Applied Physics Systems

Model 1540 24-Bit Digital 3-Axis Miniature Fluxgate Magnetometer
(7716 A to D Version)

Technical Reference and User's Manual

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I. Introduction

The 1540 System is a high-speed 3-axis fluxgate magnetometer employing 24-bit analog to digital converters. Magnetic field data transmitted by the 1540 is expressed in the units of Gauss (G). The use of 24-bit converters enables the 1540 system to measure magnetic field magnitudes from ±0.65G down to the system noise level 5 x 10^{-6} G using a single range. The 1540 package is cylindrical (1" diameter and 4.725" length) and powers from a single input voltage that ranges from +5V to +12V. Input current is 40mA. An optional rectangular package is also available with dimensions 4.75”Lx1.15”Wx0.95”H.

The 1540 system employs three ring core fluxgate sensors together with analog processing electronics to produce analog output voltages proportional to the measured magnetic field along three orthogonal axes. The analog output voltages are converted to digital form using three 24-bit A/D converters.

The 1540 digital control functions are provided by the system microprocessor (MSP430) which performs the functions: 1) control and acquisition of data from the 24-bit A/D converter; 2) correction of fluxgate sensor scale, offset and alignment factors; 3) implementation of serial communications between the system and an external computer.

The 1540 is calibrated by placing the system in a precision 3-axis Helmholtz coil which enables the application of accurately known magnetic fields to the system and the Helmholtz coil is fitted with a holding fixture with alignment holes and reference vee groove that match the 1540 alignment pins and cylindrical body. The holding fixture enables the 1540 to be accurately aligned with the Helmholtz axes so that accurate scale and alignment and offset factors can be determined. After determining the calibration factors, they are downloaded into the 1540 so that the system microprocessor can make calibration corrections on measured magnetic field data before transmission to the outside world.

The 1540 system communicates with the outside world over a bi-directional serial interface using TTL logic levels and RS232 levels.

To facilitate communication with the 1540 an ASCII character command language has been created. For instance, if the ASCII characters for 0, S and D (<u>0</u> <u>S</u>end <u>D</u>ata) are sent to the 1540, the system will respond by sending an ASCII reply of the following form:

MX: -0.2563
MY: +0.012461
MZ: +0.234612
Temp: 27.4653

Note that the 1540 system transmits magnetic field data in Gauss with 6 digits to the right of the decimal point. Typically when no averaging is used, the system noise level causes the last digit to fluctuate 4 or 5 numbers randomly.

In addition to the ASCII data transmission mode the 1540 system has a binary transmission mode and an IEEE 32-bit transmission mode. These modes are faster than the ASCII mode because considerably fewer characters need to be transmitted. Section IV discusses the binary transmission modes further.

II. Model 1540 Specifications

Digital Interface

Accuracy	± 0.5% FS
Noise Level with no averaging	5 μG (0.5 μT) peak to peak
Range	±0.625 Gauss (optional ±1.0 Gauss)
Data Rate in Auto-send Mode	Binary: 20 transmissions/sec. ASCII: 12 transmissions/sec.
Scale stability	±0.05% FS/°C
Initial offset	<±0.005 mG
Offset vs. temp.	<0.01 mG/°C
Orthogonality of axes	better than ±0.2°
Alignment of axes with package	better than ±0.2°
Linearity	±0.05%FS
Power	55mA @ +4.95 to +9 VDC
A to D	24-bit Sigma Delta
Communications	TTL and RS232 and RS422
Baud rate (user selectable)	300, 1200, 4800, 9600, 19200, 38400, 72800
Operating temperature range	-25 to 70°C
Size	4.725" L x 1" Diameter 5.00"L x 1.0"W x 0.925"H (1540S)
I/O (1540) I/O (1540S)	Flying leads Teflon insulated #28 gauge 6" L. 9 pin miniature MDM Connector

Analog Interface (Optional)

Scale factor	3V/G
Bandwidth	100 Hz

III Mechanical Features

An outline drawing of the 1540 is shown in Fig. 2 on the next page. The system is cylindrical with a 1.0" diameter and 4.725" length. An alignment slot is present on the top surface; this slot is aligned with the –Z axis direction. The 1540 cylindrical surface defines the system X-axis. The 1540 coordinate directions are shown in Fig. 2. A magnetic field direction aligned with the axis direction arrows will produce a positive output voltage.

The 1540 is also available in an alternative rectangular package shown in Fig. 2A. This package has a 4 Pin circular bayonet (Bendix) connector for powering and data interface.

IV. Electrical Interface

The electrical interface to the 1540 system is shown in Fig. 1. Six flying leads (#26 gauge Teflon insulated) are used to make connection to the system. As an option a 9 pin MDM connector can be used to connect to the system .The pin outs for this connector are also shown in Fig. 1. The system powers from a single input voltage that can range from +4.95V to +12V.

The serial communications interface to the 1540 is provided by the serial in and serial out lines shown in Fig. 2. These two lines operate at RS232 or TTL logic levels. Use the TTL interface to communicate with an external microprocessor and the RS232 interface to communicate with an external PC using a COM port. The 1540 can optionally be configured to use a four wire RS422 serial communication protocol.

Serial communications default to a baud rate of 9600 and employ 8 data bits, one stop bit and no parity but. Additional baud rates can be selected by changing the 1540 internal byte constants as discussed in section VIII.

