Project No. VI20172020068

Tools and Methods for Video and Image Processing to Improve Effectivity of Rescue and Security Services Operations (VRASSEO)

Multisensoric board usable on drone 2

Technical report

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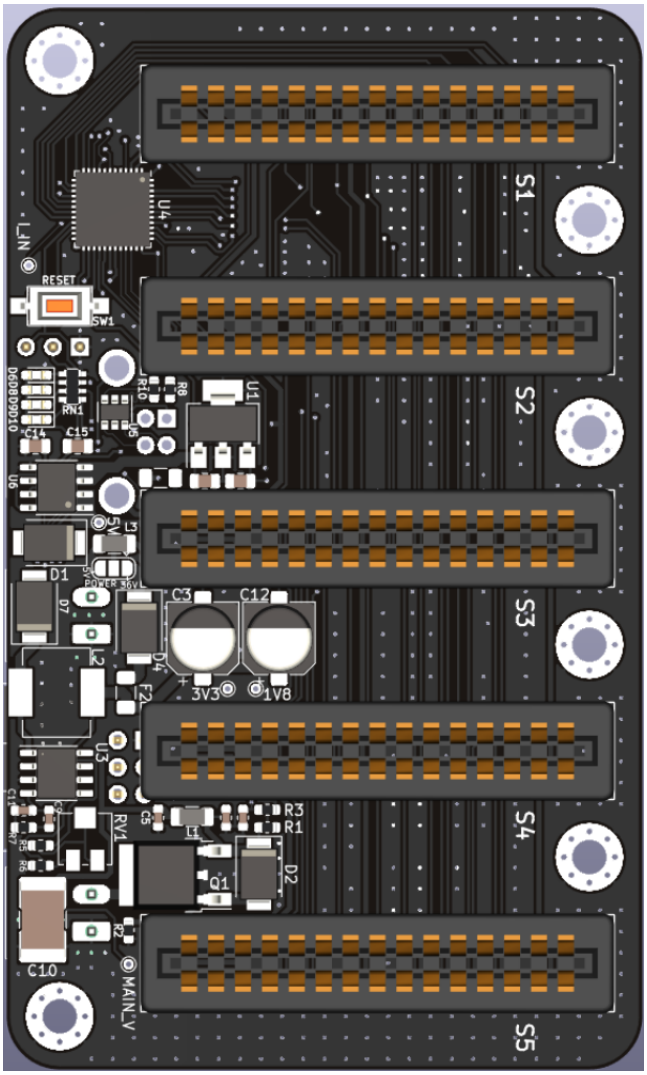
Abstract

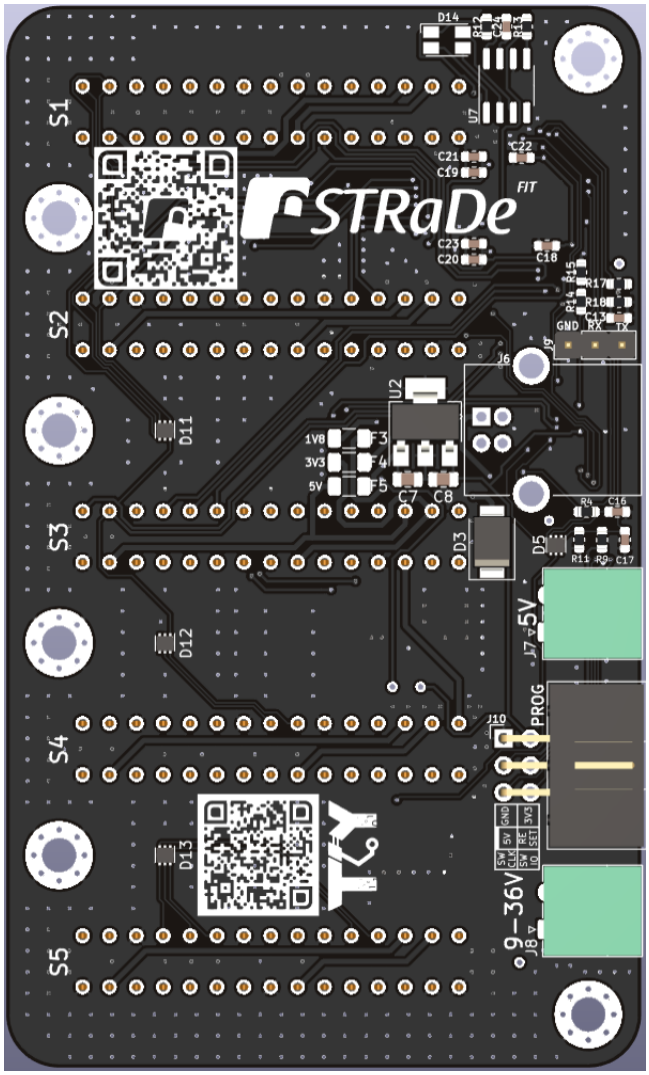
This report describes board which will be used on drone. This board could be used with large variety of sensors. So that it is possible to collect data from various sensors and it has to be also possible to change the sensors so in different flight a different set of data could be acquired. Description and design and technical parameters are discussed in this report. It is improvement on solution from previous year.

