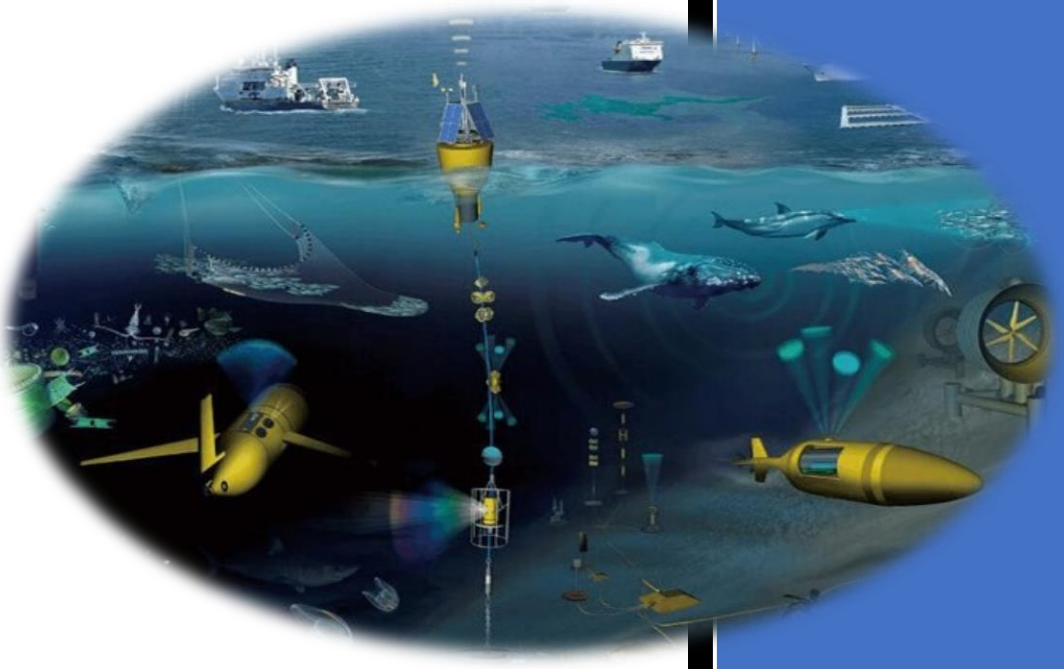
Fundamental Review of Current Emerging Technology in The Field of Underwater Wireless Communication

Summer Semester-2020



Ali Matin Nazar

Student ID: 21934206

Major: Ocean Engineering

Phone Number: 19817862810

Nationality: IRAN

Email: ali.matinnazar@zju.edu.cn

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Ali Matin Nazar

Student ID: 21934206

Major: Ocean Engineering

I declare that the assignment here submitted is original except for source material explicitly acknowledged, and that the same or related material has not been previously submitted for another course. I also acknowledge that I am aware of University policy and regulations on honesty in academic work, and of the disciplinary guidelines and procedures applicable to breaches of such policy and regulations.

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Fundamental Review of Current Emerging Technology in The Field of Underwater Wireless Communication

Ali Matin Nazar
Ocean Collage, Zhejiang University, Zhoushan 316021, Zhejiang, China

Abstract— In today's world, the dramatic growth of technology has become widespread in all fields of science. Scientists worldwide are trying to play an essential role in increasing the quality of human life by improving the development of technology. Much progress has made in using the primary source of the Earth, the oceans, and seas. In all these spaces, submerged remote communications play a vital part, where the advances accessible depend on radiofrequency, optical, and acoustic transmissions. In this report, we have investigated the communication routes in the seas and oceans, especially underwater. Also, after that, we have examined and compared them to a table. In the final section, we discuss four essential inventions in the field of underwater communication technology.

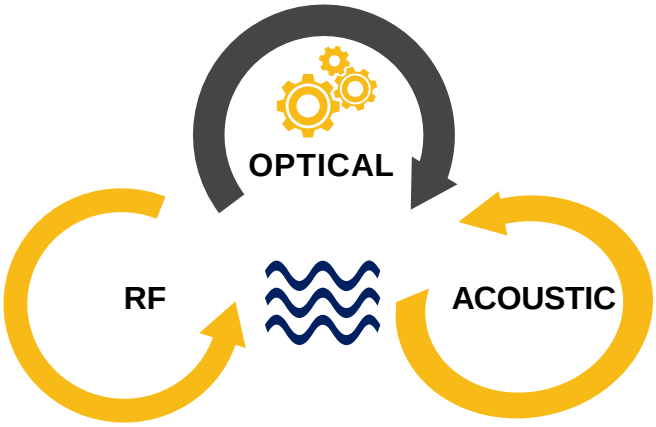
Index Terms— Ocean, Underwater, Wireless Communication.

