SP3003D DIGITAL COMPASS

User Interface Document
(SERIAL NUMBERS A400-A999 AND B100+)

VERSION 4.4

02 AUGUST 2006

TABLE OF CONTENTS

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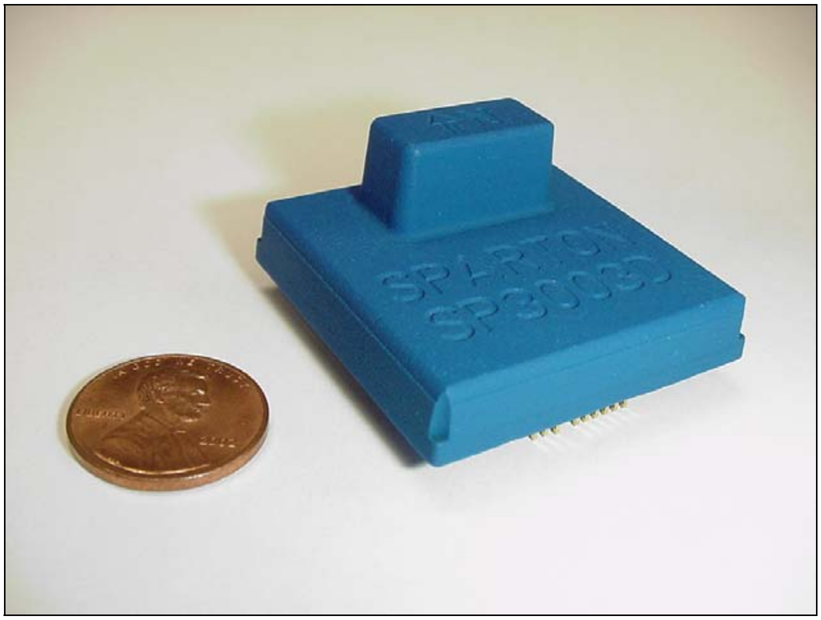
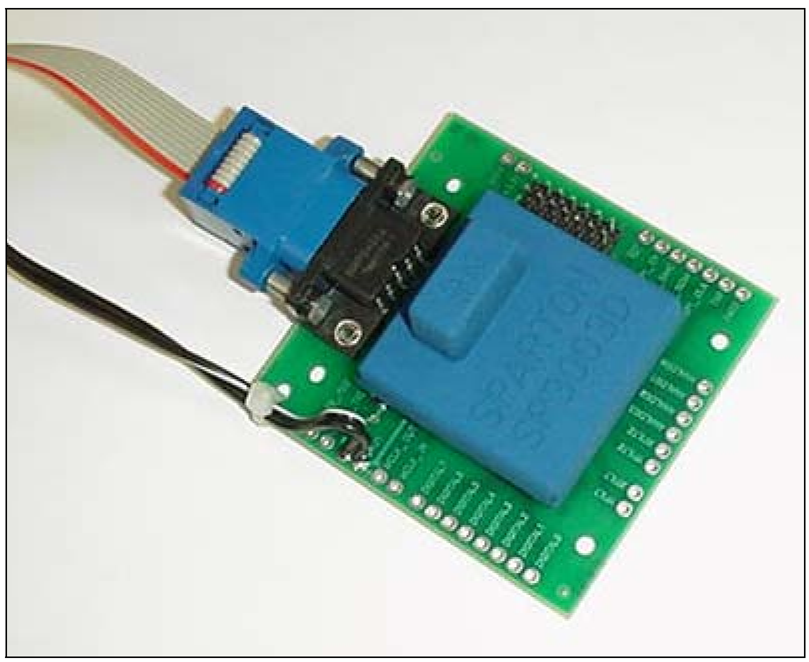
REVISION HISTORY

REV	CHANGE NO.	DATE OF CHANGE	DESCRIPTION OF CHANGE	INITIALS AND DATE
3.0	N/A	3/29/05	• ORIGINAL RELEASE	KG 3/29/05
3.1	1	4/11/05	• ADDED "DESCRIPTION OF CHANGE" PAGE • DIMENSION FOR SPACING OF 20-PIN CONNECTORS CHANGED FROM 1.15+/-.020 TO 1.125+/-.010 TO CORRECT DRAWING ERROR • DIMENSION FOR HOLE SPACING ON INTERFACE PCB CHANGED FROM 1.15 TO 1.125 TO CORRECT DRAWING ERROR • UPDATED NATIVE MODE COMMANDS FOR LATITUDE (FROM 0X0B TO 0X8B), LONGITUDE (FROM 0X0C TO 0X8C), ALTITUDE (FROM 0X0D TO 0X8D), DAY (FROM 0X0E TO 0X8E), AND MOUNTING CONFIGURATION (FROM 0X0A TO 0X4A).	KG 4/11/05
3.2	2	05/03/05	• ADDED NOTE: INSERT 10 MILLISECOND DELAY TO STOP NMEA REPEAT FUNCTION.	KG 05/03/05
4.0	3	05/16/05	• ADDED NATIVE HEADER (0XA4) AND TERMINATOR (0XA0). SIGNIFICANT CHANGES TO COMMAND RECEPTION TO IMPROVE SYNCRONIZATION. IMPROVED INVALID COMMAND REJECTION. FIXED MAGNETIC VARIATION NATIVE COMMAND (FROM 0X93 TO 0X83). ADDED RESPONSE TO ALL NATIVE COMMANDS.	KG 05/16/05
4.1	4	06/14/05	• REPLACED FIGURE 10 • ADDED THE "COCKPIT DISPLAY MODE" SECTION • UPDATED THE REMAINING FIGURE NUMBERS • UPDATED TABLE OF CONTENTS	BB 06/14/05
4.2	5	07/19/05	▪ ADDED ADDITIONAL CALIBRATION INSTRUCTIONS ▪ ADDED NOTE DESCRIBING ON-BOARD RESET ▪ ADDED SPECIFICATION ON LOGIC INPUT/OUTPUT	KG 07/19/05
4.3	6	02/06/06	▪ ADDED NOTE REGARDING DEGREDATION OF COMPASS PERFORMANCE CAUSED BY SEVERE LOCAL MAGNETIC DISTORTIONS	KG 02/06/06

REV	CHANGE NO.	DATE OF CHANGE	DESCRIPTION OF CHANGE	INITIALS AND DATE
4.4	7	08/02/06	• CORRECTED NMEA “$PSPA,CAL=RESET” COMMAND NOMENCLATURE	KG 08/02/06



SP3003D Digital Compass



SP3003D Digital Compass with Development Kit

INTRODUCTION

The Sparton SP3003D digital compass provides superior performance and flexibility. Using advanced hardware and software, the SP3003D offers an impressive list of features at an affordable price. It is the Worlds only low-cost digital compass that provides auto-adaptive in-field calibration. The SP3003D can be integrated into any system using a UART or SPI interface. Sparton also offers product development and integration, DFM, DFA and production services.

- 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 SP3003D measures the 3-dimensional magnetic and acceleration field conditions and mathematically corrects the magnetic readings based on the compass orientation.

- Adaptive In-Field Magnetic Calibration
  - The SP3003D uses a unique adaptive algorithm that continuously monitors the magnetic field conditions during movement (roll, pitch, yaw) of the compass platform. The adaptive algorithm minimizes both hard and soft magnetic distortion errors of the compass and mounting platform (i.e. distortions that move with the compass). The adaption can be turned on, off, or reset to the factory default settings.

- Full 360^o Rollover Capability
  - The SP3003D processing is able to tilt compensate the magnetic readings in any orientation. This gives the SP3003D the ability to provide an accurate magnetic heading for full 360^o roll angles.

- Motion Stabilization
  - 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 SP3003D algorithms help to stabilize heading, pitch and roll information in the presence of motion.

- Four User Analog Input Channels
  - General-purpose analog inputs, digitized to 12-bits, which can be used to monitor external analog signals such as power supply voltages, pressure sensors, or external temperature sensors.

- Eight User Digital Input/Output Channels
  - General-purpose digital inputs or outputs used to monitor or control external digital circuitry. Each channel is user-configurable to be either an input or an output. Inputs can be monitored and outputs can be controlled through the serial port.

- Variation Correction
  - The SP3003D directly determines the magnetic heading. The compass can provide true North heading when given the current magnetic variation. The SP3003D can calculate the magnetic variation when given GPS information (latitude, longitude, altitude, time) 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 due to the compass application are compensated using the in-field 3D calibration to maintained accuracy.

- True Absolute Magnetic Field Strength (in milligauss)
  - The magnetic vector components (X, Y, Z) are combined to provide the total magnetic field strength in milligauss.

- 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 SP3003D in degrees from a level condition.

- Temperature (in degrees C)
  - An on-board calibrated temperature sensor measures the temperature of the SP3003D in degrees-C.

- User Selectable Mounting Configuration
  - Mounting configuration is user-selectable between horizontal (default) and vertical orientations.

- Bi-Directional SPI Communication
  - Serial Peripheral Interface (SPI) is a standard communication for use in imbedded applications. The SPI interface uses four direct lines (Enable, Clock, Data In, Data Out) to communicate to an external controller.

- Bi-Directional RS232 Communication
  - RS232 is a standard communication for remote applications. The SP3003D is currently fixed at 9600 baud, 8 data bits, 1 stop bit, and no parity.

- +3.3V Operation or 5-20V Operation
  - Power can be supplied directly to the SP3003D (3.3V operation). If higher voltage operation is necessary, a separate 5-20V input can be used utilizing an on-board regulator to generate the 3.3V required by the SP3003D. Note that if higher voltages are used, the digital interface to the compass will still be at 3.3V logic levels. RS232 levels are standard and are unaffected by the power supplied to the compass.

- Low Power (36 mW)
  - The SP3003D requires only 3.3V at 11mA (36mW) to function making it ideal for low power applications.

- Small Size (1.5" square)
  - The small size of the SP3003D allows for use in space sensitive applications.

- Robust Design
  - The SP3003D digital compass is delivered as a potted module ready to meet the requirements of your design application and environment.

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 produce 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.

SPECIFICATIONS

Performance data applies under the following conditions unless otherwise specified:
3.3V, 25°C, 0g Acceleration for Pitch/Roll, 500mGauss Magnetic Field, Magnetic Adaption Off/Reset

MECHANICAL

PARAMETER	CONDITIONS	TYPICAL	UNITS
Dimensions (L x W x H)	Potted Assembly	3.9 x 3.9 x 1.9	cm
Weight	Potted Assembly	30	grams
Mounting Options	Connectors or Soldered	Horizontal or Vertical	---

ENVIRONMENTAL

PARAMETER	CONDITIONS
Operating Temperature	-40°C to 85°C
Storage Temperature	-40°C to 125°C
Humidity	95% Humidity, 70°C, 240 Hours Meets MIL-STD-202G - Method 103A, Test Condition A
Shock	1500g, 1ms Pulse, Half-Sine Wave Meets MIL-STD-202G - Method 213B, Test Condition F
Vibration	.06 dB Power Spectral Density, 9.26 Grms Meets MIL-STD-202G - Method 214A, Test Condition I/C

CALIBRATION

PARAMETER	AVAILABILITY
Hard-Iron Calibration	Yes
Soft-Iron Calibration	Yes
Manual Calibration	Yes
Auto Calibration	Yes

Note: Factory calibration data is available upon request for each unit.
Please specify serial number of each unit when requesting this information.

BEARING

PARAMETER	CONDITIONS	TYPICAL	UNITS
Accuracy	Static/Level[1]	0.3°	Deg RMS
Accuracy	Static/After Auto-Cal[2]	0.5°	Deg RMS
Resolution	$360^o / 2^{12}$	0.1°	Deg
Repeatability	Level	0.05°	Deg RMS

Notes:

1. *Factory calibration accuracy is valid for both horizontal and vertical mounting options of the compass. This applies for Pitch angles of +/- 90º and Roll angles of +/- 180º.*
2. *Compass accuracy under dynamic motion conditions is dependant on the specific design application.*

X-Y-Z ACCELERATION

PARAMETER	CONDITIONS	TYPICAL	UNITS
Dynamic Range	Each Axis	+/- 1.7	g
Noise Density	@25°C	200	μg/√Hz
Pitch Accuracy	0-90 Deg	<0.2°	Deg RMS
Pitch Resolution	$90^o / 2^{12}$	0.02°	Deg
Roll Accuracy	0-180 Deg	<0.2°	Deg RMS
Roll Resolution	$180^o / 2^{12}$	0.04°	Deg
Tilt Range	---	+/- 90º Pitch, +/- 180º Roll	Deg

MAGNETICS

PARAMETER	CONDITIONS	TYPICAL	UNITS
Calibrated Range	Each Axis	+/- 0.9	Gauss
Resolution	---	+/- 0.2	milliGauss
Repeatability	---	+/- 1.0	milliGauss

ELECTRICAL

PARAMETER	CONDITIONS	TYPICAL	UNITS
Input Supply[3]	Regulated	3.3V	Volts DC
Input Supply[3]	Unregulated	5V-20V	Volts DC
Logic Inputs/Outputs	Low State	0.0	Volts DC
	High State	3.3	
Current	Vcc = 3.3V	11	mA
Power	Vcc = 3.3V	36	mW
Data Update Rate	Max	10	Hz
Power-Up Time[4]	Max	600	msec
Temperature Accuracy	-40 to +85	+/- 3	°C

Notes:

3. *Voltage can be applied to either 3.3V (Connector 1, pin 17) at 3.3V regulated or +VIN (Connector 1, pin 19) at 5-20V unregulated but not both.*
4. *This is the total time until the first output, which includes reset time, boot time, and latency until first output. The on-board reset circuitry has 20k pull-up resistance. To hold the SP3003D in reset, use a transistor to pull the RST pin to GND.*

DIGITAL INTERFACE

PARAMETER	CONDITIONS	TYPICAL	UNITS
SPI_EN	Slave Only	3.3	V
SPI_MOSI	Input	LOGIC 0: 0	V
		LOGIC 1: 3.3	
SPI_CLK	Input	LOGIC 0: 0	V
		LOGIC 1: 3.3	V
		FREQUENCY = 4.0 (MAX)	MHz
SPI_MISO	Output	LOGIC 0: 0	V
		LOGIC 1: 3.3	
UART	8 Data Bits, 1 Stop Bit No Parity	9600	Baud
UART: URXD0	Input	LOGIC 0: 0	V
		LOGIC 1: 3.3	
UART: UTXD0	Output	LOGIC 0: 0	V
		LOGIC 1: 3.3	
UART RXD/TXD	Fully Compliant With RS-232-C Standard		

CAUTION: The SP3003D is an electrostatic sensitive device. Observe proper ESD precautions to avoid permanent damage caused by static discharge.

