



**Gary Kessler
Associates**

Training • Consulting • Research

Overview of the NMEA 0183 Standard For Interfacing Marine Electronic Devices

Gary C. Kessler, Ph.D., CISSP

CyberBoat Challenge 2025

Wilmington, NC

December 2025

whoami

Gary C. Kessler, Ph.D., CISSP
Gary Kessler Associates

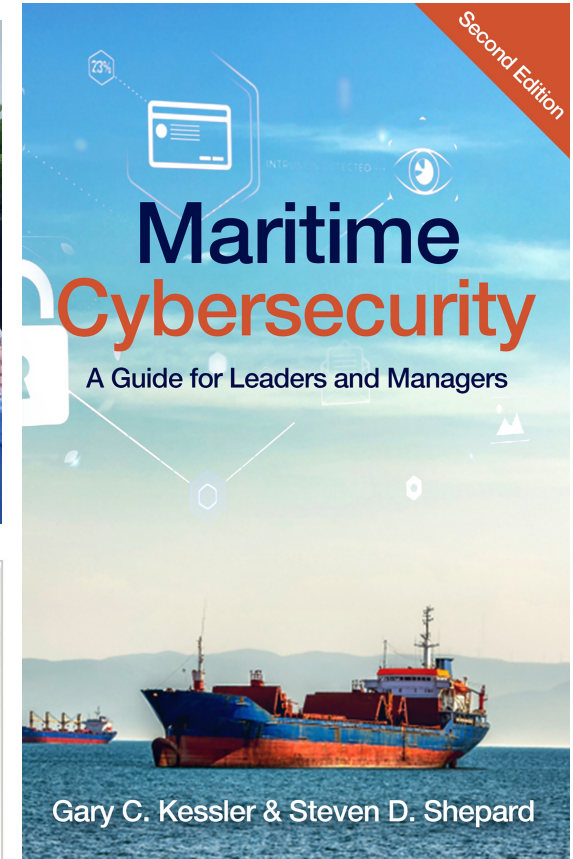
- Retired Professor of Cybersecurity
- Guest Faculty, USCG Academy
- Fellow, USCG Auxiliary Cybersecurity Directorate (AUXCYBER)
- Advisory Board and Faculty, CyberBoat Challenge
- Advisory Board, Cydome

50GT Master/Assistance Towing
Master SCUBA Diver Trainer

+1 802-238-8913
gck@garykessler.net
<https://www.garykessler.net>



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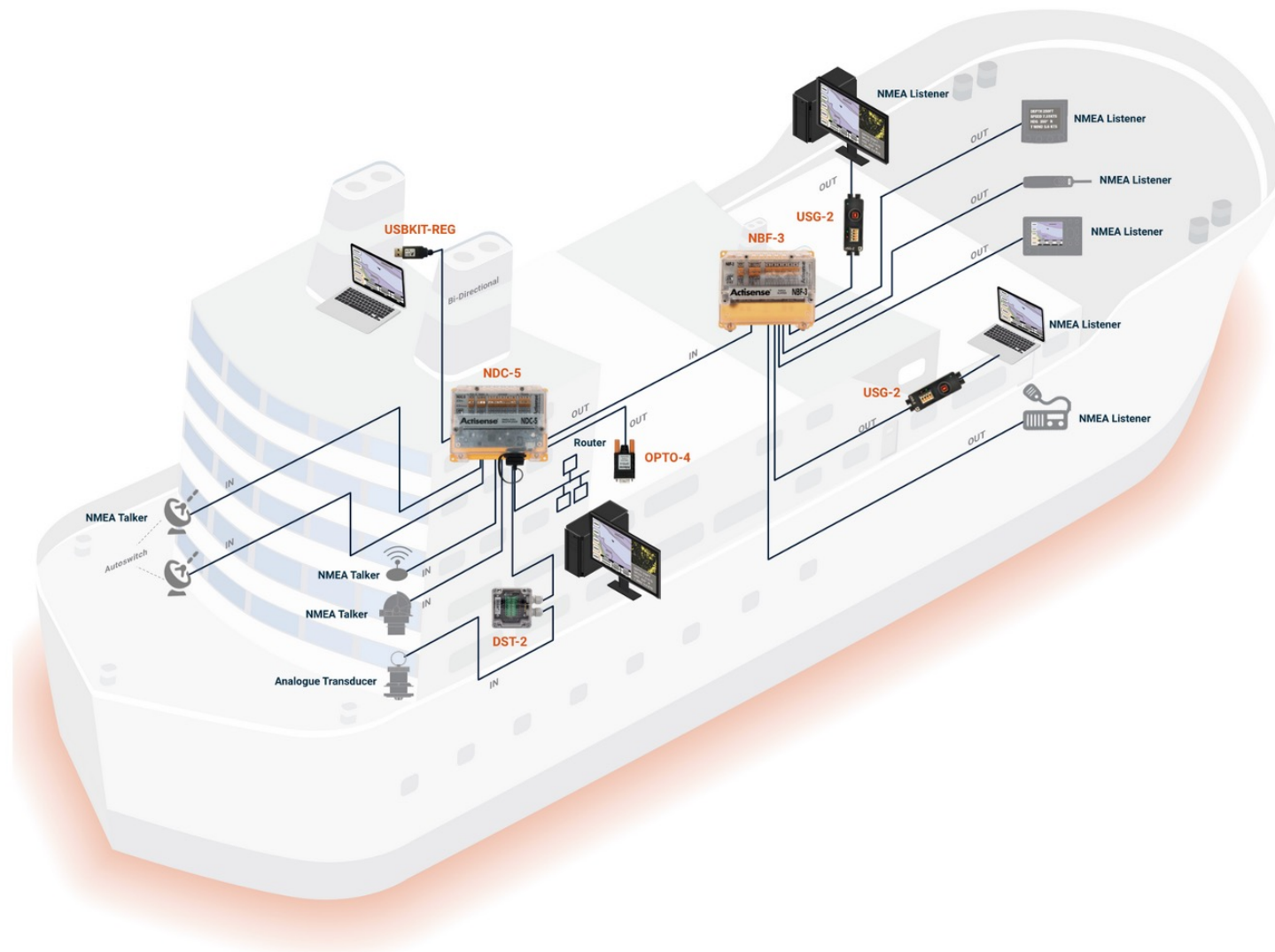
Overview

- NMEA Protocol Family Overview
- NMEA 0183 Applications and Ecosystem
- NMEA 0183 Physical and Network Protocols
- NMEA 0183 Sentences
- Demonstration and Practicum

Products, data, and configurations shown here are for demonstration purposes only, and are neither a recommendation nor endorsement.

