

KVH Industries, Inc.

C100™ Compass Engine

- Technical Manual

KVH C100

Congratulations!

You have just purchased one of the most advanced electronic compass sensors available today.

The C100 electronic compass is a state-of-the-art microprocessor-controlled fluxgate compass subsystem which consists of a detachable toroidal fluxgate sensing element and a small electronics board. The fluxgate sensor element is a saturable ring core, free floating in an inert fluid within a cylindrical lexan housing. The purpose of the floating ring core is to keep the sensing element horizontal with respect to the earth. Hard mounted cores experience significant errors when not perfectly horizontal (often more than 3 degrees of error for each degree of tilt). The lexan housing is surrounded by windings which electrically drive the coil into saturation. Pulses, whose amplitude is proportional to the sensed horizontal component of the earth's magnetic field, are detected by two secondary windings. The secondary windings are at right angles, thereby providing data on the x and y horizontal components of the earth's magnetic field. The fluxgate sensor takes ten measurements of the earth's magnetic field every second. Each measurement consists of 32 samples of both the x and y pulses from the sensing coil. These signals are converted to a DC level, digitized, and then sent to the microprocessor, which uses proprietary algorithms to translate the measurements into extremely accurate heading information. Automatic compensation corrects for sources of hard and soft iron deviations, assuring the C100 electronic compass is accurate not only on the lab bench, but when installed in your final product.

The C100 was developed to satisfy industry's need for a small, accurate, low cost magnetic heading sensor. This flexible design provides both analog and digital outputs and allows the user to configure the compass to their particular requirements. Parameters such as baud rate, update rate, damping (averaging), etc. can all be user selected.

The C100 is available with either a non-gimballed sensor (SE-25) with $\pm 16^\circ$ tilt (pitch and roll) capability or a gimbaled sensor (SE-10) with $\pm 45^\circ$ of tilt capability. A housed version of the C100 with an SE-25 sensor is also available.

Should you have any questions, comments, or suggestions, please direct them to:

C100

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Before you begin . . .

Important!

Before you start your installation:

Please read this manual thoroughly. The correct installation of the C100 is of utmost importance to its accuracy and precision, and most of all the successful operation of your new electronic compass sensor.

Serious damage, inaccuracies, or loss of warranty can result from incorrect installation.



Caution The C100 uses static sensitive components. Take the necessary precautions to avoid permanent damage caused by static discharge!

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1. Installation Instructions

1.1 Parts List

The C100 electronic compass consists of a detachable toroidal fluxgate sensing element and a small electronics board.

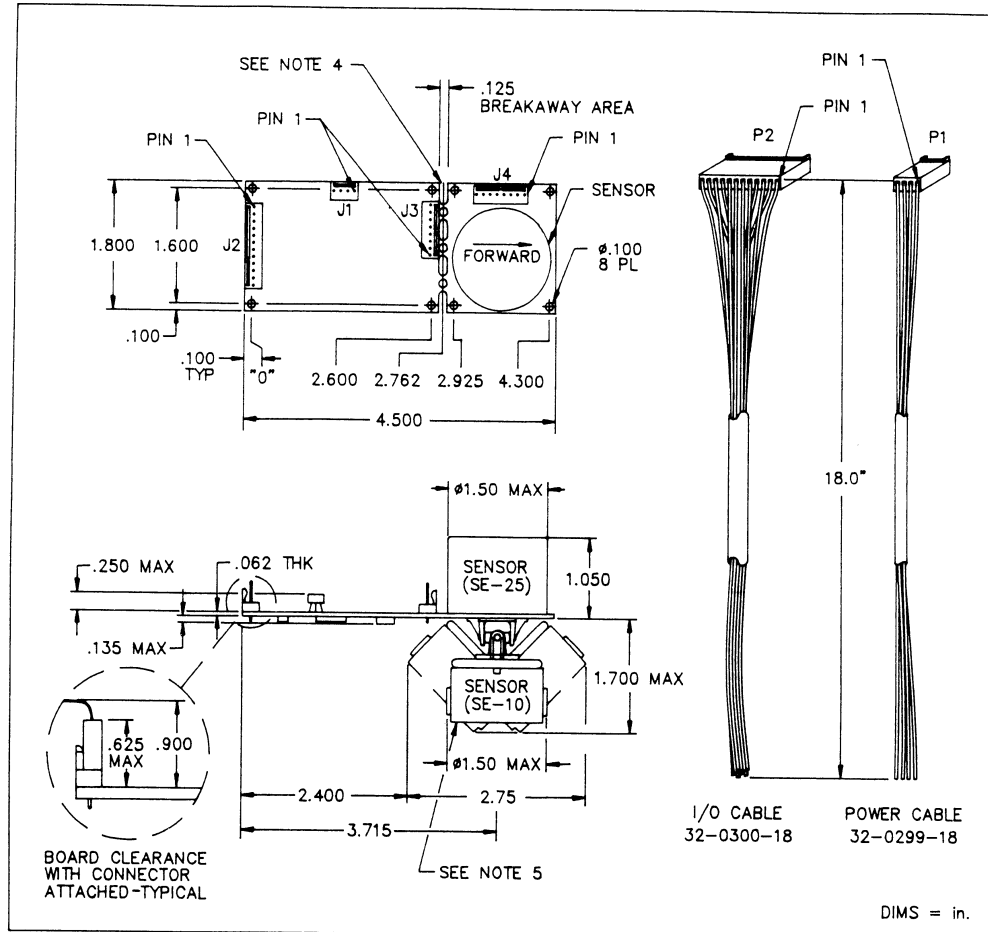


Figure 1. C100 Outline Drawing

Note

1. 18" #24AWG leads supplied with pins crimped and inserted into mating connector. Remove or cut unused wires from connector.
 2. Component height: Bottom of PCB: .135" max, Top of PCB: .250" max.
 3. Connector Identification: J1 - Power Input, J2 - I/O Data and Control, J3 - Coil, J4 - Coil (If coil board is separated use optional jumper cable between J3 and J4).
 4. To separate the coil board from the circuit board, carefully bend the breakaway joint until the two boards snap apart. Caution: Do not flex electronics board.
 5. The SE-25 sensor is standard. The gimbaled SE-10 sensor is a no charge option.
 6. Cut gray wire at P2 if strobe is not used. If strobe is used, run strobe wire separately from TXD and RS232-in wires.
 7. Remove or cut unused wires from P2.
-

1.1.1 Sensor Type

Two fluxgate sensors are available.

The SE-25 is the standard sensor provided with the C100. The C100 should be mounted in a level attitude in the host system. This sensor will operate through tilt (pitch and roll) ranges of $\pm 16^\circ$.

The SE-10 is a gimbaled sensor which will operate through $\pm 45^\circ$ of tilt (pitch and roll). Its circuit board should also be mounted in a level attitude for optimum tilt performance.

A housed version of the C100 with the SE-25 sensor is also available.

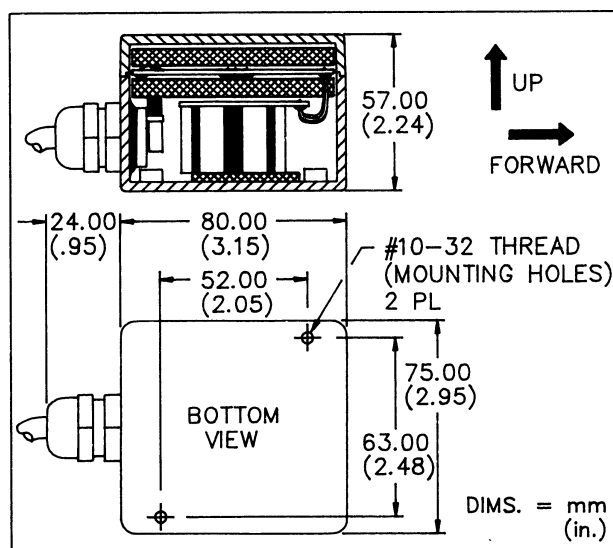


Figure 2. Outline Drawing Housed Version

Following are step-by-step instructions for correct installation. Make sure that whomever is going to install your C100 is familiar with these installation instructions and understands the principles of installation that ensure your sensor has the precision, convenience and usefulness for which it is designed.

1.2 Choosing a Location

Although the C100 can compensate for moderate magnetic interferences, it is important to select a location on the host platform that has the least amount of magnetic interferences. Place the C100 as far away as possible from iron, steel, magnets, motors, and other magnetic material. As a general guideline, a minimum separation of 12 inches should be maintained.

For installation that requires a remotely located sensor, the C100 circuit board is constructed so that the sensor circuit board can be separated from the electronics circuit board. This is easily done by placing a thumb on each side of the break-away joint and carefully bending, until the two boards snap apart.



Caution Do not flex the electronics circuit board. Support the boards so that the stress is applied only to the break-away joint. Be careful not to damage the fine wires on the coil assembly when handling this unit.

A six inch cable is provided with each C100 compass, unless otherwise specified. Optional cable assemblies up to 48 inches long are available from KVH. The shortest possible cable should be specified to minimize noise pickup in the sensor cable.

For installation near severe hard iron magnetic interference, the offending component can be shielded with a Mu Metal housing. However, some physical separation must still be maintained between the Mu Metal housing and the compass sensor. Since Mu Metal is a form of soft iron interference, comprehensive tests must be made to determine if the Mu Metal changes its magnetic signature over time and operational modes of the host system.

While the C100 can compensate for moderate deviations in a stable magnetic environment, it cannot compensate for magnetic interference that changes. Remember that wires carrying DC current generate a magnetic field. If the DC current changes, the field changes! Battery packs can be another source of changing interference. Every installation is different and the user must evaluate the installation under all expected operating conditions.

1.2.1 Overload Condition

When the compass sensor is exposed to a magnetic field outside of its operational range (either too high or too low) it will indicate this condition in the following way:

1. Serial Port

- NMEA message will indicate a heading of 800.0
- KVH message field will indicate "OL"
- x and y message will not have an error flag

2. Digital Port

- The digital output will indicate 800.0 for degrees and 8000 for mils in the Binary, BCD, and Gray Code Modes. No overload indication is provided in the C100 display or NCSC (CORDIC) Modes.

3. Analog Port

- The sine, cosine, and reference outputs will all indicate the reference voltage (i.e. 1.5 VDC).
- The linear output voltage will change, even if the compass is in the overload condition.

