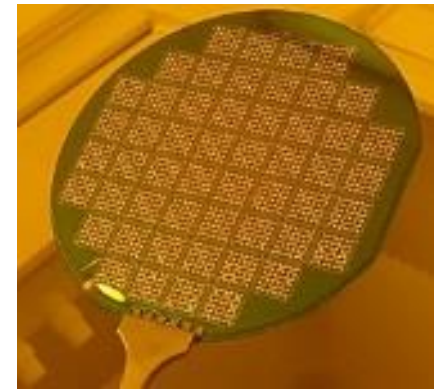
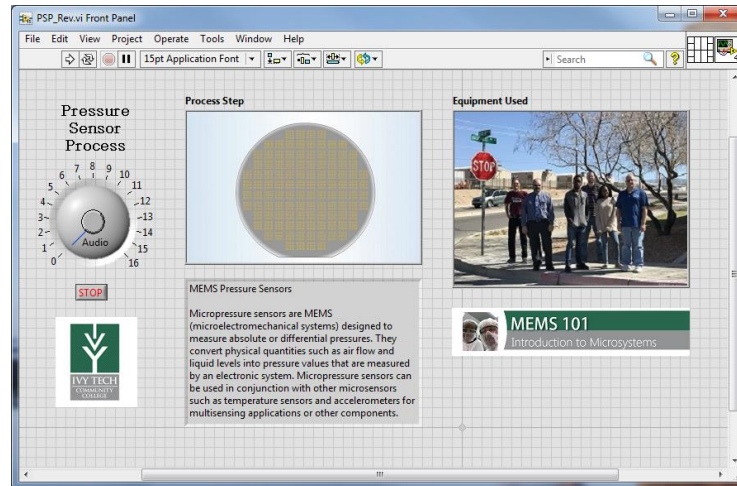


Development of MEMS Course Content using LabView and Arduino

Andrew G. Bell



July 20, 2017



CHANGING LIVES
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 170,000 students annually and has campuses throughout Indiana.

We offer TC, AS and AAS degrees in:

Electrical Engineering Technology
Mechanical Engineering Technology
Engineering Technology
Pre- Engineering
Nanotechnology
Design Technology
Electronics and Computer Technology

over 40 degree programs

<https://www.ivytech.edu/>



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.

The scope of our effort was to integrate the SCME material into some of our engineering programs courses

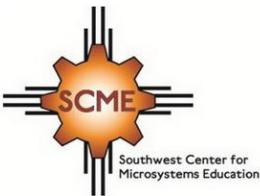
MEMS Kits Implementation Plan IVY TECH (Fort Wayne & Valparaiso)								
		ENGT	METC	METC	EECT	EECT	ENGR	ENGT
	MEMS Kit	120	111	143	111	112	251	279
1	MEMS: Making Micro Machines Kit	X						
2	Dynamic Cantilever Kit		X	X			X	
3	Crystallography Kit			X				
4	Pressure Sensor Model Kit	X			X	X	X	
5	GeneChip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

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.

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 period lead (graphite), 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.

Crystallography Kit
This kit contains the materials for two activities in the Crystallographic Learning Module. Through these activities, participants explore the crystal structure of silicon. In *Etching Silicon*, 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 Oblique 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



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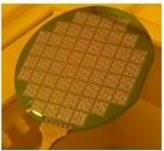
Three new MEMS courses are being developed and taught this summer as part of the NSF ATE grant (DUE 1400470)



MEMS 101

Introduction to Microsystems

Method of Instruction – Classical approach with lectures, labs and quizzes



MEMS 102

Microsystems Characterization

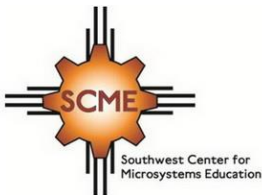
Method of Instruction – some lectures, multiple artifact generation, discovery based



MEMS 103

Microsystems and Electronics

Method of Instruction – Minimal lectures, discovery based, all labs



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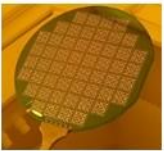
MEMS courses have been added to the Ivy Tech course listing and can be used with other course to earn a TC in Electronics and Computer Technology



MEMS 101

Introduction to Microsystems

Technology used – many SCME lectures and kits, some LabView



MEMS 102

Microsystems Characterization

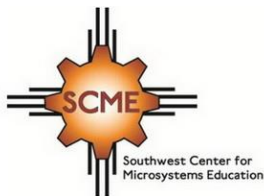
Technology used – LabView, PSPICE Model Editor, Engauge, Multisim



MEMS 103

Microsystems and Electronics

Technology used – LabView, Arduino, sensors and modifies SCME kits



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Developed 8 learning modules based on SCME kits, videos and materials.

