Working With Sensors

In this section, you will start using the sensors. This section will cover:

- Writing software to collect sensor data.
- Writing software to process sensor data.
- Testing the sensor data.

Requirements:
- Hair dryer
- Thin rubber or soft plastic hose

What Is an Analog-to-Digital Converter?

- In order to collect data from the sensors, the signals from the sensors need to be converted into digital numbers that the processor can handle. The sensors generate a varying voltage based on what is measured and the processor cannot understand it. Remember, the processor is digital so it only understands ones and zeros.
- An analog-to-digital converter or ADC allows a processor to measure voltages. The world outside the computer does not have discrete steps such as on/off, high/low, one/zero. It's an analog world. The ADC allows the computer to measure the analog world with the ADC. Take a temperature sensor as an example. A temperature sensor can convert the temperature it is measuring to a voltage that corresponds to the temperature. The ADC is used to measure the voltage and convert it to a digital number that the computer can use. The computer can take that digital number and process it to calculate the temperature. You will do this with the CanSat.

Reading the Sensors

- The processor has an interface component called and analog-to-digital converter or ADC for short. The ADC converts a voltage to an integer number. The integer number can be used to calculate the voltage that was measured. The microcontroller has a 10-bit ADC. This gives an integer range of 0 to 1024 which covers 0 to 5 volts. The following equation determines the voltage measured:

  voltage = measured / 1024 * 5

- If the ADC generated an integer number value of 512 then the voltage is 512 / 1024 * 5 or 2.5 volts which is half the voltage range and half the ADC range.
- 1024 is the number values that the ADC can generate. With an ADC value of 512, the voltage is half the maximum voltage which is 2.5 volts.
- There are three ADC channels available. They are called P0, P1, and P2.

Adin Command

- **The command to read the ADC is called Adin.**

  adin PIN,var

- **The adin command requires two arguments:**
  - **PIN which is P0, P1, or P2.**
  - **Var which is a word variable that will hold the value of the ADC. Remember that the variable has to be declared the proper size. Since the ADC can generate a value from 0 to 1023, it needs a variable declared a word which allows a range from 0 to 65535.**

Working With the Pressure Sensor

- The pressure sensor measures the atmospheric pressure and generates a voltage proportional to the air pressure. The higher the air pressure, the higher the voltage.
- An equation is provided by the manufacturer:

  $V = 5.0(0.009P - 0.095)$

- V is the voltage and P is the air pressure in kilopascals.
- The pressure sensor is connected to pin P0.
- Start a new project and write a program loop to read the pressure sensor and display the ADC value. Include a one second pause between readings. Use the information from the previous two pages to write the program. Remember to display the number as a 'dec' type number.
- The value should be in the 800s.

Working with the Pressure Sensor Calculating the Voltage

- Modify the program to calculate the voltage of the ADC. Remember that the ADC value is an integer and needs to be converted to a floating point number. The calculated voltage is a floating point number so the floating point math needs to be used.
  - When specifying a number, remember to include a decimal point and zero after the whole number. Example: 5.0
  - When converting an integer variable to a floating point, insert 'tofloat' in front of the variable name. Example: tofloat n
- The result should be around 4.0.

Working with the Pressure Sensor Calculating the Pressure Value

- Finally modify the program to calculate the pressure value in kilopascals.
- The equation for the pressure sensor needs to be solved for P.

$$V = 5.0(0.009P - 0.095)$$

$$V = (5.0 * 0.009 * P) - (5.0 * 0.095)$$

$$V = 0.045 * P - 0.475$$

$$V + 0.475 = 0.045 * P$$

$$(V + 0.475)/0.045 = P$$

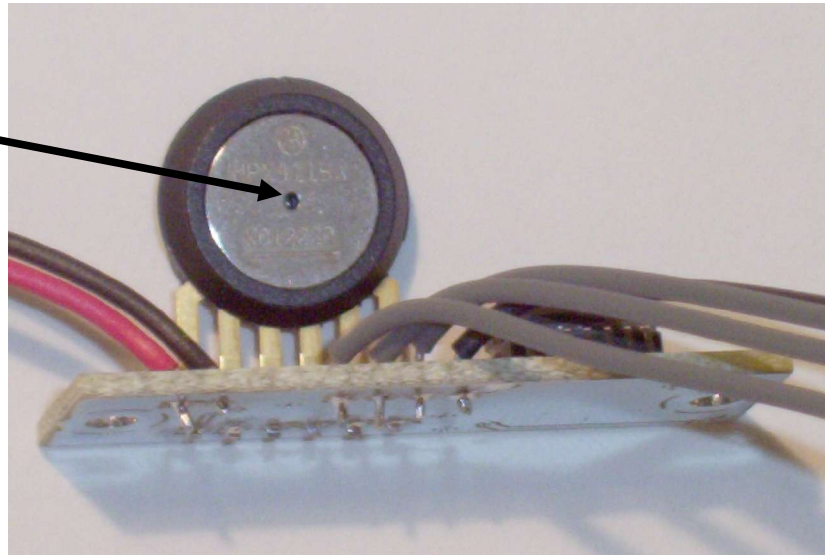
$$P = (V + 0.475) * 22.222$$

$$P = 22.222 * V + 10.556$$

- Given P = 22.222 * V +10.556, modify the program that calculated voltage and add this equation to calculate pressure. Remember to include more variables as needed and the variables need to be declared at the top of the program. The pressure calculation needs to be done with floating point math.
- The result should be around 100.0 to 102.0.

Testing the Pressure Sensor

- You will need a piece of rubber or soft plastic hose no more than a quarter inch in diameter. A pet store that sells fish has the ideal size air hose.
- Run the program that continuously displays the pressure readings.
- Cut a piece about 6 inches to a foot long. Looking at the sensor board, place one end of the hose over the hole on the metal side of the sensor.
- With the free side of the hose, suck the air out with your mouth. You should see the pressure reading drop. If not, readjust the hose on the pressure sensor until you have a better seal. Make sure the end of the hose is flat and smooth.



Working with the Temperature Sensor

- For the temperature sensor, the equation is:

  V = 0.01 * C + .5

- V is the voltage and C is the temperature in celcius.
- Solve for C

  V – 0.5 = 0.01 * C

  100 * V – 50 = C

  C = 100.0 * V - 50.0

Reading the Temperature Sensor

- The temperature sensor is connected to pin P1 so the command to read the ADC is:

```
adin P1, temp       ' temp is a word size variable
```

- Write a program to read the temperature sensor and calculate the temperature in Celcius. The program should be very similar to the pressure calculating program. Converting the ADC value to the voltage is the same as for the pressure sensor.
- Modify the program to continuously read the temperature sensor once a second.
- To test the temperature sensor, use a hair dryer to blow hot air onto the temperature sensor.
- At room temperature, the temperature reading should be around 22 to 25 degrees celcius.

Summary

- In this section, you should have written two programs to read the pressure sensor and temperature sensor, calculated the air pressure and temperature, and displayed the results on the computer.
- You should have built a vacuum chamber and tested the pressure sensor.