

Additions, corrections, and comments should be emailed to the author,
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1. What is NMEA?

The National Marine Electronics Association is dedicated to the education and advancement of the marine electronics industry and the market which it serves.

It is a non-profit association composed of manufacturers, distributors, dealers, educational institutions, and others interested in peripheral marine electronics occupations
(quoted from a promo in "NMEA News")

- 1.1 What is an NMEA standard?

For the purposes of this article, an NMEA standard defines an electrical interface and data protocol for communications between marine instrumentation. (They may also have standards for other things.)

- 1.2 NMEA Address

P.O. Box 3435
New Bern NC, 28564-3435
U.S.A.
Phone: 919-638-2626
Fax: 919-638-4885
email: nmea@coastalnet.com
web page: <http://www4.coastalnet.com/nmea/default.html>

2. Electrical Interface

These standards allow a single "talker", and several "listeners" on one circuit. The recommended interconnect wiring is a shielded twisted pair, with the shield grounded only at the talker. The standards do not specify the use of any particular connector.

The NMEA-0180 and 0182 standards say that the talker output may be RS-232, or from a TTL buffer, capable of delivering 10 mA at 4 V. A sample circuit shows an open collector TTL buffer with a 680 ohm resistor to +12 V, and a diode to prevent the output voltage from rising above +5.7 V.

NMEA-0183 accepts this, but recommends that the talker output comply with EIA-422. This is a differential system, having two signal lines, A and B. The voltages on the "A" line correspond to those on the older TTL single wire, while the "B" voltages are reversed (while "A" is at +5, "B" is at ground, and vice versa)

In either case, the recommended receive circuit uses an opto-isolator with suitable protection circuitry. The input should be isolated from the receiver's ground.

In practice, the single wire, or the EIA-422 "A" wire may be directly connected to a computer's RS-232 input.

3. NMEA-0180 and NMEA 0182

NMEA-0180 and 0182 are very limited, and just deal with communications from a Loran-C (or other navigation receiver, although the standards specifically mention Loran), and an autopilot.

From the information I have, it appears that 0180 and 0182 are identical. I suspect that equipment claiming to use NMEA-0180 will use the "simple" format described below, while those using NMEA-0182 will use the "complex" format. (but this is really just a guess... corrections??)

3.1 "Simple" data format

The simple format consists of a single data byte transmitted at intervals of 0.8 to 5 seconds, at 1200 baud with odd parity. Bits 5 - 0 give the cross-track error in units of 0.1 uS or 0.01 nautical mile. The error is given in offset binary, with a count of 1 representing full scale right error, 32 (hex 20) for on course, and 63 (hex 3f) full scale left error. Bit 6 is a 1 if the data is valid, and bit 7 is 0 to indicate the simple data format.

3.2 "Complex" data format

The complex format consists of a data block of 37 bytes of (mostly) readable ASCII text giving cross-track error, bearing to waypoint, present Lat/Long, and a binary status byte. The data block shall be sent at intervals of 2 to 8 sec. All bytes in the complex format have bit 7 = 1 to distinguish them from the simple format. It is permissible for a sending device to send both simple and complex data, and even to send a "simple" data byte in the middle of a "complex" data block.

Byte	Data
1	\$

2	M	device
3	P	address
4	K = kilometres N = nautical miles U = microseconds	cross track error units
5 - 8	0 - 9 or .	cross track error value
9	L or R	cross track error position
10	T or M	True or Magnetic bearing
11 - 13	0 - 9	bearing to next waypoint
14 - 23	12D34'56"N or 12D34.56'N	present latitude
24 - 34	123D45'56"W or 123D45.67"W	present longitude
35	non-ASCII status byte bit 0 = 1 for manual cycle lock 1 = 1 low SNR 2 = 1 cycle jump 3 = 1 blink 4 = 1 arrival alarm 5 = 1 discontinuity of TDs 6 = 1 always	
36	"NUL" character (hex 80)(reserved status byte)	
37	"ETX" character (hex 83)	

Any unavailable data is filled with "NUL" bytes.

4. NMEA-0183

4.1 General Sentence Format

Under the NMEA-0183 standard, all characters used are printable ASCII text (plus carriage return and line feed). NMEA-0183 data is sent at 4800 baud.

The data is transmitted in the form of "sentences". Each sentence starts with a "\$", a two letter "talker ID", a three letter "sentence ID", followed by a number of data fields separated by commas, and terminated by an optional checksum, and a carriage return/line feed. A sentence may contain up to 82 characters including the "\$" and CR/LF.

If data for a field is not available, the field is simply omitted, but the commas that would delimit it are still sent, with no space between them.