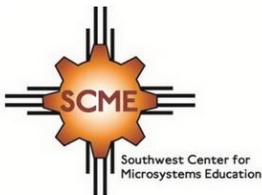
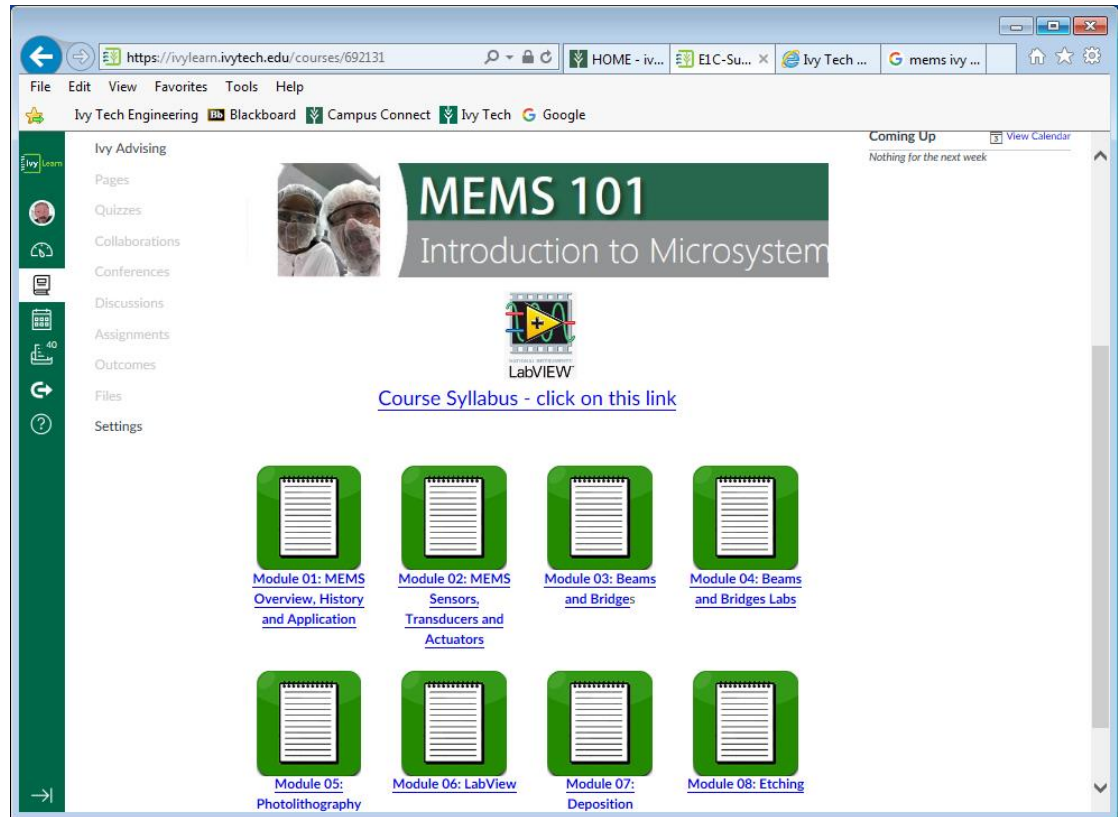
Introduced LabView

LMS – Canvas (IvyLearn)

LabView –student license

SCME Kits - 3 kits used with plan to use more

SCME Modules ~ 22 lectures and YouTube vids.



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Browser window showing the course page: <https://ivylearn.ivytech.edu/courses/692131/pages/m05-ph>

MEMS 101 > Pages > M05 Photolithography

201710 - Summer 2017 C...

