Digital Compass

Product Guide

Version 1.0

For Use with AHRS-M1 and AHRS-M2 Sparton Digital Compasses

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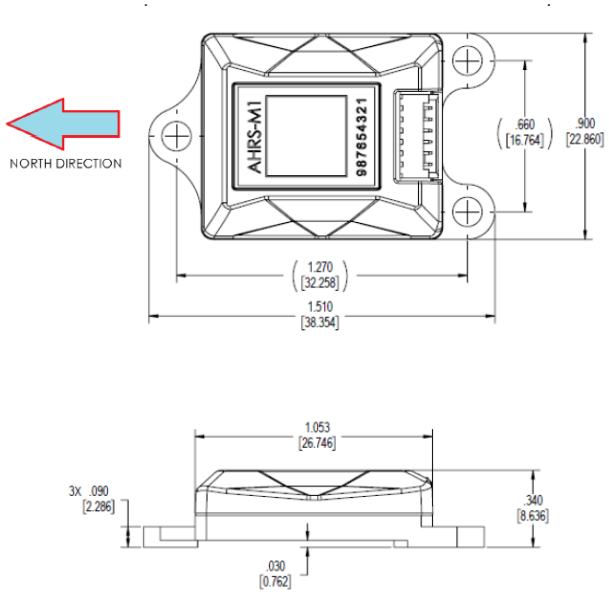
Revision History

REV	CHANGE NO.	DATE OF CHANGE	DESCRIPTION OF CHANGE	INITIALS AND DATE

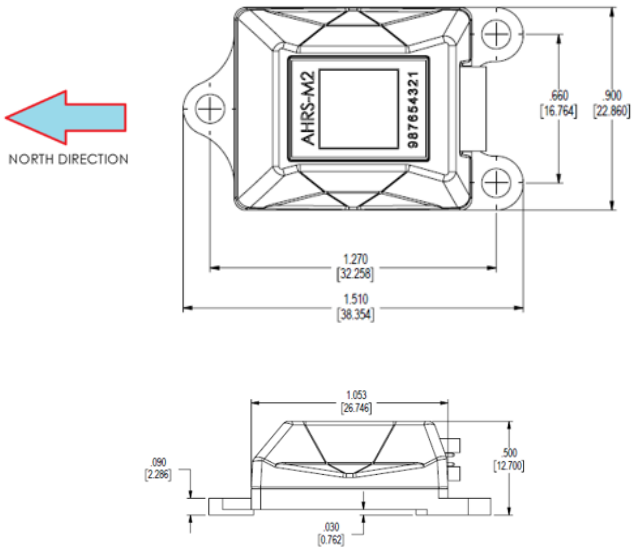
1.0	n/a	9/29/25	• ORIGINAL RELEASE	XXX

INTRODUCTION

The Sparton Navigation and Exploration line of digital compasses provides superior performance and flexibility. Using advanced hardware and software, the Sparton digital compass offers an impressive list of features at an affordable price. It is the world's only low-cost digital compass that provides adaptive in-field calibration via best-in-class AdaptNav™ sensor fusion adaptive algorithms. The AHRS-M2 and AHRS-M1 digital compasses are designed to easily integrate into any system using a logic-level Universal Asynchronous Receiver/Transmitter (UART) interface.



AHRS-M1 Digital Compass



AHRS-M2 Digital Compass

NDS-1 Navigation Development System
Evaluation Board

Specification Comparison

Please reference the data sheets for each product for detailed specifications. The table below is intended to highlight the specification differences between the AHRS-M1 and AHRS-M2.

FEATURES	AHRS-M1	AHRS-M2
Static Heading Accuracy (Deg RMS)	1.5	0.2 (<1.0 from -40C to 70 C)
Magnetic Range (calibration range)	+/- 16 G (+/- 900 mG)	+/- 1.2 G (+/- 900 mG)
Dimensions L x W x H (mm)	38.4 x 22.9 x 8.1	38.4 x 22.9 x 9.1
Mass	6.7 g	12.3 g
Input Power, Operating Mode (Typical @ 4V)	80 mW	60 mW

Features

- Accurate Tilt Compensated Magnetic Heading
  - Magnetic heading is based on a level condition relative to the surface of the Earth. When the compass platform is tilted, an incorrect heading would result if left uncompensated. The Sparton digital compass measures the 3-dimensional magnetic and acceleration field conditions and mathematically corrects the magnetic readings based on the compass orientation.

