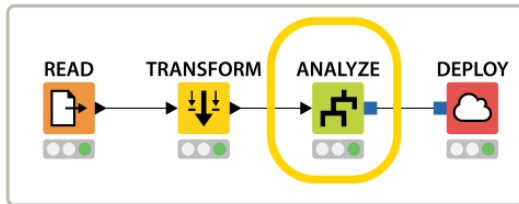


Prototyping Predictive Analytics Techniques

Class 5: Monitoring and Analyzing an Accelerometer Using The BBC micro:bit



March 22, 2019
Don Wilcher

Class 5: Monitoring and Analyzing an Accelerometer Using The BBC micro:bit



Agenda

- Mini Lab Activity: Collecting accelerometer vibration data from the BBC micro:bit
- Lab Project: Build a Talking Accelerometer Gesture Device

What is an Accelerometer?



- A device that measures the rate of change of velocity.
- Behaves as a damped mass on a spring (electromechanical).
- Mass is displaced by a spring.
 - a. spring is able to accelerate the mass

Question 1:

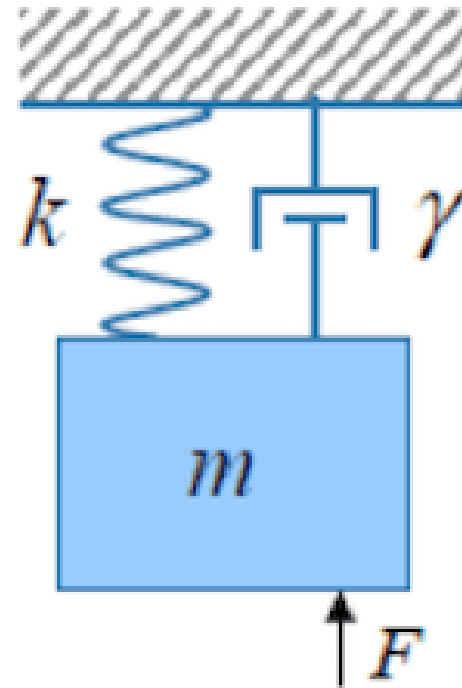


Mass is displaced by_____

What is an Accelerometer?...



Electromechanical Accelerometer



where:

k is the spring mass

m is the mass

f is the force

y is the damping constant (in this system y is the spring constant (ζ)).

What is an Accelerometer?...



Modern accelerometers have the following physical characteristics.

- small micro-electromechanical systems (MEMS)
- has a cantilever beam
- seismic mass
- damping results from the residual gas select in the device

What is an Accelerometer?...



The BBC micro:bit has a MMA8653FC 3-axis, 10bit digital accelerometer. The MMA8653FC accelerometer is

- low power
- capacitive micromachined
 - a) microstructures built by deposition
 - i. deposition process is removal of materials
 - ii. associated with subtractive manufacturing
 - b) etched structural layers over a substrate
 - c) microstructure becomes sensing surface

What is an Accelerometer?...



MMA8653FC features

- 1.95V to 3.6V supply voltage
- 1.62V to 3.6V digital interface voltage
- $\pm 2g$, $\pm 4g$, and $\pm 8g$ dynamically selectable full scale ranges.
- Output Data Rates (ODR) from 1.56Hz to 800Hz
Note: ODR is the **rate** at which it samples the values being measured.
- 10bit digital output
- I2C digital output interface with programmable interrupts



