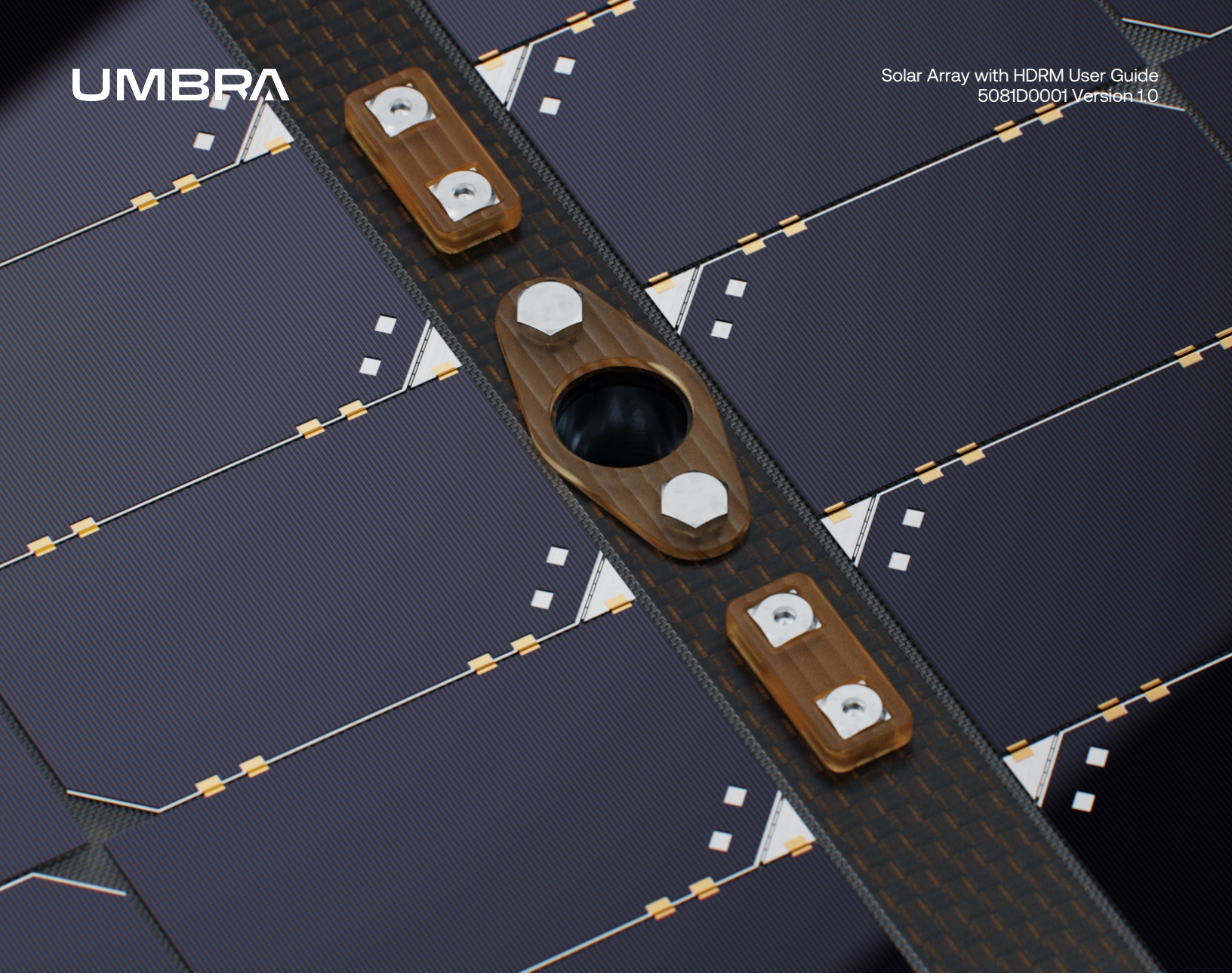

Solar Array + HDRM User Guide

Distribution Statement	Export Control
No Restrictions	No US Export Control Information

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1.0 Objective

This document provides user guidance for the integration of the Umbra Body Steered Deployable Solar Array, referred to as the Solar Array hereafter.

The Solar Array provides 120 Watts of power using a body steered tri-fold array. There are multiple Solar Array configurations available to support various mission requirements.

The Solar Array configuration described in this document includes the Umbra Hold Down and Release Mechanism, referred to as the HDRM hereafter. This HDRM is a non-explosive resettable restraint-mechanism that holds Solar Arrays in place before launch and allows these Solar Arrays to deploy when activated.

2.0 Document References

This section contains the document number and description for documents that are referenced herein.

2.1 Umbra Documents

5081H14000	7X8 H-FOLD SOLAR ARRAY MICD
5070G0001	UMBRA STOW TOOL

2.2 Standard Documents

ANSI/ESD S20.20-2021	PROTECTION OF ELECTRICAL AND ELECTRONIC PARTS, ASSEMBLIES, AND EQUIPMENT
49 CFR 172	CODE OF FEDERAL REGULATIONS HAZARDOUS MATERIALS TABLE
GSFC-STD-7000A	GENERAL ENVIRONMENTAL VERIFICATION STANDARD (GEVS)
MIL-STD-461	MILITARY STANDARD: ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS REQUIREMENTS FOR EQUIPMENT
SAE-AS22759	WIRE, ELECTRICAL, FLUOROPOLYER-INSULATED, COPPER OR COPPER ALLOY
SAE-AS50881	WIRING, AEROSPACE VEHICLE

3.0 Document Authority

In the case of a conflict between any dimensional, mounting pattern, or pinout information defined within this document and other information sources, the released mechanical and electrical drawings in Appendix B shall supersede this document.

3.1 Revision Notes

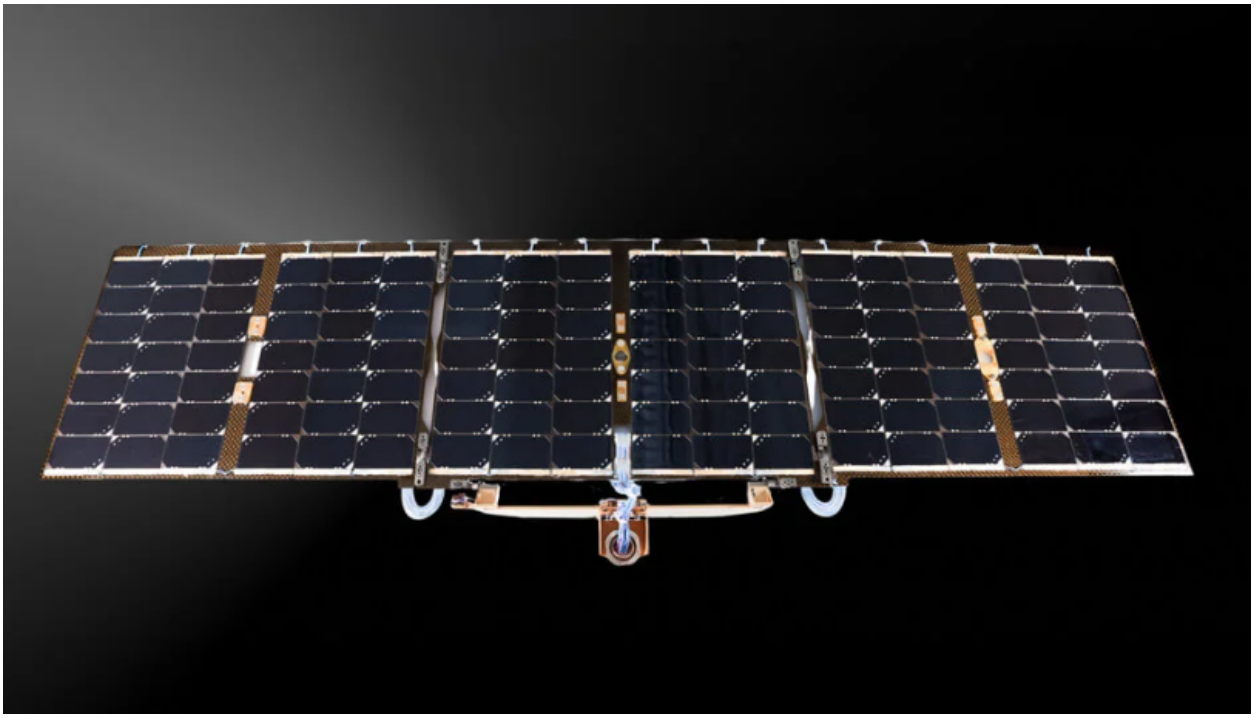
This document is Version 1.0.