VRASSEO MODULAR SENSOR SYSTEM

Top side



Bottom side



Description

This document is specification of sensoric board, which is made for UAV in project VRASSEO. Board is modular with different sensors described below. Sensors are placed on separated boards. These boards are inserted into slots on motherboard. Motherboard contains main processor which operates with sensors, power management and slots for extension cards.

Sensors and accessories overview

This is only summary of possible sensors, which can be added in future

- Barometer (difference of two barometers can serve as altimeter) or one barometer can serve as relative altitude sensor
- Thermometer and humidity meter
- GPS module (supporting GPS, Galileo, Glonass) - Ublock MAX-M8 or Teseo-LIV3F
- Wi-fi module (probably some ESP)
- SD card reader (for saving measured data)
- IMU
- RGBW sensor (VEML6040)

Motherboard basic functionality

- power management
- communication
- programming via SWD
- measuring voltages on power rails (3 channels)
- measuring internal MCU temperature
- status indication (powered, communicating, ...)

Dimensions

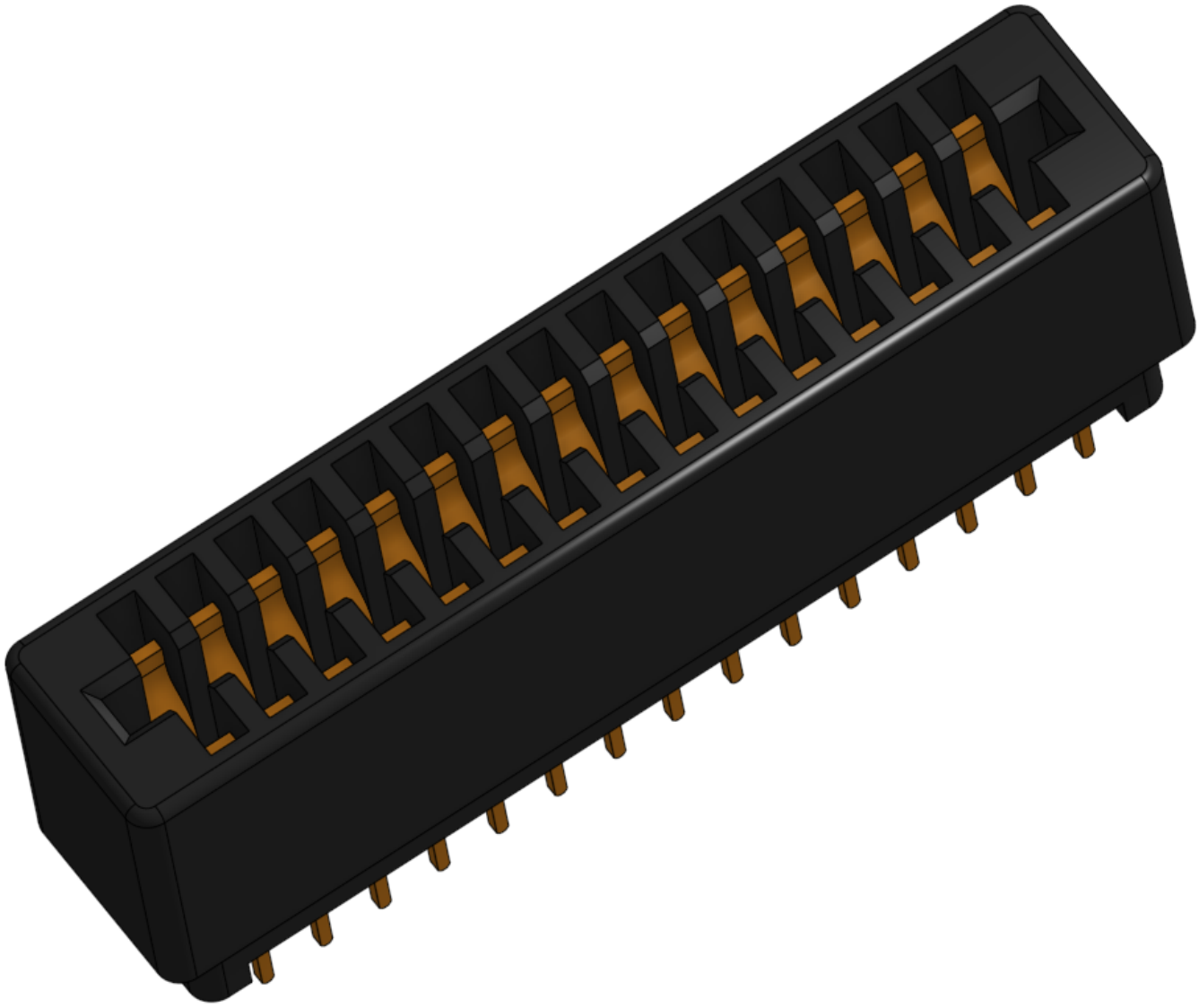
Whole device v1: 120x60x45
Motherboard v1: 120x60
Motherboard v2: 100x60
Module big: 30(+8)x60
Module small: 30(+8)x45

Module dimension are only usable part for electronic parts. Number in brackets means part of PCB which is dedicated for connector. Drawing on big module is bellow.

