Camera Open MV
-
PCB

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INTRODUCTION

OpenMv camera (H7 R2) is a camera which can be used thanks to machine vision. This device is an open-source and anyone can contribute to the OpenMv camera GitHub : https://github.com/openmv/openmv.git

The aim is to create a PCB to control this camera and to broadcast data thanks to a Bluetooth module. It will be used for a medical project : analyze blood or saliva. The aim is to notify patients if they need to go to the hospital through a mobile app.

The camera works with an image sensor. Many bus are included : I2C, CAN, I/O or PWM.

OPEN MV CAMERA - SCHEMATIC UPDATE

The schematic of the electronic board is available on the internet :

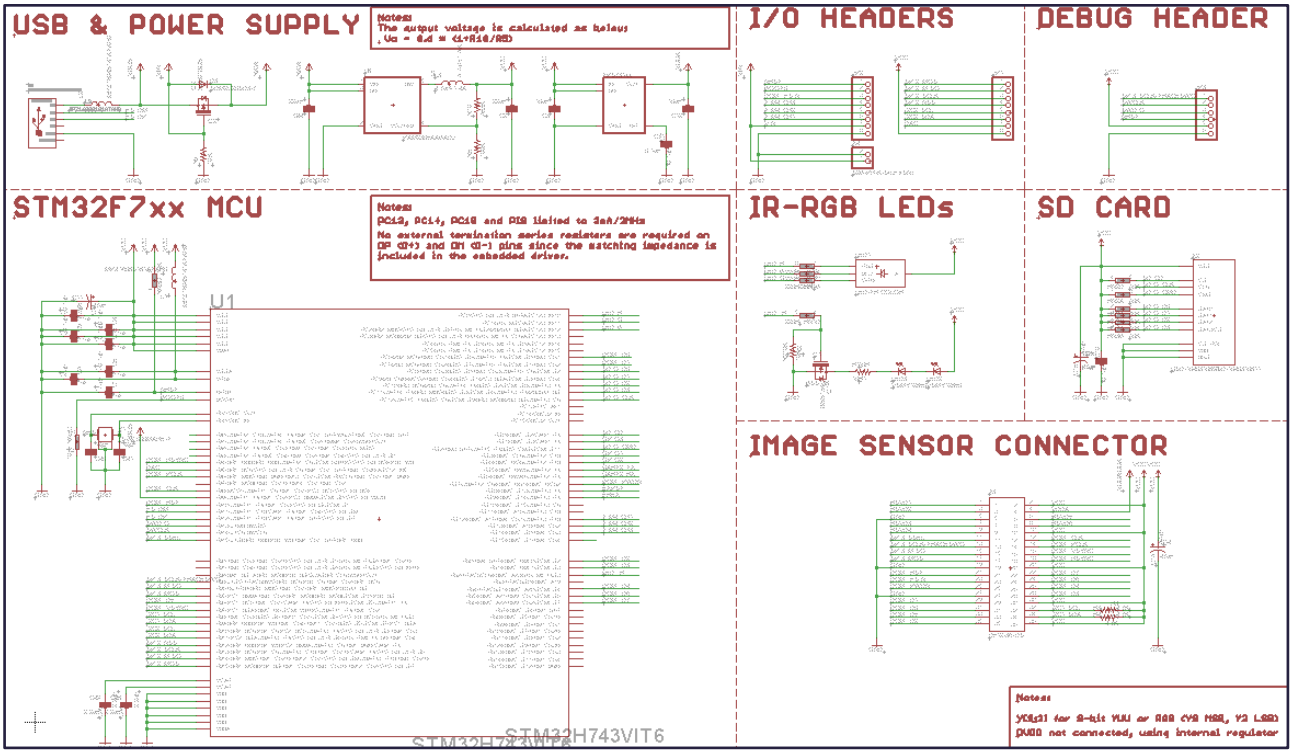


Fig 1. : Schematic of the electronic board used to control Open MV camera, from the official website of its designer

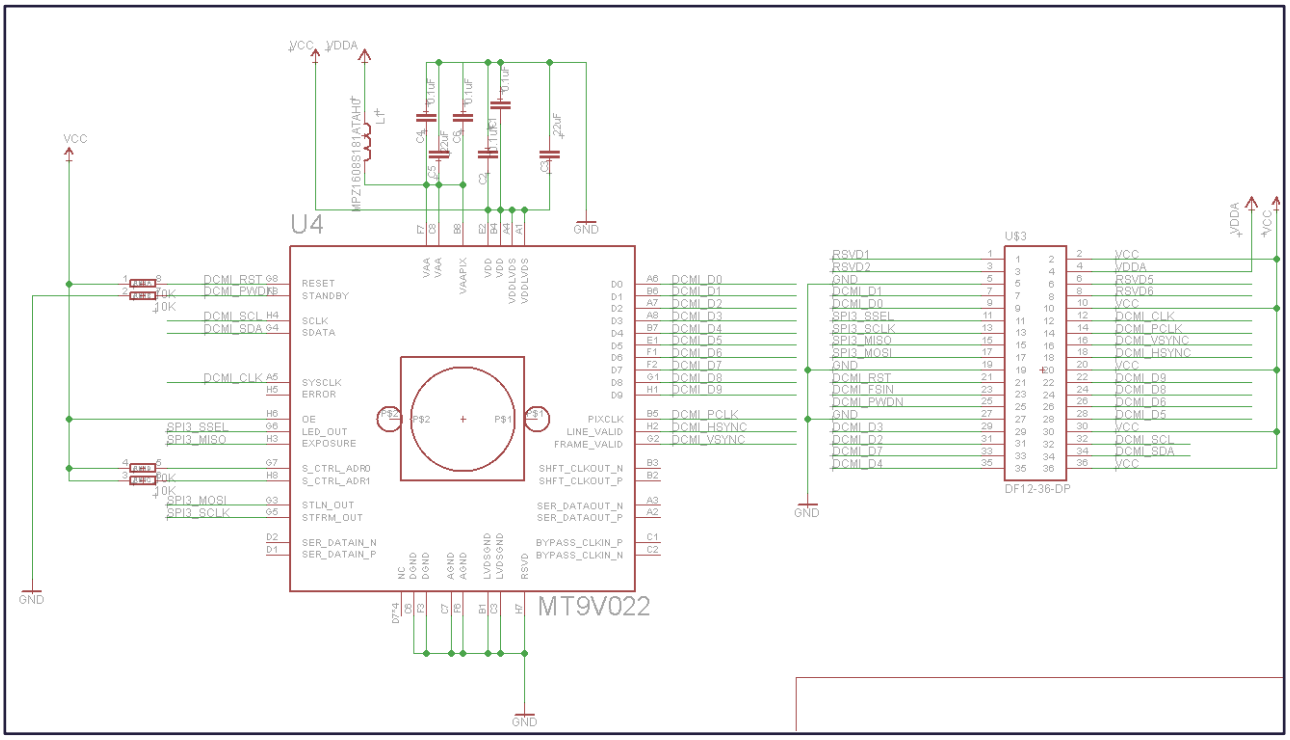


Fig 2. : Schematic of the electronic board for camera sensors, from the official website of its designer

The PCB provided by OpenMV company is the following :

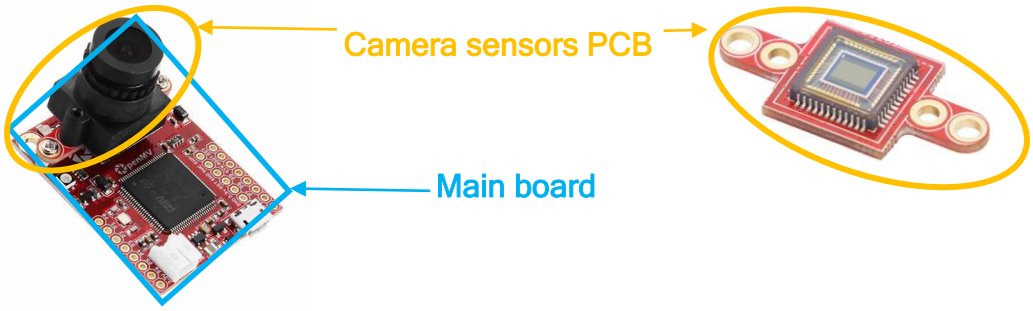


Fig 3. : Electronic board - OpenMV Camera

The following diagram allows us to understand how each component is connected and what is the purpose of this PCB :