CONNECTOR 1 DEFINITIONS

PIN NAME	PIN NUMBER	I/O	DESCRIPTION
UART0_TXD	1	O	3.3V TXD output before RS232 level conversion
UART0_RXD	3	I	3.3V RXD input before RS232 level conversion
~RST	5	I	Reset input. Pull low to reset digital compass
TDO/TDI	7	I/O	JTAG test data input/output
TDI	9	I	JTAG test data input
TCK	11	I	JTAG test clock
TMS	13	I	JTAG test mode select
---	15		No Connection. Pin removed for keying.
3.3V	17		Digital Supply
+VIN	19		Unregulated supply input (optional)
MCLK_OUT	2	O	Master clock out. Buffered internal master bus clock
---	4	I	Reserved for factory use.
DGND	6		Digital Ground
---	8	I	Reserved for factory use.
SPI_CLK	10	I/O	SPI clock
SPI_SOMI	12	O	SPI slave output
SPI_SIMO	14	I	SPI slave input
SPI_EN	16	I	SPI enable
RS232_OUT	18	O	RS232 compatible output
RS232_IN	20	I	RS232 compatible input

CONNECTOR 1 has a SAMTEC part number TMS-110-02-S-D-“015”. Its mating female part has a SAMTEC part number ASP-116524-02.

CONNECTOR 2 DEFINITIONS

PIN NAME	PIN NUMBER	I/O	DESCRIPTION
DGND	1		Digital Ground
DGND	3		Digital Ground
DIGITAL0	5	I/O	Spare digital input/output, channel 0
DIGITAL1	7	I/O	Spare digital input/output, channel 1
DIGITAL2	9	I/O	Spare digital input/output, channel 2
DIGITAL3	11	I/O	Spare digital input/output, channel 3
DIGITAL4	13	I/O	Spare digital input/output, channel 4
DIGITAL5	15	I/O	Spare digital input/output, channel 5
DIGITAL6	17	I/O	Spare digital input/output, channel 6
DIGITAL7	19	I/O	Spare digital input/output, channel 7
YFILT	2	O	Analog Y acceleration (unbuffered) (1)
XFILT	4	O	Analog X acceleration (unbuffered) (1)
DGND	6		Digital Ground
---	8		No Connection. Pin removed for keying.
YFILTZ	10	O	Reserved for future use
XFILTZ	12	O	Analog Z acceleration (unbuffered) (1)
ANALOG3	14	I	Spare analog 12-bit ADC input, channel 3
ANALOG2	16	I	Spare analog 12-bit ADC input, channel 2
ANALOG1	18	I	Spare analog 12-bit ADC input, channel 1
ANALOG0	20	I	Spare analog 12-bit ADC input, channel 0

CONNECTOR 2 has a SAMTEC part number TMS-110-02-S-D-“008”. Its mating female part has a SAMTEC part number ASP-116524-01.

NOTES:

(1) Analog X/Y/Z acceleration outputs are unbuffered. Leave pins unconnected or use a high-impedance input buffer. Loading of these outputs will cause errors in platform orientation and ultimately cause heading errors.

MECHANICAL INTERFACE

The SP3003D Digital Compass is shipped as a potted module as shown in Figures 1-3. The potting is an electrically insulating, thermally conductive epoxy. The potting provides a robust, rugged design suited for a variety of applications and installation environments.

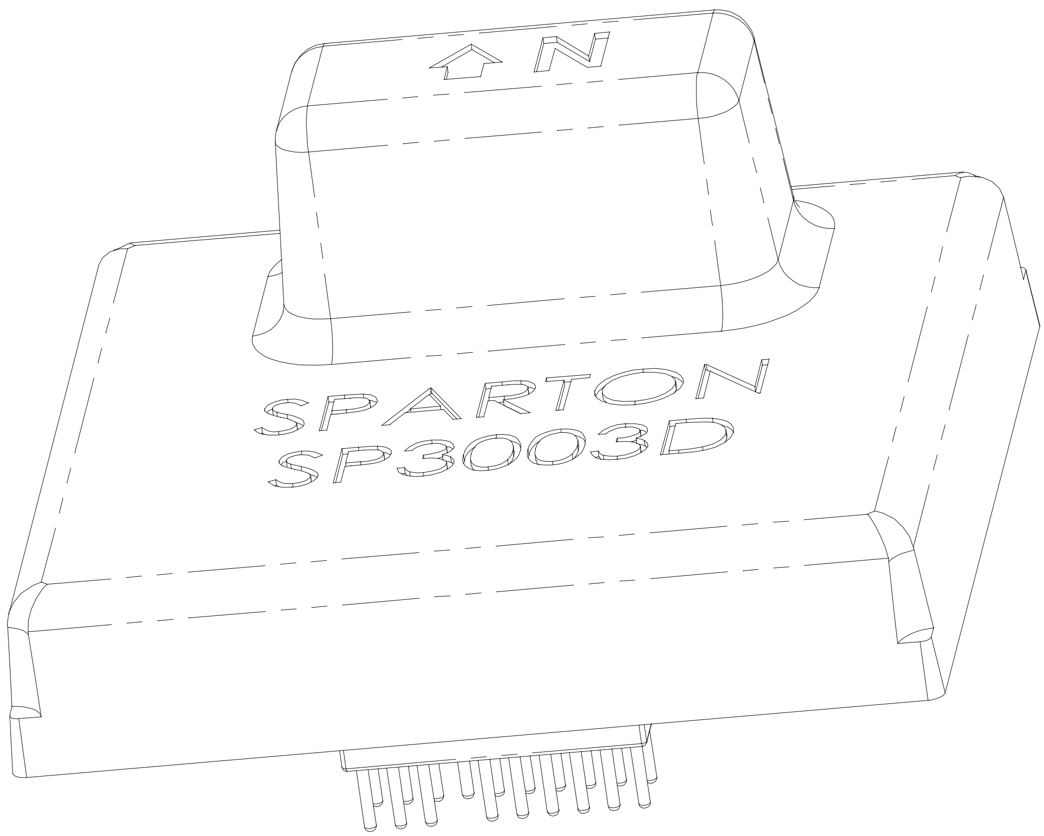


FIGURE 1 – POTTED ASSEMBLY

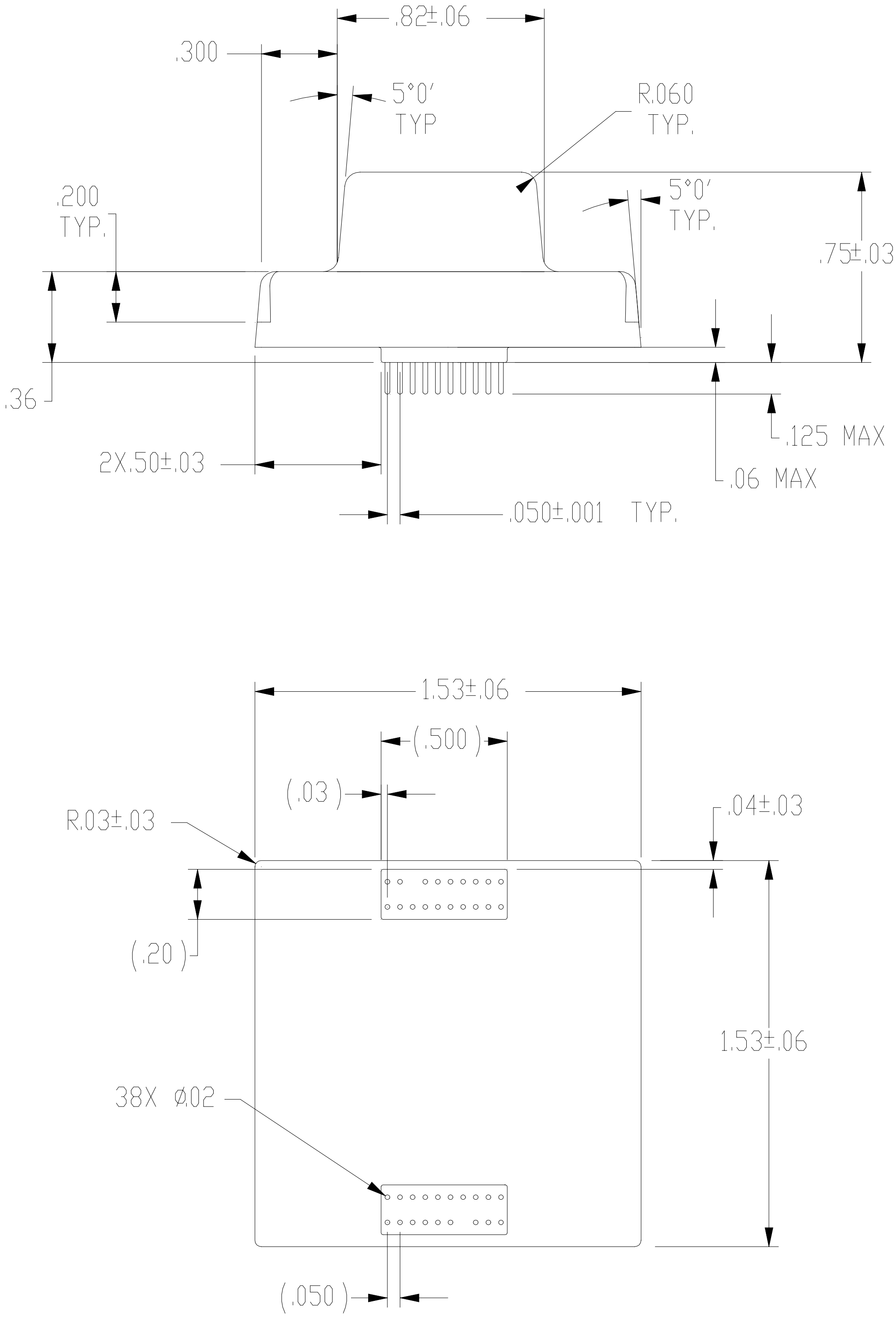


FIGURE 2 – MECHANICAL LAYOUT

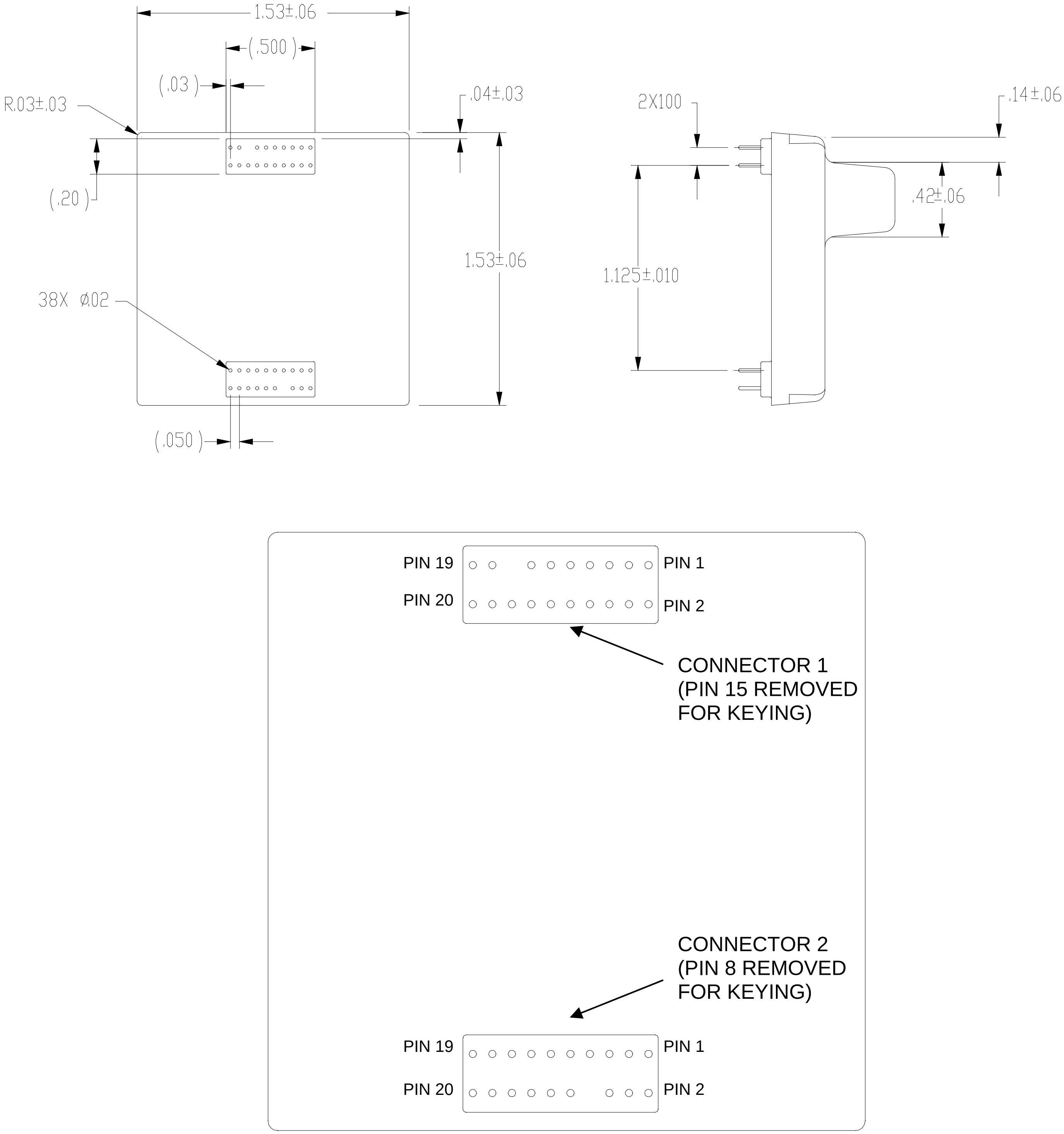


FIGURE 3 – MECHANICAL LAYOUT

HEADING IDENTIFICATION – HORIZONTAL MOUNTING (DEFAULT)

Pitch is associated with rotation about the Y-axis. It is measured using the X-axis accelerometer to measure tilt. Similarly, roll is associated with rotation about the X-axis and is measured using the Y-axis accelerometer. The board should be mounted horizontally with the Z-axis pointing toward the gravity vector (down). The compass will indicate the heading which corresponds to the angle between magnetic north and the North direction of the compass board.