Since some fields are variable width, or may be omitted as above, the receiver should locate desired data fields by counting commas, rather than by character position within the sentence.

The optional checksum field consists of a "*" and two hex digits representing the exclusive OR of all characters between, but not including, the "\$" and "*". A checksum is required on some sentences.

The standard allows individual manufacturers to define proprietary sentence formats. These sentences start with "\$P", then a 3 letter manufacturer ID, followed by whatever data the manufacturer wishes, following the general format of the standard sentences.

Some common talker IDs are:

GP	Global Positioning System receiver
LC	Loran-C receiver
OM	Omega Navigation receiver
II	Integrated Instrumentation

(eg. AutoHelm Seataalk system)

4.2 Sentences sent by specific equipment

This section lists the sentence types used by various equipment. The format and data included in each sentence type is given in section 4.3.

Eagle AccuNav

Standard: RMB, RMC, GLL, APB

Proprietary: PSLIB

It also pretends it's a Loran, sending LCGLL, as well as GPGLL

Garmin GPS-38, NMEA-0183 V. 1.5 mode

Standard: GLL, RMB, RMC, WPL, BOD, XTE, VTG, BWC

Proprietary: PGRMM (map datum), PGRMZ (altitude), PSLIB (dgps ctrl)

Garmin GPS-38, NMEA-0183 V. 2.0 mode

Standard: GLL, RMB, RMC, WPL, BOD, GSA, GSV, RTE, GGA

Proprietary: PGRME (estimated error), PGRMM, PGRMZ, PSLIB

Garmin GPS-45 (and probably GPS-40 and GPS-90)

Standard: BOD, GLL, RTE, RMB, RMC, GGA, GSA, GSV

Proprietary: PGRME, PGRMM, PGRMZ

Garmin GPS-65 (and probably GPS-75)

Standard: BWC, GLL, RMB, RMC, R00, WPL, XTE, VTG

Proprietary: PGRMM, PGRMZ, PSLIB

Magellan Trailblazer

Standard: APB, BWC, GGA, GLL, RMB, RMC, VTG

Trimble Ensign XL

Standard: APA, BWC, BWR, GGA, GLL, RMB

Trimble Flightmate Pro and Scoutmaster

Standard: APA, APB, BWC, GGA, GLL, GSA, GSV, RMB, RMC,

VTG, WCV, XTE, ZTC

Autohelm Seataalk

Autohelm Seataalk is a proprietary bus for communications between various instruments. Some of the instruments can act as NMEA-0183 talkers or listeners. Data received from an external NMEA-0183 device will, if Seataalk understands the sentence, be re-transmitted, but not necessarily in the same sentence type.

The specific sentences sent will depend on the data available on the Seataalk bus (i.e. sentences containing wind speed and direction will only be sent if the system includes a wind instrument)

Seataalk output:

Standard: APB, BPI, BWC, VWR, VHW, DBT, GLL, HDM, HDT, HCS, MTW, VTG

Seataalk input:

Standard: APA, APB, RMB, XTE, XTR, BPI, BWR, BWC, BER, BEC, WDR, WDC, BOD, WCV, VHW, VWR, DBT

4.3 Sample Sentences Dissected

4.3.1 Standard Sentences

A talker typically sends a group of sentences at intervals determined by the unit's update rate, but generally not more often than once per second.

Characters following the "*" are a checksum. Checksums are optional for most sentences, according to the standard.

APB - Autopilot format B

APB,A,A,0.10,R,N,V,V,011,M,DEST,011,M,011,M

A Lorán-C blink/SNR warning
A Lorán-C cycle warning
0.10 cross-track error distance
R steer Right to correct (or L for Left)
N cross-track error units - nautical miles
V arrival alarm - circle
V arrival alarm - perpendicular
011,M magnetic bearing, origin to destination
DEST destination waypoint ID
011,M magnetic bearing, present position to destination
011,M magnetic heading to steer

(bearings could be given in True as 033,T)

(note: some pilots, Roberston in particular, misinterpret "bearing from origin to destination" as "bearing from present position to destination". This apparently results in poor performance if the boat is sufficiently off-course that the two bearings are different.)

