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Contents

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Foreword

This draft European Telecommunication Standard (ETS) has been produced by the Terrestrial Trunked Radio (TETRA) Project 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: "Radio aspects";

Part 3: "Mobile Station to Mobile Station (MS-MS) Air Interface (AI) protocol";

Part 4: "Repeater type 1";

Part 5: "Gateways";

Part 6: "Security";

Part 7: "Repeater type 2";

Part 8: "Protocol Implementation Conformance Statement (PICS) proforma specification".

Proposed transposition dates	
Date of latest announcement of this ETS (doa):	3 months after ETSI publication
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1 Scope

This European Telecommunication Standard (ETS) defines the Terrestrial Trunked Radio (TETRA) Direct Mode Operation (DMO). It specifies the basic air interface, the inter-working between Direct Mode (DM) groups via repeaters, and inter-working with the TETRA Voice plus Data (V+D) system via gateways. 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 Direct Mode Repeater (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 supporting two calls on the air interface (type 2 DM-REP). They also cover the operation of a Direct Mode Mobile Station (DM-MS) with a type 2 DM-REP.

NOTE 1: The specifications for a Direct Mode Repeater/Gateway (DM-REP/GATE) combined implementation are provided in ETS 300 396-5 [5], together with the specifications for a Direct Mode Gateway (DM-GATE).

NOTE 2: The specifications for a DM-REP as a stand-alone unit supporting a single call on the air interface (type 1 DM-REP) are provided in ETS 300 396-4 [4].

The protocol for a DM-MS operating with a type 2 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 specifications provided in ETS 300 396-2 [2] and ETS 300 396-3 [3] for direct MS-MS operation, and ETS 300 396-4 [4] for type 1 DM-REP operation. These clauses define where the protocol in parts 2, 3 and 4 applies without change, or where it applies with the specified amendments, replacements or additions. Where no reference to parts 2, 3 or 4 exists, the subclause should be regarded as independent.

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

The normative annex mainly specifies 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] ETS 300 396-1: "Terrestrial Trunked Radio (TETRA); Technical requirements for Direct Mode Operation (DMO); Part 1: General network design".

[2] ETS 300 396-2: "Terrestrial Trunked Radio (TETRA); Technical requirements for Direct Mode Operation (DMO); Part 2: Radio aspects".

[3] ETS 300 396-3: "Terrestrial Trunked Radio (TETRA); Technical requirements for Direct Mode Operation (DMO); Part 3: Mobile Station to Mobile Station (MS-MS) Air Interface (AI) protocol".

[4] ETS 300 396-4: "Terrestrial Trunked Radio (TETRA); Technical requirements for Direct Mode Operation (DMO); Part 4: Type 1 repeater air interface".

[5] ETS 300 396-5: "Terrestrial Trunked Radio (TETRA); Technical requirements for Direct Mode Operation (DMO); Part 5: Gateway air interface".

[6] ETS 300 396-6: "Terrestrial Trunked Radio (TETRA); Direct Mode Operation (DMO); Part 6: Security".

[7] 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: there are two types of call, individual call or group call. 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.

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): 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.

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

DM channel: specific grouping of timeslots in the DM multiplex structure related to a particular DM RF carrier i.e. DM frequency (or to a pair of duplex-spaced RF carriers for operation with a type 1B or type 2 DM-REP or a type 1B DM-REP/GATE). The grouping may not always be fixed, but in DMO when operating in frequency efficient mode as an example, there are two DM channels, identified by the letters A and B.

Direct Mode Mobile Station (DM-MS): 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 synchronization 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 synchronization information to the channel;

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

DM-REP presence signal: message transmitted by a DM-REP in order to indicate its presence on an RF carrier.

Dual Watch Mobile Station (DW-MS): MS that is capable of both TETRA DMO and TETRA V+D operation. The MS is capable of periodically monitoring the V+D control channel while in a DM call or a DM RF carrier while in a V+D call; or, when idle, it periodically monitors both the DM RF carrier and the V+D control channel.

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

Direct Mode REPeater (DM-REP): device that operates in TETRA DMO and provides a repeater function to enable two or more DM-MSs to extend their coverage range. It may be either a type 1 DM-REP, supporting a single call on the air interface, or a type 2 DM-REP, supporting two calls on the air interface. A type 1 DM-REP may operate on either a single RF carrier (type 1A DM-REP) or a pair of duplex-spaced RF carriers (type 1B DM-REP). A type 2 DM-REP operates on a pair of duplex-spaced RF carriers.

frame number: counter indicating the timing of frames within a DMO multiframe.

frequency efficient mode: mode of operation where two independent DM communications are supported on a single RF carrier (or pair of duplex-spaced RF carriers for operation with a type 2 DM-REP). In frequency efficient mode the two DM channels are identified as channel A and channel B.

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

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

Medium Access Control (MAC) block: 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 half slot.

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

normal mode: mode of operation where only one DM communication is supported on an RF carrier (or pair of duplex-spaced RF carriers for operation with a type 1B DM-REP or type 1B DM-REP/GATE).

presence signal: message transmitted by a DM-REP or a gateway in order to indicate its presence on an RF carrier.

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

recent user: DM-MS that was master of the call transaction immediately prior to the current master's call transaction in a call.

recent user priority: service which gives the recent user a preferred access to request transmission when the current master is ceasing its call transaction in a group call. This service is controlled by the current master.

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

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

surveillance: process of determining the current state of the DM RF carrier.

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

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

Type 1 call: call using the protocol defined in ETS 300 396-4 [4]. There are two varieties of type 1 call:

- **type 1A call:** which is a call through a type 1A DM-REP;

- **type 1B call:** which is a call using the protocol for operation with a type 1B DM-REP.

A DM-MS may make a type 1B call through a type 1B DM-REP. It may also make a type 1B call through a type 2 DM-REP if permitted by the DM-REP.

Type 1 DM-REP: DM repeater that supports a single call on the air interface. There are two varieties of type 1 DM-REP:

- **type 1A DM-REP:** which operates on a single RF carrier;

- **type 1B DM-REP:** which operates on a pair of duplex-spaced RF carriers, one used as the "uplink" from DM-MSs to the DM-REP and the other used as the "downlink" from the DM-REP to DM-MSs.

The protocol for operation with a type 1 DM-REP (either a type 1A or a type 1B DM-REP) is based on the protocol for normal mode in ETS 300 396-3 [3].

Type 2 call: call using the protocol defined in this part of the ETS. A DM-MS may make a type 2 call only through a type 2 DM-REP.

Type 2 DM-REP: DM repeater that is capable of supporting two simultaneous type 2 calls on the air interface. A type 2 DM-REP operates on a pair of duplex-spaced RF carriers, one used as the "uplink" from DM-MSs to the DM-REP and the other used as the "downlink" from the DM-REP to DM-MSs. The protocol for type 2 calls through a type 2 DM-REP is based on the protocol for frequency efficient mode in ETS 300 396-3 [3]. (A type 2 DM-REP may also optionally offer type 1B calls using the protocol defined in ETS 300 396-4 [4].)

V+D operation: 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 Ratio
DLB	Direct Mode Linearization Burst
DLL	Data Link Layer
DM	Direct Mode
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
DU-MS	Dual Mode (V+D/Direct Mode) switchable Mobile Station
DW-MS	Dual Watch Mobile Station
FN	Frame Number
LCH	Linearization Channel
MAC	Medium Access Control
MCCH	Main Control Channel
MER	Message Erasure Rate
mod	modulo (base for counting)
PDU	Protocol Data Unit
PL	Physical Layer
QN	Quarter Symbol Number
RF	Radio Frequency
SCCH	Secondary control Channel
SCH	Signalling Channel
SDS	Short Data Service
SDU	Service Data Unit
STCH	Stealing Channel
SwMI	Switching and Management Infrastructure
TN	Timeslot Number
V+D	Voice plus Data

4 Overview of protocol

4.1 General

TETRA DMO using a DM repeater (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. It normally performs de-encoding and re-encoding operations on the DM-MS transmission bits prior to regeneration in order to improve BER performance.

The DM-REP may optionally generate a presence signal. The purpose of this signal is to inform any DM-MSs monitoring the channel that the DM-REP is now present and available for service.

The DM-REP is specifically addressed by a DM-MS if the DM-MS wishes it to support a call, by inclusion of the repeater address within the call set-up messages.

The following types of DM-REP are standardized in this ETS:

Type 1: single-call regenerating repeater:

A type 1 DM-REP can support only one call at a time. There are two varieties of type 1 DM-REP:

a) A type 1A DM-REP conducts transmit and receive operations on a single RF carrier, re-transmitting bursts received from a DM-MS during one timeslot to other DM-MS(s) in a different timeslot.

b) A type 1B DM-REP is similar to a type 1A DM-REP except that it uses a pair of duplex-spaced RF carriers, one as an "uplink" from DM-MSs to the DM-REP (RF carrier f_1) and the other as the "downlink" from the DM-REP to DM-MSs (RF carrier f_2).

The protocol for operation with a type 1 DM-REP (either a type 1A or a type 1B DM-REP) is based on the protocol for normal mode in ETS 300 396-3 [3].

Type 2: two-call regenerating repeater:

A type 2 DM-REP is capable of supporting two simultaneous calls on the air interface. It uses a pair of duplex-spaced RF carriers, one as an "uplink" from DM-MSs to the DM-REP (RF carrier f_1) and the other as the "downlink" from the DM-REP to DM-MSs (RF carrier f_2). The protocol for operation with a type 2 DM-REP is based on the protocol for frequency efficient mode in ETS 300 396-3 [3].

NOTE: In this part of the ETS, the term "frequency efficient mode" is used in the description of the protocol with a type 2 DM-REP. Similarly, in ETS 300 396-4 [4], the term "normal mode" is used in the description of the protocol with a type 1 DM-REP. These terms are used for compatibility with ETS 300 396-3 [3], since the type 1 DM-REP air interface supports a single call at a time (as for normal mode in ETS 300 396-3 [3]) whereas the type 2 DM-REP air interface supports two calls at a time (as for frequency efficient mode in ETS 300 396-3 [3]). However it should be noted that the efficiency of frequency usage with a type 1A DM-REP is actually the same as with a type 2 DM-REP.

The method of selection of the appropriate DM RF carrier(s) is not standardized in this part of the ETS.

Both type 1 and type 2 DM-REPs are primarily layer 2 devices comprising 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.

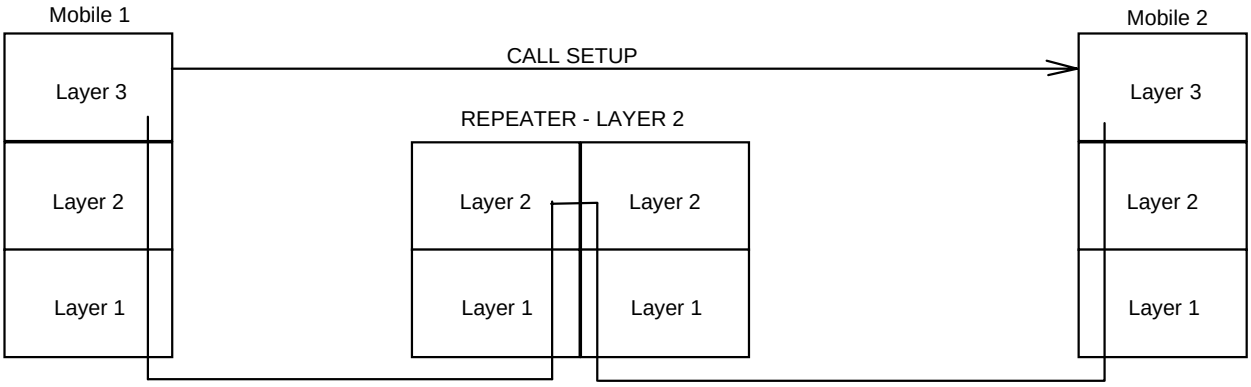

Figure 1: Protocol stack of DM-REP

It is optional for a DM-MS to support operation with a DM-REP. If a DM-MS supports operation with a DM-REP then it may support operation with one or more of the following: a type 1A DM-REP, a type 1B DM-REP or a type 2 DM-REP.

This part of this ETS covers only the operation of a type 2 DM-REP and the operation of a DM-MS with a type 2 DM-REP.

The operation of a type 1 DM-REP (either a type 1A or a type 1B DM-REP) and the operation of a DM-MS with a type 1 DM-REP (either a type 1A or a type 1B DM-REP) are described in ETS 300 396-4 [4].

The remainder of this clause contains an introduction to the protocol for operation with a type 2 DM-REP.

4.2 The DM channel

Two DM channels (designated channel A and channel B) may exist on the pair of duplex-spaced RF carriers. A call using channel A is primarily conducted in timeslots 1 and 3 in each frame on each of the RF carriers, whereas a call using channel B occupies the other two timeslots. From the perception of the DM-MSs on channel B, the channel B timeslots are also regarded as being timeslots 1 and 3.

A DM channel can be perceived as being in one of three states:

- free, where there is no activity on the channel (or in the case where a DM-REP provides a signal indicating its presence, 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 DM-MS wishing to make a call 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 transmits signalling in DM Synchronization Bursts (DSBs) in frames 6, 12, and 18, and transmits traffic in DM Normal Bursts (DNBs) in frames 1 to 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 appropriate frame and timeslot on the "slave link".

NOTE: All communications between the master DM-MS and the DM-REP are conducted on the "master link". All communications between slave DM-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 transmits DSBs 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 may become reserved after the conclusion of each call transaction, in which case it normally 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 type 2 DM-REP, timing synchronization between channel A master DM-MS and DM-REP participating in a call is handled in a similar way as for basic DMO described in ETS 300 396-3 [3]. However, in the case of operation through a DM-REP, the slave DM-MSs and channel B master DM-MS are synchronized to the DM-REP transmission timing on the slave link.

The type 2 DM-REP provides the frequency synchronization. If the type 2 DM-REP has been generating the optional presence signal on the downlink RF carrier, the first master DM-MS can align its frequency reference to the DM-REP prior to sending the initial call set-up messages on the uplink RF carrier. If the presence signal or other suitable DM-REP signalling has not been received sufficiently recently, the master DM-MS uses its own internal frequency reference to generate the transmission frequency for the initial call set-up messages.

In both of these cases the master DM-MS then aligns its internal frequency reference to the DM-REP transmissions on the downlink RF carrier and maintains that alignment while it is master.

The slave DM-MSs and channel B master in the call align their internal frequency references to the DM-REP transmissions on the downlink RF carrier and, at change-over, the new master generates the transmission frequency using this alignment.

4.3 DM call procedures for operation with a type 2 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 2 DM-REP. The procedures presented here are not exhaustive and are not intended to show every possible scenario.

Type 2 DM-REPs can support two calls at a time, using a pair of duplex-spaced RF carriers. Transmissions by DM-MSs (on both the master link and slave link) are sent on the appropriate DM "uplink" RF carrier f_1; transmissions from the DM-REP to DM-MSs (on both the master link and slave link) are sent on the associated DM "downlink" RF carrier f_2.

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

cn ≡ DM-CONNECT;
cnk ≡ DM-CONNECT ACK;
occ ≡ DM-OCCUPIED;
pa ≡ DM-PRE ACCEPT (sent in DSB);
par ≡ DM-PRE ACCEPT + DM-RELEASE (sent in DNB);
prq ≡ DM-PREEMPT;
rsv ≡ DM-RESERVED;
sdk ≡ DM-SDS ACK (or first fragment if fragmented);
sdo ≡ DM-SDS OCCUPIED;
sds ≡ DM-SDS DATA (or first fragment if fragmented);
sdu ≡ DM-SDS UDATA (or first fragment if fragmented);
su ≡ DM-SETUP;
sup ≡ DM-SETUP PRES;
txa ≡ DM-TX ACCEPT;
txc ≡ DM-TX CEASED;
txr ≡ DM-TX REQUEST.

Other abbreviations used are:

rps, representing DM-REP presence signal;
tc, representing traffic transmission;
lch, representing slots available for linearization;
p?, representing slots available for pre-emption requests;
sd, representing continuation fragments of DM-SDS UDATA or DM-SDS DATA; and
sda, representing 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 link or slave link.