1.3 Mounting the C100

Figure 1. C100 Outline Drawing, page 1, shows the mounting details and the forward orientation of the compass during factory calibration. Either the center of the mounting holes or the edge of the circuit board can be used to orientate the C100 in the host system.

If the sensor cannot be physically aligned with the forward axis of the host system, the C100 can be programmed to cancel any offset using the index error offset feature.

Similarly, the local variation (declination) value can be entered so that the C100 will output true headings. The index and variation corrections are separate and independent functions in the C100.

Figure 2. Outline Drawing Housed Version, page 3, shows the outline drawing for the housed C100.



When any feature of the C100 is selected (such as index offset), the C100 will store this in nonvolatile (EEPROM) memory. When the C100 is again powered up it will remember all the last programmed settings.

1.4 Making the Connections

1.4.1 Standard Units (without housing)

Table 1 defines the Power (P1) and Data I/O (P2) connector interface connections of the C100. All ground terminals are connected together on the circuit board.



The Data I/O connections are functionally grouped and the pin numbers are not sequential.

Refer to *Figure 1. C100 Outline Drawing*, page 1, for connector locations.

We recommend that the serial, digital, and analog output wire groups be either run separately (physically isolated), or run in separate shielded cables using braided shields. The shield should be connected to ground at the I/O Connector (P2) only.

**Table 1. C100 Interface Wiring - SE-25 and SE-10 Sensor
(Standard Unhoused Units)**

<u>Function</u>	<u>Signal</u>	<u>Wire Color</u>	<u>Connector</u>
Serial I/O Port	RXD, RS232 or 0 to +5V Data Input	Yellow	P2-4
	TXD, RS232 or 0 to +5V Data Output	Pink	P2-11
	Inverted TXD, 0 to +5V Data Output	Tan	P2-12
	Gnd, Common Ground	Black	P2-6
Digital I/O Port	Clk, 10kHz 0 to +5V Clock Output	Blue	P2-10
	Data, 0 to +5V Data Output	White	P2-9
	Strobe, 0 to +5V Strobe Input	Gray	P2-8
Analog Outputs	Sin, Sine or Analog Output	Orange	P2-3
	Cos, Cosine or Analog Output	Red	P2-2
	Ref, Reference or Analog Output	Brown	P2-1
	Gnd, Common Ground	Green	P2-5
Power Inputs	+8 to +18 VDC	White	P1-2
	+18 to +28 VDC	Red	P1-1
	Gnd, Common Ground	Black	P1-4

1.4.2 Aluminum Housed Unit (SE-25 sensor)

Table 2 defines the Power and Data interface connections for the housed C100 electronic compass.



The wire colors are different from Table 1.

**Table 2. C100 Interface Wiring - SE-25 Sensor
(Housed Unit Only)**

<u>Function</u>	<u>Signal</u>	<u>Wire Color</u>
Serial I/O Port	RXD, RS232 or 0 to +5V Data Input	Red/Black Tracer
	TXD, RS232 or 0 to +5V Data Output	Blue/Black Tracer
	Inverted TXD, 0 to +5V Data Output	Blue/White Tracer
	Gnd, Common Ground	Black/White Tracer
Digital I/O Port	Clk, 10kHz 0 to +5V Clock Output	Blue
	Data, 0 to +5V Data Output	Orange/Black Tracer
	Strobe, 0 to +5V Strobe Input	Green/Black Tracer
Analog Outputs	Sin, Sine or Analog Output	Orange
	Cos, Cosine or Analog Output	Green
	Ref, Reference or Analog Output	White/Black Tracer
Power Inputs	+8 to +18 VDC	White
	+18 to +28 VDC	Red
	Gnd, Common Ground	Black
Not Used		Green/White Tracer
Not Used		Red/White Tracer

The cable shield is connected to the aluminum housing.

1.4.3 Display Connections

The KVH C100 Optional Display shows a 3-digit heading, with a resolution of 1 degree. The display is activated with the command (=zt,4).

The C100 Display is supplied with a connector which plugs into J2 on the unhoused C100 circuit board.

When using the C100 housed version, the display connector must be cut off and the display wires must be connected to the designated wires on the C100 cable as shown in Table 3 below.

Table 3. C100 Display Connections - Housed Unit

<u>Function</u>	<u>C100 Housed Unit Wire Color</u>	<u>C100 Display Wire Color</u>
Clock	Blue	Blue
Data	Orange/Black Tracer	Green
Strobe	Green/Black Tracer	Red
Ground	Black/White Tracer	Brown



Do not connect the drain wire (cable shield) on the Display cable!

1.4.4 Using Multiple Outputs

Except when in the strobed mode, heading data from all three ports (serial, digital, and analog) may be used simultaneously. Some restrictions apply when in the strobed mode (see Paragraph 1.4.6.2 on page 11).

The programmed parameters such as message rate, variation, index, damping, etc. apply to all outputs. The NMEA, C100 display, and NCSC outputs are in degrees only. All others are selectable in degrees or mils.

The single IIR damping filter is equivalent to a single section RC low pass filter. The double IIR is equivalent to a double section (RCRC) low pass filter. The damping times are times to reach final value after a step heading change.

Sum and dump filtering is to be used in the strobed mode for the digital output only. This type of filtering is explained in paragraph 1.4.6.2 on page 11.

Since all ground terminals are connected together on the C100 circuit board, precautions should be taken to avoid ground loops. This is particularly important when using the analog outputs. If possible, connect the analog output(s) and a ground from P2 to differential inputs at the user's equipment. Use a separate ground connection for the analog output (i.e. not one used by either the power return, digital, or serial ports).

Do not connect anything to P2-7. Cut the gray wire (P2-8) off at the connector if the strobe input is not used. Remove or cut other unused wires from P2.

1.4.5 Power Input

The 4 pin Molex™ power connector (J1) accepts either +8 to +18 VDC or +18 to +28 VDC input voltages (on separate pins). Do not apply voltage to both inputs at the same time. The current drain (typically 30 mA) remains the same regardless of input voltage.

The C100 power inputs are protected against reverse polarity and voltage spikes.

When powering up the unit, switch the power on, do not gradually increase the voltage. This will ensure that the microprocessor is reset properly. A smooth voltage rise time of up to 600 ms is acceptable.

If using an electro-mechanical relay to switch power on, a filter circuit may be required to eliminate the contact bounce transients. If you experience a problem when powering up the C100 (i.e. no output) add a low pass filter consisting of a 25 ohm, 1/4 w resistor in series with the positive power lead and a 50µf or 100µf capacitor directly across the power input terminal and ground of the C100.

This problem will not occur when using a solid state relay or transistor switch.

For voltage inputs between +8 VDC and +18 VDC, connect:

- + voltage to P1-2 (white wire)
- - voltage (ground) to P1-4 (black wire)

For voltage inputs between +18 VDC and +28 VDC, connect:

- + voltage to P1-1 (red wire)
- - voltage (ground) to P1-4 (black wire)

1.4.6 Data I/O Interface

The 12 pin Molex™ connector (P2) is used to communicate with the C100 and to access the various outputs.

1.4.6.1 Serial Port

This (RS232 compatible) port is used to configure the various outputs and also transmits compass data (heading and status information) in an ASCII format.

The RS232-in (RXD) input can accept either true RS232 levels or 0 to +5V logic levels in a standard ASCII format. The TXD provides output data at 0 to +5V levels. We have found that these levels are directly compatible with most PC and data terminals. The incoming message will be checksummed if the message contains an * in the receive string, i.e. \$HCHDM,xxx,M*checksum. This checksum will be just like the NMEA specification; it will ignore \$ and * in the message. The checksum is a XOR'ing of the bytes between the \$ and the *. This is true for input and output.

The $\overline{\text{TXD}}$ output is merely the TXD signal inverted.

The TXD and $\overline{\text{TXD}}$ signals can be used as an RS422 compatible output.



The RS422 compatible output does not have the drive capability of a standard RS422 driver.

The Serial Port interface requires two connections plus ground to the host system.

- RS232-in (RXD) receives ASCII characters with 1 start, 8 data, 1 stop, no parity format. Voltage levels can be either RS232 or 0 to +5 VDC where a logical "0" = +5V (P2-4 yellow wire).
- TXD transmits data in the same ASCII format described above (P2-11 pink wire). Output voltage levels are 0 to +5V where a logical "0" = +5 VDC.
- Ground. Host system ground can be either the power ground (P1-4) or the I/O ground (P2-6 black wire).

The default baud rate is 4800.

1.4.6.2 Digital Port

The digital port is used to provide synchronous data either in a continuous or a strobed mode. In the continuous mode, clock (at 10kHz rate) and data is provided at a 10Hz fixed update rate. In the strobed mode, the clock (at 10kHz rate) and data are initiated by momentarily grounding the strobe input.

The digital port requires three connections plus a ground to the host system. Figure 4-1 is a timing diagram for this port. The same ground used for the power or serial port will probably be acceptable. User should thoroughly test wiring configurations for proper operation. If the digital port is not used, it should be turned off by the command =zt0.

- Ground connection P2-5 (green wire).
- Clock output is a 10kHz (P2-10 blue wire) squarewave signal at 0 to +5V CMOS levels. It tells the host system when to sample the data output line (i.e. on the positive clock transitions).
- Data output (P2-9 white wire) is a 0 to +5V CMOS level signal where a logic "0" is a low level (i.e. 0 VDC).
- Strobe input (P2-8 gray wire). If the digital port is in the continuous mode of operation the strobe input is not used. In the continuous mode the strobe input wire (P2-8 gray) should be disconnected and cutoff at the P2 connector. This will prevent any noise being coupled into this port. The update rate is fixed at 10Hz in the continuous mode.

The strobe input is tied to +5V on the C100 with a 20k pullup resistor and accepts 0 to +5V CMOS input levels. To strobe a data sample, this line must be pulled low for 1 μ s minimum and then returned high. Clock and data is initiated within 2 ms of the positive transition of this input. The maximum strobe rate is 10Hz.



In the strobe mode it is important that noise not be coupled into this input. This wire should not be in a long cable bundle along with the serial RS232 port. Short cables 1-2 ft. should be acceptable. If absolutely necessary to have this wire in the same cable bundle, a 0.001 μ f capacitor placed directly across pins 8 and 6 at P2 will usually decouple any noise pickup. However, each setup should be well tested. In order to completely avoid this condition, do not read the data on the digital port during the instant when entering commands to the C100 over the serial port.