The NMEA Protocol Family

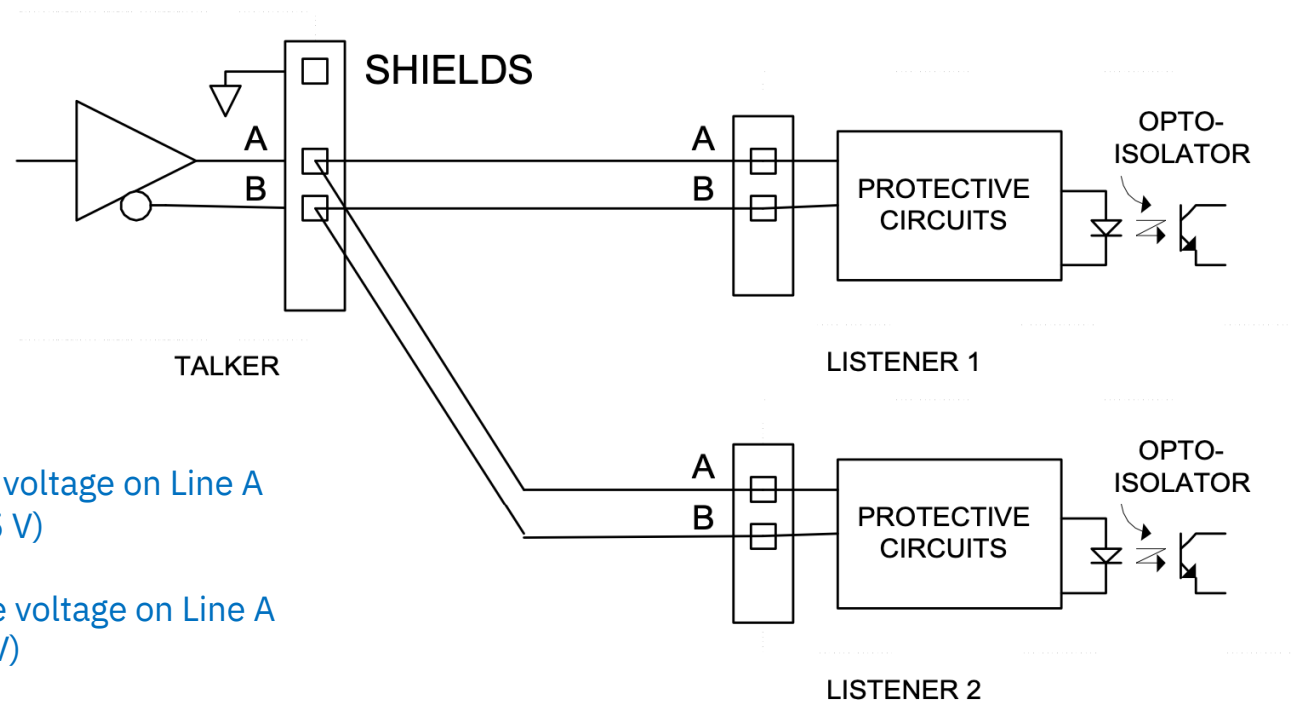
- NMEA standards describe inter-device communications onboard a vessel
 - *NMEA 0183 (1983; V4.30, 01/2024)*: ASCII text messages over EIA-232/422 serial lines at 4,800 or 38,400 bps
 - Single-talker/multiple-listener: IEC 61162 Part 1 (NMEA 0183, low-speed) and Part 2 (high-speed)
 - Multiple-talker/multiple-listener: IEC 61162 Part 450 (Lightweight Ethernet)
 - *NMEA 2000 (2001; Ed. 3.101, 03/2016)*: Binary messages on CAN bus at 250 kbps
 - Serial data instrument network, multiple talkers/listeners: IEC 61162 Part 3 (NMEA 2000)
 - *OneNet (2021)*: Binary messages using IPv6 over Ethernet at speeds up to 10 Gbps; IPsec for security
- ITU-R M.1371-5 (02/2014) describes AIS transmissions over VHF
 - Employs NMEA 0183 encapsulated ASCII message format at 9,600 bps



NMEA 0183 Serial Connections

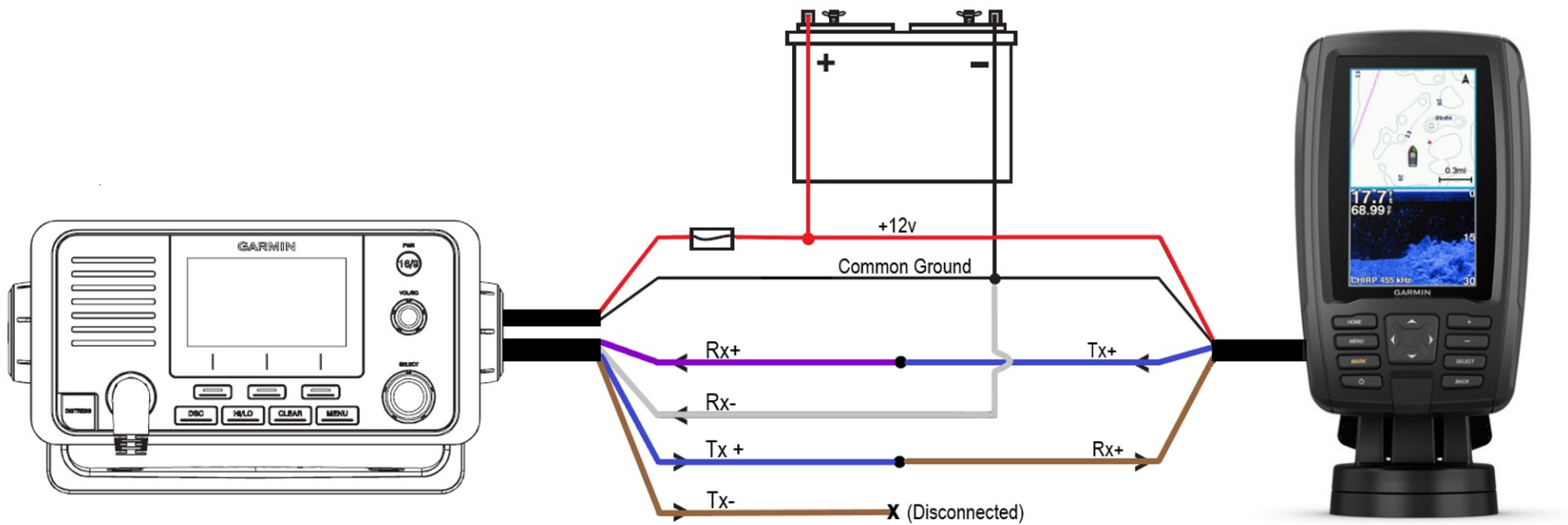
- The original NMEA 0183 standard employed EIA RS-422 serial communication over shielded twisted pair
 - Data transmitted as a voltage difference, making it more resistant to electrical interference over longer distances
 - Designed for a single talker and one or more listeners
- Addressing
 - Automatically assigned talker IDs
- Bits are organized into data units called *sentences*
- Error detection
 - No parity checking for bytes
 - 8-bit XOR checksum for sentences

