

ETSI TS 144 006 V16.0.0 (2020-09)



**Digital cellular telecommunications system (Phase 2+) (GSM);
Mobile Station - Base Station System (MS - BSS) interface;
Data Link (DL) layer specification
(3GPP TS 44.006 version 16.0.0 Release 16)**



ReferenceRTS/TSGR-0644006vg00

KeywordsGSM

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

The present document can be downloaded from:

<http://www.etsi.org/standards-search>

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at www.etsi.org/deliver.

Users of the present document should be aware that the document may be subject to revision or change of status.

Information on the current status of this and other ETSI documents is available at

<https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:

<https://portal.etsi.org/People/CommitteeSupportStaff.aspx>

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.

The content of the PDF version shall not be modified without the written authorization of ETSI.

The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2020.

All rights reserved.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members.

3GPP™ and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.

oneM2M™ logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners.

GSM® and the GSM logo are trademarks registered and owned by the GSM Association.

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: "*Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards*", which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<https://ipr.etsi.org/>).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

Legal Notice

This Technical Specification (TS) has been produced by ETSI 3rd Generation Partnership Project (3GPP).

The present document may refer to technical specifications or reports using their 3GPP identities. These shall be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between 3GPP and ETSI identities can be found under <http://webapp.etsi.org/key/queryform.asp>.

Modal verbs terminology

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

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Contents

Intellectual Property Rights	2
Legal Notice	2
Modal verbs terminology.....	2
Foreword.....	7
1 Scope	8
2 References	8
3 Abbreviations	8
4 General	8
4.1 Options	9
5 Frame structure for peer-to-peer communication.....	9
5.1 General	9
5.2 Frame delimitation and fill bits	11
5.3 Address field	12
5.4 Control field	12
5.5 Length indicator field	12
5.5a Short L2 header type 1	12
5.6 Information field	12
5.7 Transparency	12
5.8 Format convention.....	12
5.8.1 Numbering convention	12
5.8.2 Order of bit transmission	13
5.8.3 Field mapping convention	13
6 Elements of procedures and formats of fields for Data Link Layer peer-to-peer communication.....	13
6.1 General	13
6.2 Address field format	13
6.3 Address field variables	14
6.3.1 Address field extension bit (EA).....	14
6.3.2 Command/response field bit (C/R)	14
6.3.3 Service access point identifier (SAPI).....	14
6.4 Control field formats	14
6.4.1 Information transfer format - I.....	15
6.4.2 Supervisory format - S.....	15
6.4.3 Unnumbered format - U.....	15
6.4a Short L2 header type 1	15
6.5 Control field parameters and associated state variables	15
6.5.1 Poll/Final bit	16
6.5.2 Multiple frame operation - variables and sequence numbers.....	16
6.5.2.1 Modulus	16
6.5.2.2 Send state variable V(S).....	16
6.5.2.3 Acknowledge state variable V(A)	16
6.5.2.4 Send sequence number N(S)	16
6.5.2.5 Receive state variable V(R).....	17
6.5.2.6 Receive sequence number N(R).....	17
6.5.2.7 Other parameters and variables	17
6.5.3 Unacknowledged operation variables and parameters	17
6.6 Length indicator field format.....	17
6.7 Length indicator field variables.....	17
6.7.1 Length indicator field extension bit (EL).....	17
6.7.2 More data bit (M).....	17
6.7.3 Length indicator (L).....	18
6.8 Commands and responses	18
6.8.1 Information (I) commands	18

6.8.2	Set asynchronous balanced mode (SABM) command	19
6.8.3	Disconnect (DISC) command	19
6.8.4	Unnumbered information (UI) command	20
6.8.5	Receive ready (RR) command/response	20
6.8.6	Reject (REJ) command/response	20
6.8.7	Receive not ready (RNR) command/response	20
6.8.8	Unnumbered acknowledgement (UA) response	21
6.8.9	Disconnected mode (DM) response	21
7	Elements for layer-to-layer communication	21
7.1	Definition of primitives and parameters	21
7.1.1	Generic names	21
7.1.1.1	DL-ESTABLISH	22
7.1.1.2	DL-RELEASE	22
7.1.1.3	DL-DATA	22
7.1.1.4	DL-UNIT DATA	22
7.1.1.5	DL-SUSPEND	22
7.1.1.6	DL-RESUME	22
7.1.1.7	DL-RECONNECT	22
7.1.1.8	DL-RANDOM ACCESS	22
7.1.1.9	MDL-RELEASE	22
7.1.1.10	MDL-ERROR	22
7.1.1.11	PH-DATA	23
7.1.1.12	PH-RANDOM ACCESS	23
7.1.1.13	PH-CONNECT	23
7.1.1.14	PH-READY-TO-SEND	23
7.1.1.15	PH-EMPTY-FRAME	23
7.1.2	Primitives types	23
7.1.2.1	REQUEST	23
7.1.2.2	INDICATION	23
7.1.2.3	RESPONSE	23
7.1.2.4	CONFIRM	23
7.1.3	Parameter definition	24
7.1.3.1	Message unit	24
7.1.3.2	Channel type	24
7.1.3.3	Service Access Point	24
7.1.3.4	Release mode	25
7.1.3.5	Error cause	25
7.1.3.6	Establish mode	25
7.1.3.7	L2 header type	25
7.1.3.8	Priority	26
7.2	Primitive procedures	30
8	Definition of the peer-to-peer protocol LAPDm	30
8.1	General	30
8.2	General Protocol Procedures	31
8.2.1	Unacknowledged information transfer	31
8.2.2	Acknowledged multiple frame information transfer	32
8.3	Procedures for unacknowledged information transfer	32
8.3.1	General	32
8.3.2	Transmission of unacknowledged information	32
8.3.3	Receipt of unacknowledged information	32
8.4	Procedures for establishment and release of multiple frame operation	32
8.4.1	Establishment of multiple frame operation	32
8.4.1.1	General	32
8.4.1.2	Normal establishment procedures	33
8.4.1.3	Procedure on expiry of timer T200: Normal establishment	34
8.4.1.4	Contention resolution establishment procedure	34
8.4.1.5	Procedure on expiry of timer T200: contention resolution (MS only)	36
8.4.2	Information transfer	36
8.4.2.1	General requirements	36
8.4.2.2	Error conditions	36

8.4.2.3	Fill frames	37
8.4.3	Suspension and resumption of multiple frame operation.....	37
8.4.3.1	General	37
8.4.3.2	Suspension	38
8.4.3.3	Resumption	38
8.4.3.3.1	Procedure after channel change	38
8.4.3.3.2	Procedure after returning to the old channel (MS only)	39
8.4.4	Termination of multiple frame operation.....	39
8.4.4.1	General	39
8.4.4.2	Normal release procedure	39
8.4.4.3	Procedure on expiry of timer T200 for normal release	40
8.4.4.4	Local end release procedure.....	40
8.4.5	Idle state.....	40
8.4.6	Collision of unnumbered commands and responses	41
8.4.6.1	Identical transmitted and received commands	41
8.4.6.2	Different transmitted and received commands.....	41
8.4.6.3	Unsolicited DM response and SABM or DISC command.....	41
8.5	Procedures for information transfer in multiple frame operation	41
8.5.1	Transmitting I frames.....	41
8.5.2	Receiving I frames	42
8.5.2.1	P bit of the received I frame set to "1"	42
8.5.2.2	P bit of the received I frame set to "0"	42
8.5.3	Receiving acknowledgement	43
8.5.3.1	On receipt of a valid I frame	43
8.5.3.2	Receiving supervisory command frames with the P bit set to "1"	43
8.5.4	Receiving REJ frames.....	43
8.5.4.1	Receipt of a valid REJ frame.....	43
8.5.4.2	Transmitting frames	44
8.5.5	Receiving RNR frame.....	44
8.5.6	Data link layer own receiver busy condition.....	46
8.5.7	Waiting acknowledgement	46
8.5.8	Preemption	47
8.5.8.1	Sender Requirements	47
8.5.8.2	Receiver Requirements	47
8.6	Abnormal release and re-establishment of multiple frame operation.....	47
8.6.1	Criteria for re-establishment	47
8.6.2	Criteria for abnormal release	47
8.6.3	Procedures for re-establishment.....	48
8.6.4	Procedures for abnormal release.....	48
8.7	Exception condition reporting and recovery for multiple frame operation	48
8.7.1	N(S) sequence error	48
8.7.2	Timer recovery.....	49
8.7.3	Invalid frame condition.....	49
8.7.4	N(R) sequence error.....	49
8.8	List of system parameters.....	50
8.8.1	Timer T200	50
8.8.1.1	For SAPI=0 and SAPI=3.....	50
8.8.1.2	For SAPIs other than 0 or 3.....	50
8.8.2	Maximum number of retransmissions (N200).....	50
8.8.2.1	For SAPI=0 and 3	50
8.8.2.2	For SAPIs other than 0 or 3.....	51
8.8.3	Maximum number of octets in an I, UI, SABM and UA frame partially or entirely available for the information field (N201).....	51
8.8.4	Maximum number of outstanding I frames (k).....	51
8.8.5	Maximum number of octets in a Layer 3 message	51
8.9	System performance requirements	51
9	Special protocol operation on SAPI=0 and SAPI=3	52
10	Repeated Downlink FACCH.....	53
10.1	General	53
10.2	The FACCH Repetition.....	53

10.3	BSS requirements	53
10.4	MS requirements	53
11	Repeated SACCH.....	54
11.1	General	54
11.2	Procedure for Repeated SACCH on the downlink	54
11.3	Procedure for Repeated SACCH on the uplink	54
Annex A (normative): Random access procedures		55
A.1	Description of the procedure	55
A.1.1	Procedure in the MS	55
A.1.2	Procedure in the BS	55
A.2	Format	55
Annex G (normative): Handling of frames with parameter errors in the address, control and length indicator fields.....		56
G.1	General	56
G.2	Parameter errors in the address field	56
G.2.1	Unallocated SAPI	56
G.2.2	Wrong value of the C/R bit	56
G.2.3	EA bit set to "0".....	56
G.3	Parameter errors in the control field.....	57
G.3.1	Supervisory frames.....	57
G.3.2	Unnumbered frames	57
G.4	Parameter errors in the length indicator field	57
G.4.1	EL bit error	57
G.4.2	Information frames	57
G.4.3	Supervisory frames.....	58
G.4.4	DISC and DM frames.....	58
G.4.5	SABM UA and UI frames	58
Annex C (informative): Change History		59
History		60

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
 - 1 presented to TSG for information;
 - 2 presented to TSG for approval;
 - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document defines a data link layer protocol to be used for signalling, and possibly also for other applications, on the MS-BS interface.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] 3GPP TS 21.905: "Vocabulary for 3GPP Specifications".
- [2] 3GPP TS 44.001: "Mobile Station - Base Station System (MS - BSS) Interface General Aspects and Principles".
- [3] 3GPP TS 44.003: "Mobile Station - Base Station System (MS - BSS) interface Channel structures and access capabilities".
- [4] 3GPP TS 44.004: "Layer 1 General requirements".
- [5] 3GPP TS 44.005: "Data Link (DL) layer General aspects".
- [6] 3GPP TS 24.007: "Mobile radio interface signalling layer 3; General aspects".
- [7] 3GPP TS 44.018: "Mobile radio interface layer 3 specification; Radio Resource Control Protocol".
- [8] 3GPP TS 24.010: "Mobile radio interface layer 3 Supplementary services specification; General aspects".
- [9] 3GPP TS 44.012: "Short Message Service Cell Broadcast (SMSCB) support on the mobile radio interface".
- [10] 3GPP TS 45.002: "Multiplexing and multiple access on the radio path".
- [11] 3GPP TS 48.056: "Base Station Controller - Base Transceiver Station (BSC - BTS) interface; Layer 2 specification".
- [12] 3GPP TS 48.058: "Base Station Controller - Base Transceiver Station (BSC - BTS) interface; Layer 3 specification".
- [13] CCITT Recommendation Z.100: "Specification and description language (SDL)".

3 Abbreviations

Abbreviations used in the present document are listed in 3GPP TS 21.905.

4 General

The present document describes the frame structure, elements of procedure, format of fields and procedures for the proper operation of the Link Access Procedure on the Dm channel, LAPDm.

NOTE 1: The term Dm channel is used for convenience to designate the collection of all the various signalling channels required in the GSM system. See also 3GPP TS 44.003.

The concepts, terminology, overview description of LAPDm functions and procedures, and the relationship with other Technical Specifications are described in general terms in 3GPP TS 44.005.

The frame formats defined for LAPDm are based on those defined for LAPD. However, there are important differences between LAPDm and LAPD, in particular with regard to frame delimitation methods and transparency mechanisms. These differences are necessary for operation within the constraints set by the radio path.

LAPDm supports two modes of operation:

- unacknowledged operation using UI frames;
- acknowledged operation using the multiple frame procedure.

As a choice of implementation, the two modes of operation may be implemented independently of each other. This is possible since there is no interactions between the two modes, other than queuing at the transmitter, even when they coexist on the same physical channel. For BCCHs and CCCHs only the unacknowledged mode of operation needs to be implemented.

LAPDm is used for information sent on the control channels BCCH, AGCH, NCH, PCH, FACCH, SACCH and SDCCH as defined in 3GPP TS 44.003.

NOTE 2: AGCH, NCH and PCH are sometimes referred to by the collective name CCCH and FACCH, SACCH and SDCCH are, similarly, referred to by the collective name DCCH.

LAPDm may also be used on other types of channel.

NOTE 3: As stated in 3GPP TS 44.005, the term "data link layer" is used in the main text of this Technical Specification. However, mainly in figures and tables, the terms "layer 2" and "L2" are used as abbreviations. Furthermore, in accordance with 3GPP TS 24.007 and 3GPP TS 44.018, the term "layer 3" is used to indicate the layer above the data link layer.

This Technical Specification is organized as follows:

The frame structure for peer-to-peer communication is given in clause 5. The elements of procedure and formats of fields are given in clause 6. The elements of layer-to-layer communication are contained in clause 7. The details of the peer-to-peer procedures are given in clause 8. clause 6 summarizes the special protocol operations used mandatorily with SAPI=0 and SAPI = 3.

The specification for the random access channel is contained in annex A, even though it is not a LAPDm function. The present document is descriptive and does not constrain the implementation of the random access function. The procedure is used for CHANNEL REQUEST on the RACH and HANDOVER ACCESS on the main DCCH.

(Annexes B to F are deleted).

Annex G gives an overview of actions taken on frames containing parameter errors.

4.1 Options

Support of short L2 header type 1 is an option in both the mobile station and the network; under certain conditions the support is mandatory, as specified in other Specifications. A layer 2 protocol entity not implementing short L2 header type 1 shall diagnose an E/A bit error and proceed as defined in annex G.2.3.