View All Pages

M05 Photolithography

[MEMS 101 Photolithography](#)

Course & Module Objectives

By the end of this module, you will be able to:

- [Photolithography relative to MEMS](#)
- [Photolithography Overview Participant Guide](#)
- [LabVIEW vids](#)

When you are ready to get started on this module, click the [next](#) button below

◀ Previous

Browser window showing the course page: <https://ivylearn.ivytech.edu/courses/692131/pages/m05-ph>

MEMS 101 > Pages > M05 Photolithography for MEMS

201710 - Summer 2017 C...

View All Pages

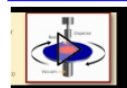
Published

M05 Photolithography for MEMS

SCME material on Photolithography - Photolithography is the process that defines and transfers a pattern onto a thin film layer on the wafer. In the photolithography process a light source is typically used to transfer an image from a patterned mask to a photosensitive layer (photoresist or resist) on a substrate or another thin film. This same pattern is later transferred into the substrate or thin film (layer to be etched) using a different process called etch.

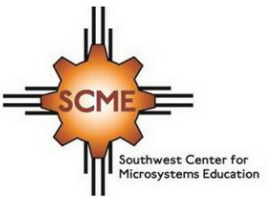
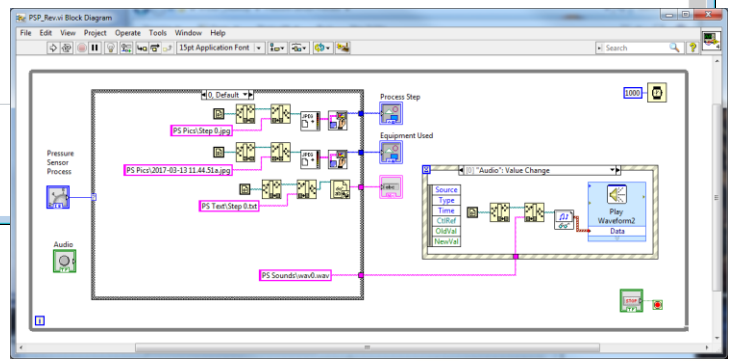
[Photolithography presentation](#)

[Photolithography presentation YouTube](#)



[Photolithography quiz](#)

◀ Previous



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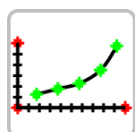
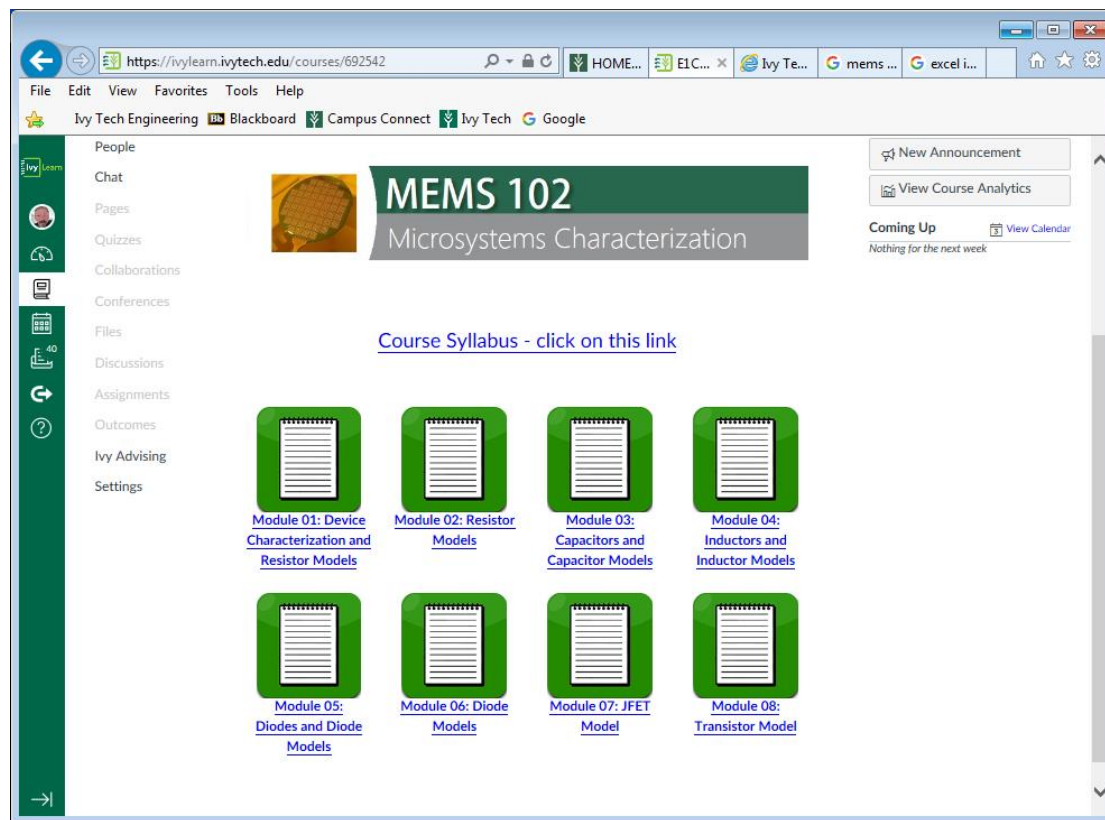
Developed 8 learning modules with 40 artifacts related to device modeling

