**Radio at Sea**

Radio has been the foundation of the distress and safety systems used by ships at sea since the first instance of the use of radio to save lives at sea in 1899. It was soon realized that, to be effective, a radio-based distress and safety system has to be founded on internationally agreed rules concerning the type of equipment, the radio frequencies used and operational procedures. The first international agreements were established under the auspices of the predecessor to the International Telecommunication Union (ITU). Many of the operational procedures for Morse telegraphy established at the turn of the century have been maintained to the present day.

**1974 SOLAS Convention**

As more detailed regulations became necessary for the shipping industry, the most recent of International Conventions for the Safety of Life at Sea (SOLAS 1974) was adopted in 1974. The 1974 SOLAS Convention has become one of the main instruments of the International Maritime Organization (IMO).

The distress and safety system used by most of the world’s shipping until 1992, as defined by chapter IV of the 1974 SOLAS Convention and the ITU Radio Regulations, required a continuous Morse radiotelegraphy watch on 500 kHz for passenger ships, irrespective of size, and cargo ships of 1600 gross tonnage and upwards. The Convention also required a radiotelephone watch on 2182 kHz and 156.8 MHz (VHF channel) on all passenger ships and cargo ships of 300 gross tonnage and upwards. Although the system has proven itself reliable over many years, its limitations of short range, manual alerting and aural watchkeeping have become a matter of increasing concern. Advances of technology led the IMO member governments to develop a new system based on modern technology and automation.

**The GMDSS**

The new system called the Global Maritime Distress and Safety System (GMDSS). This system was adopted by IMO in 1988 and replaces the 500 kHz Morse code system. The GMDSS provides a reliable ship-to-shore communications path in addition to ship-to-ship alerting communications. The new system is automated and uses ship-to-shore alerting by means of terrestrial radio and satellite radio paths for alerting and subsequent communications. The GMDSS will apply to call cargo ships of 300 gross tonnage and above, and to all passenger ships, regardless of size, on international voyages.

**GDMSS Implementation**

The GMDSS requirements for radiocommunications are contained in the new chapter IV of SOLAS 1974 adopted at the GMDSS Conference held in 1988. There is a transition period from the old to the new system in order to allow industry time to overcome any unforeseen problems in implementation of the new system. The transition period began on 1 February 1992 continues to 1 February 1999.

The phased implementation of the GMDSS started with a general requirement for the carriage of NAVTEX receivers for the reception of maritime and satellite EPIRBs (Emergency Position-Indicating Radio Beacons) from 1 August 1993. During the transition period, ships operating under the GMDSS will have to comply with the 1988 amendments to chapter IV of SOLAS 1974. Until 1 February 1999, both systems will require watchkeeping on 2182 kHz and VHF channel 16. Governments have undertaken to ensure that the necessary shore installations will be in place in order to provide the required communication services.

**Digital Selective Calling – DSC**

DSC Technology provides a method of calling a station or stations using digital techniques, and as such forms the basis of GMDSS communications on VHF, MF and HF. DSC provides automated access to coast stations and ships, in particular, for the transmission and reception of both routine and distress calls, i.e., it is to be used as the initial means of contact with other stations. The DSC system allows for the name of the vessels in distress, the nature of the distress and the last recorded position to be displayed or printed out on receipt of a distress alert. DSC receivers sound an alarm when a distress call is received. Distress priority ship-to shore DSC calls receive priority handling by coast stations and are routed to the nearest Rescue Co-ordination Centre (RCC).

**Functional requirements**

The GMDSS is a largely, but not fully, automated system which requires ships to have a range of equipment capable of performing the nine radiocommunication functions of the GMDSS:

1. transmission of ship-to-shore distress alerts by at least two separate and independent means, each using a different radiocommunication service;
2. reception of shore-to-ship distress alerts;
3. transmission and reception of ship-to-ship distress alerts;
4. transmission and reception of search and rescue co-ordinating communications;
5. transmission and reception of on-scene communications;
6. transmission and reception of signal for locating;
7. transmission and reception of maritime safety information;
8. transmission and reception of general radiocommunications to and from shore-based radio systems or networks; and
9. transmission and reception of bridge-to-bridge communications.

**Sea areas**

**A1**. An area within the radiotelephone coverage of at least one VHF coast station in which continuous DSC alerting is available. Such an area could extend typically 30 to 50 nautical miles from the coast station.

**A2**. An area, excluding sea area A1, within the radiotelephone coverage of at least one MF coast station in which continuous DSC alerting is available. For planning purposes this are typically extend to up to 150 nautical miles offshore, but would exclude any A1 designated areas. In practice, satisfactory coverage may often be achieved out to around 400 nautical miles offshore.

**A3**. An area, excluding sea areas A1 and A2, within the coverage of an Inmarsat geostationary satellite in which continuous alerting is available. This area lies between about latitudes 76° of latitude, but excludes any other areas.

