Raw Power Interface Subsystem Test Plan

These tests are designed to test the operation of the RPI system. Other issues of compliance that cannot be completed through physical tests of the completed subsystem will be dealt with in the requirements analysis of the system-level ATP.

TEST-RPI-001

This test will verify the normal operation of the Raw Power Interface during normal conditions of direct sunlight, and no problems within the system.

Preconditions:

1) Plug safety loop jumper plug into RPI connector J3 to "close" the loop.
2) Attach system power cord W2 to RPI connector J2.
3) Place voltmeters at HV input and output test points in RPI enclosure.
4) Connect wires from the RS485 interface of the RPI board to the RS485 interface of the SCADA board.
5) Connect the RS232 interface from a computer running the SCADA software (or equivalent test software) to the RS232 interface of the SCADA board.
6) Turn Manual Battery Disconnect Switch ESS2 to "On."
7) Press the reset button on the ground fault monitor, ensuring that it is not tripped prior to the test.
8) Press the safety circuit reset button, to reset the system.

Test:

1) Pull double throw switch to the "down" position, marked. HVPV power is now flowing into RPI.
2) Run the test software to measure the five RPI sensors; V_PV, V_RPI, I, T1, T2

Acceptance Criteria:

1) Voltages measured at HV input and output compared to verify that the voltage passes through the system with a voltage drop of less than 4V. e.g. (300V in => 296V+ out)
2) 30V+ indicator lights should be lit.
3) DC power indicator lights should be lit.
4) Fault indicator light should not be lit.
5) Ground fault monitor's alarm LED should not be lit.
6) The test software should return the following sensor values:

V_PV	= ???v (Should match the PV input)
V_RPI	= ???v (Should be with 4V of PV input)
I	= >0A
T1	= within an acceptable range (will be greater than room temp.)
T2	= n/a

TEST-RPI-002

This test will simulate the system reaction when a ground fault is detected.

Preconditions:

1) Plug safety loop jumper plug into RPI connector J3 to "close" the loop.
2) Attach system power cord W2 to RPI connector J2.
3) Connect wires from the RS485 interface of the RPI board to the RS485 interface of the SCADA board.
4) Connect the RS232 interface from a computer running the SCADA software (or equivalent test software) to the RS232 interface of the SCADA board.
5) Place voltmeters at HV input and output test points in RPI enclosure.
6) Turn Manual Battery Disconnect Switch ESS2 to "On."
7) Press the reset button on the ground fault monitor, ensuring that it is not tripped prior to the test.
8) Press the safety circuit reset button, to reset the system.
9) Pull double throw switch to the "down" position, marked. HVPV power is now flowing into RPI.

Test:

1) Qualified personnel places a 40KΩ resistor across positive and ground test points on PV side of the relay
2) Run the test software to measure the five RPI sensors; V_PV, V_RPI, I, T1, T2

Acceptance Criteria:

1) Output voltage should be below 30V within 10 seconds of adding the 40KΩ resistor.
2) Input voltage at test point should match the power source (300V).
3) 30V+ indicator lights should be lit.
4) DC power indicator lights should not be lit.
5) Fault indicator light should be lit.
6) Ground fault monitor's alarm LED should be lit.
7) The test software should return the following sensor values:

V_PV	= ???v (Should match PV input)
V_RPI	= <30v
I	= 0A
T1	= within an acceptable range (will be greater than room temp.)
T2	= n/a

TEST-RPI-003

This test will simulate a general failure, 12V System power will remain throughout the system.

Preconditions:

1) Plug safety loop jumper plug into RPI connector J3 to "close" the loop.
2) Attach system power cord W2 to RPI connector J2.
3) Connect wires from the RS485 interface of the RPI board to the RS485 interface of the SCADA board.
4) Connect the RS232 interface from a computer running the SCADA software (or equivalent test software) to the RS232 interface of the SCADA board.
5) Place voltmeters at HV input and output test points in RPI enclosure.
6) Turn Manual Battery Disconnect Switch ESS2 to "On."
7) Press the reset button on the ground fault monitor, ensuring that it is not tripped prior to the test.
8) Press the safety circuit reset button, to reset the system.
9) Pull double throw switch to the "down" position, marked. HVPV power is now flowing into RPI.