INTRODUCTION

Compared to wired and remote communications through the climate, submerged remote communications display unused and unmistakable challenges that require modern communication gadgets to realize generally moo transmission rates, indeed over brief separations. The submerged environment has a few recognizing highlights that make it unique and somewhat distinctive from regional radio proliferation, where conventional communication frameworks are sending. Submerged, numerous wonders such as salt concentration, weight, temperature, the sum of light, winds, and their impacts on waves, as it were to say many, may impact communications [1], [2]. Despite all challenges, remote communications certainly play a noteworthy part in compelling submerged frameworks. In numerous diverse applications, such as oil and gas investigation, coastal security, natural effect reconnaissance, route, and ocean-pollution control, checking diverse wonders within the submerged environment is essential [3]. Particular cases incorporate transmission of information among gadgets, such as AUV (independent submerged vehicle) to AUV and buoy to AUV, especially those employing remote joins. A complete submerged remote communication organization may send through parts of setups such as coasting gadgets, AUVs, seafloor-attached sensors or handling towers, submarines, or ships. Indeed, even though there are numerous openings, one can discover exceptionally few off-the-shelf arrangements for reliable and financially practical submerged remote communications, a state of mind that will, without a doubt, alter without further ado, given the current developing request. In submerged remote transmissions, there are three driving innovations accessible.

One of them highlights high information throughput at a brief run and endures from mellow Doppler Impact is radio-frequency (RF) communication. The other one is an optical transmission, which needs line-of-sight situating, ideally in blue-green wavelength. Another innovation is acoustic communication, which is the foremost utilized one. This last-mentioned innovation is the one that accomplishes moo throughput, but permits the first expanded run of communication, influenced by expansive delay spread that leads to extreme inter-symbol impedances, and is profoundly impede by Doppler impacts [4]. It is vital to consider both the usage costs related to a target information throughput for an endorsed communication extend and the relative transmission control that might lead to natural impacts like with marine life in all these innovations. Overview the most highlights inalienable to each submerged remote communication innovation is the reason for this paper. How signal preparation brings approximately conceivable arrangements to current viable challenges to improve information communication within the submerged environment is another subject that this paper examines. Communication and flag handling researchers/students and practicing engineers are the target gathering of people. The introduction takes after a commonplace among those expecting peruses, centering on equitably displaying the

most standards of the subject matter. Giving analysts, understudies, and engineers with a clear picture of the specialized perspectives, inquire about issues, and the business potential of this product and still promising communication field is the most thought of this paper.



RF COMMUNICATIONS

For recurrence ranges utilized by portable administrations, TV, radio, and adherent communications, from the material science perspective, the seawater is greatly conductive, hence exceptionally influencing the proliferation of electromagnetic waves. As a result, setting up communication joins for separations past 10 m within the sea isn't simple [2] in both exceptionally- and ultra-high recurrence ranges (VHF and UHF, individually). The electromagnetic-wave constriction can be considered moo sufficient to permit for reliable communications over a few kilometers at lower frequencies, specifically at substantially- and very-low-frequency ranges (Mythical being and VLF, separately). Shockingly, these recurrence ranges from 3 Hz to 3 kHz, and from 3 kHz to 30 kHz are not wide sufficient for empowering transmissions at high information rates. Performing communication in Mythical person and VLF recurrence ranges have operational and money related challenges, despite being utilized in maritime [5] and native applications [6]. The gear is expansive, costly, and requires great control. Another detail of submerged RF signal is that they can travel through a few ways. The signal can cross the water-air boundary and proliferate through the seabed, in shallow water, it could be conceivable to utilize these numerous ways to extend the signal proliferation separate and, a submerged station can transmit data to a coastal station as a result, [7]. In this case, the signal navigating the seabed or the discuss might endure lower weakening than the signal proliferated as it were within the water. In addition to these highlights, the RF signal moreover endures the Doppler Impact. This channel include should be appropriately considered and treated despite being not so articulated as within the acoustic case.

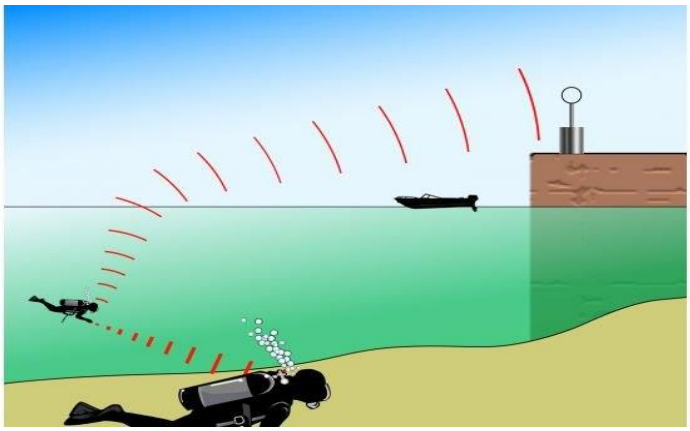


Fig. 1. Underwater radio frequency communications [6].

