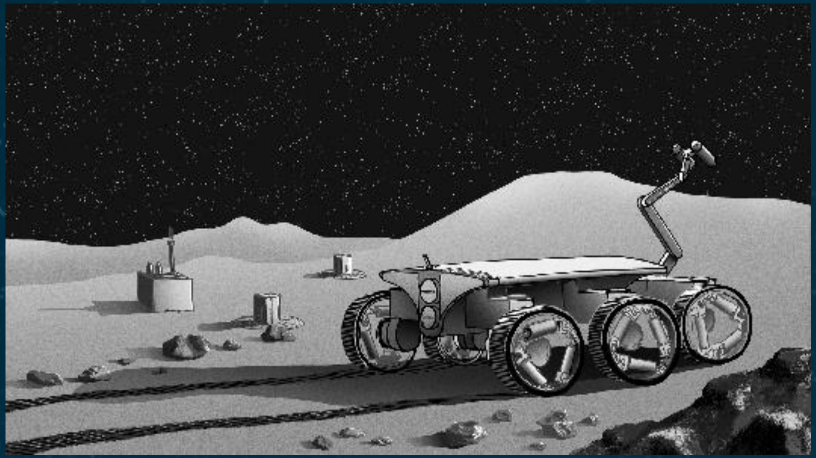

COTS based Power stages for robotic applications in lunar environment

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Intelligent COTS based Power Stages for Robotic Application

Contractor(s): DFKI (DE)					ESA Budget:	200k€
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TRL	Initial: 2	Achieved: 5-6	Target TRL: 5 Date: Q1 2023			

Background and justification:
With the increasing interest in the exploration of celestial bodies, such as the lunar surface, or on orbit servicing, the demands on robotic systems for future space missions are constantly increasing in terms of performance and compactness. In this context the actuators and the associated motor electronics play a key role in robotic systems. The implementation of those systems utilizing the most advance COTS electronics and implementing wisely key mitigation measures, derating for the radiation is a key element for the development of those robotics mission with a short life time expectation.

Objective(s):
- The development of a BLDC power stage for robotic systems with short and medium mission lifetime in lunar environment. Key points to be introduced in the market: component miniaturiarization, flexibility and compatibility, competitive process and lead times.
- The power stage is designed for a nominal power of up to 80 W at 28 V. Five to ten times higher peak performances are conceivable due to the derating of critical components.

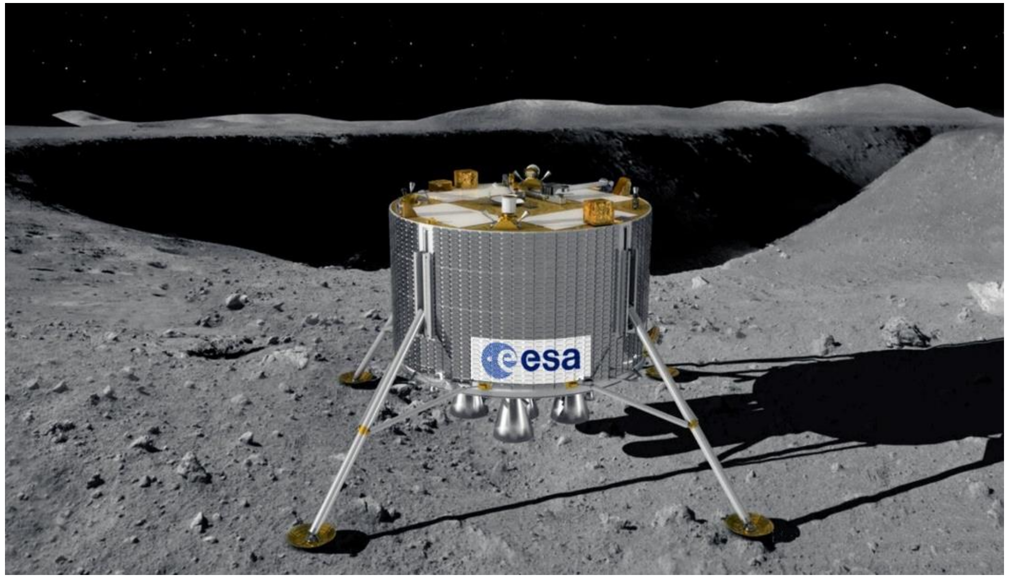
Achievements and status:
- Within the iCOTS activity a modular GaN-FET BLDC power stage for robotic space application was designed and manufactured based on selected COTS components. The selection consists of GaN-FETs, **COTS driver was not screened assuming the risks in HI** for a short mission lifetime. Envisaged missions are high risk missions with short duration in the lunar environment.
- Paper with all results published in iEEE: Cots-Based Modular BLDC Power Stage Using GaN-FETs for Robotic Space Applications | IEEE Conference Publication | IEEE Xplore

