International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 10, October - 2013

Development of Embedded Processor Based "Communication and Acquisition System"

[1]**G.P.S.Prasanthi,**
Student ,
Gayatri Vidya Parishad College of Engineering for Women (Affiliated to JNTU Kakinada, A.P.,India), Visakhapatna.

[2]**Smt. K. S. Padmaja,**
Scientist 'F',
Naval Science and Technological Laboratory (NSTL), Government of India, Visakhapatnam.

[3]**Mr. R. Sunil Kumar,**
Assistant Professor ,
Gayatri Vidya Parishad College of Engineering for Women, Visakhapatnam, AP, India.

Abstract

There has been growing interest in acquiring Oceanographic data due to the importance of the natural resources at different aspects of human life and monitoring aqueous environments (including oceans, rivers, lakes, ponds and reservoirs, etc.) for scientific exploration, commercial exploitation and protection from attacks. The traditional approach for Oceanographic data acquisition is based on Sea King 704 series/Sea Net System, which is interfaced to the PowerPC440Embedded Processor based Communication and Acquisition System (CAS) in the Underwater Vehicle. This Embedded Processor based system provides communication between the subsystems of the Underwater Vehicle using high performance Octal Universal Asynchronous Receiver Transmitter (UART) and Tritech underwater coaxial connectors. The most challenging part of this system is to establish communication between the mother ship and underwater vehicle using Acoustic and Ultra High Frequency (UHF) modems. The PPC440EP based CAS system is simpler to calibrate different torpedo parameters, can readily accept wireless communication networks and achieved good quality results compare with the sensors designed in previous works. Software is to be developed in higher level language Embedded 'C' using Green hills cross compiler to acquire, store the data and monitor the health of the system. To download the data from vehicle to surface a user friendly GUI (Graphical User Interface) has been developed using Visual basic 6.0 and MAT lab simulink.

"1. Introduction"

Embedded Processor plays a vital role in marine applications for acquiring the oceanographic data continuously and controlling the essential functions of underwater vehicle without human intervention. The PPC440EP [5] provides high performance and offers low power dissipation with CPU executing at sustained speeds approaching two instructions per cycle. It operates at high frequencies upto 667MHz and also supports dominant communication and storage capabilities. On-chip peripherals reduce chip count and design complexity in systems and improve system throughput. This is the main reason that chips of PowerPC family accounting for more than 80% of the market share.

The Embedded Processor based Communication and Acquisition system (CAS) is interfaced with different sensors and instruments such as Sea King system (Altimeter with CTD), Acoustic and UHF modems via underwater connectors, which are placed in the underwater vehicles. The PowerPC440Embedded Processor based CAS has an on the chip Analog to Digital Converters (ADC's) to convert the acquired analog data into digital form.

There are two processes in this discipline namely online or Real-time process and offline process. In online process, three main functions are "Acquisition, Storage and Monitoring the health of the underwater vehicle by providing wireless Acoustic and UHF sensor networks". The acquired oceanographic data is stored in Embedded Processor's NAND Flash memory [6] for future run analysis. To program NAND Flash devices Trace 32 [7] is used and the most frequently used development tool for PowerPC440EmbeddedProcessor is Green Hills Cross Compiler.

