Embedded System Architecture - CSEN 701

Module 2: *Microcontroller Fundamentals*

Lecture 03: *Introduction to RP2040 Microcontroller and Architecture*

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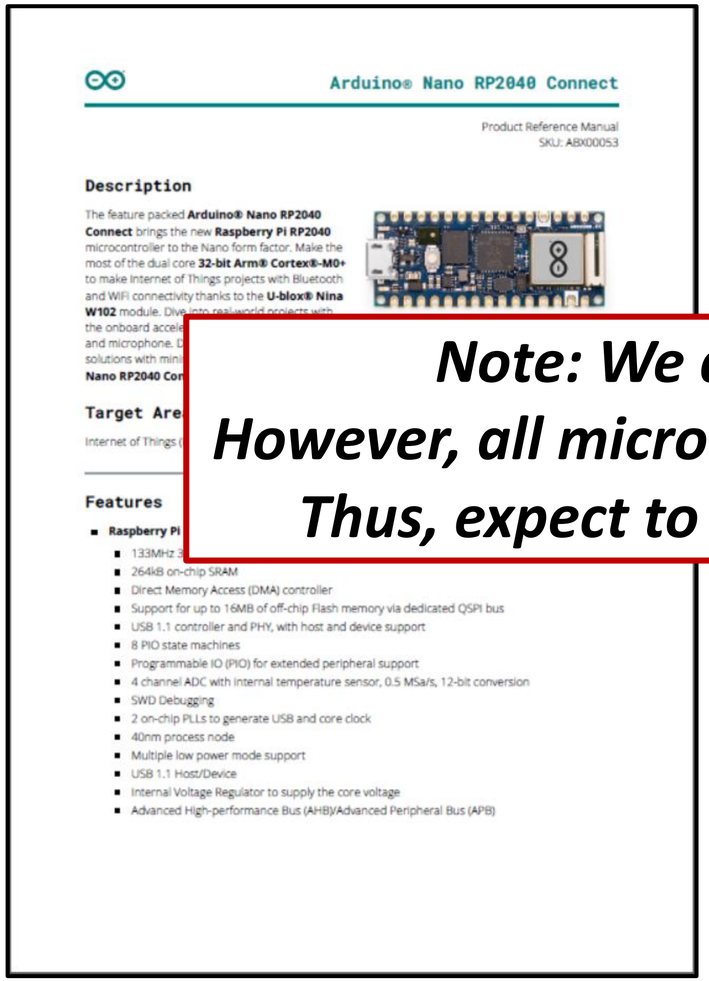
Outline

- Exploring The Microcontrollers
- The RP2040
- The ARM Processors

Exploring The Microcontrollers

Always Refer to the Datasheet!!!!



Arduino® Nano RP2040 Connect

Product Reference Manual
SKU: ABX00053

Description

The feature packed **Arduino® Nano RP2040 Connect** brings the new **Raspberry Pi RP2040** microcontroller to the Nano form factor. Make the most of the dual core **32-bit Arm® Cortex®-M0+** to make Internet of Things projects with Bluetooth and WiFi connectivity thanks to the **U-blox® Nina W102** module. Dive into real-world projects with the onboard accele
and microphone. D
solutions with mini
Nano RP2040 Cor

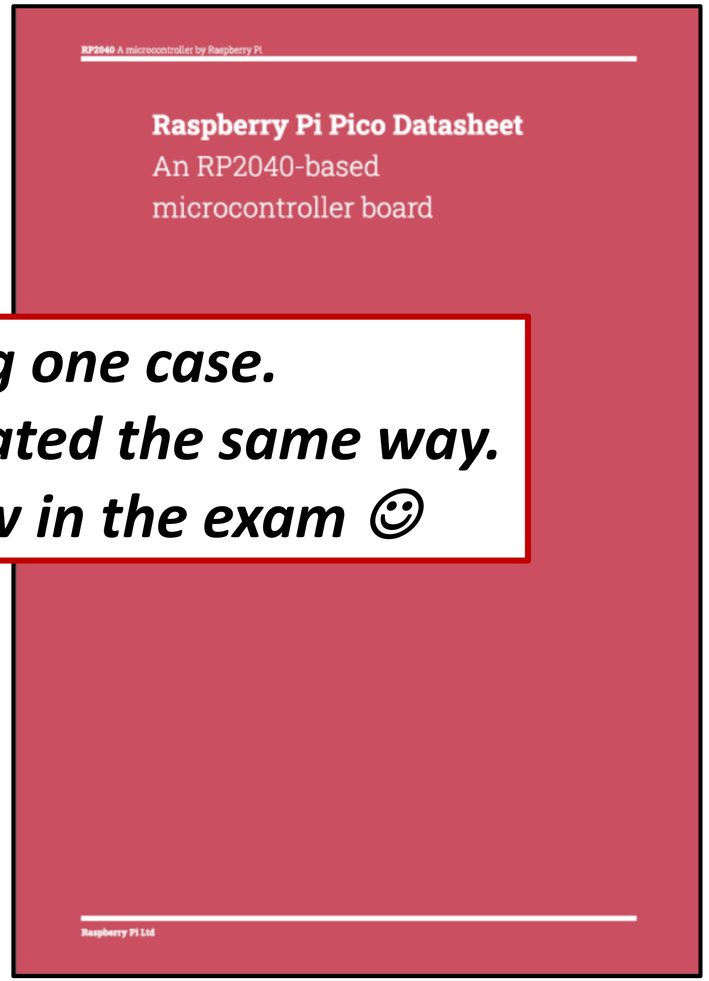
Target Are

Internet of Things (

Features

- **Raspberry Pi**
  - 133MHz
  - 264kB on-chip SRAM
  - Direct Memory Access (DMA) controller
  - Support for up to 16MB of off-chip Flash memory via dedicated QSPI bus
  - USB 1.1 controller and PHY, with host and device support
  - 8 PIO state machines
  - Programmable IO (PIO) for extended peripheral support
  - 4 channel ADC with internal temperature sensor, 0.5 MSa/s, 12-bit conversion
  - SWD Debugging
  - 2 on-chip PLLs to generate USB and core clock
  - 40nm process node
  - Multiple low power mode support
  - USB 1.1 Host/Device
  - Internal Voltage Regulator to supply the core voltage
  - Advanced High-performance Bus (AHB)/Advanced Peripheral Bus (APB)

https://content.arduino.cc/assets/ABX00053-datasheet.pdf



RP2040 A microcontroller by Raspberry Pi

Raspberry Pi Pico Datasheet

An RP2040-based
microcontroller board

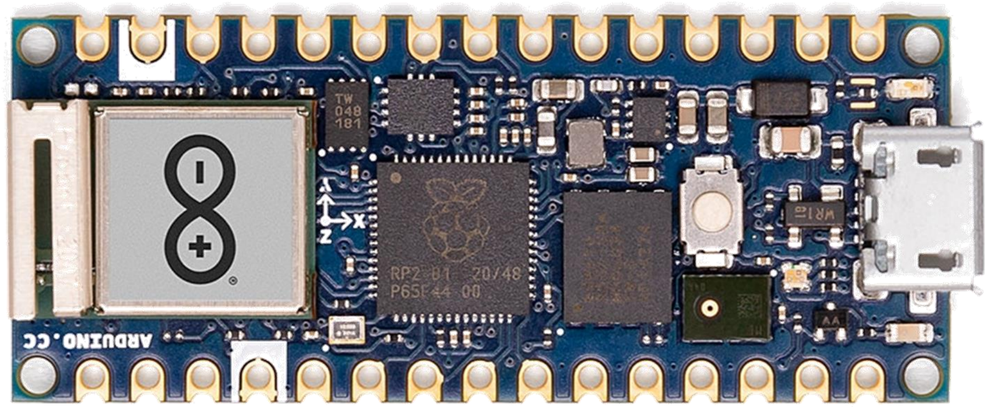
Raspberry Pi Ltd

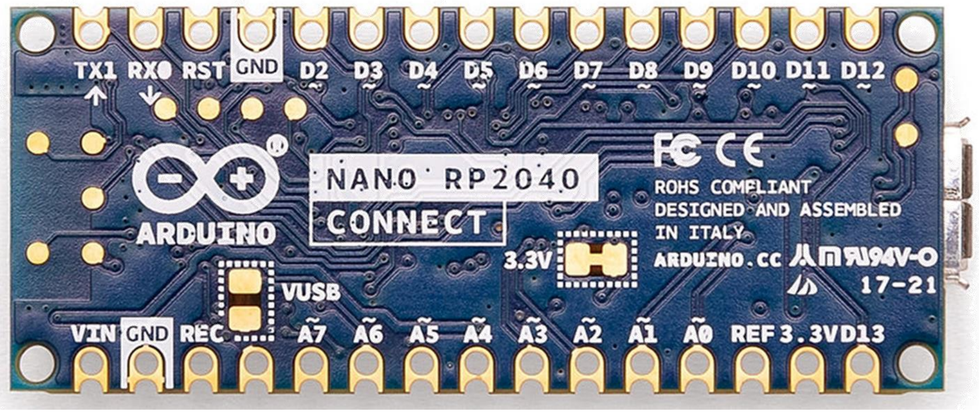
https://datasheets.raspberrypi.com/pico/pico-datasheet.pdf

Note: We are here presenting one case.
However, all microcontrollers are treated the same way.
Thus, expect to see something new in the exam ☺

