FINAL DRAFT
pr **ETS 300 133-4**

January 1997

Second Edition

EUROPEAN TELECOMMUNICATION STANDARD

Source: TC-RES

Reference: RE/RES-04007-4

ICS: 33.020

Key words: ERMES, paging, radio, air interface

Radio Equipment and Systems (RES); Enhanced Radio MEssage System (ERMES); Part 4: Air interface specification

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Foreword

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

This ETS comprises seven parts with the generic title "Radio Equipment and Systems (RES); Enhanced Radio MEssage System (ERMES)". The title of each part is listed below:

Part 1: "General aspects";

Part 2: "Service aspects";

Part 3: "Network aspects";

Part 4: "Air interface specification";

Part 5: "Receiver conformance specification";

Part 6: "Base station specification";

Part 7: "Operation and maintenance aspects".

This part, ETS 300 133-4, specifies the radio subsystem aspects including:

- the transmission protocol and its operation;
- modulation characteristics;
- channel coding;
- quasi-synchronous operation;
- receiver battery saving techniques.

NOTE: In this part of the ERMES ETS, some protocol bits have been "reserved for future definition". It is intended that these bits will be allocated for specific options in a future enhanced version of the standard.

Suggestions for potential enhancements to the protocol using these bits should be communicated via the normal ETS maintenance procedures to the ETSI Secretariat at the address given on the title page.

ETSI Interim Intellectual Property Rights (IPR) Policy

The attention of ETSI has been drawn to the Intellectual Property Rights (IPRs) listed below which are, or may be, or may become, essential to the present standard. The IPR owner has undertaken to grant irrevocable licences on fair, reasonable and non-discriminatory terms and conditions to these IPRs pursuant to the ETSI Interim IPR Policy. Further details pertaining to these IPRs can be obtained directly from the IPR owner.

The present information is accurate to the best of ETSI's knowledge. Pursuant to the ETSI Interim IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs, which are, or may be, or may become, essential to the present standard.

IPRs:

EP Patent No. 0090851: Decoder for Transmitted Message Activation Codes;

EP App. No. 89909668,9: Multiple Frequency Message System;

EP App. No. 89913131,2: Power Conservation Method and Apparatus for a Portion of Information Signal;

EP App. No. 92901376,1: Multiple Format Signalling Protocol for a Selective Call Receiver;

EP App. No. 90915018,7: Nationwide Paging with Local Modes of Operation;

EP App. No. 91904526,0: Multiple Frequency Scanning.

IPR owner:

MOTOROLA Ltd, 110 Bath Road, Slough, GB-BERKSHIRE SL1 3SZ.

Proposed transposition dates	
Date of latest announcement of this ETS (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this ETS (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	6 months after doa

1 Scope

This European Telecommunication Standard (ETS), describes the radio air interface specification of the Enhanced Radio Message System (ERMES). All aspects of the radio subsystem are defined including the transmission protocol, information format, channel coding and modulation characteristics. Operation of the radio subsystem and procedures on the air interface are defined and described.

2 Normative references

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

[1] prETS 300 133-2 (1997): "Radio Equipment and Systems (RES); Enhanced Radio MEssage System (ERMES) Part 2: Service aspects".

[2] prETS 300 133-5: (1997): "Radio Equipment and Systems (RES); Enhanced Radio MEssage System (ERMES) Part 5: Receiver conformance specification".

[3] prETS 300 133-6: (1997): "Radio Equipment and Systems (RES); Enhanced Radio MEssage System (ERMES) Part 6: Base station conformance specification".

[4] ITU-T Recommendation E.212 : "Identification plan for land mobile stations".

[5] CEPT Recommendation T/R 25-07: "Frequency co-ordination for the Enhanced radio message system (ERMES)".

3 Definitions, abbreviations and symbols

3.1 Definitions

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

associated operator: One of the network operators with which the home operator has an agreement to exclusively transfer calls.

basic Radio Identity Code (RIC): The prime identity of a paging receiver allocated by the network operator when service is initiated. It can not be changed without safeguards against unauthorized changes.

batch number: The 4 bit number corresponding to a particular batch type. Batch type A corresponds to batch number 0000. Batch type P corresponds to batch number 1111.

batch type: The letter (A to P) which identifies one of the 16 batches within a subsequence.

character set indicator: Indicates which additional character set is to be used. The basic set defined in ETS 300 133-2 [1], table B.3, is 00000.

codeblock: Nine codewords interleaved as a unit as used in the message partition.

codeword: The standard information unit of 30 bits length.

country code: Binary representation of the country number defined in ITU-T Recommendation E.212 [4], annex A. The country code consists of 7 bits (see also subclause 5.3.1.1).

End Of Message (EOM) character: A specific character used to indicate the end of an alphanumeric message. It corresponds to DC1 as defined in annex B.3 of ETS 300 133-2 [1].

external receiver: A receiver operating in a network which is not its home network.

frequency divided network: A network that uses different frequency channels in adjacent paging areas.

geographical area: One or several paging areas in an operator network. Defined by agreements between network operators for inter-network roaming or by a single operator for roaming within his own network. It is used for roaming and choice of destination supplementary services.

home network: The operator network with which a mobile subscriber has signed a subscription.

home operator: The network operator to which a specific user has subscribed.

initial address: The 18 most significant bits of the local address.

I1 interface: The radio interface between the base stations and the paging receivers.

I2 interface: An interface between the Paging Area Controller and the Base Station (BS).

local address: The number used by a network to identify the receivers subscribed to it. It consists of 22 bits. The four least significant bits of the local address denote the batch number of the receiver.

long message: A message that has been split into two or more parts (sub-messages) for transmission.

operator code: The number used by the system on the radio path to identify an operator within a country. It consists of 3 bits.

operator identity: The number used by the system on the radio path to identify the home operator of a receiver. It has a total length of 13 bits and consists of three parts, the zone code, the country code and the operator code.

paging area: The area controlled by a Paging Area Controller (PAC). It is the minimum area to which a mobile subscriber is permitted to subscribe in order to receive his paging messages.

paging area code: The number used by the system to identify the paging area.

paging area controller: Functional entity controlling the base stations within one paging area.

paging message: The tone-only, numeric, alpha-numeric or transparent data information sent to a paging receiver.

paging signal: The signal sent on the radio path to a paging receiver.

radio identity code: The number used by the system on the radio path to identify the receiver(s) for which the paging message is intended. The RIC has a total length of 35 bits and consists of five parts: the zone code (3 bits), the country code (7 bits), the operator code (3 bits), the initial address (18 bits) and the batch number (4 bits).

	Operator Identity			**Local Address**	
	Zone code	Country code	Operator Code	Initial address	Batch number
No. of bits	3	7	3	18	4

Figure 1: Radio identity code

reserved for future definition: The bits indicated are not specified in this edition of the standard but may be in future editions. The bits should be set to a default value of zero and not used to convey information. The function of any equipment is independent of these bits. No fixed pattern of reserved bits should be assumed and no combination of reserved bits should cause equipment to malfunction.

roaming area: The geographical area where the mobile subscriber asks for his messages to be transmitted when he uses the roaming service.

service area: The paging area(s) to which the mobile subscriber has subscribed and in which a paging message will normally be transmitted.

sub-message: Part of a long message. All sub-messages of any one long message carry the same message number.

symbol: Two bits of information which are the basic unit of information on the air interface. It corresponds to one of the four modulation levels specified in subclause 8.3.1.

time divided network: A network that uses the same frequency channel during different sub-sequences (periods of a time cycle) in adjacent paging areas.

zone code: Binary representation of the zone number defined in ITU-T Recommendation E.212 [4], annex A. The zone code consists of 3 bits (see also subclause 5.3.1.1).

3.2 Abbreviations

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

AII	Additional Information Indicator
AIF	Additional Information Field
AIN	Additional Information Number
AIT	Additional Information Type
APT	Address Partition Terminator
BAI	Border Area Indicator
BS	Base Station
CTA	Common Temporary Address
CTAP	Common Temporary Address Pointer
EB	External Bit
ETI	External Traffic Indicator
FSI	Frequency Subset Indicator
FSN	Frequency Subset Number
IA	Initial Address
LSB	Least Significant Bit
MSB	Most Significant Bit
OPID	Operator Identity
PA	Paging Area
PR	Preamble
PAC	Paging Area Controller
PAM/FM	Pulse Amplitude Modulated Frequency Modulation
RF	Radio Frequency
RIC	Radio Identity Code
RSVD	Reserved bits for future definition
SI	System Information
SM	Subsequence Mask
SSI	Supplementary System Information
SSIF	Supplementary System Information Field
SSIT	Supplementary System Information Type
SSN	Subsequence Number
SW	Synchronization Word
SYN	Synchronization Word
SYS	System information partition
UMI	Urgent Message Indicator
UTC	Universal Time Co-ordinated
VIF	Variable Information Field

3.3 Symbols

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

ENL	Number of Least Significant Bits (LSB) to be compared when operating outside home network
HNL	Number of LSBs to be compared when operating within home network

4 Transmission protocol

4.1 General description of the protocol

The structure of the basic transmission protocol on channel one (of channels numbered 1 - 16) is illustrated in figure 2.

