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TECHNICAL REPORT

Digital VHF Maritime Radio;
Air interface for voice and data services using
FDMA in 6,25 KHz bandwidth

Reference
DTR/ERM-TGMAR-614

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Modal verbs terminology

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

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Executive summary

The present document describes a possible air interface implementation of digital voice technology in the maritime VHF market based on ETSI TS 102 658 [i.3].

Introduction

The availability of voice communication channels in the maritime VHF band continues to be reduced due to the introduction of new digital communication standards (AIS, ASM, VDE, AMRD etc.). As the technical characteristics of the maritime VHF channels are defined by Recommendations ITU-R M.489-2 [i.7] and Recommendation ITU-R M.1084-5 [i.6] as well as by Appendix 18 of the Radio Regulations [i.8], this regulatory framework will require a formal procedure for the implementation of more spectrum-efficient solutions. There are currently no radio channels allocated to implement more spectrum-efficient solutions in Appendix 18 of the Radio Regulations [i.8].

The present document has an informative status providing information about a possible future implementation of spectrum-efficient solutions for the maritime mobile service. Further developments of regulatory amendments, which were to be defined by IMO and ITU for the maritime mobile service, would be required prior to a possible implementation.

In other marine fora, dPMR has been identified as a potential candidate for alleviating these issues by improving the spectral efficiency. CEPT ECC Report 329 [i.9] provides information about practical field trials for the dPMR system. dPMR provides a mechanism to improve the spectral efficiency and so to increase the number of voice communication channels by using the technology described in ETSI TS 102 658 [i.3] which can re-farm an existing 25 kHz analogue FM voice channel into four digital voice channels.

The original dPMR standard [i.3] has been used as the basis for the present document, with a number of changes to suit the maritime environment:

- Addressing range expanded from 24 to 32 bits
- Header types simplified
- Redundant data fields removed
- Type 1 data facility removed
- Type 3 data facility removed
- CRC8 used in place of CRC7 to improve robustness
- Slow data channel used to provide position during a call as the default mode

Type 2 data (with FEC) is implemented to support a low rate data system suitable for SMS / text messaging type applications. Provision for Type 3 data (packet data) is removed as other data exchange mechanisms (such as VDES) are more appropriate for exchange of large blocks of data.

System Header types are reserved for possible future expansion of the system or special features.

In addition to the much improved spectrum efficiency, the use of this protocol identifies each and every transmission with the calling stations MMSI and their position, so all users can be easily identified and correlated with other communications systems (AIS for instance) to enhance security and situational awareness.

The Tx-timeout is mandatory (currently set to 3 minutes) to ensure that "stuck mic" situations do not block the radio channels.

The use of the Tx_Wait timer at the end of every "over" allows a station with a non-routine category call to break-into an ongoing communication session.

1 Scope

The present document is a proposal for using digital voice for Routine category calls in the marine VHF band (all transactions handled as data calls). Provision for handling other Recommendation ITU-R M.493 calls is also provided.

The equipment is based on FDMA with channel spacing of 6,25 kHz supporting voice and data applications.

The present document does not provide the specification or operational detail for system implementations which include but are not limited to, vocoder, security, data, remote control and other interfaces.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Recommendation ITU-R M.493-15 (01/2019): "Digital selective-calling system for use in the maritime mobile service".

[i.2] ETSI EN 301 166 (V2.1.1): "Land Mobile Service; Radio equipment for analogue and/or digital communication (speech and/or data) and operating on narrow band channels and having an antenna connector; Harmonised Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU".

[i.3] ETSI TS 102 658: "Digital Private Mobile Radio (dPMR) using FDMA with a channel spacing of 6,25 kHz".

[i.4] Recommendation ITU-R M.1371-5 (02/2014): "Technical characteristics for an automatic identification system using time division multiple access in the VHF maritime mobile frequency band".

[i.5] Recommendation ITU-R M.585-8 (10/2019): "Assignment and use of identities in the maritime mobile service".

[i.6] Recommendation ITU-R M.1084-5 (03/2012): "Interim solutions for improved efficiency in the use of the band 156-174 MHz by stations in the maritime mobile service".

[i.7] Recommendation ITU-R M.489-2 (10/1995): "Technical characteristics of VHF radiotelephone equipment operating in the maritime mobile service in channels spaced by 25 kHz".

[i.8] ITU Radio Regulations Appendix 18 (WRC-19).

[i.9] CEPT ECC Report 329: "Implementation of digital voice radio telephony in the VHF maritime mobile band".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

bearer service: type of telecommunication service that provides the capability for the information transfer between user network interfaces, involving only low layer functions (layers 1 to 3 of the OSI model)

NOTE: Confirmed Data and Unconfirmed Data are examples of bearer services.

burst: smallest predefined block of continuous bits containing information or signalling

NOTE: The burst may include a guard time at the beginning and end of the burst used for power ramp-up and ramp-down.

call: complete sequence of related transactions between radios

NOTE: Transactions may be one or more bursts containing specific call related information.

Control plane (C-plane): part of the protocol stack dedicated to control and data services

feature: attribute intrinsic to a station, e.g. MS has an address

Handportable Station (HS): physical grouping that contains all of the mobile equipment that is used to obtain mobile services and operating with an integral antenna

late entry: where receiving stations that have missed the start of a transmission are able to recover all information about the call from data that is interspersed within each superframe

logical channel: distinct data path between logical endpoints

payload: bits in the information field

peer-to-peer mode: mode of operation where radios may communicate outside the control of a network

NOTE: This is communication technique where any radio unit may communicate with one or more other radio units without the need for any additional equipment (e.g. BS).

personalization: address and configuration information that characterizes a particular radio

NOTE: This information may be implanted by the installer before putting an HS into service.

physical channel: FDMA transmission

polite protocol: Listen Before Transmit (LBT) protocol

NOTE: This is a medium access protocol that implements a LBT function in order to ensure that the channel is free before transmitting.

Protocol Data Unit (PDU): unit of information consisting of protocol control information (signalling) and possibly user data exchanged between peer protocol layer entities

radio frequency channel: radio frequency carrier (RF carrier)

NOTE: This is a specified portion of the RF spectrum. The RF carrier separation is 6,25 kHz.

Received Signal Strength Indication (RSSI): root mean squared value of the signal received at the receiver antenna

signalling: exchange of information specifically concerned with the establishment and control of connections, and with management, in a telecommunication network

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

NOTE: Simplex is also known as half duplex.

superframe: four concatenated FDMA frames

NOTE: A superframe has a length of 320 ms.

supplementary service: service modifying or supplementing a tele-service or bearer service

NOTE: A supplementary service cannot be offered to a user as a standalone service. It is always offered together with or in association with a tele-service or bearer service. The same supplementary service may be common to a number of telecommunication services. Late entry is an example of supplementary service.

telecommunication service: offered by a radio entity in order to satisfy a specific telecommunication requirement

tele-service: type of telecommunication service that provides the complete capability, including terminal equipment functions, for communication between users

NOTE: Individual voice calls and group voice calls are examples of tele-services.

User plane (U-plane): part of the protocol stack dedicated to user voice services

vocoder socket: 216 bits vocoder payload

wildcard: character in the user domain that represents all digits 0 to 9

3.2 Symbols

For the purposes of the present document, the following symbols apply:

dBm	absolute power level relative to 1 mW, expressed in dB
dBp	Power relative to the average power transmitted over a burst in decibel
Eb	Energy per bit
No	Noise per Hz

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

4FSK	Four-level Frequency Shift Keying
ACK	ACKnowledgment
AI	Air Interface
ARQ	Automatic Retransmission reQuest
BS	Base Station
CC	Channel Code
CCH	Control CHannel
CCL	Call Control Layer
Cont	Continuation flag
C-plane	Control-plane
CRC	Cyclic Redundancy Checksum for data error detection
Di-bit	2 bits grouped together to represent a 4-level symbol
DLL	Data Link Layer
DP	Data Position
ET	End Type
FDMA	Frequency Division Multiple Access
FEC	Forward Error Correction
FN	Frame Numbering
FS	Frame Synch
HI	Header Information
HS	Handportable Station
HT	Header Type
ID	Identifier
IMO	International Maritime Organization
LBT	Listen Before Transmit
MMSI	Marine Mobile Station Identifier

MS	Mobile Station
NACK	Negative ACKnowledgment
PDU	Protocol Data Unit
PTT	Press To Talk
PL	Physical Layer
RF	Radio Frequency
RSSI	Received Signal Strength Indication
SF	SuperFrame
SLD	SLow Data
SYNC	SYNChronization
TCH	Traffic CHannel
U-plane	User-plane

4 Overview

The present document describes the air interface for a narrow band Digital Mobile Radio system which employs a Frequency Division Multiple Access (FDMA) technology with an RF carrier bandwidth of 6,25 kHz. This is based on the existing dPMR ETSI TS 102 658 [i.3] used in land mobile radio, suitably modified to support the requirements of maritime use.

Changes to support similar call control and addressing features of the existing Recommendation ITU-R M.493-15 VHF DSC [i.1], have been implemented.

In particular it should be noted that the most used call type in marine VHF is an "all ships, routine" call, whereas in land mobile an addressed individual or group call is more normal. It is expected that all voice calls, irrespective of the call type, will be audible on all stations on the channel. Individual (addressed) calls should additionally trigger an audible and visual indication to alert the operator to mimic the existing operation using analogue FM.

The present document describes the Physical Layer (PL) and the Data Link Layer (DLL) of the Air Interface (AI) as well as the standardized services and facilities of the radio. Radio equipment which conforms to the present document are interoperable at the PL and DLL.

The voice encoding system (vocoder) is not defined in the present document as this will need to be agreed by international convention to ensure global interoperability. Provision is reserved to accommodate a number of standard voice encoders currently available in the market.

5 Protocol architecture

5.1 Overview

The purpose of this clause is to provide a model where the different functions and processes are identified and allocated to different layers in the protocol stack.

The protocol stack in this clause and all other related clauses describe and specify the interfaces, but this stack does not imply or restrict any implementation.

The protocol architecture which is defined herein follows the generic layered structure, which is accepted for reference description and specification of layered communication architectures.

The present document defines the protocols for the following 3 layered model as shown in figure 1.

The base of the protocol stack is the Physical Layer (PL) which is the layer 1.

The Data Link Layer (DLL), which is the layer 2, will handle sharing of the medium by a number of users. At the DLL, the protocol stack will be divided vertically into two parts, the User plane (U-plane), for transporting information without addressing capability (e.g. voice or data stream), and the Control plane (C-plane) for signalling with addressing capability, as illustrated by figure 1.

The Call Control Layer (CCL), which is layer 3, lies in the C-plane and is responsible for control of the call (addressing, facilities, etc.), provides the services supported by the radio, and supports the Data Service. U-plane access at layer 2 (DLL) supports voice service.

