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Overview of the Habitat Demonstration Unit Power System Integration and Operation at Desert RATS 2010

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Abstract

A habitat demonstration unit (HDU) was constructed at NASA Johnson Space Center (JSC) and designed by a multicenter NASA team led out of NASA Kennedy Space Center (KSC). The HDU was subsequently utilized at the 2010 Desert Research and Technology Studies (RATS) program held at the Black Point Lava Flow in Arizona. This report describes the power system design, installation and operation for the HDU. The requirements for the power system were to provide 120 VAC, 28 VDC, and 120 VDC power to the various loads within the HDU. It also needed to be capable of providing power control and real-time operational data on the load's power consumption. The power system had to be capable of operating off of a 3 phase 480 VAC generator as well as 2 solar photovoltaic (PV) power systems. The system operated well during the 2 week Desert RATS campaign and met all of the main goals of the system. The power system is being further developed to meet the future needs of the HDU and options for this further development are discussed.

1.0 Introduction and Background

The design and operation of a lunar habitat module, illustrated in Figure 1, requires the integration of a number of independent systems. These systems together provide an environment for astronauts to live and work on the lunar surface. The power system is a critical element in the overall habitat design; it must be capable of connecting to various outside power sources, distributing that power within the habitat module, and meeting the voltage and current requirements of the module's internal equipment and systems.

The habitat demonstration unit (HDU) is designed to look and operate similar to a habitat module on the lunar surface that will provide a realistic experience of lunar operations for the personnel and controllers. However, the HDU and its systems will not need to physically be capable of operating within the harsh lunar environment. The goal for the systems is to provide a functional capability and be functionally representative of what the lunar system would be like.

Figure 1.—Illustration of the habitat demonstration unit (HDU).

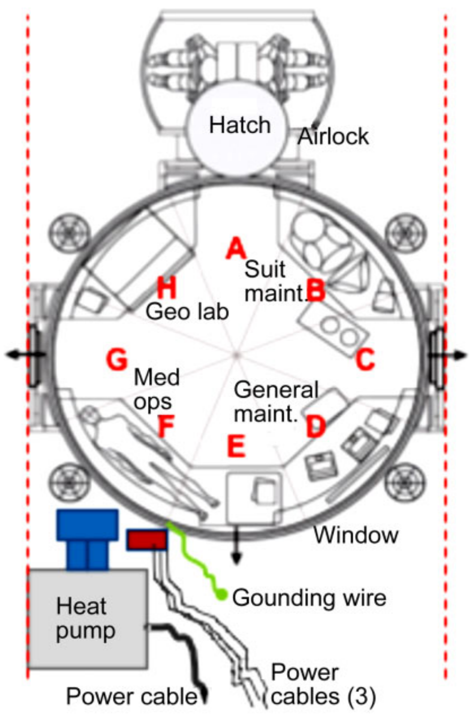

Figure 2.—HDU segments.

The equipment installation within the HDU was broken down into 8 segments, listed as A through H. These segments are illustrated in Figure 2. Power was provided to each segment through a dedicated bank of outlets on the power distribution units (PDUs) installed within the HDU. Depending on the equipment installed in a given section, power conditioning was also supplied providing 28 and 120 VDC along with the 120 VAC.

The goal of the power system design was to provide a controllable system that was operationally representative of what would be utilized in a lunar habitat module. The power system had to be capable of operating off of a number of different power sources, such as building supplied power, generator power and solar power. An additional goal in the system design was to demonstrate the interconnection and load sharing between the various power sources. This load sharing capability specifically applies to the connection of the PV power systems to jointly power the HDU. Combining the PV sources provides a “mini-grid” for distributing and supplying power to the loads within the HDU, which is representative of how a lunar power grid would be initially established. Lunar landing vehicles and other fixed surface assets would have power systems incorporated into them. Once the primary mission for these assets is completed, it would be advantageous to utilize these power sources to provide additional power to other nearby assets. Being able to sync and utilize the separated PV power systems for powering the HDU is a first step in demonstrating this desired capability.

2.0 HDU Power System Summary

The power system within the HDU consisted of a number of distribution, control and conditioning components, as listed in Table 1.

TABLE 1.—POWER SYSTEM COMPONENT LIST

Component	Quantity	Mass, kg	Dimensions W, H, D, m
120 VAC to 28 VDC power converter	2	17.2	0.25, 0.20, 0.10
120 VAC to 120 VDC power converter	2	17.2	0.25, 0.20, 0.10
Power Distribution Unit (PDU)	3	9	0.11, 0.44, 0.09
Power supply unit	1	15	0.45, 0.25, 0.15
120 VAC outlets (outside)	2	1	0.10, 0.10, 0.08
120 VAC outlets (inside)	2	1	0.10, 0.10, 0.08
Junction box	1	7	0.51, 0.41, 0.15
Primary switch	1	14	0.46, 0.25, 0.15
Primary distribution wiring harness	1	5.5	NA
Secondary distribution wiring harness	1	23	NA
Terminal strip junction boxes	4	4	NA
Grounding straps	16	32	NA
220 to 120 VAC transformer	1	80	0.25, 0.28, 0.38

The power distribution units (PDU) provided power distribution and control within the HDU. The PDUs were installed beneath the flooring of the HDU and connected to the outside power source through a main junction box.

The PDUs consisted of three APC (model AP7902, shown in Fig. 3) Switched Rack Mount 3.6 kVA units with L5-30 input power connector and standard 120 VAC outlet connectors. Each PDU has a maximum 30-amp output capacity with 16 outlets controllable in two banks of 8. Communication to the PDU is over an Ethernet connection. Each outlet of the PDU is capable of being commanded on or off remotely or on a schedule through the communication line. Each bank of the PDU is circuit breaker protected with a 20 amp breaker switch. Data can be gathered on the PDU operation such as:

- Overall current versus Time, low, near-high and high thresholds
- Bank A (outlets 1 to 8) Overall Current versus Time; low, near-high and high thresholds
- Bank B (outlets 9 to 16) Overall Current versus Time; low, near-high and high thresholds

To provide DC power, required by some loads, 2 types of AC to DC converters were utilized. These converters were powered through the PDUs, which also provided control over their operation. These converters consisted of two Astron 18A 28VDC rack mount power supplies, ZAS-LSRM-18A 28 VDC, as shown in Figure 4 and two Sorensen 8A variable output rack mount power supplies, models DCS150-7 and DCS150-7E, shown in Figure 5. The Sorensen power supplies were capable of output voltages up to 150 VDC, however for this application they were set and locked at 120 VDC output.

Figure 3.—APC AP7902 power distribution unit (PDU).

Figure 4.—Aston ZAS–LSRM–18A power converter.

Figure 5.—Sorensen DCS150–7 power converter.

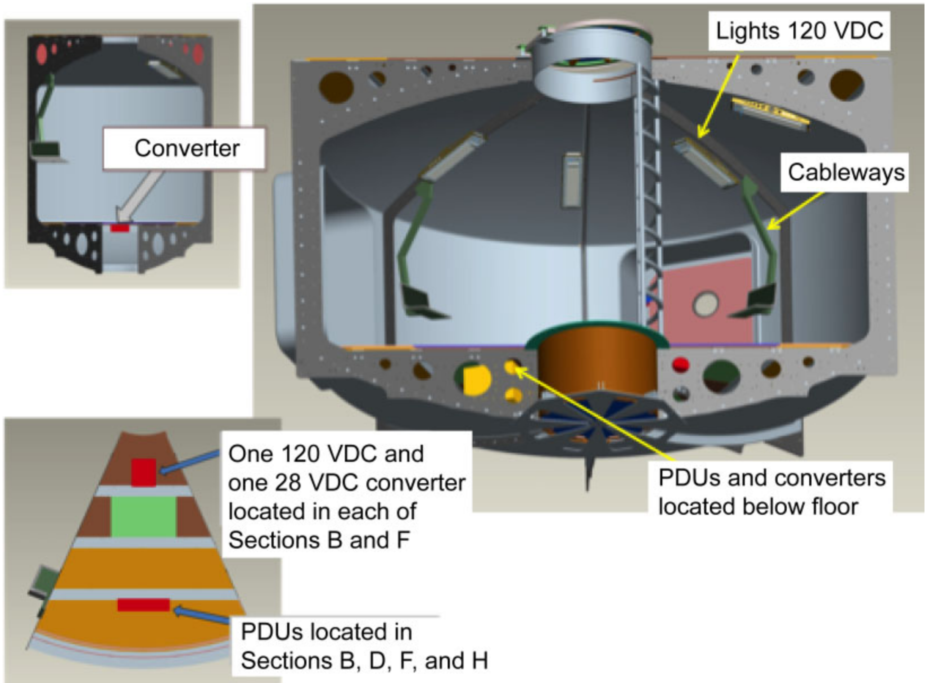

Figure 6.—Mounting locations for the power conditioning components.

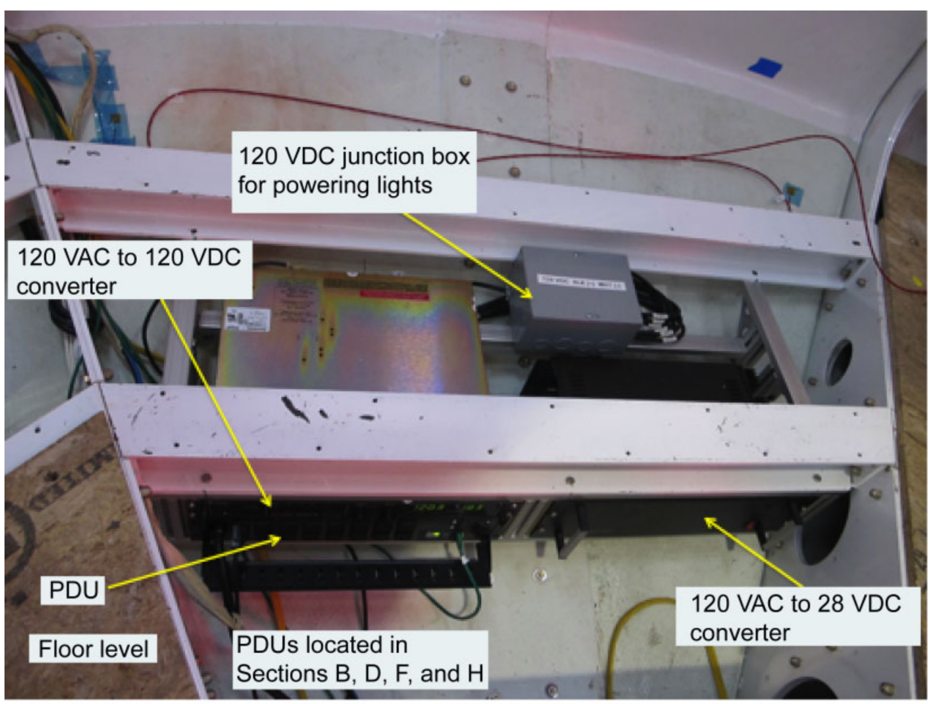

Figure 7.—Installed power conditioning and control equipment.

The power conditioning and control equipment was mounted below the floor level in the HDU. Cooling air was circulated in the space beneath the floor to maintain the electronics at their required operational temperature. The installation locations for this equipment are illustrated in Figure 6 and the actual installations are shown in Figures 7 and 8.

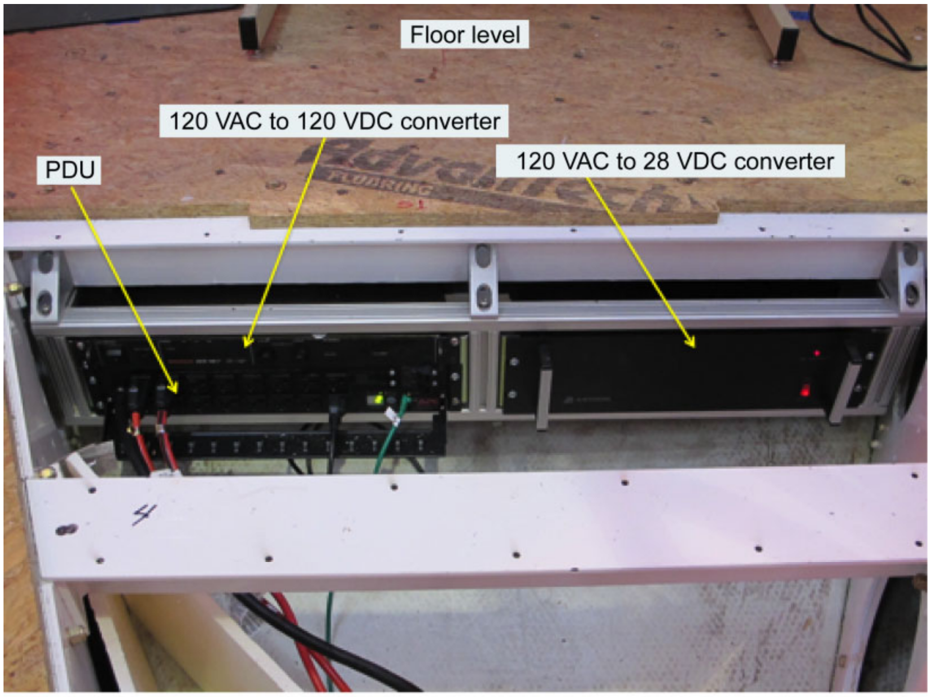

Figure 8.—Installed power conditioning and control equipment below floor level.

Figure 9.—120 VDC light power junction box.

Junction boxes, as shown in Figure 9, contain terminal strips that were used to connect the loads to the DC power supplies. These junction boxes provided a single connection to the power supply and multiple outputs for the various loads.

A single input was provided from the external power sources to the interior of the HDU. To connect the multiple PDUs to the single power input, junction boxes were used as shown in Figure 10. Two separate junction boxes were utilized, one to connect the PDUs to the diesel powered generator and the second to connect them to the solar powered systems.

The sections of the HDU, shown in Figure 2, in which the power system components were mounted are listed in Table 2. All of the lights throughout the HDU were connected to the 120 VDC converter located in section B.