A sequence of 60 minutes total duration and comprising 60 cycles shall be provided. Sequences shall be co-ordinated with the Universal Time Co-ordinated (UTC) so that on the hour a new sequence commences.

A paging cycle of exactly one minute duration, co-ordinated with UTC, shall be used to allow the necessary co-ordination between different networks. Receivers may listen to one or a few cycles in a sequence in order to reduce battery consumption (clause 11).

Each cycle shall be divided into five subsequences commencing at 12 second intervals. To allow co-ordination between networks the Subsequence Number (SSN) = 0 subsequence shall always be transmitted first after the UTC minute marker.

The transmission of a subsequence may end before the full 12 seconds has elapsed. The subsequence length may be reduced by a small amount to allow for transmitter switching times. Occasionally a greater reduction may be made in order that test or system transmissions can be made by individual transmitters.

Each subsequence shall be further divided into 16 batches labelled A-P. The receiver population should be divided into 16 groups and each receiver allocated to one of the 16 batch types according to the 4 least significant bits of its basic RIC. Further RICs used by this receiver shall be of the same batch type.

Each receiver shall only be initially addressed in its own batch type transmission. When the receiver detects its initial address it should wait on the same channel for the message to be sent. The message may be sent in the same batch, in any subsequent batch of the same subsequence or in the following subsequence (see subclause 10.6 regarding time-out conditions).

An initial address may be transmitted more than once in the same batch (subclause 10.2).

The time of transmission of a particular batch type on each frequency channel is shifted by a single time batch with respect to the others as shown in figure 3. Consequently a receiver can, if necessary, step through the paging frequency channels without losing any messages.

The first fifteen batches in every subsequence shall have length 154 codewords. The final batch in every subsequence shall have length 190 codewords. This is so that messages in time divided networks may be completed within a subsequence.

Each batch is further subdivided into four partitions. These are the synchronization, system information, address and message partitions. A detailed description of the batch structure is given in subclause 4.4 and the contents of each partition specified in subclauses 5.2 to 5.5.

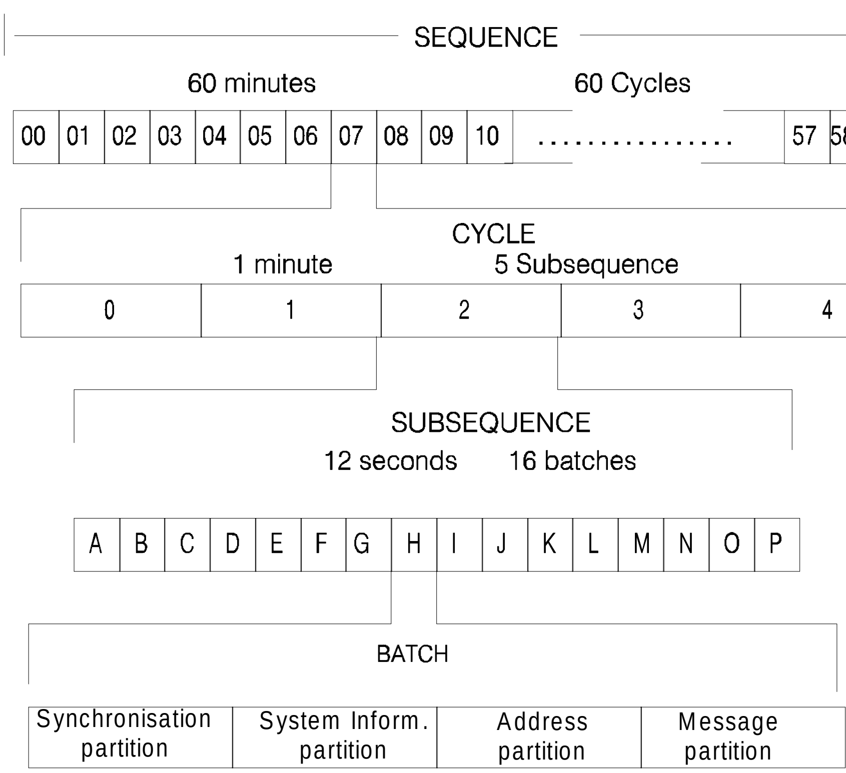


Figure 2: Structure of the radio protocol on channel one

■ = Active batch for a type A receiver

Chan	◄ 12 seconds ►																										
01	■	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	■	B	C	D	E	F	G	H	I	J	K	L
03	P	■	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	■	B	C	D	E	F	G	H	I	J	K
05	O	P	■	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	■	B	C	D	E	F	G	H	I	J
07	N	O	P	■	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	■	B	C	D	E	F	G	H	I
09	M	N	O	P	■	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	■	B	C	D	E	F	G	H
11	L	M	N	O	P	■	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	■	B	C	D	E	F	G
13	K	L	M	N	O	P	■	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	■	B	C	D	E	F
15	J	K	L	M	N	O	P	■	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	■	B	C	D	E
16	I	J	K	L	M	N	O	P	■	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	■	B	C	D
14	H	I	J	K	L	M	N	O	P	■	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	■	B	C
12	G	H	I	J	K	L	M	N	O	P	■	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	■	B
10	F	G	H	I	J	K	L	M	N	O	P	■	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	■
08	E	F	G	H	I	J	K	L	M	N	O	P	■	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
06	D	E	F	G	H	I	J	K	L	M	N	O	P	■	B	C	D	E	F	G	H	I	J	K	L	M	N	O
04	C	D	E	F	G	H	I	J	K	L	M	N	O	P	■	B	C	D	E	F	G	H	I	J	K	L	M	N
02	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	■	B	C	D	E	F	G	H	I	J	K	L	M

NOTE: The relation between Radio Frequency (RF) channel frequencies and channel numbers is defined in subclause 8.2.

Figure 3: Channel synchronization and the scanning procedure

4.2 Outline of the air interface model

The air interface transmissions are organized in four levels:

L4 - information format;

L3 - error correction coding;

L2 - codeword interleaving;

L1 - modulation.

4.2.1 Information format L4

Co-ordination of the basic paging system data and paging message data is performed at the format information level. It is a way of arranging the transmitted data in a predefined format that will be recognized by the receivers.

Throughout this ETS the bit transmission order shall be from left to right. Accordingly the Most Significant Bit (MSB), which is the left most bit, is transmitted first. The Least Significant Bit (LSB) is the right most bit and is transmitted last.

4.2.2 Error correction coding L3

Forward error correction coding adds redundancy to the transmitted codewords so that after demodulation and de-interleaving transmission errors may be detected and corrected.

4.2.3 Codeword interleaving L2

Interleaving is the technique to spread burst errors that occur on radio channels subject to multipath/fading and impulsive noise. This is achieved by changing the order of bits in the transmitted data stream so that on reception any burst of errors that has occurred is spread over several codewords and there is a chance that some or all of them may be corrected. This is further described in clause 7.

4.2.4 Modulation L1

The function of the modulation level is to distribute by radio transmission the coded and formatted information from the base station transmitters to the paging receivers.

4.3 Application of the model to the air interface

Each of the processing levels will be described in detail in the following clauses. Not all levels shall be applied to all parts of the interface transmissions. This is best specified at the batch level (figure 2) where the following shall apply:

- synchronization partition: L1 & L4;
- system information partition: L1, L3 & L4;
- address partition: L1, L3 and L4;
- message partition: L1, L2, L3 and L4.

4.4 Batch structure

The synchronization partition and system information partition are of fixed length. The boundary between the address and message partitions can be altered depending on traffic type and density. The requirement for codeword interleaving in the message partition imposes detailed constraints on the position of the boundary. As shown in clause 7 the protocol specifies codeword interleaving to a depth of nine codewords. Hence messages shall be assembled and transmitted in blocks of 9 codewords (which are called codeblocks) and the address partition/message partition boundary positioned to allow this. Unused codewords within an address partition shall be filled with Address Partition Terminators (APTs) as defined in subclause 5.4. Unused codewords within an interleaved message codeblock shall be filled with message delimiters as defined in subclause 5.5.4. Unused bits within a message codeword shall be filled as described in subclause 5.5.3. The detailed composition of a batch is shown in figure 4.

PR	SYN	SI	SI	SSI	$I \times IA$	$J \times APT$	$K \times$ CODEBLOCKS
SYNCH PART		SYSTEM INF PARTITION			ADDRESS PARTITION		MESSAGE PARTITION

Figure 4: Batch structure

Table 1: Batch structure fields

Field	Function	Definition
PR	preamble word	defined in subclause 5.2
SYN	synchronization word	defined in subclause 5.2
SI	system information	defined in subclause 5.3.1
SSI	supplementary system information	defined in subclause 5.3.2
IA	initial address	defined in clause 2
APT	address partition terminator	defined in subclause 5.4
CODEBLOCK	interleaved messages	defined in subclause 5.5
I	number of initial addresses	$0 \le I \le 139$
J	number of address partition terminators	note 1
K	number of codeblocks in the message partition	note 2
NOTE 1: J = 9 - MOD{(4+I),9)} where MOD {M, N} = M - N $\times$ INT(M/N) and INT returns the integer part of a number.		
NOTE 2: $K \le (149 - I - J)/9$ first 15 batches of a subsequence. $K \le (185 - I - J)/9$ last batch of a subsequence.		

