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Foreword

This draft European Telecommunication Standard (ETS) has been produced by the Radio Equipment and Systems (RES) Technical Committee of the European Telecommunications Standards Institute (ETSI), and is now submitted for the Public Enquiry phase of the ETSI standards approval procedure.

This ETS is a multi-part standard and will consist of the following parts:

Part 1: "General network design".

Part 2: "Direct MS-MS Air Interface - Radio Aspects".

Part 3: "Direct MS-MS Air Interface - Protocol".

Part 4: "Repeater Air Interface".

Part 5: "Gateway Air Interface", (DE/RES-06007-5).

Part 6: "Security".(DE/RES-06007-6).

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1 Scope

This European Telecommunication Standard (ETS) defines the Trans-European Trunked Radio (TETRA) system Direct Mode Operation (DMO). It specifies the basic air interface, the inter-working between DM groups via Direct Mode Repeaters (DM-REP), and inter-working with the TETRA Voice plus Data (V+D) system via Direct Mode Gateways (DM-GATE). It also specifies the security aspects in TETRA DMO, and the intrinsic services that are supported in addition to the basic bearer and teleservices.

This part applies to the TETRA DM-REP air interface and contains the specifications, where applicable, of the physical, data link and network layers according to the ISO model.

The specifications contained herein apply to a DM-REP as a stand-alone unit and also to the DM-REP portion of a Direct Mode Repeater/Gateway (DM-REP/GATE) combined implementation. The specification also covers the operation of a DM-MS with a DM-REP.

The protocol for a DM-MS operating through a DM-REP is specified in clauses 5 through 8, 10 and 11. Much of this protocol is defined in the form of a "delta document" relative to the specification provided in ETS 300 396-2 [3] and ETS 300 396-3 [4] for direct MS-MS operation. These clauses define where the protocol in parts 2 and 3 applies without change, or where it applies with the specified amendments, replacements or additions. Where no reference to parts 2 or 3 exists, the subclause should be regarded as independent.

The protocol for the DM-REP is specified in clauses 9 and 12.

The normative annexes mainly specify the parameter values used in the protocol.

2 Normative references

This ETS incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] ETR 265: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Technical requirements specification for Direct Mode (DM)".

[2] prETS 300 396-1: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Technical requirements for Direct Mode Operation (DMO); Part 1: General network design".

[3] prETS 300 396-2: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Technical requirements for Direct Mode Operation (DMO); Part 2: Radio aspects".

[4] prETS 300 396-3: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Technical requirements for Direct Mode Operation (DMO); Part 3: Mobile Station to Mobile Station (MS-MS) Air Interface (AI) protocol".

[5] ETS 300 392-2: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Voice plus Data (V+D); Part 2: Air Interface (AI)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this ETS, the following definitions apply:

Bit Error Ratio (BER): The ratio of the bits wrongly received to all bits received in a given logical channel.

call related service: A service is call related if it is requested from call set up initiation until call disconnection and also related to the same call.

call: . There are two types of call, individual or group. An individual call is a complete sequence of related call transactions between two DM-MSs. There are always two participants in an individual call. A group call is a complete sequence of related call transactions involving two or more DM-MSs. The number of participants in a group call is not fixed, but is at least two. Participants may join (late entry) and leave an ongoing group call.

call transaction: All of the functions associated with a complete unidirectional transmission of information during a call. A call is made up of one or more call transactions. In a simplex call these call transactions are sequential.

call unrelated service: A service is call unrelated if it is either requested outside a call or inside a call but not referring to that actual call.

called user application: The user application which receives an incoming call.

calling user application: The user application which initiates an outgoing call.

changeover: Within a call, the process of effecting a transfer of the master role (and hence transmitting MS) at the end of one call transaction so that another can commence.

Direct Mode (DM): A mode of simplex operation where mobile subscriber radio units may communicate using radio frequencies which may be monitored by, but which are outside the control of, the TETRA V+D network. DM is performed without intervention of any Base Station (BS).

Direct Mode Call Control (DMCC): The layer 3 entity responsible for setting up and maintaining a call in DM.

Direct Mode channel (also physical channel): A specific grouping of timeslots in the DM multiplex structure related to a particular DM frequency (carrier). A channel nominally occupies timeslots 1 and 3 within a frame.

Direct Mode frame number: A counter indicating the timing of frames within a multiframe.

Direct Mode Mobile Station (DM-MS): A physical grouping that contains all of the mobile equipment that is used to obtain TETRA DM services. By definition, a MS contains at least one Mobile Radio Stack (MRS). For synchronisation purposes, DM-MSs can have one of two status levels:

- **master:** If the DM-MS is either active in a call transaction transmitting traffic or control data, or is reserving the channel by means of channel reservation signalling and hence is providing synchronisation information to the channel;

- **slave:** If the DM-MS is receiving traffic and/or signalling and hence is deriving synchronisation information from the channel.

DM-REP presence signal: A signal transmitted by a DM-REP in order to indicate its presence on a DM radio frequency channel.

direct set-up signalling: A signalling procedure where immediate communication can take place between the calling and the called users without the alerting process and without an explicit response from the called user that he has answered.

Dual Watch Mobile Station (DW-MS): A MS that can operate either in TETRA DM or TETRA V+D mode. Only one mode can be selected at any given time but it is capable of monitoring the V+D control channel while in DM or a DM channel while in V+D mode.

Direct Mode GATEway (DM-GATE): A device which provides gateway connectivity between a DM-MS and the TETRA V+D network. The gateway provides the interface between TETRA DM and TETRA V+D mode.

Direct Mode REPeater (DM-REP): A device that operates in TETRA DM and provides a repeater function to enable two or more DM-MSs to extend their coverage range.

logical channel: A generic term for any distinct data path. Logical channels are considered to operate between logical endpoints.

Medium Access Control (MAC) block: The unit of information transferred between the upper MAC and lower MAC for a particular logical channel (e.g. SCH/F or STCH). The lower MAC performs channel coding for insertion into the appropriate physical slot or halfslot.

master link: The communication link used for transmissions between master MS and DM-REP.

Message Erasure Rate (MER): The ratio of the messages detected as wrong by the receiver to all messages received in a given logical channel.

MS timing offset: The delay of the received signal relative to the expected signal from an MS at zero distance under static channel conditions.

quarter symbol number: The timing of quarter symbol duration 125/9 µs within a burst.

simplex: A mode of single or dual frequency working in which information can be transferred in both directions but not at the same time.

slave link: The communication link used for transmissions between the DM-REP and slave MSs.

surveillance: The process of monitoring the quality of the radio link.

timebase: A device which determines the timing state of signals transmitted by a DM-MS.

timeslot number: A counter indicating the timing of timeslots within a DMO frame.

V+D mode: A mode of operation where MSs may communicate via the TETRA V+D air interface which is controlled by the TETRA Switching and Management Infrastructure (SwMI).

3.2 Abbreviations

For the purposes of this ETS, the following abbreviations apply:

BER	Bit Error Rate
BKN	Block Number
BN	Bit Number
CRC	Cyclic Redundancy Check
DCC	Direct Mode Colour Code
DLB	Direct Mode Linearization Burst
DLL	Data Link Layer
DM-GATE	Direct Mode Gateway.
DM-MS	Direct Mode Mobile Station
DM-REP	Direct Mode Repeater
DM-REP/GATE	Direct Mode Repeater/Gateway
DMCC	Direct Mode Call Control entity
DMO	Direct Mode Operation
DNB	Direct Mode Normal Burst
DO-MS	Direct Mode Only Mobile Station
DSB	Direct Mode Synchronization Burst
DTX	Discontinuous Traffic Transmission
DU-MS	Dual Mode (V+D Mode / Direct Mode) switchable Mobile Station
DW-MS	Dual Watch Mobile Station
FCS	Frame Check Sequence
FN	Frame Number
GSSI	Group Short Subscriber Identity
GTSI	Group TETRA Subscriber Identity
ISSI	Individual Short Subscriber Identity

ITSI	Individual TETRA Subscriber Identity
LCH	Linearization Channel
MAC	Medium Access Control
MCC	Mobile Country Code
MER	Message Erasure Rate.
MN	Multiframe Number
MNC	Mobile Network Code
MNI	Mobile Network Identity
mod	modulo (base for counting)
MS	Mobile Station
PACQ	Probability of synchronisation burst acquisition
PDU	Protocol Data Unit
PL	Physical Layer
PTT	Press To Talk
PUEM	Probability of Undetected Erroneous Message
QoS	Quality of Service
QN	Quarter Symbol Number
RDC	Radio Downlink Counter
RSSI	Radio Signal Strength Indication
SAP	Service Access Point
SCH	Signalling Channel
SCK	Static Cipher Key
SDS	Short Data Service
SDU	Service Data Unit
SN	Symbol Number
SSI	Short Subscriber Identity
STCH	Stealing Channel
SwMI	Switching and Management Infrastructure
TCH	Traffic Channel
TDMA	Time Division Multiple Access
TE	Terminal Equipment
TEI	TETRA Equipment Identity
TN	Timeslot Number
TP	Traffic Physical channel
TPNI	Transmitting Party Number Identification
TSI	TETRA Subscriber Identity
TVP	Time Variant Parameter
Ud	TETRA Direct Mode air interface.
Um	TETRA Voice plus Data (V+D) air interface
V+D	TETRA V+D operation

4 Overview of protocol

4.1 General

TETRA DMO using a DM-REP offers the possibility to support DM communications over an enhanced coverage area from that typically achieved in direct MS-MS operation.

A DM-REP re-transmits information received from one DM-MS to other DM-MS(s) over the DM air interface Ud. Three possible types of DM-REP are outlined in ETR 265 [1]:

Type 1: time division regenerating repeater:

a time division regenerating repeater conducts transmit and receive operations on a single frequency. A type 1 repeater performs de-encoding and re-encoding operations on the MS transmission bits prior to regeneration in order to improve BER performance. A type 1 DM-REP retransmits bursts received during one timeslot from a DM-MS to other DM-MS(s) in a different time slot;

Type 2: regenerating transponder:

a regenerating transponder uses two frequencies, one as an "uplink" and another as a "downlink", and performs the same regeneration processes as described for the case of the type 1 DM-REP.

Type 3: linear transponder:

a linear transponder uses two frequencies on which it receives on one DM frequency (uplink) and re-transmits the same information in an unmodified form on another DM frequency (downlink).

Both type 1 and type 2 DM-REPs are primarily layer 2 devices comprising of a Physical Layer (PL) (layer 1) and a Data Link Layer (DLL) (layer 2). The protocol stack applicable to either type 1 or type 2 DM-REPs is shown in figure 1.

For either type 1 or type 2 DM-REP it is optional to generate a DM-REP presence signal in order to indicate its operation on a DM channel.

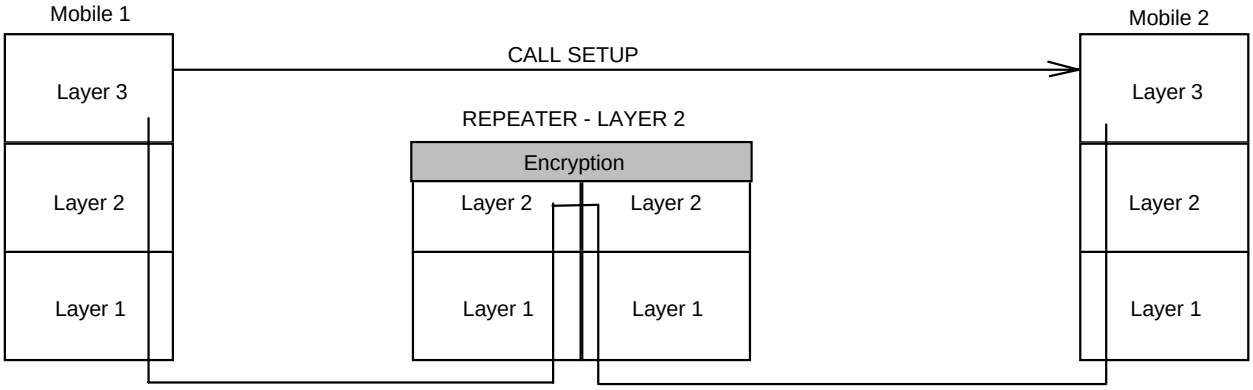

Figure 1: Protocol stack of type 1 or type 2 DM-REP

It is optional for a DM-MS to support operation through a DM-REP, therefore there are 4 possible classes of DM-MS operation with a DM-REP:

- DM-MS capable of DM MS-MS operation only; or
- DM-MS capable of DM MS-MS operation and operation through type 1 DM-REP; or
- DM-MS capable of DM MS-MS operation and operation through type 2 DM-REP; or
- DM-MS capable of DM MS-MS operation and operation through either a type 1 or type 2 DM-REP.

NOTE: The above DM-MS classification is independent of the reference models defined in ETS 300 396-1 [2].

This part of this ETS covers only the operation of a type 1 DM-REP and the operation of a DM-MS through a type 1 DM-REP.

The remainder of this clause contains an introduction to the protocol for operation through a type 1 DM-REP.

4.2 The DM channel

A DM channel can be in one of three states:

- free, where there is no activity on the channel, or in the case where a DM-REP provides a presence signal, when this presence signal indicates that the channel is free;
- occupied, where a call transaction is in progress on the channel;

- reserved, where a "channel reservation" signal is present on the channel.

The actions and procedures followed by a MS wishing to make a call on a DM channel through a DM-REP vary depending on the state of the channel.

When the channel is free, it is available for use by any DM-MS which can tune to that channel.

When a DM channel is occupied a master DM-MS provides synchronisation signalling for the channel in frames 6, 12, and 18, and transmits traffic in DM normal bursts in frames 1-17 on the master link. The information received by the DM-REP in a particular frame and timeslot on the master link is then decoded, error corrected and re-transmitted in the corresponding slave link timeslot and frame.

NOTE: All communications between the master MS and the DM-REP are conducted on the master link. All communications between a slave MS(s) and the DM-REP are conducted on the slave link.

When a DM channel is reserved, it has been in use for an individual or group call. The master DM-MS for that call transaction continues to transmit DM synchronisation bursts in frames 6, 12, and 18 on the master link with parameters indicating the fact that the channel is reserved, for which group or individual it is being reserved, and for how long the channel may continue to be reserved. This information is re-transmitted by the DM-REP on the slave link. A DM channel becomes reserved after the conclusion of each call transaction, and stays reserved until either a changeover of the master role has been successfully achieved, or until the channel reservation timer of the master DM-MS has expired.

For TETRA DMO through a DM-REP, synchronisation between master MS and DM-REP participating in a call is handled in the same way as for basic DMO described in ETS 300 396-3 [4]. However in the case of operation through a DM-REP the slave MSs are synchronised to the DM-REP transmission timing on the slave link.

4.3 DM call procedures for operation with a type 1 DM-REP

The procedures and sequences given in the following subclauses are intended to illustrate possible scenarios and the mechanisms which the protocol may take in those circumstances for DM-MS operation with a type 1 DM-REP. Type 1 DM-REPs operate on a single carrier frequency and can support one call. The procedures presented here are not exhaustive and are not intended to show every possible scenario.

Abbreviations are used in the diagrams to represent PDUs sent within the protocol. The actual message types are as follows:

cak	≡	DM-TX ACCEPT;
crq	≡	DM-TX REQUEST;
Pak	≡	DM-RELEASE + DM-PRE ACCEPT (sent in DM Normal Burst (DNB));
pak	≡	DM-PRE ACCEPT (sent in DM Synchronization Burst (DSB));
pca	≡	DM-CONNECT;
prq	≡	DM-PREEMPT;
sy	≡	DM-SETUP;
syp	≡	DM-SETUP PRES;
syr	≡	DM-RESERVED;
sys	≡	DM-SDS DATA (or first fragment if fragmented);
syo	≡	DM-OCCUPIED;
sdo	≡	DM-SDS OCCUPIED;
txC	≡	DM-TX CEASED;
dak	≡	DM-SDS ACK (or first fragment if fragmented).

Other abbreviations used are: tc, representing traffic transmission; lch, representing slots available for linearization; p?, representing slots available for pre-emption requests; sd, continuation fragments of DM-SDS DATA; sda, continuation fragment of DM-SDS ACK.

NOTE: In all cases an abbreviation with a (') indicates a repeated transmission generated by the DM-REP which may take place on either the master or slave link.

4.3.1 Constraints on the frame structure

For DMO through a type 1 DM-REP the entire protocol procedure is based on a fixed frame structure and a knowledge of the current position (in time) within this structure, as described in ETS 300 396-2 [3], subclause 4.5.1. The essential building blocks of the DM structure are the frame which comprises four time slots, and the multiframe which comprises 18 frames. For type 1 DM-REP operation the master and slave link frame boundaries are offset in time, such that the beginning of the frame n on the master link occurs 3 timeslot duration before the beginning of the corresponding frame n on the slave link.

In order to facilitate the DM protocol through a DM-REP, a number of constraints are placed on this structure, in terms of what can be transmitted in any particular slot.

In order to explain the DM-REP protocol the following points are of importance (not relevant to a free channel):

- frame 18 is always used for synchronisation purposes, and carries a DSB in both slots 1 and 3;
- frames 6 and 12 carry occupation information in a DSB in slot 3, and may carry traffic in a DNB in slot 1;
- frames 6 and 12 carry reservation information in a DSB in slots 1 and 3;
- frames 6, 12 and 18 of the slave link may carry occupation or reservation information in a DSB in slot 4;
- pre-emption signalling from a slave MS to the DM-REP is permitted, during occupation, in slot 3 of frames 2, 5, 8, 11, 14 and 17. The DM-REP then re-transmits the pre-emption message to the current master MS in slot 3 of either frame 1, 4, 7, 10, 13 or 16;
- linearization, which is carried out in a DLB, may be permitted in slot 3 of frame 3 during a call;
- during occupation, frames 1 to 17 usually carry traffic in slot 1 (in a DNB).

4.3.2 Setting up a call

In DMO through a type 1 DM-REP there are two options for call set-up; A direct set-up whereby transmission commences without explicit knowledge of the presence of any receiving MS (s), and set-up with presence checking whereby a specific acknowledgement is sought before transmission commences. However in both cases the master DM-MS monitors the slave link in order to determine that DM-REP has successfully received and retransmitted the messages. For group (point-to-multipoint) and individual (point-to-point) calls a direct set-up is the most basic mode of setting up a call in a DM channel.

4.3.2.1 Direct set-up

After following the procedures to ascertain the state of the channel and provided the channel is found to be in the state 'free' a DM-MS establishes the channel synchronisation and simultaneously its role as 'master' by transmitting a sequence of synchronisation bursts ('sy' in figure 2, with 7 being sent in this example) on the master link using the DSB structure as given in ETS 300 396-2 [3], subclause 9.4.3. These synchronisation bursts contain frame count information which in the example defines their position in the timing structure in frames 17 and 18 of the 18 frame cyclic multiframe structure. The master MS then listens for the synchronisation bursts to be retransmitted by the DM-REP in frames 18 and 1 of the slave link in order to confirm that the master MS signalling to the DM-REP was successful. The master DM-MS may then transmit traffic ('tc' in the figure) using the DNB structure, as given in ETS 300 396-2 [3], subclause 9.4.3, in the next available frame which in this example is frame number 3 of the master link.

Figure 2 also illustrates the position of slots which are allocated to allow pre-emption requests to be made ('p?' in the figure), the slot available for linearization ('lch' in the figure), and the synchronisation bursts denoting occupation of the channel ('syo' in the figure) which occur in slot 3 of frames 6, 12 and 18 following the initial synchronisation.

