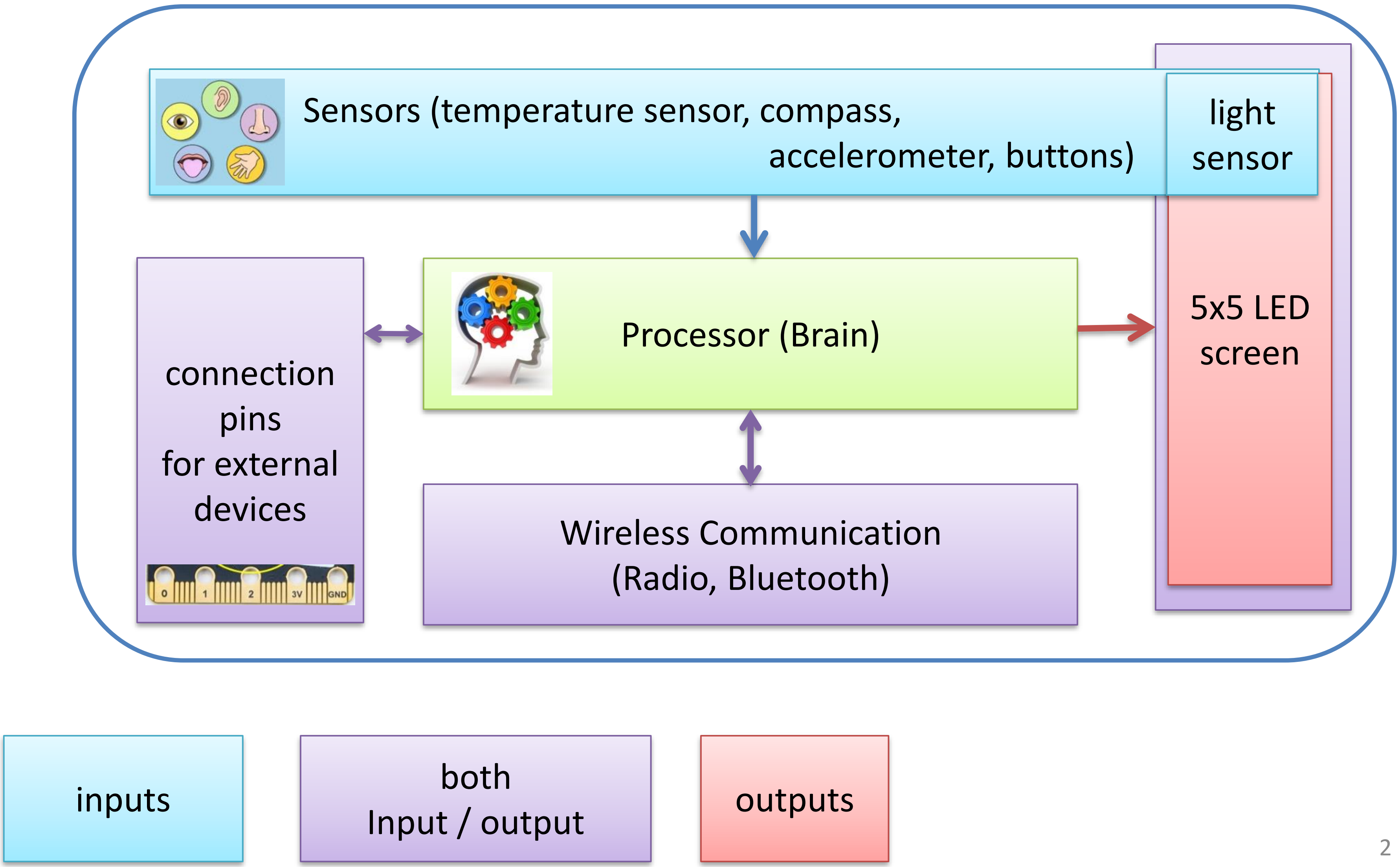
Programming with MicroBit

Overview on Hardware Features

Sensors and Actuators

Micro:bit as a System



Basic Descriptions

- LED (Light Emitting Diode)
  - Allow you to display text, numbers and images
- Buttons (button A and button B)
  - Allow you to trigger codes on the device by detecting when these buttons are pressed or not.
- Pins
  - Allow you to read a sensor (as input) or control an actuator (as output) by connecting them to the pins

Basic Descriptions

- Light sensor
  - By reversing the LEDs, they can be used to detect ambient light
- Temperature sensor
  - To detect the current ambient temperature, in degrees Celsius
- Accelerometer
  - To measure the acceleration of your micro:bit;
  - It can sense when the micro:bit is accelerating or detect other actions, e.g. shake, tilt, and free-fall.

