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Electromagnetic compatibility and Radio spectrum Matters (ERM); VHF air-ground Data Link (VDL) Mode 4 radio equipment; Technical characteristics and methods of measurement for ground-based equipment; Part 1: General description and physical layer

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Contents

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Foreword

This European Standard (Telecommunications series) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM), and is now submitted for the Vote phase of the ETSI standards Two-step Approval Procedure.

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

Part 1: **"Physical layer"**;

Part 2: "Data Link Layer".

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	6 months after doa

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 (118,000 MHz to 136,975 MHz), using Gaussian-filtered Frequency Shift Keying (GFSK) Modulation with 25 kHz channel spacing. Optionally the transmitters, transceivers and receivers may tune between 113,000 MHz to 117,975 MHz.

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;

- equipment comply with EN 301 489-22 [5].

1   Scope

The present document states the minimum performance requirements for radio transmitters receivers and transceivers for ground VHF Datalink mode 4 (VDL mode 4) equipment intended to be used for air-ground data communications, operating in the VHF band (118,000 MHz to 137,000 MHz and optionally 113,000 MHz to 117,975 MHz) allocated to the aeronautical mobile service. It is designed to ensure that equipment certified to it will be compatible with the relevant ICAO VHF Digital Link (VDL) mode 4 Standards and Recommended Practices (SARPs) [1].

Manufacturers should note that in the future, all or part of the frequency band 108,000 MHz to 117,975 MHz may become available for aeronautical communications.

The present document applies to Gaussian-filtered Frequency Shift Keying (GFSK) systems, with channel separations of 25 kHz intended for air-ground digital communications. The scope of the present document is limited to ground stations.

The VDL mode 4 system provides data communication exchanges between aircraft and ground systems supporting surveillance applications. The supported modes of communication for VDL mode 4 include:

- broadcast and point-to-point communication,

- air-air and ground-air,

- operation without ground infrastructure.

VDL Mode 4 is designed to be an Air/Ground subsystem of the Aeronautical Telecommunication Network (ATN) using the AM(R)S band and it is organized according to the Open Systems Interconnection (OSI) model (defined by ISO). It provides reliable subnetwork services to the ATN system.

The present document specifies functional specifications of radio transmitters, receivers and transceivers at ground-based VHF communication equipment intended to be used for air-ground data communications. The present document is derived from the specifications:

- Mode 4 standards produced under the auspices of the International Civil Aviation Organization (ICAO) [1].

- Other relevant standards as defined in clause 2.

The present document includes:

- Clause 2 provides references to relevant documents.

- Clause 3 provides general definitions, abbreviations and symbols used.

- Clause 4 provides a general description and architecture of VDL Mode 4 including reference to the OSI model, communication services, ADS-B and operational scenarios.

- Clause 5 provides functional specifications applicable to the physical layer including transmitter/receiver requirements and the modulation scheme.

- Clause 6 provides general equipment requirements.

- Clause 7 provides general design requirements.

- Clause 8 covers general test conditions, environmental tests and calibration.

- Clause 9 provides detailed test procedures for the physical layer.

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

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

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.

[1]   Annex 10 to the Convention on International Civil Aviation: "Aeronautical Telecommunications", International Civil Aviation Organization.

[2]   ISO/IEC 7498-1 (1994): "Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model".

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

[4]   ETSI EN 300 113-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Land mobile service; Radio equipment intended for the transmission of data (and/or speech) using constant or non-constant envelope modulation and having an antenna connector; Part 1: Technical characteristics and methods of measurement".

[5]   ETSI EN 301 489-22: "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".

[6]   ISO/IEC 3309: "Information technology - Telecommunications and information exchange between systems - High-level data link control (HDLC) procedures - Frame structure".

[7]   ISO/IEC 8208: "Information technology - Data communications - X.25 Packet Layer Protocol for Data Terminal Equipment".

[8]   ITU-T Recommendation X.25: "Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit".

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 [2]:

- 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 [3]:

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

Adjacent Channel Rejection: 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 2:   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: mobile service between aeronautical stations and aircraft stations, or between aircraft stations, in which survival craft stations may participate

Aeronautical Telecommunications Network: 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 air-ground communications, navigation and surveillance

NOTE 3: 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 data link for use by any air and/or ground users requiring it

NOTE 4: 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): expressed as the ratio between the number of erroneous bits received and the total number of bits received

burst: a VHF digital link (VDL) specific services burst is composed of a sequence of source address, burst ID, information, slot reservation, and frame check sequence (FCS) fields, bracketed by opening and closing flag sequences

NOTE 5: The start of a burst may occur only at quantized time intervals and this constraint allows the propagation delay between the transmission and reception to be derived.

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

Co-Channel Interference (CCI): co-channel interference protection defines the 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 6: 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: 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 7: 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 8: 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 Telecommunications 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 9:   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 10: 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 11: 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 12: 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 13: 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 14: 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: 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 protocol model

NOTE 15: 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 exchange identity (XID) frames 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 μs

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 16: 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 17: 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 18: 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

VDL Mode 4 burst: VHF digital link (VDL) Mode 4 burst is composed of a sequence of source address, burst ID, information, slot reservation, and frame check sequence (FCS) fields, bracketed by opening and closing flag sequences

> NOTE 19: The start of a burst may occur only at quantized time intervals and this constraint allows the propagation delay between the transmission and reception to be derived.

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

VSS user: user of the VDL Mode 4 Specific Services

NOTE 20: The VSS user could be higher layers in the VDL Mode 4 Technical Manual or an external application using VDL Mode 4.

VDL Management Entity (VME): VDL-specific entity that provides the quality of service requested by the ATN-defined subnetwork system management entity

NOTE 21: A VME uses the LMEs (that it creates and destroys) to acquire the quality of service available from peer systems.

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

VDL Mode 4 Station Address: 27-bit identifier used to uniquely identify a VDL Mode 4 station

VDL Station: VDL-capable entity

NOTE 23: A station may either be a mobile station or a ground station. A station is a physical entity that transmits and receives frames over the air/ground (A/G) interface and comprises, at a minimum: a physical layer, media access control sublayer, and a unique DLS address. The particular initiating process (i.e., DLE or LME) in the station cannot be determined by the source DLS address. The particular destination process cannot be determined by the destination DLS address. These can be determined only by the context of these frames as well as the current operational state of the DLEs.

VDL System: VDL-capable entity

NOTE 24: A system comprises one or more stations and the associated VDL management entity. A system may either be a mobile system or a ground system.

3.2   Abbreviations

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

A/A	Air-to-air
A/G	Air/Ground
ACP	Adjacent Channel Protection
ACR	Adjacent Channel Rejection
ADS-B	Automatic Dependent Surveillance Broadcast
AM(R)S	Aeronautical Mobile (Route) Service
ATN	Aeronautical Telecommunication Network
AWG	Arbitrary Waveform Generator
BER	Bit Error Rate
CCI	Co-Channel Interference
dB	deciBel
dBm	deciBels with respect to 1mW
DCE	Data Circuit-terminating Equipment
DLE	Data Link Entity
DLS	Data Link Service
DTE	Data Terminal Equipment
FCS	Frame Check Sequence
FM	Frequency Modulation
GFSK	Gaussian Filtered Frequency Shift Keying
GSC	Global Signalling Channel
HDLC	High-Level Data Link Control
ICAO	International Civil Aviation Organization
ID	Identity
ISO	International Organization for Standardization
LME	Link Management Entity
MAC	Media Access Control
NRZI	Non-Return to Zero Inverted

OSI	Open Systems Interconnection
PC	Personal Computer
ppm	parts per million
RF/rf	Radio Frequency
SARPs	Standards and Recommended Practices
SNAcP	SubNetwork Access Protocol
STDMA	Self-organizing Time Division Multiple Access
T	the baud period or 1/baud rate
TDMA	Time Division Multiple Access
UTC	Universal Coordinated Time
VDL	VHF Digital Link
VHF	Very High Frequency
VME	VDL Management Entity
VSA	Vector Signal Analyser
VSS	VDL Mode 4 Specific Services
VSWR	Voltage Standing Wave Ratio
XID	eXchange IDentity (frame)

4　General description and architecture of VDL Mode 4

4.1　General

VDL Mode 4 is a VHF data link, providing digital communications between mobile stations (aircraft and airport surface vehicles) and between mobile stations and fixed ground base stations. It was developed for aviation applications, including broadcast applications (e.g. ADS-B) and point-to-point communications (e.g. ADS-C). The most prominent properties of VDL Mode 4 are its efficient exchange of short repetitive messages and its ability to support time-critical applications.

VDL Mode 4 transmits digital data in a standard 25 kHz VHF communications channel and employs a Time Division Multiple Access (TDMA). A TDMA system divides the communication channel by time segments by first specifying a superframe, which in turn is subdivided into *time slots*. The start of each slot is an opportunity for a station to transmit.

A surveillance system such as ADS-B cannot have restrictions that specify the maximum number of participating stations. VDL Mode 4 is capable of handling overload situations (i.e. more slots are required than currently available), and to adapt to the traffic in a controlled and safe manner.

Built on the Self-organizing TDMA (STDMA) concept, the unique feature of VDL Mode 4 is the way that the available transmission time is divided into a large number of short time-slots synchronized to UTC. Each time slot may be used by a radio transponder (mounted on aircraft, ground vehicles or at fixed ground stations) for transmission of data. The exact timing of the slots and planned use of them for transmissions are known to all users in range of each other, so that efficient use of the data link can be made and users do not transmit simultaneously. As a result of this "self-organizing" protocol, VDL Mode 4 does not require any ground infrastructure to operate and can therefore support air-air as well as ground-air and ground-ground communications and applications.

