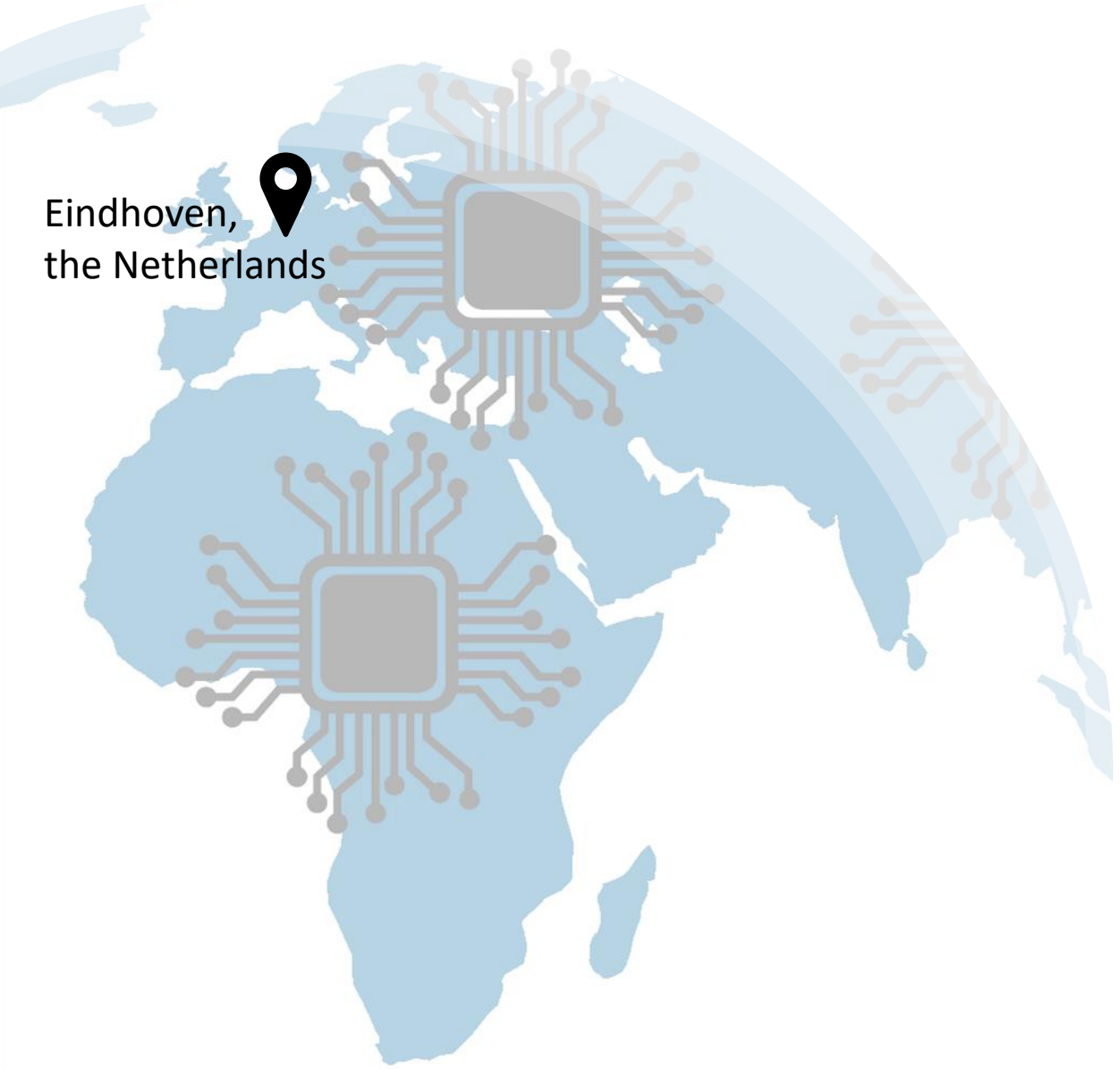


Battery management in NuttX with NXP RDDRONE-BMS772

Jari van Ewijk

Cis van Mierlo

August 15-16 2020

NuttX Online Workshop

NuttX Online Workshop

Together with our valued customers, we're not just advancing technology, we're advancing society.

AUTOMOTIVE

Enabling carmakers to develop smarter solutions for complex autonomy, connectivity, and electrification challenges

Accelerating the shift to greater mobility

INDUSTRIAL

Reducing wasted time, money, and effort by helping business run more efficiently.

Enabling more efficient data processing

MOBILE

Giving wearable and mobile devices easier access to the services that make modern life more convenient without compromising security and safety.

Transforming how people and devices connect

SMART HOME

Solutions that listen, learn, and adapt into the places we call home for more comfort, affordability, safety, and convenience.

Powering the intelligence behind the technologies

SMART CITY

Simplifying how people access and interact with local services to achieve new standards of sustainability, efficiency, mobility, and economic growth.

Anticipating the demands of tomorrow

COMMUNICATION INFRASTRUCTURE

Powering insights and inspiring performance with hardware solutions for handling 5G connectivity across the emerging communications spectrum.

