



# **Microprocessors & Microcontrollers**

## **: Arm Cortex M0+**

### **(Using RP2040)**

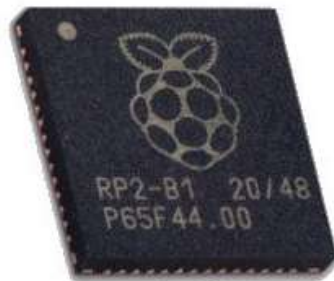
**ESM10**

Introduction to RP2040

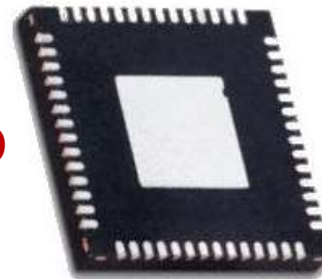
# Focus

- System Overview of RP2040
  - Introduction
  - Components
  - System Overview
  - Specification
  - Pin Details
  - ROM/RAM Details
  - Nomenclature
  - Feature Summary

# RP2040 (Introduction)



**RP2040**



**56 pin SMD**

**SMD: Surface Mounted Device**

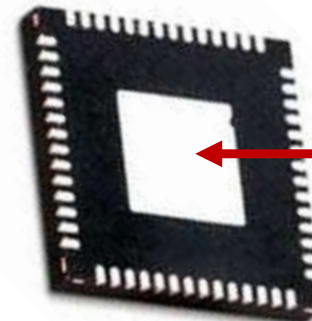
# RP2040: Chip



**SMD:**  
Surface  
Mounted  
Device



Front side

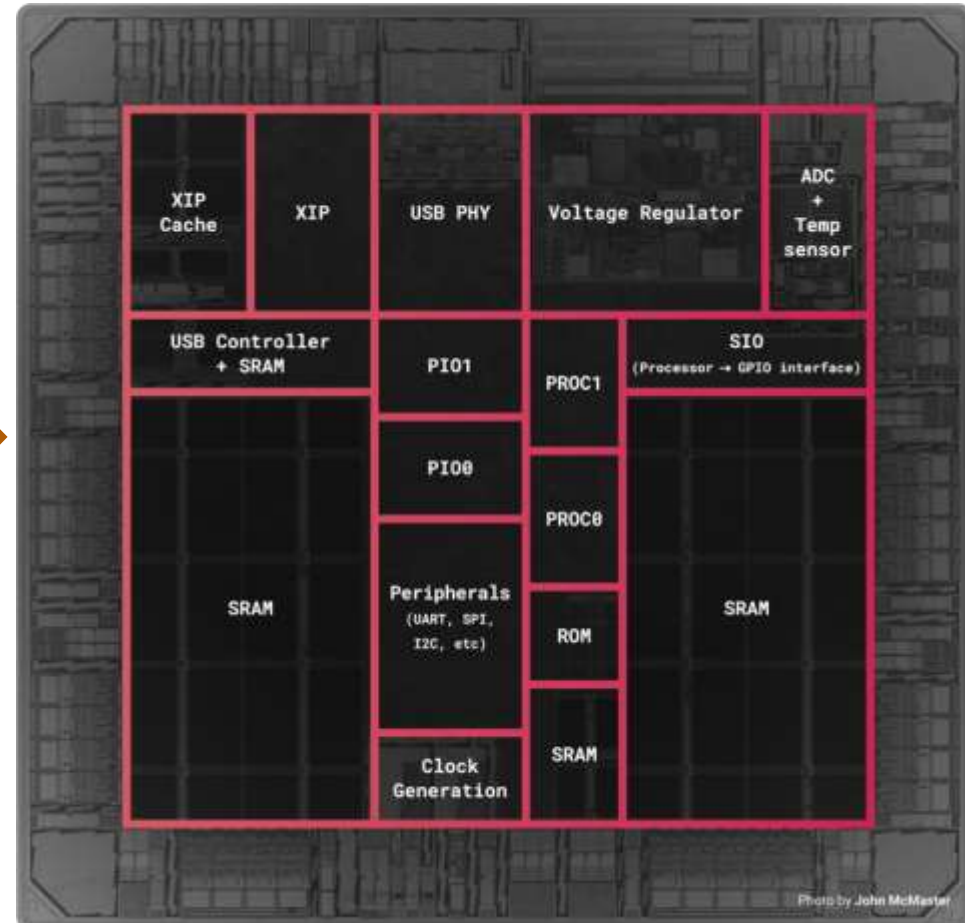
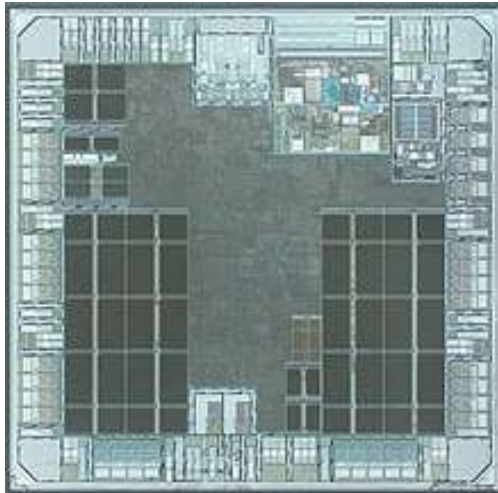