The DM-REP presence signal is a message sent by the DM-REP during calls. It may also be sent on a free channel to indicate to receiving DM-MSs that the DM-REP is switched on and within range. It includes the DM-REP's 10-bit repeater address and may indicate which DM-MSs are permitted to use that DM-REP.

When a DM-MS makes a call through a DM-REP, it includes the DM-REP's 10-bit repeater address within the set-up message. It needs to know the correct repeater address before making the call, either by prior arrangement or by receiving the DM-REP presence signal. It also needs to know the repeater type (i.e. type 1A, type 1B or type 2).

4.3.1 Constraints on the frame structure

For DMO through a type 2 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 shown in ETS 300 396-2 [2], subclause 4.5.1, the essential building blocks of the DMO structure are the frame which comprises four timeslots, and the multiframe which comprises 18 frames. For type 2 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 4 timeslots duration before the beginning of the corresponding frame n on the slave link.

In order to facilitate the DMO protocol through a type 2 DM-REP, a number of constraints are placed on this structure, in terms of what can be transmitted in any particular slot:

- frame 18 is always used for synchronization 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;

- pre-emption signalling from a slave DM-MS is permitted, during occupation, in slot 3 of slave link frames 3, 6, 9, 12, 15 and 18; the DM-REP then re-transmits the pre-emption message to the current master DM-MS in slot 3 of master link frame 5, 8, 11, 14, 17 or 2 respectively;

- linearization, which is carried out in a DM Linearization Burst (DLB), may be permitted in slot 3 of master link frame 3 (equivalent to slave link frame 2) during a call;

- during occupation, frames 1 to 17 usually carry traffic in slot 1 (in a DNB);

- frames 2, 8 and 14 of the master link may carry a DM-REP presence signal in a DSB in slot 3.

These constraints apply independently for channel A and channel B.

4.3.2 Setting up a call

In DMO through a type 2 DM-REP there are two options for call set-up: a set-up without presence checking whereby transmission commences without explicit knowledge of the presence of any receiving DM-MS(s), and set-up with presence checking whereby a specific acknowledgement is sought before transmission commences. In both cases the master DM-MS monitors the slave link in order to determine that the DM-REP has successfully received and re-transmitted the messages.

4.3.2.1 Call set-up without presence check

For group (point-to-multipoint) and individual (point-to-point) calls a set-up without presence check is the most basic mode of setting up a call in a DM channel. Figure 2 illustrates this procedure for a call being set up on a completely free pair of RF carriers. In this case the call is established on channel A.

master link	17				18				1				2				3				4			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
master-rep f_1	su	su	su	su	su	su	su	su									tc		lch		tc			
rep-master f_2																			lch					

slave link	16				17				18				1				2				3			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
rep-slave f_2									su'	su'	su'	su'	su'	su'	su'	su'			lch		tc'			
slave-rep f_1																			lch				p?	

master link	5				6				7				8				9				10			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
master-rep f_1	tc	su		su	tc	su	occ	su	tc				tc				tc	tc			tc	tc		
rep-master f_2			p?'												rps									

slave link	4				5				6				7				8				9			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
rep-slave f_2	tc'				tc'				tc'	su'	occ'	su'	tc'	su'		su'	tc'				tc'	tc'		
slave-rep f_1											p?												p?	p?

Figure 2: Call sequence for set-up without presence check through type 2 DM-REP

After following the procedures given in subclause 8.4.2 to ascertain the state of the channel, provided the channel is found to be in the state "free", the calling DM-MS may linearize its transmitter. It then establishes the channel synchronization and simultaneously its role as "master" by transmitting a sequence of set-up messages on the master link. These are sent in an appropriate number of frames, using the DSB structure as given in ETS 300 396-2 [2], subclause 9.4.3. These synchronization bursts contain frame count information which defines their position in the timing structure of the 18-frame cyclic multiframe structure. In the example shown in figure 2, 8 synchronization bursts ("su" in the figure) are sent containing frame count information defining their position in frames 17 and 18.

The master DM-MS then listens for the synchronization bursts to be re-transmitted by the DM-REP on the slave link in order to confirm that its signalling to the DM-REP was successful. The DM-REP may transmit in a different number of frames from the number used by the master DM-MS. However, in this example, it sends synchronization bursts in 2 frames giving a total of 8 bursts.

NOTE: In this example the DM-REP does not start re-transmission on the slave link until after the end of the master DM-MS's set-up messages. However, if it had received one of the first of the master DM-MS's set-up messages, it could have chosen to start the re-transmission sooner. This would have allowed the DM-REP to indicate as soon as possible that channel A had become busy, thereby preventing other DM-MSs from sending colliding set-up signalling.

The master DM-MS may then transmit traffic ("tc" in the figure) using the DNB structure, as given in ETS 300 396-2 [2], subclause 9.4.3, in the next available frame which in this example is Frame Number (FN) 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 slots available for linearization ("lch" in the figure), and the synchronization bursts denoting occupation of the channel ("occ" in the figure) which occur in slot 3 of frames 6, 12 and 18 following the initial synchronization.

In this example, pre-emption opportunities occur in slot 3 of frames 3, 6 and 9 on the slave link. A pre-emption request made in slot 3 of frame 3 on the slave link would be re-transmitted 4 slots later in slot 3 of frame 5 on the master link. Figure 2 also shows the transmission of the DM-REP presence signal in slot 3 of frame 8 on the master link. (This slot would have been used for the re-transmission of a pre-emption request from a slave if such a request had been received in slot 3 of frame 6 on the slave link).

Figure 2 also shows a second call being placed on the DM-REP while the first call is still in progress. A DM-MS wishing to make a call will have been monitoring the DM-REP downlink and will have established synchronization to the existing channel A call. The DM-MS then acts as a channel B master and sends call set-up messages in slots 1 and 3 of channel B (in this example these are sent in frames 5 and 6 on the master link and are shown in slots 2 and 4 from the perception of channel A). These set-up messages are repeated by the type 2 DM-REP on the slave link in frames 6 and 7. The channel B master DM-MS monitors the downlink for these repeat transmissions and sends its traffic after completion of transmission of these messages. In this example the first burst of traffic for the call on channel B is sent in frame 9 on the channel B master link (shown as slot 2 from the perception of channel A).

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.

master link	17				18				1				2				3				4			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
master-rep f_1	sup	sup	sup	sup	sup	sup	sup	sup																
rep-master f_2																							cn'	

slave link	16				17				18				1				2				3			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
rep-slave f_2			sup'	sup'	sup'	sup'	sup'	sup'	sup'	sup'	sup'	sup'	sup'	sup'	sup'									
slave-rep f_1																	lch		cn		cn		cn	

master link	5				6				7				8				9				10			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
master-rep f_1					cnk		cnk		tc				tc				tc				tc			
rep-master f_2	cn'		cn'												rps									

slave link	4				5				6				7				8				9			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
rep-slave f_2									cnk'		cnk'		tc'				tc'				tc'			
slave-rep f_1																							p?	

Figure 3: Call sequence for set-up with presence check through type 2 DM-REP

The procedure starts in a similar manner to the set-up without presence check, but the set-up message in the synchronization burst ("sup" in figure 3, with 8 being sent in this example) now requests a response indicating the 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 connect message ("cn" in the figure) indicating its wish to receive the call. In this example, the slave linearizes its transmitter in slot 1 of frame 2 of the slave link, sending a connect message in slot 3 of this frame and then repeating the connect message in the following frame. The connect message is re-transmitted by the DM-REP to the master DM-MS in the appropriate frames on the master link, in this case frames 4 and 5. On receipt of a connect message, the master responds with a connection acknowledgement message ("cnk" in the figure) sent in at least one frame and then, in this example, begins traffic transmission in frame 7 of the master link.

NOTE: In this example the DM-REP received the master DM-MS's first set-up message and chooses to start the re-transmission on the slave link as soon as possible, thereby preventing other DM-MSs from sending colliding set-up signalling.

4.3.3 Changeover in a call

In a DM call through a type 2 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. Note that figure 4 shows the signalling on only one DM channel and that the other DM channel may be supporting another call.

master link	11				12				13				14				15				16			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
master-rep f_1	tc				txc		txc		txc								txa		txa		txa		txa	
rep-master f_2															txr'									

slave link	10				11				12				13				14				15			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
rep-slave f_2	tc'				tc'				txc'		txc'		txc'								txa'		txa'	
slave-rep f_1											txr													

master link	17				18				1				2				3				4			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
master-rep f_1					*su		su		su		su										tc			
rep-master f_2																								

slave link	16				17				18				1				2				3			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
rep-slave f_2	txa'		txa'										su'		su'		su'		su'					
slave-rep f_1																							p?	

NOTE: * indicates start of transmissions by new master DM-MS

Figure 4: Call sequence for changeover in call through type 2 DM-REP (no collisions)

In order to change over the talker (or sender) in a call, the master DM-MS first indicates 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 re-transmitted 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 ("txr" in the figure) in this example is sent by a requesting DM-MS in the next available slot 3 on the slave link following reception of the txc'. This changeover request message is re-transmitted by the DM-REP in the appropriate frame on the master link.

On receipt of a valid changeover request (txr'), the master may then surrender the channel to the successful applicant using a series of changeover acknowledgement messages ("txa" in the figure). On transmission of the changeover acknowledgement messages on the master link, the master then becomes a slave and has no further responsibility for the channel. On receipt of the repeated changeover acknowledgement message (txa'), the requester transmits a sequence of synchronization bursts ("su" in the figure) on the master link using the same frame and slot timing as the previous master. The action of sending the new sequence of synchronization bursts effects the call changeover with the requester becoming the new master for the next call transaction. The set-up messages sent by the new master in frames 18 and 1 of the master link are sent only in slots 1 and 3 and not slots 2 and 4 in case there may be a call on the other DM channel. The DM-REP, when repeating the call set-up messages on the slave link, may choose to use slots 2 and 4 if the other DM channel is free.

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 3 on the master link.

4.3.4 Pre-emption of a DM call

During a DM call through a type 2 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. Note that figure 5 shows the signalling on only one DM channel and that the other DM channel may be supporting another call.

master link	11				12				13				14				15				16			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
master-rep f_1	tc				tc		occ		tc				tc				par		pa		par		pa	
rep-master f_2															prq'									

slave link	10				11				12				13				14				15			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
rep-slave f_2	tc'				tc'				tc'		occ'		tc'				tc'				par'		pa'	
slave-rep f_1											prq													

master link	17				18				1				2				3				4			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
master-rep f_1					*su		su		su		su										tc			
rep-master f_2																								

slave link	16				17				18				1				2				3			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
rep-slave f_2	par'		pa'										su'		su'		su'		su'					
slave-rep f_1																							p?	

NOTE: * indicates start of transmissions by new master DM-MS

Figure 5: Call sequence for pre-emption of call through type 2 DM-REP (no collisions)

The first master sequence in figure 5 shows normal progress of a call through a type 2 DM-REP, with traffic bursts in slot 1 of each frame (1 to 17) on the master link being re-transmitted by the DM-REP on the slave link. A DM-MS wishing to interrupt this call would, if not participating in the call, in any case have had to first determine the state of the channel and in this illustration would have identified that the ongoing call is a call being transmitted through a type 2 DM-REP. The pre-empting DM-MS would then have synchronized 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 transmits a pre-emption request message ("prq" in the figure) at an appropriate position in the slave link frame structure. During occupation, pre-emption is allowed only in slot 3 of slave link frames 3, 6, 9, 12, 15 and 18. When the master successfully decodes the repeated pre-emption request 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 ("par" and "pa" 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 DM-MS ceases its role and relinquishes the channel.

The successful pre-emptor now transmits synchronization bursts to the DM-REP using the master link for the 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 4 on the master link.

4.3.5 Terminating a call

At the end of a call transaction, the master DM-MS sends transmit ceased messages (as usual) and then provides reservation DSBs in frames 6, 12 and 18; these messages are re-transmitted by the type 2 DM-REP on the slave link. If the channel reservation timer expires without either a changeover of the master role having occurred or the master DM-MS resuming traffic transmission then the master DM-MS stops sending reservation DSBs and the channel becomes free.

Alternatively, there is an option for the master DM-MS to terminate the call prematurely by sending channel release messages (DM-RELEASE PDU). The DM-REP re-transmits these messages on the slave link.

4.3.6 DM short data call

4.3.6.1 Unacknowledged short data message

A DM-MS wishing to send an unacknowledged short data message through a type 2 DM-REP follows the procedures to ascertain the state of the channel. Provided that the channel is found to be in the state "free" the DM-MS may linearize its transmitter. It then establishes the channel synchronization and simultaneously its role as "master" by transmitting a sequence of DM-SDS UDATA message headers on the master link, in an appropriate number of frames, using the DSB structure. The DM-SDS UDATA message headers contain frame count information which defines their position in the timing structure of the 18-frame cyclic multiframe structure. In the example shown in figure 6, 8 synchronization bursts ("sdu" in the figure) are sent containing frame count information defining their position in frames 17 and 18. In this example the DM-MS sends in slots 2 and 4 (in addition to slots 1 and 3) as it has determined that the RF carrier is completely free and that there is not a call already on the DM-REP.

The master DM-MS then listens for the DM-SDS UDATA message headers to be re-transmitted by the DM-REP on the slave link in order to confirm that its signalling to the DM-REP was successful. The DM-REP may transmit in a different number of frames from the number used by the master DM-MS. However, in this example, it sends synchronization bursts in 2 frames giving a total of 8 bursts.

The master DM-MS then transmits the remaining parts of the short data message ("sd" in the figure), using the DNB structure, in slot 1 of the following frames. In this example the remaining parts of the message occupy two slots and are sent in frames 3 and 4.

For reliability, the master DM-MS may repeat the complete message transmission immediately (without re-checking that the channel is free), and starting again with DSBs. In this example there is one message repetition, with the DSBs sent in frames 5 and 6; the two DNBs are sent in frames 9 and 10. Note that the master DM-MS does not use slots 2 and 4 in case the other DM channel may now be in use. The DM-REP may choose to use slots 2 and 4 when it repeats the messages on the slave link if the other DM channel is not in use. In this example it has chosen to do so in order to increase the reliability of the signalling.

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

master link	17				18				1				2				3				4			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
master-rep f_1	sdu	sdu	sdu	sdu	sdu	sdu	sdu	sdu									sd		lch		sd			
rep-master f_2																								

slave link	16				17				18				1				2				3			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
rep-slave f_2									sdu'	sdu'	sdu'	sdu'	sdu'	sdu'	sdu'	sdu'					sd'			
slave-rep f_1																			lch					

master link	5				6				7				8				9				10			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
master-rep f_1	sdu		sdu		sdu		sdu										sd				sd			
rep-master f_2																								

slave link	4				5				6				7				8				9			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
rep-slave f_2	sd'								sdu'	sdu'	sdu'	sdu'	sdu'	sdu'	sdu'	sdu'					sd'			
slave-rep f_1																								

Figure 6: Call sequence for SDS (for unacknowledged data) through type 2 DM-REP

4.3.6.2 Acknowledged short data message

When sending short data to an individual DM-MS, the calling DM-MS may request an acknowledgement from the called DM-MS. Figure 7 illustrates the procedure for an acknowledged short data message comprising the DM-SDS DATA message headers followed by three DNBs. Again, in this example, the sending DM-MS has determined that the DM-REP is completely free and so sends in all 4 slots in each frame for enhanced reliability.

The procedure starts in a similar manner to an unacknowledged short data message, but the DM-SDS DATA message headers request an acknowledgement from the receiving slave DM-MS. The slave DM-MS sends the acknowledgement following the receipt of the last burst containing data. In this example data is included in the acknowledgement; the slave DM-MS sends SDS acknowledgement DSBs ("sdk" in the figure) in slots 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" in the figure). The acknowledgement is re-transmitted by the DM-REP to the master DM-MS in the appropriate frames on the master link, in this case frames 8 and 9.

NOTE 1: In this example, the receiving slave DM-MS can linearize its transmitter in slot 3 of slave link frame 2. It therefore does not need to use slot 1 of slave link frame 6 for linearization, so sends the first transmission of its acknowledgement DSB in that slot.

