MAN-3DM502User
Ver 1

User Manual

For

3DM®

Solid State 3-axis Pitch, Roll, & Yaw Sensor

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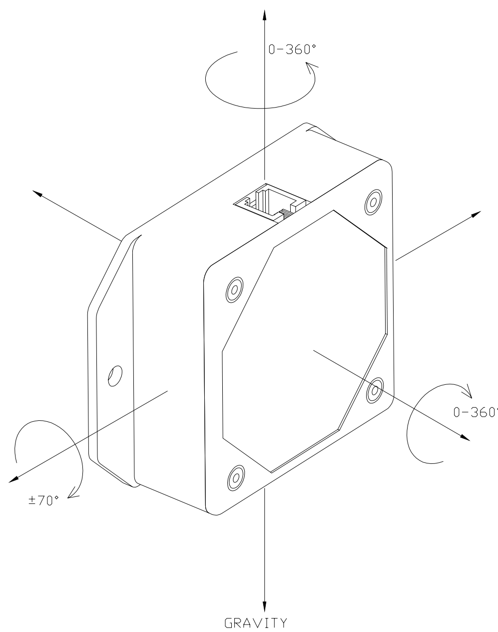
Table of Contents

Overview

3DM

The 3DM Solid State 3-axis Pitch, Roll, & Yaw Sensor utilizes three magnetometers and three accelerometers to calculate pitch, roll, and yaw (compass heading) angles relative to the earth's magnetic and gravitational fields. The 3DM unit is also programmed to provide raw accelerometer in true physical units and normalized magnetometer data. The device is capable of measuring angles from 0 to 360 degrees on the yaw axis, 0 to 360 degrees on the pitch axis, and -70 to +70 degrees on the roll axis.

The 3DM unit calculates the yaw angle using earth's magnetic field, and compensates for tilt errors using the accelerometers. Earth's magnetic field is easily distorted by local objects that are ferromagnetic. Therefore, erroneous results can be obtained when the device is in close proximity to ferrous metal objects. When mounting the device, take care to use hardware that is not ferromagnetic, such as aluminum, brass, or plastics.



Unpacking your 3DM

If you ordered a 3DM starter kit, you should find the following items:

Qty	Item	Part#
1	3DM Sensor	3DM-M
1	RS-232 Sensor Cable and Power Connector	3DM-CBL-RS232
1	9VDC Power Supply	T402
1	3DM Data Acquisition and Display Software on CD-ROM (includes User Manual and Help File)	SW-CD-3DM502

If you ordered a 3DM-M only, you should find the following items:

Qty	Item	Part#
1	3DM Sensor	3DM-M

Note: If an item is missing or damaged, please immediately contact MicroStrain Support at info@microstrain.com or:

MicroStrain, Inc.
310 Hurricane Lane
Williston, VT 05495
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Software Installation

3DM Data Acquisition and Display Software Version 5.0.2 only supports 3DM firmware 2.12 and higher. The software does not support previous versions of 3DM firmware.

System requirements

To use 3DM Data Acquisition and Display software, your computer must have the following minimum specifications:

- Pentium Microprocessor
- Microsoft Windows 98 operating system
- CD-ROM drive
- Video resolution 800 X 600 High Color 16-bit
- Minimum of 16MB of memory
- Minimum of 10MB of free hard disk space
- Microsoft-compatible mouse

Software installation

Step 1: If you have any previous version of 3DM software, uninstall it using the following procedure; otherwise, skip to Step 2.

- Click <Start> in lower left hand corner of your desktop.
- Click <Settings> on the pop-up menu.
- Click <Control Panel>.
- Double-click <Add/Remove Programs>. A pop-up menu entitled ‘Add/Remove Program Properties’ will appear.
- Click <Install/Uninstall> tab.
- Scroll the programs in the window and highlight any previous 3DM program.
- Click <Add/Remove> button.
- Follow uninstall instructions as stated.
- When uninstall is completed, ‘Add/Remove Program Properties’ screen will return.
- Click <OK>.

Step 2: Place the 3DM Software CD-ROM in your CD-ROM drive and close the drive.

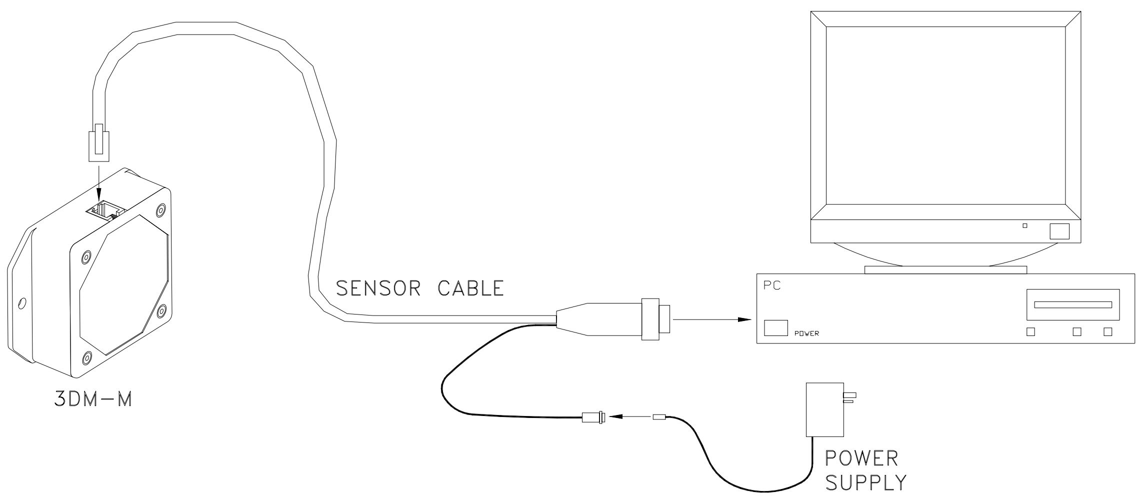
- Double-click <My Computer> on your desktop.
- Double-click the icon that represents your CD-ROM drive.
- Click the <3DM Folder> to highlight it.
- Click <Copy>.
- Using the drop down arrow in the Address box, select your C:\ drive.
- Click <Paste>. The 3DM folder will copy from the CD-ROM to your C:\ drive.
- When the 3DM folder has completed pasting, double-click it.
- Double-click the <Install folder>.
- Double-click the <Setup.exe> icon.