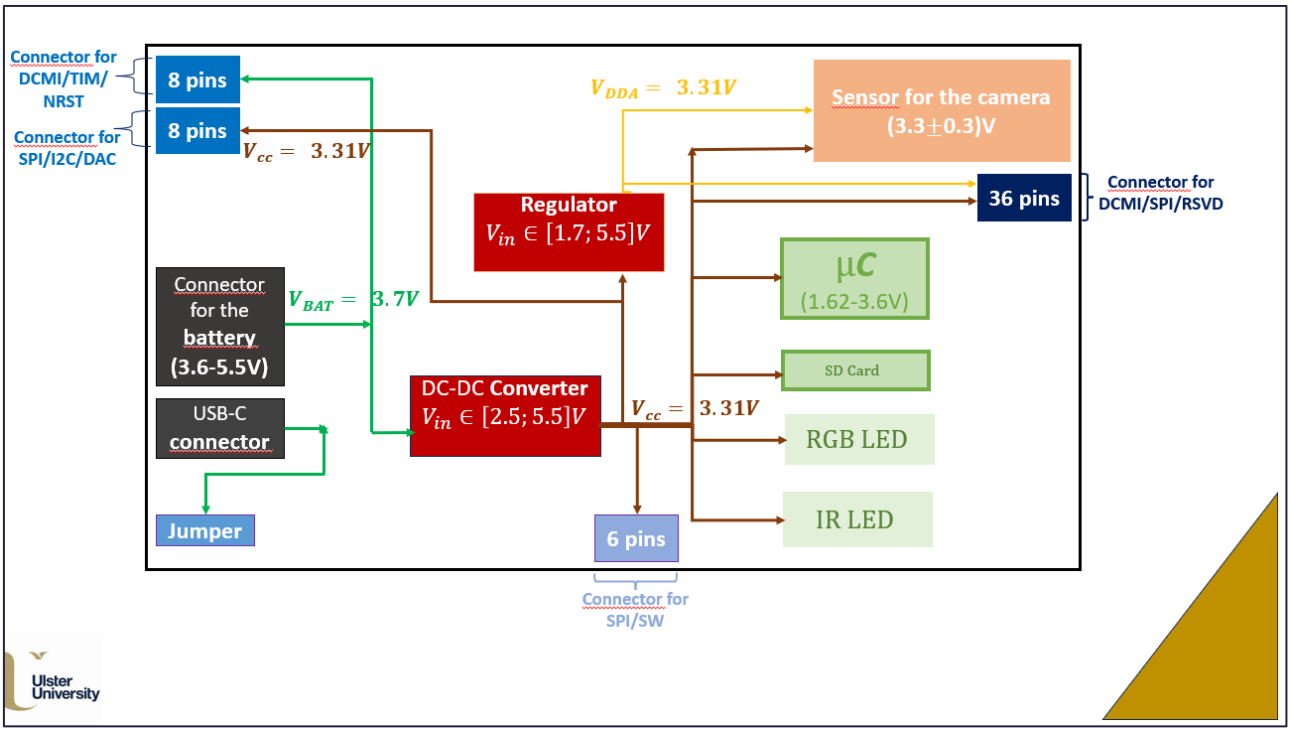


Fig 4. : Diagram explaining the electronic board

The next part of the report focuses on the changes we implemented to adapt this electronic board to our project.

Removed components

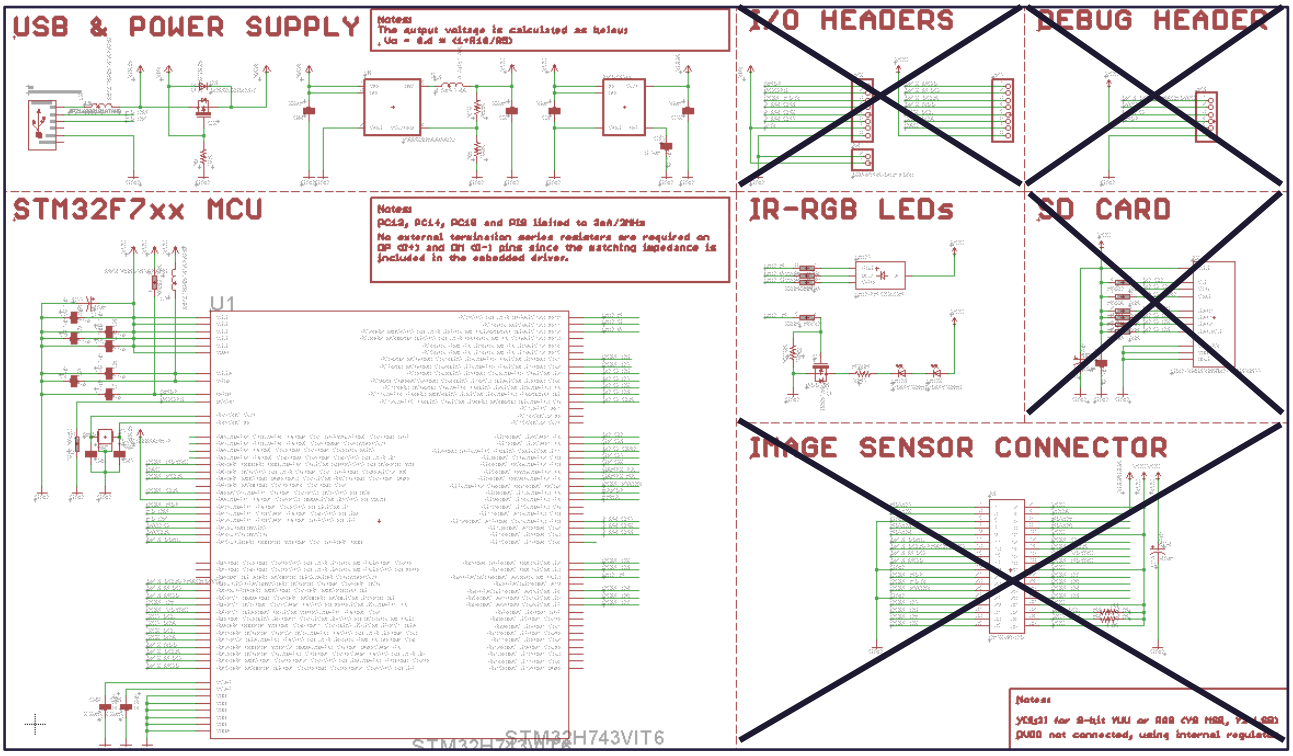


Fig 5. : Components removed from the schematic

As we will use the camera for a specific project, we needed to remove unnecessary components and to add some others.

- **SD Card :** Firstly, we removed SD Card components because we will not have to store data on the PCB.
- **I/O Headers & Debug Headers :** As we knew exactly which sensors we needed to use, we didn't require to keep all the headers and decided to remove them.
- **Image sensors connector :** The designer of this board decided not to put the camera directly on the main PCB but to screw a small PCB on the main one. The sensors used for the camera were connected to the microcontroller thanks to a special connector. We decided to delete the image sensor connector because we wanted to connect directly the camera and its sensors on the main board.

