

Embedded Wireless Water Detection System Based on WinCE

Haixu XI, Renjun DAI

School of Computer Engineering, Jiangsu University of Technology,
No. 1801, Zhong Wu Avenue, Changzhou City, Jiangsu Province, 213001, China
Tel.: +8613776826323
E-mail: jsut_xhx@126.com

Received: 22 August 2013 /Accepted: 22 October 2013 /Published: 30 December 2013

Abstract: This paper describes a design of embedded wireless water detection system based on WinCE, the software design of the system including the design of method of automatic detection system; detection result and data transportation based on data transmission module; controlling of automatic sampling system; detection of arsenic from sub-differential pulse stripping voltammetry; wavelet analysis and de-noising of detection data of arsenic; calculation of the peak area and concentration of arsenic. Software interface of arsenic/fluorine automatic detection system for drinking water is friendly, the operation of it is relatively simple, and we can set the important test parameters to know the real-time operation status of the instrument. Reasonable design of automatic detection method can avoid too much human interference on instrument and make the instrument realize the automatic measurement. *Copyright © 2013 IFSA.*

Keywords: Wireless communication, Server, Data acquisition, Data transmission.

1. Introduction

Arsenic is one of the most harmful ions in a variety of harmful ions in water. Many authoritative institutions such as the American Institute of Environmental Health Sciences, the U.S. Environmental Protection Agency, the World Health Organization (WHO) and others finds that arsenic can enter the body through contacting with respiratory, skin and gastrointestinal tract and induce many systems metabolic dysfunction [1, 2]. Since the 1970s, there have endemic fluorosis phenomenon in many places of China. Studies have shown that the prevalence of endemic fluorosis is not entirely due to the high fluoride content in drinking water, when the content of fluorine is too low in water are often also

cause disease [8, 9]. For mature adults, ranging from excessive consumption of fluoride can cause dental fluorosis, fluoride bone disease and even cause cancer. For young children, it needs a certain amount of fluorine intake, too little intake of fluoride can cause Caries [3]. Thus, real-time monitoring of the concentration of heavy metals in drinking water has a very important significance for the ecological environment testing, clinical, food as well as human health for survival.

For requirement of real-time and on-spot monitoring of toxic and harmful elements in drinking water, we have developed arsenic/fluorine automatic detection and analysis system for drinking water based on the principle of electrochemical detection, the instrument has many advantages such as simple,

low-cost, targeted, high precision and high degree of automation, so that makes it possible to monitor arsenic/fluoride and other elements in drinking water in real-time and on spot rapidly [4, 5]. Real-time monitoring of the content of harmful ions in drinking water is extremely significant in ecological environment testing, clinical, food as well as the health of people's lives. Test data is first stored in the hard drive in the test equipment on spot, then the data and results are sent to a central server by wireless data transmission module. In the laboratory environment, testers can effectively download test data for further analysis [6-8].

2. Circuit Design of Wireless Control Automatically Detects System

2.1. Potentiostat Circuit for Measurements

Field work electrode can be prevented from interfering spurious signal, thereby increasing the

current and the voltage stability and accuracy in the circuit. Thus, a constant electric potential can keep a constant fixed potential value on condition of ensuring no current flows through the reference electrode. The reference potential is applied to the inverting terminal of the control amplifier (CA), Adding controlling potential in the non-inverting input terminal of the CA control voltage is applied as a reference potential, and connecting Auxiliary electrode with output terminal of the Control amplifier to form closed-loop negative feedback control system. The potential at the inverting input changes along with the input potential terminal, so that when a reference potential terminal is constant and the current in the electrode changes, any slight change in the reference potential with respect to the working electrode potential, will both be corrected by negative feedback voltage of circuit to achieve the purpose of automatic constant potential. Fig. 1 is a schematic diagram of the potentiostat circuit. Constant potential output in the -5 V ~ +5 V within the error range less than 3 mV.

