INTERNATIONAL STANDARD

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First edition
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Maritime navigation and radiocommunication equipment and systems – Global navigation satellite systems (GNSS) –

Part 4: Shipborne DGPS and DGLONASS maritime radio beacon receiver equipment – Performance requirements, methods of testing and required test results

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Maritime navigation and radiocommunication equipment and systems –
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Part 4:
Shipborne DGPS and DGLONASS maritime radio beacon receiver equipment – Performance requirements, methods of testing and required test results

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MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS – GLOBAL NAVIGATION SATELLITE SYSTEMS (GNSS) –

Part 4: Shipborne DGPS and DGLONASS maritime radio beacon receiver equipment – Performance requirements, methods of testing and required test results

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International Standard IEC 61108-4 has been prepared by IEC technical committee 80: Maritime navigation and radiocommunication equipment and systems.

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

FDIS	Report on voting
80/394/FDIS	80/398/RVD

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- withdrawn;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.

IEC 61108 consists of the following parts, under the general title *Maritime navigation and radiocommunication equipment and systems – Global navigation satellite systems (GNSS):*

Part 1: Global positioning system (GPS) – Receiver equipment – Performance standards, methods of testing and required test results

Part 2: Global navigation satellite system (GLONASS) – Receiver equipment – Performance standards, methods of testing and required test results

Part 3: (To be used at a later date)

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

MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS – GLOBAL NAVIGATION SATELLITE SYSTEMS (GNSS) –

Part 4: Shipborne DGPS and DGLONASS maritime radio beacon receiver equipment – Performance requirements, methods of testing and required test results

1 Scope

This part of IEC 61108 specifies the minimum operational and performance requirements, methods of testing and required test results conforming to performance standards not inferior to those adopted by the IMO in resolution MSC.114(73). In addition, it takes account of IMO resolution A.694(17) and is associated with IEC 60945. When a requirement of this standard is different from IEC 60945, the requirement in this standard shall take precedence.

This standard may be satisfied by equipment integral with GNSS equipment.

This standard is applicable to HSC.

All text of this standard, whose wording is identical to that in IMO resolution MSC.114(73) and ITU-R M.823 is printed in *italics* and the resolution (abbreviated to – 114 and M.823 respectively) and paragraph numbers are indicated in brackets i.e. (114/3.3 or M.823/3.3).

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*

IEC 61162-1, *Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 1: Single talker and multiple listeners*

IEC 61162-2, *Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 2: Single talker and multiple listeners, high speed transmission*

IMO Resolution MSC.114(73), *Revised recommendation on performance standards for shipborne DGPS and DGLONASS maritime radio beacon receiver equipment*

IMO Resolution A.694(17), *General requirements for shipborne radio equipment forming part of the Global Maritime Distress and Safety System (GMDSS) and for electronic navigational aids*

ITU-R M.823-2, *Technical characteristics of differential transmissions for Global Navigation Satellite Systems (GNSS) from maritime radio beacons in the frequency band 283,5 – 315 kHz in Region 1 and 285 – 325 kHz in Regions 2 and 3*

3 Terms, definitions and abbreviations

For the purposes of this standard the following definitions and abbreviations apply.

3.1 Definitions

3.1.1
Eurofix
the Eurofix datalink is a scheme for modulation of the Loran-C and Chayka signals to establish a broadcast capability that can be used for distribution of GNSS corrections, integrity data and other information. Similar developments in the US are referred to as LORAN-COMM

3.1.2
global navigation satellite system (GNSS)
is a world-wide position, time and velocity radio determination system comprising space, ground and user segments

3.1.3
integrity
is the ability to provide users with warnings within a specified time when the system should not be used for navigation

3.2 Abbreviations

BER	Bit error rate
bps	Bits per second
DGLONASS	Differential GLONASS
DGNSS	Differential GNSS
DGPS	Differential GPS
EGNOS	European Geo-stationary Navigational Overlay System
EPFS	Electronic position fixing system
EUT	Equipment under test
MSAS	Multi-Satellite Augmentation System
MSK	Minimum shift keying
RTK	Real-Time Kinematics
SNR	Signal to noise ratio
UDRE	User defined range error
VTS	Vessel Tracking Services
WAAS	Wide-Area Augmentation System
WER	Word error rate

4 Performance requirements

4.1 Introduction

Differential services broadcast information for augmenting Global Positioning System (GPS) and the Global Navigation Satellite System (GLONASS) to provide the accuracy and integrity required for entrances and harbour approaches and other waters in which the freedom to manoeuvre is limited. Various service providers are broadcasting differential information applicable to localised areas. Different services provide information for augmenting GPS, GLONASS, or both.(114/1.1)

Receiver equipment for the reception and proper de-modulating / *decoding of differential GPS and GLONASS maritime radio beacon broadcasts (fully compliant with ITU-R M.823) intended for navigational purposes on ships with maximum speeds not exceeding 70 knots shall, in addition to the general requirements contained in resolution A.694(17), comply with the following minimum performance requirements*.(114/1.2) As noted in Clause 1 – Scope: This standard is applicable to HSC.

This standard covers the basic requirements of maritime radio beacon receiver equipment providing augmentation information to position-fixing equipment, including health messages. *It does not cover other computational facilities which may be in the equipment.*(114/1.3)

Additional functionality (e.g. use of differential corrections and integrity, from multiple beacon reference stations, Eurofix, LORAN-COMM, VTS, FM subcarrier, commercial satellite, WAAS, EGNOS, MSAS and RTK) is permitted if the manufacturer can demonstrate that this does not degrade performance.

4.2 Composition

The words "DGPS and DGLONASS maritime radio beacon receiver equipment" as used in this performance standard includes all the components and units necessary for the system to properly perform its intended functions. The equipment shall include the following minimum facilities:(114/2)

1) *antenna capable of receiving DGPS or DGLONASS maritime radio beacon signals*;(114/2.1)
2) *DGPS and DGLONASS maritime radio beacon receiver and processor;* (114/2.2)
3) *receiver control interface;* (114/2.3) (See also 4.3 2))
4) *data output interface* (114/2.4) (See also 4.3 5)), and
5) broadcast station database capable of storing at least the following data for a minimum of 1000 stations. These data elements can be initially downloaded and shall be updated from DGNSS broadcasts:

   ID_{REF1}, ID_{REF2}

   BROADCAST STATION ID

   BROADCAST STATION NAME

   FREQUENCY

   REFERENCE STATION POSITION

   REFERENCE STATION DATUM

   OFFICIAL OPERATION STATUS (operational, test, or not operational)
6) broadcast station database capable of calculating and storing at least the following data for a minimum of 10 closest stations. The receiver shall update these data elements from information included in DGNSS broadcasts:

   TIME/DATE of UPDATE

   REFERENCE STATION HEALTH

   WORD ERROR RATE (WER)

   DISTANCE (user to reference station(s))

4.3 Functional requirements

The DGPS and DGLONASS maritime radio beacon receiver equipment shall: (114/3)

1) *operate in the band of 283,5 to 315 kHz in Region 1 and 285 to 325 kHz in Regions 2 and 3 in accordance with ITU-R M.823* (114/3.1). The receiver shall perform to the requirements of this standard while subjected to typical radio frequency interference and noise sources, as follows:

– atmospheric noise (e.g. local thunderstorms);
– man-made noise (e.g. own ship, shipyard industrial, etc.);
– Gaussian noise;
– interference from LF and MF radio stations outside the band.

The specifications of these are further developed in Annex A.

– precipitation static (especially in the high latitudes) is not specified or tested against, but H-field antennas are recommended to be used on ships that go to the high latitudes that experience this environmental interference; (See Annex D.)

2) *provide means of automatically and manually selecting the station;* (114/3.2) When in manual mode, operator action shall be required for a change and the receiver shall provide an indication of other available stations. The database shall be continually updated and utilised to select reference stations;(See Annex E.)
3) *make the data available for use with a delay not exceeding 100 ms after its reception;* (114/3.3) The delay from the first bit of the modulated data to the last bit of the decoded data output from the receiver shall be less than 100 ms plus the transmission time of the message;
4) *be capable of acquiring a signal in less than 45 s in the presence of electrical storms*; (114/3.4);
5) *have an omni-directional antenna in the horizontal plane.* (114/3.6) The difference between the maximum and minimum signal strength shall be less than:
   .1 5 dB over frequency range
   .2 3 dB over azimuth
   .3 3 dB over roll of 20°;
6) and make available the health status, of the station being used, to the system.

4.4 Protection

Precautions shall *be taken to ensure that no permanent damage can result from an accidental short circuit or grounding of the antenna or any of its input or output connections or any of the DGPS and DGLONASS maritime radio beacon receiver equipment inputs or outputs for a duration of five minutes.* (114/4)

4.5 Integrity

The following functions shall be performed in either an integrated DGNSS receiver or an associated GNSS receiver. As a consequence, there are no tests for these clauses within this standard.

4.5.1 DGNSS integrity status

When in differential mode, the GNSS receiver shall give a DGNSS integrity indication:

a) if no DGNSS message is received within 10 s;
b) while in manual station selection mode and the selected station is unhealthy, unmonitored, or signal quality is below threshold;
c) while in automatic station selection mode and the only available station is unhealthy, unmonitored, or signal quality is below threshold.

4.5.2 GNSS integrity status

If the Range-rate Correction or the Pseudorange Correction of a satellite is out of tolerance, the binary code in the ITU-R M.823-2 types 1, 9, 31 and 34 messages will indicate to the GNSS receiver that the satellite shall not be used.

4.6 Interfaces

The equipment shall *have at least one serial data output that conforms to the relevant international marine interface standard*; (114/3.5) as defined in IEC 61162-1, IEC 61162-2, or IEC 61162-3 as appropriate.

