CEC Continuing Education Center

DesignNews

Exploring Smart AI Lens with the Micro:bit

DAY 1: Introduction to the Smart-AI Lens With The Micro:bit

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Dr. Don Wilcher

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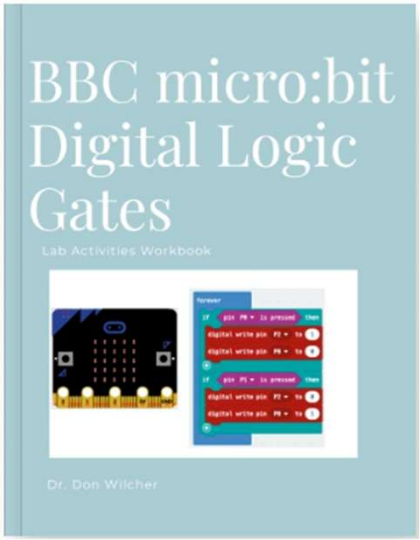
Patreon Page:
https://www.patreon.com/c/DrDon683

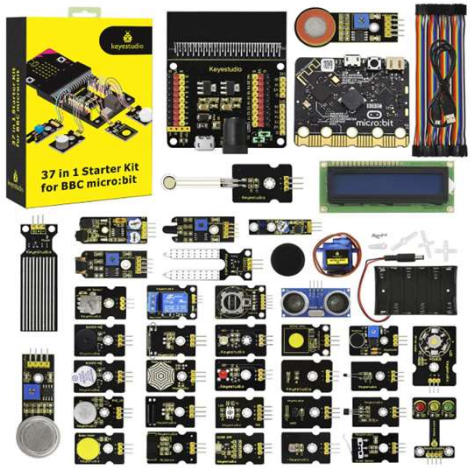
Course Kit and Materials

Micro:bit Version 2

Smart-AI Lens

BBC Micro:bit Digital Logic Gates Lab Activities Workbook





Keyestudio 37-In-1 Sensor Starter Kit

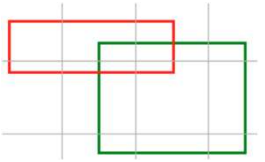
Research Perspective

"A single neural network predicts bounding boxes and class probabilities, directly from full images in one evaluation[1]."

Agenda:

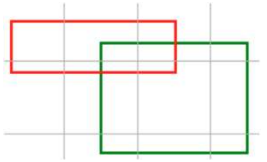
- Key Terms and Definitions
- Smart AI-Lens and Micro:bit
- Kendryte's K210 Neural Processing Unit (NPU)
- Nordic Semiconductor's nRF51822/52833 System on Chip (SoC)
- Lab: Micro:bit logic gate-enabled I2C LCD

Key Terms and Definitions. . .

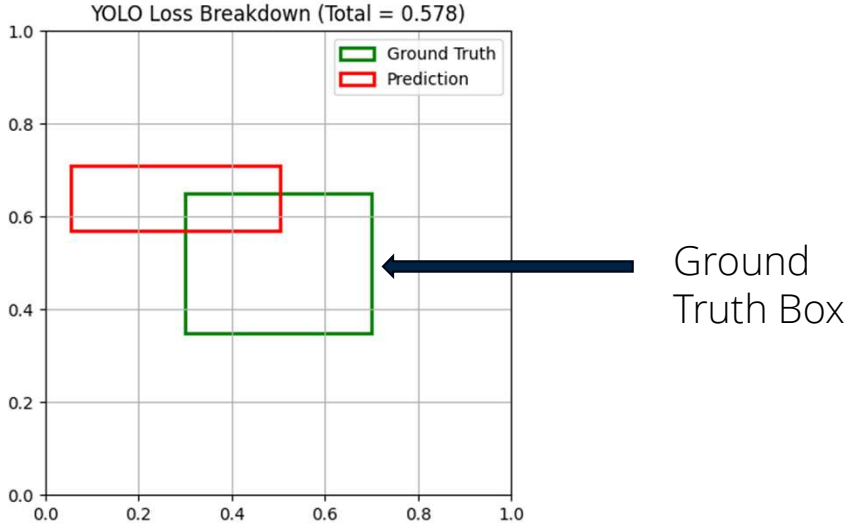


- Object Detection – A computer vision task that involves identifying and locating objects in images or video.
- Regions with Convolutional Neural Network (R-CNN) – Is a deep learning model for object detection that first identifies potential object locations (region proposals) using an algorithm. The CCN extracts features from the regions to classify the objects.
- Single-Shot Object Detection – A detection approach used to make predictions about the presence and location of objects in the image made with a one pass of the input image.
- Two-Shot Object Detection – A detection approach that uses two passes of the input image to make predictions about the presence and location of objects.
- Intersection over Union (IoU) – A popular metric used to measure localization accuracy and calculate localization errors in object detection model.
- Average Precision (AP) – A calculation based on the area under a precision vs. recall curve for a set of prediction.
- Recall – A calculation based on the ratio of the total predictions made by a model under a class with a total of existing labels for the class.

Key Terms and Definitions



- Precision – A ratio of true positives with respect to the total predictions made by the model.
- mean Average Precision (mAP) – The average of all the classes.
- You Only Look Once (YOLO) – A single-shot detector that uses a fully CNN to process an image.
- Ground Truth Box – Manually labeled bounding box for the object in the image. The Ground Truth Box contains the true position and dimensions of the object.

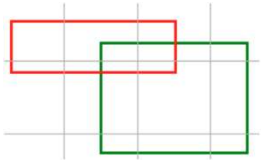


Question 1

What attributes does the Ground Truth Box contain?

a) true direction and dimensions of the object
b) true image and dimensions of the object
c) true width and true height of the object
d) true position and dimensions of the object

Key Terms and Definitions. . .



IoU Equation

IoU measures how much the predicted bounding box overlaps with the ground-truth bounding box.

$$IoU = \frac{\text{Area of Overlap}}{\text{Area of Union}}$$

Where:

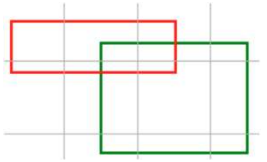
- **Area of Overlap** = area of intersection between predicted box and ground-truth box.
- **Area of Union** = sum of both box areas − overlap.

Formally, if B_p is predicted box and B_{gt} is ground-truth box:

$$IoU(B_p, B_{gt}) = \frac{|B_p \cap B_{gt}|}{|B_p \cup B_{gt}|}$$

- $0 \leq IoU \leq 1$
- IoU = 1 → perfect match
- IoU = 0 → no overlap

Key Terms and Definitions. . .



Average Precision Equation

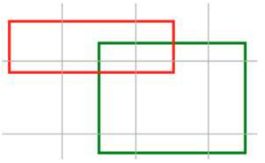
$$AP = \int_0^1 P(R)\, dR$$

Where:

- $P(R)$ = precision as a function of recall
- This integral is often approximated by **11-point interpolation** or modern COCO-style trapezoidal integration.

Key Terms and Definitions. . .

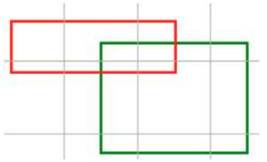
What is COCO?



COCO stands for Common Objects in Context.
It's a large-scale object detection, segmentation, and captioning dataset introduced by Microsoft Research.

