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Mobile Radio Interface - Layer 3 Specification

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No changes since the previously distributed version.

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PREFATORY NOTE

ETSI has constituted stable and consistent documents which give specifications for the implementation of the European Cellular Telecommunications System. Historically, these documents have been identified as "GSM recommendations".

Some of these recommendations may subsequently become Interim European Telecommunications Standards (I-ETSs) or European Telecommunications Standards (ETSs), whilst some continue with the status of ETSI-GSM Technical Specifications. These ETSI-GSM Technical Specifications are for editorial reasons still referred to as GSM recommendations in some current GSM documents.

The numbering and version control system is the same for ETSI-GSM Technical Specifications as for "GSM recommendations".

RECOMMENDATION GSM 04.08 - DCS

Title: **Mobile Radio Interface Layer 3 Specification**
(based on version 3.13.0 of GSM 04.08)

Date: February 1992

(detailed list of contents given on next pages)

List of Contents:

Number of pages: 82

Detailed list of contents:

1 GENERAL

This Recommendation specifies the procedures used at the radio interface (Reference Point Um, see GSM Rec. 04.02) for call control, mobility management and Radio Resource management.

When the mention for "further study" or "FS" or "FFS" is present throughout this document this means this is not relevant for ETSI-GSM phase 1 standard.

These procedures are defined in terms of messages exchanged over the control channels of the radio interface. The control channels are described in Rec. GSM 04.03.

The structured functions and procedures of this protocol and the relationship with other layers and entities are described in general terms in Rec. GSM 04.07.

1.1 Scope of the Recommendation

The procedures currently described in this Recommendation are for the call control of circuit-switched connections, the control of packet-mode communication, mobility management and radio resource management. The transport of other message-based information flows is a subject for further study.

Procedures for supplementary services are contained in Recommendation GSM 04.10.

Note 1: The term "layer 3" is used for the functions and protocol described in this Recommendation.

The terms "data link layer" and "layer 2" are used interchangeably to refer to the layer immediately below layer 3.
This delta recommendation only includes modified parts concerning specifically the DCS 1800 short term solution (phase 1).

3.2 Idle mode procedures

3.2.1 MS side

In idle mode, the MS listens to the BCCH and to the paging sub-channel for the paging group the MS belongs to (Cf. Rec. GSM 03.13); it measures the radio propagation for connection with other cells.

Measurements are treated to assess the need of a cell change as specified in Rec. GSM 05.08. When a cell change is decided, the MS switches to the BCCH of the new cell. The broadcast information is then checked to verify the allowance to attach to this cell (cf. section 3.2.2). If allowed, the cell change is confirmed, and the broadcast information is then treated for mobility management actions (cf. section 4). Similarly, physical contexts are updated (list of neighbouring cells frequencies, thresholds for some actions, etc... cf. Rec. GSM 05.08 and section 3.2.2).

3.2.2 Network side

3.2.2.1 System information broadcasting

SYSTEM INFORMATION TYPE 1 to 4 messages, and optionaly TYPE 2bis, are regularly broadcast by the network on the BCCH. Based on this information the Mobile Station is able to decide whether and how it may gain access to the system via the current cell.

Note: The exact order of sending SYSTEM INFORMATION messages on the BCCH is specified in Rec. GSM 05.02.
The same information is sent in SYSTEM INFORMATION TYPE 5~~-and~~, 6 and optionaly 5bis, on the SACCH just after handover, and whenever there is no other use of that channel.

The information broadcast may be grouped in the following classes:

- information giving unique identification of the current network, location area and cell;

- information used for cell selection and candidate cell measurements for handover procedures;

- information describing the current control channel structure;

- information controlling the random access channel utilisation; and

- information defining different options supported within the cell.

3.2.2.2 Paging

The network is required to send valid layer 3 messages continuously on all paging subchannels.

4.4.1 Location updating procedure

The location updating procedure is a general procedure which is used for the following purposes:

- normal location updating (described in this section);
- periodic updating (see section 4.4.2);
- IMSI attach (see section 4.4.3).

The normal location updating procedure is used to update the registration of the actual Location Area of a Mobile Station in the network. The location updating type information element in the LOCATION UPDATING REQUEST message shall indicate normal location updating. The location updating procedure is only performed if a subscriber identity module is available in the Mobile Station. It is initiated when the Location Area Identification received on the BCCH of the current serving cell (chosen as specified in Rec. GSM 05.08) differs from the value stored , e.g. if:

i) the Mobile Station has been switched on in a Location Area different from the one stored in a non volatile memory or when there is no stored Location Area Identification;

ii) the Mobile Station moves across the boundaries of a Location Area while being in the "idle" state;

The location updating procedure is also started if the network indicates that the Mobile Station is unknown in the VLR as a response to MM-connection establishment request.

To limit the number of location updating attempts made, where location updating is unsuccessful, an attempt counter is used. The attempt counter is reset when a Mobile Station is switched on or a SIM card is inserted.

Upon successful location updating the Mobile Station stores the received Location Area Identification in a non-volatile memory and the attempt counter shall be reset.

The detailed handling of the attempt counter is described in 4.4.4.5 to 4.4.4.8.

The Mobile Equipment shall contain a list of "forbidden location areas for national roaming". The list shall be erased when the MS is switched off or when the SIM is removed, and periodically (with period in the range 12 to 24 hours). The location area identification received on the BCCH that triggered the location updating request shall be added to the list whenever a location update reject message is received with the cause "National roaming not allowed in this location area". The list shall accommodate 10 or more location area identifications. When the list is full and a new entry has to be inserted, the oldest entry shall be deleted.

The cell selection processes in the different states are described in Rec. GSM 05.08.

The location updating procedure is always initiated by the Mobile Station.

4.4.4.6 Location updating not accepted by the network

If the location updating cannot be accepted the network sends a LOCATION UPDATING REJECT message to the Mobile Station.
The Mobile Station receiving a LOCATION UPDATING REJECT message shall stop the timer T3210, store the reject cause, start T3240 and enter the location updating rejected state awaiting the release of the RR-connection triggered by the network.
Upon the release of the RR-connection the MS shall take the following actions depending on the stored reject cause:

2 (IMSI unknown in HLR), or
3 (Illegal MS):
For the Mobile Station this corresponds to authentication failure. The Mobile Station shall delete any TMSI, stored LAI, cipher key and cipher key sequence number and enter the "idle, no IMSI" state. In this state the Mobile Station shall act in the following way:

- not start any normal location updating attempt
- not perform periodic updating
- not perform IMSI detach if powered down
- reject any requests from CM entities for MM-connections except emergency calls
- not respond to paging

11 (PLMN not allowed):
12 (Location Area not allowed):

The Mobile Station shall delete any TMSI, cipher key and cipher key sequence number, reset the attempt counter and in the case of normal location updating, store the LAI received on the BCCH that triggered the location updating request, and then enter the "idle, roaming not allowed" state and memorize which of the above mentioned causes has been received. In this state, it shall in case of "Location Area not allowed":

- perform normal location updating when a new location area is entered - not perform periodic updating
- not perform IMSI detach
- not perform IMSI attach if activated in the same location area
- reject any requests from CM entities for MM-connections except emergency calls
- respond to paging (with IMSI) when roaming not allowed in this area.

In case of "PLMN not allowed", it shall:

- perform normal location updating when a new PLMN is entered
- not perform periodic updating
- not perform IMSI detach
- not perform IMSI attach if activated in the same location area
- reject any requests from CM entities for MM connections except emergency calls, and
- it may respond to paging (with IMSI).

13 (National roaming not allowed in this location area)

The Mobile Station shall reset the attempt counter, add to the "list of forbidden location areas for national roaming", the location area identification received on the BCCH that triggered the location updating request, and perform the cell selection procedure as defined in GSM 05.08 - DCS, with the HPLMN as the selected PLMN (see GSM 02.11 - DCS).

Other values are considered as abnormal cases and the specification of the MS behaviour in those cases is given in section 4.4.4.8.

9.1 Messages for radio resources management

Table 9.1/GSM 04.08 summarizes the messages for radio resources management.

Channel establishment messages:	**Reference**
ADDITIONAL ASSIGNMENT	9.1.1
IMMEDIATE ASSIGNMENT	9.1.17
IMMEDIATE ASSIGNMENT EXTENDED	9.1.18
IMMEDIATE ASSIGNMENT REJECT	9.1.19
Ciphering messages:	**Reference**
CIPHERING MODE COMMAND	9.1.9
CIPHERING MODE COMPLETE	9.1.10
Handover messages:	**Reference**
ASSIGNMENT COMMAND	9.1.2
ASSIGNMENT COMPLETE	9.1.3
ASSIGNMENT FAILURE	9.1.4
HANDOVER ACCESS	9.1.13
HANDOVER COMMAND	9.1.14
HANDOVER COMPLETE	9.1.15
HANDOVER FAILURE	9.1.16
PHYSICAL INFORMATION	9.1.27
Channel release messages:	**Reference**
CHANNEL RELEASE	9.1.7
PARTIAL RELEASE	9.1.25
PARTIAL RELEASE COMPLETE	9.1.26
Paging messages:	**Reference**
PAGING REQUEST TYPE 1	9.1.21
PAGING REQUEST TYPE 2	9.1.22
PAGING REQUEST TYPE 3	9.1.23
PAGING RESPONSE	9.1.24

TABLE 9.1/GSM 04.08
Messages for radio resources management

System information messages:	Reference
SYSTEM INFORMATION TYPE 1	9.1.29
SYSTEM INFORMATION TYPE 2	9.1.30
SYSTEM INFORMATION TYPE 2bis	9.1.30a
SYSTEM INFORMATION TYPE 3	9.1.31
SYSTEM INFORMATION TYPE 4	9.1.32
SYSTEM INFORMATION TYPE 5	9.1.33
SYSTEM INFORMATION TYPE 5bis	9.1.33a
SYSTEM INFORMATION TYPE 6	9.1.34
Miscellaneous messages:	**Reference**
CHANNEL MODE MODIFY	9.1.5
CHANNEL MODE MODIFY ACKNOWLEDGE	9.1.6
CHANNEL REQUEST	9.1.8
CLASSMARK CHANGE	9.1.11
FREQUENCY REDEFINITION	9.1.12
MEASUREMENT REPORT	9.1.20
SYNCHRONISATION CHANNEL INFORMATION	9.1.28
RR-STATUS	9.1.27a

TABLE 9.1/GSM 04.08
Messages for radio resources management
(continued)

9.1.2 Assignment command

This message is sent on the main DCCH by the network to the mobile station to change the channel configuration to another independent dedicated channel configuration, no timing adjustment needed. See Table 9.3/GSM 04.08

Message type: ASSIGNMENT COMMAND
Significance: dual
Direction: network to mobile station

Information element	Reference	Direction	Type	Length
Protocol discriminator	10.2	n -> ms	MF	
Transaction identifier	10.3	n -> ms	MF	2
Message type	10.4	n -> ms	MF	
Channel description	10.5.2.5	n -> ms	MF	3
Power command	10.5.2.16	n -> ms	MF	1
~~Frequency list 7)~~	~~10.5.2.9a~~	~~n -> ms~~	~~OV~~	~~4-131~~
Cell channel descr. 6)	10.5.2.1	n -> ms	OF	17
Channel mode 1)	10.5.2.6	n -> ms	OF	2
Channel description 2)	10.5.2.5	n -> ms	OF	4
Channel mode 2 3)	10.5.2.6a	n -> ms	OF	2
Mobile allocation 4)	10.5.2.12	n -> ms	OV	2-10
Starting time 5)	10.5.2.20	n -> ms	OF	3

TABLE 9.3/GSM 04.08
ASSIGNMENT COMMAND message content

Note 1: This information element appears if the channel mode is changed for the channel defined in the mandatory part of the message

Note 2: This information element appears in the case of a so-called intracell handover or an assignment occuring after a call reestablishment if the MS carries two connections (on two dedicated channels, e.g. Lm+Lm).
The connection using the channel previously defined in the mandatory part of an ASSIGNMENT COMMAND or HANDOVER COMMAND message shall use the channel defined in the mandatory part of the ASSIGNMENT COMMAND message defining the new configuration.
The first indicated channel (i.e. in the mandatory part) carries the main DCCH. The SACCH used is the one associated with that channel.

Note 3: this information element apears if te channel mode is changed for the channel defined in the optional channel description information element.

Note 4: This information element appears in the case of frequency hopping. It applies to all assigned channels. This element shall not be included if the frequency list information element is present.

Note 5: This information element appears in particular if a frequency change is in progress.

Note 6: This information element if present must be used to decode the mobile allocation in the same message and in subsequent messages.

Note 7: This information element provides the mobile allocation used for frequency hopping. If this element is present, then the cell channel description information element is not required, and the mobile allocation information element shall not be included.

9.1.14 Handover command

This message is sent on the main DCCH by the network to the mobile station to change the dedicated channel configuration, timing adjustment needed. See Table 9.15/GSM 04.08.

