WEC Data description document for public release

AMOG WEC Phase 2 at FaBTest

University of Exeter, Falmouth Campus

Engineering solutions

Engineering solutions

16th October 2019

WEC Data description document

AMOG WEC Phase 2 at FaBTest

University of Exeter, Falmouth Campus

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1 DISCLAIMER

We are releasing the attached WEC (Wave Energy Converter) dataset and information on an "AS-IS" basis. We do not represent, warrant, or otherwise guarantee, expressly or impliedly, the merchantability, fitness for a particular purpose, suitability, accuracy, reliability, or completeness of this data or information or the products, materials, or processes described. Each recipient or user is solely responsible for all determinations regarding any use of the data or information in its areas of interest. We expressly disclaim liability for any loss, damage, or injury directly or indirectly suffered or incurred as a result of or related to anyone using or relying on any of the attached data or information. Each recipient or user is solely responsible for obtaining any necessary, third-party software or other license to use the data and information. Through this release, we grant no express or implied license under any patent rights regarding the use of this data and information. We will at our sole discretion determine whether to discuss any specific questions or issues regarding the data and information. There is no endorsement of any product or process, and we expressly disclaim any contrary implication.

2 PURPOSE

The following document is a data description document that accompanies the publicly released raw data obtained as part of the Marine-i 002 AMOG Wave Energy Converter small scale testing program. The testing was carried out in the summer and autumn of 2019 at FaBTest, a nursery wave energy test site, located offshore Falmouth Cornwall UK.

This document is structured as follows:

- Section 1 is a disclaimer on the release of the database.
- Section 2 provides the purpose and structure of the document.
- Section 3 is the project background.
- Section 4 contains a data description including experiment dates (4.2). donor contact (4.3), facility location (4.4), description of tests and objectives (4.5), summary of known limitations (4.6), test procedures (4.7), experiment media (4.8), WEC device (4.9), instrumentation (4.10), components & interconnections (4.11), configurable parameters (4.12), time delay between instruments (4.13) and citations required if making use of the data for publications (4.14).
- Section 5 contains a description of the collected response data.

3 PROJECT BACKGROUND

3.1 AMOG'S WEC

AMOG Technologies is in the process of developing a Wave Energy Converter (WEC) device. The AMOG Group of Companies has a long track record in supporting other companies in developing their WEC concept, of which we have learnt from the pitfalls others have found on their way through development.

As a result, AMOG Technologies has developed their own concept, focusing on the following design principles to avoid some of the pitfalls of previous generations of devices:

- Mechanical reliability
- Survivability
- Low cost install
- Not re-inventing the wheel
- Low cost to maintain/operate

The underlying concept behind AMOG's WEC comes from decades of experience in the marine engineering industry. The concept behind AMOG's WEC is the traditional dynamic vibration absorber or roll stabilisation device. A traditionally tuned DVA system uses a small, secondary, mass moving out of phase with the vessel's motions to reduce these motions, with the effect of making the smaller mass (the DVA) dynamic – which is effectively transferring the kinetic energy from the rolling vessel into the kinetic energy of the secondary mass mass. AMOG's WEC retunes the classical DVA system to maximise the energy transfer and uses a swinging pendulum as the secondary mass which turns a generator to generate electricity.

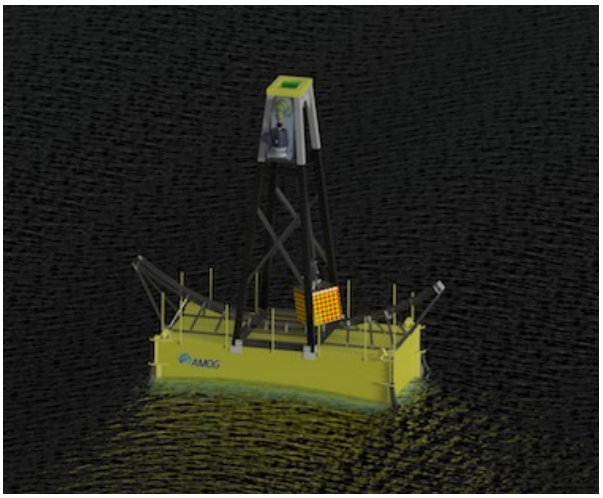


Figure 1: WEC Overview

3.2 PROJECT HISTORY – PHASE ONE

The AMOG WEC has been developed from concept sketches, utilising the fundamental principles of DVAs. Extensive hydrostatic and time domain hydrodynamic numerical modelling has been performed, with:

- 10 different hull forms trialled
- 1000s of models analysed to optimise the damping level, natural period selection and vessel roll period characteristics for different sea states and water depths.

Subsequent to numerical modelling, wave tank testing was performed in the largest facility available in Australia at AMC-UTAS. A physical scale of ~1:30 was used (where the full scale device is 25 m long and the model was ~800 mm long). This testing provided calibration parameters for numerical modelling which carried through to Phase Two.

3.3 AMOG WEC PHASE TWO - FABTEST TECHNOLOGY DEMONSTRATOR

Phase Two of AMOG's WEC development was undertaken during the UK Summer 2019, with the technology demonstrator of the AMOG WEC at approximately 1/3rd length scale. The wave energy device consisted of a floating vessel with a spread four-line mooring with drag-embedment anchors.

A series of tests were undertaken in order measure the response of the technology demonstrator WEC device to the seastates present at the FaBTest deployment site. The following document outlines the tests undertaken and the nature of the data collected during Phase two of the project.

4 DATA DESCRIPTION

The following section outlines the nature of the raw data obtained during the testing of the AMOG technology demonstrator small scale WEC.

4.1 TEST NAMES

The tests are identified as Survival mode tests or Operational mode tests.

4.2 EXPERIMENT DATES

Each data set parameter has an associated date-time value. Survival & Operational test data spans from the 14th of August to the 4th of October 2019.

4.3 DONOR CONTACT

The primary contact is:

Dr. Hayden Marcollo

Contactable via email:

hayden.marcollo@amog.consulting

4.4 TEST FACILITY & LOCATION

The test Facility is FaBTest, Falmouth, Cornwall, UK.

GPS coordinates for the location of the device are included in each dataset data sample. The device installation location coordinates are: 050° 06' 16.4" N, 004° 59' 06.0" W.

4.5 DESCRIPTION OF TESTS AND OBJECTIVES

There are two groups of tests, survival and operational.

- The survival tests are intended to measure the seaworthiness of the device and assess the response of the device and moorings during relatively energetic seastates. During survival testing the pendulum on the device is locked in place and no power is produced.

- The operational tests are intended to assess the effectiveness of the device power-take-off system and the application of dynamic vibration absorption theory for a wave energy device. During operational tests, the pendulum is allowed to swing but damped via the power-take-off system. The load on the power-take-off system is set by the variable 'damping level' and physically occurs by setting different combinations of electrical resistance on the underwater thermal heaters.

4.6 SUMMARY OF KNOWN LIMITATIONS OF THE OVERALL EXPERIMENT

The device is optimised for head-on swell conditions. Constrained by a 4 point catenary mooring, the angle of incidence of oncoming swell is dictated by local environmental

conditions. Conditions prevalent during the experiment were often beam-on to the device and suboptimal for power generation.

The heading values of the device are provided by a fluxgate compass. It is likely that interference from onboard electronics and/or the steel structure of the device led to the fluxgate compass producing unreliable values.

The device power-take-off system includes a 90 degree step-up gearbox. The manufacturers of the gearbox advise that the gearbox exhibits an initial breakout period with significant mechanical resistance. An amount of energy will have been taken from the system in order to overcome the mechanical resistance present in the power-take-off system. The amount of energy lost to this mechanical source will not have been constant for the duration of the experiment.

4.7 TEST PROCEDURES

Testing was dictated by environmental conditions at the test site. Data was logged for the majority of the deployment. During periods of unfavourable seastates the device was put into survival mode and data logged. When favourable and/or novel seastates occurred, the device was put into operational mode and data logged. When in operational mode the power take off load, or device damping, was cycled through the 7 available discrete states, each defined as a percentage of critical damping. A 15 minute interval was typically allowed per damping state during testing. Automatic shutdowns prevent the device from exceeding design limits. However, the device operator ensures the damping state chosen is sufficient to prevent regular pendulum over-motion. When assessing the data, check that the damping level variable remains constant for a period of interest. Also check that the actuator lengths are not changing dramatically as this can indicate the pendulum bob was being lowered onto the track and hence braking of the pendulum was occuring.

4.8 EXPERIMENT MEDIA

Data, test logs, videos and a photo are provided in the download data.

4.9 WEC DEVICE

Figure 2 shows a CAD render of the device tested.

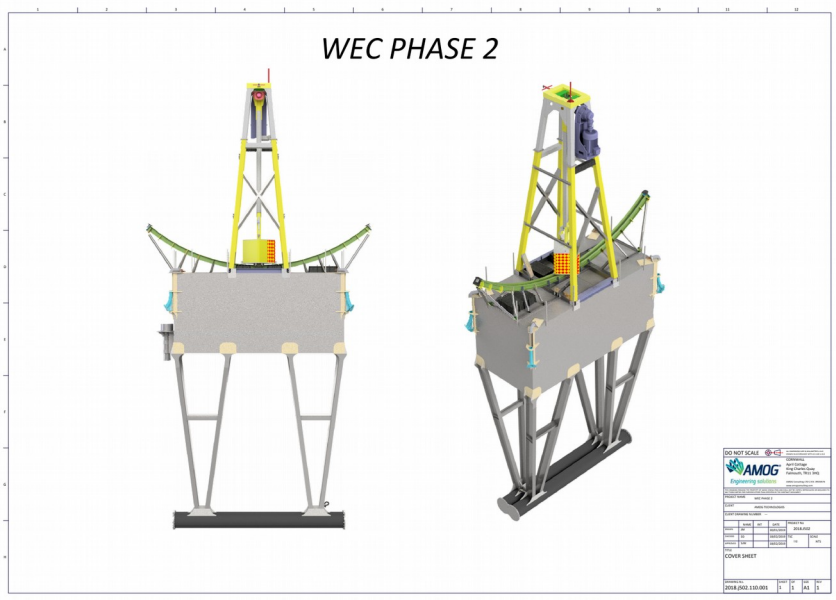


Figure 2: Small scale WEC device CAD model

Figure 3 shows the device in survival mode.

Figure 3: Small scale WEC device in survival mode at FaBTest

Figure 4 shows the device in operational mode.

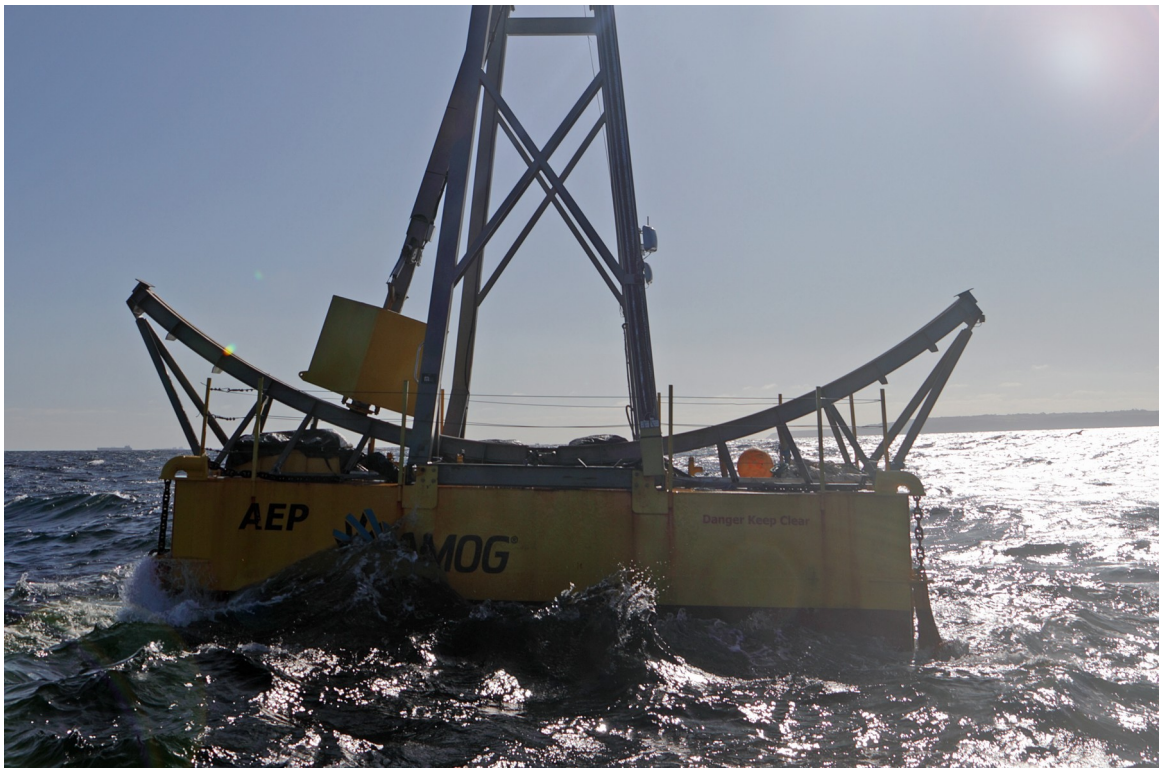


Figure 4: Small scale WEC device in operational mode at FaBTest

4.10 INSTRUMENTATION

Data is logged via various off-the-shelf telemetry components. The datasheets associated with each component is included in Appendix A.

4.11 COMPONENTS & INTERCONNECTIONS

Figure 5 shows a high-level system block diagram outlining the system structure and the origin of data values.

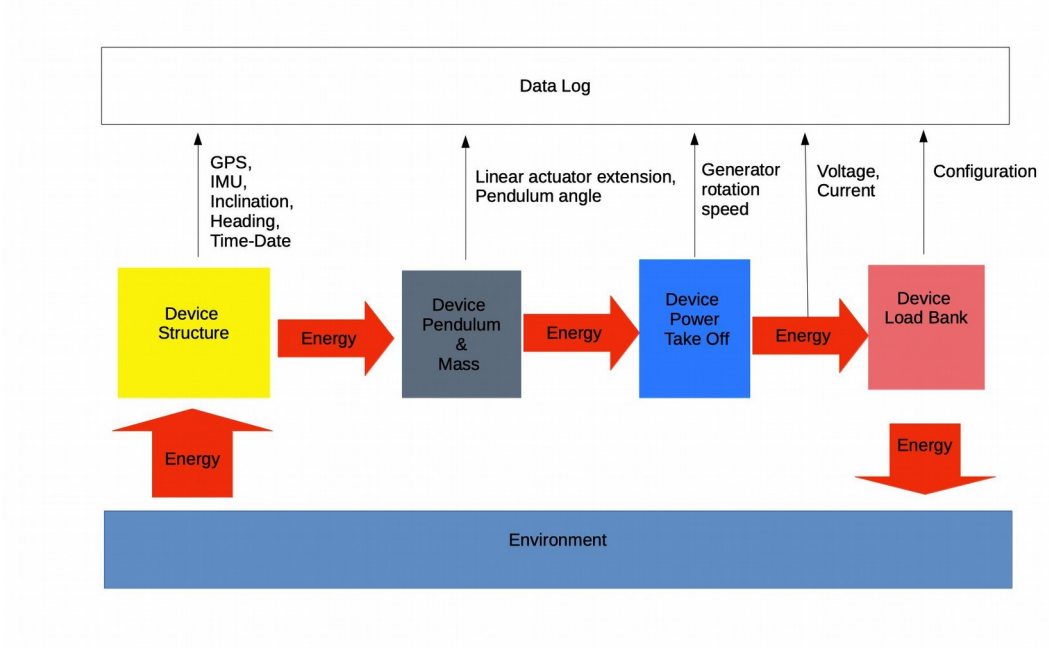


Figure 5: Small scale WEC device high-level block diagram

4.12 CONFIGURABLE PARAMETERS

The configurable parameters present in the experiment are the instrument calibrations and the device safety limits.

The majority of instrumentation was sourced in a calibrated state. Instrumentation measuring the mechanics of the device was calibrated to the device in-house. Such as, addition of an off-set constant to the pendulum angle value, in order to present a 0 degree angle value for the pendulum in the vertical position. The shaft encoder measuring the pendulum angle was initially mounted with its zero point at the pendulum resting position, therefore no off-set constant was required. It was only when, on 3Oct19, that the measured pendulum angle zero-point visibly and suddenly moved out by 16 degrees, that an offset was applied to the measurements.

Other configurable parameters are the device safety limits. Maximum values for: power generation, pendulum motion, hull motion and device wander were included in the device firmware. Exceeding any of the software defined maximum values results in the device transitioning into survival mode and appropriate alerts being generated.

4.13 TIME DELAY BETWEEN DIFFERENT COMPONENTS AND SYSTEMS

There is no significant time delay between any of the components & systems. Table 1 lists the calculated delays. At certain times the control system clock was adjusted to match UTC time when it was observed to drift over the course of a week.

Table 1: Approximate worst-case time delays of measurements

Measurement	**Worst case time delay[1]**	**Unit**
Generator voltage	0.250625	sec
Generator current	0.300625	sec
Pendulum Angle	0.000725	sec
Accelerations	0.000625	sec
Inclinometer	0.050625	sec
Generator speed	0.100002	sec
Heading	0.011667	sec
Longitude/latitude	0.261250	sec

Note:
1. Worst case time delays are relative to the time stamp that each measurement is logged with. For the 1 Hz data sets, the time delay is with respect to the time stamp applied on the PLC, as apposed to the time stamp applied on the PC.

4.14 CITATION FOR JOURNAL OR CONFERENCE PAPERS

If you are citing this data for a publication please ensure:

- that the electronic location where you obtained the data is referenced,
- you acknowledge AMOG as the provider of the data,
- you acknowledge that project was funded by ERDF c/o Marine-i and the Cornwall Development Company.

5 DATA SETS

The data is provided in two data set formats at various times of testing. The first format is logged at 10Hz and was saved locally on the device. The second format was logged at 1Hz and was streamed directly from the device. The parameters in both data sets are the same and are tabulated in Table 2. The data logged at 1Hz was only recorded when there was a constant wireless connection between the device and control PC. During periods of poor connection the parameter values for the 1Hz data remain constant until a connection is re-established.

All time is in UTC (not local summer time).

5.1 TEST LOGS

A test log register and the corresponding test logs are provided in the /Test Log folder. These are all related to Operational tests.

5.2 10HZ DATA SETS

The data sets logged at 10Hz are identifiable by a date-time file name which refers to the date-time of the first data sample in that data set, e.g. '*2019-09-13_02-15-25'.* These files are 90 minutes long. Some data sets are operational, some are survival.

5.3 1HZ DATA SETS

The 1 Hz data sets are named *WEC_Data_Log* followed by a unique number, e.g. '*WEC_Data_Log7'.* Some data sets are operational, some are survival.

5.4 WAVE BUOY DATA

Wave buoy data is also available for download from the same location. This is 30min average data. For definitions of the parameters check fabtest.com or failing that, consult with University of Exeter, Falmouth campus.

Table 2: Dataset: parameters, units and conventions

Parameter/Heading	**Unit**	**Convention**
Record	NA	Row number
Date	DD/MM/YYYY	
UTC Time	hh/mm/ss	UTC
Nanosecond	ns	Nanoseconds after UTC time
Roll	Degrees	A stbd list is positive
Pitch	Degrees	Pitching up at bow is positive
Acceleration X	g	+X points towards the stern
Acceleration Y	g	+Y points starboard
Acceleration Z	g	+Z points towards the sky
Latitude	Degrees	
Longitude	Degrees	
Pendulum Angle	Degrees	Positive to stern
Generator Speed	RPM	Absolute value
Generator Voltage	V	Voltage across phase 1 and 2
Generator Current	A	Current through phase 1
State	Number	1(Survival mode), 2(Lifting mode), 3(operational mode), 4(braking mode)
Damping	Number	Corresponds to a percentage of electrical damping 0(0%), 1(5%), 2(10%), 3(15%), 4(25%), 5(30%), 6(35%), 7(40%). Additional mechanical damping is yet to be quantified at the time of writing of this document.
CoodinationTag	Number	Number of connection coordination signals received in a given time frame
ActuatorLen1	mm	Extension length, pendulum mass rises as extension decreases
ActuatorLen2	mm	Extension length, pendulum mass rises as extension decreases

Appendix A Instrumentation Datasheets

Appendix Contents List

Document Name/Number	No of pages
Voltage Transducer Technical Specification	2
GPS 18x Technical Specification	38
Pendulum Angle Encoder Manual	15
Generator Shaft Encode Specification	4
Inclinometer datasheet	7
Accelerometer datasheet	6
Compass manual	10
Current Transducer datasheet	6

Notes:
1. All documents in this appendices maintain their original numbering.

DIN RAIL / PANEL MOUNT, TRUE RMS

Single Element
1.0 to 600 VAC Input Range

Three Element
1.0 to 600 VAC Input Range

The **CR4500** Series, True RMS Voltage Transducers and Transmitters are designed for applications where AC voltage waveforms are not purely sinusoidal. More precise and accurate than other devices, these units are ideal in chopped wave and phase fired control systems.

Applications

Phase fired controlled devices
Quickly varying voltage supplies
Chopped waveform drivers
Harmonic voltages

Features

35mm DIN rail mount or panel mount
Available with 0-5 VDC, 0-10VDC or 4-20 mADC output
24 VDC powered
Highest precision available
Outputs isolated from inputs
Connection diagram printed on case

Regulatory Agencies

Recognized to meet UL 61010B-1
Constructed to meet CAN/CSA-C22.2, No. 61010-1-2004
Meets requirement of IEC 61010-1 and BS EN 61010-1

CE RoHS 2002/95/EC c UL us **E199795**

Add suffix for input range

PART NUMBERS			
CR4510	-		Single element with 0 - 5 VDC output
CR4511	-		Single element with 0 - 10 VDC output
CR4520	-		Single element with 4 - 20 mADC output
CR4550	-		3-Phase 3-Wire with 0 to 5 VDC Output
CR4560	-		3-Phase 3-Wire with 4 - 20 mADC Output
CR4570	-		3-Phase 4-Wire with 0 to 5 VDC Output
CR4580	-		3-Phase 4-Wire with 4 - 20 mADC Output

50 - 0-50 VAC
150 - 0-150 VAC
250 - 0-250 VAC
500 - 0-500 VAC

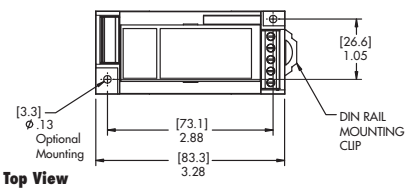
Ranges available up to and including 600 VAC

*** UL Recognized up to 300 Vac**

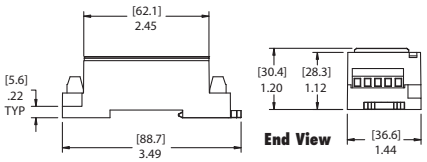
CR Magnetics has a wide selection of Potential Transformers to extend the range of any part. Contact factory for more information.

SPECIFICATIONS

Basic Accuracy:	0.5%		
Linearity:	10% to 100% FS		
Calibration:	True RMS Sensing		
Thermal Drift:	500 PPM/°C		
Operating Temperature:	0°C to +60°C		
Installation Category:	CAT II		
Vibration Tested To:	IEC 60068-2-6,1995		
Pollution Degree:	2		
Response Time:	250 ms		
Altitude:	2000 meter max.		
Insulation Voltage:	2500 Vdc		
Supply Voltage:	24 Vdc ±10%		
Frequency Range:	20 Hz - 5 KHz		
Cleaning:	Water-dampened cloth		
MTBF:	Greater than 100 K hours		
Output Load:	4-20 mADC - 0 to 300 Ω		
	0-5 VDC - 2K Ω or Greater		
Relative Humidity:	5% to 95%, Non-Condensing		
Supply Current:			
CR4510:	Typical 15mA	Max 25mA	
CR4520:	Typical 25mA	Max 40mA	
CR4550/70:	Typical 20mA	Max 60mA	
CR4560/80:	Typical 55mA	Max 110mA	
Torque Specs.:	3.0 inch lbs. (0.4Nm)		
Weight:	0.5 lbs.		



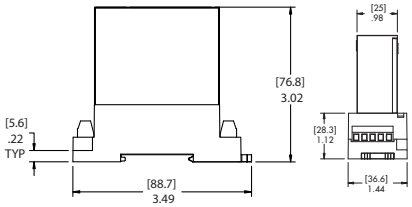
Top View



End View

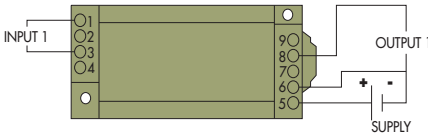
CR4510 CR4511 CR4520

End View

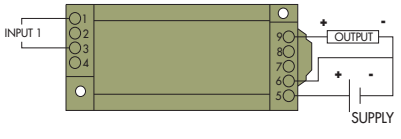


CR4550 CR4560 CR4570 CR4580

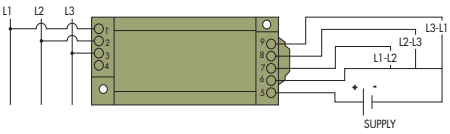
OUTLINE DRAWING



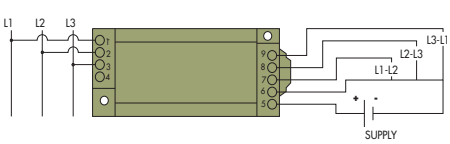
CR4510 Single Phase - 0 - 5 VDC Output
CR4511 Single Phase - 0 - 10 VDC Output



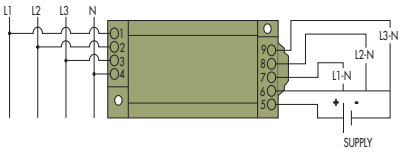
CR4520 Single Phase - 4 - 20 mADC Output



CR4550 3 Phase, 3 Wire - 0 - 5 VDC Output



CR4560 3 Phase, 3 Wire - 4-20 mADC Output



CR4570 3 Phase, 4 Wire - 0 - 5 VDC Output

CR4580 3 Phase, 4 Wire - 4 - 20 mADC Output

CONNECTION DIAGRAM

USE CR MAGNETICS LOW AND MEDIUM VOLTAGE POTENTIAL TRANSFORMERS (SECTION G)

NOTE: The building installation must have a switch or circuit-breaker that is in close proximity and within easy reach of the operator. The switch or circuit breaker shall be marked as the disconnecting device for the equipment.

