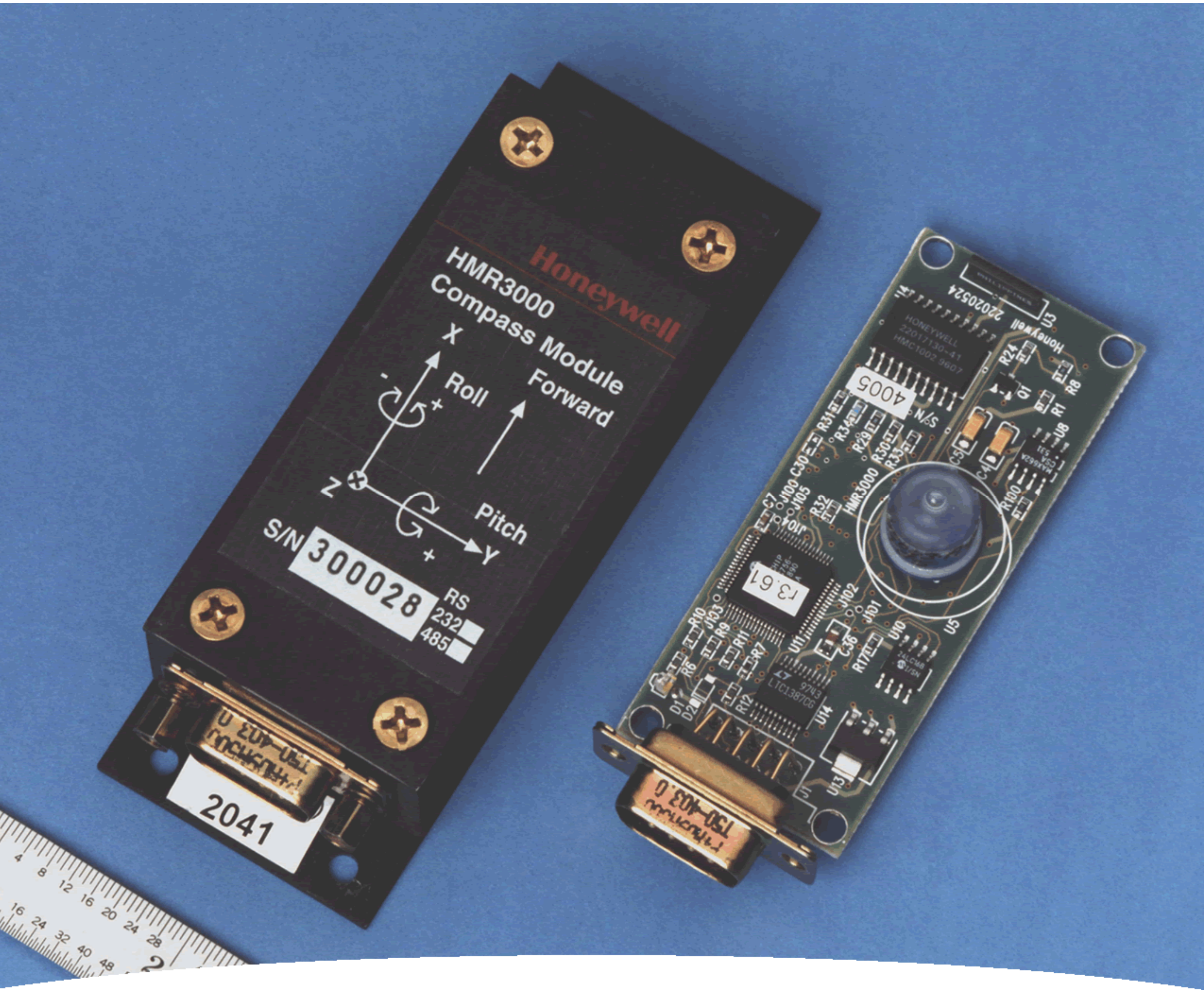
Honeywell Magnetic Sensor Products



HMR3000 Digital Compass Solution User's Guide

Honeywell

Packing List

Part Number	Items included
HMR3000-D00-232	HMR3000 RS-232 Circuit Card
HMR3000-D00-485	HMR3000 RS-485 Circuit Card
HMR3000-D21-232	Housed Compass Module RS-232
HMR3000-D21-485	Housed Compass Module RS-485
HMR3000-D21-232-DEMO	Housed Compass Module RS-232 Windows Demo Software CD Power supply and interface cable

Factory Default Settings

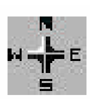
Parameter or Condition	Default Settings
Baud Rate	19200
Operation Mode	Run
Output Sentences	None
TC1 (filter 1 time constant)	4
Heading filter L value	0
Heading filter S value	0

How to Set Up and Install HMR3000 Demo Unit Software

1) Connect the interface cable between the HMR3000 and serial port of a PC. Check and select the line voltage input (110 or 220 V), turn the voltage selector to 9 volt DC mark with positive polarity, and plug in the adapter to an electrical outlet.

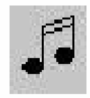
2) Install PC Demo Interface software on the PC by running setup.exe from the CD. In Windows, click start, then run and browse CD to find setup.exe in the HMR3000 PC DEMO folder.

3) Double click on ***PC Demo Interface icon*** (PCDEMO.EXE).



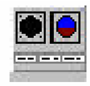
Select the correct COM port and 19200 baud rate (The serial port is usually COM1).

4) Click the ***musical note button***



5) Go to Serial Output tab and change the message rate on HPR sentence to 825.

Click on the ***attitude display button***



Note: You should have received PC Demo Interface Ver. 2.03 or higher. If you have an older version please update to the latest version. Please call Honeywell Magnetic Sensors Technical Support at 763-954-2474 if you need this new version of the software.

Computer Requirements

Minimum:	PC 486/33MHz Windows 3.1, Windows 95 or NT Operating System VGA 2 Mb disk space (more for log file and captured data) RS-232 serial port
Recommended:	Pentium/120MHz Windows 95 or newer Operating System SVGA 1024 x 768 Microsoft Excel (5.0 or greater) for capture and export of data (if desired)

Note: The Graphical output of the HMR3000 on PC Demo software may become sluggish if the PC has slow graphic capability or if other applications are running in the background.

How to Set the Baud Rate

Using the PC DEMO software interface:
1) Connect the device and run PC Demo
2) Go to Tune Parameters / Serial Output page through the main menu of the program
3) Select the baud rate
4) Power down the device
5) Power up the device and communicate with the new baud rate

Through Direct Commands
1) Set up normal communications with the current baud rate
2) Issue the commands (see Section 4.4 of the User's Guide and Baud Rate)
3) Power down the device
4) Power up the device and communicate with the new baud rate

1.0 INTRODUCTION

The HMR3000 uses Honeywell magnetic sensors with proven MR technology and a two-axis tilt sensor to bring you the heading information. This electronically gimbaled compass gives accurate heading even when the compass is tilted up to 45 degrees. This low power, small device is housed in a non-magnetic metallic enclosure that can be easily installed on any platform.

The HMR3000 allows the user to configure compass output to include any combination of six NMEA standard messages and to change measurement parameters for the magnetometer to suit the application. The sophisticated auto compass calibration routines will correct for the hard-iron magnetic effects of the platform. The wide dynamic range of the magnetometer (±1 G or 100 μT) allows the HMR3000 to be useful in applications with moderate local magnetic fields.