Socket connector

Type: Card edge connector, dual row, no flanges
Pin count: 30 positions
Link: Mouser
Width: 44.7 mm
Card edge width: 40.5 mm
Board thickness: 1.3716 - 1.778 mm
Pitch: 2.54 mm

Model



Count	Pins	Periferal	Description
1x	2	UART	Several UARTs are split between connectors
1x	3	SPI	Through all ports, as CS can be used PP or SGP Pins
1x	2	I2C	Through all ports
1x	2	CAN	Through all ports
5x	1	GPIO	Pins for any usage shared through all slots
2x	1	GPIO	Pins for any usage, exclusive one for one slot (IRQ and ADC)
1x	2	Power	1.8 V
1x	2	Power	3.3 V
1x	2	Power	5.0 V
4x	1	GND	Ground

Total required pins: 25
This is only estimation of pins usage, more detailed summary of socket pinout is in Chapter Sockets

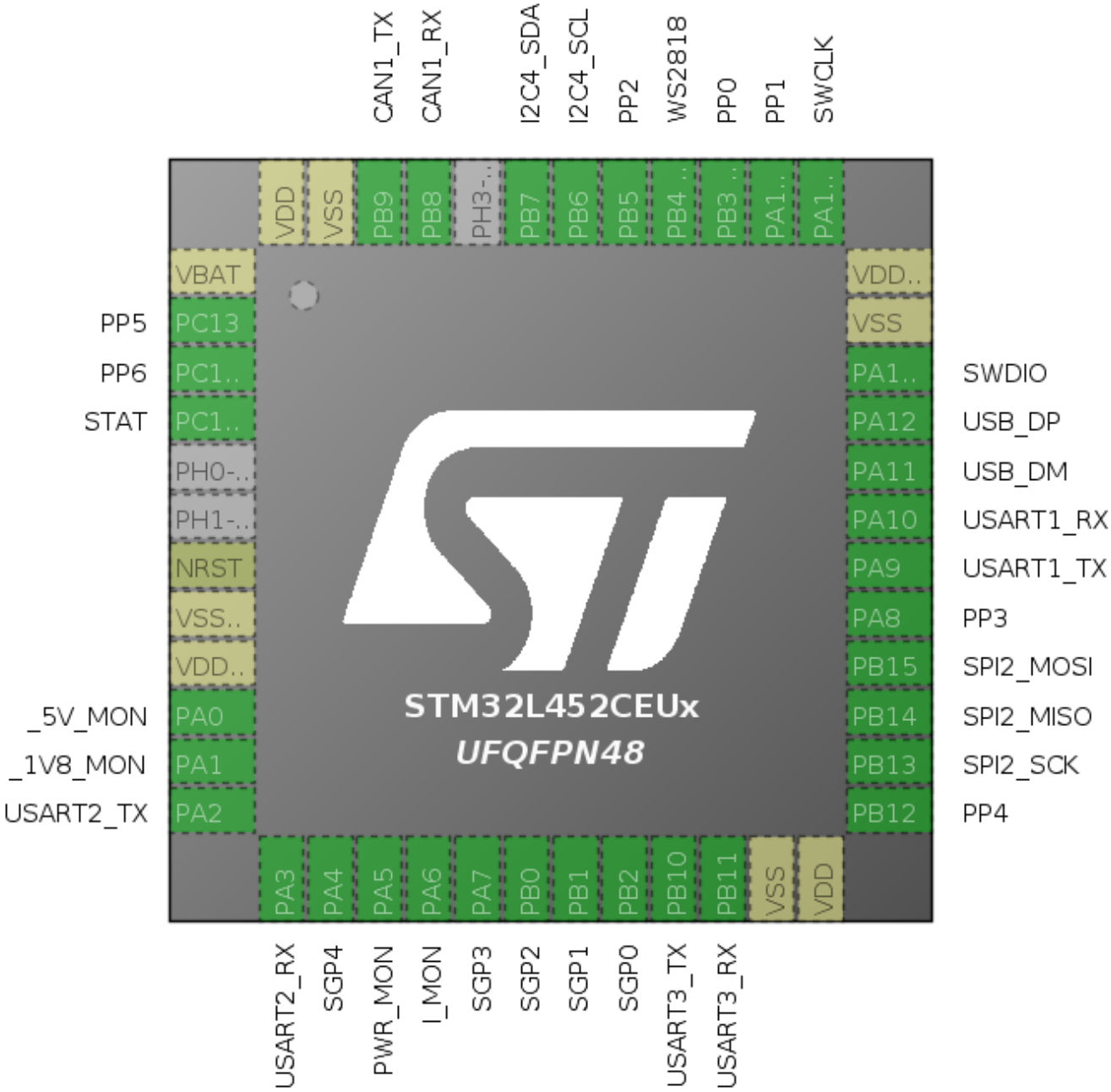
MCU

MCU requirements

- STM32 L4 series LowPower 80MHz MCU
- STM32L452CE
- 16 pins for socket peripherals (3x UART, 2x SPI, 1xI2C, 1xCAN)
- 12 pins as GPIO for slots (1x5-SGP, 7xPP)
- 3 pins for measuring of voltages: Input, 5 V, 1.8 V (VMx), power supply of MCU can be measure by internal channel
    - 1.8 V voltage can be measured by Vrefint channel because MCU is powered by 1.8 V
- 4 pins for board communication, debug and programming (JTMS, USB-VCP)
- 2 pins for status LEDs (STATx)
- crystal-less High-speed USB 2.0 (USB_Dx)
- total of 37 GPIOs -> QFPN48 package

