기상관측 부이용 전자통신시스템 설계

박수홍

Electronics System Design of a Generic Meteorological Buoy

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요 약

본 논문은 일반적인 기상관측 부이시스템에서의 전자시스템설계에 관한 것이다. 주로 기지국, 데이터처리, 파워시스템설계 등의 기상관축 부이용 전자통신시스템 설계에 관한 것이다. 연구결과 시스템 설계가 기지국에서 부이를 통하여 배터리 사용시간을 확인하였고, 추가적인 파워의 소비 없이 자체적으로 부이에서의 작용함을 알 수 있다.

ABSTRACT

This paper is to study and design a generic electronics system for a meteorological buoy. It mainly covers the communication methods of a buoy with base station, data post processing and power design of a generic weather buoy system. The experiment result shows the design is capable to works well in term of data receive from buoy at base station, battery life time and able to work standalone without any power exhausted problem.

키워드

Meteorological Buoy, Conductivity Sensor, Communication Methods, Power Design

Ⅰ. Introduction

A buoy is a floating device which can have many different purposes. It can be moored (stationary) or allowed to drift. It can serve as a seamark which allow boats and ships to navigate safely, life buoy that used as a life saving buoy designed to be thrown to a person in the water to provide buoyancy or as weather buoy/meteorological buoy where equipped to measure weather parameters such as air temperature, barometric pressure, wind speed and direction and report these data to base station via satellite RF links for use in weather forecasting and climate study. Besides weather parameters, meteorological buoy can provide service which capable to monitor hydrographical and environmental data collection system. The purpose of collecting such data is to help people understand on earth's climate and ocean, and thus, enable people to forecast the weather and warning will be given if necessary.

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This paper is focus on a generic electronics system design of a meteorological buoy. It is not aim to become a standard in weather buoy designing but it cover the most basic function of a weather buoy. This buoy design has some basic sensors which able to provide fundamental weather and oceanography information. And also it is designed to support more communication method between base stations. In addition, this design utilizes telecom service which allows buoy sends and receives SMS. As the result, buoy able to receive commands from user for failure recovery or dynamic response on interesting phenomena. Additionally, the buoy can be equipped with numerous other sensors such as wave height sensor, wave current sensor, wave period sensor, impact sensor and etc to provide user more useful information. In this paper, a general weather buoy system description is presented first, follow by buoy communication system. Data post processing along with power design then will be discussed, and finally the result of the design will be presented.

Ⅱ. Buoy System description

A weather buoy normally consists of the following modules: weather sensor module, which capture, measure and provide weather information, power management module, which is used to control power usage of a buoy, and communication module, which provide a communication link between buoy and base station or with vessels if required. Fig. 1 shows the basic block diagram of a weather buoy. Due to the accuracy of the meteorological data which is important for a weather buoy, AIRMAR weather station (PB200) is chosen as main sensor unit. In PB200, wind speed and direction are measured using four ultrasonic transducers. The internal WAAS GPS engine and three-axis, solid state compass make it possible for the PB200 to provide both apparent and true wind speed and direction.Additionally, the WAAS GPS provides navigational data as well as magnetic variation and is suitable as primary GPS source. The internal temperature and barometric pressure sensor are able to capture the method changes of weather patterns. Combined with internal heading sensor, all the necessary weather and navigational information are provided [1]. Furthermore, a conductivity sensor is added in this buoy design which provides information on sea water conductivity and temperature. Conductivity is a key parameter for in-situ determination of several fundamental physics properties of sea water. With temperature provided, a good estimation of salinity may be determined where salinity is define as total amounts of solid materials in grams dissolved in one kilogram of sea water when all carbonate has been converted to oxide, the bromine and iodine replaced by chlorine and all organic matter completely oxidized [2]. In buoy application, sealed lead acid battery will be the better choice among all rechargeable battery.