More LabView but with math emphasis

LMS – Canvas (IvyLearn)

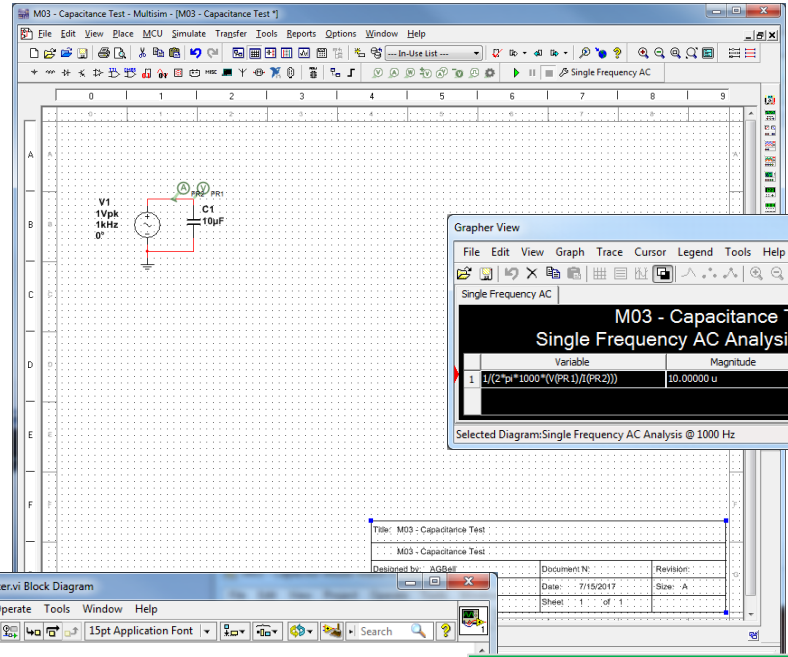
LabView –student license

Also used PSPICE Model Editor, Multisim, Excel and Engauge software packages





- Microsystems Characterization
- Capacitor Models – Artifacts needed
- 1 M03 – Capacitor Test.ms14 – This simulation calculates the capacitance based on the X_c formula at a fixed frequency using Multisim
 - 2 M03 – X_c spreadsheet.xlsx – This spreadsheet calculates the X_c of a 10uF capacitor from 100Hz to 1MHz
 - 3 M03 – parallel plate capacitor.xlsx – this spreadsheet is used to study how a parallel plate capacitor works.
 - 4 M03 – PPC prog.vi – this LabView program calculates the value of a parallel plate capacitor.
 - 5 M03 – Capacitor Model Maker.vi – using LabView create a .subckt model for a 10uF capacitor that is based on 5 voltage and current readings.