- A “Welcome to 3DM Install Program” screen will appear.
- Click <OK>.
- A “Begin the Installation by Clicking the Button Below” screen will appear.
- Click <Change Directory>.
- A “Change Directory” screen appears.
- In the Directories box, browse to find C:\3DM and click that folder so that the Path box above reads C:\3DM.
- Click <OK> and you’re back to the previous screen.
- Click the big button to continue your install.
- Follow any further installation instructions. If certain files on your PC need updating, you may have to re-boot your PC during the install process and run the Setup.exe again.
- If Setup is successful, you will receive a “Successfully Installed” message.

Hardware Installation

It is suggested that you initially layout the 3DM on your desktop before you proceed with installation of the system into your specific structure or environment. This will insure that all components (hardware and software) are working correctly. Please follow these steps to complete initial layout.

- Place the 3DM unit on your desk as shown in figure 1 below.
- Insert the male RJ-11 connector of the sensor cable into the 3DM.
- Connect the female RS-232 connector of the sensor cable into a serial cable connected (or directly) to a free serial port on your computer.
- Connect the power connector of the sensor cable to the power connector of the power supply.
- Plug the power supply into an 110VAC service. **Note:** The 3DM has no external 'on/off' switch and begins functioning whenever power is applied.
- Proceed to the Quick Start section below and follow the further instructions.



Quick Start

When you have completed the instructions in the Hardware Installation section above, proceed as follows:

Run Software

Double-click the 3DM Data Acquisition and Display Software icon on your desktop. If the system is properly configured, the software will communicate with the 3DM and perform an initialization. The user will shortly receive a confirming message indicating 'Initialize Connection Successful' and a check will occur to the left of the <Initialize Connection> menu item indicating initialization was successful. If this occurs, skip to **Test 3DM in Dials Display** below. If the initialization does not occur (as indicated by the cursor remaining in an hourglass state), proceed to **Auto Detect the 3DM** below.

Auto Detect the 3DM

- Go to Main screen.
- Click <File>.
- Click <Comm Port>. The Communication Port screen will appear.
- Click the <Auto Detect> button.
- The software will poll each of the available serial ports on your computer and find any 3DM that is connected to the computer. If a 3DM is found, the user will receive a message indicating '3DM found on serial port X'. At the same time the radio button of the communication port where the 3DM was found will be clicked.
- Click <OK> to set the communication port and return to the Main screen.
- Proceed to <Initialize Connection> below.
- **Note:** If a 3DM is not found on any of the computer's available serial ports, the user will receive a message indicating '3DM not found on serial ports 1-4'. If this occurs, a hardware problem exists either with the computer or the 3DM. The following conditions can cause problems:
    - Sensor cable is not plugged into 3DM
    - Sensor cable is not plugged into serial port or serial cable
    - Power adapter is not plugged into service
    - Power adapter is not plugged into sensor cable
    - Mis-wired serial cable
    - Serial port not configured properly on PC
    - Palm Pilot HotSync or similar software running in background
    - Serial Device Driver configured for port and running in background

Initialize Connection

- Go to Main screen.
- Click <File>.
- Click <Initialize Connection>.
- If the system is properly configured, the software will communicate with the 3DM and perform an initialization. The user will shortly receive a confirming message indicating 'Initialize Connection Successful' and a check will occur to the left of the <Initialize Connection> menu item indicating initialization was successful. If the initialization does not occur, a hardware problem exists either with the computer or the 3DM.

Test 3DM in Dials Display

- Go to Main screen.
- Click <Display>.
- Click <Dials (Angles)>. The Dials screen will appear.
- Click <Data>.
- Click <Sample>. A check will occur to the left of the menu item indicating sampling is in progress.
- The application will begin sampling the 3DM and will continuously display its pitch, yaw and roll angles.

Congratulations

You're off and running! Refer to the Help file to discover all the functions that 3DM Data Acquisition and Display Software provides. You are also welcomed to contact our technical support staff on any matter at info@microstrain.com.

