NCTR-M002 Interface Control Document

Revision 1.3

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Document Information

I. Reviewer(s)

Number	Date	Department	Position	Reviewed By	Signature
1	20-07-2018	Engineering	Design Engineer	Mark Honeth	
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II. Document History

Revision	Date	Change details	Affected Sections
0.A	03-11-2017	First draft	
1.0	06-11-2017	Submitted for review	
1.1	07-11-2017	Replaced photo with CAD model Changed positive terminal marking from knot to Kapton tape	4.1 5.1
1.2	08-11-2017	Updated electrical and magnetic functional properties	5.3, 6.1
1.3	20-07-2018	Corrected Title of document Updated paragraph 3.1. Updated Saturation (Maximum) Dipole Moment Updated Saturation (Maximum) Current Updated Residual Dipole Moment Added heading 6.2 Dipole Moment	ALL 3.1a 6.1 6.1 6.1 6.2

III. Acronyms, Abbreviations and Symbols

The ECSS glossary of terms (ECSS S-ST-00-01) is used as the normative reference for this document. The table below intends to add to or highlight the terms described in ECSS S-ST-00-01.

Term	Description
AD	Applicable Document
DOC	Document
ECSS	European Cooperation for Space Standardization
ICD	Interface Control Document
PCB	Printed Circuit Board
RD	Reference Document

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1 Introduction

1.1 Scope

This document supports interface configuration control for the NewSpace Systems NCTR-M002 magnetorquer rod. The ICD defines all interfaces between the spacecraft and the NCTR-M002.

This document is under configuration management.

2 Documents

2.1 Applicable Documents

The following documents are applicable and are referred to as [ADxx] in the text. Documents are applicable in their entirety. For unspecified issues of document, the latest signed version should be used. For specified issues, subsequent amendments to or revisions of any of these publications do not apply. However, parties to the agreement based on this document are encouraged to investigate the possibility of applying the most recent issue.

Table 2-1: Applicable Documents

Reference	Document Number	Issue/Date	Title
AD01	NCTR-MAS-001	01.A	M002 Cubesat Torque Rod Mechanical ICD

2.2 Reference Documents

The following documents are referenced for supporting information only and are referred to as [RDxx] in the text. For unspecified issues of a document, the latest issue should be used. Any sections that are applicable will be referenced directly in the requirements section of this technical specification.

Table 2-2: Reference Documents

Reference	Document Number	Issue/Date	Title
-	-	-	-

3 Principle of Operation

The magnetorquer rod produces a torque via the generation of a dipole moment which interacts with an environmental magnetic field. This moment, used against the Earth's magnetic field, allows for propellant-less application of torque on a small spacecraft, without saturation concerns.

To generate a 3D dipole moment vector, three magnetorquers mounted along the three orthogonal axes are necessary. In addition, the driving system needs to be able to supply the NCTR with current in both directions. It is worth noting that the NCTR cannot generate any torque directly along the Earth's magnetic field vector, hence the need for several torque rods in orthogonal axes.

The magnetorquer is formed by winding copper wire in multiple layers around a ferromagnetic bar which amplifies the magnetic effect of the winding. The dipole moment generated by the NCTR is uniquely dependent on, and linearly proportional to, the current that flows through the winding. Consequently, if the magnetorquer is supplied with a controlled current from a current regulator, the dipole moment generated by the NCTR is independent from temperature and from the movement of the rod in the magnetic field.

By contrast, supplying the magnetorquer with a constant voltage will lead in a variation of the generated dipole moment with temperature (due to the variation of winding resistance) and with the movement of the rod within the magnetic field, due to the movement induced voltage on the winding.

3.1 M002 Characteristics

The M002 model is a single-wound magnetorquer rod with a nominal magnetic dipole moment of 0.2 $A \cdot m^2$. Its behaviour is linear around this, and the magnetic magnitude responds as a function of current.

4 Mechanical Interface

4.1 Overview

The NCTR-M002 magnetorquer is a rod 70mm long and visually dominated by the copper coil. At each end, an acetal ring holds the windings in place and acts as a mounting point to mechanically attach the rod to a printed circuit board (PCB) or other structure. The design does not incorporate any control or electronics.

