Development of Buoy System for Meteorology and Oceanographic Purposes

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Abstract **– This research is part of the development of buoy system specially designed for meteorology and oceanographic purposes. The control system design and the brief operation of the buoy will be discussed in this paper.**

***Index Terms*— wind buoy, meteorology purpose, oceanographic purpose, CDMA**

I. INTRODUCTION

Both meteorology and oceanographic fields is important in weather forecasting work. Oceanography is a wide range of topics including marine organism and ecosystem dynamics, ocean currents, waves, and geophysical fluid dynamics; plate tectonics and the geology of the sea floor and fluxes of various chemical substances and physical properties within the ocean and across its boundaries [1]. While on the other hand, meteorology is the scientific study of the atmosphere that focuses on weather processes and forecasting [2]. The relation between the research projects with both fields is the buoy was specifically build to collect the related data for the weather analysis and forecasting work.

The widely deployment of this buoy will allow more accurate weather forecasting result. Hence, if the buoys are widely deployed and form a network, it could give marvelous result to the weather forecasting and oceanography related research.

The primary objective of the research is to build a buoy that able collect data of wind information, humidity and the ocean information and transmit the information to the main station for further research work. To achieve this, relevant sensors have been use to collect those data and several transmission media also been use to make sure the risk of lost communication is low.

Manuscript received November 4, 2009; revised November 25, 2009; accepted December 3, 2009.

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II. BUOY STRUCTURE

In this section, a brief description about the buoy structure will be discussed. Basically, the structure of the buoy can divided into 3 parts. First part is the top part of the buoy, which consists of the antennas, weather station LB150, and solar panels. The second part of the buoy is the inner and sensor part. The electronics control box, data-logger 3660, wave height sensor and battery was actually located inside the buoy; while the Doppler current sensor was located outside and bottom of the buoy. The door to cover the inner part been designed to highly resist with water because to avoid short circuit happen. Third part is the part to allow the buoy floating on top of the ocean. The key challenging aspect is to lets the buoy steadily float on top of the ocean without worrying with certain level of wave height and the wind speed. Following figure shows the outlook and the devices location of the buoy.

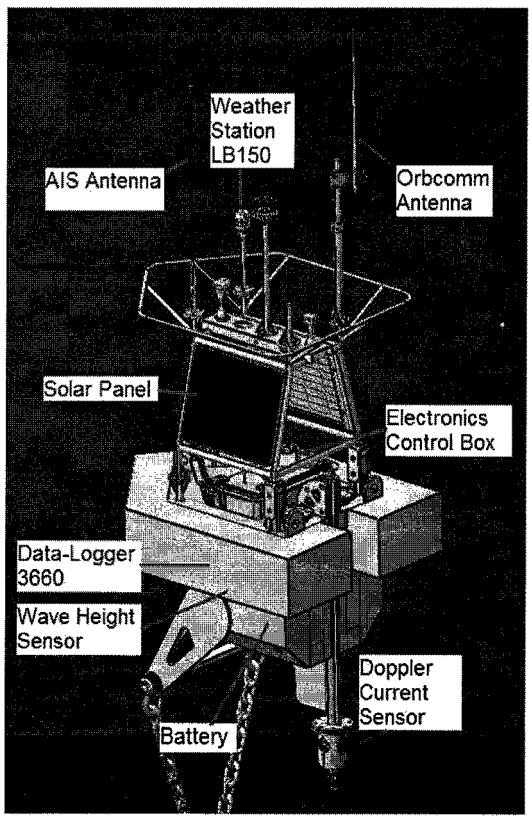

Fig.1. Buoy structure and the devices mounting positions.

III. BUOY ELECTRONICS SYSTEM

The electronics system of this buoy is specifically designed to act as a data transceiver and as a data-logger. To achieve this, it is basically inputted by some environmental sensor and transmitted the data through CDMA and Orbcomm technologies. In the main controller board, it consists of master and slave microcontrollers and both if it is ATMEGA128. Fig.2 shown below had display the basic concepts of the electronics system of the buoy.

As mentioned previously, the inputs consist of weather station LB150 sensor, data-logger 3660, collision sensor, and a water level switch. Weather station LB150 sensor from AIRMAR technology corporation able to return data of wind speed and direction, barometric pressure, air temperature, dew point temperature, relative humidity and wind chill temperature. Besides that, it can output NMEA0183 and NMEA2000 protocol. In our case, we obtained the NMEA0183 protocol for data processing and the signals is in RS422/RS485 level. To interface with it, the circuit board had integrated the RS422 interfacing IC.