Delivering real-time responsiveness at the speed of 5G

60 years of combined experience and expertise

Operations in more than **30 countries** worldwide

Approximately **30,000 employees**

Headquarters in The Netherlands – **Eindhoven**

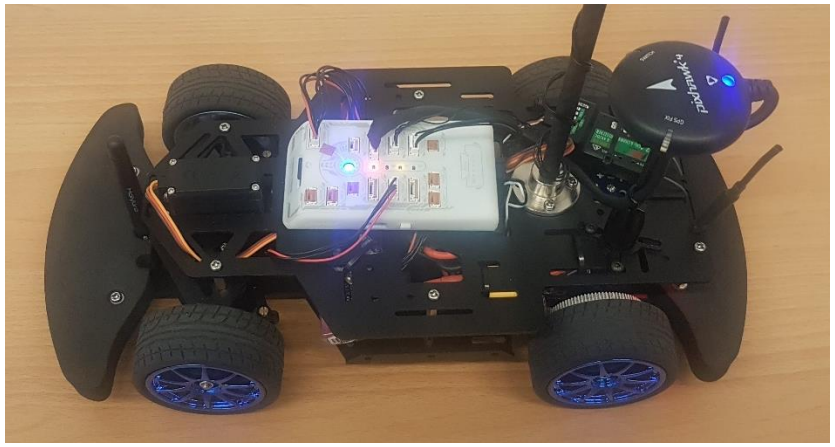
THE APACHE SOFTWARE FOUNDATION

Mobile robotics at NXP

- Started as a small drone team → Now mobile robotics
- Drones
- Rovers
- Delivery vehicles and open experimentation like X-VTOL

- Applying products from throughout the company to drones and rovers
- MCU, MPU, Safety, Security, Networking, Wireless
- Automotive functional safety parts (ISO 26262)

- “We don’t build drones, we build reference designs”



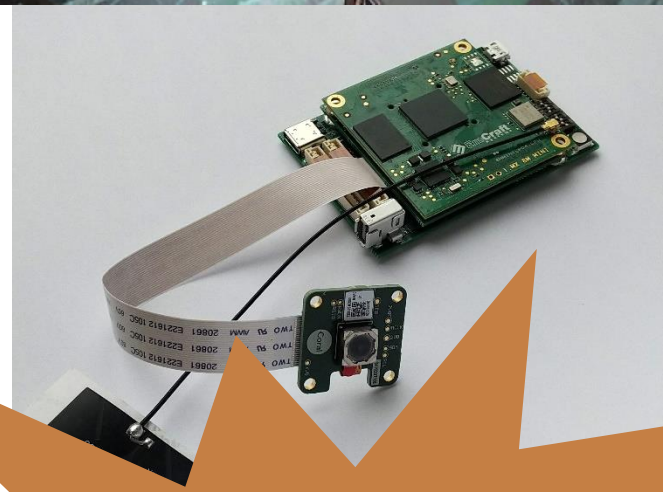
HOVERGAMES - CODING CHALLENGE

HELP DRONES HELP OTHERS DURING PANDEMICS

Challenge yourself to think creatively about drone solutions for real world problems.
Learn more on www.hovergames.com

Registration is now open https://www.hackster.io/contests/hovergames2

Winning applications receive coupon for a complete PX4 Drone Kit and NavQ i.MX 8M Mini Linux companion computer with 5MP Google Coral Camera, HDMI adapter, power adapter cables, IX industrial ethernet cables, mounting plate and USB hub
for only $300



Applications for hardware close today! (August 16)

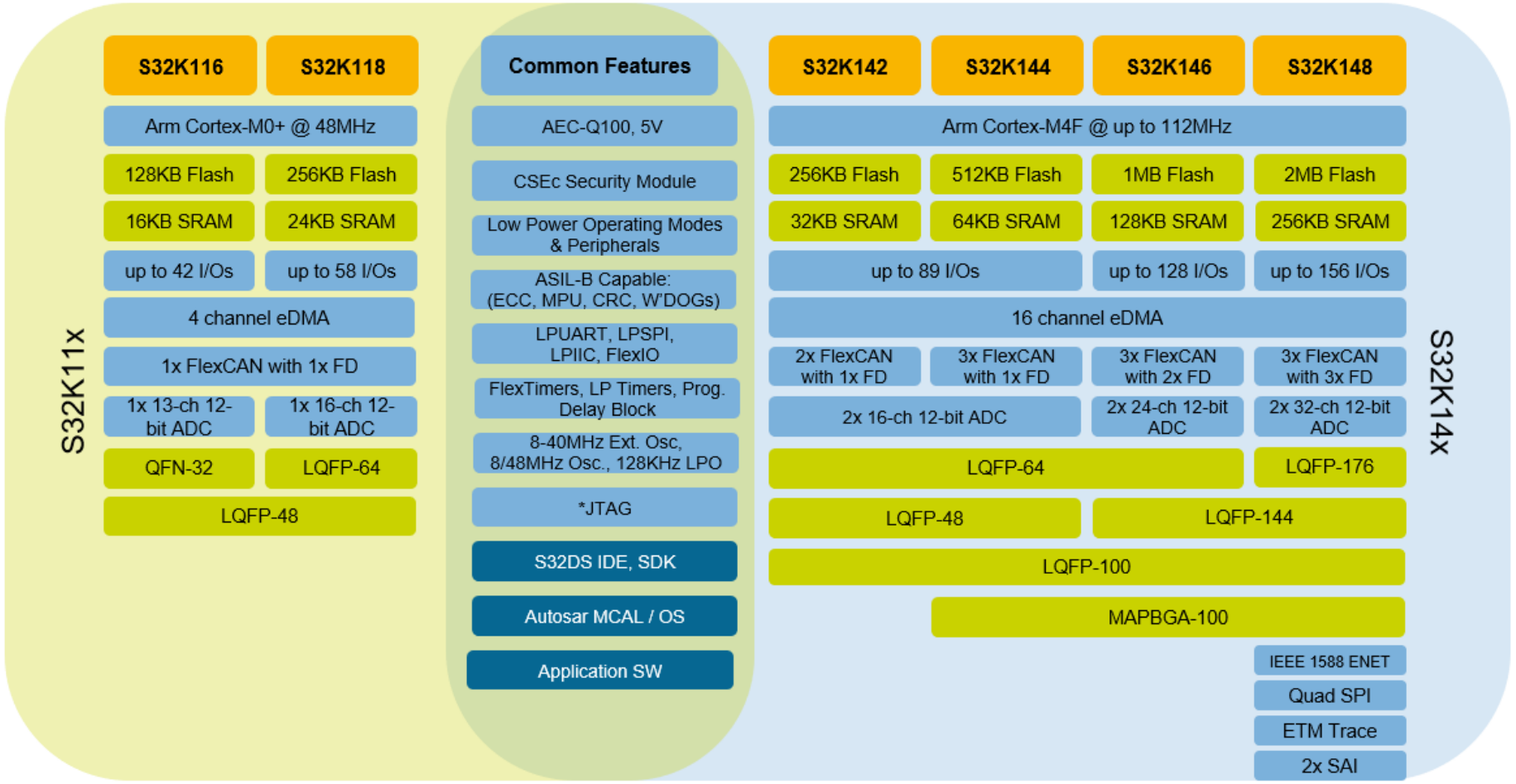
NXP and NuttX

Why does the NXP Mobile Robotics team like NuttX?

