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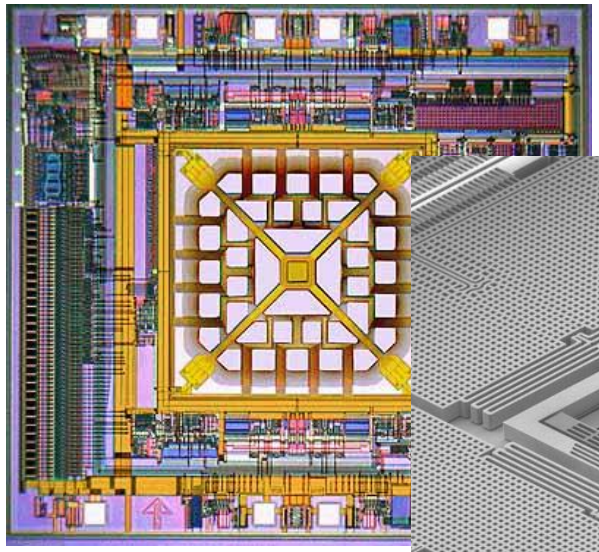
This is what we are going to learn in this training session

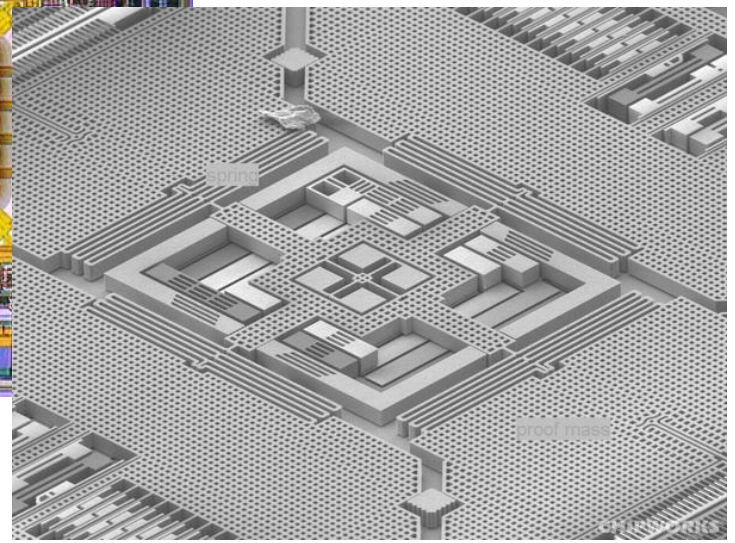
- Melee Combat Techniques
- Coordinated Air Strike
- Essential Armory
- Weapon Assembly!

What are we going to learn in this lecture?

- What are sensors?
- Amazing examples of sensors and how they work in simple terms
- What are actuators?
- Signal conditioning
- “Weapon” Assembly!



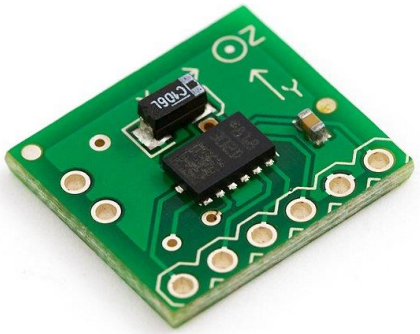
Dual axis thermal accelerometer

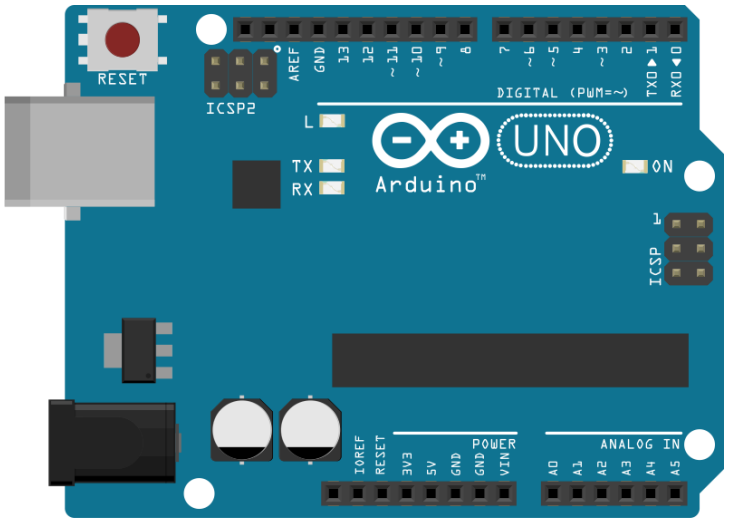


iPhone 4S gyroscope close up view

Why do we need to learn all of these things?