Message type: HANDOVER COMMAND
Significance: dual
Direction: network to mobile station

Information element	Reference	Direction	Type	Length
Protocol discriminator	10.2	n -> ms	MF	
Transaction identifier	10.3	n -> ms	MF	2
Message type	10.4	n -> ms	MF	
Cell description	10.5.2.2	n -> ms	MF	2
Channel description	10.5.2.5	n -> ms	MF	3
Handover reference	10.5.2.10	n -> ms	MF	1
Power command	10.5.2.16	n -> ms	MF	1
Synchronisation indication 1)	10.5.2.21	n -> ms	OF	1
~~Frequency short list 9)~~	~~10.5.2.9b~~	~~n -> ms~~	~~OF~~	~~10~~
~~Frequency list 9)~~	~~10.5.2.9a~~	~~n -> ms~~	~~OV~~	~~4-131~~
Cell channel description 2)	10.5.2.1	n -> ms	OF	17
Channel mode 3)	10.5.2.6	n -> ms	OF	2
Channel description 4)	10.5.2.5	n -> ms	OF	4
Channel mode 2 5)	10.5.2.6a	n -> ms	OF	2
Frequency channel sequence 6)	10.5.2.9	n -> ms	OF	10
Mobile allocation 7)9)	10.5.2.12	n -> ms	OV	2-10
Starting time 8)	10.5.2.20	n -> ms	OF	3

TABLE 9.15/GSM 04.08
HANDOVER COMMAND message content

Note 1: If this information element is omitted, the default value is "non-synchronized".

Note 2: This information element appears if frequency hopping is used on the new cell.

Note 3: this element appears if the channel mode is changed for the channel defined in the mandatory part of the message.

Note 4: This information element appears if the MS carries two connections (on two dedicated channels, e.g. Lm+Lm).
The connection using the channel previously defined in the mandatory part of an ASSIGNMENT COMMAND or HANDOVER COMMAND message shall use the channel defined in the mandatory part of the HANDOVER COMMAND message defining the new configuration.
The first indicated channel (i.e. in the mandatory part) carries the main DCCH. The SACCH used is the one associated with that channel.

Note 5: This element appears if the channel mode is changed for the channel defined in the optional channel description information element.

Note 6: ~~This element is a combination of mobile allocation element and cell channel description element. It is designed to allow the sending of the HANDOVER COMMAND in one signalling block for systems using frequency hopping. If this element is present, then the cell channel description and mobile allocation information elements are not required.~~ This element shall not be included for DCS1800 application.

Note 7: This information element appears if frequency hopping is used on the new cell. If it appears, it applies to all assigned channels. This information element cannot appear if the cell channel description information element is not present.

Note 8: This information element appears if a frequency change is in progress. It refers to the new cell time.

Note 9: One and only one of thhese information elements appears if the allocated channels are frequency hopping channels. They apply to all allocated channels

9.1.30a System information type 2bis

This message is sent optionnally on the BCCH by the network to all mobile stations within the cell giving information of control of the RACH and of the extension of the BCCH allocation in the neighbour cells. See Table 9.31a/GSM 04.08.

Message type: SYSTEM INFORMATION TYPE 2bis
Significance: dual
Direction: network to mobile station

Information element	Reference	Direction	Type	Length
Protocol discriminator	10.2	n -> ms	MF	2
Transaction identifier	10.3	n -> ms	MF	
Message type	10.4	n -> ms	MF	
Neighbour cells desc- -ription (extension)	10.5.2.13	n -> ms	MF	16
RACH control parameters	10.5.2.17	n -> ms	MF	3

TABLE 9.31a/GSM 04.08
SYSTEM INFORMATION TYPE 2bis message content

9.1.33a System information type 5bis

This message is sent optionnally on the SACCH by the network to mobile stations within the cell giving information on the extension of the BCCH allocation in the neighbour cells. See Table 9.34a/GSM 04.08.

Message type: SYSTEM INFORMATION TYPE 5bis
Significance: dual
Direction: network to mobile station

Information element	Reference	Direction	Type	Length
Protocol discriminator	10.2	n -> ms	MF	
Transaction identifier	10.3	n -> ms	MF	2
Message type	10.4	n -> ms	MF	
Neighbour cells descr- -ription (extension)	10.5.2.13	n -> ms	MF	16

TABLE 9.34a/GSM 04.08
SYSTEM INFORMATION TYPE 5bis message content

10.4 Message Type

The purpose of the message type is to identify the function of the message being sent.

The message type is the third part of every message . The message type is coded as shown in Figure 10.4/GSM 04.08 and Tables 10.3-10.5/GSM 04.08.

Bit 8 is reserved for possible future use as an extension bit.

Bit 7 in the MM- and CM-messages sent from the mobile station is reserved for the send sequence number N(SD) (see section 2.4.1) In all other messages bit 7 is set to 0.

8	7	6	5	4	3	2	1	
0	N(SD)	Message type						octet 1

FIGURE 10.4/04.08
Message type

Messages with different protocol discriminators are permitted to have the same message type i.e. the function of a message is determined by the protocol discriminator and the message type together.

8 7 6 5 4 3 2 1	
0 0 1 1 1 - - -	Channel establishment messages:
0 1 1	- ADDITIONAL ASSIGNMENT
1 1 1	- IMMEDIATE ASSIGNMENT
0 0 1	- IMMEDIATE ASSIGNMENT EXTENDED
0 1 0	- IMMEDIATE ASSIGNMENT REJECT
0 0 1 1 0 - - -	Ciphering messages:
1 0 1	- CIPHERING MODE COMMAND
0 1 0	- CIPHERING MODE COMPLETE
0 0 1 0 1 - - -	Handover messages:
1 1 0	- ASSIGNMENT COMMAND
0 0 1	- ASSIGNMENT COMPLETE
1 1 1	- ASSIGNMENT FAILURE
0 1 1	- HANDOVER COMMAND
1 0 0	- HANDOVER COMPLETE
0 0 0	- HANDOVER FAILURE
1 0 1	- PHYSICAL INFORMATION
0 0 0 0 1 - - -	Channel release messages:
1 0 1	- CHANNEL RELEASE
0 1 0	- PARTIAL RELEASE
1 1 1	- PARTIAL RELEASE COMPLETE
0 0 1 0 0 - - -	Paging messages:
0 0 1	- PAGING REQUEST TYPE 1
0 1 0	- PAGING REQUEST TYPE 2
1 0 0	- PAGING REQUEST TYPE 3
1 1 1	- PAGING RESPONSE

TABLE 10.3/GSM 04.08 (page 1 of 2)
Message types for radio resources management

8 7 6 5 4 3 2 1	
0 0 0 1 1 - - -	System information messages:
0 0 1	- SYSTEM INFORMATION TYPE 1
0 1 0	- SYSTEM INFORMATION TYPE 2
0 1 1	- SYSTEM INFORMATION TYPE 3
1 0 0	- SYSTEM INFORMATION TYPE 4
1 0 1	- SYSTEM INFORMATION TYPE 5
1 1 0	- SYSTEM INFORMATION TYPE 6
0 0 0 0 0 - - -	System information messages:
0 1 0	- SYSTEM INFORMATION TYPE 2bis
1 0 1	- SYSTEM INFORMATION TYPE 5bis
0 0 0 1 0 - - -	Miscellaneous messages:
0 0 0	- CHANNEL MODE MODIFY
1 1 1	- CHANNEL MODE MODIFY ACKNOWLEDGE
1 0 0	- FREQUENCY REDEFINITION
1 0 1	- MEASUREMENT REPORT
1 1 0	- CLASSMARK CHANGE

TABLE 10.3/GSM 04.08 (page 2 of 2)
Message types for radio resources management

Note: Bit 8 is reserved for possible future use as an extension bit.

10.5.2 Radio resources management information elements.

For the radio resources management information elements listed below, the coding of the information element identifier bits is summarized in Table 10.13/GSM 04.08.

		Reference section	Length in octets 1)
8 7 6 5 4 3 2 1			
1 : : : - - - -	Type 1 info elements		
0 0 1 - - - -	Cipher mode setting	10.5.2.7	F1
0 1 1 - - - -	Page mode	10.5.2.14	F1
1 0 1 - - - -	Synchronisation indication	10.5.2.21	F1
0 : : : : : : :	Type 3 & 4 info elements		
0 0 0 0 0 1 0	Frequency short list	10.5.2.9b	F10
0 0 0 0 1 0 1	Frequency list	10.5.2.9a	Max 131
1 1 0 0 0 0 1	Cell description	10.5.2.2	F3
1 1 0 0 0 1 0	Cell channel description	10.5.2.1	F17
1 1 0 0 0 1 1	Channel mode	10.5.2.6	F2
1 1 0 0 1 0 0	Channel description	10.5.2.5	F4
1 1 0 0 1 1 0	Channel mode 2	10.5.2.6a	F2
1 1 0 1 0 0 0	Control channel description	10.5.2.8	F4
1 1 0 1 0 0 1	Frequency channel sequence	10.5.2.9	F10
1 1 0 1 0 1 0	Handover reference	10.5.2.10	F2
1 1 0 1 0 1 1	Cell options	10.5.2.3	F2
1 1 0 1 1 0 0	Cell selection parameters	10.5.2.4	F3

TABLE 10.13/GSM 04.08 (page 1 of 2)
Information element identifier coding for radio resources management information elements

	Reference section	Length in octets 1)
8 7 6 5 4 3 2 1		
1 1 1 0 0 0 1 Measurement results	10.5.2.11	F17
1 1 1 0 0 1 0 Mobile allocation	10.5.2.12	Max. 10
1 1 1 0 1 0 0 Neighbour cells description	10.5.2.13	F17
1 1 1 0 1 0 1 Power command	10.5.2.16	F2
1 1 1 0 1 1 0 PLMN permitted	10.5.2.15	F2
1 1 1 1 0 0 0 RACH control param.	10.5.2.17	F4
1 1 1 1 0 0 1 Request reference	10.5.2.18	F4
1 1 1 1 0 1 0 RR cause	10.5.2.19	F2
1 1 1 1 1 0 0 Starting time	10.5.2.20	F3
1 1 1 1 1 0 1 Timing advance	10.5.2.22	F2
1 1 1 1 1 1 0 TMSI	10.5.2.23	F5
1 1 1 1 1 1 1 Wait indication	10.5.2.24	F2
All other values are reserved 2)		

TABLE 10.13/GSM 04.08 (page 2 of 2)
Information element identifier coding for radio resources management information elements

Note 1: For fixed length information elements the length is indicated as F length value e.g. F3. For variable length information elements the length is indicated as Max length value e.g. Max 10.
The indicated length is the length included information element identifier and a possible length indicator. When an information element is mandatory in a message the length is reduced with 1 octet as the information element identifier is stripped off.

Note 2: The reserved value with bits 5-8 coded "0000" are for future information elements for which comprehension by the receiver is required (see section 8.8.1 Unrecognized information element).

10.5.2.1 Cell channel description

The purpose of the cell channel description information element is to provide the ~~absolute-radio-frequency--channel-numbers-used-in-a-cell~~ the reference frequency list to be used to decode the mobile allocation information element.

~~The-cell-channel-description-information-element-is-coded-as-shown-in-Figure 10.20/GSM-04.08-and-Table-10.14/GSM-04.08.~~

The cell channel description is a type 3 information element with 17 octets length.

There are several formats for the cell channel description information element, distinguished by the "format indicator" subfield. Some formats are frequency bit maps, the others use a special encoding scheme.

10.5.2.1.1 General description

Figure 10.20/04.08 shows only a special bit numbering. The different general format is described in Table 10.14/04.08.

8	7	6	5	4	3	2	1	
0	1	1	0	0	0	1	0	octet 1
	Cell channel description IEI							
Bit 128	Bit 127	EXT-IND	0 spare	Bit 124	Bit 123	Bit 122	Bit 121	octet 2
Bit 120	Bit 119	Bit 118	Bit 117	Bit 116	Bit 115	Bit 114	Bit 113	octet 3
Bit 008	Bit 007	Bit 006	Bit 005	Bit 004	Bit 003	Bit 002	Bit 001	octet 17

FIGURE 10.20/GSM 04.08
Cell Channel description information element (general format)

~~CA-NO, Cell allocation number (octet 2)~~
~~Bits~~
~~8 7~~
~~0 0 Band number 0~~

~~All other values are reserved~~

EXT-IND, Extension indication (octet 2, bit 6)

This bit indicates whether the information element carries the complete CA or whether a complementary information element is sent in another message.

Note : This indicator is set to 1 in the two cell channels description information fields when two are needed to describe the frequency list.

Bit 6

0	The information elements carries the complete CA
1	The information elements carries only a part of the CA

FORMAT-ID, Format Identifier (Bit 128 and next)

The different formats are distinguished by the bits of higher number. The possible values are the following :

Bit 128	Bit 127	Bit 124	Bit 123	Bit 122	format notation
0	0	X	X	X	bit map 0
1	0	0	X	X	1024 range
1	0	1	0	0	512 range
1	0	1	0	1	256 range
1	0	1	1	0	128 range
1	0	1	1	1	variable bit map

All other combinations are reserved for future use.

The signification of the remaining bits depends on FORMAT-ID. The different cases are specified in the next sections.