Typical values of parameters for the first 15 batches are:

- I = 0, J = 5, K = 16;
- I = 4, J = 1, K = 16;
- I = 5, J = 9, K = 15;
- I = 139, J = 1, K = 1.

NOTE: K = 16 corresponds to the maximum number of messages; I = 139 to the maximum number of initial addresses.

Typical values of parameters for the last batch are:

- I = 0, J = 5, K = 20;
- I = 4, J = 1, K = 20;
- I = 22, J = 1, K = 18;
- I = 139, J = 1, K = 5.

NOTE: K = 20 corresponds to the maximum number of messages; I = 139 to the maximum number of initial addresses.

4.5 Subsequence lengths

The length of a subsequence shall be 12 seconds (2 500 codewords).

The duration of data transmission within the subsequence may, however, be less than this. In the case that less than 2 500 codewords are transmitted the number of transmitted codewords shall be 2 500 minus an integer multiple of 9 codewords.

The minimum number of codewords that may be transmitted in a subsequence is zero, notwithstanding the requirements of subclauses 9.1 and 5.4.

The minimum reduction in subsequence transmission length that may be made is 1 codeblock (9 codewords (43,2 ms)).

5 Information format

5.1 General

Each batch consists of four partitions as illustrated in subclause 4.4. Details of how the paging data is organized within each partition are defined in this clause.

5.2 Synchronization partition

Each batch shall commence with the synchronization partition which consists of two 30 bit words, which are the preamble and the Synchronization Word (SW).

The preamble may be used to obtain bit synchronization.

The preamble word shall be:

00 10 00 10 00 10 00 10 00 10 00 10 00 10 00 (30 bits).

The synchronization word may be used to obtain code word synchronization.

The synchronization word SW1 shall be:

10 00 10 10 00 10 00 00 10 10 00 00 10 10 10 (30 bits).

Alternative synchronization words may be used in future versions of the protocol.

5.3 System information partition

Network operator and system operational information is transmitted in the system information partition. The system information partition is divided into two consecutive parts - system information and supplementary system information with the system information transmitted first.

5.3.1 System information

The system information part shall comprise the elements shown in figure 5.

Country code	Operator code	PA code	ETI	BAI	FSI	Cycle No.	SSN	Batch No.
7 bits	3 bits	6 bits	1 bit	1 bit	5 bits	6 bits	3 bits	4 bits

Figure 5

Table 2

Field	Function	Subclause
Country Code	of the transmitting network.	(subclause 5.3.1.1)
Operator Code	code of the network operator.	
PA code	paging area code.	
Cycle No.	subsequence number	(subclause 5.3.1.2)
SSN		
Batch No.		
ETI	External traffic indicator: 0: External traffic will not be initially addressed in this batch; 1: External traffic will be initially addressed in this batch.	(subclause 9.4)
BAI	Border area indicator: 0: Indicates non border area; 1: Indicates border area	(subclause 9.3)
FSI	Frequency subset indicator.	(subclause 9.2)

5.3.1.1 Format of the network information

Zone and country numbers are based on ITU-T Recommendation E.212 , annex A [4]. A unique number consisting of 3 digits shall be allocated to each country or area. The first digit denotes the zone to which the country belongs. The last two digits indicate the country itself.

The first digit (zone number) shall be coded with 3 binary bits and sent as supplementary system information at least once per hour to every pager (see also clause 11). These bits represent the zone code. The last two digits shall be coded with 7 binary bits. These bits represent the country code.

Three bits are used to define up to 8 different operators within each country. (Additional codes may be provided by the use of country codes that are not currently allocated to any country).

Six bits are used to define one of up to 64 paging areas within a paging network.

5.3.1.2 Format of the time slot information

Each batch type transmission shall be identified on the radio channel by a four bit binary number. The number shall correspond to a simple alphabet to binary number translation. Thus batch type A corresponds to batch number 0000, batch type P to batch number 1111.

A three bit binary representation of the decimal numbers 0,1,2,3,4 shall be used to identify the subsequence numbers.

A six bit binary number shall be used to identify the cycle numbers 0, 1, 2 to 59, with the corresponding binary representations being 000000, 000001, 000010, to 111011.

5.3.2 Supplementary system information

The supplementary system information part shall take the form shown in figure 6.

SSIT	SSIF
4 bits	14 bits

Figure 6

Table 3

SSIT	supplementary system information type. 0000 zone/hour/date; 0001 day/month/year. All other values of SSIT shall be reserved for future definition
SSIF	supplementary system information field.

5.3.2.1 Supplementary system information field (SSIT=0000)

The supplementary system information field shall take the form shown in figure 7.

Zone	Hour	Date	RSVD
3 bits	5 bits	5 bits	1 bit

Figure 7

Table 4

Field	**Function**
Zone	zone number (subclause 5.3.1.1).
Hour	Local hour. Hours shall be numbered from zero (00000) to 23 (10111).
Date	Local date. Day of the month shall be numbered from one (00001) to 31 (11111).
RSVD	Reserved for future definition (clause 3)

5.3.2.2 Supplementary system information field (SSIT=0001)

The supplementary system information field shall take the form shown in figure 8.

Day	Month	Year
3 bits	4 bits	7 bits

Figure 8

Table 5

Day	Local day of week. Days shall be numbered 1 to 7. Day 1 (001) shall be Monday.
Month	Months shall be numbered 1 to 12. Month 1 (0001) shall be January.
Year	Year zero (0000000) shall be 1990.

5.4 Address partition

An address partition shall be provided in each of the batches A-P in a subsequence.

The address partition of a particular batch shall contain the initial addresses of the receivers to be accessed and which belong to that particular batch type. See subclause 10.6 for a definition of the time-out periods.

The address partition shall be of variable length up to a maximum of 140 codewords. It shall comprise an integral number of initial addresses. The minimum content of the address partition shall be no addresses and five Address Partition Terminators (APTs).

The addresses in a particular batch shall be arranged so that the highest initial address is sent first and others sent in descending order.

The address partition shall be terminated with an Address Partition Terminator (APT). This terminator shall be sent even if there are no addresses in the address partition. APTs may also be used as filler codewords as described in subclause 4.4.

The address partition terminator shall be:

10 01 00 11 10 00 01 10 00 10 00 11 10 01 00

5.5 Message partition

The message partition shall consist of messages separated by message delimiters. Each message partition shall comprise an integer number of codeblocks as described in subclause 4.4.

Each message shall consist of a fixed length message header (36 bits) which may be followed by the external operator identity, an additional information field and the message data.

5.5.1 Message header

The fixed length message header shall take the form shown in figure 9.

Local Address	Message Number	External bit	AII	VIF
22 bits	5 bits	1 bit	1 bit	7 bits

Figure 9

Table 6

Local Address	full local address of the called receiver.
Message Number	number of message to a particular receiver: for an individual call the initial value shall be 00001; for group calls the reserved dummy value 00000 shall be used. The reserved dummy value may also be used when the message numbering is deactivated.
External Bit	indicates if a local or an external receiver is addressed: 0: addressed receiver is in its home network; 1: external receiver is addressed.
AII	Additional Information Indicator: 0: additional information will not be sent; 1: additional information will be sent.
VIF	Variable Information Field.

5.5.1.1 Variable information field (AII=0)

The Variable Information Field (VIF) shall take the form shown in figure 10.

RSVD	Paging Category	UMI	ALERT
1 bit	2 bits	1 bit	3 bits

Figure 10

Table 7

RSVD	Reserved for future definition (clause 3).
Paging Category	of the transmitted message: 00 tone; 01 numeric; 10 alphanumeric; 11 transparent data.
UMI	Urgent Message Indicator: 0 normal message; 1 urgent message.
ALERT	Alert signal indicator for different types of alert: 000: type 0; 001: type 1; 010: type 2; 011: type 3; 100: type 4; 101: type 5; 110: type 6; 111: type 7.

5.5.1.2 Variable information field (AII=1)

The VIF shall take the form shown in figure 11.

AIT	AIN
3 bits	4 bits

Figure 11

Table 8

AIT	Additional information type: 000: Long message without additional character set - First submessage 001: Long message without additional character set - Other submessage 010: Remote programming of pager parameters 011: Reserved 100: Miscellaneous 101: Long message with additional character set - Other submessages 110: Long message with additional character set - First submessage 111: Common Temporary Address Pointers (CTAPs)
AIN	Additional information number (defined in the following subclauses).

5.5.1.2.1 Long messages (AII=1, AIT=000, 001, 101 or 110)

Table 9

AIN	Function
0000	non-urgent alert type 0
0001	non-urgent alert type 1
0010	non-urgent alert type 2
0011	non-urgent alert type 3
0100	non-urgent alert type 4
0101	non-urgent alert type 5
0110	non-urgent alert type 6
0111	non-urgent alert type 7
1000	urgent alert type 0
1001	urgent alert type 1
1010	urgent alert type 2
1011	urgent alert type 3
1100	urgent alert type 4
1101	urgent alert type 5
1110	urgent alert type 6
1111	urgent alert type 7

The Additional Information Field (AIF) associated with this Additional Information Type (AIT) (subclause 5.5.2) shall comprise 2 bits for paging category (defined in subclause 5.5.1.1) followed by 16 bits specifying the message length.

