Underwater GPS Navigation

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Abstract: This research introduces how to use the Global Positioning System (GPS) underwater although GPS cannot be used underwater due to its weak signals. SONAR modules will be used to determine the location underwater and deliver its signals to a water surface station. In the introduced system, precise location determination of a submarine, persons, Remotely Operated Vehicle (ROV) or other asset will be recorded at regular intervals. The recorded location data can be stored within the tracking unit, or it may be transmitted to a central location data base, or internet-connected computer, using a cellular (GPRS or SMS), radio, or satellite modem embedded in the unit. Navigation and communication assistance is provided by a GPS/GSM unit integrated in a surface floating buoy. First tests under real conditions were successfully carried out.
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1. Introduction

One important issue for divers is orientation. Till now divers use a watch, depth gauge and compass to navigate, which is especially important if visual orientation points are absent (caused by e.g. bad visibility or no contact to the sea bottom). Recreational divers have to navigate, if they want to dive individually without dive guide. Especially for beginners, additional navigation support could be a benefit. Special forces are often dependent on precise navigation to fulfill their mission – which is difficult especially in the presence of current.

The opportunity to communicate with the outer world during a dive might be beneficial too. The possibility of sending a SMS could be useful, if unexpected problems occur during a dive (like lost of decompression gas, lost of the diving boat, sudden current, diving accident, etc.).

Over the years compasses became slightly more sophisticated, and then GPS was introduced which could pinpoint your position to within 100 meters. This allowed pretty much anyone to work out where they were with little or no basic skills. This was a real breakthrough for hill walkers, particularly in fog. Underwater it is quite easy to lose track of where we are, and where we have been. Actually it is far worse trying to navigate underwater as there are not many points of reference to guide you and often you can get thrown off course by swells, and currents. There is also the added problem of limited visibility, 10 meters is not uncommon, whereas on land you would most often have 10 miles. Underwater it is also a little tricky unfolding an OS map and trying to read that. To my mind this makes underwater navigation far more than a skill. It is a fine and delicate art.

I met a New Jersey rescue diver in Australia last year who was telling me that because of the poor visibility conditions he used a special full face mask so that he could communicate with his dive buddy over the radio. This was required as they frequently worked in conditions where there was less that 1 meter visibility. Just imagine how claustrophobic and disorientating that must be. For companies running dive trips this would also have potential benefits. There would never be any question of "have we got everyone back on board?". If someone did manage to go missing then you would know exactly where they were and could pick them up easily.

In fact, GPS signals are fairly weak. They are coming from satellites orbiting at 11,000 miles. By the time the signals get to earth, they are so weak that even heavy tree foliage can block them. Therefore, the only way for submarine as example to use GPS signals is to come to the surface or to tow a buoy that is floating on the surface. There is no way for GPS signals to penetrate the water. So how do submarines navigate when they are underwater? The most important tool is the inertial navigation system. An INS uses precise accelerometers and gyroscopes to keep track of every change in the submarine's speed and direction. A computer monitors all the changes and therefore knows where the submarine is. Obviously over time small errors add up, so the submarine will come to the surface periodically to get a GPS reading and recalibrate the system from a known point.

GPS Underwater is not an easy way so this research introduce a system has been built that will take GPS measurement of objects in underwater sites accurately as if we took the measurements outside on land and recorded its location.

Because of GPS does not work underwater, so we use the GPS module floats on the water surface in a housing attached to the dive flag. The underwater site records the diver position coordinates by using the sonar signals through SONAR module underwater. The SONAR module resends the signals back to the surface water station which includes the GPS module which set in a fixed orientation over the water surface. At the water surface station, by some calculations we can allocate the position of the divers with respect to the GPS station.

Attaching the GPS module with GSM Network module at the water surface station give the ability to send the diver or submarine position to any cell phone user. In addition of using this system in divers or submarines tracking and guidance, it can also used in other fields such as Oil & Gas shallow water survey and Ocean science and underwater archeology.

2. Global Positioning System Module

Finding applications in remotely operated vehicle (ROV) operations, marine archaeology, and diver tracking , it has become apparent that the type of application originally envisaged for the existed system , has been quickly over taken by the ingenuity of users to find new and exciting opportunities for its use . We have noticed that divers, who are interested in using GPS, often fixate on the more obvious methods that provide a constant GPS signal. This is exactly the focus that has left the entire diving industry without a simple, user-friendly approach to the problem.

Shortly after the U.S government removed the selective availability error from the satellite signal, we could begin using the technique with great accuracy. In spite of its simplicity, this method has allowed a handful of divers to be among the first on the planet to gain GPS data.