Calibration

Background

This option will allow the user to run the calibration routines on the 3DM magnetic and acceleration sensors if required. The 3DM is shipped calibrated and generally does not need to be recalibrated. There are two instances in which the 3DM might need to be recalibrated. The first instance is where the magnetic sensors (magnetometers) located in the 3DM are mounted on or near a metallic substrate. A ferrous object such as steel will distort Earth's magnetic field. If the 3DM does not move relative to the metallic structure, recalibration will minimize the distortion. The second instance is where the 3DM requires recalibration due to the unlikely event that the sensors drift over time or they are placed in a harsh temperature environment.

The accelerometers generally will not require recalibration. The gravitational field is the same everywhere and cannot be distorted.

Recalibration requires you to rotate the 3DM in its mounting location. This type of rotation allows the 3DM to search for minimums and maximums of the magnetic and gravitational fields from which the calibration coefficients are determined (offsets and gains). The 3DM will calculate the offsets and gains of the sensors and program these to the appropriate fields.

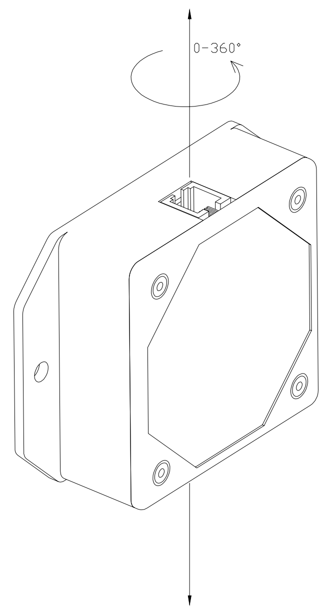
Calibrate Magnetometers

Magnetometer calibration is a two-step process. The first step is achieved by physically rotating the structure and programming the Mx and My magnetic coefficients. The second step is achieved by physically rotating the structure and programming the Mz coefficients.

Magnetometers Calibration Procedure

Step 1

- Insure that the area in which the 3DM is to be calibrated is free from ferrous objects.
- Physically place the 3DM in the orientation shown below in figure below.
- On the Calibrate screen, click <File>, then click <Read>. You will notice that the computer is now continuously acquiring orientation data from the 3DM.
- Physically rotate the 3DM around the axis specified below in a slow and deliberate manner. Spin about this axis over 360 degrees at least once. The 3DM can be rotated more than once, but must be rotated at least once through 360 degrees. Keep the 3DM in this orientation.

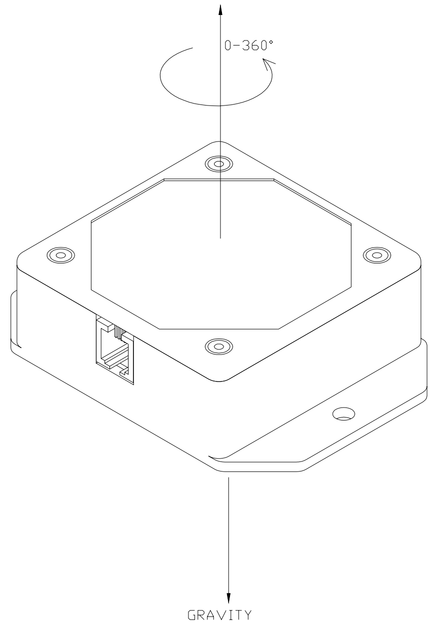


Mx and My Calibration Orientation

- On the Calibration screen use your mouse in the Select frame to check Mx and My.
- Click <File>, then click <Write>.
- Calibration values will be written to the 3DM. A confirming message will appear. Click <OK>.

Step 2

- Physically place the 3DM in the orientation shown below in figure below.
- On the Calibrate screen, click <File>, then click <Read>.
- Physically rotate the 3DM around the axis specified below in a slow and deliberate manner. Spin about this axis over 360 degrees at least once. Keep the 3DM in this orientation.



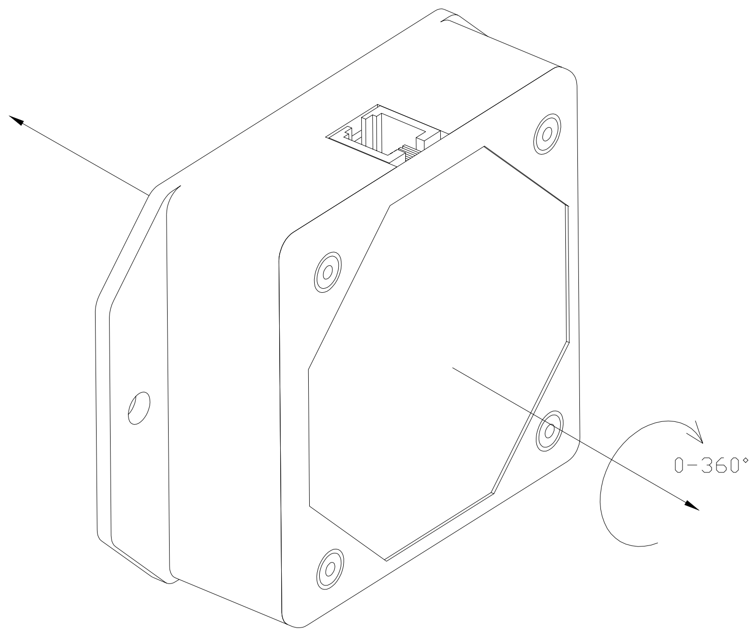
Mz Calibration Orientation

- On the Calibration screen use your mouse in the Select frame to check Mz.
- Click <File>, then click <Write>.
- Calibration values will be written to the 3DM. A confirming message will appear. Click <OK>.

