CEC Continuing Education Center

DesignNews

Exploring Smart AI Lens with the Micro:bit

DAY 2: Smart-AI Lens Micro:bit Integration

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Dr. Don Wilcher

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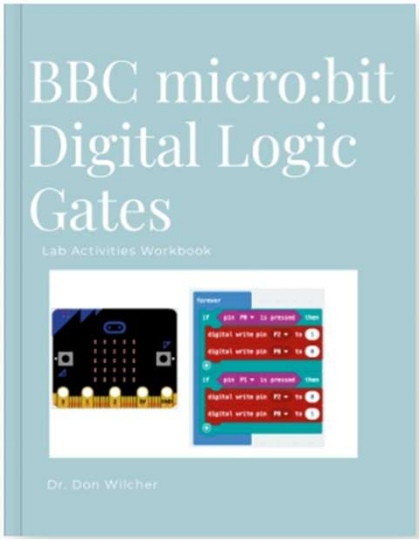
https://www.patreon.com/c/DrDon683

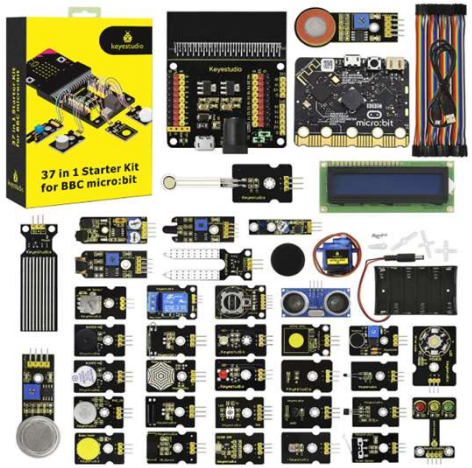
Course Kit and Materials

Micro:bit Version 2

Smart-AI Lens

BBC Micro:bit Digital Logic Gates Lab Activities Workbook





Keyestudio 37-In-1 Sensor Starter Kit

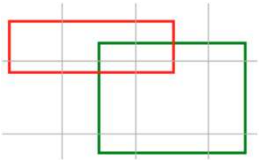
Research Perspective

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

Agenda:

- Kendrtyte K210 – Overview
- AI Solution
- Kendryte K210 Architecture Overview
- Nordic Semiconductor's nRF51822/52833 System on Chip (SoC)
- Lab: Card Recognition Device

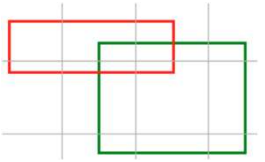
Kendryte K210 - Overview



The Kendryte K210 has the following features.

- The K210 is a System on Chip (SoC) that integrates the following capabilities into one chip.
  a) Machine Vision
  b) Machine Hearing (an embedded microphone array audio processor).
  c) AI solutions capabilities.
- Supported by a high-performance Convolutional Neural Network (CNN) hardware accelerator.
- Low dual operating voltage supplies (3.3V/1.8V)
- Includes two 64-bit RISC-V CPU Cores
- Two built-in Floating Point Units (FPUs)
- Fast Fourier Transform (FFT) capability – aids the machine learning algorithms
- The K210 has a wide range of peripheral units–see Architecture Block Diagram.
- The K210 is intended for the AI and IoT markets.

Kendryte K210 – Overview. . .



What is a Hardware Accelerator?

- A specialized computing device or circuit that is designed to perform a specific task or set of tasks faster and more efficiently than a general-purpose CPU.
- Executes software instructions instead of relying on the CPU.
- Accelerators use dedicated hardware logic to offload and speed up operations that are computationally intensive, repetitive, or highly parallel.

Question 1

What is a Hardware Accelerator?

a) A computing device or circuit that is designed to perform a human task.

b) A computer that is designed to perform non-human tasks.

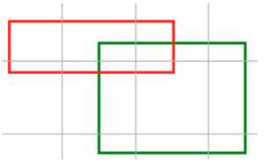
c) A computing device or circuit that is designed to perform a specific task or tasks faster and more efficiently than a general-purpose CPU.

d) none of the above

AI Solution

Here's a clear, engineering-oriented view of what ELECFREAKS' Smart AI-Lens actually does and how its "AI solution" is put together.

AI Solution. . .



What it is (at a glance):

- A self-contained AI vision sensor that runs its own models on board and reports results to a host (micro:bit, etc.) over I2C.
- It uses an RJ11 connector for electrical wiring to the micro:bit.
- Core silicon:
  a) Kendryte K210 (a dual-core RISC-V MCU
  b) Built-in CNN accelerator/KPU)
  c) Powered at 3.3 V
  d) Connected over I2C via RJ11 (P19=SCL, P20=SDA on micro:bit; GND/VCC also mapped).

AI Solution. . .

RJ11 to Smart AI-Lens Attachment

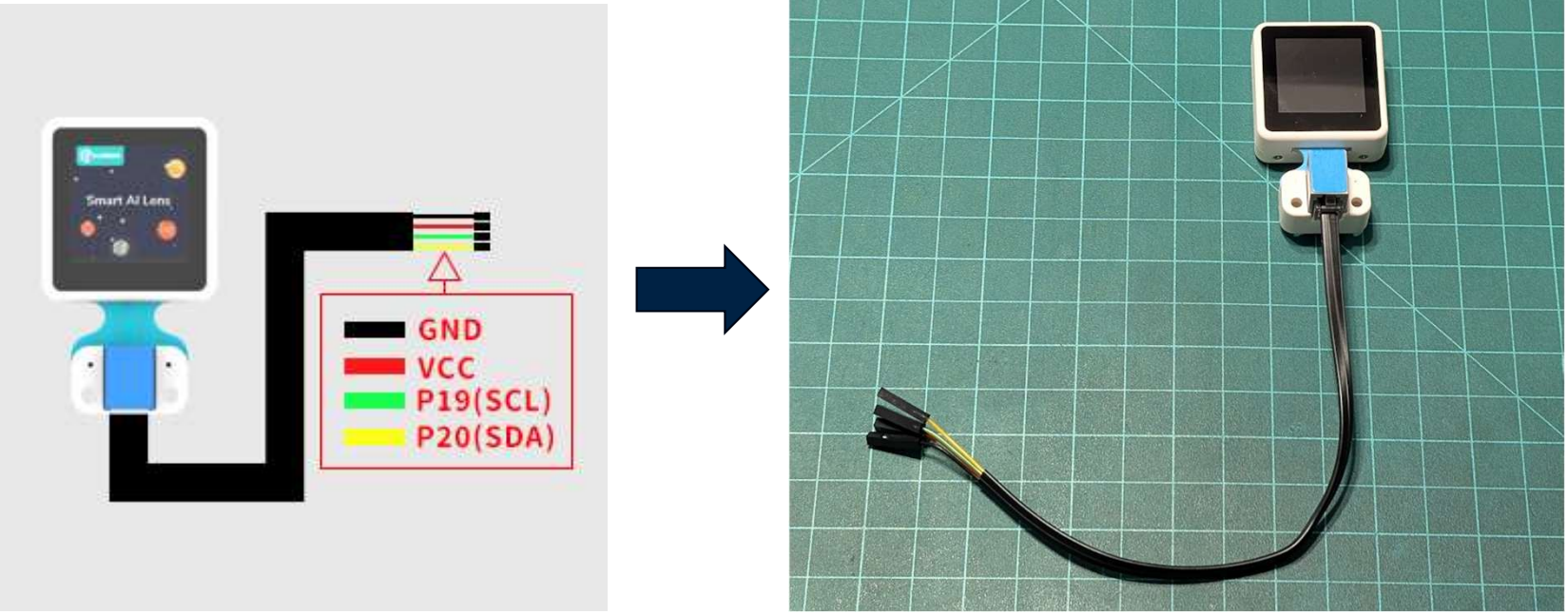
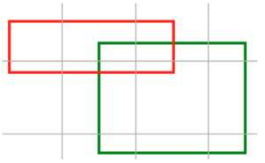


Image: Elecfreaks

AI Solution. . .