5 Frame structure for peer-to-peer communication

5.1 General

All data link layer peer-to-peer exchanges are in frames conforming to one of the formats shown in figure 1. Several format types are shown in the figure:

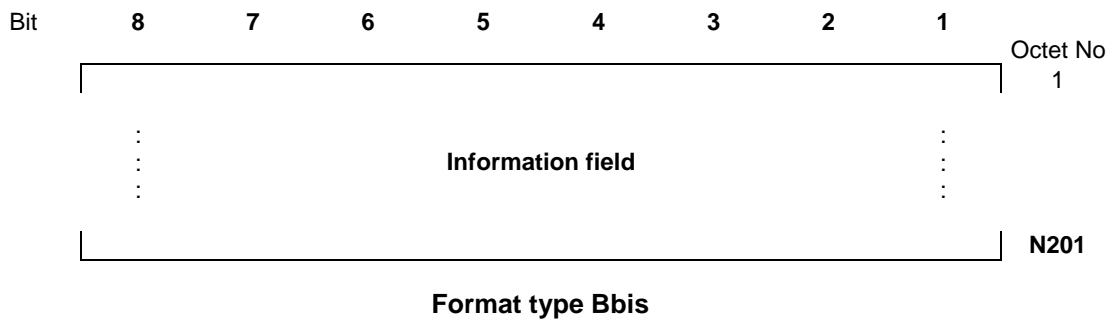


Figure 1 (sheet 2 of 3): General frame formats

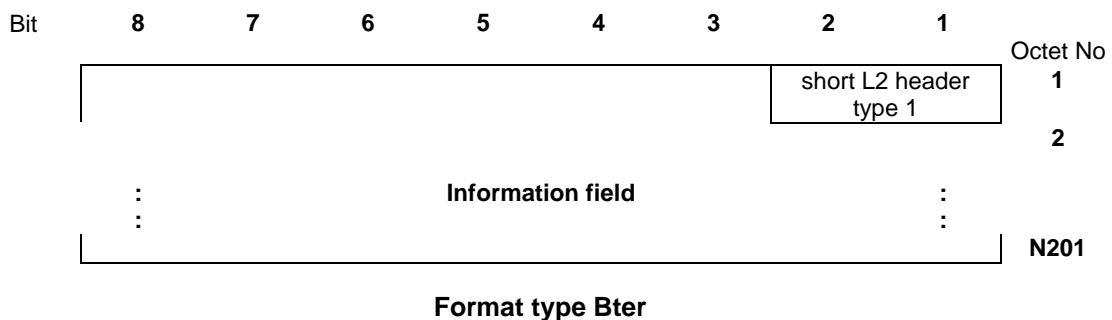
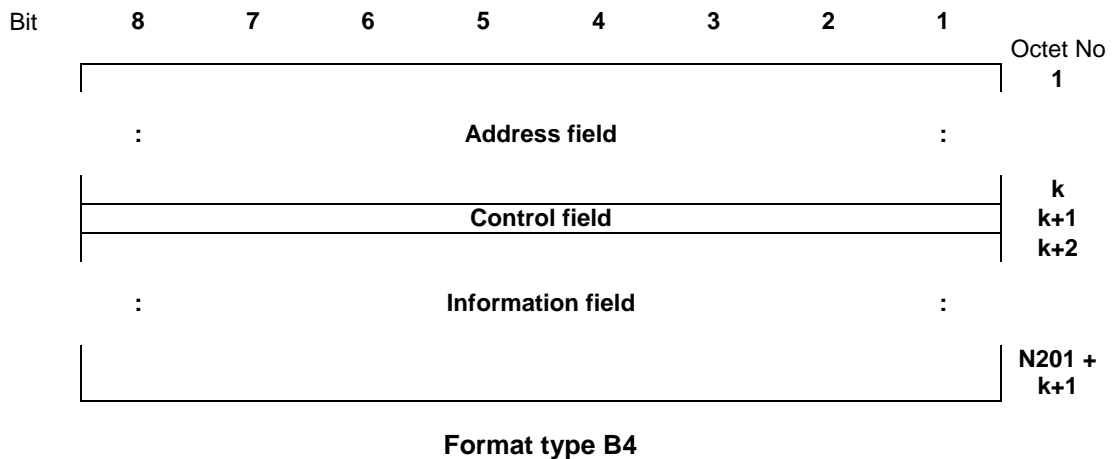


Figure 1 (sheet 3 of 3): General frame formats

The parameter N201 is the maximum number of octets which are partially or entirely available for the information field of a frame. It depends on the type of channel and the format, see sub-clause 8.8.3.

5.2 Frame delimitation and fill bits

Frame delimitation is provided by the physical layer:

- in format type A, B and B4 frames at the beginning of the frame for determining the start of the first octet in the address field, in format type Bter frames for determining the start of the octet containing the short L2 header type 1 (which is also the first octet used for the information field), and in format type Bbis frames for determining the start of the first octet for the information field;
- at the end of the frame for determining the last bit of the frame.

The end of the useful part of the frame, i.e. the end of the length indicator field in type A frames and the end of the information field in type B frames, is determined by a length indicator contained in the length indicator field. The useful part of a Bbis frames takes all N201 octets of that frame. The useful part of a Bter frame takes all N201 octets of that frame except those bits of octet 1 which contain the short L2 header type 1. The useful part of a B4 frame takes all N201 octets of that frame except those octets which contain the address field and the control field.

If a frame contains a length indicator that has a value less than N201, the frame contains fill bits. Each fill bit shall be set to a random value when sent by the mobile station. Except for the first octet containing fill bits which shall be set to the binary value "00101011", each fill bit should be set to a random value when sent by the network. Otherwise, the network shall set all octets containing fill bits to the binary value "00101011".

5.3 Address field

The address field may consist of a variable number of octets. However, for applications on control channels the field consists of only one octet. The address field identifies the SAP for which a command frame is intended and the SAP transmitting a response frame. The format of the address field is defined in sub-clause 6.2.

5.4 Control field

The control field consists of one octet. The format of the control field is defined in sub-clause 6.4.

5.5 Length indicator field

The length indicator field may consist of a variable number of octets. However, for applications on control channels the field consists of only one octet. The format of the field is defined in sub-clause 6.6.

5.5a Short L2 header type 1

The short L2 header type 1 consists of two bits. Its contents are defined in sub-clause 6.4a.

5.6 Information field

The information field of a frame, when present, has the position in the frame defined in sub-clause 5.1.

The maximum number of octets in the information field (N201) is defined in sub-clause 8.8.3.

5.7 Transparency

Because of the frame delimitation technique used (see sub-clause 5.2), the frame can include any possible sequence of bits without the need for additional transparency mechanisms.

5.8 Format convention

5.8.1 Numbering convention

The basic convention used in this Technical Specification is illustrated in figure 2. The bits are grouped into octets.

The bits of an octet are shown horizontally and are numbered from 1 to 8. Multiple octets are shown vertically and are numbered from 1 to n.

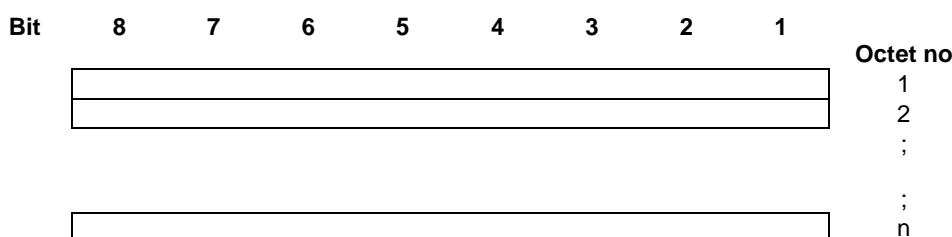


Figure 2: Format convention

5.8.2 Order of bit transmission

The order of bit transmission is defined in 3GPP TS 44.004.

5.8.3 Field mapping convention

When a field is contained within a single octet, the lowest bit number of the field represents the lowest order value.

When a field spans more than one octet, the order of bit values within each octet progressively decreases as the octet number increases. In that part of the field contained in a given octet the lowest bit number represents the lowest order value.

For example, a bit number can be identified as a couple (o, b) where o is the octet number and b is the relative bit number within the octet. Figure 3 illustrates a field that spans from bit (1, 3) to bit (2, 7). The high order bit of the field is mapped on bit (1, 3) and the low order bit is mapped on bit (2, 7).

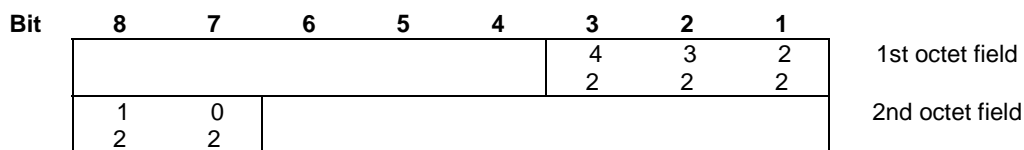


Figure 3: Field mapping convention

6 Elements of procedures and formats of fields for Data Link Layer peer-to-peer communication

6.1 General

The elements of procedures define the commands and responses that are used on the data link connections carried on the Dm channel.

Procedures are derived from these elements of procedures and are described in clause 8.

If a bit position is marked as "spare", it shall be coded as "0". For future compatibility reasons, an entity receiving frames, where spare bit positions are coded otherwise, shall ignore those values without notification of any error.

6.2 Address field format

The field consists of:

- the address field extension bit EA;
- the command/response bit C/R;
- the SAPI;
- and the Link Protocol Discriminator LPD.

The format of the address field for control channels is shown in figure 4.

The address field extension bit, EA, enables extension of the field to span more than one octet. The value "0" is used to indicate an extension, the value "1" shall be used for the final address field octet.

The Link Protocol Discriminator (LPD) corresponding to the use in this Technical Specification shall take the value "0 0", all other values are reserved.

NOTE: LPD = "0 1" corresponds to the data link protocol used for SMSCB (see 3GPP TS 44.012).

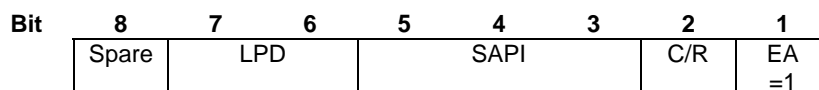


Figure 4: Address field format

6.3 Address field variables

6.3.1 Address field extension bit (EA)

The address field range is extended by reserving the first transmitted bit of the address field octets to indicate the final octet of the address field. The presence of a "1" in the first bit of an address field octet signals that it is the final octet of the address field. Figure 4 shows the case where the field consists of one octet.

6.3.2 Command/response field bit (C/R)

The C/R bit identifies a frame as either a command or a response. The MS side shall send commands with the C/R bit set to "0", and responses with the C/R bit set to "1". The BS side shall do the opposite; that is commands are sent with C/R set to "1", and responses are sent with C/R set to "0". The combinations for the BS side and MS side are shown in table 1.

Table 1: C/R field bit usage

Type	Direction	C/R value
Command	BS side to MS side	1
	MS side to BS side	0
Response	BS side to MS side	0
	MS side to BS side	1

6.3.3 Service access point identifier (SAPI)

The service access point identifier (SAPI) identifies a point at which data link layer services are provided by the data link layer to a layer 3 entity (see 3GPP TS 44.005). The SAPI allows 8 service access points to be specified initially, where bit 3 of the address field octet containing the SAPI is the least significant binary digit and bit 5 is the most significant.

The SAPI values are allocated as shown in table 2.

Table 2: Allocation of SAPI values

SAPI value	Related entity
0	Call control signalling, mobility management signalling and radio resource management signalling (see 3GPP TS 44.018 and 24.010)
3	Short message service
All others	Reserved for future standardization

6.4 Control field formats

The control field identifies the type of frame, which will be either a command or a response. The control field will contain sequence numbers, where applicable.

Three types of control field formats are specified: numbered information transfer (I format), supervisory functions (S format), and unnumbered information transfer and control functions (U format). The control field formats for LAPDm are shown in table 3.

6.4.1 Information transfer format - I

The I format shall be used to perform an information transfer between layer 3 entities. The functions of N(S), N(R) and P are independent; that is, each I frame has an N(S) sequence number, an N(R) sequence number which may or may not acknowledge additional I frames received by the data link layer entity, and a P bit that may be set to "0" or "1". The use of N(S), N(R) and P is defined in sub-clause 8.

6.4.2 Supervisory format - S

The S format shall be used to perform data link supervisory control functions such as: acknowledge I frames, request retransmission of I frames, and request a temporary suspension of transmission of I frames. The functions of N(R) and P/F are independent; that is, each supervisory frame has an N(R) sequence number which may or may not acknowledge additional I frames received by the data link layer entity, and a P/F bit that may be set to "0" or "1".

The use of N(R) and the P/F bit is described in sub-clause 8.

6.4.3 Unnumbered format - U

The U format shall be used to provide additional data link control functions and unacknowledged information transfer.

This format does not contain sequence numbers. It does include a P/F bit that may be set to "0" or "1".

Table 3: Control field format

Control field bits	8	7	6	5	4	3	2	1
I format	N(R)			P	N(S)			0
S format	N(R)			P/F	S	S	0	1
U format	U	U	U	P/F	U	U	1	1
N(S)	Transmitter send sequence number.							
N(R)	Transmitter receive sequence number.							
S	Supervisory function bit.							
U	Unnumbered function bit.							
P/F	Poll bit, when issued as a command, final bit, when issued as a response.							

For definition of values for supervisory function bits and unnumbered function bits, see table 4.

6.4a Short L2 header type 1

The short L2 header type 1 field is used in format Bter frames, see sub-clause 5.1. It consists of 2 bits, both shall take value 0.

NOTE: Introduction of further short L2 header types (longer than 2 bits, setting bit 2 to "1" and bit 1 to "0") is for further study.

The short L2 header type 1 implicitly defines a UI command frame belonging to SAPI=0, with length N201. All other parameters of a L2 frame header are irrelevant.

6.5 Control field parameters and associated state variables

The various parameters associated with the control field formats are described in this sub-clause. The coding of the bits within these parameters is such that the lowest numbered bit within the parameter field is the least significant bit.

6.5.1 Poll/Final bit

All frames contain P/F, the Poll/Final bit. The Poll/Final (P/F) bit serves a function in both command frames and response frames. In command frames the P/F bit is referred to as the P bit. In response frames it is referred to as the F bit.

The P bit set to "1" is used by a data link layer entity to create (poll) a response frame from the peer data link layer entity. The F bit set to "1" is used by a data link layer entity to indicate the response frame transmitted as a result of a soliciting (poll) command.

The use of the P/F bit is described in sub-clause 8.

6.5.2 Multiple frame operation - variables and sequence numbers

6.5.2.1 Modulus

Each I frame is sequentially numbered by a sequence number which may have the value 0 through 7.

Arithmetics acting on variables which are related to such sequence numbers (i.e. N(S), N(R), V(S), V(R), V(A); see following sub-clauses) operate modulo 8.

NOTE: Modulo 8 operation on negative numbers is performed by adding multiples of 8 to the negative number until the result becomes nonnegative. Then common modulo 8 operation is applied.

6.5.2.2 Send state variable V(S)

Each point-to-point data link connection endpoint shall have an associated send state variable (V(S)) when using I frame commands. The send state variable denotes the sequence number of the next in-sequence I frame to be transmitted.

The send state variable can take on the value 0 through 7.

The value of the send state variable shall be incremented by 1 with each successive I frame transmission, and shall not exceed V(A) by more than the maximum number of outstanding I frames k (The window size k is defined in sub-clause 8.8.4.). The value of k may be in the range of $1 \leq k < 7$.

6.5.2.3 Acknowledge state variable V(A)

Each point-to-point data link connection endpoint shall have an associated acknowledge state variable (V(A)) when using I frame commands and supervisory frame commands/responses.

The acknowledge state variable identifies the last frame that has been acknowledged by its peer (V(A) - 1 equals the N(S) of the last acknowledged I frame). The acknowledge state variable can take on the value 0 through 7. The value of the acknowledge state variable shall be updated by the valid N(R) values received from its peer (see 6.5.2.6). A valid N(R) value is one that is in the range $V(A) \leq N(R) < V(S)$.

NOTE: These inequalities shall be interpreted in the following way:
 N(R) is called valid, if and only if $(N(R) - V(A)) \bmod 8 \leq (V(S) - V(A)) \bmod 8$.
 Furthermore, from sub-clause 6.5.2.2., it is obvious that $(V(S) - V(A)) \bmod 8 \leq k$.

6.5.2.4 Send sequence number N(S)

Only I frames contain N(S), the send sequence number of transmitted I frames. At the time that an in-sequence I frame is designated for transmission, the value of N(S) is set equal to the value of the send state variable V(S).

6.5.2.5 Receive state variable V(R)

Each point-to-point data link connection endpoint shall have an associated receive state variable (V(R)) when using I frame commands and supervisory frame commands/responses. The receive state variable denotes the sequence number of the next in-sequence I frame expected to be received. The receive state variable can take on the value 0 through 7.

The value of the receive state variable shall be incremented by one with the receipt of an error-free, in-sequence I frame whose send sequence number N(S) equals the receive state variable V(R).