Basic Descriptions

- Compass / Magnetometer
  - It detects the earth's magnetic field, and hence can detect which direction the micro:bit is facing.
  - The compass needs to be calibrated before use.
- Radio
  - Allow wireless communications between micro:bits
- Bluetooth
  - Allow the micro:bit communicating with a phone
- USB Interface
  - To power up the micro:bit and download programs onto micro:bit
  - Allow wired communication with PCs

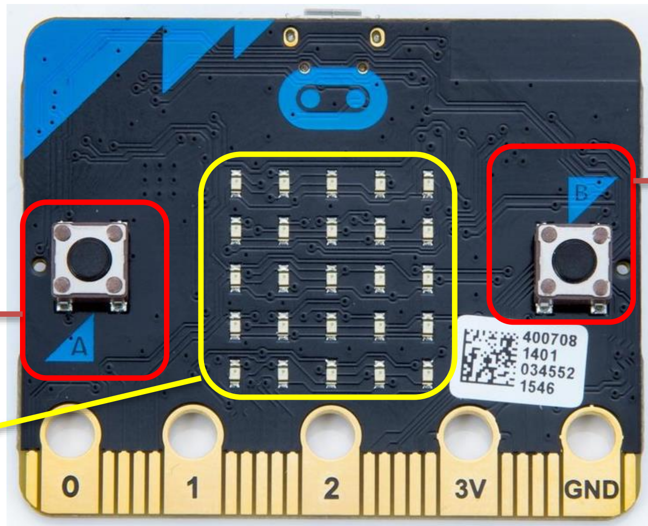
Micro:Bit Build-in Sensors

Sensors of a System

- Sensor – a device used to measure a physical property and respond with feedback

Sensors in Micro:Bit

Front

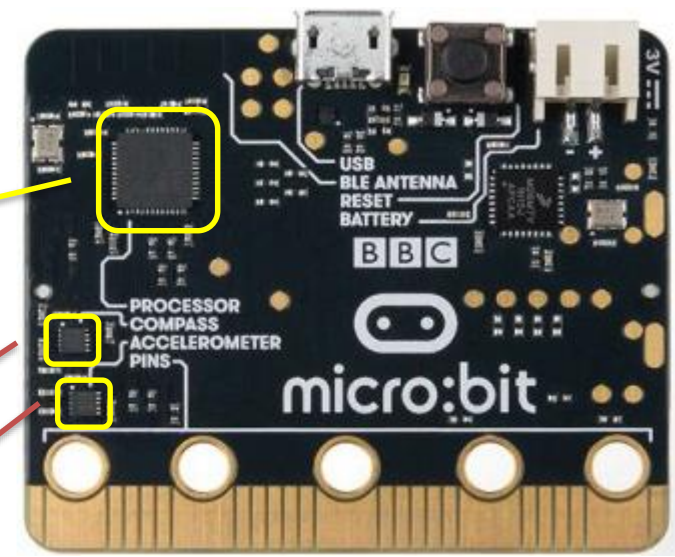


Push button
switch B

Push button
switch A

5x5 LEDs
(photo sensor)

Back



Processor M0
(temperature sensor)

Compass (magnetometer)

accelerometer

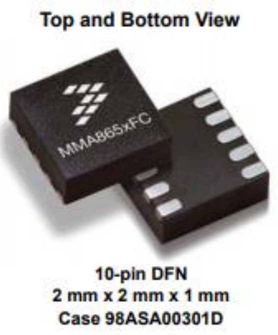
https://microbit.org/guide/features/
https://www.youtube.com/watch?v=7kTxukIcLd4

Accelerometer

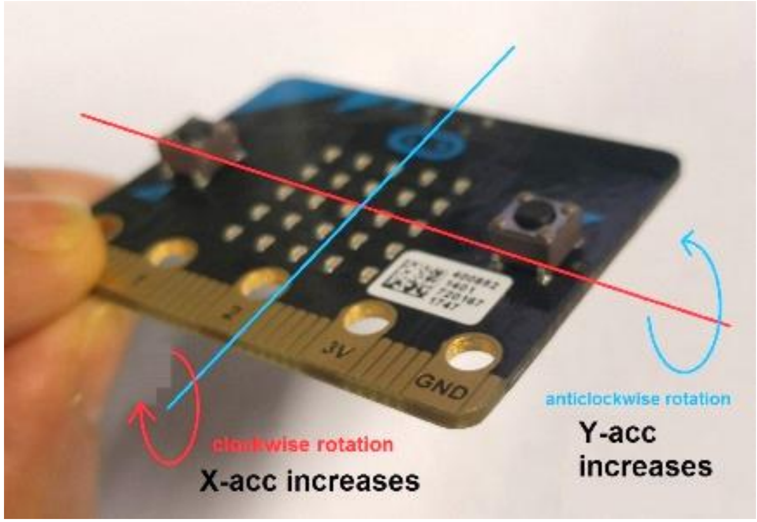
- Accelerometer measures the static acceleration of gravity in tilt-sensing applications as well as dynamic acceleration resulting from motion, shock, or vibration.
- Widely used in mobile phone/tablet, robot, …