On-device AI pipeline

- Image capture → The camera feeds frames to the K210.
- Edge inference → The K210's KPU runs pre-loaded tiny CNNs (no PC needed).
- Post-processing → Detections are turned into features like class IDs, bounding boxes, and coordinates.
- The AI-Lens uses a 0–224 coordinate space with (0,0) at the top-left—handy for mapping to servo/drive commands.
- I2C reporting → results are sent to the micro:bit (or other controller) as simple values you can read in MakeCode or
  a) Python.
  b) Arduino on other boards.

AI Solution. . .

On-device AI pipeline

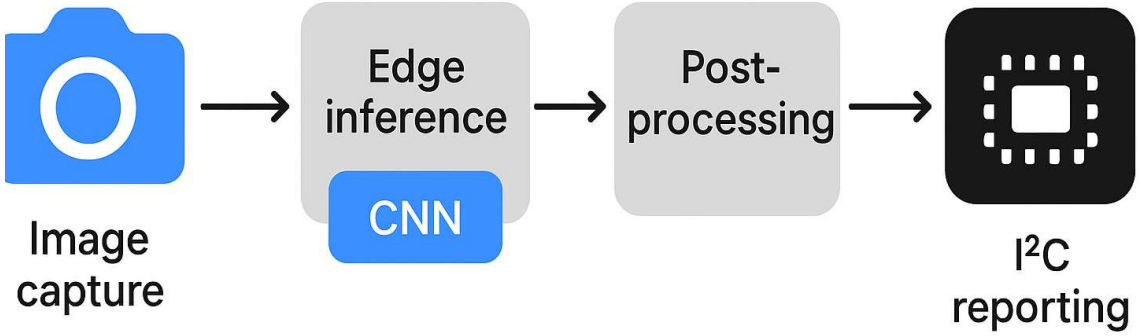
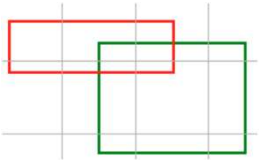


Image: ChatGPT

AI Solution. . .



Built-in vision “modes”

The device firmware exposes several ready-to-use modes so users can get results immediately, including:

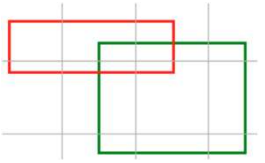
a) Face detection/tracking
b) Ball tracking
c) Color recognition
d) Card recognition (printed fiducials/cards included in kits)
e) Line tracking (used in robotics demos)

Question 2

What is the second step in the On-device AI pipeline?

a) I2C reporting
b) Input capture
c) Edge inference
d) Post-processing

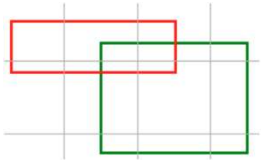
AI Solution. . .



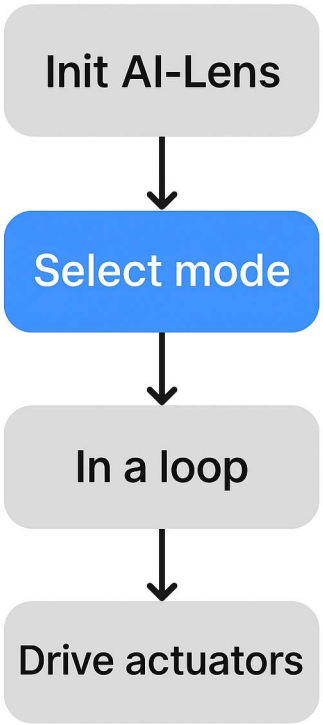
Programming model (micro:bit)

- MakeCode blocks extension: `elecfreaks/pxt-PlanetX-AI`.
  a) Blocks initialize the sensor, switch "modes,"
  b) Read detection outputs (e.g., X/Y, width/height, ID, "is detected?").
  c) keeps the development code short and readable.
    i. Microsoft MakeCode: micro:bit
    ii. MicroPython
- Typical pattern (conceptually):
  a) Init AI-Lens
  b) Select a mode (e.g., face)
  a) In a loop, poll detected? and coordinates
  b) Drive actuators (motors/servos) accordingly

AI Solution. . .



Programming Model



elecfreaks/pxt-PlanetX-AI

Kendryte K210 – Architecture

Kendryte K210 Architecture

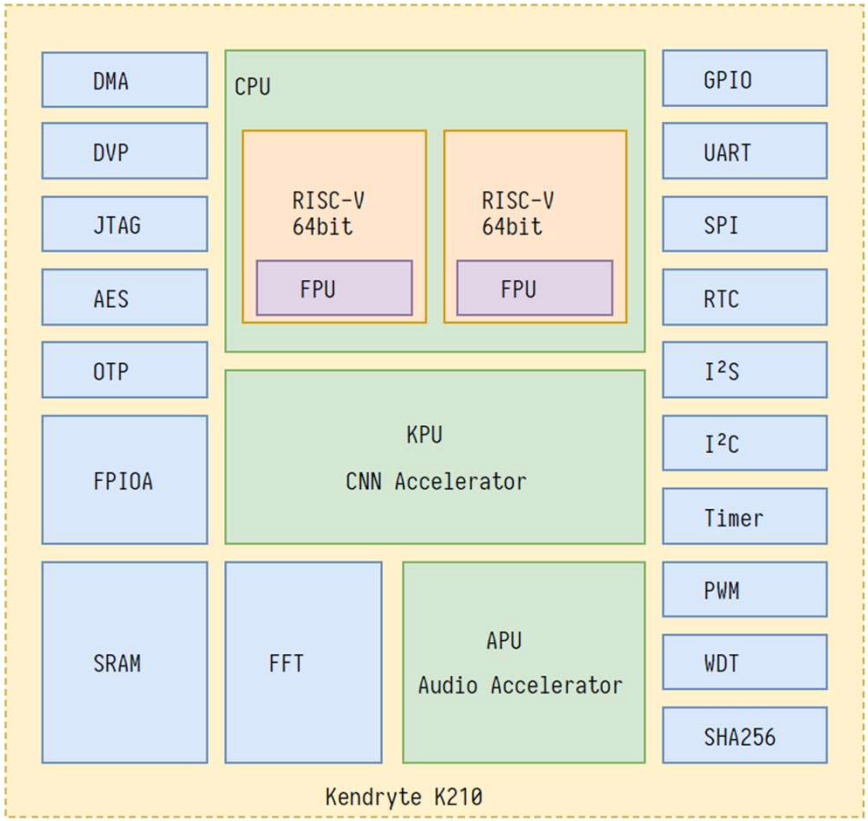
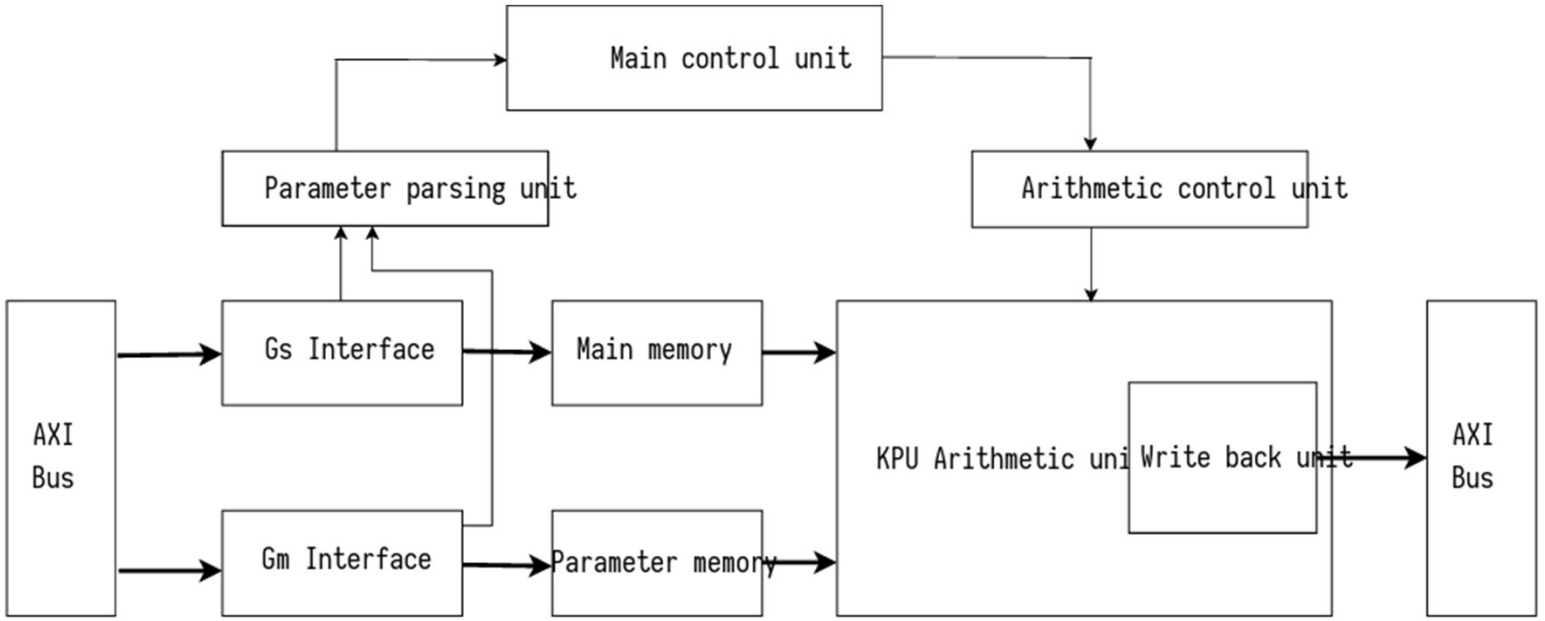