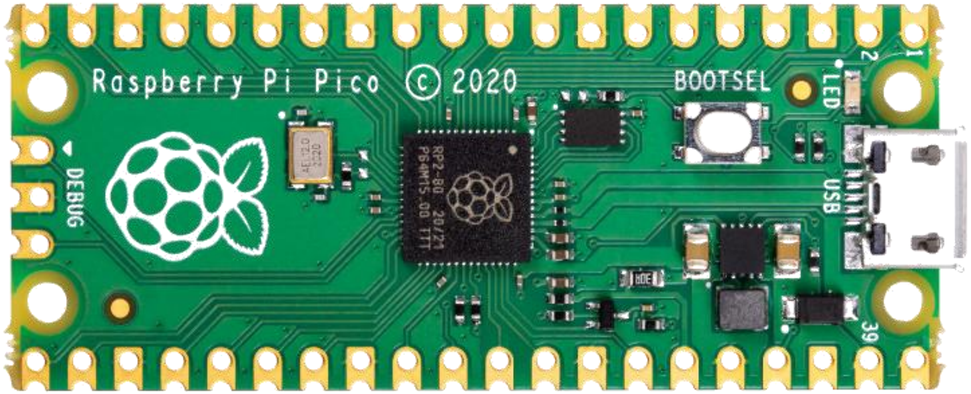
Exploring The Microcontrollers

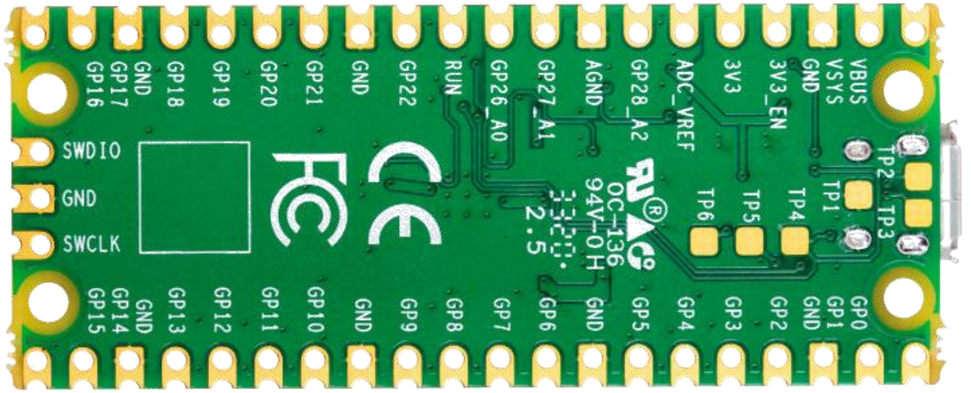
The Arduino RP2040: *Views*





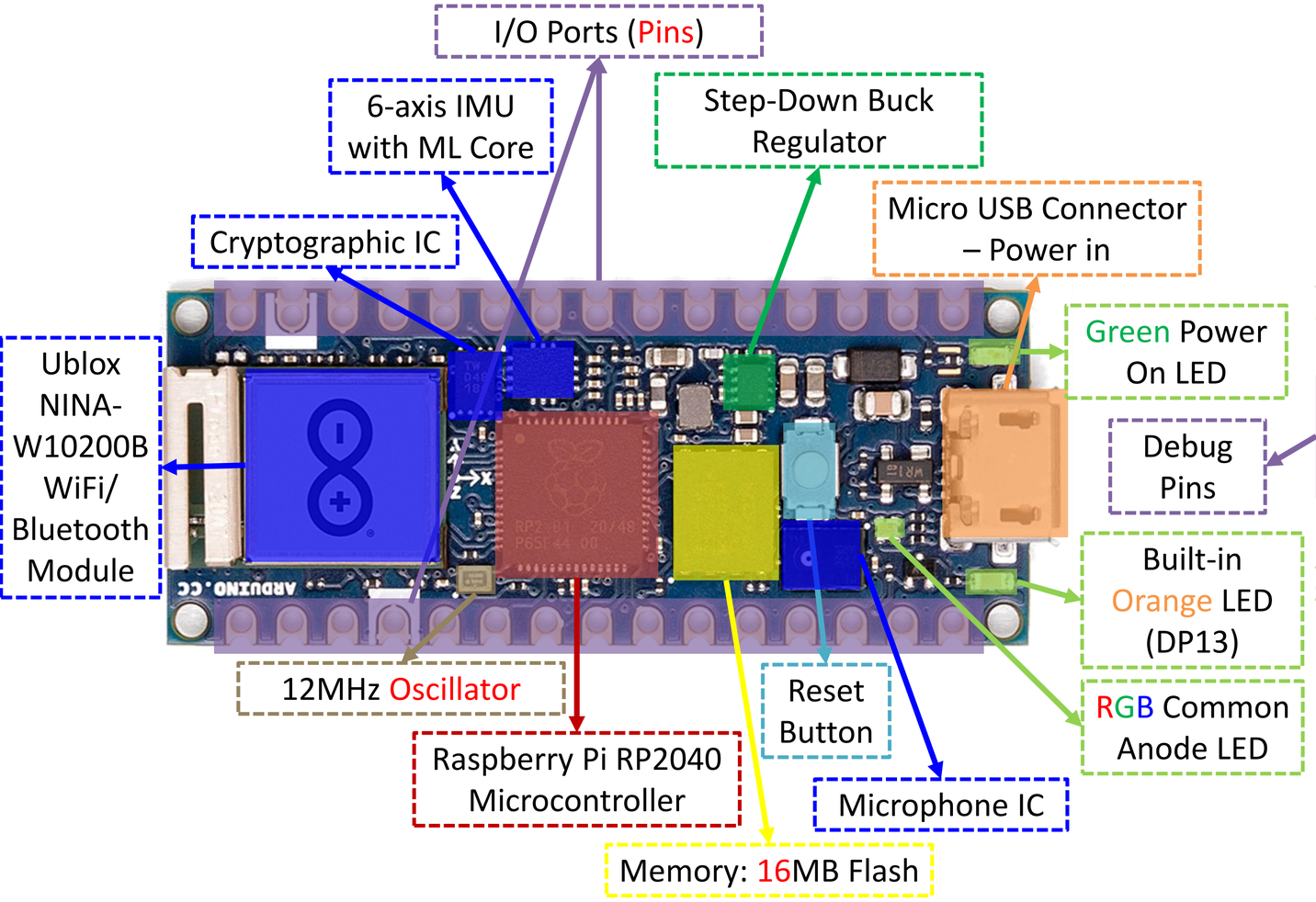
The Raspberry Pi Pico: *Views*



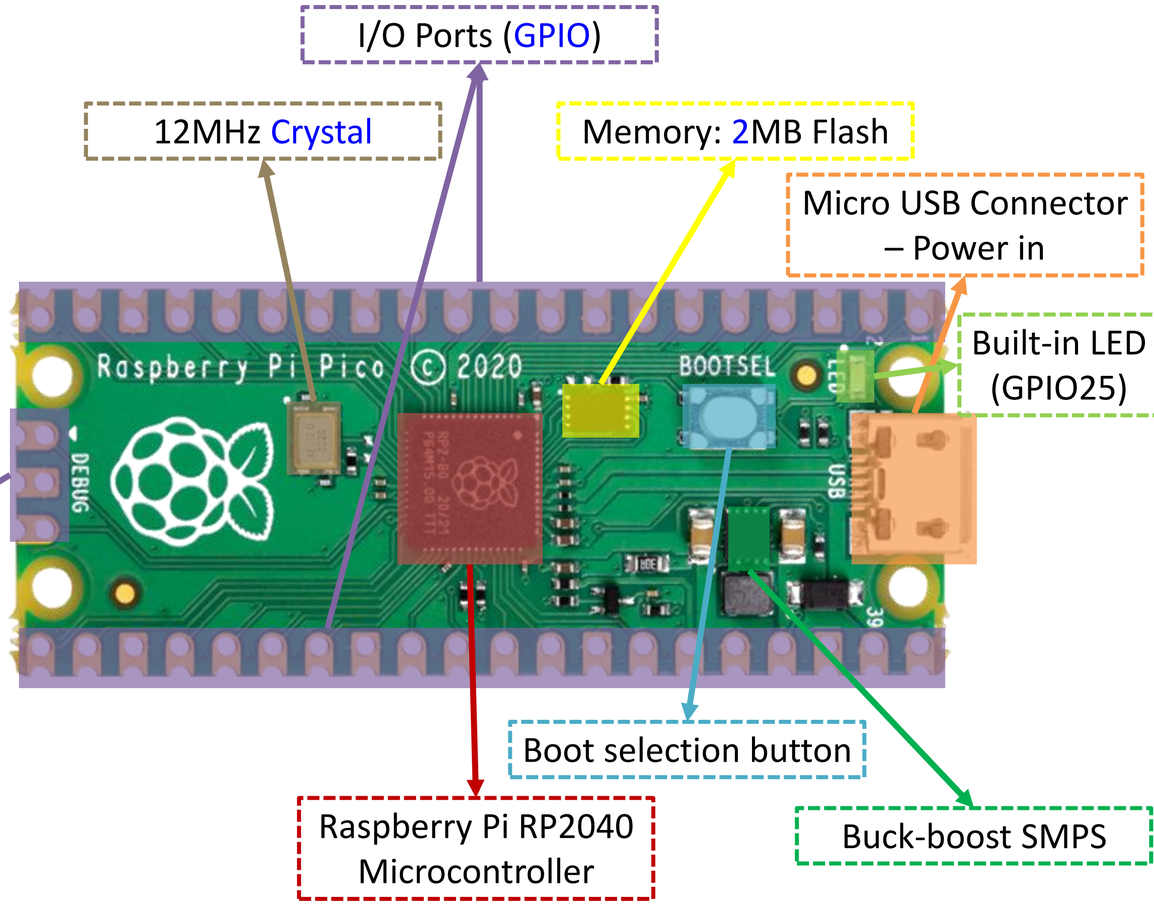


Exploring The Microcontrollers

The Arduino RP2040: *Topology*

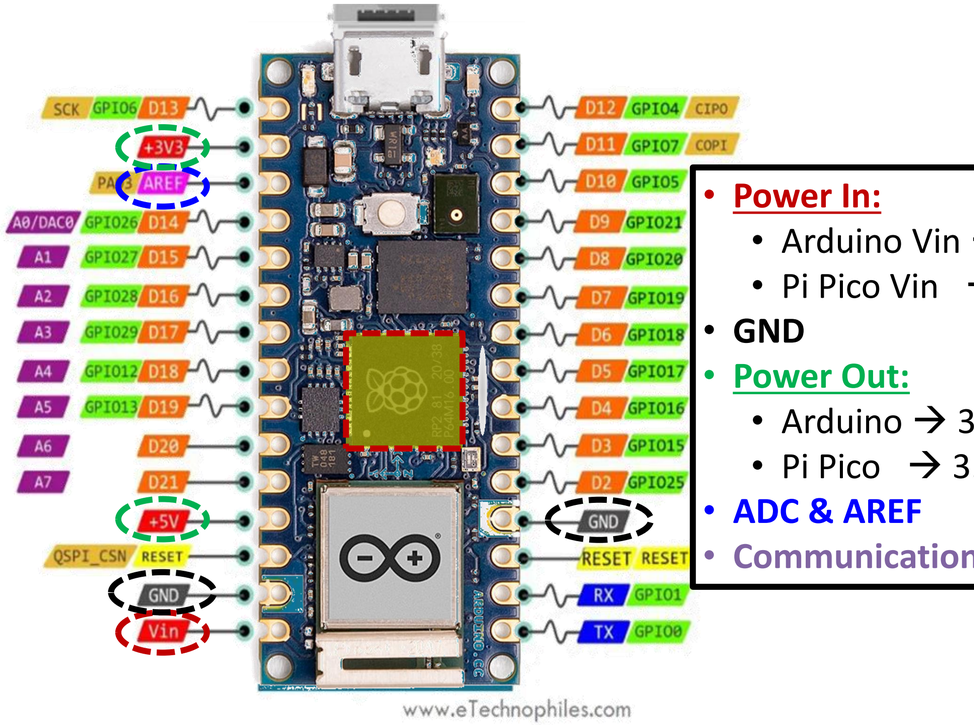


The Raspberry Pi Pico: *Topology*

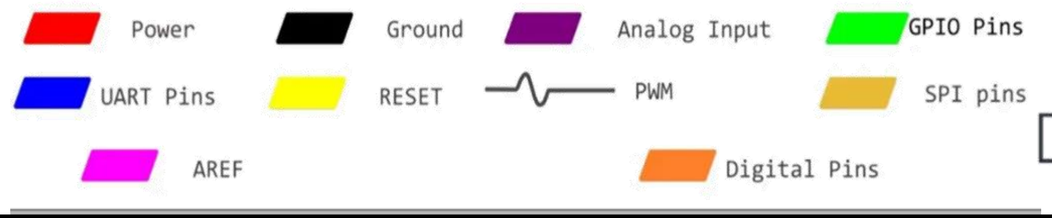