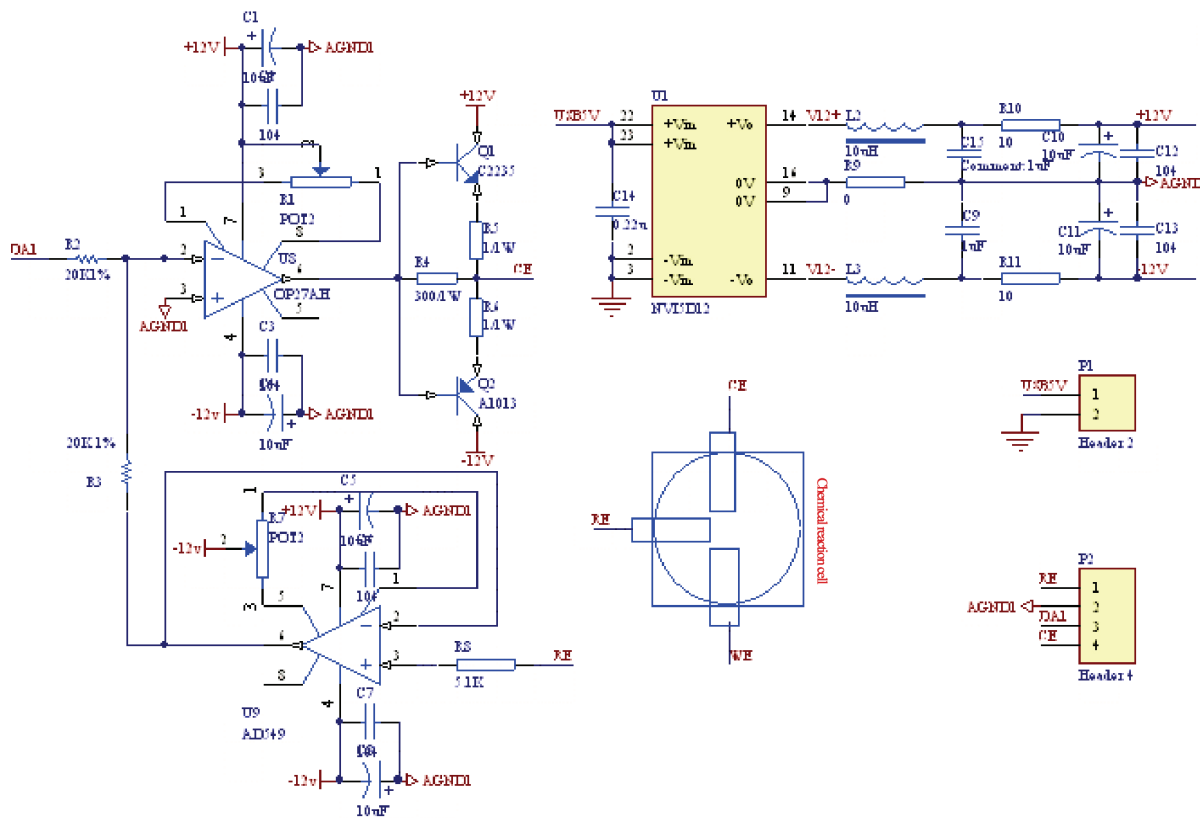


Fig. 1. Potentiostat circuit schematics.

2.2. Circuit Design of Wince-based Embedded Wireless Control System

Water pollution problems in the world become more and more important, long drink substandard water can cause a variety of diseases. The rapid development of wireless communication provides a

good development platform for the detection of harmful ions in drinking water. Wince-based embedded wireless control system can achieve a really on-line and unattended monitoring. After a number of experiments, Wince-based embedded wireless control system can still achieve a stable remote boot and data transfer in the case of a poor

communication signal. Data transfer diagram shown in Fig. 2. It is a connection diagram of circuit system of arsenic/fluorine automatic detection system for drinking water. Take National Instruments (National Instrument: NI) produced USB-6212 data acquisition

card as the core of the system, and design a constant potential instrument, weak signal detection current – voltage conversion circuit and auto-sampler control circuit based on three-electrode system.