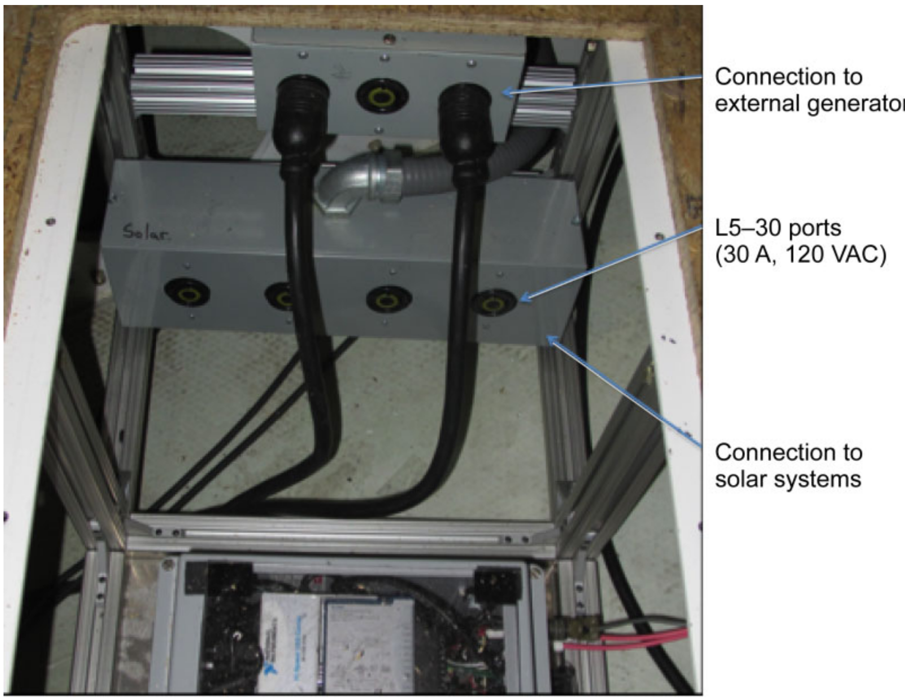

Figure 10.—PDU junction boxes from solar array and generator.

TABLE 2.—LOCATION OF THE POWER CONDITIONING COMPONENTS WITHIN THE HDU

A	None
B	• PDU • 120 VDC Power Converter (with separate terminal box • 28 VDC Power Converter (with separate terminal box)
C	None
D	None
E	None
F	• PDU Junction Box (for connecting the outside power to the individual PDUs) • PDU • 120 VDC Power Converter (with separate terminal box • 28 VDC Power Converter (with separate terminal box)
G	None
H	• PDU

The PDUs were tested prior to installation into the HDU to evaluate their operation and controls. The configuration used for this testing is illustrated in Figure 11. Building supplied power, limited to 20 A, was used during the testing. To insure that the current draw for this evaluation testing was not beyond the capacity of the outlet, only one bank on the PDU was utilized. Each bank of outlets on the PDU is circuit breaker limited to 20 A maximum output. There were no problems or operational concerns encountered with the PDU testing. The communication and control to the PDU worked well and the internal circuit breaker protection on the PDUs functioned properly.

The loads connected to the PDUs were distributed among the three installed units (B, F, H). Provisions were made so that an additional PDU could be installed in section D. The breakdown of the loads connected to each PDU is given in Table 3.

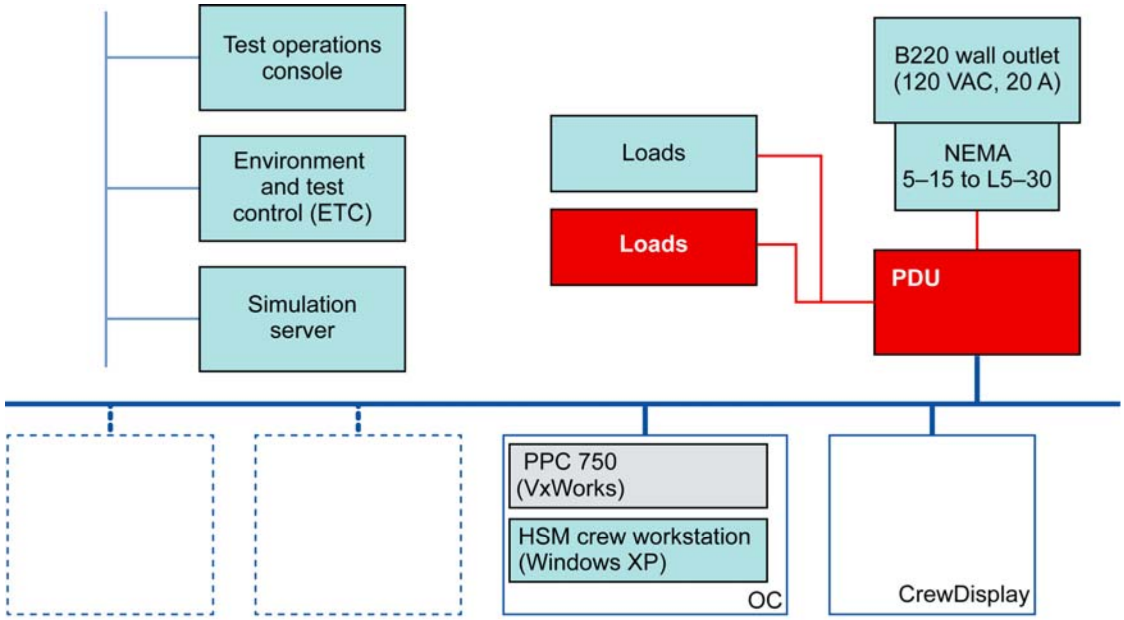

Figure 11.—PDU operation, communication and control test configuration.

TABLE 3.—PDU LOAD SUMMARY

	PDU B	PDU F	PDU H
1	120 VDC Converter	120 VDC Converter Internal Overhead Lights	GeoLab 1
2	28 VDC Converter Powering External Spotlights on Sections B,D,F and H	28 VDC Converter; Veggie, External Airlock Light	Internal Outlets in Sections B,D,F and H
3	cRIO	Control System	Electro Dynamic System
4	Not Used	Med Ops	Not Used
5	AirLock: Including, Winch, A/C Unit, Exhaust Fan, Battery Chargers, Web Cams, Sensors, Vacuum, Internal Lights.	Not Used	Not Used
6	HIMS	Not Used	Not Used
7	Not Used	Not Used	Not Used
8	Not Used	Not Used	Not Used
9	General Workstation (Power Strips)	Avionic Rack #2 (UPS)	GeoLab-2
10	General Workstation (Power Strips)	External Outlets in Sections A,C,E & G	Four Smoke/CO Monitors
11	Not Used	External Outlets for top floor in Sections F & B	WebServer
12	Overhead Light	Comm System (CSA)	Not Used
13	Rope Light	Not Used	Not Used
14	Not Used	Not Used	Not Used
15	Not Used	Not Used	Not Used
16	Not Used	Not Used	Not Used

In addition to supplying power to the interior of the HDU, a number of power outlets and lights were placed on the outside for powering external devices and nighttime lighting. The locations of these outlets and lights are illustrated in Figure 12.

Power was supplied to the HDU from different sources depending on its operating location. This is illustrated in Figure 13. The available external power sources varied depending on the operational location of the HDU. The three operational locations included, within building 220 and the Rock Yard at JSC, at the Desert RATS remote test site and at the Desert RATS base camp. The detailed layout of the power system and external power source for each of these locations is shown in Figures 14 to 16, respectively. The power system was designed to accommodate the different power sources available at the different operational locations.

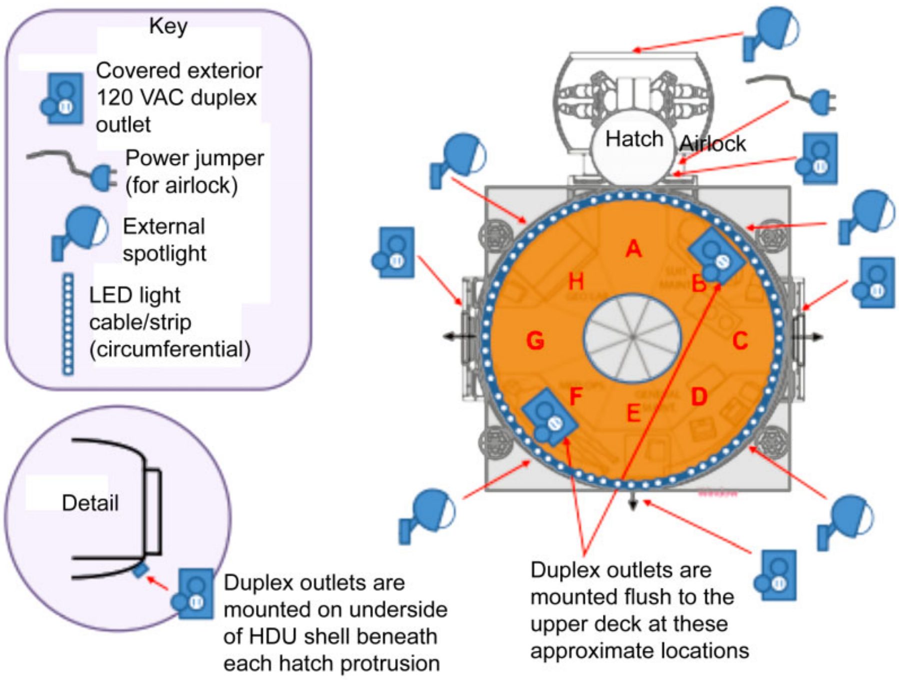

Figure 12.—HDU external power outlets and lights.

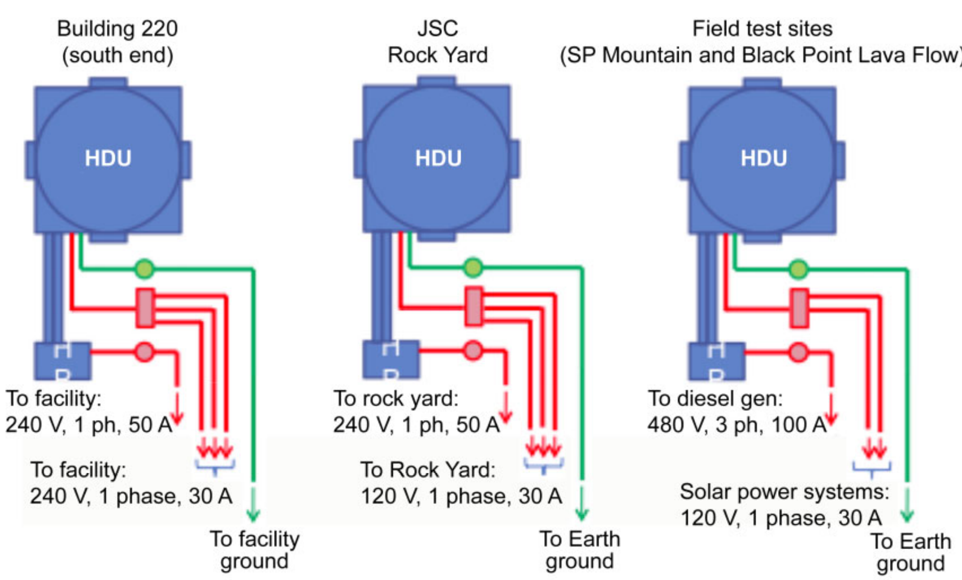

Figure 13.—HDU power sources for different operational locations.

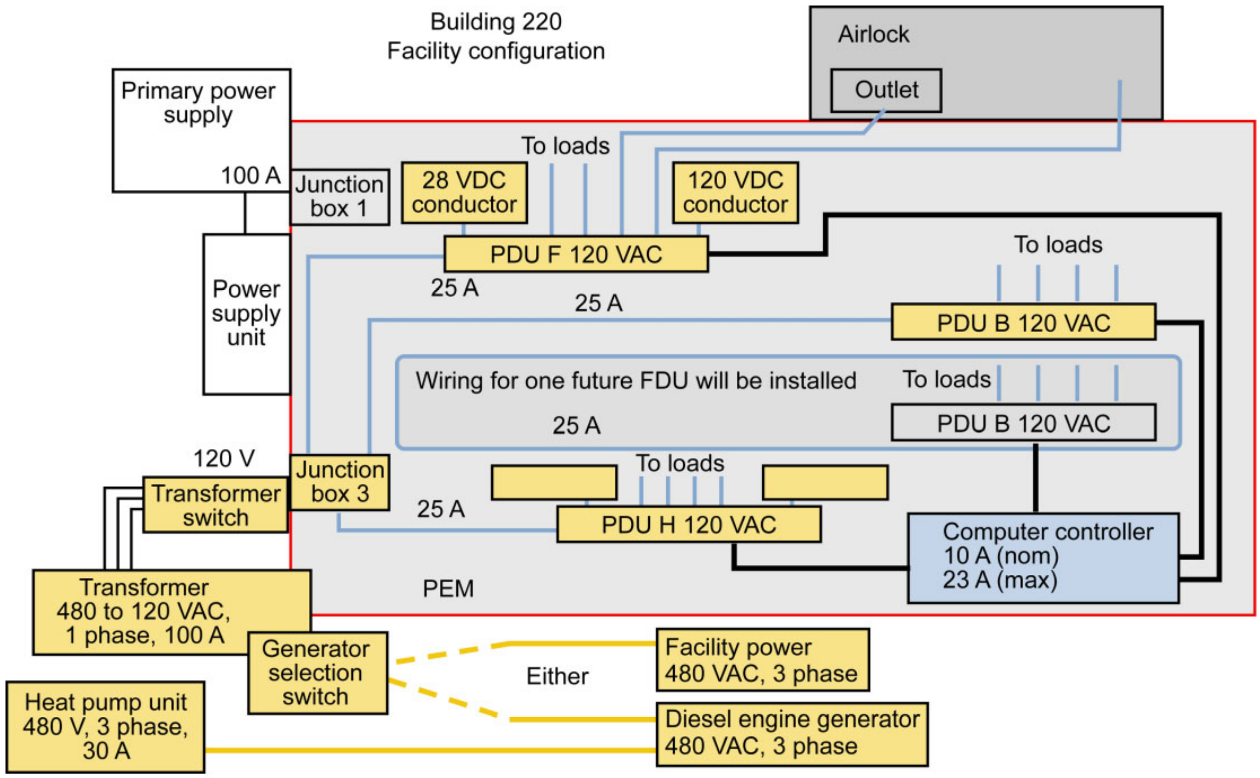

Figure 14.—Illustration of the HDU power system components and external power supply at Building 220 and Rock Yard at NASA JSC.