MCU pinout

Description of pin usage and connection is described in section Sockets



Power supply

Power Supply features

- Reverse polarity protection (P-ch MOSFET) with LED signalization
- Main voltage measuring (voltage divider to ADC)
- MCU power supply rail can be measured by internal voltage sensor
- Ferrite bead for suppressing EMI noise
- Buck regulator (step-down converter) 5 V 2 A, Output 5.5 V
    - Buck converter: L5973D, up to 2.5A, input 3-36V
- Supply from USB, with precedence of main supply 5V (ORing)
    - Power draw limited by PTC fuses to USB2.0 limit (100 mA)
        - PTC fuse can start limiting around 80mA
        - Must be tested and eventually change to 200mA
    - This fuse also protect host device against shorts
    - ORing diode lower USB voltage to 4.74V
- ORing is lowering 5.5 V to voltage around 5.1 V
    - As oring diode is possible to find diode with dropout voltage around 300mV
- Low-ripple LDO regulators from 5 V to 3.3 V and 1.8 V
    - Regulators: MCP1826S, current capability 1A, Dropout 200-250mV @ 1A
- Second power input is only 5V and is assuming that is stabilized

Protection features

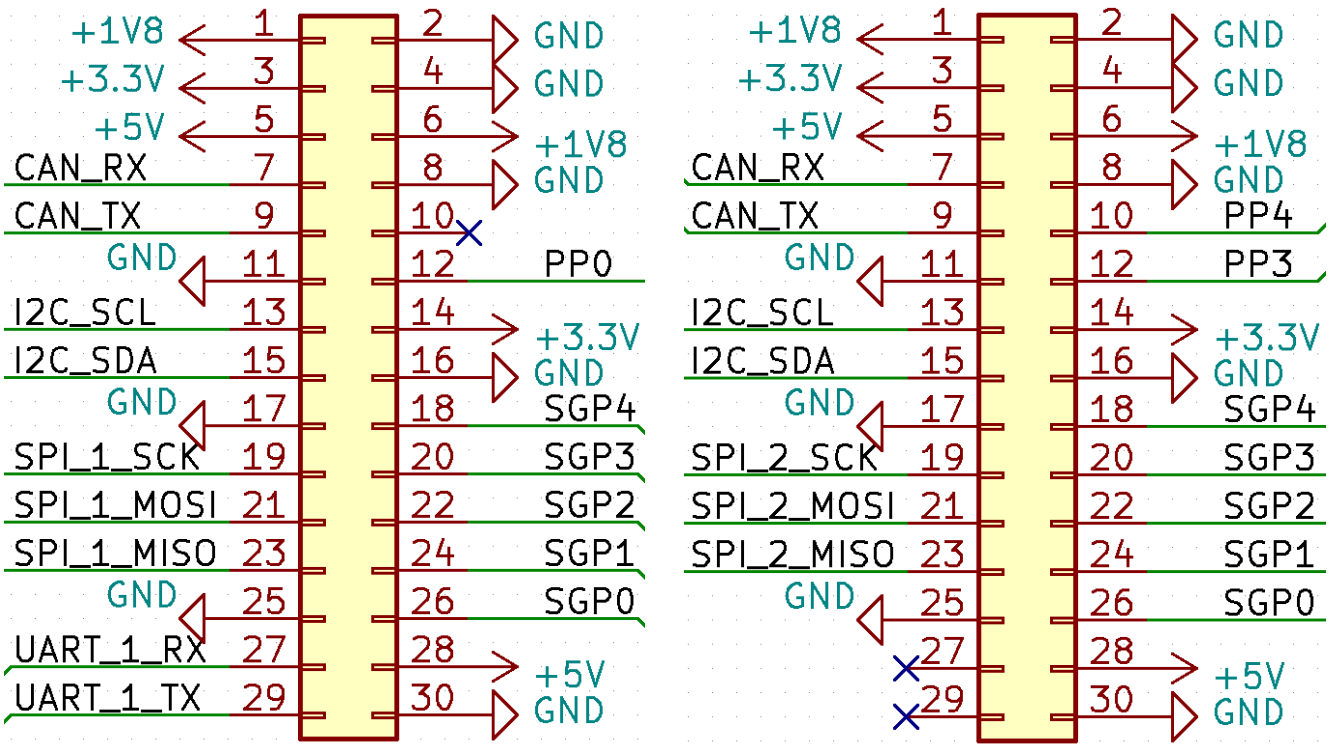
- Sockets are current limited (limit is shared through all sockets)
    - 5 V -> 1 A, 3.3 V -> 700 mA, 1.8 V -> 700 mA
    - Limitation is realized via PTC fuses
- all signal lines from MC to sockets are protected with ESD diodes
- every power input have reversed polarity protection
- USB is protected with USBLC6

Sockets

On board there are two types of sockets. These type are differ in number of peripherals, available GPIOs. In every group is SPI shared through this group.
Both types shares group of 5 GPIOs (SGP). Every socket have own private GPIO pin (PP). This pin can be use as ADC input or IRQ generator. Second type (T2) of socket have another private pin per socket.

