Maritime navigation and radiocommunication equipment and systems – Digital interfaces

Part 1: Single talker and multiple listeners
About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub
  The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub
  Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Customer Service Centre: www.iec.ch/webstore/custserv
  If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:
  Email: csc@iec.ch
  Tel.: +41 22 919 02 11
  Fax: +41 22 919 03 00
Maritime navigation and radiocommunication equipment and systems – Digital interfaces

Part 1:
Single talker and multiple listeners
**CONTENTS**

FOREWORD....................................................................................................................... 4  
INTRODUCTION................................................................................................................... 6  

1 Scope.......................................................................................................................... 7  
2 Normative references........................................................................................................ 7  
3 Terms and definitions ....................................................................................................... 8  
4 Manufacturer’s documentation .......................................................................................... 8  
5 Hardware specification...................................................................................................... 8  
  5.1 Interconnecting wire................................................................................................. 8  
  5.2 Conductor definitions ............................................................................................... 8  
  5.3 Electrical connections/shield requirements............................................................... 8  
  5.4 Connector................................................................................................................ 9  
  5.5 Electrical signal characteristics ................................................................................ 9  
6 Data transmission........................................................................................................... 10  
7 Data format protocol ....................................................................................................... 10  
  7.1 Characters............................................................................................................. 10  
  7.2 Fields .................................................................................................................... 11  
  7.3 Sentences ............................................................................................................. 13  
  7.4 Error detection and handling .................................................................................. 20  
  7.5 Handling of deprecated sentences ......................................................................... 20  
8 Data content ................................................................................................................... 20  
  8.1 Character definitions.............................................................................................. 20  
  8.2 Field definitions ..................................................................................................... 23  
  8.3 Approved sentences .............................................................................................. 25  
9 Applications................................................................................................................... .9  
  9.1 Example parametric sentences .............................................................................. 90  
  9.2 Example encapsulation sentences ......................................................................... 94  
  9.3 Examples of receiver diagrams .............................................................................. 94  

Annex A (informative) Glossary ............................................................................................ 96  
Annex B (normative) Guidelines for methods of testing and required test results ................ 103  
Annex C (normative) Six-bit binary field conversion ............................................................ 109  
Annex D (normative) Alarm system fields .......................................................................... 112  
Annex E (informative) Example of use of FIR, DOR and WAT sentences ....................... 121  
Annex F (informative) Example encapsulation sentence ..................................................... 125  

Bibliography ................................................................................................................... 131  

Figure 1 – Listener receive circuit........................................................................................ 9  
Figure 2 – Data transmission format.................................................................................. 10  
Figure 3 – Example 1, J-FET, N channel, opto-isolator based listener circuit ....................... 94  
Figure 4 – Example 2, NPN opto-isolator based listener circuit .......................................... 95  
Figure C.1 – 6-bit binary code converted to valid IEC 61162-1 character ......................... 110  
Figure C.2 – Valid IEC 61162-1 character converted to 6-bit binary code ....................... 111
Figure E.1 – Example system diagram................................................................................. 122
Figure F.1 – Message data format....................................................................................... 126
Figure F.2 – Work sheet for decoding and interpreting encapsulated string ................. 130

Table 1 – Reserved characters.............................................................................................. 20
Table 2 – Valid characters..................................................................................................... 21
Table 3 – Character symbol................................................................................................ 22
Table 4 – Talker identifier mnemonics ................................................................................... 23
Table 5 – Field type summary.............................................................................................. 24
Table B.1 – Example – Data string GGA sent by the EUT to the test receiver (listener) ...... 106
Table B.2 – Checksum ........................................................................................................ 107
Table B.3 – Example – data string GGA received by the EUT .............................................. 107
Table B.4 – Example – Checksum ....................................................................................... 108
Table B.5 – Break of data line ............................................................................................. 108
Table C.1 – Six-bit binary field conversion table................................................................... 109
Table D.1 – System alarm fields .......................................................................................... 112
Table F.1 – Example message from ITU-R M.1371 .............................................................. 129
FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.

