Magnetorquer 6 User Guide

Distribution Statement

No Restrictions

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1.0 Objective

This document provides mechanical, electrical, and environmental information for the integration of the Umbra Magnetorquer 6.

The Umbra Magnetorquer 6 is a magnetic torque rod designed for satellite attitude control and reaction wheel desaturation. The magnetorquer consists of an electromagnetic coil around a ferromagnetic core and creates a magnetic dipole that interfaces with the ambient magnetic field, such that the counterforce produced provides useful torque. The standard spacecraft application uses a set of three (3) magnetorquers arranged orthogonally to each other to provide sufficient control.

2.0 Document References

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

2.1 Umbra Documents

5031H30000	MAGNETORQUER 6 MICD

2.2 Standard Documents

49 CFR 172	CODE OF FEDERAL REGULATIONS HAZARDOUS MATERIALS TABLE
GSFC-STD-7000	GENERAL ENVIRONMENTAL VERIFICATION STANDARD (GEVS)
MIL-STD-461	MILITARY STANDARD: ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS REQUIREMENTS FOR EQUIPMENT
SAE-AS22759	WIRE, ELECTRICAL, FLUOROPOLYMER-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

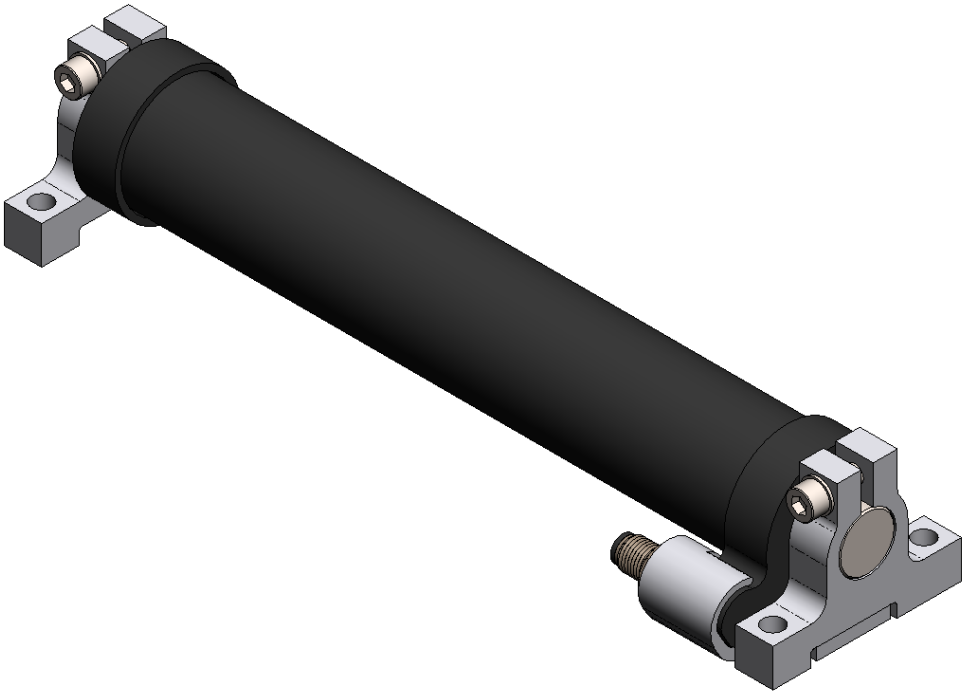
This document is Version 1.0.

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 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 Magnetorquer 6



4.1 Mechanical Handling

Contact Umbra if any Umbra Magnetorquer 6 fails any procedure as described in User Guide. Do not continue use of any Umbra Magnetorquer 6 with suspected damage.

Ensure that any transportation of the Umbra Magnetorquer 6 occurs in an environment described in 4.5 Storage and Transport Environment. If not integrated into a higher level assembly (e.g.: spacecraft or subsystem assembly), the Umbra Magnetorquer 6 should be transported in the protective case that it arrived in.

Do not drop the Umbra Magnetorquer 6.

Do not disassemble the Umbra Magnetorquer 6.