Image:
Nordic Semiconductor

Kendryte K210
MCU Package:
Ball Grid Array (BGA)

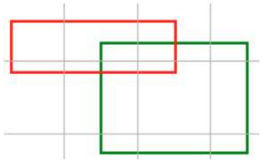
Kendryte K210 – Architecture. . .



Kendryte K210 Neural Processing Unit (NPU): Block Diagram

Image: Kendryte

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



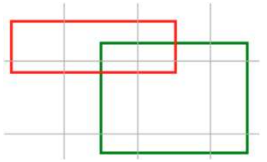
Core Architecture & Performance nRF51822:

a) Built around a 32 MHz ARM Cortex-M0 CPU.
b) Offers 256 KB or 128 KB Flash, and 32 KB or 16 KB RAM.
c) Suited for basic BLE applications.

nRF52833:

a) Uses a more powerful 64 MHz ARM Cortex-M4 with an FPU.
b) Features 512 KB Flash and 128 KB RAM—a substantial upgrade for more complex applications.

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



Wireless Capabilities & Protocol Support nRF51822:

a) Supports Bluetooth Low Energy (BLE) and proprietary 2.4 GHz protocols like Gazell.

b) Compatible with BLE data rates up to 2 Mbps.

nRF52833:

a) Supports Bluetooth 5.x (LE), including Direction Finding, Bluetooth Mesh, Thread, Zigbee, and 802.15.4(low data rate Wireless Personal Area Network: WPAN).

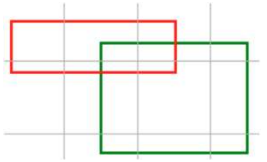
b) Offers extended range (+8 dBm TX power) and robust multiprotocol support. Note: Ideal for modern connected applications.

Question 3

Which communication capability is not supported by the nRF52833 SoC?

a) Bluetooth Mesh
b) RS232.
c) Zigbee.
d) 802.15.4

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

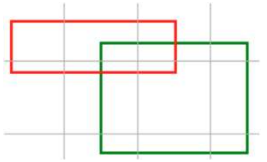


Peripheral Interfaces & Connectivity
nRF51822:

a) Provides basic interfaces:
   i. UART
   ii. Serial Peripheral Interface (SPI), Two Wire Interface(TWI)
   iii. A 10-bit Analog Digital Converter (ADC).

b) Includes a Programmable Peripheral Interconnect (PPI) for low-latency peripheral interactions.

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



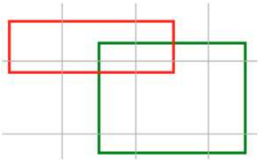
Peripheral Interfaces & Connectivity

nRF52833:

a) Offers a rich set of peripherals:
   i. USB 2.0 (Full Speed 12 Mbps)
   ii. NFC-A
   iii. 12-bit ADC,
   iv. High Speed – Serial Peripheral Interface (HS-SPI: 32 MHz)
   v. UART, TWI, PWM, Inter IC Sound (I2S), Pulse Density Modulation(PDM), I2C, Timers, and more.

b) Wide supply voltage range (1.7 V to 5.5 V) and advanced power management.

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



Operating Conditions & Power Features

nRF51822:

a) Typical supply range: 1.8 V to 3.6 V.

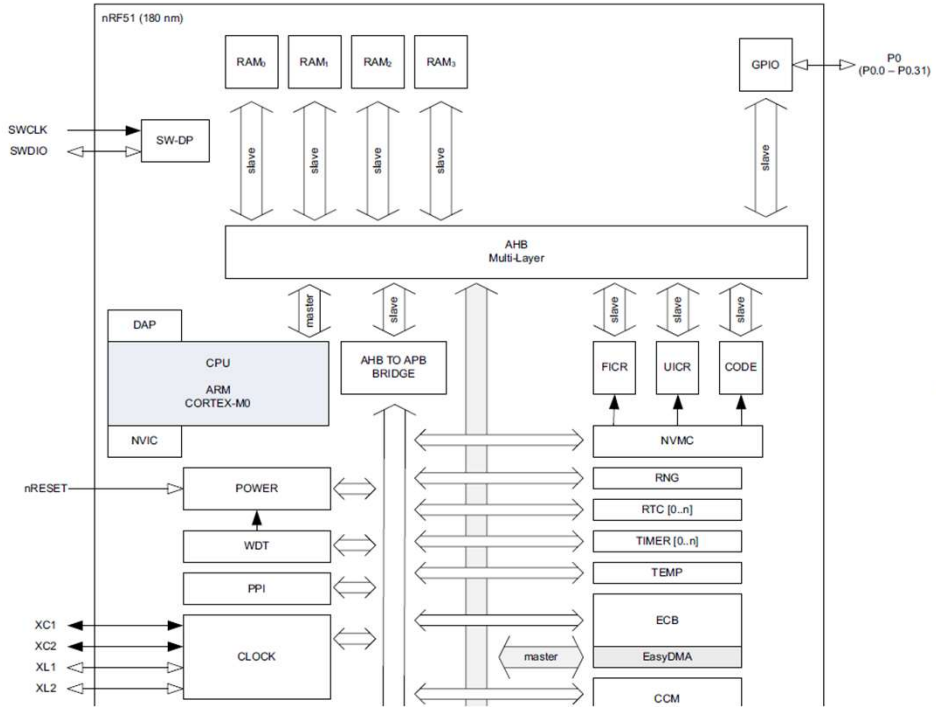
b) Includes DC/DC converter and fine-grained power control per peripheral.

nRF52833:

a) More flexible: 1.7 V to 5.5 V, making it compatible with batteries and USB.

b) Rated for industrial temperature range up to 105 °C (221°F), enabling deployment in harsh environments.