OPTICAL COMMUNICATIONS

The medium behavior is the most contrast between RF and optical engendering in seawater: the water can be seen as a conductor for RF and as a dielectric for optical engendering. Clarification for this occasion lies within the plasma recurrence, whose esteem decides the run of frequencies for which the medium carries on as a conductor or a dielectric. At frequencies around 250 GHz, The seawater changes from conductor to dielectric [2]. The optical innovation can give higher information rates compared to RF for a proliferation extend constrained to tens of meters, as in dielectric medium, the electromagnetic wave has lower weakening than in conductor medium for an engendering extend restricted to tens of meters. The Doppler spread and its impacts are nearly unimportant in remote optical communications. The speed of light is around 4 to 5 orders of greatness bigger than the proliferation of acoustic waves in liquids. That depends on the recurrence extend. The blue-green optical window has less proliferation weakening, and this information has utilized to make strides blue-green sources and locators [8], [9]. Optical communications often do not require line-of-sight between transmitter and recipient [10], which involves heading following to preserve the communication connection. Water has two vital highlights that influence light engendering, considering the impacts of natural conditions: inherent optical properties (IOPs) and precise optical properties (AOPs). Apparent optical properties depend on the light source characteristics. Be that as it may, inherent optical properties depend as it were on the medium (water), e.g., in case the laser (light enhancement by the invigorated emanation of radiation) source produces collimated or diffuse beams [11]. IOP is significant for optical submerged remote communication.

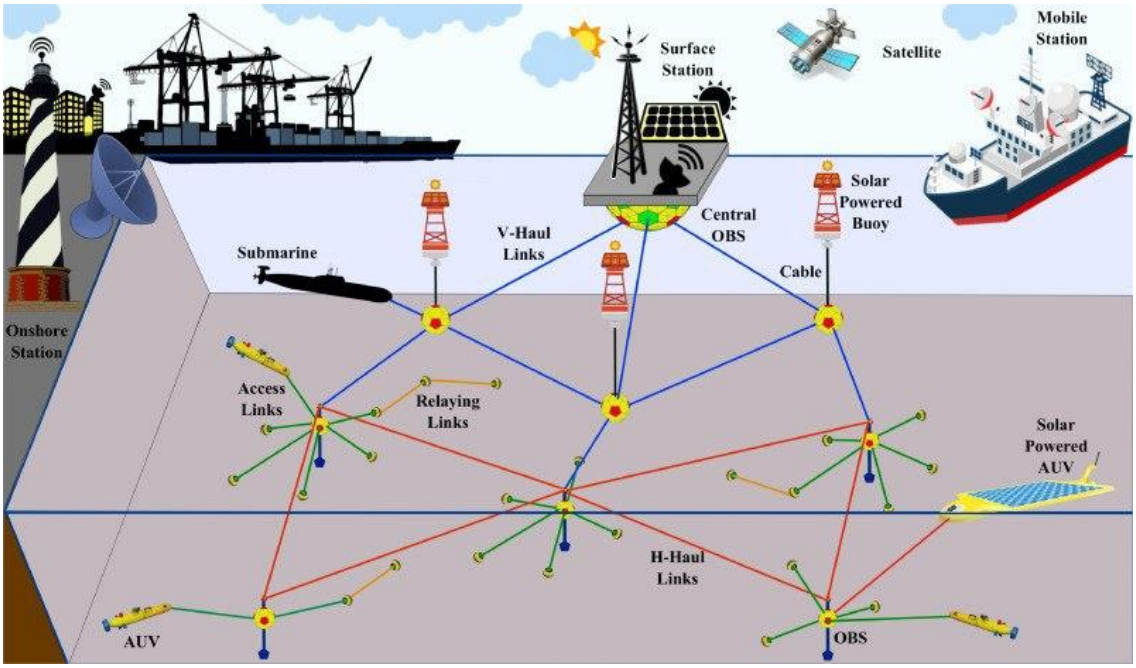
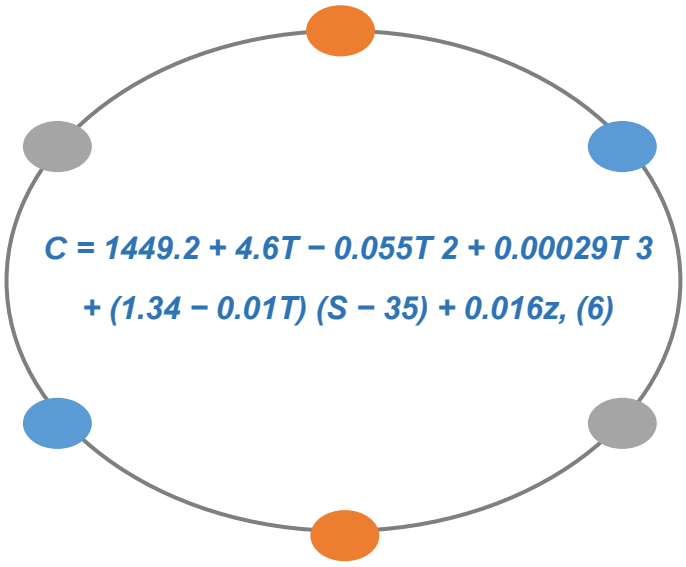


Fig. 2. Underwater optical wireless communications [10].

