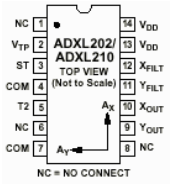
CSE426: Principle of Robotics

Lesson 8b: Analog Sensors



Accelerometer


Gyro


Pendulum Resistive Tilt Sensors

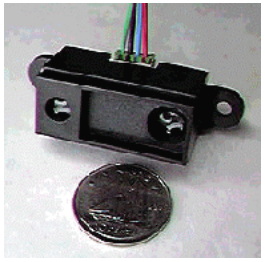

Piezo Bend Sensor


Metal Detector

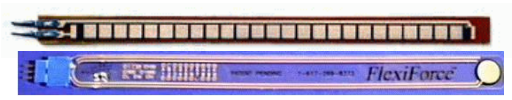
Gas Sensor


Gieger-Muller Radiation Sensor


Pyroelectric Detector


Digital Infrared Ranging


CDS Cell
Resistive Light Sensor



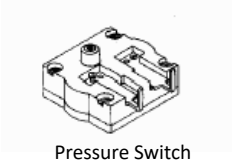
Resistive Bend Sensors

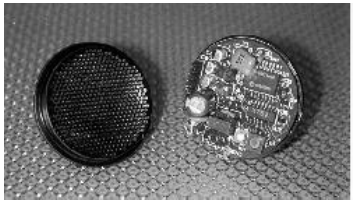

UV Detector

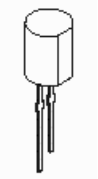

Limit Switch

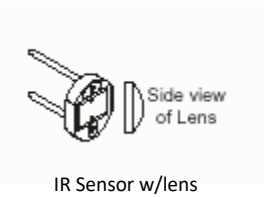

Mechanical Tilt Sensors


Touch Switch

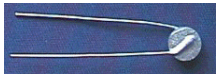

Pressure Switch


Miniature Polaroid Sensor

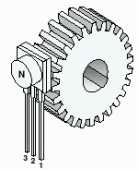

IR Pin Diode



IR Sensor w/lens

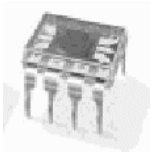

Thyristor


Magnetic Sensor


Hall Effect Magnetic Field Sensors

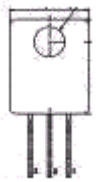

Polaroid Sensor Board

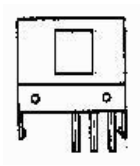

IR Reflection Sensor


IR Amplifier Sensor


IRDA Transceiver


Magnetic Reed Switch

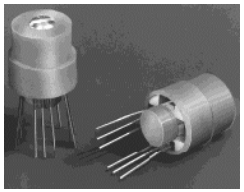

Lite-On IR Remote Receiver

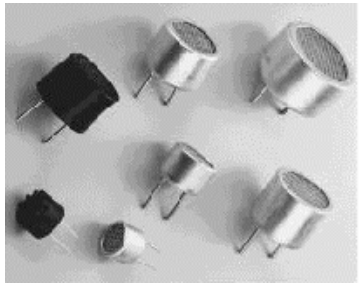

Radio Shack Remote Receiver


IR Modulator Receiver


Solar Cell


Compass


Compass

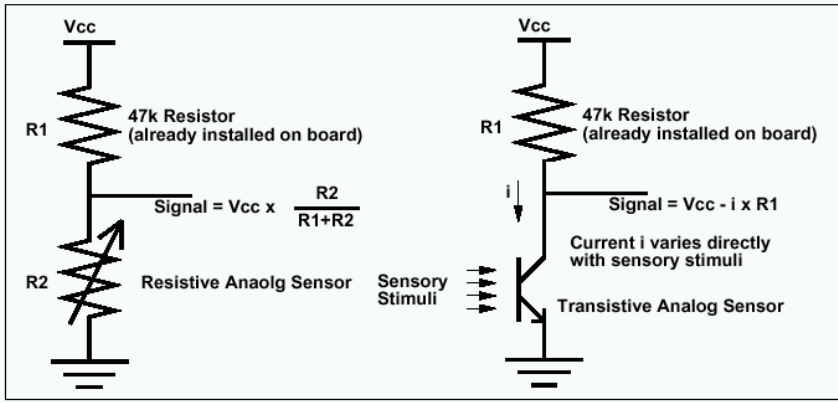

Piezo Ultrasonic Transducers

Analog Sensors

Analog Sensors

- A number of sensors have analog output signal rather than digital signals
- A/D converter is required to connect to CPU
- Examples:
  - Microphone
  - analog infrared distance sensor
  - analog compass
  - barometer sensor

Resistive Sensors



- The resistance of resistive analog sensors, like the bend sensors or potentiometers, change with changes in the environment:
  - an increase in light,
  - or a physical deformation.
- The change in resistance causes a change in the voltage at the signal input by the voltage divider relation.

$$V_{sig} = \frac{R_{sensor}}{47\Omega + R_{sensor}} * 5V$$

Transitive Analog Sensor

- Transitive analog sensors, like the photo transistors and reflectance sensors, work like a water faucet.

- Providing more of what the sensor is looking for opens the setting of the valve, allowing more current to flow.

- This makes the voltage at the signal decrease.
- A photo transistor reads around 10 in bright light and 240 in the dark.
- One problem that may occur with transitive sensors is that the voltage drop across the resistor may not be large enough when the transistor is open.
  - Some transitive devices only allow a small amount of current to flow through the transistor.

Transitive Analog Sensor (cont)

- A larger range for the sensor can be accomplished by putting a larger pull-up resistor.
  - By having a larger resistor, the voltage drop across the pull-up resistor will be proportional to the resistance.
- Martin's book gives examples of use and mountings for each type of sensor.
- Keep in mind that these are only simple examples and are not the only possible uses for them.
- It's up to you to make creative use of the sensors you have.

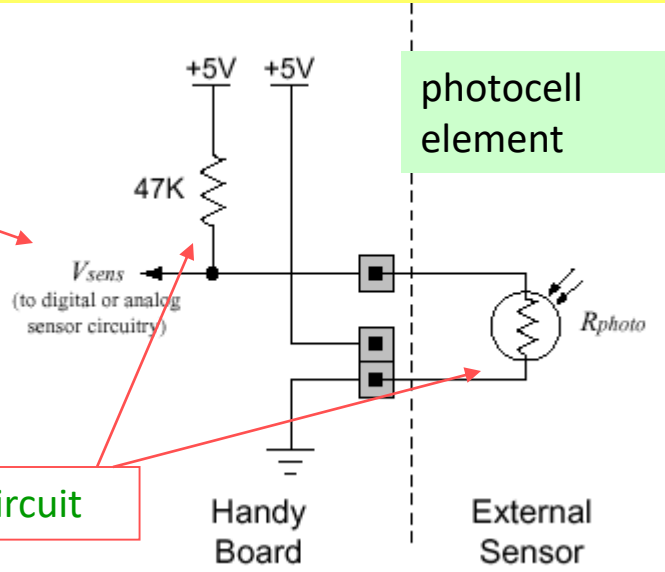
Sensor Interfacing to Analog Inputs

- V_{sens} voltage at the center tap of the two resistors is proportional to the ratio of the two resistances.

