Magnetometer + Sun Sensor User Guide

Distribution Statement

No Restrictions

Export Control

No US Export Control Information

Table of Contents

Figures

Tables

1.0 Objective

This document provides guidance for the integration of the Umbra Magnetometer Sun Sensor (MSS).

The magnetometer and fine sun sensor packaged into the MSS provide information on the magnetic field of the Earth and orientation toward the sun for guidance, navigation, and control of space vehicles. The Umbra Magnetometer Sun Sensor (MSS) is designed for and proven on Falcon 9 rideshare to Low Earth Orbit (LEO), offers standard output formats compatible with other flight controls, and is capable of “plug and play” operation with Umbra GNC Avionics.

2.0 Document References

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

2.1 Umbra Documents

5041H20000	MAGNETOMETER SUN SENSOR MICD

2.2 Standard Documents

AS22759	WIRE, ELECTRICAL, FLUOROPOLYMER-INSULATED, COPPER or COPPER ALLOY
GSFC-STD-7000	GENERAL ENVIRONMENTAL VERIFICATION STANDARD (GEVS)
MIL-STD-461	MILITARY STANDARD: ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS REQUIREMENTS FOR EQUIPMENT
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

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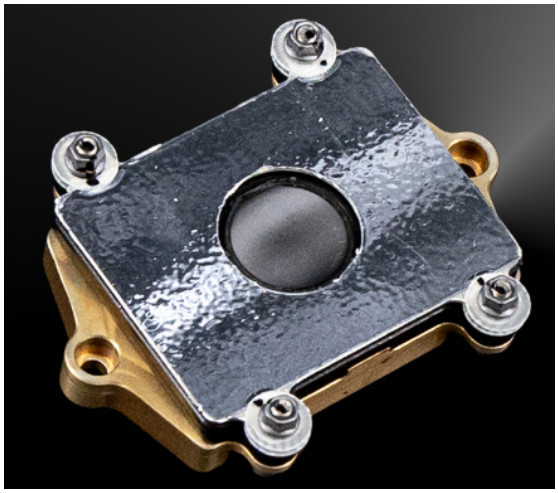
4.0 Hardware Handling

Figure 1. Magnetometer Sun Sensor (MSS)



4.1 Mechanical Handling

Avoid touching or contaminating the optical filter surface of the Umbra Magnetometer Sun Sensor (MSS).

Contact Umbra if any Umbra Magnetometer Sun Sensor (MSS) fails any procedure as described in this document or the User Guide. Do not continue use of any Umbra Magnetometer Sun Sensor (MSS) with a suspected failure.

Ensure that any transportation of the Umbra Magnetometer Sun Sensor (MSS) occurs in an environment described in the “Storage and Transport Environments” section.

Do not drop the Umbra Magnetometer Sun Sensor (MSS). Only lift an Umbra Magnetometer Sun Sensor (MSS) by the chassis.

Do not disassemble the Umbra Magnetometer Sun Sensor (MSS)

To prevent damage to the sensor, do not lay the Umbra Magnetometer Sun Sensor (MSS) on the optical face surface of the component.

4.1.1 Hazards

The Umbra Magnetometer Sun Sensor (MSS) does not contain any hazardous materials subject to exposure during intended use.

4.1.2 ESD Sensitivity

The Umbra Magnetometer Sun Sensor (MSS) is electrostatic discharge (ESD)  sensitive.

An ESD ground strap shall be worn by the person(s) handling the hardware. Refer to the ESD Standard for space hardware.

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.

4.1.3 Unpacking

If applicable, check shock detection stickers.
- Remove assembly from transportation container
- Perform visual inspection for damage
- Take pictures as received
- Inspect connections then re-apply protective dust caps

4.2 RBF/ Red Tag GSE

Items listed in Table 1 must be removed during hardware integration to customer space vehicle bus.

Table 1. RBF Items

Item	Critical/Optional	Notes
Connector Dust Cap	Critical	J1 Connector

4.3 Electrical Mate/Demate

For further information please refer to the MICD in Appendix B.