Possible functions and services provided by VDL Mode 4 are illustrated in figure 4.1.
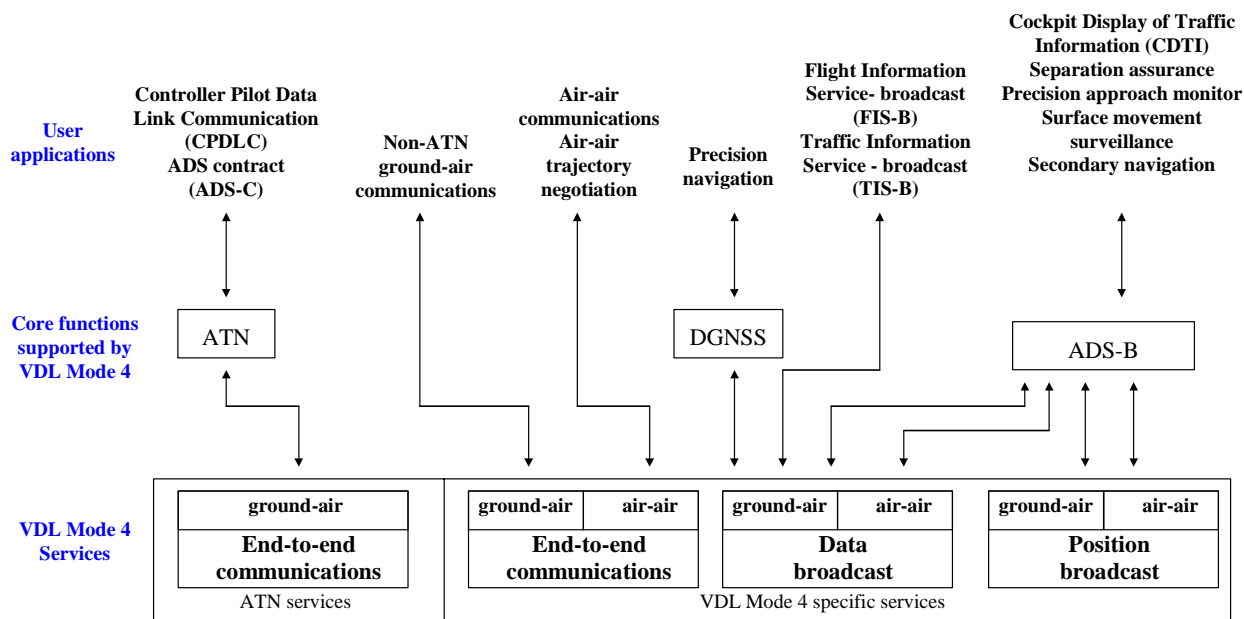
Figure 4.1: VDL Mode 4 functions and services

The above illustration is for a fully equipped ground station. However, it can be foreseen that a ground station at e.g. a G/A airfield does not have the same requirements. Consequently, there is a need to specify different classes of Ground Stations, which can be modularly upgraded.

A VDL Mode 4 ground station can be used to enable additional services and functions to the VDL Mode 4 system. A ground station can be configured in different ways depending upon the desired functions.

VDL mode 4 ground stations are capable of coordinating transmissions with other ground stations using the UTC-minute time frame.

4.2   Relationship to OSI reference model

The VDL Mode 4 sub-system implements the three lower layers of the OSI model as illustrated in figure 4.2.
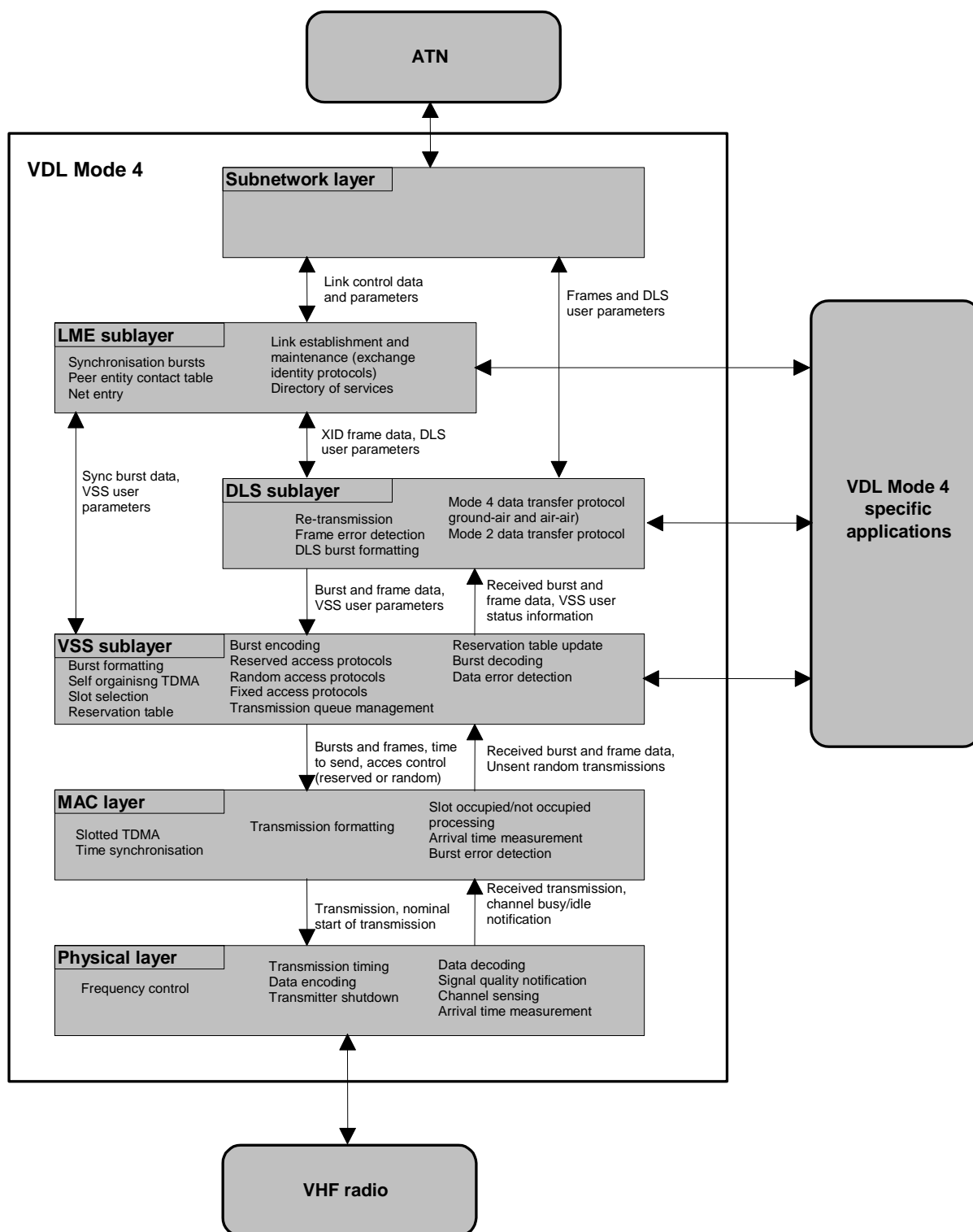
Figure 4.2: Layered structure of VDL Mode 4

Layer 1 (Physical layer) provides ground station frequency control, bit exchanges over the radio media, and notification functions. These functions are more often known as "radio" and "modulation" functions.

The ICAO VDL SARPs has defined the physical layer for VDL Mode 4: The modulation scheme is Gaussian Filtered Frequency Shift Keying (GFSK) with a nominal bit rate of 19 200 bits/s.

Layer 2 (Link Layer): is split into three sublayers and a management entity:

The Media Access Control (MAC) sublayer provides access to the Physical layer by a simple Time Division Multiple Access (TDMA) algorithm under the control of the next higher sublayer. It also provides system time functions to coordinate the TDMA channel access.

The VDL Mode 4 specific services (VSS) sublayer provides control of channel access using a self-organizing mechanism. The VSS also support a number of ground controlled access protocols. The basic services are built on reserved, random and fixed access to the TDMA slots and support broadcast and point-to-point communication.

The Data Link Services (DLS) sublayer is composed of the Aviation VHF Link Control derived from the High Level Data Link Control protocol (ISO/IEC 3309 [6]) whose main functions are frame exchanges, frame processing and error detection. The DLS protocols are adapted to make best use of the unique VSS channel access protocols.

The Link Management Entity is in charge of the links between peer DLS sublayers and also the maintenance of the broadcast link functions.

Layer 3: The VDL SARPs defines only the lowest network sublayer of layer 3 (SNAcP). It is compliant with the subnetwork sublayer requirements defined in the ATN SARPs and conforms with the ISO/IEC 8208 [7] (or network layer of ITU-T Recommendation X.25 [8]). It provides packet exchanges over a virtual circuit, error recovery, connection flow control, packet fragmentation, and subnetwork connection management functions.

4.3   Communication services

The VDL Mode 4 supports broadcast and point-to-point (addressed) communications with a minimum of overhead information for exchange of time-critical data. VDL Mode 4 also provides an ATN sub-network and thus provides fully ATN compliant communication services. Together these services support several broadcast and end-to-end communication functions that supporting a range of air-ground and air-air ATM applications. VDL Mode 4 services are accommodated on multiple VHF channels. The various applications could be combined on a single channel. The possibilities for channel sharing depends on various constraints such as channel availability, certification requirements and ATS regulations and may differ between states and regions.

Broadcast of data is the fundamental VDL Mode 4 technique, while point-to-point communications could be seen as a complement necessary for realizing specific needs in the future ATM concept. As an enabler of important applications and services such as ATS surveillance, cockpit display of traffic, surface movement surveillance and airborne separation assurance, ADS-B is the key VDL Mode 4 function.

ATN does not support broadcast transmissions. Such services are therefore defined as "specific services" in the ATN concept. Broadcast transmissions are used in many different CNS/ATM applications. Depending on the application the broadcast transmission can be made both by ground stations and mobile units.

In VDL Mode 4, end-to-end communications can be realized as a VDL Mode 4 Specific Service (VSS) or using the full ATN protocol stack.

4.4   ADS-B

The ADS-B function uses the VDL Mode 4 synchronization burst message formats to broadcast regularly an aircraft or vehicle's identity, position, altitude, time, intent and vector information for use by other users, both mobiles and ground stations. Because position reporting is an integral part of communications management in VDL Mode 4, the core elements of ADS-B are already present on the link.

The size of the time slots on the data link is adapted to accommodate an ADS-B report. A time slot may also accommodate other information elements.