Fig. 1
Electrical Interface for Model 1540 Sensor

Wire Color	Function		MDM con. pin
Red	+4.95 to +12 VDC		3
Black	Ground		5
Orange	RS232 serial in	(or Y RS422)	1
Yellow	RS232 serial out	(or Z RS422)	2
Or/White	TTL serial in	(or A RS422)	4
Yel/White	TTL serial out	(or B RS422)	6
Green	X analog output	(Optional)	7
Purple	Y analog output	(Optional)	8
Grey	Z analog output	(Optional)	9

Fig. 2
1540 MAGNETOMETER

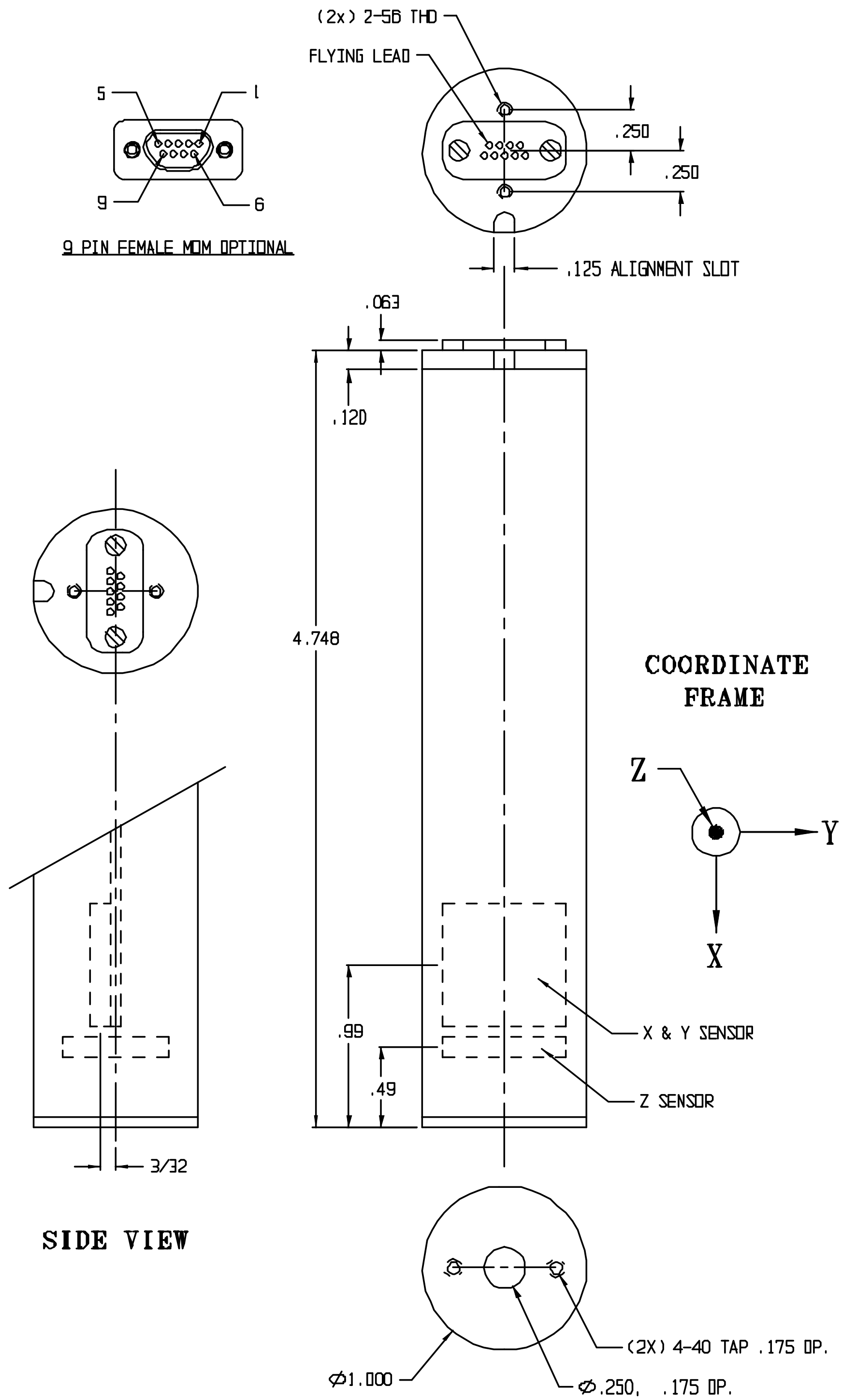
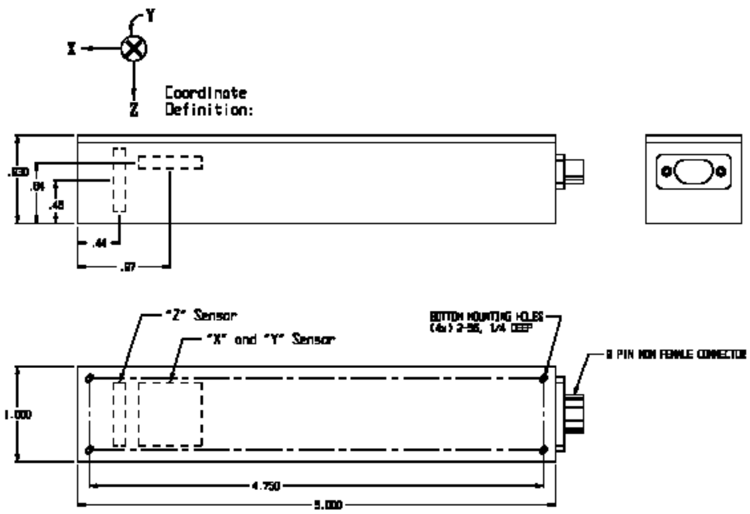


Fig. 2A
MODEL 1540S



Two communication protocols are available in the 1540: 1) ASCII and 2) BINARY. The ASCII protocol is based upon sending ASCII characters to the 1540 to obtain data. The 1540 responds by sending out an ASCII data stream complete with carriage returns and line feeds so that it can easily be displayed on a computer terminal. The binary protocol is used for high-speed computer-to-computer interchange. In this case, one byte is sent to request data (e.g. ASCII 128). The 1540 then responds with a data packet containing the desired data plus header and checksum.