- Most electronic systems that **we build to accommodate our client needs** consists of a data acquisition part, a processing part, and an actuating part, as depicted below. (However, sometimes also consist a communication part, which we'll learn next time)





What are sensors? What about transducers?

- Sensor is device that receives a stimulus and responds with an electrical signal.
- Transducer is a converter of energy of any one type of energy into another.
- Can you define sensor in terms of transducers?
- Ofcourse!

- Sensor is either (1) a single transducer that outputs electrical signal (called *direct sensor*) or (2) a series combination of transducers and a direct sensor in the end (called *complex sensor*)

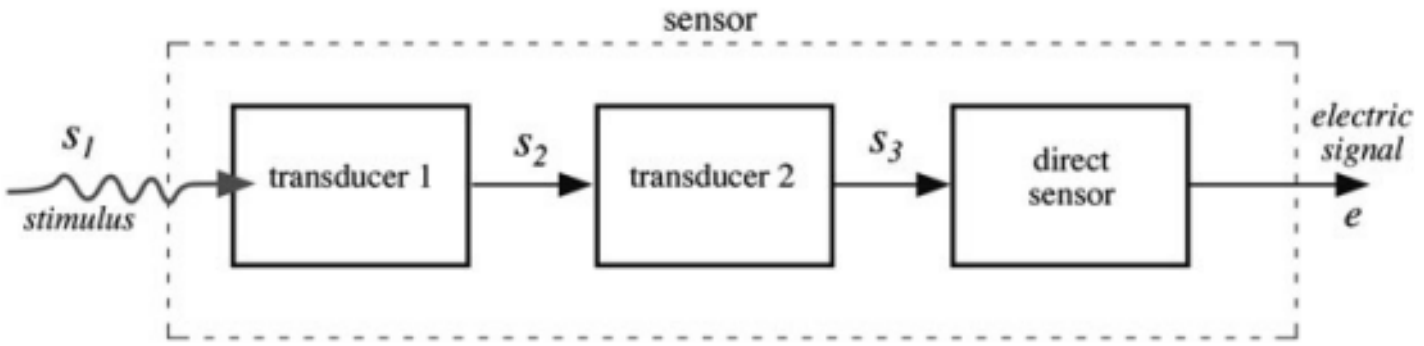
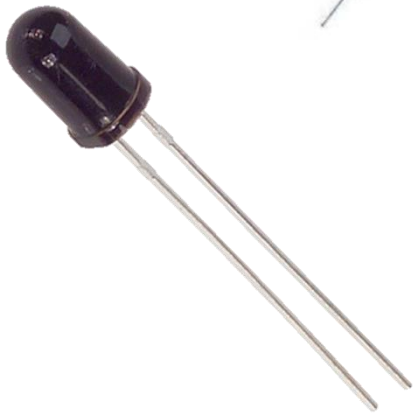


Fig. 1.2 A sensor may incorporate several transducers. s_1, s_2, and so on are various types of energy. Note that the last part is a direct sensor producing electrical output e

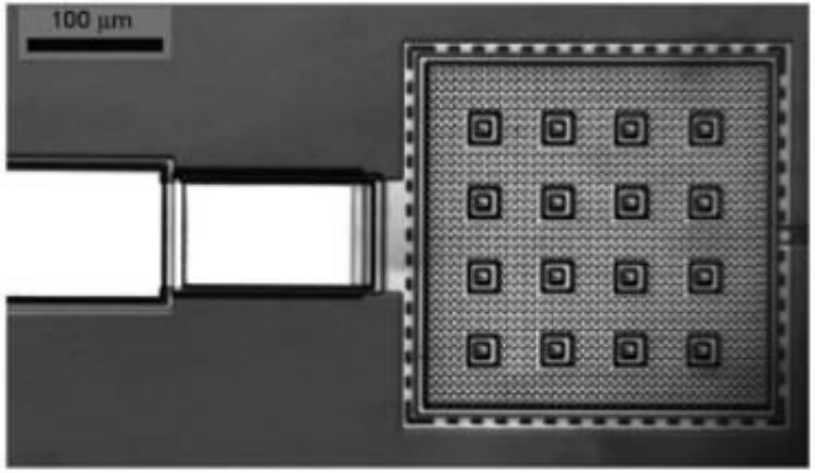
- Can you mention some examples sensor devices?
  - Humidity Sensor
  - Accelerometer
  - Microphone
  - LDR (Light Dependent Resistor)
  - IR Transiever
  - Ultrasonic Range Sensor
- How do those things works exactly?
- I hope you’re excited to know, because we’re going to find out how one by one!

Can you guess which sensor is which?