6.5.2.6 Receive sequence number N(R)

All I frames and supervisory frames contain N(R), the expected send sequence number of the next received I frame.

At the time that a frame of the above types is designated for transmission, the value of N(R) is set equal to the current value of the receive state variable V(R). N(R) indicates that the data link layer entity transmitting the N(R) has correctly received all I frames numbered up to and including N(R) - 1.

6.5.2.7 Other parameters and variables

For definition and values of parameters and variables such as timer T200, maximum number of retransmissions (N200), window size (k) and the maximum number of octets in an information field (N201), see sub-clause 8.8.

6.5.3 Unacknowledged operation variables and parameters

The only parameter defined for unacknowledged operation is the number of octets (N201) in the information field of the UI frame. See sub-clause 8.8.3.

6.6 Length indicator field format

The format of the length indicator field for control channels is shown in figure 5.

The length indicator field extension bit, EL, enables extension of the field to span more than one octet.

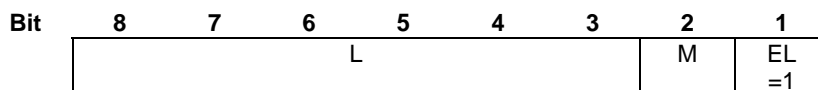


Figure 5: Length indicator field format

The field consists of the field extension bit, EL, the more data bit, M, and the length indicator, L.

6.7 Length indicator field variables

6.7.1 Length indicator field extension bit (EL)

The length indicator field is extended by reserving the first transmitted bit of the length indicator field octets to indicate the final octet of the field. Presence of a "1" in the first bit of a length indicator field octet signals that it is the final octet of the field. Figure 5 shows the case where the field consists of one octet.

6.7.2 More data bit (M)

The more data bit, M, is used to indicate segmentation of layer 3 message units on data link layer frames. Layer 3 messages, which need to be segmented, shall only be transported by I-frames.

When the M bit is set to "1", it indicates that the information field of the frame contains only a segment of the layer 3 message unit.

The M bit set to "0" indicates:

- i) that the information field contains a complete layer 3 message unit provided that the M bit of the previous frame was set to "0";
- ii) that the information field contains the last segment of a layer 3 message unit if the M bit of the previous frame was set to "1".

When the M bit is set to "1", the information field shall contain the maximum number of octets, N201, that an information frame can contain, see sub-clause 8.8.3 for the value of N201.

In frames other than information (I) frames the M bit shall be set to "0".

6.7.3 Length indicator (L)

The length indicator consists of 6 bits and is used to indicate the number of octets contained in the information field of UI, SABM, UA or I frames, i.e. any value from 0 to N201 inclusive.

The L = 0 shall be used in frames not containing an information field.

6.8 Commands and responses

The following commands and responses are used by either the MS or the BS data link layer entities and are represented in table 4. Each data link connection supports the appropriate set of commands and responses for the type of operation desired (see sub-clause 8).

For purposes of the LAPDm procedures, frames with the supervisory function bit encoding "11" and those encodings of the unnumbered function bits in table 3 not identified in table 4 are identified as "invalid or not implemented" command and response control fields and shall be treated as defined in sub-clause 8.7.3.

The commands and responses in table 4 are defined as follows.

6.8.1 Information (I) commands

The function of the information (I) command is to transfer, across a data link connection, sequentially numbered frames containing information fields provided by layer 3. This command is used in the multiple frame operation.

Table 4: Commands and responses - unacknowledged and multiple frame acknowledged operation

Format	Commands	Responses	8 7 6 5 4 3 2 1				
Information transfer	I (infor-mation)		N (R)	P	N (S)		0
Supervisory	RR (receive ready)	RR (receive ready)	N (R)	P/F	0 0	0 1	
	RNR (receive not ready)	RNR (receive not ready)	N (R)	P/F	0 1	0 1	
	REJ (reject)	REJ (reject)	N (R)	P/F	1 0	0 1	
Unnumbered	SABM (set asynchronous balanced mode)		0 0 1	P	1 1	1 1	
		DM (disconnect mode)	0 0 0	F	1 1	1 1	
	UI (un-numbered information)		0 0 0	P	0 0	1 1	
	DISC (disconnect)		0 1 0	P	0 0	1 1	
		UA (un-numbered acknowledge)		0 1 1	F	0 0	1 1

6.8.2 Set asynchronous balanced mode (SABM) command

The SABM unnumbered command is used to place the addressed user side or network side into the modulo 8 multiple frame acknowledged operation.

An information field is permitted with the SABM command only if it is used in the MS to BSS direction in order to establish a SAPI 0 data link (for contention resolution after having transmitted a random access frame on the RACH or in response to a PACKET CS COMMAND message). Layer 3 will indicate when an information field is to be included (see sub-clause 8.4.1 for procedures).

A data link layer entity confirms acceptance of a SABM command by the transmission at the first opportunity of a UA response. Upon acceptance of this command, the data link layer entity's send state variable V(S), acknowledge state variable V(A), and receive state variable V(R), are set to 0. The transmission of an SABM command indicates the clearance of any exception condition, in particular a busy condition that was reported by the earlier transmission of an RNR frame by that same data link layer entity.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged and shall be discarded. It is the responsibility of a higher layer (for example, layer 3) to recover from the possible loss of the contents of such I frames.

NOTE: SABM frames cannot contain layer 3 message units which have to be segmented.

6.8.3 Disconnect (DISC) command

The DISC unnumbered command is transmitted in order to terminate the multiple frame operation.

NOTE: See sub-clause 8.4.4.4 for local end release where the multiple frame operation is terminated without transmitting a DISC command frame.

No information field is permitted with the DISC command.

Prior to actioning the command, the data link layer entity receiving the DISC command confirms the acceptance of a DISC command by the transmission of a UA response. The data link layer entity sending the DISC command terminates the multiple frame operation when it receives the acknowledging UA or DM response.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged and shall be discarded. It is the responsibility of a higher layer (for example, layer 3) to recover from the possible loss of the contents of such I frames.

6.8.4 Unnumbered information (UI) command

When a layer 3 entity requests unacknowledged information transfer, the UI unnumbered command shall be used to send information to its peer without affecting data link layer variables. UI command frames do not carry a sequence number. Therefore, the UI frame may be lost without notification to the layer 3 entity if a data link exception occurs during transmission of the command.

The request of unacknowledged information transfer may require short L2 header type 1. If the layer 2 entity does not support short L2 header type 1, it shall report an MDL-ERROR-INDICATION with error cause "short L2 header type 1 not supported". If short L2 header type 1 is not applicable for the intended information transfer, it shall report an MDL-ERROR-INDICATION with error cause "short L2 header type 1 not applicable". If the request is not erroneous, it shall transfer the information as specified in a format Bter frame.

6.8.5 Receive ready (RR) command/response

The receive ready (RR) supervisory frame is used by a data link layer entity to:

- a) indicate it is ready to receive an I frame;
- b) acknowledge previously received I frames numbered up to and including $N(R) - 1$ (as defined in sub-clause 8);
- c) clear a busy condition that was indicated by the earlier transmission of an RNR frame by that same data link layer entity.

In addition to indicating the status of a data link layer entity, the RR command with the P bit set to "1" may be used by the data link layer entity to ask for the status of its peer data link layer entity.

No information field is permitted with the RR command/response.

6.8.6 Reject (REJ) command/response

The reject (REJ) supervisory frame is used by a data link layer entity to request retransmission of I frames starting with the frame numbered $N(R)$. The value of $N(R)$ in the REJ frame acknowledges I frames numbered up to and including $N(R) - 1$. New I frames pending initial transmission shall be transmitted following the retransmitted I frames.

Only one REJ exception condition for a given direction of information transfer shall be established at a time. The REJ exception condition is cleared (reset) upon the receipt of an I frame with an $N(S)$ equal to the $N(R)$ of the REJ frame.

The transmission of an REJ frame shall also indicate the clearance of any busy condition within the sending data link layer entity that was reported by the earlier transmission of an RNR frame by that same data link layer entity.

In addition to indicating the status of a data link layer entity, the REJ command with the P bit set to "1" may be used by the data link layer entity to ask for the status of its peer data link layer entity.

No information field is permitted with the REJ command/response.

6.8.7 Receive not ready (RNR) command/response

The receive not ready (RNR) supervisory frame shall be used by a data link layer entity to indicate a busy condition; that is, a temporary inability to accept additional incoming I frames. The value of $N(R)$ in the RNR frame acknowledges I frames numbered up to and including $N(R) - 1$.

Acknowledgement of subsequent I frames transmitted before the indication of the peer receiver busy is received, will be made in subsequent exchanges if they arrive after the peer receiver busy condition has been cleared.

In addition to indicating the status of a data link layer entity, the RNR command with the P bit set to "1" may be used by the data link layer entity to ask for the status of its peer data link layer entity.

No information field is permitted with the RNR command/ response.

NOTE: The protocol operation used on control channels with SAPI=0 or SAPI=3 shall not utilize the RNR frame type and related procedures. Therefore RNR frames received in those cases can be ignored.

6.8.8 Unnumbered acknowledgement (UA) response

The UA unnumbered response is used by a data link layer entity to acknowledge the receipt and acceptance of the mode setting commands (SABM or DISC). Received mode setting commands are not actioned until the UA response is transmitted.

An information field is permitted with the UA response, i.e. if an SABM command with an information field is received and the SABM is to be acknowledged, the UA response to that command shall contain the same information field as received in the SABM command.

The transmission of the UA response indicates the clearance of any busy condition that was reported by the earlier transmission of an RNR frame by that same data link layer entity.

6.8.9 Disconnected mode (DM) response

The DM unnumbered response is used by a data link layer entity to report to its peer that the data link layer is in a state such that multiple frame operation cannot be performed. A data link layer entity shall transmit a DM response to any valid command received which it cannot action.

No information field is permitted with the DM response.

7 Elements for layer-to-layer communication

7.1 Definition of primitives and parameters

Communications between layers and between the data link layer and layer 3 are accomplished by means of primitives.

Primitives represent, in an abstract way, the logical exchange of information and control between the data link layer and adjacent layers. They do not specify or constrain implementations.

Primitives consist of commands and their respective responses associated with the services requested of a lower layer. The general syntax of a primitive is:

XX - Generic name - Type (Parameters);

where XX designates the layer providing the service. For the present document XX is DL for the data link layer, PH for the physical layer and MDL for administrative functions (e.g. error reporting and recovery).

7.1.1 Generic names

The generic name specifies the activity that the identified layer should perform. Table 5 illustrates the primitives defined in the present document.

The primitive generic names that are defined in the present document are:

7.1.1.1 DL-ESTABLISH

The DL-ESTABLISH primitives are used to request, confirm and indicate the outcome of the procedures for establishing multiple frame operation.

7.1.1.2 DL-RELEASE

The DL-RELEASE primitives are used to request, confirm and indicate the outcome of the procedures for terminating a previously established multiple frame operation.

In the case of a data link layer malfunction, layer 3 will be notified by a RELEASE indication.

7.1.1.3 DL-DATA

The DL-DATA primitives are used to pass to and from the data link layer layer 3 message units which are to be transmitted, or have been received, using multiple frame acknowledged operation.

7.1.1.4 DL-UNIT DATA

The DL-UNIT DATA primitives are used to pass to and from the data link layer, layer 3 message units which are to be transmitted, or have been received, using unacknowledged operation.

7.1.1.5 DL-SUSPEND

The DL-SUSPEND primitive is used in the mobile station by the radio resource management entity to perform a local end release in such a way, that the layer 3 data units and the state of the transmit and receive counters are saved.

7.1.1.6 DL-RESUME

The DL-RESUME primitive is used in the mobile station by the radio resource management entity to establish multiple frame operation and resume communication with the network without loss of layer 3 messages. The layer 3 data unit passed to layer 2 together with that primitive is sent with priority (e.g. ASSIGNMENT COMPLETE or HANDOVER COMPLETE).

7.1.1.7 DL-RECONNECT

The DL-RECONNECT primitive is used in the mobile station by the radio resource management entity to restore multiple frame operation on the old channel after failure of the channel change. The layer 3 data unit passed to layer 2 with previous DL-RESUME-REQUEST (i.e. ASSIGNMENT COMPLETE or HANDOVER COMPLETE) is discarded and the layer 3 data unit passed together with that primitive is sent with priority (e.g. ASSIGNMENT FAILURE or HANDOVER FAILURE).

7.1.1.8 DL-RANDOM ACCESS

The DL-RANDOM ACCESS primitives are used to request (in the MS) the sending of a random access message, to confirm (in the MS) the transmission of the random access message including the time slot in which it was sent, and to indicate (in the network) the arrival of a random access message.

7.1.1.9 MDL-RELEASE

The MDL-RELEASE primitives are used by layer 3 entity to request local end termination of a previously established acknowledged mode operation.

7.1.1.10 MDL-ERROR

The MDL-ERROR primitives are used to notify layer 3 that an error has occurred, detected as a result of communication with the data link peer entity, which cannot be corrected by the data link layer.

7.1.1.11 PH-DATA

The PH-DATA primitives are used to pass message units containing frames used for data link layer peer-to-peer communications to and from the physical layer.

7.1.1.12 PH-RANDOM ACCESS

The PH-RANDOM ACCESS primitives are used to request (in the MS) the sending of a random access frame, to confirm (in the MS) the transmission of the random access frame including the time slot in which it was sent, and to indicate (in the network) the arrival of a random access frame.

7.1.1.13 PH-CONNECT

The PH-CONNECT primitive is used to indicate that a specific type of channel has been connected at the physical layer.

7.1.1.14 PH-READY-TO-SEND

The PH-READY-TO-SEND primitive is generated by the physical layer to enable the data link layer to synchronize to the next instant of physical transmission. On receipt of this indication layer 2 may trigger piggy backing (if applicable), the start of T200 and the forwarding of data units to layer 1.

7.1.1.15 PH-EMPTY-FRAME

The PH-EMPTY-FRAME primitive can be used by the data link layer instead of a PH-DATA-REQUEST primitive, when no frame has to be transmitted after receiving the PH-READY-TO-SEND indication. It enables handling of several layer 2 entities by layer 1 and transmission of fill frames, if necessary.

7.1.2 Primitives types

The primitives types defined in the present document are:

NOTE: For the action sequence of these primitive types, see 3GPP TS 44.001.

7.1.2.1 REQUEST

The REQUEST primitive type is used when a higher layer is requesting a service from the next lower layer.

7.1.2.2 INDICATION

The INDICATION primitive type is used by a layer providing a service to notify the next higher layer of activities related to the REQUEST primitive type.

7.1.2.3 RESPONSE

The RESPONSE primitive type is used by a layer to acknowledge receipt, from the next lower layer, of the INDICATION primitive type.

7.1.2.4 CONFIRM

The CONFIRM primitive type is used by the layer providing the requested service to confirm that the activity has been completed.

Figure 6 illustrates the relationship of the primitive types to the layer 3 and the data link layer.

