Honeywell

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Interface Control Document (ICD) for Customers Utilizing the RS-485/RS-422 Interface for the Honeywell Dual Space Magnetometer

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1 INTRODUCTION

1.1 Purpose and Scope

This document defines the standard flight functional interface definitions for the Honeywell Space Magnetometer, hereinafter referred to as the MAG.

The purpose of this document is to identify all of the mechanical, electrical and command interfaces for the MAG.

The MAG can be factory configured with different interfaces. This ICD is applicable to the 56011974-002 model, with the full duplex RS-485/422 interface factory enabled and 56011974-001 with the half duplex RS-485 interface enabled.

Throughout this document there are references to RS-485 unit configurations. While this ICD documents the intended operation of RS-485 half-duplex and full-duplex units, qualification of the RS-485 half-duplex variant has been deferred. The RS-485 full-duplex variant is compatible with RS-422 and has been fully qualified as RS-422.

1.2 Precedence

The Magnetometer System Requirement Document, SYSRD56011974 will take precedence over the ICD, however every attempt to keep these two documents aligned will be made.

2 DOCUMENTS

2.1 Reference Documents

Document Number	Document Title	Doc Rev	Date
SYSRD56011974	System Requirements Document for the Space Magnetometer	-	April 4, 2019
56011974	Magnetometer Installation Interface Control Drawing	A	April 23, 2020

3 MAG INTERFACES

3.1 General

3.1.1 Design Description

Two Magnetometer Printed Board Assemblies (PBAs) are contained in one package in order to provide redundant functionality. Both MAG PBAs are identical with the exception of unique compensation terms loaded into non-volatile memory after factory calibration.

Each PBA contains the 3 magnetic sensors to provide three axes measurement of the magnetic field, temperature monitor, set/reset circuit to invert the magnetic sensor output, conditioning circuits for the temperature and magnetic sensor outputs, 12 bit analog to digital converter, trim circuit, 8 MHz crystal, Atmel microcontroller (ATMegaS64M1), and the RS-485/RS-422 transceiver.

The device is set at the factory to support RS-485 configured for half duplex or full duplex. Full duplex RS-485 is also compliant with RS-422 and may be referred to as RS-422 within this document.

The magnetometer sensors provide three analog signals proportional to the three components of the Earth's magnetic field vector projected onto an orthogonal frame. The analog signals are sent to a 12-bit Analog to Digital (A/D) converter then read by the ATMEL's microcontroller (ATMegaS64M1). The alignment and thermally compensated sensor data are sent out through the RS-485/422 communication bus.

The maximum magnetic field that the magnetometer can be exposed to without leading to any irreversible degradation, and without impacting its performance, is less than 40 Gauss for both ON and OFF. Variation in magnetic properties of the constituent components of the MAG will lead to variations in the exposure field limit. It is best to avoid exposure to magnetic fields as much as possible.

3.1.2 Interface Description

External Interfaces from the MAG to the Spacecraft (S/C) include a mechanical attachment and two identical electrical interfaces.

Both electrical interfaces are identical to each other, and connect to identical Magnetometer Electronic PBAs. The MAG PBA's are powered individually during flight operation. There is no hardware distinction between the PBA's. Differences exist only in the physical location within the MAG package and the calibration coefficients loaded during the factory calibration process.

The MAG is installed to the S/C base using four threaded screws installed through holes in the mounting flanges. Use of mounting screws manufactured from a non-magnetic material, such as titanium, is recommended. Screws with ferrous content should be avoided for best performance and repeatability.

3.1.3 Performance

The performance parameters are specified in SysRD56011974 and summarized in Table 3.1.3-1 below. The MAG will operate to the full performance requirements in the range 0.2 to 0.75 Gauss. The MAG will function in the ranges of 0.1 to 0.2 Gauss and 0.75 to 0.8 Gauss, but may do so with degraded performance.

Table 3.1.3-1 MAG Performance Summary

Parameter	BoL Limit	EoL Limit	Units
On-axis null field error	±1.95	±2.25	mG
On-axis Scale Factor Error	±3.25	±3.75	% of Applied Field
Total Magnitude null field error	±3.4	±4.25	mG
Total Magnitude Scale Factor Error	±6.0	±6.5	% of Applied Field
Angle error	±2,25	±3.4	deg

3.2 MAG Mechanical Interface

The mechanical design of the MAG is compliant with the requirements of the SysRD and defined in the Installation - Interface Control Drawing, 56011974.

3.2.1 MAG Physical Envelope Description

The MAG Flight Assembly Installation Drawing, 56011974, defines the unit mechanical form factor. Figure 3.2.1-1 shows an isometric view and Figure 3.2.1-2 shows an orthographic projection of the unit with the dimensions for the maximum outside envelope. All dimensions are in millimeters.

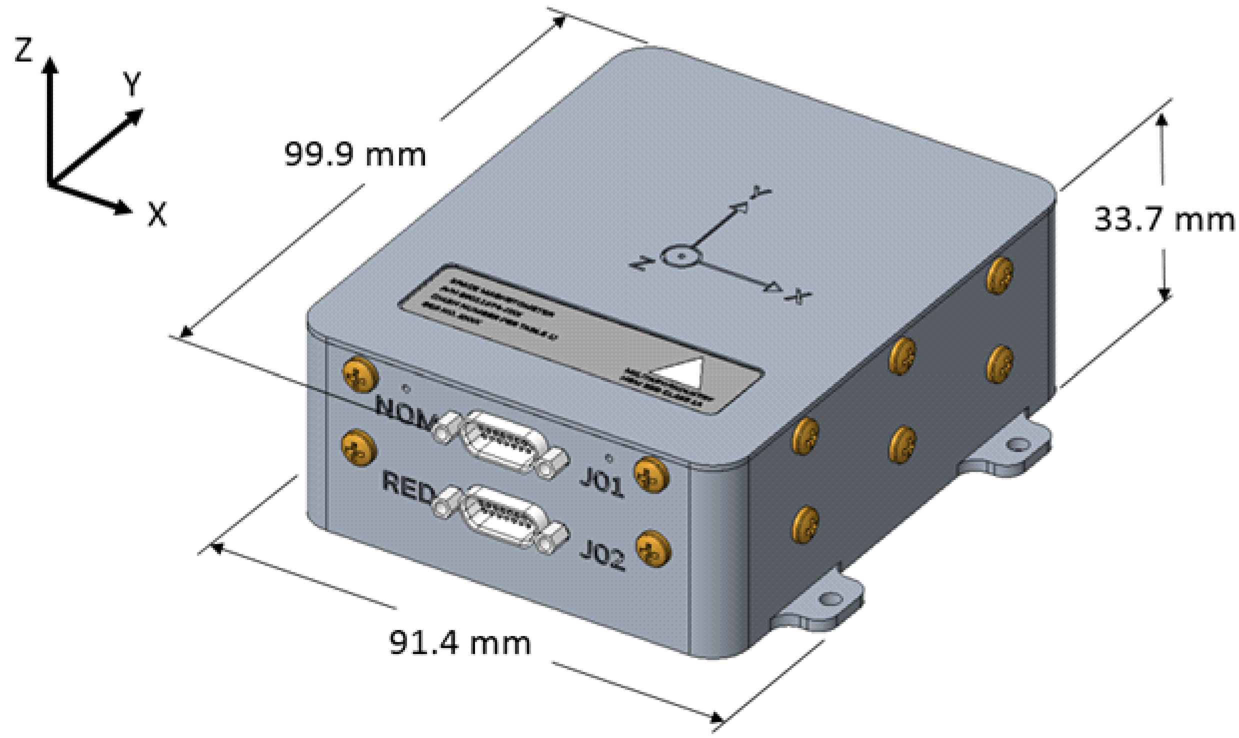

Figure 3.2.1-1 MAG Isometric View

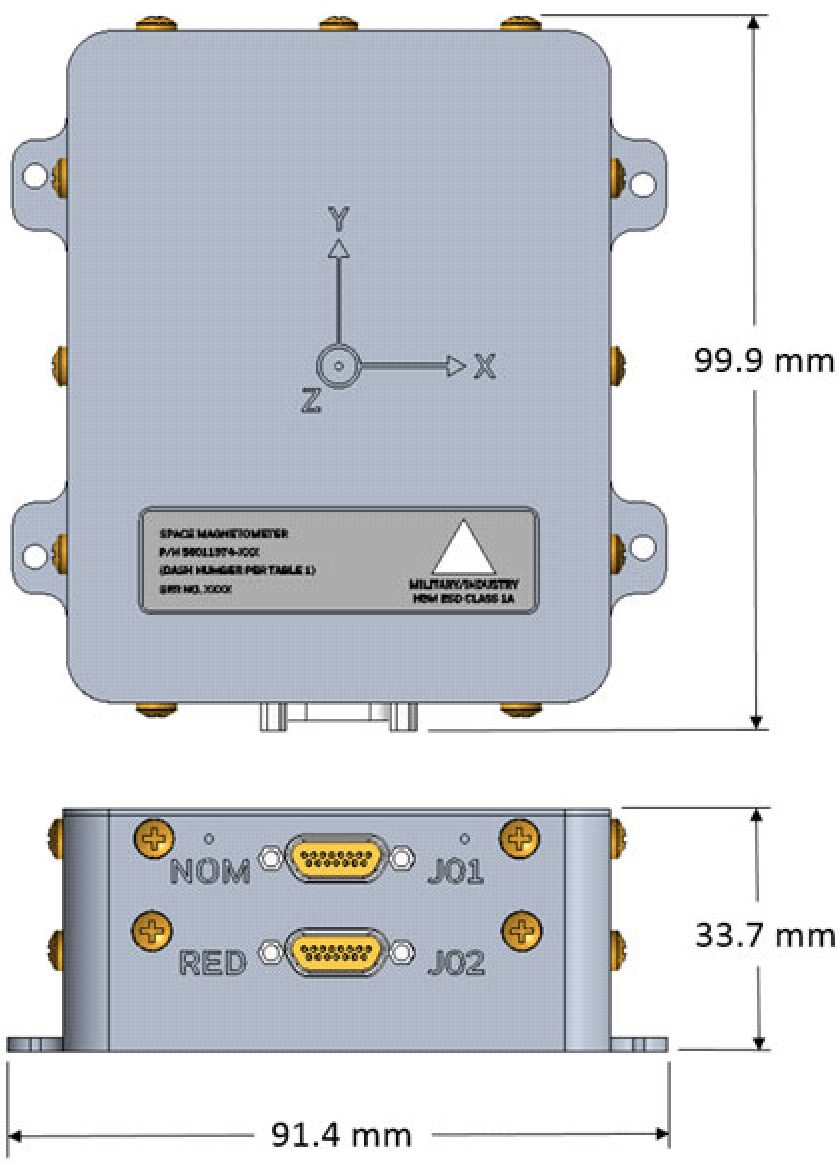

Figure 3.2.1-2 MAG Physical Envelope

3.2.2 Mass Properties

The MAG Installation - Interface Control Drawing defines the nominal calculated mass properties (weight, center of gravity, moments of inertia) of the magnetometer.

