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PUBLICLY AVAILABLE SPECIFICATION

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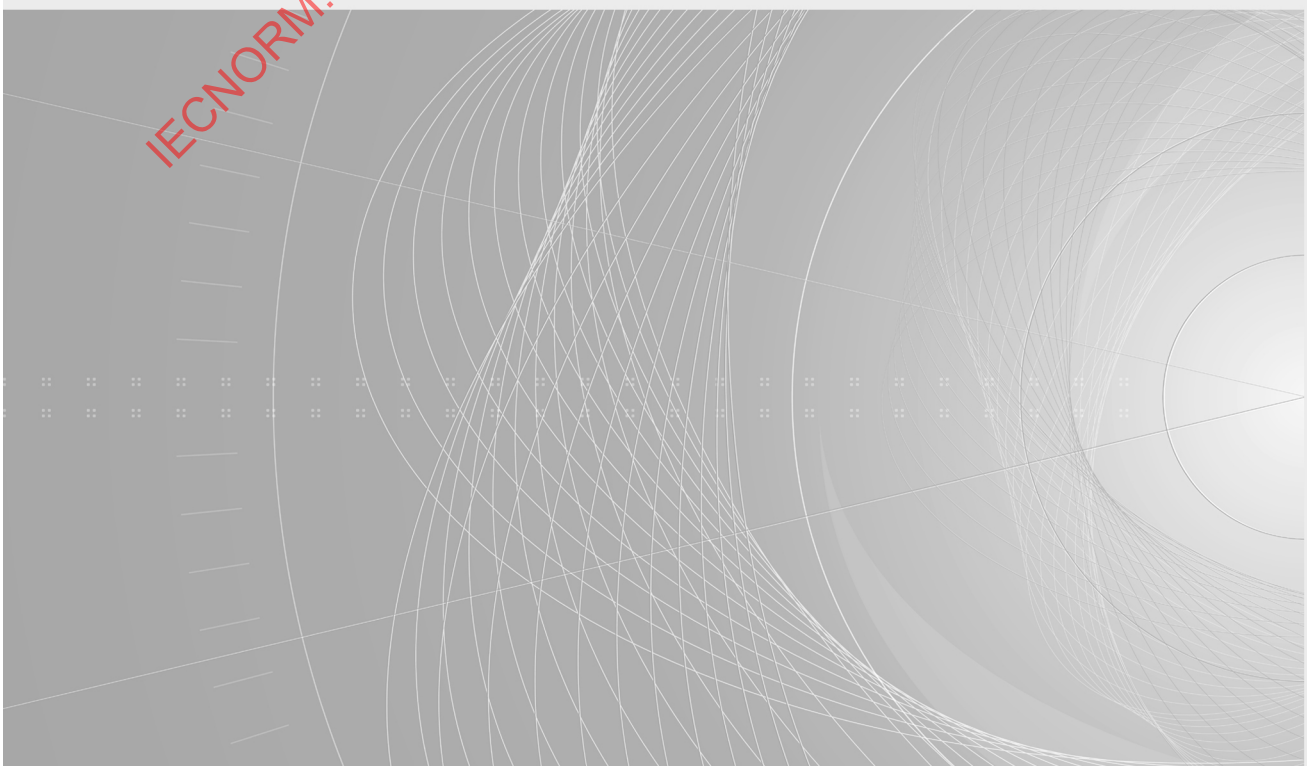
Maritime navigation and radiocommunication equipment and systems – VHF data exchange system – Requirements and methods of testing for stations including ASM functionality



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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS – VHF DATA EXCHANGE SYSTEM – REQUIREMENTS AND METHODS OF TESTING FOR STATIONS INCLUDING ASM FUNCTIONALITY

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The text of this PAS is based on the following document:	This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document
Draft PAS	**Report on voting**
80/975/DPAS	80/982/RVDPAS

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MARITIME NAVIGATION AND RADIOCOMMUNICATION EQUIPMENT AND SYSTEMS – VHF DATA EXCHANGE SYSTEM – REQUIREMENTS AND METHODS OF TESTING FOR STATIONS INCLUDING ASM FUNCTIONALITY

1 Scope

This document specifies technical requirements, methods of test and required test results for equipment implementing ASM part of the VHF Data exchange system (VDES) as defined in ITU-R M.2092.

This document is intended to be the first step of development of standard(s) describing equipment that implement functions of VDES in any combination.

NOTE All text of this document whose wording is identical to applicable external references such as ITU Recommendations is printed in *italics*, and the reference and associated paragraph numbers are indicated in brackets.

NOTE The intention of text written in notation [Future: text] in this document is to include future placeholder for topics that are considered important even for the first implementations that may comply with this document.

Requirements set in this document provide means to mitigate adverse interference to Automatic Identification System (AIS).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60945:2002, *Maritime navigation and radiocommunication equipment and systems – General requirements – Methods of testing and required test results*

IEC 61108 (all parts), *Maritime navigation and radiocommunication equipment and systems – Global navigation satellite systems (GNSS)*

IEC 61162-1:2016, *Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 1 Single talker and multiple listeners*

IEC 61162-450, *Maritime navigation and radiocommunication equipment and systems – Digital interfaces – Part 450: Multiple talkers and multiple listeners – Ethernet interconnection*

IEC 61193-2:2007, *Quality assessment systems – Part 2: Selection and use of sampling plans for inspection of electronic components and packages*

IEC 61993-2:2018, *Maritime navigation and radiocommunication equipment and systems – Automatic identification systems (AIS) – Part 2: Class A shipborne equipment of the automatic identification system (AIS) – Operational and performance requirements, methods of test and required test results*

IEC 62320-1:2015, *Maritime navigation and radiocommunication equipment and systems – Automatic identification system (AIS) – Part 1: AIS Base Stations – Minimum operational and performance requirements, methods of testing and required test results*

ITU-R Recommendation M.1371-5:2014, *Technical characteristics for an automatic identification system using time division multiple access in the VHF maritime mobile frequency band*

ITU-R M.2092-0:2015, *Technical characteristics for a VHF data exchange system in the VHF maritime mobile band*

ITU-T O.151:1992, *Error performance measuring equipment operating at the primary rate and above*

IALA G1139 Edition 3, 2019, *The Technical Specification of VDES*

3 Terms, definitions and abbreviated terms

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms and definitions

3.1.1 Input [verb]

input [verb]
used for data transaction towards the equipment in its Presentation Interface

3.1.2 Output [verb]

output [verb]
used for data transaction from the equipment at its Presentation Interface

3.1.3 Transmit [verb]

transmit [verb]
used when equipment transmits by using VHF radio

3.1.4 Receive [verb]

Receive [verb]
used when equipment receives a radio signal

3.1.5 VDES VDL

VDES VDL
AIS VDL, ASM VDL, VDE TER VDL and VDE SAT VDL

3.2 Abbreviated terms

AIS	Automatic Identification System
ASM	Application Specific Message
BW	Bandwidth
DAC	Designated Area Code
EMC	Electromagnetic Compatibility
EUT	Equipment Under Test
EVM	Error Vector Magnitude
FATDMA	Fixed Access Time Division Multiple Access
FI	Function Identifier

GLONASS	Globalnaya Navigazionnaya Sputnikovaya Sistema
GMSK	Gaussian Minimum Shift Keying
GNSS	Global Navigation Satellite System
HMI	Human Machine Interface
IF	Intermediate Frequency (of modulator)
MITDMA	Multiple Incremental Time Division Multiple Access
PAPR	Peak to Average Power Ratio
PEP	Peak Envelope Power
PER	Packet Error Rate
PI	Presentation Interface
RATDMA	Random Access Time Division Multiple Access
RF	Radio Frequency
RMS	Root Mean Square
SAR	Search and Rescue
SI	Selection Interval
UTC	Coordinated Universal Time
VDE	VHF Data Exchange
VDES	VHF Data Exchange System
VDE SAT	VDE Satellite
VDE TER	VDE Terrestrial
VDL	VHF Data Link
VHF	Very High Frequency
VSWR	Voltage Standing Wave Ratio
QPSK	Quadrature Phase Shift Keying

4 General requirements and tests of equipment

4.1 Requirements (placeholder)

4.2 Methods of tests for general requirements

5 Performance requirements

5.1 Mobile station

5.1.1 Overview

This part specifies the minimum operational and performance requirements, methods of testing and required test results for ASM Mobile station.

It takes into consideration the technical characteristics of shipborne AIS equipment, included in recommendation ITU-R M.1371 and IEC 61993-2 (see 5.1.3.11).

ASM mobile station is intended to be used onboard any marine vessel that may operate globally or regionally anywhere in the world. The main high-level functions of the ASM mobile station are:

a) transmit through ASM VHF Data Link (ASM VDL) information which is input to ASM mobile station by other onboard equipment through Presentation Interface (PI);

b) output all information received from ASM VDL applicable to own station, through PI so that this information is available to other onboard equipment;

c) handle applicable ASM radio station duties.

In following text, term "Equipment" is used to refer to ASM mobile station.

5.1.2 General requirements

An ASM mobile station shall as a minimum fulfil requirements set in IEC 61193-2, with exceptions as detailed in this document for interoperability between AIS and ASM transmission and reception.

5.1.2.1 Marking and identification

Equipment shall be marked as required by IEC 60945:2002, Clause 15. In addition, the markings shall include:

- details of the power supply from which the equipment is intended to be operated; and,
- if applicable, the date by which batteries need to be replaced.

5.1.2.2 Manuals

Manuals for Equipment shall comply with requirements set in IEC 60945:2002, Clause 14, as applicable. In addition the manuals shall include:

- the type and details of all external connectors;
- the needed information for correct siting of the antennas;
- description for each alert that may be released by the equipment. The description shall briefly explain the root causes for each alert, give guidance for users on what implications the alert has for safe operation of ship and what actions may be necessary to rectify the alert condition.

5.1.2.3 Quality assurance

The Administration shall require that the manufacturers have a quality control system audited by a competent authority to ensure continuous compliance with the conditions of conformance assessment. Alternatively, the Administration may use final product verification procedures where a competent authority verifies conformance with the certificate of conformance before the product is installed on board ships.

NOTE The ISO 9000 family standards, as applicable, meets this requirement.

5.1.2.4 Source of UTC

The Equipment shall be provided with a source of UTC, such as GNSS receiver, which is required for synchronisation purposes.

The internal GNSS receiver shall meet the following requirements of IEC 61108 (all parts): acquisition, re-acquisition, receiver sensitivity, RF dynamic range, effects of specific interfering signals, status indications.

5.1.2.5 Human Machine Interface (HMI)

Means shall be provided to allow user to observe operational status of the equipment.

NOTE This requirement can be fulfilled by providing an indicator capable of signalling three states: power off, power on – operating as intended, power on – not operating as intended.

5.1.2.6 Environmental, power supply, special purpose and safety requirements

Equipment shall as minimum comply with the requirements set for equipment category "protected" as stated in IEC 60945:2002.

5.1.2.7 EMC

Requirements applicable for Equipment are stated in IEC 60945:2002, Table 6, equipment category "protected".

5.1.2.8 Compass safe distance

Requirements stated in IEC 60945:2002, 4.5.3, apply to Equipment.

5.1.2.9 Power supply

Manufacturer shall specify the properties of power supply. The power supply shall conform to applicable requirements in IEC 60945:2002.

5.1.2.10 Update of software

The Equipment shall provide means for updating software of the equipment and to report, on demand, the current applicable software version.

5.1.3 Technical requirements

5.1.3.1 Transmitter shutdown procedure

(M.1371-5/A2-2.13) *An automatic transmitter hardware shutdown procedure and indication* shall *be provided in case a transmitter continues to transmit for more than 2 s. This shutdown procedure* shall *be independent of software control.*

5.1.3.2 Permissible initialization period

The Equipment shall be operational within 2 min of switching on.

5.1.3.3 Transceiver protection

The Equipment shall tolerate failure conditions of disconnected antenna and short circuit of antenna connector for minimum duration of 60 s. The equipment shall be capable to continue normal operation within 2 min after either of the failure conditions are rectified.

5.1.3.4 TX malfunction

The Equipment shall be able to detect malfunction of transmitter and signal this condition through Presentation Interface (see 5.1.3.8.3) and HMI (see 5.1.2.5).

5.1.3.5 Antenna VSWR

Equipment shall be able to detect excess VSWR at antenna and signal this condition through Presentation Interface (see 5.1.3.8.3) and HMI (see 5.1.2.5).

5.1.3.6 RX malfunction

Equipment shall be able to detect malfunction of receiver and signal this condition through Presentation Interface (see 5.1.3.8.3) and HMI (see 5.1.2.5).

5.1.3.7 Physical layer

5.1.3.7.1 TDMA transmitter

The transmitter shall comply with following requirements in addition to IEC 61193-2.

Transmission characteristics as described in Table 1 and Figure 1 shall apply for transmission of ASM messages.

Table 1 – Slotted transmission spectrum for ASM

Transmitter parameters	Requirements	Condition
Frequency error	±1,5 ppm	Normal
	±3 ppm	Extreme
Transmit power capability	Transmit average power should be 1 W at low power setting and 12,5 W at high power setting. ±1,5 dB normal, $^{+2}_{-6}$ dB extreme	Conducted
Slotted modulation mask	Δfc < ±8 kHz: 0 dBc (PEP of transmitted signal) ±8 kHz < Δfc < ±16 kHz: below the straight line between −25 dBc at ±8 kHz and –60 dBc at ±16 kHz ±16 kHz < Δfc < ±25 kHz: below the straight line between −60 dBc at ±16 kHz and –70 dBc at ±25 kHz ±25 kHz < Δfc < ±62,5 kHz: –70 dBc	
Spurious emissions	−36 dBm −30 dBm	9 kHz to 1 GHz 1 GHz to 4 GHz

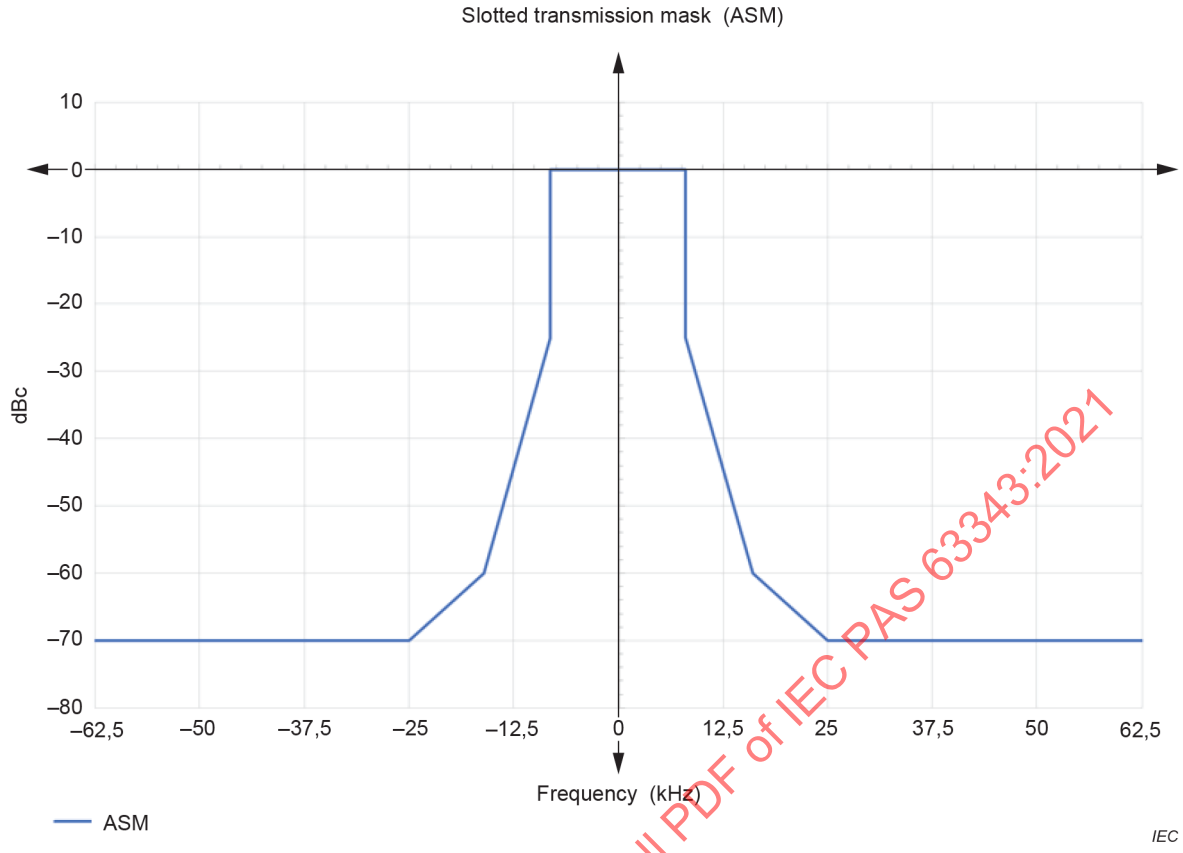

Figure 1 – Slotted transmission spectrum for ASM

For output power less than 1 W, the maximum transmission power level outside ±16 kHz shall not exceed –36 dBm.

