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Technical Specification

**VHF air-ground Digital Link (VDL) Mode 4 radio equipment;
Technical characteristics and methods of
measurement for ground-based equipment**

Reference

RTS/AERO-00012

Keywords

aeronautical, digital, radio, testing, VHF

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Aeronautics (AERO).

The present document is accompanied by equivalent airborne standards, EN 302 842-1 [i.5], EN 302 842-2 [i.6], EN 302 842-3 [i.7], EN 302 842-4 [i.8] and TS 102 842 [i.9], covering the VHF air-ground Digital Link (VDL) Mode 4 radio equipment; Technical characteristics and methods of measurement for airborne equipment.

NOTE: Following the decision taken at the ICAO Aeronautical Communication Panel (Bangkok, February 2011), it is expected that ICAO Annex 10 will be amended in 2012 changing the frequency range from 108-137,975 MHz to 112-137,975 MHz. The present deliverable will be updated accordingly once the amendment is publicly available.

Introduction

The present document states the technical specifications for Very High Frequency (VHF) Digital Link (VDL) Mode 4 ground-based radio transmitters, transceivers and receivers for air-ground communications operating in the VHF band, using Gaussian-filtered Frequency Shift Keying (GFSK) Modulation with 25 kHz channel spacing and capable of tuning to any of the 25 kHz channels from 118,000 MHz to 136,975 MHz as defined in ICAO VHF Digital Link (VDL) Standards and Recommended Practices (SARPs) [2].

The present document may be used to produce tests for the assessment of the performance of the equipment. The performance of the equipment submitted for type testing should be representative of the performance of the corresponding production model.

The present document has been written on the assumption that:

- the type test measurements will be performed only once, in an accredited test laboratory, and the measurements will be accepted by the various authorities in order to grant type approval;
- if equipment available on the market is required to be checked it may be tested in accordance with the methods of measurement specified in the present document or a documented alternative approved by the certifying authority;

equipment comply with EN 301 489-22 [3].

1 Scope

The present document applies to the following radio equipment types:

- Very High Frequency (VHF) Digital Link (VDL) Mode 4 ground-based radio transmitters and receivers for air-ground communications operating in the VHF band, using Gaussian-filtered Frequency Shift Keying (GFSK) Modulation with 25 kHz channel spacing and capable of tuning to any of the 25 kHz channels from 118,000 MHz to 136,975 MHz as defined in ICAO VHF Digital Link (VDL) Standards and Recommended Practices (SARPs) [2].

The present document is designed to ensure that equipment will be compatible with the relevant ICAO VHF Digital Link (VDL) Standards and Recommended Practices (SARPs) [2] and VDL Mode 4 Technical Manual (TM) [1].

The present document does not give a presumption of conformity related to maintenance requirements, safety, civil/military coordination or environmental constraints.

NOTE: For these ERs, please refer to the Local Air Navigation Service Provider procedures.

Manufacturers should note that in future the tuning range for the ground transceivers may also cover any 25 kHz channel from 108,000 MHz to 117,975 MHz.

The scope of the present document is limited to ground stations. The equivalent specifications for airborne stations are EN 302 842-1 [i.5], EN 302 842-2 [i.6], EN 302 842-3 [i.7], EN 302 842-4 [i.8] and TS 102 842 [i.9].

The VDL Mode 4 system provides digital communication exchanges between aircraft and ground-based systems and other aircraft supporting surveillance and communication applications. The supported modes of communication include:

- broadcast and point-to-point communication;
- broadcast services including Automatic Dependent Surveillance - Broadcast (ADS-B), Traffic Information Service - Broadcast (TIS-B) and Flight Information Service - Broadcast (FIS-B) capabilities;
- air-air, air-to-ground, and ground-to-air services;
- operation without ground infrastructure.

The present document is derived from the specifications:

- VDL Mode 4 standards produced under the auspices of the International Civil Aviation Organization (ICAO) [1] and [2].
- Other relevant standards as defined in clause 2.

It is envisaged that manufacturers may provide equipment supporting:

- broadcast services only;
- point-to-point services only;
- both broadcast and point-to-point services.