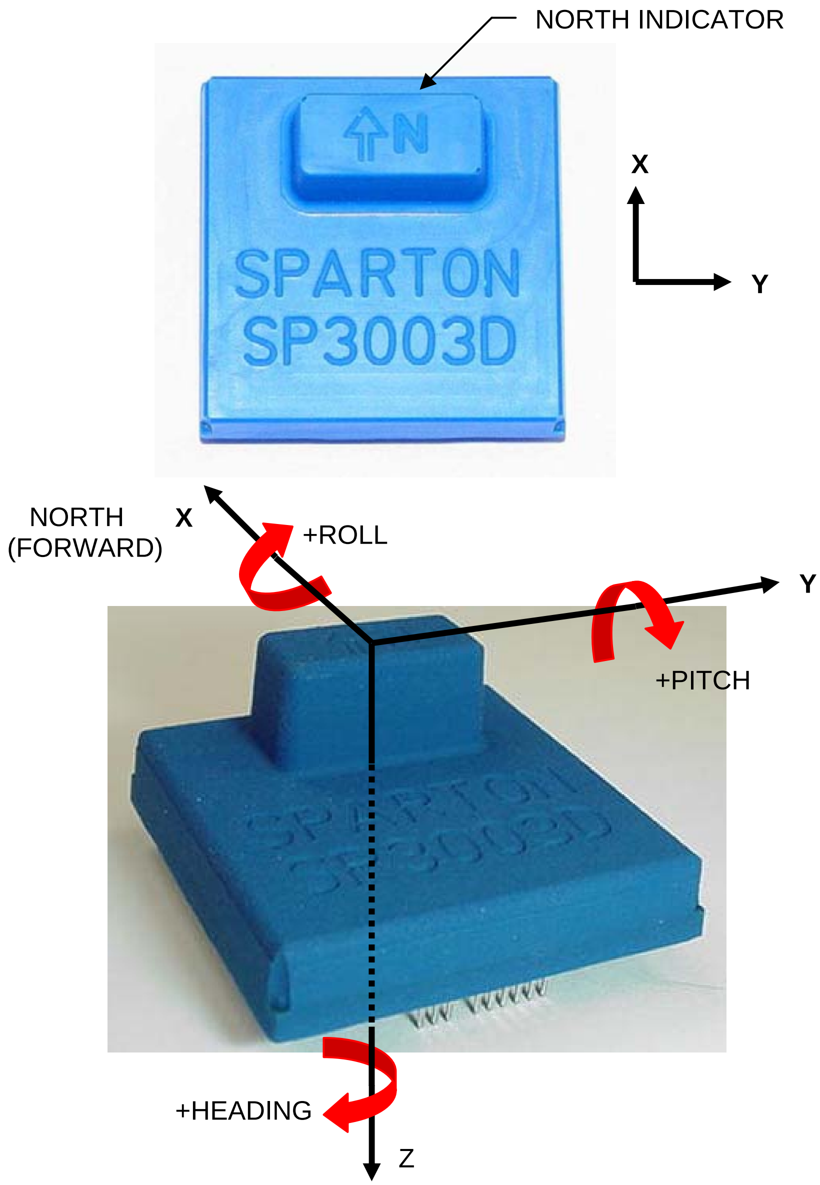


FIGURE 4 – HEADING IDENTIFICATION (HORIZONTAL MOUNT)

HEADING IDENTIFICATION – VERTICAL MOUNTING

Pitch is associated with rotation about the Y-axis. It is measured using the X-axis accelerometer to measure tilt. Similarly, roll is associated with rotation about the X-axis and is measured using the Y-axis accelerometer. The board should be mounted vertically with the Z-axis pointing toward the gravity vector (down). The compass will indicate the heading which corresponds to the angle between magnetic north and the North direction of the compass board.

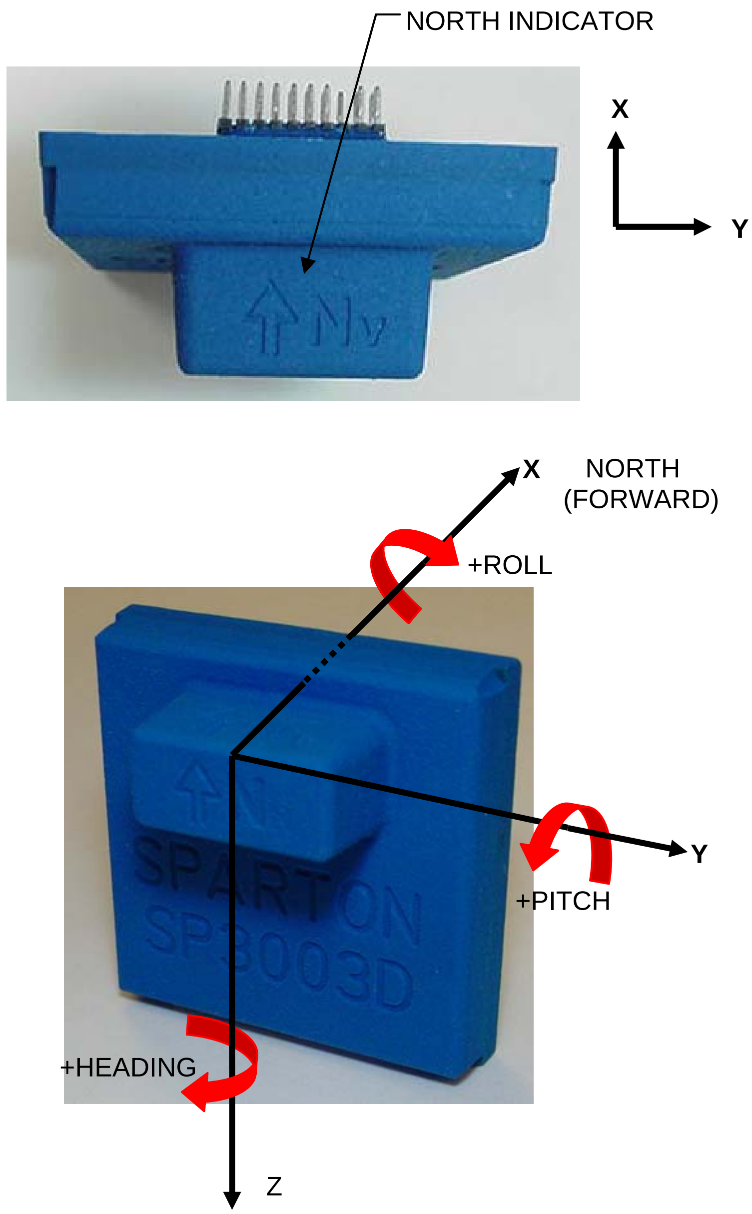


FIGURE 5 – HEADING IDENTIFICATION (VERTICAL MOUNT)

DIGITAL COMPASS MOUNTING

The SP3003D Digital Compass module can be assembled to a Customer Interface Board through the use of mating connectors or direct soldering to plated thru-holes. The plated thru-hole pattern required for direct soldering is shown in Figure 6. A pin is missing from the appropriate connector to enable orientation keying when the Digital Compass is soldered to an Interface Board. If a removable connection method is desired, the Digital Compass can be mated to an Interface Board which includes keyed female SAMTEC connector part number ASP-116524-02 for Connector #1 and ASP-116524-01 for Connector #2.

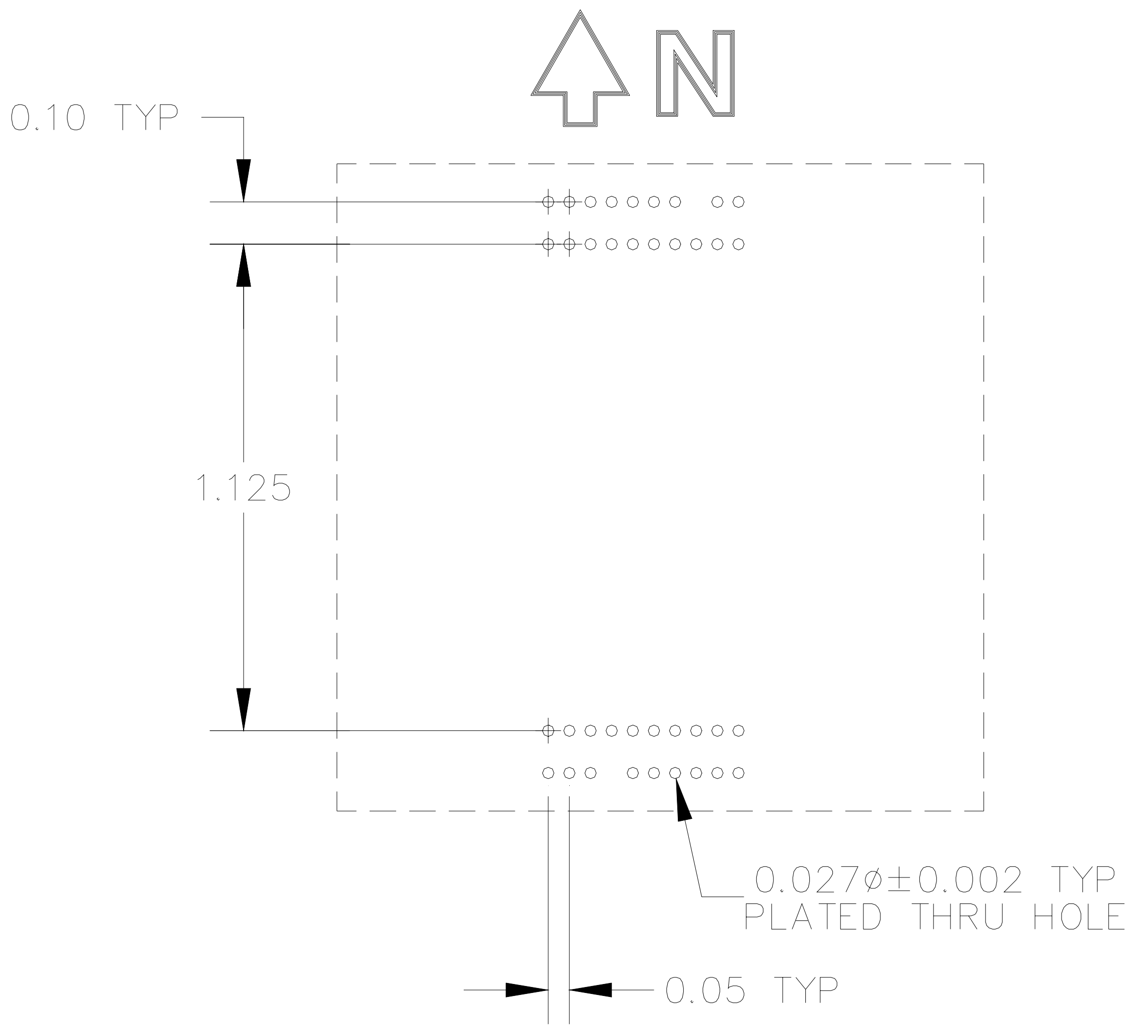


FIGURE 6 - HOLE PATTERN FOR SOLDERING TO INTERFACE BOARD

ENCAPSULANT PROPERTIES

DESCRIPTION

The potting compound is a proprietary two component, thermally conductive epoxy encapsulant. It features a low coefficient of thermal expansion and excellent electrical insulative properties.

KEY FEATURES

- Provides structural integrity to the product during handling and a robust design for applications exposed to environmental shock and vibration conditions
- Provides a top-level corrosion/moisture barrier
- Exhibits excellent thermal conductivity which readily dissipates heat from embedded components
- Has a low coefficient of thermal expansion which provides low stress on embedded components

MATERIAL PROPERTIES

Property	Test Method	Unit	Value
Hardness	ASTM-D-2240	Shore D	92
Flexural Strength	ASTM-D-790	mPa psi	106 15,300
Compressive Strength	ASTM-D-695	mPa psi	120 17,400
Linear Shrinkage	ASTM-D-2566	cm/cm	0.003
Water Absorption (24 hours)	ASTM-D-570	%	0.02
Coefficient of Thermal Expansion α1 α2	ASTM-D-3386	 10^{-6}/°C 10^{-6}/°C	 39.4 111.5
Glass Transition Temperature	ASTM-D-3418	°C	68
Thermal Conductivity	ASTM-D-2214	W/m.K Btu-in/hr-ft^2-°F	1.02 7.1
Temperature Range of Use	n/a	°C	-65 to +105
Dielectric Strength	ASTM-D-149	kV/mm V/mil	14.8 375
Dielectric Constant @ 1 mHz	ASTM-D-150	-	5.36
Dissipation Factor @ 1 mHz	ASTM-D-150	-	0.051
Volume Resistivity @ 25°C	ASTM-D-257	Ohm-cm	>10^{15}

APPLICATION INFORMATION

SERIAL PERIPHERAL INTERFACE (SPI)

The SPI port provides synchronous communication between the SP3003D and a host controller or master. The SP3003D is configured as a slave device and is controlled by commands from an external master. During SPI data transfer, the master shall assert the SPI_EN line low to signify the start of an SPI transmission. Command bits are latched on the SPI_SIMO line with the falling edge of SPI_CLK. See the *serial command definitions* section for descriptions of valid SPI commands. Once a command string has been received, the SPI_SOMI line will go high signifying that the command has been received and is being processed. Once complete, the SPI_SOMI line will go low. Results will serially shift out of the SP3003D on the SPI_SOMI line with each rising edge of SPI_CLK. The last byte transmitted by the SP3003D will always be the hexadecimal value 0xA0.