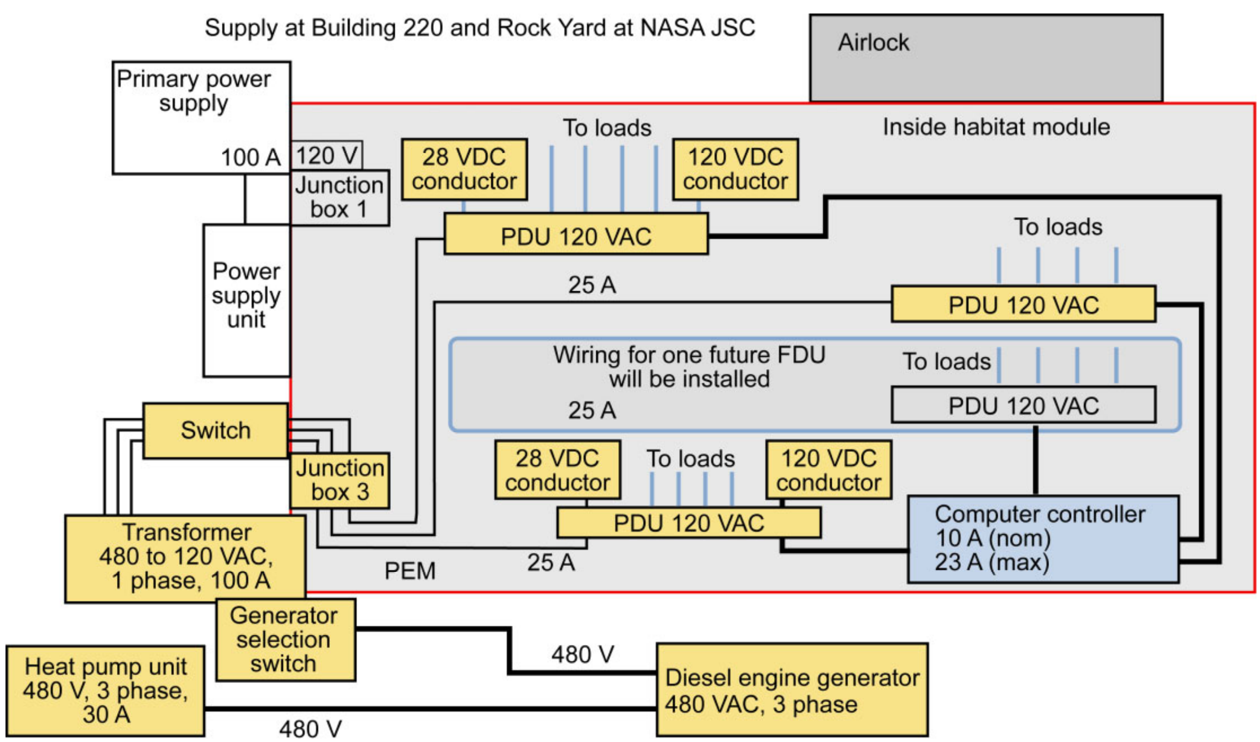

Figure 15.—Power system layout for traverse and remote site operation at Desert Research and Technology Studies (RATS).

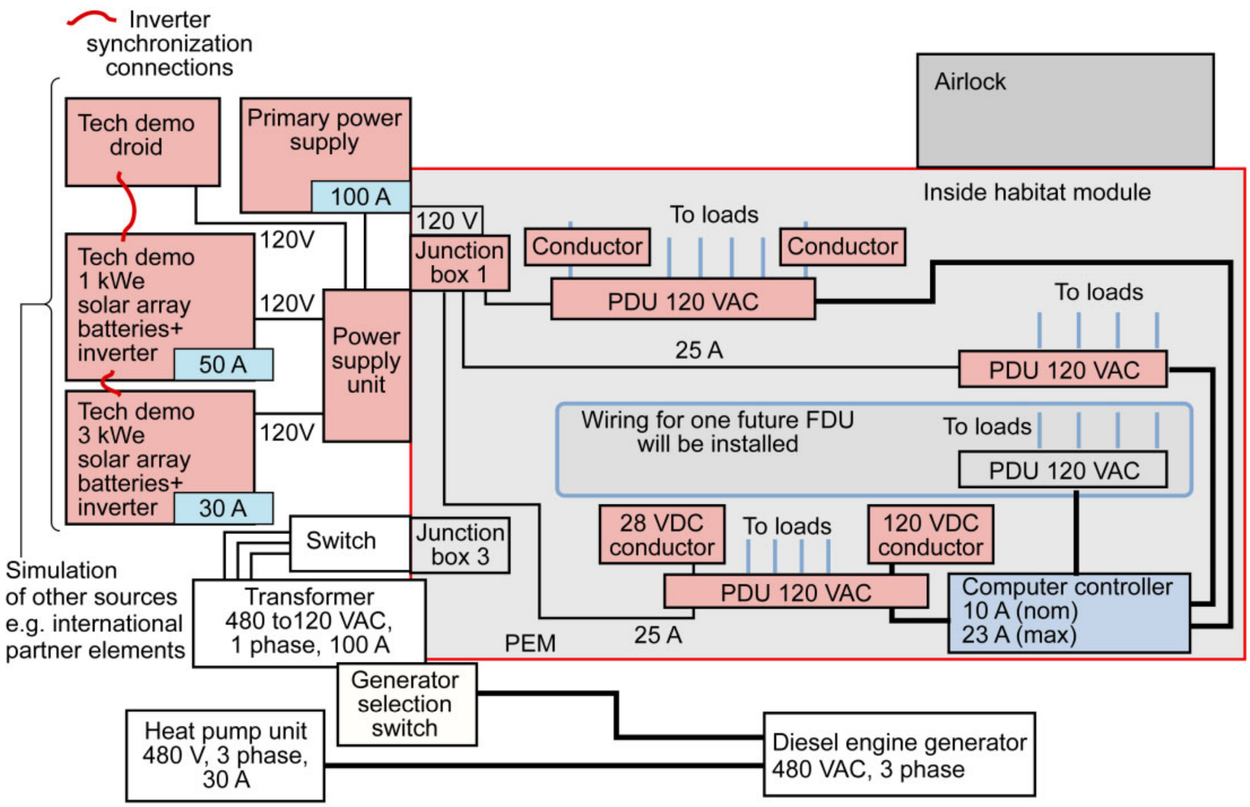

Figure 16.—Power system layout for technology demonstration and base camp operation at Desert RATS.

The external power sources were connected to the HDU power system through various connectors located on a panel on the outside of the HDU as shown in Figure 17. A power distribution cart was used to connect the HDU to the 480 VAC 3 phase external power generator. This distribution cart shown in Figure 18 consisted of 480 VAC 3 phase to 120 VAC single-phase transformer and three switches. The first switch was used to connect and disconnect the generator from the distribution cart. The other two switches were used for connecting and disconnecting the power from the HDU and heat pump.

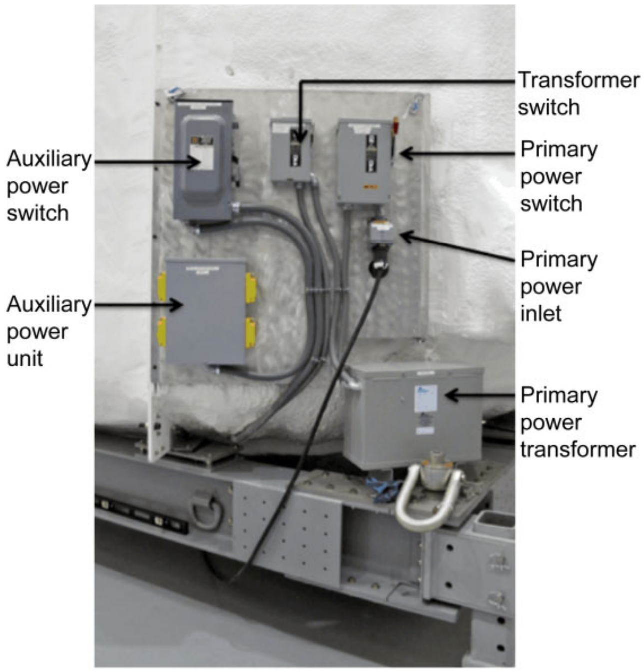

Figure 17.—External power source connection panel.

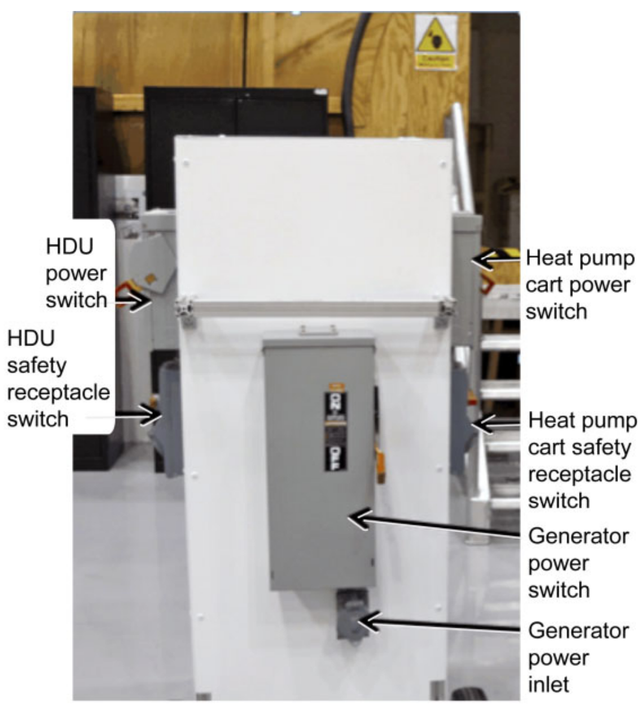

Figure 18.—480 VAC 3-phase power distribution cart.

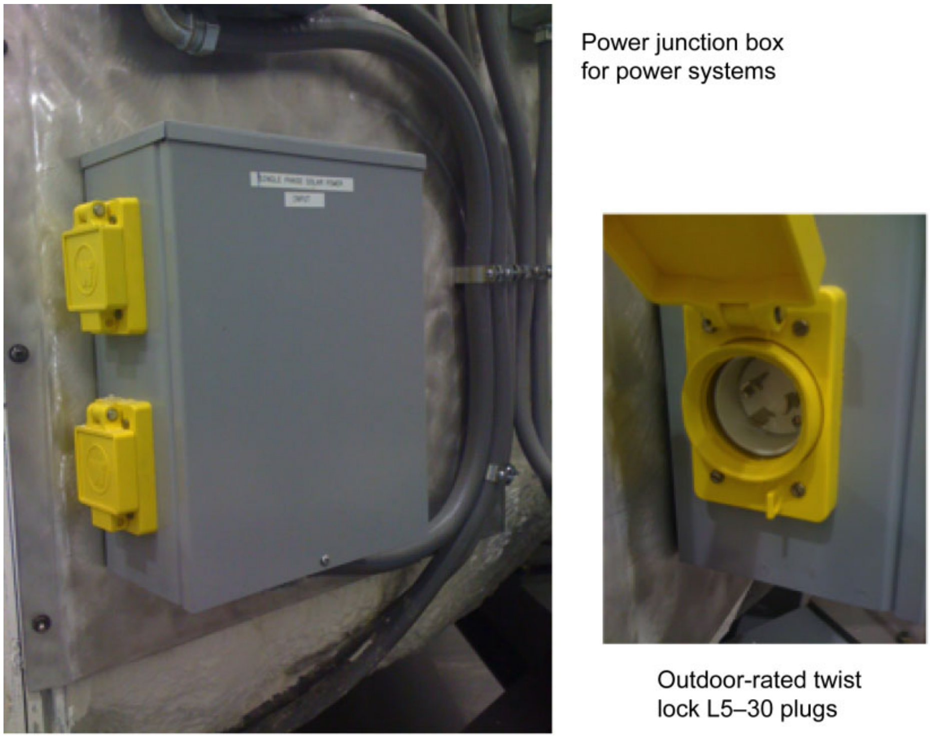

Figure 19.—Photovoltaic (PV) power systems junction box and plugs.

The solar power systems were connected to the HDU through a separate junction box, shown in Figure 19. This junction box consisted of four L5-30 male ports. The junction box combined the power from the PV sources to a single line that was fed to the main 100-amp breaker switch and into the HDU. The power output from the solar sources was 120 VAC. The power waveform was synced at the PV sources therefore no active syncing was needed at the HDU.

3.0 Power System Operation at Desert RATS

The 2010 Desert Research and Technology Studies (RATS) campaign took place at the Black Point Lava Flow outside of Flagstaff Arizona. The Black Point Lava Flow terrain provided an environment geologically similar to the lunar surface. The Desert RATS program is conducted annually, its goal being to provide analog testing of different elements of a mission operating together in an environment similar to that of an actual mission to evaluate how the different elements work together. The HDU operation was one part of the overall Desert RATS program.

The HDU was operated at 2 locations within the Black Point Lava Flow, the base camp location and the SP crater location. Both are shown in Figure 20.

The power system operation at Desert RATS consisted of two main areas, the power components and distribution within the HDU and the external power sources, which supplied power to the HDU. A WhisperWatt 125 kW diesel generator, (shown in Fig. 21) powered the HDU for the majority of time it was operating. The generator provided 3 phase 480 VAC power to both the air-conditioning unit and the main transformer which converted it to single phase 120 VAC which was utilized within the HDU. The diesel generator was used as the sole power source while the HDU was at the SP mountain location, shown in Figure 22.

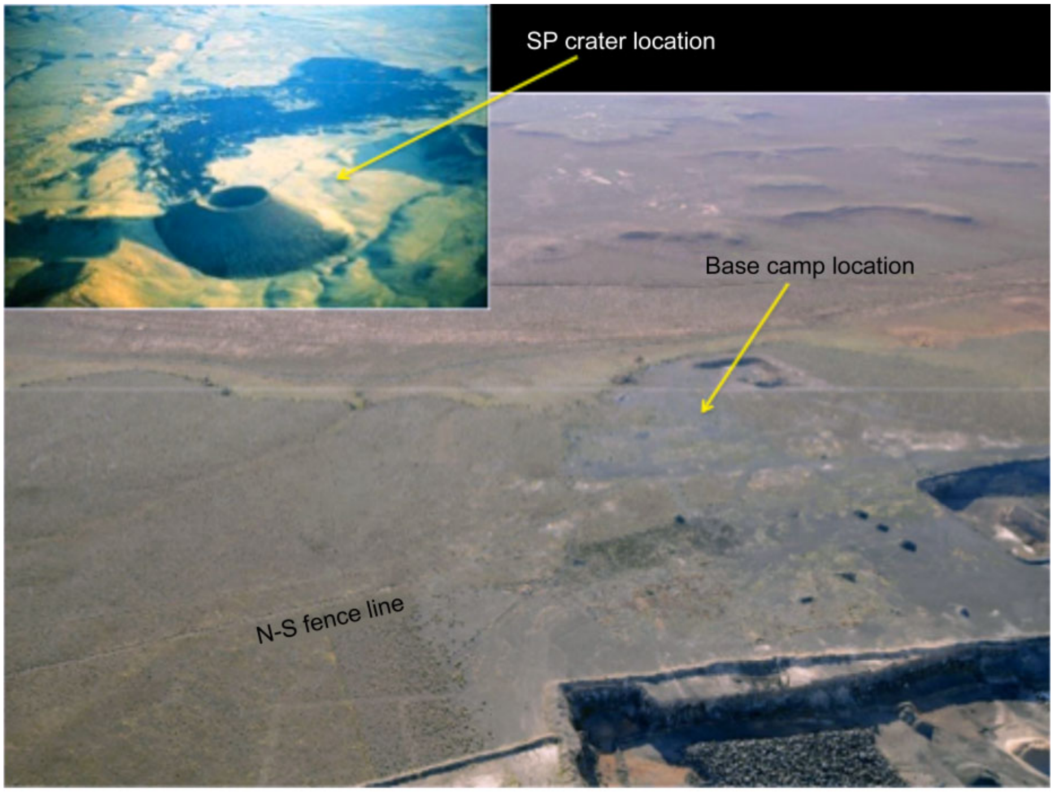

Figure 20.—Desert RATS test locations.

Figure 21.—WhisperWatt 125 kW portable diesel generator.

