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Wireless Sensor Network Based on Airport Noise Data Collection System

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Abstract: For the requirements of multipoint real-time data collection and transmission in the noise monitoring of current civil aviation airport, the design and implementation of noise data collection system based on wireless sensor network is discussed. The collection system is composed of ZigBee wireless sensor network in the airport and ARM noise data control module. Monitoring personnel can get airport noise data collected by ZigBee wireless sensor network through RS232 serial communication between ARM platform and ZigBee network coordinator.

Keywords: Airport, ARM, data collection, noise, ZigBee.

1. INTRODUCTION

Airport noise pollution is one of the major environmental problem we are facing these days. Some studies have suggested that if a person is exposed to a stronger noise environment for a long time, his auditory sense would be affected badly. With the rapid development of China's civil aviation transportation industry and the increase in the peoples' environmental awareness, many attentions are paid to the prevention and control of aircraft noise pollution. China's environmental protection department has required that the noise estimation and the assessment of its effect on environment must be conducted to all new construction and renovation and expansion of airport. So in order to reduce noise pollution and take effective noise reduction measures, airport noise data must be collected, analyzed and did research.

Now the leading Noise Monitoring System in the domestic airport is Noise and Operation Monitoring Systems (NOMS) in Beijing Capital International Airport which is built by Beijing Capital International Airport Co. Ltd. The system uses the acoustic measurement instruments and software systems developed by Denmark B&K Company, and sets number of fixed monitoring stations and a car mobile monitoring stations around airport, so it can real-time monitor the local noise. But this system is too costly to widely apply to China's aviation field. The majority of our airport noise measurement method at this stage is that monitoring personnel takes advantage of the sound level meter to measure and record one location noise, and then repeated measurements are conducted in other locations that need to measure. This measurement method has many drawbacks. For example, it spends too much human resources, also it is difficult to collect multipoint noise data simultaneously and unable to use noise data collected for sound field analysis.

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The development of wireless sensor network provides a new technical way to airport noise monitoring. For the actual needs of the airport noise monitoring, this paper presents an airport noise data collection system based on ZigBee and ARM. This system takes advantages of ZigBee technology's low-power, multi-hop ad hoc networks and synchronization mechanisms to make the implementation of multi-point simultaneous collection and transmission of airport noise data possible.

2. AIRPORT NOISE MEASUREMENT METHODS AND EVALUATION STANDARDS

2.1. Airport Noise Measurement Standards and Methods

GB 9661-88 "Measurement of aircraft noise around airports" is the basis of domestic airport noise measurement. The standard specifies measurement conditions, measuring instruments, measurement methods and measurement data's calculation methods of aircraft noise around airport. It is suitable for measuring noise around airport generated by takeoff, landing or flyby. Using this standard, noise caused by a single flight event, a series of successive flight events and flight event in a period of monitor time can be measured [1].

With the development of electronic technology, sound level meters and airport noise monitoring system has become the main measuring instrument in noise measurements around airports. GB 3785 "Electric, sonic properties and measuring methods for sound level meters" specifies the performance of sound level meter. To meet the GB 9661-88 standard, sound level meters whose precision is not lower than type 2 and other airport noise monitoring instruments should be used. Using sound level meters, A-weighted sound level's or C-weighted sound level's maximum (L_{EPN}) of one flight noise is read out and recorded. Furthermore, based on a single flight event's noise level, the noise level arising from N times successive flight events (L_{EPN}) can be calculated, or the noise level caused by flight events in a period of monitor time (L_{WEPN}) can be measured [2].

