

EZ-COMPASS-4

APPLICATION MANUAL

Feb-12-2015

Limited Warranty:

The seller warrants that its product will be free of defect in material and workmanship for a period of ninety (90) days from date of shipment thereof. Within the warranty period the seller will, at its option, either repair or replace such product which is determined by the seller to be defective and which is returned with shipping charges prepaid. This warranty will not apply to any product which has been subjected to misuse, negligence or accident; or misapplied; or modified or repaired by unauthorized persons; or improperly installed; or altered in any way. This warranty is not applicable to resale products.

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ADVANCED ORIENTATION SYSTEMS, Inc.

2525 Brunswick Ave, Suite 205, Linden NJ 07036, USA.

Tel: 908-474-9595 Fax: 908-474-9090

e-mail: sales@aositilt.com site: www.aositilt.com

EZ-COMPASS-4

**Tilt / Temperature Compensated
Compass Magnetometer**

WARNING: EZ-COMPASS-4 is equipped with an active code protection routine. Any unauthorized attempt to read, print or corrupt the EZ-COMPASS-4 internal software will immediately result in its total and unrecoverable removal, and will void the warranty.

This Application Manual presents the basic compass specifications, information on how to use the EZ-COMPASS-4 and its communication commands.

EZ-COMPASS-4 is a solid state low cost advanced pitch/roll compensated COMPASS / MAGNETOMETER system which is built around a state of the art ARM CORTEX microcontroller utilizing AOSI's proprietary algorithm and is available in four versions (General purpose, Geophysical Vertical, Geophysical Probe and DIVE). Tuned IIR filter filters gray noise and permits faster data transfer to the serial port. All versions output continuous heading, field, dual axis tilt and temperature data over the standard USB, TTL RS-232, RS-485 or RS-422 interfaces. The AZIMUTH is generated from a 3 axis solid state magnetometer with 12 bit (0.08 deg) resolution. The LINEAR tilt information is available with 12 bit resolution for up to +-180 arcdeg. The COMPASS-4 is able to output heading information in NMEA-0183 mode. Easy link via the Hyper Terminal Windows accessory facilitates custom calibration, hard iron compensation, soft iron calibration, data acquisition, data averaging and data display. Demo software is provided gratis.

EZ-COMPASS-4 COMPASS/TILT module is perfectly suitable for measurement and control in numerous navigation, marine, drilling, research, training, construction, entertainment and other precision orientation and leveling applications. EZ-COMPASS-4 is considered a logical replacement for FLUX GATE compasses.

Common notations: All EZ-COMPASS-4 commands are NOT case sensitive. All commands must end with a <CR>.

EZ-COMPASS-4 can operate in four distinct modes:

1. Main mode or TTCM (Tilt/Temperature/Compass/Magnetics mode)
2. NMEA-0183 multi output mode
3. DEBUG / CALIBRATION mode (password protected)
4. Remote serial LCD mode (installed on special orders)

EZ-COMPASS-4 GENERAL SPECIFICATIONS

AZIMUTH RANGE	---	0 -- 360	deg, continuous
PITCH RANGE	---	-90 to +90	arcdeg, continuous *
ROLL RANGE	---	-180 to +180	arcdeg, continuous *
AZIMUTH RESOLUTION	---	12 (0.08)	bits (degrees)
TILT RESOLUTION	---	12	bits, full scale, both axis
AZIMUTH ACCURACY	---	<0.5	deg, typical horizontally (with soft iron cal)
TILT REPEATABILITY	---	<0.05	arcdeg, typical
MAGNETIC FIELD	---	+4	Gauss, maximum
MAGNETIC RESOLUTION	---	<1	mGauss
SUPPLY REQUIRED	---	7-15Vdc	power (RS-422/RS-485 ports)
SUPPLY REQUIRED	---	7-15Vdc	power (TTL RS-232 in/out signals)
SUPPLY NOT REQUIRED	---	USB	port powered
CURRENT DRAW "ON"	---	45mA	during operation (nominal)
TEMPERATURE	---	-40 ⁰ to +85 ⁰	degC, operational
TEMPERATURE	---	-55 ⁰ to +125 ⁰	degC, storage
WEIGHT	---	<10	grams
CALIBRATION	---	EEPROM	non-volatile
COMMUNICATION	---	900 -- 115200	baud (8 bit, No parity, 1 stop, No flow)
OUTPUT FORMATS	---	serial	USB, TTL RS-232, RS-422, RS-485
UPDATE RATE	---	10	times/sec valid data
UPDATE MODES	---	2	continuous and on-demand
UPDATE TYPES	---	programmable	scan delay, filter and dumping factor
NMEA-0183 mode	---	5 sentences	continuous and on-demand
SIZE	---	LxWxH	2" x 0.9" x 0.25"
WEIGHT	---	5 gr	grams

