High-Efficiency Sea-Water Monopole Antenna for Maritime Wireless Communications

[1]Dr.K.O.Joseph [2]E.Karthika, [3]M.Keerthika, [4]G.Mugashini

Final year of ECE
GKM COLLEGE OF ENGINEERING AND TECHNOLOGY, Chennai

ABSTRACT:A study of sea-water monopoleantenna to show the efficient working when compared to the existing system for maritime wireless communications is proposed in this paper.A new transparent and reconfigurable sea water monopole antenna is well suited for maritime wireless communication. This monopole antenna consists of a feeding probe and a sea-water cylinder held by a clear acrylic tube. In comparison to the dynamic type sea water monopole antenna in our structure is relatively simple, mainly consists of acrylic tube filled with sea water and top loaded feeding probe. Our antenna as higher efficiency due to an efficient feeding structure and thick sea water cylinder used. The concept of our project is to save the fuel,time and life of submarine and water bound vehicles. By using sea water monopole antenna is very efficient and it could be reliable concept of sending data through salt water using tabular antenna.

***Index Terms*—Monopole antenna, radiation efficiency, reconfigurable, sea-water, transparent antennas, VHF band.**

I. INTRODUCTION

IN recent years, liquid antenna [1] was becoming an interesting topic. For a liquid antenna, the fluid that carries charged particles in the form of ions is used as the radiating medium. Due to the fluidity, the fluid can be pumped into a plastic tube and thereby “deployed” when the antenna is activated. When deactivated, the fluid can be pumped out or drained and the tube can also be removed, resulting in very small occupation space and radar cross section (RCS). As a special case of fluid antenna, water antenna is probably the most popular, due to its low cost and easy access. Many kinds of water antennas have been reported so far. The performance of this antenna was carefully studied by dissolving salt into pure water. Based on this design, a feeding probe loaded with nut and washer was introduced to improve the performance of the monopole water antenna. Another monopole water antenna was presented by inserting a dielectric basebetween water and the ground plane to maximize the bandwidth. In a cubic water dielectric resonator antenna (DRA) with compact size was designed due to high permittivity and low loss of the distilled water at the low frequencies.

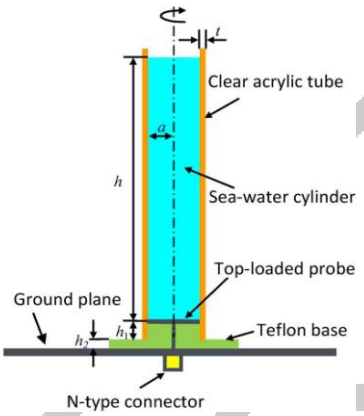
Most of the early studies of water antennas were based on fresh water, and carried out only by experimental analysis. However, in a maritime environment, sea water is more readily available than fresh water. In a sea-water monopole antenna was made by SPAWAR, which mainly consists of a current probe and a sea-water stream supplied by a pump. It has the advantages of dynamic and reconfigurability. However, at upper very high frequency (VHF) and ultra high frequency (UHF) bands, the efficiency of this sea-water monopole antenna is low because the thin sea-water stream is not an efficient radiator. It is also known that the thinner the stream becomes, the larger is the loss resistance and the lower is the radiation efficiency.In this paper, a new transparent and reconfigurable sea-water monopole antenna operating at VHF band is proposed, which is well suited for maritime wireless communications. In comparison to the dynamic-type sea-water monopole antenna in our structure isreconfigurable which means that its center frequency and band-width can be adjusted by changing the height and radius of the sea-water cylinder.

Generally speaking, the dielectric constant of sea water is 81, and the conductivity is 4 S/m. However, it is worth mentioning that the electrical properties of sea water depend on its chemical composition which varies from place to place and from time to time. In addition, electrical properties of sea water vary with the temperature, pressure, and frequency.