NMEA 0183 Receive Circuit



- Idle, 1, OFF, stop bit = negative voltage on Line A compared to Line B (-15 to +0.5 V)
- Active, 0, ON, start bit = positive voltage on Line A compared to Line B (+4 to +15 V)

Example Device Connection



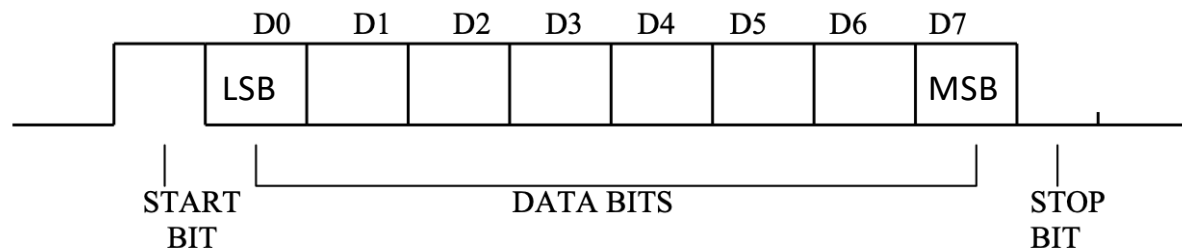
Garmin VHF 110

echoMAP Plus 44cv

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Data Transmission

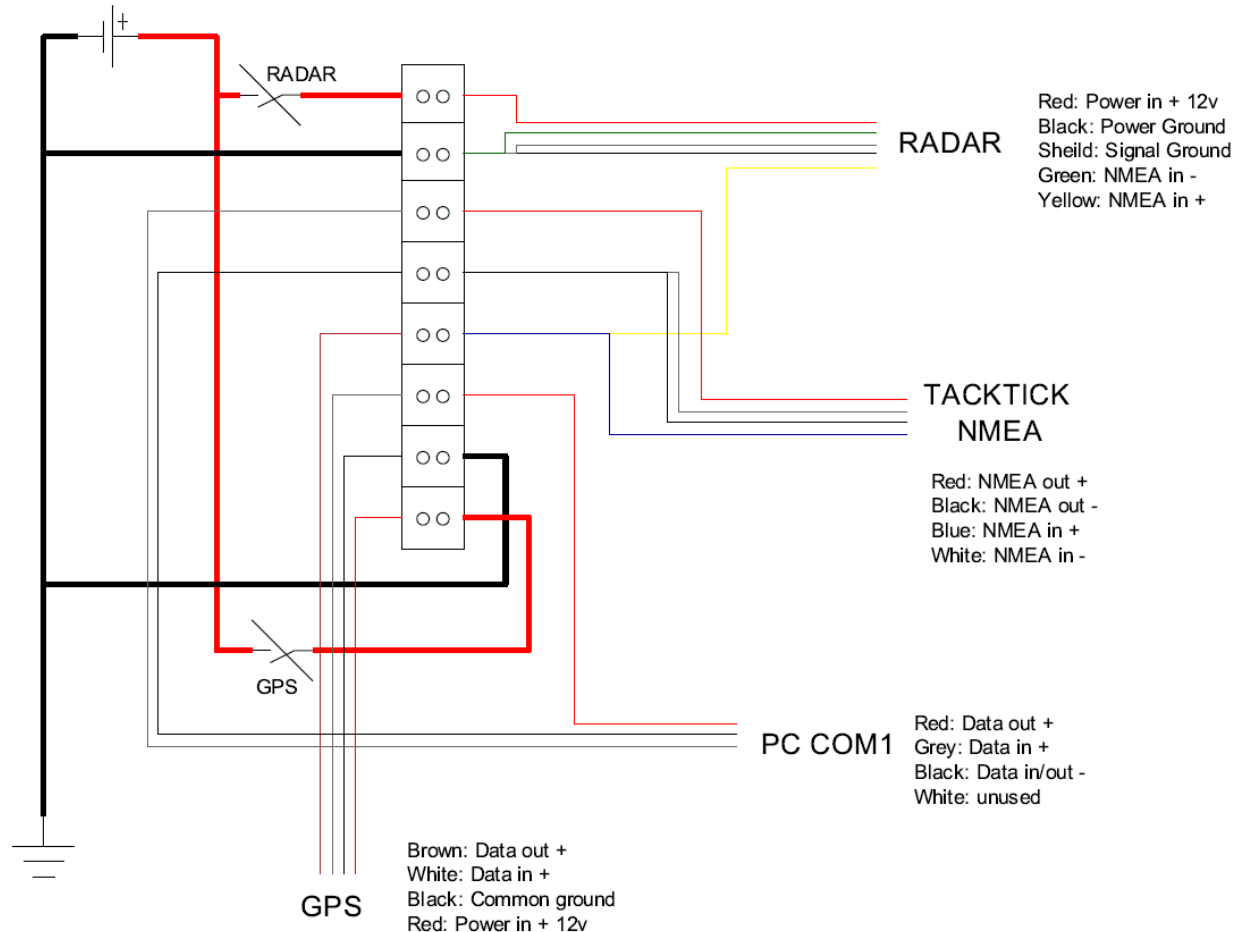
- 7-bit ASCII, printable characters [0x20-7E, 0x32-126]
- UART settings:
 - 4,800 or 38,400 bps
 - 8 data bits (MSB bit 7 = 0, no parity)
 - 1 stop bit
- Maximum cable length = 1,000 m (per EIA-422)

