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Electromagnetic compatibility and Radio spectrum Matters (ERM); 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

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European Standard (Telecommunications series)

**Electromagnetic compatibility
and Radio spectrum Matters (ERM);
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**

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Foreword

This European Standard (Telecommunications series) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

The present document is part 1 of a multi-part deliverable covering the VHF air-ground and air-air Digital Link (VDL) Mode 4 radio equipment; Technical characteristics and methods of measurement for aeronautical mobile (airborne) equipment, as identified below:

Part 1: "Physical layer";

Part 2: "General description and data link layer";

Part 3: "Additional broadcast aspects";

Part 4: "Point-to-point functions".

The present document is accompanied by an equivalent ground-based standard, EN 301 842 [8] parts 1 to 4, covering the VHF air-ground Data Link (VDL) Mode 4 radio equipment; Technical characteristics and methods of measurement for ground-based equipment.

NOTE: Minimum Operational Performance Specifications (MOPS) are also being developed for VDL Mode 4. EUROCAE have previously published Interim MOPS for VDL Mode 4 (see bibliography) which are a sub set of EN 302 842-1, 2, 3 and 4. EN 302 842-1, 2, 3 and 4 complies with the requirements of CEC Mandate M/318.

National transposition dates

Date of adoption of this EN:	22 July 2005
Date of latest announcement of this EN (doa):	31 October 2005
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	30 April 2006
Date of withdrawal of any conflicting National Standard (dow):	30 April 2006

Introduction

The present document states the technical specifications for Very High Frequency (VHF) Digital Link (VDL) Mode 4 aeronautical mobile (airborne) radio transmitters, transceivers and receivers for air-ground and air-air 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 VDL 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 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.

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1 Scope

The present document provides part 1 of the technical specifications, and means of testing compliance, for Very High Frequency (VHF) Digital Link (VDL) Mode 4 aeronautical mobile (airborne) radio transmitters, transceivers and receivers for air-ground and air-air 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 VDL SARPs [2].

The present document is designed to ensure that equipment certified to it will be compatible with the relevant ICAO VDL SARPs [2] and ICAO VDL4 Technical Manual [1].

NOTE 1: In clause 6.1.12 the requirement is more stringent than required in ICAO VDL SARPs [2].

Manufacturers should note that in future the tuning range for the transmitter may also cover any 25 kHz channel from 112,000 MHz to 117,975 MHz and the receiver(s) may cover any 25 kHz channel from 108,000 MHz to 117,975 MHz.

The present document applies to "aeronautical mobile (airborne and in some cases ground vehicles)" equipment which will hereinafter be referred to as "mobile" equipment.

The scope of the present document is limited to mobile stations. The equivalent specification for ground stations is EN 301 842 [8].

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 and ground-air services;
- operation without ground infrastructure.

The present document is derived from the specifications:

- ICAO VDL4 Technical Manual [1] and ICAO VDL SARPs [2] produced under the auspices of the International Civil Aviation Organization (ICAO).
- 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 deals with tests of the physical layer necessary to support all types of equipment.

The present document includes:

- References, definitions, abbreviations and symbols are provided in clauses 2 and 3.
- Clause 4 provides a general description and architecture of VDL Mode 4.
- Clause 5 provides functional specifications applicable to the physical layer including transmitter/receiver requirements and the modulation scheme.
- Clause 6 provides VDL Mode 4 equipment requirements.
- Clause 7 provides general design requirements.

- Clause 8 provides environmental test requirements.
- Clause 9 provides detailed test procedures for the physical layer.
- Clause 10 provides installed equipment requirements.

The full physical layer tests are provided which correspond closely to the standard set of tests used for other VDL systems.

NOTE 2: Flight tests are defined in EN 302 842-2 [7].

Mandating and recommendation phrases

- a) "Shall"
- The use of the word "Shall" indicates a mandated criterion; e.g. 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

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

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

- [1] ICAO 9816: "Manual on VHF Digital Link (VDL) Mode 4 - Part 2: Detailed Technical Specifications". First Edition 2004.
- [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] ISO/IEC 7498-1 (1994): "Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model".
- [4] ISO/IEC 10731 (1994): "Information technology - Open Systems Interconnection - Basic Reference Model - Conventions for the definition of OSI services".
- [5] EUROCAE ED-12B/RTCA DO-178B: "Software Considerations in Airborne Systems and Equipment Certification".
- [6] EUROCAE ED-14D/RTCA DO-160D: "Environmental Conditions and Test Procedures for Airborne Equipment, July 1997, as amended by Change 1 (December 2000), by Change 2 (June 2001), and by Change 3 (December 2002)".
- [7] ETSI EN 302 842-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); 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".

- [8] ETSI EN 301 842 (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); VHF air-ground Digital Link (VDL) Mode 4 radio equipment; Technical characteristics and methods of measurement for ground-based equipment".
- [9] ETSI EN 302 842-3: "Electromagnetic compatibility and Radio spectrum Matters (ERM); 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".

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 [3]:

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

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3.1.2 Service conventions definitions

The present document makes use of the following terms defined in ISO/IEC 10731 [4]:

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

3.1.3 General definitions

For the purposes of the present document, the following terms and definitions apply:

adjacent channel power: amount of the modulated rf signal power which falls within a given adjacent channel

NOTE: Adjacent channel power includes discrete spurious, signal sidebands, and noise density (including phase noise) at the transmitter output.