Exploring The Microcontrollers

The Arduino RP2040: *Pinout*



- **Power In:**
  - Arduino Vin → 5V
  - Pi Pico Vin → 3.3V
- **GND**
- **Power Out:**
  - Arduino → 3.3V & 5V
  - Pi Pico → 3.3V
- **ADC & AREF**
- **Communication**



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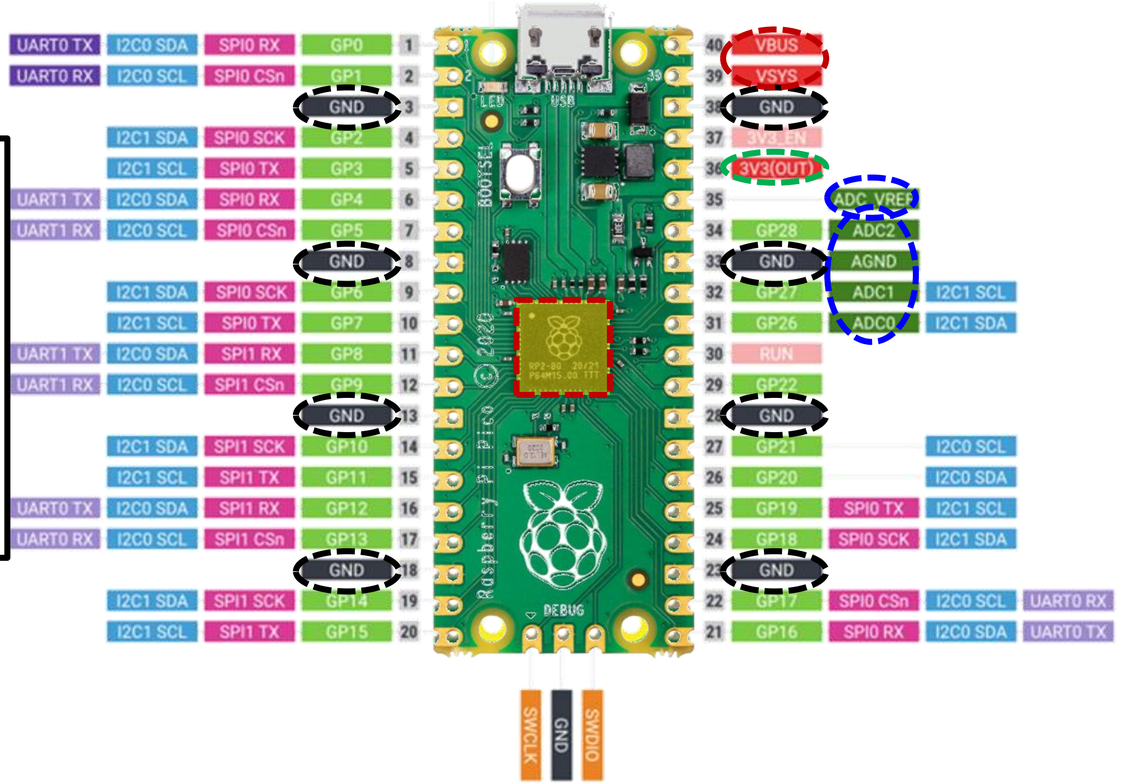
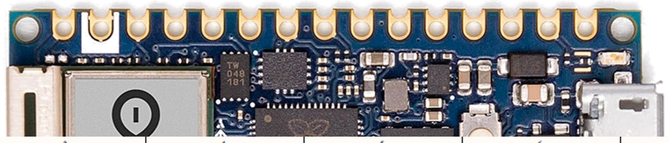
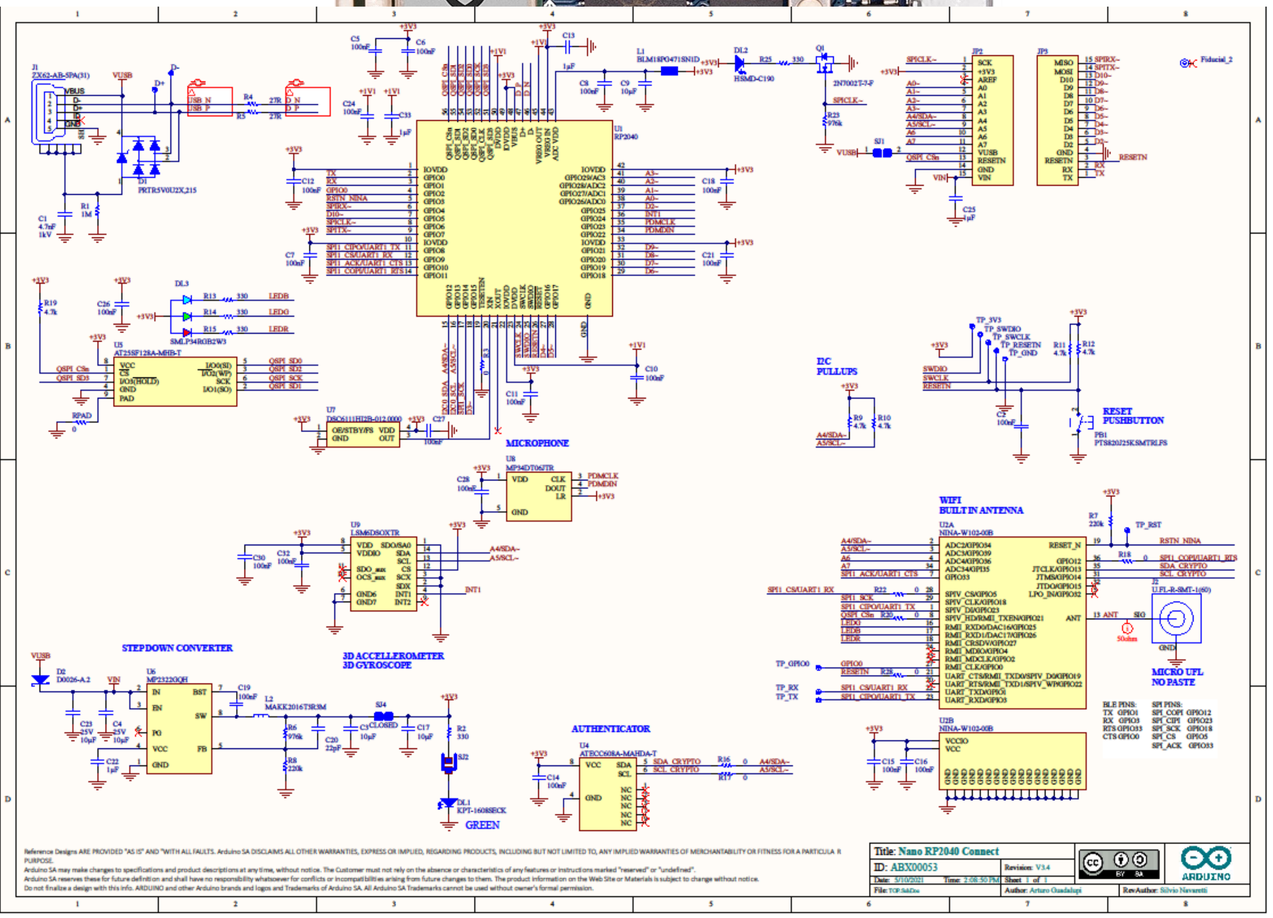


