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Electromagnetic compatibility and Radio spectrum Matters (ERM); Digital Mobile Radio (DMR) Systems; Part 2: DMR voice and generic services and facilities

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

The present document is part 2 of a multi-part deliverable covering the Technical Requirements for Digital Mobile Radio (DMR), as identified below:

Part 1: "DMR Air Interface (AI) protocol";

Part 2: "DMR voice and generic services and facilities";

Part 3: "DMR data protocol";

Part 4: "DMR trunking protocol".

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document contains technical requirements for Digital Mobile Radio (DMR) operating in the existing licensed land mobile service frequency bands, as identified in CEPT/ERC/T/R 25-08 [i.1].

The present document describes the voice and generic services and facilities of a scalable Digital Mobile Radio system which covers three tiers of possible products:

Tier I: DMR equipment having an integral antenna and working in direct mode (communication without infrastructure) under a general authorization with no individual rights operation.

Tier II: DMR systems operating under individual licences working in direct mode (unit-to-unit) or using a Base Station (BS) for repeating.

Tier III: DMR trunking systems under individual licences operating with a controller function that automatically regulates the communications.

NOTE 1: Tier II and Tier III products encompass both simulcast and non-simulcast systems.

NOTE 2: The three tiers of possible products only work independently and there is no interoperability across the tiers.

The present document specifies the voice and generic services and facilities of DMR that has been specifically developed with the intention of being suitable for all identified product tiers. The DMR protocol is intended to be applicable to the land mobile frequency bands, physical channel offset, duplex spacing, range assumptions and all other spectrum parameters without need for any change.

2 References

2.1 Normative references

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

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

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

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

[1] ETSI TS 102 361-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Digital Mobile Radio (DMR) Systems; Part 1: DMR Air Interface (AI) protocol".

[2] ETSI TS 102 361-3: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Digital Mobile Radio (DMR) Systems; Part 3: DMR data protocol".

2.2 Informative references

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

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

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

[i.1] CEPT/ERC/T/R 25-08: "Planning criteria and coordination of frequencies for land mobile systems in the range 29.7-470 MHz".

[i.2] ISO/IEC 8859: "Information processing - 8-bit single-byte coded graphic character sets".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

1:1-mode: 1 traffic channel mode

NOTE: 1:1-mode supports one "MS to fixed end" duplex call or one simplex call with an optional inbound Reverse Channel using a two frequency BS.

2:1-mode: 2 traffic channel mode

NOTE: 2:1-mode supports two independent calls which may be either "MS to fixed end" duplex calls, simplex calls using a two frequency BS or simplex calls between MS units on a single frequency.

Base Station (BS): fixed end equipment that is used to obtain DMR services

bearer service: telecommunication service providing the capability for information transfer between access points

burst: elementary amount of bits within the physical channel

NOTE 1: Three different bursts exist with different number of bits. The Traffic burst contains 264 bits, the CACH burst contains 24 bits and the RC burst contains 96 bits.

NOTE 2: The burst may include a guard time at the beginning and end of the burst used for power ramp-up and ramp-down.

NOTE 3: For detailed burst definition see ETSI TS 102 361-1 [1], clause 4.2.1.

call: complete sequence of related transactions between MSs

NOTE: Transactions may be one or more bursts containing specific call related information.

channel slot timing: time slot 1 and time slot 2 timing boundaries established by a TDMA direct mode leader

code unit: number of bits in a particular character encoding format, where some character sets may require multiple code units to realize all characters within that character set

NOTE 1: One code unit is 7 bits for a 7 bit ASCII coded character format.

NOTE 2: One code unit is 8 bits for an UTF-8 bit coded character format.

NOTE 3: One code unit is 16 bits for a UTF-16 bit coded character format.

NOTE 4: Each combined character encoding, comprising one or more code units within the character set, is referred to as a code point. For example UTF-16 has a code unit of 16 bits, but may include code points (characters) of up to two code units (32 bits).

