System on Chip based Design of a Prototype Unmanned Sea Surface Vehicle

Sudam D Adlinge[1], Dr PD Shendge[2], Dr Manu Korulla[3], and Sivayazi Kappagantula[4]

[1,2]Instrumentation and Control Engineering, College of Engineering Pune
[3]Hydrodynamic Research Wing, Naval Science and Technological Lab, DRDO, Visakhapatnam
[4]Mechanical Engineering Department, Defence Institute of Advanced Technology, Pune
Email: [1]adlingesd@gmail.com, [2]pds.instru@coep.ac.in, [3]manu.korulla@yahoo.co.in, [4]sivayazi@gmail.com

***Abstract*—This paper discusses regarding design and development of a simple, low cost, the prototype of an Unmanned Sea Surface Vehicle (USSV). Prototype USSV using System on Chip(SoC) can be developed which could be used for carrying out surveillance at sea and underwater survey operations.After implementing autonomous control system this vehicle can be used for more complex operation such as Intelligence Surveillance and Reconnaissance (ISR) operations. This vehicle is developed based on centralized architecture, System on Chip (SoC). Interfacing circuits using analog components are designed so that input-output devices can be reliably interfaced. Interfacing Software, Communication Protocols, and the Remote control panel is designed and developed for the prototype USSV. Selection of off the shelf navigation and Instrumentation sensors, Thrusters, Communication systems and Payloads with its interfacing is briefly explained in the paper. Finally tests and trial results are discussed along with conclusions and further scope for improvement.**

***Index Terms*—Unmanned Sea Surface Vehicle, System on Chip, Hardware and software design, Development of algorithm formation, Remote control design, Interfacing of sensors and Input-output device, Tests and Trials, Conclusions and scope for improvements**

I. Introduction

An Unmanned Sea Surface Vehicle (USSV) is a robotic vehicle which is driven through the water by a propulsion system and piloted by an onboard computer with remote control. A functional block diagram of basic USSV subsystems is shown in figure 1.

India has large coastal area and exclusive economic zone (EEZ) which needs to be constantly surveyed for sustainable exploitation and to be guarded and protected from infiltrators and unlawful activities. In the recent past, coastal security has become a subject of great concern. Increased awareness and demand for coastal surveillance coupled with advances in technology has brought in the possibility of deploying USSVs for maritime security and survey. USSV can relieve man out of areas of danger in the sea and accomplish repetitive surveillance of vast coastal area with ease. USSV can be used either independently or can be teamed up with Autonomous Underwater Vehicles (AUV), Unmanned Aerial Vehicles (UAV), manned aircrafts and ships, satellites or a combination of such platforms to serve as an effective force multiplier in a battle space. In this paper, an attempt has been made to design, develop and implement a Low-cost Prototype Vehicle Control System for a Remotely Operated Unmanned Sea Surface Vehicle based on System on Chip.

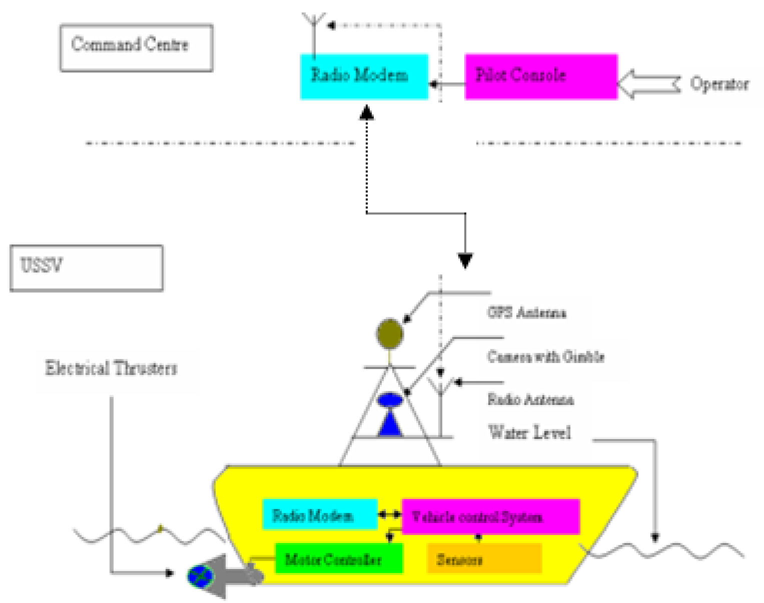

Fig. 1: USSV Block Diagram

II. Design and developments of Prototype USSV

The development of USSV technology can be dated back to World War II. First attempts were primarily to develop torpedo type vehicles to clear mines or obstacles in the surface zone. [1], In 1946 USSVs were used to collect water samples after atomic testing on Bikini Atoll. Another common use was (and still is) to use the USSV's as target drone boats for target training. [1] These vessels were typically operated as radio controlled boats. But recently, the focus has shifted from using these vehicles for mere target practice to much more complex operations such as Intelligence Surveillance and Reconnaissance (ISR) missions. Attacks on Marine Assets such as USS Cole (2000), French oil Tanker Limburg (2002), Philippine Superferry 14 (2004), and Khor Al Amaya oil terminal (2004), [7] and recent attacks in Mumbai by terrorists have driven an increased interest in anti-terrorism and littoral

