

User Manual

TargetPoint DMC

High Performance Digital Magnetic Compass



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1 Copyright & Warranty Information

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2 Introduction

Thank you for purchasing PNI Sensor Corporation's TargetPoint DMC 600 module (pn 13115) or TargetPoint DMC Demo Kit (pn 13116). The TargetPoint DMC is a ruggedized, high-accuracy digital magnetic compass (DMC) that is qualified in the United States military STORM-mLRF laser range finder. Combining PNI's patented magneto-inductive sensors and measurement circuitry with a 3-axis MEMS accelerometer, this high performance compass module was designed as a standalone DMC for easy integration into laser range finders and targeting systems. The TargetPoint DMC 600 has been extensively tested to military standards, including weapon shock, and it is field-proven by soldiers who rely on the compass for accurate heading data to facilitate a high probability of first-shot success. The accuracy and reliability of the TargetPoint DMC 600 makes it an ideal choice for threat detection, situational awareness, and neutralization.

The TargetPoint DMC Demo Kit includes the following:

- TargetPoint DMC 600 digital compass module
- Adapter Board Assembly (pn 13150) for easy use with the TargetPoint demo programs, assembled around the TargetPoint DMC 600 module
- Molex-to-RS232 cable assembly
- USB flash drive containing:
 - TargetPoint Calibration Program
 - TargetPoint Studio
 - TargetPoint DMC User Manual

We're sure the TargetPoint DMC will help you to achieve the greatest performance from your system. Thank you for selecting PNI and the TargetPoint DMC.

3 Specifications

3.1 Performance Specifications

Table 3-1: Performance Specifications¹

Parameter	Value
Azimuth (Heading) Accuracy	0.5° rms
Azimuth Specified Range	360°
Elevation (Pitch) & Bank (Roll) Accuracy	0.2° rms
Elevation & Bank Specified Range	± 45°
Angular Resolution	0.01°
Magnetometer Calibrated Range	± 150 μ T
Accelerometer Calibrated Range	± 1.0 g

Footnote:

1. Specifications subject to change. Assumes: a) a gimbal-mounted 12RT Calibration is performed, b) the magnetic field inclination (dip angle) is between -75° and +75°, c) the module is motionless, and d) the local magnetic field is clean relative to the calibration.

3.2 Operating Characteristics

Table 3-2: I/O Characteristics

Parameter		Value
Data Interface		RS232 subset ¹
Communication Protocol		ASCII
Communication Voltages	Transmit (Tx)	Low = 0 V, High = 5 V \pm 10%
	Receive (Rx)	Low = 0 to 0.9 V, High = 3.85 to 5.5 V
Communication Rate		300 to 38400 Baud, 9600 default
Reporting Rate	Continuous Measurement	1, 2, 5, 10, and 20 Hz
	Single Measurement	10 Hz maximum

Footnote:

1. The subset is defined by the Communication Voltages.

Table 3-3: Power Requirements

Parameter	Value
Supply Voltage	4.75 to 5.25 VDC
Average Current Consumption @ 10 Hz	225 mW
Current Draw when Saving to Flash Memory	82 mA max.
Sleep Mode Current Draw	0.3 mA typical

Table 3-4: Response Times

Parameter	Value
Wakeup from Sleep Mode	150 ms
Reset	10 ms
Shutdown (enter sleep mode)	500 ms
Measurement Data Request	500 ms
Status Request	500 ms

Table 3-5: Environmental Testing

Parameter		Criteria / Standard
Temperature	Specified Performance	-32° C to +55° C
	Functional Operation	-40° C to +70° C per MIL-STD-810G, Methods 501.5 and 502.5
	Storage ¹ (non-operational)	-57° C to +85° C per MIL-STD-810G, Methods 501.5 and 502.5
	Temp. Shock ¹ (non-operational)	-57° C to +71° C. 15° C/minute. Stabilized for 75 minutes at extremes. 3 cycles.
Shock (non-operational) ²		5000 shots while mounted in STORM rangefinder system on M4 rifle.
Vibration (non-operational) ²		MIL-STD-810G, Method 514.5, Procedure I – General Vibration. Random vibration per Annex C – Figure 514.5C-17, with duration of ≥1 hour on each of 3 axes.

Footnotes:

1. The TargetPoint DMC shall not suffer degradation of performance after testing.
2. The TargetPoint DMC shall be fully operable after testing.

Table 3-6: Mechanical Characteristics

Parameter		Value
Dimensions (l x w x h)	DMC module	33 x 31 x 13.5 mm (1.30" x 1.22" x 0.53")
	with adapter assembly	43 x 35 x 24.3 mm (1.69" x 1.38" x 0.96")
Weight	DMC module	20 gm max
	with adapter assembly	40 gm
Connector	DMC module	4-pin MIL-MAX, pn 850-10-004-10-001000
	with adapter assembly	9 pin Molex, pn 53780-0970
Mounting Options		Level or 90° side-mount