Figure 22.—HDU at the SP mountain test site.

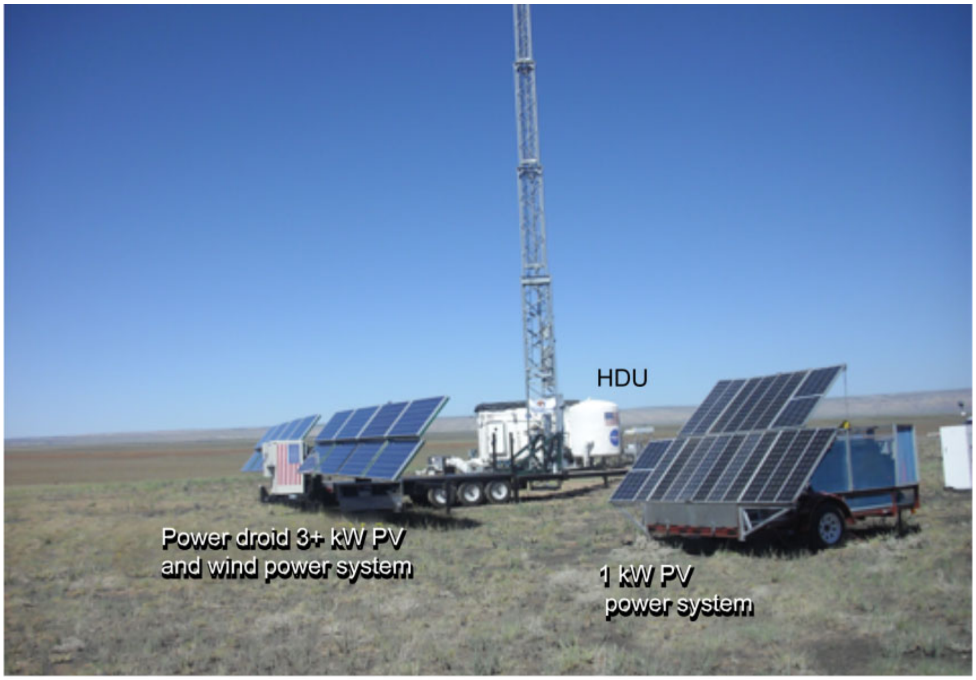

Figure 23.—PV power systems used to provide HDU power at base camp.

While at the base camp location, the diesel generator was supplemented by the two solar photovoltaic power systems shown in Figure 23. These systems consisted of the GSW-7000 photovoltaic and wind based power system from Green Trail Energy and a 1 kW solar test-bed trailer from NASA Glenn Research Center. These systems provided 120 VAC power to the HDU for daytime operations at the base camp location. The GSW-7000 power system can provide up to 4.5 kW of solar power as well as up to 2.4 kW of wind power. It has a battery storage capacity of 1500 A-hrs. The GRC power system can provide up to 1.1 kW of PV power and has a battery storage capacity of 296 A-hrs.

The GRC 1 kW mobile PV power system is a stand-alone power system capable of providing 120 VAC, 240 VAC, and 48 VDC power to nearby loads through a number of standard cable connector ports. The photovoltaic array consists of 16 Seimans M55 solar panels rated at 55 W output and 4 Kyocera 5KC50T 50 W solar panels. The panel output ratings are based on 1000 W/m^2 incident solar radiation. A battery bank consisting of four 74 A-hr deep discharge lead acid gel-cell batteries is used to store energy as well as regulate the voltage to the inverter. The batteries are charged from the array through an Outback MX60 battery charge controller. This battery charge controller has an array peak power tracking capability to maximize the output of the solar array. An Outback Grit-Tie 3.6 kW inverter, model GVFX3648, is used to provide 120 VAC output to the loads. In addition to the 120 VAC output a transformer is utilized to provide a 220 VAC output. A diagram of the system components is shown in Figure 24.

The grid tie inverter was used to sync the output of the GSW-7000 to the output of the GRC power system. This was accomplished by taking a 120 VAC output line from the GSW-7000 inverter and connecting it to the input grid power terminals for the Outback inverter. This enabled the Outback inverter to see the GSW-7000 as the gird signal and match is output frequency and phase.

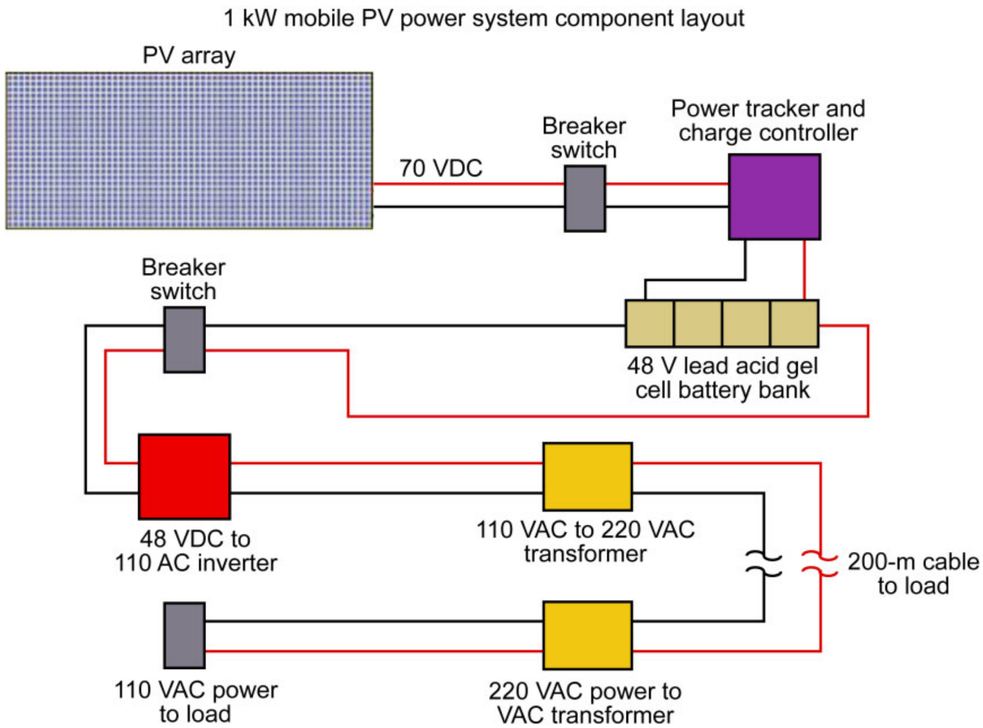

Figure 24.—Operational layout for the 1 kW mobile power system.

Once synced, the output power lines from both PV power systems were connected to the HDU's junction box, shown in Figure 19, and provided supplemental power to the internal components of the HDU. The diesel generator was not synced to the PV systems and therefore could not be used to power items connected to the PV sources. While the PV sources were operational the diesel generator was utilized to only run the air conditioning system for the HDU.

The two PV power systems operated well together and provided seamless power to the loads within the HDU. The load sharing between the systems was successful. Initially the GSW-7000 was powering the entire load and the GRC system was operating in standby. The output of the systems then shifted and the GRC system provided the majority of the power up to the output of the PV array and the GSW-7000 supplemented this to accommodate the total demand. This initial power output was approximately 750 W from the GRC system and 300 W from the GSW-7000. Throughout the day, as the sun elevation angle diminished, the GRC system array output would decrease and the GSW-7000 would pick up more of the load. The load sharing of the systems provided a demonstration of how power systems from separate vehicles or systems could potentially be gridded together to provide a power source infrastructure on the lunar surface.

Data was also taken on the power draw from each of the PDUs during operation. The power consumption from each of the PDUs is shown in Figures 25 to 28 for a 2-day period of operation. Figure 25 shows the total current draw from each PDU over that period of time. From that figure it can be seen that the total load on each PDU differed with PDU F carrying a significantly higher load over the time period then the other two PDU. The power loads on all 3 PDUs was fairly consistent with some step up and down throughout the course of the 2-day period. There were some power spikes, the largest of which occurred on PDU F in which the output current increased from approximately 2.5 to 10.5 A for a short period of time.

The subsequent Figures 26 to 28 show the individual bank current draw from each of the PDUs over the same time period. These curves show how the load power was distributed between the two banks on each of the PDUs. For the most part, the load on each PDU was fairly equally distributed between the two banks of each PDU.

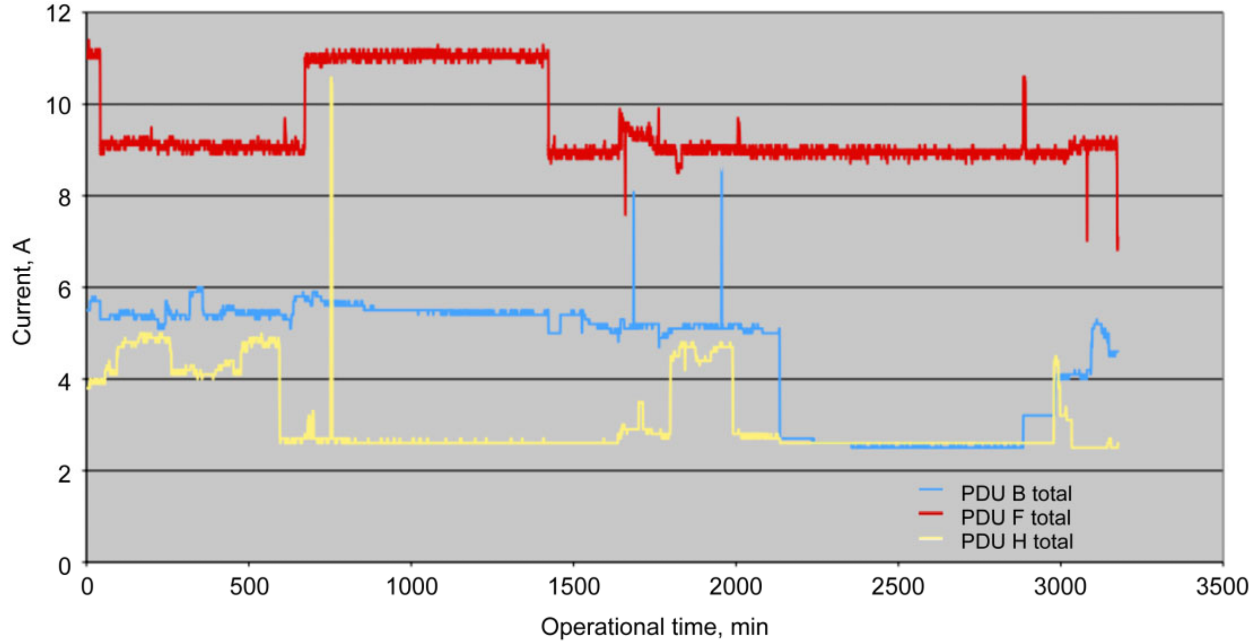

Figure 25.—Total output current for PDUs B, F, and H.

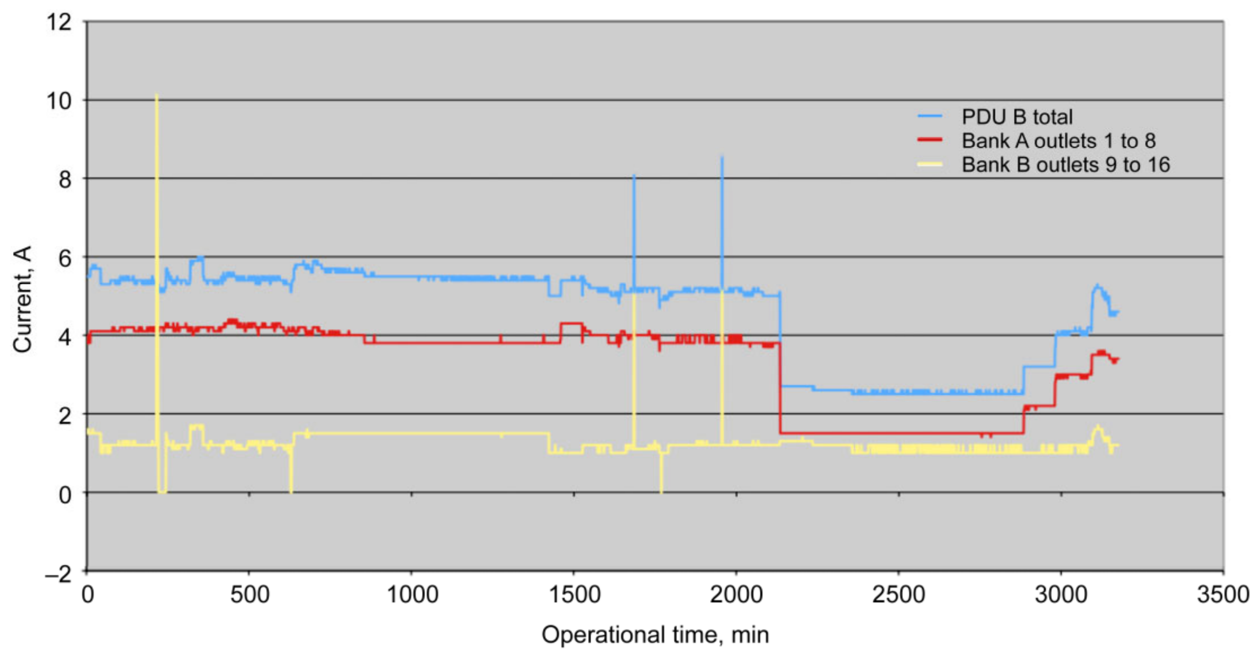

Figure 26.—PDU B, total and individual outlet bank current.

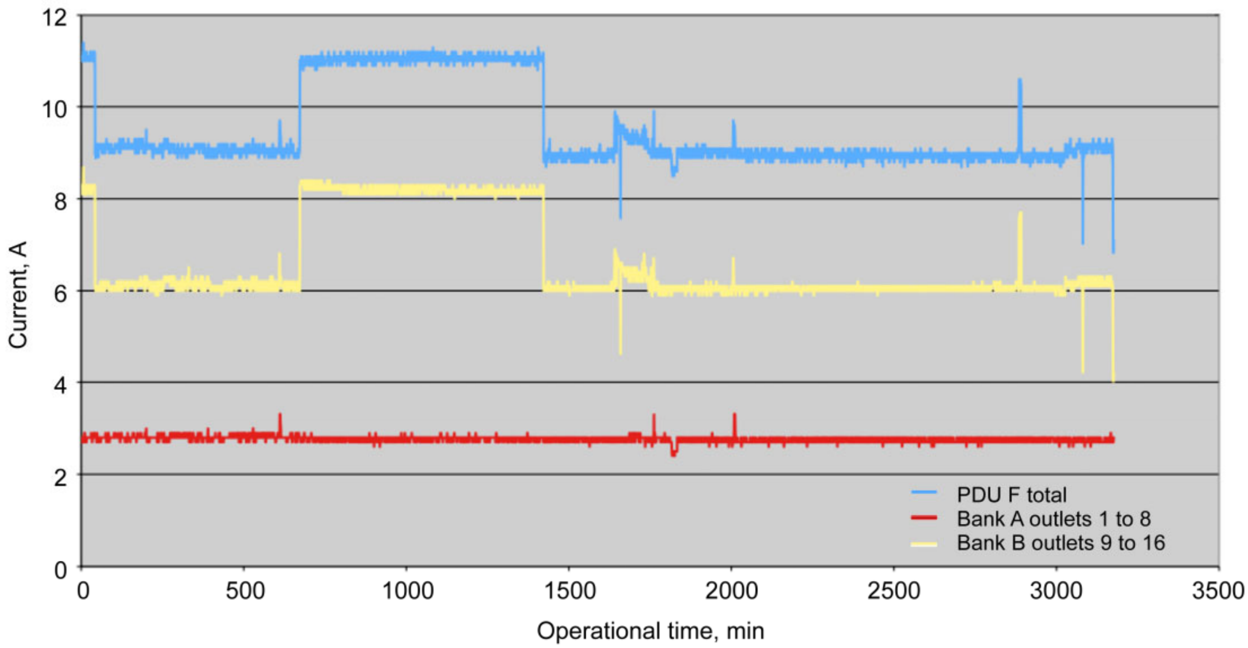

Figure 27.—PDU F, total and individual outlet bank current.

