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Design and Development of Hovercraft

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ABSTRACT

In today's world, air powered vehicle is newest vehicle for transportation. This vehicle is different from other terrestrial and conventional ones as it moves freely on various kind of surfaces and eliminates any contact with surface. It is supported on self-generated cushion of air. Our projects includes various calculations for thrust and lift forces as well as to study principle of working of hovercraft. Also the hover height that hovercraft hovers was calculated. It was observed that with reduction in static and dynamic frictional forces, less thrust forces was required. In this paper, we have discussed various components of project as well the software implementation part.

Keywords: Hover height, Air gap, Thrust, Static friction, Lift force, Dynamic friction.

I. INTRODUCTION

Hovercraft is also known as air cushion or air powered vehicle which is capable of travelling over water, ice or mud and on all kind of surfaces. In this vehicle, high pressure of air is continuously forced inside the skirt which generates cushion pressure. This process reduces friction between surface and moving vehicle. They mostly operate above 15 knots and can clear gradients upto 15 degrees and hover at heights between 250mm to 650mm over any surface. Propulsion and lift are the main principles on which hovercraft work. However, lift is main factor because it helps the vehicle to ride.

The process of lifting the craft begins by directing a large quantity of air inside the skirt or under the craft. A propeller fan is used for providing thrust force which moves the body in horizontal direction. It is necessary to incorporate steering capabilities so as to move the craft in required direction. This can be achieved by rudders. In order to move the craft in air, the shape or design of rudders is important.

II. METHODS AND MATERIAL

A. Principle of operation

The hovercraft hovers above the surface with the support of air provided by fan. The cushion pressure eliminates all kind of friction and eases the movement of hovercraft. There is a hole beneath the craft through which air is blown inside the skirt as shown in figure 1. Due to movement of air, the skirt gets inflated and when the lift force increases more than the weight of of body, the whole body gets pushed and gets lifted. In figure 1, it is shown that how exactly the pressure is produced in skirt. When the craft gets lifted, a blower is incorporated in thrust engine which exerts air in backward direction. The amount of air exerted backward provides a reaction which moves the vehicle in forward direction. Due to reduction in pressure, very less power is required. Steering effect is achieved by microcontroller. A switch is used for changing directions for going forward, backward, right and left.

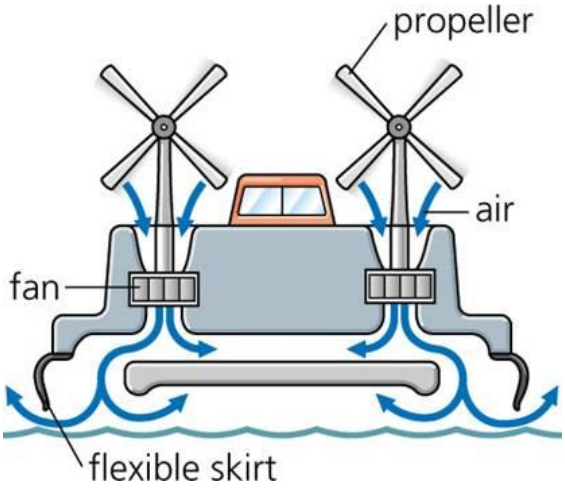

Figure 1. Schematic diagram

B. Components

We have used various mechanical and electrical components in this project. They are as follows:

1) *Microcontroller*: This microcontroller is a high performance CMOS 8-bit microcontroller, low voltage with 2k bytes of Flash programmable and erasable read-only memory (PEROM). Non-volatile memory and high density technology of Atmel is used to manufacture this device and is made compatible with industry standard MCS-51 instruction set. It consists of 15 I/O lines, two-level interrupt architecture, two 16-bit timer/counters, 128 bytes of RAM and 2K bytes of Flash. It supports two software selectable power saving modes and designed with static logic so as to operate down to zero frequency.
2) *Relay*: It is a switch which is electrically operated. Relays make use of an electromagnet so as to operate the switch mechanically. Also solid-state relays are used as operating principles. Whenever it is required to control a circuit having low power signal or where one signal is used to control several circuits, relays are used.
   Specifications:
   Coil voltage: DC 9-12V , Contact: AC240V 7A
3) *DC Motors*: DC motor are based on principle of electromagnetism and consists of almost 6 parts: stator, rotor, field magnets, commutator, brushes and axle. The most common method of interfacing the microcontroller with DC motor is H-bridge method. DC motors are usually used to harness magnetic interaction between external magnetic field and current carrying conductor which provides the necessary torque.
   Specifications:
   Size: 25mm*67mm, Output current:500mA
   Voltage: 20V , Construction: Permanent magnet
4) *Oscillator*: Normally oscillators are used to provide common clock which are used for the synchronization of various operations of microcontrollers as provided by external oscillator. They are connected to XTAL1 and XTAL2 pins of microcontroller. To support the crystal for oscillations, capacitors are provided which are of standard values. In our project the crystal frequency is 11.0592MHz.