GPS 18x TECHNICAL SPECIFICATIONS

GARMIN®

Garmin International, Inc.
1200 E. 151st Street
Olathe, KS 66062 USA

190-00879-08 Revision D
October 2011

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New Taipei City, 221, Taiwan (R.O.C.)
Tel. 886/2.2642.9199
Fax 886/2.2642.9099

Web site address: www.garmin.com

RECORD OF REVISIONS

Revision	Revision Date	Description	ECO #
A	12/7/07	Initial Release	--
B	1/15/08	Revised and Redrawn	50283
C	9/2/08	Revised and Redrawn	56061
D	10/3/11	Revised and Redrawn	85241

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LIST OF TABLES AND FIGURES

1 INTRODUCTION

1.1 CAUTIONS

CAUTION

The GPS system is operated by the government of the United States, which is solely responsible for its accuracy and maintenance. Although the GPS 18x is a precision electronic NAVigation AID (NAVAID), any NAVAID can be misused or misinterpreted, and therefore become unsafe. Use these products at your own risk. To reduce the risk, carefully review and understand all aspects of these Technical Specifications before using the GPS 18x. When in actual use, carefully compare indications from the GPS to all available navigation sources including the information from other NAVAIDs, visual sightings, charts, etc. For safety, always resolve any discrepancies before continuing navigation.

FCC Compliance

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and may cause harmful interference to radio communications if not installed and used in accordance with the instructions. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet that is on a different circuit from the GPS unit.
- Consult the dealer or an experienced radio/TV technician for help.

This product does not contain any user-serviceable parts. Repairs should only be made by an authorized Garmin service center. Unauthorized repairs or modifications could result in permanent damage to the equipment, and void your warranty and your authority to operate this device under Part 15 regulations.

1.2 LIMITED WARRANTY

This Garmin product is warranted to be free from defects in materials or workmanship for one year from the date of purchase. Within this period, Garmin will, at its sole option, repair or replace any components that fail in normal use. Such repairs or replacement will be made at no charge to the customer for parts or labor, provided that the customer shall be responsible for any transportation cost. This warranty does not apply to: (i) cosmetic damage, such as scratches, nicks and dents; (ii) consumable parts, such as batteries, unless product damage has occurred due to a defect in materials or workmanship; (iii) damage caused by accident, abuse, misuse, water, flood, fire, or other acts of nature or external causes; (iv) damage caused by service performed by anyone who is not an authorized service provider of Garmin; or (v) damage to a product that has been modified or altered without the written permission of Garmin. In addition, Garmin reserves the right to refuse warranty claims against products or services that are obtained and/or used in contravention of the laws of any country.

This product is intended to be used only as a travel aid and must not be used for any purpose requiring precise measurement of direction, distance, location or topography. Garmin makes no warranty as to the accuracy or completeness of map data in this product.

THE WARRANTIES AND REMEDIES CONTAINED HEREIN ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES EXPRESS, IMPLIED, OR STATUTORY, INCLUDING ANY LIABILITY ARISING UNDER ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, STATUTORY OR OTHERWISE. THIS WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS, WHICH MAY VARY FROM STATE TO STATE.

IN NO EVENT SHALL GARMIN BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES, INCLUDING, WITHOUT LIMITATION, DAMAGES FOR ANY TRAFFIC FINES OR CITATIONS, WHETHER RESULTING FROM THE USE, MISUSE OR INABILITY TO USE THE PRODUCT OR FROM DEFECTS IN THE PRODUCT. SOME STATES DO NOT ALLOW THE EXCLUSION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE ABOVE LIMITATIONS MAY NOT APPLY TO YOU.

Garmin retains the exclusive right to repair or replace (with a new or newly-overhauled replacement product) the device or software or offer a full refund of the purchase price at its sole discretion. SUCH REMEDY SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY BREACH OF WARRANTY.

To obtain warranty service, contact your local Garmin authorized dealer or call Garmin Product Support for shipping instructions and an RMA tracking number. Securely pack the device and a copy of the original sales receipt, which is required as the proof of purchase for warranty repairs. Write the tracking number clearly on the outside of the package. Send the device, freight charges prepaid, to any Garmin warranty service station.

Online Auction Purchases: Products purchased through online auctions are not eligible for warranty coverage. Online auction confirmations are not accepted for warranty verification. To obtain warranty service, an original or copy of the sales receipt from the original retailer is required. Garmin will not replace missing components from any package purchased through an online auction.

International Purchases: A separate warranty may be provided by international distributors for devices purchased outside the United States depending on the country. If applicable, this warranty is provided by the local in-country distributor and this distributor provides local service for your device. Distributor warranties are only valid in the area of intended distribution. Devices purchased in the United States or Canada must be returned to the Garmin service center in the United Kingdom, the United States, Canada, or Taiwan for service.

Garmin's Marine Warranty Policy: Certain Garmin Marine products in certain areas have a longer warranty period and additional terms and conditions. Go to www.garmin.com/support/warranty.html for more details and to see if your product is covered under Garmin's Marine Warranty Policy.

1.3 OVERVIEW

The GPS 18x series products include an embedded receiver and an antenna. Based on the proven technology found in other Garmin GPS receivers, the GPS 18x tracks multiple satellites at a time while providing fast time-to-first-fix, precise navigation updates (five times per second for the GPS 18x-5Hz, and once per second for the GPS 18x USB, 18x PC, and 18x LVC), and low power consumption. This generation of GPS sensors includes the capability of FAA Wide Area Augmentation System (WAAS) differential GPS.

The GPS 18x design uses the latest technology and high-level circuit integration to achieve superior performance while minimizing space and power requirements. The hardware capability combined with software intelligence makes the GPS 18x easy to integrate and use.

The GPS 18x series products are designed to withstand rugged operating conditions and are waterproof to IEC 60529 IPX7, immersion in 1 meter of water for 30 minutes. These complete GPS receivers require minimal additional components to be supplied by an OEM or system integrator. A minimum system must provide the GPS with a source of power and a clear view of the GPS satellites. Internal FLASH memory allows the GPS to retain critical data such as satellite orbital parameters, last-known position, date and time. End user interfaces such as keyboards and displays are the responsibility of the application designer.

1.4 FEATURES

- GPS receiver tracks and uses multiple satellites for fast, accurate positioning and velocity estimates.
- Differential DGPS capability using real-time WAAS corrections yielding position accuracy of less than 3 meters.
- Compact, rugged design ideal for applications with minimal space.
- Factory configuration meets the needs of most systems that expect NMEA 0183 data from a GPS receiver. Configuration commands are available to customize the NMEA 0183 output (see section 4.1 Received NMEA 0183 Sentences)
- (GPS 18x LVC and GPS 18x-5Hz only) Highly accurate measurement pulse output for precise timing measurements: one-pulse-per-second (1 Hz) for the GPS 18x LVC or 5 Hz for GPS 18x-5Hz. Pulse width is configurable in 20-millisecond increments from 20 ms to 980 ms with 1 µs accuracy.
- Configurable for binary format data output.
- FLASH-based program allows new software revisions through a Web site download.
- Non-volatile memory does not require battery backup.
- Onboard rechargeable backup battery can maintain the real-time clock for up to 10 days.
- Configurable parameters include expected position, current time and date, and preferred position fix type (3D or automatic).
- Waterproof design allows continuous exposure to the prevailing weather conditions at most locations.

1.5 GPS 18x SERIES

There are several different versions of GPS 18x available. Refer below for a list of the three major divisions of the GPS 18x Series.

1.5.1 GPS 18x USB

The GPS 18x USB interfaces to a computer with an available USB port. Drivers are available for use on Windows computers. Macintosh and Linux drivers are not available from Garmin. After the drivers are loaded, the device appears to the Windows operating system as a USB-connected device and appears in Device Manager as a Garmin USB Device.

1.5.2 GPS 18x PC

The GPS 18x PC interfaces to a serial port of a computer via a DB-9 connector and receives power through a 12-volt cigarette lighter adapter. The unit accepts TIA-232-F (RS-232) level inputs and transmits voltage levels that swing from zero V (ground) to 5 V TIA-232-F (RS-232) polarity.

The GPS 18x PC can cause an issue with Windows operating systems if the DB9 connector is plugged into the computer before the navigation software is up and running. The Windows operating system may interpret the serial connector on the GPS 18x as a serial mouse. Please refer to Appendix D: GPS 18x PC/LVC/18x-5Hz & Window Serial Mouse Issue for complete details.

1.5.3 GPS 18x LVC, GPS 18x LVC-5m, and GPS 18x-5Hz

These products interface to a serial port. The units accept TIA-232-F (RS-232) level inputs and transmit voltage levels that swing from ground to the positive supply voltage, TIA-232-F (RS-232) polarity. They also have reverse polarity protection. The cable contains wires for power, ground, receive, transmit, and measurement pulse output.

At the end of the cable, the wires are terminated in a connector that is used by Garmin for testing purposes. Most customers will remove this connector and replace it with another connector of their own choosing. Removing the factory installed connector and/or replacing with another customer-supplied connector will have no affect on the warranty (see section 1.2 Limited Warranty). The factory-installed connector will mate with JST right-angle PCB-mount connector (model BM06B-SRSS-TBT) or side-entry PCB-mount connector (model SM06B-SRSS-TB). You may obtain technical information on these PCB-mount mating connectors from the JST Web site: www.jst.com.

Note: Unless otherwise specified, all references to the GPS 18x LVC also include the GPS 18x LVC-5m.

1.6 TECHNICAL SPECIFICATIONS

Specifications are subject to change without notice.

1.6.1 Physical Characteristics

1.6.1.1 Size

61 mm (2.4 inches) in diameter and 19.5 mm (0.77 inches) in height

1.6.1.2 Weight

- GPS 18x USB: 3.7 oz (105 g)
- GPS 18x PC: 6.3 oz (180 g)
- GPS 18x LVC-5m (5 meter cable): 5.6 oz (160 g)
- GPS 18x-5Hz (5 meter cable): 5.8 oz (165 g)

1.6.1.3 Color

Black

1.6.1.4 Case Material

Polycarbonate thermoplastic that is waterproof to IEC 60529 IPX7 level (immersion in 1 meter of water for 30 minutes)

1.6.1.5 Cable Length

- GPS 18x USB: 2 meter
- GPS 18x PC: 2 meter
- GPS 18x LVC: 5 meter (Garmin Part Number 010-00321-36)
- GPS 18x-5Hz: 5 meter

1.6.2 Electrical Characteristics

1.6.2.1 Input Voltage

- GPS 18x USB: 4.4–5.5 Vdc
- GPS 18x PC: 8–30 Vdc (Automotive supply from cigarette lighter jack)
- GPS 18x LVC: 4.0–5.5 Vdc
- GPS 18x-5Hz: 4.0–5.5 Vdc

1.6.2.2 Input Current

- GPS 18x USB: 110 mA @ 5.0 Vdc
- GPS 18x PC: 65 mA @ 12 Vdc
- GPS 18x LVC: 90 mA @ 5.0 Vdc
- GPS 18x-5Hz: 100 mA @ 5.0 Vdc

1.6.2.3 CMOS Serial Output Levels

- GPS 18x PC: 0 Vdc to 5 Vdc (Asynchronous Serial, TIA-232-F (RS-232) Compatible Polarity)
- GPS 18x LVC and GPS 18x-5Hz: 0 Vdc to Vin, between 4 and 5.5 Vdc (Asynchronous Serial, TIA-232-F (RS-232) Compatible Polarity)

1.6.2.4 GPS Receiver Sensitivity

-185 dBW minimum

1.6.2.5 Environmental Characteristics

- Operating Temperature: -30°C to +80°C (-22°F to +176°F)
- Storage Temperature: -40°C to +90°C (-40°F to +194°F)

1.6.3 GPS Performance

1.6.3.1 Receiver

WAAS-enabled GPS receiver continuously tracks and uses multiple satellites to compute and update your position.

1.6.3.2 Acquisition Times

- Reacquisition: Less than 2 seconds
- Hot: Approx. 1 second (all data known)
- Warm: Approx. 38 seconds (initial position, time, and almanac known; ephemeris unknown)
- Cold: Approx. 45 seconds

1.6.3.3 Update Rate

- GPS 18x USB, PC, and LVC: 1 record per second
- GPS 18x-5Hz: 5 records per second

1.6.3.4 Accuracy

- GPS Standard Positioning Service (SPS)
  Position: < 15 meters, 95% typical
  Velocity: 0.1 knot RMS steady state
- WAAS
  Position: < 3 meters, 95% typical
  Velocity: 0.1 knot RMS steady state
- Measurement Pulse Output Time: ±1 microsecond at rising edge of the pulse
- Dynamics: 999 knots velocity (only limited at altitude greater than 60,000 feet), 2g dynamics

1.6.4 Interfaces

1.6.4.1 GPS 18x Electrical Characteristics

- GPS 18x USB: USB 2.0 full-speed protocol compatible, as well as USB 1.1 full-speed protocol.
- GPS 18x PC and LVC: TIA-232-F (RS-232) compatible asynchronous receiver. Default setting is 4800 baud.
- GPS 18x-5Hz: TIA-232-F (RS-232) compatible asynchronous receiver. Default setting is 19200 baud.

1.6.4.2 Garmin Interface and Garmin USB Protocol

Refer to the *Garmin Device Interface Specification* found in the Garmin Device Interface SDK for information about the Garmin Interface and the Garmin USB Protocol. At the time of this printing, this document is located on the Garmin Web site at www.garmin.com/support/commProtocol.html.

See Appendix B: Garmin Binary Output Format for additional information concerning access to binary data from the GPS 18x USB.

1.6.4.3 GPS 18x PC, GPS 18x LVC, & GPS 18x-5Hz Protocols

- NMEA 0183 Version 2.0 or NMEA 0183 Version 2.30 (Version 2.0 is factory default, programmable by data field 7 of the PGRMC1 sentence described in section 4.1.4 Additional Sensor Configuration Information (PGRMC1).
- Available NMEA 0183 output sentences include GPALM, GPGGA, GPGSA, GPGSV, GPRMC, GPVTG, GPGLL, PGRME, PGRMF, PGRMID, PGRMM, PGRMT, PGRMV, and PGRMB (Garmin proprietary sentences). See section 4.2 Transmitted NMEA 0183 Sentences for format descriptions.
- Configuration and initialization is accomplished with NMEA 0183 input sentences. Allows initialization of information such as expected position, date, time, earth datum, and differential mode. See section 4.1 Received NMEA 0183 Sentences for format descriptions.
- Configurable for binary data output.

1.6.4.4 Measurement Pulse Output (GPS 18x LVC & GPS 18x-5Hz only)

- GPS 18x LVC: 1 Hz pulse with programmable width, configurable in 20 ms increments form 20 ms to 980 ms. See section 4.1.3 Sensor Configuration Information (PGRMC) for details about configuring the Measurement Pulse Output (or PPS) feature.
- GPS 18x-5Hz: 5 Hz pulse synchronized with the time of fix. One of the five pulses will align with the UTC second boundary. The pulse width is programmable from 20 ms to 180 ms. The PGRMC sentence will indicate which pulse is at the top-of-the-second. See section 4.1.3 Sensor Configuration Information (PGRMC) for details about configuring the Measurement Pulse Output (or PPS) feature.
- 1 µs accuracy for all conditions in which the GPS 18x LVC or GPS 18x-5Hz has reported a valid and accurate position fix for at least the previous 4 seconds.

2 GPSX 18x LVC & GPS 18x -5Hz WIRING AND PINOUTS

The GPS 18x LVC/18x-5Hz interfaces to a serial port. The unit accepts TIA-232-F (RS-232) level inputs and transmits voltage levels from ground to the input voltage, TIA-232-F (RS-232) polarity.

The GPS 18x LVC/18x-5Hz wires are terminated with a six-wire connector that is used by Garmin for testing purposes. You can remove this connector without voiding your warranty (see section 1.2 Limited Warranty).

2.1 GPS 18x LVC & GPS 18x -5Hz PINOUT

GPS 18x Pin #	Color	Signal Name	Wire Gauge
1	Yellow	Measurement Pulse Output	28
2	Red	Vin	26
3	Black	Ground	28
4	White	Transmit Data	28
5	Black	Ground	26
6	Green	Receive Data	28

Table 1: GPS 18x LVC & GPS 18x-5Hz Wire Pinout

2.2 GPS 18x LVC & GPS 18x -5Hz WIRING DIAGRAMS

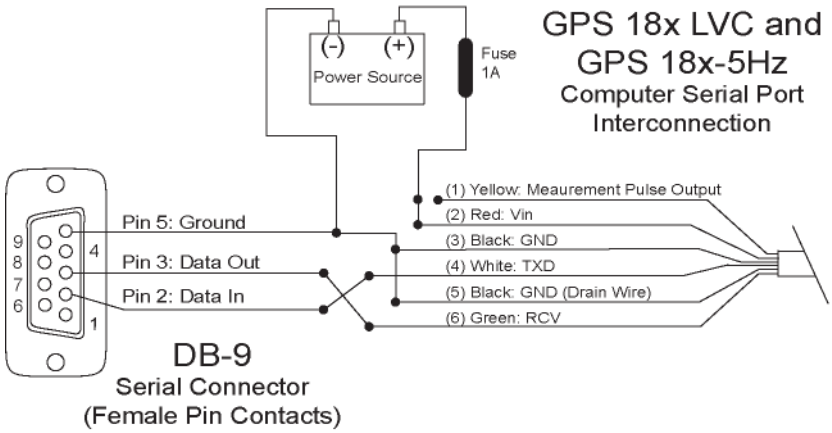


Figure 1: Computer Serial Port Interconnection

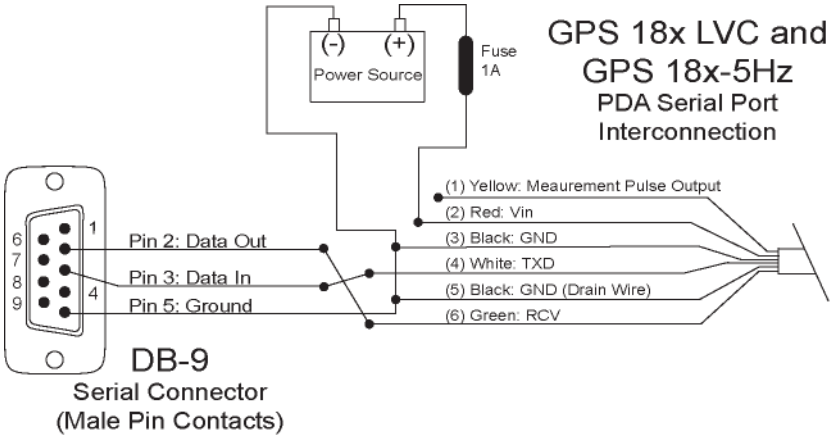


Figure 2. PDA Serial Port Interconnection

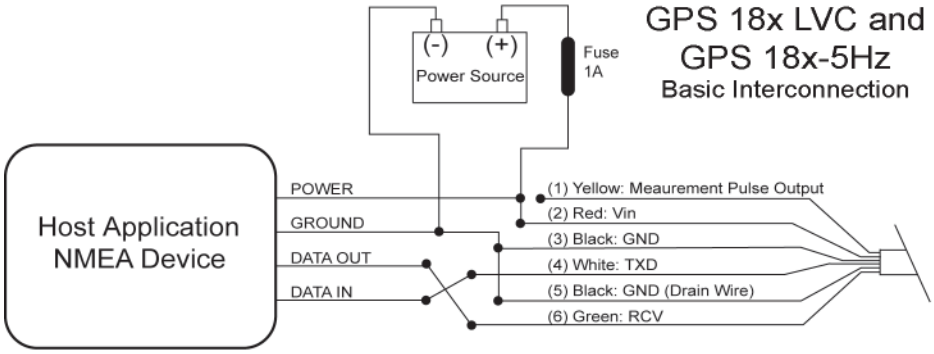


Figure 3. Basic NMEA Device Interconnection

3 MECHANICAL CHARACTERISTICS & MOUNTING

The central threaded recess accepts a metric M3 threaded bolt. The recess is approximately 4 mm deep (4.32 +/- 0.08 mm). The following drawings show example geometries for mounting hardware in case you wish to design your own custom mount. Figure 5 shows mounting geometry for a mount formed from steel sheet metal that is 1.15 mm thick. Figure 7 shows similar mounting geometry for mount formed from aluminum sheet metal that is 1.25 mm thick. Use caution when tightening the mounting bolt. Tightening the mounting bolt can cause the mount to pull tight directly against the metal insert, not against the plastic housing, which would tend to pull the insert out of the plastic. Figure 6 shows the dimensions of our GPS 18x Flush Mount, part number 010-10453-00.

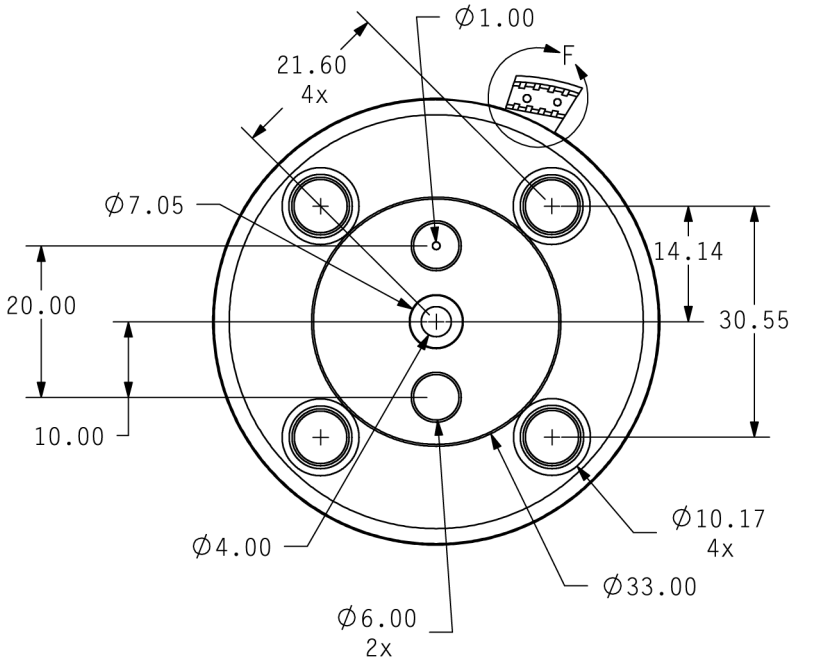


Figure 4a. GPS 18x Bottom Case Dimensions, Under Mold

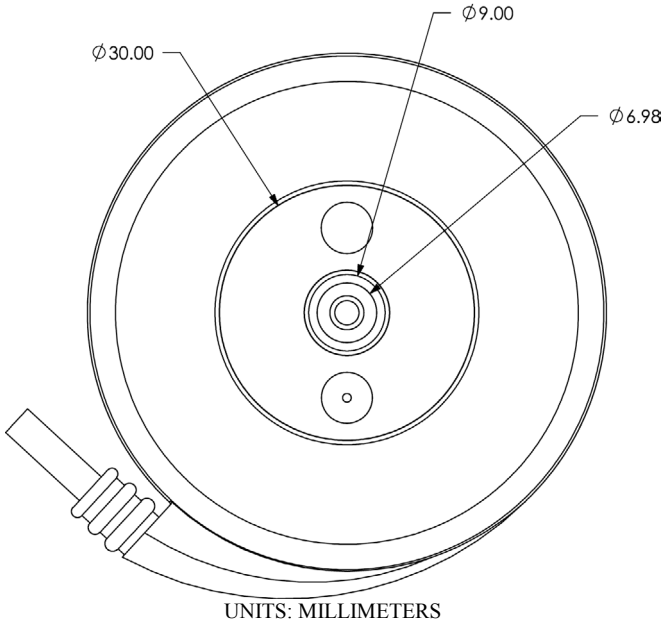
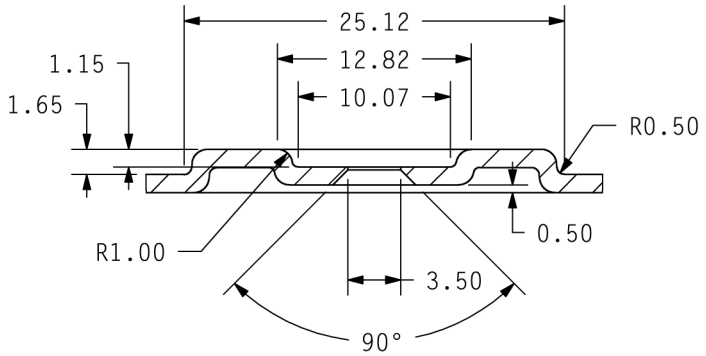
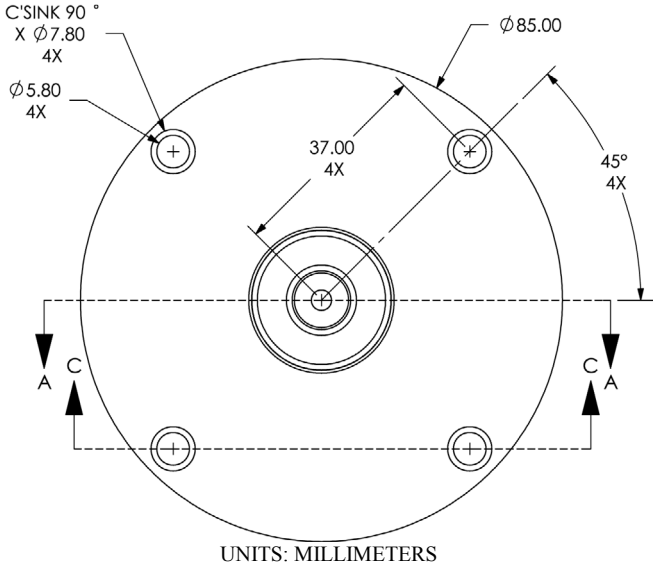


Figure 4b. GPS 18x Bottom Case, Outside of Casing



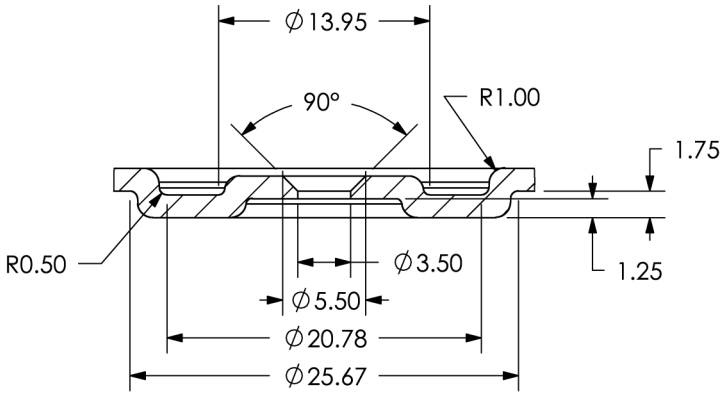
UNITS: MILLIMETERS

Figure 5. GPS 18x Suction Cup Mount Center Hole Dimensions



UNITS: MILLIMETERS

Figure 6. GPS 18x Flush Mount Dimensions



Dimension units: mm

Figure 7. GPS 18x Flush Mount Center Hole Dimensions

4 GPS 18x PC, GPS 18x LVC, & GPS 18x-5Hz SOFTWARE INTERFACE

The interface protocol design of the GPS 18x PC, LVC, and GPS 18x-5Hz products is based on the National Marine Electronics Association's NMEA 0183 ASCII interface specification. This standard is fully defined in *NMEA 0183, Version 2.30*. Copies may be obtained from NMEA at www.nmea.org.