TABLE I: Vehicle Characteristics

Sr.No	Specification	Value)
01	Length (over-all)	1.6 m
02	Width (over-all)	0.6 m
03	Depth	0.3 m Aft 0.4 m forward
04	Displacement	40 Kgs
05	Design Speed	2 to 4 knots

warfare. In the modern age, USSV was first developed in 1993 at MIT, Sea Grant College program, named ARTEMIS which was capable of testing the navigation and control systems. [2], thereafter many vehicles were developed around the world. In India there is not much research has taken place in this area.notably, National Institute of Oceanography, Goa, has developed a USSV named ROSS (remotely operable sea skimmer) which was an early prototype that could be operated remotely with a joystick. ROSS is a small craft having a length of 1.6 m, hull width of 35 cm, and a weight of 90 kg and it has two spaced out dc motor driven thrusters attached to its undercarriage [3].

- Vehicle Systems

The USSV comprises of a self-propelled the boat with different systems required for remote controlling along with power sources and other sensors as discussed in the subsequent paragraphs.

(i) Vehicle Platform: considering the facts that this vehicle will be at sea during its operation, carrying out some dedicated mission application, Catamaran hull [4], which is stable and has a low hydrodynamic drag with a high deck area is selected for the application.This vehicle is made up of Fiber reinforced plastic (FRP), which is lighter and maintenance free. The Vehicle Characteristics are indicated in Table 1.

(ii) Propulsion: To provide thrust for moving the vehicle in the forward and reverse directions, two 24 VDC, 300-watt propulsion thrusters along with PWM controller are selected.Thruster and controller are shown in figure 4.

(iii) Navigational Aids: GPS which gives latitude, longitude, course, and speed of the vehicle with 10 meters accuracy of M/s Furuno is selected for the vehicle. To obtain heading, roll, and pitch of the vehicle a magnetic compass of M/s Honeywell, the USA which is very light (92 grams) and provides accuracy of 0.5 with 0.1 Resolution is selected for the application.This Compass gives data output in serial full-duplex RS-232 format. Magnetic Compass is mounted in a watertight enclosure and antenna is mounted on a pole for getting a good signal.Figure 2 indicates Magnetic compass and GPS antenna mounting.

(iv) Communication: Ultra high frequency (UHF) radio frequency modem of M/s Elpro which has a range of 5-6 Km with a baud rate of 4.8 kbps is selected for the communication.Communication done by this modem is a half duplex.As original UHF modem is fragile and is not waterproof, an antenna is covered with FRP.Figure 3 shows communication modem mounted in a watertight enclosure and an antenna with FRP enclosure.

(v) Power: Four Lead-acid Batteries of 6 V 10 Ah capacity selected for the vehicle testing and trials.The higher capacity battery can be used for longer endurance.

(vi) Instrumentation: To monitor the health of the vehicle and systems, three kinds of sensors have been selected. Voltage sensor monitors battery status and current sensor monitors the power consumption by the systems and sub-systems. Leak sensor monitors any water leak in the vehicle. As this vehicle is designed to be operated at sea, water leak sensor is a very important tool for checking any leak in the vehicle. The Hall Effect based voltage and current sensor are used which gives a standard output of voltage of 0 to 4 Volt. Leak sensor is made up of two conductors separated by a small insulating material.Leak sensor based on Single clad PCB, which is developed by Naval Science Technological Lab is used in-view of stable and accurate performance.Single clad PCB can