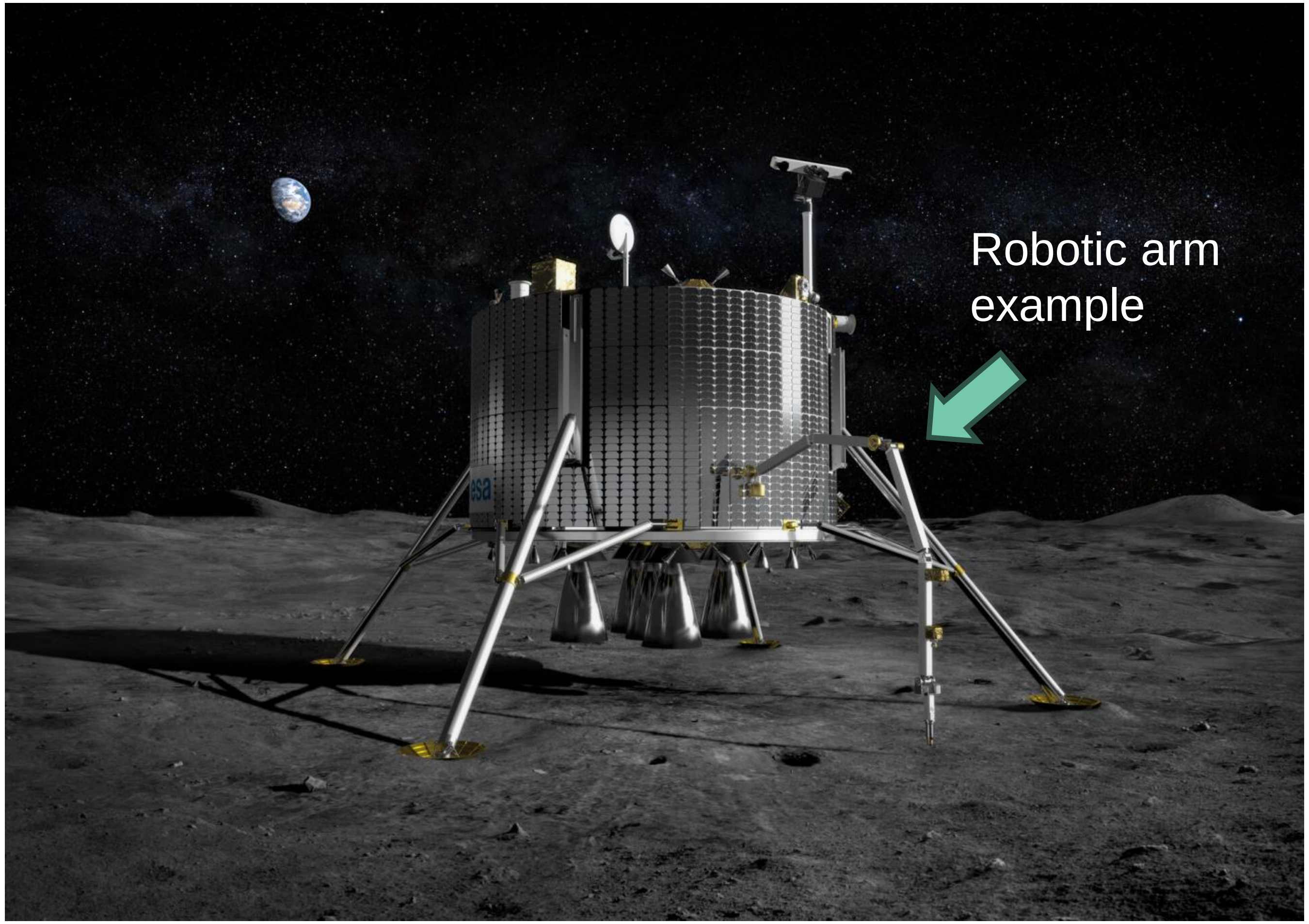
Benefits Possible application scenarios are small mobile systems for lunar application with short envisaged mission life time. The design process of the power stage and component selection process., redundancy and special electrical design considerations are covered. Furthermore, mitigation techniques for radiation environment

