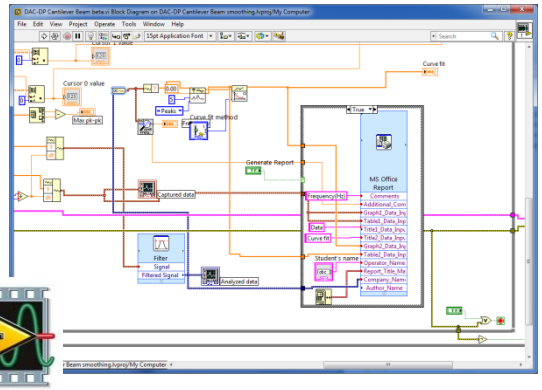
Using Arduino & LabView for Teaching MEMS Devices

Andrew G. Bell



Nov 3, 2016

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We offer Associates of Science degrees in:

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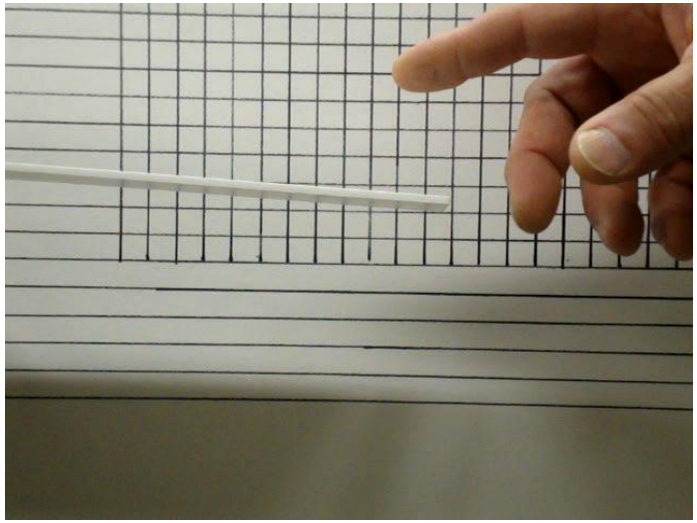
Ivy Tech started its associating with SCME in the Fall of 2012 and has been a Co-PI on Southwest Center for Microsystem Education (SCME) NSF ATE Grant. We also have a NSF ATE small project grant for Microsystems Certification

MEMS Kits Implementation Plan IVY TECH (Fort Wayne & Valparaiso)								
	MEMS Kit	**ENGT 120**	**METC 111**	**METC 143**	**EECT 111**	**EECT 112**	**ENGR 251**	**ENGT 279**
1	MEMS: Making Micro Machines Kit	X						
2	Dynamic Cantilever Kit		X	X			X	
3	Crystallography Kit			X				
4	Pressure Sensor Model Kit	X			X	X	X	
5	GeneChip Model Kit	X						
6	MEMS Innovators Kit							X
7	Lift-off Kit			X	X			
8	Pressure Sensor Process Kit				X			
9	LIGA Micromachining Simulation Kit			X				
10	Anisotropic Etch Kit			X	X			
11	Rainbow Wafer Kit	X						

http://www.scme-nm.org/
http://www.ivytech-mems.org/

In Fort Wayne we use three basic kits but our plans are to expand on the use of all kits.



MEMS are sensors that measure something that can be interfaced to electronics.

MEMS are device be used to translate mechanical motion into electrical signals.

MEMS are devices operate using the same laws of physics that describe much larger systems.

MEMS are devices can be made very small

Since MEMS devices are smaller it takes less physical space to use them in an educational setting.

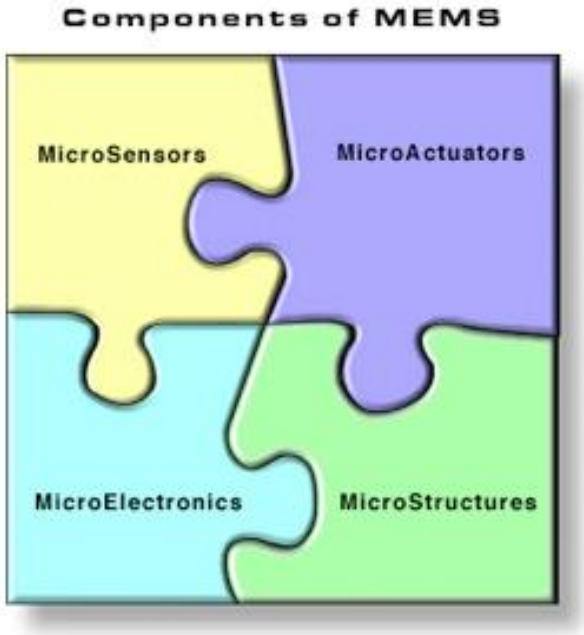
There are numerous engineering analogies that can be taught using MEMS devices and since they are small there the is a lower cost.