4.7 IEC 61162-1, IEC 61162-2 implementation

Integrated equipment and stand-alone receivers shall use the following IEC 61162-1 messages for control and status reporting:

– MSK – MSK Receiver Interface (input/output)

– MSS – MSK Receiver Signal (output)

The Talker Identifier Mnemonic for stand-alone receivers is:

– COMMUNICATIONS: Data Receiver: CR

Stand-alone receivers shall use GGA, GNS or GLL (as defined in IEC 61162-1) to receive position data from the GNSS receiver for its automatic functions. (input)

The DGNSS receiver shall provide ITU-R M.823 data output to a port for testing. See also Annex F for informative guidance on ITU-R M.823 interface matters.

4.8 IEC 61162-3 implementation

Integrated equipment and stand-alone receivers shall use the following IEC 61162–3 parameter groups for control, status and data reporting:

– GNSS Position Data

– GNSS Differential Correction Receiver Signal Status

– GNSS Differential Correction Receiver Interface

– GNSS Differential Corrections

4.9 Display and control

The selected operational mode (manual or automatic) shall be clearly indicated or available on an appropriate interface

The following information shall be available for display of the selected station and the next two nearest stations (see 5) of 4.2):

– reference Station ID;

– station name;

– frequency;

– calculated distance to the station;

– station health (from message header);

– signal quality (acceptable < 10 % WER, unacceptable > 10 % WER).

4.10 Installation

For information guidance on installation see Annex D.

5 Technical characteristics

5.1 Carrier frequency

The carrier frequency of the differential correction signal of a radio-beacon station is *an integer multiple of 500 Hz.* (M.823/1.1)

5.2 Frequency tolerance

Frequency tolerance of the carrier is *±2 Hz.* (M.823/1.2)

5.3 Message types

Table 1 is for information and shows message types which may be transmitted by a service provider.

Table 1 – Message types (M823/1.2)

GPS message type number	Title	GLONASS message type number
1	Differential GNSS corrections (full set of satellites)	31
3	Reference station parameters	32
4	Reference Station Datum	4
5	Constellation health	33
6	Null frame	34 (*N*=0 or *N*=1)
7	Radio beacon almanacs	35
9	Subset differential GNSS corrections (this may replace Types 1 or 31)	34 (*N*>1)
16	Special message	36
27 (see note)	Extended beacon almanac	N/A
NOTE New message now being implemented worldwide. Equipment for test from 2005 should incorporate this message type.		

5.4 Data transmission rate

The receiver shall be *capable of receiving data at selectable rates of 25 (GLONASS only), 50, 100 and 200 bits/s.* (M.823/1.6)

5.5 Dynamic range

The receiver shall have *a dynamic range of 10 μV/m to 150 mV/m* (M.823/1.11). 10μV/m is the requirement to be met while tracking, 20 μV/m is the requirement for acquisition.

5.6 Maximum bit error ratio

The receiver shall *operate at a maximum bit error ratio of* 1×10^{-3} *in the presence of Gaussian noise at a signal to noise ratio of 7 dB in the occupied bandwidth.* (M.823/1.12)

5.7 Receiver selectivity and stability

The receiver shall have *adequate selectivity and frequency stability to operate with transmissions 500 Hz apart having frequency tolerances of ±2 Hz and protection ratios given in* Table 2. (M.823/1.14)

5.8 Automatic frequency selection

Automatic frequency selection as provided in the receiver, shall be capable of searching for, receiving, collecting, storing and utilising beacon almanac information from Type 7 / 35 messages and any other relevant message. (M.823/1.17)

5.8.1 Switching criteria

The receivers shall switch from the current reference station when the Reference Station Health or signal quality falls below the minimum criteria of 5.8.2 or is no longer the nearest reference station. The receiver shall be able to select, tune and acquire valid ITU-R M.823 data within 10 s from the nearest reference station that meets minimum requirements for Reference Station Health and signal quality. See informative Annex E for method of carrying out this process.

5.8.2 Minimum requirements

The minimum requirements shall be:

5.8.2.1 Reference station health

– State 000-101 – reference station OK to use;

– State 110 (unmonitored) – do not use unless no other stations are available, and then the user must be warned;

– State 111 – do not use reference station under any circumstances.

5.8.2.2 Signal quality

WER < 0,1 as measured over 25 ITU-R M.823 words, the measurement not being older than 5 min.

5.9 Protection ratios

The protection ratios to be applied shall be *as in* Table 2 (M.823-2 – Table 5)

Table 2 – Protection ratios

Frequency separation between wanted and interfering signal kHz	**Protection ratio** dB	
Wanted	**Differential (G1D)**	**Differential (G1D)**
Interfering	**Radio beacon (A1A)***	**Differential (G1D)**
0	15	15
0,5	–25	–22
1,0	–45	–36
1,5	–50	–42
2,0	–55	–47

* Applicable to radio beacons in the European maritime area under the 1985 Geneva Agreement.

6 Methods of testing and required test results

This clause defines the type test 'methods of measurement' and 'results required' ensuring that equipment complies with the requirements of Clauses 4 and 5.

6.1 General conditions of measurement and test signals

All the tests to the general requirements of IEC 60945 shall be carried out on the EUT. The equipment shall comply with those requirements of IEC 60945 appropriate to its category, i.e. 'protected' (from the weather) or 'exposed' (to the weather).

The manufacturer shall declare which equipment or units are 'protected' or 'exposed'. The manufacturer shall declare the 'preconditioning' required before environmental checks.

For the purposes of this standard the following test related definitions shall apply:

Performance check – Reconfiguration of the EUT and checking, by non-quantitative visual checks and by conducting the test procedure below, that the system is still operative for the purposes of IEC 60945.

Performance test for the purposes of IEC 60945 – Reconfigure the EUT and perform test 6.2.2.2 a), with a signal level of 34 dBμV/m, ensuring that the system is compliant.

By inspection – a visual check of the equipment or documentation.

Test procedure: After manual frequency selection and a settling time of 30 s, the EUT shall achieve continuous decoding with a WER of 0 % as measured using the methodology in Annex B.

Test signal A shall be a sequence of ITU 823 message nine type 9-3s and one type 7 that form a continuous parity loop. The station ID of test signal A shall be an ID of a station that is stored in the almanac. The type 7 message shall give data for station B.

Test signal B shall contain ITU 823 messages – Type 9-3 and 3 for station. B. The station ID of test signal B shall not be an ID of a station that is stored in the almanac.

Test signal C shall contain ITU 823 messages – Type 9-3. The station ID of test signal C shall be an ID of a station that is stored in the almanac and is closer in distance to the EUT than signal D from station D.

Test signal D shall contain ITU 823 messages – Type 9-3. The station ID of test signal D shall be an ID of a station that is stored in the almanac and is not as close in distance to the EUT as signal C from station C.

Test signal E shall contain 50 ITU 823 messages – Type 9-3 with health status "healthy", followed by a sequence of 50 ITU 823 messages – Type 9-3 with health status "unhealthy". The station ID of test signal E shall be an ID of a station that is stored in the almanac and is closer in distance to the EUT than signal D from station D.

Test signal F shall contain 150 ITU 823 messages – Type 9-3 with a WER of zero, followed by a sequence of 150 ITU 823 messages – Type 9-3 with a WER of 100 %. The station ID of test signal E shall be an ID of a station that is stored in the almanac and is closer in distance to the EUT than signal D from station D.

Test signal G shall contain 50 ITU 823 messages – Type 9-3 with health status "healthy", followed by a sequence of 50 ITU 823 messages – Type 9-3 with health status "unmonitored". The station ID of test signal G shall be an ID of a station that is stored in the almanac and is closer in distance to the EUT than signal D from station D.

Test signal H shall contain 150 ITU 823 messages – Type 9-3 with a WER of 10 %. Test signal H shall be a station listed in the almanac.

6.1.1 Test site

Tests will normally be carried out at test sites selected by the type test authority.

6.2 Operational tests

6.2.1 Composition

Show by demonstration and inspection that the requirements of 4.2 are met.

6.2.2 Operational frequency and bit rate

(See 4.3.1))

Check that the operational frequency and bit rate is as specified in 1) of 4.3 with the tests below.

6.2.2.1 Carrier frequency

(See 5.1)

Test signal A shall be applied at 20 μV/m in the absence of noise and at 200 bps. All receivers shall be tested throughout the entire band, i.e. 283,5 to 325 kHz at integer multiples of 500 Hz. After manual frequency selection and a settling time of 30 s, the receivers shall achieve continuous decoding with a word error rate (WER) of zero, as measured using the methodology in Annex B, as measured over 30 s at the output port.

6.2.2.2 Dynamic range

(See 5.5)

a) Test signal A shall be applied at 20 μV/m in the absence of noise and at 200 bps. After manual frequency selection and a settling time of 30 s, the EUT shall achieve continuous decoding with a word error rate (WER) of zero, as measured using the methodology in annex B, as measured over 30 s at the output port.

b) Reduce test signal A down to 10 μV/m in the absence of noise and at 200 bps. The EUT shall achieve continuous tracking and decoding the signal with a word error rate (WER) of zero, as measured using the methodology in Annex B, as measured over 30 s at the output port.

c) Raise test signal A up to 150 mV/m in the absence of noise and at 200 bps. The EUT shall achieve continuous tracking and decoding the signal with a word error rate (WER) of zero, as measured using the methodology in Annex B, as measured over 30 s at the output port.

6.2.2.3 Data transmission rate

(See 5.4)

Repeat the above tests using the remaining bit rates (25, 50 and 100 bps) shall be tested at 283,5, 305 and 325 kHz. In these tests the receiver shall achieve continuous decoding with a WER of zero as measured over 240 s (for 25 bps), 120 s (for 50 bps) and 60 s (for 100 bps).

6.2.2.4 Frequency tolerance

(See 5.2)

Repeat the above tests using 200 bps at 283,5 kHz ± 2 Hz, 305 kHz ± 2 Hz and 325 kHz ± 2 Hz. In these tests, the receiver shall achieve continuous decoding with a WER of zero as measured over 30 s.