The idea is that it is safe to predict that this diver GPS concept will not go very far without the participation of influential groups of divers, such as those in the marine science industry.

We realize that GPS signals are fairly weak. They are coming from satellites orbiting at 11.000 miles. By the time the signals get to earth, they are so weak that even heavy tree foliage can block them. Therefore, the only way for a submarine to use GPS signals is to come to the surface or to tow buoy that is floating on the surface. There is no way for GPS signals to penetrate the water. With a little bit of effort and readily available materials, you can build a system that will take GPS measurements of underwater sites as accurately as if you took the unit down and placed it on the site itself and record its location.

Of course a GPS does not work underwater, since water prevents communication from the unit's antenna to the GPS satellites. So, the GPS floats on the surface, in housing attached to the dive flag. The diver records sufficient data to effect the translation of the surface flag position to the underwater site itself , that was by using the sonar waves between the GPS station which is fixed in orientation over the water then by some calculations we can calculate the position of the divers with respect to the GPS station. By another meaning provided is a system that allows navigation by GPS while underwater by locating the antenna above water and the display below water.

In one embodiment, The GPS antenna is attached to a tow-able buoy having a diver-down flag. In another embodiment, The GPS antenna is carried by the diver and released to float to the surface when the diver wishes to navigate. A preferred embodiment uses a handheld computer to display GPS data, and can be expanded to also calculate and display depth and decompression data, and to provide for further expansion and integration to include other devices.

2.1 Factors that degrade and affects GPS signal accuracy

- Ionosphere and troposphere delays,
- Signal multipath,
- Receiver clock errors,
- Orbital errors,
- Number of satellites visible,
- Satellite geometry/shading,
- Intentional degradation of the satellite signal.

2.2 Underwater GPS Applications

- Mine Hunting
- EOD Divers tracking
- Mine Destruction Vehicle guidance
- Mission planning & Tactical display
- Ocean science
- Underwater archeology
- Sea Grass & coral reef mapping
- Sea Explorer Gliders
- Oil & gas
- Pipe tracking & shallow water surveys
- OBS positioning
- AUV tracking

2.3 GPS; how it works

GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this information and use triangulation to calculate the user's exact location. Essentially, the GPS receiver compares the time a signal was transmitted by a satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is. Now, with distance measurements from a few more satellites, the receiver can determine the user's position and display it on the unit's electronic map.

It is important to note that these GPS receivers only receive information and don't transmit signals in any way. For unobstructed transmittance of signals, receivers are required to have an unobstructed view of the sky, so units are generally placed outdoors and tend to perform very poorly if placed near tall buildings or within forests. GPS operations are highly dependent on accurate time references that are generally provided by atomic clocks at the U.S. Naval Observatory. Each and every GPS satellite will have an atomic clock placed on board.

So, we already know that these satellites transmit information that indicates the current time and its current location. All these GPS satellites synchronize operations so that any repeating signals can be transmitted at the very same instant. These signals move at the speed of light and arrive at the receivers end at slightly varied times, as some satellites are farther away than the others. The distance to the satellites is calculated by estimating the time taken for the signals to reach the GPS receiver.

A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude). Once the user's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination, sunrise and sunset time and more. Once the position is determined, the unit can then calculate other factors like the speed, trip distance, track, distance to the destinations, sunrise time and sunset time, and so on.

Today, there are at least 24 functional satellites doing the rounds at all times. The GPS satellites that are operated by the U.S. Air Force orbit the earth with a period of 12 hours. Ground stations can also precisely track each satellite's orbit.

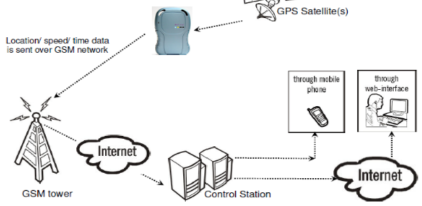

Figure 1. GPS satellite system working methodology

3. Underwater communication Module

Acoustic wave will be chosen to build underwater communication system Underwater acoustic communication is a technique of sending and receiving message below water. There are several ways of employing such communication but the most common is using hydrophones. Underwater communication is difficult due to factors like multi-path propagation, time variations of the channel, small available bandwidth and strong signal attenuation, especially over long ranges. In underwater communication there are low data rates compared to terrestrial communication, since underwater communication uses acoustic waves instead of electromagnetic waves.

