Introduction

The öchìn CM4 it's a tiny carrier board for the Raspberry Pi Compute Module 4. It is designed for applications where a powerful machine with low consumption and small dimensions is required. The small form factor makes it interesting for all those applications where the space available is not much and containing the weight is important, such as in robotics, home automation and IOT.

The board is compatible with all Raspberry Pi CM4 modules equipped with eMMC. Depending on your needs, you can select a CM4 module with an SDRAM starting from 1GB up to 8GB and the eMMC from 8GB up to 32GB, with or without the Wi-Fi / BT4 connection.

Key features of the Raspberry Pi CM4 available on öchìn are as follows:

- Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
- Small Footprint 55mm × 40mm × 4.7mm module
- H.265 (HEVC) (up to 4Kp60 decode), H.264 (up to 1080p60 decode, 1080p30 encode)
- OpenGL ES 3.0 graphics
- Options for 1GB, 2GB, 4GB or 8GB LPDDR4-3200 SDRAM with ECC
- Options for 8GB, 16GB, or 32GB eMMC Flash
  - Peak eMMC bandwidth 100MBytes/s
  - 2.4 GHz, 5.0 GHz IEEE 802.11 b/g/n/ac wireless
  - Bluetooth 5.0, BLE
  - On board electronic switch to select between PCB trace or external antenna
- 1 × USB 2.0 port (highspeed)
- MIPI CSI-2:
  - 1 × 2-lane MIPI CSI camera port, 1 × 4-lane MIPI CSI camera port
- 1 × USART, 3 × UART, 1 × I2C port, 1 × SPI port, Analog Video Output

Design

The board has the same dimensions as the RPi CM4 module, 55mm x 40mm with rounded corners. öchìn CM4 is composed of three parts, the carrier board itself and two covers, meant to protect the carrier board and the RPi CM4 module (to be purchased separately). The four cards thus form a stack of 18mm tall.
Several interfaces like USARTs, USBs are addressable bye the SM06B-GHS and SM04B-GHS connectors, available on the sides of the board. Two FCC/FPC connector are available to connect two MIPI CSI-2 cameras. The front camera is the "camera 1" which is a MIPI CSI-2 4lane camera. The side camera is the "camera 0" which is a MIPI CSI-2 2lane camera. The two FCC/FPC connectors have contacts on the bottom, the interface is the same used on the Raspberry Pi Zero.
On top of the board there is a 14x1.27mm connector, that could be used to connect a custom board on top, replacing the top PCB cover.
On the bottom of the öchìn carrier board there are the DF40HC(3.0)-100DS-0.4v mating connectors for the CM4 module. The bottom cover is meant to protect the boards and mount the whole stack. The bottom cover could be eventually replaced by a commercial heatsink for the CM4 module.

Applications

The powerful Quad core Cortex-A72 CPU and GPU, the big RAM size and the CODECs and Graphic Accelerators available on the CM4 makes the system very interesting for a huge number of applications. Are suitable all the applications related to audio / video manipulation and streaming, neural networks, machine learning, computer vision, etc.

There are several communication interfaces available on board that enables to connect the öchìn to external hardware to connect to the lower abstraction layers, closer to the physical world.