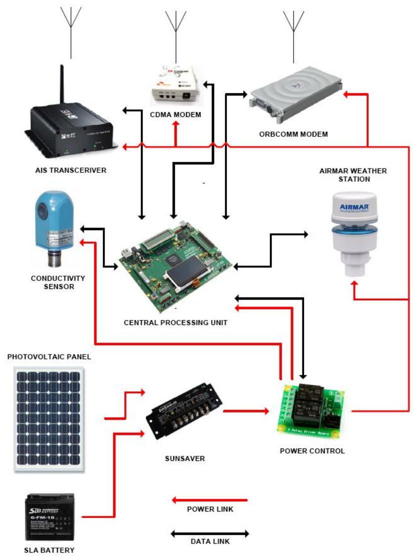

Fig. 1 Typical Weather Buoy's Electronics System

Buoy should able to recharge the battery so that it can work continuously with minimum maintenance. Without any doubts, solar energy is the best solution for current technology which provide reasonable charging rate, at the same time, it is clean energy source. The main purpose of a weather buoy is to collect all weather related information and forward those data to base station for use in weather forecasting and climate study. Usually Most of the data will forward to base station via satellite technology. Instead, there are some other ways to transmit data to base station such as AIS, Short Message System, or even via TCP/IP protocol service to a specific IP address through telephony service. A central processing unit in this system is to handle post processing of incoming weather data. All data were collected and pack into proper packet and forward to each communication device such as ORBCOMM modem, AIS modem and CDMA modem.

Ⅲ. Buoy communication system

There are 4 communications method which allow buoy to transmit data to base station, which are via satellite, AIS, SMS, and TCPIP. Typically, buoy data are sent via satellite only. By using AIS, SMS, and TCPIP, it makes the system more flexible. Data sent via satellite is simple by using modem from ORBCOMM Inc. Data to be sent via satellite first need pack into proper packet before send to ORBCOMM modem using serial protocol. Packet with appropriate header and checksum will be recognized by modem and forward to base station once satellite is connected. Fig. 2 shows the ORBCOMM modem serial protocol. Besides satellite, AIS can be used as one of the data forwarding channel. AIS stand for Automatics Identification System. It is a recent concept introduced in order to increase safety of maritime traffic, offer Aids-TO-Navigation service and improve traffic control and management. Present AIS solution is based on VHF data communication scheme.

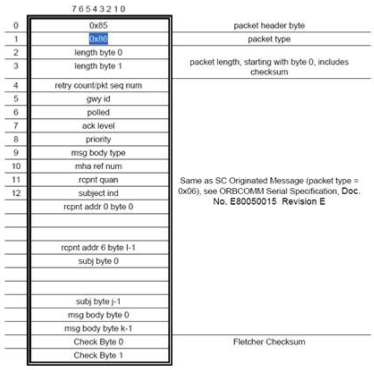

Fig. 2 ORBCOMM Modem Serial Protocol

Apart from identifying and locating vessels, it also allows automatic exchange of vessels information collected by vessels sensor with other vessels or shore station(s) [3]. Similar to ORBCOMM modem, AIS modem also used serial protocol to exchange data with central processing unit and proper packet format is needed as well. AIS packet is more complicated that ORBCOMM packet which only need appropriate header and checksum where it involves binary data encapsulation and encoding. The concept can be best explained by using layer approach which shown in Fig. 3. This example shows how the sensor data is encapsulated and encoded before broadcast via AIS transceiver. Starting at third layer, when it is time to generate a packet which contains sensors information, it needs to be packed into proper binary data format. After packing all the data into binary format, this binary data will be passed to second layer, which will construct a full binary message which consists of header and binary data with correct data format as its datagram. There are 26 different types of messages capable being sent by AIS where each message has different header as define in ITU M.1371. The binary message then will be encoded into ASCII format that will be handled by central processing unit. At first layer a complete AIS packet is constructed to hold binary message in ASCII format.

