Foldable Robotics

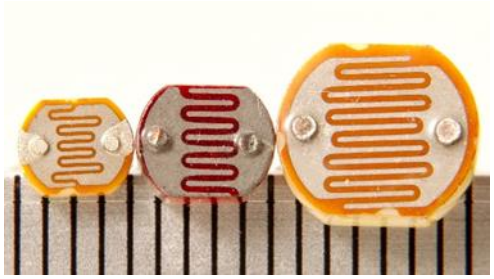
Class XVI: Sensors

Sensors

- Measure Physical properties
  - Light, Strain, Heat
  - Measuring Force is hard directly

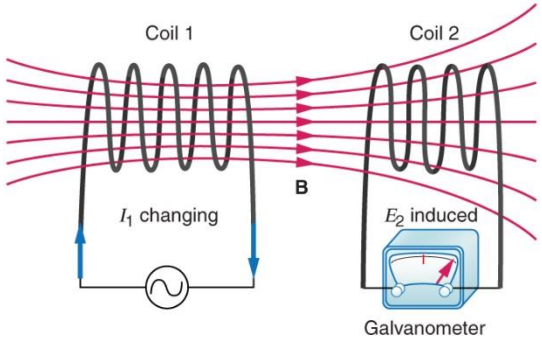
Light

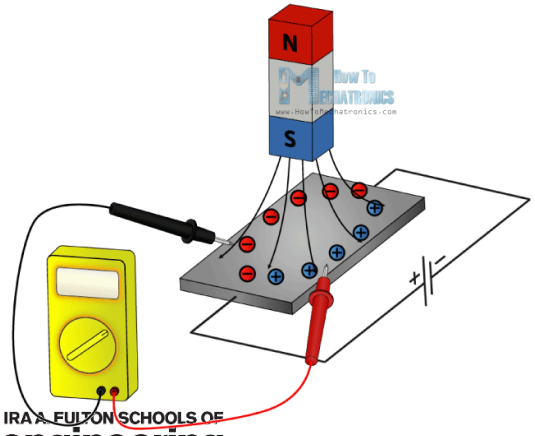
- Lots of different mechanisms for light
- Photoresistor
- Photodiode
  - Photovoltaic
    - +light→+V
  - Photoconductor
    - +light→-R
- Phototransistor
  - +light

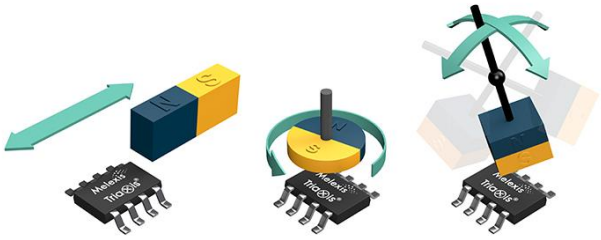


Magnetic Field

- Types
  - Reed Switch
  - Inductive - Galvonometer
  - Hall Effect Sensor – go linear.



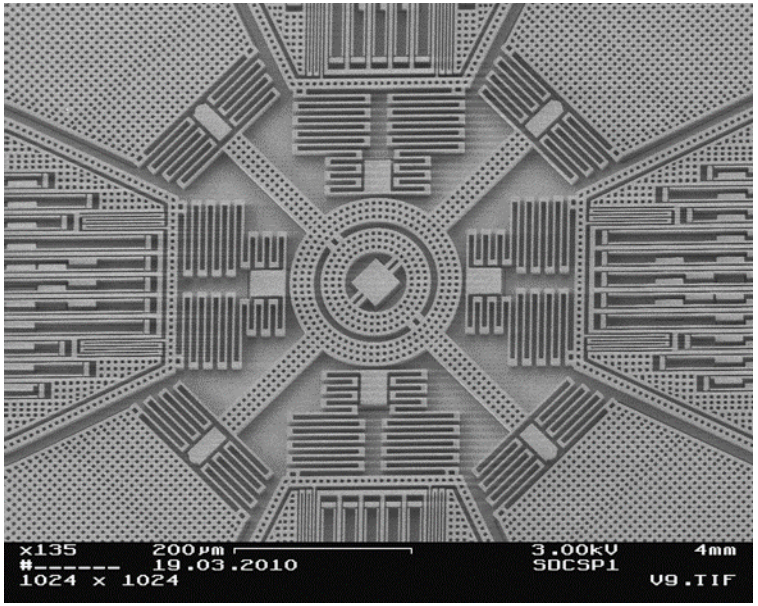




http://howtomechatronics.com/how-it-works/electrical-engineering/hall-effect-hall-effect-sensors-work/
http://www.brown.edu/Departments/Engineering/Courses/En123/CirRevFiles/Inductance2.htm