- First released in 2014.
- Contains over 330,000 images with more than 1.5 million object instances.
- Annotated with 80 object categories (e.g., person, car, dog, chair).
- Designed to reflect objects in natural, complex scenes ("in context"), rather than isolated objects on clean backgrounds.

Key Terms and Definitions

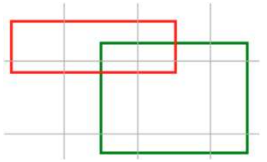


Precision and Recall Equations

$$Precision = \frac{TP}{TP + FP}, \quad Recall = \frac{TP}{TP + FN}$$

- TP: True Positives (detections correctly matched to ground truth)
- FP: False Positives (incorrect detections)
- FN: False Negatives (missed detections)

Key Terms and Definitions. . .



mAP Equation

If we have C classes:

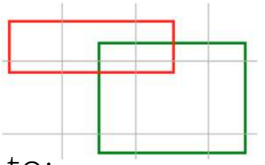
$$mAP = \frac{1}{C} \sum_{i=1}^{C} AP_i$$

Question 2

Which term is associated with the abbreviation COCO?

a) Common Objects in Content
b) Common Objects in Contact
c) Common Objects in Context
d) none of the above

Smart AI Lens and the Micro:bit



What is a Smart AI Lens?

A Smart AI Lens generally refers to a software or hardware system that uses artificial intelligence (AI) to:

a) process, interpret, and enhance information captured through a lens

b) which can be a camera lens, a data "lens," or even a conceptual framework for viewing information.

Depending on the context, it can mean:

1.In Imaging/Optics (Cameras, Smartphones, AR/VR):

a) A *smart AI lens* is a camera lens enhanced by AI algorithms that analyze and optimize images in real time.

b)Examples:

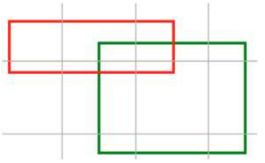
i. AI-powered autofocus and object tracking.

ii. Scene detection (e.g., recognizing food, text, faces, or landscapes).

iii. Computational photography (night mode, portrait mode).

iv. AR overlays (real-time translation, measurement, navigation).

Smart AI Lens and the Micro:bit. . .

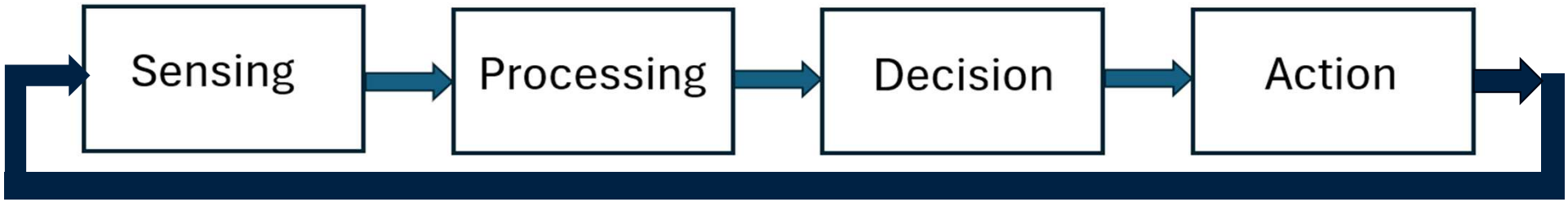


2. In Data/Analytics ("Lens" as a viewpoint):
   a) An AI lens can be a framework or perspective that uses AI to interpret data.
   b) For example, looking at industrial machine data through a "predictive maintenance AI lens" means applying AI algorithms to predict failures, not just monitor conditions.
3. In Smart Devices (IoT, Robotics, Wearables):
   a) A physical lens (camera, optical sensor, LiDAR) paired with an AI processor for smart perception.
   b) Examples:
      i. Smart glasses with AI-powered object recognition.
      ii. Autonomous robots with AI vision for navigation.

In summary, a Smart AI Lens is not just a lens, but a lens + AI intelligence layer, turning raw input (images, sensor data, or text) into meaningful, actionable insights.

Smart AI Lens and the Micro:bit. . .

Taxonomy of a Smart Robot



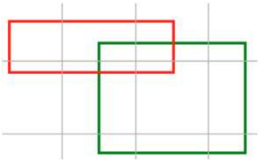
NOTES:

a) A Taxonomy is a structure or framework that classifies the behavior of a Smart Robot.

b) This taxonomy illustrates the information flow through a robotic system.

c) The information flow shows the layered intelligence that separates a robot from a simple automated machine.

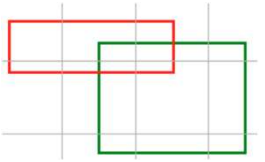
Smart AI Lens and the Micro:bit. . .



What is a Micro:bit?

BBC micro:bit is a tiny programmable microcontroller board designed to make learning coding, electronics, and digital creativity simple and fun—especially for beginners, students, and hobbyists.

- Key Features:
  a) Size: About half the size of a credit card.
  b) Processor: ARM Cortex-M0 or M4, 32-bit (depending on the version: Nordic Semiconductor nRF51822/52833).
- Inputs/Outputs (I/O):
  a) There are 25 LEDs arranged in a 5×5 grid (can display text, numbers, images, animations).
  b) There are 2 buttons (for user input).
  c) Pins for connecting sensors, motors, and external circuits.



Smart AI Lens and the Micro:bit. . .

Sensors:

a) Accelerometer (detects motion and tilt).
b) Magnetometer (compass).
c) Temperature and light sensing via onboard components.

- Connectivity: Bluetooth Low Energy (BLE) and USB.
- Power: Can run on USB or a 2x AAA battery pack.

Programming Languages:

a) Block-based coding (Microsoft MakeCode – drag-and-drop like Scratch).
Note: ABB uses Wizard Easy, which is block code, as their programming platform for their family of cobots!
b) Python (MicroPython) – text-based programming.
c) C/C++ for advanced users.

Question 3

In reviewing slide 18, what is the purpose of the taxonomy?

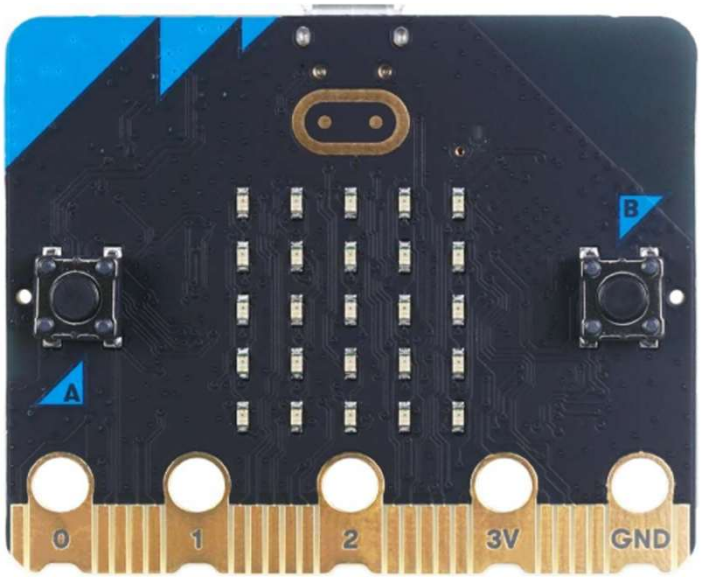
a) The taxonomy illustrates the build process of a robotic system.

b) The taxonomy illustrates the operation of a robotic system.

c) The taxonomy illustrates the information flow through a robotic system.

d) none of the above

Smart AI Lens and the Micro:bit. . .