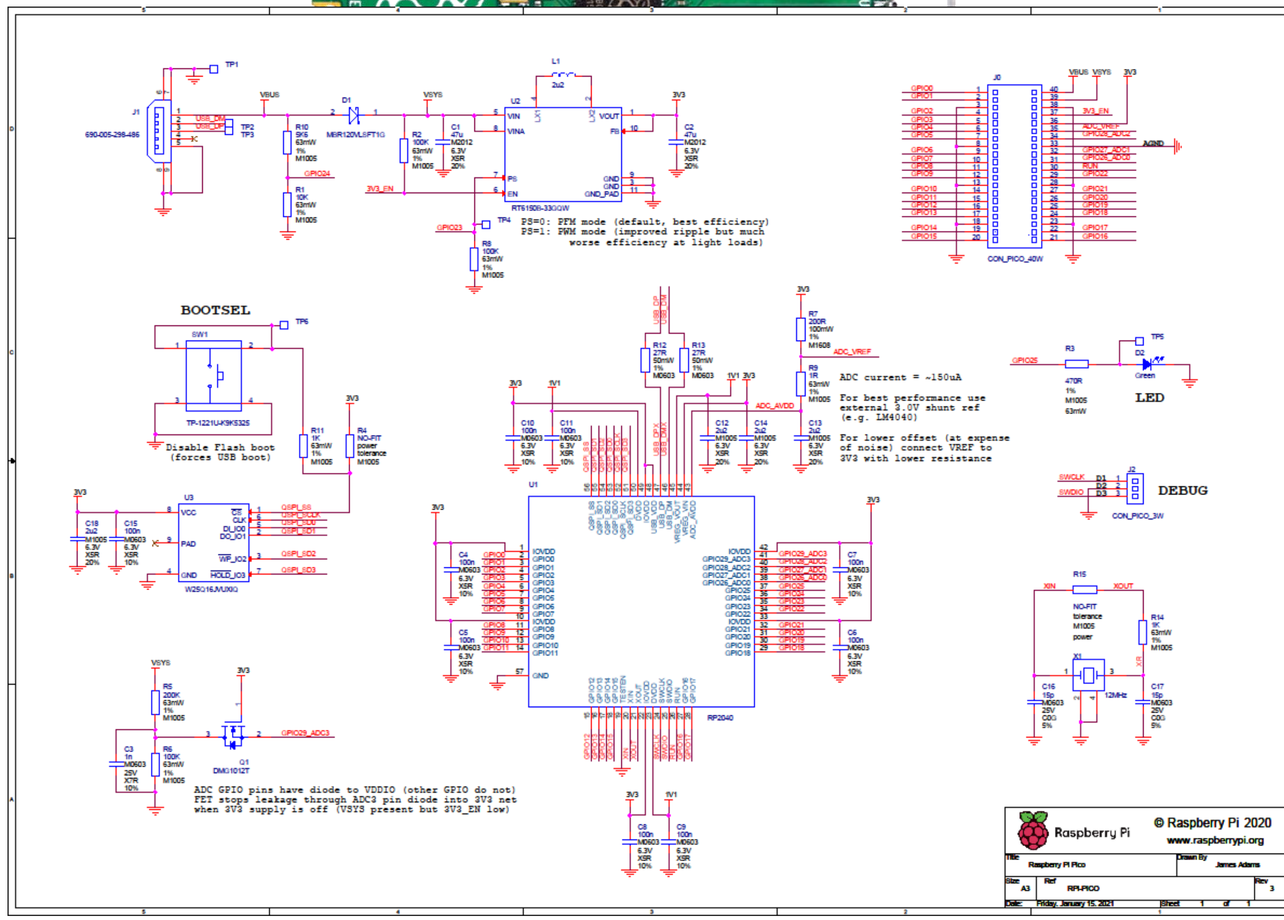
Exploring The Microcontrollers

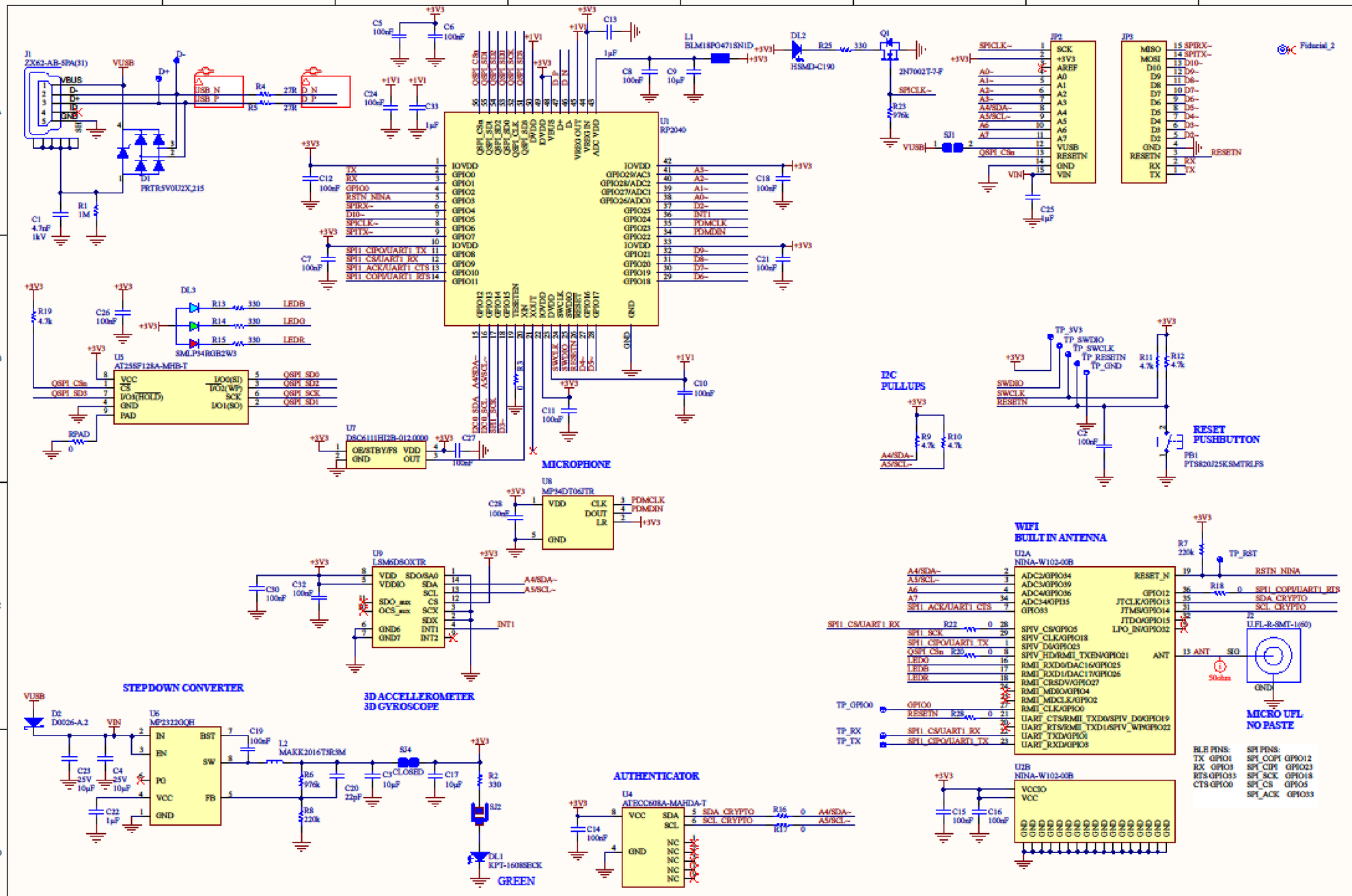
The Arduino RP2040: *Schematic*





The Raspberry Pi Pico: *Schematic*




Nano RP2040 Connect
ABX00053
MICROPHONE
I2C PULLUPS
RESET PUSHBUTTON
WIFI BUILT IN ANTENNA
STEP DOWN CONVERTER
3D ACCELLEROMETER 3D GYROSCOPE
AUTHENTICATOR
MICRO UFL NO PASTE
LED
DEBUG
GREEN
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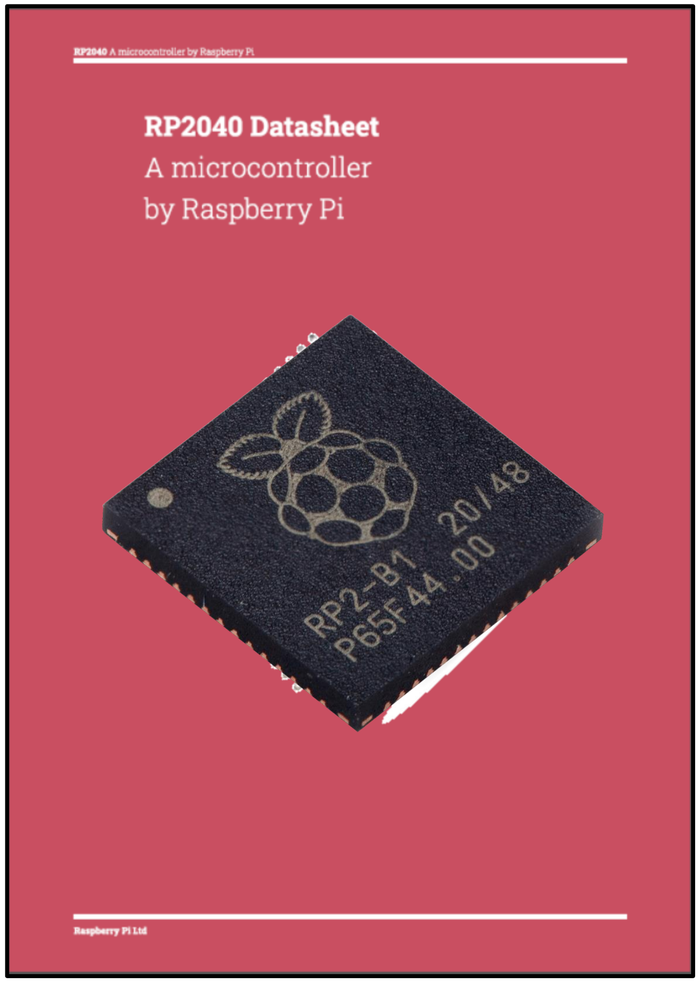
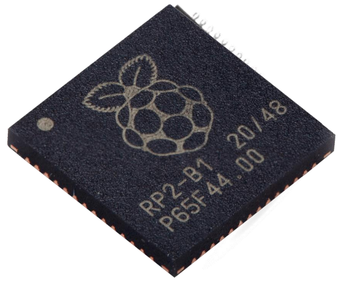
Always Refer to the Datasheet!!!!



https://datasheets.raspberrypi.com/rp2040/rp2040-datasheet.pdf

The RP2040

Why is the chip called RP2040?



RP 2 0 4 0

Manufacturer Name:
Raspberry **P**i

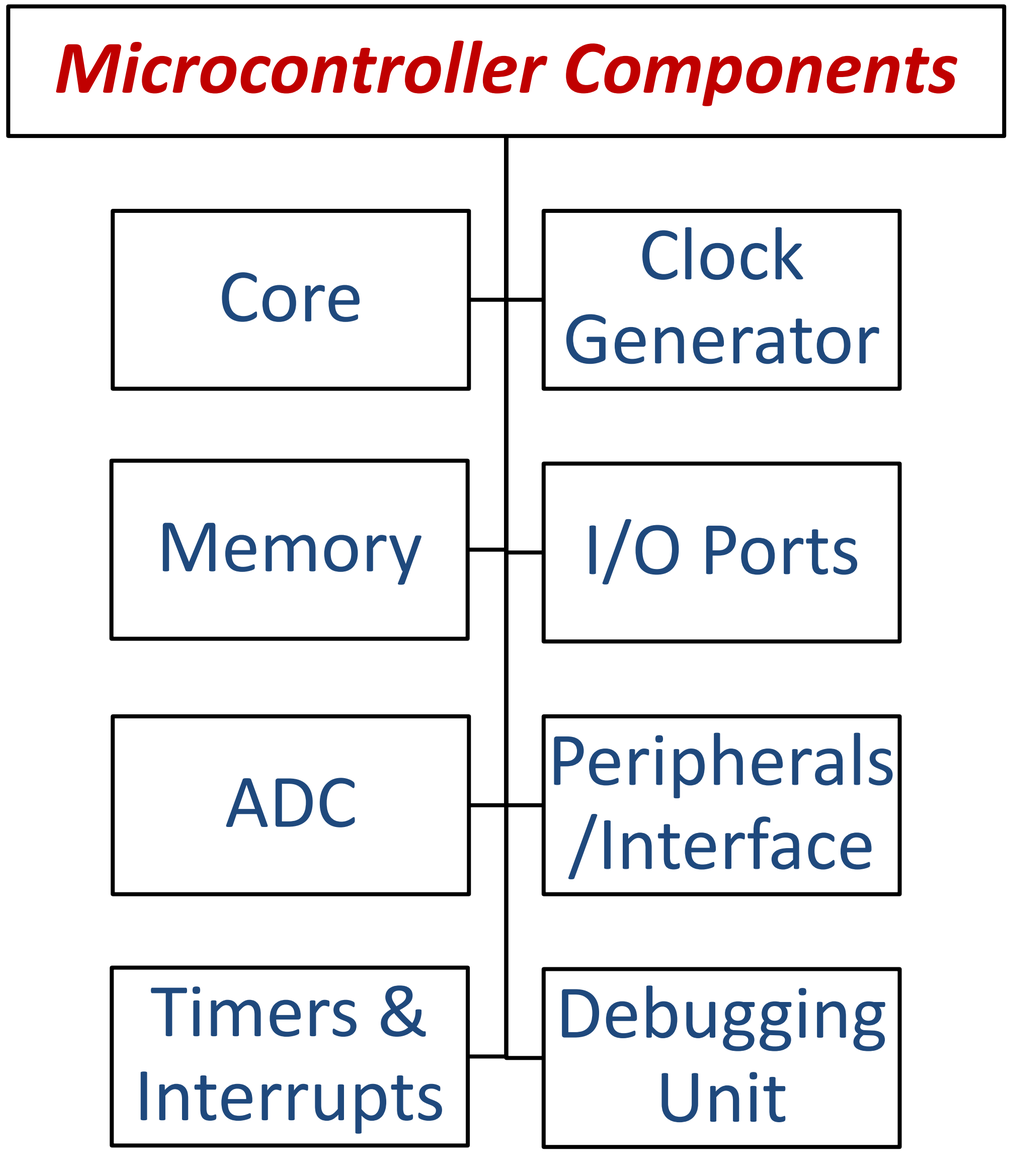
Number of Cores

Type of Core