R_{photo} = 47KΩ, V_{sens} = 2.5 v (exactly)

R_{photo} << 47KΩ, V_{sens} ~= gnd

R_{photo} >> 47KΩ, V_{sens} ~= +5 v



Two resistors form voltage divider circuit

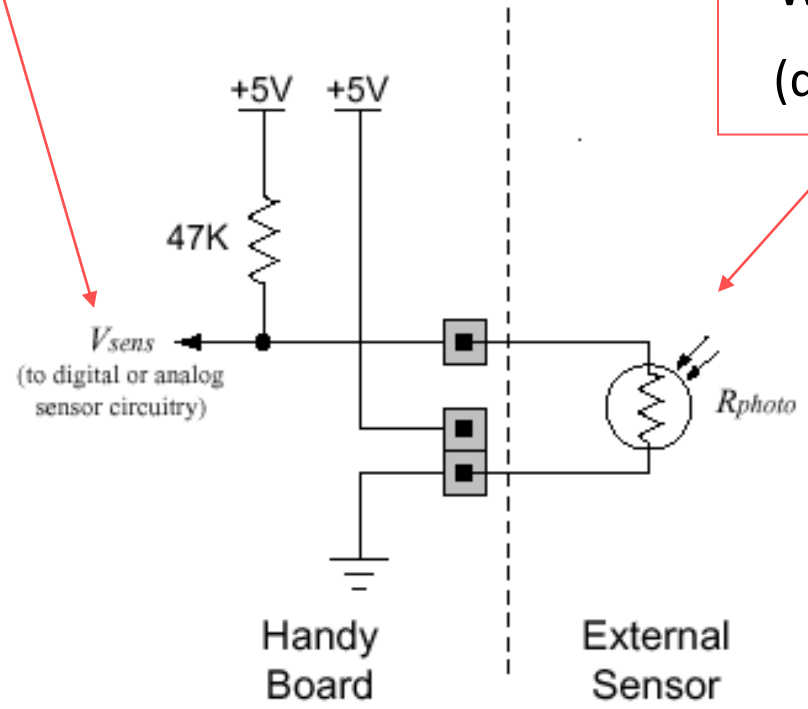
Also possible to connect circuits that generate a voltage

Sensor Interfacing to Analog Inputs

0 to 5 volts are converted into 8–bit numbers 0 to 255 (decimal) (A/D conversion)

–When the photocell resistance is small (brightly illuminated), the V_{sens} ~= 0v

– When the photocell resistance is large (dark), V_{sens} ~= +5 v

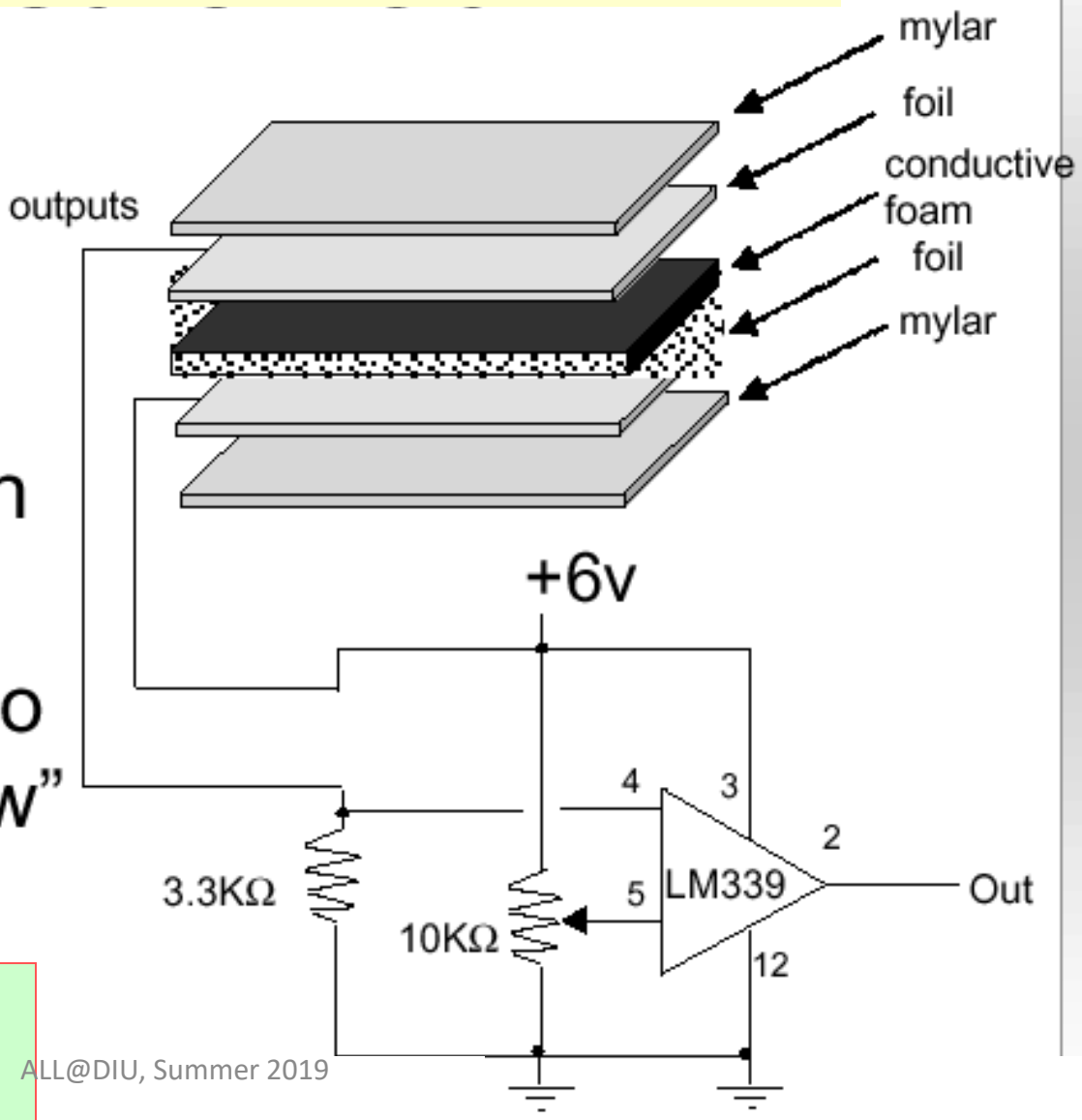


Resistive Position Sensors

Potentiometers. Glowes. Pads. Bend Sensors. Other….?