Kendryte K210 Neural Processing Unit (NPU)

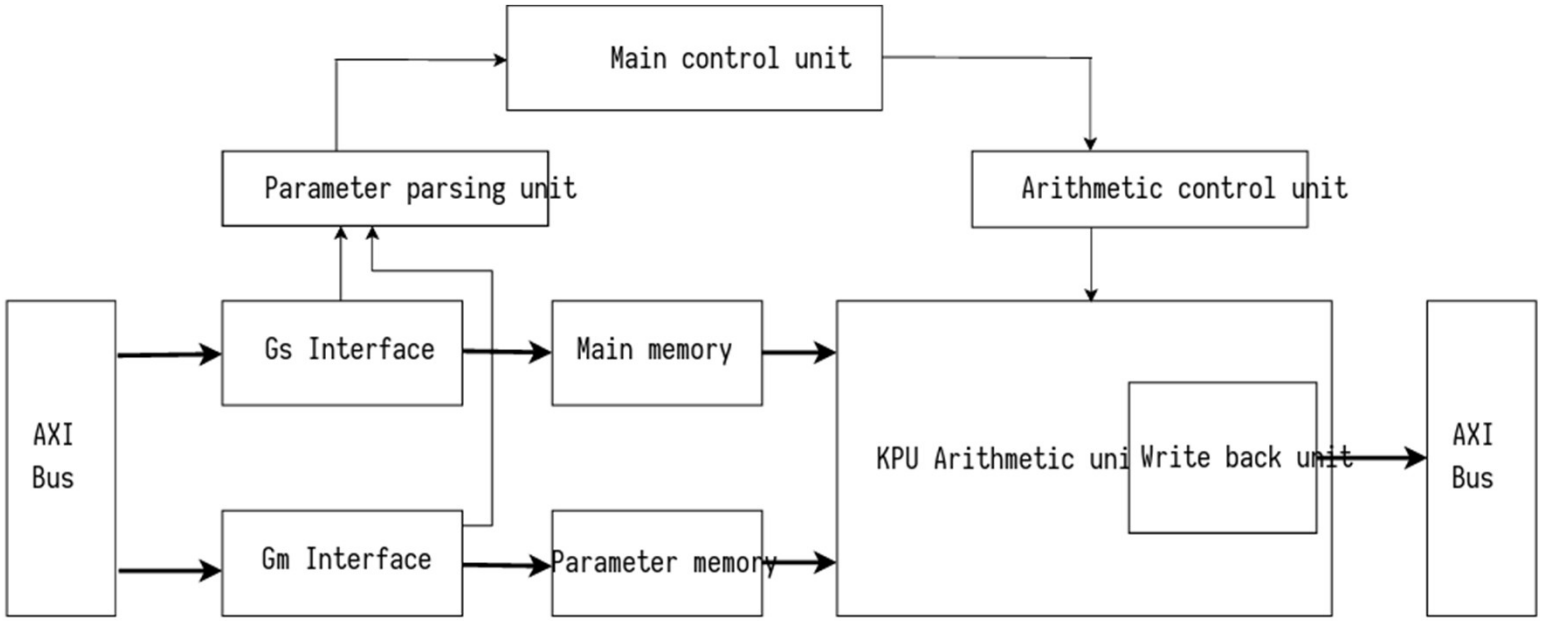
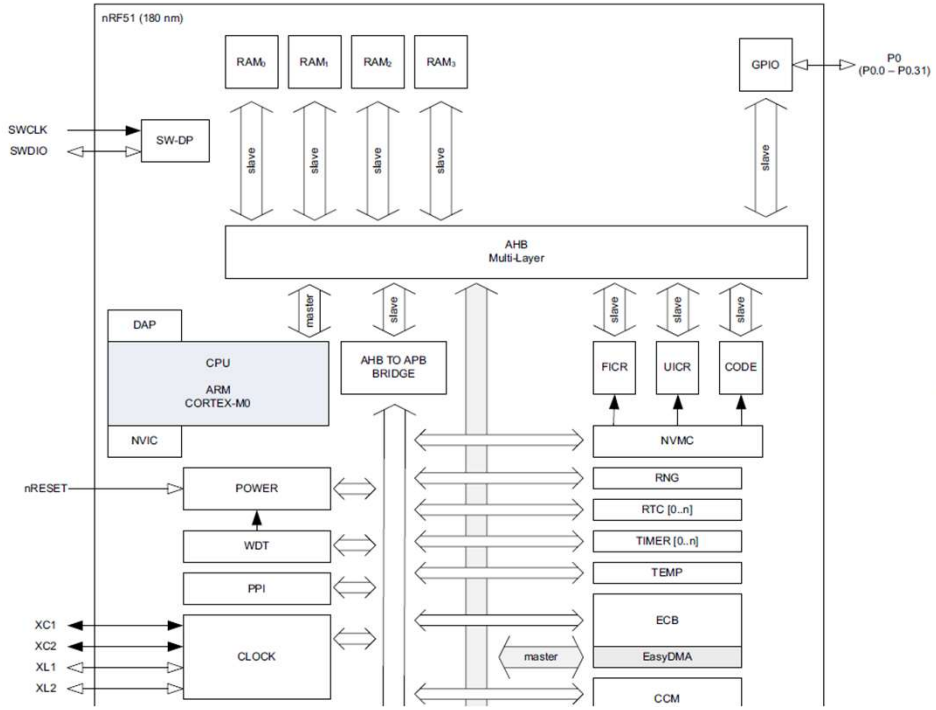


Image: Kendryte

Block Diagram

Nordic Semiconductor's nRF51822/52833 System on Chip (51822 SoC)