ADS-B supports many mobile-mobile surveillance applications such as cockpit display of traffic information, airborne situational awareness and station-keeping. When the VDL Mode 4 system also includes ground stations it is also able to support applications such as Advanced Surface Movement Guidance and Control Systems, enhanced ATC, Search And Rescue co-ordination, etc.

4.5   Operational scenarios

Three basic operational scenarios for VDL Mode 4 have been identified:

a) Autonomous operation is defined as the situation where no VDL Mode 4 ground infrastructure exists. Surveillance by means of ADS-B and air-air communication can take place between any users with overlapping cells by means of the self-organizing protocol. All activities use two globally co-ordinated Global Signalling Channels (GSCs).

b) Single Cell operation is defined as the situation where overlapping VDL Mode 4 ground stations exist, but do not co-ordinate their operation over a dedicated ground network. Thus each single cell within the coverage of one ground station can be seen as an independently operating system. Additional local channels may be available (e.g. to support SMGCS) and channel management can be supported by the transmission of the Directory of Service message on the GSCs.

c) Multi Cell operation is defined as the situation where VDL Mode 4 ground stations co-ordinate their operation by means of dedicated ground networks. The number of VDL Mode 4 ground stations within multi cell operation affects overall system capacity and redundancy.

All activities use two globally co-ordinated Global Signalling Channels, which may be complemented with additional Local Signalling Channels to increase system capacity and/or provide additional services.

4.6   VDL Mode 4 fundamentals

VDL Mode 4 operation is built up from the following fundamental features:

a) A robust modulation scheme for encoding data in each slot. VDL Mode 4 supports Gaussian Filtered Frequency Shift Keying (GFSK) with a modulation rate of 19 200 bits/sec.

b) A time division multiplex access (TDMA) frame structure. In VDL Mode 4, channel time is divided into fixed length time slots. A "superframe", which is an important term used in the VDL Mode 4 channel management, consists of a group of slots that span a period of 60 s. The superframe contains 4 500 slots (equivalent to 75 slots/s).

c) A timing reference providing a unique marker for the start of each communications slot. The Integrated Timing Concept (ITC) used in VDL Mode 4 is based upon Universal Co-ordinated Time (UTC). The source could be GNSS, but other sources may be used as long as they can be related to absolute UTC time. In the event that a station loses its source of UTC time, it may continue to derive it from the time of arrival of synchronization bursts received from other stations (known as secondary timing which is a *failure mode*).

d) Position information from the aircraft's navigation system is used to organize access to the slots. If a station loses its source of position information it may continue to derive position from synchronization bursts received from other stations (known as secondary navigation).

e) A flexible message structure that can support a wide range of broadcast and data transfer protocols.

f) A slot selection function that determines when a station can access the channel and maintains information on the current and planned slot assignments.

g) A slot access management function, controlling the use of each slot.

h) A data link service function which provides point to point and broadcast communications protocols.

i) A number of link management functions that support the communications connections with other stations and which provide access to data link services on a wide range of channels.

4.7   VDL Mode 4 Ground architecture

It is not the intention of the present document to prescribe a particular physical architecture for the VDL Mode 4 ground station. It is assumed that the equipment will include all the relevant functionality defined by ICAO VDL Mode 4 Standards [1]. However, other architectures may be more appropriate to meet user requirements.

Where necessary, appropriate Points of Control and Observation shall be provided internally to the equipment to allow the tests specified by the present document to be performed.

5   VDL mode 4 physical layer functional specifications

5.1   Overview

The ground stations shall access the physical layer operating in duplex mode.

5.1.1   Functions

The tasks of the physical layer include the following:

- to modulate and demodulate radio carriers with a bit stream of a defined instantaneous rate to create an rf link;

- to acquire and maintain bit and burst synchronization between Transmitters and Receivers;

- to transmit or receive a defined number of bits at a requested time (packet mode) and on a particular carrier frequency;

- to measure received signal strength;

- to decide whether a channel is idle or busy, for the purposes of channel management;

- to offer a notification service about the quality of link.

5.1.2   Data reception

The receiver shall decode input signals and forward them to the higher layers for processing.

5.1.3   Data transmission

The VDL physical layer shall appropriately encode the data received from the data link layer and transmit it over the rf channel.

5.2   Modulation scheme

The modulation scheme shall be Gaussian Filtered Frequency Shift Keying (GFSK), which is a continuous-phase, frequency shift keying technique using two tones and a Gaussian pulse shape filter. The first bit transmitted (in the training sequence) shall be a high tone and the transmitted tone shall be toggled when transmitting a 0 (*i.e.*, NRZI encoding). Binary *ones* and binary *zeros* shall be generated with a modulation index of $0,25 \pm 0,03$ and a BT product of $0,28 \pm 0,03$.

5.3   Tuning range and channel increments

The ground station shall be capable of tuning to any of the 25 kHz channels from 108,000 MHz to 136,975 MHz as defined in ICAO International Standards Recommended Practices and Procedures for Air Navigation Services Annex 10 Volume 1, part 1.

6   VDL Mode 4 equipment requirements

Unless otherwise stated, all specifications shall be met under room conditions, at the nominal data rate, with the transceiver tuned to any 25 kHz channel within the range 118,000 MHz to 136,975 MHz.

6.1   Receiver Requirements

For the purposes of the following requirements, the specified Bit Error Rate (BER) of the equipment shall be equal to or better than 1 in 10^4.

The reference signal level applied at the receiver input for all receiver requirements unless otherwise stated, is -87 dBm.

6.1.1   Receiver operating range

The receiver shall be capable of tuning to any of the 25 kHz channels from 118,000 MHz through 136,975 MHz.

   NOTE: Optionally the receiver may tune between 113,000 MHz – 117,975 MHz.

6.1.2   Sensitivity

A maximum signal level of -98 dBm from a modulated VDL Mode 4 signal source shall produce the BER requirement specified in clause 6.1.

6.1.3   Adjacent channel rejection

The minimum adjacent channel rejection ratio (ACR) shall be determined in the presence of the reference signal level.

The ACR required to achieve the BER (clause 6.1) shall be equal to, or greater than, 44 dB. The test shall be performed on each side of the wanted signal and at the nominal channel separation of 25 kHz from it.

6.1.4   Rejection of signals **within** the VHF Aeronautical band

The BER requirement (clause 6.1) shall be achieved when the wanted signal, set at the reference level, is combined with an unmodulated interfering signal in the following conditions:

   a) Level of the interfering signal set at -33 dBm at frequencies corresponding to second and third adjacent channels centre.

   b) Level of the interfering signal set at -27 dBm at frequencies corresponding to fourth adjacent channels centre.

   c) Level of the interfering signal set at -27 dBm at a separation of ±1 MHz from the nominal receiver frequency.

6.1.5   Rejection of signals **outside** the VHF Aeronautical band

The BER requirement (clause 6.1) shall be achieved when one of the specified unwanted signals is applied and when the wanted signal is set at the reference signal level (clause 6.1).

Unwanted signal A:

Level: -33 dBm

Modulation: None

Frequency range: 108,000 MHz to 156,000 MHz (excluding 117,950 MHz to 137,025 MHz)

Unwanted signal B:

Level: -7 dBm

Modulation: None

Frequency range: 50 kHz to 1 215,000 MHz (excluding the range 87,500 MHz to 156,000 MHz)

> NOTE 1: A maximum interfering level of -33 dBm is permitted at the receiver IF frequencies.

Unwanted signal C:

Level: -5 dBm

Modulation: None

Frequency range: 87,500 MHz to 107,900 MHz

> NOTE 2: The frequency ranges shall be swept at a rate not exceeding $1,5 \times 10^{-3}$ decades/s. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the previous frequency.

6.1.6   Desired signal dynamic range

The receiver shall continue to achieve the BER requirement when the reference signal level is increased to a level of -7 dBm.

6.1.7   Symbol rate capture range

The BER requirement shall be achieved when the reference signal level is subject to a symbol rate offset of ±50 parts per million.

6.1.8   Frequency capture range

The receiver shall be capable of acquiring and maintaining a lock to any selected channel with the maximum permitted signal frequency offset.

The BER requirement shall be achieved when the reference signal level is subject to a frequency offset of ±826 Hz.

> NOTE: This value is composed of the maximum transmitter frequency error at 136,975 MHz (±685 Hz) and the maximum Doppler shift (±141 Hz).

6.1.9   Co-channel interference

The BER requirement shall be achieved when a VDL Mode-4 interfering signal 12dB below the reference signal is applied in addition to the reference signal level.

6.1.10   Conducted spurious emission

When the receiver input is terminated in a matched impedance, the level of any spurious emission appearing across the load shall not exceed -57 dBm over the frequency range of 9 kHz to 1 GHz and –47 dBm over the frequency range of 1 GHz to 4 GHz, with the exception of the range of 108,000 MHz to 137,000 MHz, where it shall not exceed -64 dBm.

6.1.11   In-band Intermodulation

The BER requirement (clause 6.1) shall be achieved in the presence of two interfering signals, displaced in frequency, from the desired signal.

Desired signal:

Level: -75 dBm

Modulation: VDL Mode 4 (or simulated Mode 4)

Frequency: Test frequency

Unwanted signal A:

Level: -32 dBm

Modulation: none

Frequency: test frequency ±1 MHz.

Unwanted signal B:

Level: -32 dBm

Modulation: VDL Mode 4 (or simulated Mode 4)

Frequency: test frequency ±2 MHz.

6.1.12   Cabinet radiation

The receiver shall meet the cabinet radiation requirements of EN 300 113-1 [4].

6.2   Transmitter requirements

All transmitter measurements shall be made using conducted power unless otherwise stated.

Unless otherwise stated, the test reference bit sequence is specified as follows:

The maximum "transmit" period is determined by the maximum "burst" length permitted for Mode 4 operation. The maximum burst length is 1 s at the nominal symbol rate of 19 200 symbols/s.

The minimum "off" period is determined assuming that the transmitter will at least leave a suitable guard range time at the end of transmission before starting a new transmission. VDL mode 4 SARPs [1] specify this guard range as 1,25 ms which, will therefore be taken as the minimum "off" period.

The maximum duty cycle is thus 1 s in "transmit" mode followed by 1,25 ms "off". The reference bit sequence shall not exceed 15 cycles.