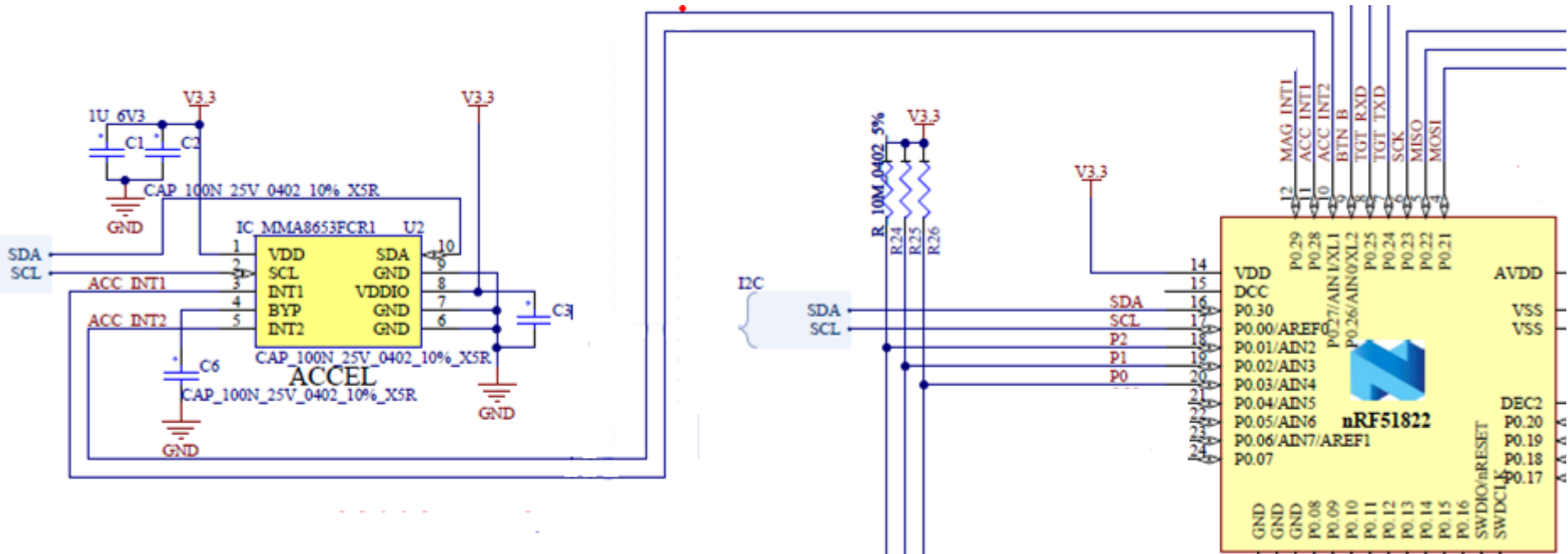
Question 2:

True or False: The MMA8653FC accelerometer has a 12bit output?

What is an Accelerometer?



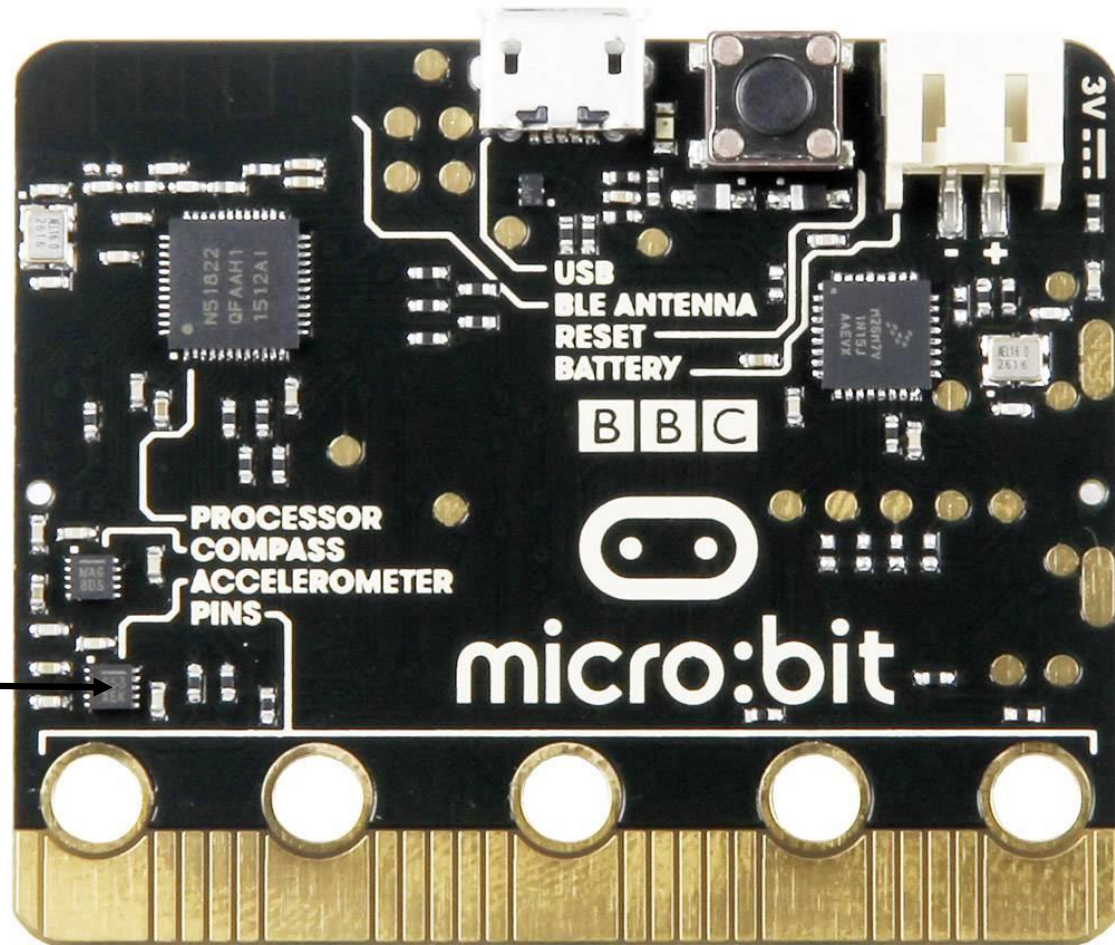
MMA8653FC accelerometer to nRF51822 uC interface circuit diagram.