Table 2. Electrical Connector

Connector Designator	Assembly Connector	Mating Flight Connector
J1	G125-MV10605M2P	G125-2240696F1

4.4 Connector Strain

See Appendix B MICD. It is recommended to secure all harnessing interfacing to the Umbra Umbra Magnetometer Sun Sensor (MSS) per the guidance found in SAE-AS50881 which describes guidance on the installation of wiring harnesses.4.5 Storage and Transport Environment
Do not store the Umbra Magnetometer Sun Sensor in direct sunlight.

Do not store the Umbra Magnetometer Sun Sensor in such a way that damages part markings.

Ensure that critical RBF components are in place during all transport of the Umbra Magnetometer Sun Sensor.

Table 3. Recommended Storage Environment

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

4.5 Operating Environment

Intended Space (Radiation) Environment: LEO

Table 4. Operating Environment

Parameter	Value
Operational Temperature	-40°C to +80 °C

4.6 Survival Environment

Table 5. Survival Environment

Parameter	Value
Survival Temperature	-40°C to +100°C
Vibration	Qualified to 14.16 g RMS profile enveloping GEVS, Falcon 9, SpaceX Rideshare, and Electron levels.
Shock	Qualified to 1000 g peak profile enveloping GEVS, Falcon 9, SpaceX Rideshare, and Electron levels.
Minimum Survivable Total Ionizing Dose	Designed to withstand at least 30 krad TID

4.7 Mounting Information

See Appendix B for the Umbra Magnetometer Sun Sensor (MSS) MICD for information on mounting the Umbra Magnetometer Sun Sensor (MSS).

5.0 Electrical Properties

Table 6. Electrical Properties

Property	Typical Value	Notes
Operating Voltage	5V	Range of +/- 1V
Average Power Draw	<50 mW	NA
Peak Power Draw	<50 mW	NA

5.1 Connector Pinouts

See Section 6.0 Software Properties for more information on signal packet structure.

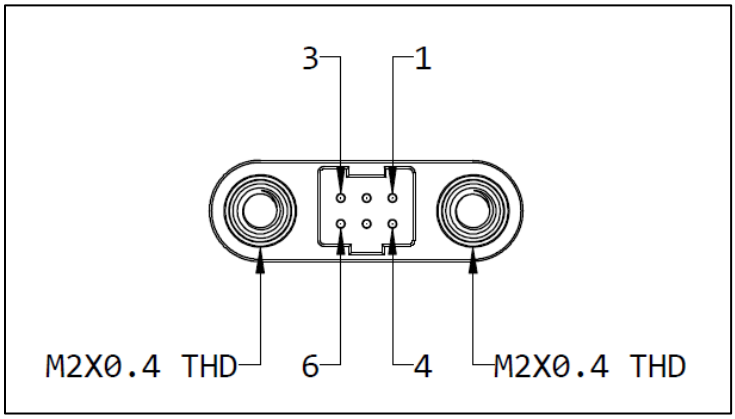
See Section 5.4 Electrical Properties for more information and reference MICD in Appendix B.

The Umbra Magnetometer Sun Sensor (MSS) connector (G125-MV10605M2P) is shown in Appendix B. Refer to Table 7 for pinout and Figure 2 for the mating face view.

Table 7. Connector Pinout

PIN	SIGNAL
1	POWER (5V)
2	RS422 MAG-CSS TO BUS P
3	RS422 MAG-CSS TO BUS N
4	GND
5	RS422 BUS TO MAG-CSS P
6	RS422 BUS TO MAG-CSS N

