Mars Lander Robot Recharger

Deliverable #6 – Operation Manual

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1.0 Functional Analysis and Flow Diagram

The top level system design is as seen in Figure 1 (below):

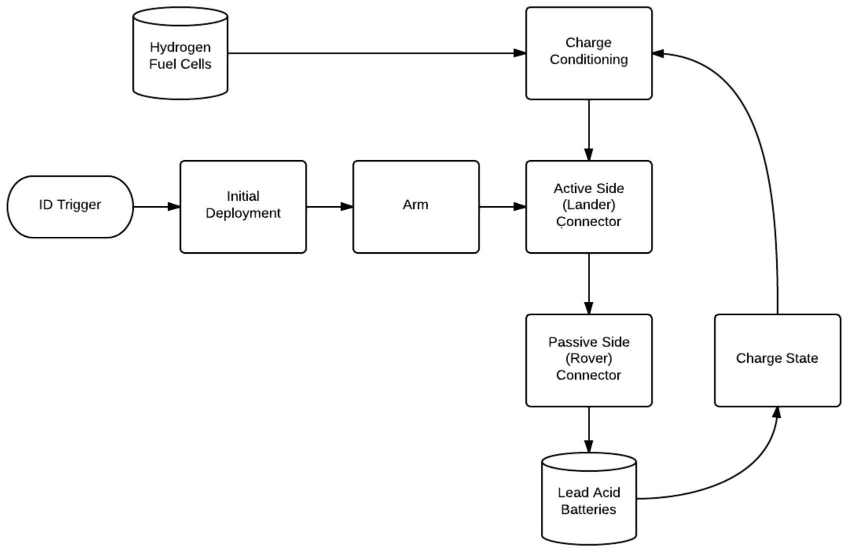

Figure 1: Top Level System Diagram

The system delivers power from a bank of hydrogen fuel cells in the belly of the lander, to a serial pair of 12V lead acid batteries. The charge control is handled by a DC-DC 24V 4-stage controller which delivers power through an external connection made between the lander and rover. As the arm is stowed during transit there is an initial deployment trigger that, when signaled, releases the arm from its stowed position to operational configuration.

2.0 Product Specs and Expected Performance

The design incorporates a DC-DC charge controller, the PST-BC2424. The charge controller is used for charging 24V batteries by sending a 20-30V electrical signal. The output power is transferred using a variable 1-10A output, which is varied by the adaptive microprocessor which implements a four state charging algorithm. The power transfer efficiency during use is 85%, with a maximum charge time of three hours.

The safety circuit is implemented in two parts. The division of the safety circuit can be divided into the lander and rover side connections. On the lander side connection, the safety features include short circuit and polarity protection inherent in the DC-DC charge controller. On the rover side connection, the safety is a two-part system. A diode has been placed behind the positive terminal on the rover, which will prevent a short circuit across the rover, and a fuse has been placed in series with the power transfer in order to provide polarity protection.

3.0 Standard Operating Procedure

1. Initial Deployment
   a. Send signal to solenoid circuit in order to deploy arm
2. Startup
   a. Deliver power to the bank of Hydrogen Fuel Cells.
3. Charging Rovers
   a. Drive rovers up to lander arm until a proper connection (indicated by a charge reading) has been established.
   b. Maintain proper connection with rovers until charge system indicates a float charge state.
4. Calibration
   a. If the rovers are not making a proper connection, use rovers to level ground in area immediately surrounding the recharging arm.
5. Shutdown
   a. Cease delivery of power to bank of Hydrogen Fuel Cells.

4.0 Additional Assembly

4.1 Mechanical System

The lander arm will need to be mounted to the top of the lander deck as shown below (Figure 2). The revolute joints that are connected to the torsional spring moving the arm need to be firmly secured to the lander deck approximately 2-5 inches behind the edge of the lander deck. The arm is to be mounted on a selected side of the lander. The solenoid trigger will need to be mounted as well to the lander 4 inches behind the where the arm is attached. This is to ensure that the solenoid is in the correct place to hold the arm upon transit prior to initial deployment. The arm and solenoid are both to be mounted using ¼-20 screws. This will ensure that both the arm and solenoid remain in place during transit to and use on the Martian surface.