In addition to the standard NMEA 0183 sentences, the GPS 18x PC, LVC, and GPS 18x-5Hz may also be configured to transmit information over their serial interface using NMEA 0183 compliant Garmin proprietary sentences. These proprietary sentences begin with the characters, "$PGRM", instead of the characters "$G" that are typical of the standard NMEA 0183 sentences. The characters "$P" indicate that the sentence is a proprietary implementation and the characters and "GRM" indicate that it is Garmin's proprietary sentence. The letter (or letters) that follow the characters "$PGRM" uniquely identifies that particular Garmin proprietary sentence.

It is also possible to configure the GPS 18x PC, LVC, and GPS 18x-5Hz to transmit binary data information over their serial interface. See Appendix B: Garmin Binary Output Format for details.

The GPS 18x USB does not transmit NMEA sentences: It transmits using the Garmin USB interface. The Garmin USB interface is discussed in the *Garmin Device Interface Specification* found in the Garmin Device Interface SDK located on the Garmin Web site at: www.garmin.com/support/commProtocol.html.

You can configure the GPS 18x USB to transmit binary data information over the USB interface. Refer to Appendix B: Garmin Binary Output Format.

The following sections describe the NMEA 0183 data format of each sentence transmitted and received by the GPS 18x PC, LVC, and GPS 18x-5Hz products.

4.1 RECEIVED NMEA 0183 SENTENCES

The following paragraphs define the sentences that can be received on the GPS sensors' port. Null fields in the configuration sentence indicate no change in the particular configuration parameter. All sentences received by the GPS sensor must be terminated with <CR><LF>, the ASCII characters for carriage return (0D hexadecimal) and line feed (0A hexadecimal). The checksum *hh is used for parity checking data and is not required, but is recommended for use in environments containing high electromagnetic noise. It is generally not required in normal PC environments. When used, the parity bytes (hh) are the ASCII representation of the exclusive-or (XOR) sum of all the characters between the "$" and "*" characters, non-inclusive. The hex representation must be a capital letter, such as 3D instead of 3d. Sentences may be truncated by <CR><LF> after any data field and valid fields up to that point will be acted on by the sensor.

4.1.1 Almanac Information (ALM)

The $GPALM sentence can be used to initialize the GPS sensor's stored almanac information in the unlikely event of non-volatile memory loss or after storing longer than six months without tracking GPS satellites.

$GPALM,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>,<15>*hh<CR><LF>

<1>	Total number of ALM sentences to be transmitted by the GPS sensor during almanac download. This field can be null or any number when sending almanac to the GPS sensor.
<2>	Number of current ALM sentence. This field can be null or any number when sending almanac to the GPS sensor.
<3>	Satellite PRN number, 01 to 32
<4>	GPS week number
<5>	SV health, bits 17–24 of each almanac page
<6>	Eccentricity
<7>	Almanac reference time
<8>	Inclination angle
<9>	Rate of right ascension
<10>	Root of semi major axis
<11>	Omega, argument of perigee
<12>	Longitude of ascension node
<13>	Mean anomaly
<14>	af0 clock parameter
<15>	af1 clock parameter

4.1.2 Sensor Initialization Information (PGRMI)

The $PGRMI sentence provides information used to initialize the GPS sensor's set position and time used for satellite acquisition. Receipt of this sentence by the GPS sensor causes the software to restart the satellite acquisition process. If there are no errors in the sentence, it will be echoed upon receipt. If an error is detected, the echoed PGRMI sentence will contain the current default values. Current PGRMI defaults (with the exception of the Receiver Command, which is a command rather than a mode) can also be obtained by sending $PGRMIE to the GPS sensor.

$PGRMI,<1>,<2>,<3>,<4>,<5>,<6>,<7>*hh<CR><LF>

<1>	Latitude, ddmm.mmm format for GPS 18x PC/LVC; ddmm.mmmmm format for GPS 18x-5Hz (leading zeros must be transmitted)
<2>	Latitude hemisphere, N or S
<3>	Longitude, ddmm.mmm format for GPS 18x PC/LVC; ddmm.mmmmm format for GPS 18x-5Hz (leading zeros must be transmitted)
<4>	Longitude hemisphere, E or W
<5>	Current UTC date, ddmmyy format
<6>	Current UTC time, hhmmss format for GPS 18x PC/LVC; hhmmss.s format for GPS 18x-5Hz
<7>	Receiver Command, A = Cold Start, R = Unit Reset

4.1.3 Sensor Configuration Information (PGRMC)

The $PGRMC sentence provides information used to configure the GPS sensor's operation. Configuration parameters are stored in non-volatile memory and retained between power cycles. The GPS sensor will echo this sentence upon its receipt if no errors are detected. If an error is detected, the echoed PGRMC sentence will contain the current default values. Current default values can also be obtained by sending $PGRMCE to the GPS sensor.

$PGRMC,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>*hh<CR><LF>

<1>	Fix mode, A = Automatic, 3 = 3D exclusively
<2>	Altitude above/below mean sea level, -1500.0 to 18000.0 meters
<3>	Earth datum index. If the user datum index (96) is specified, fields <4> through <8> must contain valid values. Otherwise, fields <4> through <8> must be null. Refer to Appendix A: Earth Datum List for a list of earth datum and the corresponding earth datum index.
<4>	User earth datum semi-major axis, 6360000.000 to 6380000.000 meters (.001 meters resolution)
<5>	User earth datum inverse flattening factor, 285.0 to 310.0 (10^{-9} resolution)
<6>	User earth datum delta x earth centered coordinate, -5000.0 to 5000.0 meters (1 meter resolution)
<7>	User earth datum delta y earth centered coordinate, -5000.0 to 5000.0 meters (1 meter resolution)
<8>	User earth datum delta z earth centered coordinate, -5000.0 to 5000.0 meters (1 meter resolution)
<9>	Differential mode, A = Automatic (output DGPS data when available, non-DGPS otherwise), D = Differential exclusively (output only differential fixes)
<10>	NMEA 0183 Baud rate, 3 = 4800, 4 = 9600, 5 = 19200, 8 = 38400 (for GPS 18x-5Hz only)
<11>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<12>	Measurement Pulse Output, 1 = Disabled, 2 = Enabled
<13>	Measurement Pulse Output pulse length, (n+1)*20 ms For 18 LVC/PC n = 0 through 48 (max. 980 ms) For GPS 18x-5Hz n = 0 through 8 (max. 180 ms) Example: n = 4 corresponds to a 100 ms wide pulse
<14>	Dead reckoning valid time 1 to 30 sec. for the GPS 18x PC/LVC or 0.2 to 30.0 sec. for the GPS 18x-5Hz

All configuration changes take effect after receipt of a valid value except baud rate and Measurement Pulse Output mode. Baud rate and Measurement Pulse Output mode changes take effect on the next power cycle or an external reset event.

4.1.4 Additional Sensor Configuration Information (PGRMC1)

The $PGRMC1 sentence provides additional information used to configure the GPS sensor operation. Configuration parameters are stored in non-volatile memory and retained between power cycles. The GPS sensor will echo this sentence upon its receipt if no errors are detected. If an error is detected, the echoed PGRMC1 sentence will contain the current default values. Current default values can also be obtained by sending $PGRMC1E to the GPS sensor.

$PGRMC1,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>,<15>*hh<CR><LF>

<1>	NMEA 0183 output time 1 to 900 (sec). Not applicable to GPS 18x-5Hz, which always outputs data at 5 Hz (200 ms)
<2>	Binary Output Data, 1 = Off, 2 = On.
<3>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<4>	No Effect (DGPS beacon frequency: 0.0, 283.5 to 325.0 kHz in 0.5 kHz steps)
<5>	No Effect (DGPS beacon bit rate: 0, 25, 50, 100, or 200 bps)
<6>	No Effect (DGPS beacon scanning, 1 = Off, 2 = On)
<7>	NMEA 0183 version 2.30 mode indicator, 1 = Off, 2 = On
<8>	DGPS WAAS mode, W = WAAS Enabled, N = WAAS Disabled
<9>	Power Save Mode, P = Power Save mode, N = Normal
<10>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<11>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<12>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<13>	Measurement Pulse Output Auto Off Mode, 1 = Off, 2 = On
<14>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<15>	Low Velocity Threshold , 1 = Off, 2 = On

Configuration changes take effect immediately, with the exception of Binary Output Data, which takes effect on the next power cycle or a reset event. Send the sentence "$PGRMI,,,,,,,R" to command a reset (refer to section 4.1.2 Sensor Initialization Information (PGRMI)). If the GPS sensor is in the Binary data mode, it is necessary to send the following eight-byte data stream to temporarily change the data format to NMEA 0183. Then follow by sending a PGRMC1 sentence that turns off the Binary Output Data format:

10 0A 02 26 00 CE 10 03 (Hexadecimal)

4.1.5 Output Sentence Enable/Disable (PGRMO)

The $PGRMO sentence provides the ability to enable and disable specific output sentences. The following sentences are enabled at the factory for the GPS 18x PC and LVC: GPGGA, GPGSA, GPGSV, GPRMC, and PGRMT.

The following sentences are enabled at the factory for the GPS 18x-5Hz: GPGGA, GPGSA, GPRMC, GPVTG, and PGRMT.

$PGRMO,<1>,<2>*hh<CR><LF>

<1>	Target sentence description (for example, PGRMT, GPGSV, etc.)
<2>	Target sentence mode, where 0 = Disable specified sentence, 1 = enable specified sentence, 2 = Disable all output sentences, 3 = Enable all output sentences (except GPALM), 4 = Restore factory default output sentences

The following notes apply to the PGRMO input sentence:

If the target sentence mode is "2" (Disable all), "3" (Enable all), or '4' (Restore defaults), the target sentence description is not checked for validity. In this case, an empty field is allowed (for example, $PGRMO,,3), or the mode field may contain from 1 to 5 characters.

If the target sentence mode is "0" (Disable) or "1" (Enable), the target sentence description field must be an identifier for one of the sentences that can be output by the GPS sensor.

If either the target sentence mode field or the target sentence description field is not valid, the PGRMO sentence will have no effect.

$PGRMO,GPALM,1 will cause the GPS sensor to transmit all stored almanac information. All other NMEA 0183 sentence transmission will be suspended temporarily.

$PGRMO,,G will cause the COM port to change to Garmin Data Transfer format for the duration of the power cycle. The Garmin mode is required for GPS 18x series product software updates.

4.2 TRANSMITTED NMEA 0183 SENTENCES

The subsequent paragraphs define the sentences that can be transmitted by the GPS 18x PC and LVC.

4.2.1 Sentence Transmission Rate

Sentences are transmitted with respect to the user selected baud rate.

The GPS sensor will transmit each sentence (except where noted in particular transmitted sentence descriptions) at a periodic rate based on the user selected baud rate and user selected output sentences. The GPS sensor will transmit the selected sentences contiguously. The length of the transmission can be determined by the following equation and Tables 2 and 3:

$$\text{length of transmission} = \frac{\text{total characters to be transmitted}}{\text{characters transmitted per second}}$$

Sentence	Output by Default?	Maximum Characters
GPRMC	✔	74
GPGGA	✔	82
GPGSA	✔	66
GPGSV	✔ (PC and LVC only)	70
PGRME		35
GPGLL		44
GPVTG	✔ (18x-5Hz)	42
PGRMV		32
PGRMF		82
PGRMB		40
PGRMID		82
PGRMM		
PGRMT	Once per minute	50

Table 2: NMEA 0183 Output Sentence Order and Size

Baud	Characters per Second
4800	480
9600	960
19200	1920
38400	3840

Table 3: Characters per Second for Available Baud Rates

The maximum number of fields allowed in a single sentence is 82 characters including delimiters. Values in the table include the sentence start delimiter character "$" and the termination delimiter <CR><LF>. For the GPS 18x PC and LVC, the factory set defaults result in a once per second transmission at the NMEA 0183 specification transmission rate of 4800 baud. For the GPS 18x-5Hz, the factory set defaults will result in a five times per second transmission at 19200 baud.

For the GPS 18x LVC: Regardless of the selected baud rate, the information transmitted by the GPS sensor is referenced to the one-pulse-per-second output pulse immediately preceding the GPRMC sentence, or whichever sentence is output first in the burst (see Table 2 above).

For the GPS 18x-5Hz: Regardless of the selected baud rate, the information transmitted by the GPS sensor is referenced to the preceding five-times-per-second output pulse.

The GPS 18x USB can use Spanner (an application that can provide NMEA output via a virtual COM port) to receive the same default NMEA sentences as the GPS 18x PC and LVC at a rate of once per second. Spanner is available for free on the Garmin web site. To download the software, start at www.garmin.com/oem, select the GPS 18x USB, and then select **Updates & Downloads**.

4.2.2 Transmitted Time

The GPS sensor outputs Coordinated Universal Time (UTC) date and time of day in the transmitted sentences. Before the initial position fix, the on-board clock provides the date and time of day. After the initial position fix, the date and time of day are calculated using GPS satellite information and are synchronized with the measurement pulse output.

The GPS 18x-5Hz outputs a UTC with a tenths-of-a-second precision: 123456.8, for example.

The GPS sensor uses information obtained from the GPS satellites to add or delete UTC leap seconds and correct the transmitted date and time of day. The transmitted date and time of day for leap second correction follow the guidelines in *"National Institute of Standards and Technology Special Publication 432 (Revised 1990)"* (for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, U.S.A.).

When a positive leap second is required, one second is inserted at the beginning of the first hour (0h 0m 0s) of the day that the positive leap is occurring. The minute containing the leap second is 61 seconds long. The GPS sensor would have transmitted this information for the leap second added December 31, 1998 as follows:

$GPRMC,235959,A,3851.3651,N,09447.9382,W,000.0,221.9,071103,003.3,E*69

$GPRMC,000000,A,3851.3651,N,09447.9382,W,000.0,221.9,081103,003.3,E*67

$GPRMC,000000,A,3851.3651,N,09447.9382,W,000.0,221.9,081103,003.3,E*67

$GPRMC,000001,A,3851.3651,N,09447.9382,W,000.0,221.9,081103,003.3,E*66

If a negative leap second should be required, one second will be deleted at the end of some UTC month. The minute containing the leap second will be only 59 seconds long. In this case, the GPS sensor will not transmit the time of day 0h 0m 0s (the "zero" second) for the day from which the leap second is removed.

$GPRMC,235959,A,3851.3650,N,09447.9373,W,000.0,000.0,111103,003.3,E*69

$GPRMC,000001,A,3851.3650,N,09447.9373,W,000.0,000.0,121103,003.3,E*6A

$GPRMC,000002,A,3851.3650,N,09447.9373,W,000.0,000.0,121103,003.3,E*69

4.2.3 Global Positioning System Almanac Data (ALM)

Almanac sentences are not normally transmitted. Send the GPS sensor a $PGRMO,GPALM,1 command to initiate almanac transmission. Upon receipt of this command, the GPS sensor will transmit available almanac information on GPALM sentences. During the transmission of almanac sentences, other NMEA 0183 data output is suspended temporarily.

$GPALM,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>,<15>*hh<CR><LF>

<field information> can be found in section 4.1.1 Almanac Information (ALM).

4.2.4 Global Positioning System Fix Data (GGA)

$GPGGA,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,M,<10>,M,<11>,<12>*hh<CR><LF>

<1>	UTC time of position fix, hhmmss format for GPS 18x PC or LVC; hhmmss.s format for GPS 18x-5Hz
<2>	Latitude, ddmm.mmmm format for GPS 18x PC/LVC; ddmm.mmmmm for GPS 18x-5Hz (leading zeros will be transmitted)
<3>	Latitude hemisphere, N or S
<4>	Longitude, dddmm.mmmm format for GPS 18x PC/LVC; dddmm.mmmmm for GPS 18x-5Hz (leading zeros will be transmitted)
<5>	Longitude hemisphere, E or W
<6>	GPS quality indication, 0 = fix not available, 1 = Non-differential GPS fix available, 2 = Differential GPS (WAAS) fix available, 6 = Estimated
<7>	Number of satellites in use, 00 to 12 (leading zeros will be transmitted)
<8>	Horizontal dilution of precision, 0.5 to 99.9
<9>	Antenna height above/below mean sea level, -9999.9 to 99999.9 meters
<10>	Geoidal height, -999.9 to 9999.9 meters
<11>	Null (Differential GPS)
<12>	Null (Differential Reference Station ID)

4.2.5 GPS DOP and Active Satellites (GSA)

$GPGSA,<1>,<2>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<4>,<5>,<6>*hh<CR><LF>

<1>	Mode, M = Manual, A = Automatic
<2>	Fix type, 1 = not available, 2 = 2D, 3 = 3D
<3>	PRN number, 01 to 32, of satellite used in solution, up to 12 transmitted (leading zeros will be transmitted)
<4>	Position dilution of precision, 0.5 to 99.9
<5>	Horizontal dilution of precision, 0.5 to 99.9
<6>	Vertical dilution of precision, 0.5 to 99.9

4.2.6 GPS Satellites in View (GSV)

$GPGSV,<1>,<2>,<3>,<4>,<5>,<6>,<7>,...<4>,<5>,<6>,<7>*hh<CR><LF>

<1>	Total number of GSV sentences to be transmitted
<2>	Number of current GSV sentence
<3>	Total number of satellites in view, 00 to 12 (leading zeros will be transmitted)
<4>	Satellite PRN number, 01 to 32 (leading zeros will be transmitted)
<5>	Satellite elevation, 00 to 90 degrees (leading zeros will be transmitted)
<6>	Satellite azimuth, 000 to 359 degrees, true (leading zeros will be transmitted)
<7>	Signal to noise ratio (C/No) 00 to 99 dB (leading zeros will be transmitted)

Note: Items <4>,<5>,<6>, and <7> repeat for each satellite in view to a maximum of four (4) satellites per sentence. Additional satellites in view information must be sent in subsequent bursts of NMEA 0183 data. These fields will be null if unused.

4.2.7 Recommended Minimum Specific GPS/TRANSIT Data (RMC)

$GPRMC,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>*hh<CR><LF>

<1>	UTC time of position fix, hhmmss format for GPS 18x PC/LVC; hhmmss.s format for GPS 18x-5Hz
<2>	Status, A = Valid position, V = NAV receiver warning
<3>	Latitude, ddmm.mmmm format for GPS 18x PC/LVC; ddmm.mmmmm format for GPS 18x-5Hz (leading zeros must be transmitted)
<4>	Latitude hemisphere, N or S
<5>	Longitude, dddmm.mmmm format for GPS 18x PC/LVC; dddmm.mmmmm format for GPS 18x-5Hz (leading zeros must be transmitted)
<6>	Longitude hemisphere, E or W
<7>	Speed over ground, GPS 18x PC and LVC: 000.0 to 999.9 knots, GPS 18x-5Hz: 000.00 to 999.99 knots (leading zeros will be transmitted)
<8>	Course over ground, 000.0 to 359.9 degrees, true (leading zeros will be transmitted)
<9>	UTC date of position fix, ddmmyy format
<10>	Magnetic variation, 000.0 to 180.0 degrees (leading zeros will be transmitted)
<11>	Magnetic variation direction, E or W (westerly variation adds to true course)
<12>	Mode indicator (only output if NMEA 0183 version 2.30 active), A = Autonomous, D = Differential, E = Estimated, N = Data not valid

4.2.8 Track Made Good and Ground Speed (VTG)

$GPVTG,<1>,T,<2>,M,<3>,N,<4>,K,<5>*hh<CR><LF>

<1>	True course over ground, GPS 18x PC and LVC: 000 to 359 degrees, GPS 18x-5Hz: 000.0 to 359.9 degrees(leading zeros will be transmitted)
<2>	Magnetic course over ground, 000 to 359 degrees, GPS 18x-5Hz: 000.0 to 359.9 degrees(leading zeros will be transmitted)
<3>	Speed over ground, GPS 18x PC and LVC: 000.0 to 999.9 knots, GPS 18x-5Hz: 000.00 to 999.99 knots (leading zeros will be transmitted)
<4>	Speed over ground, GPS 18x PC and LVC: 0000.0 to 1851.8 kilometers per hour, GPS 18x-5Hz: 0000.00 to 1851.89 (leading zeros will be transmitted)
<5>	Mode indicator (only output if NMEA 0183 version 2.30 active), A = Autonomous, D = Differential, E = Estimated, N = Data not valid

4.2.9 Geographic Position (GLL)

$GPGLL,<1>,<2>,<3>,<4>,<5>,<6>,<7>*hh<CR><LF>

<1>	Latitude, ddmm.mmmm format for GPS 18x PC/LVC; ddmm.mmmmm format for GPS 18x-5Hz (leading zeros must be transmitted)
<2>	Latitude hemisphere, N or S
<3>	Longitude, dddmm.mmmm format for GPS 18x PC/LVC; dddmm.mmmmm format for GPS 18x-5Hz (leading zeros must be transmitted)
<4>	Longitude hemisphere, E or W
<5>	UTC time of position fix, hhmmss format for GPS 18x PC/LVC; hhmmss.s format for GPS 18x-5Hz
<6>	Status, A = Valid position, V = NAV receiver warning
<7>	Mode indicator (only output if NMEA 0183 version 2.30 active), A = Autonomous, D = Differential (WAAS), E = Estimated, N = Data not valid

4.2.10 Estimated Error Information (PGRME)

$PGRME,<1>,M,<2>,M,<3>,M*hh<CR><LF>

<1>	Estimated horizontal position error (HPE), 0.0 to 999.9 meters
<2>	Estimated vertical position error (VPE), 0.0 to 999.9 meters
<3>	Estimated position error (EPE), 0.0 to 999.9 meters

4.2.11 GPS Fix Data Sentence (PGRMF)

$PGRMF,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>,<15>*hh<CR><LF>

<1>	GPS week number (0 to 1023)
<2>	GPS seconds (0 to 604799)
<3>	UTC date of position fix, ddmmyy format
<4>	UTC time of position fix, hhmmss format for GPS 18x PC/LVC; hhmmss.s format for GPS 18x-5Hz
<5>	GPS leap second count
<6>	Latitude, ddmm.mmmm format for GPS 18x PC/LVC; ddmm.mmmmm format for GPS 18x-5Hz (leading zeros must be transmitted)
<7>	Latitude hemisphere, N or S
<8>	Longitude, dddmm.mmmm format for GPS 18x PC/LVC; dddmm.mmmmm format for GPS 18x-5Hz (leading zeros must be transmitted)
<9>	Longitude hemisphere, E or W
<10>	Mode, M = Manual, A = Automatic
<11>	Fix type, 0 = no fix, 1 = 2D fix, 2 = 3D fix
<12>	Speed over ground, 0 to 1851 kilometers/hour
<13>	Course over ground, 0 to 359 degrees, true
<14>	Position dilution of precision, 0 to 9 (rounded to nearest integer value)
<15>	Time dilution of precision, 0 to 9 (rounded to nearest integer value)

4.2.12 Programmable Device ID (PGRMID)

The Garmin Proprietary sentence $PGRMID gives the device owner the flexibility of naming each sensor device with a custom text value.

$PGRMID,<1>,<2>,<3>*hh<CR><LF>

<1>	ID Configuration Command, S = Set ID, C = Clear ID, E = Echo ID
<2>	User Defined ID (Maximum number of characters = 58)
<3>	Garmin Unit ID (Predefined and unique to each device)

4.2.13 Map Datum (PGRMM)

The Garmin Proprietary sentence $PGRMM gives the name of the map datum currently in use by the GPS sensor. This information is used by the Garmin MapSource real-time plotting application.

$PGRMM,<1>*hh<CR><LF>

<1>	Name of map datum currently in use (variable length field, for example, “WGS 84”)

4.2.14 Sensor Status Information (PGRMT)

The Garmin Proprietary sentence $PGRMT gives information concerning the status of the GPS sensor. This sentence is transmitted once per minute regardless of the selected baud rate.

$PGRMT,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>*hh<CR><LF>

<1>	Product, model and software version (variable length field, for example, “GPS 18x VER 2.05”)
<2>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<3>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<4>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<5>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<6>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<7>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<8>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<9>	No Effect (This field is not used on this model and is included only for backwards compatibility)

4.2.15 3D Velocity Information (PGRMV)

$PGRMV,<1>,<2>,<3>*hh<CR><LF>

<1>	True east velocity, -514.4 to 514.4 meters/second for GPS 18x PC/LVC; -514.44 to 514.44 for GPS 18x-5Hz
<2>	True north velocity, -514.4 to 514.4 meters/second for GPS 18x PC/LVC; -514.44 to 514.44 for GPS 18x-5Hz
<3>	Up velocity, -999.9 to 999.9 meters/second for GPS 18x PC/LVC; -999.99 to 999.99 for GPS 18x-5Hz

4.2.16 DGPS Beacon Information (PGRMB)

Note: The GPS 18x products do not support PGRMB at this time.

$PGRMB,<1>,<2>,<3>,<4>,<5>,K,<6>,<7>,<8>*hh<CR><LF>

<1>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<2>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<3>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<4>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<5>	Distance to beacon reference station in kilometers
<6>	No Effect (This field is not used on this model and is included only for backwards compatibility)
<7>	DGPS fix source (R = RTCM, W = WAAS, N = Non-DGPS Fix)
<8>	DGPS mode, A = Automatic, W = WAAS Only, R = RTCM Only, N = None (DGPS disabled)

4.3 BAUD RATE SELECTION

Baud rate selection can be performed by sending the appropriate configuration sentence to the GPS sensor as described in the $PGRMC section 4.1.2 Sensor Initialization Information (PGRMI), field <10>.

4.4 MEASUREMENT PULSE OUTPUT (GPS 18x LVC & 18x-5Hz ONLY)

4.4.1 One-Pulse-Per-Second (PPS) Output (GPS 18x LVC Only)

The highly accurate one-pulse-per-second (PPS) output is provided for applications requiring precise timing measurements. After the initial position fix has been calculated, the PPS signal is generated and continues until the unit is powered down. The rising edge of the signal is aligned to the start of each GPS second within 1 µs for all conditions in which the re ceiver has reported a valid and accurate position for at least the previous 4 seconds.

