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Foreword

This European Telecommunication Standard (ETS) has been produced by the Radio Equipment and Systems (RES) Technical Committee of the European Telecommunications Standards Institute (ETSI).

The binary signalling procedure described in this ETS is an alternative to existing calling systems such as single-tone, multitone, subaudio and double-tone.

Every I-ETS and ETS prepared by ETSI is a voluntary standard. This ETS contains text concerning conformance testing of the equipment to which it relates. This text should be considered as guidance only and does not make this ETS mandatory.

Transposition dates	
Date of adoption of this ETS:	8 November 1996
Date of latest announcement of this ETS (doa):	28 February 1997
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Date of withdrawal of any conflicting National Standard (dow):	31 August 1997

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1 Scope

This ETS describes a binary signalling and data transmission system for private radio equipment operating at 1 200 bit/s using indirect modulation.

This ETS applies to systems operating on either shared, or exclusive, channels.

According to national regulations of various countries, Public Switched Telephone Network (PSTN) access and data transmission can be subject to licensing. The channel access protocol and occupation rules can also be a matter for licensing, depending on the different national regulations.

This ETS permits the addition, if necessary, of supplementary signalling, either sub-audio, multitone, or binary, as appropriate, to permit primary and secondary paging to be used. This ETS does not attempt to define the protocols necessary for such supplementary signalling.

Where parameters relating to the radio environment are specified, reference should be made to the appropriate clauses of ETS 300 113 [3]. However, selective calls according to this ETS can be implemented in equipment fulfilling I-ETS 300 219 [2] (that is messages of categories 0, 2, 4, 5 and messages of category 1 and functions 0, 1 and 2 as defined in subclause 7.2 of this ETS).

2 Normative references

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

[1] ISO 4335 (1987): "Information processing systems - Data communication - High-level data link control elements of procedures".

[2] I-ETS 300 219: "Radio Equipment and Systems (RES); Land Mobile Service; Technical characteristics and test conditions for radio equipment, transmitting signals to initiate a specific response in the receiver".

[3] ETS 300 113: "Radio Equipment and Systems (RES) Land mobile service; Technical characteristics and test conditions for radio equipment intended for the transmission of data (and speech) and having an antenna connector".

[4] ITU-T Recommendation T.50: "International Alphabet No. 5".

[5] ISO 3309 (1991): "Information technology - Telecommunications and information exchange between systems - High-level data link control (HDLC) procedures - Frame structure".

[6] ETS 300 471: "Radio Equipment and Systems (RES) Land mobile service; Access protocol and occupation rules for the transmission of data in shared channels".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

address: Information which consists of a Regional Code, a common address part, and an individual number or a group number.

address block: A block containing addresses. The first block of a transmission is always an address block. It can be followed by other address blocks (subclause 7.1).

address codeword: A 64-bit codeword. The first 48 bits contain the information, the remaining 16 bits contain the redundancy for the data protection. The first codeword of a transmission is always an address codeword that can be followed by others. The transmitter address, the receiver address and the function of the message are transmitted in the address codeword.

block: The smallest quantity of information that is exchanged over the radio channels according to this ETS. It can correspond to the transmission of either a "codeword" or an "encoded codeword".

call set-up: A complete information exchange between two or more stations, including the transmission of one or more messages.

codeword: A word correctly coded according to this ETS. It contains 48 bits of information. These bits are protected by 16 bits of redundancy, producing a total of 64 bits.

common address: A common part for an individual transmitter and individual receiver address.

data block: A block intended for the transmission of information. The data blocks can only follow address blocks in a transmission.

data codeword: A 64-bit codeword. The first 48 bits contain the information, the remaining 16 bits contain the redundancy for the data protection. The data codewords follows the address codewords. Data codewords are assigned to the transmission of any information.

encoded codeword: The 64 bits of a codeword which have been encoded with the convolutional code, producing a total of 128 bits.

external addressing: An addressing format in which the individual transmitter and receiver address are binary coded within 12 bits using the normal addressing mode. The complete transmitter address with its individual and common part is located in the first address codeword. The complete receiver address with its individual and common part is located in the second address codeword.

group address: An address shared by several stations. The group number can be any number within the normal addressing capacity of 12 bits. The group numbers are user specific.

I-frame: See subclause 10.4.

individual address: The address of a station, which is unique within the network. Each station has an individual address.

message: The contiguous transmission of a codeword sequence consisting of an address codeword which may be followed by other address codewords and by one or several data codewords.

normal addressing: An addressing format in which the individual transmitter and receiver address are binary coded within 12 bits and completely located in the address codeword not being followed by other address codewords.

reserved: Fields within codewords which are intended for a future designation. Reserved fields are intended for the values specified in the protocol.

S-frame: See subclause 10.5.

signalling cycle: A sequence of several messages having the same function which are separated by bit and block synchronization.

sub-address: The individual address of a terminal equipment if a station has connections to more than one terminal. This is defined for data transmission only.

telephone call: A message which allows dialling into telephone networks. The entire telephone number is transmitted within concatenated codewords.

transmission: The information transmitted in between the "power on" and "power off" period of a particular transmitter, which may include blocks and/or speech.

U-frame: See subclause 10.6.

3.2 Symbols

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

dTT	The maximum time during which an acknowledgement or reply may be sent after expiry of TT.
H	Hexadecimal notation, e.g. $2A_H$ is equal to 42 decimal.
K	The maximum number of unacknowledged sequentially numbered I-frames at a specific time.
N1	The highest number of data blocks which may be transmitted within an I-frame.
N2	The maximum number of retransmissions of an I-frame after the expiry of the time control T1.
NA	The number of acknowledgement repetitions within a signalling cycle.
ND	The maximum number of data blocks used for short data transfer.
NM	The number of message repetitions within a signalling cycle.
NR	The maximum number of retries of a message if an acknowledgement is not received.
T1F	The fixed part of the retry waiting time T1 after whose expiry a repetition of a frame is initiated.
T1I	The increment part of the retry waiting time T1 after whose expiry a repetition of a frame is initiated.
T3	The time after which a receiving station automatically exits the group mode.
TAC	The time waiting for an acknowledgement after whose expiry a repetition of the message is initiated.
TAD	The time waiting for a response after whose expiry a repetition of a frame is initiated.
TC	The maximum waiting time to access a channel.
TF	The time after which a call is cleared if an Radio Frequency (RF) carrier is lost.
TI	The time following an intermediate acknowledgement after which further signalling is expected.
TOF	The fixed part of the observation time TO after whose expiry the channel may be occupied.
TOI	The increment part of the observation time TO after whose expiry the channel may be occupied.

TRV	The maximum time between the last bit of a message and keying of the transmitter by the answering station.
TS1	The transmit state time within an emergency cycle.
TS2	The receive state time within an emergency cycle.
TS3	The idle state time within an emergency cycle.
TT	The maximum transmission time during which a station may access the channel for ongoing data packet transmissions.
TV	The maximum duration time of a call after which the call is automatically cleared.
TWF	The fixed part of the retry waiting time TW after whose expiry a repetition of the message is initiated.
TWI	The increment part of the retry waiting time TW after whose expiry a repetition of the message is initiated.

3.3 Abbreviations

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

ADM	Asynchronous Disconnected Mode
ABM	Asynchronous Balanced Mode
BS	Base Station
DTE	Data Terminal Equipment
FCS	Frame Check Sequence
FEC	Forward Error Correction
GM	Group Mode
HDLC	High-level Data Link Control
IA5	International Alphabet No. 5 [4]
LET	Link Establishment Time
LSB	Least Significant bit
MS	Mobile Station
MSB	Most Significant bit
PABX	Private Automatic Branch eXchange
PSTN	Public Switched Telephone Network
RF	Radio Frequency
RX	Receiver
TE	Terminal Equipment
TX	Transmitter

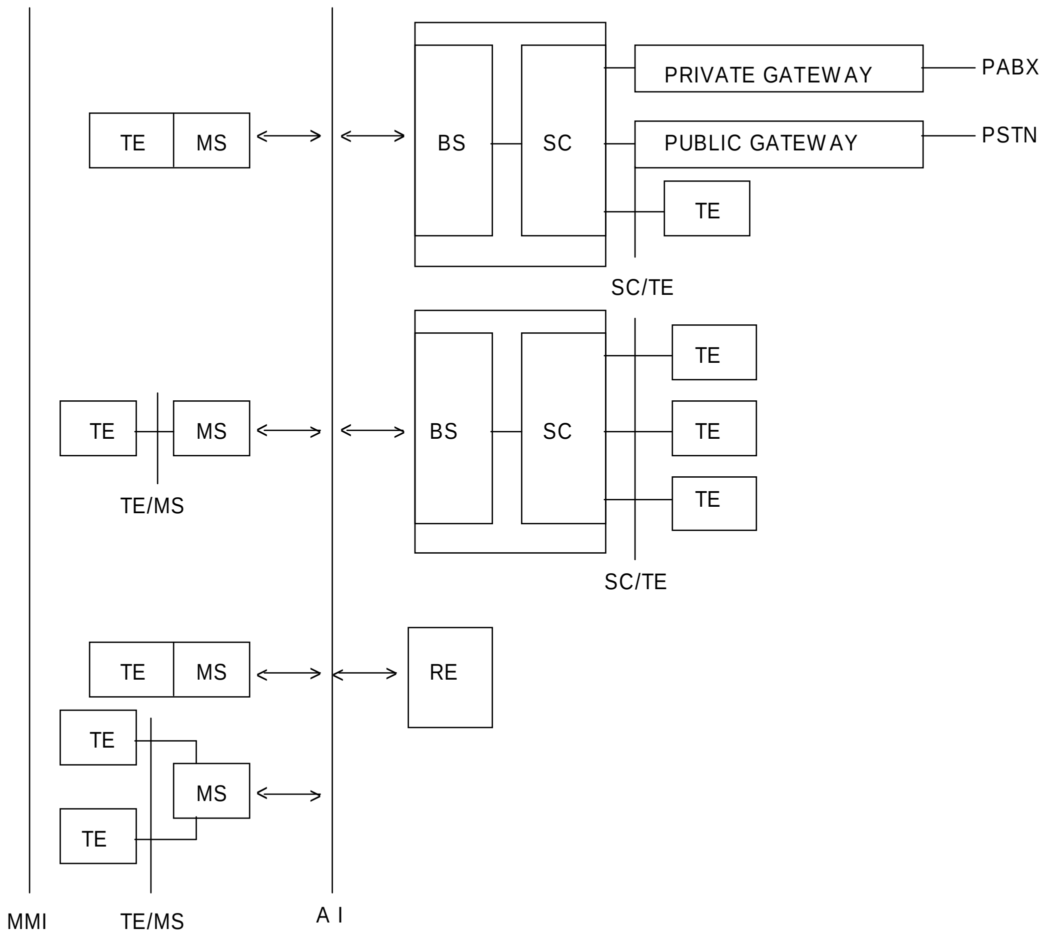
4 System architecture

This ETS may be implemented only in parts. Where parts, or options, of this ETS are implemented, the requirements of this ETS shall be met. Conversely the bits specified in this ETS for options which are not implemented, shall not be used for any other purposes.

Fields that have been reserved to provide for future extensions to this ETS shall not be used. Finally, fields have been defined as free for custom specific applications and are not further defined in this ETS.

4.1 General network configuration

One example of the network configuration is represented in figure 1, but other configurations are possible. For this example the network contains four main interfaces. The Man-Machine Interface (MMI), the Terminal-Mobile Interface (TE/MS), and the System-Terminal Interface (SC/TE) are specified by the system designer. In this ETS, only the Air Interface (AI) is defined. The recommended System-Terminal Interface (SC/TE) is outlined in annex D. The information to be transmitted is transferred to the connected terminals or gateways for processing.



NOTE:	RE:	Repeater
	TE:	Terminal Equipment
	MMI:	Man-Machine Interface
	MS:	Mobile Station
	TE/MS:	Terminal-Mobile Interface
	BS:	Base Station
	AI:	Air Interface
	SC:	System Control
	SC/TE:	System-Terminal Interface

Figure 1: Example of a network configuration

4.2 Addressing

All units of the network (mobile stations, base stations, repeaters) have one or several addresses.

These addresses include individual addresses, group call addresses and common addresses to all units of a network.

Where several data terminals are connected to the same station, sub-addresses may be used.

When gateways are used, additional information is needed to identify destination terminals.

4.3 Usage of repeaters

Systems implemented according to this ETS may include repeaters. If repeaters are used, data can be repeated in one of the three following ways:

- full transparency;
- bit by bit regeneration;
- message error correction and repetition of a transmission.

Each repeater can be addressed using its individual address.

5 Basic system definitions

This clause describes the basic system definitions for the signalling and data transmission system.

In the following figures, the transmitted bit stream is always shown with bit 1, the Most Significant bit (MSB), transmitted first.

Where data bytes or characters are transmitted, the MSB shall also be transmitted first. This differs from most line applications where the Least Significant bit (LSB) is sent first.

5.1 Modulation method

5.1.1 Subcarrier modulation

The binary data transmission is based on subcarrier modulation. Fast Frequency Shift Keying (FFSK) at 1 200 bit/s is used. The transition between bits are made at the zero crossing points of the subcarrier. The modulation parameters are represented in table 1.

Table 1: Modulation parameters

Transmission speed	1 200 bit/s ± 0,01 %
Binary 0	1 800 Hz ± 0,01 %
Binary 1	1 200 Hz ± 0,01 %

5.1.2 Frequency deviation

The nominal frequency deviation should be as shown in table 2. Under all test and operating conditions the deviation shall be within ± 2 dB of these values.

Table 2: Frequency deviation

Channel spacing(kHz)	Frequency deviation (kHz)		
	with pre-emphasis (+ 6 dB / octave)		without pre-emphasis
	binary 0	binary 1	binary 0 and 1
12,5	1,8	1,25	1,5
20,0	2,9	2,00	2,4
25,0	3,6	2,50	3,0

5.2 Transmission format

The system is able to transmit signalling and data packets consisting of an address codeword and concatenated codewords. Concatenated codewords can be address codewords or one or more data codewords. They begin directly after the last check bit of the preceding codeword.

The first codeword of a message is always an address codeword. This codeword specifies the receiver and the transmitter. The first codeword may be followed by other address codewords for further addressing.

The format of a signalling or data transmission is represented in figure 2.

Bit-no.	1	……..		n
LET	BITSYNC	BLCSYNC	codewords	H

NOTE: LET: Link Establishment Time
BITSYNC: Bit Synchronization
BLCSYNC: Block Synchronization
H: Hang-Over bit

Figure 2: Transmission format

5.3 Link establishment time

Transmissions shall be preceded by a Link Establishment Time (LET) within which a transmission, preferably unmodulated, at not less than 90 % of maximum power shall take place. The duration of the LET shall be defined on a system by system basis.

5.4 Bit synchronization

The binary transmission shall begin with a bit reversal 1010..10 so that the receiver data demodulator can be synchronized to the transmitted signal. The normal bit synchronization (BITSYNC) consists of 16 bits and ends with a binary 0. An optional bit synchronization is defined in subclause 5.5.2.

5.5 Block synchronization

5.5.1 Normal block synchronization

The block synchronization (BLCSYNC) marks the beginning of the codeword framing. It consists of 16 bits. The bit pattern and the hexadecimal equivalent are represented in figure 3.

Bit-no.	1	……..		16
Bit pattern	1 0 1 1	0 1 0 0	0 0 1 1	0 0 1 1
HEX-value	B	4	3	3

Figure 3: Block synchronization

If the block synchronization is not received correctly, the blocks that follow shall not be decoded.

The autocorrelation properties of the BLCSYNC are calculated with respect to its corresponding BITSYNC.

5.5.2 Optional bit and block synchronization

It is possible to protect all codewords with a Forward Error Correction (FEC). If the codewords are overlaid by a FEC code this is indicated by the inverse bit and block synchronization. The bit synchronization ends with a binary 1. The bit pattern and the hexadecimal equivalent of the inverse block synchronization are represented in figure 4.

Bit-no.	1	……..		16
Bit pattern	0 1 0 0	1 0 1 1	1 1 0 0	1 1 0 0
HEX-value	4	B	C	C

Figure 4: Optional block synchronization

If the block synchronization is not received correctly, the blocks that follow shall not be decoded.

The autocorrelation properties of the BLCSYNC are calculated with respect to its corresponding BITSYNC.

