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2.00AJ / 16.00AJ Exploring Sea, Space, & Earth: Fundamentals of Engineering Design
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2.00AJ/16.00AJ Lab 3: Information on Sensors

Overview

The Sensor Pack is a do it yourself project that makes complex sensors affordable and customizable to fit the criteria of your sensing needs. Although the theory that makes the sensors function is complex and encompasses many fields of technology, the fabrication and programming is simple and can be completed in just a few hours with a soldering iron, a PC and some wire cutters. At a cost of just over \$150, this sensor suite is at least one-third the price of any single sensor available in the suite that is commercially available.

The pack is affordable and easy to build as a result of the Basic Stamp microcontroller at its heart. Since the microcontroller has the ability to be reconfigured through software, no complex circuitry is required to begin sensing the environment. In fact, all the circuitry on the board with the exception of the microcontroller is exclusively used to convert the signals from the sensors to a digital range the microcontroller can process. The rest of the processing and calculation is completed on board the Basic Stamp, and stored on a USB memory stick.

The à la carte sensor pack includes the following functionality:

- PC connectivity via serial communication
- Data manipulation and storage on any USB memory stick
- Conductivity sensor (to find salinity)
- Pressure sensor (for depth)
- Temperature sensor
- Light sensor
- Four additional i/o pins for added functionality

PC Connectivity

Although it is not required to view data, it is essential that the sensor suite have the ability to communicate with a PC to upload the program to the Basic Stamp, and to modify and expand the program to incorporate customized functions. This is carried out through a 9 pin serial cable that connects to a PC and the DB9 connector installed on the sensor pack. An added bonus of communication is that the sensor pack can be used to provide live feedback through the installation program (provided for free with the sensor).

Data Manipulation and Storage

The data that is collected by the sensor suite is received as an un-calibrated 8-bit digital signal. This signal is then passed to the microcontroller and can be left alone and calibrated in post processing, or the Basic Stamp can perform the calibration and scaling as determined by the user, providing instant meaningful data, and storing the data in a form that is ready for instant upload to the digital ocean

database. This data, after all conversions and manipulation, is converted to a form which can be written to a USB memory stick in a text file, and is passed from the microcontroller to the text file for instant use. In the case of a power failure or other malfunction, the data will not be lost as it is continually saved with each incoming sample.

Conductivity

Conductivity is measured by sending an AC signal through a gap in a circuit created by spacing two screws one centimeter apart. A known voltage is passed through the circuit for a given time. On the return side of the circuit, there is a capacitor, which is continuously charged and discharged by the AC signal. The energy that makes it across the conductivity gap is stored in the capacitor, and the discharge rate of the capacitor is measured and stored in the memory of the Basic Stamp. Since more energy will take longer to discharge from the capacitor, the ease of energy transfer, and therefore the percent of transmitted energy, can be inferred from the time it takes to discharge the capacitor, and resistance of the medium (the inverse of conductivity) can be determined. The Basic Stamp takes care of the conversion and the calibration and presents the user with a measure of conductance of a liquid.

Pressure

Analyzing the change in shape of a diaphragm, and comparing this change to the steady state conditions of the diaphragm provides an accurate pressure measurement. A known voltage is passed to a transistor, which is located in the pressure sensor behind the diaphragm. While the pressure sensor experiences atmospheric pressure, the transistor allows 1% of the input voltage to pass through the transistor and into the circuitry. As the pressure increases, the diaphragm begins to move and proportionally limits the voltage passing through the sensor to somewhere between 0% and 1% the input voltage, relative to 0PSI and 30PSI (depending on the sensor installed). The circuitry between the sensor and the Basic Stamp utilizes an operation amplifier to boost this signal to the zero to five-volt scale, and then converts the analog signal to an 8-bit digital signal. This signal is converted by the microcontroller to a depth that is accurate to roughly six inches.

Temperature

Temperature is measured in a similar fashion to pressure, where a known input voltage is scaled proportionally based on changing environmental conditions. In this case, the temperature probe is made of two different metals that deform at different rates based on the temperature. This deformation changes the internal resistance of the metal, allowing more or less energy to pass through with a change in temperature. This relative change is measured by the microcontroller and converted to a temperature reading.

Light

The Photocell is a passive component, which like a solar panel has the ability to excite electrons to higher states of energy with increasing light concentration, and then moves these electrons to a storage facility. The energy created by the excited

electrons is stored in a capacitor, which is continually discharged and timed to determine rate. This rate measurement is proportional to the amount of energy stored in a given time, and available light can be inferred.

Additional pins

Since the benefit of using a microcontroller is in the software-based modification of the circuit, it is simple to add features to the sensor pack if desired. To accommodate this feature, four pins are left unfilled that can be used as inputs to or outputs from the microcontroller at a later time. Each pin has the full functionality of the Basic Stamp available to it, and the data storage mechanism can be modified to accept the new information.

Circuitry

- Conductivity
 - Stainless Steel Screws
 - Creates a gap for energy to flow through
 - NE555CN IC
 - Timer chip used to control the release of energy to the capacitor
 - 0.1uf Capacitor
 - Measured to determine energy transfer
- Pressure
 - PX26-30GV Sensor
 - Houses the diaphragm that controls the flow of energy
 - UA741CN IC
 - Operation Amplifier used to boost the signal from the pressure sensor from millivolts to volts
 - Resistors
 - Bias the operation amplifier
 - TLC0831CP IC
 - Converts the scaled voltage from the operation amplifier to an 8-bit digital signal
- Temperature
 - AD592 Probe
 - Contains the bimetallic strip for temperature measurement and an analog to digital conversion chip
- Light
 - Photodiode
 - Provides a material that can be excited by light
- Microcontroller
 - Basic Stamp 2SX
 - Processes all the data and converts it to serial data
- Data Storage
 - FTDI chip
 - Converts serial data from the Basic Stamp to the hexadecimal format required for writing to a text file on a USB memory stick