Back side

**GND**



# RP2040: Die Layout



[Ref Link: RP2040 Die](#)

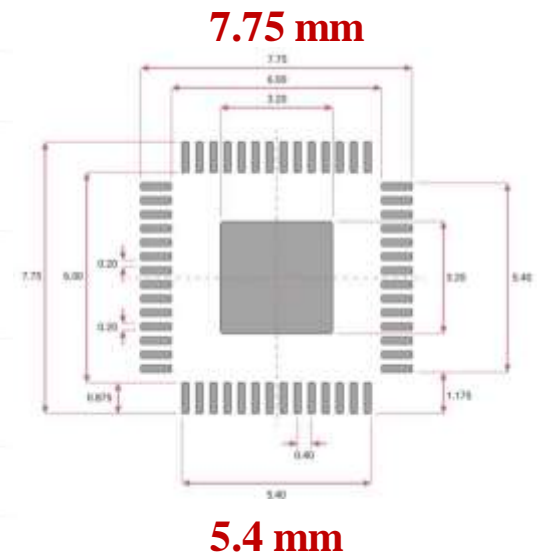
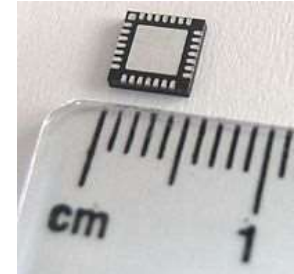