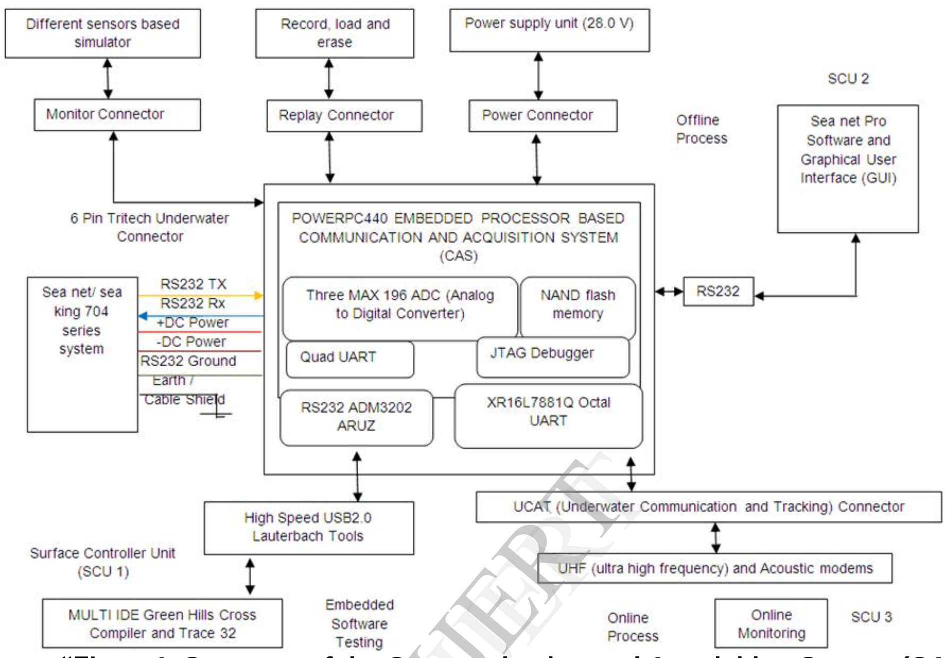
Underwater vehicles are reusable and recoverable. The critical parameters of the different subsystems of the underwater vehicle are downloaded when the underwater vehicles are resurfaced. Also, the vehicle is recoverable incase of major failures in the hardware and software. The associative function of this offline process is to "recognize and detect failures" by observing defects and various changing parameters of the dynamic vehicle.

"2. Embedded Processor Based Communication and Acquisition System (CAS)"

PowerPC440Embedded Processor based CAS is the essential unit in the underwater vehicle. The CAS controls the stability, navigation and guidance of the vehicle while executing the desired system operations. It can interface with Sea net system, Simulator, Power supply unit, Acoustic and

UHF modems via RS232ADM3202ARUZ [14] through underwater coaxial connectors. The Sea Net/ Sea King 704 Series [8] of bathymetric and oceanographic sensors are supplied with Paro scientific Digi quartz Precision Depth Sensor, Falmouth Scientific Conductivity & Temperature Sensor and Tritech PA500/6-S Precision Altimeter. Simulator can simulate the navigational data such as voltage, current values from different sensors attached to it.

Additional control of the vehicle can be achieved by human intervention from the mother ship using Acoustic and UHF through CAS via Underwater Communication and Tracking (UCAT) connector. These two modems are connected to the high performance Octal UART [9] in CAS via UCAT connector. CAS will be capable of handling command and responses. The commands received from the mother ship PC through modems will be passed to the CAS and response from CAS will be sent through modems as per requirement.



"Figure1. Structure of the Communication and Acquisition System (CAS)"

Underwater Vehicle has a number of electronic sub-systems for performing various functions. All such sub-systems operate on 24, 28 and 48 VDC supply. A dedicated power sequencing and control unit is provided in the Vehicle for logical distribution and control of these DC power supplies to the respective electronic sub-systems.

"3. Subsystems of Underwater Vehicle"

Sea King 704 Series System

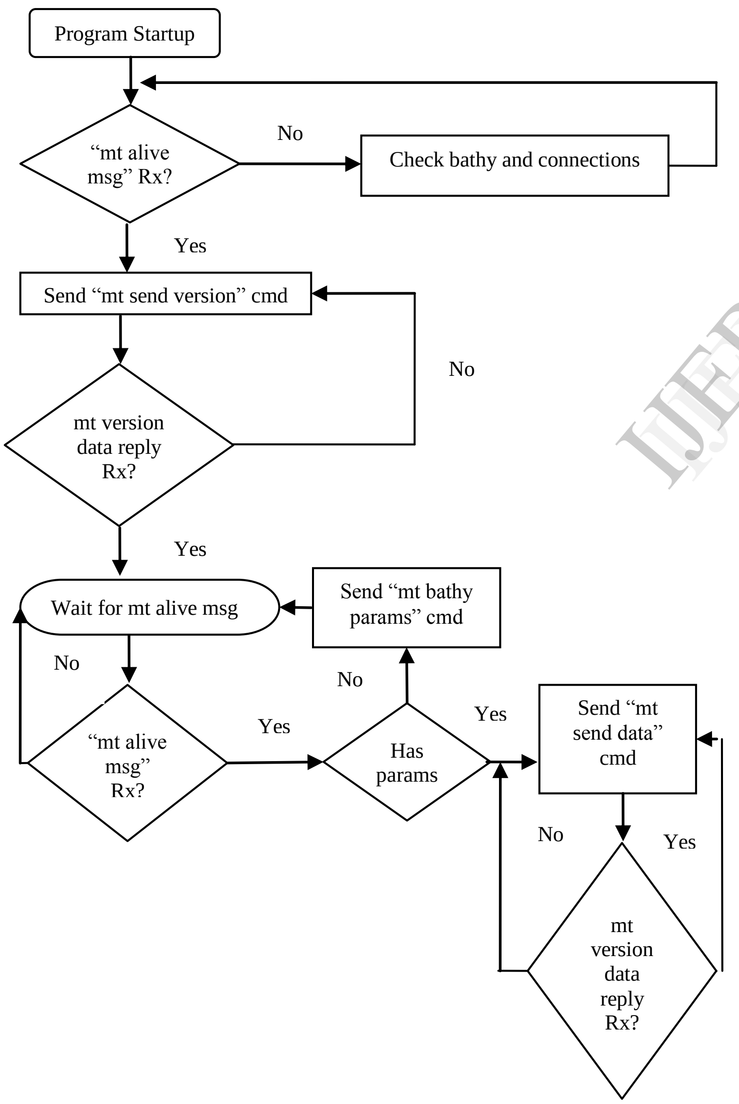
Sea Net System has greatly facilitates the ocean data in bad environments. It is a device which is normally interfaced to PPC440EP based CAS through tritech 6 way underwater connector and Quad UARTs. Sea net has RS232 signals, this signals are routed to PPC440EP Quad UART channel-0. Quad UART channel 0 has its own set of internal UART Configuration Registers for its own operation control, status reporting and data transfer.