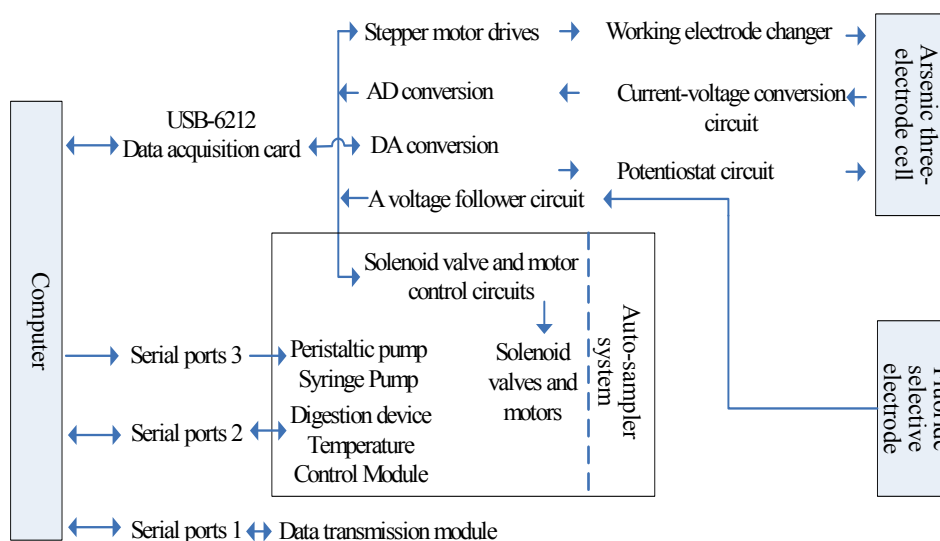


Fig. 2. Connection diagram of circuit system of arsenic/fluorine automatic detection system for drinking water.

3. Auto-sampler System Design in Wireless Control System

Heavy metal detection process needs to add liquid to be tested as well as a variety of reaction solution, and the majority of the liquid added manually or using ordinary peristaltic pump timing, with the reducing volume of added liquid, the error will be larger, there are many defects on the accuracy and repeatability in the injection process. The automatic detection system for arsenic ion detection process. The testing process in system requires several microliters of standard solution and adding the exact standard solution is a prerequisite for accurate analysis. Furthermore, a peristaltic fluid pump controlling a liquid is inefficient and the control process is cumbersome. A reasonable separation apparatus of pipes can improve the efficiency and accuracy of the test as well as the analysis results. In order to solve the above problems, the automatic detection system provides an efficient, less cross-contamination and reproducibility auto-sampler systems. It includes injection pump for adding trace precise standard solution, a peristaltic pump to extract large amounts of liquid, Manifold board and Solenoid valve for controlling pipes on and off. Liquid injection control system in comprised of the peristaltic pump, Manifold board and Solenoid valve achieves the accurate extraction of large amounts of liquid, effectively reducing the number of peristaltic pumps, while avoiding cross-contamination.

According arsenic/fluoride automatic detection system instrument functions settings and types of required auto-sampler reagents, auto-sampler system pipes include water sampling system, auto-sampler fluoride detection system and auto-sampler arsenic detection system. It's piping connections shown in Fig. 3.

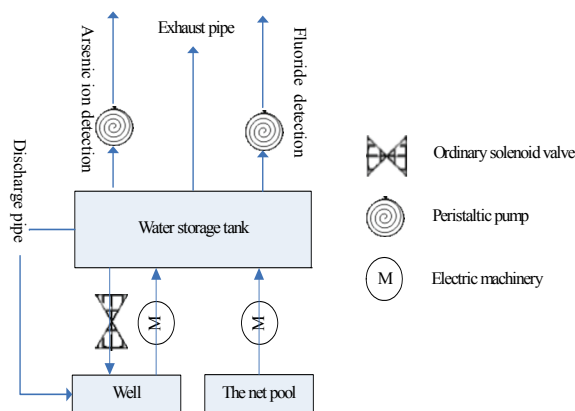


Fig. 3. Schematic water sampling device.

Water sampling system consists of common solenoid valve (1), watery storage tank (1) and pumping fluid motor (2). Fluoride detection auto-sampler system consists of common solenoid valve (4), peristaltic pump (1), and four into one Manifold

board (1), fluorine reaction tank (1) and drain the motor (1). Arsenic detection auto-sampler system consists of the injection pump (1), peristaltic pump (3), four into one Manifold board (1), and two into one Manifold board (1), common solenoid valve (5), the high-pressure solenoid valve (3), digestion tank (1), arsenic reaction tank (1) and drain the motor (1). Water sampling device structure schematic is shown below.