3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication should be clearly indicated in the latter.

5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.

6) All users should ensure that they have the latest edition of this publication.

7) No liability should attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publication.

8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC should not be held responsible for identifying any or all such patent rights.

International Standard IEC 61162-1 has been prepared by IEC technical committee 80: Maritime navigation and radiocommunication equipment and systems.


The main changes with respect to the previous edition are listed below:

- Normative references have been renumbered from 1.2 to 2, Terms and definitions from 1.3 to 3 and Manufacturers documentation from 2 to 4. Thereafter all clauses are numbered two ahead of those in the previous edition.

- Clause 7 (Clause 5 in the previous edition) has been expanded to include two types of start of sentence delimiters. The conventional delimiter "$" is used with the conventional sentences which are now called parametric sentences. A new delimiter "!" identifies
sentences that conform to special purpose encapsulation. The example applications in Clause 9 (Clause 7 in the previous edition) have been expanded to describe both types.

- The tables in Clause 8 (Clause 6 in the previous edition) have been updated. The previous Table 5 (Approved sentence formatters) and the associated Annex A (Minimum required sentences) have been deleted.
- Clause 8 has been expanded to include new and revised sentences.
- Four new annexes have been added to support the text.

The text of this standard is based upon the following documents:

<table>
<thead>
<tr>
<th>FDIS</th>
<th>Report on voting</th>
</tr>
</thead>
<tbody>
<tr>
<td>80/464</td>
<td>80/473/RVD</td>
</tr>
</tbody>
</table>

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.
INTRODUCTION

International standard IEC 61162 is a four part standard which specifies four digital interfaces for application in marine navigation, radiocommunication and system integration. The four parts are:

IEC 61162-1 Single talker and multiple listeners
IEC 61162-2 Single talker and multiple listeners, high speed transmission
IEC 61162-3 Multiple talkers and multiple listeners – Serial data instrument network (under consideration)
IEC 61162-4 Multiple talkers and multiple listeners – Ship systems interconnection

IEC technical committee 80 interface standards are developed with input from manufacturers, private and government organisations and equipment operators. The information is intended to meet the needs of users at the time of publication, but users should recognise that as applications and technology change, interface standards should change as well. Users of this standard are advised to immediately inform the IEC of any perceived inadequacies therein.

This edition is a complete revision of the second edition of IEC 61162-1. Liaison has been maintained with NMEA and this edition has been aligned as closely as possible with NMEA 0183 version 3.01. It incorporates three previously issued publicly available specifications: PAS 61162-100 Extra requirements to IEC 61162-1 for UAIS, PAS 61162-101 Modified sentences and requirements for IEC 61162 and PAS 61162-102 Extra requirements to IEC 61162-1 for the voyage data recorder.

The second edition included details of the ship equipment defined in IMO resolutions together with appropriate sentences for communication between them. It is now the practice to specify the sentence formatters in the individual standards for equipment, so, in this edition the previous Table 5 (Approved sentence formatters) and Annex A (Minimum required sentences) have not been included.

NOTE: The equipment responses and behaviour is beyond the scope for this standard and should be included in the individual equipment standards, for example alarm handling.

This edition introduces (from PAS 61162-100) two types of start of sentence delimiters. The conventional delimiter “$” is used with the conventional sentences which are now called parametric sentences. The new delimiter “!” identifies sentences that conform to special purpose encapsulation. The example applications in Clause 9 (Clause 7 in second edition) have been expanded to describe both types.

The list of sentences in Clause 8 (Clause 6 in second edition) has been updated to include all the sentences which were developed in the three public available specifications together with new sentences for display dimming (DDC), NAVTEX (NRM and NRX), rudder order (ROR), heading (THS) and user identification code transmission (UID).

As a result of experience the sentences given in PAS 61162-102 for the voyage data recorder; ALA, AKD, DOR, ETL, EVE, FIR, GEN, HSS, PRC, TRC, TRD and WAT have been modified in this edition.
1 Scope

This part of IEC 61162 contains the requirements for data communication between maritime electronic instruments, navigation and radiocommunication equipment when interconnected via an appropriate system.