Added Components

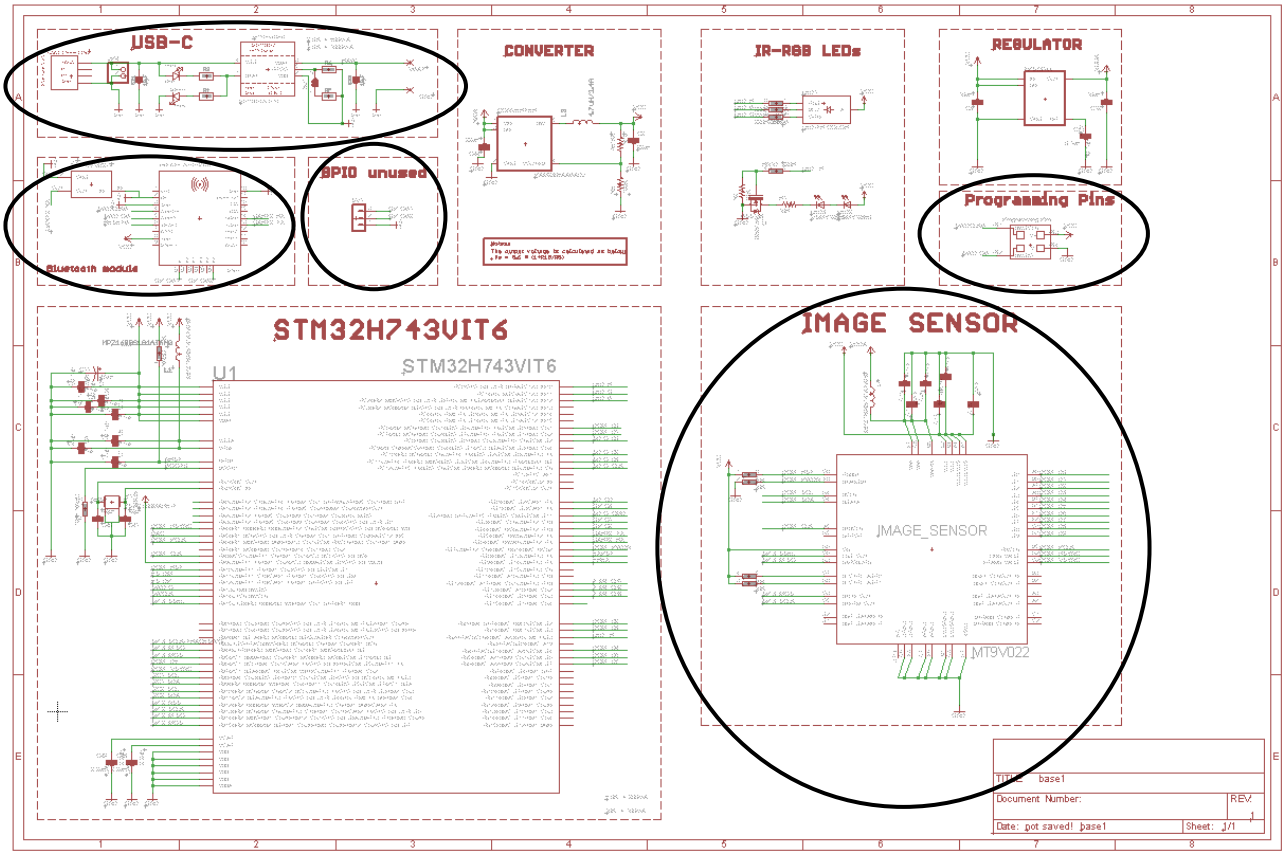


Fig 6. : Components added to the schematic

- **USB-C :** The first modification was to change USB connector. In fact, it was better to add a USB-C connector instead of a micro-USB because it is the new norm.
- **Image sensor :** Then, we added the sensors used for the camera openMV on the main board. We wanted to create an electronic board with all components on it, so we will glue plastic camera on our board.
- **Bluetooth Module :** As we wanted to be able to broadcast and receive data thanks to Bluetooth, we added a Bluetooth module on the schematic.
- **GPIO unused :** Many GPIO ports were still available on the microcontroller and on the Bluetooth module. We decided to add two pads so we can connect sensors with wires if we need to add new sensors later on.
- **Programming pins :** We added a special component used to program electronic components. This one will be used for the Bluetooth Module programming. In fact, the microcontroller (STM32) will be programmed thanks to USB.

EXPLANATION OF EACH COMPONENT

Converter

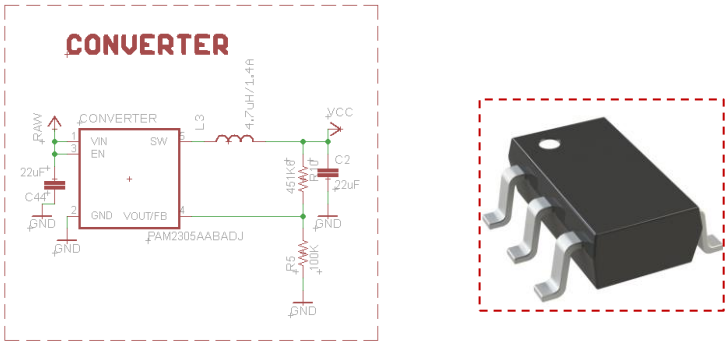


Fig 7. : Schematic and representation of the converter

The converter is a DC-DC converter which supports input voltage from 2.5V to 5.5V.
This component is used to supply a voltage of 3.31V to several components on the electronic board (microcontroller, RGB LED, IR LED). In fact, the battery used delivers 3.7V, so the converter is useful to provide a lower voltage.

- ✓ *More information on the converter in the appendix : click here*

Regulator

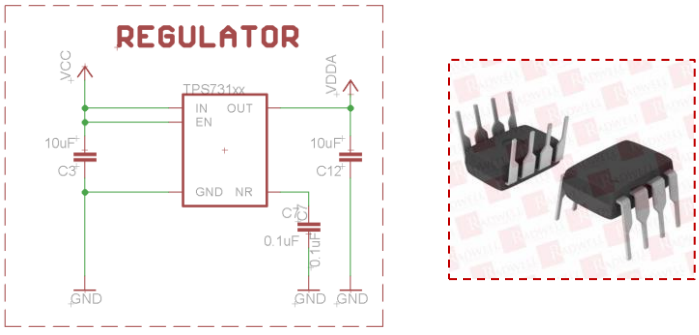


Fig 8. : Schematic and representation of the regulator

This component is a ultra-low-dropout voltage regulator. The main characteristic is that it has a low current consumption. It is used to supply power to image sensor.

- ➢ *More information on the regulator in the appendix : click here*

Programming Pins

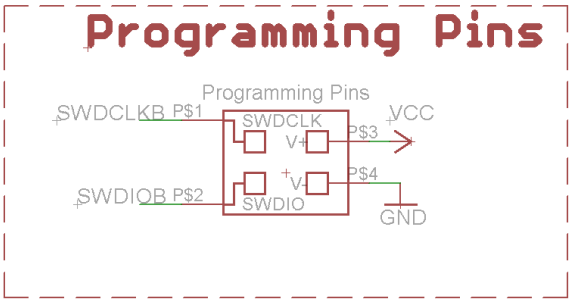


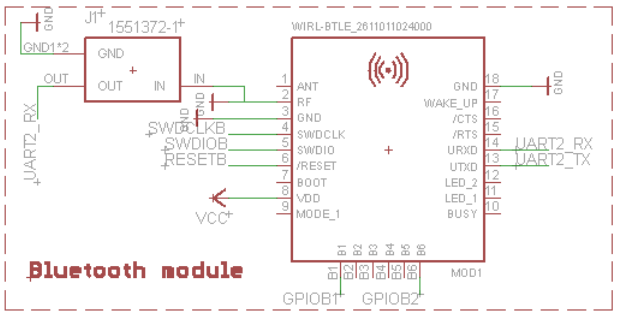
Fig 9. : Schematic of programming pins & Flasher programmer

We needed to add this component to be able to program the Bluetooth Module. Furthermore, the microcontroller of the board will be programmed thanks to the USB connector.
We have to follow the following steps to use programming pins : set up our development environment, select the board we are using, choose the programmer, upload our code.
We chose to add a four pads component because we can use a special cable to connect our board to a flasher programmer.

- ***More information on the Flash Programmer in the appendix :*** *click here*

Bluetooth module & Antenna connector

1. Description



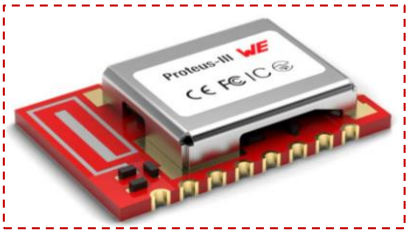


Fig 10. : Schematic and representation of the Bluetooth module and of the antenna connector

Bluetooth module will be used to collect and process data. Our first choice was this module : Getting Started with XIAO nRF52840 | Seeed Studio Wiki . Unfortunately, it was not possible to add its footprint on the schematic. As we could not fix the problem, it was probably an Eagle parameter error, we decided to use another Bluetooth module. The main characteristic was that we needed to find a module with a Nordic semiconductor. We chose a module which requires a voltage between 1.8V and 3.8V. Its communication protocol is BLE (Bluetooth Low Energy).

N.B: Labels were added on the schematic (SDWDCLK***B***, SWDIO***B***, RESET***B***, GPIO***B***1, GPIO***B***2). The letter "***B***" was wrote to specify that these labels are linked to ***B***luetooth module ports. We needed to be careful because SDWDCLK, SWDIO, RESET, GPIO1 and GPIO2 are labels used for STM32 ports.

- ***More information on the Bluetooth module in the appendix :*** *click here*

2. Bluetooth module problems

The first attempt was to use a Nordic module Bluetooth (nRF52840 {Dongle}) . The first aim was to try to getting started with the software nRF Connect. It is used to connect Nordic components to computers and to develop computer codes.