BOD - Bearing - origin to destination waypoint

BOD,045.,T,023.,M,DEST,START

045.,T bearing 045 True from "START" to "DEST"
023.,M bearing 023 Magnetic from "START" to "DEST"
DEST destination waypoint ID
START origin waypoint ID

BWC - Bearing and distance to waypoint - great circle

BWC,225444,4917.24,N,12309.57,W,051.9,T,031.6,M,001.3,N,004*29

225444 UTC time of fix 22:54:44
4917.24,N Latitude of waypoint
12309.57,W Longitude of waypoint
051.9,T Bearing to waypoint, degrees true
031.6,M Bearing to waypoint, degrees magnetic
001.3,N Distance to waypoint, Nautical miles
004 Waypoint ID

BWR - Bearing and distance to waypoint - rhumb line

(format same as BWC)

DBT - Depth below transducer

DBT,0017.6,f,0005.4,M

0017.6,f 17.6 feet
0005.4,M 5.4 Metres

GGA - Global Positioning System Fix Data

GGA,123519,4807.038,N,01131.324,E,1,08,0.9,545.4,M,46.9,M, , *42

123519 Fix taken at 12:35:19 UTC
4807.038,N Latitude 48 deg 07.038' N
01131.324,E Longitude 11 deg 31.324' E
1 Fix quality: 0 = invalid
1 = GPS fix
2 = DGPS fix
08 Number of satellites being tracked
0.9 Horizontal dilution of position
545.4,M Altitude, Metres, above mean sea level
46.9,M Height of geoid (mean sea level) above WGS84

ellipsoid
 (empty field) time in seconds since last DGPS update
 (empty field) DGPS station ID number

GLL - Geographic position, Latitude and Longitude
 GLL,4916.45,N,12311.12,W,225444,A
 4916.46,N Latitude 49 deg. 16.45 min. North
 12311.12,W Longitude 123 deg. 11.12 min. West
 225444 Fix taken at 22:54:44 UTC
 A Data valid
 (Garmin 65 does not include time and status)

GSA - GPS DOP and active satellites
 GSA,A,3,04,05,,09,12,,,24,,,,,2.5,1.3,2.1*39
 A Auto selection of 2D or 3D fix (M = manual)
 3 3D fix
 04,05... PRNs of satellites used for fix (space for 12)
 2.5 PDOP (dilution of precision)
 1.3 Horizontal dilution of precision (HDOP)
 2.1 Vertical dilution of precision (VDOP)
 DOP is an indication of the effect of satellite geometry on
 the accuracy of the fix.

GSV - Satellites in view
 GSV,2,1,08,01,40,083,46,02,17,308,41,12,07,344,39,14,22,228,45*75
 2 Number of sentences for full data
 1 sentence 1 of 2
 08 Number of satellites in view
 01 Satellite PRN number
 40 Elevation, degrees
 083 Azimuth, degrees
 46 Signal strength - higher is better
 <repeat for up to 4 satellites per sentence>
 There may be up to three GSV sentences in a data packet

HDM - Heading, Magnetic
 HDM,235.,M
 HDM Heading, Magnetic
 235.,M Heading 235 deg. Magnetic
 (HDG, which includes deviation and variation, is recommended
 instead)

HSC - Command heading to steer
 HSC,258.,T,236.,M
 258.,T 258 deg. True
 236.,M 136 deg. Magnetic

MTW - Water temperature, Celcius
 MTW,11.,C
 11.,C 11 deg. C

R00 - List of waypoint IDs in currently active route
 R00,MINST,CHATN,CHAT1,CHATW,CHATM,CHATE,003,004,005,006,007,,,*05
 (This sentence is produced by a Garmin 65, but is not listed
 in Version 2.0 of the standard. The standard lists RTE for
 this purpose.)

RMB - Recommended minimum navigation information (sent by nav.
 receiver when a destination waypoint is active)
 RMB,A,0.66,L,003,004,4917.24,N,12309.57,W,001.3,052.5,000.5,V*0B
 A Data status A = OK, V = warning
 0.66,L Cross-track error (nautical miles, 9.9 max.),
 steer Left to correct (or R = right)
 003 Origin waypoint ID
 004 Destination waypoint ID
 4917.24,N Destination waypoint latitude 49 deg. 17.24 min. N

12309.57,W Destination waypoint longitude 123 deg. 09.57 min. W
001.3 Range to destination, nautical miles
052.5 True bearing to destination
000.5 Velocity towards destination, knots
V Arrival alarm A = arrived, V = not arrived
*0B mandatory checksum

RMC - Recommended minimum specific GPS/Transit data

RMC,225446,A,4916.45,N,12311.12,W,000.5,054.7,191194,020.3,E*68
225446 Time of fix 22:54:46 UTC
A Navigation receiver warning A = OK, V = warning
4916.45,N Latitude 49 deg. 16.45 min North
12311.12,W Longitude 123 deg. 11.12 min West
000.5 Speed over ground, Knots
054.7 Course Made Good, True
191194 Date of fix 19 November 1994
020.3,E Magnetic variation 20.3 deg East
*68 mandatory checksum