What is an Accelerometer?...



**MMA8653FC
accelerometer**



Question 3 :

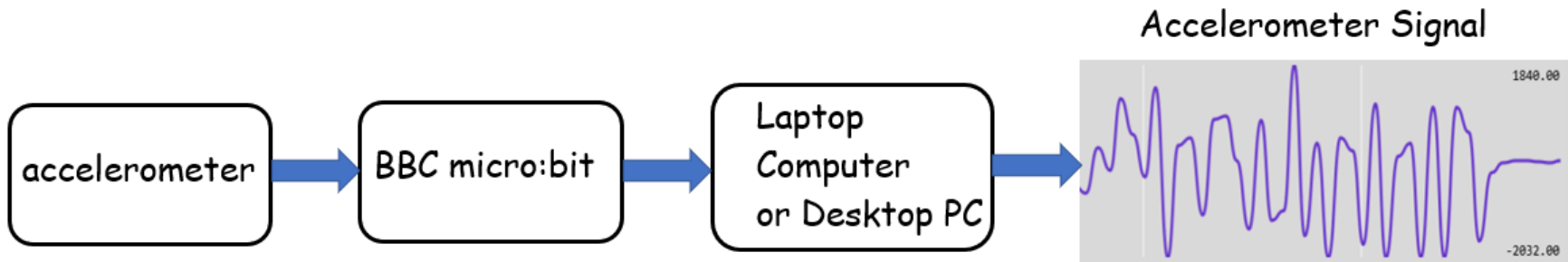


On slide 10, what are the designated I2C pins on the MMA8653FC accelerometer?

Mini Lab Activity: Collecting accelerometer vibration data from the BBC micro:bit accelerometer



Question: How can the BBC micro:bit collect vibration data?



Mini Lab Activity: Collecting accelerometer vibration data from the BBC micro:bit accelerometer...



Blockly Code

```
forever
  serial write line "Accelerometer Data"
  serial write value "x" = acceleration (mg) x
```

Javascript

```
1 basic.forever(function () {
2   serial.writeLine("Accelerometer Data")
3   serial.writeValue("x", input.acceleration(Dimension.X))
4 })
```

Mini Lab Activity: Collecting accelerometer vibration data from the BBC micro:bit accelerometer...



MMA8653FC accelerometer signal

The screenshot shows the MakeCode for micro:bit interface. On the left is a 3D model of a micro:bit with a red accelerometer icon and the text 'ax: 0'. Below it are two buttons: 'Show console Simulator' and 'Show console Device'. The main area features a graph titled 'Device' showing a blue line representing the accelerometer signal. The y-axis ranges from -2032.00 to 1840.00, and the x-axis has a label 'x: -96'. Below the graph is a console window with the following text:

```
Accelerometer Data  
x: -96  
Accelerometer Data  
x: -112  
Accelerometer Data  
x: -128  
Accelerometer Data  
x: -96
```

Mini Lab Activity: Collecting accelerometer vibration data from the BBC micro:bit accelerometer...



MMA8653FC accelerometer data

```
Accelerometer Data  
x: -96  
Accelerometer Data  
x: -112  
Accelerometer Data  
x: -128  
Accelerometer Data  
x: -96
```


Mini Lab Activity: Collecting accelerometer vibration data from the BBC micro:bit accelerometer...



Downloading accelerometer data



Click here

Mini Lab Activity: Collecting accelerometer vibration data from the BBC micro:bit accelerometer...