TABLE 10.14/GSM 04.08
Cell channel description information element, general format

10.5.2.1.2 Bit map 0 format

8	7	6	5	4	3	2	1	
0	1	1	0	0	0	1	0	octet 1
	Cell channel description IEI							
0 0 CA-NO FORMAT-ID		EXT-IND	0 spare	CA ARFCN 124	CA ARFCN 123	CA ARFCN 122	CA ARFCN 121	octet 2
CA ARFCN 120	CA ARFCN 119	CA ARFCN 118	CA ARFCN 117	CA ARFCN 116	CA ARFCN 115	CA ARFCN 114	CA ARFCN 113	octet 3
CA ARFCN 008	CA ARFCN 007	CA ARFCN 006	CA ARFCN 005	CA ARFCN 004	CA ARFCN 003	CA ARFCN 002	CA ARFCN 001	octet 17

FIGURE 10.20a/GSM 04.08
Cell Channel description information element, bit map 0 format

CA-NO, Cell allocation number (octet 2)
Bits
8 7
0 0 Band number 0
All other values are reserved
CA ARFCN N, Cell Allocation Absolute RF Channel Number N (octet 2 etc.)
For a RF channel with ARFCN = N belonging to the cell allocation the CA ARFCN N bit is coded with a "1"; N = 1, 2, .. , 124.
For a RF channel with ARFCN = N not belonging to the cell allocation the CA ARFCN N bit is coded with a "0"; N = 1, 2 .. , 124.

TABLE 10.14a/GSM 04.08
Cell channel description information element, bit map 0 format

10.5.2.1.3 Range 1024 format

8	7	6	5	4	3	2	1	
0	1 Cell channel description IEI	1	0	0	0	1	0	octet 1
1	0 FORMAT-ID	EXT-IND	0 spare	0 FORMAT-ID	F0	W(1) (high part)		octet 2
W(1) (low part)								octet 3
W(2) (high part)								octet 4
W(2) (low)	W(3) (high part)							octet 5
W(3) (low part)		W(4) (high part)						octet 6
W(4) (low part)		W(5) (high part)						octet 7
W(5) (low part)		W(6) (high part)						octet 8
W(6) (low part)		W(7) (high part)						octet 9
W(7) (low part)		W(8) (high part)						octet 10
W(8) (low)	W(9)							octet 11
W(10)							W(11) high	octet 12
W(11) (low part)						W(12) (high part)		octet 13
W(12) (low part)					W(13) (high part)			octet 14
W(13) (low part)				W(14) (high part)				octet 15
W(14) (low part)			W(15) (high part)					octet 16
W(15) (low part)		W(16)						octet 17

FIGURE 10.20b/GSM 04.08
Cell Channel description information element (1024 range format)

FO, frequency 0 indicator (octet 2, bit 4) :
0 frequency of ARFCN 0 is not in the list 1 frequency of ARFCN 0 is in the list
W(i), i from 1 to 16 (octet 2 to 17) :
Each W(i) encodes a non negative integer in binary format.
If W(k) is null, W(k+1) to W(16) must be null also.
Each non null W(k) allows to compute, together with some previous W(i) the ARFCN F(k) of a frequency in the set. The computation formulas are given in section 10.5.2.9a.3.

TABLE 10.14b/GSM 04.08
Cell channel description information element, range 1024 format

10.5.2.1.4 Range 512 format

8	7	6	5	4	3	2	1	
0	1	1	0	0	0	1	0	octet 1
	Cell channel description IEI							
1	0	EXT-IND	0 spare	1	0	0	ORIG-ARFCN high	octet 2
FORMAT-ID				FORMAT-ID				
ORIG-ARFCN (middle part)								octet 3
ORIG-ARFCN low	W(1) (high part)							octet 4
W(1) (low part)		W(2) (high part)						octet 5
W(2) (low part)		W(3) (high part)						octet 6
W(3) (low part)		W(4) (high part)						octet 7
W(4) low	W(5)							octet 8
W(6)							W(7) high	octet 9
W(7) (low part)						W(8) (high part)		octet 10
W(8) (low part)				W(9) (high part)				octet 11
W(9) (low part)		W(10)						octet 12
W(11)						W(12) (high part)		octet 13
W(12) (low part)				W(13) (high part)				octet 14
W(13) (low part)		W(14)						octet 15
W(15)						W(16) (high part)		octet 16
W(16) (low part)			W(17)					octet 17

FIGURE 10.20c/GSM 04.08
Cell Channel description information element (512 range format)

ORIG-ARFCN, origin ARFCN (octet 2, 3 and 4)
This field encodes the ARFCN of a frequency in the set. This value is also used to decode the rest of the element.
W(i), i from 1 to 17 (octet 4 to 17) :
Each W(i) encodes a non negative integer in binary format.
If W(k) is null, W(k+1) to W(17) must be null also.
Each non null W(k) allows to compute, together with some previous W(i) the ARFCN F(k) of a frequency in the set. The computation formulas are given in section 10.5.2.9a.4.

TABLE 10.14c/GSM 04.08
Cell channel description information element, range 512 format

10.5.2.1.5 Range 256 format

<table>
<tr><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th></th></tr>
<tr><td>0</td><td colspan="7">1 1 0 0 0 1 0
Cell channel description IEI</td><td>octet 1</td></tr>
<tr><td colspan="2">1 0
FORMAT-ID</td><td>EXT-
IND</td><td>0
spare</td><td colspan="3">1 0 1
FORMAT-ID</td><td>ORIG-
ARFCN
high</td><td>octet 2</td></tr>
<tr><td colspan="8">ORIG-ARFCN (middle part)</td><td>octet 3</td></tr>
<tr><td>ORIG-
ARFCN
low</td><td colspan="7">W(1)
(high part)</td><td>octet 4</td></tr>
<tr><td>W(1)
low</td><td colspan="7">W(2)</td><td>octet 5</td></tr>
<tr><td colspan="7">W(3)</td><td>W(4)
high</td><td>octet 6</td></tr>
<tr><td colspan="5">W(4) (low part)</td><td colspan="3">W(5) (high part)</td><td>octet 7</td></tr>
<tr><td colspan="3">W(5) (low part)</td><td colspan="5">W(6) (high part)</td><td>octet 8</td></tr>
<tr><td>W(6)
low</td><td colspan="6">W(7)</td><td>W(8)
high</td><td>octet 9</td></tr>
<tr><td colspan="4">W(8) (low part)</td><td colspan="4">W(9) (high part)</td><td>octet10</td></tr>
<tr><td>W(9)
low</td><td colspan="5">W(10)</td><td colspan="2">W(11)
(high part)</td><td>octet 11</td></tr>
<tr><td colspan="3">W(11) (low part)</td><td colspan="5">W(12)</td><td>octet 12</td></tr>
<tr><td colspan="5">W(13)</td><td colspan="3">W(14)(high part)</td><td>octet 13</td></tr>
<tr><td colspan="2">W(14)
low</td><td colspan="5">W(15)</td><td>W(16)
high</td><td>octet 14</td></tr>
<tr><td colspan="3">W(16)
(low part)</td><td colspan="4">W(17)</td><td>W(18)
high</td><td>octet 15</td></tr>
<tr><td colspan="3">W(18)
(low part)</td><td colspan="4">W(19)</td><td>W(20)
high</td><td>octet 16</td></tr>
<tr><td colspan="3">W(20)
(low part)</td><td colspan="4">W(21)</td><td>0</td><td>octet 17</td></tr>
</table>

FIGURE 10.20d/GSM 04.08
Cell channel description information element, range 256 format

ORIG-ARFCN, origin ARFCN (octet 2, 3 and 4)
This field encodes the ARFCN of a frequency in the set. This value is also used to decode the rest of the element.
W(i), i from 1 to 21 (octet 4 to 17) :
Each W(i) encodes a non negative integer in binary format.
If W(k) is null, W(k+1) to W(21) must be null also.
Each non null W(k) allows to compute, together with some previous W(i) the ARFCN F(k) of a frequency in the set. The computation formulas are given in section 10.5.2.9a.5.

TABLE 10.14d/GSM 04.08
Cell channel description information element, range 256 format

10.5.2.1.6 Range 128 format

8	7	6	5	4	3	2	1	
0	1 Cell channel description IEI	1	0	0	0	1	0	octet 1
1 FORMAT-ID	0	EXT-IND	0 spare	1 FORMAT-ID	1	0	ORIG-ARFCN high	octet 2
ORIG-ARFCN (middle part)								octet 3
ORIG-ARFCN low	W(1)							octet 4
W(2)						W(3) (high part)		octet 5
W(3) (low part)				W(4) (high part)				
W(4) low	W(5)					W(6) (high part)		octet 7
W(6) (low part)			W(7)					octet 8
W(8)				W(9)				octet 9
W(10)				W(11)				octet 10
W(12)				W(13)				octet 11
W(14)				W(15)				octet 12
W(16)			W(17)			W(18) (high part)		octet 13
W(18) low	W(19)			W(20)			W(21) high	octet 14
W(21) (low part)		W(22)			W(23)			octet 15
W(24)			W(25)			W(26) (high part)		octet 16
W(26) low	W(27)			W(28)			0 spare	octet 17

FIGURE 10.20e/GSM 04.08
Cell channel description information element, range 128 format

ORIG-ARFCN, origin ARFCN (octet 2, 3 and 4)
This field encodes the ARFCN of a frequency in the set. This value is also used to decode the rest of the element.
W(i), i from 1 to 28 (octet 4 to 17) :
Each W(i) encodes a non negative integer in binary format.
If W(k) is null, W(k+1) to W(28) must be null also.
Each non null W(k) allows to compute, together with some previous W(i) the ARFCN F(k) of a frequency in the set. The computation formulas are given in section 10.5.2.9a.6.

TABLE 10.14e/GSM 04.08
Cell channel description information element, range 128 format

10.5.2.1.7 Variable bit map format

8	7	6	5	4	3	2	1	
0	1	1	0	0	0	1	0	octet 1
	Cell channel description IEI							
1 0 FORMAT-ID		EXT-IND	0 spare	1 1 1 FORMAT-ID			ORIG-ARFCN high	octet 2
ORIG-ARFCN (middle part)								octet 3
ORIG-ARFCN low	RRFCN 1	RRFCN 2	RRFCN 3	RRFCN 4	RRFCN 5	RRFCN 6	RRFCN 7	octet 4
RRFCN 104	RRFCN 105	RRFCN 106	RRFCN 107	RRFCN 108	RRFCN 109	RRFCN 110	RRFCN 111	octet 17

FIGURE 10.20f/GSM 04.08
Cell channel description information element, variable bit map format

ORIG-ARFCN, origin ARFCN (octet 2, 3 and 4)
This field encodes the ARFCN of a frequency in the set. This value is also used as origin of the bit map.
RRFCN N, relative radio frequency channel number N (octet 4 etc.)
For a RF channel with ARFCN = (ORIG-ARFCN + N) mod 1024 belonging to the set, RRFCN N bit is coded with a "1": N = 1, 2, .. , 111
For a RF channel with ARFCN = (ORIG-ARFCN + N) mod 1024 not belonging to the set, RRFCN N bit is coded with a "0": N = 1, 2, .. , 111

TABLE 10.14f/GSM 04.08
Cell channel description information element, variable bit map format

10.5.2.2 Cell description

The purpose of the cell description information element is to provide a minimum description of a cell, e.g. to allow the mobile station to use its preknowledge about synchronization.

The cell description information element is coded as shown in Figure 10.21/GSM 04.08 and Table 10.15/GSM 04.08.

The cell description is a type 3 information element with 3 octets length.

8	7	6	5	4	3	2	1	
0	1 cell description IEI	1	0	0	0	0	1	octet 1
BCCH ARFCN (high part) ~~BA-NO~~		NCC			BCC			octet 2
~~BCCH-carrier-number~~ BCCH ARFCN (low part)								octet 3

FIGURE 10.21/GSM 04.08
Cell description information element

BA-NO, BCCH allocation number (octet 2)
Bits
8 7
0 0 Band number 0

All other values are reserved

NCC, PLMN colour code (octet 2)
The NCC field is coded as the binary representation of the PLMN colour code (see Rec. GSM 03.03)

BCC, BS colour code (octet 2)
The BCC field is coded as the binary representation of the BS colour code (see Rec. GSM 03.03).

BCCH carrier number (octet 3)
BCCH ARFCN (octet 2, bits 7 and 8, and octet 3)

The BCCH carrier ARFCN field is coded as the binary representation of the BCCH carrier absolute RF channel number (see rec 05.05).

Range : 1 to 124 0 to 1023

All other values are reserved.

TABLE 10.15/GSM 04.08
Cell description information element

10.5.2.5 Channel description

The purpose of the channel description information element is to provide a description of an allocatable channel together with its SACCH.

The channel description information element is coded as shown in Figure 10.24/GSM 04.08 and Table 10.18/GSM 04.08.

The channel description is a type 3 information element with 4 octets length.

8	7	6	5	4	3	2	1	
0	1 Channel description IEI	1	0	0	1	0	0	octet 1
Channel type and TDMA offset					TN			octet 2
TSC			H=1-> H	MAIO (high part)		FB-NO / ARFCN (high part)		octet 3
			H=0->	spare		ARFCN (high part)		
MAIO (low part)		HSN						octet 4
spare		ARFCN ARFCN (low part)						

FIGURE 10.24/GSM 04.08
Channel description information element

Channel type and TDMA offset (octet 2)

Bits 8 7 6 5 4	
0 0 0 0 1	Bm + ACCHs
0 0 0 1 T	Lm + ACCHs
0 0 1 T T	SDCCH/4 + SACCH/C4
0 1 T T T	SDCCH/8 + SACCH/C8

The T bits indicate the subchannel number coded in binary.