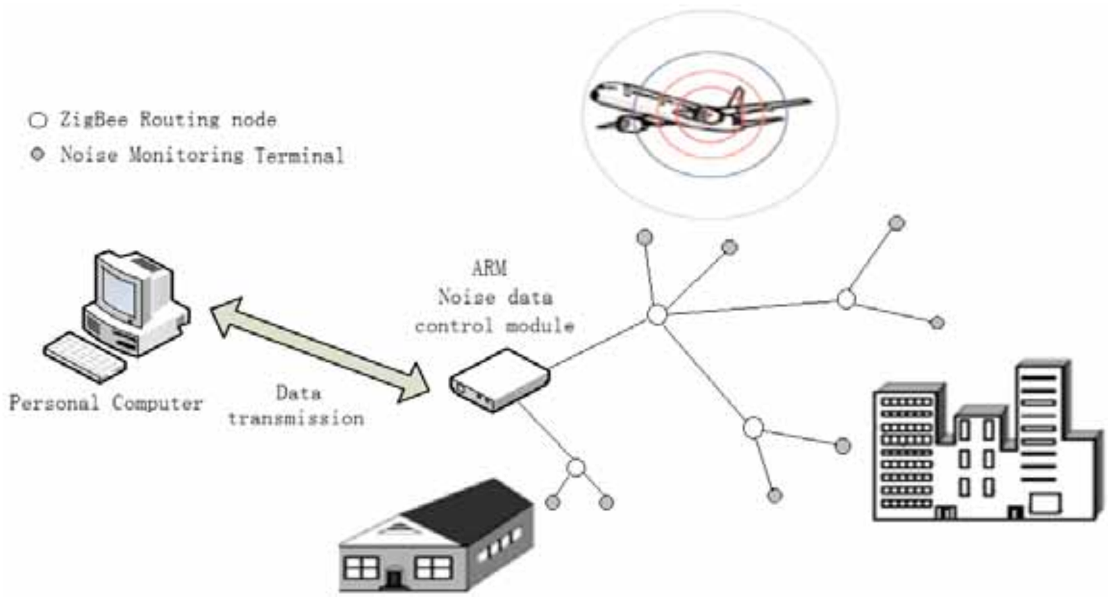

Fig. (1). The airport noise data collection system based on wireless sensor networks.

2.2. Noise Evaluation Standards

The usual evaluation method of noise is statistical method. Namely, according to the comparative survey of enough people's subjective responses to noise, average values are counted. The main indicator of the current noise evaluation is A-weighted sound level. The correction method that appropriate increase or decrease is given to objective sound pressure level of different frequency artificially in the measuring instrument is called frequency weighting. The network achieving this frequency weighting is called weighting network. The sound level measured by weighting network is called weighted sound level, and it is a subjective evaluation value to measure the strength of noise. There are four weighting network (ABCD) in the current, and A-weighted sound level measured by A weighting network is similar to loudness perception of human ear to sound. It reflects the relationship between the influence of noise and frequency. When sequence of noise is ranked according to A-weighted sound level decibel values, people's subjective evaluation of various noises can be reflected better.

A-weighted sound level is often used to stationary noise. But for non-stationary noise, an equivalent sound level based on A-weighted sound level should be used for noise evaluation. Replacing changing noise with stationary noise of A-weighted sound level, if they can give the same amount of acoustic energy to human within the same time, then the stationary noise's sound level is this changing noise's equivalent sound level. Equivalent continuous A-weighted sound level means that using a continuous and constant A-weighted sound level takes the place of non-stationary A-weighted sound levels within a certain period of time by the method of energy average.

Sound Level is that noise data collection converts the noise signals of different intensities into the corresponding and proportional electrical signals, and then presents them in the form of decibels value (unit: dB). The calculation method of Sound Level is expressed as follows:

$$L_p = 10\log_{10}(\frac{p^2}{p_0^2}) = 20\log_{10}(\frac{p}{p_0})\,dB \qquad (1)$$

Where, reference sound pressure P_0 is 20 μPa, P is the weighted sound pressure measured including frequency weighting (always using A or C-weighted) and time weighting (reading interval T is 125 ms or 1s) [3].

The calculation method of equivalent continuous sound level is that:

$$L_{eq} = 10\lg\frac{1}{T}\int_0^T 10^{0.1L_p}dt \quad (2)$$

Where, L_p is weighted sound level, L_{eq} is equivalent sound level within time T.

3. THE DESIGN OF AIRPORT NOISE DATA COLLECTION SYSTEM

The airport noise data collection system is composed of ZigBee wireless sensor network in the airport and ARM noise data control module. The system configuration diagram is shown in Fig. (**1**).

3.1. ZigBee Wireless Sensor Networks

ZigBee wireless sensor networks of the airport noise data collection system are responsible for sending airport noise data collected by sensors of each network terminal to the coordinator node in noise data control module in the form of packets. Ad hoc networks, low power consumption and noise data's synchronous collection can be achieved by setting wireless sensor networks.