6.2.1   Protection of the transmitter

The protection of the transmitter represents the ability of the transmitter to be protected against malfunction due to faults in the antenna system. Worst case mismatches, are represented by a short and open circuit test. The transmitter shall operate normally after the completion of the test.

6.2.2   Manufacturer's declared output power

The carrier power is the mean rf power delivered to the coaxial matched impedance termination during transmission. The measured power shall be ±1 dB of the manufacturer's stated maximum output power.

The requirements of the present document shall also be met for all power output levels at which the transmitter is intended to operate into 50 Ω. Output power delivered into a 50 Ω load shall be measured during signal transmission (steady state power lever) and not averaged over the time intervals between signal transmissions.

For practical reasons measurements shall be performed only at the lowest and the highest power output level at which the transmitter is intended to operate.

6.2.3 RF power rise time

The transmitter shall be within 90 % of the manufacturer declared output power level in less than 832 µs.

6.2.4 RF power release time

The transmitted power level shall decay at least by 20 dB below the manufacturer declared output power level within 300 µs after transmitting the final information symbol.

The transmitter power level shall be less than 90 dB below the manufacturer declared output power level within 832 µs after transmitting the final information symbol.

6.2.5 Channel bit rate

The data rate shall be 19,2 kbit/s ± 50 ppm.

NOTE: 50 ppm = 0,005 %.

6.2.6 Conducted Spurious emissions

When the transmitter is "active" or "idle" (or the transceiver is in receive mode) and terminated in a matched impedance load, the power of any spurious emission at the output of the transmitter shall not exceed the values given in table 6.1.

Table 6.1

Environmental phenomena	Frequency range	Units	Test limits, Tx Standby	Test limits Tx active mode	Reference bandwidth
Spurious conducted rf emissions	9 kHz to 150 kHz	dBm	-57 (2 nW)	-36 dBm	B = 1 kHz
Spurious conducted rf emissions	> 150 kHz to 1 GHz	dBm	-57 (2 nW)	-36 dBm for harmonics, -46 dBm for non-harmonic spurious	B = 10 kHz (notes 1 and 2)
Spurious conducted rf emissions	> 1 GHz to 4 GHz	dBm	-47 (20 nW)	-30 dBm for harmonics -40 dBm for non-harmonic spurious	B = 10 kHz
NOTE 1: For transmitters with an rf output above 50 W a limit of -80 dBc will be applied for harmonically related spurious.					
NOTE 2: An exclusion band of ±1 MHz about the carrier shall be used in active transmit mode.					

6.2.7 Adjacent channel power

First adjacent channel power:

The rf power measured over a 16 kHz channel bandwidth centred on the first adjacent channel shall not exceed -18 dBm.

Second adjacent channel power:

The rf power measured over the 25 kHz channel bandwidth of the second adjacent channel shall not exceed -28 dBm.

Fourth adjacent channel power:

The rf power measured over a 25 kHz channel bandwidth centred on the fourth adjacent channel shall not exceed -38 dBm.

6.2.8 Wide-band noise

The rf power measured in a 25 kHz channel bandwidth shall reduce at a minimum rate of 5 dB per octave from the fourth adjacent channel to a maximum value of -53 dBm.

6.2.9   Frequency Tolerance

The frequency of the rf carrier shall be within ±2 ppm of the selected frequency.

NOTE: 2 ppm = 0,0002 %.

6.2.10   Cabinet radiation

The transmitter shall meet the cabinet radiation requirements of EN 300 113-1 [4].

6.2.11   Load VSWR capability

When a 2:1 mismatch is applied to the transmitter output terminals by a length of feeder, which is varied in electrical length by up to half a wavelength, the requirements of clauses 6.2.7 and 6.2.8 shall be met. In addition, the power output shall not be less than -3 dB of the manufacturer's declared value (clause 6.2.2).

6.3   Transceiver timing requirements

6.3.1   Start of transmission

The transmission of the first bit of data shall start 2 083,3 µs ± 1 µs after the nominal start of transmission.

NOTE: The nominal start of transmission always coincides with the time of the start of a slot.

6.3.2   Automatic transmitter shutdown

A VDL Mode 4 station shall automatically shut-down power to any final stage amplifier in the event that output power from that amplifier exceeds -30 dBm for more than 1 s. Reset to an operational mode for the affected amplifier shall require a manual operation.

6.3.3   Receiver to transmitter turnaround time

A station shall be capable of beginning the transmission of the transmitter power stabilization sequence within 16 µs after terminating the receiver function.

6.3.4   Transmitter to receiver turnaround time

A station shall be capable of receiving and demodulating with nominal performance an incoming signal within 1 ms after completing a transmission.

6.3.5   System timing requirements

A VDL mode 4 station which is unable to maintain either primary or secondary time, shall not transmit.

7   General design requirements

7.1   Controls and indicators

The equipment shall have a visual indication that the device is switched on.

7.2   Class of emission and modulation characteristics

The equipment shall use GFSK modulation. The equipment shall be designed to operate satisfactorily with a channel separation of 25 kHz.

7.3   Warm up

After being switched on the equipment shall be operational within 5 s and shall meet the requirements of the present document within one minute under normal conditions.

   NOTE: For testing purposes, a primary time source must be available.

8   Test conditions, power sources and ambient temperatures

8.1   Test power source

During testing, the equipment shall be supplied from a test power source capable of producing normal and extreme test voltages as specified in clauses 8.4.1.2 and 8.4.2.3.

The internal impedance of the test power source shall be low enough for its effect on the test results to be negligible. For the purpose of testing the power source voltage shall be measured at the input terminals of the equipment.

During testing, the power source voltages shall be maintained within a tolerance of ±3 % relative to the voltage level at the beginning of each test.

8.2   Test channels

Tests shall be carried out on at least three channels:

   • 136,975 MHz

   • 118,000 MHz

   • 127,500 MHz

8.3   General conditions of measurement

8.3.1   Receiver test signal arrangement

Test signal sources shall be connected to the receiver input in such a way that the impedance presented to the receiver input is $50 \pm 2\ \Omega$, irrespective of whether one or more test signals are applied to the receiver simultaneously.

8.3.2   Performance check

Whilst the equipment is being subjected to the normal or extreme test conditions, establish compliance with the requirements of the following clauses:

   • 6.1.2   Sensitivity (Rx)

   • 6.2.2   Manufacturer's declared output power (Tx)

   • 6.2.9   Frequency Tolerance (Tx)

8.4   Normal and extreme test conditions

Measurements shall be made under normal test conditions and also, where stated, under extreme test conditions.

8.4.1   Normal test conditions

8.4.1.1   Normal temperature and humidity

The normal temperature and humidity conditions for tests shall be a combination of temperature and humidity within the following ranges:

- temperature: +15°C to +35°C;

- relative humidity: 20 % to 75 %.

When it is impracticable to carry out the tests under these conditions, a note to this effect, stating the ambient temperature and relative humidity during the tests, shall be added to the test report.

8.4.1.2   Normal power sources

8.4.1.2.1   Mains voltage and frequency

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage.

For the purpose of the present document, the nominal voltage shall be the declared voltage or any of the declared voltages for which the equipment was designed.

The frequency of the test power source shall be the nominal ranges declared by the manufacturer.

8.4.1.2.2   Other power sources

For operation from other power sources, the normal test voltage shall be that declared by the equipment manufacturer.

8.4.2   Extreme test conditions

8.4.2.1   Extreme temperatures

For tests at extreme temperatures, measurements shall be made at a lower temperature of -10°C and an upper temperature of +55°C. This test shall be performed at the nominal supply voltage as defined in clause 8.4.1.2.1.

8.4.2.2   Procedure for tests at extreme temperatures

8.4.2.2.1   General

The equipment shall be switched off during the temperature stabilizing periods.

For tests at the upper temperature on equipment designed for continuous operation, the equipment shall be placed in the test chamber and left until thermal equilibrium is reached. The equipment shall then be switched on for 30 minutes before measurements are made. Transmitters shall be operated in the highest rated power transmit condition in that 30 minutes period before measurements are made.

For tests at the lower temperature, the equipment shall be left in the test chamber until thermal equilibrium is reached. The equipment shall then be switched on for 1 minute in the standby or receive condition before measurements are made.

#### 8.4.2.2.2	High temperature

- Place the equipment in a chamber and heat to 55ºC (± 3ºC) and allow to stabilize for 1 hour.

- Switch on the equipment (transmitters shall be keyed).

- After 30 minutes carry out a performance check as detailed in clause 8.3.2.

- Switch off the equipment and allow the chamber to cool to room temperature over a one hour period.

- Allow time for the equipment to stabilize to normal room temperature and humidity before carrying out the next test.

#### 8.4.2.2.3	Low temperature

- Place the equipment in a chamber and cool to -10ºC (± 3ºC) for 2 hours.

- Switch on the equipment and maintain the chamber operating temperature at -10ºC (± 3ºC).

- After 1 minute carry out a performance check as detailed in clause 8.3.2.

- Switch off the equipment and allow the chamber to rise to room temperature over a 1 hour period.

- Allow time for the equipment to stabilize to normal room temperature and for moisture to disperse before carrying out the next test.

### 8.4.2.3	Extreme values of test power sources

#### 8.4.2.3.1	Mains voltage and frequency

The extreme test voltages shall be ± 10 % manufacturers declared voltages.

The frequency of the test voltage shall be the nominal frequency declared by the manufacturer.

# 9	Detailed Test Procedures for the physical layer

The following test procedures are considered to be satisfactory means of establishing compliance with the requirements of the present document. However, alternative test procedures, which provide equivalent information, may be used.

## 9.1	Receiver

### 9.1.1	BER test

A BER test shall involve a VHF signal generator representing the desired source signal and an external BER test fixture (e.g. a computer and test software or arbitrary waveform generator (AWG) interfaced to a VHF signal generator in vector modulation mode), which receives each burst payload from the receiver under test.

BER mode

A method for placing the receiver into the BER mode shall be provided by manufacturers. The BER mode is distinct from the operational mode.

The BER mode is used to measure the BER requirement (clause 6.1).

