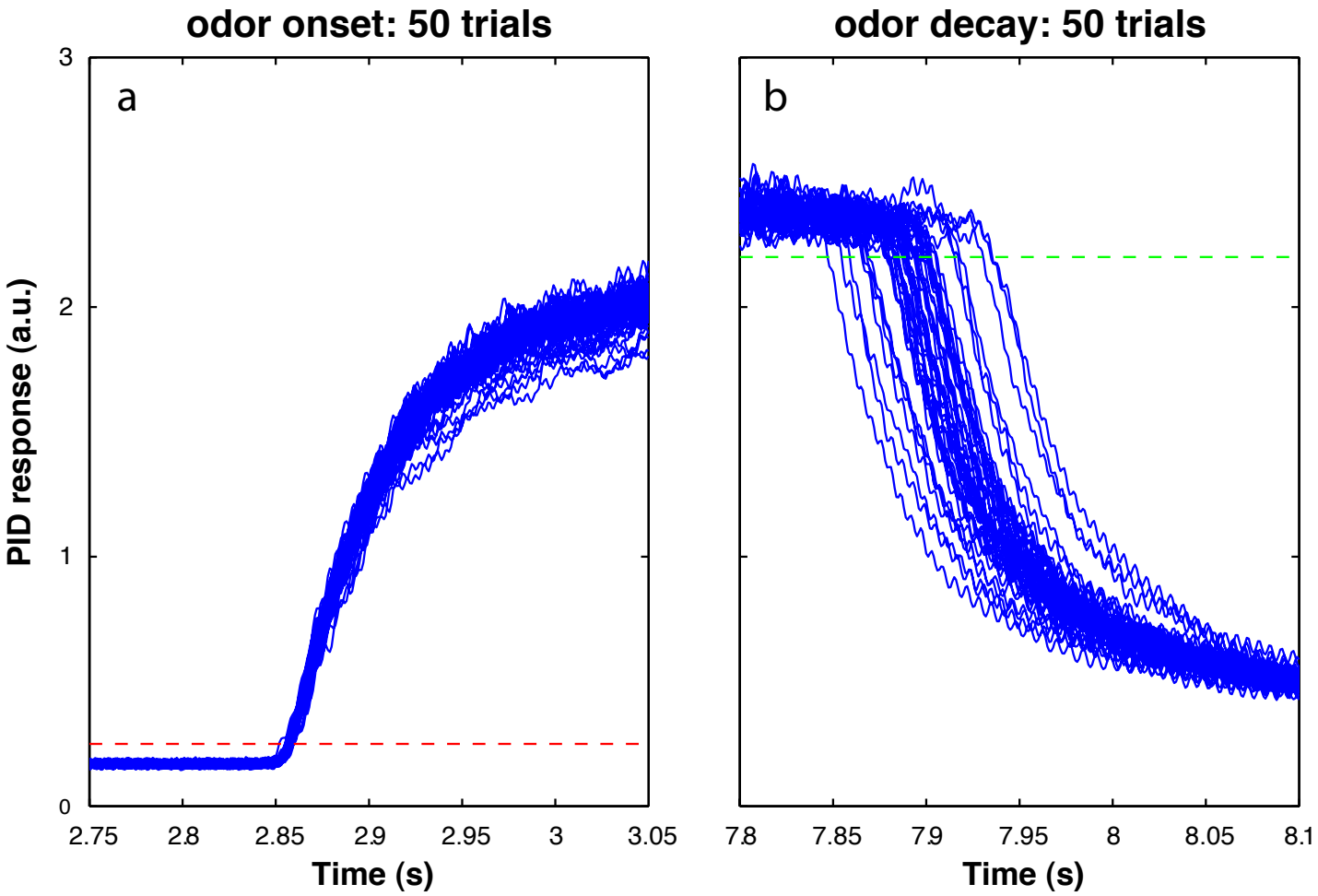

Fig. 6 - Rise and fall time of the odor signal as measured by the PID. The red and green lines are the threshold values used to calculate the jitter in the rise and fall times.