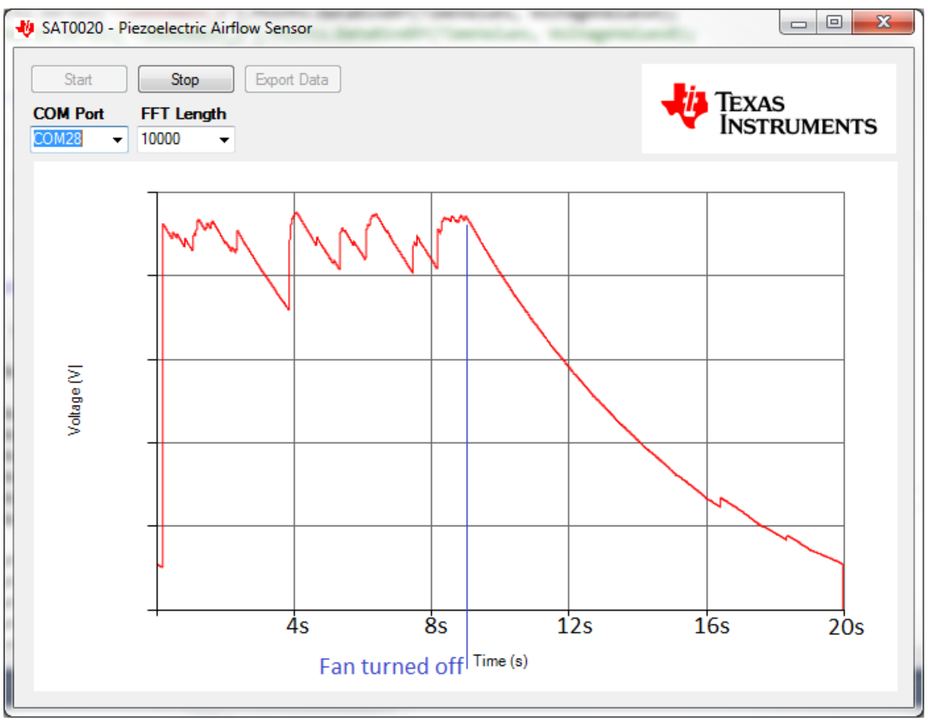
Texas Instruments Incorporated

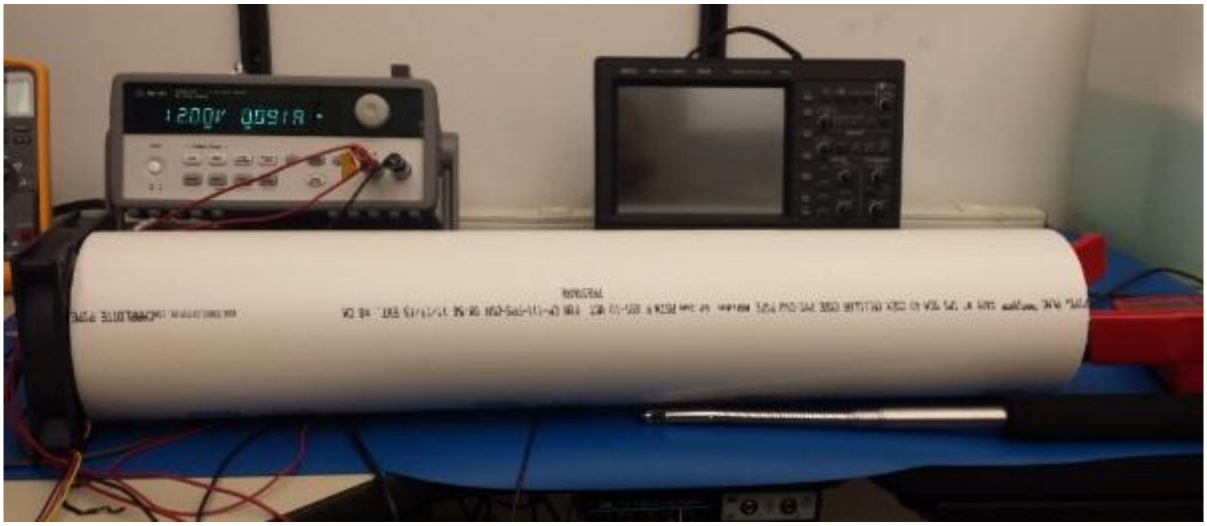
Piezoelectric Airflow Sensor

Test Results
May 2014

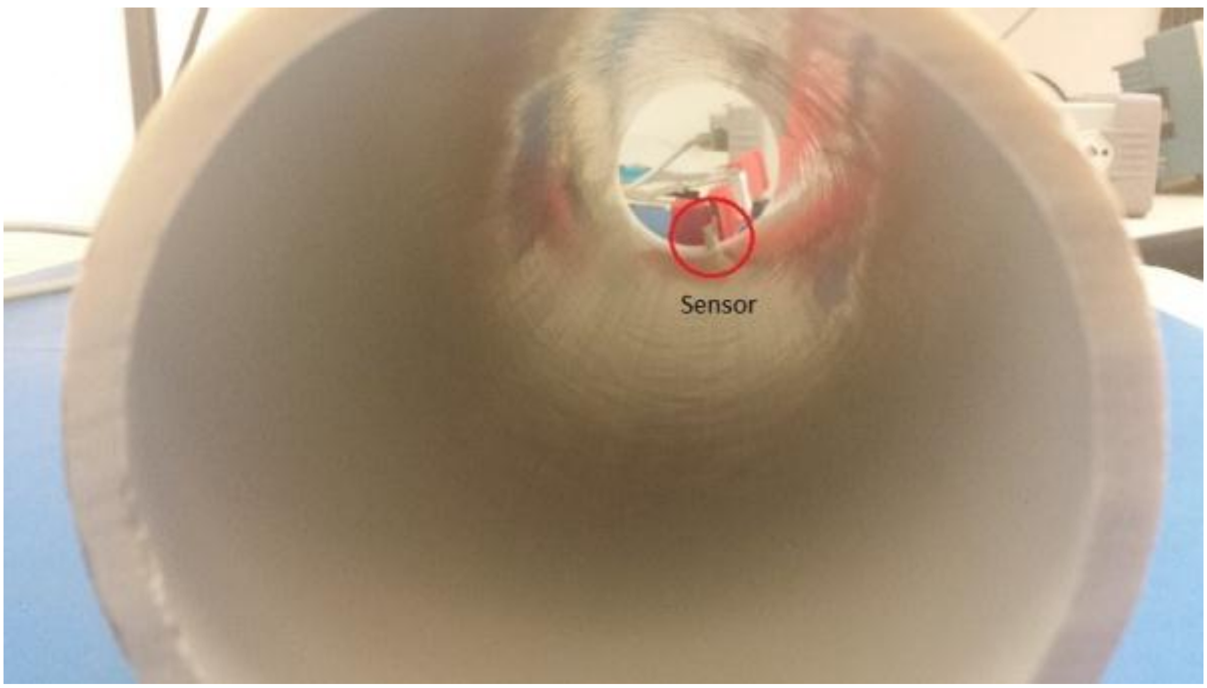


Test Setup

The Piezoelectric Airflow Sensor was tested first in a "wind tunnel" in direct airflow from a variable speed PC fan (4", variable voltage up to 12V). The PVC pipes serves to shield disturbances from the airflow in the room. It also better conditions the airflow to simulate the tight dimensions of a server. In the picture below, the 4" fan is mounted on the left end of a 2'x4" PVC pipe, and the sensor is inserted in the right end.



Test set up. The airflow sensor is "mounted" inside the PVC wind tunnel with a clamp.



Looking down the wind tunnel from the perspective of the fan.

We also used an anemometer (airflow meter) to roughly measure the airspeed at different settings of the PC fan for reference. You can see the anemometer setup in the picture below. It should be noted that since we are working with relatively low air speeds and in a tight flow cross section, the measurement is very rough and depends on the orientation of the probe and where in the PVC the flow was measured.

