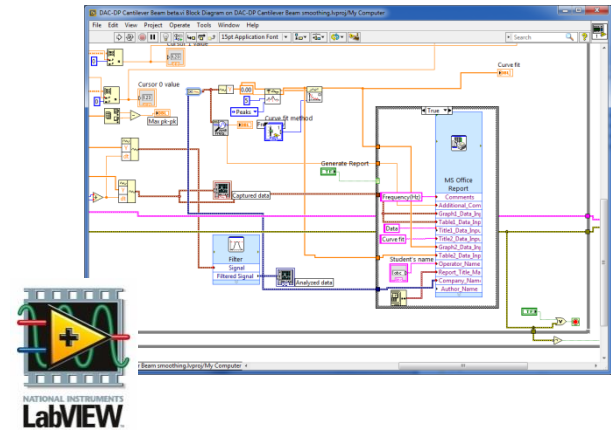


Using Arduino & LabView for Teaching MEMS Devices

Andrew G. Bell



Nov 3, 2016



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MAKING INDIANA GREAT

Ivy Tech Community College is Indiana's largest public postsecondary institution and the nation's largest singly accredited statewide community college system. Ivy Tech serves nearly 200,000 students annually and has campuses throughout Indiana.

We offer Associates of Science degrees in:

Electrical Engineering Technology
Mechanical Engineering Technology
Engineering Technology
Pre- Engineering
Nanotechnology
Design Technology

over 40 degree programs



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

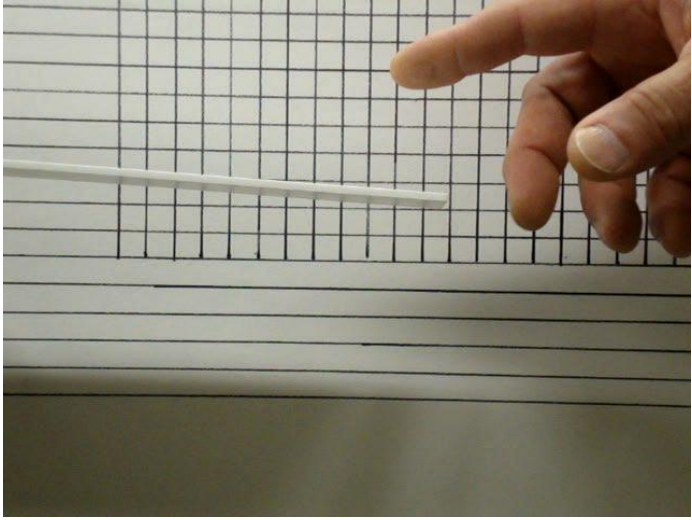


MEMS Kits Implementation Plan IVY TECH (Fort Wayne & Valparaiso)								
		ENGT	METC	METC	EECT	EECT	ENGR	ENGT
	MEMS Kit	120	111	143	111	112	251	279
1	MEMS: Making Micro Machines Kit	X						
2	Dynamic Cantilever Kit		X	X			X	
3	Crystallography Kit			X				
4	Pressure Sensor Model Kit	X			X	X	X	
5	GeneChip 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.



Microcantilever Model Kit

This kit contains most of the materials for the Microcantilever Model Activity in Book 2 of the *Microcantilever Learning Module*. This activity provides participants an opportunity to explore the motion of a cantilever under a varying mass and to determine the relationship that expresses the resonant frequency of a cantilever as a function of mass. This activity simulates the dynamic mode of operation for microcantilevers used in MEMS sensors.

Southwest Center for Microsystems Education

THE UNIVERSITY OF NEW MEXICO

Modeling a Micro Pressure Sensor Kit

This kit contains most of the materials for the Modeling a Micro Pressure Sensor Activity in the *Micro Pressure Sensors and the Wheatstone Bridge Learning Module*. This activity provides participants an opportunity to study how a micro pressure sensor works and how a change in pressure affects the output of a Wheatstone bridge sensing circuit. Participants build a macro-size pressure sensor model with a Wheatstone bridge sensing circuit using pencil lead (graphene), rubber cement, a balloon (diaphragm), and a paint can (substrate). Participants test the operation of the model by creating calibration curves of the output of the sensing circuit as pressures are applied to the diaphragm.