1) The receiver shall forward each burst payload to the external BER test fixture without error detection or correction procedures.

2) The test payload shall be forwarded to the external BER test fixture only if the burst was successfully detected via the standard 24 bit synchronization sequence.

VHF signal generators

Receiver test procedures require the use of a high performance VHF signal generator in order to permit high precision measurement. This VHF signal generator shall be capable of the specified modulation format and transmission waveform.

1) The VHF signal generator shall support transmission of VDL test bursts consisting of the ramp up period plus the standard 24 bit synchronization sequence followed by a variable length test message, up to the maximum length of 19 200 bits.

2) An external interface to the VHF signal generator shall be provided in order that the test payload can be provided via an external BER test fixture.

External BER test fixture

1) The test payload provided by the external BER test fixture shall be mapped directly into the burst payload in Mode 4 format.

2) Unless otherwise stated, tests shall be conducted with maximum length Mode 4 messages.

3) The external BER test fixture generating the test payload for transmission by the VHF signal generator, and receiving/processing the received test payload must be synchronized either explicitly (via a direct connection) or implicitly (by knowledge of the test payload).

4) Calculation of cumulative BER statistics shall begin once synchronization of the external BER test fixture between the transmitting and receiving burst payload has been accomplished. The receiving external BER test fixture shall detect the loss of an entire burst implicitly by lack of a burst payload message in the given burst period. Each test should include a running count of synchronization failures in addition to the cumulative BER.

Interfering (or undesired) source

Tests for CCI and ACR with the VDL waveform as the interfering signal shall be performed with the interfering signal applied in a continuous (non-pulsed) manner. The waveform shall simulate a VDL Mode 4 signal. A suitable interfering source is a VHF signal generator configured to produce a narrow-band frequency modulated (FM) signal modulated with a 400 Hz tone at a peak frequency deviation of 5,25 kHz.

Figure 9.1 shows the basic test set up for receiver BER tests.
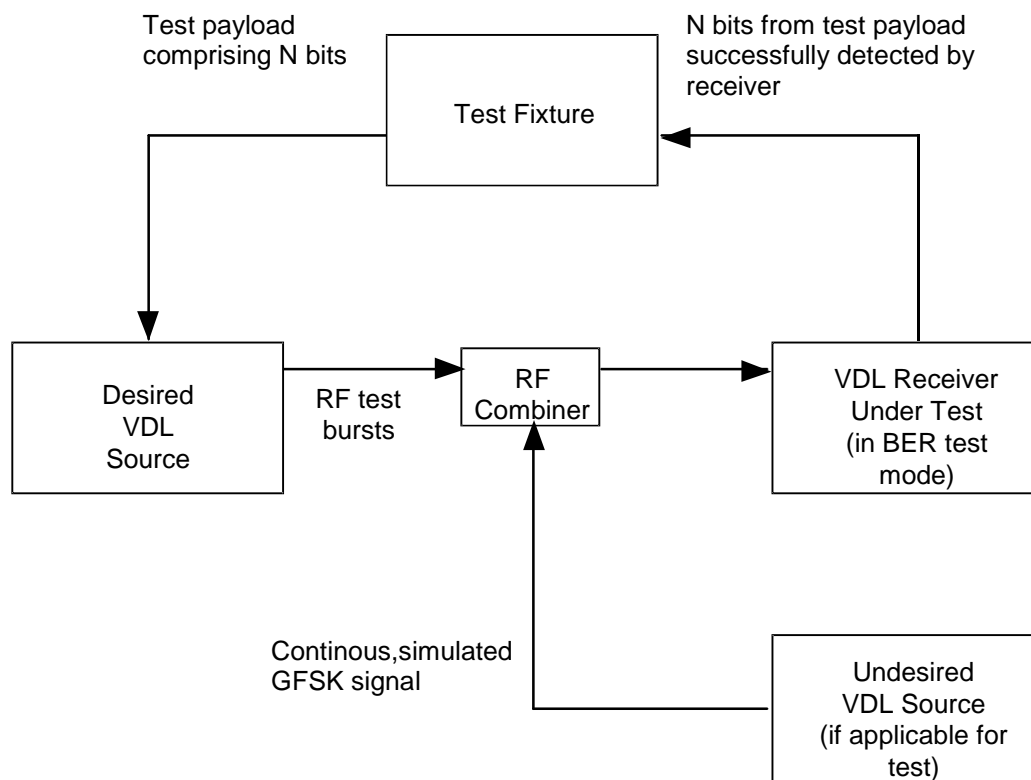
Figure 9.1: Receiver BER measurement

9.1.2   Sensitivity

Equipment Required

-   VHF Signal Generator.

-   External BER test fixture.

Measurement Procedure

Step 1:   Connect the equipment as shown in figure 9.1 but notice that the rf combiner is not required for this test. Set the receiver under test to the BER mode.

Step 2:   Set the Desired VDL Source, (a VHF signal generator) to generate an input signal to the receiver at one of the test frequencies (clause 8.2).

Step 3:   Modulate the Desired signal with the test payload (maximum burst length) provided by the external BER test fixture. Adjust the level of the signal generator to the maximum signal level (clause 6.1.2) at the receiver input terminals.

Step 4:   Repeat Steps 2 and 3 at the two remaining test channels.

Step 5:   Using the external BER test fixture, determine the BER of the demodulated data at the receiver output. Check the Sensitivity requirement (clause 6.1.2) is achieved at all of the test frequencies (clause 8.2).

9.1.3   Adjacent Channel Rejection

Equipment Required

-   2 VHF Signal Generators.

-   External BER test fixture.

-   RF combiner.

NOTE: The noise sidebands of the interfering signal must not interfere with the desired signal in the receiver pass band. The isolation offered by the rf combiner must be sufficient to prevent intermodulation between the VHF generators.

Measurement Procedure

Step 1: Connect the equipment as shown in figure 9.1 and set the receiver to the BER mode.

Step 2: Adjust the Desired VDL Source (generator A), to produce an input signal to the receiver at one of the test frequencies (clause 8.2).

Step 3: Modulate generator A with the test payload (maximum burst length of symbols) provided by the external BER test fixture. Adjust signal generator A to produce the reference signal level (clause 6.1) at the receiver input terminals.

Step 4: Use the second VHF signal generator (named B), to generate an adjacent channel interfering input signal to the receiver.

Step 5: Tune generator B to the first upper adjacent channel frequency. Set generator B to produce a narrow-band F.M signal (to simulate a second VDL Mode 4 source). Apply the desired input signal and the adjacent interfering signal to the receiver input via the rf combiner.

Step 6: Adjust the level of signal generator B until the BER is reduced to the minimum requirement (clause 6.1). Record the interfering signal level at the receiver input terminals.

Step 7: Repeat Step 5 and 6 for the lower adjacent channel.

Step 8: Determine the ratio between the interfering and desired signal levels for both upper and lower adjacent channels. Record these two ratios.

Step 9: Repeat Steps 4 to 8 at the two remaining test channels (clause 8.2).

Step 10: Check that the ACR requirement defined in clause 6.1.3 is achieved in all cases.

9.1.4   Rejection of signals **within** the VHF Aeronautical band

Equipment Required:

- 2 VHF Signal Generators.

- External BER test fixture.

- RF combiner.

NOTE: The noise sidebands of the interfering signal must not to interfere with the desired signal in the receiver pass band. The isolation offered by the rf combiner must be sufficient to prevent intermodulation between the VHF generators.

Measurement Procedure:

Step 1: Connect the equipment as shown in figure 9.1 and set the receiver to the uncorrected BER mode.

Step 2: Adjust the Desired VDL Source, generator A, to produce an input signal to the receiver at one of the test frequencies (clause 8.2).

Step 3: Modulate generator A with the test payload (maximum burst length of symbols) using the external BER test equipment. Adjust signal generator A to provide the reference signal level (clause 6.1) at the receiver input terminals.

Step 4: Set the second signal generator (named B), to produce an unmodulated (cw) interfering signal to the receiver input.

Step 5: Tune generator B to the upper second adjacent channel and adjust the signal generator to the level defined in clause 6.1.4 a).

Step 6:   Apply the wanted input signal and the unmodulated interfering signal to the receiver input via the rf combiner and determine the uncorrected BER of the demodulated data with the external BER test equipment.

Step 7:   Repeat Step 5 and 6 for the lower second adjacent channel and the upper and lower third adjacent channels.

Step 8:   Tune generator B to the upper fourth adjacent channel and adjust the signal generator to the level stated in 6.1.4 b).

Step 9:   Apply the wanted input signal and the unmodulated interfering signal to the receiver input via the rf combiner and determine the uncorrected BER of the demodulated data with the external BER test equipment.

Step 10:   Repeat steps 8 and 9 for the lower fourth adjacent channel.

Step 11:   Tune generator B to +1 MHz from the nominal receiver frequency and adjust the signal generator to the level stated in 6.1.4 c).

Step 12:   Apply the wanted input signal and the unmodulated interfering signal to the receiver input via the rf combiner and determine the uncorrected BER of the demodulated data with the external BER test equipment.

Step 13:   Repeat steps 11 and 12 for –1 MHz from the nominal receiver frequency.

Step 14:   Set the second signal generator (named B), to produce an unmodulated (cw) interfering signal to the receiver input.

Step 15:   Repeat steps 5 to 14 at the other test frequencies (clause 8.2).

9.1.5   Rejection of signals **outside** the VHF Aeronautical band

Equipment Required:

- 2 VHF Signal Generators.

- External BER test fixture.

- RF combiner.

Measurement Procedure:

Step 1:   Connect the equipment as shown in figure 9.1 and set the receiver to the BER mode.

Step 2:   Use the Desired VDL Source (generator A), to produce an input signal to the receiver at one of the test frequencies (clause 8.2).

Step 3:   Modulate generator A with the test payload (maximum burst length of symbols) using the external BER test fixture. Adjust signal generator A to provide the reference signal level (clause 6.1) at the receiver input terminals.

Step 4:   Use the second signal generator (named B), to generate one of the specified interfering signals at the receiver input.

Step 5:   Tune generator B to any frequency defined in clause 6.1.5. Adjust the level of generator B to provide the interfering signal level also defined in clause 6.1.5 at the receiver input terminals.