Undersea acoustic communications dates back to the development of manned submarines and the need to communicate with them. The past three decades have seen a growing interest in underwater acoustic communications. Continued research over the years has resulted in improved performance and robustness as compared to the initial communication systems. Research has expanded from point-to-point communications to include underwater networks as well.

A series of review papers provide an excellent history of the development of the field until the end of the last decade. The advent of digital communications in the 1960s brought about a general awareness of the principles of signaling and modulation for imperfect channels. Thus, in the highly reverberant ocean acoustic channel the data rate can be very low, and it is natural that researchers in ocean propagation would consider how to increase throughput for communications.

As electromagnetic waves propagate poorly in sea water, acoustics provides the most obvious medium to enable underwater communications. High-speed communication in the underwater acoustic channel is challenging due to limited bandwidth, extended multi-path, refractive properties of the medium, severe fading, rapid time-variation and large Doppler shifts.

Communication techniques originally developed for terrestrial wired and wireless channels need significant modifications to suit underwater channels High-speed communication in the underwater acoustic channel has been challenging due to a number of reasons. The bandwidth available for communication is severely limited due to the strong absorption of high frequency sounds by sea water. Extended multi-path, rapid time-variation and severe fading are also common in many underwater channels.

Wireless underwater communications can be established by transmission of acoustic waves. The underwater acoustic communication channels, however, have limited bandwidth and often cause signal dispersion in time and frequency. Despite these limitations, underwater acoustic communications are a rapidly growing field of research and engineering.

Acoustic waves are not the only means for underwater wireless communication, but they are the best known so far. Radio waves that will propagate any distance through conductive sea water are the extra low-frequency ones (30 to 300 Hz) that require large antennas and high transmitter powers.

Optical waves do not suffer as much from attenuation, but they are severely affected by scattering and absorption. Transmission of optical signals requires high precision in pointing the narrow laser beams, which are still being perfected for practical use. Hence, in applications where tethering is not acceptable, acoustic waves remain the single best solution for communicating underwater.

3.1 Underwater Acoustic Communication Applications & Technologies

- Underwater Sonar Communication; which used in the introduced research,
- Underwater Acoustic Telemetry
- Underwater Navigation and Tracking
- Underwater Weather and Climate Observation
- Oceanography & Marine Biology

3.2 SONAR

Sonar is used underwater for locating submerged objects and for submarine communication by means of sound waves. The word "SONAR" is an abbreviation for "SOund, NAvigation, and Ranging". This is a technology that was developed as a means of tracking enemy submarines during World War II. Sonar consists of a transmitter, transducer, receiver, and display. In the simplest terms, an electrical impulse from a transmitter is converted into a sound wave (which is also a very short burst of high frequency sound energy) by the transducer and sent into the water. When this wave strikes an object, it rebounds.

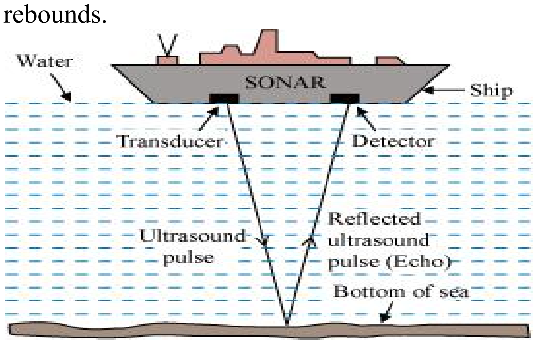

Figure 2. SONAR system operation

This echo strikes the transducer, which converts it back into an electric signal, which is amplified by the receiver and sent to the display? The time variation is displayed on the read out of the sonar screen device by means of flashing lights, Liquid Crystal Display (LCD) or Cathode Ray Tube (CRT or TV screen). Since the speed of sound in water is constant (approximately 1440 meters per second), the time lapse between the transmitted signal and the received echo can be measured and the distance to the object determined.

3.3 SONAR Modes

There are two different operational modes for sonar:

3.3.1 Passive SONAR

As the name implies, simply involves listening, where an acoustic noise source is radiated by the target, and the sonar only receives the acoustic signals. Marine biologists use passive sonar techniques to locate and study life in the oceans.

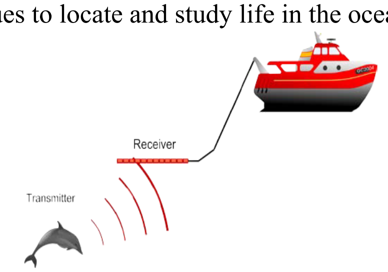

Figure 3. Passive SOANR

3.3.2 Active SONAR

Active sonar involves both the transmission and receiving of sound waves. An active sonar system sends a sound pulse and measures the length of time for the sound to be reflected back. Because the speed at which the sounds moves is very fast and remains constant, the distance to the object can be calculated quickly. Active sonar can use a concentrated pulse of sound in a specific direction, so information about an object's direction can also be obtained through some active sonar applications.