Some MEMS devices are based on variations on resistance, capacitance or inductance.

Learning how to interface sensors to electronics is an essential element in learning how to use MEMS devices.

Micro-Electro-Mechanical Systems, or MEMS, is a technology that in its most general form can be defined as miniaturized mechanical and electro-mechanical elements (i.e., devices and structures) that are made using the techniques of microfabrication.[1]

The critical physical dimensions of MEMS devices can vary from well below one micron on the lower end of the dimensional spectrum, all the way to several millimeters.[1]



In our case we will focus only on sensors and how to use MEMS devices with electronics.

1 - http://www.memsnet.org/mems/what_is.html

http://www.scme-nm.org

So what is an Arduino?

Arduino is a inexpensive Microcontroller CCA that interface to your PC via USB

They typically cost ~ 20 to 25 and are available many places online

Software to program them is free, open source. https://www.arduino.cc/

Arduino Uno (and other models) have daughter boards call “shields” that you can stack

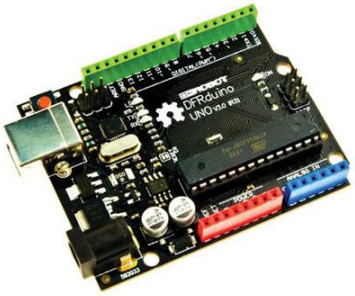
Shield include Motor Drives, Prototype boards, Displays, etc.

Arduino microcontrollers have become very popular with hobbyist, students and colleges.

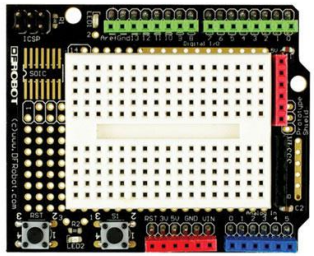
http://www.jameco.com/
https://www.adafruit.com/
http://www.elexp.com

Arduino Uno Rev3 is a 8-bit microcontroller board based on the ATmega328P,

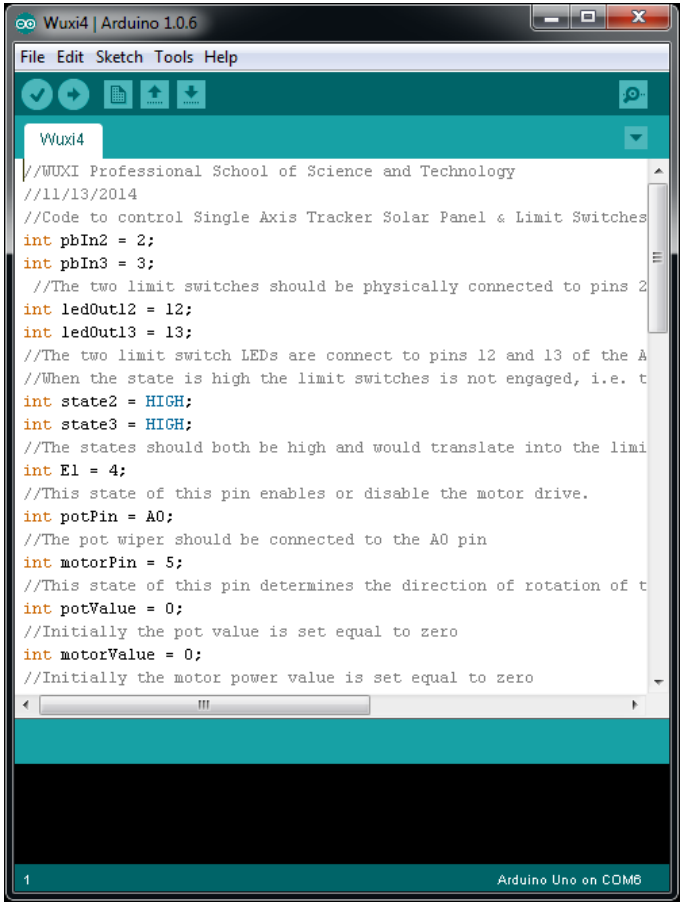
Specification	
Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage	7-12V
Digital I/O Pins	14
Analog Input Pins	6
Flash Memory	32 KB
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz
PC Interface	USB



Arduino Uno



Prototype Shield



https://www.arduino.cc/en/Main/ArduinoBoardUno

The Arduino is a small inexpensive microcontroller board that allows for easy and popular (electronic) project development.

A microcontroller typically includes, I/O, memory and a microprocessor. It is sort of a mini microprocessor board.

