NETROV PROJECT: UNDERWATER REMOTE CONTROLLED MINIVEHICLE

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ABSTRACT

The work paper presents the activities accomplished in the project NETROV: a mini-ROV design, construction and testing (partially at the date of material preparing). The purpose of the project is to make an low-cost underwater remotely operated vehicle for observation, monitoring and simple utilitarian activities. In the project a series of issues were pointed like making propulsive motors, control of the vehicle's moving, data acquisition from different sensors, navigation and positioning and the vehicle's localization in case of damage. The NETROV project consists of two major parts: the underwater vehicle and the surface control unit. These elements are connected through an umbilical cable, which assures the vehicle's energy supply, the control signals and data transmission.

KEY WORDS : remotely operated vehicle (ROV), sensors, underwater video camera, propulsion system, thruster

GENERAL DESCRIPTION

The goal of NETROV Project is to achieve an underwater observation system and to perform utilitarian activities in order to obtain data, probes and to make measurements in marine medium, to a depth of 300 meters. To fulfill this purpose, was conceived equipment containing the following components:

• Immerse unit, representing the remote controlled underwater vehicle (Fig. 1). The minivehicle contains inside the mechanic housing the following components: means of the minivehicle's propulsion, utilitarian sensors and navigation sensors. These elements, as well as the adequate software, are integrated in a system controlled by the operator through a central micro controller unit.

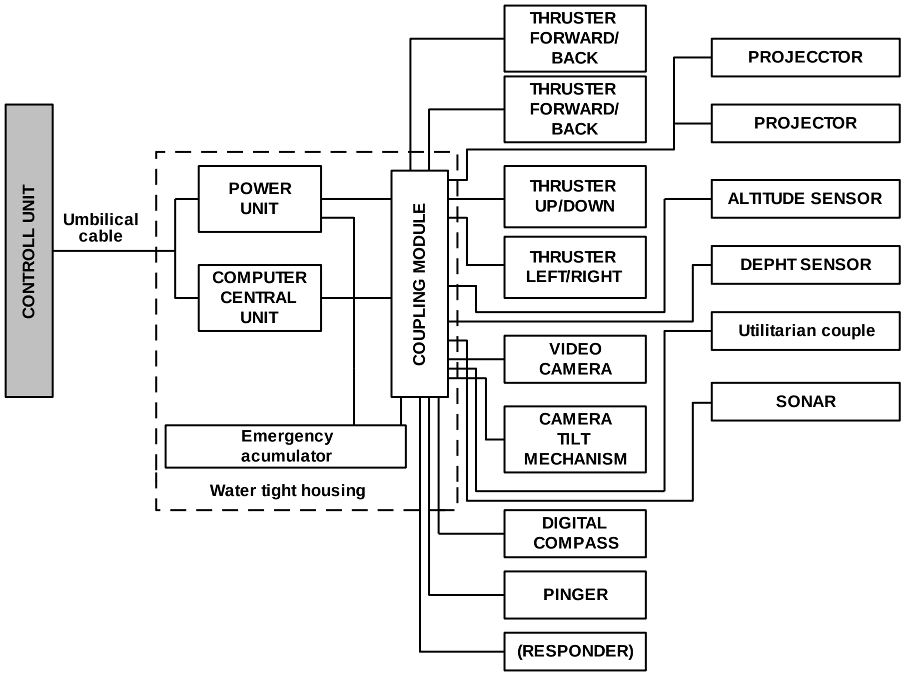

Fig. 1 - Underwater remote controlled minivehicle *NETROV* - block diagram

• The surface control unit (mounted on the surface ship from which the vehicle is launched), representing the control console (Fig. 2) includes the power supply unit (a digital controlled rectifier), a laptop type calculation structure and the control module. This structure associated with the adequate software allows the control of the underwater remotely vehicle and acquisition, displaying and recording of data.