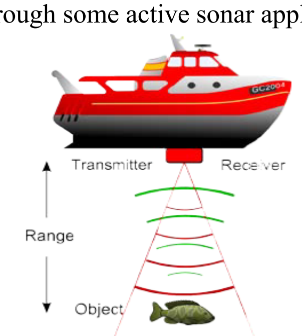

Figure 4. Active SOANR

3.4 SONAR Analysis

The sonar equations were developed to facilitate calculations of the maximum range of sonar systems. Knowledge of sonar range is essential in military operations in order to plan appropriate strategic tactics. Since this time the sonar equations have been used to design and evaluate a whole range of underwater instrumentation. The sonar equations deal with all aspects of sound generation, propagation and attenuation underwater.

The sonar equations are founded on the basic equality between the desired (signal) and undesired (background) portions of the received signal. For sonar to successfully detect an acoustic signal we require that:

Signal Level > Background Level

This basic equality can be expanded in terms of the sonar parameters. These parameters can be separated into 3 group's parts including those that deal with:

- The equipment; Source Level (SL), Directivity Index (DI), Detection Threshold (DT).
- The medium; Transmission Loss (TL), Reverberation Level (RL), and Noise Level (NL)
- The target; Target Strength (TS)

Note that all of these parameters are expressed on a logarithmic scale in dB. Here, the source level (SL): is a measure of the acoustic intensity of the signal measured one meter away from the source. This parameter assumes that the acoustic energy spreads omni-directionally outwards away from the source.

However, most acoustic sources are designed to focus the acoustic energy into a narrower beam in order to improve efficiency. This effect is accounted for in the sonar equations by the directivity index (DI), a measure of focusing. The detection threshold (DT): is a parameter defined by the system. If the observed signal to noise ratio exceeds the detection threshold a target is deemed to be present.

The intensity of an acoustic signal reduces with range. This observed reduction in the acoustic signal with distance from the source is due to the combined effects of spreading and attenuation and is accounted for by the transmission loss term (TL). The target strength (TS): is a measure of how good an acoustic reflector the target. The echo level will increase with target strength.

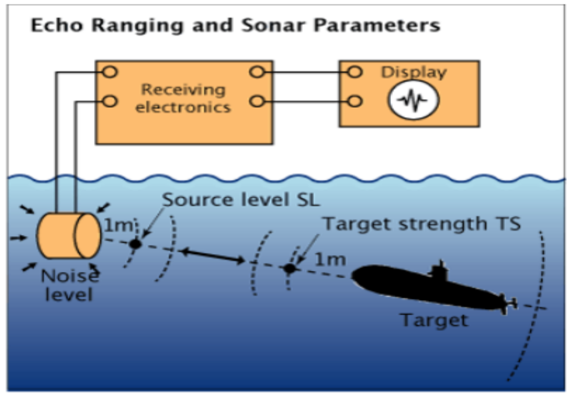

Figure 5. Echo Ranging and SONAR parameters

There are three basic forms of the sonar equations:

- Active noise background sonar equations,
- Active reverberation background,
- Passive sonar equation.

3.4.1 Active Noise-background Sonar Equation

This is probably the most commonly implemented form of the sonar equations. In an active sonar system the return signal will be increased by the source level, directivity index and target strength but reduced by the two way transmission loss and noise level. Thus, the echo to noise ratio as determined by the sonar is as equation 1.

$$SL + DIT + TS - 2TL - (NL-DI) \quad \text{Eq. 1}$$

Remember that since these parameters are all in dB the addition and subtraction represents multiplication and division in real terms. Notice also that there has been a distinction made in the equation above between the directivity of the source (DIT) that focuses the source energy and the directivity index of the hydrophone that reduces the effective noise level.

Thus, sonar performance can be improved by having both directional source and hydrophone, providing that they are directed towards the target. Often the acoustic source also acts as the hydrophone. In this situation, DIT and DI are equivalent.

It is customary to define a critical signal to noise ratio that defines whether a target is present or absent. This parameter is defined as the detection threshold (DT). Thus, the full expression for our active noise background sonar equations is as Equation 2.

$$SL + DIT + TS - 2TL - (NL-DI) = DT \quad \text{Eq. 2}$$

3.4.2 Active Reverberation-background Sonar Equation

In the reverberation limited case sound energy from the acoustic source is backscattered (from the sea surface / bed or particulates within the water) masking the received signal. The effect of reverberation puts an upper limit on the source level. In general, it is true that increasing the source level will increase the echo level. However, there is a definite upper limit to the increase in efficiency with source level. When SL exceeds a certain level, the amount of backscattered sound (reverberation) swamps the signal.

