

Project ECHO

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Abstract— There are many environmental issues that inflict aquatic life across the planet. Proper monitoring can be essential with preserving aquatic life and preventing any further damage. La Escola Politècnica Superior d'Enginyeria de Vilanova i la Geltrú (EPSEVG) and Laboratory of Applied Bioacoustics (LAB) sponsored a project, called Project ECHO, that would make monitoring aquatic easier and more efficient. This project's main goal was improve the deployment of monitoring equipment process LAB already had in place.

The most prevalent issue this project aims to solve is how much energy is wasted during deployment of monitoring equipment and how it is not guaranteed the monitoring equipment is working before deployment. In order to save energy and prevent a faulty deployment, a bidirectional communication system can be established that will receive the operating status of the monitoring equipment and be able to power it on and off.

The approach of this project was to create a remote control to act as a bidirectional communication system. During the discussion of how to implement this system, it was decided that a housing to hold the equipment and power supply should also be researched and designed. This housing eases the deployment and retrieval of the system and protects monitoring equipment at the necessary depths. The result is a system that is interacted with wirelessly and can be easily deployed for a minimum period of 6 months.

Keywords—Project ECHO, bidirectional communication system, underwater housing, power supply, remote control, efficient, deployment.

I. INTRODUCTION

FOR years the Laboratory of applied bioacoustics has been researching the marine life. To do so the LAB deploys underwater housings with acoustic recording systems, aimed at monitoring aquatic life and registering sound pressure

levels. During the years of experience the LAB has with these housings, they retrieved several empty hard disks. Sometimes the equipment in housing was not even turned on or a component was damaged during transportation. To assure that every component in the housing is properly working and turned on, Project ECHO (Electronically Controlled Housing) was

brought to life in collaboration with Escola Politècnica Superior d'Enginyeria de Vilanova i La Geltrú (EPSEVG).

The aim of this project is to ease the deployment and retrieval of aquatic monitoring equipment. This was accomplished by creating an underwater housing designed to be deployed for six months and a system to wirelessly interact with the equipment inside. The wireless system will have bidirectional communication with the equipment and will display any relevant information on a remote control. In order to carry out this project, it was divided into four subprojects, creating the design of the housing that resists depths up to 100m, researching a power supply that can power up the system for at least 6 months with a duty cycle of 5min/hour, creating the design of an easy to use remote control and establishing the bidirectional communication system tasked with interacting with the aquatic monitoring equipment and displaying its status. An overview of this can be seen in figure 1.

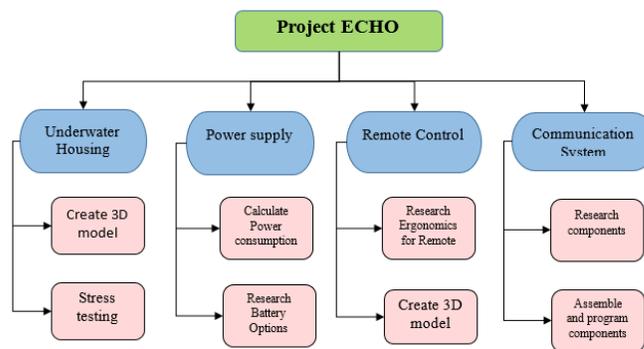


Figure 1. Work Breakdown Structure

II. ELECTRONICS

The objective of the electronics team is to establish bidirectional communication between a remote control and an underwater monitoring system by selecting and programming suitable electronic components. This objective will be completed by using two microcontrollers, two transceivers, and a LCD display. Each microcontroller will be paired with a transceiver and programmed to transmit and receive data over radio waves. The user can interact with the remote control in order to send commands to the monitoring equipment. The data received from the underwater monitoring system will be collected by its on board computer (OBC), sent through the microcontroller transceiver pair and displayed for the user on the LCD display. The major components selected to be used for the system and their functions are listed in table 1.

Table 1. List of major components

Component	Purpose
MSP430G2433IN20 [1]	Microcontroller, process data and handle hardware/software integration
ALPHA TRX433S [2]	Transceiver, sends and receives data over radio waves
4x20 LCD Parallax serial display [3]	Displays data for the user

Several minor components were used in addition to the components in table 1. To create data transmission between the OBC and microcontroller, a MAX-3232 of Maxim Integrated was used. This enables relevant information from the microcontroller (3,3V TTL) to be converted to RS-232 (+-12V) so it can be interpreted by the computer. The OBC needs 12V, display needs 5V, and microcontroller and transceiver need 3,3V. To create the appropriate voltage at a steady rate for every component a DC-to-DC convertor with a voltage regulator, MC7806CTG, was used.