The modulation accuracy shall give an RMS vector error in any burst less than [0,1] and the peak vector error magnitude shall be less than [0,3] for any symbol.

Requirements on transmitter power versus time characteristics are given in Table 2 and Figure 2. Blue line in Figure 2 is an example of transmitter power during ramp up and ramp down. For multi-slot transmissions the ramp down and guard periods (from T_E via T_G to T_0) take place at the end of the last transmission slot and sync sequence and payload period (T_B … T_E) extends through all transmission slots.

Table 2 – Transmitter power versus time characteristics

Reference	Symbols	Time ms	Definition
T_0	0	0	Start of transmission slot Power should < –50 dB of P_{ss} before T_0
	0 to 4	0 to 0,416	Power should not exceed +1,5 dB of P_{ss}
T_B	4	0,416	P_{ss} = 3,4 dB + mean power measured between T_B and T_E [b]
T_E [a]	239 or 244[a]	24,896 / 25,417[a]	
	239 to 243 or 244 to 248[a]	24,896 to 25,313 or 25,417 to 25,833[a]	Power should not exceed +1,5 dB of P_{ss}
T_G	248 to 0	25,833 to 26,667	Power should be < –50 dB of P_{ss} and stay below this for the remainder of the transmission slot

[a] T_E can vary based on burst length and can be either at symbol 239 or 244. Ramp down is always 4 symbols in length.

[b] 3,4 dB represents the 3,35 dB PAPR for the test signal used (pi/4 QPSK).

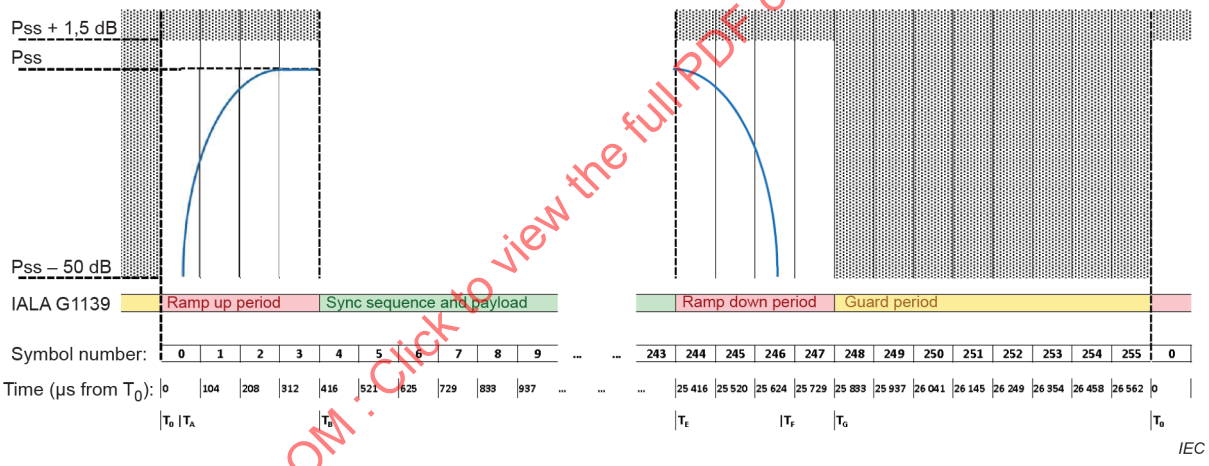

Figure 2 – Transmitter power versus time characteristics for π/4 QPSK (ASM)

5.1.3.7.2 Receiver requirements

The receiver of the equipment shall comply with the requirements of Table 3.

Table 3 – Receiver requirements without FEC (using Link ID 1)

Receiver parameters	Requirements		Note
	Normal	Extreme	
Sensitivity	20 % PER at −107 dBm 20 % PER at -104 dBm at ±250 Hz offset	20 % PER at −104 dBm	3
Error behaviour at high input levels	1 % PER at −77 dBm peak 1 % PER at −7 dBm peak	No specific requirement	-
Co-Channel rejection	20 % PER at 13 dB 20 % PER at 13 dB at unwanted signal ±500 Hz offset	No specific requirement	3,2
Adjacent channel selectivity	20 % PER at 70 dB	No specific requirement	2
Spurious response rejection	20 % PER at 70 dB	No specific requirement	1
Intermodulation response rejection	20 % PER at 71 dB	No specific requirement	-
Spurious emissions	−57 dBm (9 kHz to 1 GHz) −47 dBm (1 GHz to 4 GHz)	No specific requirement	1
Blocking	20 % PER at 86 dB	No specific requirement	1
Notes: 1: These parameters are the same as AIS (IEC 61993-2) 2: Interferer is pi/4QPSK continuous PRBS 3: The offsets are half the values used in AIS (61993-2) as the frequency accuracy in ASM is much better			

5.1.3.8 Presentation Interface (PI)

The equipment shall have a Presentation Interface (PI) for following functions:

a) input of information from other onboard equipment to be transmitted to other ASM stations by the Equipment;

b) output of all received ASM VDL data applicable to own station;

c) signal equipment internal status information to and accept related commands from other onboard equipment.

The Equipment shall be capable of assembling the entire received MITDMA chain and thereafter output the data using ASM sentence. Information received from incomplete chains shall be discarded, i.e. the received partial information shall not be output through PI using ASM sentence. In addition, the Equipment may optionally be capable of outputting all received ASM VDL radio messages relevant to own station using ADM sentence.

The Equipment shall be capable of assembling the complete payload input by related PI sentences before scheduling transmission on ASM VDL. If the Equipment detects inconsistency in the data input through PI (for example checksum error, missing sentence, interrupted input of sentences), the Equipment shall output negative acknowledgement using AMK sentence and shall discard information already received.

5.1.3.8.1 Interface for input data to be transmitted to ASM VDL

This interface shall comply with requirements described in IEC 61162-450. Table 4 defines the IEC 61162-1 talker identifiers and sentence formatters that shall be used when outputting ASM VDL data. The details of sentence formatters are described in Annex A. The timeout for input of all sentences required for transmission is 10 s. If the input of all sentences has not been

completed by the timeout, the Equipment shall output NAK sentence with an appropriate reason code ("8 = multi-sentence message not accepted due to sentence timeout").

The equipment may offer capability to serve multiple external applications by means of [IEC 61162-450 TAG block and by use of NAK (on PI related) and AMK (on VDL related)].

Table 4 – IEC 61162 Talker identifiers and sentence formatters used for input of data to Equipment for transmission to ASM VDL

Talker ID	Sentence formatter	Direction	Note
(any)	AAB[a]	Input	ASM Selective Addressed Message
	ABB[a]	Input	ASM Broadcast Message
	AGB	Input	ASM Geographical Multicast Message
	NAK	Output	ASM Addressed and Broadcast Message Acknowledgement for PI
[VA]	AMK	Output	ASM Addressed and Broadcast Message Acknowledgement
[a] Mobile station shall always transmit own (programmed) MMSI and shall ignore the input source ID, if provided by the input sentence.			

The Equipment shall be capable of supporting multiple external equipment through PI.

5.1.3.8.2 Interface to output received ASM VDL information

This interface shall comply with requirements described in IEC 61162-450. Table 5 defines the IEC 61162-1 sentence formatters that shall be used for output of ASM VDL data from Equipment. The details of sentence formatters are described in Annex A.

Table 5 – IEC 61162 sentence formatters used to output ASM VDL

Talker ID	Sentence formatter	Direction	Note
[VA]	ASM[a, c]	Output	Received ASM message assembly
	ADM[b]	Output	Received ASM VHF Data-Link Message
	ADO	Output	ASM VHF Data-Link Own-Vessel Report
(any)	ASQ[a]	Input	Query for ASM sentence content
[a] ASM sentence is output when a complete ASM VDL message/MITDMA chain has been received; it can also be queried by means of ASQ sentence. [b] Implementation of ADM sentence is optional for mobile station as ASM sentence is expected to convey the information applicable to equipment connected to own station PI. [c] Mobile station shall discard messages having satellite as intended destination (applies to ASM sentence VDL channel designations 3 and 4).			

[The Equipment shall store a minimum of [10] most recently received and successfully assembled ASM messages. Stored (i.e. successfully assembled) messages shall be output when ASM sentence is queried using ASQ sentence.]

5.1.3.8.3 Interface for exchanging alert information, equipment status and related commands

This interface shall comply with requirements described in IEC 61162-450. Table 6 defines the IEC 61162-1 sentence formatters that shall be used for outputting alerts, equipment status information to and inputting related commands from other onboard equipment.

Table 6 – IEC 61162 sentence formatters used to output equipment status and input related commands

Function	Sentence formatter	Note
Alerts	ACN, ARC, ALC, ALF,HBT	For details, see IEC 62923 (all parts) and IEC 61162-1
Local network and equipment integrity	HBT	Heartbeat between Equipment and external applications
Configuration	EPV	[Required property identifiers are to be defined]
Equipment status information	TXT	[Required TXT sentence contents are to be defined]
Software version	VER	See IEC 61162-1

The Equipment shall allow query of output sentences as indicated in Table 5 and Table 6. Conditions that may cause the Equipment to release alert include but are not restricted to:

- TX fault;
- RX fault;
- antenna fault.

5.1.3.9 Link layer requirements

5.1.3.9.1 General rules

The following general rules apply to Equipment:

- the Equipment shall at least be able to receive and transmit on channels ASM1 and ASM2;
- the Equipment shall, as a default, be identified by its own Unique Identifier on the VDL interface;
- the Equipment shall autonomously and as a response to query provide a vendor ID using a self-identification message on AIS VDL;
- the Equipment shall transmit using no more than 50 slots per frame (excluding available slots for use of retransmission of addressed data) on each of the two ASM channels (100 slots together);
- the equipment shall implement mandatory Quiet Time after each successful MITDMA transaction or a single non-MITDMA transmission;
- a maximum amount of 15 MITDMA transmissions per frame are allowed;
- transmission of an MITDMA chain shall be completed on same ASM channel (no channel switching);
- the Equipment shall as a minimum support reception of [10] in-progress MITDMA chains. In-progress MITDMA chains should be prioritized if the maximum number of supported in-progress MITDMA chains is exceeded;
- the Equipment shall not transmit bursts exceeding the length of 3 slots;
- received VDL messages shall be passed to the PI as an ASM sentence according to Table 7 if either broadcast or addressed to the own station;
- the Equipment shall transmit messages according to AAB, ABB and AGB sentences that are input to PI of the Equipment;
- every message transmitted on the VDL shall be passed to the PI as a ADO sentence;
- the TDMA receive process shall not be dependent on slot boundaries.

5.1.3.9.2 Re-transmissions

Addressed MITDMA chain data that has not been confirmed as received shall be re-transmitted. Following rules apply for re-transmissions:

- the addressed receiver shall transmit an acknowledgment after receipt of the last block of the chain or timeout after the latest possible time for the receipt of the last block. The receiver acknowledgement timeout T_{ack} is calculated as follows:

  T_{ack} = (number of blocks remaining after the last received block) x 255 slots.

- upon failure to receive an acknowledgement from the addressed station within a timeout, the Equipment may re-transmit the entire chain if the retry slot budget and retry count so allows. The transmitter wait-for-ack-from-destination timeout T_{wait} is referenced from the start of the first block and is calculated as follows:

  T_{wait} = ((number of blocks in a chain) + 1) x 255 slots

- the amount of 50 slots allowance per frame (see 5.1.3.9.1) does not include re-transmissions;
- usage of up to 22 slots (3 x 7 + 1) for re-transmission in addition to the transmission limit (of 50 slots per frame) is allowed;
- the Equipment shall not make more than 3 re-transmission attempts.

5.1.3.9.3 Equipment interaction on the VDL

5.1.3.9.3.1 VDL messages overview

The interaction of the Equipment on the VDL is presented in Table 7.

Table 7 – Use of ASM VDL messages

Message ID	Name	Description	Access scheme	Communication State
0	Broadcast AIS ASM Message	Encapsulated AIS ASM messages that are output at receiving mobile station PI by using VDM sentence	RATDMA	none
1	Scheduled Broadcast Message	Broadcast data using communication state	RATDMA MITDMA	MITDMA
2	Broadcast Message	Broadcast data with no communication state	RATDMA	none
3	Scheduled Individual Addressed Message	Individual addressed data with communication state. Requires acknowledgement	RATDMA MITDMA	MITDMA
4	Individual Addressed Message	Individual addressed data with no communication state. Requires acknowledgement	RATDMA	none
5	Acknowledgment Message	This message is used to provide and acknowledgment for one or more addressed messages	RATDMA MITDMA[a]	none
6	Geographical Multicast Message	Addressed to a group of stations defined by their geographical location with no communication state. No acknowledgment required.	RATDMA	none

[a] ASM Message 5 utilizes the MITDMA Commstate of the transmitting (other) station sending the message to own station.

For definitions of Message 1-6, see IALA G1139.

5.1.3.9.3.2 Definition of Message 0

ASM Message 0 may contain encapsulated AIS Messages 6, 8, 12, 14, 21, 25 or 26. Acknowledgement is not supported for addressed messages. This message type is for terrestrial use only.

The encapsulated message may or may not be transmitted on AIS1 or AIS2 channels.

If the encapsulation repeats a Message that was transmitted on AIS1 or AIS2 channel, the encapsulation and transmission of messages shall be performed as soon as possible, according to configuration, after receiving the relevant messages which are required to be retransmitted.

The communication state of the encapsulated message shall always be set to zero at encapsulation.

The receiving station shall output all received encapsulated AIS Messages at the PI immediately after reception. [The AIS channel field in the corresponding VDM sentences should be set to null.] The data (Messages) encapsulated in Message 0 may be output in a separate PI port. In case of congestion over the PI:

- the Equipment shall indicate this to user and
- data received through AIS shall have priority over data received through ASM.