Figure 2. Oscillator

5) *Fixed Output Voltage Regulator*: The input of a fixed voltage regulator is unregulated dc input voltage Vi which is applied to one terminal, second terminal is connected to ground and third terminal is connected to regulated dc voltage Vo. We have used 78XX regulators which are three-terminal devices which are used to provide a fixed output positive voltage. Capacitor C1 filters the unregulated input voltage which is connected to IC's input terminal. While output terminal provides a regulated voltage of +12v which gets filtered by capacitor C2. The other terminal is connected to ground.

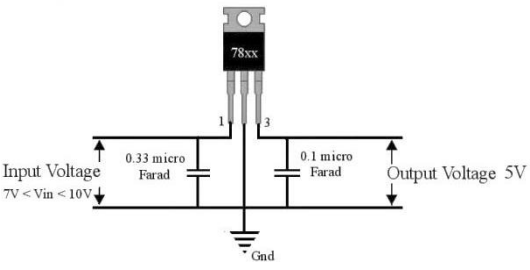

Figure 3. Regulator

6) *Tx-Rx Modules*: Circuit utilizes the RF module for making wireless remote which is used to drive an output from a distant place. A four channel encoder/decoder pair has been used. Input signals are taken from switches and output signals can drive

corresponding relays. Transmitter used is HT12E and Receiver is HT12D.

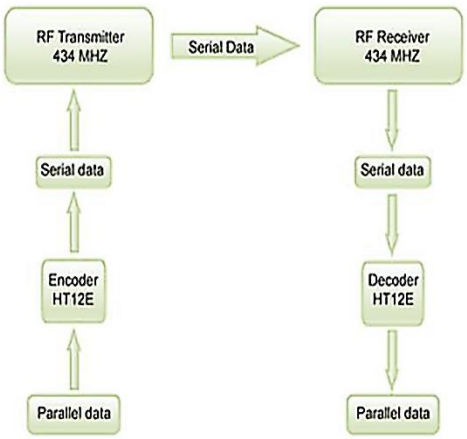

Figure 4. Transmission Diagram

C. Software Implementation

Various softwares have been used for programming the microcontroller so as to successfully operate our project. They are as follows:

1) *Keil Software*: It is used for writing the program for the operation of project. To solve various problems of complex nature in embedded software by developers, Keil 8051 development tools are used. It allows debugging and assembly of files which is offered as an evaluation package. Assembler, compiler and linker are various development tools.
2) *Flash Magic*: In this software we burn the program so as to compile in microcontroller. It is usually used to program hex code in EEPROM of micro-controller and supports microcontrollers of NXP and Philips. These controllers' supports in system programming (ISP) feature and thus program can be burnt in hex code. To find whether microcontroller supports ISP or not, its datasheet can be used which contains all detailed information.

D. Calculations

1) *Lift calculation* **:**

Total weight: 6*9.81 = 58.86 N

Area of cushion: $\pi r^2 = 0.3318\ m^2$

r = 0.325 m

Cushion pressure = Total weight / Area of cushion

Cushion pressure = 177.39 Pa.

Air pressure blown in skirt through fan is

P_f = 105000 Pa

atmospheric air pressure P_{atm} = 101325 Pa

therefore, $Pf - P_{atm}$ = 3675 Pa.

Considering 6 holes on the skirt through which air can escape and produce require thrust for uplift (hole diameter = 2cm.)

= 6 * 0.0628 = 0.377 m.