http://ieee-sensors2013.org/sites/ieee-sensors2013.org/files/Serrano_Accels.pdf

Accelerometer



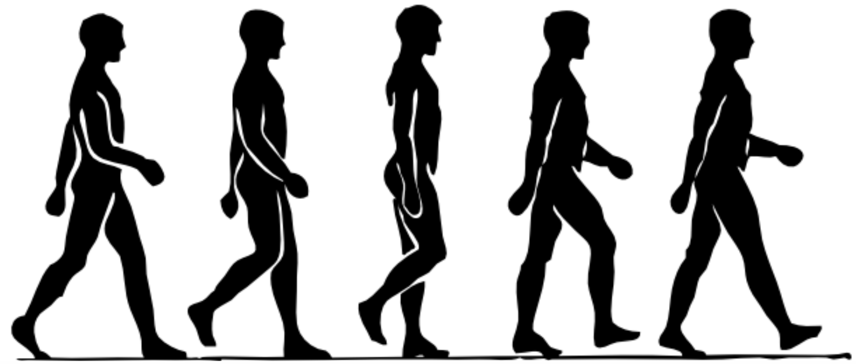
- Micro:bit on-board accelerometer
- Model: [Freescale MMA8653FC]
- 3 axis (3-dimensional) accelerometer
  - X acceleration: left and right direction.
  - Y acceleration: forward and backward direction.
  - Z acceleration: up and down direction



accelerometer

Application Example: Padometer

- Accelerometer values change when we walk.



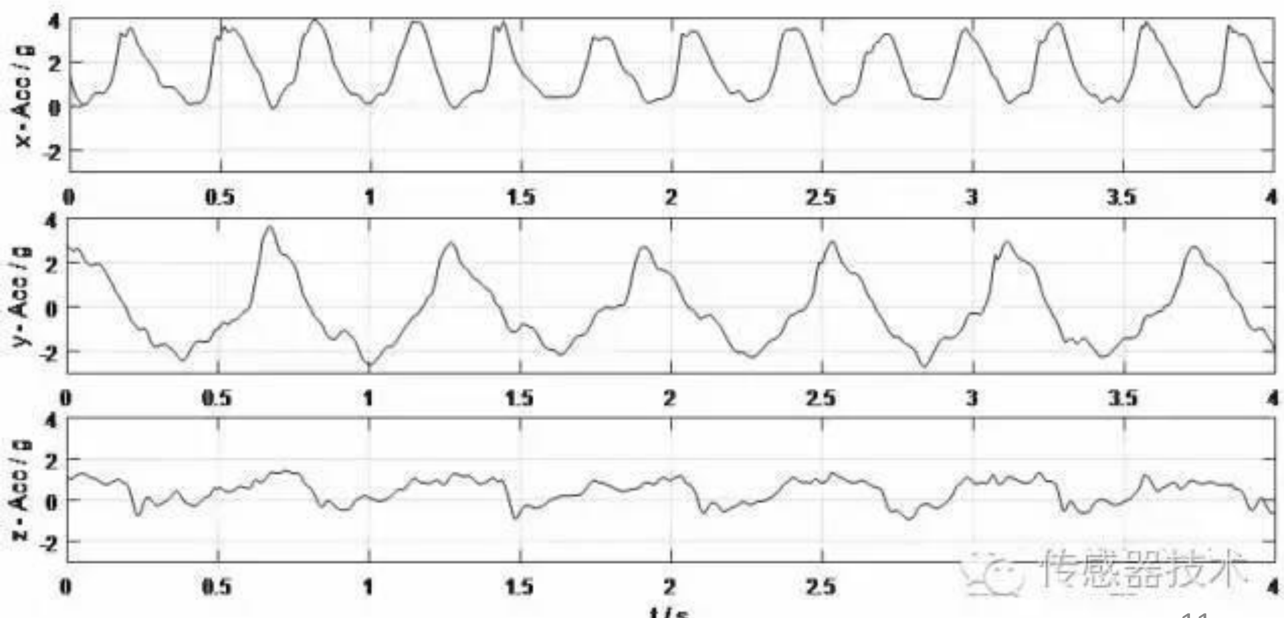
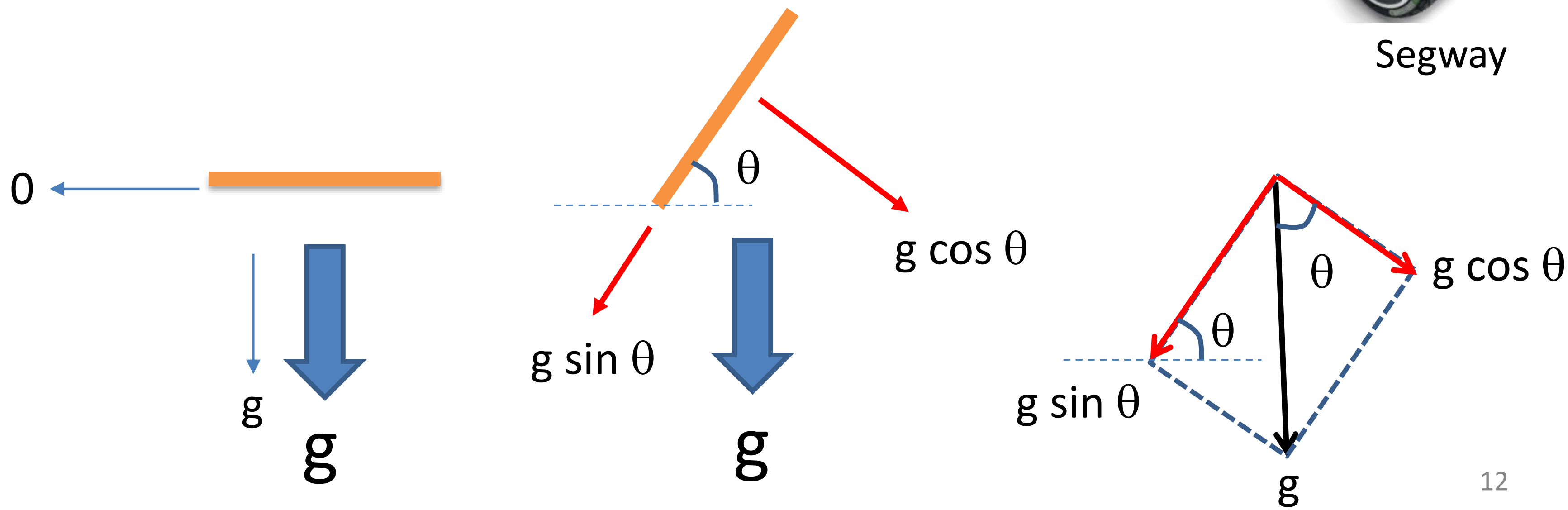


