NMEA 0183 TECHNICAL INFORMATION

Zinnos Inc.

1. Frequently Asked Questions

Q: What is the NMEA 0183 Standard?

A: The National Marine Electronics Association developed this standard in 1983 as an interface specification for digital data transfer among marine navigation instruments.

Q: Is NMEA 0183 compatible with RS-232?

A: Strictly speaking, no. RS-232 signals will drive NMEA 0183 inputs, and some older single-ended NMEA 0183 instruments will drive RS-232 inputs. Most NMEA 0183 instruments (talkers), however, are differential drive (RS-422), which is incompatible with RS-232.

Q: Can I bus or "daisy-chain" NMEA 0183 outputs together?

A: In general, no. Multiple NMEA 0183 outputs (talkers) cannot be connected to a single input (listener), because the data bursts from different instruments will collide. NMEA 0183 does not provide for data synchronization among units. Multiple "listeners", however, may be connected to a single "talker" within drive level limitations.

Q: What are NMEA 0183 "Talkers" and "Listeners"?

A: An NMEA 0183 "Talker" is any device that sends data, in the form of sentences, to a "Listener" about once each second. Most marine navigation instruments (GPS, knotmeter, compass, etc) are Talkers. Some devices, such as GPS's are also Listeners.

Q: What type of "Handshaking" does NMEA 0183 use?

A: None. The NMEA 0183 is a one-way transmission standard with no handshaking needed.

Q: What is "Opto-isolation"?

A: Opto-isolation is an input interface used to isolate a transmit circuit from a receive circuit. The transmit circuit drives a light source (usually an LED) which in turn switches a phototransistor on and off. There is no electrical interconnection between transmit and receive circuits.

Q: What is Differential drive?

A: Differential drive is an output interface consisting of two wires whose polarity will change depending upon whether a '1' or '0' is being transmitted. This causes current to flow in opposite directions for each state. Neither side of a differential line should be grounded.

2. NMEA 0183 Description

2.1 Introduction

NMEA-0183 is a standard for interfacing marine electronic devices. This standard defines the electrical signal requirements, data transmission protocol, data transmission timing, and specific message formats for a 4800-baud serial data interface. NMEA 0183 devices employ an asynchronous serial interface with the following parameters.

- Baud Rate : 4800
- Data Bits : 8(d7=0)
- Parity : None
- Stop Bits : One(or more)

Devices are designated as either talkers or listeners with some devices being both. A talker is any device that sends data to other NMEA 0183 devices. A listener is any device that receives data from other NMEA 0183 devices. Instruments that are both talker and listener will have separate connections for each function. All data either transmitted or received is interpreted as 8 bit ASCII (d7=0).

2.2 Electrical Requirements

Talker : Under the latest version of the standard, NMEA 0183 talkers are supposed to be differential drive compatible with EIA RS-422. Differential drive signals have no reference to Ground and are more immune to noise. Earlier versions of the NMEA 0183 standard allowed single-ended drive circuitry for talker(s) (i.e., 0 to +15VDC). Therefore, there are still instruments around which are not differential drive outputs. A single talker can drive multiple listeners within drive current limitations.

Listener : NMEA 0183 listeners are supposed to have input isolation from the ships Ground. Opto-isolation, which is generally used to meet this requirement, limits the input impedance. The standard specifies a minimum input resistance for listeners of 500 ohms and most devices will probably be close to this value.

2.3 Message Format

The general NMEA 0183 message formats : *$aaaaa,df1,df2,....[CR][LF]*

All NMEA 0183 messages start with a "$" and are terminated by a [Carriage

Return][Line Feed]. The five characters immediately after the "$" are the address field. The address field is interpreted based on the type of sentence (talker, query or proprietary). Multiple data fields follow the address field and are delimited by commas.

There are three basic sentence structures defined by the standard : *talker* sentence, *query* sentence, *proprietary* sentence

Talker Sentence : The general format for a talker (instrument) message is
$ttsss,df1,df2,....[CR][LF]

The address field of a talker sentence contains a five character string immediately following the "$" sign. The first two characters are the talker identifier while the next three are the sentence identifier. The sentence identifier defines the remaining data fields. Under the NMEA 0183 Standard, the data fields are uniquely defined for each sentence type. An example talker sentence is : *$HCHDM,238,M[CR][LF]*

Where the "HC" specifies the talker as being a magnetic compass, the "HDM" specifies the magnetic heading message follows. The "238" is the heading value, and "M" designates the heading value as magnetic.