Contact Umbra in the event of any suspected Umbra Magnetorquer 6 failure.

4.1.1 Hazards

The Umbra Magnetorquer 6 does not contain any hazardous materials.

While the Umbra Magnetorquer 6 is actuated, maintain magnetic keep-out distances for all magnetic sensitive devices (i.e. pacemakers, cellphones, laptops, credit cards) to avoid injury and/or property damage. See Figure 6. Magnetic Field Strength for the field strength plot.

4.1.2 ESD Sensitivity

The Umbra Magnetorquer 6 is not electrostatic discharge (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
- There are no magnetic keep out requirements in the non-energized state

4.2 RBF/ Red Tag GSE

Items listed in Table 1 must be removed before flight.

Table 1. RBF Items

Item	Critical / Optional
J1 Connector Dust Cap	Critical

4.3 Electrical Mate/Demate

The assembly's connector and required mating harness connector are listed in Table 2.

Table 2. Connector Information

Connector Designator	Assembly Connector	Mating Flight Connector
J1	NorComp Inc. 851-002-103R001	NorComp Inc. 850-002-203RLU1

Do not hot-plug the Umbra Magnetorquer 6.

See Section 5.1 Connector Pinouts for more information.

4.4 Connector Strain

It is recommended to secure all harnessing interfacing to the Umbra Magnetorquer 6 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 Magnetorquer 6 in direct sunlight.

Do not store the Umbra Magnetorquer 6 in such a way that damages part markings.

Ensure that critical RBF components are in place during all transport of the Umbra Magnetorquer 6.

Table 3. Recommend Storage Environment

Parameter	Value
Storage Temperature	5°C to 35°C

4.6 Operating Environment

Table 4. Operating Environment

Parameter	Value
Operating Temperature	-40°C to 80°C
Intended Space (Radiation) Environment	LEO

4.7 Survival Environment

Table 5. Survival Environment

Parameter	Value
Survival Temperature	-40°C to 100°C
Random 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

4.8 Mounting Information

See Appendix B for information on mounting the Umbra Magnetorquer 6.

Pay careful attention to orientation of the magnetorquers during integration.

Maintain test records of the orientation relative to the vehicle body axes to address any questions that may arise related to magnetorquer polarity.

5.0 Electrical Properties

Table 6. Electrical Properties

Property	Typical Value	Notes
Operating Voltage	12 V ± 0.5 V	for > 6 Am^2 performance
Current at Operating Voltage	350 mA	1 A Absolute Maximum
Measured Resistance	34 Ω ± 4 Ω	
Operating Power	4.24 W	

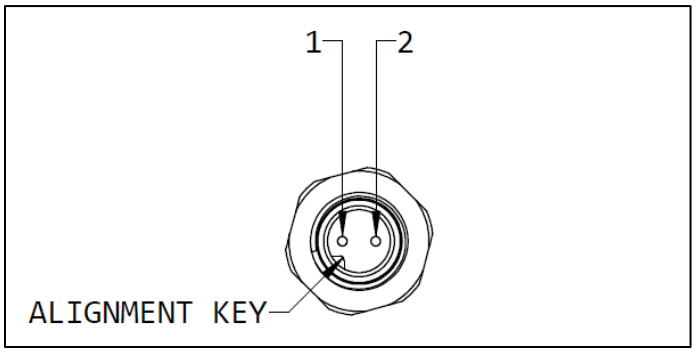
5.1 Connector Pinouts

The Umbra Magnetorquer 6 J1 connector (851-002-103R001) connects the Magnetorquer to a voltage source. Refer to Table 7 for pinout and Figure 2 for mating face view.