Figure from
https://itw01.com/2NIGYEM.html

Another Usage for Accelerometer

- Measure tilt angle with accelerometer
- Application example: Segway senses the tilt angle, and then goes forward / backward or turns left/right

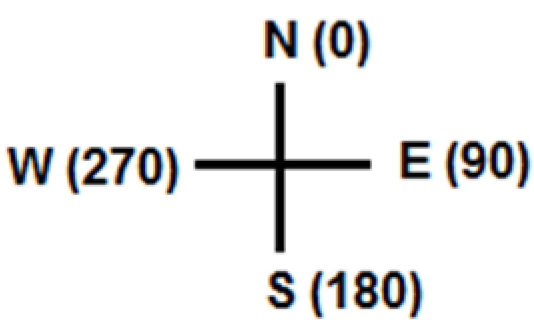
Segway



Magnetometer

- Magnetometer – sense the magnetic field strength
- Micro:bit onboard sensor: [Freescale MAG3110]
- The library converts the reading and uses it as a digital compass

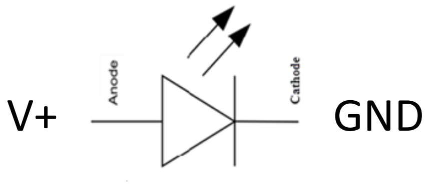
Returned value (integer): 0 - 359



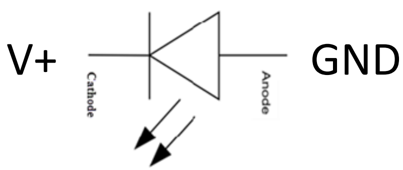
Magnetometer

On-Board Light Sensor

- Micro:bit has a 5x5 LED screen
- LEDs can also be used to measure light (i.e. as light sensor). It is because a reverse-biased LED can act as photo sensor.



Forward-biased: LED on



Reverse-biased: LED off

- Get the reading from the light sensor:
- Range (integer): 0 (dark) – 255 (bright)

Using LEDs as light sensor: https://www.sparkfun.com/news/2161

Micro:Bit External Sensors

Other Possible Sensors

- Photoresistor (light sensor)
- Force Sensor

Resistance

- Monolithic Temperature Sensor
- Air Humidity Sensing Module

Output voltage

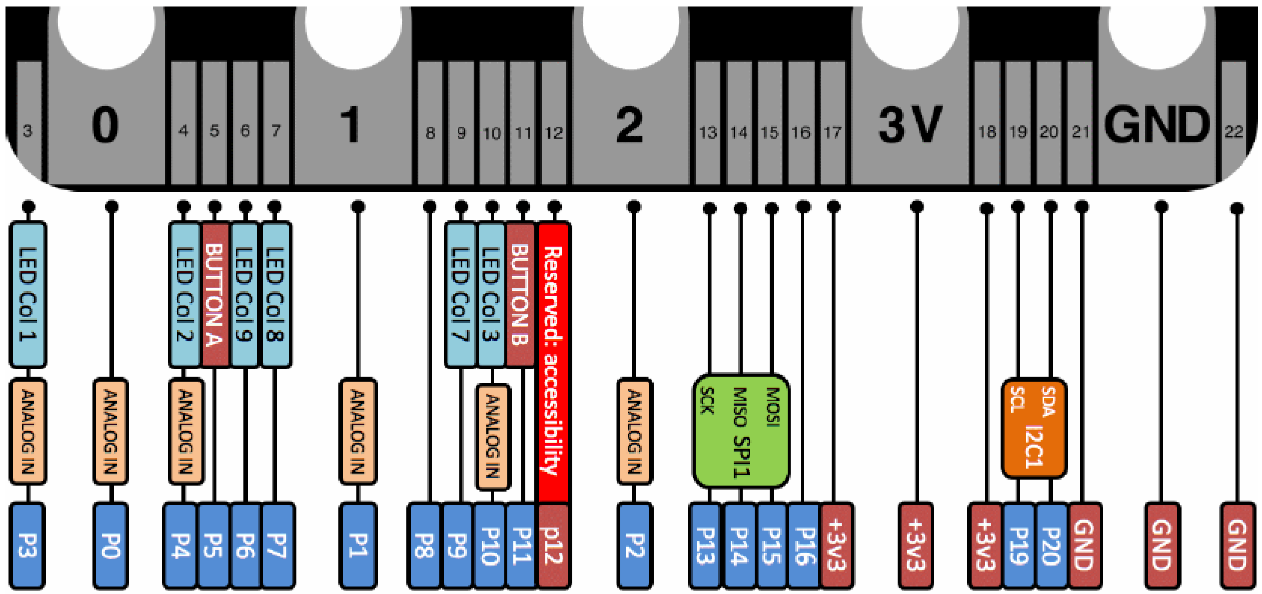
- Soil Humidity Sensing Module

Voltage output (analog and digital)