This standard is intended to support one-way serial data transmission from a single talker to one or more listeners. This data is in printable ASCII form and may include information such as position, speed, depth, frequency allocation, etc. Typical messages may be from about 11 to a maximum of 79 characters in length and generally require transmission no more rapidly than one message per second.

The electrical definitions in this standard are not intended to accommodate high-bandwidth applications such as radar or video imagery, or intensive database or file transfer applications. Since there is no provision for guaranteed delivery of messages and only limited error checking capability, this standard should be used with caution in all safety applications.

For applications where a faster transmission rate is necessary, reference should be made to IEC 61162-2.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60945: Maritime navigation and radiocommunication equipment and systems – General requirements – Methods of testing and required test results


ITU-R M.493, Digital selective-calling system for use in the maritime mobile service

ITU-R M.821, Optional expansion of the digital selective-calling system for use in the maritime mobile service

ITU-R M.825, Characteristics of a transponder system using digital selective calling techniques for use with vessel traffic services and ship-to-ship identification

ITU-R M.1371, Technical characteristics for an automatic identification system using time division multiple access in the VHF band
ITU-T X.27/V.11:1996, *Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s*

3 Terms and definitions

Common terms are defined in the glossary of Annex A. Where there is a conflict, terms shall be interpreted wherever possible in accordance with the references in Clause 2.

For the purposes of this document, the following terms and definitions apply.

**talker**
any device which sends data to other devices. The type of talker is identified by a 2-character mnemonic as listed in 8.2 (Table 4)

**listener**
any device which receives data from another device

4 Manufacturer's documentation

Operator manuals or other appropriate literature provided for equipment that is intended to meet the requirements of this standard shall contain the following information:

a) identification of the A and B signal lines;
b) the output drive capability as a talker;
c) a list of approved sentences, noting unused fields, proprietary sentences transmitted as a talker and transmission interval for each sentence;
d) the load requirements as a listener;
e) a list of sentences and associated data fields that are required as a listener;
f) the current software and hardware revision if this is relevant to the interface;
g) an electrical description or schematic of the listener/talker input/output circuits citing actual components and devices used, including connector type and part number;
h) the version number and date of update of the standard for which compliance is sought.

5 Hardware specification

NOTE Guidelines on methods of testing are given in Annex B.

One talker and multiple listeners may be connected in parallel over an interconnecting wire. The number of listeners depends on the output capability and input drive requirements of individual devices.

5.1 Interconnecting wire

Interconnection between devices may be by means of a two-conductor, shielded, twisted-pair wire.

5.2 Conductor definitions

The conductors referred to in this standard are the signal lines A and B, and shield.

5.3 Electrical connections/shield requirements

All signal line A connections are connected in parallel with all device A connections and all signal line B connections are connected in parallel with all device B connections. The shields of all listener cables should be connected to the talker chassis only and should not be connected at each listener.
5.4 Connector

No standard connector is specified. Wherever possible readily available commercial connectors shall be used. Manufacturers shall provide means for user identification of the connections used.

5.5 Electrical signal characteristics

This subclause describes the electrical characteristics of transmitters and receivers.

5.5.1 Signal state definitions

The idle, marking, logical 1, OFF or stop bit states are defined by a negative voltage on line A with respect to line B.

The active, spacing, logical 0, ON or start bit states are defined by a positive voltage on line A with respect to line B.

It should be noted that the above A with respect to B levels are inverted from the voltage input/output requirements of standard UARTs and that many line drivers and receivers provide a logic inversion.

5.5.2 Talker drive circuits

No provision is made for more than a single talker to be connected to the bus. The drive circuit used to provide the signal A and the return B shall meet, as a minimum, the requirements of ITU-T X.27/V.11.

5.5.3 Listener receive circuits

Multiple listeners may be connected to a single talker. The listener receive circuit shall consist of an opto-isolator and shall have protective circuits to limit current, reverse bias and power dissipation at the opto-diode as shown in Figure 1. Reference is made to example circuits in 9.2.

