IoT based Data Acquisition System for Real-Time Pressure Measurement of Sea Water

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***Abstract*— Pressure measurement is a very essential subject as far as the study of marine science is concerned. Sea tides and Ocean waves are the major factors determining the safety of the coastline. The methodology adopted for measuring the sea level is the detection of the hydrostatic pressure with respect to the water column that lies over the pressure transducer and determining its height. The proposed work comprises building a Data Acquisition System to measure the pressure of the water by using a piezo-resistive pressure sensor. The sampling of data is done using an ARM7 Microcontroller. The Data is logged on to an MMC chip using the Serial Peripheral Interface. The pressure readings are taken periodically using an In-built Real-Time Clock. The measured data will be sent wirelessly using IoT based Digi Xbee Wi-Fi module to the office of the National Institute of Oceanography and it will be displayed on a cloud server. The programming is through Embedded C.**

Keywords*— *ARM 7 Microcontroller, Pressure sensor, Wi-Fi, Data Acquisition, Xbee, IoT

I. Introduction

The Long term or continuous measurement of sea level is important for the study of climate change [1]. Sea tides are the increasing and decreasing earth's surface ocean due to strong tidal forces of the Moon and the Sun acting on the oceans. Tidal phenomena are due to the gravitational field varying in space and time. At high tide, the strip of the seashore important for the ecological products is submerged and exposed at low tide. Surface waves of ocean occur in the top layer of the ocean formed due to wind waves. These wind waves travel far before reaching the land. The high sea tides which are caused by geological effects like tsunamis may grow to devastating proportions at the cost due to reduced water depth [2]. Hence, it is very important to measure the hydrostatic pressure of the water level. This hydrostatic pressure corresponds to the water column that lies over the pressure transducer is detected and the height of this water column from the knowledge of depth-mean density.

Data Acquisition is used to acquire data from the surrounding environment using sensors [3]. It requires components such as, Sensor to measure a physical quantity into a signal that can be read by an observer or an instrument, Analog to Digital Converter for converting an input analog voltage (or current) to a digital form, Microcontroller which is a computer-on-a chip, consisting of a processor, memory, and input/output functions, and Data Storage Device for storing data samples for a long period of time. In this research paper, authors have proposed a real-time Data Acquisition System for measuring the pressure of seawater using a piezo-resistive pressure sensor. A survey is presented on various Data Acquisition Systems and its applications and technique [3]. Using ARM microcontroller, real-time monitoring of temperature and humidity values applicable in manufacturing industries plant is proposed with the help of wireless sensor Network Module [4]. Using Arduino Microcontroller, in real-time, Humidity, temperature light intensity and gas concentration are monitored [5]. Data Acquisition prototype System is developed for automobiles and its Analysis is made [6]. A Survey is proposed on Data Acquisition Systems [7]. Using Raspberry Pi 3, IoT based e-health monitoring system is implemented for measuring and monitoring blood pressure, oxygen level, body temperature, airflow, and sweat gland and built a graphical user interface for analyzing sensor data [8].

II. Methodology

The methodology used such that pressure is measured using the Data acquisition system and then transmitted using Xbee wireless technology and other is receiving through Xbee wireless technology and sharing or displaying on a cloud server in the office of Oceanography.

A. Pressure Measurement using Data Acquisition System

Fig.1 shows the view of the data acquisition system and transmitting unit. Here using a piezo-resistive pressure sensor interfaced with ARM 7 microcontrollers, the sensing, and measurement of pressure. The analog pressure data is sampled and then converted into digital form and digital form data is feed into Multi Media Chip (MMC) using the Serial Peripheral Interface. The measured digital data is then transmitted via IoT enabled Xbee wireless technology.

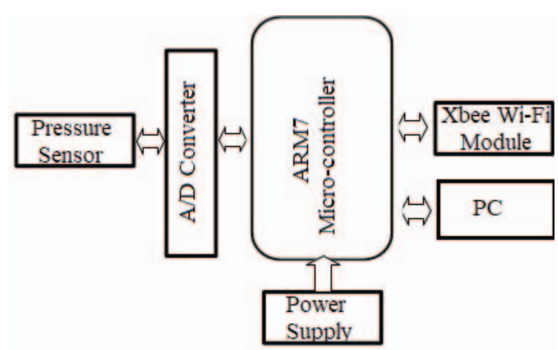

Fig. 1. Block Diagram of data acquisition and transmitting unit.

B. Pressure Measurement using Data receiving unit

Fig.2 shows the view of data receiving unit block diagram. In this unit, pressure sensor parameters are received using wireless Xbee Technology in the office National Institute of Oceanography for further analysis.