3.3 Mechanical Drawings

DIMENSIONS IN MM

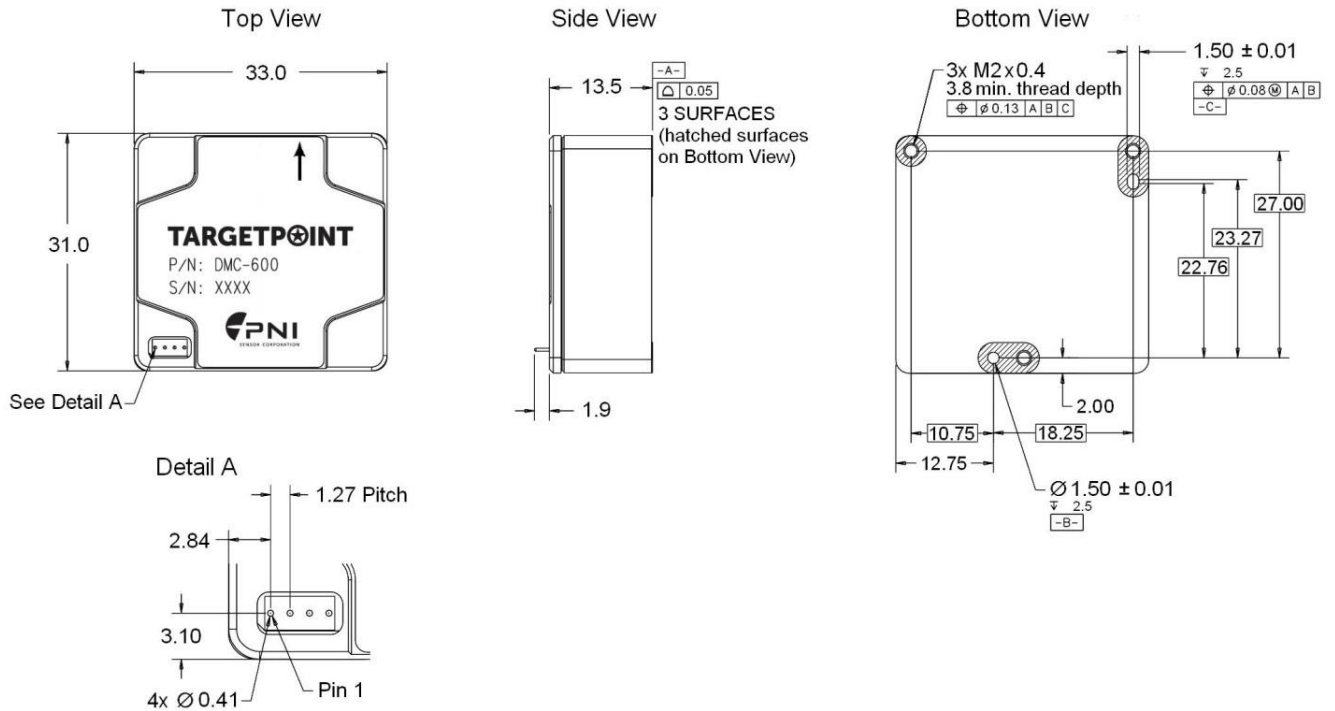


Figure 3-1: TargetPoint DMC Mechanical Drawing

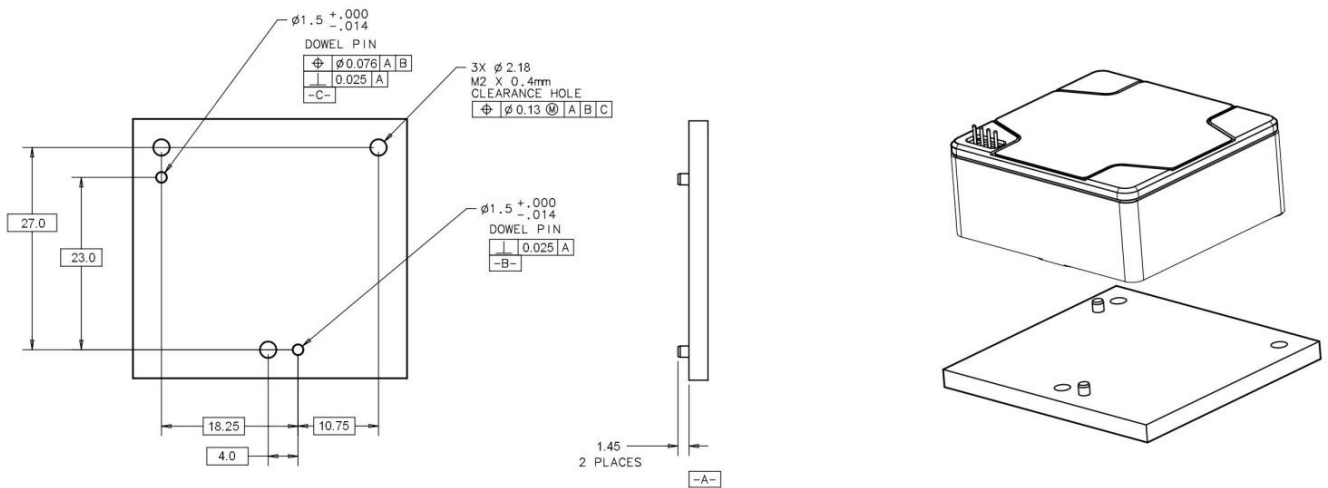


Figure 3-2: Reference Mating Interface Mechanical Drawing

Dimensions in mm

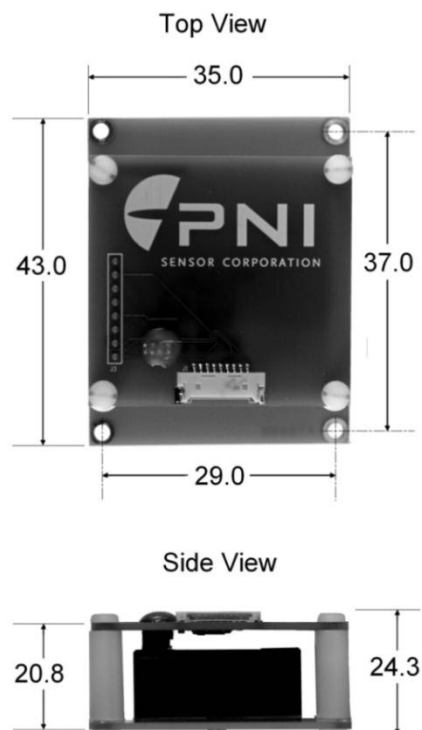


Figure 3-3: TargetPoint DMC with Adapter Board Assembly Dimensions

4 Using the TargetPoint Demo Kit

The TargetPoint Demo Kit includes the following:

- TargetPoint DMC 600 digital compass module
- Adapter Board Assembly for easy use with the TargetPoint demo programs, preassembled around the TargetPoint DMC 600 module
- Molex-to-RS232 cable assembly
- USB flash drive containing:
 - TargetPoint Calibration Program
 - TargetPoint Studio
 - TargetPoint DMC User Manual

Two demo programs are available to use with the TargetPoint DMC: the TargetPoint Calibration Program and the TargetPoint Studio. Both provide azimuth, elevation, and bank output, but the TargetPoint Calibration Program allows the user to perform a user calibration, while TargetPoint Studio provides the user with sensor data. PNI recommends first running the TargetPoint Calibration Program and performing a user calibration to properly compensate for magnetic distortions in the user's host system.

Both programs put an easy-to-use, graphical-user interface (GUI) onto the ASCII command language used by the TargetPoint DMC. The TargetPoint demo programs also include the ability to log and save the outputs of the TargetPoint DMC to a file. All of this allows you to quickly understand the capabilities of the TargetPoint DMC. Check the PNI website for the latest TargetPoint demo program updates at www.pnicorp.com.

4.1 Software Set-Up

The TargetPoint demo programs are provided as .msi files which can be downloaded from PNI's website. They work with Windows XP, Windows Vista, and Windows 7 operating systems. Simply copy the files onto your computer, then double click on the files to install the executable programs.

4.2 Hardware Set-Up

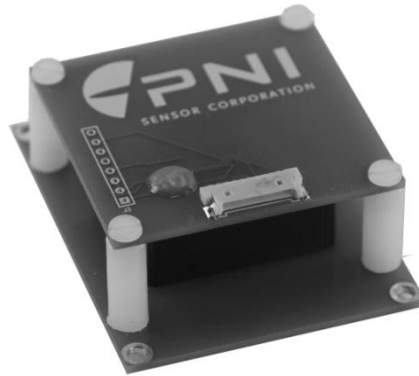


Figure 4-1: TargetPoint DMC with Adapter Board Assembly

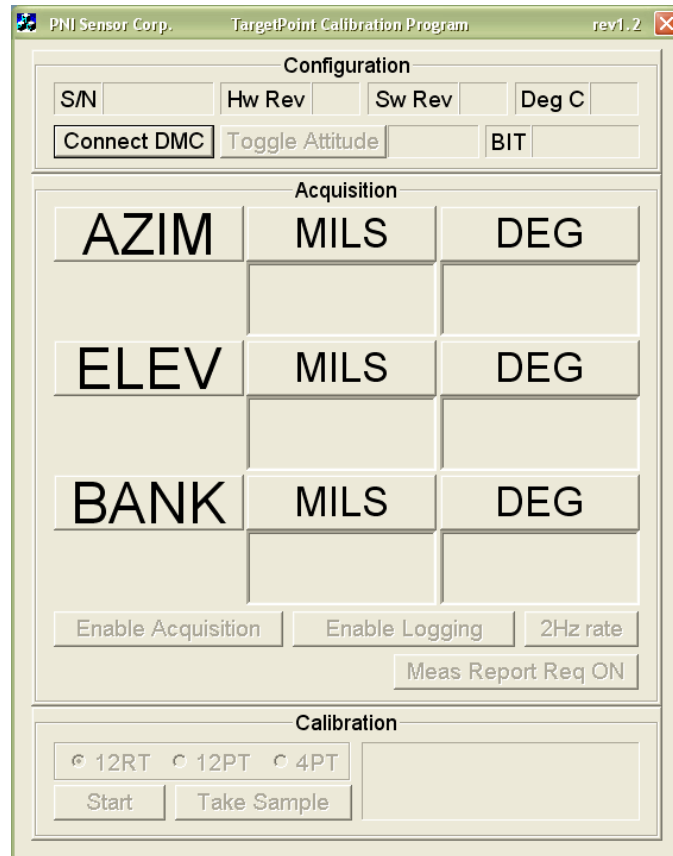
The TargetPoint DMC Adapter Board Assembly is used to simplify the evaluation of the DMC module with a PC. Specifically, it incorporates a level shifter to convert the output voltages of the DMC module to PC serial port voltages, and a keyed and locking Molex connector to help ensure the cable plugs in correctly and stays plugged in when testing. Simply plug the Molex-to-RS232 cable assembly into the Adapter Board Assembly (Molex connector) and the other end into a PC (RS232 end). Then ensure you have 3x fully charged AAA batteries installed in the cable's battery holder.