Table 8 – Message 0 description

Parameter	Number of bits	Description
Message ID	4	0 – Selected AIS messages that are output at receiving mobile station PI by using VDM sentence with no communication state
Retransmit flag	1	0 (reserved for future use)
Repeat Indicator	2	If the encapsulation repeats a Message that was transmitted on AIS1 or AIS2 channel, this is used to indicate how many times a message has been repeated. Encapsulation represents one repeat. Possible values: 0 – 3: 0 = default, shall be used in case where the message is sent only on ASM channel(s); 1: also transmitted on AIS channel(s); 2, 3 = also transmitted on AIS channel(s) and repeated as counted by the repeat indicator on ASM channel.
Session ID	6	The Session ID associates the VDL transmission with a specific PI transaction
Source ID	32	The Unique Identifier of the transmitting station as described in IALA G1139 Ed.3 Annex 1 section 3.2
Data Count	11	Size of actual data in Binary Data and ASM Identifier field in bits, excluding padding bits range: from 1 to maximum data count
Binary Data	1 slot – 296 / 200 2 slot – 808 / 584 3 slot – 1320 / 968	Content is encapsulated AIS Messages that are channelled through ASM Channels. The Message 0 is transmitted only by Base Stations. Receiver is expected to be ASM-capable mobile station where the ASM-box would relay the encapsulated AIS messages to local presentation interface. The encapsulated AIS Messages would then be output at the PI using VDM sentence. The arrangement would thus be compliant with existing nav presentations. Application data as specified by the ASM Identifier. The available length of the binary data is specified by the LinkConfigId.

5.1.3.9.4 Equipment configuration parameters

[Future: Current idea is to require configuration parameter for Source ID (to be set by EPV sentence through PI)]

5.1.3.9.5 Access to the data link

MITDMA and RATDMA access schemes shall be used for controlling access to the data transfer medium. The amount of data input through PI determines the access scheme to be used.

NOTE No intentional slot reuse.

The maximum number of slots used by one station on one channel shall not exceed 50 slots within one frame (2250 slots) (2.2% duty cycle), excluding up to 22 slots available for use for retransmission of addressed data. No more than three re-transmission attempts of the same data shall be made.

The Equipment shall be capable of transmitting broadcasts using MITDMA. In this case, there will be no acknowledgements and the quiet time will start immediately after completion of the last MITDMA transmit block.

5.1.3.9.5.1 Selection of candidate slots

Slots, used for transmission, are selected from minimum of 8 candidate slots in the selection interval (SI) which is defined as 235 slots.

The selection process shall use received data from ASM. Data received from AIS and VDE shall also be used by the selection process if these functions are part of the Equipment or if installation so requires.

NOTE Installation of ASM Equipment may have co-located antennas with AIS (Future: or with VDE equipment). Such installation may require the ASM Equipment to use data received from AIS and VDE in the candidate slot selection process (see 5.1.3.11).

Ruleset 1: no AIS dependency: the Equipment shall only use free slots with the minimum of 8 slots to choose from.

Ruleset 2: AIS [Future: or VDE] dependency is required from ASM equipment: see 5.1.3.11.

5.1.3.10 Network layer requirements

5.1.3.10.1 Data link congestion resolution

ASM channel loading shall be measured independently per channel over a window of the past one minute (2250 slots).

5.1.3.10.1.1 Mandatory quiet times

After the completion of a singular Non-MITDMA ASM channel transmission or a complete MITDMA transmission block chain including retransmissions, the ASM station shall wait for a specific time before additional transmission can be scheduled. This time is referred to as Quiet Time. The Selection Interval for finding candidate transmission slots starts after the Quiet Time.

The Quiet Time shall be increased with a multiplier, depending on channel load as per following equation and multipliers described in Table 9.

Quiet Time [seconds] = (Number of transmitted slots in previous complete chain) * (Multiplier)

Table 9 – Quiet time multiplier

Channel load	Multiplier
< 1 0%	1
10 % to 30 %	2
< 30 %	3

For a singular transmission, Quiet Time shall per default be one second per transmission slot used.

For an MITDMA linked transmission chain, the Quiet Time is a function of the number of transmission slots within that chain, including retransmissions. The Quiet Time shall be increased by one second per time slot used in the transmission chain.

5.1.3.11 Interoperability of functions within one station

5.1.3.11.1 Common requirements for stations with any functional combination

Slot states for slot selection process are defined in IALA G1139.

[Future: No transmissions during VDE bulletin board reserved timeslots.]

The candidate slots are primarily selected from slots that are free on AIS and ASM.

NOTE No intentional slot re-use on ASM channels.

5.1.3.11.2 Selection criteria of candidate slots for ASM transmissions when ASM function is co-located in same Equipment with AIS

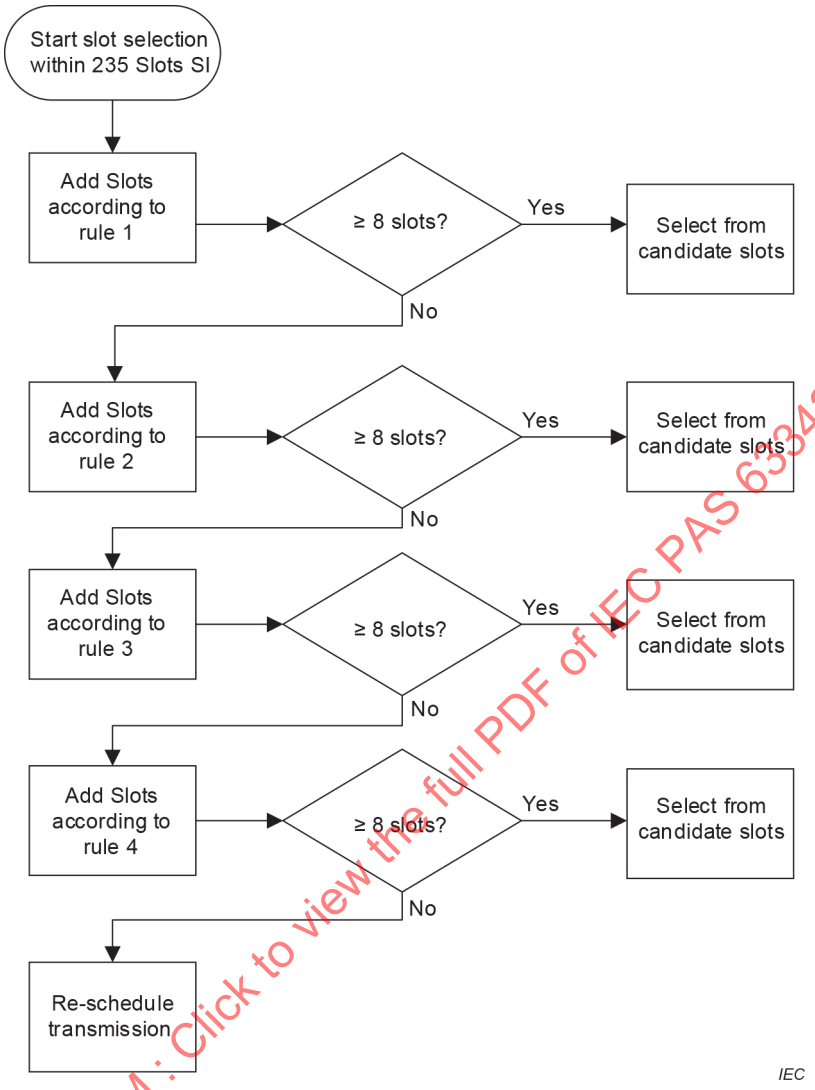

Figure 3 – Slot selection Criteria Flow Chart

Selection criteria rules:

Rule 1: free on both ASM channels (to avoid loss of incoming data) and free on both AIS1 and AIS2;

Rule 2: free on both ASM channels and available on one AIS channel and free on another AIS channel;

Rule 3: free on both ASM channels and available on both AIS channels.

Rule 4: free on transmit ASM channel, not expecting rx under interest of own station on the other ASM channel and available on both AIS channels

The available AIS slots are as defined in Recommendation ITU-R M.1371 and shall only be taken from the most distant station(s) within the SI followed by randomization among the 8 most distant candidate stations.

When selecting candidates for messages greater than one (1) slot, a candidate slot should be the first slot of a consecutive block of slots that all conform to the selection criteria stated above.

If the station cannot find sufficient number of candidate slots, the station shall not transmit and shall re-schedule the transmission.

5.2 Coast Station

5.2.1 Overview

This section specifies the minimum operational and performance requirements, methods of testing and required test results for ASM Coast Stations.

It takes into consideration the technical characteristics of non-shipborne, fixed station AIS equipment, included in recommendation ITU-R M.1371, IALA Recommendation A-124 as well as ITU-R M.2092 (see 5.2.3.11).

ASM coast station is intended to be used as a fixed installation. The main high-level functions of the ASM coast station are:

a) transmit through ASM VHF Data Link (ASM VDL) information which is input to ASM coast station by other equipment or systems through Presentation Interface (PI);

b) output all information received from ASM VDL applicable to own station, through PI so that this information is available to other equipment or systems;

c) handle applicable ASM radio station duties.

In following text, term "Equipment" is used to refer to ASM coast station.

5.2.2 General requirements

The Equipment shall as a minimum fulfil requirements set in IEC 62320-1, with exceptions as detailed in this document for interoperability between AIS and ASM transmission and reception.

5.2.2.1 Power supply

Manufacturer shall specify the properties of power supply.

5.2.2.2 Update of software

The Equipment shall provide means for updating software of the equipment and to report, on demand, the current applicable software version.

5.2.3 Technical requirements

5.2.3.1 Transmitter shutdown procedure

(M.1371-5/A2-2.13) *An automatic transmitter hardware shutdown procedure and indication* shall *be provided in case a transmitter continues to transmit for more than 2 s. This shutdown procedure* shall *be independent of software control.*

5.2.3.2 Permissible initialization period

The Equipment shall be operational within 2 minutes of switching on.

5.2.3.3 Transceiver protection

Transceiver protection requirements in IEC 62320-1 apply.

5.2.3.4 TX malfunction

The Equipment shall be able to detect malfunction of transmitter and signal this condition through Presentation Interface (see 5.2.3.8.3).

5.2.3.5 Antenna VSWR

Equipment shall be able to detect excess VSWR at antenna and signal this condition though Presentation Interface (see 5.2.3.8.3).

5.2.3.6 RX malfunction

Equipment shall be able to detect malfunction of receiver and signal this condition through Presentation Interface (see 5.2.3.8.3).

5.2.3.7 Physical layer

5.2.3.7.1 TDMA transmitter

The transmitter shall comply with following requirements in addition to requirements set in IEC 62320-1.

Transmission characteristics as described in Table 10 and Figure 4 shall apply for transmission of ASM messages.

Table 10 – Slotted transmission spectrum for ASM

Transmitter parameters	Requirements	Condition
Frequency error	± 1,5 ppm	normal
	± 3 ppm	extreme
Transmit power capability	Transmit average power should be 1 Watt at low power setting and 12,5 Watt at high power setting. ±1,5 dB normal, +2/−6 dB extreme	Conducted
Slotted modulation mask	Δfc < ±8 kHz: 0 dBc (PEP of transmitted signal) ±8 kHz < Δfc < ±16 kHz: below the straight line between −25 dBc at ±8 kHz and –60 dBc at ±16 kHz ±16 kHz < Δfc < ±25 kHz: below the straight line between −60 dBc at ±16 kHz and –70 dBc at ±25 kHz ±25 kHz < Δfc < ±62,5 kHz: −70 dBc	
Spurious emissions	−36 dBm	9 kHz to 1 GHz
	−30 dBm	1 GHz to 4 GHz

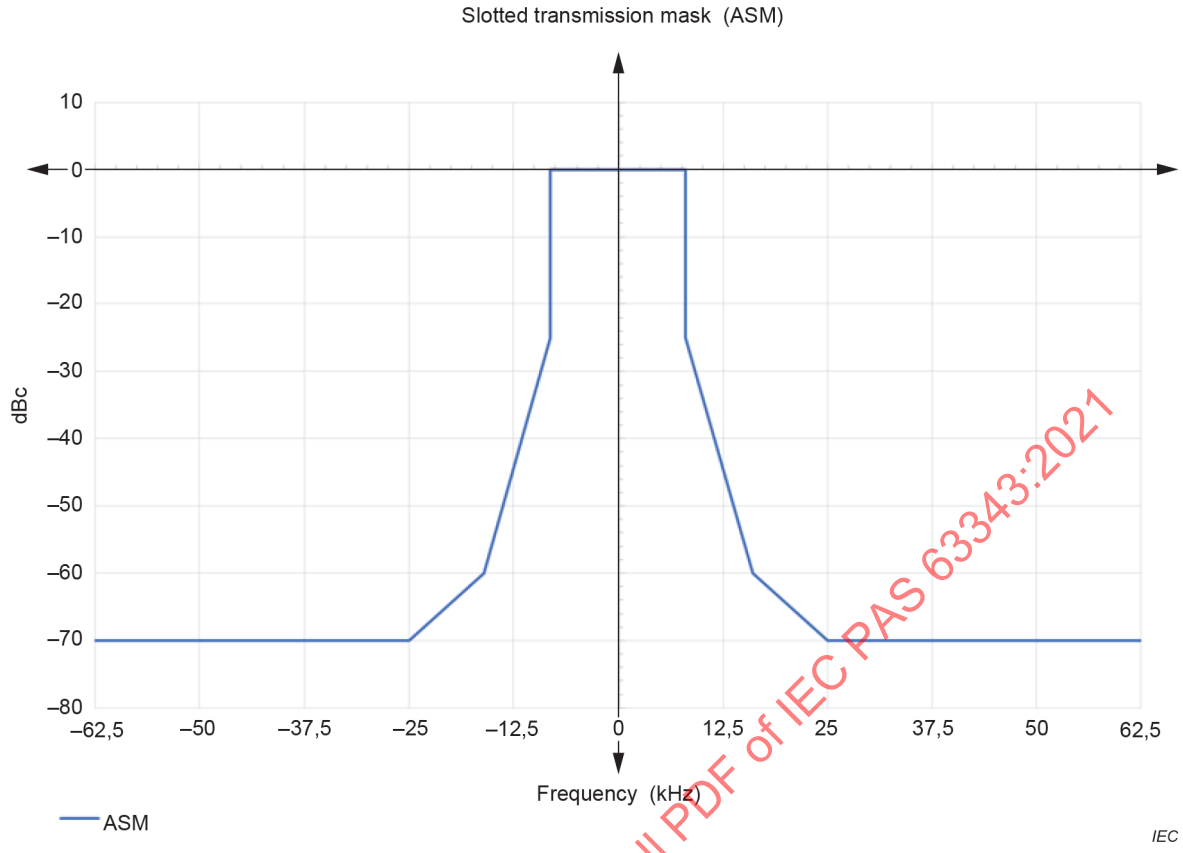

Figure 4 – Slotted transmission spectrum for ASM

For output power less than 1 W, the maximum transmission power level outside ±16 kHz shall not exceed –36 dBm.

The modulation accuracy shall give an RMS vector error in any burst less than [0,1] and the peak vector error magnitude shall be less than [0,3] for any symbol.

Requirements on transmitter power versus time characteristics are given in Table 11 and Figure 5. For multi-slot transmissions the ramp down and guard periods (from T_E via T_G to T_0) take place at the end of the last transmission slot and sync sequence and payload period (T_B … T_E) extends through all transmission slots.

Table 11 – Transmitter power versus time characteristics

Reference	symbols	Time (ms)	Definition
T_0	0	0	Start of transmission slot. Power should < –50 dB of P_{ss} before T_0
	0 to 4	0 to 0,416	Power should not exceed +1.5 dB of P_{ss}
T_B	4	0.416	P_{ss} = 3,4 dB + mean power measured between T_B and T_E [b]
T_E [a]	239 or 244[a]	24,896 / 25,417[a]	
	239 to 243 or 244 to 248[a]	24,896 to 25,313 or 25,417 to 25,833[a]	Power should not exceed +1,5 dB of P_{ss}
T_G	248 to 0	25,833 to 26,667	Power should be < –50 dB of P_{ss} and stay below this for the remainder of the transmission slot

[a] T_E can vary based on burst length and can be either at symbol 239 or 244. Ramp down is always 4 symbols in length.

[b] 3,4 dB represents the 3,35 dB PAPR for the test signal used (pi/4 QPSK).