- (PX4 community)
- We create complex systems with many different tasks and peripherals
- Standards compliance, use of POSIX and Unix APIs
- Portability, support of many different platforms
- Extensive set of drivers and applications
- Enthusiasm for NXP silicon in the NuttX community

Support for many NXP MCUs and MPUs:

- i.MX RT 105x/106x (ARM Cortex-M7)
- **S32K1xx (ARM Cortex-M0/M4)**
- Kinetis (K/L) (ARM Cortex-M0/M4)
- LPC 17xx/40xx/43xx/54xxx (ARM Cortex-M0/M3/M4)
- i.MX 6 (ARM Cortex-A9)



https://www.nxp.com/products/processors-and-microcontrollers/arm-microcontrollers/s32k-automotive-mcus/s32k1-microcontrollers-for-general-purpose:S32K

Our recent contributions

- S32K1xx arch support (thanks Gregory for the initial port!)
- S32K1xx EVB board support
- SocketCAN implementation (by Peter van der Perk)

Very soon:
- RDDRONE-UCANS32K146 UAVCAN node
- RDDRONE-BMS772 battery management system
    - MC33772 driver and battery management application

Source: https://www.youtube.com/watch?v=uQkgr5NjTVo

Problem description

- Drones
- Lithium ion polymer battery
- Unsafe
- Monitoring & protection

Sources: https://www.powerelectronicsnews.com/pushing-to-the-very-edge-of-safe-li-ion-charging/