Test:

1) Push "Safety Circuit Trip" button on RPI box.
2) Run the test software to measure the five RPI sensors; V_PV, V_RPI, I, T1, T2

Acceptance Criteria:

1) Output voltage should be below 30V within 10 seconds of tripping safety circuit
2) Input voltage at test point should match the power source (300V).
3) 30V+ indicator lights should be lit.
4) DC power indicator lights should not be lit.
5) Fault indicator light should be lit.
6) Ground fault monitor's alarm LED should not be lit.
7) The test software should return the following sensor values:

V_PV	= ???v (should match PV input)
V_RPI	= <30v
I	= 0A
T1	= within an acceptable range (will be greater than room temp.)
T2	= n/a

TEST-RPI-004

This test will simulate a general safety failure, followed by a ground fault, 12V System power will remain throughout the system.

Preconditions:

1) Remove safety loop jumper plug into RPI connector J3 to "open" the loop.
2) Attach system power cord W2 to RPI connector J2.
3) Connect wires from the RS485 interface of the RPI board to the RS485 interface of the SCADA board.
4) Connect the RS232 interface from a computer running the SCADA software (or equivalent test software) to the RS232 interface of the SCADA board.
5) Place voltmeters at HV input and output test points in RPI enclosure.
6) Turn Manual Battery Disconnect Switch ESS2 to "On."
7) Press the reset button on the ground fault monitor, ensuring that it is not tripped prior to the test.
8) Pull double throw switch to the "down" position, marked. HVPV power is now flowing into RPI.

Test:

1) Qualified personnel places a 40KΩ resistor across positive and ground test points on PV side of the relay
2) Run the test software to measure the five RPI sensors; V_PV, V_RPI, I, T1, T2

Acceptance Criteria:

1) Output voltage should remain below 30V
2) Input voltage at test point should match the power source (300V).
3) 30V+ indicator lights should be lit.
4) DC power indicator lights should not be lit.
5) Fault indicator light should be lit.
6) Ground fault monitor's alarm LED should be lit.
7) The test software should return the following sensor values:

V_PV	= ???v (Should match PV input)
V_RPI	= <30v
I	= 0A
T1	= within an acceptable range (will be greater than room temp.)
T2	= n/a

TEST-RPI-005

This test will simulate a full system shutdown during a time of full illumination.

Preconditions:

1) Remove safety loop jumper plug into RPI connector J3 to "open" the loop.
2) Attach system power cord W2 to RPI connector J2.
3) Place voltmeters at HV input and output test points in RPI enclosure.
4) Manual Battery Disconnect Switch ESS2 should remain "Off."

Test:

1) Pull double throw switch to the "down" position, marked. HVPV power is now flowing into RPI.

Acceptance Criteria:

1) Output voltage should remain below 30V
2) Input voltage at test point should match the power source (300V).
3) 30V+ indicator lights should be lit.
4) DC power indicator lights should not be lit.
5) Fault indicator light should be lit.
6) Ground fault monitor's alarm LED should not be lit.

TEST-RPI-006

This test will simulate normal system operation during a time with minimal or no illumination.

Preconditions:

1) Plug safety loop jumper plug into RPI connector J3 to "close" the loop.
2) Attach system power cord W2 to RPI connector J2.
3) Connect wires from the RS485 interface of the RPI board to the RS485 interface of the SCADA board.
4) Connect the RS232 interface from a computer running the SCADA software (or equivalent test software) to the RS232 interface of the SCADA board.
5) Place voltmeters at HV input and output test points in RPI enclosure.
6) Turn Manual Battery Disconnect Switch ESS2 to "On."
7) Press the reset button on the ground fault monitor, ensuring that it is not tripped prior to the test.
8) Press the safety circuit reset button, to reset the system.
9) Double-throw switch should remain in either the 'Off' or 'Inverter' state'

Test:

1) Run the test software to measure the five RPI sensors; V_PV, V_RPI, I, T1, T2

Acceptance Criteria:

1) Output voltage should remain below 30V
2) Input voltage at test point should match the power source (0V).
3) 30V+ indicator light should not be lit.
4) DC power indicator light should not be lit.
5) Fault indicator light should not be lit.
6) Ground fault monitor's alarm LED should not be lit.
7) The test software should return the following sensor values:
   - V_PV = <30v
   - V_RPI = <30v
   - I = 0A
   - T1 = within an acceptable range (will be greater than room temp.)
   - T2 = n/a

TEST-RPI-007

This test will simulate a system failure interrupting normal system operation during a time with minimal or no illumination.