Sum and dump filtering is to be used only in the strobed mode. When using this filtering the output data is the average value of the heading between strobe pulses (i.e. if the strobe pulses are one second apart you get one second average data, if they are six seconds apart you get a six second data average, etc). The maximum time between strobes is 256 seconds (see *Figure 3*).

C100 Digital Timing Diagram, page 13). When in the sum and dump mode, do not use the serial or analog outputs! In the strobed mode, the analog and serial outputs may be used when the damping is undamped, single IIR, or double IIR.

The other damping types (i.e. undamped, single IIR, and double IIR) may be used in the strobed mode only under the following conditions. When in the strobed mode (**=z1**) the damping type must be undamped (**=dt0,0**) unless the interval between the strobe pulses is greater than two times the selected damping value.

Figure 3. C100 Digital Timing Diagram gives an example of the BCD output. Note that the MSD and MSB's are sent first.

In the binary and gray code modes, the output data is scaled 0 - 3599 for degrees (no decimal point) and 0 - 6399 for mils.

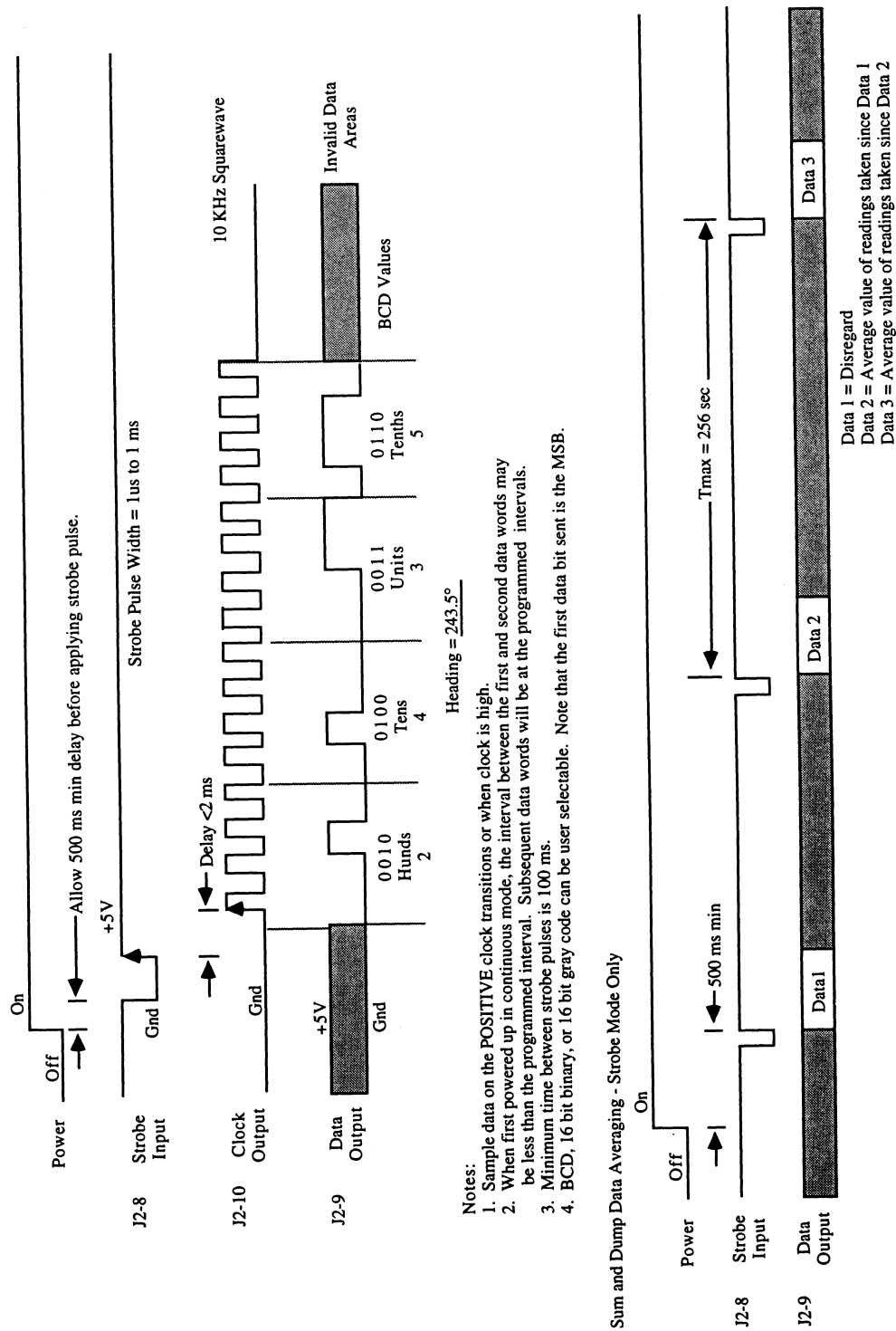


Figure 3. C100 Digital Timing Diagram

There are two other output formats available on the digital port:

1. C100 Display (=zt,4)

The KVH C100 display plugs into **J2** on the C100 Compass Engine. When the C100 is enabled with the above command, the display outputs a three digit heading with a resolution of 1 degree. Please contact KVH for pricing and availability.

Note



The C100 display is supplied with a connector which plugs into the "unhoused" C100. This may be cut off for use with the "housed" C100. (See Section 1.4.3.)

2. NCSC Output Format (=zt,5)

This output format is generally referred to as a CORDIC output. A 16 bit data word represents the heading in degrees with the MSB being sent first. The MSB (Bit 16) = 180°, Bit 15 = 90°, Bit 14 = 45°, etc. To determine the compass heading, simply sum the high bit values of the data word.

1.4.6.3 Analog Port

Two forms of analog outputs are provided: sine/cosine/reference and linear.

The sine, cosine, and reference outputs enable the user to make a ratiometric measurement of heading data.

The linear output provides a 0.1 to 1.9V linear output (corresponding to 0 to 360°) with a slope of 5mv/° and a resolution of 4mv (.8°).

The linear output with hysteresis is a variation of the standard linear output but will not shift abruptly from 1.9V to 0.1V around the 000° heading. *Figure 5. Linear Output with Hysteresis*, page 17, shows a graphic explanation.

1.4.6.3.1 Sine/Cosine/Reference Outputs

Sine/cosine/reference outputs require a three wire interconnection with the host system. The reference voltage stays constant at +1.50 VDC regardless of the compass heading. The sine and cosine outputs vary ± 1.0 VDC around the reference voltage (i.e. from +0.5 to +2.50 VDC).



Since sine/cosine measurements are made with respect to the reference voltage, no ground is required.

- P2-3 (orange wire) is the sine output.
- P2-2 (red wire) is the cosine output.
- P2-1 (brown wire) is the reference output.

The sine and cosine outputs vary as a function of compass heading. To reduce error possibility, these voltages should be measured with respect to the reference voltage and not with respect to ground. This avoids the ground loop problems associated with single ended measurement methods used with the linear outputs. The heading is resolved by taking the arc tangent of the sine voltage divided by the cosine voltage. This results in a ratiometric determination of heading having an accuracy of $\pm 0.5^\circ$ RMS.

If the user's equipment can only make unbalanced measurements (i.e. sine to ground) he should measure all three voltages with respect to ground (i.e. sin/cos/ref). Algebraically subtracting the measured reference voltage from both the sine and cosine voltages will result in a differential measurement which can be used to calculate the heading as previously described.

1.4.6.3.2 Linear Outputs

When the linear output is selected, the same linear voltage proportional to heading will appear on all three linear output terminals (i.e. sin, cos, ref). Figures 4 and 5 graphically show the response of the linear outputs as a function of heading.



The slope of both linear and linear with hysteresis is $5\text{mv}/^\circ$. The linear output accuracy is better than $\pm 1.0^\circ$ RMS.

Figure 4. *Standard Linear Output* shows the regular linear output response.



At 000° heading the output switches abruptly from 1.9 VDC to 0.1 VDC when turning clockwise. When turning counterclockwise, the output voltage will switch from 0.1 VDC to 1.9 VDC.

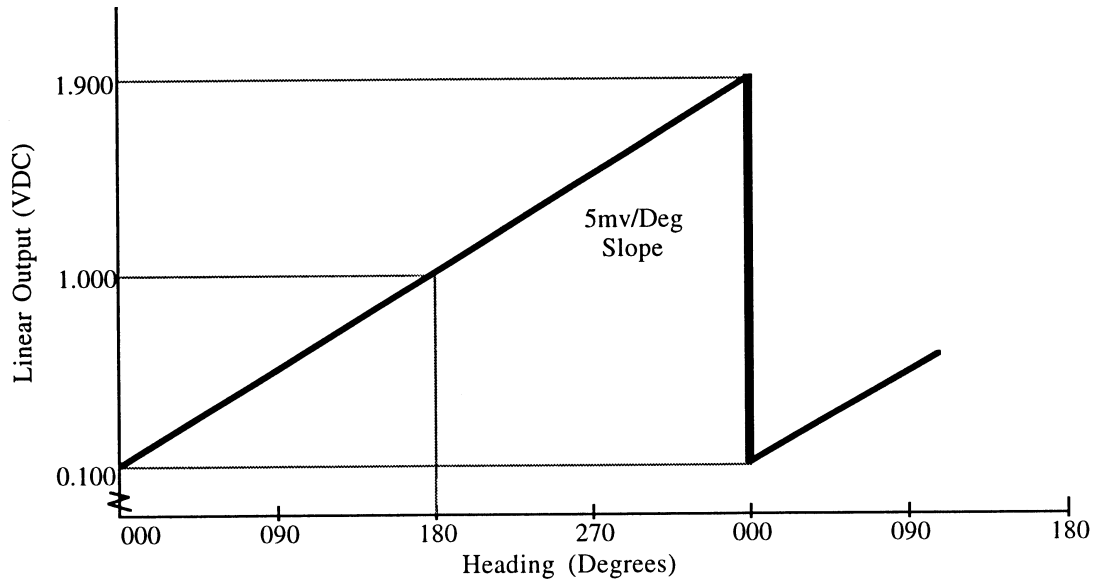


Figure 4. **Standard Linear Output**

Figure 5. *Linear Output with Hysteresis* shows the linear output with 4° of hysteresis. When turning clockwise (cw), the voltage will switch at 005° from 1.925 VDC to 0.125 VDC. When turning counterclockwise (ccw), the voltage will change at 001° from 0.105 VDC to 1.905 VDC. The 4° hysteresis (20 mv DC) prevents the output voltage from snapping back and forth while trying to maintain a northerly heading. The slope is always 5mv/°.