(e.g. M0+)

$floor(\log_2(\frac{RAM}{16k}))$

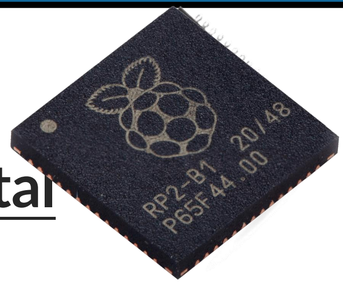
$floor(\log_2(\frac{nonvolatile}{16k}))$
or
0 if no onboard nonvolatile storage

Exploring The Microcontrollers



The RP2040

Key Features

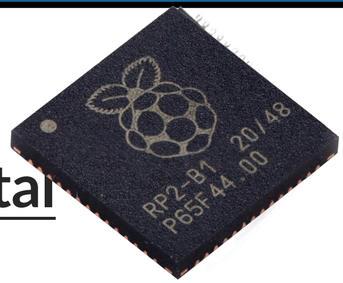


- RP2040 is a **low-cost**, **high-performance** microcontroller device with **flexible digital interfaces**:
  - ➢ **Dual ARM Cortex-M0+** @ **133MHz**
  - ➢ **264kB** on-chip **SRAM** in **six** independent banks →*Data Memory*
  - ➢ **16kB ROM** →*Program Memory*
  - ➢ Support for up to **16MB** of **off-chip Flash memory** via dedicated **Q-SPI** (Quad Serial Peripheral Interface) bus

    Remember the extra off-chip flash memory in the Arduino (16KB) and the Pico (2KB)
  - ➢ Direct Memory Access (DMA) Controller