3.2.2.1 Weight

The MAG nominal weight is 302 grams (10.7 oz). The MAG maximum weight is less than 310 grams (10.9 oz).

3.2.2.2 Volume

The unit volume is 235.2 cc (14.35 in^3) or less. The surface area is 310.1 sq. cm (48.1 sq. in) or less.

3.2.2.3 Center of gravity

The unit center of gravity is defined by the MAG Installation Drawing.

3.2.2.4 Moment of inertia

The Moment of Inertia is defined by the MAG Installation Drawing.

3.2.2.5 Loads

The MAG design meets all performance requirements for operations in the load conditions as summarized in Sections 3.3.2 and 3.3.3.

3.2.3 Axis Definition

The Magnetometer data output is defined per the coordinate axis shown in Figure 3.2.3.1-1. The Z axis is normal to the mounting plane, Y is normal to the rear side opposite of the connectors and X is the vector defined by the right-hand rule of Y into Z. The factory calibration process aligns the unit output axes to the mount coordinate axes.

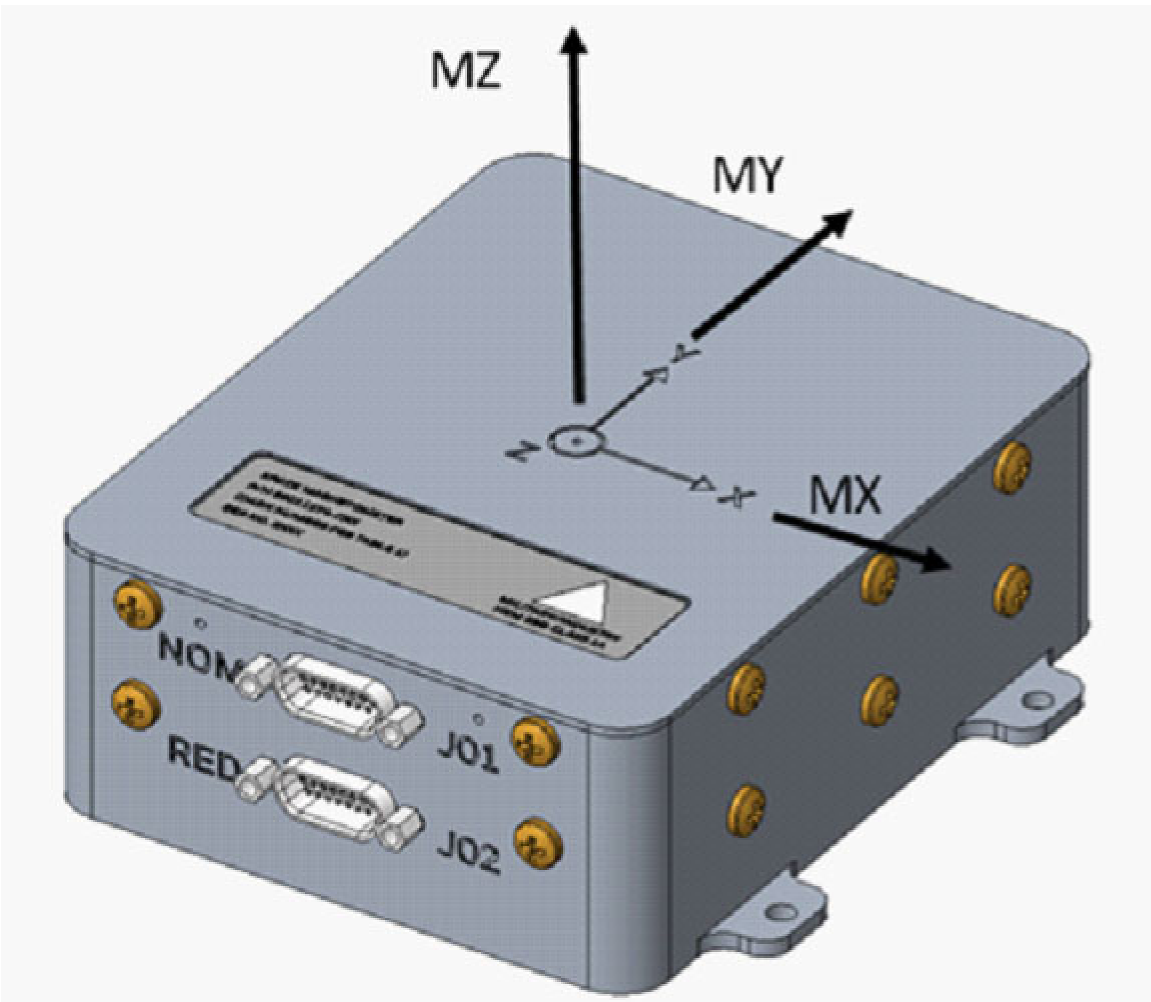

Figure 3.2.3.1-1 Reference Frame

3.2.4 Mounting Interface

The mechanical design of the MAG is defined in the Installation - Interface Control Drawing, 56011974.

3.2.4.1 Unit Mount Mating Surface

The unit's mounting surface flatness is less or equal to 100 mm (0.004 inch). This coplanar requirement contributes to the alignment accuracy and alignment stability and is included in the performance error allowance. The mounting surface should be sufficiently conductive to allow adequate electrical bonding with the MAG flush chassis bottom. The MAG will provide a conductive path to the mounting surface by direct contact with the bottom of the MAG. The use of a cold plate or thermal pad is not recommended nor required in a typical satellite installation to maintain the specified temperature range of the MAG. Any instability of the mating surface directly translates to instability in the MAG measurements and is not considered in establishing the MAG performance specification.

3.2.4.2 Mounting

The MAG design allows for installation into a structural assembly that mounts to the bottom of the MAG.

The MAG Installation / Interface Control Drawing, 56011974 defines the dimensions, position and tolerances of the 4 mounting holes.

3.2.4.2.1 Mounting Torque

Honeywell recommends mounting of the MAG with four MJ3 x 0.5 – 4h6h non-magnetic socket head bolts. Mounting screws installation torque is 1.0 Nm +/- 0.1Nm. The MAG mounting hole pattern is per the MAG Installation Drawing. Mounting screws are not supplied with the MAG.

3.2.4.2.2 Alignment

The clearance hole in the foot is 3.4 +/-0.1 mm. Basic size calculations of metric bolt threads and tolerance calculations of different tolerance classes are to be done according to ISO 965-1:1998 and ISO 965-2:1998 standards. Using the minimum bolt major diameter of 2.874 mm and maximum hole tolerance of 3.5 mm (nominal of 3.4 mm), allows for a maximum of 0.3 deg of static alignment difference between mount to mount in the X-Y plane. Another method of achieving better alignment (0.15°) is by using a protruding straight edge parallel to the back side (side opposite of the connector) that is within 90° +/- 0.1° of the center line of the bolting holes. Reference figure below. The customer can physically align the MAG to the spacecraft axes or measure mounting misalignment with respect to the S/C and compensating for it in the S/C software.

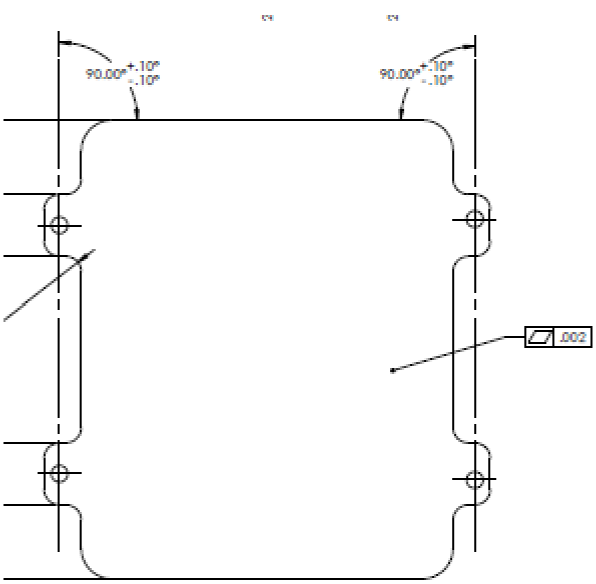

Figure 3.2.4.2.2-1 MAG Mounting Interface

3.2.5 Bonding

All conductive mechanical assembly elements are electrically bonded to chassis ground. There is no need for a provision to connect a separate grounding cable, providing the mounting surface provides S/C ground..

3.2.6 Surface Finish

3.2.6.1 Surface Roughness

The maximum surface roughness for the machined assembly is N7, 1.6 µm (63 micro in) RA or equivalent of 64 micro in RMS or better. Mounting surface roughness for the machined assembly is N6, 0.8 µm (32 micro in) RA or equivalent of 32.5 micro in RMS or better.

3.2.6.2 Surface Treatment

Aluminum surface treatment is chromate per MIL-C-5541, Class 3 to reduce any oxidation of the aluminum. MIL-C-5541. Class 3 chromate coating is an intended corrosion preventative film for electrical and electronic applications where low resistance contacts are required. Class 3 coating is applicable for electrical bonding applications per MIL-B-5087.

3.3 Environmental

The MAG design will meet all performance requirements for operations in the environment conditions as described below.

3.3.1 Thermal Interface

Thermal interface is designed and tested to the thermal requirements of Tables 3.3.1-I and 3.3.1-II.

Table 3.3.1-I: MAG Operating Temperature Ranges

Acceptance Temperatures	Qualification Temperatures	Unit Survival Temperatures
-25° C to 45° C	-25° C to 55° C	-30° C to 70° C

Table 3.3.1-II Thermal Interfaces and Boundary Definition

Thermal Interfaces and Boundary definition		
Parameter Units Value Note	**Units**	**Value**
Conductive Boundary Temperature (CBT)	°C	-25 to +45
Conductive Heat Transfer Coefficient	W/°C per bolt	0.7
Maximum Temperature Change Rate	°C/minute	2
Radiative Boundary Equivalent Temperature (RBT)	°C	34
Radiative Boundary Equivalent Emissivity (RBE)	NONE	0.1
Radiative Boundary View Factor (VF)	NONE	1

3.3.2 Shock Environment

The MAG is designed and tested to the shock requirements of Table 3.3.2-I.

Table 3.3.2-I: MAG Shock Limits

Frequency (Hz)	Shock Level (g)
100.00	20
2000.00	2000
10000.00	2000

3.3.3 Vibration Environment

The MAG is designed and tested to the random vibration requirements of Table 3.3.3-I.