Remember to avoid ground loops when using the linear output.

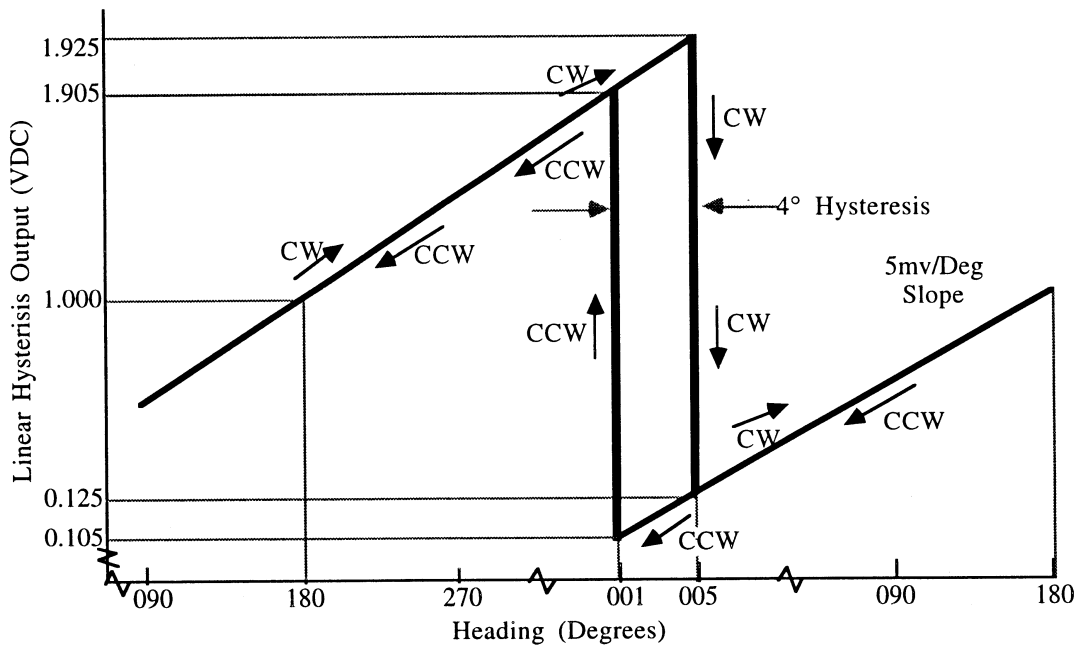


Figure 5. Linear Output with Hysteresis

2. Features and Specifications

2.1 Default Values

When you receive your C100 it will be factory configured as follows:

Heading Type:	Variation Off
Variation:	0.0
"A" Offset:	0.0
Powerup Mode:	Sending
Baud Rate:	4800
Message Rate:	1 Hz Continuous
Message Type:	NMEA
Message Units:	Degrees
Digital Output Type:	Continuous
Digital Output Format:	4 Digital BCD
Analog Output Format:	Linear
Damping Type:	Double Infinite Impulse Response Filter (Double IIR) (Similar to a 2 section RC LPF)
Damping Rate:	3 Seconds (to Final Value)

2.2 Features

The serial port allows the user to communicate and configure the C100 to their own individual requirements. The following selectable parameters and features are included in the C100 compass:

Variation:	0 to $\pm 359.9^\circ$ or 0 to ± 6399 mils
"A" Offset:	0 to $\pm 359.9^\circ$ or 0 to ± 6399 mils
Baud Rate:	300 to 9600
Message Rate:	up to 10/sec or on command
Message Type:	NMEA, KVH, X&Y corrected and uncorrected
Message Units:	degrees or mils
Digital Output Type:	continuous at selected message rate or strobed
Digital Output Format:	BCD, Binary, Gray
Analog Output Format:	sin/cos/ref, linear, linear with hysteresis
Damping Type:	undamped, single IIR, sum & dump, double IIR
Damping Rate:	3 seconds to 24 seconds (to final value)
Autocal:	user enabled

2.3 Command Summary

Action commands used to configure the C100 are preceded by an = character. Inquiry commands used to check the current status are preceded by a ? character. In the message listings, there is an implied carriage return <cr> after each message. A prompt character return > indicates that the message was accepted. An exclamation character ! indicates that the message was not accepted. The user may include an ASCII line feed character after their message. The C100 will simply ignore this character. The complete details of the C100 user commands are included in Appendix C of this manual. These commands/inquiries are used when in the Terminal Mode of the KVH User's Program or when directly communicating with the C100 using a PC, terminal or microprocessor.

<u>Action</u>	<u>Inquiry</u>	<u>Description</u>
s		Start Output - serial port only (sending mode)
h		Halt Output - serial port only (not sending mode)
d0		Send NMEA message once - serial port only
d1		Send KVH message once - serial port only
d2		Send corrected x & y values once - serial port only
d3		Send uncorrected x & y values once - serial port only
=r,X₁	?r	Message Rate (Messages/Minute): 6=1/10 sec, 60=1/sec, 600=10/sec
=t,X₁	?t	Message Type: 0=NMEA, 1=KVH, 2=x&y corrected, 3=x&y uncorrected
=i,X₁	?i	Degree/Mil: d=degree, m=mils (degrees only for NMEA)
=b,X₁	?b	Baud Rate: 3=300, 48=4800, etc. (Maximum rate 96=9600)
=z,X₁	?z	Digital Output Type: 0=Continuous, 1=Strobed
=zt,X₁	?zt	Digital Output Format: 0=Off, 1=BCD (4 char), 2=Gray Code (16 bits), 3=Binary (16 bits), 4=C100 display, 5=NCSC
=at,X₁	?at	Analog Output Format: 0=Linear .1 to 1.9V, 1=Linear w/hysteresis, 2=Sine/Cosine 1.5 ±1.0V
=v,X₁	?v	Variation On/Off: t=Variation on, m=Variation off
=vd,X	?vd	Set variation in degrees (0 to ±359.9°) or mils (0 to ±6399)
=vi,X	?vi	Set Index ("A" Coefficient) in degrees (0 to ±359.9°) or mils (0 to ±6399)
=dt0,X	?dt0	Set Damping Type: 0=Undamped, 1=Single IIR, 2=Sum & Dump, Double IIR
=d0,X	?d0	Set Damping Rate: 0=3.0 secs, 1=4.5 secs, 2=6.0 secs, 3=7.5 secs, 4=9.0 secs, 5=12 secs, 6=14 secs, 7=16 secs, 8=20 secs, 9=24 secs
zap		Warm Boot (Resets the C100.)
	?w	Serial number, software version, hardware version, type, cal date
=ce1		8-point calibration
=ce3		Circular calibration
=ce4		3-point calibration (For details, refer to page 40 of this manual.)
=cez		Calibration procedure aborted
	?cs1	Calibration score and count
	?cs2	Calibration score, hard iron influence, and count

¹ These action commands may also be implemented without the commas so as to be compatible with previous versions of the C100.

Appendix A. Technical Specifications

Performance

Accuracy ¹	±0.5° or ±10 mils RMS (SE-25 Coil Assembly and digital/serial outputs)
Repeatability	±0.2° or ±5 mils (SE-25 Coil Assembly and digital/serial outputs)
Resolution	0.1° or 1 mil
Dip Angle	±80° Maintains stated accuracy, after autocalibration, over ±80° Magnetic Dip Angles
Tilt Angle ¹	±16° (SE-25 Coil) Dev.=±0.5° RMS ±45° (SE-10 Coil - Gimballed) Dev.=±0.5° RMS
Electrical Power	Input Voltage: +8 to +18 VDC or +18 to +28 VDC - user selectable Current Drain: 40 mA DC; maximum
Variation/ Declination	±180.0° adjustment range (offset) - user selectable
Index Error Offset	±180.0° adjustment range (offset) - user selectable
Damping	0.1 to 24 seconds (to final value) - user selectable

Characteristics

Size	Electronics Board: 1.80" x 2.80" x 0.40" (4.6 cm x 7.1 cm x 1.0 cm) Sensor Board: 1.80" x 1.58" x 1.10" (4.6 cm x 4.2 cm x 2.8 cm) (SE-25 Coil). Gimballed coil (SE-10) hangs 1.70" below the PC board. Combined Board: 1.80" x 4.50" x 1.10" (4.6 cm x 11.4 cm x 2.8 cm) (SE-25 Coil)
Weight	2.25 ounces (64 grams) with SE-25 Coil Assembly
Operating Temp. ²	-40°F to +150°F (-40°C to +65°C)
Storage Temp.	-71°F to +160°F (-57°C to +71°C)
Shock/Vibration	Designed to meet MIL-STD-810 shock and vibration requirements
Altitude	Designed to meet 40,000 ft. MSL (operating and non-operating)
Reliability	MTBF calculated to exceed 30,000 hours

1 Accuracy measurements apply to a level compass module after compensation. After installation and autocompensation, typical accuracies of 0.5° are achievable on most platforms.

2 For operating temperatures above +122°F (+50°C), the power supply input voltage must not exceed +14 VDC (+24 VDC on upper range).