* linear correction calibration is available

NOTE: *The distortion in all the three magnetic axis without change in tilt suggests the presence of ferromagnetic material and should be carefully corrected with accustom software filter.*

IT IS RECOMMENDED TO TEST THE PERFORMANCE OF THE COMPASS UPON RECEIPT WITHOUT ANY ADDITIONAL HARD OR SOFT IRON COMPENSATION. IF THE RESPONSE OF THE COMPASS IS NOT LINEAR, HARD IRON COMPENSATION IS RECOMMENDED. IF THE NEW PERFORMANCE IS STILL NOT SATISFACTORY, THEN THE LOCAL SOFT IRON COMPENSATION SHOULD BE PERFORMED. GENERALLY THE COMPASS WILL OPERATE WITHOUT ANY ADDITIONAL COMPENSATION.

With questions or comments on the operation of this or any other AOSI product please contact AOSI at:

Tel: 908-474-9595

e-mail: sales@aositilt.com

Fax: 908-474-9090

Web site: www.aositilt.com

COMMANDS:

NOT case sensitive and must end with <CR>.

<u>COMMAND</u>	<u>ARGUMENT</u>	<u>DESCRIPTION</u>
help	<CR>	prints all user commands
ver	<CR>	prints version number on the screen
reboot	<CR>	Restart (* must restart Hyperterminal)
ax	<CR>	Restart (* must restart Hyperterminal)
baudrate	[# rate]	set baud rate [19200 default]
#	[1=RS232 3=RS422]	port select designator
go	<CR>	sets temporary continuous mode
auto	[on/off]	Continuous output ON / OFF
cont	[e/d]	Continuous output enable/disable
lcd	[on/off]	Continuous LCD ON/OFF (restricted)
nmea	[a/b/c/d/e]	Set NMEA [x] ON for continuous mode
nmea	[off]	cancel NMEA mode
hardiron	[cal/on/3D/off]	calibrate/activate hard iron calibration
softiron	[a/b/on/off]	select/calibrate/activate soft iron calibration
lincal	[r/p/on/off]	calibrate/select/activate linear correction
zero	<CR>	zero both pitch and roll only
zero	[r/p/c] [off]	individually set/deactivate local ZERO
zero	[h] [h off]	set/cancel retainable Hardiron zero
print	rptxyzcad	Select variables for display
comma	[on/off]	COMMA delimiter in output string
refresh	0.1 to 600sec	Select display refresh rate
filter	[1 to 50]	Select filtering coefficient, default 10
dev	[+-value]	Set deviation value in degrees
var	[+-value]	Set variation value in degrees
dev	<CR>	show deviation (deg), PC mode only
var	<CR>	show variation (deg), PC mode only
debug	[on/off]	enter debug mode (restricted)
s?	Single scan update	selected values, PC mode only
c?	Show Compass	direction (deg), PC mode only
m?	Show Magnetometer	mag. Field (mG), PC mode only
r?	Show Roll	roll angle (arcdeg), PC mode only
p?	Show Pitch	pitch angle (arcdeg), PC mode only
d?	Show Drill	hole direction & tilt, PC mode only
t?	Show Temperature	temperature (deg C), PC mode only
zero ?	Show Zero	print all zero offsets
banner1	[20chr]	set first line for LCD option only
banner2	[20chr]	set second line for LCD option only
\$TNHCQ,	NMEA QUERY	see 5 NMEA query sentences

Definitions:

MAGNETIC heading is a heading value that is already corrected for hard /soft iron.