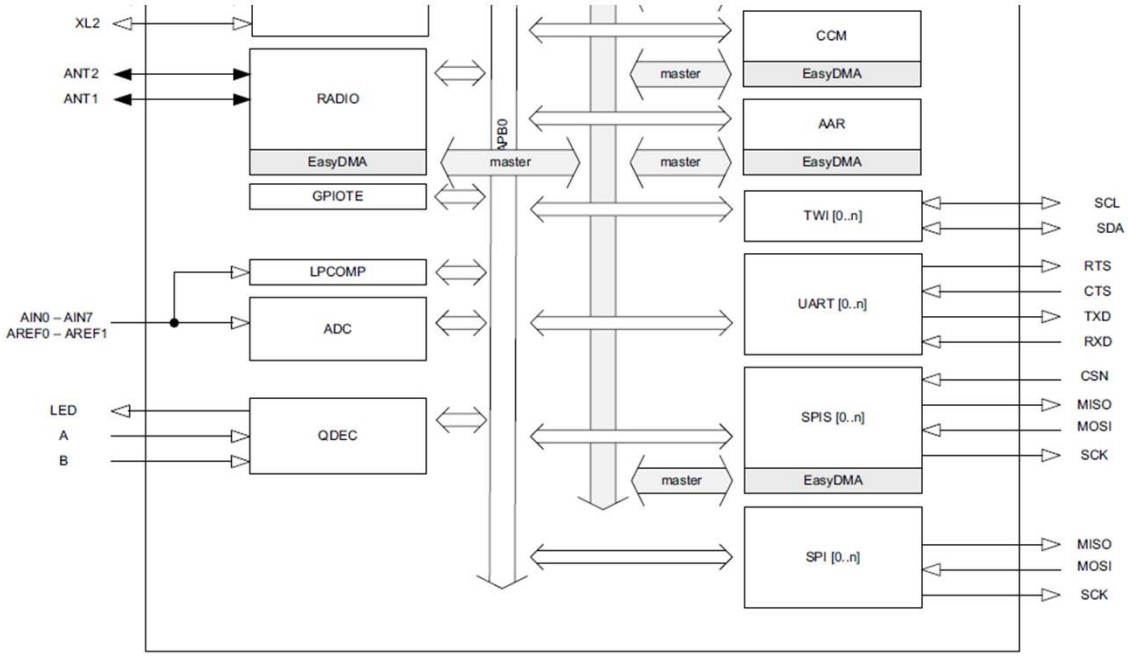


Image: Nordic Semiconductor

Block Diagram

Nordic Semiconductor's nRF51822/52833 System on Chip (52833 SoC). . .

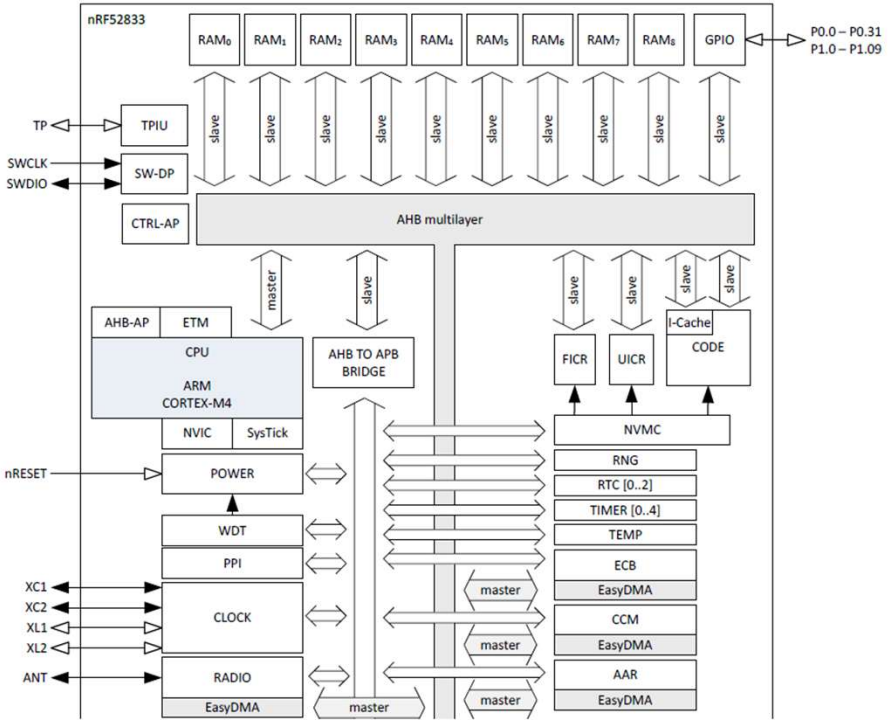
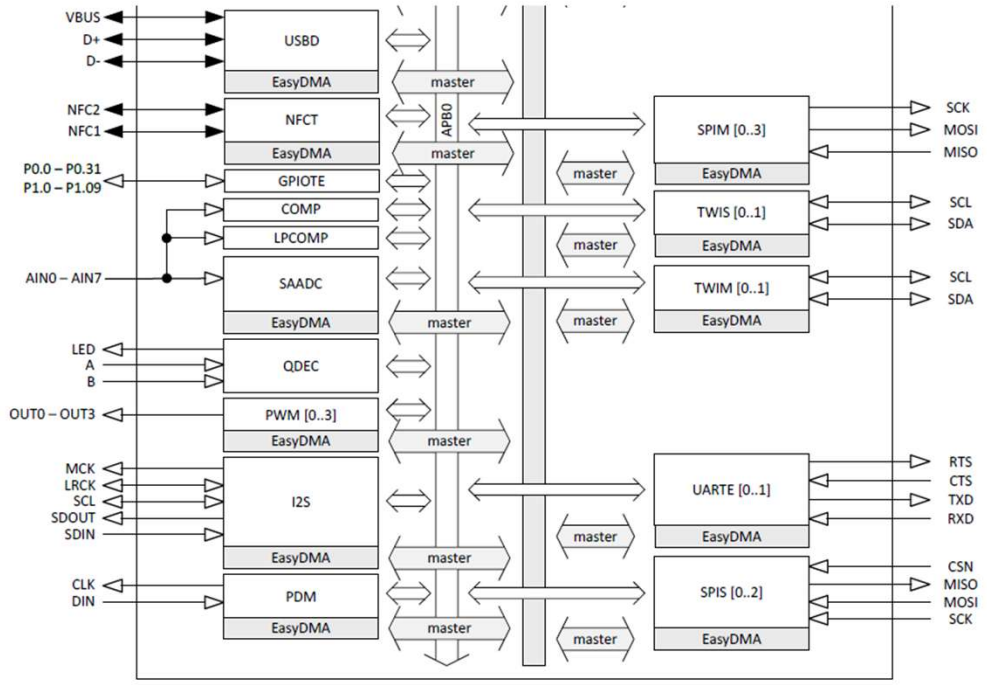