Humidity Sensor

- There are lots of ways to create a humidity sensor. One way is by using a so called *Chemicapacitive* sensor.
- A *Chemicapacitive* sensor (or *chemicapacitor*) is a capacitor that has a selectively absorbing material such as a polymer or other insulator, as a dielectric
- Below is a picture of a chemicapacitive sensor



- Below is a side view of the *chemicapacitive* sensor

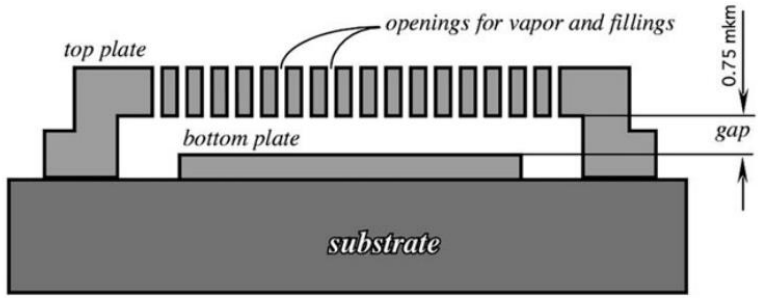
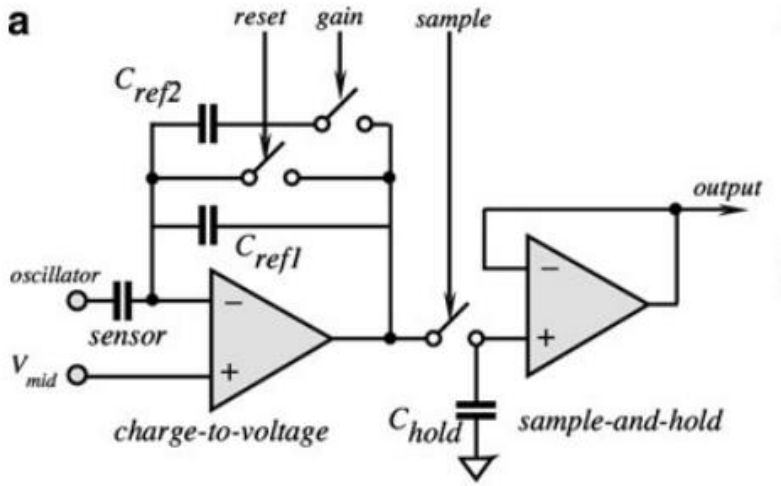


Fig. 17.9 Cross-section diagram of the parallel-plate capacitor showing the 0.75 μm gap

- Below is the circuit for calculating the change of capacitance caused by vapor/liquid concentration changes



Now before we learn deeper about accelerometers

Let us see a video about MEMS

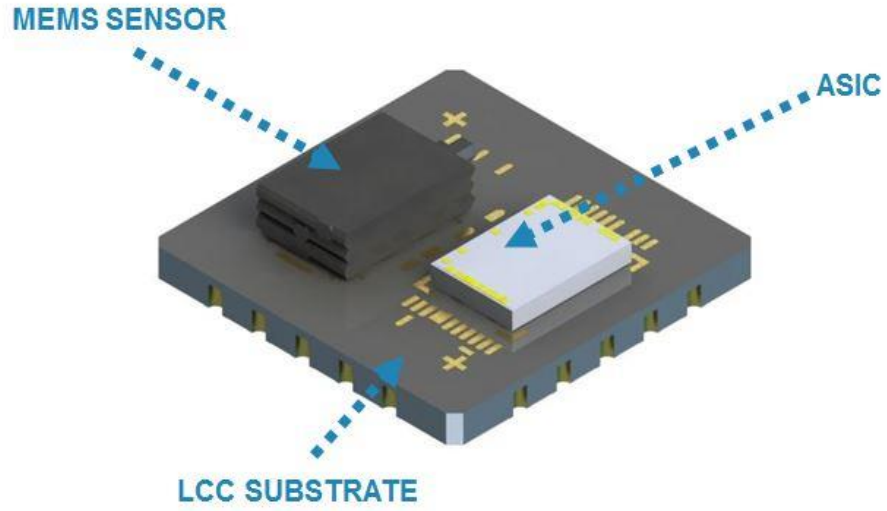
(Micro-electro-mechanical-system)

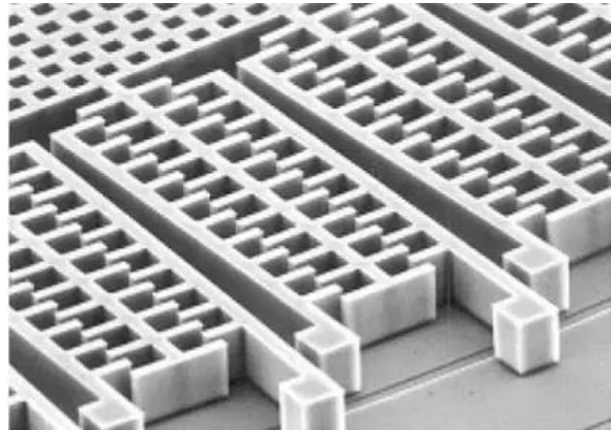
The enabling technology for most sensors (and actuators) today