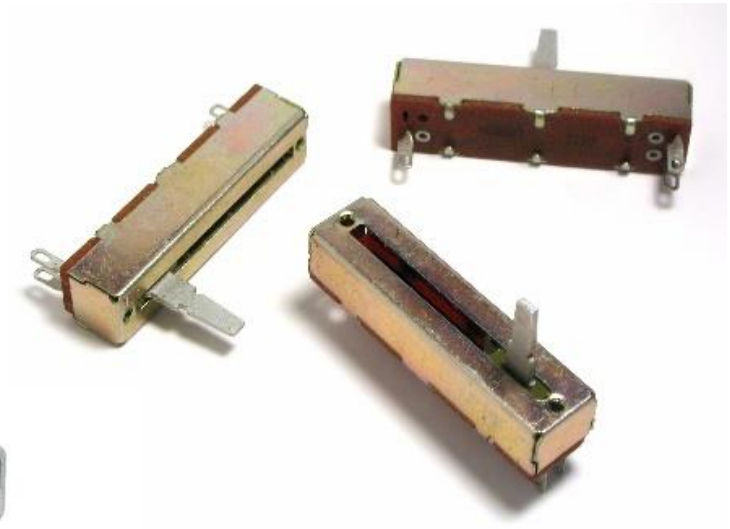
Motion

- Accelerometer
  - accelerations
- Gyro
  - Angular accelerations
- IMU
  - Everything
    - Smoothing
    - Integration
    - Position, Velocity, Acceleration
    - Rotation, rotational velocity, angular acceleration

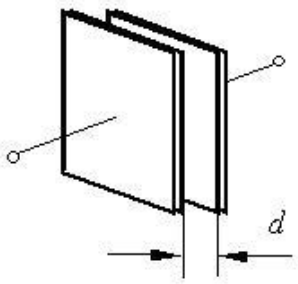


Position Resistive

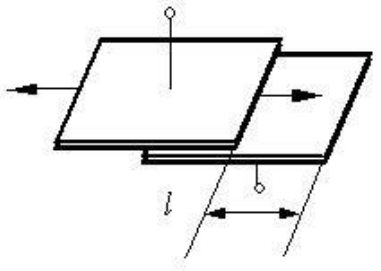
- Temperature-dependence
- Hysterisis
- Types
  - Linear Potentiometer
  - Rotary Potentiometer
  - Flex Sensor
  - etc



Position Capacitive

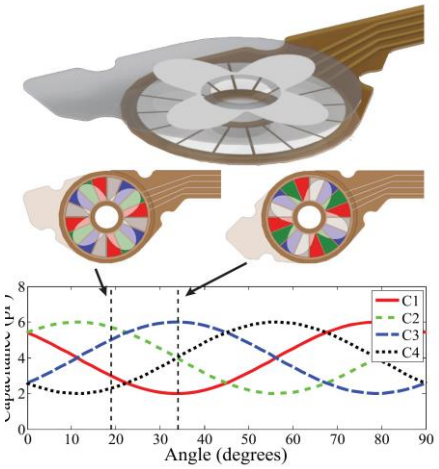


Spacing variation



Area variation

- Two charged plates
  - Spacing Change
    - $C = \frac{\epsilon A}{d}$
    - $\delta_d = \frac{pd}{\rho E}$
    - $\frac{\partial C}{\partial p} = \frac{\epsilon A}{\rho_A E d_0}$
  - Area Change
    - Digital Calipers