Thanks to nRF Connect for Desktop Bluetooth Low Energy (BLE), mobile phones can be connected to the nRF52840 :

- We need to change characteristics to choose the data we want to broadcast.
- It is possible to change many parameters on the nRF Connect for Desktop.

For example, I chose to modify time information and Time zone for the first test :

Fig 11.a *: nRF 52840 Dongle*

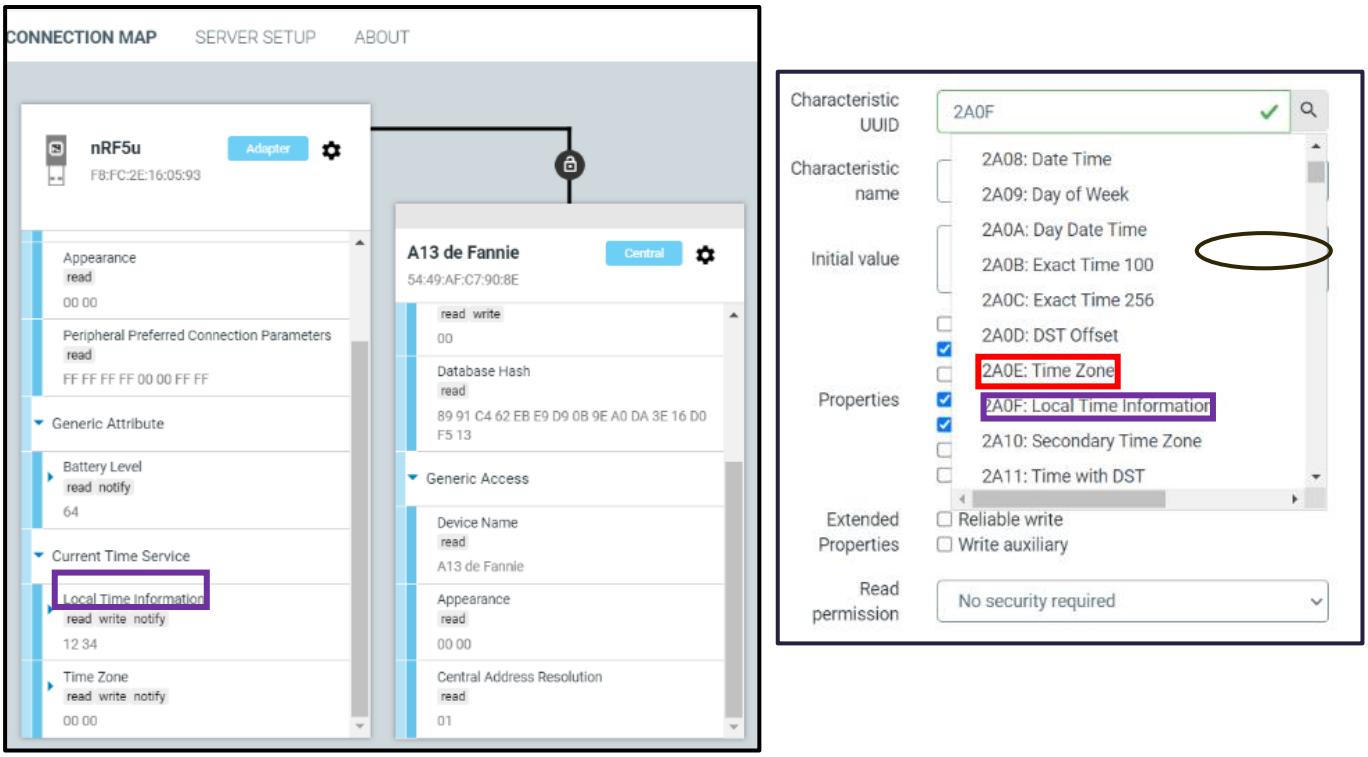


Fig 11.b *: Parameters of the nRF 52840 Dongle*

Values of parameters can be read on the Computer app and on the mobile phone app too :

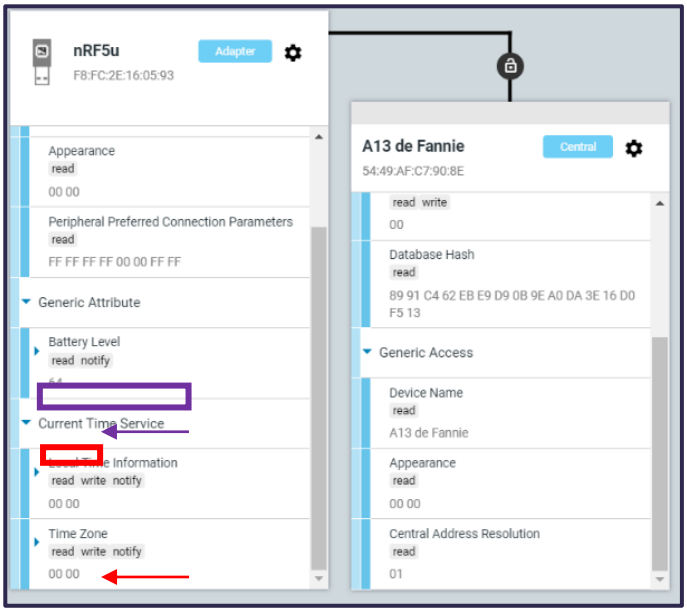


Fig 12 *: Default Parameters of nRF 52840*

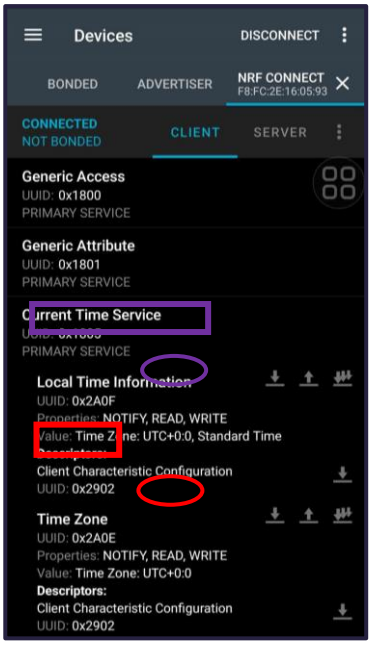


Fig 13 *: Parameters of the nRF 52840 that we can see on the nRF mobile phone app*

The values can be modified from mobile app and can be sent thanks to Bluetooth to the nRF 52 840 board.

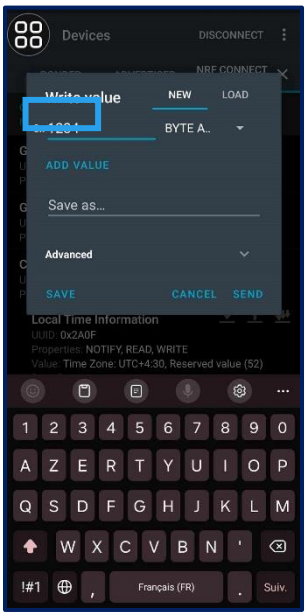


Fig 14 *: Values changed on the mobile phone app*

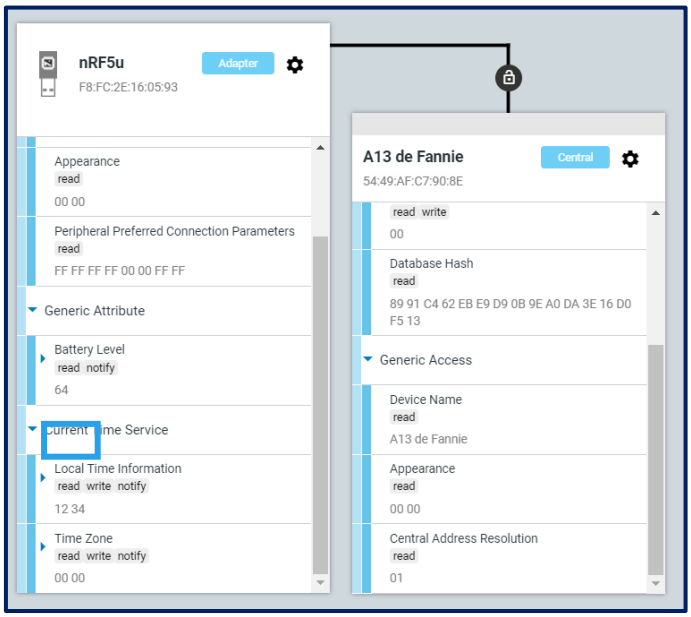


Fig 15 *: Values read on the Computer app*

It is also possible to change data values on the computer app and to receive them on the mobile phone app.