An example of use could be a drone, where a flight controller board sense the physical references and control the actuators and motors to guarantee the stability of the flight. It could handle the stability of the vehicle, collect the data from the sensors and from the remote control and send the telemetry data back to the ground station. This is a very common structure nowadays for a UAS. The öchìn board could be used to add a wide range of functionality to the system.
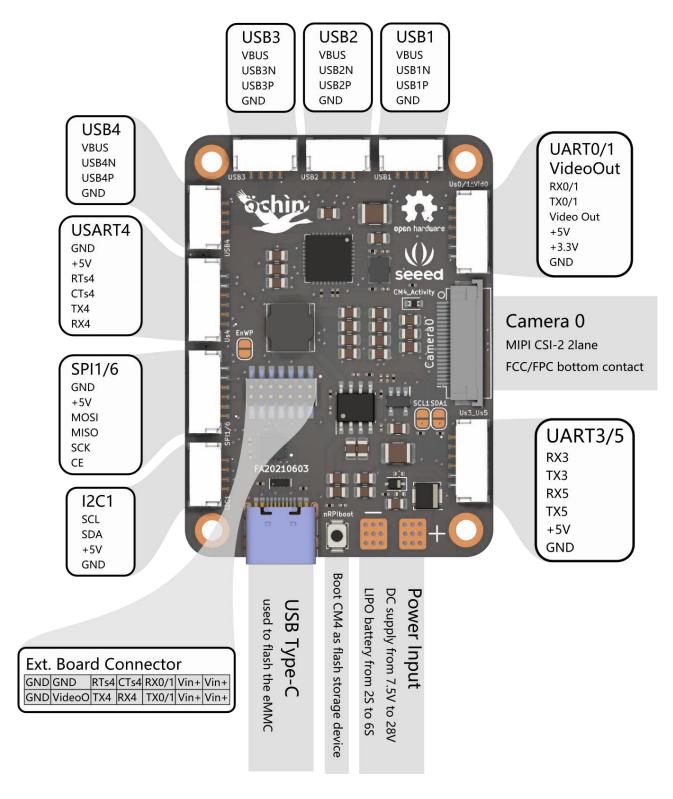
The öchìn could handles up two MIPI cameras and others connected to the USB interfaces. Other sensors could also be added to the öchìn using the UART, SPI, I2C interfaces. All those data could be processed by several threads running on the CM4. The software infrastructure available within the CM4 enables to code with C/C++, python, MATLAB, and several other languages. There is also a wide number of frameworks that can be used to develop algorithms with Deep Learning, Neural Networks or Computer Vision technique, such as OpenCV, Caffe, PyTorch, TensorFlow etc. The öchìn board also provide the analog video output from the CM4. It means that it's possible to create a video output from the whole set of data, including images and its elaboration, to transmit like a common analog video out. This is very convenient because it gives the chance to see the output of the processing in real time without taking care of creating a digital wireless bridge.

This is only an example, a similar structure could be though for rovers, submarines, airplanes and robots in general. Of course, the öchìn board it's very interesting for the IOT world also, where the size and weight is important. In this scenario, the AI is relevant and the tendency to miniaturize IOT devices and make them increasingly intelligent requires adequate hardware.
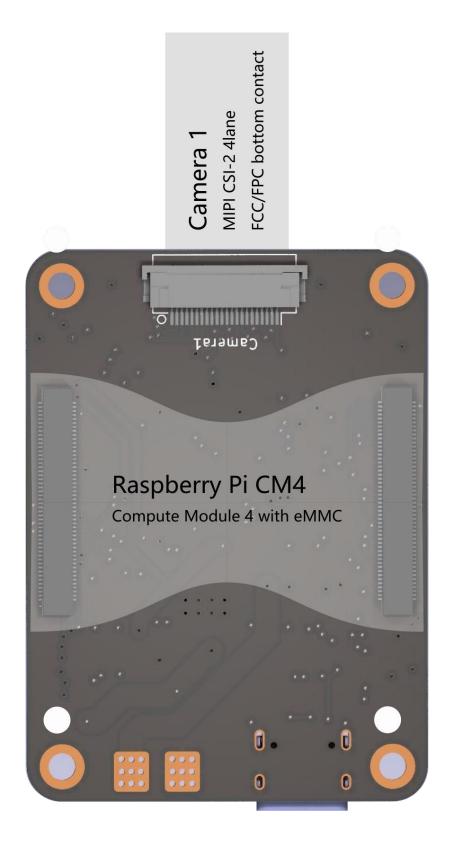
Hardware interfaces

The öchìn CM4 board provides the following interfaces on the side's connectors:

- 4x USB 2.0 480Mbps (4x SM04B-GHS-TB(LF)(SN) connectors)
- 1x USB Type-C (for flashing eMMC)
- 2x CSI camera (2x FH12-22S-0.5SH (55) connectors)
- I2C1 (SM04B-GHS-TB(LF)(SN) connector)
- SPI1 / 6 (SM06B-GHS-TB(LF)(SN) connector)
- UART0 / 1 + Video Out (SM06B-GHS-TB(LF)(SN) connector)
- UART3 / UART5 (SM06B-GHS-TB(LF)(SN) connector)
- USART4 (SM06B-GHS-TB(LF)(SN) connector)

USB3
VBUS
USB3N
USB3P
GND

USB2
VBUS
USB2N
USB2P
GND

USB1
VBUS
USB1N
USB1P
GND

USB4
VBUS
USB4N
USB4P
GND

USART4
GND
+5V
RTs4
CTs4
TX4
RX4

SPI1/6
GND
+5V
MOSI
MISO
SCK
CE

I2C1
SCL
SDA
+5V
GND

**UART0/1
VideoOut**
RX0/1
TX0/1
Video Out
+5V
+3.3V
GND

Camera 0
MIPI CSI-2 2lane
FCC/FPC bottom contact

UART3/5
RX3
TX3
RX5
TX5
+5V
GND

USB Type-C
used to flash the eMMC

Boot CM4 as flash storage device

Power Input
DC supply from 7.5V to 28V
LIPO battery from 2S to 6S

Ext. Board Connector

GND	GND		RTs4	CTs4	RX0/1	Vin+	Vin+
GND	VideoO	TX4	RX4	TX0/1	Vin+	Vin+

Top view

Camera 1

MIPI CSI-2 4lane

FCC/FPC bottom contact

Camera1

Raspberry Pi CM4

Compute Module 4 with eMMC
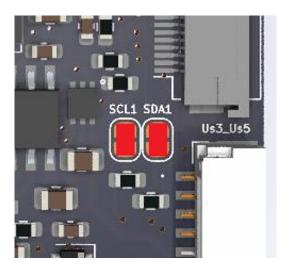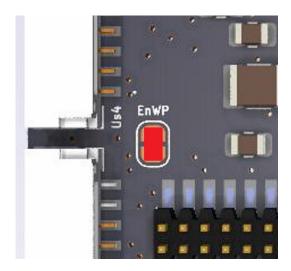
Bot view

The I2C1 interface is available on the connector, but it is shared with the Camera0, for this reason the Camera0 in not available by default. To connect the I2C1 to the Camera0, it is necessary to short the two solder-jumper on the board:

To write protect the eMMC it's necessary to short the jumper EnWp:

Software Configuration

The öchìn board is only compatible with CM4 module with eMMC, because we decided to not mount the SD card slot to save space. Having the eMMC instead of SD also gives several advantages:

1. Faster than SD with speed up to 100Mbytes/s
2. More robust to physical corruption
3. Longer lifetime
4. More rugged

Having to write the ISO image directly to the eMMC is a bit more complicated than flash an SD card, but not so much thanks to the great work done by Raspberry Pi.

The procedure to flash the CM4 module is well explained in the Raspberry Pi Documentation:

 https://www.raspberrypi.org/documentation/hardware/computemodule/cm-emmc-flashing.md

The procedure it's straightforward, what you need to do in synthesis is the following:

1. Power up the board with boot configuration as "mass storage device".
    - To do so you need to power off the board (no Vin connected)
    - Connect the board to your PC using the USB Type-C port
    - Press the "nRPiboot" button and, keeping it pressed power up the board.
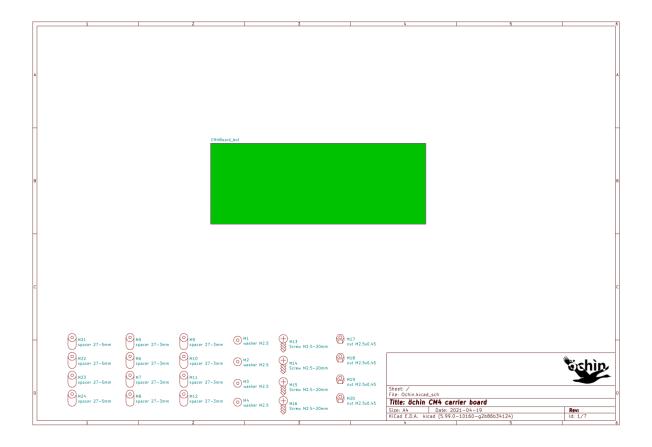
2. Run the "RPiboot" software, downloaded from the Raspberry Pi website. After the software starts, the PC will see the partition of the eMMC like if it would an SD into the SDcard reader.
3. Flash the eMMC as you normally do with the SD. You could use Win32DiskImager on Windows or "dd" command on Linux.
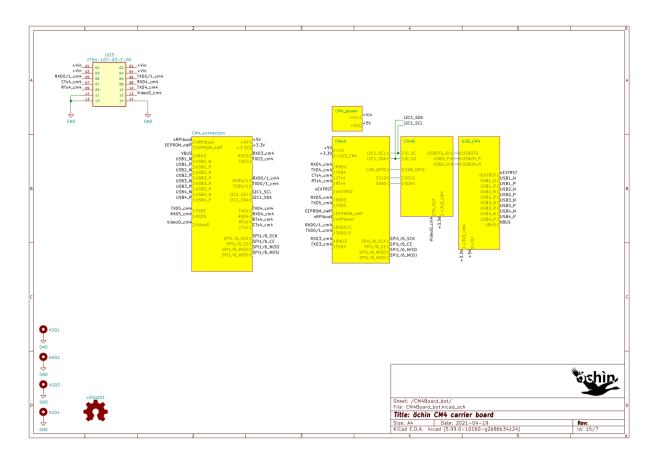
Once you have the system running for the first time, the USB interface will not work because on CM4 it is disabled by default. In order to use the USBs, you need to enable them in the "config.txt" file, adding the following line at the end of the file:
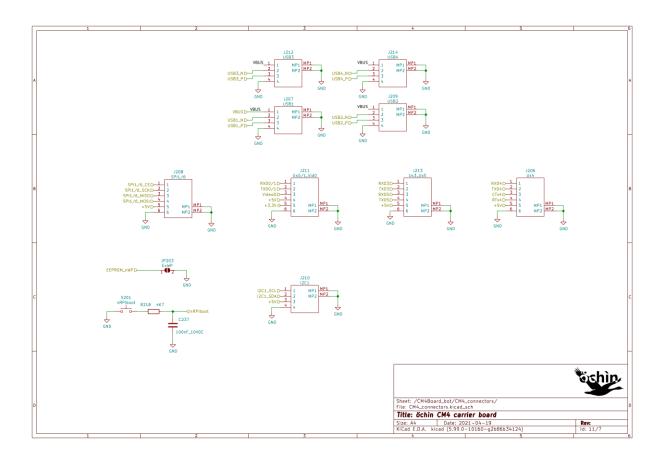
dtoverlay=dwc2,dr_mode=host
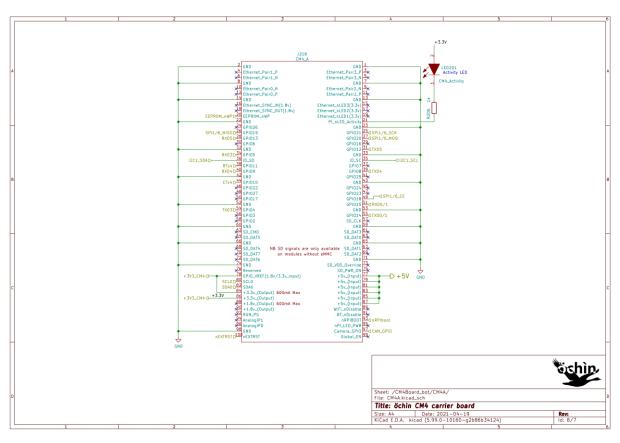
The "config.txt" file could be found within the "boot" partition. To be noted is that the "boot" partition is also accessible when you connect the CM4 to the PC booted in MSD mode, since it is formatted as FAT32.