All other values are reserved.

TN, Timeslot number (octet 2)
The TN field is coded as the binary representation of the timeslot number.

Range: 0 to 7.

TSC, Training Sequence Code (octet 3)
The TSC field is coded as the binary representation of the Training Sequence Code
H, Hopping channel (octet 3)

Bit 5	
0	Single RF channel
1	RF hopping channel

Note: The value of H affects the semantics of the channel selector field.

Channel selector (octet 3 and 4)
H = "0": The channel selector field consists of ~~the cell allocation number, FB-N0,~~ and the absolute RF channel number

Octet 3

Bits 4 3	
0 0	Spare

~~FB-N0, (octet 3)~~
~~Bits~~
~~2 1~~
~~0 0 Band number 0~~
~~All other values are reserved.~~

~~Octet 4~~
~~bit~~
~~8~~
~~0 Spare~~

TABLE 10.18/GSM 04.08
Channel description information element

ARFCN, (octet 3, bits 2 and 1, and
octet 4, bits 7-8 to 1)
The ARFCN is coded as the binary representation of the absolute RF channel number (see Rec GSM 05.05)

Range-1-to-124 0 to 1023.

All other values are reserved.

H = "1": The channel selector field consists of the mobile allocation index offset, MAIO, and the hopping sequence number, HSN.

MAIO, (octet 3 bit 4 to 1 high part and
octet 4 bit 8 to 7 low part)
The MAIO field is coded as the binary representation of the mobile allocation index offset.

Range: 0 to 63.

All other values are reserved.

HSN, (octet 4 bit 6 to 1)
The HSN field is coded as the binary representation of the hopping sequence number.

Range 0 to 63.

TABLE 10.18/GSM 04.08
Channel description information element

10.5.2.9 Frequency channel sequence

The purpose of the frequency channel sequence is to provide the absolute radio frequency channel numbers used in the mobile hopping sequence. This information element can only be used for radio frequency channels ~~in GSM band 0~~ the primary GSM band, ie for channels of ARFCN between 1 and 124.

The frequency channel sequence information element is coded as shown in Figure 10.28/GSM 04.08 and Table 10.22/GSM 04.08.

The frequency channel sequence is a type 3 information element with 10 octets length.

8	7	6	5	4	3	2	1	
0	1	1	0	1	0	0	1	octet 1
	Frequency channel sequence IEI							
0 spare	Lowest ARFCN							octet 2
inc skip of ARFCN 01				inc skip of ARFCN 02				octet 3
:								
inc skip of ARFCN 15				inc skip of ARFCN 16				octet 10

FIGURE 10.28/GSM 04.08
Frequency channel sequence information element

RXLEV-NCELL i, Received signal strength on the i'th neighbouring cell (octet 5, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16)
The RXLEV-NCELL field is coded as the binary representation of a value N. N corresponds according to the mapping defined in Rec. GSM 05.08 to the received signal strength on the i'th neighbouring cell. See note 1 & 2.

Range: 0 to 63.

BCCH-FREQ-NCELL i, BCCH carrier of the i'th neighbouring cell (octet 6, 8, 10, 12, 14, 15, 16 and 17)
The BCCH-FREQ-NCELL i field is coded as the binary representation of--of the position of the i'th neighbouring cells BCCH carrier in the BCCH channel list provided by the reference neigbour cells description information element or elements.
--The-BCCH-channel-list-is-the-list-of-absolute-------RF-channel-numbers-for-which-the-BA-ARFCN-bit-in-the--neighbour--cells--description-information-element-is-coded-with-a-"1". The absolute RF channel numbers-is are placed in increasing order in the list with the lowest frequency in position 0. See note 1 & 2.

Range: 0 to 31.

BSIC-NCELL i, Base station identity code of the i'th neighbouring cell (octet 6, 7, 8, 9, 10, 11, 13, 15 and 17)
The BSIC-NCELL i field is coded as the binary representation of the base station identity code of the i'th neighbouring cell. See note 1 & 2.

Range: 0 to 63.

Note 1: If the field extends over two octets the highest numbered bit of the lowest numbered octet is the most significant and the lowest numbered bit of the highest numbered octet is the least significant.

Note 2: If NO-NCELL-M < 6 the remaining RXLEV-NCELL i, BS- FREQ-NCELL i and BSIC-NCELL i fields (NO-NCELL-M < i <= 6) should be coded with a "0" in each bit.

TABLE 10.24/GSM 04.08
Measurement results information element (continued)

MA C i, Mobile allocation RF channel i (octet 3 etc.), i = 1, 2,..., NF The MA C i bit indicates whether or not the Mobile allocation frequency list includes the i'th frequency in the cell allocation frequency list provided by the reference cell channel description information element or elements. NF denotes the number of frequencies in the cell allocation frequency list. The absolute RF channel numbers are placed in increasing order in the list with the lowest frequency in position 0. ~~The RF channels represented in the MA C i bit fields are those which in the cell channel description information element are coded with "1"s in the CA ARFCN N bit fields. If NF denotes the number of frequencies in the mobile allocation field then:~~ ~~MA C i = CA ARFCN N(i); i = 1, 2, ..., NF.~~ ~~N(i) is an increasing function of i, i.e. the order of appearance of the RF channels in the mobile allocation field is the same as in the cell allocation field in the cell channel description information element.~~ For a RF channel belonging to the mobile allocation the MA C i bit is coded with a "1"; i = 1, 2,..., NF. For a RF channel not belonging to the mobile allocation the MA C i bit is coded with a "0"; i = 1, 2,..., NF. If NF mod 8 <> 0 then bits NF to 8n in octet 3 must be coded with a "0" in each.

TABLE 10.25/GSM 04.08
Mobile allocation information element

10.5.2.9a Frequency list

The purpose of the frequency list information element is to provide the list of the absolute radio frequency channel numbers used in a frequency hopping sequence.

The frequency list information element a type 4 information element.

There are several formats for the frequency list information element, distinguished by the "format indicator" subfield. Some formats are frequency bit maps, the others use a special encoding scheme.

10.5.2.9a.1 General description

FORMAT-ID, Format Identifier (part of octet 3)					
The different formats are distinguished by the FORAMT-ID field. The possible values are the following :					
Bit 8	Bit 7	Bit 4	Bit 3	Bit 2	format notation
0	0	X	X	X	bit map 0
1	0	0	X	X	1024 range
1	0	1	0	0	512 range
1	0	1	0	1	256 range
1	0	1	1	0	128 range
1	0	1	1	1	variable bit map
All other combinations are reserved for future use.					
The signification of the remaining bits depends on FORMAT-ID. The different cases are specified in the next sections.					

TABLE 10.22a/GSM 04.08
Cell channel description information element, general format

10.5.2.9a.2 Bit map 0 format

8	7	6	5	4	3	2	1	
0	0 Frequency list IEI	0	0	0	1	0	1	octet 1
0 Length of frequency list contents	0	0	1	0	0	0	0	octet 2
0 FORMAT-ID	0	0 spare	0	ARFCN 124	ARFCN 123	ARFCN 122	ARFCN 121	octet 3
ARFCN 120	ARFCN 119	ARFCN 118	ARFCN 117	ARFCN 116	ARFCN 115	ARFCN 114	ARFCN 113	octet 4
ARFCN 008	ARFCN 007	ARFCN 006	ARFCN 005	ARFCN 004	ARFCN 003	ARFCN 002	ARFCN 001	octet 18

FIGURE 10.28a/GSM 04.08
Frequency list information element, bit map 0 format

ARFCN N, Absolute RF Channel Number N (octet 3 etc.) For a RF channel with ARFCN = N belonging to the frequency list the ARFCN N bit is coded with a "1"; N = 1, 2, .. , 124. For a RF channel with ARFCN = N not belonging to the frequency list the ARFCN N bit is coded with a "0"; N = 1, 2 .. , 124.

TABLE 10.22b/GSM 04.08
Frequency list information element, bit map 0 format

10.5.2.9a.3 Range 1024 format

The information element contains a header, and W(1) to W(M) for some M. If, due to octet boundaries, some bits are not used at the end of the last octet, these bits must be set to 0.

8	7	6	5	4	3	2	1	
0	0 Frequency list IEI	0	0	0	1	0	1	octet 1
Length of frequency list contents								octet 2
1 FORMAT-ID	0	0 spare	0 spare	0 FORMAT-ID	FO	W(1) (high part)		octet 3
W(1) (low part)								octet 4

W(2) to W(3) are on 9 bits, when present

W(4) to W(7) are on 8 bits, when present

W(8) to W(15) are on 7 bits, when present

W(16) to W(31) are on 6 bits, when present

W(2^k) to W(2^{k+1}-1) are on 10-k bits when present

and so on

FIGURE 10.28b/GSM 04.08
Frequency list information element (Range 1024 format)

FO, frequency 0 indicator (octet 3, bit 4) :
0 frequency of ARFCN 0 is not in the list 1 frequency of ARFCN 0 is in the list
W(i), i from 1 to M (octet 3 and next) :
Each W(i) encodes a non negative integer in binary format.
If W(k) is null, W(i) for i>k must be null also.
Each non null W(k) allows to compute, together with some previous W(i) the ARFCN F(k) of a frequency in the set. The first computation formulas are given hereafter, with the following conventions :
W_i denotes W(i); F_i denotes F(i); + indicates the natural integer addition; * indicates the natural integer multiplication; n mod m indicates the remainder of the euclidian division of n by m, ie $0 \leq (n \bmod m) \leq m-1$ and there exists k such that $n = (k*m) + (n \bmod m)$;
n smod m indicates the offset remainder of the euclidian division of n by m, ie $1 \leq (n \text{ smod } m) \leq m$ and there exists k such that $n = (k*m) + (n \text{ smod } m)$;
$F_1 = W_1 \text{ smod } 1023$ $F_2 = (W_1 - 512 + W_2) \text{ smod } 1023$ $F_3 = (W_1 + W_3) \text{ smod } 1023$ $F_4 = (W_1 - 512 + (W_2 - 256 + W_4) \text{ smod } 511) \text{ smod } 1023$ $F_5 = (W_1 + (W_3 - 256 + W_5) \text{ smod } 511) \text{ smod } 1023$ $F_6 = (W_1 - 512 + (W_2 + W_6) \text{ smod } 511) \text{ smod } 1023$ $F_7 = (W_1 + (W_3 + W_7) \text{ smod } 511) \text{ smod } 1023$ $F_8 = (W_1 - 512 + (W_2 - 256 + (W_4 - 128 + W_8) \text{ smod } 255) \text{ smod } 511) \text{ smod } 1023$

TABLE 10.22c/GSM 04.08
Frequency list information element, range 1024 format

$F_9 = (W_1 + (W_3 - 256 + (W_5 - 128 + W_9)$
smod 255) smod 511) smod 1023
$F_{10} = (W_1 - 512 + (W_2 + (W_6 - 128 + W_{10})$
smod 255) smod 511) smod 1023
$F_{11} = (W_1 + (W_3 + (W_7 - 128 + W_{11})$
smod 255) smod 511) smod 1023
$F_{12} = (W_1 - 512 + (W_2 - 256 + (W_4 + W_{12})$
smod 255) smod 511) smod 1023
$F_{13} = (W_1 + (W_3 - 256 + (W_5 + W_{13})$
smod 255) smod 511) smod 1023
$F_{14} = (W_1 - 512 + (W_2 + (W_6 + W_{14})$
smod 255) smod 511) smod 1023
$F_{15} = (W_1 + (W_3 + (W_7 + W_{15})$
smod 255) smod 511) smod 1023
$F_{16} = (W_1 - 512 + (W_2 - 256 + (W_4 - 128 +$
$(W_8 - 64 + W_{16})$ smod 127)
smod 255) smod 511) smod 1023

TABLE 10.22c/GSM 04.08
Frequency list information element, range 1024 format (continued)

More generally, the computation of F(K) can be done with the following program, using ADA language (declarative parts are skipped and should be obvious):

```
INDEX := K;
J := GREATEST POWER OF 2 LESSER OR EQUAL TO(INDEX);
N := W(INDEX);
while INDEX>1 loop
  if 2*INDEX < 3*J then
    INDEX := INDEX - J/2;                    -- left child
    N := (N + W(PARENT) - 1024/J - 1) mod
          (2048/J - 1) + 1;
  else                                       -- right child
    INDEX := INDEX - J;
    N := (N + W(PARENT) - 1) mod (2048/J - 1) + 1;
  end if;
  J := J/2;
end loop;
F(K) := N;
```

10.5.2.9a.4 Range 512 format

The information element contains a header, and W(1) to W(M) for some M. If, due to octet boundaries, some bits are not used at the end of the last octet, these bits must be set to 0.

