# Developing a Nautical Platform for Embedded Modules Testing

Douglas Soares dos Santos, Neusa M.F. Oliveira,Wagner Chiepa Cunha e Cairo L. Nascimento Jr.
Instituto Tecnológico de Aeronáutica - Praça Marechal Eduardo Gomes, 50 - 12228-900 - São Jose dos Campos - SP - Brazil

*Abstract* **— The development of a nautical platform is presented focusing on its architecture for testing embedded modules and subsystems. The platform modules and subsystems are implemented in a structure based on a sailing catamaran, where the propellants are central elements of each longitudinal hull. The engines are controlled by a relay box commanded by a microcontroller device. The microcontroller receives signals from a radio modem and converts them in guiding. The command information is generated by a remote computer that also sends signals via radio modem. In the remote computer the local program allows the user to send safely the desired actions to control the platform. The nautical platform was fully implemented and the results indicate a possibility to implement a variety of payloads.**

***Keywords* — nautical, platform, embedded, navigability, guidance.**

## I. INTRODUCTION

There are many studies about autonomous vehicles [2]. The technology employed in sensor and actuator elements leads to different implementations and architectures. Using these vehicles it is possible to remotely control, the insertion of the vehicle in a hostile environment, avoiding human hazards.

The need to implement autonomous navigation systems in nautical environment [4] inspired the construction of a testing platform for embedded systems, for navigation and control. This platform consists of a mechanical structure capable of dealing with efficient navigational maneuvers for small circuits. The structure chosen was a catamaran, initially to simplify the implementation and also for the possibility of placing the engines on the outside and in middle part of each hull. This type of arrangement can dispense the use of a helm and offers a good operating condition, including the possibility that the entire structure to rotate around its own spin. The navigation control is performed by a microcontroller subsystem that process the signals sent and received by a radio frequency from a remote station, based in a common commercial microcomputer.

The implementation of this platform will enable the study of marine inertial systems [3], navigation system for GPS, communication systems, embedded systems based on an on-board computer, image capture system, autonomous navigation system, etc.

This article presents in section II the implementation of the platform showing the navigational structure.

Douglas S. Santos, dsoares@ita.br, Neusa M.F. Oliveira, neusa@ ita.br, Wagner Chiepa C., chiepa@ita.br, Cairo L. Nascimento Jr., Cairo@ita.br +, Tel. +55-12-5878, Fax +55-12-39476930

The details of how to drive the motors, the control circuit used, the form of local communication, the energy source and the communication link are described in section III. The structured diagrams to represent the platform software design and the graphical and friendly interface are presented in section IV. Section V brings the final considerations about the implementation of the nautical platform.

## II. PLATFORM ARCHITECTURE

The developed platform is composed by mechanical structure, hardware and software components which described as follows. The mechanical structure, which can be seen in Fig. 1, is a catamaran structure without helm. The electrical motors installed on each hull work as propellers, the Port motor and the Starboard motor. These are DC, 12V motors with mechanical velocity reducers and a traction system like water wheel. The motor axis is fixed in an acrylic material with eight drag blades.

Fig. 1. Mechanical structure of platform

Fig. 2 shows the block diagram of the platform control and navigation system. The Port motor and Starboard motor are driven by an arrangement of relays. Fig. 3 shows the relays circuit that drive energy to the motors. Each relay pair controls one motor, allowing the motor to rotate clockwise or anti-clockwise or turn off the motor.