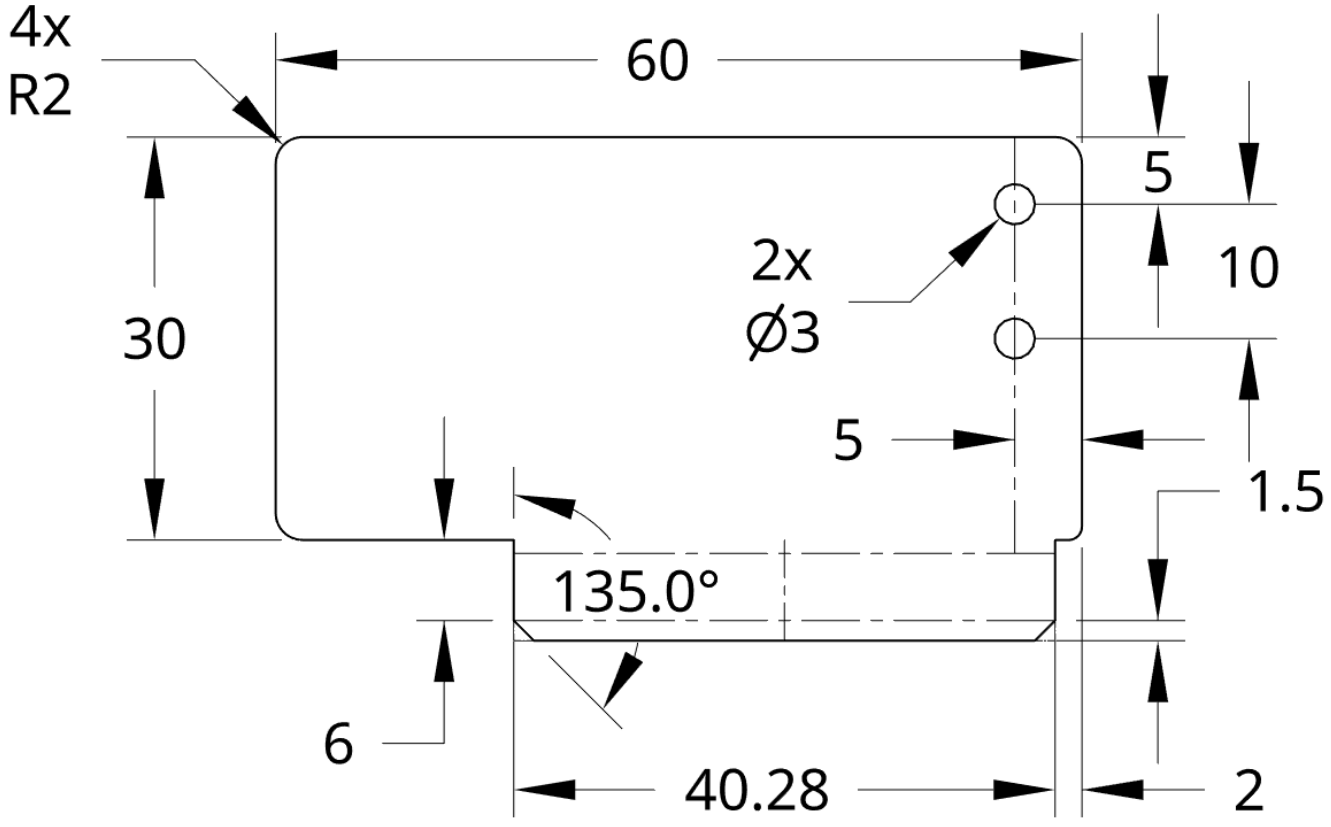
Type 1 - Available USARTs
Type 2 - More private GPIOs (+1 for every socket), No USARTs, DAC channels

Type 1 **Type 2**



Into socket are inserted modules. Module can contains any number of sensors. Module PCB has standardized dimensions, in order to fit into socket and case of whole device. There are two sizes of modules. Have length of 60mm and 45mm. DXF files are in folder `/doc`.

Drawing of module PCB (60mm)



Socket connection

Socket peripheral support

S1 - T1	S2 - T1	S3 - T1	S4 - T2	S5 - T2
UART1	UART2	UART3	---	---
SPI1	SPI1	SPI1	SPI1	SPI1
I2C1	I2C1	I2C1	I2C1	I2C1
CAN	CAN	CAN	CAN	CAN
SGP	SGP	SGP	SGP	SGP
PP0	PP1	PP2	PP3, PP4	PP5, PP6

Shared pin description (SGP)

Descriptor	Port&Number	I/O	IRQ	ADC_IN	DAC_OUT
SGP0	PB2	YES	YES (4)	NO	NO
SGP1	PB1	YES	YES (1)	YES (16)	NO
SGP2	PB0	YES	YES (0)	YES (15)	NO
SGP3	PA7	YES	YES (7)	YES (12)	NO
SGP4	PA4	YES	YES (2)	YES (9)	YES (1)

Private pin description (PP)