Preconditions:

1) Plug safety loop jumper plug into RPI connector J3 to "close" the loop.
2) Attach system power cord W2 to RPI connector J2.
3) Connect wires from the RS485 interface of the RPI board to the RS485 interface of the SCADA board.
4) Connect the RS232 interface from a computer running the SCADA software (or equivalent test software) to the RS232 interface of the SCADA board.
5) Place voltmeters at HV input and output test points in RPI enclosure.
6) Turn Manual Battery Disconnect Switch ESS2 to "On."
7) Press the reset button on the ground fault monitor, ensuring that it is not tripped prior to the test.
8) Press the safety circuit reset button, to reset the system.
9) Double-throw switch should remain in either the 'Off' or 'Inverter' state'

Test:

1) Push "Safety Circuit Trip" button on RPI box.
2) Run the test software to measure the five RPI sensors; V_PV, V_RPI, I, T1, T2

Acceptance Criteria:

1) Output voltage remain below 30V after tripping safety circuit
2) Input voltage at test point should match the power source (0V).
3) 30V+ indicator lights should not be lit.
4) DC power indicator lights should not be lit.
5) Fault indicator light should be lit.
6) Ground fault monitor's alarm LED should not be lit.

7) The test software should return the following sensor values:

V_PV	= <30v
V_RPI	= <30v
I	= 0A
T1	= within an acceptable range (will be greater than room temp.)
T2	= n/a

TEST-RPI-008

This test will simulate the transition from a normal operational state of the system to a safe state where all voltages are below 30V.

Preconditions:

1) Plug safety loop jumper plug into RPI connector J3 to "close" the loop.
2) Attach system power cord W2 to RPI connector J2.
3) Connect wires from the RS485 interface of the RPI board to the RS485 interface of the SCADA board.
4) Connect the RS232 interface from a computer running the SCADA software (or equivalent test software) to the RS232 interface of the SCADA board.

5) Place voltmeters at HV input and output test points in RPI enclosure.
6) Turn Manual Battery Disconnect Switch ESS2 to "On."
7) Press the reset button on the ground fault monitor, ensuring that it is not tripped prior to the test.
8) Press the safety circuit reset button, to reset the system.
9) Pull double throw switch to the "Down" position, marked. HVPV power is now flowing into RPI.

Test:

1) Pull double-throw switch to 'Off' position and start stopwatch.
2) Stop stopwatch when 30V+ indicator turns off & both voltmeters show under 30V.
3) Run the test software to measure the five RPI sensors; V_PV, V_RPI, I, T1, T2

Acceptance Criteria:

1) Voltages measured at HV input and output are less than 30V in under 10 seconds
2) 30V+ indicator lights should not be lit after 10 seconds.
3) DC power indicator lights should not be lit after 10 seconds.
4) Fault indicator light should not be lit.
5) Ground fault monitor's alarm LED should not be lit.
6) The test software should return the following sensor values:

V_PV	= <30v
V_RPI	= <30v
I	= 0A
T1	= within an acceptable range (will be greater than room temp.)
T2	= n/a

TEST-RPI-009

This test will verify the operation of the temperature switch

Preconditions:

1) Plug safety loop jumper plug into RPI connector J3 to "close" the loop.
2) Attach system power cord W2 to RPI connector J2.
3) Connect wires from the RS485 interface of the RPI board to the RS485 interface of the SCADA board.
4) Connect the RS232 interface from a computer running the SCADA software (or equivalent test software) to the RS232 interface of the SCADA board.
5) Place voltmeters at HV input and output test points in RPI enclosure.
6) Turn Manual Battery Disconnect Switch ESS2 to "On."
7) Press the reset button on the ground fault monitor, ensuring that it is not tripped prior to the test.
8) Press the safety circuit reset button, to reset the system.
9) Double-throw switch remains in the "Off" position.