NOTE 2: The short data occupation signalling DSBs which usually occur in slot 3 of frames 6, 12 and 18 following the initial synchronization are only sent during data message transmission and not during the acknowledgement period.

master link	17				18				1				2				3				4			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
master-rep f_1	sds	sds	sds	sds	sds	sds	sds	sds									sd		lch		sd			
rep-master f_2																								

slave link	16				17				18				1				2				3			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
rep-slave f_2									sds'	sds'	sds'	sds'	sds'	sds'	sds'	sds'					sd'			
slave-rep f_1																			lch				p?	

master link	5				6				7				8				9				10			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
master-rep f_1	sd																							
rep-master f_2			p?'										sdk'		sdk'		sda'							

slave link	4				5				6				7				8				9			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
rep-slave f_2	sd'				sd'																			
slave-rep f_1									sdk		sdk		sda											

Figure 7: Call sequence for SDS (for acknowledgement with data) through type 2 DM-REP

5 DM-MS layer 3 service description for operation with a type 2 DM-REP

ETS 300 396-4 [4], clause 5 shall apply.

6 DM-MS layer 3 protocol for operation with a type 2 DM-REP

ETS 300 396-4 [4], clause 6 shall apply except that the note in subclause 6.1 is not appropriate.

NOTE: This part of the ETS covers type 2 DM-REP operation i.e. operation in which the DM-REP can support two simultaneous calls on a pair of duplex-spaced RF carriers. References to frequency efficient mode in ETS 300 396-3 [3], clause 6 are applicable.

7 DM-MS layer 2 service description for operation with a type 2 DM-REP

ETS 300 396-4 [4], clause 7 shall apply.

8 DM-MS layer 2 protocol for operation with a type 2 DM-REP

8.1 Introduction

ETS 300 396-1 [1], clause 5 provides a brief overview of the general architecture and a description of all layers within the DMO protocol including the functionality of the Data Link Layer (DLL). This clause describes in detail the layer 2 protocol and defines the operation of the DLL in a DM-MS operating with a type 2 DM-REP.

NOTE 1: For operation with a type 2 DM-REP, transmissions by DM-MSs are sent on the appropriate DM "uplink" RF carrier f_1 and transmissions from the DM-REP to DM-MSs are sent on the associated (duplex-spaced) DM "downlink" RF carrier f_2. A type 2 DM-REP can support two simultaneous calls on the pair of RF carriers.

NOTE 2: Since a type 2 DM-REP can support two simultaneous calls on the air interface, the protocol for type 2 DM-REP operation is based on the protocol for frequency efficient mode in ETS 300 396-3 [3].

NOTE 3: The methods of slot usage are different in the case of a type 1 DM-REP. The procedures for operation with a type 1 DM-REP are described in ETS 300 396-4 [4].

The DLL in the DM-MS is divided into two sub-layers: the upper MAC and the lower MAC.

8.1.1 Functions of lower MAC

ETS 300 396-3 [3], subclause 8.1.1 shall apply.

See clause 11 for specific details of the lower MAC functionality.

8.1.2 Functions of upper MAC

ETS 300 396-3 [3], subclause 8.1.2 shall apply.

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

8.2 Interface between lower and upper MAC

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

8.3 Basic capabilities of the physical layer

8.3.1 DM-MS capabilities

The following subclauses describe the capabilities required of DM-MSs for operation with a type 2 DM-REP. DM-MSs are classified as either DM only DO-MS, dual mode capable DU-MS or dual watch capable DW-MS.

8.3.1.1 DM only and dual mode capable MS operation

A DO-MS or DU-MS shall be capable of either transmitting on one DM RF carrier (the "uplink" frequency f_1 from DM-MSs to the DM-REP) or receiving on a different DM RF carrier (the "downlink" frequency f_2 from the DM-REP to DM-MSs), in two-frequency simplex mode.

A DO-MS or DU-MS shall be capable of switching between DM transmit and receive within one timeslot duration, approximately 14 ms.

A DO-MS or DU-MS shall be capable of transmitting in all four timeslots of at least two consecutive frames.

A DO-MS or DU-MS which is operating as a channel B master MS shall be capable of adjusting its current transmit timing reference in steps of 1/4 symbol duration, as defined in subclause 8.4.2.5.2 and clause 11.

NOTE: A DW-MS which is operating as a channel A master MS is permitted to adjust its transmit timing reference in steps of 1/4 symbol duration if appropriate.

A DO-MS or DU-MS shall be capable of adjusting its transmission frequency as defined in clause 11.

8.3.1.2 Dual watch capable MS operation

A DW-MS shall support all the operations described in subclause 8.3.1.1 and in addition shall be capable of switching between operating on the DM channel frequency (either uplink or downlink) and the V+D channel frequency within 0,5 of a timeslot duration (approximately 7 ms). This is illustrated in figure 8.

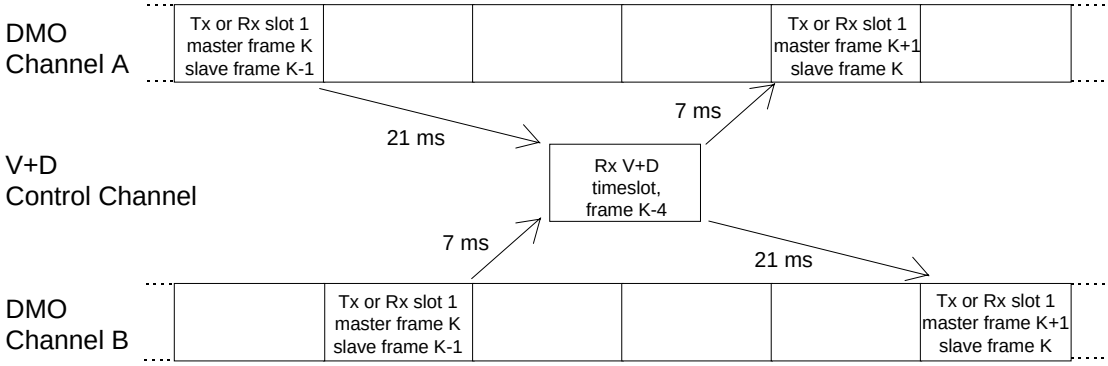

Figure 8: Dual watch timing on type 2 DM-REP

8.4 Usage of DM channel with type 2 DM-REP

A DM channel may be perceived as being in any one of three states, i.e. free, occupied or reserved.

When the DM channel is in occupation or reservation, there is a timing structure which is divided into multiframes, 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 the master DM-MS, on the master link, shall use the master link's slot and frame numbering;

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

For operation with a type 2 DM-REP, the slot and frame numbering on the slave link lags four timeslots behind the master link's slot and frame numbering. Therefore the same slot numbering applies on both the master link and slave link. However, the frame numbering on the slave link lags one frame behind the frame numbering on the master link.

All transmissions from the DM-REP to DM-MSs are sent on the selected DM downlink RF carrier f_2. All transmissions by DM-MSs are sent on the associated (duplex-spaced) DM uplink RF carrier f_1. This applies to both master link and slave link transmissions.

NOTE: The defined master link slot and frame numbering for one DM channel applies on both the uplink RF carrier f_1 and the downlink RF carrier f_2. Similarly, the defined slave link slot and frame numbering for the DM channel applies on both the uplink RF carrier f_1 and the downlink RF carrier f_2.

8.4.1 Definition of DM channel

8.4.1.1 DM channel arrangement

For operation with a type 2 DM-REP, a DM channel existing during occupation and reservation consists of two timeslots on each of the pair of duplex-spaced RF carriers f_1 and f_2, each timeslot lasting for 14,167 ms. The end of one DM channel timeslot and the beginning of the other timeslot associated with the DM channel are separated in time by one timeslot duration. Time on the DM channel is further divided into frames and multiframes, each frame equal to 4 timeslots duration and each multiframe equal to 18 frames duration (see ETS 300 396-2 [2], clause 9 for further details).

For operation with a type 2 DM-REP, the slot and frame numbering on the slave link lags four timeslots behind the master link's slot and frame numbering (as defined above). Thus the master link and the slave link for one DM channel use the same two timeslots on both the uplink RF carrier f_1 and the downlink RF carrier f_2 (on a time-sharing basis). See figure 9.

NOTE: This contrasts with operation on a type 1 DM-REP, for which two timeslots are allocated primarily for the master link and the other two timeslots are allocated primarily for the slave link.

As defined in subclauses 8.4.1.2 and 8.4.1.3, two DM channels (designated channel A and channel B) may exist on the pair of duplex-spaced RF carriers. A call using DM channel A is primarily conducted in timeslots 1 and 3 in each frame on each of the RF carriers, whereas a call using DM channel B occupies the other two timeslots. (From the perception of DM-MSs on channel B, the channel B timeslots are also regarded as being timeslots 1 and 3).

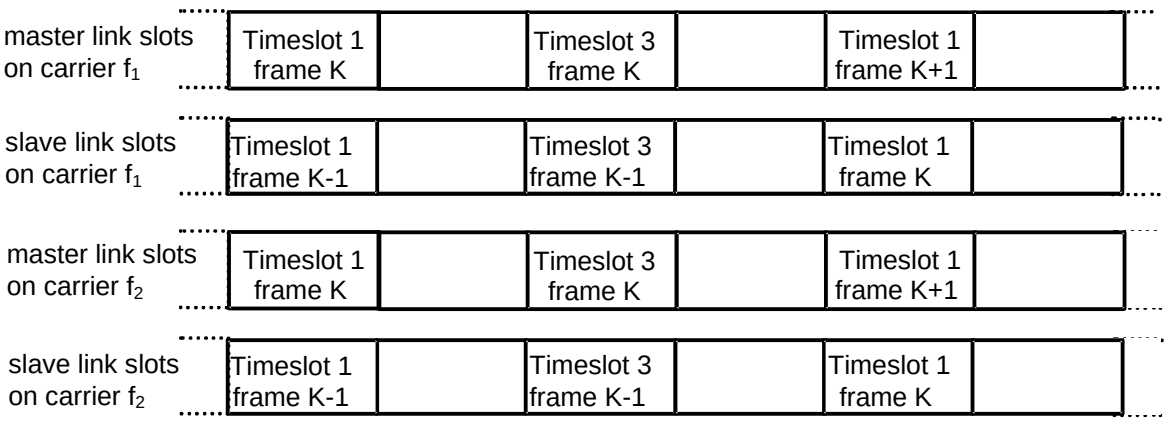

Figure 9: Master link/slave link arrangement for one DM channel on type 2 DM-REP

8.4.1.2 DM channel A operation

A DM-MS wishing to begin a call, and having determined that the selected DM downlink RF carrier is free, shall begin master MS operation - transmitting on the associated uplink RF carrier and using the master link's slot and frame numbering. The channel which is thus occupied is defined as DM channel A.

A call using the DM channel A shall primarily be conducted in timeslots 1 and 3 in each frame. See the following subclauses for exceptions to this rule.

When a DM-MS first becomes master on a free carrier, it shall define the DM timing reference including slot and frame numbering. This includes the case where the DM-REP has been generating a presence signal on the selected downlink RF carrier.

- If the master is not performing dual watch then the DM timing reference (including slot and frame numbering) may be chosen arbitrarily.

NOTE 1: For example, the master may choose to define the frame numbering such that its final repetitions of the call set-up message are sent in frame 18 of the master link.

Or, if the DM-REP has been generating a free-carrier presence signal on the selected downlink RF carrier, the master may choose a DM timing reference based on the timing defined by the DM-REP presence signal (in case that presence signal may have been using the dual watch synchronization). If doing so then it should set the master link's slot and frame numbering four timeslots ahead of the numbering received in slave link DM-REP presence signals.

- If the master is performing dual watch then it shall define the slot boundaries and the slot and frame numbering so that timeslot 1 of frame K of the channel A master link occurs 18,5 timeslot durations before V+D downlink timeslot J of frame K, where timeslot J is the V+D receive timeslot (normally timeslot 1). This timing shall be achieved with an accuracy of 0,5 ms. The DM channel timing is illustrated in figure 8. Refer also to subclause 8.4.7.10.

NOTE 2: The V+D receive timeslot used in this procedure is the downlink slot of the appropriate common control channel i.e. Main Control CHannel (MCCH) or common Secondary Control CHannel (SCCH). The DM-MS should not align the DM slot numbering with a V+D assigned channel.

When a DM-MS first becomes master on a free carrier, it defines the initial frequency synchronization. However, if the DM-REP has been generating a presence signal on the selected downlink RF carrier then the master should take its initial frequency synchronization from the presence signal. See also clause 11.

8.4.1.3 DM channel B operation

DM channel B operation is conducted during the timeslot periods unused by channel A operation i.e. in timeslots 2 and 4 of each channel A frame. If the DM-MS has determined that:

1) DM channel A on the selected DM downlink RF carrier is occupied or reserved; and

2) the channel A master is indicating type 2 DM-REP operation (i.e. the "communication type" element is set to 01_2 and the "A/B channel usage" element is set to 01_2); and

3) channel B is free,

then the DM-MS may begin master MS operation through the DM-REP, using the free timeslots in each frame. The channel B master DM-MS shall take its initial timing and frequency synchronization from the current channel A downlink transmissions; see also subclause 8.4.2.5.2 and clause 11.

From the perception of a DM-MS on channel B, operation shall be conducted in timeslots 1 and 3 in each frame. These timeslots coincide with timeslots 2 and 4 as seen by channel A. This structure is illustrated in figure 10.

The master DM-MS on channel B shall align its frame numbering with the frame numbering on channel A so that the slot and frame numbering on the channel B master link lags one timeslot behind the slot and frame numbering on the channel A master link (or, equivalently, so that the slot and frame numbering on the channel B master link runs three timeslots ahead of the slot and frame numbering on the channel A slave link). The slot and frame numbering on the channel B slave link then lags one timeslot behind the slot and frame numbering on the channel A slave link.

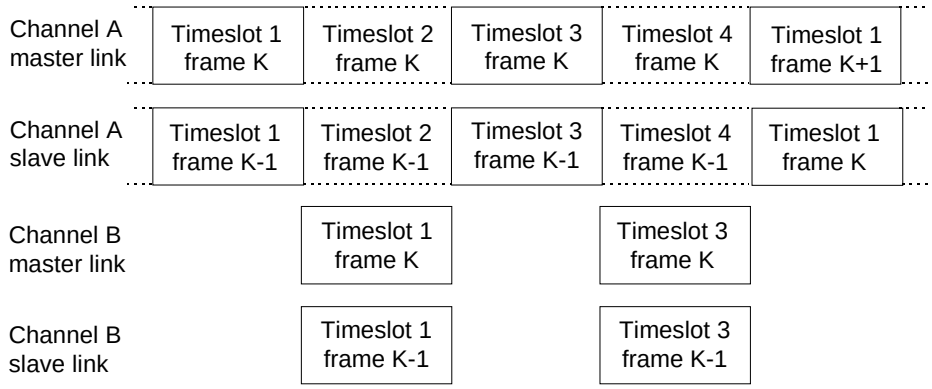

Figure 10: Illustration of DM channel A and B timeslots on type 2 DM-REP

8.4.2 DM channel states

The MAC layer of the DM-MS is responsible for monitoring activity on the selected DM downlink RF carrier in order to determine the current perceived state of that RF carrier. 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 activity detected on the selected DM downlink RF carrier (other than possible receipt of DM-REP or gateway presence signals indicating that the channel is free).

Channel occupied or reserved:

- traffic or signalling activity detected on the selected DM downlink RF carrier (other than DM-REP or gateway presence signals indicating that the channel is free) i.e. channel A and/or channel B is in occupation or reservation. The DM-MS when in idle mode shall determine the state of both channel A and channel B.

8.4.2.2 DM-MS channel surveillance procedures

A DM-MS shall conduct the following channel surveillance procedures on the selected DM downlink RF carrier in order to determine the current DM channel state. Surveillance procedures may vary dependent upon the current operation of the DM-MS.

The DM-MS when in idle mode shall retain valid channel state information for both channel A and channel B on the selected DM downlink RF carrier.

