

Wire antenna for high frequency emission

The present invention relates to a wire antenna for high frequency emission for submarines, of the type comprising a coaxial cable and a radiating element, one of which is connected to the coaxial cable and dimensioned for transmitting waves of high frequency between 3 MHz and 30 MHz.

The invention applies to the field of radio-communications in the high frequency (HF) and very low frequency (VLF) bands, extending from 3 to 30 MHz and from 3 to 30 kHz, respectively.

Submarines transmit and receive signals via wire antennas tugged or towed by the submarines, the floatability of which is such that the antennas are close to the surface while the submarine is immersed at a greater depth.

These wire antennas are electrically dimensioned in order to operate at very low frequency since VLF waves penetrate down to a depth of 10-50 m in water, depending on the frequency and the salinity of the water, unlike high frequency (HF) waves which penetrate very little in water.

In a known way, the ideal length of the radiating element of the wire antenna is equal to a quarter of the wavelength of the waves to be transmitted, i.e. the quarter of the ratio of the wave velocity in the propagation medium by its frequency. This is called a quarter wave antenna.

In practice, VLF wire antennas, i.e. adapted for operating in the very low frequency band, are much shorter than the ideal length. This is the case of present VLF reception wire antennas, which are much shorter than what theory would suggest but sufficiently sensitive for receiving waves from the VLF band. It turns out that this length may reach the ideal length required for transmission at the beginning of the high frequency band to a few MHz.

Nevertheless, these VLF antennas are not adapted for operating in the remainder of the high frequency band.

Also, for using a wire antenna at frequencies which do not correspond to the physical length or height of the radiating element, there exist electronic adaptation circuits positioned at the foot of the antenna, when the latter is an aerial, called antenna « adaptation box ». A drawback of this device is that the adaptation has to be done in a different way for each frequency used. For example, in the high frequency range, the adaptation boxes contain about 25 components to be used in a combinatorial way (i.e. 2^{25} combinations) determined by a computer. Further, the volume of such an adaptation

system is proportional to the power delivered by the transmitter, i.e. about 200 L for a 500 W transmitter, which is not adaptable to a submarine.

The object of the invention is to overcome this adaptation drawback of the antenna upon transmitting in the high frequency band.

5 For this purpose, the object of the invention is a wire antenna of the aforementioned type, characterized in that it comprises at least one isolation filter positioned on the radiating element of the wire antenna.

According to particular embodiments, the wire antenna includes one or more of the following features, taken separately or as a combination:

10 - said or each isolation filter is a circuit comprising an inductor and a capacitor in parallel;

- said or each isolation filter is positioned at a distance equal to the quarter of a wavelength of a high frequency wave to be transmitted from the end of the radiating element connected to the coaxial cable;

15 - said or each distance is comprised between the quarter of the wavelength of a high frequency wave in water and the quarter of the wavelength of a high frequency wave in air;

- it comprises at least first and second isolation filters successively positioned along the radiating element of the wire antenna;

20 - the wire antenna has a length substantially comprised between 10 and 40 m;

- the radiating element is capable of receiving very low frequency waves between 3 kHz and 30 kHz.

The object of the invention is also a transmission system, characterized in that it comprises a transmitter of waves with high frequencies comprised between 3 MHz and 30 MHz and a wire antenna for transmitting these waves as described above.

25 According to a particular embodiment, the transmission system comprises a receiver of waves with very low frequencies comprised between 3 kHz and 30 kHz, and with high frequencies comprised between 3 MHz and 30 MHz, the receiver being connected with the same wire antenna for receiving these waves.

30 The object of the invention is also a submarine vehicle, characterized in that it includes a transmission system as described above.

The invention will be better understood upon reading the description which follows, only given only as an example and made with reference to the drawings, wherein:

35 - Fig. 1 is a schematic view of a wire antenna according to the invention connected to a submarine,

- Fig. 2 is an enlarged view of a portion of the wire antenna of Fig. 1, and

- Fig. 3 is a schematic view of a wire antenna according to the invention comprising two isolation filters.

With reference to Fig. 1, the invention relates to a wire antenna 2 connected to a submarine 4.

When the submarine wishes to communicate in a high frequency or very low frequency band while remaining in deep immersion, the wire antenna 2 is deployed and towed by the submarine while floating from its end to the surface of the water 5.