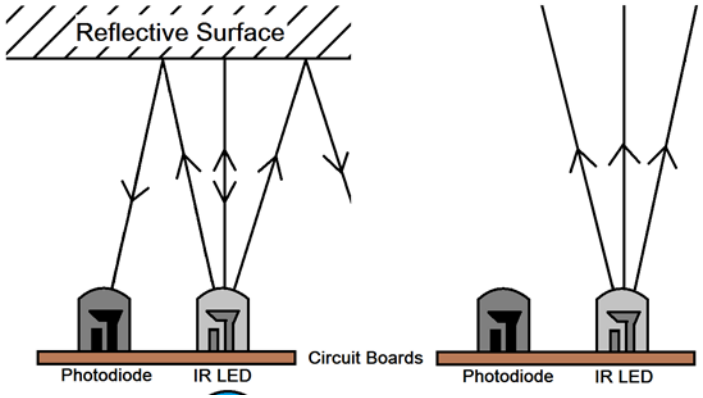


http://www.chenyang-ism.com/CapaSensorPosi.htm

D. M. Aukes, B. Heyneman, J. Ulmen, H. Stuart, M. R. Cutkosky, S. Kim, P. Garcia, A. Edsinger, J. Ulmen, P. Garcia, H. Stuart, and A. Edsinger, "Design and testing of a selectively compliant underactuated hand," *Int. J. Rob. Res.*, Feb. 2014.

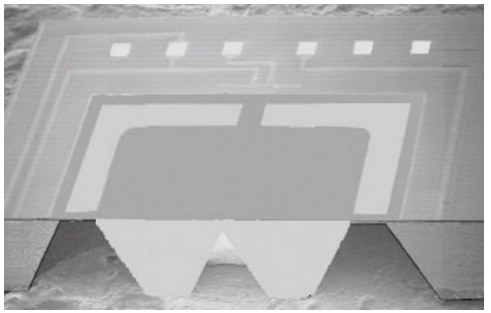
Position - Other

- Emittor/Detector Pair
  - Proximity
  - Based on reflectance
- Ultrasonic
  - High Noise
  - Longer distances

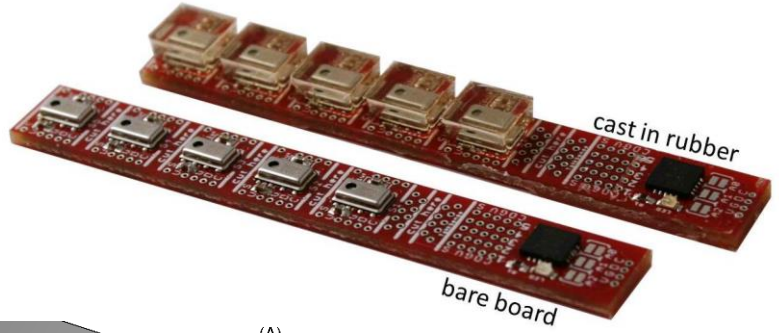


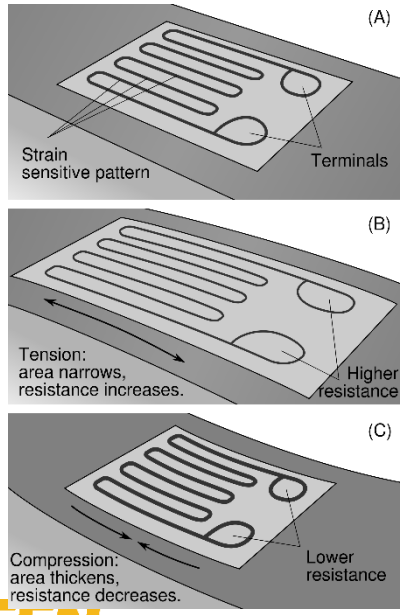
http://maxembedded.com/2013/08/how-to-build-an-ir-sensor/

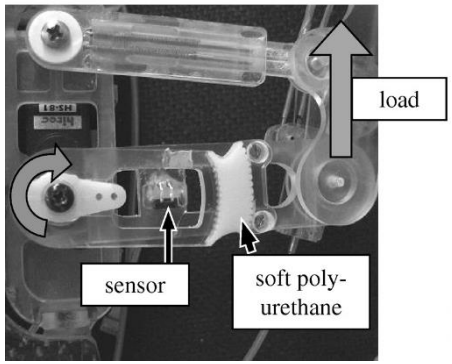
Pressure / Force

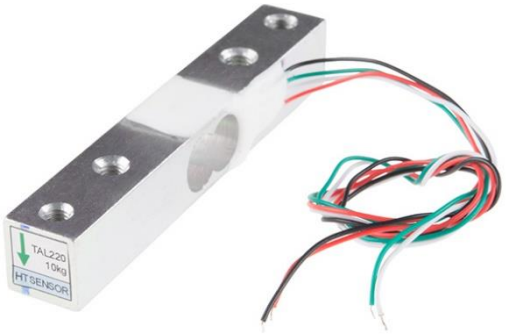


- Strain Gauge
  - Temperature-sensitive
  - Wheatstone Bridge
  - Load Cell
- Other Position Sensors