**A4**. An area outside sea areas A1, A2 and A3. this is essentially the polar regions, north and south of about 76° of latitude, but excludes any other areas.

***Carriage requirements***

Equipment carriage requirements for ship at sea now depend upon the sea in which the ship is sailing. (In the past it was only dependent upon the type/or size of the ship). Furthermore, ships operating in the GMDSS are required to carry a primary and secondary means of distress alerting. This means having VHF DSC as a primary system for a ship near coastal areas, backed up by a satellite Emergency Position-Indicating Radio Beacon (EPIRB). A ship operating in an offshore ocean area could have Medium-Frequency DSC, High-Frequency DSC or Inmarsat satellite communications as a primary system backed up by a satellite EPIRB. The type of equipment used in the primary system is determined by the sea area in which the ship will be navigating.

**Minimum GMDSS Carriage Requirements**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Equipment | Sea Area | | | |
| A1 | A2 | A3 | A4 |
| VHF with DSC | ✓ | ✓ | ✓ | ✓ |
| SART (1 or 2 units) | ✓ | ✓ | ✓ | ✓ |
| NAVTEX | A | A | A | A |
| EGC receiver | B | B | B | B |
| 406 MHz COSPAS-SARSAT EPIRB | ✓ | ✓ | ✓ | ✓ |
| VHF portable (2 or 3 units) | ✓ | ✓ | ✓ | ✓ |
| 2182 kHz watch receiver (until Feb. 1, 1999) | ✓ | ✓ | ✓ | ✓ |
| 2182 kHz 2-tone alarm signal generator (until Feb. 1, 1999) |  | ✓ | ✓ | ✓ |
| MF Radiotelephone with DSC |  | ✓ | ✓ | ✓ |
| Inmarsat |  |  | ✓or |  |
| HF Radiotelephone with DSC and telex |  |  | ✓ | ✓ |
| Notes:   1. Required only in those areas where the NAXTEX service is available 2. Required only in those areas where the NAXTEX service is NOT available; the EGC receive facility is included in the standard Inmarsat-C terminal. | | | | |

**Maintenance requirements**

The means of ensuring the availability of equipment are determined by the sea areas in which this ship sails (see chapter IV of SOLAS). In sea areas A1 and A2, the availability of equipment shall be ensured by one of the following strategies:

(a) duplication of equipment

(b) shore-based maintenance

(c) et-sea electronic maintenance

(d) or a combination of the above, as may be approved

by the Administration.

In sea areas A3 and A4, the availability of equipment shall be ensured by using a combination of at least two of the above, as may be approved by the Administration.

**Radio Personnel**

Regulation IV/16 of the SOLAS Convention requires that:

*Every ship shall carry personnel qualified for distress and safety radiocommunication purpose to the satisfaction of the Administration. The personnel shall be holders of certificates specified in the Radio Regulations as appropriate, any one of whom shall be designated to have primary responsibility radiocommunications during distress incidents.*

The provisions of the Radio Regulations require that the personnel of ship stations and ship earth stations for which a radio installation is compulsory under international agreements (SOLAS convention) and which use the frequencies and techniques of the GMDSS shall include at least:

(a) for station on board ships which sail beyond the range of VHF coast stations, taking into account the provisions of SOLAS: a holder of a first-or second-class radio electronic certificate or a general operator’s certificate (GOC)

(b) for station on board ships which sail within the range of VHF coast stations, taking into account the provision SOLAS: a holder of first or second- class radio electronic certificate or a general operator’s certificate or a restricted operator’s certificate (ROC)

*An ROC covers only the information of GMDSS equipment required for GMDSS sea area A1, and does not cover the operation of GMDSS A2/A3/A4 equipment fitted on a ship over and above the basic A1 requirements, even if the ship is in a sea area A1.*

The combined effect of the requirements for maintenance and personnel in the four sea area is that there must be at least one GOC holder on board ships sailing in A2, A3 or A4 sea areas. The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978, as amended in 1995, requires that all deck officers shall hold an appropriate qualification to operate VHF radiocommunication equipment; that is, ROC standard on GMDSS ships or whatever international/national requirement determine.

Chapter IV of the STCW Code 1978, with the 2010 Manila Amendments contains guidance regarding radiocommunication and radio operators. This chapter presents the guidelines for training of first-class radioelectronic certificate, second-class radioelectronic certificate, general operator’s certificate, and restricted operator’s certificate holder. This includes the guidelines on the requirements for theoretical background, regulations and documentation, watchkeeping and procedures, and practical training.

In those cases, particularly in sea area A1, where additional equipment, over and above the minimum carriage requirements, is fitted, a higher standard of operator certification may also be required in order to ensure that the operator knowledge requirements match the actual equipment comprising the radio installation.

**G*MDSS Equipment Introduction***

***VHF Radiotelephone***

Operated in the band 156-174 MHz. Duplex channels are available for Ship/Shore working and simplex channels for Ship/Ship and routine Ship/Shore calling. Maximum range around 30-40 nautical miles, dependent upon heights of antennas.