Next steps:
Full commissioning of the assembled BLDC power stage and performance characterization• Carry out foreseen irradiation tests of identified critical COTS components specially the driver COTS in HI.

Background and justification

- Lunar landers
- Lifespan short (hours-days)
- Low-cost approach
- Short time development

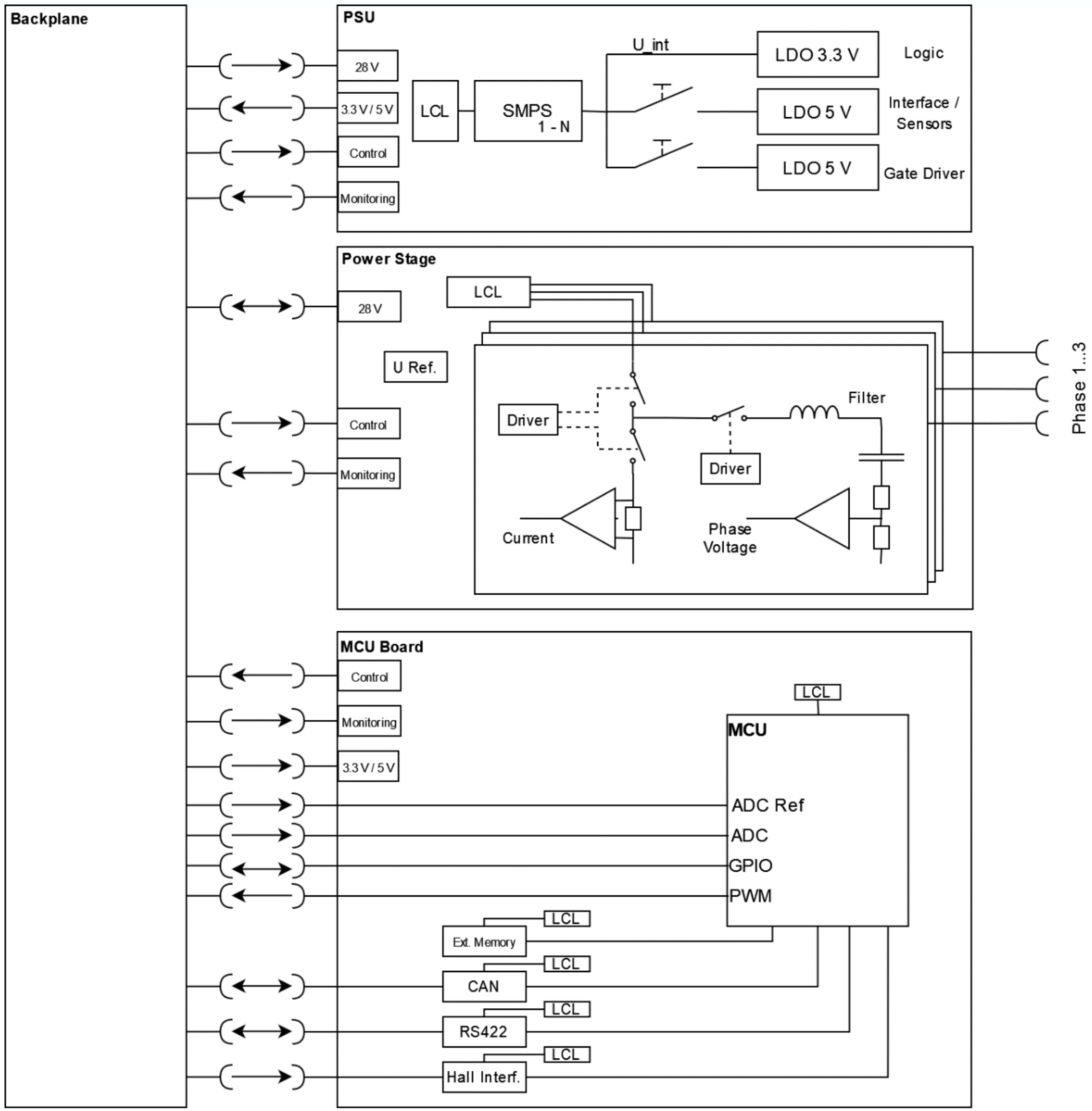




Functional units:

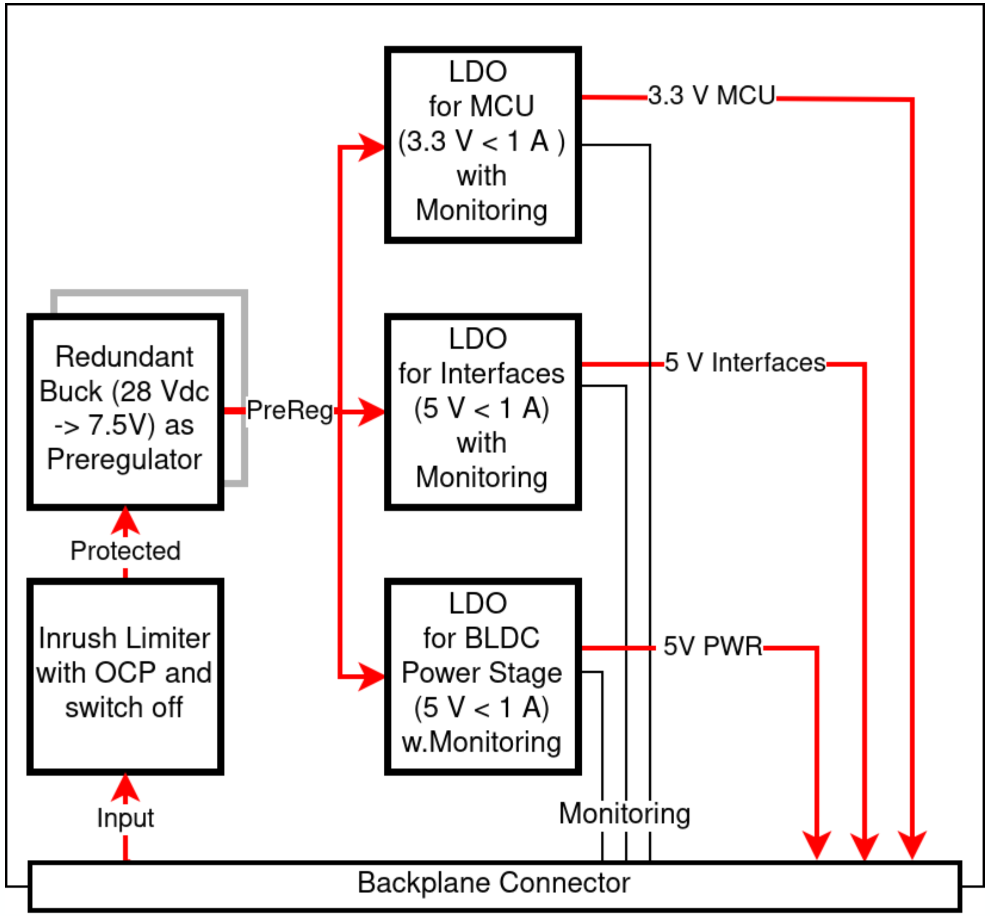
- **PSU** (Power Supply Unit)
- **Power Stage** (Motor drivers)
- **MCU Board**
- Backplane