Southwest Center for Microsystems Education

Crystallography Kit

This kit contains the materials for two activities in the *Crystallography Learning Module*. Through these activities, participants explore the crystal structure of silicon. In *Breaking Water*, participants determine the crystal orientation of two silicon wafers by carefully breaking the wafers and identifying the crystal planes on which the wafers break.

In *An Octahedral Crystal*, participants construct a 3-dimensional representation of a silicon crystal showing the different crystal planes as defined by Miller indices.

www.scme-nm.org



What are MEMS?

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.

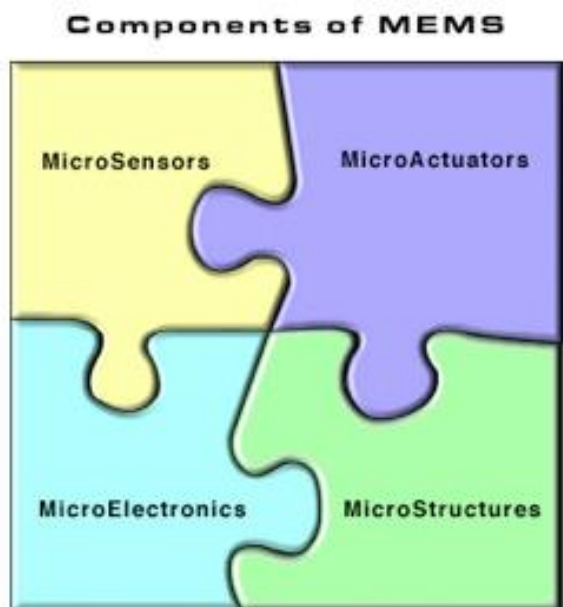
Some MEMS devices are based on variations on resistance, capacitance or inductance.

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

What are MEMS?

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.memsnet.org/mems/what_is.html)

<http://www.scme-nm.org>

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What is an Arduino?

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/>

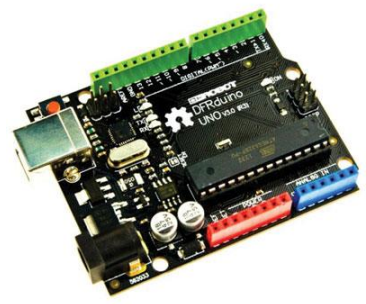
<http://www.elexp.com>



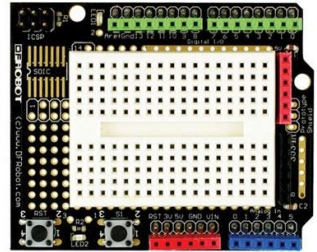
What is an Arduino?

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

```
Wuxi4 | Arduino 1.0.6
File Edit Sketch Tools Help
Wuxi4
//WUXI Professional School of Science and Technology
//11/13/2014
//Code to control Single Axis Tracker Solar Panel & Limit Switches
int pbIn2 = 2;
int pbIn3 = 3;
//The two limit switches should be physically connected to pins 2
int ledOut12 = 12;
int ledOut13 = 13;
//The two limit switch LEDs are connect to pins 12 and 13 of the A
//When the state is high the limit switches is not engaged, i.e. t
int state2 = HIGH;
int state3 = HIGH;
//The states should both be high and would translate into the limi
int E1 = 4;
//This state of this pin enables or disable the motor drive.
int potPin = A0;
//The pot wiper should be connected to the A0 pin
int motorPin = 5;
//This state of this pin determines the direction of rotation of t
int potValue = 0;
//Initially the pot value is set equal to zero
int motorValue = 0;
//Initially the motor power value is set equal to zero
```

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

What is an Arduino?

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/>

What is LabView?

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.