2.0 GETTING TO KNOW THE HMR3000 PRODUCT

2.1 Identifying the HMR3000

The HMR3000 Compass module comes in three different options:
(1) Bare circuit board with RS-232 or RS-485 electrical interface
(2) Housed Compass Module with RS-232 or RS-485 electrical interface
(3) Demonstration Kit (Housing and RS-232 only)

The electrical interface of the compass module is clearly marked on the circuit board in option (1) and on the product label in option (2). Option (3) only comes with RS-232 electrical interface.

2.2 Setting Up the HMR3000

Interface and power cables—Interface and power supply should be included in the Demonstration Kit (see **Electrical Connections** in Section 2.4).

For other HMR3000 product options, a cable having a standard 9-pin D shell female connector should be wired according to the pin-out defined below. Power should only be connected to ***either*** pin 9 ***or*** pin 8. It is sufficient to connect the pins listed in Table 1 for most applications. However, pins 1, 4, 6 and 7 serve specific purposes in the operation of HMR3000 and should be kept open (high logic state) in normal operation (see Table 2 for complete pin out description). See Figures below for suggested cabling diagram for connection between HMR3000 and serial port of a personal computer.

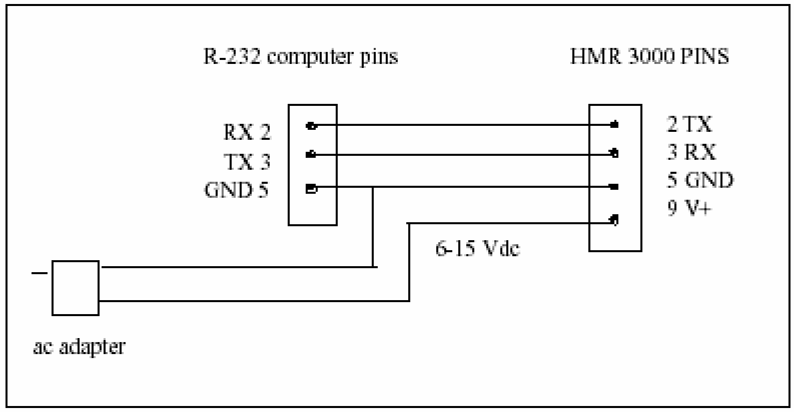
Name	In/Out	Pin	Description
TxD / A	Out	2	RS-232 transmit out / RS-485 transmit-receive signal
RxD / B	In	3	RS-232 receive in / RS-485 transmit-receive return
GND	In	5	Power and signal common
6-15V	In	9	Unregulated power input
5V	In	8	Regulated power input

Pin Assignment for Typical Operation of HMR3000

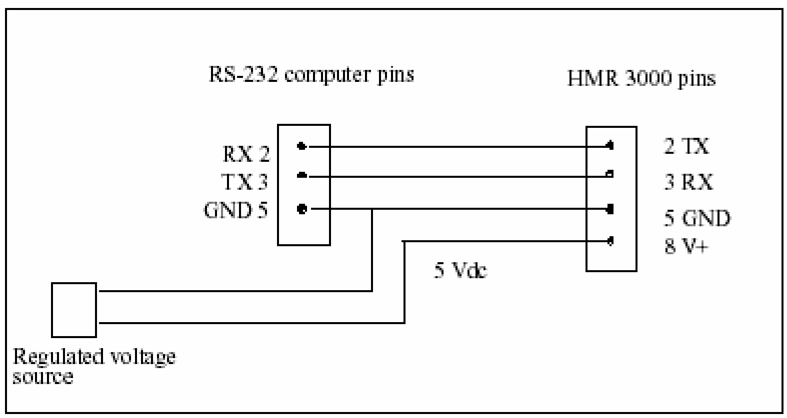
Caution: Do NOT exceed +5.5V at regulated power input (pin 8). Higher voltages will damage components.

2.3 HMR3000 Connection Diagram—Computer RS-232 to HMR3000

Unregulated Supply



Regulated Supply



2.4 Electrical Connections

Connect the cable between HMR3000 and the serial port of the IBM compatible computer. Connect AC adapter or alternate power source to supply power to the HMR3000 (6 to 15V at the unregulated power input, or 5V regulated).

If you purchased a theHMR3000 Demonstration Kit, use the power and interface cable to connect between HMR3000 and your computer's serial port. Make sure the line voltage selection (110 or 220V) in the adapter is appropriate and that 6 Vdc or higher output voltage (<15V) is selected.

2.5 Communication - RS-232 Option

The HMR3000 communicates with an external host via RS-232 or RS-485 electrical standard through simple ASCII character command strings. A host computer can direct operation of HMR300 with these commands. With the RS-232 demo kit option a user friendly graphical interface (PC DEMO Software) is provided to direct operation of the compass.

2.6 Getting Data Using PC DEMO Software

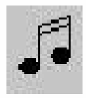
Once the power and interface cables are connected and the PC DEMO software is installed in your computer, you can begin to acquire compass data from the HMR3000. See the beginning section on software installation if you have not done this yet.

1. Double click on ***PC Demo Interface icon*** (PCDEMO.EXE).

2. Select the correct COM port and 19200 baud rate (The serial port is usually COM1).

3. Message box, identifying the Firmware Version, should appear, and confirms good interface connections.

4. Click the ***musical note button*** (tune parameters).



5. Go to Serial Output tab and change the message rate on HPR sentence to 825. Now the compass should output heading, pitch and roll data at 825 sentences/min rate.

6. Note that the message rates for all the output sentences are set to 0 at the factory. Click on the *View Interface*, or *Monitor NMEA Sentences* selections on the Display menu (or left two buttons) to see the result of the HPR sentence output. The *View Log* selection under the Diagnostics menu is another option to inspect compass data. Make sure the Log all messages (logging page in Diagnostics menu) option is activated. A non-zero HPR message rate should be chosen to view the displays to be active.

The HMR3000 output can be changed to include all or any of the six NMEA sentences each with its own rate. Users can capture the output messages to a file using the Capture Mode by selecting the message to be captured.

2.8 Configuring the HMR3000 with PC DEMO Software

Following is a list of basic parameters that would be accessed routinely and at installation. Advanced parameters that control the operation of the magnetometer, heading output, and warning levels are described in the Configuration Parameters section.

Activate the Tune Parameters button to configure.

Function	Parameter / Description	Located Under	Range
Declination	Declination Angle Angle between magnetic north and the geographic north. Add a declination angle to magnetic heading to obtain a true north heading.	General page	0-180 deg 0- 3200 mils
Output Messages and Rate	HDG, HDT, XDR, HPR, RCD, CCD NMEA sentence outputs Rates in sentences per minute	Serial Output page	None or All 0-1200 updates/min
Data Filter	TC1 Time constant for IIR filter		0-255 1=72 ms
Heading Output	L and S Smoothing factors for non linear filter		0<S<1 L= integer >1 L=0 disable L<256
Deviation	Deviation Angle The angle between compass forward direction and that of the platform. Add deviation to get platform heading	General page	0-180 deg 0- 3200 mils

2.9 Communication—RS485 Option

The HMR3000 Compass module's RS-485 interface is half duplex, i.e. transmit and receive circuits share the same physical pair of wires. The HMR3000 must disable its transmitter to allow characters to be received from a host system. If the unit is operating in the Run mode, i.e. generating repetitive output; then the Run/Stop pin (pin 6) should be forced low before the host attempts to transmit a command. See details in Description of hardware interrupt section.