The receive circuit shall be designed for operation with a minimum differential input voltage of 2.0 V \(^1\) and shall not take more than 2.0 mA from the line at that voltage.

---

**Figure 1 – Listener receive circuit**

\(^1\) For reasons of compatibility with equipment designed to comply with earlier versions of NMEA 0183, it is noted that the idle, marking, logical "1", OFF or stop bit state had previously been defined to be in the range \(-15.0 \text{ V to } +0.5 \text{ V}\). The active, spacing, logical "0", ON or start bit state was defined to be in the range \(+4.0 \text{ V to } +15.0 \text{ V}\) while sourcing was not less than 15 mA.
5.5.4 Electrical isolation

Within a listener, there shall be no direct electrical connection between the signal line A, return line B, or shield and ship’s ground or power. Isolation from ships’ ground is required.

5.5.5 Maximum voltage on bus

The maximum applied voltage between signal lines A and B and between either line and ground shall be in accordance with ITU-T X.27/V.11.

For protection against mis-wiring and for use with earlier talker designs, all receive circuit devices shall be capable of withstanding 15 V between signal lines A and B and between either line and ground for an indefinite period.

6 Data transmission

Data is transmitted in serial asynchronous form in accordance with the standards referenced in Clause 2. The first bit is a start bit and is followed by data bits, least-significant-bit first, as illustrated by Figure 2.

The following parameters are used:
– baud rate 4 800;
– data bits 8 (D7 = 0), parity none;
– stop bits 1.

![Figure 2 – Data transmission format](image)

7 Data format protocol

7.1 Characters

All transmitted data shall be interpreted as ASCII characters. The most significant bit of the eight-bit character shall always be transmitted as zero (D7 = 0).

7.1.1 Reserved characters

The reserved character set consists of those ASCII characters shown in 8.1 (Table 1). These characters are used for specific formatting purposes, such as sentence and field delimiting, and except for code delimiting, shall not be used in data fields.

7.1.2 Valid characters

The valid character set consists of all printable ASCII characters (HEX 20 to HEX 7E) except those defined as reserved characters. The list of the valid character set is given in 8.1 (Table 2).
7.1.3 Undefined characters

ASCII values not specified as either “reserved characters” or “valid characters” are excluded and shall not be transmitted at any time.

When it is necessary to communicate an 8-bit character defined by ISO/IEC 8859-1 that is a reserved character (Table 1) or not listed in Table 2 as a valid character (e.g. in a proprietary sentence or text sentence), three characters shall be used.

The reserved character “^" (HEX 5E) is followed by two ASCII characters (0-9, A-F) representing the HEX value of the character to be communicated. For example:

– to send heading as "127.5°", transmit “127.5 ^F8”;
– to send the reserved characters <CR><LF>, transmit “^0D^0A”;
– to send the reserved character ”^", transmit “^5E”.

IEC 60945 states that, as a minimum requirement, English language shall be used for controls and displays. Other languages/characters are only supported by the TUT sentence.

7.1.4 Character symbols

When individual characters are used in this standard to define units of measurement, to indicate the type of data field, type of sentence, etc. they shall be interpreted according to the character symbol in 8.1 (Table 3).

7.2 Fields

A field consists of a string of valid characters, or no characters (null field), located between two appropriate delimiter characters.

7.2.1 Address field

An address field is the first field in a sentence and follows the "$" or “!” delimiter; it serves to define the sentence. The "$" delimiter identifies sentences that conform to the conventional parametric and delimited field composition rules as described in 7.3.2. The "!” delimiter identifies sentences that conform to the special-purpose encapsulation and non-delimited field composition rules as described in 7.3.3. Characters within the address field are limited to digits and upper case letters. The address field shall not be a null field. Only sentences with the following three types of address fields shall be transmitted.

7.2.1.1 Approved address field

Approved address fields consist of five digits and upper case letter characters defined by this standard. The first two characters are the talker identifier, listed in 8.2 (Table 4). The talker identifier serves to define the nature of the data being transmitted.