3.2 Document Disclaimer

DISCLAIMER: This User Guide is intended to provide a brief summary of our knowledge and guidance regarding the use of this item. The information contained herein has been compiled from sources considered by Umbra to be dependable and is accurate to the best of Umbra's knowledge. It is not meant to be an all-inclusive document on worldwide hazard communication regulations. This information is offered in good faith. Each user of this material needs to evaluate the conditions of use and design the appropriate protective mechanisms to prevent employee exposure, personal injury, property damage or release to the environment of any hazardous substances. Umbra assumes no responsibility for injury, damage, or loss sustained by the recipient or third persons or for any damage to any property resulting from misuse of the product. Purchase and use of the product(s) identified herein are governed by the terms of sale under which you purchase the product(s) from Umbra.

4.0 Hardware Handling

Figure 1. Umbra Solar Array



4.1 Mechanical Handling

Failure to read and follow the instructions contained in this user guide may result in damage to the Solar Array with HDRM, operators, and other property if stored or used improperly.

Contact Umbra if any Solar Array with HDRM fails any procedure as described in this document. Do not continue use of any Solar Array with HDRM with a suspected failure.

Ensure that any transportation of the Solar Array with HDRM occurs in an environment described in Section 4.5 Storage and Transport Environment.

Do not drop the Solar Array and/or HDRM. Impact damage and scratches will affect the performance of the Solar Array.

Only lift the Solar Array by the panel edges or the back of the panels Do not support the Solar Array via the solar array cells, welds, or tabs.

Do not handle HDRM after heater usage. See Section 4.1.1 Hazards for more information.
Do not disassemble the Solar Array and/or HDRM.

Always wear powder-free latex or nitrile gloves while handling the Solar Array. Do not handle the Solar Array while wearing rings or other hard items that may scratch the solar array cells. Gloves will additionally prevent oils from contaminating or damaging the solar array.

When setting the Solar Array on a flat surface, ensure there is clearance and relief for all bundles and wires. See Appendix B.1 Solar Array MICD for location information.

Do not overextend the hinges of the Solar Array. The Solar Array has stops to ensure the deployed state of the Solar Array is stable. These stops may be damaged or broken by overextension of the hinges.

Do not let the Solar Array hang in a state where it is only supported by the root hinge bracket. In the deployed state, the Solar Array must be supported at the hinges at all times while in Earth's gravity to prevent damage to the hinges.

4.1.1 Hazards

The Solar Array does not contain any hazardous materials as defined by 49 CFR 172 that are subject to anticipated exposure when used as indicated.

When deploying the Solar Array and/or HDRM, ensure clearance requirements described in this user guide are met. Snagging during testing or operational deployments may result in operator injury, damage to the Solar Array, damage to the HDRM, damage to surroundings, and/or failure to deploy. The Solar Array limit switches are very sensitive to snagging and may be damaged if clearances are not respected at all times. See Appendix B.1 Solar Array MICD for location information.

The HDRM will become very hot during deployment. Do not handle the HDRM during deployment. Do not handle the HDRM until its temperature has cooled to a safe handling temperature post-deployment. Do not store flammable materials next to the HDRM during or immediately after deployment.

The HDRM utilizes compressed springs to stow the system. Operators should be trained to handle this hazardous energy and follow all stow tooling operation instructions to avoid injury and property damage.

The Solar Array generates power to be used by peripherals, and is recommended to be paired with a power management system such as the Umbra Power Management Unit. The power generated by the Solar Array can potentially harm the user if not handled properly.

4.1.2 ESD Sensitivity

The Solar Array is electrostatic discharge (ESD) sensitive.

Failure to follow ESD requirements and recommendations may result in damage to components and/or personnel injury.

Follow ANSI/ESD S20.20 while handling ESD sensitive components.

The HDRM is not ESD sensitive.

4.1.3 Unpacking

- Check shock detection stickers
- Remove from protective case
- Perform visual inspection for damage
- Take pictures as received
- There are no cleanliness requirements or contamination risks

4.2 RBF/ Red Tag GSE

Items listed in Table 1. RBF Items must be removed before flight.

Table 1. RBF Items

Item	Critical / Optional	Notes
Solar Array J1 Connector Dust Cap	Critical	
HDRM J1 Connector Dust Cap	Critical	
Solar Array Dust Covers	Critical	X3, per each panel

See Appendix B for more information.

4.3 Electrical Mate/Demate

Table 2. Electrical Connectors

Connector Designator	Assembly Connector	Mating Flight Connector
Solar Array J1	TVS07RF-17-35S	MIL-DTL-38999, TVS06RF-17-35P
HDRM J1	M80-5610805	M80-4810805

See Section 5.1 Connector Pinouts for more information.

4.4 Connector Strain

The Solar Array J1 Connector does not require strain relief.

It is recommended to secure all harnessing interfacing to the HDRM per the guidance found in SAE-AS50881 which describes guidance on the installation of wiring harness.

4.5 Storage and Transport Environment

Do not store the Solar Array and HDRM in direct sunlight.

Do not store the Solar Array and HDRM in such a way that damages part markings.

Ensure that critical RBF components are in place during all transport of the Solar Array and HDRM.

Impact damage and scratches will affect the performance of the Solar Array. Do not store items on top of the Solar Array to prevent compression damage.

Only transport the Solar Array in the stowed position. Follow Section 8.6 Solar Array with HDRM Manual Stow Procedure as needed to restow the Solar Array.

Table 3. Recommend Storage Environment

Parameter	Value
Storage Temperature	5℃ to 35℃
Storage Humidity	< 50% Relative Humidity

4.6 Operating Environment

Table 4. Operating Environment

Parameter	Value
Operating Temperature	-50℃ to 90℃
HDRM Self Actuation Temperature	65℃ (TBR)

4.7 Survival Environment

Table 5. Survival Environment

Parameter	Value
Survival Temperature	-60℃ to 120℃
Random Vibration	Qualified to 14.16 Grms profile enveloping GEVS, Falcon 9, SpaceX Rideshare, and Electron levels
Shock	Qualified to 1000G peak profile enveloping GEVS, Falcon 9, SpaceX Rideshare, and Electron levels
Minimum Survivable Total Ionizing Dose	Designed to withstand at least 30 krad TID

4.8 Mounting Information

See B.1 Solar Array MICD for information about mounting the Solar Array.

See B.2 HDRM MICD for information about mounting the HDRM.