The second attempt was to use the xiaonRF52840 sense module to add Bluetooth communication on the PCB. This module can be programmed with Arduino IDE or with nRF Connect for computer and for mobile phone. I tried to test some examples given by Arduino IDE and then I used nRF Connect app in order to transfer data between the board and my mobile phone.

***Fig 16** : Seed xiao nRF52840*

3. Antenna connector

As explained in the user manual for the Bluetooth module, it is possible to use an internal or an external antenna. We decided to add an antenna connector (a socket connector) :

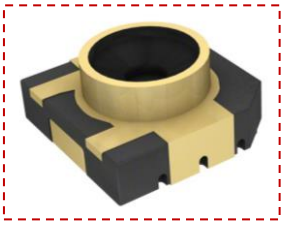


***Fig 17** : 3D model of the antenna connector*

- ***More information on the antenna connector here :*** 1551372_Dwg.pdf (digikey.com)

Microcontroller

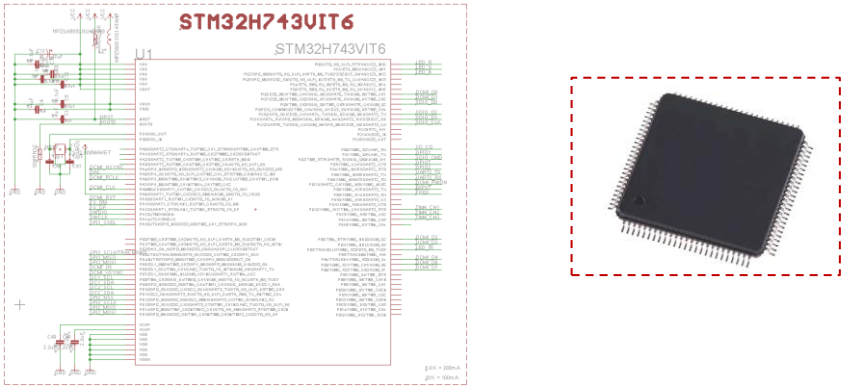


Fig 18. : Schematic and representation of the STM32

This microcontroller requires a voltage between 1.62V and 3.6V . Up to 168 I/O ports can be used. It controls LEDs and SPI, I2C, DCIM or GPIO ports are available. For example, some of these ports are used to manage the image sensor.

- ***More information on the microcontroller in the appendix :*** *click here*

Image sensor

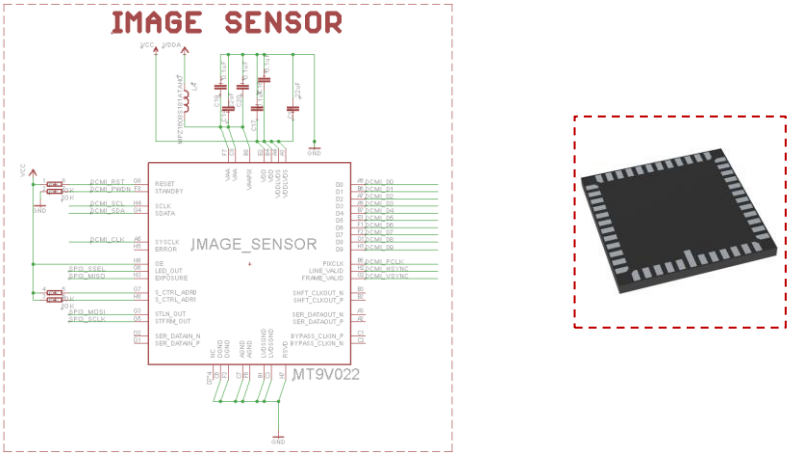


Fig 19. : Schematic and representation of the image sensor

This sensor is a CMOS active-pixel digital image sensor used for OpenMV Camera. We decided to add this component on our board instead of a connector to only have one PCB with the camera glue on it.

- ***More information on the converter in the appendix :*** *click here*

LEDs

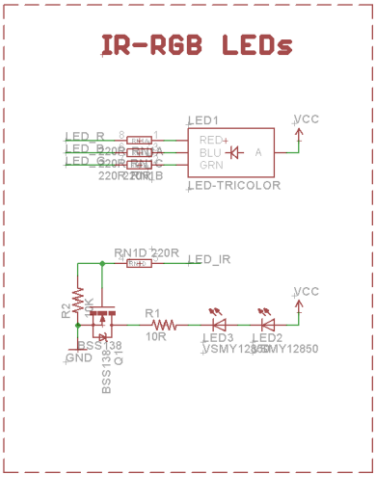
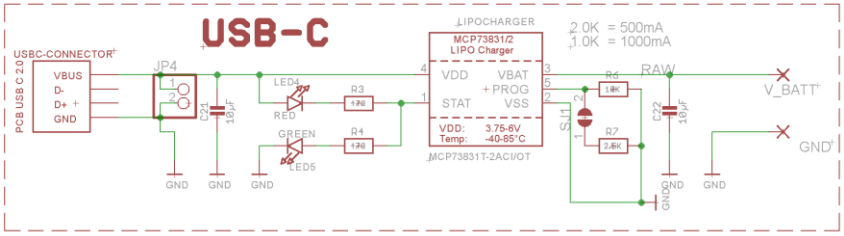


Fig 20. : Schematic and representation of the LEDs

USB-C connector and Lipo charger



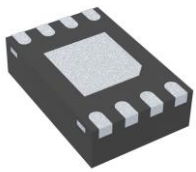


Fig 21. : Schematic and representation of the Lipo charger

We added an USB-C connector instead of a micro-USB because USB-C is the new norm.

- ***More information on the converter in the appendix :*** *click here*

ROUTING

The different versions of the board

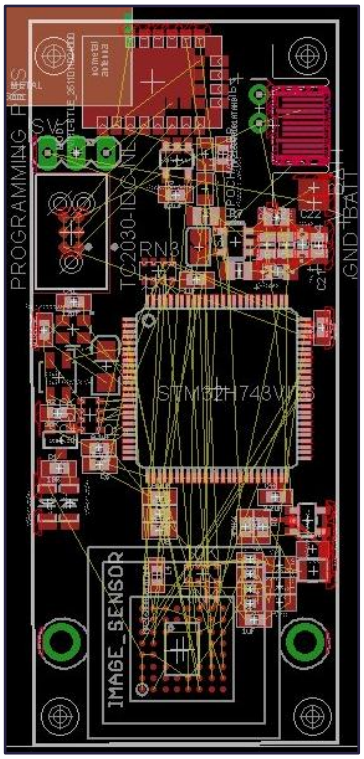


Fig 22. : Board - version 1

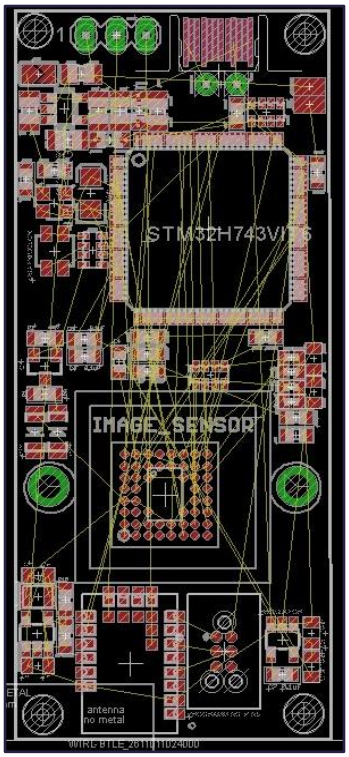


Fig 23. : Board - version 2

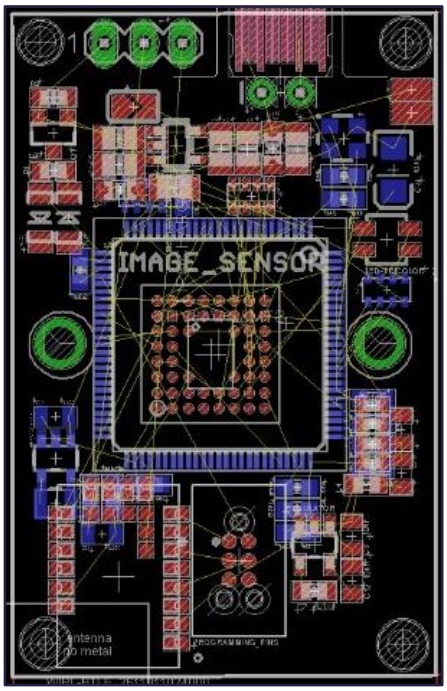


Fig 24. : Board - version 3

- The first version was designed to try to place all the components on the top of the board. I needed to change it because the board was not optimized .
- The second version was better for components placement but I had to narrow the length of the board.
- Then, with the third version I tried to place all the components on both side (Top & Bottom) but I had to reduce the width of the board.