# RP2040 (Introduction)

# RP2040: Specification

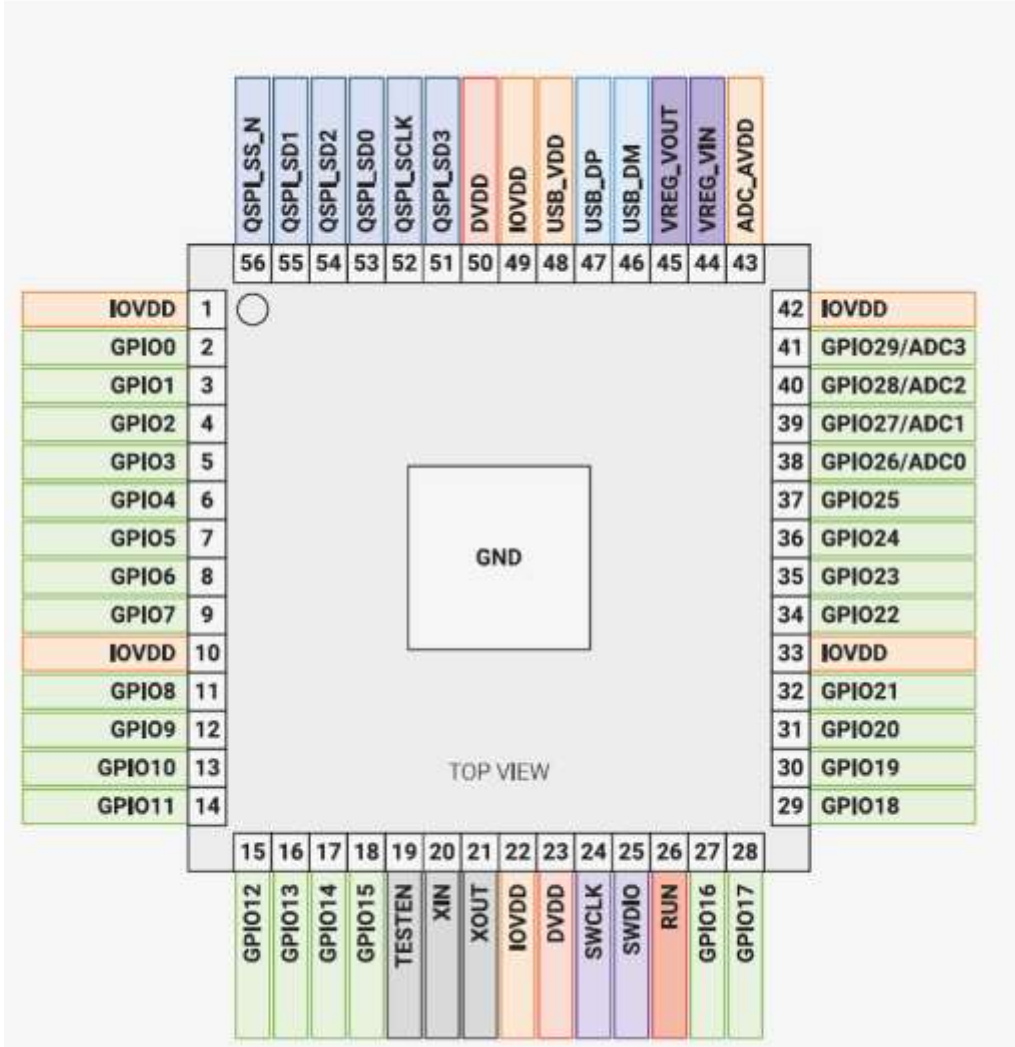
Brand	Raspberry Pi	Family Name	ARM
Package Type	QFN	Mounting Type	Surface Mount
Pin Count	56	Device Core	ARM Cortex M0+
Data Bus Width	32bit	Program Memory Size	16 MB
Maximum Frequency	133MHz	RAM Size	264 kB
USB Channels	1 x Device, 1 x Host	Number of PWM Units	2 x 32 bit
Number of SPI Channels	2	Typical Operating Supply Voltage	3.63 V
Height	0.9mm	Width	7.75mm
Minimum Operating Temperature	-20 °C	Dimensions	7 x 7 x 0.9mm
Instruction Set Architecture	RISC	Number of ADC Units	1
Maximum Operating Temperature	+85 °C	Number of UART Channels	2
Program Memory Type	Flash	Length	7.75mm
ADCs	4 x 12 bit	Number of Timers	4
Number of I2C Channels	2	Country of Origin	TW

**QFN: Quad-Flat No-leads**



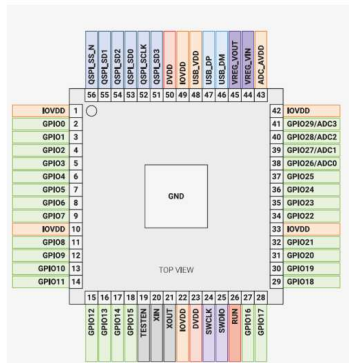
**TW: Taiwan**

## RP2040: Pin Details





# RP2040: Pin Details



GPIOx

### General-purpose digital input and output

GPIOx/ADCy

General-purpose digital input and output, with analogue-to-digital converter function

QSPix

Interface to an SPI, Dual-SPI or Quad-SPI Flash device, with execute-in-place support

## USB\_DM and USB\_DP

USB controller, supporting full-speed device and full-/low-speed host

## XIN and XOUT

### Connect a crystal to RP2040's crystal oscillator

**RUN**

Global asynchronous reset pin; reset when driven low, run when driven high

## SWCLK and SWDIO

Access to the internal Serial Wire Debug multi-drop bus; provides debug access to both processors

## TESTEN

Factory test mode pin

**GND**

Single external ground connection, bonded to a number of internal ground pads on the RP2040 die

IOVDD

Power supply for digital GPIOs, nominal voltage 1.8 V to 3.3 V

USB\_VDD

Power supply for internal internal USB full-speed PHY, nominal voltage 3.3 V

ADC\_AVDD

Power supply for analogue-to-digital converter, nominal voltage 3.3 V

VREG\_VIN

Power input for the internal core voltage regulator, nominal voltage 1.8 V to 3.3 V

VREG\_VOUT


Power output for the internal core voltage regulator, nominal voltage 1.1 V,  
100 mA max current