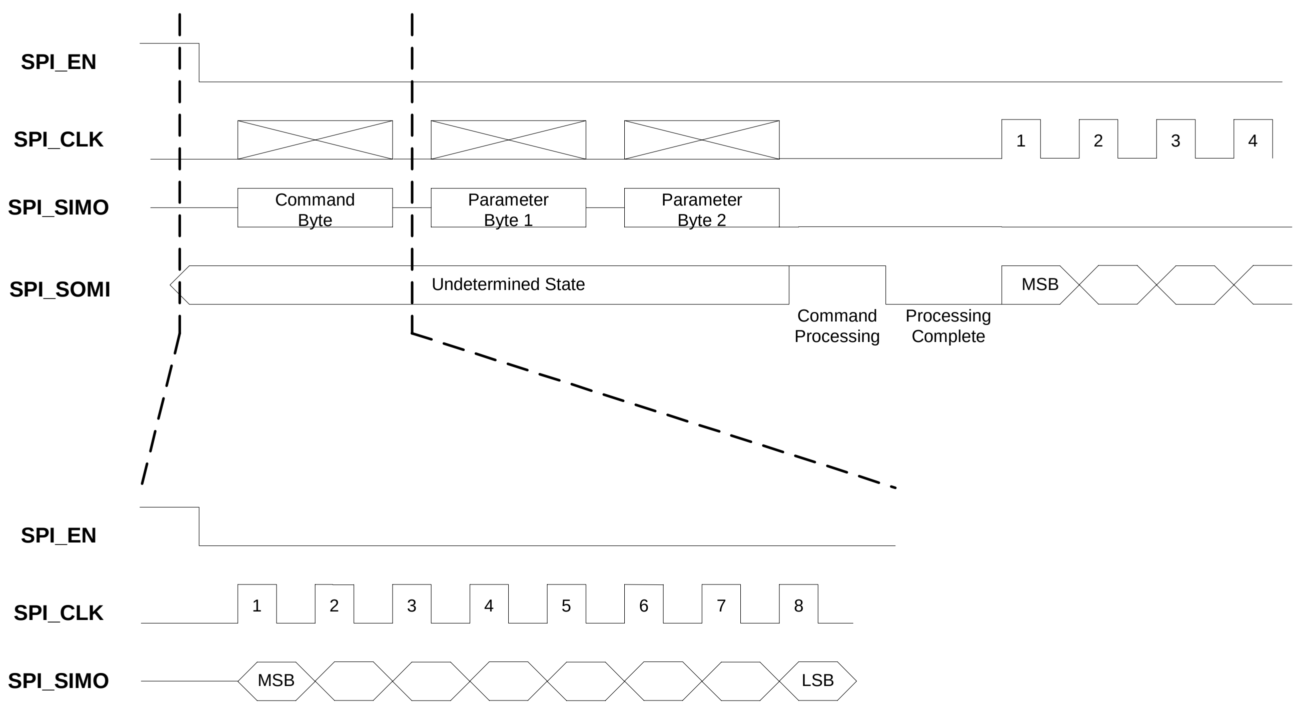


FIGURE 7 – SPI COMMANDS

UNIVERSAL ASYNCHRONOUS RECEIVER TRANSMITTER (UART)

The UART communicates with the digital compass using standard RS232 format (9600BUAD, 8data bits, 1stop bit, no parity). Similar to the SPI port, the UART provides full duplex communication. See the *Native or NMEA serial command definitions* section for description of valid RS232 commands.

JTAG INTERFACE

The JTAG interface allows for in-circuit emulation and programming of the FLASH memory within the microcontroller. During development, this is useful for refining the software code and adapting it to a particular application. Once the software is finalized, the security fuse within the micro is blown. This permanently disables the JTAG port and protects the CODE and RAM information from being accessed or modified. The JTAG fuse is blown on all SP3003D digital compass units.

NATIVE SERIAL COMMAND DEFINITIONS

Native commands allow for compact and efficient communication with the digital compass using the UART or SPI interface. Data is formatted on a hexadecimal byte level requiring minimal communication time to transfer commands to and from the compass. Processing of data received from the compass also becomes easier as parsing of text strings is not required. All native commands sent to the SP3003D begin with a header byte (0xA4) and end with a termination byte (0xA0).

If the SP3003D does not recognize a sequence of bytes as being a native command, no response is produced. If the SP3003D recognizes the command but, for some reason, cannot execute it, it will respond with an error code. All error codes begin with a header byte (0xAE) and end with a termination byte (0xA0).

Error Code Format: 3 Bytes (0xAE, 8-bit error code, 0xA0)

8-bit Error Codes:

0xFF = Improper command termination (i.e. no 0xA0 found)
0xFE = Receive buffer overflow
0xFD = Invalid parameter associated with given command

RAW MAGNETICS

Send: 3 Byte (0xA4, 0x01, 0xA0)
Response: 9 Bytes (0xA4, 0x01, Mx, My, Mz as 16-bit integers, 0xA0)

Reads current magnetics directly from magnetometers (Mx, My, and Mz). These are raw sensor readings and do not yet have any calibration parameters applied.

HEADING - TRUE

Send: 3 Byte (0xA4, 0x02, 0xA0)
Response: 5 Bytes (0xA4, 0x02, Heading as a 16-bit signed integer, 0xA0)

Heading (degrees) = (16-bit Heading value)*360/4096
Heading Range = 0.0 to +359.9

Reads the current true heading. The heading is compensated for platform tilt. True heading is the magnetic heading corrected for magnetic variance.

HEADING - MAGNETIC

Send: 3 Byte (0xA4, 0x09, 0xA0)
Response: 5 Bytes (0xA4, 0x09, Heading as a 16-bit signed integer, 0xA0)

Heading (degrees) = (16-bit Heading value)*360/4096
Heading Range = 0.0 to +359.9

Reads the current magnetic heading. The heading is compensated for platform tilt.

MAGNETIC VARIATION

Send: 5 Bytes (0xA4, 0x83, 16-bit signed integer value MSB first, 0xA0)
Response: 5 Bytes (0xA4, 0x83, 16-bit signed Variation, 0xA0)

Set the magnetic variation angle. The heading will be adjusted to indicate true north. Magnetic variation angles >+180 and <-180 will be limited to +180 and –180 respectively.

16-bit signed integer = (Magnetic Variation)*10.0

AUTOMATIC MAGNETIC VARIATION

Send: 3 Byte (0xA4, 0x0F, 0xA0)
Response: 5 Bytes (0xA4, 0x0F, Variation as a 16-bit signed integer, 0xA0)

16-bit signed integer = (Magnetic Variation)*10.0

Latitude, Longitude, Altitude, and Day should be programmed separately using their respective commands before issuing this command. Automatic variation will compute the local magnetic variance based on your current geographical location (geodetic coordinate system referenced to the WGS 84 ellipsoid). Once the computation is complete, the magnetic variance will be updated in the SP3003D. *NOTE: TO RETAIN MAGNETIC VARIANCE ACCURACY, THE MAGNETIC MODEL MUST BE UPDATED EVERY FIVE YEARS. A SEPARATE PROGRAM IS AVAILABLE ON THE SUPPLIED CD WHICH WILL ASSIST IN DOWNLOADING NEW COEFFICIENTS INTO THE SP3003D DIGITAL COMPASS. THIS ONLY AFFECTS THE CALCULATION OF TRUE HEADING AND DOES NOT AFFECT MAGNETIC HEADING ACCURACY.*

LATITUDE

Send: 5 Bytes (0xA4, 0x8B, 16-bit signed integer value MSB first, 0xA0)
Response: 5 Bytes (0xA4, 0x8B, 16-bit Latitude, 0xA0)

16-bit signed integer = (North(+) or South(-) Latitude in degrees)*100.0

Set the geodetic latitude angle in degrees (geodetic coordinate system referenced to the WGS 84 ellipsoid). The magnetic variation will not change until latitude, longitude, altitude, and day have been programmed and the Automatic Variance command is issued. Latitude >+90 or <-90 will be limited to +90 and –90 respectively.

LONGITUDE

Send: 5 Bytes (0xA4, 0x8C, 16-bit signed integer value MSB first, 0xA0)
Response: 5 Bytes (0xA4, 0x8C, 16-bit signed Longitude, 0xA0)

16-bit signed integer = (East(+) or West(-) Longitude in degrees)*100.0

Set the geodetic longitude angle in degrees (geodetic coordinate system referenced to the WGS 84 ellipsoid). The magnetic variation will not change until latitude, longitude, altitude, and day have been programmed and the Automatic Variance command is issued. . Latitude >+180 or <-180 will be limited to +180 and –180 respectively.

ALTITUDE

Send: 5 Bytes (0xA4, 0x8D, 16-bit signed integer value MSB first, 0xA0)
Response: 5 Bytes (0xA4, 0x8D, 16-bit signed Altitude, 0xA0)

16-bit signed integer = +/- Altitude in meters

Set the geodetic altitude in meters above sea level (geodetic coordinate system referenced to the WGS 84 ellipsoid). The magnetic variation will not change until latitude, longitude, altitude, and day have been programmed and the Automatic Variance command is issued. Altitude >+32767 or <-32767 will be limited to +32767 and –32767 respectively.

DAY

Send: 5 Bytes (0xA4, 0x8E, 16-bit unsigned integer value MSB first, 0xA0)
Response: 5 Bytes (0xA4, 0x8E, 16-bit unsigned Day, 0xA0)

16-bit unsigned integer = (Fractional Day)*10.0

The day is entered as a fractional year based on the current day of the year (i.e. February 15 is the 46th day of the 2005. In fractional terms, this would be 46/365 = 0.126. The Fractional Day value for February 15, 2005 would then be 2005.1 (resolution beyond a tenth causes negligible change in variance). The magnetic variation will not change until latitude, longitude, altitude, and day have been programmed and the Automatic Variance command is issued. Day < 2005 will be limited to 2005.

MAGNETIC VECTOR

Send: 3 Byte (0xA4, 0x04, 0xA0)
Response: 11 Bytes (0xA4, 0x04, MAx, MAy, MAz, MAtotal as 16-bit integers, 0xA0)

Measures the magnetic field strength along each axis (X, Y, and Z) and total absolute field strength (MAtotal) in milligauss.

MAGNETIC CALIBRATION

Send: 4 Bytes (0xA4, 0x56, 8-bit configuration {0x00=OFF, 0x01=AUTO, 0x02=MANUAL, 0xFF = RESET}, 0xA0)
Response: 4 Bytes (0xA4, 0x56, 8-bit configuration, 0xA0)

Controls compass calibration process. Magnetic calibration can be set to OFF, AUTO, MANUAL, or RESET to the factory-default values. Turning off calibration will save and freeze the current magnetic calibration parameters disabling any further corrections. AUTO calibration will apply adaptive magnetic corrections once the field distortions have been sufficiently sampled. MANUAL calibration mode allows the user to quickly calibrate the compass. After manual calibration, this mode must be changed to either AUTO or OFF. Resetting magnetic auto-calibration will force the magnetic calibration parameters to their factory-default values. The magnetic calibration parameters prior to pressing RESET are not saved and cannot be recovered.

When the compass is first used, it must learn the local magnetic distortions. This will automatically occur over time as the orientation of the compass is changed. The following steps will help to speed the adaption process when the compass is first used:

1) Set magnetic adaption to OFF.
2) Press RESET to start calibration at the factory default settings.
3) Point the compass North and set magnetic adaption to MANUAL.
4) Pitch compass slowly a full 360^o.
5) Point compass East or West and then roll compass slowly a full 360^o.
6) Set magnetic adaption to AUTO.
7) Repeat steps (4) and (5) by pitching and then rolling a full 360^o.
8) The magnetic error will continue to improve over time as the compass orientation is changed. Eventually, the adaption error will reach a minimum for all orientations.
9) Calibration parameters are automatically stored when the magnetic adaption error drops below 25. The current magnetic calibration parameters will also be saved whenever the magnetic calibration is set to Auto, Off or Reset.

MAGNETIC ADAPTION ERROR

Send: 3 Byte (0xA4, 0x08, 0xA0)
Response: 5 Bytes (0xA4, 0x08, Error as a 16-bit unsigned integer, 0xA0)

Indicates quality of the adaptive magnetic calibration process. Smaller values represent better magnetic calibration. Adaption error is limited to the range 0 to 10,000.

RAW ACCELERATION

Send: 3 Byte (0xA4, 0x05, 0xA0)
Response: 9 Bytes (0xA4, 0x05, AccelX, AccelY, AccelZ as 16-bit integers, 0xA0)

Reads current acceleration directly from accelerometers (AccelX, AccelY, AccelZ). These are raw sensor readings and do not yet have any calibration parameters applied.

PITCH AND ROLL OUTPUT

Send: 3 Byte (0xA4, 0x06, 0xA0)
Response: 7 Bytes (0xA4, 0x06, Pitch, Roll as 16-bit signed integers, 0xA0)

Reads the current platform orientation (Pitch and Roll).

Pitch (in degrees) = (Response Value)*90/4096
Pitch Range = -90 to +90

Roll (in degrees) = (Response Value)*180/4096
Acceleration Vector Roll Range = -180 to +180

ACCELERATION VECTOR

Send: 3 Byte (0xA4, 0x07, 0xA0)
Response: 11 Bytes (0xA4, 0x07, Ax, Ay, Az, Atotal as 16-bit integers, 0xA0)

Measures the acceleration along each axis (X, Y, and Z) and total absolute strength (Atotal) in milli-g.

DATA FILTER

Send: 5 Bytes (0xA4, 0x90, 16-bit filter value MSB first, 0xA0)

Response: 5 Bytes (0xA4, 0x90, 16-bit filter value, 0xA0)

Sets amount of filtering applied to the heading, pitch, and roll information. Filtering is accomplished by using a single-pole digital filter. Acceptable filter values are in the range 1 to 65535. Low values provide less filtering. Higher values will make the compass less responsive providing more stable heading, pitch, and roll.

Filtered Data = [(Filtered Data)*(Filter Value-1) + (New Data)] / (Filter Value)

TEMPERATURE

Send: 3 Bytes (0xA4, 0x11, 0xA0)
Response: 5 Bytes (0xA4, 0x11, Temperature as 16-bit unsigned integer MSB first, 0xA0)

Reads the internal temperature channel of the on-board microcontroller. This measurement is calibrated at the factory, though not required by the SP3003D in determining an accurate heading.