High electronics density achieved:

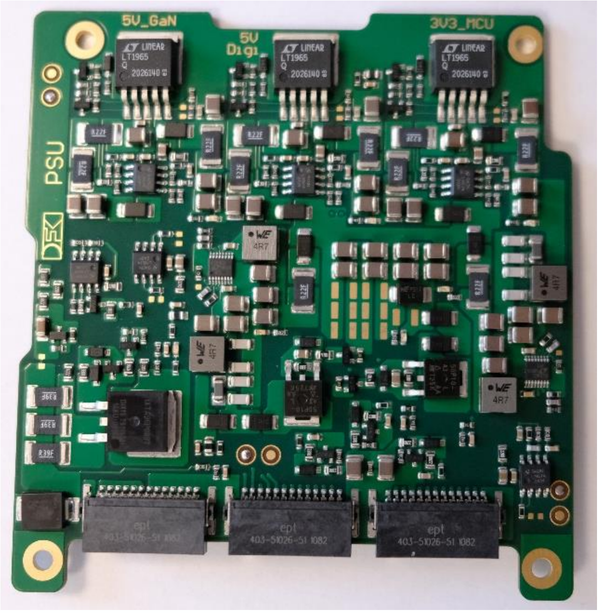


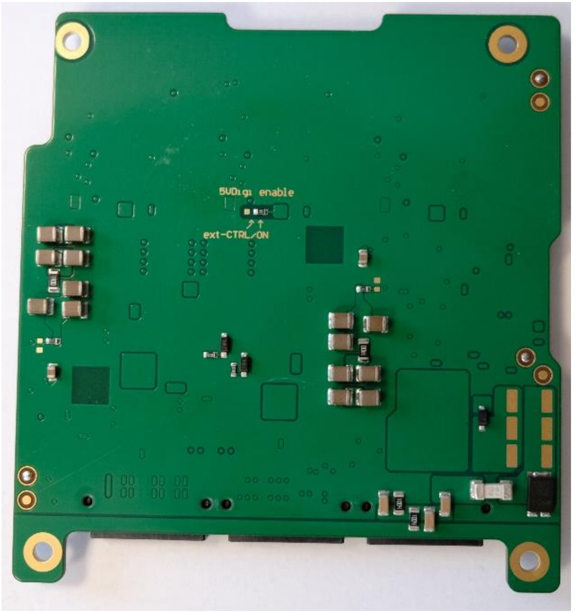
PSU

Block diagram:



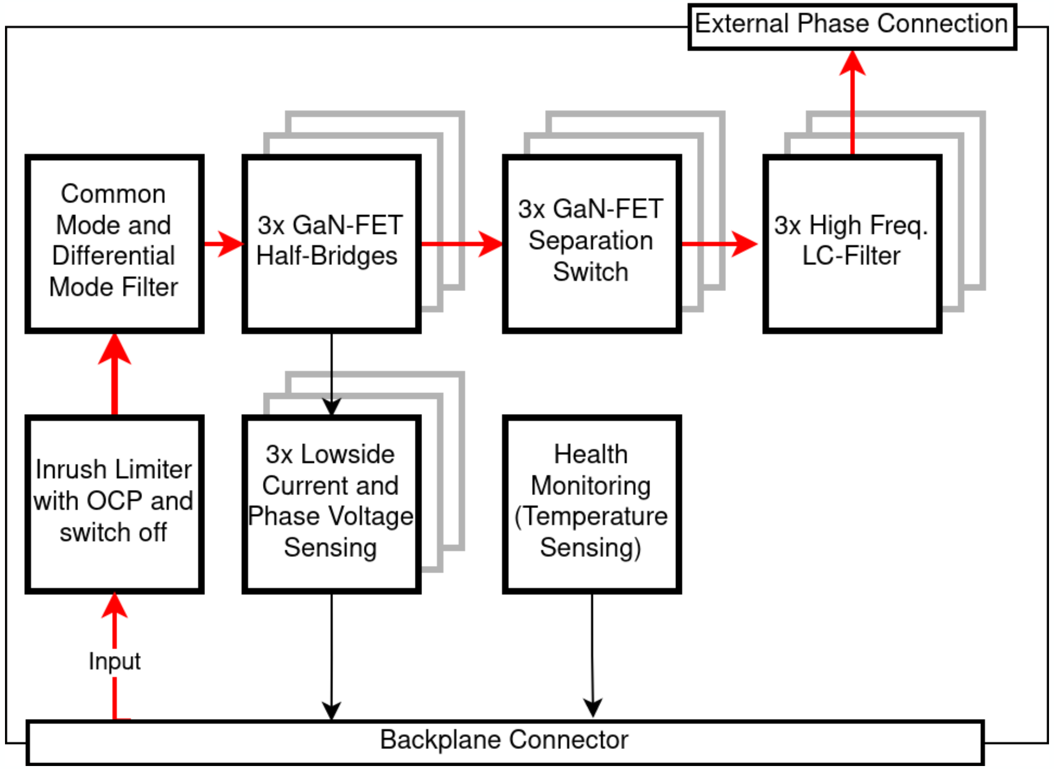
- Directly connected to the 28 V dc.
- It has an inrush current limiter that can also serve as a disconnector.
- Two redundant switching power supplies (buck / step-down topology) in hot or cold redundancy (user-defined) serve as pre-regulators and generate approximately 7.5 V output voltage from the 28 V dc



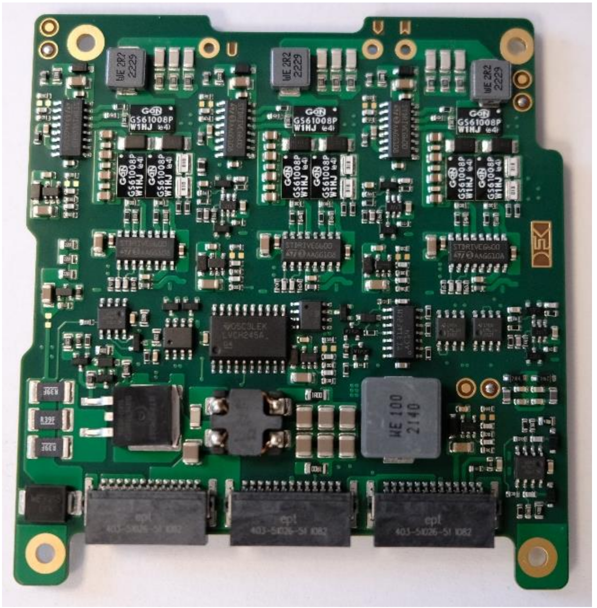


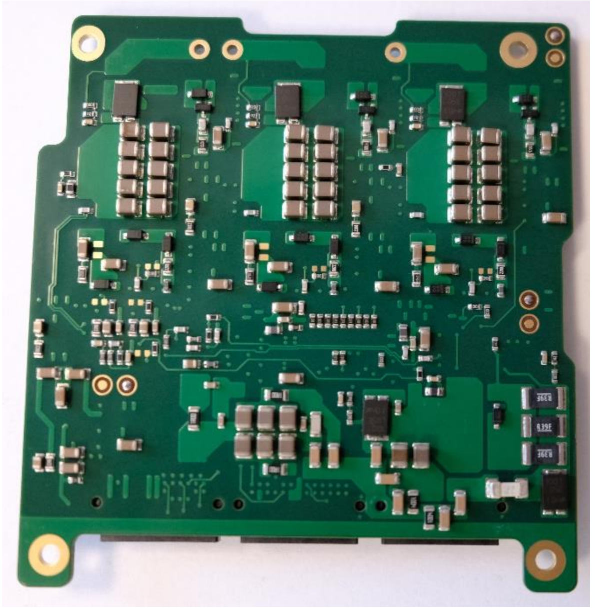
Power stage

Block diagram:



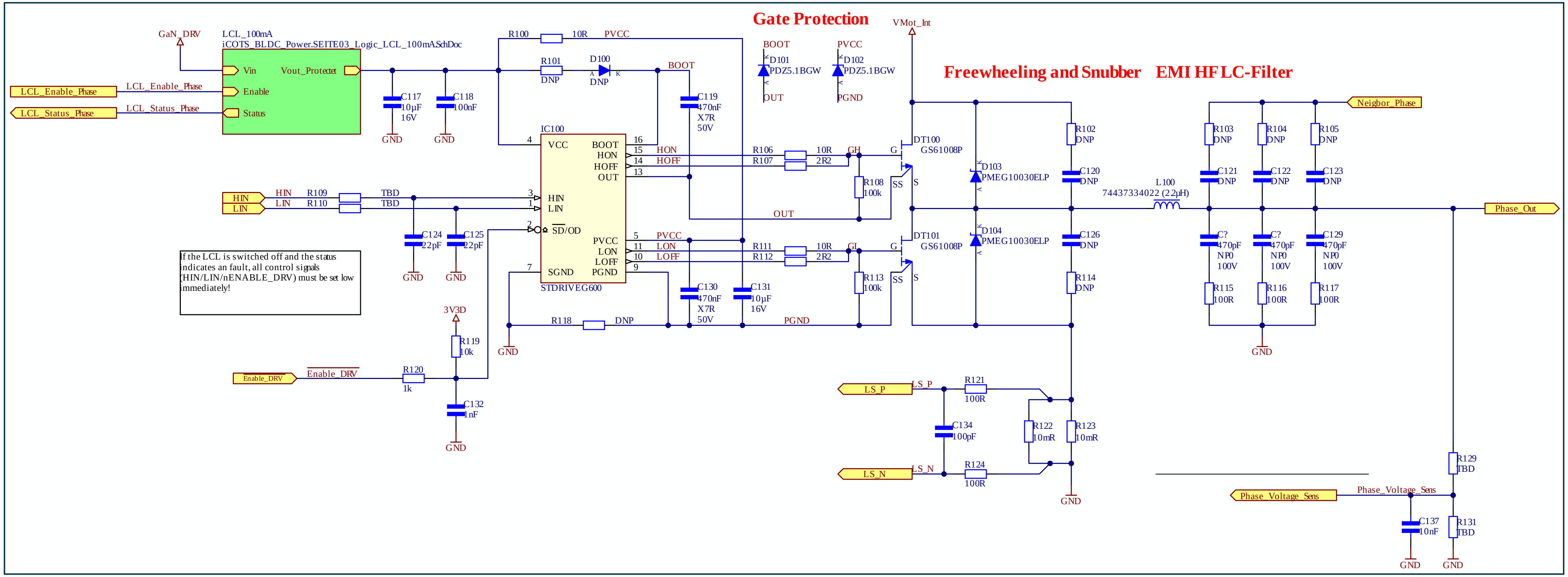
- It has an inrush limiter with over current protection and switch off functionality.
- The power stage implements a common-mode and differential mode filter. Each phase can be separated and is filtered with a high frequency LC-filter.
- There is a low side current and phase voltage measurement for each phase.