The reverberation-limited case will be particularly important when trying to detect targets that are close to the seabed or seafloor. In the case of reverberation, the directivity of the receiving hydrophone is not appropriate, as reverberation is not isotropic. Thus, the NL-DI term in the active sonar equations is replaced by the reverberation level term, RL. As expressed in Equation 3.

$$SL + DIT + TS - 2TL - RL = DT \quad \text{Eq. 3}$$

3.4.3 Passive Sonar Equation (listening devises)

In the passive case, the sonar itself is the source (SL), target strength becomes irrelevant, and the transmission loss term (TL) is one-way. Thus, the passive sonar is as equation 4.

$$SL + DIs - TL - (NL-DI) = DT \quad \text{Eq. 4}$$

Active SONAR is the most common type and is the most one used in real applications.

3.5 SONAR Difficulties

- Sound propagation
- Scattering
- Transmission Loss

3.6 Ultrasonic Ranging Module HC - SR04

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit. The basic principle of work:

- Using IO trigger for at least 10us high level signal.
- The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.
- IF the signal back, through high level , time of high output IO duration is the time from sending ultrasonic to returning.

$$\text{Test distance} = (HLT \times VS\ (340\text{m/sec})/2 \quad \text{Eq. 5}$$

where,

HLT: High Level Time
VS: Velocity of Sound

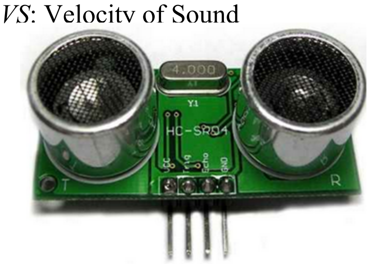

Figure 6. Ultrasonic module (HC - SR04)

3.6.1 Timing diagram

The Timing diagram is shown below. You only need to supply a short 10uS pulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion.

You can calculate the range through the time interval between sending trigger signal and receiving echo signal. Formula: usec / 58 = centimeters or usec / 148 =inch, or: the range = high level time * velocity (340M/S) / 2, we suggest to use over 60ms measurement cycle, in order to prevent trigger signal to the echo signal.

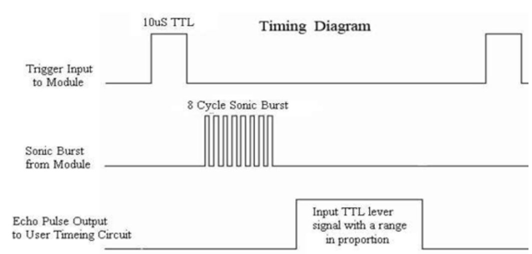

Figure 7. Timing Diagram

4. GSM Module for Tracking

With the development of communication technology, the service price of GSM network's SMS and GPRS are comparatively low, thus it is possible to send GPS positioning information via GSM network which set multiple functions of security, positioning, monitoring surveillance, emergency alarms and tracking in its entirety. It can be used in several applications such as Locating and tracking service for cars, trucks, container trucks, special vehicles, cargo and criminal investigation officer.

But the required challenge is to use it in Underwater GPS tracking. Then short message service based on GSM is studied in detail include architecture, protocol, channel and the process of its sending and receiving. Based on this, we build a mathematic model to analyze the time delay and loss probability of short message transmitting, and get the corresponding simulation results, so it can direct the design of navigation system.

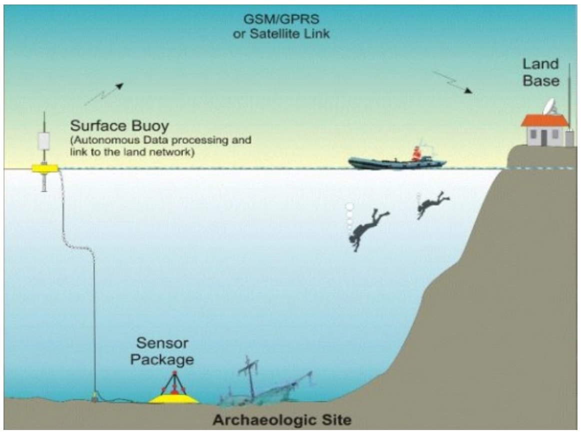

Figure 8. GSM/GPRS Links

4.1 Functional Description

A GSM modem is a wireless modem that works with a GSM wireless network. A wireless modem behaves like a dial-up modem. The main difference between them is that a dial-up modem sends and receives data through a fixed telephone line while a wireless modem sends and receives data through radio waves.