The Arduino is built to accept daughter boards called Shields and there exists many commercially available shield that you can stack onto your Arduino boards.

One of the most common shields is called a prototype shield and it allow the user to develop their own electronics.

The Arduino can be programmed with simple free open source code or even high level or graphically based languages like LabView.

https://www.arduino.cc/

LabView is graphical based programming language developed by National Instruments and used extensively in industry. http://www.ni.com/labview/

LabView programs are called "vi" programs and typically include a block diagram type of program that is programmed via block interconnections of various functional blocks.

Students can use LabView to build custom executable software.

LabView training has three basic level: LabView Core 1, 2 and 3

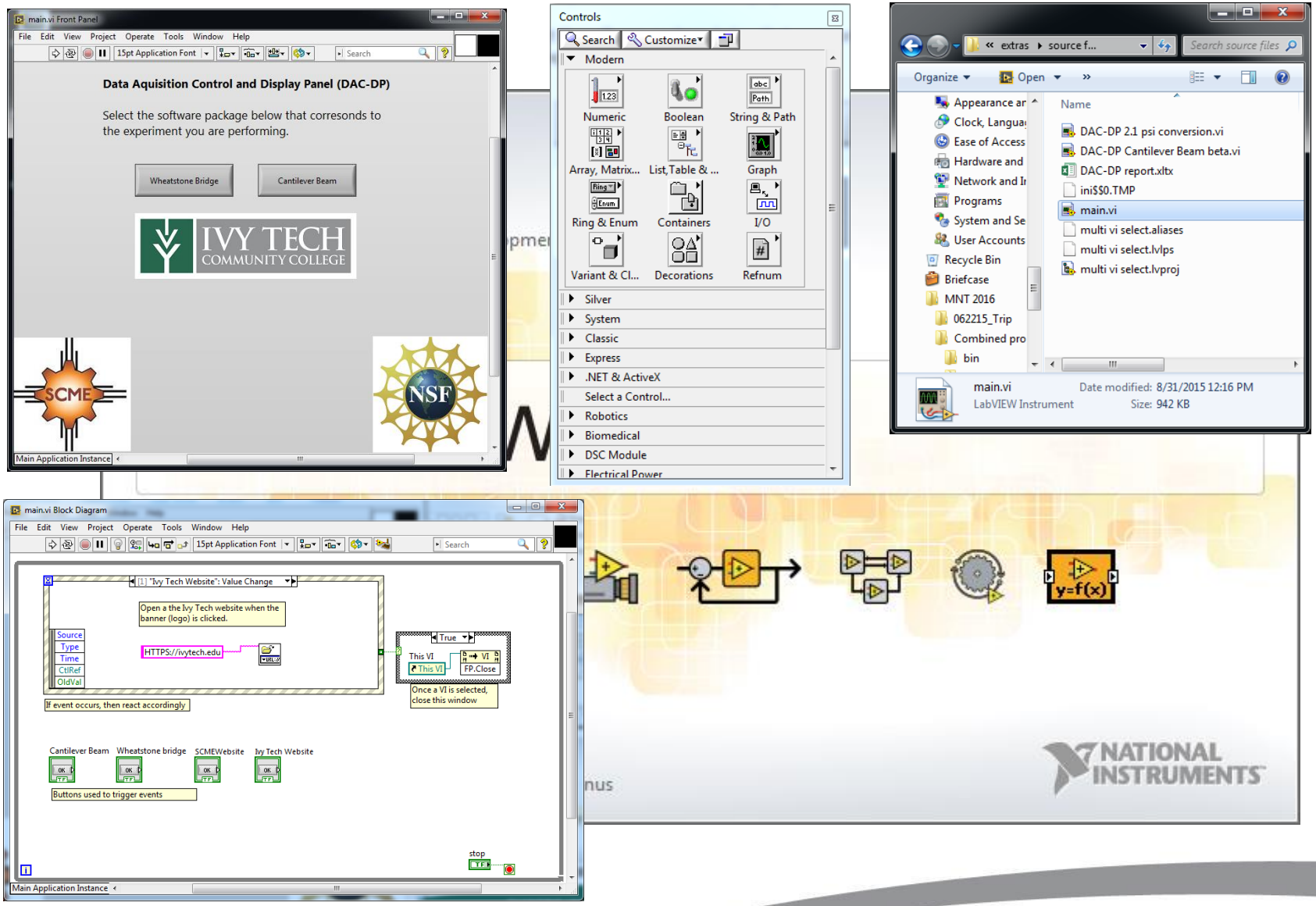
LabView program also have a gui interface window that can be designed to allow users to view the data and control the programs.