RTE - Waypoints in active route

RTE,2,1,c,0,W3IWI,DRIVWY,32CEDR,32-29,32BKLD,32-I95,32-US1,BW-32,BW-198*69
2 two sentences for full data
1 this is sentence 1 of 2
c c = complete list of waypoints in this route
w = first listed waypoint is start of current leg
0 Route identifier
W3IWI... Waypoint identifiers

VHW - Water speed and heading

VHW,259.,T,237.,M,05.00,N,09.26,K
259.,T Heading 259 deg. True
237.,M Heading 237 deg. Magnetic
05.00,N Speed 5 knots through the water
09.26,K Speed 9.26 KPH

VWR - Relative wind direction and speed

VWR,148.,L,02.4,N,01.2,M,04.4,K
148.,L Wind from 148 deg Left of bow
02.4,N Speed 2.4 Knots
01.2,M 1.2 Metres/Sec
04.4,K Speed 4.4 Kilometers/Hr

VTG - Track made good and ground speed

VTG,054.7,T,034.4,M,005.5,N,010.2,K
054.7,T True track made good
034.4,M Magnetic track made good
005.5,N Ground speed, knots
010.2,K Ground speed, Kilometers per hour

WCV - Waypoint Closure Velocity

WDC - Distance to Waypoint

WDR - Waypoint Distance, Rhumb Line

WPL - waypoint location

WPL,4917.16,N,12310.64,W,003*65
4917.16,N Latitude of waypoint
12310.64,W Longitude of waypoint
003 Waypoint ID

When a route is active, this sentence is sent once for each waypoint in the route, in sequence. When all waypoints have been reported, GPR00 is sent in the next data set. In any group of sentences, only one WPL sentence, or an R00 sentence, will be sent.

XTE - Cross track error, measured

XTE,A,A,0.67,L,N

whether a certain device is DTE or DCE, hence my standard RS-232 disclaimer:

if it doesn't work, swap pins 2 and 3!

The standard RS-232 connector is a 25 conductor DB-25, although many PCs (and some other equipment) now use a 9 pin DE-9 (often incorrectly called DB-9)

Serial Port Connections

Computer (DTE)				Modem
DB-25	DE-9	Signal	Direction	DB-25
2	3	Tx Data	->	2
3	2	Rx Data	<-	3
4	7	Request to send	->	4
5	8	Clear to send	<-	5
6	6	Data Set Ready	<-	6
7	5	signal ground		7
8	1	Data CarrierDetect	<-	8
20	4	Data Terminal Ready	->	20
22	9	Ring Indicator	<-	22

For NMEA-0183 interfacing, we are only concerned with Rx Data, signal ground (and possibly Tx Data, if we want the computer to talk to the GPS)

NMEA-0183 data is sent at 4800 baud.

6. Troubleshooting

First check that the talker (usually GPS or Loran) can send NMEA-0183, and determine what sentences it sends. Also, verify that the listener understands NMEA-0183, and that it understands the sentences the talker is sending. In some cases the same information may be sent in two or more different sentences. If the talker and listener don't both use the same sentences, there will be no communication. It may be possible to change the sentences sent by the talker, to match those understood by the listener.

Next, check that the talker is indeed set to send NMEA-0183 data. Some talkers may have provision to send NMEA-0180 or 0182, or some proprietary format.

A computer, using any convenient terminal program (Telix, Procomm, Windows Terminal, etc.) set to 4800 baud, can be used to monitor the NMEA data, and confirm what sentences are sent, and that the data is in the correct format.

Verify that the wiring is correct - that the talker data output is connected to the listener data input, and that a signal ground line is connected between the two pieces of equipment.

If you have multiple listeners connected to a single talker, you may be overloading the talker port. Try connecting only one listener at a time.

On any NMEA-0183 circuit, there can only be one talker. If you must have more than one talker, and one of the talker devices can also act as a listener, you may be able to connect things "in series", so a talker-only output is connected to a listener/talker input, and the listener/talker output is connected to other listeners. However, some listener/talker devices may reformat the data, or only pass data they understand. (The Autohelm Seatalk system does this, and claims the data as it's own, starting all output sentences with "\$II".)

Particularly with older equipment, the equipment may claim to

comply with NMEA-0183, but in fact have an error in the data format. (My Kings 8001 Loran-C claims to send an APB sentence, but gets some of the fields in the wrong order, so my autopilot can't understand it.) This sort of problem can be verified by capturing the NMEA-0183 data on a computer, and comparing the data formats with those given above.

7. About the author

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I have an FTP site containing this file, a GPS FAQ, and other NMEA information files and PC programs for capturing and displaying NMEA data, and related things:

<ftp://sundae.triumf.ca/pub/peter/index.html>
This site is mirrored in Germany at:
<ftp://ftp-i2.informatik.rwth-aachen.de/pub/arnd/GPS/peter/index.html>

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