

# Latest contributions to Guanay II

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**Abstract-** This work presents the last contributions incorporated into AUV Guanay II, these have been emerged after some test fields, tests in the swimming pool and in the ocean, such as Mar Menor and Mar Mediterrani.

These improvements are: First in the communication and control systems, for a more fluid communication a WiFi system has been incorporated, this allows access to PC-104 of Guanay II without disassemble it; second, a new RF system to connect and disconnect the electronics and a new method to charge the batteries have been designed; third, a new driver for lateral motor has been developed that allows control the motor in both directions; then the software of the vehicle and the base station has been upgraded to obtain a major and better user control; finally, a new ballast system has been incorporated.

All of new contributions have been tested in the laboratory and in the field.

**Keywords –** AUV, Full bridge, WiFi, buoyancy

## I. INTRODUCTION

Guanay II [1] is an AUV designed for SARTI Research Group of Universitat Politècnica de Catalunya (UPC) with the objective of providing a platform for measuring oceanographic variables, such as temperature and salinity of the water column (upper-water-column), with a high simultaneously spatial and temporal resolution. This project has gone through several processes of evolution in recent years. After performing various field tests and participated in campaigns [2] a number of improvements have been incorporated.

This article aims to present the new contributions made in the vehicle, these improvements have been tested both pool and sea showing a satisfactory progress.

## II. IMPROVEMENTS

### A. Power system: Power on/off and battery charging

In water vehicles the access to connect and disconnect the power source is an important point because the marine environment is hostile. To obtain better access in connect/disconnect control and obtain better security a new antenna with AM receiver has been designed and incorporated. These allow turn on the vehicle Guanay II even in the water.

The bandwidth of AM system is 433 MHz. This bandwidth called Amateur Radio from radio frequency spectra are designated for purposes of private recreation. The system consists of two parts, the receiver and the remote control (Figure 1 A and B). The last one has been incorporated in the new antenna of the vehicle.

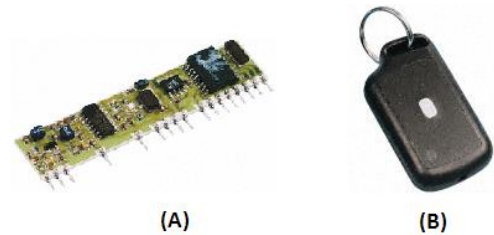


Fig. 1 Receiver (A) and remote control (B) of the connect/disconnect system of the AUV Guanay II

In the other hand, a new external system has been created in order to charge the batteries, allowing charging without disconnect all the electronics. The chemical of the vehicle batteries are NiCd, with 2 packets in serial and 3 in parallel to obtain 24V and 21Ah (figure 2). Until now, to load these batteries it has been used a commercial charger for all single packs. This system involves many problems such as: disconnect the electronics, the time required and the unnecessary risks. To solve these problems a single external charger has been designed.

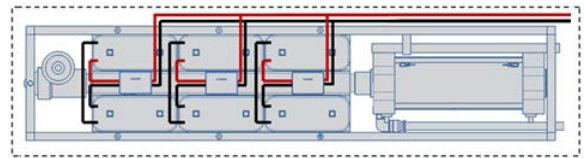


Fig. 2 The two NiCd battery packets in serial and three in parallel (2s3p configuration) of Guanay II AUV

The methods of charge for NiCd batteries can be classified as follows according to the purpose of use and the charge time [3]:

#### Cycle use

- 1 to 2 hours →  $\Delta v$  cut-off charge system  
dT/dt charge system
- 6 to 8 hours → Timer-controlled charge system
- 15 hours → Semi-constant-current charge system

#### Standby use

- Continuous charge → Trickle charge system

A semi-constant-current charge system has been used. This method is recommended for charging batteries in parallel. In

addition requires less hardware [4], this allows use one of remaining power SubConn connectors in the sealed cylinder.