For the last version, I tried to optimize the board before routing :

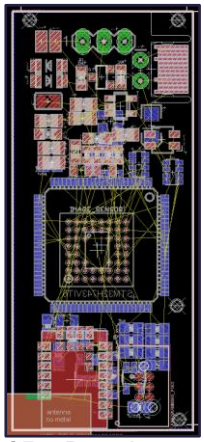


Fig 25. : Board - version 4

The last step was to route the board. We chose the following parameters :

- Route - width : 0.006
- Circle Via - drill : 0.01

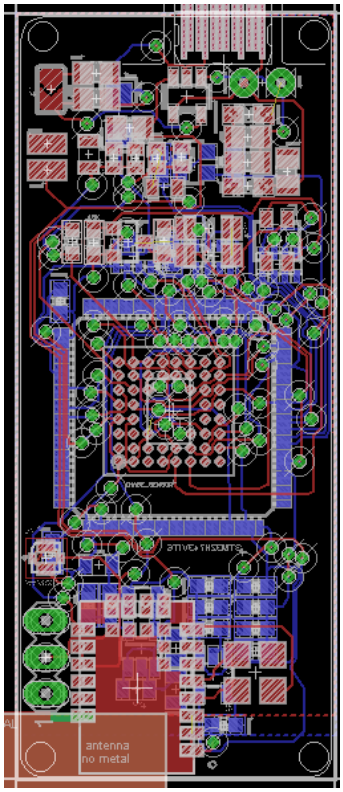
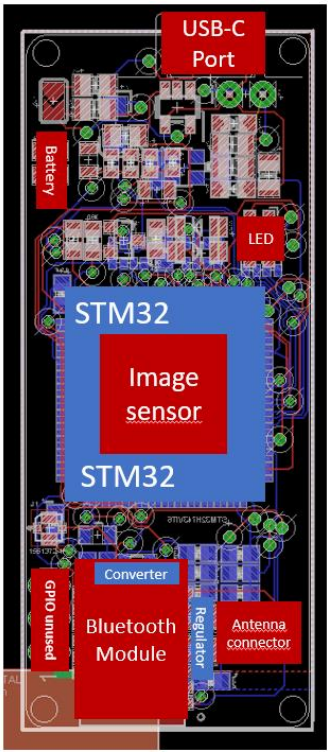


Fig 26. : Routed board

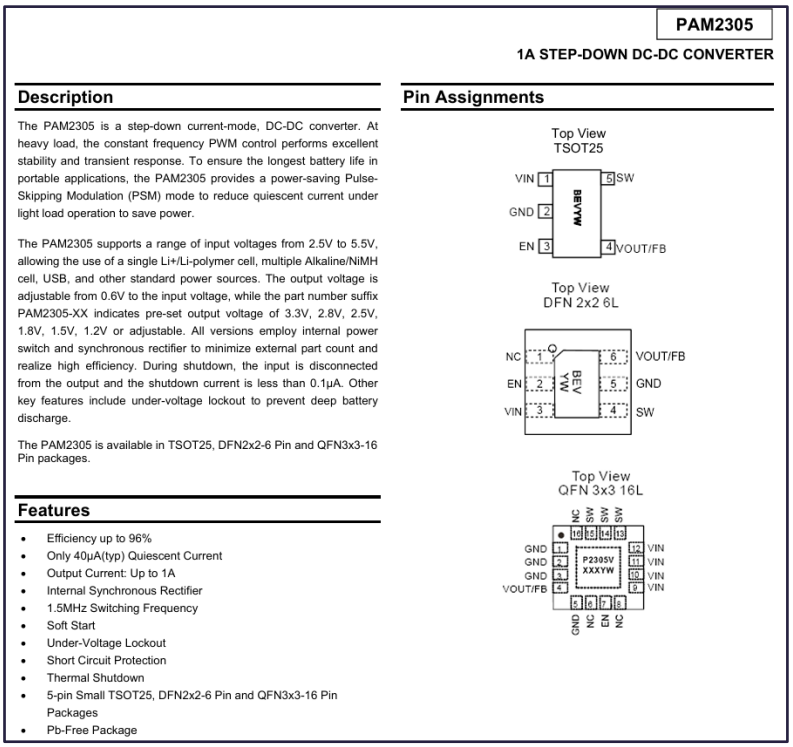


Bottom layer components
Top layer components

Fig 27. : Legend of the final version of the PCB

APPENDICES

Converter documentation



PAM2305

1A STEP-DOWN DC-DC CONVERTER

Description

The PAM2305 is a step-down current-mode, DC-DC converter. At heavy load, the constant frequency PWM control performs excellent stability and transient response. To ensure the longest battery life in portable applications, the PAM2305 provides a power-saving Pulse-Skipping Modulation (PSM) mode to reduce quiescent current under light load operation to save power.

The PAM2305 supports a range of input voltages from 2.5V to 5.5V, allowing the use of a single Li+/Li-polymer cell, multiple Alkaline/NiMH cell, USB, and other standard power sources. The output voltage is adjustable from 0.6V to the input voltage, while the part number suffix PAM2305-XX indicates pre-set output voltage of 3.3V, 2.8V, 2.5V, 1.8V, 1.5V, 1.2V or adjustable. All versions employ internal power switch and synchronous rectifier to minimize external part count and realize high efficiency. During shutdown, the input is disconnected from the output and the shutdown current is less than 0.1μA. Other key features include under-voltage lockout to prevent deep battery discharge.

The PAM2305 is available in TSOT25, DFN2x2-6 Pin and QFN3x3-16 Pin packages.

Features

- Efficiency up to 96%
- Only 40μA(typ) Quiescent Current
- Output Current: Up to 1A
- Internal Synchronous Rectifier
- 1.5MHz Switching Frequency
- Soft Start
- Under-Voltage Lockout
- Short Circuit Protection
- Thermal Shutdown
- 5-pin Small TSOT25, DFN2x2-6 Pin and QFN3x3-16 Pin Packages
- Pb-Free Package

Pin Assignments

Top View
TSOT25

Top View
DFN 2x2 6L

Top View
QFN 3x3 16L

Fig 28. : Extract from converter datasheet

Converter datasheet link : [PAM2305-247289.pdf (mouser.com)]

Regulator documentation

TPS731xx Capacitor-Free, NMOS, 150-mA Low Dropout Regulator With Reverse Current Protection

1 Features

- Stable With or Without Capacitors of All Types
- Input Voltage Range of 1.7 V to 5.5 V
- Ultralow Dropout Voltage: 30 mV Typical (150-mA Load)
- Excellent Load Transient Response—With or Without Optional Output Capacitor
- New NMOS Topology Provides Low Reverse Leakage Current
- Low Noise: 30 μV_{RMS} Typical (10 kHz to 100 kHz)
- 0.5% Initial Accuracy
- 1% Overall Accuracy Over Line, Load, and Temperature
- Less Than 1-µA Maximum I_Q in Shutdown Mode
- Thermal Shutdown and Specified Minimum and Maximum Current Limit Protection
- Available in Multiple Output Voltage Versions
  - Fixed Outputs of 1.20 V to 5 V
  - Adjustable Outputs from 1.2 V to 5.5 V
  - Custom Outputs Available

3 Description

The TPS731xx family of low-dropout (LDO) linear voltage regulators uses a new topology: an NMOS pass element in a voltage-follower configuration. This topology is stable using output capacitors with low equivalent series resistance (ESR), and even allows operation without a capacitor. The device also provides high reverse blockage (low reverse current) and ground pin current that is nearly constant over all values of output current.

The TPS731xx uses an advanced BiCMOS process to yield high precision while delivering very low dropout voltages and low ground pin current. Current consumption, when not enabled, is less than 1 µA and ideal for portable applications. The extremely low output noise (30 μV_{RMS} with 0.1-µF C_{NR}) is ideal for powering VCOs. These devices are protected by thermal shutdown and foldback current limit.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TPS731xx	SOT-23 (5)	2.90 mm × 1.60 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Fig 29. : Extract from regulator datasheet

Regulator datasheet link :tps731.pdf (ti.com)

Flasher Programmer documentation

Pinout SWD

The 20-pin connector of Flasher is also compatible to ARM's Serial Wire Debug (SWD) interface.