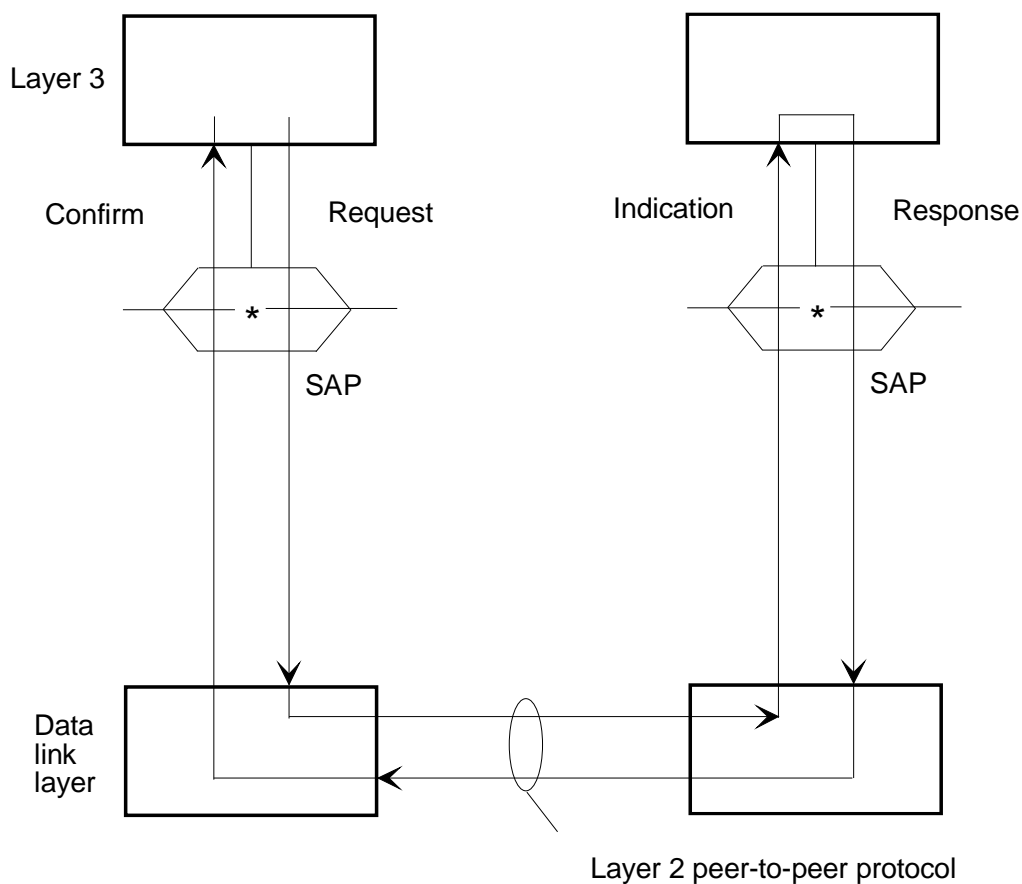


Figure 6: Relationship of the primitive types to the layer 3 and the data link layer

7.1.3 Parameter definition

7.1.3.1 Message unit

The message unit contains additional layer-to-layer information concerning actions and results associated with requests. In the case of the DATA and UNIT DATA primitives, the message unit contains the requesting layer peer-to-peer messages. For example, the DL-DATA message unit contains the layer 3 message unit; the PH-DATA message unit contains the data link layer frame.

NOTE: The operations across the data link layer/layer 3 boundary shall be such that the layer sending the DATA or UNIT DATA primitive can assume a temporal order of the bits within the message unit and that the layer receiving the primitive can reconstruct the message with its assumed temporal order.

7.1.3.2 Channel type

Since the Dm channel procedures are distributed on several types of channel (CCCH, BCCH and various types of DCCH), a parameter will be needed in order to distribute the layer 3 message units correctly on the various types of channel. The control channel types to be used are defined in 3GPP TS 44.003.

7.1.3.3 Service Access Point

Since data links on different SAPs may be multiplexed, the SAPI parameter is used to indicate the respective association.

7.1.3.4 Release mode

The release mode parameter is used to enable the data link layer to operate in different release modes depending on whether the data link is to be released in the normal way or that a local end release shall take place on command from the layer 3. The values of the parameter are:

- normal;
- local end release.

7.1.3.5 Error cause

This parameters is used by the data link layer to report procedure error to layer 3. The following causes may be reported:

- timer T200 expired (N200 +1) times: perform abnormal release;
- re-establishment request;
- unsolicited UA response;
- unsolicited DM response;
- unsolicited DM response, multiple frame established state: perform abnormal release;
- unsolicited supervisory response;
- sequence error: perform abnormal release;
- U frame with incorrect parameters;
- short L2 header type 1 not supported;
- short L2 header type 1 not applicable;
- S frame with incorrect parameters;
- I frame with incorrect use of M bit;
- I frame with incorrect length;
- frame not implemented;
- SABM command, multiple frame established state;
- SABM command with information field not allowed in this state.

7.1.3.6 Establish mode

This parameter is used in the MS to indicate to the data link layer the type of establishment that is required. The parameter takes the following values:

- normal;
- contention resolution.

7.1.3.7 L2 header type

This parameter is used by higher layers to ask for application of a specific L2 header type; as values for the parameter, only "short L2 header type 1" and "normal L2 header" are actually defined.

7.1.3.8 Priority

This parameter is used by the higher layers to indicate the priority of a Layer 3 message on SAPI 0 with multiple frame operation. The parameter is not applicable to unacknowledged information transfer or to other SAPIs. The parameter takes the following values:

- high;
- normal;
- low.

The parameter need not be included if the higher layers do not support the sending of low priority messages as defined in 3GPP TS 44.018. If the parameter is not included, the data link layer shall assume a priority value of "normal".

Table 5: Data Link Service primitives

Generic name and type	Parameters							Message unit contents
	SAPI	Channel type	Error Cause	Release mode	Establish mode	L2 header type	Priority	
DL-ESTABLISH- REQUEST	0	DCCH			CoRes			Layer 3 message
	0	DCCH, SACCH			Norm			
	3	DCCH, SACCH			Norm			
DL-ESTABLISH- INDICATION	0	DCCH			CoRes			Layer 3 message
	0	DCCH, SACCH			Norm			
	3	DCCH, SACCH			Norm			
DL-ESTABLISH- CONFIRM	0	DCCH			CoRes			
	0	DCCH, SACCH			Norm			
	3	DCCH, SACCH			Norm			
DL-RELEASE- REQUEST	0,3	DCCH, SACCH		any				
DL-RELEASE- INDICATION	0,3	DCCH, SACCH		any				
DL-RELEASE- CONFIRM	0,3	DCCH, SACCH		any				
DL-SUSPEND- REQUEST	0	DCCH						
DL-SUSPEND- CONFIRM	0	DCCH						
DL-RESUME- REQUEST	0	DCCH						Layer 3 peer-to- peer message
DL-RESUME- CONFIRM	0	DCCH						
DL-RECONNECT- REQUEST	0	DCCH						Layer 3 peer-to- peer message
DL-RECONNECT CONFIRM	0	DCCH						
DL-DATA-REQUEST	0,3	DCCH, SACCH					any (SAPI 0 only)	Layer 3 peer-to- peer message
DL-DATA- INDICATION	0,3	DCCH, SACCH						Layer 3 peer-to- peer message
DL-UNIT DATA-REQUEST	0	BCCH CCCH DCCH SACCH				normal L2 header / short L2 header type 1		Layer 3 peer-to- peer message
	3	DCCH SACCH						Layer 3 peer-to- peer message

Generic name and type	Parameters							Message unit contents
	SAPI	Channel type	Error Cause	Release mode	Establish mode	L2 header type	Priority	
DL-UNIT DATA-INDICATION	0	BCCH CCCH DCCH SACCH						Layer 3 peer-to- peer message Layer 3 peer-to- peer message
	3	DCCH SACCH						
MDL-RELEASE- REQUEST	0,3	DCCH, SACCH						
MDL-ERROR- INDICATION	0,3	DCCH, SACCH	any					
DL-RANDOM ACCESS-REQUEST	0	RACH						Channel request (see 3GPP TS 44.018) Handover access (see 3GPP TS 44.018)
	0	DCCH						
DL-RANDOM ACCESS-INDICATION	0	RACH						Request reference (see 3GPP TS 48.058) Handover reference (see 3GPP TS 48.058)
	0	DCCH						
DL-RANDOM ACCESS-CONFIRM	0	RACH						Request reference (see 3GPP TS 44.018)

Table 6: Physical Service primitives used

Generic name and type	Parameters					Message unit contents
	SAPI	Channel type	Error Cause	Release mode	Establish mode	
PH-DATA-REQUEST	any					Data link peer-to-peer message
PH-DATA-INDICATION	any					Data link peer-to-peer message
PH-RANDOM ACCESS-REQUEST	RACH, DCCH					Random access data link message unit
PH-RANDOM ACCESS-INDICATION	RACH, DCCH					Random access data link message unit and TDMA frame nr.
PH-RANDOM ACCESS- CONFIRM	RACH, DCCH					TDMA frame number
PH-CONNECT-INDICATION	any					
PH-READY-TO-SEND-INDICAT.	any					
PH-EMPTY-FRAME-REQUEST	any					

NOTE 1: Table 5 and table 6 do not contain a complete list of conditional dependencies of service primitive parameters. If a field is left blank, the respective parameter shall not be used or is not applicable. If a field is marked by "any", the respective parameter shall be used and shall be set to a valid value according its specification.

NOTE 2: In table 5 and table 6, the term "DCCH" denotes the respective main DCCH (i.e. SDCCH or FACCH).

7.2 Primitive procedures

The procedures in the MS and the network are described by use of the primitives defined above. See also 3GPP TS 44.018.

8 Definition of the peer-to-peer protocol LAPDm

8.1 General

In the following sub-clauses, a protocol for use by the data link layer on the radio interface is specified, referred to as "LAPDm". Beside this, there may be signalling and data transfer between layer 3 entities, which does not comply to the procedures described hereafter (e.g. for the random access procedure see annex A; for short message cell broadcast see 3GPP TS 44.012).

The LAPDm elements of procedure (frame types) which apply are:

- a) for unacknowledged information transfer (sub-clause 8.3):

UI-command.

b) for multiple frame acknowledged information transfer (sub-clauses 8.4 to 8.8):

SABM-command;

UA-response;

DM-response;

DISC-command;

RR-command/response;

RNR-command/response;

REJ-command/response;

I-command.

For the various channel types the following applies:

- BCCH; unacknowledged operation only;
- CCCH; unacknowledged operation only;
- all types of DCCH; unacknowledged operation and multiple frame acknowledged operation.

For acknowledged mode (multiple frame operation) on SAPI=0 and SAPI=3, a special protocol operation shall be used mandatorily, as specified in sub-clause 9.

For handling of timers, the procedures and terminology of CCITT Recommendation Z.100 will be used, i.e.

set <timer name> means that:

- a) if the timer is inactive, the timer becomes active, i.e. a timer value is associated with the timer and it starts running;
- b) if the timer is active, the timer is first reset, as in c) below and then set as in a) above;

reset <timer name> means that:

- c) if the timer is active, the timer becomes inactive, i.e. the association with the timer value is lost and it stops running;
- d) if the timer is inactive, it remains inactive.

NOTE: The task set T200 shall be performed at the instant right before transmitting a frame, when the PH-READY-TO-SEND primitive is received from the physical layer.

8.2 General Protocol Procedures

8.2.1 Unacknowledged information transfer

Higher layers may ask for unacknowledged transmission transfer with normal L2 header; higher layers may also ask for unacknowledged transmission transfer on SAPI 0 using short L2 header type 1.

When a protocol entity receives a valid UI frame, this requires no further response to the transmitting entity.

For unacknowledged information transfer with normal L2 header, the P/F bit is not used and shall be set to "0".

8.2.2 Acknowledged multiple frame information transfer

A data link layer entity receiving an SABM, DISC, RR, REJ or I command, shall respond to the originating entity by an appropriate response frame (as specified in sub-clauses 8.4 through 8.7) within the time limits given in sub-clause 8.9.

If the received command frame carries a P bit set to "1", the F bit in the corresponding response frame shall be set to "1", too.

Frames containing SAPI values not used by the current version of the present document, shall be ignored without any notification.

8.3 Procedures for unacknowledged information transfer

8.3.1 General

The procedures which apply to the transmission of information in unacknowledged operation are defined below.

No data link layer error recovery procedures are defined for unacknowledged operation.

8.3.2 Transmission of unacknowledged information

NOTE 1: The term "transmission of a UI frame" refers to the delivery of a UI frame by the data link layer to the physical layer.

Unacknowledged information is passed to the data link layer by layer 3 using the primitive DL-UNIT DATA-REQUEST. This DL-UNIT DATA-REQUEST specifies whether a short L2 header type 1 is to be used or not. The layer 3 message unit shall be transmitted in a UI command frame.

Layer 2 shall construct a layer 2 message unit from the layer 3 message unit and pass it to layer 1 for transmission using the primitive PH-DATA-REQ. The layer 2 message unit uses the frame type as defined in sub-clause 5.1.

If the layer 2 message unit contains a control field, the P bit shall be set to "0".

NOTE 2: On a DCCH, UI frames with the length indicator set to "0" may be used as fill frames, see sub-clause 8.4.2.3.

8.3.3 Receipt of unacknowledged information

On receipt of a UI command frame with a SAPI which is supported by the receiver, the contents of the information field shall be passed to the layer 3 entity identified by the SAPI using the data link layer to layer 3 primitive DL-UNIT DATA-INDICATION. UI frames with invalid SAPI values shall be discarded. UI frames received with the length indicator set to "0" shall be ignored.

8.4 Procedures for establishment and release of multiple frame operation

8.4.1 Establishment of multiple frame operation

8.4.1.1 General

These procedures shall be used to establish multiple frame operation between the BS and a designated MS entity.

Layer 3 will initiate the establishment procedure after a physical channel supporting this type of operation (see sub-clause 8.1) has been allocated to the MS.

NOTE: In order to avoid loss of layer 3 information if the SABM has to be retransmitted because the UA response message is lost, the data link layer should be established when needed by the entity that will send an I command frame. For SAPI 0 the data link is always established by the MS.

Two establishment procedures are specified:

- normal establishment where the SABM does not contain an information field. Layer 3 will indicate a request for this type of establishment by the use of the DL-ESTABLISH-REQUEST primitive (sub-clauses 8.4.1.2 and 8.4.1.3);
- contention resolution where the SABM contains an information field. The procedure is always initiated by the MS, i.e. the SABM is sent by the MS. Layer 3 will indicate a request for this type of establishment by the use of the DL-ESTABLISH-REQUEST primitive containing the layer 3 message unit (sub-clauses 8.4.1.4 and 8.4.1.5). This procedure is only applicable for SAPI 0.

Re-establishment may be initiated, using the normal establishment procedure, as a result of the data link layer procedure defined in sub-clause 8.6.

8.4.1.2 Normal establishment procedures

A data link layer entity shall initiate a request for the multiple frame operation to be set by transmitting the Set Asynchronous Balanced Mode (SABM) command with the P bit set to "1". Since the DL-ESTABLISH-REQUEST primitive does not contain a layer 3 message unit, the length indicator, L, is set to "0".

All existing exception conditions shall be cleared, the retransmission counter shall be reset, and timer T200 shall be set right before transmitting a frame, when the PH-READY-TO-SEND primitive is received from the physical layer (timer T200 is defined in sub-clause 8.8.1).

The establishment procedure implies the discard of any outstanding DL-DATA-REQUEST primitive which has been invoked prior to the DL-ESTABLISH-REQUEST. It also implies the discard of any segmented layer 3 message unit for which the last segment has not been received (see sub-clause 8.5.2 for the concatenation procedure).

All frames other than unnumbered frame formats received during the establishment procedures shall be ignored.

A data link layer entity receiving an SABM, if it is able to enter the multiple-frame-established state, shall:

- respond with an Unnumbered Acknowledgement (UA) response with the F bit set to the same binary value as the P bit in the received SABM command, the same SAPI value as in the received SABM command, and with the length indicator, L, set to "0";
- set the send state variable V(S), receive state variable V(R) and acknowledge state variable V(A) to 0;
- enter the multiple-frame-established state and inform the associated layer 3 entity using the primitive DL-ESTABLISH-INDICATION;
- clear all existing exception conditions;
- clear an existing peer receiver busy condition.

If the data link layer entity is unable to enter the multiple-frame-established state, it shall respond to the SABM command with a DM response with the F bit set to the same binary value as the P bit in the received SABM command.

Upon reception of the UA response with the F bit set to "1", the originator of the SABM command shall:

- reset timer T200;
- set the send state variable V(S), the receive state variable V(R) and the acknowledge state variable V(A) to 0;
- enter the multiple-frame-established state and inform the associated layer 3 entity using the primitive DL-ESTABLISH-CONFIRM.

A UA response with the F bit set to "0" shall be ignored.