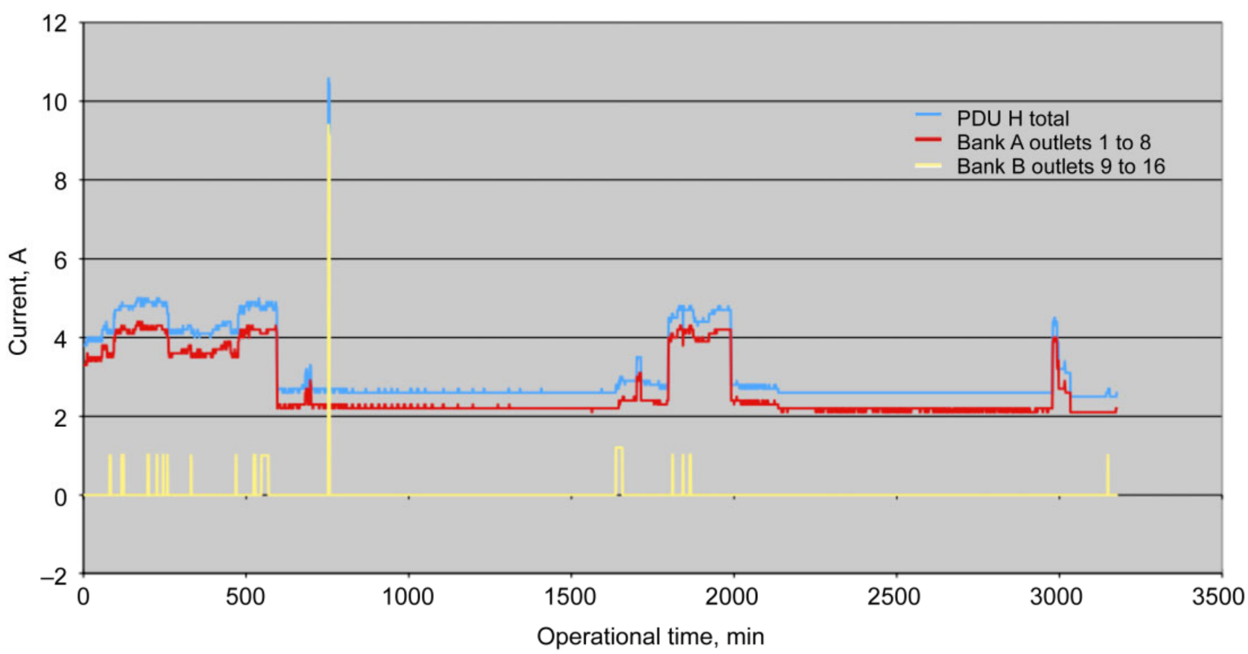

Figure 28.—PDU H, total and individual outlet bank current.

4.0 Options for Future Development

The future development of the HDU power system will be focused on meeting any additional power needs of the HDU as well as incorporating additional types of power sources that are representative of the systems that would be utilized in a space application.

4.1 Power System for X-Hab Living Loft

The near term development of the HDU calls for an expansion above the main level to provide living quarters for crew. A Power System to accommodate this loft area will include the following additional items:

- Eight 2-outlet plugs will be incorporated into the floor of the loft. These will be symmetrically distributed along the floor and located near the outer wall of the loft. A 28 VDC power junction box will also be supplied to provide power to test and data equipment. This is illustrated in Figure 29.
- An additional PDU will be added to accommodate the power requirements of the loft. This PDU can provide a total of 30 A at 120 VAC in two banks of 15 A each. One of these banks will be dedicated to the loft area and connected to the 8 outlets installed in the loft floor.
- The other bank will be available to the main Hab or could potentially also be utilized to power the loft if needed. Using this second bank for powering the loft would require running an additional power line from the PDU to the loft and connecting some (half) of the plugs to this second power line.
- A separate power line from the generator will power the additional PDU. This will require a transformer, junction box and switch. This arrangement will be identical to the one presently installed that provides power to the existing 3 PDUs within the HDU. The 4th PDU will be powered through a separate input line. The external power input and conditioning components will be duplicated to provide power to the 4th PDU. Duplicating the existing power connection components has 2 main benefits. It enables the existing power input infrastructure to remain unchanged and it will provide the capacity to add 2 additional PDUs for future expansion.
- A second PV source junction boxes and switch will also be added to provide PV power to the 4th (and potentially 2 additional PDUs).

These items are illustrated in Figure 30.

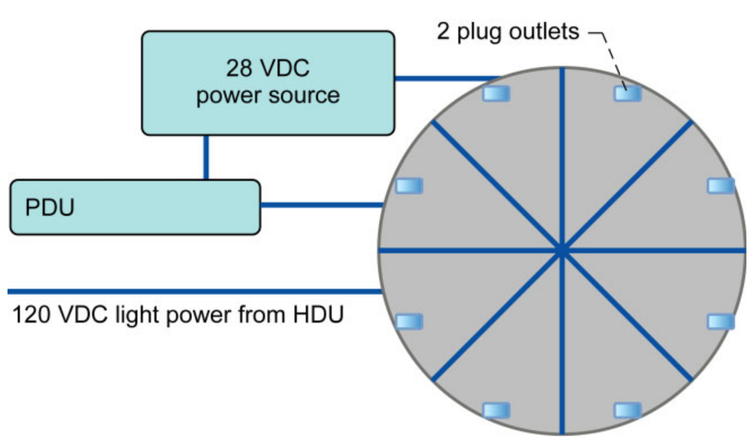

Figure 29.—Proposed power availability for the HDU loft (X-Hab).

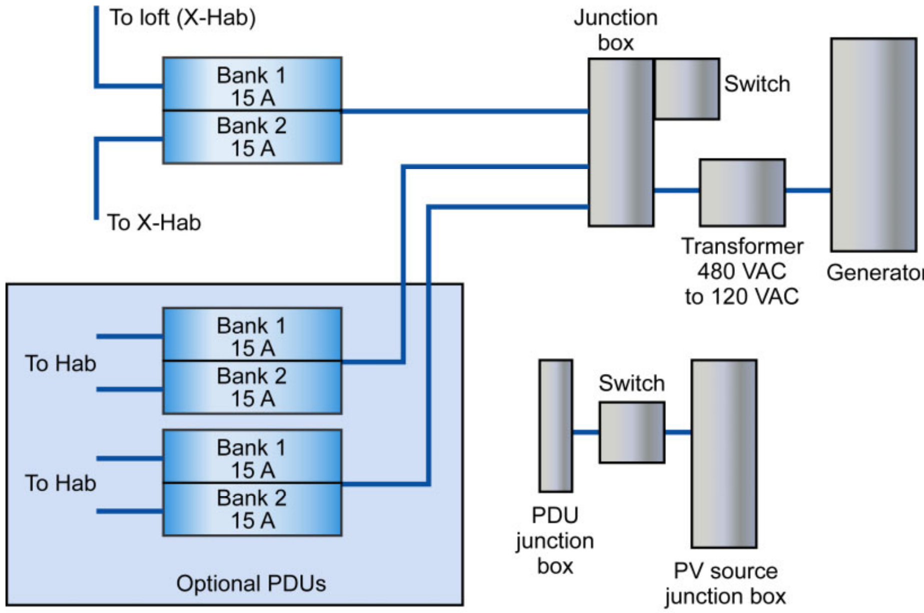

Figure 30.—Additional power conditioning components to support the X-Hab.

4.2 Power Production Integration

As the development of the HDU system continues, the integration of power production systems and components will be necessary. One concept in the incorporation and integration of additional power sources is to include a fuel cell power source. An approach to this is to integrate the fuel cell system along with a deployable solar array onto the roof of the HDU as shown in Figure 31. This concept provides an integrated power production and storage system that is part of the HDU.

Integrating the power production system into the HDU is a logical progression in the development of the HDU as a complete standalone habitat. As the HDU system architecture grows and becomes closer to space hardware in its configuration, the integration of a power generation capability will be an important aspect of the design. As an example, the growth and integration of a multiunit habitat system for a lunar surface application is illustrated Figure 32. The power production integration is a longer-term goal of the overall power system architecture development. Many incremental steps will be necessary before a system, as shown in Figures 31 and 32 is produced. However, the main power production and conditioning components of this type of system can be developed as stand-alone items and utilized in near term demonstrations towards the goal of ultimately developing a fully integrated system.

4.3 Construction of a 3 kW PV Mobile Power System

The objective is to provide a second PV based power system with greater capacity than the 1 kW system presently used. A 3 kW system can be constructed with the ability to be used as a stand-alone system or connected to the 1 kW system, allowing them to function together as a single power source. The 3 kW mobile power system will be constructed in a similar manner as the 1 kW system. The main difference is in the structural layout that will need to accommodate the larger solar array. Some of the components for the 3 kW system are shown in Figure 33.

The 3 kW mobile PV power system would be capable of providing approximately 2400 W of output power continuously from dawn to dusk at the Black Point Lava Flow location during September, as shown in Figure 34. The system would also be capable of syncing to the 1 kW through the capabilities of the Outback inverter. Once synced, the output of both power systems can be combined within a junction box to provide a single output power connection enabling both systems to provide power to the HDU simultaneously. This is illustrated in the component layout shown in Figure 35.

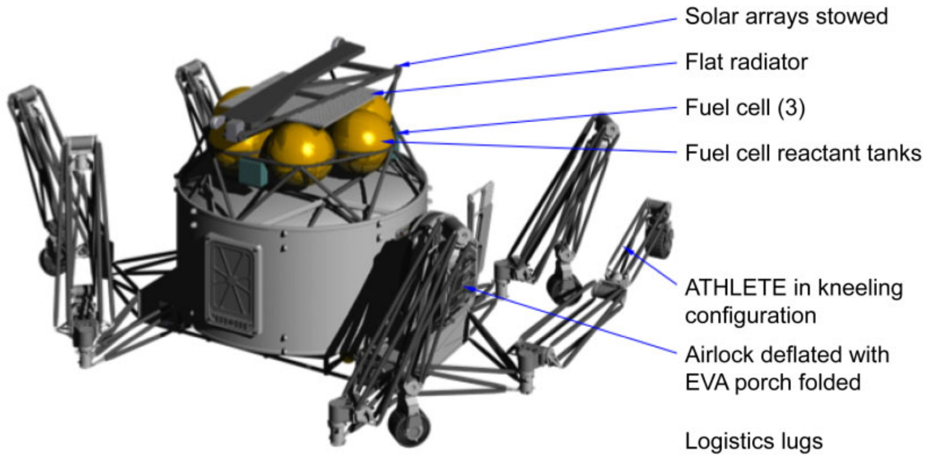

Figure 31.—HDU option with integrated power generation system.

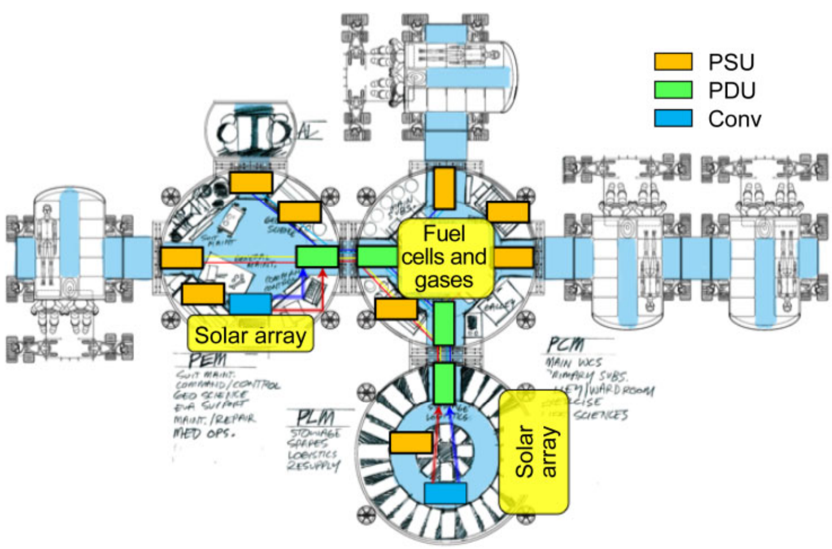

Figure 32.—Integration of power systems for multiple habitat units.

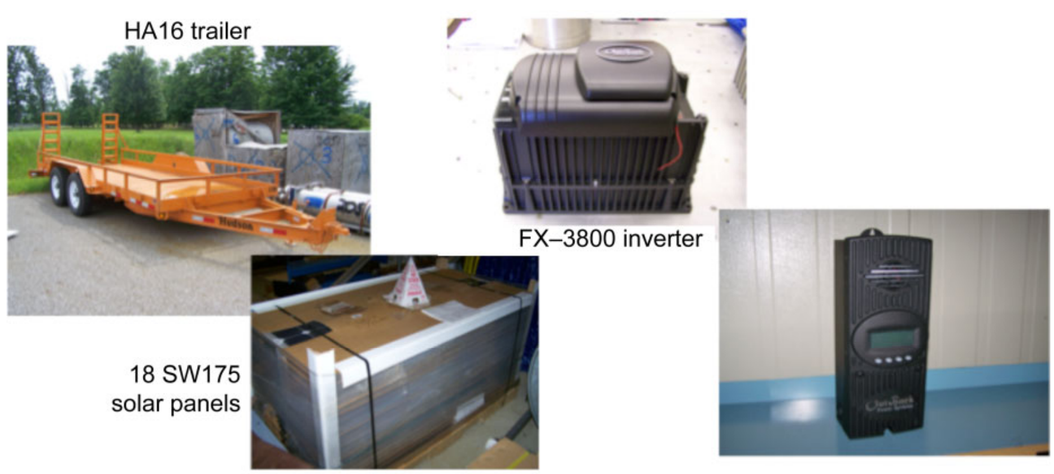

Figure 33.—3 kW mobile power system components.

