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Digital voice communication system on MF/HF radio channels of the maritime mobile service for shore-to-ship/ship-to-shore applications

M Series

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REPORT ITU-R M.2288-0

Digital voice communication system on MF/HF radio channels of the maritime mobile service for shore-to-ship/ship-to-shore applications

(2013)

1 Introduction

The MF and HF frequency bands allocated to maritime services remain the most economic means to connect ships to land on distances from hundreds to several thousands of kilometres.

During WRC-12, the revision of Appendix **17** of the Radio Regulations introduced the possibility to use radio channels with narrowband or wideband for digital modulations.

For shipping activities (merchant navy and fishing boats), several studies highlighted the social isolation of the ships crews for which it would be appropriate to offer a possibility of communications at low cost with their families.

Many maritime radio coast station monitoring the communications with the ships have stopped today their activities.

Taking into account these elements, it is proposed to introduce in the radio maritime radiocommunications:

– transmission of digital voice with full confidentiality;
– transmission of data at low data rate in complement to the digital voice (e.g. for SMS or picture);
– automation of coastal stations for exchanges shore to ship and ship to shore.

2 Today's situation and possibilities

The current maritime radio voice communications are analogue and use the single sideband (SSB) (upper single sideband (USB)) mode in a 3 kHz channel for the MF and HF bands (1.6 to 30 MHz).

The goals are:

1 To preserve the today Global Maritime Distress and Safety System (GMDSS) MF/HF radio equipment on the ships as a priority.

The MF/HF radio stations of ships are today dedicated mainly to GMDSS. They are approved for this usage and any modification on the equipment requires obtaining a new approval necessary to be compliant with the "wheel mark" type approval. The use of these radio stations also requires a certificate of operator.

Although it is possible to add the functionalities of DIGITAL VOICE on this equipment (subject to access for the remote control by external interface) it appears however very desirable for the above reasons to use dedicated equipment exclusively for digital links thus preserving the main radio station for its first target: distress and safety.

On the other hand, it would be interesting that new equipment developed within the future GMDSS can include the system DIGITAL VOICE.

2 To be able to automate the coast stations for the establishment of the communications shore/ship/shore in maritime MF/HF radio bands from 1.6 to 30 MHz

This automation, made possible by using digital modulation, brings an important economy on the operating cost for coast radio station.

3 Digital ship radio station

Two types of installations could be considered:

– For large ships.

– For small and medium size of ships.

3.1 Large ships

On this kind of ship the number of people constituting the crew is rather important, and cannot reach the equipment on the bridge and does not have the certificate of radio operator.

Thus, it is advisable to install a dedicated digital radio transceiver like a black box connected to its own antenna system.

The operational use of this transceiver is automatic. The access for the crew could be done by a fixed terminal interface (like a telephone) or via a mobile phone using the Bluetooth function or Wi-Fi/WLAN using 2.4 or 5 GHz allocations worldwide. The transceiver is equipped with GNSS receiver (or has access to the ship position information) to inform the coast station on the geographical position of the ship.

3.2 Small ships

For small ships, the crew is reduced and does not have a certificate of radio operator. The access to the bridge is not always possible or easy.

The dedicated digital transceiver connected on its own antenna is the best solution.

The operational use of this transceiver is automatic and its access is done via an integrated interface with display on the front panel of the transceiver; and (or) via a standard mobile phone (or a personal computer) using Bluetooth or Wi-Fi network. The transceiver is equipped with GNSS receiver (or access port for ship position information) to inform the coast station on the geographical position of the ship.

3.3 Operating

In both cases, each crew member who wishes to use these systems of communication must subscribe to the maritime radio operator network that offers the DIGITAL VOICE / SMS (short message service) services.

After subscribing, he will obtain a unique identification number; he can thus receive a call or a SMS automatically. In the same way, he can send a SMS or a phone call to a terrestrial subscriber.

To facilitate the update of coast stations' databases, the ship transceiver will transmit at the request of the coast stations the update of the on board team members which have subscribed to the service (each crew updates himself the ship transceiver when boarding). The call sign and the ship maritime mobile service identify (MMSI) are used for this purpose with the personal call number of the subscriber.

