Objective: As part of our series of low-cost experiments for students to explore glass science, we are also developing a simple, low cost platform for data logging and temperature control appropriate for the high school or college laboratory. The Parallax Basic Stamp Microcontroller provides an ideal foundation, utilizes an easy to learn Basic language for programming and hosting a variety of sensors with associated sample code. A very popular robotics platform (BOEBOBOT) has already been developed around these microprocessors by Parallax Inc., but our focus is to use their use in the science laboratory and classroom.

We present here applications for measuring and controlling temperature, as well as logging temperature and voltage data directly into Excel. Schemes for simple "on-off" and proportional control of temperature are presented, compared and applied to a home built microscope hot stage. A student built Differential Thermal Analysis (DTA) apparatus illustrates the data logging capacity and how it can enable quantitative explorations of glass and other physical sciences on a student budget.

Basic Stamp Microcontrollers - An Experimenter's Dream

The Basic Stamp is a microcontroller platform from Parallax Inc., popular among educators to assess its ease of use, capability, strong support and focus on education.

- Powerful yet easy to learn and program (easy, simple Basic language)
- Well-documented and supported with large collection of example code - all free
- Lots of accessory hardware & sensors (temp, humidity, pressure, generations, color, etc.)
- USB serial communication to PC
- Free data logging software and macro for including directly into Excel
- Reasonable cost

Enables students to design & build their own experiments requiring either measurement or control.

http://www.parallax.com/

Simple Temp Measurement and Control with Thermistor and any Stamp Module

The resistance of the thermistor is read via the RCTIME command. It returns RC discharge time in units of 2 microseconds.

Temperature Control

Proportional Control Scheme Improves Ripple

Temperature Measurement Options

Temperature Sensor Options for Microcontrollers:

- Thermocouples (TC) -
  - advantage: good over wide range of temperature (> 1000 C)
  - limitation: interface device needed to measure low voltages (~ 40 mV/C)

TC Temp Sensors - several types (LM 35, etc.)

- advantages: linear with T and calibrated (~ 10 mV/C)
- limitations: limited to below 150 C and output is analog requiring AtoD with good resolution (~ 10 bit)

Stamp Board Capabilities for Temperature Measurement:

BOE (Board of Education) – comes with BOE BOBOT robotics kit (with BS2 chip)

- reads resistance but requires longer code for TC module

MOBO (Mother Board):

- Inexpensive cost path to powerful data logging capability
- Analog input (4) with 10 Bit onboard AtoD
- Analog output

The MOBO package above costs under $125 (including the TC module) and is sufficient for collecting a wide range of input data from thermocouples to analog voltages or resistances, as well as many additional capabilities.

Data Logging Application with the MOBO and TC Module (DS2760)

Our student-built Differential Thermal Analysis (DTA) shown right (more details on our website) is an ideal application for automated data collection. Here both temperature and the differential temperature (ΔT) (between a test tube with the sample and one with the reference) must be recorded several times a minute while the solution is being heated. Automated data collection is especially helpful when measuring the multiple runs required for the development of a project or a new method. Keeping with our low cost, hands-on approach, we chose to build our own data logging apparatus using the MOBO platform combined with the add-on thermocouple module.

The data is collected and sent to the PC over the serial (USB) line and pulled directly into an active Excel spreadsheet, where data can be plotted real-time, as it is collected. Details of design and evaluation can be found on our website.

Summary:

The Basic Stamp Microcontroller provides a relatively simple platform for students to control and collect temperature, enabling a wide range of experiments of their own design. Two different examples have been described which illustrate the ease of use and range of possibilities. The Basic Stamp platform has an advantage over traditional approaches by Vernier and Pascal in allowing the student open access to the hardware and software, providing more understanding of microcontrollers and greater control over their own designs. And all at a lower overall cost. Many other senses such as humidity, light, color and pressure are available from Parallax Inc., along with excellent documentation. We have introduced this platform to students in our REU program at Lehigh University where it has generated much enthusiasm and some excellent instruments. Construction details and software code for the projects described above are available on our website (see below).

For additional details and future updates please see our education page at: www.lehigh.edu/GlassEducation.htm

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