The currently supported binary commands and their definitions follow:

Command	**Command Definition**
128	**send sensor data in binary format**
129	**send sensor data in IEEE 32-bit format**

The 1540 response to these commands is of the following form:

<number of data bytes> <MX><MY><MZ><MT>
<0> <DATA CHECK SUM><EOT>

Refer to the Appendix of this manual (Heading Sensor Command Set) for a more detailed discussion of the data format for binary transmissions.

V. System Startup and Checkout

5.1 SETTING UP THE 1540

The easiest way to get the 1540 operational is to connect the RS232 interface to a PC COM port.

PC COM ports employ 9-pin "D" connectors. The 1540 communication flying leads should be connected to a 9-pin PC female "D" connector as follows:

"D" Pin	1540 Wire	Function
3	Orange	serial to 1540
2	Yellow	serial from 1540
5	Black	Ground

In addition, power must be supplied to the 1540. Connect +V to the red wire and ground to the black wire. Connect a standard 9-pin COM port cable between the 1540 "D" connector and a PC COM port connector on the computer.

Apply power to the red (+) and black (ground) wires. Adjust the input voltage to a value between +5V and +12V. The 1540 uses low dropout linear regulators to produce internal working voltages of ±4.5 V so the lower the input voltage the lower the power consumed by the 1540. *Insure that the input voltage does not drop below 4.90 volts on the low end to prevent the internal regulators from dropping out.*

To communicate with the 1540, a terminal program should be run on the PC. The Windows HyperTerminal program will suffice for this. Other suitable programs are ProComm and ASCII Pro. These programs turn the computer into a dumb terminal. In this mode, whatever you type on the keyboard goes out the selected serial port (e.g. COM 1) and whatever comes in the serial port is displayed on the computer video display.

If you use HyperTerminal, you must select the proper COM port (e.g. COM 1, COM 2, etc.) and set the baud rate to be 9600 with one stop bit and no parity. Set the port up for direct connect and turn off any handshaking.

The easiest method of determining if a working communications link with the 1540 has been established is to observe the PC display when the 1540 is powered up. The 1540 will transmit a power up sign on message, which should appear in readable form on the PC display. The appearance of an unreadable message at power up may indicate incorrect baud rate selection on the computer.

5.2 STARTUP USING A TERMINAL EMULATOR PROGRAM

Connect the 1540 System to a computer (Section IV); use the RS232 interface when connecting to a PC COM port.

Start up a terminal emulator program on the PC, e.g. Windows HyperTerminal, PC Plus, etc. Configure the terminal emulator program for direct connect to an available COM port and select the baud rate 9600 with one stop bit and no parity.

Apply power to the system and check to see that the unit transmits a start up message:

APS : S/N XYZ
VER : 3.70 M24

VI. Operation of the System

After establishing communication with the 1540, data can be obtained from the system by sending (typing) the command 0SD (0 Send Data). The 0 in this sequence is the default serial number of the unit (in this case zero). After sending this command, the 1540 will respond with an output that appears as follows:

MX: -0.256349
MY: +0.012469
MZ: +0.234612
t: 45.0

The numbers following the MX, MY and MZ headers represent the sensor magnetometer output in Gauss. The temperature (°C) follows the t header.

The above outputs represent data sent when the 1540 is in sensor mode. If A/D raw count data is required the system mode will need to be changed. In general the 1540 operating characteristics are controlled by the values of internal byte constants. These constants are stored in the system EEROM and can be changed by a two-step process. The two-step process is used for security reasons to ensure that these constants are not inadvertently changed.

To change the 1540 to A/D count mode byte 02 must be changed from 02 (sensor mode) to 00 (count mode). To accomplish this type:

0l <CR>

where 0 is a zero, l is the letter "l" and <CR> is a carriage return. The unit will respond with the message:

enabled!

next, type the sequence:

0WC02b00 <CR>

The unit will respond by sending the message:

Done

Now request data by sending the sequence:

0SD <CR>

The response will look something like this:

MX: 32516310
MY: 12365121
MZ: 15236123
t: 24.3

The numbers following MX, MY and MZ represent the system A/D count outputs for the three sensor axes.

In order to observe the value of any internal system constant send the commands:

0SC02b <CR>
0SC*b <CR>

The first command results in the value of byte constant 02 being transmitted. The second command evokes a response containing the values of all byte constants.

The 1540 can transmit data in three formats: 1) ASCII standard ;2) ASCII Data Only and; 3) binary. The two ASCII transmissions are formatted to display correctly when the 1540 is connected to a PC running a terminal emulator program (e.g. PC PLUS, HyperTerminal, etc.). Binary transmissions are faster than ASCII transmissions and are more suited to interfacing the 1540 to a microprocessor system. In command node, binary transmissions are initiated by sending the single byte ASCII 128 to the 1540.

ASCII standard transmissions have the structure shown above where each data output is preceded by a data type identifier (e.g. MX:). ASCII data only outputs have the simpler structure shown as follows:

+0.2393145 +0.03288605 +0.1188259 +25.986

The first number represents the X axis output and the second the Y Axis output etc. This data output format is much easier to bring into an Excel spreadsheet in a form where graphing of the output can be easily accomplished.