FIGURE 1

Solutions for large ships

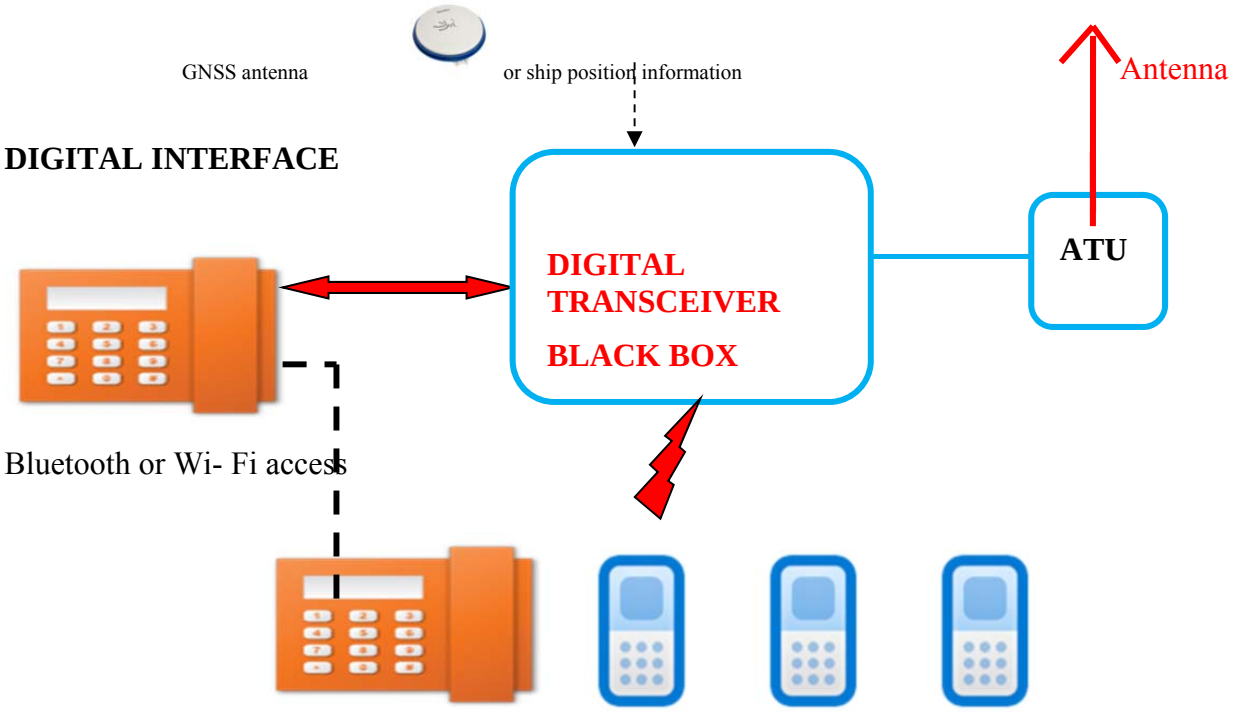
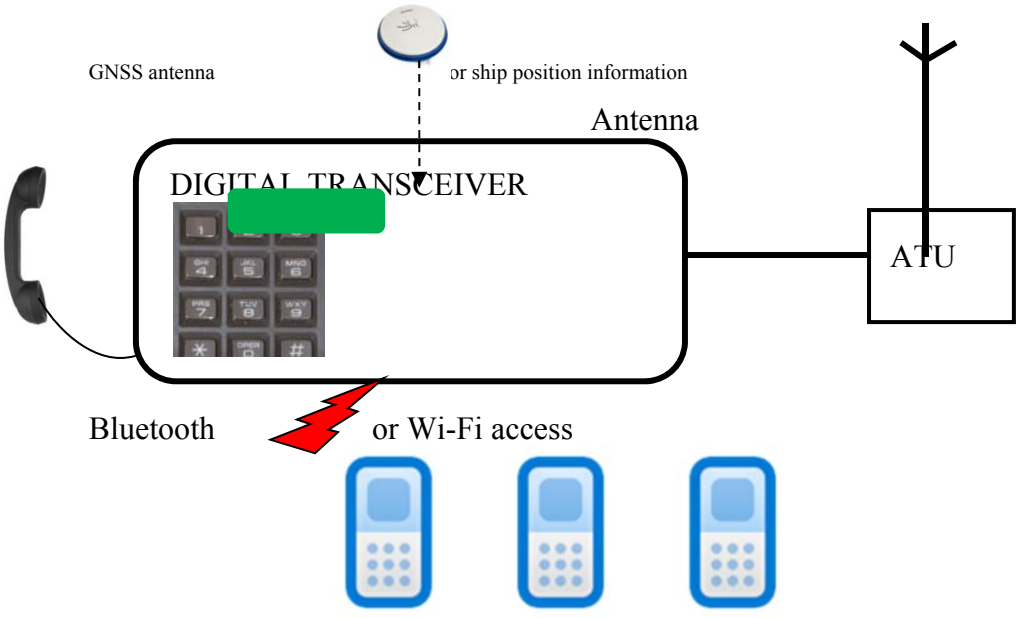


FIGURE 2

Solutions for small ships



4 Ship transceiver specification

As all maritime radio equipment, the digital transceiver must be compliant to all existing rules and standards (radio, EMC and environmental), e.g. ETSI EN 300 373/IEC 60945.

This transceiver can be stopped immediately by the main ship radio station in case of GMDSS traffic.

