A Miniaturized Ion Mobility Spectrometer (IMS) Sensor for Wireless Operation.

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The work on the development of a self-contained microcontroller sensor network for the detection of environmental contaminants will be described. This development includes semiconductor chemical sensors and miniature ion mobility spectrometer (IMS) sensors. A microcontroller controls both the sensors. The sensors and controller are being designed to be housed in a cone penetrometer to specifications developed by the environmental engineers on the team.

The chemical sensor material will be combined with a semiconductor device to form a device called a chemical field-effect transistor (chemfet). Two types of chemfets were specifically designed to sense both benzene and mercury.

The ion mobility spectrometer sensor is being constructed from low temperature co-fired ceramics (LTCC) and will sense most volatile organic compounds. The novel aspects of this design include pulsed operation, self-calibration, CO_2 drift gas and a self-contained microcontroller. The microcontroller performs the IMS control signal preprocessing, data reduction, and communications functions. The microcontroller function is shown in Figure 1. The microcontroller development is the major emphasis of this presentation.

The requirements for controlling the IMS and preprocessing of the output signal were compared with available microcontroller specifications. A microcontroller with internal memory for the program and data was chosen. To reduce noise, thirty-two traces were converted into digital signals and averaged. The resulting averaged trace is then compared, time sample by time sample to determine the time of peaks, and the corresponding peak amplitude. The peak values are compared against a table of values corresponding to chemical ions that have been previously characterized to determine which ions are present. This provides with a data reduction of 60,000 to 1 as compared to sending the detected ion signal.

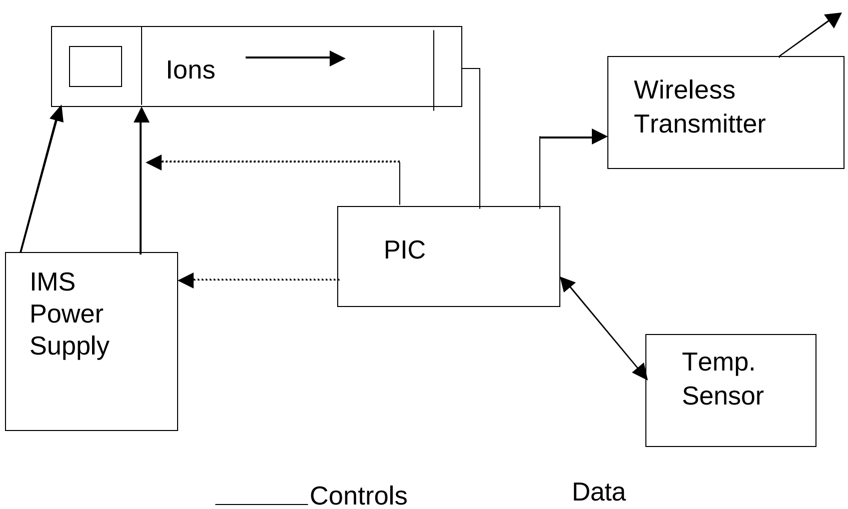

Figure 1. IMS System block diagram

To verify the noise reduction operation of the controller, a test waveform was sent to the controller and the output was observed as shown in Figure 2. The upper trace in Figure 2 shows the last eight out of the thirty-two pulses and the lower trace is the average of the thirty-two pulses.