***VHF DSC***

Operates on channel 70 and is used for both distress alerting and for routine calling.

***VHF Portable Two-way* Radiotelephones**

Required for emergency communications from survival craft.

***SART***

Search and rescue radar transpoder operating on the 3 cm radar X band (9.3-9.5 GHz). Used to help search and rescue (SAR) units to locate survivors.

***NAVTEX receiver***

Used to receive maritime safety information (MSI) automatically by means of narrowband direct printing from selected stations, using 518 kHz, 490 kHz and 4209.5 kHz.

***EPIRBs***

Satellite emergency position-indicating radio beacons operate on 406MHz (including 121.5 MHz for homing by rescue aircraft) through the COSPAS-SARSAT network and on 1.6 GHz (L-band Inmarsat-E) through the Inmarsat network. DSC EPIRBs operating on VHF channel 70 may be used in sea areas A1. EPIRB transmission serve to identify

the ship in distress, to inform the RCC of a distress incidents and to help to determine the position of survivors.

*Note* ***EPIRB transmissions are regarded as a distress alert***

**MF/HF DSC**

Used to monitor the DSC distress frequencies in the 2, 4, 6, 8, 12 and 16 MHz bands.Also for routine calling or replying on the 2, 4, 6, 8, 12, 16, 18, 22 and 25 MHz bands.

***MF/HF transceiver***

With full R/T and telex facilities on all the Marine bands.

*Note* ***The DSC unit uses this equipment in order to transmit and to await a reply to a routine call***

***Inmarsat-A/B***

Used for voice, telex, data, video and facsimile communications.

***Inmarsat-C***

Provides telex, data, E-mail and polling on a store-and forward basis. Usually incorporates an EGC (Enhanced Group Call) receiver for the automatic reception of maritime safety information via the International SafetyNET service.

**2182 kHz Watchkeeping Receiver**

Receiver, with a muted loudspeaker, which is used to listen for the two-tone alarm, upon reception of which the mute is lifted to enable the distress call and message to be heard.

**2182 kHz Radiotelephone Alarm Signal Generator**

Fitted into the MF R/T transceiver, it produces the two-tone alarm signal for 1 minute to alert others that a distress call and message is about to follow.

GMDSS ships are required to carry the following minimum equipment:

1. A VHF radio installation capable of transmitting DSC on channel 70, and radiotelephony on channels 16, 13 and 6.
2. One SART if under 500 GRT, 2 SARTs if over 500 GRT.
3. Two portable VHF transceivers for use in survival craft if under 500 GRT, three if over 500 GRT.
4. A NAVTEX receiver, if the ship is engaged on voyages in any area where NAVTEX service is provided.
5. An Inmarsat EGC receiver, if the ship is engaged on voyages in any area of Inmarsat coverage where MSI services are not provided by NAVTEX or HF NBDP (see note 1).
6. A 406 MHz or 1.6 GHz EPIRB

*Note: In practice, this means that all GMDSS A3 and A4 vessels are required to carry at least one Inmarsat C system.*

**Radio equipment - Sea area Al**

Every ship engaged on voyages exclusively in sea area A1 shall be provided with the minimum equipment specified previously, with the option to replace the 406 EPIRB with a VHF DSC EPIRB.

**Radio equipment - Sea areas A1 and A2**

Every ship engaged on voyages **beyond sea area A1, but remaining within sea area A2**, shall be provided with the minimum equipment specified previously, plus:

1. **An MF radio installation** capable of transmitting and receiving on the frequencies 2187.5 kHz using DSC and 2182 kHz using radiotelephony;
2. **a DSC watchkeeping receiver** operating on 2187.5 kHz
3. A **406 MHz EPIRB**

The ship shall, in addition, be capable of transmitting and receiving general radio communications using radiotelephony or direct-printing telegraphy by:

1. **A HF radio installation** operating on working frequencies in the (marine) bands between 1,605 kHz and 27,500 kHz. (This requirement is normally fulfilled by the addition of this capability in the MF equipment referred to earlier).

**Radio equipment - Sea areas A1, A2 and A3**

*These vessels have two options to satisfy their GMDSS requirements. The options allow a vessel to choose from the* ***primary method to be used for ship-shore alerting*** *;*

Every ship engaged on voyages **beyond sea areas A1 and A2, but remaining within sea area A3** shall be provided with the minimum equipment specified previously, pluseither:

1. **An Inmarsat C ship earth station :**
2. **An MF radio installation and 2187.5 kHz DSC watchkeeping receiver;**
3. **A 406 MHz EPIRB**

or

1. **An MF/HF radio installation** capable of transmitting and receiving on all distress and safety frequencies in the (marine) bands between 1,605 kHz and 27,500 kHz: using DSC, radiotelephony; and NBDP
2. **An MF/HF DSC watchkeeping receiver** capable of maintaining DSC watch on 2,187.5 kHz, 8,414.5 kHz and on at least one of the distress and safety DSC frequencies 4,207.5 kHz, 6,312 kHz, 12,577 kHz or 16,804.5 kHz; at any time, it shall be possible to select any of these DSC distress and safety frequencies
3. **A 406 MHz EPIRB**
4. An **Inmarsat ship earth station**

In addition, ships shall be capable of transmitting and receiving general radiocommunications using radiotelephony or direct-printing telegraphy by an MF/HF radio installation operating on working frequencies in the (marine) bands between 1,605 kHz and 27,500 kHz. This requirement is normally fulfilled by the addition of this capability in the MF/HF equipment referred to earlier. In practice, MF only transceivers are not produced - all marine MF radio equipment is

also fitted with HF facilities.