Query Sentence : A query sentence is a means for a listener to request a particular sentence from a talker. For example, a query message might be sent to a GPS receiver to request that "DISTANCE-TO-WAYPOINT" information should be transmitted. In response, the GPS will start sending the requested sentences until it is told to send some other sentence(s).

The general format of a query sentence is : *$ttllQ,sss,[CR][LF]*
The first two characters of the address field are termed the talker identifier of the requester and the next two characters are the talker identifier of the device being queried (listener). The fifth character is always a "Q" defining the message as a query. The next field (sss) contains the three letter mnemonic of the sentence being requested. An example query sentence is : *$CCGPQ,GGA[CR][LF]*

Where the "CC" device (computer) is requesting from the "GP" device (GPS) the "GGA" sentence. The GPS will then transmit this sentence once per second until a different query is requested.

Proprietary Sentence : The proprietary sentence is a means for manufacturers to use special sentences that are not pre-defined by the standard.

The general format of a proprietary message is : *PmmmA,df1,df2,...,[CR][LF]*

Where the "P" indicates that it is a proprietary message and that the data fields that follow do not necessarily correspond to any approved sentence structure. The "mmm" is defined as the manufacturers message code. The fifth character of the address field is a letter (A-Z) that defines the specific message type.

Checksum : The NMEA 0183 Standard allows for an optional checksum. The checksum is preceded by the asterisk (*) character placed after the last data field. It is a two-character field equal to the hex value obtained by XOR'ing all the character bytes of the sentence.

2.4 Practical Considerations

Most navigation instruments commonly encountered (compass, knotlog, depthsounder, etc.) will send one or more talker sentences usually once per second. More sophisticated instruments such as a GPS or Radar will also accept data from other instruments via their "listener" connection.

A single talker is generally capable of driving multiple listeners within limits of the drive circuitry. If many outputs need to be driven or if isolation between listeners is desired, then an "expander" or amplifier is necessary.

Conversely, if it is necessary to combine multiple talkers into a single listener, a "multiplexer" (also called "combiner" or "concentrator") is required. There is no limit to how many talkers can be combined this way, but NMEA 0183 is restricted to 4800 baud and this limits total throughput at any listener port to about 450 characters per second. A single sentence may contain up to 72 characters and some instruments transmit sentences up to 10 times per second. Therefore, when combining multiple talkers, diligence must be exercised so as not to exceed throughput limits.

3. Interfaces; RS-232, RS-422, NMEA 0183, ...

3.1 Introduction

The NMEA 0183 Standard, along with RS-232, RS-422, etc., belongs to the class of "Asynchronous Serial" interfaces. This means that data is transmitted serially (bit-by-bit) on a single line. Furthermore, the transmission is asynchronous because no "clock" signal is transmitted with the data.

When using asynchronous communications, "TIMING IS EVERYTHING". In order to synchronize to the incoming data, a receiver needs to know the bit rate (baud) of the incoming data and the number of Start, Stop, and Data bits. Without this information ahead of time, the receiver (usually a UART) has no chance of correctly deciphering the Serial bit stream. The receiver will "resynch" on each new byte of data when it receives the "Start" bit. This allows for timing errors of a few percent to be tolerated. The tradeoff is that nearly 40% of the channel bandwidth is used for overhead (synchronization).

What distinguishes NMEA 0183, RS-232, and RS-422 from each other is their physical voltage and current interface levels. NMEA 0183 originally allowed "single-ended" drive, but was later updated to differential drive (RS-422). RS-232 is a bipolar interface and RS-422 is differential drive. These are explained in more detail next.

3.2 RS-232

The RS-232 has been around since the very early days of Digital Communications. Early implementations required elaborate hardware "handshaking" to maintain communication. 25 pin connectors with several handshaking and "flow-control" lines were needed in most installations. Later, with the advent of microprocessors, hardware handshaking disappeared in favor of software flow control. Nowadays, most RS-232 interfaces use only a "transmit Data" (TD) wire, a "receive data" (RD) wire, and "ground" (GND). For one-way transmission (or reception), only two wires are needed.

An RS-232 line will go to a negative or positive voltage with respect to Ground, depending on whether a binary "one" or "zero" is transmitted. Any voltage greater than +3.0 is considered a "zero" (space), whereas any voltage less than -3.0 are taken as a "one" (mark). The range between +3.0 and -3.0 volts is undefined. These voltages worked fine for the old mechanical Teletype terminals, but they do not interface easily with modern digital electronics that operate in the 0-5 volt range.