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



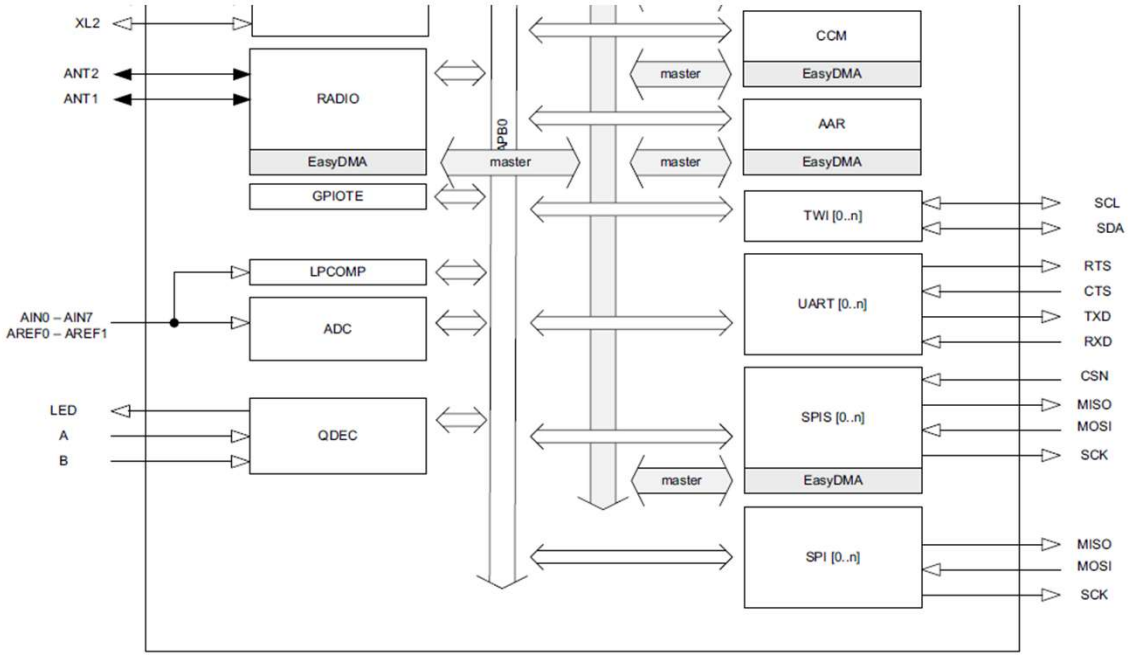


Image: Nordic Semiconductor

Block Diagram

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

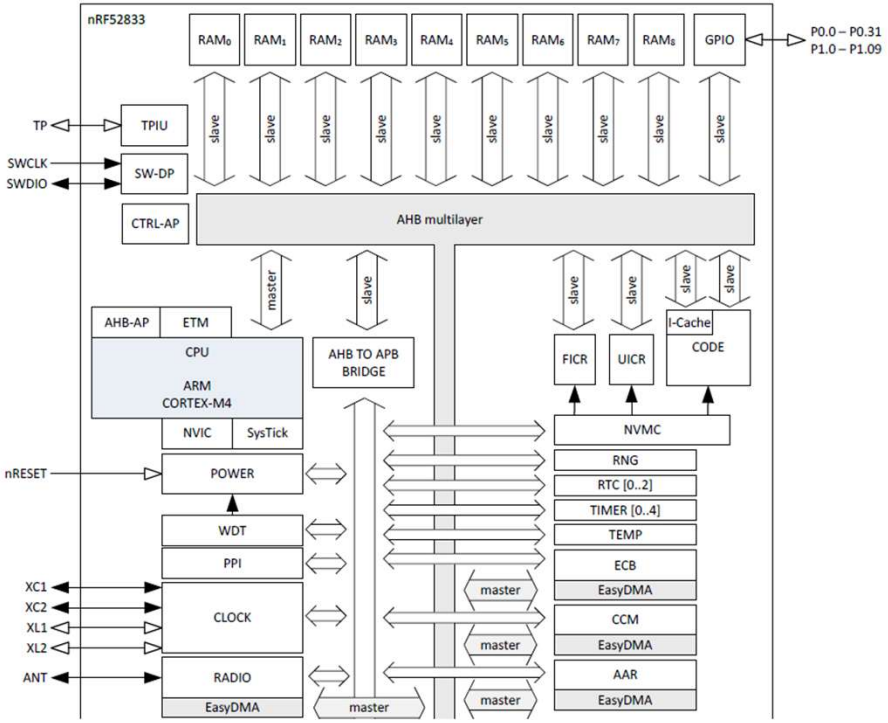
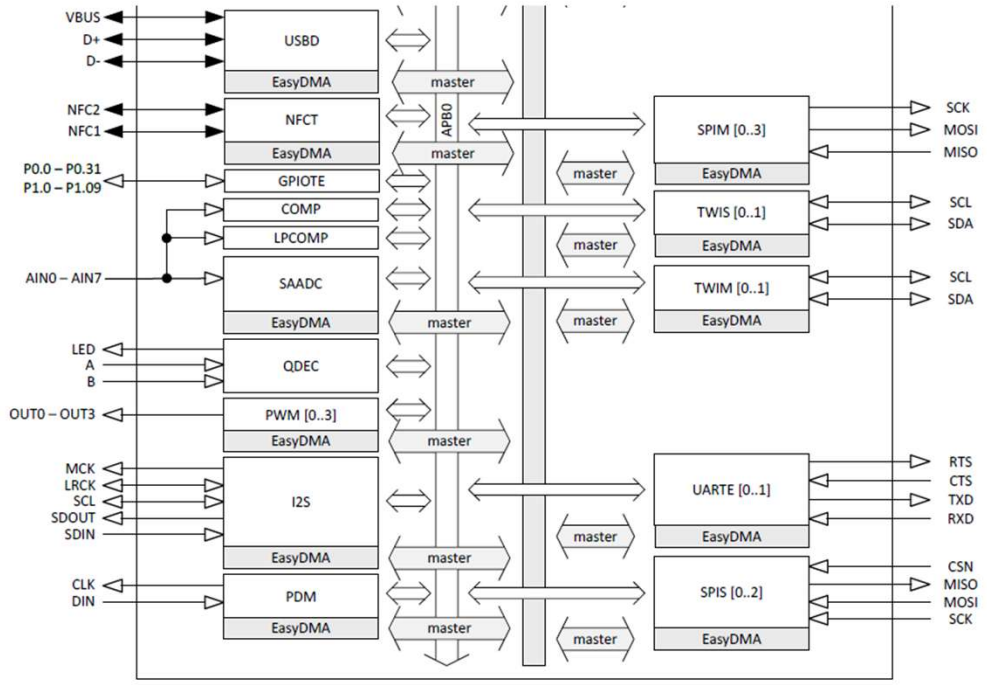
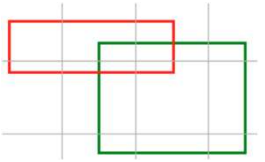