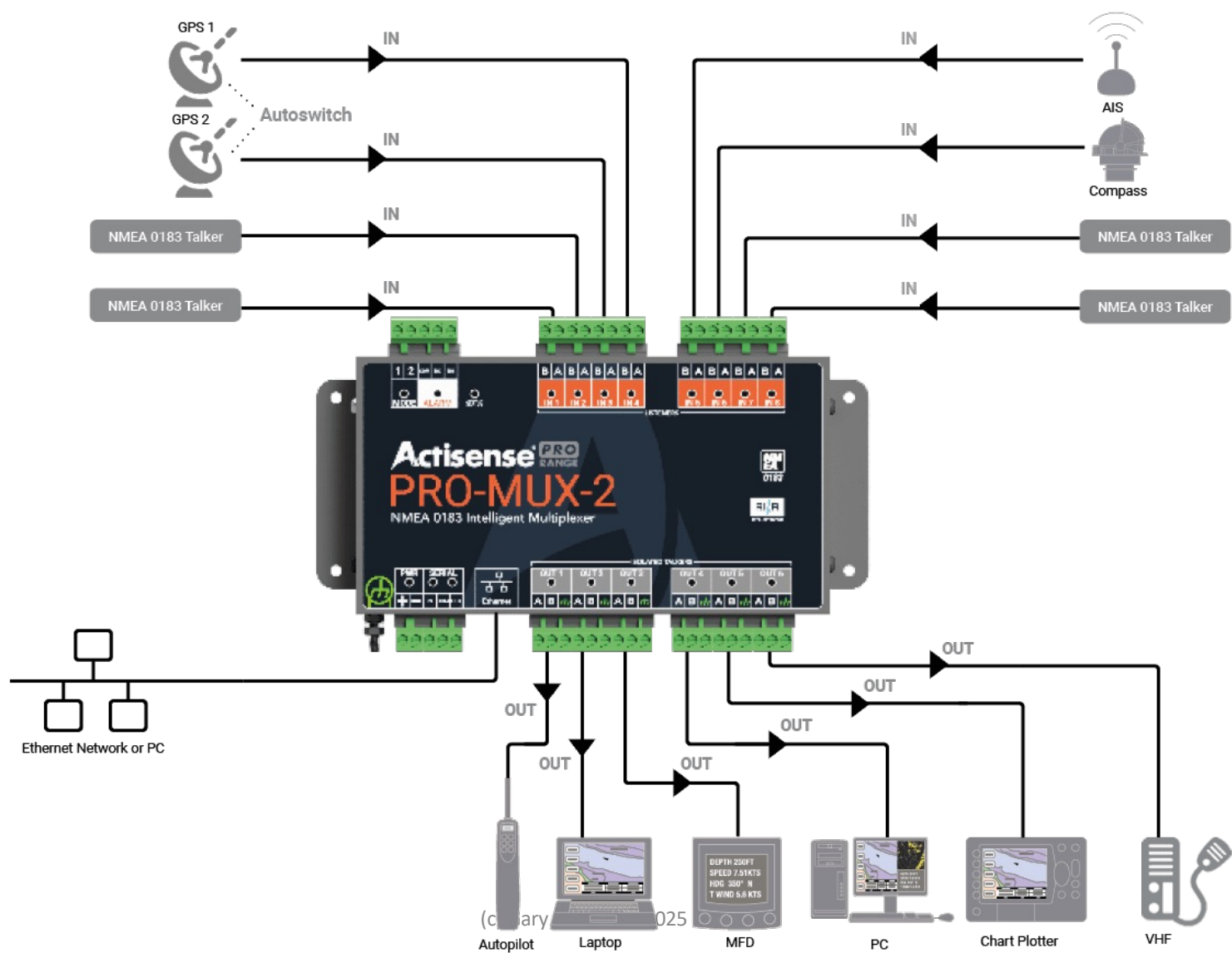


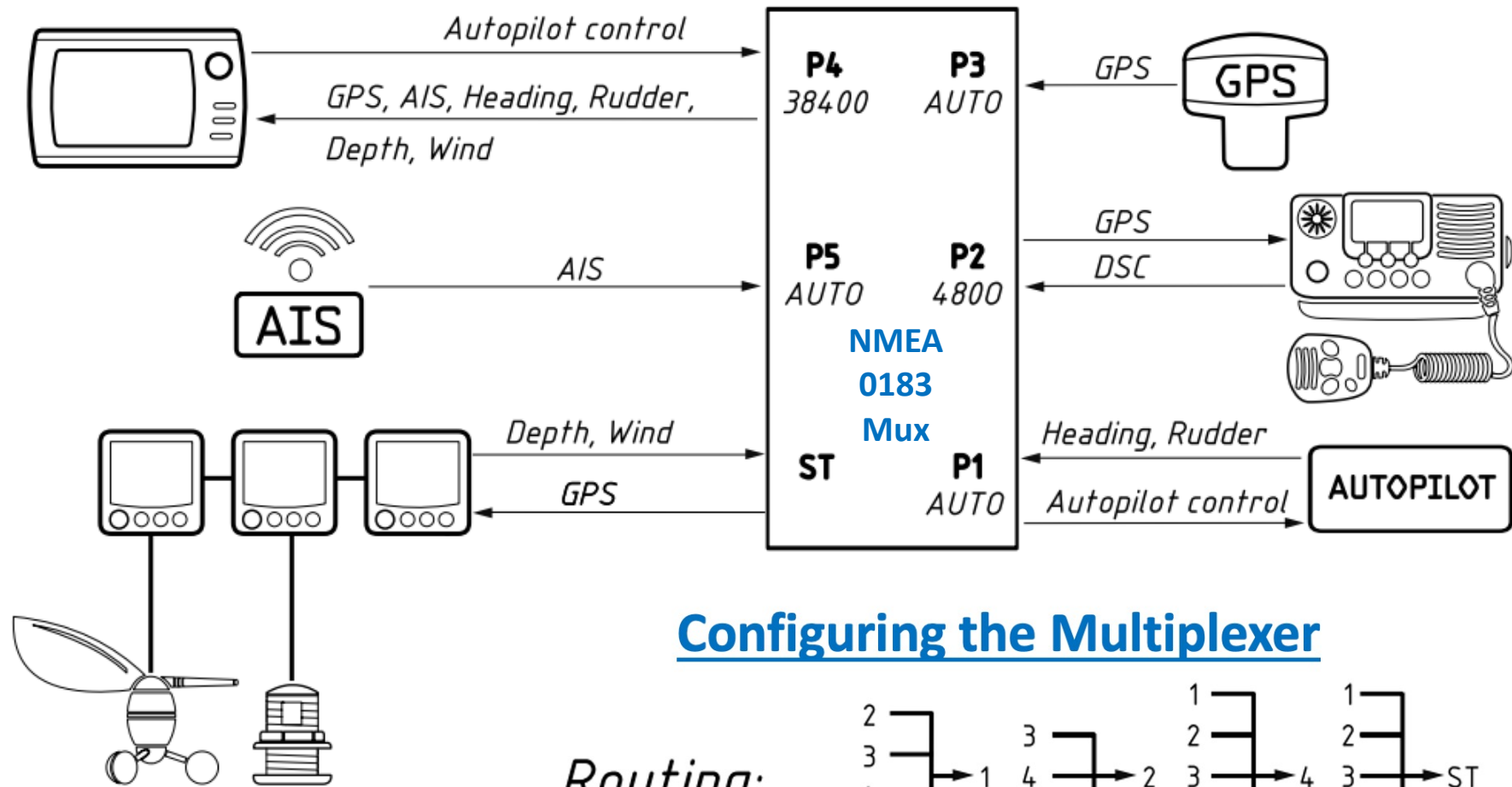
NMEA 0183 Junction Box

A junction box is the simplest way to interconnect many NMEA 0183 devices without a multiplexer