The present document includes:

- clause 2 provides references to relevant documents;
- clause 3 provides general definitions, abbreviations and symbols used;
- clause 4 refers to a general description and architecture of VDL Mode 4 contained in EN 301 842-2 [5];
- clause 5 provides tables tracing technical requirements specifications applicable to the interoperability Regulation [i.4];
- annex A provides a Bibliography;

- a document history.

Mandating and Recommendation Phrases

- a) **"Shall"**
The use of the word "Shall" indicates a mandated criterion; i.e. compliance with the particular procedure or specification is mandatory and no alternative may be applied.
- b) **"Should"**
The use of the word "Should" (and phrases such as "It is recommended that...", etc.) indicate that though the procedure or criterion is regarded as the preferred option, alternative procedures, specifications or criteria may be applied, provided that the manufacturer, installer or tester can provide information or data to adequately support and justify the alternative.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at <http://docbox.etsi.org/Reference>.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

- [1] ICAO Doc 9816 - AN/448 (First Edition 2004): "Manual on VHF Digital Link (VDL) Mode 4, Part 2: Detailed Technical Specifications".
- [2] ICAO Annex 10 to the Convention on International Civil Aviation: "Aeronautical Telecommunications, Volume III: Communication Systems, Part I: Digital Data Communication Systems, Chapter 6".
- [3] ETSI EN 301 489-22 (V1.3.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 22: Specific conditions for ground based VHF aeronautical mobile and fixed radio equipment".
- [4] ETSI EN 301 842-1 (V1.3.2): "VHF air-ground Digital Link (VDL) Mode 4 radio equipment; Technical characteristics and methods of measurement for ground-based equipment; Part 1: EN for ground equipment".
- [5] ETSI EN 301 842-2 (V1.6.1): "VHF air-ground Digital Link (VDL) Mode 4 radio equipment; Technical characteristics and methods of measurement for ground-based equipment; Part 2: General description and data link layer".

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] ISO/IEC 7498-1 (1994): "Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model".
- [i.2] ISO/IEC 10731 (1994): "Information technology - Open Systems Interconnection - Basic Reference Model - Conventions for the definition of OSI services".

- [i.3] Regulation (EC) No 552/2004 of the European Parliament and of the Council of 10 March 2004 on the interoperability of the European Air Traffic Management network (the interoperability Regulation), OJ L 96, 31.03.2004 as amended by Regulation (EC) No 1070/2009.
- [i.4] Commission Regulation (EC) No 2150/2005 of 23 December 2005 laying down common rules for the flexible use of airspace.
- [i.5] ETSI EN 302 842-1 (V1.2.2): "VHF air-ground and air-air Digital Link (VDL) Mode 4 radio equipment; Technical characteristics and methods of measurement for aeronautical mobile (airborne) equipment; Part 1: Physical layer".
- [i.6] ETSI EN 302 842-2 (V1.3.1): "VHF air-ground and air-air Digital Link (VDL) Mode 4 radio equipment; Technical characteristics and methods of measurement for aeronautical mobile (airborne) equipment; Part 2: General description and data link layer".
- [i.7] ETSI EN 302 842-3 (V1.3.1): "VHF air-ground and air-air Digital Link (VDL) Mode 4 radio equipment; Technical characteristics and methods of measurement for aeronautical mobile (airborne) equipment; Part 3: Additional broadcast aspects".
- [i.8] ETSI EN 302 842-4 (V1.2.2): "VHF air-ground and air-air Digital Link (VDL) Mode 4 radio equipment; Technical characteristics and methods of measurement for aeronautical mobile (airborne) equipment; Part 4: Point-to-point functions".
- [i.9] ETSI TS 102 842: "VHF air-ground and air-air Digital Link (VDL) Mode 4 radio equipment; Technical characteristics and methods of measurement for aeronautical mobile (airborne) equipment".

3 Definitions and abbreviations

3.1 Definitions

3.1.1 Basic reference model definitions

The present document is based on the concepts developed in the open systems interconnect basic reference model and makes use of the following terms defined in ISO/IEC 7498-1 [i.1]:

- layer;
- sublayer;
- entity;
- service;
- service access point;
- service data unit;
- physical layer;
- data link layer.

3.1.2 Service conventions definitions

The present document makes use of the following terms defined in ISO/IEC 10731 [i.2]:

- service provider;
- service user;

- service primitive;
- request;
- indication;
- confirm.