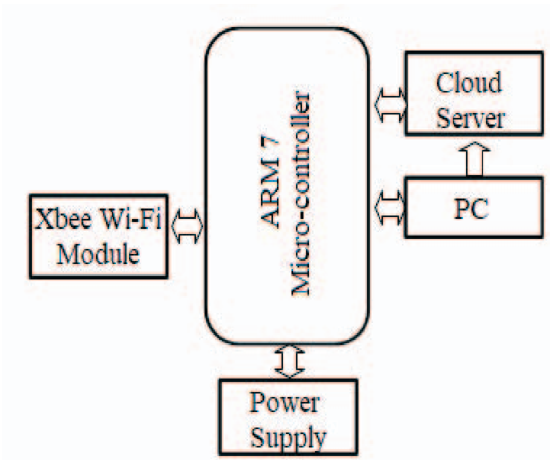

Fig. 2. Block Diagram of data receiving and displaying unit.

III. ALGORITHM

- Initialization of the UART0 (Universal Asynchronous Receiver Transmitter) for a microcontroller to communicate with the computer using the serial port, Initialization of the SSP(Serial Synchronous Port) which is used as Serial Peripheral Interface, Initializing the MMC (Multimedia Card) which should be set in SPI mode to be used by a microcontroller and Initializing the RTC (Real Time Clock)to storing and displaying date and time.
- Sampling the Sensor as the data produced by the sensor in the electrical voltage is analog and this analog voltage which is in real-time is proportional to the pressure of the water at that very instant. This real-time voltage is present at the A/D converter.
- Storing the sampled data on the MMC as a string of characters so that while reading the data can directly be printed on the screen.
- Reading the stored sampled data from MMC.
- Sent Data wirelessly using Xbee Wi-Fi Module.

IV. FLOWCHART

Fig. 3 shows the flowchart used by authors which describes the real-time monitoring of pressure of the seawater status using a piezo-resistive pressure sensor.

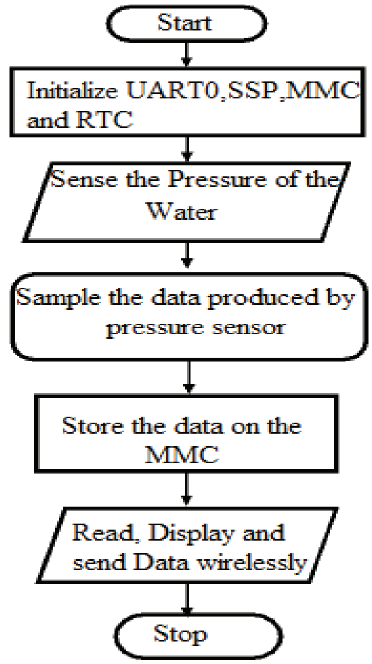

Fig. 3. Flowchart

V. SYSTEM DETAILS

A. Pressure sensor

The pressure transducer NPI-19 series has used for the measurement of the Pressure of the seawater. This sensor is a piezo-resistive pressure sensor which has a strain-gauge. There is a change in electrical resistance when a strain-gauge made of semiconducting material like silicon is stretched. This electrical change is recognized by diaphragm attached to a strain-gauge when the sensor element is deformed due to applied pressure. The electrical resistance change is measured using a Wheatstone bridge circuit which is converted into output voltage [14]. This makes a sensor that can measure pressure with high accuracy of ± 0.5% and high reliability. Also, these sensors are designed to operate on hostile environments giving excellent sensitivity, hysteresis, and linearity [10]. Fig.4 shows the application circuit diagram of a pressure sensor [10].

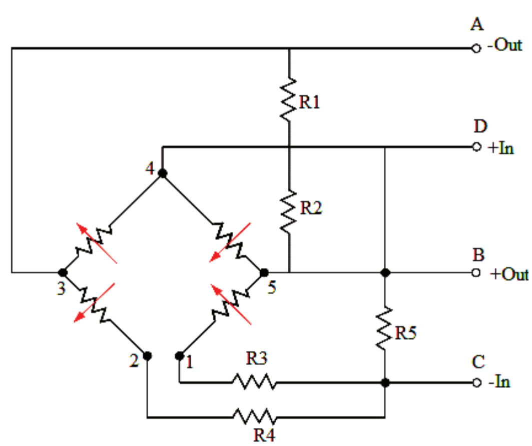

Fig. 4. Circuit diagram of the Pressure sensor

B. ARM 7 Microcontroller

The LPC2148 microcontrollers used have 16/32-bit ARM7TDMI-S CPU with real-time emulation with embedded trace making microcontrollers embedded with high-speed flash memory ranging from 32 KB to 512 KB. Owing to their low consumption of power and small size, these microcontrollers are ideal for access control [11].