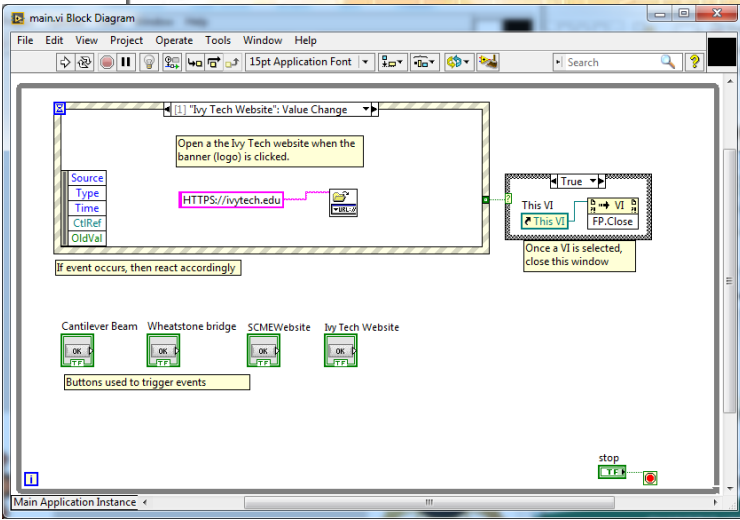
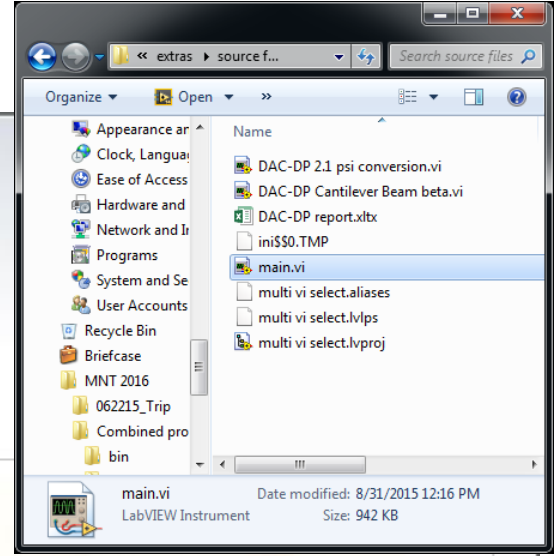
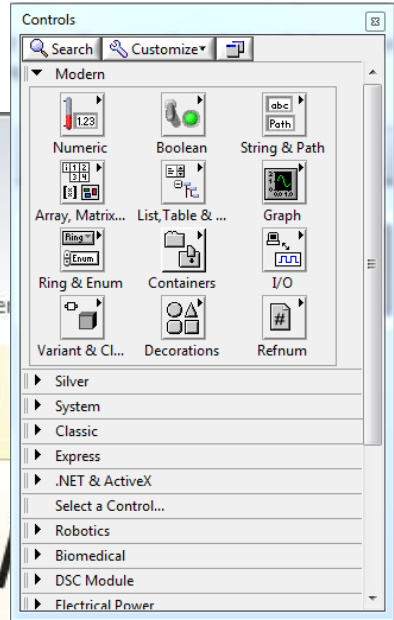
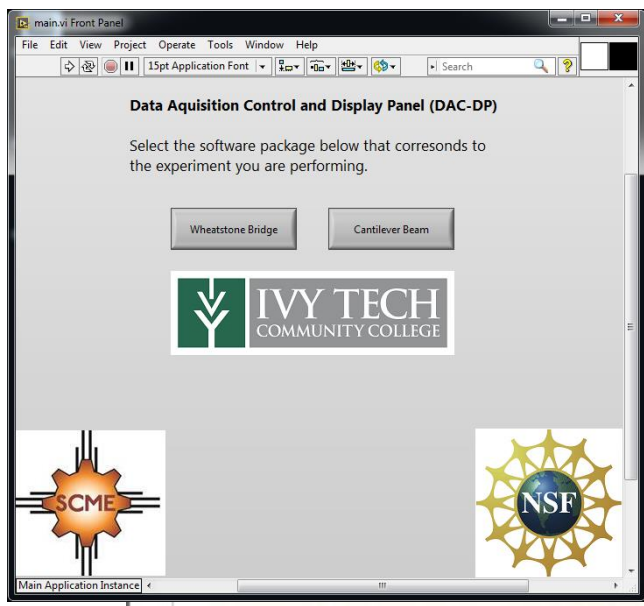
LabView can be used for control, data acquisition and displaying results using custom

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?