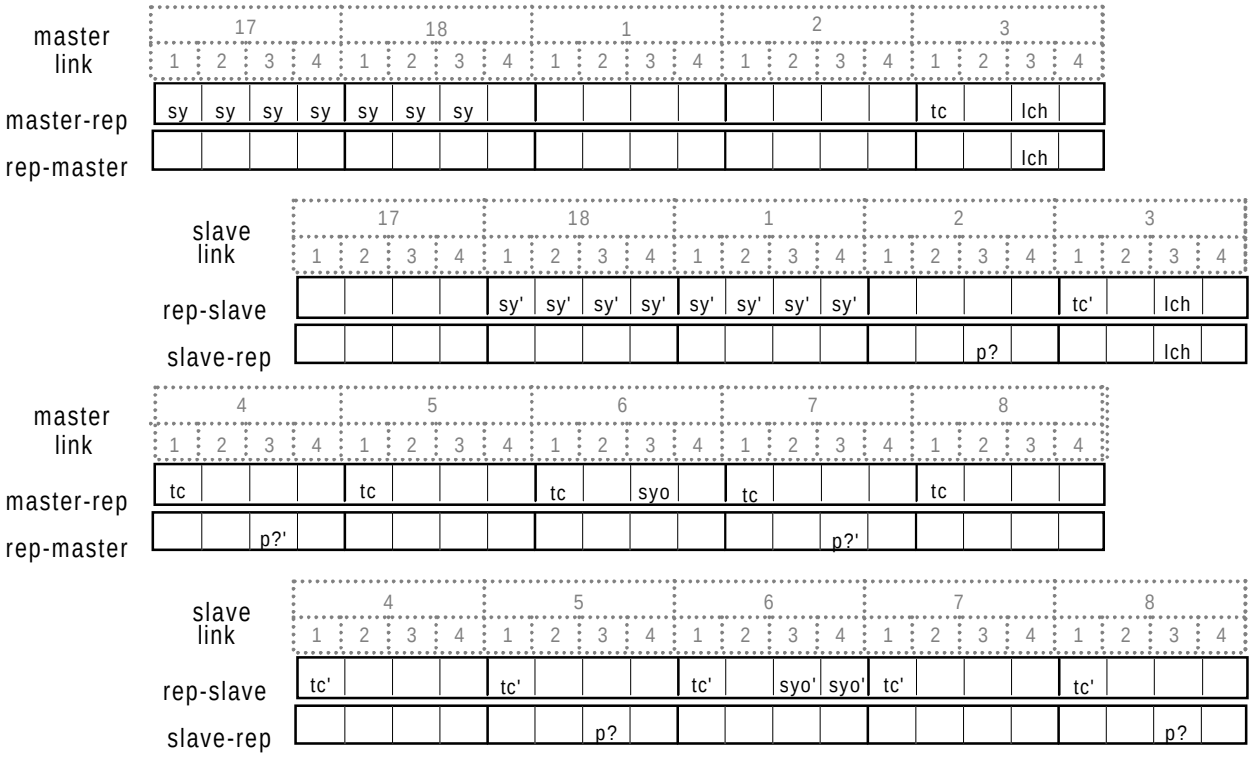

Figure 2: Call sequence for direct call set-up through a type 1 DM-REP

4.3.2.2 Call set-up with presence check

For individual (point-to-point) calls, but not for group calls, it is also possible to set-up a call using a presence check in order to ascertain the availability of the destination DM-MS. Figure 3 illustrates this procedure.

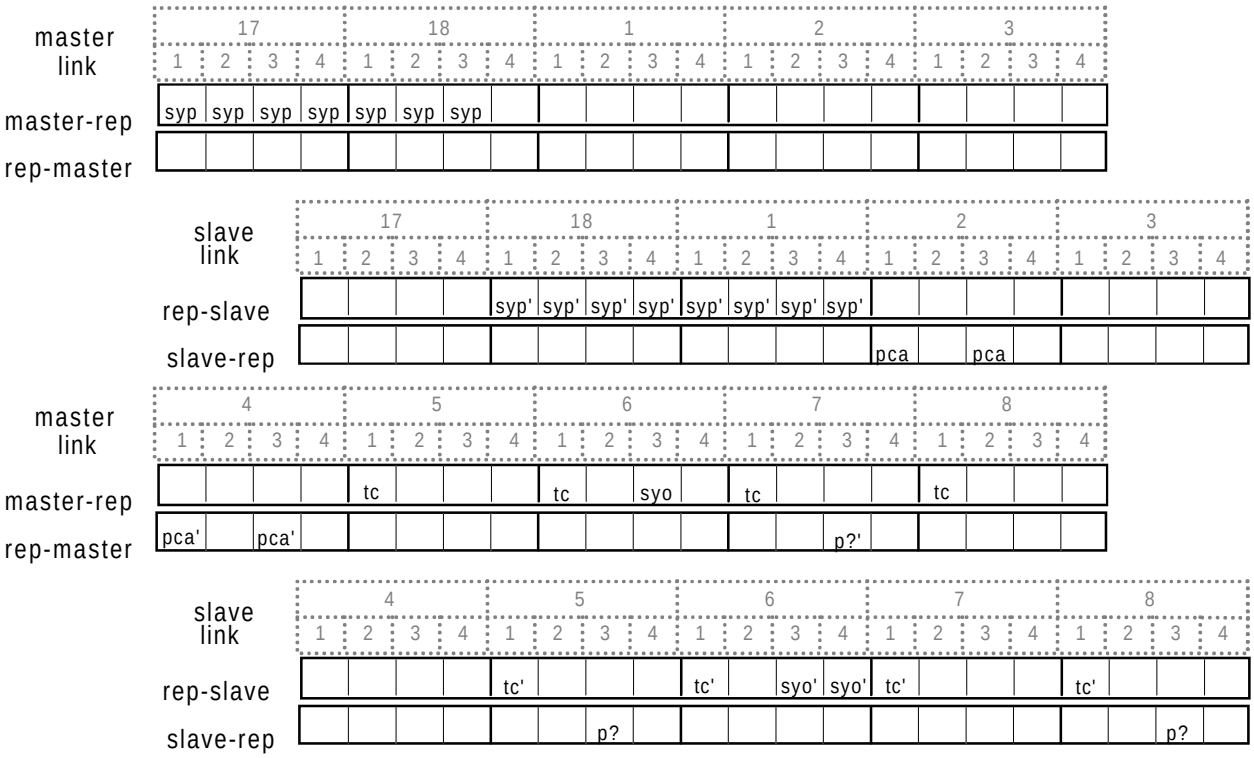

Figure 3: Call sequence for call set-up with presence check through a type 1 DM-REP

The procedure starts in a similar manner to the direct set-up, but the synchronisation burst ('syp' in figure 3, with 7 being sent in this example) now includes a parameter which is set to request a response

indicating presence of the DM-MS which has been addressed as the recipient in the set-up attempt. This DM-MS which is defined as a 'slave' for the transaction responds on the slave link with a presence check acknowledge message ('pca' in the figure) indicating its wish to receive the call and for the master to go ahead and transmit traffic. The slave responds with a minimum of two presence check acknowledge messages sending them in this example in frame 2 of the slave link. The presence check acknowledge message is retransmitted by the DM-REP to the master MS in the next available frame on the master link, in this case frame 4. The master on successfully receiving the acknowledgement in this example begins traffic transmission in frame 5 of the master link.

4.3.3 Changeover in a call

In a DM call transmitted through a DM-REP, each call transaction constitutes a separate transmission, with a designated master and slave(s) for each call transaction. The procedure for terminating one call transaction and starting another during a call is termed changeover and is illustrated in figure 4.

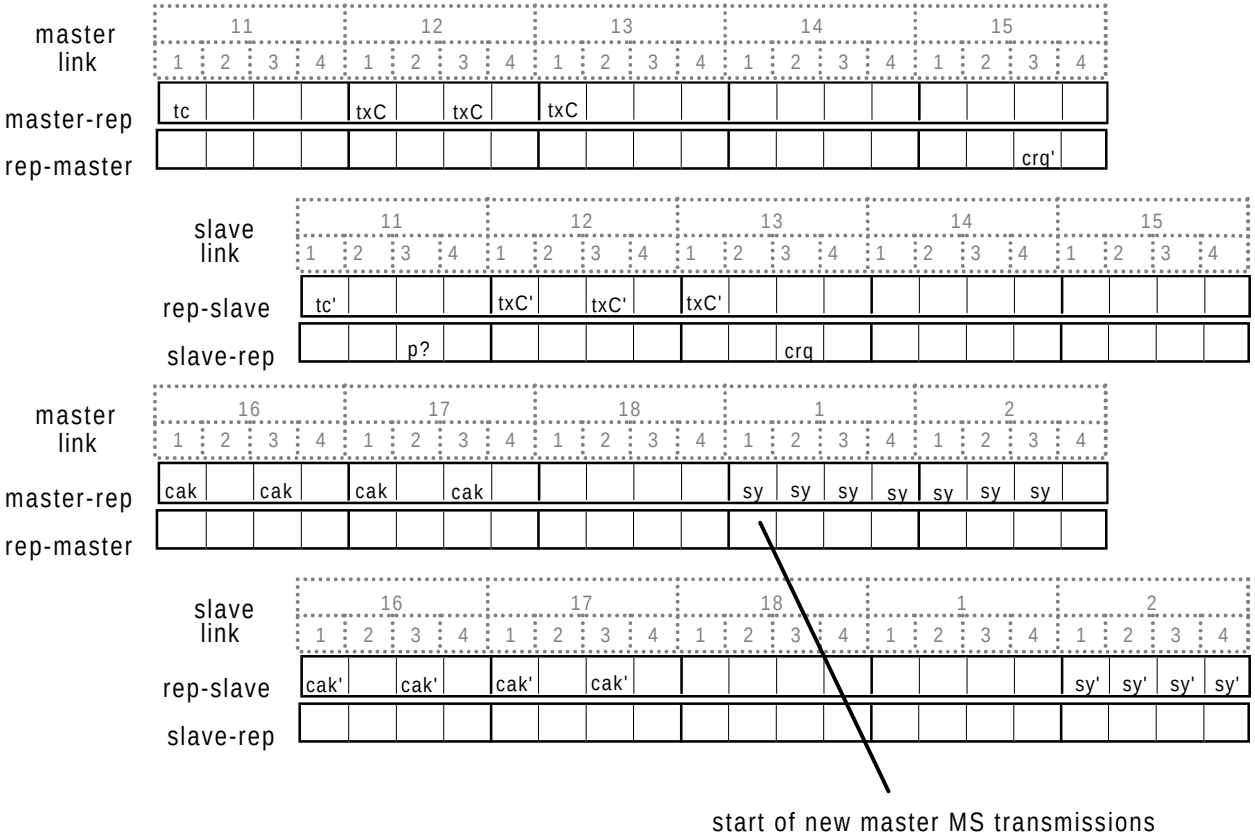

Figure 4: Call sequence for change over in call through a type 1 DM-REP (no collisions)

In order to changeover the talker (or sender) in a call, the master DM-MS has to first indicate that its call transaction has come to an end, using a transmit ceased message ('txC' in figure 4). This message is sent at least twice in slot 1 of consecutive frames on the master link and using the same burst format (i.e. DNB) as for normal traffic. These messages are subsequently retransmitted by the DM-REP on the slave link (txC'). Recipients of the call listening to the slave link are therefore aware of the termination of that call transaction and can then apply to the master, through the DM-REP, to continue the call with a new call transaction. The changeover request message ('crq' in the figure) in this example is sent by a requesting mobile in the next available slot 3 on the slave link following reception of the repeated txC'. This changeover request message is retransmitted by the DM-REP in the next available frame on the master link.

On receipt of a valid changeover request (crq'), the master may then surrender the channel to the successful applicant using a series of changeover acknowledgement messages ('cak' in the figure). On transmission of the changeover acknowledgement messages on the master link, the master MS then becomes a slave and has no further responsibility for the channel. On receipt of the repeated changeover acknowledgement messages (cak'), the requester now transmits a sequence of synchronisation bursts ('sy' in the figure) on the master link using in this case the same frame and slot timing as the previous master. The action of sending the new sequence of synchronisation bursts effects the call changeover

with the requester now providing the synchronisation to the channel and thus becoming the new master for the next call transaction.

The frame numbering in figure 4 has been chosen arbitrarily as an example, but in this illustration, the first traffic burst of the new master would take place in frame 5 on the master link.

4.3.4 Pre-emption of a DM call

During a DM call through a DM-REP, a DM-MS, who may or may not be from another group, may wish to access the DM channel for a priority reason such as an emergency. In this case a mechanism for pre-empting the already occupied channel exists. This is illustrated in figure 5.

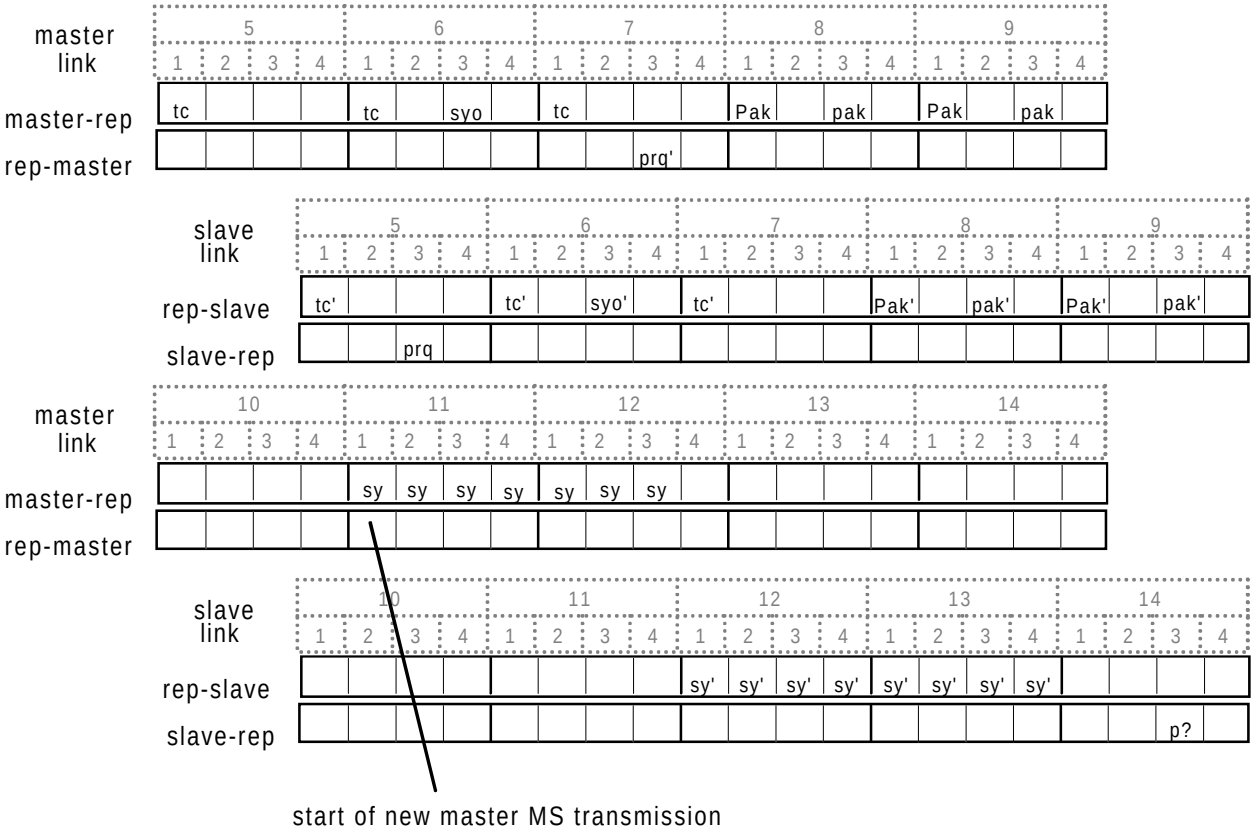

Figure 5: Call sequence for pre-emption of a call through a type 1 DM-REP (no collisions)

The first master sequence in figure 5 shows normal progress of a call through a type 1 DM-REP, with traffic bursts in slot 1 of each frame (1-17) on the master link being retransmitted by the DM-REP on the slave link. A DM-MS wishing to use the channel would in any case have had to first determine the state of the channel and in this illustration would have identified that the on-going call was being transmitted through a DM-REP. The pre-empting DM-MS has to synchronise to the DM-REP transmissions on the slave link and in the process determined the timing state of the channel, including the slave link frame and slot numbers.

To effect the pre-emption, the DM-MS submits a pre-emption request message ('prq' in the figure) at an appropriate position in the slave link frame structure. Pre-emption is allowed only on the slave link in slot 3 of frames 2, 5, 8, 11, 14 and 17. When the master successfully decodes the repeated pre-emption request sent on the master link, assuming it is a valid request, it announces that the channel has been pre-empted to both the pre-empting DM-MS and the other DM-MSs which were involved in the ongoing call. This announcement is by means of the pre-emption acknowledgement message ('Pak' and 'pak' in the figure) sent on the master link and subsequently repeated on the slave link. Having issued the pre-emption acknowledgement messages on the master link the master MS ceases its role and relinquishes the channel.

NOTE: In the case where the pre-empting slave MS has not included a timing advance indication within the DM-PREEMPT, then in the new call set-up it will adopt the timing reference and frame numbering used by the old master MS.

The successful pre-emptor now must transmit synchronisation bursts to the DM-REP using the master link for what is in effect a new call, with a new group or individual addressee, and becomes master for the initial transaction of this new call. In this example the traffic transmissions begin in slot 1 of frame 15.

4.3.5 Terminating a call

In DM the termination of a call is effected in the same way as cessation of a call transaction. After conclusion of its traffic, the master DM-MS issues transmit ceased messages and then provides reservation synchronisation bursts in frames 6, 12 and 18 until its channel reservation timer has expired. The master then ceases its transmission and the channel becomes free.

4.3.6 DM short data call through a DM-REP

A DM-MS wishing to send a short data message through a type 1 DM-REP follows the procedures to ascertain the state of the channel. Provided the channel is found to be in the state 'free' the DM-MS establishes the channel synchronisation and simultaneously its role as 'master' by transmitting a sequence of DM-SDS DATA message headers ('sys' in figure 6, with 7 being sent in this example) on the master link using the DSB structure as given in ETS 300 396-2 [3], subclause 9.4.3. The DM-SDS DATA message headers contain frame count information which in the example defines their position in the timing structure in frames 17 and 18 of the 18 frame cyclic multiframe structure. The master MS then listens for the DM-SDS DATA message headers to be retransmitted by DM-REP in frames 18 and 1 of the slave link in order to confirm that the signalling to the DM-REP was successful. The master DM-MS then transmits the remaining parts of the short data message ('sd' in the figure) using the DNB structure in the following frames, which in this example cover frames 3 to 5 on the master link.

In the case where an acknowledgement of receipt of the short data is required the receiving slave MS sends an acknowledgement, in this example with data, to the master MS following the receipt of the last burst containing data . The slave MS sends SDS acknowledgement message (dak) in a DSB in slot 1 and 3 of frame 6 of the slave link, indicating that the message is fragmented and is continued in the next frame, frame 7 (sda).

Figure 6 also illustrates where pre-emption signalling is permitted on both slave and master links during a SDS transmission.

NOTE: The short data occupation signalling DSBs which usually occur in slot 3 of frames 6, 12 and 18 following the initial synchronisation are only sent during data message transmission and not during the acknowledgement period.

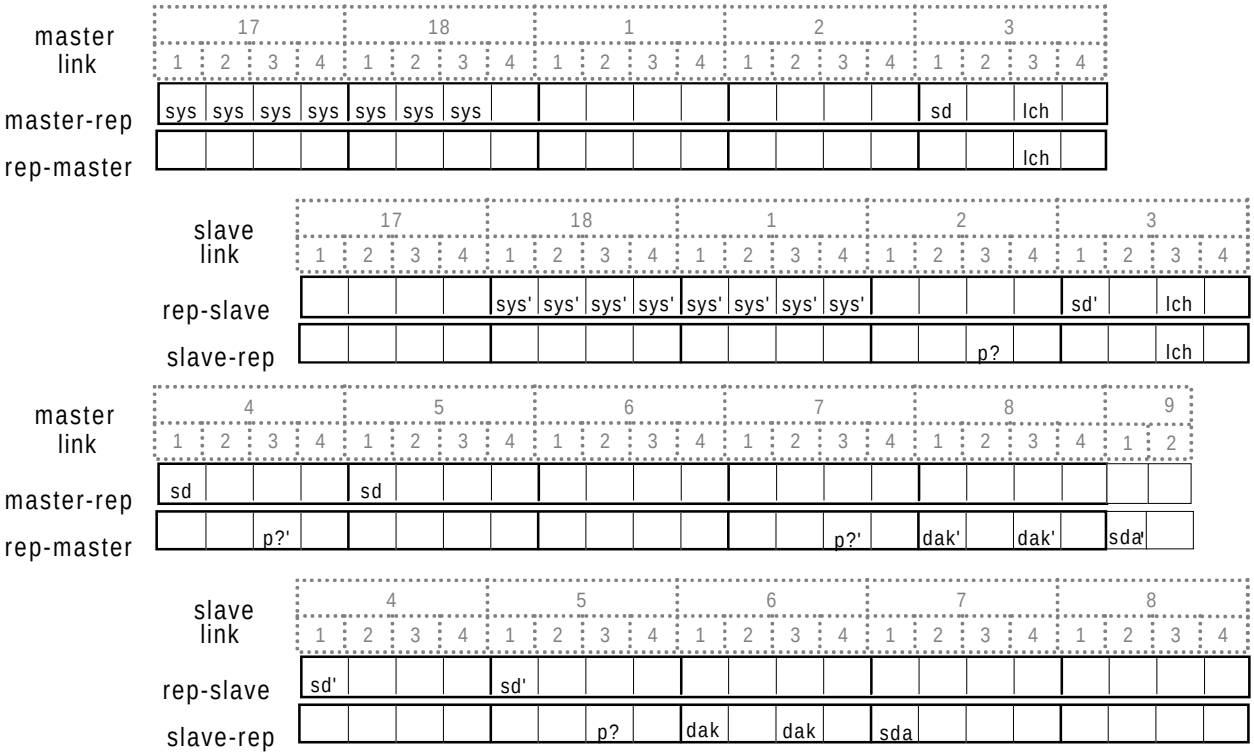

Figure 6: Call sequence for SDS (for acknowledgement with data) through a type 1 DM-REP

5 DM-MS layer 3 service description (for operation through a type 1 DM-REP)

ETS 300 395-3 [4], clause 5 shall apply, with the following differences in subclause 5.4.