The NMEA 0183 sentences that follow each rising edge of the PPS signal tell when you were and where you were at that previous rising edge of the PPS signal, beginning with the GPRMC sentence as the lead sentence in any particular NMEA 0183 record.

Regardless of the selected baud rate, the information transmitted by the GPS 18x series products is referenced to the pulse immediately preceding the NMEA 0183 RMC sentence.

The accuracy of the one-pulse-per-second output is maintained only while the GPS receiver is computing a valid position fix. To obtain the most accurate results, the one-pulse-per-second output should be calibrated against a local time reference to compensate for cable and internal receiver delays and the local time bias.

The default pulse width is 100 ms, however; it may be programmed in 20 ms increments between 20 ms and 980 ms as described in $PGRMC section 4.1.2 Sensor Initialization Information (PGRMI), field <13>.

4.4.2 Five-Pulse-Per-Second Output (GPS 18x-5Hz Only)

The highly accurate five-pulse-per-second output is provided for applications requiring precise timing measurements. After the initial position fix has been calculated, the GPS 18x-5Hz generates the pulse signal, which continues until power down. The rising edge of the signal is aligned to the start of each GPS second within 1 µs for all conditions in which the receiver has reported a valid and accurate position for at least the previous 4 seconds.

The NMEA 0183 sentences that follow each rising edge of the Measurement Pulse Output signal tell when and where you were at that previous rising edge of the Measurement Pulse Output signal, beginning with the GPRMC sentence as the lead sentence in any particular NMEA 0183 record.

Regardless of the selected baud rate, the information transmitted by the GPS 18x-5Hz is referenced to the preceding five times per-second output pulse.

The accuracy of the five-pulse-per-second output is maintained only while the GPS 18x-5Hz can compute a valid position fix. To obtain the most accurate results, the five-pulse-per-second output should be calibrated against a local time reference to compensate for cable and internal receiver delays and the local time bias.

The default pulse width is 100 ms, however; it may be programmed in 20 ms increments between 20 ms and 180 ms as described in $PGRMC section 4.1.2 Sensor Initialization Information (PGRMI), field <13>.

APPENDIX A: EARTH DATUM LIST

The following is a list of the Garmin GPS 18x Earth datum indices and the corresponding earth datum name (including the area of application):

0 ADINDAN–Ethiopia, Mali, Senegal, Sudan

9 AUSTRALIAN GEODETIC 1984–Australia, Tasmania Island

10 ASTRO DOS 71/4–St. Helena Island

11 ASTRONOMIC STATION 1952–Marcus Island

12 ASTRO B4 SOROL ATOLL–Tern Island

13 BELLEVUE (IGN)–Efate and Erromango Islands

14 BERMUDA 1957–Bermuda Islands

15 BOGOTA OBSERVATORY–Colombia

16 CAMPO INCHAUSPE–Argentina

17 CANTON ASTRO 1966–Phoenix Islands

18 CAPE CANAVERAL–Florida, Bahama Islands

19 CAPE–South Africa

20 CARTHAGE–Tunisia

21 CHATHAM 1971–Chatham Island (New Zealand)

22 CHUA ASTRO–Paraguay

23 CORREGO ALEGRE–Brazil

24 DJAKARTA (BATAVIA)–Sumatra Island (Indonesia)

25 DOS 1968–Gizo Island (New Georgia Islands)

26 EASTER ISLAND 1967–Easter Island

27 EUROPEAN 1950–Austria, Belgium, Denmark, Finland, France, Germany, Gibraltar, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland

28 EUROPEAN 1979–Austria, Finland, Netherlands, Norway, Spain, Sweden, Switzerland

29 FINLAND HAYFORD 1910–Finland

30 GANDAJIKA BASE–Republic of Maldives

31 GEODETIC DATUM 1949–New Zealand

32 ORDNANCE SURVEY OF GREAT BRITAIN 1936–England, Isle of Man, Scotland, Shetland Islands, Wales

33 GUAM 1963–Guam Island

34 GUX 1 ASTRO–Guadalcanal Island

35 HJORSEY 1955–Iceland

36 HONG KONG 1963–Hong Kong

37 INDIAN–Bangladesh, India, Nepal

38 INDIAN–Thailand, Vietnam

39 IRELAND 1965–Ireland

40 ISTS O73 ASTRO 1969–Diego Garcia

41 JOHNSTON ISLAND 1961–Johnston Island

42 KANDAWALA–Sri Lanka

43 KERGUELEN ISLAND–Kerguelen Island

44 KERTAU 1948–West Malaysia, Singapore

45 L.C. 5 ASTRO–Cayman Brac Island

46 LIBERIA 1964–Liberia

47 LUZON–Mindanao Island

48 LUZON–Phillippines (excluding Mindanao Island)

49 MAHE 1971–Mahe Island

50 MARCO ASTRO–Salvage Islands

51 MASSAWA–Eritrea (Ethiopia)

52 MERCHICH–Morocco

53 MIDWAY ASTRO 1961–Midway Island

54 MINNA–Nigeria

55 NORTH AMERICAN 1927–Alaska

56 NORTH AMERICAN 1927–Bahamas (excluding San Salvador Island)

57 NORTH AMERICAN 1927–Central America (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua)

58 NORTH AMERICAN 1927–Canal Zone

59 NORTH AMERICAN 1927–Canada (including Newfoundland Island)

60 NORTH AMERICAN 1927–Caribbean (Barbados, Caicos Islands, Cuba, Dominican Republic, Grand Cayman, Jamaica, Leeward Islands, Turks Islands)

61 NORTH AMERICAN 1927–Mean Value (CONUS)

62 NORTH AMERICAN 1927–Cuba

63 NORTH AMERICAN 1927–Greenland (Hayes Peninsula)

64 NORTH AMERICAN 1927–Mexico

65 NORTH AMERICAN 1927–San Salvador Island

66 NORTH AMERICAN 1983–Alaska, Canada, Central America, CONUS, Mexico

67 NAPARIMA, BWI–Trinidad and Tobago

68 NAHRWAN–Masirah Island (Oman)

69 NAHRWAN–Saudi Arabia

70 NAHRWAN–United Arab Emirates

71 OBSERVATORIO 1966–Corvo and Flores Islands (Azores)

72 OLD EGYPTIAN–Egypt

73 OLD HAWAIIAN–Mean Value

74 OMAN–Oman

75 PICO DE LAS NIEVES–Canary Islands

76 PITCAIRN ASTRO 1967–Pitcairn Island

77 PUERTO RICO–Puerto Rico, Virgin Islands

78 QATAR NATIONAL–Qatar

79 QORNOQ–South Greenland

80 REUNION–Mascarene Island

81 ROME 1940–Sardinia Island

82 RT 90–Sweden

83 PROVISIONAL SOUTH AMERICAN 1956–Bolivia, Chile, Colombia, Ecuador, Guyana, Peru, Venezuela

84 SOUTH AMERICAN 1969–Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Venezuela, Trinidad and Tobago

85 SOUTH ASIA–Singapore

86 PROVISIONAL SOUTH CHILEAN 1963–South Chile

87 SANTO (DOS)–Espirito Santo Island

88 SAO BRAZ–Sao Miguel, Santa Maria Islands (Azores)

89 SAPPER HILL 1943–East Falkland Island

90 SCHWARZECK–Namibia

91 SOUTHEAST BASE–Porto Santo and Madeira Islands

92 SOUTHWEST BASE–Faial, Graciosa, Pico, Sao Jorge, and Terceira Islands (Azores)

93 TIMBALAI 1948–Brunei and East Malaysia (Sarawak and Sabah)

94 TOKYO–Japan, Korea, Okinawa

95 TRISTAN ASTRO 1968–Tristan da Cunha

96 User defined earth datum

97 VITI LEVU 1916–Viti Levu Island (Fiji Islands)

98 WAKE-ENIWETOK 1960–Marshall Islands

99 WORLD GEODETIC SYSTEM 1972

100 WORLD GEODETIC SYSTEM 1984

101 ZANDERIJ–Surinam

102 CH-1903–Switzerland

103 Hu-Tzu-Shan

104 Indonesia 74

105 Austria

106 Potsdam

107 Taiwan–modified Hu-Tzu-Shan

108 GDA–Geocentric Datum of Australia

109 Dutch

APPENDIX B: GARMIN BINARY OUTPUT FORMAT

In Binary Output mode, GPS 18x series products will transmit packets once per second. The record contains primarily post-process information such as position and velocity information. For the GPS 18x PC, GPS 18x LVC, and GPS 18x-5Hz the record is sent at a default baud rate of 4800 baud, 8 data bits, and no parity.

To turn this record on for the GPS 18x PC, GPS 18x LVC, and GPS 18x-5Hz versions, use the $PGRMC1 NMEA sentence as described in section 4 GPS 18x PC, GPS 18x LVC, & GPS 18x-5Hz Software Interface. Refer to the *Garmin Device Interface Specification* found in the Garmin Device Interface SDK for details on how to form and parse Garmin packets. At the time of this printing, these specs are available from the technical suppport section of our Web site www.garmin.com/support/commProtocol.html.

Note: For the GPS 18x-5Hz, a baud rate of 9600 is not high enough to transmit all of the packets (since they are output at a 5 Hz rate). You will need to change the baud rate to at least 38400 to be able to transmit all of the packets. Refer to Appendix C: Changing the Baud Rate in Garmin Mode for information.

For the GPS 18x USB, the records must be enabled by commands to the unit. Refer to the *Garmin Device Interface Specification* found in the Garmin Device Interface SDK for details on how to form and parse Garmin packets over USB. At the time of this printing, these specs are available from the technical suppport section of our Web site: www.garmin.com/support/commProtocol.html. The ID of each command should be 10 decimal to signify that the record is a command. The data portion of the packet should be one of the following:

Function	Command (base 10)
Position Record On	49
Position Record Off	50

Note that the satellite data information is also enabled when the position record is enabled.

Records sent over RS232 begin with a delimiter byte (10 hex). The second byte identifies the record type (33 hex for a position record, 34 hex for a receiver measurement and 72 hex for a satellite data record). The third byte indicates the size of the data. The fourth byte is the first byte of data. The data is then followed by a checksum byte, a delimiter byte (10 hex), and an end-of-transmission character (03 hex). Additionally, any DLEs (0x10) that appear between the delimeters are escaped with a second DLE. There is sample code at the end of this section that will strip off the DLEs and ETXs.

RS232 Packet:

- 0x10 (DLE is first byte)
- 0x## (Record ID – single byte)
- 0x## (Number of data bytes – single byte)
- data bytes (See descriptions below)
- 0x## (2's complement of the arithmetic sum of the bytes between the delimiters)
- 0x10 (DLE)
- 0x03 (ETX is last byte)

USB packets contain a header with a USB transport ID, a record ID, and the size of the record data in bytes. All unused reserved bytes in the header must be zero. Immediately following the header is the record data payload. Refer to the *Garmin Device Interface Specification* found in the Garmin Device Interface SDK for details on how to form and parse Garmin USB packets.

USB Packet:

- 0x## 0x00 0x00 0x00 (USB transport ID, 1 byte unsigned, 4 bytes reserved)
- 0x## 0x## 0x00 0x00 (Record ID, 2 bytes unsigned, 4 bytes reserved)
- 0x## 0x## 0x## 0x## (Number of data bytes in record, 4 bytes unsigned)
- record data payload

The data bytes of each packet contain the record specified by the record ID. A description of each record follows.

Satellite Data Record

The satellite data has a record ID of 0x72 with 84 (0x54) data bytes. The data bytes contain data for 12 satellites as described below.

```
typedef        struct
    {
    uint8      svid; //space vehicle identification (1-32 and 33-64 for WAAS)
    uint16     snr;      //signal-to-noise ratio
    uint8      elev; //satellite elevation in degrees
    uint16     azmth;    //satellite azimuth in degrees
    uint8      status;   //status bit-field
    } cpo_sat_data;
```

The status bit field represents a set of booleans described below:

Bit	Meaning when bit is one (1)
0	The unit has ephemeris data for the specified satellite.
1	The unit has a differential correction for the specified satellite.
2	The unit is using this satellite in the solution.

This pattern is repeated for 12 satellites for a total of 12 X 7 bytes = 84 (0x54) bytes.

The RS-232 Packet for the Satellite Record looks like:

- 0x10 (DLE is first byte)
- 0x72 (Record ID – single byte)
- 0x54 (Number of data bytes – single byte)
- 12 cpo_sat_data records
- 0x## (2's complement of the arithmetic sum of the bytes between the delimiters)
- 0x10 (DLE)
- 0x03 (ETX is last byte)

The USB Packet for the Satellite Record looks like:

- 0x14 0x00 0x00 0x00 (USB Transport ID, 1 byte unsigned, 4 bytes reserved)
- 0x72 0x00 0x00 0x00 (Record ID, 2 bytes unsigned, 4 bytes reserved)
- 0x54 0x00 0x00 0x00 (Number of data bytes, 4 bytes unsigned)
- 12 cpo_sat_data records

Position Record

The Position Record has a record identifier of

```
typedef struct
     {
     float      alt;
     float      epe;
     float      eph;
     float      epv;
     int        fix;
     double     gps_tow;
     double     lat;
     double     lon;
     float      lon_vel;
     float      lat_vel;
     float      alt_vel;
     float      msl_hght;
     int        leap_sec;
     long       grmn_days;
     } cpo_pvt_data;
```

alt	Ellipsoid altitude (meters)
epe	Estimated position error (meters)
eph	Position error, horizontal (meters)
epv	Position error, vertical (meters)
fix	0 = no fix; 1 = no fix; 2 = 2D; 3 = 3D; 4 = 2D differential; 5 = 3D differential; 6 and greater = not defined
gps_tow	GPS time of week (sec)
lat	Latitude (radians)
lon	Longitude (radians)
lon_vel	Longitude velocity (meters/second)
lat_vel	Latitude velocity (meters/second)
alt_vel	Altitude velocity (meters/second)
msl_hght	Height (mean sea level) (meters)
leap_sec	UTC leap seconds
grmn_days	Garmin days (days since December 31, 1989)

DLE and ETX bytes:
Sample C code to receive the two records should filter DLE and ETX bytes as described below:

```
typedef enum
    {
    DAT,
    DLE,
    ETX
    } rx_state_type;

/* Declare and initialize static variables */
static char          in_que[ 256 ];
static int           in_que_ptr = 0;
static rx_state_type rx_state = DAT;

.
.
.

void add_to_que( char data )
{
#define DLE_BYTE 0x10
#define ETX_BYTE 0x03

if ( rx_state == DAT )
    {
    if ( data == DLE_BYTE )
        {
        rx_state = DLE;
        }
    else
        {
        in_que[ in_que_ptr++ ] = data;
        }
    }
else if ( rx_state == DLE )
    {
    if ( data == ETX_BYTE )
        {
        rx_state = ETX;
        }
    else
        {
        rx_state = DAT;
        in_que[ in_que_ptr++ ] = data;
        }
    }
else if ( rx_state == ETX )
    {
    if ( data == DLE_BYTE )
        {
        rx_state = DLE;
        }
    }

if ( in_que_ptr > 255 )
    {
    in_que_ptr = 0;
    }
}
```

APPENDIX C: CHANGING THE BAUD RATE IN GARMIN MODE

In certain cases, you may need to change the default baud rate of your Garmin GPS receiver while in Garmin mode. Follow these steps to temporarily change the baud rate.

Refer to the *Garmin Device Interface Specification* found in the Garmin Device Interface SDK for details on how to form and parse Garmin packets. At the time of this printing, these specs are available from the technical suppport section of our Web site: www.garmin.com/support/commProtocol.html.

1. Turn off all requests by transmitting packet:

   id = IOP_RQST_DATA (0x1C)

   data = 0 (16-bit unsigned integer)

2. The GPS unit will respond by sending a packet with id = IOP_ACK_BYTE (0x06)

3. After you receive the above packet, transmit packet:

   id = IOP_BAUD_RQST_DATA (0x30)

   data = baud rate to change to (32-bit unsigned integer; for example, 38400)

4. The GPS unit will respond by sending a packet:

   id = IOP_BAUD_ACPT_DATA (0x31)

   data = highest acceptable baud rate closest to what was requested
   (32-bit unsigned integer; for example, 38361 decimal)

5. Determine the actual baud rate value from the data sent in step 4. This value will be within +/- 5% of the actual baud rate. (For example, the GPS unit might send a baud rate of 38361, which correlates to a baud rate of 38400).

6. If the baud rate in step 5 is acceptable, transmit packet:

   id = IOP_ACK_BYTE (0x06)

   data = IOP_BAUD_ACPT_DATA (0x31)

7. Sleep for a small amount of time, about 100 milliseconds, to make sure the packet in (6) was successfully transmitted to the GPS unit.

8. Close the current connection to the GPS unit and immediately open a new connection with the new baud rate obtained in step 5.

9. Immediately after establishing a connection, transmit packet:

   id = IOP_CMND_DATA (0x0A)

   data = IOP_ACK_PING (0x3A)

10. The GPS will respond by sending a packet:

    id = IOP_ACK_BYTE (0x06)

    data = IOP_CMND_DATA (0x0A)

11. After you receive the above packet, transmit the same packet in step 9 again.

    id = IOP_CMND_DATA (0x0A)

    data = IOP_ACK_PING (0x3A)

12. The GPS will respond again with the same packet in step 10.

    id = IOP_ACK_BYTE (0x06)

    data = IOP_CMND_DATA (0x0A)

13. The baud rate has been successfully changed upon receiving the above packet. If the GPS unit does not receive these two IOP_CMND_DATA packets within two seconds, it will reset its baud rate to 9600.

APPENDIX D: GPS 18x PC/ LVC/18x-5HZ & WINDOWS SERIAL MOUSE ISSUE

Problem: It is possible for Windows to incorrectly interpret the NMEA 0183 output of the GPS 18x PC as the output of a Microsoft Serial BallPoint Mouse. When that happens, Windows loads drivers for the Serial BallPoint Mouse. This causes the cursor to move erratically about the display, clicking, right clicking, double clicking, dragging and dropping displayed items as it goes. On Windows 2000 and Windows XP, you may not experience the problem if you wait until after the computer is booted before connecting the GPS 18x PC to the serial communications port. This problem is not specific to the GPS 18x PC. Any NMEA 0183 device connected to a Windows computer's serial port is likely to cause this problem. Below are several possible solutions to this problem.

Note: If your GPS 18x PC came with Garmin nRoute™ Navigation Software, you will not have this problem; the unit is programmed to produce data according to the binary format that is described in Appendix B: Garmin Binary Output Format.

If you wish to use a different navigation software application with your GPS 18x PC, you will need to de-select the "Binary Output Data" option that is discussed in Solution 3 below.

Solution 1: The easiest solution is to disable the Serial BallPoint mouse in the Device Manager. This solution assumes that you do not need to use a Serial BallPoint mouse with your computer. When erratic mouse movements occur, follow the steps below.

1. Unplug the DB9 connector.
2. Right-click the **My Computer** icon on your desktop and select **Properties** to open Device Manager.
3. Go to the hardware tab of the resulting pop-up window and click on the **Device Manager** button.
4. Right-click on **Serial BallPoint Mouse** and choose the option to **Disable** (NOT uninstall) this device.

Solution 2: Do not plug the DB9 connector into the computer until the computer is turned on and the operating system is completely booted up and running. Every time you use the GPS 18x PC/LVC, you will need to start the computer and operating system before making the connection between the GPS 18x PC and the computer. This solution usually works on Windows 2000 and Windows XP computers.

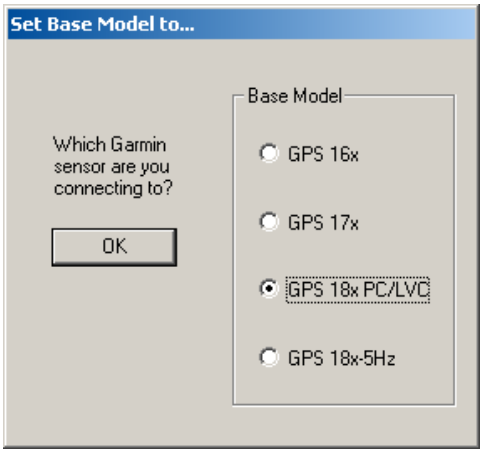
Solution 3: Change the default output of the GPS 18x PC/LVC so that it does not automatically send NMEA 0183 data to the computer (change the default configuration to enable "Binary Output Data"). Use the Garmin Sensor Configuration Software, named SNSRCFG.EXE, provided on the Web site to enable "Binary Output Data." To download the software, start at www.garmin.com/oem, select the GPS 18x, and then select **Updates and Downloads**.

Please note that by enabling "Binary Output Data," the device will no longer appear as a NMEA 0183 device to your computer. As a result, mapping applications that expect to hear NMEA 0183 data will not recognize your GPS 18x P/LVC until you re-enable the NMEA 0183 output, disabling the "Binary Output Data" in the process.

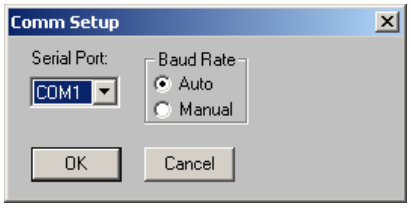
Refer to Appendix E: Sensor Configuration Software for complete information about downloading the Sensor Configuration Software application.

After the Sensor Configuration Software is installed and running on your computer, follow the steps below to change the default data output of the GPS 18x PC, LVC, or GPS 18x-5Hz.

1. Select the **GPS 18x PC / LVC** or the **GPS 18x-5Hz** from the list of sensors and click **OK.** The Sensor Configuration Software opens with the default configuration file for the GPS 18x, as shown on the next page.
2. Select **Config** > **Switch to NMEA Mode** (or press the F10 key).
3. Select **Comm** > **Setup** to open the Comm Setup Window.

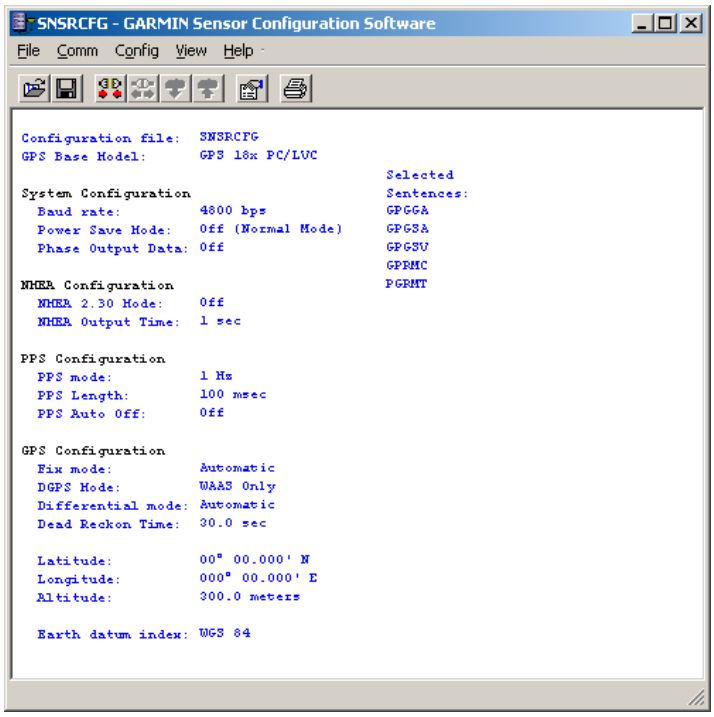


4. Select the serial port to which the GPS 18x is connected. Select **Auto** to have the program automatically determine the baud rate, or select **Manual** to manually select the baud rate of the GPS 18x. Click **OK** when done.



5. Click the Connect icon  , or select **Comm** > **Connect** to connect to the GPS 18x.

6. To view the current programming of the GPS 18x, select **Config > Get Configuration from GPS** (or press the F8 key). The current programming of the GPS 18x is displayed in the window, as shown on the previous page.



7. Open the Sensor Configuration Window by pressing the F6 key or selecting **Config > Sensor Configuration.**

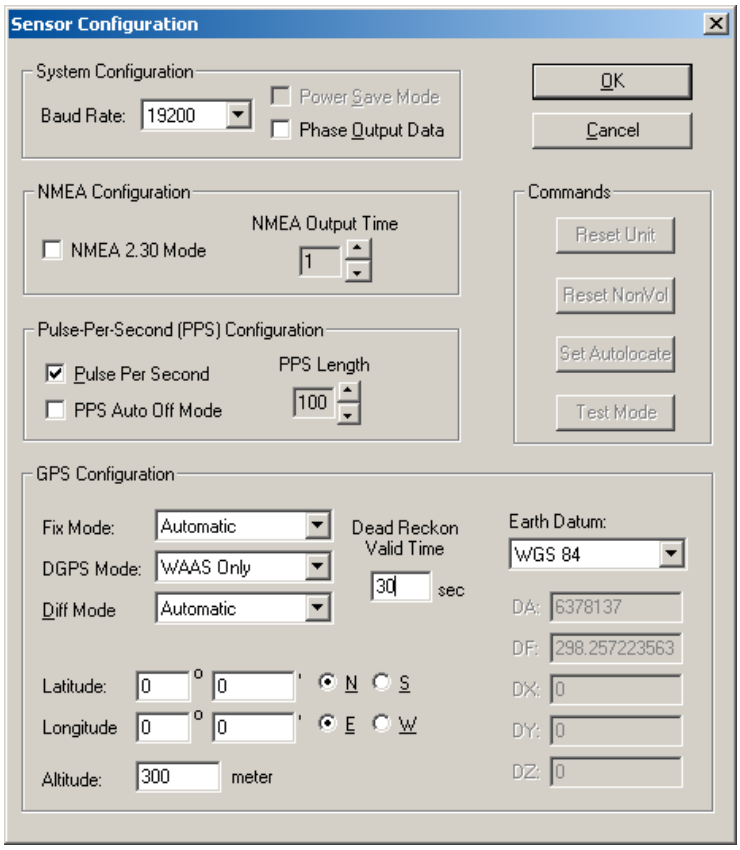
8. Place a check mark in the box next to "Binary Output Data" to change the GPS 18x to Garmin Mode. The unit will keep this change in the programming until you change it again in the software.

   Note: Selecting **Config** > **Switch to Garmin Mode (**or pressing the F11 key) only changes the unit to work in Garmin Mode until power is cycled through the unit again. For a more permanent change, refer to step 8 above.

9. Click **OK**.

10. When you are ready to upload the changes into the GPS 18x, select **Config > Send Configuration to GPS** (or press the F9 key). The new configuration is then loaded into the GPS 18x.

11. You may disconnect and close the software when finished. The software configuration can also be saved for future reference.



Refer to Appendix E: Sensor Configuration Software for complete information about downloading the Sensor Configuration Software application.