NOTE: The standard does not preclude that a DM-MS may undertake to conduct channel surveillance on more than one DM RF carrier.

8.4.2.2.1 Initial determination of DM channel state

ETS 300 396-3 [3], subclause 8.4.2.2.1 shall apply with the following addition.

In the case where a received DSB contains a DM-REP presence signal indicating that channel A or channel B is occupied or reserved, the receiving DM-MS shall update the DM-MAC state model appropriately.

NOTE: The DM-MS determines the current state of both channel A and channel B.

8.4.2.2.2 DM-MS channel surveillance in idle mode

ETS 300 396-3 [3], subclause 8.4.2.2.2 shall apply.

NOTE 1: The protocol for operation with a type 2 DM-REP is based on the protocol for frequency efficient mode in ETS 300 396-3 [3]. Therefore the procedure for frequency efficient mode in ETS 300 396-3 [3], subclause 8.4.2.2.2, paragraph 4 is applicable.

NOTE 2: When one DM channel is in use and the other DM channel is free, the DM-REP may transmit set-up DSBs for the ongoing call in all four timeslots (see subclause 9.5.1.1). Therefore, in subclauses 8.4.2.2.2 and 8.4.2.2.3, the DM-MS should not change its perception of the state of the free DM channel if it receives set-up signalling in slot 2 or slot 4 of the active DM channel.

If a received DSB contains a DM-REP presence signal indicating that channel A or channel B is occupied or reserved then the receiving DM-MS shall update the DM-MAC state model appropriately.

If a received DSB contains a DM-REP presence signal indicating that channel A or channel B is free then:

- if the DM channel is currently perceived as occupied or reserved in a call through that DM-REP then the receiving DM-MS shall change the perceived DM channel state to free;

- if the DM channel is currently perceived as occupied or reserved in a call not involving that DM-REP then the receiving DM-MS shall not change the perceived DM channel state.

8.4.2.2.3 DM-MS channel surveillance at call set-up

ETS 300 396-3 [3], subclause 8.4.2.2.3 shall apply with the following differences:

i) In the third and fourth paragraphs of ETS 300 396-3 [3], subclause 8.4.2.2.3, the DM-MS should not regard the free-channel presence signal as "traffic or signalling activity" causing the call set-up to be abandoned.

ii) The procedure for a retransmission of DM-SETUP PRES by the DMCC and for a non-immediate retransmission of DM-SDS DATA shall apply also for a retransmission of DM-SETUP or DM-SDS UDATA by the DMCC (i.e. for a retransmission by the DMCC after layer 2 has reported failure of link establishment to the DM-REP).

NOTE 1: A type 2 DM-REP is required to be capable of frequency full duplex operation. Therefore a DM-MS may transmit on the uplink RF carrier f_1 while the DM-REP is sending the free-channel presence signal on the downlink RF carrier f_2.

NOTE 2: The procedures in this subclause apply to both channel A and channel B.

8.4.2.3 Master DM-MS channel surveillance procedures during a call

During a circuit mode call, if the master DM-MS receives a presence signal from the DM-REP (on either the master link or slave link) indicating that either the carrier or the DM channel is free, or if a time DT225 elapses without receipt of a DSB in timeslot 3 of master link frame 2, 8 or 14 containing:

- a random access request addressed to itself; or

- a DM-REP presence signal indicating that the DM channel is occupied or reserved,

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, which the DM-MAC transmits before becoming idle.)

During channel reservation, if the master DM-MAC receives DN208 signalling messages on the DM channel indicating that the channel has become occupied by other users then it shall inform the higher layers (using the DMC-REPORT indication) and shall begin idle mode operating procedures.

NOTE: The above procedures, and the procedures in subclause 8.4.2.4, refer only to the DM channel being used for the call (i.e. channel A or channel B).

See also subclause 8.4.2.5.

8.4.2.4 Slave DM-MS channel surveillance procedures during a call

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

8.4.2.4.1 Slave MS channel surveillance during call transaction

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

8.4.2.4.2 Slave MS signal quality measurement during call transaction

ETS 300 396-3 [3], subclause 8.4.2.4.2 shall apply except that the slave MS estimates the success rate of decoding the relevant signalling messages received in timeslot 3 of slave link frames 6 and 12 and timeslot 1 or 3 of slave link frame 18.

8.4.2.4.3 Slave MS channel surveillance during reservation

ETS 300 396-3 [3], subclause 8.4.2.4.3 shall apply.

8.4.2.5 Additional master DM-MS surveillance procedures

8.4.2.5.1 Surveillance by channel A master MS

At the start of a new call on a free carrier, the channel A master DM-MS defines the DM timing reference and the initial frequency synchronization, as defined in subclause 8.4.1.2. (After receiving DSBs from the DM-REP on the downlink RF carrier f_2, the DM-MS re-aligns its frequency synchronization as defined in clause 11).

However, a DM-MS may wish to make a call when the only ongoing communication is labelled as a channel B. Then the new calling DM-MS may use the free channel, labelling it as "channel A, frequency efficient mode". The new channel A master DM-MS shall take its initial timing and frequency synchronization from the current channel B downlink transmissions. It shall begin transmitting DSBs adopting a master link slot and frame numbering that runs one timeslot ahead of the channel B master link timing (or, equivalently, five timeslots ahead of the channel B slave link timing).

NOTE 1: In this case, when sending the call set-up DSBs, the new channel A master DM-MS is not permitted to use channel A timeslots 2 and 4, since these slots are in use for the channel B call.

NOTE 2: Following initial synchronization the channel A master DM-MS is no longer required to monitor channel B.

After a pre-emption or changeover, the new channel A master DM-MS shall take its initial timing and frequency synchronization from the current channel A downlink transmissions.

During occupation and reservation, the channel A master DM-MS shall monitor the downlink channel A in timeslot 3 of master link frames 2, 8 and 14 in order to receive DSBs from the DM-REP and subsequently re-align its frequency synchronization. Refer to clause 11.

NOTE 3: During occupation and reservation, the channel A master DM-MS does not re-align its transmission timing based on DSBs received from the DM-REP (since the DM-REP follows the slot timing used by the channel A master).

8.4.2.5.2 Surveillance by channel B master MS

At the start of a new call on a free channel B, the channel B master DM-MS shall take its initial timing and frequency synchronization from the current channel A downlink transmissions, as defined in subclause 8.4.1.3.

NOTE 1: Following initial synchronization the channel B master DM-MS is no longer required to monitor channel A.

After a pre-emption or changeover, the new channel B master DM-MS shall take its timing and frequency synchronization from the current channel B downlink transmissions.

During occupation and reservation, the channel B master DM-MS shall monitor the downlink channel B in timeslot 3 of master link frames 2, 8 and 14 in order to receive DSBs from the DM-REP and subsequently re-align its transmission timing and frequency synchronization. Refer to clause 11.

NOTE 2: For example, the channel B master DM-MS re-aligns its transmission timing if it perceives a difference of more than 1/4 symbol between its own slot timing and the timing of DSBs received from the DM-REP.

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 with a type 2 DM-REP.

8.4.3.1 DM-MAC state definitions

ETS 300 396-3 [3], subclause 8.4.3.1 shall apply.

NOTE: The DM-MS when in idle mode determines the state of both channel A and channel B.

8.4.3.2 Criteria for changing DM-MAC state

ETS 300 396-3 [3], subclause 8.4.3.2 shall apply.

The DM-MAC shall also change the current state condition if one of the following criteria occurs:

- a slave DM-MS receives a presence signal from the DM-REP used for the call, indicating a channel state change;
- an idle DM-MS receives an appropriate DM-REP presence signal (as defined in subclause 8.4.2.2).

8.4.4 DM-MS channel monitoring procedures

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 subclauses define the DM-MS monitoring procedures for operation with a type 2 DM-REP.

NOTE 1: The DM-MS performs the channel monitoring procedures on the selected DM downlink RF carrier f_2.

NOTE 2: The channel monitoring procedures refer to the DM channel being used for the call i.e. channel A or channel B.

NOTE 3: The slave link timeslots are physically coincident with the master link timeslots. However received DSBs can be identified as master link DSBs or slave link DSBs by the setting of the "master/slave link flag". Received DNBs can be identified as master link DNBs or slave link DNBs by context.

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

ETS 300 396-4 [4], subclause 8.4.4.1 shall apply.

NOTE: The monitoring may be performed in all four timeslots of the DN232 or DN233 frames on the slave link. (It is not required that the master MS is able to monitor the first or last transmission of the DMAC-SYNC PDU on the slave link.) As in ETS 300 396-4 [4], the DM-MS looks for successful re-transmission of its own call set-up signalling. Note that it is possible that signalling for another call may be present in timeslots 2 and 4.

8.4.4.2 DM channel during call set-up with presence check

ETS 300 396-4 [4], subclause 8.4.4.2 shall apply.

8.4.4.3 DM channel in occupation during a circuit mode call

ETS 300 396-4 [4], subclause 8.4.4.3 shall apply with the following differences:

i) A master MS during an active call transaction shall monitor timeslot 3 of frames 2, 5, 8, 11, 14 and 17 on the master link (instead of frames 1, 4, 7, 10, 13 and 16).

ii) Timing change request signalling is not valid for operation with a type 2 DM-REP.

iii) For a slave MS during channel occupation, a DM random access transmission in timeslot 3 of slave link frame 6 or 12 may take precedence over the requirement to monitor for occupation signalling.

8.4.4.4 DM channel in reservation during a circuit mode call

ETS 300 396-4 [4], subclause 8.4.4.4 shall apply except that timing change request signalling is not valid for operation with a type 2 DM-REP.

NOTE 1: The master link frames "corresponding to slave link frames which are precluded by the requests bitmap" may be different from those in ETS 300 396-4 [4]; see subclause 8.5.7.

NOTE 2: The linearization frame for slave MSs is slave link frame 2 (instead of slave link frame 3).

8.4.4.5 DM channel in occupation during an SDS call

ETS 300 396-4 [4], subclause 8.4.4.5 shall apply except that, during SDS transmissions, the master MS shall monitor timeslot 3 of frames 2, 5, 8, 11, 14 and 17 on the master link (instead of frames 1, 4, 7, 10, 13 and 16).

8.4.4.6 DM channel usage during pre-emption signalling

ETS 300 396-4 [4], subclause 8.4.4.6 shall apply.

8.4.4.7 DM channel usage during timing change request signalling

Timing change request signalling is not valid for operation with a type 2 DM-REP.

8.4.5 Transmission of layer 3 messages by DM-MAC

NOTE: The DM-MS transmits on the uplink RF carrier f_1.

8.4.5.1 Transmission of C-plane messages by DM-MAC

ETS 300 396-3 [3], subclause 8.4.5.1 shall apply with the following differences:

i) When the DM-MS is sending a DM-SETUP, DM-SETUP PRES, DM-SDS UDATA or DM-SDS DATA message on a free carrier, it shall transmit the DSB in all four timeslots of the first two signalling frames. If sending the DSB in more than two signalling frames then timeslots 2 and 4 shall not be used in the subsequent signalling frames.

   When the DM-MS is sending a DM-SETUP, DM-SETUP PRES, DM-SDS UDATA or DM-SDS DATA message at other times, timeslots 2 and 4 shall not be used in any of the signalling frames. (This applies on channel B, on channel A if there is already a call on channel B, if the DM-MS is master on a reserved DM channel, after changeover, after pre-emption, for repetitions of DM-SDS UDATA and for immediate retransmission of DM-SDS DATA).

ii) When transmitting DM-RELEASE, the DM-MAC shall send the message in timeslot 1 in at least two frames. It should also send the message, in a DSB, in each corresponding timeslot 3 (except timeslot 3 of linearization frames) unless it is sending DM-PRE ACCEPT. After a failure of link establishment to the DM-REP, the DM-MAC shall choose the initial value of the "frame countdown" element to ensure that it sends the DM-RELEASE message in timeslot 3 in at least two frames.

iii) Transmission of the DM-OCCUPIED message in timeslot 1 of frame 18 is mandatory for both channel A and channel B operation.

iv) The pre-emption frames are slave link frames 3, 6, 9, 12, 15 and 18 (instead of frames 2, 5, 8, 11, 14 and 17). The frames represented by the "requests bitmap" element are slave link frames 1, 4, 7, 8, 10, 13, 14 and 16 (instead of frames 1, 4, 7, 9, 10, 13, 15 and 16).

v) 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.

8.4.5.2 Transmission of U-plane messages by DM-MAC

During channel occupation, a master DM-MAC on receiving a DMD-UNITDATA request from the U-plane application shall perform the procedures as defined in subclause 8.6.

8.4.6 Transmission of layer 2 messages generated by DM-MAC

ETS 300 396-3 [3], subclause 8.4.6 shall apply with the following differences:

i) Transmission of the DM-RESERVED and DM-SDS OCCUPIED message in timeslot 1 of frame 18 is mandatory for both channel A and channel B operation.

ii) Messages DM-TIMING REQUEST and DM-TIMING ACK are not used.

   NOTE: Timing changes are not permitted when type 2 DM-REP operation is being used. Therefore, when an MS becomes master, it should set the "timing flag" element to "0".

8.4.7 General DM-MAC procedures

8.4.7.1 DM-MAC repeat transmissions

ETS 300 396-3 [3], subclause 8.4.7.1 shall apply.

8.4.7.2 DM-MAC frame countdown procedure

ETS 300 396-3 [3], subclause 8.4.7.2 shall apply.

8.4.7.3 Use of timers

The DM-MAC shall use a set of timers e.g. to determine how long it should wait for a response to a random access message. See annex A.

8.4.7.4 Linearization

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.

During circuit mode occupation and reservation, a master MS may linearize in timeslot 3 of frame 3 of any multiframe on the master link.

During circuit mode occupation, a slave MS (or idle MS) may only conduct linearization if permitted by the master MS; if permitted then the valid linearization slot is timeslot 3 of frame 2 of the slave link. The DM-MAC in the master MS shall in order to permit transmitter linearization to be conducted on the DM channel allocate the use of timeslot 3 of frame 2 of the slave link for linearization, by setting the "LCH in frame 3 flag" equal to 1 in the call set-up and occupation signalling.

NOTE 1: Linearization is not permitted during the call set-up signalling. This restriction includes the time for any DM-CONNECT/DISCONNECT and DM-CONNECT ACK messages (except for the called MS - refer to the last paragraph of this subclause).

If linearization is permitted then it may be performed in timeslot 3 of frame 2 of the slave link after the completion of the frame countdown for the transmissions of the DM-SETUP or DM-CONNECT ACK message on the slave link.

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 editions of this ETS. Therefore, recipients have to check the setting of the "LCH in frame 3 flag".

NOTE 3: The element name "LCH in frame 3 flag" is used for compatibility with ETS 300 396-3 [3]. However note that, for operation with a type 2 DM-REP, the slave linearization frame is actually slave link frame 2 as defined above.

During reservation, a slave MS (or idle MS) may conduct linearization in timeslot 3 of frame 2 of any multiframe on the slave link.

During short data occupation, a master MS may conduct linearization in timeslot 3 of master link frame 3 if timeslot 1 of master link frame 3 is an SCH/F slot. Also, for a DM-SDS DATA message, it may conduct linearization in timeslot 3 of master link frame 3 if timeslot 1 of master link frame 2 was an SCH/F slot.

During short data occupation, a slave MS (or idle MS) may conduct linearization in timeslot 3 of slave link frame 2 if timeslot 1 of slave link frame 2 is an SCH/F slot (as indicated by the "number of SCH/F slots" element in the SDS call set-up DSBs) - except that, for a DM-SDS UDATA message, the MS shall not conduct linearization in the slave link frame containing the final SCH/F slot. Also, the MS may conduct linearization in timeslot 3 of slave link frame 2 if timeslot 1 of slave link frame 3 will be an SCH/F slot.

When a called MS sends a response to a non-fragmented message (received in slave link frame X and containing "frame countdown" element F), the called MS may linearize its transmitter in timeslot 1 of slave link frame (X+F) mod 18 + 1. When a called MS sends a response to a fragmented message, the called MS may linearize its transmitter in timeslot 1 of the slave link frame following the slave link frame that contained the DMAC-END PDU.