3.1.3 General definitions

For the purposes of the present document, the terms and definitions given in EN 301 842-1 [4], EN 301 842-2 [5], and the following apply:

Automatic Dependent Surveillance-Broadcast (ADS-B): surveillance application transmitting parameters, such as position, track and ground speed, via a broadcast mode data link for use by any air and ground users requiring it

NOTE: ADS-B is a surveillance service based on aircraft self-determination of position/velocity/time and automatic, periodic or random, broadcast of this information along with auxiliary data such as aircraft identity (ID), communications control parameters, etc. ADS-B is intended to support multiple high-level applications and associated services such as cockpit display of traffic information, traffic alert and collision avoidance functionality, enhanced traffic management in the air and on the ground, search and rescue support and others.

current slot: slot in which a received transmission begins

Data Link Service (DLS) sublayer: sublayer that resides above the VDL Mode 4 Specific Services (VSS) and the MAC sublayers

NOTE: The data link service (DLS) manages the transmit queue, creates and destroys data link entities (DLEs) for connection-oriented communications, provides facilities for the link management entity (LME) to manage the DLS, and provides facilities for connection-less communications.

DLS system: VDL system that implements the DLS and subnetwork protocols to carry Aeronautical Telecommunications Network (ATN) or other packets

environmental profile: range of environmental conditions under which equipment within the scope of the present document is required to comply with the provisions of the present document

equipment: constituent parts of the VDL Mode 4 system

ground base station: aeronautical station equipment, in the aeronautical mobile service, for use with an external antenna and intended for use at a fixed location

ground station co-ordination: co-ordination of transmissions from two or more ground stations using the UTC-minute time frame

link: connects a mobile DLE and a ground DLE and is uniquely specified by the combination of mobile DLS address and the ground DLS address

NOTE: A different subnetwork entity resides above every link endpoint.

link establishment: process by which two stations discover each other, determine to communicate with each other, decide upon the communication parameters, create a link and initialize its state before beginning communications

link layer: layer that lies immediately above the physical layer in the Open Systems Interconnection protocol model

NOTE: The link layer provides for the reliable transfer of information across the physical media. It is subdivided into the data link sublayer and the media access control sublayer.

Link Management Entity (LME): protocol state machine capable of acquiring, establishing, and maintaining a connection to a single peer system

NOTE: An LME establishes data link and subnetwork connections, "hands-off" those connections, and manages the media access control sublayer and physical layer. An aircraft LME tracks how well it can communicate with the ground stations of a single ground system. An aircraft VDL management entity (VME) instantiates an LME for each ground station that it monitors. Similarly, the ground VME instantiates an LME for each aircraft that it monitors. An LME is deleted when communication with the peer system is no longer viable.

Media Access Control (MAC): sublayer that acquires the data path and controls the movement of bits over the data path

mobile: radio equipment designed for installation into vehicles

physical layer: lowest level layer in the Open Systems Interconnection protocol model

NOTE: The physical layer is concerned with only the transmission of binary information over the physical medium (e.g. VHF radio).

primary time source: normal operation timing mode in which a VDL Mode 4 station maintains time synchronization to Universal Co-ordinated Time (UTC) second to within a two-sigma value of 400 ns

station: VDL Mode 4 Specific Services (VSS)-capable entity

NOTE: A station may be either a mobile station or a ground station. A station is a physical entity that transmits and receives bursts over the RF interface (either air-ground (A/G) or air-to-air (A/A)) and comprises, at a minimum: a physical layer, media access control sublayer, and a unique VSS address. A station which is also a DLS station has the same address.

subnetwork layer: layer that establishes, manages, and terminates connections across a subnetwork

synchronization burst (or "sync" burst): VDL Mode 4 burst which announces, as a minimum, existence and position

NOTE: Ground stations announce existence, position, and the current time. Mobile stations lacking timing information can then derive the slot structure from ground synchronization bursts. Mobile stations lacking position information can derive position from both mobile and ground synchronization bursts. This periodic information is used in various ways including ADS-B, secondary navigation, and simplifying the LME algorithms.