Table 3.3.3-I: MAG Random Vibration Limits

In plane levels:

R500	PSD (g2/Hz)	
Frequency (Hz)	Qualification	Acceptance
20-80	+ 4 dB/oct	+ 4 dB/oct
80-500	0.1	0.045
500-2000	-5 dB/oct	-5 dB/oct
Overall Level	9.5 g (rms)	6.3 g (rms)
Duration	180s	60s

Out of plane Levels:

R400	PSD (g2/Hz)	
Frequency (Hz)	Qualification	Acceptance
20-80	+ 9 dB/oct	+ 9 dB/oct
80-250	1.0	0.45
250-2000	-8 dB/oct	-8 dB/oct
Overall Level	18.3 g (rms)	12.2 g (rms)
Duration	180s	60s

The MAG is tested to the sine vibration requirements of Table 3.3.2-II, but is not intended to be subjected to long-term sinusoidal vibration.

Table 3.3.3-II: MAG Sinusoidal Vibration Test Levels

Frequency (Hz)	Sine Vibration (g)
5-100	20

3.3.4 Humidity Environment

The MAG is designed to withstand a relative humidity of 65% maximum during testing and transport. Long term operation is intended for a space environment.

3.3.5 Pressure Environment

The MAG is designed to operatte from atmospheric to space pressure without arcing or corona and can withstand, without degradation, a de-pressurization rate of 70 hPa/s maximum and a Delta-P of 150 hPa over ambient.

3.3.6 Radiation Environment

The MAG is designed to meet all performance requirements when operating in the natural space radiation environment(s) defined in Table 3.3.6-I. The spacecraft structure **is** assumed to provide 2mm equivalent Al shielding isotropic or greater.

Table 3.3.6-I: Natural Space Radiation Environment for unit design

Parameter	**Mission Scenario**
Mission type:	Low earth orbit (LEO), polar
Orbital parameters:	1200km circular x 87.9°
Mission life:	6 years
Dose calculations	
Trapped electron fluence mode:	AE8, solar maximum, average

Trapped proton fluence model:	AP8, solar minimum, average
Solar proton fluence model:	ESP-PSYCHIC, 90% confidence
SEE calculations	
Galactic cosmic ray flux model:	CREME96, solar minimum
Solar flare flux model, average:	CREME96, worst week
Solar flare flux model, peak:	CREME96, peak 5-minutes
Trapped proton flux model:	AP8, solar minimum, peak
Spacecraft charging calculations	
Trapped electron flux model:	AE9, Monte-Carlo, 100 histories, 90% confidence

3.3.7 Electromagnetic Environment-

The MAG is designed for robustness in EMI radiation and susceptibility and has been tested to tailored requirements of MIL-STD-464C and MIL-STD-461F. Specific tests and tailored limits are summarized below. Testing was performed with unshielded cables.

RS-422 configuration EMI test limits		
Method	Standard	Test Level
Bonding	Mil-Std 464C	2.5 milliohms
CE102	Mil-Std 461F	Honeywell Tailored CE102-1, Basic Curve +10 dB
CS101	Mil-Std 461F	Honeywell Tailored CS101-1, Curve #2 -20 dB
CS114	Mil-Std 461F	CS114, Curve 3
CS115	Mil-Std 461F	Honeywell Tailored 0.5 Apk
CS116	Mil-Std 461F	Honeywell Tailored Imax = 1.0 Apk
RE102	Mil-Std 461F	RE102-3, Fixed Wing Internal <25 meters Nose to Tail limits
RS103	Mil-Std 461F	20 V/m 2 MHz to 40 GHz

3.4 Electrical

3.4.1 Top Level System Electrical Interface

The top-level system electrical input/output (I/O) interfaces are shown in Figure 3.4.1-1

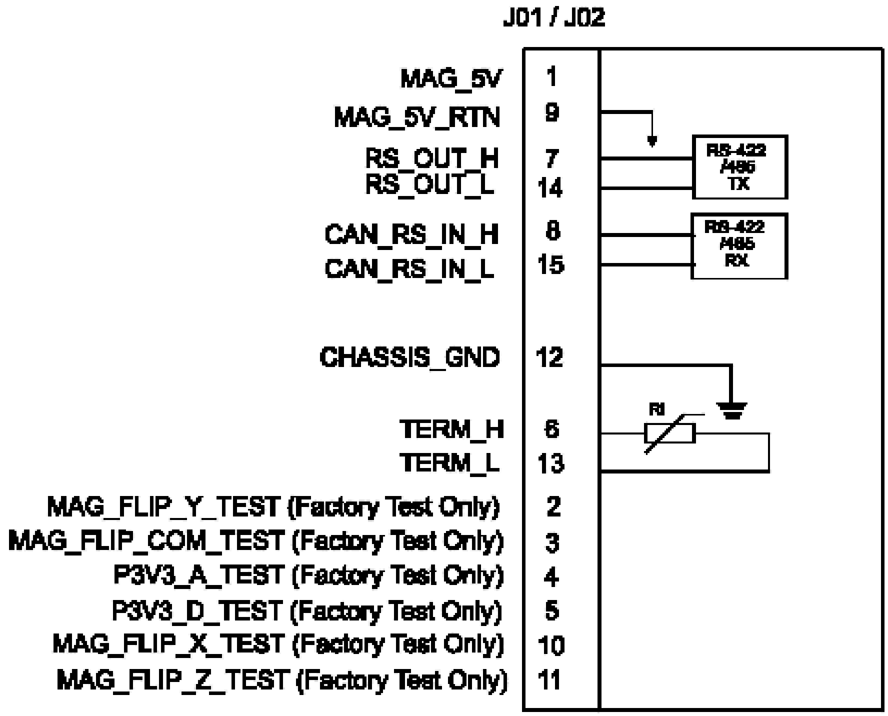

Figure 3.4.1-1 Connection Diagram

3.4.2 MAG J01/J02 Connector Definition

Micro-D connectors provide electrical interface. There are 6 non-flight test signals that are intended for factory test use only and should not have wires connected during flight operation. Proper MAG operation and EMI characteristics are not guaranteed if S/C cable connections are made to the factory test signals.

Both J01 and J02 are identical connectors and have identical physical, electrical, and mechanical properties. The pin out and signal definition are identical.

3.4.2.1 Connector Type

The J01 and J02 connecters are 15 position micro D socket shell connectors, MDA series corrosion resistant electro-deposited nickel plated (IAW SAE-AMS-2404, Class 4) on aluminum alloy type 6061.

The user supplied mating connectors require similar metal shells in order to prevent corrosion.

3.4.2.2 Connector Hardware

The unit connectors J01 & J02 are 15 pin connectors.

Any connector covers used on J01 & J02 are non-flight items.

3.4.2.2.1 Jackpost

Connector jackposts are per MIL-DTL-83513 for rear panel mount connectors.

3.4.2.3 Connector Location

The prime and redundant connectors are found on the side of the MAG as shown in Figure 3.5.1-1. J01, associated with the board closest to the cover, is designated the prime or nominal connector and J02, associated with the board closest to the mounting surface, is designated the redundant connector.

3.4.2.4 Connector Pin Out Definition

The keying, power and signal pin out is as depicted in Figure 3.4.2.4-1.

The Figure 3.5.2.4-1 show the view of connector pin outs looking into connector face.

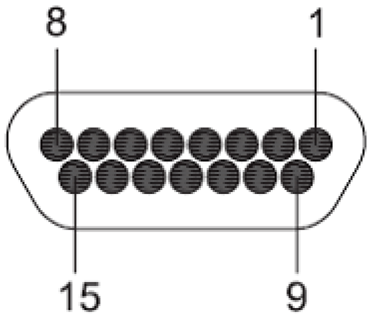

Figure 3.4.2.4-1 J01/J02 Connector Pin Out

3.4.3 Electrical Interfaces

3.4.3.1 Signal Definition

The Table 3.5.3-1 defines the J01/J02 connector pin assignments.

The MAG will accept +5VDC power from the S/C secondary power subsystem on one power bus over two pins (one for power and one for power return).

Table 3.4.3-1 J01/J02 Power Connector Pin Assignments

Pin #	Signal Name	Signal Description
1	MAG_5V	5V Power Input
2	MAG_FLIP_Y_TEST	Internal factory use only. No flight connection.
3	MAG_FLIP_COM_TEST	Internal factory use only. No flight connection.
4	P3V3_A_TEST	Internal factory use only. No flight connection.
5	P3V3_D_TEST	Internal factory use only. No flight connection.
6	TERM_H	Termination top resistor, 120 ohm
7	RS_OUT_H	RS-422/485 bus line for high level output
8	CAN_RS_IN_H	RS-422/485 bus line for high level input
9	MAG_5V_RTN	5V Power Return
10	MAG_FLIP_X_TEST	Internal factory use only. No flight connection.
11	MAG_FLIP_Z_TEST	Internal factory use only. No flight connection..
12	CHASSIS_GND	Chassis ground
13	TERM_L	Termination bottom resistor, 120 ohm
14	RS_OUT_L	RS-422/485 bus line for low level output
15	CAN_RS_IN_L	RS422/285 bus line for low level input

3.4.3.2 Power Interface

The power interface and expected input voltage performance criteria are defined in **Table 3.4.3-2**.

A minimum 200 ms time delay is recommended from power off to subsequent power on to insure proper unit reset.

The nominal BoL steady state power for the unit with a single connection powered is 280mW and the maximum EoL power, which occurs at power-on, is 525mW. For RS-485 units, the nominal BoL steady state power for the unit is 210mW and the maximum EoL power, which occurs at power-on, is 475mW. Unit to unit variation in nominal power of up to ±20mW has been observed.

Table 3.4.3-2 Power Interface voltage

Description	**Value**	**Units**
Nominal input voltage	5	V
Full performance input voltage range	4.5 to 5.5	V
Minimum Survival Voltage	-0.5	V
Minimum Input Voltage Rise Time	606	µs
Maximum Input Voltage Rise Time	2558	µs
Maximum Allowed Ripple on Input Voltage	50 mVp-p	V
Maximum Input Capacitance	100	µF

Typical power-on inrush at 5V input is depicted in the figures below.

Note that Figures 3.4.3-4 and 3.4.3-5 are not applicable to the RS-422 interface unit and are not included in the 422 document version.