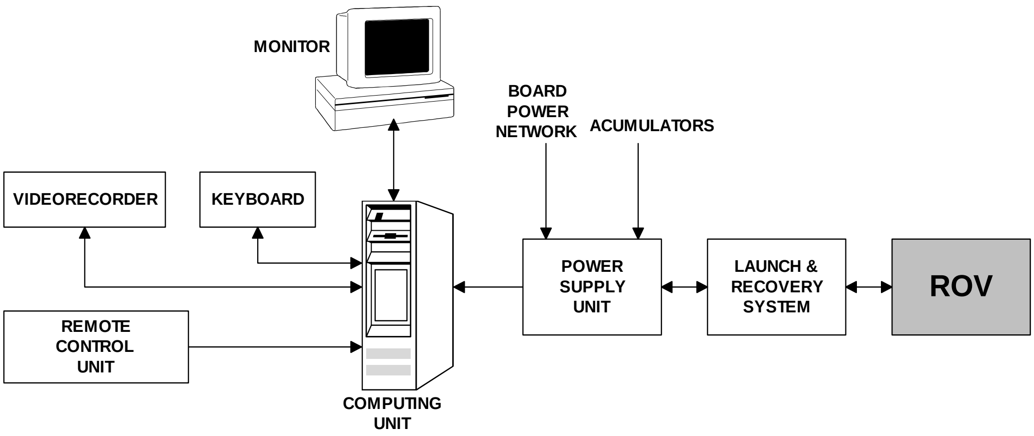

Fig. 2 - The surface control unit block diagram

- A special umbilical cable assures the energy for the ROV's modules and the transmissions between ROV and the surface control unit.

The communication between ROV and control unit is made through serial interface RS 485. The video camera signal (complex video signal CVBS) is transmitted to the computing module through a video USB interface.

The minivehicle's power supply consists in a 400VDC, located at surface vessel and a DC-DC converter (400VDC-24VDC) located at the ROV. This solution has been chosen to reduce the minivehicle's weight by eliminating the accumulators and also to assure an unlimited working autonomy using an umbilical cable that does not disturb the governing.

Navigation and positioning of underwater minivehicle and utilitarian tools control (video camera, projectors and manipulator) is assured through the remote control module by the surface operator (Fig. 3).

THE MECHANICAL CONSTRUCTION OF THE UNDERWATER MINIVEHICLE

From a mechanical point of view, the underwater remotely operated mini-vehicle is made of a metallic framework on which all the components are assembled together, forming an integrated system. For the minivehicle to be stable it was necessary to make the assamblance of components in such a manner that will produce a large weight in the bottom of framework and a small weight in the superior part.

In order to keep a constant behavior, the underwater vehicle has a neutral (zero) buoyancy. Neutral buoyancy is obtained by situating adequate flotors (from polyurethane foam) on the superior part of the housing that compensate the block weight that is larger than the dislocated water volume. The polyurethane flotors have a structure that can be adjusted in accordance with the vehicle's charging.