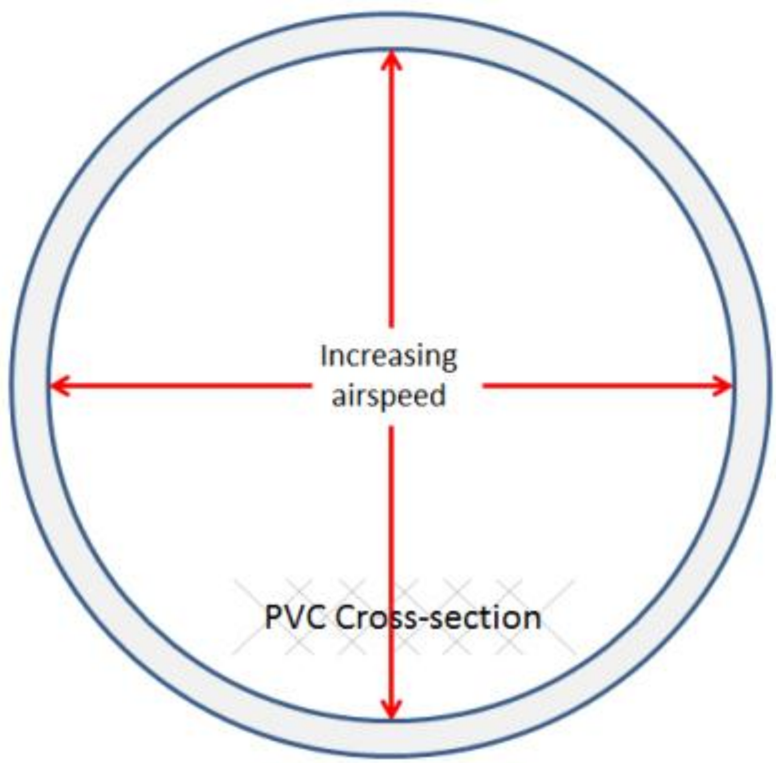
Image showing the use of the anemometer to measure air flow speeds.

Test Considerations

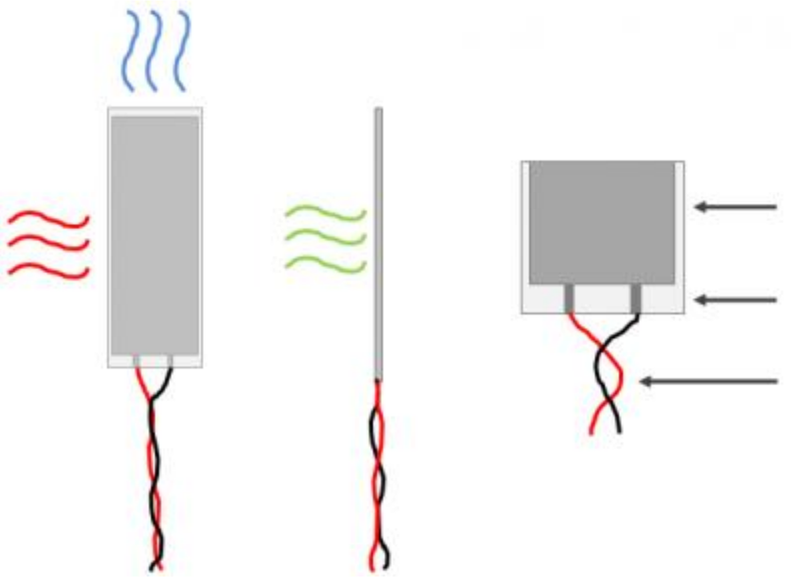
Several things need to be noted about the test set-up.

First of all, the positioning and mounting of the airflow sensor itself (the piezo element) is extremely critical to the test output in several ways that were observed during testing:

- The airspeed seemed to be higher locally around the edges of the 'wind tunnel' and calmer in the center. This is most likely due to the fact that the airflow is more turbulent at the edges and indicates that, in an end application, the presence of other objects around the sensor can affect how relatively sensitive it is to the "same" airflow. For our testing we found placing the sensor near the sides of the PVC gave best results for the sensitivity of our particular sensor element.