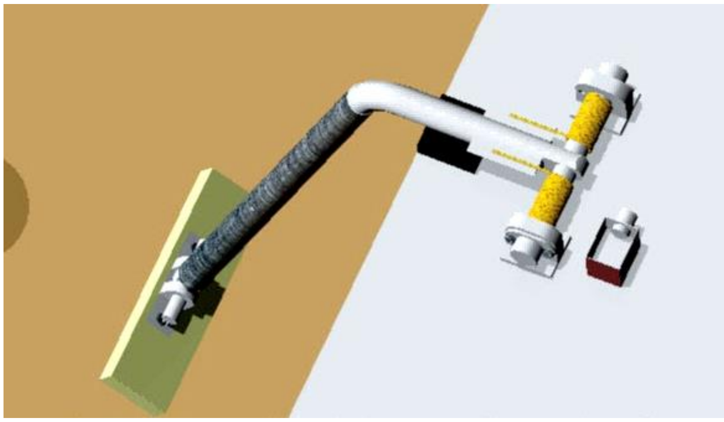

Figure 2: Lander Arm

The rover connection will need to be mounted directly to the rover racks. Figure 3 (below) shows how the aluminum connection pieces as well as the copper plating will be mounted piece by piece. Figure 4 (below) shows the complete connection screwed directly into the metal rack on top of the rover, which is the only assembly, needed. The connection will need to be screwed in 1-3 inches back from the start of the rack to ensure a solid assembly. The bottom plate requires 3 screws on each side to secure the rover connection. The umbilical will then be soldered to the copper plates after mechanical assembly.

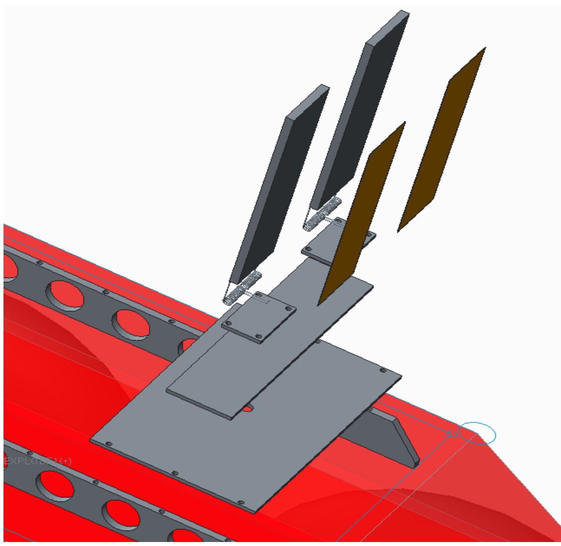

Figure 3: Rover Connection Exploded View

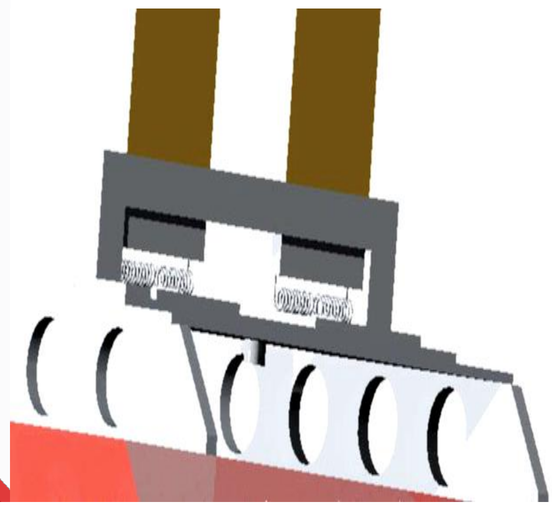

Figure 4: Rover Connection Side View

4.2 Electrical System

On the rover side, once the connection is mounted to the top of the rover, the plug leading from the two terminals should be connected to the existing 3-prong port at the rear of the ATRV-Jr used by the OEM charger. On the lander side the 24-30V output of the hydrogen fuel cells should be attached to the positive and negative input terminals at the rear of the DC-DC charge controller.

4.3 System Overview

Detailed CAD images containing the overall system can be found in Appendix A.

5.0 Troubleshooting

5.1 Short-Circuit Across the Safety Diode

In order to short-circuit the safety diode, the battery in the rover would need to be installed backwards, that is, the rover would have the positive and negative terminals connected to the opposite corresponding lead from the plates. In order to prevent this damaging the circuit, a safety fuse has been installed in the circuit to prevent damage to electrical components. In the event of a short, replace the battery in the correct orientation and replace the fuse.

5.2 Battery Below Operational Voltage

During testing on Earth or use on Mars, it is possible that the batteries may, either intentionally or unintentionally, be drained below the 50% specification. If this happens, the DC-DC charge converter will be capable of reviving cells which may have died, but this may extend the charge time by a significant amount. Pay attention to the charge state indicated by the circuit. If it does not read full capacity, you may damage the battery by removing the external power source.