See Section 5.2 for specific issues to consider when mounting or using the TargetPoint DMC.

4.3 Running the TargetPoint Calibration Program

To help ensure accurate heading output, it is necessary to first calibrate the TargetPoint DMC. If you have not already done so, please review Section 7 for general information on calibration and the calibration methods available with the TargetPoint DMC. Section 7 explains the differences between calibration methods, when each one is appropriate, and the recommended calibration pattern for each method.

Double-click on the TargetPoint_Cal_Program icon. The window shown below will open.

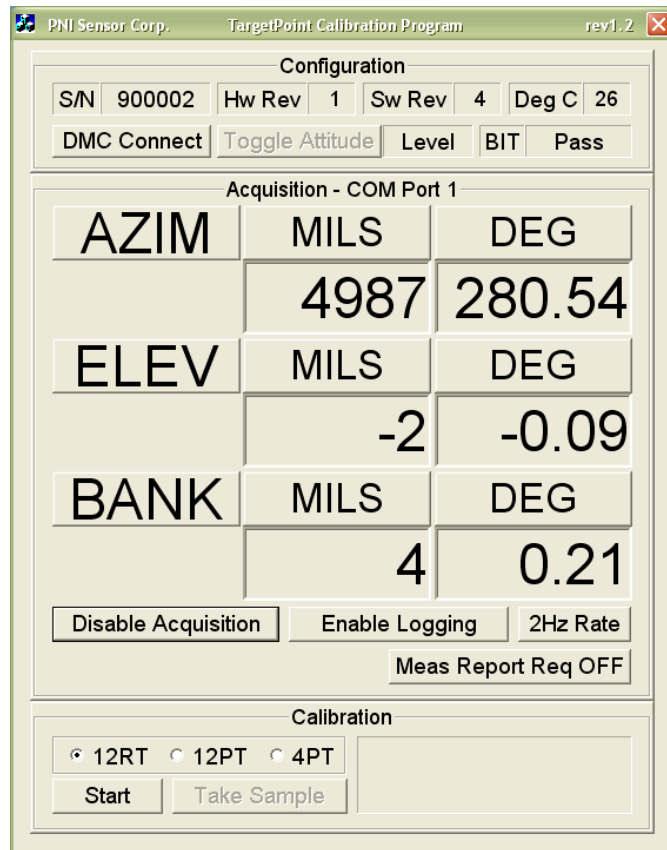


Click the “DMC Connect” button to initiate communication with the TargetPoint DMC. The program will automatically scan COM ports 1 to 50, looking for the module. Once the correct port is found, communication with the module will be enabled and the GUI will populate the “S/N”, “Hw Rev”, “Sw Rev”, and “Deg C” fields, plus the “Acquisition” line will identify the appropriate COM port.

After making a connection, the “Toggle Attitude” button will become active and indicate “Level”. If the module is mounted on its side, click the “Toggle Attitude” button and it will now read “90 Deg”. The accelerometer in the module will determine if the module is mounted on its right or left side.

The “2Hz Rate” button indicates the data rate is set to 2 Hz. Clicking this button changes the data rate to 10 Hz and the button will now read “10Hz Rate”.

To begin outputting data to the screen, first click “Meas Report Req ON”. The button will now say “Meas Report Req OFF”. Next click “Enable Acquisition”. The button will now say “Disable Acquisition”. The azimuth, elevation, and bank fields should now be populated, as shown in the example below.



4.3.1 Performing a Calibration

See Section 7 for general information on calibration and the calibration methods available with the TargetPoint DMC. Section 7 explains the differences between the methods, when each one is appropriate, and the specific calibration pattern for each method.

To perform a calibration in the TargetPoint Calibration Program it is necessary that data acquisition and measurement reporting are enabled, such that orientation data is now streaming on the screen. To start the calibration, first select the desired type of calibration to be performed (“12RT”, “12PT”, or “4PT”), then click the “Start” button. The “Start” button will now change to “Stop”, and the calibration can be aborted anytime by clicking the “Stop” button. During the user calibration, the Azimuth, Elevation, and Bank values are updated. Note that the data rate will be 1 Hz during calibration, regardless of the “...Rate” button. To take a calibration sample, click the “Take Sample” button. After clicking this button it becomes disabled and the orientation data is halted while the TargetPoint DMC records the sample. Once the calibration sample is recorded the “Take Sample” button becomes active and the calibration status box is updated with the last acquired sample. Now another sample may be taken. Note that the TargetPoint DMC needs to be completely still when clicking “Take Sample”. Also, it is best if the module’s location remains fixed while the orientation is changed. Once the final

calibration sample has been taken, the program will calculate the calibration score. An acceptable calibration score is <1.0 for a 12RT or 12PT calibration and should be “1” for a 4PT calibration.

4.3.2 Logging Data

To log data in the TargetPoint Calibration Program, first ensure both the “Enable Acquisition” and the “Meas Report Req ON” buttons have been selected, such that orientation data is now streaming on the screen. Next click the “Enable Logging” button. The button will now say “Disable Logging”. Once you have logged your data, click the “Disable Logging” button. A .txt file will be created in the same folder where the TargetPoint_Cal_Program.exe resides. The log file contains azimuth, elevation, and bank outputs in raw units, degrees, and mils. Data is logged every 500 ms (2 Hz).

4.4 Running TargetPoint Studio

Double-click the TargetPoint_Studio.exe icon. The program will open and immediately scan the COM ports for the TargetPoint DMC. Once the appropriate port is located the window will appear as shown below.

TargetPoint Studio rev1.1

Model DMC
Firmware Rev 0004
Serial Number 9000002
PCA Version DMC-410

COM Port ID COM1
DMC Status OK

Acquisition

Sensor Readings

Magnetometer		
	Raw	Calibrated
X	00000	0.000
Y	00000	0.000
Z	00000	0.000

Accelerometer		
	Raw	Calibrated
X	00000	0.000
Y	00000	0.000
Z	00000	0.000

Temperature 00.0

DMC Output (deg)

Azimuth Elevation Bank

To begin outputting data to the screen, click the “Start Acquisition” button, which will now change to “Stop Acquisition”. The Azimuth, Elevation, and Bank information is provided in degrees in the “DMC Output” box, while sensor data is provided in the “Sensor Readings”

box. The Raw data represents the basic sensor readings, while the calibrated data applies any factory and/or user calibration coefficients and additional filtering. Click the “Stop Acquisition” button to stop the outputting of data to the screen.