- 2D and 3D In-Field Magnetic Calibration
  - The Sparton digital compass uses a unique adaptive algorithm that monitors the magnetic field conditions during movement (roll, pitch, and yaw) of the compass platform. The adaptive algorithm minimizes both hard and soft magnetic distortion errors of the mounting platform (i.e. distortions that move with the compass). This revolutionary calibration algorithm is capable of full 3D magnetic calibration as well as accurate 2D calibration for applications with limited pitch and roll capability.

- Full 360° Rollover Capability
  - The Sparton digital compass processing is able to tilt compensate the magnetic readings in any orientation. This gives the compass the ability to provide an accurate magnetic heading for full 360° roll angles.

- AdaptNav™ Sensor Fusion Adaptive Algorithms
  - Best in class *AdaptNav™* adaptive algorithms outperform traditional Kalman filter based approaches by providing real-time optimizations when used in varying magnetic and dynamic operating environments, assuring an industry leading compass performance.

- Motion Stabilization: Gyroscopes
  - Most compasses measure the direction of acceleration due to Earth's gravity to determine a level orientation for tilt compensation. Acceleration due to platform movement can cause errors in heading determination. The gyroscopes and their unique algorithms developed for the Sparton AHRS-M1 and AHRS-M2 digital compass help to stabilize heading, pitch and roll information in the presence of motion.

- Variation Correction/World Magnetic Model
  - The Sparton digital compass directly determines the magnetic heading. The compass can provide True North heading when given the current magnetic variation. The compass can calculate the magnetic variation when given positional information (latitude, longitude, altitude, date) or can be entered directly if the variation angle is known.

- True 3D Magnetic Measurements (in milligauss)
  - The on-board magnetometers are calibrated in-factory to provide true X, Y, and Z magnetic field strengths in milligauss. This magnetic vector is relative to the compass platform. Stray magnetic fields within the compass application are compensated for by using the in-field adaptive calibration to maintain accuracy.

- True 3D Acceleration Measurements (in milli-g)
  - The on-board accelerometers are calibrated in-factory to provide true X, Y, and Z acceleration strengths in milli-g (where 1000milli-g = Earth's Gravity).

- Pitch and Roll (in degrees)
  - Pitch and Roll angles describe the orientation of the Sparton digital compass in degrees from a level condition.

- Temperature (in degrees C)
  - The internal temperature of the Sparton digital compass in degrees-C is available as output.

- User Selectable Mounting Configuration
  - Mounting configuration is user-selectable between horizontal, vertical, left edge, right edge and inverted orientations. Custom orientations are possible via NorthTek™ software scripts.

- Bi-Directional 3.3V Logic-Level UART Communication
  - A 3.3V Logic Level UART interface is provided. The specifics are detailed in the digital interface section of this guide (see page 19).
  - Selectable baud rates in the range of 300 baud to 115.2k baud.

- High Resolution Magnetics
  - The compasses offer high resolution magnetic measurements which provide precise heading accuracy for the most demanding applications.

- Small Size and Weight
  - The small size and low weight of the Sparton digital compasses allow for use in space sensitive applications.

- Robust Design
  - The Sparton digital compass is a RoHS compliant potted module ready to meet the requirements of your design application and environment.
  - Humidity, shock and vibration resistance meets MIL-STD-202G. Please see the specification tables for additional details.

- Quaternion/Rotation Matrix Output
  - The Sparton digital compass provides a Quaternion/Rotation Matrix output.

- User Configurable Messages
  - Provides three user configurable output protocols.

- User Available EEPROM
  - EEPROM not used by the compass is available for use by the customer using NorthTek commands. Contact Sparton for a list of available addresses.

- User Programmable Sensor Customizations via NorthTek™ Development System
  - The Sparton compasses are the world's only programmable digital compasses, providing programming capability for powerful in-compass customizations via a built in Forth interpreter. For more information, please reference the NorthTek™ System Programming Guide.