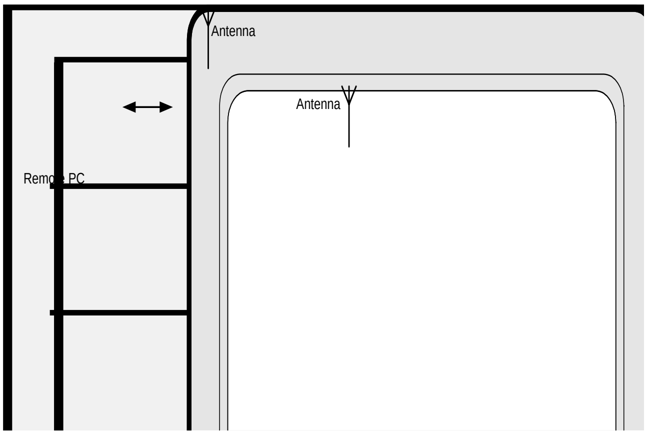


Fig. 2. Architecture of the platform

The hardware developed to control the platform has as its major components, the microcontroller 8051, [1] from Family MSC51, which has serial communication interface, digital input and output ports, analog input and output terminals, program memory and data memory, all integrated in one chip; the RS232 serial interface, which converts the TTL signals used by the microcontroller to signals RS232 used by the radio modem; and the radio modem system, which works at 908MHz, FM mode and the transference rates can be selected by 19.600 bauds. The communication link reaches 500 m in line of sight. The Modem is present in the local control system, transmitting and receiving data, and in remote computer as well. The hardware development is detailed in the next sections.

The electrical power energizing the system is supplied by a conventional lead-acid battery of 13,8VDC and 7Ah current capability.

## III. HARDWARE DEVELOPMENT

The hardware system for the local control system, shown in Fig. 1 is described in this section. The platform has two motors and each of them is driven by a pair of relays. The structure used to drive the motors is shown in Fig. 3. The symbols NO1, NO2, NO3 and NO4 are used to represent the normal open contacts and NC1, NC2, NC3 and NC4 to represent the normal closed contacts of relays 1, 2, 3 and 4 respectively. The Port Motor rotates in one direction, when relay 1 contacts operate (NO1 closed and NC1 open) and relay 2 contacts not operate (NO2 open and NC2 closed). The Port Motor rotate in opposite direction, when relay 2 contacts operate (NO2 close and NC2 open) and relay 1 contacts not operate (NO1 open and NC1 closed). The Starboard motor works in a similar way using the relay 3 and relay 4. When the four relays are OFF the motors are also OFF. By controlling both motors simultaneously, the platform can perform a variety of movements including spinning in port or starboard direction.

It is also important to state that the relay circuit chosen to command the motors prevents any inconsistency in the command action, such as, turning a motor in the clockwise direction and anti-clockwise direction simultaneously.

The RC branches shown in Fig. 3 are necessary to suppress interferences generated by the motors that could disturb the microcontroller operation.

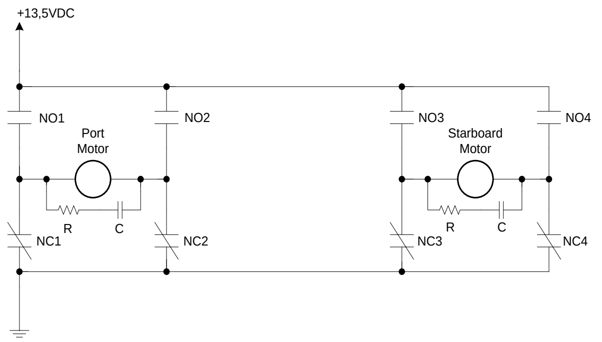


Fig. 3. The contacts relay circuit to driver the motors

Fig. 4 shows the relays command circuit. To turn the relays ON or OFF, it is assigned a digital microcontroller output (a port bit) for each one, which in Fig. 4 are the digital signal S1, S2, S3 and S4. The microcontroller is programmed such that each output is controlled individually but the composition of signals reflects the command action selected, as described before. This selection is done by the microcontroller based on the signals received from the remote computer through the radio modem link.

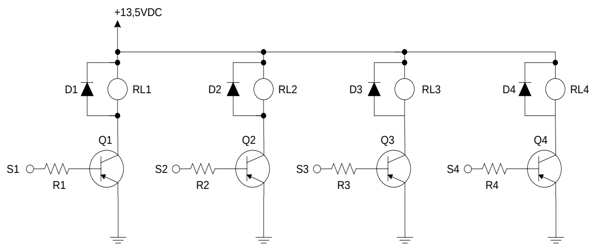


Fig. 4. Command relay circuit

Fig. 5 shows the microcontroller sub system, the interface to match the pattern of electrical signals between the radio modem and the serial output of the microcontroller, and the radio modem and the input and output signals.