4.4.1 Logging Data

To log data, click the “Start Logging” button. The button will change to read “Stop Logging”. Click “Stop Logging” when logging is complete. A .txt file will be created in the same folder where the TargetPoint_Studio.exe resides. The log file contains the temperature reading; the azimuth, elevation, and bank readings in degrees; and raw and calibrated sensor data. Data is logged every ~75 ms (~13 Hz).

5 TargetPoint DMC Module Set-Up

This section describes how to configure the TargetPoint DMC module in your host system. To install the TargetPoint DMC into your system, follow these steps:

- If you have purchased a TargetPoint DMC Demo Kit, disassemble the Adapter Board Assembly by unscrewing the 4 screws that hold it together such that the DMC module is stand-alone
- Make electrical connections to the TargetPoint DMC module.
- Choose a mounting location.
- Mechanically mount the TargetPoint DMC in the host system.
- Perform a user calibration.

5.1 Electrical Connections

The TargetPoint DMC module incorporates a 4 pin Mil-Max connector, part number 850-10-004-10-001000, which mates with Mill-Max part 851-XX-004-10-001000 or equivalent. The pin-out is given in Table 5-1.

Table 5-1: Pin Descriptions

Pin #	Pin Function
1	GND
2	+5 VDC
3	TxD
4	RxD

Note: The 4 pin connector of the TargetPoint DMC module is not keyed, so it is possible to plug it in backwards. This won't damage the device, but will stop it from functioning. Additionally, there is no locking mechanism to keep the connector in place, so the user should take care to ensure the connector is actually connected. Since the TargetPoint DMC module normally is used as a board-mounted device, these issues generally are not a problem when using the DMC in a system, but can cause some confusion when performing off-line testing.

After making the electrical connections, PNI recommends performing some simple tests to ensure the TargetPoint DMC is working as expected. Section 6 for how to operate the TargetPoint DMC using PNI's ASCII-protocol command language.

5.2 Installation Location

The TargetPoint DMC should be mounted with the following considerations in mind.

5.2.1 Operate within the device's dynamic range

The TargetPoint DMC can be user calibrated by the user to correct for static magnetic fields created by the host system. Each axis of the TargetPoint DMC has a calibrated dynamic range of $\pm 150 \mu\text{T}$, so the total field should be within this range to ensure accurate heading readings. For example, this range might be exceeded if the TargetPoint DMC is placed too closely to large masses of ferrous metals, large electric currents, permanent magnets such as electric motors, and so on.

5.2.2 Locate away from changing magnetic fields

It is not possible to calibrate for changing magnetic anomalies. Thus, for greatest accuracy, keep the TargetPoint DMC away from sources of local magnetic distortion that will change with time; such as electrical equipment that will be turned on and off, or ferrous bodies that will move. Ensure the module is not mounted close to cargo or payload areas that may be loaded with materials that distort the local magnetic field.

5.2.3 Mount in a physically stable location

The TargetPoint DMC works best when stationary. Non-gravitational accelerations result in distorted readings of Earth's gravitational vector, thus distorting the heading reading. Choose a location isolated from excessive shock, oscillation, or vibration.

5.2.4 Location-verification testing

Location-verification testing should be performed at an early stage of development to understand and accommodate the magnetic distortion contributors in a host system.

Determine the distance range of field distortion.

Place the TargetPoint DMC in a fixed position, then move or energize suspect components while observing the module's output to determine when the suspect components begin to distort the readings.

Determine if the maximum field is within the compass' dynamic range.

With the compass mounted, rotate and tilt the system in as many positions as possible. Monitor the magnetometer outputs while doing this, observing if the dynamic range is exceeded.

5.3 Mechanical Mounting

Refer to Section 3.3 for dimensions, hole locations, and the reference frame orientation. The TargetPoint DMC is factory calibrated with respect to its mounting holes and it should be aligned within the host system with respect to these mounting holes. The arrow should be pointing in the same direction as the host system. The TargetPoint DMC can be mounted either level or on its side. Ensure any stand-offs and screws used to mount the module are non-magnetic.

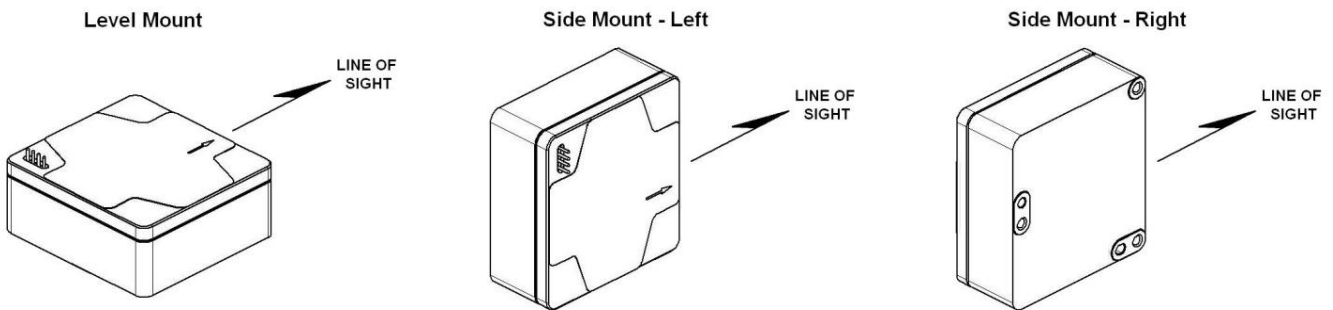


Figure 5-1: TargetPoint DMC Mounting Orientations

5.4 Elevation & Bank Convention

The TargetPoint DMC uses MEMS accelerometers to measure the tilt of the compass. This data is output as elevation (pitch) and bank (roll) data, and also is used in conjunction with the magnetometers to provide a tilt-compensated azimuth (heading) reading.

The module references both elevation and bank to the horizontal plane. A positive elevation is when the front edge of the module is rotated upward and a positive bank is when the left edge of the module is rotated downward.

Note: The convention for the TargetPoint DMC is different from that for PNI's TCM and Prime compasses. For the TCM and Prime, positive bank (roll) is when the right edge of the module is rotated downward. Also, for the TCM and Prime elevation is similarly referenced to gravity, but bank is referenced to the longitudinal axis (pitched axis) of the module, not to the horizontal plane.

6 Operation with ASCII Protocol

The TargetPoint DMC utilizes an ASCII protocol that is transmitted over a CMOS-level serial interface. Measurement and configuration values generally are reported in hexadecimal format.

The serial interface should be configured as follows. The default baud rate is 9600.

Table 6-1: Serial Interface Configuration

Parameter	Value
Number of Data Bits	8
Start Bits	1
Stop Bits	1
Parity	none

6.1 Command Set

Table 6-2 summarizes the command set for the TargetPoint DMC, and the following sections provide additional detail on these commands. Note that examples of command code are provided in Section 6.6, and more detailed information regarding User calibration (Mode 6) is provided in Section 7.