5.6 Codewords

The codewords have a constant length of 64 bits. 48 bits contain the information and 16 bits contain the redundancy for the data protection. The structure is represented in figure 5.

Bit-no.	1..48	49.............64
	I N F O R M A T I O N	redundancy
Length	48	16

Figure 5: Codeword structure

5.6.1 Redundancy

The redundancy comprises 16 bits and shall be used for error detection. Error corrections may also be performed. The check bits are calculated in three steps:

- the first 15 check bits originate from a (63,48) cyclic block code. The 48 information bits represent the coefficients of a polynomial. This polynomial is divided modulo 2 by the following generating polynomial:

  $$x^{15} + x^{14} + x^{13} + x^{11} + x^4 + x^2 + 1$$

  The first 15 check bits correspond to the coefficients of the terms from x^{14} to x^0 in the remaining polynomial after the complete division;

- the 15th check bit is then inverted;

- finally, a parity bit is appended to the 63 bit block to provide an even parity of the complete 64 bit block.

The error control properties of the codewords, using a hard decision decoding, can be one of the following:

- detection of all odd number of errors, any random errors up to 5, and any error burst up to length 16;

- correction of any single bit error and detection of any random errors up to 4, and any error burst up to length 11;

- correction of any two errors and detection of any random errors up to 3, and any error burst up to length 4;

- correction of any single error burst up to length 5.

5.6.2 Optional data protection for error correction

In order to enable increased error correction, the 64 bits of each codeword may optionally be encoded with a (20,10) convolutional code. Using the "tail-biting" procedure the encoded codeword has a length of 128 bits. The code is defined by the parity check matrix shown in figure 6.

```
      |01                       |
      |0001                     |
      |000001                   |
      |10000001                 |
      |0010000001               |
H =   |000010000001             |
      |10000010000001           |
      |0010000010000001         |
      |000010000010000001       |
      |00000010000010000001     |
      |0000000010000010000001   |
      |000000000010000010000001 |
```

Figure 6: Parity check matrix

This code results from interleaving an (8,4) convolutional code (see annex K) at the order 3. It is able to correct each 6 bit error burst for a 20 bit protection range.

Encoding and decoding with logic circuits can be carried out by:

- a 3rd order demultiplexing of the information bits, to encode separately the three resulting bit streams with an (8,4) encoder and to interleave the three signals obtained for transmission, a similar, but inverse method can be utilized for decoding; or

- replacing in the logic circuits of an (8,4) encoder and decoder every elementary cell of the shift registers by three cells in series. At the decoder, there is a 9-bit syndrome register $S_1...S_9$. When a syndrome:

  $S_1...S_9$ = xx1xx1xx0

  is obtained (where the x indicates 0 or 1), a correction is applied at the circuit output (and the syndrome is reset to $S_1...S_9$=xx0xx0xx0). For an example of encoding and decoding using an (8,4) code, see annex K.

A microprocessor can be used for encoding, using the so-called procedure of "tail-biting". The message MA of 64 bits to be encoded is considered. The messages MB and MC are deduced from MA by a cyclic shift of respectively 3 and 6 bits. The redundancy is obtained by summing, modulo 2, MB and MC; it is transmitted interleaved with MA (128 bits transmitted).

The convolutional code described above, and the cyclic code as well, are systematic codes: the information bits are transmitted unchanged, and can be received with a receiver not equipped with the corresponding decoder(s), provided the signal to interference ratio is sufficient to render the bit error rate sufficiently low.

5.7 Hang-over bit

To ensure reliable demodulation and decoding of the last bit of the last received block, it is required that binary transmission ends with an appended hang-over bit H. This bit is system dependent and shall not contain information.

5.8 Signalling cycle

The probability of success of a selective call in a simplex (single or two frequency) system can be improved by the method described in this subclause.

By repeating the same message several times in a multiple transmission (a signalling cycle), the overhead of link establishment and waiting times in transmission of separate messages is reduced. This method of calling is particularly useful in systems where portable unit battery savings are important because a receiver may not always be fully active. However, it can increase the duration of certain transmissions.

The signalling cycle consists of several messages containing identical information which are separated by bit and block synchronization (SYN). This method is represented in figure 7. The LET precedes only the first bit synchronization. The hang-over bit H is only appended to the last signalling message.

In two frequency systems where the base station has duplex capability the receiving mobile station may signal an acknowledgement as soon as a single message of the cycle is decoded correctly. This acknowledgement may be used to cut short the signalling cycle (the acknowledgement may itself be a signalling cycle).

In simplex systems, the full signalling cycles shall always be transmitted. When the receiving station has decoded one message of the cycle correctly, it immediately switches to transmit an LET followed by the required acknowledgement. The length of the LET shall be long enough to enable the first transmitting station to complete its signalling cycle and revert to the receive mode. The number of repetitions of the messages NM and thus the length of the LET are system specific. The number of the repetitions of the acknowledgements NA is also system specific and may be different from NM.

Two or more bits of each message (in the COM-field as described in annex L) may be used to indicate the number of messages remaining in the signalling cycle. In this case the receiving station is able to reply just at the end of the received call (by pre-calculation of the timing).

NM and NA are system-specific.

Bit-no.	1				……..			n
LET	SYN	message	SYN	message		SYN	message	H

NOTE: LET: Link Establishment Time
SYN: bit- and Block synchronization
message: messages containing identical information
H: Hang-Over bit

Figure 7: Signalling cycle

The parameters of the signalling cycle (length of LET, number of repetitions etc.) should be chosen with respect to any shared usage of the channel, and may be subject to license restrictions. Examples of the signalling cycles are shown below.

EXAMPLE 1: A signalling cycle with two calls is transmitted. If the first call is decoded, the receiving station answers with a cycle of two acknowledgements.

LET	SYN	call	SYN	call	H

L E T	SYN	ack	SYN	ack	H

Figure 8: Signalling cycle, first call decoded

EXAMPLE 2: A signalling cycle with two calls is transmitted. If the first call is not detected but the second call is correctly decoded, the receiving station answers with a cycle of acknowledgements.

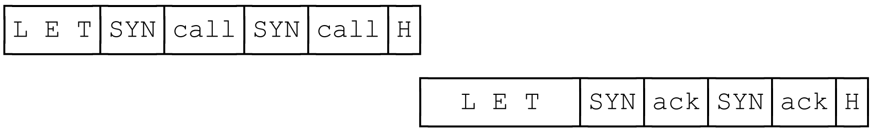


Figure 9: Signalling cycle, second call decoded

If an acknowledgement cannot be decoded, the call cycle is repeated until the maximum number of transmissions is reached.

When the loudspeaker is switched on, users may be annoyed by interference from RF-carriers.

This method may also be used for group calls when no acknowledgement is expected.

6 Services and facilities

The services and facilities supported by the signalling system are as described below.

Further details on the services and facilities offered by data transmission are given in subclause 10.1.

6.1 Selective calls

A selective call is a call which can be set up between two or more users of a radio system, but excluding other users. The system permits call transmission to and from both fixed stations and mobile (and portable) stations.

Selective calls may be made within a user group, where up to 4 096 user addresses are possible; or where an increased addressing capability is required, between user groups using an external addressing facility.

Selective calls may be made on an individual or group basis (see subclauses 6.1.1 to 6.1.3).

The individual and group address allocation is user specific.

6.1.1 Individual call

An individual selective call is one set-up between two users, to the exclusion of other users of the system. The same mechanism may be used to include other users in an already set-up call, one at a time.

6.1.2 Group call

A group call is one set up by one individual to a group of two or more users. The signalling system does not differentiate between individual and group calls, and relies on the receiving unit to make the distinction.

One station may respond to several group call addresses, in addition to an individual address.

6.1.3 Broadcast call

A broadcast call is a call to which a reply is generally neither required nor expected from the called user. A broadcast call may be made to either individual users, or to groups (see subclause 8.2 for exceptions).

6.2 Call priority levels

This ETS includes provisions for levels of priority, which are given in subclauses 6.2.1 to 6.2.3.

6.2.1 Normal call

A normal call shall have the lowest level of priority on the system.

6.2.2 Priority call

A priority call shall have the intermediate level of priority on the system. This call may attempt immediate channel access even if the channel is busy; however, system access is not guaranteed.

6.2.3 Emergency call

An emergency call shall have the highest level of priority on the system. An emergency call is permitted immediate channel access, and can force a priority treatment in all receiving stations. An emergency call may enter special procedures to ensure a distinction from lower priority calls.

6.3 Call management

The signalling system offers various features for management of calls either in progress, or during set-up. These features are both in the form of acknowledgements for previous signalling and of additional signalling for call progression or termination.

6.3.1 Acknowledgements

There are various acknowledgement types which can be implemented in selective calling systems, to ensure system flexibility. The facilities that these can provide are given in subclauses 6.3.1.1 to 6.3.1.4.

6.3.1.1 Automatic acknowledgement

An automatic "general acknowledgement" shall be sent by a radio unit in response to most types of signalling, except where stated.

6.3.1.2 Emergency acknowledgement

A specific acknowledgement shall be provided as a response to emergency calls to enhance the probability of successful call set-up.

6.3.1.3 Informative acknowledgements

Different acknowledgements may be used to provide information to the calling party about the state of the call set-up, or the state of the called user. Types are available for use when the called user is busy; when the called user is unavailable or absent from the radio; when the called user is unavailable, but will return the call at a later time or request for repetition of a transmission.

Additionally, an "intermediate acknowledgement" may be utilized to inform a calling user of the success of the signalling, but that a delay may be expected before the signalling sequence is completed.

6.3.1.4 Invalid call acknowledgement

A "reject acknowledgement" may be used to inform a calling user that the call requested is invalid for some reason.

6.3.2 Manual response

The manual response shall be sent by a radio unit in addition to, or instead of, an automatic acknowledgement where it is required to force a user to make a manual response to a call.

6.3.3 Call cancellation

A call cancellation function permits cancellation of a call set-up, before the signalling is completed.

6.3.4 Emergency reset

The emergency reset may be used to clear down the emergency procedure. The mobile stations which were involved in the emergency shall return to the stand-by mode.

6.3.5 Repeater access

Facilities exist within the signalling system to permit access to a repeater.

6.4 Telephone access

Facilities exist within the signalling system to make outgoing calls to a telephone system. Both Private Automatic Branch eXchange (PABX) and Public Switched Telephone Network (PSTN) systems can be accessed.

6.4.1 PABX access

A call may be set up either to a PABX, where a limited number of digits are available for number dialling, or to any telephone user accessed by a predetermined "short form" number memory within the radio system infrastructure. The use of this facility is system specific.

6.4.2 PSTN access

A call may be set up to a PSTN destination.

6.5 Special functions

The signalling system permits a number of specialized functions to be implemented. These are summarized in subclauses 6.5.1 to 6.5.6.

6.5.1 Request to call back

This facility can be used to inform the user that a particular station should be called back.

The facility forces the called station to store the calling address for later use. The user should be alerted in a suitable way which is device specific.

6.5.2 Channel control

An over-air command may be sent, which causes an addressed unit to move to another permitted operating frequency.

6.5.3 Mobile enable/disable

Mobile control functions are provided, whereby a station may command a mobile station either to become disabled and therefore prevented from taking part in calls, or to be re-enabled and permitted therefore to participate in calls.

6.5.4 Status transmission

The signalling system permits users to send up to sixteen predefined status values to each other, without the need to enter into speech communication. The information corresponding to these status values shall be determined on a system specific basis.

6.5.5 Data transmission

Two methods are provided within the signalling system whereby data can be exchanged between system users, without the need to enter into speech communication. The implementation of these methods is equipment dependent.

6.5.6 System control

The signalling system has provisions for system control functions. The use of these functions is system specific and is not specified in this ETS.

6.6 Identification

The signalling system shall have provisions for automatic transmitter identification, although this is not strictly a user facility.

In order to identify a transmitting radio station, a call maintenance identification may be transmitted at certain times independently of other signalling. The identification code contains the selective call address of the radio station.

If the call maintenance identification is used it may be sent:

1) at start of transmission;
2) at end of transmission;
3) periodically during transmission;
4) any combination of 1) to 3) above.

Identification is compliant with ETS 300 113 [3] where appropriate.

7 Codeword and block definition

Three types of blocks are defined in this ETS; address blocks, control blocks, and data blocks. The structure and the contents of the address block is defined in subclause 7.1.

For application of the individual functions, see the procedure definition in clause 8.

It is not required that all functions shall be implemented by the mobile station.

7.1 Address block

7.1.1 General

The general address block structure is represented in figure 7. This is always the first codeword of a message which may be followed by concatenated codewords.

Bit no.	1..........6	7..........12	13........24	25........36	37........48
	OMC	RC	COM	TX	RX
Length:	6	6	12	12	12

NOTE:
OMC: Operating Mode Characteristic
RC: Regional Code
COM: Common address part
TX: Transmitter address
RX: Receiver address

Figure 10: General address block structure

The 6 bit Operating Mode Characteristic field (OMC) contains the definition of the message.

The field provided for the Regional Code (RC) is 6 bits binary coded. The coding is defined in annex D.

The 12 bit Common field COM is the common part for the individual 12 bit transmitter address TX and the individual (or group) 12 bit receiver address RX.

7.1.2 Concatenated codewords

Concatenated codewords are the results of concatenation of different address codewords, control codewords, or data codewords. Address blocks always contain an OMC field. The concatenated codeword structure is represented in figure 11.

Bit-no.	1			…….. _ _ _ _ _ _		n
	SYN	address	concat	_ _ _ _ _ _ _	concat	H

NOTE:
SYN: bit- and Block synchronization
address: address codeword
concat: further Address Codeword or Control Codeword or Data Codeword
H: Hang-Over bit

Figure 11: Concatenated codeword structure

7.1.3 Normal address mode

In the normal address mode, only one address codeword is used. The space provided for the transmitter and receiver address is 12 bit binary coded corresponding to the following quantity:

- 4 096 addresses.

More than 4 096 addresses may be provided by use of the common field (see annex L).

The individual and group address allocation is user specific.

7.1.4 External address mode

The external address mode is used for a precise definition of the complete receiver and the complete transmitter address, if the country and/or common part is not identical for the transmitter and receiver.

Two address codewords with the normal addressing mode shall be used. The transmitter address is located in the first address codeword, the receiver address is located in the second address codeword. Unused individual address fields (transmitter, receiver) in these codewords are set to the hexadecimal value F_H. The structure is represented in figure 12.

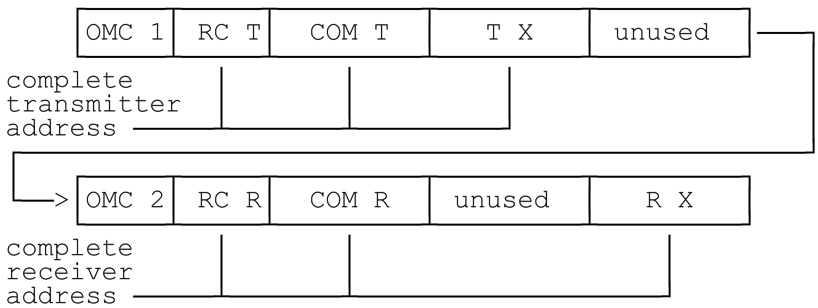


Figure 12: External addressing structure

For the coding of OMC 1 and OMC 2, see subclause 7.2.3.8.

7.2 Operating mode characteristic

The definition of a codeword is determined by the operating mode characteristic OMC. The OMC field has the structure represented in figure 13.

Bit-no.	1 … 3	4 … 6
	CAT	FNC
Length	3	3

NOTE:
CAT: category code
FNC: function code

Figure 13: Operating Mode Characteristic (OMC)

The OMC coding with all categories and functions defined is summarized as a category-function matrix in annex E.

7.2.1 Category definitions

The Category code (CAT) defines a global classification of the message. The category definitions are represented in table 3.

Table 3: Category definitions

CAT	Definition
000	System functions
001	Calls
010	Acknowledgements
011	Special functions
100	Status transfer
101	Status transfer
110	Reserved category
111	Custom functions

The Function code (FNC) has a special significance in each category. The meaning of the FNC is indicated in the definition of the messages.

The bits specified in the OMC field for options which are not implemented shall not be used for any other purposes.

7.2.2 System functions

This category contains functions for call termination, identification, and repeater access.