TRUE heading is a heading obtained by adding var value to the calculated Magnetic heading.

- The deviation is a difference between the actual raw magnetic direction and the direction calculated after hard iron/soft iron compensation. In case dev is inputted , it will be added to the measured magnetic heading for display. Upon each powerup dev is reset to ZERO.
- Variation is inputted at any time by the external instrument var=xx.xx. Upon powerup variation is reset to ZERO.

NMEA MODE:

All heading readings in mode a, b, c, d, e and f are magnetic

Heading True: In the heading field, the variation is null if variation has not been programmed. If deviation has not been programmed, it is assumed to be zero, otherwise it is added to measured magnetic heading and variation to express true heading.

SIX NMEA query commands:

\$TNHCQ,HDM*58<CR><LF>	The answer is line “a” below.
\$TNHCQ,HDT*34<CR><LF>	The answer is line “b” below.
\$TNHCQ,HDG*27<CR><LF>	The answer is line “c” below.
\$TNHCQ,HPR*78<CR><LF>	The answer is line “d” below.
\$TNHCQ,XDR*22<CR><LF>	The answer is line “e” below.
\$TNHCQ,XPR*36<CR><LF>	The answer is line “f” below.

Output formats:

a. Magnetic heading: \$HCHDM,<compass>,M*checksum<CR><LF>

<compass> is calculated value after hard/soft iron or dev and zero command

=====
b. Heading True: \$HCHDT,<xxx.x>,T,*shecksum<CR><LF>

<compass> is calculated value after hard/soft iron or dev, +var and zero command

=====
c. Head,dev,var:

\$HCHDG<compass>,<deviation>,q,<variation>,j,*checksum<CR><LF>

<compass> is calculated value after hard/soft iron or dev and zero command

q is E if <deviation> is positive, W if <deviation> is negative

j is E if <variation> is positive, W if <variation> is negative

=====

d. Head,Pitch,Roll: \$HCHPR,<heading>,<pitch>,<roll>,*checksum<CR><LF>

<compass> is calculated value after hard/soft iron or dev and zero command
<pitch> is pitch angle, <roll> is roll angle

=====

e. Temp,Pitch,Roll:

\$HCXDR,A,<pitch>,D,PITCH,A,<roll>,D,ROLL,C,<temp>,C,*checksum<CR><LF>

<temp> is temperature in degC, <pitch> is pitch angle, <roll> is roll angle

=====

f. Head,Pitch,Roll: \$HCXPR,<heading>,<-pitch>,<-roll>,*checksum<CR><LF>

<compass> is calculated value after hard/soft iron or dev and zero command
<-pitch> is negative pitch angle, <-roll> is negative roll angle

STANDARD NON USB WIRING

JP4	TTL output	RS-232	Rider PCB	RS232 ADAPTER	JP2	RS-422	485
Pin 1	----	Tx		Tx	Pin 1	----	Tx+ 485
Pin 2	----	Rx		Rx	Pin 2	----	Tx- 485
Pin 3	----	6-15Vdc		6-15Vdc	Pin 3	----	Rx+
Pin 4	----	GND		GND	Pin 4	----	GND
					Pin 5	----	Rx-
					Pin 6	----	7-15Vdc

For RS485 special wiring contact AOSI for special instructions.

For special orders / enclosure wiring please refer to GENERAL NOTES section at the end of this manual.

GENERAL COMMUNICATION NOTES

Before running the compass for the first time with your PC via USB port you are required to:

1. Plug in the cable into the USB port in your computer.
2. Plug in the MICRO USB connector into the compass
3. Direct the computer to install the USB driver from the CD drive
4. After driver installation is complete disconnect the compass from PC
5. After 5 sec reconnect the compass to PC via USB port
6. Select the Hyper Terminal mode from the Accessories menu
7. Create a link and an icon named “ compass4 “
8. Set the communication for the new com”X” X is new port number.
9. Configure for 19200 baud, 8 bits, No parity, 1 stop bit, No flow control.