The screenshot shows an Excel spreadsheet with the following data:

time (source1)	x
0	32
0.2	32
0.386	32
0.58	32
0.785	32
0.943	32
1.136	32
1.333	32
1.528	32
1.734	32
1.931	32
2.096	32
2.285	32
2.481	32
2.674	16
2.883	32
3.085	32
3.284	16
3.447	32
3.651	32
3.851	32
4.031	32
4.234	32
4.429	32
4.591	32
4.785	32
4.983	32
5.184	32

Accelerometer data
downloaded into Excel
spreadsheet

Mini Lab Activity: Collecting accelerometer vibration data from the BBC micro:bit accelerometer...



```
2 0,32
3 0.2,32
4 0.386,32
5 0.58,32
6 0.785,32
7 0.943,32
8 1.136,32
9 1.333,32
10 1.528,32
11 1.734,32
12 1.931,32
13 2.096,32
14 2.285,32
15 2.481,32
16 2.674,16
17 2.883,32
18 3.085,32
19 3.284,16
20 3.447,32
21 3.651,32
22 3.851,32
23 4.031,32
24 4.234,32
25 4.429,32
```

**Partial
accelerometer
data csv file**

Question 4 :

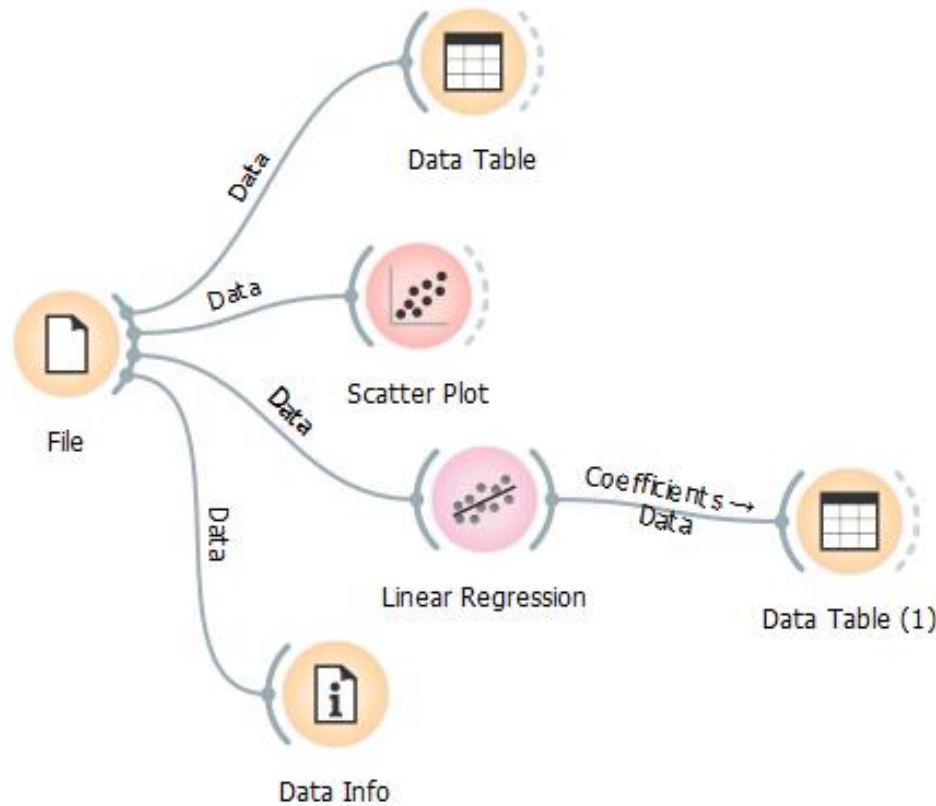


What file format is used when the accelerometer data is downloaded into an Excel spreadsheet?

Mini Lab Activity: Collecting accelerometer vibration data from the BBC micro:bit accelerometer...



Orange Linear Regression Model



Mini Lab Activity: Collecting accelerometer vibration data from the BBC micro:bit accelerometer...



Setting target name in Orange

File: accelerometer_data.csv

Info

3023 instance(s)
2 feature(s) (no missing values)
Data has no target variable.
0 meta attribute(s)

Columns (Double click to edit)