LabView can be used for control, data acquisition and displaying results using custom

LabView can also be used with microcontrollers like the Arduino Uno

Support for this is now provided by MakerHub @ https://www.labviewmakerhub.com/

What is LabView?



In 2014 we decided to develop supplemental data acquisition electronics for two of the kits.

Reasons

- To improve on data collection of the experiments
- Add more “electronics” to the kit material

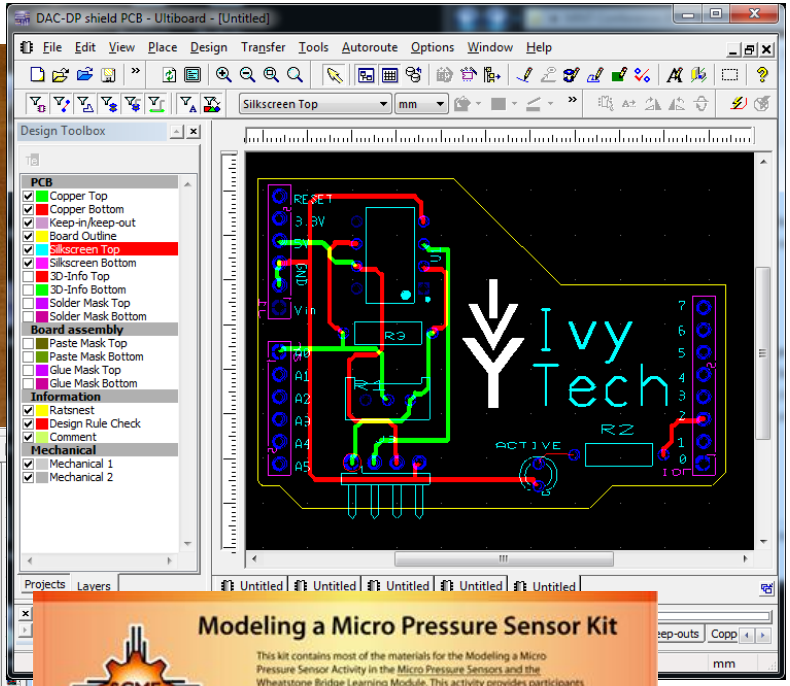
Approach

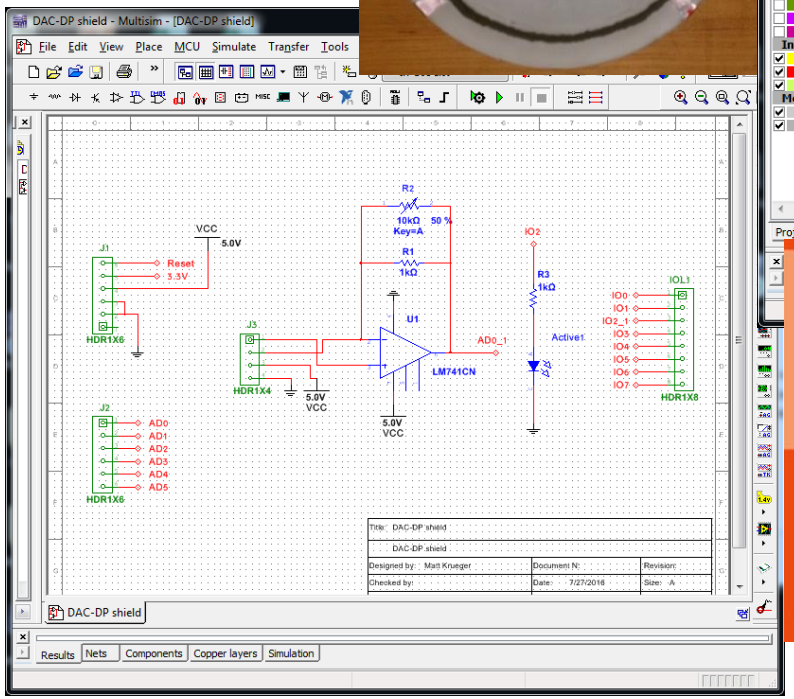
Use LabView and Arduino micro-controllers

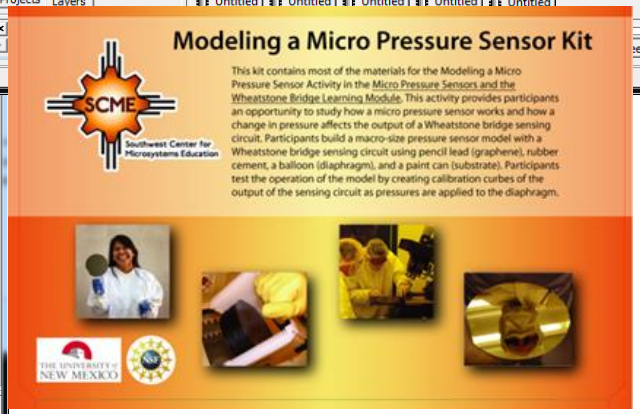
Reasons

- Knowledge of LabView can help students get a job
- Arduinos are cheap, popular and very flexible