Image: Nordic Semiconductor



Block Diagram

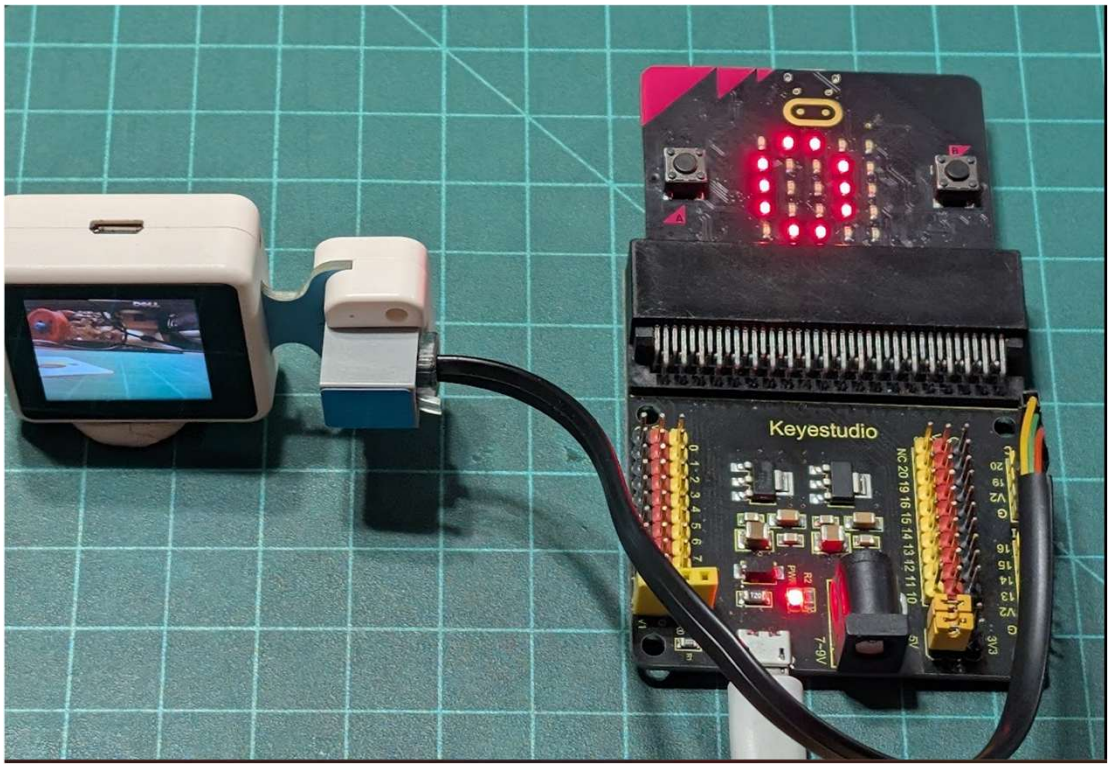
Nordic Semiconductor's nRF51822/52833 System on Chip (SoC). . .



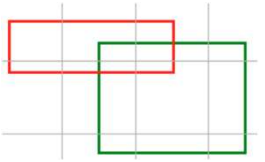
Summary Table

Feature	nRF51822	nRF52833
CPU	Cortex-M0, ~16 MHz	Cortex-M4F, 64 MHz
Flash / RAM	256/128 KB Flash, 32/16 KB RAM	512 KB Flash, 128 KB RAM
Wireless Protocols	BLE, proprietary 2.4 GHz	BLE 5.x, Mesh, Thread, Zigbee, FS 802.15.4
TX Power	Up to +4 dBm	Up to +8 dBm
Peripherals	UART, SPI, TWI, 10-bit ADC, PPI	USB FS, NFC, HS-SPI, ADC, I^2S, PDM, PWM, etc.
Power Supply	1.8–3.6 V	1.7–5.5 V
Temperature Rating	Commercial	Industrial (–40 °C to +105 °C)

Lab: Card Recognition Device



Lab: Card Recognition Device. . .

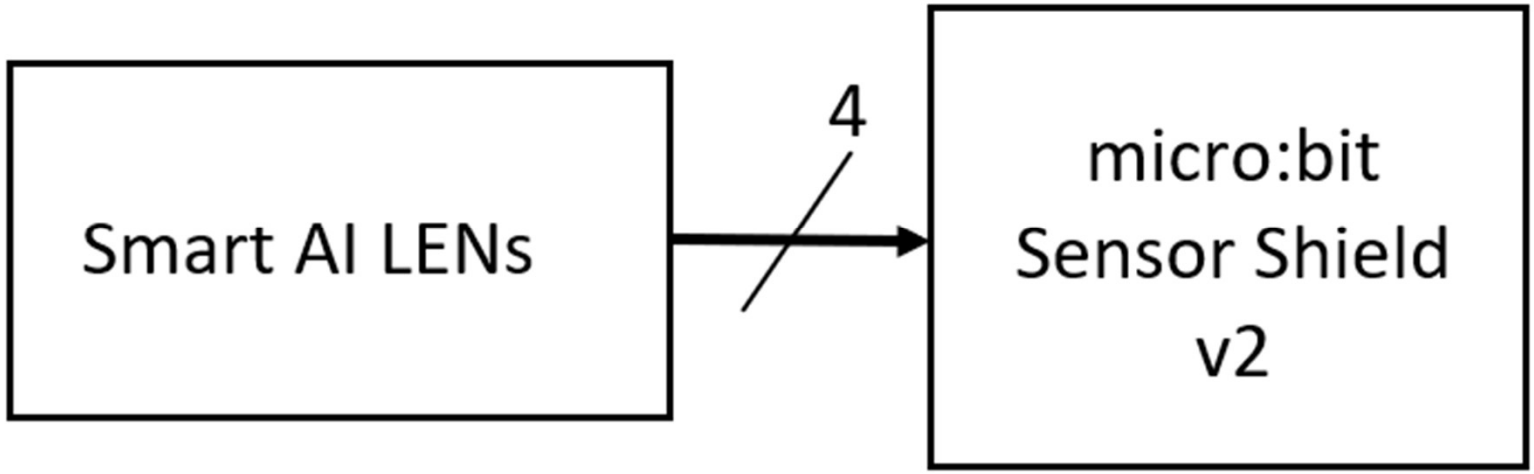


Participant Learning Objectives:

- Participants will learn to wire a Smart AI-Lens to Micro:bit Sensor Shield.
- Participants will learn to add the Smart AI-Lens code blocks to the Microsoft MakeCode micro:bit programming environment.
- Participants will learn to program the Smart AI-Lens to recognize a specific card using Blockly code.
- Participants will learn to test the Card Recognition Device using the Blockly test code.