4.1 Available band for the radio channel

ETSI standard EN 300 373 specifies the minimal acoustic band of the audio channel for the MF/HF transmitters and receivers using a 3 kHz radio channel. This band is contained between 300 and 2 700 Hz with a useful band of 2 400 Hz. One will retain 2 300 Hz as reference to maintain a qualitative margin.

It is thus advisable to use:

– a suitable system of compression and coding for the voice;

– a digital process of modulation getting a sufficient productive data flow in a channel of 2 300 Hz.

4.2 Mode

The communications will be in simplex mode (or half duplex mode) in order to be adapted for all sizes of ships. The duplex mode remains possible but accessible only to large ships which can install separate antennas, for TX and RX, at enough distance to obtain a sufficient decoupling.

This simplex mode implies to manage two constraints:

– the delay of RX/TX switching;

– the synchronization of the signals to each cycle of transmission.

4.3 Voice coding

The choice of voice coding is very important to obtain good quality for the reproduction of any voice in all languages.

Many tests of comparison were carried out giving an index of quality: the mean opinion score (MOS) for each existing type of coding.

Nowadays, several methods of compressions and digital coding for the voice exist, intended for narrowband channels, some being covered by licences.

To allow the realization of economic equipment and a fast introduction of the DIGITAL VOICE system, it is preferable to use commercially available technologies. There are low cost, digital signal processing (DSP) based voice codec half duplex real and non-real time voice compression applications.

These are in use today in many systems of radio communications for land and satellite applications.

These technologies allow coding for adjustable flow rates between 2 kbit/s and 9.6 kbit/s.

The technology includes variable rate forward error correction (FEC). This FEC provides good robustness to noise and fading during skywave radio propagation. Such solutions are available in the form of chips without licensing fees or royalties.

FIGURE 3

Vocoder chip synoptic

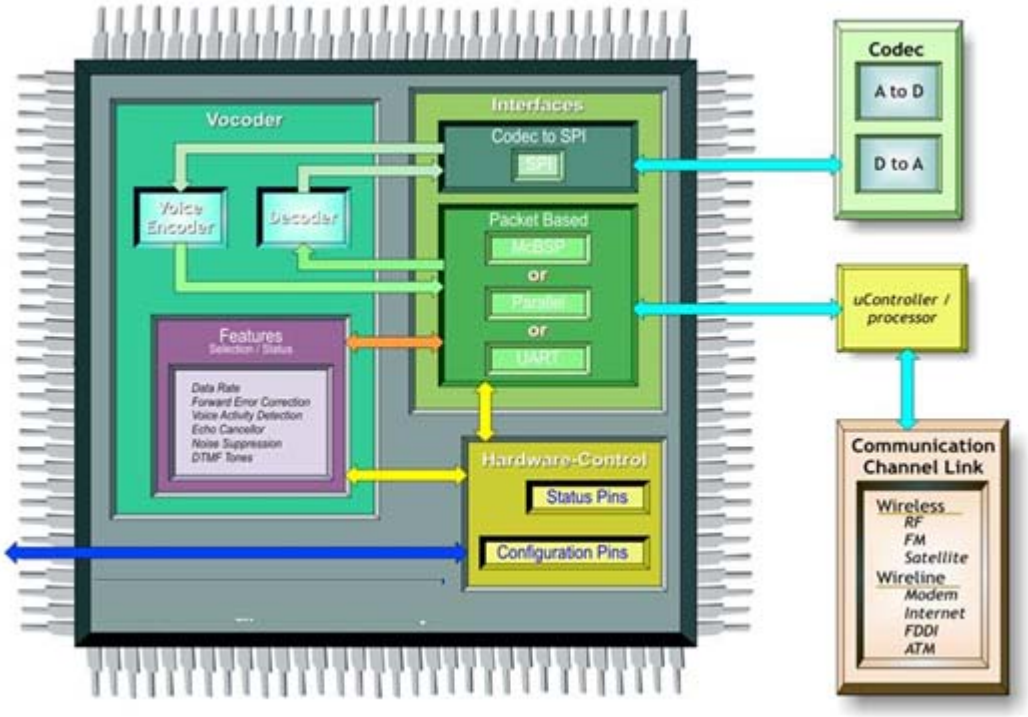
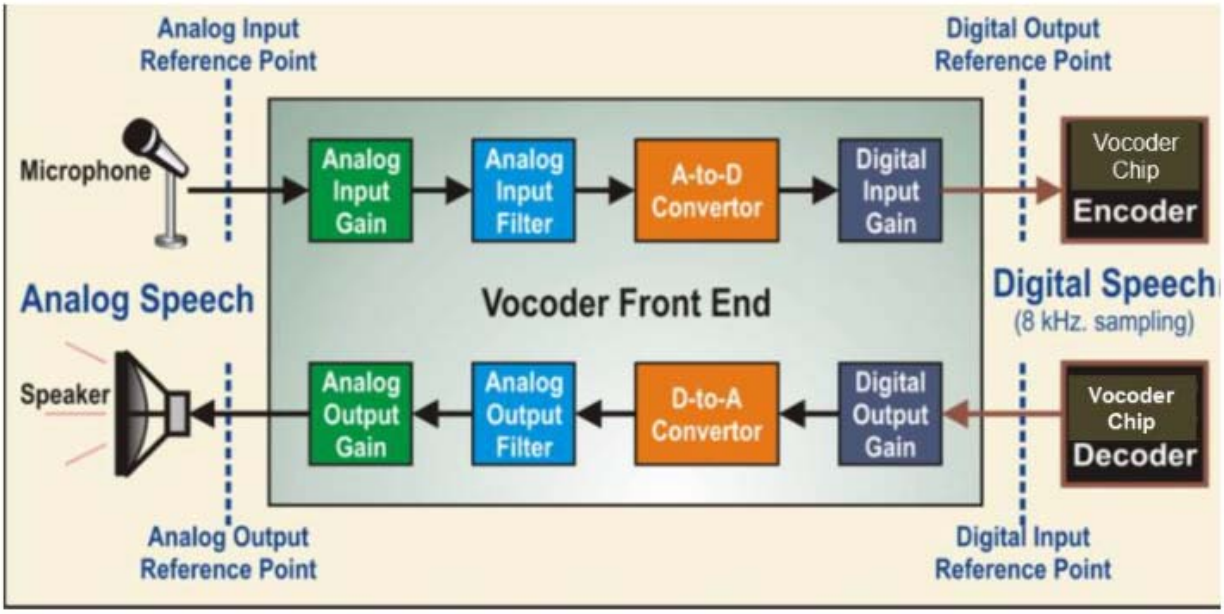