- Parameter "Release cause" shall have an additional possible value:

  link to DM-REP not established or failed (indication only).

- Parameter "SDS transfer result" shall have an additional possible value:

  link to DM-REP not established.

6 DM-MS layer 3 protocol (for operation through a type 1 DM-REP)

The layer 3 protocol defined in ETS 300 396-3 [4], clause 6 also generally applies to a DM-MS operating through a DM-REP except that, for DM-REP operation:

a) a call may fail because the layer 2 in the calling DM-MS does not see its call set-up message re-transmitted by the DM-REP on the slave link. This is regarded as a failure of link establishment to the DM-REP;

b) a circuit mode call in progress may fail if the layer 2 in the calling DM-MS reports that the link to the DM-REP has been lost during the occupation or reservation period.

The changes to the layer 3 protocol are detailed below.

6.1 Introduction

ETS 300 396-3 [4], subclause 6.1 shall apply.

6.2 Circuit mode calls

ETS 300 396-3 [4], subclause 6.2 shall apply with the following differences:

1) subclause 6.2.1.1

Replace the fourth paragraph (i.e. "If the DMCC receives ...") with the following text:

- if the DMCC receives a DMA-REPORT indication reporting that the PDU has been transmitted then it shall wait for a further DMA-REPORT indication from layer 2 indicating the status of the link to the DM-REP;

- if it receives a DMA-REPORT indication reporting successful link establishment to the DM-REP (or that the link to the DM-REP was already known to be available) then the DMCC shall enter state CALL ACTIVE Tx Occupation (following the procedures for a master DM-MS during occupation), inform the user application with a DMCC-SETUP confirm, issue a DMC-CONFIGURE request for lower layer traffic configuration and start timer T.311;

- if it receives a DMA-REPORT indication reporting failure of link establishment to the DM-REP then the DMCC shall issue a DMC-CONFIGURE request and shall immediately send the DM-RELEASE PDU. It shall then either send the DM-SETUP PDU again (without indicating 'immediate retransmission' in the DMA-UNITDATA request), or otherwise issue a DMCC-RELEASE indication to the user application and return to state IDLE. The DMCC shall attempt the call set-up for up to a maximum of N.304 times or until successful.

2) subclause 6.2.2.1

Replace the fourth indent (i.e. "If it does not receive a response ...") with the following text:

- if it does not receive a response within a time T.303 following the DMA-REPORT indication (i.e. the DMA-REPORT indication which reported that the DM-SETUP PRES PDU had been transmitted the appropriate number of times), the DMCC shall issue a DMC-CONFIGURE request and shall immediately send the DM-RELEASE PDU. Then, if N.303 or N.304 has not been reached (see below), the DMCC shall send the DM-SETUP PRES PDU again (without indicating 'immediate retransmission' in the DMA-UNITDATA request). Otherwise it shall issue a DMCC-RELEASE indication to the user application and shall return to state IDLE.

  if the DMCC has received a DMA-REPORT indication from layer 2 reporting successful link establishment to the DM-REP (or that the link to the DM-REP was already known to be available) then it shall attempt the call set-up for up to a maximum of N.303 times or until successful. If the DMCC has received a DMA-REPORT indication reporting failure of link establishment to the DM-REP then it shall attempt the call set-up for up to a maximum of N.304 times or until successful.

3) subclause 6.2.4.1

The following procedure shall be added to the procedures for a master DM-MS sending circuit mode traffic:

e) if layer 2 reports that the link to the DM-REP has failed (DMC-REPORT indication) then the DMCC shall send a DM-RELEASE PDU to the called DM-MS(s), stop timer T.311, inform the user application with a DMCC-RELEASE indication and return to state IDLE.

4) subclause 6.2.5.1

The following procedure shall be added to the procedures for a master DM-MS during the reservation period:

h) if layer 2 reports that the link to the DM-REP has failed (DMC-REPORT indication) then the DMCC shall send a DM-RELEASE PDU to the called DM-MS(s), inform the user application with a DMCC-RELEASE indication and return to state IDLE.

6.3 Short data service

ETS 300 396-3 [4], subclause 6.3 shall apply with the following differences:

1) subclause 6.3.1.1

Replace the third indent (i.e. "For a DM-SDS UDATA PDU ...") with the following text:

- for a DM-SDS UDATA PDU:

  if the DMCC receives DMA-REPORT indication(s) reporting that either:

  - the PDU has not been completely sent because of failure of link establishment to the DM-REP; or

  - the PDU has been completely sent without fragmentation, but that link establishment to the DM-REP may have failed;

  then it shall either send the DM-SDS UDATA PDU again (without indicating 'immediate retransmission' in the DMA-UNITDATA request), or issue a DMCC-SDS REPORT indication to the user application reporting the failure and return to state IDLE. The DMCC shall attempt the short data transmission up to a maximum of N.317 times or until successful; or

  if the DMCC receives a DMA-REPORT indication reporting that the PDU has been transmitted the required number of times, it shall inform the user application using a DMCC-SDS REPORT indication with parameter 'transfer completed' and shall return to state IDLE.

2) subclause 6.3.1.1

Replace the final indent (i.e. "If it does not receive a response ...") with the following text:

- if it does not receive a response within a time T.316 following the DMA-REPORT indication (i.e. the DMA-REPORT indication which reported that the DM-SDS DATA PDU had been transmitted) then, if N.316 or N.317 has not been reached, the DMCC shall send the DM-SDS DATA PDU again, without indicating 'immediate retransmission' in the DMA-UNITDATA request; otherwise it shall issue a DMCC-SDS REPORT indication to the user application reporting the failure and shall return to state IDLE;

  if the DMCC has received a DMA-REPORT indication from layer 2 reporting successful link establishment to the DM-REP (or that the link to the DM-REP was already known to be available) then it shall attempt the short data transmission up to a maximum of N.316 times if no acknowledgement has been received. If the DMCC has received a DMA-REPORT indication reporting failure of link establishment to the DM-REP then it shall attempt the short data transmission up to a maximum of N.317 times or until successful.

3) subclause 6.3.1.4.3

Replace point d) with the following text:

d) after completion of the short data transfer (other than in case of being pre-empted or failure of DM-REP link establishment) then, instead of returning to state IDLE, the DMCC shall enter state CALL ACTIVE Tx as a master DM-MS during reservation and shall follow the procedures defined in subclause 6.2.5.1.

6.4 Usage of DMA-UNITDATA primitive

ETS 300 396-3 [4], subclause 6.4 shall apply.

7 DM-MS layer 2 service description (for operation through a type 1 DM-REP)

7.1 Introduction

ETS 300 396-3 [4], subclause 7.1 shall apply.

7.2 Layer 2 architecture

ETS 300 396-3 [4], subclause 7.2 shall apply.

7.3 Service description

ETS 300 396-3 [4], subclause 7.3 shall apply with the following differences:

1) subclause 7.3.1

Replace the seventh and eighth paragraphs (i.e. "The signalling service offered ..." and "If the random access protocol is used ...") with the following text:

The signalling service offered by layer 2 to layer 3 shall be an unacknowledged service except for call set-up messages or when the random access protocol is used. Layer 2 receives a DMA-UNITDATA request primitive from layer 3, transmits the message (in one or more MAC blocks) sending it the appropriate number of times, and then reports to layer 3 when the message has been sent. Acknowledgements and re-transmissions are under the control of layer 3.

For call set-up messages for circuit mode calls and short data messages, layer 2 is responsible for checking and reporting whether or not the link to the DM-REP has been established (or reporting if the link to the DM-REP was already known to be available). The repeated message on the slave link is regarded as an implicit layer 2 acknowledgement from the DM-REP to the master DM-MS. For a call set-up, the layer 2 in the master DM-MS receives a DMA-UNITDATA request primitive from layer 3 and transmits the message (or first fragment) sending it the appropriate number of times. In the protocol description, it is assumed that layer 2 reports to layer 3 both when the message has been sent and when the status of the link to the DM-REP is known. Re-transmissions, and acknowledgements from the called DM-MS, are under the control of layer 3.

NOTE 1: For a call set-up sent after a successful pre-emption or changeover procedure, layer 2 may assume that the link to the DM-REP is already known to be available without looking for the repeated message on the slave link. However, in the protocol description, it is assumed that layer 2 still issues the additional report to layer 3.

For messages other than call set-up messages, layer 2 always assumes that the link to the DM-REP is available and there is no additional report issued to layer 3.

NOTE 2: For a fragmented DM-SDS DATA message, layer 2 reports when the status of the link to the DM-REP is known and then after complete transmission of the message (i.e. after transmission of the DMAC-END). In the layer 3 procedure for acknowledged short data, timer T.316 is measured from the latter report.

If the random access protocol is used (i.e. for pre-emption and changeover requests), layer 2 is responsible for sending retries until a response is received or the access attempt fails.

2) subclause 7.3.2.2.1

The DMC-CONFIGURE primitive (table 11) shall have an additional parameter:

DM-REP address: Conditional (C) in both Request and Confirm.

3) subclause 7.3.2.2.2

For operation though a DM-REP, the DMC-REPORT indication is used to issue two additional types of report on the status of the DM channel, not required for direct MS-MS operation.

i) it is used to report to the higher layers whether layer 2 is receiving a DM-REP presence signal;

ii) it is used, during a circuit mode call, for the layer 2 in the master DM-MS to report to layer 3 that the link to the DM-REP has failed.

7.4 Parameter listing

ETS 300 396-3 [4], subclause 7.4 shall apply with the following differences:

1) Replacement for subclause 7.4.25 (Report)

Report shall generally indicate the progress or failure of information transfer and the cause of it.

At the DMA-SAP, possible reports include:

- first complete transmission;
- transmissions completed;
- random access success;
- random access abandoned (and type of failure);
- channel is busy;
- successful link establishment to DM-REP (or link to DM-REP already known to be available);
- failure of link establishment to DM-REP.

8 DM-MS layer 2 protocol (for operation through a type 1 DM-REP)

8.1 Introduction

ETS 300 396-3 [4], subclause 8.1 shall apply.

8.2 Interface between lower and upper DM-MAC

ETS 300 396-3 [4], subclause 8.2 shall apply.

8.3 Basic capabilities of the Physical Layer (PL)

8.3.1 DM-MS capabilities

8.3.1.1 DM only and dual mode capable MS operation

ETS 300 396-3 [4], subclause 8.3.1.1 shall apply.

8.3.1.2 DW-MS operation

A DW-MS shall support all the operations described in subclause 8.3.1 and in addition shall be capable of switching between operating on the selected DM channel frequency and the V+D mode channel frequency within 0,5 of a timeslot duration (approximately 7 ms). This is illustrated in figure 7.

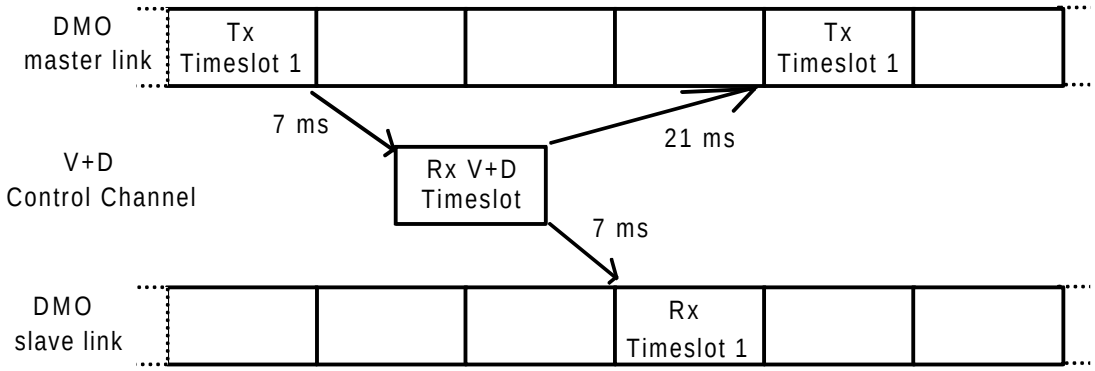

Figure 7: Illustration of DW-MS timing on type 1 DM-REP

8.4 Usage of DM channel with DM-REP

A DM channel may exist in any one of three states:

- free;
- occupied; or
- reserved.

Only when the DM channel is in occupation or reservation does there exist a timing structure which is divided into multi-frames, frames and timeslots.

In the channel free condition, no overlying DM timing reference exists other than that which may be provided by a DM-REP presence signal or implicitly provided by an external network.

In DM-REP operation all communications between the DM-REP and master MS on the master link, shall use the master link frame and slot numbering.

In DM-REP operation all communications between the DM-REP and slave MSs on the slave link, shall use the slave link frame and slot numbering.

In the case of operation with a type 1 DM-REP, the slot and frame numbering on the master link runs 3 timeslots ahead of the slave link slot and frame numbering.

8.4.1 Definition of DM channel

A DM channel existing on single radio frequency during occupation and reservation is divided, in time, into master link timeslots and slave link timeslots. As shown in figure 8, two timeslots are allocated primarily for the master link and two timeslots primarily for the slave link. Each timeslot lasts 14,167 ms, the end of one master link timeslot and the beginning of the other are separated, in time, by one timeslot duration. The slave link timeslots are similarly arranged. Time on the DM channel is further divided into frames and multi-frames, each frame lasting 4 timeslot durations and each multiframe lasting 18 frame durations. Refer to ETS 300 396-2 [3], clause 9.

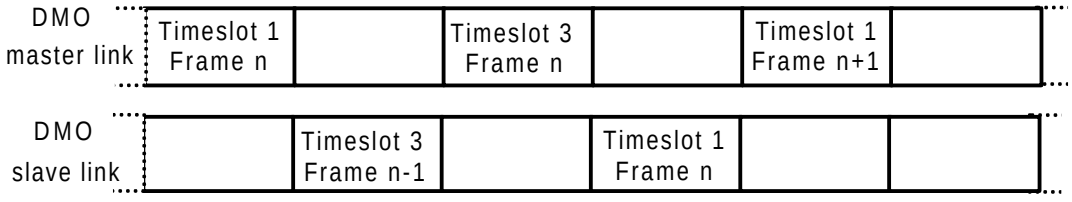

Figure 8: Master link/slave link arrangement

8.4.1.1 DM-channel operation

A DM-MS wishing to begin a call, and having determined that the selected DM channel is free, shall begin master MS operation on the master link of the DM-REP.

When a DM-MS first becomes master on a free channel, it shall define the timing reference including slot and frame numbering. This includes the case where a DM-REP is generating a presence signal on the selected DM channel. The frame numbering may be chosen arbitrarily. However, unless unsuitable for its dual watch operation, it is recommended that the master defines the frame numbering such that its final repetitions of the call set-up message are sent in frame 18 of the master link. If it is performing dual watch, the master MS shall define the slot boundaries using the timing shown in figure 7.

8.4.2 DM channel states

The MAC layer of the DM-MS is responsible for monitoring activity on a selected DM channel in order to determine the current perceived state of that DM channel. Accurate DM channel state information is essential if a DM-MS is to employ the correct signalling and monitoring procedures. The perceived DM channel state combined with the current DM-MS mode of operation shall be used to update the DM-MAC state model.

8.4.2.1 DM channel state definitions

Channel free

No signalling or traffic activity detected on the selected DM channel. In the case where a DM-REP generates a presence signal, this presence signal indicates that the DM channel is free.

Channel occupied or reserved

Any traffic or signalling activity detected on the selected DM channel other than DM-REP presence signals.

8.4.2.1 Determination of DM channel state

To determine the current state of the DM channel a DM-MS in idle mode shall continuously monitor the selected DM radio frequency in order to receive any DSB present on the channel and signal strength and channel conditions permitting decoding any layer 2 information available.

In the case where DSB signals are present and can be decoded and decrypted, the slave MS shall, dependent upon the content, enter the appropriate mode of operation and update the DM-MAC state model.

In the case where the DSB signal contains a DM-REP presence signal indicating that the channel is free, the slave MS shall update the DM-MAC state model and begin idle mode operating procedures. In this case the slave MS shall subsequently ensure to monitor the channel at least to receive the next scheduled DM-REP presence signal transmission.

In the case where DSB signals are present and can be decoded, but the message type cannot be decrypted, the DM-MS shall regard the channel as occupied by other DM-MSs.

In the case where DSB signalling cannot be detected, the DM-MS shall having followed the procedure described in subclause 8.4.2.3.1, update the DM-MAC state model and begin idle mode operating procedures.

During a call, a DM-MS shall, based upon the signalling present on the channel, update the DM-MAC state model accordingly.

For a slave MS during a circuit mode call where no DSB signalling can be detected, and having followed the procedure described in subclause 8.4.2.4 the DM-MS shall update the DM-MAC state model and begin idle mode operation procedures.

For a master MS during a circuit mode call: if it receives a presence signal from the DM-REP indicating that the channel is free or if a time T.225 elapses without receipt of a DSB in timeslot 3 of master link frame 1, 7 or 13 containing either:

- a random access request addressed to itself on the master link; or

- its own DM-OCCUPIED or DM-RESERVED message retransmitted in slot 4 of frame 18, 6 or 12 respectively on the slave link.

Then the master DM-MAC shall issue a DMC-REPORT indication to the higher layers reporting that the link to the DM-REP has failed. (The DMCC then sends a DM-RELEASE message).

8.4.2.3 Criteria for occupying a free channel

ETS 300 396-3 [4], subclause 8.4.2.3 shall apply, except that channel B operation is not valid.

8.4.2.3.1 Signal strength measurement to determine channel free condition

RSSI measurements shall be made during those periods where the DM-MS is determining whether the channel is free prior to becoming a master MS at the beginning of a new call. The measurements shall be conducted over a period of at least 1 multiframe and consist of at least 6 measurements. The measurement sample duration shall be at least SD2 as defined in ETS 300 396-2 [3], clause 10. The DM channel shall be declared free when the RSSI level is less than a predetermined threshold value.

NOTE: The determination of appropriate threshold values are outside the scope of this ETS but this parameter should be configurable within the radio.

8.4.2.4 DM-MS channel surveillance procedures

A slave MS, operating either in signalling or traffic mode on a DM channel, may conduct the procedures in the following subclauses or equivalent channel surveillance operations on the slave link.

8.4.2.4.1 Signal quality measurement during call transaction

ETS 300 396-3 [4], subclause 8.4.2.4.1 shall apply.

NOTE: In the case where the channel is idle and the DM-REP transmits a presence signal a slave MS may conduct similar signal quality measurements based upon decoding of the DM-REP presence signal.

8.4.3 DM-MAC states

The DM channel state information combined with the current DM-MS mode of operation define the current DM-MAC state and this shall be used to determine which procedure the DM-MAC should follow at any point in time for operation through a DM-REP. The DM-MAC states are as defined in ETS 300 396-3 [4].

8.4.3.1 Criteria for changing DM-MAC state

The DM-MS MAC shall retain the current state condition until one of the following occurs:

- the master MS receives and acknowledges request for pre-emption or channel changeover and enters either idle or signalling mode of operation;

- the DM-MS transmits a channel state change command. e.g. end of channel occupation or reservation;

- the DM-MS obeys a channel state change command from the current or new master DM-MS. i.e. slave DM-MS successfully receives messages indicating change of channel state. e.g. end of channel occupation or end of channel reservation;

- the DM-MS is required to relinquish a call by one of the channel surveillance procedures described in subclause 8.4.2.4;

- the master MS does not receive a DSB from the DM-REP within the prescribed time during both occupation and reservation (according to procedure described in subclause 8.4.2.2);

- the slave MS receives a DM-REP presence signal indicating a channel state change;

- the DM-MS is switched to an alternative mode of operation by the user.