Test:

1) Set a heat gun to 90 degrees C, and apply heat to the temperature switch.
2) When switch reaches 85 degrees, the safety loop should break.
3) Run the test software to measure the five RPI sensors; V_PV, V_RPI, I, T1, T2

Acceptance Criteria:

1) Voltages measured at HV input and output are less than 30V.
2) 30V+ indicator lights should not be lit.
3) DC power indicator lights should not be lit.
4) Fault indicator light should be lit.
5) Ground fault monitor's alarm LED should not be lit.
6) The test software should return the following sensor values:

V_PV	= <30v
V_RPI	= <30v
I	= 0A
T1	= >80C
T2	= n/a

TEST-RPI-010

This test will verify the operation of the stealth diode in the forward direction.

Preconditions:

1) Plug safety loop jumper plug into RPI connector J3 to "close" the loop.
2) Attach system power cord W2 to RPI connector J2.
3) Connect wires from the RS485 interface of the RPI board to the RS485 interface of the SCADA board.
4) Connect the RS232 interface from a computer running the SCADA software (or equivalent test software) to the RS232 interface of the SCADA board.
5) Place voltmeters at HV input and output test points in RPI enclosure. Also place a voltmeter across the stealth diode.
6) Turn Manual Battery Disconnect Switch ESS2 to "On."
7) Press the reset button on the ground fault monitor, ensuring that it is not tripped prior to the test.
8) Press the safety circuit reset button, to reset the system.

Test:

1) Pull double throw switch to the "Down" position, marked. HVPV power is now flowing into RPI.
2) Run the test software to measure the five RPI sensors; V_PV, V_RPI, I, T1, T2

Acceptance Criteria:

1) Voltages measured at HV input and output compared to verify that the voltage passes through the system with a voltage drop of less than 5V. e.g. (300V in => 295V+ out)
2) Voltage across the stealth diode should be less than 2V.
3) 30V+ indicator lights should be lit.
4) DC power indicator lights should be lit.
5) Fault indicator light should not be lit.
6) Ground fault monitor's alarm LED should not be lit.
7) The test software should return the following sensor values:

V_PV	= ???v (Should match PV input)
V_RPI	= ???v (Should be within 4V of PV input)
I	= >0A
T1	= within an acceptable range (will be greater than room temp.)
T2	= n/a

TEST-RPI-011

This test will verify the operation of the stealth diode in the reverse direction.

Preconditions:

1) Plug safety loop jumper plug into RPI connector J3 to "close" the loop.
2) Attach system power cord W2 to RPI connector J2.
3) Place voltmeters at HV input and output test points in RPI enclosure.

Also place a voltmeter across the stealth diode.

4) Connect wires from the RS485 interface of the RPI board to the RS485 interface of the SCADA board.
5) Connect the RS232 interface from a computer running the SCADA software (or equivalent test software) to the RS232 interface of the SCADA board.
6) Turn Manual Battery Disconnect Switch ESS2 to "On."
7) Press the reset button on the ground fault monitor, ensuring that it is not tripped prior to the test.
8) Double-throw switch remains in the "Off" position.

Test:

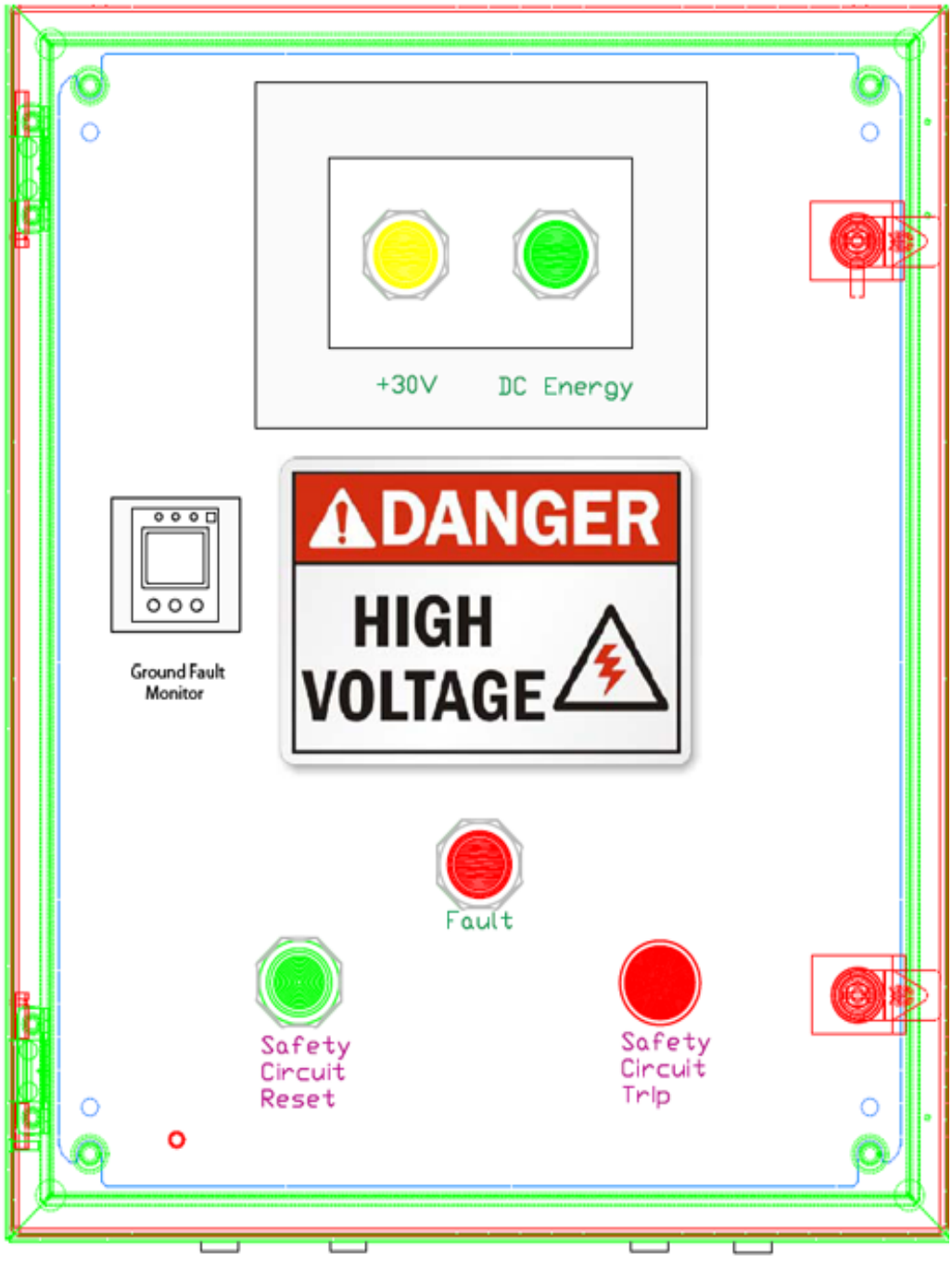
1) Press the safety circuit reset button, to reset the system.
2) Run the test software to measure the five RPI sensors; V_PV, V_RPI, I, T1, T2

Acceptance Criteria:

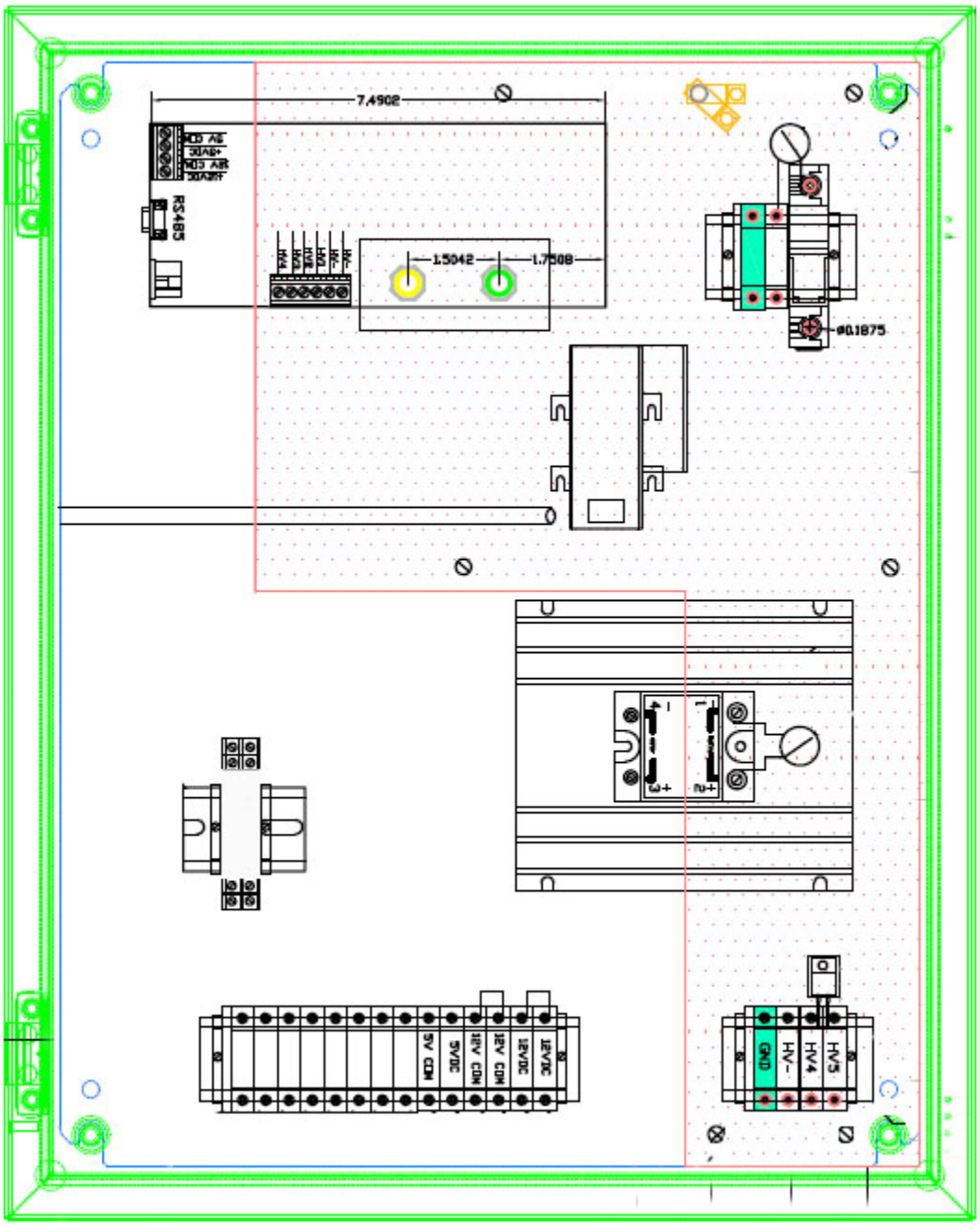
1) Voltage measured at HV input should be less than 30V
2) Voltage measured at HV output should be equal to the ESS battery voltage (nominally 210).
3) 30V+ indicator lights should be lit.
4) DC power indicator lights should not be lit.
5) Fault indicator light should not be lit.
6) Ground fault monitor's alarm LED should not be lit.
7) The test software should return the following sensor values:

V_PV	= <30v
V_RPI	= <30v
I	= <1A
T1	= within an acceptable range (will be greater than room temp.)
T2	= n/a

RPI Exterior



RPI Interior



RPI QA AUDIT	Pg 1/6
Test	Pass/Fail
TEST-RPI-001 Normal Operation	
RPI causes PV=>EDS voltage drop of less than 4V	
30V+ indicator lit	
DC power indicator lit	
Fault indicator not lit	
Ground fault monitor's alarm LED not lit	
Sensor V_PV matches PV input voltage (+/-10%)	
Sensor V_RPI within 4 volts of PV input voltage	
Sensor I reads greater than 0A	
Sensor T1 within an acceptable range (will be greater than room temp.)	
TEST-RPI-002 Ground Fault	
Output voltage remains below 30V	
Input voltage matches power source	
30V+ indicator lit	
DC power indicator not lit	
Fault indicator lit	
Ground fault monitor's alarm LED lit	
Sensor V_PV matches PV input voltage (+/-10%)	
Sensor V_RPI reads <30V	
Sensor I reads <1 mA	
Sensor T1 within an acceptable range (will be greater than room temp.)	