Calibrating Accelerometers
Accelerometer calibration is a two-step process. The first step is achieved by physically rotating the structure and programming the Ax and Az acceleration coefficients. The second step is achieved by physically rotating the structure and programming the Ay coefficients.

Step 1

- Physically place the 3DM in the orientation shown below in figure below.
- On the Calibrate screen, click <File>, then click <Read>. You will notice that the computer is now continuously acquiring orientation data from the 3DM.
- Physically rotate the 3DM around the axis specified below in a slow and deliberate manner. Spin about this axis over 360 degrees at least once. Keep the 3DM in this orientation.

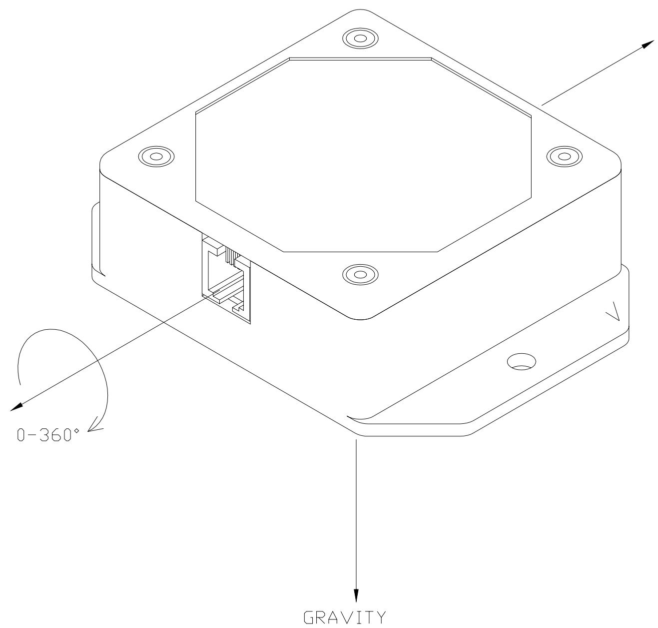


Ax and Az Calibration Orientation

- On the Calibration screen use your mouse in the Select frame to check Ax and Az.
- Click <File>, then click <Write>.
- Calibration values will be written to the 3DM. A confirming message will appear. Click <OK>.

Step 2

- Physically place the 3DM in the orientation shown below in figure below.
- On the Calibrate screen, click <File>, then click <Read>. You will notice that the computer is now continuously acquiring orientation data from the 3DM.
- Physically rotate the 3DM around the axis specified below in a slow and deliberate manner. Spin about this axis over 360 degrees at least once. Keep the 3DM in this orientation.



Ay Calibration Orientation

- On the Calibration screen use your mouse in the Select frame to check Ay.
- Click <File>, then click <Write>.
- Calibration values will be written to the 3DM. A confirming message will appear. Click <OK>.

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WWW: www.microstrain.com

Standard Appendix

3DM Specifications

Range	Yaw: ± 180 degrees
	Pitch: ± 180 degrees
	Roll: ± 70 degrees
A/D Resolution	12 bits
Digital Filter	Infinite Impulse Response (IIR) User programmable weighted moving average
Angle Resolution (no digital filtering)	Pitch: 0.30 degrees (typical)
	Roll: 0.25 degrees (typical)
	Yaw: 0.50 degree (typical)
Angle Resolution (most aggressive digital filtering)	Pitch: < 0.1 degrees
	Roll: < 0.1 degrees
	Yaw: < 0.1 degrees
Resolution specs. taken during static motions.	
Accuracy	Pitch: ±0.93 degree typical (yaw from 0 - 360 degrees & roll=0 degrees)
	Roll: ±0.33 degree typical (yaw from 0 - 360 degrees & pitch =0 degrees)
	Yaw: ±1.0 degrees typical (pitch & roll=0 degrees)
Accuracy is defined as the square root of the sum of the errors squared (non repeatability, temperature coefficients & non-linearity).	
Angle measurement non-linearity (pitch & roll)	±0.23% F.S.
Angle measurement repeatability	Pitch: 0.07 degrees (typical)
	Roll: 0.07 degrees (typical)
	Yaw: 0.26 degrees (typical)
Update rate (angle mode)	45 Hz/ 3 channels (maximum) 30 Hz/ 3 channels (typical)
The update rate is specified with a maximum and typical value since it depends on how many points the A/D converter averages.	
Update rate (raw mode)	70 Hz/ 6 channels
Output modes	Raw: ax, ay, az accelerometer
	Raw: mx, my, mz magnetic field

	Units: pitch, roll, & yaw in degrees
Output format	RS-232 serial or RS-485 multi-drop network
Transmission Rate	9600 bits/sec
Supply voltage	5.3 volts DC min
Supply current	50 milliamps/node @ standard speed
Connectors	Sensor: RJ11 type power: min. coaxial jack
Operating Temperature	- 25 degrees C to 70 degrees C
Temperature Drift (%/ deg. C) (mean, std.dev.)	Pitch: 0.009+/-0.008
	Roll: 0.033+/-0.025
	Yaw: 0.019+/-0.019
Module size	1.7" wide, 2.5" long, 0.7 " thick
3DM enclosure	2.05" wide x 3.815" long x 0.9" thick