Table 6-2: Command Set

General Function	Command Description	ASCII Character Number								
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th
General Operation	Wake Up	z								
	Shutdown	S	h	u	t	d	o	w	n	<CR>
	Status Request	I								
Making Measurements (Modes 1 and 3)	Begin Continuous Output of Measurement Data (Mode 1)	S	9	1	<CR>					
	Place in Single Measurement Mode (Mode 3)	S	9	3	<CR>					
	Request Single Measurement	M								
User Calibration (Mode 6)	Start 12 Point Hard & Soft Iron Calibration	S	9	6	<CR>	X				
	Start 4PT Hard Iron Calibration	S	9	6	<CR>	y				
	Reset Hard/Soft Iron Coefficients	S	9	6	<CR>	X	S	0	<CR>	
	Reset Hard Iron Coefficients	S	9	6	<CR>	y	S	0	<CR>	
	Request Calibration Sample	Q								
Configuration	Reset	R								
	Store current configuration	S	7	<CR>						
	Set Level Mount	S	6	3	<CR>					
	Set Side Mount	S	6	4	<CR>					
	Get Mounting Orientation	S	6	?	<CR>					
	Set 300 Baud	S	B	0	1	2	C	<CR>		
	Set 600 Baud	S	B	0	2	5	8	<CR>		
	Set 1200 Baud	S	B	0	4	B	0	<CR>		
	Set 2400 Baud	S	B	0	9	6	0	<CR>		
	Set 4800 Baud	S	B	1	2	C	0	<CR>		
	Set 9600 Baud	S	B	2	5	8	0	<CR>		
	Set 19200 Baud	S	B	4	B	0	0	<CR>		
	Set 38400 Baud	S	B	9	6	0	0	<CR>		
	Set 1 Hz Rate	S	4	0	A	<CR>				
	Set 2 Hz Rate	S	4	0	5	<CR>				
	Set 10 Hz Rate	S	4	0	1	<CR>				
	Set 20 Hz Rate	S	4	0	0	<CR>				
	Sets Resolution ASCII Characters 3 to 6 ('#') define the range in HEX.	S	3	#	#	#	#	<CR>		

6.2 General Operation

6.2.1 Wakeup from Sleep Mode

The Wakeup command re-activates the TargetPoint DMC from Sleep Mode. Upon issuing a Wakeup command, the host system should wait at least 100 ms before issuing subsequent TargetPoint DMC commands.

Command String: ' z '

Response String: none

6.2.2 Shutdown

The host system issues a Shutdown command to the TargetPoint DMC to place it in Sleep Mode. In Sleep Mode the sensors and many of the functions of the microprocessor are turned off, such that power consumption is significantly reduced. The TargetPoint DMC is re-activated by the host system by sending the Wakeup command.

Command String: ' Shut down<CR> '

Response String: none

6.2.3 Request Status

The Request Status command is issued by the host system to retrieve the TargetPoint DMC's hardware and software revisions, operational configuration, temperature, CPU and temperature status.

Command String: ' I '

Response Strings:

Table 6-3 provides the format of the Request Status response message from the TargetPoint DMC. The ASCII numeric values are in hexadecimal.

Note: The Data Valid bit is 'Valid' when the CPU Status and Temperature Status bits are "Pass". The Data Valid bit is "Error" if either the CPU Status or Temperature Status bits are "Fail". The checksum calculation is to add characters 2 through 24 as an 8-bit sum, then 'OR' the 8-bit sum with the Data Valid bit.

Table 6-3: Request Status Response

Character Number	Value	Description
1	S	Message Frame Start.
2 and 3	00	Software version.
4 and 5	00	Hardware version.
6 to 9	0000	Unused. Always 0.
10 and 11	00	Reporting Rate. 1 Hz = 0A, 2 Hz = 05, 10 Hz = 01, 20 Hz = 00
12 and 13	00	Unused. Always 0.
14 to 17	0000	Measuring Range, MSD first, 2's complement.
18 and 19	00	Temperature (deg C), MSD first, 2's complement.
20	0	Operation Mode: 1 (continuous) or 3 (single measurement).
21 and 22	00	CPU Status. 0xFF = Pass, 0x7F = Fail
23 and 24	00	Temperature Status. 0xFF = Pass, 0xFB = Fail.
25 and 26	00	Checksum/Data Valid. MSD first. Bit 7 = data (1 = Valid, 0 = Error) Bit 6 = checksum MSB Bit 5 = checksum Bit 4 = checksum Bit 3 = checksum Bit 2 = checksum Bit 1 = checksum Bit 0 = checksum LSB
27	<CR>	End of message frame (carriage return).

6.3 Taking Measurements (Modes 1 & 3)

The TargetPoint DMC can report data either continuously (Mode 1) or one data set at a time after receiving a request for data (Mode 3). The sections below discuss how to obtain data from the module in these two modes.

6.3.1 Setting the Operation Mode

The commands to put the TargetPoint DMC into continuous measurement mode (Mode 1) or single measurement mode (Mode 3) are given below. The default on powering up is Mode 3. For Mode 1, data will start being reported right after issuing the command,

while for Mode 3 a Request Measurement command must be sent to obtain data. In both cases, azimuth, elevation, and bank are reported.

Note: *If the TargetPoint DMC is put into continuous measurement mode (Mode 1), the current configuration is saved, and then the DMC is turned off, when the DMC is powered up again it will revert to Mode 3. If continuous reporting is desired, it is necessary to issue the Mode 1 command string each time the DMC is powered on.*

Command Strings:

Continuous measurement : ' S91<CR>'

Single measurement : ' S93<CR>'

Response Strings:

The following table illustrates the response format for azimuth, elevation and bank measurement data for Operation Modes 1 and 3. Note that the azimuth, elevation, and bank values are given in hexadecimal format.

Table 6-4: Measurement Response Data

Character Number	Value	Description
1	S	Frame Start
2 to 5	AAAA	Azimuth
6 to 9	EEEE	Elevation
10 to 13	BBBB	Bank
14 and 15	FF	Checksum / data valid: MSB first. Bit 7 = data valid (always 1). Bit 6 = checksum MSB Bit 5 = checksum Bit 4 = checksum Bit 3 = checksum Bit 2 = checksum Bit 1 = checksum Bit 0 = checksum LSB
16	<CR>	Frame End (Carriage Return).

Reported measurement values are based on circle division units whereby the unit circle is divided by the value set by the Measurement Range command. The TargetPoint DMC uses a default measurement range value of 0x7FFF or 32767. The reported azimuth, elevation and bank can thereby be converted to degrees or mils as follows.

- Units per deg: $32767/360 = 91.019444$ units/deg
- Units per mil: $32767/6400 = 5.119843$ units/mil.

The default TargetPoint DMC measurement ranges are as follows:

- Azimuth: 0 to 32767 units for a range of 0 to 360 deg.
- Bank: 0 to +/-8191 units for a range of +/- 90 deg.
- Elevation: 0 to +/-8191 units for a range of +/- 90 deg.

6.3.2 Request Measurement

While in Operation Mode 3 (single measurement mode) or Operation Mode 6 (calibration mode), the host system issues a Request Measurement command to obtain azimuth, elevation, and bank measurements from the TargetPoint DMC.

The TargetPoint DMC produces a Request Measurement response within 100 ms. Therefore, the host system can reliably issue a Request Measurement command to the TargetPoint DMC at a 10 Hz rate. The host system should not issue a Request Measurement command to the TargetPoint DMC at a rate greater than 10 Hz.

If issuing a Request Measurement command while in Operation Mode 6 (calibration), the host system should issue the command at a 1 Hz rate. The rate should not exceed this.

Command String: 'M

Response String:

See Table 6-4 for the Measurement Response Data message format.

6.4 User Calibration (Mode 6)

See Section 7 for general information on calibration and the 3 calibration methods (12RT, 12PT, and 4PT) available with the TargetPoint DMC. Section 7 explains the differences between the methods, when each one is appropriate, and the specific calibration pattern for each one.