**B. Control system: Communication unit**

Other improvement introduced in the vehicle is a WiFi communication system. This system allows connect directly to the PC-104. With this connection the software can be modified and is possible to download vehicle data stored remotely in laboratory and in field tests. This avoids opening the sealed cylinder of electronics. Thus, greatly improves the preparation time.

A USB-WiFi modem has been incorporated in the new antenna of the vehicle to provide to PC-104 a wireless connection. So, a local access network can be created with this antenna and a wifi modem in base station for allow communicate with PCs or tablets (figure 3).



Fig. 3 Diagram for communication system of Guanay II AUV

**C. Propulsion systems: Lateral thruster driver**

A new driver for lateral thrusters has been designed. This driver allows control the motors in both directions, obtaining a better turn radius of Guanay II. For this purpose a full bridge controller is designed for each lateral thruster. Figure 4 shows a block diagram for the thrusters system. The PC-104 is the main control of the vehicle and it controls a slave micro controller (PIC16Fxx) via RS-232 communication. This slave controller generate appropriate PWM signals to control the two full bridges driver.

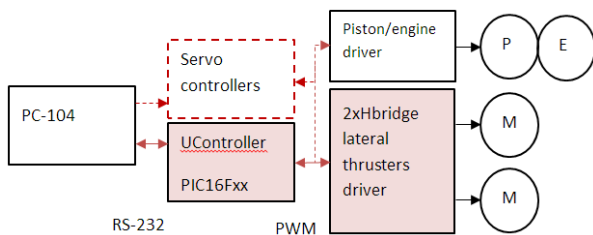


Fig. 4 Block diagram for the thrusters system of the Guanay II AUV

The specific IC has been chosen is DRV8432, a dual full bridge from Texas Instruments. Figure 5 shows PCB prototype of this system.



Fig. 5 DRV8432 dual full bridge driver for the two lateral thrusters

The DRV8432 has high performance, using dual full bridge motor drivers with an advanced protection system. These safeguards are short-circuit protection, overcurrent protection, undervoltage protection, and two-stage thermal protection. In the other hand, this IC has a programmable overcurrent detector that allows an adjustable current limit and protection level to meet different motor requirements.

**D. Ballast system**

A new system for buoyancy and tilt adjustment has been added. This system consists of a mobile carriage in the bottom of the vehicle shell (figure 6). Changing the weight of the carriage and position will change the buoyancy and inclination. A payload of 4 kg can also be added.

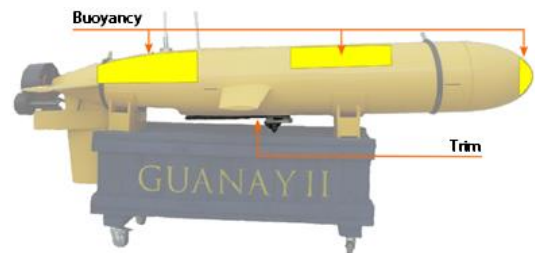


Fig. 6 New systems for buoyancy and tilt adjustment

In the other hand, a new buoyancy module has been developed, using hard polyurethane H130 capable of supporting high pressures. Three modules are manufactured with hydrodynamic shapes to be placed on the vehicle (figure 6).

**III. RESULTS**

All systems have been tested in the laboratory and in field. First, figure 7 shows the output of thruster driver. Two signals can be seen, one with duty cycle of 90% (18.3V of mean voltage) and one with duty cycle of 10% (-17.8V of mean voltage). These signals can drive the thrusters in both directions and can control the energy supplied.

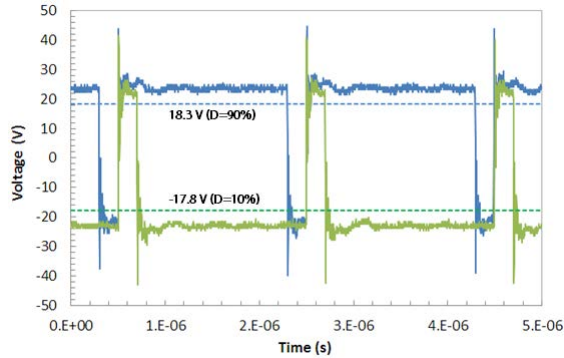


Fig. 7 Signals for the two lateral thruster driver

Also, a battery system study has been made to observe their behavior during loading, basically their load currents through a test bed. The results can be seen in figure 8 shows that one of the serial packets has a different load current. This is one of the reasons that are critically charge NiCd in parallel.