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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



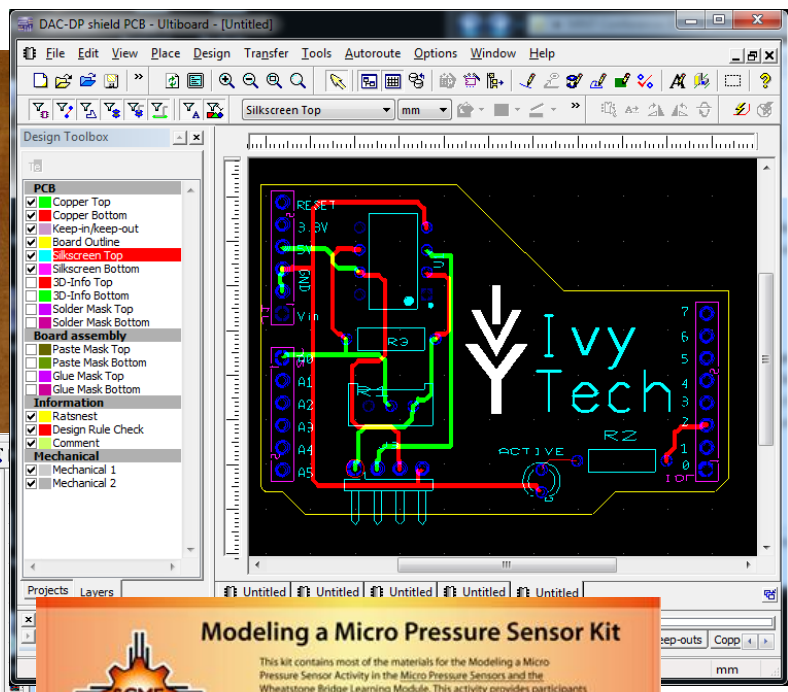
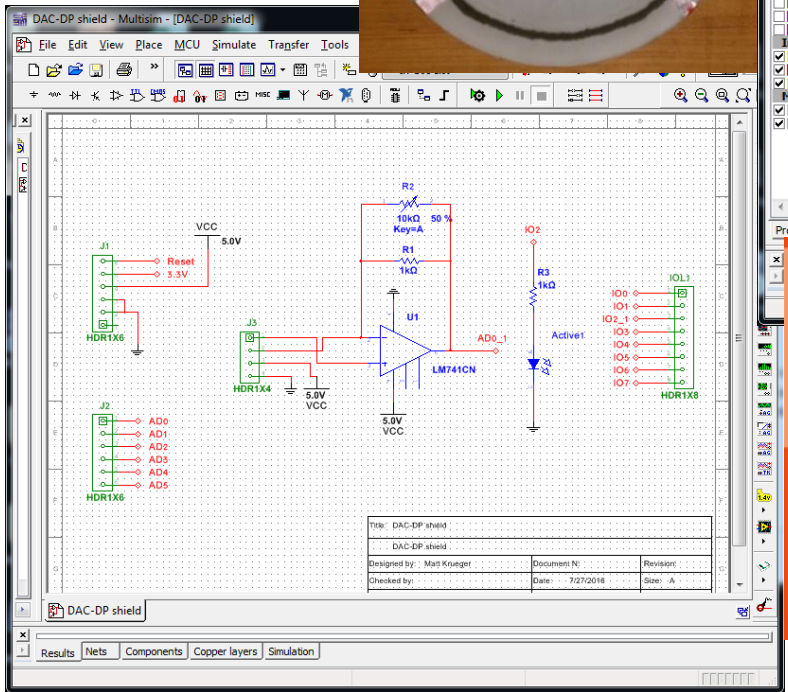
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MEMS: Data Acquisition Kit
This kit is an electronic extension of the SCME pressure sensor model kit. DAC-DP interface module and LabView software allows the SCME pressure sensor model kit to interface to a computer provides a graphical display pressure sensor differential output voltage. Includes - Arduino Uno based DAC-DP interface module, instruction manual, executable LabView Data acquisition software, USB cable, and pressure sensor interface cable.

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









Modeling a Micro Pressure Sensor Kit



Southwest Center for Microsystems Education

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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.