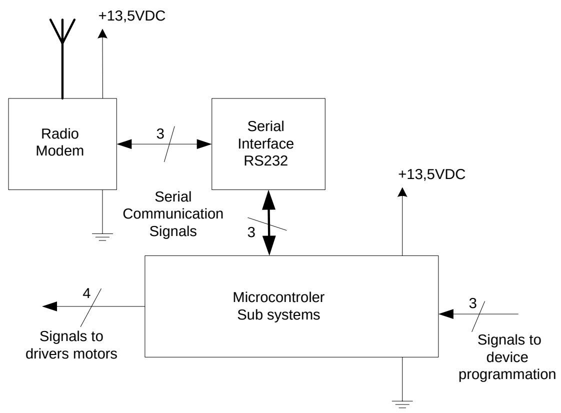


Fig. 5. Control sub system and communication link

### *A. The remote microcomputer*

The remote microcomputer is a commercial PC with an operating system capable of supporting the control application and provide a standard serial interface RS232 for electrical connection of the radio modem.

## IV. SOFTWARE DEVELOPMENT

In the local system, the software code was written in the microcontroller assembly language. The software development is based in the serial communication capability of the microcontroller. Any signal received in this interface generates an interruption and the treatment of these interruption begins the solving the command. Fig. 6 shows the structured block diagram [6] with the serial interface setup, the communication link monitor, the logical solution for each signal received from the remote system, and the motors status.

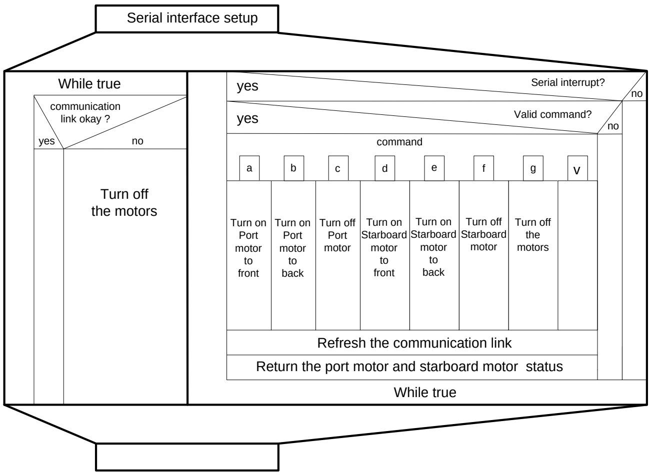


Fig. 6. Software diagram with the local solution

The structured block diagram of Fig. 6 also shows how the local device was programmed. Initially, the mode and rate of serial communication interface is set, then the programming is divided into two functions. The main function that handles the communication link assuring that the engines only react to commands if the link is active. If the communication link fail, the motors will shut down unconditionally until a new command is accept. The other function is used to interrupt the serial interface. This function reads the contents of the serial buffer and compares this data with the possible actions already determined. If the data is {a} then leads to connect the Port motor to forward; if it is {b} it implies in turn the Port motor backwards; if it is {c} it disconnects the Port motor; if it is {d}it implies connecting the Starboard motor forwards; if it is {e} it turns the Starboard motor backwards; if it is {f} it turns off the Starboard motor; if it is {g} the two motors are shut down; and if it is {v} the link is refreshed. All valid commands refreshes the communication link unconditionally and return to the remote microcomputer a signal with the motors status.

On the remote computer, the software was programmed in a DELPHI development environment [5] allowing to draw a friendly graphical interface and all necessary actions to control the nautical platform. A virtual panel was implemented with buttons and indicators that make up actions to go forward, to go backward, turn around to port side, turn around to starboard side, take to port, take to starboard and stop. The panel indicators show the status of motors and the link of communication. Fig. 7 shows the screen of the platform remote control software.