Applications

- Weather, data, and ocean surveillance
- Electro-optical target designation sensors
- Accurate vehicle attitude position and orientation sensing
- Precision autonomous vehicle guidance
- Ground, sea surface and sub sea surface survey and monitoring
- Not appropriate for aerial applications

Digital Interface

Parameter	Conditions	Typical	Units
UART	8 Data Bits, 1 Stop Bit No Parity	115.2K Factory Default 300 – 115.2K	Baud
UART: USER_RXD, DEBUG_RXD	Input	Logic 0: 0 Logic 1: 3.3	V
UART: USER_TXD, DEBUG_TXD	Output	Logic 0: 0 Logic 1: 3.3	V

Connections

Please refer to the Hardware ICD for detailed connection and mechanical interface specifications.

DIGITAL COMPASS MOUNTING AND HEADING IDENTIFICATION OPTIONS

Both digital compasses are capable of being mounted in a variety of orientations or heading identifications. By selecting the corresponding option code in the Spartacus graphical user interface, the user can select the desired heading identification (see Spartacus Development System Users Guide). Heading is defined to be the angle between magnetic North and the X- axis as shown below. Pitch is the angle of rotation from level about the Y-axis with the positive direction indicated by an arrow about the axis. Roll is the angle of rotation from level about the X-axis with the positive direction also indicated by an arrow. The following table lists all five available mounting options:

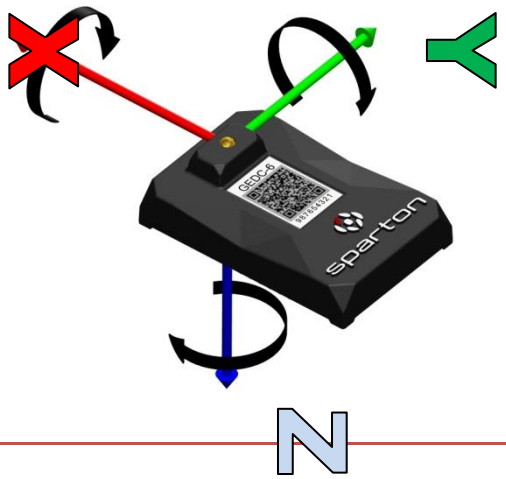
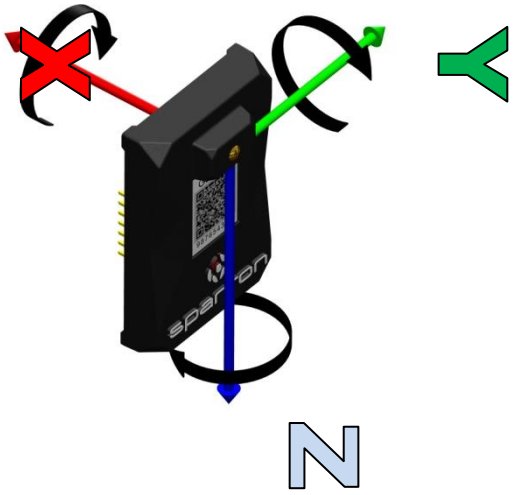
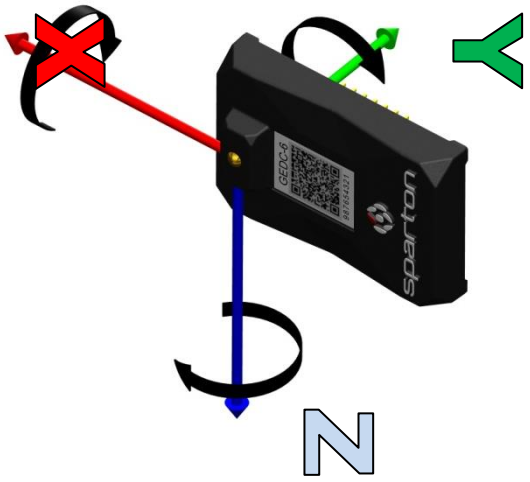
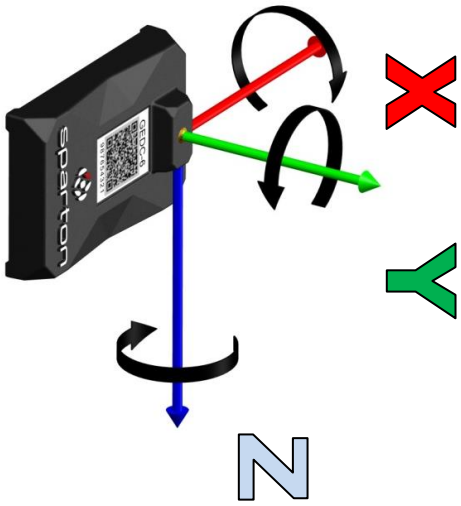
Option #	Heading Identification	Picture
0	Horizontal (Default)	
1	Vertical Mounting	