4. Software Design of Automatic Sampling System and a Data Transmission Module

The automatic control system with software components to form a complete control system.

Drinking water of arsenic/fluorine automatic detection system has software design includes: software design of automatic sampling control system; module of wireless communication and data transmission; testing software design for fluoride ion; detection software design of differential pulse stripping voltammeter based on arsenic ion; used in differential pulse stripping Voltametric wavelet analysis data processing and its software realization; calculation method of peak area and the concentration of arsenic ions. The program design of the research based on LabVIEW software development platform, which is graphical programming language software driven with a programming interface, is required for measurement applications create the device VI, function etc...Drinking water arsenic and fluorine automatic detection system software display panel as shown in Fig. 4.

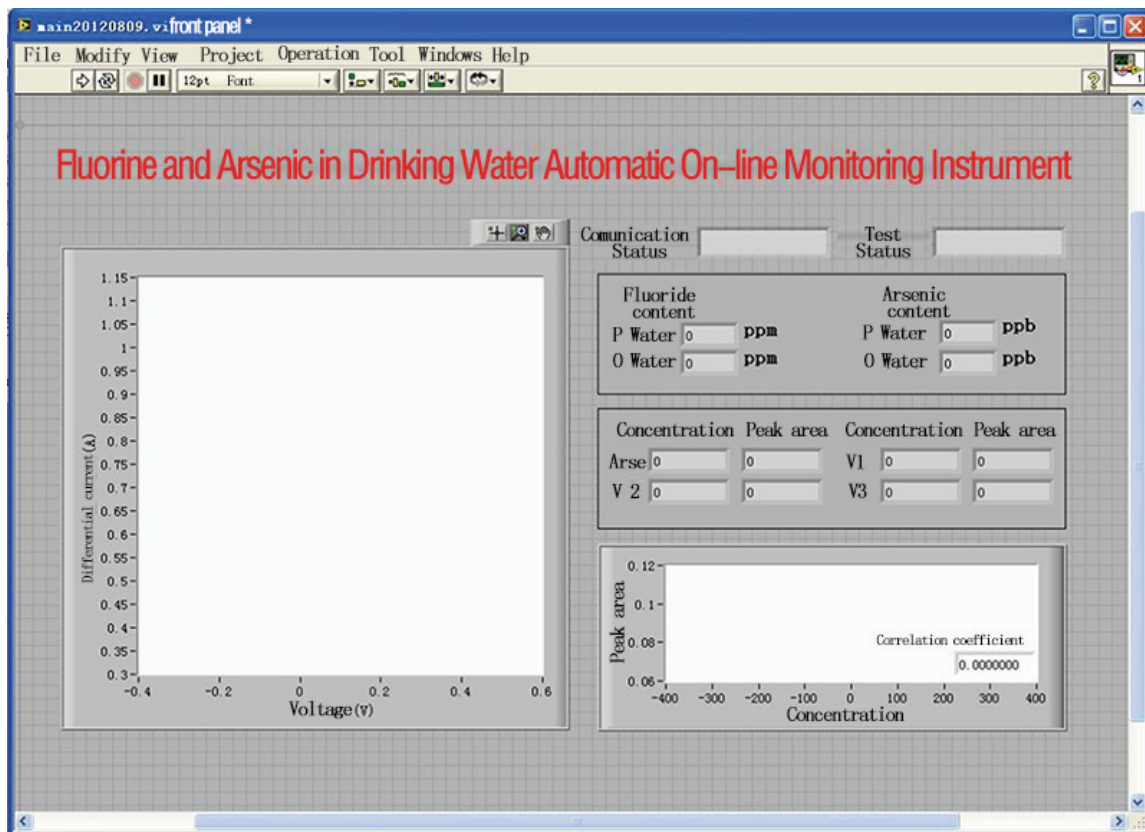


Fig. 4. Drinking water arsenic and fluorine automatic detection system.