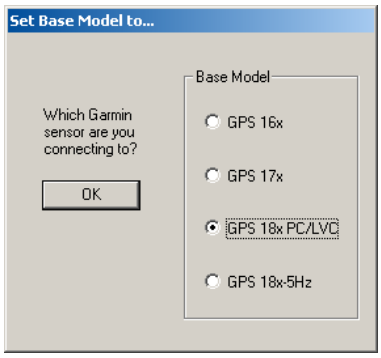
APPENDIX E: SENSOR CONFIGURATION SOFTWARE

The Garmin Sensor Configuration Software (SNSRCFG.exe) configures the GPS sensors based on user-selected parameters. Some application features include the ability to download GPS sensor configuration, maintain different configurations in files, and perform GPS sensor configurations quickly with the use of one function key.

This section provides a brief overview of the Sensor Configuration Software. Refer to this section when using the software to configure your Garmin sensor.

Downloading the Sensor Configuration Software

SNSRCFG.exe is available from the Garmin Web site. To download the software, go to www.garmin.com/oem. Click **GPS 18x 5Hz** or **GPS 18x OEM** (for the GPS 18x USB, 18x PC, and 18x LVC), and click **Updates & Downloads**. SNSRCFG.exe is included in the software update download.



Selecting a Model

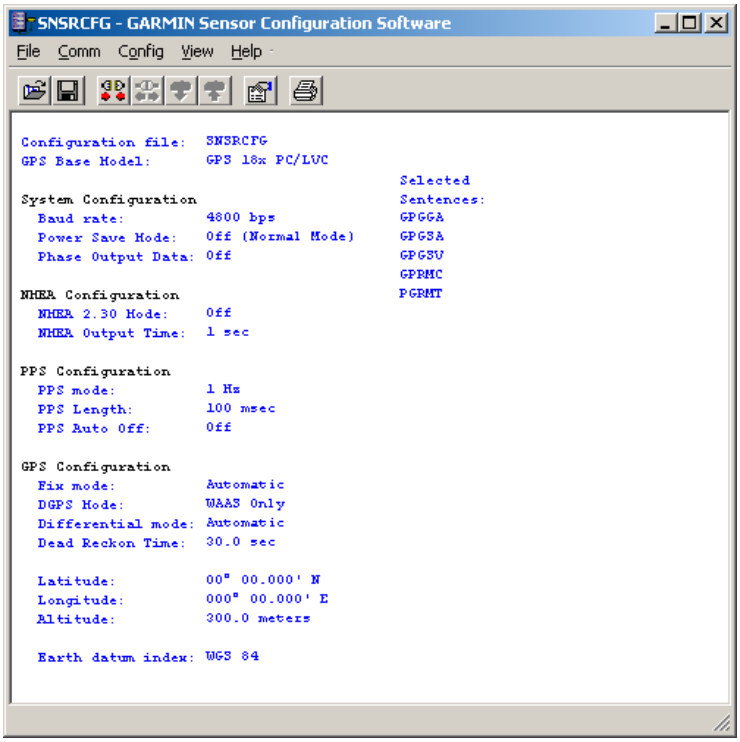
Double-click **SNSRCFG.exe**. The Set Base Model to… window appears. Select the radio button next to the type of Garmin sensor you are configuring.

Connecting to the Sensor

After selecting the type of sensor, the following window opens. This is the Main Interface Screen for the program.

To configure your sensor, you must first connect to the sensor.

1. Select **Config** > **Switch to NMEA Mode (**or press the F10 key).
2. Select **Comm** > **Setup** to open the Comm Setup window.
3. Select the serial port to which the sensor is connected. Select **Auto** to have the program automatically determine the baud rate, or select **Manual** to manually select the baud rate of the GPS 18x. Click **OK**.
4. Click the **Connect** icon, or select **Comm** > **Connect**.
5. To view the current programming of the sensor, select **Config > Get Configuration from GPS** (or press the F8 key). The current programming of the sensor appears as shown in the example to the right.



Menus

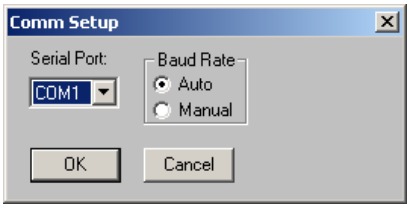
File Menu

The File Menu allows you to open, save, and print sensor configurations. The items in the File Menu work like most Windows-based programs.

Comm Menu

The Comm (Communication) Menu allows you to set the port number and baud rate, as well as connect to the sensor and disconnect from the sensor.

Setup: Opens the Comm Setup window. Select the serial port to which the sensor is connected from the drop-down list. Select **Auto** (the program determines the baud rate on its own) or **Manual** (you enter the baud rate) for the baud rate entry.



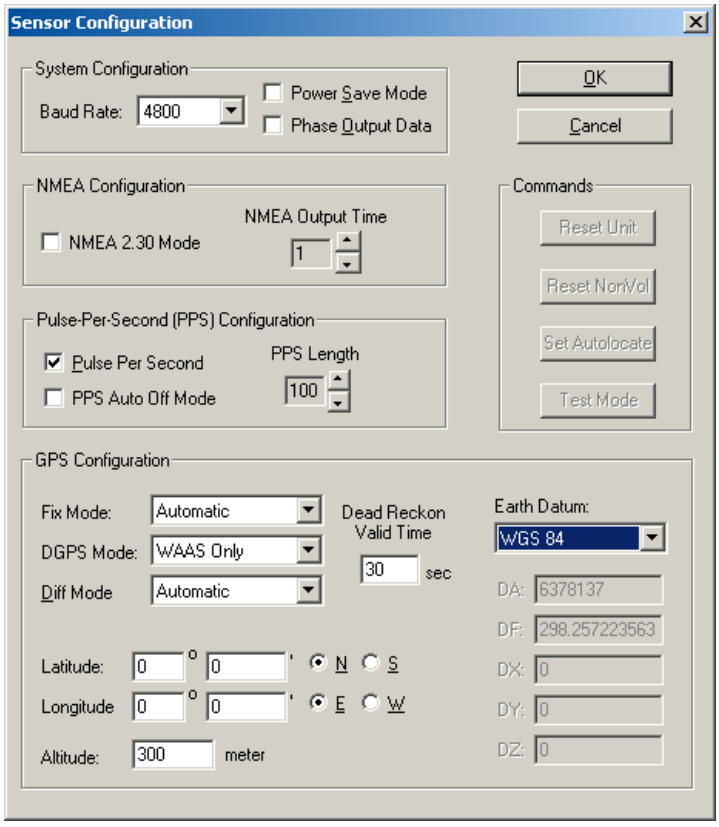
Connect: Select **Connect** to connect to the sensor in order to change or view the configuration.

Disconnect: Select **Disconnect** to disconnect from the sensor.

Config Menu

The Config (Configuration) Menu allows you to configure the sensor as it is connected.

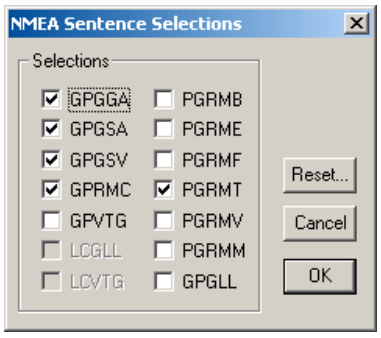
Sensor Configuration (F6): Opens the Sensor Configuration window, shown to the right. Many of the fields in this window should not be changed. Refer to the beginning of this manual for information on many of these fields. This window is used to enter a new latitude, longitude, and altitude for the sensor. This is especially helpful when you are programming the sensor for use in a particular geographic location.



Click **Reset Unit** to perform a reset on the unit, much like cycling the power.

Resetting the non-volatile memory (**Reset NonVol**) clears all of the data from the non-volatile memory.

NMEA Sentence Selections (F7): Displays the NMEA Sentence Selections window. If the sentence is enabled, a check mark appears in the box to the left of the sentence name. Click the box to enable or disable to the sentence.



Get Configuration From GPS (F8): Retrieves the current programming from the sensor. The programming is then displayed in the Main Interface window.

Send Configuration To GPS (F9): Sends your updated configuration programming to the sensor.

Switch to NMEA Mode (F10): Switches the unit to NMEA Mode. The sensor must be in NMEA Mode when connected to this software.

Switch to Garmin Mode (F11): Switches the unit to Garmin Mode.

Update Software (F12): After you have downloaded a new software version for the sensor, you can update the sensor with the new software. Select **Update Software** and then select the file using the Open dialog box. You must locate both the .rgn file and the updater.exe file.

View Menu

The View Menu allows you to view the NMEA sentences transmitted by the sensor. You can also customize how the program looks by showing and hiding the Toolbar and Status Bar.

Help Menu

The Help Menu displays the software version and copyright information.

For the latest free software updates (excluding map data) throughout the life of your Garmin products, visit the Garmin Web site at www.garmin.com.

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Part Number 190-00879-08 Rev. D

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ABSOLUTE IXARC MAGNETIC ROTARY ENCODER
WITH ANALOG INTERFACE

ANALOG

User Manual

IXARC UCD Analog Current + Voltage

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ABSOLUTE IXARC MAGNETIC ROTARY ENCODER WITH ANALOG INTERFACE

1. Introduction

1.1 IXARC Magnetic Encoders

This manual explains how to install and configure the IXARC absolute rotary encoder with Analog interface. Magnetic rotary encoders determine positions using the Hall effect sensor technology developed for the automotive mass market. A permanent magnet fixed to the shaft generates a magnetic field that is sampled by the Hall sensor, which translates the measured value into a unique absolute position value. To register revolutions even when no voltage is applied, energy from the turning of the shaft must suffice for proper operation. An innovative, patented technology makes this feasible even at low rotational speeds and through long standstill periods – a Wiegand wire ensures that the magnetic field can only follow the turning of the shaft in discrete steps. A coil wound on the Wiegand wire receives only brief, strong voltage spikes, which prompt the reliable recognition of each revolution.

1.2 General Information

This description is not intended to replace the documentation for the product concerned. Hazardous voltage and mechanisms, death, or serious injury due to electrical shock, burns and entanglement in moving parts, or property damage will result if safety instructions in the documentation are not followed. Do not service or touch until you have de-energized high voltage, grounded all terminals and turned off the control voltage. If the pertinent documentation is not in your hands, please ask for it using the order key in the product catalog or contact your FRABA POSITAL contact person. Only proper trained staff aware of local safety regulations are allowed to commission and operate, or to work on and around this product after procedures contained in the documentation. Before touching electronic assemblies make sure static charges are eliminated by touching an earthed component.

Instructions to mechanically install and electrically connect the angular encoder


Do not remove or mount the connector while the encoder is powered on!


Do not stand on the encoder!


Do not adapt the driving shaft additionally!


Avoid mechanical load!


Do not adapt the housing additionally!

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ABSOLUTE IXARC MAGNETIC ROTARY ENCODER WITH ANALOG INTERFACE

High-resolution absolute rotary encoder with analog output based on contactless magnetic Hall Effect technology. The Multi Turn rotary encoder can measure up to 65536 revolutions (16Bit). The Voltage or Current output of this rotary encoder is programmable, thus it can be scaled to fit perfect in any kind of application, particularly as a replacement for potentiometers. The PushButton and visible LED feedback makes the programming very easy. This rotary encoder can be used as a replacement for less reliable Multi Turn potentiometers. The sensor can be also used as an economical Multi Turn feedback sensor for low cost control systems with analog inputs.

Main Features

- Compact Industrial Design
- Interface: Analog – Current, Voltage
- Housing: Ø 36,5 mm
- Shaft: Ø 6 mm
- Blind Hollow / Hub Shaft: Ø 6 mm
- 13 Bit Total Resolution
- Factory Default Turns: 16 (0 To 5760°)
- Inputs for User Defined Measuring Range
- Over Range and Under Range Deadband
- EMC: EN 61000-6-2, EN 61000-6-4

Mechanical Structure

- Aluminum Flange
- Coated Steel Housing
- Stainless Steel Shaft
- Precision Ball Bearings

Suitable for Applications Requiring

- Packaging machines
- Material Handling
- Buses and Trucks
- Solar Tracking
- Wind Turbines
- Construction Machines
- Defense Equipment

Electrical Features

- Reverse Voltage Protection
- Over-Voltage Protection
- Programmable Measurement Range
- Short Circuit Protection of Output

ABSOLUTE IXARC MAGNETIC ROTARY ENCODER
WITH ANALOG INTERFACE

2. Electrical Data

Current Options	4–20 mA	0–20 mA
Max Load Resistance	500 Ω	
Supply Voltage[1]	8–32 V DC (absolute maximum ratings)	
Linearity	0.15 %	
Analog Accuracy	@ 20mA = ± 20 µA (for ideal power supply)[2]	
Settling Time	32 ms	
Current Consumption	Typical 20 mA @24 V DC (no load)	

Voltage Options	0–5 V	0.5–4.5V	0–10 V	0.5–9.5V
Min Load Resistance	5 kΩ			
Supply Voltage[1]	8-32 V DC (absolute maximum ratings)			
Linearity	0.15%			
Analog Accuracy	@ 10V = ± 10mV (for ideal power supply)[2]			
Settling Time	32 ms			
Current Consumption	Typical 15 mA @24 V DC (no load)			

1) Supply voltage according to EN 50 178 (safety extra-low voltage)

2) The analog accuracy would be less (the numeric value stated greater) if a non-steady or switching power supply is used

2.1 General Data

Turn On Time	< 1 s
Minimum Measurement Range	0 to 22.5 °

3. Interface

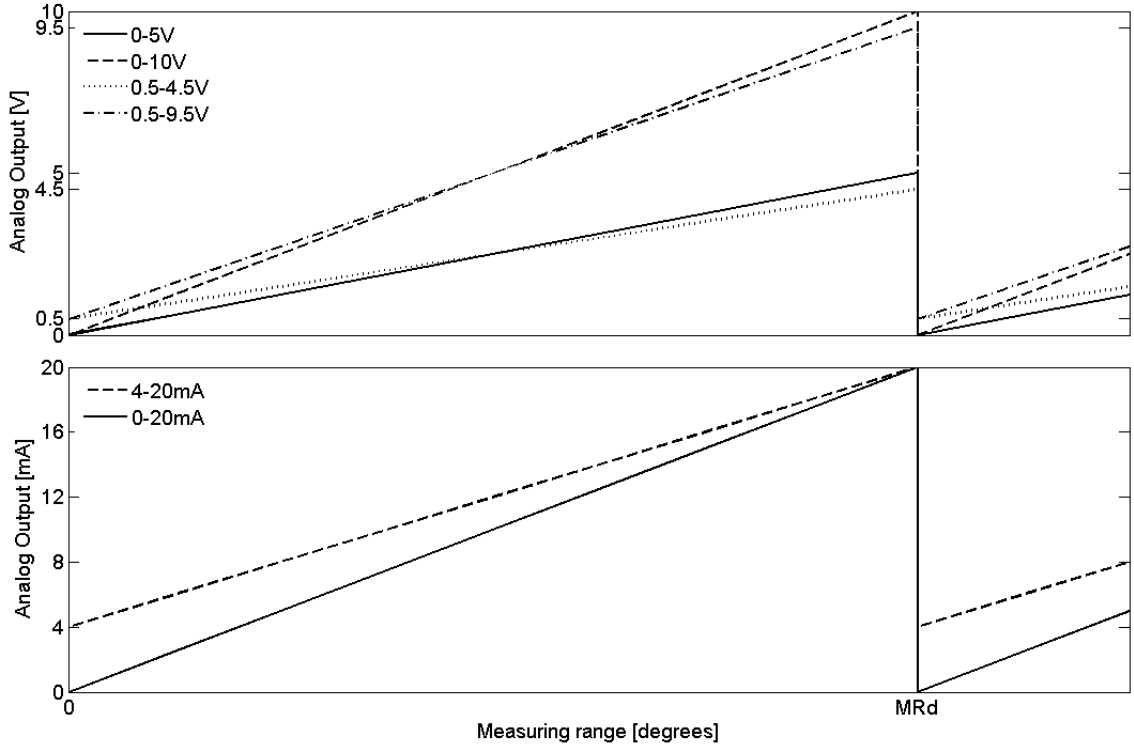
3.1 Output Characteristics of Scalable Encoders Incorporating Pushbutton and Non-Pushbutton Versions (UCD-AxP0x-… or UCD-Ax00x-…)

Code sense: Counter clockwise (CCW) shaft movement (front view on shaft) leads to increasing analog output

Analog output of standard singleturn (ST) and multiturn (MT) encoders with factory settings:

- Type keys of ST encoders: UCD-AxP0x-0013-… or UCD-Ax00x-0013-…
- Type keys of MT encoders: UCD-AxP0x-0413-… or UCD-Ax00x-0413-…

The graph below shows the output of the standard ST and MT encoders obeying the type keys denoted above with factory settings. For ST encoders the default measuring range (denoted as MR_d on the x-axis) equals 360°, whereas for MT encoders the default measuring range MR_d equals 16 turns, i.e. 5760°.



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ABSOLUTE IXARC MAGNETIC ROTARY ENCODER WITH ANALOG INTERFACE

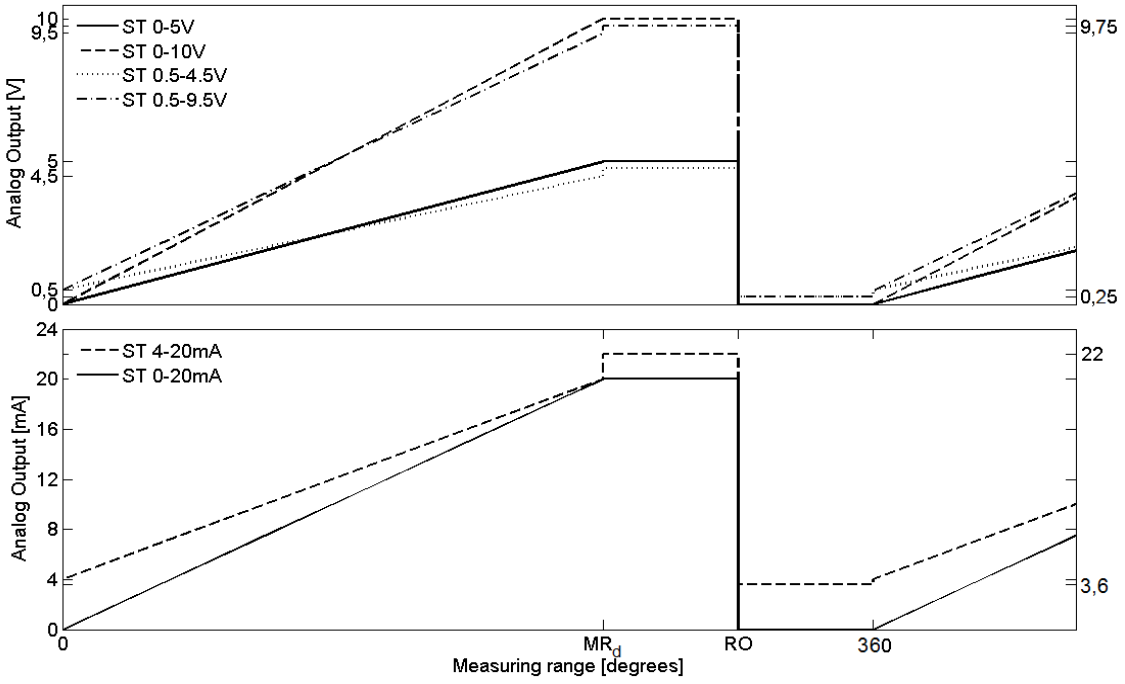
Analog output of ST encoders with fractional-turn measuring ranges as factory settings:

Type keys: UCD-AxP0x-00yy-… or UCD-Ax00x-00yy-…

You may order ST encoders having less than one turn measuring range as factory setting using the type key structure above, where yy= AP, AR or AS for default measuring ranges of 90°, 180°, and 270°, respectively.

The graph below shows the output of these encoders taking their respective default measuring ranges (denoted as MR_d on the x-axis) of 90°,180° and 270° into account. The encoders operate as default in rollover mode. Rollover (denoted as RO on the x-axis) occurs at the midpoint between MR_d and 360°. Hence, RO equals 225°, 270° and 315° for yy= AP, AR, AS respectively.

For measuring ranges between MR_d and 360° the encoder operates in the deadband regime, i.e. the output of the encoder equals the constant high and low deadband values when the measuring range is between (MR_d & RO) and (RO & 360°), respectively. The low and high deadband values for different encoder types are listed in the table below.



	Deadband Values [mA/V]	
Encoder Type	**Low**	**High**
0–5 V	0 V	5 V
0.5–4.5 V	0.25 V	4.75 V
0–10 V	0 V	10 V
0.5–9.5 V	0.25 V	9.75 V
4–20 mA	3.6 mA	22 mA
0–20 mA	0 mA	20 mA

ABSOLUTE IXARC MAGNETIC ROTARY ENCODER WITH ANALOG INTERFACE

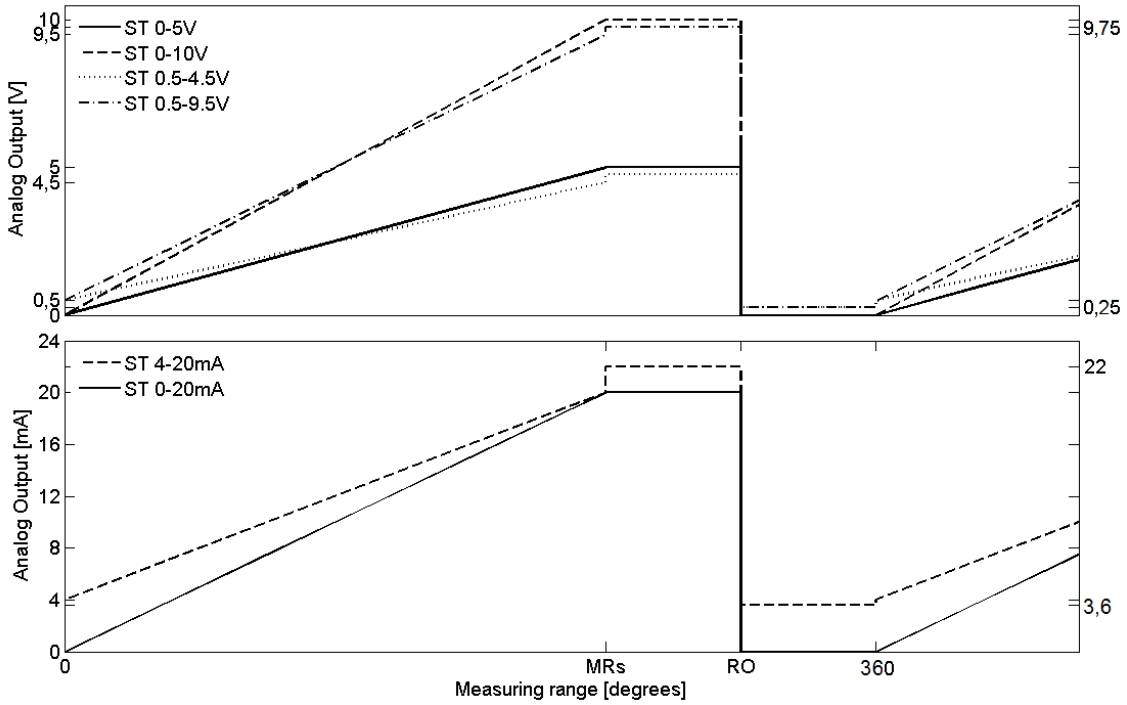
Analog output of user scaled ST encoders:

Type keys: UCD-AxP0x-00yy-… or UCD-Ax00x-00yy-…

The graph below shows the output of the encoders for an exemplary scaled measuring range (denoted as MR_s on the x-axis) of 60°,120°,180°,240° for yy= AP; AR; AS; 13, respectively.

The encoder operates as default in rollover mode. Rollover (denoted as RO on the x-axis) occurs at the midpoint between MR_s and 360°. Hence, for the exemplary MR_s denoted above RO equals 210°, 240°, 270° and 300° for yy= AP; AR; AS; 13, respectively.

For measuring ranges between MR_s and 360° the encoder operates in the deadband regime, i.e. the output of the encoder equals the constant high and low deadband values when the measuring range is between (MR_s & RO) and (RO & 360°), respectively. The low and high deadband values for different encoder types are listed in the table below.



	Deadband Values [mA/V]	
Encoder Type	**Low**	**High**
0–5 V	0 V	5 V
0.5–4.5 V	0.25 V	4.75 V
0–10 V	0 V	10 V
0.5–9.5 V	0.25 V	9.75 V
4–20 mA	3.6 mA	22 mA
0–20 mA	0 mA	20 mA

ABSOLUTE IXARC MAGNETIC ROTARY ENCODER WITH ANALOG INTERFACE

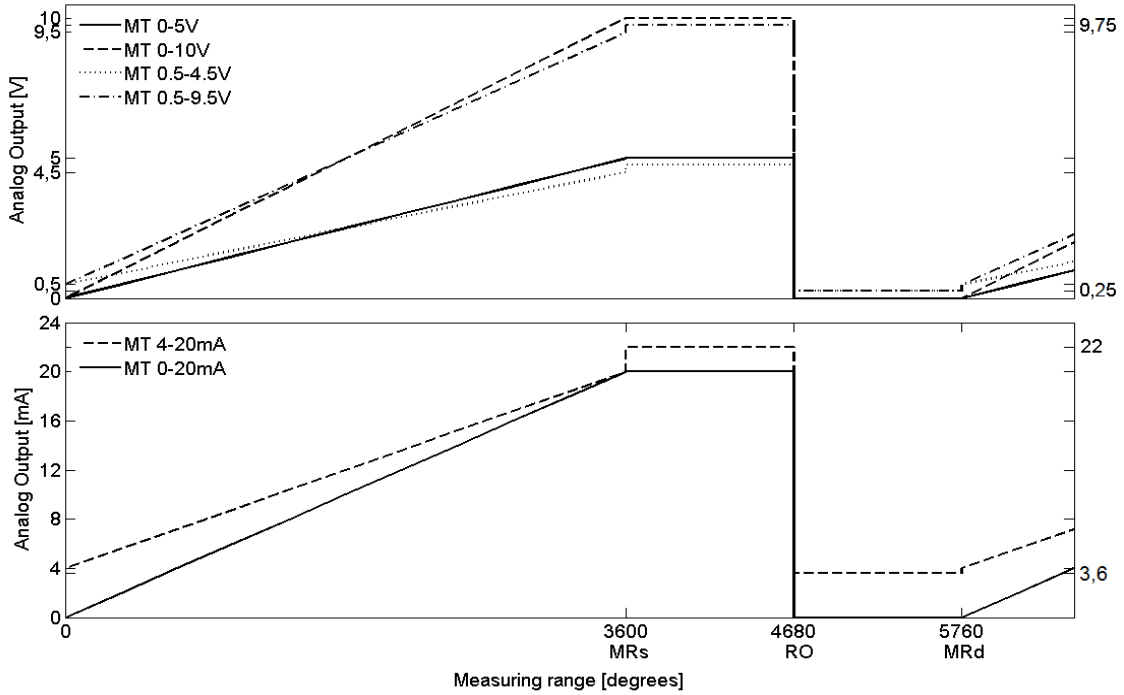
Analog output of user scaled MT encoders:

Type keys: UCD-AxP0x-0413-… or UCD-Ax00x-0413-…

Principally, the measuring range of MT encoders can be scaled up to 2^{16} turns. The graph below shows the output of the encoders for an exemplary scaled measuring range (denoted as MR_s on the x-axis) of 3600°or in terms of user scaled turns n_s = 10.