Control plane (C-plane): part of the DMR protocol stack dedicated to control and data services

Digital Mobile Radio (DMR): physical grouping that contains all of the mobile and/or fixed end equipment that is used to obtain DMR services

direct mode: mode of operation where MSs may communicate outside the control of a network

NOTE 1: This is communication technique where any radio unit (MS) may communicate with one or more other radio units (MSs) without the need for any additional equipment (e.g. BS).

NOTE 2: Supports one transmission per 12,5 kHz frequency; 12,5 kHz equivalent (12,5e) spectral efficiency.

duplex: mode of operation by which information can be transferred in both directions and where the two directions are independent

NOTE: Duplex is also known as full duplex.

frame: two contiguous time slots labelled 1 and 2

NOTE: A frame has a length of 60 ms.

inbound: MS to BS transmission

logical channel: distinct data path between logical endpoints

NOTE: The logical channels are labelled 1 and 2. The logical channel may consist of sub-channels, e.g. SYNC, embedded signalling, etc.

Mobile Station (MS): physical grouping that contains all of the mobile equipment that is used to obtain DMR mobile services

octet: 8 bits grouped together, also called a byte

outbound: BS to MS transmission

payload: bits in the information field

personalization: address and configuration information that characterizes a particular DMR MS

NOTE: This information may be programmed by the installer before putting an MS into service.

physical channel: RF carrier that is modulated with information bits of the bursts

NOTE: The RF carrier may be a single frequency or a duplex pair of frequencies. The physical channel of a DMR subsystem is required to support the logical channels.

polite protocol: "Listen Before Transmit" (LBT) protocol

NOTE: This is a medium access protocol that implements a LBT function in order to ensure that the channel is free before transmitting.

prefix: most significant digit of a MS address in the user domain

privacy: secret transformation

NOTE: Any transformation of transmitted information that is derived from a shared secret between the sender and receiver.

Protocol Data Unit (PDU): unit of information consisting of protocol control information (signalling) and possibly user data exchanged between peer protocol layer entities

Radio Frequency channel: Radio Frequency carrier (RF carrier)

NOTE: This is a specified portion of the RF spectrum. In DMR, the RF carrier separation is 12,5 kHz. The physical channel may be a single frequency or a duplex spaced pair of frequencies.

repeater mode: mode of operation where MSs may communicate through a BS

NOTE: This is a communication technique where any radio unit (MS) may communicate with one or more other radio units (MSs) with the need for an intermediate BS.

signalling: exchange of information specifically concerned with the establishment and control of connections, and with management, in a telecommunication network

simplex: mode of working by which information can be transferred in both directions but not at the same time

superframe: 6 continues traffic bursts on a logical channel labelled "A" to "F"

NOTE: A superframe has a length of 360 ms and is used for voice traffic only.

TDMA direct mode: direct mode operation that supports two transmissions per 12,5 kHz frequency

NOTE: Supports 6,25 kHz equivalent (6,25e) spectral efficiency.

time slot (or slot): elementary timing of the physical channel

NOTE: A timeslot has a length of 30 ms and will be numbered "1" or "2".

transmission: transfer period of bursts containing information or signalling

NOTE: The transmission may be continuous, i.e. multiple bursts transmission without ramp-up, ramp-down, or discontinuous, i.e. single burst transmission with ramp-up and ramp-down period.

trunking: network controlled communication

NOTE: This is a communication technique where any radio unit (MS) may communicate with one or more other radio units (MSs) using a trunking protocol and all MSs will be under control of a network.

user numbering: decimal representation of DMR air interface addresses

NOTE: The user numbering is that visible to a user or seen by the user.

User plane (U-plane): part of the DMR protocol stack dedicated to user voice services

wildcard: character in the user domain that represents all digits 0 to 9

3.2 Symbols

Void.