Initially the code will be developed in Visual Basic6.0 according to the flow chart [8, Figure 2] designed for sea king 704 series to test whether it is working or not. After testing it, the user has to create a program in Embedded 'C' using Green hills cross compiler to operate the device in real time.

Sea Net Operation: When a sea king device is first powered up, it will ready to transmit a "short broad cast message (mt alive message) of 22 bytes" to the surface controller at a one second time interval. This data represents the status of the sea net device. Once mt alive message have been received through the serial port, the user can start issuing commands and assume full control of sea king bathy operation. The first command send by the user to the device is 'mt send version' command of 14 bytes. The user sends this command to know "software version" of subsea device.

During initially writing the program, the user should communicate with the subsea device and first receive an 'mt version data' reply of 25 bytes back from the subsea device. Within this reply, there can be found 'Program length', 'check sum' information and also supplied with information of what "software version" is pre-installed inside it. Along with 'mt version data' reply, the user has to wait for 'mt alive message' to confirm whether the sea net device broadcasted valid set of environmental parameters [Figure 3] or not. The information of these parameters is available in 14^{th} byte of 'mt alive' message. If this 14^{th} byte does not toggle to the correct value it represents that the device has "No parameters". In this situation surface controller has to send 'mt Bathy Params' command of 56 bytes to the bathy to upload the parameters. These 56 bytes of command includes important instructions and control settings to inform the device "how it should operate". By using these settings the user can control the operation of subsea device otherwise the sea net cannot go to perform its routine functions.

After sending this command to bathy, the user has to wait until the 'mt alive' message has received by bathy. Whenever the parameters are available, the surface controller can send 'mt send data' command of 18 bytes to sea king bathy. 'Mt send data' command is sent to the subsea device in order to instruct the device to perform one sample set. Once the sample set data has been collected, the bathy will transmit an 'mt bathy data' reply message back to the sender. The reply contains all the device parameters such as Echo time, A/D conductivity ('Vc'), A/D Zero end-point Reference ('Vo'), A/D Full end-point Reference ('Vf'), Conductivity sensor's calibration coefficients ('Co', 'Cf'), A/D temperature ('Vt') and Temperature sensor's calibration coefficients ('To', 'T f').



"Figure 2. Flow chart for Sea King Bathy"

Sea Net Calibrations: Altimeter is used to measure the vertical distance of Underwater vehicle with respect to the Sea bottom and CTD is used to continuously measure the Conductivity ,Temperature ,Depth ,Density and Salinity of the Sea water .With this Data vehicle can understand sea Contours and Avoid Grounding during Underwater operation.

The return path echo time [10], in 200 nanosecond clock units, transmitted by the Bathy altimeter. The Altitude can be calculated from this Echo Time by using following equation.

Equation (1): Altitude [meters] = 'Echo Time' * (200 / 10e8)* Velocity of Sound (V.O.S) [m/s] / 2.