6.4.1 Resetting Calibration Coefficients

The TargetPoint DMC comes with factory-generated calibration coefficients. These are very accurate coefficients for cases where no local magnetic distortions are present (i.e. the magnetic field surrounding the module is clean). In most cases, the host system of the module is not magnetically clean and a calibration must be performed to compensate for magnetic distortions present in the host system. After a new user calibration, with an acceptable score, the calibration coefficients should be saved in the module. These

calibration coefficients can be subsequently refined (12PT and 4PT Calibrations). However, if the local field has changed substantially it is wise to reset the calibration coefficients back to their factory-generated values and recalibrate with these as the baseline (12RT Calibration). The commands below are for resetting the coefficients to their factory values.

Command Strings:

Reset Soft/Hard Iron Coefficients:	' S96<CR>XS0<CR>'
Reset Hard Iron Coefficients:	' S96<CR>YS0<CR>'

Response Strings:

Reset Soft/Hard Iron Successful	' CS- - <CR>'
Reset Soft/Hard Iron Not Successful	' CSxx<CR>'
Reset Hard Iron Successful	' CS- <CR>'
Reset Hard Iron Not Successful	' CSx<CR>'

6.4.2 Initiating a User Calibration

There are two basic commands for initiating a user calibration, as given below. The Soft/Hard Iron Calibration requires taking 12 calibration samples, and corrects for both soft and hard iron distortions. The Hard Iron Calibration requires taking 4 calibration samples and corrects for only changes in hard iron distortions. Initially the coefficients should be reset and a 12 point Soft/Hard Iron Calibration should be performed (eg. 12RT Calibration). After this the calibration coefficients can be refined by either performing another 12 point Soft/Hard Iron Calibration without resetting the coefficients (eg. 12PT Calibration) or by performing a 4 point Hard Iron Calibration (eg. 4PT Calibration). When the TargetPoint DMC is first calibrated in the host system, PNI recommends first performing a 12RT Calibration and immediately following this with a 12PT Calibration.

Command Strings:

Initiate Soft/Hard Iron Calibration:	' S96<CR>X'
Initiate Hard Iron Calibration:	' S96<CR>Y'

Response Strings:

After a soft/hard iron or hard iron user calibration is performed, the TargetPoint DMC issues a Score Results message indicating the quality of the user calibration. See the tables below.

Table 6-5: Soft/Hard Iron Calibration Score Results

Character Number	Value	Description
1	C	Calibration message.
2	S	Frame Start.
3 and 4	01 to 99 (OK) or xx (Bad).	Calibration score. If the score is ≤ 99 , the calibration coefficients are programmed to non-volatile memory. If the score is > 99 , "xx" is sent and the coefficients are not programmed. The score should be ≤ 10 to ensure acceptable accuracy.
5	<CR>	End of frame (Carriage Return).

Table 6-6: Hard Iron Calibration Score Results

Character Number	Value	Description
1	C	Calibration message.
2	S	Frame Start.
3	1 to 9 (OK) or x (Bad).	Calibration score. If score ≤ 9 , calibration coefficients are programmed to non-volatile memory. If score > 9 , "x" is sent and coefficients are not programmed. The score should be 1 to ensure acceptable accuracy.
4	<CR>	End of frame (Carriage Return).

6.4.3 Request Calibration Sample

The Request Calibration Sample command is sent by the host system to the TargetPoint DMC to command the TargetPoint DMC to take a calibration sample during a user calibration. The host must wait for a Calibration Sample Request Response from the TargetPoint DMC before issuing the next sample request.

Command String: ' Q

Response String:

See the tables below for the Calibration Sample Request Response message format.

Table 6-7: Soft/Hard Iron Calibration Sample Request Response

Character Number	Value	Description
1	S	Frame Start.
2	0 to 1	Current calibration measurement MSD.
3	0 to 9	Current calibration measurement LSD.
4	' '	Space
5	' ' or E	Space = OK, or E = Error
6	<CR>	End of frame (Carriage Return).

Table 6-8: Hard Iron Calibration Sample Request Response

Character Number	Value	Description
1	S	Frame Start.
2	0	Current calibration measurement MSD. Note: Always 0.
3	1 to 4	Current calibration measurement LSD.
4	' '	Space
5	' ' or E	Space = OK, or E = Error
6	<CR>	End of frame (Carriage Return).

6.5 Configuration

The following settings can be configured within the TargetPoint DMC, where the default values are also given. Changes can be saved with the Store Startup Configuration command.

- Mounting Orientation (default = Level)
- Measurement Report Rate (default = 2 Hz)
- Baud Rate (default = 9600)
- Measurement Range (default = 0x7FFF [32767_d])

6.5.1 Set Mounting Orientation

This command is issued by the host system in order to set the TargetPoint DMC's mounting orientation to either Level or Side mount. If "Side Mount" is selected, the accelerometer within the DMC will determine if it is mounted on the left or right side.

Note: Whenever the TargetPoint DMC's mounting orientation is changed, the user must immediately perform a successful 12RT calibration. Only a successful 12RT calibration will save the new mounting orientation to the TargetPoint DMC's non-volatile memory.

Command Strings:

Set Level Mbunt : ' S63<CR>'
Set Si de Mbunt : ' S64<CR>'

Response Strings: none

6.5.2 Get Mounting Orientation

This command is issued by the host system to query the module's mounting orientation.

Command String: ' S6?<CR>'

Response Strings:

Level mount : ' S63<CR>'
Si de mount : ' S64<CR>'

6.5.3 Baud Rate

The Baud Rate command is sent by the host system to configure the TargetPoint DMC's data communication rate. This command must be followed by a Store Startup Configuration command to permanently store the desired baud rate. Note that one must sequentially step through all the baud rates between the current and the desired rate. It is not possible to jump from e.g. 9600 to 38400 (or reverse).

Command Strings:

Set Baud Rat e 300: ' SB012C<CR>'
Set Baud Rat e 600: ' SB0258<CR>'
Set Baud Rat e 1200: ' SB04B0<CR>'
Set Baud Rat e 2400: ' SB0960<CR>'
Set Baud Rat e 4800: ' SB12C0<CR>'
Set Baud Rat e 9600: ' SB2580<CR>'
Set Baud Rat e 19200: ' SB4B00<CR>'
Set Baud Rat e 38400: ' SB9600<CR>'

Response String: none

6.5.4 Set Reporting Rate

This command sets the measurement data reporting rate of the TargetPoint DMC. The TargetPoint DMC supports 1, 2, 10, and 20 Hz reporting rates.

Command Strings:

1 Hz report rate: ' S40A<CR>'
2 Hz report rate: ' S405<CR>'
10 Hz report rate: ' S401<CR>'
20 Hz report rate: ' S400<CR>'

Response Strings: none

Note: The reporting rate must not exceed 2 Hz when performing a user calibration. The measurement response time to a Request Measurement command is based on the programmed report rate (1 Hz rate = 1 second, 2 Hz rate = 500ms).

6.5.5 Set Measurement Range

The Set Measurement Range command is sent by the host system to set the circle division units (resolution) reported back for azimuth, elevation and bank. The default measurement range value used by the TargetPoint DMC is 0x7FFF.

Table 6-9: Set Measurement Range

Character Number	Value	Description
1	S	Frame Start.
2	3	Set Measurement Range value.
3 to 6	0002 to 7FFF	Measurement Range hexadecimal value.
7	<CR>	End of message frame (carriage return).