Step 6:   Apply the desired input signal and the interfering signal to the receiver input via the rf combiner and determine the BER with the external BER test fixture.

Step 7:   Repeat Step 5 and 6 at the other test frequencies (clause 8.2).

Step 8:   Check that the BER requirement (clause 6.1) is achieved in all cases.

NOTE 1: The noise sidebands of the interfering signal must not interfere with the desired signal in the receiver pass band. The isolation offered by the rf combiner must be sufficient to prevent intermodulation between the VHF generators.

NOTE 2: Any interfering signal found to reduce the BER below the minimum requirement should be investigated using a spectrum analyser connected to the combiner output. This should determine whether the rf combiner/test setup is producing an on-channel signal into the receiver under test.

NOTE 3: Alternative procedures or theoretical calculation may be used to reduce the number of discrete frequencies which need to be tested.

9.1.6   Desired Signal dynamic range

Equipment Required:

-   VHF Signal Generator.

-   External BER test fixture.

Measurement Procedure:

Step 1:   Connect the equipment as shown in figure 9.1 but notice that the rf combiner is not needed for this test. Set the receiver to the BER mode.

Step 2:   Adjust the Desired VDL Source (generator A) to generate an input signal, to the receiver, at one of the test frequencies (clause 8.2).

Step 3:   Modulate generator A with the test payload (maximum burst length of symbols) using the external BER test fixture. Adjust generator A to provide the maximum reference signal level (clause 6.1.6) at the receiver input terminals.

Step 4:   Apply the modulated signal to the receiver and determine the BER of the demodulated data at the receiver output with the external BER test fixture.

Step 5:   Repeat Steps 2 to 4 at the two remaining test channels.

Step 6:   Check that the BER requirement (clause 6.1) is achieved in all cases.

9.1.7   Symbol rate capture range

Equipment Required:

-   VHF Signal Generator.

-   External BER test fixture.

Measurement Procedure:

Step 1:   Connect the equipment as shown in figure 9.1 but notice that the rf combiner is not needed for this test. Set the receiver to the BER mode.

Step 2:   Tune the Desired VDL Source (generator A) to generate an input signal to the receiver at one of the test frequencies (clause 8.2). Adjust generator A to provide the reference signal level (clause 6.1) at the receiver input terminals.

Step 3:   Tune the VHF signal generator to the receiver channel frequency and modulate it with the test payload (maximum burst length of symbols) provided by the external BER test fixture.

Step 4:   Adjust the transmitted data clock offset of the external BER test fixture to the maximum offset specified in clause 6.1.7.

Step 5:   Apply the modulated signal to the receiver and determine the BER of the demodulated data at the receiver output with the external BER test fixture.

Step 6: Repeat Steps 4 and 5 after adjusting the transmitted data clock offset to the minimum offset specified in clause 6.1.7.

Step 7: Check that the BER requirement (clause 6.1) is achieved in all cases.

9.1.8 Frequency capture range

Equipment Required:

- VHF Signal Generator.

- External BER test fixture.

Measurement Procedure:

Step 1: Connect the equipment as shown in figure 9.1 but notice that the rf combiner is not needed for this test. Set the receiver to the BER mode.

Step 2: Set the Desired VDL Source (generator A) and the external BER test fixture to generate a receiver input signal.

Step 3: Tune generator A to one of the test frequencies (clause 8.2) plus the frequency offset defined in clause 6.1.8 and modulate it with the test payload (maximum burst length of symbols) provided by the external BER test fixture. Adjust generator A to provide the reference signal level (clause 6.1) at the receiver input terminals.

Step 4: Apply the modulated signal to the receiver and determine the BER of the demodulated data at the receiver output with the external BER test fixture.

Step 5: Repeat Steps 3 5 for the negative frequency offset (clause 6.1.8).

Step 6: Check that the BER requirement (clause 6.1) is achieved in all cases.

9.1.9 Co-channel interference

Equipment Required:

- 2 VHF Signal Generators.

- External BER test fixture.

- RF combiner.

Measurement Procedure:

Step 1: Connect the equipment as shown in figure 9.1 and set the receiver to the BER mode.

Step 2: Use the Desired VDL Source (named A), to generate a desired input signal to the receiver.

Step 3: Tune the generator A to one of the test frequencies (clause 8.2) and modulate the carrier with the test payload (maximum burst length of symbols) provided by the external BER test fixture. Adjust generator A to provide the reference signal level (clause 6.1) at the receiver input terminals.

Step 4: Use the second signal generator (named B), to generate a co-channel interfering input signal to the receiver.

Step 5: Tune the signal generator B to the receiver channel frequency and configure it to produce a narrow band FM signal with a maximum peak deviation of ±5,25 kHz. Modulate generator B with a 400 Hz sine wave. Adjust generator B to produce an interfering signal level 12 dB below the reference signal level (clause 6.1) at the receiver input terminals.

Step 6: Apply the desired signal and the co-channel interfering FM modulated signal to the receiver input via the rf combiner and measure the BER of the demodulated data at the receiver output with the external BER test fixture.

Step 7:   Repeat Steps 2 to 6 at the two remaining test channels (clause 8.2).

Step 8:   Check that the BER requirement (clause 6.1) is achieved in all cases.

9.1.10   Conducted spurious emission (clause 6.1.10)

Equipment Required:

- Resistive load equal to the nominal input impedance of the receiver.

- Calibrated spectrum analyser to cover the frequency range defined in clause 6.1.10.

Measurement Procedure:

Step 1:   Connect the rf output of the equipment under test directly into the rf input of the spectrum analyser. Exercise caution, do not allow the transmitter to radiate.

Step 2:   Tune the ground station to one of the test frequencies (clause 8.2).

Step 3:   Using the calibrated spectrum analyser, measure the power level of any spurious emissions across the matching resistive load at the input of the receiver over the frequency range defined in clause 6.1.10.

Step 4:   Record the frequency and power level of all signals which exceed the limit specified in clause 6.1.10.

Step 5:   Repeat Steps 2 to 4 at the two remaining test channels (clause 8.2).

Step 6:   Check that the requirements of clause 6.1.10 are achieved in all cases.

9.1.11   In-band Intermodulation

Equipment Required:

- 3 VHF Signal Generator.

- External BER test fixture.

- RF combiner.

Measurement Procedure:

Step 1:   Connect the equipment as shown in figure 9.2.

Step 2:   Use a signal generator (named A), to generate the desired input signal to the receiver.

Step 3:   Tune generator A to one of the test frequencies (clause 8.2) and modulate the carrier with the test payload (maximum burst length of symbols) provided by the external BER test fixture. Adjust generator A to provide a level of -75 dBm. at the receiver input terminals.

Step 4:   Tune interfering signal generator B to a frequency 1 MHz above the selected test frequency. Set signal generator B to produce an unmodulated carrier, input to the receiver input terminals at a level of -32 dBm.

Step 5:   Tune interfering signal generator C to a frequency 2 MHz above the selected test frequency. Set signal generator C to produce a simulated Mode 4 signal, input to the receiver input terminals at a level of -32 dBm.

Step 6:   Apply the desired signal and the two interfering signals to the receiver input via the rf combiner and determine the BER of the demodulated data at the receiver output with the external BER test fixture.

Step 7:   Repeat Steps 3 to 6 for the remaining frequency combinations by retuning generators B and C.

Step 8:   Check that the BER requirement (clause 6.1) is achieved in all cases.

NOTE: In the absence of the desired signal (i.e. Generator A switched "off"), the intermodulation products
          produced by any interaction between the interfering signal generators B and C, must be less than
          -105 dBm at the receiver input. Additional band-pass filters, inserted between each generator and the rf
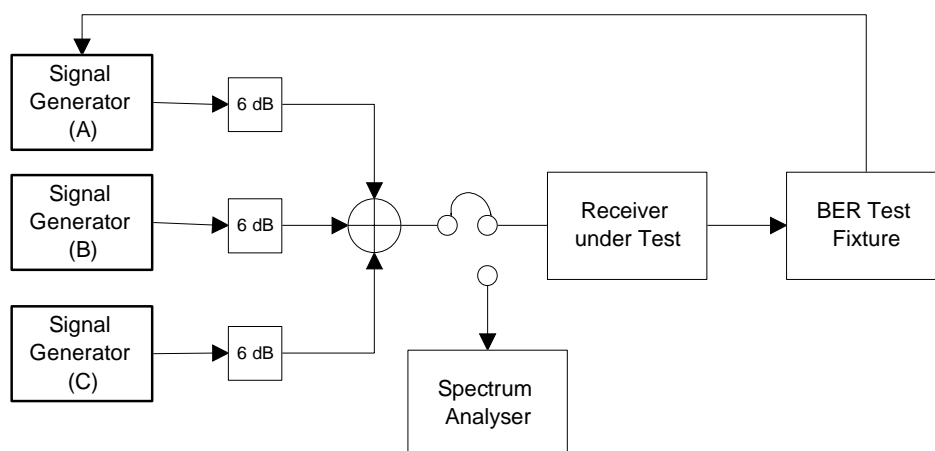   combiner, may be necessary to reduce the intermodulation product.

Figure 9.2: Intermodulation measurement

9.2   Transmitter

9.2.1   Channel Bit Rate

This requirement may be satisfied by written evidence.

The manufacturer shall declare crystal stability, aging and temperature coefficients.

The evidence shall demonstrate that consideration has been given to the temperature variation to which the equipment
will be subjected and the frequency range for which the equipment is designed to operate.

9.2.2   Manufacturer's declared output power

Equipment Required:

-   Transmission generator, PC with suitable software.

-   Attenuator 30 dB, 30 W.

-   Power meter, with pulse power measurement facility or vector signal analyser.

Measurement Procedure:

Step 1:   Connect the equipment as shown in figure 9.3.

Step 2:   Tune the transmitter to one of the test frequencies (clause 8.2).

Step 3:   Key the transmitter under test "on" and modulate the carrier with continuous maximum length
                 Mode 4 messages from the transmission generator.

Step 4:   Set the power meter (or vector signal analyser) to capture the Mode 4 transmitted signal and
                 determine the transmitter output power during the message period.