NOTE 4: The DM-MS linearizes on the uplink RF carrier f_1.

8.4.7.5 Fragmentation

ETS 300 396-3 [3], subclause 8.4.7.5 shall apply.

8.4.7.6 Fill bit indication

ETS 300 396-3 [3], subclause 8.4.7.6 shall apply.

8.4.7.7 Selection of pseudo address

ETS 300 396-3 [3], subclause 8.4.7.7 shall apply.

8.4.7.8 Slot flag indication

ETS 300 396-3 [3], subclause 8.4.7.8 shall apply.

8.4.7.9 Requests bitmap

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 slave link frames, in addition to those allocated for pre-emption, may be used for random access messages e.g. DM-TX REQUEST messages. The DM-MAC shall using an 8-bit element indicate in which frames a slave MS may send a random access message on the slave link. The 8-bit element used shall relate to frames 1, 4, 7, 8, 10, 13, 14 and 16 of the slave link.

8.4.7.10 DM aspects of dual watch operation

8.4.7.10.1 Model of operation

ETS 300 396-3 [3], subclause 8.4.7.10.1 shall apply with the following differences:

i) The list of DM frames not normally available for V+D reception shall be replaced by the following list of DM frames:

- slot 3 of master link frames 6, 12 and 18 (used for occupation/reservation signalling);
- slot 3 of slave link frames 6, 12 and 18 (used for repeated occupation/reservation signalling);
- slot 3 of master link frames 2, 5, 8, 11, 14 and 17 (used for repeated pre-emption signalling or the DM-REP presence signal); and
- slot 3 of master link frame 3 ≡ slot 3 of slave link frame 2 (used for linearization).

ii) In addition to energy economy mode 1 (EG1), energy economy modes 2 and 4 (i.e. EG2 and EG4) are also not applicable for dual watch purposes.

8.4.7.10.2 Dual watch synchronization

The dual watch synchronization defines the frame and slot alignment between the V+D control channel and the DM channels. For the purposes of dual watch synchronization, only the Main Control Channel (MCCH) or a common Secondary Control Channel (SCCH) are considered as V+D control channels.

For dual watch operation the DM channel synchronization with respect to the appropriate V+D downlink control channel is defined such that slot 1 of the channel A master link shall lead the appropriate V+D downlink slot by 18,5 slot durations. This means that:

- slot 1 of the channel A slave link leads the appropriate V+D downlink slot by 14,5 slot durations;
- slot 1 of the channel B master link leads the appropriate V+D downlink slot by 17,5 slot durations;
- slot 1 of the channel B slave link leads the appropriate V+D downlink slot by 13,5 slot durations.

See also subclause 8.4.1.2.

Figure 11 illustrates the dual watch synchronization. In this scenario there is a call ongoing on DM channel A. The DM channel abbreviations are as defined in subclause 4.3. It is assumed in this scenario that the MS is monitoring the V+D MCCH (i.e. slot 1) and that the SwMI has assigned energy economy mode EG3. V+D downlink slots 1's in "awake" frames are denoted as "rx".

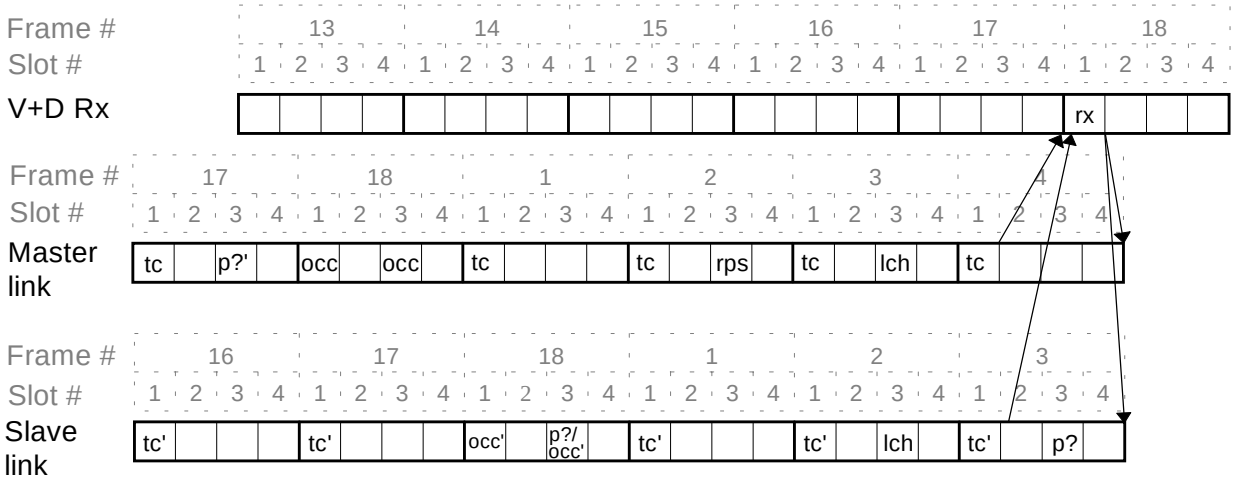

Figure 11: Illustration of dual watch synchronization for DM channel A

NOTE: When operating with a type 2 DM-REP, timing adjustment cannot be requested by slave MSs to achieve the dual watch synchronization.

8.4.7.10.3 Dual watch precedence rules

ETS 300 396-3 [3], subclause 8.4.7.10.3 shall apply.

NOTE: DM requirements for a master MS to monitor the slave link in order to detect the re-transmission of its call set-up signalling by the DM-REP may take precedence over V+D dual watch reception.

8.4.7.11 Air interface encryption

ETS 300 396-3 [3], subclause 8.4.7.11 shall apply.

8.4.7.12 Channel A or B operation

When the DM-MAC sends a DMAC-SYNC PDU on DM channel A, it shall set the "A/B channel usage" element to indicate "channel A, frequency efficient mode".

When the DM-MAC sends a DMAC-SYNC PDU on DM channel B, it shall set the "A/B channel usage" element to indicate "channel B".

After a changeover or pre-emption, the new master DM-MAC shall indicate the same DM channel (i.e. channel A or channel B) as the previous master.

8.4.7.13 Sending short data as a transaction within a circuit mode call

ETS 300 396-3 [3], subclause 8.4.7.13 shall apply.

8.4.7.14 SDS time remaining

ETS 300 396-3 [3], subclause 8.4.7.14 shall apply.

NOTE: The DM-MS should include an allowance of DN233 frames within the SDS time remaining for the DM-REP's re-transmission of the short data DSBs on the slave link.

8.4.7.15 Timing change procedure

During a call through a type 2 DM-REP, DM-MSs shall not request a timing adjustment.

8.4.7.16 Timing change at changeover or pre-emption

During a call through a type 2 DM-REP, a DM-MS requesting changeover or pre-emption shall not include a "timing adjustment" element within the request message.

8.5 MAC procedures for transfer of signalling messages

8.5.1 Formation of MAC PDU

ETS 300 396-4 [4], subclause 8.5.1 shall apply.

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 synchronization burst

ETS 300 396-4 [4], subclause 8.5.2.1.1 shall apply.

NOTE: Thus, as defined in ETS 300 396-4 [4], the DM-MAC sets the "communication type" element to 01_2 in the DMAC-SYNC PDU. It also includes the correct 10-bit repeater address and sets the "master/slave link flag" appropriately.

8.5.2.1.2 Addressing in normal burst

ETS 300 396-4 [4], subclause 8.5.2.1.2 shall apply.

8.5.2.2 Reception of message

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

i) 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 that, 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 8.4.4.1 and subclause 8.5.6.

ii) If a slave or idle 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.

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.

8.5.3 Use of air interface encryption

ETS 300 396-4 [4], subclause 8.5.3 shall apply.

8.5.4 Fragmentation and reconstruction

ETS 300 396-4 [4], subclause 8.5.4 shall apply.

8.5.5 Fill bit addition and deletion

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

8.5.6 Transmission and reception of messages by layer 2

ETS 300 396-4 [4], subclause 8.5.6 shall apply with the following differences:

i) In subclause 8.5.6.2 c), 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 requires an increase of four 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 four times). Then the transmission of the DSBs shall start in either master link frame (X+F+1) mod 18 + 1 or master link frame (X+F+2) mod 18 + 1.

ii) In subclause 8.5.6.2 e), the responding DM-MS is not permitted to linearize in slot 2 of slave link frame (X+F) mod 18 + 1.

NOTE: For operation with a type 2 DM-REP, the DM-MS transmits on the uplink RF carrier f_1 and receives on the downlink RF carrier f_2.

8.5.7 Random access protocol

8.5.7.1 Introduction

ETS 300 396-3 [3], subclause 8.5.7.1 shall apply except that timing change request signalling is not valid for operation with a type 2 DM-REP.

For operation with 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 with a type 2 DM-REP, the pre-emption slots on the slave link are slot 3 of slave link frames 3, 6, 9, 12, 15 and 18. The additional request slots on the slave link are slot 3 of slave link frames 1, 4, 7, 8, 10, 13, 14 and 16. In most cases the DM-REP repeats the request on the master link four slots later, so a request sent in slot 3 of slave link frame X is repeated in slot 3 of master link frame (X+1) mod 18 + 1. For example, a pre-emption request sent in slot 3 of slave link frame 3 is repeated in slot 3 of master link frame 5. (Exceptions are requests sent in slot 3 of slave link frames 1, 4, 10 and 16; these are repeated in slot 3 of master link frames 4, 7, 13 and 1 respectively, thereby avoiding frames in which the master DM-MS is linearizing or sending 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-CONNECT ACK and DM-OCCUPIED messages:

- it shall set the "timing flag" to 0 to indicate that timing change requests are not allowed;

- it shall set the "pre-emption flag" to 1 to indicate that slot 3 of frames 3, 6, 9, 12, 15 and 18 on the slave link is available for 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" and "changeover 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. If random access requests are invited then the master DM-MAC shall also set the "requests bitmap" element to indicate whether random access requests may be sent on the slave link in slot 3 of frames 1, 4, 7, 8, 10, 13, 14 and 16 during the reservation period (in addition to the pre-emption slots). It should allow random access requests on the slave link in slot 3 of frames 1, 4, 7, 8, 10, 13, 14 and 16 unless it may be performing dual watch or battery economy procedures in master link frames 4, 7, 9, 10, 13, 15, 16 or 1 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 2, 5, 8, 11, 14 and 17 on the master link for pre-emption requests addressed to itself.

During channel reservation (and, if requests are invited, during the final few frames of circuit mode occupation i.e. during the frame countdown for the DM-TX CEASED message), the master DM-MAC shall monitor slot 3 of frames 2, 5, 8, 11, 14 and 17 on the master link, looking for pre-emption or changeover requests addressed to itself. It shall also monitor the following slots for pre-emption or changeover requests addressed to itself:

- if, in the requests bitmap, the master DM-MAC allowed requests on the slave link in slot 3 of frame 1 then it shall monitor slot 3 of frame 4 on the master link;

- if, in the requests bitmap, the master DM-MAC allowed requests on the slave link in slot 3 of frame 4 then it shall monitor slot 3 of frame 7 on the master link;

- if, in the 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 requests bitmap, the master DM-MAC allowed requests on the slave link in slot 3 of frame 8 then it shall monitor slot 3 of frame 10 on the master link;

- if, in the requests bitmap, the master DM-MAC allowed requests on the slave link in slot 3 of frame 10 then it shall monitor slot 3 of frame 13 on the master link;

- if, in the 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 requests bitmap, the master DM-MAC allowed requests on the slave link in slot 3 of frame 14 then it shall monitor slot 3 of frame 16 on the master link;

- if, in the requests bitmap, the master DM-MAC allowed requests on the slave link in slot 3 of frame 16 then it shall monitor slot 3 of frame 1 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 for a DM-SDS DATA message, the master DM-MAC shall monitor slot 3 of frames 2, 5, 8, 11, 14 and 17 on the master link for pre-emption requests addressed to itself.

NOTE: If the protocol requires the DM-MS to transmit in any of the monitoring slots specified in this subclause, the transmission takes precedence over the monitoring requirement.

8.5.7.2.3 Response to pre-emption or changeover request

ETS 300 396-3 [3], subclause 8.5.7.2.3 shall apply with the following differences:

i) In the first paragraph of a), text "time DT211 minus 1 frame duration" shall be replaced by text "time DT211 minus 3 frame durations". Also, text "time DT212 minus 1 frame duration" shall be replaced by text "time DT212 minus 3 frame durations".

ii) After accepting a pre-emption or changeover request, the DM-MS shall stop being master (as defined in ETS 300 396-3 [3], subclause 8.5.7.2.3), and starts to receive on the slave link. The DM-MS should expect the slot and frame numbering on the slave link to run four timeslots behind the slot and frame numbering that it has been using on the master link.

iii) In procedure b), if the master DM-MS sends the DM-REJECT message in slot 3 during circuit mode occupation, it may use only master link frame 9 or 15.

NOTE: References in ETS 300 396-3 [3], subclause 8.5.7.2.3 to transmission by the master DM-MAC in "slot 1" or "slot 3" refer to slot and frame numbering on the master link.

8.5.7.2.4 Response to timing change request

Timing change request signalling is not valid for operation with a type 2 DM-REP. Therefore ETS 300 396-3 [3], subclause 8.5.7.2.4 does not apply.

8.5.7.3 Procedures for requesting DM-MS

8.5.7.3.1 Preparing for random access

ETS 300 396-3 [3], subclause 8.5.7.3.1 shall apply except that the pre-emption frames are slave link frames 3, 6, 9, 12, 15 and 18 (instead of frames 2, 5, 8, 11, 14 and 17).

8.5.7.3.2 First transmission of request

ETS 300 396-3 [3], subclause 8.5.7.3.2 shall apply except that timing change request signalling is not valid for operation with a type 2 DM-REP.

8.5.7.3.3 Valid access slots

For random access to send a pre-emption request, the "valid access slots" are as follows:

- During circuit mode occupation: slot 3 of slave link frames 3, 6, 9, 12, 15 and 18, if allowed by the "pre-emption flag".

  NOTE 1: If pre-emption requests are permitted during circuit mode occupation, the "valid access slots" as defined may be used after the completion of the frame countdown for the transmissions of the DM-SETUP or DM-CONNECT ACK message on the slave link.

- During channel reservation and if the most recently received "requests flag" was set to 1: slot 3 of slave link frames 3, 6, 9, 12, 15 and 18, and optionally also the slot 3's indicated by the "requests bitmap". It is a DM-MS choice whether to change the pattern of valid access slots in reservation.

NOTE 2: The frames represented by the "requests bitmap" element are slave link frames 1, 4, 7, 8, 10, 13, 14 and 16 (instead of frames 1, 4, 7, 9, 10, 13, 15 and 16).

- During short data occupation for DM-SDS DATA: slot 3 of slave link frames 3, 6, 9, 12, 15 and 18, but restricted to those frames in which the DM-MS expects the DM-REP to transmit SCH/F on the slave link in slot 1. (Those frames were indicated by the combination of the "frame countdown" and "number of SCH/F slots" elements in the DMAC-SYNC PDU that contained the DM-SDS DATA header.) 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 slave link FN 3, 6, 9, 12, 15 or 18.

- During short data occupation for DM-SDS UDATA: as for short data occupation for DM-SDS DATA except that the requesting DM-MS shall not regard either slot 3 of the slave link frame containing the final SCH/F slot or slot 3 of the slave link frame preceding the final SCH/F slot as "valid access slots".

For random access to send a changeover request during channel reservation, and if the most recently received "requests flag" and "changeover requests flag" were both set to 1, the "valid access slots" are slot 3 of slave link frames 3, 6, 9, 12, 15 and 18 and those slot 3's indicated by the "requests bitmap" element. (Changeover requests shall not be sent during short data or circuit mode occupation).

NOTE 3: Slots may be "valid access slots" for changeover requests using the above rule for channel reservation as soon as the DM-MS has received a DM-TX CEASED message. It need not wait for the end of the frame countdown on the DM-TX CEASED.