6.5.6 Store Startup Configuration

The Store Startup Configuration command is issued by the host system to store the following current TargetPoint DMC configuration parameters:

- Mounting Orientation
- Baud Rate
- Reporting Rate
- Measurement Range

Command String: ' S7<CR>'

Response String: none

6.5.7 Reset

The Reset command is issued by the host system to reset the TargetPoint DMC to its last saved configuration state. The stored configuration parameters include the following:

- Mounting Orientation
- Baud Rate
- Reporting Rate
- Measurement Range

Command String: ' R'

Response String: none

Note: The host system should wait at least 100ms before issuing TargetPoint DMC commands immediately following a TargetPoint DMC Reset command and at least 800 ms immediately following a TargetPoint DMC Power Up.

6.6 TargetPoint DMC Command/Response Examples

The following sections list the commands generated by the host system and responses generated by the TargetPoint DMC for TargetPoint DMC initialization, status, measurement and calibration.

6.6.1 Initialization

A typical TargetPoint DMC initialization is as follows:

```
CMD      - RESET
CMD      - SET REPORTING RATE:  2.00 Hz
CMD      - SET MEASUREMENT RANGE: 7FFF
CMD      - SELECT OPERATION MODE: 3
CMD      - SET MOUNTING ORIENTATION: LEVEL
```

The following listing is an initialization that checks, changes and saves the TargetPoint DMC attitude.

```
CMD      - RESET
CMD      - SET REPORTING RATE:  2.00 Hz
CMD      - SET MEASUREMENT RANGE: 7FFF
CMD      - SELECT OPERATION MODE: 3
CMD      - GET MOUNTING ORIENTATION
RESP     - Mounting Orientation: SIDE
CMD      - SET MOUNTING ORIENTATION: LEVEL
CMD      - STORE START-UP CONFIGURATION
CMD      - RESET
CMD      - GET MOUNTING ORIENTATION
RESP     - Mounting Orientation: LEVEL
```

Note that the ‘Store Startup Configuration’ command in the listing above results in the default TargetPoint DMC mounting orientation of Level after issuing a ‘Reset’ command.

6.6.2 Status

The following shows a transaction between the host system and the TargetPoint DMC during initialization, whereby the TargetPoint DMC is queried for status.

```
CMD      - RESET
CMD      - SET REPORTING RATE:  2.00 Hz
CMD      - SET MEASUREMENT RANGE: 7FFF
CMD      - SELECT OPERATION MODE: 3
CMD      - GET MOUNTING ORIENTATION
RESP     - Mounting Orientation: LEVEL
CMD      - REQUEST STATUS
```

```

RESP      - Status Output :
              Software Version      : 01
              Hardware Version      : 01
              Unused                  : 0000
              Measurement Time      : 05
              Unused                  : 00
              Measurement Range      : 7FFF
              Temperature (C)       : 19
              Operation Mode        : 3
              CPU Status             : FF
              Temperature Status    : FF

```

6.6.3 Measurement

The following listing shows a transaction between the host system and the TargetPoint DMC, whereby the TargetPoint DMC is initialized and then queried for measurement output of azimuth, elevation and bank data:

```

CMD      - RESET
CMD      - SET REPORTING RATE: 2.00 Hz
CMD      - SET MEASUREMENT RANGE: 7FFF
CMD      - SELECT OPERATION MODE: 3
CMD      - GET MOUNTING ORIENTATION
RESP     - Mounting Orientation: LEVEL
CMD      - REQUEST MEASUREMENT
RESP     - Measurement Output .

```

Note: Selecting Operation Mode 1 in lieu of Operation Mode 3 produces a continuous stream of measurement output from the TargetPoint DMC at the initialized reporting rate. For Operation Mode 1, the user does not issue a Measurement Data Request.

6.6.4 12RT and 12PT Calibration

The following commands and responses illustrate a 12RT Calibration with measurement reporting between calibration sample requests. The 12PT Calibration would be identical to the 12RT Calibration except the first two commands to reset the hard iron and soft/hard iron coefficients would be omitted. For best results, first run a 12RT Calibration and immediately after this run a 12PT Calibration.

Note: The programmed reporting rate must not exceed 2 Hz during a user calibration. The measurement output response time to a Request Measurement command is based on the programmed report rate (1 Hz rate = 1 second, 2 Hz rate = 500ms).

Sequence of commands and responses:

CMD - RESET HARD IRON COEFFICIENTS
RESP - Hard Iron Calibration Reset Successful.
CMD - RESET SOFT/HARD IRON COEFFICIENTS
RESP - Soft/Hard Iron Calibration Reset Successful.
CMD - RESET
CMD - INITIATE SOFT/HARD IRON CALIBRATION
CMD - REQUEST MEASUREMENT
RESP - Measurement Output.
CMD - REQUEST CALIBRATION SAMPLE
RESP - Soft/Hard Iron Cal. Current Measurement: 01
CMD - REQUEST MEASUREMENT
RESP - Measurement Output.
CMD - REQUEST CALIBRATION SAMPLE
RESP - Soft/Hard Iron Cal. Current Measurement: 02
CMD - REQUEST MEASUREMENT
RESP - Measurement Output.
CMD - REQUEST CALIBRATION SAMPLE
RESP - Soft/Hard Iron Cal. Current Measurement: 03
CMD - REQUEST MEASUREMENT
RESP - Measurement Output.
CMD - REQUEST CALIBRATION SAMPLE
RESP - Soft/Hard Iron Cal. Current Measurement: 04
CMD - REQUEST MEASUREMENT
RESP - Measurement Output.
CMD - REQUEST CALIBRATION SAMPLE
RESP - Soft/Hard Iron Cal. Current Measurement: 05
CMD - REQUEST MEASUREMENT
RESP - Measurement Output.
CMD - REQUEST CALIBRATION SAMPLE
RESP - Soft/Hard Iron Cal. Current Measurement: 06
CMD - REQUEST MEASUREMENT
RESP - Measurement Output.
CMD - REQUEST CALIBRATION SAMPLE
RESP - Soft/Hard Iron Cal. Current Measurement: 07
CMD - REQUEST MEASUREMENT
RESP - Measurement Output.
CMD - REQUEST CALIBRATION SAMPLE
RESP - Soft/Hard Iron Cal. Current Measurement: 08
CMD - REQUEST MEASUREMENT
RESP - Measurement Output.
CMD - REQUEST CALIBRATION SAMPLE
RESP - Soft/Hard Iron Cal. Current Measurement: 09
CMD - REQUEST MEASUREMENT

```

RESP - Measurement Out put .
CMD - REQUEST CALI BRATI ON SAMPLE
RESP - Soft / Hard Iron Cal . Current Measurement : 10
CMD - REQUEST MEASUREMENT
RESP - Measurement Out put .
CMD - REQUEST CALI BRATI ON SAMPLE
RESP - Soft / Hard Iron Cal . Current Measurement : 11
CMD - REQUEST MEASUREMENT
RESP - Measurement Out put .
CMD - REQUEST CALI BRATI ON SAMPLE
RESP - Soft / Hard Iron Cal . Current Measurement : 12
RESP - Soft / Hard Iron Cal Score = 5. Stored to non-
      volatile memory.

```

Following the TargetPoint DMC's response to the final calibration sample request, the user should stop issuing Request Measurement commands to the TargetPoint DMC and wait at least 20 seconds for the final score to be reported. It typically takes less than 10 seconds to determine the score, but the amount of time varies depending on the surrounding environment and the quality of the user calibration.