Pressure Pad

- Often used in grippers to detect the amount of pressure applied in picking up objects
- Relatively simple to build a “home-brew” version



You can purchase such pad for Nintendo games

Pressure Pad

Pressure Pad

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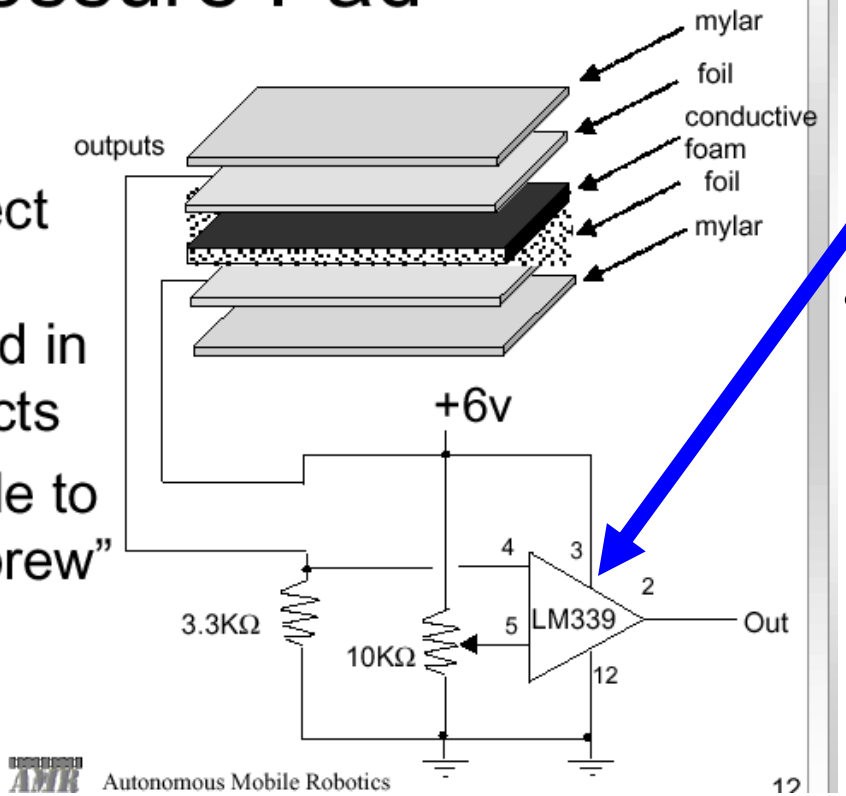


- LM339 is a quad comparator circuit:
  - Output will be +6V
- Another approach is to use ohm meter to detect the resistance change which would be proportional to amount of pressure applied.

Potentiometer: the main ideas

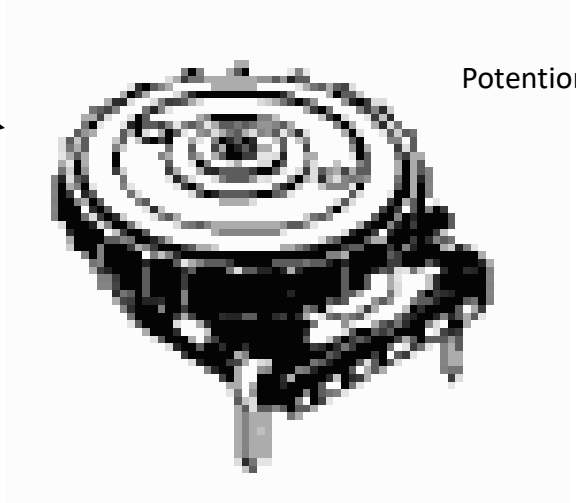
- **Potentiometers** are very common for manual tuning; you know them from some controls (such as volume and tone on stereos).
- Typically called ***pots*****,** they allow the user to manually adjust the resistance.

- The general idea is that the device consists of a movable tap along two fixed ends.
- As the tap is moved, the resistance changes.

- As you can imagine, the resistance between the two ends is fixed, but the resistance between the movable part and either end varies as the part is moved.
- In robotics, pots are commonly used to ***sense*** and **tune position** for sliding and rotating mechanisms.

Potentiometers versus resistance sensors

- Fixed Rotation Sensors
- Easy to find, easy to mount



Potentiometer

Light Sensor

- Good for detecting direction/presence of light
- *Non-linear* resistance
- Slow response

Look to catalogs:

Cadmium Sulfide Cell

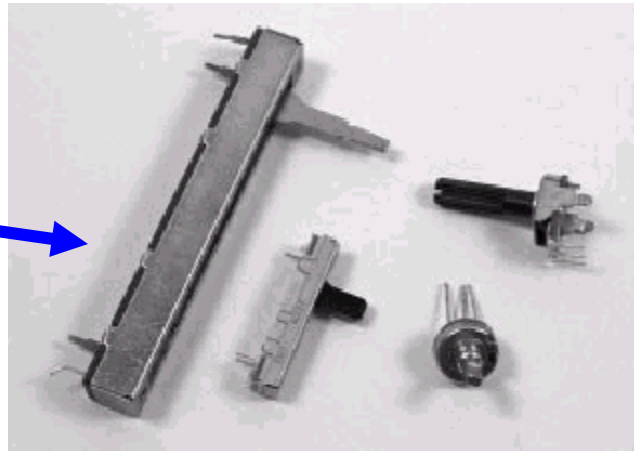
HANDYBOARD: Gleason Research. http://www.gleasonresearch.com/

http://handyboard.com

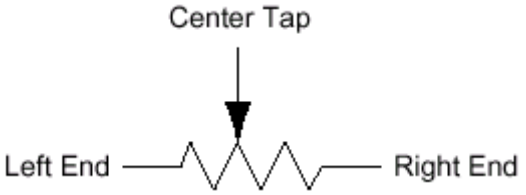
DISTRIBUTOR OF AGE BEND SENSOR: Images Company: http://www.imagesco.com

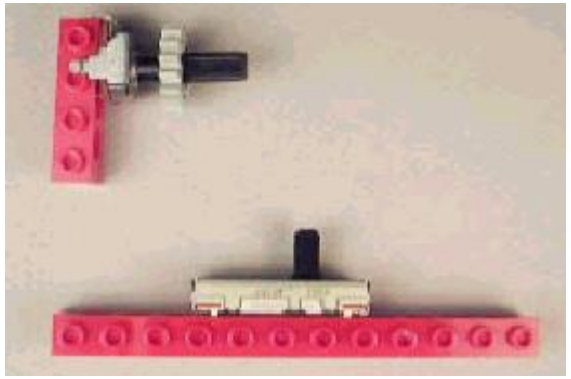
PITSCO LEGO DACTA, JAMECO, ETC - see the book and my webpage.

