Camemake CM_P4-A1-N16R32
Datasheet
Version 1.0

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1.1 Product introduction
CM_P4-A1-N16R32 is a compact compute module based on the Espressif ESP32-P4. The ESP32-P4 has two subsystems:

- High-performance system. Dual-core 32-bit RISC-V CPU up to 360 MHz. Multimedia and high-speed IO.
- Low-power system. Always-on controller for standby and wake logic.

The high-performance domain integrates:

- JPEG encoder and decoder
- Pixel Processing Accelerator (PPA)
- ISP
- H.264 video encoder
- Camera interface
- Display interface
- Audio interfaces

This allows local image processing, video streaming, and voice processing without an external application processor.

The module integrates 16 MB Flash and 32 MB PSRAM on board.
Module size is 25.00 mm × 20.00 mm.

CM_P4-A1-N16R32 = Flash 16 MB + PSRAM 32 MB variant.

1.2 Key features

- ESP32-P4 application processor
- Dual-core 32-bit RISC-V up to 360 MHz
- Low-power controller for always-on tasks
- 16 MB Flash + 32 MB PSRAM on module
- MIPI CSI-2 camera input
- MIPI DSI display output
- Parallel camera / display interface
- USB 2.0 OTG High-Speed and Full-Speed
- Integrated 10/100 Ethernet MAC (RMII)
- CAN / TWAI
- SDIO
- I^2C / I3C / SPI / UART / I^2S / PWM / ADC / touch sense

- 55+ GPIO
- Operating temperature −40 °C to +85 °C
- Single 5 V supply
- 25.00 mm × 20.00 mm footprint

1.3 Module photos
Top and bottom views show the ESP32-P4 package, memory, and dual header rows. All high-speed camera, display, USB, and RMII pins are routed to the board edge for ease of baseboard design.

1.4 Application scenarios

- Human Machine Interface (HMI) panels
- Smart control panels
- Industrial automation controllers
- Robot main board
- Edge vision node (camera in, stream out)
- Multimedia IoT terminal
- USB-connected embedded product

2. Product specification

2.1 Block diagram
High-performance RISC-V cores + multimedia accelerators + external Flash + external PSRAM.
Interfaces exposed to the baseboard:

- MIPI CSI-2 (camera)
- MIPI DSI (display)
- USB 2.0 OTG HS / FS
- RMII Ethernet MAC
- CAN / TWAI
- SDIO
- SPI / UART / I^2C / I3C / I^2S
- ADC / touch / PWM / timers
- 55+ GPIO

2.2 Hardware parameters

CPU

- SoC: ESP32-P4
- High-performance subsystem
    - Dual-core 32-bit RISC-V
    - Up to 360 MHz
- Low-power subsystem
    - Low-power controller core
    - Always-on domain

On-chip memory (ESP32-P4 internal)

- High-performance ROM: 128 KB
- Low-power ROM: 16 KB
- High-performance L2 memory: 768 KB
- Low-power SRAM: 32 KB
- Other peripheral SRAM regions present in HP and LP domains

External memory on module

- Flash: 16 MB
- PSRAM: 32 MB

Peripheral sets and I/O resources

- GPIO: 55+
- SPI: 2 high-performance SPI
- LP SPI: 1 low-power SPI
- UART: 5 high-performance UART
- LP UART: 1 low-power UART
- I^2C: 2 high-performance I^2C
- I3C: 1 I3C master
- LP I^2C: 1 low-power I^2C
- I^2S: 3 high-performance I^2S

- LP I^2S: 1 low-power I^2S
- SDIO: 1
- USB Serial / JTAG controller
- LED PWM controller
- MCPWM: 2 motor control PWM units
- CAN / TWAI controllers
- USB 2.0 OTG High-Speed
- USB 2.0 OTG Full-Speed
- 10/100 Ethernet MAC with RMII
- MIPI CSI-2 camera interface
- MIPI DSI display interface
- Parallel IO interface (camera or LCD panel)
- 12-bit ADC blocks
- On-chip temperature sensor
- Touch sensing channels on LP GPIO
- Analog comparator
- Brown-out detector

Multimedia acceleration

- JPEG codec
- Pixel Processing Accelerator (PPA)
- Image Signal Processor (ISP)
- H.264 encoder
  These blocks allow direct camera capture and encoding and display driving without an external MPU or GPU.

