# Technical Note

**Title:** Power supply specifications

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## Revision History

| Revision | Author | Description | Date |
|---|---|---|---|
| **R01** | Arion Zimmermann | Document Baseline | 24.02.2021 |
| **R02** | Arion Zimmermann | Clarified some requirements | 3.03.2021 |

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## 1. Abstract

EPFL Xplore's Rover has many subsystems that must be powered at very specific voltages. The power supply will have to provide 5 different voltage channels, namely 3.3V, 5V, 15V, 24V, 48V and take, as an input, from 21V to 30V.

## 2. High-level requirements

The power supply unit (PSU) has 5 output channels and 1 input channel. The state of the converters between input and output must be controllable by a power supply controller (PSC). This controller must also receive active feedback from every converter.

The PSU must accept an input voltage of 21V to 30V. The DC input originates from a battery pack but passes through a circuit breaker and an automotive relay before arriving at the power supply's input.

Inside the PSU, a battery charge estimator counts how much charge is left in the battery pack and reports it to the controller. This charge estimator must take into account the voltage-charge profile of the battery cells.

Further, an undervoltage protection mechanism prevents the DC/DC converters from starting switching in an undervoltage condition, which could eventually result in unstable behaviour.

The PSU has to convert its input to different voltage levels. First of all, a 3.3V converter is necessary to power the rover's Avionics. Then, the Raman laser must be powered by a 5V input and 15V must be supplied to the main computer. Further, the LiDAR will have to be supplied with 24V and finally, the ethernet switches require an input voltage of 48V.

Each of these converters must shutdown if their respective connected load exceeds the maximum load they are designed for. Their output power must be measured at any time and reported to a supervising controller. This supervising controller must be able to shutdown any of the converters at any time and expects to receive a "power good" signal from the converter when the output voltage is within 10% of nominal output voltage.

The PSU's controller (PSC) controls the state of the DC/DC converters and receives information from those, as previously mentioned. This information must be transmitted by WiFi to the control station in a 2.4Ghz band and to the avionics through an I2C bus.

The output connectors of the DC/DC converters must accept cables with diameters ranging from AWG12 and AWG22. Specifications about the connector to the avionics are specified in RF01.

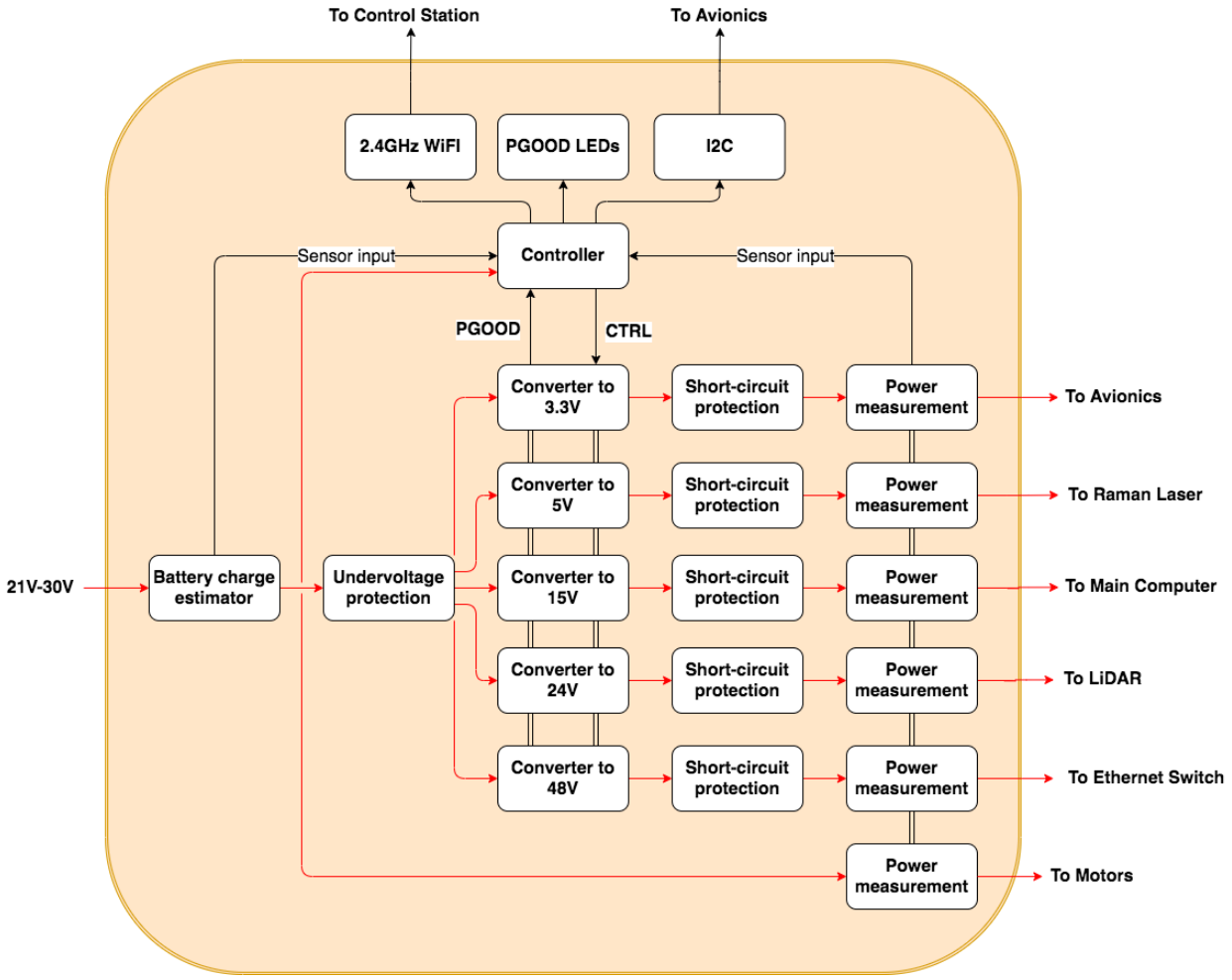


Fig. 1: Block diagram of the PSU architecture (in red: power path, in black: data path)