ACOUSTIC COMMUNICATIONS

As said sometime recently, both RF and optical transmissions have restricted proliferation run. The previous is extremely influenced by solid constriction, which leads to a little proliferation remove, while the last-mentioned depends on the water turbidity. In this way, an elective innovation to reach higher separations is acoustic communication, which is now the overwhelming innovation for remote submerged communications. The speed of the engendering of waveforms depends on the electromagnetic or mechanical properties of the medium. Force's

colossal imperatives on the by and large transmission prepare by utilizing acoustic waves. The parameters influencing the speed of proliferation play a major part in acoustic-based communications. A show for the sound speed profile (SSP) for submerged situations with profundity up to 1000 meters is [12] (in meters per moment):



S is the saltiness T is the temperature (in degrees Celsius), and z is the water profundity (meters). Another show for the SSP by considering all profundities may found in [1]. It is worth specifying that the proliferation speed is continuously an expanding work of temperature, saltiness, and profundity. An in-situ CTD (conductivity, temperature, and profundity) estimation must perform in arrange to assess the sound speed profile, in case a more practical show for the sound speed is required. Another pertinent issue in submerged acoustic communication is signal engendering. Different postponed and misshaped adaptations of the transmitted flag arrive at the collector owing to the multipath channel. These wonders create mutilations within the signal as an illustration of intersymbol-interference (ISI) that must compensate with the handset. As a result, the channel show might empower the plan of more productive handsets [13]– [14], driving to communication with moved forward information rate. So, an enormous concern is the characterization of the submerged acoustic channel [15]– [16], as well as its capacity [17], [18]. The acoustic waves engender by confronting frequency-dependent constriction and delay, and this truth plays a central part in planning conventional remote communication frameworks. To decide the constriction behavior as a work of recurrence is completely alluring for a framework architect. It gives specialized bolster for the choice of recurrence groups to utilized within the communication. The acoustic flag endures expanding weakening at higher frequencies and small weakening at moo frequencies. In any case, two major issues that might ruin high-throughput undersea communications are moo recurrence ranges and moo speed of engendering. Moo transmission capacity forces a limitation on the sum of bits that can transmit in each channel utilization. At the same time, the moo speed of proliferation increments the round-trip time and intensifies Doppler Impact. From a signal-prepared perspective, considering the engendering properties, a given preview of the beneath- water channel might characterize by its channel-impulse reaction. Inferring that the converse framework isn't steady since the channel exchange work might have known- least stage [19]. This reality can turn the equalization handle harder to actualize. MMSE-based DFEs (least mean-squared error-based decision-feedback equalizers) [20], versatile turbo equalizers [21], and TRM (time inversion reflect) [22], [23] are a few well-known equalization strategies connected for submerged acoustics. Another common issue happens when the collector is at a shadow zone, so that they gotten signals are generally powerless, to cause misfortune of association [30]. Tides, currents, and inside waves are other wonders that surrender variety within the sound engendering [24].