Upon reception of a DM response with F bit set to "1", the originator of the SABM command shall indicate this to the layer 3 entity by means of the primitive DL-RELEASE-INDICATION and reset timer T200. DM responses with the F bit set to "0" shall be ignored.

8.4.1.3 Procedure on expiry of timer T200: Normal establishment

If timer T200 expires before the UA or DM response is received, the data link layer entity shall:

- retransmit the SABM command as above;
- set timer T200 right before transmitting a frame, when the PH-READY-TO-SEND primitive is received from the physical layer; and
- increment the retransmission counter.

After retransmission of the SABM command N200 times, the data link layer entity shall indicate this to the associated layer 3 entity by means of the primitive DL- RELEASE-INDICATION. Layer 3 shall also be notified by using the primitive MDL-ERROR-INDICATION with the cause "timer T200 expired N200 + 1 times: perform abnormal release".

The value of N200 is defined in sub-clause 8.8.2.

8.4.1.4 Contention resolution establishment procedure

This procedure is always initiated by the MS for establishing a data link in order to resolve contention after having accessed the BS on the RACH. The procedure may also be used by the MS for establishing a data link in response to a PACKET CS COMMAND message (see 3GPP TS 44.060). Layer 3 decides when this establishment procedure is to be used and will request the data link layer to initiate the procedure by a DL-ESTABLISH-REQUEST primitive containing the layer 3 message unit and with the parameter established mode set to contention resolution.

The data link layer shall, however, ignore any such service request if it is not in the idle state when the request is received.

The data link layer entity in the MS shall initiate the establishment by transmitting an SABM command with the P bit set to "1". The SABM command shall contain the layer 3 message unit received in the DL-ESTABLISH-REQUEST primitive and the length indicator, L, shall be set to the appropriate value.

NOTE 1: According to sub-clause 9, the contention resolution procedure is only permitted with SAPI value 0.

The information field of the SABM command shall be stored in the data link layer entity of the MS. The information field is removed when the data link layer enters the multiple frame established state or the idle state, see below.

All existing exception conditions shall be cleared, the retransmission counter shall be reset, and timer T200 shall be set when right before transmitting a frame, when the PH-READY-TO-SEND primitive is received from the physical layer.

The peer data link layer entity in the BS receiving the SABM shall, if the entity is in the idle state and an "establishment in progress" flag has not been set:

- set the "establishment in progress" flag;
- store the information field received in the SABM command;
- respond, at the earliest possible opportunity, with a UA response with:
 - the same SAPI value as received in the SABM command;
 - the F bit set to the same binary value as the P bit received in the SABM command;
 - the length indicator, L, set to the same value as that contained in the SABM command;
 - the same information field as that contained in the SABM command;
- set the send state variable V(S), the receive state variable V(R) and the acknowledge state variable V(A) to 0;
- enter the "contention resolution receiver" state and inform the layer 3 entity using the DL-ESTABLISH- INDICATION primitive. The primitive shall contain the received layer 3 message unit;
- clear all existing exception conditions.

If an SABM command with an information field is received when the "establishment in progress" flag has been set, the data link layer entity in the BS shall compare the stored information field with the information field received in the SABM command. If they are not identical, the SABM command shall be ignored without any notification. If they are identical, the data link entity shall respond, at the earliest possible opportunity, with a UA response with:

- the same SAPI value as received in the SABM command;
- the F bit set to the same binary value as the P bit contained in the SABM command;
- the length indicator, L, set to the same value as that contained in the SABM command;
- the stored information field.

NOTE 2: This case corresponds to a retransmission of the SABM command by the MS (see sub-clause 8.4.1.5).

NOTE 3: The specification is very different from the normal establishment procedure: in the latter case the reception of a subsequent SABM frame triggers a re-establishment (see sub-clause 8.6).

The data link layer entity in the BS shall remove the "establishment in progress" flag and delete the stored information field when:

- an I frame or supervisory frame is received. If the frame is in sequence, the data link layer entity shall enter the multiple frame established state and process the frame as specified for operation in the multiple frame established state. If the frame is out of sequence, the BS shall initiate abnormal release using the procedure of sub-clause 8.6;
- a release request is received from layer 3. In this case the data link layer entity shall enter the idle state if the primitive received is DL-RELEASE-REQUEST or the null state if the primitive is MDL-RELEASE-REQUEST.

The procedure when awaiting acknowledgement in the MS is as follows:

Upon reception of a UA response containing an information field and with the F bit set to "1", the data link layer entity in the MS shall compare the stored information field with the information field received in the UA response. If the two fields are identical, the data link layer entity shall:

- reset timer T200;
- set the send state variable V(S), the receive state variable V(R) and the acknowledge state variable V(A) to 0;
- delete the stored information field;
- enter the multiple-frame-established state and inform the layer 3 entity using the DL-ESTABLISH-CONFIRM primitive.

If the two fields are different, the data link layer entity shall:

- reset timer T200;
- delete the stored information field;
- enter the idle state and inform the layer 3 entity using the DL-RELEASE-INDICATION primitive.

All frames other than unnumbered frame formats received for the SAPI in use during the establishment procedures shall be ignored.

The reception of unnumbered frames other than UA is treated as specified for the normal establishment case.

NOTE 4: In fact, there are no foreseen cases in which the network will send SABM, DISC or DM, but for sake of completeness these occurrences are specified and must be treated.

8.4.1.5 Procedure on expiry of timer T200: contention resolution (MS only)

If timer T200 expires before a UA response has been received, the data link layer entity shall:

- retransmit the SABM command as in sub-clause 8.4.1.4;
- set timer T200 right before transmitting a frame, when the PH-READY-TO-SEND primitive is received from the physical layer; and
- increment the retransmission counter by 1.

After retransmission of the SABM command N200 times, the data link layer shall enter the idle state and issue a DL- RELEASE-INDICATION primitive to the layer 3 entity. Layer 3 shall also be notified by using the primitive MDL-ERROR- INDICATION with cause "timer T200 expired N200 + 1 times: perform abnormal release".

8.4.2 Information transfer

8.4.2.1 General requirements

Having either transmitted the UA response to a received SABM command or received the UA response to a transmitted SABM command, I frames and supervisory frames shall be transmitted and received according to the procedures described in sub-clause 8.5.

If an SABM command is received while in the multiple-frame-established state, the data link layer entity shall proceed as follows:

- if the SABM command carries no information field (i.e. L=0), then the data link layer entity shall conform to the re-establishment procedure described in sub-clause 8.6;
- if the SABM command carries an information field (i.e. L>0), and can be considered as a part of a contention resolution procedure, then the SABM command shall be ignored without any notification;
- otherwise, the SABM command shall be ignored, and the layer 3 shall be informed by issuing a MDL-ERROR-INDICATION indicating "SABM command with information field not allowed in this state" or "U frame with incorrect parameters".

On receipt of a UI command, the procedures defined in sub-clause 8.3 shall be followed.

8.4.2.2 Error conditions

Error conditions which will require abnormal release of the data link are given in sub-clause 8.6.

Cases which do not lead to release but may cause the data link layer entity to issue an MDL-ERROR-INDICATION are summarized in table 7.

Table 7: Actions taken on response frames

Response frame	Multiple frame established	Timer recovery
UA F=1	MDL-ERROR-INDICATION (unsolicited UA response)	MDL-ERROR-INDICATION (unsolicited UA response)
UA F=0	MDL-ERROR-INDICATION (unsolicited UA response)	MDL-ERROR-INDICATION (unsolicited UA response)
DM F=1	MDL-ERROR-INDICATION (unsolicited DM response)	Normal
DM F=0	MDL-ERROR-INDICATION (unsolicited DM response, multiple frame established state: perform abnormal release)	MDL-ERROR-INDICATION (unsolicited DM response, multiple frame established state: perform abnormal release)
Supervisory response F=1	MDL-ERROR-INDICATION (unsolicited supervisory response)	Normal
Supervisory response F=0	Normal	Normal

8.4.2.3 Fill frames

In periods where no other frames are scheduled for transmission and something must be sent on the radio path, a fill frame as defined below shall be sent (3GPP TS 44.018 and 3GPP TS 45.002 prohibit such periods for PCH and BCCH).

On a DCCH, a fill frame is a UI command frame for SAPI 0 with P=0 and with an information field of 0 octet length (hence, it is a frame of type A). It has the following structure:

Bit	8	7	6	5	4	3	2	1		
	0	0	0	0	0	0	C	1	1	(note 1)
	0	0	0	0	0	0	1	1	2	
	0	0	0	0	0	0	0	1	3	
	X	X	X	X	X	X	X	X	4	(note 2)
	X	X	X	X	X	X	X	X	21 or 23	(note 2)

NOTE 1: Bit C is set to:
0 if sent by MS
1 if sent by network.

NOTE 2: See sub-clause 5.2.

Fill frame for a BCCH, PCH, AGCH, or NCH is the following:

Bit	8	7	6	5	4	3	2	1		
	0	0	0	0	0	0	0	1	1	
	0	0	1	0	1	0	1	1	2	(note)
	0	0	1	0	1	0	1	1	23	(note)

NOTE: The value "00101011" is chosen due to the modulation and interleaving scheme used in the GSM system.

8.4.3 Suspension and resumption of multiple frame operation

8.4.3.1 General

These procedures shall be used in a MS entity to suspend the uplink multiple frame operation for SAPI=0 during a change of dedicated channels (dedicated channel assignment or handover procedure on layer 3) and to resume the operation after the new physical channel has been connected. The purpose of these procedures is to provide a mechanism for reliably avoiding message loss during a change of dedicated channels. The procedures are only described for the case where the window size is one; it should, however, be obvious how to adapt them to larger window sizes.

As the procedures may delay the actual channel change, they shall only be used to protect layer 3 messages pertaining to SAPI=0. Applications using the multiple frame established service on SAPIs other than 0 are expected to cope with message loss or duplication autonomously, i.e. on layers above layer 2.

Both layer 3 procedures, dedicated channel assignment and handover, are initiated and controlled by a network entity (BSS or MSC). This entity therefore will suspend the flow of layer 3 messages towards the MS after the ASSIGNMENT or HANDOVER COMMAND message has been issued. When the data link on the new channel has been established, the message flow may resume. Obviously, no provisions in layer 2 are needed on the network side to prevent message loss or duplication on the downlink during channel change.

In the following, the procedures in the MS are described. For the description of the procedures, a conceptual configuration of a send queue, a send buffer and a transmit buffer are assumed.

In order to ease the description of the procedures in the MS, it is assumed that any layer 3 message passed to layer 2 via SAPI 0 in DL-DATA-REQUEST or DL-UNIT-DATA primitive is first placed in the send queue. The layer 2 entity will

take out the messages "first in-first out" and put them into a send buffer. The send buffer can hold no more than one layer 3 message at a time. From the contents of the send buffer, an I frame or UI frame is constructed, only one at a time, and placed in a transmit buffer. (If the layer 3 message needs to be segmented, then this last step will be performed several times). The frame is then transmitted.

Upon transmission and after it has been acknowledged if it has been an I frame, the transmit buffer is cleared and filled with the next frame. When the contents of the send buffer have been transmitted and acknowledged, the send buffer is cleared and filled with the next layer 3 message from the send queue.

8.4.3.2 Suspension

A layer 3 entity in the MS shall indicate a request for the suspension of multiple frame operation by use of the DL-SUSPEND-REQUEST primitive. The layer 2 entity, upon receipt of this primitive, shall act as follows:

No further layer 3 messages shall be taken from the send queue for SAPI=0.

- If there is a layer 3 message in the send buffer which has not yet been transmitted, it shall not be transmitted. The contents of the send buffer shall be put back to the first position of the send queue. The send and transmit buffers shall be cleared. A layer 3 message is considered to be transmitted as soon as its final segment has been transmitted at least once; it need not yet have been acknowledged. (This ensures that all segments of a segmented and possibly partly transmitted layer 3 message will be transmitted on the new channel. Those segments already transmitted and received on the network side will be discarded by the network upon release of the old channel because the layer 3 message is not yet complete).
- If there is a layer 3 message in the send buffer, the last segment of which has been transmitted but is not yet fully acknowledged, i.e. the frame carrying the last segment of the message has been transmitted but is not yet acknowledged, then the contents of the send buffer shall be put back to the first position of the send queue and the send and transmit buffers shall be cleared.
- The layer 2 entity shall then return a DL-SUSPEND-CONFIRM primitive to layer 3.

The data link layer entity is now in the suspended state. the only difference to the multiple frame established state is that no UI frames and no I frames are transmitted (all SAPIs).

The MS may now change to the new channel.

8.4.3.3 Resumption

8.4.3.3.1 Procedure after channel change

This procedure is initiated by the DL-RESUME primitive. A data link layer entity shall initiate a request for the multiple frame operation by transmitting the SABM command.

All existing exception conditions shall be cleared and the retransmission counter shall be reset. All outstanding DL-DATA- REQUEST primitives and layer 3 message units, which are not fully acknowledged, shall be saved. Any segmented layer 3 message unit, for which the last segment has not been received shall be discarded.

The send buffer is cleared.

A layer 3 message included in the DL-RESUME-REQUEST primitive (in general, ASSIGNMENT COMPLETE or HANDOVER COMPLETE) is put into the send buffer for transmission in acknowledged mode.

Upon reception of UA response the data link layer shall:

- reset T200;
- set send variable V(S), the receive state variable V(R) and the acknowledge state variable V(A) to 0;
- enter the multiple established state;
- confirm establishment to layer 3 using DL-ESTABLISH-CONFIRM;
- send the layer 3 message unit passed together with the DL-RESUME primitive.

The data link layer shall then continue normal operation.

8.4.3.3.2 Procedure after returning to the old channel (MS only)

This procedure is initiated by the DL-RECONNECT primitive. A data link layer entity shall initiate a request for the multiple frame operation by transmitting the SABM command. All existing exception conditions shall be cleared and the retransmission counter shall be reset. All outstanding DL-DATA-REQUEST primitives and layer 3 message units, which are not fully acknowledged, shall be saved; this does not include a message carried by a possible previous DL-RESUME-REQUEST. Any segmented layer 3 message units, for which the last segment has not been received shall be discarded.

The send buffer is cleared.

A layer 3 message included in the DL-RECONNECT-REQUEST primitive (in general, ASSIGNMENT FAILURE or HANDOVER FAILURE) is put into the send buffer for transmission in acknowledge mode.

Upon reception of a UA response the data link layer shall:

- reset T200;
- set send state variable V(S), the receive state variable V(R) and the acknowledge state variable V(A) to 0;
- enter the multiple frame established state;
- confirm establishment to layer 3 using DL-ESTABLISH-CONFIRM;
- send the layer 3 message unit passed together with DL-RECONNECT-REQUEST primitive.

The data link layer shall then continue normal operation.

8.4.4 Termination of multiple frame operation

8.4.4.1 General

These procedures shall be used to terminate the multiple frame operation between the BS and a designated MS entity.

A layer 3 entity shall indicate a request for termination of the multiple frame operation by use of the DL-RELEASE-REQUEST primitive. The DL-RELEASE-REQUEST primitive will contain a parameter indicating whether normal release or local end release shall take place. In the first case the data link layer will initiate the release procedure of sub-clause 8.4.4.2. In the second case the data link layer shall follow the procedures of sub-clause 8.4.4.4.

If a physical channel is disconnected at the physical layer, layer 3 will request release (i.e. local end release) by issuing an MDL-RELEASE-REQUEST primitive. The actions to be taken are defined in sub-clause 8.4.4.4.

All frames other than unnumbered frames received during the release procedure shall be ignored.

For normal release the release procedure implies the discard of any outstanding DL-DATA-REQUEST primitive which has been invoked prior to the DL-RELEASE-REQUEST. It also implies the discard of any segmented layer 3 data units for which the last segment has not been received (see sub-clause 8.5.2 for the concatenation procedure).

8.4.4.2 Normal release procedure

A data link layer entity shall initiate a request for release of multiple frame operation by transmitting the Disconnect (DISC) command with the P bit set to "1". Timer T200 shall then be set right before transmitting a frame, when the PH-READY-TO-SEND primitive is received from the physical layer. The retransmission counter shall be set to "0" (RC=0).