8	7	6	5	4	3	2	1	
0	0	0	0	0	1	0	1	octet 1
	Frequency list IEI							
Length of frequency list contents								octet 2
1	0	0	0	1	0	0	ORIG-ARFCN high	octet 3
FORMAT-ID		spare	spare	FORMAT-ID				
ORIG-ARFCN (middle part)								octet 4
ORIG-ARFCN low	W(1) (high part)							octet 5
W(1) (low part)		W(2) (high part)						octet 6

W(2) to W(3) are on 8 bits, when present

W(4) to W(7) are on 7 bits, when present

W(8) to W(15) are on 6 bits, when present

W(16) to W(31) are on 5 bits, when present

W(2k) to W(2k+1-1) are on 9-k bits when present

and so on

FIGURE 10.28c/GSM 04.08
Frequency list information element (Range 512 format)

ORIG-ARFCN, origin ARFCN (octet 3, 4 and 5)

This field encodes the ARFCN of a frequency in the set. This value is also used to decode the rest of the element.

W(i), i from 1 to M (octet 5 and next) :

Each W(i) encodes a non negative integer in binary format.

If W(k) is null, W(i) for i>k must be null also.

Each non null W(k) allows to compute, together with some previous W(i) the ARFCN F(k) of a frequency in the set. The first computation formulas are given hereafter, with the following conventions :

W_i denotes W(i); W_0 denotes the value of ORIG-ARFCN
F_i denotes F(i);
\+ indicates the natural integer addition;
* indicates the natural integer multiplication;
n mod m indicates the remainder of the euclidian division of n by m, ie $0 \le (n \bmod m) \le m-1$ and there exists k such that $n = (k*m) + (n \bmod m)$;

n smod m indicates the offset remainder of the euclidian division of n by m, ie $1 \le (n \text{ smod } m) \le m$ and there exists k such that $n = (k*m) + (n \text{ smod } m)$;

$F_1 = (W_0 + W_1) \bmod 1024$
$F_2 = (W_0 + (W_1 - 256 + W_2) \text{ smod } 511) \bmod 1024$
$F_3 = (W_0 + (W_1 + W_3) \text{ smod } 511) \bmod 1024$
$F_4 = (W_0 + (W_1 - 256 + (W_2 - 128 + W_4) \text{ smod } 255) \text{ smod } 511) \bmod 1024$
$F_5 = (W_0 + (W_1 + (W_3 - 128 + W_5) \text{ smod } 255) \text{ smod } 511) \bmod 1024$
$F_6 = (W_0 + (W_1 - 256 + (W_2 + W_6) \text{ smod } 255) \text{ smod } 511) \bmod 1024$
$F_7 = (W_0 + (W_1 + (W_3 + W_7) \text{ smod } 255) \text{ smod } 511) \bmod 1024$
$F_8 = (W_0 + (W_1 - 256 + (W_2 - 128 + (W_4 - 64 + W_8) \text{ smod } 127) \text{ smod } 255) \text{ smod } 511) \bmod 1024$
$F_9 = (W_0 + (W_1 + (W_3 - 128 + (W_5 - 64 + W_9) \text{ smod } 127) \text{ smod } 255) \text{ smod } 511) \bmod 1024$

TABLE 10.22d/GSM 04.08
Frequency list information element, range 512 format

```
F10 = (W0 + (W1 - 256 + (W2         + (W6 - 64 + W10)
        smod 127) smod 255) smod 511) mod 1024
F11 = (W0 + (W1         + (W3         + (W7 - 64 + W11)
        smod 127) smod 255) smod 511) mod 1024
F12 = (W0 + (W1 - 256 + (W2 - 128 + (W4         + W12)
        smod 127) smod 255) smod 511) mod 1024

F13 = (W0 + (W1         + (W3 - 128 + (W5         + W13)
        smod 127) smod 255) smod 511) mod 1024
F14 = (W0 + (W1 - 256 + (W2         + (W6         + W14)
        smod 127) smod 255) smod 511) mod 1024
F15 = (W0 + (W1         + (W3         + (W7         + W15)
        smod 127) smod 255) smod 511) mod 1024
F16 = (W0 + (W1 - 256 + (W2 - 128 + (W4 - 64 +
        (W8 - 32 + W16)
      smod 63) smod 127) smod 255) smod 511) mod 1024
F17 = (W0 + (W1         + (W3 - 128 + (W5 - 64 +
        (W9 - 32 + W17)
      smod 63) smod 127) smod 255) smod 511) mod 1024
```

TABLE 10.22d/GSM 04.08
Frequency list information element, range 512 format (continued)

More generally, the computation of F(K) can be done with the following program, using ADA language (declarative parts are skipped and should be obvious):

```
INDEX := K;
J := GREATEST_POWER_OF_2_LESSER_OR_EQUAL_TO(INDEX);
N := W(INDEX);
while INDEX>1 loop
  if 2*INDEX < 3*J then                    -- left child
    INDEX := INDEX - J/2;
    N := (N + W(PARENT) - 512/J - 1) mod
          (1024/J - 1) + 1;
  else                                     -- right child
    INDEX := INDEX - J;
    N := (N + W( INDEX) - 1) mod (1024/J - 1) + 1;
  end if;
  J := J/2;
end loop;
F(K) := (W(0) + N) mod 1024;
```

10.5.2.9a.5 Range 256 format

The information element contains a header, and W(1) to W(M) for some M. If, due to octet boundaries, some bits are not used at the end of the last octet, these bits must be set to 0.

8	7	6	5	4	3	2	1	
0	0 0 0 0 1 0 1 Frequency list IEI							octet 1
Length of frequency list contents								octet 2
1 0 FORMAT-ID		0 spare	0 spare	1 0 1 FORMAT-ID			ORIG-ARFCN high	octet 3
ORIG-ARFCN (middle part)								octet 4
ORIG-ARFCN low	W(1) (high part)							octet 5
W(1) low	W(2)							octet 6

W(2) to W(3) are on 7 bits, when present

W(4) to W(7) are on 6 bits, when present

W(8) to W(15) are on 5 bits, when present

W(16) to W(31) are on 4 bits, when present

W(2^k) to W(2^{k+1}-1) are on 8-k bits when present

and so on

FIGURE 10.28d/GSM 04.08
Frequency list information element (Range 256 format)

ORIG-ARFCN, origin ARFCN (octet 3, 4 and 5)

This field encodes the ARFCN of a frequency in the set. This value is also used to decode the rest of the element.

W(i), i from 1 to M (octet 5 and next) :

Each W(i) encodes a non negative integer in binary format.

If W(k) is null, W(i) for i>k must be null also.

Each non null W(k) allows to compute, together with some previous W(i) the ARFCN F(k) of a frequency in the set. The first computation formulas are given hereafter, with the following conventions :

W_i denotes W(i); W_0 denotes the value of ORIG-ARFCN
F_i denotes F(i);
\+ indicates the natural integer addition;
* indicates the natural integer multiplication;
n mod m indicates the remainder of the euclidian division of n by m, ie 0 ≤ (n mod m) ≤ m-1 and there exists k such that n = (k*m) + (n mod m);

n smod m indicates the offset remainder of the euclidian division of n by m, ie 1 ≤ (n smod m) ≤ m and there exists k such that n = (k*m) + (n smod m);

$F_1 = (W_0 + W_1) \bmod 1024$
$F_2 = (W_0 + (W_1 - 128 + W_2) \text{ smod } 255) \bmod 1024$
$F_3 = (W_0 + (W_1 + W_3) \text{ smod } 255) \bmod 1024$
$F_4 = (W_0 + (W_1 - 128 + (W_2 - 64 + W_4) \text{ smod } 127) \text{ smod } 255) \bmod 1024$
$F_5 = (W_0 + (W_1 + (W_3 - 64 + W_5) \text{ smod } 127) \text{ smod } 255) \bmod 1024$
$F_6 = (W_0 + (W_1 - 128 + (W_2 + W_6) \text{ smod } 127) \text{ smod } 255) \bmod 1024$
$F_7 = (W_0 + (W_1 + (W_3 + W_7) \text{ smod } 127) \text{ smod } 255) \bmod 1024$

TABLE 10.22e/GSM 04.08
Frequency list information element, range 256 format

$F_8 = (W_0 + (W_1 - 128 + (W_2 - 64 + (W_4 - 32 + W_8) \text{ smod } 63) \text{ smod } 127) \text{ smod } 255) \text{ mod } 1024$
$F_9 = (W_0 + (W_1 + (W_3 - 64 + (W_5 - 32 + W_9) \text{ smod } 63) \text{ smod } 127) \text{ smod } 255) \text{ mod } 1024$
$F_{10} = (W_0 + (W_1 - 128 + (W_2 + (W_6 - 32 + W_{10}) \text{ smod } 63) \text{ smod } 127) \text{ smod } 255) \text{ mod } 1024$
$F_{11} = (W_0 + (W_1 + (W_3 + (W_7 - 32 + W_{11}) \text{ smod } 63) \text{ smod } 127) \text{ smod } 255) \text{ mod } 1024$
$F_{12} = (W_0 + (W_1 - 128 + (W_2 - 64 + (W_4 + W_{12}) \text{ smod } 63) \text{ smod } 127) \text{ smod } 255) \text{ mod } 1024$
$F_{13} = (W_0 + (W_1 + (W_3 - 64 + (W_5 + W_{13}) \text{ smod } 63) \text{ smod } 127) \text{ smod } 255) \text{ mod } 1024$
$F_{14} = (W_0 + (W_1 - 128 + (W_2 + (W_6 + W_{14}) \text{ smod } 63) \text{ smod } 127) \text{ smod } 255) \text{ mod } 1024$
$F_{15} = (W_0 + (W_1 + (W_3 + (W_7 + W_{15}) \text{ smod } 63) \text{ smod } 127) \text{ smod } 255) \text{ mod } 1024$
$F_{16} = (W_0 + (W_1 - 128 + (W_2 - 64 + (W_4 - 32 + (W_8 - 16 + W_{16}) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ smod } 255) \text{ mod } 1024$
$F_{17} = (W_0 + (W_1 + (W_3 - 64 + (W_5 - 32 + (W_9 - 16 + W_{17}) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ smod } 255) \text{ mod } 1024$
$F_{18} = (W_0 + (W_1 - 128 + (W_2 + (W_6 - 32 + (W_{10} - 16 + W_{18}) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ smod } 255) \text{ mod } 1024$
$F_{19} = (W_0 + (W_1 + (W_3 + (W_7 - 32 + (W_{11} - 16 + W_{19}) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ smod } 255) \text{ mod } 1024$
$F_{20} = (W_0 + (W_1 - 128 + (W_2 - 64 + (W_4 + (W_{12} - 16 + W_{20}) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ smod } 255) \text{ mod } 1024$
$F_{21} = (W_0 + (W_1 + (W_3 - 64 + (W_5 + (W_{13} - 16 + W_{21}) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ smod } 255) \text{ mod } 1024$

TABLE 10.22e/GSM 04.08
Frequency list information element, range 256 format (continued)

More generally, the computation of F(K) can be done with the following program, using ADA language (declarative parts are skipped and should be obvious):

```
INDEX := K;
J := GREATEST_POWER_OF_2_LESSER_OR_EQUAL_TO(INDEX);
N := W(INDEX);
while INDEX>1 loop
   if 2*INDEX < 3*J then                    -- left child
      INDEX := INDEX - J/2;
      N := (N + W(INDEX) - 256/J - 1) mod
            (512/J - 1) + 1;
   else                                     -- right child
      INDEX := INDEX - J;
      N := (N + W(INDEX) - 1) mod (512/J - 1) + 1;
   end if;
   J := J/2;
end loop;
F(K) := (W(0) + N) mod 1024;
```

10.5.2.9a.6 Range 128 format

The information element contains a header, and W(1) to W(M) for some M. If, due to octet boundaries, some bits are not used at the end of the last octet, these bits must be set to 0.

8	7	6	5	4	3	2	1	
0	0	0	0	0	1	0	1	octet 1
	Frequency list IEI							
Length of frequency list contents								octet 2
1	0	0	0	1	1	0	ORIG-ARFCN high	octet 3
FORMAT-ID		spare	spare	FORMAT-ID				
ORIG-ARFCN (middle part)								octet 4
ORIG-ARFCN low	W(1) (high part)							octet 5

W(2) to W(3) are on 6 bits, when present

W(4) to W(7) are on 5 bits, when present

W(8) to W(15) are on 4 bits, when present

W(16) to W(31) are on 3 bits, when present

W(2^k) to W($2^{k+1}-1$) are on 7-k bits when present

and so on

FIGURE 10.28e/GSM 04.08
Frequency list information element (Range 128 format)

ORIG-ARFCN, origin ARFCN (octet 3, 4 and 5)

This field encodes the ARFCN of a frequency in the set. This value is also used to decode the rest of the element.

W(i), i from 1 to M (octet 5 and next) :

Each W(i) encodes a non negative integer in binary format.

If W(k) is null, W(i) for i>k must be null also.