First up the Pressure Sensor kit => ***Modeling a Micro Pressure Sensor Kit***

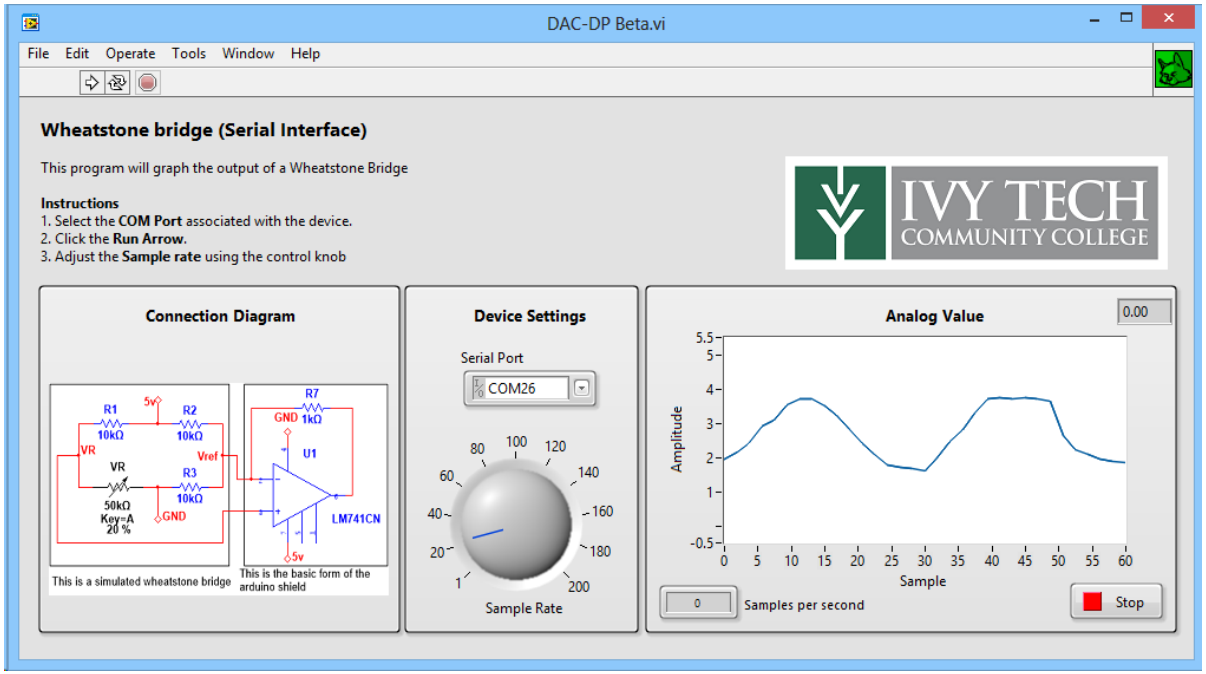


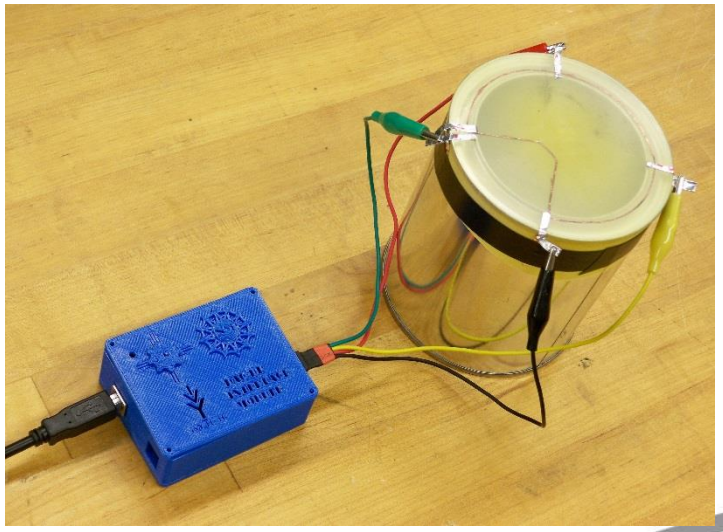


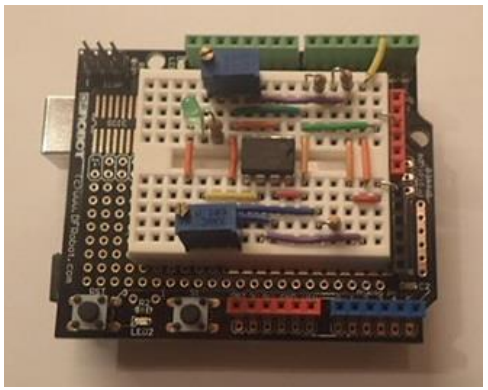


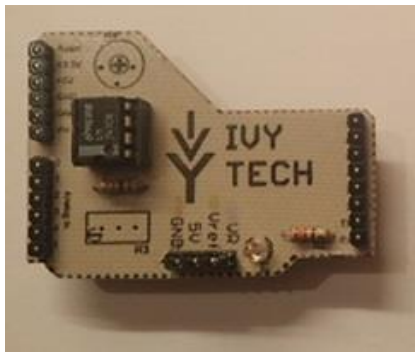
The new DAK Kit for Pressure Sensor Kit

Includes - Arduino Uno based DAK interface module, instruction manual, Executable LabView Data acquisition software, USB cable, and pressure sensor interface cable.