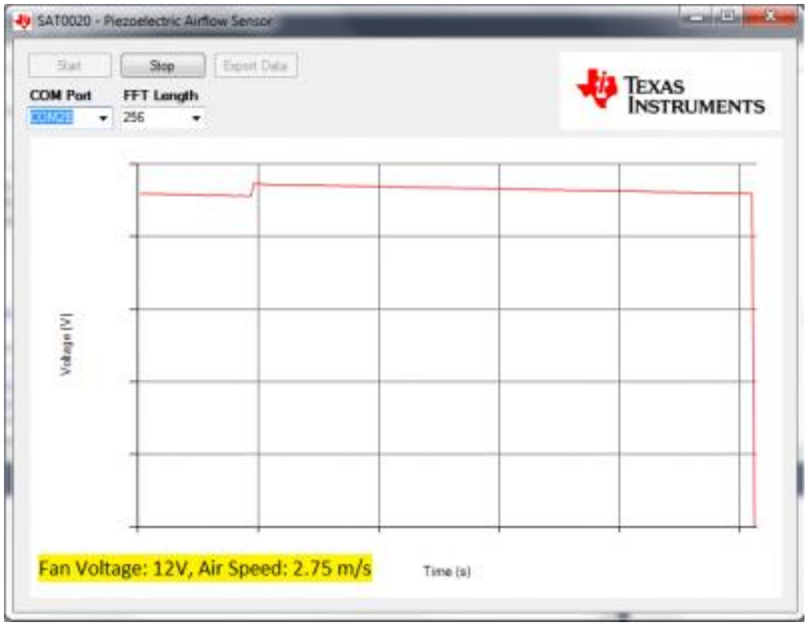
- The orientation of the sensor with respect to the airflow is very important. On the left of the image below you can see 3 ways in which the airflow could hit the sensor; either on-edge to the length (red), on-edge to the width (blue), or catching it broad-side (green). We found that the blue option seems to be the best, with the sensor just slightly askew from being directly on-edge. The red option gave good sensitivity but a less consistent amplitude/frequency. The green option was very poor in low conditions and almost no response except when the airflow was quite high. All tests performed below were done with the 'blue' option.