The FNC of this category are listed in table 4.

Table 4: Function definition of category 000

FNC	Definition
000	Emergency Reset
001	Cancel
010	Clear Down
011	Maintenance-ID
100	TX Key ON
101	TX Key OFF
110	Repeater ON
111	Repeater OFF

7.2.2.1 Emergency reset

The emergency reset may be used to clear down the emergency procedure. The mobile stations which were involved in the emergency shall return to the stand-by mode.

7.2.2.2 Cancel

The cancel message may be used to stop any type of procedure prior to completion.

7.2.2.3 Clear down

The clear down message shall be used to terminate a completed conversation. The mobile stations which were involved in the call shall return to the stand-by mode.

This message shall not be acknowledged.

7.2.2.4 Maintenance Identification

The Maintenance Identification (Maintenance-ID) may be used to identify a transmitting radio unit.

7.2.2.5 Transmitter key on

The TX key on message is an identification sent at every initiation of a transmission when the TX key is pressed. This message should be used for repeater access.

This message shall not be acknowledged.

7.2.2.6 Transmitter key off

The TX key off message is an identification sent at every termination of a transmission whenever the TX key is released. This message should be used for repeater release.

This message shall not be acknowledged.

7.2.2.7 Repeater on

The repeater on message is a control command to switch on a repeater.

7.2.2.8 Repeater off

The repeater off message is a control command to switch off a repeater.

7.2.3 Call messages

This category contains messages necessary for establishing calls between radio stations and for dialling into telephone networks.

The function codes FNC of this category are listed in table 5.

Table 5: Function definition of category 001

FNC	Definition
000	Emergency Radio Call
001	Priority Radio Call
010	Normal Radio Call
011	Telephone Call
100	Broadcast Radio Call
101	Request to Call back
110	Manual Response
111	External Addressing

Address codewords with OMC equal to external addressing are always followed by concatenated address codewords giving further information in the last OMC.

7.2.3.1 Emergency radio call

The emergency call is a radio call providing the highest level of priority. The station transmitting an emergency call may directly access the radio channel. This call forces a special emergency procedure to distinguish it from other calls.

7.2.3.2 Priority radio call

The priority call is a radio call providing a higher priority relative to normal calls. This call may have immediate channel access. The use of the call is system specific, and not defined in this ETS.

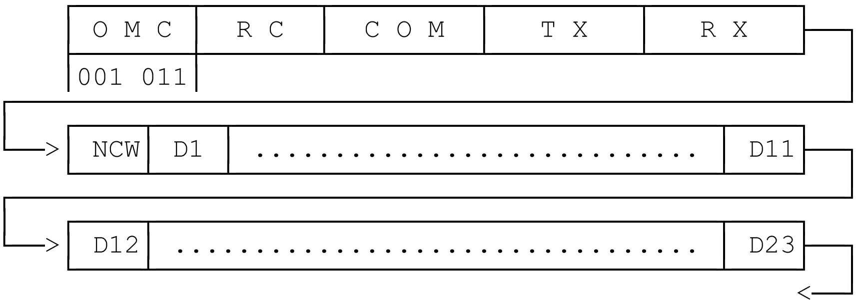
7.2.3.3 Normal radio call

The normal call shall be used by mobile or base stations to establish a connection.

7.2.3.4 Telephone call

The telephone call message allows dialling into telephone networks. The complete telephone number shall be transmitted within two or more blocks with hexadecimal digit coding as described in annex E.

The message structure is shown in figure 14.



NOTE: NCW: Number of Codewords that follow
Dxx: Hexadecimal Digits

Figure 14: Telephone call message

The first block is the address block defined in subclause 7.1.1 and the receiver address identifies base stations or gateways. The first 4 bits in the second block are used for a 4 bit counter NCW (Number of Codewords) which indicate the number of codewords to follow after this codeword. After NCW the coded telephone number follows. Remaining unused digits shall be set to hexadecimal value F_H.

7.2.3.5 Broadcast radio call

The broadcast radio call is a one-way call to radio units during which the TX keys of the called parties are disabled. After the reception of the broadcast call message, the called parties are only permitted to switch on their loudspeakers.

7.2.3.6 Request to call back

The facility requests the called station to store the calling address for later use. The user should be alerted in a suitable way which is device specific.

7.2.3.7 Manual response

The manual response is assigned for predefined messages. The use of this function is system specific and is not defined in this ETS. The transmission of this message follows the usual channel access rules for mobile initiated transmissions.

7.2.3.8 External addressing

External addressing is a method to enable an address extension to establish a communication between parties with different country and/or COM fields. Therefore, the complete receiver and transmitter address shall be transmitted within two address codewords.

In the first address codeword the receiver field is reserved for future use and shall be set to the hexadecimal value FFF_H. In the second address codeword, the transmitter field is reserved for future use and shall be set to the hexadecimal value FFF_H.

The OMC coding for an external message is represented in figure 15. OMC 1 contains the function code for external addressing. OMC 2 contains the desired call function.

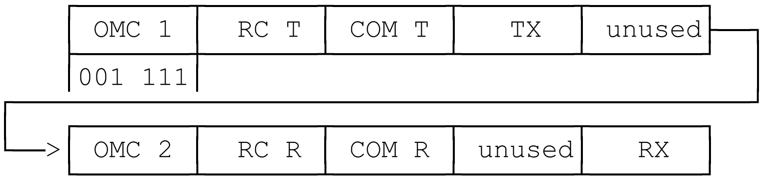


Figure 15: External message

7.2.4 Acknowledgements

Normally every selective transmission shall be acknowledged automatically. The status request message is an exception and is acknowledged indirectly with a status message.

The function codes (FNC) of this category are listed in table 6.

Table 6: Function definition of category 010

FNC	Definition
000	Emergency Acknowledgement
001	Repeat Acknowledgement
010	General Acknowledgement
011	Absent/Unavailable Acknowledgement
100	Busy Acknowledgement
101	Call Back Acknowledgement
110	Intermediate Acknowledgement
111	Reject Acknowledgement

7.2.4.1 Emergency acknowledgement

The emergency acknowledgement shall be used to acknowledge an emergency call message.

7.2.4.2 Repeat acknowledgement

The repeat acknowledgement should be used as a response to the transmission of concatenated codewords where the address block has been received correctly but one or more of the subsequent codewords have been corrupted and a complete repetition of a transmission is requested.

7.2.4.3 General acknowledgement

The general acknowledgement shall be used as a positive response to non-emergency messages requiring acknowledgement. The meaning "user present" may be allocated to the general acknowledgement.

7.2.4.4 Absent/unavailable acknowledgement

If the general acknowledgement with the meaning "user present" is used, the absent/unavailable acknowledgement shall be transmitted automatically if the user (normally MS) is absent or the facility (normally BS) is unavailable. The calling station has the option of cancelling the call.

7.2.4.5 Busy acknowledgement

The busy acknowledgement should be used if the system or called party is busy.

7.2.4.6 Call back acknowledgement

The call back acknowledgement is a response which should be used to indicate that the called party is busy but it will call back.

7.2.4.7 Intermediate acknowledgement

The intermediate acknowledgement should be used to indicate that the called station is not yet ready for communication and further response or signalling will follow.

7.2.4.8 Reject acknowledgement

The reject acknowledgement shall be used as a reaction to not allowed or not implemented messages.

7.2.5 Special functions

The functions of this category represent messages which do not serve to establish speech calls.

The FNC of this category are listed in table 7.

Table 7: Function definition of category 011

FNC	Definition
000	System Control
001	Short Data Transfer
010	Dialogue Data Transfer
011	Change Channel
100	Vote Now
101	Status Request
110	Mobile Enable
111	Mobile Disable

7.2.5.1 System control

The system control message may be used as a system specific base station control command which is not defined within this ETS.

The fields labelled "TX" and "RX" in the general address block structure are available for re-use in the system control message.

The system control message structure is represented in figure 16.

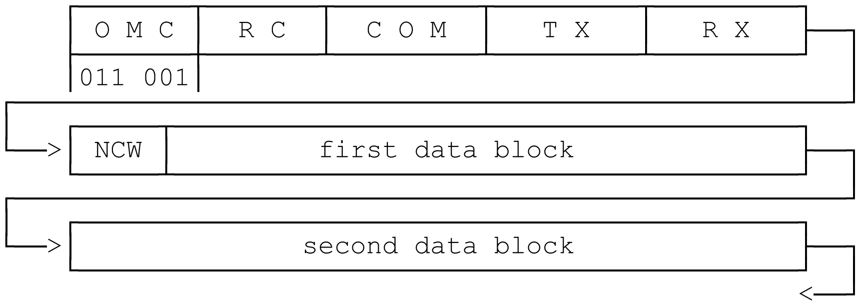
O M C	R C	C O M	C U S T O M
011 000			

NOTE: CUSTOM: Custom specific system control functions

Figure 16: System control message

7.2.5.2 Short data transfer

The short data message indicates that short data transmission takes place. The short data message structure is represented in figure 17.



NOTE: NCW: Number of Codewords that follow

Figure 17: Short data structure

The first block is the address block defined in subclause 7.1.1. The first 4 bits in the second block are used for a 4 bit counter NCW which indicate the number of data codewords to follow after this first data codeword. From this codeword onwards, 48 data bits are always used. The maximum number of data codewords is defined by the parameter ND. The parameter ND is system specific and may be dependent on the frequency allocation and related propagation conditions.

7.2.5.3 Dialogue data transfer

A dialogue data transfer procedure is available for dialogue data communication. The protocol is based on the High-level Data Link Control (HDLC) procedure. The original procedure has been changed and extended in some aspects in order to fulfil the specific requirements of a mobile radio channel.

For a detailed definition of the protocol, see clauses 10 to 12.

7.2.5.4 Change channel

The Change Channel command may be used as a system command to force the called party to change the RF-channel. The channel to which the radio unit is directed shall be transmitted by using the short data structure or if permitted within the address block COM field. The allocation of the channel information is system specific.

7.2.5.5 Vote now

The vote now message may be used as a system command to force mobile stations to commence a scan cycle for the channel with the best transmission quality. All further actions are system specific and not defined within this ETS.

7.2.5.6 Status request

With the status request message, an internally stored subscriber status can be requested automatically. The receiver answers with a status response serving as acknowledgement.

7.2.5.7 Mobile enable

The mobile enable message may be used as a system command to enable the mobile station for operation.

7.2.5.8 Mobile disable

The mobile disable message may be used as a system command to disable the mobile station from any operation.

On receipt of the message, the mobile shall disable its user interface to appear non functional. The mobile shall, however, leave its receiver active on some default channel to permit possible response to the mobile enable message only.

7.2.6 Status transfer

Up to 16 different status messages can be transmitted. The status information is system specific. Status messages transmitted spontaneously require acknowledgement. Status messages are not acknowledged after a status request. Alternatively the category CAT=100 can be reserved for spontaneous status messages, and the category CAT=101 can be exclusively reserved for status requests.

7.2.7 Reserved category

This category is reserved for future extension of this ETS.

7.2.8 Custom functions

This category is at free disposal for custom specific functions not defined within this ETS.

8 Message procedures

This clause outlines call set-up, call acknowledgement and call clear-down by specified procedures.

If the user wishes to cancel an ongoing call procedure, he has to employ a cancellation function. During a procedure no other call or message may be transmitted except for emergency calls, unless the user cancels the call in a suitable device-specific way.

If not otherwise defined, a calling station attempts to set up a connection until:

- it receives a valid acknowledgement;
- the user cancels the call;
- the unit times out while waiting to access the channel for a time TC;
- no acknowledgement has been received after a specified number of re-tries NR.

NR and TC are system-specific.

If the unit cancels the connection, the user should be alerted in a suitable device-specific way.

The call between users can be cleared down in one of the following ways:

- one of the stations transmits a clear down message;
- the RF-carrier is lost for a specified time TF;
- the call exceeds a maximum time TV;
- the user or the unit cancels the call.

TF and TV are system-specific.

To clear down a call which is no longer required, a radio unit shall transmit the clear down message to the other station(s). A signalling cycle may be used to improve the reliability of this transmission.

For a group call, only the station which initiated the call shall be permitted to transmit the clear down message.

On completion of the clear down transmission the radio unit shall return to standby mode.

On receipt of the clear down message, the addressed station shall return to standby mode without transmitting an acknowledgement to the clear down message.

8.1 Normal or priority radio call procedure

The calling station transmits a normal or a priority call with an individual or a group receiver address.

For an individual call, the expected acknowledgement from the called unit which is transmitted automatically shall be one or more of the following:

- **General Ack:** call accepted, loudspeaker and microphone of both parties are enabled;

- **Absent/Unavailable Ack:** call not accepted if the user is not present or the facility is not available;

- **Intermediate Ack:** signalling accepted, further acknowledgement will follow within a certain time TI. TI is system-specific. The further acknowledgement can be another Intermediate Ack;

- **Call Back Ack:** the called party is busy but will call back;

- **Busy Ack:** call not accepted because called party or system is busy;

- **Reject Ack:** call not accepted because the call is not allowed or not implemented.

Neither a normal call nor a priority call should interrupt an ongoing emergency procedure.

For group calls, no acknowledgement is expected.

8.2 Broadcast call procedure

If a broadcast call is transmitted to a group of subscribers, no acknowledgement is expected. If a broadcast call is transmitted to an individual subscriber, the automatically transmitted acknowledgement shall be one or more of the following:

- **General Ack:** call accepted;

- **Absent/Unavailable Ack:** the user is not present or the facility is not available;

- **Busy Ack:** call not accepted because the called party is busy;

- **Intermediate Ack:** signalling accepted, further acknowledgement will follow within a certain time TI. TI is system-specific. The further acknowledgement can be another Intermediate Ack;

- **Reject Ack:** call not accepted because the call is not allowed.

8.3 Emergency call procedure

An emergency call cancels other ongoing procedures. The emergency call need not follow normal channel discipline.

The procedure is represented in figure 18 and is as follows:

- the calling station transmits the emergency call message. The calling station then reverts to receive mode and awaits an acknowledgement for time TAC.

The expected acknowledgement is an Emergency Ack or an Emergency Reset command.

When an Emergency Ack is received or when timer TAC expires then the station:

- transmits with microphone enabled for time TS1; followed by
- receiving with loudspeaker enabled for time TS2; followed by
- waiting in idle state in receive mode for time TS3.

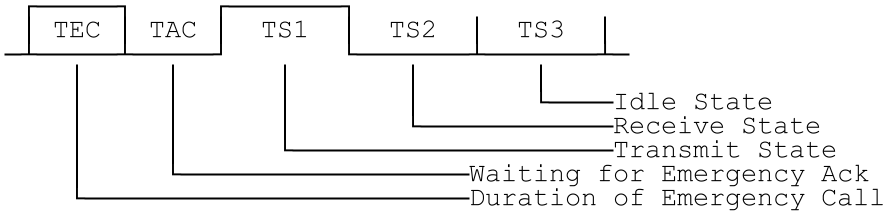


Figure 18: Emergency cycle timing

The above cycle is then repeated a number NE of times. If an Emergency Ack is received during time TAC on any cycle then the Emergency Call message and wait for acknowledgement (TAC) may be optionally omitted. If this option is implemented, the transmit state starts without delay after TS3. This new transmit state has a duration:

TS4 = TEC + TAC + TS1.

During time TS3 all stations involved in the emergency procedure should be in reception mode.

NE, TEC, TAC, TS1, TS2, TS3, TS4 are system parameters.

The emergency procedure shall be terminated on reception of the Emergency Reset command. This may be received at any time during TAC, TS2 or TS3, whether the station has successfully received an Emergency Ack or not.

On receipt of the Emergency Reset command, the station shall exit the emergency procedure, and transmit a General Ack.

The usage of other acknowledgements is permitted, but this is system specific.

8.4 Manual response procedure

After receiving a message which requires the user to provide a manual response, the called radio unit shall indicate in a device-specific way to its user that a response is required. On receiving the required activation from its user, the radio unit shall initiate the manual response procedures in order to send the required manual response message to the calling radio unit.

The radio unit shall transmit a manual response message to the party which sent the message requiring a manual response. After completing the manual response transmission, the radio unit shall wait for a time TA for one of the following acknowledgements:

- **General Ack:** manual response received as required;
- **Intermediate Ack:** signalling accepted, further acknowledgement will follow within a certain time TI. TI is a system parameter. The further acknowledgement can be a repetition of the Intermediate Ack;
- **Reject Ack:** no manual response was expected (error situation).