A GSM modem can be an external device or a PC Card / PCMCIA Card. Typically, an external GSM modem is connected to a computer through a serial cable or a USB cable. A GSM modem in the form of a PC Card / PCMCIA Card is designed for use with a laptop computer. It should be inserted into one of the PC Card / PCMCIA Card slots of a laptop computer. Like a GSM mobile phone, a GSM modem requires a SIM card from a wireless carrier in order to operate.

While GPRS modem is a GSM modem that additionally supports the GPRS technology for data transmission. GPRS stands for General Packet Radio Service. It is a packet-switched technology that is an extension of GSM. (GSM is a circuit-switched technology.) A key advantage of GPRS over GSM is that GPRS has a higher data transmission speed.

GPRS can be used as the bearer of SMS. If SMS over GPRS is used, an SMS transmission speed of about 30 SMS messages per minute may be achieved. This is much faster than using the ordinary SMS over GSM, whose SMS transmission speed is about 6 to 10 SMS messages per minute. A GPRS modem is needed to send and receive SMS over GPRS. Note that some wireless carriers do not support the sending and receiving of SMS over GPRS. If you need to send or receive MMS messages, a GPRS modem is typically needed.

LEON-G100/G200 modules are cost efficient solutions offering full quad-band GSM /GPRS data and voice functionality in a compact LCC (Leadless Chip Carrier) form factor. Featuring low power consumption and GSM/GPRS class 10 data transmission with voice capability, LEON-G100/G200 combine baseband, RF transceiver, power management unit, and power amplifier in a single, easy-to-integrate solution.LEON-G100/G200 are fully qualified and certified solutions, reducing cost and enabling short time to market.LEON-G100/G200 can provide TCP/IP, UDP/IP and internet that use protocols (FTP used for downloading, HTTP used for browsing, SMTP used for e-mailing).

4.2 SIM interface

A SIM card interface is provided on the board-to-board pins of the LEON-G100/G200 modules: the high-speed SIM/ME interface is implemented as well as the automatic detection of the required SIM supporting voltage. Both 1.8 V and 3 V SIM types are supported: activation and deactivation with automatic voltage switch from 1.8 V to 3 V are implemented, according to ISO-IEC 7816-3 Specifications. The SIM driver supports the PPS (Protocol and Parameter Selection) procedure for baud-rate selection, according to the values proposed by the SIM Card.

4.3 Asynchronous serial interface (UART)

The UART interface is a 9-wire unbalanced asynchronous serial interface provided for all communications with LEON-G100/G200 modules: AT commands interface, GPRS data and CSD data, software upgrades.

4.4 Audio

LEON-G100/G200 modules provide four analogue and one digital audio interfaces:

4.4.1 Two microphone inputs

First microphone input: it can be used for direct connection of the electrets condenser microphone of a handset. This audio input is used when audio uplink path is set as "Handset Microphone". Second microphone input: it can be used for direct connection of the electrets condenser microphone of a headset. This audio input is used when audio uplink path is set as "Headset Microphone".

4.4.2 Two speaker outputs

First speaker output: a single ended low power audio output can be used to directly connect the receiver (earpiece) of a handset or a headset. This audio output is used when audio downlink path is "Normal earpiece" or "Mono headset". These two downlink path profiles use the same physical output but have different sets of audio parameters.

Second speaker output: a differential high power audio output can be used to directly connect a speaker or a loud speaker used for ring-tones or for speech in hands-free mode. This audio output is used when audio downlink path is "Loudspeaker".

4.4.3 Headset detection input

The headset detection, if enabled, causes the automatic switch of the uplink audio path to "Headset Microphone "and downlink audio path to "Mono headset". Enabling / disabling of detection can be controlled by parameter <headset_indication> in AT+USPM command.

4.4.4 I2S digital audio interface

This audio path is selected when parameters <main_uplink> and <main_downlink>. In +USPM command respectively "I2S input line"and "I2S output line".