A data link layer entity receiving a DISC command while in the multiple-frame-established state or timer recovery state shall transmit a UA response with the F bit set to the same binary value as the P bit in the received DISC command. A DL-RELEASE-INDICATION shall be passed to layer 3, timer T200 shall be reset and the idle state shall be entered.

If the originator of the DISC command receives either:

- a UA response with the F bit set to "1"; or

- a DM response with F bit set to "1", indicating that the peer data link layer entity was in the idle state, it shall reset timer T200 and inform the layer 3 entity using the primitive DL-RELEASE-CONFIRM.

The data link layer entity which issued the DISC command will now be in the idle state. The conditions relating to this state are defined in sub-clause 8.4.5.

The DL-RELEASE-INDICATION or - CONFIRM primitives shall contain an indication whether or not there are outstanding acknowledgements or unserved DL-DATA-REQUEST primitives.

8.4.4.3 Procedure on expiry of timer T200 for normal release

If timer T200 expires before a UA or DM response is received, the originator of the DISC command shall:

- retransmit the DISC command as defined in sub-clause 8.4.4.2;
- set timer T200 right before transmitting a frame, when the PH-READY-TO-SEND primitive is received from the physical layer; and
- increment the retransmission counter.

If the data link layer entity has not received the correct response as defined in sub-clause 8.4.4.2, after N200 attempts to recover, the data link layer entity shall enter the idle state and inform the layer 3 entity using the primitive DL-RELEASE-CONFIRM and MDL-ERROR-IND with cause "Timer T200 expired (N200+1) times: perform abnormal release".

The value of N200 is defined in sub-clause 8.8.2.

8.4.4.4 Local end release procedure

When receiving a DL-RELEASE-REQUEST primitive from layer 3 with the release mode parameter set to "local end release", the data link layer shall in all states:

- return a DL-RELEASE-CONFIRM primitive;
- enter the idle state without issuing any commands to the peer entity.

The DL-RELEASE-CONFIRM primitive shall contain an indication whether or not there are outstanding acknowledgements or unserved DL-DATA-REQUEST primitives.

When receiving an MDL-RELEASE-REQUEST primitive, the data link layer entity, when in the idle state, shall enter the null state. In all other states the data link layer shall:

- if there is no outstanding DL-RELEASE-REQUEST primitive, issue a DL-RELEASE-INDICATION primitive to layer 3;
- if there is an outstanding DL-RELEASE-REQUEST primitive, issue a DL-RELEASE-CONFIRM primitive to layer 3;
- enter the null state without issuing any commands to the peer entity.

NOTE: The null state is the state, as viewed from the data link layer, where no physical resource exists for the specific data link layer entity.

8.4.5 Idle state

While in the idle state:

- the receipt of a DISC command shall result in the transmission of a DM response with the F bit set to the value of the received P bit;
- the receipt of an I frame or supervisory frame with the P bit set to "1" shall result in the transmission of a DM response with the F bit set to "1" (as defined in sub-clause 8.2.2);
- the content of any received I frame shall be discarded;

- on receipt of an SABM command, the procedures defined in sub-clause 8.4.1 shall be followed;
- on receipt of UI commands, the procedures defined in sub-clause 8.3 shall be followed;
- all other frame types shall be discarded.

8.4.6 Collision of unnumbered commands and responses

Collision situations shall be resolved in the following way:

8.4.6.1 Identical transmitted and received commands

If the transmitted and received unnumbered commands (SABM or DISC) are the same, the data link layer entities shall send the UA response at the earliest possible opportunity. The indicated state shall be entered after receiving the UA response. The data link layer entities shall each notify its respective layer 3 entity by means of the appropriate confirm primitive, i.e. DL-ESTABLISH-CONFIRM or DL-RELEASE-CONFIRM.

8.4.6.2 Different transmitted and received commands

If the transmitted and received unnumbered commands (SABM or DISC) are different, the data link layer entities shall issue a DM response at the earliest possible opportunity. Upon receipt of a DM response with the F bit set to 1, the data link layer shall enter the idle state and notify layer 3 by means of the appropriate primitive. The entity receiving the DISC command will issue a DL-RELEASE-INDICATION primitive, while the other entity will issue a DL-RELEASE-CONFIRM primitive.

Timer T200 shall be reset.

8.4.6.3 Unsolicited DM response and SABM or DISC command

In order to avoid misinterpretation of the DM response received, a data link layer entity shall always send its SABM or DISC command with the P bit set to "1".

A DM response with the F bit set to "0" colliding with the SABM or DISC command shall be ignored.

8.5 Procedures for information transfer in multiple frame operation

The procedures which apply to the transmission of I frames are defined below.

NOTE: The term "transmission of an I frame" refers to the delivery of an I frame by the data link layer to the physical layer.

8.5.1 Transmitting I frames

Information received by the data link layer entity from a layer 3 entity by means of a DL-DATA-REQUEST primitive shall be transmitted in one or more I frames. If the layer 3 message unit consists of N201 or fewer octets, the message unit is to be contained in one I frame. The M bit of 6.7.2 shall be set to "0" in such I frames. If the layer 3 message unit exceeds N201 octets, the data link layer shall segment the message unit in such a way that all segments, possibly except the last segment, consist of N201 octets.

The M bit of sub-clause 6.7.2 shall be set to "1" for each segment except for the last segment for which the M bit shall be set to "0".

The parameter N201 is defined in sub-clause 8.8.3.

When transmitting an I frame, the control field parameters N(S) and N(R) shall be assigned the values of the send and receive state variables V(S) and V(R), respectively. The value of the send state variable V(S) shall be incremented by 1 at the end of the transmission of the I frame.

If timer T200 is not running at the time right before transmitting a frame, when the PH-READY-TO-SEND primitive is received from the physical layer., it shall be set. If timer T200 expires, the procedures defined in sub-clause 8.5.7 shall be followed.

If the send state variable $V(S)$ is equal to $V(A)$ plus k (where k is the maximum number of outstanding I frames - see sub-clause 8.8.4), the data link layer entity shall not transmit any new I frames, but shall retransmit an I frame as a result of the error recovery procedures as described in sub-clauses 8.5.4 and 8.5.7.

When the BS side or MS side is in the own receiver busy (note 2) condition, it may still transmit I frames, provided that a peer receiver busy condition does not exist.

NOTE 1: Any DL-DATA-REQUEST primitive received while in the timer recovery condition shall be stored and serviced on clearance of this condition.

NOTE 2: In the following text in the present document, the term own/peer receiver busy refers to the peer-to-peer flow control state in the data link layer entities.

8.5.2 Receiving I frames

When a data link layer entity is not in an own receiver busy condition and receives a valid I frame whose send sequence number is equal to the current receive state variable $V(R)$, the data link layer entity shall:

- if the M bit is set to "0", concatenate it with previously received frames with the M bit set to "1", if any, and pass the complete layer 3 message unit to the layer 3 entity using the primitive DL-DATA-INDICATION;
- if the M bit is set to "1", store the information field of the frame and concatenate it with previously received frames with the M bit set to "1", if any (Note: no information is passed to the layer 3 entity);
- increment by 1 its receive state variable $V(R)$, and act as indicated below.

NOTE: The M bit is defined in sub-clause 6.7.2.

8.5.2.1 P bit of the received I frame set to "1"

If the P bit of the received I frame was set to "1", the data link layer entity shall respond to its peer in one of the following ways:

- if the data link layer entity receiving the I frame is still not in an own receiver busy condition, it shall send an RR response with the F bit set to "1";
- if the data link layer entity receiving the I frame enters the own receiver busy condition upon the receipt of the I frame, it shall send an RNR response with the F bit set to "1".

8.5.2.2 P bit of the received I frame set to "0"

If the P bit of the received I frame was set to "0" and:

- a) if the data link layer entity is still not in an own receiver busy condition:
 - if no I frame is available for transmission or if an I frame is available for transmission but a peer receiver busy condition exists, the data link layer entity shall transmit an RR response with the F bit set to "0"; or
 - if an I frame is available for transmission and no peer receiver busy condition exists, the data link layer entity shall transmit the I frame with the value of $N(R)$ set to the current value of $V(R)$ as defined in sub-clause 8.5.1 (this I frame then acknowledges the receipt of an I frame); or
- b) if, on receipt of this I frame, the data link layer entity is now in an own receiver busy condition, it shall transmit an RNR response with the F bit set to "0".

When the data link layer entity is in an own receiver busy condition, it shall process any received I frame according to sub-clause 8.5.6.

NOTE 1: The term "available for transmission" should be interpreted to mean available for transmission at the instant when the physical layer is ready to transmit the next frame. Making this decision as close as possible to that instant, will ensure minimum delay in the transmission of I frames.

NOTE 2: Any I frame received in the timer recovery condition shall be handled as stated above.

8.5.3 Receiving acknowledgement

8.5.3.1 On receipt of a valid I frame

On receipt of a valid I frame or supervisory frame (RR, RNR or REJ), even in the own receiver busy or timer recovery conditions, the data link layer entity shall treat the N(R) contained in this frame as an acknowledgement for all the I frames it has transmitted with an N(S) up to and including the received N(R) - 1. The value of the acknowledge state variable V(A) shall be set to the value of N(R). When not in the timer recovery condition, the data link layer entity shall reset the timer T200 on receipt of a valid I frame or supervisory frame with N(R) higher than V(A) (actually acknowledging some I frames), or an REJ with an N(R) equal to V(A).

NOTE 1: If a supervisory command frame with P bit set to "1" or an I frame command with P bit set to "1" has been transmitted and not acknowledged, by a supervisory frame response with F bit set to "1" timer T200 shall not be reset.

NOTE 2: Upon the receipt of a valid I frame, timer T200 shall not be reset if the data link layer entity is in the peer receiver busy condition.

If timer T200 has been reset by the receipt of an I, RR or RNR frame, and if there are outstanding I frames still unacknowledged, the data link layer entity shall set timer T200. If timer T200 then expires, the data link layer entity shall follow the recovery procedure as defined in sub-clause 8.5.7 with respect to the unacknowledged I frames.

If timer T200 has been reset by the receipt of an REJ frame, the data link layer entity shall follow the retransmission procedures in sub-clause 8.5.4.

8.5.3.2 Receiving supervisory command frames with the P bit set to "1"

When receiving supervisory command frames with the P bit set to "1", the following responses with the F bit set to "1" shall be given:

- if the data link layer entity is neither in an own receiver busy condition nor in an N(S) sequence error exception condition, the appropriate supervisory response is the RR response;
- if the data link layer entity is not in an own receiver busy condition, but is in an N(S) sequence error exception condition (i.e. an N(S) sequence error has been detected but a REJ frame has not yet been transmitted), the appropriate supervisory response is the REJ response;
- if the data link layer is in its own receiver busy condition, the appropriate supervisory response is the RNR response.

8.5.4 Receiving REJ frames

8.5.4.1 Receipt of a valid REJ frame

On receipt of a valid REJ frame the data link layer entity shall act as follows:

- i) if it is not in the timer recovery condition:
 - clear an existing peer receiver busy condition;
 - set its send state variable V(S) and its acknowledge state variable V(A) to the value of the N(R) contained in the REJ frame control field;
 - reset timer T200;

- if it was an REJ command frame with the P bit set to "1", transmit an appropriate supervisory frame with the F bit set to "1" (see sub-clause 8.5.3.2);
 - transmit the corresponding I frame as soon as possible as defined in sub-clause 8.5.1 taking into account the conditions given in sub-clause 8.5.4.2;
 - if it was an REJ response frame with the F bit set to "1", notify a protocol violation to layer 3 by means of the MDL-ERROR-INDICATION primitive (cause: unsolicited supervisory response);
- ii) if it is in a timer recovery condition and it was an REJ response frame with the F bit set to "1":
- clear an existing peer receiver busy condition;
 - clear the timer recovery condition;
 - set its send state variable V(S) and its acknowledge state variable V(A) to the value of the N(R) contained in the REJ frame control field;
 - reset timer T200;
 - transmit the corresponding I frame as soon as possible as defined in sub-clause 8.5.1 taking into account the conditions given in sub-clause 8.5.4.2;
- iii) if it is in a timer recovery condition and it was an REJ frame other than an REJ response with the F bit set to "1":
- clear an existing peer receiver busy condition;
 - set its acknowledge state variable V(A) to the value of the N(R) contained in the REJ frame control field; and
 - if it was an REJ command frame with the P bit set to "1", transmit an appropriate supervisory response frame with the F bit set to "1" (see sub-clause 8.5.3.2).

If the network receives a valid REJ frame following the application of the *Repeated Downlink FACCH* functionality (see sub-clause 10), and if it can be established that this frame is resulting from the reception of a repeated FACCH block by the Mobile Station, then this REJ frame may be ignored by the network.

NOTE: This case could typically occur when *Repeated Downlink FACCH* is used toward a Mobile Station not supporting the functionality (i.e. a pre-Release 6 Mobile Station).

8.5.4.2 Transmitting frames

When transmitting frames the following conditions are to be observed:

- 1) if the data link layer entity is transmitting a supervisory frame when it receives the REJ frame, it shall complete that transmission before commencing transmission of the requested I frame;
- 2) if the data link layer entity is transmitting an SABM or DISC command or a UA or DM response when it receives the REJ frame, it shall ignore the request for retransmission;
- 3) if the data link layer entity is not transmitting a frame when the REJ is received, it shall immediately commence transmission of the requested I frame.

All outstanding unacknowledged I frames, commencing with the I frame identified in the received REJ frame, shall be transmitted. Other I frames not yet transmitted may be transmitted following the transmitted I frames.

8.5.5 Receiving RNR frame

After receiving a valid RNR command or response, provided that the data link layer entity is not engaged in a mode setting operation, the data link layer entity shall set a peer receiver busy condition.

For RNR commands/responses with the P/F bit set to 1, the following special conditions apply:

- if it was an RNR command with the P bit set to "1", it shall respond with an RR response with the F bit set to "1" if the data link layer entity is not in an own receiver busy condition, and shall respond with an RNR response with the F bit set to "1" if the data link layer entity is in an own receiver busy condition;

- if it was an RNR response with the F bit set to "1" and timer recovery condition exists, the timer recovery condition shall be cleared and the N(R) contained in this RNR response shall be used to update the send state variable V(S).

The data link layer entity shall take note of the peer receiver busy condition and not transmit any I frame towards the peer having indicated a busy condition.

NOTE 1: This condition may not apply if the protocol operation on SAPI=0 and SAPI=3 is implemented (see sub-clause 9).

NOTE 2: The N(R) in any received supervisory command, irrespective of the setting of the P bit, will not be used to update the send state variable V(S).

The data link layer entity shall then:

- treat the receive sequence number N(R) contained in the received RNR frame as an acknowledgement for all the I frames that have been transmitted or retransmitted with an N(S) up to and including N(R) -1, and set its acknowledge state variable V(A) to the value of the N(R) contained in the RNR frame; and
- set timer T200 unless a supervisory response frame with the F bit set to "1" is still expected.

If timer T200 expires, the data link layer entity shall:

- if it is not yet in a timer recovery condition, enter a timer recovery condition, and set the retransmission count variable to 0;
- if it is already in a timer recovery condition, add one to its retransmission count variable.

The data link layer entity shall then:

- if the value of the retransmission count variable is less than N200, transmit an appropriate supervisory command (see sub-clause 8.5.3.2) with the P bit set to "1", and set timer T200 right before transmitting a frame, when the PH-READY-TO-SEND primitive is received from the physical layer; or
- if the value of the retransmission count variable is equal to N200, it shall initiate the abnormal release procedure described in sub-clause 8.6. Layer 3 shall be notified via the MDL-ERROR-INDICATION primitive with cause "timer T200 expired N200 + 1 times: perform abnormal release".

The peer data link layer entity receiving the supervisory frame with the P bit set to "1" shall respond, at the earliest opportunity, with the appropriate supervisory response frame (see sub-clause 8.5.3.2) with the F bit set to "1", to indicate whether or not its own receiver busy condition still exists.