Devices that have the capability to transmit data from multiple sources shall transmit the appropriate talker identifier (for example a device with both a GPS receiver and a LORAN-C receiver shall transmit GP when the position is GPS-based, LC when the position is LORAN-C-based, and IN for integrated navigation shall be used if lines of position from LORAN-C and GPS are combined into a position fix).

Devices capable of re-transmitting data from other sources shall use the appropriate identifier (for example GPS receivers transmitting heading data shall not transmit $GPHCD unless the compass heading is actually derived from the GPS signals).

The next three characters form the sentence formatter used to define the format and the type of data. A list of sentence formatters is given in 8.3.
7.2.1.2 Query address field

The query address field consists of five characters and is used for the purpose of requesting transmission of a specific sentence on a separate bus from an identified talker.

The first two characters are the talker identifier of the device requesting data, the next two characters are the talker identifier of the device being addressed and the final character is the query character “Q”.

7.2.1.3 Proprietary address field

The proprietary address field consists of the proprietary character “P” followed by a three-character manufacturer's mnemonic code, used to identify the talker issuing a proprietary sentence, and any additional characters as required.

NOTE A list of valid manufacturer's mnemonic codes may be obtained from NMEA (see 7.3.5).

7.2.2 Data fields

Data fields in approved sentences follow a “,” delimiter and contain valid characters (and code delimiters “^”) in accordance with the formats illustrated in 8.2 (Table 5). Data fields in proprietary sentences contain only valid characters and the delimiter characters “,” and “^”, but are not defined by this standard.

Because of the presence of variable data fields and null fields, specific data fields shall only be located within a sentence by observing the field delimiters “,”. Therefore, it is essential for the listener to locate fields by counting delimiters rather than counting the total number of characters received from the start of the sentence.

7.2.2.1 Variable length fields

Although some data fields are defined to have fixed length, many are of variable length in order to allow devices to convey information and to provide data with more or less precision, according to the capability or requirements of a particular device.

Variable length fields may be alphanumeric or numeric fields. Variable numeric fields may contain a decimal point and may contain leading or trailing zeros.

7.2.2.2 Data field types

Data fields may be alpha, numeric, alphanumeric, variable length, fixed length or fixed/variable (with a portion fixed in length while the remainder varies). Some fields are constant, with their value dictated by a specific sentence definition. The allowable field types are summarized in 8.2 (Table 5).

7.2.2.3 Null fields

A null field is a field of length zero, i.e. no characters are transmitted in the field. Null fields shall be used when the value is unreliable or not available.

For example, if heading information were not available, sending data of "000" is misleading because a user cannot distinguish between "000" meaning no data and a legitimate heading of "000". However, a null field, with no characters at all, clearly indicates that no data is being transmitted.

Null fields with their delimiters can have the following appearance depending on where they are located in the sentence:

```
  ,
  ,
```


The ASCII NULL character (HEX 00) shall not be used as the null field.

7.2.3 Checksum field

A checksum field shall be transmitted in all sentences. The checksum field is the last field in a sentence and follows the checksum delimiter character "*". The checksum is the eight-bit exclusive OR (no start or stop bits) of all characters in the sentence, including "," and "^" delimiters, between but not including the "$" or "!" and the "*" delimiters.

The hexadecimal value of the most significant and least significant four bits of the result is converted to two ASCII characters (0-9, A-F) for transmission. The most significant character is transmitted first.

Examples of the checksum field are:

$GPGLL,5057.970,N,00146.110,E,142451,A*27 and
$GPVTG,089.0,T,,,15.2,N,,,*53.

7.2.4 Sequential message identifier field

This is a field that is critical to identifying groups of 2 or more sentences that make up a multi-sentence message. This field is incremented each time a new multi-sentence message is generated with the same sentence formatter. The value is reset to zero when it is incremented beyond the defined maximum value. The maximum value, size, and format of this field is determined by the applicable sentence definition in Clause 8. This is one of three key fields supporting the multi-sentence message capability (see 7.3.8).