3.3 Abbreviations

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

ACK	(positive) ACKnowledgement
AI	Air Interface
AL	Accept Leader
ANL	Announce New Leader
ASCII	American Standard Code for Information Interchange
AT	Access Type
BOC	Beginning Of Call
BOR	Beginning Of Repeat
BOT	Beginning Of Transmission
BS	Base Station
CACH	Common Announcement Channel
CBF	CSBK Blocks to Follow
CC	Colour Code
CCE	CT_CSBK Evaluation
CCITT	Consultative Committee on International Telegraphy and Telephony
CCL	Call Control Layer
CCL_1	Call Control Layer: Slot 1 process
CCL_2	Call Control Layer: Slot 2 process
CCL_BS	Call Control Layer: Both Slot process
C-plane	Control-plane
CRC	Cyclic Redundancy Checksum for data error detection
CSBK	Control Signalling BlocK
CSBKO	CSBK Opcode

CT	Channel Timing
CT_CSBK	Channel Timing CSBK
CTO	Channel Timing Opcode
DI	Dynamic Identifier
DLL	Data Link Layer
DMR	Digital Mobile Radio
EOC	End Of Call
EOR	End Of Repeat
EOT	End Of Transmission
FEC	Forward Error Correction
FID	Feature set ID
FLCO	Full Link Control Opcode
FNS	Feature Not Supported
Gen	Generation
GPS	Global Positioning System
Grp_V_Ch_Usr	Group Voice Channel User
HMSC	High level Message Sequence Chart
ID	Identifier
IO	Input Output
IP	Internet Protocol
LB	Last Block
LBT	Listen Before Transmit
LC	Link Control
LDI	Leader Dynamic Identifier
LDR	LeaDeR CT_CSBK evaluation
LID	Leader Identifier
LIP	Location Information Protocol
LLC	Logical Link Control
LSB	Least Significant Bit
LWATID	Leader Wide Area Timing IDentifier
MAC	Medium Access Control
MFID	Manufacturer's FID
MMI	Man Machine Interface
MS	Mobile Station (either portable or mobile unit)
MSB	Most Significant Bit
MSC	Message Sequence Chart
MS_DI	Mobile Station Dynamic Identifier
N_xxxx	Layer 3 constant

NOTE: As defined in clause A.2.

NA	Not Applicable
NL	New Leader
OACSU	Off Air Call SetUp
OVCM	Open Voice Channel Mode service
PABX	Private Automatic Branch eXchange
PATCS	Press And Talk Call Setup
PDU	Protocol Data Unit
PF	Protect Flag
PL	Physical Layer
PSTN	Public Switched Telephone Network
PTT	Push-To-Talk
RC	Reason Code
RC	Reverse Channel
RF	Radio Frequency
RX	Receive
SA	Sync Age
SC	Send Correction
SDI	Source Dynamic Identifier
SDL	Specification and Description Language
SFID	Standards FID
SID	Source Identifier

SLCO	Short Link Control Opcode
SMS	Short Message Service
SWATID	Source Wide Area Timing IDentifier
SYNC	Synchronization
T_xxxx	Layer 3 Timer

NOTE: As defined in clause A.1.

TD_LC	Terminator Data Link Control
TDMA	Time Division Multiple Access
TO	Time Out
TP	Timing Push
TS	Technical Specification
TX	Transmit
U-plane	User-plane
UTF	Unicode Transformation format

4 Overview

4.0 Overview introduction

The present document describes a Digital Mobile Radio (DMR) system for Tier II and Tier III products which employ a Time Division Multiple Access (TDMA) technology with a 2-slot TDMA solution and RF carrier bandwidth of 12,5 kHz (see note 1).

NOTE 1: DMR system for Tier I products employ a continuous transmission variation of the previously mentioned technology.

The present document describes the Call Control Layer (CCL) of the DMR Air Interface (AI). Radio equipments (fixed, mobile or portable) which conform to the present document shall be interoperable at the Air Interface with equipment from other manufacturers. Radio equipment of the present document shall also comply with ETSI TS 102 361-1 [1].

The present document will not provide the specification or operational detail for system implementations which include but are not limited to trunking, roaming, network management, vocoder, security, data, subsystems interfaces and data between private and public switched telephone networks. It describes only the appropriate access requirements compatible with the Air Interface.

NOTE 2: The DMR standard consists of a multi-part deliverable, which will be referred to in the present document if needed.

4.1 Protocol architecture

4.1.0 Protocol architecture - Introduction

The purpose of this clause is to provide a model where the different functions and processes are identified and allocated to different layers in the DMR protocol stack.