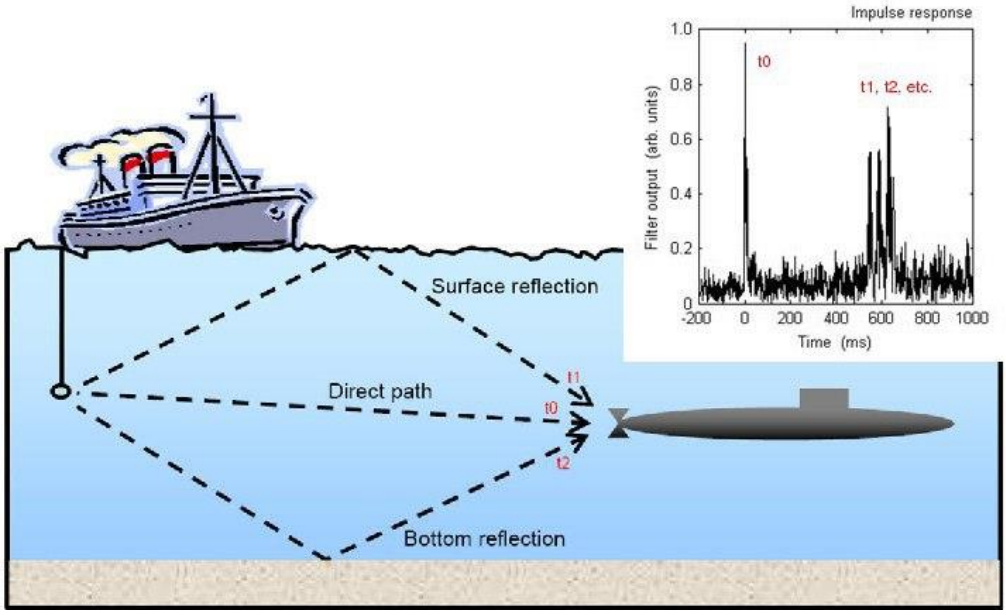


Fig. 3. Underwater acoustic communication [14].

VIUNDERWATER NETWORKS

Submerged systems (UWNs) can utilize in a few distinctive scenarios that depend on information recovery, trade of control commands between pieces of hardware, or in a broader sense, typical data exchange. Illustrations of these scenarios ended up unmistakable in seismology, oceanography, marine life checking and observation, characteristic calamity anticipation, and control, astuteness check of oil & gas offices, and military-strategic operations. The arrange necessities of these applications are exceptionally distinctive and depend upon the specific transmission innovation utilized by the organized hubs. The organized hubs must have a vast number of functionalities that incorporate measuring, putting away, and transmitting capabilities by utilizing conceivably unmistakable transmission innovations. As an illustration, it is canonical that oil & gas mechanical applications of UWNs utilize a set of organizing hubs that settled at the sea foot, which have to be trade data with other hubs on the sea surface or with a central hub. In order to do that, the hubs at the sea foot may need to utilize multi-hop communication for transferring their data through a submerged door hub that's able to perform all fundamental convention changes to other sorts of systems. Too, indeed the hubs at the ocean bottom may have to communicate with each other for evaluating a few parameters of intrigued agreeably in this way a choice may take proficiently and quickly. For some applications, gadgets within the submerged environment are somehow (coherently) associated with each other through a UWN need. As portrayed some time recently, the specific example in which one must send or get information to or from a submarine with a concealed position may require covering a tremendous zone to include a few square kilometers.

On the other hand, retrieving data from an observing gadget in oil wells may be performed by an ROV (remotely worked vehicle) in a brief run by utilizing moo control. Too, ROVs and AUVs posture unused challenges to UWNs since they can act like hubs conceivably requiring an expansive transmission capacity for video and sound substance exchange. All these cases make self-evident that the common prerequisites to convey UWNs are very troublesome to list since the particular application can force or maybe distinctive imperatives. The coexistence of remote and wired UWNs appears to be a joint arrangement for satisfying the framework necessities.

RF, OPTICAL OR ACOUSTIC TECHNOLOGY:

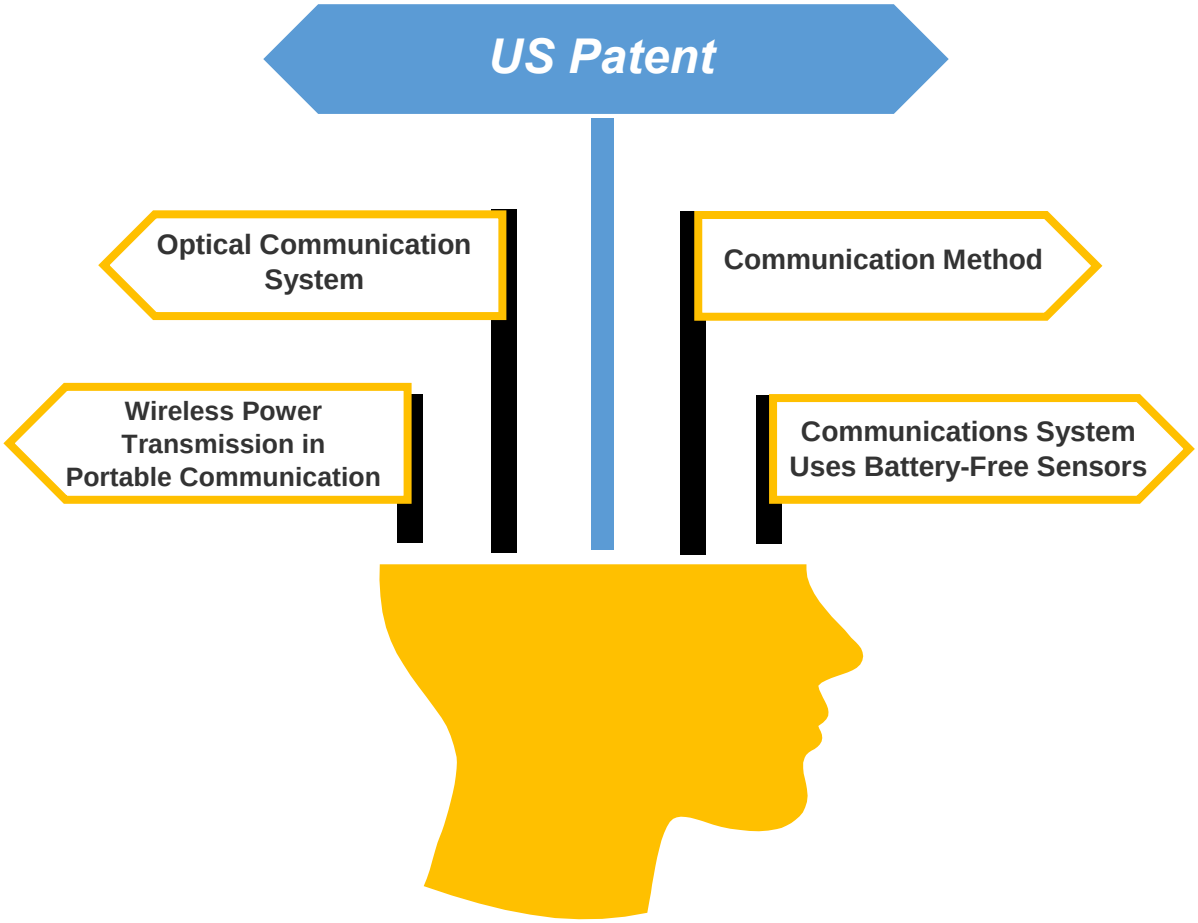
Transport data, one must know in which natural circumstance, the framework should work, and the communication necessities. The water properties that generally influence each transmission procedure is comparing in this table: saltiness for RF, water turbidity for optical, and water profundity for acoustic. Particular water highlights primarily influence each innovation. The interested per user can allude to [25]– [26] for advanced data to respect achievable information rates for distinctive innovations and parameters. Moreover, for accomplishing reliable and dependable submerged communication, the challenge is to propose adaptable communication frameworks counting all the previously mentioned communication innovations. This adaptable framework may be intelligent so that the most excellent transmission rate may well be accomplish considering, for the case, natural conditions, separate, and relative

development between transmitter and recipient. This different framework would be able to switch innovation of transmission/reception agreeing to a predefined taken-toll work: from time to time; an affirmation flag is sent by the collector to the transmitter that would take a suitable activity. In expansion, the utilize of systems counting a few sensors and transfers, with the help of savvy conventions, appears to be a characteristic arrangement since all underwater communication frameworks have special restrictions about associations over long separations. The arrange hubs may be settled, or portable and all hubs ought to in a perfect world be able to transmit and/or get with the three advances [26]. The portable hubs ought to be keen enough to move to an adjacent position would result in improved communication with optimizing a fitting fetched work.

PARAMETER	***ACOUSTIC***	***RF***	***OPTICAL***
Attenuation	Distance and frequency dependent(0.1- 4 dB/km)	Frequency and conductivity dependent(3.5- 5 dB/m)	0.39 dB/m (ocean) 11dB/m (turbid)
Speed	1500 ms^{-1}	23×10^{8} ms^{-1}	23×10^{8} ms^{-1}
Data Rate	kbps	Mbps	Gbps
Latency	High	Moderate	Low
Distance	More than 100 km	≤10 m	10-150 m (500 m potential)
Bandwidth	1 kHz-100 kHz	MHz	150 MHz
Frequency Band	10-15 kHz	30-300 MHz	5×10^{14} Hz
Transmission Power	10 W	mW-W	mW-W

Table 1. Comparison between acoustic, RF and Optical [27].

The acoustic bandwidth is very low, which is not suitable for high data transmission and also drastically slows down the transmission speed and the ability to pass low frequencies up to 15kHz. Acoustic has a high-power consumption, which means it consumes much energy and also sends little information with this energy. According to the table, it can conclude that acoustic has many disadvantages compared to the other two models. In addition to a low sampling rate, low frequency, low bandwidth, low transmission speed, it consumes much power, which is not a good example between the other two models. It shows that RF and Optical show better results depending on the type of consumption and distance required and the bandwidth sent by RF.