DVDD

Digital core power supply, nominal voltage 1.1 V

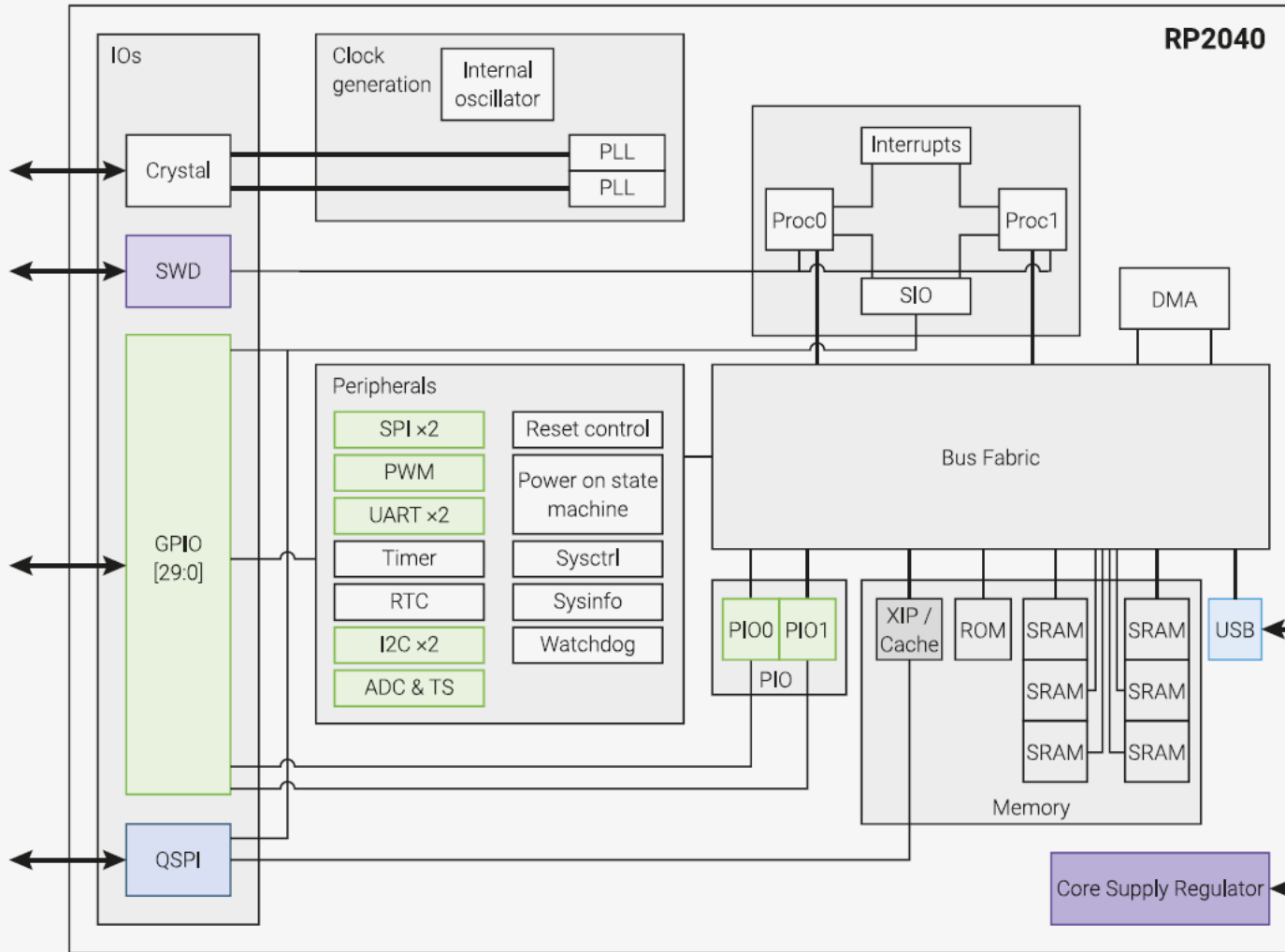
## Flash type: NOR Flash

Ref: RP2040 Product Brief



# RP2040 (System Overview)

# RP2040: System Overview



**PLL:** Phase Locked Loop

**SIO:** Single-cycle IO

**SPI:** Serial Peripheral Interface

**QSPI:** Quad SPI

**XIP:** Execute In Place

**SRAM:** 264 kB in 6 independent banks

**GPIO:** General Purpose IO

**UART:** Universal Asynchronous Receive/Transmit

**PWM:** Pulse Width Modulator

**RTC:** Real-time Clock

**I<sup>2</sup>C:** Inter-Integrated Circuit

**ADC:** Analog-to-Digital Converter

**SWD:** Serial Wire Debug    **PIO:** Programmable I/O    **DMA:** Direct Memory Access

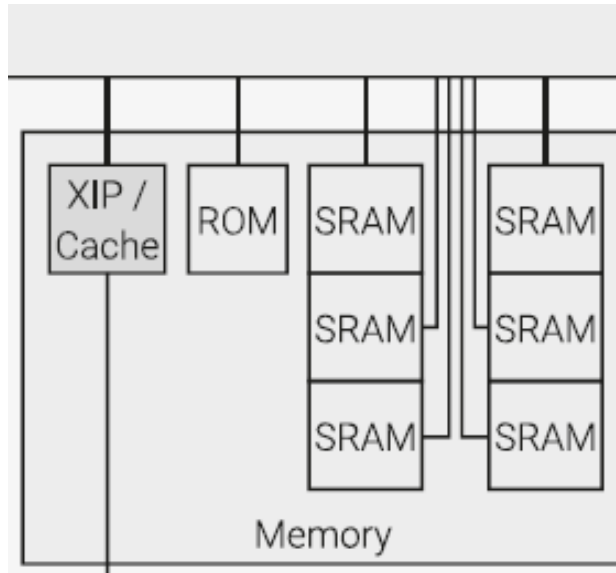
# RP2040: Key Features

CPU:	Dual ARM Cortex-M0+ @ 133 MHz	<b>LDO:</b>
Memory:	264kB on-chip SRAM in six independent banks Support for up to 16MB of off-chip Flash memory via dedicated QSPI bus	<b>Linear</b>
Architecture:	DMA controller Fully connected AHB crossbar Interpolator and integer divider peripherals On-chip programmable LDO to generate core voltage Two on-chip PLLs to generate USB and core clocks	<b>Low-Dropout</b>