Data-logger 3660 is a rugged unit for reading standard sensors and for displaying, storing and transmitting the data in engineering unit. Data-logger 3660 able to scan up to 17 sensors and thus, making them well suit for variety field of data-logging application. In this buoy system, the data-logger 3660 is connected to Doppler current sensor and wave-height sensor. The data-logger will collect the data and transmit the data when request by the system. There are several ways the data-logger transmit its output, the serial RS232 standard output had been used in the buoy system.

The collision sensor in the buoy system is to detect any collision happen to the buoy, and if it happens, the system will reset itself by using the relay and the relative circuit to restart all operation. Due to the reset function, the main power of the electronics system is connected through the relay. The main power of the buoy consists of one 12V lead acid battery. To maintain a continuous power supply to the system, 2 solar panel had been attached to the buoy and continuously charging the battery while the battery supplying power to the system. Hence, this will allow the buoy to operate without stop.

All the data from the system will output to the main server through several media. The Orbcomm and CDMA technologies take the main concern in this part. Hence, a modem for Orbcomm and a modem for CDMA had been installed in the buoy electronics system. Basically the communication method use to communicate with Orbcomm and CDMA modem is using serial RS232 standard. It is a common and widely used method. Orbcomm is a leading global satellite data Communication Company focused exclusively on machine to machine communications. It provides a global network of low-earth orbit (LEO) satellites and accompanying ground infrastructure [3]. The data transmitted through Orbcomm will finally reach at the end user side in email format. On the other side, CDMA which stands for Code Division Multiple Access is a technologies used for digital communication and particularly in wireless technology. The CDMA technology allows the buoy send the SMS to the user, so data will reach the user even if the user in mobile status. The data reachable range will be limited by the coverage range of the service provider. Moreover, the data also able to output to a 4x20 LCD display. A connection space was ready to let user connect the LCD on it. The purpose of this is to ease the user trouble shoot problems when needed. Problem might occur due to collision happen or maybe worst weather circumstances causing the sensors malfunction. A switch is connected to the electronics board to allow the user enter to the debug mode when necessary.

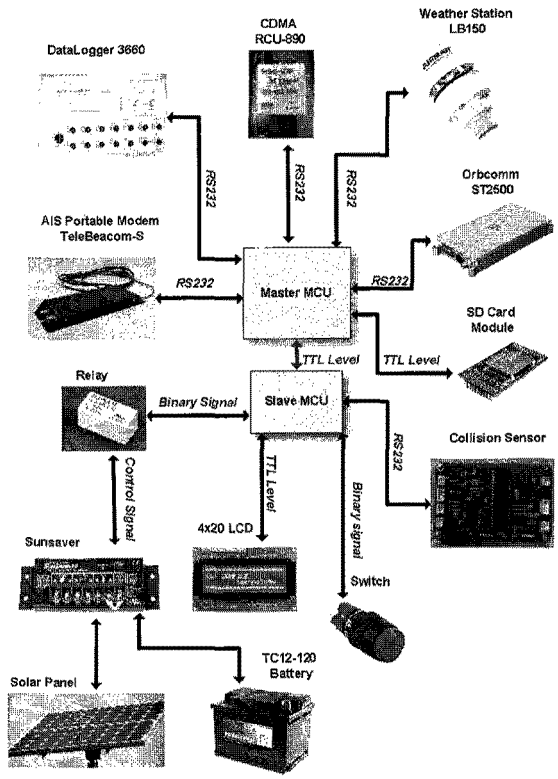

Fig. 2. Buoy electronics system block diagram.

IV. BUOY SENSORS SYSTEM

In this section, sensor system attach to the buoy will be discuss in detail.

A. Weather Station PB100.

As mention previously, NMEA0183 output protocol will use to process the sensor data. The 3 main NMEA0183 sentence was used to get respective sensor data. First sentence is $HCHDG and it content the information of magnetic heading, magnetic deviation and magnetic variation. This sentence is the information of the magnetic compass that build-in in the LB150 sensor. The magnetic heading will be use in this buoy system. This information used to determine the buoy heading direction and it is one of the information to determine the situation and location of the buoy. Secondly, $WIMDA sentence content the meteorological composite information. The sentence itself content 20 information such as barometric pressure value, air temperature, water temperature, humidity information, dew point value, and wind direction. Most of the data in this sentence will be used to let user analyses the environment condition around the buoy. Third sentence used is $GPRMC. It is a recommended minimum specific GPS/Transit data. From this sentence, the buoy will know its own current position on the earth and also the current UTC time.

B. Data-Logger 3660

The data-logger 3660 was connected to 2 sensors as mentioned. One of it is Doppler current sensor. Doppler current sensor is a true vector-averaging sensor for measuring current speed and direction in the sea. The sensor is based on the backscatter acoustic Doppler principle that comprising several distinct frequencies are combine into a single acoustic pulse that is send out in right angles at regular intervals.