Step 5:   Repeat Steps 2 to 4 at the two remaining test channels.

Step 6:   Check that the measured output power is consistent with the manufacturer's declared output power
                 according to clause 6.2.2, and remains so at all three test channels.

NOTE: Output power delivered into a 50 Ω load shall be measured during signal transmission and shall not be
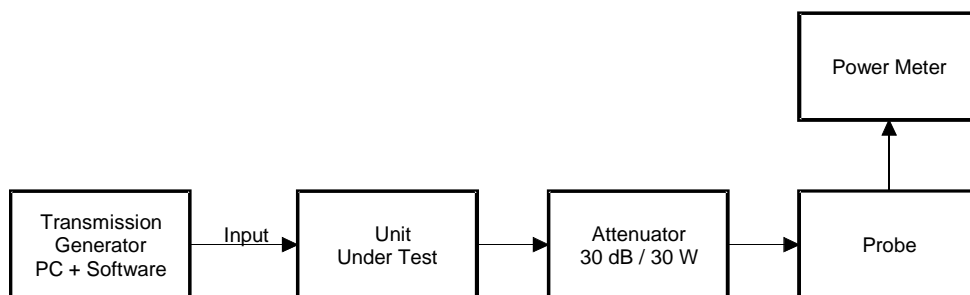   averaged over the time intervals between signal transmissions.

Figure 9.3: Output power measurement

9.2.3   RF power rise time

Equipment Required:

-    Transmission Generator, PC with suitable software.

-    Attenuator 30 dB, 30 W.

-    Vector signal analyser.

Measurement Procedure:

Step 1:   Connect the equipment as shown in figure 9.4.

Step 2:   Configure the vector analyser to display both constellation diagram and power versus time charts.

Step 3:   Use the transmission generator to produce a Mode 4 message and capture the start of this message.

Step 4:   Using both constellation and power versus time display identify the first symbol of the
               synchronization sequence.

Step 5:   Record rf power level at the first synchronization symbol defined in clause 5.2.

Step 6:   Check that the rf power rise time defined in clause 6.2.3 is achieved.
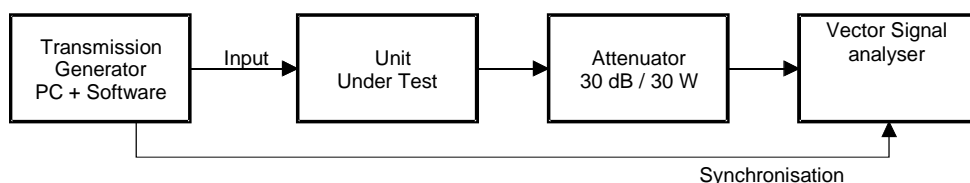

Figure 9.4: RF power rise and release time measurement

9.2.4   RF power release time

Equipment Required:

-    Transmission Generator, PC with suitable software.

-    Attenuator 30 dB, 30 W.

-    Vector signal analyser.

Measurement Procedure:

Step 1:   Connect the equipment as shown in figure 9.4.

Step 2:   Configure the vector signal analyser in digital demodulation mode, to display log magnitude of I and Q vectors, with normalization disabled. Set the Y axis to read "dBm" The symbol times are displayed on the resultant profile of power versus time. Use of the trigger hold off function will aid signal acquisition.

Step 3:   Using the transmission generator to produce a Mode 4 message. Capture the end of this message on the vector signal analyser.

Step 4:   Use the power versus time display to determine the corresponding profile for each symbol of the "power down" ramp.

Step 5:   Check that the rf power release time defined in clause 6.2.4 is achieved.

9.2.5   Spurious emissions

Equipment Required:

-    Transmission Generator, PC with suitable software.

-    Attenuator 30 dB, 30 W.

-    Notch filter or band pass filter, to suppress the on-channel signal by at least 60 dB.

-    Spectrum analyser with power band marker function.

Measurement Procedure:

Step 1:   Connect the equipment as shown in figure 9.5.

Step 2:   Tune the transmitter to one of the test frequencies.

Step 3:   Using the filter to reject the on-channel signal in order to increase the dynamic range of the measurement without overloading the spectrum analyser.

Step 4:   Set the transmission generator to produce continuous maximum length Mode 4 messages and key the transmitter under test "on".

Step 5:   Adjust the spectrum analyser reference level to provide the maximum dynamic range for display and set the input attenuator to minimum required to ensure that no signal at the analyser input exceeds the maximum allowable level.

Step 6:   Measure the power level at each visible spurious signal using power band markers appropriate to the bandwidths specified in clause 6.2.6.

Step 7:   Measure the frequency response of the filter and take this into account when presenting spurious measurement results. If a band pass filter is used, it will need to be tuned to several measurement frequencies, covering the overall measured frequency range.

Step 8:   Check that the results do not exceed the limits specified in clause 6.2.6.
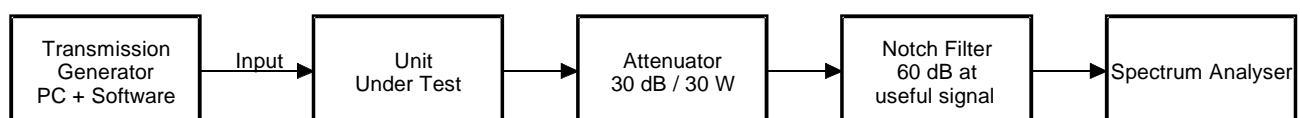
Figure 9.5: Spurious emissions measurement

9.2.6   Adjacent channel power

9.2.6.1   Method of measurement for the first adjacent channel

Equipment Required:

- Transmission Generator, PC with suitable software.

- Attenuator 30 dB, 30 W.

- Spectrum analyser with power band marker function.

Measurement Procedure:

Step 1:   Connect the equipment as shown in figure 9.6.

Step 2:   Tune the transmitter to one of the test frequencies (clause 8.2).

Step 3:   Key the transmitter under test "on" and modulate it with the transmission generator to produce continuous maximum length Mode 4 messages.

Step 4:   Adjust the attenuator in the analyser to the minimum value which does not overload the input stage of the unit.

Step 5:   Using 100 kHz span display the Mode 4 signal envelope. Use the analyser IF signal power as the trigger source for the display and set averaging to 10.

Step 6:   Using the power band marker function of the analyser measure the power in a 16 kHz bandwidth, of the first upper adjacent channel.

Step 7:   Repeat Steps 3 to 6 for the first lower adjacent channel.

Step 8:   Record the highest of the two measured values. Check that the first adjacent channel power meets the first adjacent channel power requirement defined in clause 6.2.7.

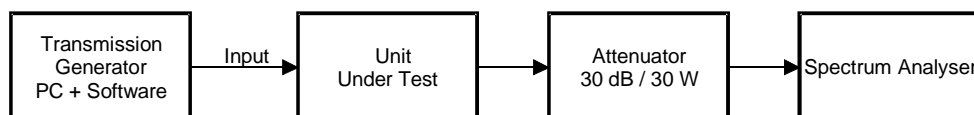Step 9:   Repeat Steps 2 to 8 at the two remaining test frequencies (clause 8.2).

Figure 9.6: First adjacent channel power measurement

9.2.6.2   Method of measurement for the second adjacent channel

Equipment Required:

- Transmission Generator, PC with suitable software.

- Attenuator 30 dB, 30 W.

- VHF crystal filter with a 3 dB bandwidth of 25 kHz and, with attenuation in excess of 50 dB at ± 50 kHz.

- Spectrum analyser with power band marker function.

Measurement Procedure:

NOTE: To protect the analyser and the crystal filter, ensure that the transmitter cannot be keyed "on", at the frequency of the crystal filter used for this test.

Step 1:   Connect the equipment as shown in figure 9.7.

Step 2:   Tune the transmitter to one of the test frequencies (clause 8.2).

Step 3:   Offset the tuned frequency of the transmitter under test to 50 kHz above the VHF crystal filter centre frequency. Key the transmitter under test "on". Use the transmission generator to produce continuous maximum length Mode 4 messages.

Step 4:   Set the analyser span to 50 kHz and centre frequency to the centre frequency of the VHF crystal filter. Decrease the analyser input attenuator to the minimum level at which the attenuated rf signal from the transmitter under test does not overload the analyser. Use the analyser IF signal power as the trigger source for the display and set averaging to 10.

Step 5:   Set the analyser's power band marker function to 40 kHz. Notice that the measurement bandwidth is defined by the VHF crystal filter and setting the power band marker to the same bandwidth will give an erroneous result.

Step 6:   Determine the second lower adjacent channel power.

Step 7:   Repeat Steps 2 to 5 with the transmitter under test tuned to 50 kHz below the crystal filter. Determine the second upper adjacent channel power.

Step 8:   Record the second adjacent channel power as the highest of the two measured values.

Step 9:   Check that the second adjacent channel power is less than the second adjacent channel power requirement defined in clause 6.2.7.

Step 10:   Repeat Steps 2 to 9 at the two remaining test frequencies (clause 8.2).
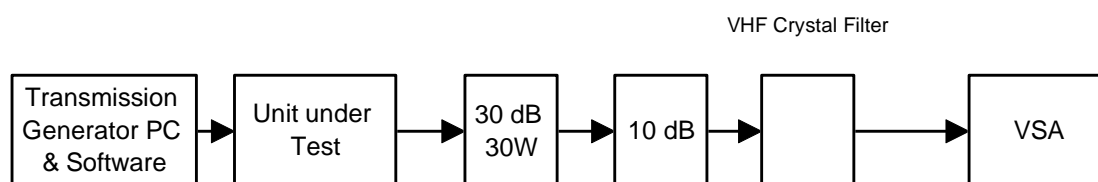

Figure 9.7: Second and fourth adjacent channel power measurement

9.2.6.3   Method of measurement for the fourth adjacent channel

Equipment Required:

- Transmission Generator, PC with suitable software.

- Attenuator 30 dB, 30 W.

- VHF crystal filter with a 3 dB bandwidth of 25 kHz and, with attenuation in excess of 50 dB at ± 50 kHz.

- Spectrum analyser with power band marker function.

Measurement Procedure:

Step 1:   Connect the equipment as shown in figure 9.6.