VTref	1	2	Vsupply
Not used	3	4	GND
Not used	5	6	GND
SWDIO	7	8	GND
SWCLK	9	10	GND
Not used	11	12	GND
SWO	13	14	GND
RESET	15	16	GND
Not used	17	18	GND
V5-Supply	19	20	GND

Fig 30. : Extract from Flasher programmer datasheet

Flasher Programmer datasheet link : UM08022 Flasher - SEGGER Wiki

Bluetooth module documentation

General Properties:

Properties		Test conditions	Value	Unit
Communication Protocol/ Standard	Bluetooth Low Energy 5.1			
Antenna Connector Type	ANT_{Conn}		RF pad and internal antenna	
Microcontroller	µC		SoC	
Radio Chipset	RF-IC		Nordic - nRF52840	
Memory Size (Flash)			1048576	B
Memory Size (RAM)			262144	B
Radio channel min.	0			
Radio channel max.	39			
Interface 1	IO_1		UART	
Interface 1 Bitrate Range	$IO_{1\ Bitrate}$	latest FW revision	115.2	kbps
Number of I/O Ports	IO_{Ports}	latest FW revision	6	

Electrical Properties:

Properties		Test conditions	Value	Unit
Operating Supply Voltage Min.	$V_{DD\ min.}$	TAMB = 25 °C, RH = 60 %	1.8	V
Operating Supply Voltage Max.	$V_{DD\ max.}$	TAMB = 25 °C, RH = 60 %	3.6	V
Supply Current Sleep	I_{sleep}	VDD = 3 V,TAMB = 25 °C, RH = 60 %	0.4	µA

Additional General Information:

Operating Temperature	-40 up to +85 °C
Storage Conditions (in original packaging)	< 40 °C ; < 90 % RH

Fig 31. : Extract from Bluetooth module datasheet

Bluetooth Module datasheet link : [A700000007100829.pdf (rs-online.com)]

STM32 documentation

32-bit Arm® Cortex®-M7 480MHz MCUs, up to 2MB Flash, up to 1MB RAM, 46 com. and analog interfaces

Datasheet - production data

Features

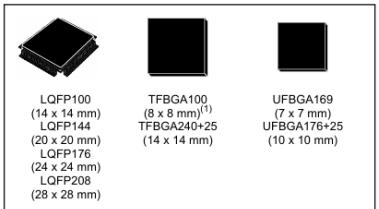
Includes ST state-of-the-art patented technology

Core

- 32-bit Arm® Cortex®-M7 core with double-precision FPU and L1 cache: 16 Kbytes of data and 16 Kbytes of instruction cache; frequency up to 480 MHz, MPU, 1027 DMIPS/ 2.14 DMIPS/MHz (Dhrystone 2.1), and DSP instructions

Memories

- Up to 2 Mbytes of Flash memory with read-while-write support
- Up to 1 Mbyte of RAM: 192 Kbytes of TCM RAM (inc. 64 Kbytes of ITCM RAM + 128 Kbytes of DTCM RAM for time critical routines), Up to 864 Kbytes of user SRAM, and 4 Kbytes of SRAM in Backup domain
- Dual mode Quad-SPI memory interface running up to 133 MHz
- Flexible external memory controller with up to 32-bit data bus: SRAM, PSRAM, SDRAM/LPSDR SDRAM, NOR/NAND Flash



LQFP100 (14 x 14 mm) LQFP144 (20 x 20 mm) LQFP176 (24 x 24 mm) LQFP208 (28 x 28 mm)

TFBGA100 (8 x 8 mm)(1) TFBGA240+25 (14 x 14 mm)

UFBGA169 (7 x 7 mm) UFBGA176+25 (10 x 10 mm)

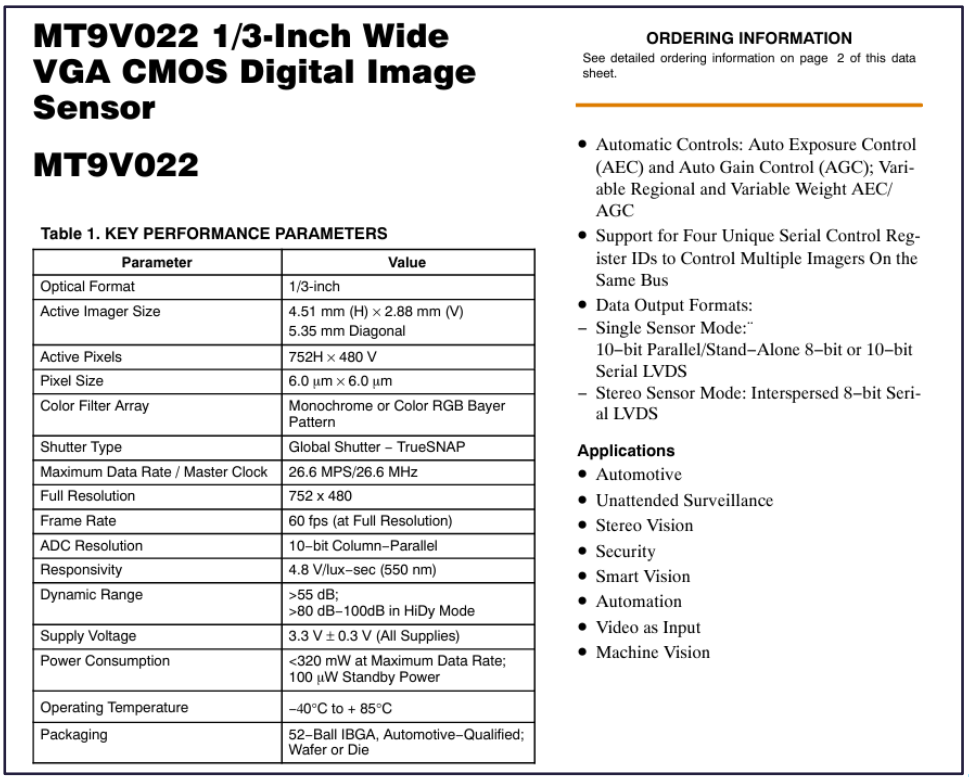
- D2: communication peripherals and timers
- D3: reset/clock control/power management

- 1.62 to 3.6 V application supply and I/Os
- POR, PDR, PVD and BOR
- Dedicated USB power embedding a 3.3 V internal regulator to supply the internal PHYs
- Embedded regulator (LDO) with configurable scalable output to supply the digital circuitry
- Voltage scaling in Run and Stop mode (6 configurable ranges)
- Backup regulator (~0.9 V)
- Voltage reference for analog peripheral/V_{REF+}
- Low-power modes: Sleep, Stop, Standby and V_{BAT} supporting battery charging

Fig 32. : Extract from stm32 sdatasheet

Microcontroller datasheet link : [stm32h745zg-1760969.pdf (mouser.com)]

Image sensor documentation



MT9V022 1/3-Inch Wide VGA CMOS Digital Image Sensor

MT9V022

Table 1. KEY PERFORMANCE PARAMETERS

Parameter	Value
Optical Format	1/3-inch
Active Imager Size	4.51 mm (H) × 2.88 mm (V) 5.35 mm Diagonal
Active Pixels	752H × 480 V
Pixel Size	6.0 µm × 6.0 µm
Color Filter Array	Monochrome or Color RGB Bayer Pattern
Shutter Type	Global Shutter – TrueSNAP
Maximum Data Rate / Master Clock	26.6 MPS/26.6 MHz
Full Resolution	752 x 480
Frame Rate	60 fps (at Full Resolution)
ADC Resolution	10–bit Column–Parallel
Responsivity	4.8 V/lux–sec (550 nm)
Dynamic Range	>55 dB; >80 dB–100dB in HiDy Mode
Supply Voltage	3.3 V ± 0.3 V (All Supplies)
Power Consumption	<320 mW at Maximum Data Rate; 100 µW Standby Power
Operating Temperature	–40°C to + 85°C
Packaging	52–Ball IBGA, Automotive–Qualified; Wafer or Die

ORDERING INFORMATION

See detailed ordering information on page 2 of this data sheet.