Figure – 7 The remote software interface

Fig. 8 shows the structured block diagram to resolve the application for remote control of the platform. The structure is composed of the following tasks: setup of the serial interface communication; stimulus for the communication link validation; selection of control actions; and dialog boxes containing information about the status of the Port motor, the Starboard motor, communication link and shipping time.

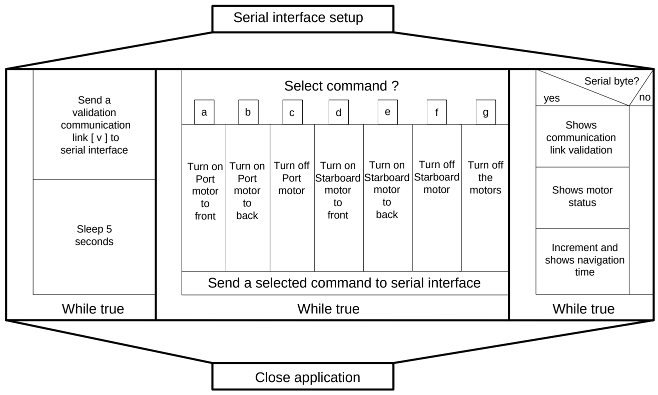


Fig. 8. Software diagram with remote application

The structured block diagram in Fig. 8 also shows how the remote software was developed. The remote serial interface, in accordance with the mode and rate of serial interface in platform, has the same setup. Consequently the programming is divided in tree functions. A function that handles the communication link and ensures that the platform react to commands if the link is active, with the validation command {v} is sent each 5 seconds. If the control software breaks or shuts down, the link validation fails and the motors in the platform will shut down unconditionally. Another function, that selects a choice command to navigate control, sends a proper code {a}, {b},{c},{d},{e},{f} or {g} to the serial interface. The third function, that receives data from the platform, shows the communication link status, motors status and the navigation time.

## V. TESTING AND CONSIDERATIONS

The platform was built mechanically with the electric devices and electronic control for propulsion properly installed. Initial tests were performed in an area of 5000m² , where the navigability and the communication link have proven reliable. The tests have confirmed that the choice of the catamaran architecture with the propellants implementation in the center of each hull showed a good seaworthy condition without the need for a large area for small maneuvers ($1.5m^2$). This feature leads to a considerable saving of energy. The battery used in the power system have supplied energy for more than an hour, of non stop maneuvering, with a loss of 10% of rated voltage.

For electronic systems, the platform held several exercises, including tests to verify the integrity of the communication link failures and central system action. Thus, the results show that the platform is ready to incorporate the sensors and a variety of payloads to support several applications such as the study of marine inertial systems , navigation system for GPS, communication systems, embedded systems based on an on-board computer, image capture system, autonomous navigation system, etc.

Further studies are necessary to optimize the mechanical structure such as propellers, with the goal of improving the hydro-dynamic characteristics and to increase the autonomy of the power system.

## REFERENCES

[1] Boyet, H.,1982 "8051 programming interafacing, paplications: 81 hands-on experiments with Intel´s sdk-51", New York, NY : MIT Publ., 396p.
[2] Gabriela, W, G., 2003, "Desenvolvimento de um software para acionamento de uma plataforma móvel autonoma com microcontrolador" et al São José dos Campos: CTA/ITA, 2003. Único 108p.
[3] Galvão, R.K.H., 2000, "Um barco autônomo para experimentos didáticos" et al. São José dos Campos: CTA/ITA, 2000. Único. 10 p. (CTA/ITA- IEE/AE-022/2000).
[4] Larson, J., 2006, "Autonomous navigation and obstacle avoidance for unmanned surface vehicles" Space and Naval Warfare System Center, San Diego.
[5] Longo, M.B., 1997, "DELPHI 3 total: dominando a ferramenta" Rio de Janeiro, Brasport, 561p.
[6] Shneiderman, B. (2003). "A short history of structured flowcharts". 3 May 2009, http://www.cs.umd.edu/hcil/members/bshneiderman/nsd/