FIGURE 4

Vocoder front end

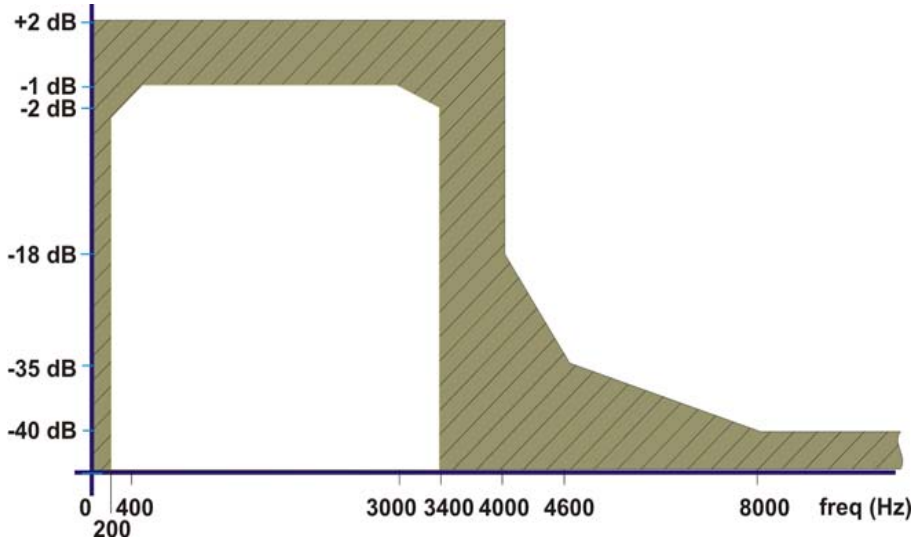


It is recommended that the analog input gain be set such that the root mean square (RMS) speech level under nominal input conditions is 25 dB below the saturation point of the A-to-D converter (+3 dBm). This level which equates to –22 dBm is designed to provide sufficient margin to prevent the peaks of the speech waveform from being clipped by the A-to-D converter.

The voice coder interface requires the A-to-D and D-to-A converters to operate at an 8 kHz sampling rate (i.e. a sampling period of 125 µs) at the digital input/output reference points. This requirement necessitates the use of analog filters at both input and output to eliminate any frequency components above the Nyquist frequency (4 kHz). The recommended mask filter is shown in Fig. 5.