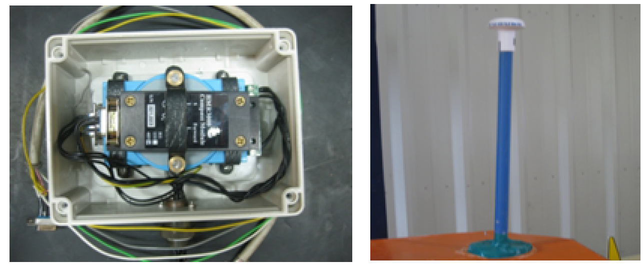

Fig. 2: Magnetic Compass and GPS Antenna

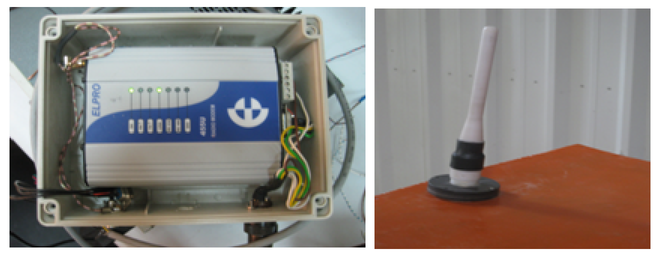

Fig. 3: UHF Modem and Antenna

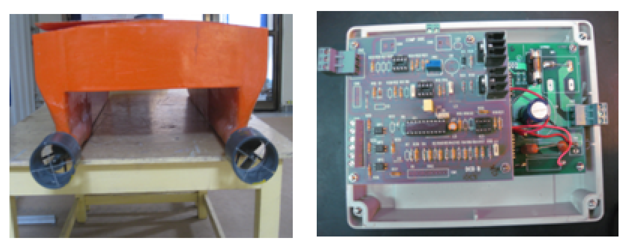

Fig. 4: Thruster and Controller

be easily mounted to the hull of USSV.When seawater is in contact with the two conductors a short circuit is created and the leak is sensed.Figure 5 indicates Integrated voltage sensor and leak sensor

(vii) Payloads: ISR and underwater survey operation are the two functions which are considered to be performed by this vehicle. CCTV camera with real-time transmission capability is considered for the vehicle.CCTV camera to be mounted on the mast of the vehicle. This camera can capture continuous images and after capturing these images, are transmitted in real time to the command and control station with the help of a dedicated Radio transmitter and Receiver.Altimeter with measuring a range of 100 meters with a range resolution of 2 mm is considered for carrying out underwater survey operation.

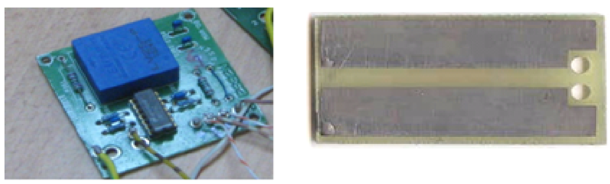

Fig. 5: Voltage sensor and Leak sensor

(viii) Control of the vehicle: USSV requires to be controlled to maintain course and to change course during any mission. To keep the control simpler and to reduce the sub-systems on board the vehicle, control using differential mode of propulsion thruster has been selected using PD controller. Vehicle Control using rudder will be added on in future

(ix) Development of Vehicle Control system: The Vehicle control system (VCS) is the brain of the vehicle.SoC alongwith interfacing circuits, power supply unit and its connectors form the VCS. The Vehicle Control System will receive data from command and control station through UHF link, VCS which in-turn decode this data and control the vehicle operation based on the remote commands and its internal algorithm. VCS will also have the provision to record instrumentation data and transmit important data to command and control station. To reduce the software and hardware complexity a Centralized Architecture for the vehicle development has been selected. An Alarm will be initiated by the VCS which in-turn transmitted to the Command and Control Station over UHF link, whenever an emergency arises in the vehicle. System on Chip C8051F120 manufactured by Silicon Laboratories is considered for the development of VCS due to reasonably good speed, a sufficient number of I/O, ADC, DAC, UART devices is provided onboard. Specifications [12] are provided in Table II.

III. HARDWARE AND SOFTWARE DESIGN FOR VEHICLE CONTROL SYSTEM

A. *Hardware Design:*

The Hardware of the system on chip cannot drive high power systems [12], and it has limited serial ports. Hence, interfacing circuits are required to be designed to interface with the other systems of the vehicle.

TABLE II: SOC Specifications

Sr.No	Specification	Value)
01	Core	High Speed 8051
02	Clock Sources	a) Internal oscillator 24.5 MHz
03	Memory	128 kB Flash, 8 K RAM
04	12-Bit and 8 - bit ADC	08 Each
05	12-Bit DACs	02
06	Serial Ports	02
07	Supply Voltage	3.0 to 3.6 V

(a) Analog to Digital Converter design: This device has 12 - bit SAR ADC (ADC0) with a 9-channel input multiplexer and programmable gain amplifier. With a maximum throughput of 100 kbps, the 12-bit ADC offers true 12-bit linearity. There is a requirement of monitoring three sensors analog output data, one voltage and two current sensors.Hence first three channels of SoC are allocated for each sensor. As the voltage and current sensors output voltage are 0 to 4 V and analog Input channel can accept a maximum voltage of 2.4V, sensor output voltage needs to be suitably reduced before supplying to SoC. Voltage divider network is designed using resistors as shown in figure 6.

(b) Digital to Analog converter Design: SoC include two on-chip 12-bit Digital-to-Analog converters (DAC's). The Starboard (STBD) and Port propulsion thrusters controller need to be controlled via analog channels.Analog output channel can produce output voltage range from 0 V to 2.4 V. But both Motor controllers require control voltage from 0 to 15 V. Hence analog output voltage required to be suitably amplified. Amplifier circuit designed using a non-inverting operational amplifier. The Circuit is shown in figure 7.

