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Development of an Autonomous Underwater Robot

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Abstract

The project work consist of developing an "autonomous under water robot". Underwater robots are increasingly used for marine exploration, sea bed mapping and for fish population estimation. Model of the robot was achieved by using solid work software.L293d motor driver is used along with arm 7 microcontroller to give necessary motion commands to robot. Electronic compartment was developed to accommodate the electronics parts onboard. Calculation of centre of gravity and other parameters of robot have been done .Circuit design was drawn and Coding has been done using keil-c vision4. An additional PIR sensor was used to detect any objects nearby the robot.

Index Terms— Autonomous, Circuit design, Electronics bay, Processor, robot.

I. INTRODUCTION

Underwater vehicles are widely used for ocean mapping, oceanography, object detection, underwater videography and recovery .Underwater exploration is one of the most challenging usage and commonly used employing underwater exploration. The vehicles of smaller size used to operate underwater is called submersibles, it typically has shorter range and operate underwater.

Autonomous under water robot is a type of submersible robot. The word autonomous means "self functioning" or "self operated. An autonomously operated underwater vehicle is designed to work without an operator and without a direct connection to the surface .

They are usually designed for a specific application and are pre-programmed to perform certain specific task such as finding fish school, sea-floor mapping and imaging, temperature, salinity check etc. Some of the major events that underwater robots had been used are to find the parts of lost aircraft MH 170 malaysian airline, position of Russian submarine in 2005 in arctic region , during the search of Titanic, study on largest lake in world lake Baikal in eastern Siberia.

In autonomous underwater vehicle ,the module will move through certain pattern like circle, rectangle or pentagon formation or they can move in a straight line until result are obtained .normally underwater robot will go deeper nearer to the seabed and do its operations.In that case AUR should be completely enclosed and water tight to protect the electronics on board .Other type of AUR is skimming through the surface of water. In this type the module can be of open shape and electronics can be kept on top of the module[3]

Weight of the module mainly depend upon the onboard sensors and other electronic component. Normally an open Autonomous underwater Robot (AUR) weights between 3 to 6 kg and the closed AUR weights between 50 to 200kg,closed AUR can reach upto depth of 7000 meter according to design .

2. ROBOT DESIGN

The structure should be stable and in which the turning effect due to imbalance in buoyancy and gravity will be minimum. A rectangular structure is chosen. The ease of construction is an important advantage of the rectangular frame. Tilting of vehicle has very less probability in rectangular structures with better height. The mathematical model for the structure can be devised easily. Mounting of the floaters and attachment of skids are easy for rectangular frame[1][4]. The skids in this module are attached to the bottom side of the frame and the frame itself acts as floaters. The ballast are of fixed type.

The frame consist of two horizontal thrusters and one vertical thruster. The thrusters help in forward, backward, upward, downward movements and turning motion towards left and right direction. The purpose of the frame is to support the water-proof enclosure, The thruster motors and any trimming weights. The principle design goal for the frame taking into account thrusters and enclosure positioning and support, was to ensure there was maximum water flow through the open frame , therefore minimize drag.

The chosen design consists of four sections placed vertically perpendicular to the forward direction of travel, two along the right and two along the left. Two rectangular frames on top and bottom. To support the enclosure and for cross bracing and vertical thruster support and horizontal thruster support. The vertical sections join the two rectangular sub-frames that are parallel to the forward direction of travel.

The hollow frame is designed to fill with water during operation to assist with buoyancy and ballast trimming. In addition ,there is a mesh attached to the bottom of the frame which serves as a surface on which to attach the trimming weights and a mesh attached to the top to support the floaters fig 2.2 . The four small vertical beams connect the top and bottom, they are equally spaced. In addition to this, for mounting of the vertical motor two horizontal beam are fitted from the four vertical vertical beams shown in fig 2.1. Given for extra support of the structure and for mounting of the vertical motor in the center of gravity which helps in elimination of the tilting of structure.

The frame is tightly sealed, the air within the frame of the robot is sufficient for the floatation of the module. The autonomous vehicle has positive buoyancy without the use of additional floaters. The weights are used to increase the downward acting gravity of the module. Pipes are filled with lead balls for increasing weight. The frames was constructed using plastic tubes(CPVC). The frames and skids are constructed using 2.5cm diameter pipes, with an approximately outer diameter of 2.82cm. The material is more ductile in comparison with PVC pipes. The advantage of ductility are greater flexure and crush resistance[2].

The thrusters are used for propulsion of the vehicle through the water , both vertically and horizontally. The thrusters used are one sealed vertical DC motor and two waterproof horizontal DC motors. It is necessary to choose the proper drive motor as minimizing turbulence is important. All the three thrusters requires bi-directional control. The single vertical acting thruster should be mounted exactly at the centroid of the robot otherwise it will impart a rotational force on the module. The RPM of the motor approximately ranges from 2500-4500. The propeller fans has four blades, it will provide maximum thrust and smooth cruising operation. The propeller has a diameter of 11 cm with each blade of length 4cm.