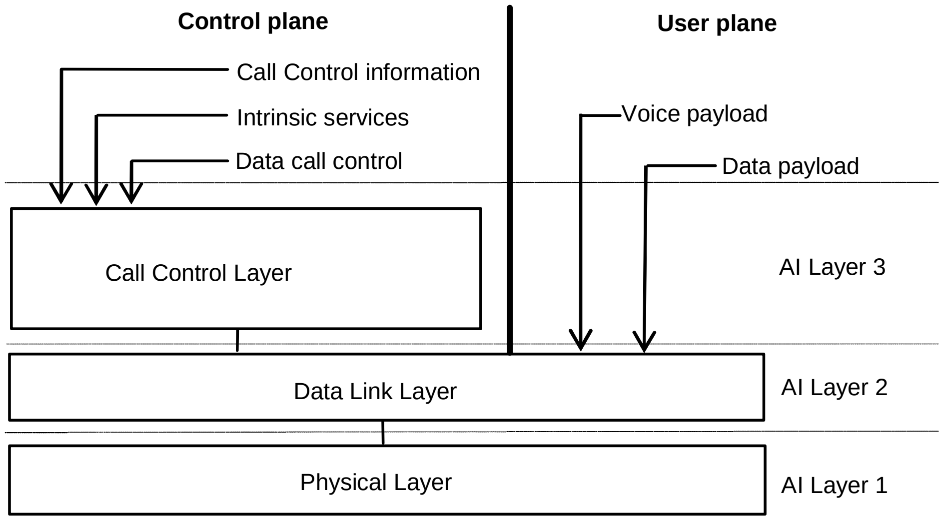


Figure 1: Protocol stack

5.2 Air Interface Physical Layer (layer 1)

The Air Interface layer 1 is the physical interface. It deals with the physical transmission or burst, composed of bits, which is to be sent and/or received. The Physical Layer is described in clause 12. The Air Interface layer 1 contains the following functions:

- modulation and demodulation;
- transmitter and receiver switching;
- RF characteristics;
- bits and symbol definition;
- frequency and symbol synchronization;
- transmission or burst building.

5.3 Air Interface Data Link Layer (layer 2)

The Air Interface layer 2 handles logical connections and hides the physical medium from the upper layers. The Data Link Layer is described in clauses 8 to 10.

The main functions are as follows:

- channel coding (FEC, CRC);
- interleaving, de-interleaving and bit ordering;
- acknowledgement and retry mechanism;
- media access control and channel management;
- framing, superframe building and synchronization;
- burst and parameter definition;
- link addressing (source and/or destination);

- interfacing of voice applications (vocoder data) with the PL;
- data bearer services;
- exchanging signalling and/or user data with the CCL.

5.4 Air Interface Call Control Layer (layer 3)

Air Interface layer 3 (CCL) is applicable only to the C-plane, and is an entity for the services and facilities supported by the radio on top of the layer 2 functionality.

The CCL provides the following functions:

- establishing, maintaining and terminating of calls;
- all-call, individual or group call transmission and reception;
- destination addressing;
- support of intrinsic services (late entry, call divert, etc.);
- data call control.

5.5 FDMA Structure

5.5.1 Overview of transmission and burst structure

The described solution is based on a FDMA structure.

All transmissions are asynchronous, since there is no entity to provide frame or slot timing.

The physical resource available to the radio system is an allocation of the radio spectrum.

A transmission or burst is a period of RF carrier that is modulated by a data stream. The physical channel of an FDMA transmission is required to support the logical channels.

A logical channel is defined as a logical communication pathway between two or more parties. The logical channels represent the interface between the protocol and the radio subsystem. The logical channels may be separated into two categories:

- the traffic channels carrying speech or data information; and
- control channels carrying signalling.

5.5.2 Transmission format

The FDMA transmission is made up of 80 ms payload frames, each comprising 384 bits.

Payload frame:

a	b	c	d	e	f

a: 24 bits FrameSync2 (FS2) or ColourCode (CC) bits
b: 72 bits Control Channel (CCH) data
c: 72 bits Traffic channel (TCH)
d: 72 bits TCH
e: 72 bits TCH
f: 72 bits TCH

Four 80 ms payload frames are concatenated to form a superframe of 320 ms.

Superframe:

FS2 CCH TCH x 4	CC CCH TCH x 4	FS2 CCH TCH x 4	CC CCH TCH x 4

The Header frame is of 80 ms (384 bits) in length.

Header:

P	FS1	HI0	CC	HI1

P: Preamble, minimum of 72 bits
FS1: 48 bit Frame Sync 1 sequence
HI0: Header Information 0, 120 bits
CC: Channel code, 24 bits
HI1: Header Information 1, 120 bits

The End message is a shortened 96 bit frame.

End:

FS3	END

FS3: Frame sync, 24 bits
END: End data, 72 bits

5.5.3 Transmission sequences

Voice or data payload continuous transmission:

These transmissions are always started with a Header frame containing a preamble (for bit synchronization) and a frame synch (for frame synchronization). The Header is followed by a series of superframes that contain both the payload (voice or data) and the information about the call such that receiving stations can implement late entry. A call always consists of an integral number of superframes and is terminated by an End frame.

For receiving stations, purpose and content of any transmission can be determined by the Header Information (HI0 and HI1).

H	SF	SF	SF	SF	SF	E

H: Header frame
SF: Superframe
E: End frame

Call set up, service request, etc:

These transmissions are simply a concatenation of a Header frame and an End frame. Their purpose is to inform the receiving station of the call, type of call or information required.

H	E

Acknowledgement:

Acknowledgements are a type of Header that contains information such as confirmation of received data, errors in received data etc.

H

Status request acknowledgements:

As the status information is contained within the End frame then the response of a receiving station to a status request call will be a Header + End frame pair.

H	E

Disconnection:

Sending stations can signal that all exchanges of a call have been completed by transmitting a disconnection request. This is a Header + End frame pair that is repeated.

H	E	H	E

Call procedures:

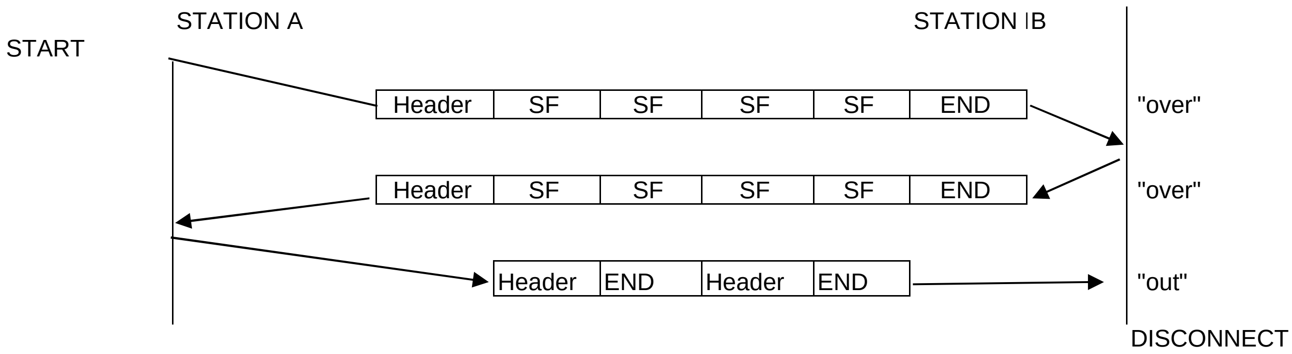


Figure 2: Routine all-ships voice call progress

For a normal, routine All-Call, the user selects the (default) All-Call setting on the sending station, press the PTT and talk. The radio will transmit the Header Block with the Called-ID set to the All-Call value and the Own-ID set to the MMSI of the sending station. The radio will then transmit voice frames with slow-data until the PTT is released. The receiving station will decode the voice frames and present the audio signal to the user. When the END frame is received, it will mute the audio. Before a response can be transmitted, the Tx_Wait timer will be invoked to allow higher priority calls to override the conversation.

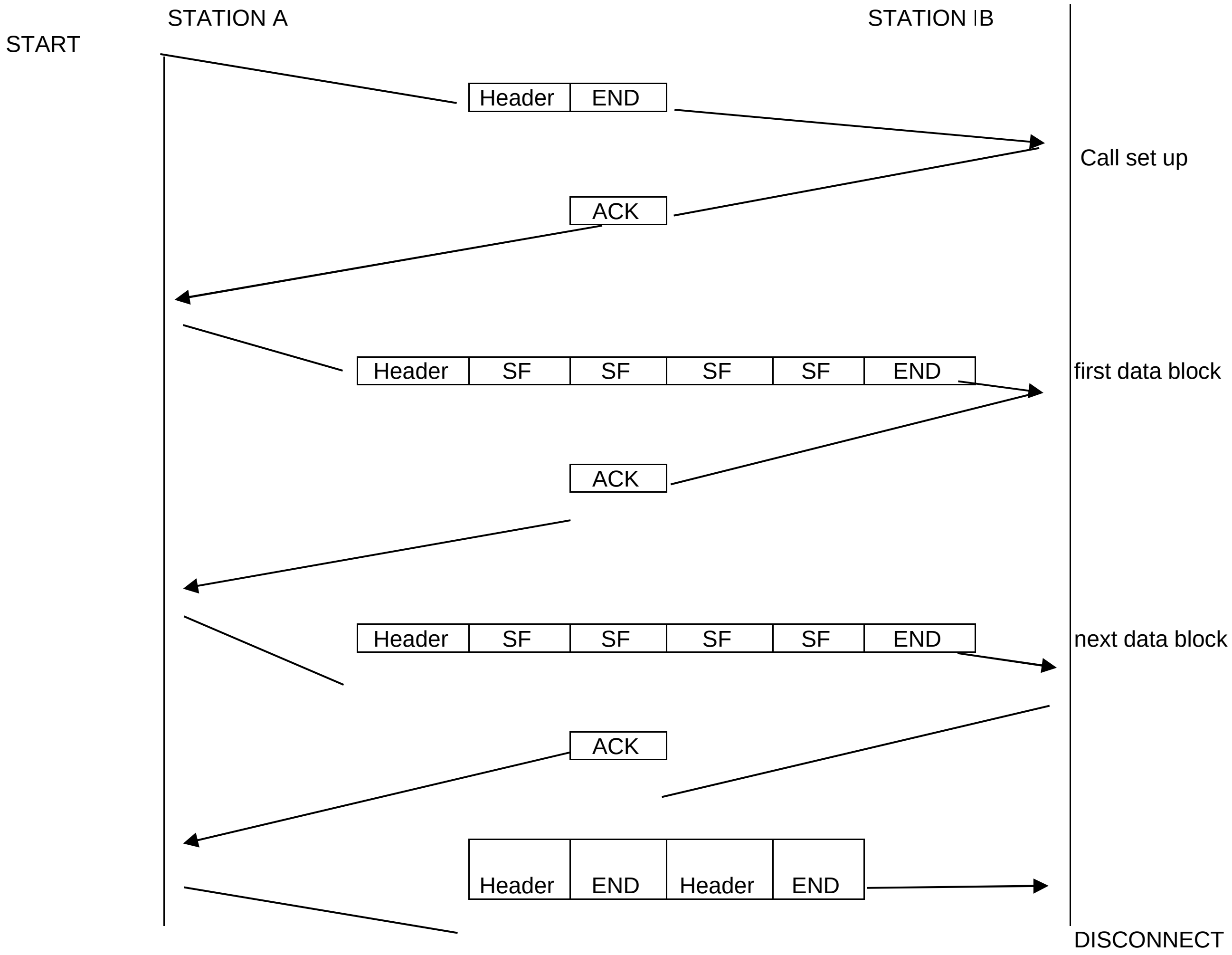


Figure 3: Addressed data call progress

Figure 3 shows an example of the exchanges involved in the call set-up and exchanges of an individual (addressed) data call.