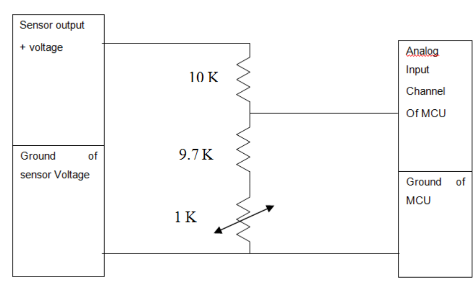

Fig. 6: Voltage divider circuit diagram

(c)Serial Ports Interface design: USSV has two sensors which are giving a serial output that is GPS and Magnetic

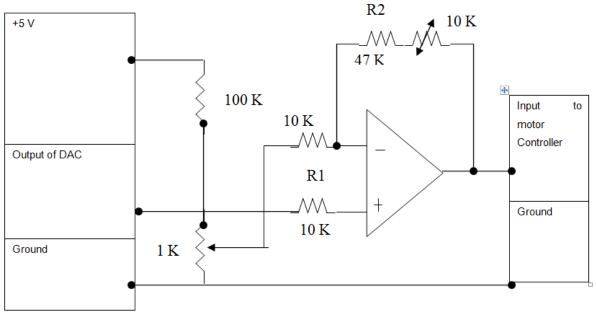

Fig. 7: Voltage amplifier circuit diagram

compass. But SoC has limited UART port.So as to share the UART 1 port, multiplexing is carried out. [6], Multiplexer is switched by MCU digital signal. Selection is based on the time. Magnetic compass data is supplied to UART 1 for 0.5 seconds and next 0.5 seconds GPS data is supplied to UART1. Block diagram is shown in figure 8.

(aa) Multiplexer design: IC 74 LS 158 is selected for 2-

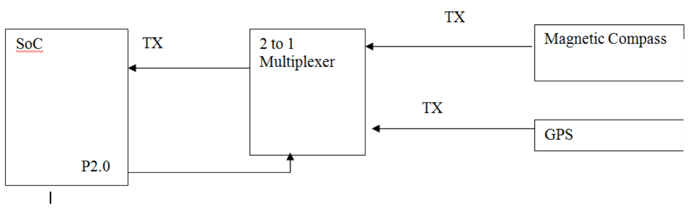

Fig. 8: multiplexer block diagram

1 multiplexer. Select line is controlled by port 2.0. Tx line of magnetic compass and GPS is connected to 1 A and 1 B of multiplexer respectively.The output is taken from 1Y. As the multiplexer output needs to be complemented, inverter IC 74 LS 04 is selected to be interfaced at the output of the multiplexer.

(ab) Serial RS 232 interface: As UART 1 is not configured for RS 232 communication protocol, MAX 232 IC is connected between SoC and inverter IC

(d) Digital Input and output design: Alarm signals are interfaced with digital Input.The digital input can tolerate maximum 5 Volt, hence alarms signals sent through deep relays and in-turn deep relays are interfaced with Digital Input.Digital output pins are interfaced with switching circuits. The digital output can not drive relays directly as SoC maximum output is 3.0 V 20 mA, hence Darlington pair IC 2803 used which can drive load up to 500 mA used to switch electronics systems and deep relays used for switching ON motor power.

B. Software design:

Software design requires allocation of particular channels to the Device, configuring the channel of a system on chip and the data interpretation. Summary of Special Function Register configuration of SoC is given in figure 9 and 10.

Sr.No.	Interface	Port Allocation	Configuring the port	Special function register programming
01	Digital output	Port 2.0 to port 2.7	Configured as push pull	P2MDOUT and crossbar XBR2.6 enable
02	Digital Input	Port 3.0 to port 3.3	Configured as open drain and port pins as logic 1	P2MDOUT and crossbar XBR 2.6 enable
03	Serial channel Port allocation	(i). Port 0.0 Tx & port 0.1 for Rx of UART 0 (ii). Port 1.0 Tx & port 1.1 for Rx of UART 1	Configured Tx pin as push pull and Rx pin as open drain	(i). P0MDOUT and crossbar XBR0.3 enable (ii). P1MDOUT and crossbar XBR 2.3 enable
04	Digital to Analog Converter	(i). DAC 0 and (ii). DAC1	(i). Enabling DAC (ii). Selecting DAC mode (iii). Selecting DAC Data Format Bits (iv). Enabling Reference supply	(i). DAC Control register DAC0CN (ii). Reference supply Control register REF0CN
05	Analog to Digital Converter	(i). ADC 0 .1 to 0.3	(i). Timer configuration (ii). ADC tracking mode (iii). Start of conversion (iv). Selection of Data format (v). SAR Conversion setting (vi). PGA Gain Setting (vii). Multiplexer selection viii). Reference supply selection	(i). Timer 3 control register TMR3CN (ii). ADC control Register ADC0CN (iii). ADC Configuration Register ADC0CF (iv). Reference supply control register REF0CN