Upon receipt of the supervisory response with the F bit set to "1", the data link layer entity shall reset timer T200, and:

- if the response is an RR or REJ response, the peer receiver busy condition is cleared and the data link layer entity may transmit new I frames or retransmit I frames as defined in sub-clauses 8.5.1 or 8.5.4, respectively; or
- if the response is an RNR response, the data link layer entity receiving the response shall proceed according to sub-clause 8.5.5, first paragraph.

If a supervisory command (RR, RNR or REJ) with the P bit set to "0" or "1", or a supervisory response frame with the F bit set to "0" is received during the enquiry process, the data link layer entity shall:

- if the supervisory frame is an RR or REJ command or response frame with the F bit set to "0", clear the peer receiver busy condition and if the supervisory frame was a command with the P bit set to "1", transmit the appropriate supervisory response (see sub-clause 8.5.3.2) frame with the F bit set to "1". However, the transmission or retransmission of I frames shall not be undertaken until the appropriate supervisory response frame with the F bit set to "1" is received or until the expiry of timer T200; or
- if the supervisory frame is an RNR command or an RNR response with the P/F bit set to "0", retain the peer receiver busy condition, and if the supervisory frame received was an RNR command with the P bit set to "1", transmit the appropriate supervisory response (see sub-clause 8.5.3.2) with the F bit set to "1".

Receiving an SABM command, the data link layer entity shall clear the peer receiver busy condition.

8.5.6 Data link layer own receiver busy condition

When the data link layer entity enters an own receiver busy condition, it shall transmit an RNR frame at the earliest opportunity. The RNR frame may be either:

- an RNR response with the F bit set to "0"; or
- if this condition is entered when receiving a command frame with the P bit set to "1", an RNR response frame with the F bit set to "1"; or
- if this condition is entered on expiry of timer T200, an RNR command with the P bit set to "1".

All received I frames with the P bit set to "0" shall be discarded, after updating the acknowledge state variable V(A).

All received supervisory frames with the P/F bit set to "0" shall be processed, including updating the acknowledge state variable V(A).

All received I frames with the P bit set to "1" shall be discarded, after updating the acknowledge state variable V(A). However, an RNR response frame with the F bit set to "1" shall be transmitted.

All received supervisory frames with the P bit set to "1" will be processed including updating the acknowledge state variable V(A). An RNR response with the F bit set to "1" shall be transmitted.

To indicate to the peer data link layer entity the clearance of the own receiver busy condition, the data link layer entity shall transmit an RR frame, or, if a previously detected N(S) sequence error has not yet been reported, an REJ frame with the N(R) set to the current value of the receive state variable V(R).

The transmission of an SABM command or a UA response (in reply to an SABM command) also indicates to the peer data link layer entity the clearance of the own receiver busy condition.

8.5.7 Waiting acknowledgement

The data link layer entity shall maintain an internal retransmission count variable.

If timer T200 expires, the data link layer entity shall:

- if it is not yet in the timer recovery condition, enter the timer recovery condition and set the retransmission count variable to 0; or
- if it is already in the timer recovery condition, add one to its retransmission count variable.

The data link layer entity shall then:

- a) if the value of the retransmission count variable is less than N200:
 - retransmit the last transmitted I frame (V(S)-1) with the P bit set to "1"; or
 - send the appropriate supervision frame, with the P bit set to "1";
 - set timer T200 right before transmitting a frame, when the PH-READY-TO-SEND primitive is received from the physical layer; or
- b) if the value of the retransmission count variable is equal to N200, indicate this by means of the primitive MDL-ERROR-INDICATION with cause "timer T200 expired N200 + 1 times: perform abnormal release" to layer 3.

NOTE: It is then the responsibility of layer 3 to release or re-establish the data link. The data link layer remains in the timer recovery state until further actions are taken by layer 3.

The following paragraph applies only for data link layer being in the timer recovery condition as the case of receiving acknowledgement in multiframe established state is described in sub-clause 8.5.3.1.

The timer recovery condition is only cleared if the data link layer entity receives a valid supervisory frame response with the F bit set to "1". If the N(R) of this received supervisory frame is within the range from its current state variable V(A) to its current send state variable V(S) inclusive, it shall set its send state variable V(S) to the value of the received N(R). Timer T200 shall be reset if the received supervisory frame response is an RR or REJ response with F bit set to "1". The data link layer entity shall then resume with I frame transmission or retransmission, as appropriate.

Timer T200 shall be set if the received supervisory response is an RNR response, and the data link layer shall proceed with the enquiry process in accordance with sub-clause 8.5.5.

8.5.8 Preemption

The preemption capability allows high priority layer 3 messages to avoid significant queuing delay at layer 2 due to the transmission of preceding low priority layer 3 messages.

8.5.8.1 Sender Requirements

If higher layers do not send any message defined in 3GPP TS 44.018 to have a "low" priority, the data link layer may treat all layer 3 messages as having "normal" priority. This provides backward compatibility with previous versions of this standard.

For multiple frame operation on SAPI 0, the Layer 3 shall indicate the priority of each message by providing a priority value in a DL-DATA-REQUEST primitive. Layer 3 messages with a priority value of "high" are allowed to preempt preceding untransmitted and partially transmitted layer 3 messages with a priority value of "low". Layer 3 messages with a priority value of "normal" shall neither preempt not be preempted by other Layer 3 messages.

On receiving a DL-DATA-REQUEST carrying a Layer 3 message with a "high" priority value, the data link layer entity shall discard all preceding untransmitted Layer 3 messages using the same data link layer connection (i.e. same SAPI and channel) that have a "low" priority value. Layer 3 messages with a "low" priority value whose entire contents have been transmitted, but for which acknowledgements are still outstanding, shall not be affected. If there is any layer 3 message (at most one) with a "low" priority value for which some but not all octets were transmitted, the data link layer shall discard all untransmitted octets following the first N201 untransmitted octets if the total number of untransmitted octets exceeds N201. If there are N201 or fewer untransmitted octets, no data shall be discarded. When untransmitted octets are discarded, the remaining N201 untransmitted octets shall be transmitted when permitted by flow control in a single I frame with the M bit set to "0".

Low priority data that is not discarded (i.e. previously transmitted but unacknowledged data and up to N201 octets of untransmitted data) shall be retransmitted if necessary until acknowledged by receiving data link layer entity.

8.5.8.2 Receiver Requirements

The receiving data link layer entity is not affected by, nor aware of, preemption at a sender. Detection of and recovery from preemption is the responsibility of the higher layers. The procedures employed at the data link layer ensure that when a "low" priority message is truncated, at least the first $2*N201$ octets are delivered reliably to the receiving layer 3.

8.6 Abnormal release and re-establishment of multiple frame operation

8.6.1 Criteria for re-establishment

The procedures for re-establishing the multiple frame operation are initiated by:

- a) the receipt of a DL-ESTABLISH-REQUEST;
- b) the receipt, while in the multiple frame established or timer recovery state, of an SABM command.

8.6.2 Criteria for abnormal release

The procedures for abnormal release of the multiple frame operation are initiated by:

- a) the receipt of a frame containing an invalid N(R) (see note);
- b) the receipt, while in the multiple-frame-established state, of an unsolicited DM response with the F bit set to "0".

A valid N(R) is one that is in the range $V(A) \leq N(R) \leq V(S)$.

NOTE: These inequalities shall be interpreted in the following way:
N(R) is called valid, if and only if $(N(R)-V(A)) \bmod 8 \leq (V(S)-V(A)) \bmod 8$.

8.6.3 Procedures for re-establishment

When the data link layer receives in the multiple frame established state or timer recovery state a DL-ESTABLISH-REQUEST primitive from layer 3 or an SABM (with L=0), the normal establishment procedure of sub-clause 8.4.1.2 shall be initiated. Any information frames in the I queue (including I frames for DL-DATA-REQUEST primitives and any received segmented layer 3 message units for which the last segment has not been received) shall be discarded.

A DL-ESTABLISH-INDICATION or -CONFIRM primitive sent to layer 3 shall contain an indication whether or not there are outstanding acknowledgements or unserved DL-DATA-REQUEST primitives.

8.6.4 Procedures for abnormal release

The data link layer shall inform layer 3 that an exception condition exists from which the data link layer cannot recover. The information is provided in an MDL-ERROR-INDICATION primitive with causes "sequence error: perform abnormal release" or "unsolicited DM response, multiple frame established state: perform abnormal release".

The release of the data link shall then be performed by layer 3 by either of the following primitives:

- DL-RELEASE-REQUEST (release mode=normal release). Then the data link layer shall follow the procedures of sub-clause 8.4.4.2.
- DL-RELEASE-REQUEST (release mode=local end release). Then the data link layer shall follow the procedure of sub-clause 8.4.4.4.
- MDL-RELEASE-REQUEST. Then the data link layer shall follow the procedure of sub-clause 8.4.4.4.

The data link layer shall remain in the same state (i.e. multiple frame established or timer recovery) until the primitive is received.

8.7 Exception condition reporting and recovery for multiple frame operation

Exception conditions may occur as the result of physical layer errors or data link layer procedural errors.

The error recovery procedures which are available to effect recovery following the detection of an exception condition at the data link layer are defined in this sub-clause.

8.7.1 N(S) sequence error

An N(S) sequence error exception condition occurs in the receiver when a valid I frame is received which contains an N(S) value which is not equal to the receive state variable V(R) at the receiver. The information field of all I frames whose N(S) does not equal the receive state variable V(R) shall be discarded.

The receiver shall not acknowledge (nor increment its receive state variable) the I frame causing the sequence error, nor any I frames which may follow, until an I frame with the correct N(S) is received.

A data link layer entity which receives one or more I frames having sequence errors but otherwise error-free, or subsequent supervisory frames (RR, RNR and REJ), shall use the control field information contained in the N(R) field and the P or F bit to perform data link control functions; for example, to receive acknowledgement of previously transmitted I frames and to cause the data link layer entity to respond if the P bit is set to "1". Therefore, a retransmitted

I frame may contain an N(R) field value and P bit that are updated from, and therefore different from, the ones contained in the originally transmitted I frame.

The REJ frame is used by a receiving data link layer entity to initiate an exception condition recovery (retransmission) following the detection of an N(S) sequence error.

Only one REJ exception condition for a given direction of information transfer shall be established at a time.

A data link layer entity receiving an REJ command or response shall initiate sequential transmission (retransmission) of I frames starting with the I frame indicated by the N(R) contained in the REJ frame.

An REJ exception condition is cleared when the requested I frame is received or when an SABM or DISC command is received.

8.7.2 Timer recovery

If a data link layer entity, due to a transmission error, does not receive a single I frame or the last I frame(s) in a sequence of I frames, it will not detect an out-of-sequence exception condition and therefore will not transmit a REJ frame.

The data link layer which transmitted the unacknowledged I frame(s) shall, on the expiry of timer T200, take appropriate recovery action as defined in sub-clause 8.5.7 to determine at which I frame retransmission must begin.

8.7.3 Invalid frame condition

Any frame received which satisfies one or more of the following conditions shall be discarded after notification to layer 3 by means of the primitive MDL-ERROR-INDICATION (with cause as indicated):

- a supervisory or unnumbered frame with incorrect parameters (e.g. a length indicator $L > 0$ in frames where an information field is not permitted, an M bit set to "1", a length indicator set to $L > N201$ in frames permitted with an information field) (causes "S frame with incorrect parameters" and "U frame with incorrect parameters", respectively);
- an I frame with length indicator which indicates more than N201 octets in the frame (cause "I frame with incorrect length");
- an I frame with the M bit set to "1" and the length indicator set to less than N201 octets (cause "I frame with incorrect use of M bit");
- a command or response frame with a control field which is not implemented (cause "frame not implemented").

No other action shall be taken as a result of such frames, i.e. information fields shall be discarded and N(S) fields, N(R) fields and P/F bits shall be ignored.

8.7.4 N(R) sequence error

An N(R) sequence error exception condition occurs in the transmitter when a valid supervisory frame or I frame is received which contains an invalid N(R) value.

A valid N(R) is one that is in the range $V(A) \leq N(R) \leq V(S)$.

NOTE: These inequalities shall be interpreted in the following way:
N(R) is called valid, if and only if $(N(R) - V(A)) \bmod 8 \leq (V(S) - V(A)) \bmod 8$.

The information field contained in an I frame which is correct in sequence and format but contains an invalid N(R) shall be delivered to layer 3 by means of the primitive DL- DATA-INDICATION (if it contains a complete layer 3 message unit or the last segment of a segmented layer 3 message unit; otherwise the information field is discarded) and a P bit set to "1" shall be processed before taking subsequent actions.

The data link layer entity shall then inform layer 3 on this exception condition by means of the primitive MDL-ERROR- INDICATION with the cause "sequence error: perform abnormal release", as defined in 8.6.4. The data link shall remain in the current state until it is released by layer 3.

8.8 List of system parameters

The system parameters listed below are associated with each individual service access point and apply to both unacknowledged operation and multiple frame operation.

NOTE 1: The only parameter required for unacknowledged operation is the maximum number of octets in the information field (sub-clause 8.8.3).

NOTE 2: The values given below for the parameters may be changed as a result of optimization of the system performance.

8.8.1 Timer T200

8.8.1.1 For SAPI=0 and SAPI=3

The exact value of timer T200 for data links with SAPI=0 and SAPI=3 is implementation dependent. It depends on synchronization mechanisms and processing delays both in layer 1 and layer 2 entities. Generally, it shall be chosen such that a predictable behaviour at the Um reference point can be guaranteed. The general principles for choosing a value for timer T200 are:

- a possible loss of frames on the radio path should be detected as soon as possible;
- a necessary retransmission of a frame should take place at the earliest possible opportunity;
- the use of Repeated Downlink FACCH (see sub-clause 10);
- T200 shall not time out before the next frame in the other direction is received and treated, assuming some reasonable response delays for the peer entities (see sub-clause 8.9);
- if T200 times out, provided no other frame takes priority, the repeated frame is sent in the block following immediately after the next PH-READY-TO-SEND indication.

Values of T200 shall be chosen implementation dependent for the various types of channels according to the rules given above and the performance requirements of sub-clause 8.9.

8.8.1.2 For SAPIs other than 0 or 3

The value of timer T200 for data links with SAPIs other than 0 or 3 is for further study.

8.8.2 Maximum number of retransmissions (N200)

8.8.2.1 For SAPI=0 and 3

For SAPI=0 and 3, the maximum number of retransmissions N200 depends on the state and on the channel used. This ensures a common time value for layer 2 link failure on all channels when multiple frame operation is established. The N200 value for layer 2 link establishment and release is 5.

In the state "timer recovery", N200 is set to:

- 5 for use on SACCH;
- 23 for use on SDCCH;
- 34 for use on FACCH/full rate (Note 1);
- 48 for use on E-FACCH/full rate;
- 29 for use on FACCH/half rate.

NOTE 1: All types of FACCH/Full rate except E-FACCH/F.

8.8.2.2 For SAPIs other than 0 or 3

For SAPIs other than 0 or 3, the value of N200 is 5.

8.8.3 Maximum number of octets in an I, UI, SABM and UA frame partially or entirely available for the information field (N201)

The maximum number of octets partially or entirely available for the information field (N201) is:

- for frames of format A and B:
 - for the SACCH: N201 = 18;
 - for the FACCH and SDCCH: N201 = 20.
- for frames of format Bbis:
 - for BCCH, AGCH, NCH and PCH: N201 = 23;
- for frames of format Bter:
 - for the SACCH: N201 = 21;
 - for the FACCH and SDCCH: N201 = 23;
- for frames of format B4:
 - for the SACCH: N201 = 19.

8.8.4 Maximum number of outstanding I frames (k)

The maximum number (k) of sequentially numbered I frames that may be outstanding (that is, unacknowledged) at any given time is a system parameter which shall not exceed 7.

For data links with SAPI=0 or 3 (see sub-clause 9), the value of k shall be k = 1.