	Name	Type	Role	Values
1	time (source1)	numeric	feature	
2	g	numeric	feature	

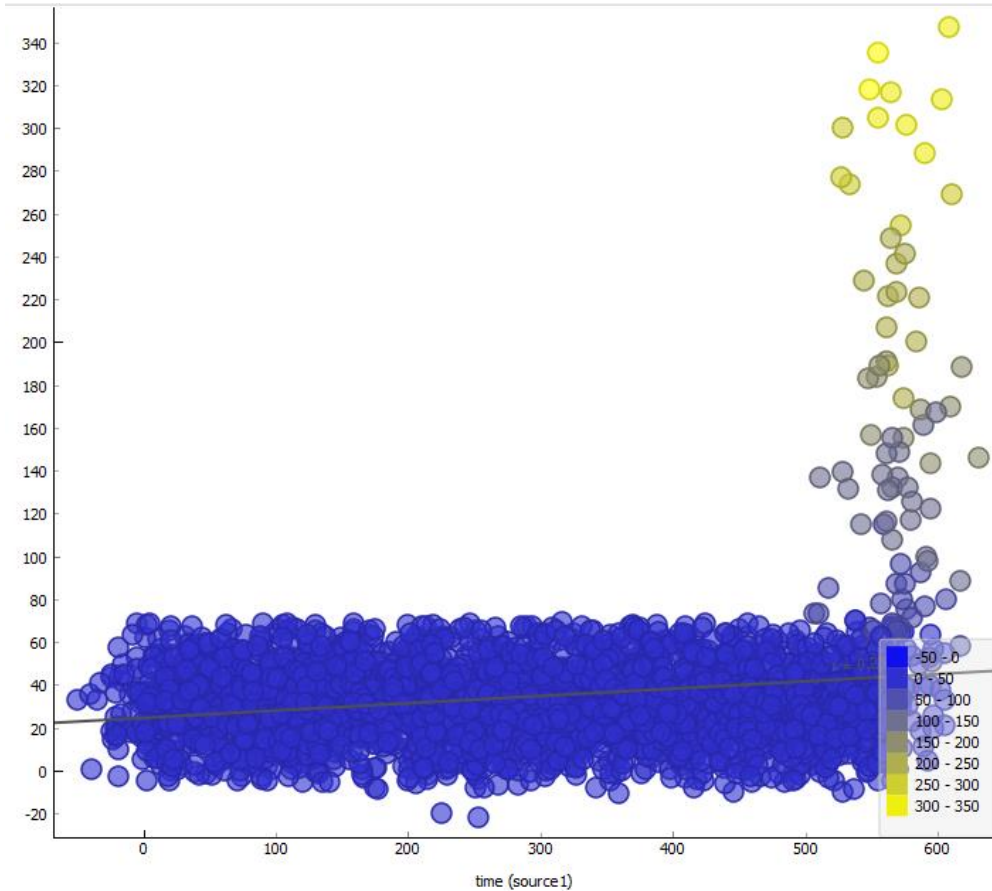
target

Apply

Select "g" name as target

Click here to "Apply" to confirm target setting change.

Mini Lab Activity: Collecting accelerometer vibration data from the BBC micro:bit accelerometer...



Accelerometer Data: Scatter Plot

Mini Lab Activity: Collecting accelerometer vibration data from the BBC micro:bit accelerometer...



name	coef
intercept	24.8984775
time (source1)	0.0341277

Coefficients from Coefficient Data Table

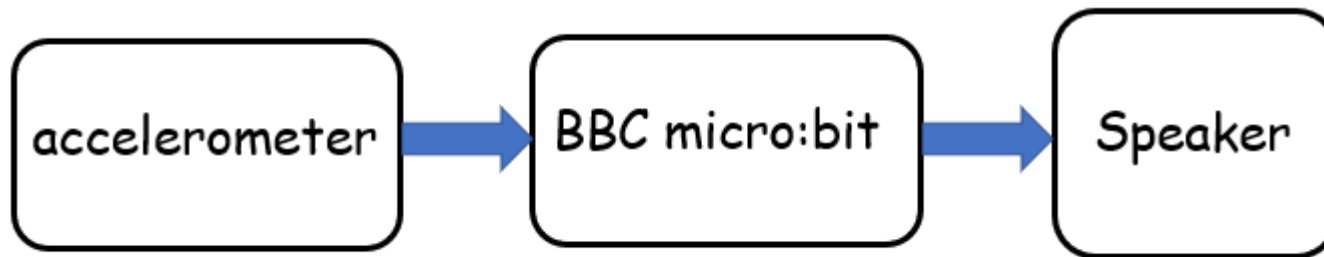
$$y = 0.0341277x + 24.8984775$$

Accelerometer Linear Regression Equation

Lab Project: Building a Talking Accelerometer Gesture Device



Question: How can an accelerometer talk?