Schematics

J212 USB3
VBUS
USB3_ND
USB3_PD
MP1 MP2
GND

J214 USB4
VBUS
USB4_ND
USB4_PD
MP1 MP2
GND

J207 USB1
VBUS
USB1_ND
USB1_PD
MP1 MP2
GND

J209 USB2
VBUS
USB2_ND
USB2_PD
MP1 MP2
GND

J208 SPI1/6
SPI1/6_CE
SPI1/6_SCK
SPI1/6_MISO
SPI1/6_MOSI
+5V
MP1 MP2
GND

J211 Us0/1_Vid0
RXD0/1
TXD0/1
Video0
+5V
+3.3V
MP1 MP2
GND

J213 Us3_Us5
RXD3
TXD3
RXD5
TXD5
+5V
MP1 MP2
GND

J206 Us4
RXD4
TXD4
CTs4
RTs4
+5V
MP1 MP2
GND

JP203 EnWP
EEPROM_nWP
GND

S201 nRPIboot
R218 4K7
nRPIboot
C237
100nF_10VDC
GND

J210 I2C1
I2C1_SCL
I2C1_SDA
+5V
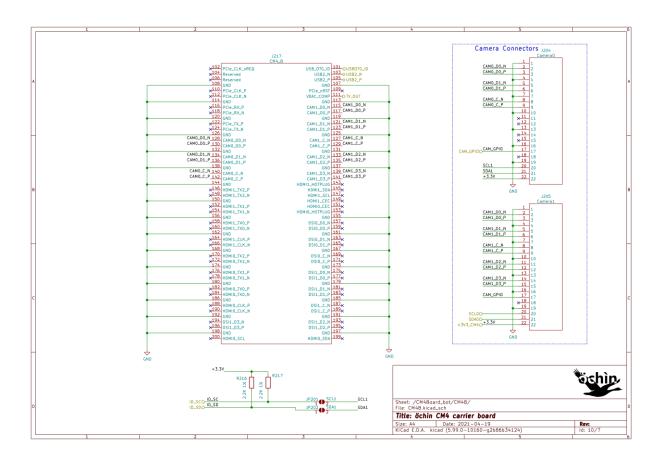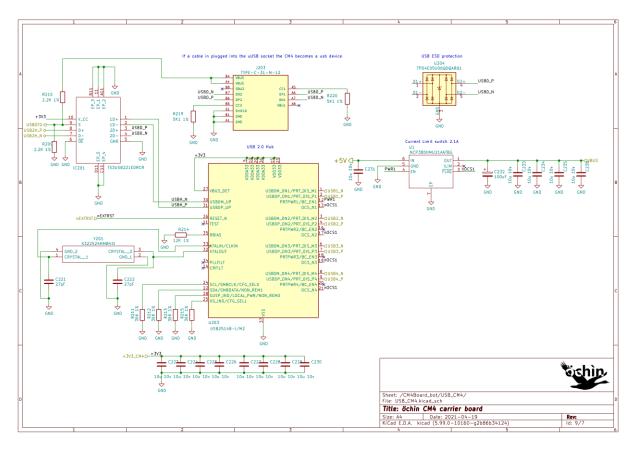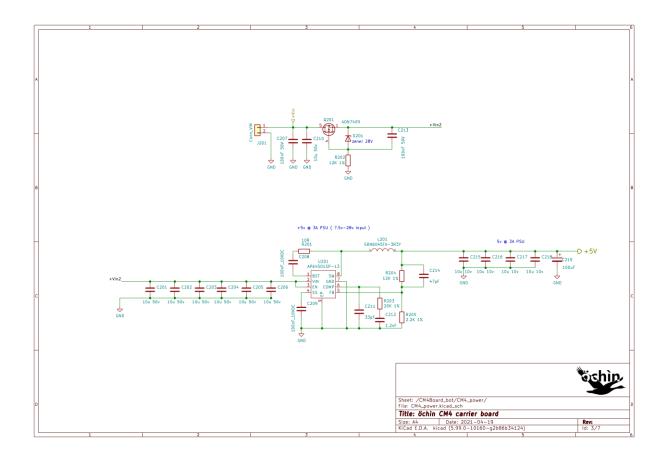MP1 MP2
GND