The RS-232 interface is intended for use in high-impedance circuits. This means that the drivers are not expected to provide large drive currents. Receivers will usually have impedances in excess of several k-ohms. RS-232 interfaces are somewhat sensitive to environmental noise (motors, ignition pulses, etc.) and are therefore usually limited to installations of tens of feet or less.

3.3 RS-422

RS-422 is most commonly called "differential drive". Two wires, A and B are used for this interface, but neither wire is grounded. A "zero" is produced by making A positive with respect to B and a "one" by making B positive with respect to A. It is therefore the direction of current flow rather than a voltage level that determines the logic state. It is important to note that the current originates from the driver and must be returned to the driver, not to Ground.

RS-422 is a low impedance interface and can often drive loads down to tens of ohms. It is very immune to external noise, and so can be used over greater distances (hundreds of feet). Under the latest version of NMEA 0183, all talkers are supposed to be RS-422. RS-422 is not compatible with RS-232, TTL or any other single ended drive that uses a ground reference. It is only compatible with differential receivers, opto-isolators, and other receivers not dependent on a ground reference.

3.4 NMEA 0183

Early versions of the NMEA 0183 Standard specified that "listeners" must be isolated from ship's ground but allowed "talkers" to be simple single-ended drivers (referenced to ground). Furthermore, the input impedance of a listener was specified to be greater than 500 ohms, and opto-isolation was recommended. Later versions of the Standard retained the opto-isolated listener recommendation, but revised the talker requirement to be RS-422 compliant. As a result, there exist some instruments (talkers) with single-ended outputs and others with RS-422 (differential) outputs. Fortunately, both types of outputs will drive opto-isolated listeners.

Single-ended drivers are perhaps the simplest to design. The desired state indicated by the presence or absence of a voltage above some threshold. For NMEA 0183 (ver. 1.5), a "one" was any voltage less than +0.5, while a 'zero' was any voltage greater than +4.0. Besides their design simplicity, single ended drivers need only one wire to transmit data. Since voltages are referenced to Ground, no signal return line is needed.

The conversion of NMEA 0183 talkers to RS-422 (ver. 2.0) was a good move, although it increased the confusion factor among installers and required the use of "two-wire" connections. RS-422 has excellent noise immunity even in long cable runs and has ample drive capacity. A single RS-422 talker can easily drive 4 or more opto-isolated listeners.

On the listener side, most manufacturers seemed to have adopted the NMEA "opto-isolation" recommendation. Opto-isolators are actually quite simple devices. They consist of a light source (LED) coupled to a phototransistor. The input data signal turns the LED on and off which causes the phototransistor to switch on and off. The LED and phototransistor are completely isolated from each other electrically. The data source (talker) must provide sufficient current and voltage to power the LED. A current limiting resistor of about 500 ohms in series with the LED is generally used for protection.

The advantage of opto-isolated inputs is that virtually any type of driver can activate them. A typical LED wants about 5 milliamps at about 2 volts (minimum) to turn on. All of the driver interfaces discussed above can provide this.

3.5 Interface Compatibility

The question of interface compatibility often comes up in NMEA 0183 installations. Here is a summary of what to expect:

- Almost any type of driver (TTL, RS-232, RS-422, etc.) will drive at least one opto-isolated NMEA 0183 listener. RS-232 drivers will usually drive two listeners while RS-422 will often drive more than four listeners.
- RS-232 listeners (i.e., computers) can only be reliably driven by RS-232 drivers because of the negative voltage in the "idle" state. In practice, however, many RS-232 receivers will interpret a 0-volt input as an "idle" (logic 1) state and thereby correctly interpret data from single-ended drivers such as TTL or older NMEA 0183 talkers. This is why some GPS units have been successfully connected directly to a PC serial input without any signal conversion.
- RS-422 drivers cannot drive RS-232 listeners because neither side of the RS-422 output can be grounded to the RS-232 common. Therefore, most NMEA 0183 talkers cannot be directly connected to a PC.

The bottom line on interfacing is that few problems will be encountered unless an RS-232 interface is involved. RS-232 receivers are finicky about what will drive them and RS-232 drivers have limited output capacity.