5.0 Electrical Properties

Table 6. Solar Array Electrical Properties

Property	Typical Value
Peak Power	120 W
Open Circuit Voltage	38.08 V
Maximum Power Voltage	22.68 V
Maximum Power Current	2.3 A

Table 7. HDRM Electrical Properties

Property	Typical Value
Nominal Power at 28 V	8 W per heater

5.1 Connector Pinouts

5.1.1 Solar Array J1

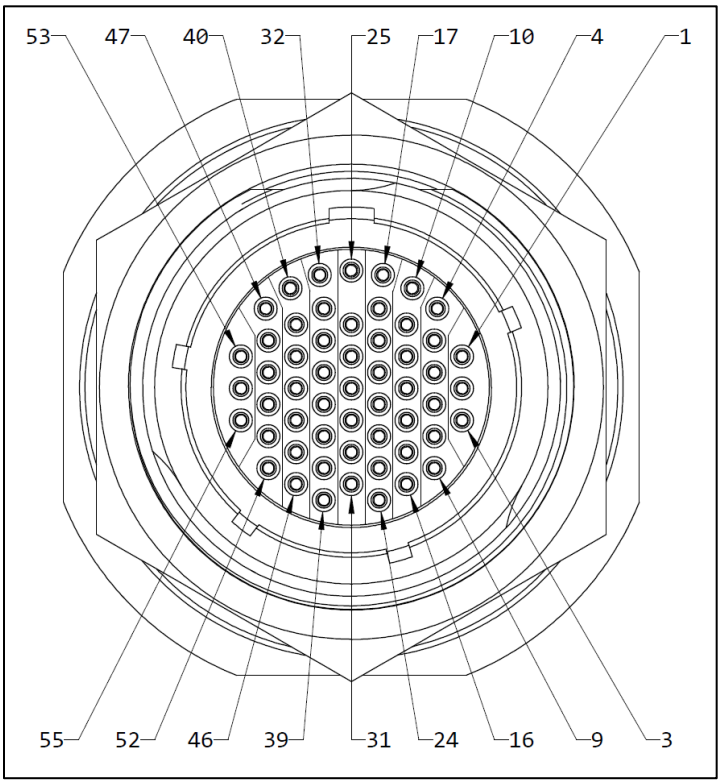
The Solar Array J1 connector (TVS07RF-17-35S) provides connection to the photovoltaic strings and temperature sensors. Refer to Table 8 for pinout and
Figure 2 for the mating face view.

Table 8. Solar Array J1 Connector Pinout

PIN	SIGNAL
1	SA_LIMIT1-
2	SA_LIMIT1+
3	SA_LIMIT2-
4	SA_LIMIT2+
5	SA_TEMP1-
6	SA_TEMP1+
7	SA_TEMP2-
8	SA_TEMP2+
9	SA_TEMP3-
10	SA_TEMP3+
11	SA_STR1-
12	SA_STR1-
13	SA_STR1+
14	SA_STR1+
15	SA_STR2-
16	SA_STR2-
17	SA_STR2+

PIN	SIGNAL
18	SA_STR2+
19	SA_STR3-
20	SA_STR3-
21	SA_STR3+
22	SA_STR3+
23	SA_STR4-
24	SA_STR4-
25	SA_STR4+
26	SA_STR4+
27	SA_STR5-
28	SA_STR5-
29	SA_STR5+
30	SA_STR5+
31	SA_STR6-
32	SA_STR6-
33	SA_STR6+
34	SA_STR6+
35	SA_STR7-
36	SA_STR7-
37	SA_STR7+
38	SA_STR7+
39	SA_STR8-
40	SA_STR8-
41	SA_STR8+
42	SA_STR8+
43	SA_STR9-
44	SA_STR9-
45	SA_STR9+
46	SA_STR9+
47	NC
48	NC
49	NC
50	NC
51	NC
52	NC
53	NC
54	NC
55	NC

Figure 2. TVS07RF-17-35S Connector Mating Face View



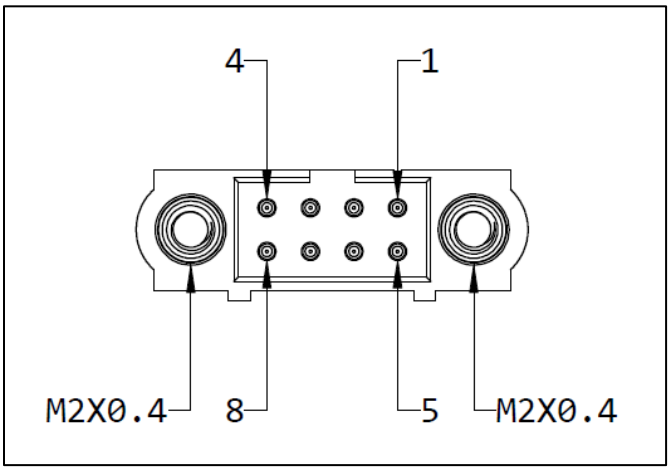
5.1.2 HDRM J1

The HDRM J1 connector (M80-5610805) provides connection to the deployment heaters and temperature sensors. Refer to Table 9 for pinout and Figure 3 for the mating face view.