The underwater optical communication system (US9031413B2)

A strategy of submerged optical communications comprises applying a Wellspring code to a majority of information pieces. A grouping of optical information parcels is transmitting through a submerged communications channel. Each optical information parcel comprises one of the majorities of information squares gone before by a preface. The arrangement of optical information parcels transmitted through the submerged communication channel is gotten to create an arrangement of gotten information parcels. The grouping of gotten information parcels is tested with the examining clock to recoup the majority of information squares*[28].*

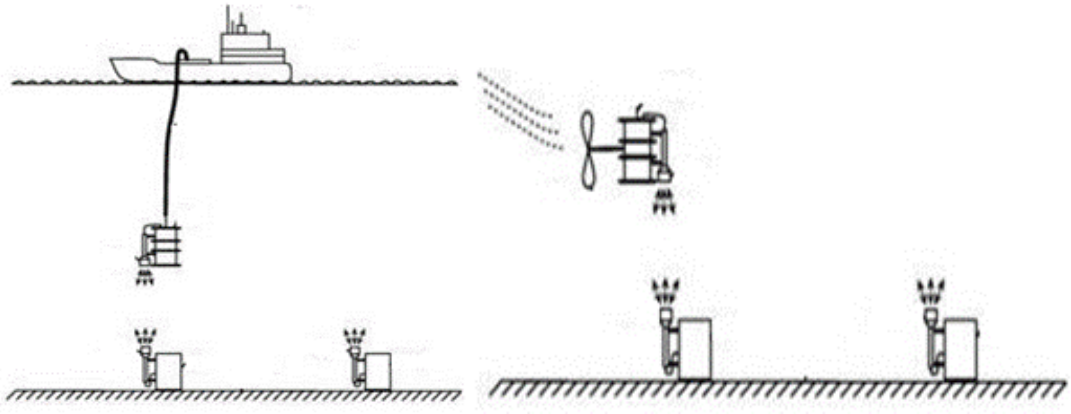


Fig. 4. optical communication system (US9031413B2) [28].

Underwater communication apparatus and communication method (US6125080A)

A individual submerged communication gadget which comprises: A show; A memory unit for putting away a majority of preset messages, each message being assigned a standard message distinguishing proof code; Implies for relegating a unique distinguishing proof code to each individual gadget; Implies for selecting one of said preset messages, to be transmitted to a getting gadget; Implies for selecting one or more getting gadgets to which a message is to be transmitted; Implies for creating a string encoding said message distinguishing proof code and the recognizable proof code of the transmitting gadget; Implies for balancing said string with at slightest one ultrasound acoustic tweaking recurrence, subsequently to create a balanced flag; Implies for

transmitting said balanced flag in water; Implies in each gadget for getting transmitted ultrasound acoustic tweaked signals; Implies for demodulating tweaked signals which are gotten by said gadget, subsequently to deliver a demodulated string; Implies for translating a message from said demodulated string; and Implies for showing on the show of the getting gadget the gotten message and the distinguishing proof code of the transmitting gadget [29].

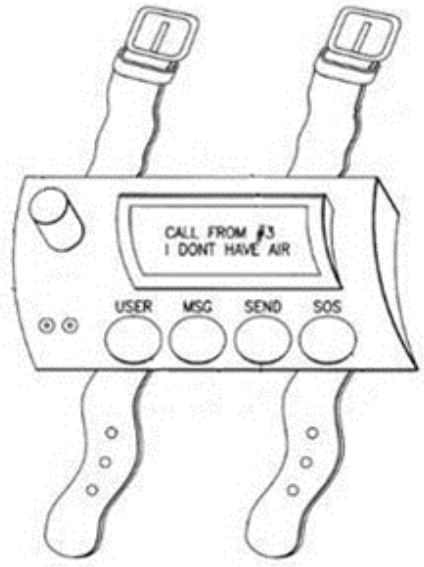


Fig. 5. An individual submerged communication gadget (US6125080A) [29].

Wireless power transmission in portable communication devices (US9525311B2)

The display innovation to intentioned transmit control wirelessly from a versatile communication gadget like a versatile phone, smart-phone, tablet, or phone observes utilizing radio recurrence, ultrasound, microwave, or laser advances to control up or charge gadgets outside to the versatile communication gadget. Specifically, the remote-control transmitter physically puts interior the convenient communication gadget or interacts with it to arrange to have an implied exchange control without wires or cables to other gadgets. The display innovation may utilize in applications like sensors, embedded gadgets for restorative utilize, speakers, mouse, console, electrical glasses for 3D seeing, little shows, contraptions within the car, electronic toys, and so on [30].

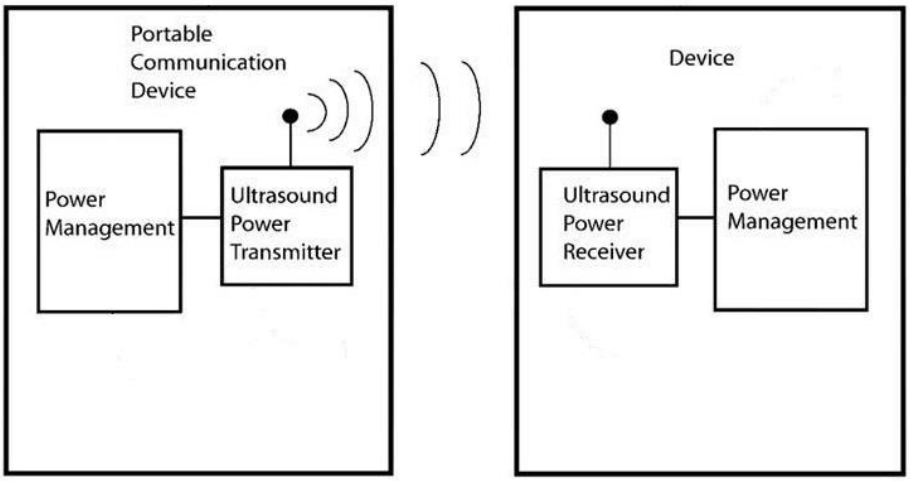


Fig. 6 Wireless power transmission (US9525311B2) [30].

