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Planetary Rover Power and Communications System

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Abstract

The University at Buffalo Space Bulls team has designed a prototype planetary rover to compete at the NASA Johnson Space Center as part of the 2014 RASC-AL Exploration Robo-Ops Competition. The drive system design includes four wheels with independent suspension that are directly driven with four high torque DC motors. A front-mounted, two-link arm with a two-section scoop end effector will retrieve objective rocks while requiring reduced precision. Lightweight materials, along with a high energy density battery and more efficient electrical systems, will reduce the overall rover weight. The culmination of these design features will lead to a successful rover designed to accomplish all competition challenges.

Control and Communications System Design

The onboard rover computer utilizes a Zotac motherboard in the mini-ITX form factor paired with an AMD A-Series A10-6700 APU and 8GB of DDR3-1866 RAM. The motherboard contains 6 USB 3.0 ports, two gigabit Ethernet ports, and, onboard Wi-Fi.

The four DC drive motors are controlled by two dual-channel Roboclaw 30 amp motor controllers, which have been researched extensively and selected due to their high output current, built-in protection, encoder inputs, and the ability for USB control.

The Axis P5534 PTZ camera has been selected as the main camera. It has 180° tilt, 360° pan and 12x optical zoom. Several additional cameras will be mounted for auxiliary views to provide the rover operator with a greater field of vision. The Logitech C910 has a wide field of view at 83°, which makes it suitable to be mounted on the camera mast. Two C310 webcams will provide coverage of the work area of the arm and manipulator. These capabilities will be a significant advantage and will give more control over the rover's vision to the operators.

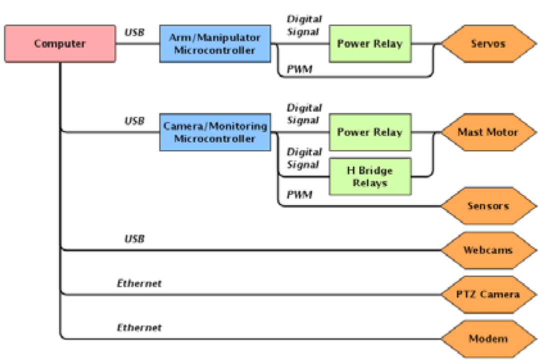

Figure 1 – Control and Communications System

Power System Design

The rover's power source is a 25.9V lithium-ion polymer battery with a peak output of 30A and a 21Ah capacity. The limited peak output poses a challenge: when the motors are running at maximum torque, the battery still needs to supply the computer, camera, and communications hardware with power. To overcome this, current limits will be set on each of the motor controllers so that the vital systems will remain online at all times.

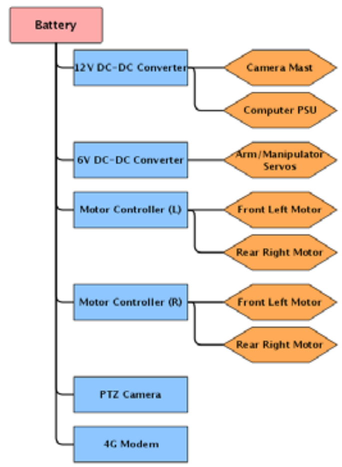

Figure 2 – Power System

Two DC-DC voltage converters are employed to power peripheral hardware such as the servos for the arm and manipulator, which run at 6V, and the computer's picoPSU, which runs at 12V. These buck converters were chosen for their compact size and low conversion losses. The 4G LTE modem and PTZ camera will run directly off of the battery.

The monitoring system consists of an Arduino microcontroller and LCD display that shows measured voltages and currents of various components to analyze system performance. A secondary menu will also display several component temperatures. This data will also be streamed to the rover operator.

Table 1 – Monitoring System

Component	Monitored Parameters
Battery	Voltage, Current, Temperature
Motor Controllers (2)	Voltage, Current Temperature
DC Drive Motors (4)	Current
Computer	Voltage, Current, Temperature
Modem	Temperature
6V DC-DC Converter	Voltage, Current, Temperature
PTZ Camera	Voltage, Current, Temperature
Rear Section Ambient	Temperature

Implementation

We have installed all hardware into the rover and we are currently in the testing and data acquisition phase. All hardware has been installed so that any component can be easily removed for isolated testing or replacement. Connectors have been chosen to be easily detachable, yet reliable during the competition.

In order to research and evaluate our system performance, the power consumption of the components has been measured. We must be able to run the rover for a minimum of one hour on a single charge. Our research indicates that this will be possible. Steps will be taken to reduce component power consumption, particularly with the DC drive motors.

Table 2 – System Power

Component	Peak Current Draw (A)	Peak Power Consumption (W)
Drive Motors (4)	16.0	416.0
Computer	7.0	85.0
Arm Servo Motors (5)	5.0	30.0
Peripherals	2.0	24.0

Conclusions and Moving Forward

The hardware installation and preliminary evaluation is complete. All hardware has performed adequately and has met our initial design specifications. Work on the monitoring system is ongoing as this system is for the protection of the power and communications system hardware. The rover will be completed and refined in time to participate in the competition at Johnson Space Center in early June 2014.

Upcoming Tasks:

- Cooling and ventilation system to ensure reliable operation in competition conditions and environment
- Integration of cooling system into monitoring system to maintain a temperature threshold for heat sensitive components
- Systems testing, reevaluation, and redesign as necessary
- Investigation into safe shipment of lithium-ion batteries and rover

Acknowledgments

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National Institute of Aerospace | ESI Energy Systems Integration | NASA