Fig. 9: Summary of Special Function Register Configuration

Sr.No.	Interface	Port Allocation	Configuring the port	Special function register programming
06	Serial Input /output	UART0 & UART 1	(I).Timer Configuration (II).Serial port Control setting (III). UART Status & clock selection (IV).Receive Baudrate selection (V). Transmit Baud rate selection	(I).Timer Configuration Register TMR2CN & TMR1CN (II). Serial port Control Register SCON0 and SCON1 UART Status & clock selection register SSTA0 & SSTA1
07	Oscillator settings	(I).Internal Oscillator control settings (II). System Clock selection settings (III).External oscillator Control settings (IV).PLL Control Settings (V).PLL Pre-divider settings (VI). PLL Clock Scalar Setting (VII). PLL Filter control Setting (VIII).Selecting PLL as a clock		(I).Internal Oscillator control Register OSCICN (II).System Clock selection Register CLKSEL (III).External oscillator Control Register OSXCN (IV).PLL Control Settings Register PLLOCN (V). PLL Pre-divider settings Register PLL0DIV (VI). PLL Clock Scaler Setting Register PLL0MUL (VII). PLL Filter control Setting Register PLLOFLT (VIII). Selecting PLL as a clock CLKSEL

Fig. 10: Summary of Special Function Register Configuration

IV. ALGORITHM FOR SOFTWARE DEVELOPMENT ON SYSTEM ON CHIP (SOC)

A. Remote control of USSV

(a) Initialize oscillator.
(b) Initialize crossbar and Group I/O.
(c) Initialize UART 0 and timer

(d) Initialize DAC0 and DAC1.
(e) Receive data on UART0.
(f) If Byte = A, store byte in a CONTROL-CMDS(cnt) array.
(g) If Byte = D, assume data transmission is complete and carry out.
(aa) Switching of Output ports: Eight switching ON/OFF commands to be executed.
(ab) Send data to DAC: data is shifted to left by 4 bits and multiplied by 455 and written to DAC0 and DAC 1.
(h) Continue (f) and (g) till remote control command are being sent.

B. *Data Acquisition of sensors which are giving analog o/p*

(a) Initialize ADC.
(b) Initialize timer 3.
(c) Receive data on AIN0.1.
(d) 12-bit ADC value is averaged across measurements.

$$Measurement(mV) = \frac{V_{ref}(mV)}{2^{12} - 1(bits)} \times Results(bits) \quad (1)$$

(e) The result is then stored as right-justified in an array.

samples[input] [num-samples] = measurement
(f) If Measurement ≥ 4000 mV set voltage-alarm Bit.
(g) Receive next analog input i.e. AIN0.2 and repeat paragraph (d) to (f).
(h)If Measurement ≥ 4000 mV set Current_alarm Bit.
(j) Receive next analog input i.e. AIN0.3 and repeat para (d) to (f).
(k) Update sample count.
(l) If a number of samples = 1024 samples then reset the sample count.
(m) Repeat (c) to (l).

C. *Data acquisition of sensors which are giving serial o/p*

(a) Initialize UART 1 and timer 1.
(b) Initialize timer 4.
(c) Start timer 4 and set timer 4 to 500 milliseconds delay.
(d) Receive data on UART1.
(aa) Store byte in a Compass- data(i) array.
(e) Carry out para (c) operation for 500 milliseconds. At the end of 0.5 seconds set the port 2.0 to high so that multiplexer changes the UART 1 input.
(f) Receive data on UART1.
(aa) Store byte in a GPS- data[i] array.
(g) Carry out para (f) operation for 500 milliseconds. at the end of 500 milliseconds. Set the Port 2.0 to low so that multiplexer changes the UART 1 input
(h) Repeat para (c) to (g)

D. *Transmission of data to remote :*

(a) Initialize data-out (i) array: following data to be initialized
(aa) Leak Alarm
(ab) Motor Shutdown
(ac) Voltage alarm
(ad) Current alarm
(ae) GPS data
(b) Initialize UART0
(c) Send the data via UART 0

E. *Communication Protocols Development:*

(a) Communication Protocol from Remote control Panel PC to USSV: Data is required to be transmitted and received from remote control panel and USSV hence communication protocol is designed which is indicated in Table III

F. *Communication Protocol from USSV to Remote Control Panel PC :*

(a) Byte1- Header Byte A
(b) Byte 2 Leak-alarm
(c) Byte 3 Shutdown alarm
(d) Byte 4 Voltage-alarm
(e) Byte 5 Current- alarm
(f) Byte 6- GPS data
(g) Byte 7 - Carriage return byte