Each non null W(k) allows to compute, together with some previous W(i) the ARFCN F(k) of a frequency in the set. The first computation formulas are given hereafter, with the following conventions :

W_i denotes W(i); W_0 denotes the value of ORIG-ARFCN
F_i denotes F(i);
\+ indicates the natural integer addition;
* indicates the natural integer multiplication;
n mod m indicates the remainder of the euclidian division of n by m, ie $0 \le (n \bmod m) \le m-1$ and there exists k such that $n = (k*m) + (n \bmod m)$;

n smod m indicates the offset remainder of the euclidian division of n by m, ie $1 \le (n \text{ smod } m) \le m$ and there exists k such that $n = (k*m) + (n \text{ smod } m)$;

$F_1 = (W_0 + W_1) \bmod 1024$
$F_2 = (W_0 + (W_1 - 64 + W_2) \text{ smod } 127) \bmod 1024$
$F_3 = (W_0 + (W_1 + W_3) \text{ smod } 127) \bmod 1024$
$F_4 = (W_0 + (W_1 - 64 + (W_2 - 32 + W_4) \text{ smod } 63) \text{ smod } 127) \bmod 1024$
$F_5 = (W_0 + (W_1 + (W_3 - 32 + W_5) \text{ smod } 63) \text{ smod } 127) \bmod 1024$
$F_6 = (W_0 + (W_1 - 64 + (W_2 + W_6) \text{ smod } 63) \text{ smod } 127) \bmod 1024$
$F_7 = (W_0 + (W_1 + (W_3 + W_7) \text{ smod } 63) \text{ smod } 127) \bmod 1024$

TABLE 10.22f/GSM 04.08
Frequency list information element, range 128 format

$F_8 = (W_0 + (W_1 - 64 + (W_2 - 32 + (W_4 - 16 + W_8\ ) \text{ smod } 31)$
$\text{smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_9 = (W_0 + (W_1 + (W_3 - 32 + (W_5 - 16 + W_9\ ) \text{ smod } 31)$
$\text{smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{10} = (W_0 + (W_1 - 64 + (W_2 + (W_6 - 16 + W_{10}) \text{ smod } 31)$
$\text{smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{11} = (W_0 + (W_1 + (W_3 + (W_7 - 16 + W_{11}) \text{ smod } 31)$
$\text{smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{12} = (W_0 + (W_1 - 64 + (W_2 - 32 + (W_4 + W_{12}) \text{ smod } 31)$
$\text{smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{13} = (W_0 + (W_1 + (W_3 - 32 + (W_5 + W_{13}) \text{ smod } 31)$
$\text{smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{14} = (W_0 + (W_1 - 64 + (W_2 + (W_6 + W_{14}) \text{ smod } 31)$
$\text{smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{15} = (W_0 + (W_1 + (W_3 + (W_7 + W_{15}) \text{ smod } 31)$
$\text{smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{16} = (W_0 + (W_1 - 64 + (W_2 - 32 + (W_4 - 16 + (W_8 - 8 + W_{16})$
$\text{smod } 15) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{17} = (W_0 + (W_1 + (W_3 - 32 + (W_5 - 16 + (W_9 - 8 + W_{17})$
$\text{smod } 15) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{18} = (W_0 + (W_1 - 64 + (W_2 + (W_6 - 16 + (W_{10} - 8 + W_{18})$
$\text{smod } 15) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{19} = (W_0 + (W_1 + (W_3 + (W_7 - 16 + (W_{11} - 8 + W_{19})$
$\text{smod } 15) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{20} = (W_0 + (W_1 - 64 + (W_2 - 32 + (W_4 + (W_{12} - 8 + W_{20})$
$\text{smod } 15) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{21} = (W_0 + (W_1 + (W_3 - 32 + (W_5 + (W_{13} - 8 + W_{21})$
$\text{smod } 15) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{22} = (W_0 + (W_1 - 64 + (W_2 + (W_6 + W(_{14} - 8 + W_{22})$
$\text{smod } 15) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{23} = (W_0 + (W_1 + (W_3 + (W_7 + (W_{15} - 8 + W_{23})$
$\text{smod } 15) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{24} = (W_0 + (W_1 - 64 + (W_2 - 32 + (W_4 - 16 + (W_8 + W_{24})$
$\text{smod } 15) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{25} = (W_0 + (W_1 + (W_3 - 32 + (W_5 - 16 + (W_9 + W_{25})$
$\text{smod } 15) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{26} = (W_0 + (W_1 - 64 + (W_2 + (W_6 - 16 + (W_{10} + W_{26})$
$\text{smod } 15) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{27} = (W_0 + (W_1 + (W_3 + (W_7 - 16 + (W_{11} + W_{27})$
$\text{smod } 15) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{28} = (W_0 + (W_1 - 64 + (W_2 - 32 + (W_4 + (W_{12} + W_{28}$
$\text{smod } 15) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ mod } 1024$
$F_{29} = (W_0 + (W_1 + (W_3 - 32 + (W_5 + (W_{13} + W_{29}$
$\text{smod } 15) \text{ smod } 31) \text{ smod } 63) \text{ smod } 127) \text{ mod } 1024$

TABLE 10.22f/GSM 04.08
Frequency list information element, range 128 format

More generally, the computation of F(K) can be done with the following program, using ADA language (declarative parts are skipped and should be obvious):

```
INDEX := K;
J := GREATEST POWER OF 2 LESSER OR EQUAL TO(INDEX);
N := W(INDEX);
while INDEX>1 loop
   if 2*INDEX < 3*J then                        -- left child
      INDEX := INDEX - J/2;
      N := (N + W(INDEX) - 128/J - 1) mod
            (256/J - 1) + 1;
   else                                         -- right child
      INDEX := INDEX - J;
      N := (N + W(INDEX) - 1) mod (256/J - 1) + 1;
   end if;
   J := J/2;
end loop;
F(K) := (W(0) + N) mod 1024;
```

10.5.2.9a.7 Variable bit map format

8	7	6	5	4	3	2	1	
0	0	0	0	0	1	0	1	octet 1
	Frequency list IEI							
Length of frequency list contents								octet 2
1	0	0	0	1	1	1	ORIG-ARFCN high	octet 3
FORMAT-ID		spare	spare	FORMAT-ID (continued)				
ORIG-ARFCN (middle part)								octet 4
ORIG-ARFCN low	RRFCN 1	RRFCN 2	RRFCN 3	RRFCN 4	RRFCN 5	RRFCN 6	RRFCN 7	octet 5
RRFCN 8k-40	RRFCN 8k-39	RRFCN 8k-38	RRFCN 8k-37	RRFCN 8k-36	RRFCN 8k-35	RRFCN 8k-34	RRFCN 8k-33	octet k

FIGURE 10.28f/GSM 04.08
Cell channel description information element, variable bit map format

ORIG-ARFCN, origin ARFCN (octet 3, 4 and 5)
This field encodes the ARFCN of a frequency in the set. This value is also used as origin of the bit map.
RRFCN N, relative radio frequency channel number N (octet 5 etc.)
For a RF channel with ARFCN = (ORIG-ARFCN + N) mod 1024 belonging to the set, RRFCN N bit is coded with a "1": N = 1, 2, . . , 8M+7 with 1 ≤ M ≤ 127
For a RF channel with ARFCN = (ORIG-ARFCN + N) mod 1024 not belonging to the set, RRFCN N bit is coded with a "0": N = 1, 2, . . , 8M+7 with 1 ≤ M ≤ 127

TABLE 10.22g/GSM 04.08
Cell channel description information element, variable bit map format

10.5.2.9b Frequency short list

The purpose of the frequency short list information element is to provide the list of the absolute radio frequency channel numbers used in a frequency hopping sequence, in a small fixed length information element to obtain when possible the HANDOVER COMMAND message in a single block.

The frequency short list information element a type 3 information element of 10 octet length.

This element is encoded exactly as the frequency list information element, except that it has a fixed length instead of a variable length.

10.5.2.11 Measurement results

The purpose of the measurement results information element is to provide the results of the measurements made by the mobile station on the serving cell and the neighbour cells.

The measurement results information element is coded as shown in Figure 10.30/GSM 04.08 and Table 10.24/GSM 04.08.

The measurement results is a type 3 information element with 17 octets length.

<table>
<tr><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td></td></tr>
<tr><td>0</td><td colspan="7">1 1 1 0 0 0 1
Measurement results IEI</td><td>octet 1</td></tr>
<tr><td>BA-USED</td><td>DTX USED</td><td colspan="6">RXLEV-FULL-SERVING-CELL</td><td>octet 2</td></tr>
<tr><td>0 spare</td><td>MEAS-VALID</td><td colspan="6">RXLEV-SUB-SERVING-CELL</td><td>octet 3</td></tr>
<tr><td>0 spare</td><td colspan="3">RXQUAL-FULL SERVING-CELL</td><td colspan="3">RXQUAL-SUB SERVING-CELL</td><td>NO-NCELL M (high part)</td><td>octet 4</td></tr>
<tr><td colspan="2">NO-NCELL-M (low part)</td><td colspan="6">RXLEV-NCELL 1</td><td>octet 5</td></tr>
<tr><td colspan="5">BCCH-FREQ-NCELL 1</td><td colspan="3">BSIC-NCELL 1 (high part)</td><td>octet 6</td></tr>
<tr><td colspan="3">BSIC-NCELL 1 (low part)</td><td colspan="5">RXLEV-NCELL 2 (high part)</td><td>octet 7</td></tr>
<tr><td>RXLEV NCELL 2 (low part)</td><td colspan="5">BCCH-FREQ-NCELL 2</td><td colspan="2">BSIC-NCELL 2 (high part)</td><td>octet 8</td></tr>
</table>

FIGURE 10.30/GSM 04.08
Measurement results information element

BSIC-NCELL 2 (low part)	RXLEV-NCELL 3 (high part)		octet 9
RXLEV-NCELL 3 (low part)	BCCH-FREQ-NCELL 3	BSIC-NCELL 3 (high part)	octet 10
BSIC-NCELL 3 (low part)	RXLEV-NCELL 4 (high part)		octet 11
RXLEV-NCELL 4 (low part)	BCCH-FREQ-NCELL 4		octet 12
BSIC-NCELL 4	RXLEV-NCELL 5 (high part)		octet 13
RXLEV-NCELL 5 (low part)	BCCH-FREQ-NCELL 5 (high part)		octet 14
BCCH-FREQ-NCELL 5(low part)	BSIC-NCELL 5	RXLEV NCELL 6 (high part)	octet 15
RXLEV-NCELL 6 (low part)	BCCH-FREQ-NCELL 6 (high part)		octet 16
BCCH-FREQ-NCELL 6 (low part)	BSIC-NCELL 6		octet 17

FIGURE 10.30/GSM 04.08
Measurement results information element (continued)

BA-USED (octet 2), the value of the BA-IND field of the neighbour cells description information element defining the BCCH allocation used for the coding of BCCH-FREQ-NCELL fields. Range 0 to 1

DTX-USED (octet 2)
This bit indicates whether or not the MS used DTX during the previous measurement period.

Bit 7	
0	DTX was not used
1	DTX was used

RXLEV-FULL-SERVING-CELL and RXLEV-SUB-SERVING-CELL, Received signal strength on serving cell, measured respectively on all slots and on a subset of slots (see Rec. GSM 05.08)
(octets 2 and 3)
The RXLEV-FULL-SERVING-CELL and RXLEV-SUB-SERVING-CELL fields are coded as the binary representation of a value N. N corresponds according to the mapping defined in Rec. GSM 05.08 to the received signal strength on the serving cell.

Range: 0 to 63

MEAS-VALID (octet 3)
This bit indicates if the measurement results for the dedicated channel are valid or not

bit 7	
0	The measurement results are valid
1	the measurement results are not valid

RXQUAL-FULL-SERVING-CELL and RXQUAL-SUB-SERVING-CELL received signal quality on serving cell, measured respectively on all slots and on a subset of the slots (see Rec. GSM 05.08)
(octet 4)

TABLE 10.24/GSM 04.08
Measurement results information element

RXLEV-NCELL i, Received signal strength on the i'th neighbouring cell (octet 5, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16)
The RXLEV-NCELL field is coded as the binary representation of a value N. N corresponds according to the mapping defined in Rec. GSM 05.08 to the received signal strength on the i'th neighbouring cell. See note 1 & 2.

Range: 0 to 63.

BCCH-FREQ-NCELL i, BCCH carrier of the i'th neighbouring cell (octet 6, 8, 10, 12, 14, 15, 16 and 17)
The BCCH-FREQ-NCELL i field is coded as the binary representation of--of the position of the i'th neighbouring cells BCCH carrier in the BCCH channel list provided by the reference neigbour cells description information element or elements.
--The-BCCH-channel-list-is-the-list-of-absolute-------RF-channel-numbers-for-which-the-BA-ARFCN-bit-in-the--neighbour--cells--description-information-element-is-coded-with-a-"1". The absolute RF channel numbers-is are placed in increasing order in the list with the lowest frequency in position 0. See note 1 & 2.

Range: 0 to 31.

BSIC-NCELL i, Base station identity code of the i'th neighbouring cell (octet 6, 7, 8, 9, 10, 11, 13, 15 and 17)
The BSIC-NCELL i field is coded as the binary representation of the base station identity code of the i'th neighbouring cell. See note 1 & 2.

Range: 0 to 63.

Note 1: If the field extends over two octets the highest numbered bit of the lowest numbered octet is the most significant and the lowest numbered bit of the highest numbered octet is the least significant.

Note 2: If NO-NCELL-M < 6 the remaining RXLEV-NCELL i, BS- FREQ-NCELL i and BSIC-NCELL i fields (NO-NCELL-M < i <= 6) should be coded with a "0" in each bit.

