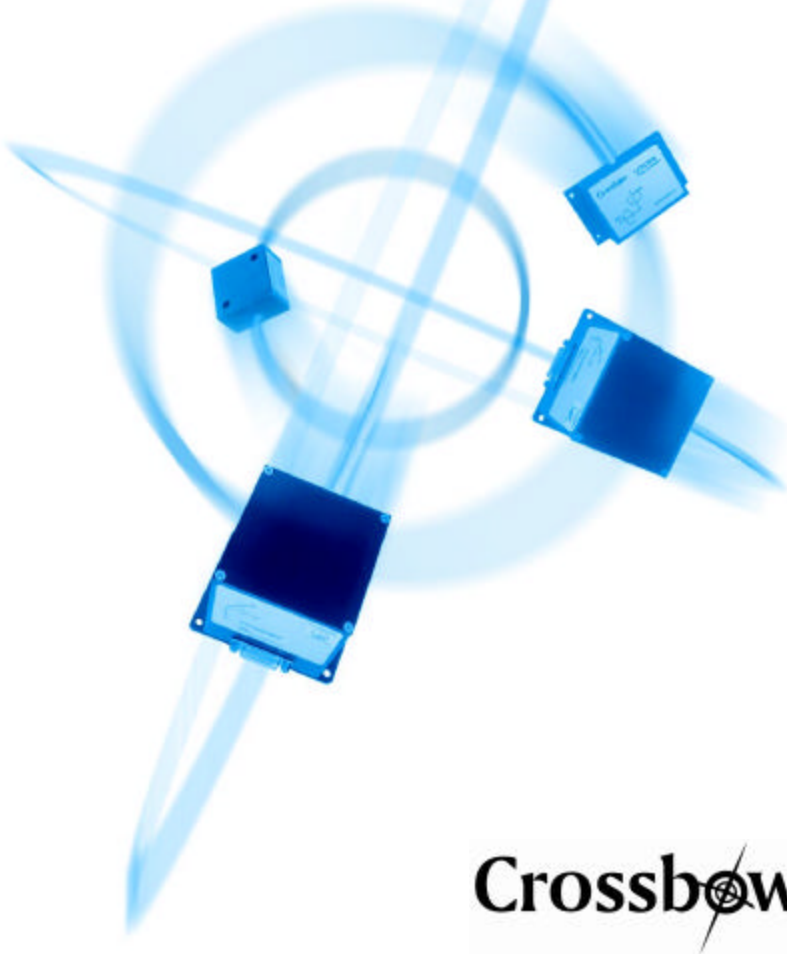
CXM539 User's Manual

High Speed Digital 3-Axis Fluxgate Magnetometer

Revision 1.2 October 2001

PN 6001-0014



Crossbow

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Table of Contents

About this Manual

The following annotations have been used to provide additional information.

NOTE

Note provides additional information about the topic.

☑ EXAMPLE

Examples are given throughout the manual to help the reader understand the terminology.

IMPORTANT

This symbol defines items that have significant meaning to the user

WARNING

The user should pay particular attention to this symbol. It means there is a chance that physical harm could happen to either the person or the equipment.

The following paragraph heading formatting is used in this manual:

1 Heading 1

1.1 Heading 2

1.1.1 Heading 3

Normal

1 Description of the System

The model CXM539 High Speed Digital 3 Axis Fluxgate Magnetometer is the first high-speed digital output 3-axis fluxgate magnetometer to be commercially available. The system can convert and transmit over its serial port (at 38400 baud) all three axes outputs at a rate of 250 samples per second. Slower data rates can also be selected; transmission rate and baud rates are user programmable. The CXM539 uses 3 separate 16-bit sigma delta analog to digital (A to D) converters to achieve the high throughput. The scale factor is set so that a full scale input of 10^{-4} T (1 G) represents 32768 counts on the system A to D converters. The least count represents about 3 nT. Noise of the system is 1 - 2 counts.

The CXM539 system is ideally suited to situations where high speed magnetic data must be acquired and analyzed. In the past, such systems have normally used a combination of an analog output fluxgate and an A to D board in a PC. The CXM539 simplifies and reduces the cost of the magnetic data acquisition system by eliminating the cumbersome A to D board.

The CXM539 can be used in either a command mode or autosend mode. In the command mode, the CXM539 responds to commands to transmit data issued by an external computer. In the autosend mode, the CXM539 commences sending data as soon as power is applied to the unit.

The CXM539 can be supplied with an optional connector box, which allows easy powering and connection to an external computer.