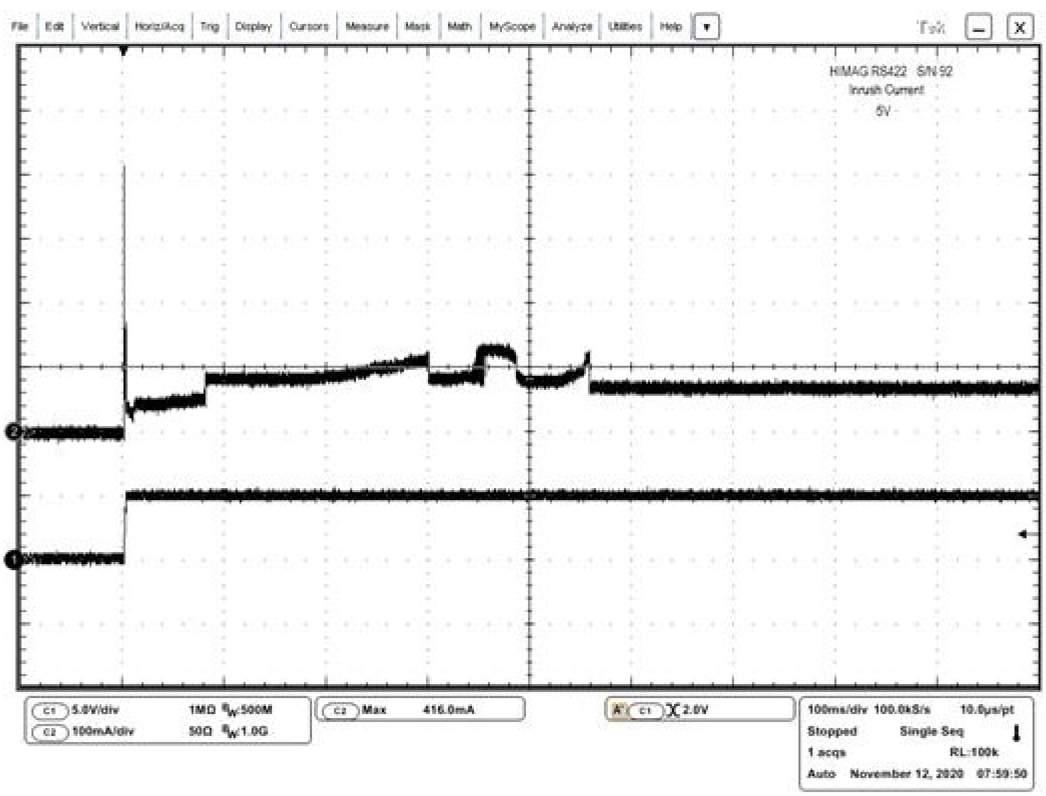

Figure 3.4.3-2 RS-422 Typical Input Power Inrush (100msec/div).

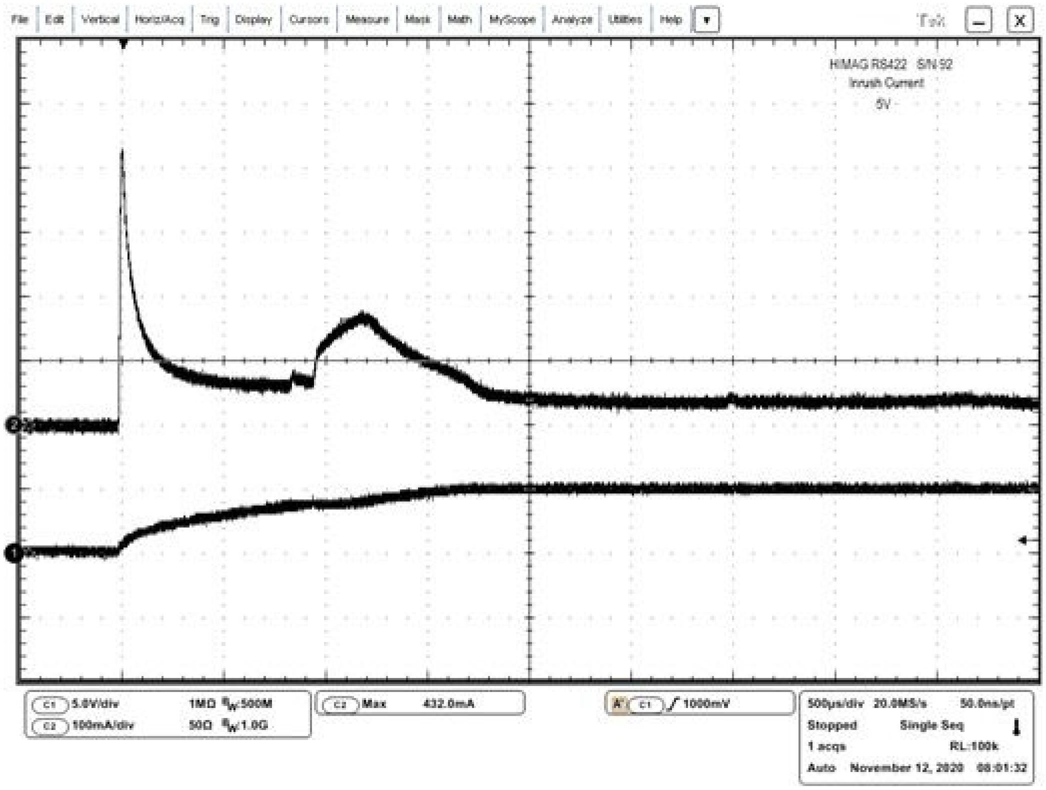

Figure 3.4.3-3 RS-422 Typical Input Power Inrush (500µsec/div).

3.4.3.2.1 Power Isolation

The primary power lines are isolated from the unit structure/chassis and from secondary ground. The minimum resistance between any power line and the chassis is 1 mega-ohm.

3.4.3.3 Flight Signal Interface

3.4.3.3.1 Communication bus input/output signals

The RS bus line for high level input CAN_RS_IN_H signal goes to the receiver.

The RS bus line for low level input CAN_RS_IN_L signal goes to the receiver.

The RS-422/485 bus line for high level output RS_OUT_H signal goes to the transmitter.

The RS-422/485 bus line for low level output RS_OUT_L signal goes to the transmitter.

For half-duplex RS-485 protocol, CAN_RS_IN_H must be tied to RS_OUT_H and CAN_RS_IN_L must be tied to RS_OUT_L.

3.4.3.3.2 TERM_H & L

These two connections allow for termination of the communication bus with an internal 120 ohm resistor, .25W, 1% tolerance, if required by the S/C bus architecture.

3.4.3.4 Test Signal Characteristics

This section is for Factory Test Only.

Signals labeled "Factory Test Only" are reserved for factory use and are not intended for connection to any satellite interface.

3.4.4 Frequency Plan

The following frequencies are used in the magnetometer design:
- Crystal Oscillator 8MHz @ 3.3V
- PWM 7.8125 kHz

3.5 Power on and Mode Sequencing

The following section specifies the different modes of operation, including transition requirements to each mode and the unique functional requirements that are executed in each mode.

3.5.1 Init Mode

The MAG autonomously transitions to the Init Mode upon application of input power and initializes the selected interface in accordance with the interface mode and slave address stored in EEPROM.

During Init Mode, the three redundant values of the MAG INTERFACE_SELECT parameter in EEPROM are compared and any single mismatch is replaced with the value contained in the other two. In the event no two values match, the MAG defaults to RS-485 mode.

During Init Mode, the three redundant values of the MAG SLAVE_ADDRESS parameter in EEPROM are compared and any single mismatch is replaced with the value contained in the other two. In the event no two values match, the MAG defaults to slave address 0x09.

3.5.2 Service Mode

The MAG autonomously transitions to the Service Mode upon completion of the Init Mode..

The Service Mode provides the functionality of reading/writing of memory areas using the active flight interface, as specified in Para 3.6 and subparagraphs applicable to the Service Mode and selected interface.

3.5.3 Operational Mode

The MAG transitions to the Operational Mode upon receipt of a valid OPMODE command, as specified in Para 3.6 and subparagraphs applicable to the selected interface, providing the User App CRC is valid, as specified in para 7.1.2. In the event a CRC mismatch is detected, the MAG remains in service mode.

The Operational Mode provides the full functionality of the MAG using the selected flight interface protocols, as specified in Para 3.6 and subparagraphs applicable to the Operational Mode and selected interface.

3.5.4 Watchdog Timer Reset

The MAG is equipped with a watchdog timer which resets the unit in the event of an unrecoverable software error. Upon watchdog timer reset, the MAG re-enters Init Mode and performs a normal power-on mode transition, including the requirement for an OPMODE command to enter Operational Mode.

3.6 Command and Data Interface

3.6.1 RS422/485 Interface Description

The MAG RS422/485 interface is derived from industry standards. The frame format of message is derived from the MODBUS-RTU standard. The Function code meaning is optimized for use in the MAG context.

Network configuration consists of one master node connected to one slave for RS-422 and one master to between one or up-to 31 slave nodes for RS-485. The network has to be single master bus architecture. The RS-485 network configuration is shown in Figure 3.6.1-1.

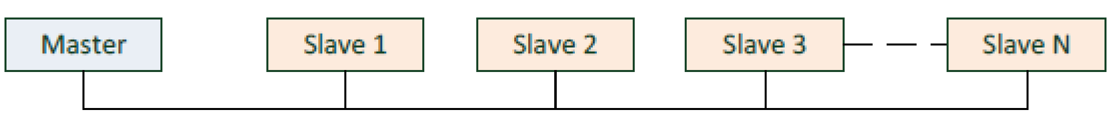

Figure 3.6.1-1 RS485 network configuration

MAG supports full-duplex RS422 and RS485 and half-duplex RS485 communication. For the half-duplex RS485 mode, respective Tx and Rx lines must be interconnected via S/C cabling.

3.6.1.1 Message Format

Two message types are supported: receive messages, which are used to transport data from the master to a slave, and transmit messages, which are used to transport data from one slave to the master.
The protocol separates messages by a silent interval corresponding to at least 256us transmission time. The entire message frame must be transmitted as a continuous stream of bytes. The first two bytes are used for transport control "Slave Address and Function Code" and the two last bytes are used for CRC. The rest of the bytes are defined as data. Figure 3.6.1-2 shows the message frame.

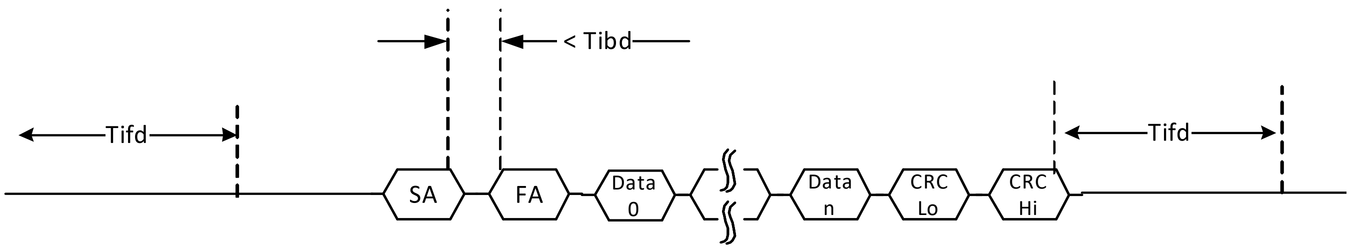

Figure 3.6.1-2 Message format

Table 3.6.1-1 Message Word and Frame Definition

Tifd and Tibd are defined as follows.