- Automatic Controls: Auto Exposure Control (AEC) and Auto Gain Control (AGC); Variable Regional and Variable Weight AEC/AGC
- Support for Four Unique Serial Control Register IDs to Control Multiple Imagers On the Same Bus
- Data Output Formats:
  - Single Sensor Mode: 10–bit Parallel/Stand–Alone 8–bit or 10–bit Serial LVDS
  - Stereo Sensor Mode: Interspersed 8–bit Serial LVDS

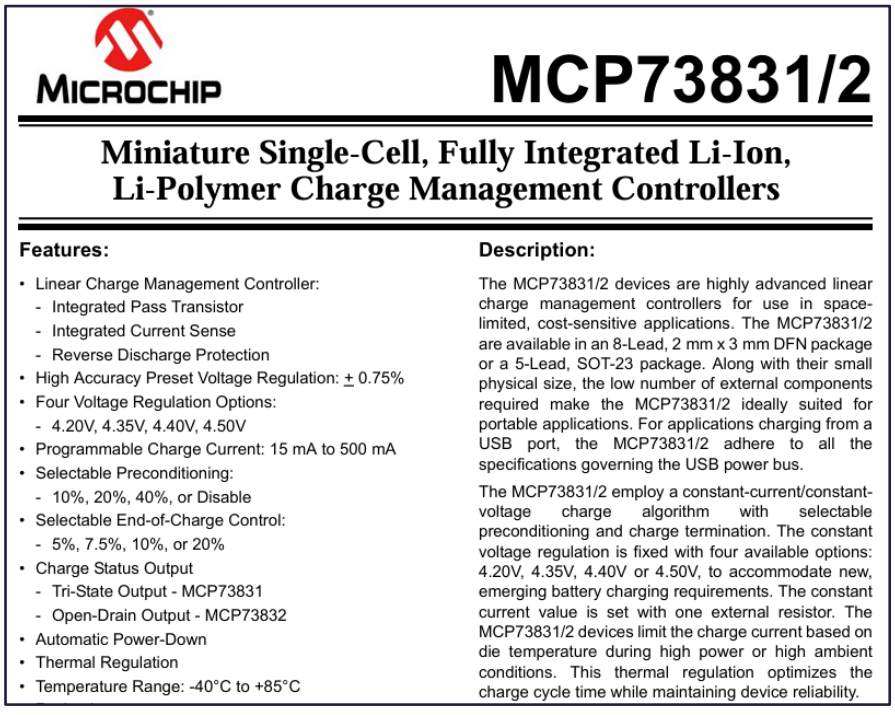
Applications

- Automotive
- Unattended Surveillance
- Stereo Vision
- Security
- Smart Vision
- Automation
- Video as Input
- Machine Vision

Fig 33. : Extract from Image sensor datasheet

Image sensor datasheet link : [MT9V022_D-2316502.pdf (mouser.com)]

Battery charge documentation



MICROCHIP

MCP73831/2

Miniature Single-Cell, Fully Integrated Li-Ion, Li-Polymer Charge Management Controllers

Features:

- Linear Charge Management Controller:
  - Integrated Pass Transistor
  - Integrated Current Sense
  - Reverse Discharge Protection
- High Accuracy Preset Voltage Regulation: ± 0.75%
- Four Voltage Regulation Options:
  - 4.20V, 4.35V, 4.40V, 4.50V
- Programmable Charge Current: 15 mA to 500 mA
- Selectable Preconditioning:
  - 10%, 20%, 40%, or Disable
- Selectable End-of-Charge Control:
  - 5%, 7.5%, 10%, or 20%
- Charge Status Output
  - Tri-State Output - MCP73831
  - Open-Drain Output - MCP73832
- Automatic Power-Down
- Thermal Regulation
- Temperature Range: -40°C to +85°C

Description:

The MCP73831/2 devices are highly advanced linear charge management controllers for use in space-limited, cost-sensitive applications. The MCP73831/2 are available in an 8-Lead, 2 mm x 3 mm DFN package or a 5-Lead, SOT-23 package. Along with their small physical size, the low number of external components required make the MCP73831/2 ideally suited for portable applications. For applications charging from a USB port, the MCP73831/2 adhere to all the specifications governing the USB power bus.

The MCP73831/2 employ a constant-current/constant-voltage charge algorithm with selectable preconditioning and charge termination. The constant voltage regulation is fixed with four available options: 4.20V, 4.35V, 4.40V or 4.50V, to accommodate new, emerging battery charging requirements. The constant current value is set with one external resistor. The MCP73831/2 devices limit the charge current based on die temperature during high power or high ambient conditions. This thermal regulation optimizes the charge cycle time while maintaining device reliability.

Fig 34. : Extract from Battery charge datasheet

Battery Charge datasheet link : [0900766b814f3cb1.pdf (rs-online.com)]

Bill Of Materials

1	HEADER-1X2ROUND	1X02_ROUND	JP4	PIN HEADER
1	MA03-1	MA03-1	SV1	PIN HEADER
2	SMD2	SMD1,27-2,54	GND, V_BATT	SMD PAD
1	SOLDERJUMPER	SOLDERJUMPER_ARROW_NOPASTE	SJ1	SMD Solder JUMPER
4 0.1uF	CAP0402-CAP	0402-CAP	C16, C17, C19, C20	Capacitor
6 0.1uF	CAP0603-CAP	0603-CAP	C5, C6, C7, C8, C9, C13	Capacitor
1 100K	RESISTOR0603-RES	0603-RES	R5	Resistor
2 10K	4R-NEXBV8V	EXBV8V	RN3, RN4	Array Chip Resistor
unknown unknown				
1 10K	RESISTOR0603-RES	0603-RES	R2	Resistor
1 10K\	RESISTOR0805_NOOUTLINE	0805-NO	R6	Resistors
1 10R	RESISTOR0603-RES	0603-RES	R1	Resistor
2 10uF	CAP0805	0805	C3, C12	Capacitor
2 10uF	CAP_CERAMIC0805-NOOUTLINE	0805-NO	C21, C22	Ceramic Capacitors
2 12pF	CAP0603-CAP	0603-CAP	C40, C41	Capacitor
2 1uF	CAP0603-CAP	0603-CAP	C1, C4	Capacitor
2 2.2uF	CAP0603-CAP	0603-CAP	C48, C49	Capacitor
1 2.5K	RESISTOR0805_NOOUTLINE	0805-NO	R7	Resistors
1 220R	4R-NEXBV8V	EXBV8V	RN1	Array Chip Resistor
4 22uF	CAP0805	0805	C2, C14, C18, C44	Capacitor
1 4.7uH/1.4A	INDUCTOR1007	1007	L3	Inductors
1 451K6	RESISTOR0603-RES	0603-RES	R10	Resistor
2 470	RESISTOR0805_NOOUTLINE	0805-NO	R3, R4	Resistors
1 47uF	CAP_POL1206	EIA3216	C11	Capacitor Polarized
1 7S-12.000MAHE-T	CRYSTAL2.5X2.0	CRYSTAL-2.5X2.0	Y1	Crystals
1 BSS138	MOSFET-NCHANNELSMD	SOT23-3	Q1	
1 GREEN	LED0805_NOOUTLINE	CHIPLED_0805_NOOUTLINE	LED5	LED
1 LED-TRICOLOR	LED-TRICOLOR	LED-TRICOLOR-SMD-MF	LED1	Tri-Color LED SMD
1 MCP73831T-2ACI/OT	MCP73831/2	SOT23-5	LIPOCHARGER	MCP73831/2 LIPO Charger
2 MPZ1608S181ATAH0	INDUCTOR0603	0603	L1, L4	Inductors
1 MT9V022	MT9V022	IBGA52	IMAGE_SENSOR	
1 PAM2305AABADJ	PAM2305AAB330	TSOT25	CONVERTER	
1 PCB_USB_C_2.0DS_2	PCB_USB_C_2.0DS_2	USB_TYPE_C_DS_2	USBC-CONNECTOR	
1 RED	LED0805_NOOUTLINE	CHIPLED_0805_NOOUTLINE	LED4	LED
1 STM32H743VIT6	STM32F746LQFP100	LQFP100	U1	
1 TC2030-IDC-NL	TC2030-IDC-NL	TAG_TC2030-IDC-NL	PROGRAMMING_PINS	CABLE ADAPTER 6 POS Check availability Not in stock
https://www.snapeda.com/parts/TC2030-IDC-NL/Tag-Connect/view-part/?ref=eda PLUG-OF-NAILS 6-PIN W/O LEGS 8 Tag-Connect TC2030-IDC-NL				
None None https://www.snapeda.com/parts/TC2030-IDC-NL/Tag-Connect/view-part/?ref=snap				
1 TPS731XX	TPS731XX	SOT23-5	REGULATOR	
2 VSMY12850	LED1206	LED-1206	LED2, LED3	LEDs
1 WIRL-BTLE_2611011024000	WIRL-BTLE_2611011024000	WE-FP-4+	MOD1	Proteus-III - Bluetooth® LE 5.1 Module

Fig 35. : BOM (Bill Of Materials) of the new PCB