**Radio equipment - Sea areas Al, A2, A3 and A4**

**In addition to carrying the equipment listed previously**, every ship engaged on voyages in **all sea areas** shall be provided with:

1. **An MF/HF radio installation** as described earlier
2. **An MF/HF DSC watchkeeping receiver** as described earlier
3. A **406 MHz EPIRB**

In addition, ships shall be capable of transmitting and receiving general radio communications using radiotelephony or direct-printing telegraphy by an MF/HF radio installation as described earlier.

**Equipment to be duplicated for area A3 vessels**

GMDSS ships operating in A3 areas are required to provide the following duplicated equipment:

1. Two complete VHF installations (including DSC), and either;
2. Two complete Inmarsat C systems and one MF radio system, or;
3. One complete Inmarsat C system and one complete MF/HF radio system (including a scanning DSC receiver and NBDP equipment).

Many GMDSS ships opt for the latter option (1 Inmarsat C and one MF/HF DSC system), on cost grounds. Unfortunately, this has proven to be one of the underlying causes of the present extremely high false alerting rate on some GMDSS systems.

**Power supply requirements**

GMDSS equipment is required to be powered from three sources of supply:

1. ship's normal alternators/generators;
2. ship's emergency alternator/generator (if fitted); and
3. a dedicated radio battery supply.

The batteries are required to have a capacity to power the equipment for 1 hour on ships with an emergency generator, and 6 hours on ships not fitted with an emergency generator.

The batteries must be charged by an automatic charger, which is also required to be powered from the main and emergency generators.

Changeover from AC to battery supply must be automatic, and effected in such a way that any any data held by the equipment is not corrupted (ie: "no break").

**Operator qualifications**

There are a number of different types of GMDSS qualifications, as follows:

1. First Class Radio-Electronic Certificate;
2. Second Class Radio-Electronic Certificate; and
3. GMDSS General Operator's Certificate

The First and Second Radio-Electronic Certificates are diploma and associate diploma level technical qualifications. They are designed for Ship's Radio-Electronic Officers, who sail on GMDSS ships which use the option of at-sea electronic maintenance.

The GMDSS General Operator's Certificate is a operator qualification, designed for Navigating Officers.

**Survival Craft Radio Equipment**

**Search and Rescue (Radar) Transponders (SARTs)**

SART is a self-contained, portable and buoyant Radar Transponder (receiver and transmitter).

SARTs operate in the 9 GHz marine radar band, and when interrogated by a searching ship's radar, respond with a signal which is displayed as a series of dots on a radar screen.

Although SARTs are primarily designed to be used in lifeboats or liferafts, they can be deployed on board a ship, or even in the water.

SARTs are powered by integral batteries which are designed to provide up to 96 hours of operation.

**Operation**

When activated, a SART responds to a searching radar interrogation by generating a swept frequency signal which is displayed on a radar screen as a line of 12 dots extending outward from the SARTs position along its line of bearing.

The spacing between each dot is 0.6 nautical miles.

As the searching vessel approaches the SART, the radar display will change to wide arcs. These may eventually change to complete circles as the SART becomes continually triggered by the searching ship's radar.

Some slight position error will also be caused by the SART switching from receive to transmit mode.

SARTs will also provide a visual and audible indication to users when interrogated by a searching radar.

**Range**

The range achievable from a SART is directly proportional to its height above the water. A SART mounted at 1m (ie: in a liferaft) should be able to be detected at 5 nautical miles by a ship's radar mounted at 15m. The same SART should be able to be detected at 30 nautical miles by an aircraft flying at 8000 feet.

**Portable VHF transceivers**

These units are designed to allow communications between searching vessels and survivors in liferafts. They operate on the VHF marine band in voice mode. DSC capability is not fitted.