Therefore the electrical properties of sea water used here are characterized by using a coaxial line reflection method to obtain an accurate design. It is found that the dielectric constant of the available sea water varies between 77.6 and 79.8 over the frequency range of 30–300 MHz, while the conductivity varies between 3.9 and 4.2 S/mrelatively simple, mainly consists of a transparent plastic tube filled with sea-water and a top- loaded feeding probe. Furthermore, our proposed antenna has a higher efficiency due to an efficient feeding structure and the thick sea-water cylinder used. A theoretical study of the sea- water monopole antenna based on the three-term theory is presented, which has not appeared in the literature. Experimental results are provided to verify the theoretical calculations, and reasonable agreements between them are obtained. Measurements show that our pro-posed antenna has a higher radiation efficiency compared to the water antennas in due to the small surface resistance of our sea-water monopole. In addition, due to the transparency and liquidity of the sea water, the proposed antenna is almost optically transparent and can be readily reconfigurable. Details of the antenna design and experimental results are presented and discussed.

II. STRUCTURE OF THE SEA-WATER MONOPOLE ANTENNA

The figure shows the geometry of the sea-water monopole antenna mounted on a ground plane. As shown, in order to hold the sea-water cylinder, a clear acrylic $(\varepsilon = 2.7)$ tube is chosen to be vertically fixed on a Teflon base and sealed with silicone gasket. Its transmittance is nearly perfect; therefore it can be used to design an optically transparent antenna. The feeding probe is loaded with an aluminium disk on the top before being inserted into the sea water, which improves the excitation of TM mode. To achieve the desired TM mode, the clear acrylic tube and the feed probe are concentric to maintain its structural sym-metry. It is clear that the sea-water monopole antenna can be



III.PROJECT WORK MODULES:

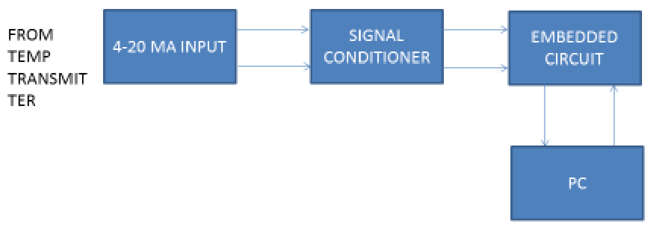
- Design and implementation of sea water monopole antenna consists of 5 modules.
  - Data acquiring system
  - Design of signal conditional system
  - Data manipulation mode
  - Design of wireless module
  - Design of receiving module

DATA ACQUIRING MODULE:

Data acquisition is the process of sampling signals that measure real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer.

The components of data acquisition systems include:

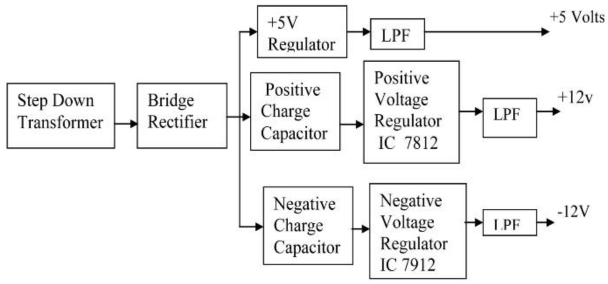
- Sensors, to convert physical parameters to electrical signals.
- Signal conditioning circuitry, to convert sensor signals into a form that can be converted to digital values.
- Analog-to-digital converters, to convert conditioned sensor signals to digital values.



A sensor, which is a type of transducer, is a device that converts a physical property into a corresponding electrical signal (e.g. thermistor).An acquisition system to measure different properties depends on the sensors that are suited to detect those properties. Signal conditioning may be necessary if the signal from the transducer is not suitable for the DAQ hardware being used. The signal may need to be filtered or amplified in most cases. A thermocouple is an electrical device used for measuring temperature, consisting of two different conductors forming electrical junctions at differing temperatures. A thermocouple produces a temperature-dependent voltage as a result of the thermoelectric effect, and this voltage can be interpreted to measure temperature.Type J (iron – constantan)is used which has a more restricted range (−40 °C to +750 °C) higher sensitivity of about 50 µV/°C. The Curie point of the iron (770 °C) causes a smooth change in the characteristic, which determines the upper temperature limit.