Descriptor	Port&Number	I/O	IRQ	ADC_IN	DAC_OUT
PP0	PB3	YES	YES (3)	NO	NO
PP1	PA15	YES	YES (15)	NO	NO
PP2	PB5	YES	YES (5)	NO	NO
PP3	PA8	YES	YES (8)	NO	NO
PP4	PB12	YES	YES (12)	NO	NO
PP5	PC13	YES	YES (13)	NO	NO
PP6	PC14	YES	YES (14)	NO	NO

- all PP are IRQ capable on different vectors
- numbers in brackets are describing channel/vector of ADC,DAC/IRQ

Sensors

Board 1 - Weather module

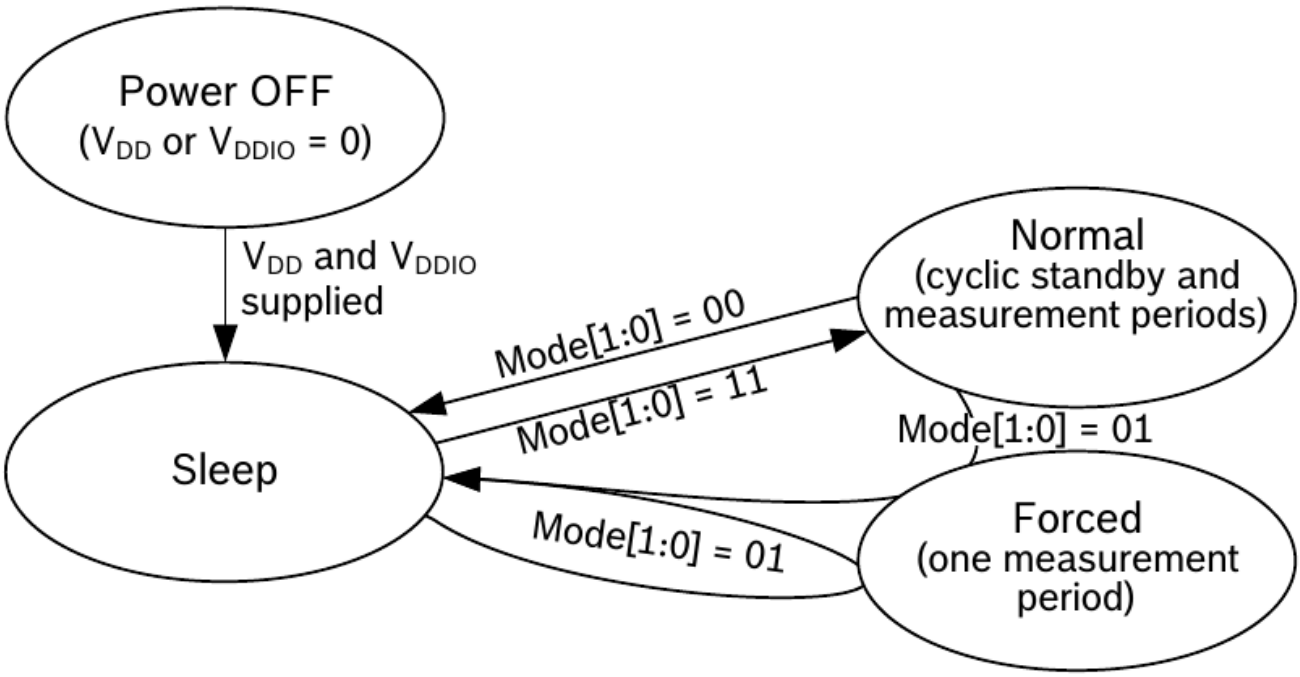
Can be inserted into slots: 1,2,3,4,5
Recommended slots: 4,5
Default slot: 4
All sensors are on I2C bus with 1.8 V and 3.3 V voltage supply

- BME208 -> temperature, pressure, humidity - Mouser
- VEML6040 -> color sensor RGBW - Mouser
- SI1145 -> IR and ambient light sensor, UV index measurement - Mouser
  Note: SI1145 is nearly impossible to solder without IR soldering station, for now is this sensor left not populated

BME208

- LGA package - 2.5 x 2.5 x 0.93 mm
- I2C with freq. up to 3.4 Mhz
- VCC is 1.8 V
- Current consumption is around 8.2 uA in 1 Hz measure mode
- Sleep current is 0.1 uA
- Operational temperature is from -40°C to +85°C
- Accuracy of sensors:
  - 3% of relative humidity
  - typical +-1.0 hPa
  - +-0.5°C at 25°C (1°C at -15°C or 65°C)
- I2C address: 111011x
  - first bit is selectable via input pin of sensor
- Three operation modes:
  - Sleep mode: no operation, all registers accessible, lowest power, selected after startup
  - Forced mode: perform one measurement, store results and return to sleep mode
  - Normal mode: perpetual cycling of measurements and inactive periods

Sensor state transition diagram:



VEML6040

- OPLGA package - 2.0 x 1.25 x 1.0 mm
- VCC is 3.3 V
- I2C interface (SMBus compatible) (max 400kHz)
- 16-bit resolution for every color channel
- 16-bit registers
- I2C address: 0010000

Board 2 - GNSS module

Can be inserted into slots: 1,2,3 (4,5 are working without UART export)
Recommended slots: 1,2
Default slot: 1

GNSS modul is Teseo-LIV3F.
Teseo can supply data via stream over UART
Or can be pooled to retrieve data to over I2C