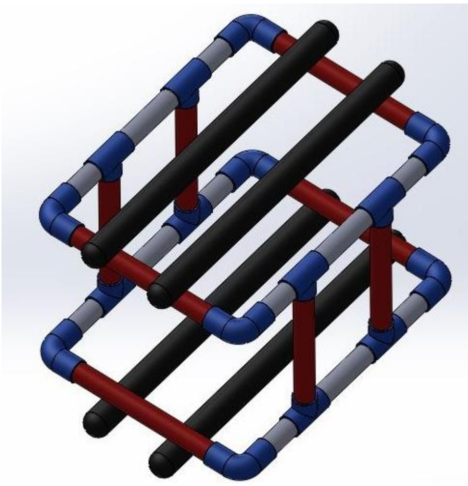

Fig: 2.1 Final Design

Fig: 2.2 Floater .

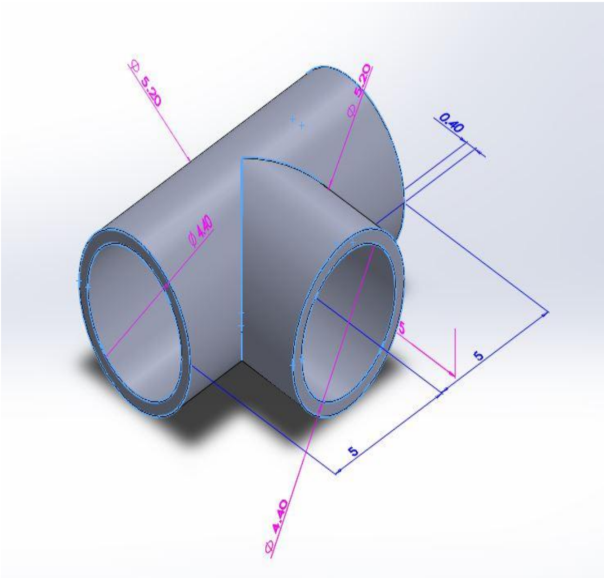

Fig:2.3 T-joint connecting vertical and horizontal pipes

3. CONSTRUCTION OF ELECTRONIC COMPARTMENT.

The primary vehicle design is an open one, so to make the module an autonomous vehicle we have to program the module and electronics component should be on board since the vehicle was completely submerged and only the top of the module was touching the water line .It was decided to keep the battery, microcontroller, motor driver and other electronics parts on the top of the module. By this way we can protect the component from getting wet. For that we made a platform consist of two layer of low wetable thermocol each having thickness 3cm and a wall was made around the base with 3cm thickness. Initially expanded polyethylene sheets was considered because of very low wetability but the material was not available for the exact dimensions to construct the EC. Fig 3.1

Fig 3.1 Robot with Electronics compartment on top

4. CIRCUIT DESIGN

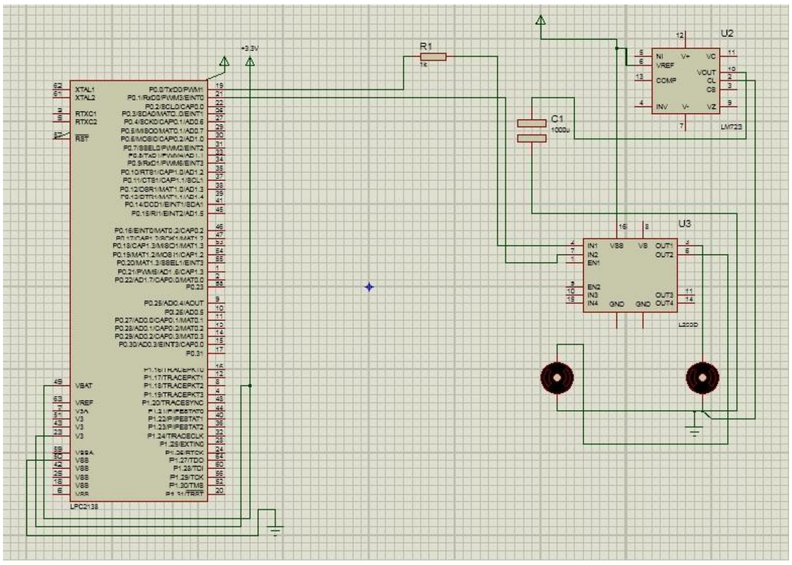

Figure 4.1 Microcontroller Design circuit

Fig 4.1 shows the design of circuit showing LPC2138 Processor(ARM) ,2 simple DC motors, one 1000 ohm Resistor, L293D motor driver ,one capacitor and a voltage regulator. Voltage regulator will regulate the voltage from the motor driver to the DC motor. The input voltage is 12v.