8.5 Call cancellation procedure

The Cancel command is used to cancel the effects of a previously transmitted message or a call set-up signalling.

After transmitting the cancel command the calling station shall wait for a time TA for one of the following acknowledgements:

- **General Ack:** the call has been cancelled;
- **Absent/Unavailable Ack:** the station is not permitted to cancel its last requested function;

- **Intermediate Ack:** signalling accepted, further acknowledgement will follow within a certain time TI. TI is a system parameter. The further acknowledgement can be a repetition of the Intermediate Ack;

- **Reject Ack:** there are no ongoing procedures to cancel.

If no acknowledgement is received within time TA of the transmitted Cancel command, the station may implement the retry procedures provided that no confirmation has been received that the previous function has been completed. If confirmation has been received that the previous function is completed, the calling station shall not attempt to cancel the call, but may clear down if the call is not required.

8.6 Repeater access procedure

If a repeater is used, the normal call procedures are preceded by repeater activation and followed by its de-activation.

To activate the repeater the following message shall be sent:

- **Repeater ON:** command to switch on a repeater.

After a Repeater ON command the repeater sends one of the following acknowledgements:

- **General Ack:** the repeater is activated;

- **Reject Ack:** activation not accepted because the function is not allowed;

- **Absent/Unavailable Ack:** the repeater is not available;

- **Intermediate Ack:** signalling accepted, further acknowledgement will follow within a certain time TI. TI is a system parameter. The further acknowledgement can be a repetition of the Intermediate Ack.

Where simplex and semi-duplex mode systems can be mixed, the calling mobile has to inform the called station on which channel to answer.

The repeater may be deactivated by the following message:

- **Repeater OFF:** command to switch off a repeater.

The repeater transmits the following acknowledgement and switches off:

- **General Ack:** the repeater is deactivated.

The use of other acknowledgements is permitted but this is system specific.

8.7 Telephone call procedure

The telephone call is only defined for mobile stations. A call from a telephone subscriber to a mobile subscriber is carried out as a selective call or an external call by the base station.

The expected acknowledgement is transmitted from the base station containing the interface of the telephone equipment and performing the line call. The acknowledgement transmitted automatically is one or more of the following:

- **General Ack:** call accepted by the gateway. Loudspeaker and microphone of calling radio are enabled;

- **Intermediate Ack:** signalling accepted, further acknowledgement will follow within a certain time TI. TI is system-specific. The further acknowledgement can be another Intermediate Ack;

- **Reject Ack:** call not accepted because the call is not allowed;

- **Busy Ack:** call not accepted because the system is busy;

- **Absent/Unavailable Ack:** call not accepted because the gateway is not available;

- **Repeat Ack:** call not accepted and repetition of a transmission is required;

- **Call Back Ack:** system dependent.

8.8 Call back request procedure

After receiving the Absent/Unavailable Ack or the Busy Ack after an attempted call, the calling station may use the Request for Call Back message to ask the called station to call back when the Absent/Unavailable or Busy condition no longer applies.

To request the called station to call back, the calling station shall transmit a Request for Call Back message and wait for one of the following acknowledgements:

- **General Ack:** the called station will call back;

- **Intermediate Ack:** signalling accepted, further acknowledgement will follow within a certain time TI. TI is a system parameter. The further acknowledgement can be a repetition of the Intermediate Ack;

- **Reject Ack:** the called station will not call back.

If no acknowledgement is received within a time TA of the transmitted Request for Call Back message, the calling station may implement retry procedures.

8.9 Change channel procedure

After a station receives a Change Channel command, immediately one of the following acknowledgements is sent:

- **General Ack:** command accepted;

- **Reject Ack:** command not accepted because the function or channel is not allowed or not implemented.

After the general acknowledgement is sent, the unit shall change to the radio channel indicated in the received command.

NOTE: Care should be taken to avoid misuse of this function (system specific).

8.10 Mobile enable and mobile disable procedure

The Mobile Disable command is sent from controlling station to mobile. The mobile shall acknowledge with one of the following messages:

- **General Ack:** the mobile will execute the disable function;

- **Reject Ack:** command not accepted either because the function is not implemented or the controlling station is not permitted to request the function.

The Mobile Enable command is sent from controlling station to mobile. The mobile shall acknowledge with:

- **General Ack:** the mobile will execute the enable function;

- **Reject Ack:** command not accepted either because the function is not implemented or the controlling station is not permitted to request the function.

  NOTE: Care should be taken to avoid misuse of this (system specific) function.

8.11 Status transfer procedure

The status transfer can be set up by transmitting one of the following messages:

- Status Message;
- Status Request.

Following a status message, the automatically transmitted acknowledgement is one or more of the following:

- **General Ack:** after an accepted Status Message;
- **Absent/Unavailable Ack:** status not accepted if the service is not available;
- **Busy Ack:** status not accepted because the called party is busy;
- **Intermediate Ack:** signalling accepted, further acknowledgement will follow within a certain time TI. TI is system-specific. The further acknowledgement can be another Intermediate Ack;
- **Reject Ack:** Status Message is not allowed.

Following a Status Request, the automatically transmitted message is one or more of the following:

- **Status Message:** Status Request accepted;
- **Absent/Unavailable Ack:** Status Request not accepted if the service is not available;
- **Busy Ack:** Status Request not accepted because the called party is busy;
- **Intermediate Ack:** signalling accepted, further acknowledgement will follow within a certain time TI. TI is system-specific. The further acknowledgement can be another Intermediate Ack;
- **Reject Ack:** Status Request is not allowed.

The status transfer procedure does not require a special Clear Down message.

8.12 Short data transfer procedure

After transmission of a short data message, the expected acknowledgement automatically transmitted is one of the following:

- **General Ack:** message accepted;
- **Absent/Unavailable Ack:** message not accepted because the user is not present or the facility is not available;
- **Intermediate Ack:** signalling accepted, further acknowledgement will follow within a certain time TI. TI is system-specific. The further acknowledgement can be another Intermediate Ack;
- **Busy Ack:** message not accepted because called party or system is busy;
- **Reject Ack:** message not accepted because short data transfer is not allowed;

- **Repeat Ack:** message not accepted and repetition of a transmission is required.

The short data call is automatically cleared down after having received the expected acknowledgement.

9 Channel access protocol and occupation rules

This clause describes the methods used by a radio accessing the RF channel. Each feature on a radio which is signalling related has a channel access protocol defined for it.

The major components of a channel access protocol are determined by two considerations:

- whether the message expects an acknowledgement; and
- whether the radio waits for a free channel before transmitting.

9.1 Channel access

A channel is busy when legal users are occupying the radio channel.

Two access methods are defined:

a) immediate channel access (impolite access):

   - the radio should not wait to transmit even if the channel is busy. The message is transmitted after the Link Establishment Time (LET) to allow for transmitter rise time and other system delays;

b) waiting for free channel (polite access):

   - if the channel is busy, the radio should not transmit but wait for the channel to become unoccupied.

The receiver shall determine whether or not the channel is and has been unoccupied for a certain time period, the observation time (TO). If the channel is occupied during a part of TO, the process shall be repeated.

TO is the sum of the fixed part TOF and the random part $n \times TOI$:

$$TO = TOF + n \times TOI$$

The fixed time TOF and the increment time TOI are system dependent times. The number n is a random number in the range 1,2,...,m; this means that 1,2,...,m is the event field of the random number n. The random number n shall be determined by use of a random generator with a uniform distribution. To achieve short delays during low traffic, the observation time should be short, i.e. m should be a small integer.

TOF and TOI are system parameters.

A short random part of TO however, increases the probability of several users simultaneously attempting access to the channel. In the event of an unsuccessful transmission attempt, a retry procedure (see subclause 9.2) takes place.

Access and occupation rules of several types of messages are given in table 8.

Table 8: Access rules

Message	Access rules
Emergency Call	Impolite
Priority Call	possibly Impolite (system dependent)
Other Messages	Polite

Acknowledgements may need to be impolite depending on system implementation.

9.2 Retry procedure

Two methods are defined:

a) Acknowledgement expected:

- after a message is sent, the radio reverts to receive mode and awaits an acknowledgement for time TAC. If no acknowledgement is received, the radio waits for a random time (TW) before next retry;

- if an acknowledgement is not received and the channel becomes busy during TW then the procedure for polite channel access is followed;

b) Acknowledgement not expected:

- If no acknowledgement is expected for a message, the message may be sent more than once (system dependent).

The waiting time TW is the sum of the fixed part TWF and the random part $n \times TWI$:

$$TW = TWF + n \times TWI$$

The fixed time TWF and the increment time TWI are system dependent times. TWF may be zero. The number n is a random number in the range 0, 1, 2, or 3; this means that 0, 1, 2, or 3 is the event field of the random number n. The random number n shall be determined by use of a random generator with a uniform distribution.

TWF and TWI are system parameters.

Where a repeater or a two frequency base station is in use the retry procedure may implement impolite channel access following an initial polite channel access.

9.3 Reversion time

The reversion time TRV is the maximum time between the last bit of a message and the keying of the transmitter by the answering station, e.g. with an acknowledgement. To ensure that no other user can access the channel during a time interval, the reversion time shall not exceed a specific value. The RF-carrier may overlay if signalling cycles are used.

TRV is a system parameter which should be smaller than TOF.

10 Data protocol

The data protocol is described for applications that require long transmissions of data and/or data dialogue configurations. The link protocol is full-duplex in the sense that data exchange is allowed simultaneously in both directions, irrespective of whether the radio link is simplex or duplex.

The main procedures and terminology are based on the High-Level Data Link Control (HDLC) protocol, see ISO 4335 [1].

The data protocol controls the data exchange between stations and may be in one of the following three modes:

- Asynchronous Balanced Mode (ABM);

- Group Mode (GM);

- Asynchronous Disconnected Mode (ADM).

ABM is the data link operational mode in which both stations of a point-to-point configuration may initiate, cancel or terminate a data transmission spontaneously and therefore utilize the same commands and responses.

GM is the data link operational mode in which one station may initiate, cancel or terminate a data transmission to several stations simultaneously in an unbalanced mode in which the co-ordinating control is the initiating station. Only the initiating station may transmit data packets.

ADM is the data link non-operational mode in which a station is logically disconnected from the data link, and shall neither transmit nor accept numbered commands or responses.

10.1 Dialogue protocol services and facilities

The services and facilities supported by the Data Dialogue Protocol are given in subclauses 10.1.1 to 10.1.3.

10.1.1 Acknowledged point-to-point information transfer

Acknowledged point-to-point operation is used for multiple information packet transmission in a balanced mode. The information transfer is acknowledged at the data link level. Error recovery, packet sequence integrity, and flow control are defined.

10.1.2 Acknowledged broadcast information transfer

Acknowledged broadcast operation is used for limited multiple information packet transmission in an unbalanced mode. The information transfer is acknowledged at the data link level under control of the initiating station by a polling mechanism. Error recovery, packet sequence integrity, and flow control are defined.

10.1.3 Unacknowledged information transfer

Unacknowledged operation is used for point-to-point or broadcast single (un-numbered) information packet transmission. No error recovery and no flow control is defined at the data link level.

10.2 Data transmission structure

The general dialogue data transmission structure is represented in figure 19. The first block is the address block defined in subclause 7.1.1 with the OMC coding defined in subclause 7.2.5 (OMC = 011010). The address block is followed by a control block which contains the control information for the protocol. For a data packet transmission, the control block is followed by data blocks containing the information to be transferred. For a control packet transmission, the control block may be followed by an extra control block if necessary. The maximum number of data blocks in a packet is N1. N1 cannot be greater than 64. N1 may be dynamically varied according to the retransmission rate of previous messages. The range of values of N1 are system specific.

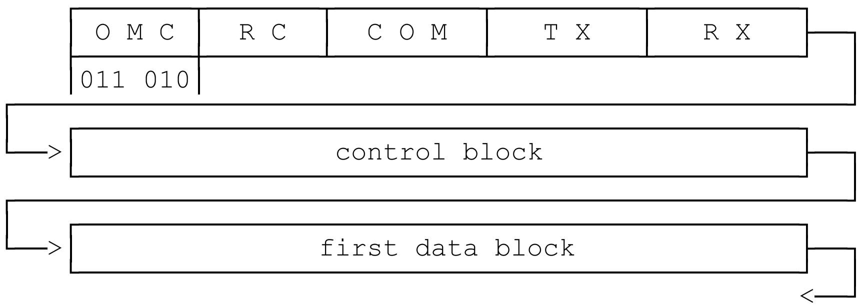


Figure 19: General dialogue data transmission structure

In conformance with HDLC rules, messages containing data and/or control information are called frames, although the flag sequence with opening and closing flag as defined in ISO 3309 [5] is not used.

10.3 Elements of the control block

The control block contains a PARAMETER field of 32 bits, which is used to transfer parameter information depending on the type of message that is used. There is also a 7 bit data terminal sub-address ADR, a single bit command/response flag C/R and an 8 bit control field, CONT. The control block structure is represented in figure 20.

Bit-no.	1...7	8	9.......16	17........................48
	ADR	C/R	CONT	PARAMETER
Length	7	1	8	32

NOTE:
ADR: Data Terminal Sub-address
C/R: Command/Response bit
CONT: Control field
PARAMETER: Parameter field

Figure 20: Control block structure

10.3.1 Data terminal sub-address, ADR

The 7 bit data terminal sub-address is used for a precise definition of the Data Terminal Equipment (DTE) of a station. The binary coding is represented in table 9.

Table 9: Sub-address (ADR)

000000	**no-station address**
000001	available for allocation
:	:
111110	available for allocation
111111	all-station address

The values 1 to 126 of the 7 bit address are available for allocation. A terminal can have one or more common addresses (group address) as well as its own individual address.

The address 0 is a "no-station" address. This address is reserved for tests and is not allocated to a DTE. The address 127 is an "all-station" address for directing information to all DTEs of a station.

Compared to the rules of HDLC, no address extension for DTE sub-address is defined and, therefore, no extension bit is used.

10.3.2 Command/Response bit, C/R

The C/R bit defines a frame as either a command or a response. The C/R bit is set to 1 for commands and set to 0 for responses.

10.3.3 Control field (CONT)

The control field (CONT) has a length of 8 bits and is used to distinguish between frame types in the same way as the 8-bit HDLC-control field is used. In the control field commands, responses and sequence numbers are encoded. The control field structure is illustrated in figure 21.

Bit -no.	21	22	23	24	25	26	27	28
I-Frame	0	N (S)			P / F	N (R)		
S-Frame	1	0	S	S	P / F	N (R)		
U-Frame	1	1	M	M	P / F	M	M	M

NOTE: N(R): Receive Sequence Number
P/F: Poll/Final bit
N(S): Send Sequence Number
SS: Supervisory function bits
MMM: Modifier function bits

Figure 21: Control field - CONT

As for the HDLC procedures, three frame formats can be defined for the data protocol, these are as follows:

- I-frames: Information transfer format;
- S-frames: Supervisory format;
- U-frames: Un-numbered format.

10.3.3.1 Sequence numbers, N(R) and N(S)

Each I-frame is sequentially numbered and may have the value 0 to 7 (modulo 8). All arithmetic operations on state variables and sequence numbers defined are affected by the modulo 8 operation.

Each I-frame contains a 3 bit send sequence number N(S). If an in-sequence I-frame is designated for transmission, N(S) is set equal to a send state variable V(S).

All I-frames and S-frames contain a 3 bit receive sequence number N(R), the expected send sequence number of the next received I-frame. If not otherwise defined, the value of N(R) indicates that all I-frames correctly received are acknowledged up to and including N(R)-1. If an I-frame or S-frame is designated for transmission, N(R) is set equal to a receive state variable V(R).

The send state variable V(S) denotes the sequence number of the next in-sequence I-frame to be transmitted. V(S) can take the values 0 to 7 (modulo 8). The value of V(S) shall be incremented by 1 with each successive I-frame transmission, but shall not exceed an acknowledge state variable V(A) by more than the maximum number of outstanding I-frames, K. K is a system parameter which may have the values 1 to 7.

The receive state variable V(R) denotes the sequence number of the next in-sequence I-frame expected to be received. V(R) can take the value 0 to 7 (modulo 8). V(R) shall be incremented by 1 with each correctly received in-sequence I-frame whose N(S) equals V(R).