Data File Samples

Sample of Angles Data File

MicroStrain 3DM Data File Version 5.0.2
Date file created: 9/4/01
Time file created: 1:34:11 PM

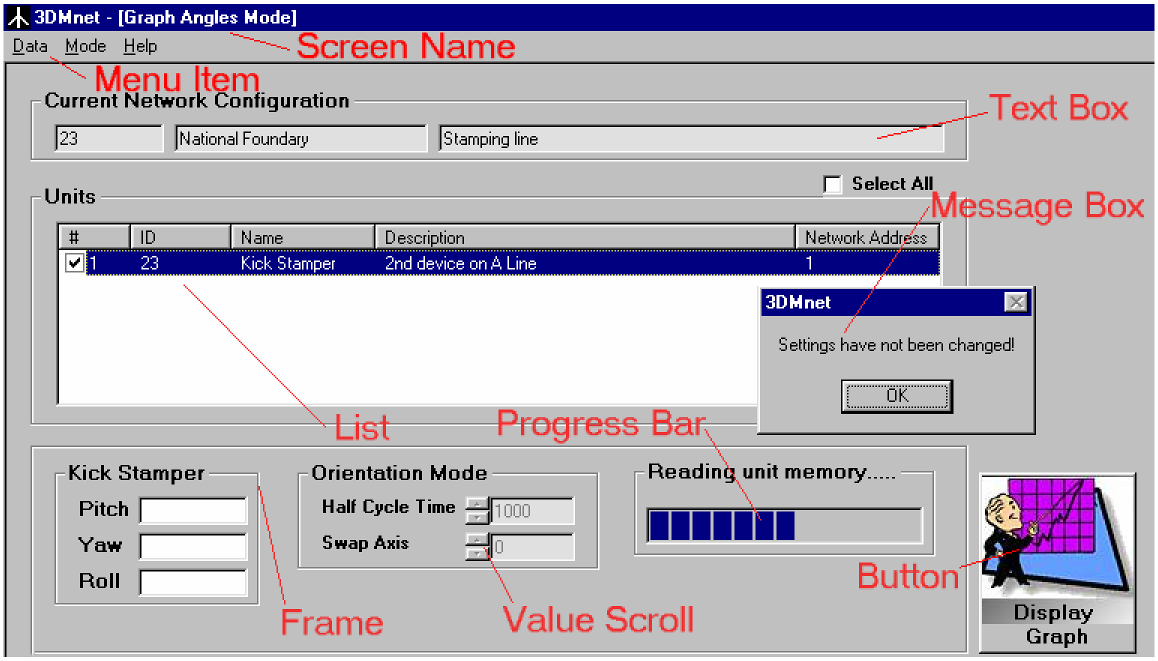
Time (Seconds)	Pitch	Yaw	Roll
0.05	255.1	134.3	-63.2
0.11	255	134.2	-63.3
0.16	255.4	134.8	-63.2
0.19	255.4	134.8	-63.1
0.23	255.7	135.2	-63.1
0.27	255.4	134.8	-63.1
0.3	255.4	134.8	-63.1
0.34	255.3	134.7	-63.2
0.37	255.3	134.7	-63.2
0.4	255.3	134.7	-63.2

Sample of Bits Data File

MicroStrain 3DM Data File Version 5.0.2
Date file created: 9/4/01
Time file created: 1:34:27 PM

Time (Seconds)	Ax	Ay	Az	Mx	My	Mz	
0.06	-1182	1228	-717	222	-1274	-51	
0.11	-1125	1223	-617	239	-1274	-71	
0.17	-1072	1296	-584	266	-1263	-88	
0.23	-1001	1194	-560	325	-1238	-117	
0.29	-872	1141	-431	441	-1156	-202	
0.35	-660	1355	-304	575	-1004	-343	
0.41	-468	1365	-92	650	-853	-484	
0.47	-369	1322	114	682	-663	-653	
0.53	-296	1315	409	677	-463	-810	
0.59	-346	1221	635	636	-351	-915	

Conventions



3DM Data Communication Protocol *(Comm spec REV 1.00)*

Document last modified September 27, 2002

This document describes the communications protocol associated with 3DM firmware version 3.0.00.

Communications Commands

The data transmitted by the 3DM can be controlled by the issuance of one or more single byte commands. Each command will generate a response of a fixed number of bytes. The 3DM will not transmit unsolicited data. The user can select what data the 3DM will transmit by selecting one or more of the commands as defined in the following sections.

Calculation Cycle

The 3DM's on-board processor operates with a 0.008192 second clock tick interval. The processor continually reads the raw sensor outputs, scales them into physical units, and (if requested by a user issued command) generates an estimate of its orientation. The time required to perform all the required calculations is called the calculation cycle. The duration of the calculation cycle can be several clock ticks, depending on what data the user requests.

Polled Command Mode

The 3DM has two command modes. The first is Polled mode. This is the default. In polled mode, the 3DM will transmit a data packet each time a command byte is issued by the host computer. The 3DM will not transmit unsolicited data packets. The user may issue a command at any time. The 3DM will respond by transmitting the corresponding data packet upon completion of the current calculation cycle. Multiple commands issued by the host will be buffered on-board the 3DM with one being processed at the completion of each successive calculation cycle.