G. *Remote Control Panel Programming:*

Remote control panel programming is carried out using Labview software
(i) Following Commands are given from remote panel
(a) Header byte A
(b) Switch ON /OFF all system
(c) Switch On Motor supply
(d) Emergency shutdown
(e) Remote/Auto
(f) Direction of STBD thruster
(g) Direction of Port thruster
(h) Direction of Rudder
(i) Auto Override
(j) STBD Thruster Command
(k) PORT Thruster Command
Serial No (a) to (i) are On/Off commands and serial number (j) and (k) are analog commands. These all commands are combined as one string and this string is sent to COM port every after the set delay time.
(ii) Following Data is displayed on remote control Panel
(a) Leak -alarm
(b) Shutdown-bit alarm
(c) Voltage-alarm
(d) Current-alarm
(e) GPS data
This data is received in the serial channel, the data is

TABLE III: Communication Protocol from Remote to USSV

Sr.No	Byte No	Command Description	Byte Data
01	Byte 1	Header byte	A
02	Byte 2	Switch ON all system	01-ON 00-0FF
03	Byte 3	Switch On Motor Supply	01-ON 00-0FF
04	Byte 4	Emergency shut down	01- Shut down 00- NO Action
05	Byte 5	Remote/Auto	01- Auto 00 Remote
06	Byte 6	Direction of rotation of STBD thruster	01- Anti-clockwise 00 Clock wise
07	Byte 7	Direction of rotation of PORT thruster	01- Anti-clockwise 00 Clock wise
08	Byte 8	Direction of Rudder	01- Right 00 Left
09	Byte 9	Auto override	01- Override 00- NO Action
10	Byte 10	Switch on Lights and Camera	01-ON 00-0FF
11	Byte 11	STBD Propulsion Thruster Command	Analog Value
12	Byte 12	PORT Propulsion Thruster Command	Analog Value
13	Byte 13	Carriage return Byte	D

separated as per protocols and the particular alarm is initiated. GPS data is decoded for Latitude, Longitude, course, and speed of the vehicle.

The Graphical user interface front panel design is shown in figure 10.

V. RESULTS AND DISCUSSIONS

Conduct of Lab Test and trials were conducted at Naval Science and Technological lab of DRDO at Visakhapatnam. Few results are shown below.

- Test results

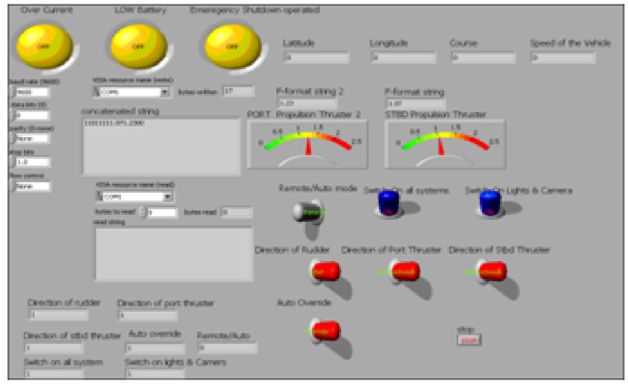

Fig. 11: Remote Control panel display

(i) Execution of remote commands test: Execution of remote commands test:- In this test remote commands Execution were tested. Figure 12 shows Remote Control of Command and Scale V/s DAC O/P Scale in the USSV, Figure 13 shows Amplification of DAC output. From this, it is found that amplification circuit, software, hardware design of vehicle control system is working as expected as per design

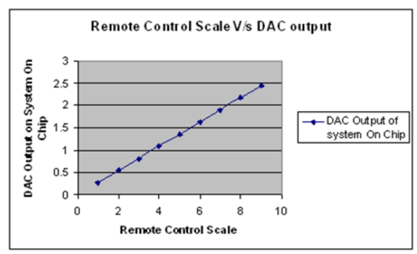

Fig. 12: Remote Control command versus analog output of DAC in the USSV

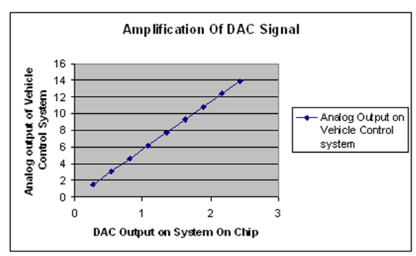

Fig. 13: Amplification of SOC signal

(ii) Data logging of ADC channels: Voltage and current sensor output checked for data logging operation. Figure 14 shows voltage sensor output graph and Figure 15 shows current sensor output graph during calibration.