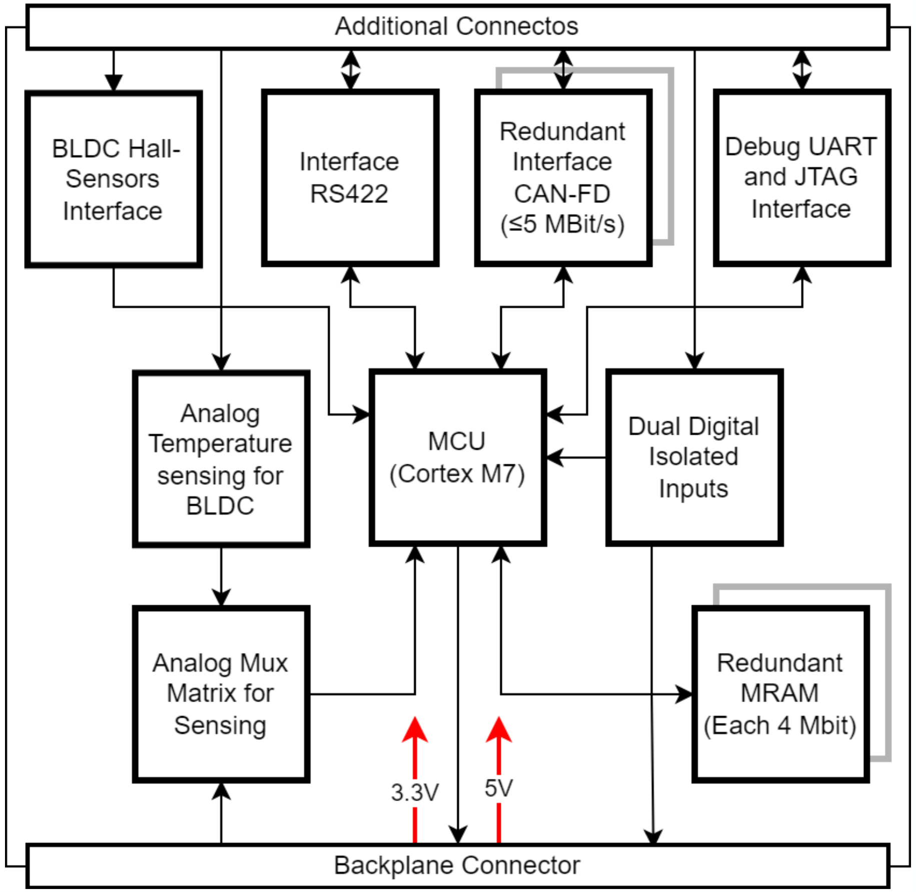
COTS GaN Driver accepting risks

- STDRIVERG600 driver COTS not screened
- Based on GaN-FETs (higher switching speed, lower losses, smaller PCB design)
- 28Vin 5Anom/12Apeak (suitable for 100W and above motor class @ 28Vdc Supply)
- 30-100kHz PWM (50 till 100kHz will be beneficial)
- Phase separation switch for redundant power stage option

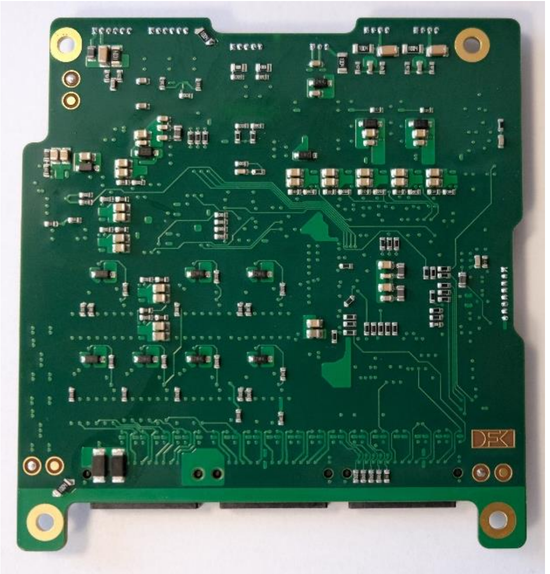


MCU

Block diagram:



it is equipped with multiple interfaces for communication in operation and debugging. The MCU is based on a Cortex M7 with additional redundant external memory.



Conclusions

- High risk missions with **short duration (hours)** in the lunar environment is possible to propose the adoption of the most advance COTS.
- The power stage is designed for a nominal continuous power of 80 W at 28 V dc bus voltage.
- High electronics density, low cost is possible implementing COTS
- Redundancies of critical functions
- Anti latch-ups protections are adopted as failure barrier.
- Massive derating was applied in the design and components selection.
- Radiations tests were not performed due limited budget, the planned radiation tests a modular test adapter was developed.

Questions?