- Ultrasonic Distance Module

Voltage output (timing)

MicroBit input/output pins



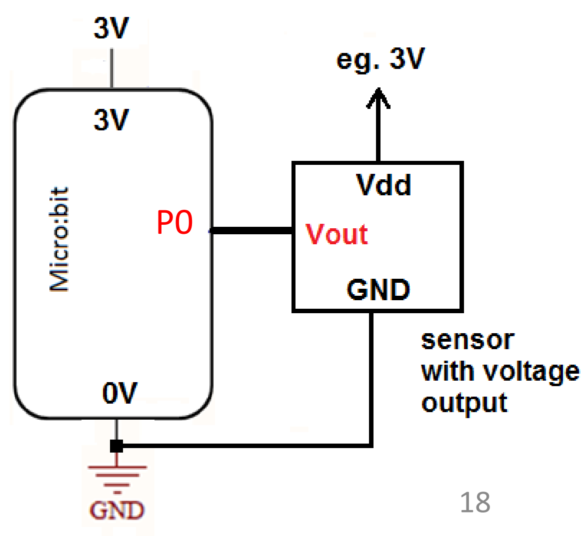
- **P0**: GPIO, analog, touch, PWM, UART
- **P1**: GPIO, analog, touch, PWM, UART
- **P2**: GPIO, analog, touch, PWM, UART
- **P8**: GPIO, PWM, UART
- **P13 ~ P16**: GPIO, PWM, UART

GPIO: General Purpose Input/Output
Touch: Touch sensing
PWM: Pulse width modulation
UART: Universal asynchronous receiver/transmitter
Analog: Analog input

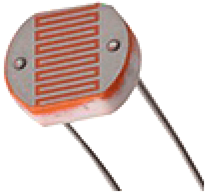
Basic Connection and Programming

- Using I/O pin to connect an external device (eg. Sensor)
- Use analog read/digital read (Unit 3B)
- Store in a variable

Measure the voltage
Connect to the pin.



External Light Sensor



- Photoresistor (or light dependent resistor LDR) are often used to measure the light intensity. (eg. PGM5399)
- when the LDR sensor is exposed to light, the resistance changes according to the light intensity (eg. dark -> 1MΩ; bright -> a few KΩ).
- LDRs have a sensitivity that varies with the wavelength of the light applied and are nonlinear devices.

Light intensity ↑ Resistance ↓

http://www.resistorguide.com/photoresistor/

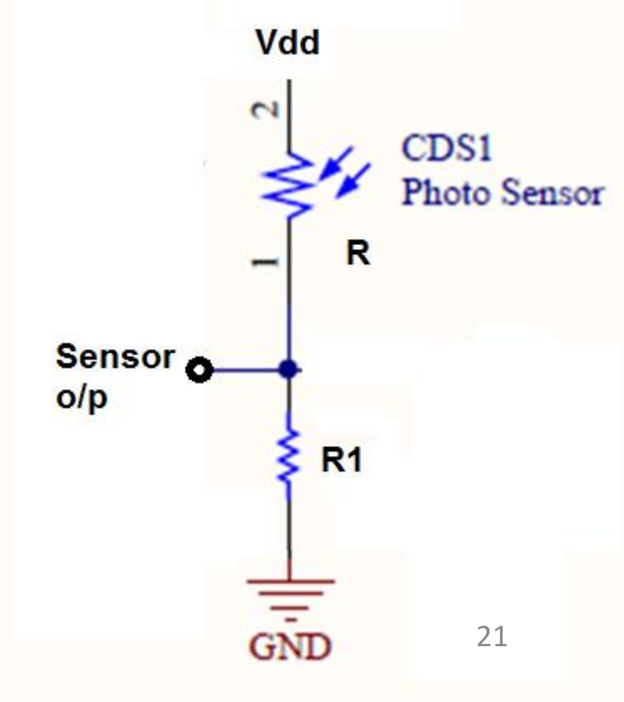
Force Sensor (Force Sensing Resistor)

- Transform the stress exerted on sensitive area into two-line resistance variation;
- the more the stress is, the lower the sensor output resistance

Force ↑ Resistance ↓

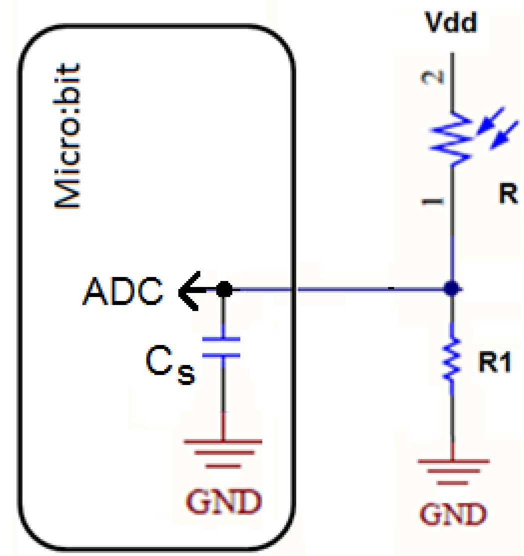
How to Use LDR/Force Sensor as Input?