Table 7. Connector Pinout

PIN	SIGNAL NAME	NOTES
1	TR_P	Positive
2	TR_N	Negative

Figure 2. Connector Mating Face View



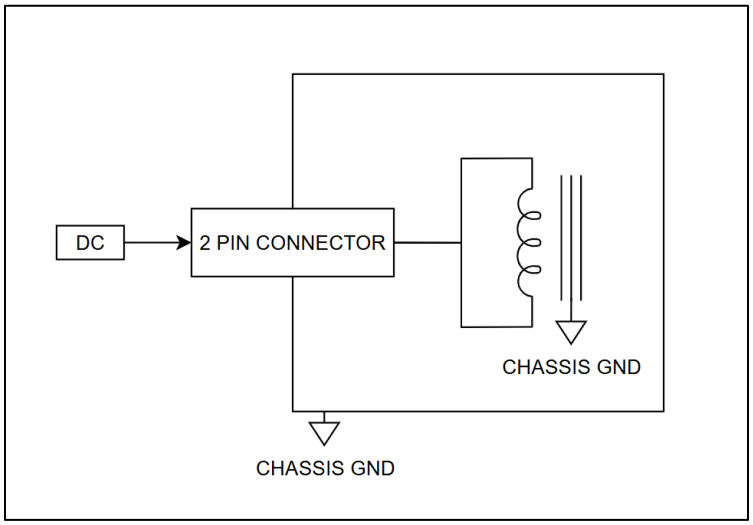
Actuating the Umbra Magnetorquer 6 requires applying voltage across the two pins as described in 5.4.2 Magnetorquer Field Orientation.

5.2 Harnessing Recommendations

Space-rated harnesses connecting to the Umbra Magnetorquer 6 should use wire following SAE AS22759. Umbra recommends the use of 24AWG wire.

5.3 Grounding Block Diagram

Figure 3. Magnetorquer Grounding Diagram.



5.4 EMI/EMC Properties

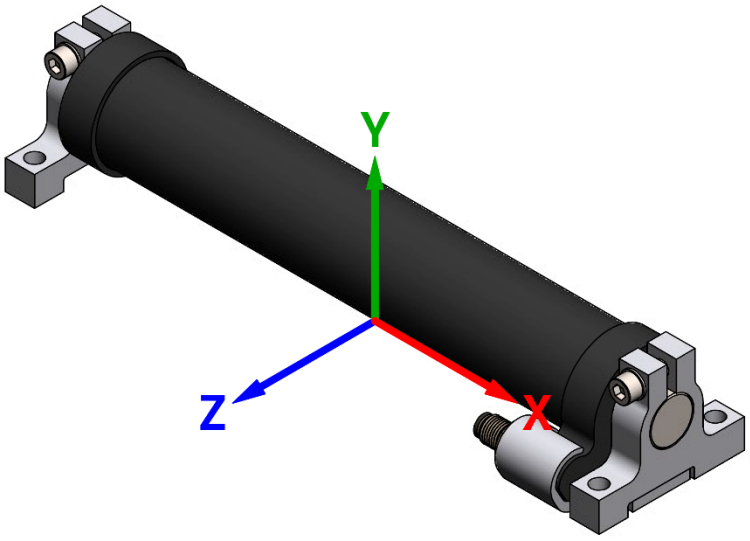
The Umbra Magnetorquer 6 emits an electromagnetic field during operation.

The Umbra Magnetorquer 6 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.

5.4.1 Magnetorquer Coordinate Axis

The intended coordinate axes of the magnetorquer is approximately shown in Figure 4. Refer to Appendix B for exact coordinate axis position, center of mass position, and moment of inertia values.