FIGURE 5

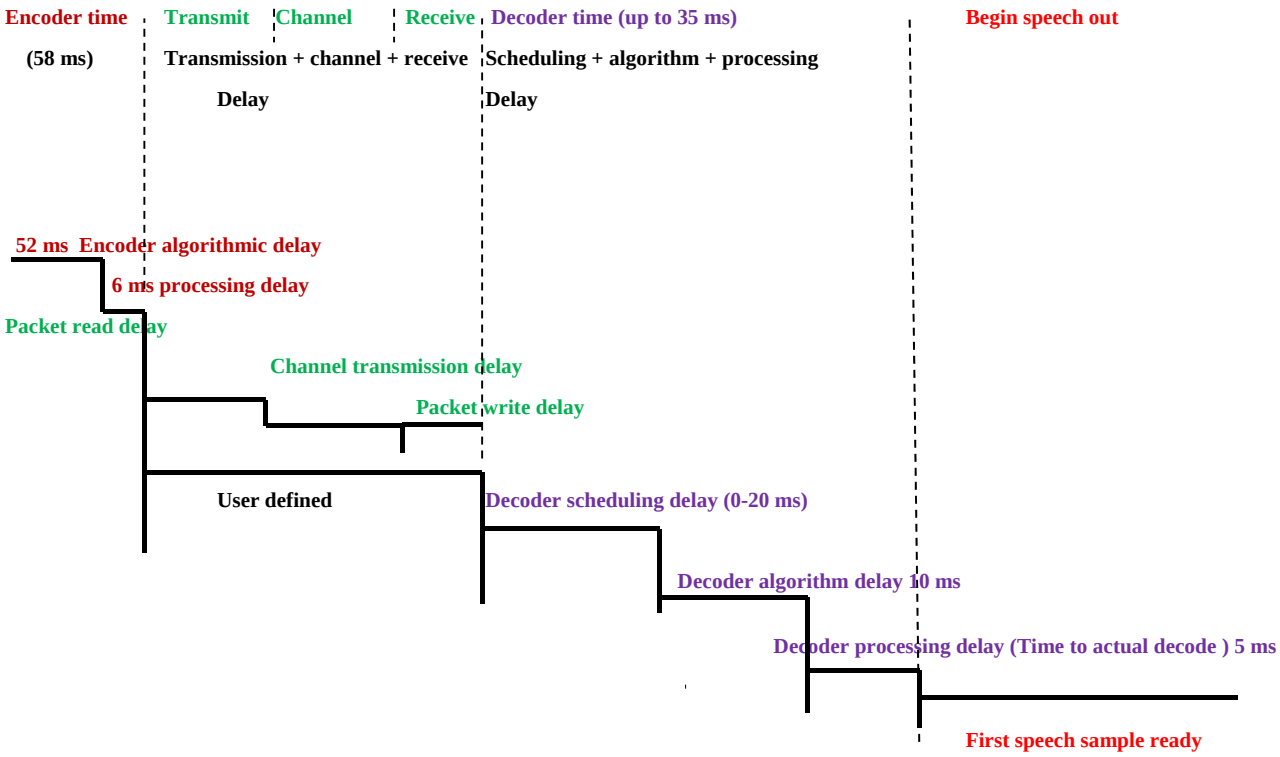
Input/output filter mask



4.3.1 Vocoder algorithmic and processing delays

The total delay due to the coding/decoding algorithm is 62 ms.

FIGURE 6



This delay includes the delays associated with collecting enough pulse code modulation (PCM) samples for the encoder algorithm to begin process.

4.3.2 Vocoder rate by index number

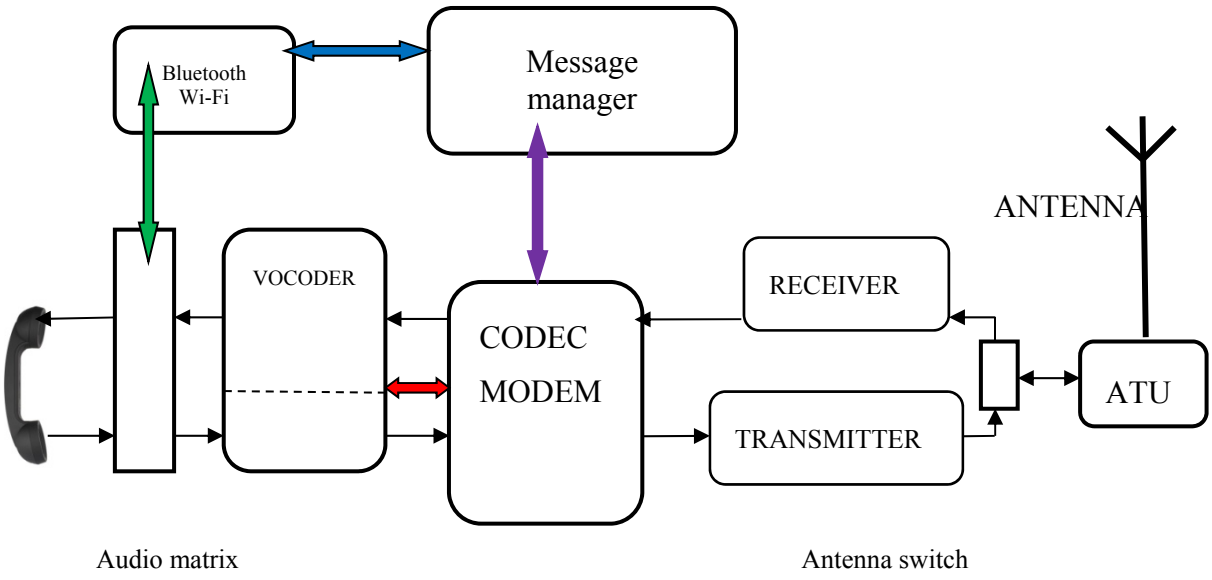
Rate index	Total Rate	Speech Rate	FEC Rate
33	3600	2450	1150
34	2450	2450	0
35	3400	2250	1150
36	2250	2250	0
37	2400	2400	0
38	3000	3000	0
39	3600	3600	0
40	4000	4000	0
41	4400	4400	0
42	4800	4800	0
43	6400	6400	0
44	7200	7200	0
45	8000	8000	0
46	9600	9600	0
47	2700	2400	250