2 System Specifications

Accuracy	±0.1 μT (±1 mGauss)
Noise level	±0.003 μT (±0.03 mGauss)
Range	±100 μT (±1 Gauss)
Scale stability	±.05% FS/°C
Initial offset	<±200 nT (±2 mG)
Offset vs. temp	<5 nT/°C (<0.05 mG)
Orthogonality of axes	better than ±0.5°
Alignment of axes with package	better than ±0.5°
Linearity	±0.1% full scale
Maximum data transfer speed(38,400 baud)	250 - 3 - axis samples/sec
Power	100 ma @ +6 to +15 VDC
A to D	3 - 16 bit Sigma Delta
Baud rate (user selectable)	300, 1200, 2400, 4800, 9600, 19200, 38400, 72800
Temperature range	-25 to 70°C
Size	1.60"W x 4.08"L x 1.13"H 4 cm x 10.4 cm x 2.9 cm
Connector	9 pin nonmagnetic "D" (female)

3 Electrical and Mechanical Interface

The CXM539 is powered from a single input voltage that can range between +6 V and +15 V. Current consumption is 100 ma. Two serial interfaces are present; one that uses RS-232 levels and one that uses TTL levels. The baud rate is user programmable and can be set at the following values: 300, 1200, 2400, 4800, 9600, 19200, 38400, and 72800. The data words employ 8 bits with one stop bit and no parity.

A female 9 pin D connector is used to provide an electrical interface to the CXM539 system. The Pin out of this connector is as follows:

Pin	Function
1	not used
2	RS 232 out
3	RS 232 in
4	not used
5	ground
6	TTL serial out
7	TTL serial in
8	configure
9	+ V in (+7.5 V to +15 V)

A drawing showing the dimensions and mounting hole design of the CXM539 is shown below in Fig. 1.

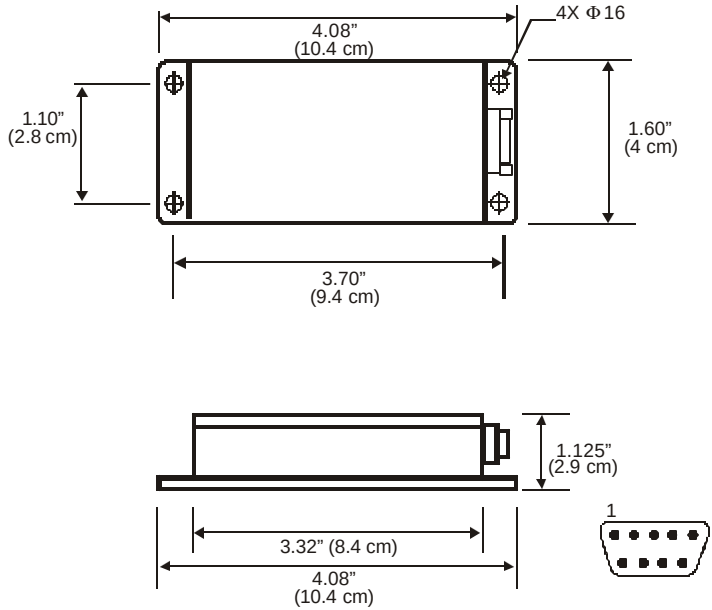

Fig. 1 CXM539 High Speed Digital 3 Axis Fluxgate Magnetometer

4 System Startup and Checkout

4.1 Startup Using a Terminal Emulator Program

Connect the CXM539 to the connection box using the supplied ribbon cable (use 9 pin male on connection box). Connect a cable from a serial port on a PC to the connection box (use 9 pin female on connection box). Select the AUTO option on the connection box switch. This connects pin 1 (CD) of the 9 pin serial interface connector to the configure port on the CXM539. Note that on the 9 pin computer connector, pins 1, 4 and 6 are shorted and pins 7 and 8 are shorted). Connect a power supply (+7.5 V to +15 V) to the red (positive) and black banana plug on the connection box.

Alternatively, according to the I/O pin functions described in Chapter 3, use the RS-232 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. On the electrical interface to the system ground pin 8; this will put the system in configure mode and assure that the baud rate is 9600 baud. If a connection box is used, select the "config" option on the connector box switch.

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

APS 539 V1.12 Config. Mode

The system can now be configured for operation in various modes as described in Appendix A by issuing commands over the serial interface.

After configuring the CXM539 system, ungrounded pin 8. If a connector box is used, select the "Run" option in the connector box switch. In run mode, the CXM539 sign on message sent at power on is

APS 539 V1.12.

