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, Signals From the Sensors Must Be Converted Into Units That the Processor Can Handle
  - Sensors Generate an 'Analog' Voltage That Varies Based on What Is Measured and the Processor Cannot Understand It
    - Remember, the Processor Is 'Digital' So It Only Understands Ones and Zeros (i.e., Binary Data)
- An Analog-to-Digital Converter (ADC) Allows a Processor to Measure Voltages
  - It's an Analog World Outside the Processor
    - Measurements Do Not Have Discrete Steps (i.e., On/Off, High/Low, One/Zero)
    - An ADC Allows the Processor to Measure the Analog World
- As An Example, Look at a Temperature Sensor
    - A Temperature Sensor Converts the Measured Temperature to a Voltage That Corresponds to the Temperature
    - The ADC Measures the Voltage and Converts It to a Digital Number That the Processor Can Use
    - The Processor Take The Digital Number and Processes It to Calculate the Temperature
    - You Will Do This With the *CanSat*

Reading the Sensors

- The Processor Has an Interface Component Called an Analog-to-Digital Converter (ADC)
  - The ADC Converts a Voltage to an Integer Number
  - The Integer Number Is Used to Calculate the Measured Voltage
  - The Microcontroller Has a 10-Bit ADC
    - This Gives an Integer Range of 0 to 1023 Covering 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 = 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 Holds 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

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

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

$$V = 0.045 * P - 0.475$$

$$V + 0.475 = 0.045 * P$$

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

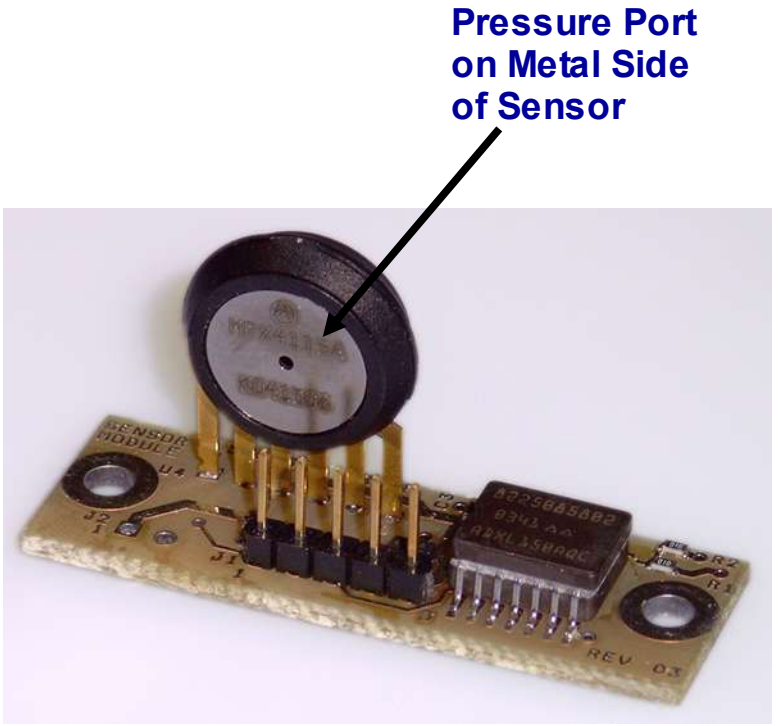
$$P = (V + 0.475) * 22.222$$

$$P = 22.222 * V + 10.556$$

- 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 ¼ Inch in Diameter; A Pet Store That Sells Fish Has the Ideal Size Air Hose; A Straw Can Be Used Also
- Run the Program That Continuously Displays the Pressure Readings
- Cut a Piece About 6 – 12 Inches in Length
- 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 Celsius
- 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 Celsius
  - 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
- At Room Temperature, the Temperature Reading Should Be Around 22 - 25 deg Celsius
- To Test the Temperature Sensor, Use a Hair Dryer to Blow Hot Air Onto the Temperature Sensor

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 Tested the Pressure Sensor and Temperature Sensor