Wheatstone bridge (Serial Interface)

This program will graph the output of a Wheatstone Bridge

Instructions

1. Select the COM Port associated with the device.
2. Click the Run Arrow.
3. Adjust the Sample rate using the control knob

Connection Diagram

This is a simulated wheatstone bridge

This is the basic form of the arduino shield

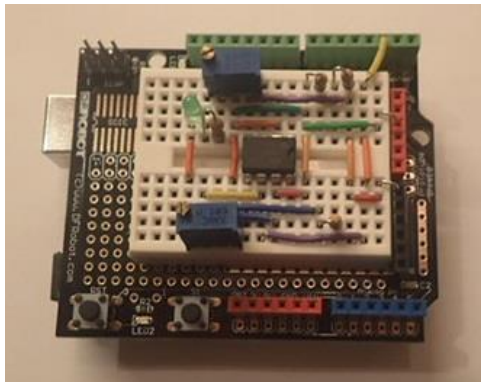
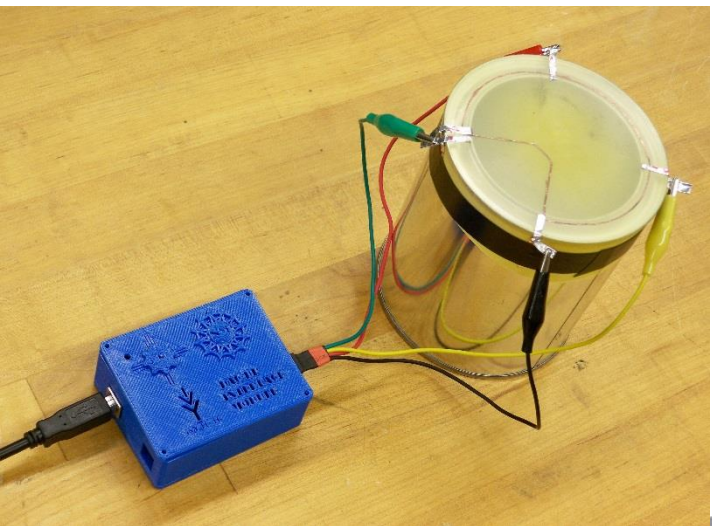
Device Settings

Serial Port: COM26

Sample Rate: 100

Analog Value

Amplitude vs Sample graph showing a fluctuating signal between 1.5 and 4.0.



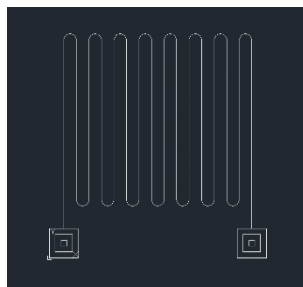
Second up the Cantilever Beam kit => *Microcantilever Model Kit*