Potentiometers

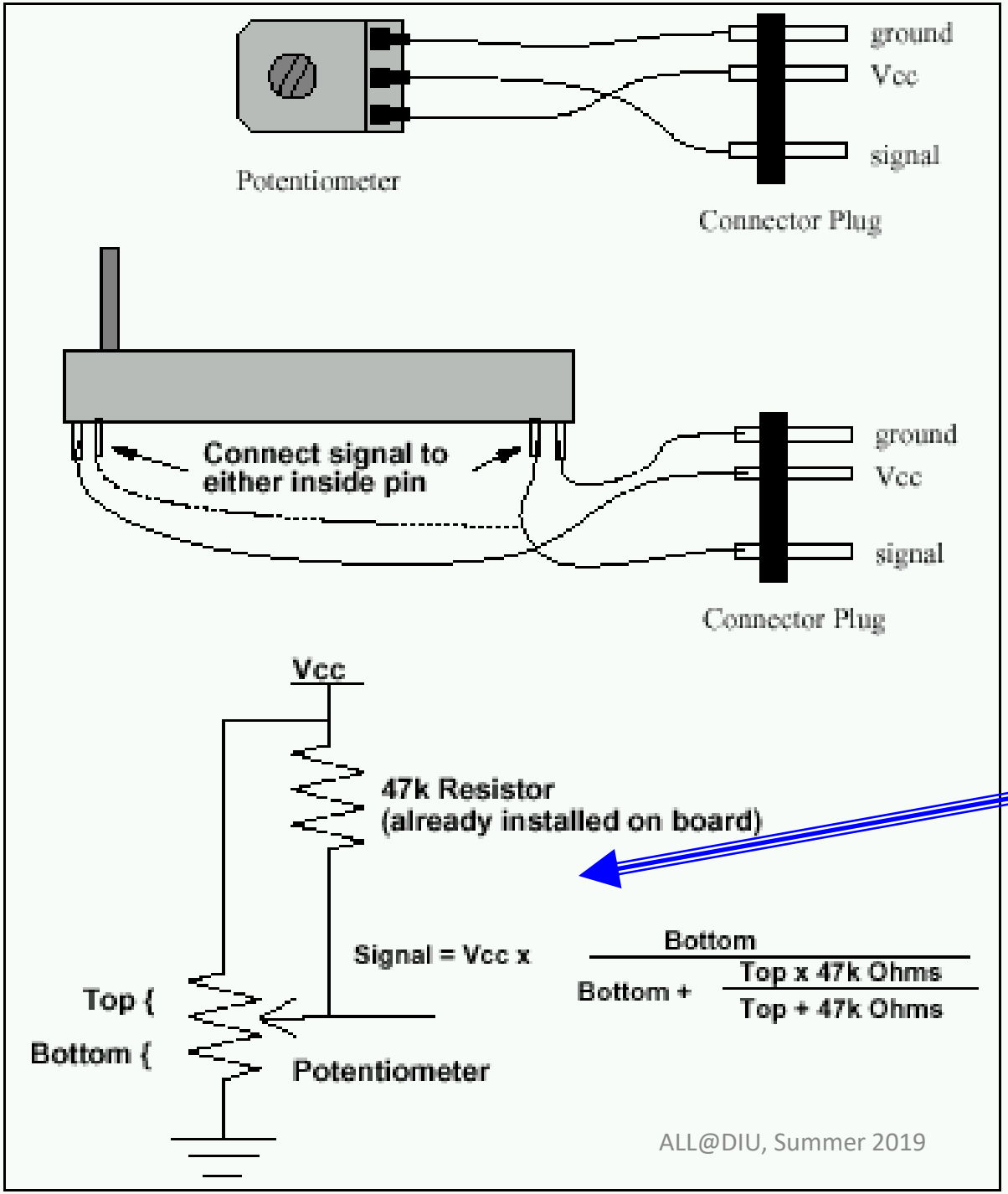


- Manually-controlled variable resistor, commonly used as volume/tone controls of stereos
- Mechanical varieties:
  - Linear and rotational styles - make position sensors for both sliding mechanisms and rotating shafts
  - Resistance between the end taps is fixed, but the resistance between either end tap and the center swipe varies based on the position of the swipe
- Electrical varieties:
  - Linear taper - linear relationship between position and resistance. Turn the pot 1/4 way, the resistance between the nearer end and the center is 1/4 of end-to-end resistance
  - Audio taper - *logarithmic* relationship between position and resistance. At one end, 1/4 turn would swipe over a small bit of total resistance range, while at the other end, 1/4 turn would be most of the range





Potentiometer Assemblies

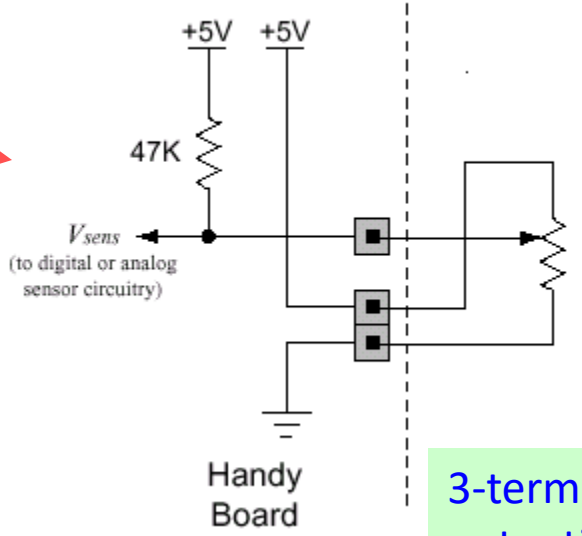


- **Kits contain several sizes of potentiometers, also known as variable resistors.**
- **Potentiometers should be wired with Vcc and ground on the two outside pins, and the signal wire on the center tap.**
  - **This will, in effect, place the resistance of the potentiometer in parallel with the 47K pull-up on the expansion board and is more stable than just using one side and the center tab to make a plain variable resistor**