48	3600	3350	250
49	4000	3750	250
50	4800	4550	250
51	4400	2450	1950
52	4800	2450	2350
53	6000	2450	3550
54	7200	2450	4750
55	4000	2600	1400
56	4800	3600	1200
57	4800	4000	800
58	6400	4000	2400
59	7200	4400	2800
60	8000	4000	4000
61	9600	3600	6000

4.4 Technical description of ship transceiver

FIGURE 7

Digital transceiver synoptic



The analog vocal signals generated by the microphone or from the Bluetooth/Wi-Fi interface are sending to the VOCODER through the audio matrix. These signals are compressed and digitized by the VOCODER.

These digital signals are sending to the CODEC MODEM. The role of this modem is to transpose these digital signals in audio baseband from 300 to 2 700 Hz according to the model of modulation selected (ex: DQPSK) making it possible to modulate the transmitter on its final frequency in SSB (USB channel).

The ATU matches the antenna on the traffic frequency.

At the reception, the RF signals received by the antenna are transposed in audio baseband and demodulated by the CODEC MODEM.

Digital signals thus available are decoded by the VOCODER and transmitted to the ear-phone and the Bluetooth/Wi-Fi interface.

Another access on the CODEC allows the possibility to send and receive SMS messages.

This message manager can be equipped with a Bluetooth and/or Wi-Fi interface, allowing the use of a standard mobile phone (or a PC) equipped with this function as terminal for phone call or text (SMS).

4.5 Codec and modem

Remember that communications are in simplex mode or half duplex mode (simplex mode on duplex channel).

This implies to manage two constraints:

– short delay for RX/TX switching;

– fast synchronization of digital signals to each transmission cycle.

Any appropriate digital modulation adapted for 3 kHz narrowband RF channel described in Recommendation ITU-R M.1798 – Characteristics of HF radio equipment for the exchange of digital data and electronic mail in the maritime mobile service or any other suitable process of modulation described and added in the future in this Recommendation can be used.

For example, we can use a differential quadrature phase shift keying (DQPSK) with 18 carriers separated from 120 Hz. The maximum of audio occupied band is 2 200 Hz. The signal being centred on 1 500 Hz; the first tone will be 480 Hz and the last tone will be 2 520 Hz, thus respecting the audio bandwidth of the transceiver.

In this situation, the highest raw bit rate transferred on the physical protocol layer is 3 600 bit/s.

A very good BER is obtained with 12/14 dB *S/N* for received RF signal.

4.6 Crest factor and transmitter RF output power

When multicarrier modulations are used, it is necessary to guarantee the linearity of the transmitter to prevent any distortions.

The reference for the RF power of the transmitter is the maximum peak envelope power (PEP) RF power.

The crest factor (CF) is the power reduction necessary when using digital modulation.