6.2.3 Manual and automatic station selection

(see 4.3 2))

6.2.3.1 Manual method

Manual frequency/ station selection shall be demonstrated with the following test:-

Initial conditions: no signals in band. The signal level for these tests shall be 75 µV/m in the absence of noise and at a data rate of 200 bps.

Test method and required results:

Step 1: select a frequency / station on the EUT;

Step 2: introduce test signal A on the adjacent channel;

Step 3: verify using the test procedure that a WER of 100 % is achieved for test signal A;

Step 4: introduce test signal B on the selected channel;

Step 5: verify using the test procedure that valid test signal B is being received on the selected channel with a WER of zero.

6.2.3.2 Automatic method

Initial conditions: the signal level for these tests shall be 75 µV/m in the absence of noise and at a data rate of 200 bps.

Position information (GGA, GLL, GNS or GNSS position data, as appropriate) shall be provided to the beacon receiver.

6.2.3.2.1 Almanac test procedure

a) Check if the receiver works with almanac

Test method:

Step 1: reset receiver almanac;

Step 2: upload almanac into receiver where station A is included in the almanac and is the closest station in distance to the EUT position;

Step 3: introduce test signal A.

Required result:

The EUT shall achieve continuous decoding of signal A with a WER of zero within 10 s as measured using the methodology in Annex B.

b) Check update procedure of almanac

Test method:

Step 1: introduce test signal A for 5 min;

Step 2: introduce test signal B where station B is not in the almanac loaded in the previous test and is the closest station in distance to the EUT position;

Step 3: allow the EUT to run for 10 s;

Step 4: download almanac or display its contents.

Required results:

The EUT shall achieve continuous decoding of signal B with a WER of zero as measured using the methodology in Annex B and station B has been added to the almanac.

6.2.3.2.2 Automatic mode

a) Check closest station from almanac

Test method:

Step 1: introduce test signals C and D where station C is closer in distance to EUT position than station D;

Step 2: turn on EUT;

Required results:

EUT is decoding signal C with a WER of zero within 10 s.

b) Change station if tracked station becomes unhealthy

Test method:

Step 1: introduce test signals E and D where station E is closer in distance to EUT position than station D;

Step 2: turn on EUT;

Step 3: confirm that the EUT is decoding signal E with a WER of zero within 10 s;

Step 4: force station health of signal E unhealthy.

Required results:

EUT is decoding signal D with a WER of zero within 10 s.

c) Change station if tracked station becomes unmonitored

Test method:

Step 1: bring up test signals G and D where station G is closer in distance to EUT position than station D;

Step 2: turn on EUT;

Step 3: confirm that the EUT is decoding signal G with a WER of zero within 10 s;

Step 4: force station health of signal G unmonitored.

Required results:

Confirm that the EUT is decoding signal D with a WER of zero within 10 s.

d) Change station if WER of tracked station is higher than 0,1

Test method:

Step 1: introduce test signals F and D where station F is closer in distance to EUT position than station D;

Step 2: turn on EUT;

Step 3: confirm that the EUT is decoding signal F with a WER of zero within 10 s;

Step 4: force station WER of signal F > 0,1.

Required results:

Confirm that the EUT is decoding signal D with a WER of zero within 10 s.

e) Change "position" of EUT

Test method:

Step 1: introduce test signals C and D where station C is closer in distance to EUT position than station D;

Step 2: turn on EUT;

Step 3: confirm that the EUT is decoding signal C with a WER of zero within 10 s;

Step 4: change position of EUT so that station D is closer in distance to EUT position than station C.

Required results:

Confirm that the EUT is decoding signal D with a WER of zero within 10 s.

6.2.4 Latency

(see 4.3.3))

6.2.4.1 Objective

The receiver shall be tested using a known ITU-R M.823 modulated input. This data shall be compared to the data output of ITU-R M.823 data to measure the delay between transmitted and received.

6.2.4.2 Method of measurement

The serial output of the reference station is fed to the EUT via a beacon modulator. The output signal of the reference station is compared with the output of the EUT in order to measure the latency. The measurement shall take into account the latency of the beacon modulator and the duration for the reception of 30 bits plus the time needed to transmit these 30 bits packed into 5 bytes (plus start and stop bits) for transmission over the serial interface.

6.2.4.3 Required results

The maximum latency time shall be 100 ms.

6.2.5 Acquisition and performance in noise

(see 4.3.4))

Initial conditions:

Three separate signals are used to test for acquisition (see Annex A for descriptions):

a) Noise signal 1 (Gaussian noise): A 300 kHz, 200 bps MSK signal incident upon the antenna at a level of 75 µV/m and with an SNR of 7 dB in the 99 % containment bandwidth of the MSK signal.

b) Noise signal 2 (electrical storm noise): A 300 kHz, 200 bps MSK signal of 75 µV/m incident upon the antenna along with a pulse train with an amplitude of 500 mV/m, a period of 0,5 ms, a pulse width of 20 µs, and with a rise and fall time (90 %) of less than 50 ns.

c) Noise signal 3 (man-made noise): A 300 kHz, 200 bps MSK signal of 75 µV/m incident upon the antenna along with a pulse train with amplitude of 15 V/m, a period of 1,5 ms, a pulse width of 20 µs, and with rise and fall time (90 %) of less than 50 ns.

The test should be performed using a Helmholz coil to provide a homogeneous H-field or by using a large capacitor to provide a homogeneous E-field.

Test methods and required results:

Step 1: introduce noise signal 1;

Step 2: verify that a WER of < 10,0 % measured over 5 min;

Step 3: repeat for noise signal 2;

Step 4: verify that a WER of < 10,0 % measured over 5 min;

Step 5: repeat for noise signal 3;

Step 6: verify that the MSK signal is acquired in less than 45 s.

6.2.6 Interface

(see 4.6)

Connect a simulator for the appropriate IEC 61162 interface, both input and output, and ensure compliance.

6.2.7 Antenna

(see 4.3.5))

The antenna shall be tested while tracking an MSK signal of 75 dBµV/m at 200 bps using:

a) frequencies of 283,5 kHz, 300 kHz and 325 kHz;

b) an azimuth every 15° through 360°; and

c) roll of +20°, 0° and –20°.

6.3 Protection of external connections

(see 4.4)

The EUT shall be tested in two steps:

Step 1: short the antenna connections, energise the unit for 5 min, replace any damaged fuses and check for proper operation;

Step 2: short input and output ports individual leads to ground (not power) for a duration of 5 min, replace any damaged fuses and check for proper operation.

6.4 Integrity

(see 4.5)

Unhealthy and unmonitored status modes are tested under 6.2.3.2.2 b) and c). All other integrity tests are specified in the GNSS receiver.

6.5 Technical tests

(see Clause 5)

6.5.1 Message types

(See 5.3)

Test method:

A test signal that includes all messages in Table 1 (GPS or GLONASS as appropriate) shall be applied at 75 µV/m in the absence of noise at the data rate of 200 bps.

Results required:

The receiver shall successfully decode the messages with WER of 0,0 %.

6.5.2 Protection ratios

(see 5.9)

6.5.2.1 Protection against another differential transmission

a) Initial conditions:

Two signals in band, one wanted and one interfering.

The interfering signal level shall be 300 µV/m, MSK modulated at 200 bps, in the absence of noise. The wanted signal consists of test signal A varied in power and frequency in accordance with Table 2, columns 1 and 3.

b) Test method:

Step 1: introduce both the wanted and interfering signals;

Step 2: select the wanted frequency/station on the EUT;

Step 3: repeat steps 1-3 for all combinations in Table 2.

c) Required results:

Verify using test procedure A that a WER of 0,0 % is achieved for test signal A.

6.5.2.2 Protection against a radio beacon transmission

a) Initial conditions:

Two signals in band, one wanted and one interfering.

The interfering signal level shall be a 300 μV/m continuously keyed carrier (A1A), in the absence of noise. The wanted signal consists of test signal A varied in power and frequency in accordance with Table 2, columns 1 and 2.

b) Test method:

Step 1: introduce both the wanted and interfering signals;

Step 2: select the wanted frequency/station on the EUT;

Step 3: repeat steps 1 to 3 for all combinations in Table 2.

c) Required results:

Verify using test procedure A that a WER of 0,0 % is achieved for test signal A.

6.5.3 Intermodulation tests

(see 4.3 1))

Initial conditions:

Five signals are used:

a) wanted signal: test signal A, MSK modulated at 200 bps, using a signal strength of 34 dBμV/m (nominal field strength) and a frequency of 310 kHz;

b) interfering signal 1: A2A modulated (30 %, 1000 Hz), using a signal strength of 90 dBμV/m and a frequency of 255 kHz;

c) interfering signal 2: continuous wave signal, using a signal strength of 90 dBμV/m and a frequency of 200 kHz;

d) interfering signal 3: A2A modulated (30 %, 1000 Hz), using a signal strength of 90 dBμV/m and a frequency of 550 kHz;

e) interfering signal 4: continuous wave signal, using a signal strength of 90 dBμV/m and a frequency of 790 kHz.

The test should be performed using a Helmholz coil to provide a homogeneous H-field or by using a large capacitor to provide a homogeneous E-field. The interfering signals can be produced by using standard signal generators.

Precautions should be taken during testing to ensure that intermodulation products are not produced within the test generators or combiner system.

Test method

a) Test for interfering LF signals

Step 1: introduce the wanted signal;

Step 2: verify using test procedure A that a WER of 0,0 % is achieved for test signal A;

Step 3: additionally introduce interfering signal 1;

Step 4: verify using test procedure A that a WER of 0,0 % is achieved for test signal A;

Step 5: additionally introduce interfering signal 2;

Step 6: verify using test procedure A that a WER of 0,0 % is achieved for test signal A.

b) Test for interfering MF signals

Step 1: introduce the wanted signal;

Step 2: verify using test procedure A that a WER of 0,0 % is achieved for test signal A;

Step 3: additionally introduce interfering signal 3;

Step 4: verify using test procedure A that a WER of 0,0 % is achieved for test signal A;

Step 5: additionally introduce interfering signal 4;

Step 6: verify using test procedure A that a WER of 0,0 % is achieved for test signal A.