In this case the sending station uses the call set-up (Header and End frames) to establish that the receiving station is within range and not busy. When the receiving station has acknowledged with an ACK the sending station commences to send the data in 4 superframe bursts. After each burst the receiving station decodes and error checks the data and if there are no errors a positive ACK is sent. If errors are detected then a negative ACK would be sent and the sending station would repeat that transmission. When all the data has been transmitted User defined clause(s) from here onwards.

6 Frame coding

6.1 Superframe

Table 1: Superframe content, payload frame 1

	FRAME 1	Bits	FEC	Transfer	Rate
FS2	Frame Sync	24	None	24	
CCH	Control Channel	(40)	CRC 8 bit (12, 8) Short Hamming Interleave 12 x 6 Scramble	72	513 bps
FN	Frame Number	2			25 bps
ID0	Called ID (upper 16 bits)	16			38 bps
M	Communications mode	2			38 bps
CAT	Category	2			25 bps
SLD	Slow Data	18			225 bps
	CRC	8			
	FEC	24			
TCH	Payload	72 x 4		288	

Table 2: Superframe content, payload frame 2

	FRAME 2	Bits	FEC	Transfer	Rate
CC	Channel code	12	Di-bit	24	
CCH	Control Channel	(40)	CRC 8 bit (12, 8) Short Hamming Interleave 12 x 6 Scramble	72	513 bps
FN	Frame Number	2			25 bps
ID1	Called ID (lower 16 bits)	16			38 bps
M	Communications mode	2			38 bps
CAT	Category	2			25 bps
SLD	Slow Data	18			225 bps
	CRC	8			
	FEC	24			
TCH	Payload	72 x 4		288	

Table 3: Superframe content, payload frame 3

	FRAME 3	Bits	FEC	Transfer	Rate
FS2	Frame Sync	24	None	24	
CCH	Control Channel	(40)	CRC 8 bit (12, 8) Short Hamming Interleave 12 x 6 Scramble	72	513 bps
FN	Frame Number	2			25 bps
ID2	Own ID (upper 16 bits)	16			38 bps
M	Communications mode	2			38 bps
CAT	Category	2			25 bps
SLD	Slow Data	18			225 bps
	CRC	8			
	FEC	24			
TCH	Payload	72 x 4		288	

Table 4: Superframe content, payload frame 4

	FRAME 4	Bits	FEC	Transfer	Rate
CC	Channel code	12	Di-bit	24	
CCH	Control Channel	(40)	CRC 8 bit (12, 8) Short Hamming Interleave 12 x 6 Scramble	72	513 bps
FN	Frame Number	2			25 bps
ID3	Own ID (lower 16 bits)	16			38 bps
M	Communications mode	2			38 bps
CAT	Category	2			25 bps
SLD	Slow Data	18			225 bps
	CRC	8			
	FEC	24			
TCH	Payload	72 x 4		288	

6.2 Header frame

Table 5: Header frame content

		Bits	**FEC**			**Transfer**
P	Preamble	≥ 72	none			72
FS1	Frame Sync	48	none			48
HI0	**Header Information**	**(72)**	8 bit CRC (12,8) Hamming	Interleave 12 x 10	Scramble	120
HT	Header type	4				
ID0+1	Called station ID	32				
ID2+3	Own ID	32				
M	Communication mode	2				
CAT	Category	2				
	CRC	8				
	FEC	40				
CC	Channel code	12	Di-bit			24
HI1	**Header Information**	**(72)**	8 bit CRC (12,8) Hamming	Interleave 12 x 10	Scramble	120
HT	Header type	4				
ID0+1	Called station ID	32				
ID2+3	Own ID	32				
M	Communication mode	2				
CAT	Category	2				
	CRC	8				
	FEC	40				

6.3 End frame

Table 6: End frame content

		Bits	**FEC**			**Transfer**
FS3	Frame Sync	24	none			24
END0	**End Information**	**(17)**	7 bit CRC (12,8) Short Hamming	Interleave 12 x 10	Scramble	72
ET	End type	2				
ARQ	Ack request	2				
WAIT	Tx wait	4				
STAT	Status message	9				
	CRC	7				
	FEC	12				
END1	**End Information**	**(17)**	7 bit CRC (12,8) Short Hamming	Interleave 12 x 10	Scramble	
ET	End type	2				
ARQ	Ack request	2				
WAIT	Tx wait	4				
STAT	Status message	9				
	CRC	7				
	FEC	12				

6.4 ACK frame

The ACK frame has identical composition to the Header Frame. It is identified as an acknowledgement by the Header Type (HT) bits setting. The use of ACK frames is applicable only to individually addressed calls.

Table 7: Ack frame content

		Bits	**FEC**			**Transfer**
P	Preamble	≥ 72	none			72
FS1	Frame Sync	48	none			48
HI0	**Header Information**	**(72)**	8 bit CRC (12,8) Hamming	Interleave 12 x 10	Scramble	120
HT	Header type	4				
ID0+1	Called station ID	32				
ID2+3	Own ID	32				
AKR	Ack Response	2				
CAT	Category	2				
	CRC	8				
	FEC	40				
CC	Channel code	12	Di-bit			24
HI1	**Header Information**	**(72)**	8 bit CRC (12,8) Hamming	Interleave 12 x 10	Scramble	120
HT	Header type	4				
ID0+1	Called station ID	32				
ID2+3	Own ID	32				
AKR	Ack Response	2				
CAT	Category	2				
	CRC	8				
	FEC	40				

6.5 Frame numbering

Frame used This is the FN field in the payload frames.

Data length 2 bits.

Two bits are allocated for frame numbering within each superframe.

Table 8: Frame numbering

00	1st frame
01	2nd frame
10	3rd frame
11	4th frame

6.6 Communication Mode

Frame used This is the M field in the Header Frame/Packet data Header and in the CCH of the payload frame.

Data length 2 bits.

Table 9: Communications mode

00	Voice communication + Slow Data
01	Voice communication + Slow Data + Appended Data
10	Data communication type 2 (User Data with FEC)
11	Reserved
NOTE 1: Value 00 is the default value for voice calls. NOTE 2: When this field is set to 01 in the Header Frame, the call should start with voice frames, but when the voice has finished, the appended data will start in the next frame when the value of this field should change to 10 to indicate that the following payload is type 2 data. Thus the minimum amount of data that can be appended in each frame is 72 x 4 bits = 288 bits with coding applied, which equates to 40 x 4 bits = 160 bits of protected user data. NOTE 3: Whilst the appended data is being transmitted, the SLD field will be used as in clause 6.9.3.	

6.7 Category

Frame used This is the CAT field (derived from DSC) used in Header, End and Ack frames

Data length 2 bits

Table 10: Communication format

00	Routine
01	Safety
10	Urgency
11	Distress
NOTE: The default is 00, Routine.	

6.8 Acknowledgement Response

Frame used This is the AKR field in the Ack Frame

Data length 2 bits

Table 11: Acknowledgement Response

AKR	Definition
00	Reserved
01	ACK (Rx OK)
10	NACK (data error, resend request)
11	NACK (rejected, not available)

6.9 SLD format

6.9.1 Overview

Within the superframe there are 18 bits allocated in the CCH data for each frame for the transmission of slow data, allowing up to 72 bits of slow data in each superframe. Within this 72 bit allocation there are 2 Slow Data ID bits and 70 bits of data.

Additionally, the SLD field is used during Type 2 data transmissions to indicate the type of data being transmitted as well as a flag to indicate if the data terminates after the current frame.

6.9.2 Slow data in the voice superframe

The normal use of the slow data field is to transmit the stations position at the same time as a voice communication. This allows a complete latitude and longitude position to be communicated in the first superframe of any voice transmission allowing the talkers position to be located as soon as possible. The data may be repeated in subsequent superframes to allow late entry stations to have access to the position data and to update the position as the call matures.

Slow Data ID:

Table 12: Slow Data ID

00	There is no slow data in this superframe
01	Position data in frames 1 to 4
10	Type 2 data in the frame
11	Reserved

Position Data:

Frames 1 and 2 contain 28 bits of longitude while Frames 3 and 4 contain the 27 bits of latitude, both of them in the same format as Recommendation ITU-R M.1371-5 [i.4] (see Table 13).

Table 13: Position data

Parameter	Number of bits	Description
Longitude	28	Longitude in 1/10 000 min (±180°, East = positive (as per 2's complement), West = negative (as per 2's complement). 181° (6791AC0 hex) = not available = default
Latitude	27	Latitude in 1/10 000 min (±90°, North = positive (as per 2's complement), South = negative (as per 2´s complement), 91° (3 412 140 hex) = not available = default)

Slow data content is shown in Table 14.

Table 14: Position data

Frame 1		Frame 2		Frame 3	Frame 4	
ID	longitude	Longitude	spare	Latitude	latitude	spare
2 bits	16 msb	12 lsb	6 bits	18 msb	9 lsb	9 bits

6.9.3 Slow data field use with Type 2 data

When Type 2 data is transmitted, the SLD field is used to convey information of data format, position and continuation, etc. The SLD field is also used when a voice transmission has data appended to the end of the transmission.

ID	Reserved	DP	Format	Cont.	Data length (bytes)
2 bits (=10)	3 bits	2 bits	4 bits	1 bit	6 bits

Data Position (DP):

Table 15: DP coding

00	There is no data in this frame
01	Reserved
10	Reserved
11	There is data in this frame

Format:

Table 16: Format coding

0000	Status message
0001	Precoded message
0010	Free text message (SMS radio generated data)
0011	Short file transfer
0100	User defined data 1
0101	User defined data 2
0110	User defined data 3
0111	User defined data 4
Other	Reserved

Continuation flag:

Table 17: Format coding

0	Data continues after this frame.
1	Data finishes at this frame.

6.10 Header type

Frame used This is the HT field in the Header Frame/Packet Data Header Frame.

Data length 4 bits.

Table 18: Header type

0000	Communication start header (a superframe follows)
0001	Connection request header (an END frame follows)
0010	Unconnect request header (an END frame follows)
0011	ACK (this a single frame, ACK or NACK is differentiated by the ACS bits)
0100	System request header (an END frame follows)
0101	ACK header reply to a system request (a superframe follows)
0110	System delivery header (a superframe follows)
0111	Status response header (an END frame follows)
1000	Status request header
Other	Reserved

NOTE 1: For a routine all-ships call, HT = 0000 is appropriate.