- GPS output (positional data) wired to TackTick NMEA input and to radar input
- TackTick NMEA output (positional data and all instrument data) wired to PC input
- PC output wired to GPS input for uploading waypoints
- Power and signal grounds are provided by the earth connection of the 12V DC power supply (batteries)
- GPS and radar have individual power switches

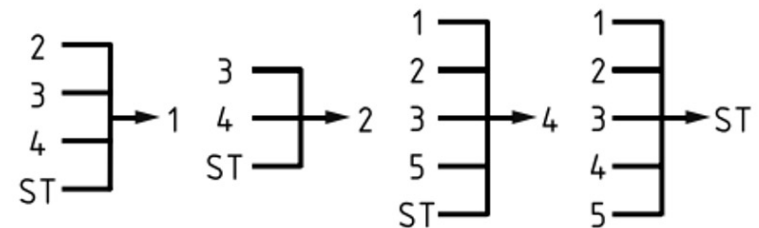






Configuring the Multiplexer

Routing:



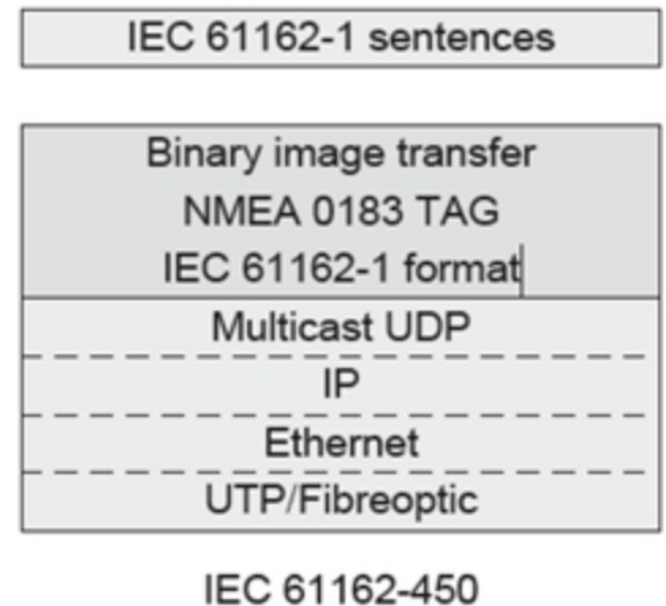
ST = SeaTalk proprietary port

The Routing Table

INPUT PORTS	OUTPUT PORTS					
	P1	P2	P3	P4	P5	ST
	P1		n/a	x	n/a	x
	P2	x	n/a	x	n/a	x
	P3	x	x	n/a	x	x
	P4	x	x	n/a		x
	P5		n/a	x	n/a	x
	ST	x	x	n/a	x	n/a

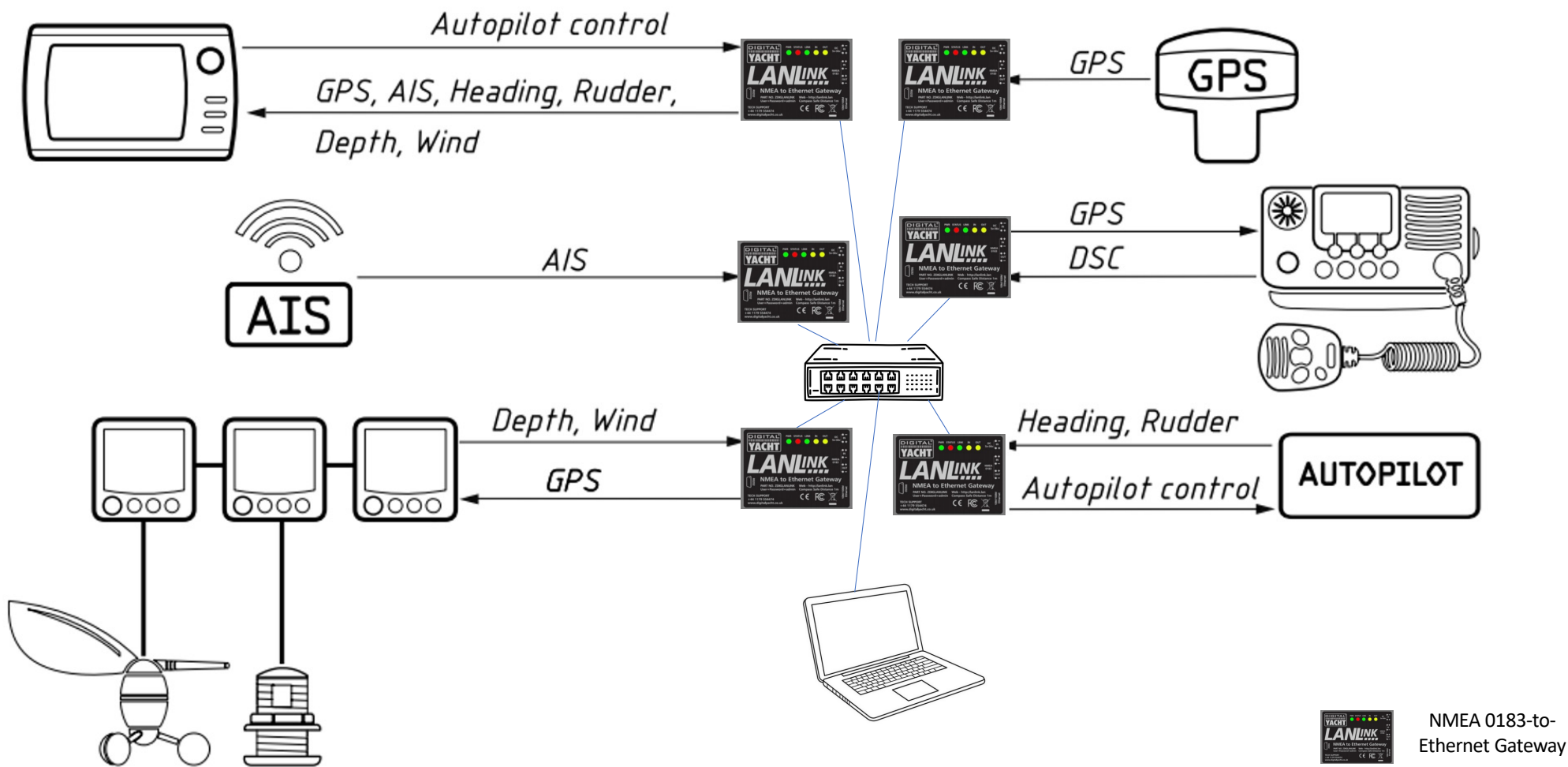
NMEA 0183 and Lightweight Ethernet

- Lightweight Ethernet (LWE) protocol stack described in IEC 61162-450
 - NMEA 0183 (IEC 61162-1) sentence format
 - User Datagram Protocol (UDP) using multicast addresses
 - Internet Protocol (IP) version 4
 - Ethernet frame format and data link layer
 - Star wiring physical topology with UTP or fiber
- Supports multiple talkers and multiple listeners
- Each cable segment up to 100 m
- Speeds from 1-10 Mbps



