

**Military Technical College**

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**Cairo, Egypt**



**10<sup>th</sup> International Conference**

**on Electrical Engineering**

**ICEENG 2016**

## **Submarine Very Low Frequency $\sim$ VLF $\smile$ Communication**

**Abstract** 'Submarine' as one of the most important undersea strategic weapon platform 'has the advantage of mobility and disguise. Therefore, receiving command signal must be completed under water. Navies around world mostly complete orders and target steering in this band due to VLF has the ability of penetrating seawater. This paper mainly focuses on the prospect of transmitting, receiving and antenna feeder of the latest generation of VLF Communication System.

**Key words:** VLF communication, transmitter, receiver, antenna feed system and its carrying platform

As a strategic underwater platform, submarine has the good performance of aggression and concealment. Ballistic nuclear missile submarine (SSBN) could remain ten to several hundred meters underwater for months at a time; its strategic significance is obvious. Underwater communication must be guaranteed by VLF, so that underwater capabilities and commanding communications of other tactical operation can be satisfied.

Although, conductive medium exists in seawater, the majority of radio wave is hard to penetrate through seawater to complete submarine communications. Radio wave, which works on VLF, has the unique features comparing with the radio wave works on other band:

- a. Can be used to spread through a certain depth of the sea water.

- b. Can be satisfied the requirement of Submarine communications in deep water.

VLF communication system so far is still the one of the most reliable communication for submarine communication.

## **1. Configuration, feature and existing problem of VLF communication system**

### 1.1 Configuration of VLF communication system

- a. transmitting terminal
- b. exciter
- c. transmitter
- d. transmitting antenna
- e. multi-coupler
- f. receiver
- g. receiving terminal

VLF transmitter is the key device.

In order to enhance the output power, MMPA parallel operation has been used.

1.2 The band of VLF is the most effective communication for remote commanding under water in each country's navy. VLF usually refers to space wave that frequency within the range between 10-100km and transmission rate is up to 75bps. Its main feature as follows:

- a. The attenuation in this band is much smaller than in short wave and medium wave.
- b. Excellent penetration in sea water, so submarine communication can be realized.
- c. Highly reliable and stable broadcasting to realize remote communications; apply to transmission of submarine and strategic bomber.

1.3 Although submarine communication has been realized by VLF communication, a

lot of problem is still exist:

a. Vast scale of feed system

Low efficiency, large area occupied, many towers, large object and poor performance of strike-resistance

b. narrow wave band

Only low-speed telegram can be transmitted, no voice communication, only one way communication

c. poor hiding performance

Come-up to receive signal, increase the chance of revealing itself.

## **2. Mobile VLF communication system**

For the existing problem, the majority of countries who own submarine developed a series of mobile VLF vehicle communication system.

a. Antenna lift-off, launching terminal and exciter. The power station is in vehicle cabin form to re-deploy, open quickly and set up in a short time if needed.

b. Airborne submarine communications system. A complete set of equipment is installed on large aircraft .Using a 200kw transmitter and 10km Trailing Wire Antenna (TWA) with a stabilizing parachute on its bottom. Aircraft flied continuously, when transmitting, along small radius of the circle to make the effective length of antenna reaches 70% of actual length in vertical direction. In order to promise at least one aircraft is in the cruising state, and prepare to transponder message to strategic submarines in any time, when land-based VLF is destroyed.

## **3. The characteristic of VLF transmitting antenna and its construction**

VLF transmitting antenna is equivalent to T-type, which is installed vertical to the earth to produce vertical polarized wave. Electromagnetic wave (15kHz-30kHz)

that corresponding to the wavelength is 20km-100km. Due to the spectrum of the wavelength of electromagnetic wave is very long, transmitting antenna erection height is often limited. The feature is as follows:

- a. Radiation resistance is small, and much smaller than loss resistance, so that the antenna efficiency is quite low.
- b. Transmitting antenna input impedance has a large capacitive reactance; small resistance component; antenna Q value is quite high; the tuning curve sharp; narrow work band.
- c. When transmitting antenna input power is large, the antenna input voltage is very high; the voltage at the top of the antenna is higher, which is easy to appear over voltage and corona phenomenon.

T-type antenna includes the radial body part and top load. In order to increase the radiation efficiency of antenna, top load is needed to be designed appropriately. The top load and earth plane formed capacitance effect, so the VLF transmitting antenna is mostly capacitance type in working frequency range. According to the requirements of different constitution sites and applications, erect modes can be divided into following types:

(i). Tower model antenna

Tower model antenna is mainly used in various types of plains. In the circumstances of better soil conductivity, the radiation rate of antenna is higher. The height of antenna erection is higher, the more effective. To construct the height of antenna is about 200m-300m, coverage radius is 600m, within the scope of 500km-1mw, good efficiency can be achieved in the existing technology.

(ii). Valley-span antenna

As the name implies, set up the tower on the peak based on the valley terrain and mountain area. The radiation efficiency is higher compare with tower antenna. Generally speaking, span is about 2km, effective span is 1km, effective height is 400m around, and coverage is  $1.5\text{km}^2$ . This kind of antenna is difficult to construct affected by the geographical terrain.

(iii).Balloons lifting antenna

Balloon, as a platform, is widely used in mobile emergency communication. If the antenna radiation efficiency is high, the effective height reaches above 2000m. Balloon antenna parameter changes relatively great, then higher requirement of transmitter technology. After the balloon antenna reaches working height, forming a projection with the earth plane is the balloon antenna of equivalent load.

(iii). Airborne antenna

TACAMO is the navy's current main invulnerability strategic communication system, it is also the component of C<sup>3</sup>I system in the national strategy, which ensure the effective communication can be set up with ballistic missile submarine and nuclear power attacking submarine and National command authority when the ground VLF system is destroyed. E-6A Hermes jet aircraft, 200km transmitter, effective power of antenna radiation is 100kw, 10m drag antenna, stabilizing parachute at bottom of antenna. When transmitting signal, aircraft flew along the small radius of circle continuously to make the effective length reaches 70% of the actual length in the vertical direction. In order to promise at least one aircraft is in the cruising state, and prepare to transponder message to strategic submarines in any time, when land-based VLF is destroyed. This kind of VLF communication system has been widely used in U.S Navy. However, it is basically no mobility when working.

#### 4. How to enhance the capability of submarine VLF communication

a. How to enhance the duration of transmitting antenna

Even airborne VLF transmitting antenna is not optimistic in the modern war

b. How to communicate without a break

Communication can be realized with submarine no matter when and where

c. How to improve the anti-interference ability of the communication system

Due to working frequency is open and low, narrow bandwidth, it is harm for anti-interference technology. The traditional way is increasing the radiation

power and optimizing demodulation and decoding method.

- d. How to improve transmission rate of communication system

Mainly limited to narrow band of transmitting antenna, receiving is completed under water, the electromagnetic noise is large and so on, severely restricted the transmission speed.