After the identification is displayed, the compass is ready for local calibration.

HARD IRON CALIBRATION THEORY:

The EZ-COMPASS-4 includes active Hard Iron compensation, which removes the influence of constant magnetic anomalies located in the proximity of the compass. It is not possible to compensate for variable magnetic sources, however it is possible to detect them and suspend or try and correct readings during these variable anomalies.

During the installation of the compass the operator should continuously check the x,y and z magnetic fields while the magnetic anomaly is on. The compass should be placed as far as possible from the source of that anomaly and upon final installation the reading of x, y and z should be recorded when the anomaly is on and off. Please note that this should be done while the tilt outputs are ZERO on both axis.

In case of installation of the compass *in or near* a strong metal object it is recommended to rotate the complete structure horizontally 360 CW or CCW for about 1-2 minutes while the compass records magnetic data during the <hardiron> mode.

After completing the calibration the compass will compensate for the metal mass of the structure.

HARD IRON CALIBRATION

To calibrate for HARD IRON your are required to place the compass FLAT on the surface and type "hardiron cal" <CR>. The computer will instruct you to slowly rotate the compass board one full revolution while it collects the surrounding magnetic field. Keep the unit as horizontal as possible while rotating. The computer will display four lists of data. Continue rotating until no more new points are printed. Upon completion of the rotation press any key to stop calibration. The computer will display correction coefficients. To activate the hard iron calibration please type: *hardiron on*<CR>

The "HARDIRON" command has an option "3D". You have to perform "HARDIRON CAL", "HARDIRON 3D". "HARDIRON CAL" will tell you to rotate the sensor around the Z axis. Based on this calibration, "3D" will tell you to rotate either around X or around Y.

"HARDIRON 3D" is optional, the Z readings will not be affected if you don't calibrate.

Soft Iron pre-Calibration Note

For best results this procedure should be used in conjunction with the "compass calibration fixture" which is provided with your compass. Please carefully read the section of the manual describing the Soft Iron Calibration in order to understand the its basic principle.

1. Position the calibration fixture on a flat surface. Confirm that the location does not have any metal frame or tubing/piping under the surface.
2. Position the four pedestals on the four designated markers.
3. Rotate the inner disk until the arrow points to N or (0 degrees).
4. Place the compass aligned with the four markers on the top circle. Confirm that the word "FORWARD" on the compass board is in the same direction as NORTH on the calibration fixture.
5. Plug in the compass into Hyper Terminal and power it up.

STANDARD DYNAMIC SOFT IRON CALIBRATION

During SOFT IRON calibrations the compass should be keep FLAT on the surface

EZ-COMPASS-4 includes special **soft iron a** compensation. To calibrate for SOFT IRON place the compass FLAT on the surface and type "softiron a" <CR>. This compensation will remove the residual influence of multi-pole magnetic field interference and most linearity errors. In response to the above command, the computer will ask to select the number of correction intervals (10 to 72) and after <CR> will instruct to orient the compass board to point to Zero (or any other direction that is required to be ZERO). Pressing <CR> will store the raw compass value and automatically instruct the user to advance to the next angular orientation. This sequence will continue until the full revolution is completed. Upon completion of the full rotation the "softiron a" calibration will automatically end and the correction formula stored. To activate this calibration the user should type **softiron on<CR>**

NON RESTRICTIVE SOFT IRON CALIBRATION.

EZ-COMPASS-4 includes special NON segment restrictive **soft iron b** calibration. This calibration permits users to select any segment size in any section of the output curve and correct the output for linear errors. In this calibration the user is directed to put the compass in any known orientation and then input that location. The compass will use this data to create a new curve based on operators input. This calibration is useful in application where the user is unable to rotate the structure the complete 360 degrees, or needs to correct for linearity in a specific segment of the output curve.