A. *Observations and modifications after bench tests :*

Observations and modifications after bench tests (i) Thruster motor controller were designed to operate at control

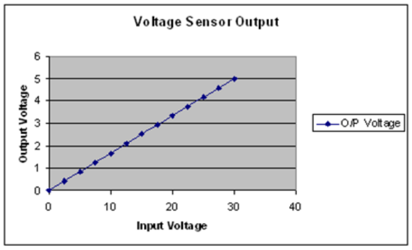

Fig. 14: The Voltage Sensor output

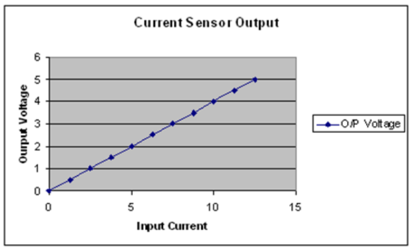

Fig. 15: The Current sensor output

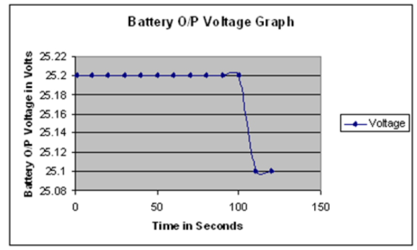

Fig. 16: Battery output graph

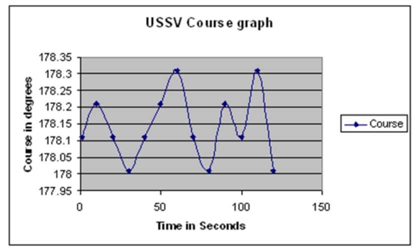

Fig. 17: Course followed by USSV during 2 minutes run

voltage 0 to 15 voltage but after testing it was found that it is operating only up to 0 to 12.40V, hence amplification factor in the vehicle control systems reduced to 5 from 6.Thus R2 resistor replaced with 37 K value resistor instead of 47 K value.
(ii) Digital input/output interfacing: Darlington pair buffer IC ULN 2803 performance was not consistent, hence this IC was replaced with the opto-isolator IC.

- Trials

After carrying out relevant bench tests all the systems and subsystems were installed in the vehicle as per layout plan. After installation, all the systems were connected to each other as per electrical wiring diagram. System checks were carried out again before taking the vehicle for trials. Once the system checks were satisfactory, the vehicle was taken to the High speed towing tank of NSTL. The vehicle was lowered in water and allowed to settle down. Then commands were given through the command and control panel. Figure 18 shows command and Control Station PC during trials and Figure 19 shows USSV in water during trials.

Trial result i) Data logging of ADC channels: After the trials, Data downloaded from the SoC and analyzed.Figure 6.16 shows Battery output voltage graph and figure 6.17 shows course followed by USSV in water. It indicates that battery lasted for run but after that battery supply got disconnected after run.Course graph indicates vehicle traveled straight with minor deviations.

VI. CONCLUSION

This paper presents simple, low-cost approach towards implementation of prototype Unmanned Sea Surface Vehicle platform with remote control using off the shelf components.following are the conclusions
(i)Centralized architecture based on system on Chip is ideally suited for concept proving and to reduce the software complexity.
(ii) GPS and UHF antenna can be covered with Fiber Reinforced Plastics material so as to make it waterproof, without losing signal strength.
(iii) I/O devices can be interfaced using voltage divider network, amplifiers based on OPAMPs, multiplexers etc.
(iv) Data acquisition and control of USSV can be done using algorithm and communication protocols explained in the paper.
(v) Remote Control Panel programming can be done with user-friendly GUI software such as Labview.
(vi) This USSV can also be used as a standalone unit which can carry any mission payloads up to 5 Kg in weight
(vii) Optical buffer IC need to be used instead of transistor based IC as this will give good isolation characteristics.

VII. SCOPE FOR IMPROVEMENT

There is a ample scope for improving and upgrading the system performance. Following improvements are suggested.
(i) System on Chip with more serial ports can be considered for future Development.
(ii) Higher capacity flash memory will be useful to store more data for a longer duration.
(iii) Vehicle Control System hardware to be rugadized to sustain the shock, Vibration and it is to be made heat resistant.
(iv) UHF Modem with full duplex communication to be used for this kind of application so that data transmission and reception happen simultaneously.
(v) This vehicle can be made to work in autonomous mode