Continuous Mode

The second command mode is continuous mode. To enter continuous mode, the host computer must issue the "Set Continuous Mode" command byte (0x15), followed by a null byte (0x00), followed by another command byte of the user's choosing. The 3DM responds by transmitting the corresponding data packet at the completion of every calculation cycle. This provides a stream of data at the maximum possible rate, and at uniformly spaced time intervals (i.e., the calculation cycle time interval) with no gaps. The host computer must be capable of the buffering and interpreting the data stream at sufficient speed to prevent loss of data. For example, if the host issues the 0x15 byte followed 0x00, followed by the 0x11 byte, the 3DM will be set into continuous mode and will continuously transmit the "Send Scaled Sensor Vectors" data packet.

Once continuous mode is set, it will remain in effect until it is terminated by the host issuing the "Set Continuous Mode" command byte followed by 0x00, followed by the null command byte (0x00). Note that while in continuous mode, the selected data packet to be transmitted at each calculation cycle can be changed at any time by issuing the "Set Continuous Mode" byte followed by the new desired command byte.

Normally, the 3DM starts in Polled Mode on power up. In some applications, it may be desirable to have the 3DM enter continuous mode immediately on power-up. To accomplish this, the user can set the value of the LSB of EEPROM location 218 to the desired command byte (the MSB of location 218 should be set to 0x00). On subsequent power-ups, the 3DM will automatically enter continuous mode with the selected command active. Note that following power-up the user may subsequently turn continuous mode off by issuing the "Set Continuous Mode" byte followed by 0x00. To disable the automatic power-up entry into continuous mode, set the value of EEPROM location 218 to 0x0000.

Combined Continuous and Polled Mode

While in continuous mode, the host computer may still issue individual commands as in polled mode. The responses to these commands will be interleaved with the continuous mode responses. At the completion of each calculation cycle, the 3DM first transmits the response to the continuous mode command if continuous mode is active. The 3DM then transmits the response to any individual command that has been issued in polled mode. In this case, two data packets will be transmitted (one for the continuous command, and one for the polled command) during the same calculation cycle. The host computer's data interpretation software must be capable of differentiating such data packets.

Whenever a polled command is issued while in operating in continuous mode, the calculation cycle in which it is interpreted may be extended beyond its normal duration due to the extra processing required. Therefore, the continuous data stream may contain irregular time intervals at the points where polled commands were issued. The exact time interval can be determined by examining the "TimerTicks" value that is returned as part of the response to most commands.

Data Quantities Available

The 3DM is capable of calculating and reporting data of various types. These can be accessed by selecting and sending the appropriate command byte (see following sections). The data that is available is the following:

RawMag – (3 components): These are the raw voltage outputs of the three axis magnetometer. They are expressed in terms of A/D converter codes where 0 represents 0 Volts, and 4096 represents 5 volts. They are not scaled into physical units, nor are the individual components necessarily orthogonal, or forming a right-handed coordinate system. For most applications, transmitting the MagField will be more appropriate.

RawAccel – (3 components): These are the raw voltage outputs of the three axis accelerometer. They are expressed in terms of A/D converter codes where 0 represents 0 Volts, and 4096 represents 5 volts. They are not scaled into physical units, nor are the individual components necessarily orthogonal, or forming a right-handed coordinate system. For most applications, transmitting the Accel will be more appropriate.

MagField – (X, Y and Z components): This is a vector quantifying the direction and magnitude of the instantaneously measured magnetic field that the 3DM is exposed to. This quantity is derived from the magnetometer outputs, but has been scaled, and corrected for mechanical misalignment. It is expressed in terms of the 3DM's local coordinate system. Each component of the MagField vector is transmitted as a 16 bit signed integer. To complete the conversion to physical units, these values must be divided by the scale constant, 8192, i.e.,

$$\text{Magnetic Field Vector (Earth Field Units}^{*}) = \begin{pmatrix} \text{MagField\_X} \\ \text{MagField\_Y} \\ \text{MagField\_Z} \end{pmatrix} / 8192$$

* The magnetometers are scaled with respect to one another, but not to an absolute standard. One "Earth Field Unit" is equivalent to Earth's geomagnetic field strength present in the factory during calibration.

Accel – (X, Y and Z components): This is a vector quantifying the direction and magnitude of the instantaneously measured acceleration that the 3DM is exposed to. This quantity is derived from the accelerometer outputs, but has been scaled into physical units, and corrected for mechanical misalignment. It is expressed in terms of the 3DM's local coordinate system. Each component of the Accel vector is transmitted as a 16 bit signed integer. To complete the conversion to physical units, these values must be divided by the scale constant, 8192, i.e.,

$$\text{Acceleration Vector } (G^{*}) = \begin{pmatrix} \text{Accel\_X} \\ \text{Accel\_Y} \\ \text{Accel\_Z} \end{pmatrix} / 8192$$

* 1 G = 9.81m/sec^2

Temp – This is the temperature of the interior of the 3DM unit.

$$\begin{aligned} \text{Temperature } (^{\circ}\text{C}) &= \text{Temp} * 5/(4096*0.01) \\ &= \text{Temp} * 0.12207 \end{aligned}$$

TimerTicks - This is the value of the on-board clock tick counter sampled at the beginning of the current calculation cycle. Each clock tick has a duration of 8.192 msec. The value of TimerTicks rolls over from +32767 to –32768 (or from +65535 to 0 if

TimerTicks is treated as an unsigned 16 bit integer). This rollover occurs approximately every 8 minutes. The host computer's software must be capable of detecting and compensating for this rollover if a real-time record of when data was received is required.