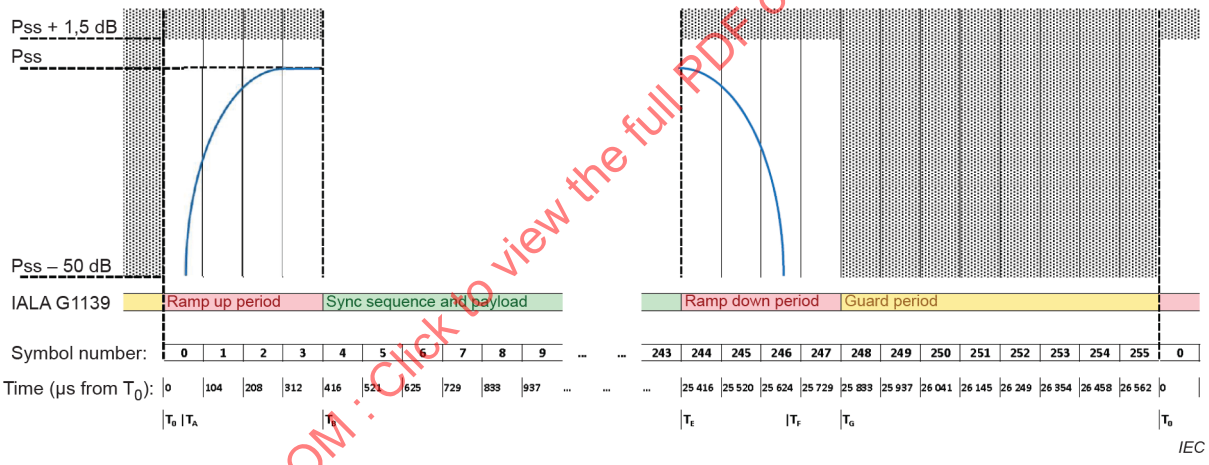

Figure 5 – Transmitter power versus time characteristics for π/4 QPSK (ASM)

5.2.3.7.2 Receiver requirements

The receiver of the equipment shall comply with following requirements.

Table 12 – Receiver requirements without FEC (using Link ID 1)

Receiver parameters	Requirements		Note
	Normal	Extreme	
Sensitivity	20% PER at −107 dBm 20% PER at -104 dBm at +/-250 Hz offset	20% PER @ -104 dBm	3
Error behaviour at high input levels	1% PER at −77 dBm peak 1% PER at −7 dBm peak	No specific requirement	-
Co-Channel rejection	20% PER at 13 dB 20% PER at 13 dB at unwanted signal +/-500 Hz offset	No specific requirement	3,2
Adjacent channel selectivity	20% PER at 70 dB	No specific requirement	2
Spurious response rejection	20% PER at 70 dB	No specific requirement	1
Intermodulation response rejection	20% PER at 71 dB	No specific requirement	-
Spurious emissions	−57 dBm (9 kHz to 1 GHz) −47 dBm (1 GHz to 4 GHz)	No specific requirement	1
Blocking	20% PER at 86 dB	No specific requirement	1
NOTES: 1: These parameters are the same as AIS (IEC 61993-2) 2: Interferer is pi/4QPSK continuous PRBS 3: The offsets are half the values used in AIS (61993-2) as the frequency accuracy in ASM is much better			

5.2.3.8 Presentation Interface (PI)

The equipment shall have a Presentation Interface (PI) for following functions:

a) Input of information from other equipment or system to be transmitted to other ASM stations by the Equipment;

b) Output of all received ASM VDL data;

c) Signal equipment internal status information to and accept related commands from other equipment or system.

The Equipment shall be capable of assembling the entire received MITDMA chain and thereafter output the data using ASM sentence. Information received from incomplete chains shall be discarded i.e. the received partial information shall not be output through PI using ASM sentence. In addition, the Equipment shall be capable of outputting all received VDL messages station using ADM sentence. [Future: consider aspects related to network].

The Equipment shall be capable of assembling the complete payload input by related PI sentences before scheduling transmission on ASM VDL. If the Equipment detects inconsistency in the data input through PI (for example checksum error, missing sentence, interrupted input of sentences), the Equipment shall output negative acknowledgement using AMK sentence and shall discard information already received.

5.2.3.8.1 Interface for input data to be transmitted to ASM VDL

This interface shall comply with requirements described in IALA A-124. Table 13 defines the IEC 61162-1 talker identifiers and sentence formatters that shall be used when outputting ASM VDL data. The details of Sentence Formatters are described in Annex A of this document. The timeout for input of all sentences required for transmission is 10 seconds. If the input of all sentences has not been completed by the timeout, the Equipment shall output NAK sentence

with an appropriate reason code ("8 = multi-sentence message not accepted due to sentence timeout").

The equipment may offer capability to serve multiple external applications by means of [IEC 61162-450 TAG block and by use of NAK (on PI related) and AMK (on VDL related)].

Table 13 – IEC 61162 Talker Identifiers and Sentence Formatters used for input of data to Equipment for transmission to ASM VDL

Talker ID	Sentence formatter	Direction	Note
(any)	AAB	Input	ASM Selective Addressed Message
	ABB	Input	ASM Broadcast Message
	AGB	Input	ASM Geographical Multicast Message
[VA]	AMK	Output	ASM Addressed and Broadcast Message Acknowledgement
	NAK	Output	ASM Addressed and Broadcast Message Acknowledgement for PI

5.2.3.8.2 Interface to output received ASM VDL information

This interface shall comply with requirements described in IALA A-124. Table 14 defines the IEC 61162-1 sentence formatters that shall be used for output of ASM VDL data from Equipment. The details of Sentence Formatters are described in Annex A of this document.

Table 14 – IEC 61162 Sentence Formatters used to output ASM VDL

Talker ID	Sentence formatter	Query yes/no	Note
[VA]	ASM	yes[a]	Received ASM application data
	ADM	[tbd]	Received ASM VHF Data-Link Message
	ADO	[tbd]	ASM VHF Data-Link Own-Vessel Report
(any)	ASQ	Input	Query for ASM sentence content

[a] ASM sentence is output when a complete ASM VDL message/MITDMA chain has been received, it can also be queried by means of ASQ sentence.

[The Equipment shall store a minimum of [10] most recently received and successfully assembled ASM messages. All stored messages shall be output when ASM sentence is queried.]

5.2.3.8.3 Interface for exchanging alert information, equipment status and related commands

This interface shall comply with requirements described in IALA A-124. Table 15 defines the IEC 61162-1 and NMEA 0183 sentence formatters that shall be used for outputting alerts, equipment status information to and inputting related commands from other equipment or systems.

Table 15 – IEC 61162 Sentence Formatters used to output equipment status and input related commands

Function	Sentence formatter	Query yes/no	Note
Alerts	ALR	[tbd]	
Local network and equipment integrity	ALR	yes	Heartbeat between Equipment and external applications
Configuration	ACC, [New sentences equivalent to DLM, ECB, SPO, TPC, MEB/CBR]	[tbd]	[sentences awaiting development]
Equipment status information	FSR, VSI	No	FSR for ASM1 and ASM2 and VSI for the received ADM message shall be grouped in TAG block. (TODO:FSR sentence to be amended to provide information about incomplete messages received)
Dependent coast station equipment status information	[New sentences equivalent to TFR, TSA+ADM, TSR]	[tbd]	[tbd]
Software version	VER	yes	See IEC 61162-1

The Equipment shall allow query of output sentences as indicated in tables. Conditions that may cause the Equipment to release alert include but are not restricted to:

- TX fault
- RX fault
- Antenna fault

5.2.3.9 Link layer requirements

5.2.3.9.1 General rules

The following general rules apply to Equipment:

- the Equipment shall be able to receive and transmit on channels ASM1 and ASM2;
- the Equipment shall, as a default, be identified by its AIS Identifier on the VDL interface;
- the Equipment shall autonomously and as a response to query provide a vendor ID using a self-identification message on AIS VDL;
- the Equipment should be able to query other stations for self-identification message;
- transmission of an MITDMA chain shall be completed on same ASM channel (no channel switching);
- the Equipment shall as a minimum support reception of [10] in-progress MITDMA chains. In-progress MITDMA chains should be prioritized if the maximum number of supported in-progress MITDMA chains is exceeded;
- the Equipment shall not transmit bursts exceeding the length of 3 slots;
- received VDL messages shall be passed to the PI as a ADM sentence according to Table 14;
- the Equipment shall transmit messages according to AAB, ABB and AGB sentences that are input to PI of the Equipment;
- every message transmitted on the VDL shall be passed to the PI as a ADO sentence;
- the TDMA receive process shall not be dependent on slot boundaries.

5.2.3.9.2 Re-transmissions

Addressed MITDMA chain data that has not been confirmed as received shall be re-transmitted. Following rules apply for re-transmissions:

- the addressed receiver shall transmit an acknowledgment after receipt of the last block of the chain or timeout after the latest possible time for the receipt of the last block. The receiver acknowledgement timeout T_{ack} is calculated as follows:

  T_{ack} = (number of blocks remaining after the last received block) x 255 slots.

- upon failure to receive an acknowledgement from the addressed station within a timeout, the Equipment may re-transmit the entire chain if the retry slot budget and retry count so allows. The transmitter wait-for-ack-from-destination timeout T_{wait} is referenced from the start of the first block and is calculated as follows:

  T_{wait} = ((number of blocks in a chain) + 1) x 255 slots

- the Equipment shall not make more than 3 re-transmission attempts.

5.2.3.9.3 Equipment interaction on the VDL

5.2.3.9.3.1 VDL messages overview

The interaction of the Equipment on the VDL is presented in Table 16.

Table 16 – Use of ASM VDL messages

Message ID	Name	Description	Access scheme	Communication State
0	Broadcast AIS ASM Message	Encapsulated AIS ASM messages that are output at receiving mobile station PI by using VDM sentence	RATDMA	none
1	Scheduled Broadcast Message	Broadcast data using communication state	RATDMA MITDMA	MITDMA
2	Broadcast Message	Broadcast data with no communication state	RATDMA	none
3	Scheduled Individual Addressed Message	Individual addressed data with communication state. Requires acknowledgement	RATDMA MITDMA	MITDMA
4	Individual Addressed Message	Individual addressed data with no communication state. Requires acknowledgement	RATDMA	none
5	Acknowledgment Message	This message is used to provide and acknowledgment for one or more addressed messages	RATDMA MITDMA[a]	none
6	Geographical Multicast Message	Addressed to a group of stations defined by their geographical location with no communication state. No acknowledgment required.	RATDMA	none

[a] ASM Message 5 utilizes the MITDMA Commstate of the transmitting (other) station sending the message to own station.

For definitions of Message 1-6, see IALA G1139.

5.2.3.9.3.2 Definition of Message 0

ASM Message 0 may contain encapsulated AIS Messages 6, 8, 12, 14, 21, 25 or 26. Acknowledgement is not supported for addressed messages. This message type is for terrestrial use only.

The encapsulated message may or may not be transmitted on AIS1 or AIS2 channels.

If the encapsulation repeats a Message that was transmitted on AIS1 or AIS2 channel, the encapsulation and transmission of messages shall be performed as soon as possible, according to configuration, after receiving the relevant messages which are required to be retransmitted.

The communication state of the encapsulated message shall always be set to zero at encapsulation.

The receiving station shall output all received encapsulated AIS Messages at the PI immediately after reception. [The AIS channel field in the corresponding VDM sentence should be set to null.] The data (Messages) encapsulated in Message 0 may be output in a separate PI port. In case of congestion over the PI:

- the Equipment shall indicate this to user;
- data received through AIS shall have priority over data received through ASM.

Table 17 – Message 0 description

Parameter	Number of bits	Destination
Message ID	4	0 – Selected AIS messages that are output at receiving mobile station PI by using VDM sentence with no communication state
Retransmit flag	1	0 (reserved for future use)
Repeat Indicator	2	If the encapsulation repeats a Message that was transmitted on AIS1 or AIS2 channel, this is used to indicate how many times a message has been repeated. Encapsulation represents one repeat. Possible values: 0 – 3: 0 = default, shall be used in case where the message is sent only on ASM channel(s); 1: also transmitted on AIS channel(s); 2, 3 = also transmitted on AIS channel(s) and repeated as counted by the repeat indicator on ASM channel.
Session ID	6	The Session ID associates the VDL transmission with a specific PI transaction
Source ID	32	The Unique Identifier of the transmitting station as described in IALA G1139, Annex 1, 3.2
Data Count	11	Size of actual data in Binary Data and ASM Identifier field in bits, excluding padding bits range: from 1 to maximum data count
Binary Data	1 slot – 296 / 200 2 slot – 808 / 584 3 slot – 1320 / 968	Content is encapsulated AIS Messages that are channelled through ASM Channels. The Message 0 is transmitted only by Base Stations. Receiver is expected to be ASM-capable mobile station where the ASM-box would relay the encapsulated AIS messages to local presentation interface. The encapsulated AIS Messages would then be output at the PI using VDM sentence. The arrangement would thus be compliant with existing nav presentations. Application data as specified by the ASM Identifier. The available length of the binary data is specified by the LinkConfigId.

5.2.3.9.4 Equipment configuration parameters

[Future: Current idea is to require configuration parameters (to be set by [TBD] sentences through PI)]

5.2.3.9.5 Access to the data link

MITDMA and RATDMA access schemes shall be used for controlling access to the data transfer medium. The amount of data input through PI determines the access scheme to be used.

NOTE No intentional slot reuse.

The Equipment shall be capable of transmitting broadcasts using MITDMA. In this case, there will be no acknowledgements.

[Future: Placeholder for requirements on FATDMA]

5.2.3.9.5.1 Selection of candidate slots

Slots, used for transmission, are selected from minimum of 8 candidate slots in the selection interval (SI) which is defined as 235 slots.

The selection process shall use received data from ASM. Data received from AIS and VDE shall also be used by the selection process if these functions are part of the Equipment or if installation so requires.

NOTE Installation of ASM Equipment may have co-located antennas with AIS (Future: or with VDE equipment). Such installation may require the ASM Equipment to use data received from AIS and VDE in the candidate slot selection process (see 5.2.3.11).

Ruleset 1: no AIS dependency: the Equipment shall only use free slots with the minimum of 8 slots to choose from.

Ruleset 2: AIS (Future: or VDE) dependency is required from ASM equipment: see 5.2.3.11.

5.2.3.10 Network layer requirements

5.2.3.10.1 Data link congestion resolution

ASM channel loading shall be measured independently per channel over a window of the past one minute (2250 slots).

5.2.3.10.1.1 [Mandatory quiet times [TBD]

After the completion of a singular Non-MITDMA ASM channel transmission or a complete MITDMA transmission block chain including retransmissions, the ASM station shall wait for a specific time before additional transmission can be scheduled. This time is referred to as Quiet Time. The Selection Interval for finding candidate transmission slots starts after the Quiet Time.

The Quiet Time shall be increased with a multiplier, depending on channel load as per following equation and multipliers described in Table 18.

Quiet Time [seconds] = (Number of transmitted slots in previous complete chain) * (Multiplier)

Table 18 – Quiet time multiplier

Channel load	Multiplier
< 10 %	1
10 % to 30 %	2
> 30 %	3

For a singular transmission, Quiet Time shall per default be one second per transmission slot used.

For an MITDMA linked transmission chain, the Quiet Time is a function of the number of transmission slots within that chain, including retransmissions. The Quiet Time shall be increased by one second per time slot used in the transmission chain.]

5.2.3.11 Interoperability of functions within one station

5.2.3.11.1 Common requirements for stations with any functional combination

Slot states for slot selection process are defined in IALA G1139.

The candidate slots are primarily selected from slots that are free on AIS and ASM.

NOTE No intentional slot re-use on ASM channels.