The Conductivity sensor is calibrated at both limits of its operating range; a low point and a high point. Calibrations co-efficient ('Co', 'Cf') are provided with each sensor for both end points.

$Cs = (C f - Co)/ (V f – V o)$

$C z = C f - (Cs * V f)$

Equation (2): Conductivity (m mho/cm) = Cs * V c + C z

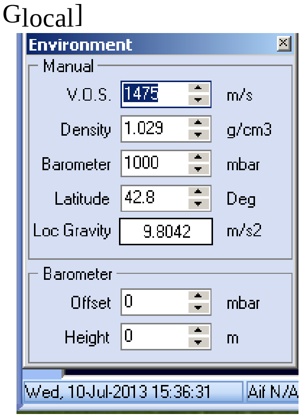
The Temperature sensor is calibrated at both end points (low and high) of its operating range. Calibrations co-efficient ('To', 'T f') are supplied with the sensor for each end point.

$Ts = (T f - To)/ (V f – V o)$

$T z = T f - (Ts * V f)$

Equation (3): Temperature (°C) = Ts * V t + T z

Equation (4): Depth= [((p (a*0.01450377))*0.70307)/ d] *[G_{std} / G_{local}]



"Figure 3. Environmental Parameters of Sea Net Pro Software"

Where d is the Manual density update from Sea King bathy 704 series. Density (d) is used in the depth calculation. P is the Absolute Pressure measured by digi quartz precision depth sensor. G local is the local acceleration due to gravity (Latitude dependent – entered into surface software menu) and G std is the standard gravity.

Underwater Wireless Sensor Networks

Underwater sensor networks have a wide range of oceanographic applications including marine exploration, environmental monitoring and coastal surveillance. In emergency situations the vehicle can be controlled by user with acoustic and UHF communication protocols. UHF modem is used for surface communication and Acoustic modem for underwater communication for data transfer between the mother ship and underwater vehicle. The 455U-D radio modem

[11] transmits serial data over a long distance via radio. Up to 1020 bytes of data can be transmitted in one transmission. If more than 1020 bytes is input, the 455U-D unit will transmit the first 1020 bytes, then the next 1020 bytes, and so on until all of the data has been transmitted.

The Benthos ATM-890 Series Acoustic Modems [12] provide reliable wireless digital communications between underwater instrument packages and surface or subsea platforms. The ATM-890 Series can both transmit and receive at baud rates as high as 15,360 bits/sec. Applications of ATM-890 Series Acoustic Modems include remote monitoring of oceanographic sensors, control of wellhead and pipeline valves, and control of underwater vehicles. The ATM-890 Series Acoustic Modems are the most advanced, the most multi path and noise tolerant, and the most cost efficient ever available. They are designed to meet the high data rate requirements of commercial users, and the higher reliability, lower data rate requirements of the military. Hence the modems employ two modulation techniques phase shift keying (PSK), which provides the highest baud rate, and multiple frequency shift keying (MFSK), which provides good reliability in a multi path environment and provide better spectral efficiency. The modems are required to operate in a low signal-to-noise (SNR) environment.

"4. Simulation Process"

Simulation process of various sensors involving concurrent mapping and localization. The range and characteristics of subsystems within complex ocean robots mean that not all can be simulated in real time. This requires some form of synchronization between different sensors that can run in real time. Simulator simulates different torpedo or underwater vehicle sensors namely HX series current Sensor, Hall Effect based LV25P type voltage Sensor, Depth sensor, Brush less DC Electric Thruster Motor voltage and current meters, Altimeter and Sonar. Sonar identifies any obstacle in the path of the Vehicle and passes the information to the CAS through Quad UART channel 0 via Monitor connector and RS232 so that the CAS will create a new safe trajectory to avoid the obstacle and later will guide the vehicle to return back to the original trajectory.

"5. Hardware Implementation"

Acquisition and Conversion

The acquired analog data from sea king, acoustic, UHF and simulator systems is converted into digital form using MAX 196 [13] Analog to Digital Converter (ADC). The Maxim196 is a multi range, fault-tolerant ADC uses successive approximation register (SAR) type to convert an analog signal to a 12-bit digital output. Successive Approximation is based on a binary search algorithm, and thus is more component efficient than Flash ADCs which use a brute force approach to perform data conversion. The significant advantage of the SAR ADC is that it uses only a few analog components (notably only a single comparator) to implement N-bit data conversion, resulting in a compact area and simple design.