However if the DM-MAC receives a message other than DM-TX CEASED or DM-REJECT in a DSB in a slot 1, with "frame countdown" element F not equal to 00_2, then it shall regard the slot 3 of that frame as not being a valid access slot. If it receives a message other than DM-TX CEASED or DM-REJECT in a DSB (in a slot 1 or slot 3) with $F > 01_2$ then it shall regard the slot 3 of the next F-1 frames as not being valid access slots.

If the DM-MAC has not successfully decoded a message from the master indicating that the random access is permitted, within the previous time DT214, then it shall regard all slots as not being valid access slots until it decodes an appropriate message from the master (sent by the master through the DM-REP).

NOTE 4: Messages defining the currently permitted types of random access (either explicitly or implicitly) are DM-SETUP, DM-CONNECT ACK, DM-OCCUPIED, DM-TX CEASED, DM-RESERVED, DSB of DM-SDS UDATA and DSB of DM-SDS DATA.

If the DM-MS is not adequately linearized then it shall regard all slots as not being valid access slots until it has linearized its transmitter.

8.5.7.3.4 Waiting for response

ETS 300 396-3 [3], subclause 8.5.7.3.4 shall apply with the following differences:

i) Timing change request signalling is not valid for operation with a type 2 DM-REP.

ii) For a request sent in slot 3 of slave link frame 1, 4, 10 or 16, the time-out waiting for a random access response shall be increased by 1 frame duration i.e. text "time DT211" shall be replaced by text "time DT211 plus 1 frame duration" and text "time DT212" shall be replaced by text "time DT212 plus 1 frame duration". (For requests sent in frames other than slave link frames 1, 4, 10 and 16, text "time DT211" and text "time DT212" apply without amendment).

NOTE: References in ETS 300 396-3 [3], subclause 8.5.7.3.4 to monitoring slot 1 and slot 3 of the following frames for a response refer to slot and frame numbering on the slave link.

8.5.7.3.5 Subsequent transmission of request

ETS 300 396-3 [3], subclause 8.5.7.3.5 shall apply with the following differences:

i) During occupation, if the K'th valid access slot is slot 3 of a slave link frame 6 or 12 then the DM-MAC may choose to transmit the request instead in the K+1'th valid access slot.

NOTE: For example, the DM-MAC may choose to use this option if it has not received a message from the master recently and wishes to monitor the downlink slot for an occupation message (sent by the master through the DM-REP).

ii) Timing change request signalling is not valid for operation with a type 2 DM-REP.

8.5.7.3.6 Abandoning random access attempt

ETS 300 396-3 [3], subclause 8.5.7.3.6 shall apply except that timing change request signalling is not valid for operation with a type 2 DM-REP.

8.6 MAC procedures in traffic mode

ETS 300 396-4 [4], subclause 8.6 shall apply.

NOTE 1: In subclause 8.6.2, the new case 6) applies only to the DM channel being used for the call (i.e. channel A or channel B).

NOTE 2: In subclause 8.6.3.1.1 and subclause 8.6.3.2.1, the call set-up may take place on either channel A or channel B.

9 DM-REP layer 2 protocol for a type 2 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 2 DM-REP.

NOTE 1: For type 2 DM-REP operation, transmissions by DM-MSs are sent on the appropriate DM "uplink" RF carrier f_1 and transmissions from the DM-REP to DM-MSs are sent on the associated (duplex-spaced) DM "downlink" RF carrier f_2. A type 2 DM-REP can support two simultaneous calls on the pair of RF carriers (f_1 and f_2).

NOTE 2: The methods of slot usage are different in the case of a type 1 DM-REP. The procedures for a type 1 DM-REP are described in ETS 300 396-4 [4].

NOTE 3: 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).

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

9.1.1 Functions of lower MAC

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

See clause 12 for specific details of the lower MAC functionality.

9.1.2 Functions of upper MAC

ETS 300 396-4 [4], subclause 9.1.2 shall apply.

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

NOTE: A type 2 DM-REP can support two simultaneous calls on the pair of duplex-spaced RF carriers (f_1 and f_2). When the DM-REP is active in two calls, the upper MAC procedures generally apply independently for each call. So, for example:

the DM-REP receives signalling messages and traffic from the master DM-MS, on each master link, and re-transmits the received messages and traffic on the corresponding slave link;

the DM-REP receives signalling messages from slave DM-MSs, on each slave link, and re-transmits the received messages on the corresponding master link.

9.2 Interface between lower and upper MAC

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

9.3 Basic capabilities of the DM-REP physical layer

A type 2 DM-REP shall be capable of transmitting on one DM RF carrier (the selected "downlink" frequency f_2 from the DM-REP to DM-MSs) and receiving on a different DM RF carrier (the associated "uplink" frequency f_1 from DM-MSs to the DM-REP), using frequency full duplex operation.

The DM-REP shall be capable of transmitting in all four timeslots of frames whenever required by the procedures in this clause.

NOTE: While the DM-REP is active in circuit mode occupation in two simultaneous calls, it needs to transmit for an average of approximately 67 % of the time. A higher transmission ratio may be needed at call set-up (i.e. 100 % transmission for several frames), whereas less transmission is generally needed during reservation than in occupation.

9.4 Usage of DM channel

9.4.1 DM-REP operation

9.4.1.1 Channel structure

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

During calls that use the 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 re-transmits those messages to the master DM-MS.

During calls, communications between the DM-REP and the master DM-MS shall use the master link's slot and frame numbering. Communications between the DM-REP and slave DM-MSs shall use the slave 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 sometimes may use all four timeslots).

Transmissions from the DM-REP to DM-MSs are sent on the selected DM downlink RF carrier f_2 whereas transmissions by DM-MSs are sent on the associated uplink RF carrier f_1. This applies to both master link and slave link transmissions.

A type 2 DM-REP can support two simultaneous calls on the pair of duplex-spaced RF carriers (f_1 and f_2). Each call takes place on one DM channel. Thus two DM channels (designated channel A and channel B) may exist on the pair of RF carriers. In order to avoid signalling collisions between the two calls, the DM channels are arranged so that a call using DM channel A is conducted primarily in two timeslots on each of the RF carriers, whereas a call using DM channel B occupies the other two timeslots. In order to achieve this:

a) the master link and the slave link for one DM channel need to use the same two timeslots on both the uplink RF carrier f_1 and the downlink RF carrier f_2 (on a time-sharing basis); and so

b) the slot and frame numbering on the slave link lags four timeslots behind the master link's slot and frame numbering.

Therefore the same slot numbering applies on both the master link and the slave link for one DM channel. However, the frame numbering on the slave link lags one frame behind the frame numbering on the master link. The channel structure is illustrated in figures 9 and 10.

A call using channel A is conducted primarily in timeslots 1 and 3 in each frame according to the channel A numbering. From the perception of channel B, a call using channel B is also conducted in timeslots 1 and 3; these timeslots coincide with timeslots 2 and 4 as seen by channel A.

9.4.1.2 Channel synchronization

When the DM-REP is active in a call on channel A, it shall adopt and follow the slot timing defined by the current channel A master DM-MS for all transmissions on the downlink RF carrier f_2 - though with different frame numbering for channel A slave link transmissions, and different slot and frame numbering for channel B transmissions. (The channel B master DM-MS follows the slot timing received on the downlink RF carrier f_2).

When the DM-REP is active in a call on channel B and channel A is free, the DM-REP shall maintain the slot timing. (The channel B master DM-MS still follows the slot timing received on the downlink RF carrier f_2).

At the start of a new call on a free carrier, the channel A master DM-MS defines the initial frequency synchronization on the uplink RF carrier f_1. However the DM-REP uses its own frequency reference when transmitting on the downlink RF carrier f_2. The DM-REP then maintains the frequency, as defined in clause 12, and both the channel A and channel B master DM-MSs follow the DM-REP.

The DM-REP shall use the same frequency for all transmissions on the downlink RF carrier f_2 i.e. it shall use the same frequency for both master link and slave link and for both channel A and channel B.

When the DM-REP is active, it shall use the same power level for all transmissions on the downlink RF carrier f_2 i.e. it shall use the same power level for both master link and slave link and for both channel A and channel B.

9.4.2 DM-REP states

The DM-REP shall monitor activity on the appropriate DM RF carrier 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 "repeater address" element in the DMAC-SYNC PDU).

When the DM-REP receives a MAC PDU, 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.

NOTE: The DM-REP may decode and use any of the elements that are visible at layer 2, irrespective of whether it is addressed by the message.

9.4.2.1 DM-REP state definitions

The following 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 channel which is perceived as free i.e. no 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 (i.e. channel A and/or channel B occupied or reserved)
The DM-REP is currently operating in idle mode, and channel A and/or channel B is perceived as being:

- occupied i.e. signalling or traffic information not addressed to the DM-REP is detected on the DM channel; or

- reserved i.e. channel reservation signalling not addressed to the DM-REP is detected on the DM channel,

or other activity is detected on the channel.

3) DM-REP active in occupation or reservation on channel A and/or channel B
The DM-REP is in active mode on channel A and/or channel B. On each DM channel the DM-REP may be active in:

- channel occupation, re-transmitting traffic and/or signalling in a call transaction (either a circuit mode traffic transmission or a short data transmission); or

- channel reservation, intermittently re-transmitting signalling during a reservation period.

In state 2) and state 3), the DM-REP shall retain channel state information for both channel A and channel B when appropriate.

NOTE: Thus, within state 2 (i.e. when idle on a busy channel), the DM-REP may need to be able to maintain the following sub-states:

- channel A free, channel B occupied;
- channel A free, channel B reserved;
- channel A occupied, channel B free;
- channel A occupied, channel B occupied;
- channel A occupied, channel B reserved;
- channel A reserved, channel B free;
- channel A reserved, channel B occupied;
- channel A reserved, channel B reserved;
- channel A occupied in normal mode (or other activity detected on channel);
- channel A reserved in normal mode.

Within state 3 (i.e. when active), the DM-REP needs to be able to maintain the following sub-states:

- channel A free, DM-REP active in occupation on channel B;
- channel A free, DM-REP active in reservation on channel B;
- DM-REP active in occupation on channel A, channel B free;
- DM-REP active in occupation on channel A, active in occupation on channel B;
- DM-REP active in occupation on channel A, active in reservation on channel B;
- DM-REP active in reservation on channel A, channel B free;
- DM-REP active in reservation on channel A, active in occupation on channel B;
- DM-REP active in reservation on channel A, active in reservation on channel B.

9.4.2.2 DM-REP channel surveillance procedures

A DM-REP shall conduct channel surveillance procedures on the appropriate DM RF carrier in order to determine its current state.

9.4.2.2.1 DM-REP channel surveillance when idle on a free channel (i.e. in state 1)

ETS 300 396-4 [4], subclause 9.4.2.2.1 shall apply with the following differences:

i) Procedure a) (concerning type 1A DM-REP operation) is not appropriate.

ii) In procedure b), the DM-REP shall continue to monitor the uplink RF carrier f_1 when it is transmitting its DM-REP presence signal and linearizing.

NOTE: The optional procedure described in note 1 of ETS 300 396-4 [4], subclause 9.4.2.2.1 for a type 1B DM-REP may be used also by a type 2 DM-REP.

9.4.2.2.2 DM-REP channel surveillance when idle on a busy channel (i.e. in state 2)

ETS 300 396-4 [4], subclause 9.4.2.2.2 shall apply.

NOTE 1: This procedure applies to both channel A and channel B when they are both busy.

If channel B is perceived as free then the DM-REP monitors channel A as specified and, in addition, should monitor at least the timeslot following timeslot 3 of channel A frames 6, 12 and 18. If channel A is perceived as free then the DM-REP monitors channel B as specified and, in addition, should monitor at least the timeslot preceding timeslot 3 of channel B frames 6, 12 and 18.

NOTE 2: The procedure described in note 2 of ETS 300 396-4 [4], subclause 9.4.2.2.2 for a type 1B DM-REP applies also for a type 2 DM-REP.

9.4.2.2.3 DM-REP channel surveillance when idle at DM-MS call set-up

ETS 300 396-4 [4], subclause 9.4.2.2.3 shall apply.

NOTE 1: An idle DM-REP may accept a call set-up only if the channel surveillance procedures indicate that the channel was completely free i.e. both channel A and channel B. This ETS does not support operation where the DM-MSs on channel B may use a different DM-REP (or communication type) from the DM-MSs on channel A.

NOTE 2: The procedure described in note 2 of ETS 300 396-4 [4], subclause 9.4.2.2.3 for a type 1B DM-REP applies also for a type 2 DM-REP.

9.4.2.2.4 DM-REP channel surveillance when active with one DM channel free

When the DM-REP is active on one DM channel (i.e. channel A or channel B), it shall perform channel surveillance on that DM channel as defined in subclause 9.4.2.3.

The DM-REP should monitor the two unused timeslots on the uplink RF carrier f_1 in order to detect any DSBs present and decode any layer 2 information available.

If the DM-REP receives a call set-up message (i.e. a DM-SETUP or DM-SETUP PRES message or a DM-SDS UDATA or DM-SDS DATA DSB) indicating the free DM channel (i.e. channel B or channel A respectively) and containing its own 10-bit repeater address then it may accept the call set-up:

- if accepting the call set-up, the DM-REP shall become active in the call and shall re-transmit the signalling information and any traffic relating to the call; or

- if not accepting the call set-up, the DM-REP shall ignore the message.

9.4.2.3 DM-REP channel surveillance when active during a call

ETS 300 396-4 [4], subclause 9.4.2.3 shall apply.

NOTE: These procedures refer to the DM channel being used for the call i.e. channel A or channel B. When the DM-REP is active in two calls, the procedures apply independently for each call. Note that the requirement to enter idle mode on expiry of timer DT256 or DT258 applies only to the call that has been lost.

9.4.3 Criteria for changing DM-REP state

ETS 300 396-4 [4], subclause 9.4.3 shall apply.

NOTE: The DM-REP needs to retain channel state information for both channel A and channel B (when appropriate).

9.4.4 DM-REP channel monitoring procedures

A DM-REP in idle mode (and when one DM channel is free) shall monitor the appropriate DM RF carrier(s) in order to keep an up-to-date record of the perceived state of the channel and to receive any call set-up messages containing its own 10-bit repeater address; refer to subclause 9.4.2.2.

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 repeater address. The methods for the re-transmission of received messages and traffic are defined in subclauses 9.5 and 9.6 respectively.

NOTE 1: The following channel monitoring procedures refer to the uplink RF carrier f_1.

NOTE 2: In the following channel monitoring procedures, the DM-REP should monitor in slots on the uplink RF carrier f_1, when appropriate, while it is transmitting on the downlink RF carrier f_2. (This contrasts with a type 1 DM-REP, which is not required to be capable of frequency full duplex operation).

NOTE 3: The following channel monitoring procedures refer to the DM channel being used for the call i.e. channel A or channel B. When the DM-REP is active in two calls, the channel monitoring procedures apply independently for each call.

NOTE 4: The slave link timeslots are physically coincident with the master link timeslots. However received DSBs can be identified as master link DSBs or slave link DSBs by the setting of the "master/slave link flag". Received DNBs can be identified as master link DNBs or slave link DNBs by context.

9.4.4.1 DM channel during call set-up with presence check

ETS 300 396-4 [4], subclause 9.4.4.1 shall apply.

9.4.4.2 DM channel in occupation during a circuit mode call

ETS 300 396-4 [4], subclause 9.4.4.2 shall apply with the following differences:

i) The pre-emption frames on the slave link are slave link frames 3, 6, 9, 12, 15 and 18 (instead of slave link frames 2, 5, 8, 11, 14 and 17).

ii) Timing change request signalling is not valid for operation with a type 2 DM-REP.

9.4.4.3 DM channel in reservation during a circuit mode call

ETS 300 396-4 [4], subclause 9.4.4.3 shall apply with the following differences:

i) The note is not valid.

ii) The pre-emption frames on the slave link are slave link frames 3, 6, 9, 12, 15 and 18 (instead of slave link frames 2, 5, 8, 11, 14 and 17).

iii) Timing change request signalling is not valid for operation with a type 2 DM-REP.