6.6.5 4PT Calibration

The following commands and responses illustrate a 4PT Calibration with measurement reporting by the TargetPoint DMC between calibration sample requests.

Note: The programmed reporting rate must not exceed 2 Hz during a user calibration. The measurement output response time to a Request Measurement command is based on the programmed report rate (1 Hz rate = 1 second, 2 Hz rate = 500ms).

Sequence of commands and responses:

```

CMD - RESET
CMD - I N I T I A T E H A R D I R O N C A L I B R A T I O N
CMD - REQUEST MEASUREMENT
RESP - Measurement Out put .
CMD - REQUEST CALI BRATI ON SAMPLE
RESP - Hard Iron Cal . Current Measurement : 1
CMD - REQUEST MEASUREMENT
RESP - Measurement Out put .
CMD - REQUEST CALI BRATI ON SAMPLE
RESP - Hard Iron Cal . Current Measurement : 2
CMD - REQUEST MEASUREMENT
RESP - Measurement Out put .
CMD - REQUEST CALI BRATI ON SAMPLE
RESP - Hard Iron Cal . Current Measurement : 3

```

CMD - REQUEST MEASUREMENT
RESP - Measurement Output.
CMD - REQUEST CALIBRATION SAMPLE
RESP - Hard Iron Cal. Current Measurement: 4
RESP - Hard Iron Cal Score = 1. Stored to non-volatile memory.

Following the TargetPoint DMC's response to the final calibration sample request, the user should stop issuing Request Measurement commands to the TargetPoint DMC and wait at least 20 seconds for the final score to be reported. It typically takes less than 10 seconds to determine the score, but the amount of time varies depending on the surrounding environment and the quality of the user calibration.

7 User Calibration

The magnetic sensors in the TargetPoint DMC are factory calibrated in a magnetically controlled environment. Consequently, sources of magnetic distortion positioned near the TargetPoint DMC in the user's system will distort Earth's magnetic field and should be compensated for. Examples of such sources include ferrous metals and alloys (ex. iron, nickel, non-stainless steel, etc.), batteries, audio speakers, current-carrying wires, and electric motors. Compensation is accomplished by user calibrating the module while mounted in the user's system. It is expected the sources of magnetic distortion will remain fixed relative to the module's position within the user's system. By performing a user calibration, the TargetPoint DMC identifies the local sources of magnetic distortion within the host system and negates their effects from the overall reading to provide an accurate compass heading. Both hard iron and soft iron sources can be compensated for, wherein hard iron sources generate a magnetic field and soft iron sources distort an existing field. For additional information on this, see PNI's white paper "Local Magnetic Distortion Effects on 3-Axis Compassing", which can be found at www.pnicorp.com.

The TargetPoint DMC provides three methods of calibration, termed 12RT Calibration, 12PT Calibration and 4PT Calibration. 12RT Calibration and 12PT Calibration compensate for hard and soft iron distortions in the host system, and store both hard iron and soft iron calibration coefficients after completing the calibration routine. For 12RT Calibration, the existing soft iron and hard iron calibration coefficients are reset to factory-generated values prior to running the calibration routine, while 12PT Calibration refines the existing calibration coefficients. The only difference between 12RT Calibration and 12PT Calibration is that the calibration coefficients are reset for 12RT Calibration and they are not reset for 12PT Calibration. A 12RT Calibration should be run when the module is first calibrated in the host system and whenever significant changes in the local magnetic field occur. A 12PT Calibration can be run when the local field has not changed significantly. For best results, run a 12RT Calibration and immediately follow this with a 12PT Calibration. The 4PT Calibration is a relatively quick procedure to update the hard iron coefficients of a prior calibration. A 4PT Calibration is particularly useful to compensate for changes in the magnetic signature of a gun barrel after it has been fired.

For 12RT and 12PT Calibrations, 12 calibration samples are taken with the first 6 samples collected at +30° elevation, 0° bank, and in 60° azimuth increments. The remaining 6 samples are collected at -30° elevation, 0° bank, and in the same 60° azimuth increments. See Figure 7-1 below. PNI recommends performing 12RT and 12PT Calibrations on a gimbaled fixture. For 4PT Calibration, 4 calibration samples are collected at 90° azimuth increments with the compass kept at 0° bank and alternating between +30° and -30° elevation.

Note: The programmed sample rate must not exceed 2 Hz during a user calibration. The measurement output response time to a Request Measurement command is based on the programmed report rate (1 Hz rate = 1 second, 2 Hz rate = 500ms).

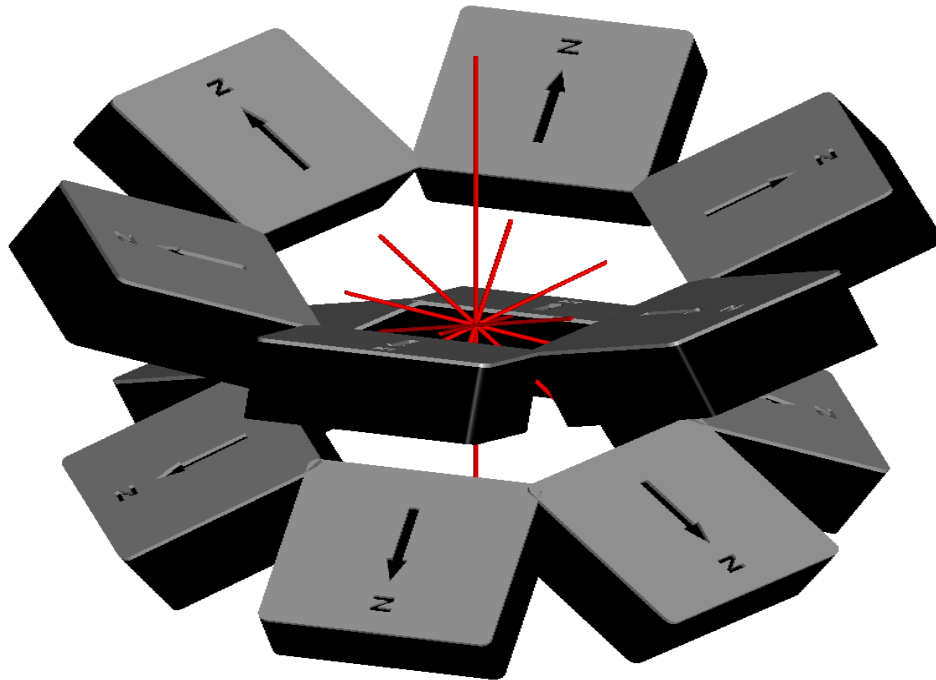


Figure 7-1: 12RT and 12PT Calibration Pattern

Table 7-1: 12RT and 12PT Calibration Pattern

Sample #	Azimuth	Elevation	Bank
First Circle			
1	0°	+30°	0°
2	60°	+30°	0°
3	120°	+30°	0°
4	180°	+30°	0°
5	240°	+30°	0°
6	300°	+30°	0°
Second Circle			
7	0°	-30°	0°
8	60°	-30°	0°
9	120°	-30°	0°
10	180°	-30°	0°
11	240°	-30°	0°
12	300°	-30°	0°

Table 7-2: 4PT Calibration Pattern

Sample #	Azimuth	Elevation	Bank
1	0°	+30°	0°
2	90°	-30°	0°
3	180°	+30°	0°
4	270°	-30°	0°