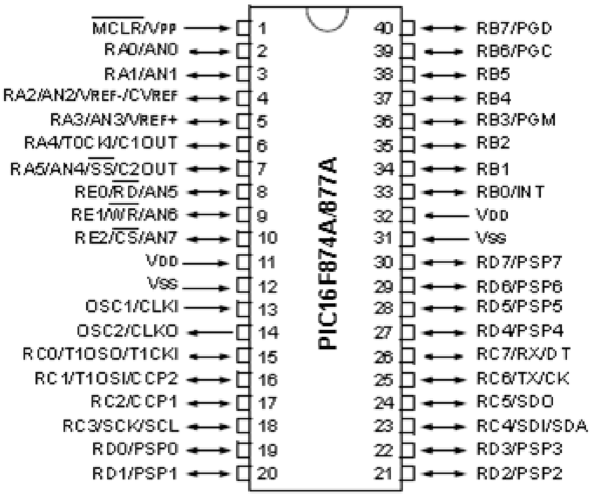
POWER UNIT: All the electronic components starting from diode to Intel IC's only work with a DC supply ranging from -+5v to -+12v.

We are utilizing the same by cheaply and commonly available energy source of 230v-50Hz and stepping down, rectifying, filtering and regulating the voltage. The transformer of 230v/15-0-15v is used to perform the step down operation where 230v AC appears as 15V AC across the secondary winding.A commonly used circuit for supplying large amounts of DC power is the bridge rectifier with four diodes (4*IN4007) and are used to achieve full wave rectification.

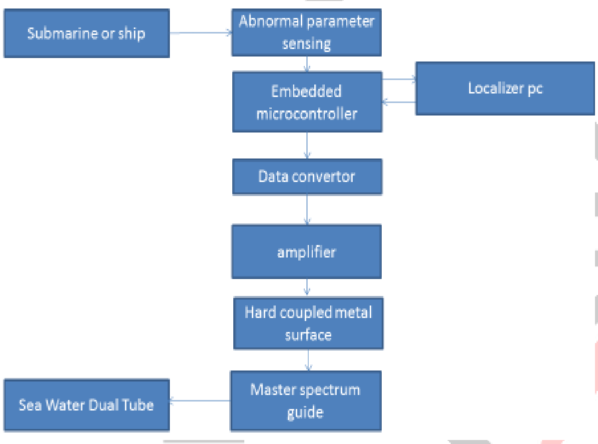


Rectifier units are usually capacitors acting as a surge arrester. This capacitor is also called as a decoupling capacitor or a bypassing capacitor.Regulator is connected to the DC output to maintain the voltage within a close tolerant region of the desired output. IC7812 and 7912 is used for providing +12v and –12v DC supply.

MICROCONTROLLER:



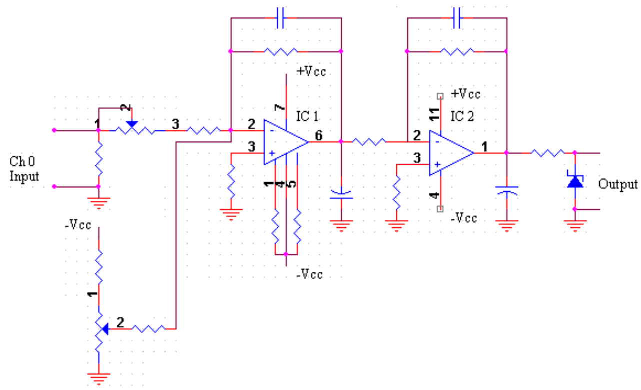
The microcontroller used here is PIC16F877A.The microcontroller has three 8-bit ports, one 6-bit port and one 3-bit port.It also consists of an 8-channel 10-bit ADC.The microcontroller is programmed such that the intensity is sunlight is measured at one



point and stored in a register.Then the speed of the wind is monitored.The input and output signals are controlled ,monitored and displayed.The multiple charging batteries are monitored.

SIGNAL CONDITIONING:

Signal conditioners are essential to improve field received signals.Signal conditioner job starts from simple amplification to protection. For our circuit input will be 0v to 1000mv and must be amplified to 5volts.When we do amplification we would like to follow below mentioned objectives.