Temperature_C = (Temperature_MSB*256 + Temperature_LSB)/10.0

READ ANALOG INPUT

Send: 4 Bytes (0xA4, 0x52, 8-bit channel value MSB first, 0xA0)
Response: 5 Bytes (0xA4, 0x52, A/D value as 16-bit unsigned integer, 0xA0)

Reads the selected analog channel (0 through 8) to a resolution of 12-bits. A response of 0xFFFF indicates an invalid channel was selected.

Channel 0 = General Purpose Analog Input (ANALOG0)
Channel 1 = General Purpose Analog Input (ANALOG1)
Channel 2 = General Purpose Analog Input (ANALOG2)
Channel 3 = General Purpose Analog Input (ANALOG3)
Channel 4 = Zx Accelerometer (XFILTZ)
Channel 5 = Zy Accelerometer (YFILTZ)
Channel 6 = Horizontal X Accelerometer (XFILT)
Channel 7 = Horizontal Y Accelerometer (YFILT)
Channel 8 = Raw Temperature

SET DIGITAL I/O DIRECTION

Send: 4 Bytes (0xA4, 0x53, 8-bit pin direction value MSB first, 0xA0)
Response: 4 Bytes (0xA4, 0x53, 8-bit pin direction value, 0xA0)

Sets I/O pin directions on the expansion port. Setting a bit to 1 will configure that digital I/O pin as an output. All pins are configured as inputs after a reset.

READ DIGITAL INPUT

Send: 3 Byte (0xA4, 0x14, 0xA0)
Response: 4 Bytes (0xA4, 0x14, 8-bit port value, 0xA0)

Reads the current state of all eight digital I/O pins.

SET DIGITAL OUTPUT

Send: 4 Bytes (0xA4, 0x55, 8-bit port value MSB first, 0xA0)
Response: 4 Bytes (0xA4, 0x55, 8-bit port value, 0xA0)

Sets the state of the digital output pins. Pins configured as inputs are not affected.

MOUNTING CONFIGURATION

Send: 4 Bytes (0xA4, 0x4A, 8-bit orientation {0x00=Horizontal, 0x01=Vertical}, 0xA0)
Response: 4 Bytes (0xA4, 0x4A, 8-bit orientation, 0xA0)

Sets the mounting orientation of the SP3003D compass platform. The default orientation is horizontal (see Figure 4). For vertical orientations, refer to Figure 5. To determine the orientation setting, read the acceleration vector. When in a static level condition, Az should be approximately +1000mg and Ax and Ay should be close to zero.

NMEA SERIAL COMMAND DEFINITIONS

NMEA commands use ASCII text strings to communicate with the digital compass through the UART interface. Data is formatted with the first character being "$" to signify the start of a NMEA command and include a "*" to signify the start of the checksum. It is not necessary to include any checksum characters in commands sent to the digital compass. Each command sent shall be terminated with a carriage return <CR> and line feed <LF>. All NMEA responses from the compass will contain a checksum followed by a carriage return and line feed.

The checksum value is the result of XORing the ASCII bytes between the "$" and "*" characters. This one byte value is reported in the output word by two ASCII characters representing two hex digits, with the most significant nibble first.

Example: $HCHDM,300.4,M*2E<CR><LF>

"$" = Start of NMEA text message
"HCHDM" = Response header from compass. (HC=Magnetic Compass, HDM = Magnetic Heading)
"300.4" = Heading in degrees
"M" = Magnetic Heading
"*" = Start of checksum field
"2E" = Hexadecimal checksum value

Any NMEA command can be repeated continuously by adding the repeat (RPT) instruction to the end of the command string (before the checksum). The repetition rate is given in seconds and should be in the range 0.1 to 500.0 seconds. For example, to request magnetic heading continuously at a 0.5second (2Hz) rate, the following command should be issued:

$xxHDM,RPT=0.5<CR><LF>

The compass will respond by continuously sending magnetic heading information every 0.5 seconds. To discontinue RPT function, simply send another NMEA command. If the compass is powered off during a continuous transmit mode, the compass will continue to transmit continuously when the power is restored.

Note: A minimum delay of 10 millisecond must be inserted immediately after the '$' to allow the compass time to properly turn off the NMEA repeat function. This delay is only required on the first NMEA command following a NMEA repeat function.

Send Example:

1) *Send "$" character*
2) *Wait minimum 10 milliseconds while compass terminates the repeat function*
3) *Send "xxHDM<cr><.lf>" to finish the NMEA command*
4) *All following commands can now be sent as "$xxHDM<cr><lf>"*

RAW MAGNETICS

Send: $PSPA,MR
Response: $PSPA,MRx=<int#>,MRy=<int#>,MRz=<int#>*<checksum in hex>

Response Example: $PSPA,MRx=1553,MRy=-1669,MRz=-1419*60

Reads current magnetics directly from magnetometers (Mx, My, and Mz). These are raw sensor readings and do not yet have any calibration parameters applied.

HEADING - MAGNETIC

Send: $xxHDM
Response: $HCHDM,<###.# in range 000.0 to 359.9>,M*<checksum in hex>

Response Example: $HCHDM,300.4,M*2E

Reads the current magnetic heading. The heading is compensated for platform tilt.

HEADING - TRUE

Send: $xxHDT
Response: $HCHDT,<###.# in range 000.0 to 359.9>,T*<checksum in hex>

Response Example: $HCHDT,295.9,T*2B

Reads the current true heading. The heading is compensated for platform tilt. True heading is the magnetic heading corrected for magnetic variance.

MAGNETIC VARIATION

Send: $xxVAR,<###.#>,<E or W>
Response: $HCVAR,<###.#>,<E or W>*<checksum in hex>

<###.#> = Variation in range 000.0 to 180.0
<E or W> = Direction of variation East(+) or West(-)

Send Example: $xxVAR,4.2,W
Response Example: $HCVAR,004.2,W*31

Set the magnetic variation angle. The heading will be adjusted to indicate true north.

AUTOMATIC MAGNETIC VARIATION

Send: $PSPA,AUTOVAR,<#Latitude>,<#Longitude>,<#Altitude>,<#Day>
Response: $PSPA,AutoVar=<###.#>,*<checksum in hex>

#Latitude = Geodetic latitude in degrees. North(+) or South(-).
#Longitude = Geodetic longitude in degrees. East(+) or West(-).
#Altitude = Geodetic altitude in meters from sea-level
#Day = Fractional day

Send Example: $PSPA,AUTOVAR,29.12,-81.35,100,2005.2
Response Example: $PSPA,AutoVar=-005.3*6C

Computes the local magnetic variance based on your current geographical location (geodetic coordinate system referenced to the WGS 84 ellipsoid). Latitude and longitude are entered in degrees with + being north and east respectively. Altitude is entered in meters above sea level. The day is entered as a fractional year based on the current day of the year (i.e. February 15 is the 46th day of the 2005. In fractional terms, this would be 46/365 = 0.126. The Day value for February 15, 2005 would then be entered as 2005.1 (resolution beyond a tenth causes negligible change in variance). Once the computation is complete, the magnetic variance will be updated in the SP3003D. *NOTE: TO RETAIN MAGNETIC VARIANCE ACCURACY, THE MAGNETIC MODEL MUST BE UPDATED EVERY FIVE YEARS. A SEPARATE PROGRAM IS AVAILABLE ON THE SUPPLIED CD WHICH WILL ASSIST IN DOWNLOADING NEW COEFFICIENTS INTO THE SP3003D DIGITAL COMPASS. THIS ONLY AFFECTS THE CALCULATION OF TRUE HEADING AND DOES NOT AFFECT MAGNETIC HEADING ACCURACY.*

MAGNETIC VECTOR

Send: $PSPA,M
Response: $PSPA,Mx=<int#>,My=<int#>,Mz=<int#>,Mt=<int#>*<checksum in hex>

Response Example: $PSPA,Mx=63,My=-261,Mz=-262,Mt=376*29

Measures the magnetic field strength along each axis (X, Y, and Z) and total absolute field strength (MAtotal) in milligauss.

MAGNETIC CALIBRATION

Send: $PSPA,CAL=OFF
$PSPA,CAL=AUTO
$PSPA,CAL=MANUAL
$PSPA,CAL=RESET

Response: $PSPA,Cal=Off*<checksum in hex>
$PSPA,Cal=Auto*<checksum in hex>
$PSPA,Cal=Manual*<checksum in hex>
$PSPA,Cal=Reset*<checksum in hex>

Controls compass calibration process. Magnetic calibration can be set to OFF, AUTO, MANUAL, or RESET to the factory-default values. Turning off calibration will save and freeze the current magnetic calibration parameters disabling any further corrections. AUTO calibration will apply adaptive magnetic corrections once the field distortions have been sufficiently sampled. MANUAL calibration mode allows the user to quickly calibrate the compass. After manual calibration, this mode must be changed to either AUTO or OFF. Resetting magnetic auto-calibration will force the magnetic calibration parameters to their factory-default values. The magnetic calibration parameters prior to pressing RESET are not saved and cannot be recovered.

When the compass is first used, it must learn the local magnetic distortions. This will automatically occur over time as the orientation of the compass is changed. The following steps will help to speed the adaption process when the compass is first used:

1) Set magnetic adaption to OFF.
2) Press RESET to start calibration at the factory default settings.
3) Point the compass North and set magnetic adaption to MANUAL.
4) Pitch compass slowly a full 360°.
5) Point compass East or West and then roll compass slowly a full 360°.

6) Set magnetic adaption to AUTO.
7) Repeat steps (4) and (5) by pitching and then rolling a full 360°.
8) The magnetic error will continue to improve over time as the compass orientation is changed. Eventually, the adaption error will reach a minimum for all orientations.
9) Calibration parameters are automatically stored when the magnetic adaption error drops below 25. The current magnetic calibration parameters will also be saved whenever the magnetic calibration is set to Auto, Off or Reset.

MAGNETIC ADAPTION ERROR

Send: $PSPA,MAGERR
Response: $PSPA,MagErr=<int#>*<checksum in hex>

Response Example: $PSPA,MagErr=16*0A

Indicates quality of the adaptive magnetic calibration process. Smaller values represent lower error corresponding to better magnetic calibration. Adaption error is limited to the range 0 to 10,000.

RAW ACCELERATION

Send: $PSPA,AR
Response: $PSPA,ARx=<int#>,ARy=<int#>,ARz=<int#>*<checksum in hex>

Response Example: $PSPA,ARx=2052,ARy=1991,ARz=1284*61

Reads current acceleration directly from accelerometers (AccelX, AccelY, AccelZ). These are raw sensor readings and do not yet have any calibration parameters applied.

PITCH AND ROLL OUTPUT

Send: $PSPA,PR
Response: $PSPA,Pitch=<##.#>,Roll=<###.#>*<checksum in hex>

Pitch range (degrees): -90.0 to +90.0
Roll range (degrees): -180.0 to +180.0

Example Response: $PSPA,Pitch=+18.2,Roll=-042.4*56

Reads the current platform orientation (Pitch and Roll).

ACCELERATION VECTOR

Send: $PSPA,A
Response: $PSPA,Ax=<int#>,Ay=<int#>,Az=<int#>,At=<int#>*<checksum in hex>

Example Response: $PSPA,Ax=-11,Ay=35,Az=-1040*3A

Measures the acceleration along each axis (X, Y, and Z) and total absolute strength (Atotal) in milli-g.

DATA FILTER

Send: $PSPA,FILTER=<int#>
Response: $PSPA,Filter=<int#>*<checksum in hex>

Send Example: $PSPA,FILTER=1
Response Example: $PSPA,Filter=1*12

Sets amount of filtering applied to the heading, pitch, and roll information. Filtering is accomplished by using a single-pole digital filter. Acceptable filter values are in the range 1 to 65535. Low values provide less filtering. Higher values will make the compass less responsive providing more stable heading, pitch, and roll.

Filtered Data = [(Filtered Data)*(Filter Value-1) + (New Data)] / (Filter Value)

TEMPERATURE

Send: $PSPA,TEMP
Response: $PSPA,Temp=<##.# in –20.0 to +70.0C>,C*<checksum in hex>

Response Example: $PSPA,Temp=+24.1,C*72

Reads the internal temperature channel of the on-board microcontroller and converts to degrees C. This measurement is calibrated at the factory for general use even though it is not required by the SP3003D in determining an accurate heading.

READ ANALOG INPUT

Send: $PSPA,READAIN=<channel# 0-8>
Response: $PSPA,ReadAIN=<channel# 0-8>,<return value in hex>*<checksum in hex>

Send Example: $PSPA,READAIN=1
Response Example: $PSPA,ReadAIN=1,07B5*1A

Reads the selected analog channel (0 through 8) to a resolution of 12-bits.

Channel 0 = General Purpose Analog Input (ANALOG0)
Channel 1 = General Purpose Analog Input (ANALOG1)
Channel 2 = General Purpose Analog Input (ANALOG2)
Channel 3 = General Purpose Analog Input (ANALOG3)
Channel 4 = Zx Accelerometer (XFILTZ)
Channel 5 = Zy Accelerometer (YFILTZ)
Channel 6 = Horizontal X Accelerometer (XFILT)
Channel 7 = Horizontal Y Accelerometer (YFILT)
Channel 8 = Raw Temperature

SET DIGITAL I/O DIRECTION

Send: $PSPA,SETDDIR=<## in hex to set pin direction as input or output>
Response: $PSPA,SetDDIR=<## in hex>*<checksum in hex>

Send Example: $PSPA,SETDDIR=0F
Response Example: $PSPA,SetDDIR=0F*2C

Sets I/O pin directions on the expansion port. Setting a bit to 1 will configure that digital I/O pin as an output. All pins are configured as inputs after a reset.

READ DIGITAL INPUT

Send: $PSPA,READDIN
Response: $PSPA,.ReadDIN=<input ## in hex>*<checksum in hex>

Response Example: $PSPA,ReadDIN=0F*04

Reads the current state of all eight digital I/O pins.

SET DIGITAL OUTPUT

Send: $PSPA,SETDOUT=<## in hex>
Response: $PSPA,SetDOUT=<## in hex>*<checksum in hex>

Send Example: $PSPA,SETDOUT=FF
Response Example: $PSPA,SetDOUT=FF*4B

Sets the state of the digital output pins. Pins configured as inputs are not affected.