NOTE 2: For a routine addressed call, HT = 0001 is appropriate initially to ensure the called party is available to accept the call. Following a positive acknowledgement, the call would then progress with HT = 0000.

NOTE 3: Values 0100 to 0110 are intended for trunked mode operations which are not covered in the present document.

6.11 End type

Frame used This is the ET field in the EN: D Frame.

Data length 2 bits.

Definition:

Table 19: End type

00	Normal End frame with status
01	Normal End frame with channel no.
10	System End Frame
11	Reserved

6.12 ARQ

Frame used This is the ARQ field in the END Frame.

Data length 1 bits.

Definition:

Table 20: ARQ

0	No ACK request to called station
1	ACK request to called station

6.13 TxWait

Frame used: This is the TxWait field in the END frame.

Data length: 4 bits

Definition: This sets the minimum delay period after reception of an END frame for a unit to start a routine transmission. Urgent or Distress calls are permitted to start transmissions during this period to allow them to take priority and "interrupt" an on-going routine conversation. The value is specified in multiples of 80 ms. The default value for routine calls is 0001_b, i.e.: 80 ms.

6.14 End Data

Frame used This is the STAT field in the END Frame. This contains either the status value or the binary value of the channel number to be used in the next communication.

Data length 9 bits.

Definition:

0 to 31	Status message

NOTE: The nature and meaning of each status message is still to be defined.

6.15 Control Channel CCH

FN	Frame number 0 to 4	2 bits
ID	16 bits of ID data (see clause 10.1)	16 bits
M	Communication Mode	2 bits
CAT	Category	2 bits
SLD	Slow User Data	18 bits

7 Synchronization

7.1 Frame synchronization

7.1.1 FS1

The Frame sync 1 sequence contained in the non packet data header frame (Header 1) is a 48 bit sequence that will have the following value:

Binary: 010101111111111101011111011101011101010101110111.

Hex: 57 FF 5F 75 D5 77.

7.1.2 FS2

The Frame sync 2 sequence contained in the superframe (frames 1 and 3) is a 24 bit sequence that will have the following value:

Binary: 010111111111011101111101.

Hex: 5F F7 7D.

7.1.3 FS3

The Frame sync 3 sequence contained in the End frame is a 24 bit sequence that will have the following value:

Binary: 011111011101111111110101.

Hex: 7D DF F5.

7.1.4 FS4

The Frame sync 4 sequence is reserved for future use. It is a 48 bit sequence that will have the following value:

Binary: 111111010101010111110101110111110111111111011101.

Hex: FD 55 F5 DF 7F DD.

7.1.5 Channel Code

MS and BS will determine the Channel Code applicable from the channel centre transmit frequency. In this case, as dPMR may be operated both in existing 12,5 kHz channel rasters and in 6,25 kHz channel rasters, the Channel Code will be calculated as follows:

For 12,5 kHz channel rasters:

CC number = 64 x (f modulo 0,4) where f is the channel frequency in MHz.

For 6,25 kHz channel rasters:

CC number = [64 x (f modulo 0,4)] - 0,5 where f is the channel frequency in MHz.

Both algorithms result in integer values of CC from 0 to 63.

(f modulo 0,4) is calculated as follows:

a) the frequency 'f' in MHz is divided by 0,4;

b) the part to the right of the decimal point of the result from a) is retained.

Table 21: Channel Code

Code number	Channel Code (Bits)	Channel Code (Hex)
0	$0101\ 0111\ 0101\ 1111\ 0111\ 0111_2$	$57\ 5F\ 77_{16}$
1	$0101\ 0111\ 0111\ 0101\ 0111\ 0111_2$	$57\ 75\ 77_{16}$
2	$0101\ 0111\ 1101\ 1101\ 0111\ 0101_2$	$57\ DD\ 75_{16}$
3	$0101\ 0111\ 1111\ 0111\ 0111\ 0101_2$	$57\ F7\ 75_{16}$
4	$0101\ 0101\ 0101\ 0111\ 0111\ 1101_2$	$55\ 57\ 7D_{16}$
5	$0101\ 0101\ 0111\ 1101\ 0111\ 1101_2$	$55\ 7D\ 7D_{16}$
6	$0101\ 0101\ 1101\ 0101\ 0111\ 1111_2$	$55\ D5\ 7F_{16}$
7	$0101\ 0101\ 1111\ 1111\ 0111\ 1111_2$	$55\ FF\ 7F_{16}$
8	$0101\ 1111\ 0101\ 0101\ 0101\ 1111_2$	$5F\ 55\ 5F_{16}$
9	$0101\ 1111\ 0111\ 1111\ 0101\ 1111_2$	$5F\ 7F\ 5F_{16}$
10	$0101\ 1111\ 1101\ 0111\ 0101\ 1101_2$	$5F\ D7\ 5D_{16}$

Code number	Channel Code (Bits)	Channel Code (Hex)
11	$0101\ 1111\ 1111\ 1101\ 0101\ 1101_2$	$5F\ FD\ 5D_{16}$
12	$0101\ 1101\ 0101\ 1101\ 0101\ 0101_2$	$5D\ 5D\ 55_{16}$
13	$0101\ 1101\ 0111\ 0111\ 0101\ 0101_2$	$5D\ 77\ 55_{16}$
14	$0101\ 1101\ 1101\ 1111\ 0101\ 0111_2$	$5D\ DF\ 57_{16}$
15	$0101\ 1101\ 1111\ 0101\ 0101\ 0111_2$	$5D\ F5\ 57_{16}$
16	$0111\ 0111\ 0101\ 1101\ 1101\ 0111_2$	$77\ 5D\ D7_{16}$
17	$0111\ 0111\ 0111\ 0111\ 1101\ 0111_2$	$77\ 77\ D7_{16}$
18	$0111\ 0111\ 1101\ 1111\ 1101\ 0101_2$	$77\ DF\ D5_{16}$
19	$0111\ 0111\ 1111\ 0101\ 1101\ 0101_2$	$77\ F5\ D5_{16}$
20	$0111\ 0101\ 0101\ 0101\ 1101\ 1101_2$	$75\ 55\ DD_{16}$
21	$0111\ 0101\ 0111\ 1111\ 1101\ 1101_2$	$75\ 7F\ DD_{16}$
22	$0111\ 0101\ 1101\ 0111\ 1101\ 1111_2$	$75\ D7\ DF_{16}$
23	$0111\ 0101\ 1111\ 1101\ 1101\ 1111_2$	$75\ FD\ DF_{16}$
24	$0111\ 1111\ 0101\ 0111\ 1111\ 1111_2$	$7F\ 57\ FF_{16}$
25	$0111\ 1111\ 0111\ 1101\ 1111\ 1111_2$	$7F\ 7D\ FF_{16}$
26	$0111\ 1111\ 1101\ 0101\ 1111\ 1101_2$	$7F\ D5\ FD_{16}$
27	$0111\ 1111\ 1111\ 1111\ 1111\ 1101_2$	$7F\ FF\ FD_{16}$
28	$0111\ 1101\ 0101\ 1111\ 1111\ 0101_2$	$7D\ 5F\ F5_{16}$
29	$0111\ 1101\ 0111\ 0101\ 1111\ 0101_2$	$7D\ 75\ F5_{16}$
30	$0111\ 1101\ 1101\ 1101\ 1111\ 0111_2$	$7D\ DD\ F7_{16}$
31	$0111\ 1101\ 1111\ 0111\ 1111\ 0111_2$	$7D\ F7\ F7_{16}$
32	$1101\ 0111\ 0101\ 0101\ 1111\ 0111_2$	$D7\ 55\ F7_{16}$
33	$1101\ 0111\ 0111\ 1111\ 1111\ 0111_2$	$D7\ 7F\ F7_{16}$
34	$1101\ 0111\ 1101\ 0111\ 1111\ 0101_2$	$D7\ D7\ F5_{16}$
35	$1101\ 0111\ 1111\ 1101\ 1111\ 0101_2$	$D7\ FD\ F5_{16}$
36	$1101\ 0101\ 0101\ 1101\ 1111\ 1101_2$	$D5\ 5D\ FD_{16}$
37	$1101\ 0101\ 0111\ 0111\ 1111\ 1101_2$	$D5\ 77\ FD_{16}$
38	$1101\ 0101\ 1101\ 1111\ 1111\ 1111_2$	$D5\ DF\ FF_{16}$
39	$1101\ 0101\ 1111\ 0101\ 1111\ 1111_2$	$D5\ F5\ FF_{16}$
40	$1101\ 1111\ 0101\ 1111\ 1101\ 1111_2$	$DF\ 5F\ DF_{16}$
41	$1101\ 1111\ 0111\ 0101\ 1101\ 1111_2$	$DF\ 75\ DF_{16}$
42	$1101\ 1111\ 1101\ 1101\ 1101\ 1101_2$	$DF\ DD\ DD_{16}$
43	$1101\ 1111\ 1111\ 0111\ 1101\ 1101_2$	$DF\ F7\ DD_{16}$
44	$1101\ 1101\ 0101\ 0111\ 1101\ 0101_2$	$DD\ 57\ D5_{16}$
45	$1101\ 1101\ 0111\ 1101\ 1101\ 0101_2$	$DD\ 7D\ D5_{16}$
46	$1101\ 1101\ 1101\ 0101\ 1101\ 0111_2$	$DD\ D5\ D7_{16}$
47	$1101\ 1101\ 1111\ 1111\ 1101\ 0111_2$	$DD\ FF\ D7_{16}$
48	$1111\ 0111\ 0101\ 0111\ 0101\ 0111_2$	$F7\ 57\ 57_{16}$
49	$1111\ 0111\ 0111\ 1101\ 0101\ 0111_2$	$F7\ 7D\ 57_{16}$
50	$1111\ 0111\ 1101\ 0101\ 0101\ 0101_2$	$F7\ D5\ 55_{16}$
51	$1111\ 0111\ 1111\ 1111\ 0101\ 0101_2$	$F7\ FF\ 55_{16}$
52	$1111\ 0101\ 0101\ 1111\ 0101\ 1101_2$	$F5\ 5F\ 5D_{16}$
53	$1111\ 0101\ 0111\ 0101\ 0101\ 1101_2$	$F5\ 75\ 5D_{16}$
54	$1111\ 0101\ 1101\ 1101\ 0101\ 1111_2$	$F5\ D\ D5F_{16}$
55	$1111\ 0101\ 1111\ 0111\ 0101\ 1111_2$	$F5\ F7\ 5F_{16}$
56	$1111\ 1111\ 0101\ 1101\ 0111\ 1111_2$	$FF\ 5D\ 7F_{16}$
57	$1111\ 1111\ 0111\ 0111\ 0111\ 1111_2$	$FF\ 77\ 7F_{16}$
58	$1111\ 1111\ 1101\ 1111\ 0111\ 1101_2$	$FF\ DF\ 7D_{16}$
59	$1111\ 1111\ 1111\ 0101\ 0111\ 1101_2$	$FF\ F5\ 7D_{16}$
60	$1111\ 1101\ 0101\ 0101\ 0111\ 0101_2$	$FD\ 55\ 75_{16}$
61	$1111\ 1101\ 0111\ 1111\ 0111\ 0101_2$	$FD\ 7F\ 75_{16}$
62	$1111\ 1101\ 1101\ 0111\ 0111\ 0111_2$	$FD\ D7\ 77_{16}$

Code number	Channel Code (Bits)	Channel Code (Hex)
63	$1111\ 1101\ 1111\ 1101\ 0111\ 0111_2$	$FD\ FD\ 77_{16}$

7.1.6 Preamble

The preamble consists of a minimum of 72 bits and will have the form 5F 5F 5F 5F 5F 5F 5F 5F 5F. If a preamble pattern longer than 72 bits is used then the repeated 5F pattern (01011111) will be maintained.