6.6 Additional functionality tests

The manufacturer shall declare any additional functionality and provide a full description, and means to demonstrate that the additional functionality requirements of 4.1 are met.

Annex A
(normative)

Simulation of noise situations for the test of shipborne DGPS maritime radio beacon receiver equipment

A.1 Parameters describing noise

Due to the interference of many individual incidents the global thunderstorm activity causes considerable background noise from which impulses created by local thunderstorm activity stand out. The interference intensity depends on the thunderstorm activity and its propagation speed within the ionosphere. CCIR published maps on the basis of measurements taken worldwide which the interference level to be expected can be read from, in relation to its geographical position, time of the year and time of the day (in 4-hourblocks). These indications are made by means of noise factor $F_{\alpha} = 10 \times \log(N_r/N_{th})$, which indicates the relation of the received interference activity N_r to the thermic noise output $N_{th} = kT_0B$ within the reception band width B. k is the Boltzmann-constant $1,38 \times 10^{-23}$ J/K and $T_0 = 288$ K the reference temperature.

The existing background noise creates an interference voltage on the output of a receiver which can be described by means of its amount and its phase. As the interference signal phase is in equipartition, the absolute value, the generating curve of an envelope, is of interest for further studies.

To be able to characterize the stochastic nature of atmospherics different figures describing the measurement have to be used. The values and functions indicated in the following have been introduced into literature and thus it can be guaranteed that the evaluations are comparable to measurements taken and published so far, for example to those in [32288].

Given the signal of the generating curve of an envelope $\upsilon(t)$, the average value υ_{av} during measuring time T_m is defined by

$$\upsilon_{av} = \frac{1}{T_m}\int_0^{T_m} \upsilon(t)dt \qquad (A.1)$$

υ_{av} is also known as the first moment.

The RMS (root mean square) υ_{rms} is calculated with the help of the second moment:

$$\upsilon_{rms}^2 = \frac{1}{T_m}\int_0^{T_m} \upsilon^2(t)dt \qquad (A.2)$$

Further more the ratio V_{av}/V_{rms} is a measure for evaluating the interference effect. It is indicated as V_d:

$$V_d = -20 \times \log\left(\frac{\upsilon_{av}}{\upsilon_{rms}}\right) \qquad (A.3)$$

In the case of a Rayleigh amplitude distribution of the generating curve of an envelope

V_d = 1,05

The median υ_{med} of a signal $\upsilon (t)$ during a timespan T_m is defined by the amplitude, which for a total of $k/2$ time intervals T_α is both, passed over and passed under. Hereto T_m is to be divided into small measuring intervals $T_\alpha = T_m /k$. In contrast to the arithmetic average, the first moment mentioned above, extreme amplitude values do not enter directly into the figure describing the measurement.

The probability that the amplitude υ of the generating curve of an envelope exceeds a level of T_s is indicated by the *APD*, Amplitude Probability Distribution:

$$APD(\upsilon) = P(\upsilon > T_s) = 1 - P(\upsilon) \quad \text{(A.4)}$$

Here $P(\upsilon)$ is the distribution function of the amplitudes υ of the signal of the generating curve of an envelope. If there is a white Gaussian noise on the receiver input, $P(\upsilon)$ is a Rayleigh distribution.

A.2 Noise models

A.2.1 Atmospheric noise model

Feldman [Fel72] made noise measurements in the summer of 1971. He divided the data in three scenarios:

a) quiet (-night); a quiet situation, in which the pulse shaped component, created by single flashes, is relatively small;
b) tropical; this situation is typical for regions of mean latitude during the summer months. Here numerous thunderstorms occur distributed over a wide area. Sometimes interference's have to cover long distances until they reach the receiver in the vicinity of which there is not necessarily a firm interference area;
c) frontal; here a thunderstorm is assumed to be in the vicinity of the receiver, i.e. a local firm interference area.

The noise model he suggested can be seen as a refinement of the one introduced by Hall [Hal66]. It does not only take account of the amplitude distribution function but also of the time correlation of the pulse shaped (flash) interferences. His noise model has this form:

$$y(t) = n_2(t) + X(t)\, A(t)\, n_1(t) \quad \text{(A.5)}$$

Here $n_2(t)$ is the Gaussian component of the background noise. The second independent Gaussian disturbance source $n_1(t)$ is modulated by the time dependent intensity function $A(t)$. This multiplicative term was first described by Hall [Hal66] and is called Hall component. Hall suggested to create $A(t)$ out of the reciprocal of a Chi-square distribution with M degrees of freedom:

$$A(t) = \left[\sum_{i=1}^{M} b_i(t)^2 \right]^{-0,5} \quad \text{(A.6)}$$

The $b_i(t)$ are values of an independent Gaussian process.

The Hall component itself is switched on and off by the two-state [0, 1] random process $X(t)$. This switching simulates the impulsive nature of lightning noise.

Not only time of occurrence but also duration and intensity of the pulse shaped interference's are stochastic and non-stationary. Figure A.1 shows how $Y(t)$ is generated. $X(t)$ is given by means of two Poisson processes with the parameters λ_{10} = Const. and $\lambda_{01} = \frac{P}{1-P}\lambda_{10}$, which control the time behavior of pulse interferences. The index xy of the parameter λ_{xy} stands for the transition from state x into state y. The parameter P itself which defines λ_{01}, is generated by another Markov process which enforces in its 1-state the probability p_x^f *for* P and in its 0-state $P = p_x^s \times W(t)$, too, is characterized by two transition parameters: μ_{10}=const. and $\mu_{01} = \mu_{10}\frac{P_w}{1-P_w}$, P_w =const.. The constant μ_{10} controls the correlation between multiple flashes, whereas the constant μ_{01} (indirectly via P_w) defines the occurrence of the 0-1 transition. With each transition of $X(t)$ from 0 to 1 a new $A(t)$ is defined by first squaring M values of a N(0,1) normal distribution and then adding them. The reciprocal of the square root from this is finally being multiplied by an intensity factor to result in $A(t)$ (equation A.6).

Table A.1 – Parameters for different interference situations

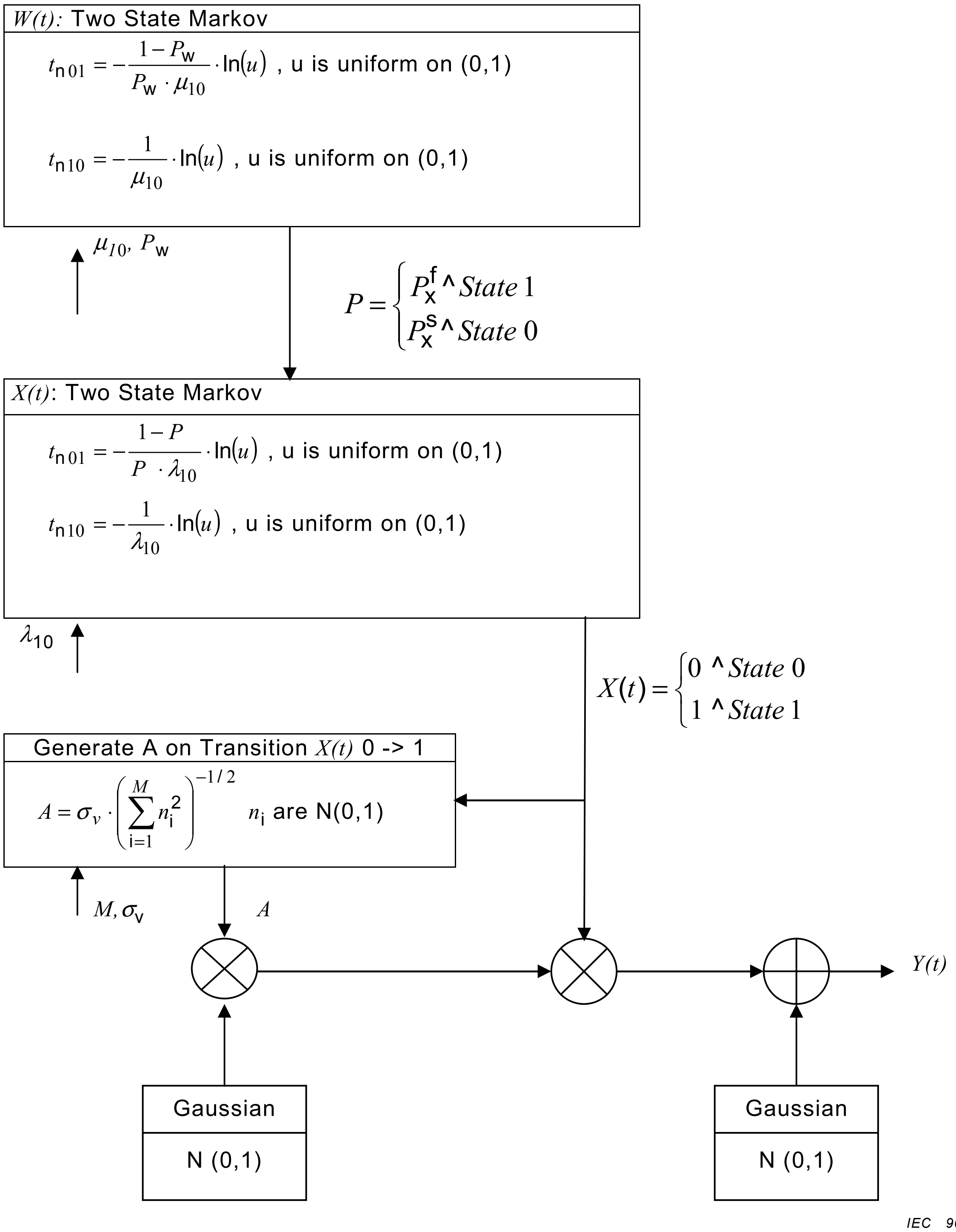
Situation	σ_v	M	p_x^f	p_x^s	P_w	μ_{10}	λ_{10}
Quiet	2,222	2	0,11	0,11	–	–	850
Quiet-Night	1,34	2	0,75	0,25	0,50	1,00	850
Frontal	3,50	1	0,99	0,15	0,89	0,20	850
Tropical	1,26	1	0,99	0,27	0,66	0,60	850
Gauss	0,00	–	–	–	–	–	–
Moderate	0,04	1	0,90	0,18	0,90	0,42	850
Strong	0,12	1	0,69	0,08	0,95	0,20	10 000
NOTE The situations 'Moderate' and 'Strong' were modeled to fit the thunderstorm recordings made in Germany in 1996 and 1997.							

