



**Electromagnetic compatibility
and Radio spectrum Matters (ERM);
Digital Mobile Radio (DMR)
General System Design**

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Foreword

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

Modal verbs terminology

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Introduction

The present document has been produced to provide an introduction to DMR for potential system purchasers, network operators and service users.

It is in relation to multi-part ETSI TS 102 361 [i.1] to [i.4] 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".

It provides an overview, a description on the DMR services and facilities, technical background and radio aspects, protocol and service performance, and guidance on numbering and addressing.

It should be understood that, as in all standard setting activities, there is an inherent conflict between the wish to have as broad a standard as possible and at the same time wanting to have as much of that broad standard available and implemented right from the beginning. Potential system purchasers, network operators and service users should make sure they influence the suppliers to have their required functionality available when they need it.

Equipment manufacturers will use the broad flexibility provided within the standard to develop and implement systems in various ways, and still be conforming according to the standard. This broad availability of systems, each optimized around certain features and functionalities, needs to be carefully analysed by a network operator and system user to find the supplier with a system suited best for their needs.

Clause 5 provides an overview of the DMR over-the-air protocol.

Information about DMR services is given in clause 6. In addition, clause 7 contains a summary of the DMR data services.

Information on DMR trunking is in clause 8 as well as annex A (power save) and annex B (channel access and throughput).

A short introduction to numbering and addressing is in clause 9.

Information on network design and management is in clause 10.

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1 Scope

The present document is written as a "Read-me-first" manual or "Getting started with DMR". It is not intended to be a complete guide to the DMR technical specifications. If any conflict is found between the present document and the clauses in the DMR specifications then the technical specifications in ETSI TS 102 361 (all parts) [i.1] to [i.4] take precedence.

The aims of the present document are many, for example:

- 1) to provide the reader with sufficient knowledge to engage in qualified discussions with the equipment and service suppliers;
- 2) to expose the reader to the specific language and technical terminology used in the DMR specifications;
- 3) to enable the reader to understand the flexibility in system design, system network topography, system availability and various modes of operation;
- 4) information on radio aspects and network design and management is given.

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.

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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] | ETSI TS 102 361-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Digital Mobile Radio (DMR) Systems; Part 1: DMR Air Interface (AI) protocol". |
| [i.2] | ETSI TS 102 361-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Digital Mobile Radio (DMR) Systems; Part 2: DMR voice and generic services and facilities". |
| [i.3] | ETSI TS 102 361-3: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Digital Mobile Radio (DMR) Systems; Part 3: DMR Data protocol". |
| [i.4] | ETSI TS 102 361-4: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Digital Mobile Radio (DMR) Systems; Part 4: DMR trunking protocol". |

- [i.5] ETSI EN 300 113-2: "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 2: Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive".
- [i.6] ETSI EN 300 390-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Land mobile service; Radio equipment intended for the transmission of data (and speech) and using an integral antenna; Part 2: Harmonized EN covering essential requirements under article 3.2 of the R&TTE Directive".
- [i.7] CEPT Recommendation T/R 25-08: "Planning criteria and coordination of frequencies in the Land Mobile Service in the range 29.7-921 MHz".
- [i.8] CEPT ERC Report 25: "The European table of frequency allocations and utilizations covering the frequency range 9 kHz to 275 GHz".
- [i.9] MPT1318: "Engineering Memorandum, Trunked Systems in the Land Mobile Service". February 1986, United Kingdom Department of Trade and Industry.
- [i.10] CEPT ECC/DEC/(05)12: "ECC Decision of 28 October 2005 on harmonized frequencies, technical characteristics, exemption from individual licensing and free carriage and use of digital PMR 446 applications operating in the frequency band 446,1-446,2 MHz".
- [i.11] Draft CEPT ECC Decision (06)06 (WGFM, Cavtat, April 2006): "ECC Decision on the availability of frequency bands for the introduction of Narrow Band Digital Land Mobile PMR/PAMR in the 80 MHz, 160 MHz and 400 MHz bands".
- [i.12] IEC 61162-1: "Maritime navigation and radiocommunications equipment and systems - Digital Interfaces - Part 1: Single talker and multiple listeners".
- [i.13] IETF RFC 2529: "Transmission of IPv6 over IPv4 Domains without Explicit Tunnels".
- [i.14] IETF RFC 3056: "Connection of IPv6 Domains via IPv4 Clouds".
- [i.15] IETF RFC 3142: "An IPv6-to-IPv4 Transport Relay Translator".
- [i.16] IETF RFC 4213: "Basic Transition Mechanisms for IPv6 Hosts and Routers".
- [i.17] "Unicode: technical standards".
- NOTE: Available at www.unicode.org.
- [i.18] ISO 8859 (parts 1 to 16): "Information technology - 8-bit single-byte coded graphic character sets".
- [i.19] IETF RFC 791: "Internet Protocol".