NOTE: The frames represented by the "requests bitmap" element are slave link frames 1, 4, 7, 8, 10, 13, 14 and 16 (instead of slave link frames 1, 4, 7, 9, 10, 13, 15 and 16).

9.4.4.4 DM channel in occupation during an SDS call

ETS 300 396-4 [4], subclause 9.4.4.4 shall apply except that the pre-emption frames on the slave link are slave link frames 3, 6, 9, 12, 15 and 18 (instead of slave link frames 2, 5, 8, 11, 14 and 17).

9.4.4.5 DM channel following pre-emption or changeover acceptance

ETS 300 396-4 [4], subclause 9.4.4.5 shall apply except that, after the frame countdown for a DM-TX ACCEPT message or for a DM-PRE ACCEPT message accepting a pre-emption within the ongoing call, the DM-REP shall then monitor the master link only in slots 1 and 3 of the following frames (instead of in all four slots).

NOTE: The requirement to enter idle mode on expiry of timer DT252, or after the frame countdown for a DM-PRE ACCEPT message accepting a new call pre-emption, applies only to this DM channel (i.e. channel A or channel B).

9.4.4.6 DM channel following timing change announcement

Timing adjustment is not valid for operation with a type 2 DM-REP.

9.4.5 DM-REP presence signal

9.4.5.1 Channel free

9.4.5.1.1 DM-REP idle on a free carrier (i.e. in state 1)

ETS 300 396-4 [4], subclause 9.4.5.1 shall apply.

NOTE 1: When sending the presence signal on a free carrier (i.e. when both channel A and channel B are free), the DM-REP sets element "channel usage" to 00_2 and sets element "channel state" to 00_2 to indicate channel free.

NOTE 2: If the DM-REP sends the presence signal on a free carrier, it may choose to use a DM timing reference based on the timing of a previous call (in case that call may have been using the dual watch synchronization). If using this option then, after a type 2 call, the DM-REP should base the slot and frame numbering in free-carrier slave link presence signals on the slot and frame numbering of the channel A slave link. However, after a type 1B call through the DM-REP, the DM-REP should return to the type 2 dual watch synchronization; thus it should set the slot and frame numbering in free-carrier slave link presence signals two frames ahead of the slot and frame numbering of the type 1B slave link.

NOTE 3: If the DM-REP detects call set-up signalling while it is transmitting the free-channel presence signal then it may stop transmitting the presence signal irrespective of the frame countdown value.

9.4.5.1.2 DM-REP active with one DM channel free

When the DM-REP is active on one DM channel (i.e. channel A or channel B), it shall transmit the appropriate presence signals on that DM channel as defined in subclauses 9.4.5.2 and 9.4.5.3.

The DM-REP may transmit the free-channel presence signal on the unused DM channel (i.e. channel B or channel A respectively). If this option is used then the DM-REP designer should choose when the presence signal is sent.

NOTE: When sending the presence signal on the active DM channel, the DM-REP sets element "channel usage" to 01_2 or 10_2 as appropriate (and sets element "channel state" to indicate occupation or reservation).

When sending the presence signal on the unused DM channel, the DM-REP sets element "channel usage" to the unused DM channel value (i.e. 10_2 or 01_2 as appropriate) and sets element "channel state" to 00_2 to indicate channel free.

9.4.5.2 DM channel in occupation

NOTE: The procedures in this subclause, and in subclause 9.4.5.3, refer to the DM channel being used for the call i.e. channel A or channel B (and the DM-REP sets element "channel usage" to 01_2 or 10_2 as appropriate). When the DM-REP is active in two calls, the procedures apply independently for each call.

When active in circuit mode occupation or during the SCH/F frames for a short data message:

- if the DM-REP did not receive a random access message in slot 3 of slave link frame 6 then it shall send a presence signal, indicating occupation, in slot 3 of master link frame 8;

- if the DM-REP did not receive a random access message in slot 3 of slave link frame 12 then it shall send a presence signal, indicating occupation, in slot 3 of master link frame 14;

- if the DM-REP did not receive a random access message in slot 3 of slave link frame 18 then it shall send a presence signal, indicating occupation, in slot 3 of master link frame 2;

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

The DM-REP is not precluded from sending the DM-REP presence signal during occupation in those timeslots not used within the call.

Also the DM-REP, after receiving a call set-up DSB from a master DM-MS, may send the presence signal, indicating occupation, until it starts to re-transmit the master DM-MS's set-up message on the slave link.

9.4.5.3 DM channel in reservation

When active in channel reservation:

- if the DM-REP did not receive a random access message in slot 3 of slave link frame 6 then it shall send a presence signal, indicating reservation, in slot 3 of master link frame 8;

- if the DM-REP did not receive a random access message in slot 3 of slave link frame 12 then it shall send a presence signal, indicating reservation, in slot 3 of master link frame 14;

- if the DM-REP did not receive a random access message in slot 3 of slave link frame 18 then it shall send a presence signal, indicating reservation, in slot 3 of master link frame 2;

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

The DM-REP is not precluded from sending the DM-REP presence signal during channel reservation in those timeslots not used within the call.

9.4.6 DM-REP linearization

ETS 300 396-4 [4], subclause 9.4.6 shall apply except that, when active during occupation or reservation, the DM-REP is not permitted to linearize in timeslot 3 of frame 3 of the slave link.

NOTE 1: Thus, when active during circuit mode occupation or reservation, the DM-REP may linearize only in timeslot 3 of frame 3 of the master link - or, equivalently, in timeslot 3 of slave link frame 2. When active during short data occupation, the DM-REP may linearize only in timeslot 3 of frame 3 of the master link (if timeslot 1 is an SCH/F slot or, for DM-SDS DATA, if timeslot 1 of the previous frame was an SCH/F slot).

NOTE 2: When the DM-REP is active in two calls, it may use either DM channel for linearization.

NOTE 3: The DM-REP linearizes on the downlink RF carrier f_2.

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

The procedures in this subclause define the re-transmission functions for a type 2 DM-REP. The DM-REP receives signalling messages and traffic sent by the master DM-MS, on each master link, and re-transmits that information on the corresponding slave link to the slave DM-MSs. It may also receive signalling messages from slave DM-MSs, on each slave link, in which case it re-transmits those messages on the corresponding master link to the master DM-MS.

NOTE 1: The re-transmission procedures apply to reception on the appropriate uplink RF carrier f_1 and re-transmission on the downlink RF carrier f_2.

NOTE 2: The re-transmission procedures refer to the DM channel being used for the call i.e. channel A or channel B. When the DM-REP is active in two calls, the re-transmission procedures apply independently for each call.

NOTE 3: The re-transmission procedures apply to all call transactions. The re-transmission is needed, even for individual calls, so that other DM-MSs perceive the DM channel as busy and to enable pre-emption.

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

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

9.5.1.1.1 General procedures

ETS 300 396-4 [4], subclause 9.5.1.1.1 shall apply except that the DM-TIMING ACK message is not used for operation with a type 2 DM-REP.

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

ETS 300 396-4 [4], subclause 9.5.1.1.2 shall apply with the following differences:

i) When re-transmitting a DM-SETUP message, the DM-REP shall transmit in slot 1 and slot 3 of each of the transmission frames (except that, if the DM-REP received the master DM-MS's message only in slot 4 of the frame with F = 0, then it need not transmit in the immediately following slot 1 on the slave link).

   For a DM-SETUP message sent when the carrier was free, the DM-REP shall also transmit the message in slot 2 and slot 4 of each of the transmission frames (unless the other DM channel ceases to be free). For DM-SETUP messages sent at other times, the DM-REP may transmit in slot 2 and slot 4 if the other DM channel is currently free.

ii) When re-transmitting a DM-SETUP PRES message, the same slot usage shall apply as for DM-SETUP except that slot 4 of the final transmission frame shall not be used.

NOTE: The optional procedure described in note 2 of ETS 300 396-4 [4], subclause 9.5.1.1.2 for a type 1B DM-REP may be used also by a type 2 DM-REP.

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

ETS 300 396-4 [4], subclause 9.5.1.1.3 shall apply with the following differences:

i) When re-transmitting a DM-SDS UDATA DSB, the DM-REP shall transmit in slot 1 and slot 3 of each of the transmission frames (except that, if the DM-REP received the master DM-MS's DSB only in slot 4 of the frame with F = 0, then it need not transmit in the immediately following slot 1 on the slave link).

   For a DM-SDS UDATA DSB sent when the carrier was free, the DM-REP shall also transmit the DSB in slot 2 and slot 4 of each of the transmission frames (unless the other DM channel ceases to be free). For DM-SDS UDATA DSBs sent at other times, the DM-REP may transmit in slot 2 and slot 4 if the other DM channel is currently free.

ii) When re-transmitting a DM-SDS DATA DSB, the same slot usage shall apply as for DM-SDS UDATA except that, for a non-fragmented message, slot 4 of the final transmission frame shall not be used.

iii) The "corresponding slot 1 on the slave link" lags four slots behind slot 1 of the master link (instead of lagging three slots behind).

   NOTE: The optional procedure described in note 2 of ETS 300 396-4 [4], subclause 9.5.1.1.3 for a type 1B DM-REP may be used also by a type 2 DM-REP.

9.5.1.1.4 Re-transmission of other messages in a DSB when not using multi-slot regeneration

ETS 300 396-4 [4], subclause 9.5.1.1.4 shall apply.

If, in a slot 3, the DM-REP has a random access message to send on the master link and also a DM-RESERVED message to send on the slave link then the random access message takes precedence.

NOTE: The "corresponding slot on the slave link" lags four slots behind the master link.

9.5.1.1.5 Re-transmission of other messages in a DSB during traffic transmission with multi-slot regeneration

ETS 300 396-4 [4], subclause 9.5.1.1.5 shall apply except that, in note 2, the delay of N - 1 traffic frames is in addition to the four-slot delay of the slave link relative to the master link.

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

Refer to subclause 9.6 for the DM-REP procedures for the re-transmission of the master DM-MS's circuit mode traffic.

9.5.1.2.1 Call transaction without multi-slot regeneration

ETS 300 396-4 [4], subclause 9.5.1.2.1 shall apply.

NOTE: The "corresponding slot 1 on the slave link" lags four slots behind the master link.

9.5.1.2.2 Call transaction with multi-slot regeneration

ETS 300 396-4 [4], subclause 9.5.1.2.2 shall apply except that, in note 1 and note 2, the delay of N - 1 traffic frames is in addition to the four-slot delay of the slave link relative to the master link.

9.5.1.3 Regeneration of additional repetitions on the slave link

ETS 300 396-4 [4], subclause 9.5.1.3 shall apply with the following differences:

i) The DM-TIMING ACK message is not used for operation with a type 2 DM-REP.

ii) Note 2 is not appropriate.

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

9.5.2.1 General procedures

ETS 300 396-4 [4], subclause 9.5.2.1 shall apply except that the DM-TIMING REQUEST message is not used for operation with a type 2 DM-REP.

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

ETS 300 396-4 [4], subclause 9.5.2.2 shall apply.

9.5.2.3 Re-transmission of random access request

If the DM-REP is active in a call and it receives a random access request (i.e. DM-TX REQUEST or DM-PREEMPT) in a slot 3 on the slave link, containing "communication type" element 01_2 and its own 10-bit repeater address, the DM-REP should repeat the request on the corresponding master link except in the cases described below. It shall transmit the request once, in the appropriate slot 3 on the master link, setting the "master/slave link flag" to 1 and the "frame number" element to the master link FN. The frame for transmission of the request on the master link shall be as defined in table 1.

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

Reception frame on slave link	Transmission frame on master link
1	4
3	5
4	7
6	8
7	9
8	10
9	11
10	13
12	14
13	15
14	16
15	17
16	1
18	2

In most cases, this results in a delay of 4 slots relative to direct MS-MS operation. However, this delay is increased to 8 slots for a request received in slave link frame 1, 4, 10 or 16 in order to avoid the frames in which the master DM-MS may be linearizing or sending reservation messages.

NOTE: Re-transmission of a request in slot 3 of master link frame 7, 13 or 1 takes precedence over re-transmission of a reservation message in slot 3 of slave link frame 6, 12 or 18.

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

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

b) if it chooses to perform addressing checks on the request and finds that the request is not addressed to the current master DM-MS; or

c) if the current master DM-MS is sending set-up signalling for a new call transaction.

9.5.3 DM-REP signalling mechanisms

9.5.3.1 Frame countdown procedure

ETS 300 396-4 [4], subclause 9.5.3.1 shall apply.

9.5.3.2 Fill bit addition and deletion

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

9.5.3.4 Air interface encryption

ETS 300 396-4 [4], subclause 9.5.3.4 shall apply.

9.5.3.5 Timing change procedure

Timing change procedures are not used for operation with a type 2 DM-REP.

9.5.3.6 Random access procedures for DM-REP

ETS 300 396-4 [4], subclause 9.5.3.6 shall apply except that the DM-TIMING ACK message is not used for operation with a type 2 DM-REP.

9.6 DM-REP procedures in traffic mode

ETS 300 396-4 [4], subclause 9.6 shall apply with the following differences:

i) In subclause 9.6.1, timing adjustment information should not be received in DM-TX CEASED and DM-PRE ACCEPT messages.

ii) In subclause 9.6.2.2, the requirement to enter idle mode after re-transmitting DM-RELEASE messages or on expiry of timer DT250 applies only to the call that has failed.

iii) In subclauses 9.6.3.2.1 and 9.6.3.2.2, the "corresponding slot 1 on the slave link" lags four slots behind slot 1 of the master link (instead of lagging three slots behind).

iv) In subclause 9.6.3.2.2, note 1 and note 2, the delay of N - 1 traffic frames is in addition to the four-slot delay of the slave link relative to the master link.

NOTE: The DM-REP procedures in traffic mode refer to the DM channel being used for the call i.e. channel A or channel B. When the DM-REP is active in two circuit mode calls, the procedures apply independently for each call.

10 PDU descriptions

ETS 300 396-4 [4], clause 10 shall apply with the following differences for operation with a type 2 DM-REP:

i) Element "A/B channel usage" in the DMAC-SYNC PDU shall be set to 01_2 when sent on channel A in a type 2 call or to 10_2 when sent on channel B.

NOTE 1: If a DM-MS makes a type 1B call through a type 2 DM-REP then, as usual for a type 1B call, the DM-MS sets element "A/B channel usage" to 00_2. Then, for the duration of the call, the DM-MSs and the DM-REP use the procedures defined in ETS 300 396-4 [4] - obeying the procedures for operation with a type 1B DM-REP (except that the DM-REP should continue to set the "repeater operating modes" element to 10_2 when it sends the presence signal).

ii) When the DPRES-SYNC PDU is sent by a type 2 DM-REP:

- element "two-frequency repeater flag" shall always be set to 1;
- element "repeater operating modes" shall be set to 01_2 or 10_2 as appropriate;
- element "channel usage" shall be set to:
  - 00_2 when sent on a free carrier; or
  - 00_2 when sent during a type 1B call through the DM-REP; or
  - 01_2 or 10_2 when sent during a type 2 call through the DM-REP.

iii) Messages DM-TIMING REQUEST and DM-TIMING ACK are not used.

iv) The definition of the "LCH in frame 3 flag" shall be modified as shown in table 2.

NOTE 2: For operation with a type 2 DM-REP, the "LCH in frame 3 flag" indicates whether timeslot 3 of slave link frame 2 is available for MSs to carry out linearization. (The element name "LCH in frame 3 flag" is retained for compatibility with ETS 300 396-3 [3] and ETS 300 396-4 [4]).

Table 2: LCH in frame 3 flag

Information element	Length	Value	Remark
LCH in frame 3 flag	1	0	TN3 of slave link FN2 not available for LCH
		1	TN3 of slave link FN2 available for LCH

v) The definition of the "requests bitmap" element shall be modified as shown in table 3.

NOTE 3: The "requests bitmap" element is an 8-bit bitmap used to indicate the slave link frames in which random access requests are allowed (in addition to the pre-emption frames 3, 6, 9, 12, 15 and 18).