The front panel is placed in a waveform, waveform display data for arsenic ion detection; two string display window, one for the prompt communication module state of on the instrument and server communication, a used to indicate the operating state of the instrument, is mainly the display of the operation steps; four numerical display window, respectively. For the purification of display of fluoride concentration test value in water, display

of fluoride concentration test value in water, show that arsenic ions test value in water purification, arsenic ion concentration test value show of well; eight addition method for standard numerical display window, four for the display of arsenic ion concentration test sample of arsenic ion and the concentration of standard solution, four for peak area for standard solution in arsenic ion and dissolved arsenic ion test sample; a Express XY diagram, used

to display the numerical peak area fitting points, curve fitting and correlation of dissolved arsenic.

5. Data Acquisition and Signal Processing

In this study, the differential pulse voltammeter can effectively improve the sensitivity and accuracy, but in the measurement of ion concentration, the stripping peak shape is irregular, it is difficult to accurately and give a peak current. Using wavelet demising analysis can be effectively separated signals from noise, improve the detection limit. In this paper, extracting the differential pulse voltammograms of arsenic stripping peak by using DOG wavelet function.

If the functions satisfy $\psi(x)$ the admissibility condition:

$$C_\psi = \int_{\mathbb{R}} |\hat{\psi}(\omega)|^2 |\omega|^{-1} d\omega < \infty \quad (1)$$

Called $\psi(x)$ an admissible wavelet, the chemical signal $f(x)$ with continuous wavelet transform as the base $\psi(x)$ for the

$$W_\psi f(a,b) = \frac{1}{\sqrt{|a|}} \int f(x) \overline{\psi\left(\frac{x-b}{a}\right)} dx$$

$$(f \in L^2(\mathbb{R}), (a,b) \in \mathbb{R}, a \neq 0) \quad (2)$$

The symbol $\psi_{a,b}(x)$ is defined as

$$\psi_{a,b}(x) = \frac{1}{\sqrt{|a|}} \psi\left(\frac{x-b}{a}\right)$$

$$(a,b \in \mathbb{R}, a \neq 0) \quad (3)$$

$\psi_{a,b}(x)$ called by the parent function ψ generated depends on the parameter a , continuous wavelet transform based a, b . a is called the scale factor, b is called a translation factor. The continuous wavelet transform $W_\psi f(a,b)$ is a function of $F(x)$ in the projection functions of $\psi_{a,b}(x)$. It will be a one-dimensional function $f(x)$ is transformed into a two-dimensional function.

In order to make the wavelet transform has good local character in the time domain and frequency domain, hope window width of $\psi_{a,b}(x)$ and $\hat{\psi}_{a,b}(\omega)$ as small as possible. Wavelet transform window width is variable, it uses the narrow window at high frequency, and the use of wide window at low frequencies, which fully embodies the constant relative bandwidth frequency analysis and adaptive multiresolution analysis idea. In practical application, in order to practice the application of wavelet transform in signal analysis, must be discredited to transform parameters. By using the properties of discrete wavelet transform, meanwhile considering the differential pulse voltammeter standard data for

the Gauss signal, select the DOG (Difference of Gaussian) wavelet function, which follows the time formula is the difference of Gauss function of the two scales one times, expression:

$$W(x) = e^{-\frac{x^2}{2}} - e^{-\frac{x^2}{8}} / 2 \quad (4)$$

The frequency formula

$$\hat{W}(\omega) = \frac{1}{\sqrt{2\pi}} \int W(x) e^{-i\omega x} dx = e^{-\frac{\omega^2}{2}} - e^{-2\omega^2} \quad (5)$$

Select a certain time interval T , Dog continuous wavelet function can be divided into:

$$W(a,iT) = T \frac{1}{\sqrt{a}} \sum_n \psi\left[\frac{(n-i)T}{a}\right] f(nT) \quad (6)$$