Adjacent Channel Rejection (ACR): receiver's ability to demodulate the desired signal and meet the BER requirement in the presence of an interfering signal in an adjacent channel

NOTE: The ratio (in dB) between the adjacent interfering signal level and the desired signal level necessary to achieve the specified minimum BER, is the adjacent channel rejection (ACR) ratio.

Aeronautical Mobile Service (AMS): mobile service between aeronautical stations and aircraft stations, or between aircraft stations, in which survival craft stations may participate

Aeronautical Telecommunication Network (ATN): internetwork architecture that allows ground, air/ground, and aircraft data subnetworks to interoperate by adopting common interface services and protocols based on the International Organization for Standardization Open Systems Interconnection Reference Model

aircraft address: unique combination of 24 bits available for assignment to an aircraft for the purpose of communications, navigation and surveillance.

NOTE: An aircraft may choose not to use this unique address and can use instead a non-unique address.

Automatic Dependent Surveillance-Broadcast (ADS-B): surveillance application transmitting parameters, such as position, track and ground speed, via a broadcast mode digital 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.

autotune function: function, performed by the Link Management Entity that allows a ground VDL Mode 4 station to command an aircraft to change the operating characteristics of synchronization burst transmissions

Bit Error Rate (BER): ratio between the number of erroneous bits received and the total number of bits transmitted

burst length: number of slots across which the VDL Mode 4 burst is transmitted

Co-Channel Interference (CCI): capability of a receiver to demodulate the desired signal and achieve the minimum specified BER performance in the presence of an unwanted signal at the same assigned frequency

NOTE: The ratio (in dB) between the wanted signal level and the unwanted signal level is the co-channel interference ratio. The co-channel interference ratio has a major impact on frequency re-use planning criteria.

conducted measurements: measurements which are made using a direct rf connection to the equipment under test

current slot: slot in which a received transmission begins

Data Link Entity (DLE): protocol state machine capable of setting up and managing a single data link connection

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.

data rate: Mode 4 nominal data rate is 19 200 bits/s

delayed burst: VDL Mode 4 burst that begins sufficiently after the beginning of a slot so that the transmitting VDL Mode 4 station is confident that no other VDL Mode 4 station that it could receive from and is within the guard range is transmitting in the slot

NOTE: The delayed VDL Mode 4 burst terminates by the end of the slot in which it began (its length is shortened to ensure completion by the nominal time).

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

frame: link layer frame is composed of a sequence of address, control, information and FCS fields, bracketed by opening and closing flag sequences

NOTE: A valid frame is at least 11 octets in length and contains an address field (8 octets), a link control field (1 octet) and a frame check sequence (2 octets). A frame may or may not include a variable-length information field.

Global Signalling Channel (GSC): channel available on a world wide basis which provides for communication control

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 coordination: coordination of transmissions from two or more ground stations uses the UTC-minute time frame

hand held: radio equipment with integral batteries, designed to be hand portable and operated hand held

NOTE: Provisions may be made for external connections and temporary installation into vehicles.

integral antenna equipment: radio communications equipment with an antenna integrated into the equipment without the use of an external connector and considered to be part of the equipment

NOTE: An integral antenna may be internal or external to the equipment. In equipment of this type, a 50 Ω rf connection point shall be provided for test purposes.

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 an aircraft and a ground LME 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 handoff: process by which peer LMEs, already in communication with each other, create a link between an aircraft and a new ground station before disconnecting the old link between the aircraft and the current ground station

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

non-integral antenna equipment: radio communications equipment with a connector intended for connection to an antenna

physical layer: lowest level layer in the Open Systems Interconnection (OSI) 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 Coordinated Time (UTC) second to within a two-sigma value of 400 ns

private parameters: parameters that are contained in CTRL and UCTRL DLPDUs and that are unique to the VHF digital link environment

radiated measurements: measurements which involve the measurement of a radiated field

reference signal level: signal level used in the receiver performance specifications except otherwise stated

reference bit sequence: sequence of bits used in the transmitter performance specifications

secondary time source: timing source used in a failure mode, which applies when the primary time source fails, in which a VDL Mode 4 station maintains time synchronization to UTC second to within a two-sigma value of 15 μ s

Self-organizing Time Division Multiple Access (STDMA): multiple access scheme based on time-shared use of a radio frequency (rf) channel employing:

- 1) discrete contiguous time slots as the fundamental shared resource; and
- 2) a set of operating protocols that allows users to mediate access to these time slots without reliance on a master control station.

slot: in VDL Mode 4, time is divided into a series of time slots of equal period. Each VDL Mode 4 burst transmission starts at the beginning of a slot

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 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

superframe: group of slots that span a period of one minute

NOTE: The start of the current superframe is aligned with the start of the slot that is currently being used for transmission. The next superframe starts one minute after the current slot.

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.

Time Division Multiple Access (TDMA): multiple access scheme based on time-shared use of an rf channel employing:

- 1) discrete contiguous time slots as the fundamental shared resource; and
- 2) a set of operating protocols that allows users to interact with a master control station to mediate access to the channel.

unicasted transmission: transmission addressed to a single station

VDL Mode 2: VHF data link using a differentially encoded 8 phase shift keying modulation scheme and carrier sense multiple access

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