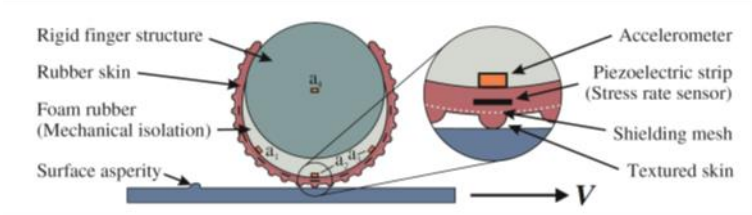






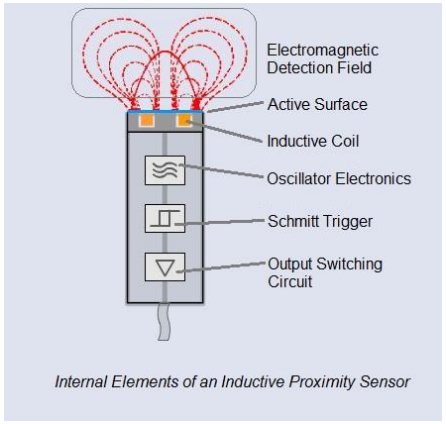
Dynamic Tactile Sensing

- Piezo

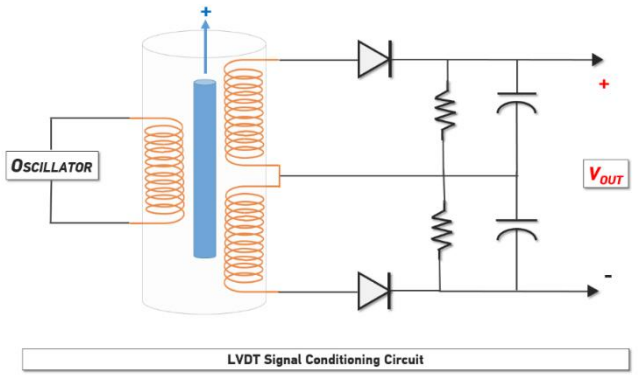


Position Induction

- Non-contacting
- Requires AC
- Senses Metals, esp Ferrous Metals
- Types:
  - Inductive Proximity Switch, Position Sensors
  - LVDT
  - Inductive Encoders



Internal Elements of an Inductive Proximity Sensor

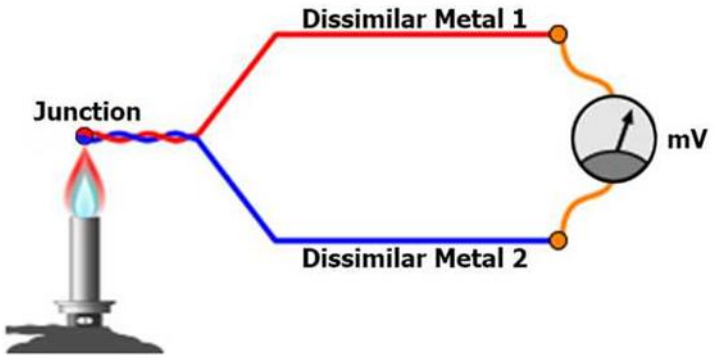


LVDT Signal Conditioning Circuit

https://sensorsteeringandlinkages.com/2014/03/05/basic-operating-principle-of-an-inductive-proximity-sensor/
http://sensorwiki.org/doku.php/sensors/linear_variable_differential_transformer