Digikey microbus project:
- https://www.digikey.com/en/maker/projects/teseo-liv3f-mikrobus-add-on-board/c4072044fba34f7b9d5210b973331940
- https://github.com/mkmielke/LIV3F_mikroBUS
Data are exported in NMEA format

Antenna can be used SMD or remote, if antenna is passive there is need to mount LNA (Low Noise Amplifier) and SAW (Surface Acoustic Wave) filter
Possible passive antenna: https://www.tme.eu/cz/details/1461860100/anteny-gps/molex/

Easier will be to used active antenna, like this: https://www.tme.eu/cz/details/gps-ant045/anteny-gps/sr-passives/

Also battery can be placed in order as backup for Teseo module
Is important to create isolated ground around power ground pin (1) -> Hardware_notes.pdf page 20

For limiting current could be use some load switching IC to prevent shorts on antenna.
Candidate is: https://www.tme.eu/cz/details/ap2151aw-7/power-switches-integrovane-obvody/diodes-incorporated/
Current limit should be higher then 40mA, this has 500mA
Also connection should contains inductor and with capacitor on line, based on Hardware_notes.pdf page 15

Module contains 3 LED which informs about status of module (color of LED may vary):
- PWR - Red - On when module is powered
- ANT - Yellow - On when antenna is active, off when is disabled for example due to standby mode
- PPS - Green(blue)- On when Teseo generates PPS pulse, this pulse is generated every 1s

Via I2C can be Teseo set to standby mode with lower power consumption, from this mode can be wake up via rising edge on wake up pin
Wake up pin is connected to PP0 of socket
Power consumption during normal operation is around 85mW for GPS, in standby is around 0.29uW

Board 3 - IMU module

Can be inserted into slots: 1,2,3,4,5
Recommended slots: 4,5
Default slot: 5

This module contains accelerometer, gyroscope and magnetometer (compass).

Accelerometer: **ASM330LHH**

- https://www.st.com/content/st_com/en/products/mems-and-sensors/automotive-sensors/asm330lhh.html
- Package: LGA-14 (KiCAD have it, 3x2.5mm, P0.5mm)
- Supply voltage: 3.3V
- I2C speed: up to 400kHz
- Can work in these modes: Bypass, FIFO, Continuous (and combination of modes)
- Have Data ready IRQ (INT2) and Programmable IRQ (INT1)
- Power supply should be filtered with capacitors (100nF and 10uF)
- In I2C mode can be lowest bit address selector, connect to ground (0)
- On register map is Status register (0x1E) and ID register (0x0f)

Gyroscope: **A3G4250D**

- https://www.st.com/content/st_com/en/products/mems-and-sensors/gyroscopes/a3g4250d.html
- Package: LGA-16 (KiCAD have it, 4x4mm, P0.65mm)
- Supply voltage: 3.3V
- I2C speed: up to 400kHz
- Embeds 32-slot 16-bit FIFO for all 3 output channels (roll, pitch yaw)

- Can work in three modes: Bypass, FIFO, Stream
- Contains temperature data which can be used to compensate thermal drift
- Have Data ready IRQ (INT1) and Programmable IRQ (INT2)
- Must be connected to external low pass filter at pin 14
- Power supply should be filtered with capacitors (100nF and 10uF)
- In I2C mode can be SDO pin used as lowest bit address selector, connect to ground
- In register map is Status register (0x27) and ID register (0x0f)

Magnetometer: **IIS2MDC**

- https://www.st.com/en/mems-and-sensors/iis2mdc.html
- Package: LGA-12 (KiCAD have it, 2x2mm, P0.5mm)
- Supply voltage: 3.3V
- I2C speed: up to 400kHzs
- Must be connected to external filter at pin 5 (C = 220nF)
- In register map is Status register (0x67) and ID register (0x4f)
- Contains temperature data which can be used to compensate thermal drift

All these sensors support communication over SPI or I2C. But these module have connected only I2C.
Address of devices
Accelerometer: 1101010b (lowest bit is selectable)
Gyroscope: 1101000b (lowest bit is selectable)
Magnetometer: 0011110b