Fig. 3 Layer Approach of AIS Packet's Encapsulation

Similar to binary message, AIS packet consists of header and data. After this process, AIS message will be broadcast via AIS transponder [4].Another option for base station to receive data from buoy is via telecommunication service provided by telecom. Assuming mobile network build on CDMA technology, buoy can send data via SMS through CDMA modem. Since there is a total characters limitation per SMS and also binary data is not allowed in a SMS, similar technique which is used in AIS data encoding is applied in this situation. Assuming there is latitude information (49.200283 degree) contain in a SMS with precision 6 positions after decimal point. A typical SMS will be sent as string "49.200283" which occupied 9 characters space of a SMS where encoded message will only occupied 27 bits or 5 bytes that capable to provide latitude with same precision. Since there is no standard for similar application, hence SMS data format is can be determined by user themselves. Considering TCPIP service is supported by CDMA modem, weather information can also forward to a specific computer via TCPIP. A typical TCPIP packet support long data size and binary data. Thus, data can be sent without any encoding technique. Only several step need to perform before TCPIP data can be sent. Target computer need to open port listen for incoming data. If there is any firewall installed in target computer, setting is required to make sure incoming data will not be dropped by firewall. Extra care is needed in setting up firewall to prevent any undesired problem due to port open to public. For CDMA modem, it needs to request service from telecom, and request connect to specific IP address and port which is user configurable. Echo will be reply from telecom if connection successfully established. User can send data only if connection is created. Finally, connection needs to be closed after data were forwarded. Fig. 4 demonstrates example of CDMA modem's (Model: RCU890) TCPIP operation. Different CDMA modem will have different operation and commands.

Each communication method has own advantages. Table 1 illustrates the differences between these few methods.

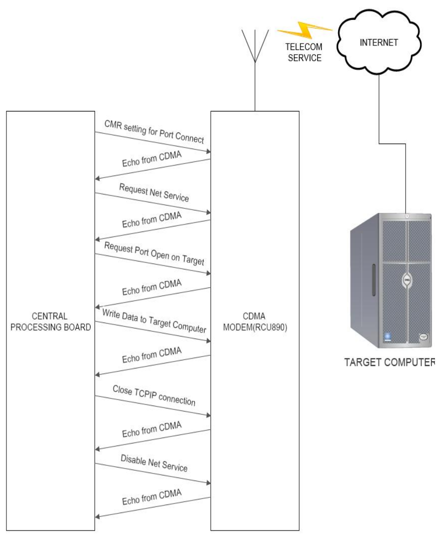

Fig. 4 TCPIP Operation of CDMA Modem

Table 1. Differences between AIS, ORBCOMM and CDMA Communication Method

Method	Coverage	Data Length
ORBCOMM (Satellite)	Worldwide	Unlimited
AIS (VHF)	Within few Kilometers	Large. Predefine standard.
SMS (Telecom)	Within Telecom Coverage	80 Bytes (Korea CDMA Network)
TCPIP (Telecom)	Within Telecom Coverage	Unlimited

Ⅳ. Power design

Power system of a buoy must be designed carefully. As the primary power source of a buoy, battery selection needs to be very cautious to make sure buoy able to work all the time and with maintenance free. Sealed lead acid (SLA) rechargeable batteries are used for power storage due to its durability and stability of its chemical substances under all condition. Additionally, photovoltaic panels are added as charging unit in a buoy system. Both battery and solar power are managed through a power distribution module Sunsaver inside the buoy. The Sunsaver is fully automatic PV system controller that includes electronic functions to protect both the controller and the PV system. An optimized voltage PWM algorithm is utilized in battery charging/discharging purpose. Calculation needs to be performed to make sure the battery supply and photovoltaic panels' charging rate can support buoy operation continuously. Assuming buoy consumes 1A during active state (where all the devices are switch on), 50mA while in sleep condition (only central processing unit and CDMA modem still operating) and 4A when data is transmitting out via ORBCOMM, AIS and CDMA modem. Consider everyday hour buoy wake for 10minutes, collect and send the data. Hence for one hour, power consumption is shown as (1). Due to transmission process take very short time to transmit a data, therefore the power consumption can be ignored.