Table 3: Requests bitmap element

Information element	Length	Value	Remark
Slot 3 of slave link frame 1	1	0	Random access requests not allowed
		1	Random access requests allowed
Slot 3 of slave link frame 4	1	0	Random access requests not allowed
		1	Random access requests allowed
Slot 3 of slave link frame 7	1	0	Random access requests not allowed
		1	Random access requests allowed
Slot 3 of slave link frame 8	1	0	Random access requests not allowed
		1	Random access requests allowed
Slot 3 of slave link frame 10	1	0	Random access requests not allowed
		1	Random access requests allowed
Slot 3 of slave link frame 13	1	0	Random access requests not allowed
		1	Random access requests allowed
Slot 3 of slave link frame 14	1	0	Random access requests not allowed
		1	Random access requests allowed
Slot 3 of slave link frame 16	1	0	Random access requests not allowed
		1	Random access requests allowed

11 Radio aspects of DM-MS for operation with a type 2 DM-REP

11.1 Introduction

This clause details the radio aspects of DM-MS operation with a type 2 DM-REP.

11.2 Modulation

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

11.3 Radio transmission and reception

11.3.1 Introduction

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

11.3.2 Frequency bands and channel arrangement

DM-MSs may only transmit and receive in those channels allocated for TETRA DMO. For operation with a type 2 DM-REP, transmissions by the DM-MS are sent on the appropriate "uplink" RF carrier f_1 while transmissions from the DM-REP are received on the associated (duplex-spaced) DM "downlink" RF carrier f_2.

Dual Watch Mobile Stations (DW-MSs) and Dual Mode Mobile Stations (DU-MSs) shall also be able to transmit and receive within TETRA Voice plus Data (V+D) channels.

The TETRA DM RF carrier separation (i.e. channel spacing) shall be 25 kHz.

11.3.3 Reference test planes

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

11.3.4 Transmitter characteristics

ETS 300 396-2 [2], subclause 6.4 shall apply.

11.3.5 Receiver characteristics

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

11.3.6 Transmitter/receiver performance

ETS 300 396-2 [2], subclause 6.6 shall apply.

11.4 Radio sub-system synchronization

11.4.1 Introduction

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

11.4.2 Definitions and general requirements for synchronization of DM-MSs

In communication through a type 2 DM-REP, the DM-REP provides the frequency synchronization reference via the downlink transmissions. All DM-MSs, including the "master" DM-MSs for both channel A and channel B, synchronize in frequency to the DM-REP transmissions on the downlink RF carrier f_2.

A DM-MS which initiates a call as a channel A master on a completely free carrier defines the initial frequency and timing synchronization. If the DM-REP has been sending signalling on the selected downlink RF carrier f_2, the master DM-MS should take its initial frequency synchronization from this signalling. Otherwise it shall use its own internal free-running reference to generate the carrier as specified in ETS 300 396-2 [2], subclause 7.2.

NOTE 1: Even when the channel A master DM-MS has chosen to synchronize in frequency to the DM-REP prior to sending the call set-up messages, it need not adopt the slot timing or slot and frame numbering defined by the signalling messages from the DM-REP.

At the beginning of a call on a completely free carrier, the channel A master DM-MS shall transmit its call set-up messages in synchronization bursts. The master DM-MS shall then synchronize in frequency to the DM-REP using the synchronization bursts transmitted by the DM-REP on the downlink RF carrier f_2. It shall maintain this frequency synchronization using the synchronization bursts transmitted periodically by the DM-REP on the downlink. When synchronizing to the DM-REP, the master should meet the requirements for the synchronization of a slave DM-MS as specified in ETS 300 396-2 [2], subclause 7.5.

NOTE 2: When the master DM-MS perceives that its uplink transmissions are not adequately synchronized in frequency to the DM-REP downlink transmissions it should perform the necessary correction before its next transmission.

The synchronization bursts transmitted by the DM-REP at the start of a call and at intervals during the call shall be used by the slave DM-MSs and the channel B master DM-MS to synchronize themselves in terms of frequency and time, and to maintain synchronization. The DM-MS shall align its burst transmission on the uplink in time to the timeslots received on the downlink from the DM-REP, as specified in subclause 11.4.5. It shall also generate the uplink RF carrier f_1 using a frequency reference which has been synchronized to the carrier frequency received on the downlink from the DM-REP, as specified in subclause 11.4.5.

The timebase of a DM-MS shall continuously count quarter symbols, symbols, timeslots and frames, independently of whether the DM-MS is transmitting or not (see subclause 11.4.3). A slave DM-MS or a channel B master DM-MS is said to be fully time synchronized if all of its timebase counters run synchronously, within a specified tolerance to those of the DM-REP.

NOTE 3: The channel A master DM-MS does not re-align its transmission timing when it receives DSBs from the DM-REP (since the DM-REP follows the slot timing used by the channel A master).

The timing information contained in the SCH/S transmitted by the DM-REP in the synchronization burst shall refer to the slot and FN at which the synchronization burst is transmitted. Upon reception of an SCH/S, the slave DM-MS shall use this timing information to set its slot and frame counters.

A slave DM-MS which becomes the new master DM-MS after a changeover or pre-emption has been carried out successfully shall adopt the state of the timing counters used by the previous master DM-MS.

The DM-MS taking over the master role shall continue to maintain its frequency synchronization to the DM-REP via the synchronization signals received on the downlink RF carrier f_2.

11.4.3 Timebase counters

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

11.4.4 Requirements for the frequency source of DM mobiles

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

11.4.5 Requirements for the synchronization of a slave DM mobile

ETS 300 396-2 [2], subclause 7.5 shall apply, except that references to the master DM-MS shall be replaced by references to the type 2 DM-REP.

11.4.6 Synchronization requirements for a master MS operating on channel B

At the start of a new call on a free channel B, the channel B master DM-MS shall take its initial timing and frequency synchronization from the current channel A downlink transmissions. It shall set the slot and frame numbering as specified in subclause 8.4.1.3.

NOTE 1: Following initial synchronization the channel B master DM-MS is no longer required to monitor channel A.

After a pre-emption or changeover, the new channel B master DM-MS shall take its timing and frequency synchronization from the current channel B downlink transmissions.

While the DM-MS is the channel B master, ETS 300 396-2 [2], subclause 7.6 shall apply except that the DM-MS monitors the channel B transmissions sent on the DM-REP downlink in order to maintain the necessary timing synchronization. The DM-MS shall also use the channel B transmissions sent on the DM-REP downlink to maintain frequency synchronization.

NOTE 2: When the master DM-MS perceives that its uplink transmissions are no longer adequately synchronized in frequency to the DM-REP downlink transmissions it should perform the necessary correction before its next transmission.

When synchronizing to the DM-REP, the master should meet the requirements for the synchronization of a slave DM-MS as specified in ETS 300 396-2 [2], subclause 7.5.

11.5 Channel coding and scrambling

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

11.6 Channel multiplexing for DM operation through a type 2 DM-REP

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

i) In subclause 9.3.1, all DM-MSs in a call shall transmit on the "uplink" RF carrier f_1 and receive on the "downlink" RF carrier f_2.

ii) In subclause 9.4.1, a DM physical channel is defined as a pair of duplex-spaced RF carriers (f_1 as the "uplink" with f_2 as the associated "downlink") and two timeslots per frame on each of the RF carriers.

iii) The following addition shall also apply to clause 9:

- The start of the multiframe and frame on the slave link shall occur 4 timeslot durations after the start of the corresponding multiframe and frame on the master link.

11.7 Radio sub-system link control

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

Adaptive DM-MS RF power control shall be optional for operation through a type 2 DM-REP for both master and slave DM-MSs.

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 [7], clauses 21 and 23.

12 Radio aspects of a type 2 DM-REP

12.1 Introduction

This clause details the radio aspects of the type 2 DM-REP.

12.2 Modulation

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

12.3 Radio transmission and reception

12.3.1 Introduction

ETS 300 396-2 [2], 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. For a type 2 DM-REP, transmissions by the DM-MSs are received on the appropriate "uplink" RF carrier f_1 while transmissions from the DM-REP are sent on the associated (duplex-spaced) DM "downlink" RF carrier f_2.

The TETRA DM RF carrier separation (i.e. channel spacing) shall be 25 kHz.

12.3.3 Reference test planes

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

12.3.4 Transmitter characteristics

12.3.4.1 Output power

ETS 300 396-2 [2], subclause 6.4.1 shall apply.

12.3.4.2 Power classes

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

12.3.4.3 Unwanted conducted emissions

12.3.4.3.1 Definitions

ETS 300 396-2 [2], subclause 6.4.3.1 shall apply.

12.3.4.3.2 Unwanted emissions close to the carrier

ETS 300 396-2 [2], subclause 6.4.3.2 shall apply.

12.3.4.3.3 Unwanted emissions far from the carrier

These unwanted emissions are emissions (discrete, wideband noise, modulated or un-modulated) occurring at offsets equal to, or greater than, 100 kHz from the carrier frequency, measured in the frequency range 9 kHz to 4 GHz.

12.3.4.3.3.1 Discrete spurious

The maximum allowed power for each spurious emission shall be less than -36 dBm measured in 100 kHz bandwidth in the frequency range 9 kHz to 1 GHz and -30 dBm measured in 1MHz bandwidth in the frequency range 1 GHz to 4 GHz. Specific measurement method are required both when measuring within $\pm$ f_x of carrier frequency, due to the presence of wideband noise, and in the lower part of the spectrum.

12.3.4.3.3.2 Wideband noise

The following wideband noise levels, measured through the modulation filter defined in ETS 300 396-2 [2], subclause 5.6 should not exceed the limits shown in table 5 for the power classes as stated and at the listed offsets from the actual carrier frequency.

Table 5: DM-REP wideband noise limits

Frequency offset (kHz)	Maximum wideband noise level (dBc)			
	DM-REP nominal power level = 1W (class 4)	DM-REP nominal power level = 3W (class 3)	DM-REP nominal power level = 10W (class 2)	DM-REP nominal power level = 30W (class 1)
100 kHz to 250 kHz	- 75 dBc	- 78 dBc	- 80 dBc	- 80 dBc
250 kHz to 500 kHz	- 80 dBc	- 83 dBc	- 85 dBc	- 85 dBc
>500 kHz	- 80 dBc	- 85 dBc	- 90 dBc	- 90 dBc

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

In the case where a DM-REP transmits on a DM channel frequency which is within the normal V+D MS Tx band, then the limits in table 5 shall apply symmetrically to both sides of the V+D MS Tx band.

Table 6: DM-REP 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, 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 (as declared by the equipment manufacturer), plus a guard band of 5 MHz on either side as shown in figure 12.

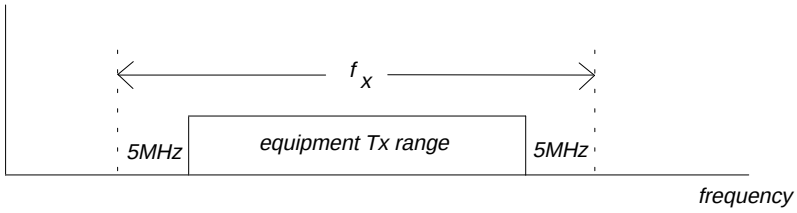

Figure 12: Definition of f_x

In any case no limit tighter than -55 dBm for offsets < f_{rb} or -70 dBm for offsets > f_{rb} shall apply.

12.3.4.3.4 Unwanted emissions during the Linearization CHannel (LCH)

ETS 300 396-2 [2], subclause 6.4.3.4 shall apply.

12.3.4.3.5 Unwanted emissions in the non-transmit state

ETS 300 396-2 [2], subclause 6.4.3.5 shall apply.

12.3.4.4 Unwanted radiated emissions

ETS 300 396-2 [2], subclause 6.4.4 shall apply.

12.3.4.5 Radio frequency tolerance

The radio frequency tolerance for DM-REPs is defined in subclause 12.4.4.

12.3.4.6 RF output power time mask

ETS 300 396-2 [2], subclause 6.4.6 shall apply except that during the non-active transmit state the specification L_{min} = -40 dBc or L_{min} = -36 dBm, whichever is greater, shall apply.

12.3.4.7 Transmitter intermodulation attenuation

ETS 300 396-2 [2], subclause 6.4.7 shall apply.

12.3.5 Receiver characteristics

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

12.3.6 Transmitter/receiver performance

ETS 300 396-2 [2], subclause 6.6 shall apply.

12.4 Radio sub-system synchronization

12.4.1 Introduction

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

12.4.2 Definitions and general requirements for synchronization

The DM-REP shall synchronize itself in terms of time to the initial call set-up transmissions from a channel A master DM-MS, received on a completely free uplink RF carrier. Moreover, the DM-REP shall use the timing information contained in the SCH/S transmitted by the master DM-MS to set its slot and frame counters.

The DM-REP shall in its turn transmit synchronization bursts on the slave link to enable timing synchronization of the slave DM-MSs and the channel B master DM-MS. The timing information contained in the SCH/S transmitted by the DM-REP shall refer to the slot and FN at which the synchronization burst is transmitted.

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

The DM-REP, when signalling on the downlink RF carrier f_2, shall generate the carrier using its own internal frequency reference.

NOTE 2: Thus this includes the DM-REP's transmissions of the initial call set-up messages from the channel A master DM-MS, even when the master DM-MS used its own frequency reference to generate the uplink RF carrier f_1. The master DM-MS then synchronizes in frequency to the DM-REP using the synchronization bursts transmitted by the DM-REP on the downlink RF carrier f_2. See also subclause 11.4.2.

The timebase of a DM-REP shall continuously count quarter symbols, symbols, timeslots and frames, in accordance with ETS 300 396-2 [2], subclause 7.3, independently of whether the DM-REP is transmitting or not.

12.4.3 DM timebase counters

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

12.4.4 Requirements for the frequency source of the type 2 DM-REP

A type 2 DM-REP shall use a frequency source of accuracy better than $\pm$ 500 Hz for RF frequency generation. For clocking the timebase, a frequency source of better than $\pm$ 2 ppm shall be used.

12.4.5 Requirements for the synchronization of the type 2 DM-REP

The DM-REP, when signalling on the downlink RF carrier f_2, shall generate the carrier using its own internal frequency reference.

The following requirement for timebase accuracy shall be met by the DM-REP for a transmission period of one multiframe duration following initial synchronization to a channel A master DM-MS. This requirement shall be achieved at receive signal levels greater than or equal to 3dB below the reference sensitivity:

- whenever the DM-REP transmits signalling on the downlink RF carrier f_2 while a channel A call is ongoing, its burst timing shall be accurate to within 1/2 symbol period compared to signals received from the channel A master DM-MS.

The following requirement for the timebase shall be met by the DM-REP for the time period following one multiframe duration after initial synchronization until the end of the channel A call:

- whenever the DM-REP transmits signalling on the downlink RF carrier f_2 while a channel A call is ongoing, its burst timing shall be accurate to within 1/4 symbol period compared to signals received from the channel A master DM-MS.

The signals received from the channel A master DM-MS shall be averaged over sufficient time so that errors due to noise, interference or Doppler spread are minimized.

When a call is ongoing on channel B and channel A is free, the DM-REP shall provide the timing synchronization for channel B.

12.5 Channel coding and scrambling

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

12.6 Channel multiplexing for a type 2 DM-REP

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

i) In subclause 9.3.1, the type 2 DM-REP shall receive on the "uplink" RF carrier f_1 and transmit on the "downlink" RF carrier f_2.

ii) In subclause 9.4.1, a DM physical channel is defined as a pair of duplex-spaced RF carriers (f_1 as the "uplink" with f_2 as the associated "downlink") and two timeslots per frame on each of the RF carriers.

iii) The following addition shall also apply to clause 9:

- The start of the multiframe and frame on the slave link shall occur 4 timeslot durations after the start of the corresponding multiframe and frame on the master link.

12.7 Radio sub-system link control

ETS 300 396-2 [2], clause 10 shall apply.

A DM-REP shall always transmit at its nominal power according to subclauses 12.3.4.1 and 12.3.4.2.

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

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

History

Document history			
April 1999	Public Enquiry	PE 9933:	1999-04-16 to 1999-08-13