It is used with header frames, packet data headers and acknowledgements.

8 Interleaving and FEC coding

8.1 Di-bit coding

This is the coding scheme applicable to the Channel code:

0 >	01
1>	11

8.2 CRC addition

Use	CRC	Polynomial
Frame (CCH)	CRC7	X^7 + X^3 + 1
Header (HI)	CRC8	X^8 + X^2 + X^1 + 1

8.3 Hamming code

A shortened Hamming code (12,8) is employed and the generator matrix is shown below:

X7,X6,X5,X4,X3,X2,X1,1 is Identity bit (8 bit): C3,C2,C1,C0 is Parity bit (4 bit).

Table 22: Generator matrix

	12	11	10	9	8	7	6	5	4	3	2	1
	X7	X6	X5	X4	X3	X2	X1	1	C3	C2	C1	C0
1	1	0	0	0	0	0	0	0	1	1	1	0
2	0	1	0	0	0	0	0	0	0	1	1	1
3	0	0	1	0	0	0	0	0	1	0	1	0
4	0	0	0	1	0	0	0	0	0	1	0	1
5	0	0	0	0	1	0	0	0	1	0	1	1
6	0	0	0	0	0	1	0	0	1	1	0	0
7	0	0	0	0	0	0	1	0	0	1	1	0
8	0	0	0	0	0	0	0	1	0	0	1	1

Shortened Hamming code (12,8) Polynomial: X^4 + X + 1.

8.4 Scrambling

The scrambling polynomial is X^9 + X^5 + 1 with an initial preset value of all "1"s.

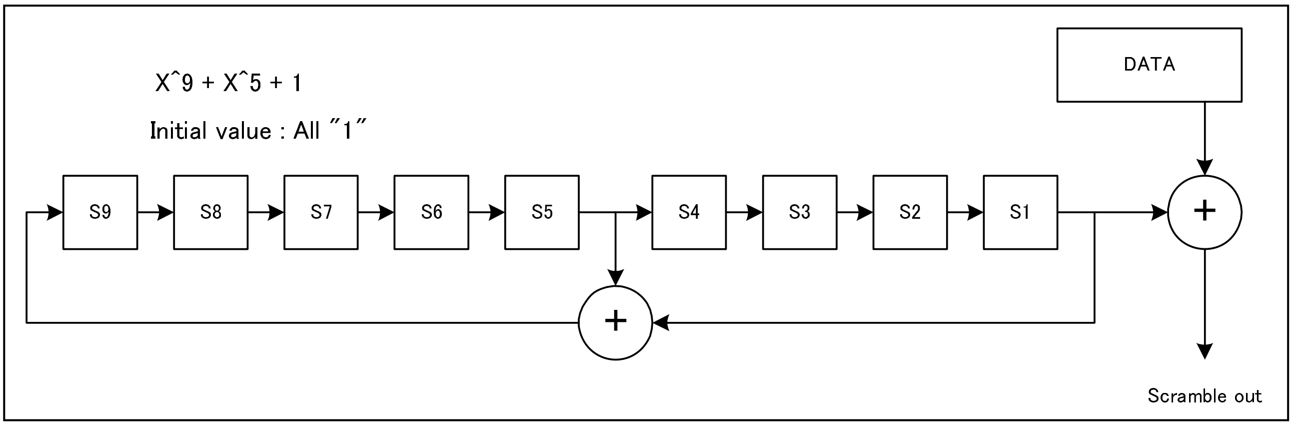


Figure 4: Scrambling format

8.5 Interleaving

There are two interleaving matrices, one for the TCH and one for the HI field.

TCH interleave structure matrix:

Table 23: TCH Interleaving matrix

	1	2	3	4	5	6
1	1	13	25	37	49	61
2	2	14	26	38	50	62
3	3	15	27	39	51	63
4	4	16	28	40	52	64
5	5	17	29	41	53	65
6	6	18	30	42	54	66
7	7	19	31	43	55	67
8	8	20	32	44	56	68
9	9	21	33	45	57	69
10	10	22	34	46	58	70
11	11	23	35	47	59	71
12	12	24	36	48	60	72

The Interleave Structure Matrix Map (Tx side: 12 bit x 10).

Table 24: HI field Interleaving matrix

	1	2	3	4	5	6	7	8	9	10
1	1	13	25	37	49	61	73	85	97	109
2	2	14	26	38	50	62	74	86	98	110
3	3	15	27	39	51	63	75	87	99	111
4	4	16	28	40	52	64	76	88	100	112
5	5	17	29	41	53	65	77	89	101	113
6	6	18	30	42	54	66	78	90	102	114
7	7	19	31	43	55	67	79	91	103	115
8	8	20	32	44	56	68	80	92	104	116
9	9	21	33	45	57	69	81	93	105	117
10	10	22	34	46	58	70	82	94	106	118
11	11	23	35	47	59	71	83	95	107	119
12	12	24	36	48	60	72	84	96	108	120
NOTE: Applied in the Header HI0/HI1.										

Use of interleaving matrices:

- Transmit data is input to the matrix in vertical columns from top left to lower right. Data is output from the matrix in horizontal rows from top left to lower right.

- Receive data is input to the matrix in horizontal rows from top left to lower right. Data is output from the matrix in vertical columns from top left to lower right.

9 Bearer services, tele-services and supplementary services

9.1 Standard mode

Table 25 shows the services in standard mode.

Table 25: Services

<table>
<tr><th>Bearer services</th><th>Tele-services</th><th>Supplementary services</th></tr>
<tr><td rowspan="13">Voice</td><td rowspan="6">Individual Call</td><td>Late Entry</td></tr>
<tr><td>Cancel call set-up</td></tr>
<tr><td>PTT call</td></tr>
<tr><td>Slow user data (position)</td></tr>
<tr><td>Short appended data</td></tr>
<tr><td>Talking Party Identification</td></tr>
<tr><td rowspan="7">Group Call</td><td>Late Entry</td></tr>
<tr><td>All Call</td></tr>
<tr><td>PTT Call</td></tr>
<tr><td>Slow user data (position)</td></tr>
<tr><td>Short appended data</td></tr>
<tr><td>Talking Party Identification</td></tr>
<tr><td>Short file transfer</td></tr>
<tr><td rowspan="8">Type 2 data</td><td rowspan="4">Individual Short Data Message</td><td>Status Message</td></tr>
<tr><td>Precoded Message</td></tr>
<tr><td>Free Text Message</td></tr>
<tr><td>Short file transfer</td></tr>
<tr><td rowspan="4">Group Short Data Message</td><td>Status Message</td></tr>
<tr><td>Precoded Message</td></tr>
<tr><td>Free Text Message</td></tr>
<tr><td>Short file transfer</td></tr>
</table>

9.2 All Call

As a default, all voice transmissions use slow data to attach the vessel's enhanced position to every call.

The default call type in the maritime environment is unaddressed so that all stations on the radio channel are aware of the stations situation. Depending on the situation, these may be categorized as routine, urgent, safety or distress in a similar manner as in Recommendation ITU-R M.493-15 [i.1].

Recommendation ITU-R M.585-8 [i.5] does not define an All-Call, so the over-air Called-ID value should be set to a value outside of the ITU range, $3F00\ 0000_{16}$. It is left to the equipment manufacturer to display this setting in a meaningful way - the text "ALL CALL" is suggested as this can be indicated on a 7-segment display as well as dot-matrix or other styles.

All stations should respond to this format to ensure full situational awareness. An audible or visual alarm is optional in this case, but the following voice communication sent by the calling station should be audible on all receiving stations, unless manually muted.

All-calls do not require ACK.

All non-routine calls should over-ride any user applied audio muting.

9.3 Individual call

An individual call is a call made to a unique MMSI address that is not identified as a group address and needs to be placed according to Recommendation ITU-R M.493-15 (Individual, Routine, Data) [i.1]:

Called ID = MMSI of called station

Own-ID = MMSI of calling station

Category = 00 (Routine)

Frequency = Proposed 6,25 kHz Channel

NOTE: Where a group of vessels have an agreed working channel, they can call each other directly using this protocol without calling with DSC on CH70.

9.4 Group call

Recommendation ITU-R M.493-15 [i.1] supports Group calls, using the existing MMSI addressing scheme, which can also be used for maritime digital call.

NOTE: Where a group of vessels have an agreed working channel, they can place Group calls to each other directly using this protocol without calling with DSC on CH70. This can be used for both Voice and Data calls.

9.5 Addressing

The addressing is based on an allocation of 32 bits. The two msb of the ID field specify the addressing mode:

	Addressing mode
00	Remaining 30 bits are an MMSI or special code
01	reserved
1x	reserved

For Addressing Mode 00, the 30 data bits represent the 9-digit MMSI of the station in binary format. The maximum possible data range is 000 000 000 to 999 999 999 decimal (0000 000_{16} to 3B9A $C9FF_{16}$). Values outside this range can be used for special codes (for an "All Ships" call the value 3F00 0000_{16} is used as the Called ID instead of the ITU scheme).

Geographic calls are not supported in VHF.

Radios use a 9 digit MMSI addressing scheme that is binary encoded into the 30 bit address field.

All-ships calls use the format outside that described in Recommendation ITU-R M.585-8 [i.5], selection of an "All Call" by the user resulting in a value of 3F00 0000_{16} in the address field.

Own_ID is the 30 bit binary representation of the MMSI of the calling station.

NOTE: ATIS id's for inland waterways use can be allocated to addressing mode 01, by dropping the initial "9" from the ATIS code and using the 30 bit binary representation of the remaining digits.

9.6 Channel codes

Radios use the channel code determined according to clause 7.1.5.

10 Channel coding process

10.1 Voice superframe

Construction of the voice superframe starts with CCH control channel data.

Frame Numbering (FN) is from 00 to 11 (1 to 4).

FN is followed by 16 bits of the called station address or own ID as follows:

The called station ID and own ID make a total of 64 bits. These bits are split into 16 bit blocks and one block is included in each of the 4 frames of the superframe.

- FN 00 will include the upper 16 bits of the called station ID.
- FN 01 will include the lower 16 bits of the called station ID.
- FN 10 will include the upper 16 bits of the own ID.
- FN 11 will include the lower 16 bits of the own ID.