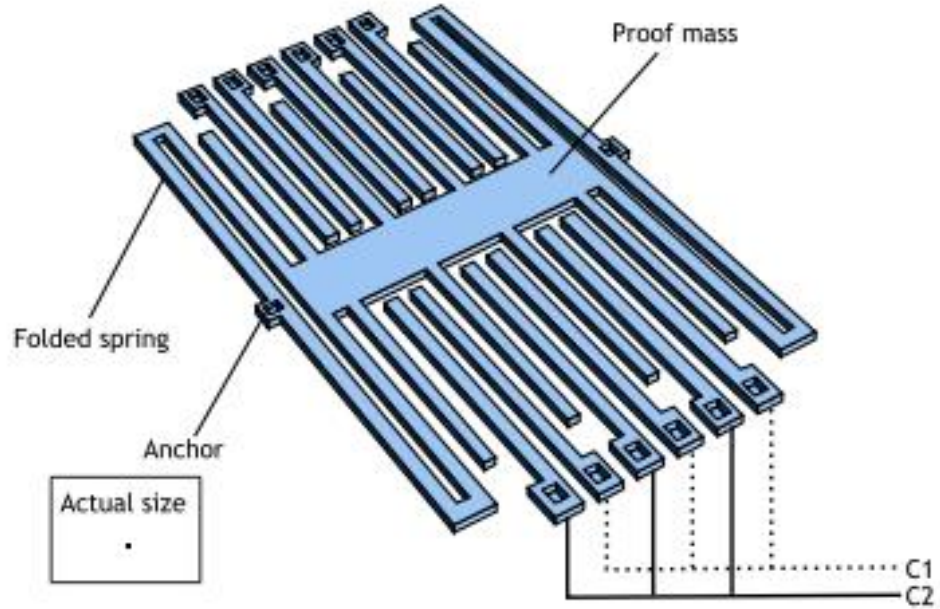
The video is available in the same folder
as this presentation

Accelerometer

- Accelerometer is a sensor that could sense acceleration trough a system consisting of a proof mass and a spring.

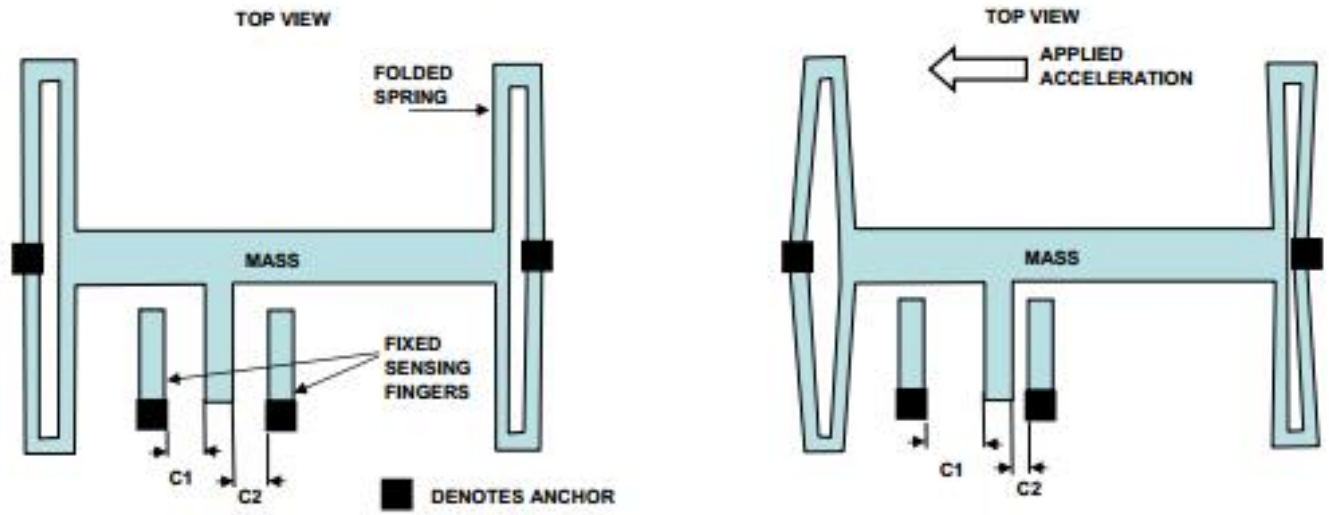






Parameter	Value	Units
Resonant frequency, f_0	25	kHz
Mass, m	0.2	nkg
Spring constant, k	5	N/m
Sense capacitance, C_0	0.1	pF
Quality factor, Q	5	

(a) A surface micromachined accelerometer and typical element parameters corresponding to ADXL50 accelerometer from Analog Devices.