To select the standard ASCII data transmission format issue the commands:

0l <CR>
0wv0<CR>

To select the data only ASCII format issue the commands:

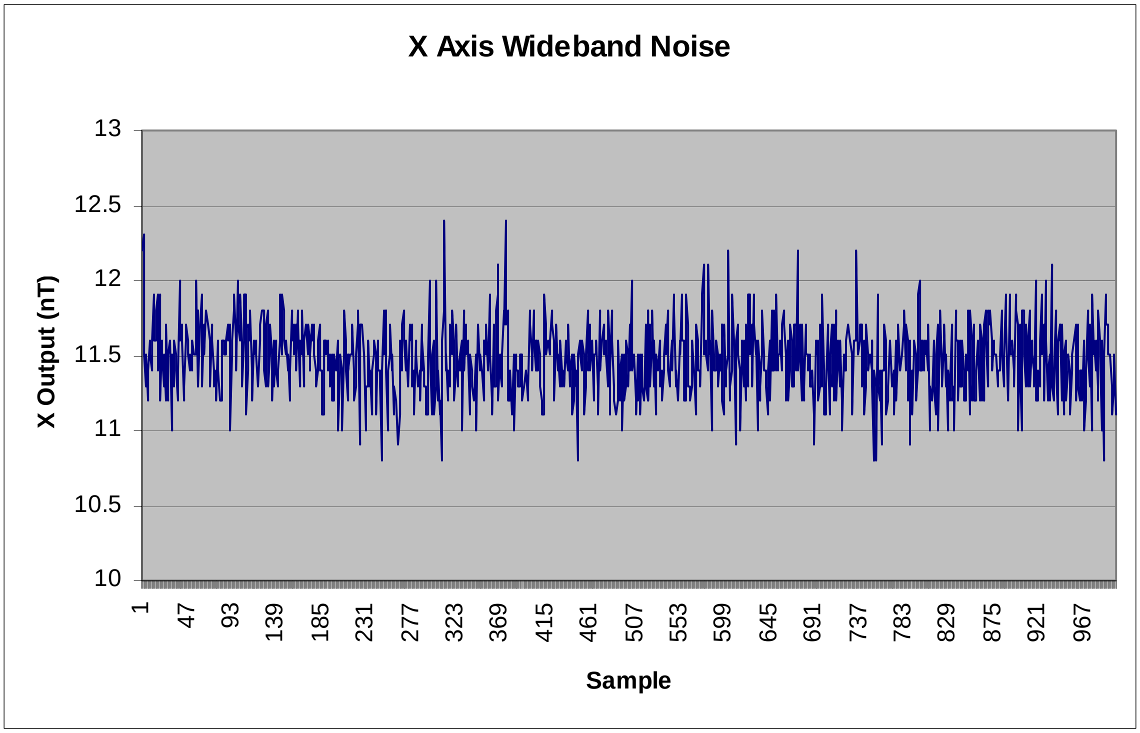
0l<CR>
0wv1<CR>

The model 1540 has an auto send mode, which enables data to automatically be sent repeatedly upon power up. Byte 01 must be set equal to 5A for auto send mode to be active. The format of the data sent in auto sends mode is determined by the value of byte 08. For repetitive text transmissions, set byte 08=10. For repetitive binary transmissions, set byte 08=11. To slow down data transmissions, set byte 35 to a non-zero value. If byte 35=40 data transmission is slowed to about one transmission per second.

After the model 1540 is operational and communicating with a computer, its proper operation can be qualitatively checked out by using it to measure the earth's magnetic field. Around the globe, the magnitude of the earth's magnetic field varies from about 0.4 Gauss to 0.6 Gauss. In the northern hemisphere, the field points north and dips into the ground (dip angle) at about 60°.

Point the X-axis generally north and down at an angle of 60° from horizontal. Verify that the X-axis reads about 0.5G and the Y and Z-axes read near zero. Repeat the measurement with the Y and Z-axes in turn pointed into the field and verify that these two axes correctly read the earth's magnetic field magnitude.

The noise level of the 1540 can be observed by placing the sensor in a magnetic shield, which typically consists of a 2-layer mu metal shield. An example of data taken using ASCII auto send mode with the 1540 positioned in a mu metal shield is shown in the following figure. Note that the noise level is about 0.005 G (0.5nT) peak to peak. This noise level can be reduced by lowering the filter value or averaging data samples (see section 8.3). The noise data taken in the figure was taken at a sample rate of 12 Samples per second. Output noise is given in the units of nT (nano Tesla). Note that 1nT=0.01G



VII. Descriptions of the System Internal Constants

The model 1540 employs two types of internal constants: 1) byte and 2) floating. Generally, the byte constants are used to configure the operating characteristics of the 1540 and the floating constants are used for system calibration. The most important byte constants and their functions follow:

Byte	Function
00	Enables echoing when non zero
01	Enables auto send when =5A
02	Enables sensor A/D count output when =0, sensor output when =02
08	Sets power on mode (e.g. =10 enables auto send in ASCII mode upon powering)
09	Baud rate lock (=5A if any baud rate other than 9600 is to used)
10	Sets baud rate
23	Specifies number of samples to be averaged
35	Enables a pause between data transmissions

Detailed descriptions of all the internal byte constants can be found in the Appendix of this manual.

The 1540 float constants can be read by issuing the command:

0SC*f

The most important floating constants and their definitions follow:

Byte	Definition
04	X magnetometer offset
05	Y magnetometer offset
06	Z magnetometer offset
10	X magnetometer scale
11	Y magnetometer scale
12	Z magnetometer scale

Floating constants 22 to 30 contain the system alignment calibration constants See the appendix for alignment constants definitions. Generally, the user should not change the system's float constants as this will change the system's calibration.

VIII. Configuring the 1540

8.1 Changing the Baud Rate

The communications baud rate can be changed by using the following sequence:

1. Set binary constant 10 according to Table 1.
2. Set binary constant 09 to 0x5a.
3. Cycle power off and on.

The following commands illustrate setting the baud rate to 2400.

```
0l<CR>
0wc10b32<CR>
0l<CR>
0wc09b5a<CR>
```

When byte constant 09 is set to any value other than 0x5a, the system baud rate is 9600.

Baud Rate	Byte 10 Value
300	0x35
1200	0x33
2400	0x32
4800	0x31
9600	0x30
19,200	0x38
38,400	0x05

Table 1. Baud Rate Settings

8.2 Configuring the 1540 for Autosend

To configure the 1540 for auto send, binary constant 01 must to be set to 0x5a and binary constant 08 needs to be set in accordance with table 2.