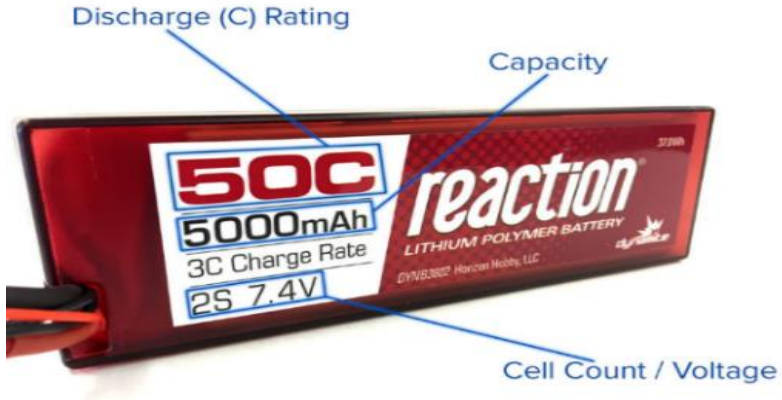
LiPo comparison

Pros

- Weight and shape
- High capacity
- High discharge rate

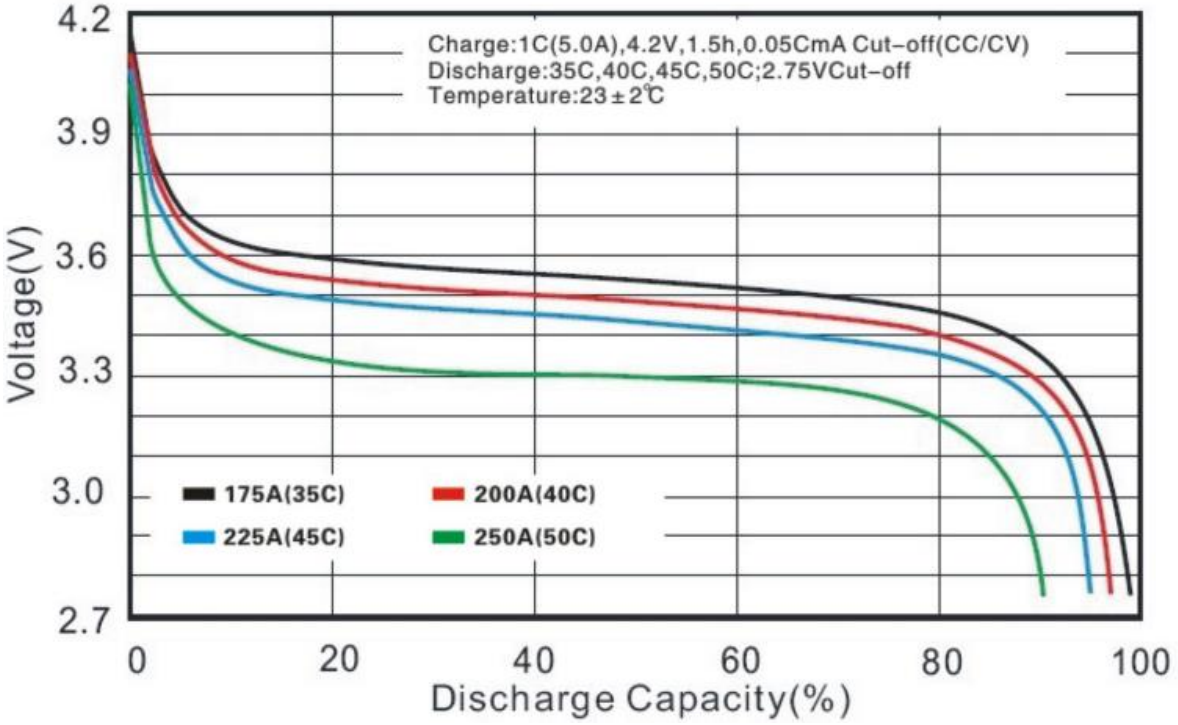
Cons

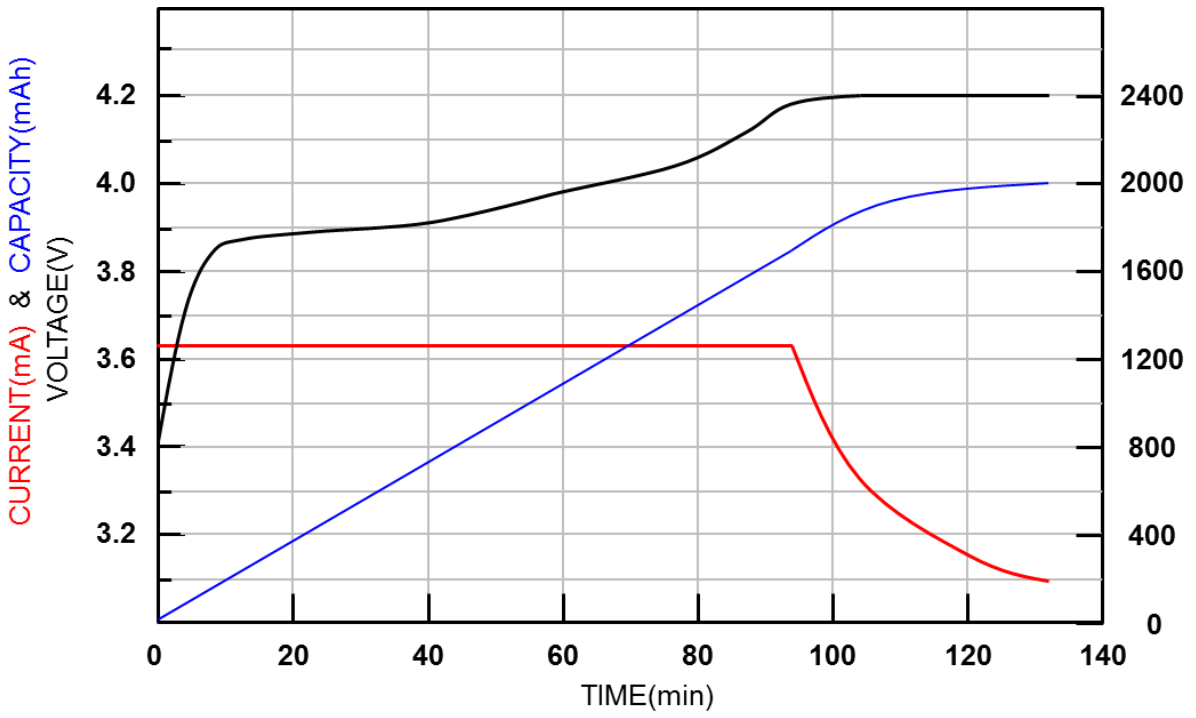
- Special attention
- Sensitive chemistry
- Short lifetime (150-250 cycles)



Source: https://rogershobbycenter.com/lipoguide

LiPo curves





Source: https://www.richtek.com/Design%20Support/Technical%20Document/AN024

What should this BMS do?

Measure

Batt voltage

Cell voltages

Batt current

Batt temperature

PCB temperatures

Estimate

State of charge

State of health

Avg power

Full charge capacity

T_{charge}

BMS status

Act

Cut power with an extreme fault

React on:

- Overcurrent
- Over & under voltage
- Over & under temperature

Balance cells

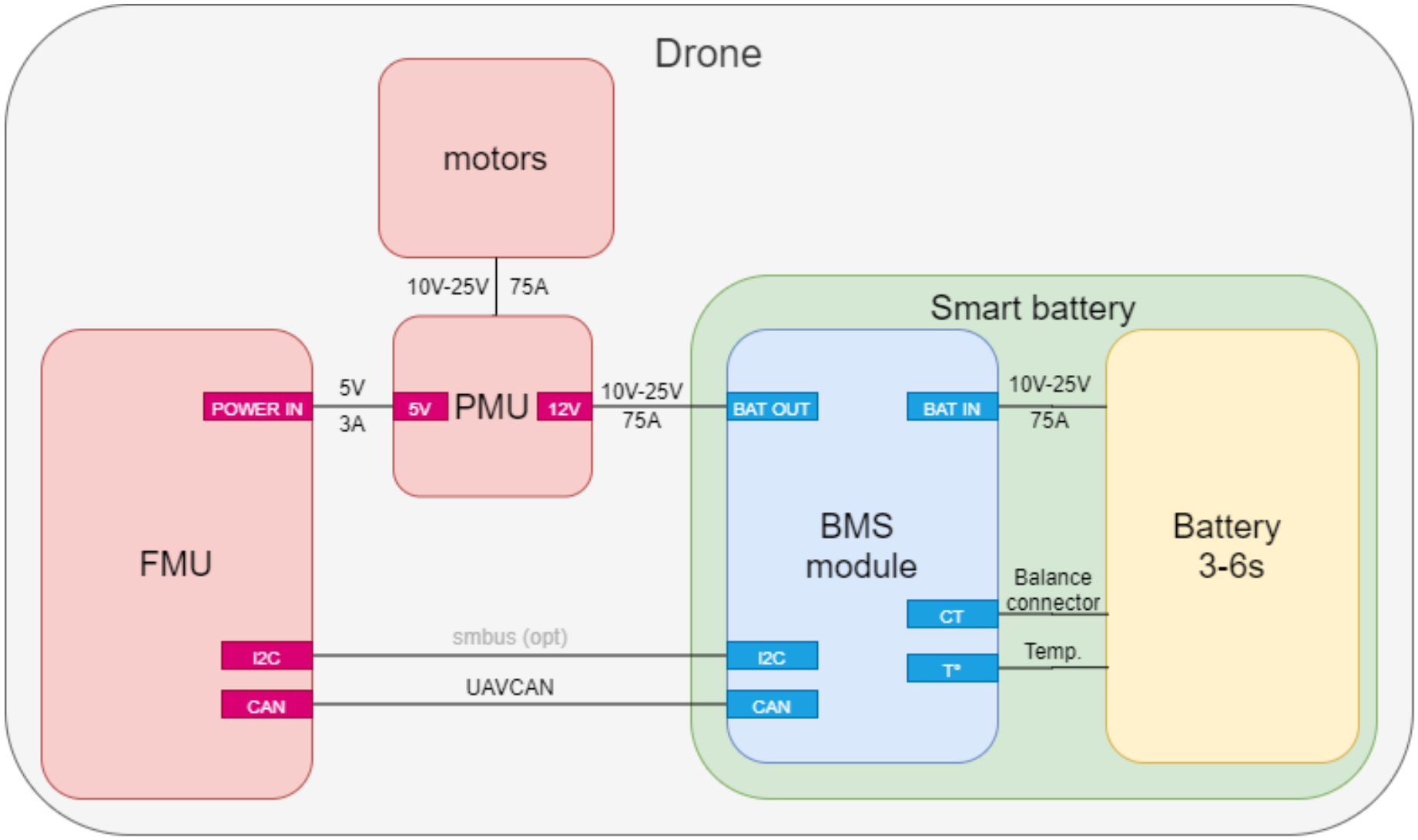
Communicate

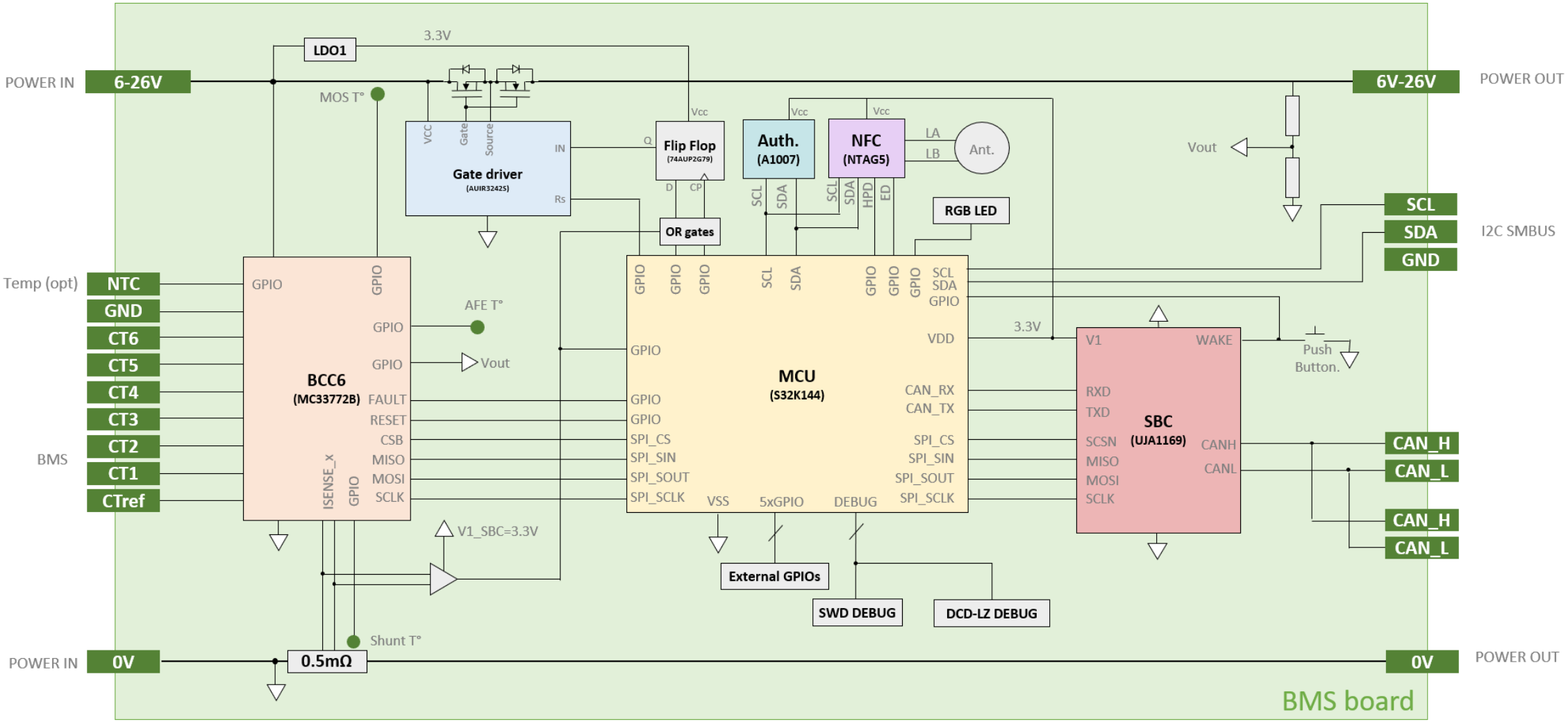
UAVCAN

LED

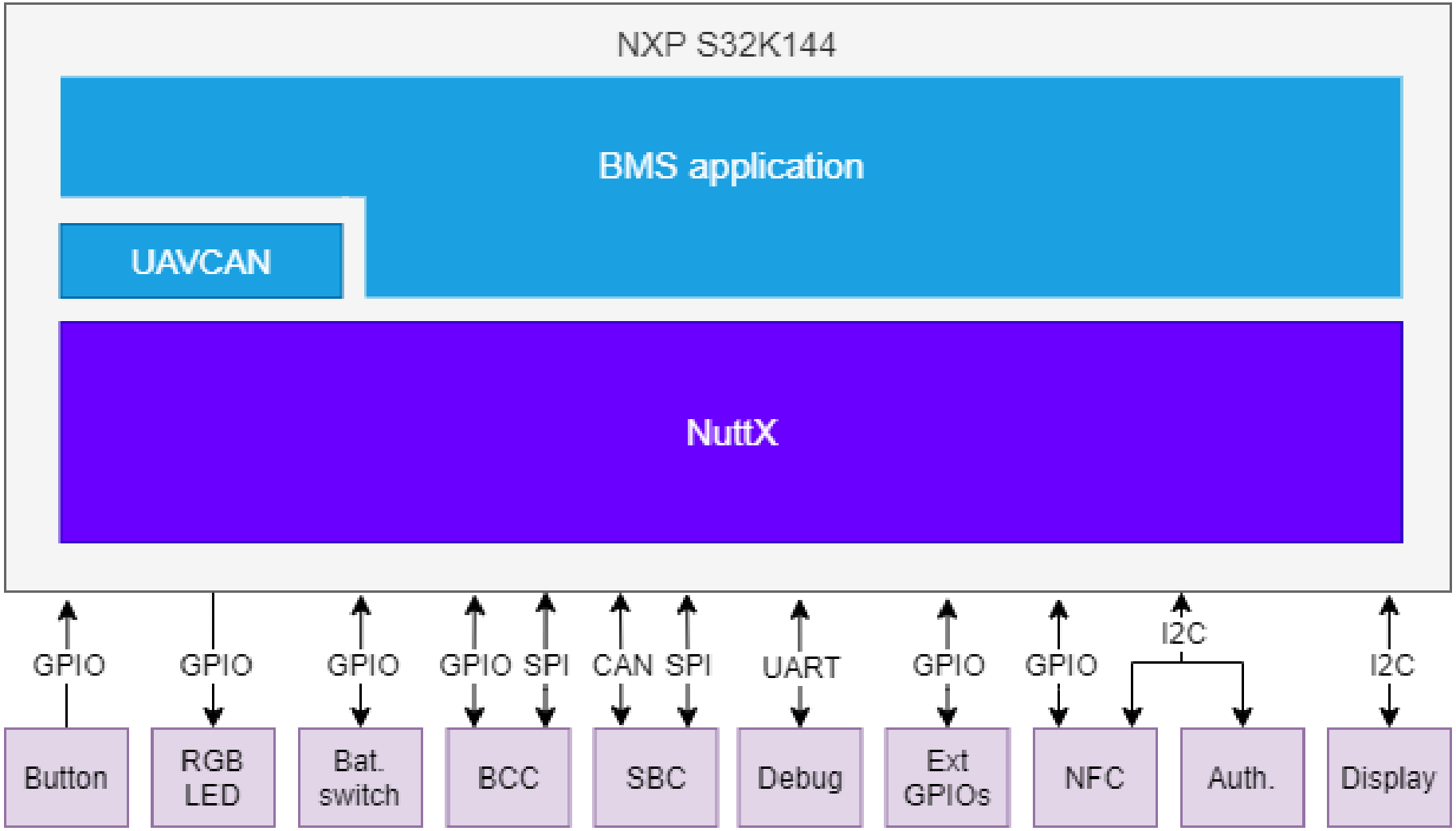
(NFC)

(Display)


Drone
motors
10V-25V
75A
Smart battery
POWER IN
5V
3A
5V
PMU
12V
10V-25V
75A
BAT OUT
BAT IN
10V-25V
75A
FMU
BMS
module
Battery
3-6s
Balance
connector
CT
smbus (opt)
I2C
I2C
Temp.
T°
UAVCAN
CAN
CAN


POWER IN
6-26V
LDO1
3.3V
MOS T°
Gate driver
(AUIR3242S)
VCC
Gate
Source
IN
Rs
Flip Flop
(74AUP2G79)
Q
D
CP
Vcc
Auth.
(A1007)
NFC
(NTAG5)
LA
LB
Ant.
SCL
SDA
HPD
ED
OR gates
RGB LED
6V-26V
POWER OUT
Vout
SCL
SDA
GND
I2C SMBUS
Temp (opt)
NTC
GND
CT6
CT5
CT4
CT3
CT2
CT1
CTref
BMS
BCC6
(MC33772B)
GPIO
FAULT
RESET
CSB
MISO
MOSI
SCLK
ISENSE_x
AFE T°
Vout
V1_SBC=3.3V
MCU
(S32K144)
VDD
CAN_RX
CAN_TX
SPI_CS
SPI_SIN
SPI_SOUT
SPI_SCLK
VSS
5xGPIO
DEBUG
External GPIOs
SWD DEBUG
DCD-LZ DEBUG
3.3V
SBC
(UJA1169)
V1
WAKE
RXD
TXD
SCSN
MISO
MOSI
SCLK
CANH
CANL
Push
Button.
CAN_H
CAN_L
CAN_H
CAN_L
Shunt T°
POWER IN
0V
0.5mΩ
0V
POWER OUT
BMS board