(b) The movement of the proof mass is detected by measuring the capacitance change between

Actuators

- Actuators are devices that receives an electrical stimulus, and responses by acting on something, e.g. rotates, pushes, vibrates, sounds, change the environment temperature, and shines.
- Basically, actuators are “reversed sensor”
- Now, can you mention examples of actuators?
  - Induction Motor
  - Push Solenoid
  - Buzzer
  - Speaker
  - Peltier Thermo-Electric Cooler
  - LED
  - Projector

Signal conditioning

- In reality, sensors are only a small part (however the most essential) of a data acquisition system as depicted below.

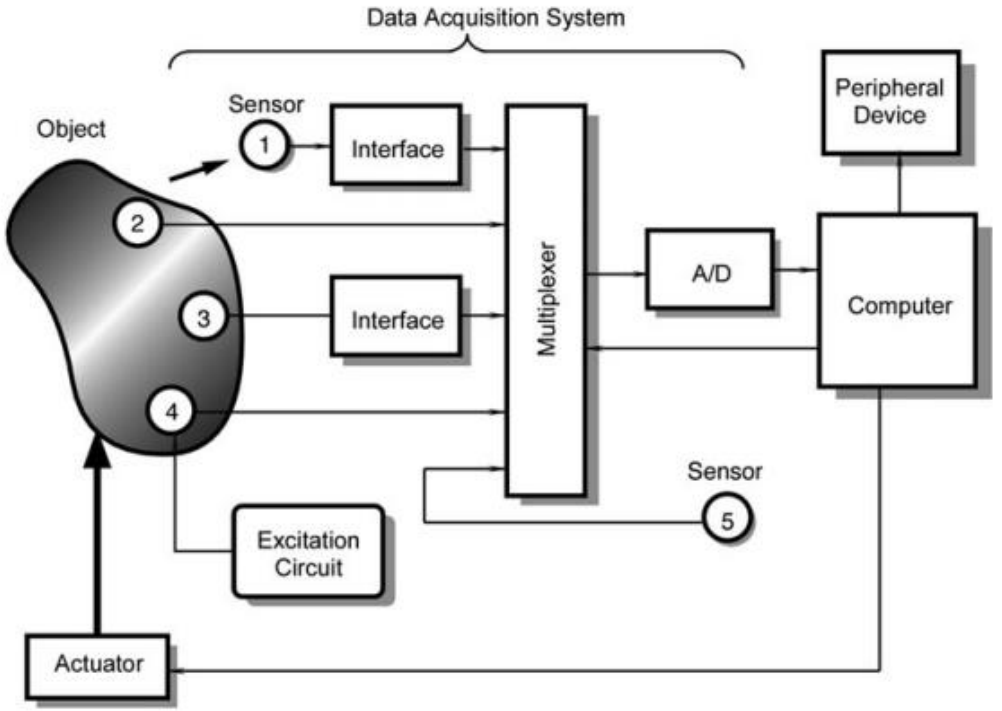


Fig. 1.3 Positions of sensors in a data acquisition system. Sensor 1 is noncontact, sensors 2 and 3 are passive, sensor 4 is active, and sensor 5 is internal to a data acquisition system

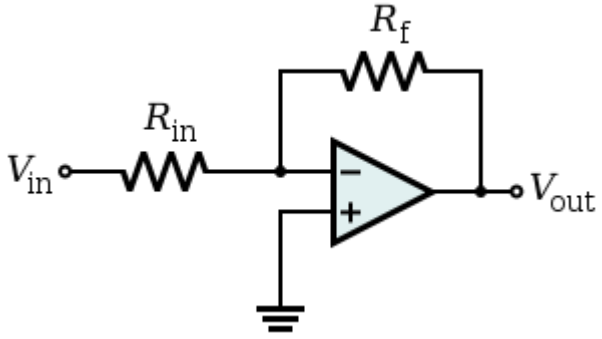
- In a data acquisition system, there could be:
  - Excitation circuit
    - Circuitry that provide required electrical condition for sensor operation
  - Interface circuit
    - Circuitry that preprocess signals from sensors before entering the digital processing part. We will talk about this more later.
  - Multiplexer
    - Circuitry that enables use of many sensors even though only one A/D available