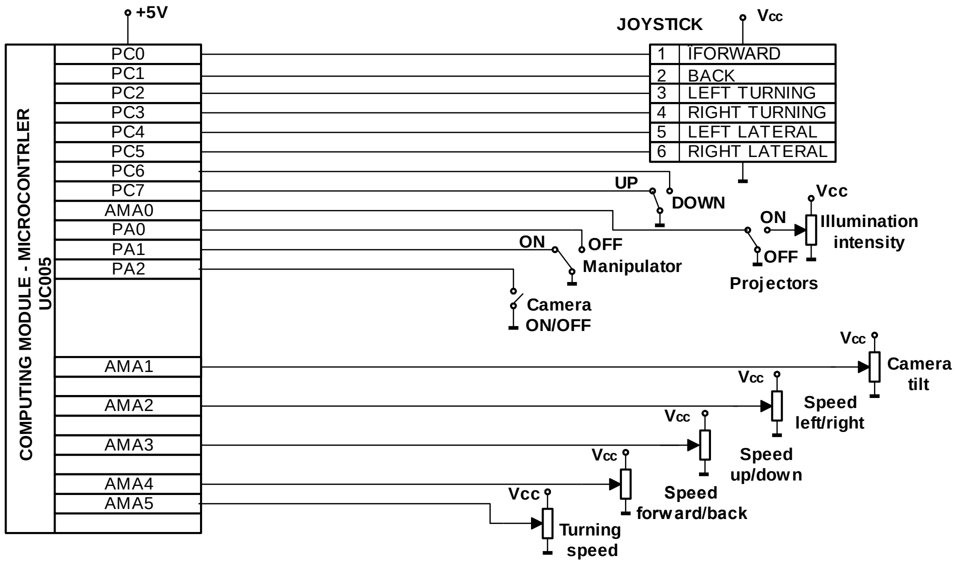

Fig. 3 - The remote control unit

The vehicle's governing is carried out through a system of four thrusters that assure the control of its movement on 4 degrees of freedom: front/back, rotation to left/right, vertical and lateral movement. Choosing the thrusters' position is very important, so the vehicle won't get rocking and rolling motions during maneuvers. Choosing the right placing for thrusters assures the vehicle's stability and an efficient control of its movement.

Another important element of the minivehicle is the color video camera. This is mounted in the front part of the minivehicle, being maneuvered on the vertical side through a rotating system.

The minivehicle's component parts are fixed on the metallic framework. This framework is designed as a parallelepiped box and is made of non-magnetic stainless steel pipe. The construction is solid, easy and resistant to external pressure and to the seawater corrosion. It also permits easy position modifications for thrusters, flotors, ballast elements, electronics, and acoustic transponder. The non-magnetic stainless steel assures also protection against corrosion of seawater.

The minivehicle's components, the housing of electronics and the metallic framework resist at an external medium pressure corresponding to a depth of 300 meters, meaning aprox. 30 bars.

The NETROV minivehicle contains the following watertight components: electronic module, DC-DC converter, video camera, and underwater projectors. These housings are made of plastic pipe (PVC) having aluminum lids. Water tightness is assured by o-rings. The connectors are fixed on the lids and are built to be also watertight.

Flotors assuring a null floatability are made as PAFS tubes located along the metallic framework in which is included, as needed, flotor elements. It was necessary to adapt this solution because it was difficult to estimate the precise distribution of masses and also for the reason that the minivehicle's weight modifies with supplementary utilitarian charges depending on the mission's type. The flotors are made of rigid polyurethane foam.

PROPULSION SYSTEM

To assure the settled objective of moving the underwater minivehicle with the maximum speed of 3Nd, an electric thruster with adjustable number of rotation was designed. The thruster components - stator and rotor - works directly in sea water and assures a forward pushing power of about 40 kilos at a speed of 1m/s. Working directly in sea water assures a simpler exploiting operation and a lower cost price comparative to the brushless engine types, isolated in oil.

The thruster working voltage is 24VDC and permits the following actions through external command over the incorporated electronics control circuit: shift rotating direction and continuous adjustment on the number of rotations from zero to maximum value, through a control voltage between 0 and 5VDC.

By using two thrusters for forward/backward motion is assured a push force of 80 kilos at a speed of 1m/s; this is sufficient to move the minivehicle with the imposed speed, having an advancing resistance coefficient of about 0.9.

The minivehicle's left /right rotation in horizontal plane is made through the corresponding commands over the number of rotations and the thrusters' rotating direction. A fine movement on vertical and sideways is made with the same thruster type. The commands are given from a micro controller central unit, placed in the minivehicle, through a module of command and control. The thruster was verified at an external pressure of 30 bars.

SENSORS

The NETROV minivehicle is provided with a number of sensors that assures all the necessary data for navigation:

- Digital compass
- Navigational acoustic probe
- Pressure sensor
- Pinger for recovering in case of damage.