**Performance standards**

The IMO performance standard requires that the equipment:

1. provide operation on VHF channel 16 (the radiotelephone distress and calling channel) and one other channel
2. be capable of operation by unskilled personnel
3. be capable of operation by personnel wearing gloves
4. be capable of single handed operation, except for channel changing
5. withstand drops on to a hard surface from a height of 1 meter
6. be watertight to a depth of 1 meter for at least 5 minutes, and maintain watertightness when subjected to a thermal shock of 45 degrees Celsius.
7. not be unduly effected by seawater or oil
8. have no sharp projections which could damage survival craft
9. be of small size and weight
10. be capable of operating in the ambient noise level likely to be encountered on board survival craft
11. have provisions for attachment to the clothing of the user
12. be either a highly visible yellow/orange color or marked with a surrounding yellow/orange marking strip
13. be resistant to deterioration by prolonged exposure to sunlight

**GMDSS Master Plan**

Contains information to users on shore-based facilities regarding space and terrestrial communications services for the GMDSS.

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**Radio Paths**

This topic area deals with the path taken by a radio wave when it leaves the transmitting antenna. The main factor which determines the path taken is the frequency or wavelength of the transmission.

Radio waves travel at the velocity of light, metres per second. The relationship between the velocity of light (c), frequency (f), and wavelength (λ) is : , i.e., longer wavelength corresponds to lower frequency, shorter wavelength to higher frequency.

**Need for Radio**

The radio waves are needed to carry the signal information efficiently and without distortion. In the case of audio frequencies, which may range from about 50 Hz to 15 kHz, it would not be technically feasible to radiate the information directly from a practical transmitter and antenna.

Higher frequencies can be radiated efficiently from antennas having dimensions typically between a quarter and one wavelength. Thus, practical communication systems use a radio wave to carry the audio or other (e.g., vision or data) information between the transmitting and receiving sites.

**Modes of Propagation**

**Line – of – Sight Propagation**

Above about 50 MHz, propagation is essentially by line – of – sight. This is accomplished, in the case of terrestrial radio, via the lower part of the atmosphere –termed the troposphere – and in the case of space communication via earth – orbiting satellites.

**Ground – Wave Propagation**

In principle, a transmitting antenna sited at the earth’s surface will set up a surface wave which follows the curvature of the earth. The distance over which reliable communication can be achieved by the surface, or ground wave, depends on the frequency and the physical properties (i.e., ground conductivity and dielectric constant) be established with useful efficiency where the wavelength is greater than several tens of meters.

Seawater has highest conductivity and will support the propagation of a ground wave with very little attenuation, in much the same manner as a metal plate. At the other end of the scale, an arid desert provides very lossy ground conditions and will not support the efficient propagation of a ground wave signal.

The significance of this form maritime communications is that long distance working is possible at medium to low frequencies using only modest transmitter powers compared to those for broadcasting at similar frequencies over land.

**Sky – Wave Propagation**

Within the frequency range of 1 – 30 MHz, ionospheric reflection is the controlling factor in achieving long – distance communications by radio waves.

Because the ionization processes in the upper atmosphere that is responsible for this effect is caused by the sun, it will be evident that the density of ionization will vary with the time of day and the season of the year. The sunspot cycle, which takes approximately 11 years, also has an effect. Ionospheric storms and other disturbances occur from time to time and – in extreme cases – can cause a communication black-out lasting for some days.

In general, the net result is that, to communicate over a given distance, a higher frequency is necessary when the density of ionization is high and a lower frequency when the density of ionization falls.

**The Radio Spectrum**

Practical transmitter and radiating systems can be realized for radio waves with frequencies above 15 kHz. The radio frequency spectrum is divided into several major bands:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Radio frequencies and their primary mode of propagation** | | | | |
| **Band** | | **Frequency** | **Wavelength** | **Propagation via** |
| [ELF](http://en.wikipedia.org/wiki/Extremely_low_frequency) | Extremely Low Frequency | 3–300 [Hz](http://en.wikipedia.org/wiki/Hertz) | 1000-100,000 km |  |
| [VLF](http://en.wikipedia.org/wiki/Very_low_frequency) | Very Low Frequency | 3–30 [kHz](http://en.wikipedia.org/wiki/Kilohertz) | 100–10 km | Guided between the earth and the [ionosphere](http://en.wikipedia.org/wiki/Ionosphere). |
| [LF](http://en.wikipedia.org/wiki/Low_frequency) | Low Frequency | 30–300[kHz](http://en.wikipedia.org/wiki/Kilohertz) | 10–1 km | Guided between the earth and the [D layer](http://en.wikipedia.org/wiki/D_layer) of the ionosphere. [Surface waves](http://en.wikipedia.org/wiki/Surface_wave). |
| [MF](http://en.wikipedia.org/wiki/Medium_frequency) | Medium Frequency | 300–3000[kHz](http://en.wikipedia.org/wiki/Kilohertz) | 1000–100 m | Surface waves. E, [F layer](http://en.wikipedia.org/wiki/F_layer) ionospheric refraction at night, when D layer absorption weakens. |
| [HF](http://en.wikipedia.org/wiki/High_frequency) | High Frequency ([Short Wave](http://en.wikipedia.org/wiki/Shortwave)) | 3–30 [MHz](http://en.wikipedia.org/wiki/Megahertz) | 100–10 m | [E layer](http://en.wikipedia.org/wiki/E_layer) ionospheric refraction. F1, [F2](http://en.wikipedia.org/wiki/F2_propagation) layer ionospheric refraction. |
| [VHF](http://en.wikipedia.org/wiki/Very_high_frequency) | Very High Frequency | 30–300[MHz](http://en.wikipedia.org/wiki/Megahertz) | 10–1 m | Infrequent [E ionospheric (Es) refraction](http://en.wikipedia.org/wiki/Sporadic_E_propagation). Uncommonly [F2](http://en.wikipedia.org/wiki/F2_propagation) layer ionospheric refraction during high sunspot activity up to 50 MHz and rarely to 80 MHz. Generally direct wave. Sometimes [tropospheric ducting](http://en.wikipedia.org/wiki/Tropospheric_ducting). |
| [UHF](http://en.wikipedia.org/wiki/Ultra_high_frequency) | Ultra High Frequency | 300–3000[MHz](http://en.wikipedia.org/wiki/Megahertz) | 100–10 cm | [Direct wave](http://en.wikipedia.org/wiki/Line-of-sight_propagation). Sometimes [tropospheric ducting](http://en.wikipedia.org/wiki/Tropospheric_ducting). |
| [SHF](http://en.wikipedia.org/wiki/Super_high_frequency) | Super High Frequency | 3–30 [GHz](http://en.wikipedia.org/wiki/Gigahertz) | 10–1 cm | Direct wave. |
| [EHF](http://en.wikipedia.org/wiki/Extremely_high_frequency) | Extremely High Frequency | 30–300[GHz](http://en.wikipedia.org/wiki/Gigahertz) | 10–1 mm | Direct wave limited by absorption. |