$$50/60\ \text{Hx}50\text{mA} + 10/60\ \text{Hx}1\text{A} = 0.20833333\text{AH} \quad (1)$$

Assume there is no sunlight available continuously for one month, to support buoy operation without charging within a month, a battery with capacity of 0.2083333x720x2 = 300AH (with safety factor of 2) must be used. Power generated by photovoltaic need to be calculated as well. If power generated is too small, it will not enough to charge battery and cause buoy stop working sooner or later due to battery exhausted. In the consideration of average current 0.208333A required to keep buoy working properly, theoretically, a photovoltaic panel rated at 0.20833333Ax12V = 2.5W should be enough to handle. Because of photovoltaic panel will not always face right to the sunlight and sunlight only available on day time; furthermore there is winter season which sunlight is weak compare to other seasons in a year. A safety factor of at least 10 to 20 must be take in count to determine the power rating of photovoltaic panels. Thus, photovoltaic panel of 50watts is recommended in similar buoy system.

Ⅴ. RESUIT

A test buoy was moored at Haeundae, Busan on 03 December 2009 to capture meteorological and oceanography data. A monitoring system was setup at base station to receive data from buoy. Base station will receive ORBCOMM data and TCPIP data from buoy and then display the buoy info via graphical user interface (GUI) through internet as shown in Fig. 5.

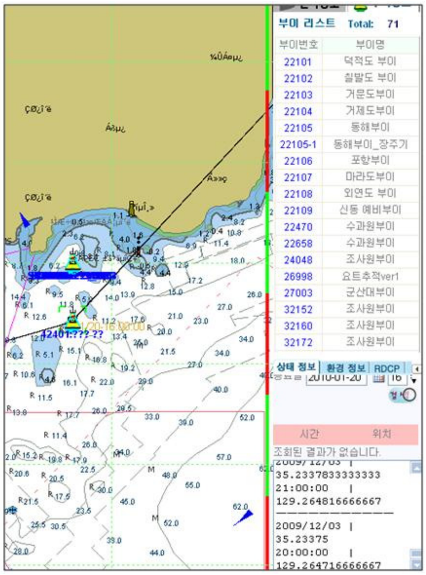

Fig. 5 Internet GUI Based Buoy Information Monitoring System

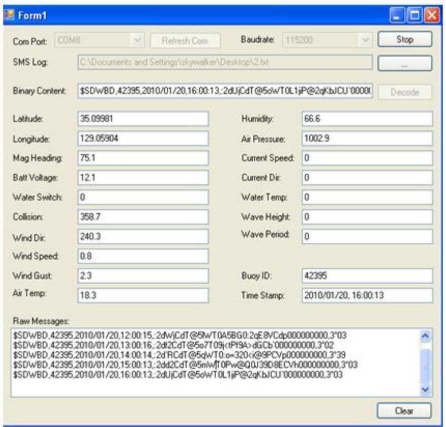

Fig. 6 SMS Monitoring Software

SMS Monitoring software was also installed at base station to verify data received from buoy via SMS method. Fig. 6 illustrates software interface for SMS monitoring software. Software will decode SMS and display in appropriate field in human readable format.

From the data observed, first data of the battery voltage level during mooring process was 12.20V (03 December 2009), and last data of the last battery voltage reading was captured is 11.4V (20 January 2010). Average voltage measure between these periods is 11.6V with standard deviation 0.3V ; hence this proved the power consumption of the system and charging rate from photovoltaic panel is able to support operation of this buoy.

VI. Conclusion

Main purpose of this project is to discuss on a typical electronics system design of a meteorological buoys. Basic concepts such as communication method, data processing, and power design were discussed. Also the experiment data was from real buoy for the duration of one month. The experiment result shows the design is capable to works well in term of data receive from buoy at base station, battery life time and able to work standalone without any power exhausted problem.. Besides, it can effectively perform main task which is oceanographic and meteorological information monitoring. Future similar buoy can be enhanced or improved from this design depend to the specification.

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