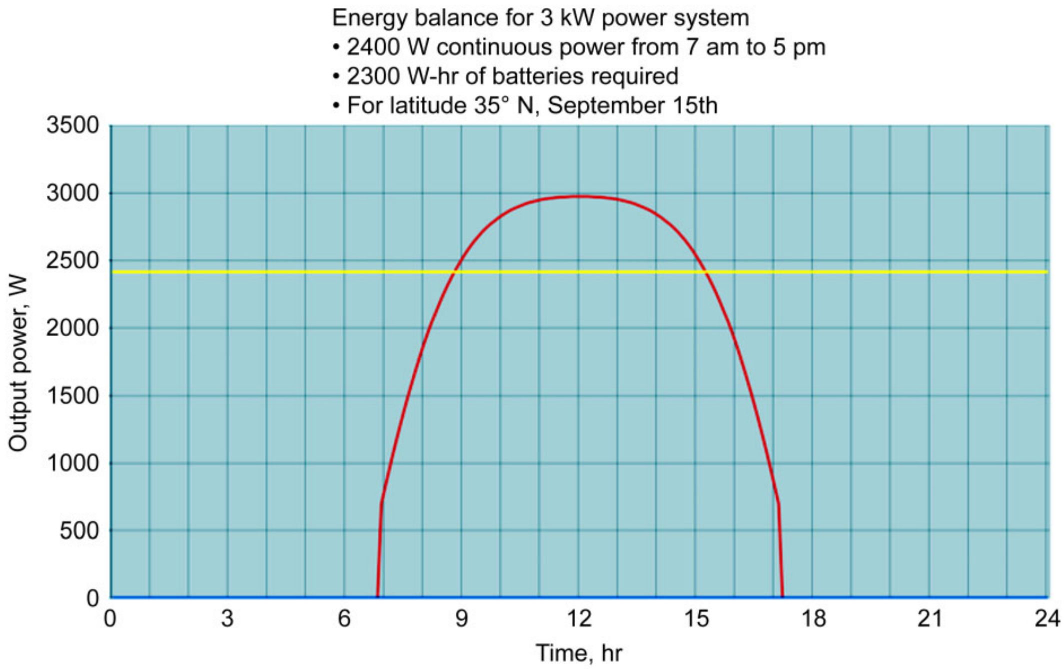

Figure 34.—Energy balance output for the 3 kW mobile power system.

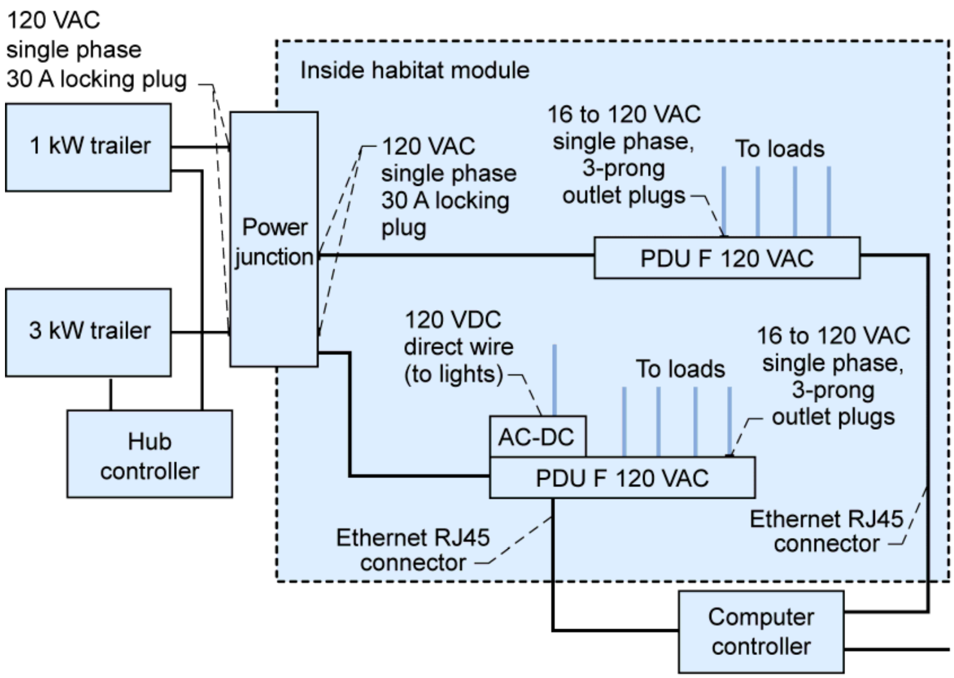

Figure 35.—Layout of power system with 2 PV sources.

4.4 Fuel Cell Power Source

A mobile fuel cell platform can be constructed to provide auxiliary and nighttime power to the HDU through the same interface as the PV systems. The fuel cell systems can be built up on one or more small trailers. Each system would include four Ballard Nexa hydrogen-air fuel cells, shown in Figure 36. Each of these fuel cells can provide 1.2 kW of power for a total of 4.8 kW per mobile system. The fuel cells would be wired to provide a 48 VDC output which would enable them to operate with the same inverters as the PV systems. To accomplish this task, 2 fuel cells would be connected in parallel and 2 sets of these groupings would be connected in series.

To provide fuel for the fuel cells, hydrogen gas would need to be stored on tanks located on the mobile platform. The tanks can be constructed of carbon composite with an aluminum liner to minimize weight. The hydrogen gas can be supplied from either a stored hydrogen source that would need to be located near the operational location or it can be produced on site through the use of an electrolyzer. The electrolyzer option would provide a demonstration of the operation of an additional critical power system component.

An available Proton HoGen 10 electrolyzer, shown in Figure 37, can be utilized for producing high purity hydrogen gas. The electrolyzer is capable of providing 200-psi hydrogen at a rate of 10 scf/hr. It is also capable of producing 200-psi oxygen. If higher-pressure hydrogen gas is desired the storage pressure can be increased beyond the 200 psi supplied by the electrolyzer with the use of a hydrogen compressor. The electrolyzer along with storage tanks and the associated gas handling systems, shown in Figure 38, can be mounted onto a small trailer to provide a mobile hydrogen source for use in refilling tanks for the fuel cell system.

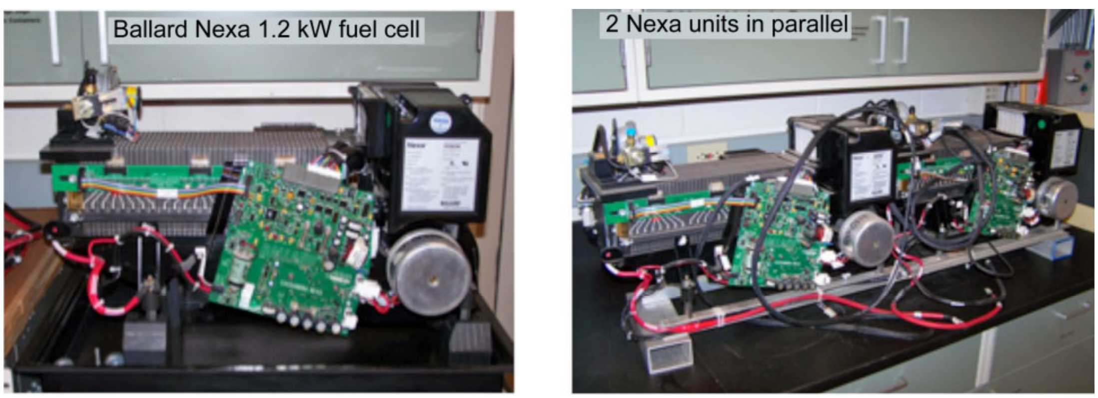

Figure 36.—Ballard Nexa fuel cell systems.

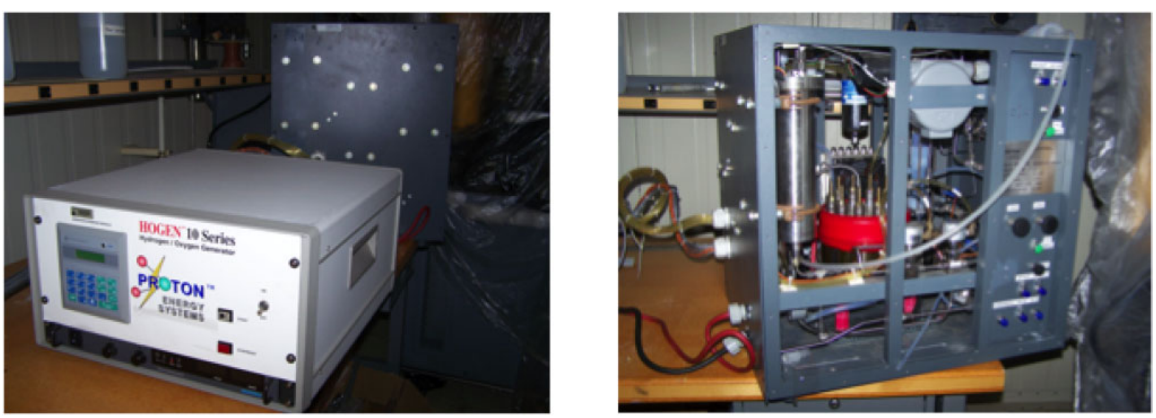

Figure 37.—Proton HoGen 10 electrolyzer.

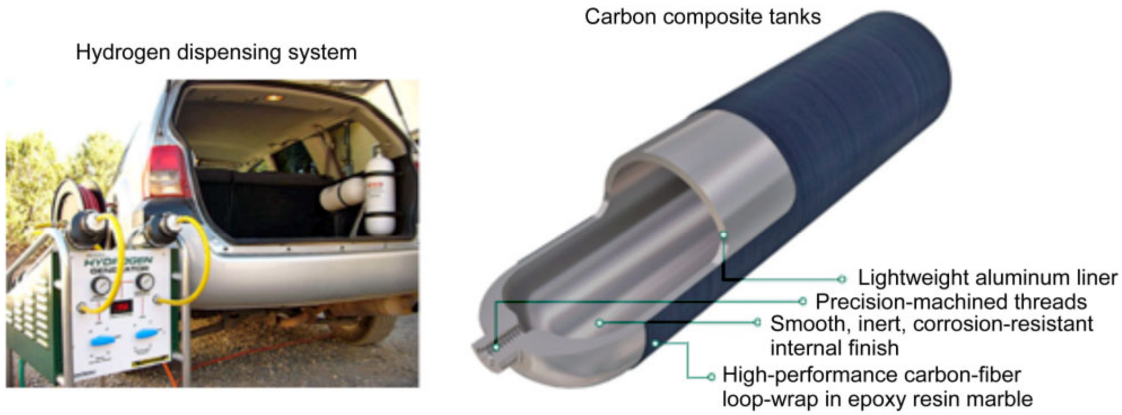

Figure 38.—Gas handling and tanks for the electrolyzer system.

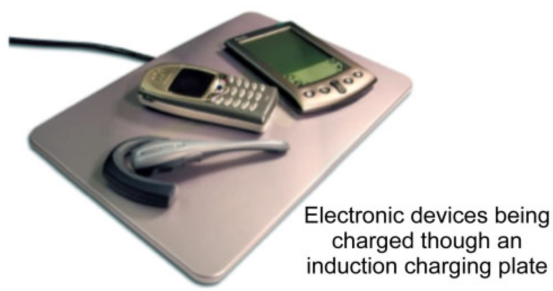

Figure 39.—Example of an induction charging system.

4.5 Induction Charging System

The implementation of an induction charging system can provide a connection-free method for charging various devices and systems from the HDU power system. This type of charging system can be utilized within the HDU to provide easy charging for electronics, as shown in Figure 39. It can also be utilized as a means of recharging the batteries within a spacesuit without having to bring the spacesuit into the HDU. The spacesuit can be left on the outside of the HDU or within the airlock against a specially designed charging pad. The system would automatically charge the batteries within the suit to prepare it for the next EVA. It can also be used as a means of charging a rover. The rover could drive over a specially designed charging pad that would electrically couple to the rover and provide charging to the battery.

5.0 Summary

The operation of the HDU power system during the 2010 Desert RATS was successful. The power system met the various loads power requirements and provided continuous operation of the loads throughout the testing. The main power source for the testing was the 3-phase 480 generators. However, 2 photovoltaic systems were also utilized during the testing as a means of demonstrating a more space-like power source. The power system design allowed both the generator and the PV sources to provide power to the loads. This was accomplished with minimal interruption to the loads. The 2 PV systems were successfully synchronized so that their output could be combined and fed to the HDU. However, the PV systems were not capable of synchronizing with the generator. Therefore the power from the PV systems was used to provide power to a single PDU, while the generator provided power to the remaining 2 PDUs. This kept both the generator and PV systems isolated from each other during operation. The power system will be further developed for the next generation HDU testing. This development will include increasing the capacity of the system and providing an easier and more standardized means of connecting and conditioning power from various sources.

Appendix—Power Schematic for HDU Sections

Section A

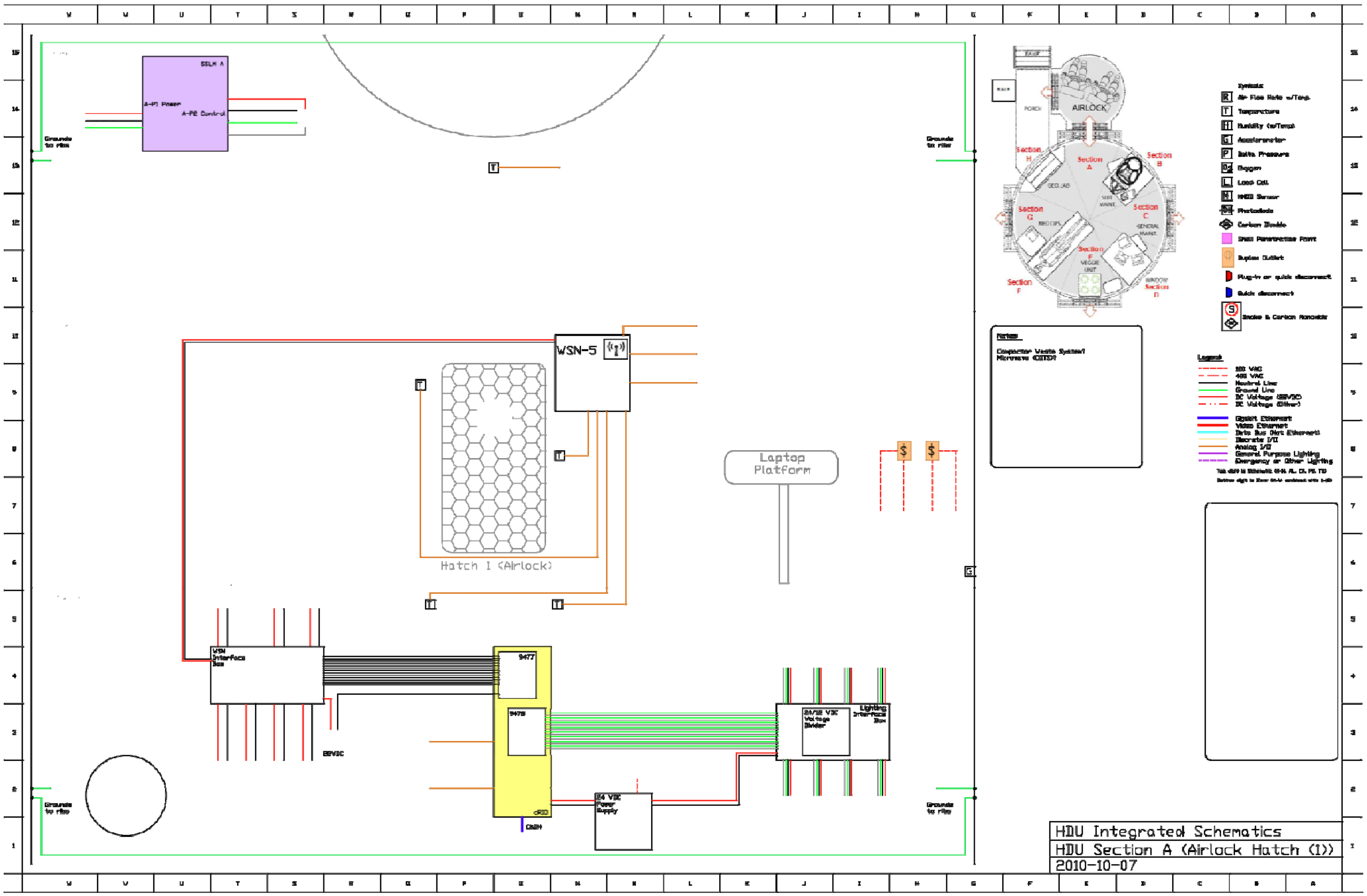

Figure 40.—Section A power system schematic.