How to make a strain gauge

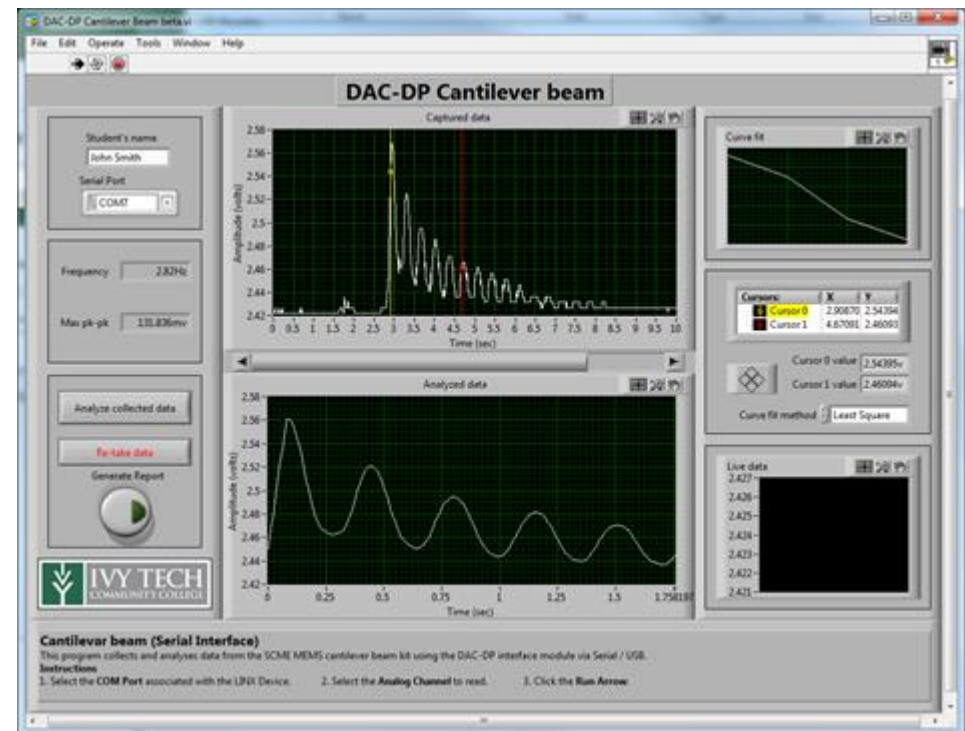
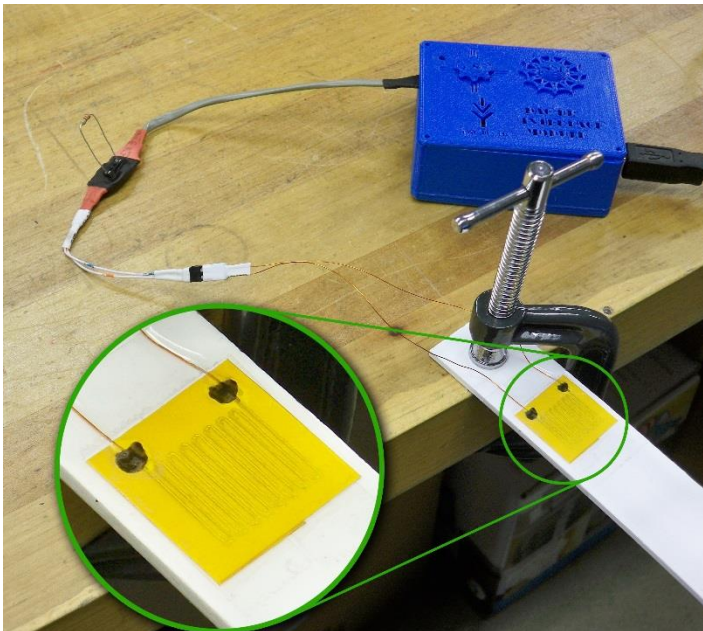
What you will need

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

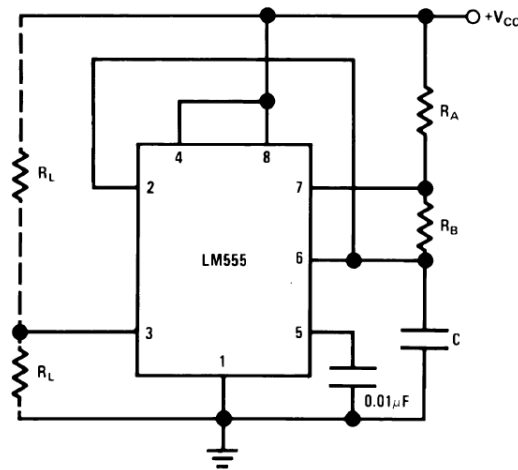
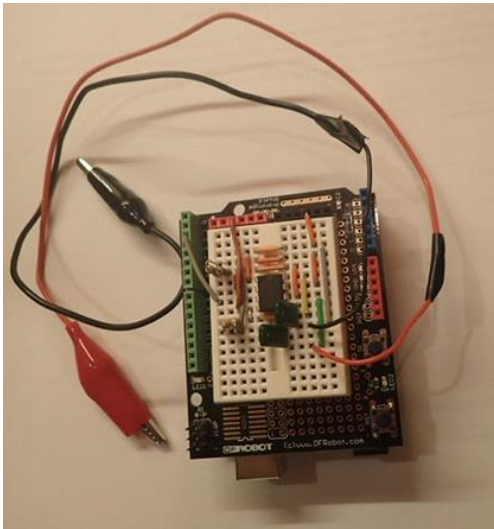
Includes - Arduino Uno based DAK interface module, instruction manual, executable LabView Data acquisition software, USB cable, and Cantilever beam Strain gauge interface – Discovered “How to make a Strain Gauge”