To start the calibration type **softiron b<CR>**. The unit will ask for actual position of the compass at all new locations, input the required value. It is recommended to start from North and verify that the first uncompensated reply to the **c?<CR>** command is a bit larger then ZERO. Repeat until done within the limit of available room for storage. The routine will sort all points to be in proper ascending order and save data. If you want to stop and save - hit ENTER without entering any numbers. Hit ESC if you want to abort calibration and discard all the data. To activate this calibration the user should type **softiron on<CR>**

Type **softiron off<CR>** to disable calibration.

IMAGES:

General purpose version: EZ-COMPASS-4



0.9 inch wide x 2.0 inch long x 0.25 inch high

Geophysical Vertical version: EZ-COMPASS-4V



Same version as EZ-COMPASS-4, however to be used with the compass oriented in a vertical orientation, with a mark "FORWARD" pointing DOWN.

High reliability submersible version: EZ-COMPASS-4-DIVE-M



EZ-Compass-4-M is provided with a mating connector and approximately 4 foot long cable.

The compass is 1.5” diameter at the bottom and 1.8” diameter at the top. The compass is 4.5” high and is made from Marine grade black anodized Aluminum.

RS-232 and RS-422 Wiring for the pig-tale cable:

RS-232

Pin1= +6 to +15Vdc
Pin2 = N/C
Pin3 = Rx-
Pin4 = Tx+
Pin5 = N/C
Pin6 = 0V and to RS232 common GND

RS-422

+6 to +15Vdc
Tx-
Tx+
Rx-
Rx+
GND & 0Vdc supply

Below is the view into the inside of the mating connector on the cable.

Two bumps on the outside of the cable connector are the marking for the "WHITE" wire alignment (mates to the thick pin → pin1 on the compass connector).

Pin1
white
orange-pin5 blue-pin6 black-pin2
red-pin4 green-pin3

General notes:

To zero either pitch or roll axis position the compass in its final vertical orientation, perform **r?<CR>** or **p?<CR>** for position verification, than type **zero p<CR>** or **zero r<CR>**. The compass will offset either one or both tilt axis and record these values in the internal memory. To remove any tilt offsets using **zero p off** and **zero r off** commands.

In TTCM (tilt/temp/comp/magnetics) mode various values are set or removed from the output string by using the **print** command. Following is the ASCII string that is printed by the Hyper-terminal as a reply to **s?** or **go** commands when all variables are enabled.

\$R-2.61P1.08T21.5X206.7Y95.Z-367.5C3.9D32.A1.6*d

\$	is a start character	P	pitch(arcdeg)	T	temperature (degC)
*	is an end character	R	roll (arcdeg)	X,Y,Z	magnetic fields (mGauss)
d	is checksum characters	C	azimuth (deg)	D,A	DRILL values

You can display the above string with/without a come delimiter by using **coma on/off<CR>** command

TURCK cable

PROBE RS-232

PROBE RS-422

RED	--	7-15 Vdc power	7-15 Vdc power
BLACK	--	GND common	GND common
BLUE	--	Tx TTL or STD	TX+
WHITE	--	Rx TTL or STD	RX-
GREY	--	N/C	RX+
BROWN	--	N/C	TX-

STANDARD "SOFT IRON A" CALIBRATION (Refer to the enclosed images of calibration fixture)

1. Verify that the compass points to North after it is positioned on the four pedestals.
2. Type **softiron a<CR>** Upon the above command, the computer will ask you to select the number of correction intervals (10 to 72)
3. Reply with number of sections that you want the circle to be divided into and **press<CR>** Example: 20 points will divide the circle into 18 degree intervals.
4. After **<CR>** the compass will instruct you to orient the compass board to point to Zero (or any other direction that is required to be ZERO). Rotate the large bottom page together with the compass until the desired direction overlaps with the North arrow on the fixture. Secure the fixture with masking tape at four corners. Pressing **<CR>** will store the raw compass value and automatically instruct the user to advance to the next angular orientation.