Tibd < Tifd = 256us.

Tifd	*Start and End of frame*	*Start and End of frame is marked as at least Tifd times of silence. "Inter-Frame Delay"*
Tibd	*"Inter-Bytes Delay"*	*Tibd has to be shorter than Tifd(Tibd < Tifd)*
SA	Slave Address	*Address is 8-bit length identify slave device on the bus.* *Address range is limited to 0-31* *Default Address is 0x09*
FA	Function Address	*Function is 8-bit length and indicates the function code (Service Function)*
DATA	-	*Data filling is depending on the message type.*
CRC	Cyclic Redundancy Check	*MODBUS CRC-16, polynomial: (0xA001), Init value = 0xFFFF* *CRC is calculated over SA, FA and DATA*

3.6.1.2 Data Flow

Each byte is sent according the format below.

Coding System: 8-bit binary

Baud Rate: 57600 bit/sec

Bits per Byte: - 1 start bit

- 8 data bits, least significant bit sent first
- 1 even parity bit
- 1 stop bit

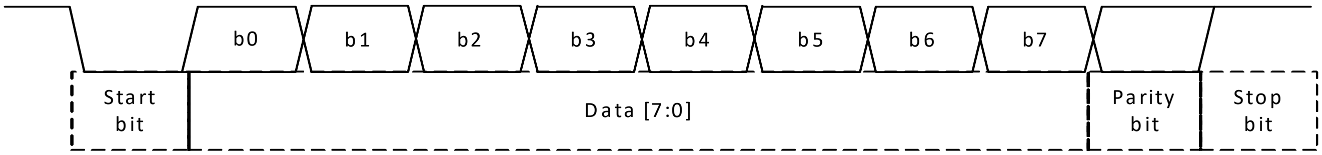

Figure 3.6.1.2-1 UART Word Format

3.6.1.3 Supported Functions

The following section specifies the message handling for the MAG during the SERVICE MODE and OPERATIONAL MODE. The table below shows the supported function addresses for the RS485/422 interface.

Table 3.6.1.3-1 Supported Functions

Function Address	Name	Mode	Description
0x01	MAGDATA	Operational	Request magnetometer transmission of compensated magnetic field data. When the request is received, the magnetometer sends data processed during the previous request. Once the data are transmitted, the magnetometer delays for the TUNABLE_DELAY period, then invokes field measurement and processing to have data ready for the next request (see Appendix D). In the first MAGDATA request response message following power-on or reset, the data bytes are set to zero.
0x02	MAGID	Operational	Request magnetometer transmission of SW Version, Unit product number and serial number.
0x05	MAGTEMP	Operational	Request magnetometer transmission of the last temperature value of MAG Magnetometer MAGTEMP response message data bytes are set to zero until the first magnetic field measurement is processed
0x0C	MEMREAD	Service	Request for transmission of data from RAM memory.
0x0D	MEMWRITE	Service	Request for writing data to RAM memory.
0x0E	MEMCMD	Service	Request for non-volatile memory command execution.
0x0F	OPMODE	Service	Request for mode transition from SERVICE mode to OPERATIONAL mode.

Functions not shown are reserved for factory use.

3.6.1.4 Message Handling

- Any message with a different slave address is ignored.
- If an Unknown function address is received, the MAG ignores the message and does not transmit a response.
- If a MEMWRITE, MEMREAD, MEMCMD or OPMODE function is received during OPERATIONAL MODE, the MAG ignores the message and does not transmit a response.
- If a MAGDATA, MAGID or MAGTEMP is received during SERVICE MODE, the MAG transmits the respective response message with data bytes set to zero

The following tables describe master message requests and slave responses in specific operation modes. Compositions of messages are shown as word sequences. Detailed data representation and word definitions are defined in Appendix A: Message Data Definition.

Table 3.6.1.4-1 RS422/485 Magnetometer Data Messages

	Communication Frame																Length
	1/17	2/18	3/19	4/20	5/21	6/22	7/23	8/24	9/25	10/26	11/27	12/28	13/29	14/30	15/31	16/32	
FA = 0x01 - Read Magnetometer Data – Operational Mode / Service Mode *1																	
M. Req	SA	0x01	CRC_{LO}	CRC_{Hi}													4
S. Resp	SA	0x01	STS	X_{HI}	X_{LO}	Y_{HI}	Y_{LO}	Z_{HI}	Z_{LO}	M_{STS}	CRC_{LO}	CRC_{Hi}					12
S. Resp – Service M	SA	0x01	STS	0x00	0x00	0x00	0x00	0x00	0x00	M_{STS}	CRC	CRC					12

Table 3.6.1.4-2 RS422/485 Magnetometer ID Messages

	Communication Frame																Length
	1/17	2/18	3/19	4/20	5/21	6/22	7/23	8/24	9/25	10/26	11/27	12/28	13/29	14/30	15/31	16/32	
FA = 0x02 - Read Magnetometer ID – Operational Mode / Service Mode *1																	
M. Req	SA	0x02	CRC_{LO}	CRC_{Hi}													4
S. Resp	SA	0x02	STS	SW_{MI}	SW_{MI}	SW_{MA}	SW_{MA}	UP_1	UP_2	UP_3	UP_4	UP_5	UP_6	UP_7	UP_8	UP_9	22
	UP_{10}	UP_{11}	SN_{HI}	SN_{LO}	CRC_{LO}	CRC_{Hi}											
S.Resp – Service M	SA	0x02	STS	0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x00	22
	0x00	0x00	0x00	0x00	CRC	CRC											

Table 3.6.1.4-3 RS422/485 Magnetometer Temperature Messages

	Communication Frame																Length
	1/17	2/18	3/19	4/20	5/21	6/22	7/23	8/24	9/25	10/26	11/27	12/28	13/29	14/30	15/31	16/32	
FA = 0x05 - Read Magnetometer Temperature – Operational Mode																	
M. Req	SA	0x05	CRC_{LO}	CRC_{Hi}													4
S. Resp	SA	0x05	STS	T_{HI}	T_{LO}	CRC_{LO}	CRC_{Hi}										7

Table 3.6.1.4-4 RS422/485 Read Memory Messages

	Communication Frame																Length
	1/17	2/18	3/19	4/20	5/21	6/22	7/23	8/24	9/25	10/26	11/27	12/28	13/29	14/30	15/31	16/32	
FA = 0x0C – MEMREAD - Read Memory – Service Mode Only																	
M. Req	SA	0x0C	MT	AD0	AD1	AD2	AD3	LEN	CRCLo	CRCHi							10
S.Resp -	SA	0x0C	STS	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	37
	D14	D15	D16	D17	D18	D19	D20	D21	D22	D23	D24	D25	D26	D27	D28	D29	
	D30	D31	D32	CRCLo	CRCHi												

Note: Response example is for MEMREAD when LEN = 32

Table 3.6.1.4-5 RS422/485 Write Memory Messages

	Communication Frame																Length
	1/17	2/18	3/19	4/20	5/21	6/22	7/23	8/24	9/25	10/26	11/27	12/28	13/29	14/30	15/31	16/32	
FA = 0x0D – MEMWRITE - Write Memory – Service Mode Only																	
Master Msg	SA	0x0D	MT	AD0	AD1	AD2	AD3	LEN	D1	D2	D3	D4	D5	D6	D7	D8	42
	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19	D20	D21	D22	D23	D24	
	D25	D26	D27	D28	D29	D30	D31	D32	CRCLo	CRCHi							
S. Resp	SA	0x0D	STS	CRCLo	CRCHi												5

Note: Example is for MEMWRITE message when LEN = 32

Table 3.6.1.4-6 RS422/485 Memory Command Messages

	Communication Frame																Length
	1/17	2/18	3/19	4/20	5/21	6/22	7/23	8/24	9/25	10/26	11/27	12/28	13/29	14/30	15/31	16/32	
FA = 0x0E – MEMCMD - Memory Command – Service Mode Only																	
Master Msg	SA	0x0E	CMD	AD0	AD1	AD2	AD3	LEN	LEN	CRCLo	CRCHi						11
S. Resp	SA	0x0E	STS	CRCLo	CRCHi												5

Table 3.6.1.4-7 RS422/485 Operation Mode Command Messages

	Communication Frame																Length
	1/17	2/18	3/19	4/20	5/21	6/22	7/23	8/24	9/25	10/26	11/27	12/28	13/29	14/30	15/31	16/32	
FA = 0x0F – OPMODE - Go To Operation Mode Command – Service Mode Only																	
Master Msg.	SA	0x0F	CRCLo	CRCHi													4
S. Resp	SA	0x0F	STS	CRCLo	CRCHi												5

Note: For a number divided into two bytes XLO represents the lower part of number (least significant byte) and XHI represents the higher part of number (most significant byte).

3.6.1.5 Message Byte Sequence

During a transmission of multi-byte numbers, the byte containing the most significant byte (MSB) is transmitted first followed by subsequent bytes in decreasing significance order and completing the transmission with the byte containing the least significant byte (LSB) transmitted in the last place - Big Endian.

Cyclic Redundancy Check and Address Bytes are transmitted in reversed order - Little Endian.

3.6.2 CAN Interface Description

The CAN communication protocol is not applicable to this version of the ICD..

Functions not shown are reserved for factory use.

3.6.3 Memory Area Map

The MAG memory area map is presented in Figure 3.6.3-1.

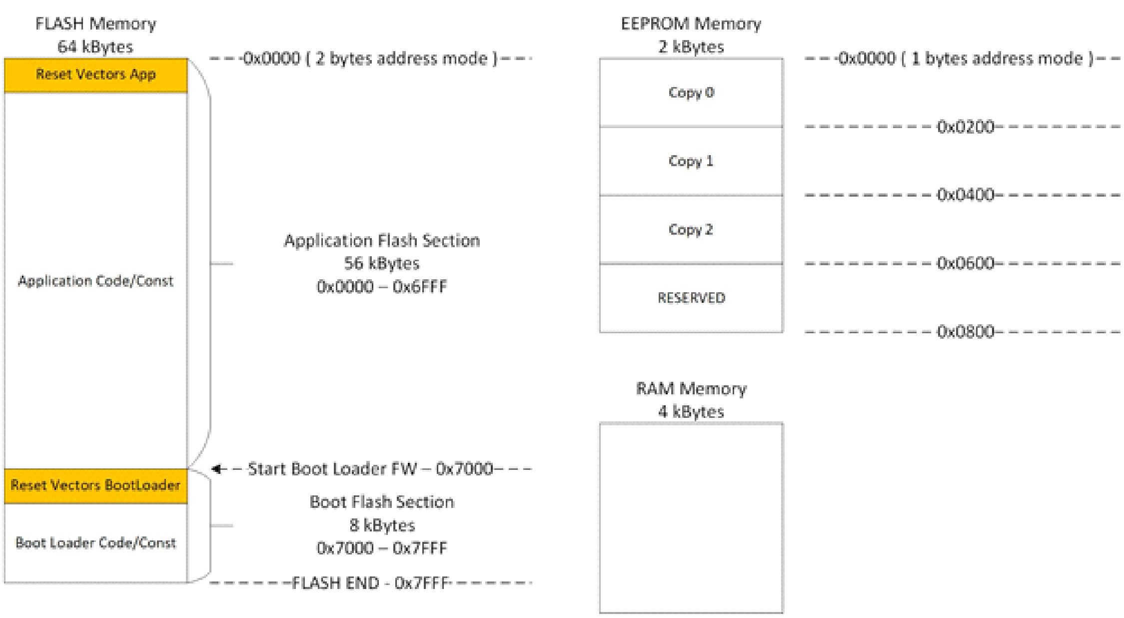

Figure 3.6.3-1 Memory Area

The user can access RAM Memory area using MEMWRITE, MEMREAD commands. To access non-volatile memory areas (FLASH or EEPROM) the user has to additionally use the MEMCMD command, which copies the desired data between non-volatile memory and RAM.