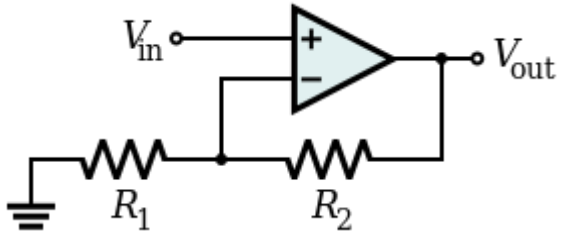
Interface Circuit

- “Interface circuit is a circuitry that preprocess signals from sensors before entering the digital processing part “
- What kind of preprocesses are required?
- It could be:
  - Increasing signal gain
  - Limiting the frequency range
  - Increasing/decreasing the input/output impedance
- Lets find out how can we do all of that one by one

Increasing Signal Gain

- Why do we need to increase signal gain? a) to accommodate the required voltage/current level at the data processing part b) to improve sensor reading resolution
- How can we increase the gain of a signal? One way is by using an Operational Amplifier in an inverting/non-inverting feedback loop.





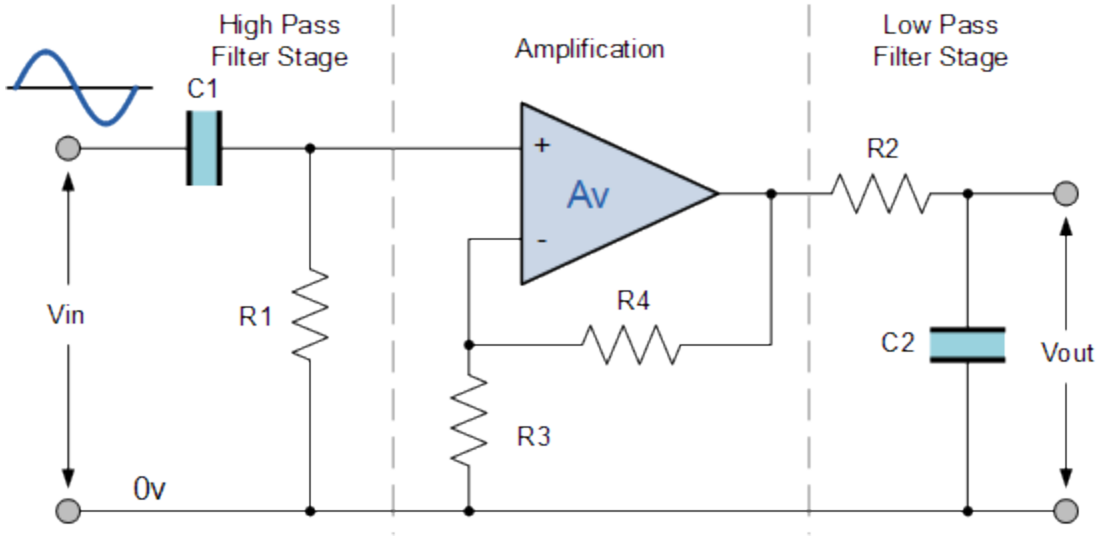
Output/Input Impedance

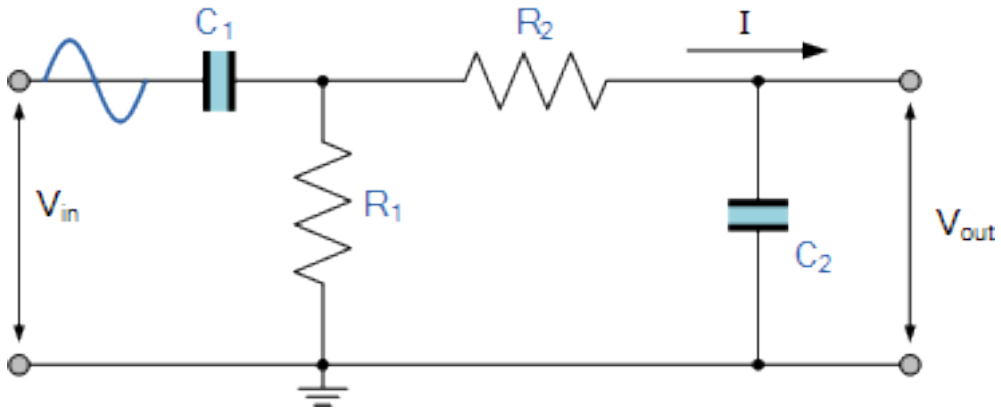
- Output/ Input impedance of a circuit is the impedance seen from the output/input of the circuit.
- Output/Input impedance is an important factor to consider when we are trying to connect one part of circuit to another part of a circuit.
- We'll talk about this more later

Frequency limitting

- Frequency limiting is basically a process of reshaping the frequency response of the system. Therefore, circuits that can do this are *Low Pass Filters, Band Pass Filters,* and *High Pass Filters.*
- Why do we need to limit the frequency range before the data processing? Apart from the Nyquist sampling rate requirement (which we will not talk about), it is rarely used because this process can be done in the digital realm.