Auto send Mode	BINARY BYTE 08 VALUE
Send ASCII data once on power up	0x01
Send ASCII data continuously on power up	0x10
Send Binary Data Continuously on power up	0x11

Table 2. Auto Send Modes

8.3 Averaging and filtering of 1540 Output Data

Averaging of the acquired data can be enabled by setting binary constant 23 according to the table shown below. The response times shown are for in a sensor output change from 0 Gauss to 0.5 Gauss.

Binary constant 23 value	Number of averages n	Time to reach 90% of final value (seconds)
08	8	0.25
10	16	0.5
20	32	1
40	64	2

The maximum number of data samples that can be averaged is 64.
Each data output of the 1540 is a running average of the previous n data acquisitions. When a new data point is acquired, a new average is computed by dropping the oldest data point from the average and adding the new data point.

8.4 Single Packet Binary Communication Modes

In addition to an ASCII communication mode, the 1540 also has a binary communications mode. Single data packet binary communications are initiated by an external computer by the issuance of the single byte command ASCII 128. On some computers, these commands can be sent from a terminal emulator program by holding the control key down and typing the command number on the number pad on the right side of the keyboard.

The 1540, upon receiving this command responds by sending a binary data packet with on the structures described below.

Command <128>   Sends All Data in an encoded Binary Format.
The data is returned as:

<<<<Sent First <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<Sent Last<<<<

<NUM DATA BYTES>	<MX>	<MY>	<MZ>	<MT>	<V>	<DATA CHECK SUM>	<END>
8b	24b	24b	24b	16b	16b	16b	16b

<END> = 0x7FFF
<NUM DATA BYTES>= 0x0D=13 decimal
<DATA CHECK SUM>= The lower 8 bits of the sum of all the bytes in the bytes from <MX> to <0>.
<MX>, <MY>, <MZ>= The 24 bit Mag. data encoded as discussed below.
<MT>= The Temp Data encoded as discussed below.
<V>= unused with value 0x00
All Data is Sent most significant byte first.
Magnetometer Data is encoded in a three byte signed integer format as the float value times 1,000,000, e.g. 123456=0.123456 Gauss

The Temp Data is in a two byte signed integer format encoded as the float value times 100, e.g. 12345=123.45 deg. C
Each data packet consists of a total of 18 bytes.

8.5 Auto send Binary Communication Mode

The use of auto send binary communication mode results in the continuous transmission of data packets with the structure described in the previous section.
Auto send binary mode is selected by setting up the system binary constants as follows:

binary constant 08=11 selects auto send continuously
binary constant 01=5a auto send enable
binary constant 35=10 inserts a small delay between data packets (optional)

IX. WINDOWS SOFTWARE AND THE MODEL 1540 MAGNETOMETER

The purpose of the Sensor interface program is to provide a graphics interface to the magnetometer and allow the user to configure the system.

It allows each sensor to be monitored in every mode that the sensor can be programmed. Each sensor can be programmed to allow for ASCII or BINARY transfer mode and corrected or non-corrected data. Log files of sensor data can be created. A scrolling graph of the digital data and graphical indicators of the angular data are displayed to the operator. Minimum and maximum values are maintained for the magnetometer. The sensor's special features are supported.

Install the Sensor software by using the following procedure:

1. Insert the CD-ROM containing the Sensor software into the CD-ROM drive.
2. Click on "My Computer" and then the disk drive the software disk was inserted in.
3. Left click and hold on the Sensor icon and drag it to the desktop. Release mouse button. The software icon should now be on your desktop and the software ready to use.