Section B

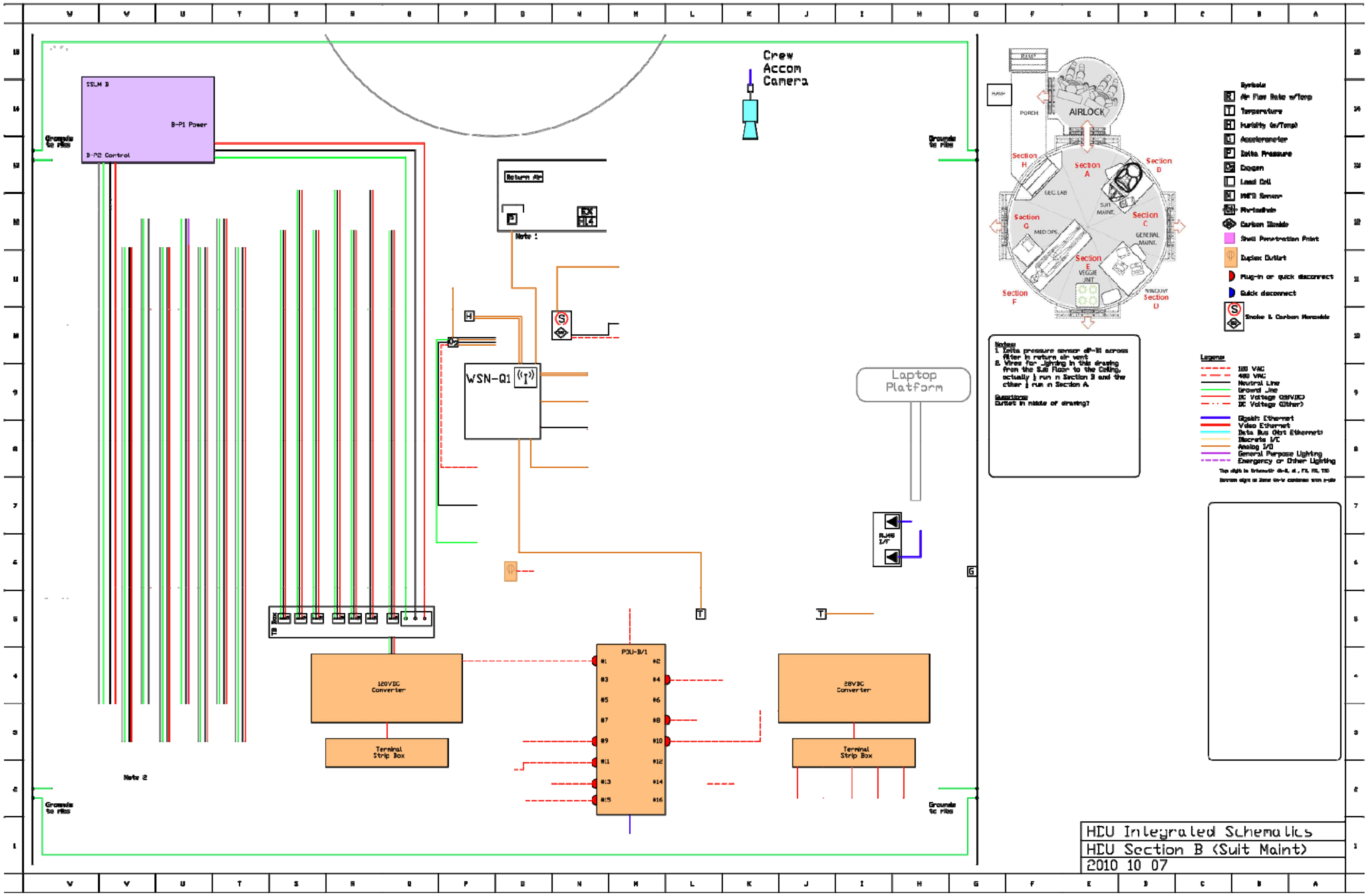

Figure 41.—Section B power system schematic.

Section C

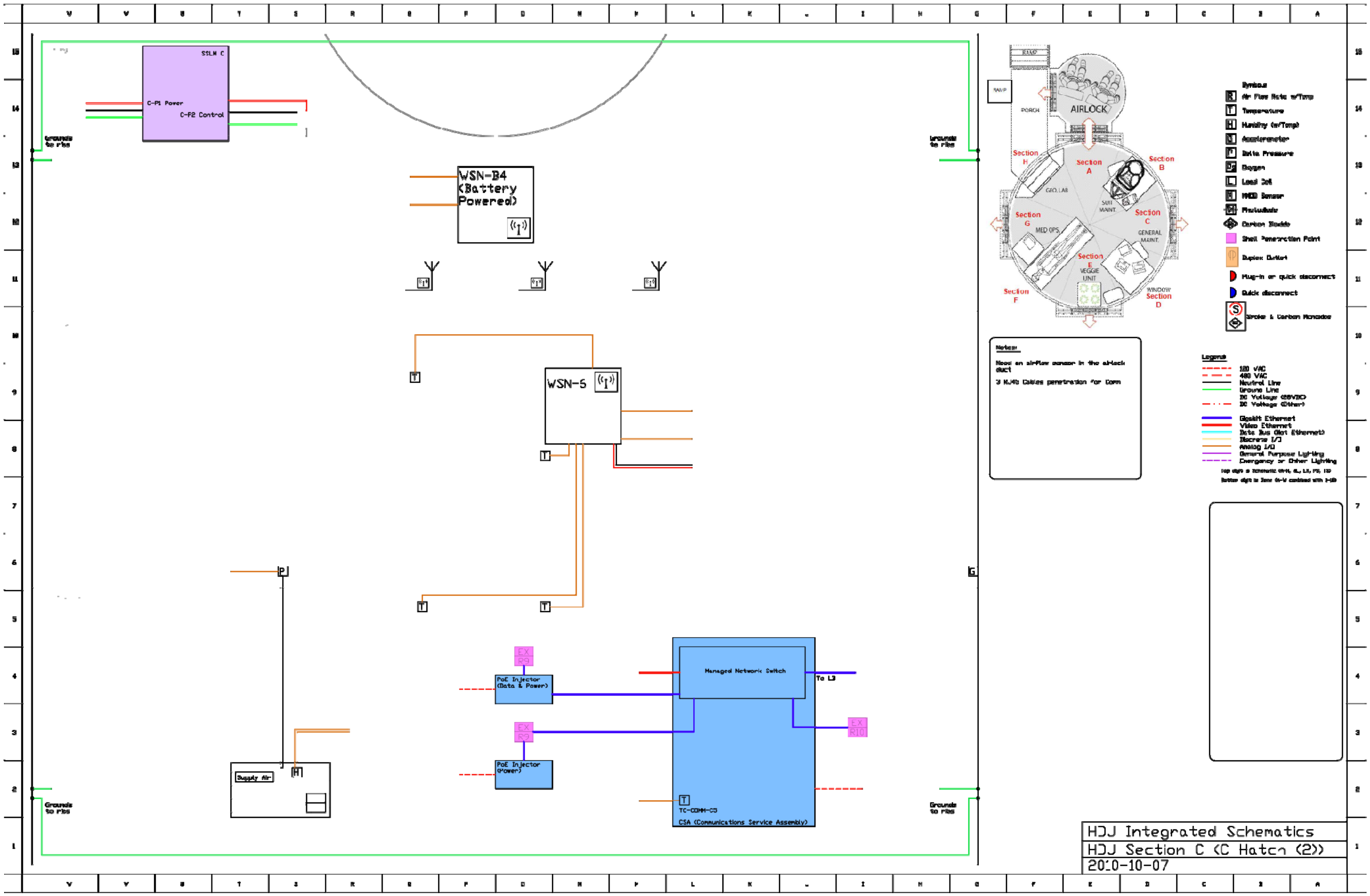

Figure 42.—Section C power system schematic.

Section D

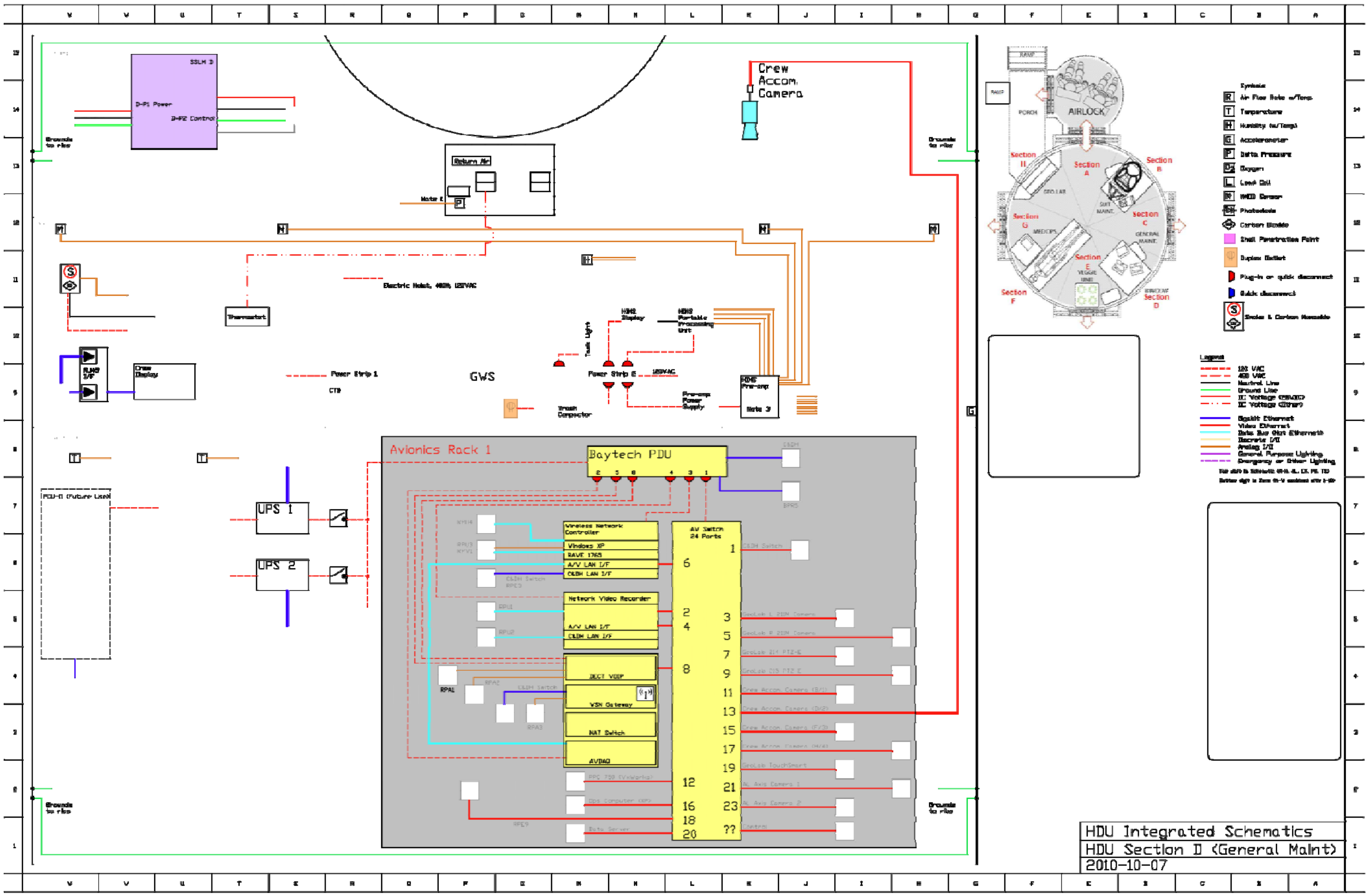

Figure 43.—Section D power system schematic.