8.4.4 DM-MS monitoring requirements

The monitoring procedures to be conducted by a DM-MS are dependent upon the current perceived state of the DM channel and the DM-MS operating mode. The following subclause defines the DM-MS monitoring requirements, the procedures for which are detailed in subclauses 8.4.2.2, 8.4.2.3 and 8.4.2.4.

8.4.4.1 Free DM channel

A DM-MS in idle mode shall monitor the selected DM channel frequency at least once every multiframe duration for DSB messages in order to keep an up to date record of the current state of the channel. In order to reliably receive any signalling messages addressed to it or a group of which it is a member and achieve fast call set-up more frequent monitoring of the channel may be required.

8.4.4.2 DM channel during initial call set-up and new call transaction by current master MS

During the initial stages of the call set-up or during reservation if the current master MS begins a new call transaction the master MS shall, following the transmission of the last DSB containing the DMAC-SYNCPDU on the master link, monitor the slave link in order to detect the successful re-transmission of the call set-up signalling by the DM-REP. Monitoring of the repeated call set-up signalling on the slave link shall take place within the immediately following N.231 or N.232 frames on the slave link.

NOTE: It is not required that the master MS is able to monitor the first transmission of the DMAC-SYNC PDU on the slave link.

8.4.4.3 DM channel in occupation during call set-up

For a circuit mode call set-up with presence check the master MS shall monitor timeslot 1 and 3 on the master link for a DSB in the frames allocated for acknowledgements transmitted from a slave MS through a DM-REP.

8.4.4.4 DM channel in occupation during a circuit mode call

A master MS during an active call transaction shall monitor time slot 3 on the master link of frames 1, 4, 7, 10, 13 and 16 for a DSB containing pre-emption or time change request signalling coming from a slave MS via a DM-REP or a DM-REP presence signal; or, in frames 1, 7 and 13, a DSB containing its own DM-OCCUPIED message.

A slave MS shall during channel occupation monitor and attempt to decode the DSB containing occupation signalling in timeslots 3 of frames 6, 12 and 18 of the slave link transmitted by the current master MS through a DM-REP.

8.4.4.5 DM channel in reservation during a circuit mode call

Following the end of a circuit mode call transaction the master MS shall monitor timeslot 3 on the master link for a DSB containing transmit request, timing change request or pre-emption request signalling coming from a slave MS via a DM-REP or a DM REP presence signal; or, in frames 1, 7 and 13, a DSB containing its own DM-RESERVED message.

The master MS shall conduct this monitoring in all frames except:

- frame 3;
- those frames in which it is transmitting channel reservation signalling; and
- those frames which are precluded as indicated by the 'change over requests' bit map.

A slave MS shall monitor timeslot 1 or 3 of frames 6, 12 and 18 in each multiframe on the slave link for a DSB containing reservation information. Additional monitoring may be required in order to determine when a new call transaction has begun.

A slave MS wishing to become the new master on the channel shall. following the transmission of the transmit request message on the slave link, monitor timeslot 1 and 3 in the following frames on the slave link for a DSB indicating the result of the request.

8.4.4.6 DM channel in occupation during a SDS call

During SDS transmissions the master MS shall monitor timeslot 3 of frames 1, 4, 7, 10, 13 and 16 on the master link for a DSB carrying pre-emption requests coming from a slave MS via a DM-REP.

For SDS transmissions that require an acknowledgement from a slave MS, the master MS shall on the master link monitor timeslots 1 and 3 in those frames assigned for acknowledgement messages.

NOTE: The DM channel during SDS is always in occupation i.e. no reservation, even during periods where acknowledgement messages are to be sent.

8.4.4.7 DM channel during pre-emption signalling

A slave DM-MS following the transmission of a request to pre-empt the channel shall monitor timeslots 1 and 3 in the following frames on the slave link to determine the result of the pre-emption request. This information may be sent by the master MS using either a DSB or DNB with slot flag set.

8.4.4.8 DM channel during timing change request signalling

A slave MS following the transmission of a request for timing change shall monitor timeslots 1 and 3 in the following frames on the slave link to determine the result of the timing change request.

However, the actual timing change shall not occur before the end of the current call transaction.

8.4.5 Transmission of layer 3 messages by DM-MAC

ETS 300 396-3[4], subclause 8.4.5 shall apply with the following differences:

i) whenever the DM-MS is sending a DM-SETUP, DM-SETUP PRES, DM-SDS UDATA or DM-SDS DATA message, it may transmit the DSB in all four timeslots in each of the signalling frames, except in the final signalling frame where timeslot 4 shall not be used;

ii) following the transmission of the DSBs for a fragmented DM-SDS UDATA or DM-SDS DATA message, the timing of the next fragment shall be as defined in subclause 8.5.4.1.

iii) channel B operation is not valid.

8.4.6 Transmission of layer 2 messages generated by DM-MAC

Subclause 8.4.6 of part 3 of this ETS [4] shall apply except that channel B operation is not valid.

8.4.7 Transmission of messages by DM-MAC

ETS 300 396-3 [4], subclause 8.4.7 shall apply, with the following differences:

Replacement for subclause 8.4.7.3 (timers)

In the case of reservation and random access the DM-MAC shall use a set of timers to determine how long signalling or reservation signalling should be transmitted and how long a master DM-MS shall wait for an acknowledgement to a signalling message. The range of timers and their maximum values are given in annex A.

Replacement for subclause 8.4.7.4 (linearization)

During channel occupation and reservation a master MS may linearize in frame 3 timeslot 3 of every multiframe on the master link.

During circuit mode occupation, a slave MS may only conduct linearization in frame 3 of the slave link if permitted by the master MS. The DM-MAC in the master MS shall in order to permit transmitter linearization to be conducted on the selected channel allocate the use of timeslot 3 of frame 3 on the slave link for linearization, by setting a flag within the call set-up and occupation signalling.

NOTE 1: Linearization is not permitted during the call set-up signalling (including the time for any presence check acknowledgements).

NOTE 2: The requirement on the master DM-MS to permit linearization during circuit mode occupation may be relaxed for some types of call in future releases of the standard. Therefore, slave DM-MSs should check the setting of the 'LCH in frame 3' flag.

During reservation, a slave MS may conduct linearization in timeslot 3 of frame 3 of the slave link. During short data occupation, a slave MS may conduct linearization in timeslot 3 of frame 3 if timeslot 1 of frame 3 is an SCH/F slot (as indicated by the 'number of SCH/F slots' element in the SDS call set-up message).

A DM-MS wishing to begin a call may, after determining that the selected channel is free, linearize its transmitter in the time prior to sending the call set-up signalling.

Replacement for subclause 8.4.7.9 (change over requests bit map)

In order that a master MS may conduct dual watch operation or some form of battery economy mode during channel reservation the DM-MAC may dictate which frames, in addition to those allocated for pre-emption, may be used for DM-TX REQUEST messages. The DM-MAC shall using an 8 bit field indicate in which frames a slave MS may send a DM-TX REQUEST message on the slave link. The eight bit field used shall relate to frames 1, 4, 7, 9, 10, 13, 15 and 16 of the slave link.

Replacement for subclause 8.4.7.12 (channel A or B operation)

The DM-MAC shall indicate in the call set-up, occupation and reservation signalling that a type 1 DM-REP is being used.

Amendment to subclause 8.4.7.14 (Timing change procedure)

ETS 300 396-3 [4], subclause 8.4.7.14 shall apply except that, after the transmission of the requisite number of DM-TX CEASED or DM-TIMING ACK messages, the master MS shall transmit the first DM-RESERVED messages using the new timing reference in timeslots 1 and 3 of the two frames following the next frame.

8.5 MAC procedures for transfer of signalling messages

8.5.1 Formation of MAC PDU

ETS 300 396-3 [4], subclause 8.5.1 shall apply. The usage of PDU elements specific to DM-REP operation are described in clause 10. See also subclause 8.5.2.

For direct MS-MS operation, the only MAC PDU that can be carried in the synchronisation burst (DSB) is the DMAC-SYNC PDU. This MAC PDU is used also by DM-MSs operating through a DM-REP.

For DM-REP operation, an additional MAC PDU may be sent in the DSB. This is the DM-REP presence signal DPRES-SYNC PDU, which may be generated by the DM-REP. The DM-REP presence signal comprises layer 2 elements only; refer to clause 10 for a description of the PDU. The contents of the DPRES-SYNC PDU are visible to the DM-MAC in any DM-MS that receives it.

For operation through a DM-REP, the same MAC PDUs may be sent within the normal burst (DNB) as for direct MS-MS operation.

8.5.2 Addressing

8.5.2.1 Transmission of message

The source and destination address elements in a message refer to the address of the source DM-MS and destination DM-MS respectively, as for direct MS-MS operation.

8.5.2.1.1 Addressing in synchronisation burst

ETS 300 396-3 [4], subclause 8.5.2.1.1 shall apply, with the following additions.

For operation through a DM-REP, the master DM-MAC shall set the 'communication type' element appropriately in the DMAC-SYNC PDU and shall include the 10-bit DM-REP address in the SCH/H block. These values of 'communication type' element and DM-REP address shall be re-transmitted by the DM-REP on the slave link. If a slave DM-MS sends a signalling message to the master DM-MS then it shall use the same 'communication type' element and DM-REP address in the DMAC-SYNC PDU.

For a transmission by a master DM-MS, the master DM-MAC shall set the 'master/slave link flag' to 1 in the DMAC-SYNC PDU and shall use the master link's slot and frame numbering. When the DM-REP re-transmits the message, it shall set the 'master/slave link flag' to 0 and shall use the slave link's slot and frame numbering. The slave link's slot and frame numbering runs three timeslots behind the master link's slot and frame numbering.

For a transmission by a slave DM-MS, the slave DM-MAC shall set the 'master/slave link flag' to 0 in the DMAC-SYNC PDU and shall use the slave link's slot and frame numbering. When the DM-REP re-transmits the message, it shall set the 'master/slave link flag' to 1 and shall use the master link's slot and frame numbering.

8.5.2.1.2 Addressing in normal burst

ETS 300 396-3 [4], subclause 8.5.2.1.2 shall apply, with the following additions.

Normal bursts are only ever sent following a synchronisation burst, which defines the DM-REP address and information about the purpose of the normal burst. Therefore those MAC PDUs that are sent in normal bursts do not include either a communication type element, DM-REP address or master/slave link flag.

The synchronisation burst also defines the link type and slot numbering for that link. Then any following normal bursts for that link shall be sent only in slot 1 of frames 1 to 17 according to that slot and frame numbering. Thus normal bursts on the master link shall only ever be sent in slot 1 of frames 1 to 17 in the master link's slot and frame numbering; and normal bursts on the slave link shall only ever be sent in slot 1 of frames 1 to 17 in the slave link's slot and frame numbering.

8.5.2.2 Reception of message

ETS 300 396-3 [4], subclause 8.5.2.2 shall apply, with the following differences.

If the master DM-MS receives a DMAC-SYNC PDU with 'master/slave link flag' set to 0 then it shall ignore that message (even if it is addressed by the message), except in the following cases:

a) during call set-up for a circuit mode call or short data transmission, the master DM-MAC shall (when required) use the repeated call set-up message on the slave link to deduce the success of its link establishment to the DM-REP; refer to subclause 8.5.6;

b) during circuit mode occupation and reservation, the master DM-MAC shall use the repeated DM-OCCUPIED and DM-RESERVED messages in slot 4 of frames 6, 12 and 18 on the slave link to deduce whether its link to the DM-REP is still active; refer to subclauses 8.4.2.2 and 9.5.1.1.3.

If a slave DM-MS receives a DMAC-SYNC PDU with 'master/slave link flag' set to 1 then it shall ignore that message for the purposes of the procedures for the transfer of signalling messages. The DM-MAC shall not pass the message to layer 3 (nor assume a start of fragmentation) even if it is addressed by the message.

NOTE: After reception of a DMAC-SYNC PDU on the master link, a slave DM-MS no longer regards the channel as free; refer to subclause 8.4.2. Also, the slave DM-MS may choose to modify its channel monitoring procedure to increase the probability of receiving the message when it is repeated on the slave link.

If the master DM-MS receives a DMAC-DATA PDU, and if the reception slot was not a slot 1 in the master link's slot numbering, then it shall ignore that message even if it is addressed by the message.

If a slave DM-MS receives a DMAC-DATA PDU, and if the reception slot was not a slot 1 in the slave link's slot numbering, then it shall ignore that message even if it is addressed by the message.

8.5.3 Usage of air interface encryption

ETS 300 396-3 [4], subclause 8.5.3 shall apply for 'air-interface encryption state' = 00_2 and 10_2.

'Air-interface encryption state' = 01_2 shall only be used if the DM-MS knows (by local co-ordination or equivalent) that the DM-REP holds the appropriate air-interface encryption information.

NOTE: In order to function correctly, the DM-REP needs to be able to process the addressing information, message type and message-dependent elements in the DMAC-SYNC and DMAC-DATA PDUs. For 'air-interface encryption state' = 01_2, these elements are encrypted. Therefore the DM-REP needs to hold the encryption information.

For a DM-REP that is also a gateway this is implicitly true whereas, for a pure DM-REP, it is an additional requirement. The DM-REP should then also be able to receive any Over-The-Air Re-keying (OTAR) information for air-interface encryption.

8.5.4 Fragmentation and reconstruction

8.5.4.1 Fragmentation

ETS 300 396-3 [4], subclause 8.5.4.1 shall apply, with the following differences:

When sending a fragmented DM-SDS UDATA or DM-SDS DATA message, the master DM-MAC shall send the first fragment in the DMAC-SYNC PDU on the master link in the usual way i.e. setting the 'fragmentation flag' to indicate start of fragmentation and the 'number of SCH/F slots' element to indicate the number of following fragments (n + 1), and using the frame countdown mechanism to indicate when the repetitions of the DMAC-SYNC have been completed. Then, if the link to the DM-REP is not already known to be available, the master DM-MAC shall monitor the slave link looking for its DMAC-SYNC PDU to be re-transmitted by the DM-REP.

a) If the master DM-MAC receives the re-transmission on the slave link (or if it already knew that the link to the DM-REP was available) then it shall start to send the n DMAC-FRAG PDUs and the DMAC-END PDU on SCH/F on the master link, in consecutive slot 1's of frames 1 to 17 and without repetition. If the frame containing the master's final transmission of the DMAC-SYNC PDU was frame X, then the master shall send the first DMAC-FRAG PDU (or DMAC-END PDU) in slot 1 of frame Y = (X + N.231) mod 18 1 (if Y is in the range 1 to 17) or otherwise in slot 1 of frame 1. The master DM-MAC shall then continue to follow the procedure defined in ETS 300 396-3 [4], subclause 8.5.4.1.

   NOTE: N.231 is the number of frames in which the DM-REP transmits the DMAC-SYNC PDU on the slave link. For example, if N.231 = 2, and if the master DM-MAC sends its final DMAC-SYNC in master frame 18, then it starts transmitting SCH/F in slot 1 of master frame 3.

b) If the master DM-MAC does not receive the re-transmission on the slave link then:

   - for a DM-SDS UDATA message, the DM-MAC shall cease transmission and shall issue a DMA-REPORT indication to the DMCC reporting that the message has not been completely sent because of failure of link establishment to the DM-REP;

- for a DM-SDS DATA message, the DM-MAC shall continue to transmit the message as in a) above (and shall look for a response DM-SDS ACK in the usual way). However, it shall issue a DMA-REPORT indication to the DMCC reporting the perceived failure of link establishment to the DM-REP.

When sending a fragmented DM-SDS ACK message, the slave DM-MAC shall use the slave link. It shall follow the procedure defined in ETS 300 396-3 [4], subclause 8.5.4.1 sending the DMAC-SYNC PDUs and then sending the DMAC-END PDU in slot 1 of the frame following the frame with 'frame countdown' element set to 00_2. However, the slave DM-MAC shall choose its initial 'frame countdown' value such that the frame with 'frame countdown' element set to 00_2 is neither frame 15 nor frame 17.

8.5.4.2 Reconstruction

ETS 300 396-3 [4], subclause 8.5.4.2 shall apply, with the following differences:

When receiving a fragmented DM-SDS DATA or DM-SDS UDATA message, where the DMAC-SYNC PDU indicating start of fragmentation was received in frame X on the slave link and contained 'frame countdown' element F, the slave DM-MAC shall look for the first DMAC-FRAG/DMAC-END in slot 1 of frame Y = (X + F+1) mod 18 + 1 (if Y is in the range 1 to 17) or otherwise in slot 1 of frame 1. The slave DM-MAC shall then continue to follow the procedure defined in ETS 300 396-3 [4], subclause 8.5.4.2.

When receiving a fragmented DM-SDS ACK message, the master DM-MAC shall obey the procedure defined in ETS 300 396-3 [4], subclause 8.5.4.2 without amendment. (So, if the DMAC-SYNC PDU indicating start of fragmentation was received in frame X on the master link and contained 'frame countdown' element F, the master DM-MAC shall look for the DMAC-END in slot 1 of frame Y = (X + F) mod 18 + 1 (if Y is in the range 1 to 17) or otherwise in slot 1 of frame 1).

8.5.5 Fill bit addition and deletion

ETS 300 396-3 [4], subclause 8.5.5 shall apply.

8.5.6 Transmission and reception of messages by layer 2 unacknowledged service

When the DM-MAC receives a DMA-UNITDATA request primitive from layer 3, it shall use its current state and the message type parameter to decide how to send the message.

a) For the initiation of a new call, or for non-immediate retransmission, the DM-MAC shall check whether the channel is free (as defined in subclause 8.4) before transmitting the DM-SETUP, DM-SETUP PRES, DM-SDS DATA or DM-SDS UDATA message. After sending the DSB the appropriate number of times, the DM-MAC shall look for the repeated DSB on the slave link, regarding that DSB as an implicit layer 2 acknowledgement from the DM-REP to itself.

   The DM-MAC shall issue a DMA-REPORT indication to layer 3 reporting when the message has been sent the appropriate number of times. It shall issue another DMA-REPORT indication reporting whether or not the link to the DM-REP has been established (i.e. whether or not it saw its call set-up DSB repeated at least once on the slave link).

   If the DM-MAC is unable to send the message because the channel becomes busy then it shall report the failure to layer 3 with a single DMA-REPORT indication.

b) For a call continuation after changeover, or for a call set-up after pre-emption, the DM-MAC shall transmit the DM-SETUP, DM-SETUP PRES, DM-SDS DATA or DM-SDS UDATA message using the DSB and timing its message using the frame countdown element from the received DM-TX ACCEPT or DM-PRE ACCEPT.

   The DM-MAC may assume that the link to the DM-REP is already known to be available, without looking for the repeated call set-up DSB on the slave link. However, it shall still issue two DMA-REPORT indications to layer 3: one to report that the message has been sent the appropriate number of times and another to report that the link to the DM-REP was already known to be available.

c) If the DM-MS is already a master, the DM-MAC may transmit the message and shall use the appropriate burst. For example, this may apply to DM-SETUP, DM-SETUP PRES, DM-SDS DATA, DM-SDS UDATA, DM-OCCUPIED, DM-TX CEASED, DM-RELEASE, DM-TX ACCEPT, DM-PRE ACCEPT, DM-REJECT and DM-INFO messages.

   If the master DM-MS re-starts transmission during circuit mode reservation, the DM-MAC transmits the DM-SETUP, DM-SETUP PRES, DM-SDS DATA or DM-SDS UDATA message without re-checking that the channel is free. However, it shall check the DM-REP link, looking for the repeated DSB on the slave link and shall issue two DMA-REPORT indications to layer 3: one to report that the message has been sent the appropriate number of times and another to report whether or not the link to the DM-REP has been re-established.

   For other message types, the DM-MAC shall not check whether the message is re-transmitted on the slave link. It shall issue a single DMA-REPORT indication when the message has been sent the appropriate number of times.

d) If the DM-MS is not the master and if the message is a response to a message from the master (i.e. if the message is DM-CONNECT, DM-DISCONNECT, DM-SDS ACK or DM-REJECT), the DM-MAC shall transmit the message using the DSB and timing the response using the 'frame countdown' element from the invoking message.

   The DM-MAC shall not check whether the message is re-transmitted on the master link. It shall issue a single DMA-REPORT indication when the message has been sent the appropriate number of times.

e) If the message is a DM-PREEMPT or DM-TX REQUEST, the DM-MAC shall use the random access protocol for sending the message. In the random access protocol, the DM-MAC sends retries until a response is received or the access attempt fails. The random access protocol is described in subclause 8.5.7.

This subclause describes the transmission of messages other than random access messages.