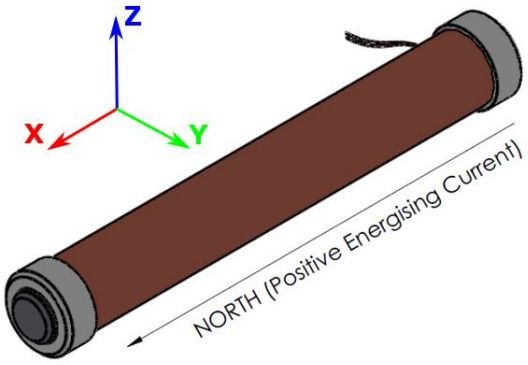

Figure 4-1: Illustration of NCTR-M002 torquer rod with axis definition

The mechanical ICD for the NCTR-M002 magnetorquer rod design is available as AD01.

4.2 Recommended Mounting Solution

Figure 4-2 illustrates the recommended mounting configuration of the NCTR-M002 magnetorquer rod to a PCB or other structure.

Figure 4-2 (a) shows a plan view of cut-outs on the mounting panel. The larger, central cut-outs cradle the ring at each end of the rod. These prevent the rod from sliding along its main axis. The smaller cut-out pairs beside these central holes accommodate a mounting lace which runs under the panel, though one of the smaller holes, over the rod's ring, back through the other hole.

Figure 4-2 (b) shows the rod end view (viewed along the main axis), which better illustrates the method for attaching the rod to a panel using mounting lace.

Finally, the rod should be glued to the mounting panel with a thermally conductive but electrically insulating compound to improve mechanical strength and thermal performance.

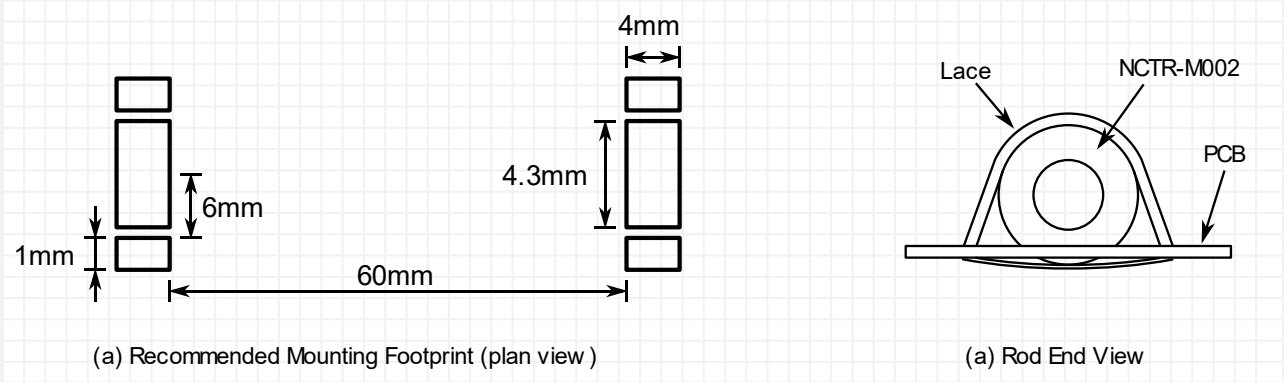

Figure 4-2: Recommended mounting solution

5 Electrical Interface

5.1 Terminals

The magnetorquer rod has two free wires that come out from the winding. These can be soldered or crimped according to need.

These should be connected to a driving system. This system may consist of an H-bridge to control direction of current flow, and a current regulator to control the magnitude of the current. The current regulator can be substituted for a voltage regulator, but the dipole moment will incur temperature and motion effects.

5.2 Pinout

Table 5-1 illustrates the connector pinout / wire definition.

Table 5-1: Connector pinout

Wire Number	Function	Indicator
1	Positive Terminal (Current In)	Kapton tape attached
2	Negative Terminal (Current Out)	None

5.3 Electrical Properties

Table 5-2 details the electrical properties of the NCTR-M002 magnetorquer rod.

Table 5-2: Electrical properties

Parameter	Value
Resistance	109Ω [±5%]
Inductance	355mH [±5%]

6 Magnetic Interface

6.1 Magnetic Properties

Table 6-1 details the magnetic (performance) properties of the NCTR-M002 magnetorquer rod.

Table 6-1: Magnetic properties

Parameter	Value
Nominal Dipole Moment	0.2 A·m^2
Nominal Current	31 mA
Saturation (Maximum) Dipole Moment	1.4 A·m^2
Saturation (Maximum) Current	215 mA
Residual Dipole Moment	< 0.005 A·m^2
Linearity	< 5% error
Scale Factor	± 6.5 m^2

6.2 Dipole Moment

The following figure shows the dipole moment variation per coil versus current.