The protocol stack in this clause and all other related clauses describe and specify the interfaces, but these stacks do not imply or restrict any implementation.

The DMR protocol architecture which is defined herein follows the generic layered structure, which is accepted for reference description and specification of layered communication architectures.

The DMR standard defines the protocols for the following 3 layered model as shown in figure 4.1.

The base of the protocol stack is the Physical Layer (PL) which is the layer 1.

The Data Link Layer (DLL), which is the layer 2, shall handle sharing of the medium by a number of users. At the DLL, the protocol stack shall be divided vertically into two parts, the User plane (U-plane), for transporting information without addressing capability (e.g. voice), and the Control plane (C-plane) for signalling information, both control and data, with addressing capability, as illustrated by figure 4.1.

NOTE 1: It is appropriate to bear in mind the different requirements of C-plane and U-plane information. C-plane information needs only a discrete (or non-continuous) physical link to pass information although it needs a continuous virtual link to support the service. This may also be called signalling or packet mode service. Acknowledgements may or may not be requested. U-plane information, on the other hand, requires a regular physical link to be available so that a constant delay service can be supported. This may also be called circuit mode service.

NOTE 2: The DLL identified in figure 4.1 may be further sub-divided in the air interface protocol to separate the functionality of Medium Access Control (MAC) and Logical Link Control (LLC), which is often performed in radio air interface protocols due to the specialized nature of these two tasks. Such separation is not presented in the present document and is implementation specific. It is further implementation specific if layer 2 at U-plane offers only MAC for the service.

The Call Control Layer (CCL), which is layer 3, lies in the C-plane and is responsible for control of the call (addressing, features, etc.), provides the services supported by DMR, and supports Short Data and Packet Data service. U-plane access at layer 2 (DLL) supports voice service which is available in DMR. The Control Layer and the features and services offered by DMR are described in the present document. The Short Data and Packet Data Protocol offered by DMR are described in ETSI TS 102 361-3 [2].

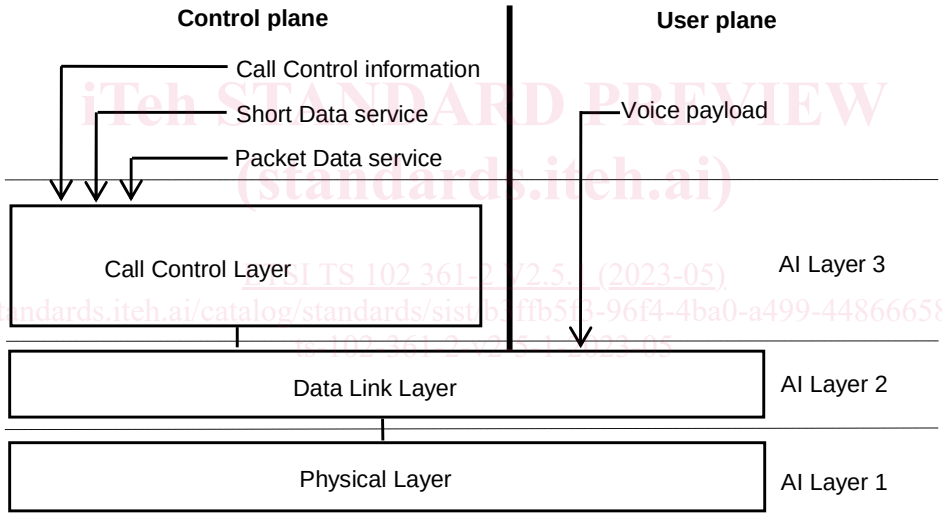

Figure 4.1: DMR protocol stack

4.1.1 Air Interface Physical Layer (layer 1)

The Air Interface layer 1 shall be the physical interface. It shall deal with the physical burst, composed of bits, which is to be sent and/or received. The Physical Layer is described in ETSI TS 102 361-1 [1].

The Air Interface layer 1 contains the following functions:

- modulation and demodulation;
- transmitter and receiver switching;
- RF characteristics;
- bits and symbol definition;
- frequency and symbol synchronization;
- burst building.