8.5.6.1 Transmission of message

ETS 300 396-3 [4], subclause 8.5.6.1 shall apply, with the following differences:

i) For a DM-SETUP, DM-SETUP PRES, DM-SDS DATA or DM-SDS UDATA message, the master DM-MS shall send the DSB in both slot 1 and slot 3 on the master link. It may also send the DSB in slot 2 and/or slot 4. This applies to all transmissions of these messages, not only in the case of initiation of a circuit mode call or short data message on a free channel. However, the DM-MS shall not transmit the DM-SETUP, DM-SETUP PRES, DM-SDS DATA or DM-SDS UDATA message in slot 4 of the frame with 'frame countdown' element set to 00_2.

ii) For a fragmented message, the 'frame countdown' element refers only to repetitions of the DMAC-SYNC PDU. The timing of the first DMAC-FRAG PDU (or DMAC-END PDU) shall be as defined in subclause 8.5.4.1.

iii) If the DM-MAC is transmitting DM-TX CEASED, and if layer 3 then issues a DM-TX ACCEPT message (or a DM-PRE ACCEPT if it is required to be sent in a DSB), then the DM-MAC shall complete the transmissions of the DM-TX CEASED message according to the ongoing frame countdown process before starting to transmit the DM-TX ACCEPT (or DM-PRE ACCEPT).

   NOTE: For example, if a slave DM-MS receives the first DM-TX CEASED, and transmits a changeover request immediately in slot 3, then the master DM-MS cannot receive that changeover request on the master link until it has sent DM-TX CEASED in at least three frames. If using a full four-frame countdown, the master then transmits its DM-TX CEASED in the fourth frame before sending the DM-TX ACCEPT in a DSB.

For operation through a DM-REP, transmissions by the master DM-MAC use the slot and frame numbering on the master link. Transmissions by a slave DM-MAC use the slot and frame numbering on the slave link.

8.5.6.2 Reception of message

The recipient DM-MAC may use the 'frame countdown' element F in received messages in several ways:

a) suppression of duplicates:

ETS 300 396-3 [4], subclause 8.5.6.2 a) shall apply;

b) delaying switch into traffic mode:

when the DM-MS receives a message indicating that it should change into traffic mode (i.e. DM-SETUP or DM-CONNECT), it shall use the timing defined in subclause 8.6.3;

c) timing of set-up signalling for pre-emption or changeover:

When the DM-MS receives a DM-PRE ACCEPT or DM-TX ACCEPT message (received in frame X on the slave link), giving it permission to send call set-up signalling or a short data message, the DM-MAC shall use the 'frame countdown' element F from the DM-PRE ACCEPT or DM-TX ACCEPT to deduce when the signalling can be sent without risking message collision.

In normal cases, the slave DM-MS which becomes the new master after a successful pre-emption or changeover shall adopt the state of the timing counters currently in use on the master link. This shall require an increase of three timeslots relative to the state of the slot and frame counters currently indicated by the DM-REP on the slave link (i.e. counter TN shall be incremented three times). The first set-up signalling may then be sent in master frame (X + F + 1) mod 18 + 1.

The exception occurs if the DM-MS requested a timing change within its DM-PREEMPT or DM-TX REQUEST message. Then, on becoming the new master, it shall adopt the state of the timing counters currently in use on the master link and then modify those counters again to give the required timing advance.

d) timing of immediate SDS retransmission:

ETS 300 396-3 [4], subclause 8.5.6.2 d) shall apply;

NOTE: The timings given refer to reception of the DM-SDS ACK as repeated on the master link, and then retransmission of the DM-SDS DATA message on the master link.

e) timing of response to message from master DM-MS:

ETS 300 396-3 [4] subclause 8.5.6.2 e) shall apply;

NOTE: The timings given refer to reception of the master's message in frame X on the slave link, and then transmission of the response on the slave link (with the first response DSB(s) sent in slave frame (X+F) mod 18 + 1).

When sending a fragmented DM-SDS ACK message, the slave DM-MAC shall choose its initial 'frame countdown' value such that the frame with 'frame countdown' element set to 00_2 is neither frame 15 nor frame 17;

f) timing of response to fragmented message from master DM-MS:

For a fragmented message headed by the DMAC-SYNC PDU, the 'frame countdown' element F refers only to the DMAC-SYNC. This then indicates where the first DMAC-FRAG PDU (or DMAC-END PDU) shall be expected, as specified in subclause 8.5.4.2.

The procedure for timing the response to a fragmented DM-SDS DATA message shall be as described in ETS 300 396-3 [4], subclause 8.5.6.2 f).

NOTE: These timings refer to reception of the master's message as repeated on the slave link, and then transmission of the response on the slave link.

When sending a fragmented DM-SDS ACK message, the slave DM-MAC shall choose its initial 'frame countdown' value such that the frame with 'frame countdown' element set to 00_2 is neither frame 15 nor frame 17.

Points e) and f) above define when the first transmission of a response message must be sent. According to the protocol description, it is assumed that, when the DM-MS has received a DM-SDS DATA message addressed to itself, and if layer 3 does not immediately return a response DM-SDS ACK, then the DM-MAC shall issue a DMC-REPORT indication primitive as a prompt to layer 3 in time to allow transmission in the correct slot(s).

8.5.7 Random access protocol

8.5.7.1 Introduction

ETS 300 396-3 [4], subclause 8.5.7.1 shall apply, with the following addition.

For operation through a DM-REP, a requesting slave DM-MS sends its random access message on the slave link in an appropriate slot 3. When the DM-REP receives a random access message, it simply repeats the random access message on the master link; it does not send any form of interim response to the slave. It is the responsibility of the master DM-MS to decide whether to accept the request and then to send a response (on the master link). The DM-REP then repeats the response on the slave link.

For operation through a DM-REP, the usual numbering for pre-emption slots as slot 3 of frames 2, 5, 8, 11, 14 and 17, and changeover request slots as slot 3 of frames 1, 4, 7, 9, 10, 13, 15 and 16, still applies to the slave link. However, from the perception of the master DM-MAC, there is generally a two-frame delay relative to the numbering for direct DM-MS operation. For example, a pre-emption request sent in slot 3 of frame 5 on the slave link is repeated in slot 3 of frame 7 on the master link. (Exceptions are requests sent in slot 3 of frames 1, 4, 10 and 16 on the slave link; these are repeated in slot 3 of frames 4, 7, 13 and 1 respectively on the master link, thereby avoiding collision with the master DM-MS's linearization and reservation signalling.)

8.5.7.2 Procedures for master DM-MS

8.5.7.2.1 Indicating frames available for requests

When the DM-MAC transmits DM-SETUP, DM-SETUP PRES and DM-OCCUPIED messages, it shall set the 'pre-emption flag' to indicate that slot 3 of frames 2, 5, 8, 11, 14 and 17 on the slave link is available for random access requests (e.g. pre-emption requests) during the occupation period.

NOTE: This requirement may be relaxed for some types of call in future editions of this ETS.

When the master DM-MAC transmits DM-TX CEASED and DM-RESERVED, it shall set the 'requests flag' to indicate that random access requests may be sent, unless it has already received and is accepting a pre-emption or changeover request or is changing the channel timing. It shall also set the 'changeover requests bitmap' element to indicate whether random access requests may be sent on the slave link in slot 3 of frames 1, 4, 7, 9, 10, 13, 15 and 16 during the reservation period (in addition to the pre-emption slots). It shall allow random access requests on the slave link in slot 3 of frames 1, 4, 10 and 16, since this does not impose any additional monitoring requirements on itself. It should also allow random access requests on the slave link in slot 3 of frames 7, 9, 13 and 15 unless it may be performing dual watch or battery economy procedures in master link frames 9, 11, 15 or 17 respectively.

8.5.7.2.2 Monitoring frames available for requests

During occupation for a circuit mode call, the master DM-MAC shall monitor slot 3 of frames 1, 4, 7, 10, 13 and 16 on the master link for pre-emption or timing change requests addressed to itself.

During reservation for a circuit mode call and, near the end of circuit mode occupation, during the frame countdown for the DM-TX CEASED message, the master DM-MAC shall monitor slot 3 of frames 1, 4, 7, 10, 13 and 16 on the master link, looking for pre-emption, timing change or changeover requests addressed to itself. It shall also monitor the following slots for pre-emption, timing change or changeover requests addressed to itself:

- if, in the changeover requests bitmap, the master DM-MAC allowed requests on the slave link in slot 3 of frame 7 then it shall monitor slot 3 of frame 9 on the master link;

- if, in the changeover requests bitmap, the master DM-MAC allowed requests on the slave link in slot 3 of frame 9 then it shall monitor slot 3 of frame 11 on the master link;

- if, in the changeover requests bitmap, the master DM-MAC allowed requests on the slave link in slot 3 of frame 13 then it shall monitor slot 3 of frame 15 on the master link;

- if, in the changeover requests bitmap, the master DM-MAC allowed requests on the slave link in slot 3 of frame 15 then it shall monitor slot 3 of frame 17 on the master link.

When sending SCH/F for a fragmented DM-SDS UDATA or DM-SDS DATA message, and in the following two frames, the master DM-MAC shall monitor slot 3 of frames 1, 4, 7, 10, 13 and 16 for pre-emption requests addressed to itself.

8.5.7.2.3 Response to pre-emption or changeover request

ETS 300 396-3 [4], subclause 8.5.7.2.3 shall apply except that, in the first paragraph of a):

- text "time T.211 minus 1 frame" shall be replaced by "time T.211 minus 4 frames";

- text "time T.212 minus 1 frame" shall be replaced by "time T.212 minus 4 frames".

NOTE: References to transmission by the master DM-MAC in "slot 1" or "slot 3" refer to slot and frame numbering on the master link.

After accepting a pre-emption or changeover request, the DM-MS shall stop being master (as defined in ETS 300 396-3 [4], subclause 8.5.7.2.3), and starts to receive on the slave link. In normal cases, the DM-MS should expect the slot and frame numbering on the slave link to run exactly three timeslots behind the slot and frame numbering that it has been using on the master link. The exception occurs if the requesting DM-MS included a timing change within its DM-PREEMPT or DM-TX REQUEST message. Then the old master should expect the timing on the slave link to be modified also according to the 'timing advance' element.

8.5.7.2.4 Response to timing change request

ETS 300 396-3 [4], subclause 8.5.7.2.4 shall apply.

NOTE: References to transmission by the master DM-MAC in "slot 1" or "slot 3" refer to slot and frame numbering on the master link.

8.5.7.3 Procedures for requesting DM-MS

ETS 300 396-3 [4], subclause 8.5.7.3 shall apply.

The following points may be noted relating to transmission and reception by the requesting DM-MS:

NOTE 1: In subclauses 8.5.7.3.1 and 8.5.7.3.2, the expression "slot 3 of frames 2, 5, 8, 11, 14 and 17" refers to slot and frame numbering on the slave link.

NOTE 2: In subclauses 8.5.7.3.1 and 8.5.7.3.2, the slots and frames defined by the 'changeover requests bitmap' refer to slot and frame numbering on the slave link.

NOTE 3: In subclause 8.5.7.3.3, the expression "it shall look for the response in both slot 1 and slot 3 of the following frames" refers to slot and frame numbering on the slave link.

NOTE 4: In the last of the indented paragraphs in subclause 8.5.7.3.2 (i.e. "During short data occupation .."), the expression "those frames in which the master DM-MS intends to send SCH/F in slot 1" refers to the expected SCH/F slots as re-transmitted by the DM-REP on the slave link. The requesting DM-MS may also (optionally) regard slot 3 of the frame preceding the first SCH/F slot as a 'valid access slot', if that frame has frame number 2, 5, 8, 11, 14 or 17.

8.6 MAC Procedures in Traffic Mode

8.6.1 Introduction

ETS 300 396-3 [4], subclause 8.6.1 shall apply.

8.6.2 Criteria for transmission and reception of traffic

ETS 300 396-3 [4], subclause 8.6.2 shall apply, with the following additional procedure.

After starting to receive traffic, a slave DM-MAC may remain in traffic mode, processing received TCH and STCH, until one of cases i) to v) occurs or the following case vi) occurs:

vi) it receives a presence signal from the DM-REP used for the call, indicating that the channel is free.

In case vi), the DM-MAC shall report to the higher layers that the call has been lost (using the DMC-REPORT indication primitive).

8.6.3 Change of U-plane mode

The references to transmission by the master DM-MAC in slot 1 of a particular frame refer to the slot and frame numbering on the master link. References to reception by a slave DM-MAC in slot 1 of a particular frame refer to the slot and frame numbering on the slave link.

8.6.3.1 Set-up without presence check

At call set-up (or for a call continuation), the DMCC issues a DM-SETUP message in a DMA-UNITDATA request primitive. If a channel is available, the DM-MAC shall become master and shall send the message the appropriate number of times on the master link using the frame countdown mechanism to indicate the number of frames in which the message has still to be repeated. It shall issue a DMA-REPORT indication to the DMCC reporting when the PDU has been transmitted, and then another DMA-REPORT indication reporting the success or failure of the link establishment to the DM-REP (or reporting that the link to the DM-REP was already known to be available); refer to subclause 8.5.6. The master DM-MAC shall then switch to traffic mode. If the frame containing the master's final transmission of the DM-SETUP message was frame X, then the master DM-MAC shall start sending traffic (TCH and/or STCH) in slot 1 of frame Y = (X + N.232) mod 18 + 1 (if Y is in the range 1 to 17) or otherwise in slot 1 of frame 1.

NOTE 1: N.232 is the number of frames in which the DM-REP transmits the DM-SETUP message on the slave link. For example, if N.232 = 2, and if the master DM-MAC sends its final DM-SETUP in master frame 18, then it starts transmitting traffic in slot 1 of master frame 3.

NOTE 2: The DM-MAC switches into traffic mode even if the link establishment to the DM-REP failed. In this case, the DMCC then issues a DM-RELEASE message, to be sent on STCH.

On receipt of a DM-SETUP message on the slave link for one of its addresses, received in frame X and with 'frame countdown' element set to F, and if the DMCC issues a DMC-CONFIGURE request primitive, a slave DM-MAC shall assume that traffic will start on the slave link in slot 1 of frame Y = (X + F + 1) mod 18 + 1 (if Y is in the range 1 to 17) or otherwise in slot 1 of frame 1.

8.6.3.2 Set-up with presence check

At call set-up (or for a call continuation), the DMCC issues a DM-SETUP PRES message. If a channel is available, the DM-MAC shall send the message the appropriate number of times, as master. It shall issue a DMA-REPORT indication to the DMCC reporting when the PDU has been transmitted the appropriate number of times, and then another DMA-REPORT indication reporting the perceived success or failure of the link establishment to the DM-REP (or reporting that the link to the DM-REP was already known to be available). It shall then wait for a response (DM-CONNECT or DM-DISCONNECT) from the addressed DM-MS or for the DMCC to issue a DM-RELEASE message.

- If it receives a DM-CONNECT message on the master link in frame X, with 'frame countdown' element set to F, the DM-MAC shall start traffic transmission on the master link in slot 1 of frame Y = (X+F) mod 18 + 1 (if Y is in the range 1 to 17) or otherwise in slot 1 of frame 1.

- If it receives a DM-DISCONNECT message then the DM-MAC shall not switch into traffic mode. (The DMCC then issues a DM-RELEASE message, to be sent in the DSB).

- If the DMCC issues a DM-RELEASE message then the DM-MAC shall switch into traffic mode to send the message on STCH.

After receiving a DM-SETUP PRES message, the addressed slave DM-MS shall send DM-CONNECT or DM-DISCONNECT; refer to clause 6. This message shall be sent the appropriate number of times on the slave link (using the frame countdown mechanism).

- After sending DM-CONNECT, the slave DM-MAC shall switch to traffic receive mode. It shall attempt to receive traffic on the slave link in slot 1 of the third frame following the frame with 'frame countdown' element set to zero (if that third frame is in the range 1 to 17) or otherwise in slot 1 of frame 1. Note however that, in some cases, traffic may not be received in the first few frames.

- After sending DM-DISCONNECT, the slave DM-MAC shall not switch into traffic mode.

  NOTE: If, for example, the addressed slave DM-MS sends DM-CONNECT, with its final DM-CONNECT message in slave frame 3, then it expects to receive traffic on the slave link in slot 1 of frame 6.

8.6.3.3 Late entry

ETS 300 396-3 [4], subclause 8.6.3.3 shall apply.

8.6.3.4 End of traffic transmission

ETS 300 396-3 [4], subclause 8.6.3.4 shall apply.

8.6.4 Exchange of information at the DMD-SAP

ETS 300 396-3 [4], subclause 8.6.4 shall apply.

8.6.5 Stealing from circuit mode capacity

ETS 300 396-3 [4], subclause 8.6.5 shall apply.

9 DM-REP Layer 2 Protocol (for type 1 DM-REP)

9.1 Introduction

As described in clause 4, a DM-REP comprises only a Physical Layer (PL) and Data Link Layer (DLL). This clause describes the operation of the DLL in a type 1 DM-REP.

The DLL in the DM-REP is divided into two sub-layers: the Upper MAC and the Lower MAC.

NOTE: This clause defines only the procedures specific to the DM-REP functions. If the DM-REP has a handset attached then the equipment is in essence a combined DM-REP and terminating mobile, obeying both sets of procedures.

9.1.1 Functions of Lower MAC

The lower MAC in the DM-REP provides the following services to the upper MAC:

- transfer of MAC PDUs into suitable PL bursts in accordance with the appropriate timeslot;
- choice of preamble and training sequence corresponding to the slot flag value and vice versa;
- signal strength measurement (RSSI);
- frame and multiframe synchronisation;
- channel coding;
- Forward Error Correction (FEC) and interleaving of MAC blocks;
- scrambling and de-scrambling of MAC blocks;
- CRC calculation.

Refer to clause 11 for specific details of the lower MAC functionality.

9.1.2 Functions of Upper MAC

The principal functions of the upper MAC in the DM-REP are as follows:

- reception of signalling messages from the master DM-MS, on the master link, and regeneration and re-transmission of the received message on the slave link;
- reception of signalling messages from slave DM-MSs, on the slave link, and regeneration and re-transmission of the received message on the master link;
- reception of traffic from the master DM-MS, on the master link, and re-transmission of that traffic on the slave link;
- determination of the Direct Mode channel state;
- transmission of the DM-REP presence signal (optional).

The functions of the upper MAC in the DM-REP are described in this clause.

9.2 Interface between Lower and Upper MAC

The procedures defined for a DM-MS in ETS 300 396-3 [4], subclause 8.2 shall apply also for a DM-REP, with the following differences:

i) In figure 23, there is no functionality above the Upper MAC for a DM-REP.

ii) In subclause 8.2.6.1, "Idle mode" for the DM-REP shall be defined as follows.

The DM-REP shall operate in idle mode when it is not currently involved in any ongoing transmission except, optionally, the transmission of its DM-REP presence signal. The DM-REP in idle mode shall however monitor the selected DM channel frequency in order to determine the current state of the channel and to receive any new signalling messages addressed to itself (i.e. with its address as the 'DM-REP or gateway address' element in the DMAC-SYNC PDU).

NOTE: The scrambling mechanism for SCH/F, STCH and TCH is based on the 'mobile network identity' element and the layer 2 'source address' element from the appropriate DMAC-SYNC PDU, as defined in ETS 300 396-3 [4], subclause 8.2.4 where the 'source address' element contains the SSI or pseudo SSI of the DM-MS that generated the message. This colour code applies both when the DM-REP receives on one link (i.e. master link or slave link), and then again when it re-transmits on the other link (i.e. slave link or master link respectively).

9.3 Basic capabilities of the DM-REP PL

A DM-REP shall be capable of either transmitting or receiving (i.e. simplex mode operation) on a single radio frequency carrier. It shall be capable of switching from DM transmit to receive, or from DM receive to transmit, between consecutive slots i.e. within the guard + ramping + PA linearization time.

NOTE: This timing requirement applies only to the actual switching. It does not require the DM-REP to be able to decode and process a message between consecutive slots. When the DM-REP switches from receive to transmit between consecutive slots, the message to be transmitted was received by the DM-REP at least one slot earlier.

The DM-REP shall be capable of transmitting in alternate timeslots in consecutive frames. It shall also be capable of transmitting in all four timeslots of at least Z consecutive frames, where Z is equal to N.231 or N.232, whichever is the greater (typically two, maximum four).

9.4 Usage of DM channel

9.4.1 DM-REP operation

A DM-REP can support a single call on the selected DM radio frequency channel.

When the DM-REP is idle (i.e. when it is not supporting a call), and when the DM channel is perceived as free, the DM-REP may transmit a presence signal announcing its presence.