These messages are only valid during Service Mode. If these Messages are transmitted during Operational Mode, the MAG does not process them nor transmit any response.

3.6.3.1 Memory Area Access

Memory Areas specified in Figure 3.6.3-1 can be accessed only during Service Mode. During Operational Mode, read and write access to these areas is disabled.

3.6.3.2 Memory Sector: RAM

Specific RAM memory areas are readable and writable in Service Mode. To read and write data from RAM memory, the MEMREAD and MEMWRITE commands are used. The MAG has two user accessible areas in RAM memory: Status/config registers area and Memory Buffer area. The user must select the appropriate area in the MEMREAD and MEMWRITE commands.

3.6.3.2.1 RAM Memory Buffer

The Memory Buffer is a 256 byte area in RAM dedicated to non-volatile memory operations. MEMCMD command can transfer data between the RAM Memory buffer and non-volatile memory.

3.6.3.2.2 Status/Config Registers

Status/Config registers are read and write registers located in RAM memory.

3.6.3.2.2.1 Memory Status Register

The status register is Read Only register at address 0x00 in the Status/Config Registers area of RAM memory. Every non-volatile read or write operation is a time consuming event. Therefore, the magnetometer bootloader implements the busy indication bit in the status register during these operations.

If the non-volatile memory operation is in-progress the busy bit is set.

If the non-volatile memory operation is not active -- All EEPROM or FLASH operation are finished -- then the busy indication bit is cleared

Table 3.6.3.2.2.1-1 Memory Status Register Definition

Memory Status register (0x00 - Read Only)								
bits	7	6	5	4	3	2	1	0
	-	-	-	-	-	-	-	0/1
name	Reserved							busy
busy			0	Non-volatile memory interface is free. “ready for cmd”				
			1	Non-volatile memory interface is busy				

3.6.3.2.2.2 Configuration Register (Memory Key Enable)

To enable reading/writing to non-volatile memory areas via MEMCMD, the specific key has to be written into the Configuration Register. The Configuration Register is a Read/Write register at address 0x01 in the Status/Config Registers area of RAM memory. The Memory Key Input value specified in Table 3.6.3.2.2.2-1 must be in the register to enable the MEMCMD command.

Table 3.6.3.2.2.2-1 Memory Key Input

Memory Access Key	**Location in Status/Config Register (hex)**	**Value (hex)**
Memory Key	0x01 - 0x08	0x55AA55AA55AA55AA

Reading and writing to some non-volatile memory areas is restricted to factory use. Use of the memory command must be carefully controlled to avoid inadvertent changing of values not intended to be changed. Improper values can result in a non-responsive unit.

3.6.3.3 Memory Sector: EEPROM

The EEPROM memory area is readable and writable in Service Mode when the Memory Key is present in the Configuration Register. For detailed descriptions of content within EEPROM memory areas, refer to Appendix B: EEPROM Map.

Parameters identified as critical data in EEPROM are stored in triplicated EEPROM memory sectors. Multiple copies allow the MAG to auto correct any critical parameter that has been inadvertently modified and could make the MAG inoperable. The following table specifies the parameters that are identified as critical data.

Table 3.6.3.3-2 - EEPROM Critical Parameters

EEPROM Parameter	**EEPROM Location Primary**	**EEPROM Location (Copy 1)**	**EEPROM Location (Copy 2)**
SLAVE_ADDR	0x0008	0x0208	0x0408
TUNABLE_DELAY	0x000A	0x020A	0x040A

Note:

1. If the Slave Address cannot be verified or re-constructed by majority vote, or the specified address is invalid (outside the range of 0 to 31), ,the address defaults to 0x09.
2. If the Interface Select cannot be verified or reconstructed by majority vote, or the specified mode is invalid (outside the range of 0 to 2), the interface defaults to RS-485.
3. An invalid CAL DATA CRC16 will result in zeroed MAGDATA and MAGTEMP messages transmitted and an error reported. Refer to MAGDATA definition in Appendix A: Message Data Definition for details.
2. Only CAL DATA parameters are protected by a CRC16 algorithm in the Primary and both Redundant Locations. Updates to other parameters in EEPROM do not require a CRC update.

3.6.3.3.1 EEPROM Read Mechanism

To read data from EEPROM, the user must perform a two step process.

1. MEMCMD (Read Command) is sent to the MAG in order to specify the address and number of bytes to read. The MAG then dumps the respective data into RAM Memory Buffer (MEMDATA).

2. MEMREAD is sent to the MAG. This message commands the MAG to transmit the data from RAM Memory Buffer.

3.6.3.3.2 EEPROM Write Mechanism

To load data to EEPROM, the user must use a two-step process similar to EEPROM read and the proper key value must be in the Configuration Register.

1. MEMWRITE is sent to the MAG in order to fill RAM Memory Buffer with desired data.
2. MEMCMD (Write Command) is sent to the MAG. This message commands the MAG to write RAM data to the desired non-volatile memory area.

Refer to Figure 3.6.3.3.1-1 EEPROM Write Mechanism

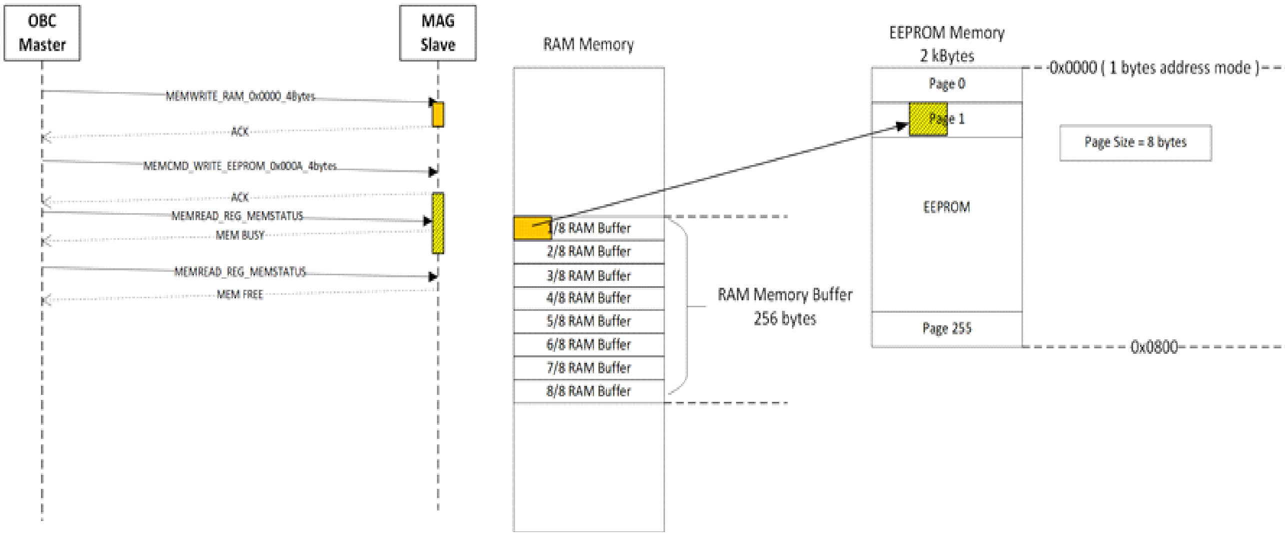

Figure 3.6.3.3.2-1 EEPROM Write Mechanism

3.6.3.3.3 Updating Critical EEPROM Data

Critical Data in EEPROM, as defined in Table 3.6.3.3-2, can be updated using the MEMWRITE and MEMCMD command as previously specified in section 3.6.3.1. During MAG initialization, a majority voting process is performed where the critical EEPROM data primary and redundant locations are compared to identify corrupt values. In the case of CAL DATA, a CRC computation is also performed in the primary and the two redundant locations. Any mismatch value is auto-corrected by the MAG, if possible. If the majority voting process determines a mismatch between all redundant locations and/or there is no calibration data with a valid CRC, a failure error is reported in the MAGDATA message. Refer to Appendix A: Message Data Definition for MAGDATA Message definition.

Due to the majority voting process and auto-correct feature, when updating critical data in EEPROM, care must be taken to update all redundant copies. Failure to do so could result in the overwrite of written parameters or a failure bit enunciation in the MAGDATA message.

To facilitate the maintenance of critical configuration data, the MAG allows for the auto write of redundant locations when writing the primary location. This feature is only implemented for the SLAVE_ADDR, TUNABLE_DELAY, and INTERFACE_SELECT parameters. In order to utilize the auto write process, the MEMCMD message must be transmitted with the address of the critical data parameter and a 1 byte length. Therefore, the only parameter being updated during the MEMCMD transmission must be the critical parameter. This allows the MAG to auto-write the redundant copies for that specific parameter. Due to the majority voting process and auto-correct feature, when updating critical data in EEPROM, the use of writes to individual redundant addresses is not recommended. A critical data mismatch could result in the overwrite of written parameters or a failure bit enunciation in the MAGDATA message.

The USER_APP_ADDR, USER_APP_SIZE, and USER_APP_CRC16 are not intended to be user modified.

3.6.3.4 FACTORY KEY Enabling

Selected messages within the MAG are 'locked' against user modification and are reserved for factory use only.

3.6.3.5 FACTORYPROG KEY Enabling

The Factory Program Key is reserved for factory use.

3.6.3.6 Memory Sector: Flash Memory

- The FLASH memory area is not intended to be modified by the user.

4 NOTES

4.1 Abbreviations and Acronyms

The following list defines the acronyms and abbreviations used in this document.