Table 9. HDRM J1 Connector Pinout

PIN	SIGNAL
1	HEATER 1+
2	RTD 1+
3	HEATER 2+
4	RTD 2+
5	HEATER 1-
6	RTD 1-
7	HEATER 2-
8	RTD 2-

Figure 3. M80-5610805 Connector Mating Face View



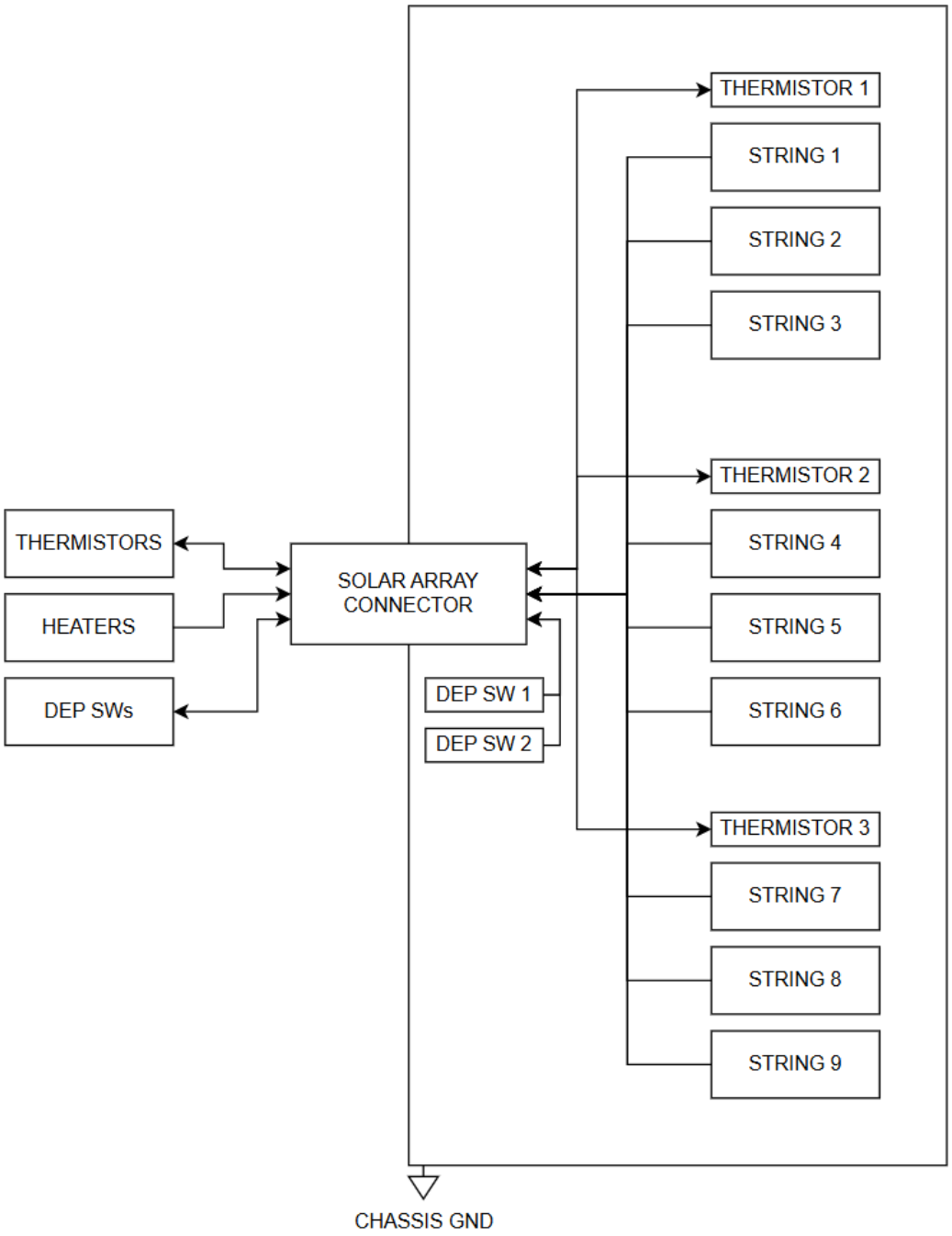
5.2 Harnessing Recommendations

Space-rated harnesses connecting to the Solar Array and/or HDRM should use wire following SAE AS22759. Umbra recommends 24AWG wire.

5.3 Grounding Block Diagrams

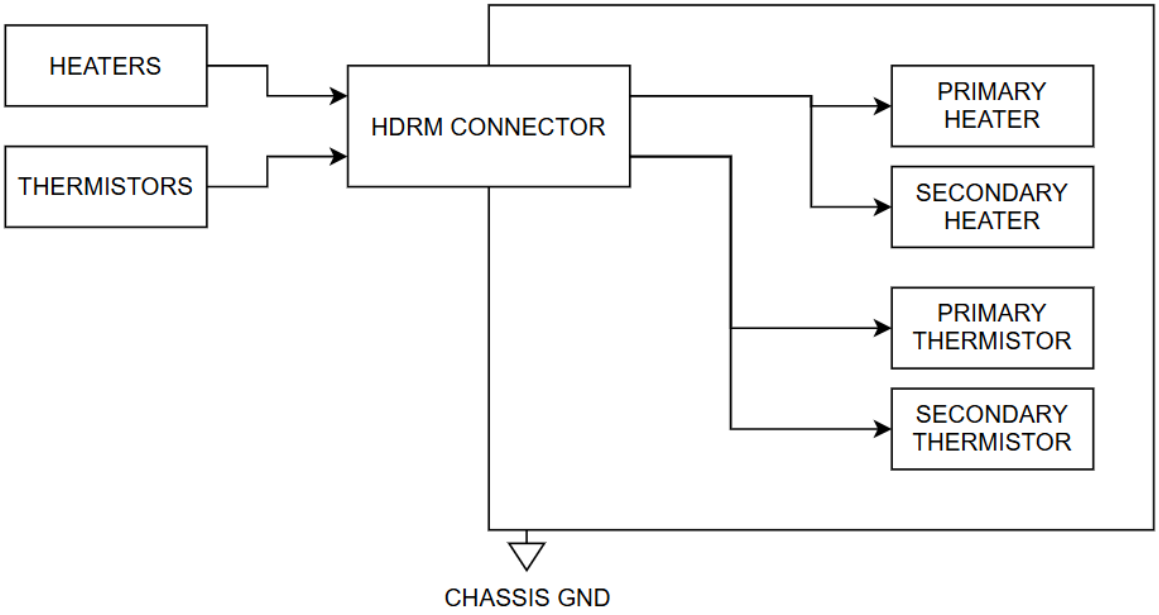
5.3.1 Solar Array Grounding Block Diagram

Figure 4. Solar Array Grounding Block Diagram



5.3.2 HDRM Grounding Block Diagram

Figure 5. HDRM Grounding Block Diagram



5.4 EMI/EMC Properties

The Solar Array and HDRM do not contain components that are responsible for or influenced by Electromagnetic Interference (EMI) / Electromagnetic Compatibility (EMC) requirements.

5.5 Material Properties

All Umbra products are manufactured from materials deemed space-rated based on low outgassing.

See Appendix B for more information on material properties of the Solar Array and HDRM.

6.0 Software Properties

Not applicable.

7.0 Performance Specifications

7.1 Solar Array Performance

The Solar Array utilizes triple junction photovoltaic cells to allow the absorption of a broad range of wavelengths for high energy conversion efficiency and high power to weight ratio.

The Solar Array also utilizes cell bypass diodes. These bypass diodes allow the spacecraft to shunt the arrays for reduced power generation to prevent overcharge of the spacecraft. Each string has its own set of pins (see Table 8) to allow strings to be shunted in groups of three. Customer software will be required to implement shunting schema without the use of the Umbra Power Management Unit as described in Section 7.3 Umbra Power Package Compatibility.

The Solar Array is available with a variety of coverglass options for various mission profiles, including extended mission lifetime and a variety of orbits. Standard Solar Array coverglass is designed for a 5-year mission lifetime in LEO. Please contact Umbra if your mission profile requires a different coverglass.

Prior to deployment, the Solar Array has high stowed packing efficiency due to its ability to deploy. The Solar Array has a stowed state designed for stability and compaction during launch. The Solar Array enters its deployed state when the HDRM actuates. The form factors of these stowed and deployed states are described in Appendix B.1 Solar Array MICD.

When deployed, the Solar Array has high dynamic stability for highly maneuverable spacecraft. The Solar Array hinges have a high torque margin to maintain solar array deployment throughout maneuvers. The composite panels of the Solar Array have high stiffness to ensure their structural stability.

The HDRM is resettable without refurbishment during ground testing. The Solar Array Stow Tool may be used as described in 8.1.1 Stow Tool to manually deploy and restow the Solar Array.

7.1.1 Solar Array J1 Signals

The Solar Array sends signals over its SA_LIMIT pins and SA_TEMP pins. SA_STR pins are used to send power generated by the Solar Array to the host spacecraft. See Section 5.1.1 Solar Array J1 for referenced signals and connector pinouts.

SA_LIMIT pins on the Solar Array are switches that open or close depending on the Solar Array position. When the Solar Array is in the stowed position, the SA_LIMIT signal is nominally closed. When the Solar Array is in the deployed position, the SA_LIMIT signal is nominally open.

SA_TEMP pins on the Solar Array connect to a TS665TKY40BC thermistor.

SA_STR pins send power to the host vehicle. For Solar Array shunting scheme recommendations, see documentation on the Umbra Power Management Unit.

7.2 HDRM Performance

The HDRM is a paraffin-actuated, resettable hold down and release mechanism designed for use with Solar Arrays. Paraffin actuators use heat expansion of a wax block to drive a piston. This piston allows the locking mechanism to retract and the spring system to poise the solar array.

The HDRM is resettable without refurbishment during ground testing. After firing, the paraffin actuator within the HDRM will reset to its stowed position through thermal dissipation. Once the actuator returns to its stowed position, Umbra provided GSE described in Section 8.1.1 Stow Tool may be used to restow the Solar Array to the HDRM.

Two heaters are included in the HDRM. Only one heater is necessary for deployment of the HDRM.

7.2.1 HDRM J1 Signals

The HDRM receives signals via its HEATER pins. RTD (Resistance Temperature Detector) pins send signals used to monitor temperature. See Section 5.1.2 HDRM J1 for referenced signals and connector pinouts.

HEATER+ pins on the HDRM receive to 28 V, 0.5 A to trigger deployment, while HEATER- pins are used for grounding. HEATER 1 pins correspond to the primary HDRM heater and HEATER 2 pins correspond to the secondary HDRM heater.