TABLE 10.24/GSM 04.08
Measurement results information element (continued)

10.5.2.12 Mobile allocation

The purpose of the mobile allocation information element is to provide that part of the RF channels belonging to the cell allocation (coded with a "1" in the cell channel description information element) which is used in the mobile hopping sequence.

The mobile allocation information element is coded as shown in Figure 10.31/GSM 04.08 and Table 10.25/GSM 04.08.

The mobile allocation is a type 4 information element with 10 octets length maximal.

8	7	6	5	4	3	2	1	
0	1 Mobile allocation IEI	1	1	0	0	1	0	octet 1
Length of mobile allocation contents								octet 2
MA C 8n	MA C 8n-1	MA C 8n-2	MA C 8n-3	MA C 8n-4	MA C 8n-5	MA C 8n-6	MA C 8n-7	octet 3
MA C 008	MA C 007	MA C 006	MA C 005	MA C 004	MA C 003	MA C 002	MA C 001	octet n+2

FIGURE 10.31/GSM 04.08
Mobile allocation information element.

MA C i, Mobile allocation RF channel i (octet 3 etc.), i = 1, 2,..., NF

The MA C i bit indicates whether or not the Mobile allocation frequency list includes the i'th frequency in the cell allocation frequency list provided by the reference cell channel description information element or elements. NF denotes the number of frequencies in the cell allocation frequency list. The absolute RF channel numbers are placed in increasing order in the list with the lowest frequency in position 0.

~~The RF channels represented in the MA C i bit fields are those which in the cell channel description information element are coded with "1"s in the CA ARFCN N bit fields. If NF denotes the number of frequencies in the mobile allocation field then:~~

~~MA C i = CA ARFCN N(i); i = 1, 2,..., NF.~~

~~N(i) is an increasing function of i, i.e. the order of appearance of the RF channels in the mobile allocation field is the same as in the cell allocation field in the cell channel description information element.~~

For a RF channel belonging to the mobile allocation the MA C i bit is coded with a "1"; i = 1, 2,..., NF.

For a RF channel not belonging to the mobile allocation the MA C i bit is coded with a "0"; i = 1, 2,..., NF.

If NF mod 8 <> 0 then bits NF to 8n in octet 3 must be coded with a "0" in each.

TABLE 10.25/GSM 04.08
Mobile allocation information element

10.5.2.13 Neighbour cells description

The purpose of the neighbour cells description information element is to provide the absolute radio frequency channel numbers of the BCCH carriers to be monitored by the MSs in the cell.

The neighbour cells description information element is coded ~~in-Figure-10.32/GSM 04.08-and-Table-10.26/GSM-04.08.-~~as the cell channel description information element, as specified in section 10.5.2.1, with the exception of bit 5 of octet 2. Figure 10.32/GSM 04.08 and Table 10.26/GSM 04.08 contains the difference of specifications.

The neighbour cells description information element is a type 3 information element with 17 octets length.

8	7	6	5	4	3	2	1	
0	1	1	1	0	1	0	0	octet 1
	Neighbour cells description IEI							
Bit 128	Bit 127	EXT-IND	BA-IND	Bit 124	Bit 123	Bit 122	Bit 121	octet 2
Bit 120	Bit 119	Bit 118	Bit 117	Bit 116	Bit 115	Bit 114	Bit 113	octet 3
Bit 008	Bit 007	Bit 006	Bit 005	Bit 004	Bit 003	Bit 002	Bit 001	octet 17

FIGURE 10.32/GSM 04.08
Neighbour cells description information element

EXT-IND, Extension indication (octet 2, bit 6)

This bit indicates that the BA is incomplete, and that a complementary BA is sent in another message.

Bit 6

Bit 6	
0	The BA is complete
1	The BA is incomplete

BA-IND, BCCH allocation sequence number indication (octet 2). Range 0 to 1.

FORMAT-ID, Format Identifier (Bit 128 and next)

The different formats are distinguished by the bits of higher number. The possible values are the following :

Bit 128	Bit 127	Bit 124	Bit 123	Bit 122	format notation
0	0	X	X	X	bit map 0
1	0	0	X	X	1024 range
1	0	1	0	0	512 range
1	0	1	0	1	256 range
1	0	1	1	0	128 range
1	0	1	1	1	variable bit map

All other combinations are reserved for future use.

The signification of the remaining bits depends on FORMAT-ID. The different cases are specified as in section 10.5.2.1.

TABLE 10.26/GSM 04.08
Neighbour cells description information element

10.5.3.6 Reject cause

The purpose of the reject cause information element is to indicate the reason why a request from the mobile station is rejected by the network.

The reject cause information element is coded as shown in Figure 10.49/GSM 04.08 and Table 10.44/GSM 04.08.

The reject cause is a type 3 information element with 2 octets length.

8	7	6	5	4	3	2	1	
0	1	0	0	0	1	0	0	octet 1
	reject cause IEI							
reject cause value								octet 2

FIGURE 10.49/GSM 04.08
Reject cause information element

Reject cause value (octet 2)

Bits 8 7 6 5 4 3 2 1	
0 0 0 0 0 0 0 1	Unallocated TMSI
0 0 0 0 0 0 1 0	IMSI unknown in HLR
0 0 0 0 0 0 1 1	Illegal MS
0 0 0 0 0 1 0 0	IMSI unknown in VLR
0 0 0 0 0 1 0 1	IMEI not accepted
0 0 0 0 1 0 1 1	PLMN not allowed
0 0 0 0 1 1 0 0	Location Area not allowed
0 0 0 0 1 1 0 1	National roaming not allowed in this location area
0 0 0 1 0 0 0 1	Network failure
0 0 0 1 0 1 1 0	Congestion
0 0 1 0 0 0 0 0	Service option not supported
0 0 1 0 0 0 0 1	Requested service option not subscribed
0 0 1 0 0 0 1 0	Service option temporarily out of order
0 0 1 0 0 1 1 0	Call cannot be identified
0 1 0 1 1 1 1 1	Invalid message, unspecified
0 1 1 0 0 0 0 0	Mandatory information element error
0 1 1 0 0 0 0 1	Message type non-existent or not implemented
0 1 1 0 0 0 1 0	Message not compatible with the call state or not implemented
0 1 1 0 0 0 1 1	Information element non-existent or not implemented
0 1 1 0 0 1 0 0	Invalid information element contents
0 1 1 0 0 1 0 1	Message not compatible with the call state
0 1 1 0 1 1 1 1	Protocol error, unspecified

All other values are reserved.

Note: The listed reject cause values are defined in Annex G.

TABLE 10.44/GSM 04.08
Reject cause information element

ANNEX G
(to Recommendation GSM 04.08)

GSM specific cause values for mobility management

G.1 Causes related to MS identification

Cause value = 1 Unallocated TMSI.

This cause is sent to the MS if the MS identifies itself by a TMSI which is not allocated in the relevant location area and open identification is not requested.

Cause value = 2 IMSI unknown in HLR

This cause is sent to the MS if the MS is not known (registered) in the HRL.

Cause value = 3 Illegal MS

This cause is sent to the MS when the MS does not pass the authentication check, i.e. the SRES received from the MS is different from that generated by the network.

Cause value = 4 IMSI unknown in VLR

This cause is sent to the MS when the given IMSI is not known at the VLR.

Cause value = 5 IMEI not accepted

This cause is sent to the MS if the IMEI given cannot be accepted by the network.

G.2 Cause related to subscription options

Cause value = 11 PLMN not allowed

This cause is sent to the MS if it requests location updating in a PLMN where the MS, by subscription is not allowed to operate.

Cause value = 12 Location Area not allowed

This cause is sent to the MS if it requests location updating in a Locationn area where the MS, by subscription, is not allowed to operate.

Cause value = 13 National roaming not allowed in this location area

This cause is sent to an MS which requests location updating in a location area of a PLMN which offers national roaming to that MS, but not in that specific location area.

G.3 Causes related to PLMN specific network failures and congestion

Cause value = 17 Network failure

This cause is sent to the MS if the MSC cannot service an MS generated request because of PLMN failures, e.g. problems in MAP.

Cause value = 22 Congestion

This cause is sent if the service request cannot be actioned because of congestion (e.g. no channel, facility busy/congested etc.)

G.4 Causes related to nature of request

Cause value = 32 Service option not supported

This cause is sent when the MS requests a service/facility in the CM SERVICE REQUEST message which is not supported by the PLMN.

Cause value = 33 Requested service option not subscribed

This cause ist sent when the MS requests a service option for which it has no subscription.

Cause value = 34 Service option temporarily out of order

This cause is sent when the MSC cannot service the request because of temporary outage of one or more functions required for supporting the service.

Cause value = 38 Call cannot be identified

This cause is sent when the network cannot identify the call associated with a call re- establishment request.

G.5 Causes related to invalid messages

Cause value = 96 Mandatory information element error.

See Annex H, sect. H.6.1.

Cause value = 97 Message type non-existent or not implemented.

see Annex H, sect. H.6.2.

Cause value = 98 Message non compatible with call state or message type non-existent or not implemented.

see Annex H, sect. H.6.3.

Cause value = 99 Information element non-existent or not implemented

See Annex H, sect. H.6.4.

Cause value = 100 Invalid information element contents

See Annex H, sect. H.6.5.

Cause value = 101 Message not compatible with call state

See Annex H, sect. H.6.6.

Cause value = 111 Protocol error, unspecified

See Annex H, sect. H.6.8.

ANNEX J
(to Recommendation GSM 04.08)

ALGORITHM TO ENCODE FREQUENCY LIST INFORMATION ELEMENTS

J.1 Introduction

Some information elements encode frequency lists with a special method. The main specification specifies the meaning of the fields and hence the way to decode them, but the corresponding encoding algorithm is difficult to infer from the decoding algorithm. This annex is intended as an help for implementers of the encoding algorithm.

It could be shown that any set of frequency with less or the same number of frequencies as the number of words can be encoded with a careful choice of F_1, F_2, and so on, ie that a set of W_i can be found so that the decoding algorithm given in the main section will give back the frequency set. The right order is not the order of the frequency values.

J.2 General principle

The encoding algorithm is based on a recursive dichotomy of both the range (ie the set of values that are possible) and the subset (the values to encode).

The dichotomy is best understood if the range is seen as a circle. For instance, for the 1023 range :

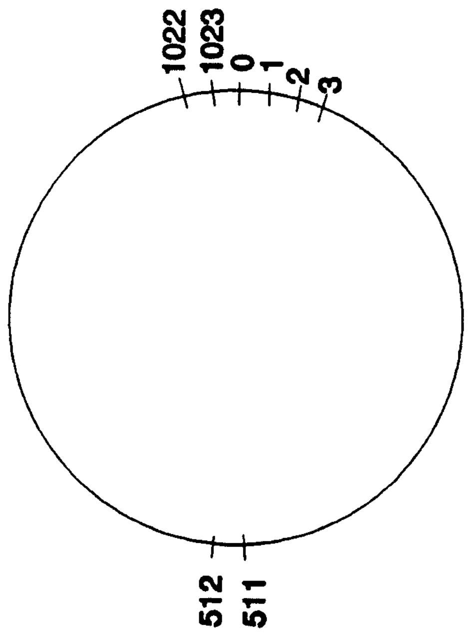

Figure 1 : Circular arrangement of 0..1022

The dichotomy consists in finding a value in the subset such that the diameter determined by this value splits the subset in two equal or nearly equal sub-subsets. In the following case, we see that value 250 is acceptable (the two sub-subsets have 3 elements), when value 290 is not acceptable (the two sub-subsets have 4 and 2 elements) :

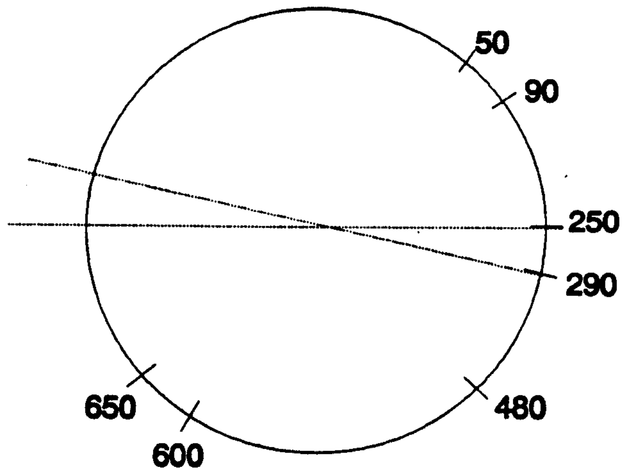

Figure 2 : Example of dichotomy

The pivot value is part of the information field, then the two sub-subsets are renumbered and the same algorithm is applied again on each of them. Because the range is halved at each step, the number of bits needed to encode a pivot value is 1 bit less than the number of bits needed to encode the parent pivot value.

The convention is that if the number of values is even, the left sub-subset (that is to say the values that can be expressed as the pivot value minus some integer between 1 and half the range) will have 1 element more than the right subset.

At each step the subset is numbered from 0 to the range minus 1. The coding in the information field of the pivot value is its value as renumbered, plus 1. Value 0 is reserved to indicate no element.