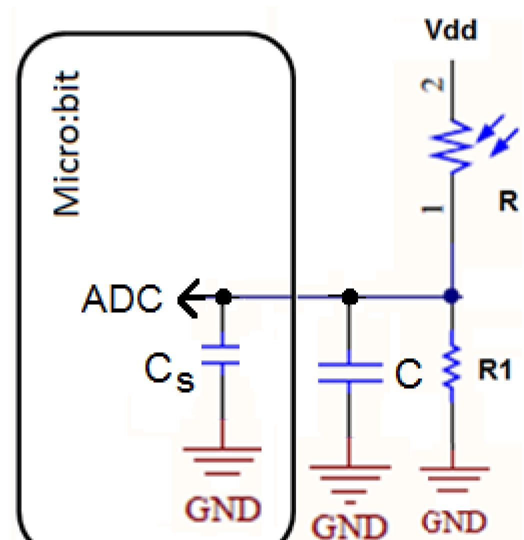
- Micro:bit (same for all other controllers) only considers voltage as input; not resistance!
- To convert resistance to voltage, we can use a voltage divider
- Sensor o/p $= V_{dd}\frac{R1}{(R+R1)}$
- When R increases (decreases),
  - sensor o/p decreases (increases).



Other Consideration

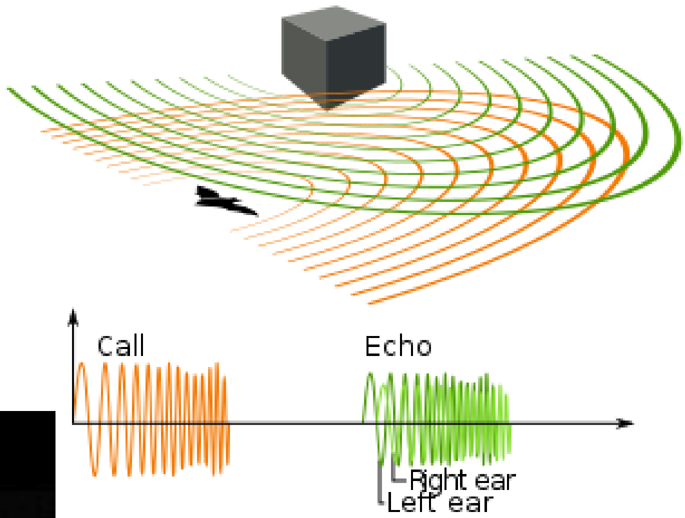
- Problem with internal impedance of the ADC [There is a small sampling cap Cs, in pF, which needs to be charged up for ADC operation]
- If R and R1 are large, current goes to charge Cs is too small, introducing errors to ADC output
- Solution: Add a capacitor C (eg. 0.1uF) as a charge reservoir
  – error can be reduced
  – But may reduce the sampling frequency





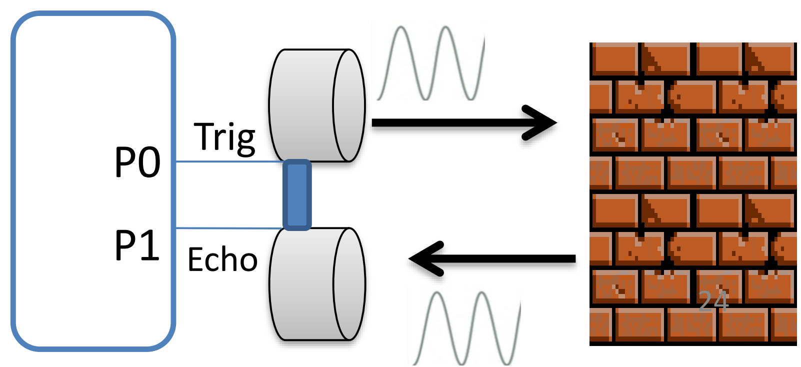
Ultrasonic Echolocation

Echolocation can sense nearby objects: By emitting a certain frequency and seeing how long it returns back, we can determine the location and even the speed of an object.