During calls in which the DM-REP acts as a DM-REP, the DM-REP receives signalling messages and traffic from the master DM-MS and shall re-transmit that information to the called slave DM-MSs. It also may receive signalling messages from slave DM-MSs, in which case it shall re-transmit those messages to the master DM-MS.

During calls, all communications between the DM-REP and the master DM-MS shall use the master link's slot and frame numbering. All communications between the DM-REP and slave DM-MSs shall use the slave link's slot and frame numbering, which runs three timeslots behind the master link's slot and frame numbering. For each link, the call is conducted primarily in timeslots 1 and 3 in each frame according to that link's slot and frame numbering (except for call set-up messages, which may use all four timeslots).

When the DM-REP receives a MAC PDU transmitted by a DM-MS, it may decode and use any of the elements that are visible at layer 2 (including the 'message type' element and the message-dependent elements). For example, it shall use received layer 2 elements to decide whether and how to re-transmit the message, to adapt its monitoring procedures and to update its state model.

9.4.2 DM-REP states

The DM-REP shall monitor activity on a selected DM channel in order to determine the current state of the channel and to receive any signalling messages addressed to itself (i.e. with its address as the 'DM-REP or DM-GATE address' element in the DMAC-SYNC PDU).

9.4.2.1 DM-REP state definitions

Four primary states are defined for the DM-REP, based on its own activity and the current state of the channel. These shall be used to determine which procedure the DM-REP follows at any point in time.

1) DM-REP idle - channel free

   The DM-REP is currently operating in idle mode on a DM channel which is perceived as free i.e. no signalling or traffic activity is detected on the channel,(except possible detection of other DM-REP or gateway presence signals indicating that the channel is free).

2) DM-REP idle - channel busy

   The DM-REP is currently operating in idle mode on a DM channel which is perceived as busy i.e. signalling or traffic information not addressed to the DM-REP is detected on the channel, or activity is detected on the channel.

3) DM-REP active in channel occupation

   The DM-REP is in active mode, re-transmitting traffic and/or signalling in a call transaction. This may be either a circuit mode traffic transmission or a short data transmission (DM-SDS UDATA or DM-SDS DATA).

4) DM-REP active in channel reservation

   The DM-REP is in active mode, intermittently re-transmitting signalling during a circuit mode reservation period.

9.4.2.2 Determination of DM channel state

To determine the current state of the DM channel, a DM-REP in idle mode shall continuously monitor the selected DM radio frequency (except when transmitting its DM-REP presence signal) in order to receive any DSBs present on the channel and, signal strength and channel conditions permitting, decode any layer 2 information available.

In the case where DMAC-SYNC PDUs are present, and contain the DM-REP's address, the DM-REP shall, dependent upon the content, enter the appropriate mode of operation and update its state model.

In the case where DMAC-SYNC PDUs are present not containing the DM-REP's address, the DM-REP shall regard the channel as busy.

In the case where presence signals from another DM-REP or DM-GATE are present indicating that the channel is occupied and reserved, the DM-REP shall regard the channel as busy.

In the case where DSB signalling cannot be detected the DM-REP shall, having followed the procedure described in subclause 9.4.2.3.1, update its state model and begin idle mode operating procedures.

During a call that uses the DM-REP, the DM-REP shall, based upon the DSB and DNB signalling present on the channel, update its state model accordingly. Where no DSB signalling has been detected from the master DM-MS for the appropriate time (refer to subclause 9.4.2.4), the DM-REP shall update its state model and begin idle mode operating procedures.

9.4.2.3 Criteria for occupying a free channel

The DM-REP may accept a call set-up for a new circuit mode call or short data message if the call set-up message contains its own DM-REP address and the results of the channel monitoring procedures described in subclauses 9.4.2.2 and 9.4.2.3.1 indicate that the DM channel is free. The DM-REP shall conduct those procedures while in idle mode i.e. prior to receipt of the call set-up message. If accepting the call set-up, the DM-REP shall enter active mode and shall re-transmit the signalling information and any traffic relating to the call.

9.4.2.3.1 Signal strength measurement to determine channel free condition

When the DM-REP is in idle mode, and has not received DMAC-SYNC PDUs indicating that the DM channel is in use, it shall make RSSI measurements to determine whether the channel is free. The measurements shall be conducted over a period of at least 1 multiframe and consist of at least 6 measurements. The measurement sample duration shall be at least SD2 as defined in ETS 300 396-2 [3], clause 10. The DM channel shall be declared free when the RSSI level is less than a predetermined threshold value.

NOTE: Determination of appropriate threshold values are outside the scope of this ETS but this parameter should be configurable within the DM-REP.

9.4.2.4 Channel surveillance during a circuit mode call

During channel occupation and reservation for a circuit mode call, the DM-REP shall monitor the master link as defined in subclauses 9.4.3.2 and 9.4.3.3.

If, during channel occupation, a time T.262 elapses without receipt of a DM-OCCUPIED message for the call then the DM-REP shall assume that the call has been lost and shall enter idle mode.

If, during channel reservation, a time T.263 elapses without receipt of a DM-RESERVED message for the call then the DM-REP shall assume that the call has been lost and shall enter idle mode.

In either case the DM-REP may then send the DM-REP presence signal, indicating that the channel is free, which causes receiving DM-MSs to release the call.

9.4.2.5 Criteria for changing DM-REP state

The DM-REP shall retain the current state condition until one of the following occurs:

i) its channel monitoring procedures indicate a change from channel free to channel busy, or from channel busy to channel free;

ii) it receives and re-transmits a call set-up message containing its own DM-REP address;

iii) it receives and re-transmits a channel state change command from the current or new master DM-MS i.e. a message indicating change of channel state (e.g. the end of channel occupation or reservation);

iv) it is required to relinquish a call by one of the procedures described in subclause 9.4.2.4.

In case iii), the DM-REP shall not change state until the master DM-MS's frame countdown for the channel state change command message has expired.

9.4.3 DM-REP monitoring requirements

The monitoring procedures to be conducted by a DM-REP are dependent upon the current perceived state of the DM channel and of any ongoing call.

A DM-REP in idle mode shall continuously monitor the DM channel frequency in order to keep an up-to-date record of the current state of the channel and to receive any call set-up signalling messages containing its own DM-REP address. Refer to subclauses 9.4.2.2 and 9.4.2.3.1.

The following subclauses define the minimum monitoring requirements when the DM-REP is in active mode repeating signalling and/or traffic, after reception and re-transmission of call set-up messages containing its own DM-REP address. The methods for the re-transmission of received messages are defined in subclauses 9.5 and 9.6.

9.4.3.1 DM channel during circuit mode call set-up

For a circuit mode call set-up with presence check, the DM-REP shall monitor timeslot 1 and 3 for a DSB in the slave frames allocated for acknowledgements transmitted from the called DM-MS. Refer to subclause 9.6.2.2.

9.4.3.2 DM channel in occupation during a circuit mode call

During occupation for a circuit mode call, the DM-REP shall monitor as follows.

i) The DM-REP shall monitor slot 1 of frames 1 to 17 on the master link for DNBs containing TCH or STCH. The timings for switching in and out of traffic mode are defined in subclause 9.6.2.

ii) The DM-REP shall monitor slot 1 of frame 18 on the master link for DSBs. It shall also monitor for DSBs in slot 3 of all frames except those in which it is transmitting to the master DM-MS or linearising. For example, the master DM-MS may send a DM-OCCUPIED or DM-TX CEASED message in frames 6, 12 and 18; or it may send a DM-PRE ACCEPT or DM-RELEASE message in any frame.

iii) The DM-REP shall monitor slot 3 of frames 2, 5, 8, 11, 14 and 17 on the slave link for DSBs carrying pre-emption or timing change requests containing its own DM-REP address.

When the DM-REP has received and re-transmitted the first DM-TX CEASED message, during the master DM-MS's frame countdown on the DM-TX CEASED message, the DM-REP shall start to monitor slot 3 of the slave frames indicated as valid for random access in the master DM-MS's 'changeover requests bitmap' (in addition to slot 3 of the pre-emption frames). I.e., it shall start to monitor for random access requests as in procedure ii) of subclause 9.4.3.3.

Following the re-transmission on the master link of a pre-emption or timing change request, the DM-REP shall continue to monitor slots 1 and 3 in the following master frames, as defined in i) and ii) above, to determine the result of the request.

9.4.3.3 DM channel in reservation during a circuit mode call

During reservation for a circuit mode call, the DM-REP shall monitor as follows.

i) The DM-REP shall monitor slot 1 of all frames on the master link, and slot 3 of all frames on the master link except those in which it is either transmitting to the master DM-MS or linearising, looking for DSBs. For example, the master DM-MS may send:

- a DM-RESERVED or DM-RELEASE message for the call; or
- a call set-up message indicating that it is re-starting transmission (to send either circuit mode traffic or short data); or
- a response to a pre-emption, timing change or changeover request.

NOTE: Improved operation may be achieved in detecting that the current master DM-MS is re-starting transmission if the DM-REP also monitors slots 2 and 4 on the master link when practicable. (The 'master/slave link flag' indicates whether a received DSB was sent on the master link or slave link.)

See also procedure iii) below. If procedure iii) requires that the DM-REP temporarily monitors on the master link for a DNB in slot 1 of frames 1 to 17 then procedure iii) shall take precedence. The DM-REP is not required to be able to monitor for both a DSB and a DNB in a single slot.

ii) The DM-REP shall monitor slot 3 of frames 2, 5, 8, 11, 14 and 17 on the slave link, and also slot 3 of the slave frames indicated as valid for random access in the master DM-MS's 'changeover requests bitmap', looking for DSBs carrying pre-emption, timing change or changeover requests containing its own DM-REP address.

iii) Following the re-transmission on the master link of a pre-emption, timing change or changeover request, the DM-REP shall monitor slots 1 and 3 in the following master frames to determine the result of the request. For a timing change or changeover request, the response messages are sent in the DSB. For a pre-emption request, the response messages are sent in the DSB unless the 'perceived channel state' element in the DM-PREEMPT message indicated that the requesting DM-MS perceives the channel as being still in circuit mode occupation, in which case response messages in slot 1 of frames 1 to 17 are sent in the DNB. Refer to subclause 8.5.7.2.3.

Following the re-transmission on the master link of a DM-PREEMPT message containing 'perceived channel state' element set to 00_2 (i.e. circuit mode occupation), the DM-REP shall monitor slot 1 of master frames 1 to 17 for DNBs until it receives a DM-PRE ACCEPT or DM-REJECT message from the master DM-MS (in which case the DM-REP shall continue to monitor for DNBs during the frame countdown) or until a time T.253 has elapsed. During this time, the DM-REP shall continue to monitor slot 3 for DSBs as defined in i) above.

9.4.3.4 DM channel in occupation during a SDS call

During a short data transaction (i.e. while the 'SDS time remaining' element indicates a positive value), the DM-REP shall monitor as follows.

i) After receiving and re-transmitting a DMAC-SYNC PDU indicating a fragmented DM-SDS UDATA or DM-SDS DATA message, the DM-REP shall monitor slot 1 of frames 1 to 17 on the master link for DNBs containing SCH/F until it receives and re-transmits the DMAC-END PDU or a DMAC-DATA PDU (e.g. a Null PDU) or fails to decode one of the SCH/F slots.

It shall then revert to monitoring for DSBs in slot 1 of all frames on the master link except those in which it is transmitting to the master DM-MS. For example, the master DM-MS may send a DM-PRE ACCEPT message or a call set-up message indicating that it is re-starting transmission.

ii) The DM-REP shall monitor slot 1 of frame 18 on the master link for DSBs. It shall also monitor for DSBs in slot 3 of all frames except those in which it is transmitting to the master DM-MS or linearising. For example, the master DM-MS may send a DM-SDS OCCUPIED message in frames 6, 12 and 18; or it may send a DM-PRE ACCEPT message in any frame.

iii) During the SCH/F frames for a fragmented DM-SDS UDATA or DM-SDS DATA message, and in the preceding frame, the DM-REP shall monitor slot 3 of frames 2, 5, 8, 11, 14 and 17 on the slave link for DSBs carrying pre-emption requests containing its own DM-REP address.

iv) After transmission of a non-fragmented DM-SDS DATA message on the slave link, or after transmission of the last SCH/F slot of a fragmented DM-SDS DATA message, the DM-REP shall monitor slots 1 and 3 of the slave link for DSBs until it receives a DM-SDS ACK or DM-REJECT message from the called DM-MS (plus any repetitions within the frame countdown) or until a time T.254 has elapsed. If the received DSB indicates a fragmented DM-SDS ACK message then the DM-REP shall monitor for the final fragment (DMAC-END PDU on SCH/F, carried in a DNB) using the timing defined in subclause 9.5.2.1.

If the DM-REP failed to decode one of the SCH/F slots in a fragmented DM-SDS DATA message then, unless it has received a DM-PRE ACCEPT or call set-up message in the interim time, it shall look for a response DSB in slots 1 and 3 of the slave frame following the slave frame that would have contained the last SCH/F slot (as indicated by the 'number of SCH/F slots' element from the master DM-MS's DMAC-SYNC PDU).

Following the re-transmission on the master link of a pre-emption request, the DM-REP shall continue to obey all the procedures i) to iv) above until it receives a DM-PRE ACCEPT message. (The DM-PRE ACCEPT message, if sent, will be in a DSB.).

9.4.3.5 DM channel following pre-emption or changeover acceptance

After receiving and re-transmitting a DM-PRE ACCEPT or DM-TX ACCEPT message from the master DM-MS, the DM-REP shall continue to monitor master slots 1 and 3 during the master DM-MS's frame countdown and shall re-transmit any received messages on the slave link. It shall then monitor the master link in all four slots of the following frames looking for DSBs carrying call set-up messages (for a circuit mode call or short data) from the new master DM-MS.

If the DM-REP does not receive a call set-up message within a time T.255 then it shall enter idle mode and may send the DM-REP presence signal, indicating that the channel is free, which causes receiving DM-MSs to release the call.

9.4.3.6 DM channel following timing change announcement

After receiving and re-transmitting a DM-TIMING ACK or DM-TX CEASED message containing 'timing change announcement flag' set to 1, the DM-REP shall continue to monitor the master link using the old timing reference during the master DM-MS's frame countdown and shall re-transmit any received messages on the slave link. It shall then monitor the master link in slots 1 and 3 of the following frames, using the new timing reference, looking for DSBs from the master DM-MS e.g. containing DM-RESERVED messages.

9.4.4 DM-REP presence signal

As an option, the DM-REP may transmit a presence signal (the DPRES-SYNC PDU) periodically on the Direct Mode channel during the time when the DM-REP is otherwise idle and the channel is perceived by the DM-REP as being free.

If used on a free channel, the presence signal shall be sent in a DSB at intervals corresponding to time T.251. The structure of the presence signal shall be as defined in clause 10.

The DM-REP presence signal indicates to receiving DM-MSs that a DM-REP with the specified address is switched on and within range. It need not be used as the timing reference when a DM-MS makes a call through the DM-REP. For example, the DM-REP's slot timing may be unsuitable for the DM-MS's dual watch operation. It is the responsibility of a DM-MS that becomes master on a free channel to define the timing reference including the slot timing and the slot and frame numbering. Therefore, when monitoring the channel in idle mode, the DM-REP should be prepared to receive DSBs at any time.

During circuit mode occupation if the DM-REP does not receive a DSB from the master DM-MS in slot 1 of frame 18 or slot 3 of frames 6, 12 or 18, it may send a presence signal, indicating occupation, in the corresponding slot on the slave link.

During circuit mode reservation if the DM-REP does not receive a DSB from the master DM-MS in slot 1 or 3 of frames 6, 12 or 18, it may send a presence signal, indicating reservation, in the corresponding slot on the slave link.

NOTE: If using the proprietary features of the DPRES-SYNC PDU the DM-REP presence signal may also be sent during channel occupation and reservation in those timeslots not used within the current circuit mode call.

9.4.5 DM-REP linearization

When the channel is free, the DM-REP may linearize its transmitter at any time.

During circuit mode occupation and reservation, the DM-REP may linearize in timeslot 3 of frame 3 of either the slave link or the master link.

NOTE: The linearization opportunities during circuit mode occupation may be restricted for some types of call in future editions of this ETS.

During short data occupation, the DM-REP may conduct linearization in timeslot 3 of frame 3 of either the slave link or the master link, if timeslot 1 of frame 3 is an SCH/F slot (as indicated by the 'number of SCH/F slots' element in the SDS call set-up message).

9.5 DM-REP procedures for re-transmission of signalling messages

9.5.1 Re-transmission of messages received from the master DM-MS

9.5.1.1 Re-transmission of master DM-MS messages received in DSB

When the DM-REP receives a DMAC-SYNC PDU on the master link (i.e. with 'master/slave link flag' set to 1) containing the appropriate 'communication type' element and its own DM-REP address, it shall decide whether to repeat the message as follows.

- The DM-REP may accept and re-transmit a call set-up message (DM-SETUP, DM-SETUP PRES, DM-SDS DATA or DM-SDS UDATA) for a new circuit mode call or short data transmission if the results of the channel monitoring procedures described in subclauses 9.4.2.2 and 9.4.2.3 indicate that the DM channel is free. If the results of the channel monitoring procedures indicate that the DM channel is busy then the DM-REP shall ignore the call set-up message.

- For a call set-up message (DM-SETUP, DM-SETUP PRES, DM-SDS DATA or DM-SDS UDATA) following a pre-emption or changeover procedure, or if the master DM-MS re-starts transmission during the reservation period, the DM-REP shall re-transmit the message.

- For other message types, the DM-REP shall re-transmit the message.

If the DM-REP re-transmits the message then it shall set the 'master/slave link flag' to 0 and shall use the slave link's slot and frame numbering. It shall use the appropriate procedure as defined in the following subclauses.

When re-transmitting DM-SETUP, DM-SETUP PRES, DM-SDS DATA and DM-SDS UDATA messages, the DM-REP shall regenerate new values for the 'frame countdown', 'slot number' and 'frame number' elements in the DMAC-SYNC PDU as defined below.

For other messages, the DM-REP shall re-transmit the 'frame countdown' and 'frame number' elements without any change from the values set by the master DM-MS. It also re-transmits the 'slot number' element unchanged for the principal re-transmission, though it may sometimes regenerate an additional transmission in a later slot in the same frame, as defined below.

When re-transmitting DM-SETUP, DM-SETUP PRES, DM-OCCUPIED and DM-RESERVED messages, the DM-REP shall set the 'power class' element to its own power class or to the null value. A non-null value provides the option for a DM-MS to perform power control procedures.

All elements other than the 'master/slave link flag' and the 'frame countdown', 'slot number', 'frame number' and 'power class' elements shall remain unchanged from the values set by the master DM-MS.

9.5.1.1.1 Re-transmission of DM-SETUP or DM-SETUP PRES message

For a DM-SETUP or DM-SETUP PRES message, and if the DM-REP received the master DM-MS's message in master frame X and with 'frame countdown' element set to F, then it shall re-transmit the message in all four slots of N.232 frames on the slave link, using the 'frame countdown' element to indicate how many more transmission frames remain. The first transmission frame on the slave link shall be slave frame (X+F-1) mod 18 + 1; those transmissions shall contain 'frame countdown' element set to N.232-1. The final transmission frame on the slave link shall be slave frame (X+F-2+N.232) mod 18 + 1, and those transmissions shall contain 'frame countdown' element set to 0. The procedure for entering traffic mode shall then be as defined in subclause 9.6.2.

NOTE: If the DM-REP received the master DM-MS's message only in slot 3 of the frame with F = 0 then it need not transmit in the immediately following slot 1 on the slave link, but must transmit in slots 2, 3 and 4.

9.5.1.1.2 Re-transmission of DM-SDS DATA or DM-SDS UDATA message

For a DM-SDS DATA or DM-SDS UDATA message, and if the DM-REP received the master DM-MS's DMAC-SYNC PDU in master frame X and with 'frame countdown' element set to F, then it shall re-transmit the DMAC-SYNC PDU in all four slots of N.231 frames on the slave link, using the 'frame countdown' element to indicate how many more transmission frames remain. The first transmission frame on the slave link shall be slave frame (X+F-1) mod 18 + 1; those transmissions shall contain 'frame countdown' element set to N.231-1. The final transmission frame on the slave link shall be slave frame (X+F-2+N.231) mod 18 + 1, and those transmissions shall contain 'frame countdown' element set to 0.

NOTE: If the DM-REP received the master DM-MS's message only in slot 3 of the frame with F = 0 then it need not transmit in the immediately following slot 1 on the slave link, but must transmit in slots 2, 3 and 4.