4. Connecting & Viewing with a PC

4.1 Connecting NMEA 0183 directly to a PC

The question is often asked if an NMEA Talker (GPS, Compass, etc) can be directly connected to a PC. The simple answer is no, but it may work in a few cases. The reason is that the serial input to a PC is RS-232 but most NMEA Talkers are RS-422 (differential). RS-232 signals are referenced to ground while RS-422 signals are not. Grounding one side of an RS-422 signal will usually cause improper operation. Some older NMEA instruments, however, put out signals that are not RS-422 compliant and these may drive an RS-232 input. The only way to know for sure is to try it and see.

The best solution for all installations is to convert the NMEA output to an RS-232 signal before sending it to the PC. A variety of devices from several vendors are available to do this.

4.2 Viewing NMEA Sentences with HyperTerminal

One of the most useful tools in troubleshooting NMEA 0183 installations is a way to view the actual sentences at any given point in the network. This can be easily done with a Computer running "Hyperterminal". For those unfamiliar with this program, it is a very handy utility that is included with most Operating Systems. For the "Windows" operating system it can be found under the "Communications" subheading of the "Windows Setup". It can be installed from the "System Disks" (or CD-ROM) if it is not currently installed on your machine.

To set the Hyperterminal program up for viewing NMEA sentences, open the application, select the "New Connection" option, and use the following settings (properties):

- Connection : Direct to COM1 (or other COM port as appropriate)
- baud rate : 4800 - data bits : 8
- parity : None - stop bits : 1
- flow control : None

Select "OK" to start the program running. A terminal screen will appear with each line displaying an NMEA sentence as it is received.

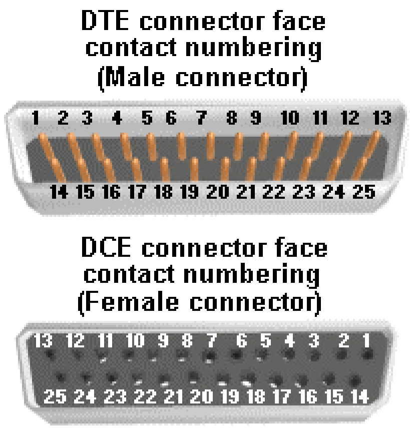
5. RS-232

5.1 Standard.

- CCITT V.24 Does not specify pin numbers. Details the types of signals to be exchanged. Specifies the absolute voltage levels, impedance's, and timing characteristics for each line.

- EIA RS232-C Uses V.24 recommendations and further specifies the mechanical connector type and pin numbers to be used (DB-25 pin connector).
- EIA RS232-C Mechanical Standard Female connector is connected to DCE and male connector to DTE. Short cables of less than 15 meters (50 feet) are recommended. The pin assignments detailed above must be used.
- EIA RS232-C Electrical Standard All circuits carry bi-polar low-voltage signals, measured at the connector with respect to signal ground (AB), and may not exceed ±25 volts. Signals are valid in the range ±3 volts to ±25 volts. Signals within the range -3 volts to +3 volts are considered invalid.
- For data lines, binary 1 (a high) is represented by -3 volts to -25 volts, whilst binary 0 is +3 volts to +25 volts.
- For control lines, OFF is represented by -3 volts to -25 volts, whilst binary 0 is +3 volts to +25 volts.

5.2 RS232 Connectors



5.3 Comparison

Specification	RS232C	RS423	RS422	RS485
Mode	Single-Ended	Single-Ended	Differential	Differential
Max No. of Driver, Receiver	1 Driver 1 Receiver	1 Driver 10 Receivers	1 Driver 10 Receivers	32 Drivers 32 Receivers

Max. Length	약 15 m	약 1.2 km	약 1.2 km	약 1.2 km
Max. Speed	20 Kb/s	100 Kb/s	10 Mb/s	10 Mb/s
Transmit Mode	Full Duplex	Full Duplex	Full Duplex	Half Duplex
Max. Output Voltage	±25V	±6V	-0.25V to +6V	-7V to +12V
Max. Input Voltage	±15V	±12V	-7V to +7V	-7V to +12V

5.4 Signals Functional Description

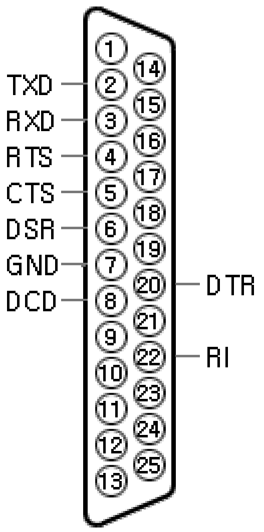
General: The first letter of the EIA signal name categorizes the signal into one of five groups, each representing a different "circuit":