Shown in Fig. (**1**), ZigBee wireless sensor networks of the airport noise data collection system use the structure of tree topology. ZigBee coordinator node is responsible for forming networks, selecting channels and assigning ad-

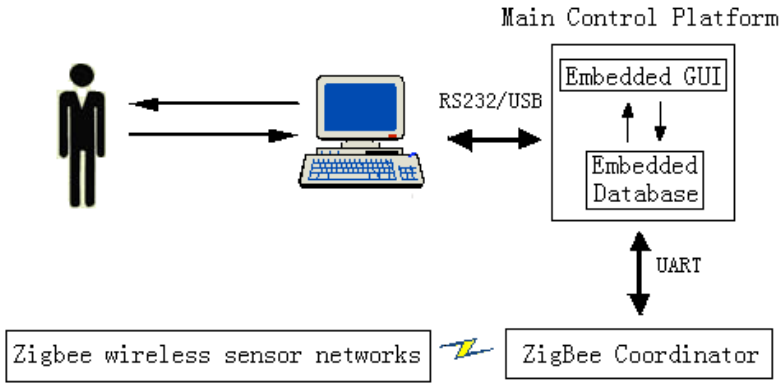

Fig. (2). The working schematic diagram of noise data control module.

dresses for other nodes in the network. Routing node is responsible for adding the other node to the network and is regarded as the parent node of terminal node. Terminal node is the child device of routing device and can collect noise data. Terminal node sends noise data collected by sensors to routing node, and then routing node transmits them to coordinator node. So ZigBee networks can meet the requirements of long distance transmission via this multi-hop data transmission ways.

Routing node's introduction to network can not only reflect the multi-hop routing features of ZigBee network, but also reflects the low power consumption features of ZigBee networks. Routing nodes generally use the main power supply, and terminal nodes are battery-powered. Terminal devices normally work in dormant state unless they are woken by the router when needed to work.

For the synchronous collection requirement of airport noise data, the beacon mechanism is introduced to the process of noise data's wireless transmission by ZigBee wireless sensor network to achieve time synchronization of each node in the network. In order to achieve all devices' working and sleeping synchronously and maximize power savings, ZigBee coordinator sends a beacon frame to each terminal node in the network through broadcast at a certain time interval (15ms-4mins).

3.2. ARM Noise Data Control Module

The implementation of noise data control module is based on ARM Embedded System. This module is used to control data's synchronization collection, wireless transmission, storage and display. Monitoring personnel can read out the actual value of the collected noise data directly through the LCD display of control module. Noise data control module can also be connected to PC *via* RS232 or USB for data's further analysis by analytical software.

Noise data control module mainly includes main control platform and ZigBee coordinator node. ZigBee coordinator node can control data transmission in wireless sensor network and implement data's simultaneous collection. ZigBee wireless sensor network sends the collected noise data to coordinator node. Main control platform reads these data and stores them to embedded database, and then they will be displayed on LCD by the graphics software of the embedded system. The schematic diagram is shown in Fig. (**2**).

4. THE ACHIEVEMENT OF SYSTEM DESIGN

4.1. Design of ZigBee Wireless Sensor Network

Selection of ZigBee chip is fundamentality to the design of ZigBee network node hardware. CC2530 chip produced by TI Company that this paper selects is a system on chip solution which supports ZigBee protocol. The chip sustain 802.15.4 standard. In the chip, there are a 2.4G normal RF transceiver, a 8 kB RAM, a Flash memory which volume up to 256 kB, a 8051 microprocessor and many other peripherals integrated. To complete the hardware design of each node of ZigBee, only need combined with the actual demand to increase necessary peripheral circuits based on the CC2530 chip.

Different node types' realization unrelated to the hardware design, the node type can be selected *via* ZigBee protocol stack. In this paper, Z-Stack software launched by TI has been selected as ZigBee protocol stack. Beacon mechanism provided by Z-Stack software can be used in achieving time synchronization between nodes in the network [4].

As coordinator and routers need to continue working, the design is that they supplied by power source, and data storage module can be utilized to satisfy the requirements of a relatively large amount of data storage. Terminal nodes are battery-powered, and expand common data interface to connect noise measuring device.