The underwater communications system uses battery-free sensors

Making an undersea organize of interconnected sensors for checking and transmitting information faces one key challenge: controlling the various sensors that stay submerged for long terms. Analysts at the Massachusetts Founded of Innovation have created a battery-free submerged communication framework that employments near-zero control to transmit sensor information. The researchers imagine the framework utilizing to screen ocean temperatures to think about climate alter and track marine life over-amplified periods. The communications framework makes utilize of the "piezoelectric effect," which happens when vibrations in certain materials produce an electrical charge. The framework depends on "backscatter," a communication method commonly utilized for RFID labels, that transmits information by reflecting tweaked remote signals off a tag and back to a peruse [31].

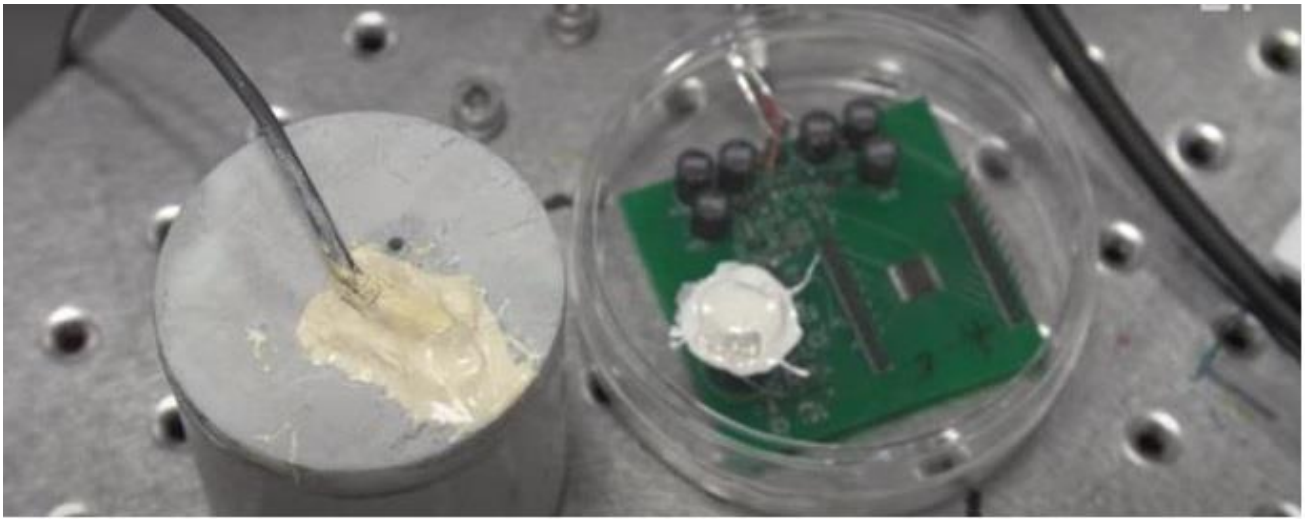


Fig. 7 The underwater communications system with battery-free sensors [31].

CONCLUSION

Fitting misuse of the sea environment for communications requires a self-evident understanding of the components that influence the submerged signal, just like the weakening characteristics begun from the proliferation properties of RF, optical, and acoustic transmissions. Shallow water is one of the challenging media to bargain within submerged acoustic channels, since of the time-shifting multipath and Doppler Impact. It is exceptionally troublesome to demonstrate submerged flag engendering; in any case, its understanding plays a fundamental part in deciding the successful information handling at the transmitter and the recipient. So reliable and correct communications are conceivable. As anticipated, each communication innovation requires unmistakable channel modeling, to turn the errand of conceiving a arrange utilizing adaptable modems exceedingly challenging. Flag handling devices for accomplishing high-data rates at Future era modems certainly will incorporate a part of the physical layer when utilizing any of the advances accessible or a combination of them at whatever point the natural circumstances permit. A wanted objective to be finished with the crucial help of today's omnipresent flag handling instruments is coming to information rates nearing open channel(s) capacity. This paper, with giving an up-to-date overview of the most specialized angles and investigate challenges of remote submerged communications, contributes to this heading. Within the final portion, we attempt to appear modern obvious that for understanding concept.

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