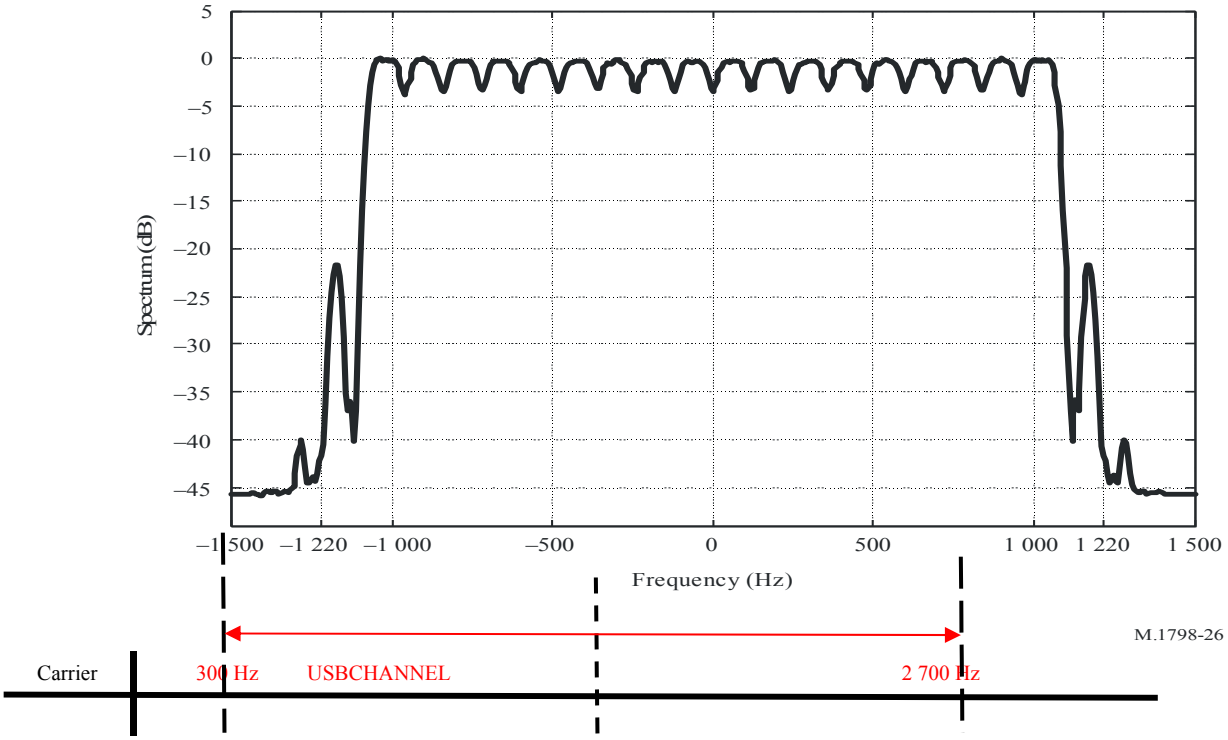
For the above-mentioned modulation (DQPSK), the crest factor would be –6 dB/PEP.

4.7 RF spectrum

Digital modulation must be contained inside the standard 3 kHz spectrum.

FIGURE 8

DQPSK spectrum from Recommendation ITU-R M.1798 (18 carriers)



5 Radio channels watching

The transceiver has a database, regularly updated during connections with coast stations which memorizes:

– the operational coast stations with their call sign and MMSI;

– the geographical position of these stations;

– frequencies used by these stations.

Thus, the ship transceiver can watch the best frequencies in the navigational area.

6 Technical specifications for ship transceiver

6.1 General

Frequency coverage:	3.5 to 27.5 MHz (optional 1.6 to 30 MHz)
Frequency stability	< ±10 Hz
Type of emission	J2D
RF occupancy	3 kHz
Number of channels	> 400
Antenna impedance	50 Ω
Power supply requirement	24V DC +30%/–10% or AC power supply
Operating temperature range	–15° to +55°C

6.2 Transmitter

Output RF power	200 to 500 W PEP
Carrier suppression	> –40 dB
Unwanted sideband suppression	> –53 dB
Spurious emission	> –53 dB
Crest factor for digital modulation	–6 to –8 dB
Audio band pass	300 Hz to 2700 Hz ±1.5 dB
Harmonic suppression	> –53 dB
Intermodulation distortion	> –30 dB/PEP

6.3 Receiver

Sensitivity	< 3 μV for 20 dB (*S/N*) or 10^{-6} BER
Selectivity	2.7 kHz at –3 dB; –5 kHz and +8 kHz at –60 dB
Audio response	300 Hz to 2 700 Hz ±1.5 dB
Spurious response	> 60 dB
Image and IF rejection	> 70 dB
AGC	Automatic
Intermodulation distortion	In band –45 dB or better

6.4 ATU (automatic tuning unit)

Frequency range	3.5 to 27.5 MHz (optional 1.6 to 30 MHz)
RF power input range	10 to 500 W PEP
Input impedance	50 Ω
First tuning time	60 s
Recurrent set time	< 300 ms
Memory capacity	> 150
Matching capacity	for antennas from 10 to 30 metres
Operating temperature	–20 to +55°C

7 Automation of coast stations

The possibility for any member of a ship crew of being able to communicate with its family at shore at a reasonable cost with full confidentiality brings a real social progress.

Aboard some ships, the crew does not have access directly to the radiocommunications equipment and moreover does not have competences and no operator certificate for their uses.

It is thus advisable to simplify the procedures of communications to make them available by the means of remote radio stations, or any other current multimedia system. The connection with the person you are calling will have to be accessible without particular technical training, helping by a display assistance menu in multi languages and universal symbols.

To achieve this goal, the automation of the coastal stations is necessary reducing in a notable way the operating costs.

The infrastructures of the coast stations, used in the past for ships communications, with the transmitting station, the antennas system and reception station, are unchanged allowing the re-use of some existing coast stations very quickly.

On the other hand, the exchanges with the ships would be completely automated, thanks to the digital signals.

Consequently, some parameters will have to be defined by operators:

1) Protocols for exchanges between the coast station and the ship.
2) Operational procedures.
3) Account procedures for the communications cost.
4) Definition of the access to the phone and data networks.

For the benefit of the maritime community some existing radio networks already used for exchange of e-mail could easily add digital voice to their service offering and managing the subscriptions.