2.10 Digital Compass Installation

To get optimum performance when installing the HMR3000, follow the guidelines listed below for your vehicle or platform:

Location—Install the HMR3000 as far as possible from any source generating a magnetic field and far from ferrous metal objects. Honeywell magnetic sensors used in HMR3000 have a large field range of 2 gauss (200 μT), compared to 0.65 gauss (65 μT); the maximum of earth's total magnetic field, and therefore would not saturate in most platforms. Calibration and compensation routines in the compass can effectively compensate for static magnetic fields superimposed on the earth's field components, which are used for heading calculations. However, compasses can not compensate for the effects of varying fields produced by dc and ac currents in nearby wires.

Level—The HMR3000 is electronically gimbaled and it is not necessary to mount the compass perfectly level. However, to get the maximum possible tilt range, the compass should be mounted level (flanges down) when the vehicle or platform is in normal operation.

Orientation—Forward direction of the compass can be oriented at any angle from that of the platform. Use Deviation Angle parameter to convert the compasses magnetic heading to the true or magnetic heading of the vehicle/platform.

2.11 HMR3000 Hard-Iron Calibration

All magnetic compasses have to be calibrated in order to compensate for magnetic fields other than the earth's field components to get accurate heading. These additional magnetic fields (hard-iron effects) are generated by the near environment and therefore depend on the compass mounting location. By performing a simple procedure, the HMR3000 can compensate for these steady, static magnetic fields. Field components found after a calibration are only valid for the particular orientation and location of the compass. A re-calibration is necessary after a relocation of the compass or if the platform has changed its magnetic character.

Typically hard-iron calibration is performed by following a calibration procedure specified by the manufacturer. During this procedure the compass collects data required for the compensation algorithms. The goal of the calibration procedure is to sample the magnetic field components for many possible orientations of the host system. Rotating the host system through 360 degrees or driving in a circle (in the case of a vehicle) will enable the compass to sample its magnetic environment and derive the magnetic offset and scaling numbers to null out the hard-iron effects. The HMR3000 can be calibrated by either using the built in calibration method or by using the PC Demo Interface software program. The calibration procedure for both these methods is the same.

2.11.1 Built-in Calibration Method

This method uses an iterative procedure to calculate the hard iron offsets. In most situations 275 iterations would produce good results. The calibration procedure has to continue until this iteration count is reached.

To put the HMR3000 into calibration mode issue the calibration command #F33.4=0*51<cr><lf>.

Slowly rotate the host system through a full circle in a gentle motion while changing roll and pitch as much as the host will allow. Generally this procedure will take over two minutes.

You may check the iteration count periodically during the rotation by issuing #I26C?*31<cr><lf>. HMR3000 will reply with a #*nnnn**hh<cr><lf> message, where *nnnn* is the value of the iteration count. If this value is less than 275 continue with the calibration procedure until that number reaches 275.

At the end of this procedure issue a command to save the results in the HMR3000's EEPROM (#F2FE.2=1*67<cr><lf>). Put the compass back into operate mode by issuing a #F33.4=1*50<cr><lf> command. This method works when the hard iron field effects are small.

2.11.2 PC DEMO Calibration Method

This method is recommended when the hard iron field effects are large. The PC DEMO software interface will collect the raw magnetic vector information and analyze the data to find the hard iron offsets.

1. In PC Demo, go to Diagnostics menu, and then to the Perform 3D Calibration selection.

2. On calibration page, activate Read Data button. You should see the Total Valid Readings number (# of data points collected) go up with motion.

3. Slowly rotate the platform through a full circle in a gentle motion while changing roll and pitch as much as the platform will allow. Generally this procedure will take over two minutes.

4. At the end of this procedure click the Stop button. The magnetic vector offsets will display as results. Click the Apply button to put the Hard Iron offsets values into effect. In clean magnetic environments, the offsets will be only a few hundred counts away from zero.

5. If sufficient tilt change were not encountered during the calibration procedure, then the calculated Zoffset value may not be reliable. In such a case the Z offset would likely will appear in red, and the corresponding check box empty. User has the option to accept this Z offset value by checking the box.

At the end of each calibration, PC DEMO software calculates and reports a variation number as a sign of magnetic environment change/goodness; the lower the number the better the calibration. The compass should be relocated if the variation number is greater than 40.

2.11.3 PC DEMO Z Reference Calibration Method

In applications which changing the tilt of the host is not possible, an approximate value of the Zoffset can be found by using the Z Reference Method. This method directly compares the Z component of the earth’s magnetic field in an undisturbed location to that of the host. This procedure involves two steps:

Step 1. Collect Z reference value near the calibration site, away from large metal objects that will distort the earth’s field by:

1 Select the Diagnostics menu, and then select Capture/Clear Z Reference.

2. Hit Read Data, and hold the compass approximately level.

3. Hit the Stop button after capturing 10-20 readings, and hit the Apply New button to save the new Z Reference value in the EEPROM of HMR3000.

Step 2. Install the compass on the vehicle/mount and follow the normal 3D Calibration described above in 2.11.2. Mag Z offset will be computed from the Z Reference method as well as the normal method.

1. At the end of the calibration, between the Stop and Apply button selections, ensure the MagZ check box is un-checked, and the Z Reference check box is checked.

2. Select the Apply button to save the new offset values.

3.0 OPERATION OF THE HMR3000 IN DETAIL

3.1 GENERAL

The HMR3000 digital compass consists of three magnetoresistive magnetic sensors, and a liquid filled two-axis tilt sensor to produce tilt compensated heading data. A microprocessor controls the measurement sequence of the sensors, and all the parameters that control the operation are stored in an EEPROM. The output sentences of the HMR3000 conform to the NMEA 0813 standard for Marine communication (NMEA = National Marine Electronics Association).

The HMR3000 has four operational modes:

Continuous Mode

Output unsolicited NMEA standard message(s) at a configurable rate

Strobe Mode

Active Strobe Mode- Measurement is continuous and message output on request

Passive Strobe Mode- Measurement and output upon request

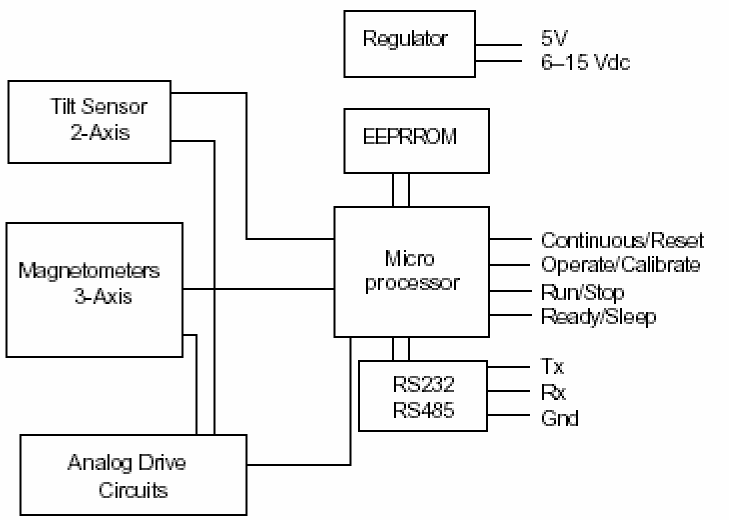
Sleep Mode (requires an interrupt signal at the connector)