New Variable Capacitor design

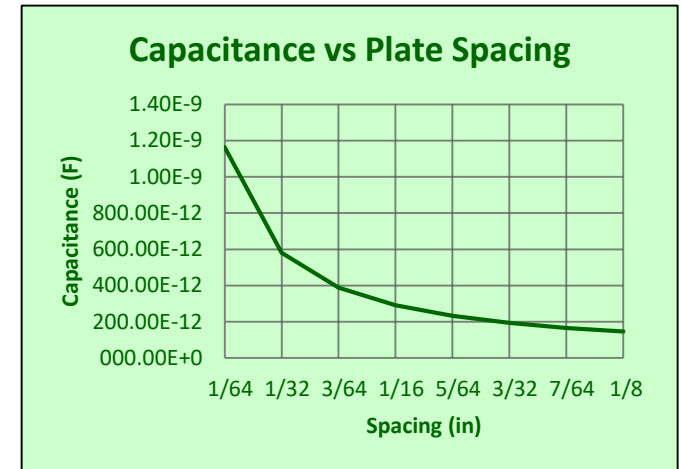
Can use same code as Cantilever LabView code

Based on common 555 Timer design



DS007851-8

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

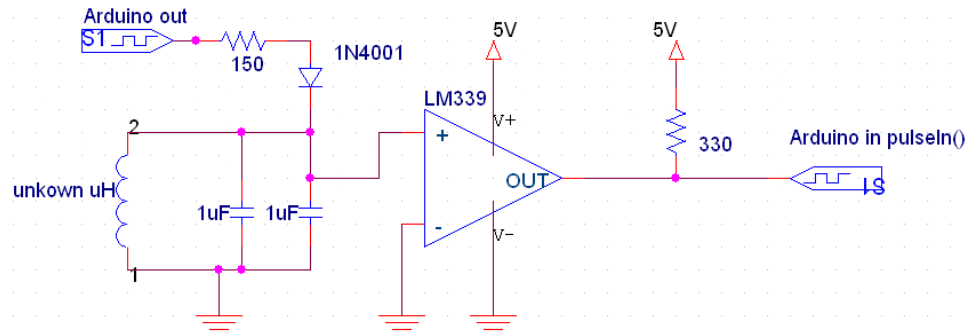
<http://langster1980.blogspot.com/2013/07/arduino-lc-meter-shield.html>

<https://forum.arduino.cc/index.php?topic=80357.0>

<http://mchp.blogspot.com/2014/11/arduino-rclf-meter.html>

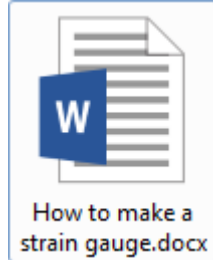
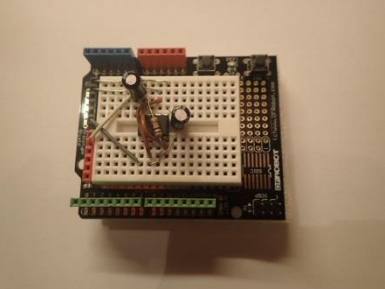
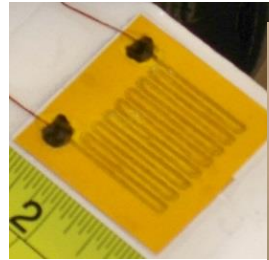
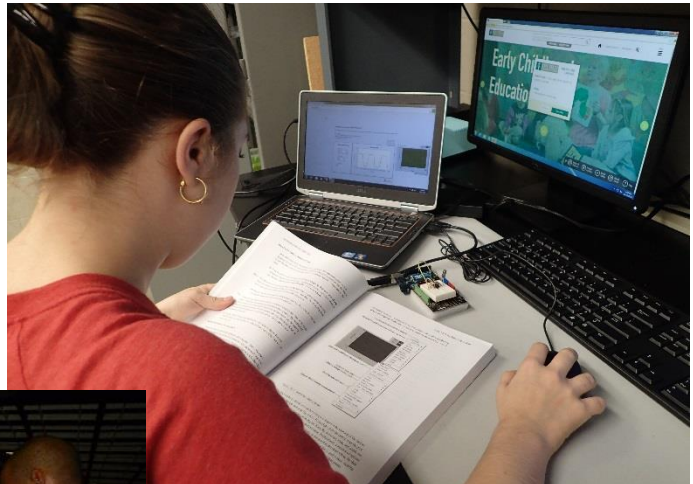
<http://hackaday.com/2011/07/24/using-an-arduino-to-measure-inductance/>

<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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