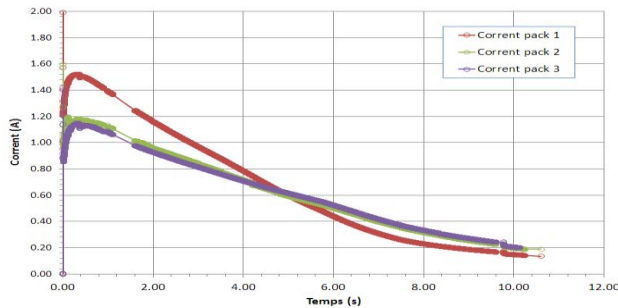


Fig. 8 Load currents of each of the three battery packs

In the other hand, a test field has been carried out. For example, a navigation test has been conducted at the Canal Olímpic de Catalunya in Castelldefels. This test has been used to test the thrusters control system and the new communications system with the vehicle (figure 9).



Fig. 9 Tests at Canal Olímpic de Catalunya in Castelldefels for test the thrusters control system and the communications with the vehicle

Finally, all the latest contributions have been tested in the Mar Mediterrani sea at OBSEA [5] (expandable seafloor

observatory, near Vilanova i la Geltrú coast). This is a good place for test the vehicle and validates the new systems implemented.

#### IV. CONCLUSIONS

All of new contributions have been tested in the laboratory and in the field, obtaining good results in both cases. Results show that the new contributions improve handling and performance of the vehicle. For example: RF connect/disconnect system allow turn-on the vehicle in the water; a better turning radius thanks to new thruster driver; or the improvements in the manipulation and control thanks to WiFi communications and ballast system.

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#### REFERENCES

- [1] I. Masmitja, G. Masmitja, J. González, S. Shariat-Pahani, S. Gomáriz, "Development of a control system for an autonomous underwater vehicle". OES-IEEE AUV'10. Septiembre 2010. Monterey, California.
- [2] González, J.; Masmitjà, I.; Gomáriz, S.; Molino, E.; Del Río, J.; Manuel, A.; Busquets, J.; Guerrero, A.; López, F.; Carreras, M.; Ribas, D.; Carrera, A.; Candela, C.; Ridao, P.; Sousa, J.; Calado, P.; Pinto, J.; Sousa, A.; Martins, R.; Borrajo, D.; Olaya, A.; Garau, B.; González, I.; Torres, S.; Rajan, K.; McCann, M.; Gilabert, J. "AUV based multi-vehicle collaboration: Salinity studies in Mar Menor Coastal Lagoon" Navigation, Guidance and Control of Underwater Vehicles, volume #3 | part# 1. DOI: 10.3182/20120410-3-PT-4028.00048.
- [3] Matsushita Battery Industrial Co "Panasonic Nickel Cadmium Batteries Technical Handbook" Matsushita Battery Industrial Company, Alkaline Storage Battery Division. August 1998, page 11.
- [4] Ivan Masmitjà, Julián González, Gerard Masmitjà, Spartacus Gomáriz, Joaquín del Río Fernández. "Measuring system and power management of the Guanay II AUV" 19th IMEKO TC 4 Symposium. July 2013, Barcelona.
- [5] Nogueras, M.; del Rio, J.; Cadena, J.; Sorribas, J.; Artero, C.; Danobeitia, J.; Manuel, A. "OBSEA an oceanographic seafloor observatory" Industrial Electronics (ISIE), 2010 IEEE International Symposium. 10.1109/ISIE.2010.5637675.