Time (sec) = TimerTicks*0.008192

M - This is a 9 component coordinate transformation matrix which describes the orientation of the 3DM with respect to the fixed earth coordinate system. The earth fixed coordinate system has X pointing North, Y pointing East, and Z pointing down. The M matrix is derived from the Accel and MagField vectors. If the 3DM is exposed to linear accelerations, or magnetic interference, M will contain artifacts. To obtain a matrix with unit determinant, the individual components values must be divided by the constant 8192.

$$M = \begin{pmatrix} M\_11, & M\_12, & M\_13 \\ M\_21, & M\_22, & M\_23 \\ M\_31, & M\_32, & M\_33 \end{pmatrix} / 8192$$

M satisfies the following equation:

$$V\_3DM_i = M_{ij} \cdot V\_E_j$$

Where: V_3DM is a vector expressed in the 3DM's local coordinate system.
V_E is the same vector expressed in the stationary, earth-fixed coordinate system

EulerAngles - This consists of three angles, **Roll**, **Pitch**, and **Yaw** giving the orientation of the 3DM with respect to the fixed earth. These angles are calculated according to the ZYX, or "Aircraft" convention. Yaw is a rotation about the Z axis, Pitch is a rotation about the Y axis, and Roll is a rotation about the X axis. Each angle is given in the form of a signed 16 bit integer. Each of these must be multiplied by the scaling constant of (360/65536) to obtain angles in units of degrees. The range of Yaw is +/-180 degrees. The range of Pitch is +/-90 degrees, and the range of Roll is +/-180 degrees.

Command Set Summary

Command	Definition
0x00	**Null Command**
0x10	**Send Raw Sensor Bits**
0x11	**Send Scaled Sensor Vectors**
0x12	**Send Orientation Matrix**
0x13	**Send Euler Angles**
0x14	**Send Temperature**
0x15	**Set Continuous Mode**
0x16	**Send Orientation Matrix and Scaled Sensor Vectors**
0x66	**Send EEPROM Value**

0x65	**Program EEPROM Value**
0xF0	**Send Firmware Version Number**
0xF1	**Send Device Serial Number**

Command Set Overview

All commands are one byte in length. All commands generate a response of a fixed number of bytes. Two commands (0x65, 0x66, and 0x15) require that the host transmit additional data bytes following the command byte to fully define the action to be taken.

The response to most commands begins with a header byte (which has the same value as the corresponding command byte), and ends with a 16 bit checksum. The intervening bytes comprise a series of 16 bit signed integers that correspond to the requested data.

The checksum is evaluated as the sum of all preceding 16 bit integers and the header byte. When generating checksums, the header byte is treated as a 16 bit integer with an MSB of 0x00. This means that the individual data byte pairs must be assembled into 16 bit integers prior to evaluating the checksum. For example, the checksum in the response to the "Send Euler Angles" command (0x13) would be evaluated as:

Checksum = 0x0013 + Roll + Pitch + Yaw + TimerTicks

Data Packet Format

Send Raw Sensor Outputs

Function:	The 3DM will transmit the raw sensor output voltages
Command Byte:	0x10
Command Data:	None
Response:	17 bytes defined as follows
Byte 1	Header byte = 0x10
Byte 2	RawMag_1 MSB
Byte 3	RawMag_1 LSB
Byte 4	RawMag_2 MSB
Byte 5	RawMag_2 LSB
Byte 6	RawMag_3 MSB
Byte 7	RawMag_3 LSB
Byte 8	RawAccel_1 MSB
Byte 9	RawAccel_1 LSB
Byte 10	RawAccel_2 MSB
Byte 11	RawAccel_2 LSB
Byte 12	RawAccel_3 MSB
Byte 13	RawAccel_3 LSB

Byte 14	TimerTicks MSB
Byte 15	TimerTicks LSB
Byte 16	Checksum MSB
Byte 17	Checksum LSB

Send Instantaneous Vectors

Function:	The 3DM will transmit the magnetic field and acceleration, vectors
Command Byte:	0x11
Command Data:	None
Response:	17 bytes defined as follows
Byte 1	Header byte = 0x11
Byte 2	MagField_X MSB
Byte 3	MagField_X LSB
Byte 4	MagField_Y MSB
Byte 5	MagField_Y LSB
Byte 6	MagField_Z MSB
Byte 7	MagField_Z LSB
Byte 8	Accel_X MSB
Byte 9	Accel_X LSB
Byte 10	Accel_Y MSB
Byte 11	Accel_Y LSB
Byte 12	Accel_Z MSB
Byte 13	Accel_Z LSB
Byte 20	TimerTicks MSB
Byte 21	TimerTicks LSB
Byte 22	Checksum MSB
Byte 23	Checksum LSB

Send Orientation Matrix

Function:	The 3DM will transmit the orientation matrix
Command Byte:	0x12
Command Data:	None
Response:	23 bytes defined as follows
Byte 1	Header byte = 0x12
Byte 2	M_11 MSB
Byte 3	M_11 LSB
Byte 4	M_21 MSB
Byte 5	M_21 LSB
Byte 6	M_31 MSB