Annex 1

Glossary

A to D	Analogue to digital
ATU	Automatic tuning unit
Bluetooth	Short range radio network protocol
CF	Crest factor
D to A	Digital to analogue
DQPSK	Differential quadrature phase shift keying
ETSI	European Telecommunications Standards Institute
FEC	Forward error correction
GMDSS	Global maritime distress and safety system
GNSS	Global navigational satellite system
ISM	Industrial scientific and medical radio bands
MMSI	Maritime mobile service identity
MOS	Mean opinion score
PC	Personal computer
PCM	Pulse code modulation
PEP	Peak envelope power
RMS	Root mean square
RX	Receiver

SMS	Short message service
SSB	Single sideband
TX	Transmitter
USB	Upper single sideband
Wheel Mark	Mark of conformity for ship equipment
Wi-Fi	Radio network using IEEE802.11 protocol

Annex 2

Example of existing HF global network

FIGURE 8

Geographical position

The coastal radio stations

Australia	Wantokmail	VZG420	4/6/8/12/17 MHz
Switzerland	Bernradio	HEB	4/6/8/12/17 MHz
Germany	Kielradio	DAO	4/6/8/12/17 MHz
People's Republic of China	Chinaham	XSF	8/12/17 MHz
Washington, USA	KKL radio	KKL	4/8/13 MHz
Florida, USA	Ste Augustine	WHL	6/8/13/17 MHz
Philippines	Manilla radio	DZO	4/8/13/16 MHz

Annex 3

A3 Example of general operational procedures

Four modes can be used:

Calls SHIP to LAND

Calls LAND to SHIP

Sending SMS

Received SMS

A3.1 Phone call SHIP to LAND

When a ship subscriber wishes to call a land subscriber, the following procedure can be used.

Choice of the coast station	Automatic according to the ship position
Choice of the frequency	The receiver watches continuously all frequencies from regional coast station and a free frequency is selected by the transceiver on the most favourable band (according to distance to the station and time).
Call for validation of the radio channel	The ship transceiver calls the coast station on selected frequency by using its call sign, MMSI and adds ship position.
Validation of the radio channel	An exchange of data between the coast station and the ship makes it possible to check the good quality of the radio channel (S/N > 15/20 dB). If necessary a new frequency is selected.
Dialling the land subscriber phone number	The ship subscriber dials the phone number of the land subscriber. At this number is added the identity of the ship subscriber to check the state of its subscription.
Wait for the connection	The coast station processes the call. When the land subscriber is on line the communication is open. This communication is made in simplex mode.
End of communication	The communication is stopped on the initiative of one of the subscribers (ship or land). The coast station sends a subscription update to the ship subscriber and at the same time updates the transceiver database if necessary.

A3.2 Phone call LAND to SHIP

The land subscriber makes a request for call near the service network centre by email or telephone with: the call sign of the ship, MMSI, the No. of the ship subscriber and if possible the navigational area of the ship.

The network centre will seek the last known position of the ship and will thus select the appropriate radio coast station.

This coast station selects the best maritime radio band to use according to the ship position, selects a free frequency and calls the ship during 10 seconds, repeated 2/3 times in event of no automatic reply.

If the ship station receives and decodes correctly the call from the coast station, the radio channel is kept and the ship transceiver displays the identity of the subscriber required on ship board and runs an audible alarm; at the same time this information is sent to the own terminal of the ship subscriber via Bluetooth or Wi-Fi radio networks.

If the ship subscriber cannot reply to the call, the request remains displayed and the ship subscriber must take the initiative to contact again the coast station.

If the ship subscriber can reply to the call he sends an acknowledgement of receipt. At this time the station calls the land subscriber and processes the connection.

A3.3 Sending and received SMS

Contrary to the phone calls, SMS are not done in real time.

A3.3.1 SHIP to LAND

The ship subscriber prepares his message on the transceiver terminal or on his own terminal.

This message contains in preamble the identity number of the ship subscriber and the phone number of the land subscriber. Other information like ship call sign, MMSI position of the ship are automatically added by the message manager interface inside the transceiver.

Once composed, the message is transferred in the message manager interface who processes to select automatically the best coast station and the usable free frequency.

Once the message is transmitted, the coast station sends an acknowledgment of delivery and updates the subscription of the ship subscriber.

A3.3.2 LAND to SHIP

The message composed by the land subscriber is transmitted to the service network centre (by email or SMS call) with ship information: call sign, MMSI and identity number of the ship subscriber.

The network centre selects the best radio coast station according to the last ship position and proceeds automatically to send the message to the ship.

When the ship transceiver receives the message, the message manager interface advises the ship subscriber (display of the identity No. + audible alarm) and sends also this information to the own terminal of the ship subscriber.

NOTE – The access to the message received on the transceiver terminal is readable only by the right subscriber who must use a personal code to validate the possibility to display the full message.