Another sensor connected to data-logger 3660 is wave height sensor 3595 from Aanderaa Data Instruments. This sensor is able to output significant wave height and wave period. Wave height and wave period parameter are useful for the mariner which is helpful in the ocean wave characteristic analysis work. Figure 3 shows the connection of the data-logger and the sensor.

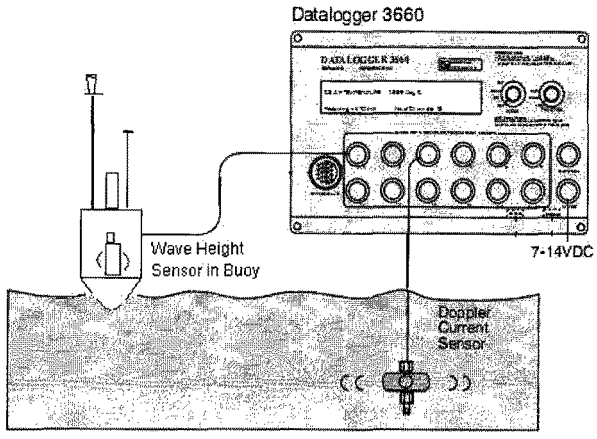

Fig. 3. Data-logger and sensors connection diagram.

C. Collision Sensor

The purpose to have a collision sensor in the buoy is to detect sudden change of acceleration or we called impulse. The build-in accelerometer allow the collision sensor detect the impulse impact to the buoy. Supposing the buoy will always in the steady state unless if it is collide with something or anything unexpected happen have crash the buoy, it might affect some devices inside or outside the buoy. If the impact exceeds certain value, the collision sensor will send a signal to main controller to restart the whole buoy system. At the same time, the collision status will also send to the main station to allow further adequate action to be taken.

V. BUOY OPERATION

In brief, the operation of this buoy is mainly responsible to collect environment data, and broadcast it out to the main station. As mention in section electronics system, the main controller board consists of master and slave microcontroller. The master microcontroller is connected to the communications modules and the environmental sensors. After all the data been collected it will send out the data out through CDMA modem and Orbcomm. The figure below shows the program flow of the master microcontroller.

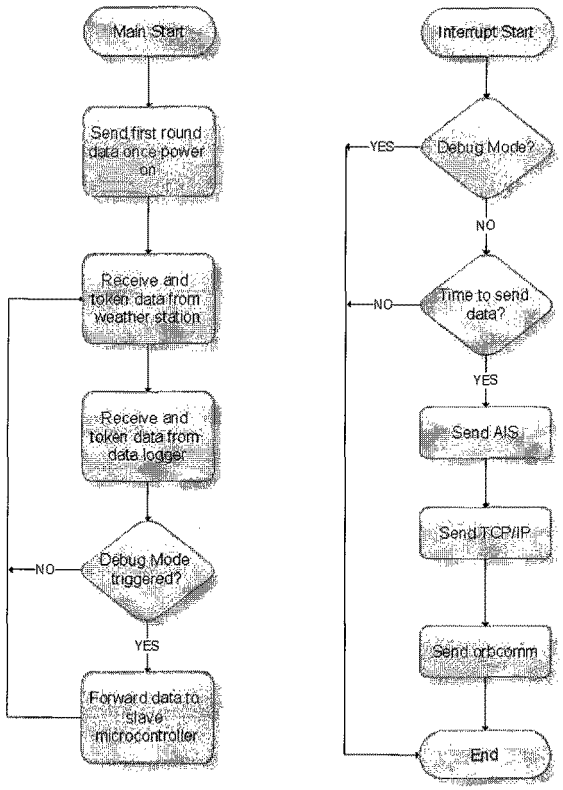

Fig. 4. Program flow of the master microcontroller.

While the master controller processing the tasks, the slave microcontroller is responsible to check the collision sensors status and reset the system when needed. Beside, when entered into the debug mode, it will update all the data from master to the LCD that connected to it. The purpose of the debug mode is to ease the user trouble shoot the problem. The figure below shows the processing operations in the slave microcontroller.