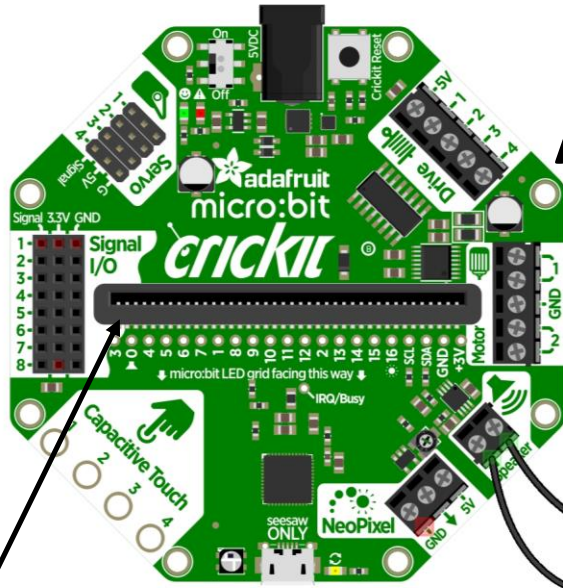


Talking Accelerometer Gesture Device Block Diagram

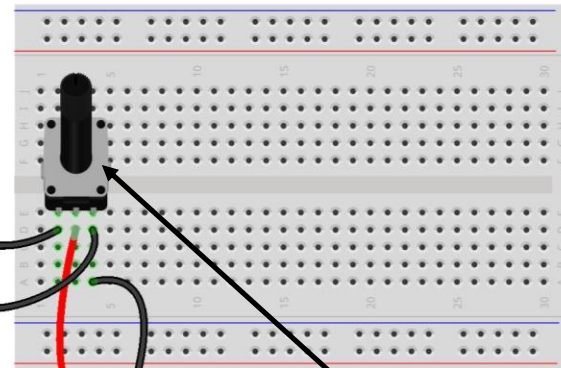
Lab Project: Building a Talking Accelerometer Gesture Device...



Hardware: Talking Accelerometer Gesture Device Electrical Wiring Diagram

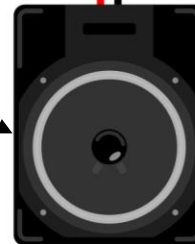


BBC micro:bit
inserts here



SPK1
 8Ω

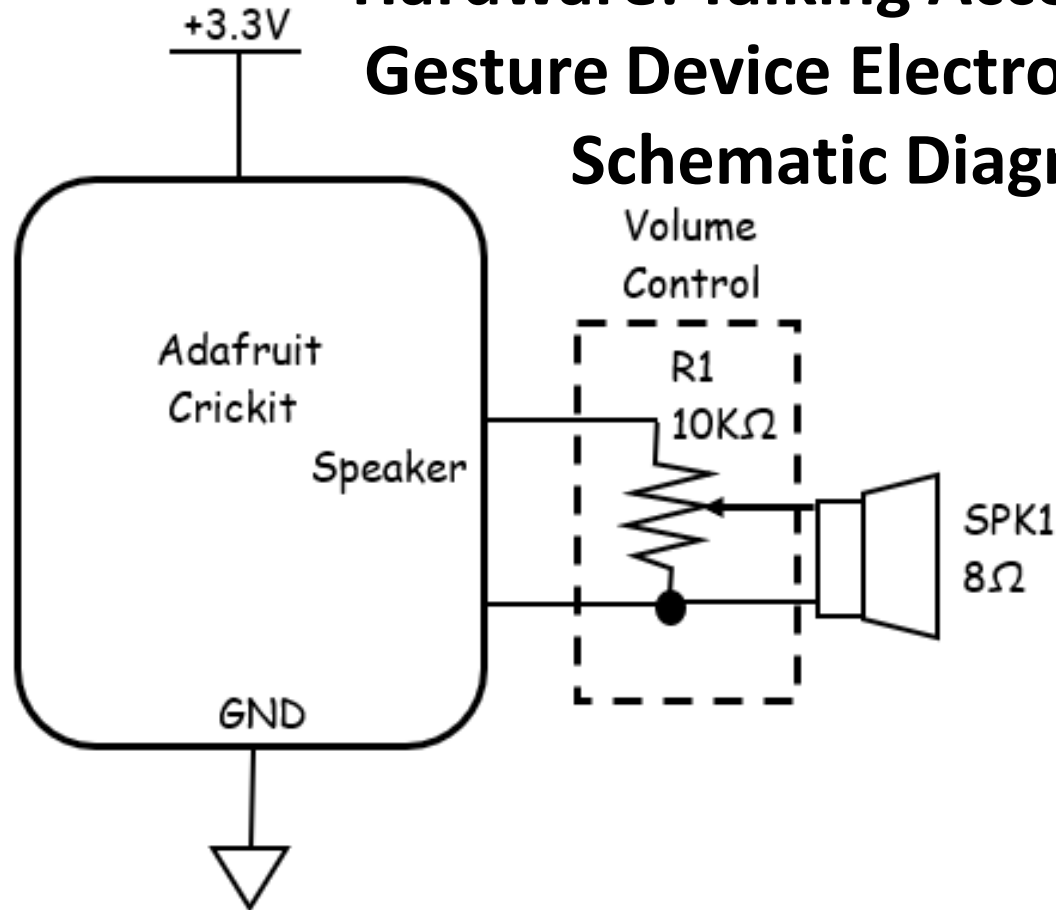
R1
 $10K\Omega$ } Volume
Control



Lab Project: Building a Talking Accelerometer Gesture Device...