The acknowledge state variable V(A) identifies the last frame that has been acknowledged by N(R). V(A) can take the value 0 to 7 (modulo 8). V(A) shall be updated on receipt of a valid N(R) and thus V(A)-1 equals the N(S) of the last acknowledged I-frame. A test algorithm to check the validity of a received N(R) value is given in annex E.

10.3.3.2 Poll and final bit, P/F

The poll and final bit (P/F bit) is used for commands and responses. 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 shall be used to solicit a response frame with F bit set to 1 from the remote station. The F bit set to 1 shall be used to acknowledge the receipt of a command with P bit set to 1. A response with F bit set to 1 shall be transmitted at the earliest opportunity after receiving a command with P bit set to 1. In a given direction, only one P bit set to 1 shall be outstanding at a given time. Similarly, another F bit set to 1 shall not be used until another P bit set to 1 is received.

The receive sequence number N(R) contained in a frame with P/F bit set to 1 can be used to detect that I-frame retransmission is required. This capability is referred to as checkpointing.

10.3.3.3 Supervisory and modifier function bits, S and M

The S bits and M bits are used for a precise definition of a command or response.

The coding of commands and responses used for the data dialogue protocol are illustrated in figure 22.

Frame	Command	Response	Control bit no.							
			1	2	3	4	5	6	7	8
I-frame	I		0	N(S)			P	N(R)		
S-frame	RR	RR	1	0	0	0	P/F	N(R)		
	RNR	RNR	1	0	1	0	P/F	N(R)		
	REJ	REJ	1	0	0	1	P/F	N(R)		
	SREJ	SREJ	1	0	1	1	P/F	N(R)		
U-frame		DM	1	1	1	1	F	0	0	0
	SABM		1	1	1	1	P	1	0	0
	DISC		1	1	0	0	P	0	1	0
		UA	1	1	0	0	F	1	1	0
		FRMR	1	1	1	0	F	0	0	1
	UI		1	1	0	0	P	0	0	0
	SGM		1	1	0	1	P	1	1	1

Figure 22: Coding of commands and responses

All frames defined in figure 22, except the SGM frame, are in conformance with HDLC.

10.3.4 PARAMETER field

The 32 bit field PARAMETER is used to transfer parameter information depending on the type of data message or frame which is sent.

10.4 I-frames

I-frames are always commands (C/R = 1) which are used to transfer sequentially numbered information within data blocks following the control block. The number of data blocks following the control block is at least one and shall be within the range 1 to N1 inclusive, where N1 is a system parameter. The contents of these data blocks is fully user specific.

The actual number of data codewords (blocks) and the amount of user bits in a particular I-frame is given by the fields NDW and NLB which are included in the PARAMETER field of the control block.

The PARAMETER field definition of an I-frame is given in figure 23.

Bit-no.	17...22	23...28	29	30	31................48
	N D W	N L B	V	C	reserved
Length	6	6	1	1	18

NOTE:
- NDW: Number of data codewords that follow
- NLB: Number of last bits
- V: I-frame integrity verification indicator
- C: Data compression indicator

Figure 23: PARAMETER field for I-frames

The first sub-field, NDW, indicates the number of data codewords following the first data codeword. The value of NDW can range between 0 and 63.

The second sub-field, NLB, indicates the number of bits used for the transfer of user specific data in the last of the appended data codewords. The value of NLB can range between 1 and 48.

The maximum permitted data length is given by system parameter N1, which has a value ranging between 1 and 64 codewords.

Any number n of data bits in an I-frame is calculated as follows:

$$n = (NDW \times 48) + NLB$$

With NDW = 63 and NLB = 48, the maximum number of data bits is 3 072, and an I-frame of length 16 bits is indicated by the values NDW = 0 and NLB = 16.

Verification of the integrity of I-frames and/or a data compression method may optionally be performed.

The bit V of the PARAMETER field of the I-frame indicates whether the mechanism for verification of integrity of the I-frames is in use or not:

V = 0: verification not in use and no extra bits are appended to the information of the I-frame;

V = 1: verification is in use and the appropriate CRC bits are added at the end of the information of the I-frame.

An example of implementation of a mechanism for the verification of integrity is represented in annex J.

The bit C of the PARAMETER field of the I-frame indicates whether the data bits are compressed, using the Radix-40 data compression technique, as defined in subclause 10.7, or not:

C = 0: Radix-40 data compression method is not in use;

C = 1: Radix-40 data compression method is in use.

10.5 S-frames

S-frames can be either commands or responses. They shall be used for controlling and supervising the data transmission phase, such as the acknowledgement of correctly received I-frames, requesting retransmission and requesting temporary suspension of I-frame transmission.

10.5.1 Receive Ready (RR) command/response

The S-frame RR is used for commands and responses. RR is used to indicate that the station is operating in the ready-to-receive state for I-frames and to acknowledge all received I-frames up to and including N(R)-1. A previous not-ready-to-receive state, initiated by RNR, (see subclause 10.5.2) is cancelled with RR.

10.5.2 Receive Not Ready (RNR) command/response

The S-frame RNR is used for commands and responses. RNR indicates that further I-frames cannot currently be accepted by that station. All I-frames up to and including N(R)-1 are acknowledged by RNR. The I-frame with N(S) equal to the value of N(R) and all following I-frames are regarded as not acknowledged.

The not-ready-to-receive state is cancelled by the transmission of one of the following commands/responses:

RR, REJ, SREJ, SABM, UA.

10.5.3 Reject (REJ) command/response

The S-frame REJ is used for commands and responses. A retransmission of one or multiple I-frames transmitted between N(R) and the last received N(S) is demanded with REJ. All I-frames up to and including N(R)-1 are acknowledged as correctly received. The exception condition initiated with REJ is finished if all expected I-frames are received.

I-frames awaiting transmission shall be transmitted following the retransmitted I-frame(s). Only one REJ frame may be activated in each transmission direction at one time.

The I-frame requested, not necessarily consecutive, is indicated in an 8 bit sub-field by a bit mapping method. The 8 bit sub-field IMAP is within the REJ PARAMETER field as illustrated in figure 24.

Bit-no.	17...24	25.................48
	IMAP	reserved
Length	8	24

NOTE: IMAP: I-frame bit-map field

Figure 24: PARAMETER field for REJ

All bits at IMAP set to 1 indicate a reject request of all I-frames transmitted before starting with N(R). Otherwise, only the selected I-frames between the range N(R) to N(R)+K (this is a maximum of 7) marked by its bits of the sub-field set to 1, are requested.

Bit 0 (MSB) at IMAP corresponds to the I-frame having N(S) equal to N(R) of the REJ frame. The next bit corresponds to N(S)+1, etc. All bits not used for selection shall be set to 0.

10.5.4 Selective reject (SREJ) command/response

The S-frame SREJ is used for commands and responses. With SREJ a retransmission of specified data codewords from a single I-frame with the sequence number N(R) is requested. The P/F bit of an SREJ frame is always set to 0 and the N(R) of the SREJ frame does not acknowledge any I-frame. An SREJ exception condition is cleared upon receipt of parts of the requested I-frame (i.e. requested codewords) with N(S) equal to the N(R) of the SREJ frame.

I-frames that may have been transmitted following the I-frame, requested by SREJ, shall not be retransmitted. I-frames awaiting transmission shall be transmitted following the retransmission of the requested I-frame by the SREJ frame.

One or more SREJ exception conditions may be active at a given time, each SREJ frame containing a different N(R).

The PARAMETER field of the SREJ control block is used to identify selected codewords from the frame which requires retransmission.

The PARAMETER field in the SREJ frame control block as illustrated in figure 25, identifies the required codewords using a bit mapping method.

Bit-no.	17.........................48
	CMAP
Length	32

NOTE: CMAP: Codeword bit-map field

Figure 25: PARAMETER field for SREJ

The bits 17 to 48 (CMAP) of the PARAMETER field, and if needed an extra control block, shall be used to specify which codewords from the frame need to be retransmitted.

The bits 17 to 48 of the first control block (from left to right) shall be used to designate data codewords 1 to 32 of the I-frame, and the bits 1 to 32 of the extra control block (from left to right) shall be used to designate data codewords 33 to 64 of the I-frame, where data codeword 1 is defined as the data codeword directly following the control codeword. The remaining bits of the extra control block are reserved for future definition.

If a data codeword needs to be retransmitted, then the bit corresponding to that codeword position shall be set to 1, all bits not used for selection shall be set to 0.

If the maximum number of data codewords N1 is less or equal to 32, the extra control codeword is not used.

10.6 U-frames

U-frames can either be commands or responses. They are used for the general control of a connection. U-frames do not contain sequence numbers.

10.6.1 Set Asynchronous Balanced Mode (SABM) command

The command SABM requests the addressed station to begin the data transfer phase (ABM - Asynchronous Balanced Mode). An individually addressed SABM command shall be acknowledged using a UA or DM response at the earliest possible opportunity. When a SABM command is accepted, V(R), V(S), and V(A) shall be set to zero. I-frames transmitted before, but not acknowledged, remain without acknowledgement and are discarded.

The observation of a data loss, as well as an error treatment for this loss, is the responsibility of a higher layer protocol.

10.6.2 Disconnect (DISC) command

The command DISC terminates the existing data transfer and sets the co-ordinating control and the sequential control in an independent waiting status (ADM - Asynchronous Disconnected Mode), where no I-frames can be transmitted or received. Receipt of the DISC command cancels the operating mode. In the case of an individually addressed command, the mode is cancelled after acknowledgement of its reception using the response UA. After transmitting a DISC command, the station sets itself to the disconnected state (after receipt of the response UA where applicable). I-frames transmitted before but not acknowledged remain without acknowledgement and are discarded.

The observation of a data loss as well as an error treatment for this loss is the responsibility of a higher layer protocol.

10.6.3 Un-numbered Acknowledgement (UA) response

The response UA is used to accept individually-addressed commands (SABM, SGM, DISC). The received command is executed after the UA is transmitted. The UA response indicates that a not-ready-to-receive state is cleared if it was reported before with an RNR frame.

10.6.4 Frame reject (FRMR) response

The response FRMR shall be used by a station to report that one of the following conditions, which is not correctable by retransmission of an identical frame, resulted from receipt of a frame with no CRC error:

a) the receipt of a command or response that is undefined or not implemented;

b) the receipt of an I-frame with a data length in excess of the maximum data length which can be accommodated by the station;

c) the receipt of an invalid N(R) from the station, i.e. an N(R) which identifies an I-frame which has previously been transmitted and acknowledged or an I-frame which has not been transmitted and is not the next sequential I-frame awaiting transmission; or,

d) the receipt of a frame containing an information field when no information field is permitted by the associated control field.

For the FRMR response, the 32 bit PARAMETER field of the control codeword is defined as given in figure 26.

Bit-no.	17.......24	25	26..28	29	30..32	33	34	35	36	37......48
	REJ-CONTROL	0	N(S)	C/R	N(R)	w	x	y	z	reserved
Length	8	1	3	1	3	1	1	1	1	12

Figure 26: PARAMETER field for FRMR

The function of these fields shall be as follows:

a) the REJ-CONTROL field shall be the control field of the received frame which caused the FRMR response;

b) N(S) shall be the current value of the send state variable at the station;

c) C/R shall indicate whether the frame which caused the FRMR response was a command (C/R = 1) or a response (C/R = 0);

d) N(R) shall be the current value of the receive state variable at the station;

e) w set to 1 shall indicate that the REJ-CONTROL field was undefined or not implemented;

f) x set to 1 shall indicate that the REJ-CONTROL field was considered invalid because the frame contained an information field which is not permitted with this command or response. bit w shall be set to 1 in conjunction with this bit;

g) y set to 1 shall indicate that the data length received exceeded the maximum data length which can be accommodated by the station;

h) z set to 1 shall indicate that the REJ-CONTROL contained an invalid N(R).

10.6.5 Disconnected Mode (DM) response

The response DM is used to inform a calling station that the required called station is in the disconnected state (asynchronous disconnected mode) and remains there if that station cannot perform the call request.

10.6.6 Un-numbered Information (UI) command

A UI frame shall be used to transfer un-numbered information to one or more stations without affecting the internal state variables V(S), V(R) and V(A) at the station(s). There is no defined response to a UI command and the information transferred is not verified by sequence numbering. The poll bit of an UI frame is set to zero. The UI frame may be sent at any time and any data link mode. The number of information bits is defined with the fields NDW and NLB as described in subclause 10.4.

UI frames may be used for group data calls or broadcast data calls with no acknowledgement.

The PARAMETER field for the UI frame is used as given in figure 27.

Bit-no.	17..22	23..28	29....36	37................48
	NDW	NLB	NX	reserved
Length	6	6	8	12

NOTE: NX: An eight bit sequence number

Figure 27: PARAMETER field for UI

It is strongly recommended that a signalling cycle is used to permit receiving stations to assemble a complete message even when errors are received in some data codewords.

NX shall remain the same for each repeat of the same message during a signalling cycle. NX shall, however, be incremented before transmission of each new message. Use of NX ensures that repeat messages are recognized as such even if address or control codewords from some repeat messages in the signalling cycle are corrupted.

10.6.7 Set Group Mode (SGM) command

A Group Mode (GM) is provided in order to allow information to be transferred to several stations simultaneously. It is expected that the amount of information broadcasted will be limited and therefore the procedure is designed to allow the transfer of a maximum of 8 packets of data per transfer (8 times 3 072 bits maximum). The acknowledgements used in this procedure are handled individually by the different stations, ensuring the same security as in point-to-point asynchronous balanced mode.

The SGM (Set Group Mode) command requests the addressed station to begin the data transfer phase (GM). An individually addressed SGM command shall be acknowledged using a UA or DM response at the earliest possible opportunity. When this command is received, the receive state variable V(R), the send state variable V(S) and the acknowledge variable V(A) shall be set to zero.

The PARAMETER field of the SGM includes a twelve bit sub-field, NMG which is used to specify the number of members in the group to whom data is to be transferred. If this facility is not used, the bits of the sub-field NMG shall be set to zero. The PARAMETER field for the SGM frame is shown in figure 28.

Bit-no.	17...28	29........................48
	NMG	reserved
Length	12	20

NOTE: NMG: Number of members of the group

Figure 28: PARAMETER field for SGM

The parameter NMG is sent for timing purposes only, and therefore need not be set with great accuracy.

The group mode uses the normal commands and responses defined in the protocol, but is initialized using SGM instead of SABM.

The SREJ frame is not used in this mode for the rejection of selected codewords within an I-frame: only complete I-frames shall be repeated.

10.7 Data compression

If data compression is switched on, then the following information in the data blocks is compressed according to the Radix-40 procedure. Three characters out of a subset comprising 40 characters of the International Alphabet No.5 (IA5), see ITU-T Recommendation T.50 [4] set can be packed and analysed into two bytes with the Radix-40 data compression method. With the maximum possible I-frame length of 384 bytes (64 data codewords), 576 IA5 characters can be transmitted.

The Radix-40 characters have the hexadecimal values 00_H to 27_H which correspond to decimal 0 to 39. A Radix-40 word is formed using the following formula:

$$r = [(i \times 28_H + j) \times 28_H + k]$$

where i, j and k are the value of the required characters. The maximum value that a Radix-40 word can reach is:

$$rmax = [(27_H \times 28_H + 27_H) \times 28_H + 27_H] = F9FF_H$$

The 16-bit values $FA00_H$ to $FFFF_H$ may be used for single special control characters. If these values are used for the IA5 control characters 00_H to $1F_H$, these characters may be represented by the values $FA00_H$ to $FA1F_H$.

The analysis is effected by division. The remainder when the Radix-40 word is divided by 28_H yields the value of k. The result of this division is again divided by 28_H and delivers j as the remainder with i as the result.

$$r/28_H = q \quad ; \quad k = r - q \times 28_H$$

$$[q/28_H] = i \quad ; \quad j = q - i \times 28_H$$

Two character sets are available:

1) character set 1 contains the capital letters A-Z, the figures 0-9, space, the IA5 control character CR (Carriage Return), the control character NULL and the control character SO (Shift-Out);

2) character set 2 contains the special characters of columns 2, 3 and 5 of the IA5 code, the figures 0-9, space, the IA5 control character CR (Carriage Return), the control character NULL and the control character SI (Shift-In).