Byte 7	M_31 LSB
Byte 8	M_12 MSB
Byte 9	M_12 LSB
Byte 10	M_22 MSB
Byte 11	M_22 LSB
Byte 12	M_32 MSB
Byte 13	M_32 LSB
Byte 14	M_13 MSB
Byte 15	M_13 LSB
Byte 16	M_23 MSB
Byte 17	M_23 LSB
Byte 18	M_33 MSB
Byte 19	M_33 LSB
Byte 20	TimerTicks MSB
Byte 21	TimerTicks LSB
Byte 22	Checksum MSB
Byte 23	Checksum LSB

Send Euler Angles

Function:	The 3DM will transmit the Euler Angles
Command Byte:	0x13
Command Data:	None
Response:	23 bytes defined as follows
Byte 1	Header byte = 0x13
Byte 2	Roll MSB
Byte 3	Roll LSB
Byte 4	Pitch MSB
Byte 5	Pitch LSB
Byte 6	Yaw MSB
Byte 7	Yaw LSB
Byte 8	TimerTicks MSB
Byte 9	TimerTicks LSB
Byte 10	Checksum MSB
Byte 11	Checksum LSB

Send Temperature

Function:	The 3DM will transmit the current temperature
Command Byte:	0x14
Command Data:	None
Response:	7 bytes defined as follows

Byte 1	Header byte = 0x14
Byte 2	Temp MSB
Byte 3	Temp LSB
Byte 4	TimerTicks MSB
Byte 5	TimerTicks LSB
Byte 6	Checksum MSB
Byte 7	Checksum LSB

Set Continuous Mode

Function:	This command enables/disable continuous communications mode. To enable continuous mode, set the Command Data Byte to the desired command byte. To disable continuous mode, set the Command Data byte to 0x00.
Command Byte:	0x15
Command Data:	2 Bytes defined as follows
Byte 1	0x00
Byte 2	Command Byte to which continuous response is desired
Response:	7 bytes defined as follows
Byte 1	Header byte = 0x15
Byte 2	0x00
Byte 3	Command Byte
Byte 4	TimerTicks MSB
Byte 5	TimerTicks LSB
Byte 6	Checksum MSB
Byte 7	Checksum LSB

Send Orientation Matrix and Scaled Sensor Vectors

Function:	The 3DM will transmit the orientation matrix and the magnetic field and acceleration vectors.
Command Byte:	0x16
Command Data:	None
Response:	35 bytes defined as follows
Byte 1	Header byte = 0x16
Byte 2	M_11 MSB
Byte 3	M_11 LSB
Byte 4	M_21 MSB
Byte 5	M_21 LSB
Byte 6	M_31 MSB
Byte 7	M_31 LSB
Byte 8	M_12 MSB
Byte 9	M_12 LSB

Byte 10	M_22 MSB
Byte 11	M_22 LSB
Byte 12	M_32 MSB
Byte 13	M_32 LSB
Byte 14	M_13 MSB
Byte 15	M_13 LSB
Byte 16	M_23 MSB
Byte 17	M_23 LSB
Byte 18	M_33 MSB
Byte 19	M_33 LSB
Byte 20	MagField_X MSB
Byte 21	MagField_X LSB
Byte 22	MagField_Y MSB
Byte 23	MagField_Y LSB
Byte 24	MagField_Z MSB
Byte 25	MagField_Z LSB
Byte 26	Accel_X MSB
Byte 27	Accel_X LSB
Byte 28	Accel_Y MSB
Byte 29	Accel_Y LSB
Byte 30	Accel_Z MSB
Byte 31	Accel_Z LSB
Byte 32	TimerTicks MSB
Byte 33	TimerTicks LSB
Byte 34	Checksum MSB
Byte 35	Checksum LSB

Send EEPROM Value

Function:	The 3DM will transmit the 2 byte signed integer value stored in EEPROM at the specified address.
Command Byte:	0x66
Command Data:	1 Bytes defined as follows
Byte 1	Address
Response:	Responds with value at specified memory location
Byte 1	data MSB
Byte 2	data LSB

Program EEPROM Value

Function:	The 3DM will write the specified integer value to EEPROM at

	the specified address
Command Byte:	0x65
Command Data:	5 Bytes defined as follows
Byte 1	0x71
Byte 2	Address
Byte 3	data MSB
Byte 4	data LSB
Byte 5	0xAA
Response:	Responds with 2 bytes defined as follows
Byte 1	data MSB
Byte 2	data LSB

Send Firmware Version Number

Function:	The 3DM will transmit the firmware version number. After converting to decimal format the 5 digit number should be interpreted as version XX.X.XX
Command Byte:	0xF0
Command Data:	None
Response:	5 bytes defined as follows
Byte 1	Header byte = 0xF0
Byte 2	Version MSB
Byte 3	Version LSB
Byte 4	Checksum MSB
Byte 5	Checksum LSB

Send Serial Number

Function:	The 3DM will transmit its serial number
Command Byte:	0xF1
Command Data:	None
Response:	5 bytes defined as follows
Byte 1	Header byte = 0xF1
Byte 2	Serial MSB
Byte 3	Serial LSB
Byte 4	Checksum MSB
Byte 5	Checksum LSB