Hardware: Talking Accelerometer Gesture Device Electronic Circuit Schematic Diagram



Lab Project: Building a Talking Accelerometer Gesture Device...



Mu IDE

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Code with Mu: a simple Python editor for beginner programmers.

Download Start Here

Mode New Load Save Stop Debug REPL Plotter Zoom-in Zoom-out Theme Check Help Quit

```
hello.py x
1 print("Hello from Mu!")
2
```

Running: hello.py
Hello from Mu!
>>> |

<https://codewith.mu/>

Lab Project: Building a Talking Accelerometer Gesture Device...

Software: Talking Accelerometer



Python Code

```
from microbit import *
import speech
while True:
    if accelerometer.is_gesture("up"):
        display.show(Image.ARROW_N)
        speech.say("up")
        sleep(100)
    elif accelerometer.is_gesture("right"):
        display.show(Image.ARROW_E)
        speech.say("right")
        sleep(100)
    elif accelerometer.is_gesture("down"):
        display.show(Image.ARROW_S)
        speech.say("down")
        sleep(100)
    elif accelerometer.is_gesture("left"):
        display.show(Image.ARROW_W)
        speech.say("left")
        sleep(100)
    else:
        display.clear()
        sleep(20)
```

Lab Project: Building a Talking Accelerometer Gesture Device...

Software: Talking Accelerometer



```
1 from microbit import *
2 import speech
3 while True:
4     if accelerometer.is_gesture("up"):
5         display.show(Image.ARROW_N)
6         speech.say("up")
7         sleep(100)
8     elif accelerometer.is_gesture("right"):
9         display.show(Image.ARROW_E)
10        speech.say("right")
11        sleep(100)
12    elif accelerometer.is_gesture("down"):
13        display.show(Image.ARROW_S)
14        speech.say("down")
15        sleep(100)
16    elif accelerometer.is_gesture("left"):
17        display.show(Image.ARROW_W)
18        speech.say("left")
19        sleep(100)
20    else:
21        display.clear()
22    sleep(20)
```

Python Code (Zoom In)

Lab Project: Building a Talking Accelerometer...

Accelerometer Objects



MultiWingSpan

[Home](#) [Programming](#) [Web Design](#) [Computer Science](#) [Twisting Puzzles](#) [Arduino](#) [BBC micro:bit](#)

BBC micro:bit

The Accelerometer

Introduction

The micro:bit module for MicroPython is a little more flexible to work with than the statements built into the other code editors. This means that, if your Python skills are up to it, you have lots of things that you can do with the readings. You can capture gestures as well as take the raw accelerometer readings.

Raw Readings

Press the REPL button in Mu. When you do this, it should open a text box at the bottom of the screen. Ignore this for now and type the following program,

```

from microbit import *
while True:
    x = accelerometer.get_x()
    print(x)
    sleep(1000)

```

When you flash the program, you should see a reading of the accelerometer x axis being printed to the text box at the bottom of the Mu application. The one second delay is used so that you can see the readings, you will need to tilt to the left or right in one clear movement to be sure you are seeing the reading that corresponds to your movement.

You use the `get_y` and `get_z()` methods to find out the readings on the other axes.

Gestures

The accelerometer object gives you access to the following methods for detecting gestures,

<code>accelerometer.is_gesture(name)</code>	returns True or False if the named gesture is currently being performed
<code>accelerometer.was_gesture(name)</code>	returns True or False if the named gesture was carried out since last checked
<code>accelerometer.get_gestures()</code>	returns a tuple containing the history of gestures performed
<code>accelerometer.reset_gestures()</code>	resets the history of gestures