The control characters SO and SI are used to select the character sets. A character set is activated for the formation/analysis of the data until SO or SI switches over to the other character set. Character set 1 is the default character set which is switched on at the beginning of the compression/decompression.

The Radix-40 character sets and a table to form and analyse the Radix-40 words are given in annex C.

Different forms of data compression can be used. Other compression techniques are system specific.

If the compression technique defined here is in use, then the compression bit C in the I-frame control block shall be set to 1. Otherwise this bit shall be set to 0.

11 Definition of the data transfer protocol

A data transaction can be divided into the following phases:

- data link set-up: initiation of a data link by the command SABM;
- data transfer: exchange of data and control frames;
- resetting: re-initiation of the data link in case of uncorrectable errors;
- data link termination: termination of a data link by the disconnect command.

If a station receives a frame with faulty block protection on the control block, the frame is discarded and ignored.

Examples of the procedures described in this clause are given in annex H.

11.1 Data link set-up phase

11.1.1 Point-to-point link set-up

A station wishing to activate a data link shall transmit an SABM command. Then an internal time control T1 shall be started (T1 is a system parameter) and all existing exception conditions shall be cleared. For balanced mode operation, any station may initiate a link set-up. Once the initiative has been taken, the initiating (or calling) station becomes the co-ordinating control for that particular data link.

If a station receives an SABM command and accepts the establishment of the data link, it shall transmit a UA response with the F bit set to the value of the P bit in the received SABM command. Then the variables V(R), V(S) and V(A) shall be set to zero and all exception conditions shall be cleared. This station (the called station) is now ready to receive and transmit I- and S-frames as the sequential control for this particular data link.

If the co-ordinating control receives a UA response while T1 is still running after having transmitted an individually addressed SABM command, it shall reset its variables V(S), V(R) and V(A) to zero and stop timer T1. This station is now ready to transmit and receive I-frames and S-frames for this particular data link.

If a station does not accept the establishment of a data link, it shall transmit a DM response with the F bit set to the P bit of the received SABM command.

If the co-ordinating control receives a DM response while T1 is still running, then the set-up phase is terminated and the station remains in the disconnected state and stop timer T1.

If the time control T1 expires before reception of a UA or DM response, the co-ordinating control shall retransmit its SABM command and restart its internal time control T1. This procedure may be repeated as necessary up to N2 times, where N2 is a system parameter. After N2 failed attempts at link set-up the station returns to disconnected mode.

11.1.2 Group link set-up

The group mode data link set-up phase is based on the point-to-point data link set-up phase and uses the SGM frame. The SGM frame is addressed to each station of the group using its individual address.

Reception of the SGM frame shall initiate the internal variables of the addressed station in the same manner as an SABM would do.

If a station receives an SGM command and accepts the establishment of the data link, it shall transmit a UA response with the F bit set to the value of the P bit in the received SGM command. Then the variables V(R), V(S) and V(A) shall be set to zero and all exception conditions shall be cleared. This station (the called station) is now ready to receive I-frames as a member of the called group.

11.2 Data transfer phase

The following protocol for the transfer of I-frames is valid for data transfer in either direction over an established point-to-point data link, or for transfer of a restricted amount of data in one direction only (from the co-ordinating control) over a group data link.

11.2.1 Transmission of I-frames

11.2.1.1 Transmission of I-frames on a point-to-point connection

A station is permitted to transmit I-frames when the remote station is ready to receive.

An I-frame which has not previously been transmitted shall, on transmission, be allocated with an N(S) corresponding to the value of V(S) and N(R) corresponding to the value of V(R). The value of V(S) shall be increased by 1, and the time control T1 shall be (re)started.

The transmission of I-frames shall be stopped when V(S) is equal to V(A) plus K (where K is the highest number of unacknowledged I-frames permitted), unless the transmitting station is requested to repeat by SREJ or REJ.

11.2.1.2 Transmission of I-frames on a group connection

During this phase, I-frames are sent using similar rules as for a point-to-point data transfer, except that the group address is used and no immediate responses are expected. The P bit shall be set to 0 for every I-frame transmitted to indicate that no responses are expected during this phase.

A maximum of K I-frames can be transmitted during this phase (where K is the highest number of unacknowledged I-frames permitted), however, this maximum number may be further reduced due to limitations of a particular system.

11.2.2 Reception confirmation

11.2.2.1 Point-to-point reception confirmation

On receipt of an I- or RR, RNR, or REJ supervisory frame from the remote station, the value of N(R) shall be analysed and considered as positive acknowledgement for all outstanding I-frames with an N(S) up to and including the received N(R) - 1. V(A) shall be set to N(R).

If an I-frame or RR, RNR, or REJ frame with N(R) equal to V(S) (acknowledging all outstanding I-frames) is received, the internal time control T1 shall be stopped.

If an I-frame or RR, RNR, or REJ frame with N(R) higher than V(A) and lower than V(S) (acknowledging some outstanding I-frames) is received, the internal time control T1 shall be restarted.

On receipt of a REJ response, V(S) and V(A) shall be set to the value of N(R) contained in the REJ response and all outstanding I-frames transmitted shall be repeated.

On receipt of an SREJ response, the I-frame marked by N(R) in the control field of the response, or selected codewords of this I-frame, shall be transmitted or repeated at the first available opportunity. No information about any other outstanding I-frames is gained from this response.

When repeating just selected codewords, the requested codewords shall be placed in sequential order relating to their positions in the original packet. The value of N(S) shall be set to the same value as for the original transmission. However, the parameters NDW and NLB shall be set so that they indicate the actual length of this packet of repeated codewords.

If an SREJ or REJ command with P bit set to 1 is received, then an RR or RNR response with F bit set to 1 shall be transmitted first, followed by the repeated I-frames.

If, during duplex operation an SREJ or REJ command is received during the transmission of an I-frame, S-frame or U-frame, the active message shall be completed first, and then the required I-frames shall be transmitted.

On receipt of an RNR command or response, the station shall not send any further I-frames until the not-ready-to-receive state is cancelled. If it was an RNR command with P bit set to 1, then an RR or RNR response with F bit set to 1 shall be transmitted.

If a station receives a UA or an I-frames or S-frame with N(R) higher than the last received N(R), an internal repeat counter shall be set to zero.

If this repeat counter reaches the value of the maximum permitted number of transmissions, given by system parameter N2, a reset procedure shall be initiated (see subclause 11.3).

11.2.2.2 Group reception confirmation

During this phase, the station which has initiated the group transfer shall send an RR command with P bit set to 1 to each member of the group, using that member's individual address, in order to force a response.

If an S-frame is received from the remote station in which N(R) does not acknowledge all outstanding I-frames, retransmission has to be made. If a REJ frame is received, all I-frames from N(R) inclusive shall be retransmitted. If an SREJ frame is received, only the complete information frame identified by N(R) is repeated.

The repeated I-frames shall be addressed to the group address, even though the repetitions are requested on an individual basis.

Any member of the called group can utilize the retransmitted I-frames to reconstruct the data if needed.

11.2.3 Checkpointing

Checkpointing is initiated by the transmission of an I-frame or RR command, RNR command, or REJ command with P set to 1. The value of N(R) in the response to this command indicates which of the outstanding sequence of I-frames need to be repeated. Time control T1 shall be restarted on transmission of this command.

If during the time control a response with F bit set to 1 and a valid N(R) is received, then time control T1 shall be stopped.

If an RR command, RNR command, or REJ command with valid N(R) is received, the co-ordinating control shall not stop the time control but shall consider all I-frames up to the sequence number N(R)-1 as acknowledged. After the time control has expired, the repeat counter is incremented and a RR command, RNR command, or REJ command shall be repeated with the P bit set to 1.

11.2.4 Recovery by time control

11.2.4.1 Point-to-point time control

If a remote station has not received or cancelled the last I-frame(s) of a sequence, it can not discover the error and can not request repetition using SREJ or REJ. If a station has unacknowledged I-frames when its internal time control T1 expires, then it shall use checkpointing to discover which I-frames, if any, need to be repeated.

11.2.4.2 Group time control

The co-ordinating control shall follow the time control mechanism as defined in the point-to-point data link, using timer T1.

The recipients of a group mode data transmission shall employ a timer T3 which is reset on receipt of a transmission addressed to either their individual or group address. This timer is system specific and may depend on the number of members in the group.

T3 may be determined on a call specific basis by utilizing the value of the NMG field as detailed in subclause 10.6.7.

On expiry of timer T3, the station shall revert to the ADM without making any further transmissions.

11.2.5 Reception of I-frames

11.2.5.1 Ready-to-receive state

If an addressed station is ready to receive and receives a correct I-frame with N(S) corresponding to the value of its V(R), it shall accept the information contained in the I-frame and increase its V(R) by 1.

In an individual data link, the I-frame shall be acknowledged by an I-frame available for transmission, if the P bit of the received I-frame was set to 0. If no I-frame is available for transmission or the P bit of the received I-frame was set to 1, an RR response with the F bit set to the P bit of the received I-frame shall be transmitted. N(R) in the acknowledgement shall be set to the current value of the V(R).

If the addressed station is ready to receive and receives a correct I-frame with N(S) which does not correspond to the value of its V(R), it shall accept the information contained in the I-frame and store it intermediately. It shall not increase the value of its V(R). Any intermediately stored I-frames shall be added to the updated value of V(R) when the expected frame is received.

In an individual data link, the I-frame shall be acknowledged by an SREJ response with the F bit not set to 0. N(R) in this acknowledgement shall be set to correspond to the current value of V(R).

11.2.5.2 Not-ready-to-receive state

If a station is experiencing difficulties which cause it to be unable, temporarily, to receive further data, then it enters the not-ready-to-receive state. In an individual data link it shall transmit an RNR frame at the next occasion and then shall pass over to the not-ready-to-receive state. While operating in this state, received RR, RNR, or REJ frames shall be processed after updating of V(A). All received I-frames shall be discarded, after updating of V(A). If an I- or RR, RNR, or REJ frame with the P bit set to 1 is received, an RNR response with the F bit set to 1 shall be transmitted.

In order to leave the not-ready-to-receive state, a station in an individual data link shall transmit an RR or REJ frame with N(R) set to the value of its V(R) or an SREJ frame.

11.3 Resetting phase

The reset procedure is used in the data transfer to reset the internal variables at both stations and to re-start the transfer in case of uncorrectable errors.

The reset procedure is initiated by the transmission of an SABM command, if during the data transfer a DM response has been received. The station receiving an SABM command shall transmit a UA response and sets its V(S), V(R), and V(A) to zero. At the same time an active not-ready-to-receive state is terminated, unless an RNR frame is transmitted at the earliest opportunity after the UA response.

If during the phase of the data transfer a station receives a UA response or a response with the F bit set, although no command with the P bit set was transmitted, the remote station can be requested to reset by transmitting a DM response. The station transmitting DM passes directly over to the disconnected state.

11.4 Transfer termination phase

11.4.1 Point-to-point link termination

If a station wants to terminate the data transfer, it transmits a DISC command and starts its internal time control T1.

On receipt of a DISC command an individually addressed station transmits a UA response and then passes over to the disconnected state (ADM - Asynchronous Disconnected Mode).

If the time control T1 expires and no UA response has been received from an individually addressed station, a DISC command is transmitted again and the time control T1 is restarted. After having transmitted the DISC command N2 times the station passes over to the disconnected state.

If an individually addressed station is in the disconnected state when it receives a DISC command, then it responds with a DM response. If the station receives another command with P bit set, it sends a DM response with the F bit set to 1. All other commands and responses are ignored.

If a station in an individual link passes over to the disconnected state after an error condition, it transmits a DM response instead of a DISC command and starts the time control T1. If the time control expires before an SABM or DISC command has been received, the DM response is retransmitted and the time control T1 is restarted. After having transmitted the DM response N2 times the station remains in the disconnected state.

11.4.2 Group link termination

In a group link, only the co-ordinating control station (calling party) is permitted to initiate the clear-down transmissions (DISC command).

Termination of a group mode transfer is performed using the individual addresses, as described in the point-to-point termination procedure specified in subclause 11.4.1.

On completion of the termination procedure, each station reverts to the Asynchronous Disconnected Mode (ADM).

Any of the called units in a group link may leave the link and automatically revert to the disconnected state at any stage during the established link. These units shall not transmit any clear-down signalling.

A station which is addressed as a member of a group shall enter the disconnected state without transmitting a response to the DISC command.

If a group-addressed station receives a DISC command while in the disconnected state, it shall ignore the command.

12 Channel access protocol and occupation rules for data transmission

If not otherwise defined below, the channel access and occupation rules defined in clause 9 shall be used.

12.1 Channel access for data transmission

The maximum time interval during which a station may access the channel for ongoing data packet transmissions is called TT. To ensure that only the initiating station shall monitor the time interval, acknowledgements and replies may exceed the time interval TT by the time dTT respecting the reversion time TRV. After expiry of the time interval TT the initiating station shall release the channel and start the observation time TO before the next transmission.

TT and dTT are system parameters.

12.2 Retry procedure

Instead of TW, defined in clause 9, the time T1 is used.

T1 is the time control after whose expiry a repetition of a frame is initiated. The time control should be started after a transmission. The time T1 is the sum of the fixed part T1F and the random part $n \times T1I$:

$$T1 = T1F + n \times T1I$$

The fixed time T1F and the increment time T1I are system dependent times. T1F may be zero. The number n is a random number in the range 0,1,2, or 3; this means that 0,1,2, or 3 is the event field of the random number n. The random number n shall be determined by use of a random generator with a uniform distribution.

Instead of TAC, the time TAD is used. TAD is the time waiting for a response after whose expiry a repetition of the transmitted frame is initiated according to the channel access rules defined in clause 9.

Annex A (normative): Values of system parameters

The ranges, step sizes, and the suggested values of some parameters for the call and data dialogue procedures may be selected from table A.1 or table A.2. They have to be identical for all units within one network. Parameters not included in the tables below are system specific.

Table A.1: Call parameters

Parameter	Range	Step size	Suggested value
ND	1 - 16		4
TAC	0,1 - 0,5 s	10 ms	200 ms
TOF	0 - 500 ms	10 ms	200 ms
TOI	5 - 50 ms	5 ms	15 ms
TWF	0 - 500 ms	10 ms	50 ms
TWI	5 - 50 ms	5 ms	15 ms
TRV	1 - 50 ms	1 ms	system-specific
TS1	5 - 20 s	1 s	10 s
TS2	5 - 20 s	1 s	10 s
TS3	0 - 1 s	100 ms	500 ms

Table A.2: Data dialogue parameters

Parameter	Range	Step size	Suggested value
N1	1 - 64	1	system-specific
N2	1 - 8	1	5
K	1 - 7	1	7
T1F	0 - 500 ms	10 ms	50 ms
T1I	5 - 50 ms	5 ms	15 ms
TT	1 - 60 s	1 s	30 s
dTT	0,1 - 1 s	100 ms	500 ms

Annex B (normative): The Radix 40 data compression method

The Radix 40 character set 1 given in table B.1, shall be used for composing and analysing the Radix 40 values. The character set 2 is switched on with SO ($0E_H$).

Table B.1: Radix 40 character set 1

IA5 character	Hexadecimal equivalent	Hexadecimal Radix 40 values for		
		1. character	2. character	3. character
CR	0D	0000	0000	0000
SO	0E	0640	0028	0001
NULL	00	0C80	0050	0002
SPACE	20	12C0	0078	0003
0	30	1900	00A0	0004
1	31	1F40	00C8	0005
2	32	2580	00F0	0006
3	33	2BC0	0118	0007
4	34	3200	0140	0008
5	35	3840	0168	0009
6	36	3E80	0190	000A
7	37	44C0	01B8	000B
8	38	4B00	01E0	000C
9	39	5140	0208	000D
A	41	5780	0230	000E
B	42	5DC0	0258	000F
C	43	6400	0280	0010
D	44	6A40	02A8	0011
E	45	7080	02D0	0012
F	46	76C0	02F8	0013
G	47	7D00	0320	0014
H	48	8340	0348	0015
I	49	8980	0370	0016
J	4A	8FC0	0398	0017
K	4B	9600	03C0	0018
L	4C	9C40	03E8	0019
M	4D	A280	0410	001A
N	4E	A8C0	0438	001B
O	4F	AF00	0460	001C
P	50	B540	0488	001D
Q	51	BB80	04B0	001E
R	52	C1C0	04D8	001F
S	53	C800	0500	0020
T	54	CE40	0528	0021
U	55	D480	0550	0022
V	56	DAC0	0578	0023
W	57	E100	05A0	0024
X	58	E740	05C8	0025
Y	59	ED80	05F0	0026
Z	5A	F3C0	0618	0027

The Radix 40 character set 2 given in table B.2, shall be used for composing and analysing the Radix 40 values. The character set 1 is switched on with SI ($0F_H$).