Table 1 shows the parameters used by Feldman as well as those for the newly introduced situations 'Moderate' and 'Strong'.

The output of a software realization of the noise generator is a composition of white Gaussian noise sources each having a bandwidth of exactly half the frequency with which the samples are generated. Hence, this is not quite comparable to the output of a real digital receiver. The latter one has a bandwidth of less than half of its sampling frequency combined with the characteristic of the filters in the signal path.

Furthermore, the characteristic measures use the signal's envelope. So, some further processing was done in order to yield comparable results. A simple software receiver was used to extract a section with a bandwidth of 3 kHz[1] from the generated noise. From the complex baseband output as a first step, the envelope signal was calculated and as a second step the characteristic values were determined.

[1] 'The same filter is used in the DME-1 receiver with which the noise measurements were recorded.



NOTE See reference 4. of the bibliography.

Figure A.1 – Generating atmospherics according to Feldman

The factor A will be generated anew on each transition of $X(t)$ from 0 to 1. Hence, $A \cdot X(t)$ can be written as $A(t) \cdot X(t)$ to clarify the time dependency of A.

A.2.1.1 Examples of simulated atmospheric noise

In 1996 and 1997, the Federal Waterways Administration of Germany carried out some noise measurements (at a latitude of about 50 degrees north) with specially made recording equipment[2]. These data were recorded with a bandwidth of 3 kHz and stored digitally on a hard disk of a PC. A comparison of the characteristic measures showed some correspondence with these of the situation 'Quiet-Night'. Now a further investigation was carried out. The parameters of the Feldman noise model were adjusted so as to match the measurements. These new situations are called 'Moderate' and 'Strong'. The situation 'Gauss' models is the case in which no impulsive noise components are present. The situation 'Moderate models is a thunderstorm which is relatively far away from the receiver whereas 'Strong' is appropriate for cases where a nearby thunderstorm is to be simulated.

NOTE It seems advisable to do some more measurements at different latitudes to verify if other parameters are more appropriate to simulate atmospheric noise for those regions.

A.2.2 Man-made noise

Several measurements were made by the Federal Waterways Administration of Germany near electrified railway lines, power transmission lines, a shipyard and onboard a ship. As a common component periodic impulses with an intensity of about 12 dB above the Gaussian part can be seen. The impulsive noise component is very often always only detectable if an E-Field antenna type is used. The following procedure to generate man-made noise is suggested: Every 33 ms, a factor A is set to 4 for a time of 0,7 ms. All the time in-between, the factor A is set to 0. The noise is formed from two parts. One source is a white Gaussian noise generator the output of which is multiplied 'by the factor A. Added to this switched component is the output of a second white Gaussian noise generator.

Table A.2 – Characteristic parameters of the simulated situations

Measurement	v_{rms}	v_{av}	V_d	v_{med}	v_{rms}/v_{med}
Quiet	1,30	0,83	3,9	0,66	5,9 dB
Quiet-Night	2,10	1,19	4,9	0,71	9,4 dB
Tropical	27,7	3,85	17,1	0,71	31,8 dB
Frontal	40,8	6,06	16,6	0,78	34,4 dB
Man-made	0,95	0,74	1,9	0,64	3,4 dB
Gauss	0,79	0,69	1,2	0,63	1,9 dB
Moderate	3,9	0,77	14,0	0,65	15,6 dB
Strong	10,4	0,97	20,6	0,65	24,0 dB

In order to be able to compare the APD-curves with the data given in literature the ratio v_{rms}/v_{med} was indicated; as the levels there refer to the RMS value. White Gaussian noise is to be regarded as the common component of all received data (in RF). The median happens to be a good assessed value for this part of the signal at the output of a receiver when the envelope is analyzed. For the simulations the magnitude of the factor $A(t)$ was limited to 10^6 = 120 dB.

2 The receiver is a DME-1 made by Attingimus Nachrichtentechnik GmbH, 38102 Braunschweig, Germany. A transmitter called DMS-1 is also available. It uses the recorded (and processed, i.e. added with an MSK-signal) data to retransmit into the 300 kHz domain.

A.3 Test procedures

A common approach to the generation of test signals is as follows. All noise scenarios use two independent white Gaussian noise generators. One noise generator provides a constant part within the noise model. The other one is switched over time in its intensity. While the switching itself doesn't pose a problem the changing intensity of this component is a bit more difficult to achieve. The suggested way to reach this goal is to use a waveform synthesizer with a programmable Gaussian noise generator The synthesizer's remote control interface can be used to program different amplitudes.

An implementation of the noise models discussed could use a PC to calculate the amplitude factor A and the switching function $X(t)$. This can be done before the measurement for each noise model used. So the only task for the PC is to read the data and program the waveform synthesizer accordingly. Depending on the speed of the PC model used it can be advisable to store all data in RAM to avoid time consuming reading from the hard disk. Figure A.2 shows the structure of this test set-up.

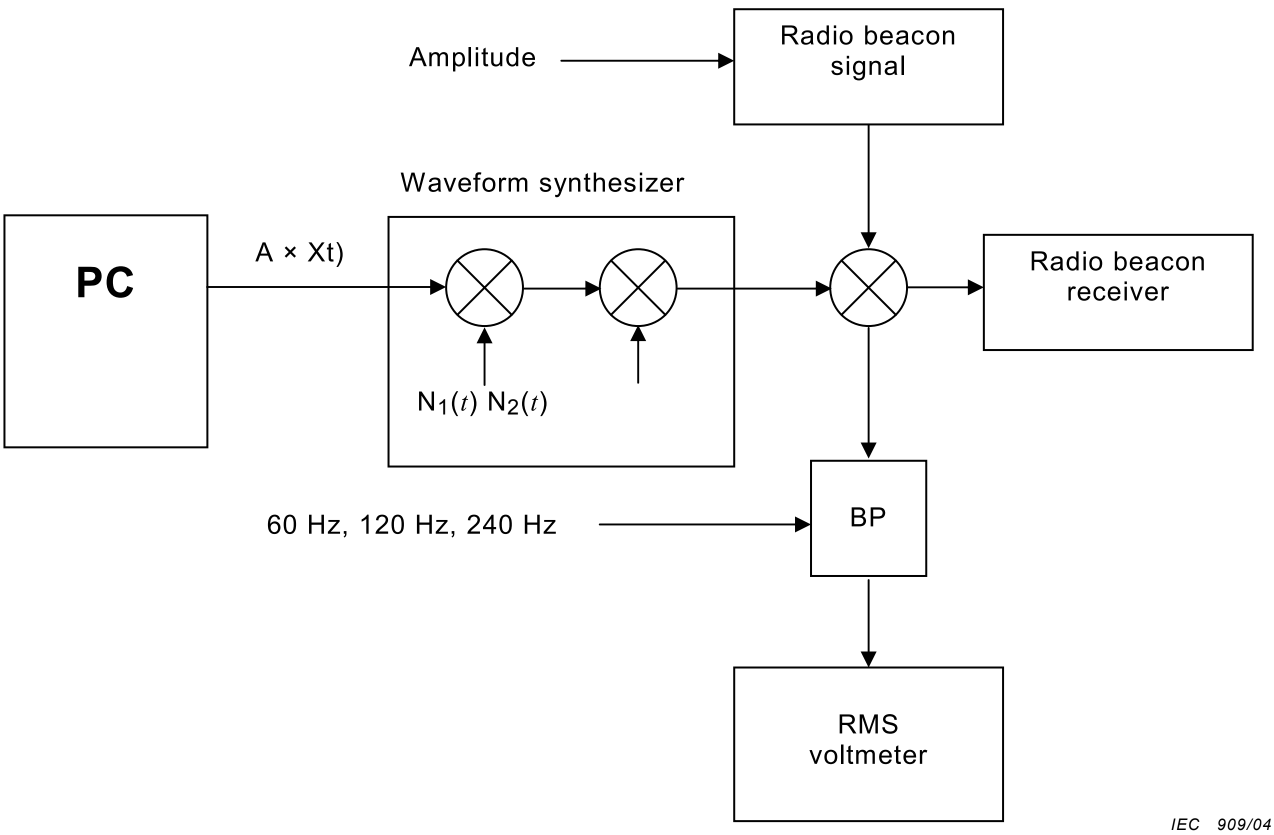


Figure A.2 – Test set-up using a PC to program a waveform synthesizer

The component $A \times X(t)$ selects the duration and amplitude of the noise component from the white Gaussian noise generator $N_1(t)$. The second white Gaussian noise generator is constantly switched on, Depending on the data rate of the radio beacon signal (50 bps, 100 bps or 200 bps) the signal to noise ratio (SNR) has to be calibrated using an equivalent noise bandwidth of 60 Hz, 120 Hz or 240 Hz. To this end, an adjustable band-pass filter (BP) and an RMS voltmeter will be used. In conjunction with the amplitude of the Radio Beacon Signal, the absolute level of the noise generators can be programmed to achieve the desired SNR value. It is suggested to use only the noise component $N_2(t)$ as a reference.