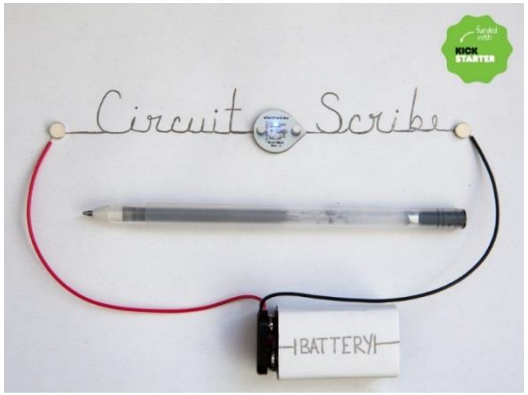


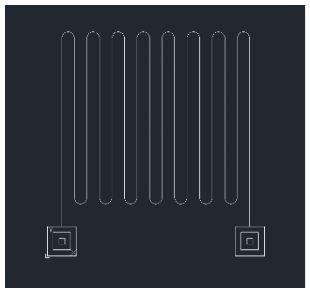






Second up the Cantilever Beam kit => ***Microcantilever Model Kit***





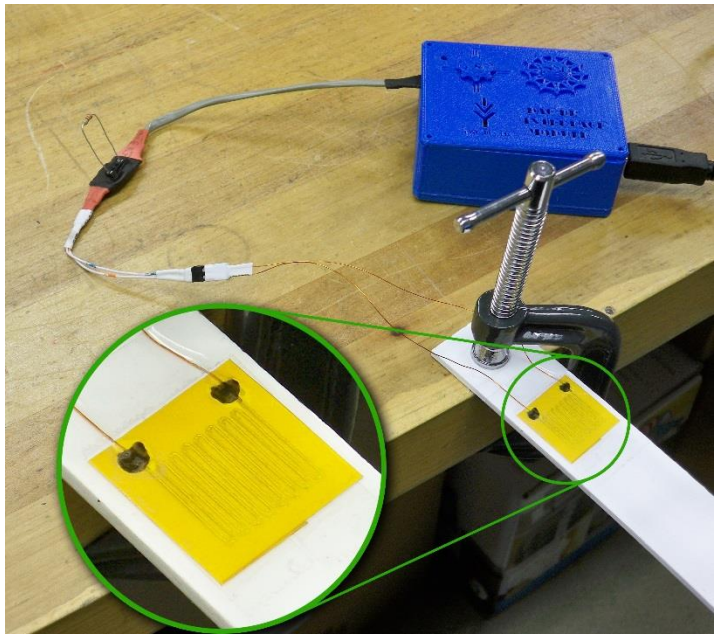
How to make a strain gauge

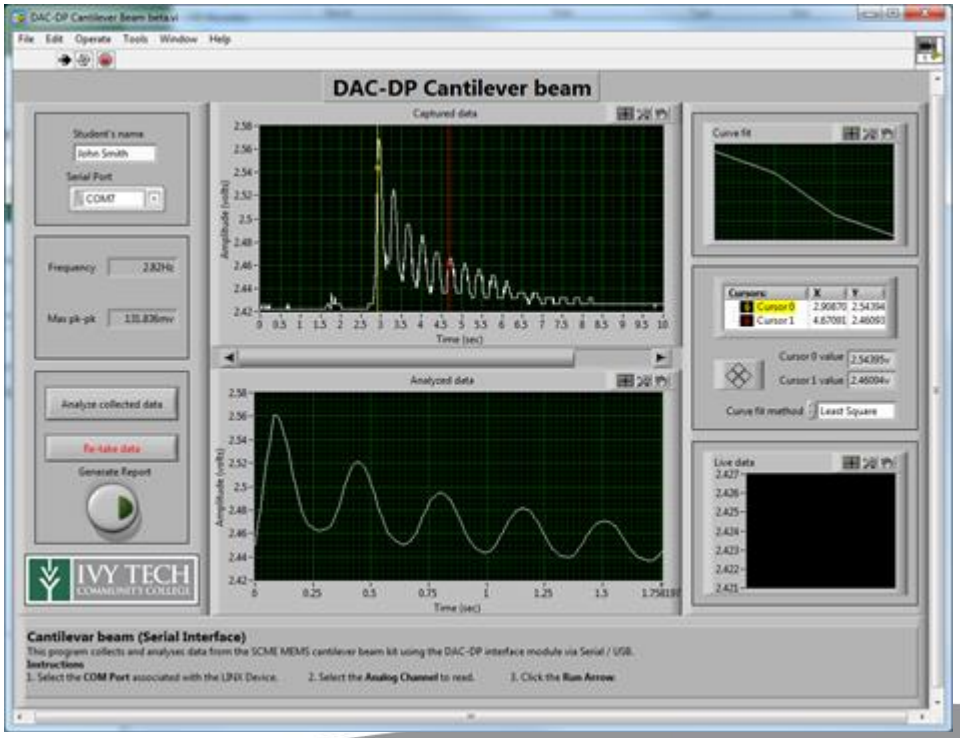
What you will need

1. Silhouette cameo
2. Computer with Silhouette studio
3. Silhouette pen holder
4. Electroninks Circuitscribe conductive ink pen
5. Common white printer paper
6. Kapton tape 1'' wide
7. 30ga Magnet wire