The RP2040

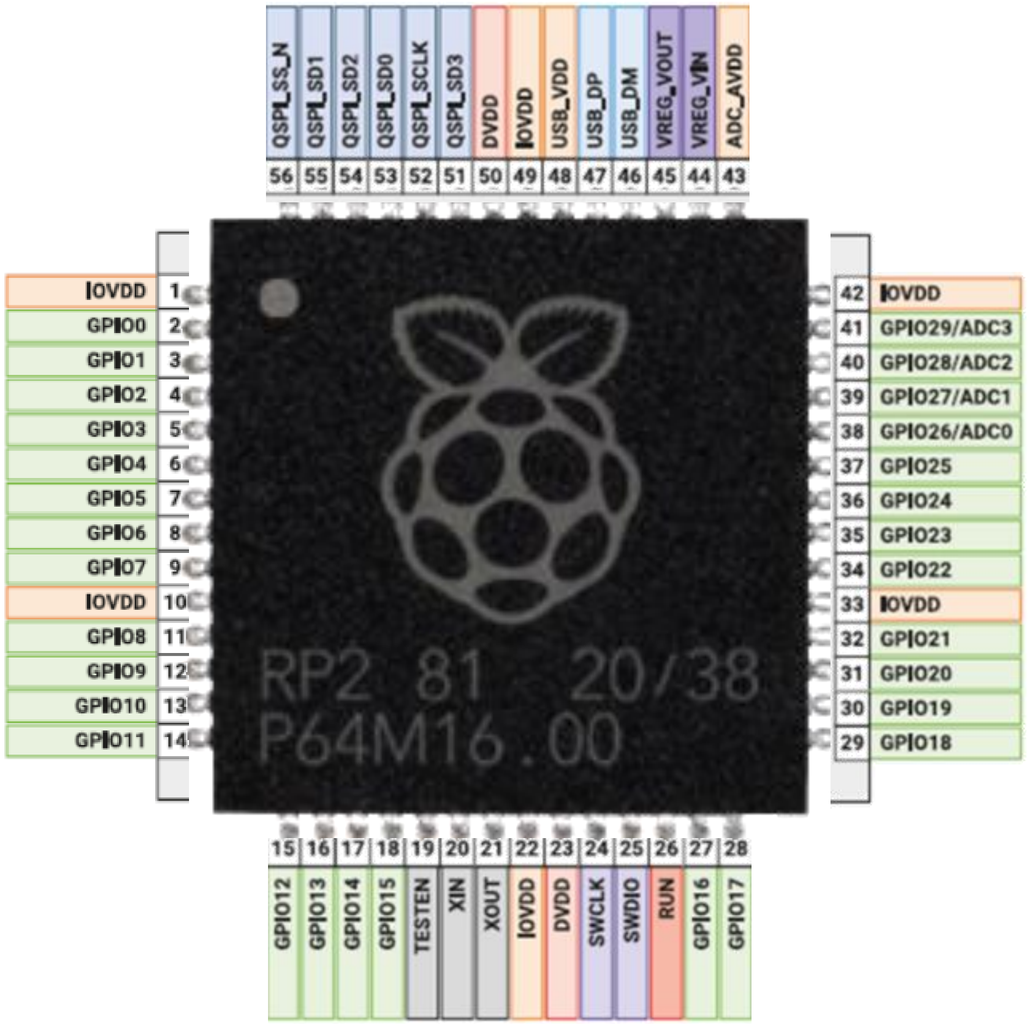
Key Features



- RP2040 is a **low-cost**, **high-performance** microcontroller device with **flexible digital interfaces**:
  - **30 GPIO** pins, 4 of which can be used as **analogue inputs** → *WHY?*
  - 4 channel ADC with internal temperature sensor, **500ksps** (KSamples Per Seconds), **12-bit conversion**

    We will get back to the ADC & AREF in the upcoming lectures ☺
  - **Peripherals:**
    - 2 UARTs
    - 2 SPI controllers
    - 2 I2C controllers
    - 16 PWM channels
    - USB 1.1 controller and PHY, with host and device support
    - 8 PIO state machines

System Overview of the RP2040 Chip



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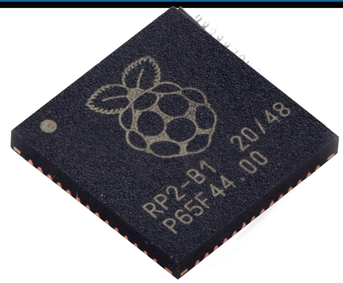

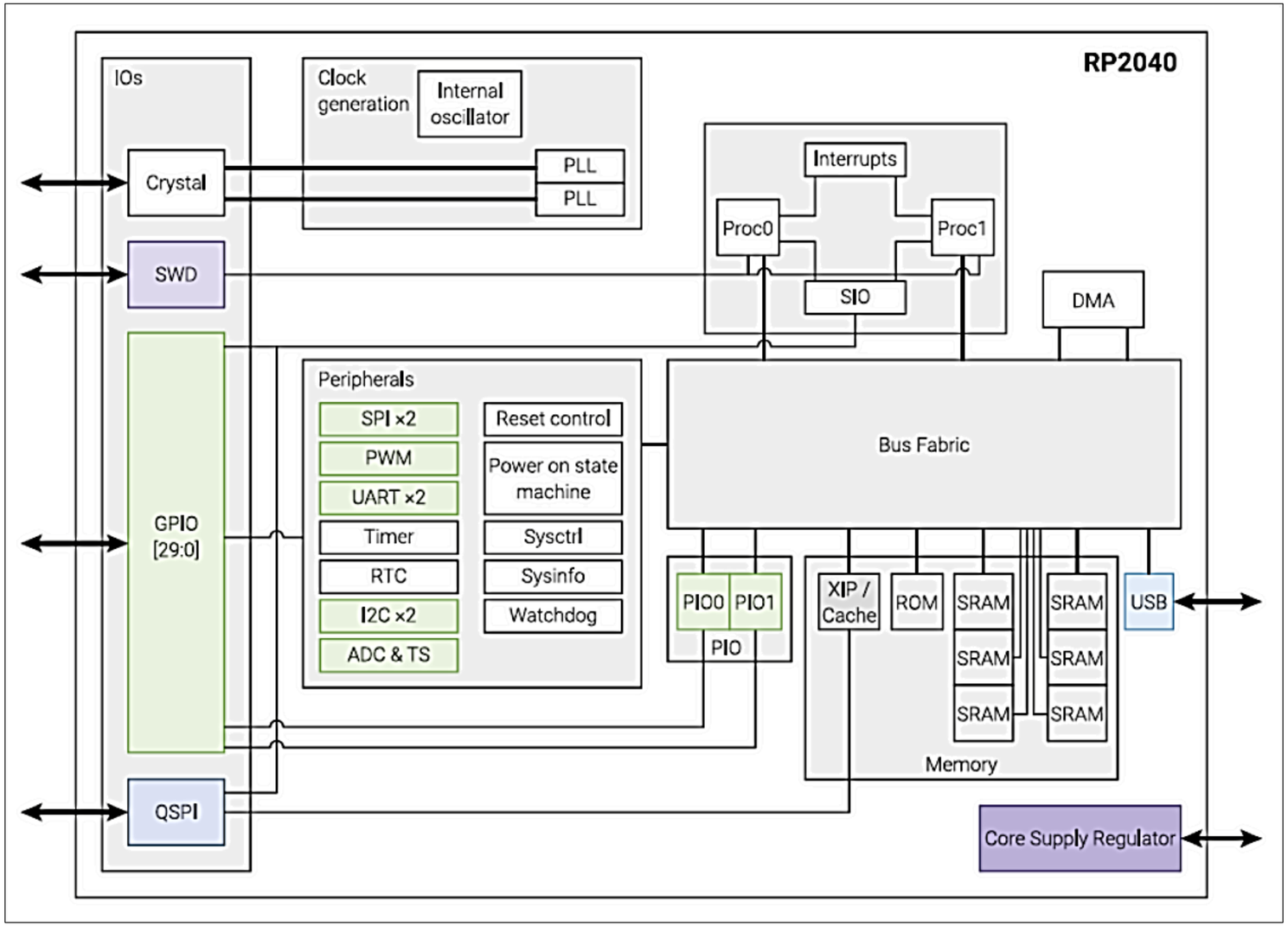

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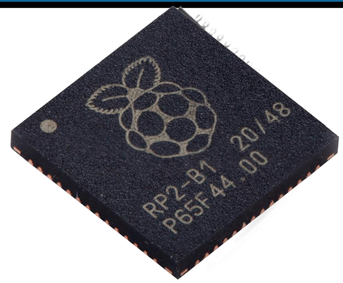