Annex B
(informative)

Methodology for measuring WER

The RTCM in the USA have studied this methodology and the following algorithm describes how to determine the word-error-rate of a recorded RTCM data stream via a PC.

B.1 Recording the RTCM data stream

The aim of the test is to determine how many RTCM words the beacon receiver in a noisy environment can receive.

The test signal that is applied to the beacon receiver consists of a MSK signal that is superimposed with a noise signal (e.g. gaussian, thunderstorm, etc.).

The time the beacon receiver needs to lock to the signal is different and depends on several parameters. This shall not influence the results of the tests.

So a “start word“ is introduced: there is a delay time of e.g. 90 s, where only the MSK signal is transmitted to ensure, that all receivers are able to lock to the signal. After this period, a start word (e.g. „abcd“, transmitted with message type 16) is sent. In addition to that, the noise signal is added to the MSK signal.

B.2 Analysing the RTCM data stream

Basically, the algorithm counts the number of valid received RTCM words after the initial start word has been occurred.

The knowledge of the number of RTCM words in the transmitted signal makes it possible to calculate the word-error-rate.

The complete algorithm is shown in Figures B.1 and B.2 of this international standard.

B.3 Caution

a) The pattern of the preamble may also appear within a data word even though it is not exclusively reserved for this purpose. Even the parity check of each word cannot prevent this in all cases.

   So the algorithm decodes the message type number and the station – id and checks them for plausibility.

b) Data words (words 3..n) can only be checked by the parity test. If word 1 or word 2 is not received correctly, the whole message is rejected. This means the algorithm looks for the next valid preamble and continues at the next message.

   It is also possible to read 30 bit words until the next preamble appears.

   But regarding a GPS receiver connected to a beacon receiver, the GPS receiver needs word 1 and word 2 to process the message. If one of these two words is not received correctly the whole message has to be skipped.

NOTE The described algorithm has been realised as a computer program using “Borland Delphi“ and has been used to do the “Tests of beacon receiver in a noisy environment“ by the Aids to Navigation Centre of Germany, Seezeichenversuchsfeld, in 1998.

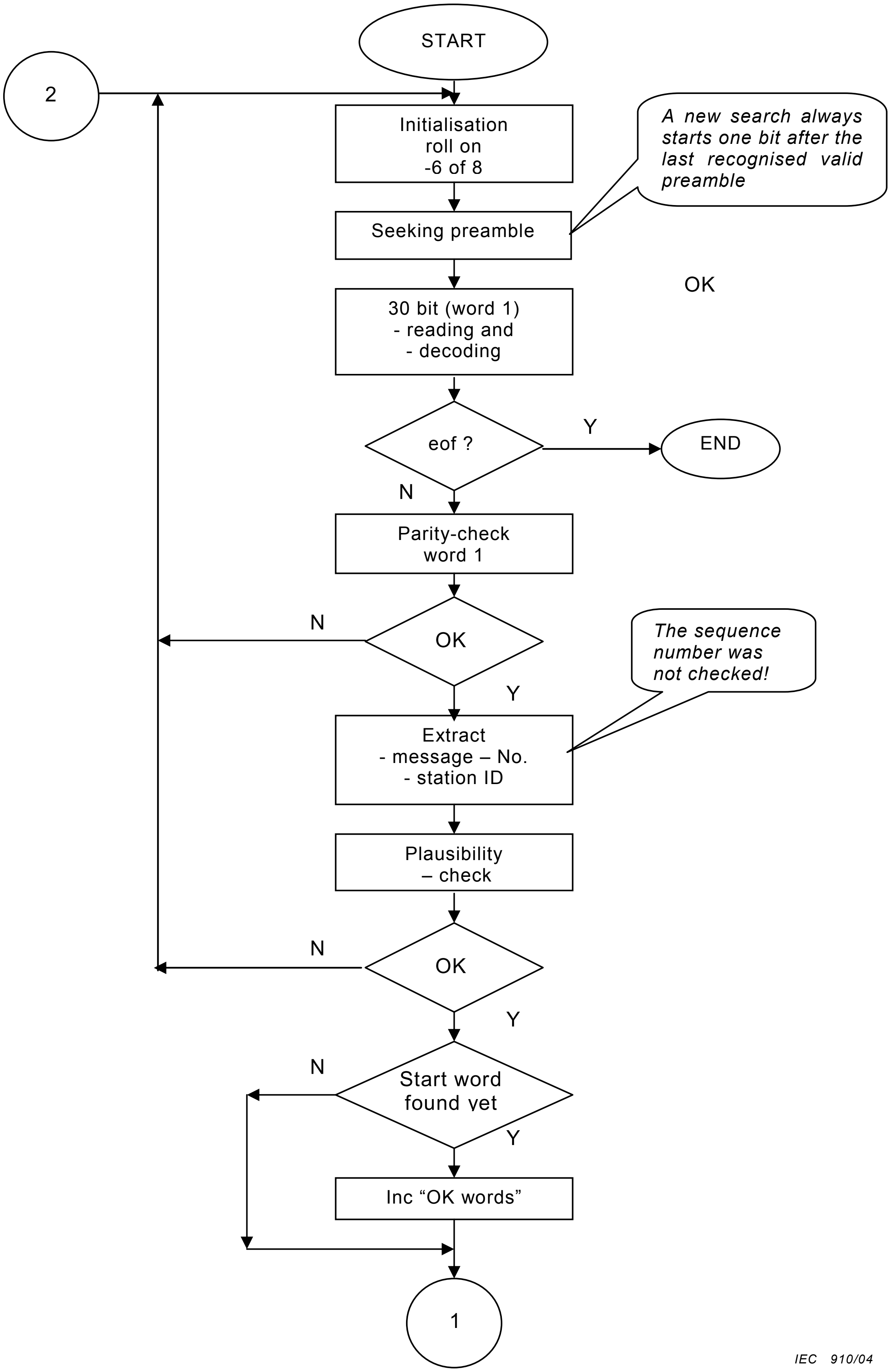


Figure B.1 – Word error rate algorithm (first part)

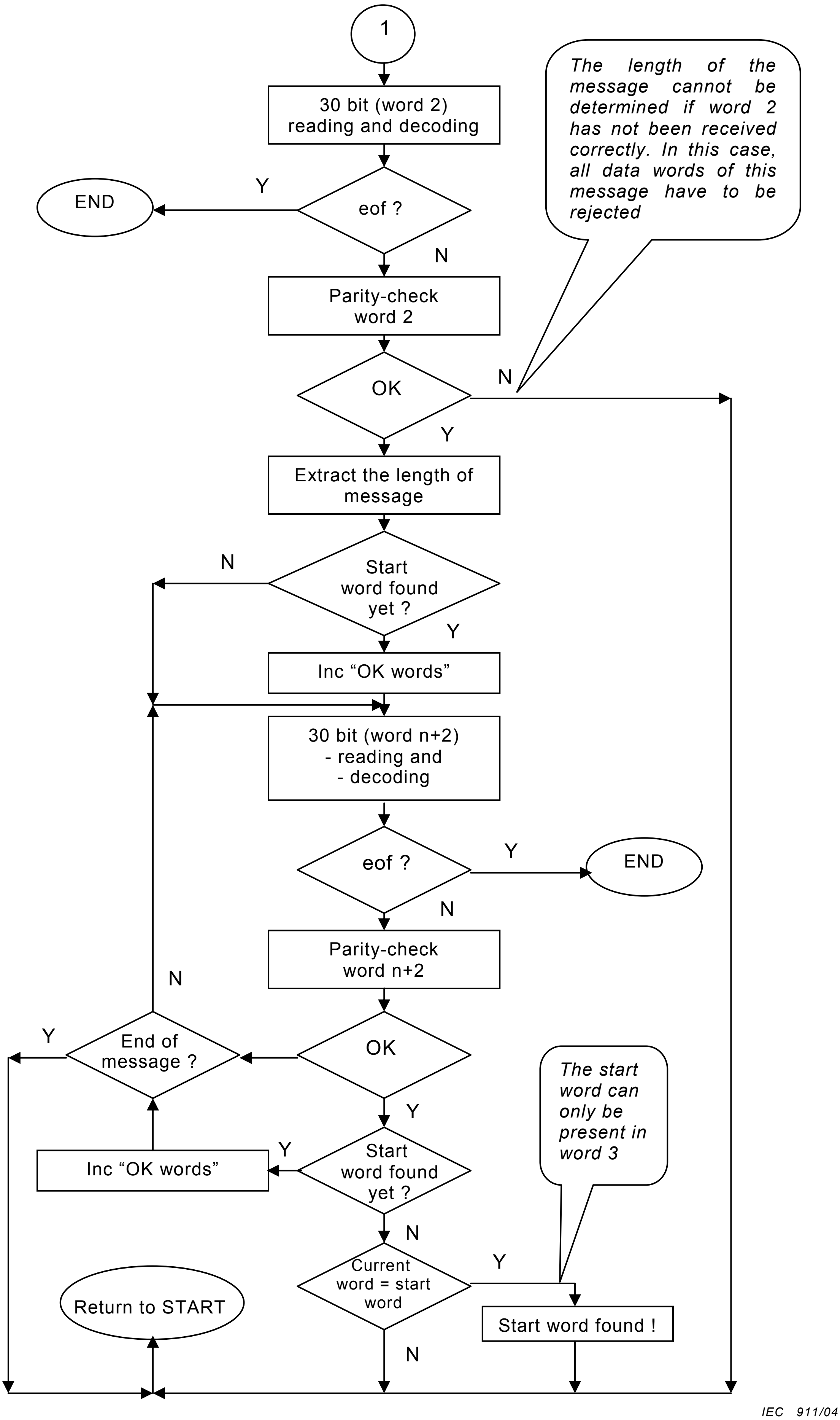


Figure B.2 – Word error rate algorithm (second part)

Annex C
(normative)

Tests that are specific to integrated equipment that does not provide an output port for testing

C.1 General requirements

Test of integrated equipment is based on either the output of decoded ITU-R M.823 data on the output port or display on the integrated receiver of relevant data, related to the reference station used and nearest stations or a combination of these.