8. 2x1 Female pin header/terminals
9. Conductive Wire glue
10. Strain gauge silhouette file
11. Silhouette grid cut file

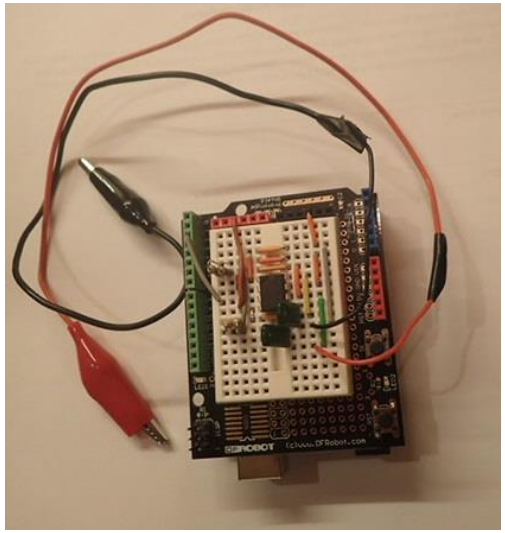
The new DAK Kit for
Cantilever Kit

Includes - Arduino Uno based DAK interface module, instruction manual, executable LabView Data acquisition software, USB cable, and Cantilever beam
Strain gauge interface – Discovered “How to make a Strain Gauge”





New Variable Capacitor design
Can use same code as Cantilever LabView code
Based on common 555 Timer design