RTD pins on the HDRM increase in resistance as temperature increases. HEATER.RTD 1 and RTD 2 pins read the same body temperature. Umbra recommends halting any heating of the HDRM when a resistance of 1.350 k-ohm is noted on any RTD pin to prevent damage to the HDRM.

7.3 Umbra Power Package Compatibility

The Solar Array with HDRM can be purchased as part of the modular Umbra Power Package, with the Umbra Power Management Unit included. See documentation on the Umbra Power Management Unit for more details about compatibility with this system.

7.4 Performance Verification

Customer recommended checkout is described in this document in Section 8.0 Operational Procedures.

8.0 Operational Procedures

Follow all requirements and recommendations in Section 4.1 Mechanical Handling while carrying out any and all procedures in this section. The Solar Array and HDRM may be damaged by carrying out any procedure listed in this section if mechanical handling requirements and recommendations are not followed.

8.1 Ground Support Equipment

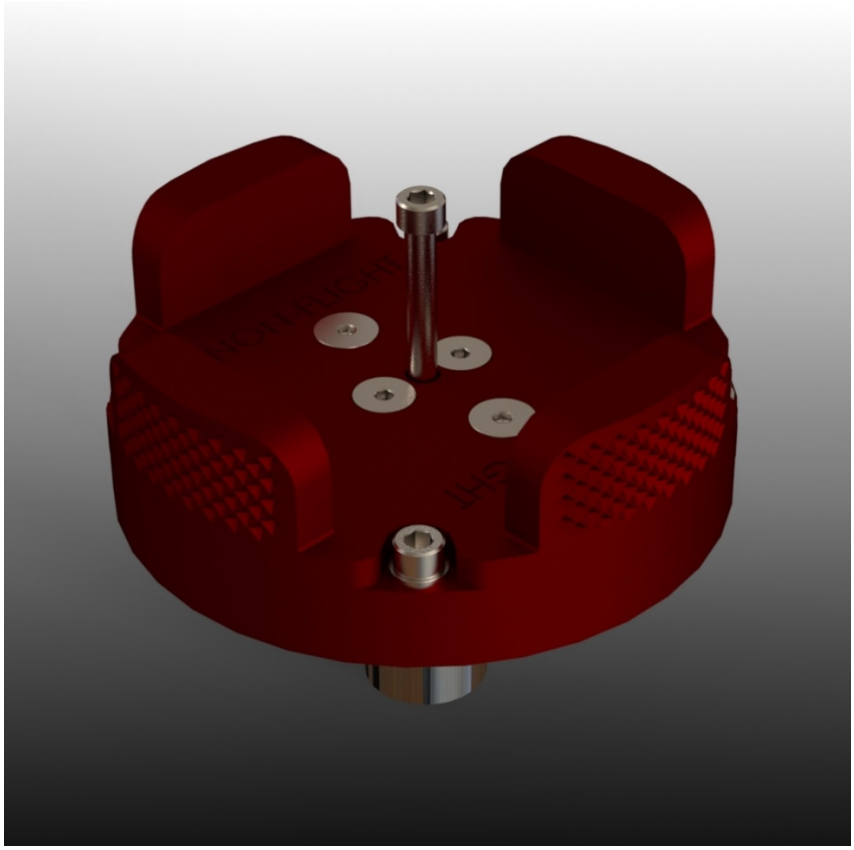
To ensure operator and equipment safety, ensure Ground Support Equipment (GSE) follows the recommendations laid out in this section.

All Umbra supplied GSE should be used without substitution. Contact Umbra if any Umbra provided GSE requires replacement.

8.1.1 Stow Tool

Umbra provides GSE tool 5070G0001 for manual deployment of the Solar Array and HDRM described in this user guide as the “Umbra Stow Tool.”

Figure 6. Umbra Stow Tool



8.1.2 Solar Array Support Tool

Umbra recommends users support Solar Array inner and middle panels at 10 degrees above the bump stops when the Solar Array is deployed. Users should ensure that this support tool does not touch the solar array cells to prevent scratching.

8.2 First Use Procedure

The following must be completed before any other procedures in this user guide are carried out.

8.2.1 Assembly

No customer assembly required.

8.2.2 Checkouts

Users should take pictures of Solar Arrays to record the state of all solar cells and hinges.

Users should also ensure Solar Arrays and HDRMs are clear of FOD.

8.2.3 Initial Configuration

The Solar Array and HDRM will be shipped with partially loaded springs in their initial configuration. Follow Section 4.0 Hardware Handling at all times.

The Solar Array will be delivered in a stowed state to ensure stability during transport. Electrical tape may be used to ensure the Solar Array remains in its stowed state throughout transport.

The HDRM will be delivered in a deployed state.

8.3 HDRM Stow

The objective of this procedure is to stow the HDRM.

8.3.1 Success Criteria

The HDRM shall be manually stowed.

8.3.2 Configuration and Equipment

This procedure shall be carried out with the equipment in the listed configurations and quantities as described in Table 10.

Table 10. HDRM Stow Equipment

Part Number	Part Name	Configuration	Quantity
5070H0001	HDRM	Deployed state	x1
5070G0001	Umbra Stow Tool	N/A	x1

8.3.3 Test Procedure

This procedure should only be carried out if the HDRM is in the deployed position as shown in Appendix B.2 HDRM MICD.

1. Secure the HDRM.
2. Align the screw of the Umbra Stow Tool with the hole at the top of the HDRM.
3. Firmly but carefully press the screw of the Umbra Stow Tool into the hole at the top of the HDRM. The fine threads of the screw may be damaged if pressure is applied without correct alignment.
4. Thread the Umbra Stow Tool screw into the HDRM until secure. This resets the piston of the HDRM. The HDRM top should enter the stowed position.
5. Unthread the Umbra Stow Tool from the HDRM. Now that the HDRM is in the stowed position, it has stored compressive energy. See Section 4.1.1 Hazards for more information on how to handle the HDRM in the stowed state.

8.4 HDRM Heated Deployment

The objective of this procedure is to confirm HDRM functionality.

8.4.1 Success Criteria

The HDRM shall successfully deploy within timed tolerances.

8.4.2 Configuration and Equipment

This test shall be carried out with the following equipment in the listed configurations and quantities.

Table 11. HDRM Heated Deployment Equipment

Part Number	Part Name	Configuration	Quantity
5070H0001	HDRM	Stowed state	x1
5070G0001	Umbra Stow Tool	N/A	x1
N/A	Timer	N/A	x1
N/A	Power Supply	N/A	x1
N/A	Digital Multimeter (DMM)	N/A	x1

8.4.3 Test Procedure

This procedure should only be carried out if the HDRM is in the stowed position as shown in B.2 HDRM MICD.

1. Determine if this test will be used to activate the HDRM primary OR secondary heater. Consistently follow this procedure for the HDRM primary OR secondary heater usage. Do not activate the HDRM primary heater AND secondary heater simultaneously.
2. Secure the HDRM.
3. Attach a compatible harness to the HDRM as described in Section 5.2 Harnessing Recommendations.
4. Harness the DMM to the HDRM RTD1 or RTD2 pins as described in Section 5.1.2 HDRM J1. Note that these signals should be very similar regardless of which HEATER pins are used.
5. Turn on DMM. Set to measure resistance.
6. Harness the power supply to the HDRM primary HEATER pins OR secondary HEATER pins as described in Section 5.1.2 HDRM J1 to activate the primary heater OR secondary heater.
7. Set power supply settings to 28 V, 0.5 A.
8. Simultaneously start a timer and supply power.
9. Continue to supply power until any of the following:
    a. HDRM deployment
    b. Timer reaches 3 minutes 30 seconds without deployment
    c. Resistance measured by DMM reaches 1.350 k-ohm without deployment
10. Turn OFF the power supply.
11. Record success/fail status, time to deploy or end test, and maximum resistance measured.
12. Allow the HDRM to cool before any handling.