## 3. Electrical specifications

**Input characteristics**

| Parameter | Comment | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Input voltage | Supplied from battery pack | 21 | 25.4 | 29.4 | V |
| Source impedance | Measured at 1KHz | 7 | 12 | 16 | mΩ |
| Input current | | - | - | 25 | A |

**3.3V output characteristics**

| Parameter | Comment | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Output voltage | At nominal load | 3 | 3.3 | 3.6 | V |
| Output noise & ripple | | - | 50 | 100 | mVpp |
| Output current | | - | 1.12 | 1.3 | A |
| Output power | | - | 3.7 | 4.3 | W |
| Nominal load | | 2.5 | 3 | - | Ω |
| Efficiency | At nominal load | 80 | - | - | % |
| Efficiency | At half load | 70 | - | - | % |

**5V output characteristics**

| Parameter | Comment | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Output voltage | At nominal load | 4.8 | 5 | 5.2 | V |
| Output noise & ripple | | - | 20 | 50 | mVpp |
| Output current | | - | 4 | 5 | A |
| Output power | | - | 20 | 25 | W |
| Nominal load | | 1 | 1.25 | - | Ω |
| Efficiency | At nominal load | 85 | - | - | % |
| Efficiency | At halfload | 80 | - | - | % |
| Transient response | Response to ±50% step input | - | 250 | 500 | mV |
| Transient recovery | Response to ±50% step input | - | 0.5 | 1 | ms |

**15V output characteristics**

| Parameter | Comment | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Output voltage | At nominal load | 9 | 15 | 19 | V |
| Output noise & ripple | | - | 100 | 500 | mVpp |
| Output current | | - | 2.2 | 3.2 | A |
| Output power | | - | 33.2 | 47.5 | W |
| Nominal load | | 4.7 | 6.8 | - | Ω |
| Efficiency | At nominal load | 90 | - | - | % |
| Efficiency | At half load | 85 | - | - | % |

**24V output characteristics**

| Parameter | Comment | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Output voltage | At nominal load | 22 | 24 | 26 | V |
| Output noise & ripple | | - | 100 | 500 | mVpp |
| Output current | | - | 0.75 | 0.85 | A |
| Output power | | - | 18 | 22 | W |
| Nominal load | | 28 | 32 | - | Ω |
| Efficiency | At nominal load | 90 | - | - | % |
| Efficiency | At half load | 85 | - | - | % |
| Transient response | Response to ±50% step input | - | 1000 | 2000 | mV |
| Transient recovery | Response to ±50% step input | - | 1 | 5 | ms |

**48V output characteristics**

| Parameter | Comment | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Output voltage | At nominal load | 44 | 48 | 57 | V |
| Output noise & ripple | | - | 100 | 500 | mVpp |
| Output current | | - | 0.81 | 0.87 | A |
| Output power | | - | 39 | 41.5 | W |
| Nominal load | | 55 | 59 | - | Ω |

| | | | | | |
|---|---|---|---|---|---|
| Efficiency | At nominal load | 90 | - | - | % |
| Efficiency | At half load | 85 | - | - | % |
| Transient response | Response to ±50% step input | - | 2000 | 4000 | mV |
| Transient recovery | Response to ±50% step input | - | 1 | 5 | ms |

**Measurement characteristics**

| Parameter | Comment | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Battery charge estimator precision | Integrator runs for at most one hour. Expected energy: 600Wh | - | 2 | 5 | % |
| Power measurement precision per channel | | - | 1 | 5 | % |
| Power measurement CMRR per channel | | 80 | 100 | - | dB |

**RF characteristics**

| Parameter | Comment | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Operating frequency | Central frequency (excluding band channels) | - | 2.4 | - | GHz |
| RX sensitivity | Independant from antenna gain | - | -100 | -90 | dBm |
| TX power | Independant from antenna gain | 18 | 19 | - | dBm |
| TX signal power | | - | - | 1 | W |

**Mechanical characteristics**

| Parameter | Comment | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Length | From the battery pack's geometry | - | 165 | 165 | mm |
| Width | From the battery pack's geometry | - | 120 | 120 | mm |
| Height | From the battery pack's geometry | - | 20 | 30 | mm |
| Weight | | - | 300 | 400 | g |
| PCB material | Specified by manufacturer (Aisler) | - | FR-4 | - | - |
| Number of PCB layers | Specified by manufacturer (Aisler) | 2 | 4 | 4 | - |

**Thermal characteristics**

| Parameter | Comment | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| PCB Temperature rise | Tested at full load (all outputs on) at 25°C | - | 30 | 60 | K |

## 4. References

| Reference | Title | Description | Link |
|---|---|---|---|
| **[RF01]** | | Specifies the requirements for the 5V channel. | Cobolt 08-01 Series |
| **[RF02]** | | Specifies the requirements for the 3.3V channel. The avionics consists of 4 of those Nucleo STM32H745ZI-Q boards. | STM32H7 Nucleo-144 boards (MB1363) - User manual |
| **[RF03]** | | Specifies the requirements for the 24V channel. | OS1 Mid-Range High-Resolution Imaging Lidar |

## 5. Glossary

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|---|---|
| **RF** | Reference |
| **PSU** | Power supply unit |
| **PSC** | Power supply control |