In order to make a robot it should need an on-board electronics and program to guide the motions of robot. The robot has to move in a rectangular path such that the robot should reach the initial position after one cycle. The time taken for one complete cycle is user defined in the program. The microcontroller program was written and complied using keil-c software. Special precaution should be taken for sealing the electronic compartment so that no water should enter the electronics part . No control system was used in developing the robot ,so a slight disturbance on the water medium can deviate the original path position of robot. In the above circuit diagram only two horizontal motors were shown.The vertical motor should always in reverse turning mode to get an upward thrust so that the robot will float on the water. In order to turn the robot in left direction, the left motor should be off and right motor be on and be slow. It makes a clean turn without much tilting.

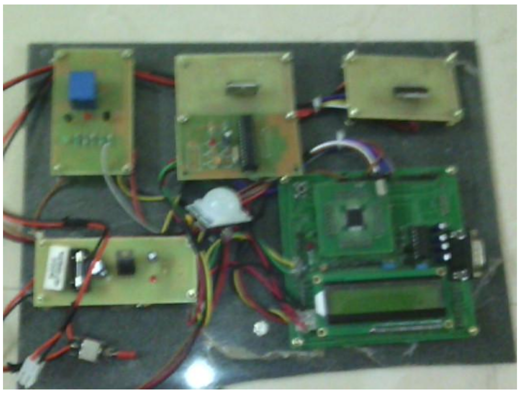

Fig 4.2 shows the ciruit board having ARM-7 and PIR sensor.

PIR sensor was used to detect any nearby object with respect to the robot. The circuit board should be kept inside the electronic compartment and sealed with water proof glue. Two separate switches were provided to “ON” the vertical and horizontal motors.

5. PARAMETERS CALCULATED

Table 4.1Calculated parameters of AUR

SL NO:	PARAMETERS	CALCULATED VALUE (SI)
1)	CENTRE Of GRAVITY	(X,Y)= 0.3716m,0.1304m
2)	META-CENTRE POSITION	0.1918m From base.
3)	TURNING VELOCITY	0.013m/s
4)	TURNING RADIUS	0.18m
5)	SPEED OF MODULE	10.59m/s
6)	ACCELERATION	1.028m/s2

The table 4.1 shows the necessary parameters value for the vehicle motion and stability.In order to develop an autonomous robot determination of above six values are must.

Table 4.2Motor Specification

Selection criterion	Horizontal Motor	Vertical motor
Voltage	12V (4v~12v)	12V(4v~12v)
Stall current	3.5 A	3.5A
Shaft Diameter	3mm	3mm
Shaft Length	12mm	10mm

The table 4.2 shows Motor specifications. The propeller fan has four blades, it provides maximum thrust and smooth cruising operation. The propeller has a diameter of 11 centimeters with each blade of length of 4cm.one 12V battery of 7 Ah is used for horizontal and one battery is used to power vertical thrusters.

Table 4.3 Module Specification.

Weight	3kg
Height	0.223m
Length	0.43m
Breadth	0.225m

6. ROBOT PSEUDO CODE

Micro-controller Pseudo code using Keil-c 14

```
void Delay(int count)   (Main program starts)
{
unsigned a=65000;
while(count--)
{
while(a--);
}
}
#define FS 65000   (arbitrary values)
#define LS 40000
#define StraightDelay 20000
#define SlowSpeedDelay 10000
#define TurnDelay 10000
int32_t main (void)
{
UNLOCKREG();
SYSCLK->PWRCON.XTL12M_EN = 1;
SYSCLK->CLKSEL0.HCLK_S = 0;
LOCKREG();
Delay(1000);
while(1)
{
PWMA0(FS);   (full speed)
PWMA1(FS);
Delay(StraightDelay);
PWMA0(LS);   (slow speed)
PWMA1(LS);
Delay(SlowSpeedDelay);
PWMA0(0);   (left propeller off)
```

```
PWMA1(LS);   (right propeller low speed)
Delay(TurnDelay);///
PWMA0(FS);   (first turn)
PWMA1(FS);
Delay(StraightDelay);
PWMA0(LS);
PWMA1(LS);
Delay(SlowSpeedDelay);
PWMA0(0);
PWMA1(LS);
Delay(TurnDelay);//
PWMA0(FS);   (second turn)
PWMA1(FS);
Delay(StraightDelay);
PWMA0(LS);
PWMA1(LS);
Delay(SlowSpeedDelay);
PWMA0(0);
PWMA1(LS);
Delay(TurnDelay);//
PWMA0(FS);   (third turn)
PWMA1(FS);
Delay(StraightDelay);
PWMA0(LS);
PWMA1(LS);
Delay(SlowSpeedDelay);
PWMA0(0);   (fourth turn)
PWMA1(LS);
Delay(TurnDelay);    (End of first loop)
}
}
```

7. CONCLUSION

The Design, Fabrication, Calculation of Parameters, Development of electronics compartment and electronics, Robot program for robot motion through water have been done .As stated this work will be the basic model of coming underwater robots. Research scholars can incorporate any additional sensor to the developed Robot such as SONAR, Ph indicator, Temperature Sensors so as to study various Ocean engineering problems in real time. The study conducted above can be used for military application by adding passive sonar sensors. Thus the work done had immense application in both civil and defence.

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