Input/Outputs

Digital Interfaces³

Serial Port	RS232 Compatible	Bidirectional Serial Data, UART Format with ASCII Characters, (1 start, 8 data, 1 stop, no parity), 300 to 9600 baud - user selectable
	Serial Input	Accepts RS232 levels or 0 to +5V Logic Levels
	Serial Output	Same as RS232 except for 0 to +5V Logic Levels, (Logic "0" = +5V) 10K Ohm - minimum load
	Inv. Serial Output	Same as above serial output excepts Logic "1" = +5V
	NMEA 0183	NMEA 0183 compatible bidirectional data/levels/formats
Digital Port	Synchronous	Strobe Input: Ground momentarily (1 μ S minimum) to obtain data output Clock Output: 0 to +5V squarewave @ 10kHz rate. Data Output: 0 to +5V levels Data Format: 4 digit BCD, 16 Bit binary or 16 Bit Serial Gray Code, C100 Display ⁴ , NCSC ⁴ - user selectable through serial port 10K Ohm minimum load on output signals
Analog Outputs	Sine/Cosine/Ref	Output voltage +1.5V $\pm$ 1.0V, Reference Voltage +1.5 VDC, 20K Ohm minimum load capability
	Linear Voltage	+0.1 to +1.9 VDC into 20K Ohm minimum load (5mv/ $^{\circ}$ slope)
	Linear Voltage with Hysteresis	+0.105 to +1.925 VDC into 20K Ohm minimum load (5mv/ $^{\circ}$ slope)



Accuracies using the ratiometric sine/cosine outputs are within the specified $\pm 0.5^{\circ}$ RMS. Linear output accuracies are within $\pm 1.0^{\circ}$ RMS.

³ Digital (synchronous) outputs can be user configured to provide strobed or free running data at up to a 10Hz message rate.

⁴ Contact KVH for details.

Appendix B. NMEA 0183 Interface

The NMEA 0183 interface transmits heading data organized into sentences defined as follows:

- Sentence length is 19 bytes.
- Update Rate = 1 Hz.
- Format parameters:
 - Bytes are encoded as 7 bit ASCII characters in an 8 bit byte with the most significant bit set to zero.
 - No Parity bit.
 - One start bit and one stop bit.
 - 4800 Baud.
 - The total number of bits per transmitted data byte is 10.

The sentence is:

\$HCHDM,abc.d,M*<checksumMS><checksumLS><cr><lf> where *a* is the BCD hundreds digit of the heading, *b* is the tens digit, *c* is the ones digit, and *d* is the tenths digit.

<checksumMS> is an ASCII character in the range 0-9 or A-F that represents the most significant nibble of the checksum. Similarly, <checksumLS> represents the least significant nibble of the checksum.

The checksum is calculated by XOR'ing together all the characters in the sentence starting with the "H" and up to, but not including the "*" character. [i.e. XOR together "H", "C", "H", "D", "M", ",(comma)", "hundreds digit", "tens digit", "ones digit", "decimal point", "tenths digit", ",(comma)", "M"]. The checksum does not include the "\$".

Appendix C. C100 User Commands

C.1 Introduction

The following is a brief description that will tell the user how to use the "C100". For detailed information, refer to the C100 Technical Manual.

C.1.1 Power Connections

Power is located on the 4 pin Molex™ connector and has the following connections:

- Pin 1 (RED) Power input +18 to +28 Volts
- Pin 2 (WHT) Power input +8 to +18 Volts
- Pin 3 (GRN) No connection
- Pin 4 (BLK) Ground

The red and white wires on the 4 pin Molex™ connector are the power inputs, only "one" input can be used. **Do not connect both inputs at the same time.**

The black wire is the power's return (ground).

Once you have connected to your power supply, the unit will start running automatically. If it is the first time the unit has been powered up since you received it from the factory, it will power up with the factory standard default settings. Custom defaults can be provided on request. Refer to *Section 2.1 Default Values*, page 18, for the standard default settings.

If it is not the first time the unit has been powered up, then the unit will power up with the last configuration saved when the unit was powered down.

C.1.2 I/O Connections

The 12 pin Molex™ connector contains input and output connections that are used to communicate with, or get information from, the compass.

- Pin 1 (BRN) Reference voltage for sine cosine output
- Pin 2 (RED) Cosine output
- Pin 3 (ORG) Sine output
- Pin 4 (YEL) RS232 input for serial port
- Pin 5 (GRN) Ground
- Pin 6 (BLK) Ground
- Pin 7 No connection
- Pin 8 (GRY) Strobe input for digital port
- Pin 9 (WHT) Data output for digital port
- Pin 10 (BLU) Clock output for digital port
- Pin 11 (PNK) Txd, Transmit data output for serial port
- Pin 12 (TAN) Inverted Txd, Transmit data output for serial port

C.2 Programming the RS232 Compatible Serial Port

The <cr> stands for a carriage return or enter key.

In the message listings below, there is an implied carriage return <cr> after all the messages, a prompt character (>) indicates that the message was accepted or an exclamation character (!) indicates that the message was not accepted.

To accommodate a broad range of terminals and communication protocols, an ASCII "line feed" character (0x0a, transmitted by user) will be accepted by the communications message handler in the C100, but it will be ignored.

If the command sent to the compass has a * and two checksum characters (plus **cr** and **lf**) in the message, the command will be checksummed by the compass. The checksum includes from the first character up to the *, but not including the *. If the first character is a \$, it would not be included in the checksum. The checksum is calculated by XOR'ing the ASCII bytes. The checksum is two ASCII bytes. The MSB is sent first. If the message read by the compass does not agree with the checksum received, the compass would send a "#!" and no data will be sent.

C.2.1 Serial Port Commands

All checksums for the message (if present) are computed by XOR'ing the ASCII bytes between the dollar sign (\$) and the asterisk (*). The checksum excludes the \$ and the *. The checksum is split up into two ASCII bytes. The MSB is sent first.

To enable sending of the current data message:

--User Action-- Type **s<cr>**

--Compass Response-- >
 \$HCHDM,182.3,M*<CHECKSUM><cr><lf>

The compass will respond with the currently selected data message (as well as sending an acknowledgement that the message was received) which will be continuously sent at the currently selected data rate. As an example, if data message type 0 is selected, then the compass will respond with the NMEA message shown above.

The "s" command will place the C100 in the sending mode and store this mode in the EEPROM memory. If the power is turned off and then on again (or if the compass is reset with the "zap" command), the C100 will come up in the sending mode.

To disable sending of the current data message:

--User Action-- Type **h<cr>**

--Compass Response-- > No response other than an acknowledgement will be sent.

The "h" command will place the compass in the non-sending (halt) mode and store this mode in EEPROM memory. If the power is turned off and then on again (or if the compass is reset with the "zap" command), the C100 will come up in the non-sending mode.

To send data message #0 once (NMEA message):

--User Action-- Type **d0<cr>**

--Compass Response-- **>**
 \$HCHDM,271.8,M*<CHECKSUM><cr><lf>

The compass will respond by sending an acknowledgement and data message 0, which is the NMEA 0183 format message for magnetic compass data. The NMEA message is only expressed in degrees.

The first field, **HCHDM**, is the standard lead in indicating that the message is from a compass that is giving magnetic heading.

The second field, **271.8**, is the compass heading to the tenth of a degree.

The third field, **M**, is the indicator that the heading is magnetic, not true heading.

The ***** field indicates the beginning of the two byte checksum of the message.

The **<checksum>** includes all characters between the **\$** and the *****.

If the heading reads 800.0° then the compass is over or under loaded.

If variation (declination) is enabled then the NMEA message will change to the following (The **T** character is indicating true heading, not magnetic heading.):

\$HCHDT,271.8,T*<CHECKSUM><cr><lf>

To send data message #1 once (KVH message):

--User Action-- Type **d1<cr>**

--Compass Response-- **>**
 \$271.8,X,YY*<CHECKSUM><cr>

The compass will respond by sending an acknowledgement and data message 1, which is the short heading message of **\$abc.d*<checksum><cr>** where **abc.d** represents an ASCII format message for magnetic compass data.

The first field, **271.8**, is the compass heading to the tenth of a degree.

The second field, **X** being D if in degree mode, M if in mil mode.

The third field, **YY** being the status of the magnetic surroundings of the compass, **OL** = overload or underload condition and the data is NOT VALID, **OK** = that the current data is VALID.

The ***** field indicates the beginning of the two byte checksum of the message.

The **<checksum>** includes all characters between the **\$** and the *****.

To send data message #2 once:

--User Action-- Type **d2<cr>**

--Compass Response-- >
 \$xxxxxx.xxxxxx,yyyyyy.yyyyyy,*<CHECKSUM><cr>

The compass will respond by sending an acknowledgement and data message 2, which consists of the corrected x and y coil values (unitless). The corrected values include the current field compensation constants. These values do not include variation or index offsets.

The first field, **xxxxxx.xxxxxx**, is the corrected x value.

The second field, **yyyyyy.yyyyyy**, is the corrected y value.

The ***** field indicates the beginning of the two byte checksum of the message.

The **<checksum>** includes all characters between the **\$** and the *****.

C.2.2 Query Commands for Serial Port

Query the compass for the existing data message rate:

--User Action-- Type **?r<cr>**

--Compass Response-- >
 ?r X<cr>

X being:

A number representing the number of messages per minute: 6 represents a 1/10 Hz data rate, 60 represents a 1 Hz data rate, 600 represents a 10 Hz rate. **X** can be any whole number between 0 and 600.

Query the compass for the message type of the currently selected output message:

--User Action-- Type **?t<cr>**

--Compass Response-- >
 ?t X<cr>

X being:

- 0 = Standard NMEA 0183 message
- 1 = KVH Version
- 2 = X and Y corrected output
- 3 = X and Y uncorrected output

Query the compass for the status of the mil/degree flag: (i.e. is the compass data in mils or degrees ?):

--User Action-- Type **?i<cr>**

--Compass Response-- **>**
 ?i X<cr>

X being:

The status of the mil/degree flag.

d = degrees

m = mils

Note: 6400 mils = 360 degrees

Query the baud rate for the next reset:

--User Action-- Type **?b<cr>**

--Compass Response-- **>**
 ?b <baud rate><cr>

Send the baud rate setting for the next reset.



The reply will only tell what the EEPROM baud rate memory holds (i.e. you must already know what the current baud rate is in order to be able to communicate with the C100). The baud rate number, when multiplied by 100 will be the baud rate of the compass after a reset. For example a 003 means 300 baud and 096 means 9600 baud.

When the C100 is powered down and then up again (or reset with a **zap** command), the baud rate stored in the EEPROM will be used.

C.2.3 Set Commands for Serial Port

To set the compass for the data message rate:

--User Action-- Type =r,X<cr>

--Compass Response-- >

X being:

A number representing the number of messages per minute: 060 represents a 1 Hz data rate and 600 represents a 10 Hz rate. The maximum rate is 10 Hz and the minimum rate is 0 Hz.