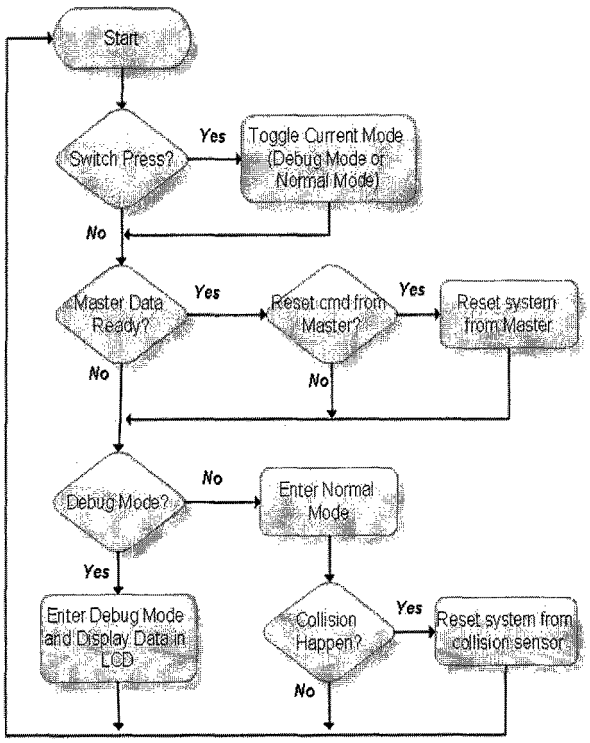

Fig. 6. Program flow of the slave microcontroller.

VI. RESULT

To evaluate the performance of the buoy, data from the sensors have been collected to perform the analytical work of the buoy. The following data was collected during day 22th October 2009, 7:00pm till 23th October 2009, 9:30am. This section will show and briefly discuss about the 3 major information wind speed, wave height and wave period. This section is not intended for a detailed reporting of scientific results obtained during testing but simply gives an overview of the overall performance of the buoy.

Figure 7 shows the result of wave height and wave period versus time. These data is collected from the Doppler current sensor.

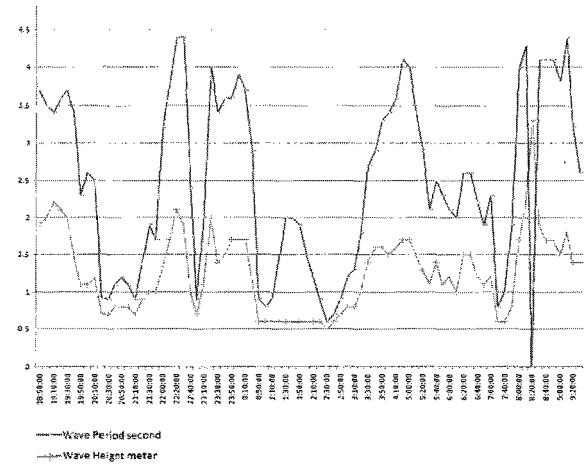

Fig. 7. Graph of the wave height and wave period versus time.

From the graph, we can observe the value of wave period and wave height is tight closely together. Wave are formed by wind blowing along the water's surface and wave height is dependent on wind speed, fetch length and duration of time the wind blows consistently over the fetch[4]. Following graph shows the reading wind speeds towards wave height. All this information is useful in weather forecasting research works.

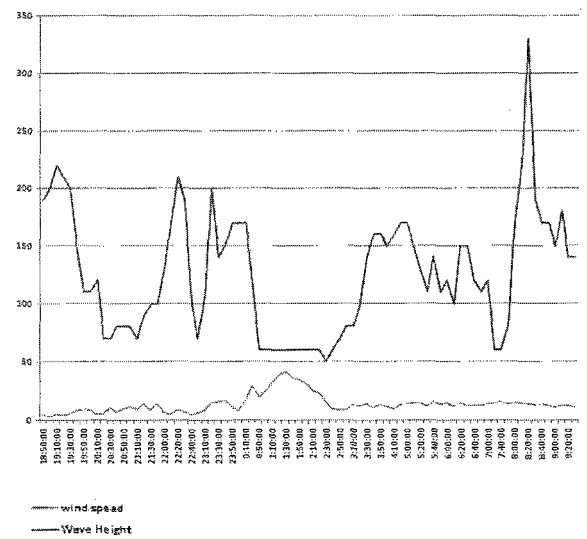

Fig. 8. Graph of the wave height and wind speed versus time.

VII. CONCLUSION

The information that provided from this buoy is sufficiently performing various analysis works towards weather forecasting. The results shows that this buoy able to operate normally and prove that the algorithm of the control system is working. The suggested upgrade for this buoy system in future is attach more environmental sensor at the buoy and also perform basic analytic work before send it to the main station to ease the analysis work at the main station.

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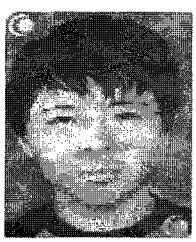

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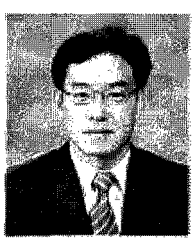

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