The following named gestures are defined for this object,

- up
- down

BBC Microbit

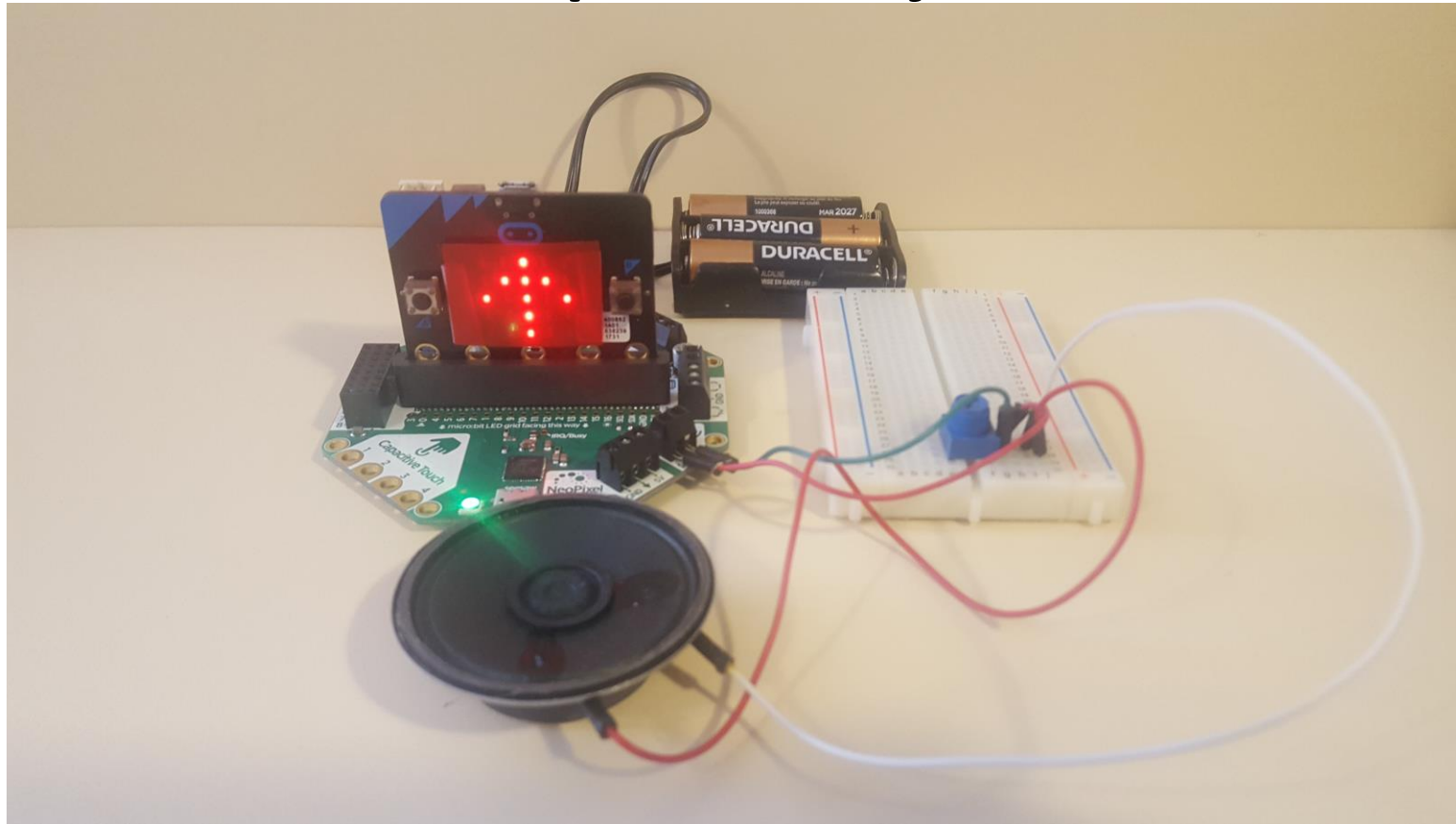
- + Block Editor - The Basics
- + Block Editor - Components
- + Kodu - micro:bit Worlds
- + JavaScript Blocks
- + JavaScript Blocks - Exercises
- + Blocks - Bit:Bot
- + Blocks - Bit:Commander
- MicroPython - Starting Off
- ✖ About MicroPython
- ✖ First MicroPython Program
- ✖ MicroPython Matrix
- ✖ Buttons A & B
- ✖ The Accelerometer
- ✖ The Compass
- ✖ Touchy Feely
- ✖ Timing
- ✖ Hot Hot Hot
- ✖ The File System
- ✖ The Speech Module
- ✖ Radio micro:bit
- + MicroPython - Examples
- + MicroPython - Components
- + MicroPython - Breakout Boards
- + MicroPython - Exercises
- + MicroPython - Pi Accessories
- + MicroPython - Bit:Bot
- + MicroPython - Bit:Commander
- + MicroPython - Projects

<http://www.multiwingspan.co.uk/micro.php?page=pyacc>

Lab Project: Building a Talking Accelerometer Gesture Device...



Completed Project!



Question 5 :



What Python library is used to allow the micro:bit to speak?

Lab Project: Building a Talking Accelerometer Gesture Device...



Congratulations!



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