VDL Mode 4 (VDL4): VHF data link using a Gaussian Filtered Frequency Shift Keying modulation scheme and self-organizing time division multiple access

VDL Mode 4 Specific Services (VSS) sublayer: sublayer that resides above the MAC sublayer and provides VDL Mode 4 specific access protocols including reserved, random and fixed protocols

VDL Mode 4 station: physical entity that transmits and receives VDL Mode 4 bursts over the RF interface (either A/G or air-to-air (A/A)) and comprises, as a minimum: a physical layer, Media Access Control sublayer and a VSS sublayer

NOTE: A VDL Mode 4 station may either be a mobile VDL Mode 4 station or a ground VDL Mode 4 station.

VSS user: user of the VDL Mode 4 Specific Services

NOTE: The VSS user could be higher layers in the VDL Mode 4 Technical Manual or an external application using VDL Mode 4.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

A/A	Air-to-Air
A/G	Air-to-Ground
ADS-B	Automatic Dependent Surveillance-Broadcast
ATN	Aeronautical Telecommunication Network
DLE	Data Link Entity

DLS	Data Link Service
EATM	European Air Traffic Management
FIS-B	Flight Information Service-Broadcast
GFSK	Gaussian-filtered Frequency Shift Keying
ICAO	International Civil Aviation Organization
ID	IDentity
ISO	International Organization for Standardization
LME	Link Management Entity
MAC	Media Access Control
OSI	Open Systems Interconnection
RF	Radio Frequency
SARP	Standards and Recommended Practices
SWAL	SoftWare Assurance Level
TIS-B	Traffic Information Service-Broadcast
UTC	Universal Co-ordinated Time
VDL	VHF Digital Link
VDL4	VDL Mode 4
VHF	Very High Frequency
VME	VDL Management Entity
VSS	VDL Mode 4 Specific Services

4 General description and architecture of VDL Mode 4

4.1 General

A description of VDL Mode 4, the communication services provided, the equipment classes, the structure of the standards material and guidance on equipment performance verification is provided in EN 301 842-2 [5], clause 4.

In most respects, the VDL Mode 4 ground station follows the provisions of the ICAO standards material for VDL Mode 4. Within the ICAO standard, there are some requirements that apply explicitly only to airborne stations. These are addressed in the accompanying document EN 302 842-1 [i.5], EN 302 842-2 [i.6], EN 302 842-3 [i.7], EN 302 842-4 [i.8].

A number of other requirements will also not apply because of the assumed services provided by the ground station.

4.2 Coverage of the interoperability Regulation

Table 4.1 indicates which of the essential requirements in Annex of the interoperability Regulation [i.4] are considered in the present document.

Table 4.1: Coverage of the interoperability Regulation

Essential requirements Part A: General requirements				
No.	Title	Constituent level	System level	Explanation
A1	Seamless operation	Part covered	N/A	System requirements are not covered. Requirements relating to maintenance and operation are not relevant.
A2	Support for new concepts of operation	N/A	N/A	This requirement can only be applied to systems and is not relevant at the constituent level.
A3	Safety	Part covered	N/A	The design and build requirements for ground based constituents are covered. Systems and operations of the EATM shall achieve agreed high levels of safety. Agreed safety management and reporting methodologies shall be established to achieve this. The systems design, built and maintenance are covered. Using the appropriate and validated procedures, in such a way that the tasks assigned to the control staff are compatible with human capabilities, in both the normal and degraded modes of operation.
A4	Civil-military coordination	N/A	N/A	
A5	Environmental constraints	N/A	N/A	This requirement can only be applied to systems and is not relevant at the constituent level.
A6	Principles governing the logical architecture of systems	N/A	N/A	This requirement can only be applied to systems and is not relevant at the constituent level.
A7	Principles governing the construction of systems	N/A	N/A	This requirement can only be applied to systems and is not relevant at the constituent level.
Essential requirements Part B: Specific requirements				
B1	Systems and procedures for airspace management	N/A	N/A	This requirement can only be applied to systems and is not relevant at the constituent level.
B2	Systems and procedures for air traffic flow management	N/A	N/A	This requirement can only be applied to systems and is not relevant at the constituent level.
B3	Systems and procedures for air traffic services	Part covered	N/A	The design and build requirements for ground-based constituents are covered.
B4	Communications systems and procedures for ground-to-ground, air-to-ground and air-to-air communications	N/A	N/A	This requirement can only be applied to systems and is not relevant at the constituent level.
B5	Navigation systems and procedures	N/A	N/A	This requirement can only be applied to systems and is not relevant at the constituent level.
B6	Surveillance systems and procedures	N/A	N/A	This requirement can only be applied to systems and is not relevant at the constituent level.
B7	Systems and procedures for aeronautical information services	Covered	N/A	Provision of information and the standards governing its format and content are relevant for constituents are covered.
B8	Systems and procedures for the use of meteorological information	N/A	N/A	This requirement can only be applied to systems and is not relevant at the constituent level.
NOTE: SoftWare Assurance Level (SWAL) is out of the scope of the present document.				