- *A – Ground*
- *B – Data*
- *C – Control*
- *D – Timing*
- *S - Secondary channel*

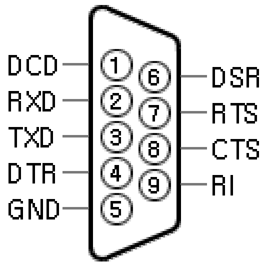
Pin	Description	Nm	Dir	Note.
1	Protective Ground	AA	-	This pin is usually connected to the frame of one of the devices, either the DCE or the DTE, which is properly grounded
2	Transmit Data	BA	->	Serial data (primary) is sent on this line from the DTE to the DCE
3	Receive Data	BB	<-	Serial data (primary) is sent on this line from the DCE to the DTE
4	Request To Send	CA	->	Enables transmission circuits. The DTE uses this signal when it wants to transmit to the DCE
5	Clear To Send	CB	<-	An answer signal to the DTE. When this signal is active, it tells the DTE that it can now start transmitting
6	Data Set Ready	CC	<-	On this line the DCE tells the DTE that the communication channel is available
7	Signal Ground	AB	-	This pin is the reference ground for all the other signals, data and control
8	Data Carrier Detect	CF	<-	The DCE uses this line to signal the DTE that a good signal is being received
9	Reserved (+P)			This pin is held at +12 volts DC for test purposes
10	Reserved (-P)			This pin is held at -12 volts DC for test purposes
11	Unassigned			
12	Secondary Receive Line Signal Detect	SCF	<-	This signal is active when the secondary communication channel is receiving a good analog carrier
13	Secondary Clear To Send	SCB	<-	An answer signal to the DTE. When this signal is active, it tells the DTE that it can now start transmitting
14	Secondary Transmitted Data	SBA	->	Serial data (secondary channel) is sent on this line from the DTE to the DCE
15	Transmission Signal Element Timing	DB	<-	The DCE sends the DTE a clock signal on this line
16	Secondary Receive	SBB	<-	Serial data (secondary channel) is received on this line

	Data			from the DCE to the DTE
17	Receiver Signal Element Timing	DD	<-	The DCE sends the DTE a clock signal on this line
18	Unassigned			
19	Secondary Request To Send	SCA	->	The DTE uses this signal to request transmission from the DCE on the secondary channel
20	Data Terminal Ready	CD	->	When on, tells the DCE that the DTE is available for receiving
21	Signal Quality Detector	CG	<-	This line is used by the DCE to indicate whether or not there is a high probability of an error in the received data
22	Ring Indicator	CE	<-	On this line the DCE signals the DTE that there is an incoming call
23	Data Signal Rate Selector	CH/CI	->	The DTE uses this line to select the transmission bit rate of the DCE
24	Transmitter Signal Element Timing	DA	->	The DTE sends the DCE a transmit clock
25	Unassigned (+5V)			

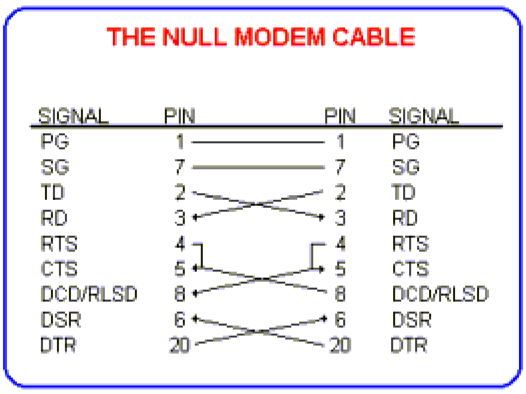
5.5 Pin Assignment



DB-25 RS232 코넥터



DB-9 RS232 코넥터



5.6 The major organisations responsible for standards

- Electronics Industries Association (EIA) Made up by manufacturers in the USA. Responsible for RS232 and similar standards.

- Institute of Electrical and Electronic Engineers (IEEE) Professional organisation of engineers. An example is the IEEE-754 standard for representing floating point numbers. http://www.ieee.org/
- American National Standards Institute (ANSI) Represents a number of US standards organisations. Member organisations submit their standards for acceptance. An example is the ANSI standards for representing ASCII characters. http://www.ansi.org/
- Consultative Committee on International Telephone and Telegraph (CCITT) International committee concerned with telecommunications. These standards deal with telephone and data traffic. An example is X.25

- International Organisation for Standards (ISO) Has standards covering a wide range of computer related topics. The US representative is ANSI. An example is ISO9000 standard for quality assurance. http://www.iso.ch