Image: Nordic Semiconductor



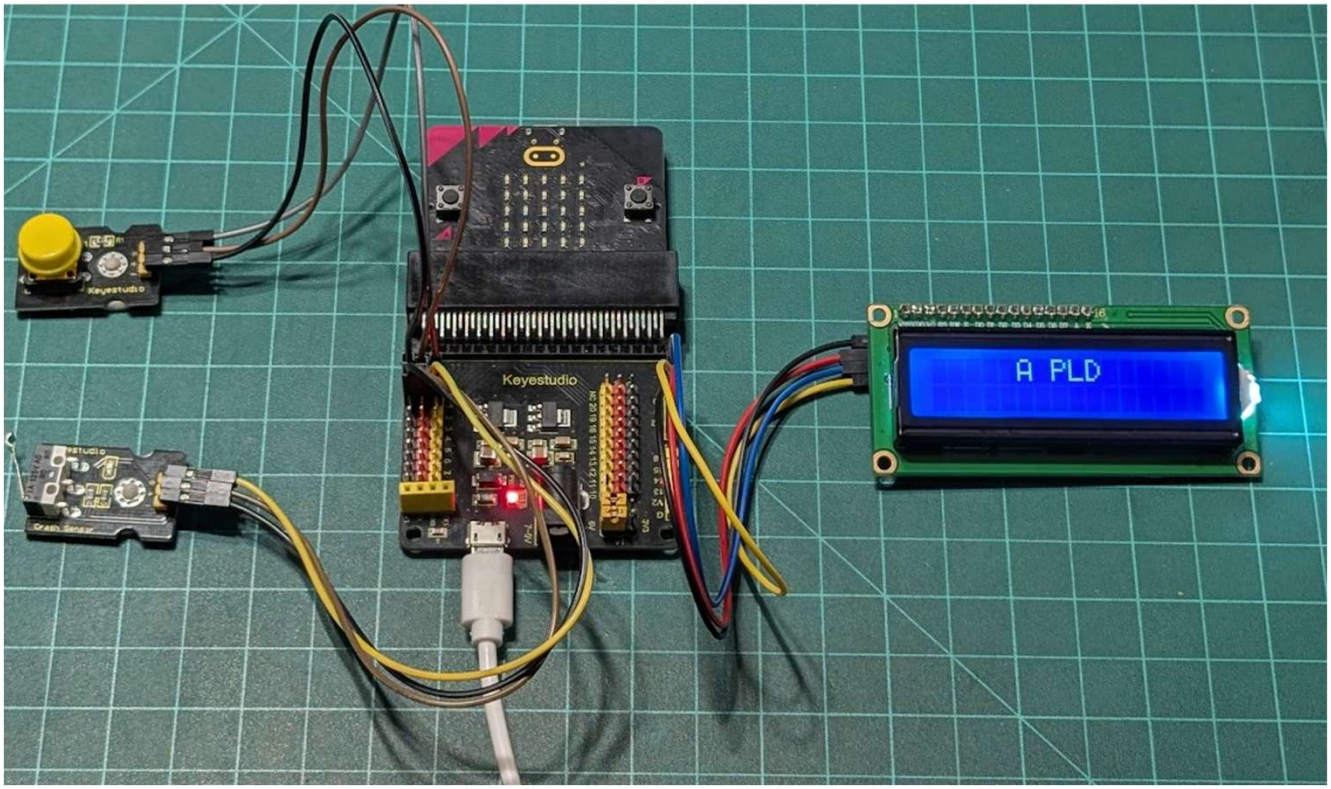
Block Diagram

Question 4

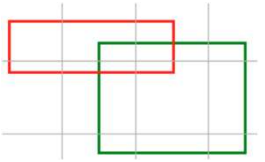
Which CPU is used within the 52833 SoC?

a) ARM CORTEX-M0
b) ARM CORTEZ-M4
c) ARM CORTEX-M4
d) none of the above

Lab: Micro:bit logic-gate enabled I2C LCD



Lab: Micro:bit logic-gate enabled I2C LCD. . .

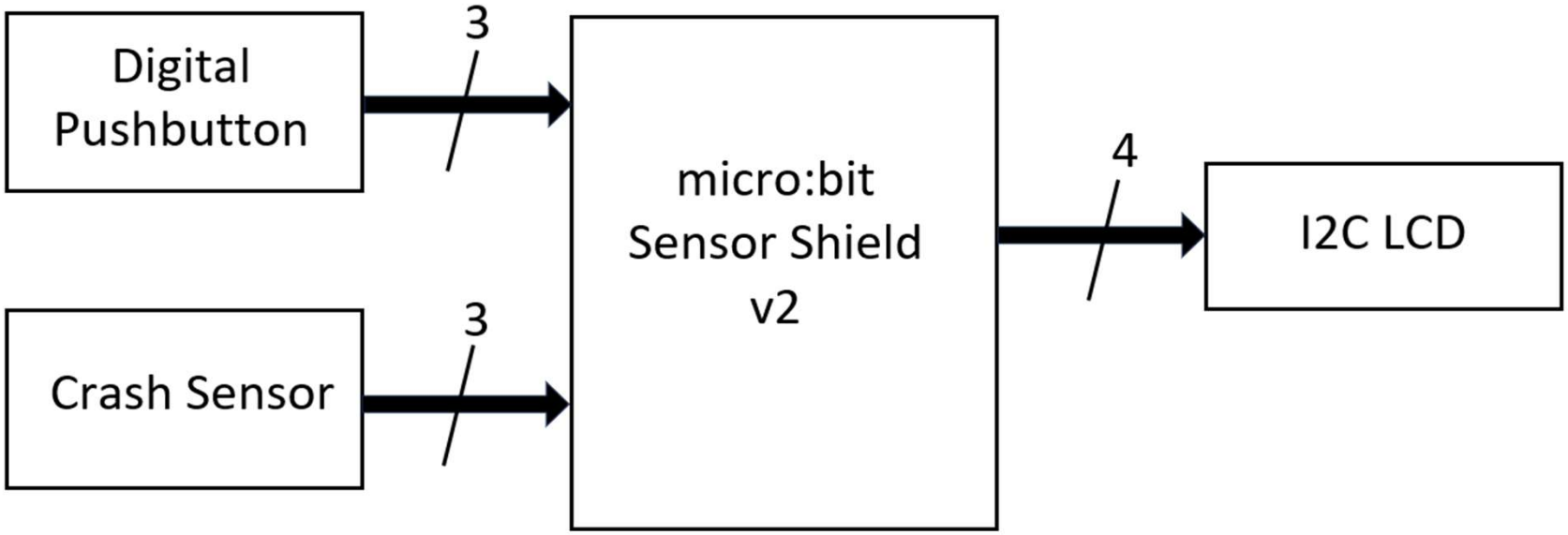


Participant Learning Objectives:

- Participants will learn to wire a Digital Pushbutton switch, Crash Sensor, and an I2C LCD to a Micro:bit Sensor Shield.
- Participants will learn to add the I2C LCD code blocks to the Microsoft MakeCode micro:bit programming environment. Participants will learn to test the Micro:bit logic-gate enabled I2C LCD (A PLD Demonstrator).

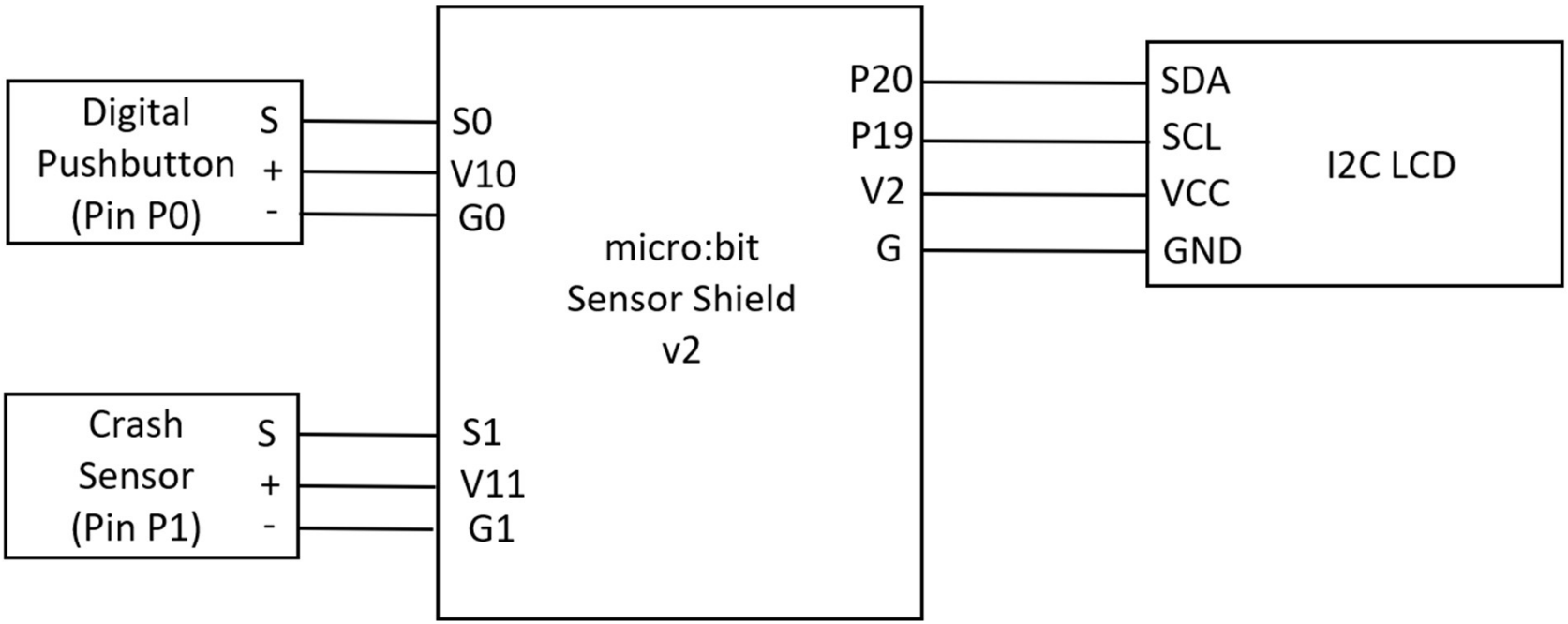
Lab: Micro:bit logic-gate enabled I2C LCD. . .