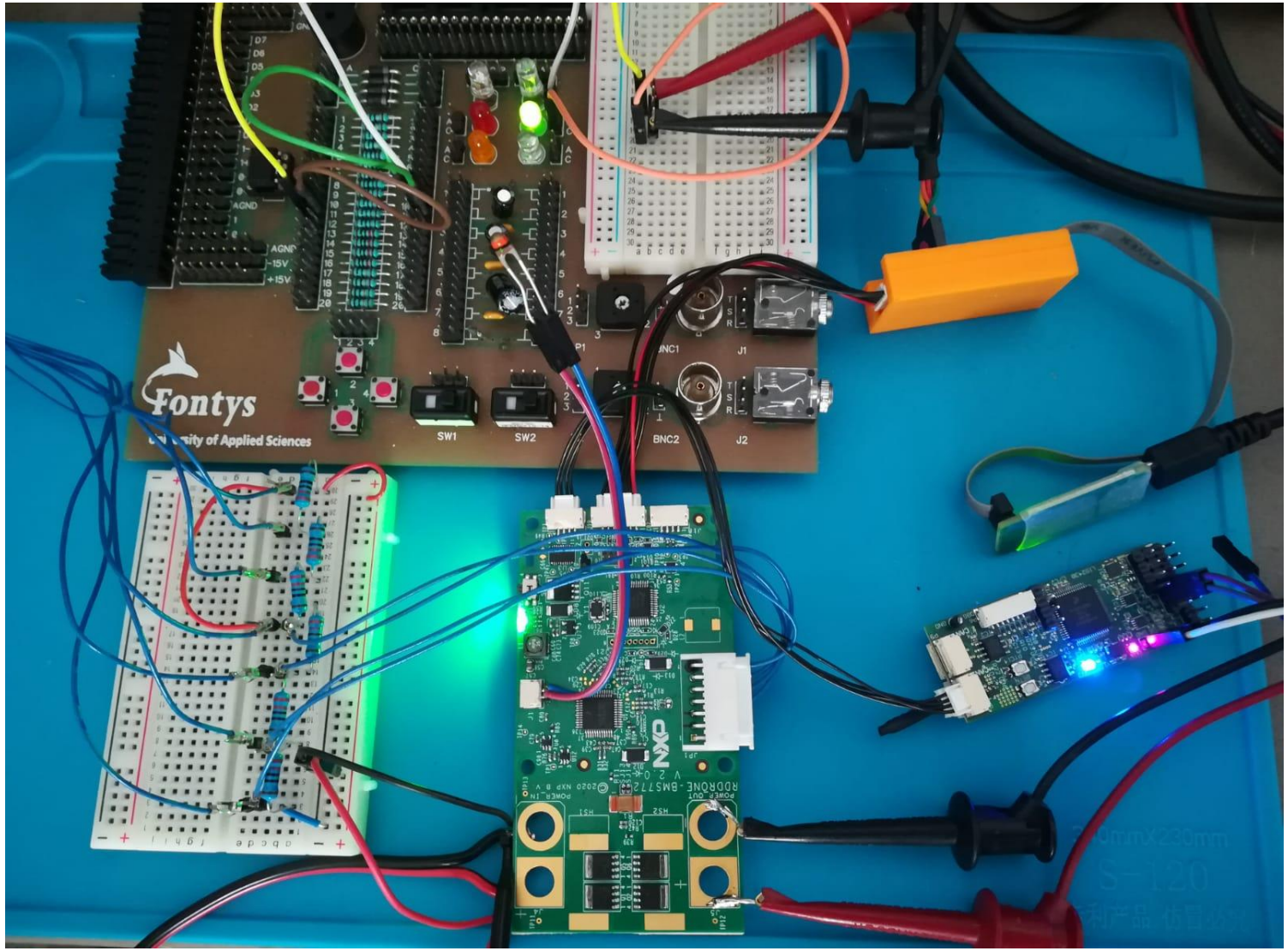
NuttX Online Workshop



NuttX Online Workshop

Data	Shared memory Multi-thread access Easy save to flash
CLI	Easy debugging Easy configuration
LED state	Visual indication NuttX userled functions
Battery management	Monitoring, configuration BCC (library & SPI driver) Control the output
UAVCAN	Draft of the battery standard socketCAN API Communication with FMU