MOUNTING CONFIGURATION

Send: $PSPA,MOUNT=<'H' for horizontal or 'V' for vertical>
Response: $PSPA,Mount=<'H or V'>*<checksum in hex>

Send Example: $PSPA,MOUNT=V
Response Example: $PSPA,Mount=V*18

Sets the mounting orientation of the SP3003D compass platform. The default orientation is horizontal (see Figure 4). For vertical orientations, refer to Figure 5. To determine the orientation setting, read the acceleration vector. When in a static level condition, Az should be approximately +1000mg and Ax and Ay should be close to zero.

READ TRANSDUCERS

Send: $xxXDR
Response: $HCXDR, <Transducer string as described below>*<checksum in hex>

<Transducer String> =

A,	- Angular Displacement Measurement
###.#,	- Magnetic Heading
D,	- Units of Degrees for Magnetic Heading
A,	- Second Angular Displacement Measurement
###.#,	- True Heading
D,	- Units of Degrees for True Heading
A,	- Third Angular Displacement Measurement
+##.#,	- Pitch
D,	- Units of Degrees for Pitch
A,	- Fourth Angular Displacement Measurement
+###.#	- Roll
D,	- Units of Degrees for Roll
C,	- Temperature Measurement
+##.#,	- Temperature
C,	- Units of Degrees C for Temperature
G,	- Generic Measurement
###	- Magnetic Error (measurement is unitless)

Send Example: $xxXDR
Response Example:

$HCXDR,A,281.3,D,A,281.3,D,A,+07.9,D,A,-000.8,D,C,+21.1,C,G,0216*2C

Reads current magnetic heading, true heading, pitch, roll, temperature, and magnetic error. This commands provides the most frequently used information in one command string.

DEVELOPMENT KIT

The SP3003D-KIT is designed as a development tool for Sparton's digital compass. This tool gives the user a pre-designed platform to interface and communicate with the digital compass. Included in the development kit are:

- One compass interface board and Power Supply
- One 6-Ft serial communication cable
- One software disk (Windows compatible)
  - User documentation
  - Calibration Data
  - Demo software

The interface board allows the digital compass to be connected directly to the serial port of a PC. Communication is fixed at 9600 Baud, 8 data bits, 1 stop bit, and no parity. The interface also provides convenient solder connections to all compass signals for development and testing.

Caution:

Set Power Management of all computers to "Always On". Laptop users – disable the Hibernate feature.

Analog X/Y/Z acceleration outputs are unbuffered. Leave pins unconnected or use a high-impedance input buffer. Loading of these outputs will cause errors in platform orientation and ultimately cause heading errors.

HARDWARE SETUP

Mate the SP3003D digital compass with the interface board provided in the kit as shown in Figure 8. North marking on bottom of SP3003D should match north marking on interface board. Connect the supplied serial cable to the compass interface and any spare COM port of the host computer (COM1 – COM4).

CAUTION:
The SP3003D is an electrostatic sensitive device. Observe proper ESD precautions to avoid permanent damage caused by static discharge.

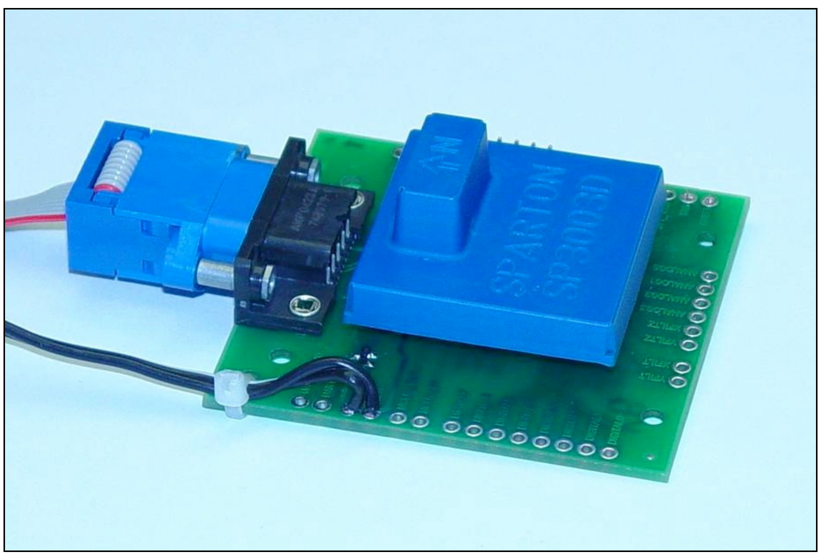


FIGURE 8 - SP3003D MATED TO DEVELOPMENT BOARD

WARNING: Make sure the SP3003D is mated correctly to the interface board. Misalignment of the pins can cause serious electrical damage to the SP3003D compass. Sparton's warranty does not cover faulty user hardware setup.

SOFTWARE INSTALLATION

Insert the CD into a drive and run **setup.exe**. Software will be installed onto the host system by following the on screen instructions. If an earlier version of software is detected, it will be removed from the system. If this happens, simply run **setup.exe** again to install the SP3003D development kit software.

SOFTWARE OPERATION

With the SP3003D and interface board mated, use the supplied serial cable to connect the interface board to COM1 of the computer. Plug in the DC converter wall adapter and run **SP3003D Development Kit** from the Windows Start menu located under SP3003D Development Kit. With the compass connected and program running, the communication port selection screen will be displayed (See Figure 9). Select the RS232 communication port to use with the SP3003D development kit press OK.

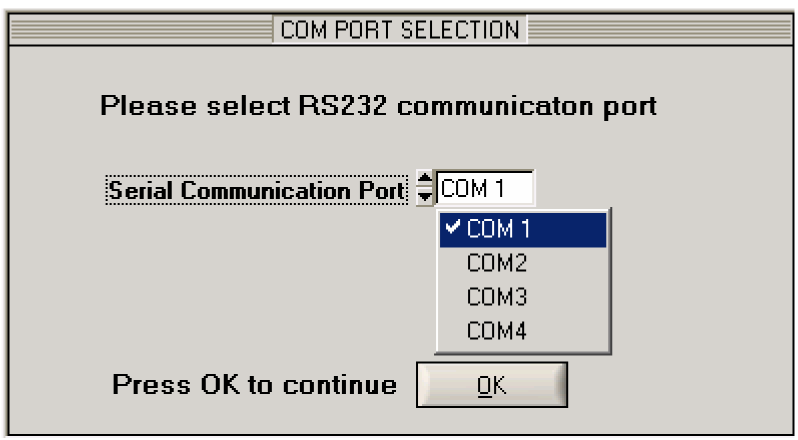


FIGURE 9 - COMMUNICATION PORT SELECTION

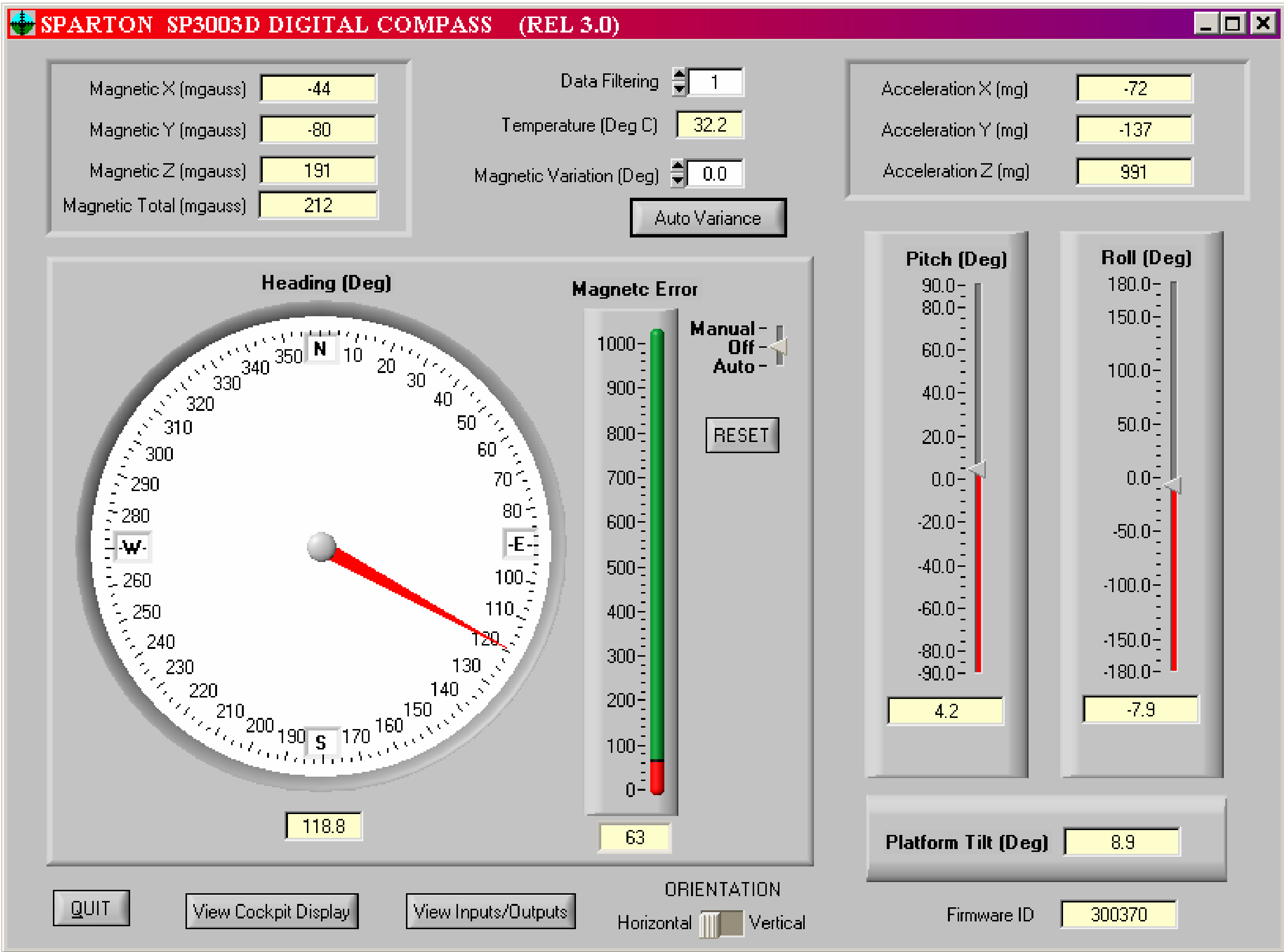


FIGURE 10 - DEVELOPMENT SOFTWARE DISPLAY

The development kit will continually update the display with information (See Figure 10). To exit the program, select the **Quit** button on the interface panel display, and then power down the compass assembly.

Magnetic measurements are displayed in milli-gauss. These measurements consist of the true X, Y, and Z components of the magnetic field as seen by the compass. Along with the magnetic vector components, the total magnetic field strength is also displayed. The magnetic measurements are relative to the compass platform orientation and do not include any pitch and roll compensation. Magnetic heading is shown graphically on a compass dial as well as numerically below the dial and indicates the direction in which the compass platform is pointing.

The compass mounting orientation is selected by using the slide switch at the bottom of the screen. Refer to Figures 4 and 5 for descriptions of the horizontal and vertical orientations.

The magnetic heading can be adjusted to indicate true North by setting the magnetic variance angle. The magnetic variance angle depends on your geographical location The SP3003D can calculate the variance angle based on latitude, longitude, altitude, and time information obtained from an external GPS source or can be set directly if the magnetic variance is known. To compute the magnetic variation angle, select AUTO VARIANCE.

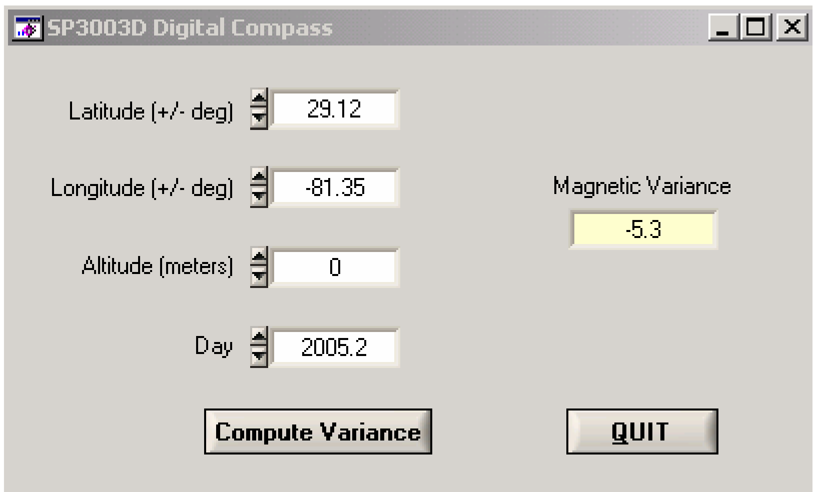


FIGURE 11 – AUTOMATIC MAGNETIC VARIANCE

Enter your current geographical location (geodetic coordinate system referenced to the WGS 84 ellipsoid). Latitude and longitude are entered in degrees with + being north and east respectively. Altitude is entered in meters above sea level. The day is entered as a fractional year based on the current day of the year (i.e. February 15 is the 46th day of the 2005. In fractional terms, this would be 46/365 = 0.126. The Day value for February 15, 2005 would then be entered as 2005.1 (resolution beyond a tenth causes negligible change in variance). Once the location and time values have been entered, select COMPUTE VARIANCE to send the data to the SP3003D. The COMPUTE VARIANCE button will turn red while the SP3003D computes the magnetic variance. Once the computation is complete, the magnetic variance will be updated in the SP3003D. *NOTE: TO RETAIN MAGNETIC VARIANCE ACCURACY, THE MAGNETIC MODEL MUST BE UPDATED EVERY FIVE YEARS. A SEPARATE PROGRAM IS AVAILABLE ON THE SUPPLIED CD WHICH WILL ASSIST IN DOWNLOADING NEW COEFFICIENTS INTO THE SP3003D DIGITAL COMPASS. THIS ONLY AFFECTS THE CALCULATION OF TRUE HEADING AND DOES NOT AFFECT MAGNETIC HEADING ACCURACY.*

The SP3003D digital compass uses a proprietary adaptive algorithm to keep the digital compass in constant calibration. The adaptive algorithm monitors the 3-dimensional behavior of the magnetics as the compass is being used. Magnetic material near the compass will cause a distortion in the magnetic field. The SP3003D can detect field distortions caused by any material that move with the compass (i.e. mounting platform). Any detected field distortions cause the adaptive algorithm to automatically adjust the calibration parameters so that the compass retains accuracy under all orientations. The adaptive algorithm can be turned on by moving the selector switch to AUTO. Turning the adaptive algorithm OFF will stop any further updating of the calibration parameters and retain the current settings. Pressing RESET will force the calibration parameters back to the factory default settings.