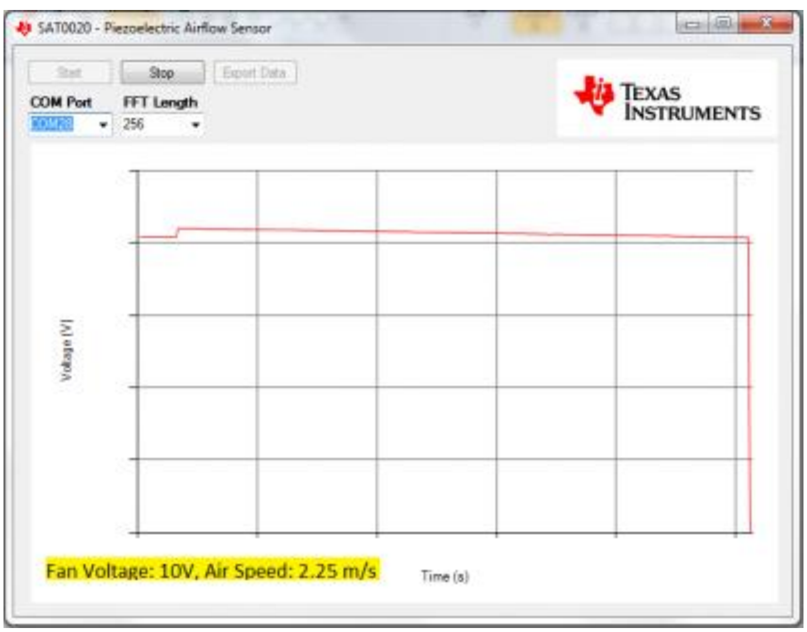


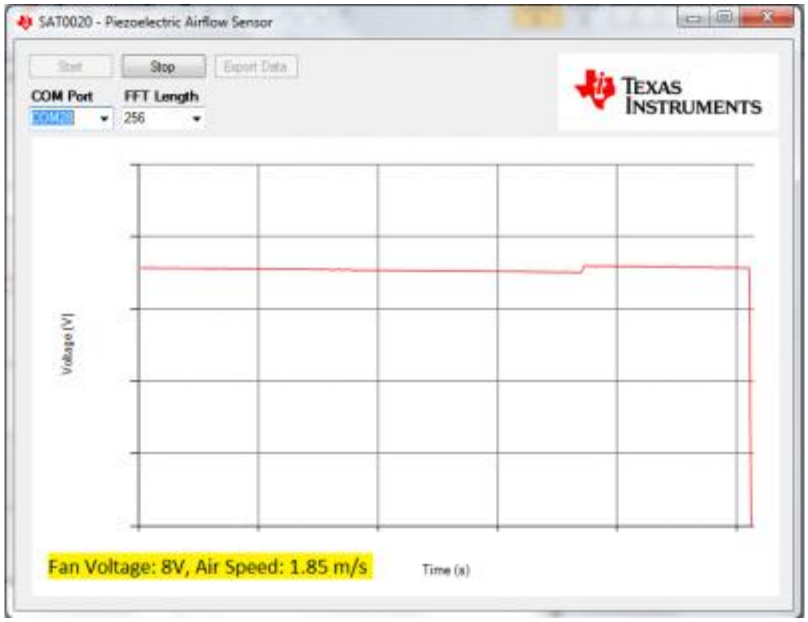
- The way that the sensor is mounted was quite important to the sensitivity. On the right side of the picture above there are 3 different arrows indicating different options for where to "hold" the sensor; held by the wires near the sensor element, held just on the edge of the sensor laminate material, and held on the sensor element itself. The main affect of this is affecting the rigidity of the sensor and therefore the level of airflow it is sensitive to: the less rigidly held, lower airspeeds gave good response, but not at higher speeds. The opposite is true for more rigid sensors. The length of the sensor used is actually also very important; the longer the sensor, the more responsive it is to low air speed. The sensor we used was ~3" long and best results were found by mounting it just on the edge of the laminate material. In our testing, almost no response is seen when using very short sensors, especially when board-mounted, or longer sensors 'choked' by mounting them further up the sensor element.