Concept Block Diagram for a Programmable Logic Device (PLD) Demonstrator



Lab: Micro:bit logic-gate enabled I2C LCD. . .

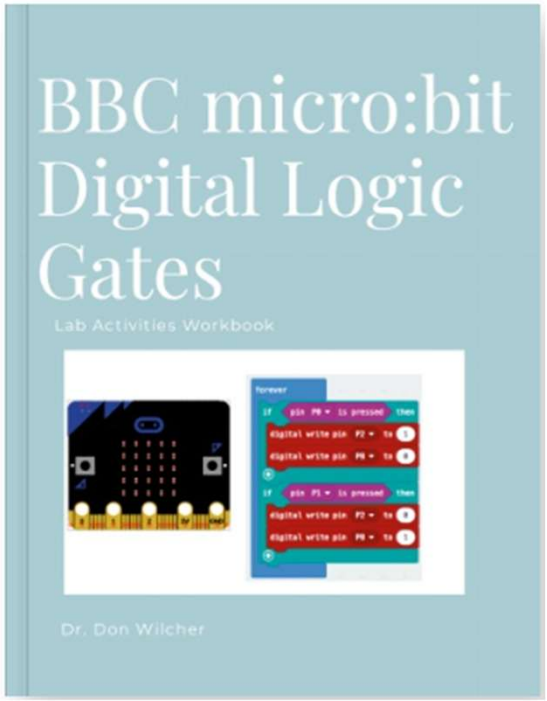
PLD Demonstrator Electrical Wiring Diagram



Lab: Micro:bit logic-gate enabled I2C LCD. . .

BBC Micro:bit Digital Logic Gate Lab Activities Workbook

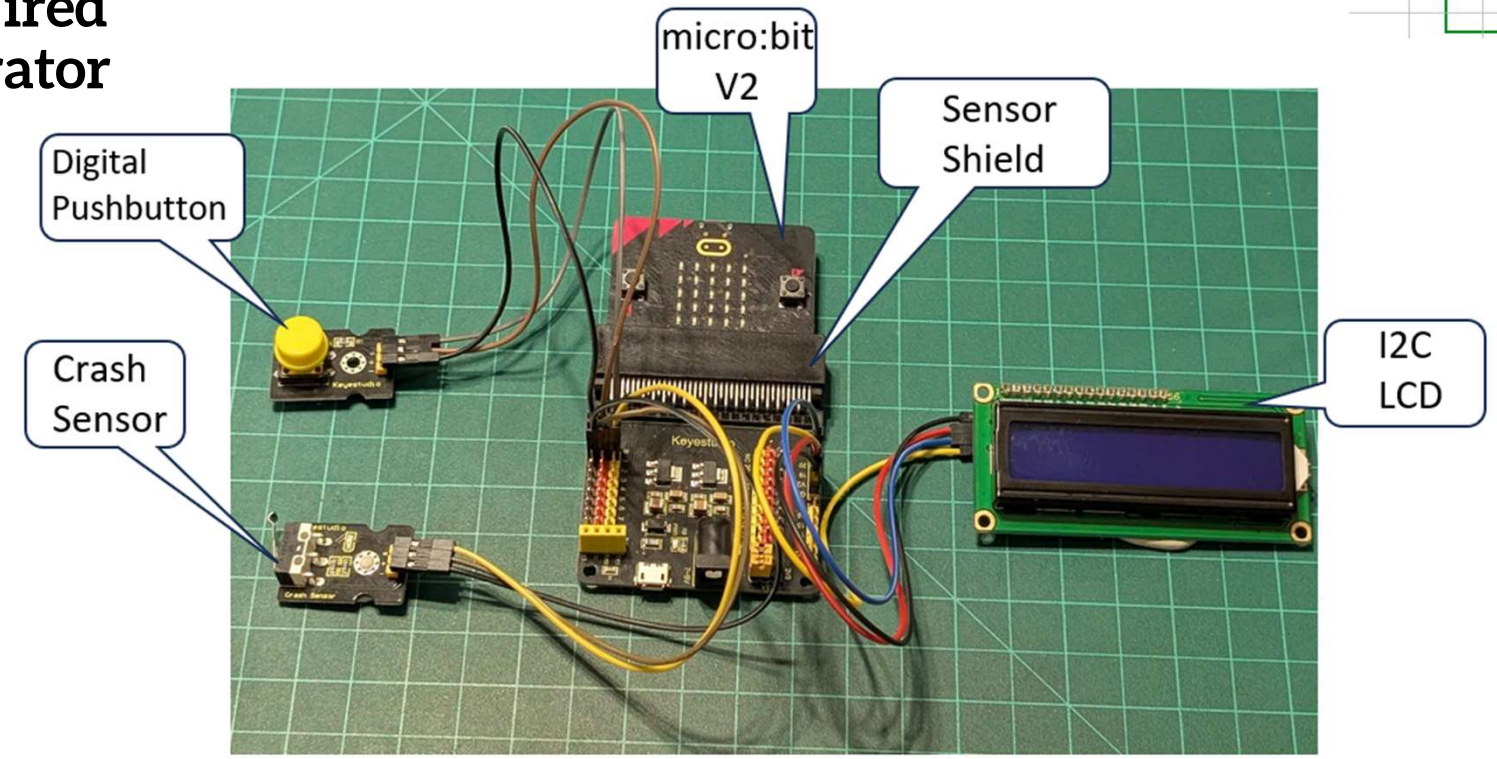
Pages 14- 17 in the workbook provide examples of how to wire the Digital Pushbutton Switch and the Crash Sensor to the Sensor Shield's header connectors.



Lab: Micro:bit logic-gate enabled I2C LCD. . .