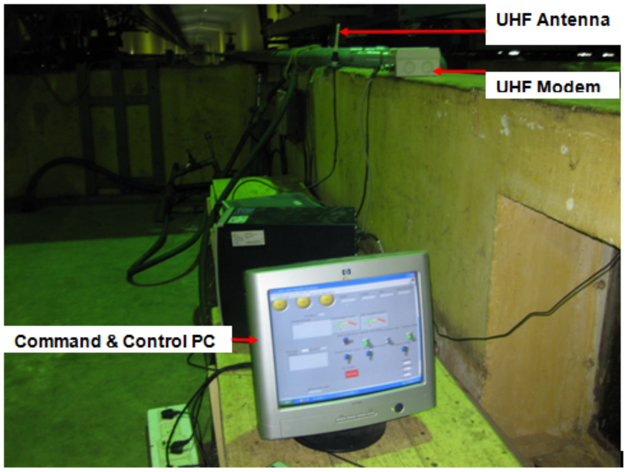

Fig. 18: Remote Control Station during Trials

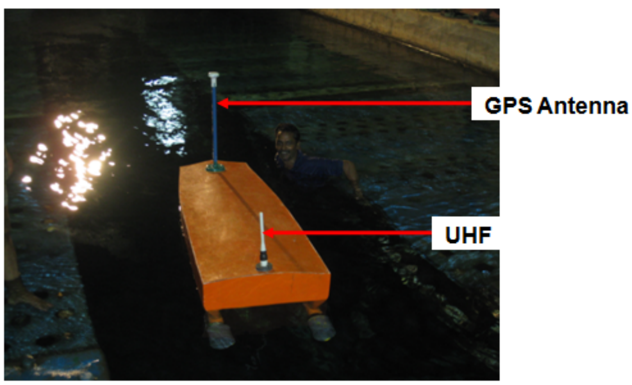

Fig. 19: USSV in water during trials

by using suitable algorithm and controller.
(vi) DGPS can be used in place of GPS for more accuracy.
(vii) Graphical User Interface Software can be made more user-friendly and imitate real driving wheels and speed control.

ACKNOWLEDGMENT

I express my sincere and heartfelt gratitude to Dr. V. Bhujanga Rao, the then Director, NSTL for giving me permission to do the project work at the Naval Sciences and Technological Laboratory (NSTL), Visakhapatnam. I express my profound the sense of gratitude to Dr. Manu Korulla, Scientist 'G' and Sri. Bharatwaja Srinivasan, scientist 'E' of NSTL for the constant guidance in every stage of work. I express my deep sense of gratitude to Dr. PD Shendge, Associate Professor, Department of Instrumentation and Control Engineering, College Of Engineering, Pune for his valuable suggestions, benevolent guidance, support and encouragement during the paper writing.

REFERENCES

[1] Volker Bertram,"Unmanned Surface Vehicles A Survey", ENSIETA, 2 rue Franois Verny, F-29806 Brest, France.
[2] Justin E. Manley,"Unmanned Surface Vehicles, 15 Years of Development".
[3] Elgar Desa, Pramod Kumar Maurya,et.al,"A Small Autonomous Surface Vehicle for Ocean Color Remote Sensing", IEEE JOURNAL OF OCEANIC ENGINEERING, vol. 32, no - 2, April 2007,page353 to 364.
[4] J. Alves, P. Oliveira, R. Oliveira, A. Pascoal, M. Rufino, L. Sebastiao, C. Silvestre,"Vehicle and Mission Control of the DELFIM Autonomous Surface Craft", Institute for Systems and Robotics, 1046-001 Lisboa, Portugal.
[5] Joseph Curcio, John Leonard, and Andrew Patrikalakis,"SCOUT A Low Cost Autonomous Surface Platform for Research in Cooperative Autonomy", Department of Mechanical Engineering Massachusetts Institute of Technology, Cambridge, MA.
[6] Muhammad Ali Mazidi, Rolin D. McKinlay,"the 8051 Microcontroller and embedded systems using assembly and C".
[7] James Colito,"Autonomous Mission Planning and Execution for Unmanned Surface Vehicles in Compliance with the Marine Rules of the Road", A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Aeronautics and Astronautics, University of Washington 2007.
[8] M.Caccia, R.Bono, et.al "Design and preliminary sea trials of SESAMO: an autonomous surface vessel for the study and characterization of the air-sea interface", CNR-ISSIA Sez. di Genova, Via De Marini 6, 16149 Genova, Italy, and Dip. Scienze Ambientali, Calle Larga Santa Marta 2137, 30123 Venezia, Italy.
[9] Seth Clark, Evan Karlik, Harry Lichter, Mitul Luhar, Cha- Ling O Connell, Roberto Rangel, James Sannino, Nina Young,"Knight Boat: Design of an Autonomous, Homing Surface Vessel", A Powerpoint presentation.
[10] Volker Bertram,"Unmanned Surface Vehicles A Survey", ENSIETA, 2 rue Franois Verny, F-29806 Brest, France.
[11] Dr. Robert Mons,"Design and Testing of the Spartan USV Mine Warfare Module", Sr. Advisory Engineer, Northrop Grumman Corporation, Power point presentation 14 June, 2005.
[12] Data sheet and User Guide,"Mixed Signal ISP Flash MCU Family 8051F120/1/2/3/C8051F130/1/2/3 "
[13] Data sheet and User Guide,"Max 232 ,LM124/LM224/LM324/LM2902 "