If the HDRM has deployed, users may restow the HDRM, following Section 8.3 HDRM Stow. If the HDRM does not deploy, this test may be repeated after the 10 minute cooling time.

Note that Umbra recommends using the provided Umbra Stow Tool during ground testing of the Solar Array as defined in Section 8.5 Solar Array with HDRM Deployment Procedure. Caution must be exercised during any deployment in an on-earth environment as damage may result due to gravitational forces if the Solar Array is not properly supported at all times. Also, keep in mind the potential for pinch or injury as stated elsewhere in this User Guide.

8.5 Solar Array with HDRM Deployment Procedure

The objective of this procedure is to automatically deploy the Solar Array using the HDRM.

8.5.1 Success Criteria

Solar Array shall be deployed by the HDRM.

8.5.2 Configuration and Equipment

This procedure shall be carried out with the following equipment in the listed configurations and quantities.

Table 12. Solar Array with HDRM Deployment Equipment

Part Number	Part Name	Configuration	Quantity
5081H0001	Solar Array	Stowed	x1
5070H0001	HDRM	Stowed	x1
5070G0001	Umbra Stow Tool	N/A	x1
N/A	Solar Array Support Tool	8.1.2 Solar Array Support Tool	x1

8.5.3 Procedure

Only hold the Solar Array panels by the edges of the array during this procedure. Touching the Solar Arrays may lead to scratching. Handling the hinges during movement of the arrays may lead to pinching.

This procedure requires multiple operators.

1. Find a cleared space large enough for the form factor of the deployed Solar Array as described in Appendix B.1 Solar Array MICD free of FOD. These clearances must be observed at all times during this procedure to prevent damage to operators, Solar Arrays, and surroundings.
2. Secure the HDRM.
3. Align the Solar Array center release cup at the top of the HDRM. The center release cup floats in the Solar Array.
4. Ensure the Solar Array hinges have clearances. Items caught in the Solar Arrays may be damaged by pinching. The Solar Array hinges may be damaged by items caught in the hinges and limit switches.
5. Gently hold the edges of the inner panel of the Solar Array. This panel must be supported throughout the deployment process until solar arrays are supported by the Solar Array Support Tool to prevent damage to the hinges.
6. Begin to unscrew the Solar Array counterclockwise using the Solar Array Stow Tool. As the tool is used, the inner panel of the solar array should unfurl.
7. Once the inner panel has unfolded enough to access the middle panel, additionally support the middle panel.
8. While supporting both outer panels of the Solar Array, continue unscrewing the system with the Solar Array Stow Tool until the edges of each Solar Array panel are supported by the Umbra Stow Tool.
9. Do not remove the Solar Array from the Umbra Stow Tool while the Solar Array is in a deployed state. Umbra recommends users follow Section 8.6 Solar Array with HDRM Manual Stow Procedure before any transport of the Solar Array.

8.6 Solar Array with HDRM Manual Stow Procedure

The objective of this procedure is to manually stow the Solar Array using the Umbra Stow Tool.

8.6.1 Success Criteria

Solar Array shall be stowed.

8.6.2 Configuration and Equipment

This procedure shall be carried out with the following equipment in the listed configurations and quantities.

Table 13. Solar Array with HDRM Manual Stow Equipment

Part Number	Part Name	Configuration	Quantity
5081H0001	Solar Array	Deployed	x1
5070H0001	HDRM	Deployed	x1
5070G0001	Umbra Stow Tool	N/A	x1
N/A	Solar Array Support Tool	8.1.2 Solar Array Support Tool	x1

8.6.3 Procedure

Only hold the Solar Array panels by the edges of the array during this procedure. Touching the Solar Array cells may lead to scratching. Handling the hinges during movement of the arrays may lead to pinching.

This procedure requires multiple operators.

1. Ensure all Solar Array panels are clear of all FOD, tools, etc. Stowing the Solar Array with particulate on cells may result in damage to the cells. Stowing the Solar Array with any items on the panels may result in damage to the cells or hinges.
2. Ensure the Solar Array hinges have clearance to fold inwards. Items caught in the Solar Arrays may be damaged by pinching. The Solar Array hinges may be damaged by items caught in the hinges.
3. Gently support the outer edges of the Solar Array panels, not touching the cells and hinges. Both outer panels must be supported throughout the manual deployment process until stow is complete.
4. Insert the Solar Array Stow Tool into the top of HDRM through the Solar Array release hole.
5. Slowly screw the Solar Array Stow Tool clockwise. As the tool is used, the middle panel should begin to fold into the array. The panels should not touch each other until fully folded.
6. Continue using the Solar Array Stow Tool until the inner panel appears to be fully stowed. Continue support of panels until each panel is in stowed position.
7. Remove the Solar Array from the Umbra Stow Tool. If desired, RBF panel covers may now be added to the Solar Array. Umbra recommends gently taping the edges of the solar arrays away from the cells similar to the shipped stowed state during all transport.

8.7 Solar Array Charging Test

The objective of this procedure is to confirm the functionality of the Solar Arrays through outdoor testing.

8.7.1 Success Criteria

Solar arrays generate charge as described.

8.7.2 Configuration and Equipment

This test shall be carried out with the following equipment in the listed configurations and quantities.

Table 14. Solar Array Charging Test Equipment

Part Number	Part Name	Configuration	Quantity
5081H0001	Solar Array	N/A	x1
5070G0001	Umbra Stow Tool	N/A	x1
N/A	Solar Array Test Load	Must be capable of dissipation of maximum Solar Array power generation as described in Table 6. Solar Array Electrical Properties	As needed

8.7.3 Test Procedure

Umbra recommends validating the charging performance of the Solar Arrays using a trusted illumination source.

If outdoor testing is necessary, this test will require a clear, sunny sky at approximately high noon to maximize the amount of light received by Solar Arrays. Solar Arrays WILL be damaged by rain, snow, particulate in wind, etc. Do not store Solar Arrays outside.

1. Stow the Solar Array per Section 8.6 Solar Array with HDRM Manual Stow Procedure and ensure RBF covers are ON.
2. Transport the Solar Array to a flat, dry, cleared space with an unobstructed view of the light source. This space should be large enough for the deployed form factor of the Solar Array as described in Appendix B.1 Solar Array MICD. Keep RBF covers on during transport and ensure all recommendations and requirements described in Section
3. 4.1 Mechanical Handling requirements are met throughout transport.
4. Deploy the solar arrays using the provided GSE as described in Section 8.5 Solar Array with HDRM Deployment Procedure.
5. Identify the SA_STR_#_+ and SA_STR_#_- pins for each string of the Solar Array as shown in Table 8. Solar Array J1 Connector Pinout. These strings should be harnessed to test loads on a per string basis, with all strings in parallel to a load.
6. Connect the Solar Array to a battery module with a harness described in Section 5.2 Harnessing Recommendations. Make sure everything is powered off during connection.
7. With the solar array cells UP, remove RBF covers.
8. Allow the solar array to charge the battery module. Record observed current.
9. Bright red lights may be noted on the solar arrays when they are lit by the sun or a powerful light. These lights are the max potential voltages and are nominal under powerful light sources.
10. Disconnect from battery.

11. Umbra recommends that users should stow Solar Arrays per Section 8.6 Solar Array with HDRM Manual Stow Procedure and ensure RBF covers are ON if no other testing is planned to prevent damage to the Solar Array.