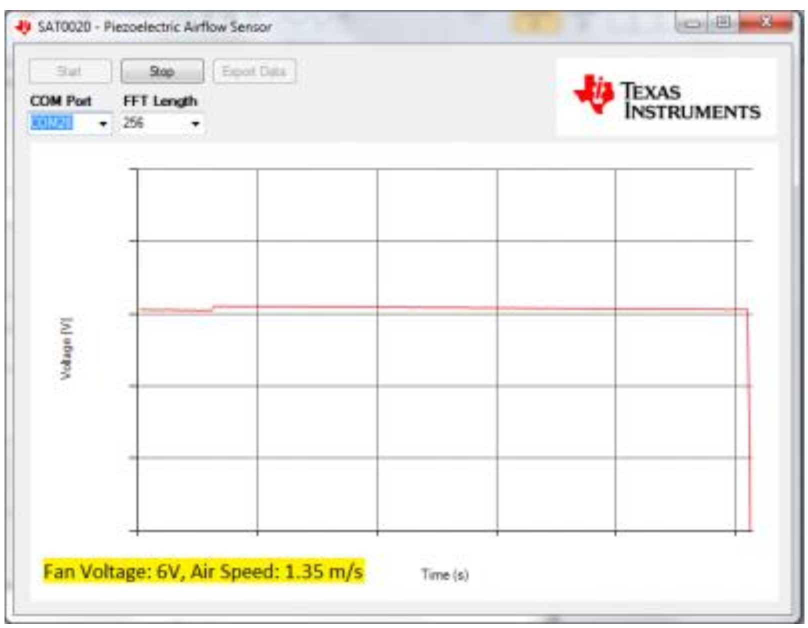
Test Results

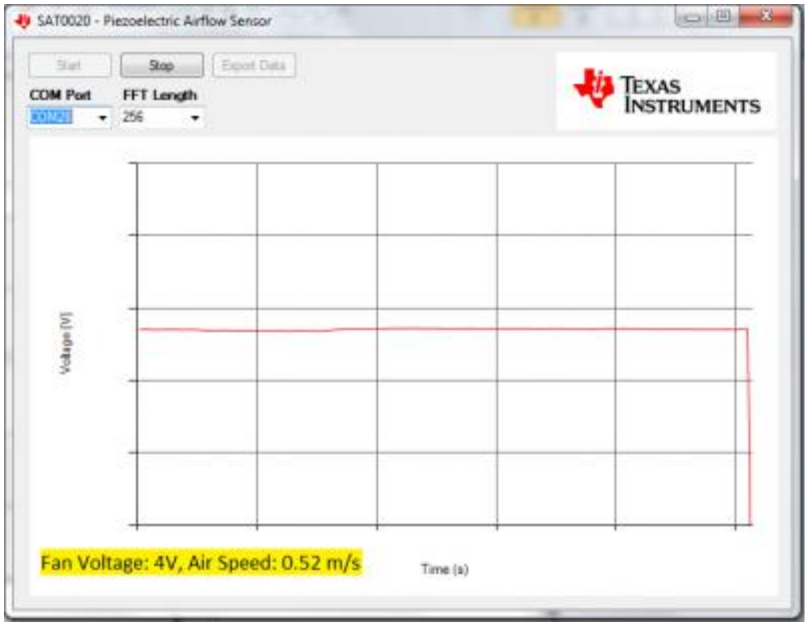
The figures below show the output of the GUI at various fan settings/ air speeds.

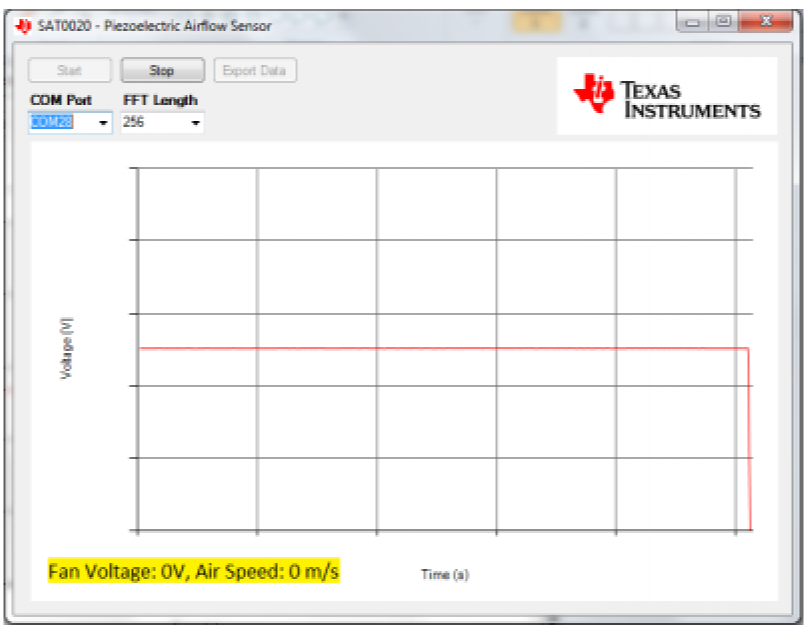





SAT0020 - Piezoelectric Airflow Sensor
Start
Stop
Export Data
COM Port
FFT Length
256
TEXAS INSTRUMENTS
Voltage (V)
Fan Voltage: 8V, Air Speed: 1.85 m/s
Time (s)