Test set-up



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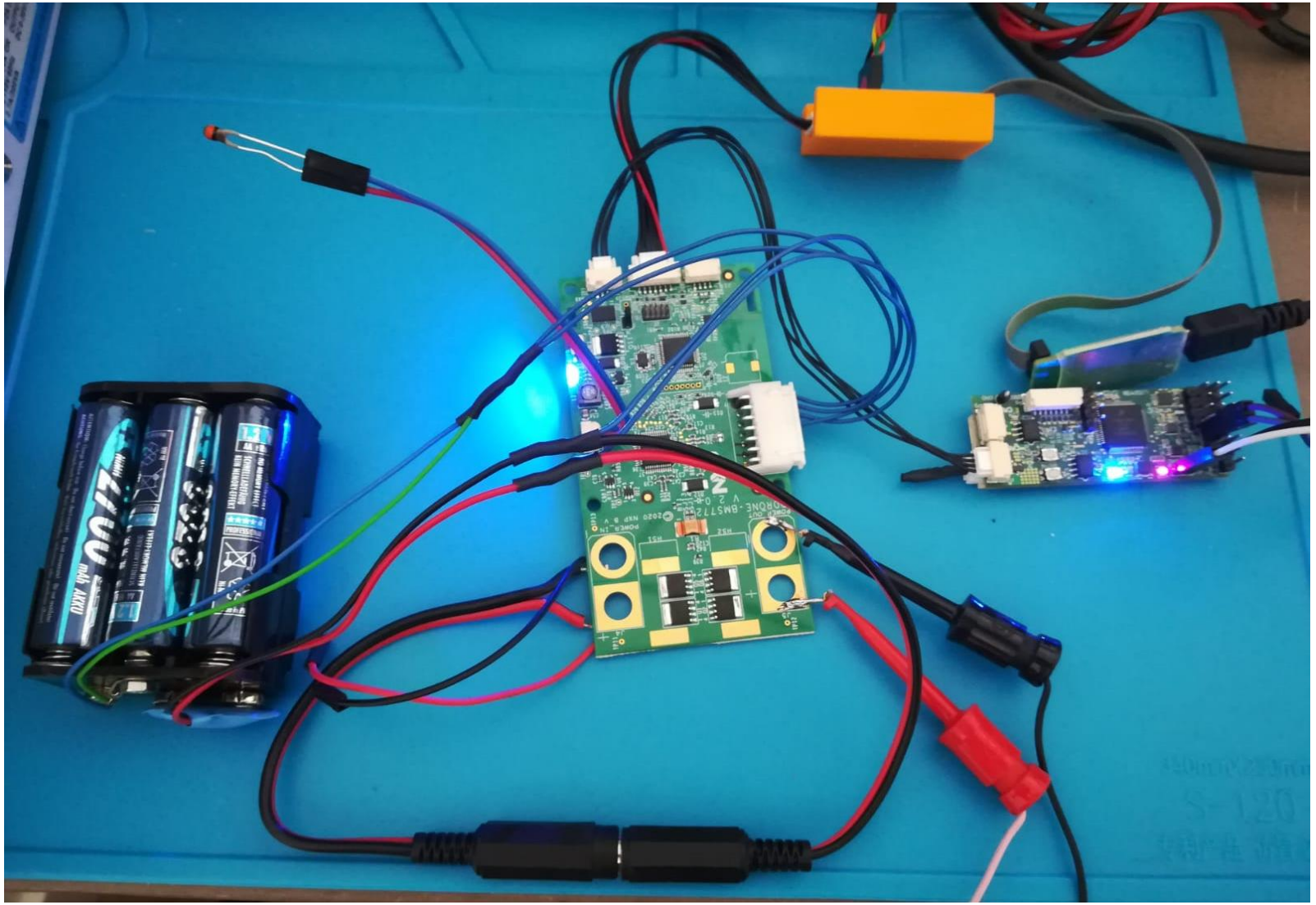
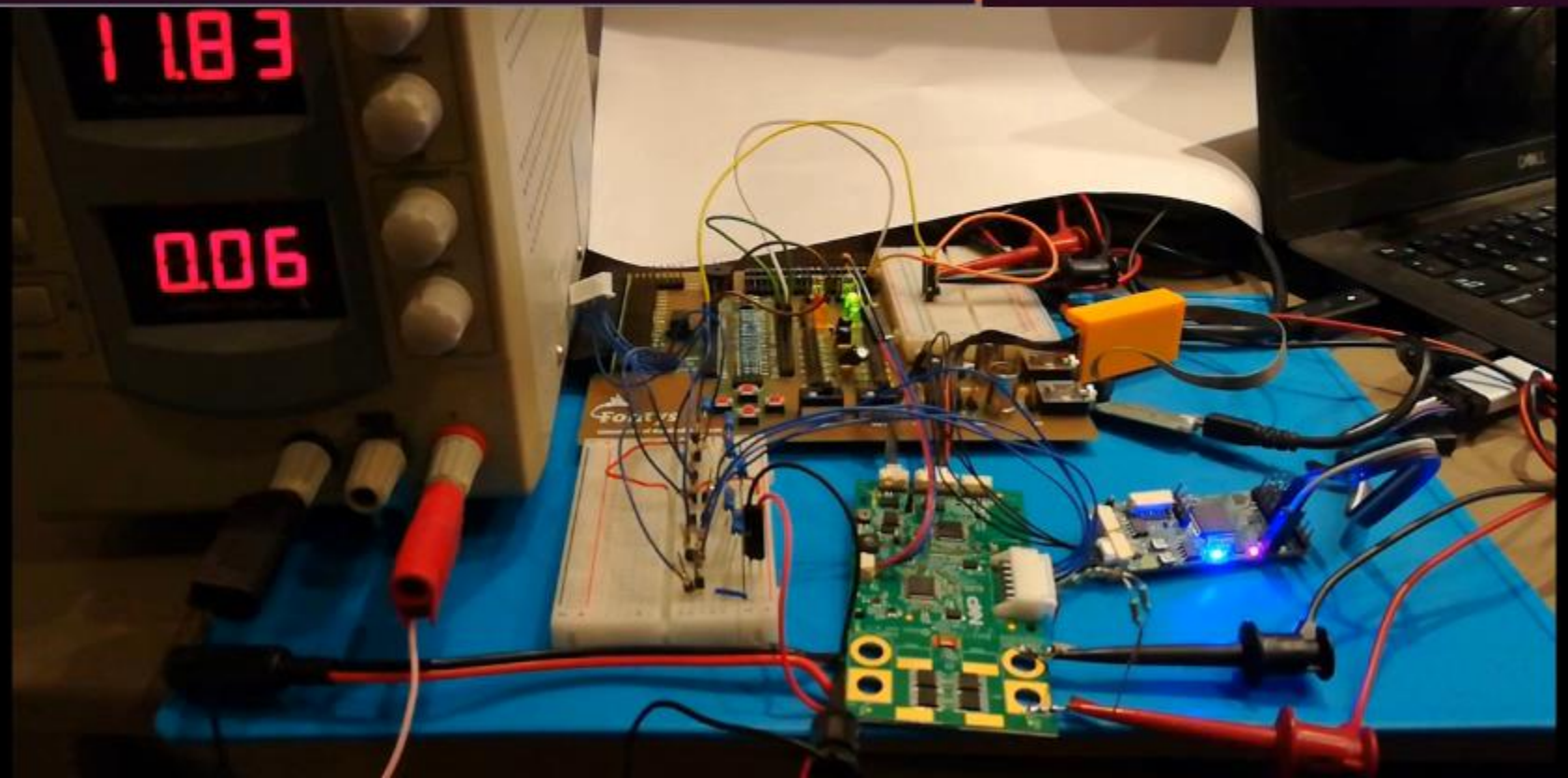


File Edit View Search Terminal Help

```
nsh>
```

File Edit View Search Terminal Help

```
regulated.drone.sensor.BMSStatus.1.0
temperature: 10.1328125
voltage: 11.796875
current: -0.0180816650390625
energy_consumed: 0.0017948150634765625
battery_id: 0
state_of_charge: 53
output_status: True
status: regulated.drone.sensor.BMSStatusValue.1.0(status: 255))
```



Results

Measure

Batt voltage

Cell voltages

Batt current

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PCB temperatures

Estimate

State of charge

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UAVCAN

LED

CLI

NFC

Display

More information

RDDRONE-BMS772 on NXP.com:
https://www.nxp.com/design/designs/rddrone-bms772-smart-battery-management-for-mobile-robotics:RDDRONE-BMS772

Documentation on GitBook:
https://nxp.gitbook.io/rddrone-bms772/

Software will be released soon!

HoverGames:
https://www.hovergames.com/

Thank you for watching!