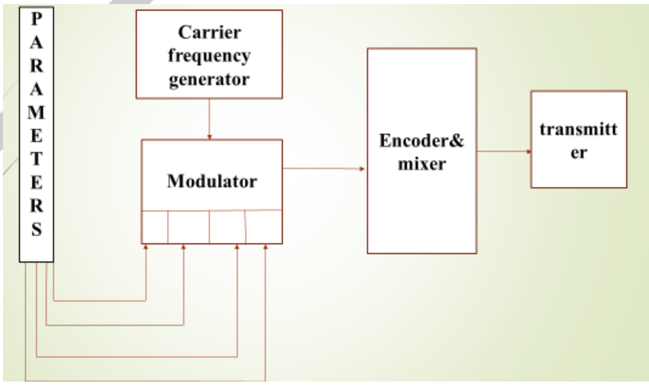
It must consume very low current from the source.It should have greater isolation between input and output.Provision to adjust zero value (minimum operating point).Provision to operate span (maximum operating point).Removing the unwanted frequencies during amplification and from the power source.Creating offset and null adjustments which may occur during amplification.Offset and null is the one which is available in all OPAMPS.To provide good enough current to the subsequent devices with protection. Signal conditioner must protect the subsequent devices from hazardous high voltage signals.

Transmitter end :

The block diagram of transmission end is shown in the figure. The parameters which is used for the indicating the requirements are

- ✓ Thermocouple
- ✓ Engine turbine
- ✓ Smoke
- ✓ Fire

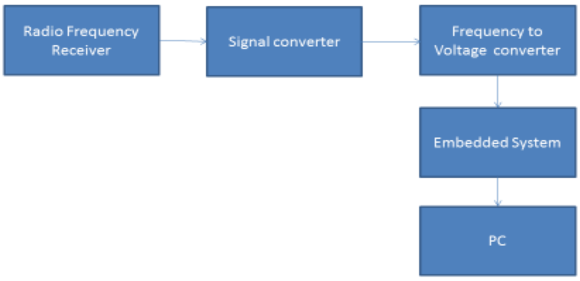
Thermocouple is used with signal conditioning and it acts as an active transducer. Then the pic controller is used for analog to digital converter. All the remaining indications are given to the controller directly and also get encoded.

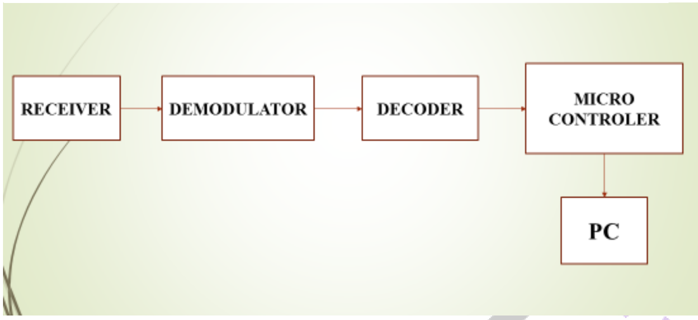


Through the controller the data will be displayed in the pc. Due to the characteristics of monopole antenna multiple data can be send in a single transmission.

RECEIVER END:

The data is received in a receiver circuit with the liquid antenna . The receiver circuit will again convert the digital signal to analog signal. An also the demodulating and decoding process will be done.





Then the multiple data through single transmission is displayed in the pc.

IV.THEORETICAL ANALYSIS

In the frequency range of interest from 40 to 100 MHz, sea water can be treated as a good conductor $(\sigma/\omega\varepsilon \gg 1)$; butfresh water $(\sigma/\omega\varepsilon \ll 1)$ can only be treated as imperfect dielectric. As a result, a sea- water cylinder acts as a monopole antenna, while a fresh -water cylinder may serve as a dielectric resonator antenna. In this paper, we only focus on monopole antenna made of sea water. The analysis of the sea-water monopole antenna is conducted by employing the three-term theory introduced by King and Wu for imperfectly conducting cylindrical antenna . It begins with the well-known Pocklington integral equation for the surface current $I(z)$ along a cylindrical half-wavelength dipole antenna made of sea water. For simplicity, the dielectric constant ε_r of sea water is chosen to be 78.7, and the conductivity σ is chosen to be 4 S/m over the operating frequency range. Meanwhile, the thickness of the clear acrylic tube is much smaller than the operating wave-length, therefore its effect is almost negligible. The cylindrical dipole antenna is along the z-axis of a system of cylindrical coordinates $(r\theta z)$ with a radius of a and a height of $2h$, where h is the height of the monopole antenna. It is driven at $z=0$by a gap delta-function source with electromotive force (EMF)V_0 and Z_s is the surface impedance per unit length of the sea-water cylinder. In the frequency range of interest, sea water can be treated as a good conductor $(\sigma/\omega\varepsilon \gg 1)$, its surface impedance can well be approximated .Then, the surface current $I(z)$ of the cylindrical dipole antenna can be approximately solved from the above integral equation by using the three -term theory. The input impedance of the cylindrical dipole antenna can be obtainedas $ZZ_{dipole=}V_0/I_0$. For the coresponding cylindricalmonopole antenna, as known to all, the distribution of the surface current is the same as the cylindrical dipole antenna,and the input impedance can be expressed as $Z_{in=}Z_{dipole}/2$. Once the input impedance is determined, the reflection coefficient of this cylindrical monopole antenna can be obtained as