ADC	Analog to Digital Converter
BIT	Built-In-Test
BOL/BoL	Beginning of Life
CAL	Calibration
CAN	Controller Area Network
CRC	Cyclic Redundancy Check
dB	Decibels
Deg	Degree
EEPROM	Electrically Erasable Programmable Memory
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EOL/EoL	End of Life
GND	Ground
HIMAG	Honeywell Magnetometer
HW	Hardware
Hz	Hertz
ICD	Interface Control Document
IRU	Inertial Reference Unit
kHz	Kilo Hertz
LSB	Least Significant Bit
MAG	Magnetometer
Max	Maximum
Mb	Mega bit
MDA	Military Defense Agency
MHz	Megahertz
Min	Minimum
mS	Millisecond
MSB	Most Significant Bit
N/A or NA	Not Applicable
PBA	Printed Board Assembly
PROM	Programmable Memory
PWA	Printed Wiring Assembly
PWM	Pulse Width Modulation
RAM	Random Access Memory
RMS / rms	Root Mean Square
Sec	Second
SW	Software

µS/µsec	Microsecond
µF	Micro Farads
uV/µV	Micro Volts
VDC/Vdc	Volts Direct Current

5 Appendix A: Message Data Definition

5.1 OBC Command Messages

5.1.1 MEMWRITE

Parameter	Parameter Name	Word	Unit	Data Type	Min Value	Max Value	LSB	Comments
MT	Memory Type	1	NA	UINT	0			0 = memory buffer [256 bytes] 1 = status/config registers area
AD	Memory Address	2-5	NA	UINT	0			
LEN	Number of Bytes to Write	6	NA	UINT	1	32	1	
D	Data Byte 1-32	7-38	NA	NA	NA	NA	NA	

5.1.2 MEMCMD

Parameter	Parameter Name	Word	Unit	Data type	Min Value	Max Value	LSB	Comments
CMD	Memory Command	1	NA	UINT	1	4	1	1 = FLASH READ 2 = EEPROM READ 3 = FLASH WRITE 4 = EEPROM WRITE
AD	Memory Address	2-5	NA	UINT	1		1	
LEN	Number of Bytes to process	6-7	NA	UINT	1	256	1	

MEMCMD command is available only during Service Mode when MEMORY KEY is entered as described in 3.6.3.2.2.2 Configuration Register. Use of the memory command must be carefully controlled to avoid inadvertent changing of values not intended to be changed. Improper values can result in a non-responsive unit.

5.1.3 OPMODE

This message has no data part.

5.1.4 TRIM (FACTORY USE ONLY)

Reserved for factory use.

5.2 OBC Data Acquisition Messages

5.2.1 MAGDATA

This message has no data part.

5.2.2 MAGTEMP

This message has no data part.

5.2.3 MAGID

This message has no data part.

5.2.4 MEMREAD

Parameter	Parameter Name	Word	Unit	Data type	Min Value	Max Value	LSB	Comments
MT	Memory Type	1	NA	UINT	0		1	0 = memory buffer [256 bytes] 1 = status/config registers area
AD	Memory Address	2-5	NA	UINT	0		1	
LEN	Number of Bytes to process	6	NA	UINT	1	32	1	

5.2.5 MAGRAW (FACTORY USE ONLY)

Reserved for factory use.

5.2.6 MAGSETRST (FACTORY USE ONLY)

Reserved for factory use.

5.3 MAG Response Messages

5.3.1 MAG Status Words

This section defines status bytes used in MAG response messages.

5.3.1.1 Magnetometer STATUS "STS"

Parameter	Parameter Name	Bit Offset	Data Type	Comments
RESERVED	N/A	0-4	N/A	
MSGE	Message Error	5	Discrete	0 = Message Valid 1 = Message Invalid
COME	Communication Error	6	Discrete	0 = No parity or CRC error event 1 = Parity or CRC error has happened
DEVM	Device Mode	7	Discrete	0 = Device is in the OPERATIONAL MODE 1 = Device is in the SERVICE MODE

5.3.1.2 Magnetometer Sensors STATUS "Msts"

Parameter	Parameter Name	Bit Offset	Data Type	Comments

Xsat	X Magnetometer Saturated	0	Discrete	0 = Normal 1 = Saturated Saturation Threshold: SATURATION_LIMIT * F.S/100 < M_{avg} < (1 - X/100) * F.S
Ysat	Y Magnetometer Saturated	1	Discrete	0 = Normal 1 = Saturated Saturation Threshold: SATURATION_LIMIT * F.S/100 < M_{avg} < (1 - X/100) * F.S
Zsat	Z Magnetometer Saturated	2	Discrete	0 = Normal 1 = Saturated Saturation Threshold: SATURATION_LIMIT * F.S/100 < M_{avg} < (1 - X/100) * F.S
FLAE	FLASH CRC error	3	Discrete	0 = No error 1 = FLASH CRC error detected
EEPE	EEPROM CAL DATA CRC error	4	Discrete	0 = No error 1 = CRC error detected
SAE	EEPROM MAG SA parameter error	5	Discrete	0 = No error 1= Slave Address cannot be determined; default address is set(0x09)
TDE	EEPROM TD parameter error	6	Discrete	0 = No error 1 = MAG Tunable Delay Mismatch detected
UAPE	EEPROM User App Error	7	Discrete	0 = No error 1 = EEPROM User App CRC/Mismatch Error detected Note: Error can be set for two conditions: - EEPROM USER_APP_CRC16 value does not match computed Application Software CRC16

5.3.2 MAGDATA

Parameter	Parameter Name	Word	Units	Data type	Min Value	Max Value	LSB	Comments
STS (RS485 only)	MAG Status	0	NA	Discrete	NA	NA	NA	For more details see section 5.3.1.1, Magnetometer STATUS "STS"
X	X MAG Data Compensated	1-2	Gauss	INT	2^{15} * LSB	(2^{15} - 1)*	0.00016	Note: X=0x0 in response to the first

						LSB		MAGDATA request after entering OPMODE or when a CALDATA mismatch is detected
Y	Y MAG Data Compensated	3-4	Gauss	INT	2^{15} * LSB	(2^{15} - 1)* LSB	0.0001 6	Note: Y=0x0 in response to the first MAGDATA request after entering OPMODE or when a CALDATA mismatch is detected
Z	Z MAG Data Compensated	4-6	Gauss	INT	2^{15} * LSB	(2^{15} - 1)* LSB	0.0001 6	Note: Z=0x0 in the response to the first MAGDATA request after entering OPMODE or when a CALDATA mismatch is detected
MSTS	Magnetometer Sensor Status	7	NA	Discre te	NA	NA	NA	For more details see section 5.3.1.2, Magnetometer STATUS “Msts”

5.3.3 MAGTEMP

Parameter	Parameter Name	Word	Unit	Data type	Min Value	Max Value	LSB	Comments
STS (RS485 only)	MAG Status	0	NA	Discre te	NA	NA	NA	For more details see section 5.3.1.1, Magnetometer STATUS “STS”
T	Temperature	1-2	° C	INT	-30	70	0.5	Note: T=0x0 before the first MAGDATA message is processed or when a CALDATA mismatch is detected

5.3.4 MAGID

Parameter	Parameter Name	Word	Unit	Data type	Min Value	Max Value	LSB	Comments
STS (RS485 only)	MAG Status	0	NA	Discre te	NA	NA	NA	For more details see section 5.3.1.1, Magnetometer STATUS “STS”
SWMI	SW Version Minor	1-2	NA	ASCII	0	99	1	
SWMA	SW Version Major	3-4	NA	ASCII	0	99	1	
UP	Unit Part Number	5-15	NA	ASCII	0	99	1	Example ASCII: '56011974001'

SN	Unit Serial Number	16-17	NA	UINT	0	65,535	1	

5.3.5 MEMDATA

Parameter	Parameter Name	Word	Unit	Data type	Min Value	Max Value	LSB	Comments
STS (RS485 only)	MAG Status	0	NA	Discrete	NA	NA	NA	For more details see section 5.3.1.1, Magnetometer STATUS “STS”
D	Data byte 1-32	1-32	NA	NA	NA	NA	NA	

6 Appendix B: EEPROM Map

The following section provides a detailed map of the EEPROM content. Where a parameter requires more than 1 byte, the lower EEPROM address holds the parameter's LSB and the higher address holds the parameter's MSB.

The MSB and LSB sequence for EEPROM parameters for DataType equal to ASCII are defined in the Comments column.

Address	Description	Parameter Name	# of Bytes	Data Type	Units	Min Value	Max Value	Scale Factor	Default Value	Comments
0x0000	Factory Key	FACTORY_KEY	8	UINT64	NA	NA	NA	NA	0x00	Factory Reserved
0x0008	Slave Address	SLAVE_ADDR	1	UINT	NA	0x00	0x1F	NA	0x09	
0x0009	Watchdog Time Address	WDT_TMR_ADDR	1	UINT	NA	0x03	0x07	NA	0x07	WDT Timeouts: 3 = 117.6 ms 4 = 235.2 ms 5 = 470.4 ms 6 = 940.8 ms 7 = 1881.6 ms Code sets timeout to 1881.6 ms if value in EEPROM not in range.
0x000A	MAG Data Freshness Delay	TUNABLE_DELAY	1	UINT	mS	0x11	0x37	1 mS	0x37	Out of range values default to 55 ms
0x000B	Interface Select	INTERFACE_SEL	1	UNIT	NA	0x00	0x02	NA	0x01	Factory Reserved
0x000C	RESERVED		4							Factory Reserved
0x0010	User Application Address	USER_APP_ADDR	2	UINT	NA	0x0000	0xFFFF	NA		
0x0012	User Application Size	USER_APP_SIZE	2	UINT	NA	0x0000	0xFFFF	NA	Varies	
0x0014	User Application CRC16 Value	USER_APP_CRC16	2	UINT	NA	0x0000	0xFFFF	NA	Varies	
0x0016	RESERVED		2						Factory Reserved	Factory Reserved
0x0018	Unit Part Number	UNIT_P_N	11	ASCII	NA	NA	NA	NA		Unit Part Number: (MSB ...... LSB): Example: 56011974001
0x0023	PWA Serial Number	PWA_S_N	2	UINT	NA	0x0000	0xFFFF	NA	Varies	
0x0025	Chassis Serial Number	CHASS_S_N	2	UINT	NA	0x0000	0xFFFF	NA	Varies	
0x0027	PWA production week	MFG_WEEK	1	UINT	NA	0x01	0x34	NA	Varies	0x01 = Week 1 0x34 = Week 52
0x0028	RESERVED	N/A	1							
0x0029	PWA production year	MFG_YEAR	2	UINT	NA	0x07E0	0xFFFF	NA	Varies	0x07E0 = 2016
0x002B	Honeywell Hardware Part Number	HW_P_N	12	ASCII	NA	NA	NA	NA	Varies	HW Part Number: (MSB ...... LSB): 56011974-001 (FLT–RS485) or 56011974-002 (FLT–RS422) or 56011974-003 (FLT–CAN)

Address	Description	Parameter Name	# of Bytes	Data Type	Units	Min Value	Max Value	Scale Factor	Default Value	Comments
0x0037	Honeywell Software Part Number	SW_P_N	14	ASCII	NA	NA	NA	NA	Varies	SW Part Number: (MSB ...... LSB): 56011971-xx.yy - where xx is 2 bytes ASCII numeric from 01 to 99 - where yy is 2 Bytes ASCII numeric (Set to 00 for flight units)
0x0045	Boot Loader SW		14	ASCII	NA	NA	NA	NA		Example 56011971-xx.yy
0x0053	RESERVED		5							Factory Reserved
0x0058	Calibration Data	Various	63	Various	°Variou s	Various	Various	Various)	Varies	Factory Reserved

7 Appendix C: Error Reporting Capability

7.1 CRC Error

7.1.1 Calibration Data Validity Memory Protection

During the initialization phase of the magnetometer embedded software (SW), calibration and compensation values are loaded from EEPROM memory to RAM memory. The validity of these data are checked by computation CRC and compared to the CRC stored in the EEPROM. The table below defines the memory locations of calibration data and their CRC.