Table B.2: Radix 40 character set 2

IA5 character	Hexadecimal equivalent	Hexadecimal Radix 40 values for		
		1. character	2. character	3. character
CR	0D	0000	0000	0000
SI	0F	0640	0028	0001
NULL	00	0C80	0050	0002
SPACE	20	12C0	0078	0003
0	30	1900	00A0	0004
1	31	1F40	00C8	0005
2	32	2580	00F0	0006
3	33	2BC0	0118	0007
4	34	3200	0140	0008
5	35	3840	0168	0009
6	36	3E80	0190	000A
7	37	44C0	01B8	000B
8	38	4B00	01E0	000C
9	39	5140	0208	000D
!	21	5780	0230	000E
"	22	5DC0	0258	000F
#	23	6400	0280	0010
$ (note)	24	6A40	02A8	0011
%	25	7080	02D0	0012
&	26	76C0	02F8	0013
'	27	7D00	0320	0014
(	28	8340	0348	0015
)	29	8980	0370	0016
*	2A	8FC0	0398	0017
+	2B	9600	03C0	0018
,	2C	9C40	03E8	0019
-	2D	A280	0410	001A
.	2E	A8C0	0438	001B
/	2F	AF00	0460	001C
:	3A	B540	0488	001D
;	3B	BB80	04B0	001E
<	3C	C1C0	04D8	001F
=	3D	C800	0500	0020
>	3E	CE40	0528	0021
?	3F	D480	0550	0022
[	5B	DAC0	0578	0023
\	5C	E100	05A0	0024
]	5D	E740	05C8	0025
^	5E	ED80	05F0	0026
_	5F	F3C0	0618	0027
NOTE:	This character may be replaced by a national currency symbol.			

A 16-bit Radix 40 word is formed from 3 characters of the Radix 40 character set by adding table entries (first to third character).

EXAMPLE 1: Character string E F S

E = 7080	value from column "1. character"
+ F = 02F8	value from column "2. character"
+ S = 0020	value from column "3. character"

7398	the Radix 40 word representing the string EFS

The analysis is effected by subtracting the respectively higher table value (first to third character).

EXAMPLE 2: Radix 40 word 7 398_H

7 398	
- E = 7 080	value from column "1. character"
------------------	smaller than 7 398
0 318	
- F = 02F8	value from column "2. character"
------------------	smaller than 0 318
S = 0 020	value from column "3. character"

The MSB of the 16 bit value is transmitted first.

Within a codeword, the 16 bit value representing the first 3 characters of a character string shall be transmitted first.

Annex C (normative): Hexadecimal digit coding

For hexadecimal digit coding in this ETS, the representations given in table C.1 shall always be used.

Table C.1: Hexadecimal digit coding

Hexadecimal representation	Binary representation	Character representation
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
A	1010	reserved
B	1011	*
C	1100	#
D	1101	reserved
E	1110	reserved
F	1111	NULL

The first bit of the binary representation (MSB) in the table C.1 shall be transmitted first.

Annex D (normative): Regional Code

The 6 bit Regional Code (RC) is coded with a 6 bit national code allocated as given in table D.1. All other codes not defined below are reserved.

The codes found in this table have been allocated so that the codes corresponding to countries close to each other are separated by a large Hamming distance (many bits are different).

Table D.1: Regional Codes

Code	Symbol	Country
000000	---	Others
000001	SCV	Vatican (City)
000010	P	Portugal
000011	CZ	Czech Republic
	SK	Slovak Republic, (note 2)
000100	CY	Cyprus
000101	CH	Switzerland
000110	BG	Bulgaria
	H	Hungary, (note 2)
	ROM	Romania, (note 2)
000111	GR	Greece
001000	DK	Denmark
001001	GB	United Kingdom
001010	I	Italy
001011	SF	Finland
001100	B	Belgium
001101	N	Norway
001110	AND	Andorra
	FR	Faroe Islands, (note 2)
001111	D	Germany
010000	F	France
010001	NL	Netherlands
010010	S	Sweden
010011	---	Russia and IET
010100	YU	Yugoslavia
010101	PL	Poland
010110	SMR	San Marino
	---	Baltic Republics, (note 2)
010111	E	Spain
011000	IS	Iceland
011001	A	Austria
011010	FL	Liechtenstein
011011	L	Luxembourg
011100	TR	Turkey
011101	M	Malta
	SLO	Slovenia, (note 2)
	CRO	Croatia, (note 2)
011110	IRL	Ireland
011111	MC	Monaco

NOTE 1: In the allocation some codes are missing due to recent developments in Europe. This table will be completed when possible in the future.

NOTE 2: Two or more countries can use the same RC code in which case the differentiation can be made using the COM field. The code used for this country shall be the code above in the table e.g., Czech Republic and Slovak Republic share the same RC.

NOTE 3: When mobiles from two or more countries are not expected to interfere with each other, then these countries can use the same RC code.

The first bit in the code (MSB) in table D.1 shall be transmitted first.

Annex E (normative): OMC coding

The OMC coding, structured in a 3 bit category field (CAT) and a 3 bit function field (FNC) is represented as a category-function matrix. For detailed definitions see subclause 7.2.

Table E.1: OMC coding

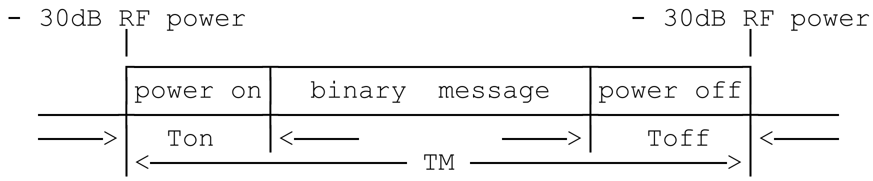
CAT	0	1	2	3	4	5	6	7
FNC	System	Calls	Acks	Special	Status	Status	Reserved	Custom
0	Emergency	Emergency	Emergency	System	Status	Status		
	Reset	Call	Ack	Control	1	9		
1	Cancel	Priority	Repeat	Short	.	.		
		Call	Ack	Data	.	.		
2	Clear	Normal	General	Dialogue	.	.		
	Down	Call	Ack	Data	.	.		
3	Maint	Telephone	Absent	Change	.	.		
	ID	Call	Unavail.	Channel	.	.		
4	TX Key	Broadcast	Busy	Vote	.	.		
	ON	Call	Ack	Now	.	.		
5	TX Key	Request	Call	Status	.	.		
	OFF	Call Back	Back Ack	Request	.	.		
6	Repeater	Manual	Interm.	Mobile	.	.		
	ON	Response	Ack	Enable	.	.		
7	Repeater	Extern	Reject	Mobile	Status	Status		
	OFF	Address	Ack	Disable	8	16		

Category 6 is reserved for future extension. Category 7 is spare for user specific functions not defined by this ETS.

Annex F (informative): Examples of channel access and occupation rules

The definition of the message duration should be in accordance with ETS 300 113 [3] and ETS 300 471 [6].

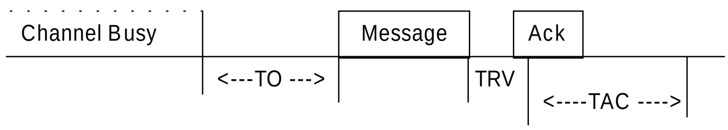
F.1 Message duration



NOTE: Ton and Toff are system parameters and should not be a significant proportion of the message duration. The message time TM is defined to start and to end at - 30dB of nominal RF power.

Figure F.1: Message duration

F.2 Successful transmission of a message

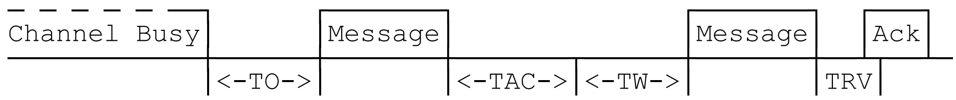


NOTE: The message starts after the observation time TO. The acknowledgement has to be sent within the acknowledgement time TAC.

Figure F.2: Message transmission

F.3 Unsuccessful transmission of a message and repetition

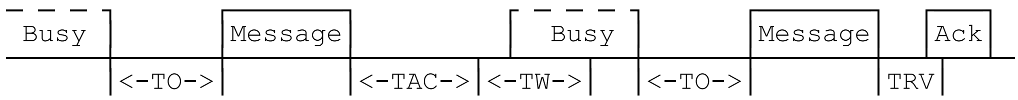
a) the channel is free during the waiting time TW:



NOTE: The message is initiated after the observation time T0. After expiry of the waiting time TW a repetition of the message is initiated. The retry has to be successfully acknowledged.

Figure F.3: Message repetition if the channel is free

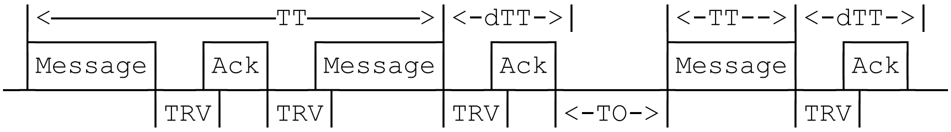
b) the channel becomes busy during the waiting time TW:



NOTE: The message is initiated after the observation time T0. During the waiting time TW the channel becomes busy. After the channel becomes free the observation time TO is started. After expiry of this time T0, a repetition of the message is initiated. The retry has to be successfully acknowledged.

Figure F.4: Message repetition after a busy channel

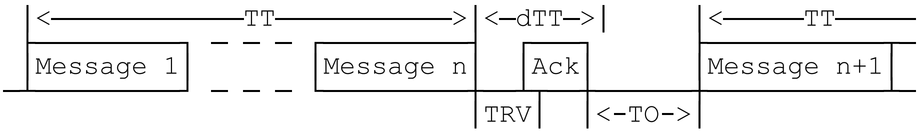
F.4 Channel access with time intervals



NOTE: A station accesses the channel and transmits two messages within the time interval TT. The distance between the transmissions should not exceed the reversion time TRV. The last message is acknowledged within the time dTT. After the observation time TO, the second time interval is started. This time interval is used for one message and is successfully acknowledged within dTT.

Figure F.5: Message time interval

F.5 Channel access for data transmission with time intervals



NOTE: A station accesses the channel and transmits several successive data packets within a time interval TT. The acknowledgement is sent within the time dTT. The second time interval is started after expiry of the observation time TO.

Figure F.6: Data transmission with time intervals

Annex G (informative): System-terminal interface

G.1 Interface for data terminal equipment

Data terminal equipment (computer, PC, printer, etc.) has to be connected via the widespread ITU-T Recommendation V.24 (RS232C) interface to a station. The signal level corresponds to the ITU-T Recommendation V.28. The station represents a Data Communication Equipment (DCE) and contains a receptacle. The base station should have either, a 25 poles submin D receptacle, or a 9 poles submin D receptacle with a reduced V.24 interface. The mobile station contains a device specific receptacle. For the assignment of a reduced interface, see table G.1. For other than submin D connectors, the assignment is device specific. Since the 9 poles interface does not contain any timing lines, it is only suited for asynchronous protocols.

Table G.1: Reduced V.24 interface

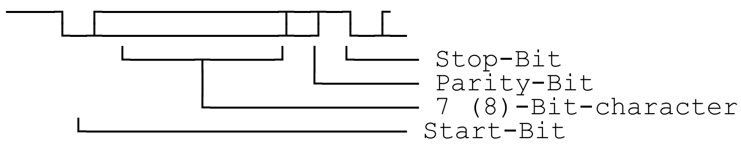
Definition	Assignment		Direction	Remarks
	9 poles	**25 poles**	**DTE DCE**	
Protective Ground	Screen	Screen+1	<--->	
Data Carrier Detect	1	8	<----	
Receive Data	2	3	<----	mandatory
Transmit Data	3	2	---->	mandatory
Data Terminal Ready	4	20	---->	
Signal Ground	5	7	<--->	mandatory
Data Set Ready	6	6	<----	
Request to Send	7	4	---->	
Clear to Send	8	5	<----	
Ring Indicator	9	22	<----	
Transmit Clock	-	15	<----	
Receive Clock	-	17	<----	
Transmit Clock	-	24	---->	

G.2 Procedure for the system-terminal interface

Data formats and procedures for asynchronous and synchronous DTE have to be implemented, so that different data terminal equipment with mobile stations or base stations are able to exchange data.

Two asynchronous and two synchronous procedures are defined. The asynchronous operation 1 and both synchronous operations with the parity bit definition corresponds to the ITU-T Recommendation V.25bis. The asynchronous operation 2 should be used alternatively for a STX-ETX procedure.

For asynchronous operation the data format given in figure G.1 can be used with 7 or 8 bit characters:



NOTE: If the protocol does not provide a data flow control and if no hardware control is made via the interface, the following XON-XOFF data flow procedure should be used:

Figure G.1: Asynchronous data format

XON: Transmit (Receive) DC1=11_H - (Remote) Terminal is ready;

XOFF: Transmit (Receive) DC3=13_H - (Remote) Terminal is busy.

G.2.1 Asynchronous procedure 1 (CR/LF)

For the asynchronous operation 1 the structure given in figure G.2 should be used:

OFF	Message	CR	LF	OFF

NOTE: In this operation 8-bit data format should be used for 7(8)-bit characters plus an even parity bit. The "new line" function may be used in a way other than CR/LF (system specific).

Figure G.2: Asynchronous CR/LF procedure

G.2.2 Asynchronous procedure 2 (STX/ETX)

For the asynchronous operation 2 the structure, given in figure G.3 should be used:

OFF	STX	Message	ETX	OFF

NOTE: In this operation 8-bit data format should be used for 7(8)-bit characters plus an even parity bit.

Figure G.3: Asynchronous STX/ETX procedure

G.2.3 Synchronous procedure 1 (STX/ETX)

For the synchronous character oriented operation, the structure shown in figure G.4 should be used:

	SYN	SYN	STX	Message	ETX	

NOTE: In this operation 8-bit data format should be used for 7(8)-bit characters plus an odd parity bit.

Figure G.4: Synchronous STX/ETX procedure

G.2.4 Synchronous procedure 2 (HDLC)

For the synchronous bit oriented operation, the structure shown in figure G.5 should be used:

	F	A	C	Message	FCS	F	

NOTE: The flag F, the address field A, the control field C, and the Frame Check Sequence (FCS), shall be used in accordance to HDLC.

Figure G.5: Synchronous HDLC procedure

Annex H (informative): Examples for the data dialogue procedure

H.1 Test algorithm for the validity of N(R)

A valid N(R) shall be in the range V(A)<=N(R)<=V(S) calculated by modulo 8 operation.

The test for the validation of N(R) may be carried out, using decimal arithmetic in the algorithm given in figure H.1.

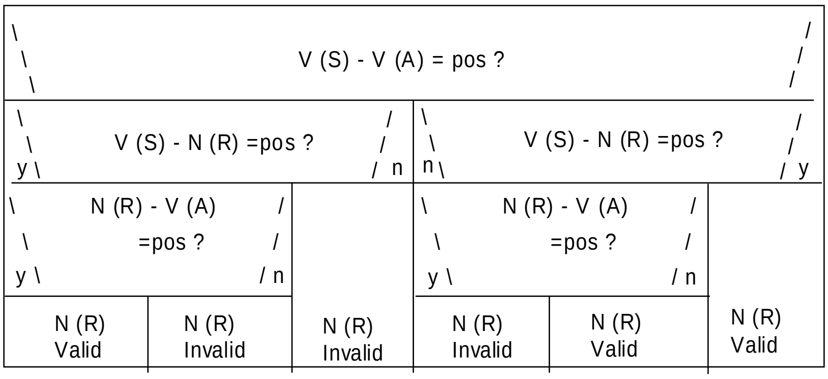


Figure H.1: Validity test algorithm

H.2 State transition table of the data dialogue procedure

The following description shows state transition tables of the asynchronous balanced mode. This annex is intended to assist the system designer with the protocol implementation, but other implementations are possible.