The encoder operates as default in rollover moder. Rollover (denoted as RO on the x-axis) occurs at the midpoint between the scaled measuring range MR_s and MR_d = 2^nx360°, where n is the smallest integer satisfying $2^n \geq n_s$. In the exemplary case shown in the graph below MR_d equals 2^4x360° = 5760°.

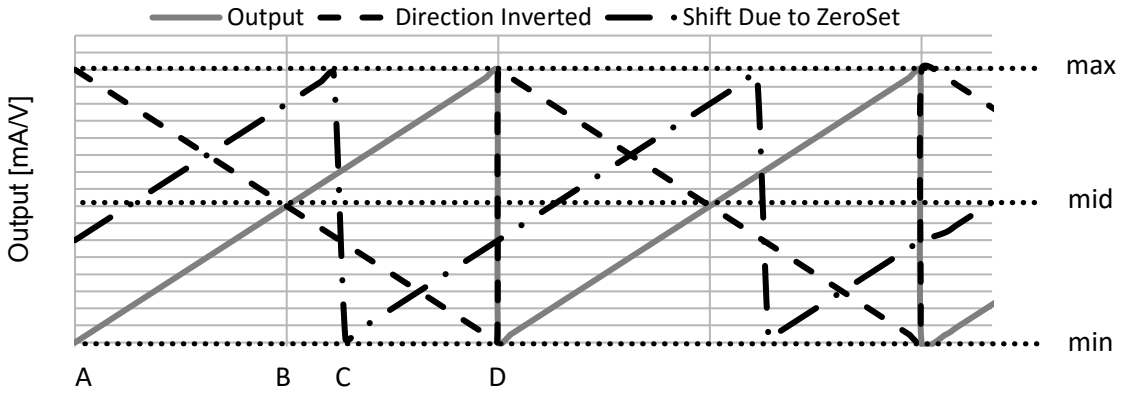
For measuring ranges between MR_s and MR_d the encoder operates in the deadband regime, i.e. the output of the encoder equals the constant high and low deadband values when the measuring range is between (MR_s & RO) and (RO & MR_d), respectively. The low and high deadband values for different encoder types are listed in the table below.



	Deadband Values [mA/V]	
Encoder Type	**Low**	**High**
0–5 V	0 V	5 V
0.5–4.5 V	0.25 V	4.75 V
0–10 V	0 V	10 V
0.5–9.5 V	0.25 V	9.75 V
4–20 mA	3.6 mA	22 mA
0–20 mA	0 mA	20 mA

3.2 Output Characteristics of Encoders with Zero Set and Direction Set but no Scaling Functionality (UCD-Ax10x-..)

Code sense : Clockwise shaft movement (front view on shaft) leads to increasing analog output



	Absolute Position [Degree]			
Encoder Type	A	B	C	D
UCD-AX10X-0013-…	0	180°	Zero Set Position	360° or 0°
UCD-AX10X-0413-…	0	2880°	Zero Set Position	5760° or 0°

		Analog Output Value [mA/V]		
Encoder Type		**max**	**mid**	**min**
0–5 V	UCD-AV101-…	0 V	2.5 V	5 V
0.5–4.5 V	UCD-AV103-…	0.5 V	2.5 V	4.5 V
0–10 V	UCD-AV102-…	0 V	5 V	10 V
0.5–9.5 V	UCD-AV104-…	0.5 V	5 V	9.5 V
4–20 mA	UCD-AC105-…	4 mA	12 mA	20 mA
0–20 mA	UCD-AC106-…	0 mA	10 mA	20 mA

3.3 Analog accuracy

The total analog accuracy of the encoder depends on the following factors:

- Linearity: Deviation from ideal linear transfer function [%]
- Analog accuracy: Offset at endpoints, basically linear function with different slope

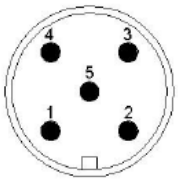
The total analog accuracy of the encoder depends on the measuring range since analog errors are only dependent on the output range. Using the mini-tool below the total analog accuracy error can be calculated in units of degrees and also percentage of the measuring range after selecting the output and measuring range of the encoder and specifying the offset. Major influences on the total analog accuracy are caused by the offsets which are typically compensated for at application setup. Therefore, the default value for the Offset/Accuracy field is selected to be 0. Nevertheless, the user can enter non-zero offset values to analyze its effects on the total analog accuracy.

Inputs			**Total analog accuracy**	
Encoder type	Measuring range [number of turns]	Offset/Accuracy [mV/µA]	[% of measuring range]	[Degrees]

4. Pin Configuration and Wiring

- Connect using a female M12 5pin round connector with a tightening torque in the range of 0.4 – 0.6 Nm
- IP69K protection guaranteed only with appropriate mating connector and secure connection
- Use a shielded cable for maximum protection from electromagnetic interference

Pin M12	Wire End	Function
1	Green	Current/Voltage Output
2	Red	+ V_S Supply Voltage
3	Yellow	GND (Supply)
4	White	Set 2 / Zero Set
5	Brown	Set 1 / Direction
		Shielding



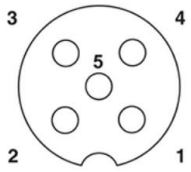
5 pin M12 Male Front View on Encoder

- WARNING: For pushbutton versions, i.e. those with type keys UCD-AxP…, do not use the pins/wires for Set 1 and Set 2 along with the pushbuttons at the same time while scaling and with different voltages.

4.1 Adapter cables for encoders with connectors and their wiring

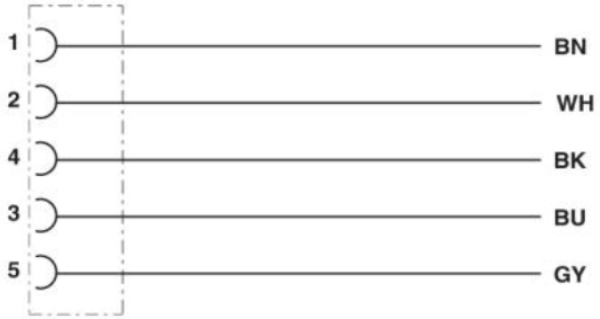
If you have purchased an encoder with a 5pin M12 connector you could make use of the adapter cables listed below for your application. The contact assignment and the color code of wires of these adapter cables are shown below.

Pin assignment:

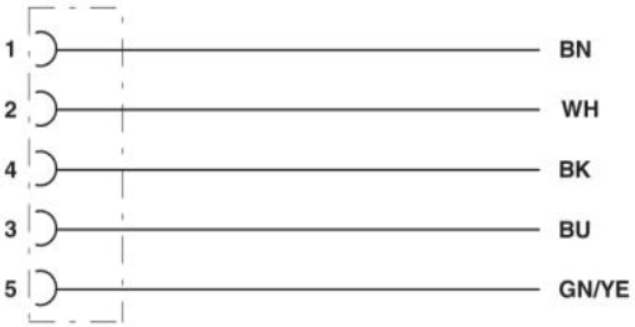


Contact assignment:

- 10017217 - 2m PUR Cable, 5pin, A-Coded, f
- 10017218 - 5m PUR Cable, 5pin, A-Coded, f
- 10017031 - 10m PUR Cable, 5pin, A-Coded, f



- 10032662 - 10m PUR Cable, 5pin, A-Coded, f



5. Scaling Functionality

5.1 Scaling Functionality For Non-Pushbutton Versions (UCD-Ax0xx-...)

Using the Set 1 and Set 2 input signals the measuring range (min range of 22.5º) with the analog output range can be scaled

- Turn the encoder shaft to the min position (One end of the measuring range)
- Connect Set 1 signal to high level for 1 second
- On release the analog output value jumps to the minimum output value (e.g.: 4 mA)
- Turn the encoder shaft to the max position (Other end of the measuring range)
- Connect Set 2 signal to high level for 1 second
- On release the analog output value jumps to the maximum output value (e.g.: 20 mA)
- Analog output is scaled to the new measuring range

Set 2 (White)	Set 1 (Brown)	Function / Output Value
0 (Input = N.C. or GND)	0 (Input = N.C. or GND)	Normal Operation
0 (Input = N.C. or GND)	1 (Input ≥ 5 V / Input ≤ V_S)	Preset Zero Point / Minimum
1 (Input ≥ 5 V / Input ≤ V_S)	0 (Input = N.C. or GND)	Preset Max Point / Maximum
1 (Input ≥ 5 V / Input ≤ V_S)	1 (Input ≥ 5 V / Input ≤ V_S)	Reset Midpoint of Default Scale[1)]

1) See table on page 10 for exact values.

Additionally, using the sequence shown in the table below the counting direction can also be changed after teach-in.

Teach-in mode					Results after teach-in
SET1	Release SET1	Set Range with Direction: Turning CW (as seen on shaft)	SET2	Release SET2	Turn CW (as seen on shaft) → Encoder is counting UP
SET1	Release SET1	Set Range with Direction: Turning CCW (as seen on shaft)	SET2	Release SET2	Turn CW (as seen on shaft) → Encoder is counting DOWN
SET2	Release SET2	Set Range with Direction: Turning CW (as seen on shaft)	SET1	Release SET1	Turn CW (as seen on shaft) → Encoder is counting DOWN
SET2	Release SET2	Set Range with Direction: Turning CCW (as seen on shaft)	SET1	Release SET1	Turn CW (as seen on shaft) → Encoder is counting UP

5.2 Scaling Functionality For Pushbutton Versions (UCD-AxPxx-...)

Using the Lim1 and Lim2 pushbuttons on the housing the measuring range (min range of 22.5º) with the analog output range can be scaled

- Press Lim1 and Lim2 together for 15 sec to enter programming mode
- Turn the encoder shaft to the min position (One end of the measuring range)
- Press Lim1 for 1 sec
- Turn the encoder shaft to the max position (Other end of the measuring range)
- Press Lim2 for 1 sec
- Analog output is scaled to the new measuring range

- WARNING: Do not use the pins/wires for Set1 and Set 2 along with the pushbuttons at the same time for scaling and with different voltages.

Timing Value: Operation Mode

Action	Time (Sec)	Device State
Both Buttons	15.0	Enter programming mode
Both Buttons	30.0	Reset to Mid of default
Single Button	–	Normal operation

Timing Value: Programming Mode

Action	Time (Sec)	Device State
Both buttons	–	Abort programming mode
Lim 1 pressed	1.0	Set position 1
Lim 2 pressed	1.0	Set position 2

LED States

Yellow LED	Green LED	Description
On	Off	Operation with default scale (“factory mode”)
Off	On	Operation with user scale
On	On	Entering programming mode (temporary state)
Flashing	Flashing	Programming mode
On	Flashing	Position 2 set, waiting for position 1
Flashing	On	Position 1 set, waiting for position 2

5.3 Versions with Zero Set and Direction Set but no Scaling (UCD-Ax1xx-…)

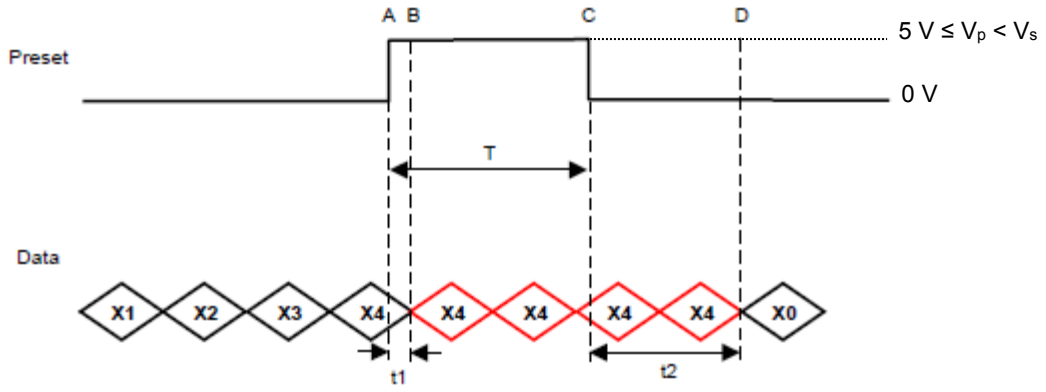
Direction Change

- Please set the direction before Zero Setting the encoder
- When the Direction pin is connected to GND or not connected, the encoder has a increasing output signal when the shaft is turned clockwise
- When the Direction pin is connected to ≥ 5 V up to max Supply Voltage the encoder changes the signal sense, i.e. CCW shaft movement leads to increasing analog output value
- The Direction pin needs to be always connected to ≥ 5 V for this functionality to remain

Preset Functionality

- Connect the Zero Set pin to greater than or equal to 5 V & less than 32 V for at least T=100 msec
- On releasing the pin the encoder output is set to the min position
- Make sure the shaft is not moving during zero setting

The Preset function allows setting the analog output value to min value at the present mechanical position. Input resistance is at high impedence.



T = 103msec +/- 2msec

t1 = 3msec +/- 2msec

T+t2 = 225msec (+/- 13msec)

Disclaimer

5.3 Versions with Zero Set and Direction Set but no Scaling (UCD-Ax1xx-…)

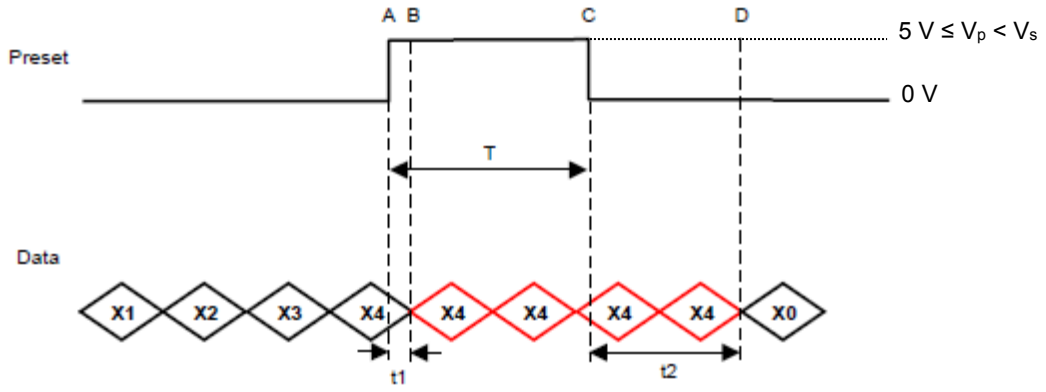
Direction Change

- Please set the direction before Zero Setting the encoder
- When the Direction pin is connected to GND or not connected, the encoder has a increasing output signal when the shaft is turned clockwise
- When the Direction pin is connected to ≥ 5 V up to max Supply Voltage the encoder changes the signal sense, i.e. CCW shaft movement leads to increasing analog output value
- The Direction pin needs to be always connected to ≥ 5 V for this functionality to remain

Preset Functionality

- Connect the Zero Set pin to greater than or equal to 5 V & less than 32 V for at least T=100 msec
- On releasing the pin the encoder output is set to the min position
- Make sure the shaft is not moving during zero setting

The Preset function allows setting the analog output value to min value at the present mechanical position. Input resistance is at high impedence.



T = 103msec +/- 2msec

t1 = 3msec +/- 2msec

T+t2 = 225msec (+/- 13msec)

Disclaimer

SPECIFICATIONS

Item No.：SCA128T

Description: Current Type Dual-Axis Inclinometer

Production implementation standard reference

- Enterprise quality system standards: ISO9001: 2008 standard (certification number: 128101)
- Tilt sensor production standards: GB / T 191 SJ 20873-2003 inclinometer general specification of Level
- The Academy of metrology and quality inspection Calibrated in accordance to: JJF1119-2004 Electronic Level calibration Specification
- Gyro accelerometer test standard: QJ 2318-92 Gyro accelerometer test methods
- Software development reference standard: GJB 2786A-2009 military software development General requirements
- Product environmental testing standards: GJB150
- Electromagnetic anti-interference test standards: GB / T 17626
- Version：Ver.09
- Date:2014.4.22

SCA128T- Current Type Dual-Axis Inclinometer

General Description

SCA128T is a standard industrial output dual-axis inclinometer, standard current 4 ~ 20mA output, meanwhile output dual axis inclination,can be long-distance transmission of up to 2000 meters. The output signal with strong anti-interference, professional be used to work on engineering machinery and equipment in harsh environment. The product uses the latest MEMS sensor production technology for production, made precise compensation and correction to temperature error and nonlinearity error, small measuring range the highest accurate up to 0.03 ° (more precision index, please refer to product Electronic Characteristics), high accuracy , small size, high packaging technology, good capacity to withstand shock and vibration, built-in anti-RF, anti-electromagnetic interference circuit , is particularly suitable for application underground trenchless type of machinery and other harsh industrial environments. In addition to this product is better than the ordinary market product on technical parameters, on the reliability and stability the product is also using the high-end application-level MCU,three-proofing PCB board, imported cable, wide temperature shielded metal enclosure and other measures to improve product industrial level.

Features

- ●Dual-Axis Inclinometer
- ●Accuracy :refer to the technical data
- ●Output interface : 4-20mA
- ●IP67 protection class
- ●Resolution: 0.01°
- ●Measuring Range :±1～±90° optional
- ●Wide voltage input: 9～36V
- ●Wide temperature working: -40～+85℃
- ●Highly anti-vibration performance >2000g
- ●Small Volume : 90×40×26mm（customized）

Application:

- ●Engineering vehicles automatic leveling
- ●Aerial platform vehicle,lifter safety & protection
- ●Underground drill posture navigation
- ●Based on the angle direction measurement
- ●Bridge & dam detection
- ●Medical facilities angle control
- ●Shield pipe jacking application
- ●Geological equipment inclined monitoring
- ●Directional satellite communications antenna pitching angle measurement
- ● Equipment level control
- ●Alignment control , curve control
- ●Mining machinary, oil-well drilling equipment

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Electronic Characteristics

Parameters	Conditions	Min	Standard	Max	Unit
Power supply	Standard	9	12、24	36	V
Working current			50		mA
Output overload	Resistive		400	1000	Ω
Working temperature		-40		+85	℃
Store temperature		-55		+125	℃

Technical Data

Parameters	Conditions	SCA128T-10	SCA128T-30	SCA128T-60	SCA128T-90	unit
Measuring range		±10	±30	±60	±90	°
Measuring axis		X,Y	X,Y	X,Y	X,Y	
Zero output	0° output	12	12	12	12	M A
Resolution		0.01	0.01	0.01	0.01	°
Absolute accuracy		0.02	0.05	0.08	0.1	°
Long term stability		0.05	0.05	0.05	0.05	
Zero temperature coefficient	-40～85°	±0.006	±0.006	±0.006	±0.006	°/℃
Sensitivity temperature coefficient	-40～85°	≤100	≤100	≤100	≤100	ppm/℃
Power on time		0.5	0.5	0.5	0.5	S
Response time		0.05	0.05	0.05	0.05	s
Response frequency		1～20	1～20	1～20	1～20	Hz
Electromagnetic compatibility	According to EN61000 and GBT17626					
MTBF	≥50000hours/times					
Insulation Resistance	≥100M					
Shockproof	100g@11ms、3Times/Axis(half sinusoid))					
Anti-vibration	10grms、10～1000Hz					
Protection glass	IP67					
Cables	Standard 1M length、wearproof、grease proofing、wide temperature、Shielded cables4*0.4mm2					
Weight	120g(without cable)					

* This Technical data only list ± 10 °, ± 30 °, ± 60 °, + 90 ° series for reference, other measuring range please refer to the adjacent parameters

SCA128T- Current Type Dual-Axis Inclinometer

Key words：

Resolution：Refers to the sensor in measuring range to detect and identify the smallest changed value.

Absolute accuracy：Refers to in the normal temperature circumstances,the sensor absolute linearity, repeatability, hysteresis, zero deviation, and transverse error comprehensive error.

Long term stability : Refers to the sensors in normal temperature conditions, the deviation between the maximum and minimum values after a year's long time work.

Response time：Refers to the sensor in an angle change, the sensor output value reached the standard time required.

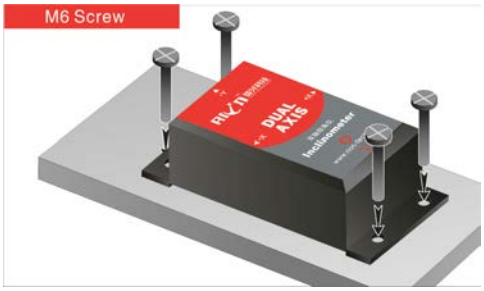
Mechanical Parameters

○ Connectors：1m lead cable（customized）

○ Protection glass：IP67

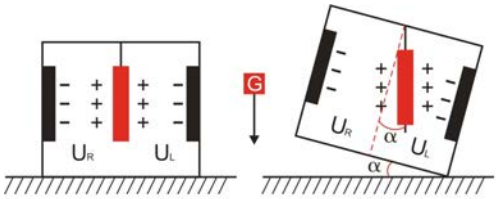
○ Enclosure material ：Aluminum Oxide

○ Installation ：4*M6 screws



Working Principle

Adopt the European import of core control unit, using the capacitive micro pendulum principle and the earth gravity principle, when the the inclination unit is tilted, the Earth's gravity on the corresponding pendulum will produce a component of gravity, corresponding to the electric capacity will change, , by enlarge the amount of electric capacity , filtering and after conversion then get the inclination.

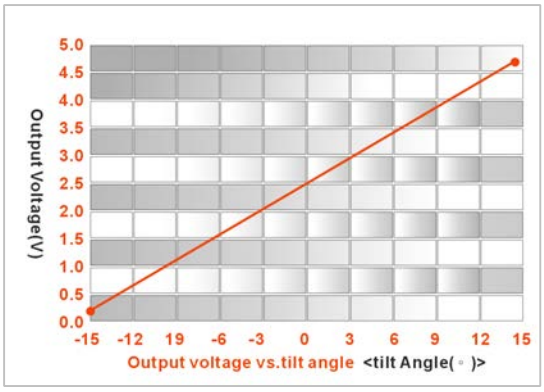


U_R, U_LRespectively is the pendulum left plate and the right plate corresponding to their respective voltage between theelectrodes, when the tilt sensor is tilted, U_R, U_L Will change according to certain rules, so f(U_R, U_L,) On the inclination of α function:

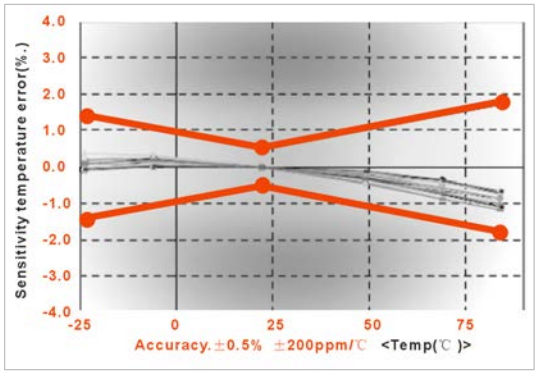
$$\alpha = (U_R, U_L,)$$

Typical performance diagram

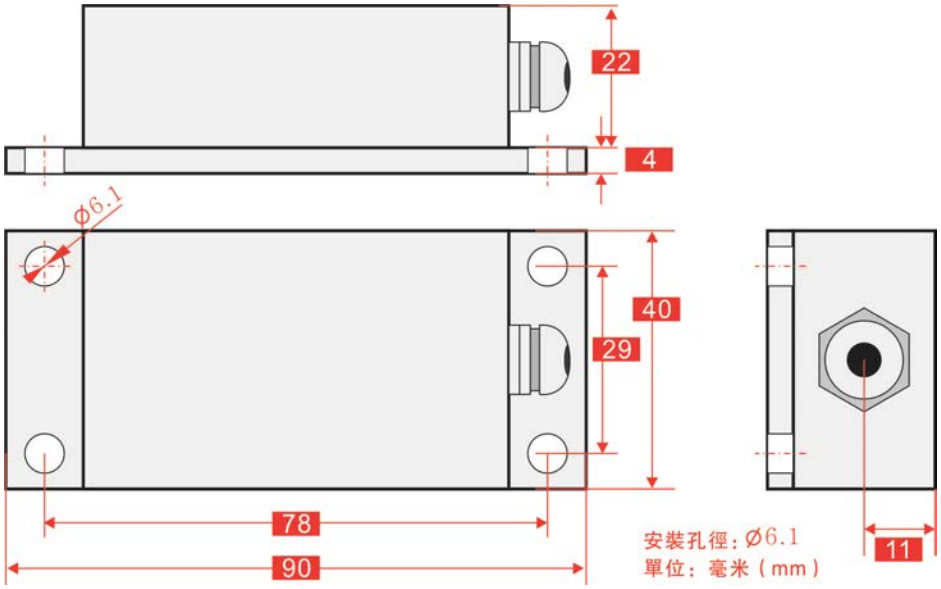
1： Input and Output characteristics：



2：Temperature characteristic chart：



Dimension



Size：L90×W40×H26mm

Angle output computational formula

Angle = (Output current－ZERO position current)÷ Angle sensitivity

Angle sensitivity= Output current range÷ Angle measuring range

E.g：SCA128T-30-A1（±30° Measuring range 16mA Output current range）

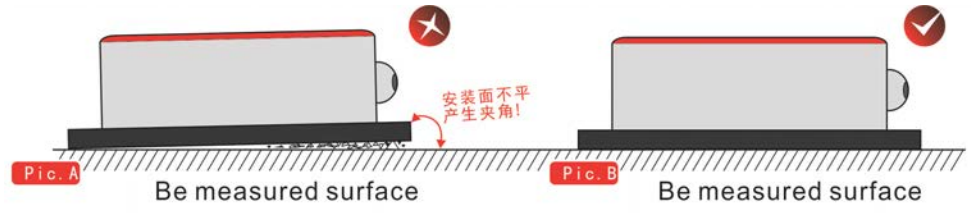
Angle sensitivity= 16÷60=0.266666 mA/°

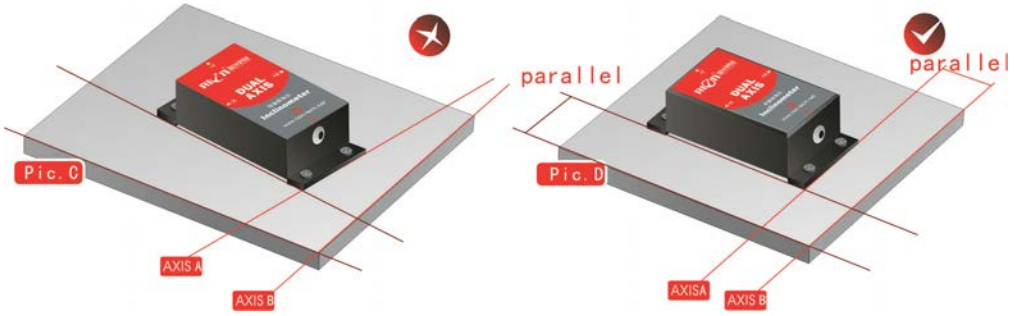
Production installation notes :

Please follow the correct way to install tilt sensor, incorrect installation can cause measurement errors, with particular attention to the "surface", "line"：

1）The Sensor mounting surface and the measured surface must be fixed closely, smoothly, stability,if mounting surface uneven likely to cause the sensor to measure the angle error. See Figure Pic.AB

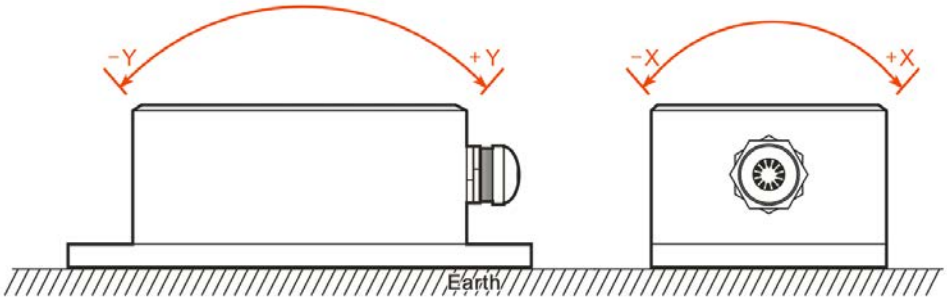
2) The sensor axis and the measured axis must be parallel ,the two axes do not produce the angle as much as possible. See Figure Pic.CD





Measuring Directions&Fix

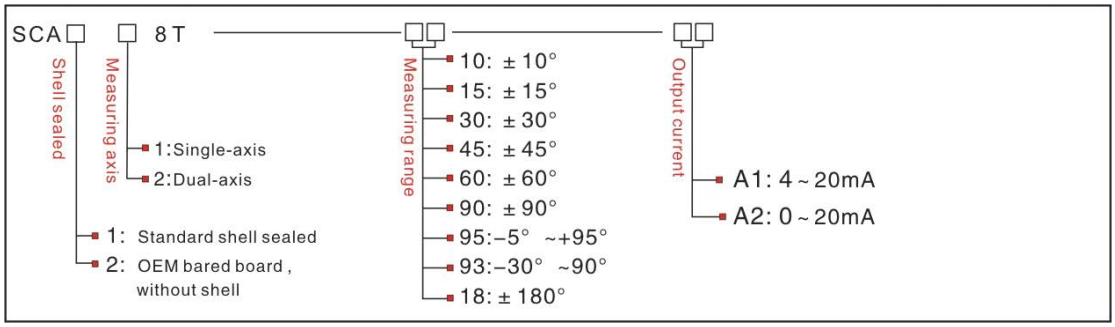
The installation must guarantee the product bottom is parallel to measured face，and reduce the influence of dynamic and acceleration to the sensor. This product can be installed horizontally or mounted vertically (mounted vertically selection is only applicable to the single axis), for installation please refer to the following scheme.