If the DMAC-SYNC PDU contained 'fragmentation flag' set to 0 then the transmission of the short data message is now complete.

If the DMAC-SYNC PDU contained 'fragmentation flag' set to 1 then the DM-REP shall expect the master DM-MS to start sending SCH/F in slot 1 of master frame Y = (X + F + N.231) mod 18 + 1 (if Y is in the range 1 to 17) or otherwise in slot 1 of frame 1. It shall re-transmit each SCH/F slot once, in the corresponding slot 1 on the slave link, until it receives and re-transmits the DMAC-END PDU or a DMAC-DATA PDU or fails to decode one of the SCH/F slots. The "corresponding slot 1 on the slave link" lags three slots behind slot 1 on the master link.

9.5.1.1.3 Re-transmission of other messages received in DSB

Each time any other message is received from the master DM-MS in a DMAC-SYNC PDU, the DM-REP shall re-transmit the DMAC-SYNC PDU in the corresponding slot on the slave link (i.e. without changing the slot and frame numbers set by the master DM-MS). The DM-REP shall also leave the 'frame countdown' element unchanged. Thus it shall change only the setting of the 'master/slave link flag' (and the 'power class' element for a DM-OCCUPIED or DM-RESERVED message).

For a DM-OCCUPIED or DM-RESERVED message received in frame 6, and if the DM-REP did not receive a random access message in slave frame 4 or 5, the DM-REP shall send an additional repetition of the DM-OCCUPIED or DM-RESERVED message in slot 4 of slave frame 6. For a DM-OCCUPIED or DM-RESERVED message received in frame 12, and if the DM-REP did not receive a random access message in slave frame 10 or 11, the DM-REP shall send an additional repetition of the DM-OCCUPIED or DM-RESERVED message in slot 4 of slave frame 12. For a DM-OCCUPIED or DM-RESERVED message received in frame 18, and if the DM-REP did not receive a random access message in slave frame 16 or 17, the DM-REP shall send an additional repetition of the DM-OCCUPIED or DM-RESERVED message in slot 4 of slave frame 18. In each case, in addition to changing the setting of the 'master/slave link flag' and 'power class' element, the DM-REP shall set the 'slot number' element to 11_2.

If the DM-REP receives a message in a DMAC-SYNC PDU from the master DM-MS in a slot 1 and does not receive a message in slot 3, and if the master DM-MS procedure defined in clause 8 specifies that the message may be sent also in slot 3, then the DM-REP may (optionally) regenerate an additional repetition in slot 3 of that frame on the slave link, modifying the 'slot number' element appropriately. The DM-REP shall not regenerate any additional repetitions in a later frame.

9.5.1.2 Re-transmission of master DM-MS messages received in DNB

For signalling messages received from the master DM-MS in a normal burst (DNB), the DM-REP shall decode and error correct the PDU. It shall then re-encode the PDU, without changing any element values from the values set by the master DM-MS, and shall re-transmit it in the corresponding slot on the slave link. The DM-REP shall not regenerate any additional repetitions in any other slot or frame.

9.5.2 Re-transmission of messages received from a slave DM-MS

If the DM-REP is in the channel occupation or channel reservation state, and if it receives a DMAC-SYNC PDU on the slave link (i.e. with 'master/slave link flag' set to 0) containing the appropriate 'communication type' element and its own DM-REP address, then it shall repeat that message on the master link, setting the 'master/slave link flag' to 1 and using the master link's slot and frame numbering.

The only messages that may be sent by a slave DM-MS are:

- responses to a message from the master i.e. DM-CONNECT, DM-DISCONNECT, DM-REJECT and DM-SDS ACK; and

- random access messages i.e. DM-TIMING REQUEST, DM-TX REQUEST and DM-PREEMPT.

The methods for re-transmission of these messages by the DM-REP are defined in the following subclauses.

When re-transmitting a DMAC-SYNC PDU from a slave DM-MS, the DM-REP shall change the 'frame number' element to the master frame number, as defined below. It shall re-transmit the 'slot number' element unchanged for the principal re-transmission (though it may sometimes re-generate an additional transmission in another slot within the same frame).

All elements other than the 'master/slave link flag', 'slot number' and 'frame number' elements shall remain unchanged from the values set by the slave DM-MS.

9.5.2.1 Re-transmission of response messages from a slave DM-MS

Each time a response message is received from a slave DM-MS, the DM-REP shall re-transmit the DMAC-SYNC PDU on the master link. For a DMAC-SYNC PDU received in slot S of slave frame X, the DM-REP shall re-transmit the DMAC-SYNC PDU in slot S of master frame (X+1) mod 18 + 1.

In either of the following cases, the DM-REP may (optionally) regenerate one additional transmission of the slave's response DMAC-SYNC PDU.

i) If it receives a response DMAC-SYNC PDU from the slave DM-MS in slot 1 of slave frame X, and does not receive a message from the slave in slot 3 of slave frame X, then the DM-REP may regenerate an additional repetition in slot 3 of master frame (X+1) mod 18 + 1.

ii) If it receives a response DMAC-SYNC PDU from the slave DM-MS in slot 3 of slave frame X, and did not receive a message from the slave in slot 1 of frame slave X, then the DM-REP may regenerate an additional repetition in slot 1 of master frame (X+1) mod 18 + 1.

In either case, the DM-REP shall modify the 'slot number' element appropriately. The DM-REP shall not regenerate any additional repetitions in any other frame.

If the slave's DMAC-SYNC PDU contained 'fragmentation flag' set to 1 (i.e. if this is a fragmented DM-SDS ACK message), with 'frame countdown' element set to F, then the DM-REP shall expect the slave DM-MS to send the SCH/F slot in slot 1 of slave frame (X+F) mod 18 + 1. It shall re-transmit the SCH/F slot once, in slot 1 of master frame (X + F + 2) mod 18 + 1.

NOTE: The slave DM-MS is required to choose its initial frame countdown value so that neither frame (X + F) mod 18 + 1 nor frame (X + F + 2) mod 18 + 1 is a frame 18.

9.5.2.2 Re-transmission of random access request

On reception of a random access request (i.e. DM-TIMING REQUEST, DM-TX REQUEST and DM-PREEMPT) in a slot 3 on the slave link, containing its own DM-REP address, the DM-REP shall repeat the request on the master link except in the cases described below. It shall transmit the request once, in the appropriate slot 3 on the master link. The frame for transmission of the request on the master link shall be as defined in table 1.

Table 1: Frame for DM-REP transmission of random access message on master link

Reception frame on slave link	Transmission frame on master link
1	4
2	4
4	7
5	7
7	9
8	10
9	11
10	13
11	13
13	15
14	16
15	17
16	1
17	1

In most cases, this results in a delay of 5 slots relative to direct MS-MS operation. However, this delay is increased to 9 slots for a request received in slave frame 1, 4, 10 or 16 in order to avoid the master DM-MS's linearization and reservation messages.

If, according to the above algorithm, the DM-REP has two requests to be sent in master frame 1, 4, 7 or 13 then the DM-REP shall transmit the higher priority request (or, for equal priority requests, the first received request) and shall discard the other request.

The DM-REP shall also refrain from repeating a request on the master link in the following cases:

i) if it has already received a DM-PRE ACCEPT, DM-TX ACCEPT or DM-RELEASE message from the current master DM-MS; or

ii) if the channel is in circuit mode occupation, and the DM-REP has not received a DM-TX CEASED message from the master DM-MS, and the request is a DM-PREEMPT message with 'perceived channel state' element set to 01_2 or 10_2; or

iii) its timer T.253 is running (i.e. the DM-REP is looking for DNBs during reservation).

9.5.3 DM-REP signalling mechanisms

9.5.3.1 Frame countdown procedure

For all messages other than call set-up messages, the DM-REP shall re-transmit the received 'frame countdown' element unchanged on the other link.

For DM-SETUP and DM-SETUP PRES messages, the DM-REP transmits the message in all four slots of N.232 frames on the slave link. For DM-SDS DATA and DM-SDS UDATA messages, the DM-REP transmits the message in all four slots of N.231 frames on the slave link. In each case, it shall set the 'frame countdown' element appropriately. The 'frame countdown' element shall indicate how many more transmission frames remain following the current slave frame. The DM-REP shall decrement the 'frame countdown' element by 1 for each frame in which the message is sent. When the 'frame countdown' element = 0 this shall indicate that this is the last frame containing this information.

9.5.3.2 Fill bit addition and deletion

The procedures defined for a DM-MS in ETS 300 396-3 [4], subclauses 8.5.5.1 and 8.5.5.2 shall apply also for a DM-REP.

9.5.3.3 Null PDU

The procedures defined for a DM-MS in ETS 300 396-3 [4], subclause 8.5.5.3 shall apply also for a DM-REP.

9.5.3.4 Air interface encryption

For a message received with 'air-interface encryption state' = 10_2, the DM-REP shall re-transmit the encrypted information without decrypting or modifying the information content.

For a message received with 'air-interface encryption state' = 01_2, and if the DM-REP is unable to perform the decryption, the DM-REP shall ignore the message.

For a message received with 'air-interface encryption state' = 01_2, and if the DM-REP is able to perform decryption, the DM-REP shall re-transmit the encrypted information without modifying the information content. However, it shall decrypt the encrypted layer 2 elements (i.e. the addressing information, message type and message-dependent elements) for use in its own algorithms e.g. for scrambling and de-scrambling, for message re-transmission and for updating its state model.

9.5.3.5 Timing change procedure

If the DM-REP receives and re-transmits a DM-TIMING ACK, DM-TX CEASED, DM-TX ACCEPT or DM-PRE ACCEPT message containing 'timing change announcement flag' set to 1, received in frame X and with 'frame countdown' element set to F, then it shall expect the announced timing advance to be used on the master link in master frame (X + F + 1) mod 18 + 1 and onwards. This is the first master frame following the end of the slave frame containing the re-transmitted DM-TIMING ACK, DM-TX CEASED, DM-TX ACCEPT or DM-PRE ACCEPT message(s) with 'frame countdown' element equal to 0. After receipt of a DMAC-SYNC PDU from the master DM-MS using the new timing reference, the DM-REP shall use that new timing reference also for transmission and reception of messages on the slave link.

9.5.3.6 Random access procedures for DM-REP

The random access procedures for the DM-REP comprise the following three aspects.

i) During circuit mode occupation and circuit mode reservation and when transmitting SCH/F for a fragmented DM-SDS UDATA or DM-SDS DATA message, the DM-REP shall monitor slot 3 of the appropriate frames on the slave link for random access requests containing its own DM-REP address. Refer to subclause 9.4.3.

ii) On reception of a random access request on the slave link, containing its own DM-REP address, the DM-REP shall repeat the request on the master link. It shall transmit the request once, in the appropriate slot 3 on the master link, as defined in subclause 9.5.2.

iii) It is the responsibility of the master DM-MS to decide whether to accept a random access request and then to send the response. If the DM-REP receives a DM-PRE ACCEPT, DM-TX ACCEPT, DM-REJECT or DM-TIMING ACK from the master DM-MS in slot 1 or slot 3 on the master link then it shall transmit the message in the corresponding slot on the slave link, as defined in subclause 9.5.1.

9.6 DM-REP procedures in traffic mode

9.6.1 Introduction

During traffic transmission in DM, the master DM-MS transmits traffic TCH or stealing channel STCH in slot 1 of frames 1 to 17 on the master link. The DM-REP re-transmits this information in the corresponding slot 1 on the slave link. The "corresponding slot 1 on the slave link" lags three slots behind slot 1 on the master link.

In the case of STCH, the DM-REP decodes and processes the information in the PDU (as well as re-transmitting the PDU on the slave link). In particular, for C-plane stealing, the DM-REP uses appropriate layer 2 information from DM-TX CEASED, DM-RELEASE and DM-PRE ACCEPT messages. For example, the DM-REP uses the 'frame countdown' element from DM-TX CEASED and DM-RELEASE messages to decide when to switch out of traffic mode; it should record the 'changeover requests bitmap' from DM-TX CEASED messages for use during circuit mode reservation; and it should use any timing advance information included within DM-TX CEASED and DM-PRE ACCEPT messages.

During traffic transmission, slot 3 of frames 1 to 17 and slots 1 and 3 of frame 18 are used for synchronisation and signalling purposes e.g. occupation messages and pre-emption requests; refer to subclauses 9.4 and 9.5. This subclause describes the DM-REP's procedures for the transfer of TCH and STCH.

Refer to subclause 9.2 for the configuration of the lower MAC in synchronisation, signalling and traffic mode.

9.6.2 Change of U-plane mode

9.6.2.1 Set-up without presence check

For a call set-up without presence check, and if accepting the call set-up, the DM-REP shall re-transmit the master DM-MS's DM-SETUP message on the slave link in N.232 frames, as defined in subclause 9.5.1, and shall then switch into traffic mode. If the DM-REP received the master DM-MS's DM-SETUP message on the master link in frame X and with 'frame countdown' element set to F, it shall expect the master DM-MS to start traffic transmission in slot 1 of master frame Y = (X + F + N.232) mod 18 + 1 (if Y is in the range 1 to 17) or otherwise in slot 1 of frame 1. The DM-REP shall expect the traffic type defined by the 'circuit mode type' element from the DM-SETUP message.

9.6.2.2 Set-up with presence check

For a call set-up with presence check, and if accepting the call set-up, the DM-REP shall re-transmit the master DM-MS's DM-SETUP PRES message on the slave link in N.232 frames. It shall then look for a response from the called DM-MS in slot 1 and slot 3 of the following frames on the slave link.

- If the DM-REP receives DM-CONNECT message(s) from the called DM-MS on the slave link, the DM-REP shall re-transmit the DM-CONNECT message(s) on the master link as defined in subclause 9.5.2. If a DM-CONNECT message was received on the slave link in frame X and with 'frame countdown' element set to F, the DM-REP shall re-transmit the DM-CONNECT message on the master link in master frame (X+1) mod 18 + 1. It shall then expect the master DM-MS to start traffic transmission in slot 1 of master frame Y = (X + F + 2) mod 18 + 1 (if Y is in the range 1 to 17) or otherwise in slot 1 of frame 1. The DM-REP shall expect the traffic type defined by the 'circuit mode type' element from the DM-CONNECT message.

- If the DM-REP receives DM-DISCONNECT messages(s) from the called DM-MS on the slave link, the DM-REP shall re-transmit the DM-DISCONNECT message(s) on the master link. It shall not switch into traffic mode.

- If the DM-REP does not receive DM-CONNECT or DM-DISCONNECT from the called DM-MS within a time T.261 following its last transmission of the DM-SETUP PRES message on the slave link then the DM-REP shall switch into traffic mode (expecting the master DM-MS to send DM-RELEASE messages immediately).

9.6.2.3 End of traffic transmission

At the end of traffic transmission, the master DM-MS sends the DM-TX CEASED or DM-RELEASE message at least twice on the master link. After each reception, the DM-REP shall re-transmit the message in the corresponding slot on the slave link. On receipt of a DM-TX CEASED or DM-RELEASE message from the master DM-MS, received in master frame X and with 'frame countdown' element set to F, the DM-REP shall switch out of traffic mode at the end of frame (X+F-1) mod 18 + 1.

The DM-REP shall also switch out of traffic mode if one of the following occurs:

i) it receives a DM-RESERVED message for the call; or

ii) a time T.262 elapses without receipt of a DM-OCCUPIED message for the call.

In case i), the DM-REP shall assume that the channel is now in reservation for the call. In case ii), the DM-REP shall assume that the call has been lost; then, instead of sending the DM-OCCUPIED message, the DM-REP may send the DM-REP presence signal indicating the channel is free.

9.6.3 DM-REP traffic operation

During traffic mode, the DM-REP shall attempt to receive slot 1 of frames 1 to 17 on the master link, expecting TCH and/or STCH.

The training sequence in each slot shall indicate whether stealing has occurred.

For the full slot training sequence (T1), the DM-REP shall assume that the slot contains only TCH and shall re-transmit the information in the corresponding slot 1 on the slave link (again using training sequence T1).

For the half slot training sequence (T2), the DM-REP shall assume that the first half slot contains STCH and shall decode (and error correct) that STCH. The MAC PDU type indicates whether the first half slot was stolen for C-plane signalling (DMAC-DATA PDU) or for U-plane signalling (DMAC-U-SIGNAL PDU). The DM-REP shall inspect the 'second half slot stolen flag' in the MAC header to discover whether the second half slot is also stolen; also, for a DMAC-DATA PDU, the DM-REP shall store appropriate layer 2 information from DM-TX CEASED, DM-RELEASE and DM-PRE ACCEPT messages and shall update its channel state model. The DM-REP shall re-encode the PDU without changing any element values and shall re-transmit it in the first half slot of the corresponding slot 1 on the slave link (again using training sequence T2).

If the first half slot is not decodeable, the DM-REP shall re-transmit the same bit stream in the slave link's first half slot as it received (i.e. type 5 bits received before de-scrambling and decoding, as described in ETS 300 396-2 [3], subclause 8.2.1). It shall then attempt to interpret the second half slot as STCH.

If the second half slot is not stolen, the DM-REP shall assume that the second half slot contains TCH and shall re-transmit the information in the second half slot of the corresponding slot 1 on the slave link.

If the second half slot is stolen, the DM-REP shall interpret the second half slot as STCH and shall decode (and error correct) that STCH. The MAC PDU type indicates whether the second half slot was stolen for C-plane signalling (DMAC-DATA or DMAC-END PDU) or for U-plane signalling (DMAC-U-SIGNAL PDU); for a DMAC-DATA PDU, the DM-REP shall store appropriate layer 2 information from DM-TX CEASED, DM-RELEASE and DM-PRE ACCEPT messages and shall update its channel state model. The DM-REP shall re-encode the PDU without changing any element values and shall re-transmit it in the second half slot of the corresponding slot 1 on the slave link.

If the second half slot is not decodeable, the DM-REP shall re-transmit the same bit stream in the slave link's second half slot as it received (i.e. type 5 bits received before de-scrambling and decoding, as described in ETS 300 396-2 [3], subclause 8.2.1).

If the DM-REP does not receive data on the master link in slot 1 of a frame in the range 1 to 17 then it shall still transmit in the corresponding slot 1 on the slave link, filling the slot with two stolen half slots each containing the C-plane Null PDU.

For TCH/S, TCH/7,2, TCH/4,8 with N=1 and TCH/2,4 with N=1, channel decoding and re-encoding may be performed by the DM-REP, allowing error correction before re-transmission on the slave link. This ETS does not support traffic regeneration (i.e. decoding and re-encoding) by the DM-REP for TCH/4,8 or TCH/2,4 with N=4 or N=8. However in all cases STCH shall be decoded and re-encoded by the DM-REP.

10 PDU descriptions

Refer to annex C.

10.1 Layer 2 PDUs sent in DSB

10.1.1 DMAC-SYNC PDU

ETS 300 396-3 [4], subclause 9.1.1 shall apply.

Additionally the following applies.

- Element 'communication type' shall be set to 01_2 for operation through a DM-REP, or to 11_2 for operation through a DM-REP/gateway. This shall apply for both the master and slave link, and for signalling both to and from the DM-REP.

- For operation through a DM-REP, the 'master/slave link flag' shall be included and shall be set to indicate whether the PDU is being sent on the master link or the slave link.

- For a PDU sent on the master link, the slot and frame number elements shall be set using the master link's slot and frame numbering. For a PDU sent on the slave link, the slot and frame number elements shall be set using the slave link's slot and frame numbering.

- For operation on a type 1 DM-REP, element 'A/B channel usage' shall be set to 00_2.

- The DM-REP address shall be included within the SCH/H block.

10.1.2 DPRES-SYNC PDU

If used, the DPRES-SYNC PDU shall be transmitted using the 60 available bits of the logical channel SCH/S and the 124 available bits of the logical channel SCH/H. Its purpose is to announce the presence of a DM-REP (or DM-GATE) to MSs on the DM channel. Its content shall be as given in tables 2 and 3.

Table 2: DPRES-SYNC PDU contents in SCH/S

Information element	Length	Type	Remark
System code	4	M	
SYNC PDU type	2	M	value 01_2 indicates DPRES-SYNC PDU
Communication type	2	M	value 00_2 not valid
DM-REP or gateway address	10	M	
Type 1 / Type 2 DM-REP	1	M	
Power class	3	M	
Channel state	2	M	indicates channel free, in occupation or in reservation
A/B Channel Usage	2	M	
Slot number	2	M	
Frame number	5	M	
Reserved	27	M	

Table 3: DPRES-SYNC PDU contents in SCH/H

Information element	Length	Type	Remark
Reserved	30	M	
Proprietary	94	M	

10.2 Layer 2 PDUs sent in DNB

ETS 300 396-3 [4], subclause 9.2 shall apply.