RPI QA Audit	Pg 2/6
TEST-RPI-003 Safety Loop Cutout	
Output voltage drops below 30V within 10 seconds of opening safety circuit	
Input voltage matches power source	
30V+ indicator lit	
DC power indicator not lit	
Fault indicator lit	
Ground fault monitor's alarm LED not lit	
Sensor V_PV matches PV input voltage (+/-10%)	
Sensor V_RPI reads <30V	
Sensor I reads <1 mA	
Sensor T1 within an acceptable range (will be greater than room temp.)	
TEST-RPI-004 Safety Loop Cutout & Ground Fault	
Output voltage remains below 30V	
Input voltage matches power source	
30V+ indicator lit	
DC power indicator not lit	
Fault indicator lit	
Ground fault monitor's alarm LED lit	
Sensor V_PV matches PV input voltage (+/-10%)	
Sensor V_RPI reads <30V	
Sensor I reads <1 mA	
Sensor T1 within an acceptable range (will be greater than room temp.)	

RPI QA Audit	Pg 3/6
TEST-RPI-005 Total System (Full Sun)	
Output voltage remains below 30V	
Input voltage matches power source	
30V+ indicator lit	
DC power indicator not lit	
Fault indicator not lit	
Ground fault monitor's alarm LED not lit	
TEST-RPI-006 Normal Operation (No Sun)	
Output voltage remains below 30V	
Input voltage matches power source	
30V+ indicator not lit	
DC power indicator not lit	
Fault indicator not lit	
Ground fault monitor's alarm LED not lit	
Sensor V_RPI reads <30V	
Sensor V_RPI reads <30V	
Sensor I reads <1 mA	
Sensor T1 within an acceptable range (will be greater than room temp.)	

RPI QA Audit	Pg 4/6
TEST-RPI-007 Safety Loop Cutout (No Sun)	
Output voltage remains below 30V	
Input voltage matches power source	
30V+ indicator not lit	
DC power indicator not lit	
Fault indicator lit	
Ground fault monitor's alarm LED not lit	
Sensor V_RPI reads <30V	
Sensor V_RPI reads <30V	
Sensor I reads <1 mA	
Sensor T1 within an acceptable range (will be greater than room temp.)	
TEST-RPI-008 Voltage Drop	
Output voltage drops below 30V within 10 seconds of opening safety circuit	
Input voltage drops below 30V within 10 seconds of opening safety circuit	
30V+ indicator not lit after 10 secs	
DC power indicator not lit after 10 seconds	
Fault indicator not lit	
Ground fault monitor's alarm LED not lit	
Sensor V_RPI reads <30V	
Sensor V_RPI reads <30V	
Sensor I reads <1 mA	
Sensor T1 within an acceptable range (will be greater than room temp.)	

RPI QA Audit	Pg 5/6
TEST-RPI-009 Temperature Switch	
Input & Output voltages remain below 30V	
Input voltage drops below 30V within 10 seconds of opening safety circuit	
30V+ indicator not lit	
DC power indicator not lit	
Fault indicator lit	
Ground fault monitor's alarm LED not lit	
Sensor V_RPI reads <30V	
Sensor V_RPI reads <30V	
Sensor I reads <1 mA	
Sensor T1 reads greater than 80C	
TEST-RPI-010 Stealth Diode Forward Bias	
Output voltage HV3 is within 4V of input voltage	
Output voltage HV4 is within 2V of HV3	
30V+ indicator lit	
DC power indicator lit	
Fault indicator not lit	
Ground fault monitor's alarm LED not lit	
Sensor V_PV matches PV input voltage (+/-10%)	
Sensor V_RPI within 4 volts of PV input voltage	
Sensor I reads >0A	
Sensor T1 within an acceptable range (will be greater than room temp.)	

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TEST-RPI-011Stealth Diode Reverse Bias	
Output voltage HV3 is less than 30V	
Output voltage HV4 matches ESS output voltage	
30V+ indicator not lit	
DC power indicator not lit	
Fault indicator not lit	
Ground fault monitor's alarm LED not lit	
Sensor V_RPI reads <30V	
Sensor V_RPI reads <30V	
Sensor I reads <1 mA	
Sensor T1 within an acceptable range (will be greater than room temp.)	