To set the output message type:

--User Action-- Type =t,X<cr>

--Compass Response-- >

X being:

0 = Standard NMEA 0183 message (degrees only)
1 = KVH Version (degrees and mils)
2 = X and Y corrected output
3 = X and Y uncorrected output

To set the compass for degrees or mils:

--User Action-- Type =i,X<cr>

--Compass Response-- >

X being:

The status of the mil/degree flag.
d = degrees
m = mils
Note: 6400 mils = 360 degrees

To set the baud rate for the next reset:

--User Action-- Type **=b,X<cr>**

--Compass Response-- **>**



The new baud rate will not be implemented until the C100 is powered down and then up again (or reset with the **zap** command).

C.3 Programming the Digital Output

C.3.1 Query Commands

To query the compass for the current mode of the digital output (i.e. continuous or strobed):

--User Action-- Type **?z<cr>**

--Compass Response-- **>**
 ?z X<cr>

X being:

The current digital output mode.
0 = continuous at sample rate of system
1 = strobed

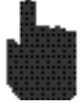
To query the compass for the digital output type:

--User Action-- Type **?zt<cr>**

--Compass Response-- **>**
 ?zt X<cr>

X being:

0 = OFF:no output
1 = bcd code output (4 characters)
2 = gray code output (16 bits)
3 = binary output (16 bits)
4 = C100 display
5 = NCSC output (CORDIC) format

Note

If the digital output port is not used it should be turned off.

C.3.2 Digital Set Commands

Set the current mode of digital output (i.e. continuous or strobed):

--User Action-- Type = **z,X**<cr>

--Compass Response-- >

X being:

The current digital output mode.

0 = continuous at sample rate of system

1 = strobed

Set the digital output for the compass:

--User Action-- Type = **zt,X**<cr>

--Compass Response-- >

X being:

0 = OFF:no output

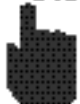
1 = bcd code output (4 characters)

2 = gray code output (16 bits)

3 = binary output (16 bits)

4 = C100 display

5 = NCSC output (CORDIC) format

Note

If the digital output port is not used it should be turned off.

C.4 Programming the Analog Outputs

C.4.1 Query Commands

To query the compass for the type of analog output:

```
--User Action-- Type      ?at<cr>

--Compass Response--      >
                          ?at X<cr>
```

X being:

- 0 = regular linear output (0.1 to 1.9 VDC)
- 1 = hysteresis linear output
- 2 = sine/cosine/reference output

To query the compass for the analog output's reference voltage:

```
--User Action-- Type      ?a1<cr>

--Compass Response--      >
                          ?a1 1.50<cr>
```

The reference voltage value that has been programmed (i.e. 1.50 VDC).



The reference voltage is fixed at +1.50 VDC.

To query the compass for the analog (sine/cosine) output's swing voltage:

```
--User Action-- Type      ?a3<cr>

--Compass Response--      >
                          ?a3 1.00<cr>
```

The swing voltage value that has been programmed (i.e. ± 1.00 VDC).



The sine/cosine voltage swing is fixed at ± 1.00 VDC

C.4.2 Analog Set Commands

Set the compass analog output type:

--User Action-- Type =at,X<cr>

--Compass Response-- >

X being:

0 = regular linear output (0.1 to 1.9 VDC).

1 = hysteresis linear output.

2 = sine/cosine output.

C.5 Controlling the C100 Functions

C.5.1 Execute a Warm Boot (Start execution from location 0)

--User Action-- Type zap<cr>

This command will restart the compass just like it was powered down and then back up. It will not give hard reset to the microprocessor. Turn power off then on for a hard reset.

C.5.2 Query Commands

Ask the compass to report the compass serial number, software version number, hardware version number, what type of compass, calibration date:

--User Action-- Type ?w<cr>

--Compass Response-- >
?w XXXXXXXX,A,B,C100,99/99/99*<checksum><cr>

The first field, **XXXXXXXX**, is the serial number of the unit.

The second field, **A**, is the software version of the unit.

The third field, **B**, is the hardware version of the unit.

The fourth field, **C100**, is the unit type.

The fifth field, **99/99/99**, is the date that the unit was calibrated at the factory (i.e. YY,MM,DD).

The sixth field, **<checksum>** is a two digit checksum of all characters up to, but not including, the *.

Query if variation is off or on:

--User Action-- Type ?v<cr>

--Compass Response-- >
 ?v X<cr>

X being:

true heading = variation is on (being used to offset compass heading)

magnetic heading = variation is off (not being used to offset compass heading)

Query the current variation (declination):

--User Action-- Type ?vd<cr>

--Compass Response-- >
 ?vd X<cr>

X being:

The declination angle in the current output mode (mils or degrees). If the compass is in degree mode the output will have a decimal point (i.e. 345.6 degrees). In mils mode the output does not have a decimal point.

--User Action-- Type ?vi<cr>

--Compass Response-- >
 ?vi X<cr>

X being:

The index ("A" coefficient offset) angle in the current output mode (mils or degrees). If the compass is in degree mode the output will have a decimal point (i.e. 345.6 degrees). In mils mode the output does not have a decimal point.

Query the compass for the current type of damping filter being used for all the outputs:

--User Action-- Type ?dt0<cr>

--Compass Response-- >
 ?dt0 X<cr>

X being:

0 = Undamped

1 = Single IIR (Infinite Impulse Response Filter - RC)

2 = Sum and dump

3 = Double IIR (Infinite Impulse Response Filter - RCRC)



Sum and dump filter is to be used only in the digital strobed output mode! Do not use the heading data from the serial or analog ports when using this filter.

Query the compass for the damping time:

--User Action-- Type **?d0<cr>**

--Compass Response-- >
 ?d0 X<cr>

X being:

Values from 0 through and including 9. These values are offsets into a table with the corresponding damping time:

0 = 3 seconds
1 = 4.5 seconds
2 = 6 seconds
3 = 7.5 seconds
4 = 9 seconds
5 = 12 seconds
6 = 14 seconds
7 = 16 seconds
8 = 20 seconds
9 = 24 seconds

Damping is response time to final value.

Query the compass for calibration status:

--User Action-- Type **?cs1<cr>**

--Compass Response-- >
 ?cs1,X,Z<cr>

X being: noise score

Z being: calibration count

Query the compass for calibration status:

--User Action-- Type **?cs2<cr>**

--Compass Response-- **>**
 ?cs2,X,Y,Z<cr>

X being: noise score

Y being: magnetic environment

Z being: calibration count

C.5.3 Set Commands

Set the variation (declination) on or off:



The terms variation and declination are used interchangeably. Variation is the angle between true north and magnetic north. Declination is the angle between grid north and magnetic north.

--User Action-- Type **=v,X<cr>**

--Compass Response-- **>**

X being:

t = variation set on (tells the C100 to use the variation value to offset compass heading)

m = variation set off (the C100 will not use the variation value to offset compass heading)

Set the variation (declination) to a specified value:

--User Action-- Type **=vd,X<cr>**

--Compass Response-- **>**

X being:

The variation (declination) angle can be entered in degrees or mils. **X** is entered to the nearest tenth of a degree (i.e. 345.0) leading zeros are optional (i.e. 045.0) or to the nearest mil (i.e. 1645). Positive or negative values can be used. The maximum variation values are 359.9 degrees or 6399 mils.

Set the offset index ("A" coefficient) to the specified value:

--User Action-- Type **=vi,X<cr>**

--Compass Response-- >

X being:

The index ("A" coefficient offset) angle can be entered in degrees or mils. The compass must be in the degree mode to enter degrees or in the mil mode to enter mils (see paragraph 2.2.3). X is entered to the nearest tenth of a degree (i.e. 345.0) leading zeros are optional (i.e. 045.0), or to the nearest mil (i.e. 1645). Positive or negative values can be used. The maximum offset values are 359.9 degrees or 6399 mils.

Example: If the compass headings are all 2.5° high, the "A" coefficient should be set to -2.5°.

Set the compass for the type of damping filter for all the outputs:

--User Action-- Type **=dt0,X<cr>**

--Compass Response-- >

X being:

- 0 = Undamped
- 1 = Single IIR
- 2 = Sum and Dump
- 3 = Double IIR
- 4 = Window Averaging



Do not use the Window Averaging command, it is not yet implemented in the C100.)

Sum and dump filter is to be used only in the digital strobed output mode! Do not use the heading data from the serial or analog ports when using this filter.

Set the compass for the damping time used for all the outputs:

--User Action-- Type = **d0,X<cr>**

--Compass Response-- >

X being a:

- 0 = 3 seconds
- 1 = 4.5 seconds
- 2 = 6 seconds
- 3 = 7.5 seconds
- 4 = 9 seconds
- 5 = 12 seconds
- 6 = 14 seconds
- 7 = 16 seconds
- 8 = 20 seconds
- 9 = 24 seconds

Damping is the response time to final value.

To abort any calibration procedure:

--User Action-- Type = **cez<cr>**

--Compass Response-- >
 Calibration aborted

C.6 Autocompensation



When performing any of the autocompensation procedures, it is important that the compass be installed in the host platform. You cannot perform a valid compensation by turning only the compass!

C.6.1 Autocompensation Procedure (Eight Point)

The Eight Point option allows you to perform an 8-point field calibration on the C100 board. During calibration, you will be asked to position the compass to certain headings. It is not important to position the compass exactly, just as long as it's pointing roughly the right way (i.e. $\pm 15^\circ$). All that is required is that the compass reads eight data points in a rough circle, two points per quadrant. It is also permissible to start at any arbitrary heading.

Once the calibration is complete, the program will display a **Score** (first number) and a **Magnetic Environment Count** (second number). The noise score is an indication of the quality of the calibration procedure. The noise score will be a number in the range 0 to 9, 0 being the worst and 9 the best. If the noise score is 7 or below, re-calibration is recommended for optimum accuracy.

The noise score indicates the quality of the data collected:

Noise Score	Approximate <u>Accuracy</u>
9	.5° or better
8	1° or better
7	2° or better
6	4° or better
5	8° or better
4	16° or better
3	32° or better
2	64° or better
1	128° or better
0	256° or better

The magnetic environment count gives an indication of the quality of the magnetic environment, with 9 being the best and 0 the worst. If the value is less than 5, you should consider relocating and re-calibrating the compass in a better environment (i.e. away from magnetic fields and material).

The count indicates the number of times the C100 has been calibrated, and will be a number between 0 and 255.