4.3 Scope of interoperability

It is only possible to trace the constituent parts of the VDL Mode 4 ground-based equipment with the interoperability Regulation. System-level configurations are outside the scope of the present document, as they are not manufacturer specific.

The scope of the present document is illustrated by the figure 4.1.

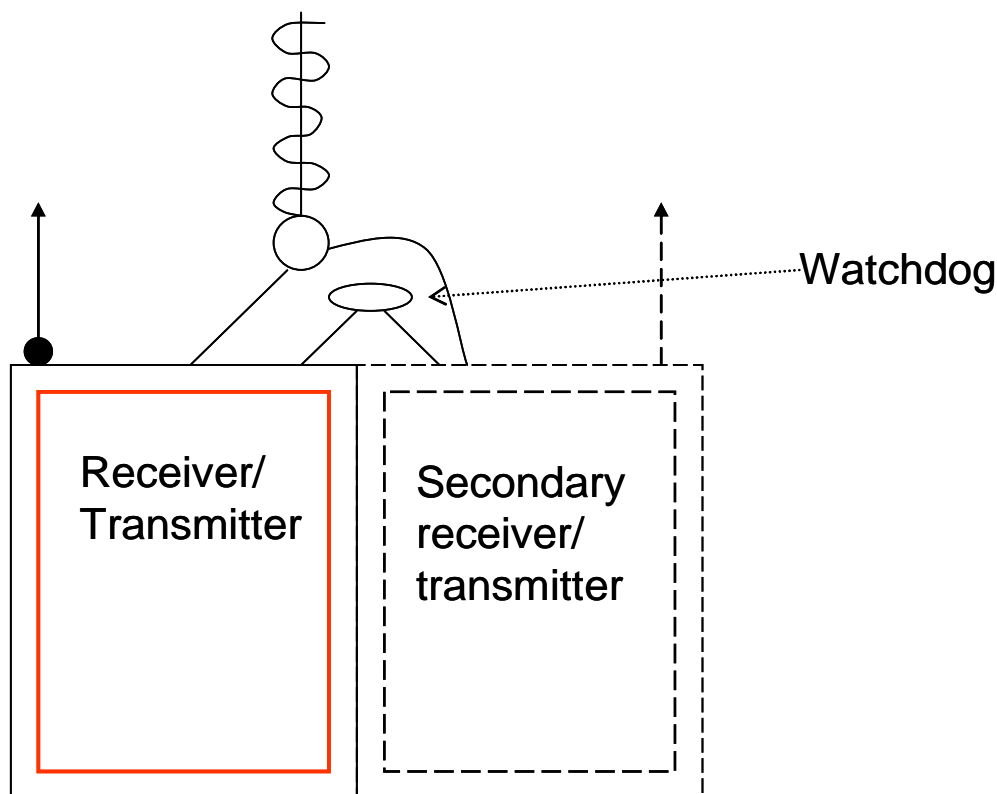


Figure 4.1: Ground-based equipment

5 Traceability to interoperability Essential Requirements

5.1 Requirement traceability

EC 552/2004 [i.3] has been examined by ETSI TC AERO and the VDL4 ground station equipment shows compliance with the requirements stated in the present document.

Annex A (informative): Bibliography

- EUROCAE ED-78A: "Guidelines for approval of the provision and use of ATS supported by data communications".
- EUROCAE ED-108A: "MOPS for the Very High Frequency (VHF) Digital Link (VDL) Mode 4 Aircraft Transceiver".
- ETSI TR 102 579: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Report on the development of harmonized standards under the Single European Sky (SES) interoperability (IOP) regulation 552/2004 (Community Specifications)".

History

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