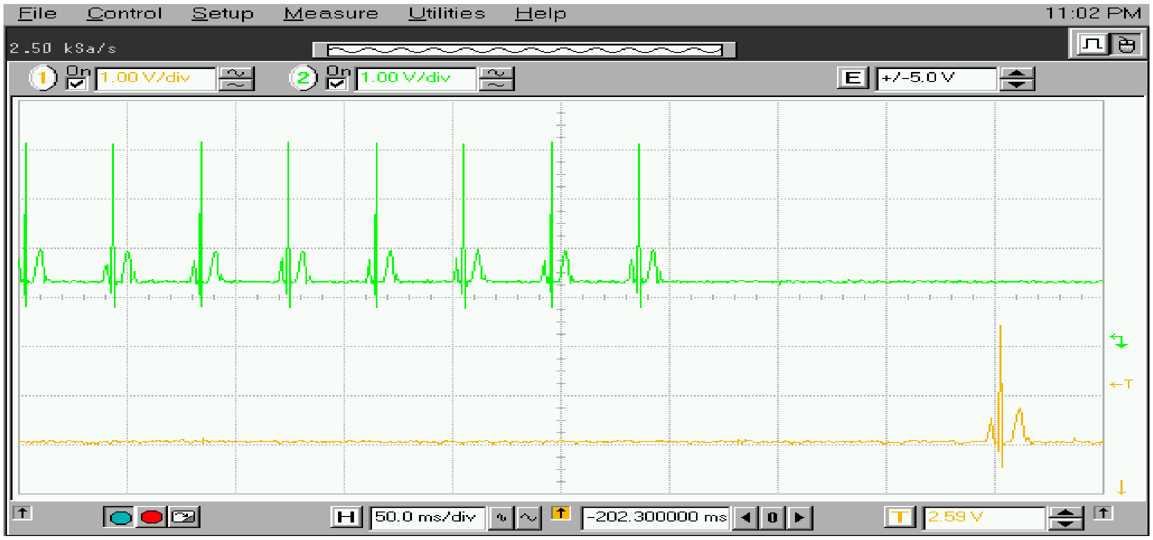

Figure 2 Input signals before sampling and the averaged output of the input trace.

Noise was added to the input circuit with a peak-to-peak value of 4 volts. As shown in the top trace of Figure 3, the noise masks the signal. In the bottom trace, the added noise has been averaged out.

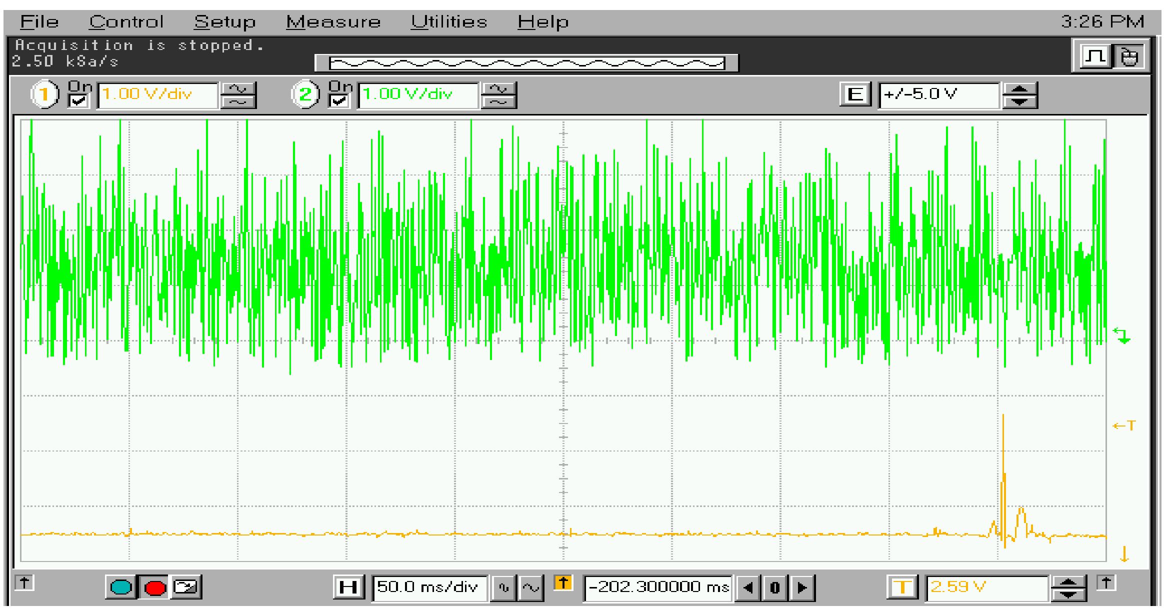

Figure 3 Noise added to the input signals, and the output after signal averaging.

The entire timing, temperature recording, and signal preprocessing functions were written in C and compiled to the PIC assembly language code. The program uses 3200 bytes of read only memory and 800 bytes of data memory. A low-power controller with a data reduction of 60,000 to 1 was built, programmed, and tested with simulated input signals.