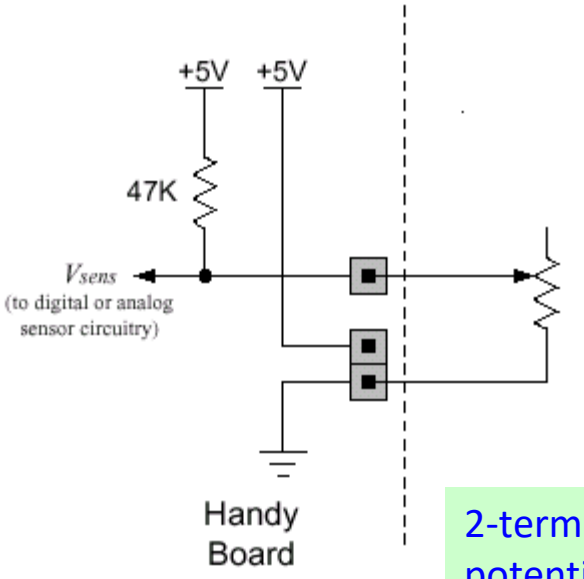
Two ways of using Potentiometers as

Resistive Posit

works best when the potentiometer resistance is small enough such that a 47K resistance in parallel with the pot's resistance has only a small effect



3-terminal potentiometer



2–terminal potentiometer works best when the pot's value is large

2-terminal potentiometer

Various uses of Potentiometers

- Potentiometers have a variety of uses:
  - In the past, they have been used for menuing programs
  - For angle measurement for various rotating limbs
  - For scanning beacons.

- They can be used with a motor to mimic servos, but that's a difficult task.
  - It is important to notice that the pots are ***not designed to turn more than about 270 degrees.***
  - Forcing them farther is likely to break them.

Tell about our previous project of animation inverse kinematics robot with many pots and A/D board. (the one that was stolen)

Various uses of Potentiometers

- A potentiometer can be attached to a LEGO beam
  - such that it can be used in place of a bend sensor.
  - The rotation of the beam will produce a rotation in the potentiometer.

- See if you can come up with an assembly that can be used in place of a bend sensor.

  - The advantage to such a sensor is that it is much sturdier than the bend sensor.
  - The disadvantage is that it is bulkier.

Linear Potentiometers and their use in HandyBoard

- A linear potentiometer can be used to measure precise linear motion,
  - such as a gate closing,
  - or a cocking mechanism for ring balls or blocks.

- **Frob-knob**
  - The frob knob is the small white dial on the lower left corner of the Expansion Board.

- *It returns values between 0 and 255* and provides a handy user input for adjusting parameters on the y or for menuing routines to select different programs.

- You may find it useful to glue a small LEGO piece to the frob knob to make turning it easier.

Resistive (Analog) Position Sensors

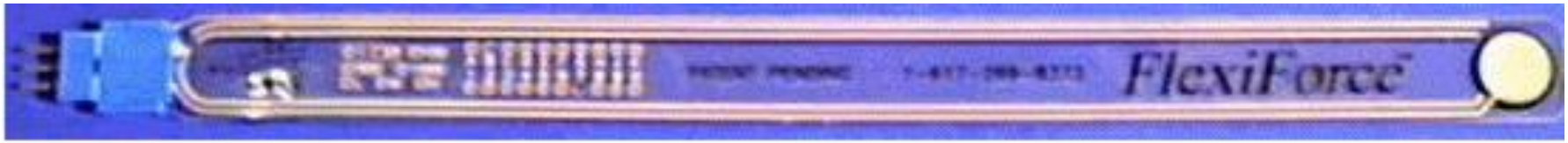
Resistive Position Sensors: bending

- We said earlier that a photocell is a resistive device, i.e., it senses resistance in response to the light.

- We can also sense resistance in response to other physical properties, such as ***bending***.
  - **The resistance of the device increases with the amount it is bent.**

- These bend sensors were originally developed for video game control
- They are generally quite useful:
  - Nintendo Powerglove
  - Video game accessories are in general useful for robotics and virtual reality and very cheap.

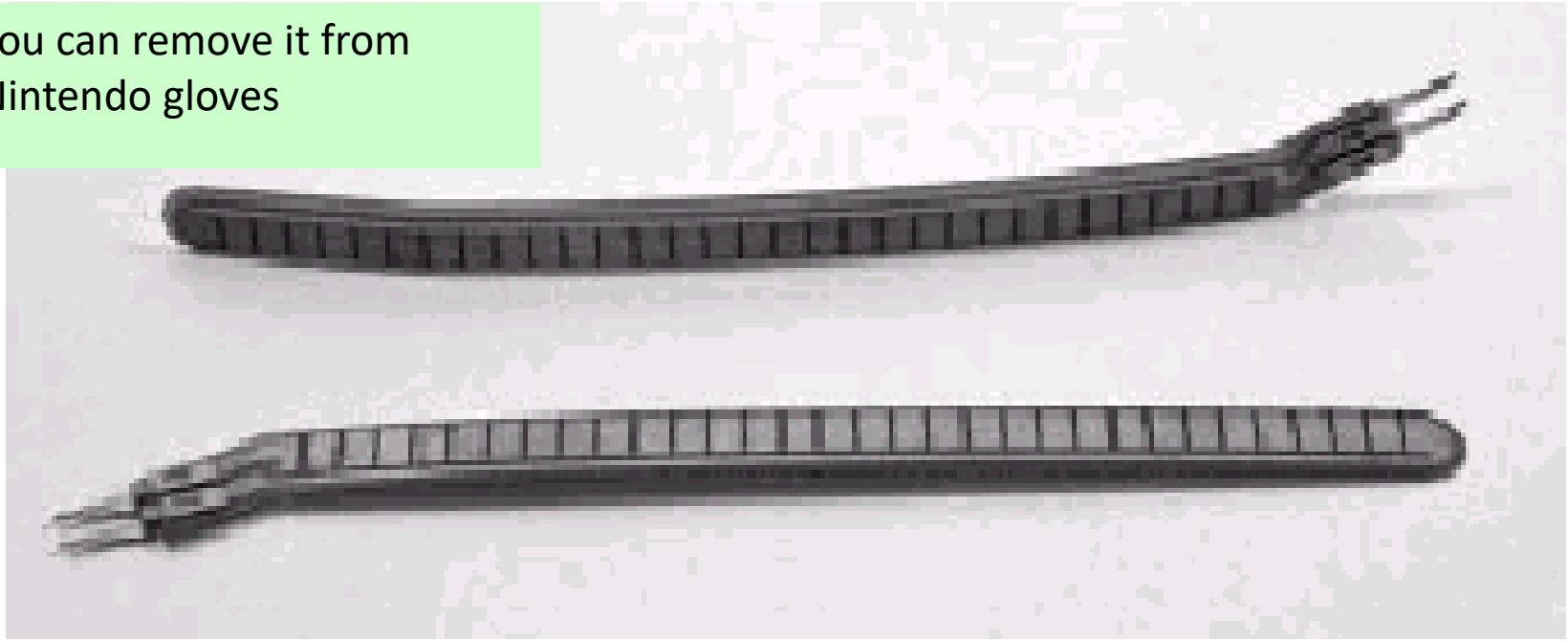
Resistive Bend Sensors



- Resistance = 10k to 35k
- Force to produce 90deg = 5 grams
- www.jameco.com = 10$