Long messages with additional character set:

For long messages with additional character set, the Additional Information Number (AIN) shall be as defined above in this subclause. The associated AIF (subclause 5.5.2) shall comprise 2 bits for the paging category (defined in subclause 5.5.1.1), 16 bits specifying the message length (subclause 10.4), 5 bits for additional character set selection and 2 reserved bits.

5.5.1.2.2 Remote programming of pager parameters (AII=1, AIT=010)

Table 10

AIN	Function
0001	Initial Address
0010	Paging Area
0100	Associated operator identity
1000	Subsequence set in home network (note)
0111	Subsequence set outside home network
1011	For future definition
1101	For future definition
1110	For future definition
NOTE: A subsequence set is that set of cycles and subsequences during which transmissions are scheduled for a particular receiver.	

All other combinations of AIN bits shall be reserved in order to give security to the currently allocated AINs.

The Additional Information Fields (AIF) associated with this AIT (subclause 5.5.2) shall comprise the following:

Two functional bits are used at the start of the AIFs. Their interpretation shall be as shown in table 11.

Table 11

F bits	Interpretation
F = 00	Add to, or replace (note 1) data stored in the pager
F = 01	Remove from data stored in the pager (note 2).
F = 10	Restore default values (note 3).
F = 11	Reserved for future definition
NOTE 1: Only in the case of subsequence sets (i.e. for AIN=1000 or 0111) shall this function take the meaning "replace". This is to allow for updating of a subsequence set in a single step procedure. For all other values of AIN it shall take the meaning of "add". NOTE 2: This function is meaningless in the case of subsequence sets and shall be ignored by the receiver. NOTE 3: For AIN equals to 0001 this function shall remove all RICs with the exception of the basic RIC stored in the receiver. For AIN equals to 1000 or 0111 this function shall reset Subsequence Mask (SM), HNL, and ENL to default values as defined in subclauses 12.3 and 12.4. For AIN equals to 0010 this function shall instruct the receiver to store all values for P.A. from 0 to 63 inclusive. For AIN equals to 0100 this function shall reset all associated operator identities to match the Operator Identity (OPID) of the basic RIC.	

Table 12

AIN	AIF
0001	F + Zone + Country + Operator + Initial address (2+3+7+3+18 bits) (note 1)
0010	F + Zone + Country + Operator + Paging Area(2+3+7+3+6 bits) (note 1)
0100	F + Zone + Country + Operator (2+13 bits)
1000	F + Subsequence set in home network, SM + HNL (2+5+3 bits) (note 2)
0111	F + Subsequence set outside home network, SM + ENL (2+5+3 bits) (note 2)
NOTE 1: The receiver shall ignore the content of zone, country and operator fields. Only initial address and paging area code fields shall be acted upon. NOTE 2: SM id the 5 bit subsequence mask that identifies active subsequences for the receiver (subclause 11.3). HNL and ENL are the 3 bit fields which identify active cycles in the home network and in the non-home network respectively (subclause 11.4).	

5.5.1.2.3 Miscellaneous (AII=1, AIT=100)

Table 13

AIN	Function.
0001	Retransmission of latest message number (AIF has zero length) The most recent message number (contained in the message header) is sent to the addressed receiver. (ETS 300 133-2 [1] subclause 4.3.1.3.3).
0010	Character set for associated message Identifies one of up to 32 additional character sets for associated message. AIF has 11 bits. The basic character set as defined in ETS 300 133-2 [1], table B.3, shall be identified by 00000. Contents of additional character sets are for future definition.

The AIF takes the form shown in figure 12.

	UMI	ALERT	Character Set Indicator	Paging Category
No. of bits	1	3	5	2

Figure 12

All other values of AIN are for future definition.

5.5.1.2.4 Common temporary address pointers (AII=1, AIT=111)

Table 14

AIN	CTAP	CTA
0000	0	111111111111111111 0000
0001	1	111111111111111111 0001
0010	2	111111111111111111 0010
0011	3	111111111111111111 0011
. . . .	etc. up to	
1110	14	111111111111111111 1110
1111	15	111111111111111111 1111

The function of Common Temporary Address Pointers (CTAP) and the relationship between address pointers and addresses is described in subclause 10.3. The AIF associated with this AIT has zero length.

5.5.2 Additional information and external operator identity

When the Additional Information Indicator (AII) bit is set to one, additional information will be sent in or after the message header.

The additional information will be contained in an additional information field (AIF) of variable length. The length of the AIF may be zero (as in the case of AII=1, AIT=111).

When External Bit (EB) = 1 the AIF (if any) will be preceded by the operator identity OPID of the receiver's home operator (13 bits). The first bit of the AIF shall immediately follow the last bit of the OPID.

Trailing binary zeros shall be added to the OPID or AIF in order to complete a codeword (18 information bits).

5.5.3 Message data

Message characters (7 bit alphanumeric, 4 bit numeric) or transparent data shall be placed continuously in the 18 bit information fields of message codewords. The MSB of the first message character to be displayed shall be placed in the MSB of the first codeword following the message header. Message characters are defined in ETS 300 133-2 [1], annex B.

After the last character (or bit) of the message the following message termination procedures shall be used:

- alphanumeric: an EOM character (0010001) shall be appended;
- numeric: no terminating character required;
- transparent data: a single bit set to one shall be appended.

As messages can be of any length up to the maximum specified in subclause 10.4, most will not fit exactly into the 18 information bit codeword structure dictated by the error correction code. Unused bits in message codewords shall be set to the following default values:

- alphanumeric: EOM characters and partial EOM characters (MSB used first) shall be repeated to fill the remaining bits;
- numeric: space character and partial space characters (MSB used first) shall be repeated to fill the remaining bits;

- transparent data: binary zeros shall be used to fill the remaining bits.

| XXXXXXX:1:0000000000 | Message delimiter |

where XXXXXXX = Transparent data

Figure 13

Codeblocks consisting entirely of message delimiters may be transmitted in order to complete a batch.

5.5.4 Message delimiter

Every message shall be preceded and terminated by a message delimiter. A single message delimiter shall separate different messages.

The message delimiter shall be aligned with the codeword boundary and take the form:

11 01 01 01 11 10 01 11 11 10 11 10 11 10 11

5.5.5 Completion of message codeblocks

Since message partition data will not in general fill a codeblock (as required for interleaving) unused codewords after the last message delimiter shall be filled with further message delimiters. If continuous signal transmission is not required, the transmitter may be turned off after the last completed codeblock.

5.5.6 Unused codeblocks

During periods of transmission after the last message has been sent, interleaved codeblocks consisting entirely of message delimiters should be transmitted by those operators who choose not to switch off their transmitters.

6 Error correction coding

The shortened cyclic (30,18) code shall be used. Each codeword shall consist of 18 information bits and 12 check bits. The generator polynomial for the code shall be:

$$g(x) = x^{12} + x^{11} + x^9 + x^7 + x^6 + x^3 + x^2 + 1 = 15315_8$$

This generator polynomial is derived from the generator polynomial of the BCH(31,21) code, $g(x)_{31,21} = 3551_8$. The relation between these polynomials is given by:

$$g(x) = g(x)_{31,21}(x+1)(x+1)$$

The Hamming distance for the (30,18) code is 6. For hard decision decoding any two errors may be corrected whilst any three errors may be detected.

The twelve bit check word shall be formed by taking the remainder after multiplication of the 18 information bits by x^{12} and then division (modulo-two) by the generator polynomial g(x) of the message word.

Thus if the polynomial:

$$m(x) = m_{17}x^{17} + m_{16}x^{16} + ...m_1x + m_0$$

where the coefficients m_n having value 0 or 1 represent the 18 bit message word , then the 30 bit codeword is given by:

$$c(x) = m(x)x^{12} + m(x)x^{12} \bmod g(x)$$

The codeword shall be transmitted MSB first - that is to say information bits c_{29} to c_{12}, followed by check bits c_{11} to c_0.

The encoding process may alternatively be considered in terms of its generator matrix G which is derived from the generator matrix (last row).

$$
G = \left|\begin{array}{l|l}
100000000000000000 & 111100001000 \\
010000000000000000 & 011110000100 \\
001000000000000000 & 001111000010 \\
000100000000000000 & 000111100001 \\
000010000000000000 & 110110010110 \\
000001000000000000 & 011011001011 \\
000000100000000000 & 111000000011 \\
000000010000000000 & 101001100111 \\
000000001000000000 & 100001010101 \\
000000000100000000 & 100101001100 \\
000000000010000000 & 010010100110 \\
000000000001000000 & 001001010011 \\
000000000000100000 & 110001001111 \\
000000000000010000 & 101101000001 \\
000000000000001000 & 100011000110 \\
000000000000000100 & 010001100011 \\
000000000000000010 & 111101010111 \\
000000000000000001 & 101011001101
\end{array}\right|
$$

The check bits of the codeword are readily generated by the modulo-two addition of all the rows of the generator matrix for which the corresponding coefficient in the message word is "1". Thus for the message word:

m(x) = 000 000 000 000 000 001

The corresponding codeword is:

c(x) = 000 000 000 000 000 001 101 011 001 101 = g(x)

Similarly for the all "1"s message word:

m(x) = 111 111 111 111 111 111

The corresponding codeword is:

c(x) = 111 111 111 111 111 111 110 001 001 011

7 Codeword interleaving

The message partition consists of a number of codeblocks (subclause 4.4). A codeblock shall be assembled from nine message codewords interleaved such that each of the codewords constitutes a row of a nine row by thirty column matrices as shown below.