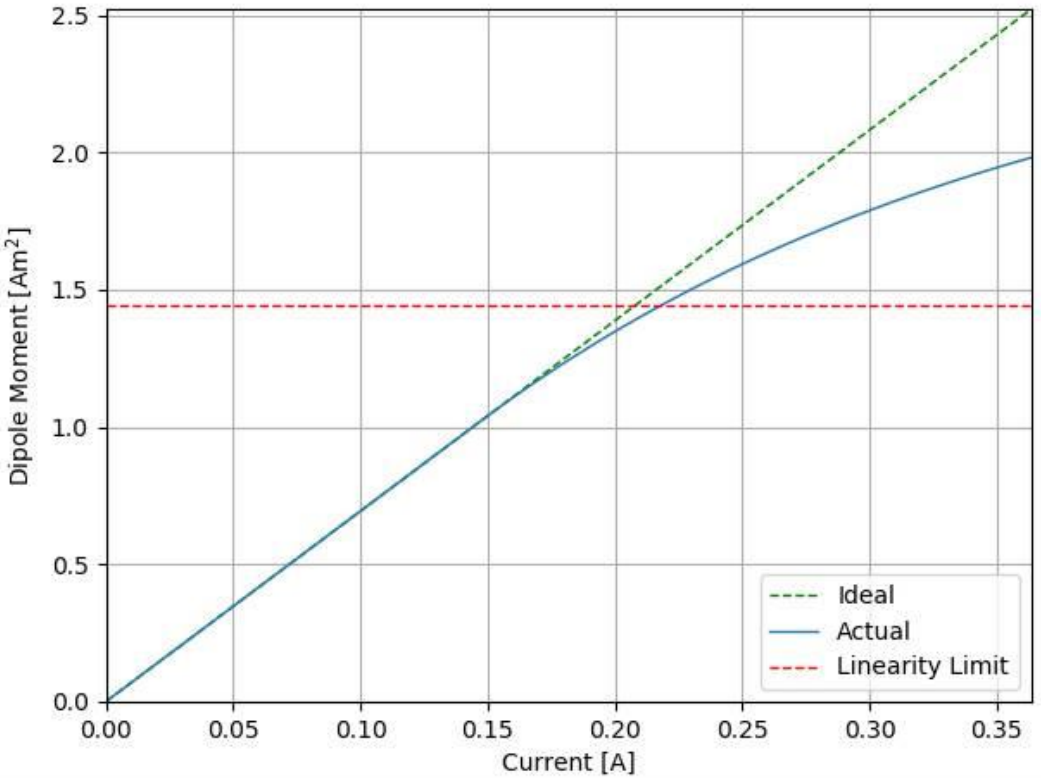

Figure 6-1 Dipole moment against current

As mentioned previously, if the magnetorquer rod is controlled in current mode the performance does not vary with temperature. The scale factor in Table 6-1 is slope of the linear part of the curve in Figure 6-1, i.e. the product of the input current and the scale factor is the output dipole moment in the linear region.

7 Thermal Interface

7.1 Thermal Properties

A portion of the power consumed by the magnetorquer rod is transformed into mechanical power. The proportion of input that is transformed into mechanical power depends on the movement itself and therefore on the characteristics of the spacecraft on which the rod is mounted.

The worst-case scenario for heat generation is a state in which the NCTR-M002 magnetorquer is in a constant magnetic field and supplied with a constant current. In such case, all power consumed by the magnetorquer rod is transformed into heat.

7.2 Thermal Surface Area

The total thermal interface surface area is described in the mechanical ICD [AD01], and is dependent on mounting method. In the recommended mounting method in 3.2, a thermally conductive adhesive is suggested to improve thermal dissipation.

7.3 Non-Operating Temperature Range

Table 7-1 details the survivable (non-operating) temperature range for the NCTR-M002 magnetorquer rod.

Table 7-1: Survivable (non-operating) temperature range

Parameter	Value
Min Survivable (Non-Operating) Temperature	-40°C
Max Survivable (Non-Operating) Temperature	+80°C

7.4 Operating Temperature Range

Table 7-2 details the operating temperature range for the NCTR-M002 magnetorquer rod.

Table 7-2: Operating temperature range

Parameter	Value
Min Operating Temperature	-20°C
Max Operating Temperature	+60°C