Battery management in NuttX with NXP RDDRONE-BMS772

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August 15-16 2020
NuttX Online Workshop
Together with our valued customers, we’re not just advancing technology, we’re advancing society.

60 years of combined experience and expertise
Operations in more than 30 countries worldwide
Approximately 30,000 employees
Headquarters in The Netherlands – Eindhoven

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
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”
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)
# NuttX Online Workshop

**S32K11x**
- **S32K116**
  - Arm Cortex M0+ @ 48MHz
  - 128KB Flash
  - 16KB SRAM
  - up to 42 I/Os
  - 4 channel eDMA
  - 1x FlexCAN with 1x FD
  - 13-ch 12-bit ADC
  - QFN-32
  - LQFP-48
- **S32K118**
  - Arm Cortex M0+ @ 48MHz
  - 256KB Flash
  - 24KB SRAM
  - up to 58 I/Os

**Common Features**
- AEC-Q100, 5V
- CSEC Security Module
- Low Power Operating Modes & Peripherals
- ASIL-B Capable (ECC, MPU, OES, WDG0s)
- LPUART, LPSPI, LPICL, FlexIO
- FlexTimers, LP Timers, Prog. Delay Block
- 8-40MHz Ext. Osc., 8/48MHz Osc., 128KHz LPO
- "JTAG
- S32DS IDE, SDK
- Autosar MCAL / OS
- Application SW

**S32K142**
- Arm Cortex M4F @ up to 112MHz
- 256KB Flash
- 32KB SRAM
- up to 89 I/Os
- 16 channel eDMA
- 2x FlexCAN with 1x FD
- 2x 16-ch 12-bit ADC
- LQFP-84

**S32K144**
- 512KB Flash
- 64KB SRAM
- up to 128 I/Os
- LQFP-48

**S32K146**
- 1MB Flash
- 128KB SRAM
- up to 156 I/Os
- LQFP-144

**S32K148**
- 2MB Flash
- 256KB SRAM
- MAPBGA-100
- IEEE 1588 ENET
- Quad SPI
- ETM Trace
- 2x SAI

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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
Problem description

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

Sources: https://www.powerelectronicsnews.com/pushing-to-the-very-edge-of-safe/
# 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](https://rogershobbycenter.com/lipoguide)
LiPo curves

**Charge:** 1C (5.0A), 4.2V, 1.5h, 0.05CmA Cut-off (CC/CV)

**Discharge:** 35C, 40C, 45C, 50C; 2.75VCut-off

Temperature: 23 ± 2°C
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 $T_{\text{charge}}$
- 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
<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>Shared memory, Multi-thread access, Easy save to flash</td>
</tr>
<tr>
<td>CLI</td>
<td>Easy debugging, Easy configuration</td>
</tr>
<tr>
<td>LED state</td>
<td>Visual indication, Nuttx userled functions</td>
</tr>
<tr>
<td>Battery management</td>
<td>Monitoring, configuration, BCC (library &amp; SPI driver), Control the output</td>
</tr>
<tr>
<td>UAVCAN</td>
<td>Draft of the battery standard, socketCAN API, Communication with FMU</td>
</tr>
</tbody>
</table>
Test set-up
Test set-up
regulated.drone.sensor.BMSStatus.1.0
temperature: 18.1328125
voltage: 11.796875
current: 0.0108816650390025
energy_consumed: 0.00179401506034765625
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
- 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
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Communicate
- 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!