Bend Sensors

You can remove it from Nintendo gloves



- Useful for contact sensing and wall-tracking
- The bend sensor is a simple resistance
  - As the plastic strip is bent (with the silver rectangles facing outward), the resistance increases

Resistive Position Sensors

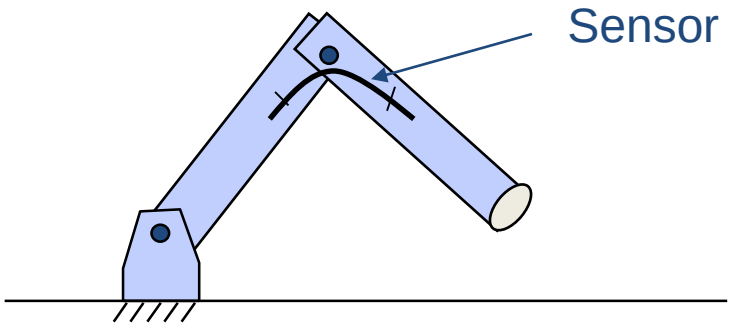
- Mechanically, the bend sensor is not terribly robust, and requires strong protection at its base, near the electrical contacts.
  - Unless the sensor is well-protected from direct forces, it will fail over time.

- Notice that even in a good arrangement, repeated bending will **wear out** the sensor.

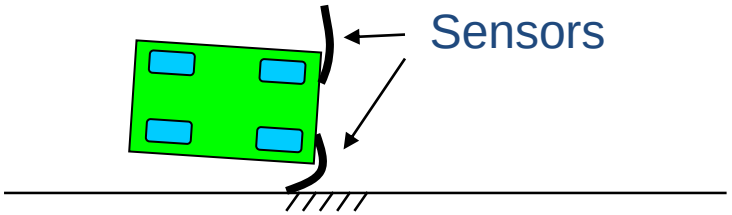
- **Remember:** a bend sensor is much *less robust* than light sensors,
  - although they use the same underlying resistive principle.

Applications of Resistive Analog Sensors

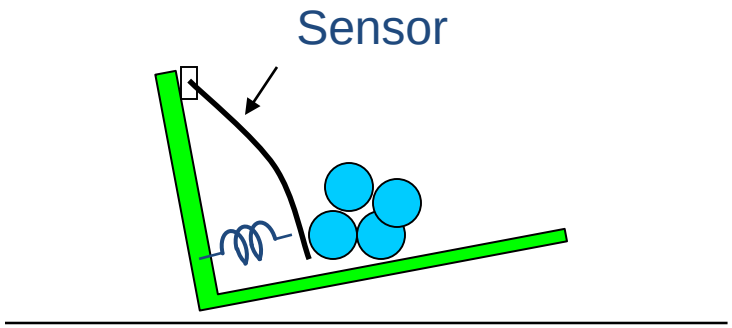
- Measure bend of a joint



- Wall Following/Collision Detection



- Weight Sensor

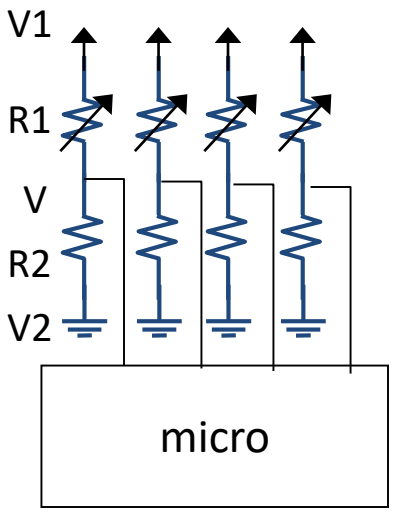


Inputs for Resistive Sensors

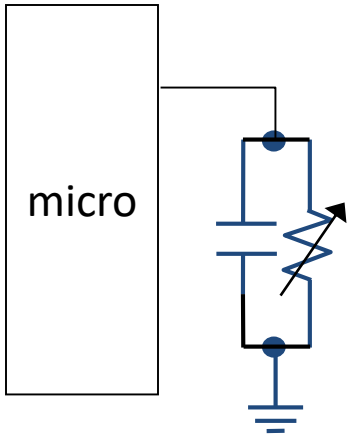
Voltage divider:
You have two resisters, one is fixed and the other varies, as well as a constant voltage

V1 – V2 * (R2/R1+R2) = V

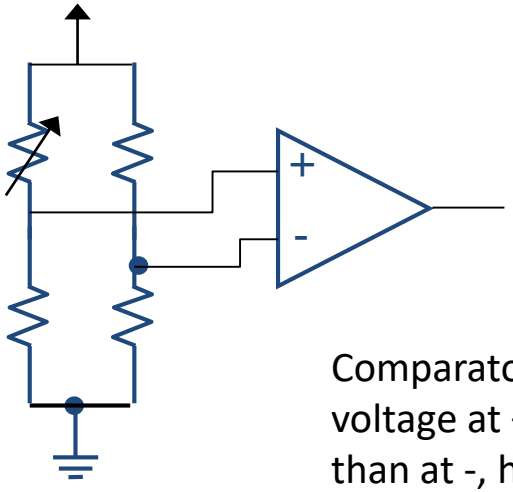
Known unknown measure



Analog to Digital
(pull down)