C. Digi Xbee Wi-Fi Module

This Xbee Wi-Fi Module is an Embedded RF module which provide ultra-low-power IEEE 802.11b/g/n connectivity. It generates advanced IoT based wireless opportunities for management of energy, factory automation, process, wireless sensor networks and, many more. It helps users to get fast IP-to-device and device-to-cloud capability. This Wi-Fi module operates at 2.4 GHz frequency band with high data rates [12].

D. A/D Converter

The Analog-to-Digital Converter used i.e. MCP3550 is a low-power and Low-noise device [13].

VI. INTERFACING

A. Interfacing between the sensor and A/D Converter

Fig.5 provides the interfacing between the pressure transducer and Analog-to-Digital Converter. The sensor provides an analog voltage proportional to the physical phenomenon. The A/D Converter provides the references for the voltage levels. Thus, Pin Connections can be given such that the negative voltage is provided to the A/D converter as OUT-to-Vin-, the positive voltage is provided by the sensor as OUT+ to Vin+, the negative reference voltage is provided by the A/D Converter, and the positive reference voltage is provided to the sensor.

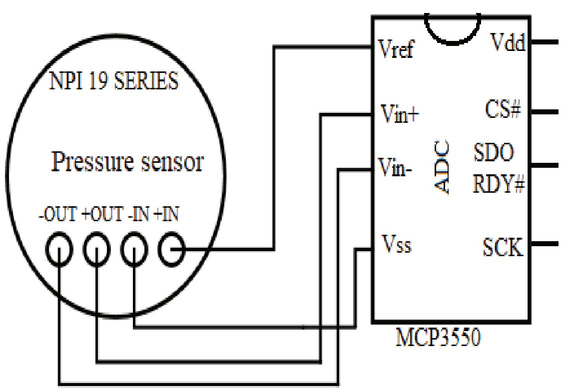

Fig. 5. The Interface between the sensor and the A/D converter

B. Interfacing between the micro-controller and A/D Converter

Fig.6 provides the interfacing between the A/D Converter and the microcontroller. The analog voltage is present at the A/D Converter all the time. Thus, the microcontroller must provide the necessary signals to the A/D converter to start the conversion and provide the digital signal. To provide the signals 5 pins of the 64-pin microcontroller are needed. The pin Connections can be given such that the 3.3V power supply is provided as the positive voltage and also reference voltage as 3.3V to Vdd and Vref, the ground i.e. 0v is taken as the reference to measure other voltages as GND to Vss, the P0.30 is used as General Purpose I/O pin to give the chip select high or low as P0.30 to CS#, the P0.29 is used as a GPIO pin to give the clock signals as P0.29 to SCK, and P0.28 is used to accept data on this pin.

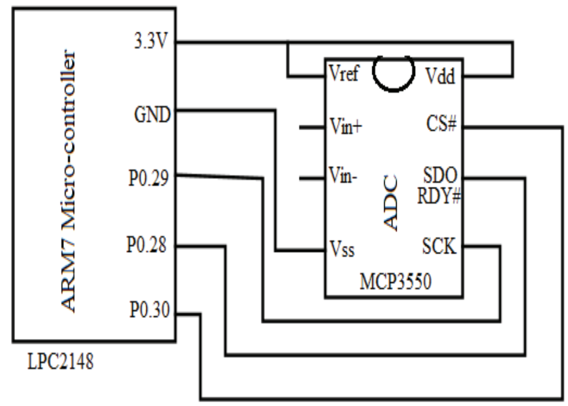

Fig. 6. The Interface between the A/D converter and the Micro-controller

C. Interfacing between the MMC and the Micro-controller

The Storage device used is MMC (Multimedia Card). It has seven pins as shown in Fig. 7. The MMC is used in SPI mode and the SSP module of the microcontroller is interfaced with the MMC so that serial communication can take place.