Now hovercraft is designed to lift 3 mm off the floor, the total area through which the air will escape (Ae) = (.377 * .003) = $1.131 * 10^{-3}\ m^2$.

By calculating Velocity pressure

$(Pv2) = ½\ \rho\ V^2$ = 177.38 Pa

ρ =density = 1.22 kg/m^3

Therefore, V = velocity = 17.05 m/s.

This is the escape velocity (*Ve*) of the air from where it escapes through the gap at a given cushion Pressure (*Pc*)

The Volume of air lost (*V*) = Escape Velocity (*Ve*) x Escape Area (*Ae*)

= $17.05 * 1.131*10^{-3}$ = 0.019283 m^3/sec.

Power = $\rho * A_e * V_e^3$

= $1.22 * 1.131* 10^{-3} * 17.05^3$ = 6.83 W.

2) *Thrust calculation* **:**

The basic equation for Gross thrust is given by:-

$T_g = m * V_d$

Where: -

T_{ag} = Gross thrust

V_d = Discharge velocity (Efflux velocity) and

m = mass flow rate = $\rho * A * V_d$

Where

Duct Diameter = 1000mm (Area (A) = $0.785m^2$)

Discharge Velocity V_d = 10 m/sec

Density of air ρ = 1.22 kg / m^3

Power required:

$P = T_n * V = 95.77 * 0.1$

= 9.577 W.

Total power req = 2 * 9.577 = 19.154 W

III. RESULTS AND DISCUSSION

Thus we designed RC controlled hovercraft. In this project we used microcontroller so as to control the

operation of project. RF modules are made used so as to control the body from a distant (wireless). In below figure, we have shown some of our parts of project. In figure 6, we have shown our receiver parts. Similarly, in figure 7, transmitter has been shown.

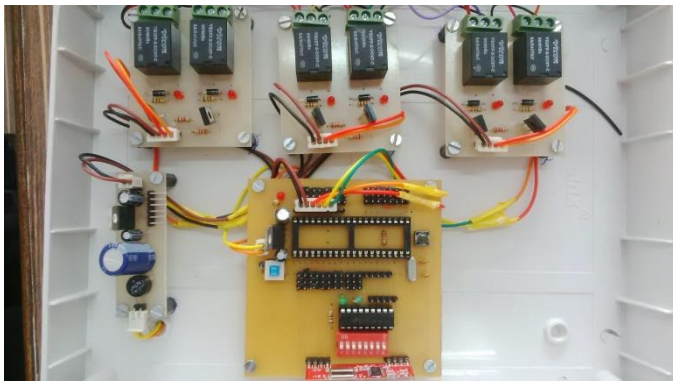

Figure 6. Receiver

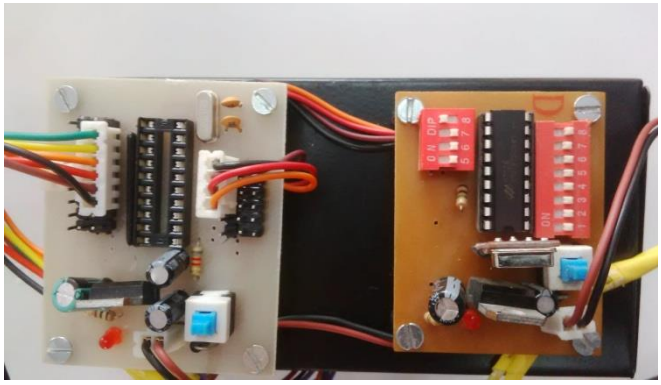

Figure 7. Transmitter

IV. CONCLUSION

Though hovercraft may appear as a simple mechanism in theory but its process till manifestation is very difficult. Number of problems exist and are faced so as to move the hovercraft in stable direction. All the calculations and plans must be perfect and flawless. For this, we must consider the shape and weight of each component in order to avoid the instability and poor functioning of craft. Various numbers of factors and problems are considered while constructing and designing the craft. When every process is done properly, this machine can hover smoothly cutting off the friction. However its applications are limited due to the problems faced in operating it in a stable manner and thus restricted to military or transportation purpose. Also the overall cost is another great hurdle for the widespread use of this vehicle.

V. REFERENCES

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