CODEWORD	MSB												LSB
1	$c_{1,29}$	$c_{1,28}$	$c_{1,27}$	$c_{1,26}$	$c_{1,25}$	$c_{1,24}$	$c_{1,23}$	$c_{1,22}$	$c_{1,21}$	$c_{1,20}$	....	$c_{1,1}$	$c_{1,0}$
2	$c_{2,29}$	$c_{2,28}$	$c_{2,27}$									$c_{2,1}$	$c_{2,0}$
3	$c_{3,29}$	$c_{3,28}$	$c_{3,27}$									$c_{3,1}$	$c_{3,0}$
4	$c_{4,29}$	$c_{4,28}$	$c_{4,27}$									$c_{4,1}$	$c_{4,0}$
5	$c_{5,29}$	$c_{5,28}$	$c_{5,27}$									$c_{5,1}$	$c_{5,0}$
6	$c_{6,29}$	$c_{6,28}$	$c_{6,27}$									$c_{6,1}$	$c_{6,0}$
7	$c_{7,29}$	$c_{7,28}$	$c_{7,27}$									$c_{7,1}$	$c_{7,0}$
8	$c_{8,29}$	$c_{8,28}$	$c_{8,27}$									$c_{8,1}$	$c_{8,0}$
9	$c_{9,29}$	$c_{9,28}$	$c_{9,27}$									$c_{9,1}$	$c_{9,0}$

The bits shall be sent to the modulator column by column so the transmit order is as follows:

$c_{1,29}$ $c_{2,29}$ $c_{3,29}$ $c_{4,29}$ $c_{5,29}$ $c_{6,29}$ $c_{7,29}$ $c_{8,29}$ $c_{9,29}$ then,
$c_{1,28}$ $c_{2,28}$ $c_{3,28}$ $c_{4,28}$ $c_{5,28}$ $c_{6,28}$ $c_{7,28}$ $c_{8,28}$ $c_{9,28}$ followed by
$c_{1,27}$ $c_{2,27}$ $c_{3,27}$ $c_{4,27}$ $c_{5,27}$ $c_{6,27}$ $c_{7,27}$ $c_{8,27}$ $c_{9,27}$ and
$c_{1,26}$ $c_{2,26}$ $c_{3,26}$ $c_{4,26}$ $c_{5,26}$ $c_{6,26}$ $c_{7,26}$ $c_{8,26}$ $c_{9,26}$ etc.
. . . .
. . . . until the final column is transmitted
$c_{1,0}$ $c_{2,0}$ $c_{3,0}$ $c_{4,0}$ $c_{5,0}$ $c_{6,0}$ $c_{7,0}$ $c_{8,0}$ $c_{9,0}$

8 Modulation

8.1 General

The air interface, which is the subject of this part of the specification, can support frequency divided, time divided or time and frequency divided modes of operation. All these implementations operate on common frequency channels with the same modulation format. Furthermore it is an operational requirement (ETS 300 133-2 [1]) that paging receivers work throughout the system radio coverage area regardless of the prevailing time/frequency division mode. The radio related aspects of these requirements are addressed in this clause.

8.2 RF channels and channel numbering

The paging system shall operate in the frequency band 169,412 5 MHz to 169,812 5 MHz. The channel spacing shall be 25 kHz. The nominal frequencies and channel numbers shall be defined by the following expression:

$$f_n = 169{,}400 + n*0{,}025 \text{ MHz}$$

where n = channel number = 1 to 16.

Co-ordination between paging areas and the corresponding propagation criteria shall comply with CEPT Recommendation T/R 25-07 [5], annex 1.

8.3 Modulation format

The modulation format shall be four level Pulse Amplitude Modulated Frequency Modulation (4-PAM/FM).

The modulated signal shall be equivalent to that obtained with the block diagram shown in figure 14.

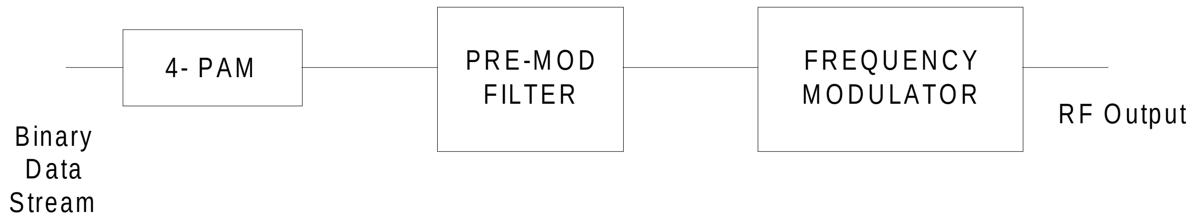


Figure 14

Four level pulse amplitude modulated FM is a technique where the communication of two data bits is achieved by the transmission of one of four signalling frequencies. A continuous phase and premodulation pulse shaping of the data stream constrain the transmitted RF spectrum. To minimize bit errors Gray code mapping between the digit symbols and the signalling frequencies is employed.

Digit symbols are sent to the modulator beginning with the two bits from the MSB end of the codewords.

8.3.1 Symbol alphabet

The symbol mapping of the signal shown in table 15 shall be implemented.

Table 15

Nominal frequency	Symbol
carrier + 4 687,5 Hz	10
carrier + 1 562,5 Hz	11
carrier – 1 562,5 Hz	01
carrier – 4 687,5 Hz	00

8.3.2 Data rate and symbol rate

The basic system parameters shown in table 16 shall apply.

Table 16

Parameter	Value
Data rate	6,25 kbits/s
Symbol rate	3,125 kbaud

8.3.3 Premodulation pulse shaping

The premodulation pulse shaping is defined by the amplitude and group delay masks shown in figure 15.

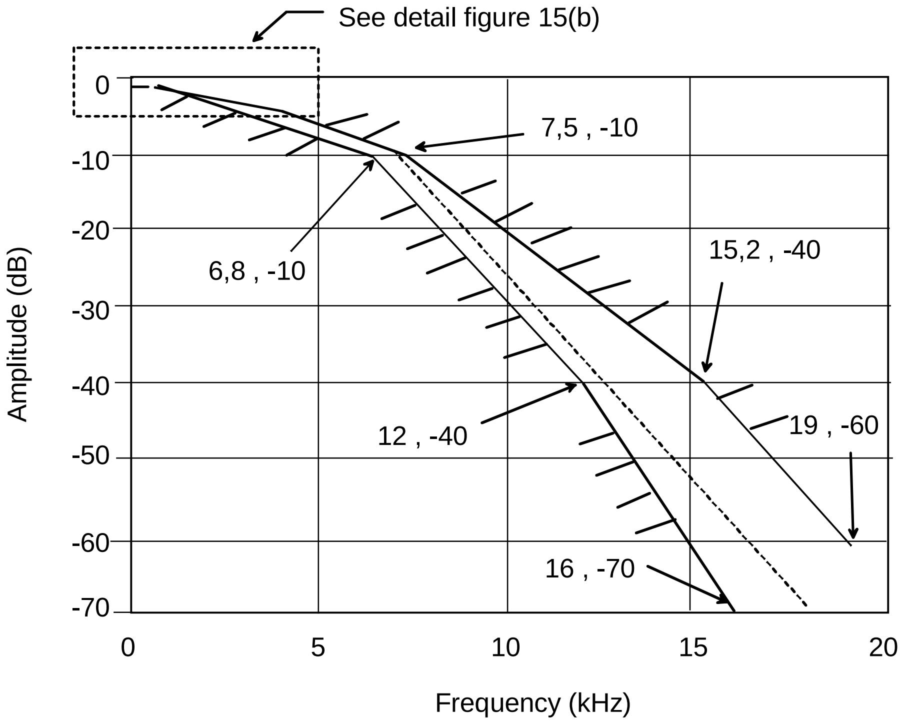


Figure 15(a): Upper and lower masks for the 4-PAM/FM premodulation filter. The dashed curve is the shape of the 10th order low pass Bessel filter with the 3 dB bandwidth of 3,9 kHz

