EMBEDDED SYSTEMS PROGRAMMING

PRACTICUM 8

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1. **Raspberry Pi Pico**

   Raspberry Pi Pico is a tiny, fast, and versatile board built using RP2040, a brand new microcontroller chip designed by Raspberry Pi in the UK. Designed by Raspberry Pi, RP2040 features a dual-core Arm Cortex-M0+ processor with 264KB internal RAM and support for up to 16MB of off-chip Flash. A wide range of flexible I/O options includes I2C, SPI, and — uniquely — Programmable I/O (PIO). These support endless possible applications for this small and affordable package.

   From controlling appliances to operating a light display, Raspberry Pi Pico puts the technology that underpins countless everyday operations into your hands. Programmable in C and MicroPython, Pico is adaptable to a vast range of applications and skill levels, and getting started is as easy as dragging and dropping a file. More experienced users can take advantage of Raspberry Pi Pico's rich peripheral set, including SPI, I2C, and eight Programmable I/O (PIO) state machines for custom peripheral support.

   Specification

   - 21 mm × 51 mm form factor
   - RP2040 microcontroller chip designed by Raspberry Pi in the UK
   - Dual-core Arm Cortex-M0+ processor, flexible clock running up to 133 MHz
   - 264KB on-chip SRAM
   - 2MB on-board QSPI Flash
   - 26 multifunction GPIO pins, including 3 analogue inputs
   - 2 × UART, 2 × SPI controllers, 2 × I2C controllers, 16 × PWM channels
   - 1 × USB 1.1 controller and PHY, with host and device support
   - 8 × Programmable I/O (PIO) state machines for custom peripheral support
   - Supported input power 1.8–5.5V DC
   - Operating temperature -20°C to +85°C
   - Castellated module allows soldering direct to carrier boards
   - Drag-and-drop programming using mass storage over USB
   - Low-power sleep and dormant modes
   - Accurate on-chip clock
   - Temperature sensor

- Accelerated integer and floating-point libraries on-chip

2. **Raspberry Pi 4**

   The speed and performance of the new Raspberry Pi 4 is a step up from earlier models. For the first time, it is built a complete desktop experience. Whether editing documents, browsing the web with a bunch of tabs open, juggling spreadsheets or drafting a presentation, it will find the experience smooth and very recognisable — but on a smaller, more energy-efficient and much more cost-effective machine.

   The fanless, energy-efficient Raspberry Pi runs silently and uses far less power than other computers. Raspberry Pi 4 comes with Gigabit Ethernet, along with onboard wireless networking and Bluetooth. The new Raspberry Pi 4 has upgraded USB capacity: along with two USB 2 ports it will find two USB 3 ports, which can transfer data up to ten times faster. They're making different variants of the Raspberry Pi 4 available, depending on how much RAM you need — 2GB, 4GB, or 8GB.

   Specifications

   - Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
   - 2GB, 4GB or 8GB LPDDR4-3200 SDRAM (depending on model)
   - GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE
   - Gigabit Ethernet
   - 2 USB 3.0 ports; 2 USB 2.0 ports.
   - Raspberry Pi standard 40 pin GPIO header (fully backwards compatible with previous boards)
   - 2 × micro-HDMI ports (up to 4kp60 supported)
   - 2-lane MIPI DSI display port
   - 2-lane MIPI CSI camera port
   - 4-pole stereo audio and composite video port
   - H.265 (4kp60 decode), H264 (1080p60 decode, 1080p30 encode)
   - OpenGL ES 3.1, Vulkan 1.0
   - Micro-SD card slot for loading operating system and data storage
   - 5V DC via USB-C connector (minimum 3A*)

- 5V DC via GPIO header (minimum 3A*)
- Power over Ethernet (PoE) enabled (requires separate PoE HAT)
- Operating temperature: 0 – 50 degrees C ambient

* A good quality 2.5A power supply can be used if downstream USB peripherals consume less than 500mA in total.

3. **Raspberry Pi 3 Model A+**

   1.4GHz 64-bit quad-core processor, dual-band wireless LAN, Bluetooth 4.2/BLE in the same mechanical format as the Raspberry Pi 1 Model A+.

   Specifications

   The Raspberry Pi 3 Model A+ extends the Raspberry Pi 3 range into the A+ board format.

   - Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz
   - 512MB LPDDR2 SDRAM
   - 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2/BLE
   - Extended 40-pin GPIO header
   - Full-size HDMI
   - Single USB 2.0 ports
   - CSI camera port for connecting a Raspberry Pi Camera Module
   - DSI display port for connecting a Raspberry Pi Touch Display
   - 4-pole stereo output and composite video port
   - Micro SD port for loading your operating system and storing data
   - 5V/2.5A DC power input

4. **Raspberry Pi 3 Model B+**

   The final revision of the third-generation single-board computer. 1.4GHz 64-bit quad-core processor, dual-band wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and Power-over-Ethernet support (with separate PoE HAT).

   Specification

   The Raspberry Pi 3 Model B+ is the final revision in the Raspberry Pi 3 range.

   - Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz

- 1GB LPDDR2 SDRAM
- 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE
- Gigabit Ethernet over USB 2.0 (maximum throughput 300 Mbps)
- Extended 40-pin GPIO header
- Full-size HDMI
- 4 USB 2.0 ports
- CSI camera port for connecting a Raspberry Pi camera
- DSI display port for connecting a Raspberry Pi touchscreen display
- 4-pole stereo output and composite video port
- Micro SD port for loading your operating system and storing data
- 5V/2.5A DC power input
- Power-over-Ethernet (PoE) support (requires separate PoE HAT)

5. **Raspberry Pi 3 Model B**

   Single-board computer with wireless LAN and Bluetooth connectivity.

   Specification

   The Raspberry Pi 3 Model B is the earliest model of the third-generation Raspberry Pi. It replaced the Raspberry Pi 2 Model B in February 2016. See also the Raspberry Pi 3 Model B+, the latest product in the Raspberry Pi 3 range.

   - Quad Core 1.2GHz Broadcom BCM2837 64bit CPU
   - 1GB RAM
   - BCM43438 wireless LAN and Bluetooth Low Energy (BLE) on board
   - 100 Base Ethernet
   - 40-pin extended GPIO
   - 4 USB 2 ports
   - 4 Pole stereo output and composite video port
   - Full size HDMI
   - CSI camera port for connecting a Raspberry Pi camera
   - DSI display port for connecting a Raspberry Pi touchscreen display
   - Micro SD port for loading your operating system and storing data
   - Upgraded switched Micro USB power source up to 2.5A

6. **Raspberry Pi 2 Model B**

The Raspberry Pi 2 Model B is the second-generation Raspberry Pi. It replaced the original Raspberry Pi 1 Model B+ in February 2015.

Specification

Compared to the Raspberry Pi 1 it has:

- A 900MHz quad-core ARM Cortex-A7 CPU
- 1GB RAM

Like the (Pi 1) Model B+, it also has:

- 100 Base Ethernet
- 4 USB ports
- 40 GPIO pins
- Full HDMI port
- Combined 3.5mm audio jack and composite video
- Camera interface (CSI)
- Display interface (DSI)
- Micro SD card slot
- VideoCore IV 3D graphics core

7. **Raspberry Pi 1 Model B+**

The Model B+ is the final revision of the original Raspberry Pi. It replaced the Model B in July 2014 and was superseded by the Raspberry Pi 2 Model B.

Specification

Compared to the Model B it has:

- More GPIO pins. The GPIO header has grown to 40 pins, while retaining the same pinout for the first 26 pins as the Model A and B.
- More USB ports. It comes with 4 USB 2.0 ports, compared to 2 on the Model B, and better hotplug and overcurrent behaviour.
- Micro SD. The old friction-fit SD card socket has been replaced with a much nicer push-push micro SD version.
- 100 Base Ethernet (same as the original Model B)

- Lower power consumption. By replacing linear regulators with switching ones we've reduced power consumption by between 0.5W and 1W.
- Better audio. The audio circuit incorporates a dedicated low-noise power supply.
- Neater form factor. We've aligned the USB connectors with the board edge, moved composite video onto the 3.5mm jack, and added four squarely-placed mounting holes.

8. Raspberry Pi 1 Model A+

The Model A+ is the low-cost variant of the Raspberry Pi. It replaced the original Model A in November 2014.

Specification

Compared to the Model A it has:

- More GPIO pins. The GPIO header has grown to 40 pins, while retaining the same pinout for the first 26 pins as the Model A and B.
- Micro SD. The old friction-fit SD card socket has been replaced with a much nicer push-push micro SD version.
- Lower power consumption. By replacing linear regulators with switching ones we've reduced power consumption by between 0.5W and 1W.
- Better audio. The audio circuit incorporates a dedicated low-noise power supply.
- Smaller neater form factor. We've aligned the USB connector with the board edge, moved composite video onto the 3.5mm jack, and added four squarely-placed mounting holes. Model A+ is approximately 2cm shorter than the Model A.

9. Raspberry Pi Zero

The Raspberry Pi Zero is half the size of a Model A+, with twice the utility. A tiny Raspberry Pi that's affordable enough for any project!

Specifications

The Raspberry Pi Zero is half the size of a Model A+, with twice the utility. A tiny Raspberry Pi that's affordable enough for any project!

- 1GHz single-core CPU
- 512MB RAM
- Mini HDMI port
- Micro USB OTG port
- Micro USB power
- HAT-compatible 40-pin header
- Composite video and reset headers
- CSI camera connector (v1.3 only)

10. Raspberry Pi Zero W

The Raspberry Pi Zero W extends the Pi Zero family and comes with added wireless LAN and Bluetooth connectivity.

Specification

The Raspberry Pi Zero W extends the Pi Zero family. Launched at the end of February 2017, the Pi Zero W has all the functionality of the original Pi Zero, but comes with added connectivity, consisting of:

- 802.11 b/g/n wireless LAN
- Bluetooth 4.1
- Bluetooth Low Energy (BLE)

Like the Pi Zero, it also has:

- 1GHz, single-core CPU
- 512MB RAM
- Mini HDMI and USB On-The-Go ports
- Micro USB power
- HAT-compatible 40-pin header
- Composite video and reset headers
- CSI camera connector