Electrical Connection

Line color function	BLACK	WHITE	GREEN	RED
	GND Power negative	Out X X Axis output current	Out Y Y Axis output current	Vcc Power supply Power positive

Ordering information:



E.g：SCA128T-10-A1：Dual-axis /Standard /±10° Measuring range /4-20mA Output current

ESD Sensitive Device

※More information please visit Rion's company website: www.rion-tech.net

深圳市瑞分科技有限公司

CHINA SHENZHEN RION TECHNOLOGY CO.,LTD.

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Accurate Solution Provider

SPECIFICATIONS

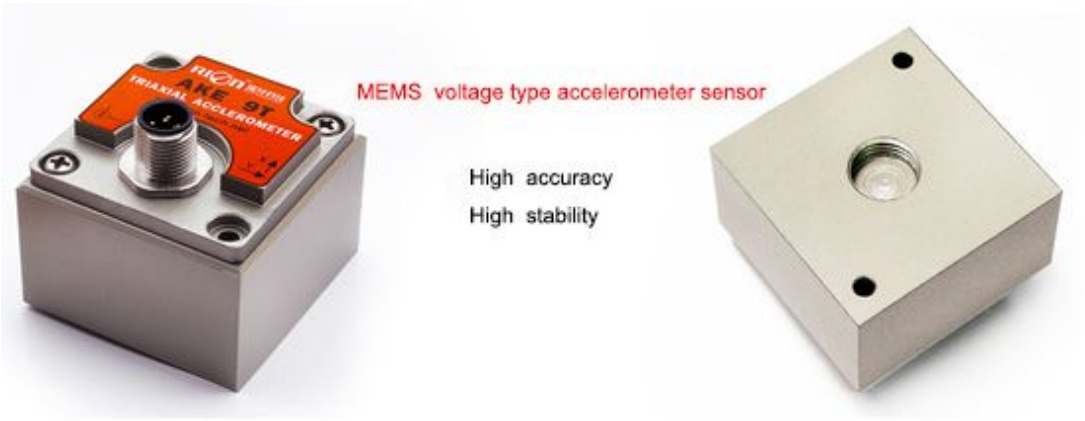
Item No.：AKE398B

Description：MEMS Current Type Accelerometer

Production implementation standard reference

- Enterprise quality system standards: ISO9001: 2008 standard (certification number: 128101)
- Tilt sensor production standards: GB / T 191 SJ 20873-2003 inclinometer general specification of Level
- The Academy of metrology and quality inspection Calibrated in accordance to: JJF1119-2004 Electronic Level calibration Specification
- Gyro accelerometer test standard: QJ 2318-92 Gyro accelerometer test methods
- Software development reference standard: GJB 2786A-2009 military software development General requirements
- Product environmental testing standards: GJB150
- Electromagnetic anti-interference test standards: GB / T 17626
- Version|:ver.07

●Revision Date:2014.4.29



General Description

AKE398B current type accelerometer sensor series products is RION company imported the Switzerland patented technology to produce for using widely, suitable for vibration testing, impact testing and more fields. This series products with firm structure,low power consumption, excellent deviation stability .etc characteristics to guarantee the reliability of outstanding output .

AKE398B is a monocrystalline silicon capacitive sensor, composed by a silicon chip of micro-mechanical treatment, low power ASIC for the signal adjustment, a microprocessor for storing compensation value and a temperature sensor. The product with low power consumption, after calibration, firm structure, stable output . New electronic configuration reset to provide a solid-state power, to provide comprehensive protection for over current. Scale factor in the full range of long-term stability and the deviation is typically less than 0.1%.For AKE398B, the deviation temperature coefficient typical value is 100μg / ℃, the scale factor temperature coefficient is 100 ppm / ° C

Key Features

- ●Three axis measurement optional (X、Y、Z)
- ●Output signal：4-20mA
- ●Voltage supply：9-36V
- ●Shock resistance：2000G
- ●Measuring range optional：±01G；±02G；±04G；±08G；±16G；±32G；±40G
- ●Excellent deviation stability ● Good environment performance shock，vibration and temperature）
- ●Size：L50×W50×H38mm
- ●Weight：100g
- ●Working temperature：-40°C to +85°C
- ●Storage temperature：-55°C to +100°C

Application

- ● Crash records, fatigue monitoring and forecasting ● The shipboard satellite tracking system
- ● Traffic system monitoring, the roadbed analysis and high-speed railway fault detection
- ● Military and civilian flight simulator
- ● Low frequency vibration and automatic monitoring

Technical Data

AKE398B Three-Axis accelerometer				
	AKE398B-02	AKE398B-08	AKE398B-40	Unit
Measuring range	±2	±08	±40	g
Deviation calibration	<10	<50	<150	mg
48h deviation stability	0.5	<1	<2	mg Typical value
Meausring Axis	X,Y,Z	X,Y,Z	X,Y,Z	Axis
Annual deviation stability[2]	1.5 (<5)	7.5 (<25)	22 (<75)	mg Typical value(Maximum value)
Power on/off repeatability	<2	<10	<20	mg(Maximum value)
Deviation temperature coefficient[3]	0.1	0.5	1.5	mg/℃ Typical value
	±0.4	±2	±6	mg/℃ maximum value
Annual scale factor stability	300 (< 1000)	300 (< 1000)	300 (< 1000)	ppm Typical value
Scale factor temperature coefficient	100	100	100	ppm/℃（Typical value）
	-50 / 250	-50 / 250	-50 / 250	（Minimum/Maximum value）
Resolution/threshold (@ 1Hz)	< 1	< 5	< 15	mg(Maximum value)
Nonlinearity	<0.1	<0.5	<0.6	% FS（Maximum value）
	<0.02	<0.09	<0.27	g(Maximum value)
Bandwidth[4]	1~≥400	1~≥400	1~≥400	Hz
Resonance frequency	1.6	6.7	6.7	kHz
Operating temperature	-40°C to +85°C			
Reliability	MIL-HDBK-217，Grade two			
Shock resistance	100g@11ms、3Times/Axis(half sinusoid)			
Recovery time	<1ms(1000g, 1/2 sin 1ms, impact in I shaft)			
Vibration	20g rms,20~2000Hz (Random noise，o ,p,I each shaft effect 30 minutes)			
LCC sealed	Meet MIL-STD-833-E			
Input（VDD_VSS）	9-36 VDC.			
Output current range	4-20mA @12VDC Input voltage（ %FS)			
Operating current consumption	<3mA @ 12 VDC no load			
Output resistance/load	Maximum 1kΩ@24V power			
Weight	Typical value：100g			
Size	Typical value : L50×W50×H38mm，			
Unless other specified，all the parameter values were tested under ±20℃（±68℉）and 12VDC conditions.				

Mechanical Parameters

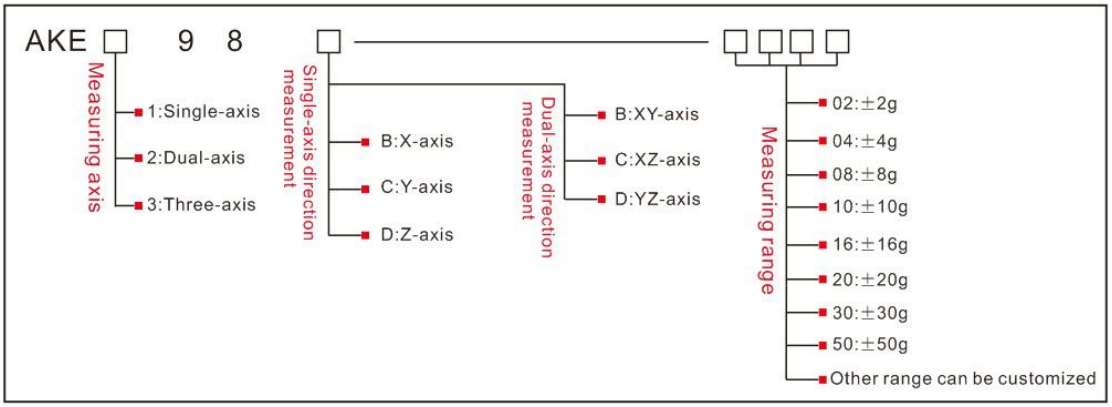
○ Connectors：waterproof air-plug

○ Protection class：IP67

○ Enclosure material：Aluminum Oxide

○ Installation：2XM4 screws or M16*1.5 bottom screws installation

Ordering Information



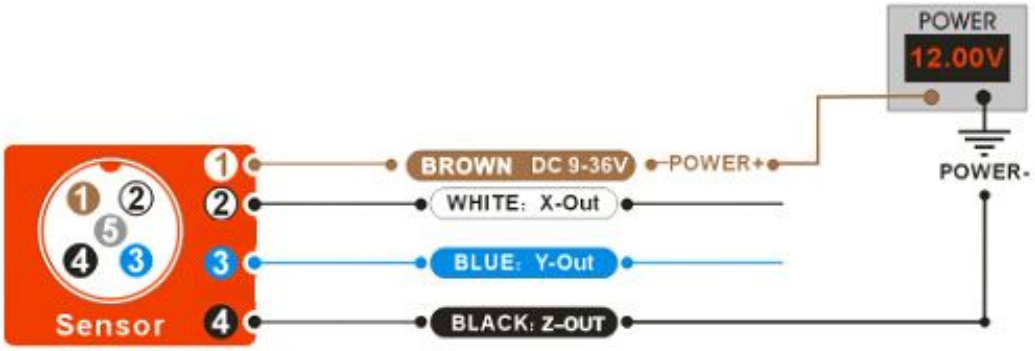
E.g：AKE198B-02：single-axis、X Axis direction measurement、+/-2g selection

AKE298B-02：dual-axis、XY Axis directions measurement、+/-2g selection

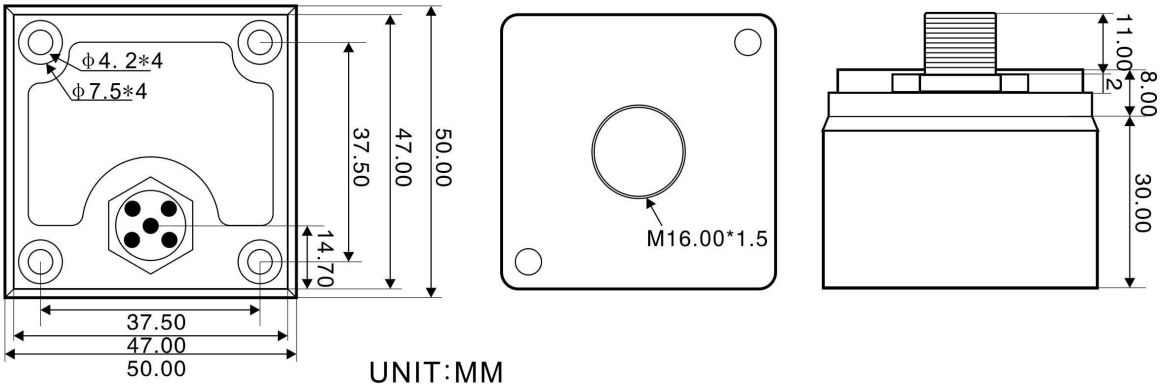
AKE398B-02：three-axis、XYZ Axis directions measurement、+/-2g selection

Electrical Connection

4cables socket pin	5cables socket pin	Cable color	Single-axis accelerometer	Dual-axis accelerometer	Three-axis accelerometer
1	1	Brown	Power positive	Power positive	Power positive
2	2	White	X Axis current signal	X Axis current signal	X Axis current signal
3	3	Blue	Y Axis current signal	Y Axis current signal	Y Axis current signal
4	4	Black	Power GND	Power GND	Power GND
	5	Gray	Z Axis current signal	Z Axis current signal	Z Axis current signal



Dimension

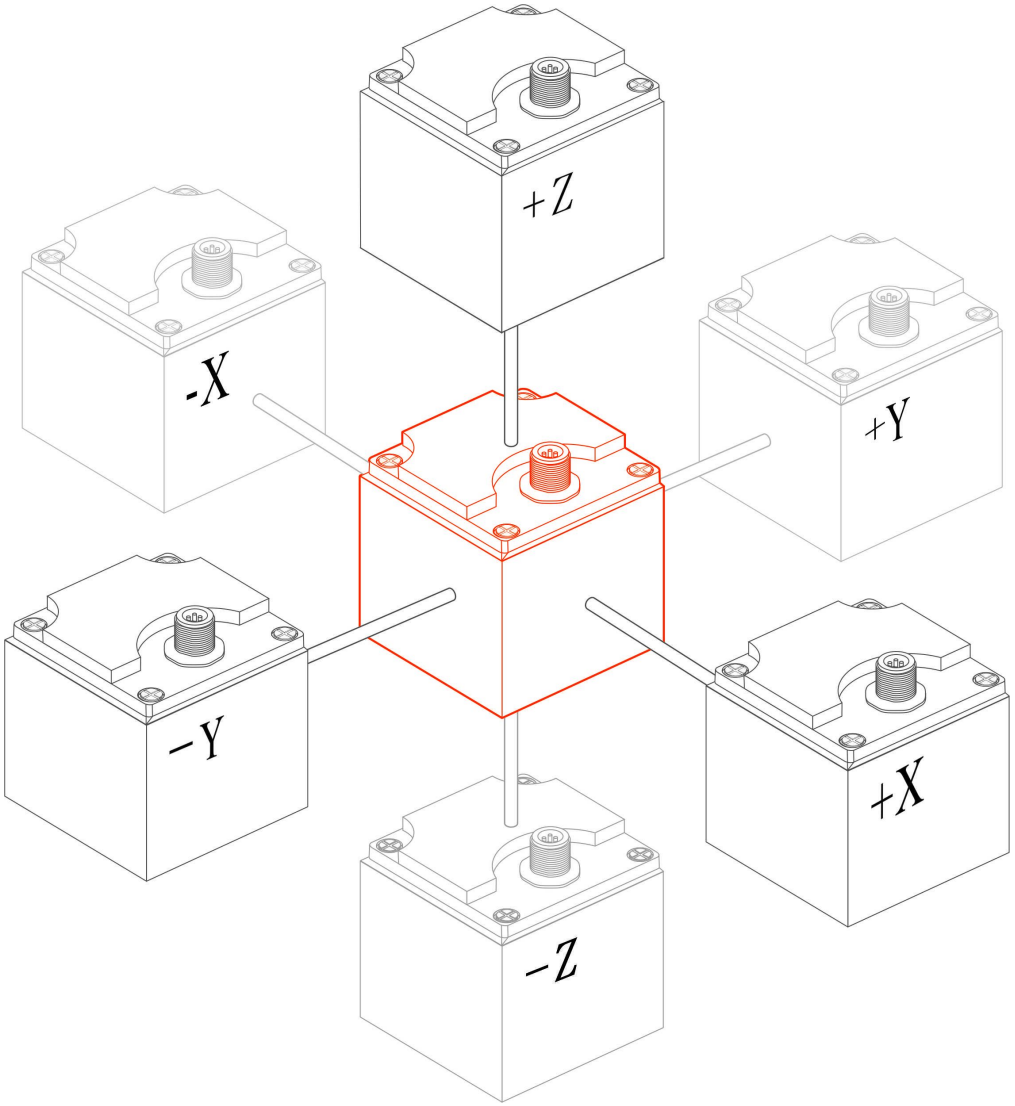


UNIT:MM

TOP VIEW　　BACK VIEW　　SIDE VIEW

Size:50*50*49mm

Products measuring directions



ESD Sensitive Device

※More information please visit Rion's company website: www.rion-tech.net

RION™

深圳市瑞芬科技有限公司

CHINA SHENZHEN RION TECHNOLOGY CO.,LTD.

✓倾角传感器 ✓倾角（调平）开关 ✓数显水平仪 ✓陀螺仪
✓三维电子罗盘 ✓加速度计 ✓航姿参考系统 ✓寻北仪

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Accurate Solution Provider

SPECIFICATIONS

Item No.：DCM260B

Description：High Accuracy 3D Digital Compass(with enclosure)

Production implementation standard reference

- Enterprise quality system standards: ISO9001: 2008 standard (certification number: 128101)
- Tilt sensor production standards: GB / T 191 SJ 20873-2003 inclinometer general specification of Level
- The Academy of metrology and quality inspection Calibrated in accordance to: JJF1119-2004 Electronic Level calibration Specification
- Gyro accelerometer test standard: QJ 2318-92 Gyro accelerometer test methods
- Software development reference standard: GJB 2786A-2009 military software development General requirements
- Product environmental testing standards: GJB150
- Electromagnetic anti-interference test standards: GB / T 17626
- Version|:ver.07
- Revision Date:2014.4.30

DCM260B-High Accuracy 3D Digital Compass(with enclosure)

General Description

DCM260B is a low-cost 3D electronic compass (with enclosure), using USA patented technology of hard magnetic and soft magnetic calibration algorithm, make the compass eliminate the magnetic influence through calibration algorithm in the magnetic interference environment ,DCM260B integrated three-axis fluxgate sensor, in real time solver heading through the central processor, and using 3-axis accelerometer to proceed heading compensation for the wide range tilt angle, to ensure the compass still can provide high-precision heading data when the tilt angle up to ±85°.Electronic compass integrated high-precision MCU control, various output mode, standard interfaces including RS232/RS485/TTL and other interfaces, and accept other communication interface customization.

DCM260B with small size, low power consumption, can be used for the antenna stability, vehicles, systems integration and other more fields , high shock resistance, high reliability makes the compass work properly in extremely harsh environments, and is more suitable for nowadays miniaturization military high-precision measurement integrated control system.

Features:

- ●Heading accuracy: 0.8°
- ●Tilt angle measuring range :±85°
- ●Tilt angle resolution: 0.1°
- ●Tilt angle accuracy: 0.2°
- ●Wide temperature : -40℃～+85℃
- ●Size: L55×W37×H24mm
- ●With hard magnetic ,soft magnetic and angle compensation
- ●DC 5V power supply
- ●Standard RS232/RS485/TTL output interface
- ● IP67 protection class

Application :

- ●Satellite antenna search satellite
- ●Marine navigation surveying and mapping
- ●GPS integrated navigation
- ●Antenna servo control
- ●Gun emission system
- ●Infrared imager
- ●Laser range finder
- ●Map for plotter
- ●ROV underwater robot navigation
- ●Oceanography measurement instruments
- ●Special occasion robot
- ●Unmanned aircraft

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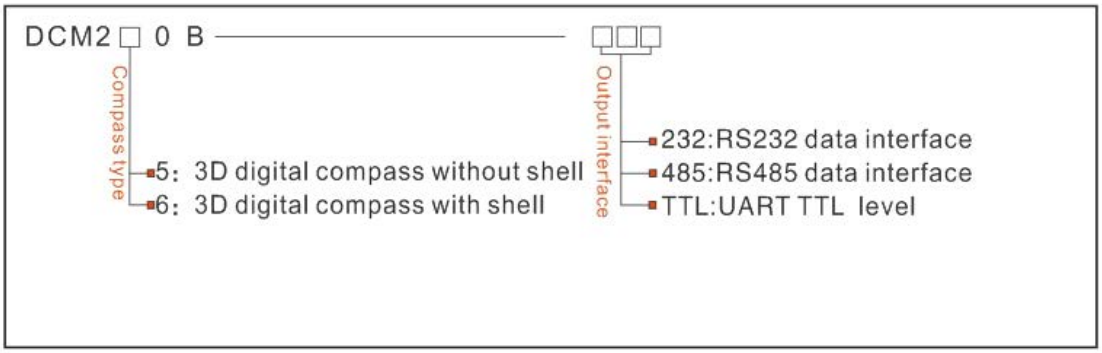
Electrical Characteristics

DCM260B Technical Data		
Compass heading parameter	The best heading accuracy	0.8° tilt <10°
		1.5° tilt <30°
		2.0° tilt <40°
		3.0° tilt <70°
	Resolution	0.1°
Compass tilt parameter	Pitch accuracy	0.1°<15°（Measuring range）
		0.2°<30°（Measuring range）
		0.3°<60°（Measuring range）
		0.4°<90°（Measuring range）
	Pitch tilt range	±85°
	Roll accuracy	0.1°<15°（Measuring range）
		0.2°<30°（Measuring range）
		0.3°<60°（Measuring range）
		0.4°<90°（Measuring range）
	Roll tilt range	±85°
	Resolution	0.1°
	The best compensation angle range of compass tilt	<40°
Calibration	Hard iron calibration	Yes
	Soft iron calibration	No
	Magnetic field interference calibration method	Plane rotation in a circle (2D calibration)
Physical features	Dimension	L55×W37×H24mm
	Weight	20g
	RS-232/RS485/TTL interface connector	5cable 1M direct lead line
Interface features	Start delay	<50MS
	Maximum output rate	20Hz/s
	Communication rate	2400 to 19200baud
	Output format	Binary high performance protocol
Power	Power supply	（Default）DC+5V
		（Customized）DC9～36V
	Current(Maximum)	45mA
	Ideal mode	35mA
	Sleep Mode	TBD

Enviroment	Operating range	-40℃～+85℃
	Storage temperature	-40℃～+100℃
	Resistance shock performance	2500g
Electromagnetic compatibility	According to EN61000 and GBT17626	
MTBF	≥40000 hours/times	
Insulation resistance	≥100M	
Shock resistance	100g@11ms、3Times/Axis(half sinusoid)	
Anti-vibration	10grms、10～1000Hz	
Weight	30g(without cable)	

Ordering information:



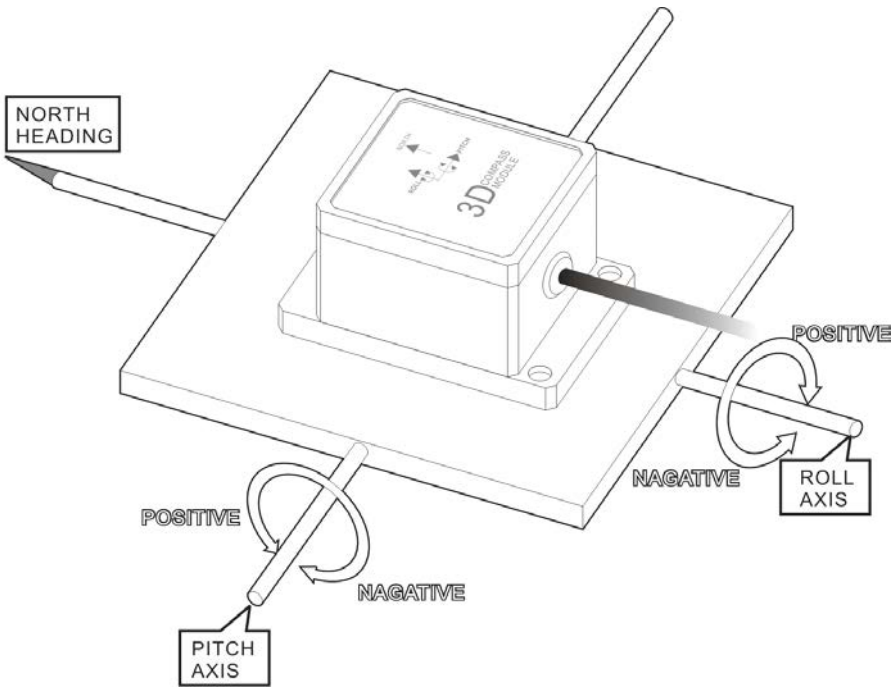
E.g：DCM260B-232：3D with enclosure sealed/RS232 output

DCM260B Measuring Directions&Fix

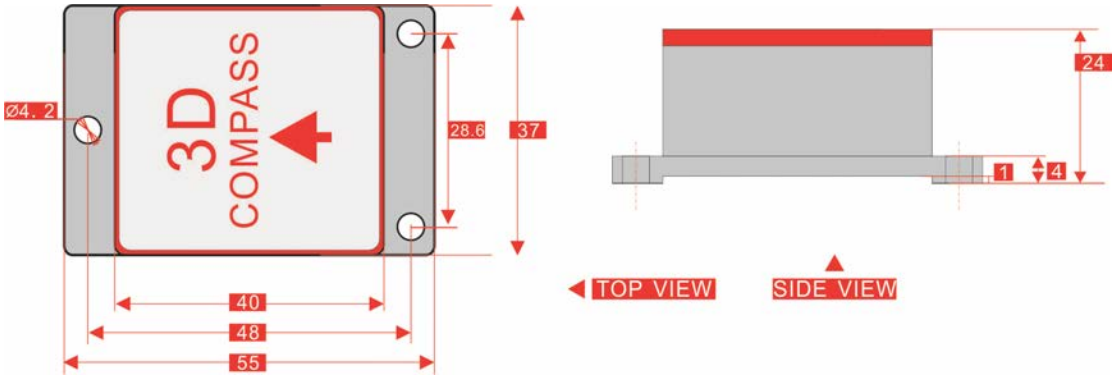
The DCM260B 3D electronic compass azimuth is using geomagnetic principle, so it is very important to select a minimum magnetic interference environment for installation positon. Please place and install the DCM260B away from the iron, magnets, engines and other magnetic objects as much possible as you can. Need control over 40CM distance(different magnetic interfere with the compass in different distance) at least even there are these magnetic medium around . In order to ensure optimal measurement environment please must use the **M3 stainless screws for installation .**

Although DCM260B can compensate the moderate deviation in the stable magnetic environment, but it can not compensate the changed magnetic interference. Please pay much attention to the wire with DC will generates a magnetic field , because if the DC change then the magnetic field will also change in size . The battery also is another interference source of changing . Each installation is different, and the user must evaluate the feasibility of installation under all possible operating environment.