Figure 4- Digital compass mounting options

Option #	Heading Identification	Picture
2	Left Edge Mounting	
3	Right Edge Mounting	

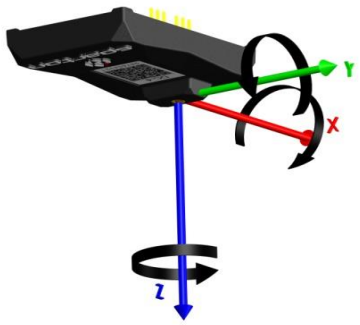
4	Inverted	

Figure 4- Digital compass mounting options

Additionally, it is also possible to mount the Sparton digital compasses in any arbitrary orientation by utilizing available NorthTek™ TARE Command program scripts to set the boresight matrix. To use the TARE command, the host application must first be set flat and level and pointed North. The command to invoke the TARE is “InvokeTare 0 set drop”.
The boresight matrix can also be computed by mechanical design and sent to the compass.

DIGITAL COMPASS INSTALLATION CONSIDERATIONS

Magnetic compasses measure the Earth's local magnetic field and acceleration due to gravity to determine an accurate heading. Any magnetic material that would change the intensity or direction of the Earth's magnetic field will affect compass performance. The following guidelines should be considered when installing the digital compass:

- Install compass away from magnetic materials such as iron or steel. If the compass is to be enclosed, use aluminum, copper, or other non-magnetic material. Please note such an enclosure does not shield the compass from magnetic interference.
- Batteries are magnetic and should be kept as far away as possible.
- Permanent magnets and electric motors generate both static and time-varying magnetic disturbances and should be kept away from the compass
- High-current carrying wires can also generate static and time-varying magnetic fields and should be routed away from the compass
- Characterize the host system to find a good location for placement by observing mag data from the sensor at different positions inside the host device. The goal is to find a location that has a low standard deviation/variance for mag and that the DC offset, if any, is static and does not drift over time. Turn on/off individual components if possible: camera zoom, camera focus, GPS acquiring/tracking. This will provide information as to when the output is more accurate and which internal systems will affect the magnetometer readings. This can be done by streaming/capturing the data by commanding "1 magp.p" or by using the strip chart option for mag in the Spartacus GUI.
- The Sparton digital compass can be mounted in any orientation due to the ability of the compass to translate from its own frame of reference to that of its host using the boresight matrix.

WARNING: It is important to note that operating environments can adversely affect magnetic compasses. Any device operating in the vicinity of a magnetic compass that produces a time-varying magnetic field may degrade compass performance. In addition, any magnetic material that causes severe magnetic distortions in the vicinity of the compass may also degrade compass performance. It is recommended that Sparton be included at the front-end of your product design to assist with compass integration.

DIGITAL COMPASS OPERATIONAL CONSIDERATIONS

- The digital compass is an electrostatic sensitive device. Observe proper ESD precautions to avoid permanent damage caused by static discharge.
- See the data sheet for pin connection specifications.
- The Sparton compasses operate on an unregulated voltage in the range of 4 to 10V.
- The compass reset can be used to force a hardware reset of the compass. This pin has an internal 100k pull-up resistance to the internal 3.3V. Reset is accomplished by pulling this pin to GND.
- In applications with strong EMI or ESD, it is recommended that inputs #RESET and #EINT0 be connected to compass 3.3V supply when not used.
- The in-field magnetic calibration must be performed after installation to achieve specified accuracy. Follow the calibration steps listed in the Software Interface User's Manual. Pitch and roll are factory calibrated and require no additional field calibration.

INTERFACE INFORMATION

Universal Asynchronous Receiver Transmitter (UART)

The UART communicates with the digital compass using 3.3V logic-level signaling.

Communication settings: 115.2K Baud (factory default), selectable from 1200 to 115.2K Baud, 8 data bits, 1 stop bit, no parity.