Single Pin
Resistance
Measurement



Binary
Threshold

Comparator: if voltage at + is greater than at -, high value out

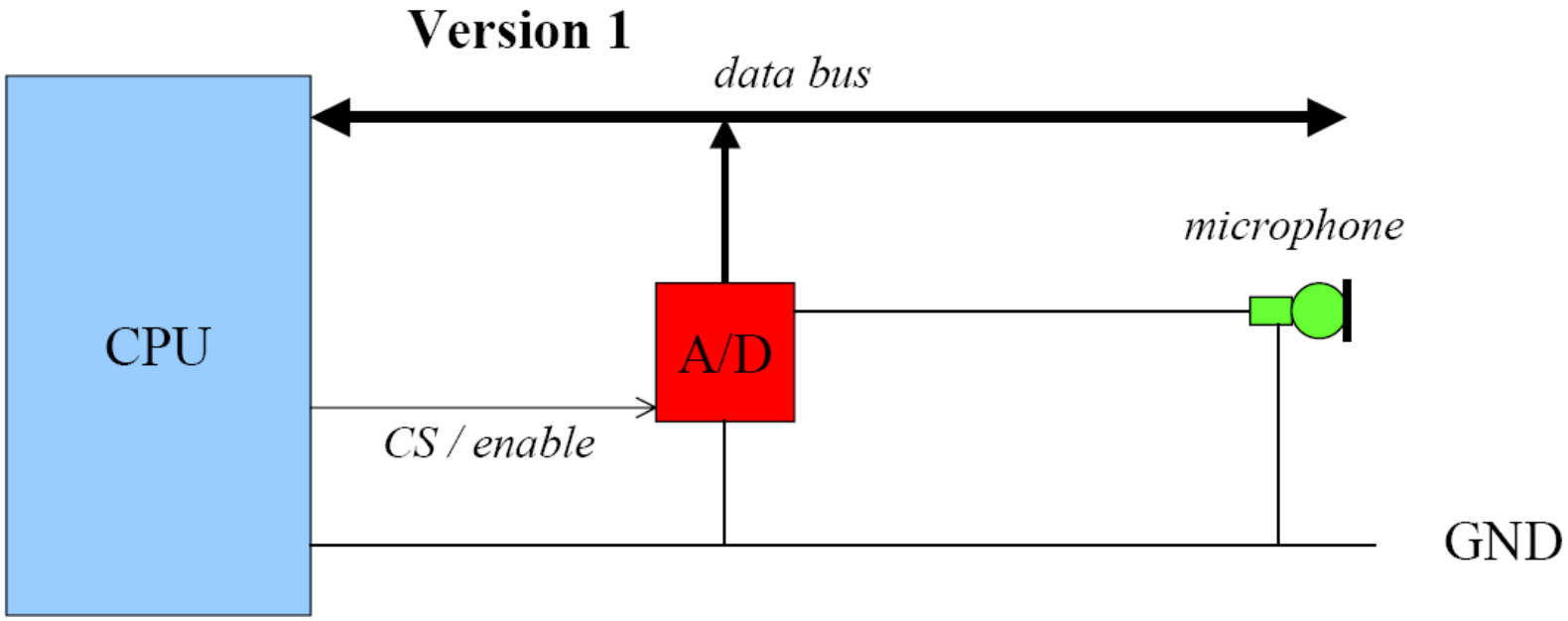
A/D Converter

- Signal has to be provided at correct level, e.g. between 0 .. 5V
- If multiple channels are read: low internal resistance of signal line is important
- A/D converter translates analog voltage level into digital value
- Digital output from A/D converter can be
  - – parallel

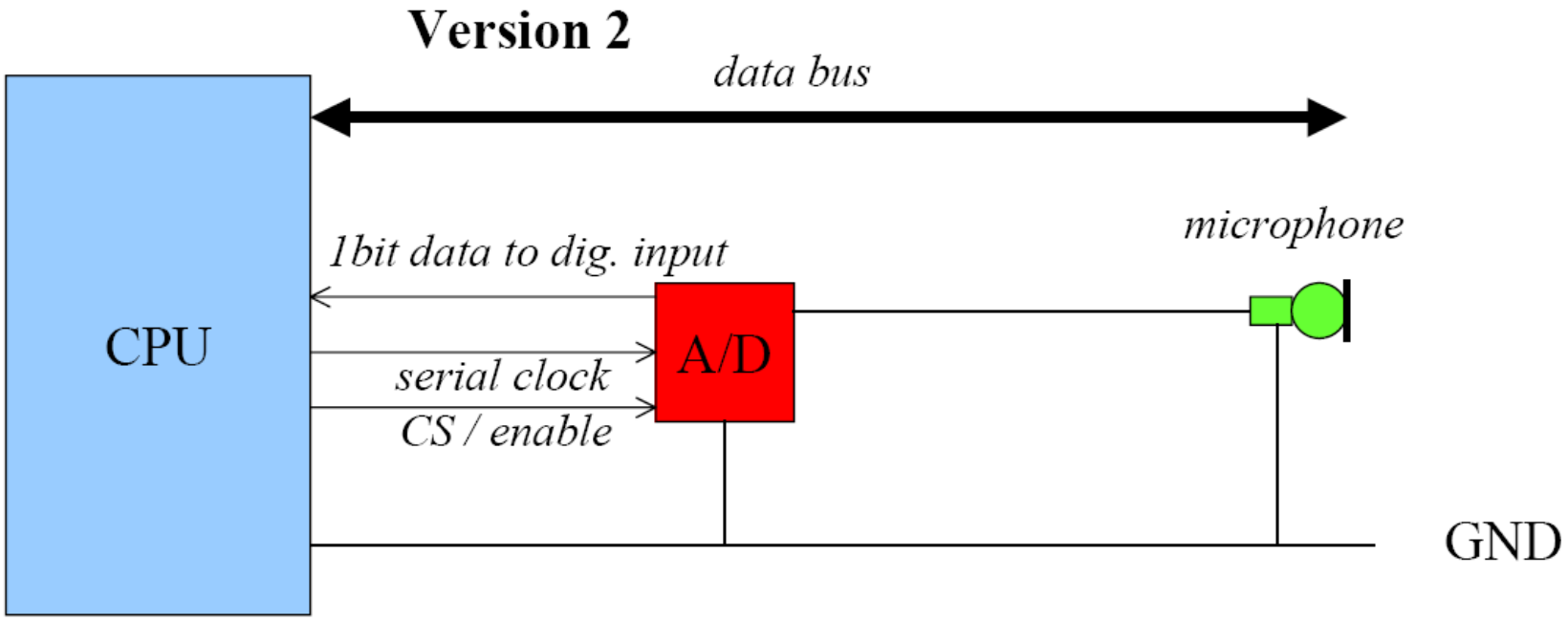
    (e.g. 8 bit, direct connection to data bus)
  - – serially digital

    (provide programmed clock signal to converter to read data bit by bit)