Both measurement and output are suspended with serial inputs ignored

Calibrate Mode

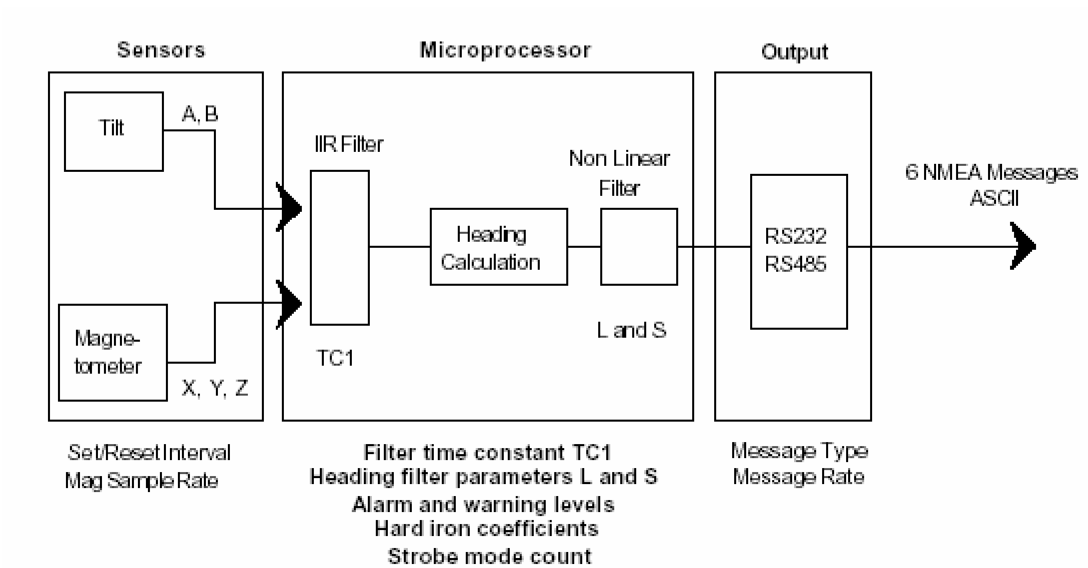
Enter the compass in to user Hard Iron calibration mode

3.2 HMR3000 ELECTRICAL BLOCK DIAGRAM



3.3 HMR3000 PROCESS CONTROL BLOCK DIAGRAM

User configurable parameters that control the measurement and heading calculation process are denoted in the figure below.



3.4 HMR3000 Measurement Sequence

In normal operation, the microprocessor takes a set of seven measurements, four tilt and three magnetic, that are combined to produce heading, roll, and pitch data.

A set of magnetic measurements can be taken at 110, 55, 27.5, or 13.75 Hz rates. The fluidic ilt sensor is driven with a constant 55 Hz pulse. Raw data are normalized, linearized, and filtered at the 13.75 Hz rate. Normalization includes gain matching, offset nulling, and hard-iron compensation offsets for the three magnetic measurements; and the gain and offset compensation for tilt measurements. Tilt measurements are linearized to account for the non-linear characteristics of the inclinometer function. All five measurements, TiltX, TiltY, MagX, MagY, and MagZ, are low-pass filtered, using an IIR filter (Infinite Impulse Response), depending on the setting for the TC1. This filter may be disabled by setting the time constant to zero.

Magnetic sensor operation includes a Set/Reset pulse routine to achieve high sensitivity magnetic measurements. The active area of the MR element is Set and Reset periodically by 3 amp current pulses through the magnetic sensor set/reset straps. The periodicity of this Set/Reset operation can be changed to achieve high heading accuracy or to conserve power.

Compass heading is calculated 13.75 times per second from the 5 filtered measurements. A form of non-linear smoothing can be applied to the current heading to produce a smooth heading. The transfer function of the algorithm is a high degree of smoothing applied for small changes in heading, i.e. noise, while little or no smoothing is applied to larger, more significant changes by setting the parameters of this non linear filter.

In may not make sense to use the IIR filter and the non-linear smoothing for a given application. If the compass is mounted on a vessel that cannot change direction quickly, then it is probably better to use the IIR filter and disable smoothing. On the other hand, smoothing works well for hand-held applications or where noise is a problem.

3.5 HMR3000 Interface Pin Descriptions

The table below shows pin assignments for the 9-pin D-shell connector. Different pins are used to supply either regulated $5V_{dc}$ or unregulated 6V to 15V power. Only one of the two power pins (9 or 8) should be connected in a given installation.

Name	In/Out	Pin	Description
TxD / A	Out	2	RS-232 transmit out / RS-485 transmit-receive signal
RxD / B	In	3	RS-232 receive in / RS-485 transmit-receive return
GND	In	5	Power and signal common
6-15V	In	9	Unregulated power input
5V	In	8	Regulated power input
Oper / Calib *	In	1	Operate / Calibrate-* input (open = Operate)
Run / Stop *	In	6	Run / Stop- input (open = Run)
Ready / Sleep *	In	4	Ready / Sleep- input (open = Ready)
Cont / Reset *	In	7	Continue / Reset- input (open = Continue)

*A dash following a signal name is used to denote that the signal is asserted active low.
In this case, when pin 1 is low the Calibrate function is selected.

3.6 HMR3000 Serial Data Communication

The HMR3000 serial communications are governed by a simple, asynchronous, ASCII protocol modeled after the NMEA 0183 standard. Either an RS-232 or an RS-485 electrical interface can be used. ASCII characters are transmitted and received using 1 start bit, 8 data bits (LSB first), no parity (MSB always 0), and 1 stop bit; 10 bits total per character. Baud rate can be any one of 1200, 2400, 4800, 9600, 19200, 38400.

The HMR3000 supports both standard NMEA 0183 and proprietary messages. Unsolicited NMEA messages are sent by the HMR3000 in Continuous Mode at the rates programmed in EEPROM. HMR3000 also responds to all input messages from the host. An HMR3000 response to a command input may be delayed due to transmission of an unsolicited output. The host processor must wait for HMR3000 to respond to the last command input before sending another command message.

All communication from and to HMR3000 contain a two-character Checksum Field at the end of the data fields, and are denoted in the following sentences by 'hh'. The checksum assures the accuracy of the message transmitted. This checksum is calculated per NMEA 0183 Standard, and is outlined in section 3.11.

3.7 HMR3000 Input Data

There are two kinds of serial data input to the HMR3000; either a request for output sentence, or a setting of a configuration parameter.

HMR3000 sends a response to all valid inputs with a correct checksum value.

1. Response to a Request for output sentence is the appropriate sentence.

2. Response to parameter input will be #!0000*21 to indicate the command and the parameter was accepted.

3.8 HMR3000 Output Data

There are six possible NMEA messages, three standard and three proprietary, that can be automatically sent from the HMR3000 in Continuous Mode by selecting their Update Rates. Additionally, there is a seventh, non-conforming ASCII display message that can also be sent. The ASCII display message is not expected to commingle with the other six NMEA messages. It is intended for simpler systems where the HMR3000 is connected to a numerical readout device instead of a host processor.

The update rate for each message can be set independently to one of the following: 0, 1, 2, 3, 6, 12, 20, 30, 60, 120, 180,300, 413, 600, 825, or 1200 sentences per minute. If the output channel, due to its programmed baud rate, cannot accommodate the total number of sentences selected, then the channel will operate at full speed and highest priority will be given to responses to input, followed by sentences with update rates from lowest to highest. Fairness will be implemented in the priority scheme so that each sentence ready for output is transmitted at least once before higher priority sentences are repeated.