5.2.3.11.2 Selection criteria of candidate slots for ASM transmissions when ASM function is co-located in same Equipment with AIS

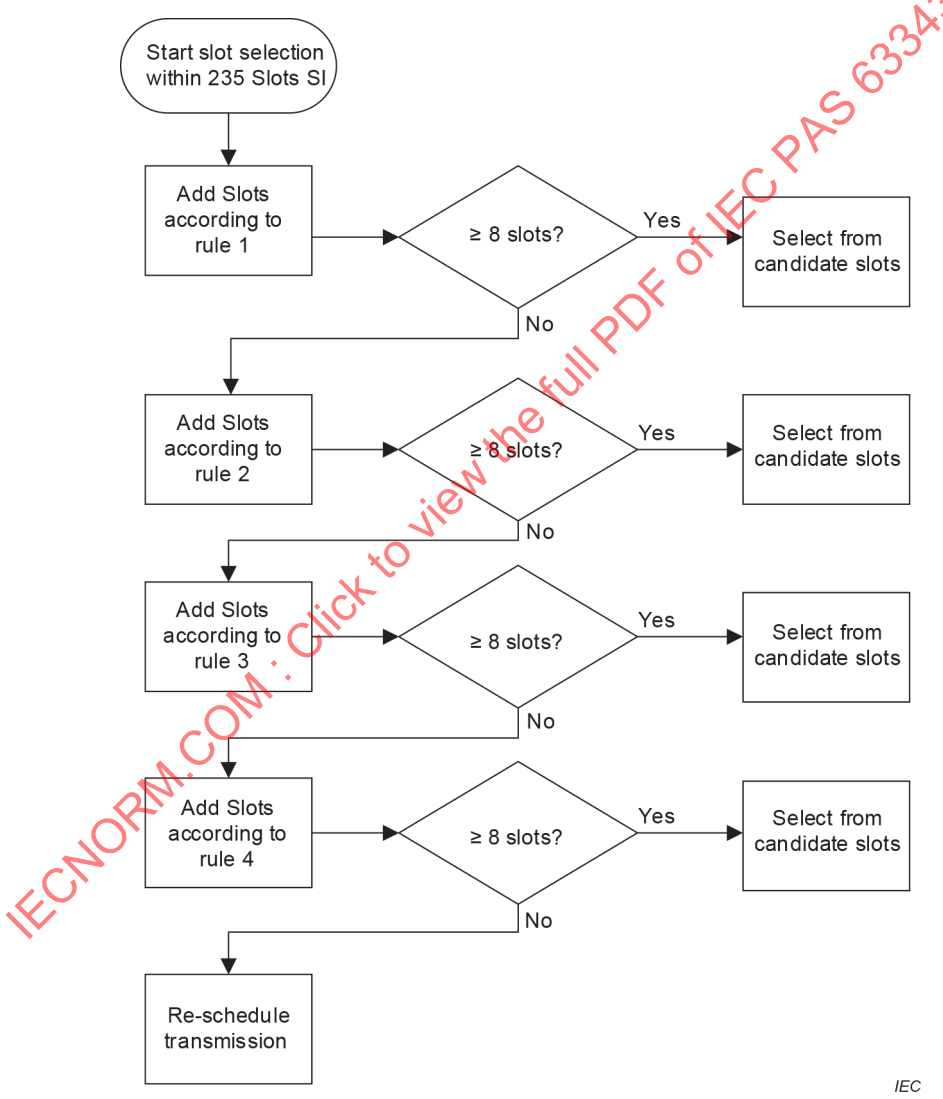

Figure 6 – Slot selection criteria flow chart

Selection criteria rules:

Rule 1: free on both ASM channels (to avoid loss of incoming data) and free on both AIS1 and AIS2.

Rule 2: free on both ASM channels and available on one AIS channel and free on another AIS channel.

Rule 3: free on both ASM channels and available on both AIS channels.

Rule 4: free on transmit ASM channel, not expecting rx under interest of own station on the other ASM channel and available on both AIS channels.

The available AIS slots are as defined in Recommendation ITU-R M.1371 and shall only be taken from the most distant station(s) within the SI followed by randomization among the 8 most distant candidate stations.

When selecting candidates for messages greater than one (1) slot, a candidate slot should be the first slot of a consecutive block of slots that all conform to the selection criteria stated above.

If the station cannot find sufficient number of candidate slots, the station shall not transmit and shall re-schedule the transmission.

5.3 AtoN Station

[tbd]

6 Methods of testing and required results

6.1 Mobile station

6.1.1 Test environment

The Equipment is tested in an environment using test equipment to simulate and log VDL messages. The environment will consist of at least 10 simulated other stations. The simulated other stations shall include number of stations of the following type, as applicable to the equipment under test (EUT).

a) Class A Mobile;
b) Class B "CS" Mobile;
c) Class B "SO" Mobile;
d) AIS base station;
e) AIS AtoN Station;
f) SAR Aircraft;
g) Locating device;
h) (Future: reservation for VDE Mobile);
i) ASM Mobile;
j) (Future: reservation for VDE Base Station);
k) ASM Base Station.

The signal input level at the RF input port of the EUT for any simulated station shall be at least 6 dB above the sensitivity level.

All RF levels specified in dBm are RMS/average values unless otherwise stated.

All sentences input and output at the Presentation Interface (PI) shall comply with IEC 61162-1. Where proprietary IEC 61162-1 sentences are used, these should be declared.

6.1.2 Test signals

The following test signals are applicable for testing ASM.

NOTE Test signal indexes 1-5 are reserved for testing AIS function which is co-located with ASM function in same Equipment.

Standard test signal number 6

ASM message, using π/4 QPSK encoding in 25 kHz band (only band supported by ASM) with PRBS payload as specified in ITU-T O.151:1992, 2.1: 32767 bit pattern length, with all shift registers initialised to "1", using Link Configuration IDs 1 or 5 as applicable, as described in IALA G1139, A 1.2.7, Table 7.

6.1.3 Environmental, power supply, special purpose and safety tests

6.1.3.1 General

Test method and required results according to equipment category "protected" as stated in IEC 60945:2002 apply to EUT.

Tests for power supplies, special purposes and safety shall be performed as specified in IEC 60945:2002, Clause 7, Clause 11 and Clause 12 as applicable to the EUT. Waivers as indicated in IEC 60945:2002 shall apply.

6.1.3.2 Conducted spurious emissions

6.1.3.2.1 Method of measurement

The tests shall be performed as specified by IEC 61993-2:2018, 15.3.

6.1.3.2.2 Required results

6.1.3.2.2.1 Transmitter

The power of any spurious emission on any discrete frequency shall not exceed 0,25 µW (−36 dBm) in the frequency range 9 kHz to 1 GHz and 1 µW (−30 dBm) in the frequency range 1 GHz to 4 GHz.

6.1.3.2.2.2 Receiver

The power of any spurious emission on any discrete frequency shall not exceed 2 nW (−57 dBm) in the frequency range 9 kHz to 1 GHz and 20 nW (−47 dBm) in the frequency range 1 GHz to 4 GHz.

6.1.3.3 EMC tests

Tests for EMC emissions shall be performed and their results are required as specified in IEC 60945:2002, Clause 9. Tests for EMC immunity shall be performed and their results are required as specified in IEC 60945:2002, Clause 10.

NOTE Related requirements for equipment category "protected" are stated in IEC 60945:2002, Table 6.

6.1.3.4 Compass safe distance

Test method and required results as described in IEC60945:2002, 11.2, apply to EUT.

6.1.3.5 Extreme power supply

Test method and required results according to IEC 60945:2002, 7.1, apply to EUT. Tests and performance checks at extreme power supply conditions shall be performed under the environmental conditions indicated in Table 19.

Table 19 – Power supply test schedule

Environment	Normal Power Supply	Extreme power supply
Dry heat	PT	PC
Damp heat	PC	-
Low temperature	PT	PC
Normal temperature	PT	PT

6.1.3.6 Power supply excessive conditions

Test method and required results according to IEC 60945:2002, 7.2, apply to EUT.

6.1.3.7 Power supply short-term variation

Test method and required results according to IEC 60945:2002, 7.3, apply to EUT. The test applies only to AC powered equipment.

6.1.3.8 Power supply failure

Test method and required results according to IEC 60945:2002, 7.4, apply to EUT. Subject the EUT to three breaks in power supply of duration 60 s each.

Perform a PC after the test to ensure that the unit is still operating correctly with no corruption or loss of software or essential data.

6.1.3.9 Update of software

Confirm by observation that EUT provides means for updating software and to display, on demand, the current applicable software version.

6.1.4 Operational tests

6.1.4.1 Transceiver protection

6.1.4.1.1 Method of measurement

Set up standard test environment and operate EUT in normal mode. Open circuit and short circuit VHF-antenna terminals of the EUT for at least 60 s each.

6.1.4.1.2 Required results

The EUT shall be operative again within 2 min after refitting the antenna without damage to the transceiver.

6.1.4.2 TX malfunction

6.1.4.2.1 Method of measurement

Check the manufacturer's documentation details how the EUT detects Tx malfunction.

6.1.4.2.2 Required results

Confirm that the requirements of 5.1.3.1 and 5.1.3.4 are fulfilled.

6.1.4.3 Antenna VSWR

6.1.4.3.1 Method of measurement

Prevent the EUT from radiating with full power by mismatching the antenna for a VSWR of 3:1. During the mismatch the output power is not required to be the rated output power.

6.1.4.3.2 Required results

Verify that the EUT continues operating. Verify that respective status is output at PI.

6.1.4.4 RX malfunction

Confirm by inspection of manufacturer's documentation that the Equipment is able to detect Rx malfunction and capable to output respective status at PI.

6.1.5 Specific tests of physical layer

6.1.5.1 TDMA transmitter

Applicable additional tests for ASM transmitters are described in further sub-clauses.

6.1.5.1.1 Frequency error

6.1.5.1.1.1 Method of measurement

The frequency error of the transmitter is the difference between the measured carrier frequency with modulation, and the nominal frequency of the transmitter.

The equipment shall be connected via the power attenuator to the frequency meter as shown in Figure 7.

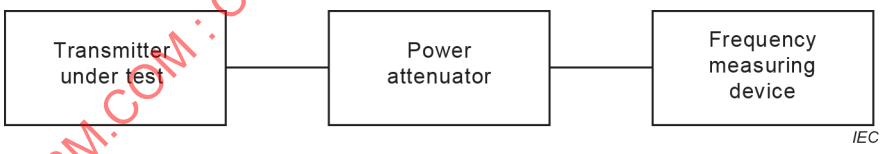

Figure 7 – Test setup for frequency error measurement

The carrier frequency shall be measured using test signal 6 under normal and extreme test conditions.

6.1.5.1.1.2 Required results

The frequency error shall not exceed ±243 Hz (±1,5 ppm) on normal test conditions and ±486 Hz (±3 ppm) on extreme test conditions.

6.1.5.1.2 Carrier power

6.1.5.1.2.1 Definition

The transmitted power (conducted) is defined as the average power delivered to a nominal 50 Ω load between ramp-up and ramp-down of a transmission slot.

6.1.5.1.2.2 Method of measurement

The measurement shall be performed with test signal 6 in slotted transmission mode.

The EUT shall be connected to a spectrum analyser measuring signal amplitude in time domain. The test shall use test signal 6. Tests shall be performed on lowest and highest applicable channels.

The measurement shall begin after the ramp-up completes and shall end before the ramp-down starts.

All provided power settings shall be verified using the specified test signals.

6.1.5.1.2.3 Required results

Required results are described in Table 20 for each test signal.

Table 20 – Carrier power, required results

Test signal	Power setting	Normal	Extreme
6	high (12,5 W average)	±1,5 dB	$^{+2}_{-6}$ dB
	low (1 W average)	±1,5 dB	$^{+2}_{-6}$ dB

6.1.5.1.3 Slotted transmission spectrum

6.1.5.1.3.1 Definition

This test is to ensure that the modulation and transient sidebands produced by the transmitter under normal operating conditions fall within the allowable mask.

6.1.5.1.3.2 Method of measurement

The test shall use test signal 6. The EUT shall be connected to a spectrum analyser. A resolution bandwidth of 300 Hz, video bandwidth of 3 kHz or greater and positive peak detection (maximum hold) shall be used for this measurement. A sufficient number of sweeps and sweep points shall be used and sufficient transmission packets measured to ensure that the emission profile is developed. Tests shall be performed on lowest and highest applicable channels defined by each module of this document.

6.1.5.1.3.3 Required results

The spectrum for slotted transmission shall be within the emission mask as described in Table 1 and Figure 1, depending on the test signal used. 0 dBc in the emission mask shall be the peak envelope power (PEP) of the used test signal, i.e. nominal output power plus PAPR of the test signal modulation.

EXAMPLE An ASM station with 12,5 W nominal transmit power is interpreted so that 0 dBc equals 44,4 dBm which is 41 dBm nominal plus 3,4 dB PAPR of the specific ASM station.

6.1.5.1.4 Modulation accuracy

6.1.5.1.4.1 Method of measurement

The modulation accuracy shall be tested as specified in IEC 61993-2:2018, 15.1.4.2. Test signal number 6 shall be used. The high transmit power setting shall be used.

An error vector magnitude (EVM) measurement shall be used to verify the ASM modulation performance. A burst used for the test shall contain at least 200 symbols.

The modulation accuracy shall be tested as follows.

a) A measurement system shall capture a representation of the transmit burst's vector error at sampling times t_k (symbol by symbol) where t_k is the symbol time corresponding to the k^{th} symbol.

   For each symbol, the sampling system shall compute the vector error Z'(k) – S(k), where Z'(k) is the normalized modulation symbol transmitted by the MS and S(k) is the modulation symbol which would be transmitted by an ideal MS.

   The measurement system shall calculate the RMS vector error for all symbols of the burst.

   The measuring system shall also calculate the peak vector error magnitude |Z'(k)-S(k)| for each symbol of the burst and shall calculate the mean residual carrier magnitude <C0> averaged over all values C0 of the burst;

b) The procedures described in previous step shall be performed on lowest and highest applicable channels defined by each module of this document.

6.1.5.1.4.2 Required results

The RMS vector error in any burst shall be less than [0,1] and the peak vector error magnitude shall be less than [0,3] for any symbol.

6.1.5.1.5 Transmitter output power characteristics

6.1.5.1.5.1 Definition

Transmitter output power characteristics are a combination of the transmitter delay, ramp-up time, ramp-down time and transmission duration, as specified in Figure 2, where:

- Transmitter delay (T_A) is the time between the start of the candidate transmission time period and the time when the transmission power exceeds –50 dBc;
- Transmitter ramp-up time ($T_B - T_A$) is the time between the transmit power exceeding –50 dBc and the moment when the transmit power has reached a level of the measured steady-state power (P_{ss}) and maintains a level within +1,5 dB from P_{ss} thereafter;
- Transmitter ramp-down time ($T_F - T_E$) is the time between the end of the last transmitted symbol and the moment when the transmitter output power has reduced to a level 50 dB below P_{ss} and remains below this level thereafter;
- Transmission duration ($T_F - T_A$) is the time from when power exceeds –50 dBc to when the power returns to and stays below –50 dBc.

The power between T_B and T_E is measured during carrier power measurement and not a requirement of this test.

6.1.5.1.5.2 Method of measurement

The test shall use standard test signal number 6.

Tests shall be performed on 2 channels (161,950 MHz, 162,000 MHz). The EUT shall be connected to a spectrum analyser. A resolution bandwidth of 1 MHz, video bandwidth of 1 MHz and a sample detector shall be used for this measurement. The analyser shall be in zero-span mode for this measurement. The spectrum analyser shall be synchronised to the nominal start time of the slot (T_0), which may be provided externally, or from the EUT.

6.1.5.1.5.3 Required results

The transmitter power shall remain within the mask shown in Figure 2 and associated timings given in Table 2.

6.1.5.2 TDMA receiver

Tests applicable for EUT which is capable of ASM or VDE functions are defined in further sub-clauses.

6.1.5.2.1 Sensitivity

6.1.5.2.1.1 Method of measurement

Follow the method described in IEC 61993-2:2018, 15.2.1.2, with the signals and properties specified in Table 21.