7.3 Sentences

This subclause describes the general structure of sentences. Details of specific sentence formats are found in 8.3. Some sentences may specify restrictions beyond the general limitations given in this standard. Such restrictions may include defining some fields as fixed length, numeric or text only, required to be non-null, transmitted with a certain frequency, etc.

The maximum number of characters in a sentence shall be 82, consisting of a maximum of 79 characters between the starting delimiter "$" or "!" and the terminating delimiter <CR><LF>.

The minimum number of fields in a sentence is one (1). The first field shall be an address field containing the identity of the talker and the sentence formatter which specifies the number of data fields in the sentence, the type of data they contain and the order in which the data fields are transmitted. The remaining portion of the sentence may contain zero or multiple data fields.

The maximum number of fields allowed in a single sentence is limited only by the maximum sentence length of 82 characters. Null fields may be present in the sentence and shall always be used if data for that field is unavailable.

All sentences begin with the sentence-starting delimiter "$" or "!" and end with the sentence-terminating delimiter <CR><LF>.

7.3.1 Description of approved sentences

Approved sentences are those designed for general use and detailed in this standard. Approved sentences are listed in 8.3 and shall be used wherever possible. When a deprecated sentence has been replaced by an approved sentence, this is indicated in 8.3 by a note.

Other sentences, not recommended for new designs, may be found in practice.

NOTE Such sentences are listed in NMEA 0183. Information on such sentences may be obtained from the National Marine Electronics Association (NMEA) (see 7.3.5).
An approved sentence contains, in the order shown, the following elements:

<table>
<thead>
<tr>
<th>ASCII</th>
<th>HEX</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;$&quot;</td>
<td>24</td>
<td>– start of sentence</td>
</tr>
<tr>
<td>&lt;address field&gt;</td>
<td></td>
<td>– talker identifier and sentence formatter</td>
</tr>
<tr>
<td>[&quot;,&quot; &lt;data field&gt;]</td>
<td></td>
<td>– zero or more data fields</td>
</tr>
<tr>
<td>[&quot;,&quot; &lt;data field&gt;]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>&quot;</strong> &lt;checksum field&gt;</td>
<td></td>
<td>– checksum field</td>
</tr>
<tr>
<td>&lt;CR&gt;&lt;LF&gt;</td>
<td>0D 0A</td>
<td>– end of sentence</td>
</tr>
</tbody>
</table>

7.3.2 Parametric sentences

7.3.2.1 Description

These sentences start with the "$" delimiter, and represent the majority of sentences defined by this standard. This sentence structure, with delimited and defined data fields, is the preferred method for conveying information.

The basic rules for parametric sentence structures are:

- the sentence begins with the "$" delimiter;
- only approved sentence formatters are allowed. Formatters used by special-purpose encapsulation sentences cannot be reused. See 8.2;
- only valid characters are allowed. See 8.1 (Tables 1 and 2);
- only approved field types are allowed. See 8.2 (Table 5);
- data fields (parameters) are individually delimited, and their content is identified and often described in detail by this standard;
- encapsulated non-delimited data fields are NOT ALLOWED.

7.3.2.2 Structure

The following provides a summary explanation of the approved parametric sentence structure:

\[\text{\$aacc}, \ c---c*hh<CR><LF>\]

<table>
<thead>
<tr>
<th>ASCII</th>
<th>HEX</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;$&quot;</td>
<td>24</td>
<td>Start of sentence: starting delimiter.</td>
</tr>
<tr>
<td>aacc</td>
<td>24</td>
<td>Address field: alphanumeric characters identifying type of talker, and sentence formatter. The first two characters identify the talker. The last three are the sentence formatter mnemonic code identifying the data type and the string format of the successive fields. Mnemonics will be used as far as possible to facilitate read-outs by users.</td>
</tr>
<tr>
<td>&quot;,&quot;</td>
<td>2C</td>
<td>Field delimiter: starts each field except address and checksum fields. If it is followed by a null field, it is all that remains to indicate no data in a field.</td>
</tr>
<tr>
<td>c---c</td>
<td>2C</td>
<td>Data sentence block: follows address field and is a series of data fields containing all of the data to be transmitted. Data field sequence is fixed and identified by the third and subsequent characters of the address field (the sentence formatter). Data fields may be of variable length and are preceded by delimiters &quot;,&quot;.</td>
</tr>
</tbody>
</table>
checksum delimiter: follows last data field of the sentence. It indicates that the following two alpha-numeric characters show the HEX value of the checksum.