NMEA 0183-to-Ethernet Gateway



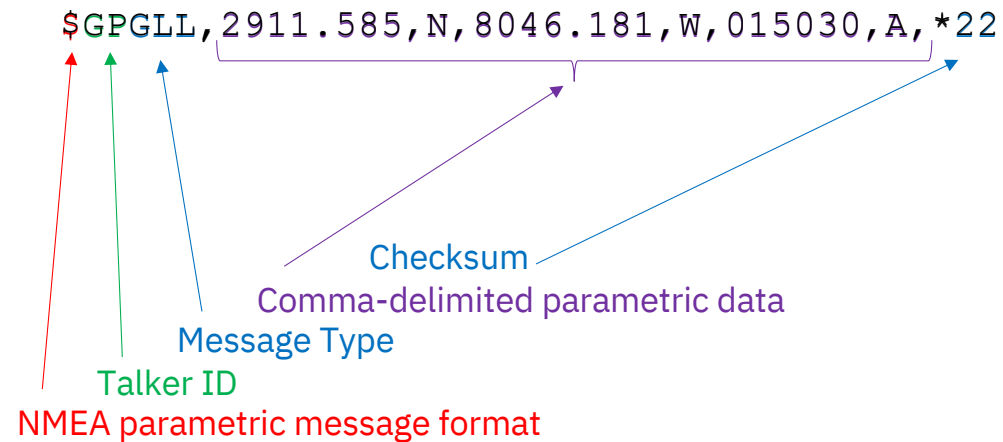


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NMEA 0183-to-Ethernet Gateway

NMEA 0183 Parametric Message Format



Commas (,) are field separators and the asterisk (*) indicates the checksum field

Some NMEA 0183 Talker IDs

AG - Autopilot - General
AI - Mobile AIS Station
AN - AIS Aid to Navigation
BD - BeiDou (China)
BN - Bridge navigational watch alarm system
CD - Communications - DSC
CS - Communications - Satellite
CV - Communications - Radio-Telephone (VHF)
DF - Direction Finder
DM - Velocity Sensor, Speed Log, Water, Magnetic
DP - Dynamic Position
EC - ECDIS
EP - Emergency Position Indicating Beacon (EPIRB)
GA - GALILEO
GB - BeiDou System (BDS)
GI - NavIC (IRNSS)
GL - GLONASS

GN - Global Navigation Satellite System (GNSS)
GP - Global Positioning System (GPS)
GQ - QZSS
HC - Heading - Magnetic Compass
II - Integrated Instrumentation
IN - Integrated Navigation
JD - Propulsion Control
LC - Loran C
WI - Weather Instrument
P - Vendor-specific, proprietary message
RA - RADAR and/or ARPA
RI - Rudder Angle Indicator
SD - Depth Sounder
TI - Turn Rate Indicator
VM - Velocity Sensor, Speed Log, Water, Magnetic
VR - Voyage Data recorder

Some NMEA 0183 Message Types

AAM - Waypoint Arrival Alarm
ALM - Almanac Data
APA - Auto Pilot A sentence
APB - Auto Pilot B sentence
BOD - Bearing Origin to Destination
BWC - Bearing Using Great Circle Route
DTM - Datum Being Used
GGA - Fix Information
GLL - Latitude/Longitude Data
GRS - GPS Range Residuals
GSA - Overall Satellite Data
GST - GPS Pseudorange Noise Statistics
GSV - Detailed Satellite Data
MSK - Send Control for a Beacon Receiver
MSS - Beacon Receiver Status Information

RMB – Rec. Navigation Data for GPS
RMC – Rec. Minimum Data for GPS
RTE - Route Message
TRF - Transit Fix Data
SSD – UAIS Ship Static Data
STN - Multiple Data ID
VBW - Dual Ground / Water Speed
VSD – UAIS Voyage Static Data
VTG - Vector Track and Speed Over Ground
WCV - Waypoint Closure Velocity (Speed Made Good)
WPL - Waypoint Location Information
XTC - Cross Track Error
XTE - Measured Cross Track Error
ZTG - Zulu (UTC) Time and Time to Destination
ZDA - Date and Time

Sample Parametric Message

\$GPGLL,2911.585,N,8046.181,W,015030,A,*22

```
***** NMEA 0183 Parser (Version: 3.2.29, Build date: 02-SEP-2025) *****
NMEA 0183 sentence input from command line.

NMEA 0183 sentence: $GPGLL,2911.585,N,8046.181,W,015030,A,*22
  Talker: GP -- Global Positioning System (GPS)
  Message Type: GLL -- Geographic Position -- Latitude/Longitude
-----
  Position: 29°11.585'N, 080°46.181'W
  Time: 01:50:30 UTC
  Status: Data valid (A)
  Positioning system mode indicator: (--)
-----
Checksum: 22 (checksum verified)
*****
1 sentence(s) processed
```

Note that the message is preceded by a "\$" and is human-readable...

***** NMEA 0183 Parser (Version: 3.2.29, Build date: 02-SEP-2025) *****

NMEA 0183 sentence input from command line.

NMEA 0183 sentence: \$GPALM,30,01,01,2210,00,617b,0f,1da7,fd70,a10d0a,24de91,6fe696,16263f,17c,ffe*7B

Talker: GP -- Global Positioning System (GPS)

Message Type: ALM -- GPS Almanac Data

Total number of messages: 30

Message sequence number: 1

Satellite PRN number: 1

GPS week number: 2,210

***** Refer to the IS-GPS-200L specification for details about the following parameter fields. *****

SV health (bits 17-24 of each page): 0x00 (00000000)

** LNAV Data Health Indications: ALL DATA OK (0)

** Health of SV Signal Components: All Signals OK (0)

Eccentricity: 0.01189947128 (0x617B)

Almanac reference time: 61,440 seconds (0x0F) [17 hour(s) 4 minute(s) 0 second(s)]

Orbital inclination: 0.01447868347 radians (0x1DA7)

Rate of right ascension: -2.386514097e-09 radians/sec (0xFD70)

Sq. root of semi-major axis (A): 5153.629883 sqrt(meters) (0xA10D0A)

Argument of perigee: 0.2880421877 radians (0x24DE91)

Longitude of ascension node: 0.8742244244 radians (0x6FE696)