The digital compass is used to determine the minivehicle's heading towards the magnetic nord. A two axe digital compass was projected and made, based on Hall sensor technology that offers, on serial interface, the azimuth in NMEA 0183 format.

The navigation acoustic probe is used to determine the distance from the bottom (the altitude of ROV).

An acoustic probe was designed on a frequency of 200 KHz that provides the depth, on the serial interface, in NMEA 0183 format.

The pressure sensor measures the operating depth of the minivehicle. It provides a proportional signal with the measured pressure. An industrial miniature sensor is used and it communicates with the exterior through a hole in the watertight lid of the electronic block. In case of damage, the recovery pinger assures the transmission of an acoustic signal on a fixed frequency, having as purpose the minivehicle's recovery by divers.

THE MINIVEHICLE'S POWER SUPPLY

The thrusters, underwater projectors, electric devices and sensors supplying is made trough a DC-DC converter that provides a 24VDC voltage. The input voltage of 400VDC applied to the DC - DC converter is provided from a digital controlled rectifier located in surface control unit. The DC-DC converter assures through a distribution module: the 24VDC/2,5A voltage for each of the 4 thrusters, the 24VDC/4A voltage for underwater projectors and 5VDC/1A voltage for micro controller and the afferent electronic modules, the 12VDC/0,2A voltage for the video camera and other sensors and a 24VDC/3A voltage for utilitarian couple.

The converter is dimensioned to supply attached utilitarian devices, the vehicle having a couple for this purpose. The solution to supply the vehicle from the control unit located on surface vessel was taken in order to increase autonomy and to reduce the vehicle’s dimensions, by eliminating the accumulators.

A distribution module assures the necessary power supplies and control signals for consumers on the vehicle and for protection of the 24VDC DC-DC converter. Other supply voltages, apart from 24VDC power supply, are obtained through DC-DC converter having as primary source the 24VDC voltage.

ILLUMINATION AND VIDEO CAMERA

The minivehicle is equipped with a color video camera to capture images from the seawater. The camera is mounted in a watertight structure from a plastic tube and can be rotated +/- 90 degrees. The video camera provides a complex video signal, transmitted through the umbilical cable to the control console located at the surface vessel. Having quality image capture implies a proper lighting. In this way the camera have its own incorporated illuminating system. Additional, the vehicle has two tungsten halogen lamps of 100 Watts each. Their luminous intensity is controlled through the board micro controller. The operator, considering the luminosity in the seawater, in which the ROV is operated, makes the adjustment of illumination intensity manually.

CENTRAL MICRO CONTROLLER UNIT

The minivehicle’s movement control and data acquisition from the navigation sensors is assured through a micro controller central unit from the 80C51 series. The microcontroller brings a series of facilities:

- Is incorporated with an analog digital converter necessary for data acquisition form the temperature and pressure sensors in the working environment.
- Contains digital inputs for executing the yes/no commands necessary to shifting thrusters’ rotation, video camera coupling, underwater projectors coupling, commanding step by step an electric motor to rotate the video camera.
- Generates a modulated in duration signal, necessary to command the number of thruster rotations and the projectors’ luminous intensity.

To command the 4 thrusters and the underwater projectors an auxiliary control module is used.

- Assures serial communications: serial communication with the control console situated on the surface vessel and data acquisition in NMEA 0183 format, from the flux gate compass and acoustic probe.

The micro controller assures a serial 8 bits communication with a rate of 9600bauds. It uses a quartz-stabilized clock on 24 MHz.

CONCLUSIONS

The NETROV project comprises a large range of mechanical, electrical and electronic components connected hardware and software in an integrated system. This system is able to perform utilitarian actions: to obtain video images, to measure medium's parameters, sample collecting and so on. Data and navigation parameters are displayed on the operator's screen or recorded. The NETROV system collaborates interactively with the operator. Partial tests show that objectives were fulfilled.

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