M03 - Capacitor Model Maker.vi Front Panel

Capacitor Model Maker

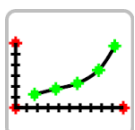
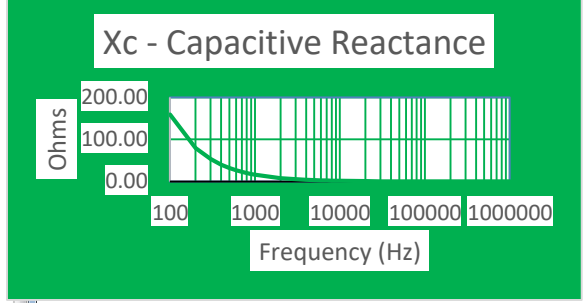
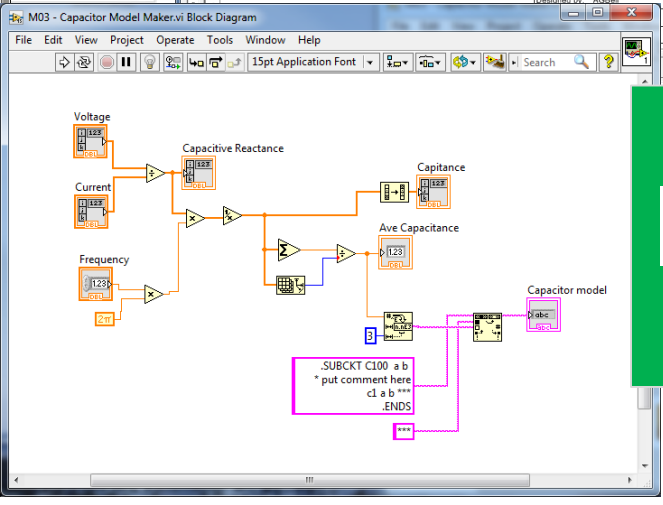
This program builds a spice model based on the average measured current and voltage measurements across a capacitor based on X_c . The model is created and can be used in Multisim.

Input	Output
Voltage: 1	Capacitive Reactance: 15.361
Current: 65.1m	Capacitance: 9.82u
Frequency: 1000	Ave Capacitance: 10.25u

```

.SUBCKT C100 a b
* put comment here
c1 a b 10.250E-6
.ENDS
    
```

MEMS 102
Microsystems Characterization





Developing 8 learning modules with 8 sensor labs

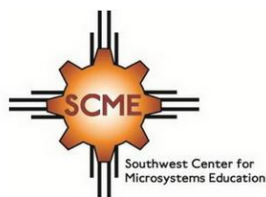
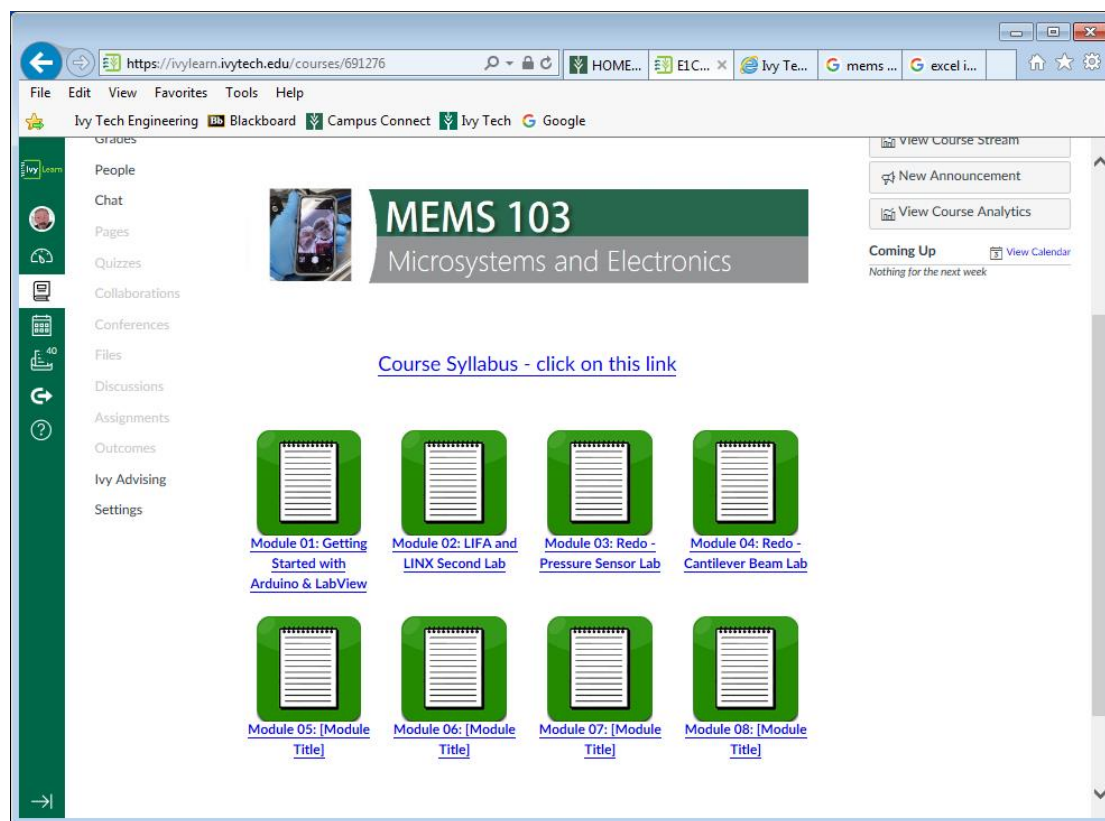
Student written LabView code for data acquisition of sensor data using Arduino UNO and Prototyping Shield