5.3 Excessive Variance in Topography

During use on the Martian surface, the rover may not be able to approach the lander using the proper orientation. A majority of the time, this will be due to variations in the topography on Mars. In the event that the variations in topography exceed prescribed maximums, the rover may not be able to make a proper connection with the lander arm. In this event, any charging will be impossible until the rovers, or another system capable of excavation, return the surface to a flat topography around the lander deck.

6.0 Spare Parts Needed

Under proper operation, no additional parts should be required. The rover side connection includes a fuse to protect against shock during a short when the polarity of the batteries is reversed. It is important to note that both of these connections are necessary to burn the fuse; the batteries must be installed backwards AND the terminals must be shorted. In this event the batteries should be reversed and the fuse replaced.

As the initial deployment system has been designed for a single use, abnormal wear of its components is possible during extended testing. After excessive use the torsional spring within the hinge of the initial deployment system should be replaced to ensure proper function on Mars.

Appendix A

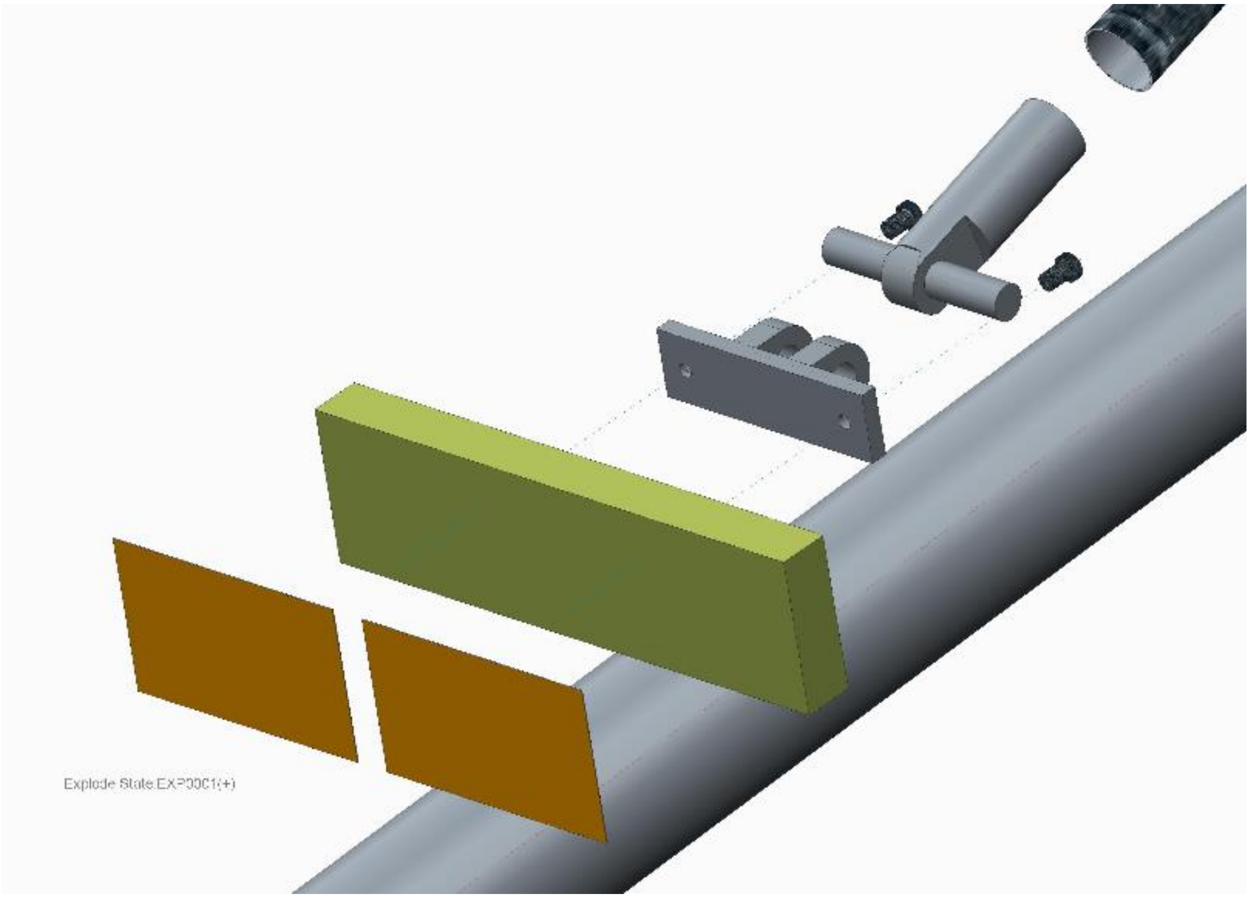

Figure 5: Exploded View of Lander Connection Plate

Figure 6: Rover Approaching Stowed Lander Arm

Figure 7: Rover Approaching Deployed Lander Arm