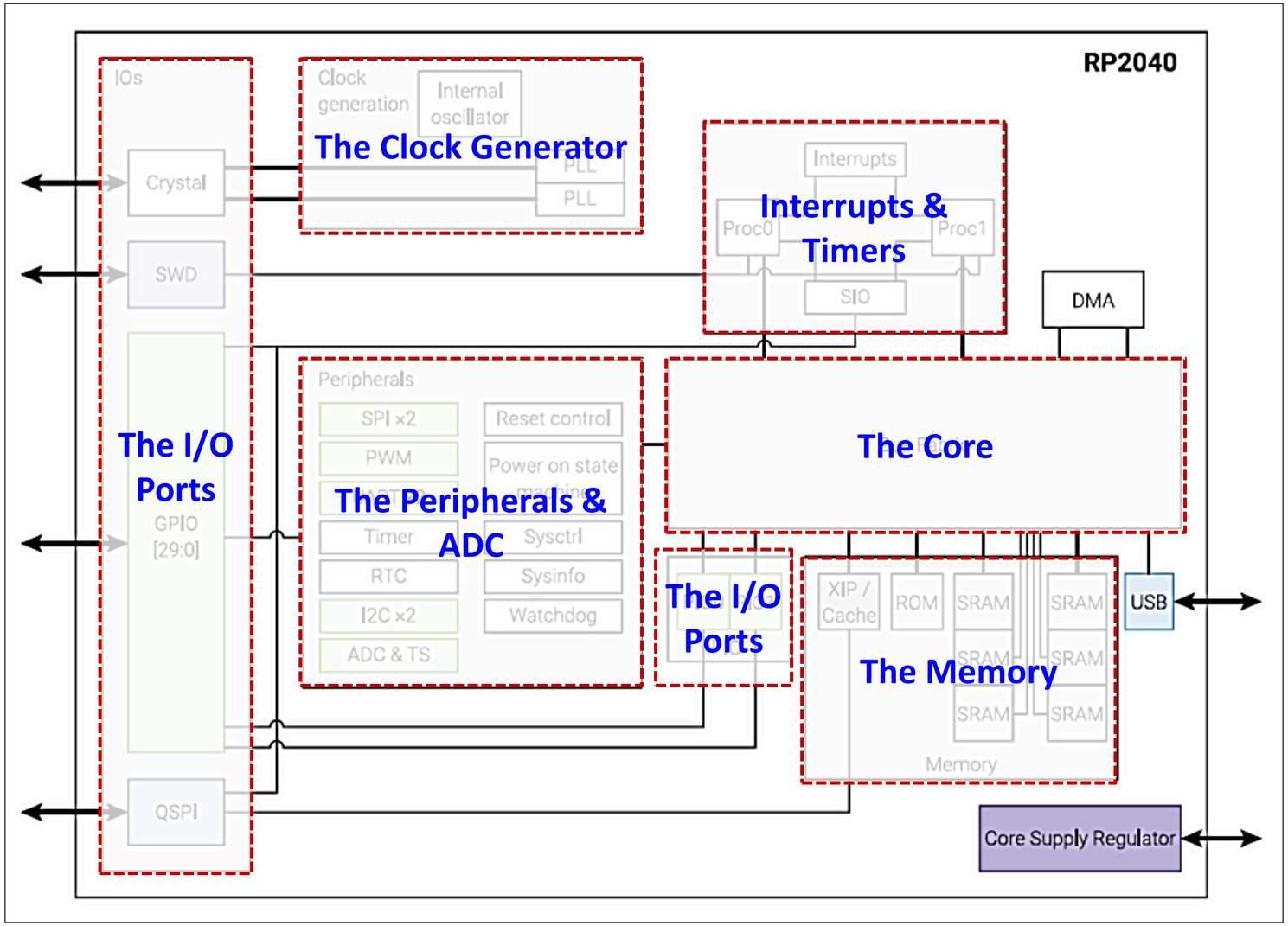

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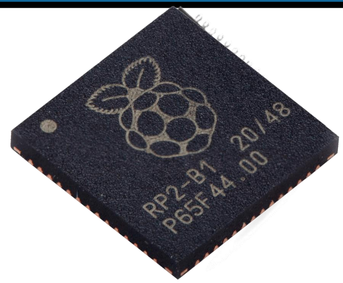

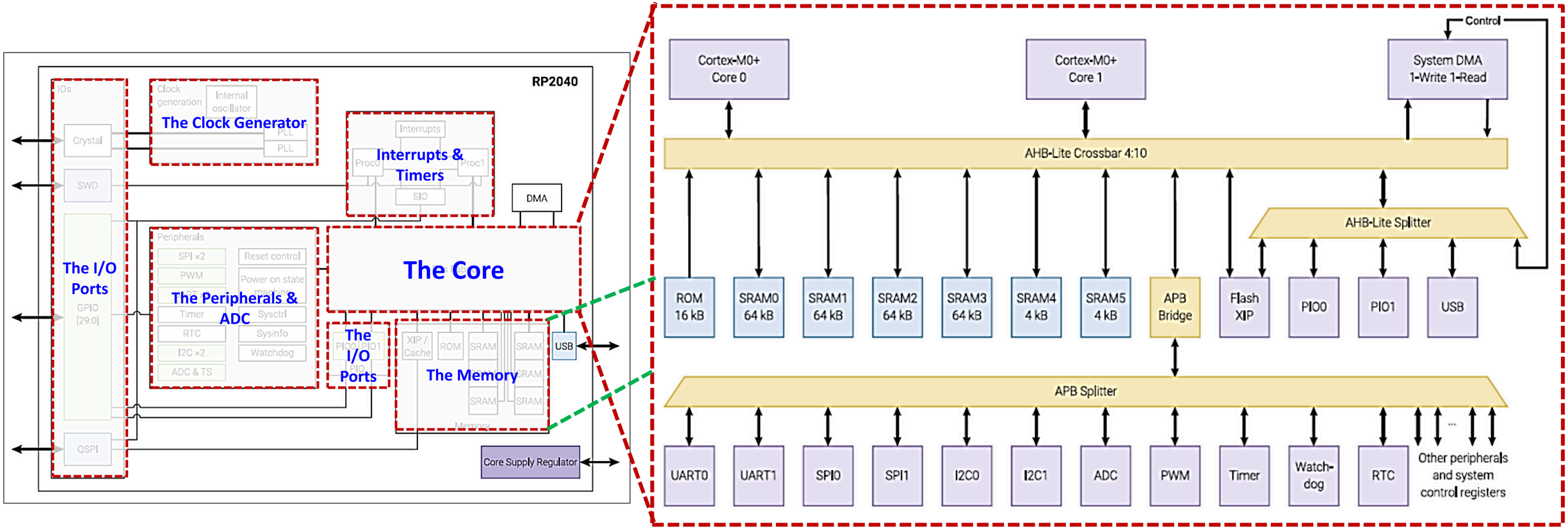

The RP2040

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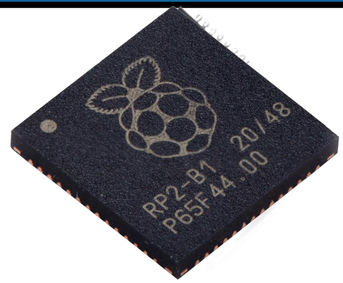