3.9 Query for NMEA Sentences

The three NMEA standard sentences (HDG, HDT, and XDR) and three proprietary (HPR, RCD, and CCD) messages can be queried as follows.

The three standard query messages accepted are:

$TNHCQ,HDG*27<cr><lf>
$TNHCQ,HDT*34<cr><lf>
$TNHCQ,XDR*22<cr><lf>

The three proprietary query messages accepted are:

$PTNT,HPR*78<cr><lf>
$PTNT,RCD*67<cr><lf>
$PTNT,CCD*76<cr><lf>

3.10 Format of NMEA Sentence Outputs

HDG Heading, Deviation, & Variation

$HCHDG,x.x,x.x,a,x.x,a*hh<cr><lf>

If either the deviation or variation parameter has not been programmed, the corresponding field will be null (per NMEA 0183 version 2.1, section 5.2.2.3). Parameters have not been programmed if their absolute values are greater than 3200 mils or 180.0 degrees. Positive deviation and variation is indicated by a = E; negative values by a = W. Heading field will be null if it cannot be calculated (see HPR proprietary sentence). NMEA requires that units for heading measurement be degrees.

Eg. In Degree Mode

$HCHDG,85.8,0.0,E,0.0,E*77
$HCHDG,271.2,0.0,E,0.0,E*44
$HCHDG,271.1,10.7,E,12.2,W*52
$HCHDG,0.0,10.7,E,12.2,W*57

Mil Mode is not allowed by NMEA standard

HDT Heading, True

$HCHDT,x.x,T*hh<cr><lf>

The heading field will be null if variation has not been programmed (see HDG and Definitions), or if heading cannot be calculated. If deviation has not been programmed, it is assumed to be zero, otherwise it is added to measured heading and variation to express true heading of compass board.

Eg. In Degree Mode

$HCHDT,86.2,T*15
$HCHDT,271.1,T*2C
$HCHDT,0.9,T*20

Mil Mode not allowed by NMEA standard

XDR Transducer Measurements

$HCXDR,A,x.x,D,PITCH,A,x.x,D,ROLL,G,x.x,,MAGX,G,x.x,,MAGY,
G,x.x,,MAGZ,G,x.x,,MAGT*hh<cr><lf>

Each of the six possible measurements - pitch; roll; and magnetic x, y, z, and total—can be individually included in or excluded from the message (see "XDR has …" parameters). See NMEA 0183 for a detailed description of the "Type-Data-Units-ID" field encoding. The "Data" field of an included measurement will be null if its contents cannot be determined due to saturated measurements. Only units of degrees are allowed by NMEA for pitch and roll measurements.

Magnetic measurements are transmitted in engineering units (milli Gauss) determined by a tunable conversion factor. MAGX aligns with the compass board north-south axis, and MAGZ is perpendicular to the plane of the compass board. MAGT is the total magnetic field strength determined by calculating the square root of the sum of the squares of MAGX, MAGY, and MAGZ.

Eg. In Degree Mode

$HCXDR,A,-0.8,D,PITCH,A,0.8,D,ROLL,G,122,,MAGX,G,1838,,MAGY,G,-
667,,MAGZ,G,1959,,MAGT*11

In Mil Mode

$HCXDR,A,-3,D,PITCH,A,14,D,ROLL,G,1090,,MAGX,G,5823,,MAGY,G,-
20,,MAGZ,G,5924,,MAGT*2B

The following describes the proprietary sentences in detail:

HPR Heading, Pitch, & Roll
$PTNTHPR,x.x,a,x.x,a,x.x,a*hh<cr><lf>

This sentence combines HMR3000’s three significant measurements with useful status information. Data fields represent, in order: heading, magnetic field status, pitch, pitch status, roll, and roll status. Heading, pitch, and roll measurements are presented in degrees or mils depending on the setting in EEPROM. The heading measurement is corrected for deviation and variation when these factors are programmed in the EEPROM.

Eg. In Degree Mode

$PTNTHPR,85.9,N,-0.9,N,0.8,N*2C
$PTNTHPR,7.4,N,4.2,N,2.0,N*33
$PTNTHPR,354.9,N,5.2,N,0.2,N*3A
In Mil Mode
$PTNTHPR,90,N,29,N,15,N*1C

Status fields can contain one of six letter indicators:

L = low alarm,
M = low warning,
N = normal,
O = high warning, or
P = high alarm.
C = Tuning analog circuit

If any of the three status fields indicates alarm, then the heading field will be null as well as the corresponding measurement field. Thresholds for alarm and warning levels can be changed in the EEPROM.

RCD Raw Compass Data
$PTNTRCD,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x,x.x*hh<cr><lf>

This sentence provides raw tilt and magnetic measurements for diagnostic use. Contents of each field represent A/D readings for, in order: TiltAp, TiltAm, TiltBp, TiltBm, MagA, MagB, MagC, MagAsr, MagBsr, MagCsr. All values represent the actual A/D readings from the most recent conversions, except that tilt readings are adjusted if low gain was used for the conversion. Mag_sr values represent the sum of the most recent calibration Set and Reset pulse measurements for each sensor. There are never any null fields in this sentence.

Eg. In Degree Mode

$PTNTRCD,1509,1551,1548,1553,15199,16146,17772,17055,16176,17059*42

In Mil Mode

$PTNTRCD,1435,1512,1497,1453,16776,14066,9477,17403,16073,17225*7F

CCD Conditioned Compass Data

$PTNTCCD,x.x,x.x,x.x,x.x,x.x,x.x,x.x*hh<cr><lf>

This sentence provides conditioned tilt and magnetic measurements for diagnostic use. The fields are, in order:

TiltX 32768 times tangent of angle, between compass board north-south axis and level plane. This value is the difference between the raw tilt measurements normalized, linearized, and filtered according to parameter settings. The pitch measurement is determined by taking the arctan of TiltX/32768.

TiltY Same as TiltX but for the compass board east-west axis (roll).

MagX normalized and filtered magnetic field strength along the north-south axis of the compass board. This value has been adjusted for any hard-iron offset determined during calibration (or tuned manually).

MagY same as MagX but along the compass board east-west axis.

MagZ same as MagX and MagY, but along the axis perpendicular to the plane of the board. This value has been adjusted both for gain variation with the X-Y sensor pair and for hard-iron.

MagT Total magnetic field strength

Heading calculated heading based on the magnetometer and inclinometer data in this sentence. Presented in degrees or mils depending on the setting in EEPROM. This field will be null if the heading cannot be calculated.

Eg. In Degree Mode

$PTNTCCD,522,-472,109,1841,677,1964,86.3*44

In Mil Mode

$PTNTCCD,-25187,351,-3909,1899,-4394,6180,1838*58

ASCII Message

The special ASCII display message normally consists of a string of 4 digits that represent the heading in degrees and tenths, followed by a terminating carriage return character. Heading is corrected for deviation and variation when these factors are programmed in the EEPROM. When the heading cannot be transmitted due to a magnetometer or tilt signal out of range, then 4 minus signs are transmitted instead.

Eg. In Degree Mode

3.11 NMEA Checksum Field

This absolute value is calculated by exclusive OR operation on the 8 data bits (ASCII code) (no start or stop bits) of each character in the message, between, but excluding "$" and "*" (or between "#" and "*") characters. The hexadecimal value of the most significant and the least significant 4 bits of the result is converted to two ASCII characters (0-9, A-F) for transmission of the. The most significant character is transmitted first. These characters fill the "hh" positions in the commands and command responses described within this user's guide.