The packet error rate (PER) shall be observed at PI port output for minimum number of 200 sentences.

Table 21 – Used parameters and required results for ASM and VDE sensitivity tests

Test Signal	Channel Centre Frequency [MHz]	BW [kHz]	Level [dBm]
6	161,950 and 162,000	25	See 5.1.3.7.2
6 extreme	161,950 and 162,000	25	See 5.1.3.7.2

6.1.5.2.1.2 Required results

The PER shall not exceed values defined in 5.1.3.7.2.

6.1.5.2.2 Error behaviour at high input levels

6.1.5.2.2.1 Method of measurement

Follow the method described in IEC 61993-2:2018, 15.2.2.2. Use signals and properties as specified in Table 22.

The packet error rate shall be observed at PI port output for minimum number of 200 sentences.

Table 22 – Used parameters and required results for ASM and VDE high input level tests

Test Signal	Channel Centre Frequency [MHz]	BW [kHz]	Level [dBm peak]
6	161,950 or 162,000	25	See 5.1.3.7.2

6.1.5.2.2.2 Required results

The PER shall not exceed values defined in 5.1.3.7.2.

6.1.5.2.3 Co-channel rejection

6.1.5.2.3.1 Method of measurement

For ASM, follow the method described in IEC 61993-2:2018, 15.2.3.2, with the wanted and the unwanted signal levels at the receiver input set as described in Table 23.

NOTE The signal notation "6" and "6b" in Table 23 is to indicate that the two signals use the same modulation scheme, but the data is not correlated.

Table 23 – Additional channel combinations used for co-channel rejection tests

Generator A Test Signal	Bandwidth [kHz]	Wanted signal level [dBm]	Generator B Test Signal	Unwanted signal level [dBm]
6 (no coding)	25	–86	6b (no coding)	See 5.1.3.7.2

6.1.5.2.3.2 Required results

The PER shall not exceed value defined in 5.1.3.7.2.

6.1.5.2.4 Adjacent channel selectivity

6.1.5.2.4.1 Method of measurement

Use test setup described in Figure 8.

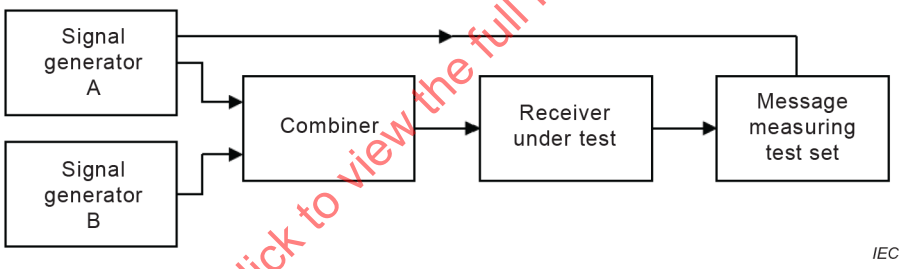

Figure 8 – Test setup for adjacent channel selectivity

The wanted signal, provided by signal generator A, shall be at the nominal frequency of the receiver and shall be modulated to generate the test signal as described in Table 24.

The unwanted signal, provided by generator B, shall be the test signal as described in Table 24. Generator B shall be at the upper adjacent channel.

The level of the wanted signal from generator A and level of unwanted signal from generator B shall be adjusted to the applicable level at the receiver.

The message measuring test set shall be monitored and the packet error rate observed.

Repeat the above measurement with the unwanted signal on the lower adjacent channel.

Test shall be performed on lowest and highest applicable channels defined by each module of this document and repeated under extreme conditions with level of wanted signal from generator A and level of unwanted signal from generator B adjusted to the applicable level at the receiver as described in Table 24.

Table 24 – Test signals used for adjacent channel selectivity tests

Generator A Test Signal	**Bandwidth** [kHz]	**Wanted signal level** [dBm]	**Generator B Test Signal**	**Unwanted signal level** [dBm]
6 (no coding)	25	–104	FM modulated with 400 Hz with deviation of ±3 kHz [a]	See 5.1.3.7.2
[a] See IEC 61993-2:2018, 15.2.4.2.				

6.1.5.2.4.2 Required results

The PER shall not exceed value defined in 5.1.3.7.2.

6.1.5.2.5 Spurious response rejection

6.1.5.2.5.1 Objective

The spurious response rejection is a measure of the capability of the receiver to discriminate between the wanted modulated signal at the nominal frequency and an unwanted signal at any other frequency at which a response is obtained.

6.1.5.2.5.2 Method of measurement

The manufacturer shall provide the test house with the information regarding the equipment. In general, a block diagram from which it appears what signal path architecture there has been chosen.

If the equipment is built using heterodyne principles, the following shall be stated:

- IF frequencies used;
- the local oscillator frequencies;
- filter arrangements ahead of the first mixer.

If the equipment uses analogue to digital converter techniques, the following shall be stated:

- whether the sampling is done directly on the RF frequency or on an IF frequency;
- the sampling frequency used for the conversion.

The arrangements for applying two test signals to the receiver input shall be according to 6.1.2.

The wanted signal shall be applied using relevant frequencies as specified by Table 21. The level of the wanted signal shall be 3 dB above the sensitivity level specified in Table 21. The level of the unwanted signal shall be –36 dBm.

The equipment shall be in compliance for frequencies from 9 kHz to 2 GHz with the exception of the receiver passband and the adjacent channels.

The equations below for calculation of spurious frequencies can be used as a guidance.

a) For equipment using super heterodyne principles

$f_{\text{spurious}} = (1 - n)/\text{m} \times f_{\text{if}} - n/m \times f_{\text{receive}}$

where m and n are integers with values from –5 to +5.

Spurious frequency calculation should be applied to all frequency conversions (IF1, IF2, etc).

b) For equipment using analog to digital converter techniques

$f_{\text{spurious}} = f_{\text{receive}} / m - n/m \times f_{\text{sample clock}}$

where m and n are integers with values from –5 to +5.

c) For equipment where both heterodyne principles and digital techniques are used, both equations should be taken into consideration.

6.1.5.2.5.3 Required results

The PER shall be equal to or less than value defined in 5.1.3.7.2.

6.1.5.2.6 Intermodulation response rejection

6.1.5.2.6.1 Purpose

The intermodulation response rejection is the capability of the receiver to receive a wanted modulated signal, without exceeding a given degradation due to the presence of two close-spaced unwanted signals with a specific frequency relationship to the wanted signal frequency.

6.1.5.2.6.2 Method of test

Use test setup described in Figure 9.

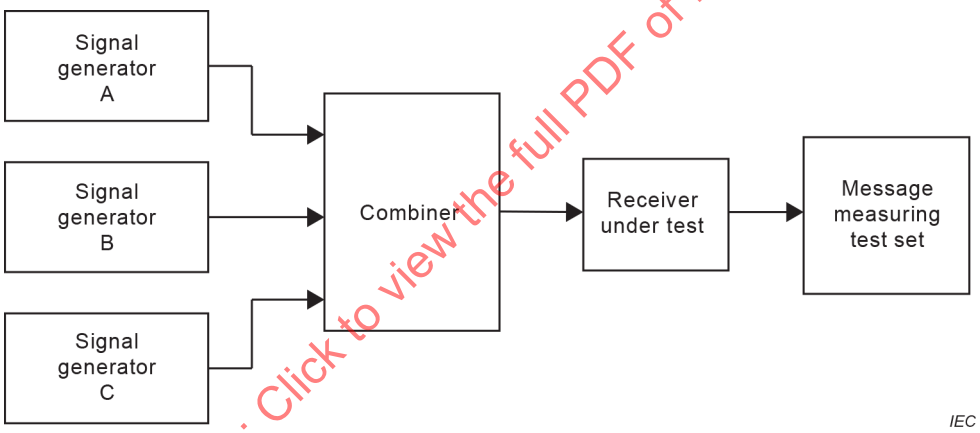

Figure 9 – Measurement arrangement for intermodulation

The measurement procedure shall be as follows:

a) three signal generators shall be connected to the receiver via a combining network as shown in Figure 9;

b) the wanted signal, provided by signal generator A, shall be at the specified frequency of the receiver and shall be modulated to generate applicable test signal. For ASM, the test signals shall be as described in Table 26;

c) the unwanted signal from generator B shall be unmodulated;

d) the unwanted signal from generator C shall be frequency modulated with a 400 Hz sine wave at a deviation of ±3 kHz.

e) the signal level from generator A (wanted) shall be set for 6 dB above the sensitivity level stated in Table 21 at the receiver input;

f) the signal level from generators B and C shall be set to applicable level at the receiver input. For ASM, see Table 26;

g) the frequencies of generators A, B, C shall be set as per test number 1 of Table 25;

h) the message measuring test set shall be monitored and the PER observed over 200 transmissions;

i) repeat the measurement with frequencies set as per test number 2 of Table 25.

Table 25 – Frequencies for inter-modulation test

Test number	Generator A Wanted signal	Generator B Unmodulated ±500 kHz offset	Generator C Modulated ±1 000 kHz offset
1 (ASM)	161,950 MHz	161,450 MHz	160,950 MHz
2 (VDE low band)	157,250 MHz	157,750 MHz	158,250 MHz
3 (VDE high band)	161,850 MHz	161,350 MHz	160,850 MHz

Table 26 – Test signals used for inter-modulation test

Generator A Test Signal	Bandwidth [kHz]	Wanted signal level [dBm]	Generator B Test Signal	Unwanted signal level [dBm]	Generator C Test Signal	Unwanted signal level [dBm]
6 (no coding)	25	–101	Unmodulated ±500 kHz offset	See 5.1.3.7.2	Modulated ±1000 kHz offset	See 5.1.3.7.2

6.1.5.2.6.3 Required results

The PER shall not exceed value defined in 5.1.3.7.2.

6.1.5.2.7 Blocking

6.1.5.2.7.1 Purpose

Blocking is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted input signal at any frequency other than those of the spurious responses or the adjacent channels.

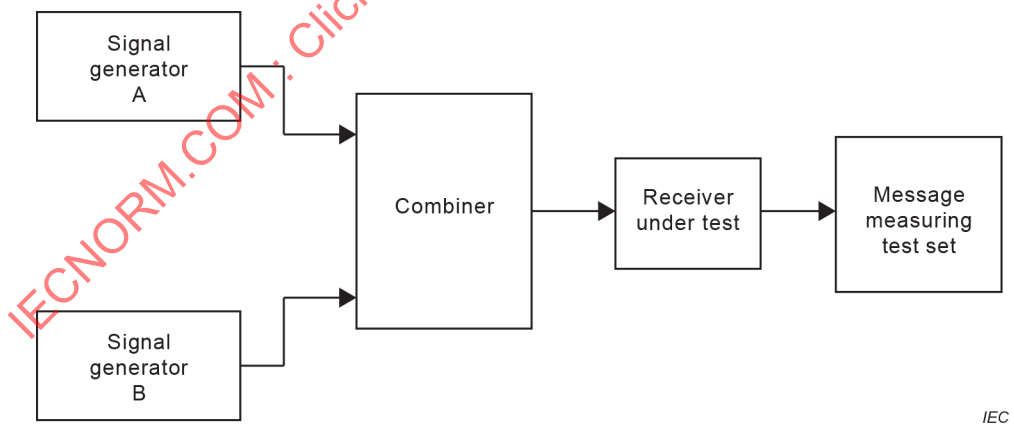

Figure 10 – Measurement arrangement for blocking or de-sensitisation

6.1.5.2.7.2 Method of measurement

The measurement procedure shall be as follows:

a) two generators A and B, shall be connected to the receiver via a combining network as shown in Figure 10;

b) the wanted signal, provided by signal generator A, shall be initially at the lowest frequency of the EUT and be modulated to generate the applicable test signal. For ASM, see Table 27 and Table 28;

c) the unwanted signal from generator B shall be unmodulated and tuned to applicable frequency, see Table 27. Initially, signal generator B (unwanted signal) shall be switched off (maintaining the output impedance). The level of the wanted signal from generator A shall be adjusted to 6 dB above the sensitivity level stated in Table 21 at the receiver input;

d) generator B shall then be switched on, and the level of the unwanted signal set to –15 dBm;

e) 200 packets shall be transmitted and the PER recorded;

f) repeat the test steps a) to e) with the wanted signal generator tuned to highest frequency of the EUT and the unwanted signal generator tuned to applicable frequency. For ASM, see Table 27.

Table 27 – Frequencies for blocking test

Test number	Generator A Wanted signal	Generator B Unmodulated carrier
1 (ASM1)	161,950 MHz	156,300 MHz
2 (ASM2)	162,000 MHz	156,300 MHz

Table 28 – Test signals used for blocking test

Generator A Test Signal	Bandwidth [kHz]	Wanted signal level [dBm]	Unwanted signal level [dBm]
6 (no coding)	25	–101	See 5.1.3.7.2

6.1.5.2.7.3 Required results

The PER shall not exceed value defined in 5.1.3.7.2.

6.1.5.2.8 Transmit to receive switching time

[Future: This is to be tested in protocol layer tests. Idea is to require a test mode where the EUT can be commanded to transmit on a specific slot. Then, in combination with external equipment that will be able to do the same, the EUT can be confirmed to receive on both slots adjacent to the slot the EUT was commanded to transmit on.]

6.1.5.2.9 Immunity to out-of-band energy

6.1.5.2.9.1 Method of measurement

Follow the method described in IEC 61993-2:2018, 15.2.8.2, where applicable. Wanted signal at the highest frequency supported by the EUT. Transmitting a test signal at level of 6 dB above the sensitivity level stated in Table 21 and the level of the unwanted signal set to −5 dBm.

6.1.5.2.9.2 Required results

The packet error rate shall not exceed 20 %.

6.1.6 Specific tests of Link layer

The following test assumes that the EUT is a combined AIS and ASM box.

6.1.6.1 Synchronisation and jitter accuracy

6.1.6.1.1 Definition

Synchronisation jitter (transmission timing error) is the time between the nominal slot start as determined by the UTC synchronisation source and the start of data (T_B as in Figure 2).

6.1.6.1.2 Method of measurement

Set up the standard test environment.

a) Operate the ASM box such that it utilizes UTC direct synchronisation. Initiate the transmission of a single slot broadcast binary message (ASM VDL Message 2),

b) Operate the ASM box such that it utilizes UTC indirect synchronisation by disconnecting the GNSS antenna of the EUT. Initiate the transmission of a single slot broadcast binary message (ASM VDL Message 2).

Record transmitted VDL messages and measure the time between the nominal beginning of the slot interval and the start of data.

6.1.6.1.3 Required results

The synchronisation, including its jitter, shall not exceed

a) ± 104 μs using UTC direct synchronisation,

b) ± 312 μs relative to the synchronisation source using UTC indirect synchronisation.

6.1.6.2 Transmission of ASM Messages

6.1.6.2.1 Definition

The EUT shall be able to transmit all the ASM VDL messages as defined in Table 7.

6.1.6.2.2 Method of measurement

Set up the standard test environment. Initiate the transmission of messages according to Table 7 by the EUT. Record transmitted messages and messages output by the PI of EUT.

6.1.6.2.3 Required results

Confirm that:

a) the EUT transmits ASM VDL message on both ASM1 and ASM2 as specified;

b) no transmission burst is greater than three slots;

c) every message transmitted on the VDL shall be passed to the PI with correct field content and format as an ADO sentence;

d) the EUT transmits messages according to AAB, ABB and AGB sentences that are input to PI of the EUT;

e) the EUT implements the mandatory Quiet Time after each successful MITDMA transaction or a single non-MITDMA transmission;

f) the EUT will transmit no more than 50 slots per frame (excluding available slots for the use of re-transmission of addressed data) on each of the two ASM channels (100 slots together).