Checksum field: the absolute value calculated by exclusive-OR'ing the eight data bits (no start bits or stop bits) of each character in the sentence between, but excluding, "$" and "*". The hexadecimal value of the most significant and least significant four bits of the result are converted to two ASCII characters (0-9, A-F) for transmission. The most significant character is transmitted first. The checksum field is required in all cases.

End of sentence: sentence terminating delimiter.

### 7.3.3 Encapsulation sentences

#### 7.3.3.1 Description

These sentences start with the "!" delimiter. The function of this special-purpose sentence structure is to provide a means to convey information, when the specific data content is unknown or greater information bandwidth is needed. This is similar to a modem that transfers information without knowing how the information is to be decoded or interpreted.

The basic rules for encapsulation sentence structures are:

- the sentence begins with the "!" delimiter;
- only approved sentence formatters are allowed. Formatters used by conventional parametric sentences cannot be reused. See 8.2;
- only valid characters are allowed. See 8.1 (Tables 1 and 2);
- only approved field types are allowed. See 8.2 (Table 5);
- only six-bit coding may be used to create encapsulated data fields. See 8.2 (Table 5);
- encapsulated data fields may consist of any number of parameters, and their content is not identified or described by this standard;
- the sentence shall be defined with one encapsulated data field and any number of parametric data fields separated by the "," data field delimiter. The encapsulated data field shall always be the second to last data field in the sentence, not counting the checksum field. See 7.2.2;
- the sentence contains a "total number of sentences" field. See 7.3.3.1;
- the sentence contains a "sentence number" field. See 7.3.3.1;
- the sentence contains a "sequential message identifier" field. See 7.3.3.1;
- the sentence contains a "fill bits" field immediately following the encapsulated data field. The fill bits field shall always be the last data field in the sentence, not counting the checksum field. See 7.3.3.1.

NOTE: This method to convey information is to be used only when absolutely necessary, and will only be considered when one or both of two conditions are true, and when there is no alternative.

Condition 1: The data parameters are unknown by devices having to convey the information. For example, the ABM and BBM sentences meet this condition, because the content is not known to the Automatic Identification System (AIS).

Condition 2: When information requires a significantly higher data rate than can be achieved by the IEC 61162-1 (4 800 baud) and IEC 61162-2 (38 400 baud) standards utilizing parametric sentences.

By encapsulating a large amount of information, the number of overhead characters, such as "," field delimiters can be reduced, resulting in higher data transfer rates. It is very unusual for this second condition to be fulfilled. As an example, an AIS has a data rate capability of 4 500 messages per minute, and satisfies this condition, resulting in the VDM and VDO sentences.
7.3.3.2 Structure

The following provides a summary explanation of the approved encapsulation sentence structure:

!aaccc,x1,x2,x3,c--c,x4*hh<CR><LF>

ASCII HEX description

"!" 21 start of sentence: starting delimiter.

aaccc address field: alphanumeric characters identifying type of talker, and sentence formatter. The first two characters identify the talker. The last three are the sentence formatter mnemonic code identifying the data type and the string format of the successive fields. Mnemonics will be used as far as possible to facilitate readouts by users.

