Delving into the Electrical Domain

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2017 Research Education for Teachers
Internet of Things
Apopka High School

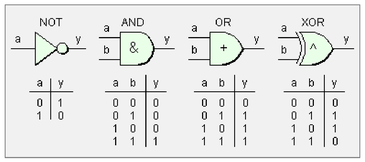
UCF College of Engineering & Computer Science

Summary

Electronics are everywhere! They are in our computers and phones, but increasingly they are in many everyday objects too! They are in our thermostats, dishwashers, cars, TVs and perhaps soon they will be wearable. Students need to learn the physics behind this technology so they can understand the emerging job requirements for creating, manufacturing, and utilizing electronic technologies.

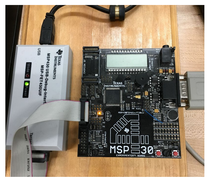
The sensors in mobile devices are often made with Micro Electro Mechanical Systems (MEMS). They are miniaturized versions of circuits that convert mechanical movement into the electrical domain via the piezoelectric effect. MEMS are so small that 100s of MEMS can fit on a chip this size of a human fingernail.

Through the use of diodes, Boolean Logic (AND / OR) can be translated into the electrical domain. These Logic Gates are the building blocks to the memory in a computer. The Electricity Unit Plan will delve deeper into electricity to demonstrate its usefulness and prevalence in our society



Java Programming

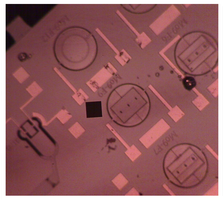
```
import java.io.*;
import java.util.*;
public static void main(String[] args)
{
     int[] arr=new int[5];
     arr[1]=4;
     arr[0]=5;
     arr[2]=3;
     arr[3]=2;
     arr[4]=1;
     System.out.println("The average of the array is ");
     System.out.println(average(arr));
}
// METHOD
public double average(int[] arr)
{
     double sum = 0;
     for (int i=0; i<arr.length; i++)
          sum = sum+arr[i];
     return sum/arr.length;
}
```



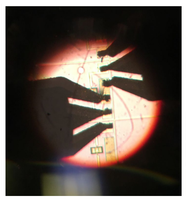
Raspberry Pi

Cutting Edge Research Activities

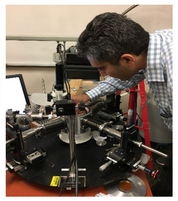
Sarah Shahraini a graduate student holds a MEMS chip in her hand.



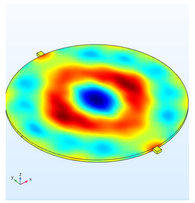
The MEMS chip as viewed through a microscope shows hundreds of MEMs components.

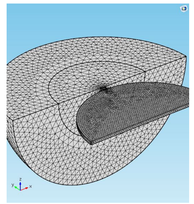


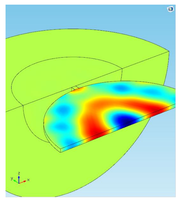
The fingers of a probe viewed through the eyepiece of a microscope via an iPhone5.



Dr. Abdolvand adjusting the fingers of a MEMS probe in a vacuum chamber.

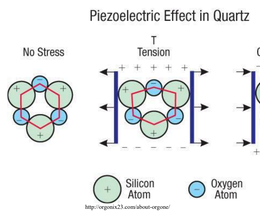






Finite Element Analysis program Comsul is used to look for vibrational nodes at the tethers of a piezo device.

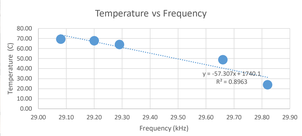
My Research Activities



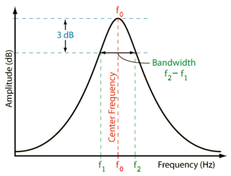
Notice how the charged electron moves down during tension and up during compression. The movement of electrons is what causes current. Squeezing and relaxing a crystal can cause an alternating current in the crystal.

Piezo device:
Black wire bottom plate.
Crystal filling no wire.
Red wire top plate white

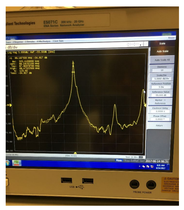
Project 6- Turn a piezoelectric buzzer into a temperature sensor.

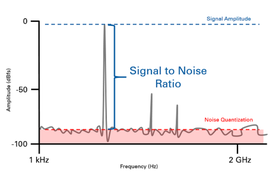


By heating the piezo device and measuring the resonant frequency at various temperatures, we were able to document a relationship for Temperature vs. Frequency



Measuring the frequency bandwidth at half power (3dB)
http://www.sengpielaudio.com/calculator-cutoffFrequencies.htm





A high Q value or signal to noise ratio is desired. (High amplitude narrow bandwidth)
https://qph.ec.quoracdn.net/main-qimg-84fc89e195d13dcd76eea3530cd30f2f

Sunshine State Science Standards

SC.912.P.10.1 Differentiate among the various forms of energy and recognize that they can be transformed from one form to others.

SC.912.P.10.13 - Relate the configuration of static charges to the electric field, electric force, electric potential, and electric potential energy.

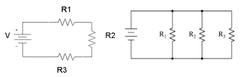
SC.912.P.10.14 - Differentiate among conductors, semiconductors, and insulators. (Content

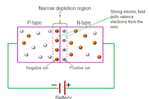
SC.912.P.10.15 -Investigate and explain the relationships among current, voltage, resistance, and power.

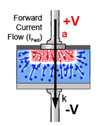
Lesson Plan

My research included using a piezo electric device to transfer energy from the mechanical domain to the electrical domain. Alternating pressure makes alternating current. A diode is made of a semiconducting material and is used to limit the current flow to one direction. Using Problem Based Learning strategies, the students will make and explain how a piezoelectric generator is used to make an LED flash.

Implementation Strategy

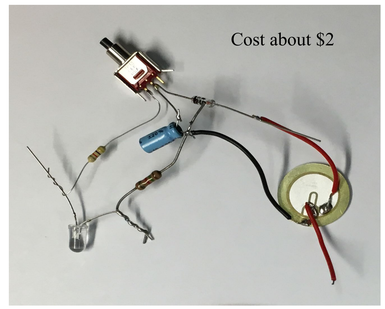


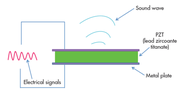


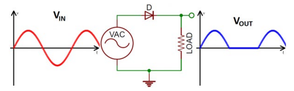


Topics

- Energy
- Energy Transfer
- Coulomb's Law
- Piezoelectricity
- Capacitors
- Ohm's Law
- Kirchoffs Laws
- Semiconductors
- Diodes
- Piezo generator







Lessons Learned and Assumptions

Capacitors, piezoelectricity, semiconductors, and diodes are not normally taught in high school physics due to time constraints. This research experience has taught me that an understanding of the electrical domain is one of the most important things I can teach my students to prepare them for the design, manufacturing, and use of technology. Everything we own will most likely end up with a circuit in it. Further, resonance is a key concept that can be explored across multiple domains and is exploited to make modern sensors.

Acknowledgments

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References

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Wu, X., Chen, W., & Reza, A. (2015). Optimal design of piezoelectric micromachined modal gyroscope (PMMG) with modes matched: modal analysis. *Microsystem Technologies*, (1), 101. doi:10.1007/s00542-014-2156-1

Ludic Science https://www.youtube.com/watch?v=ACsy6xSIBm8&feature=youtu.be

learn.sparkfun.com