In run mode, most of the CXM539 parameters, e.g. baud rate, sample rate, etc. can be set by the user. The main differences between the system operation in run and configure mode are as follows:

1. The CXM539 can only be calibrated in config mode (by issuing the l command). The unit is always factory calibrated and recalibration by the user is not normally required.
2. The unit always starts in the (known) baud rate of 9600 baud.
3. The unit always starts in command mode (as opposed to autosend mode).
4. The data output format is selected to be A to D count mode.

The main functions of the config mode are to assure that the CXM539 communicates using a known baud rate (9600) and to enable calibration of the system.

WARNING

Always operate the CXM539 in run mode (when using a terminal program) unless the baud rate setting of the unit is unknown or calibration of the unit is required. The output of the CXM539 in the calibrated mode (M=C) is only valid in the run and auto modes.

4.2 System Checkout

After the CXM539 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 axis is 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.

If a terminal program is used before checking the system operation, ensure that the following commands are given:

M = T <CR> <LF>
M = C <CR><LF>
A <CR> <LF>

These commands set the transmission mode to be autosend calibrated text. After issuing the A command, the terminal output will display the continuous output from the CXM539. Orient the system in the earth's magnetic field to verify proper operation as discussed above.

5 CXM539 Configuration Options and Data Output Formats

The user can configure the CXM539 system in the following ways:

1. Mode
2. Autosend or command
3. Baud rate
4. Pacing

The mode settings are used to change the format of the data output. The user can select the data output to be raw A/D counts (M=R) or calibrated (in Gauss) (M =C) data. The serial output format can be selected to be text (M=T) or binary (M=B). The user can also choose whether to append a checksum to the transmission (M=E) or omit this (M=N).

Some examples of different data output formats and the commands used to create them are as follows:

Commands to set up	**Data Formats**
M=T	Raw data in a text hex format without a checksum:
M=R	X Y Z
M=N	1234 5678 9ABC <CR><LF>
	The X,Y,& Z values are encoded as four digit hex values separated from each other with a single space. The last digit of the Z data is followed by a carriage and a line feed.
M=T	Raw data in a text hex format with a checksum (cs):
M=R	X Y Z cs
M=E	1234 5678 9ABC 4E <CR><LF>
	This just like the last example except for an addition of a space and a two digit checksum in Hex between the last digit of Z and the carriage return. The checksum is composed of the sum of all of the digits in the X,Y,& Z data values.

M=T	Corrected data in a text decimal format without a checksum:
M=C	X Y Z
M=N	0.23456 0.78900 0.23997 <CR><LF>
	The X,Y,& Z values are encoded as decimal values in Gauss. Each is separated from the next with a single space. The last digit of the Z data is followed by a carriage return and a line feed.
M=T	Corrected data in a text decimal format with a checksum:
M=C	X Y Z cs
M=E	0.23456 0.78900 0.23997 4C <CR><LF>
	This is just like the last example except for an addition of a space and the two-digit checksum in Hex between the last digit of Z and the carriage return. The checksum is composed of the sum of all of the digits in the X,Y,& Z data values.

M=B	Raw Data in a binary format without a checksum:
M=R	X Y Z SB
M=N	12 34 56 78 9A BC 5A <CR> <LF>
	The X,Y,& Z values are each encoded as a two byte value. The X, Y, Z data is followed by a constant synchronization byte (SB) of 5A.

M=B	Raw data in a binary format with a checksum:
M=R	X Y Z cs SB
M=E	12 34 56 78 9A BC AE 5A <CR><LF>

IMPORTANT

When in Binary mode, the X, Y & Z values for magnetometer data are encoded as a signed integer, 2's complement, with a conversion factor of

$$M_x \text{ or } M_y \text{ or } M_z = \frac{(MSB * 256 + LSB)}{2^{15}} \text{ in Gauss}$$

This is followed by a checksum consisting of the lower eight bits of the sum of the bytes comp rising the X, Y & Z Data and calculated as

$$Checksum = \left| \frac{sum\ of\ \ all\ bytes\ except\ checksum\ and\ 5A}{256} \right|$$

This is followed by a synchronization byte of 5 A, which represents the end of the data packet.

To determine the mode of a CXM539, issue the command M?

The autosend command (A) enables data to be sent continuously upon power on. The output rate of the sent data is set by the pacing variable, which can vary from 0000 (full speed) to FFFF (very slow). Pacing values are set by commands of the form:

P = XXXX <CR><LF>

The filter value for A/D can be set and the data rate can be accordingly changed by,

F = XXXX <CR><LF>

Different filter values and corresponding data rates, resolution and frequency are provided in Appendix B.