This 12-bit data acquisition system (DAS) requires single +5V supply for operation. To acquire data from different sensors require three MAX 196 ADCs. Each ADC has a 6 analog input channels that are independently programmable for a variety of ranges. The 6 analog input channels of each ADC can be selected using 3 bits (A0 – A2) in control byte. Conversions are initiated with a write operation, which selects the multiplexer channel and configures the ADC for either a unipolar or bipolar input range.

Storage and Monitoring

The converted digital data is stored in PPC440EmbeddedProcessor's NAND Flash memory via RS232 ADM3202ARUZ [14] through underwater connectors. The RS232 signals are routed to PPC440EP's Quad UART and external interrupt Octal UART. The external interrupt consists of the device configuration registers and global interrupt source register INT0 that are monitoring the status of acoustic and UHF modems. The PPC440EP contains two Universal Interrupt Controllers (UIC0 and UIC1) that provide all necessary control, status, and communication between the various internal and external interrupt sources.

PowerPC440Embedded Processor supports four NAND flash devices providing memory up to 32MB. The PPC440EP External Bus Controller (EBC) provides direct attachment for Flash memory and peripheral devices. The EBC interface minimizes the amount of external glue logic needed to communicate with memory and peripheral devices, reducing embedded system device count, circuit board area, and cost. NAND Flash is a type of memory device called non volatile memory. In NAND Flash (Single Level transistor cell) the cells are arranged in series with the adjacent cells sharing Source and Drain, similar to the way the NMOS transistors are arranged in building the NAND gate. SLC can be used for up to 1, 00, 000 erase/program cycles. The sharing of Source and Drain of adjacent cells eliminated the need for metal contact and tremendously reduces the die size. Due to the efficient architecture of the NAND Flash, its cell size is almost half the size of a NOR cell.

"6. Software Implementation"

Embedded software Testing

To continuously acquire, store and monitor the oceanographic data using PowerPC440Embedded Processor, the software is developed in Embedded 'C' using green hills compiler. MULTI Integrated Development Environment (MULTI IDE) is designed especially for embedded systems engineers to assist them in compiling, optimizing, debugging and editing embedded applications. MULTI IDE is registered trademark for the Green hills Compiler.

In PowerPC based systems TRACE32 tool is used for Testing, Monotoring of the software operations and Loading application software into Flashmemory. Trace 32 describes concept of the NAND Flash Programming. It allows to see the contents of all PowerPC registers and memories, while execution of program.

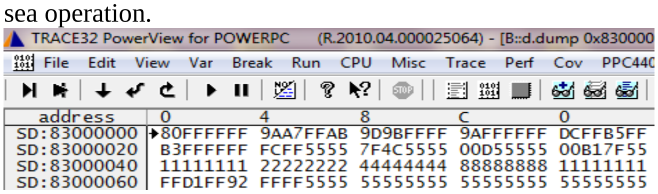
The debug facilities of the PPC440EP include support for several debug modes for debugging during hardware and software development. Debug registers control these debug modes and debug events. The debug registers are accessed through Lauterbach tools. Lauterbach Debugger establishes step by step debugging of application software in PowerPC based systems.

Graphical User Interface (GUI)

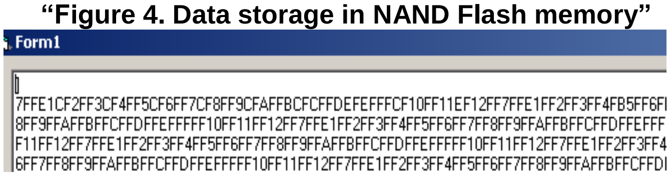
GUI operates in two different modes online monitoring (Real Time) mode and data downloading (offline Process) mode. Online monitoring mode is used to test the working status of Sea King system in emergency situations and monitoring health of the vehicle by sending different commands using Acoustic and UHF. In downloading mode, the stored data in Flash memory during the underwater operation is downloaded to the surface controller's PC for further analysis.

"7. Experimental Results and Analysis with Previous Works"

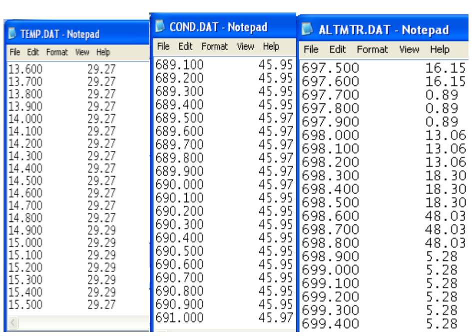
The stored data in the Embedded Processor's Flash memory can be downloaded via RS232 serial communication using user friendly GUI in Visual Basic 6.0. After downloading data into a raw file, the graphs for different parameters such as altitude, conductivity and temperature are plotted using MAT lab 7.0 to analyze the underwater vehicle performance during sea operation.