Using the knowledge of **Input/Output Impedance**, which one is preferable?





Lets recap!

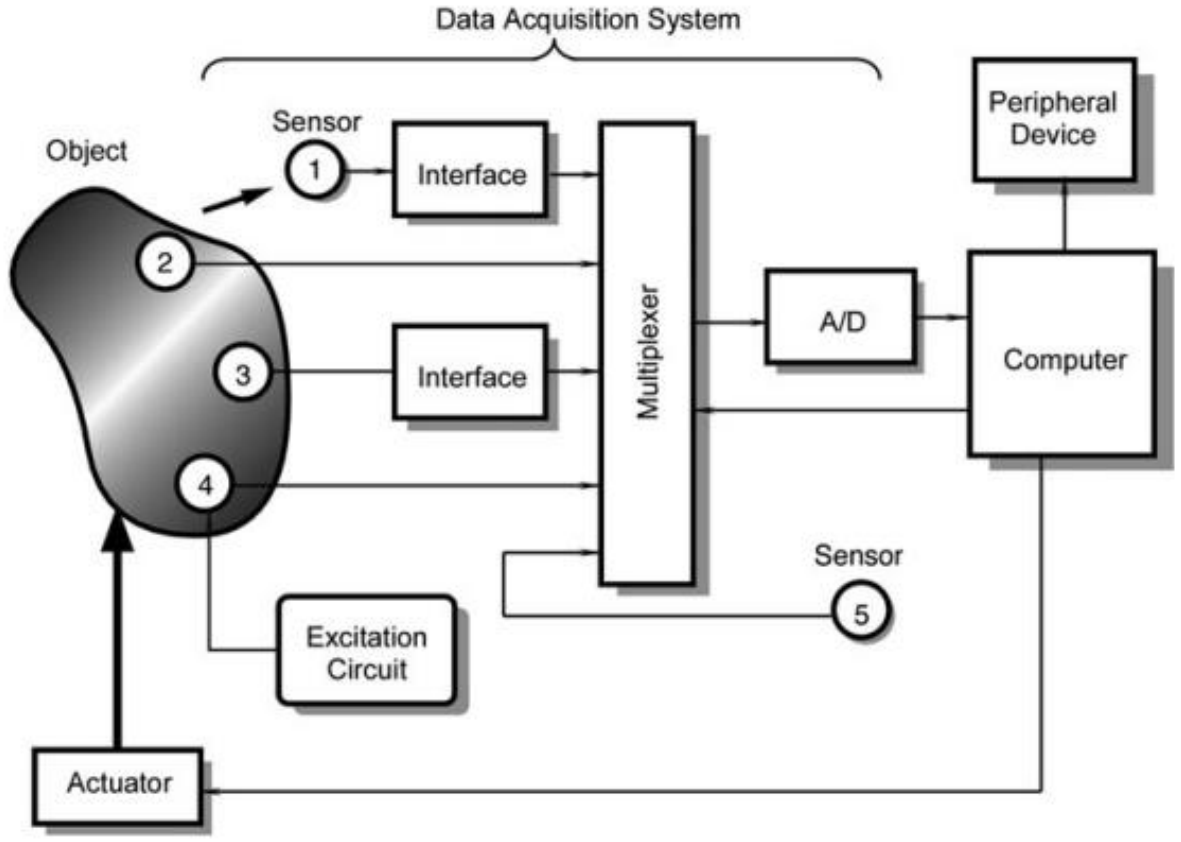


Fig. 1.3 Positions of sensors in a data acquisition system. Sensor 1 is noncontact, sensors 2 and 3 are passive, sensor 4 is active, and sensor 5 is internal to a data acquisition system

Okay, SAS soldiers, let us meet your weapon parts, and assemble them!