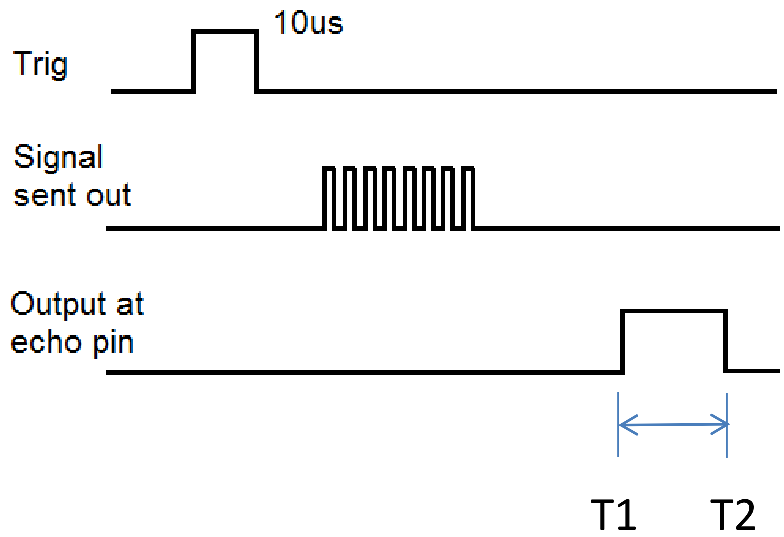


Ultrasonic Distance Module (HC-SR04)

- Principle:
  - Give HIGH pulse with width $\geq 10\ \mu s$ to Trig pin
  - The module will send out eight 40KHz square wave pulses, then check whether there is any echo signal received
  - When signal is echoed back, the Echo pin will output a square pulse, for which its width equals to the time taken for the sent-out signal returns back (so, proportional to the distance)



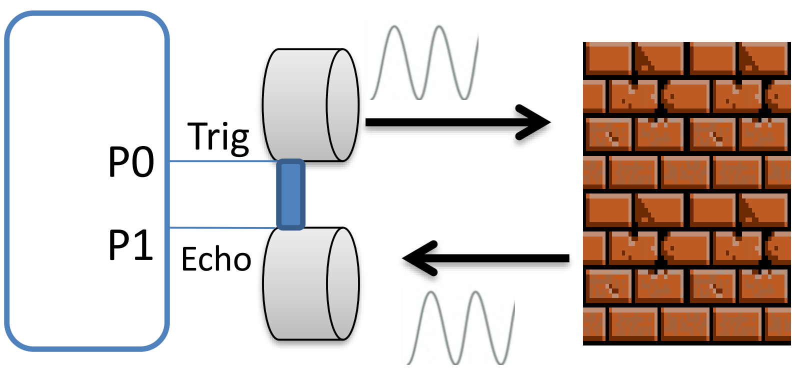
Details



Note: Minimum 10us, can be longer

Measure t=(T2-T1) to indicate the distance

T1: P1 from 0 to 1
T2: P1 from 1 to 0



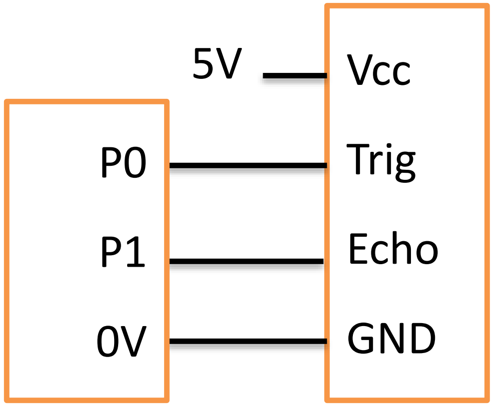
Calculation:

$D = t \times 340\text{ms}^{-1} / 2$

t is the time with high; *D* is the distance.

Ultrasonic Distance Module (HC-SR04)

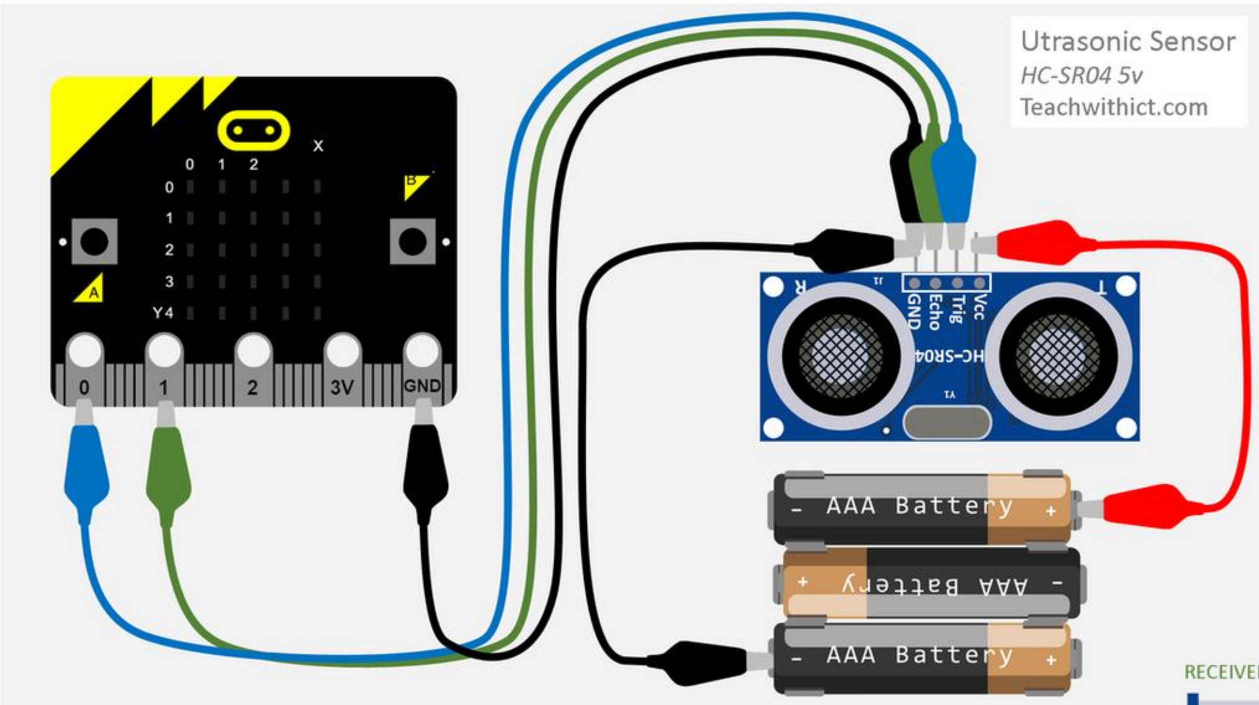
- Vcc : 5V DC
- Signal level: HIGH = Vcc; LOW = 0V
- Sensing angle $\leq$ 15 degree
- Measuring distance: 2cm to 400 cm
- Pin assignment
  - Vcc (5V)
  - Trig (input)
  - Echo (output)
  - GND