The value of k for other values of SAPI is for further study.

8.8.5 Maximum number of octets in a Layer 3 message

The number of octets in a L3-message passed to layer 2 for transmission in acknowledged mode shall not exceed 251, due to corresponding limits in 3GPP TS 48.056.

The number of octets in a L3-message passed to layer 2 for transmission in unacknowledged mode is limited by the maximum number of octets in the information field of an UI-frame, as defined in sub-clause 8.8.3.

8.9 System performance requirements

An implementation of data link layer service for SAPI=0 and SAPI=3 consisting of a data link layer entity and an entity necessary for physical transmission on the GSM radio channels, shall have sufficient processing capacity to satisfy the following performance requirements. Those requirements are to be satisfied by a local implementation without reference to the (remote) peer implementation:

- Available response delay:

If a data link entity receives a data link command frame requesting response whose last burst has been physically transmitted in the TDMA frame number FNcomm, then the first burst carrying a segment of the corresponding data link response shall be physically transmitted in the TDMA frame number FNresp, where:

$$FNresp \leq FNcomm + Tresp + 1;$$

and Tresp denotes the number of TDMA frames corresponding to the available response delay for the logical channel in use, as indicated in table 8. When Repeated Downlink FACCH is used (see clause 10) to send a

command frame, FNcomm denotes the TDMA frame number of the last burst of the FACCH block used to recover the LAPDm frame. When Repeated Downlink FACCH is used to send a response frame (see clause 10), FNresp denotes the TDMA frame number of the first burst of the FACCH block used to send the first instance of the repeated LAPDm frame.

- Observable repetition delay:

if a data link entity transmits a data link command frame whose first burst is physically contained in the TDMA frame number FNcomm1, then in case of retransmission the first burst carrying a segment of the retransmitted data link command frame shall be contained in the TDMA frame number FNcomm2 satisfying;

$$\text{FNcomm1} + \text{Trmin} \leq \text{FNcomm2} \leq \text{FNcomm1} + \text{Trmax};$$

where Trmin resp. Trmax denote the number of TDMA frames corresponding to the minimum resp. maximum observable repetition delay for the logical channel in use, as indicated in table 8. When Repeated Downlink FACCH is used (see clause 10) to send a command frame, FNcomm1 denotes the TDMA frame number of the first burst of the FACCH block used to send the repeated LAPDm frame.

NOTE: Arithmetics on TDMA frame numbers as specified in 3GPP TS 45.002 operates modulo $(\text{FN_MAX}+1) = 2715648$.

Table 8: Performance Parameters

SAPI	Type of channel	Available Response Delay Tresp	Minimum Repetition Delay Trmin	Maximum Repetition Delay Trmax (Note 3)
0	SDCCH	MS: 11 BSS: 32	51	51
0	FACCH/Full rate (Note 4)	9	26	39
0	E-FACCH/Full rate	9	17	26
0	FACCH/Half rate	10	34	44
3	SDCCH	MS: 11 BSS: 32	51	51 (Note 1)
3	SACCH (with TCH)	25/129 (Note 2)	312	416 (Note 2)

Values given in this table are measured in units of TDMA frame numbers, thus 1 unit corresponds to 120/26 ms (approx. 4.615 ms).

NOTE 1: Only applicable if no SAPI 0 transmission is in progress. Otherwise no upper bound can be given due to the priority of SAPI 0 transmission.

NOTE 2: This higher value is only applicable when the physical channel was not available for SAPI=3 due to the transmission of a SAPI=0 frame.

NOTE 3: Only applicable if, when available for transmission, there is no supervisory frame with F=1 to send (see for example sub-clause 8.5.2.1).

NOTE 4: All types of FACCH/Full rate except E-FACCH/F.

9 Special protocol operation on SAPI=0 and SAPI=3

This sub-clause summarizes the specialities of the LAPDm protocol regarding the acknowledged mode operation on SAPI=0 and SAPI=3.

The purpose is to adapt the multiple frame operation of LAPDm to the needs and the characteristics of the GSM system.

The adaptations and simplifications specified in this sub-clause are mandatory for both entities, Mobile Station and Network for SAPI=0 and SAPI=3.

As indicated in sub-clause 8, the protocol operates on SAPI=0 in the following way:

- Data link establishment for SAPI=0 is always initiated by the Mobile Station.
- Data link establishment according to the contention resolution procedure (see sub-clause 8.4.1.4) is supported when initiated by the MS on the main DCCH immediately after "immediate assignment" of that radio channel. In other cases of link establishment contention resolution is not used.

- When changing the radio channel during assignment or handover procedures (layer 3 procedures), in acknowledged mode on SAPI=0, the MS supports continuous transmission of layer 3 messages without loss by offering the SUSPEND, RESUME and RECONNECT primitives, as specified in sub-clause 8.4.3. However, duplication of at most one layer 3 data unit (in the MS to network direction) is possible.

For protocol operation on SAPI=0 as well as on SAPI=3 the following holds:

- For multiple frame operation, the window size $k = 1$ shall be used.
- The data link layer entity is not allowed to transmit an RNR frame and therefore shall never enter the own-receiver busy state. The same applies to the peer-receiver-busy condition. This is applicable, because buffer capacities necessary for avoiding such exception conditions are limited.
- When receiving, the data link layer entity may ignore RNR frames without notification.
- The procedure of enquiring the peer entity status by spontaneous transmission of a RR or REJ command frame, as indicated in sub-clauses 6.8.5 and 6.8.7, need not be supported. However, reaction on receiving such frames shall be as specified throughout the present document.

10 Repeated Downlink FACCH

10.1 General

The Repeated Downlink FACCH functionality is applicable when sending LAPDm frames on the TCH/F or TCH/H channel (excluding O-TCH and E-TCH channels). An MS supporting the TCH/F or TCH/H, as described above, shall support the Repeated Downlink FACCH functionality. The BSS may use the Repeated Downlink FACCH functionality when it considers it to be appropriate.

10.2 The FACCH Repetition

A repeated FACCH block shall be sent in such a way that, if the first burst of the downlink FACCH block containing the first instance of a LAPDm frame is sent in TDMA frame M, the first burst of the downlink FACCH block containing the repeated instance of the LAPDm frame is sent in TDMA frame M+8 or M+9 (the latter corresponding to the case where the two FACCH blocks are separated by either a SACCH frame or an idle frame, see 3GPP TS 45.002).

NOTE: On a channel using Repeated Downlink FACCH the value of T200 should be increased to cope with the case where the receiving entity failed to decode the downlink FACCH block used to send the first instance of a repeated LAPDm frame. This applies to a BSS supporting Repeated Downlink FACCH and to an MS that has signalled the Repeated ACCH Capability bit as '1' (see 3GPP TS 24.008).

10.3 BSS requirements

The BSS may, based on implementation-dependent criteria (e.g. downlink measurements), decide to repeat any downlink LAPDm command frame sent in a FACCH block over the radio interface. If the MS has signalled the Repeated ACCH Capability bit as '1' (see 3GPP TS 24.008), the BSS may also, based on implementation-dependent criteria, decide to repeat any downlink LAPDm response frame sent in a FACCH block over the radio interface. In both cases, the repeated FACCH block shall be sent as specified in sub-clause 10.2.

NOTE: If an MS has not signalled a Repeated ACCH Capability bit as '1' the BSS may only use Repeated Downlink FACCH to send command frames.

10.4 MS requirements

The MS shall, when receiving a downlink FACCH block, always attempt to decode it without combining with any previously received FACCH block.

If the current FACCH block is successfully decoded and an identical FACCH block was previously received (successfully decoded and spaced in time from the current FACCH block as specified in sub-clause 10.2), the MS shall not send the LAPDm frame of the current FACCH block to the LAPDm entity.

If the current FACCH block is successfully decoded and there was no such previously received identical FACCH block the LAPDm frame of the current FACCH block is sent to the LAPDm entity.

If the current FACCH block is unsuccessfully decoded and there was an unsuccessfully decoded FACCH block spaced in time from the current FACCH block as specified in sub-clause 10.2, a new decoding using the information from both these FACCH blocks shall be performed. If this decoding is successful the LAPDm frame produced by the new decoding is sent to the LAPDm entity.

11 Repeated SACCH

11.1 General

The Repeated SACCH functionality is applicable when a layer 3 message unit is to be sent or received in a SAPI=0 frame (i.e. in unacknowledged mode) on the SACCH channel. The MS shall support the Repeated SACCH functionality. The BSS may use the Repeated SACCH functionality when it considers it to be appropriate.

11.2 Procedure for Repeated SACCH on the downlink

If a downlink SACCH block is incorrectly decoded (prior to combining with any previously received SACCH block), and the next uplink SACCH block is not a repetition as per the Repeated SACCH procedure (see sub-clause 11.3), then the MS shall set the SACCH Repetition Request in the next uplink SACCH block to "Repeated SACCH required" (see 3GPP TS 44.004). If a downlink SACCH block is correctly decoded (prior to combining with any previously received SACCH block), and the next uplink SACCH block is not a repetition as per the Repeated SACCH procedure (see sub-clause 11.3), the MS shall set the SACCH Repetition Request in the next uplink SACCH block to "Repeated SACCH not required".

At the BSS side, if a transmitted downlink SACCH block contains a SAPI 0 frame and is not already a repetition, then it is a repetition candidate. If a SACCH block is a repetition candidate then the BSS may, based on the value of the last correctly received SACCH Repetition Request from the MS, or based on implementation-dependent criteria, repeat this SACCH block at the next SACCH period. If a SAPI 3 frame was also scheduled to be sent at this next SACCH period, the BSS may delay the sending of the SAPI 3 frame by one SACCH period in order to make room for the repetition.

When receiving a downlink SACCH block, the MS shall first attempt to decode it without combining with any previously received SACCH block. If this decoding fails, then a new decoding using the information from this SACCH block and from the SACCH block received at the previous SACCH block period shall be performed.

11.3 Procedure for Repeated SACCH on the uplink

The BSS may set the value of the SACCH Repetition Order (see 3GPP TS 44.004) of any downlink SACCH block based on implementation-dependent criteria.

At the MS side, if a transmitted uplink SACCH block contains a SAPI 0 frame and is not already a repetition, then it is a repetition candidate. If a SACCH block is a repetition candidate and if the last correctly received SACCH Repetition Order was set to "Repeated SACCH required", then the MS shall repeat this SACCH block at the next SACCH block period. If a SAPI 3 frame was also scheduled to be sent at this next SACCH period, the MS shall delay the sending of the SAPI 3 frame by one SACCH period in order to make room for the repetition.

When receiving an uplink SACCH block, the BSS may first attempt to decode it without combining with any previously received SACCH block. If this decoding fails, then a new decoding using the information from this SACCH block and from the SACCH block received at the previous SACCH block period may be performed.

Annex A (normative): Random access procedures

A.1 Description of the procedure

A.1.1 Procedure in the MS

The random access procedure is initiated by layer 3. The data link layer will receive the 8 bit information content of the random access burst in a DL-RANDOM ACCESS-REQUEST primitive. The primitive will also contain an indication of the type of channel to be used. The data link layer will then pass the information field to the indicated physical layer entity in a PH-RANDOM ACCESS-REQUEST primitive.

The physical layer will, upon sending the random access burst, send a PH-RANDOM ACCESS-CONFIRM primitive containing the time slot in which the burst was sent. This information is passed then to layer 3 in a DL-RANDOM ACCESS-CONFIRM primitive.

A.1.2 Procedure in the BS

The physical layer will provide the random access information field and an indication of the time slot in which the random access burst was received to the data link layer in a PH-RANDOM ACCESS-INDICATION primitive. The primitive will also contain an indication of the type of channel on which the burst was received. The data link layer will pass the information to layer 3 in a DL-RANDOM-ACCESS-INDICATION primitive.

A.2 Format

The format of the random access message at the data link layer consists of 8 bits. The order of bit transmission is defined in 3GPP TS 44.004.

Annex G (normative): Handling of frames with parameter errors in the address, control and length indicator fields

G.1 General

The parameters contained in frames received with parameter errors in the address, control and length indicator fields shall be ignored and an information field shall be discarded.

For some parameter errors an indication is given to the mobile management entity in an MDL-ERROR-INDICATION primitive.

G.2 Parameter errors in the address field

G.2.1 Unallocated SAPI

No action shall be taken on frames containing an unallocated SAPI.

G.2.2 Wrong value of the C/R bit

- I frame, C/R bit indicates response;
- SABM frame, C/R bit indicates response;
- UI frame, C/R bit indicates response;
- UA frame, C/R bit indicates command;
- DISC frame, C/R bit indicates response;
- DM frame, C/R bit indicates command.

Actions:

- An MDL-ERROR-INDICATION primitive with cause "frame not implemented" is sent to the mobile management entity.

G.2.3 EA bit set to "0"

Frames with EA bit set to "0" are not allowed in the GSM system.

Actions:

- An MDL-ERROR-INDICATION primitive with cause "frame not implemented" is sent to the mobile management entity.

G.3 Parameter errors in the control field

G.3.1 Supervisory frames

The control field coding:

bit 8 7 6 5 4 3 2 1

N(R) P/F 1 1 0 1

is not allowed:

Actions:

- An MDL-ERROR-INDICATION primitive with cause "frame not implemented" is sent to the mobile management entity.

G.3.2 Unnumbered frames

The control field coding.

Bit	8	7	6	5	4	3	2	1
	x	x	x	P/F	1	0	1	1
	x	x	x	P/F	0	1	1	1
	0	1	0	P/F	1	1	1	1
	0	1	1	P/F	1	1	1	1
	1	0	0	P/F	1	1	1	1
	1	0	1	P/F	1	1	1	1
	1	1	0	P/F	1	1	1	1
	1	1	1	P/F	1	1	1	1
	0	0	1	P/F	0	1	1	1
	0	0	1	P/F	0	0	1	1
	1	0	0	P/F	0	0	1	1
	1	0	1	P/F	0	0	1	1
	1	1	0	P/F	0	0	1	1
	1	1	1	P/F	0	0	1	1

are not allowed.

Actions:

- An MDL-ERROR-INDICATION primitive with cause "frame not implemented" is sent to the mobile management entity.

G.4 Parameter errors in the length indicator field

G.4.1 EL bit error

If the EL bit is set to "0", an MDL-ERROR-INDICATION primitive with cause "frame not implemented" is sent to the mobile management entity.

G.4.2 Information frames

If the length indicator of an I frame is set to a numerical value $L > N201$ or $L = 0$, an MDL-ERROR-INDICATION primitive with cause "I frame with incorrect length" is sent to the mobile management entity.

If the numerical value of L is $L < N201$ and the M bit is set to "1", then an MDL-ERROR-INDICATION primitive with cause "I frame with incorrect use of M bit" is sent to the mobile management entity.

G.4.3 Supervisory frames

If a supervisory frame is received with $L > 0$ or with the M bit set to "1", an MDL-ERROR-INDICATION primitive with cause "S frame with incorrect parameters" is sent to the mobile management entity.

G.4.4 DISC and DM frames

If a DISC or DM frame is received with $L > 0$ or with the M bit set to "1", an MDL-ERROR-INDICATION primitive with cause "U frame with incorrect parameters" is sent to the mobile management entity.

G.4.5 SABM UA and UI frames

If SABM, UA or UI frames are received with $L > N201$ or with the M bit set to "1" an MDL-ERROR-INDICATION primitive with cause "U frame with incorrect parameters" is sent to the mobile management entity.

Annex C (informative): Change History

TSG #	TSG Doc.	CR	Rev	Subject/Comment	New
January 2016	-	-	-	Version 13.0.0 based on version 12.0.0	13.0.0

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Cat	Subject/Comment	New
2017-03	RP-75	-	-	-	-	Release 14 version (frozen at TSG-75)	14.0.0
2018-06	RP-80	-	-	-	-	Release 15 version (frozen at TSG-80)	15.0.0
2020-07	RP-88e	-	-	-	-	Upgrade to Rel-16 version without technical change	16.0.0

History

Document history		
V16.0.0	September 2020	Publication