The communications mode value is added according to Table 9 in clause 6.6. For example, if appended data is being included within the voice superframe then communications mode value is set to 01.

- If the communications mode is set to 00 or 01 the 18 bits of slow user data (SLD) are added (clause 6.9.2).
- If the communications mode is set to 10 the slow user data (SLD) field is assembled according to clause 6.9.3 and appended.

This is followed by the 2 bits of CAT data.

This gives the total of 40 bits of CCH data.

The 8 bit CRC checksum is added using the polynomial given in clause 8.2 giving a total of 48 bits.

These 48 bits are now separated into 6 bytes. Each byte is now coded by a shortened 12,8 Hamming Code (clause 8.3) giving 6 x 12 bit blocks.

To protect against burst interference, these 6 x 12 bit blocks are now interleaved using the 12 x 6 TCH interleaving matrix given in Table 23.

Then the interleaved CCH data is scrambled using the polynomial given in clause 8.4.

The frame is completed by prefixing with either the 24 bits of FS2 (frame numbers 00 or 10) or the 24 bits of Channel code (frame numbers 01 or 11).

Finally the 4 x 72 bit blocks of Forward Error corrected vocoder data (TCH) are appended.

If the PTT is released before the end of the current superframe, then the superframe will be completed using silence data for the TCH ("silence data" is the vocoder output data when no sound is input).

In the case of a voice + data and the voice transmission ends before the end of the current superframe, the current frame will be completed using silence data for the TCH ("silence data" is the vocoder output data when no sound is input). After completion of the current frame, subsequent frames in the superframe are available for data and coded according to clause 10.2. ID and DP in the SLD field will indicate if the frame contains voice or data information (see clause 6.9).

In each transmitted item the format is always that of a series of complete superframes (SF) with Header and End frames as shown below:

H	SF	SF	SF	SF	SF	E

Within each superframe, there are 4 payload frames.

For this example, it is assumed that the PTT is released in frame 2 and the voice codec data stops. 36 bytes of data with FEC (type 2) will be appended. As each frame has a capacity of 20 bytes of type 2 data, both frames 3 and 4 will be required.

Frame 1	Frame 2	Frame 3	Frame 4
FS2 CCH TCH x 4	CC CCH TCH x 4	FS2 CCH Type-2 data	CC CCH Type-2 data

The SLD field in each of these frames is composed as below:

Frame 1: with voice payload

ID	Longitude
01	16 msb's

Frame 2: with voice payload ending in this frame

ID	Longitude	Spare
01	12 lsb's	00 0000

Frame 3: with data payload starting in this frame

ID	Reserved	DP	Format	Cont.	Data length (bytes)
10	000	11	4 bits	0	010100 (20 bytes in this frame)

Frame 4: with data payload ending in this frame

ID	Reserved	DP	Format	Cont.	Data length (bytes)
10	000	11	4 bits	1	010000 (16 bytes in this frame)

Notes for TCH payload:

NOTE 1: In frame 2 the voice codec data ends when the PTT is released. "Silence data" is used to complete the TCH payload of frame 2 as previously stated.

NOTE 2: In frame 4 the 16 bytes of data is not enough to complete the frame. Therefore 4 bytes of dummy data (i.e. zeros) is appended to complete the TCH payload of frame 4. The TCH payload is coded according to clause 10.2. The receiving party will know that there are 4 bytes of dummy data as the SLD data length field indicates that only 16 of the 20 bytes are valid data.

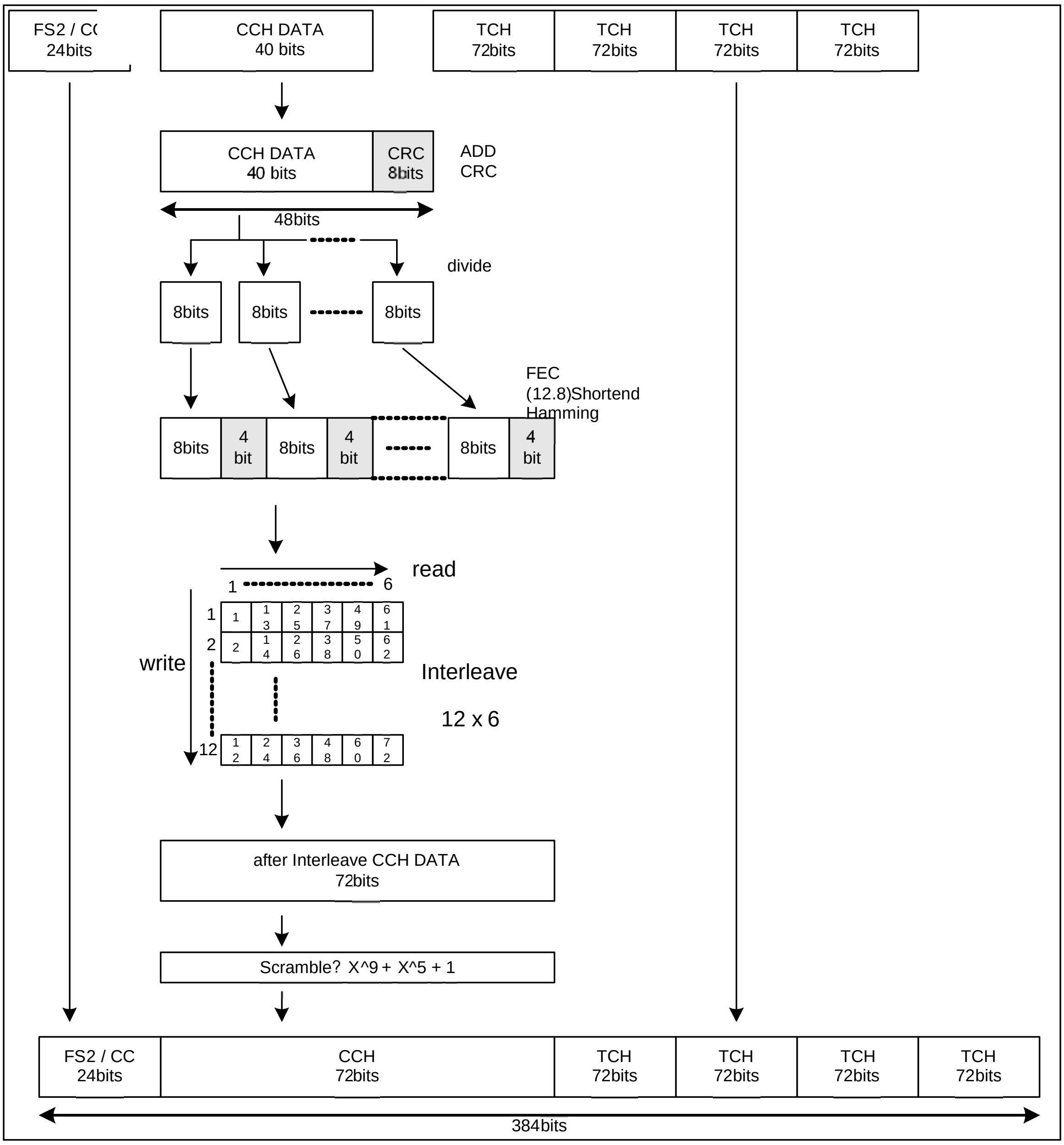


Figure 5: Voice frame coding

10.2 Type 2 Data superframe

NOTE: Error corrected data with 6 Bytes per frame, 24 Bytes per superframe.

Construction of the type 2 data superframe starts with CCH control channel data.

Frame Numbering (FN) is from 00 to 11 (1 to 4).

FN is followed by 12 bits of the called station address or own ID as follows.

The called station ID and own ID make a total of 64 bits. These bits are split into 16 bit blocks and one block is included in each of the 4 frames of the superframe:

- FN 00 will include the upper 16 bits of the called station ID.
- FN 01 will include the lower 16 bits of the called station ID.
- FN 10 will include the upper 16 bits of the own ID.

- FN 11 will include the lower 16 bits of the own ID.

The communications mode, 10_b is added (clause 6.6).

This is followed by the 1 bit of CAT data.

Finally there are the 18 bits of the slow user data field (SLD). These bits are set according to clause 6.9 depending on the data to be transmitted.

This gives the total of 40 bits of CCH data.

The 8 bit CRC checksum is added using the polynomial given in clause 8.2 giving a total of 48 bits.

These 48 bits are now separated into 6 bytes. Each byte is now coded by a shortened 12,8 Hamming Code (clause 8.3) giving 6 x 12 bit blocks.

To protect against burst interference, these 6 x 12 bit blocks are now interleaved using the 12 x 6 TCH interleaving matrix given in Table 23.

The user data is broken down into 5 byte blocks (40 bits) to which 1 bit of null data (i.e. set to 0) is appended. 4 of these 41 bit blocks will be allocated to each frame.

The 7 bit CRC checksum is added to each 41 bit block using the polynomial given in clause 8.2 giving a total of 48 data bits.

These 48 data bits are now separated into 6 bytes. Each byte is now coded by a shortened 12,8 Hamming Code (clause 8.3) giving 6 x 12 bit blocks.

To protect against burst interference, these 6 x 12 bit blocks are now interleaved using the 12 x 6 TCH interleaving matrix given in Table 23.

Next 4 of the 72 bit coded data blocks are appended to the interleaved CCH data and scrambled using the polynomial given in clause 8.4.

The frame is completed by prefixing with either the 24 bits of FS2 (frame numbers 00 or 10) or the 24 bits of Channel code (frame numbers 01 or 11).