3.12 HMR3000 Warning and Alarm Settings

Tilt and magnetometer limits can be programmed in to the EERROM to generate Warning and Alarm conditions in the status fields of the HPR sentence output.

Tilt Settings

When the tilt measured is below the warning level, the status fields will indicate 'N'.

$PTNTHPR,59.6,N,-0.2,N,-3.0,N*0F

Tilt high warning and high alarm can be user programmed. When the pitch or roll measured is between the warning and alarm levels, the HPR message will indicate this with letter. 'O' in the corresponding pitch or roll status field.

$PTNTHPR,72.9,N,-1.6,N,-29.6,O*33

When the pitch or roll measured is beyond the alarm level, the HPR message will indicate this with letter 'P' in the corresponding pitch or roll status field, and the heading field will be null.

$PTNTHPR,,N,-1.5,N,,P*03

Four levels can be set for the magnetometer alarm and warning levels. High Warn and Alarm levels, and Low Alarm and Warning levels. Five settings are generated depending on the measured total magnetic field value (Mag T) and the levels programmed in the EEPROM.

Level	Mag Status Field	Heading Field
Low Warn < Mag T < High Warn	N	normal
High Warn < Mag T < High Alarm	O	normal
High Alarm < Mag T	P	Null
Low Alarm < Mag T < Low Warn	M	normal
Mag T < Low Alarm	L	Null

Table 4. Relationaship between the Mag total measured and the mag status field

Magnetometer high alarm condition example

$PTNTHPR,,P,0.3,N,0.1,N*06

4.0 CONFIGURATION PARAMETERS

This section describes the configuration parameters that can be set on the HMR3000.

4.1 HMR3000 Operational Parameters

Using the serial protocol described in the previous section, an external host can direct operation of the HMR3000 with the following commands:

Command	Description	Command Syntax	Action
Run	1 = Run	#FA0.3=1*26<CR><lf>	Start Compass measurements
Stop	0 = Stop (Strobe mode)	#FA0.3=0*27<CR><lf>	Stop Compass measurements
Query *Response*	query for Run/Stop status Run Stop	#FA0.3?*15<CR><lf> #1*31<CR><lf> #0*30<CR><lf>	Respond with status
Force Reset	Perform power up reset sequence	#F33.6=1*52<CR><lf>	
Initialize Filters	Reset IIR filter (set after changing TC1)	#F33.2=1*56	

4.2 General Configuration Parameters

The parameters in this section affect the general operation of the HMR3000 compass.

Parameter Name	Description	Command Syntax
Degrees Mils *Query* *Response*	Sets the units for heading, pitch, and roll: 1 = degrees (0.0 to 359.9) 0 = mils (0 to 6399) Degrees = mils * 9 / 160 Degree Mils	#FA0.4=1*21<CR><lf> #FA0.4=0*20<CR><lf> *#FA0.4?*12<CR><lf>* #1*31<CR><lf> #0*30<CR><lf>
Decimal Hex *Query* *Response*	Sets the default number base for data I/O: 1 = decimal 0 = hexadecimal query for I/O number base Decimal Hexadecimal	#FA0.5=1*20<CR><lf> #FA0.5=0*21<CR><lf> #FA0.5?*13*<CR><lf>* #1*31<CR><lf> #0*30<CR><lf>
Deviation angle *Query*	Sets the Deviation angle to value nnn.n (in degree mode) ‘hh’ is the checksum	#IE2=nnn.n*hh<CR><lf> *#IE2?*01<CR><lf>*

Response	value Deviation angle	#nnn.n*hh<CR><lf>
Variation angle *Query* *Response*	Sets the Variation angle to value nnn.n (in degree mode) 'hh' is the checksum value Variation angle	#IE4=nnn.n*hh<CR><lf> *#IE4?*07<CR><lf>* #nnn.n*hh<CR><lf>

4.3 HMR3000 Measurement Parameters

Parameters in this section affect the measurement functions of the HMR3000 digital compass. "Mag sample rate" is a key setting that affects both continuous and strobe mode measurements. In continuous mode, either 1, 2, 4, or 8 magnetometer measurements are averaged per tilt measurement depending on the "Mag sample rate" setting.

In strobe mode, measurements are suspended until an NMEA query command is received. When this occurs, "Mag sample rate" determines how many magnetometer readings are collected per tilt measurement as above, and "Strobe mode count" determines the number of readings to be averaged before returning the resulting requested sentence. A "Strobe mode count" of zero will result in 256 samples being averaged, which will require 18.6 seconds between the end of the query request and the start of the output sentence.

The "Mag units factor" setting is used to convert normalized magnetometer readings to milliGauss for output in XDR and CCD messages. The intent is to provide outputs with approximate field strength units so that the magnitude of the numbers make sense.

Parameter Name	Description	Command Syntax
Mag sample rate *Query* *Response*	Magnetometer sampling rate 13.75 , 27.5, 55, 110 Hz This parameter will determine the number of magnetometer readings averaged per heading output. Set to 13.75 Hz for low power consumption m=1 for 13.75, m=2 for 27.5, m=4 for 55, m=8 for 110 Hz	#BA6=1*39<CR><lf> for 13.75 Hz #BA6=2*3A<CR><lf> for 27.5 Hz #BA6=4*3C<CR><lf> for 55 Hz #BA6=8*30<CR><lf> for 110 Hz *#BA6?*0A<CR><lf>* *#m*hh<CR><lf>*
Strobe Mode Count *Query* *Response*	Number of heading measurements to be average before issuing an output in Strobe Mode operation (0 to 255) N= Number of reading to average (0 to 255)	#BA7=nn*hh<CR><lf> *#BA7?*0B<CR><lf>* #N*hh<CR><lf>

Set / Reset	Controls the magnetometer Set/Reset operation. Set / Reset ON (Set/Reset at 13.75 Hz) Set/Reset OFF	#FA0.6=1*23<CR><lf> #FA0.6=0*22<CR><lf>
Query		*#FA0.6?*10<CR><lf>*
Response	ON OFF	#1*31<CR><lf> #0*30<CR><lf>

Set / Reset interval (ddd)	Time interval between magnetometer Set/Reset calibrations in seconds:
	0 = disable, 255 = 4 min, 15 sec (=max)
	Use long time interval to reduce power consumption. Use continuous or short time intervals for high repeatability.
	(This parameter applies only when Set Reset is turned OFF)
		#BA9=ddd*hh<CR><lf>
		ddd= Set/Reset interval in seconds