6.1.6.3 Reception of ASM Messages

6.1.6.3.1 Definition

The EUT shall be able to receive all the ASM VDL message as defined in Table 7.

6.1.6.3.2 Method of measurement

Set up the standard test environment and operate EUT in autonomous mode. Apply messages according to Table 7 to the ASM VDL, including multiple slot messages up to 3 slots. Record messages output by the PI of EUT.

6.1.6.3.3 Required results

Confirm that:

a) the EUT receives ASM VDL message on both ASM1 and ASM2, as appropriate;

b) received ASM VDL messages are passed to the PI as an ASM sentence according to Table 5 if either broadcast or addressed to the own station;

c) the TDMA receive process is not dependent on slot boundaries;

d) the EUT is capable of receiving correctly structured ASM VDL messages that are not yet defined in Table 7 and outputting the related data at PI by using ADM sentence.

6.1.6.4 MITDMA transmission

6.1.6.4.1 Definition

The transmission of a MITDMA chain shall be in accordance with IALA Guideline 1139 [ITU-R M.2092-1 under development].

6.1.6.4.2 Method of measurement

Set up the standard test environment. Initiate the transmission of MITDMA transmissions according to Table 7. Simulate the failure of some received blocks within the MITDMA chain. Record transmitted messages and messages output by the PI of EUT.

6.1.6.4.3 Required results

Confirm that the EUT:

a) transmits a complete MITDMA chain with all transmission on the specified ASM channel (no channel switching);

b) properly implements the MITDMA communication states to announce future transmission slots for MITDMA chain;

c) makes no more than three re-transmission attempts when the MITDMA chain fails;

d) upon failure to receive an acknowledgment from the addressed station within a timeout, re-transmits the entire chain if the retry slot budget and retry count so allows;

e) allows up to 22 slots (3 x 7 + 1) for re-transmission in addition to the transmission limit (of 50 slots per frame);

f) will only allow up to 15 MITDMA chains per frame and that the appropriate NACK is provided on the PI when this number is exceeded.

6.1.6.5 MITDMA reception

6.1.6.5.1 Definition

Addressed MITDMA chain data that has not been confirmed as received shall be re-transmitted as defined in IALA Guideline 1139 [ITU-R M.2092-1 under development].

6.1.6.5.2 Method of measurement

Set up the standard test environment. Initiate the transmission of MITDMA transmissions according to Table 7. In addition, simulate the failure of some received blocks within the MITDMA chain. Record transmitted messages and messages output by the PI of EUT.

6.1.6.5.3 Required results

Confirm that the EUT:

a) as a minimum supports the reception of [10] in-progress MITDMA chains;

b) transmits the acknowledgment when the last block of the MITDMA chain is received;

c) if the last block of the MITDMA chain is not received, transmits the acknowledgment after the acknowledgment timeout has expired;

d) outputs only the complete MITDMA chains at PI by using ASM sentence.

6.1.7 Specific tests of Network layer

6.1.7.1 High load test using highest (¾) coding

NOTE It is expected that this test will be amended in the future.

6.1.7.1.1 Definition

This test confirms that the EUT has the resources of receiving all messages from both the AIS and the ASM when the VDL is at 90 % capacity. The EUT shall be capable of transmitting ASM messages when the VDL is at 90 % scheduled capacity.

6.1.7.1.2 Method of measurement

Set up the standard test environment such that the AIS VDL and the ASM VDL is loaded to 90 % scheduled capacity. These AIS targets and the scheduled ASM messages shall have a slot arrangement such that there are sufficient slots to select from when transmitting the ASM message. Initiate the transmission of messages according to Table 7 by the EUT. Record transmitted messages and messages output by the PI of EUT.

6.1.7.1.3 Required results

Confirm that the EUT:

a) receives all messages from both the AIS VDL and the ASM VDL;

b) is able to transmit the ASM messages according to the scheduling rules.

6.1.7.2 Selection of candidate slots

NOTE It is expected that this test will be amended in the future.

6.1.7.2.1 Definition

Slots, used for transmission, are selected from a minimum of 8 candidate slots in the selection interval (SI) which is defined as 235 slots. The selection process shall use received data from both ASM and AIS, noting that AIS has the highest priority.

6.1.7.2.2 Method of measurement

Set up the standard test environment. Simulate the AIS targets and scheduled ASM messages (using MITDMA) as described below and initiate the transmission of ASM messages according to Table 7 by the EUT. Record transmitted messages of EUT. The AIS targets and the scheduled ASM message shall have a slot arrangement such that there are sufficient slots to select from when transmitting the ASM message.

a) Simulate AIS test targets on AIS 1 and AIS 2 with a 50 % channel load and scheduled ASM message on ASM 1 and ASM 2 with a 50 % channel load.

b) Simulate AIS test targets on AIS 1 with a 100 % channel load with some targets at a distance of 1 NM and some targets with a distance of 10 NM and AIS 2 with 50 % channel load. Simulate scheduled ASM message on ASM 1 and ASM 2 with a 50 % channel load.

c) Simulate AIS test targets on AIS 1 and AIS 2 with a 100 % channel load with some targets at a distance of 1 NM and some targets with a distance of 10 NM. Simulate scheduled ASM message on ASM 1 and ASM 2 with a 50 % channel load.

d) Simulate AIS test targets on AIS 1 and AIS 2 with a 100 % channel load with some targets at a distance of 1 NM and some targets with a distance of 10 NM. Simulate addressed

scheduled ASM message on ASM 1 with a channel load of 100 % with some ASM messaged addressed to the EUT and some not, and ASM 2 with a 50 % channel load.

6.1.7.2.3 Required results

Confirm that the EUT:

a) only transmits on slots that are free on both ASM channels and on both AIS 1 and AIS 2;
b) only transmits on slots that are free on both ASM channels, free on one AIS 2 and the most distant targets on AIS 1;
c) only transmits on slots that are free on both ASM channels and the most distant targets on both AIS 1 and AIS 2;
d) only transmits on slots that are the most distant targets on AIS 1 and AIS 2, and ASM 1 where the addressed ASM message is not the EUT.

6.1.8 Specific tests of Transport layer

[tbd]

6.1.8.1 Concurrent Mode tests

Check that Rx operation is functional when fully loaded with 100% traffic on all Rx channels AIS1, AIS2, ASM1 and ASM2.

Check that an AIS Tx will always have priority over an ASM transmission when scheduling transmissions.

6.2 Coast station

6.2.1 Test environment

The Equipment is tested in an environment using test equipment to simulate and log VDL messages. The environment will consist of at least 10 simulated other stations. The simulated other stations shall include a number of stations of the following type, as applicable to the Equipment Under Test (EUT):

a) Class A Mobile;
b) Class B "CS" Mobile;
c) Class B "SO" Mobile;
d) AIS base station;
e) AIS AtoN Station;
f) SAR Aircraft;
g) Locating device;
h) (Future: reservation for VDE Mobile);
i) ASM Mobile;
j) (Future: reservation for VDE Base Station);
k) ASM Base Station.

The signal input level at the RF input port of the EUT for any simulated station shall be at least 6 dB above the sensitivity level.

All RF levels specified in dBm are rms/average values unless otherwise stated.

All sentences input and output at the Presentation Interface (PI) shall comply with IEC 61162-1 or NMEA 0183 as applicable. Where proprietary IEC 61162-1 sentences are used, these should be declared.

6.2.2 Test signals

The following test signals are applicable for testing ASM.

NOTE Test signal indexes 1-5 are reserved for testing AIS function which is co-located with ASM function in same Equipment.

6.2.2.1 Standard test signal number 6

ASM message, using π/4 QPSK encoding in 25 kHz band (only band supported by ASM) with PRBS payload as specified in ITU-T O.151:1992, 2.1: 32767 bit pattern length, with all shift registers initialised to "1", using Link Configuration IDs 1 or 5 as applicable, as described in IALA G1139, A 1.2.7, Table 7.

6.2.3 Environmental, power supply, special purpose and safety tests

6.2.3.1 General

Test method and required results according to equipment category as declared by the manufacturer.

Tests for power supplies, special purposes and safety shall be performed as declared by the manufacturer.

6.2.3.2 Conducted spurious emissions

6.2.3.2.1 Method of measurement

The tests shall be performed as specified by IEC 62320-1:2015, 9.5.

6.2.3.2.2 Required results

####### 6.2.3.2.2.1 Transmitter

The power of any spurious emission on any discrete frequency shall not exceed 0,25 µW (−36 dBm) in the frequency range 9 kHz to 1 GHz and 1 µW (−30 dBm) in the frequency range 1 GHz to 4 GHz.

####### 6.2.3.2.2.2 Receiver

The power of any spurious emission on any discrete frequency shall not exceed 2 nW (−57 dBm) in the frequency range 9 kHz to 1 GHz and 20 nW (−47 dBm) in the frequency range 1 GHz to 4 GHz.

6.2.3.3 EMC tests

Tests for EMC emissions shall be performed and their results are required as specified in IEC 60945:2002, Clause 9. Tests for EMC immunity shall be performed and their results are required as specified in IEC 60945:2002, Clause 10.

NOTE Related requirements for equipment category "protected" are stated in IEC 60945:2002, Table 6.

6.2.3.4 Compass Safe Distance

Not applicable to shore station.

6.2.3.5 Extreme power supply

Test method and required results as defined in IEC 62320-1.

6.2.3.6 Power supply excessive conditions

Not applicable to shore station.

6.2.3.7 Power supply short-term variation

Not applicable to shore station.

6.2.3.8 Power supply failure

Not applicable to shore station.

6.2.3.9 Update of software

Confirm by observation that EUT provides means for updating software and to display, on demand, the current applicable software version.

6.2.4 Operational tests

6.2.4.1 Transceiver protection

6.2.4.1.1 Method of measurement

Set up standard test environment and operate EUT in normal mode. Open circuit and short circuit VHF-antenna terminals of the EUT for at least 5 min each.

6.2.4.1.2 Required results

The EUT shall be operative again within 2 min after refitting the antenna without damage to the transceiver.

6.2.4.2 TX malfunction

6.2.4.2.1 Method of measurement

Check the manufacturer's documentation details how the EUT detects Tx malfunction.

6.2.4.2.2 Required results

Confirm that the requirements of 5.2.3.1 and 5.2.3.4 are fulfilled.

6.2.4.3 Antenna VSWR

6.2.4.3.1 Method of measurement

Prevent the EUT from radiating with full power by mismatching the antenna for a VSWR of 3:1. During the mismatch, the output power is not required to be the rated output power.

6.2.4.3.2 Required results

Verify that the EUT continues operating. Verify that respective status is output at PI.

6.2.4.4 RX malfunction

Confirm by inspection of manufacturer's documentation that the Equipment is able to detect Rx malfunction and capable to output respective status at PI.

6.2.5 Specific tests of Physical layer

6.2.5.1 TDMA transmitter

NOTE Applicable additional tests for ASM transmitters are described in further sub-clauses.

6.2.5.1.1 Frequency error

6.2.5.1.1.1 Method of measurement

The frequency error of the transmitter is the difference between the measured carrier frequency with modulation, and the nominal frequency of the transmitter.

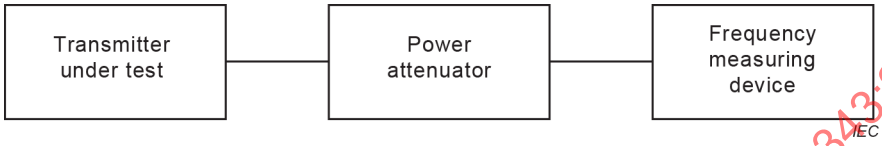

Figure 11 – Test setup for frequency error measurement

The carrier frequency shall be measured using test signal 6 under normal and extreme test conditions.

6.2.5.1.1.2 Required results

The frequency error shall not exceed ±243 Hz (±1,5 ppm) on normal test conditions and ±486 Hz (±3 ppm) on extreme test conditions.

6.2.5.1.2 Carrier power

6.2.5.1.2.1 Definition

The transmitted power (conducted) is defined as the average power delivered to a nominal 50 Ω load between ramp-up and ramp-down of a transmission slot.

6.2.5.1.2.2 Method of measurement

The measurement shall be performed with test signal 6 in slotted transmission mode.

The EUT shall be connected to a spectrum analyser measuring signal amplitude in time domain. The test shall use test signal 6. Tests shall be performed on lowest and highest applicable channels.

The measurement shall begin after the ramp-up completes and shall end before the ramp-down starts.

All provided power settings shall be verified using the specified test signals.

6.2.5.1.2.3 Required results

Required results are described in Table 29 for each test signal.

Table 29 – Carrier power, required results

Test signal	Power setting	Normal	Extreme
6	high (12,5 W average)	±1,5 dB	$^{+2}_{-6}$ dB
	low (1 W average)	±1,5 dB	$^{+2}_{-6}$ dB

6.2.5.1.3 Slotted transmission spectrum

6.2.5.1.3.1 Definition

This test is to ensure that the modulation and transient sidebands produced by the transmitter under normal operating conditions fall within the allowable mask.

6.2.5.1.3.2 Method of measurement

The test shall use test signal 6. The EUT shall be connected to a spectrum analyser. A resolution bandwidth of 300 Hz, video bandwidth of 3 kHz or greater and positive peak detection (maximum hold) shall be used for this measurement. A sufficient number of sweeps and sweep points shall be used and sufficient transmission packets measured to ensure that the emission profile is developed. Tests shall be performed on lowest and highest applicable channels defined by each module of this document.

6.2.5.1.3.3 Required results

The spectrum for slotted transmission shall be within the emission mask as described in Table 10 and Figure 4, depending on the test signal used. 0 dBc in the emission mask shall be the Peak Envelope Power (PEP) of the used test signal; i.e. nominal output power plus PAPR of the test signal modulation.

EXAMPLE An ASM station with 12,5 W nominal transmit power is interpreted so that 0 dBc equals 44,4 dBm which is 41 dBm nominal plus 3,4 dB PAPR of the specific ASM station.

6.2.5.1.4 Modulation accuracy

6.2.5.1.4.1 Method of measurement

The modulation accuracy shall be tested as specified in IEC 61993-2:2018, 15.1.4.2. Test signal number 6 shall be used. The high transmit power setting shall be used.

An Error Vector Magnitude (EVM) measurement shall be used to verify the ASM modulation performance. A burst used for the test shall contain at least 200 symbols.

The modulation accuracy shall be tested as follows:

a) a measurement system shall capture a representation of the transmit burst's vector error at sampling times t_k (symbol by symbol) where t_k is the symbol time corresponding to the k^{th} symbol.

   For each symbol, the sampling system shall compute the vector error Z'(k) – S(k), where Z'(k) is the normalized modulation symbol transmitted by the MS and S(k) is the modulation symbol which would be transmitted by an ideal MS.

   The measurement system shall calculate the RMS vector error for all symbols of the burst.

   The measuring system shall also calculate the peak vector error magnitude |Z'(k) – S(k)| for each symbol of the burst and shall calculate the mean residual carrier magnitude <C0> averaged over all values C0 of the burst;

b) the procedures described in previous step shall be performed on lowest and highest applicable channels defined by each module of this document.

6.2.5.1.4.2 Required results

The RMS vector error in any burst shall be less than [0,1] and the peak vector error magnitude shall be less than [0,3] for any symbol.

6.2.5.1.5 Transmitter output power characteristics

6.2.5.1.5.1 Definition

Transmitter output power characteristics are a combination of the transmitter delay, ramp-up time, ramp-down time and transmission duration, as specified in Figure 5, where:

- Transmitter delay (T_A) is the time between the start of the candidate transmission time period and the time when the transmission power exceeds –50 dBc;
- Transmitter ramp-up time (T_B – T_A) is the time between the transmit power exceeding –50 dBc and the moment when the transmit power has reached a level of the measured steady-state power (P_{ss}) and maintains a level within +1,5 dB from P_{ss} thereafter;
- Transmitter ramp-down time (T_F – T_E) is the time between the end of the last transmitted symbol and the moment when the transmitter output power has reduced to a level 50 dB below P_{ss} and remains below this level thereafter;
- Transmission duration (T_F – T_A) is the time from when power exceeds –50 dBc to when the power returns to and stays below –50 dBc.