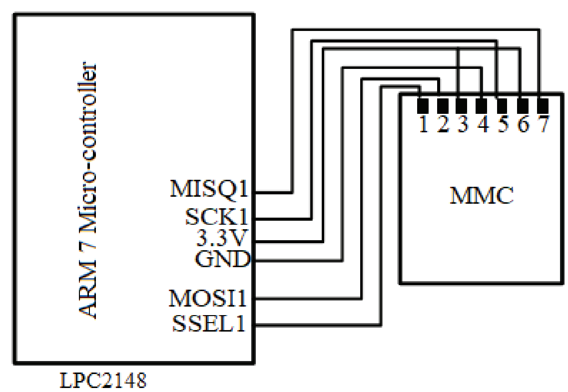

Fig. 7. The Interface between the MMC and the Micro-controller

D. Interfacing between Xbee and Micro-controller

The interfacing between Xbee and Micro-controller is through voltage compatible UART (Universal Asynchronous Receiver or Transmitter) interface which is logic or through Serial peripheral interface (SPI) is shown in Fig.7 [9].

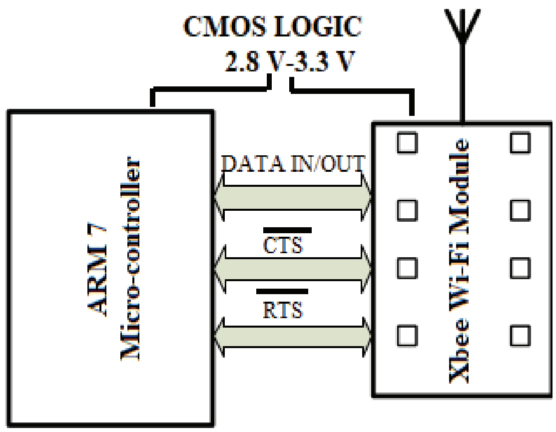

Fig. 8. The Interface between the Xbee and Micro-controller

VII. RESULT

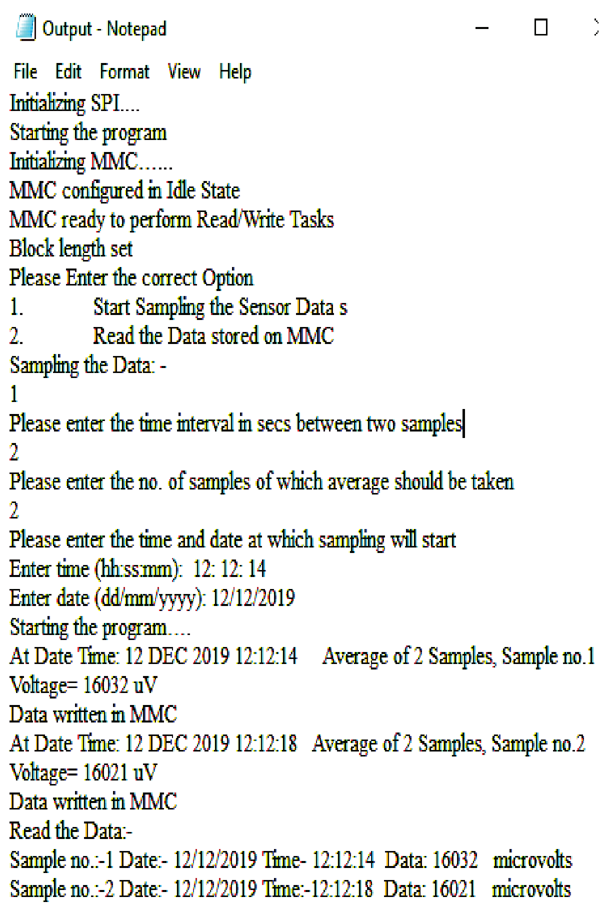

Fig. 9. Sampled output reading.

VIII. CONCLUSION AND FUTUREWORK

The Data Acquisition system for pressure measurement seawater is successfully built with the following observations:

- The sensor data is accurately measured.
- The program written is error-free and the size of the hex file is small enough to be stored on the ROM without disturbing the functions of the Micro-controller.
- The Reading taken by the DAS is satisfactory. The variations between the two readings are tolerable.
- The Data is accurately stored on the Multimedia Card without error.
- The Data is read accurately from MMC and displayed on PC.

Future work can be carried out using Raspberry pi which has higher processing power and better performance than proposed LPC2148 ARM 7 Micro-controller or any other advanced micro-controller like Microchip PIC16F1887, Hercules RM57L843 which are facilitating communication at low-power and analysis can be made using soft computing techniques like fuzzy logic which is based on human knowledge and reasoning or MATLAB using Fuzzy Logic Toolbox or MATLAB Data Acquisition Toolbox which provides an excellent platform for configuration of sensors (hardware) and reading data into MATLAB and Simulink and writing data into Data Acquisition analog and digital output channel or LabVIEW which involves data acquisition through graphical programming.

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