The wire antenna 2 comprises a coaxial cable 6 and a floating radiating element 8.

The coaxial cable 6 is connected at one end 6A to the radiating element 8 and at the other end 6B to the submarine 4.

The wire antenna 2 is of the « VLF wire antenna » type, i.e. adapted for operating at a very low frequency between 3 and 30 kHz, and in particular for receiving VLF waves.

The radiating element 8 of the wire antenna 2 has a shorter length than theory would suggest but is sufficiently sensitive for receiving waves of the VLF band between 3 kHz and 30 kHz. The length is substantially equal to the ideal length required for transmission at the beginning of the high frequency band to a few MHz. For example, a length is substantially comprised between 10 and 40 m for transmitting waves at about 6 MHz.

Further, the wire antenna 2 includes a switching system 12 located in the submarine 4 and also electrically connected to the coaxial cable 6, giving the possibility of switching between the high frequency operation (transmission and reception) and the very low frequency operation (reception). The wire antenna 2 further comprises at least one isolation filter 14 positioned on the radiating element 8 of the wire antenna 2.

The radiating element 8 is electrically cut in several locations for placing the different isolation filters 14. This electrical cut is similar to the electrical cut made between the radiating element 8 and the coaxial cable 6 which conveys the received signal to a receiver of the submarine 4. In a known way, a mechanical assembly ensures the support between the different segments of the radiating element 8 and the coaxial cable 6 or the isolation filters 14.

Each isolation filter 14 is an electric circuit comprising an inductor 16 and a capacitor 18 in parallel, as illustrated in Fig. 2 and commonly called a trap circuit.

The values L of the inductor 16 and C of the capacitor 18, are selected according to the central transmission frequency F in the desired high frequency band, according to the mathematical relationship $F^2 = 1/(4\pi^2 LC)$. For example, the value of the inductance is of the order of 1 μ H.

In a known way, the ratio between the value L of the inductor 16 and the value C of the capacitor 18 determines the bandwidth of the isolation filter 14 around the central frequency F. The bandpass width is substantially equal to 2 MHz around the central frequency.

Each isolation filter 14 is positioned on the radiating element 8 at a set distance from the end of the radiating element 8 connected to the coaxial cable 6.

In a known way, this distance is preferably equal to the quarter of the wavelength of the high frequency wave to be transmitted, in order to form a « quarter wave antenna ».

The distance is comprised between the quarter of the wavelength of a high frequency wave in water and the quarter of the wavelength of a high frequency wave in air.

According to an alternative, the distance is equal to three quarters of the ratio of the velocity divided by a frequency of the wave. In a known way, this is a «three quarter wave antenna». For a same frequency, the efficiency will not be as good as for a quarter wave antenna.

Thus, each isolation filter 14 allows adjustment of the length of the VLF antenna to a virtual length shorter than the physical length. This virtual length allows the segment of the radiating element located between the end 6A of the coaxial cable 6 and the isolation filter 14 to transmit in the high frequency band.

Thus, the wire antenna may be segmented in as many frequency bands as desired, separated by isolation filters dimensioned according to the central frequency of each band. The radiating element is then dimensioned for transmitting high frequency waves between 3 MHz and 30 MHz.

The invention also relates to a transmission system including a transmitter of waves of high frequencies comprised between 3 MHz and 30 MHz and a wire antenna as described earlier for transmitting these waves. The wire antenna is connected to the transmitter.

Further, this transmission system comprises a receiver for waves of very low frequencies comprised between 3 kHz and 30 kHz and of frequencies comprised between 3 MHz and 30 MHz. The receiver is connected with the same wire antenna in order to receive these waves.

The submarine 4 includes such a transmission system for transmitting high frequency waves.

The operation of the wire antenna will be detailed with regard to Fig. 3 which illustrates a wire antenna according to the invention comprising two isolation filters noted

as 14a and 14b. Each isolation filter comprises an inductor 16a, 16b and a capacitor 18a, 18b, of respective values L_a , L_b , C_a and C_b .

The first isolation filter 14a and the second isolation filter 14b are respectively placed at a distance L_1 and L_2 from the end 6A of the coaxial cable 6 on the radiating element 8 in order to cut it up into three segments.