DATA communication Type 2

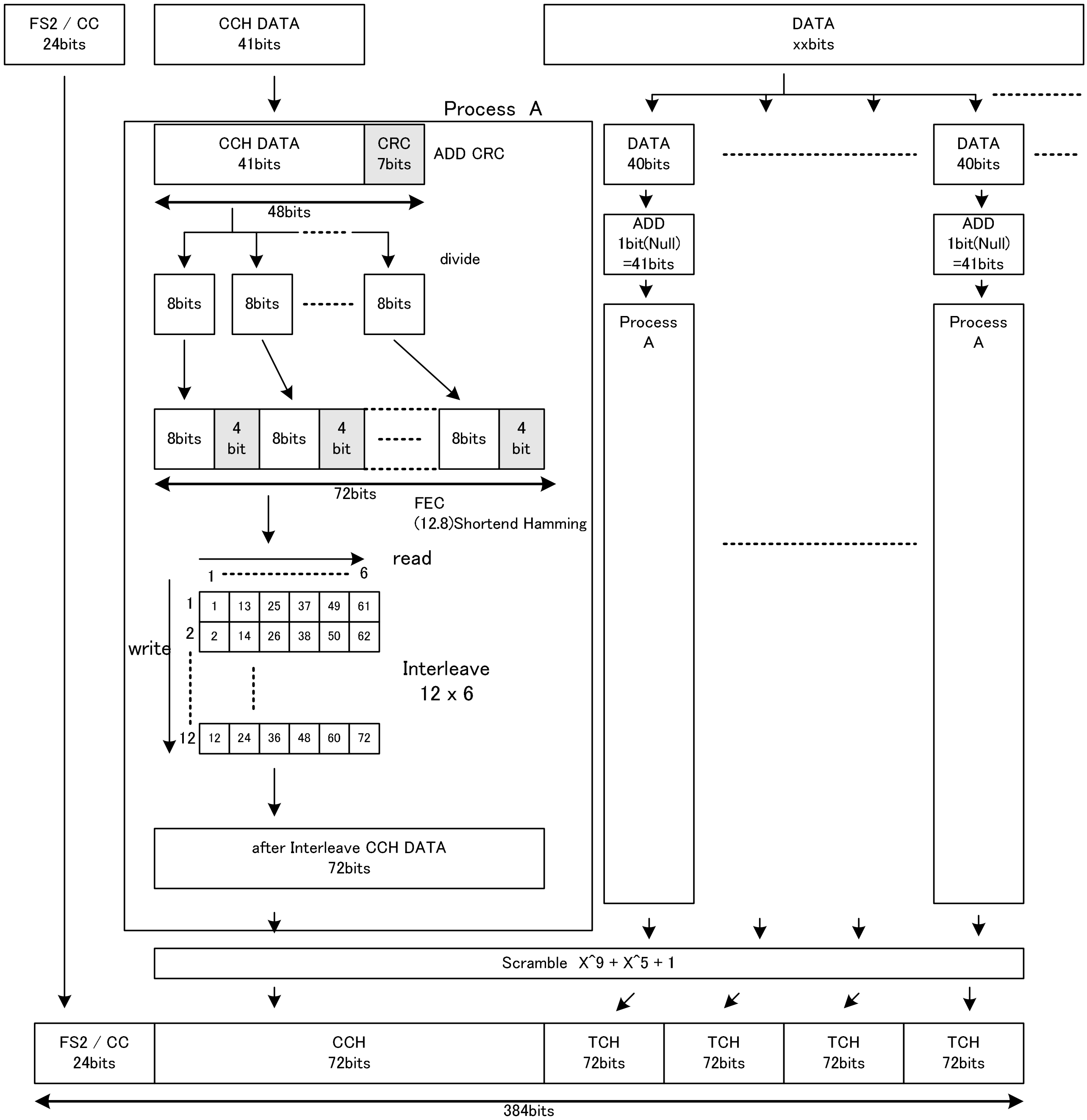


Figure 6: Type 2 data frame coding

10.3 Headers

Construction of a Header starts with the Header Information (HI) bits.

First there are 4 bits allocated to Header Type (HT) which is selected according to clause 6.10.

HT is followed by the 32 bits of the called station ID. To this the 32 bits of the own ID is added.

The 2 bits of communications mode value is added according to Table 9 in clause 6.6.

This is followed by the 2 bits of CAT data.

This gives the total of 72 bits of HI data.

The 8 bit CRC checksum is added using the polynomial given in clause 8.2 giving a total of 80 bits.

These 80 bits are now separated into 10 blocks of 1 byte. Each block is now coded by a 12,8 Hamming Code (clause 8.3), giving 10 x 12 bit blocks.

To protect against burst interference, these 10 x 12 bit blocks are now interleaved using the 12 x 10 HI interleaving matrix given in clause 8.5.

Then the interleaved HI data is scrambled using the polynomial given in clause 8.4.

The 24 bit Channel code is appended to the HI data and then the HI data is repeated after the CC.

The header is completed by prefixing with the 48 bit FS1 synchronization sequence (see clause 7.1.1) and then prefixing the synchronization sequence with a minimum of 72 bits of preamble.

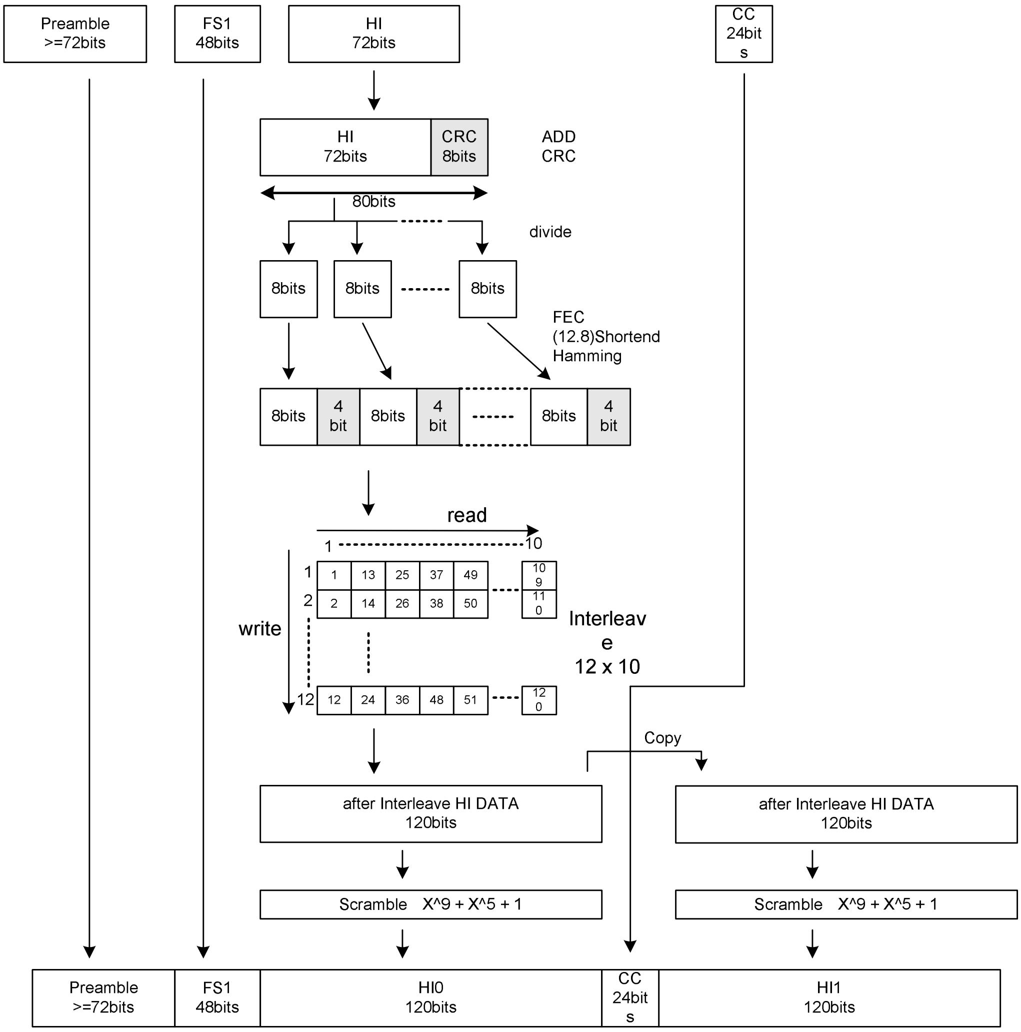


Figure 7: Header Frame coding

10.4 End frames

Construction of the End frame starts with the 17 bits of End data.

The end data starts with the End Type (ET) which is either 00 (normal end frame) or 01 (end frame with status message).

The next 2 bit are the Acknowledgement Request (ARQ). 00 signifies that no acknowledgement is requested and 01 requires an acknowledgement.

The next 4 bits define any Tx wait time (WAIT) using the values given in clause 6.13.

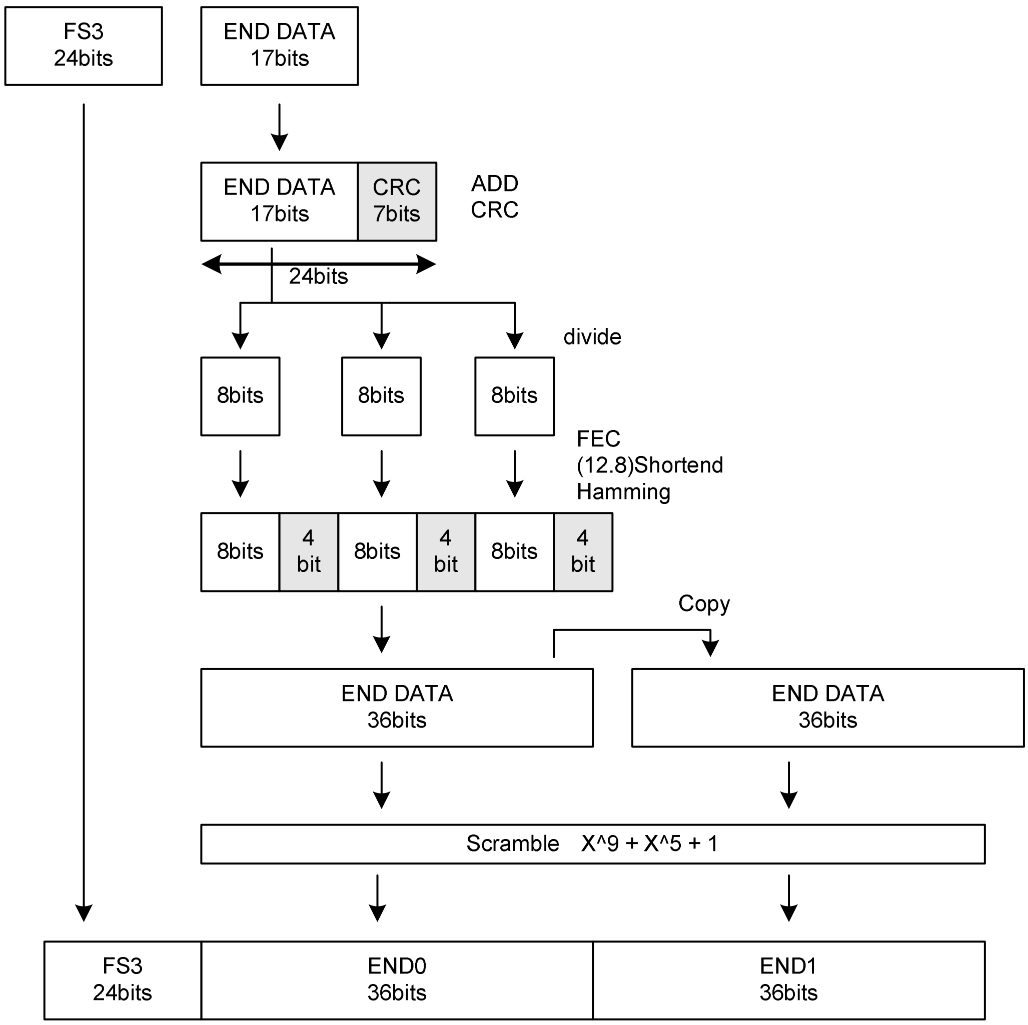
5 bit of status message will then follow if ET has been set to 00 (a value of 00000 indicates no status).

Finally the 4 reserved bits are set to 0000.

The 7 bit CRC checksum is added using the polynomial given in clause 8.2 giving a total of 24 bits.