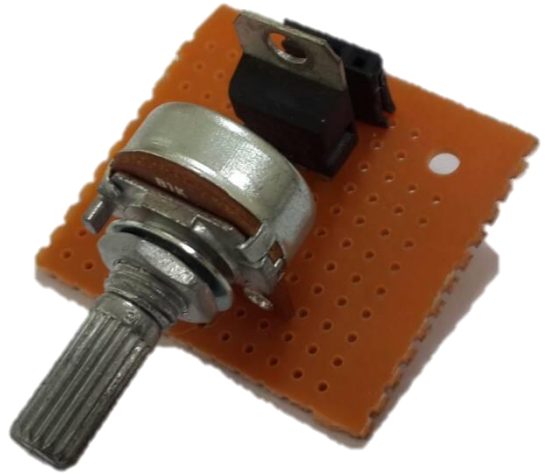
The 33 Power Stack

- Consist of a double stacked CR2303 3V battery (6 Volts!)
- CR2023: button cell lithium battery that can deliver a whopping voltage level of 3 Volts! (open circuit measured 3.3 V)
- It is highly trained for use in:
  - Computer CMOS battery
  - Calculating machine battery
  - Remote control battery

Get to know him more before recruiting from his CV below:
http://data.energizer.com/PDFs/cr2032.pdf

The Control Freak

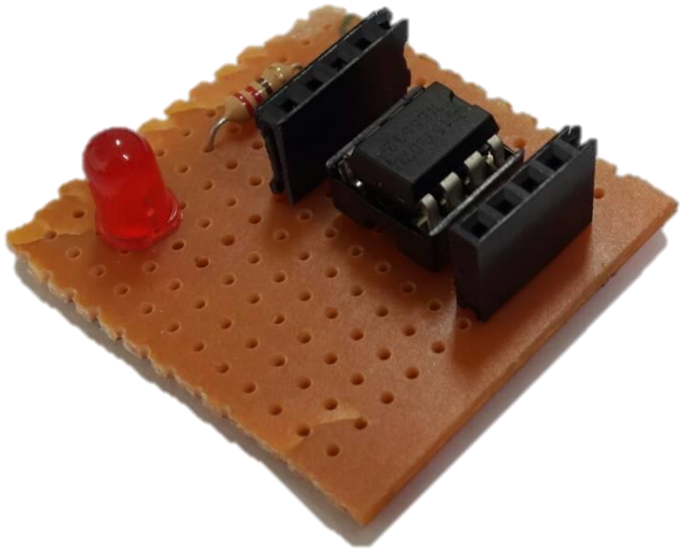
- This amazing animal consist of an LM317 Variable Voltage Regulator, and a large-easy-to-control Potentiometer!
- LM317: a variable voltage regulator that is capable of delivering adjustable voltage from 1.25 Volts up to 37 Volts!
- Potentiometer: a variable resistor that can be set to any resistance from 0-1 kOhm!



Get to know LM317 more before recruiting from his CV below:
http://www.ti.com/general/docs/lit/getliterature.tsp?baseLiteratureNumber=slvs044

The Judgemental Red

- A monster consisting of the well known **high performance Op-Amp combining excellent dc and ac characteristic**, NE5532! (and a cool red diode)
- NE5532: A monster with UGB upto 10 MHz Typical, slew rate of 9V/uS, and more!
- Red diode: It shines. Shines red.



Get to know NE5532 more before recruiting from his CV below:
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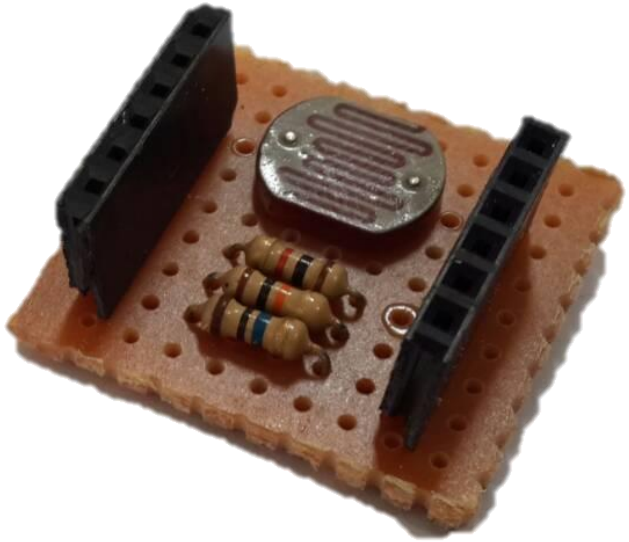
Baby Dracula

- This baby consist of a **light sensitive resistor** (LDR) carrying three resistor dolls that she got from her mommy.
- Eventhough she is not as cool at first sight as the other beasts, this baby is the most important part of our weapon, the ***Sensor***
- ***Don’t underestimate her power***



She’s a baby, she doesn’t have a clear CV yet, just measure and her characteristic yourself

Lets Assemble an Evil Darkness Indicator

Create a circuit (from the parts mentioned before) that shines red light only when darkness is near.

- Firstly, determine the required excitation circuit to operate an LDR
- Second, create the processing part (in the analog realm, with an Op-Amp) so that when the LDR (together with the excitation circuit) detects darkness, the processing part (the Op-Amp) turns on the red light (*Hint: use the Op-Amp in a comparator configuration*)