"," 2C field delimiter: starts each field except address and checksum fields. If it is followed by a null field, it is all that remains to indicate no data in a field.

x1 total number of sentences field: encapsulated information often requires more than one sentence. This field represents the total number of encapsulated sentences needed. This may be a fixed or variable length, and is defined by the sentence definitions in 8.3.

x2 sentence number field: encapsulated information often requires more than one sentence. This field identifies which sentence of the total number of sentences this is. This may be fixed or variable length, and is defined by the sentence definitions in 8.3.

x3 sequential message identifier field: this field distinguishes one encapsulated message consisting of one or more sentences, from another encapsulated message using the same sentence formatter. This field is incremented each time an encapsulated message is generated with the same formatter as a previously encapsulated message. The value is reset to zero when it is incremented beyond the defined maximum value. The maximum value and size of this field are determined by the applicable sentence definitions in Clause 8.

c--c data sentence block: follows sequential message identifier field and is a series of data fields consisting of one or more parametric data fields and one encapsulated data field. Data field sequence is fixed and identified by 3rd and subsequent characters of the address field (the "sentence formatter"). Individual data fields may be of variable length and are preceded by delimiters ",,". The encapsulated data field shall always be the second to the last data field in the sentence.

x4 fill bits field: this field represents the number of fill bits added to complete the last six-bit coded character. This field is required and shall immediately follow the encapsulated data field. To encapsulate, the number of binary bits shall be a multiple of six. If it is not, one to five fill bits are added. This field shall be set to zero when no fill bits have been added. The fill bits field shall always be the last data field in the sentence. This shall not be a null field.

*** 2A checksum delimiter: follows the last data field of the sentence. It indicates that the following two alphanumeric characters show the HEX value of the checksum.
hh checksum Field: the absolute value calculated by exclusive-OR'ing the 8 data bits (no start bits or stop bits) of each character in the sentence, between, but excluding "!" and "*". The hexadecimal value of the most significant and least significant 4 bits of the result are converted to two ASCII characters (0-9, A-F (upper case)) for transmission. The most significant character is transmitted first. The checksum field is required in all transmitted sentences.

<CR><LF> 0D 0A end of sentence: sentence terminating delimiter.

7.3.4 Query sentences

7.3.4.1 Description

Query sentences are intended to request approved sentences to be transmitted in a form of two-way communication. The use of query sentences implies that the listener shall have the capability of being a talker with its own bus. Query sentences shall always be constructed with the "$" – start of sentence delimiter.

The approved query sentence contains, in the order shown, the following elements:

<table>
<thead>
<tr>
<th>ASCII</th>
<th>HEX</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;$&quot;</td>
<td>24</td>
<td>start of sentence</td>
</tr>
<tr>
<td>&lt;aa&gt;</td>
<td>talker identifier of requester</td>
<td></td>
</tr>
<tr>
<td>&lt;aa&gt;</td>
<td>talker identifier for device from which data is being requested</td>
<td></td>
</tr>
<tr>
<td>&quot;Q&quot;</td>
<td>query character, identifies query address</td>
<td></td>
</tr>
<tr>
<td>&quot;*&quot;</td>
<td>data field delimiter</td>
<td></td>
</tr>
<tr>
<td>&lt;ccc&gt;</td>
<td>approved sentence formatter of data being requested</td>
<td></td>
</tr>
<tr>
<td>***</td>
<td>checksum field</td>
<td></td>
</tr>
<tr>
<td>&lt;CR&gt;&lt;LF&gt;0D 0A</td>
<td>end of sentence</td>
<td></td>
</tr>
</tbody>
</table>

7.3.4.2 Reply to query sentence

The reply to a query sentence is the approved sentence that was requested. The use of query sentences requires cooperation between the devices that are interconnected. A reply to a query sentence is not mandatory and there is no specified time delay between the receipt of a query and the reply.

7.3.5 Proprietary sentences

These are sentences not included within this standard; these provide a means for manufacturers to use the sentence structure definitions of this standard to transfer data which does not fall within the scope of approved sentences. This will generally be for one of the following reasons:

a) data is intended for another device from the same manufacturer, is device specific, and not in a form or of a type of interest to the general user;

b) data is being used for test purposes prior to the adoption of approved sentences;

c) data is not of a type and general usefulness which merits the creation of an approved sentence.