Interfacing:	30 GPIO pins, four of which can be used as analogue inputs	<b>Regulator</b>
Peripherals:	2 × UARTs 2 × SPI controllers 2 × I2C controllers 16 × PWM channels 1 × USB 1.1 controller and PHY, with host and device support 8 × PIO state machines	<b>AHB:</b>
Package:	7 × 7 mm QFN-56 package	<b>Advanced</b>
Product lifetime:	Raspberry Pi understands the value to customers of long term availability of product and therefore aims to continue supply for as long as practically possible. We expect RP2040 to remain in production until at least January 2041.	<b>High Performance</b>
		<b>Bus</b>

Ref: RP2040 Product Brief



# RP2040: ROM/RAM Details



**ROM: 16 kB**

**Internal SRAM: 264 kB**

There are 6 banks: 256 kB + 8 kB

**4 banks: 64 kB each = 256 kB**

**2 banks: 4 kB each = 8 kB**

**Additional RAM**

**XIP/Cache: 16 kB**

If USB is not used: **4 kB**

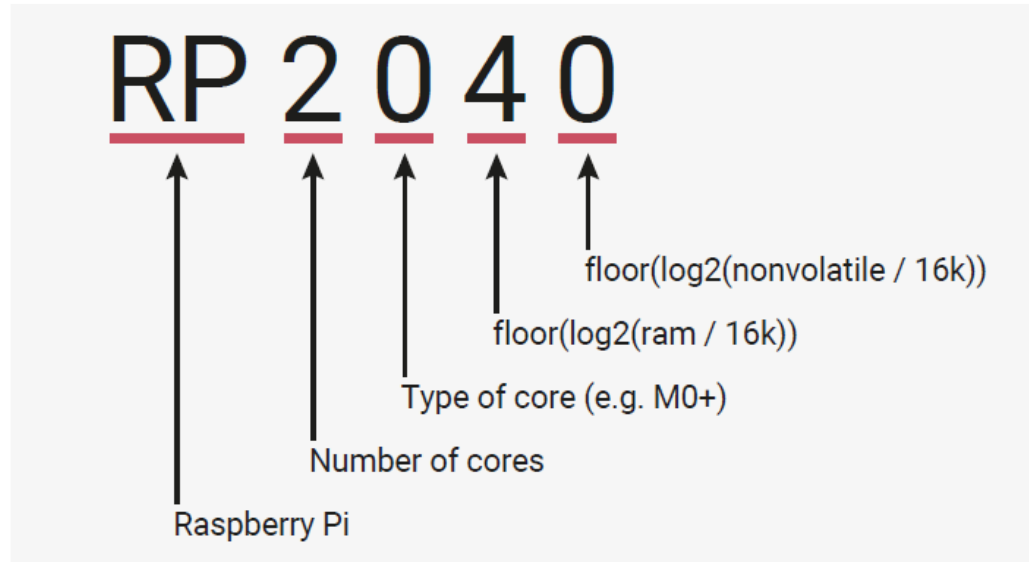
**Thus, Max total RAM:  $264 + 16 + 4 = 284$  kB**