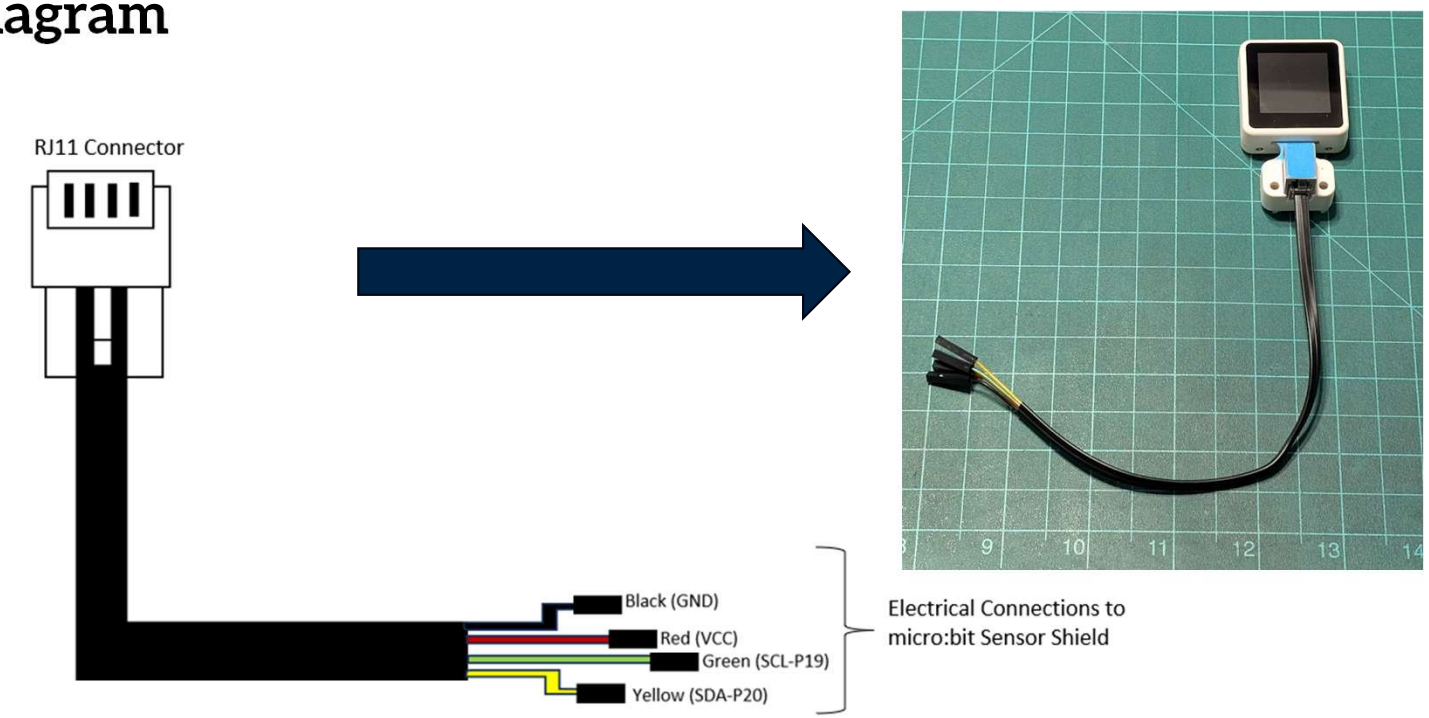
Lab: Card Recognition Device. . .

Concept Block Diagram for a Card Recognition Demonstrator



Lab: Card Recognition Device. . .

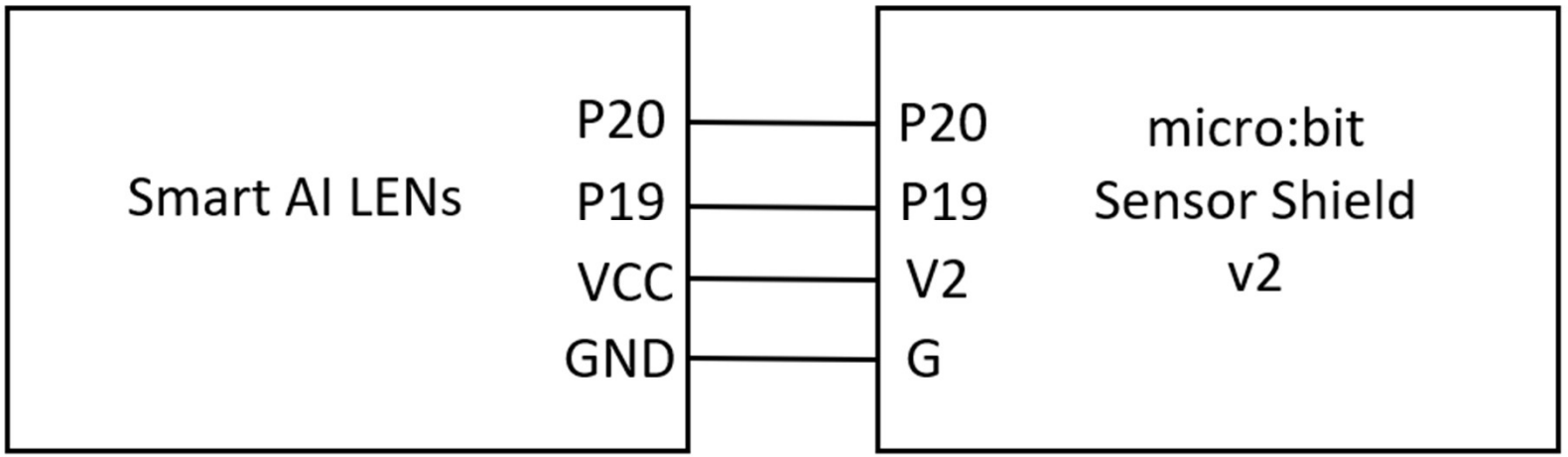
Card Recognition Demonstrator Electrical Wiring Diagram



Lab: Card Recognition Device. . .

Card Recognition Demonstrator Electrical Wiring Diagram

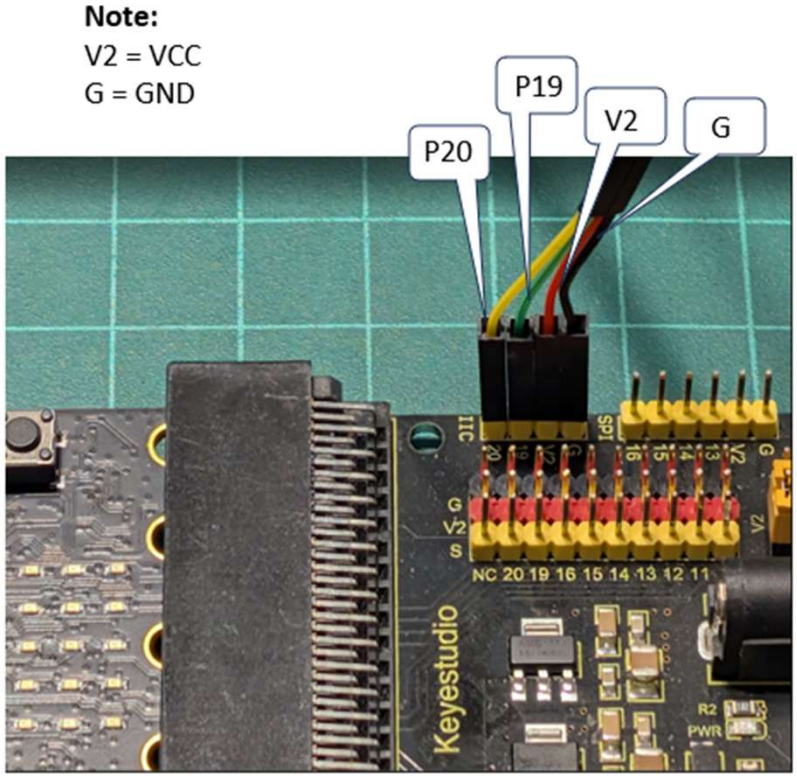
Smart AI-Lens To Micro:bit: Electrical Wiring Diagram



Lab: Card Recognition Device. . .

Card Recognition Demonstrator Electrical Wiring Diagram

RJ11 wire harness connected to Micro:bit Sensor Shield



Question 4

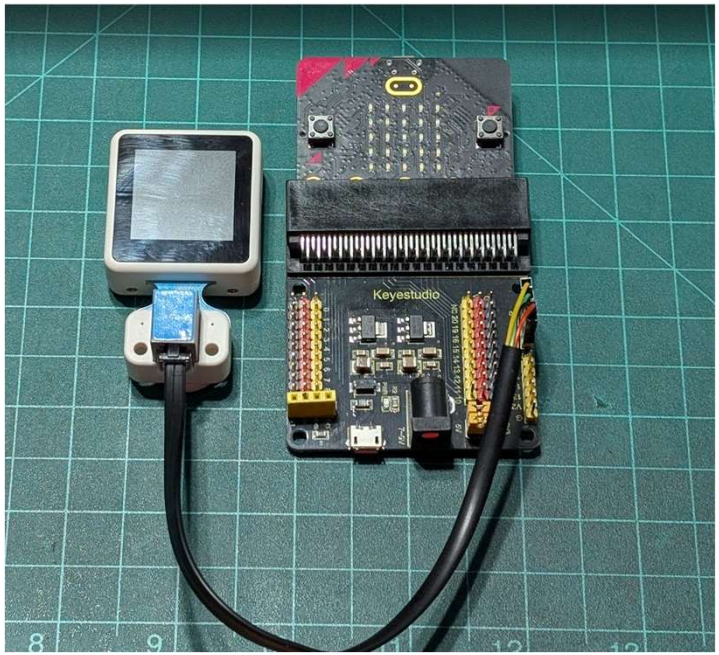
How many electrical connections are required to attach the Smart AI-Lens to the micro:bit Sensor Shield?