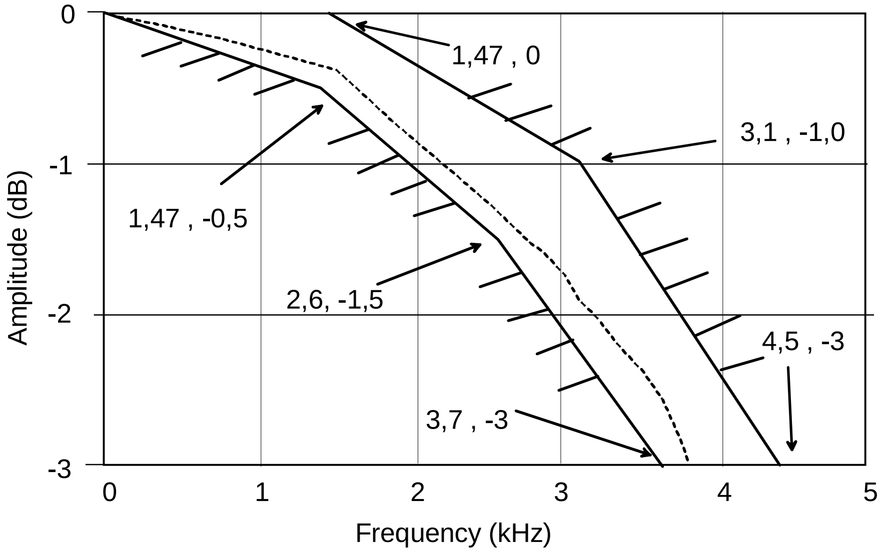


Figure 15(b): Detail expansion of above low pass filter characteristic

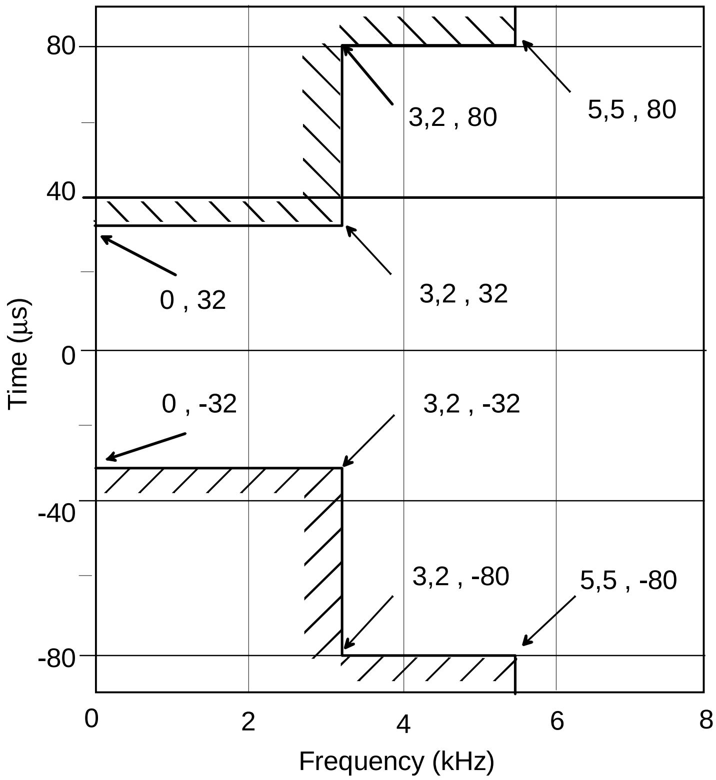


Figure 15(c): Group delay mask for the 4-PAM/FM premodulation filter

8.3.4 Paging receiver performance

The paging receiver shall comply with the requirements specified in ETS 300 133-5 [2].

8.3.5 Transmitter performance

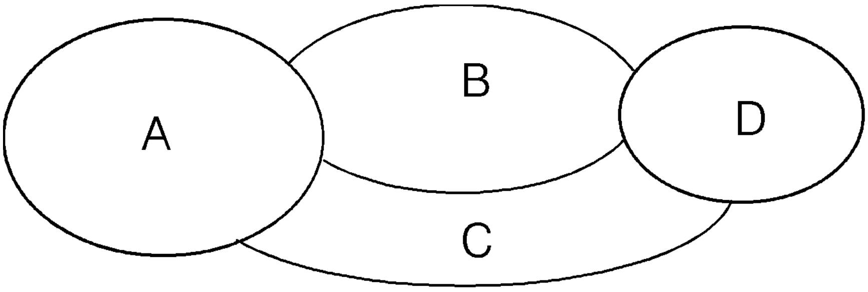
Transmitter characteristics shall comply with the requirements specified in ETS 300 133-6 [3].

9 Operation of the radio subsystem

9.1 General

The transmission protocol specified in clause 4 has sufficient flexibility to support time and/or frequency divided operation.

In a time divided network, paging area coverage is provided using different subsequences (from the same cycle) for each paging area. Transmissions on the same frequency for each batch type shall occur at least once every minute in areas where coverage is offered. Adjacent paging areas may transmit on different subsequences to avoid interference between neighbouring areas using the same frequency. This is illustrated by figure 16.



NOTE 1: Paging areas A and D have the most traffic and so transmit on the first three subsequences. Areas B and C use one subsequence each.

NOTE 2: Areas B and C provide the necessary physical separation to prevent interference between areas A and D which transmit simultaneously on the same frequency.

Figure 16: Time divided network

Frequency divided network operation implies that adjacent paging areas use different frequencies. No time sharing between paging areas should be used. Within the home network a receiver should use different frequencies in different paging areas.

When the paging area is adjacent to a network operator boundary the border area indicator bit may be set to one in the system information partition. This signifies that a receiver associated with that network may expect to receive a call from an alternative network and should then take the appropriate action (subclause 9.3).

The external traffic indicator shall be set to one in the system information partition to indicate to receivers who can not find their home network that there may be messages for them in this batch.

9.2 Frequency subset indicator and frequency subset number

In multi-frequency networks the paging receiver is informed on which channel to expect its messages. This is accomplished with a combination of the Frequency Subset Indicator (FSI) transmitted in the system information partition and the Frequency Subset Number (FSN) permanently stored in the receiver. The frequency subset indicator shall be transmitted for all receivers in home or external networks.

All receivers shall be assigned an FSN between 0 and 15. Each FSN defines a unique subset of five FSIs as indicated in figure 17. Each FSI defines a unique subset of FSNs to which the transmitted message may be directed. It is intended that the FSI shall be used in descending order. Thus in single channel networks the transmitted FSI shall be set to 30. In two channel networks the transmitted FSI shall be set to 28 and 29. The FSI/FSN arrangement offers the possibility to have a dynamic number of channels in use.

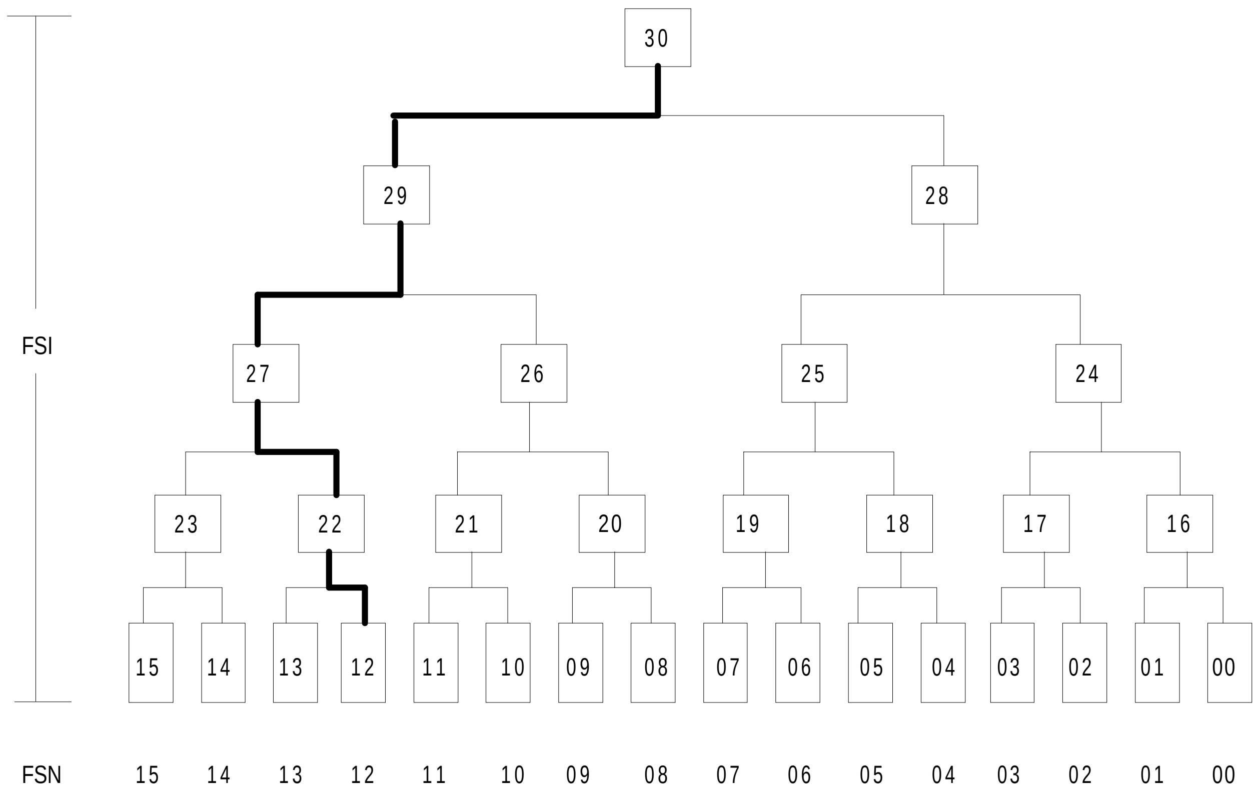


Figure 17: Illustrates FSI subsets

The FSI broadcast on the paging channel indicates that messages will be transmitted for pagers with an FSN in that FSI's subset. For example when the FSI on a channel equals 27 (see figure 17) only messages to receivers with FSNs of 12, 13, 14 or 15 will be carried. Conversely a receiver with FSN = 12 should look for its messages only on channels broadcasting FSI values of 12, 22, 27, 29 or 30.