Figure 4. Umbra Magnetorquer 6 Coordinate Axes



5.4.2 Magnetorquer Field Orientation

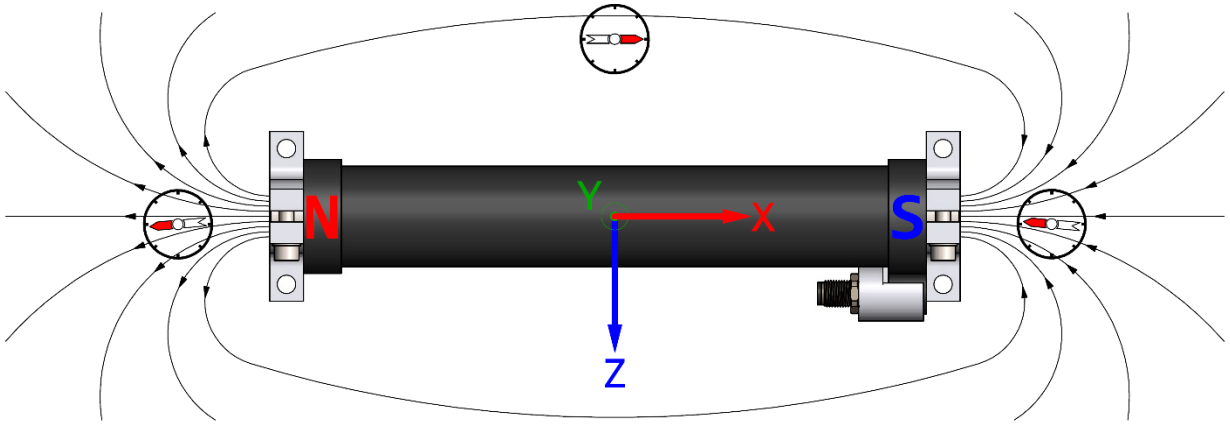
The direction of the magnetic field generated by the actuation of the Umbra Magnetorquer 6 is specified by Table 8. Magnetic Field Orientation. The magnetic field orientation listed refers to the magnetic field direction internal to the Magnetorquer's core. The positive actuation direction is depicted in Figure 5.

Table 8. Magnetic Field Orientation

Actuation Direction	Voltage Across Connector Pins	Magnetic Field Orientation
Positive	+12 V on Pin 1 0 V on Pin 2	-X (As shown in Figure 3)
Negative	0 V on Pin 1 +12 V on Pin 2	+X
Not Actuated	0 V on both pins	Residual Field

This direction of the magnetic field is verified for each magnetorquer assembly as described in 8.3 Magnetic Field Polarity Verification.

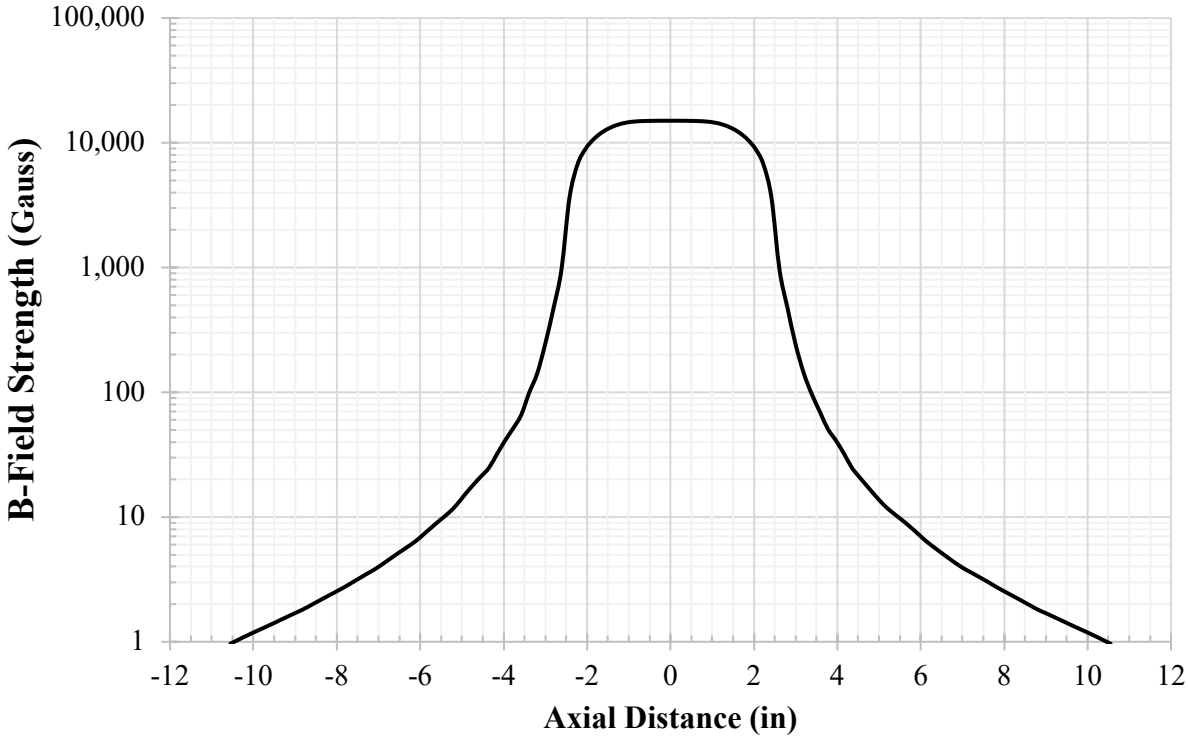
Figure 5. Positive Actuation Magnetic Field Orientation