Query		*#BA9?*05<CR><lf>*
Response	T= Time between Set Reset in Seconds	#T*hh<CR><lf>
Mag units factor	Conversion factor for normalized Mag readings to mGauss.	
Query		*#WB4?*1E<CR><lf>*
Response		
MagX offset (nnnn) in counts	Hard-iron offset along north-south axis in magnetometer counts. Allows the user to input a value.	#IC4=nnnn*hh<CR><lf>
Query		*#IC4?*01<CR><lf>*
Response	N=Hard Iron offset (in counts)	#N*hh<CR><lf>
MagY offset (nnnn) in counts	Hard-iron offset along east-west axis in magnetometer counts. Allows the user to input a value.	#IC6=nnnn*hh<CR><lf>
Query		*#IC6?*03<CR><lf>*
Response	N=Hard Iron offset	#N*hh<CR><lf>
MagZ offset (nnnn) in counts	Hard-iron offset along vertical axis in magnetometer counts. Allows the user to input a value.	#IC8=nnnn*hh<CR><lf>
Query		*#IC8?*0D<CR><lf>*
Response	N=Hard Iron offset	#N*hh<CR><lf>
Mag high alarm	Sets the magnetometer Over Range Alarm level in magnetometer counts. Issues an Alarm condition (P) in the magnetic field status of the HPR output sentence when the total mag field value (Mag T) exceeds the parameter setting.	#WB6=nnnn*hh<CR><lf>
Query		*#WB6?*1C<CR><lf>*
Response		#nnnnn*hh<CR><lf>

Mag high warn *Query* *Response*	Sets the magnetometer Over Range Warning level in magnetometer counts. Issues a Warning condition (O) in the magnetic field status of the HPR output sentence when the total mag field value (Mag T) exceeds the parameter setting.	#WB8=nnnn*hh<CR><lf> *#WB8?*12<CR><lf>* #nnnnn*hh<CR><lf>
Mag low warn *Query* *Response*	Sets the magnetometer Under range warning level in magnetometer counts. Issues a Warning condition (M) in the magnetic field status of the HPR output sentence when the total mag field value (Mag T) falls below the parameter setting.	#WBA=nnnn*hh<CR><lf> *#WBA?*6B<CR><lf>* #nnnnn*hh<CR><lf>
Mag low alarm *Query* *Response*	Sets the magnetometer Under range alarm level in magnetometer counts. Issues an Alarm condition (L) in the magnetic field status of the HPR output sentence when the total mag field value (Mag T) falls below the parameter setting.	#WBC=nnnn*hh<CR><lf> *#WBC?*69<CR><lf>* #nnnnn*hh<CR><lf>
Pitch / roll alarm (nn.n) *Query* *Response*	Sets the Over range alarm level for pitch and roll. Issues an Alarm condition (P) in the Pitch or Roll status fields of the HPR output sentence when either pitch or roll output exceeds the parameter setting. In degrees Pitch/ Roll alarm level	#WE6=nn.n*hh<CR><lf> *#WE6?*1B<CR><lf>* #nn.n*hh<CR><lf>
Pitch / roll warn (nn.n) *Query* *Response*	Sets the Over range warn level for pitch and roll. Issues an warn condition (O) in the Pitch or Roll status fields of the HPR output sentence when either pitch or roll outputexceeds the parameter setting. In degrees	#WE8=nn.n*hh<CR><lf> *#WE8?*15<CR><lf>* #nn.n*hh<CR><lf>

TC1 time constant (T)	Sets the filter constant. Normalized time constant for IIR filter 1 T=0 (disable), T=1 (= 72 msec), T=255 (= 18.4 sec)	#BA2=T*hh<CR><lf>
Query		_#BA2?*0E<CR><lf>_
Response	Normalized time constant, T,	#T*hh<CR><lf>
S smoothing factor (S)	Sets the parameter (S) for the non-linear Heading filter. Smoothing amount (see algorithm in text) 0 = disable, Max = 0.999985 m=S*65535	#WB2=m*hh<CR><lf>
Query		_#WB2?*18<CR><lf>_
Response	m=S*65535	#m*hh<CR><lf>
L smoothing factor (L)	Sets the parameter (L) for the non-linear Heading filter. Difference knee in mils (see algorithm in text) 0 = disable, 1 = 1 mil, max = 255 mils Smoothing factor (L)	#BB1=L*hh<CR><lf>
Query		_#BB1?*0E<CR><lf>_
Response		#L*hh<CR><lf>

4.4 Serial I/O Parameters

Parameters in this section affect the serial output functions of the compass board.

Name	**Description**	**Command Syntax**
Baud Rate	Sets the Serial I/O Baud rate: Index Value (I) 1200 : (2) 2400 : (4) 4800 : (8) 9600 : (16) 19200 : (32) **Should be followed by a Force Reset command for new rate to be active immediately or a power up is required**	#BA4H=2T*24 <CR><lf> #BA4H=4T*22<CR><lf> #BA4H=8T*2E<CR><lf> #BA4H=16T*11<CR><lf> #BA4H=32T*17<CR><lf>
Query		_#BA4H?*40<CR><lf>_
Response	Returns the Index value for the baud rate	#I*hh<CR><lf>
HDG Update Rate (R)	Sets the HDG message update rate (R) in sentences per minute Allowed R values are indexed with an integer (I) - see table below	#BAA=I*hh<CR><lf>
Query		_#BAA?*7D<CR><lf>_
Response	Returns Index value, I, for HDG update rate	#I*hh<CR><lf>

HDT Update Rate (R) *Query* Response	Same as above, for HDT sentence Returns the Index value, I, for HDT rate	#BAB=I*hh<CR><lf> *#BAB?*7E<CR><lf>* #I*hh<CR><lf>
XDR Update Rate *Query* Response	Same as previous for XDR sentence I= Index value Returns the Index value, I, for XDR rate	#BAC=I*hh<CR><lf> *#BAC?*7F<CR><lf>* #I*hh<CR><lf>
HPR Update Rate *Query* Response	Same as previous for HPR sentence I= Index value Returns the Index value, I, for HPR rate	#BAD=I*hh<CR><lf> *#BAD?*78<CR><lf>* #I*hh<CR><lf>
RCD Update Rate *Query* Response	Same as previous for RCD sentence I= Index value Returns the Index value, I, for RCD rate	#BAE=I*hh<CR><lf> *#BAE?*79<CR><lf>* #I*hh<CR><lf>
CCD Update Rate *Query* Response	Same as previous for CCD sentence I= Index value Returns the Index value, I, for CCD rate	#BAF=I*hh<CR><lf> *#BAF?*7A<CR><lf>* #I*hh<CR><lf>
ASCII Update Rate *Query* Response	Same as previous for ASCII display sentence I= Index value Returns the Index value, I, for ASCII rate	#BB0=I*hh<CR><lf> *#BB0?*0F<CR><lf>* #I*hh<CR><lf>
XDR has Pitch *Query* Response	Include or exclude PITCH in XDR sentence Exclude Include m=1 (include), m=0 (exclude)	#FA1.0=0*25<CR><lf> #FA1.0=1*24<CR><lf> *#FA1.0?*17<CR><lf>* #m*hh<CR><lf>
XDR has Roll *Query* Response	Include ROLL in XDR sentence m=1 (include), m=0 (exclude)	#FA1.1=0*24<CR><lf> #FA1.1=1*25<CR><lf> *#FA1.1?*16<CR><lf>* #m*hh<CR><lf>
XDR has MagX *Query* Response	Include MAGX in XDR sentence m=1 (include), m=0 (exclude)	#FA1.2=0*27<CR><lf> #FA1.2=1*26<CR><lf> *#FA1.2?*15 <CR><lf>* #m*hh<CR><lf>

XDR has MagY *Query* Response	Include MAGY in XDR sentence m=1 (include), m=0 (exclude)	#FA1.3=0*26<CR><lf> #FA1.3=1*27<CR><lf> *#FA1.3?*14 <CR><lf>* #m*hh<CR><lf>
XDR has MagZ *Query* Response	Include MAGZ in XDR sentence m=1 (include), m=0 (exclude)	#FA1.4=0*21<CR><lf> #FA1.4=1*20<CR><lf> *#FA1.4?*13 <CR><lf>* #m*hh<CR><lf>
XDR has MagT *Query* Response	Include MAGT in XDR sentence m=1 (include), m=0 (exclude)	#FA1.5=0*20<CR><lf> #FA1.5=1*21<CR><lf> *#FA1.5?*12 <CR><lf>* #m*hh<CR><lf>

In the current configuration software, when the baud rate is changed, the new rate will not take effect until a “Force Reset” command is issued or until the unit is powered off then on. When any output sentence rate is changed, the current interval will expire before the new rate takes effect.