Sheet: /CM4Board_bot/CM4_connectors/
File: CM4_connectors.kicad_sch
Title: öchin CM4 carrier board
Size: A4   Date: 2021-04-19   Rev:
KiCad E.D.A. kicad (5.99.0-10160-g2b86b34124)   Id: 11/7

+3.3V

J216 CM4_A
GND
Ethernet_Pair1_P
Ethernet_Pair1_N
GND
Ethernet_Pair0_N
Ethernet_Pair0_P
GND
Ethernet_SYNC_IN(1.8v)
Ethernet_SYNC_OUT(1.8v)
EEPROM_nWP   EEPROM_nWP
GND
GPIO26
SPI1/6_MISO GPIO19
RXD5 GPIO13
GPIO6
GND
RXD3 GPIO5
ID_SD
RTs4 GPIO11
RXD4 GPIO9
GND
CTs4 GPIO10
GPIO22
GPIO27
GPIO17
GND
GPIO4
GPIO3
GPIO2
GND
TXD3 SD_CMD
SD_DAT5
GND
SD_DAT4
SD_DAT7
SD_DAT6
GND
Reserved
GPIO_VREF(1.8v/3.3v_Input)
+3V3_CM4 SCL0
SDA0 SDA0
+3.3v_(Output) 600mA Max
+3V3_CM4 +3.3v_(Output)
+1.8v_(Output)
+1.8v_(Output) 600mA Max
RUN_PG
AnalogIP1
AnalogIP0
GND
nEXTRST nEXTRST

GND
Ethernet_Pair3_P
Ethernet_Pair3_N
GND
Ethernet_Pair2_N
Ethernet_Pair2_P
GND
Ethernet_nLED3(3.3v)
Ethernet_nLED2(3.3v)
Ethernet_nLED1(3.3v)
Pi_nLED_Activity
GND
GPIO21   SPI1/6_SCK
GPIO20   SPI1/6_MOSI
GPIO16
GPIO12   TXD5
GND
ID_SD
GPIO7
GPIO8   TXD4
GPIO25
GND
GPIO24
GPIO23
GPIO18
GPIO15   SPI1/6_CE
GND   RXD0/1
GPIO14   TXD0/1
SD_CLK
GND
SD_DAT3
SD_DAT0
GND
SD_DAT1
SD_DAT2
GND
SD_VDD_Override
SD_PWR_ON
+5v_(Input)
+5v_(Input)
+5v_(Input)
+5v_(Input)
+5v_(Input)
+5v_(Input)
WiFi_nDisable
BT_nDisable
nRPIBOOT   nRPIboot
nPI_LED_PWR
Camera_GPIO   CAM_GPIO
Global_EN

NB SD signals are only available on modules without eMMC

LED201 Activity LED
CM4_Activity
R206 1k

+5V
GND
+3.3V
GND

Sheet: /CM4Board_bot/CM4A/
File: CM4A.kicad_sch
Title: öchin CM4 carrier board
Size: A4   Date: 2021-04-19   Rev:
KiCad E.D.A. kicad (5.99.0-10160-g2b86b34124)   Id: 8/7

Mechanical stack view