C.6.1.1 Detailed Calibration Procedure - Terminal Mode (Eight Point)

User calibration consists of entering the calibration mode and sequentially pointing the compass to eight different headings, approximately 45° apart, as directed by the prompt on the screen.

The calibration procedure can be aborted at any time by typing **=cez**.

It is not necessary to start at any particular heading. It is also not critical that these eight points be exactly 45° apart but try to be within $\pm 15^\circ$ of the desired heading. For optimum results, the installed compass should be on a stable platform (i.e. turntable) during this procedure. After installing the C100 in the host system, the calibration procedure should be done in a magnetically clean area.

To start the user calibration process proceed as follows:

1. Halt the output by typing `h <cr>`.



The commands response `>` uses small letters not capital letters. The command `=ce1` consists of an `=` character, two lower case characters `c` and `e`, and the number character `1`.

2. --User Action-- Type `=ce1 <cr>`

--Compass Response-- `>`
 `$000.0`

3. Turn the compass to 000° (This can be any reference heading.)

4. --User Action-- Type `=ce1 <cr>`

--Compass Response-- `>`
 `$045.0`

5. Turn the compass to 045° (This is approx. 45° cw from step 3 position.)

6. --User Action-- Type `=ce1 <cr>`

--Compass Response-- `>`
 `$090.0`

7. Turn the compass to 090° (This is approx. 90° cw from step 3 position.)

Etc. through 315° (turning in 45° steps).

8. --User Action-- Type `=ce1 <cr>`

--Compass Response-- `>`
 `$315.0`

9. Turn the compass to 315° (This is approx. 315° cw from step 3 position.)

10. --User Action-- Type **=ce1**

 --Compass Response-- >

 >

Field Calibration Complete.

Noise Score: X, Y

Calibration Count 21

11. To obtain compass headings type s <cr>

Compass will now provide heading in the mode last programmed.

C.6.2 Autocompensation Procedure (Three Point)

Three Point calibration is only available if you have a compass with revision "C" software or above.

In order to perform 3-point calibration, you will need an accurate external heading reference. You will be prompted to position the compass at 0°, 120°, and 240°. Once the compass is pointed in approximately the correct direction, you need to enter the ACTUAL heading (in degrees only, to the nearest 0.1°), as obtained from your external reference source. You can abort the calibration at any time by typing **=cez**.



Any three reference headings that are approximately 120° ($\pm 10^\circ$) apart can be used. It is not necessary that the first heading entered be at 000°, or that the reference headings be entered in any particular sequence.

The compass accuracy after 3-point calibration is completely dependent on the accuracy of the 3 reference headings.

C.6.2.1 Detailed Calibration Procedure - Terminal Mode (Three Point)

--User Action-- Type **=ce4,0**

--Compass Response-- >

\$000.0, enter actual heading

--User Action-- Type **=ce4, enter first reference heading <cr> (i.e. ce4,002.0<cr>)**

--Compass Response-- >

\$120.0, enter actual heading

--User Action-- Type =ce4, enter second reference heading <cr> (i.e. ce4,115.0<cr>)

--Compass Response-- >
\$240.0, enter actual heading

--User Action-- Type =ce4, enter third reference heading <cr> (i.e. ce4,230.0<cr>)

--Compass Response-- >
>
Three Point Calibration complete

--User Action-- Type ?cs2

--Compass Response-- >
?cs2,9,9,25



Note No cal score is provided at the end of the 3-point method since known points are entered. The cal score will show as a 9,9 followed by a calibration count when ?cs2 is typed in.

C.6.3 Autocompensation Procedure (Circular)

Circular calibration is only available if you have a compass with revision "C" software or above.

Once circular calibration is started, SLOWLY turn the compass in a circle. This should take between 1 and 2 minutes to complete. Once the unit has collected sufficient data, the program will indicate that it is now calculating the calibration coefficients.

Once the calibration is complete, the program will display a **Score** (first number) and a **Magnetic Environment Count** (second number). The noise score is an indication of the quality of the calibration procedure. The noise score will be a number in the range 0 to 9, 0 being the worst and 9 the best. If the noise score is 7 or below, re-calibration is recommended for optimum accuracy.

The noise score indicates the quality of the data collected:

Noise Score	Approximate Accuracy
9	.5° or better
8	1° or better
7	2° or better
6	4° or better
5	8° or better
4	16° or better
3	32° or better
2	64° or better
1	128° or better
0	256° or better

The magnetic environment count gives an indication of the quality of the magnetic environment, with 9 being the best and 0 the worst. If the value is less than 5, you should consider relocating and re-calibrating the compass in a better environment (i.e. away from magnetic fields and material).

The count indicates the number of times the C100 has been calibrated, and will be a number between 0 and 255.

C.6.3.1 Detailed Calibration Procedure - Terminal Mode (Circular)

--User Action-- Type =ce3 <cr>

--Compass Response--

> Circular Calibration Started. > Data Collection Completed. > Circular Calibration complete: Noise Score X,Y Calibration Count 21	The user must turn the compass in a circle until the following message is received. The user now must wait for the response.
--	--

Appendix D. C100 Menu Driven Setup Program

D.1 General

The C100 Compass Engine is a microprocessor-controlled fluxgate compass subsystem which consists of a detachable fluxgate sensing element, a small electronics board, and menu-driven software which allows specific parameters of individual outputs to be controlled via a RS232 input. This software also allows configuration of the C100 for a specific product or connection to a PC (IBM Compatible Personal Computer) for prototype testing.

D.1.1 Introduction

This menu driven setup program enables the user to perform the following operations on the C100 compass board:

- Display/modify the C100 setup parameters (baud rate, output, etc.).
- Communicate with board via Terminal Emulator.
- Perform Field Calibration.

D.1.2 Hardware/Software Requirements

The program runs on any IBM compatible personal computer with 512kb RAM and MS-DOS 3.0 or higher. At least one serial port is required. The program will work with a Microsoft compatible mouse, however a mouse is not required.

D.1.3 Cabling Requirements

In order for the PC to talk to the C100 board, a connecting cable that meets the following guidelines is required:

C100 Pin Number		PC Pin Number on Serial Port	
		DB-9	DB-25
J2-6 (gnd)	Blk	5	7
J2-11 (TXD output)	Pink	2	3
J2-4 (RXD input)	Yellow	3	2



On some PC's, it may be required to connect the following pins together on the serial port connector.

- RTS (Request to Send) to CTS (Clear to Send)
- DSR (Data Set Ready) to DTR (Data Terminal Ready)

D.2 Program Operation

D.2.1 Installation

The program is provided on a 3½ inch, high density, 1.44 MB diskette. The program can be run directly off the distribution diskette or copied onto a hard disk. If you do wish to install the program on a hard disk, please make sure that the following files are included:

- **C100USR.EXE** - Main program file
- **CLIST.TXT** - Contains choice list text

D.2.2 Running the Program

At the DOS prompt, change to the drive and directory where the .EXE file is located and type **C100USR** and press <ENTER>. Alternatively, you could include the drive and directory in the PATH statement in your AUTOEXEC.BAT file.

The program will display the main menu from which all your selections are made. The options include:

D.2.2.1 Setup

The **Setup** option allows you to configure the communications setup for your hardware. Using this option you can select the port to which the C100 board is connected, and the baud rate at which to communicate. The default port is COM1 and the default baud rate is 4800.

Use the up and down cursor keys to select which COM port you wish to use and press <ENTER>. Now select the appropriate baud rate, again using the up and down cursor keys, and press <ENTER>. The new port and baud rate settings will now take effect. You can discard your changes by pressing <ESC>.



The setup mode applies only to the PC and does not affect the baud rate of the C100.

Selecting the "Echo Characters?" choice causes the typed in commands and inquiries to be displayed on the screen in the Terminal Mode. This choice is normally selected.

Selecting the "Display Unprintables?" choice causes the carriage return and line feed characters to be displayed. This choice is not normally selected.

[KVH Industries Inc - C100 Setup Program]

Setup **Parameters** **Terminal Mode** **Calibrate** **Quit**

[System Default Setup]

[Port]	[Baud]
(.) COM1	() 9600
() COM2	(.) 4800
() COM3	() 2400
() COM4	() 1200
	() 600
	() 300

☒ Echo characters?

☐ Display unprintables?

OK CANCEL

Set system defaults.

Setup Display

D.2.2.2 Parameters

The **Parameters** option allows you to display/edit the C100 board setup parameters. All the relevant information is displayed on an easy-to-read form. Certain fields are for informational purposes only and cannot be altered. Using the cursor keys, you can move the highlight bar from field to field.

As you move around the form, a message will be displayed on the bottom line of the screen giving you more information about the currently highlighted field, including what actions can be performed on that field.

Most of the fields cannot be edited directly. Instead, valid values for the field can be selected from a choice list that is activated by pressing the <F2> key. When a choice list is active, you can use the up and down cursor keys to highlight the item you wish and then press <ENTER> to select it. If you wish to leave the contents of the field unchanged, simply press <ESC>.

Some of the fields that have a choice list attached to them may also be entered manually. The **Message Rate** field is an example of this. You can either select a pre-defined rate using the <F2> as described above, or type in one of your own.

Where a field has only one of two possible values, pressing the <SPACE> bar will toggle between them. No other keys have any effect. The **Powerup Mode** field is an example of this type. Its two values are **SENDING** and **NOT SENDING**, indicating whether or not the compass will be sending continuous heading messages at the default data rate when it is switched on, or when you go into the terminal mode.

One special feature is the ability to save the current parameters and then recall them later, possibly for use on a different C100 compass board. This can be very useful if you wish to set up a number of boards with identical parameters; you don't have to go through the whole setup process with every single board, just the first one. To save the current parameters, press <CTRL-S>. Once you have saved a set of parameters you can press <CTRL-D> to recall them. If no parameters have been saved yet, this will have no effect.

These defaults are saved between sessions in a file called **C100.CFG** in the current directory of the current drive. If there is not enough space on the drive for this file, the defaults are **NOT** saved. This program will only store one set of parameters. If you save a new set, the old one is overwritten.

When you have made all the changes you want, press the <F10> key and the program will update the parameters on the C100 board itself. If no changes have been made, nothing will be stored. If you have made changes and decide that you do not want them written to the compass, pressing the <ESC> key will abandon what you have done. You will be prompted to confirm that this is indeed what you wish to do.