Section E

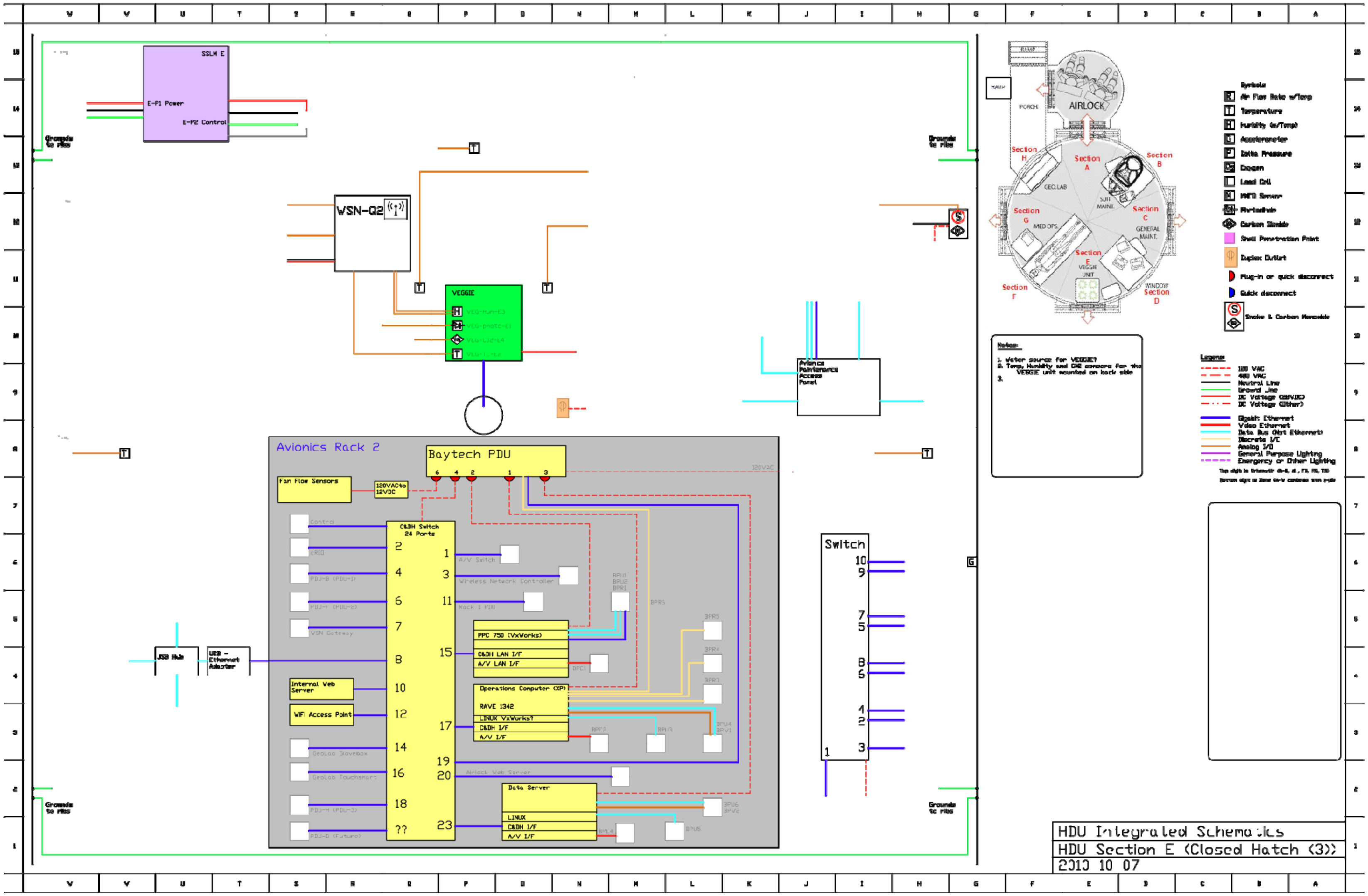

Figure 44.—Section E power system schematic.

Section F

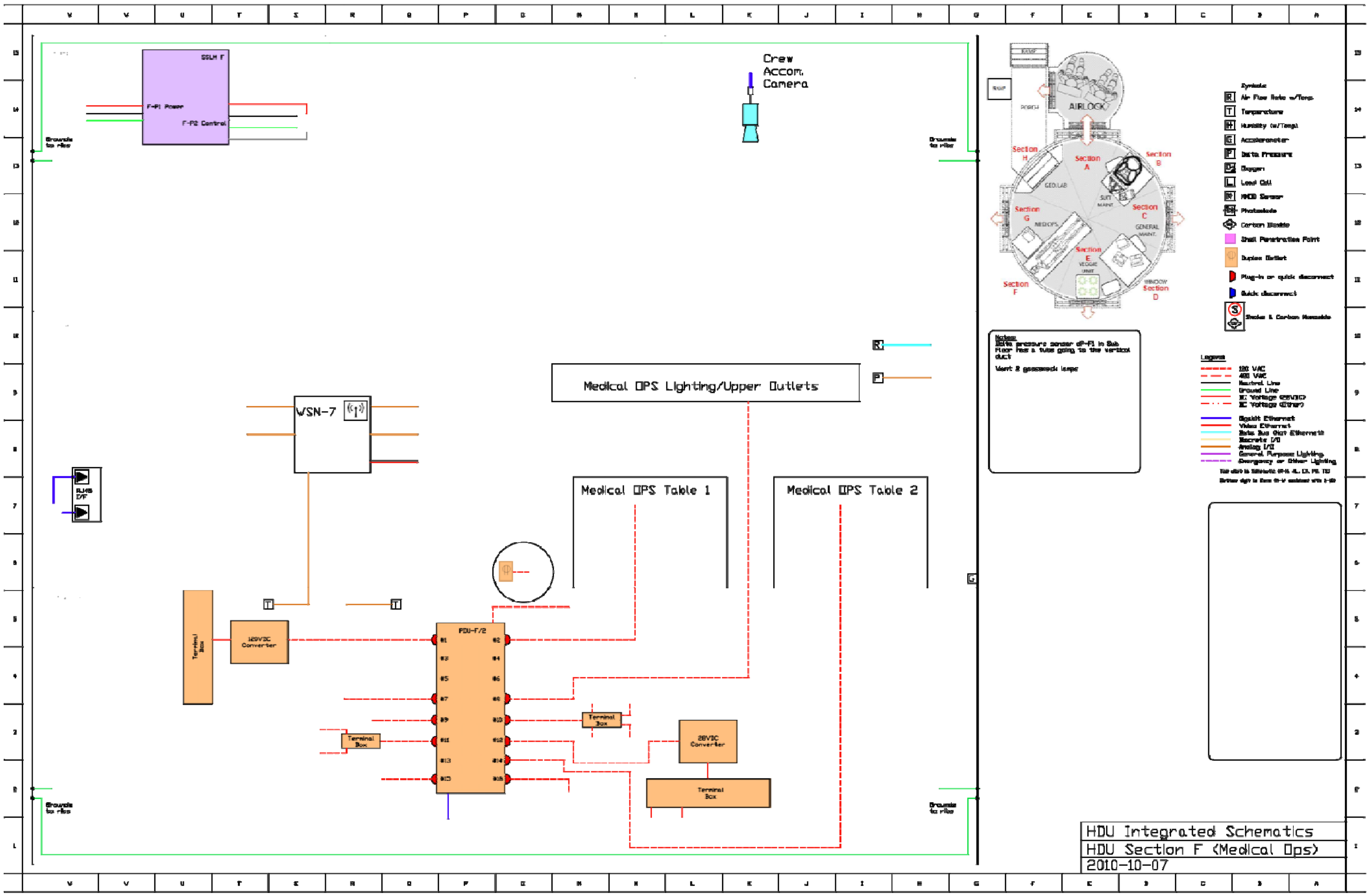

Figure 45.—Section F power system schematic.

Section G

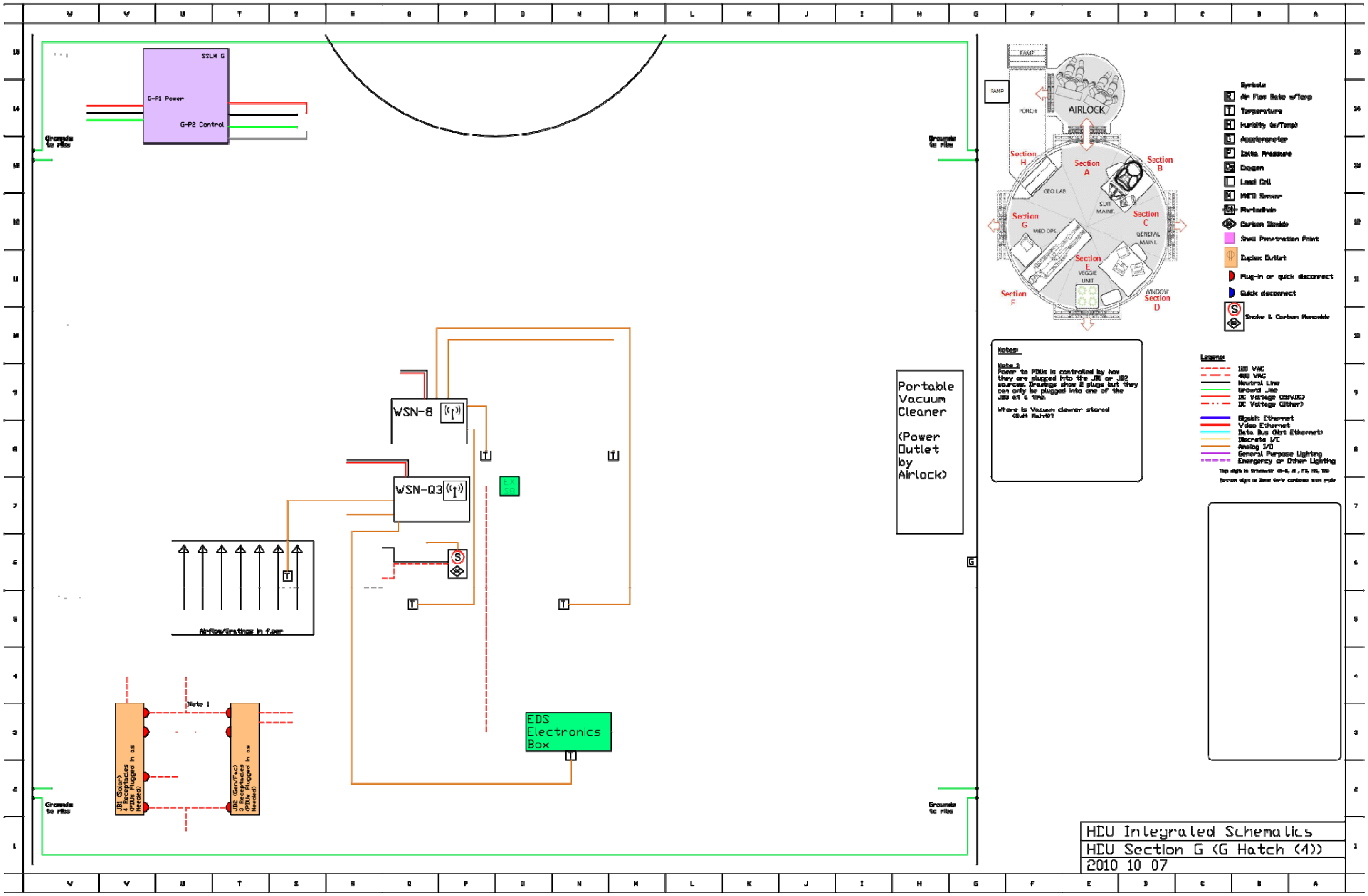

Figure 46.—Section G power system schematic.

Section H

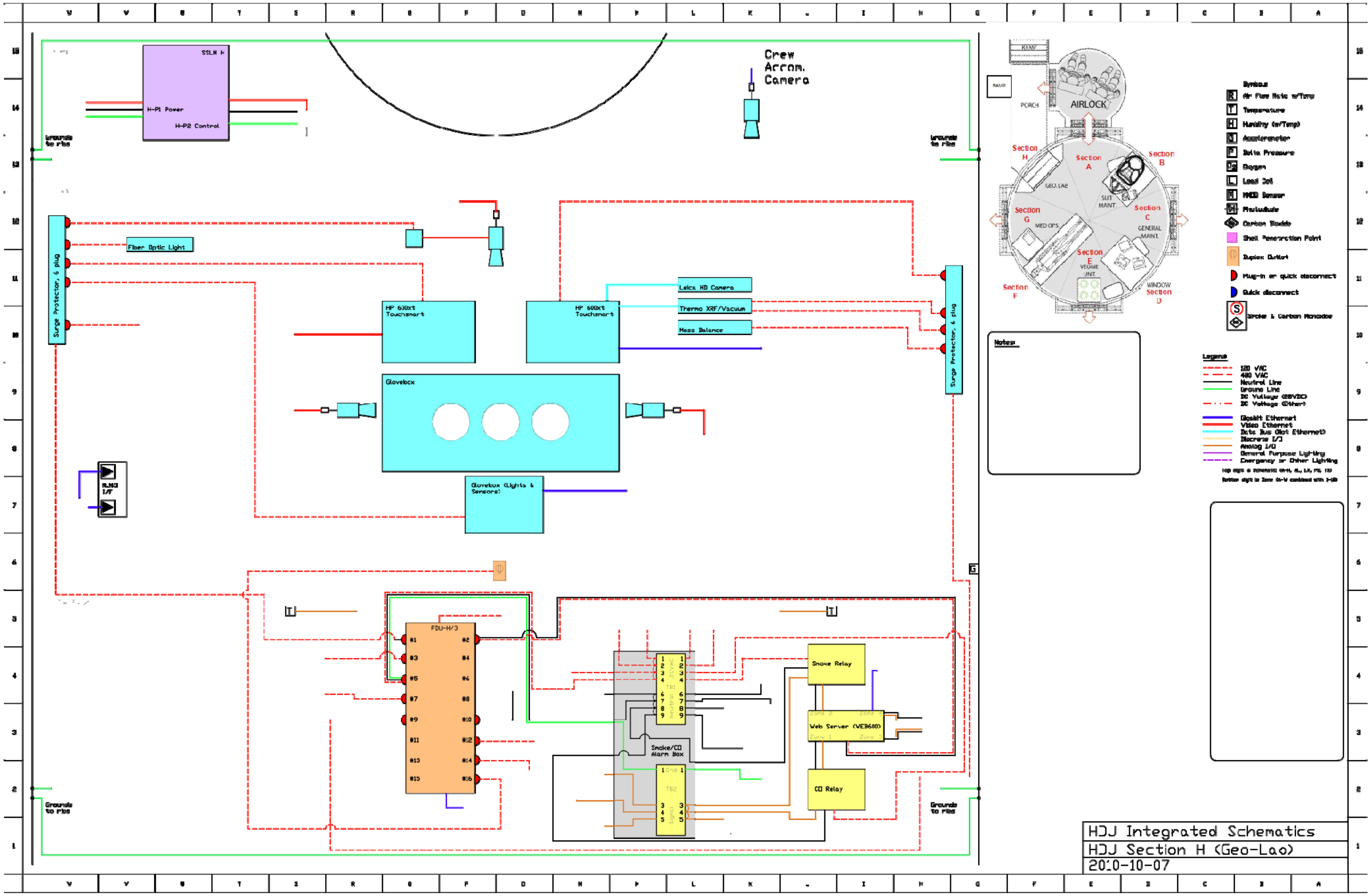

Figure 47.—Section H power system schematic.

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14. ABSTRACT A habitat demonstration unit (HDU) was constructed at NASA Johnson Space Center (JSC) and designed by a multicenter NASA team led out of NASA Kennedy Space Center (KSC). The HDU was subsequently utilized at the 2010 Desert Research and Technology Studies (RATS) program held at the Black Point Lava Flow in Arizona. This report describes the power system design, installation and operation for the HDU. The requirements for the power system were to provide 120 VAC, 28 VDC, and 120 VDC power to the various loads within the HDU. It also needed to be capable of providing power control and real-time operational data on the load's power consumption. The power system had to be capable of operating off of a 3 phase 480 VAC generator as well as 2 solar photovoltaic (PV) power systems. The system operated well during the 2 week Desert RATS campaign and met all of the main goals of the system. The power system is being further developed to meet the future needs of the HDU and options for this further development are discussed.					
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