**The Ionosphere**

Long – distance propagation of radio waver at HF is mainly the result of single or multiple reflections from ionized regions in the upper atmosphere known collectively as the ionosphere. These ionized regions are generated at heights of 100 – 400 km (55 – 220 nautical miles) as a result of partial ionization of the molecules making up the rarefied upper regions by ultraviolet and soft (long wavelength) x-ray solar radiation.

The ionization process converts the molecules into a plasma of ions and free electrons. There is a complex variation in the degree of ionization with height such that distinct layers of more intense ionization are formed. The different layers result from different parts of the ultraviolet spectrum. The heights of these layers vary from day to night and with the seasons.

The most important layers for radio wave propagation are

1. D – Layer – 40 to 90 km
2. E – Layer – 90 to 145 km
3. F1 – Layer – 145 to 250 km
4. F2 – Layer – 300 to 400 km

At night and at mid-winter, the F1 and F2 layers combine to form a single F-layer at 250 km. This is a result of a gradual recombination of the ions and electrons back into the atmospheric gas molecules during the night.

Below the E-layer is the D-layer, at a height of 50 – 90 km, which also has an influence on propagation, but more as an absorber of radio waves than as a reflecting layer. However, at VLF and LF frequencies the D-layer is sufficiently reflective to guide signals between the ground and the bottom of the D-layer for several thousand kilometers with little attenuation. After sunset, the D – Layer disappears because of the rapid recombination of its ions.

Ionospheric reflection may be simply described as the phenomenon whereby a wave appears to undergo reflection on reaching a suitably ionized region. Free electrons are set in motion so as to re-radiate the wave in a changed direction. At it passes through the ionized layers, the wave may eventually be reflected back to the earth. On a simplified view the effect may be viewed as reflection from an area at what is termed the mirror height.

The effect is frequency – dependent, with a greater degree of ionization being necessary to cause reflection as the frequency is increased. Usually the higher layers have the greater degree of ionization and therefore reflect the highest frequencies. Because of the greater mirror height, the communication range achieved by a single reflection will also be greatest under these circumstances.

The solar radiation responsible for ionizing the atmosphere varies continuously from day a night and between the seasons. Sunspot activity also has a strong underlying effect on the degree of ionization. The level of sunspot activity varies over a cycle of around 11 years, with periods of maximum ionization occurring when the number of sunspot is at a maximum.

Normally, the variation is predictable enough for the best frequency bands to be selected for the intended communication path without difficulty.

**Maximum Usable Frequency**

The maximum frequency which is reflected by the ionosphere over any particular path is known as the maximum usable frequency (MUF). The MUF depends on:

1. time of day
2. season
3. latitude
4. period of sunspot cycle

The MUF varies according to which layer is responsible for reflection back to the earth. For each layer, the highest MUF is obtained when the ray path leaves the earth tangentially, so that the ray approaches the appropriate layer at as oblique an angle as possible.

Under normal conditions, the window of available frequencies varies predictably as follows:

1. daytime MUF is higher than night-time MUF
2. winter MUFs are both lower than and vary more than summer MUFs
3. radio circuits less than 1000 km (600 nautical miles) normally use frequencies bellow 15 MHz
4. radio circuits greater than 1000 km (600 nautical miles) normally use frequencies above 15 MHz
5. MUFs are higher when the sunspot number is high

In general, the strongest signals (i.e., those with least attenuation) will occur using frequencies just below the MUF, for the particular path distance and layer involved. When a wave is sent vertically upwards, the highest frequency for which reflection by any particular layer will occur is termed the critical frequency, f0.