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 payload 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 payload channel mode

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

ALLMSID: MS ID to address all MS in a system

ambient listening: optional form of voice call where the called MS answers then may enter a proprietary listening operation such as transmitting with the microphone mute open

assigned channel: channel that has been allocated by the infrastructure to certain MSs using channel allocation command(s) addressed to those MSs

NOTE: An assigned channel may be allocated for secondary control purposes or for a circuit mode call.

asynchronous access: mode of operation whereby MS are permitted access to TS by employing the polite protocol defined in ETSI TS 102 361-2 [i.2]

NOTE: In this mode MS are not required to listen to a TSCC to first determine their access rights.

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

NOTE 2: Two bursts with different length are defined for DMR. A TDMA burst which has a length of 30 ms and a reverse channel burst which has a length of 10 ms.

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

NOTE 4: A burst represents the physical content (channel) of a timeslot.

call: complete sequence of related transactions between MSs

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

Caller Line Identity (CLI): ability to see who is calling you before answering the telephone

channel: pair of same numbered slots on the inbound and outbound duplex frequencies (in the Time Division Multiple Access (TDMA) slot structure arrangement)

composite control channel: TSCC that may temporarily revert to a payload channel (if for instance the instantaneous traffic exceeds that which may be accommodated by the available payload channels)

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

coverage area: geographical area within which the received signal strength from a radiating BS exceeds a specified threshold value

dedicated control channel: TSCC that is continuously transmitted by a TS and never reverts to a payload channel

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

downlink: process of transferring information in the outbound direction (TS to MS)

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.

extended address: source or destination that is not an MS address (such as a PABX extension, PSTN number or IP address)

First In First Out (FIFO): storage type that retrieves information in the order in which it was stored

fixed non-volatile storage: storage facility within an MS, the contents of which cannot be modified or added to by the operation of the MS or its user

high-rate: packet data transmission that uses dual slot data timing

inbound: MS to BS transmission

information element: subset (field) within a PDU

intrinsic service: service which is inherent within a voice or data service

NOTE: It forms an integral part of the signalling associated with that voice or data service.

item: MS payload transmission from the point at which the PTT is pressed to the PTT released

key: information that determines the functional output of an authentication algorithm

line connected: call whereby one end of the call is connected to the radio system that does not use the DMR Air Interface

NOTE: Examples may be connection to the PSTN or a PABX.

logical channel: distinct data path between logical endpoints

message trunking: mode of operation that a payload channel is permanently allocated for the complete duration of the call, which may include several separate PTT items (several PTT activations by separate terminals)

NOTE: The channel is only de-allocated if the call is (explicitly) released or if a time-out expires.

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

multi-item data: data session on a payload channel that consists of two or more single item data sessions between entities

multi-part call set-up: call set-up procedure whereby the full source and destination address cannot be accommodated in a single CSBK signalling block

NOTE: The UDT procedure is invoked to transfer the address information using UDT signalling. UDT is also invoked to transport supplementary_user data, user data and extended addressing between DMR entities.

network personalization: configuration parameters appropriate to network configuration programmed into an MS that may be set by an external agency but not by the user of an MS

non-volatile storage: read/write storage that stores information during operation of an MS that is protected from the effects of switching off the MS

outbound: BS to MS transmission

packet data: method for the transmission of information by which the information is transmitted as packets each containing a fragment of the total information to be transmitted