[KVH Industries Inc - C100 Setup Program]					
Setup	Parameters				
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px; vertical-align: top;"> [General] Serial Number: 0000000 Unit Type: C100 Calibration Date: 99/99/99 Hardware Version: x Software Version: X [Variation/Declination] Heading Type: magnetic Variation: 0.0 'A' Offset: 0.0 [Power-Up Mode] Powerup Mode: Sending </td> <td style="width: 50%; padding: 5px; vertical-align: top;"> [Serial] Baud Rate: 4800 Message Rate: 60 Message Type: 0 Message Units: d [Digital] Output Type: 0 Output Format: 1 [Analog] Output Format: 0 [Damping] Type: 3 Rate: 0 </td> </tr> <tr> <td style="padding: 5px; vertical-align: top;"> ESC-Quit without update. F10-Update and exit. ^S-Set Defaults. </td> <td style="padding: 5px; vertical-align: top;"> F2-Display choice list (if any). ^D-Restore Defaults. </td> </tr> </table>		[General] Serial Number: 0000000 Unit Type: C100 Calibration Date: 99/99/99 Hardware Version: x Software Version: X [Variation/Declination] Heading Type: magnetic Variation: 0.0 'A' Offset: 0.0 [Power-Up Mode] Powerup Mode: Sending	[Serial] Baud Rate: 4800 Message Rate: 60 Message Type: 0 Message Units: d [Digital] Output Type: 0 Output Format: 1 [Analog] Output Format: 0 [Damping] Type: 3 Rate: 0	ESC-Quit without update. F10-Update and exit. ^S-Set Defaults.	F2-Display choice list (if any). ^D-Restore Defaults.
[General] Serial Number: 0000000 Unit Type: C100 Calibration Date: 99/99/99 Hardware Version: x Software Version: X [Variation/Declination] Heading Type: magnetic Variation: 0.0 'A' Offset: 0.0 [Power-Up Mode] Powerup Mode: Sending	[Serial] Baud Rate: 4800 Message Rate: 60 Message Type: 0 Message Units: d [Digital] Output Type: 0 Output Format: 1 [Analog] Output Format: 0 [Damping] Type: 3 Rate: 0				
ESC-Quit without update. F10-Update and exit. ^S-Set Defaults.	F2-Display choice list (if any). ^D-Restore Defaults.				
C100 Parameter Editor.					

Parameter Display



The command "=dt0,4" (Damping Type 4) for Window Averaging is not yet implemented in the C100. Do not select Damping Type 4.

D.2.2.3 Terminal Mode

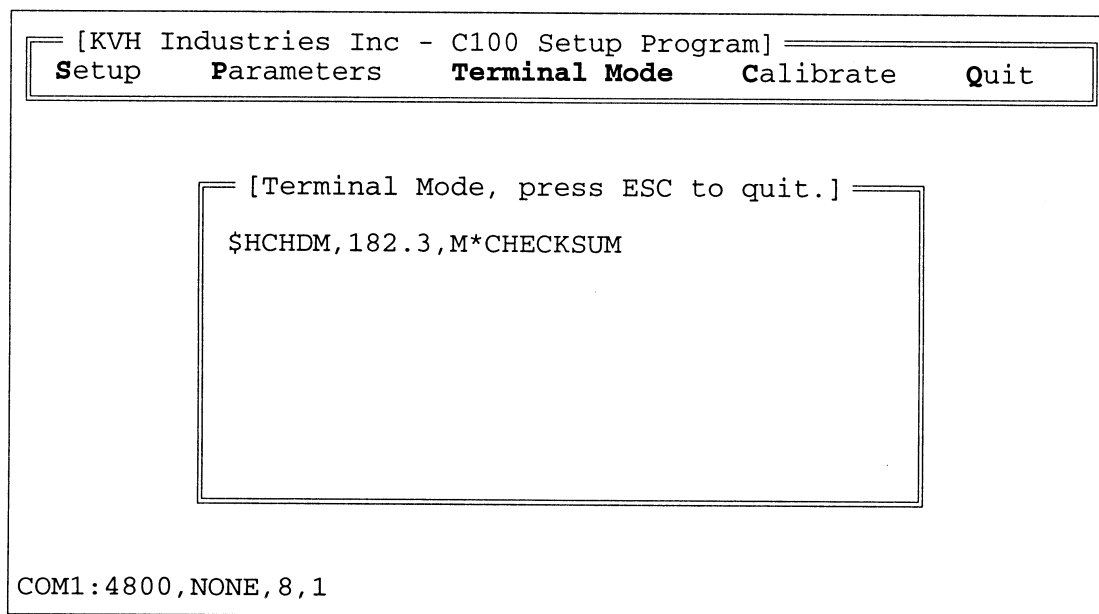
Terminal Mode allows you to communicate directly with the C100 board. Via this mode, you have access to all the functions of the compass, including those made available by the **Parameters** menu option. Refer to Appendix C "C100 User Commands", of the C100 Technical Manual for information on the commands you can use while in terminal mode.

Once connected to the C100 board, the terminal emulator will display the communications setup parameters at the bottom of the screen. The display will be similar to the following example:

COM1:4800,NONE,8,1

This indicates that the C100 is connected to **COM1** at **4800** baud, **No** parity, **8** data bits and **1** stop bit.

To leave the terminal mode, press the <ESC> key, and you will return to the main menu.



Terminal Mode Display

D.2.2.4 Calibrate

This option displays a sub-menu with the following options:

- **Eight Point** - The Eight Point option allows you to perform an 8-point field calibration on the C100 board. During calibration, you will be asked to position the compass to certain headings. It is not important to position the compass exactly, just as long as it's pointing roughly the right way (i.e. $\pm 15^\circ$). All that is required is that the compass reads eight data points in a rough circle, two points per quadrant. It is also permissible to start at any arbitrary heading.

Once the calibration is complete, the program will display a **Score** and a **Magnetic Environment Count**. The noise score is an indication of the quality of the calibration procedure. The noise score will be a number in the range 0 to 9, 0 being the worst and 9 the best. If the noise score is 7 or below, re-calibration is recommended for optimum accuracy. The magnetic environment count gives an indication of the quality of the magnetic environment, with 9 being the best and 0 the worst. If the value is less than 5, you should consider relocating and re-calibrating the compass in a better environment (i.e. away from magnetic fields and material). The count indicates the number of times the C100 has been calibrated, and will be a number between 0 and 255.

[KVH Industries Inc - C100 Setup Program]				
Setup	Parameters	Terminal Mode	Calibrate	Quit
			Eight Point Three Point Circular	
Position compass to $\pm 45^\circ$. . . Position compass to $\pm 90^\circ$. . . Position compass to $\pm 135^\circ$. . . Position compass to $\pm 180^\circ$. . . Position compass to $\pm 225^\circ$. . . Position compass to $\pm 270^\circ$. . . Position compass to $\pm 315^\circ$. . . 8-point calibration complete! Cal score = 9, environment = 9, count = 17. [Press any key . . .]				
Perform 8-point calibration on C100.				

Eight-Point Calibration Display

- **Three Point** - Three Point calibration is only available if you have a compass with revision "C" software or above.

In order to perform 3-point calibration, you will need an accurate external heading reference. You will be prompted to position the compass at 0°, 120°, and 240°. Once the compass is pointed in approximately the correct direction, you need to enter the ACTUAL heading (in degrees only, to the nearest 0.1°), as obtained from your external reference source. You can abort the calibration at any time by pressing <ESC>.



Any three reference headings that are approximately 120° (±10°) apart can be used. It is not necessary that the first heading entered be at 000°, or that the reference headings be entered in any particular sequence.

The compass accuracy after 3-point calibration is completely dependent on the accuracy of the 3 reference headings.

[KVH Industries Inc - C100 Setup Program]		
Setup	Parameters	Terminal Mode
Calibrate		Quit
Eight Point Three Point Circular		
Three-Point Calibration started. Position compass to about 0° and enter actual heading. Position compass to about 120° and enter actual heading. Position compass to about 240° and enter actual heading. Three-Point calibration complete! Cal score = 9, count = 18. [Press any key . . .]		
Perform 3-point calibration on C100.		

Three-Point Calibration Display

- **Circular** - Circular calibration is only available if you have a compass with revision "C" software or above.

Once circular calibration is started, SLOWLY turn the compass in a circle. This should take between 1 and 2 minutes to complete. Once the units has collected sufficient data, the program will indicate that it is now calculating the calibration coefficients. You can abort the calibration at any time by pressing <ESC>.

Once the calibration is complete, the program will display a **Score** and a **Magnetic Environment Count**. The noise score is an indication of the quality of the calibration procedure. The noise score will be a number in the range 0 to 9, 0 being the worst and 9 the best. If the noise score is 7 or below, re-calibration is recommended for optimum accuracy. The magnetic environment count gives an indication of the quality of the magnetic environment, with 9 being the best and 0 the worst. If the value is less than 5, you should consider relocating and re-calibrating the compass in a better environment (i.e. away from magnetic fields and material). The count indicates the number of times the board has been calibrated, and will be a number between 0 and 255.

[KVH Industries Inc - C100 Setup Program]		
Setup	Parameters	Terminal Mode
		Calibrate Eight Point Three Point Circular
Circular calibration started. Turn compass SLOWLY in a circle . . . Finished Circular calibration complete! Cal score = 9, environment = 9, count = 20. [Press any key . . .]		
Perform circular calibration on C100.		

Circular Calibration Display

D.3 Troubleshooting

If for some reason you have difficulty communicating with the C100 board, the following steps may remedy the situation:

- Check the power and serial connections.
- Check to see if the correct serial port is selected using the **Setup** menu option.
- Check to see if the correct baud rate is selected using the **Setup** menu option.
- If **Terminal Mode** works, but you get errors in **Parameters** or **Calibrate** modes, enter terminal mode and type **zap** followed by <ENTER>. This will re-boot the compass board.
- Try re-booting your PC and re-running the program.
- Try a hard reset of the C100 by turning off and on the power to the C100.
- Try using a terminal emulator program such as Procomm™ to talk to the compass. Set the communication parameters to 4800 baud, no parity, 8 data bits, and 1 stop bit. If this works and our program does not, please contact us and let us know so that we may take corrective action.



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