A. Results

The first portion of the project involved writing several programs that would be used to transmit and receive data, interpret any relevant data and display information for the user. Once the programs were created they must be downloaded onto the microcontroller and tested with the other hardware.

Combining the hardware and software resulted in two main prototypes. The first prototype, shown in figure 2, consisted of only what was needed to test some of the functionalities.

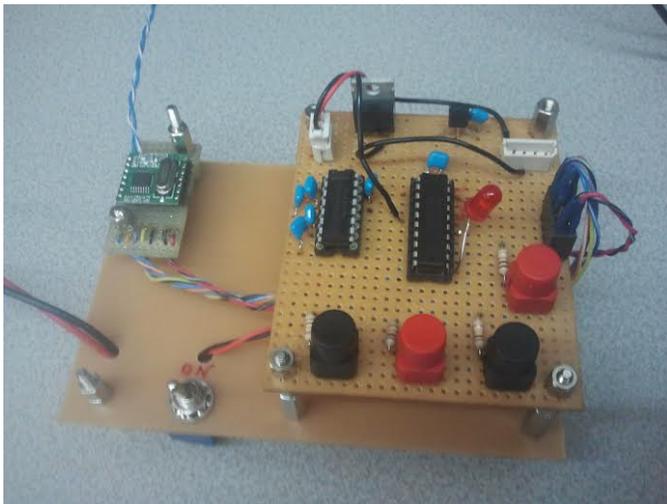


Figure 2. First prototype created

It could be used to test the display, test reading input from pressing buttons and see if the transceiver could send data. A second prototype, shown in figure 3, was made to test the ergonomics of the remote control design.



Figure 3. Prototype used for Testing Purposes

Both prototypes together can be used to simulate the link between the remote control and underwater housing. The first prototype would act as the underwater housing, transmitting data when prompted, and the second prototype would act as the remote control, prompting for data transmission, receiving data and displaying it for the user. Almost all aspects of the prototypes were tested and deemed acceptable.

Due to time restrictions the prototypes could not be fully tested. The prototypes are currently able to transmit data and display information for the user. However, the program to receive information from one transceiver to another could not be tested to its full extent. An example program was created that can be improved upon to receive information. Although the transceiver could not be fully configured to receive information, protocol and many example programs were created so the project can easily be completed by a separate team.

III. REMOTE CONTROL

A remote control had to be designed to be foolproof, dustproof, waterproof and shockproof to fulfill the objectives in this part of the project. This has been realized through communication and testing with the users. The remote control will collect data from the equipment in the housing. The data that has been collected will be displayed on an LCD screen, informing the user about the status of the equipment.

A. Physical results

The design started with the making of a top plain, that later got worked out to a 3D-model, figure 4.



Figure 4. 3D-model remote control

The model is small enough to handle with two hands and big enough to fit all the components. The next choice made was for a LCD-screen with a back light. This allows it to be used in varying light conditions. LEDs were picked to show the status of the housing equipment. The green LED represents the equipment is functional. The red LED would be illuminated when there is an error with the housing equipment.

The buttons were selected to visually represent their functions. For turning the housing on and off there is a button on the right top. This button is red, making it visible and making it appear more important. The actuator of the button lies a bit lower than the ring to prevent the button from being pressed accidentally. The two rectangular buttons underneath the screen are used to cycle information on the display. The arrows on the button show which way the button goes. Between the two arrow buttons is the okay button. The button is green to represent that it will not cause any unnecessary action. All the buttons are big enough to be pushed with gloves on, seeing that it may be used in varying environments. At the side of the remote there is a little hole making it possible to attach a wristband. This wristband will prevent the remote control from falling.

A. User Interface

Seeing that the user want to be able to turn the equipment in the housing on and off with the remote, a connection with the housing has to be established. This prompted the question to be asked, “Do you want to establish a connection with the housing?” when the remote is powered on. After the connection succeeded the equipment in the housing can be powered on. Information will be received automatically showing if the components are working. If the components are not in proper working order a warning will be displayed and the red LED turned on. If there is no error the green LED will be powered on.

IV. POWER SUPPLY

The main objective for researching the power supply was having it be a reasonable, size so it fits within the housing, and it must be able to power the system for at least six months. In addition, the weight must be low enough so when the housing is sealed it can be maneuvered manually and it must be as environmentally friendly as possible. Table 2 shows the power requirements for the housing equipment, a minimum of 3175,5W is needed.

