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                          The NMEA FAQ
                  Version 6.6   Jan 30, 2008
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Additions, corrections, and comments should be emailed to the author,
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Contents:

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

          NMEA
          7 Riggs Avenue
          Severna Park, MD 21146

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          President
          Phone: 410-975-9425
          email: director@nmea.org
          Visit us at www.nmea.org

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
communcations 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        | cross track
                        N = nautical miles    | error
                        U = microseconds      | 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         present latitude
```

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                12D34.56'N
 24 - 34        123D45'56"W or       present longitude
                123D45.67"W

 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 Seatalk 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 12XL, NMEA-0183 V 1.5
                 Standard: RMB, RMC, WPL
                 Proprietary: PGRMM (map datum), PGRMZ (altitude), PSLIB (DGPS ctrl)

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Garmin 12XL, NMEA-0183 V 2.0
    Standard: GGA, GSA, GSV, RMB, RMC, RTE, WPL
    Proprietary: PGRME (estimated error) PGRMM, PSLIB

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

Lowrance Global Map 100
    Standard: GLL, RMC, RMB, APB, GGA, GSV
    Proprietary: 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 Seatalk
    Autohelm Seatalk is a proprietary bus for communications
    between various intruments.  Some of the instruments can act
    as NMEA-0183 talkers or listeners.  Data received from an
    external NMEA-0183 device will, if Seatalk 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 Seatalk bus (i.e. sentences containing wind
    speed and direction will only be sent if the system includes
    a wind instrument)  Note that NMEA data can only be sent to,
    or received from, a SeaTalk system using AutoHelm's
    NMEA<->SeaTalk interface box, or those instruments that provide
    an NMEA-0183 interface.  SeaTalk itself is not compatible
    with NMEA, and cannot be read with a normal PC serial port.

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

    Seatalk input:
    Standard: APA, APB, RMB, XTE, XTR, BPI, BWR, BWC, BER,
        BEC,WDR, WDC, BOD, WCV, VHW, VWR, DBT
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4.3   Sample Sentences Dissected
4.3.1 Standard Sentences

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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
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```
    A             Loran-C blink/SNR warning
    A             Loran-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        breaing 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)
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    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 my 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
        A             General warning flag V = warning
                                (Loran-C Blink or SNR warning)
        A             Not used for GPS (Loran-C cycle lock flag)
        0.67          cross track error distance
        L             Steer left to correct error (or R for right)
        N             Distance units - Nautical miles

    XTR - Cross-Track Error - Dead Reckoning
    XTR,0.67,L,N
        0.67          cross track error distance
        L             Steer left to correct error (or R for right)
        N             Distance units - Nautical miles


4.3.2  Proprietary Sentences

    The following are Garmin proprietary sentences.  "P" denotes
    proprietary, "GRM" is Garmin's manufacturer code, and "E" or "Z"
    indicates the specific sentence type.

    $PGRME,15.0,M,45.0,M,25.0,M*22
        15.0,M        Estimated horizontal position error in metres (HPE)
        45.0,M        Estimated vertical error (VPE) in metres
        25.0,M        Overall spherical equivalent position error

    $PGRMZ,93,f,3*21
        93,f          Altitude in feet
        3             Position fix dimensions 2 = user altitude
                                              3 = GPS altitude
    This sentence shows in feet, regardless of units shown on the display.

    $PGRMM,NAD27 Canada*2F
```

Currently active horizontal datum

Proprietary sentences to control a Starlink differential beacon
receiver. (I assume Garmin's DBR is made by Starlink)
$PSLIB,,,J*22
$PSLIB,,,K*23
These two sentences are normally sent together in each group
of sentences from the GPS.
The three fields are: Frequency, bit Rate, Request Type. The
value in the third field may be:
        J = status request
        K = configuration request
        blank = tuning message

When the GPS receiver is set to change the DBR frequency or
baud rate, the "J" sentence is replaced (just once) by (for
example): $PSLIB,320.0,200*59 to set the DBR to 320 KHz, 200
baud.

5.   RS-232 connections

Although this is not really related to NMEA, many people want to
connect a GPS to a computer, so need to know about the RS-232
serial ports on a computer.

The RS-232 standard defines two classes of devices that may
communicate using RS-232 serial data - Data Terminal Equipment
(DTE), and Data Communication Equipment (DCE). Computers and
terminals are considered DTE, while modems are DCE. The
standard defines pinouts for DTE and DCE such that a "straight
through" cable (pin 2 to pin 2, 3 to 3, etc) can be used between
a DTE and DCE. To connect two DTEs together, you need a "null
modem" cable, that swaps pins between the two ends (eg. pin 2 to
3, 3 to 2). Unfortunately, there is sometimes disagreement
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 Web site containing this file, a GPS FAQ, and other NMEA information files and PC programs for capturing and displaying NMEA data, and related things:

              http://vancouver-webpages.com/peter