A possibility to display WER on the integrated equipment will greatly simplify the testing. If display of WER is not provided; the verification of the results shall be done by evaluating the output on the IEC 61162 port.

C.2 Test of WER display

Bring up test signal H

Verify that the displayed WER is 0,1 (10 %)

Bring up test signal F

Verify that the displayed WER is 1 (100 %)

C.3 Comments to Clause 6, methods of testing

The tests in 6.2.2, 6.2.3, 6.2.5, 6.5.1 and 6.5.2 can be verified by observing displayed data according to 4.9 and WER display on the integrated receiver.

The tests in 6.2.4 and 6.2.5 require the integrated receiver to be set to a test mode that outputs ITU-R M.823 data on the output port.

In 6.2.6 and 6.2.7 – no change.

In 6.3, step 1, is not applicable if the antenna is integrated into the DGNSS receiver.

In 6.3, step 2 – no change.

Annex D
(informative)

Installation guidelines to counteract the effect of interference

D.1 Introduction

- To provide the user with maximum performance from the beacon receiver, a proper receiver equipment installation is essential.
- These recommendations are general guidelines on common installation practice and are not intended to replace any specific manufacturer instructions.
- The recommendations deal with both separate MF receivers for the differential signal and with combined GNSS/MF receivers.
- In the context of this document, the words "maritime radio beacon receiver equipment" include all the components and units necessary for the system to properly perform its intended functions. The following basic components of the system are included in the recommendations:
  a) antenna, capable of receiving DGPS or DGLONASS maritime radio beacon signals (could also be included in a combined GNSS/MF antenna);
  b) DGPS and DGLONASS maritime radio beacon receiver and processor;
  c) antenna and interface cabling;
  d) power supply.

D.2 Antennas

D.2.1 Description of the different types of antennas

- E-field (whip)

The E-field whip antenna is sensitive to the electrical component of the radio beacon broadcast.

- H-field (loop)

The H-field loop antenna is sensitive to the magnetic component of the radio beacon broadcast.

- Combined antennas (GNSS/MF)

The combined antenna uses the same enclosure but combine two individual antennas, an H-field loop antenna and a GPS antenna.

D.2.2 Description of the advantages and disadvantages of E-field and H-field antennas

- E-field (whip)

E-field antennas are in general more sensitive than H-field antennas. When the signal plus external noise is extremely weak then the whip can have an advantage due to the very low effective height of the loop [1,2].

It should be noted here that a 6 dB increase in sensitivity is equivalent to an increase in usable range from the reference station of nearly a factor of 2 over the sea [3][3].

Disadvantage is the need for good grounding and the performance in man-made noise and in "p-static" environments.

- H-field (loop)

The H-field performance in noise (man made, "p-static") is much better than the E-field performance.

No antenna ground connection is required when using an H-field antenna.

Disadvantage is the lower sensitivity that may result in a lower usable range.

D.3 General installation requirements

D.3.1 Location of antennas

D.3.1.1 E-Field-Antenna

The E-field antenna should be mounted as vertically as possible and at least [1m] away from any radiating antennas. To get maximum sensitivity with this kind of antenna it is also essential to place the antenna as high as possible and with a separation of [3m] from large metal constructions, but to protect the antenna as much as possible from “p-static” the antenna should not be installed at the top of the mast [4].

D.3.1.2 H-field antenna

The H-Field antenna should be mounted [1m] away from any radiating antennas. To get maximum sensitivity with this kind of antenna it is also essential to place the antenna at a distance of [3m] from large metal constructions and at least 10 cm above any metal surface upon which it sits.

D.3.1.3 Combined GNSS/MF antenna

If the H-Field antenna is integrated with the GPS antenna to make a combined antenna, additional recommendations should be considered:

– clear view of sky;
– antenna out of the beam path of transmitting radars and INMARSAT terminals (beams typically ±15° from centre point);
– below and at least 3 m away from any transmitting antennas;
– keep antennas above superstructure but otherwise as low as possible. For example the antenna should not be located on a mast where the vessel pitch and roll will affect the receiver position or where it may be inadvertently used as a handhold.

D.3.2 Location of the DGPS and DGLONASS maritime radio beacon receiver and processor

- The equipment should be located so that the status indication on the front panel is visible.
- Ensure clearance between the antenna and interface connections.
- The equipment should be mounted in a location within the recommended reach of the interface cables.

[3] Figures in square brackets refer to the bibliography.

- The equipment should not constitute an obstruction.
- Equipment should be located so as to avoid exposure to extreme environmental conditions, including:
  - frequent exposure to water;
  - excessive heat (> 65 °C);
  - excessive cold (< –30 °C);
  - high vibration;
  - corrosive fluids and gases.

D.3.3 Grounding

- Seawater ground is a direct electrical connection to the water below the vessel's water-line. This is the proper ground to use for DGNSS equipment.
- For an E-Field beacon antenna, grounding is essential. Improper grounding is the primary source of poor performance with this type of antenna.
- Power cable shields should also be connected to a seawater ground.
- It is preferable to ground each piece of equipment individually to the same earth rather than grounding pieces of equipment to each other.
- The shields of interface cables should not be grounded at both ends, as this may induce ground loops.
- Fibreglass or wooden ships need to have an appropriate grounding system.
- All components of a DGNSS installation should have a common grounding.

D.3.4 Cabling

- Cables should be as short as practical.
- Manufacturers' recommended cable types should be used.
- The antenna cable should be secured along its length using tie-wraps.
- The following hazards should be avoided:
  - joining cables with adapters;
  - sharp bends in cables;
  - hot surfaces (exhaust manifolds or stacks);
  - rotating or reciprocating equipment;
  - sharp or abrasive surfaces;
  - door and window frames;
  - corrosive fluids or gases.
- If cables must pass each other, they should cross at right angles rather than run in parallel.
- If it is necessary to use longer cables than provided by the manufacturer, a cable with the same impedance but with lower attenuation should be used.

D.3.5 Power supply

- Filtering should be installed to provide surge protection and for smoothing of power supply.
- Isolated power supply may be required to enable earthing of the receiving equipment without compromising the main vessel electrical shock protection system.

- To minimise power fluctuations resulting from additional electrical accessories connected to the same power supply an in-line power filter should be used.
- The receivers power and ground wires shall be connected directly to the DC power panel on the vessel.

D.3.6 Interfacing with other equipment (GNSS, radar, ECDIS, etc.)

- Interference (particularly with beacon DGPS reception) is sometimes caused when the GPS receiver is connected to both RS232 and RS422 devices. In this case, noise on the RS232 signal ground shows up on the RS422 return line. In these cases, the RS232 output of the GPS should be used, or an NMEA buffer box should be interposed to isolate the noise.

D.4 Noise/interference sources

When investigating the source of interference signals, it is important to exercise each of the electrical sources onboard, to test their contribution to the interference [5, 6]. VHF communication transmitters should be used on as many channels as possible (particularly those with a harmonic close to L1). HF transmitters and satellite communications terminals should be used where applicable. The radar should be operated with all combinations of PRF and pulse width. Ancillary equipment such as bridge window wipers, ship's cranes air-conditioning, microwave ovens and television receivers should all be used. For the satellite communications terminal, tests should be carried out with the antenna pointing in different directions relative to the position of the measuring antennas.

Further common onboard sources of electrical and magnetic noise and interference, in a typical maritime environment, are:

- generators and alternators;
- equipment with DC to AC converters;
- TV and PC monitors;
- electric motors;
- propeller shafts;
- fluorescent lights;
- power lines;
- switched mode power supplies;
- non-metallic ships with ungrounded deck equipment, which can cause electrostatic discharge.

D.5 Testing

After installation of the beacon receiver equipment in accordance with the above recommendations, some tests should be carried out to verify correct performance:

- if the receiver is located within the specified coverage area of a DGNSS radio beacon reference station, it should be confirmed that the receiver is achieving continuous decoding of RTCM messages from that station with a word error rate (WER) of zero;
- if the signal to noise ratio (SNR) is greater than 7 dB, the receiver should achieve continuous decoding of RTCM messages with a WER of zero. As mentioned in Clause 4, it is important to exercise the various electrical noise sources onboard, by switching these possible noise sources on and off. Within the specified coverage area of a DGNSS radio beacon reference station, the field strength should be at least 50 μV/m.