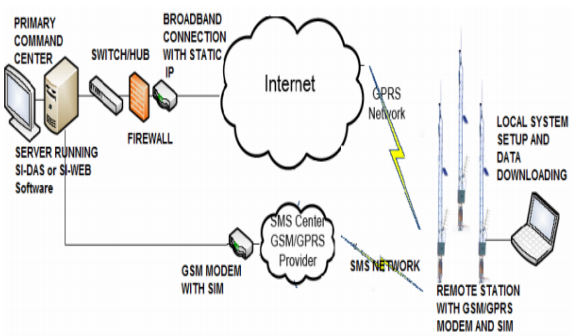

Figure 9. GSM/GPRS Network

Typically, for GSM/GPRS data communication there will be a GSM/GPRS modem with GPRS services enabled SIM at the remote automatic weather station. The modem is capable of only using GPRS mode, only GSM mode or GPRS priority with GSM secondary mode. The central receive station will have a fast broadband internet connection with a STATIC IP to receive remote station data through GPRS and a GSM modem with SIM to receive remote station data through SMS.

The central receive station will run a FTP server application to receive the GPRS data from remote station. The remote station will use a GSM/GPRS modem for registering itself to the cellular network. At schedule interval the GSM/GPRS modem collects data from data logger and transmit the remote station data to the Static IP of the central receive station through GPRS communication.

In the event of non availability of GPRS coverage, the GSM/GPRS modem will switch to GSM (SMS) mode of communication. The Remote station GSM/GPRS modem will send the collected data logger data in the form of SMS to the mobile number of the GSM modem connected to central server.

The remote station data is collected by either SI-DAS or SI-WEB application software. Both SI-DAS and SI-WEB are data collection software being used for GSM/GPRS Telemetry system. SI-DAS is typically installed in a Desktop PC for Data Acquisition and local display of collected data. SI-WEB is typically installed in the server, where the FTP application is running, for Data Acquisition and Global display of collected data. Both the software has facility to display data in tabular as well as graphical display.

4.5 GSM Module Board

In order to use SmartG100 connect antenna with Leon-G100 module, Connect power supply via AC/DC connector and now connect SmartG100 with development system.

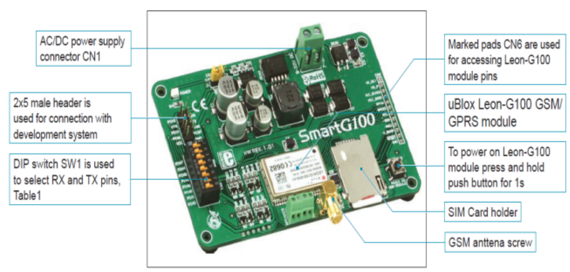

Figure 10. SmartG100 GSM Module

4.5.1 Key features

- Data transfer via UBlox Leon-G100 module.
- Microphone and speaker connectors.
- UART communication with microcontroller.
- 7-23V AC or 9-32V DC power supply voltage.

Figure 11. GSM Module with its antenna

5. Current Achievements and Research Challenges

With sensor technology and vehicular technology, wireless communications will enable new applications ranging from environmental monitoring to gathering of oceanographic data, marine archaeology, and search and rescue missions. The signals that are used to carry digital information through an underwater channel are not radio signals, as electro-magnetic waves propagate only over extremely short distances.

Instead, acoustic waves are used, which can propagate over long distances. However, an underwater acoustic channel presents a communication system designer with many difficulties. The three distinguishing characteristics of this channel are frequency-dependent propagation loss, severe multipath, and low speed of sound propagation. None of these characteristics are nearly as pronounced in land-based radio channels, the fact that makes underwater wireless communication extremely difficult, and necessitates dedicated system design.

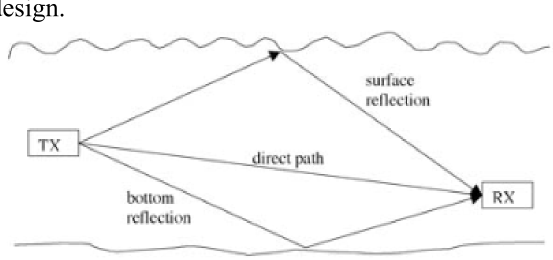

Figure 12. Shallow water multipath propagation: in addition to the direct path, the signal propagates via reflections from the surface and bottom

6. Experimental Work

The implemented work consists of two parts, underwater module and the surface water module. Firstly, the orientation of the boat (Surface water Station) that carries the GPS module is determined by using the GPS Module and the data from this module is buffered and stored on the state memory of the microcontroller Atmega 128. This data includes (satellite constellation, signal to noise ratio, time, longitude, latitude, and speed over ground, PDOP, HDOP, etc.)

Then by using the underwater SONAR module we could calculates the distance between the object (Diver) and itself by using the acoustic signal and the result is stored also on the Mc memory. By implementing the code burned on the microcontroller, it can determine the new position of the underwater object.