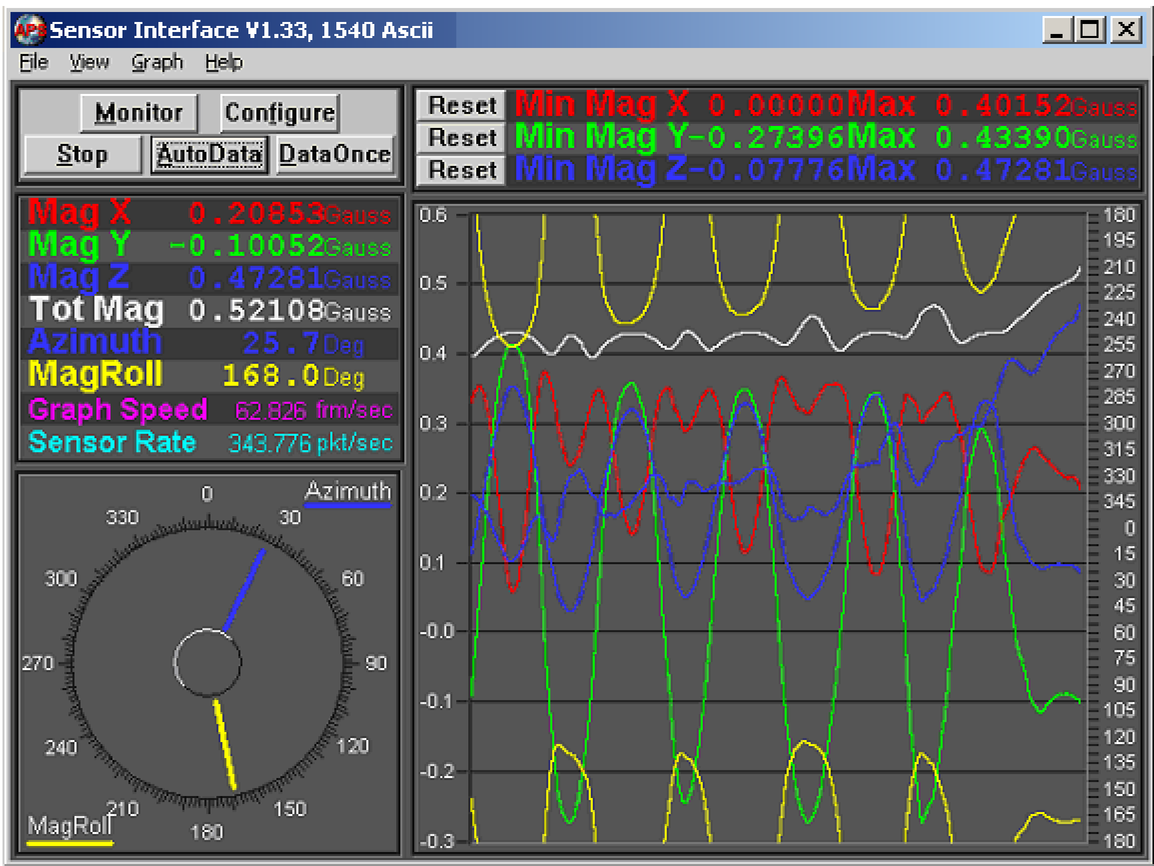


FIG. 3 MODEL 1540 MAIN DISPLAY

Fig. 3 shows the main display of the Sensor Interface Program. The upper left corner of the main window contains the command buttons. The Monitor button brings up the monitor window and the Configure button brings up the configuration window. The Stop button issues the command to the sensor to stop sending data. The Auto button issues the command to the sensor to send data repeatedly. The Once button issues the command to send the data one time.

In the View menu, each check mark before Magnetometer Min/Max or AC/DC Magnetic enables or disables the feature from appearing on the screen. In the example display, the Magnetometer Min/Max is enabled.

In the Graph menu, each check mark before Magnetic X, Y, Z, T, Mag Roll and Azimuth labels enables or disables the item to be scrolled on the graph. The color of the item on the graph matches the color of the text in the numeric display windows.

The minimum and maximum values are tracked and displayed in the upper right corner window. The values can be reset back to zero by pressing the Reset button.

The number of packets per second the sensor is receiving is displayed as Sensor Rate. This value is continually being updated and sampled.

When the Configure button is pressed the following window is displayed:

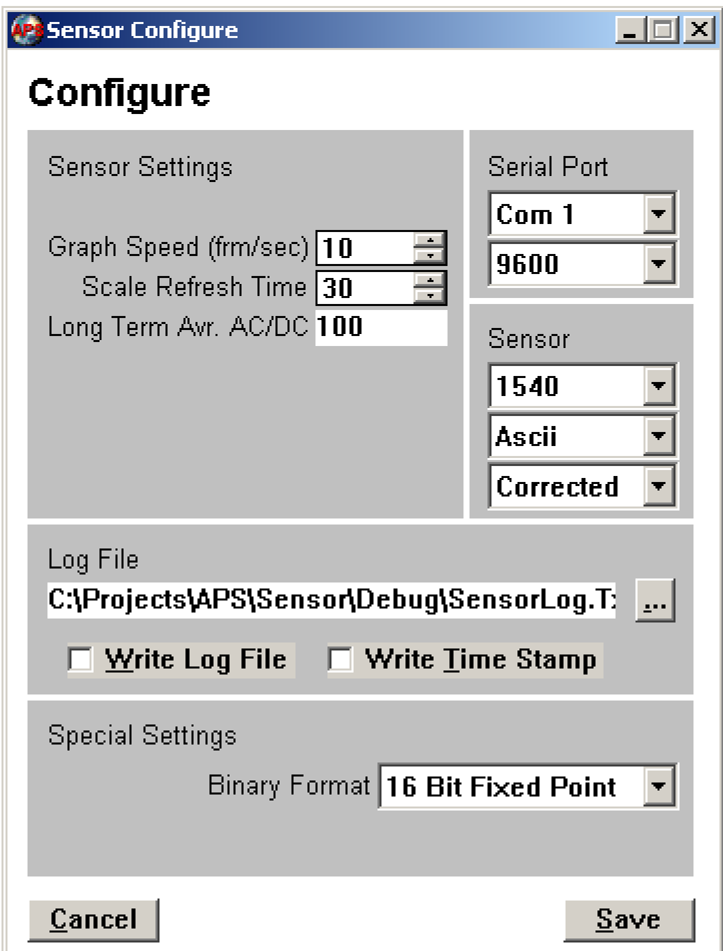


FIG. 4 SENSOR CONFIGURE WINDOW

The Graph Speed represents the maximum scrolling speed of the graph on the main window in frames per second. The PC operating system limits the maximum scrolling speed. The Scale Refresh Time sets the time at which the auto-scaling routine can decrease the scale factors on the main scrolling window. When the scrolling window scale maximum output is exceeded, it is automatically increased. To decrease the scale, Scale Refresh Timer is used. The Check Sum box allows the sensor to send a check sum with each data packet from the sensor. The Long Term Aver. AC/DC value is the number of samples of AC and DC values that are collected in order to create the AC and DC values display on the main window.

The computer serial port to be used with the 1540 may be set from Com 1 to Com 8. The default baud rate is 9600 baud. Other baud rates may be selected using this panel.

To use the 1540, the operator selects the 1540 in the top Sensor window. In the next window, below, the option for ASCII or Binary transfer may be entered. ASCII transfers may easily be viewed from the monitor window. Binary transfers are always faster. Raw data is expressed in A/D counts. Corrected data is in Gauss and has been corrected for physical misalignments, scale factors and offsets.

To save data output from the 1540, the operator may enter a logging file name. This file will capture all data sent to the program from the sensor. The type of data logged is set in the menu in the Monitor Window and can be either ASCII for Logging or Hex for Logging.

The monitor sensor window allows the operator to view the data being sent from the sensor and allows the operator to send commands to the sensor.