3. Pin definitions

3.1 Pin layout
The module uses two parallel through-hole / castellated style rows.
Total pins: 82.
Pins include power, ground, high-speed differential pairs for MIPI CSI and DSI, USB, Ethernet RMII, SDIO, UART0 for download, ADC, touch, and general GPIO.

3.2 Pin description (summary)
Below is a condensed list. Functions are primary function first, then alternates.

Power and ground

- VCC: 5 V module supply input. 4.8 V min. 5.0 V typ. 5.5 V max.
- GND: Ground return
- ESP_LDO_VO4: On-module regulated output rail.
    - 0.5 V to 2.7 V adjustable or fixed 3.3 V.
    - Up to 0.2 A available to the baseboard.

High-speed display (MIPI DSI)

- DSI_DATAP1 / DSI_DATAN1
- DSI_CLKP / DSI_CLKN
- DSI_DATAP0 / DSI_DATAN0

High-speed camera (MIPI CSI-2)

- CSI_DATAP0 / CSI_DATAN0
- CSI_CLKP / CSI_CLKN
- CSI_DATAP1 / CSI_DATAN1

USB

- USB_DM / USB_DP: High-speed USB 2.0 OTG differential pair
- Additional USB pins on GPIO24 / GPIO25 / GPIO26 / GPIO27 for Full-Speed OTG

Ethernet MAC RMII

- RMII clock
- PHY TXEN / TXD0 / TXD1 / TXER
- PHY RXDV / RXD0 / RXD1 / RXER

SDIO and storage

- SD1_CCMD_PAD
- SD1_CCLK_PAD
- SD1_CDATA0..7_PAD

Download / boot

- GPIO37 UART0_TXD (download)
- GPIO38 UART0_RXD (download)
- GPIO35 / GPIO36 strap pins for boot mode
    - SPI Boot
    - Joint Download Boot (USB / UART / SPI slave)

Audio and control

- I^2S lines on high-performance and low-power domains
- MCPWM for motor control
- Touch channels on LP_GPIOx

Analog

- ADC1_CHANNEL0..7
- ADC2_CHANNEL2..7
- Analog comparators

Note on boot straps

- GPIO35 pull up → normal SPI boot
- GPIO35 low + GPIO36 high → joint download boot
- GPIO34 selects JTAG source
  After boot these pins return to GPIO use.

3.3 Startup configuration

Boot mode
The ESP32-P4 samples GPIO35..GPIO38 at reset.
These strap levels select:

- SPI Boot (normal boot from SPI Flash)
- Joint Download Boot (USB, UART, etc)
  After reset the pins behave as normal IO.

ROM print control
The ROM can print early boot logs to UART0 and/or USB Serial JTAG.
This is controlled by strapping and eFuse options.

JTAG source
JTAG can come from classic JTAG pins or from USB Serial JTAG.
Selection is controlled by strapping and eFuse.

4. Electrical characteristics

4.1 Absolute maximum ratings
Stress beyond absolute maximum ratings may cause permanent damage.
Continuous use beyond these limits may reduce reliability.
(Values follow standard ESP32-P4 device class. Do not exceed 5.5 V on VCC.)

4.2 Power consumption
To be characterized.
Note: The main 5 V rail must be able to supply up to 1 A peak to the module and its regulators.

4.3 Recommended working conditions

- VCC: 4.8 V to 5.5 V
- IVCC (input current from baseboard 5 V rail): up to 1 A peak budget
- Ambient operating temperature: −40 °C to +85 °C

5. Reference schematic
   Typical baseboard connection includes:

- 5 V input rail to VCC
- USB connector routed to USB_DM / USB_DP
- RMII PHY connected to Ethernet pins
- Camera sensor routed to CSI
- Display panel routed to DSI
- Optional SD card or eMMC alternative via SDIO (note eMMC is not native)
- UART0 header for download and debug

Note: The original source marks “update soon” on the reference schematic. Treat as indicative.

6. Mechanical dimensions
   Module outline:

- 25.00 mm × 20.00 mm

- Height depends on connector stack and shielding height
  Tolerance ±0.2 mm on length and width.
  Two aligned pin rows suitable for vertical plug-in to a carrier board.

7. Storage conditions

- Store in sealed dry pack below 40 °C and below 90% RH (non condensing)
- After opening, use within 168 hours at 25 ± 5 °C and 60% RH
- Moisture Sensitivity Level (MSL): 3

8. Reflow profile
   Standard Pb-free SMT reflow.
   Typical profile:

- Preheat
- Soak
- Peak
- Controlled cool down
  Follow standard IPC/JEDEC Pb-free limits for peak temperature.