The UART provides full duplex communication. See the Software Interface User's Manual for a description of valid UART commands.

NDS-1 NAVIGATION DEVELOPMENT SYSTEM KIT

Features

The NDS-1 Development System Kit is designed as a development tool for Sparton's digital compasses. This tool gives the user a pre-designed platform to interface and communicate with the digital compass via a graphical user interface (GUI) or a simple serial terminal. Included in the development kit are:

- NDS-1 Adapter board with power adapter (AHRS-M1 or AHRS-M2 purchased separately)
- Non-magnetic serial cable
- USB Cable
- NDS-1 Host Application Software
- CD containing application software and documentation

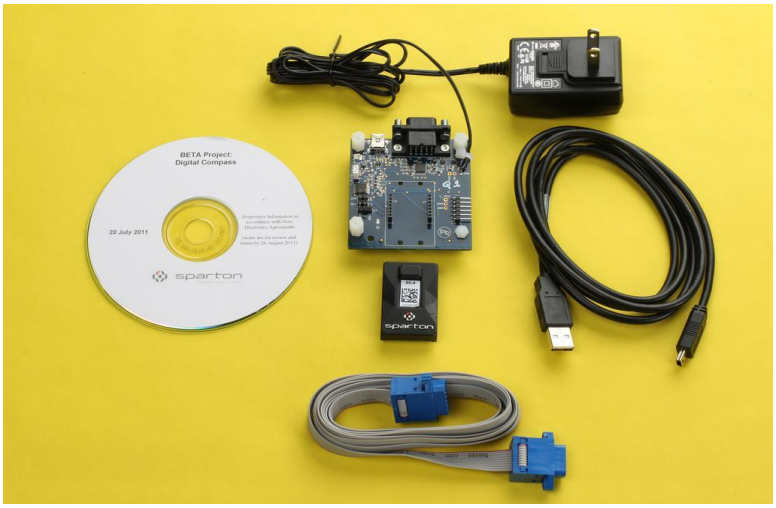


FIGURE 6. NDS-1 HARDWARE

The NDS-1 Adapter Board allows the digital compass to be connected directly to a 9 pin serial port connector or USB port of a PC. It also provides convenient access to all compass signals for development and testing.

Hardware and Software Setup

Please reference the AHRS-M1_M2 Quick Start Guide.pdf and the reference manuals AHRS-M1_M2 Software Interface Control Document.pdf and the NorthTek Programming Manual.pdf. For advice on locating the AHRS in the host product, see the section titled DIGITAL COMPASS INSTALLATION CONSIDERATIONS in this document. For instructions for the Spartacus GUI, see Spartacus_Quickstart.pdf. See the hardware ICDs for mechanical specifications.

MAGNETIC MODEL SOFTWARE UPDATES

The digital compass uses a spherical harmonic model to calculate the magnetic variance. This variance is then used to adjust the magnetic heading to provide for a true north heading. In order to retain accuracy, the magnetic model must be updated every year divisible by 5. For updates, Sparton will provide a script to be sent to the compass via the serial port. This World Magnetic Model (WMM) data only affects the calculation of True North heading (yawt) and does not affect the magnetic heading (yaw) accuracy.

Note that the AHRS-M1 and AHRS-M2 do not have a built in GPS, as a result, the user needs to provide location data to the compass in order for it to compute true north. Magnetic north does not need GPS data.

ORDERING INFORMATION

DESCRIPTION	ORDERING PART NUMBER	UNIT OF MEASURE
AHRS-M1 Digital Compass	AHRS-M1	EACH
AHRS-M2 Digital Compass	AHRS-M2	EACH
NDS-1 Development Kit w/ Software	NDS-1E	EACH

The Sparton Digital Compass is delivered as a potted module ready to meet the requirements of your design application and environment. The Sparton Digital Compass can be integrated into any system using a UART interface. Sparton also offers product integration, Design for Manufacturing (DFM), Design for Assembly (DFA) and contract manufacturing services.

For more information, please visit www.spartonnavex.com or to contact the Technical Support professionals at Sparton Navigation and Exploration in DeLeon Springs, FL, call or text (386) 363-4830.

To place an order or obtain pricing information, please email DLSNAVEX@sparton.com.

Warranty information and applicable terms and conditions (T&Cs) are available upon request.

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