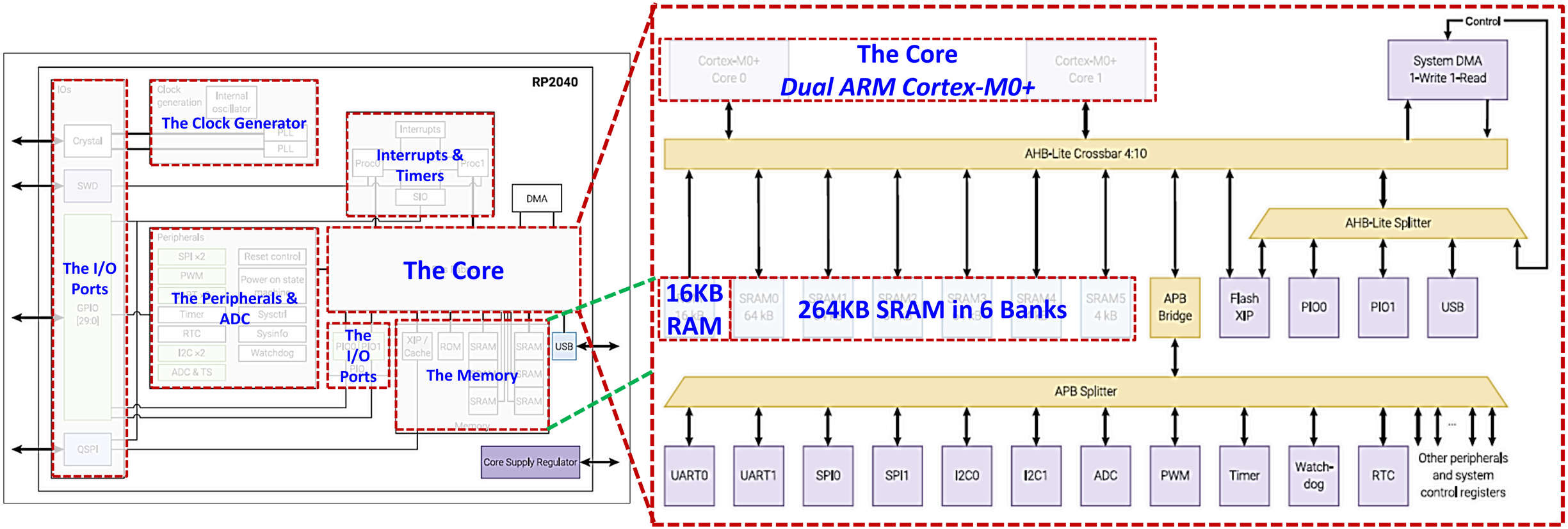

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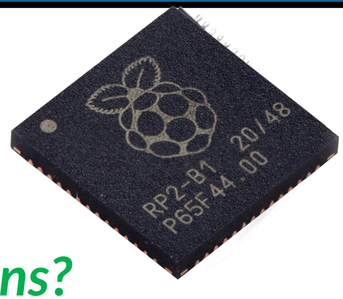
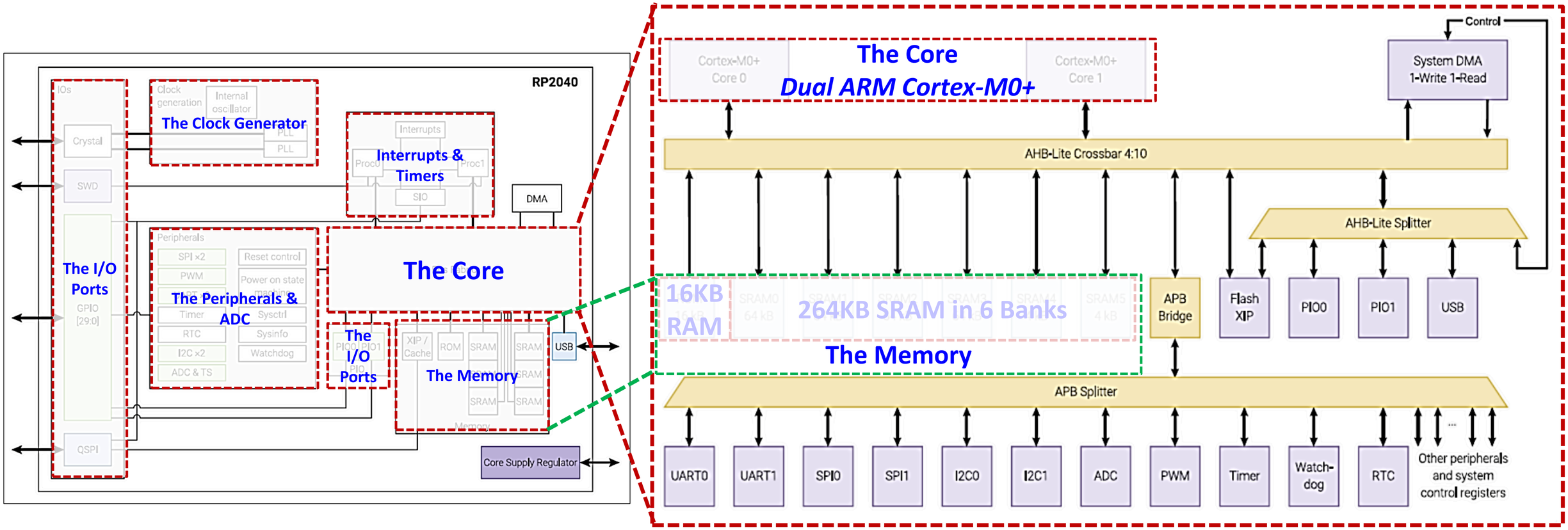


Any Observations?



The RP2040

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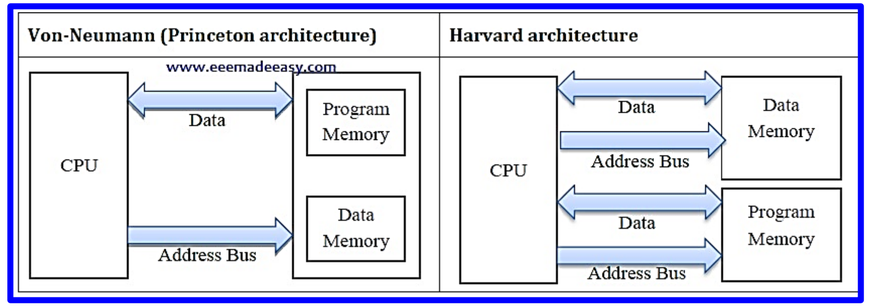

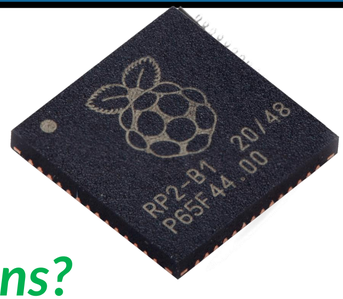

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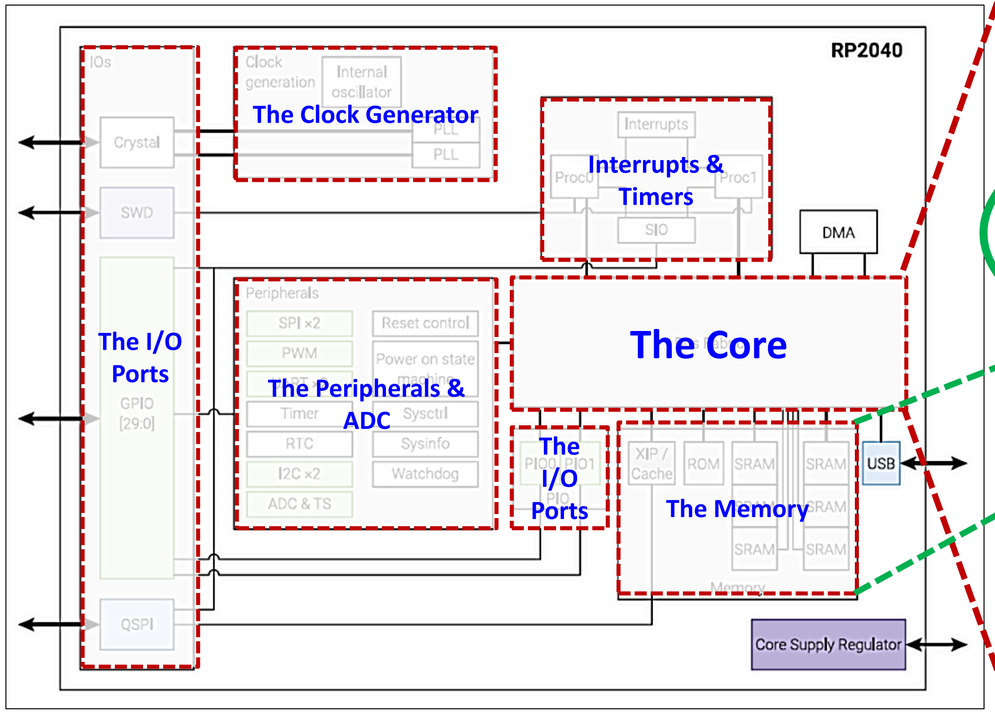

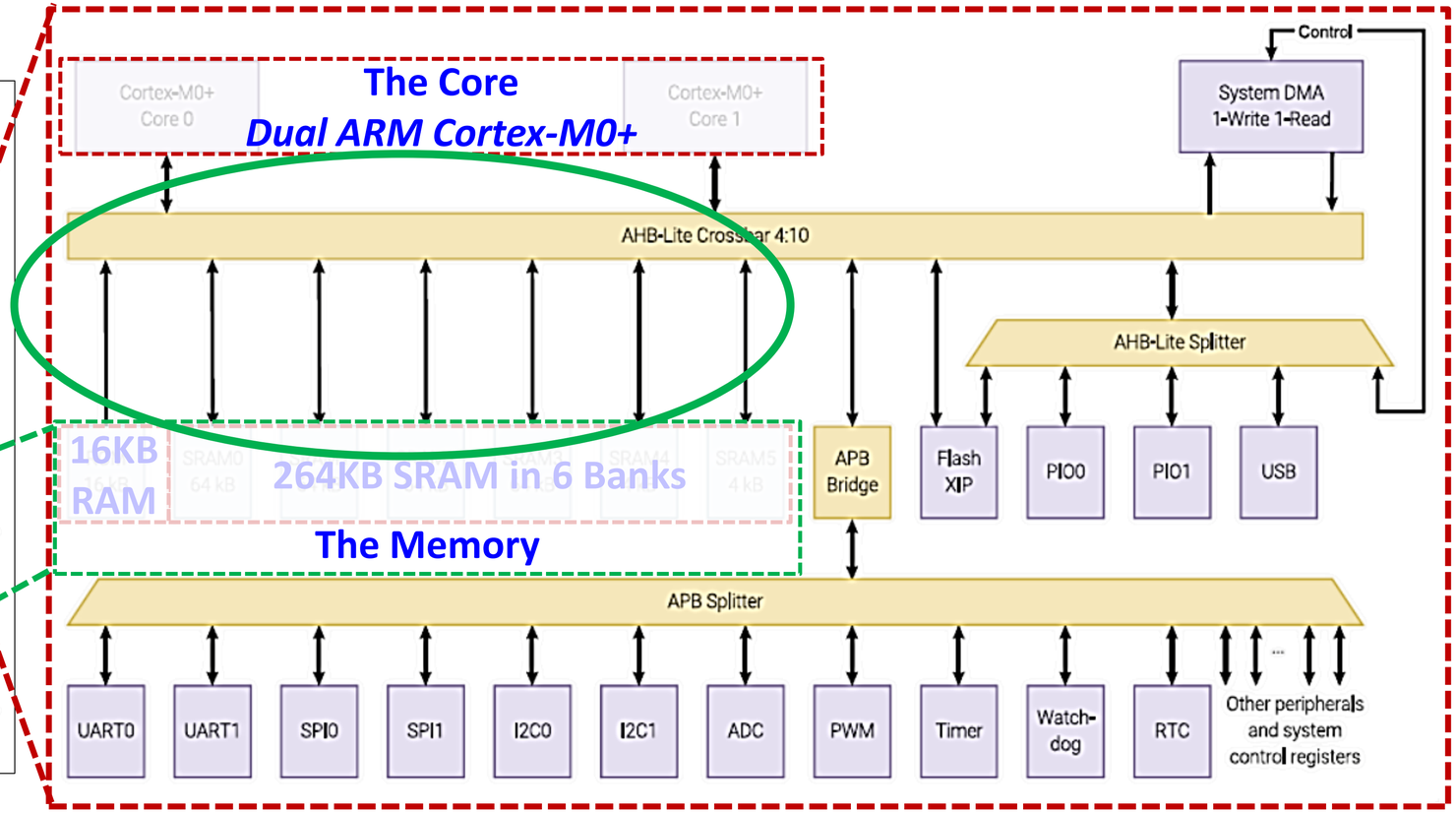

For Further Inquiries, Please send an email

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Catherine.elias@ieee.org

Thank you for your attention!

See you next time ☺