4.2. Design for ARM Noise Data Control Module

As the main control platform of the noise data control module needs to implement some complex functions, such as database creation and display of graphical interface, an embedded processor is used as the core of the system's hardware. This design uses S3C2440 chip based on the ARM920T processor core as microprocessor as the main control platform. The chip is a 32-bit microprocessor. Its main frequency can rise to 500 MHz by frequency conversion of phase-locked loop. The chip adopts system on chip architecture, and there are a wealth of on-chip peripherals and common interface integrated in the chip. It meets the hardware requirements to achieve this design [5].

Because there are many software depends on the operating system such as embedded database and graphical interface is used in noise data control module, an embedded op-

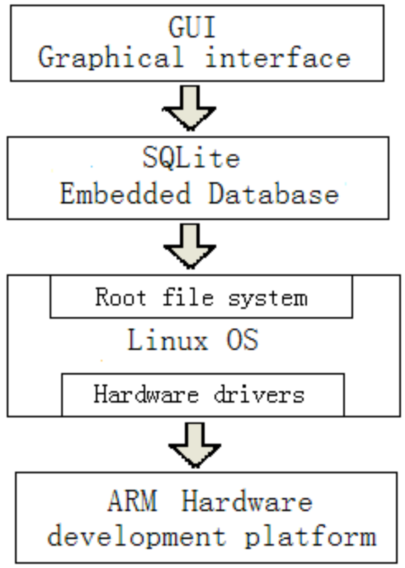

Fig. (3). The master control platform architecture of ARM noise data control module.

erating system is needed to be responsible for resource allocation of software and hardware, task and process control and scheduling, and providing support to the application software on the top. The embedded Linux operating system that this design uses is the mainstream operating system with features as follows: its code is open source and applies to a variety of processor architectures, and its kernel is stable and can be cut.

On the basis of embedded Linux operating system transplanted and the root file system mounted, graphical interface software and database need to be installed. This design uses QtEmbedded which depends on the embedded Linux as GUI development platform. Qt is a graphic design library based on C++. Its unique signals and slots mechanism enables graphical interface called the noise database. SQLite is a embedded relational database with query, add, delete and other basic functions, the data can be stored and displayed in a table. The data transmitted to the coordinator node by ZigBee wireless sensor network is stored into the SQLite database of main control platform via UART. Then the graphical interface designed by using QtEmbedded application display the data stored in SQLite [6].

The master control platform architecture diagram of noise data control module is shown in Fig. (**3**).

CONCLUSION

At present, hardware design and software system's migration and cross-development of main control platform module of the noise data control system have been completed. The next primary work of this project is to set up ZigBee wireless sensor network and to ensure synchronous collection and effective transmission of noise data.

Airport noise data collection system designed in the paper which is based on wireless sensor networks gives full play to the characteristics of ZigBee wireless sensor network, such as low power consumption and synchronous collection, and reflects the specificity and portability of embedded systems. For the actual situation of the current domestic airport noise monitoring system, this paper combines ZigBee technology with embedded technology and provides a new executable solution to achieve the collection and transmission of airport noise data.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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REFERENCES:

[1] GB9661-88, Measurement of aircraft noise around airports.

[2] K. Ilkka, "Design of networked low-cost wireless noise measurement sensors", *Sens. Transduc.*, vol. 10, February, 2011, pp. 171-190.

[3] D. Yang, "Study on the application of evaluation index of aircraft noise around airport", *Indus. Safe. Environment. Protect.*, vol. 37, August, 2011, pp. 33-35.

[4] Y. Zhou, "Design of novel intelligent transportation system based on wireless sensor network and ZigBee technology", *Sens. Transduc.*, vol. 156, Sept. 2013, pp. 95-102.

[5] Y. N. Murthy, "ARM processor based multisensor system design for the measurement of environmental parameters", *Sens. Transduc.*, vol. 136, Jan. 2012, pp. 124-126.

[6] F. Ying, Y.Feng, "Design and Realization of Home Gateway Base on SQLite, *Microcomp. Info.*, vol. 24, no. 2, May 2008, pp. 24-26.

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