10.3 Layer 2 information element coding

ETS 300 396-3 [4], subclause 9.3 shall apply.

10.4 Messages generated by layer 2

ETS 300 396-3 [4], subclause 9.4 shall apply.

When the DM-REP re-transmits the DM-RESERVED message on the slave link, it shall set the 'power class' element to its own power class, or to a null value if DM-MS power control procedures are to be disabled.

10.5 Layer 3 PDUs

Subclause 9.5 of part 3 of this ETS 300 396-3 [4], subclause 9.5 shall apply.

When the DM-REP re-transmits DM-SETUP, DM-SETUP PRES and DM-OCCUPIED messages on the slave link, it shall set the 'power class' element to its own power class, or to a null value if DM-MS power control procedures are to be disabled.

10.6 Message dependent elements coding

ETS 300 396-3 [4], subclause 9.6 shall apply.

10.7 DM-SDU elements coding

ETS 300 396-3 [4], subclause 9.7 shall apply.

NOTE: For operation through a DM-REP, 'release cause' value 110_2 may be used in the DM-RELEASE PDU to indicate failure of link establishment to the DM-REP.

11 Radio aspects of DM-MS (for operation through type 1 DM-REP)

ETS 300 396-2 [3] shall apply with the following addition.

Addition to subclause 10.2 (RF power control)

Adaptive DM-MS RF power control shall be optional for operation through a DM-REP.

Adaptive DM-MS RF power control may be implemented as a manufacturer dependent option for operation through a DM-REP according to the principles used in V+D operation ETS 300 392-2 [5], clauses 21 and 23.

12 Radio aspects of type 1 DM-REP

12.1 Introduction

This clause details only those radio aspects of DM-REP equipment which are unique from that specified for DM mobile radio equipment in ETS 300 396-2 [3].

12.2 Modulation

ETS 300 396-2 [3], clause 5 shall apply.

12.3 Radio transmission and reception

12.3.1 Introduction

ETS 300 396-2 [3], subclause 6.1 shall apply.

12.3.2 Frequency bands and channel arrangement

DM-REP equipment may only transmit and receive in those channels allocated for TETRA DM use. The TETRA DM RF carrier separation shall be 25 kHz.

12.3.3 Reference test planes

ETS 300 396-2 [3], subclause 6.3 shall apply.

12.3.4 Transmitter characteristics

ETS 300 396-2 [3], subclause 6.4 shall apply, with the following differences.

Amendment to subclause 6.4.2 (DM-REP power classes)

The DM-DM-REP nominal power shall be, according to its class, as defined in table 4.

Table 4: Nominal power of DM-REP transmitters

Power class	Nominal power
1 (30W)	45 dBm
2 (10W)	40 dBm
3 (3W)	35 dBm
4 (1W)	30 dBm
5	not defined for DM-REP

Amendment to subclause 6.4.3.3 (Unwanted conducted emissions far from the carrier)

Wideband noise limits:

Table 5: DM-REP wideband noise limits

Frequency offset (kHz)	Maximum level (dBc)			
	1W (class 4)	3W (class 3)	10W (class 2)	30W (class 1)
100 kHz - 250 kHz	-75 dBc	-80 dBc	-82 dBc	-82 dBc
250 kHz - 500 kHz	-80 dBc	-85 dBc	-87 dBc	-87 dBc
>500 kHz	-85 dBc	-88 dBc	-92 dBc	-92 dBc

All levels are expressed in dBc relative to the actual transmitted power level.

In the case where a DM-DM-REP transmits on a DM channel frequency which is within the normal V+D MS Tx band, then the following limits shall apply symmetrically to both sides of the V+D MS Tx band.

Table 6: Direct Mode wideband noise limits (continued)

Frequency offset (kHz)	Maximum level all classes (dBc)
$>f_{rb}$	-100 dBc

where f_{rb} denotes the frequency offset corresponding to the near edge of the V+D MS receive band with $f_{rb} \geq 5$ MHz.

In other cases, where DM-REP transmissions take place within the normal V+D MS Rx band, the -100 dBc requirement shall apply outside of the frequency range f_x which comprises the range of frequencies over which the equipment is able to transmit within the TETRA standard, plus a guard band of 5 MHz on either side as shown in figure 9.

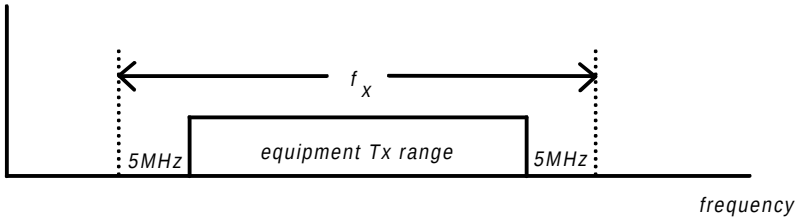

Figure 9: Definition of f_x

In any case no limit tighter than -70 dBm shall apply.

12.3.5 Receiver characteristics

ETS 300 396-2 [3], subclause 6.5 shall apply.

12.3.6 Transmitter/Receiver performance

Subclause 6.6 of part 2 of this ETS 300 396-2 [3], subclause 6.6 shall apply.

12.4 Radio sub-system synchronisation

12.4.1 Introduction

ETS 300 396-2 [3], subclause 7.1 shall apply.

12.4.2 Definitions and general requirements for synchronisation

ETS 300 396-2 [3], subclause 7.2 shall apply, with the following differences.

The DM-REP shall synchronise itself in terms of frequency and time to the current master DM-MS. Moreover, the DM-REP shall use the timing information contained in the SCH/S transmitted by the master DM-MS to set its time slot and frame counters.

During the call (channel occupation), or during channel reservation, the DM-REP shall maintain its synchronisation by continuously monitoring the synchronisation bursts sent by the master DM-MS at intervals.

The DM-REP shall time its transmissions to the master or to the slave DM-MSs in line with those received from the master DM-MS. This process is called "DM-REP timebase adjustment". The timebase of the DM-REP shall continuously count quarter symbols, symbols, timeslots and frames, in accordance with ETS 300 396-2 [3], subclause 7.3 independently of whether the DM-REP is transmitting or not.

The DM-REP shall in its turn transmit synchronisation bursts on the slave link to enable synchronisation of the slave DM-MSs. The timing information contained in the SCH/S transmitted by the DM-REP shall refer to the slot and frame number at which the synchronisation burst is transmitted.

NOTE 1: The slot and frame numberings are different on the master and slave links and the DM-REP therefore uses the slot and frame numbering system of the slave link when transmitting its synchronisation bursts on that link.

During a changeover, the DM-REP shall synchronise itself in terms of frequency and time on the synchronisation bursts sent by the new master DM-MS. In normal cases (see NOTE), the slave DM-MS which becomes the new master DM-MS after a changeover has been carried out successfully shall adopt the state of the timing counters used by the old master; refer to subclause 8.5.6.2.

NOTE 2: An exception may be in the case of dual watch.

12.4.3 Timebase counters

ETS 300 396-2 [3], subclause 7.3 shall apply.

12.4.4 Requirements for the frequency source of a DM-REP

ETS 300 396-2 [3], subclause 7.4 shall apply.

12.4.5 Requirements for the synchronisation of a DM DM-REP

ETS 300 396-2 [3], subclause 7.5 shall apply.

12.5 Channel coding

ETS 300 396-2 [3], clause 8 shall apply.

12.6 Channel multiplexing for DM operation through a DM-REP

ETS 300 396-2 [3], clause 9 shall apply, with the following addition:

- The start of the multiframe and frame on the slave link shall occur 3 timeslot duration after the start of the corresponding multiframe and frame on the master link.

12.7 Radio sub-system link control

ETS 300 396-2 [3], clause 10 shall apply, with the following difference:

- DM-REP adaptive RF power control shall not be performed.

Annex A (normative): Timers and constants in DM-MS and DM-REP

A.1 Introduction

This annex lists the timers and constants in a DM-MS when operating through a type 1 DM-REP. The values of these timers and constants shall be configurable within the DM-MS. Where indicated, a value should be chosen by the MS designer from within the specified range or given at subscription to the DM channel. For other timers and constants, a default value is specified. The default value shall be used by the MS unless it received a different value at subscription.

This annex also lists the timers and constants in the DM-REP. The values of these timers and constants shall be configurable within the DM-REP. Suggested default values for these timers and constants are given.

A.2 Layer 3 timers in DM-MS

T.303 Time-out waiting for response to DM-SETUP PRES.
Default value = 500 ms.

T.311 Call transaction timer.
Value to be chosen by MS designer or given at subscription.
Maximum permitted value = 300 seconds.

T.314 Time-out for reporting SDS failure after sending DM-PRE ACCEPT.
Default value = 600 ms.

T.316 Time-out waiting for response to DM-SDS DATA.
Default value = 600 ms.

A.3 Layer 3 constants in DM-MS

N.303 Maximum number of attempts to send DM-SETUP PRES if no response received.
MS designer choice from the range 1 to 3.

N.304 Maximum number of attempts to send DM-SETUP or DM-SETUP PRES if link establishment to DM-REP has failed.
MS designer choice from the range 1 to 3.

N.314 Number of transmissions of DM-SDS UDATA.
Value may be chosen by MS designer, or may be message dependent, from the range 1 to 6.

N.315 Maximum number of attempts to send DM-SDS DATA if negative response received.
MS designer choice from the range 2 to 6.

N.316 Maximum number of attempts to send DM-SDS DATA if no response received.
MS designer choice from the range 1 to 3.

N.317 Maximum number of attempts to send DM-SDS UDATA or DM-SDS DATA if link establishment to DM-REP has failed.
MS designer choice from the range 1 to 3.

A.4 Layer 2 timers in DM-MS

T.205 Time when randomisation is required after channel becomes free.
Default value = 36 frames.

T.210 Channel time allowed by master for acknowledgement to DM-SDS DATA.
Default value = 6 frames in all cases.

T.211 Time-out waiting for random access response (circuit mode occupation/reservation).
Default value = 6 frames.

T.212 Time-out waiting for random access response (short data occupation).
Default value = 12 frames.

T.213 Random access time-out.
MS designer choice from the range 5 to 60 multiframes.

T.214 Validity time-out when attempting random access.
Default value = 36 frames.

T.221 Inactivity time-out for reception of traffic.
Default value = 90 frames.

T.225 Link to DM-REP time-out for master DM-MS in circuit mode occupation/reservation.
Default value = 90 frames.

A.5 Layer 2 constants in DM-MS

N.205 Maximum randomisation after channel becomes free.
Default value = 6.

N.210 Maximum number of frames containing response DSB.
Default value = 3.

N.213 Maximum number of non-emergency random access transmissions.
Default value = 8.

N.231 Number of frames in which the master DM-MS expects the DM-REP to transmit the DSB heading a DM-SDS UDATA or DM-SDS DATA message on the slave link.
Default value = 2.

N.232 Number of frames in which the master DM-MS expects the DM-REP to transmit its DM-SETUP or DM-SETUP PRES message on the slave link.
Default value = 2.

NOTE: N.231 and N.232 apply to both DM-MS and DM-REP. For correct operation of the short data protocol and the air-interface encryption methods, it is essential that the master DM-MS uses the same values of N.231 and N.232 as the DM-REP.

A.6 Maximum number of frame transmissions by DM-MS

Table A.1 shows the minimum and maximum number of frames in which each message may be sent by the source DM-MS.

Table A.1: Number of frame transmissions

Message type	Min to Max no. of frames in which message may be sent
DM-SETUP	1 to 4
DM-SETUP PRES	1 to 4
DM-CONNECT	1 to N.210
DM-DISCONNECT	1 to N.210
DM-TX CEASED	2 to 4
DM-RELEASE	2 to 4
DM-TX ACCEPT	2 to 4
DM-PRE ACCEPT	2 to 4
DM-REJECT	1 to 4
DM-TIMING ACK	1 to 4 during occupation 2 to 4 during reservation
DM-SDS DATA (DSB)	1 to 4
DM-SDS UDATA (DSB)	1 to 4
DM-SDS ACK (DSB)	1 to N.210

A.7 Layer 2 timers in DM-REP

T.251 Interval between transmissions of DM-REP presence signal on a free channel.
A value of 0 indicates that the DM-REP does not transmit the presence signal.
Default value = 18 frames.

T.253 DM-REP time-out looking for DM-PRE ACCEPT in DNB during reservation.
Default value = 4 frames.

T.254 DM-REP time-out waiting for response to DM-SDS DATA on slave link.
Default value = 4 frames.

T.255 DM-REP time-out waiting for call set-up signalling after pre-emption or changeover.
Default value = 9 frames.

T.261 DM-REP time-out waiting for response to DM-SETUP PRES on slave link.
Default value = 4 frames.

T.262 Occupation time-out if DM-OCCUPIED not received.
Default value = 180 frames.

T.263 Reservation time-out if DM-RESERVED not received.
Default value = 180 frames.

A.8 Layer 2 constants in DM-REP

N.231 Number of frames in which the DM-REP transmits the DSB heading a DM-SDS UDATA or DM-SDS DATA message on the slave link.
Default value = 2.

N.232 Number of frames in which the DM-REP transmits a DM-SETUP or DM-SETUP PRES message on the slave link.
Default value = 2.

NOTE: N.231 and N.232 apply to both DM-MS and DM-REP. For correct operation of the short data protocol and the air-interface encryption methods, it is essential that the master DM-MS uses the same values of N.231 and N.232 as the DM-REP.

Annex B (normative): Mathematical definition of Frame Check Sequence (FCS)

ETS 300 396-3 [4], annex B shall apply.

Annex C (informative): Changes assumed within ETS 300 396-3 [4]

This is a temporary annex, to be deleted during the resolution phase following Public Enquiry.

During the preparation of this ETS, it was found convenient to assume that some changes would be made to the March 1996 version of ETS 300 396-3 [4] during the Public Enquiry, in order to achieve maximum compatibility between the protocols in ETS 300 396-3 [4] and this part. These changes are listed in this annex. The amended version of ETS 300 396-3 [4] should be assumed when reading this part.

1) The following re-ordering of the DMAC-SYNC PDU has been assumed, and the 'master/slave link flag' will replace the 'DM-REP flag'.

Table 20: DMAC-SYNC PDU contents in SCH/S

Information element	Length	Type	Remark
System code	4	M	
SYNC PDU type	2	M	Value 00_2 indicates DMAC-SYNC PDU
Communication Type	2	M	Set to 00_2 for direct MS-MS operation
Reserved	1	C	Included if Communication Type = 00_2 or Communication Type = 10_2; default value = 0
Master/Slave Link Flag	1	C	Included if Communication Type = 01_2 or Communication Type = 11_2
A/B Channel Usage	2	M	
Slot Number	2	M	
Frame number	5	M	
AI Encryption State	2	M	Determines interpretation of following 39 bits
Time Variant Parameter	29	C	Included if AI Encryption State $\neq 00_2$
Timestamp flag	1	C	Included if AI Encryption State $\neq 00_2$
KSG No.	4	C	Included if AI Encryption State $\neq 00_2$
Encryption Key No.	5	C	Included if AI Encryption State $\neq 00_2$
Reserved	39	C	Included if AI Encryption State = 00_2, default value = all zeroes
Reserved	1	M	Default value = 0

2) In the 'message type' element (see subclause 9.3), two values will be made available for customisation of systems: values 11110_2 and 11111_2.

3) The 'DM-REP flag' definition in subclause 9.3 will be deleted and replaced by the following definition of the 'master/slave link flag'.

The Master/Slave Link Flag indicates, for operation through a DM-REP, whether this transmission is being sent on the master link or slave link. Its inclusion is in order to avoid erroneous detection of transmissions to a DM-REP.

Information element	Length	Value	Remark
Master/Slave Link Flag	1	0	Transmission on Slave Link
		1	Transmission on Master Link

4) The SYNC PDU type in part 3 will include the DPRES-SYNC PDU.

Information element	Length	Value	Remark
SYNC PDU type	2	00_2	DMAC-SYNC
		01_2	DPRES-SYNC Refer to ETS 300 396-4
		10_2	Reserved
		11_2	Reserved

5) For clarity, message DM-SDS OCC will be re-named as DM-SDS OCCUPIED. This is because the shortened name is easily confused during discussion with DM-SDS ACK.

A 3-bit 'power class' element will be added to the DM-RESERVED message.

Table 26: DM-RESERVED message dependent elements

Information element	Length	Type	Remark
Reservation Time Remaining	6	M	
Timing flag	1	M	
Requests flag	1	M	
Changeover requests bitmap	8	M	
Power class	3	M	
Priority Level	2	M	

7) A 3-bit 'power class' element will be added to the DM-SETUP, DM-SETUP PRES and DM-OCCUPIED messages. Also, the 'basic service information' element will be split into three independent elements so that the 'circuit mode type' can become a message-dependent element (enabling visibility at the DM-REP).

Table 30 / 31 / 34: DM-SETUP / DM-SETUP PRES / DM-OCCUPIED PDU contents

Information element	Length	Type	Remark
Message dependent elements			
Timing flag	1	M	
LCH in frame 3	1	M	
Pre-emption flag	1	M	
Power class	3	M	
Reserved	4	M	Default value = 0000_2
Circuit mode type	3	M	
Reserved	4	M	Default value = 0000_2
Priority Level	2	M	
DM-SDU elements			
End-end encryption flag	1	M	
Call type flag	1	M	
Reserved	4	M	Default value = 0000_2

8. The 'basic service information' element in DM-CONNECT will be replaced by the 'circuit mode type', which becomes a message-dependent element (enabling visibility at the DM-REP).

Table 32: DM-CONNECT PDU contents

Information element	Length	Type	Remark
Message dependent elements			
Circuit mode type	3	M	
Reserved	4	M	Default value = 0000_2
DM-SDU elements			
Reserved	4	M	Default value = 0000_2

9) The following description of the 3-bit 'power class' element will be added to subclause 9.6.

The Power Class element is used to indicate the power of the transmitting party. The Power Class element shall always be set to 000_2 for direct MS-MS operation.

Information element	Length	Value	Remark
Power Class	3	000_2	Null value (i.e. power not defined)
		001_2	Power class 1
		010_2	Power class 2
		011_2	Power class 3
		100_2	Power class 4
		101_2	Power class 5
		110_2	Reserved
		111_2	Reserved

10) The 'release cause' element in subclause 9.7 will be modified as shown below, to include a value to indicate that the calling party perceived failure of link establishment to a DM-REP or gateway. Also, value 'call set-up failed' will be removed.

Information element	Length	Value	Remark
Release Cause	3	000_2	Cause not defined or unknown
		001_2	Pre-empted use of resource
		010_2	Calling user initiated release
		011_2	Called party offered unacceptable service
		100_2	Called party is not reachable
		101_2	Called party rejected call
		110_2	Link establishment to DM-REP or gateway failed (not applicable for direct MS-MS operation)
		111_2	Reserved

11) The description of the 'basic service information' element will be deleted from subclause 9.7. It will be replaced by three separate elements: the 'circuit mode type' element will be described in subclause 9.6; the 'end-end encryption flag' and 'call type flag' will be described in subclause 9.7.

Circuit Mode Type

The Circuit Mode Type element is used to indicate the basic traffic service which is requested for a circuit mode call. It indicates the traffic channel (TCH) type and the interleaving depth N (see ETS 300 396-2, clause 8).

Information element	Length	Value	Remark
Circuit Mode type	3	000_2	Speech: TCH/S
		001_2	Unprotected: TCH/7,2
		010_2	Low Protection: TCH/4,8, N=1
		011_2	Low Protection: TCH/4,8, N=4
		100_2	Low Protection: TCH/4,8, N=8
		101_2	High Protection: TCH/2,4, N=1
		110_2	High Protection: TCH/2,4, N=4
		111_2	High Protection: TCH/2,4, N=8

End-to-end Encryption Flag

The End-to-end Encryption Flag is used to indicate whether the traffic in a circuit mode call will be end-to-end encrypted.

Information element	Length	Value	Remark
End-to-end Encryption Flag	1	0	Clear Mode
		1	With end-to-end encryption

Call Type Flag

The Call Type Flag is used to indicate whether a circuit mode call is an individual or group call.

Information element	Length	Value	Remark
Call Type flag	1	0	Group Call
		1	Individual Call

12) In the A/B Channel Usage element (see subclause 9.3) value 00_2 will be defined as ' operating through type 1 DM-REP'.

History

Document history			
December 1996	Public Enquiry	PE 119:	1996-12-02 to 1997-03-28