The FSNs do not correspond directly to frequency channel numbers.

9.3 Border area indicator

The Border Area Indicator (BAI) is relevant only in a receiver's home network When BAI = 1 home receivers should not lock to this channel (subclause 9.5.2) unless a message or part of a long message is pending. If the BAI is set to zero valid traffic is expected to be carried by the home network only.

9.4 External traffic indicator

The External Traffic Indicator (ETI) indicates whether the initial address of any external receivers will be sent in the address partition of the batch. When the ETI is set to 1, one or several initial addresses of external receivers shall be sent in the batch. When the ETI is set to 0 external receivers need not look for their initial address in that batch. The ETI shall be valid only for a particular batch and shall be updated in subsequent batches.

9.5 Examples of receiver operation

Various receiver designs may be used in the ERMES system provided they conform with the requirements of ETS 300 133-5 [2]. Examples of non-locking and locking receivers will be described in this subclause.

9.5.1 Non-locking receivers

A non-locking receiver shall not lock to a specific channel. It shall check all home network channels or all sixteen channels at specific intervals as directed by information stored in the receiver and paging network controller (clause 11). The non-locking receiver shall check all 16 channels according to the battery saving techniques in clause 11.

9.5.2 Locking receiver

A locking receiver may store information about some subscribed and/or roamed networks or paging areas. This information may be conveyed to the receiver using the remote programming facility described in subclause 10.7. A locking receiver shall lock to a channel if all of the following criteria are satisfied:

- the relevant network information i.e. OPID, Paging Area (PA) and FSI is received on the channel and matches that information as stored in the receiver;
- the BAI is set to zero in all subsequences;
- the quality of reception on the channel is sufficient.

If any of these conditions are not met the locking receiver shall act as a non-locking receiver.

10 Paging message procedures on the air interface

10.1 General

The information format specified in clause 5 allows several simple format choices to be associated together to form a procedure. The more common of these procedures are described in this clause starting with individual calls, progressing to group calls, long messages and finally describing remote programming of receiver parameters. Whilst these procedures are themselves considered separately there are no restrictions in the protocol to limit the use of, for example, sending a long message as a group call or remotely programming the paging parameters of a group.

10.2 Individual call procedure

Individual calls to mobile subscribers shall be processed in two distinct stages:

1) during the first stage the called receiver shall be initially addressed in its own batch and start searching for its local address in the current and subsequent batches. Initial addresses appear in the address partition of the air interface transmissions as illustrated in subclause 4.4. In the event of messages being sent to receivers with identical initial addresses or more than one message being sent to a single receiver, then the initial address shall be transmitted once for each message.

2) during the second stage the called receiver shall be sent, in the message partition of the same or subsequent batches, an individual message to its local address or OPID plus local address if outside of its home network. This secondary addressing information is contained in the message header described in subclause 5.5.1. The individual message number is also contained in the message header along with the external bit, the Additional Information Indicator (AII) and Variable Information Field (VIF). The message number should be incremented by one from the previously transmitted message number and the other parameters set as appropriate for the transmitted message paging category and information types as specified in subclause 5.5.

Numeric characters (defined in ETS 300 133-2 [1], clause B.1), alphanumeric characters (defined in ETS 300 133-2 [1] , clause B.2), and transparent data shall follow immediately after the message header (or OPID and AIF if they are present). Completion of message codewords is specified in subclause 4.5. The message delimiter is specified in subclause 5.5.3. The following example serves to illustrate the procedure.

An F batch receiver is sent its initial address in the address partition (a receiver can only be sent its initial address in its own batch). On recognition of its initial address the receiver continues to listen to subsequent batches until it has received the message or the time-out criteria defined in subclause 10.6 are satisfied. The receiver is sent its message in the message partition of the same or any subsequent message partition (the H batch in this example). The receiver can recognize which is its message from the local address in the message header plus OPID if it is an external receiver.

F batch				G batch				H batch			
SYNC	SYS	ADD	MESS	SYNC	SYS	ADD	MESS	SYNC	SYS	ADD	MESS

NOTE: SYNC - synchronization partition

SYS - system information partition

ADD - address partition

MESS - message partition

Figure 18

10.3 Group call procedure

Group calls to mobile subscribers using individual RICs shall be handled using the principle of the Common Temporary Address (CTA). This allows a short message (of two codewords length) to be sent to every receiver of the group and then the actual message (which may be much longer) need only be sent once to a common temporary address of which the receivers have already been individually informed. The procedure shall be performed in the following three stages:

1) during the first stage each receiver of the group shall be initially addressed in its own batch and start searching for its local address in subsequent batches;

2) during the second stage each receiver of the group shall be sent an individual message to its local address or full RIC if outside of its home area, with an individual message number, with the additional information indicator AII = 1, additional information type AIT = 111 and with the AIN corresponding to one of the sixteen common temporary address pointers (for instance AIN = 0011);

   Each receiver of the group shall append the four bits of the AIN to its internally stored or generated group initial address (comprising eighteen ones) to form the CTA.

   The common temporary address shall be used by the receivers only for a single group call. All receivers of a group shall receive the same CTA.

3) at the third stage the actual message shall be sent only once using the common temporary address and a dummy message number 00000 in the message header. All other parameters of the message shall have the form of individual messages as specified in subclause 5.5. Receivers shall allocate to this message the appropriate message number transferred in the second stage of the procedure.

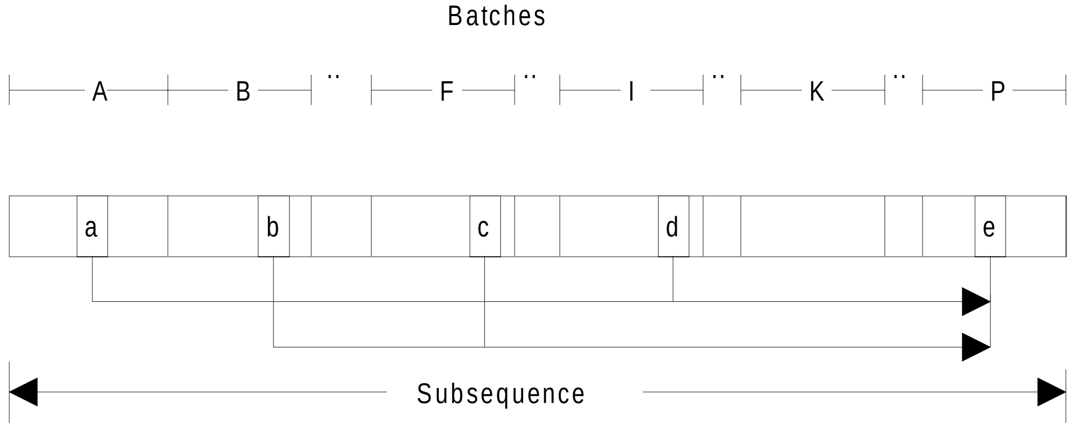
The form of the message headers at the second and third stages (see figure 19) serves to illustrate the procedure.

Second stage	Individual local address	Individual Message Number	External bit (0 or 1)	AII (1)	AIT (111)	AIN (ctap no.)

Third stage	Common Temporary Address	Message Number	External Bit	AII	VIF
	22 bits	5 bits	1 bit	1 bit	7 bits

Figure 19: Contents of the fixed message headers for group calls

A dynamic example for two receivers belonging to the same group but of different batch types further illustrates the time related aspects of the procedure. Suppose that receiver No. 1 is an A batch receiver and receiver No. 2 is a B batch receiver. A typical transmission sequence could be as shown in figure 20.



NOTE:

Stage 1: a) Initial address of receiver no. 1 transmitted in batch A (address partition);

b) Initial address of receiver no. 2 transmitted in batch B (address partition).

Stage 2: c) Full address of receiver no. 2 [AIT = 111 and CTAP] transmitted in batch F (message partition).

d) Full address of receiver no. 1 [AIT = 111 and CTAP] transmitted in batch I (message partition).

Stage 3: e) Actual message containing CTA in the message header transmitted in batch K (message partition).

Figure 20: Typical on-air calling sequence for a group call on channel one

10.4 Handling of long messages

Long messages may be divided into submessages of variable length. The submessages shall be sent in order when transmitted on the radio path and all shall have the same message number. Each submessage shall be treated in the same way as a message in respect that they shall be initially and locally addressed.

In the first submessage, the AII bit shall be set to 1 and the AIT set to 000 or 110 (according to additional character set). For the following submessages, the AII bit shall be set to 1 and the AIT set to 001 or 101 (according to character set). One of eight non-urgent or eight urgent alert types shall be chosen as indicated in subclause 5.5.1.2.1 and shall be the same for all submessages of the same message.

Information on the message structure is contained in the AIF. This has the form of a link counter. The link counter shall consist of 16 bits indicating the number of bits of the message that remain to be transmitted. Thus the maximum length of a transparent data message is 65 535 bits, numeric message 16 000 characters and alphanumeric message 9 000 characters.