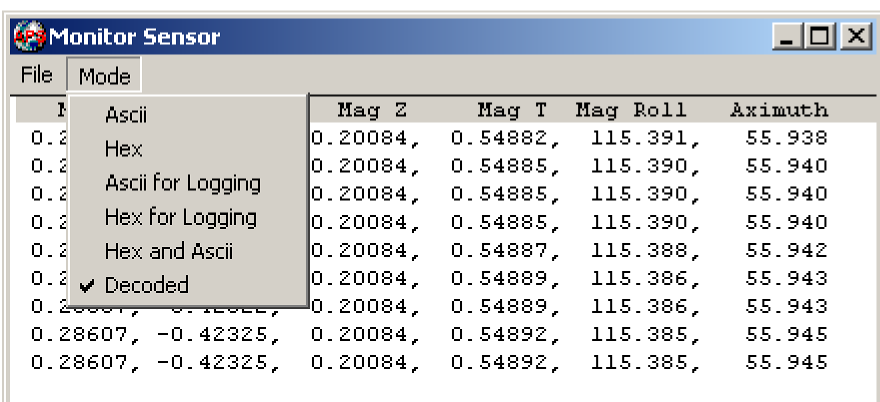


FIG. 5 MONITOR SENSOR WINDOW DISPLAY MODES

The monitor window (see Fig. 5) has a number of display modes. They are ASCII, Hex, and ASCII for Logging, Hex for Logging, Hex and ASCII, and Decoded. In ASCII mode (see Fig. 6), the monitor window acts like a simple ASCII terminal. In Hex mode (see Fig. 7), each ASCII character received is converted to the hexadecimal value that it represents, followed by a space. For example, the ASCII character ‘A’ would be printed as ‘41’, which is its hexadecimal value. ASCII for Logging and Hex for Logging are designed to be used with file logging mode. They are formatted with a <CR><LF> at the end of each line so that then can be written into a Logging file. Hex and ASCII is a mixed display with hexadecimal data on the left and the same ASCII data on the right. Decoded is a mode where only the processed data values are displayed.

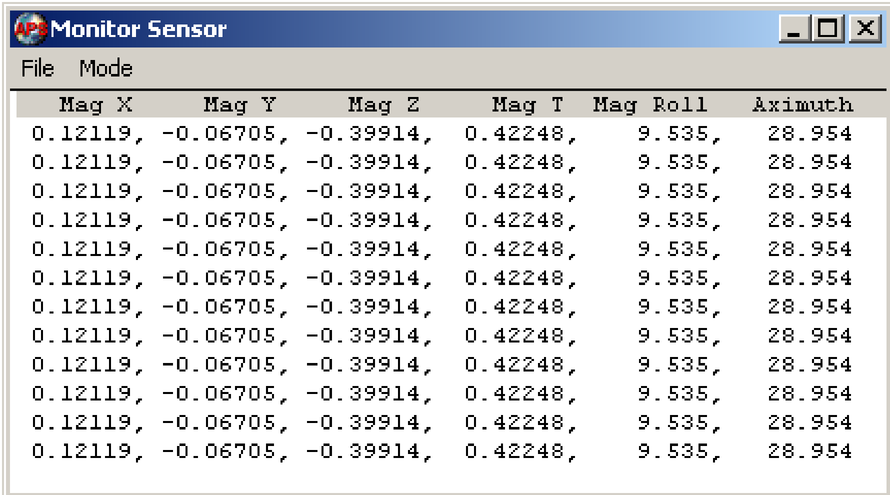


FIG. 6 MONITOR SENSOR WINDOW FOR CORRECTED ASCII MODE

Sensor commands may be entered from the monitor window. The format of the commands is defined in the Appendix of this manual.

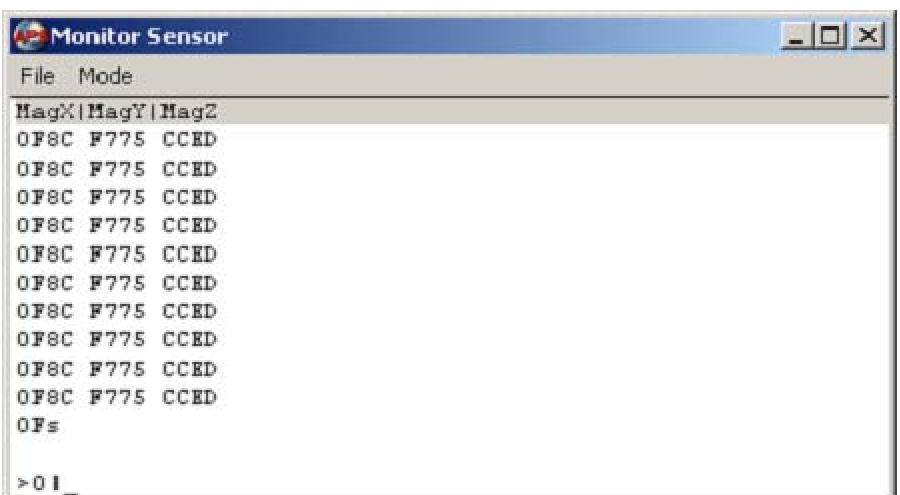


FIG. 7 MONITOR SENSOR WINDOW FOR CORRECTED HEX MODE

1540.1 Magnetometer Heading Sensor Command Set

Heading Sensor Command Set
Applied Physics Systems
V3.18DFX 1/00

Commands are always sent in the following format : <0><Command><CR>

Default address is always “0” (zero).
CR is a Carriage Return.