Temperature

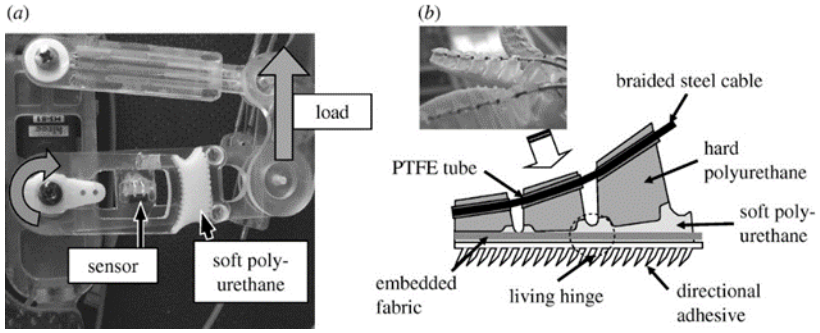
- Resistance temperature detector
- Thermistor
- Thermocouple

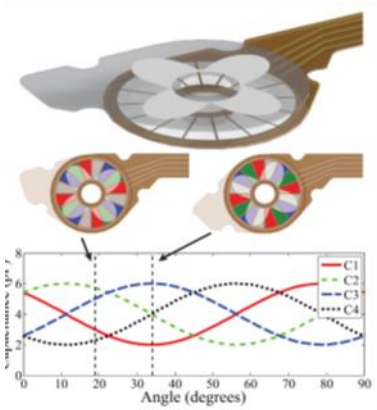


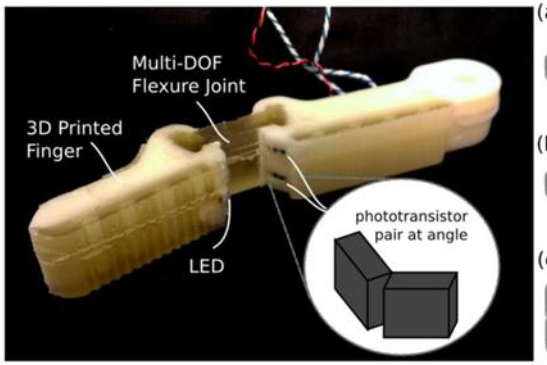
Encoders

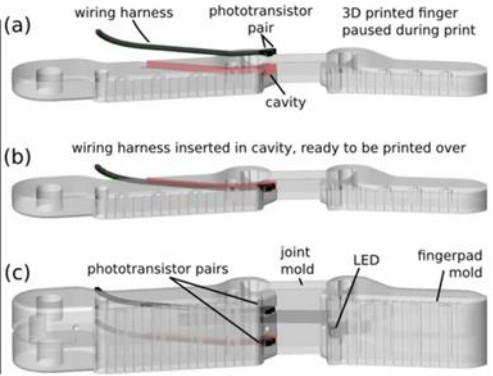
- Types
  - Optical
    - Absolute
    - Relative
  - Magnetic
  - Capacitive
  - Inductive