Each submessage shall be terminated as defined in subclause 5.5.3 and followed by a message delimiter. The receiver shall count the message bits it receives. EOM and filler bits shall not be counted as part of the message. When the message delimiter has been received the receiver should subtract the number of bits counted from the link counter. If the result differs from zero then the receiver knows that it can expect more submessages to be transmitted. If the result is zero and the AIT field of the first received submessage is 000 or 110 (according to character set) then the complete message has been received. If the AIT field of the first submessage is 001 or 101, then the receiver may determine that at least one part of the message is missing.

In a time divided network, where the long message is to be sent in different paging areas, there need be no co-ordination of transmission time nor submessage content between paging areas.

The following example shows an alphanumeric paging category message of length 10 000 bits sent as three submessages. It is an urgent message with an alert signal indicator type 4.

EXAMPLE: First submessage: 2 000 bits sent:

AII = 1 AIT = 000 AIN = 1100 AIF = 10 00 10 01 11 00 01 00 00

link counter = 10000 = total length

Second submessage: 5000 bits sent:

AII = 1 AIT = 001 AIN = 1100 AIF = 10 00 01 11 11 01 00 00 00

link counter = 10000- 2000 = 8000

Third submessage: 3000 bits sent.

AII = 1 AIT = 001 AIN = 1100 AIF = 10 00 00 10 11 10 11 10 00

link counter = 10000 - (2000 + 5000) = 3000)

The maximum time between the transmission of submessages shall not exceed the time between the start of an active cycle and the start of the next active cycle, defined by HNL or ENL, plus one minute.

10.5 Messages continued in further batches in the same subsequence

Messages may continue in further batches. If a message commences in one batch and continues in the next there shall be no message delimiter between the separate parts of the message. In the next batch the message shall be continued immediately after the address partition. A message may span several batches.

10.6 Messages continued in further subsequences

Messages may continue in further subsequences. If a message commences in one subsequence and continues in the next the same procedure as described in subclause 10.5 may be used. When a message is to be continued from one subsequence to another subsequence separated by a period of time equal to one or more subsequences the long message procedure shall be used.

10.7 Transmission of variable receiver parameters

Suitably equipped receivers may be remotely programmed via the air interface. The programming is performed by setting AII = 1 in the message header (subclause 5.5.1), then setting AIT = 010 in the variable information field (subclause 5.5.1.2), followed by the appropriate AIN. The actual programming information is sent as the AIF following the message header (subclause 5.5.2).

This facility may be used to change the internally stored receiver parameters listed under subclause 5.5.1.2.2.

The basic RIC shall be protected from erasure and corruption.

10.8 Termination of message search

When a receiver recognizes a valid initial address it should begin to search for the associated paging message. If the message is not started within a defined time period due to data corruption or confusion with an external receiver possessing an identical local address, a defined end point for the message search shall occur as specified in the following subclauses.

10.8.1 Individual calls

Two time-out criteria shall apply. The earliest detected shall prevail:

- detection of a change in paging area code in the system information partition;
- 12 seconds since the start of the batch containing the initial address.

10.8.2 Group calls

Individual members of the group shall cease message search if:

- a change in paging area code in the system information partition is detected; or
- 12 seconds have elapsed since the start of the batch containing its initial address.

Consequently group messages should commence within 12 seconds from the start of the batch containing the initial address to the first member of the group.

Further group messages re-using the same CTAP should not be started within 12 seconds of the transmission of the beginning of the batch containing the initial address of the last member of the previous group using the CTAP. The group address can be reallocated after transmission of the group message has commenced but it should be ensured that transmission of the group message with duplicate group address does not commence until all previous timers have expired. These restrictions are illustrated in figure 21.

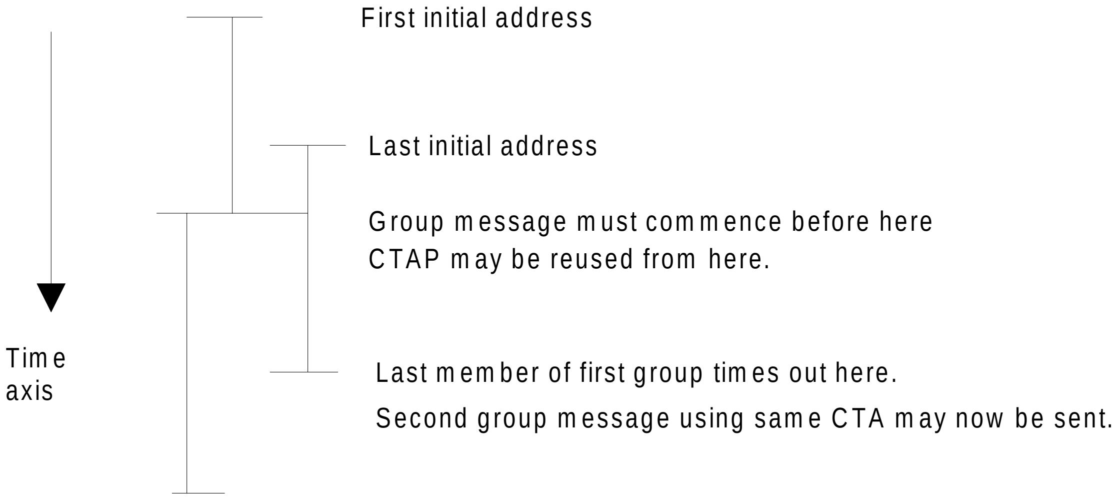


Figure 21: Time-out criteria for group calls

11 Battery saving techniques

11.1 Batch level

Battery saving on the batch level can be achieved by assigning a RIC at the high end of the addressable RIC population, since addressing is always performed in descending order with the highest initial address delivered first (subclause 5.4). A receiver may switch off if it detects an initial address lower than its own in its batch type.

Assignment of the local address of the RIC shall be decided by the network operator.

11.2 Subsequence level

Battery saving on the subsequence level is an inherent part of the protocol achieved by initially addressing the receiver in only one of the sixteen batches (A to P) in a subsequence.

11.3 Cycle level

Battery saving on the cycle level can be achieved by initially addressing the receiver in a subset of the five subsequences in a cycle.

The active subsequences for a particular pager shall be set by the subsequence mask SM (5 bits) stored in the pager. If any of the five bits is set to 1, signals should be expected on the corresponding subsequence. The MSB of SM corresponds to subsequence number 4, the LSB to subsequence number 0. The default value of SM stored in the pager shall be 11111.

This technique may not be appropriate for certain arrangements of time divided networks.

11.4 Sequence level

Battery saving on the sequence level can be achieved by initially addressing the receiver in a subset of the sixty cycles in a sequence.

The active cycles shall be determined by comparing the LSBs of the cycle number to the LSBs of the receiver's initial address. If they match then the cycle may carry initial addresses for the receiver.

The number of LSBs to be compared (in the range 0 to 5) shall be defined by two 3 bit numbers; HNL for operation within the home network and ENL for operation outside the home network. These values may be remotely changed in suitably equipped receivers (subclause 10.7).

A value HNL = 0 shall cause the receiver to be active in all cycles whilst HNL = 1 shall cause the receiver to be active in every second cycle. For HNL = 5 receivers with initial addresses ending in 00000 to 11011 shall be active in two out of sixty cycles whilst receivers with initial addresses ending in 11100 to 11111 shall be active in only one out of sixty cycles. This is summarized in table 17.

Table 17

Number of LSBs to be compared	Value of HNL or ENL	Receiver active (per sequence)
0	000	all cycles
1	001	every 2nd cycle
2	010	every 4th cycle
3	011	every 8th cycle
4	100	every 16th cycle
5	101	every 32nd cycle

HNL and ENL shall be set to default values of 000 and 010 respectively.

12 Synchronization

12.1 General

The requirements for synchronization in the paging system have three different elements:

- between paging receivers and the radio transmissions on a single channel;
- between the transmissions of identical radio signals from different transmitters in a single paging area;
- between the transmissions on different radio channels particularly when controlled by different network operators.

12.2 Synchronization between paging receiver and radio transmission

The paging system air interface is synchronous in that the start of radio transmissions to a particular receiver always occurs at fixed times. This method of operation requires that an accurate timer is incorporated into each paging receiver. The timing reference for this timer is provided by the radio transmission protocol. Details of the bit synchronization and word synchronization codes are specified in subclause 5.2.

12.3 Synchronization between base stations

The paging area network operates in a quasi synchronous manner. Several transmitters within the paging area transmit the same information simultaneously in order to enhance system coverage.

The difference in time of reception consists of three parts:

- difference in delay in base stations;
- accuracy of synchronization between base stations;
- difference in propagation times to the receiver.

Maximum adjacent base station separation results when the sum of the first two parts is kept as low as possible.

The maximum difference in times of reception of identical signals from different transmitters should not exceed 50 µs.

12.4 Co-ordination between networks

In order that paging receivers can successfully commute between different paging networks it is necessary for the timing of transmissions on the radio channels to be co-ordinated.

Transmissions by different networks shall be co-ordinated so that the start of transmissions of each of their cycles is within ± 2 ms of the common time reference (UTC). That is within 4 ms of each other.

History

Document history			
July 1992	First Edition		
January 1997	Vote	V 9711:	1997-01-14 to 1997-03-14