This frequency is much lower than the MUF = f0 / cos A is the angle of incidence of the ray to the layer. At frequencies higher than f0, the waves will penetrate the layer and be lost, but as the angle of radiation is progressively lowered an angle be reached where reflection occurs (termed the *critical wave angle*). Signals can then be received at a great distance, and radiation at lower angles will be reflected to even greater distances.

At points nearer to the transmitter, no signals will be received by ionospheric reflection, but when sufficiently close to the transmitter to be within range of the ground wave the signals will again be heard. In between there is an area of very poor reception, termed the *skip zone*. The distance from the transmitter to the nearest point at which a wave at a particular operating frequency returns, after reflection, back to the earth is known as the *skip distance*.

**Basic Transmitters and Receivers**

**Basic Transmitter**

The *radio frequency generator* produces the carrier, i.e., the frequency on which we wish to transmit.

The *modulator* is used to combine the information signals from the microphone or the telex with the carrier. The type of modulation may be amplitude (AM), frequency (FM) or phase (PM). This modulated signal is then amplified within the transmitter and fed to the antenna.

The antenna requires tuning to carrier frequency so that it will radiate efficiently.

*Antennas* made from wire elements radiate most efficiently when they are one quarter of a wavelength long. It is not practicable on board ships to install an antenna which is physically the ideal length over all of the MF or HF bands. However, the electrical length of the antenna can be lengthened or shortened with respect to its physical length by the introduction of extra radio – frequency circuit elements, inductors and capacitors, in *an Antenna Tuning Unit* (ATU).

In most modern equipment, this is achieved automatically by pressing the <Tune> button before actual transmission. A signal strength meter which measures antenna current gives a visual indication of transmission. Most equipment allows for Manual tuning mode on 2182 kHz in case the automatic tuning fails. Individual manufacturer’s manuals should be consulted for further details. The default 2182 kHz setting need only be carried out upon installation or if your antenna is moved or changed

**Basic Receiver**

The wanted signal is received by tuning the input to the receiver to the wanted frequency. Received signals vary greatly in strength due to a number or factors:

1. A local transmitter radiating high or low power.
2. A distant station radiating high or medium power.
3. Variations in the ionosphere which may affect signals on MF at night or on HF at any time – polarisation fading.
4. Simultaneous reception by ground and sky waves on MF at night which may constantly vary in strength or phase and interact with each other – interference fading.
5. On the HF bands, signals can reach the receiver having taken different paths, again causing interference fading.

The radio frequency <Gain> or <Sensitivity> control allows manual adjustment of the input amplifier so as to set up the gain to suit conditions. Continual adjustment of the gain control may be necessary if fading occurs, in which case the *Automatic Gain Control (AGC)* can be switched, thereby taking over from manual control, i.e., the AGC holds the output at a nearly constant level even though the input may fluctuate widely. Most GMDSS MF/HF receivers can be tuned into the wanted signal by more than one method, i.e., if paired HF frequencies are required you can simply select the ITU channel number.

Alternatively, the actual frequency can be keyed in. If it becomes necessary to re-tune to a station only a few kilohertz away, then the up/down <*Tune Arrows>* can be used. Fine tuning is sometimes necessary, especially when it is required to “clarify” reception of single – sideband (SSB) speech transmissions (i.e., mode of emission = J3E). Selection of the <clarifier> allows tuning down to an accuracy of 10 Hz but it is normally used by listening to the output and tuning to the speech rather than to the actual frequency.

The *<Volume>or <A.F. Gain>* control simply varies the amount of signal passing to the loudspeaker, whilst the <squelch> or <mute> control turns off the loudspeaker when no signals are being received.

**Modes of Emission**

|  |  |  |  |
| --- | --- | --- | --- |
| AM | | | |
| A1A | Unmodulated Morse Code |  | Morse transmission using carrier |
| A2A | Double-sideband (DSB) modulated Morse code |  | Morse transmission using audio tone |
| H2A | Single-sideband (SSB) modulated Morse code |  | Morse transmission using audio tone |
| J2B | SSB Telex |  | MF/HF NBDP/telex |
| A3E | DSB Telephony (Commercial broadcast) |  | LF/MF/HF broadcast stations; bandwidth 9-20 kHz |
| H3E | SSB Full-carrier telephony (2182 kHz) |  | MF |
| R3E | SSB Reduced-carrier telephony |  | MF |
| J3E | SSB Suppresed-carrier telephony |  | MF/HF, bandwidth for voice = 2.8 kHz |
| FM | | | |
| F1B | Telex |  | Uses Frequency shift Keying (FSK) for modulation |
| F3E | Frequency-modulated telephony |  | VHF |
| G3E | Phase-modulated telephony |  | VHF |

**Communication types**

In a *full duplex* system, both parties can communicate to the other simultaneously. An example of a full-duplex device is a telephone; the parties at both ends of a call can speak and be heard by the other party simultaneously. The earphone reproduces the speech of the remote party as the microphone transmits the speech of the local party, because there is a two-way communication channel between them, or more strictly speaking, because there are two communication paths/channels between them.