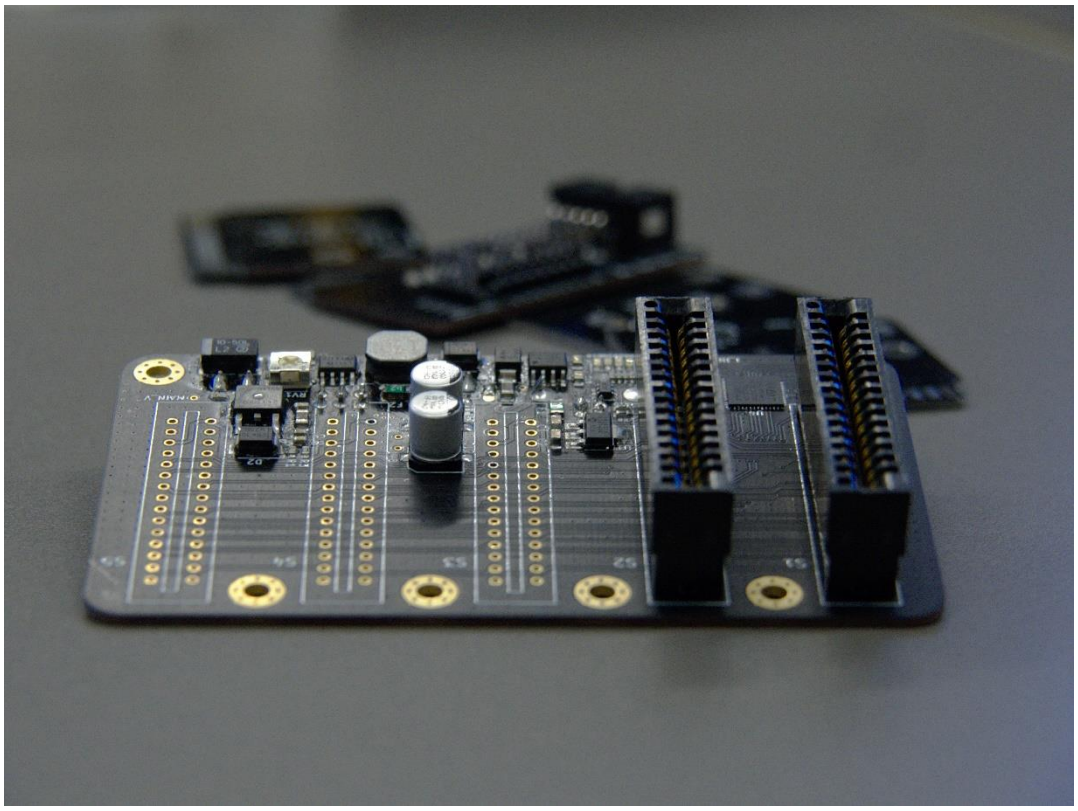
Test module

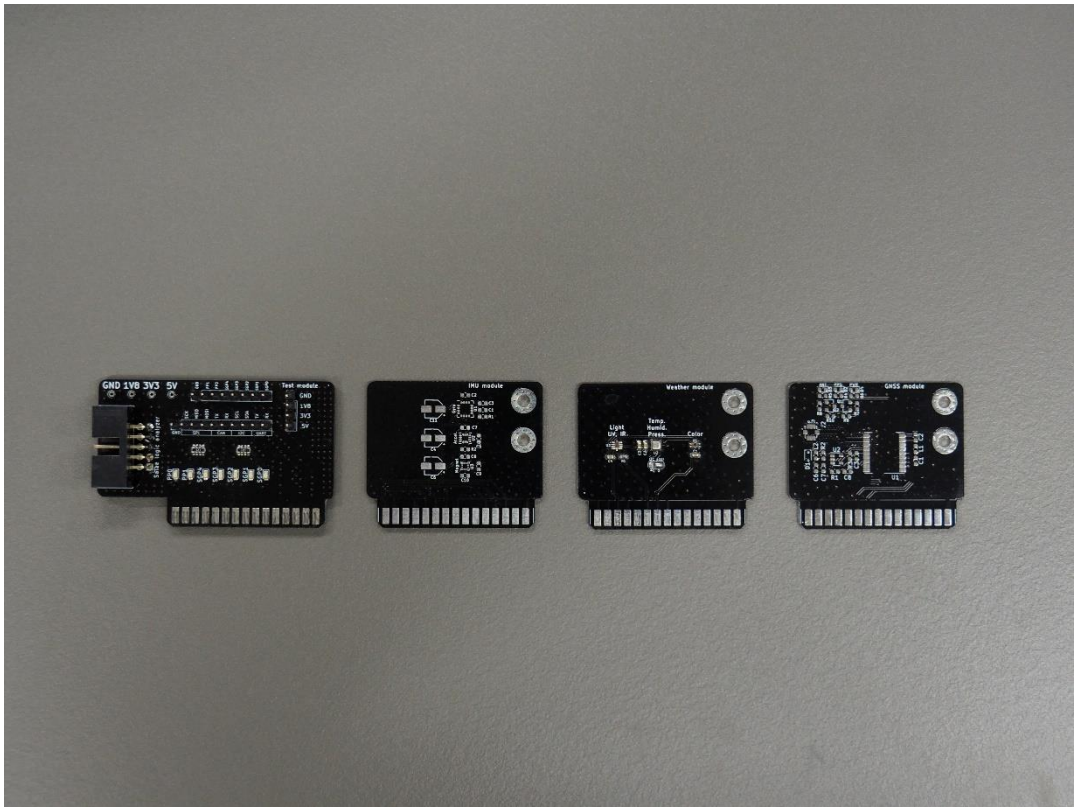
Can be inserted into slots: 1,2,3,4,5

This module did not add any functionality and is not mean as release module, servers only for diagnostic and debugging.
Contains breakout pins from socket, debug connector for Salae logic analyzer and LEd which indicates status of SGP and PP.
IDC connector on this board is compatible with Salae 10 pin connector. Pinout of connector is specified on bottom side of PCB.
Also contains measure point for all power lines.

Photos

Images below shows all currently used parts of the multisensoric board - motherboard and all 3 boards.




GND 1V8 3V3 5V
Test module
GND
1V8
3V3
5V
IMU module
Vesther module
Light
UV, IR
Temp.
Humid.
Press.
Color
GNSS module