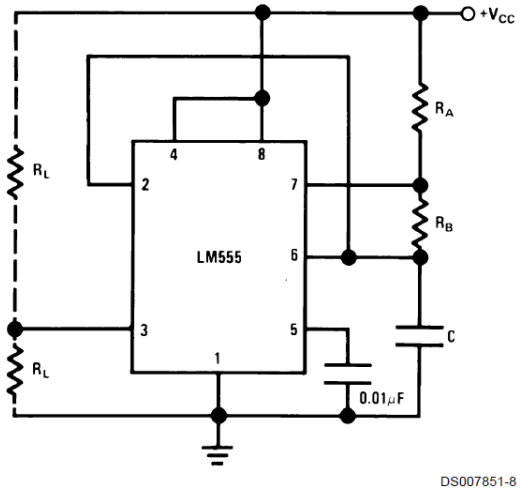
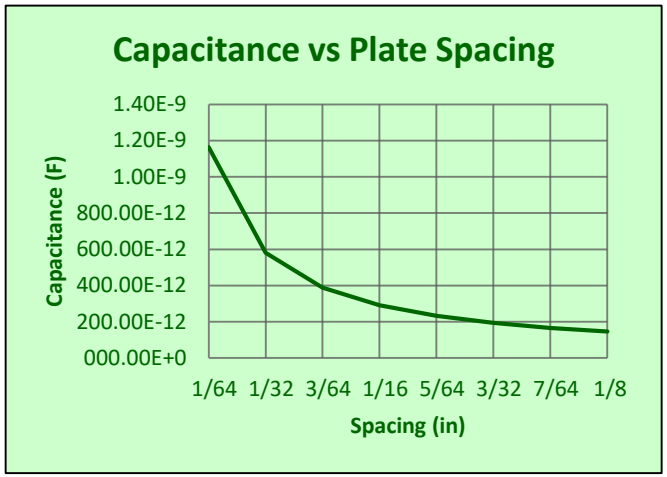
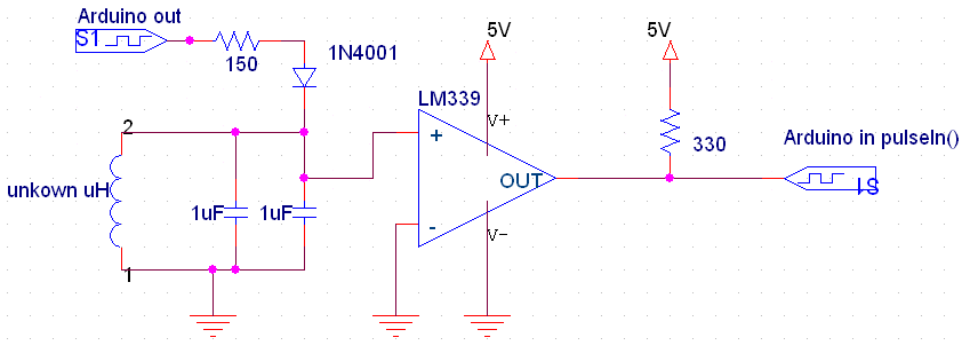


FIGURE 4. Astable



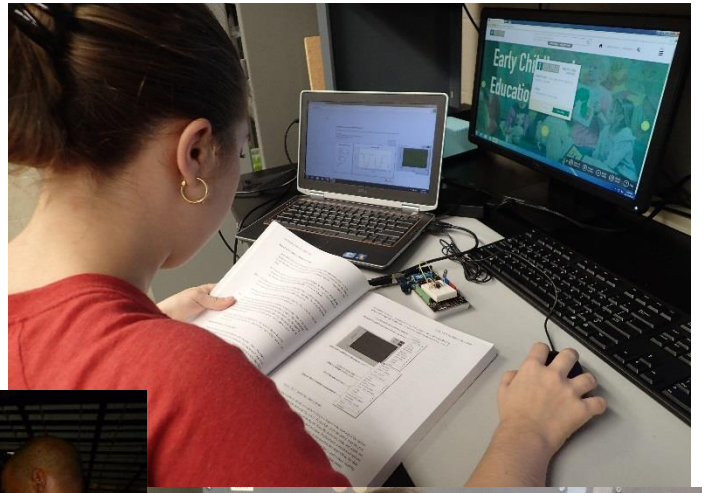
New Variable Inductor design
Want to use same code as Cantilever LabView code
Could be based on oscillator design
Could be based on LCR design
Could be based on DC-DC converter design

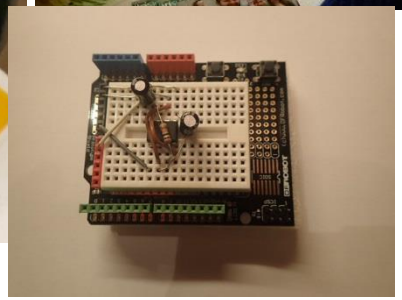
http://langster1980.blogspot.com/2013/07/arduino-lc-meter-shield.html
https://forum.arduino.cc/index.php?topic=80357.0
http://mchp.blogspot.com/2014/11/arduino-rclf-meter.html
http://hackaday.com/2011/07/24/using-an-arduino-to-measure-inductance/
https://reibot.org/2011/07/19/measuring-inductance/

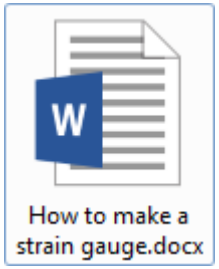


Use Discovery Based Learning Approach

1.) Give students general idea and requirements for design
2.) Provide students with resources to design, build and test
3.) Provide feedback as needed but don't micromanage
4.) Allow students time to learn, fail and succeed
5.) Provide positive feedback and recognition
6.) Step back and let them learn …







Building more electronic kits based on Arduino and LabView

Developing three new MEMS course to focus on "how to use MEMS devices" with electronics

Continue to use discovery based learning

Getting started with LabView and Arduino code
https://www.labviewmakerhub.com/

More on SCME Kits
http://scme-nm.org/

More on Ivy Tech MEMS
http://www.ivytech-mems.org

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