8.8 On-Orbit Checkout

Contact Umbra in the event of any deviation from nominal as described in this section.

Multiple Solar Arrays may be used on the same mission. If multiple Solar Arrays are connected in series, each module should have a similar maximum current on orbit if all cells on each array have an unobstructed view of the sun.

Appendix A

Acronyms and Abbreviations

A.1 Acronyms and Abbreviations

BOL	Beginning of Life
DMM	Digital Multimeter
EOL	End of Life
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
FOD	Foreign Object Debris
GSE	Ground Support Equipment
HDRM	Hold Down and Release Mechanism
LEO	Low Earth Orbit
MICD	Mechanical Interface Control Document
N/A	Not Available
RBF	Remove Before Flight
RTD	Resistance Temperature Detector
TBR	To Be Revised
TID	Total Ionizing Dose

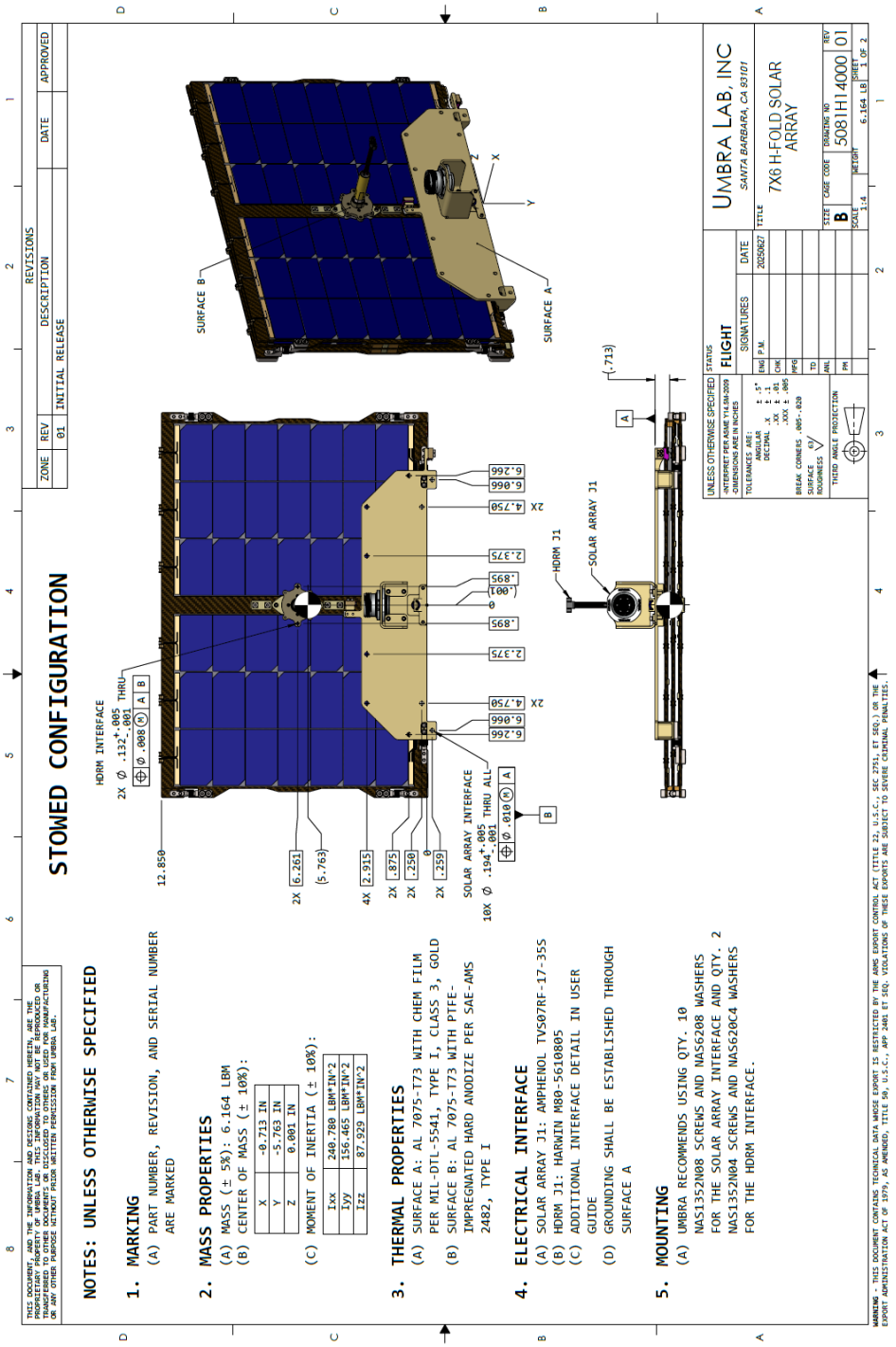
A.2 Units

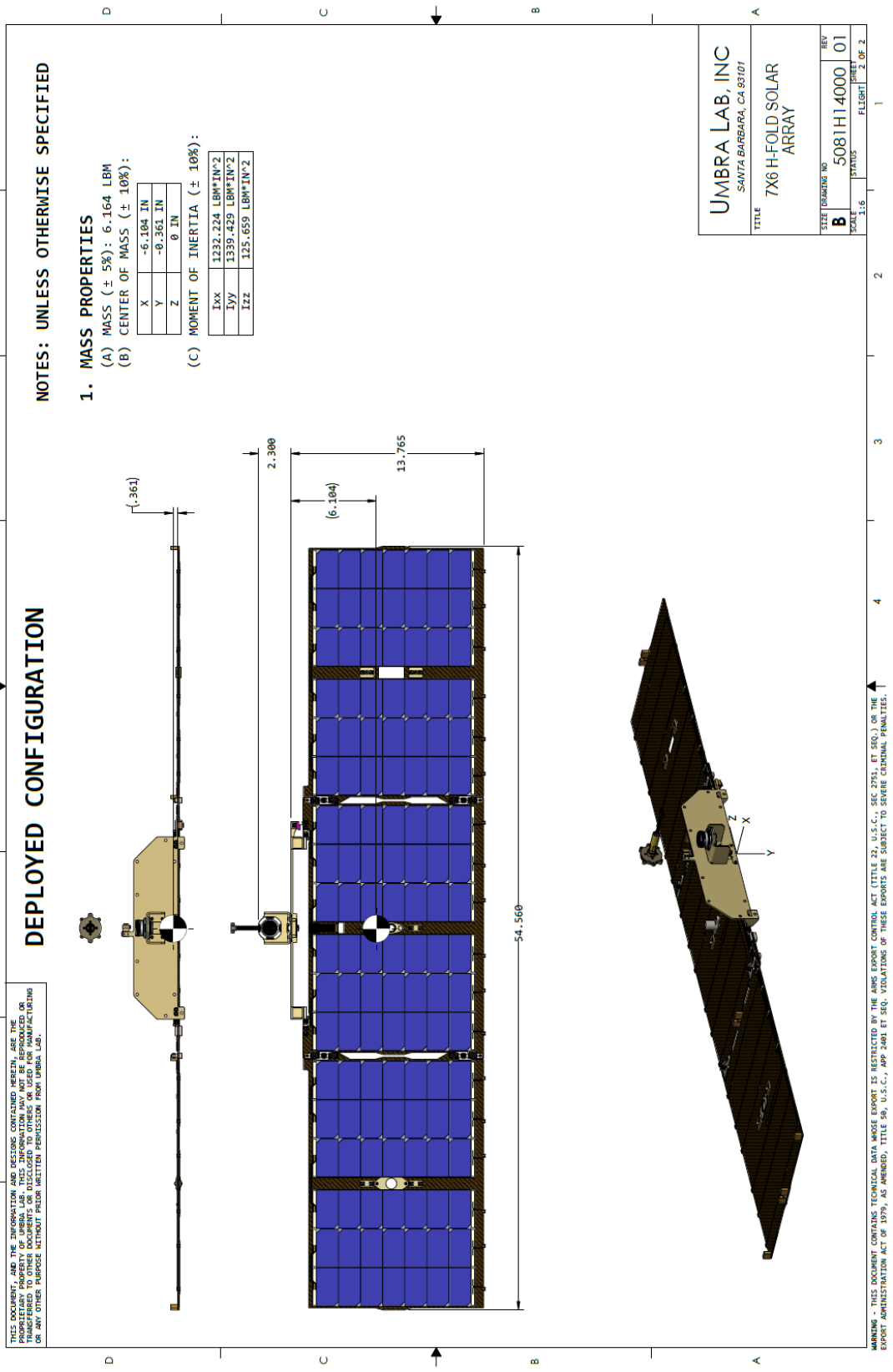
A	Amps
°C	Degrees Celsius
Grms	root mean square acceleration
k-ohm	Kilo-Ohm
krad	Kilorad
m^2	Square Meters
V	Volts
W	Watts