5.4.3 Magnetorquer Field Strength

The magnetic field strength as a function of axial distance from the rod (parallel to the X axis) is shown in Figure 6.

Figure 6. Magnetic Field Strength



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 Umbra Magnetorquer 6.

6.0 Software Properties

Not applicable.

7.0 Performance Specifications

The Umbra Magnetorquer 6 is a torque rod designed for satellite attitude control. Torque rods generate a magnetic field which interacts with the Earth's magnetic field to change the rotational momentum of a satellite. Customers should consider mission orbit when selecting a torque rod, as increased altitude will result in reduced planetary field strength.

The Umbra Magnetorquer 6 is designed to have at least 6 Am^2 dipole moment at 12 V input. The Umbra Magnetorquer 6 is designed for high torque density with minimal volume.

The Umbra Magnetorquer 6 has minimized residual dipole moment to < 0.03 Am^2. Careful core material selection (optimizing for low remanence and low coercivity) enables minimal residual magnetic field when the coil is deenergized.

7.1 Performance Verification

Customer recommended checkout and qualification testing is described in this document in Section 8.0 User Guide.

8.0 User Guide

Follow all requirements and recommendations in 4.0 Hardware Handling while carrying out any and all procedures in this section. Umbra Magnetorquer 6 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

Umbra does not provide any ground support equipment (GSE) for the Umbra Magnetorquer 6.

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

The Umbra Magnetorquer 6 will arrive fully assembled.

8.2.2 Initial Configuration

The Umbra Magnetorquer 6 will arrive in a configuration ready for flight.

8.3 Magnetic Field Polarity Verification

The objective of this procedure is to verify Umbra Magnetorquer 6 magnetic field polarity.

8.3.1 Success Criteria

Umbra Magnetorquer 6 magnetic field polarity is known.

8.3.2 Configuration and Equipment

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

Table 9. Magnetic Field Polarity Verification Equipment

Part Number	Part Name	Quantity
5031H0001	Umbra Magnetorquer 6	x1
N/A	Power Supply	x1
N/A	Compass	x1

8.3.3 Test Procedure

1. Connect the Umbra Magnetorquer 6 to a power supply via a compatible harness as described in Section 4.3
2. Actuate the Magnetorquer with a positive actuation as described in 5.4.2 Magnetorquer Field Orientation.
3. Hold a compass to the connectorized end of the Magnetorquer.
4. Verify the North end of the compass needle points towards the connectorized end of the magnetorquer during a positive actuation as shown in Figure 5.

8.4 On-Orbit Checkout

Expect current draw when the Umbra Magnetorquer 6 is connected to a nominal 12 V source.

Appendix A

Acronyms and Abbreviations

A.1 Acronyms and Abbreviations

EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
GEVS	General Environmental Verification Standard
GSE	Ground Support Equipment
LEO	Low Earth Orbit
MICD	Mechanical Interface Control Document
N/A	Not Available
NASA	National Aeronautics and Space Administration
RBF	Remove Before Flight

A.2 Units

Ω	Ohms
°C	Degrees Celsius
Am^2	Ampere-square meter
A	Ampere
krad	Kilorad
mA	Milliamperes
in	Inches
V	Volts
W	Watts

Appendix B

Mechanical Interface Control Documentation