The order of appearance in the information field of the successive pivot values is particular. If we present the values as organised as a tree, with the left child being the pivot of the left sub-subset and the right child the pivot of the right sub-subset, the order of appearance is given by the following tree :

```
                                         1
                          /                           \
              2                                           3
          /          \                          /             \
      4                     6                   5                    7
    /    \             /       \           /      \              /      \
  8       12         10         14       9         13          11        15
```

(and so on)

This order as been chosen so that

a) whatever the number N of elements in the set, the meaningful nodes are the first N and the value for all nodes from N+1 on are null (if sent).

b) the tree and all subtrees are balanced.

Important properties of these trees are used in the algorithms (with generation 1 corresponding to the root) :

Generation g contains 2^{g-1} nodes, and their indices are 2^{g-1} to $2^{g}-1$;

For generation g, nodes 2^{g-1} to $2^{g-1}+2^{g-2}-1$ are left children, the others are right children;

If node k belongs to generation g, its left child is node $k + 2^{g-1}$, and its right child is $k + 2^{g}$;

Reciprocally, if k is a left child from generation g, its parent node is node $k - 2^{g-2}$, and if k is a right child of generation g, its parent is node $k - 2^{g-1}$.

J.3 Performances

The number of bits needed to encode a given set of values depends of the number of values and on the range thay can span.

For the application on the BCCH and the SACCH (CA and BA information elements), 16 octets are available, and the number of frequencies that can be encoded in one information element is the following :

Range	Number of frequencies
513 to 1024	2 to 16 (17 if frequency 0 is in)
257 to 512	2 to 18
129 to 256	2 to 22
113 to 128	2 to 29
up to 112	any

With two messages (for the BA), and if applying the same dichotomy principle to split the set between the two information elements, the number of frequencies that can be encoded is the following

Range	Number of frequencies
513 to 1024	2 to 36
257 to 512	2 to 44
225 to 256	2 to 58
up to 224	any

The fixed length version of the frequency list information element allows the following :

Range	Number of frequencies
513 to 1024	2 to 7 (8 if frequency 0 is in)
257 to 512	2 to 8
129 to 256	2 to 9
57 to 128	2 to 12
up to 56	any

The number of frequencies as a function of the range and the length in octets of the variable length frequency list information element (including the message type and length fields) is given by the following table :

Range • octets	513 to 1024	257 to 512	129 to 256	up to 128	bit map range
5	1	1	1	1	8
6	2	2	3	3	16
7	3	3	4	4	24
8	4	4	5	6	32
9	5	6	6	8	40
10	6	7	8	10	48
11	7	8	9	12	56
12	9	9	11	14	64
13	10	11	13	16	72
14	11	12	14	18	80
15	12	13	16	21	88
16	13	15	18	24	96
17	14	16	20	26	104
18	16	18	22	29	112
19	17	19	24	32	120
20	18	21	26	--	128
21	20	22	28		136
22	21	24	30		144
23	22	26	32		152
24	24	27	34		160
25	25	29	37		168
26	26	30	40		176
27	28	32	42		184
28	29	34	45		192
29	30	36	48		200
30	32	38	50		208
31	33	40	53		216
32	35	42	56		224

Table 04.08/J.1 : Performance of the variable length frequency list information element

J.4 Encoding algorithm

The choice is done recursively as given by the following programs, written in ADA :

Let us define the recursive procedure :

```
            procedure ENCODE_SUBTREE(in INDEX : INTEGER;
                                     in SET : SET OF VALUE;
                                     in RANGE : INTEGER);
```

This procedure is given a set of integer values and an index. It chooses one of those values and computes the corresponding W(INDEX) (considered as a global variable), it splits the set less the value in two equal or nearly equal subsets, and calls itself recursively for each of those subsets, with suitable INDEX.

Assumption : all values in SET lie (inclusively) between 0 and RANGE-1, and they are all distinct.

As written, the program does not assume special values for the range. With a range such as 2^k-1, some expressions can be simplified.

Declarative part :

```
        INDEX_IN_SET : INTEGER;


    begin
```

First the program tests the leaf conditions :

```
        if SET'SIZE=0 then
          W(INDEX) := 0;
          return;
        elsif SET'SIZE=1 then
          W(INDEX) := 1 + SET(1);
          return;
        end if;
```

The following program finds a value in the set such that exactly SET'SIZE/2 values from the set are between this value plus 1 and this value plus half the range :

```
    declare
        N : INTEGER;
        J : INTEGER;
    begin
        for I in 1..SET'SIZE loop
          N:=0;
          for J in 1..SET'SIZE loop
            if (SET(J)-SET(I)) mod RANGE <= (RANGE-1)/2 then
              N := N+1;
```

```
            end if;
          end loop;             if N-1 = SET'SIZE/2 then
```

The test compares N-1 because the possible pivot value is counted.

```
              INDEX IN SET := I;
              exit;
            end if;
          end loop;
        end;
```

INDEX IN SET is then the index in the list of the pivot value.

The following sets W(INDEX)

```
        W(INDEX) := SET(INDEX IN SET) + 1;
```

Then the program does the same thing for the two halves of the range delimited by W(INDEX) and W(INDEX)+RANGE/2. First the left subset :

```
      declare
        SUBSET : SET OF VALUE(1..SET'SIZE/2);
        SUBSET INDEX : INTEGER;
        ORIGIN VALUE : INTEGER;
      begin
        ORIGIN VALUE := (SET(INDEX IN SET] + (RANGE-1)/2
                                + 1) mod RANGE;
        SUBSET INDEX:=1;
        for I in 1..SET'SIZE loop
          if (SET(I)-ORIGIN VALUE) mod RANGE) < RANGE/2 then
            SUBSET(SUBSET INDEX) :=
              (SET(I) - ORIGIN VALUE) mod RANGE;
            SUBSET INDEX := SUBSET INDEX + 1;
          end if;
        end loop;

        ENCODE SUBTREE(
            INDEX := INDEX +
              GREATEST POWER OF 2 LESSER OR EQUAL TO(INDEX),
            SET := SUBSET,
            RANGE := RANGE/2);
      end;
```

Then the right subset :

```
      declare
        SUBSET : SET OF VALUE(1..(SET'SIZE-1)/2);
        SUBSET INDEX : INTEGER;
        ORIGIN VALUE : INTEGER;
      begin
        ORIGIN VALUE := (SET(INDEX IN SET] + 1) mod RANGE;
        SUBSET INDEX:=1;
        for I in 1..SET'SIZE loop
          if (SET(I)-ORIGIN VALUE) mod RANGE) < RANGE/2 then
            SUBSET(SUBSET INDEX) :=
              (SET(I) - ORIGIN VALUE) mod RANGE;
```

```
            SUBSET INDEX := SUBSET INDEX + 1;
          end if;
        end loop;
        ENCODE SUBTREE(
          INDEX := INDEX +
            2*GREATEST POWER OF 2 LESSER OR EQUAL TO(INDEX),
          SET := SUBSET,
          RANGE := (RANGE-1)/2);
  end;

    end ENCODE SUBTREE;
```

The initial call of the procedure depends on the format. Given some set to encode, the first problem is to verify that it can be encoded, and by so doing to choose the format.

First the encoding process must find the minimum range of the set, that is to say the minimum value R such that there exists one frequency F0 in the set such that all frequencies in the set can be written (F0 + N) mod 1024, with some N, 0 ≤ N ≤ R-1. The choice of the format depends on R and the number of frequencies : the 512 range format can be chosen only if R≤512, the 256 range format can be chosen only if R≤256, the 128 range format can be chosen only if R≤128.

If the chosen format is "1024 range", then the program must first check if frequency 0 is in the set. If so the F0 subfield is set to 1, and frequency 0 is removed from the set. Otherwise, the F0 subfield is set to 0. Then ENCODE SUBTREE is called with INDEX := 1, SET set to the set of values equal to the ARFCN of all frequencies minus 1, and RANGE := 1023.

If the chosen format is "512 range", "256 range" or "128 range", F0 is chosen as ORIG-ARFCN and ENCODE SUBTREE is called with INDEX := 1, SET set to the set of values equal to the ARFCN of all frequencies except F0, minus F0+1, and RANGE set respectively to 511, 255 or 127.

J.5 Decoding

The decoding algorithm as given below in the inverse transform of the program given in the previous section, for the specific case where the original range is a power of 2 minus 1. It is given a set of integer values W(i), and an original range R, and it builds a set of values from 0..R-1.

The program is here written so that the fact that it is the inverse of the encoding program needs no more proof.

```
procedure DECODE(in W : array <> of INTEGER;
                        out SET : SET OF VALUE;
                        in ORIGINAL_RANGE : INTEGER);

    -- local variables
      INDEX : 1..W'SIZE;          RANGE : INTEGER;
        N : INTEGER;

    begin
      for K in 1..W'SIZE loop
```

The next loop follows the tree from child to parent, from the node of index K to the root (index 1). For each iteration the node of index INDEX is tackled. The corresponding range is RANGE, and N is the value of the element in the range defined by the node.

The data are set to their initial values :

```
        INDEX := K;
      RANGE := ORIGINAL_RANGE/
            GREATEST_POWER_OF_2_LESSER_OR_EQUAL_TO(INDEX);
      N := W(INDEX) - 1;

    while INDEX>1 loop
```

Due to the assumption that the original range is a power of two nimus one, the range for the parent node can be easily computed, and does not depend whether the current node is a left or right child :

```
            RANGE := 2*RANGE + 1;
```

Let us note J := 2^{g-1}, g being the generation of node INDEX. We have J = GREATEST_POWER_OF_2_LESSER_OR_EQUAL_TO(INDEX). The numbering used in the tree is such that the nodes of index J to J + J/2 - 1 are left children, and the nodes of index J/2 to J+J-1 are right children. Hence an easy test to distinguish left and right children:

```
      if 2*INDEX <
            3*GREATEST_POWER_OF_2_LESSER_OR_EQUAL_TO(INDEX)
        then          -- left child
```

The next computation gives the index of the parent node of the node of index INDEX, for a left child :

```
                INDEX := INDEX -
                      GREATEST POWER OF 2 LESSER OR EQUAL TO(INDEX)/2;
```

The next formula is the inverse of the renumbering appearing in the encoding for a left child. It gives the value of the parent node in the range defined by the grand-parent node:

```
                N := (N + W(INDEX) - 1 + (RANGE-1)/2 + 1)
                                         mod RANGE;
            else                                     -- right child
```

The next computation gives the index of the parent node of the node of index INDEX, for a right child :

```
                INDEX := INDEX -
                              GREATEST POWER OF 2 LESSER OR EQUAL TO(INDEX);
```

The next formula is the inverse of the renumbering appearing in the encoding for a right child:

```
                                   N := (N + W(INDEX) - 1 + 1) mod RANGE;
                                 end if;
                               end loop;
                               F(K) := N + 1;
                             end loop;
                           end;
```

A careful study will show that the programs given in the main part of the Recommendation are equivalent to the one presented here. The main difference is the use of different remanent variables to remove most of the calls to the function giving the greatest power of 2 lesser or equal to some integer.

The decoding must be terminated by the correction specific to the format.

J.7 A detailed example

Let us take the following subset of 16 elements of the set [0..1023] :
[13, 71, 122, 191, 251, 321, 402, 476, 521, 575, 635, 701, 765, 831, 906, 981]

Range 1024 format will be used. Frequency 0 is not is the set, thus field F0 is set to 0. The set is renumbered, so as to give a subset of 0..1022 : [12, 70, 121, 190, 250, 320, 401, 475, 520, 574, 634, 700, 764, 830, 905, 980].

For the first node (corresponding to W(1)), the value 121 satisfies the requirements. The opposite value is 121 + 511 = 633. There are 8 values between 122 and 633 (namely the lefthand subset 634, 700, 764, 830, 905, 980, 12 and 70), and 7 values between 634 and 120 (namely the righthand subset 190, 250, 320, 401, 475, 520 and 574).

The encoded value W(1) is 121 + 1, ie 122.

The second node (corresponding to W(2)) is the lefthand child of the first node. The corresponding subtree has to encode for the lefthand subset, renumbered beginning at 633. This gives the following 8 element subset of 0..510, ordered as resulting from the example of algorithm : [402, 460, 1, 67, 131, 197, 272, 347]. Out of these values, 1 splits the set in 4 and 3, and the encoded value W(2) is 2.

Similarily, the third node (W(3)) is the righthand child of the first. node and then the corresponding subtree encodes for the righthand subset, renumbered starting at 122. This gives the following set of 0..510 : [68, 128, 198, 279, 353, 398, 452]. Out of these values, 68 splits the set into 3 and 3, and the encoded value W(3) is 69.

The same method is applied for all nodes, giving the following encoded values per node :

node	value	node	value
1	122	9	83
2	2	10	3
3	69	11	24
4	204	12	67
5	75	13	54
6	66	14	64
7	60	15	70
8	70	16	9

The encoding then consists in formatting, in that order :
122 on 10 bits, then 2 and 69 on 9 bits each, then 204, 75, 66 and 60 on 8 bits each, then 70, 83, 3, 24, 67, 54, 64 and 70 on 7 bits each, and finally 9 on 6 bits.

Conversely the decoding can be done easily. For instance for node 2, the original value is

$$(122 - 512 + 2) \text{ smod } 1023 = 635$$

For node 14, we have as original value :

$$(122 - 512 + (2 + (66 + 64) \text{smod } 255) \text{smod } 511) \text{smod } 1023 = 765$$