LMS – Canvas (IvyLearn)

LabView –student license

Use LINX and LIFA LabView Add-ons

Use modified SCME kits and DFRobot Sensor kits



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DAC-OP Beta.vi

File Edit Operate Tools Window Help

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

Device Settings

Serial Port: COM26

Control knob: 20

Analog Value

DAC-OP Cantilever Beam beta.vi

File Edit Operate Tools Window Help

DAC-OP Cantilever beam

Student's name: John Smith

Serial Port: COM1

Frequency: 2820Hz

Max pk-pk: 118.83mV

Analyze collected data

Generate Report

Captured data

Analyzed data

Curve fit

Curve fit method: Least Square

Live data

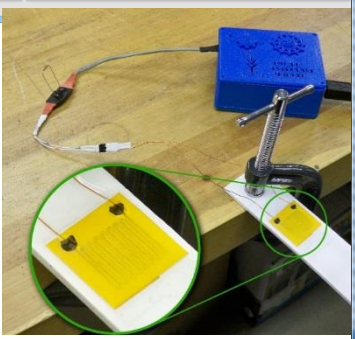
2.427
2.426
2.425
2.424
2.423
2.422
2.421

Cantilever beam (Serial Interface)

This program collects and analyzes data from the SCME MEMS cantilever beam kit using the DAC-OP interface module via Serial / USB.

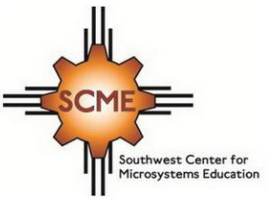
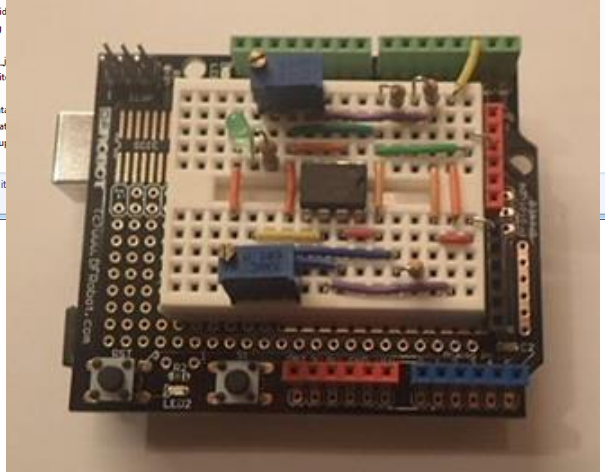
Instructions