Mean anomaly: 0.1730421782 radians (0x16263F)

F0 Clock Parameter: 0.0003623962402 seconds (0x17C)

F1 Clock Parameter: -7.275957614e-12 seconds/second (0xFFE)

Checksum: 7B (checksum verified)

1 sentence(s) processed

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```
***** NMEA 0183 Parser (Version: 3.2.29, Build date: 02-SEP-2025) *****  
NMEA 0183 sentence input from command line.
```

```
NMEA 0183 sentence: $AIVSD,30,2.3,4,ILHFA,141922.30,15,07,0,0*14
```

```
  Talker: AI -- Mobile AIS Station
```

```
Message Type: VSD -- UAIS Voyage Static Data
```

```
-----  
Type of ship and cargo category: 30 (Fishing)
```

```
Maximum present static draught: 2.3 m
```

```
Persons on board: 4
```

```
Destination: ILHFA
```

```
Estimated time of arrival at destination: 14:19:22.30 UTC
```

```
Estimated day of arrival at destination: 15
```

```
Estimated month of arrival at destination: 07
```

```
Navigational status: 0 (Under way using engine)
```

```
Regional application flags: 0 (Not used for any regional application)
```

```
-----  
Checksum: 14 (checksum verified)
```

```
*****
```

```
1 sentence(s) processed
```

Proprietary Messages

```
$PTNL,EVT,221212.000008,1,5026,1893,1,17*4F
$PGRMF,18,450873,100924,123456,1,2912.3456,N,08056.3412,W,M,2,22,45,2,8*00
```

- Proprietary messages follow the standard 0183 format
 - "P" after the \$ indicates proprietary
 - Next three characters are the vendor ID
 - Message type follows vendor ID
- E.g.,
 - \$PTNL,EVT is Trimble Event Marker Data Message
 - \$PGRMF is Garmin GPS Fix Data
- Sample Vendor IDs
 - ASH = Ashtech
 - DGY = Digital Yacht LTD
 - ELA = Wartsila ELAC NAUTIK
 - PFEC = Furuno Electric
 - PFUR = Furuno USA
 - PGRM = Garmin
 - PLWR = Lowrance Electronics
 - PMAR = Maretron
 - PSIM = Simrad
 - PSRF = SiRF Technology
 - PTNL = Trimble Navigation Ltd

***** NMEA 0183 Parser (Version: 3.2.32, Build date: 11-SEP-2025) *****

NMEA 0183 sentence input from command line.

NMEA 0183 sentence: \$PGRMF,18,450873,100924,123456,1,2912.3456,N,08056.3412,W,M,2,22,45,2,8*00

Talker: PGRM -- Garmin Proprietary

Message Type: F -- GPS Fix Data Sentence

GPS week number: 18

GPS seconds: 450,873 [5 day(s) 5 hour(s) 14 minute(s) 33 second(s)]

UTC date of position: 10-SEP-24

UTC time of position fix: 12:34:56 UTC

GPS leap second count: 1

Position: 29°12.3456'N, 080°56.3412'W

Mode: M (Manual)

Fix type: 2 (3D fix)

Speed over ground: 22 km/hr

Course over ground: 045°T

Position dilution of precision (PDOP): 2 (Good [3/5])

Time dilution of precision (TDOP): 8 (Moderate [2/5])

Checksum: 00 (checksum verified)

***** NMEA 0183 Parser (Version: 3.2.32, Build date: 11-SEP-2025) *****

NMEA 0183 sentence input from command line.

NMEA 0183 sentence: \$PTNL,EVT,221212.000008,1,5026,1893,1,17*4F

Talker: PTNL -- Trimble Navigation Ltd Proprietary

Message Type: EVT -- Event Marker Data message

Event time: 22:12:12.000008 UTC

Port number: 1

Incremental number of events on each independent port: 5,026

Week number of event since 06 January 1980: 1,893

Day of week: 1 (Monday)

Leap second offset from GPS time: 17 UTC (18 seconds as of 07 July 2017)

Checksum: 4F (checksum verified)



Apply a display filter ... <%%/>

No.	Time	Source	Destination	Protocol	Info
7	0.013806800	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=39
8	0.013969774	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=49
9	0.016290616	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=39
10	0.096576401	172.31.252.1	172.31.255.255	UDP	10021 → 10021 Len=37
11	0.108863339	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=49
12	0.109009211	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=39
13	0.109150559	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=49
14	0.109274960	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=39
15	0.114053562	172.31.252.1	172.31.255.255	UDP	10037 → 10037 Len=45
16	0.119660058	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=49
17	0.119792993	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=39
18	0.130433357	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=49
19	0.130900778	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=39

> Frame 14: 81 bytes on wire (648 bits), 81 bytes captured (648 bits) on interface enp0s31f6, id 0

> Ethernet II, Src: DigiBoard_7f:67:70 (00:40:9d:7f:67:70), Dst: Broadcast (ff:ff:ff:ff:ff:ff)

> Internet Protocol Version 4, Src: 172.31.252.1, Dst: 172.31.255.255

> User Datagram Protocol, Src Port: 10036 (10036), Dst Port: 10036 (10036)

✓ Data (39 bytes)

Data: 01530001000000000013ffffffffffff000166a22447504844542c3135302e302c542a33310d0a

[Length: 39]