For the protocol definition, 7 different states are used. The protocol inputs which forces a reaction of a station are defined within tables H.1, H.2 and H.3. A reaction may be the transmission of a command or response, and/or alteration of parameters, and/or transition to another state.

A table element which includes the reactions is defined in figure H.2.

CRXR	*
nnn	S
CRXB	*

NOTE:
- CRXR: command or response X transmitted if the station is ready
- CRXB: command or response X transmitted if the station is busy
- *: indicates the poll or final bit
- nnn: parameters set/reset under different conditions
- S: indicates the next state

Figure H.2: Table entry definition

The poll or final bit position (*) may have the following entries:

- P poll bit set to 1
- F final bit set to 1
- = final bit set to poll bit (F=P)

(no entry) poll or final bit set to zero

The parameter field nnn may have the following entries:

- abc... parameters defined by letters
- Cn a specified condition defined by a number n

Different general parameters which can be set, reset, or altered, are defined below. Specific conditions are defined in conjunction with the state tables, tables H.1, H.2 and H.3.

Inputs which have to be ignored within a state are defined with an empty element.

Variables which are not defined at the procedure section (clause 10) are as follows:

RC	Repeat Counter
IC	I-frame Counter

The following parameter alterations are defined:

a	set timer T1
b	reset timer T1
c	RC = N2-1
d	RC = RC-1
e	IC = IC+1
f	IC = IC-1
g	V(R) = V(S) = V(A) = 0
h	V(S) = V(S)+1
j	V(R) = V(R)+1
k	V(A) = V(S) = N(R)
l	V(A) = N(R)
m	IC = IC+V(S) - N(R)

H.2.1 State table for miscellaneous inputs

The state table, table H.1 following, gives the reaction to inputs other than commands or responses.

The inputs are summarized as follows:

- DL-CON REQ data link connect request from higher level;
- DL-DIS REQ data link disconnect request from higher level;
- DL-RES REQ data link reset request from higher level;
- DL-DAT REQ data link data request from higher level;
- IC>0,DIFF<7 I-frame prior to transmission;
- T1 exp timer T1 expired;
- RC,T1 exp timer T1 and repeat counter RC expired;
- N(S) inv invalid send sequence number N(S);
- Frame inv an invalid frame with uncorrectable exception condition.

Table H.1: State table for miscellaneous inputs

	DL-CON REQ	DL-DIS REQ	DL-RES REQ	DL-DATR EQ	IC>0 DIFF<7	T1 exp	RC,T1 exp	N(S) inv	Frame inv
1 Disconnect State	SABM P ac 2								
2 Link Set-up						SABM P ad 2			
3 Information transfer		DISC P ac 6		e 3	I afh 3	RR P acl 7 RNR P	1	REJ =	FRMR ac 4
4 FRMR Send State		DISC P ac 6				FRMR ad 4			
5 FRMR Receive State		DISC P ac 6	SABM P ac 2				1		
6 Link Disconnect						DISCP ad 6	1		
7 Timer Recovery Condition		DISC P ac 6				RR P ad 7 RNR P	1	REJ = C2 7	FRMR ac 4

DIFF = V(S) - N(R)

Parameter alteration under different conditions:

- C1 parameter al, if N(R)<>V(S); parameter bl, if N(R) = V(S);
- C2 parameter l, if ready and in the timer recovery condition an update at N(R) is made.

H.2.2 State table for commands received

The state table, table H.2, gives the reactions to command frames received.

The inputs are defined as follows:

- xxx specified command xxx with P bit not set;
- xxx, P specified command xxx with P bit set to 1;
- xxx, either specified command xxx with either P bit set or not set.

Table H.2: State table for commands received

	I P	I	RR P	RR	REJ P	REJ	RNR P	RNR	SABM either	DISC either
1 Disconnect State	DM F 1		DM F 1		DM F 1		DM F 1		UA = bg 3	DM = 1
2 Link Set-up									UA= 2	DM= 2
3 Information transfer	RR F C4 3 RNR F	RR C4 3 RNR	RR F C1 3 RNR F	C1 3	RR F C1 3 RNR F	bkm 3	RR F acl 7 RNR F	RR P acl 7 RNR P	UA = bg 3	UA = b 1
4 FRMR Send State	FRMR F 4		FRMR F 4		FRMR F 4		FRMR F 4		UA = bg 3	UA = 1
5 FRMR Receive State									UA = 5	UA = 1
6 Link Disconnect									DM = 6	UA = 6
7 Timer Recovery Condition	RR F C5 7 RNR F	RR C5 7 RNR	RR F C2 7 RNR F	C3 7	RR F C2 7 RNR F	C3 7	RR F C2 7 RNR F	C3 7	UA = bg 3	UA = b 1

Parameter alteration under different conditions:

- C1 parameter bl, if N(R) = V(S); parameter al, if N(R)<>V(S);
- C2 parameter l, if in the timer recovery condition an update at N(R) is made;
- C3 parameter l, if ready and in the timer recovery condition an update at N(R) is made;
- C4 parameter bjl, if ready and N(R) = V(S); parameter ajl, if ready and N(R)<>V(S);
- C5 parameter j, if ready; parameter jl, if ready and in the timer recovery condition an update at N(R) is made.

H.2.3 State table for responses received

The state table, table H.3, gives the reactions to response frames received.

The inputs are defined as follows:

- xxx specified response xxx with F bit not set;
- xxx, F specified response xxx with F bit set to 1;
- xxx, either specified response xxx with either F bit set or not set.

Table H.3: State table for response received

	RR	RR	REJ	REJ	RNR	RNR	UA	UA	DM	DM	FRMR
	F		F		F		F		F		either
1Disconnect State										SABM P ac 2	
2 Link Set-up							bg 3		b 1	2	
3 Information transfer	C1 3	C1 3	bkm 3	bkm 3	RR P acl 7 RNR P	RR P acl 7 RNR P				SABM P ac 2	5
4 FRMR Send State											
5 FRMR Receive State											
6 Link Disconnect							b 1		b 1	6	
7 Timer Recovery Condition	C2 3	C3 7	bkm 3	C3 7	C4 7	C3 7			SABM P ac 2	SABM P ac 2	5

Parameter alteration under different conditions:

- C1 parameter bl, if N(R) = V(S); parameter al, if N(R)<>V(S);
- C2 parameter bl, if N(R) = V(S); parameter bmk, if N(R)<>V(S);
- C3 parameter l, if ready and in the timer recovery condition an update at N(R) is made;
- C4 parameter cl, if in the timer recovery condition an update at N(R) is made.

Annex J (informative): Verification of the integrity of the I-frames

The I-frames transmitted according to the protocol described in this ETS may be corrupted due to interference. The protocol provides means for the reconstruction of the original I-frame, by the receiving station. Such reconstruction may be achieved using a number of retransmissions of selected codewords of the I-frames.

In order to verify the integrity of the reconstructed I-frame, it is proposed to use the following mechanism, when the V bit is set:

a) for each packet to be sent in an I-frame a CRC is calculated using the 16 bit HDLC polynomial:

$$X^{16} + X^{12} + X^{5} + 1$$

providing the ICRC bits;

b) the ICRC bits are appended at the end of the information, in the same manner as the HDLC protocol, and transmitted in the same way as the information;

c) the values of the NDW and NLB shall be calculated after the ICRC bits have been appended;

d) upon reception and reconstruction, if needed, of the I-frame, the CRC is verified and the frame is rejected, if it is found to be incorrect.

The organization of the I-frame showing the position of the ICRC bits is given in figure J.1:

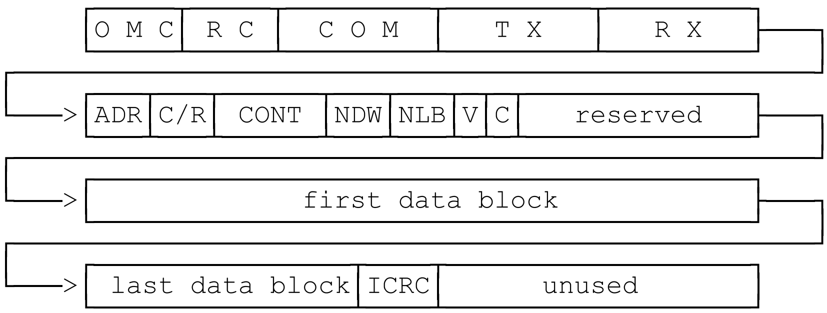


Figure J.1: I-frame integrity verification

Annex K (informative): Using forward error correction

This annex gives an example for encoding and decoding with a logic circuit using an (8,4) convolutional code defined by the following parity check matrix.

$$H = \begin{vmatrix} 01 \\ 1001 \\ 101001 \\ 00101001 \end{vmatrix}$$

NOTE: This code is able to correct any error packet of 2 bits every 8 bits.

Figure K.1: Parity check matrix

Encoding with a logic circuit is as follows:

- bits with odd indices X_{2i-1} are information bits; bits with even indices X_{2i} are redundancy bits. Therefore:

$$X_{2i} = X_{2i-3} + X_{2i-5}$$

The block diagram of an (8,4)-encoder is shown below. During the first half of the time where a bit is present at the input, these bits with odd indices (information) are sent out by 1; bits with even indices (redundancy) are sent out by 2 during the second half of this time.

At the beginning, the shift registers are filled with zeros, therefore:

$$X_2 = 0 + 0$$

$$X_4 = 0 + X_1$$

$$X_6 = X_1 + X_3$$

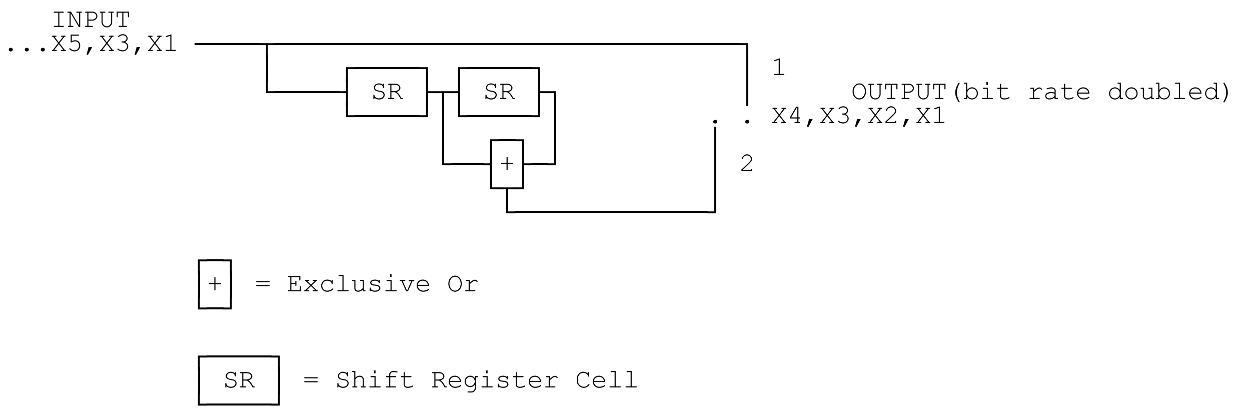


Figure K.2: Convolutional encoder

Decoding with a logic circuit is as follows:

the Block diagram of a decoder is given in figure K.2 following. bits with odd indices (information) are sent in 1 and bits with even indices (redundancy) in 2. At the beginning, the shift registers are filled with zeros. The syndrome S is read in S_0, S_1, S_2, S_3.

If E is the error vector (column) and H the parity check matrix:

$$S = H \times E$$

so that the jth column of H represents the syndrome corresponding to an error on X_j. To obtain the syndrome corresponding to many errors, it is sufficient to sum modulo 2 the corresponding columns of H. It can be seen that, in order to avoid overlapping of syndromes, the distance between 2 errors should be at least 8 (constraint length).

The logical circuit sends a correction (and resets the syndrome to zero) when we have:

$$S_1\ S_2\ S_3 = 1\ 1\ 0$$

At the end of a message, for correcting X_{2i-1}, last information bit, the bit X_{2i+4} is required, i.e.: 5 additional bits (3 redundancy bits plus 2 information bits) are lost.

Therefore for 64 information bits;

$$128 + 5 = 133$$

Bits shall be transmitted.

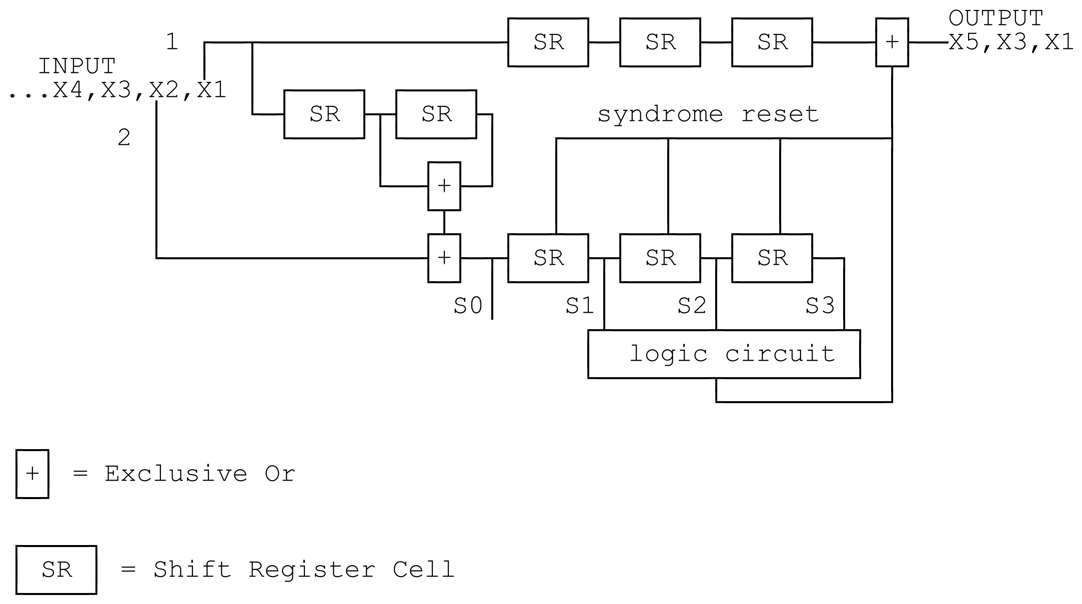


Figure K.3: Convolutional decoder

Annex L (informative): Examples of using the COM field

The 12 bit COM field may be divided into sub-fields which are defined nationally. The length of the sub-fields is system specific or defined nationally. Examples of using or defining the COM field are given in figures L.1, L.2, L.3 and L.4.

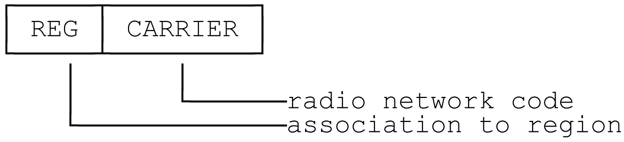


Figure L.1: Example 1 - region and carrier field

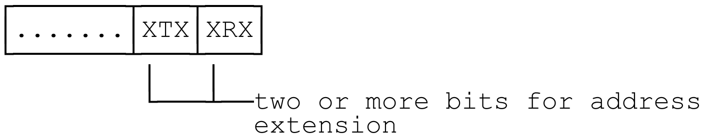


Figure L.2: Example 2 - expansion of individual address

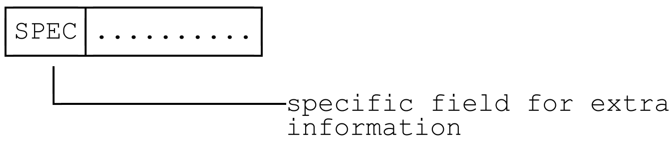


Figure L.3: Example 3 - extra information

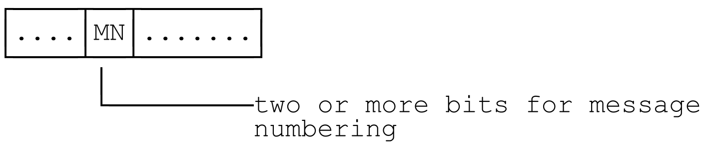


Figure L.4: Example 4 - message numbering

Annex M (informative): Bibliography

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- ISO 7809/Add.1: "Information processing systems - Data communication - High-level data link control procedures - Consolidation of classes of procedures, Addendum 1".

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