1. Select the COM Port associated with the LXK1 Device.
2. Select the Analog Channel to read.
3. Click the Run Arrow.



Program Files > National Instruments > LabVIEW 2015 > examples > MakerHub > LINX

Name	Date modified	Type
Local IO Benchmarks	7/10/2017 10:32 AM	File folder
Digilent.png	6/17/2015 12:10 PM	mspaint.exe
LINX - AD9850.vi	7/10/2017 10:34 AM	LabVIEW Instrn
LINX - Analog Read 1 Channel.vi	7/10/2017 10:34 AM	LabVIEW Instrn
LINX - Analog Read N Channels.vi	7/10/2017 10:34 AM	LabVIEW Instrn
LINX - Analog Set Voltage Reference.vi	7/10/2017 10:34 AM	LabVIEW Instrn
LINX - Blink (Advanced).vi	7/10/2017 10:34 AM	LabVIEW Instrn
LINX - Blink (Simple).vi	7/10/2017 10:34 AM	LabVIEW Instrn
LINX - Blink (Simple).vi	7/10/2017 10:34 AM	LabVIEW Instrn
LINX - Blink Smart LED.vi	7/10/2017 10:34 AM	LabVIEW Instrn
LINX - chipKIT Basic IO Shield.vi	7/10/2017 10:34 AM	LabVIEW Instrn
LINX - Digital Read 1 Channel.vi	7/10/2017 10:34 AM	LabVIEW Instrn
LINX - Digital Read N Channels.vi	7/10/2017 10:34 AM	LabVIEW Instrn
LINX - Digital Write N Channels.vi	7/10/2017 10:34 AM	LabVIEW Instrn
LINX - Digital Write Square Wave.vi	7/10/2017 10:34 AM	LabVIEW Instrn
LINX - DS1307 Real Time Clock.vi	7/10/2017 10:34 AM	LabVIEW Instrn
LINX - Interactions DHT11.vi	7/10/2017 10:34 AM	LabVIEW Instrn



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Evaluate student feedback on three courses and make modification to improve quality of instruction.

Update SCME – Ivy Tech kits for use in MEMS courses

Provide SCME with supplemental instructional material

Construct mini-kit for online courses.

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

<http://www.ivytech-mems.org/>

<http://faculty.ivytech.edu/~mems/>

<http://faculty.ivytech.edu/~abell118/>

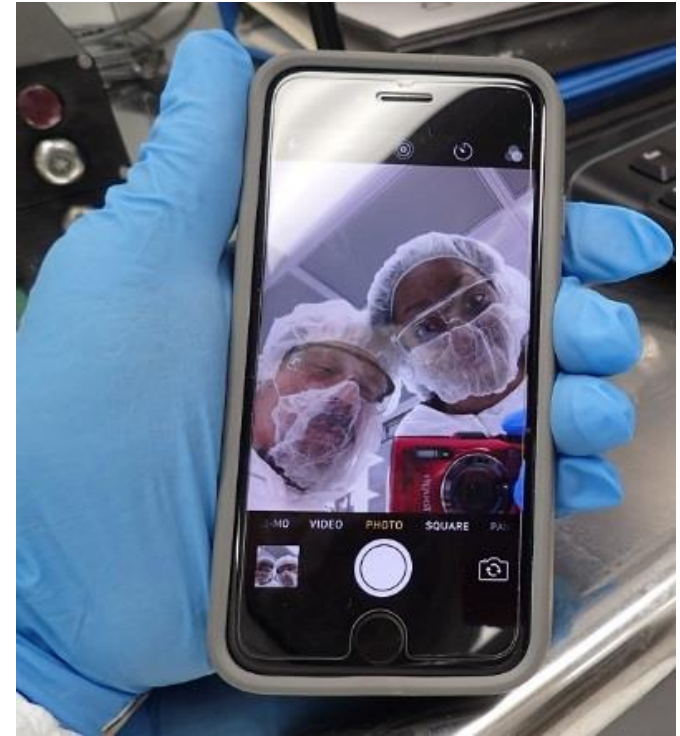
Andy Bell

Department Chair – Engineering

Ivy Tech Community College – Northeast

Phone: 260-481-2288 : Fax: 260-480-2052 : abell118@ivytech.edu

SDKB Technology Center, Room TC1240R, 3800 N. Anthony Blvd.,
Fort Wayne, IN 46805



Questions?