The GSM module is also connected to the micro controller as we can send all the information of the above water GPS station after processing and calculating the diver orientation to a mobile phone on the shore to follow or track the divers or the divers or the submarines on the real time.

Figures 13 and 14 shows the block diagram for the overall system also the applicable work with the system simulation view explaining the signals paths and modules exchanging data.

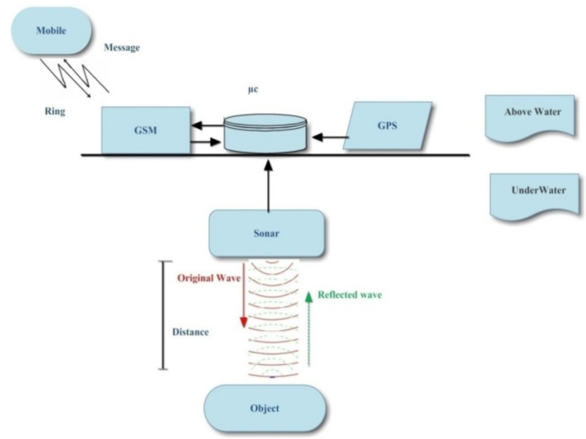

Figure 13. Block Diagram for the overall system

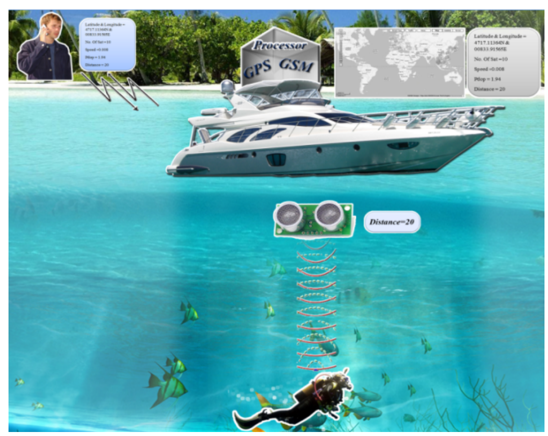

Figure 14. Navigation Underwater System overview

Figure 15 explains the different circuit after implementation in the laboratory for testing including the Ultrasonic module, GPS module and GSM module.

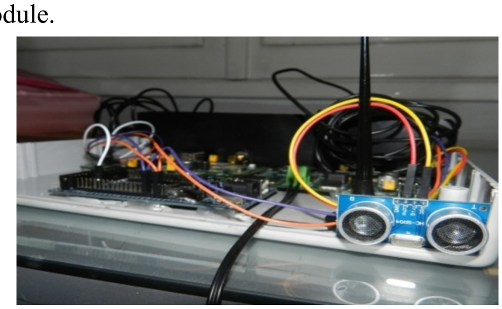

Figure 15. Overall circuits and modules overview after implementation

7. Conclusion

GPS does not work underwater, as the radio signals on which it depends cannot pass through water. Since the GPS signal comes from a constellation of satellites continuously orbiting the Earth it is very weak when it reaches the ground; as a direct result, most GPS receivers will fail to pick up signals strong enough to be usable indoors or in certain types of "shadowing" e.g. tall buildings. However, Assisted GPS is an improved technology that utilizes a cellular network's assistance server which is connected to a reference network. Through the use of cell towers, a phone relays satellite signal information to the server. These servers are able to process incoming data at much higher rates than GPS receivers, so information is transmitted quicker, and is typically more accurate than what a receiver can relay on its own or inside buildings. That was the idea of the introduced research of how to use the GPS data underwater in navigation.

GSM is used to communicate between onshore and offshore. Thirty years ago communications between offshore facilities and onshore locations was limited to a two-way radio and daily reports. Back then, oilfield workers stationed offshore were virtually cut off from the rest of the world. Additionally, the amount of staff required on each rig and facility offshore was great because all the information to make decisions was gathered at these remote locations. Now, real-time communications networks not only allow for Wi-Fi connectivity and personal cell phone use, but also real-time transfer of offshore data to onshore offices. Different communications technologies now used include satellite, microwave, fiber optics, and cellular services. Therefore, it was a wise decision to use the GSM network to send the message containing the GPS data. Extension can be made to our project by connecting to the internet to put the data (ex: the temperature or wind speed) on a website (as windfinder).

SONAR is the choice of underwater communication because it is the system that uses transmitted and reflected underwater sound waves to detect and locate submerged objects or measure the distances underwater accurately. It has been used for submarine and mine detection, depth detection, commercial fishing, diving safety and communication at sea.

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