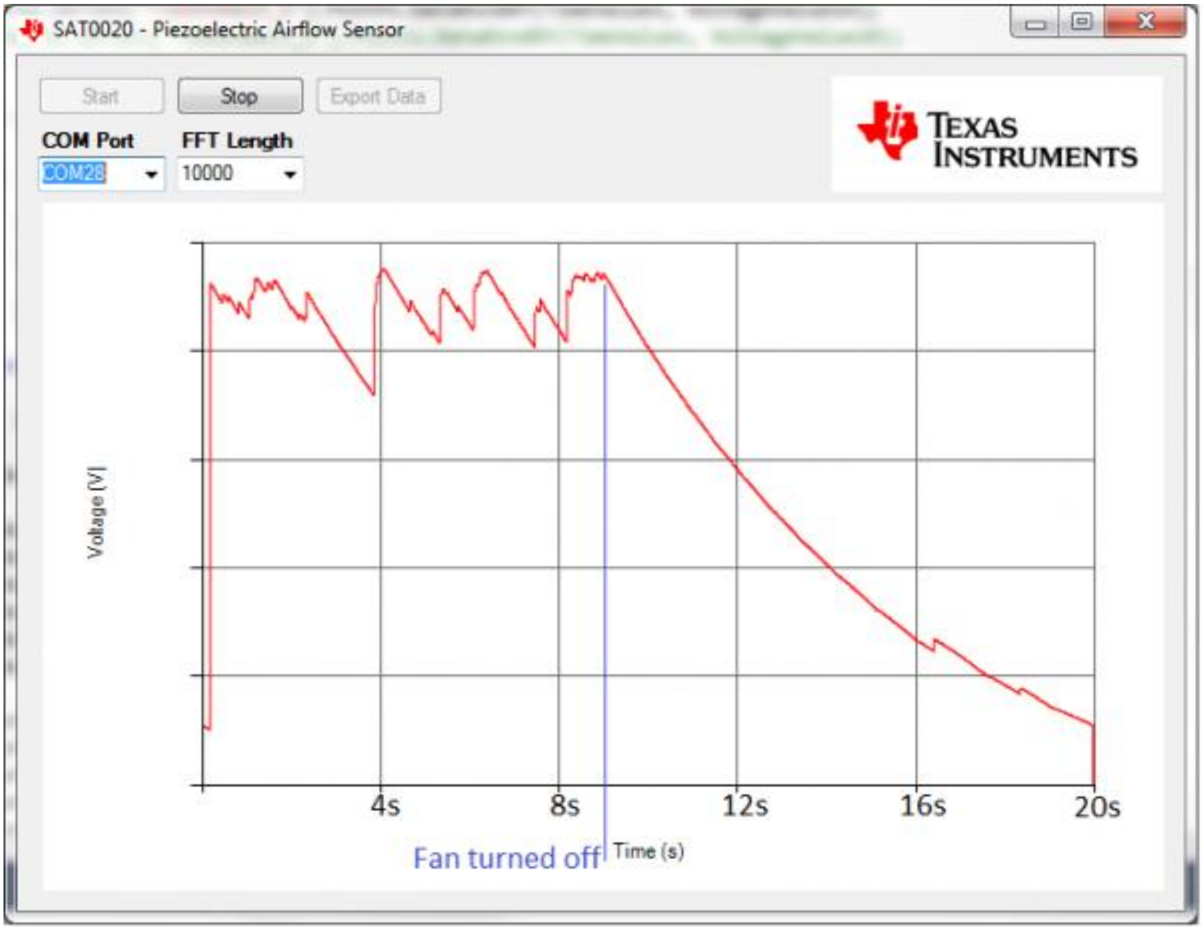

SAT0020 - Piezoelectric Airflow Sensor
Start
Stop
Export Data
COM Port
FFT Length
256
TEXAS INSTRUMENTS
Voltage (V)
Fan Voltage: 6V, Air Speed: 1.35 m/s
Time (s)





GUI output of piezo sensor exposed to different air speeds. Note that the GUI is scaled for 0->3.3V although the operational range is just 1.65->3.3V.

The figure below shows an extended (20 second) time scale to show the event of suddenly removing air flow from the sensor, and it's response. I rescaled the GUI in this view so that the scale is from ~1.5V -> 3.3V.



GUI output of piezo sensor when airflow is suddenly removed, simulating fan failure in a server

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