PARTition (PAR): information element used to partition MSs on a TS that implements two control channels (TSCCs)

payload: bits in the information field

personalization: configuration parameters that may be set by an external agency but not by the user of an MS

physical channel: TDMA burst

NOTE: The DMR radio frequency channel contains two physical 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.

power-save-frame: sixteen timeslots (480 ms) defining a period for sleeping MS to wake

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.

random access attempt: period from the initiation of the random access procedure until the MS receives a response from the BS or abandons the procedure (e.g. after sending the maximum permitted number of retries)

Ready For Communications (RFC): MS state where the user has specifically indicated the readiness to communicate, e.g. the MS equivalent of a telephone off hook

read write storage: storage facility within the MS the contents of which may be modified by the operation of the MS

NOTE: The stored data is lost when the MS is switched off.

Received Signal Strength Indication (RSSI): root mean squared (rms) value of the signal received at the receiver antenna

registration (MS view): Network procedure whereby the MS asks for and the TSCC grants access to a particular MS. The MS is required to inform the system whenever it enters a new registration area.

revive: mechanism whereby DMR facilities available to an MS that has been stunned may be restored

Service Data Unit (SDU): all the data encapsulated within a PDU

serving site: radio site that is currently providing service to the MS

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

NOTE: Simplex is also known as half duplex.

single item data: data session on a payload channel that consists of a single data item being sent from one entity to another entity

single-part call set-up: call set-up procedure whereby the full source and destination address is accommodated in a single CSBK signalling block

site: totality of BSs and trunk site control equipment that processes calls in one location

slot: See time-slot.

stun: mechanism whereby DMR facilities available to an MS user may be denied

superframe: 6 continuous TDMA bursts labelled "A" to "F"

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

Supplementary Data Transfer Service: service to transfer supplementary data between DMR MS and MS/TS entities that is additional to the primary call being set-up

TDMA-frame: two continuous time-slots

time-slot: elementary time unit for allocation of a burst

NOTE: A timeslot has a length of 30 ms.

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.

transmission trunking: mode of operation that a payload channel is individually allocated for each call transaction (for each activation of the PTT)

NOTE: The channel is immediately de-allocated at the end of the call transaction (subject to unavoidable protocol delays).

Trunked Station (TS): physical grouping that contains all of the fixed end equipment in one location that is used to obtain DMR Tier III services

Trunk Station Control Channel (TSCC): control channel transmitted by the infrastructure to control the MS population

TS Authorization: complete procedure whereby an MS tests the System Identity code and an optional step of authentication to ascertain if it is permitted to gain access

Unified Data Transport (UDT): universal methodology used to transport data in DMR systems

uplink: process of transferring information in the inbound direction (MS to TS)

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

vocoder socket: 216 bits vocoder payload

3.2 Symbols

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

| | |
|--------|---|
| dBm | absolute power level relative to 1 mW, expressed in dB |
| dBp | Power relative to the average power transmitted over a burst in decibel |
| e | Natural logarithm |
| Eb | Energy per bit |
| Hz | absolute frequency |
| Nibble | 4 bits grouped together |
| ms | millisecond |
| No | Noise per Hz |
| Octet | 8 bits grouped together, also called a byte |

3.3 Abbreviations

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

| | |
|------|-----------------------------------|
| 4FSK | Four-level Frequency Shift Keying |
| ACK | ACKnowledgment |
| ACKD | ACKnowledgement outbound |
| ACKU | ACKnowledgement inbound |
| AI | Air Interface |
| ALS | Ambient Listening Service |
| AT | Access Type |
| BCD | Binary Coded Decimal |
| BCV | Broadcast Call Voice |
| BER | Bit Error Rate |
| BMP | Basic Multilingual Plane |
| BS | Base Station |

NOTE: A reference designating a fixed end device.

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|-------|--|
| CACH | Common Announcement CHannel |
| CC | Colour Code |
| CCITT | Comité Consultatif International Téléphonique et Télégraphique |