Appendix B

Mechanical Interface Control Documentation

B.1 Solar Array MICD




NOTES: UNLESS OTHERWISE SPECIFIED
1. MASS PROPERTIES
(A) MASS (± 5%): 6.164 LBM
(B) CENTER OF MASS (± 10%):
X -6.104 IN
Y -0.361 IN
Z 0 IN
(C) MOMENT OF INERTIA (± 10%):
Ixx 1232.224 LBM*IN^2
Iyy 1339.429 LBM*IN^2
Izz 125.659 LBM*IN^2
DEPLOYED CONFIGURATION
(.361)
2.300
(6.104)
13.765
54.560
Z
X
Y
UMBRA LAB, INC
SANTA BARBARA, CA 93101
TITLE
7X6 H-FOLD SOLAR ARRAY
SIZE B
DRAWING NO 5081H14000
REV 01
SCALE 1:6
STATUS FLIGHT
SHEET 2 OF 2
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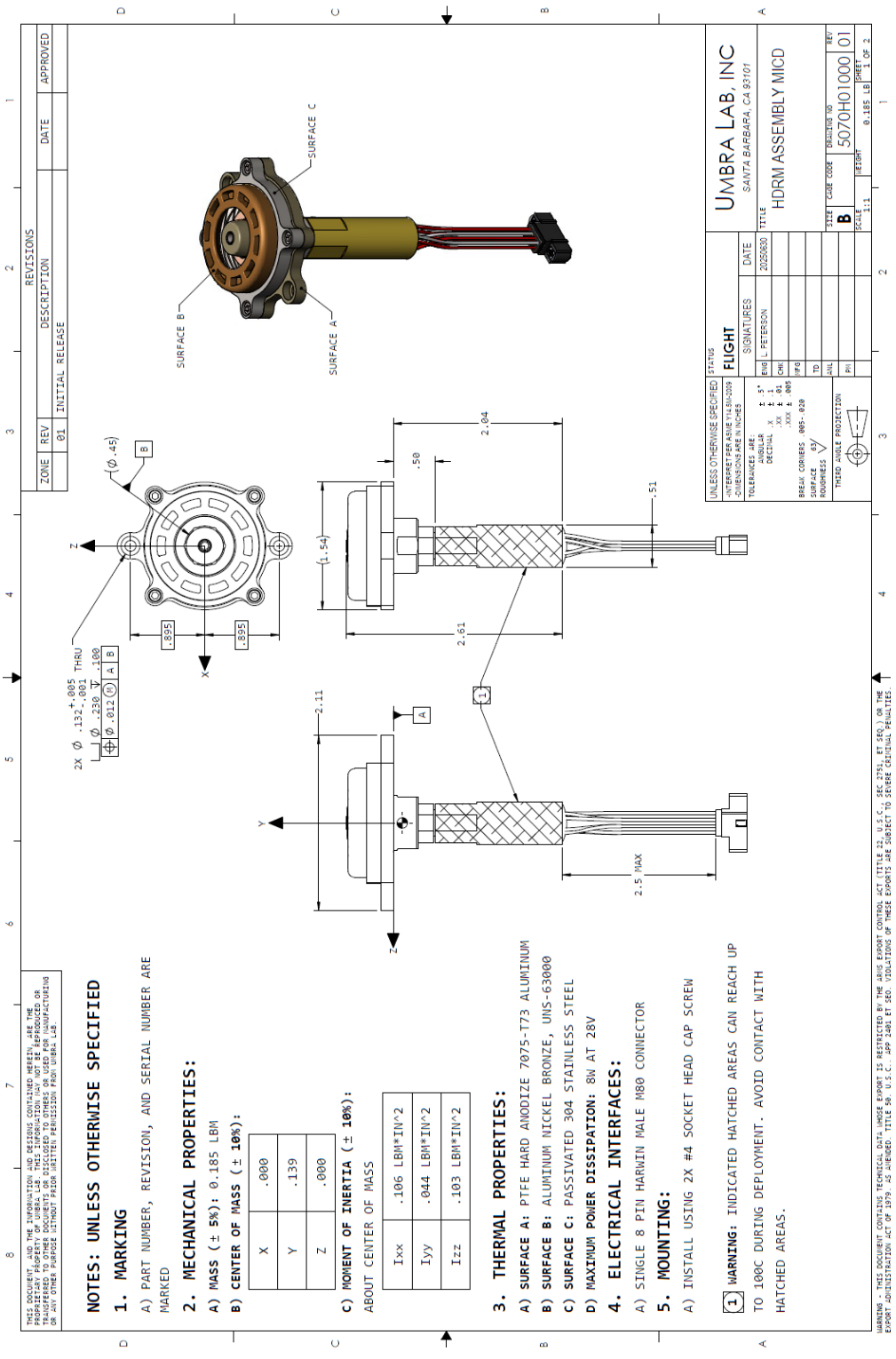
B.2 HDRM MICD


REVISIONS
ZONE | REV | DESCRIPTION | DATE | APPROVED
01 | INITIAL RELEASE
SURFACE A
SURFACE B
SURFACE C
UMBRA LAB, INC
SANTA BARBARA, CA 93101
HDRM ASSEMBLY MICD
5070H01000 01
NOTES: UNLESS OTHERWISE SPECIFIED
1. MARKING
A) PART NUMBER, REVISION, AND SERIAL NUMBER ARE MARKED
2. MECHANICAL PROPERTIES:
A) MASS (± 5%): 0.185 LBM
B) CENTER OF MASS (± 10%):
X .000
Y .139
Z .000
C) MOMENT OF INERTIA (± 10%):
ABOUT CENTER OF MASS
Ixx .106 LBM*IN^2
Iyy .044 LBM*IN^2
Izz .103 LBM*IN^2
3. THERMAL PROPERTIES:
A) SURFACE A: PTFE HARD ANODIZE 7075-T73 ALUMINUM
B) SURFACE B: ALUMINUM NICKEL BRONZE, UNS-63000
C) SURFACE C: PASSIVATED 304 STAINLESS STEEL
D) MAXIMUM POWER DISSIPATION: 8W AT 28V
4. ELECTRICAL INTERFACES:
A) SINGLE 8 PIN HARWIN MALE M80 CONNECTOR
5. MOUNTING:
A) INSTALL USING 2X #4 SOCKET HEAD CAP SCREW
1 WARNING: INDICATED HATCHED AREAS CAN REACH UP TO 100C DURING DEPLOYMENT. AVOID CONTACT WITH HATCHED AREAS.
2.04
.50
2.61
(1.54)
.51
2.11
2.5 MAX
.895
.895