**XIP: Execute In Place**



# RP2040 (Nomenclature)

# RP2040: Nomenclature

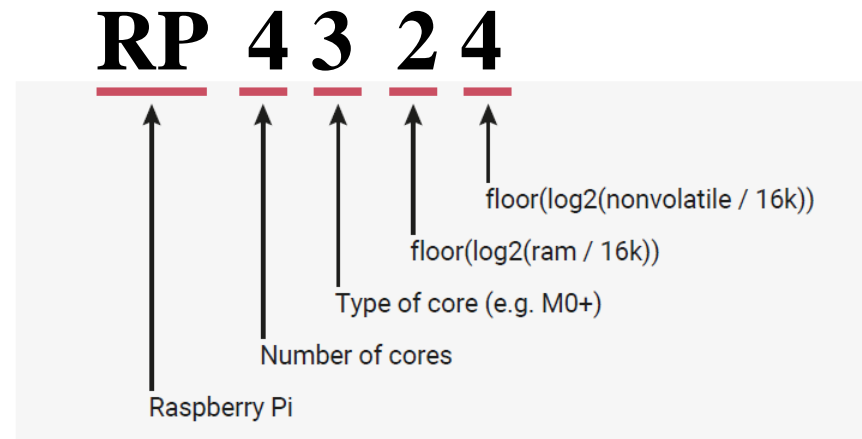


- Number of processor cores (**2**)
- Type of processor (M**0**+)
- floor(log<sub>2</sub>(ram / 16k)) ⇒ SRAM = 264k ⇒ log<sub>2</sub>(264k / 16k) ⇒ floor(log<sub>2</sub>(16.5)) ⇒ **4**
- floor(log<sub>2</sub>(nonvolatile / 16k)) or **0** if no onboard nonvolatile storage

**Note:** 16MB of flash is external to RP2040 and not part of the SoC

# Quiz 1: Nomenclature

Q. Find the configuration of this chip if the name is given as here.



**ANS:**

- Number of processor cores (**4**)
- Type of processor (M**3**) : **Cortex M3**
- $\text{floor}(\log_2(\text{ram} / 16\text{k})) \Rightarrow 2 \Rightarrow \text{floor}(\log_2(2^2)) \Rightarrow (\text{RAM size} / 16\text{k}) \rightarrow 4$   
 $\Rightarrow \text{RAM size} \rightarrow 4 * 16\text{k} \rightarrow \textbf{64k}$
- $\text{floor}(\log_2(\text{nonvolatile} / 16\text{k})) \rightarrow 4 \Rightarrow \text{floor}(\log_2(2^4)) \Rightarrow (\text{Flash size} / 16\text{k}) \rightarrow 16$   
 $\Rightarrow \text{Built-in Flash Size} \rightarrow 16 * 16\text{k} \rightarrow \textbf{256k}$



## RP2040: Feature Summary

- Dual-core Arm Cortex-M0+ @ 133MHz
- 264KB of on-chip RAM
- Support for up to 16MB of off-chip Flash memory via dedicated QSPI bus
- DMA controller
- Interpolator and integer divider peripherals
- 30 GPIO pins, 4 of which can be used as analogue inputs
- $2 \times$  UARTs,  $2 \times$  SPI controllers, and  $2 \times$  I<sup>2</sup>C controllers
- $8 \times$  Raspberry Pi Programmable I/O (PIO) state machines
- Accurate clock and timer on-chip
- Temperature sensor
- $16 \times$  PWM channels
- $1 \times$  USB 1.1 controller and PHY, with host and device support
- Accelerated floating-point libraries on-chip
- USB mass-storage boot mode with UF2 support, for drag-and-drop programming

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