During the adaption process, the algorithm estimates the error in the magnetic calibration. This error is captured, scaled, and displayed graphically on a vertical bar to indicate the overall performance of the adaptive calibration process. When significant magnetic field distortions are detected, the indicator bar will become mostly red. Over time the distortions will be canceled out and the indicator bar will become mostly green.

When the compass is first used, it must learn the local magnetic distortions. This will automatically occur over time as the orientation of the compass is changed. The following steps will help to speed the adaption process when the compass is first used:

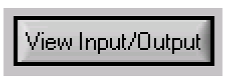
1) Set magnetic adaption to OFF.
2) Press RESET to start calibration at the factory default settings.
3) Point the compass North and set magnetic adaption to MANUAL.
4) Pitch compass slowly a full 360°.
5) Point compass East or West and then roll compass slowly a full 360°.
6) Set magnetic adaption to AUTO.
7) Repeat steps (4) and (5) by pitching and then rolling a full 360°.
8) The magnetic error will continue to improve over time as the compass orientation is changed. Eventually, the adaption error will reach a minimum for all orientations.
9) Calibration parameters are automatically stored when the magnetic adaption error drops below 25. The current magnetic calibration parameters will also be saved whenever the magnetic calibration is set to Auto, Off, or Reset.

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 produce 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.

Acceleration measurements are displayed in milli-g (where g = 9.8 meters/sec^2). These measurements consist of the true X, Y, and Z components of the acceleration as seen by the compass. It is important to note that these measurements will include acceleration due to motion of the compass platform as well as the acceleration due to gravity.

Pitch and Roll information is provided both graphically and numerically to indicate the current orientation of the platform. The overall tilt of the platform is calculated by the software development kit using the pitch and roll information. The overall platform tilt is direction independent and indicates the tilt of the platform from vertical expressed in degrees. Platform tilt values greater than 90 degrees indicate the platform is inverted.

The data filter consists of a simple lowpass IIR filter applied to the heading, pitch, and roll data. The amount of filtering can be adjusted by changing the filtering value. Low values provide less filtering. Higher values will make the compass less responsive providing more stable heading, pitch, and roll. Acceptable filter values are in the range 1 to 65535.



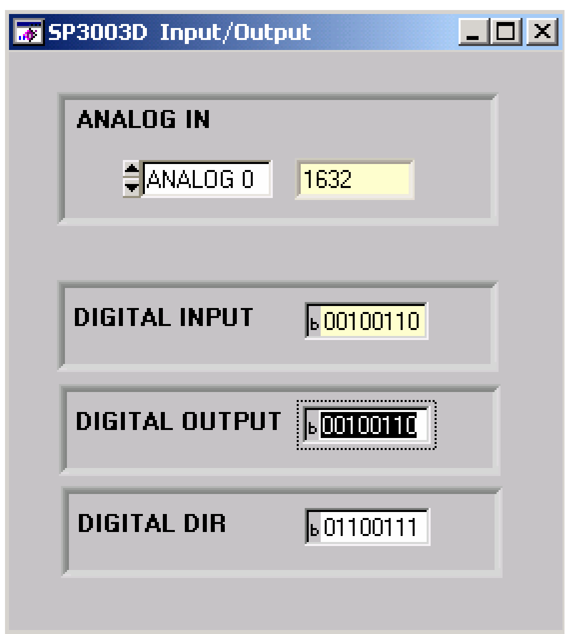


FIGURE 12 - VIEW INPUT/OUTPUT DISPLAY

Analog input channels can be monitored, one at a time, by selecting the desired input channel in the **ANALOG IN** box. The displayed data corresponds to the selected input digitized to 12-bits (0V = 0, 3.3V = 4096).

The **DIGITAL INPUT** shows the current logic state of DIGITAL0 through DIGITAL7. If the selected digital line is configured as an output channel (see **DIGITAL DIR**), then the current state of **DIGITAL OUT** will determine the input logic state. Data is displayed as binary with the most significant bit corresponding to DIGITAL7 and the least significant bit corresponding to DIGITAL0.

The **DIGITAL OUTPUT** sets the logic state of all digital channels that are defined as outputs (see **DIGITAL DIR**). Data is displayed as binary with the most significant bit corresponding to DIGITAL7 and the least significant bit corresponding to DIGITAL0.

The **DIGITAL DIR** sets the input/output direction for each digital channel (DIGITAL0 through DIGITAL7). If a digital channel is set to logic 1, that channel is configured as an output. Likewise, logic 0 will configure the corresponding channel to be an input. The default state is all inputs at powerup. Data is displayed as binary with the most significant bit corresponding to DIGITAL7 and the least significant bit corresponding to DIGITAL0.

The **Temperature** provides a measure of the compass temperature. This measurement provides an indication as to the ambient temperature by measuring the die temperature of the compass microcontroller.

COCKPIT DISPLAY MODE

The development kit software has a display mode that simulates an aircraft cockpit. To enter the cockpit display mode, select VIEW COCKPIT DISPLAY.

The display will show an artificial horizon gauge, a compass gauge, a roll indicator, a pitch indicator and a yaw indicator as depicted in Figure 14. The artificial horizon gauge roll axis is black and encircles the gauge. It is read via the black triangular pointer. The artificial horizon gauge pitch axis is yellow and is read at the center of the gauge. The artificial horizon gauge yaw axis is green and is also read at the center of the gauge. The following table lists the user commands that are available in cockpit display mode:

Command	Action
CTRL-H	Toggle the artificial horizon gauge display mode to "heads up" (Figure 15) and back.
CTRL-S	Scale the artificial horizon gauge pitch and yaw axes. The allowable range is 30 to 90 degrees and represents the distance from the center of the gauge to the bezel (gauge mode) or the distance from the center of the gauge to a corner of the gauge (heads up mode). See Figure 13.
CTRL-D Or F10	Return to the default development kit software display mode.

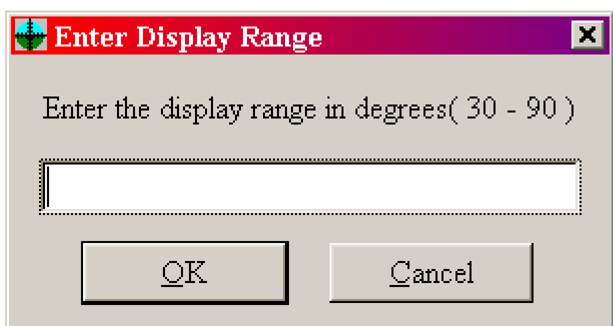


FIGURE 13 – DISPLAY RANGE ENTRY DIALOG

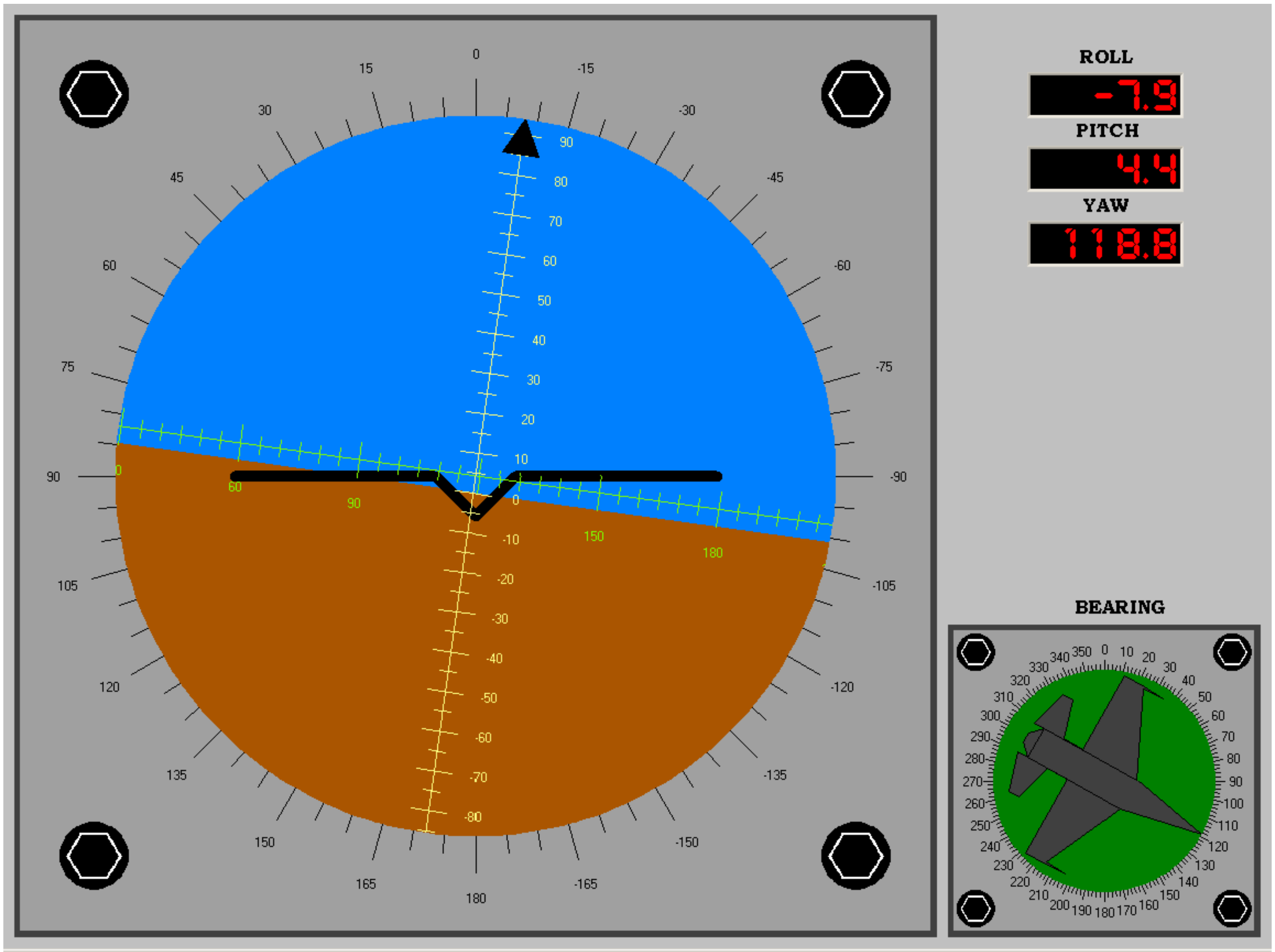


FIGURE 14 - VIEW COCKPIT DISPLAY

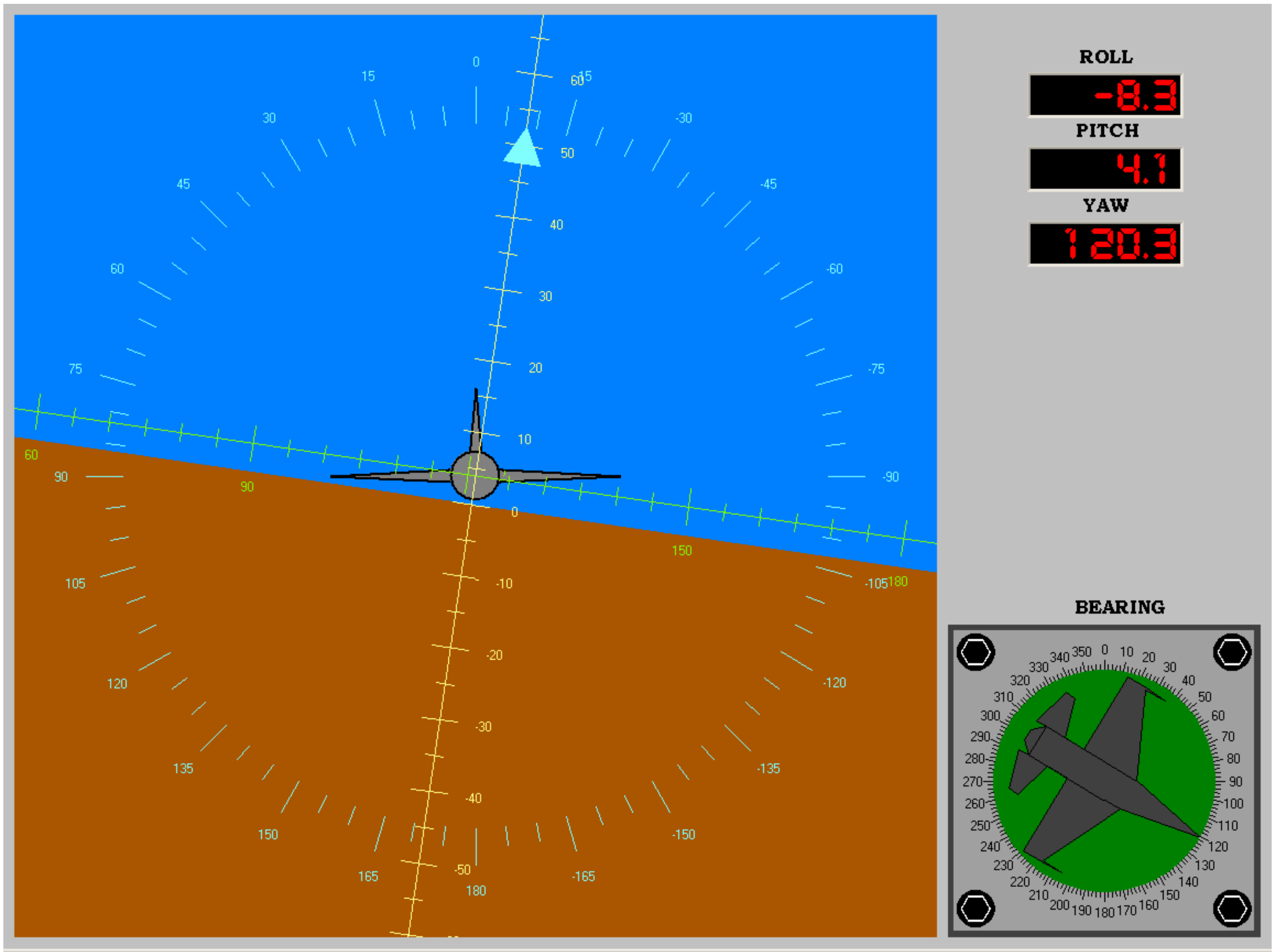


FIGURE 15 – HEADS UP COCKPIT DISPLAY

DEVELOPMENT KIT PCB INTERFACE

The development kit interface PCB includes four (4) 0.125 diameter through holes for mounting the PCB.