D.6 Troubleshooting

Table D.1 – Troubleshooting conditions

Symptom	Possible Solution
No signal lock	• Check antenna connections • Verify data rate is set correctly when in manual mode or choose automatic mode • Verify frequency of transmitting beacon when in manual mode or use automatic mode • Check antenna ground if using an E-field antenna
No valid RTCM data from beacon receiver	• Check receiver power status • Verify that the beacon receiver is locked to a valid beacon station • Check integrity of power and data cable connections • Check interface parameters
Low Signal to Noise Ratio (SNR) or low fieldstrength	• Check integrity of antenna connections • Check antenna ground if using an E-field antenna • Select alternate antenna position

Annex E
(informative)

Implementation using a concurrent process

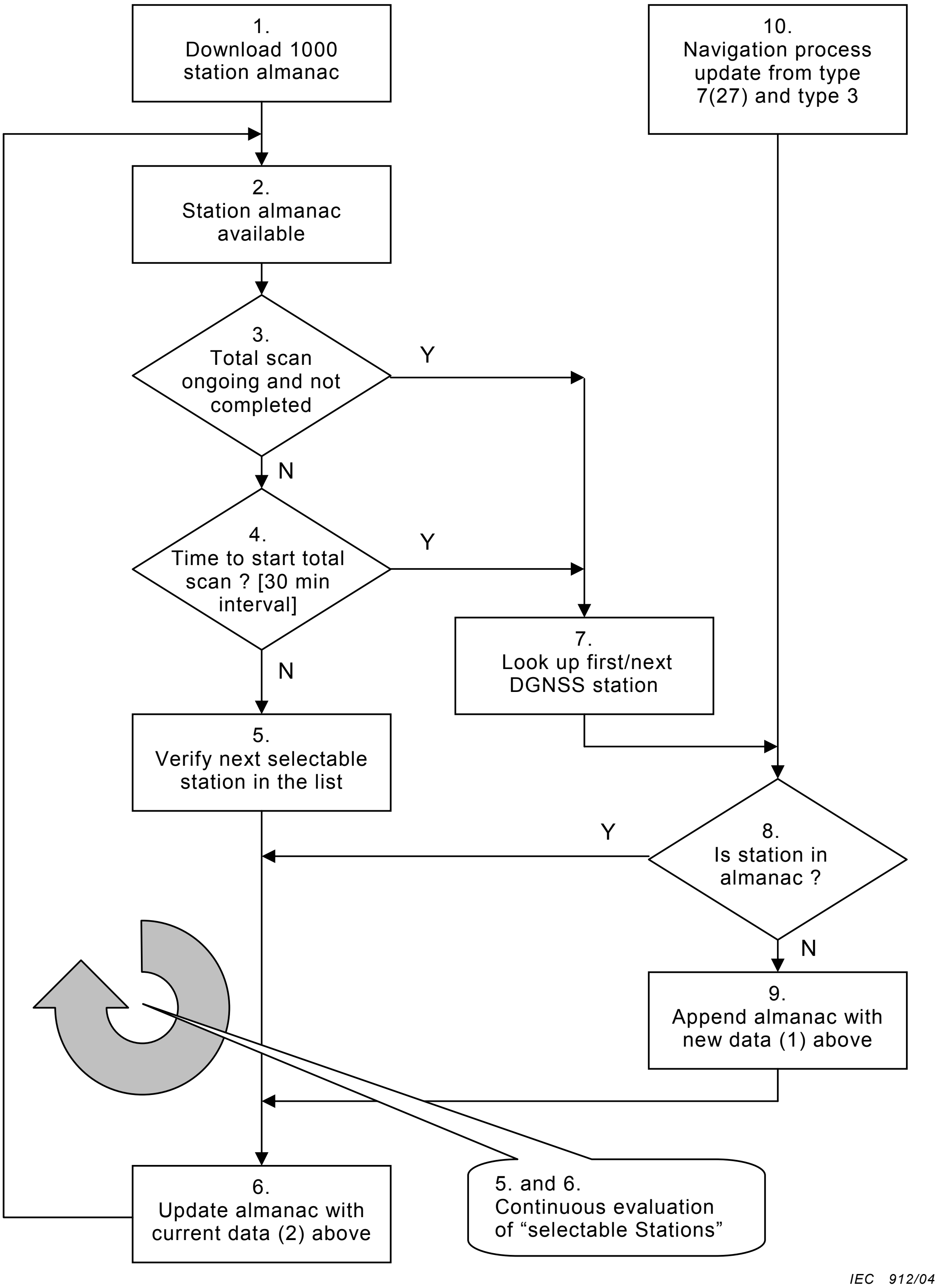


Figure E.1 – Station status update

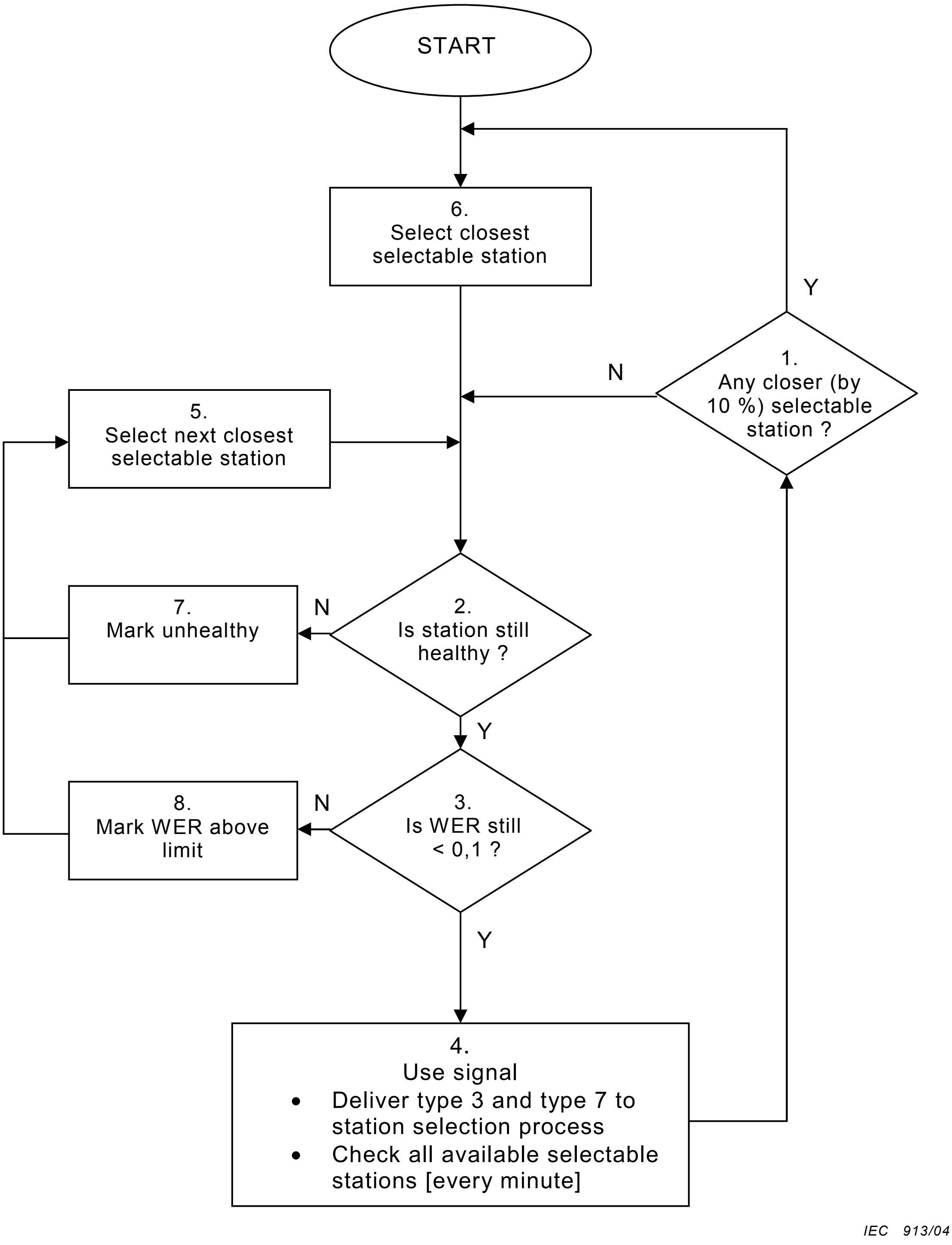


Figure E.2 – Navigation process

Annex F
(informative)

Data interface guidance

ITU-R M.823 data interface specification: the GNSS equipment shall be designed in such a way that the ITU-R M.823 digital data link information enters and exits through an asynchronous full duplex serial input/output port.

The American National Standards Institute (ANSI) X3.16 [8] and X3.15 [7] standards for eight-bit character structure shall govern the rules for serial data transfers. Note that the use of all eight bits in the transfer of serial data precludes the use of 7 bit parity formats. The recommended protocol being 8 bits, no parity, 1 stop bit. The serial data rate shall be selectable at least over the 1200 to 9600 baud range (1200, 2400, 4800, or 9600 baud).

Important interface rules: although the data is packaged in 8-bit bytes, the interpretation of what each of the 8 bits means is dictated by a combination of what is presented in ITU-R M.823 and the rules that follow.

Byte format rule: a standard 8-bit byte is described as the “8-Bit Environment” in ANSI X3.16. This standard assigns the order of the start, stop, and eight data bits: the first data bit transmitted is designated “a8” and the last is “a1”; bit “a1” is designated the least significant bit. This is a source of problems and is discussed in the next section (see – Most Significant Bit First Rule). All equipment shall support the use of the “6 of 8” format (data bits a1 through a6) to transfer the information contained in ITU-R M.823. As an indication that bits a1 through a6 are “message information”, bit a7 shall be set “marking” and a8 shall be set “spacing”. The appropriate mark and space signalling conditions are discussed in ITU-T V.28 (RS232) and ITU-T V.11 (RS422).

Most significant bit first rule: the data link binary information shall always be passed in the order it appears in ITU-R M.823. This is known as most significant bit first. Unfortunately, the ANSI X3.15-1976 standard states that the least significant bit is first. Almost all integrated circuits designed for serial communications follow this convention. The use of X3.15 standard Universal Asynchronous Receivers and Transmitters (UARTs) introduces the need for a “byte roll” prior to leaving the reference station equipment and then again just after entering the GPS user equipment. The following is from ANSI standard X 3.15-1976: “The bit sequence for an ASCII nomenclature b1 through b7 in ascending (consecutive) order, or in terms of the 8-bit nomenclature a1 through a8 in ascending (consecutive) order.”

The “roll” process is performed on each byte prior to transmission. Rolling means that bits a1 and a6, a2 and a5, a3 and a4 are swapped. This same process is repeated after user equipment accepts each byte.

Bit slip rule: in a typical installation the communications receiver or modem will assemble the received bits into 8-bit bytes. No specific (except bit synchronisation) byte or “word” synchronisation should be assumed. The user equipment shall be required to recover the message synchronisation just as it is responsible for recovering the synchronisation of the satellite navigation data. This simply means that the user equipment designer should not assume there will be any consistent relationship between the word boundaries of this standard’s 30 bits words and the communications channel 8 bit bytes.

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NOTE The above references, [1] to [6], refer to Annex D.

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NOTE The above references, 1. to 11., refer to Annex A.

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