Step 2:   Tune the transmitter to one of the test frequencies (clause 8.2).

Step 3:   Offset the tuned frequency of the transmitter under test to 100 kHz above the VHF crystal filter centre frequency. Key the transmitter under test "on". Use the transmission generator to produce continuous maximum length Mode 4 messages.

Step 4:   Set the analyser span to 50 kHz and centre frequency to the centre frequency of the VHF crystal filter. Decrease the analyser input attenuator to the minimum level at which the attenuated rf signal from the transmitter under test does not overload the analyser. Use the analyser IF signal power as the trigger source for the display and set averaging to 10.

Step 5:   Set analyser's power band marker function set to 40 kHz. Notice that the measurement bandwidth is defined by the VHF crystal filter and setting the power band marker to the same bandwidth will give an erroneous result.

Step 6:   Determine the fourth lower adjacent channel power.

Step 7:   Repeat Steps 2 to 5 with the transmitter under test tuned to 100 kHz below the crystal filter. Determine the fourth upper adjacent channel power.

Step 8:   Record the fourth adjacent channel power as the highest of the two measured values.

Step 9:   Check that the fourth adjacent channel power is less than the fourth adjacent channel power requirement defined in clause 6.2.7.

Step 10:   Repeat Steps 2 to 9 at the two remaining test frequencies (clause 8.2).

9.2.6.4   Alternative Measurement Procedure for Adjacent Channel Power (ACP)

Step 1:   Connect the equipment as shown in figure 9.7.

Step 2:   Tune the transmitter to one of the test frequencies.

Step 3:   Start the transmission generator that produces transmit blocks and simulates the transmit/receive duty cycle.

Step 4:   Use an attenuator to protect the measurement equipment and a notch filter centred on the carrier frequency, if the dynamic range of the spectrum analyser is not sufficient. Set the spectrum analyser resolution bandwidth (Br) much narrower than the channel bandwidth and the video bandwidth (Bv) equal to ten times Br in order to avoid errors due to video averaging of noise.

Step 5:   Measure and store the rf signal spectrum centred on the carrier frequency with a frequency span wide enough to display all the modulation spectrum between the -80 dB points, referred to the peak value.

Step 6:   Convert the logarithmic trace values from the spectrum analyser to linear spectral power densities by the relation:

$$P_i = \frac{10^{\frac{P_{idBm}}{10}}}{B_n}$$

where P_{idBm} = Trace values (dBm)

B_n = Effective noise bandwidth of the spectrum analyser (Hz)

P_i = Spectral power densities (mW/Hz)

NOTE: B_n = k x Br, where k is a constant specified for each spectrum analyser.

Step 7:   Perform an integration of the linear spectral power densities. For computation of the linear spectral power values in the first, second and fourth adjacent channels, use the formula:

$$P_{ch} = B_{ch} \times \frac{1}{N} \times \sum_{i=1}^{N} P_i$$

where P_{ch} = power in the considered channel

B_{ch} = assigned bandwidth of the first , second or third adjacent channel

N = Number of power samples within the limits of the assigned bandwidth, B_{ch}

Step 8:   Perform the adjacent channel measurement for the first, second and fourth adjacent channels on both sides of the carrier frequency (lower and upper adjacent channels).

Step 9:   Check that the adjacent channel power on either side of the carrier for the first, second and fourth adjacent channels are lower than the respective adjacent channel power requirements defined in clause 6.2.7.

Step 10:   Repeat Steps 2 to 9 at the two remaining test frequencies.

9.2.7   Wideband noise

Equipment Required:

- Transmission Generator, PC with suitable software.

- Attenuator 30 dB, 30 W.

- Notch filter with a minimum of 30 dB on-channel attenuation.

- Spectrum analyser with power band marker function.

Measurement Procedure:

Step 1:   Connect the equipment as shown in figure 9.8.

Step 2:   Tune the transmitter to one of the test frequencies (clause 8.2).

Step 3:   Use the filter to attenuate the carrier in order to increase the dynamic range of the measurement without overloading the spectrum analyser. Measure the frequency response of the filter and take this into account when presenting noise measurement results.

Step 4:   Key the transmitter under test using the transmission generator with repetitive maximum length Mode 4 messages.

Step 5:   Adjust the spectrum analyser reference level to provide the maximum dynamic range for display and set the input attenuator to minimum. Ensure that no signal at the analyser input exceeds the maximum allowable level.

Step 6:   Record the transmitter noise level versus the frequency displacement using the power band marker function of the analyser.

Step 7:   Check that the wide-band noise does not exceed the limit specified in clause 6.2.8.

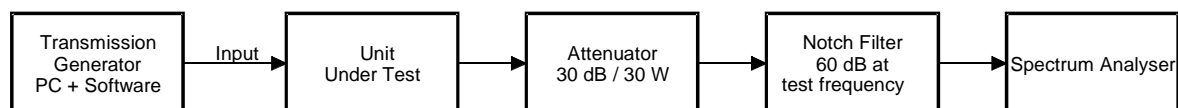Step 8:   Repeat Steps 2 to 7 at the two remaining test frequencies (clause 8.2).

Figure 9.8: Wideband noise measurement

9.2.8   Frequency Error

9.2.8.1   Definition

The frequency error is the difference between the measured carrier frequency and its nominal value.

9.2.8.2   Method of measurement

The carrier frequency shall be measured in the absence of modulation, with the transmitter connected to a coaxial termination. Measurements shall be made under extreme test conditions.

9.2.8.3   Limits

The frequency error shall be within the limits defined in clause 6.2.9.

9.2.9   Load VSWR capability (clause 6.2.11)

The following equipment is required:

- Transmission Generator, PC with suitable software

- 30 dB directional coupler

- Adjustable delay line

- 2:1 VSWR Resistive load

- Vector signal analyser with power band marker function

The measurement procedure consists in the following steps:

Step 1   Connect the equipment as shown in figure 9.9.

Step 2   Tune the transmitter to one of the test frequencies.

Step 3   Key the transmitter under test with the transmission generator with repetitive maximum length Mode 2 messages.

Step 4   Vary the VSWR phase angle of the load with the delay line and measure the minimum average forward rf output power from the Transmitter using the vector signal analyser power band marker function.

Step 5   Check that the minimum average forward rf output power is greater than the limit defined in clause 6.2.11.

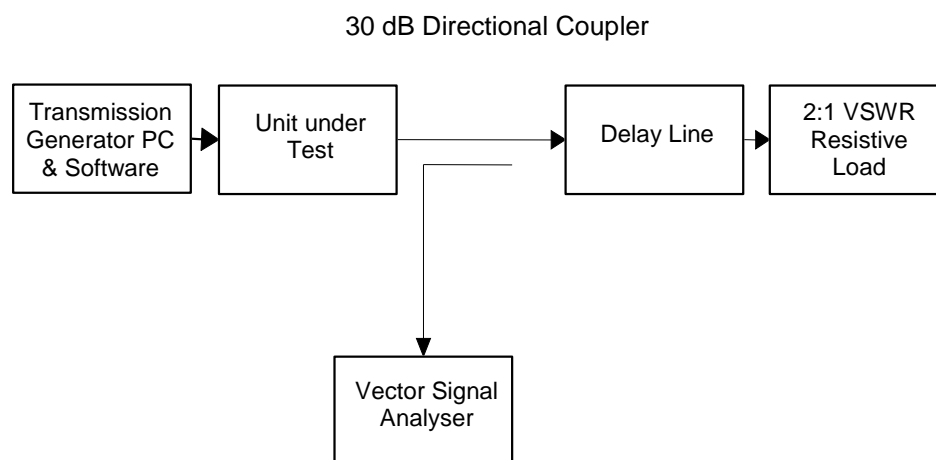Step 6   Repeat Steps 2 to 5 at the two remaining test frequencies.

30 dB Directional Coupler

Figure: 9.9: LOAD VSWR CAPABILITY

9.3   Physical layer, system parameters

9.3.1   Receiver to Transmitter turn-around time

Measurement Procedure:

Step 1:   Limit the periodic dither range of the periodic streams from the equipment to ±2.

Step 2:   Establish a series of periodic streams from the equipment under test.

Step 3:   Use the test equipment to generate a periodic reservation in the slot before each system under test periodic stream.

Step 4:   Ensure that the timing of the bursts from the test equipment result in termination of the bursts
                16 µs before the nominal slot start time.

Step 5:   Monitor the movement of the streams from the system under test to ensure that the reservations
                made by the test equipment are respected by the system under test.

NOTE: This shows that the system under test successfully decodes information in the slot before transmitting
                itself.

9.3.2   Transmitter to Receiver turn-around time

Measurement Procedure:

Step 1:   Limit the periodic dither range of the periodic streams from the system under test to ±2.

Step 2:   Establish a series of periodic streams from the equipment under test.

Step 3:   Use the test equipment to generate a periodic reservation in the slot after each periodic stream
                from the equipment under test.

Step 4:   Ensure that the timing of the bursts from the test equipment result in the start of the bursts 1 ms
                after completion of the transmission from the equipment under test.

Step 5:   Monitor the movement of the streams from the equipment under test to ensure that the reservations
                made by the test equipment are respected by the equipment under test.

NOTE 1: This shows that the equipment successfully decodes information in the slot after transmitting itself. Note
                that ideally the transmissions from the equipment should be longer than the normal sync burst length in
                order to ensure that the test equipment does not produce signals earlier than the slot boundary. A bespoke
                message format could be used.

NOTE 2: The test equipment should produce a signal at the reference level (or lower TBD) and the output of the
                system under test should be measured to monitor the successful received message rate – this should be
                shown to be greater than the equivalent of a BER at nominal performance.

9.3.3   Tuning Time

This requirement may be satisfied by written evidence.

Annex A (informative):
Bibliography

ED 92 (2000): "Minimum Operational Performance Specification for an Airborne VDL Mode-2 Transceiver Operating in the frequency range (118,000 MHz - 136,975 MHz)".

History

Document history				
V1.1.1	May 2001	Public Enquiry	PE 20010907:	2001-05-09 to 2001-09-07
V1.1.1	November 2001	Vote	V 20020104:	2001-11-05 to 2002-01-04