Table 2. Power Requirements for Underwater Housing

	Voltage (V)	Current (A)	Hours Active (h)	Power (Wh)
Hydrophone	5	0,1	0,083	0,042
Computer	5	1,6	0,083	0,667
Microcontroller	3,3	0,00023	1	$7,59 \times 10^{-4}$
Transceiver (active)	3,3	0,021	0,167	0,01155
Transceiver (standby)	3,3	0,003	0,333	0,0033
			Total Power for 5 min/hour	0,725 Wh
			Total Power for 5 min/hour for 6 months	3175,5 W

After researching different battery chemistries, three chemistries were found compatible with the power production, lead acid, alkaline and lithium-ion. The lead acid chemistry proved to be too heavy and the alkaline chemistry would take

too much time to assemble, only the lithium ion was found to be suitable.

The lithium ion battery has an electric potential of 12V and an electric charge of 300Ah. Given the lithium ion battery produces 3600 Wh and only 0,725 Wh is required by the system for 5 min every hour, the lithium ion battery will be able to power the system for six months and 24 days, exceeding the requirements.

The power supply for the remote control must power the system for as long as required. This means it must last long enough to where it will not be cumbersome to change or recharge the power supply. Since the system will not be used frequently, the decision was made to use AAA alkaline batteries, since these batteries have a high energy density and are easy to replace when needed. In order to obtain at least 5 volt, the highest voltage required by the components, four of these batteries have to be used, resulting in a total supply voltage of 6 volts. With four AAA batteries the remote has about 44 hours of continuous use.

V. HOUSING

For this part a 3D-model of a waterproof housing holding all necessary electronic equipment and that can resist up to one hundred meters for a period of six months had to be designed. This was done by researching the right pressure resistant shape. Environmentally friendly material had to be researched that would also allow the housing to be easily manufactured.

A. Shape and Material

The most important factor for the shape is that it must resist depths up to 100 meters in the sea. The most efficient shape to overcome this factor is a cylindrical or spherical shape. A round surface creates an even pressure on the whole surface, and it limits the presence of sharp edges, that are subject to increased corrosion. A round shape will provide the best pressure tolerance with the least amount of material. A cylinder was chosen, shown in figure 5, since a sphere is unpractical, expensive to manufacture and reduces the internal usable space for components which are usually rectangular or square.

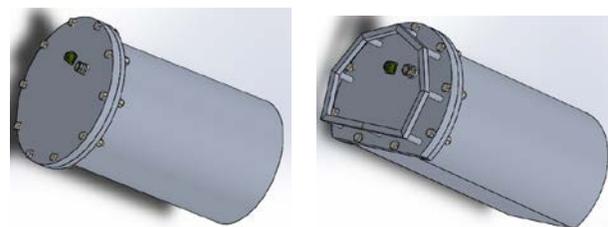


Figure 5. Cylindrical Housing (left) and Cut Housing (right)

However it is not possible to deploy a cylindrical housing in all the subsea environments, due to a Trawl Resistant Bottom Mound (TRBM) that has to be deployed with it. The TRBM prevents fishing nets from catching the housing. To make it possible to deploy the housing in different environments, other shapes were researched. In the best fitted shape, one side of the housing is cut to create a flat surface that will turn to the sea

floor, also shown in figure 5. The cut housing limits its movement on the sea floor and will not need to be mounted in a TRBM for deployment. Not having a TRBM restricts the housing to only being deployed in a Marine Protected Area and the seafloor must be checked before deployment to ensure stability. Stored within the housing will be an external frame, made from PVC, to hold the monitoring equipment and power supply, shown in figure 6.

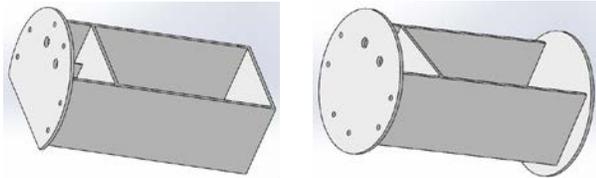


Figure 6. Internal frame for cut Housing (left) internal frame for cylindrical housing (right)

Once all components are placed inside of the internal frame, it will be sealed with an endcap bolted to the rest of the housing, shown in figure 7.