Commands and responses are as follows:

Send All Data 0 SD	All Data is Sent	MX:±#.##### MY:±#.##### MZ:±#.##### MT:±###.####<CR><LF>
Send Ana1 Input	0SA	ANA: #.#####<CR><LF><EOT>
Read Float Constant	0SC<Constant Number>F	±########±E##<CR><LF><EOT>
Read All Float Constants	0SC*F	00: ±########±E##<CR><LF> 01: ±########±E##<CR><LF> ... ##: ±########±E##<CR><LF><EOT>
Read Byte Constant	0SC<Constant Number>B	##<CR><LF><EOT> (In Hex)
Read All Byte Constants	0SC*B	00: ##<CR><LF> (In Hex) 01: ##<CR><LF><EOT> ... ##: ##<CR><LF><EOT>
Reset A/D	0RA	Resp: Done<CR><LF><EOT>
Test Serial Port	0TS	Always Echoes OK<CR><LF><EOT>
Return Software Version 0TV		Resp: Ver: #.###<CR><LF><EOT>
Enable Low Level Writes 0L		Resp: Enabled!<CR><LF><EOT>

Write Float To Constant*: WC<Constant Number>F<Value> Resp: Done<CR><LF><EOT>

Write Byte To Constant* : WC<Constant Number>B<number> Resp: Done<CR><LF><EOT>

Binary Commands:

<128> Send All Data as Vectors in a Binary Format.
<129> Send All Data as Vectors in a IEEE FloatFormat

If the binary command is <128> the resonse is as follows:

<<<<Sent First <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<Sent Last<<<<

<NUM DATA BYTES>	<MX>	<MY>	<MZ>	<MT>	<V>	<DATA CHECK SUM>	<END>
8b	24b	24b	24b	16b	16b	16b	16b

<END> = 0x7FFF (should be unique in the data stream)
<NUM DATA BYTES>= 0x0D=13 decimal
<DATA CHECK SUM>= The lower 8 bits of the sum of all the bytes in the bytes from <MX> to <0>.
<MX>,<MY>,<MZ>= The 24 bit Mag. data encoded as discussed below.

<MT>= The Temp Data encoded as discussed below.
<V>= unused with value 0x00

All Data is Sent most significant byte first.

Magnetometer Data is encoded in a three byte signed integer format as the float value times 1,000,000, e.g. 1234567=0.1234567Gauss

The Temp Data is in a two byte signed integer format encoded as the float value times 100, e.g. 12345=123.45 deg. C
Each data packet consists of a total of 18 bytes.

If the binary command is <129> the resonse is as follows:

<<<<Sent First <<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<Sent Last<<<<

<NUM DATA BYTES>	<MX>	<MY>	<MZ>	<MT>	<V>	<DATA CHECK SUM>
8b	32b	32b	32b	32b	32b	16b

<END> = 0x7FFF (should be unique in the data stream)
<NUM DATA BYTES>= 14= Decimal 20
<0> = a constant 0 (to allow END to be unique)
<DATA CHECK SUM>= The lower 8 bits of the sum of all the bytes in the data area.
<MX>,<MY>,<MZ> = The Mag. Data.
<MT> = The Temp Data.

All Data is Sent most significant byte first.

Float Constant Numbers and Their Meanings:

00 - Ana1 Scale
01 - Temp Scale
02 - Ana1 Offset
03 - Temp Offset
04 - Mag Base Offset X
05 - Mag Base Offset Y
06 - Mag Base Offset Z
07 - Not used
08 - Not used
09 - Not used
10 - Mag Base Scale X
11 - Mag Base Scale Y
12 - Mag Base Scale Z
13 - Not used
14 - Not used
15 - Not used
16 - Not used
17 - Not used
18 - Not used
19 - Not used
20 - Not used
21 - Not used
22 - Mag Base Ortho(X,X)
23 - Mag Base Ortho(X,Y) (Denotes X axis in the Y direction)
24 - Mag Base Ortho(X,Z)
25 - Mag Base Ortho(Y,X)
26 - Mag Base Ortho(Y,Y)
27 - Mag Base Ortho(Y,Z)
28 - Mag Base Ortho(Z,X)
29 - Mag Base Ortho(Z,Y)
30 - Mag Base Ortho(Z,Z)

Byte Constant Numbers and Their Meanings:

00 - Command Echo Flag 0 is no command echo else echo commands
01 - Autostart Flag. If 0x5A executes the selected autostart option on powerup.
02 - Correction Level 0- A/D Counts / 2- Ortho calibrated data
03 - Not used
04 - Version of the Calibration Software used
05 - Power on self test flag. If zero a self test will be done on power up.
06 - Enable All Error Messages
07 - This Sensor's Address Number 0-36 => 0-9,A-Z
08 - Auto Start Mode, On powerup start accepting commands then:

If 08=00 Send All Data in text mode once.
If 08=10 Send All Data In Binary mode once.
If 08=02 Send All Data In IEEE mode once.
If 08=10 Send All Data in text mode in a loop until AutoStart is not 0x5A.
If 08=11 Send All Data In Bin. mode in a loop until AutoStart is not 0x5A.
If 08=12 Send All Data In IEEE mode in a loop until AutoStart is not 0x5A.

09 - User power on baud rate lock (if not 0x5A sensor will use 9600 Baud).
10 - User power on baud rate. --Use With Caution--

Target Baud	Const #10	Target Baud	Const #10
75	37	1200	33
150	36	2400	32
300	35	4800	31
600	34	9600	30

11 - Not Used
12 - Lowest Calibration Temp. in counts. LSB
13 - Lowest Calibration Temp. in counts. MSB
14 - Distance in counts between Calibration Points LSB
15 - Distance in counts between Calibration Points MSB
16 - Number of Temp. Points in the SEEROM.
17 - The Table Mag Offset Scale Value. (Offset = TableOffset / 2^<Byte#18>)
18 - Not used
19 - The Table Mag Scale Scale Value. (Scale = TableScale / 2^<Byte#20>)
20 - Not used
21 - The Table Mag Ortho Scale Value. (Ortho = TableOrtho / 2^<Byte#22>)
22 - Not used
23 - Average control (2, 4, 8, 16).
24 - Product I.D. String char #1
25 - Product I.D. String char #2
26 - Product I.D. String char #3
27 - Product I.D. String char #4
28 - Product I.D. String char #5
29 - Product I.D. String char #6
30 - Product I.D. String char #7
31 - Product I.D. String char #8
32 - Product I.D. String char #9
33 - Product I.D. String char #10
34 - Constant 0
35 - RTS Delay is the time in ~2 millisecond units
40 - X bow calibration factor
41 - Y bow calibration factor
42 - Z bow calibration factor