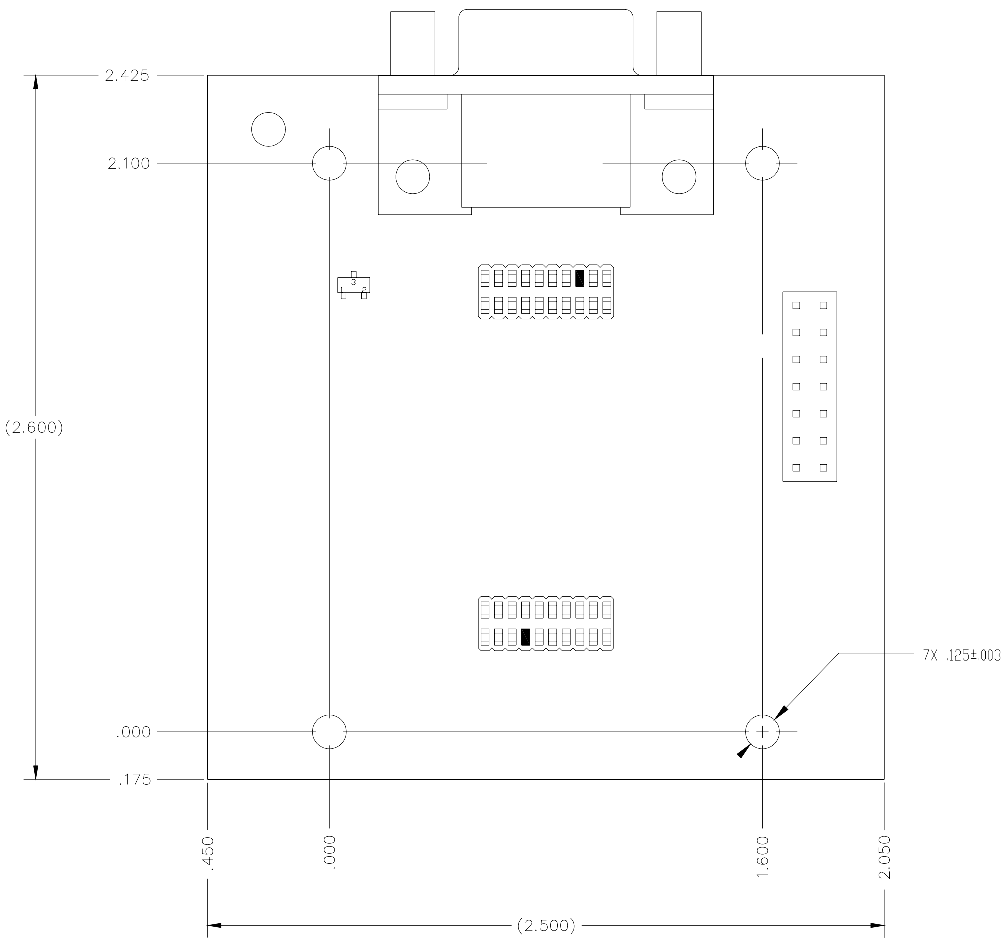


FIGURE 16 – PCB MECHANICAL OUTLINE

SP3003D UPDATES

The SP3003D digital compass uses a spherical harmonic model to calculate the magnetic variance. This variance is then used to adjust the magnetic heading to indicate a true north heading. In order to retain accuracy, the magnetic model must be updated every five years. A software program is available on the supplied CD that will assist in downloading new coefficients into the SP3003D digital compass. This only affects the calculation of true heading and does not affect the magnetic heading accuracy. Next updates must be downloaded and installed in January of 2010.

SOFTWARE INSTALLATION

Insert the CD into a drive. Open the SP3003D Update folder and run **setup.exe**. Software will be installed onto the host system by following the on screen instructions. Future updates can be obtained from the Sparton website at http://www.sparton.com.

HARDWARE SETUP

Mate the SP3003D digital compass with the interface board provided in the kit as shown in Figure 17. North marking on bottom of SP3003D should match north marking on interface board. Connect the supplied serial cable to the compass interface and any spare COM port of the host computer (COM1 – COM4). The SP3003D can also be updated in the application as long as the RS232 communication is available and the compass is powered.

CAUTION:
The SP3003D is an electrostatic sensitive device. Observe proper ESD precautions to avoid permanent damage caused by static discharge.

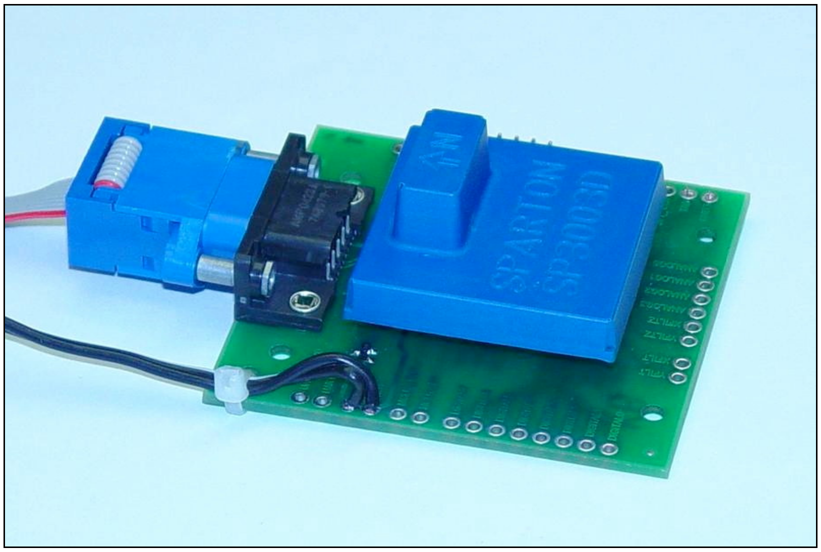


FIGURE 17 - SP3003D MATED TO DEVELOPMENT BOARD

WARNING: Make sure the SP3003D is mated correctly to the interface board. Misalignment of the pins can cause serious electrical damage to the SP3003D compass. Sparton's warranty does not cover faulty user hardware setup.

SOFTWARE OPERATION

With the SP3003D and interface board mated, use the supplied serial cable to connect the interface board to COM1 of the computer. Plug in the DC converter wall adapter and run **SP3003D Update** from the Windows Start menu located under SP3003D Update. With the compass connected and program running, the coefficient file selection screen will be displayed (See Figure 18). Browse to the coefficient file if downloaded from the Sparton website or go to the Sparton Update folder to select WMM.COF for default coefficients (used to model 2005.0 to 2010.0 date range). Once the file is selected, press the Load button.

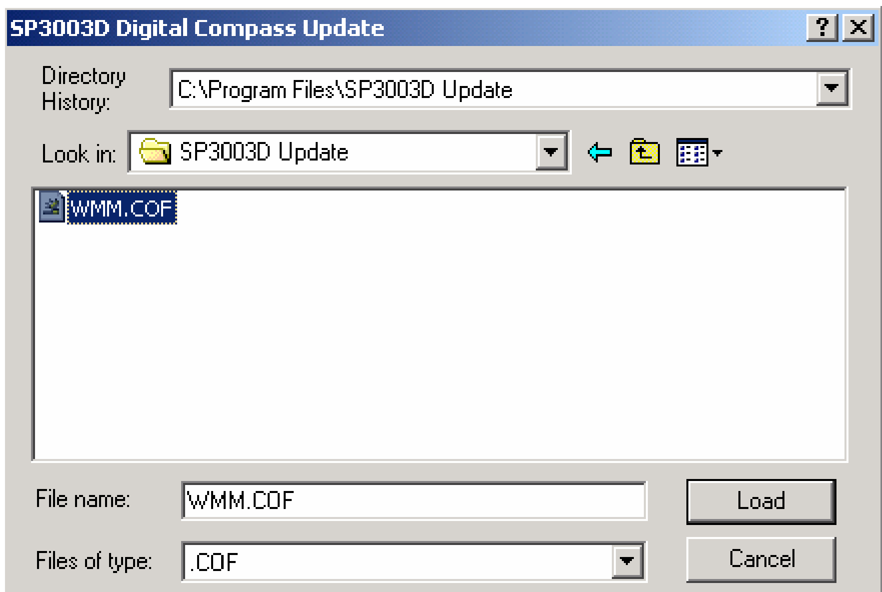


FIGURE 18 – COEFFICIENT FILE SELECTION

Next, the communication port selection screen will be displayed (See Figure 19). Select the RS232 communication port to use with the SP3003D development kit press OK.

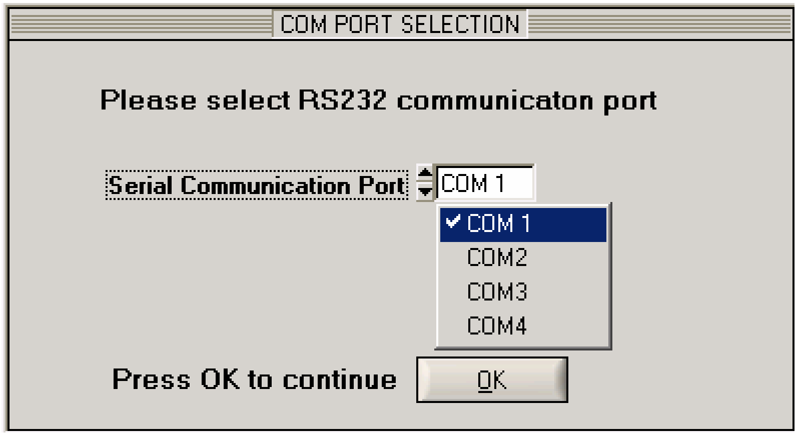


FIGURE 19 - COMMUNICATION PORT SELECTION

Once the communication port has been selected, the coefficient file will begin downloading into the SP3003D digital compass. A progress bar is displayed to show the status of the download (see Figure 20). When the progress bar reaches 100%, the download is complete. A message will be displayed indicating that the download was successful (see Figure 21).

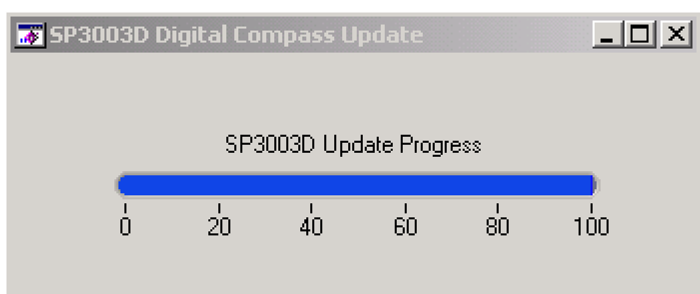


FIGURE 20 – SP3003D UPDATE PROGRESS BAR

FIGURE 21 – SP3003D DOWNLOAD COMPLETE

If the download was unsuccessful, a message will be displayed (see Figure 22). If this occurs, check the hardware connections to the SP3003D and insure that the compass is powered. Make sure the download software file selection has a .COF extension and that the correct communication port is being used.

FIGURE 22 – SP3003D DOWNLOAD UNSUCCESSFUL

IN ORDER TO RETAIN ACCURACY, THE MAGNETIC MODEL MUST BE UPDATED EVERY FIVE YEARS. FUTURE UPDATES CAN BE OBTAINED FROM THE SPARTON WEBSITE AT http://www.sparton.com. THIS UPDATE ONLY AFFECTS THE CALCULATION OF TRUE HEADING AND DOES NOT AFFECT THE MAGNETIC HEADING ACCURACY.

ORDERING INFORMATION

DESCRIPTION	ORDERING PART NUMBER	UNIT OF MEASURE
SP3003D Digital Compass	SP3003D	EACH
Development Kit w/ Software	SP3003D-KIT	EACH

To place an order:

Please email SP3003D@sparton.com or visit http://www.sparton.com or http://www.thedigitalcompass.com for additional product and ordering information.

WARRANTY

a. Sparton warrants to Customer, and to no other legal entity, that, for a period of twelve (12) months from the date of purchase: the Product delivered to Customer will be (i) free from defects in material and workmanship and (ii) free and clear of all liens and encumbrances.

b. Sparton shall have no responsibility or obligation to Customer for warranty claims related to: Product failures caused by incompatibility with other systems or devices; Products damaged by misuse, accident, neglect, or improper alterations or repairs, including the use of non-conforming parts; or the failure of the Product to perform or operate other than in conformity with Sparton's technical descriptions.

b. In the event that any Product manufactured by Sparton is not in conformity with the foregoing warranties, Sparton shall, at Sparton's option, either credit Customer for any such nonconformity [not to exceed the purchase price paid by Customer for such Product(s)], or, at Sparton's expense, replace, repair or correct such Product(s). The foregoing constitutes Customer's sole remedies against Sparton for breach of warranty claims. If Sparton elects to repair any such Products, it will use only new parts. Any Products submitted pursuant to the warranty provisions of this Agreement which passes the inspection/acceptance tests, will be returned to Customer as No Defect Found (NDF) and Sparton will invoice Customer a per lot testing and handling charge, as quoted, plus return shipping charges. Customer will be entitled to a remedy hereunder only if it notifies Sparton in writing of the alleged breach of warranty no later than thirty (30) calendar days from the expiration of the warranty or within thirty (30) calendar days of the date of discovery, whichever first occurs. Sparton will pay freight charges for returns.

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