Index(I)	Rate(R)	Index	Rate	Index	Rate	Index	Rate
0	0	4	6	8	60	12	413
1	1	5	12	9	120	13	600
2	2	6	20	10	180	14	825
3	3	7	30	11	300	15	1200

5.0 HMR3000 HARDWARE INTERRUPT PINS

The following is the detail description of the Cont./Reset, Operate/Calibrate, Ready/Sleep, Run/Stop pins.

The order of precedence for operation of the switch input pins is as follows:

1. Setting "Cont. / Reset" low unconditionally holds the HMR3000 processor in its reset state. No other functions can be performed until the switch is returned to the "Continue" position.

2. Setting "Operate / Calibrate" low (Calibrate) forces the processor into Calibrate mode. The "Run / Stop" and "Ready / Sleep" switches are ignored in this mode. When the switch is set to the Operate position, the unit can be in either mode depending on the "Select Mode" command bit that can be changed via the serial interface. The "Select Mode" command bit is initialized to the Operate state on power up.

3. Setting "Ready / Sleep" low while the unit is not in Calibrate mode forces the unit into a low power state with measurements and outputs suspended, and with serial inputs ignored. This switch must be returned to the "Ready" position before a host processor can send a serial command. When momentarily placed in the "Ready" position, the processor will run a complete measurement and output cycle (if in Run mode) before suspending operation. Mechanical switch bounce on this input can be tolerated in the firmware.

4. Setting "Run / Stop" low stops any output in progress within one character time and prevents further output. When the switch is in the Run position, the state of the internal Run/Stop command bit controls the unsolicited output. The internal Run/Stop command bit is initialized to the settings saved in the EEPROM.

6.0 ALGORITHM FOR THE NON-LINEAR HEADING FILTER

The algorithm for the non-linear heading filter is:

Assume CH = current heading

SH = smoothed output

L = tuned setting (integer > 0, 0 = disable)

S = tuned setting (0 < fraction < 1, 0 = disable, max = 0.999985)

Calculate D = CH - SH (difference)

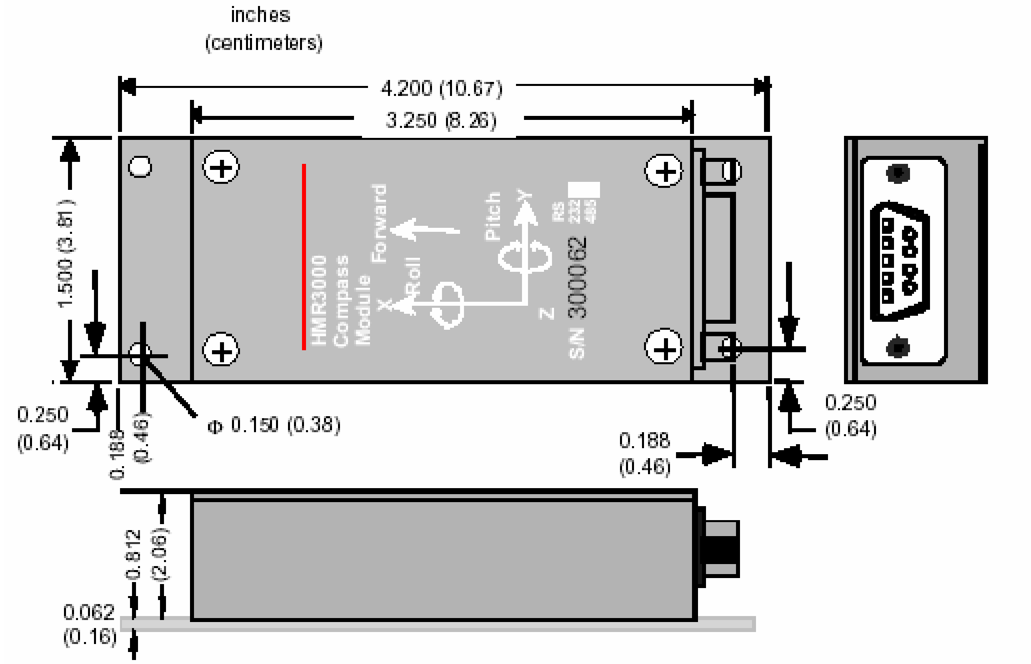
G = S + S * (D/L)**2 (saturate G as D/L gets large, S <= G <= 1)

SH = SH + D * G (note that SH = CH for G = 1)

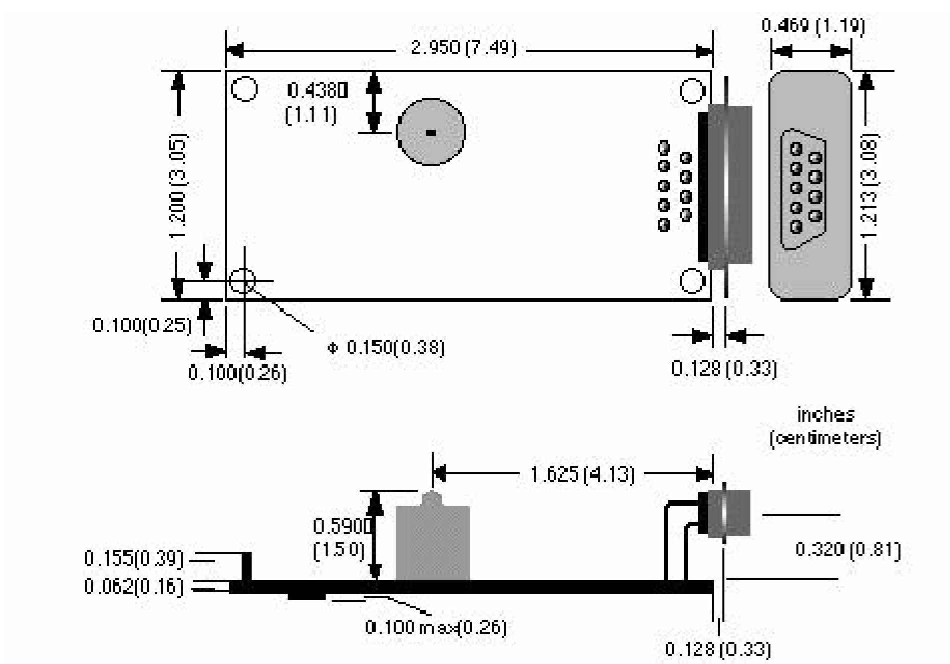
These calculations are iterated at the 13.75 Hz rate.

7.0 PHYSICAL DIMENSIONS

Enclosure Dimensions



PCB Dimensions



Aerospace Electronics Systems
Defense and Space Electronics Systems
Honeywell International Inc.
12001 Highway 55
Plymouth, MN 55441
Tel: 800-323-8295
www.honeywell.com

Form #900240 Rev C
August 2005