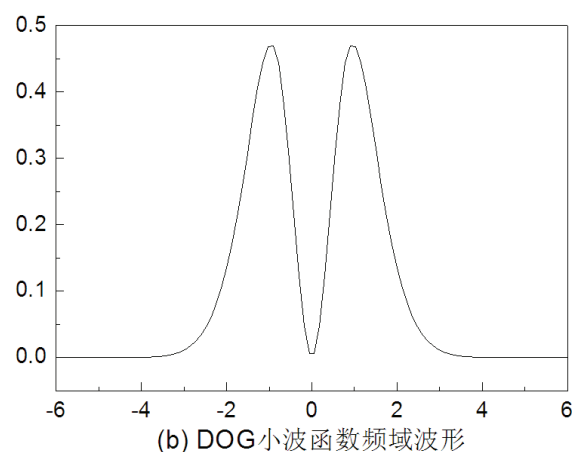
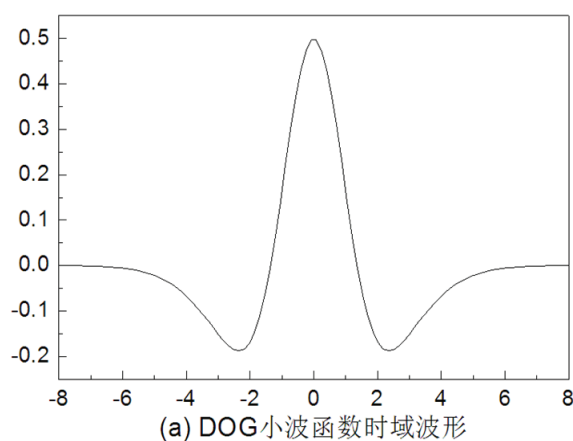


Fig. 5. Shows the time domain and frequency domain waveform of the DOG wavelet function.

6. Conclusions

The arsenic / fluoride automatic detection system for drinking water applied an electrochemical method into arsenic / fluoride concentration detection online to solve the automatic extraction of Water samples and reagents, detection of weak current signal, online

remove of organic matter in Complex body of water and other problems, and achieve fast and accurate testing of arsenic/fluoride concentration for a complex body of water. Real-time monitoring of the content of harmful ions in drinking water is extremely significant for ecological significance testing, clinical, food as well as the health of people's lives. Test data is first stored in the hard drive in the test equipment on spot, then the data and results is sent to a central server by wireless data transmission module, In the laboratory environment, testers can effectively download test data for further analysis.

Acknowledgements

The work was supported by the modern educational technology Research 2011 annual project of Jiangsu Province of China under Grant 2011-R-18859 and the Key Laboratory of Cloud Computing & Intelligent Information Processing of City under Grant No: CM20123004.

References

- [1]. G. E. Gordon, Receptor models, *Environmental Science & Technology*, Vol. 22, Issue 10, 1988, pp. 1132–1142.
- [2]. J. H. Lee, C. L. Giggiotti, J. H. Offenberg, et al., Sources of polycyclic aromatic hydrocarbons to the Hudson River Airshed, *Atmospheric Environment*, Vol. 38, Issue 35, 2004, pp. 5971–5981.
- [3]. U. M. Sofowote, B. E. Meeary, C. H. Marvin, Source apportionment of PAH in Hamilton Harbour suspended sediments: Comparison of two factor analysis methods, *Environmental Science & Technology*, Vol. 42, Issue 16, 2008, pp. 6007–6014.
- [4]. Yao Yusheng, Xie Yongping, Wen Tao, Design of Potentiostat for Three-electrode Electrochemical Sensors, *Instrument Technique and Sensor*, Issue 9, 2009, pp. 23–25.
- [5]. Yuan Shenfang, Tao Baoqi, Shi Lihua, Application of measurement and control technology in smart material and structure, *Measurement and Control Technology*, Issue 6, 1998, pp. 12–14.
- [6]. Huang Zejian, Lin Jun, Low noise design of amplifier in the voltage-ampere analysis of electrochemistry, *Chinese Journal of Scientific Instrument*, Vol. 26, Issue 5, 2005, pp. 518–521.
- [7]. Ye Xuesong, Zhang Guidong, Gao Bo, et al., A full automatic electrochemical analysis system based on virtual instrument, *Chinese Journal of Scientific Instrument*, Vol. 26, Issue 10, 2005, pp. 1002–1006.
- [8]. E. Oja, A simplified neuron model as a principal component analyzer, *Journal of Mathematical Biology*, Vol. 15, Issue 3, 1982, pp. 267–273.