The user can set the baud rate of the CXM539 to the standard values from 300 to 76800 baud. The baud rate command is of the form:

B = XXXX <CR><LF>

A complete list of the CXM539 commands can be found in Appendix A.

6 Appendix A. CXM539 command spec

6.1 Main Commands (available in all modes)

All Commands Must be followed by a return.
All changes to the mode value are saved as the power-up mode.

M?	Send the current mode value.
M=R	All Data is Sent as raw A/D Counts in ASCII four digit Hex values or Binary Values depending on the current mode.
M=C	All Data is Sent as Gammas, Formatted as base Ten fixed point Text or Binary Values depending on the current mode.
M=B	Set Data is Formatted as Binary Numbers.
M=T	Set Data is Formatted as Text Numbers.
M=E	Send a checksum with all Data.
M=N	Don't Send a checksum.
A	Start Auto Send Data.
S	Stop Auto Send.
D	Send the current Data Value.
B?	Send the run mode Baud Rate.
B=#####	Set Run Mode Baud Rate 300 - 76800 Baud is accepted. In Config Mode the baud rate is always 9600.
P?	Display the current pacing value.
P=####	Set a Pacing value to slow the data rate.
E?	Send All EEROM Data.
E####	Send EEROM Data followed by 4 hex digits address and optional 2 digits representing the number of bytes to send.
W####XX	Write EEROM Data followed by a 4 hex digit address and 2 hex digits of Data.
C	Reset and Calibrate A/D(s).
I	Send ID and many internal values.
*	Reset and Restart Sensor.
?	Display Help.

6.2 Calibration Commands (only available in config mode)

L Unlock Calibration Mode (This command is only available in config. mode)

O Zero All the Sensors for cal. (available only after executing L)

X +1/2 Gauss X Field Applied for cal. (available only after executing L)

Y +1/2 Gauss Y Field Applied for cal. (available only after executing L)

Z +1/2 Gauss Z Field Applied for cal. (available only after executing L)

Q -1/2 Gauss Applied Field Delta for cal. (available only after executing L)

6.3 EEROM Map

For all EEROM constants the least significant byte is stored in the lowest address and the most the most significant byte is stored in the highest address.

00 Not Used

01 CPU Clock Speed Divisor

1-7 Clock Divisor

8- 0=Run at Full clock speed 1=Enable clock division

CPU Speed = 4.9152 MHz/(129-ClockDivisor)

This used to allow the use of lower UART baud rates and Lower power consumption.

For example 300 baud could be used with the Clock Divisor set to 125 to divide the clock rate by 4 and the baud rate control register set to 255.

02 Operating Mode

1- Send Corrected Data.

2- Autosend Data until Stop autosend command received.

3- Send Data Only Once (On power up or single data by command)

4- Send Data in a Text Format

5- Send Data in a decimal format (Only checked if in Text format)

6- Calibration Mode 000 - Run Mode 001 - Unlocked 010 - Zero Mode

7- Calibration Mode 011 - XField 100 - YField 101 - ZField

8- Calibration Mode 110 - Field Delta

03 More Operating Mode

1- Send Check Sum with Data

2- Not Used

3- Not Used

4- Not Used

5- Not Used

6- Not Used

7- Not Used

8- Not Used

04 Baud Rate Control

BaudRate = 4.9152Mhz / 16*(BaudRateControl+1)

Values for Common Baud Rates with no clock dividing:

1200: 255(FFH) 19200: 31(1FH)

2400: 127(7FH) 38400: 7(7H)

9600: 63(3FH) 76800: 3(3H)

05 Not Used

06-07 Soft Offset X

08-09 Soft Offset Y

0A-0B Soft Offset Z

0C-0D Soft Scale X

0E-0F Soft Scale Y

10-11 Soft Scale Z

12-13 Soft Ortho XY

14-15 Soft Ortho XZ

16-17 Soft Ortho YX

18-19 Soft Ortho YZ

1A-1B Soft Ortho ZX

1C-1D Soft Ortho ZY

1E-1F Pacing Value
30-32 A/D Offset Calibration 0 Set When the A/D is Calibrated
33-35 A/D Gain Calibration 0 Set When the A/D is Calibrated
36-38 A/D Offset Calibration 1 Set When the A/D is Calibrated
39-3B A/D Gain Calibration 1 Set When the A/D is Calibrated
3C-3E A/D Offset Calibration 2 Set When the A/D is Calibrated
3F-41 A/D Gain Calibration 2 Set When the A/D is Calibrated
42-43 Filter Settings (Set for Data Rate Vs Data Noise)