Embedding Sensors

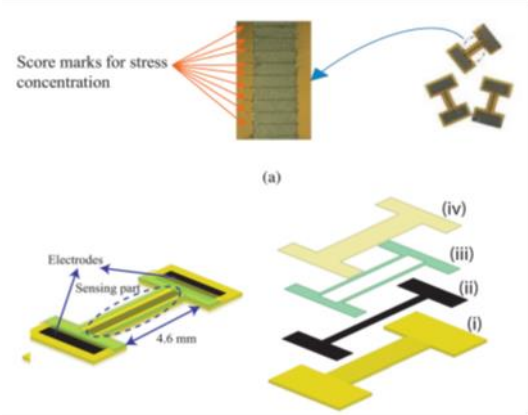


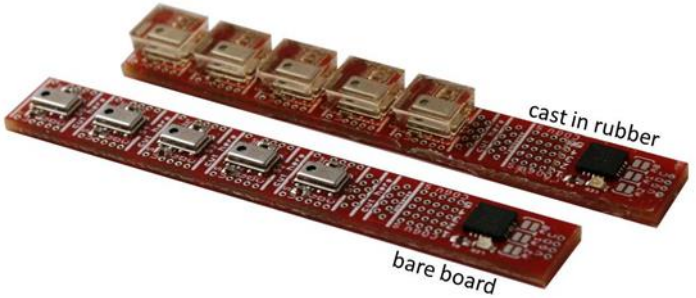


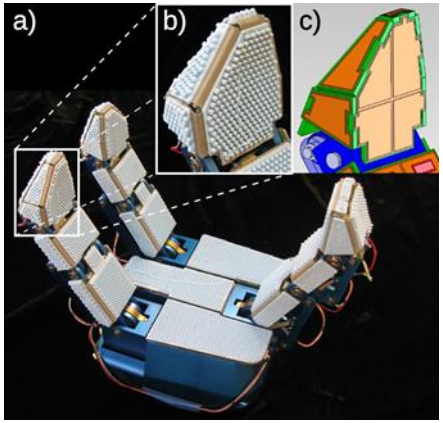


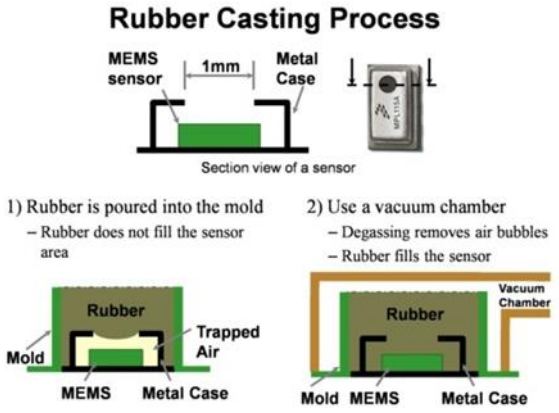


Embedding Sensors

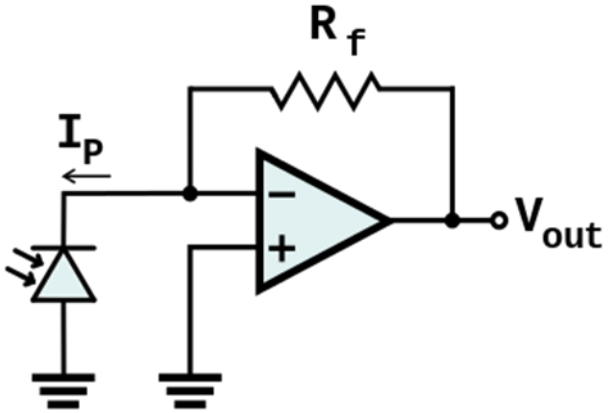


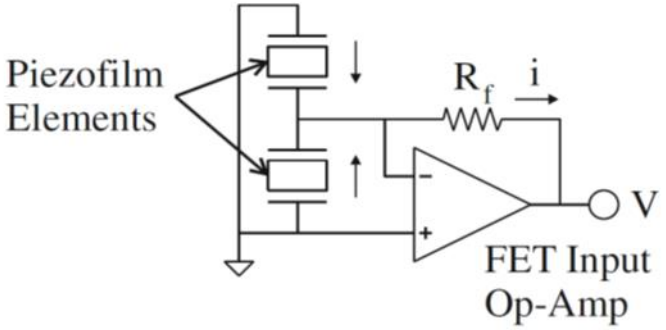


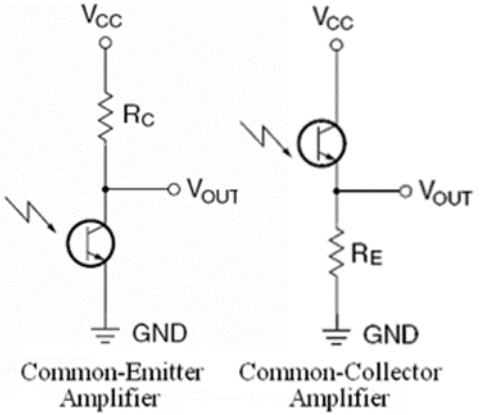


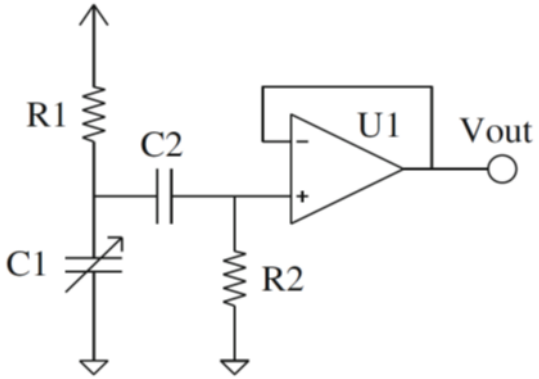


Common Circuits









http://hades.mech.northwestern.edu/index.php/Photodiodes_and_Phototransistors

Circuit Conditioning

- Self-contained packages
- Op Amps
- Transistor-based amplification