a) 2
b) 3
c) 5
d) 4

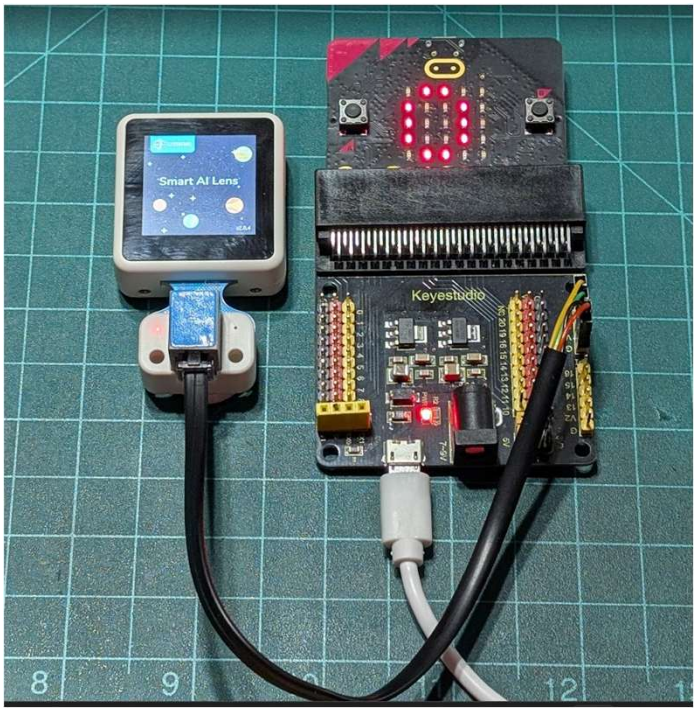
Lab: Card Recognition Device. . .

Card Recognition Demonstrator Electrical Wiring Diagram

Smart AI-Lens wired to the Micro:bit Sensor Shield



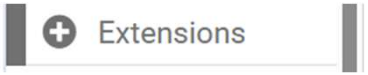
Smart AI-Lens powered ON



Lab: Card Recognition Device. . .

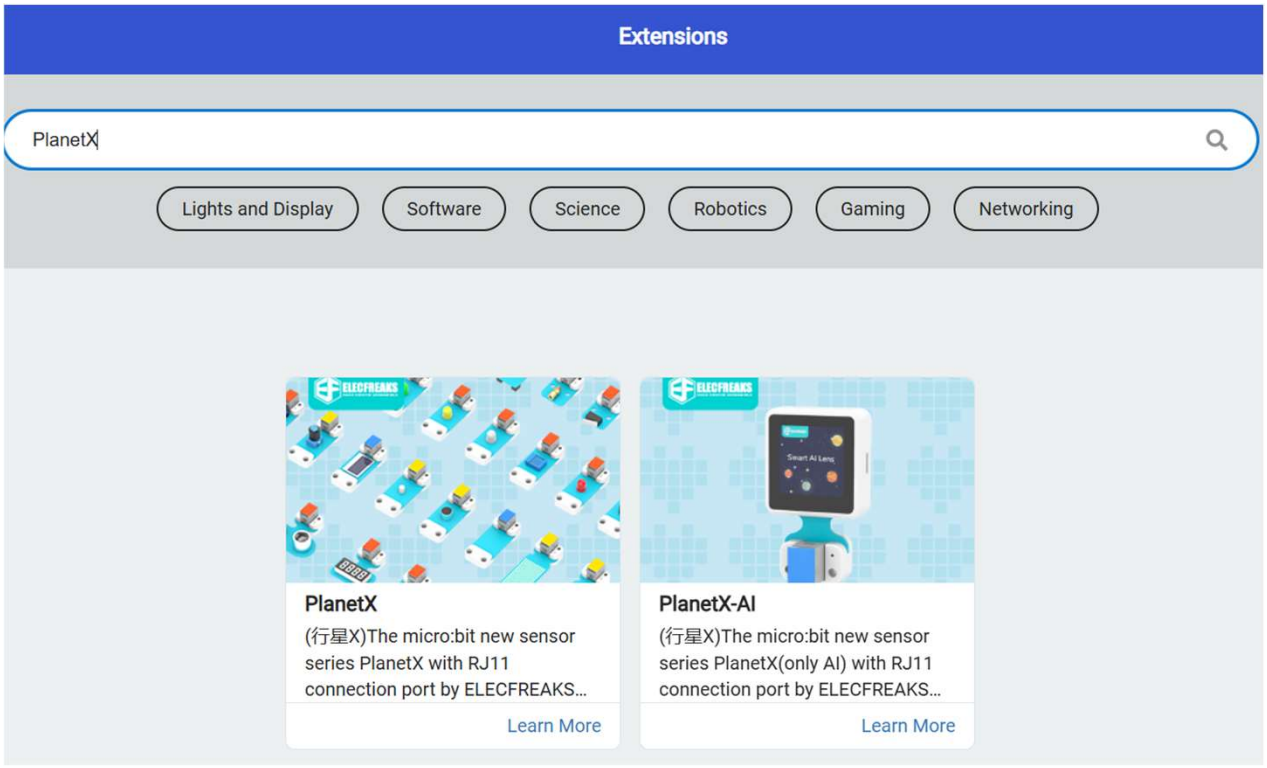
Type PlanetX

2



1

Scroll down in Microsoft MakeCode micro:bit code blocks, click the Extension Button.

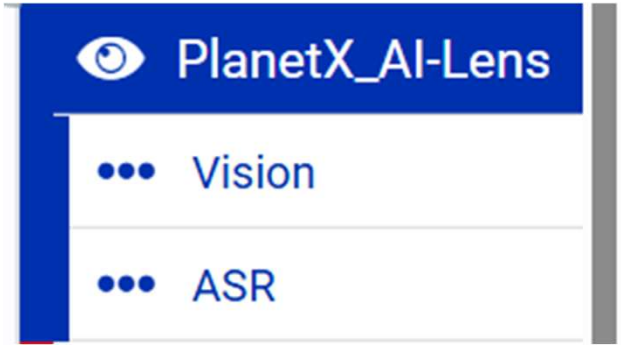


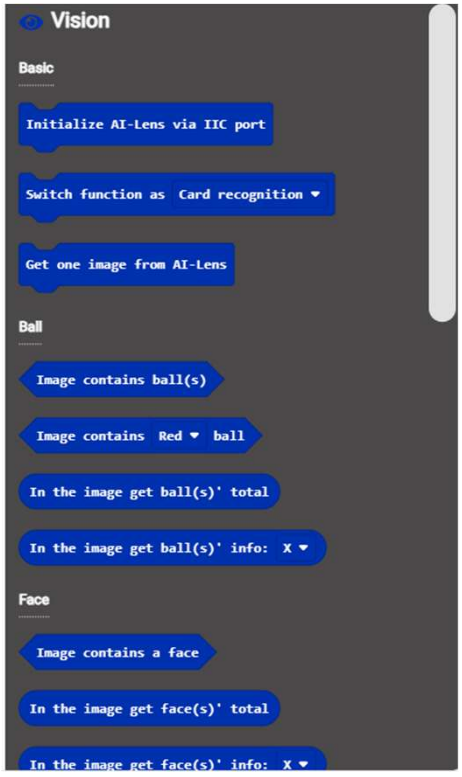
Adding PlanetX_AI-Lens Code Blocks to the Microsoft MakeCode micro:bit programming environment.