The power between T_B and T_E is measured during carrier power measurement and not a requirement of this test.

6.2.5.1.5.2 Method of measurement

The test shall use standard test signal number 6.

Tests shall be performed on 2 channels (161,950 MHz, 162,000 MHz). The EUT shall be connected to a spectrum analyser. A resolution bandwidth of 1 MHz, video bandwidth of 1 MHz and a sample detector shall be used for this measurement. The analyser shall be in zero-span mode for this measurement. The spectrum analyser shall be synchronised to the nominal start time of the slot (T_0), which may be provided externally, or from the EUT.

6.2.5.1.5.3 Required results

The transmitter power shall remain within the mask shown in Figure 5 and associated timings given in Table 11.

6.2.5.2 TDMA receiver

Tests applicable for EUT which is capable of ASM or VDE functions are defined in further sub-clauses.

6.2.5.2.1 Sensitivity

6.2.5.2.1.1 Method of measurement

Follow the method described in IEC 61993-2:2018, 15.2.1.2, with the signals and properties specified in Table 30.

The packet error rate (PER) shall be observed at PI port output for minimum number of 200 sentences.

Table 30 – Used parameters and required results for ASM and VDE sensitivity tests

Test Signal	**Channel Centre Frequency** [MHz]	**BW** [kHz]	**Level** [dBm]
6	161,950 and 162,000	25	See 5.2.3.7.2
6 extreme	161,950 and 162,000	25	See 5.2.3.7.2

6.2.5.2.1.2 Required results

The PER shall not exceed values defined in 5.2.3.7.2.

6.2.5.2.2 Error behaviour at high input levels

6.2.5.2.2.1 Method of measurement

Follow the method described in IEC 61993-2:2018, 15.2.2.2. Use signals and properties as specified in Table 31.

The packet error rate shall be observed at PI port output for minimum number of 200 sentences.

Table 31 – Used parameters and required results for ASM and VDE high input level tests

Test Signal	**Channel Centre Frequency** [MHz]	**BW** [kHz]	**Level** [dBm peak]
6	161,950 or 162,000	25	See 5.2.3.7.2

6.2.5.2.2.2 Required results

The PER shall not exceed values defined in 5.2.3.7.2.

6.2.5.2.3 Co-channel rejection

6.2.5.2.3.1 Method of measurement

For ASM, follow the method described in IEC 61993-2:2018, 15.2.3.2, with the wanted and the unwanted signal levels at the receiver input set as described in Table 32.

NOTE The signal notation "6" and "6b" in Table 32 is to indicate that the two signals use the same modulation scheme, but the data is not correlated.

Table 32 – Additional channel combinations used for co-channel rejection tests

Generator A Test Signal	**Bandwidth** [kHz]	**Wanted signal level** [dBm]	**Generator B Test Signal**	**Unwanted signal level** [dBm]
6 (no coding)	25	-86	6b (no coding)	See 5.2.3.7.2

6.2.5.2.3.2 Required results

The PER shall not exceed value defined in 5.2.3.7.2.

6.2.5.2.4 Adjacent channel selectivity

6.2.5.2.4.1 Method of measurement

Use test setup described in Figure 12.

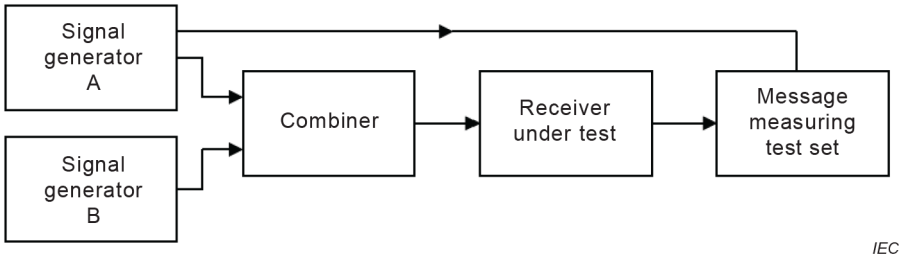

Figure 12 – Test setup for adjacent channel selectivity

The wanted signal, provided by signal generator A, shall be at the nominal frequency of the receiver and shall be modulated to generate the test signal as described in Table 33.

The unwanted signal, provided by generator B, shall be the test signal as described in Table 33. Generator B shall be at the upper adjacent channel.

The level of the wanted signal from generator A and level of unwanted signal from generator B shall be adjusted to the applicable level at the receiver.

The message measuring test set shall be monitored and the packet error rate observed.

Repeat the above measurement with the unwanted signal on the lower adjacent channel.

Test shall be performed on lowest and highest applicable channels defined by each module of this document and repeated under extreme conditions with level of wanted signal from generator A and level of unwanted signal from generator B adjusted to the applicable level at the receiver as described in Table 33.

Table 33 – Test signals used for adjacent channel selectivity tests

Generator A Test Signal	**Bandwidth** [kHz]	**Wanted signal level** [dBm]	**Generator B Test Signal**	**Unwanted signal level** [dBm]
6 (no coding)	25	–104	FM modulated with 400 Hz with deviation of ±3 kHz [a]	See 5.2.3.7.2
[a] See IEC 61993-2:2018, 15.2.4.2.				

6.2.5.2.4.2 Required results

The PER shall not exceed value defined in 5.2.3.7.2.

6.2.5.2.5 Spurious response rejection

6.2.5.2.5.1 Objective

The spurious response rejection is a measure of the capability of the receiver to discriminate between the wanted modulated signal at the nominal frequency and an unwanted signal at any other frequency at which a response is obtained.

6.2.5.2.5.2 Method of measurement

The manufacturer shall provide the test house with the information regarding the equipment. In general, a block diagram from which it appears what signal path architecture there has been chosen.

If the equipment is built using heterodyne principles, the following shall be stated:

- IF frequencies used;
- the local oscillator frequencies;
- filter arrangements ahead of the first mixer.

If the equipment uses analogue to digital converter techniques, the following shall be stated:

- whether the sampling is done directly on the RF frequency or on an IF frequency;
- the sampling frequency used for the conversion.

The arrangements for applying two test signals to the receiver input shall be according to 6.2.2.

The wanted signal shall be applied using relevant frequencies as specified by Table 30. The level of the wanted signal shall be 3 dB above the sensitivity level specified in Table 30. The level of the unwanted signal shall be –36 dBm.

The equipment shall be in compliance for frequencies from 9 kHz to 2 GHz with the exception of the receiver passband and the adjacent channels.

The equations below for calculation of spurious frequencies can be used as a guidance.

a) For equipment using super heterodyne principles

$f_{spurious} = (1 - n)/m \times f_{if} - n/m \times f_{receive}$

where m and n are integers with values from –5 to +5.

Spurious frequency calculation should be applied to all frequency conversions (IF1, IF2, etc).

b) For equipment using analog to digital converter techniques

$f_{spurious} = f_{receive}/m - n/m \times f_{sample\ clock}$

where m and n are integers with values from –5 to +5.

c) For equipment where both heterodyne principles and digital techniques are used, both equations should be taken into consideration.

6.2.5.2.5.3 Required results

The PER shall be equal to or less than 20 %.

6.2.5.2.6 Intermodulation response rejection

6.2.5.2.6.1 Purpose

The intermodulation response rejection is the capability of the receiver to receive a wanted modulated signal, without exceeding a given degradation due to the presence of two close-spaced unwanted signals with a specific frequency relationship to the wanted signal frequency.

6.2.5.2.6.2 Method of test

Use test setup described in Figure 13.

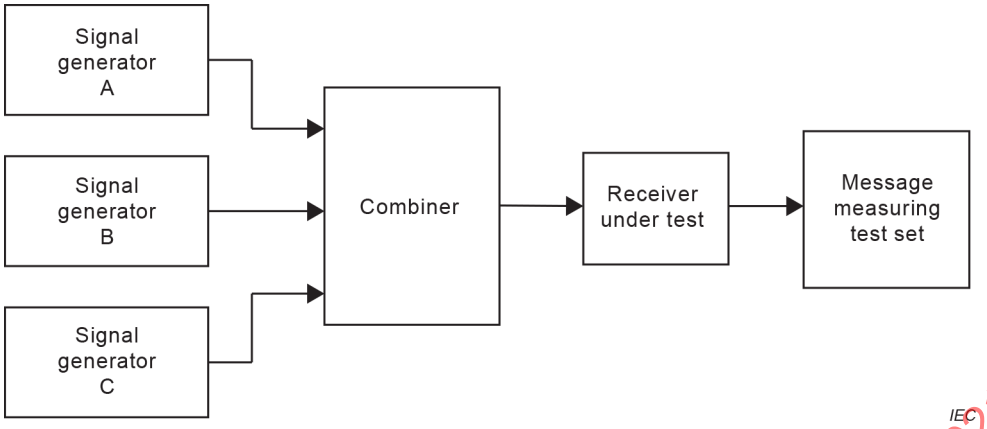

Figure 13 – Measurement arrangement for intermodulation

The measurement procedure shall be as follows:

a) three signal generators shall be connected to the receiver via a combining network as shown in Figure 13;

b) the wanted signal, provided by signal generator A, shall be at the specified frequency of the receiver and shall be modulated to generate applicable test signal. For ASM, the test signals shall be as described in Table 35;

c) the unwanted signal from generator B shall be unmodulated;

d) the unwanted signal from generator C shall be frequency modulated with a 400 Hz sine wave at a deviation of ±3 kHz.

e) the signal level from generator A (wanted) shall be set for 6 dB above the sensitivity level stated in Table 30 at the receiver input;

f) the signal level from generators B and C shall be set to applicable level at the receiver input. For ASM, see Table 35;

g) the frequencies of generators A, B, C shall be set as per test number 1 of Table 34;

h) the message measuring test set shall be monitored and the PER observed over 200 transmissions;

i) repeat the measurement with frequencies set as per test number 2 of Table 34.

Table 34 – Frequencies for inter-modulation test

Test number	Generator A Wanted signal	Generator B Unmodulated ±500 kHz offset	Generator C Modulated ±1000 kHz offset
1 (ASM)	161,950 MHz	161,450 MHz	160,950 MHz
2 (VDE low band)	157,250 MHz	157,750 MHz	158,250 MHz
3 (VDE high band)	161,850 MHz	161,350 MHz	160,850 MHz

Table 35 – Test signals used for inter-modulation test

Generator A Test Signal	Bandwidth [kHz]	Wanted signal level [dBm]	Generator B Test Signal	Unwanted signal level [dBm]	Generator C Test Signal	Unwanted signal level [dBm]
6 (no coding)	25	[–101]	Unmodulated ±500 kHz offset	See 5.2.3.7.2	Modulated ±1 000 kHz offset	See 5.2.3.7.2

6.2.5.2.6.3 Required results

The PER shall not exceed value defined in 5.2.3.7.2.

6.2.5.2.7 Blocking

6.2.5.2.7.1 Purpose

Blocking is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted input signal at any frequency other than those of the spurious responses or the adjacent channels.

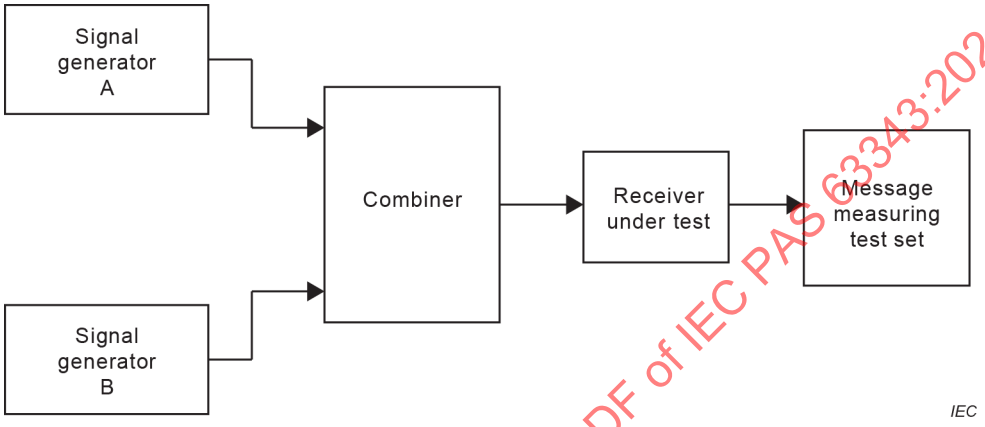

Figure 14 – Measurement arrangement for blocking or de-sensitisation

6.2.5.2.7.2 Method of measurement

The measurement procedure shall be as follows:

a) two generators A and B, shall be connected to the receiver via a combining network as shown in Figure 14;

b) the wanted signal, provided by signal generator A, shall be initially at the lowest frequency of the EUT and be modulated to generate the applicable test signal. For ASM, see Table 36 and Table 37;

c) the unwanted signal from generator B shall be unmodulated and tuned to applicable frequency, see Table 36. Initially, signal generator B (unwanted signal) shall be switched off (maintaining the output impedance). The level of the wanted signal from generator A shall be adjusted to 6 dB above the sensitivity level stated in Table 30 at the receiver input;

d) generator B shall then be switched on, and the level of the unwanted signal set to –15 dBm;

e) 200 packets shall be transmitted and the PER recorded;

f) repeat the test steps a) to e) with the wanted signal generator tuned to highest frequency of the EUT and the unwanted signal generator tuned to applicable frequency. For ASM, see Table 36.

Table 36 – Frequencies for blocking test

Test number	Generator A Wanted signal	Generator B Unmodulated carrier
1 (ASM1)	161,950 MHz	156,300 MHz
2 (ASM2)	162,000 MHz	156,300 MHz

Table 37 – Test signals used for blocking test

Generator A Test Signal	Bandwidth [kHz]	Wanted signal level [dBm]	Unwanted signal level [dBm]
6 (no coding)	25	–101	See 5.2.3.7.2

6.2.5.2.7.3 Required results

The PER shall not exceed value defined in 5.2.3.7.2.

6.2.5.2.8 Transmit to receive switching time

[Future: This is to be tested in protocol layer tests. Idea is to require a test mode where the EUT can be commanded to transmit on a specific slot. Then, in combination with external equipment that will be able to do the same, the EUT can be confirmed to receive on both slots adjacent to the slot the EUT was commanded to transmit on.]

6.2.5.2.9 Immunity to out-of-band energy

Method of measurement and required results as declared by the manufacturer.

6.2.6 Specific tests of Link layer

The following test assumes that the EUT is a combined AIS and ASM box.

6.2.6.1 Synchronisation and jitter accuracy

6.2.6.1.1 Definition

Synchronisation jitter (transmission timing error) is the time between the nominal slot start as determined by the UTC synchronisation source and the start of data (T_B as in Figure 5).

6.2.6.1.2 Method of measurement

Set up the standard test environment.

a) Operate the ASM box such that it utilizes UTC direct synchronisation. Initiate the transmission of a single slot broadcast binary message (ASM VDL Message 2).

b) Operate the ASM box such that it utilizes UTC indirect synchronisation by disconnecting the GNSS antenna of the EUT. Initiate the transmission of a single slot broadcast binary message (ASM VDL Message 2).

Record transmitted VDL messages and measure the time between the nominal beginning of the slot interval and the start of data.

6.2.6.1.3 Required results

The synchronisation, including its jitter, shall not exceed:

a) ± 104 μs using UTC direct synchronisation,

b) ± 312 μs relative to the synchronisation source using UTC indirect synchronisation.

6.2.6.2 Transmission of ASM Messages

6.2.6.2.1 Definition

The EUT shall be able to transmit all the ASM VDL messages as defined in Table 16.