The optimal heading accuracy of DCM260B can reach 1 ° , this undergo a rigorous validation indisputable, the most scientific test method is equally crucial. The test method we recommend is: Please install the DCM260B electronic compass to a vertical and erect aluminum pole (non-magnetic material), then proceed with heading accuracy measurement (of course the rotating rod perpendicular to the rotating platform, as much as possible to avoid large external magnetic field interference). Doing so can reduce the compass turning radius, to scientifically improve the measurement accuracy. This is just to provide the installation of the laboratory, must be flexible to deal with the specific situation.E.g: is mounted in the car, DCM260B should do its installation in the perpendicular to the movement direction.



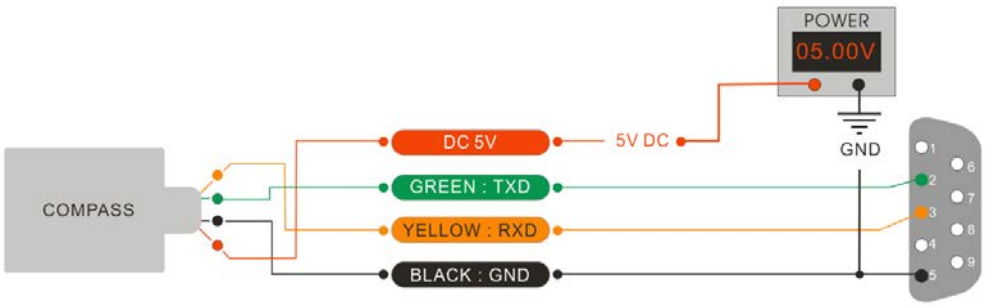
Dimension :



Size:L55*W37*H24

Electrical Connection

Line color function	RED	BLACK	YELLOW	GREEN
	Vcc 5V Power supply positive	GND Power supply negative	RS232(RXD) Or RS485(D+)	RS232(TXD) Or RS485(D-)



DCM260B Calibration methods:

Calibration lemmas:

1) The accuracy of testing compass can not reach the requirements;

2) compass installation environment have magnetic interference, the interference is fixed, and the interference magnetic field and compass installation will not happen again in distance changes (example: compass to be installed above an iron material, because the iron will have magnetic interference, at this time then need to rotate and calibrate the iron and compass, and the iron and compass will not be separated when using , once they are separated then need to recalibrate. If the iron size is not fixed, or with a compass distance change is not fixed, the interference can not be calibrated,only can install it in a very far away , safe distance control in above 40cm).

1) Please horizontally place the compass to a flat surface away from the interference, and correctly connected to the RS232 communication port, turn on the power.

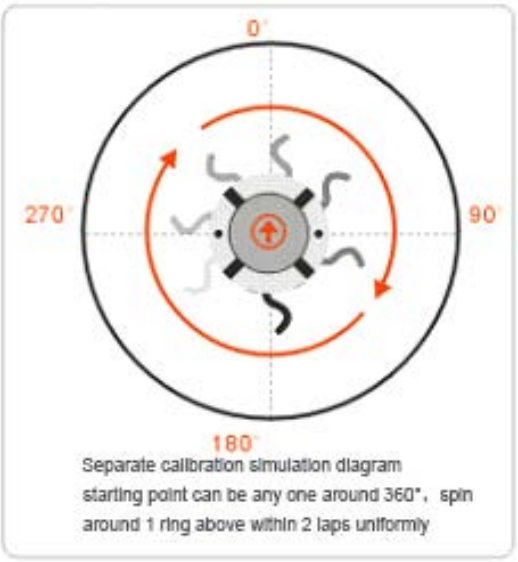
2) Send the calibration start command: 68 04 00 08 0C in hexadecimal format. (Or click the Rion's 3D debugging software "**CALI-START**" button)

3) DCM compass will return the response command.

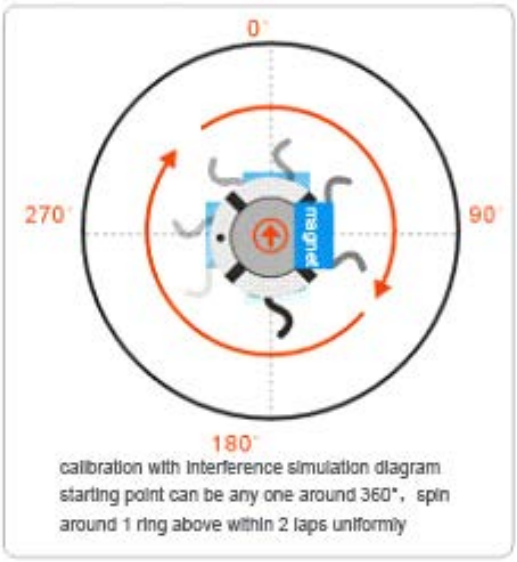
4) Rotate the compass from 0 ° to 360 ° in a circle at original position , then proceed the magnetic field data acquisition surround the compass(rotational speed should not too fast , control more than 40 seconds / turn.)

5) After back to 0 °,re-send stop calibration command: 68 04 00 0A 0E in hexadecimal format, calibration success (or click Rion's 3D the debug software "**CALI-SAVE**" button)

Note: If the compass is fixed install in other devices, the devices have magnetic interference, after compass to be installed, then rotate it with supporting devices together, to collect the interference source of the supporting products , to ensure the compass with a accurate measurement



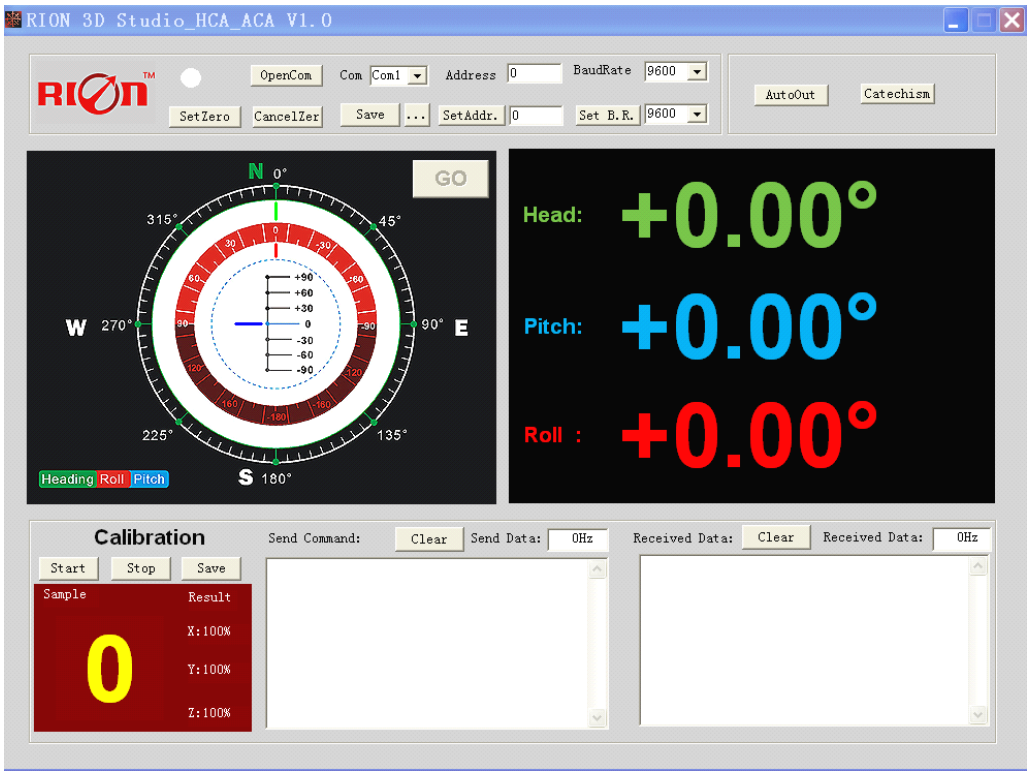
Separate calibration simulation diagram
starting point can be any one around 360°, spin around 1 ring above within 2 laps uniformly



calibration with interference simulation diagram
starting point can be any one around 360°, spin around 1 ring above within 2 laps uniformly

RION's 3D Software

You can download the RION angle debugging software from RION's official website for the preliminary angle debugging, also you Can download public version of the comassistant software on line for using .



Open/Close：Open and close COM port;

Com: Select the the device corresponding to the COM port

Address: Fill in the sensor current address code, the factory default is 00

Set Address: Set the sensor address code input box on the right to enter the desired address code, click Set Addr button

Save Data: Save the data, click here data can be synchronized Save angle data, the file is stored by default in the C: ---- COMDATA file

Set Zero: Set relative zero, the sensor current angle is 00.00 degrees

Cancel Zero: Unset the relative zero, to restore the sensor to the factory absolute zero;

Baud Rate: Select the sense baud rate , the factory default is 9600;

Set Baud Rate: Set the sensor baud rate, on the right of the selection box to select corresponding baud rate then click SetB.R. button;

Auto Output: Switch the sensor to automatically output mode, in the automatic output mode can be filled with different output frequency in Hz;

Catechism: The sensor switch to answer pattern, such as choosing the answer type, must input "send command "(command, please refer to the specification) on the left of "Send Command" input box, but also can fill in the transmit frequency in the Send Data, the unit Hz;

Mag. Dec.: Magnetic declination setting, in the right box directly enter the local magnetic declination, click "Mag.Dec." Button to confirm .

Calibration: compass calibration forum

Start: Start calibration

Save: stop calibration and save data. (Specific calibration method please refer to this specification calibration description)

Note: after install the RION's debugging software, if can not open, please operate by the following steps (please appear to the administrator status to operate):

1） Copy these three files mscomm.srg、mscomm32.ocx、mscomm32.dep from the folder to C:/Windows/system32 path below。

2） Click "Start" –"run" --regsvr32 mscomm32.ocx，You are prompted to install successful dialog。

Product Protocol

一、DATA FRAME FORMAT：（8 bits date，1 bit stop，No check，Default baud rate 9600）

Identifier (1byte)	Date Length (1byte)	Address code (1byte)	Command word (1byte)	Date domain	Check sum (1byte)
68					

Identifier：Fixed68H

Data length：From data length to check sum（including check sum）length

Address code：Accumulating module address，Default :00

Date domain will be changed according to the content and length of command word

Check sum：Data length、Address code、Command word and data domain sum,No carry.

二、COMMAND word analysis

Desc.	Meaning/Example	Description
0X04	**Meanwhile read Pitch、Roll、Heading** **Angle command *68 04 00 04 08***	Data domain（0byte） No Data domain command
0X84	Sensor answer reply **E.g:** **68 13 00 84 00 10 50 10 10 05 01 04 01 22**	Data domain（9byte） AA AB BB CC CD DD EE EF FF AA AB BB:3 Characters is Pitch Axis CC CD DD:3 Characters is Roll Axis EE EF FF: 3 Characters is Heading Angle format with same analytic method as Pitch、Roll、Heading On the left example , the angle is : Pitch: +010.50°,Roll:-010.05°，Heading+104.01°
0X06	**Setting declination command** ***68 06 00 06 02 08 16***	Data domain（2byte） SA AB S is symbol 0 positive 1 negative AA: two digits integer，B: two digits decimals E.g：02 08 is +20.8 deg
0X86	Sensor answer reply E.g: **68 08 00 86 00 8E**	Data domain（1byte） Data domain in the number means the sensor response result 00 Setting successfully FF Setting failure
0X07	**Read declination command** ***68 04 00 07 0b***	Data domain（0byte） No Data domain command
0X87	Sensor answer reply E.g: **68 06 00 87 02 08 97**	Data do（2byte） Data domain in the number means the sensor response result
0X08	**Start calibration command**	Data domain（0byte）

	68 04 00 08 0C	No Data domain command
0X88	Sensor answer reply E.g: **68 05 00 88 00 8D**	Data domain（1byte） Data domain in the number means the sensor response result 00 Start success FF Start failure
0X0A	**Save calibration command** **68 05 00 8A 00 8F**	Data domain（0byte） No Data domain command
0X8A	Sensor answer reply command E.g: **68 05 00 8A 00 8F**	Data domain（1byte） Data domain in the number means the sensor response result 00 Success FF Failure
0X0B	**Setting communication baud rate command** ***68 05 00 0B 02 12***	Data domain（1byte） Baud rate：default :9600 00 means 2400 01 means 4800 02 means 9600 03 means 19200 04 means 38400 05 means 115200
0X8B	Sensor answer reply command E.g: **68 05 00 8B 00 90**	Data domain（1byte） Data domain in the number means the sensor response result 00 Success FF Failure
0X0F	**Setting module address command** ***68 05 00 0F 01 15***	Data domain（1byte） XX module address, address from 00 to EF range Note: Our products have a unified address: **FF, If forgot the set address when operating ,can use the FF address to operate the product, still normal response.**
0X8F	Sensor answer reply command E.g: **68 05 00 8F 94**	Data domain（1byte） Data domain in the number means the sensor response result 00 Success FF Failure
0X0C	**Setting angle output mode** **68 05 00 0C 00 11**	Data domain（1byte） 00：answer reply mode 01：Auto output mode Default : answer reply mode
0X8C	Sensor answer reply command E.g:**68 05 00 8C 00 91**	Data domain（1byte）, Data domain in the number means the sensor response result 00 Success FF Failure

ESD Sensitive Device

※More products information, please refer to the company's Website : www.rion-tech.net

深圳市瑞芬科技有限公司

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Accurate Solution Provider

Mianyang Weibo Electronic Co.,Ltd

Designing, Manufacturing and Supplying WB Series Electric Isolated Sensor and Digital Electrical Transducer since 1989

USER MANUAL

WBI414F21 AC current transducer

www.wb-my.com
wbdz@yahoo.cn
Tel:86-816-2971265
Fax: 86 816 2281934

ISO9001 ISO14000 ISO18000
Certified

Quality Warranty

Any quality problem found in WB series products, we offer
Three years free charge of repair the products, and six months guaranteed free charge of change and return the products.

WBI414F21 AC Current Transducer

Safety claim

The information in the safety claim of the equipment documentation is intended to ensure that equipment is properly installed in order to maintain it in a condition.
It is assumed that everyone who would be associated with the equipment should be familiar with the contents of that safety section, or this safety guide.
When electrical equipment is in operation, dangerous voltages will be present in certain parts of the equipment (e.g. the input terminal). Failure to obverse warning notices, incorrect use, or improper use may endanger personnel and equipment and course personal injury or physical damage.
Before working in the terminal strip area, the equipment must be isolated.
Proper and safe operation of the equipment depends on appropriate shipping and handling, proper storage, installation and commissioning, and on careful operation, maintenance and servicing.
The operating manual for the equipment gives instructions for its installation, commissioning, and operation. However, the manual cannot cover all conceivable circumstances or include detailed information on all topics. In the event of questions or specific problem, do not take any action without proper authorization. Contact the appropriate WB technical sales office and request the necessary information.

Standard application

1. Accuracy

   Accurate degree is conformed to IEC688:1992

2. Safety

   2.1 Overload capability

   Overload capability is conformed to IEC688:1992

   2.2 Isolation voltage

   Can be endured testing voltage is conformed to Q/72085584-0.1-2004

   2.3 Insulation impedance

   The insulation impedance is no less than 20M Ohm, is conformed to Q/72085584-0.1-2004

3. Electromagnetic Capability

   3.1 Electromagnetic field immunity test according to IEC 61000-4-3:1995

   3.2 Power frequency magnetic field immunity test according to IEC 61000-4-8:1993

Product Description and Application

WBI414F21 converts AC input current into a load independent output signal DC (0)4-20mA.， It has adopted electromagnetic isolation principle for real time measurement of AC current from electric net or electric circuit.

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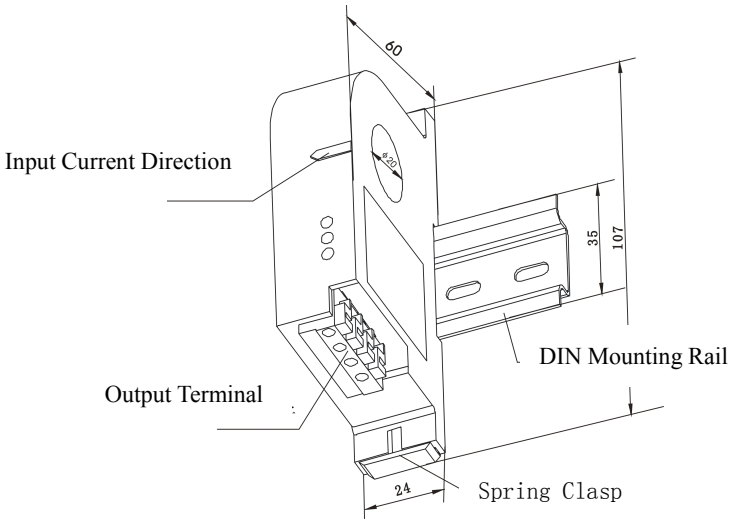
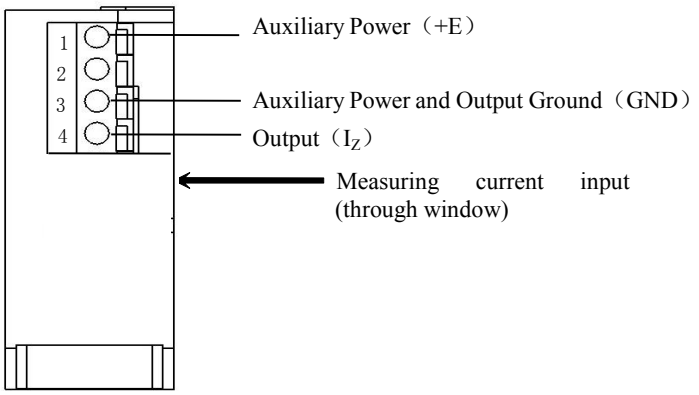
www.wb-my.com wbdz@yahoo.cn

The product has certain advantages of total galvanic isolation between input/output, high accuracy, low drifting by temperature, and wide temperature bearable range, etc.

Product Dimensional Drawing (unit: mm)



Product Terminal Identification Drawing



Non-identified terminals cannot be used

Key Technical Data:

1. Input: AC 0~30A…0~400A;
2. Output: DC (0)4-20mA
3. Frequency range: 25Hz～5kHz
4. Accuracy : 0.5%
5. Input Impedance (R): approximate zero

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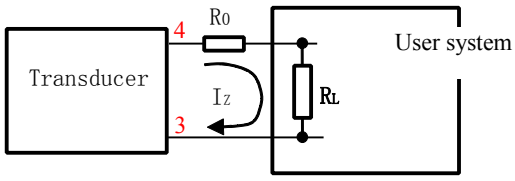
6. Linear Range:0-120% of nominal input
7. Responding Time: 300ms
8. Over Load Capacity: 30 times of nominal input, for 5 seconds;
9. Output impedance: 6V
10. Static current: 3.3mA(0mA-20mA)
    6.8mA(4mA-20mA)
11. Auxiliary Power: DC +12V/+24V
12. Isolation Voltage(Input/Output): ≥2500Vdc, for 1 minute
13. Output Ripple: ＜6mV
14. Drifting by Temperature: 3.5×10^{-4}/℃
15. Ambient Temperature: -10℃～+50℃
16. Mounting : DIN Rail 35mm Mounting or screw mounting

Instruction of Installation and Use

1. The product has adopted structure compliance with EN50022; suitable for DIN rail mounting NS35/7.5, NS35/15. Installation steps are as following (please reference to dimensional drawing):
   Step 1: Immobilize one side of product's mounting trough to the DIN mounting rail;
   Step 2: Pull out the spring clasp;
   Step 3: Place whole mounting trough to the DIN mounting rail properly;
   Step 4: Release spring clasp to make sure the installation.
2. The product has calibrated before out of factory. After correctly wiring, it can be powered and used immediately. But for further precise signal sampling, user needs to warm-up the product for 3 minutes before use.
   a) The auxiliary power requires isolation voltage≥2000V_{AC}, DC current output ripple ＜10mV, and multiple converters can share with one set auxiliary power together.
   b) Output signal (Iz) is designed to follow the impedance load value of 250Ω; When Resistance (R_1) is less than 100Ω, the user must add output current circuit a power reduced resistance load R_0 to keep the summation of total impedance value is between 100Ω～250Ω



3. The Maximum volume of line for the transducer terminal is 2.5mm^2; the insulation layer

of the line should be peeled off about 8mm～10mm and tightly twisted to connect with the transducer terminals.

4. For the less than 10A AC current measurement, it may adopt ampere-turn method for input and for this time, the resolution of the transducer increases and measuring range narrows, but other technical index may not be affected.

5. Basic testing method for accuracy

(1) According to the terminal definition table to connect the testing circuit;

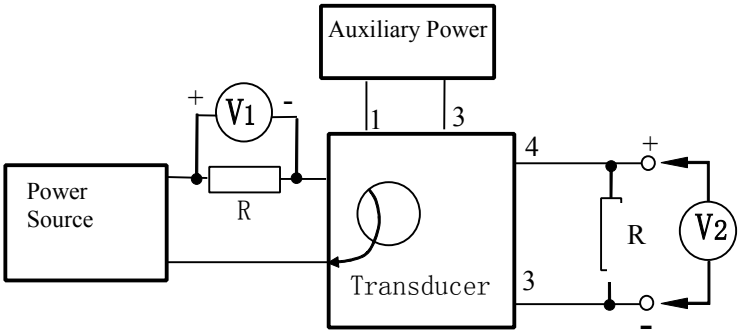
(2) The testing must to be done by under the following conditions；

Auxiliary power: 24V±0.5%，ripple≤5mV

Ambient temperature: 25℃±5℃

Relative humidity: RH(45～75)%

Accuracy for Signal Power Source instrument: 0.05



(3) Warming up the transducer for 3 minutes

(4) Using output monitoring meter V1 to measuring the output of signal power source instrument, set any input value which is within the measuring range of the transducer Ir. (e.g. if input value is 50A, the output is 4-20mA, the expected output value Iz should be calculated as: $Iz = (20mA-4mA)\times Ir/50A+4mA$)

(5) Using output monitoring meter V2 to measuring the output voltage V0 of the transducer, the basic introduced error γ of the transducer should be calculated as:

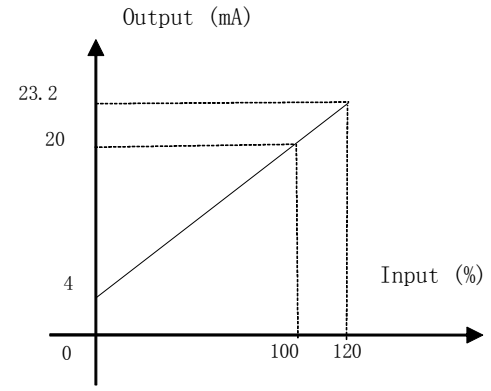
$$\gamma = (Vo-Iz\times 250\,\Omega)/[(20mA-4mA)\times 250\,\Omega]\times 100$$

(6) Repeating step (4) (5), if calculated absolute value is less than the given accuracy value of the transducer, it shows the transducer's accurate grade is qualified.

Caution:

1. Pay attention to the auxiliary power information, especially the auxiliary power grade, and polarity, other wise will damage the product.
2. Pay attention to the wire connection; wrong terminal connection will cause malfunction of the product and even damage the product;
3. Don't dismantle the product, and carry with care to avoiding bump and fall of the product;
4. If the product has been using under the environment with strong magnetic field interference, please pay attention to the shield of input wire, and the output signal wire should be as short as possible. For product intensive installation, the space between each product should not be smaller than 10mm.
5. Only use identified terminals.
6. There is no lightening strike prevention circuit design in this product. For out door and hazardous environment using, please add protective alternatives.
7. This product uses fire prevent ABS crust, its temperature withstand is only limited as +85℃, higher than this limitation will cause the product deformation. Please use and store carefully.

Product Input-Output characteristic curve



4mA～20mA Input-Output characteristic curve