01- FAST Mode Enabled
02- Skip Mode Enabled
03- Chop Mode Enabled
04- Must Be 0
05-16- 12 bit Sync Filter

6.4 Software Data Correction Equations

Xout = ((((Xin + XOffset) * XScale)/32768)+
((((Yin + YOffset) * YScale)/32768) * YOrtho)+
((((Zin + ZOffset) * ZScale)/32768) * ZOrtho))/65536
Yout = ((((Yin + YOffset) * YScale)/32768)+
((((Xin + XOffset) * XScale)/32768) * XOrtho)+
((((Zin + ZOffset) * ZScale)/32768) * ZOrtho))/65536
Zout = ((((Zin + ZOffset) * ZScale)/32768)+
((((Xin + XOffset) * XScale)/32768) * XOrtho)+
((((Yin + YOffset) * YScale)/32768) * YOrtho))/65536

7 Appendix B. Filter Values and Data Rates

A table containing some filter values and corresponding data rates, resolution and frequency tested on CXM539 at 38.4K baud is provided below.

Filter Value	Text Data rate (/sec)	Binary Data rate (/sec)	Raw Binary data rate (/sec)	A/D Sample rate (/sec)	A/D Resolution in bits	-3db Frequency (Hz)
8000	150	150	150	150	17.5	39.3
6000	200	200	200	200	17	52.4
4000	240	300	300	300	17	78.6
3000	240	370	400	400	16.5	104.8
2000	240	370	548	600	16.5	157
1800	240	370	548	800	16	209
1000	240	370	548	1200	15.5	314
900	240	370	548	1600	15	419.2
800	240	370	548	2400	14	629
600	240	370	548	3200	13	838.4
400	240	370	548	4800	12	1260
300	240	370	548	6400	11	1676

NOTE

For the text data (hex data was sent), the data sample length was 16 bytes and hence the baud rate will limit the data rate to 240 samples/sec.

For binary data, the data sample length was 7 bytes and hence the baud rate will limit the data rate to 548 samples/sec.

8 Appendix C. Warranty and Support Information

8.1 Customer Service

As a Crossbow Technology customer you have access to product support services, which include:

- Single-point return service
- Web-based support service
- Same day troubleshooting assistance
- Worldwide Crossbow representation
- Onsite and factory training available
- Preventative maintenance and repair programs
- Installation assistance available

8.2 Contact Directory

United States:	Phone:	1-408-965-3300 (7 AM to 7 PM PST)
	Fax:	1-408-324-4840 (24 hours)
	Email:	techsupport@xbow.com
Non-U.S.:	refer to website	www.xbow.com

8.3 Return Procedure

8.3.1 Authorization

Before returning any equipment, please contact Crossbow to obtain a Returned Material Authorization number (RMA).

Be ready to provide the following information when requesting a RMA:

- Name
- Address
- Telephone, Fax, Email
- Equipment Model Number
- Equipment Serial Number
- Installation Date
- Failure Date
- Fault Description

8.3.2 Identification and Protection

If the equipment is to be shipped to Crossbow for service or repair, please attach a tag TO THE EQUIPMENT, as well as the shipping container(s), identifying the owner. Also indicate the service or repair required, the problems encountered, and other information considered valuable to the service facility such as the list of information provided to request the RMA number.

Place the equipment in the original shipping container(s), making sure there is adequate packing around all sides of the equipment. If the original shipping containers were discarded, use heavy boxes with adequate padding and protection.

8.3.3 Sealing the Container

Seal the shipping container(s) with heavy tape or metal bands strong enough to handle the weight of the equipment and the container.

8.3.4 Marking

Please write the words, "***FRAGILE, DELICATE INSTRUMENT***" in several places on the outside of the shipping container(s). In all correspondence, please refer to the equipment by the model number, the serial number, and the RMA number.

8.3.5 Return Shipping Address

Use the following address for all returned products:

Crossbow Technology, Inc.
41 E. Daggett Drive
San Jose, CA 95134
Attn: RMA Number (XXXXXX)

8.4 Warranty

The Crossbow product warranty is one year from date of shipment.

Crossbow Technology, Inc.
41 E. Daggett Drive
San Jose, CA 95134
Phone: 408.965.3300
Fax: 408.324.4840
Email: info@xbow.com
Website: www.xbow.com

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