```
0000  ff ff ff ff ff ff 00 40 9d 7f 67 70 08 00 45 00  .....@..gp..E.
0010  00 43 96 c7 40 00 40 11 4f a2 ac 1f fc 01 ac 1f  .C..@.@.0.....
0020  ff ff 27 34 27 34 00 2f 1a d3 01 53 00 01 00 00  ..'4'4./...S...
0030  00 00 00 13 ff ff ff ff ff ff 00 01 66 a2 24 47  .....f..$G
0040  50 48 44 54 2c 31 35 30 2e 30 2c 54 2a 33 31 0d  PHDT,150 .0,T*31.
0050  0a
```

***** NMEA 0183 Parser (Version: 3.2.29, Build date: 02-SEP-2025) *****

NMEA 0183 sentence input from command line.

NMEA 0183 sentence: \$GPHDT,150.0,T*31

Talker: GP -- Global Positioning System (GPS)

Message Type: HDT -- Heading, True

Heading: 150.0° True (T)

Checksum: 31 (checksum verified)

1 sentence(s) processed



Apply a display filter ... <?/>

No.	Time	Source	Destination	Protocol	Info
7	0.013806800	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=39
8	0.013969774	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=49
9	0.016290616	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=39
10	0.096576401	172.31.252.1	172.31.255.255	UDP	10021 → 10021 Len=37
11	0.108863339	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=49
12	0.109009211	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=39
13	0.109150559	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=49
14	0.109274960	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=39
15	0.114053562	172.31.252.1	172.31.255.255	UDP	10037 → 10037 Len=45
16	0.119660058	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=49
17	0.119792993	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=39
18	0.130433357	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=49
19	0.130900778	172.31.252.1	172.31.255.255	UDP	10036 → 10036 Len=39

- > Frame 15: 87 bytes on wire (696 bits), 87 bytes captured (696 bits) on interface enp0s31f6, id 0
- > Ethernet II, Src: DigiBoard_7f:67:70 (00:40:9d:7f:67:70), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
- > Internet Protocol Version 4, Src: 172.31.252.1, Dst: 172.31.255.255
- > User Datagram Protocol, Src Port: 10037 (10037), Dst Port: 10037 (10037)
- ▼ Data (45 bytes)

Data: 0193000100000000019ffffffffffff000166a224504645432c47506174742c2c302e302c322e332a36370d0a
[Length: 45]

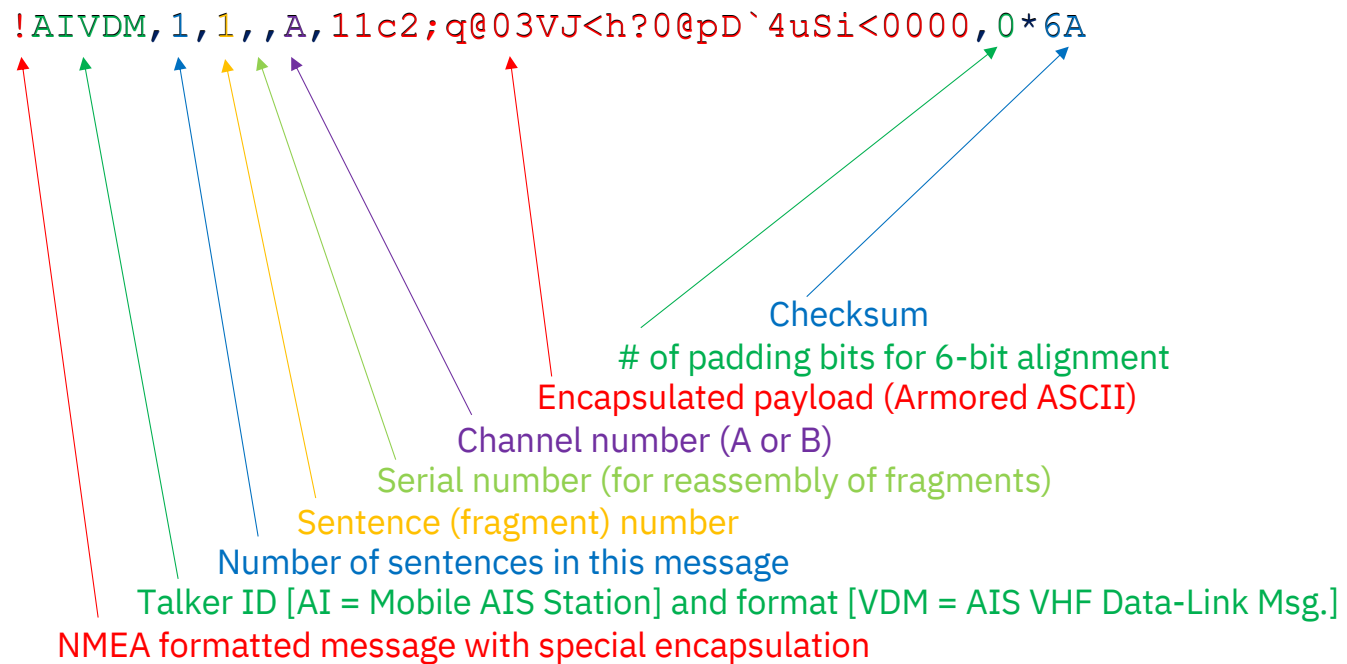
0000	ff ff ff ff ff ff 00 40	9d 7f 67 70 08 00 45 00	@..gp..E.
0010	00 49 96 c8 40 00 40 11	4f 9b ac 1f fc 01 ac 1f	.I..@..0.....
0020	ff ff 27 35 27 35 00 35	09 cd 01 93 00 01 00 00	..'5'5.5.....
0030	00 00 00 19 ff ff ff ff	ff ff 00 01 66 a2 24 50	f.\$P
0040	46 45 43 2c 47 50 61 74	74 2c 2c 30 2e 30 2c 32	FEC,GPat t,,0.0,2
0050	2e 33 2a 36 37 0d 0a		.3*67..

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```
**** NMEA 0183 Parser (Version: 3.2.29, Build date: 02-SEP-2025) ****
NMEA 0183 sentence input from command line.

NMEA 0183 sentence: $PFEC,GPatt,,0.0,2.3*67
  Talker: PFEC -- Furuno Electric Proprietary
Message Type: GPatt -- Furuno attitude message
-----
  Heading: --°T
  Pitch: 0.0°
  Roll: 2.3°
-----
Checksum: 67 (checksum verified)
*****
1 sentence(s) processed
```

Encapsulated ASCII Sentence



Commas (,) are field separators and the asterisk (*) indicates the checksum field

<https://www.garykessler.net/software/#ais>

Summary

- NMEA Protocol Family Overview
- NMEA 0183 Applications and Ecosystem
- NMEA 0183 Physical and Network Protocols
- NMEA 0183 Sentences
- Demonstration and Practicum

Acronyms and Abbreviations

AIS	Automatic Identification System	LSB	Least significant bit
ARPA	Automatic Radar Plotting Aid	LWE	Lightweight Ethernet
ASCII	American Standard Code for Information Interchange	m	meters
BDS	BeiDou Navigation Satellite System	Mbps	Megabits (millions or 10^6 bits) per second
bps	Bits per second	MSB	Most significant bit
CAN	Controller Area Network	NMEA	National Maritime Electronics Association
DC	Direct current	QZSS	Quasi-Zenith Satellite System
DSC	Digital selective calling	RS	Recommended Standard
ECDIS	Electronic chart display and information system	UART	Universal asynchronous receiver/transmitter
EIA	Electronic Industry Alliance (<i>nee</i> Association)	UDP	User Datagram Protocol
Gbps	Gigabits (billions or 10^9 bits) per second	UTP	Unshielded twisted pair
GPS	Global Positioning System	V	Volts
IEC	International Electrotechnical Commission	VHF	Very high frequency
IP	Internet Protocol	XOR	Exclusive OR
IPsec	Internet Protocol Security		
IPv6	Internet Protocol version 6		
IRNSS	Indian Regional Navigation Satellite System		
ITU-R	International Telecommunication Union, Radiocommunication sector		
kbps	Kilobits (thousands or 10^3 bits) per second		