The first segment of the radiating element 8 of the TBF wire antenna located between the end 6A of the coaxial cable 6 and the first isolation filter 14a is noted as ER1 and forms a first radiating element adapted for transmitting a wave of frequency F_1 equal to $F_1^2 = 1/(4\pi^2 L_a C_a)$ belonging to high frequency band.

Also, the second segment located between the end 6A of the coaxial cable 6 and the second isolation filter 14b is noted as ER2 and forms a second radiating element adapted for transmitting a wave of frequency F_2 equal to $F_2^2 = 1/(4\pi^2 L_b C_b)$ belonging to the high frequency band and greater than F_1 .

Indeed, around the resonance frequency of the electric circuit of each isolation filter, only the segment placed in front of the isolation filter radiates the high frequency signal. The portion placed after the filter is isolated.

When the switching system 12 is in the switching position adapted to high frequency operation, the submarine transmits the wave at the desired HF frequency which is transmitted to the radiating element 8 through the coaxial cable 6. Depending on the HF frequency of the wave, the first segment ER1 or the second segment ER2 radiates towards a receiver of the wave.

For example, it may be necessary to have three frequency bands in the high frequency range for communications of submarines: between 20 MHz and 24 MHz, 12 MHz and 15 MHz and between 5 MHz and 7 MHz.

If one of the bands corresponds to the total length of the VLF antenna used in high frequency, only two other filters are necessary. Otherwise three filters will be required for cutting the radiating element of the wire antenna into three segments.

For receiving in the VLF band, the switching system 12 in the submarine is positioned/activated in the position for operating at a very low frequency.

The electric circuits of the isolation filters are then transparent in the VLF frequency band and ensure that the wire antenna has the same performances as before in this band.

Thus, good impedance matching is achieved for the two frequency bands: high frequency (emission and reception) and very low frequency (reception).

It is then understood that the wire antenna according to the invention is capable of operating in transmission in the high frequency domain and in reception in the very low frequency and high frequency domains.

- 5 According to the invention, the adaptation is achieved in a simple way as compared with adaptation boxes and in a set way for a plurality of central working frequencies, preferably two or three, distributed in the high frequency band.

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CLAIMS

1.- A wire antenna (2) for submarines (4) comprising a coaxial cable (6) and a radiating element (8), one end of which is connected to the coaxial cable and dimensioned for transmitting high frequency waves, between 3 MHz and 30 MHz, the antenna (2) being characterized in that it comprises at least one isolation filter (14) positioned on the radiating element (8) of the wire antenna (2).

2.- The wire antenna (2) according to claim 1, characterized in that said or each isolation filter (14) is a circuit comprising an inductor (16) and a capacitor (18) in parallel.

3.- The wire antenna (2) according to any of claims 1 to 2, characterized in that said or each isolation filter (14) is positioned at a distance equal to the quarter of a wavelength of a high frequency wave to be transmitted, from the end of the radiating element (8) connected to the coaxial cable (6).

4.- The wire antenna according to claim 3, characterized in that said or each distance is comprised between the quarter of the wavelength of a high frequency wave in water and the quarter of the wavelength of a high frequency wave in air.

5.- The wire antenna according to any of claims 1 to 4, characterized in that it comprises at least first and second isolation filters (14) successively positioned along the radiating element (8) of the wire antenna (2).

6.- The wire antenna according to any of claims 1 to 5, characterized in that the wire antenna (2) has a length substantially comprised between 10 and 40 m.

7.- The wire antenna according to any of claims 1 to 6, characterized in that the radiating element is capable of receiving very low frequency waves between 3 kHz and 30 kHz.

8.- A transmission system characterized in that it comprises a transmitter of waves with high frequencies comprised between 3 MHz and 30 MHz and a wire antenna (2) according to any of claims 1 to 7 for transmitting these waves.

9.- The transmission system according to claim 8, characterized in that it comprises a receiver for waves of very low frequencies comprised between 3 kHz and 30 kHz and of high frequencies comprised between 3 MHz and 30 MHz, the receiver being connected with the same wire antenna for receiving these waves.

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10.- A submarine vehicle characterized in that it includes a transmission system according to any of claims 8 to 9.