The SW computes a CRC for all three copies of calibration data memory regions

The computed values are compared with CRC stored in the EEPROM.

If one or two of the copies have a CRC mismatch, the associated data are rewritten with a copy from a segment without a CRC error, as determined by the majority voting process, if required.

If two or more of the copies have a valid CRC, but they do not match each other, the majority voting process will utilize the value from any two matching copies to correct the third. If no two copies have the same CRC, but more than one has a valid CRC, the data from the lowest segment with a valid CRC will be utilized to correct the other two,

If all copies have a CRC mismatch, data recovery is not possible and the EEPROM CRC Error Flag is set in the Magnetometer Sensors STATUS byte.

Table 7.1.1-2 Magnetometer sensors status byte definition (EEPE)

Msts – Magnetometer sensors status byte definition								
Bits	7	6	5	4	3	2	1	0
Name	Xsat	Ysat	Zsat	FLAE	EEPE	SAE	TDE	UAPE

EEPE	‘0’	No error
	‘1’	EEPROM CRC error detected for CAL DATA parameters

7.1.2 Embedded Software FLASH Code Validity Memory Protection

Upon receipt of the OPMODE command to attempt to transition to Operational Mode, the validation of FLASH data is performed. The validity of these data are checked by computation CRC and compared to the CRC stored in EEPROM. The table below defines the significant memory locations for magnetometer SW in the FLASH.

Table 7.1.2-1 embSW EEPROM Data Structure

0x0008	Slave Addr	Watchdog T	Latency Delay	Interface	RESERVED	
0x0010	App SW Start Address		App SW size		App CRC	RESERVED
0x0018	Unit Part Number[10:3]					

App SW Start Address – The entrance pointer to memory where the magnetometer application starts.
App SW size – The size of magnetometer application in bytes.
App CRC – The pre-computed CRC value for mag. application binary.

The boot-loader computes a CRC for program data in the FLASH memory.
[App_SW_Start_Address, (App_SW_Start_Address+ App_SW_size) – 1]

The computed CRC is compared with the CRC stored in the EEPROM "App_CRC“.

If the computed CRC is not the same as CRC stored in the EEPROM then the MAG remains in Service Mode.

The FLASH CRC Error Flag is set in the Magnetometer Sensors STATUS byte.

Table 7.1.2-2 Magnetometer sensors status byte definition (FLAE)

Msts – Magnetometer sensors status byte definition								
Bits	7	6	5	4	3	2	1	0
Name	Xsat	Ysat	Zsat	FLAE	EEPE	SAE	TDE	UAPE

FLAE	‘0’	No error
	‘1’	FLASH CRC error detected

7.2 Communication Data Protection, RS422/485

The asynchronous bus communication is protected by CRC checks for both incoming commands and outgoing data using the MODBUS CRC-16 algorithm.

When the end of an incoming communication frame is detected, the computed CRC is compared with received the CRC.

When the computed CRC is not the same as the received CRC, the received message is discarded and the Communication Error (COME) Flag is set in the Magnetometer STATUS "STS“ byte.

Table 7.2-1 Magnetometer status byte definition (COME)

STS – Magnetometer status byte definition								
bits	7	6	5	4	3	2	1	0
name	Reserved					MSGE	COME	DEVM

COME	‘0’	No parity or CRC error event.
	‘1’	Parity or CRC error has happened.

The user should perform a similar CRC computation and comparison of MAG transmitted data, discarding messages with a CRC mismatch and re-issuing the associated command.

7.3 Magnetic Sensors Saturation Status

Each axis, X, Y and Z, implements a saturation flag status.stored in the EEPROM memory.

During each measurement of the magnetic field, the saturation limit is checked for all axes. If the magnetic field in any axis is higher than the SAT_LIMIT, then the Saturation Error Flag for the affected axis is set in the Magnetometer Sensors STATUS byte.

Table 7.3-1 Magnetometer sensors status byte definition (X, Y, Z sat)

Msts – Magnetometer sensors status byte definition								
Bits	7	6	5	4	3	2	1	0
Name	Xsat	Ysat	Zsat	FLAE	EEPE	SAE	TDE	UAPE

[X,Y,Z]sat	‘0’	No error
	‘1’	X axis saturated

7.4 EEPROM Parameter Read Error

Critical EEPROM values are protected by triple a redundancy and voting mechanism. During application initialization, the values are read from EEPROM and the validity of the data are checked by the triple voting mechanism. If any of the values cannot be reconstructed from these three copies, then the corresponding error flag is set.

If the Slave Address cannot be reconstructed, then the SAE Error Flag is set in the Magnetometer Sensors STATUS byte.

If Tunable Delay cannot be reconstructed, then the TDE Error Flag is set in the Magnetometer Sensors STATUS byte.

If App SW Start Address, App SW size, or App CRC cannot be reconstructed, then the UAPE Error Flag is set in the Magnetometer Sensors STATUS byte.

Table 7.4-1 Magnetometer sensors status byte definition (SAE, TDE, UAPE)

Msts – Magnetometer sensors status byte definition								
Bits	7	6	5	4	3	2	1	0
Name	Xsat	Ysat	Zsat	FLAE	EEPE	SAE	TDE	UAPE

SAE	‘0’	No error
	‘1’	MAG Slaves Addresses Mismatch detected
TDE	‘0’	No error
	‘1’	MAG Tunable Delay mismatch detected
UAPE	‘0’	No error
	‘1’	EEPROM User App CRC/Mismatch error detected

7.5 Bad Command Parameter

If the user / OBC sends a message with a valid Slave Address and a command with a valid CRC but parameters are out of range, then the Message Error (MSGE) Flag is set in the Magnetometer STATUS „STS“ byte.

Table 7.5-1 Magnetometer sensors status byte definition (EEPE)

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Msts – Magnetometer sensors status byte definition								
Bits	7	6	5	4	3	2	1	0
Name	Xsat	Ysat	Zsat	FLAE	EEPE	SAE	TDE	UAPE

EEPE	‘0’	No error
	‘1’	EEPROM CRC error detected for CAL DATA parameters

8 Appendix D: Internal Measurement Timing

The diagram below illustrates the main processor activity sequence and the time taken for each. The processor cycle starts when the HIMAG receives a request for data.

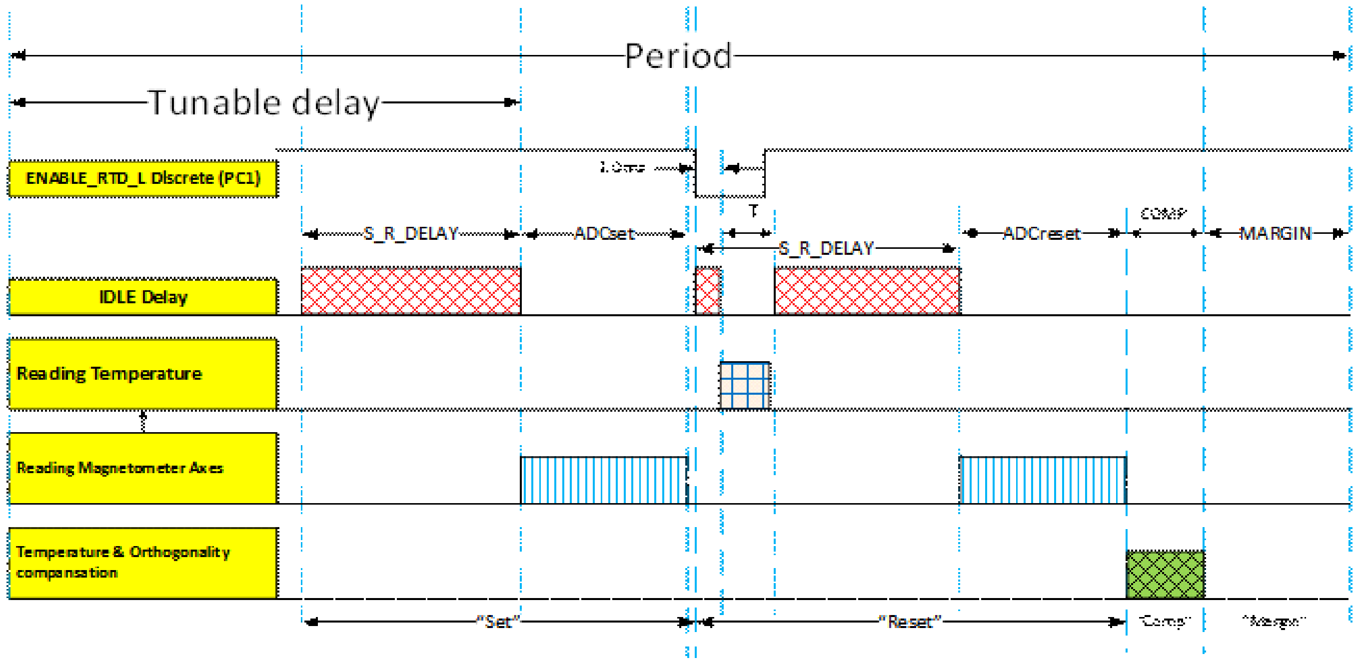

Figure 8.0-1: MAG Acquisition Process and Timing

Table 8.0-1: Time Values for Processor Tasks

Signal Name	Time (mS)	Notes
ADCset	6.2	SW/HW timing
ADCreset	6,2	SW/HW timing
T " Temperature	1	SW/HW timing
Compensation	~0.4	SW/HW timing
Tunable delay	55 (default)	EEPROM param (see note below)
S_R_DELAY	15	Reserved

NOTE: The maximum value of the Tunable delay is 55 for a 100mS request period and 21 mS for a 50 mS data request periods. This parameter can be set in EEPROM by the user to adjust the data latency.

End of Document