$$S_{11}\,(\mathrm{dB}) = 20\,\lg(\Gamma)$$

where

$$\Gamma = \frac{Z_{in} - Z_0}{Z_{in} + Z_0}$$

and Z_0 is the characteristic impedance of the feeding transmission line.The theoretical surface current $I(z)$ of the cylindrical monopole with different values of radius a. It is found that both components of the current increase continuously in magnitude with an increasing radius a. However, the rate of increase becomes slower as the radius increases. There is only a little change in the magnitude of the imaginary component, when the radius is larger than 60 mm (about one skin depth). Meanwhile, as previously mentioned, the electrical properties of sea water don't always stay the same. It is therefore necessaryto provide the current distributions $I(z)$ with different values of conductivity σ. It can be clearly seen that both components of the current increase in magnitude with the increasing conductivity σ. The rate of increase becomes slower as the conductivity increases.

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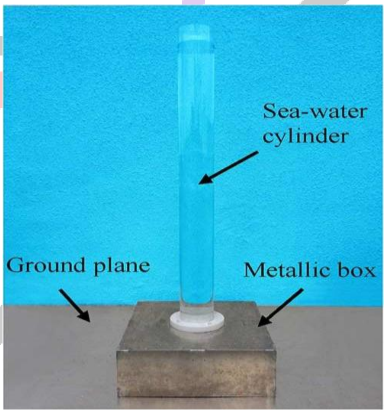

These results are very favourable, as the height of the sea -water cylinder can be easily adjusted by pumping sea water in or out.The modified Wheeler cap method is applied for measuring the radiation efficiency of the sea -water monopole antenna. Meanwhile, the method reported in is used to change the effective electrical distance between the antenna and the metallic box by varying frequency rather than the box dimensions. Compared with the conventional Wheeler cap method , the modified Wheeler cap method allows using a large metallic box since the effect of resonances in the cap can be effectively cancelled . The measured, simulated, and theoretical radiation efficiencies of our sea-water monopole antenna are illustrated. With reference to the figure, good agreement between the simulated and measured results is observed, with the discrepancy mainly caused by experimental tolerances. And reasonable agreement between the theoretical calculation and experimental results is also observed.

There are some discrepancies between experimental and theoretical results. Those disagreements can be attributed to the following three reasons.

1) Only the principal wave is considered in theoretical prediction. 2) The three-term theory involves some approximation when solving the Pocklington integral equation
Therefore, in the design frequency range of 40–100 MHz, the parameters are within the validity range of the three-term theory.3) Our fabricated model and the theoretical model are not completely identical due to the simplification made in the theoretical model.

CONCLUSION

This paper has presented a detail design of a sea-water monopole antenna at VHF band for maritime wireless communications. It is used to pass the confidential data in a secure way through the antenna in submarine. A top-loaded probe has been designed to efficiently excite the dominant TM mode. In order to design an optically transparent antenna, a clear acrylic tube has been chosen to hold the sea water. Theoretical investigation about the monopole sea-water antenna has been carried out, which has not appeared in literature.it shows the requirements of emergencies in submarine which is used to meet the needs to be solved within the time .It clearly describes the drawbacks which is seen in now a days submarine and it used to overcome the drawbacks. The main features of the monopole sea-water antenna include its high radiation efficiency, high transparency, reconfigurability, low cost, and simple structure. All these characteristics make this antenna potentially very useful for VHF and HF wireless communications on the sea.

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