Figure 2. G125-MV10605M2P Connector Mating Face View

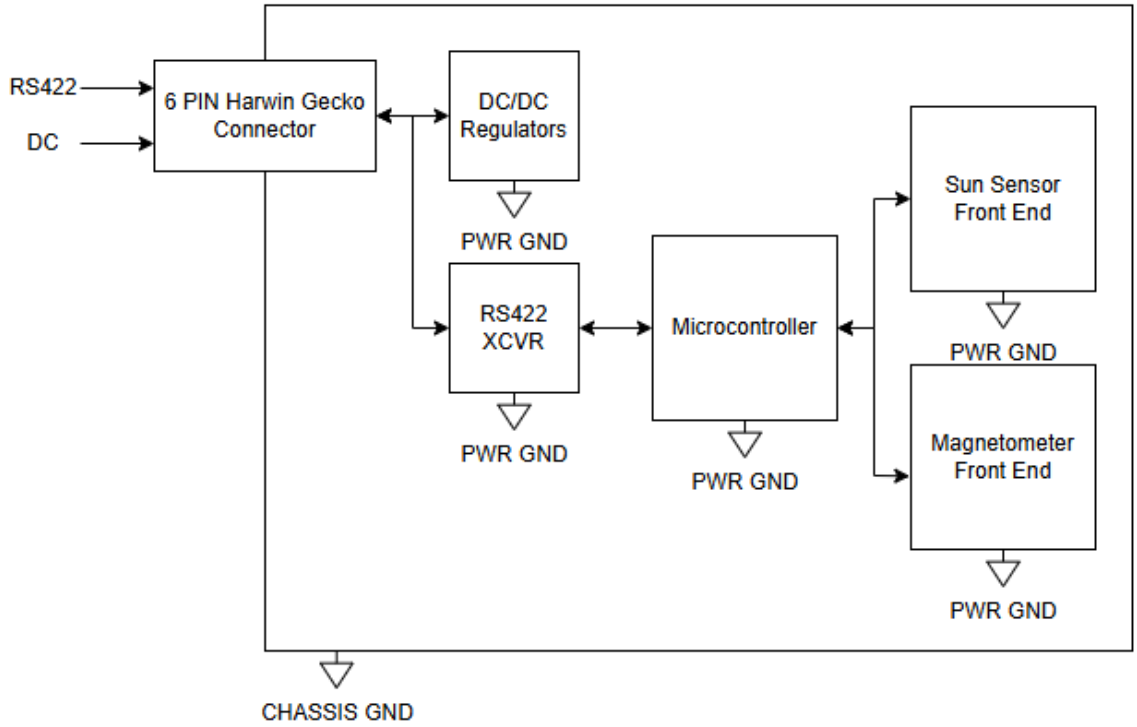


5.2 Harnessing Recommendations

Space-rated harnesses connecting to the Umbra Magnetometer Sun Sensor (MSS) should use wire in accordance with specification M22759 following SAE AS22759.

5.3 Grounding Block Diagram

Figure 3. Grounding Block Diagram



5.4 EMI/EMC Properties

The Umbra Magnetometer Sun Sensor (MSS) contains a sensitive Magnetometer and is therefore sensitive to electromagnetic interference.

The Umbra Magnetometer Sun Sensor (MSS) has not been tested for Electromagnetic Interference (EMI) / Electromagnetic Compatibility (EMC) per MIL-STD-461. It has been successfully tested for self-compatibility with X-Band, S-Band, and L-Band radios. Contact Umbra for more information.

5.5 Material Properties

All Umbra products are manufactured from materials deemed space-rated based on low outgassing. See Appendix B for the Umbra Magnetometer Sun Sensor (MSS) MICD for more information on material properties.

6.0 Software Properties

6.1 Communication Parameters

The Umbra Magnetometer Sun Sensor (MSS) uses an RS-422 interface, provides constant telemetry data at 22 Hz, and outputs a two-axis sun vector and magnetic field strength, with an internal solution rate over 10 Hz.

6.2 Telemetry

The following table lists the available telemetry names and types for the Umbra Magnetometer Sun Sensor (MSS).

Table 8. Telemetry Parameters

Telemetry Name	Type	Value
SunPointX	32 Bit Float	Unit Vector X
SunPointY	32 Bit Float	Unit Vector Y
SunPointZ	32 Bit Float	Unit Vector Z
MagX	32 Bit Float	Gauss
MagY	32 Bit Float	Gauss
MagZ	32 Bit Float	Gauss
MSSTemp1	32 Bit Float	C
MSSTemp2	32 Bit Float	C
Quad1DiodeRaw	Uint32	Counts
Quad2DiodeRaw	Uint32	Counts
Quad3DiodeRaw	Uint32	Counts
Quad4DiodeRaw	Uint32	Counts

The Umbra MSS is configured to operate in push mode transmitting data to the host at 2Hz.

6.3 Commanding

Not Applicable

6.4 Memory

Not Applicable

6.5 Error Mitigation

Not Applicable

7.0 Performance Specifications

The Umbra Magnetometer Sun Sensor (MSS) detects peak solar values using a 4 quadrant APD to generate accurate solar pointing angle coordinates for the host spacecraft. Precise magnetic field data is also provided for all 3 axes.