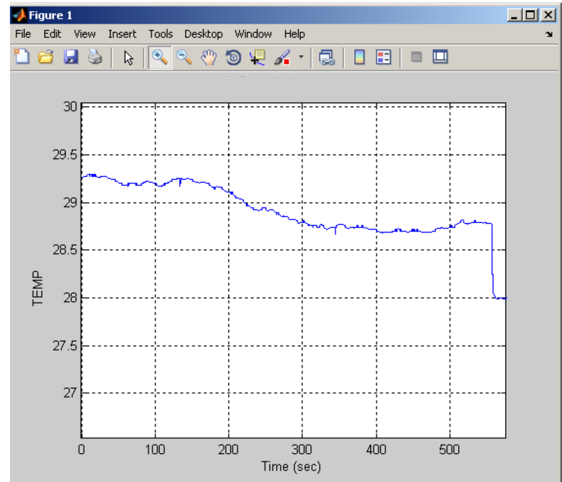
"Figure 4. Data storage in NAND Flash memory"



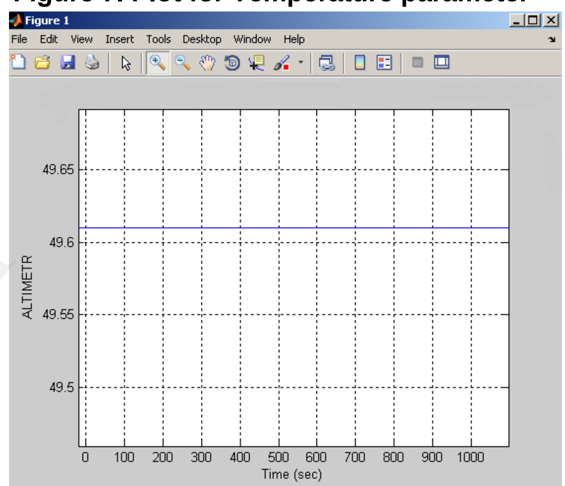
"Figure 5. Transmitting the data serially"



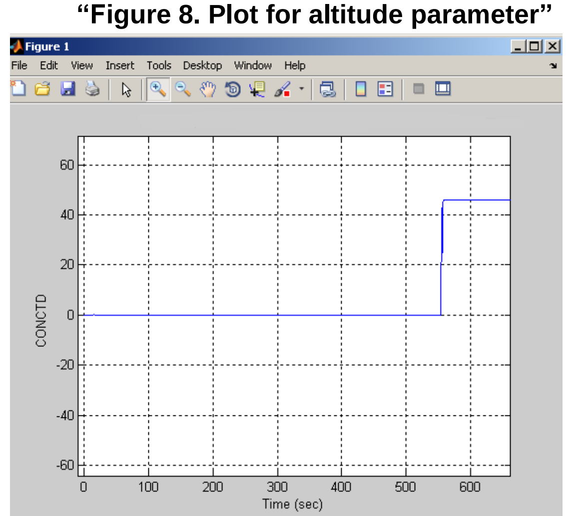
"Figure 6. Downloading the data into a Raw File"



"Figure 7. Plot for Temperature parameter"



"Figure 8. Plot for altitude parameter"



"Figure 9."Plot for conductivity parameter

Comparison with previous work

Paul J. Bucca and Roger W. Meredith (1988), Members of IEEE measured Oceanographic data with 8080

Microprocessor [1]. The data acquired by using 302A model CSTD unit, which measures ocean conductivity, temperature and depth. The CSTD probe has the capability to measure only 1000 meters of depth and 24m mho/cm of conductivity.

Jie Li, Qiao Jiang, Xi-ning Yu and Ying DU (2010) belongs to North university of China, designed an "Intelligent Temperature Detecting System" [2] based on Atmel89S52 Microcontroller and digital temperature sensor DS18B20, which was designed by Dallas. The standard error of the detected temperature with this system and actual set temperature value at each temperature point is approximately 0.5°C. Hence, the temperature detected with DS18B20 is not accurate.