This sequence will continue until the full revolution is completed. Upon completion of the full rotation the "soft iron a" calibration will automatically end and the correction

formula will be stored. Use the numbers on the outside rim of the circle to position the compass at all required orientations. If you selected intervals sizes of (5, 6, 8, 9, 10, 12, 15, 18) degrees, you can use the appropriate windows for more accurate orientation.

5. Now rotate the compass to any angle within this circle and see the reply to the c?<CR> command.

GENERAL. During this test and calibration the top small circle should rotate within the large circle centered in the center. The bottom sheet should be stationary.

When using "softiron b" command - position sensor to a new heading and enter the heading value.

Repeat until done within the limit of available room for storage.

If you want to stop and save - hit ENTER without entering any numbers.

Hit ESC if you want to abort calibration and discard all the data.

General start-up instructions via Hyperterminal.

1. Every windows based PC has a Hyper terminal program, which could be found in the Accessory section.
2. Select the hyper terminal and open it for "direct comX" communication. Make sure that the terminal settings are: 19200 baud, 8 bit, no parity, 1 stop, no flow control.
3. After the terminal is opened, the computer is ready to communicate with the module.
4. Plug the DB9 connector into the appropriate port in the PC, and then plug the blue connector to the main connector port on the module.
5. After both connectors are secured, turn the POWER ON.
6. Immediately after the power is applied, the unit will send a start header to the PC. The user will see the header displayed on the screen.
7. At this stage the module is ready to accept direct commands from the user.

Troubleshooting:

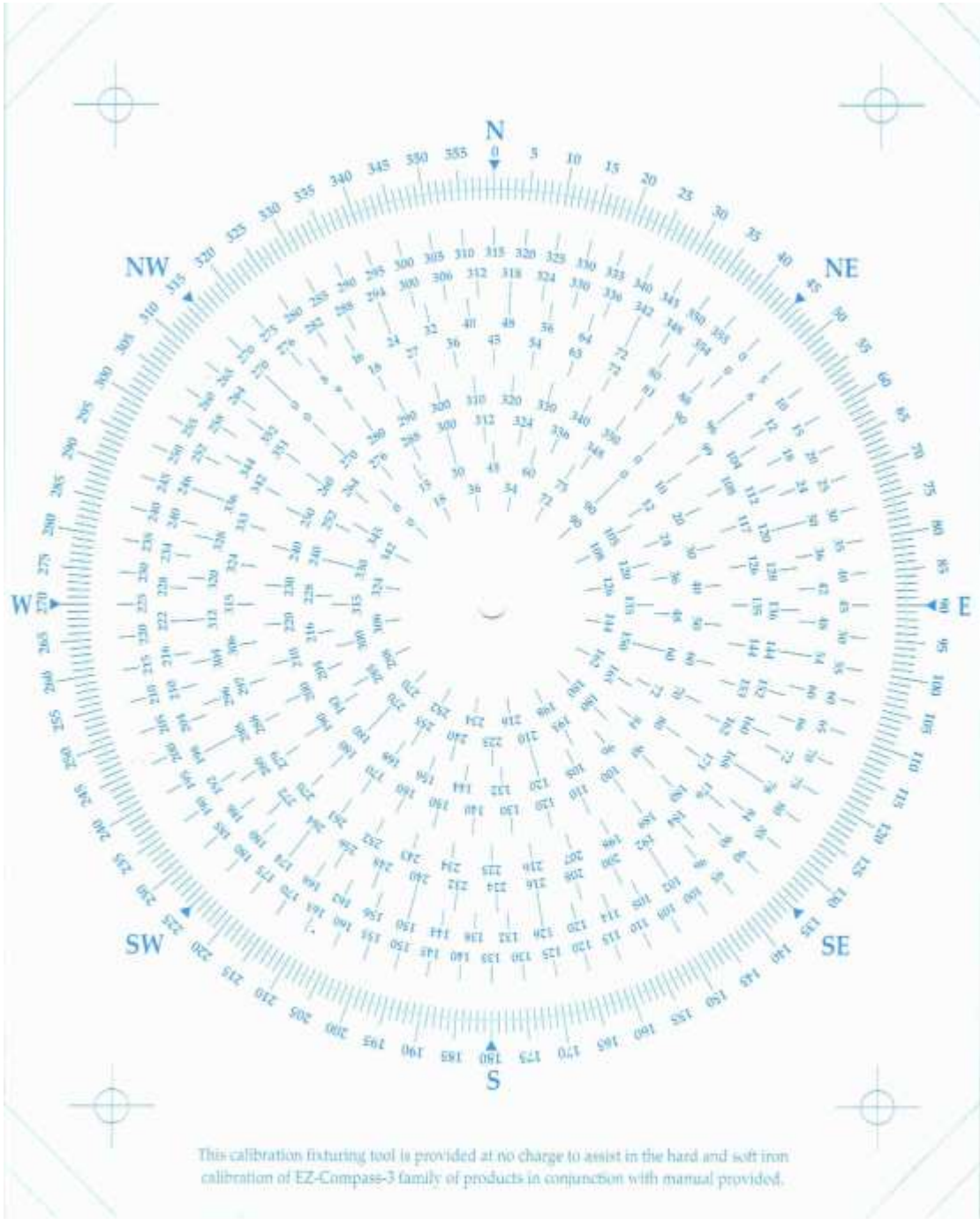
1. No Header is displayed.