Completely Wired PLD Demonstrator

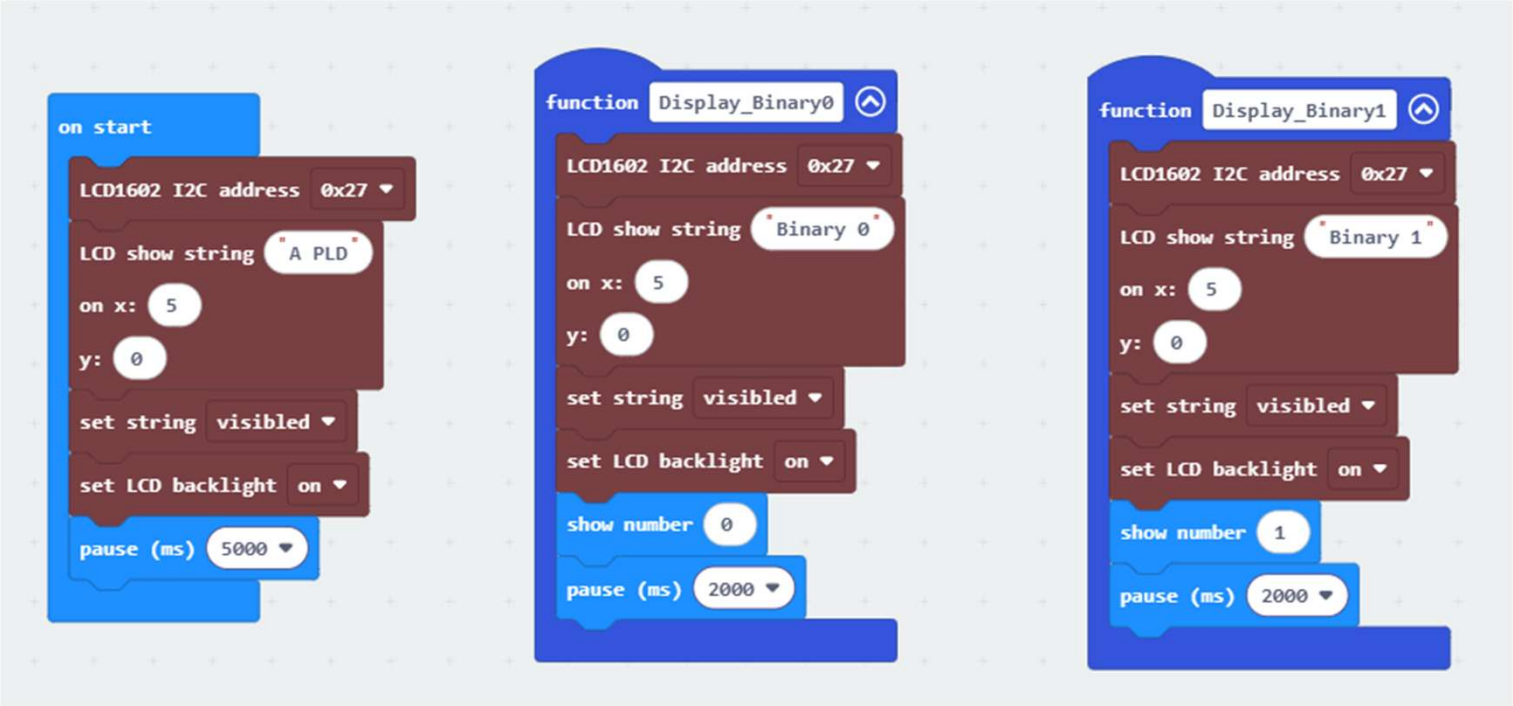
Note:
The demonstrator will work on a version 1 micro:bit.



Lab: Micro:bit logic-gate enabled I2C LCD . . .

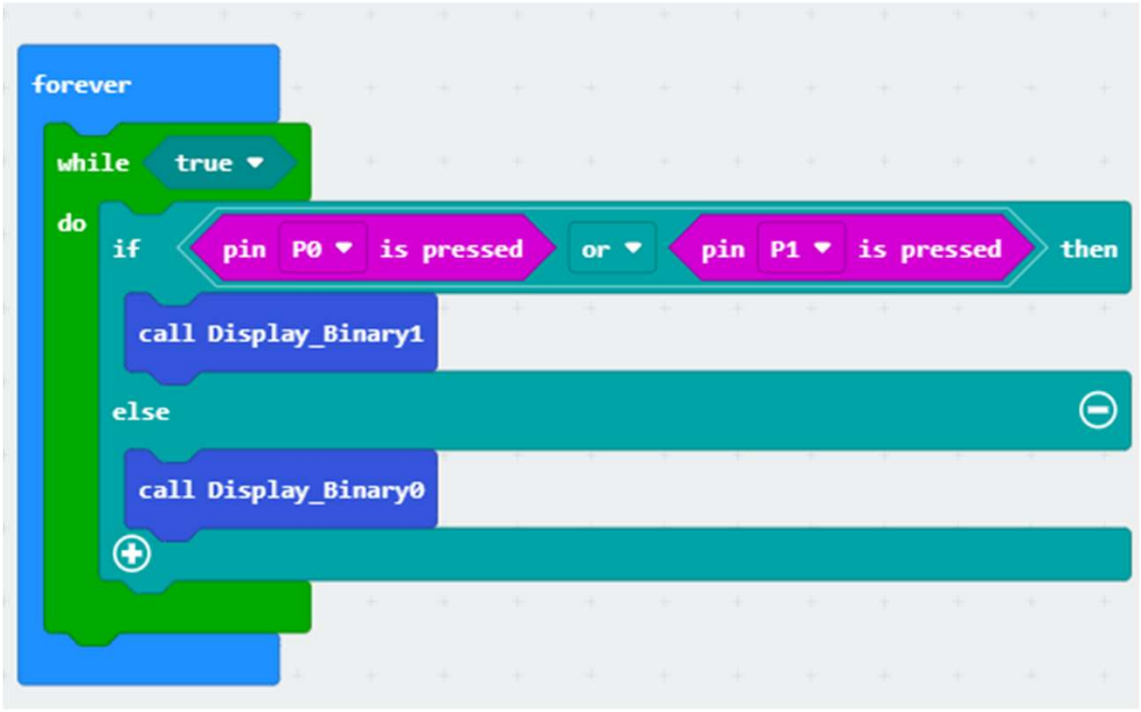
Blockly Code: On Start and Functions

Note:
To obtain the I2C LCD code blocks
a) Click the Extension Button.
b) In the textbox, type the following URL address: https://github.com/xuefengedu/pxt-lcd1602_CN
c) I2C LCD code blocks will be accessible in the Microsoft MakeCode micro:bit programming environment.



Lab: Micro:bit logic-gate enabled I2C LCD. . .