7.1 Field of View (FOV)

The Umbra Magnetometer Sun Sensor (MSS) is capable of a Field Of View (FOV) of 110 degrees x 110 degrees

7.2 Measurement Range

Single axis magnetic range of +/- 4 Gauss

7.3 Accuracy

The accuracy of the Umbra Magnetometer Sun Sensor (MSS) at boresight is < 1 degree.

The accuracy of the Umbra Magnetometer Sun Sensor (MSS) edge FOV is 8 degrees.

7.4 Sensitivity

Single Axis Magnetic Sensitivity: $1\ \mathrm{mGauss}$

Single Axis Magnetic Accuracy: $\pm\ 50\ \mathrm{mGauss}$

8.0 Operational Procedures

Follow all requirements and recommendations in 4.1 Mechanical Handling while carrying out all procedures in this section. The Umbra Magnetometer Sun Sensor (MSS) may be damaged if mechanical handling requirements and recommendations are not followed.

8.1 First Use Procedure

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

1. Inspect the connector and ensure it is free of FOD.
2. Power on the Umbra Magnetometer Sun Sensor (MSS) and read the telemetry from the RS-422 interface. See section 6.2 Telemetry for packet structure.

8.1.1 Assembly

Not Applicable

8.1.2 Checkouts

1. With the Umbra Magnetometer Sun Sensor (MSS) powered on, expose the Umbra Magnetometer Sun Sensor (MSS) to a magnetic field up to 4 Gauss
2. Verify that the reading from the RS-422 interface is reading correctly to within +/- 1 mGauss.
3. Verify that the four raw diode counts in telemetry increment and reflect a delta from an ambient or dark environment.
4. Repeat Steps 1 – 2 with the full available avionics suite running to ensure there is no magnetic interference or cross talk.
5. For final sun sensor checkout, ensure the +Z face is pointing up. Record the sun pointing vector and then illuminate the Umbra Magnetometer Sun Sensor (MSS) with an ambient light pointed from the +Z axis at the device and ensure the host spacecraft telemetry for the sun pointing vector indicates a change in the Z-axis pointing vector. It is advised to have a baseline reading with the sensor covered prior to reading with an ambient light source present.

8.1.3 Initial Configuration

Not Applicable

8.2 Sample Procedure

Not Applicable

8.2.1 Success Criteria

Not Applicable

8.2.2 Configuration and Equipment

Not Applicable

Table 9. Equipment List

Part Number	Part Name	Configuration	Quantity
N/A			

8.2.3 Test Procedure

Not Applicable

8.3 On-Orbit Checkout

With the Umbra Magnetometer Sun Sensor (MSS) powered on, perform the following checks to verify operation:

1. Read the three axis coordinate data for each axis of the sun pointing vector and ensure the axis angles make sense for the orbital position of the spacecraft during the measurement. The vector data will be dynamic based on the orbital characteristics at the time of the measurement and the user should see raw sun sensor diode counts increment when sun pointed.
2. Read the coordinate data for each of the three axis magnetic flux values. Verify the coordinate value is correct based on the orbital specifics during the measurements.
3. Read two temperature values from the Umbra Magnetometer Sun Sensor (MSS) and verify the two values are reading a temperature values within the operational temperature range (-40°C to +80 °C) of the Umbra Magnetometer Sun Sensor (MSS).

Note: Pointing vector data will vary based on orbital specifics at the time of the readings.

Appendix A

Acronyms and Abbreviations

A.1 Acronyms and Abbreviations

ESD	Electrostatic Discharge
FOD	Foreign Object Debris
FOV	Field Of View
GEVS	General Environmental Verification Standard
GSE	Ground Support Equipment
LEO	Low Earth Orbit
MSS	Magnetometer Sun Sensor
MICD	Mechanical Interface Control Document
RBF	Remove Before Flight
TBD	To Be Determined
TBR	To Be Revised
TID	Total Ionizing Dose

A.2 Units

°C	Degrees Celsius
A	Ampere
Hz	Hertz
kΩ	Kiloohms
krad	Kilorad
m^2	Square Meters
ms	Millisecond
V	Volts
W	Watts

Appendix B

Mechanical Interface Control Documentation