Heungwoo Nam and Sunshin designed "An Ultrasonic Sensor Based Low-Power Acoustic Modem for Underwater Communication In Underwater Wireless Sensor Networks" [3]. The modulation method used in this work is an Amplitude Shift Keying (ASK). Some of the problems are considered in acoustic modem are: the directional property, the reflection and the refraction. These problems are conquered in Benthos ATM890 series Acoustic Modem using Multiple Frequency Shift Keying (MFSK), which provides good reliability in a multi path environment and provide better spectral efficiency than ASK.

K. Anitha, M. Srinivasa Rao, C. R. S. Murthy presented an "Embedded Bluetooth Data Acquisition System Based on ARM for Unmanned Underwater Vehicle (UUV)" [4]. The Bluetooth device connected to the ARM processor is made as the master of the piconet and the other Bluetooth devices connected to the subsystems of the UUV become the slaves. This method of designing and implementing the Data Acquisition System using the Bluetooth medium achieves only 1.9Mbps of data rate. Whereas underwater coaxial connectors provide data transfer rates from 8.4Mbps to 274Mbps. But, the underwater coaxial connectors are too expensive.

"Table 1. Comparisons with previous works"

Paper	Oceanographic measurements with Microprocessor [1]	Intelligent temperature detecting system [2]	Embedded Processor based Communication and acquisition system (CAS)
Instrument/ sensor	Ocean data equipment (ODEC) model 302A unit	DS18B20	Sea King 704 series system
Capability of Depth measurement	Only 1000 meters	—	Up to 6800meters
Conductivity	24 m mho/cm	—	65 m mho/cm (measured 45 m mho/cm)
Altitude	—	—	300 mm to 50meters (measured 49.62 meters)
Temperature	—	Not accurate (+/- 0.5°C)	Measured 29.3°C with accuracy (+/- 0.02°C)

"8. Conclusions"

The PowerPC440Embedded Processor based Communication and Acquisition System (CAS) provided a powerful capability for measuring sea data, established communication between underwater vehicle and surface controller unit (SCU) or mother ship and achieved good quality results compare with previous works. Software is created in Embedded 'C' using Trace 32 and Multi IDE green hills cross compiler. A GUI has been created in Visual basic 6.0 for online monitoring, processing and downloading the data. The obtained graphs are plotted in MAT lab simulink.

References

[1] Paul J. Bucca and Roger W. Meredith , "Oceanographic Measurements with MicroProcessor", *IEEE Journal of Ocean Engineering*, Volume 13, no. 1, January 1988.

[2] Jie Li, Qiao Jiang, Xi-ning Yu and Ying DU, "Intelligent Temperature Detecting System", *2010 International Conference on Intelligent System Design and Engineering Application*, National Key Laboratory for Electronic Measurement, North University of China, Taiyuan, 030051, China.

[3] Heungwoo Nam and Sunshin, "An Ultrasonic Sensor Based Low-Power Acoustic Modem for Underwater Communication In Underwater Wireless Sensor Networks", *International Federation for Information Processing (IFIP)* 2007.

[4] K. Anitha, M. Srinivasa Rao and C. R. S. Murthy, "Embedded Bluetooth Data Acquisition System Based on ARM for Unmanned Underwater Vehicle (UUV)", *International Journal of Computer Science and Network Security (IJCSNS)*, VOL.11 No.7, July 2011.

[5] *Applied Micro Circuits Corporation (AMCC) PowerPC440Embedded Processor* data sheet, part number 440EP, Revision 1.26, April 25, 2007.

[6] *S29GL_P Mirror bit Flash Family*, Revision A, Amendment 8, Issue date november 28, 2007.

[7] *NAND Flash Programming Trace 32 user's guide*.

[8] *Software Notes for Controlling and operating Seaking bathy heads*, supplied by Tritech International Ltd, Document Rev. 1, 3rd september 2007.

[9] *High Performance Octal UART XR16L788* data sheet, REV1.2.2, October 2005.

[10] *Sea Net System Operator manual*, supplied by tritech international Ltd., Issue 3, TIL_ENG_Spec_051.

[11] *455U-D Radio modem* User manual.

[12] *Benthos High Speed Acoustic modems* User manual.

[13] *Maxim integrated products MAX 196 12 bit Data Acquisition Sytem* data sheet.

[14] *Analog devices low power RS232 ADM3202ARUZ* data sheet.