Blockly Code: Main Program

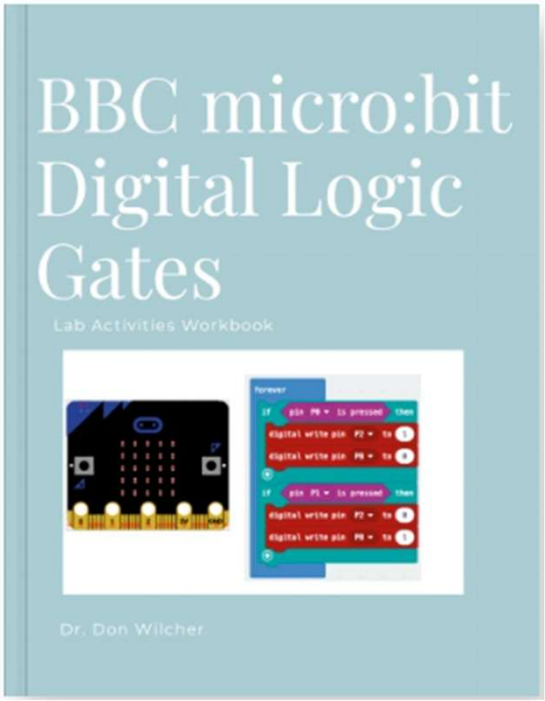


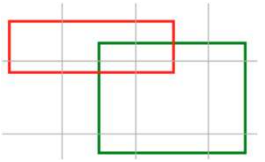
The function of Logic can be changed by selecting the down arrow, thus the behavior of a Programmable Logic Device (PLD).

Lab: Micro:bit logic-gate enabled I2C LCD. . .

BBC Micro:bit Digital Logic Gate Lab Activities Workbook

Additional Digital Logic Gates can be explored with this PLD Demonstrator, such as the OR, NOT, and Set-Reset (SR) Flip-Flop, or SR Bistable Latch. Pages 20–38 in the workbook provide details on setting up the micro:bit using Blockly Code to perform these logic gate functions.





Lab: Micro:bit logic-gate enabled I2C LCD. . .

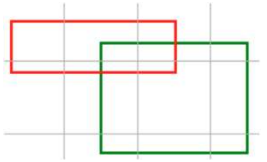
Python Code: Main Program

```
def on_forever():
    while True:
        if input.pin_is_pressed(TouchPin.P0) or input.pin_is_pressed(TouchPin.P1):
            Display_Binary1()
        else:
            Display_Binary0()
basic.forever(on_forever)
```

Python Code: On Start Function

```
lcd1602.set_address(lcd1602.I2C_ADDR.ADDR1)
lcd1602.put_string("A PLD", 5, 0)
lcd1602.set_LCD_Show(lcd1602.visibled.VISIBLE)
lcd1602.set_backlight(lcd1602.on_off.ON)
basic.pause(5000)
```

Lab: Micro:bit logic-gate enabled I2C LCD. . .



```
def Display_Binary0():
    lcd1602.set_address(lcd1602.I2C_ADDR.ADDR1)
    lcd1602.put_string("Binary 0", 5, 0)
    lcd1602.set_LCD_Show(lcd1602.visibled.VISIBLE)
    lcd1602.set_backlight(lcd1602.on_off.ON)
    basic.show_number(0)
    basic.pause(2000)
```

```
def Display_Binary1():
    lcd1602.set_address(lcd1602.I2C_ADDR.ADDR1)
    lcd1602.put_string("Binary 1", 5, 0)
    lcd1602.set_LCD_Show(lcd1602.visibled.VISIBLE)
    lcd1602.set_backlight(lcd1602.on_off.ON)
    basic.show_number(1)
    basic.pause(2000)
```

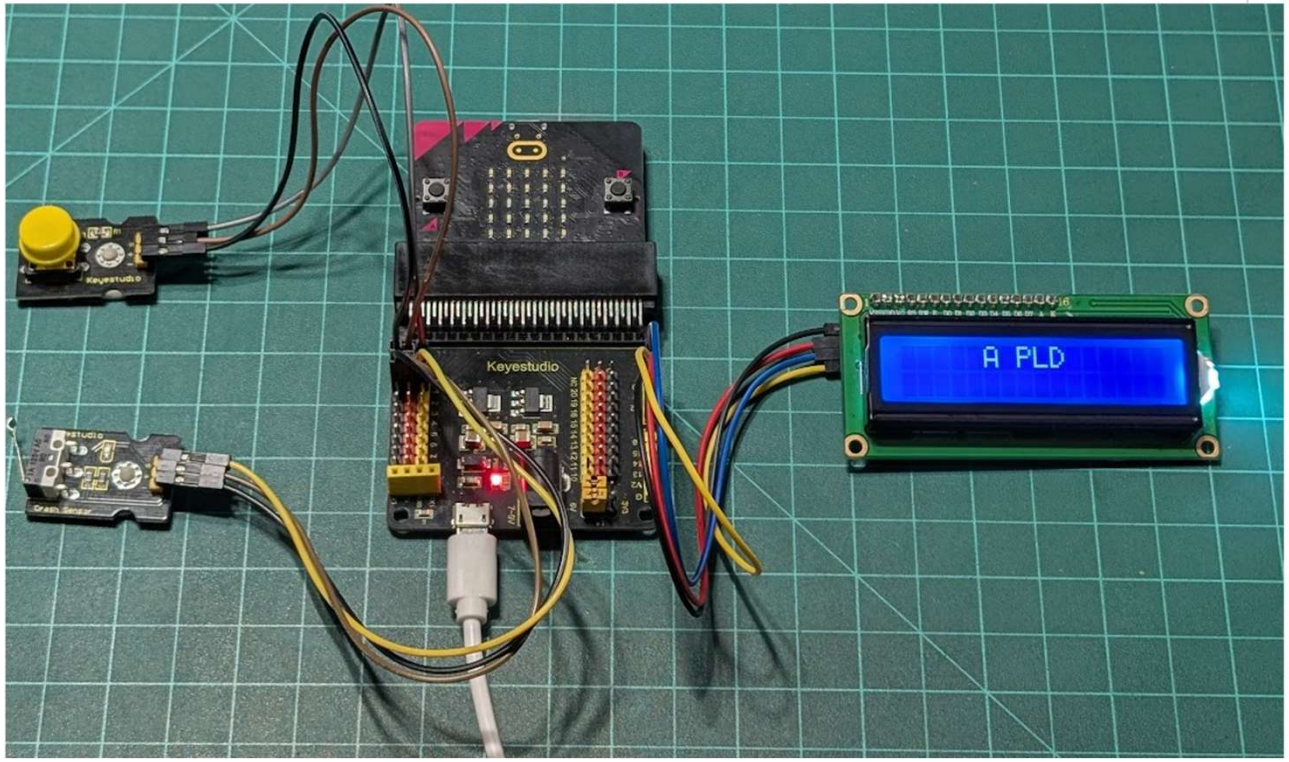
Python Functions:
Display_Binary0( )
and
Display_Binary1 ( )

Lab: Micro:bit logic-gate enabled I2C LCD. . .

Assembled and Functional PLD Demonstrator

Watch the Video Clip!

https://youtu.be/EHtAsnEdryQ



Question 5

Which I2C address is used by the Keyestudio LCD Serial driver board?

a) 0x38
b) 0x26
c) 0x27
d) none of the above

Thank you for attending

Please consider the resources below:

[1] J. Redmon, S. Divvala, R. Girshick, and A. Farhadi, “You only look once: Unified, real-time object detection,” *arXiv*:1506.02640 [cs.CV], Jun. 2016. [Online]. Available: https://arxiv.org/abs/1506.02640
[2] [1] D. Wilcher, “Designs News September 25 webinar code,” GitHub repository, Sep. 2025. [Online]. Available: https://github.com/DWilcher/DesignNews-WebinarCode/blob/main/September_25_Webinar_Code.zip

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