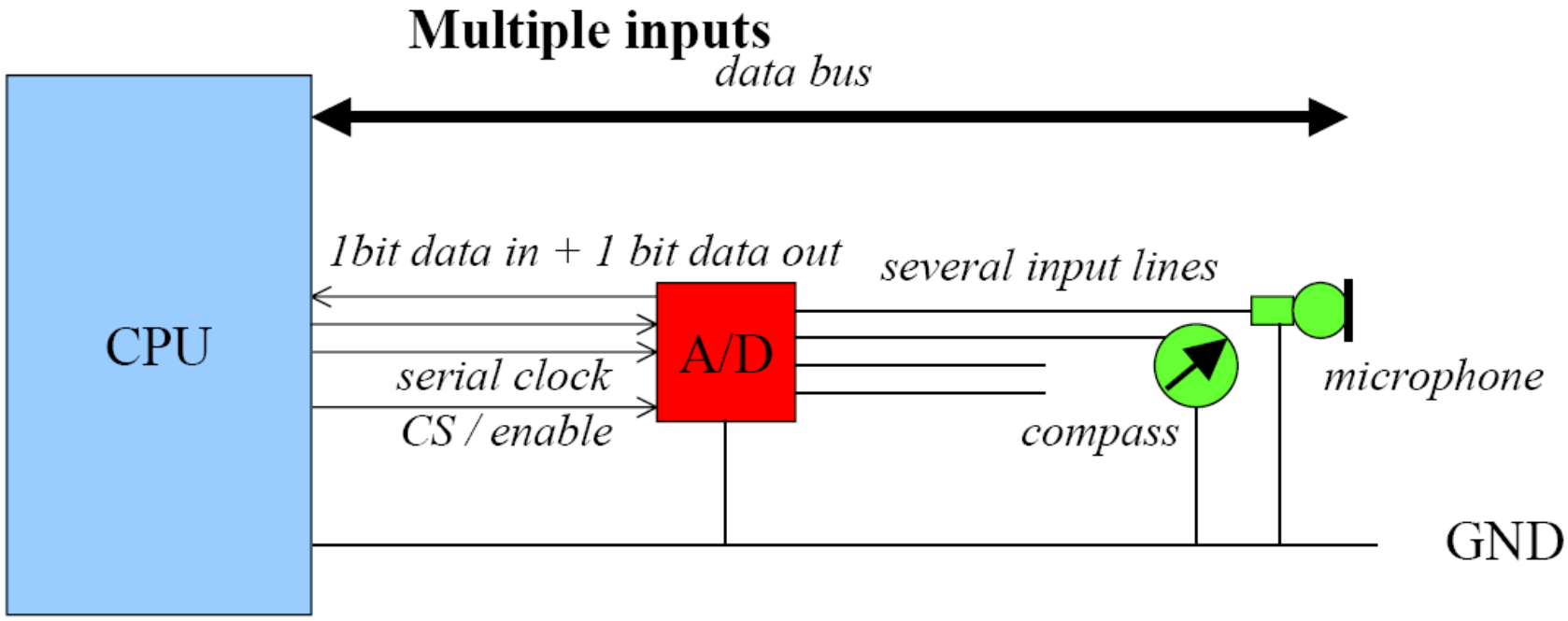
A/D Converter



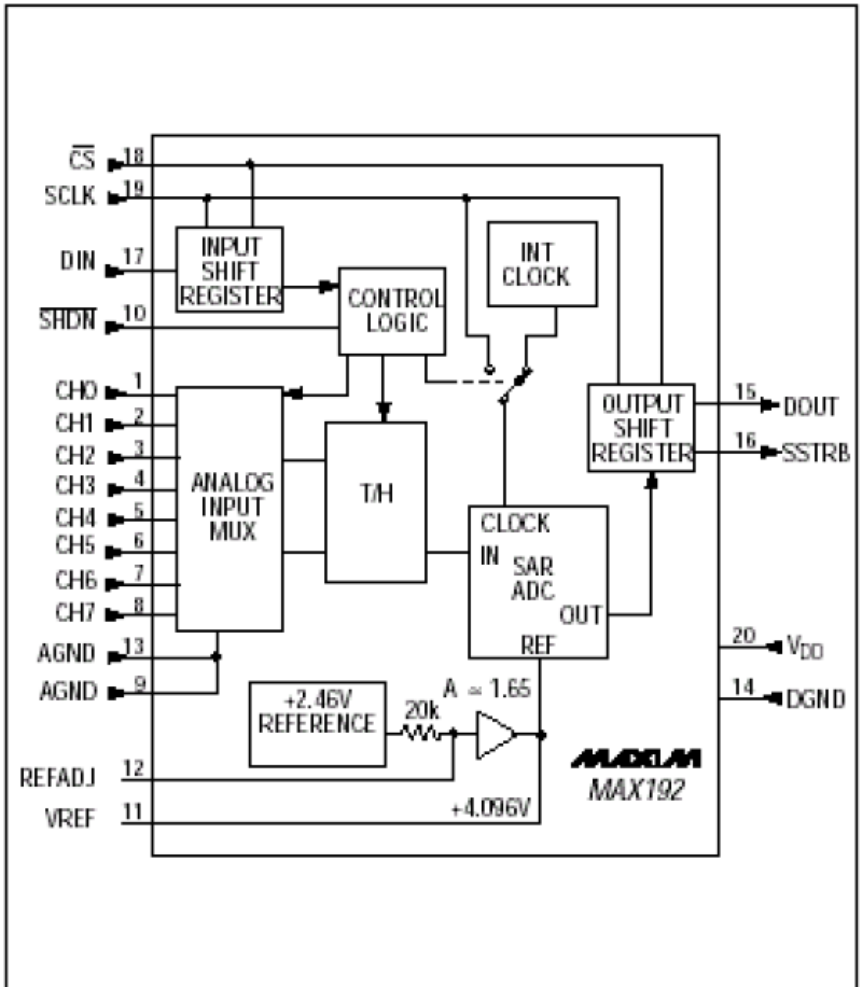
A/D Converter

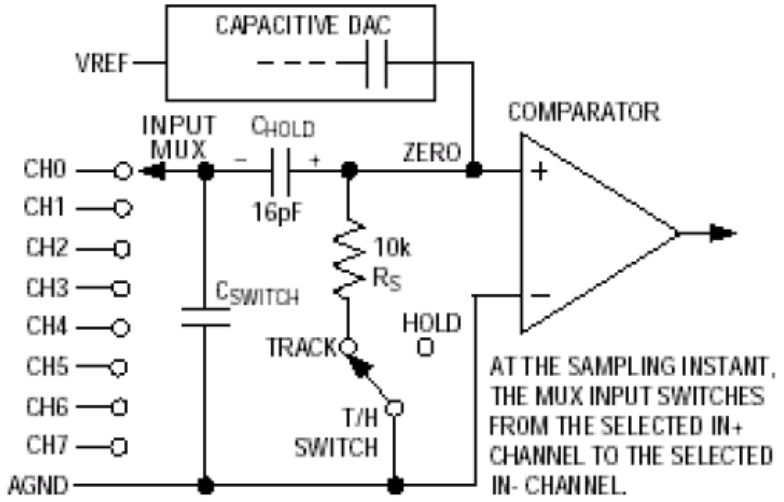


A/D Converter



A/D Converter





MAX192

A/D Converter