These 24 bits are now separated into 3 bytes. Each byte is now coded by a shortened 12,8 Hamming Code (clause 8.3) giving 3 x 12 bit blocks. These 36 bits are now repeated and the total 72 bits are scrambled using the polynomial given in clause 8.4.

Finally the 24 bit FS3 synchronization sequence is prefixed to these end data bits.



NOTE: END Frame Channel Coding.

Figure 8: End frame coding

11 Channel access

11.1 Listen Before Transmit (LBT)

When accessing a channel to transmit, a radio needs to take account of the following types of activity which may already be present on the channel:

- analogue activity on the corresponding 25 kHz channel.

When determining whether activity is present on a channel, the radio will monitor the RSSI level. If after a maximum period of time (T_ch_chk) the RSSI level has not exceeded a configurable (within a predefined range) threshold RSSI_LO, then the radio will assume that activity is not present on the channel.

RSSI_LO will be set to -105 dBm ± 3 dB.

If however the RSSI level does exceed this threshold, then the radio assumes that activity is present on the channel and it displays a warning to the user and if it is "routine" call, inhibits the PTT.

11.2 Call duration timers

Radios have a transmit TimeOut timer which limits the time of a single transmission item. This timer is set to the value of 180 seconds whenever the PTT key is pressed and counts down to zero.

If the transmit TimeOut timer expires, then all radios will stop transmitting immediately and may not re-transmit until PTT has been released, the TxWait time has expired, and the PTT pressed again.

11.3 Transmit admit criteria

11.3.1 General admit criteria

Where a radio has been solicited to transmit a response, it may transmit the response within response time [T_ack] irrespective of whether the channel is "Idle" or "Busy".

11.4 Transmission re-tries

Certain transmissions solicit responses and where these responses are not received (e.g. due to collisions, interference, etc.) the transmitting entity may repeat the original transmission a number of times either until the response is received or the transmitting entity gives up.

The waiting times for re-transmission and the maximum number of re-tries are defined in clause 11.5.

11.5 Channel access timers and constants

11.5.1 Timers

T_ch_chk: Channel check timer: 100 ms.

T_ch_free: Unsynchronizable activity timer: 200 ms.

T_ack: Acknowledgement response time: 3 seconds.

11.5.2 Constants

Automatic retries are permitted for acknowledgement (and nack) signalling.

A maximum of four retries are permitted. The time between any such repeated signalling is in the range 300 ms to 500 ms.

12 Physical Layer

12.1 General parameters

12.1.1 Assumptions

Compliance with ETSI EN 301 166 [i.2] is assumed.

12.1.2 Frequency range

The radio system operates within the permitted channels as described in Appendix 18 of the Radio Regulations [i.8].

12.1.3 RF carrier bandwidth

The radio system operates within a 6,25 kHz RF carrier bandwidth.

12.1.4 Transmit frequency error

The maximum transmit frequency error from the assigned RF carrier centre is within ±625 Hz as stated in ETSI EN 301 166 [i.2].

12.1.5 Time base clock drift error

The maximum time base clock drift error is ±2 ppm. This error is the amount of clock drift that is acceptable during a transmission.

12.2 Modulation

12.2.1 Symbols

The modulation sends 2 400 symbols/sec with each symbol conveying 2 bits of information. The maximum deviation, D, of the symbol is defined as:

The maximum deviation, D, of the symbol is defined as:

$$D = 3h / 2T$$

Where:

- h is the deviation index defined for the particular modulation; and
- T is the symbol time (1 / 2 400) in seconds.

12.2.2 4FSK generation

12.2.2.1 Overview

This clause describes the characteristics of the constant-envelope modulation, entitled 4FSK.

12.2.2.2 Deviation index

The deviation index, h, for 4FSK is defined to be 0,29. This yields a symbol deviation of 1 050 Hz at the symbol centre. The mapping between symbols and bits is given below.

Information Bits Symbol Mapping to 4FSK Deviation.

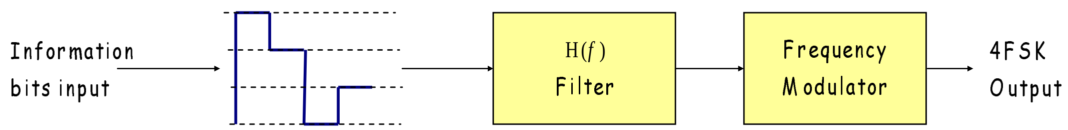
Table 26: FSK symbol mapping

Information Bits		Symbol	4FSK Deviation
Bit 1	Bit 0		
0	1	+3	+1 050 Hz
0	0	+1	+350 Hz
1	0	-1	-350 Hz
1	1	-3	-1 050 Hz

12.2.2.3 Square root raised cosine filter

The modulation scheme uses an RRC filter at both the transmit and receive ends of the radio link, so providing a matched filter response.

*Tx Baseband Filter

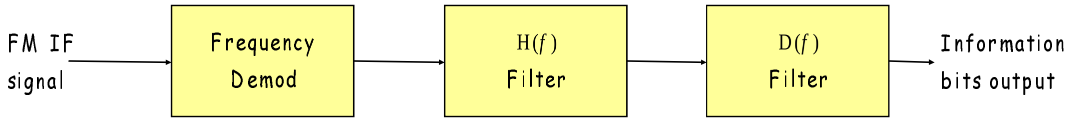


$$|H(f)| = \begin{cases} 1 & , \quad 0 \le |f| < (1-\alpha)/2T \\ \cos[(T/4\alpha)(2\pi|f| - \pi(1-\alpha)/T] & , \quad (1-\alpha)/2T \le |f| < (1+\alpha)/2T \\ 0 & , \quad (1+\alpha)/2T \le |f| \end{cases}$$

$\alpha = 0.2 \quad T = 1/2400$

4 FSK Deviation		
Di-bit	Symbol	Deviation
01_2	+3	+1 050Hz
00_2	+1	+350Hz
10_2	-1	-350Hz
11_2	-3	-1050Hz

*Rx Baseband Filter



$$|H(f)| = \begin{cases} 1 & , \quad 0 \le |f| < (1-\alpha)/2T \\ \cos[(T/4\alpha)(2\pi|f| - \pi(1-\alpha)/T] & , \quad (1-\alpha)/2T \le |f| < (1+\alpha)/2T \\ 0 & , \quad (1+\alpha)/2T \le |f| \end{cases}$$

$$|D(f)| = \frac{\pi f T}{\sin(\pi f T)}$$

$\alpha = 0.2 \quad T = 1/2400$

Figure 9: Square Root Raised Cosine Filter in the modulation/demodulation process

12.2.2.4 4FSK Modulator

The 4FSK modulator consists of a Square Root Raised Cosine Filter, cascaded with a frequency modulator as shown in figure 10. The Square Root Raised Cosine Filter is described in clause 12.2.2.3.

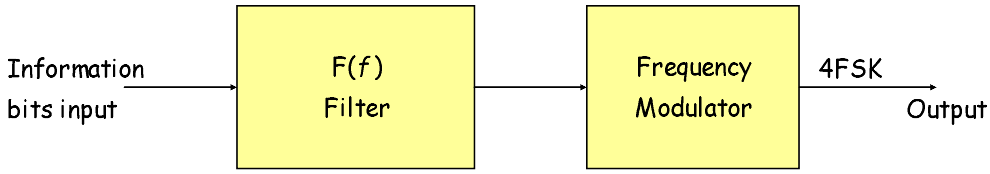


Figure 10: 4FSK Modulator

Annex A: Channel Numbering

Annex 4 of Recommendation ITU-R M.1084-5 [i.6] provides some suggestions of a potential channel allocation and numbering scheme for 6,25 kHz and 12,5 kHz channels operating within the 25 kHz marine band allocation. An example from Recommendation ITU-R M.1084-5 [i.6] is shown in Table A.1.

Table A.1

Channel bandwidth			**Frequency (MHz)**		**Simplex mode 6,25 kHz channel number**	
25 kHz	12,5 kHz	6,25 kHz	ship	coast	lower	upper
60	460	560	156,025	160,625	1560	2560
		160	156,03125	160,63125	1160	2160
	260	660	156,0375	160,6375	1660	2660
		360	156,04375	160,64375	1360	2360
01	401	501	156,050	160,650	1501	2501
		101	156,05625	160,65625	1101	2101
	201	601	156,0625	160,6625	1601	2601
		301	156,06875	160,66875	1301	2301
61	461	561	156,075	160,675	1561	2561

Whilst this scheme uniquely defines the centre frequency of each channel in any of the supported bandwidths, it does not uniquely define which bandwidth is in use for each centre frequency. This is addressed in Recommendation ITU-R M.1084-5 [i.6] for the 12,5 kHz case, shown in red text in the table, and a simple extrapolation is suggested, shown in green in the table to uniquely define the 6,25 kHz channels.

This scheme is compatible with the current usage of a leading digit to define operation in the lower band (1xxx) or upper band (2xxx) where the duplex channel is split into two simplex channels.

This allows both the centre frequency, simplex/duplex mode and bandwidth to be communicated using one four digit decimal value (or one 12 bit binary value).

Annex B: MMSI numbering scheme

Table B.1 is a summary of the MMSI allocations from Recommendation ITU-R M.585-8 [i.5]. The row in yellow highlight shows potential allocations for an All-Call MMSI number. The use of these codes would need approval from ITU and IMO and so are currently not proposed in the present document, but are presented here for completeness.

Table B.1: MMSI allocation

MMSI allocations from ITU-R M.585-8 2019										
MMSI digit										
9	8	7	6	5	4	3	2	1		
0	M	I	D	x	x	x	x	x		group call
0	1	1	1	0	0	0	0	0		all-call routine
0	0	M	I	D	1	x	x	x		Coast Stations
0	0	M	I	D	2	x	x	x		Port Stations
0	0	M	I	D	3	x	x	x		Pilot Stations
0	0	M	I	D	4	x	x	x		AIS Repeater Stations
0	0	M	I	D	5	x	x	x		AIS Base Stations
0	0	M	I	D	0	0	0	0		Call all Coast Stations of a country
0	0	9	9	9	0	0	0	0		Call all Coast Stations
1	1	1	M	I	D	0	0	0		Call all Aircraft of a country
1	1	1	M	I	D	1	x	x		Fixed Wing Aircraft
1	1	1	M	I	D	5	x	x		Helicopter
2										country specific station id
3										country specific station id
4										country specific station id
5										country specific station id
6										country specific station id
7										country specific station id
8	M	I	D	x	x	x	x	x		Handheld Radio
9	7	0	x	x	y	y	y	y		AIS-SART
9	7	2	x	x	y	y	y	y		AIS-MoB
9	7	3	x	x	y	y	y	y		AIS-DSC MoB Class M
9	7	4	x	x	y	y	y	y		AIS-EPIRB
9	7	9	x	x	x	x	x	x		AIS AMRD Group B
9	8	M	I	D	x	x	x	x		Daughter craft
9	9	M	I	D	1	x	x	x		AtoN Physical
9	9	M	I	D	6	x	x	x		AtoN Virtual
9	9	M	I	D	8	x	x	x		AtoN Mobile

History

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