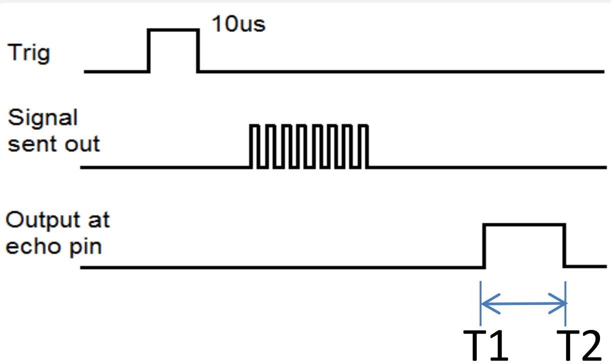


P0 and P1 are just examples. Any digital I/O pin can be used.

Ultrasonic Distance Sensor with Micro:Bit

Lab I : Ultrasonic Ruler at Week 7





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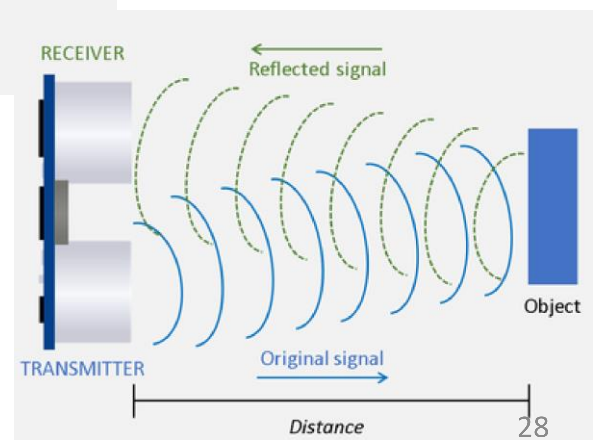
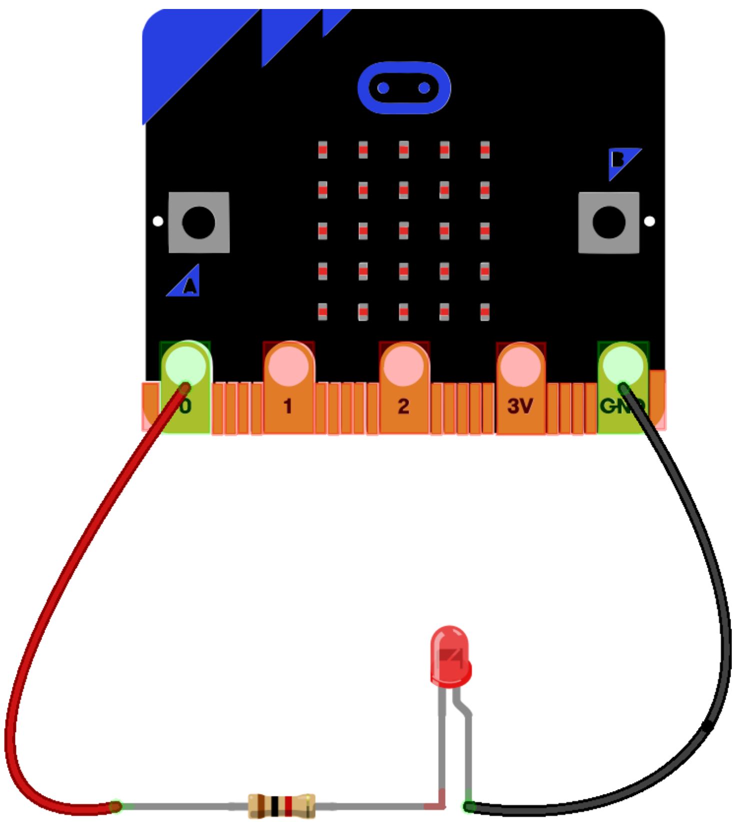


Demonstration – driving a LED




```
from microbit import *

pwm = pin0

while True:
    pwm.write_analog(1023)    # LED on
    sleep(100)                # wait 1000ms
    pwm.write_analog(0)       # LED off
    sleep(500)                # wait 1000ms
```