Lab: Card Recognition Device. . .

PlanetX_AI-Lens Code Blocks

Click Here!

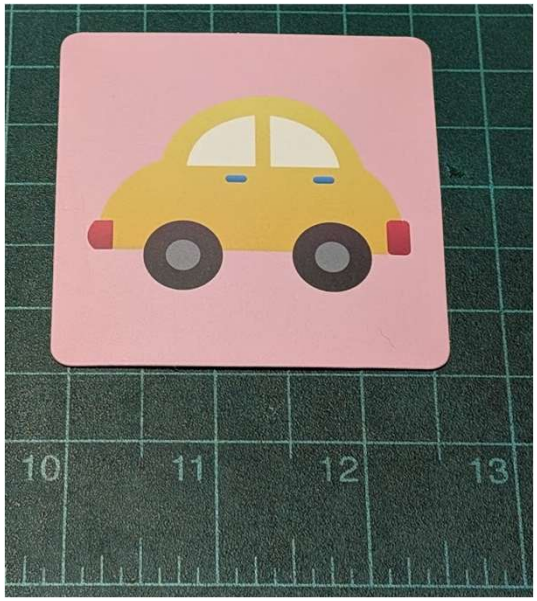


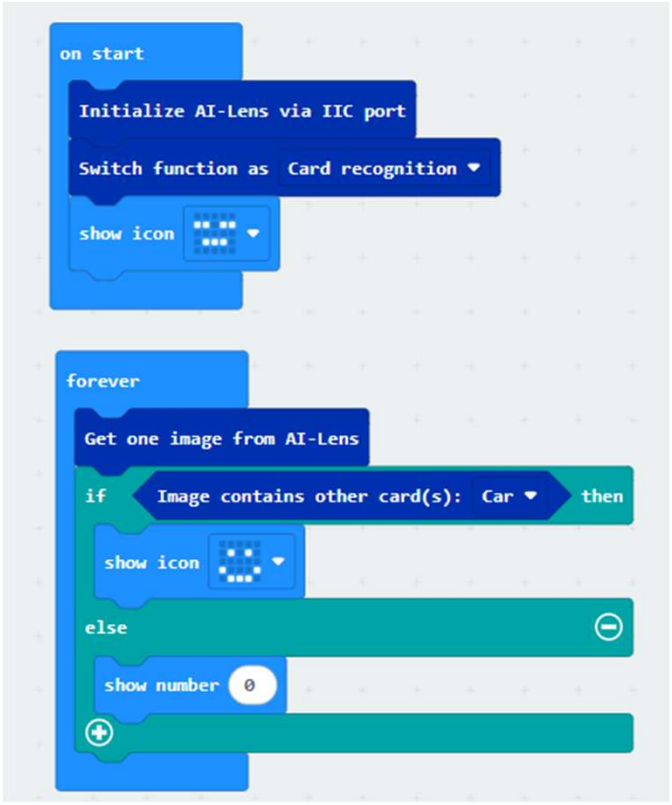


Partial Smart AI-Lens Code Blocks

Lab: Card Recognition Device. . .

Test Card





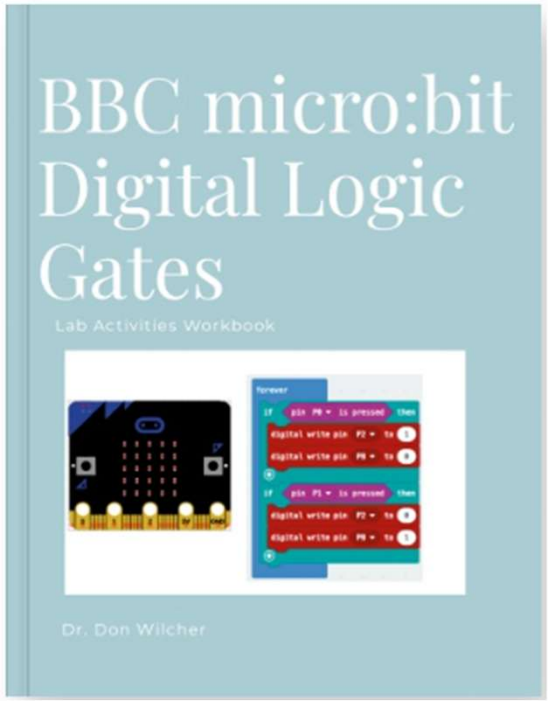
Card Recognition Test Code Blocks

Lab: Card Recognition Device. . .

BBC Micro:bit Digital Logic Gate Lab Activities Workbook Challenge

Modify the code on slide 43, where pressing a digital pushbutton **and** the Smart AI Lens detects the car image, the word “Car” will scroll on the micro:bit LED Matrix. If the condition is not met, the letter X will be displayed on the LED matrix.

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.



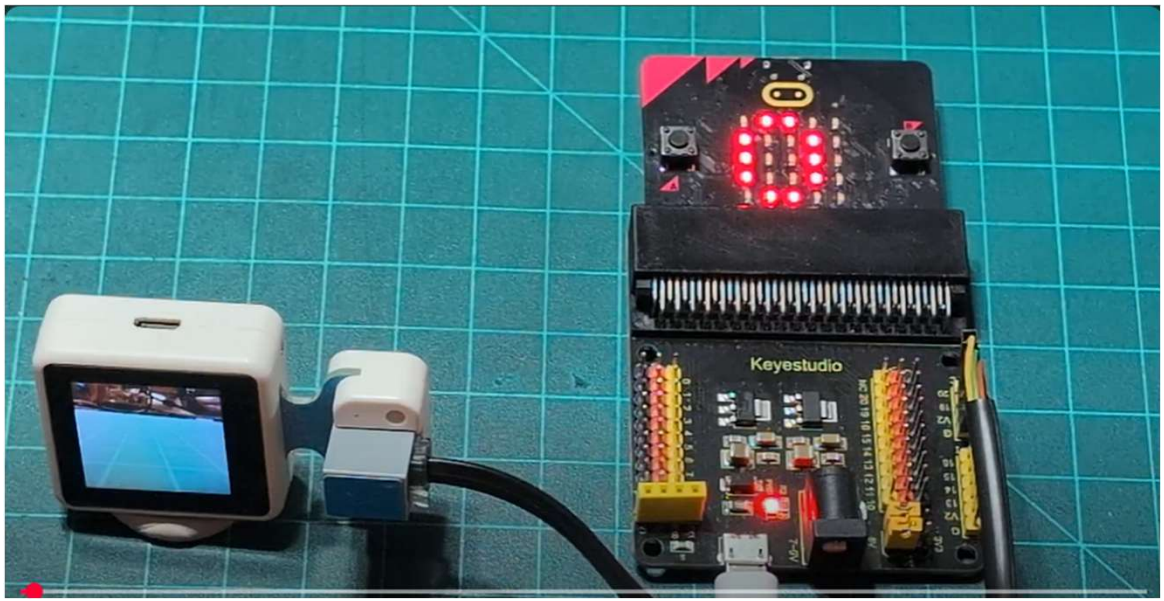
Refer to pages 20-22 in the workbook for implementing the AND logic function.

Lab: Card Recognition Device. . .

Assembled and Functional Card Recognition Device Demonstrator

Watch the Video Clip!

https://youtu.be/PP7E8y83FRg



Question 5

Within the PlanetX_AI-Lens code blocks, which code block is used in the Card Recognition Test Code?

a) Image contains Red - ball
b) Image contains a face
c) Image contains number cards(s): 0
d) Image contains other cards (s): Car

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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