Check the cable. Make sure that Rx and Tx are wired properly. Make sure there is common ground between the PC, Power Supply and the module. If necessary, swap Rx and Tx.

2. Strange characters are displayed.

This response is typical when there is a mismatch in baud rate. Change to new baud rate, and restart Hyperterminal with the new setting.

To perform calibrations using the enclosed fixture images, please cut out the small circular disk and position it in the center of the larger image. Align and secure centers in a way that the small disk can rotate on top of the large section.



BOTTOM SECTION



TOP SECTION

PRELIMINARY SECTION

LOGGING instructions for LOGGING version ONLY

The compass is equipped with the logging feature. The user first should set-up all the logging parameters using the LOG command (2) and then turn the power OFF. After the installation of the compass, or when ready, the user should re-apply the power. The compass will start logging as per the delay time indicated in the LOG command. After completion of the logging, the user should use the enclosed DATA RETRIVAL procedure.

1. LOG <no parameters> - print log system status.
2. LOG <delay> <rate> <duration> - arm log with new parameters, all timing in seconds.
3. LOG ERASE - erases the current log, not needed in practice because the old log is erased during the <delay> time anyway.
4. LOG PRINT - prints comma delimited file. The first row - header, the first column - timestamp in seconds, everything else - per the contents of the standard PRINT command.
5. LOG ON - rearm log using previous timing parameters.
6. LOG OFF - disable log so that it would not start on the next power-up, can be enabled again with LOG ON.
7. REBOOT <CR> starts logging without cycling power

To logging define the contents of the log string by using the PRINT command:
PRINT RPVTXYZCAD - or any configuration of variables, in the order you like.
EXAMPLE: LOG 120 15 600 - arms log to start 2 minutes after power-up, with samples every 15 seconds, for 10 minutes. **NOTE:** all time related data is in SECONDS.

LOG ?<CR> will display all parameters for using Logging feature

DATA RETRIVAL procedure

- 1 Select the Hyper Terminal mode from the Accessories menu
- 2 Create a link and an icon named "compass3"
- 3 Set the communication for com1 or com2
- 4 Configure for 19200 baud, 8 bits, No parity, 1 stop bit, No flow control.
- 5 Plug in the cable into the DSUB connector on your computer.
- 6 Plug in the power source or battery.
- 7 Plug in the connector into the compass
- 8 Select TRANSFER option on the top command bar
- 9 In the sub-menu select CAPTURE TEXT option
- 10 Using BROWSE locate the location for file storage
- 11 Type in FILE name for data storage
- 12 Type LOG PRINT <CR> and see data printed on the screen.
- 13 Select CAPTURE TEXT option and stop data capture.
- 14 Go to selected directory and work with the text file used to save data.