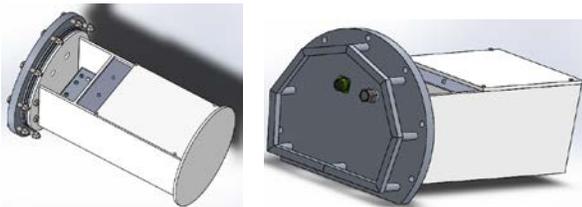


Figure 7. Assembled internal frame of the housing

The endcap contains a pressure relief valve and holder for the hydrophone. The pressure relief valve is a safety measure to handle any pressure build up if something goes wrong with the power supply.

Based on the shape a Finite Element Analysis (FEA) was completed to find the right material and dimensions of the housing. An FEA divides the problem domain into smaller portions, called finite elements, and applies varied methods from the calculus of variations to solve the problem by minimizing an associated error function. Finite elements, or small subdomains, use methods to connect simple equations to solve a complex equation over a larger domain [4].

The material was selected from either delrin or aluminum, since both could meet the specifications required. Aluminum was chosen in the end due to the fact that it would be cheaper to manufacture. Using aluminum as the material choice, dimensions for the final housing could be found for both housing designs. The final dimensions allowed complete assemble of the housing model to be created, shown in figure 8.

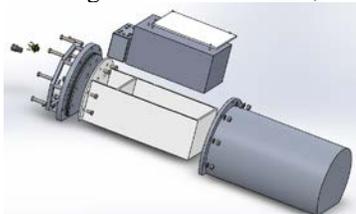


Figure 8. Complete assembly of the cut shape design

The final dimensions for the cylindrical design are a length 745 mm and radius of 420 mm, which means a total weight of 64,75Kg without any components inside and 112,27Kg when ready for deployment. The final dimensions for the cut housing design are a length of 745 mm, a height of 365 mm. The weight of the housing is 74,3 Kg, which means 118,52 Kg when ready for deployment.

B. Deployment and Retrieval

The underwater housing will be deployed by placing it in the sea and having its weight cause the housing to sink. The cut housing design is heavy enough to sink on its own, but the cylindrical design requires a ballast to be added. The extra weight from the ballast will cause the cylindrical design to sink.

The retrieval method for both housings is the same, an acoustic release system. An acoustic release is a device connected to the recording system that waits to receive an acoustic signal. The acoustic release and a buoy will be connected to the housing with rope. When the deployment period finishes the acoustic release system is will wait for an acoustic command. Once the signal is received it will release the buoy that will bring a rope fastened to the housing to the surface. With this rope, connected to the housing it will be possible to retrieve it. The cut shape housing can have the acoustic release system attached to the handle shown in figure 7. The cylindrical design will have the acoustic release stored within a TRBM with the housing, shown in figure 9.



Figure 9. Trawl Resistant Bottom Mount with Acoustic Release

C. Manufacture

Aluminum can be molded which would permit all dimensions with the right tolerances. This is also a cheap working process. The endcap and body, however, would have to be machined separately. In order to machine holes and threaded holes is possible use lathes and cutting/milling bits. Aluminum is a good material for these kinds of operations. Finally aluminum has to be anodized or hard coated.

VI. CONCLUSION

During the last few months the ECHO team has been working to simplify the deployment of underwater housings. The team divided the project in four subprojects all with their own objectives that had to be completed.

VII. REFERENCES

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For the remote control all the objectives were met and even exceeded. The remote control was designed to be user-friendly. This means that all the components were chosen and designed to be operated in the dark and light with or without gloves on. The cycle of the display has been designed to be clear without knowing how to use the remote. A prototype of the remote control was developed, this prototype however has not been tested with the users and this could change the appearance. The objectives for the electronics subproject were not fully met. The objective for the electronics portion was to create bidirectional communication between the underwater monitoring system and remote control. Bidirectional communication was created by using two microcontroller transceiver pairs. The microcontrollers would use the transceivers to send data wirelessly. The current state of the subproject allows data to be transmitted through a transceiver but not received. Although expectations for the subproject were not fully met, protocol, example programs and recommendation for further advancement were provided so the project could be completed easily at a later time.

The lithium-ion battery was chosen because it is environmentally friendly and able to power up the system for at least six months. The battery is 490,22 x 266,7 x 228,6mm and with a weight of 42,18 Kg it is easy to transport and fit in the housing. All these elements together make that the objectives for the battery are met.

There are two different housings designed, both seal of the contents from the surroundings with an endcap that is attached by the means of bolts and nuts. Both of the housings are modeled using a 3D-modeling software. The material to use was tested by applying forces on the housing with different material through an analysis program. After the analysis aluminum was selected as the material for both housing designs. Aluminum provides the best solution to having the housing resist depths of up to one hundred meters, this meets the last objective of the housing.

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