In *a half-duplex* system, there are still two clearly defined paths/channels, and each party can communicate to the other but not simultaneously; the communication is one direction at a time. An example of a half-duplex device is a walkie-talkie two-way radio that has a "push-to-talk" button.

Systems that do not need the duplex capability may instead use *simplex communication*, in which one device transmits and the others can only "listen". Examples are broadcast radio and television,  wireless microphones, and surveillance cameras.

**GENERAL REGULATIONS**

**Authority of the Master**

The radio service of a ship is under the supreme authority of the Master or other person responsible for the ship.

**Observance of Secrecy**

The holder of the radio license is required to preserve the secrecy of telecommunications, as laid down in the relevant provisions of the convention. The station is not allowed to receive any other correspondence than it is intended to. Without special permission, it is prohibited to publish or take advantage of traffic designated to others.

**Ship’s Radio Licenses**

These are normally issued by the national Administration, but can also be issued by another office or institute on behalf of the national Administration. The license should be displayed near to the radio equipment and shows the following:

1. Name of ship
2. Call sign and relevant identification numbers
3. Owner’s name
4. Frequencies
5. Transmitter output powers
6. Classes of emission
7. Public correspondence category
8. Other conditions under which the station is to be operated

The license should be permanently displayed near the main ship station control point.

**Documents to be carried**

The Radio Regulations require that ships for which a radio installation is required by international agreement carry the following documents:

1. Ship’s Radio License
2. Radio Operators’ Certificates
3. GMDSS Radio Log – book
4. ITU List of Call Signs and Numerical Identities of Stations used by the Maritime Mobile and Maritime Mobile– Satellite Services.
5. ITU List of Coast Stations.
6. ITU List of Ship Stations.
7. ITU List of Radio determination and Special Service Stations.
8. ITU Manual for Use by the Maritime Mobile and Maritime Mobile- Satellite Services.

Other international and national regulations require additional documentation and publications to be carried:

1. Radio Safety Certificate
2. Antenna Rigging
3. List of spares and where kept.

**Radio Safety Certificate**

All cargo and passenger ships obliged to be fitted with radio stations in accordance with the SOLAS convention must have a Cargo Ship Safety Radio Certificate which is valid for a maximum of One year and must be renewed every year.

**Inspection**

Surveyors or inspectors from the appropriate shore-based authorities, i.e. local maritime transport Administration or telecommunication Administration, may inspect the ship station, including the documentation and the equipment.

**Unauthorised Transmissions**

Stations are forbidden to:

1. Make unnecessary or superfluous transmission.
2. Transmit false or misleading signals.
3. Transmit without using their identification.

It is also useful to remember that you should only radiate as much power as is necessary to ensure a good communication link and that, before transmission on any frequency or channel, you must ensure you are not going to interfere with transmissions already in progress.

**Test Transmission**

These should be kept to a minimum and should, if possible, be carried out using an artificial antenna (dummy load) and/or reduced power. Distress frequencies should not be used unless absolutely necessary. Test or tuning signals should be for less than 10 seconds and should include the call sign or other identification.

**Daily Tests**

1. DSC- Without radiation-Use built-in test facility.
2. Batteries –On-/Off-load voltage checks - Fully charge if necessary
3. Printers- Check sufficient paper –DSC –NAVTEX- Telex-SATCOM.

**Weekly Tests**

1. DSC-Live call to coast station.
2. Reserve source of energy –other than battery.
3. Survival craft VHF –not on channel 16

**Monthly Tests**

1. EPIRBs –Use built-in test facility –do not radiate.
2. SARTs- Using the facility
3. Batteries – Check condition of all batteries – EPIRBs SARTs – Reserve –VHF.
4. In the case of EPIRBs and SARTs you should also check the security of the, i.e. for corrosion or damage.

**Radio Log**

The Radio Log, as required by the SOLAS convention, must be kept together with the radio and must be written in accordance with the details required by the Radio Regulations and Guidelines.

All Traffic concerning distress, urgency and safety correspondence with foreign coast and ship stations is of vital importance.

**VHF communications includes:**

-Public Correspondence

-Harbor and Pilot Service (Ch. 12)

-Intership Communications (Ch. 6, 8, 10, etc.)

-Safety Service

-Calls can be transmitted three(3) times with intervals of Two(2) minutes.

-Unanswered series of calls must be stopped and not be repeated until after an interval of three(3) minutes

-Keep listening watch on channel 16

**Traffic Lists**

Coast stations normally transmit their calls in the form of traffic lists of stations they have traffic for.