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# Research on Milk Conductivity Detection Equipment

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**Abstract.** Timely and effective detection of bovine mastitis has important significance. By monitoring the milk conductivity values and other parameters, is to automate the monitoring cow health, is the basis of the prevention of bovine mastitis infection. This design is based single-chip microcomputer processing core control sensor measurement unit, data transmission unit, display and control unit, online monitoring system to achieve real-time data collection, transmission, display and other control functions. For the relationship between electrical conductivity and the feedback voltage, we conducted simulation experiments and selected the appropriate mathematical models. Simulation results show that the conductivity measurement piecewise linear model is better, fitter factor. System better meet the monitoring requirements for the prevention of udder disease go far to provide effective technical means.

**Keywords:** Bovine Mastitis, Conductivity, piecewise linear model, simulation experiment

## 1 Introduction

Currently, there are many methods to detect mastitis in dairy cows, there somatic cell count, chemical test method, but there are detected long period, high cost, and low degree of automation shortcomings[1-3].The objective of this study is to develop a milk conductivity detection equipment, change the traditional milk conductivity monitoring mode, for the prevention of mastitis in dairy cows disease provide effective technical means, improve the intelligence level of the milk conductivity measurement, achieve a milk conductivity monitoring automation management.

## 2 Monitoring System Development Description

### 2.1 Hardware design of the system description

Figure 1 is a hardware structure diagram of the measurement and the transmission unit. It includes Single Chip Microprocessor, LCD display module, a keyboard control module, communication module, buffer measurement modules. Among them,

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the buffer measurement module includes buffer chamber, measuring sensors inside the buffer chamber. Single-chip microprocessor measuring unit collected data information is displayed on the LCD display easy for users observation data, confirm the work status of the device, greatly improving the usability of the equipment.

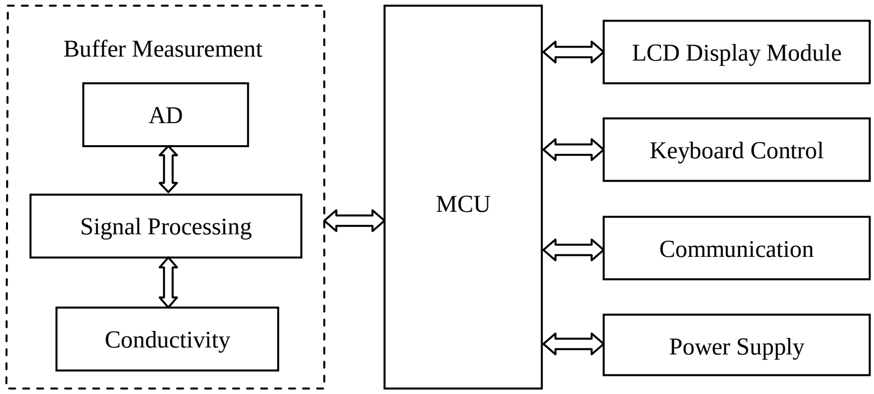


**Fig.1.** Hardware structure diagram of the measurement and transmission unit.

## 2.2 Software design of the system description

The main task of the monitoring system design is to achieve real-time monitoring of milk conductivity values. The main function of the software part is to realize the data processing and display. Figure 2 is a flowchart of the operation of the system. Power on the device after initialization of each module, the system detects the sensor signal output work and have collected through signal processing and A / D conversion, data conversion system after processing, and call the function to display data on the LCD display.

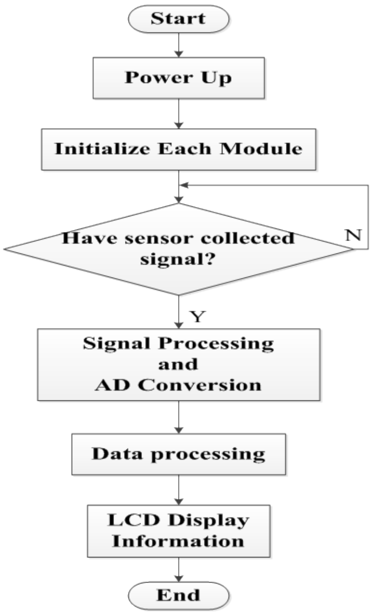


**Fig.2.** A Flow Diagram Design of the System.

# 3 Simulation Analysis of the Equipment

## 3.1 Conductivity and Feedback Voltage Relationship Verification

Because both ends of the electrode have a stable sinusoidal signal source, the feedback voltage from the change in conductivity of the solution will produce a weak change. Single-chip microprocessor processing the feedback voltage produced weak signal changes obtained corresponding solution conductivity value. Aiming at this, simulations were carried out to verify the conductivity and feedback voltage relationship[4-5]. Because the conductivity measured temperature is standard temperature 25 ° C, so this experiment simulated the 120 group solution conductivity value at 25 ° C, as much as possible so that it is evenly distributed measurement range of 0.7 mS / cm-11.7mS / cm of inside, verification solution conductivity and the feedback voltage relationships through simulation circuit. Simulation results of the verification are shown in Figure 3.


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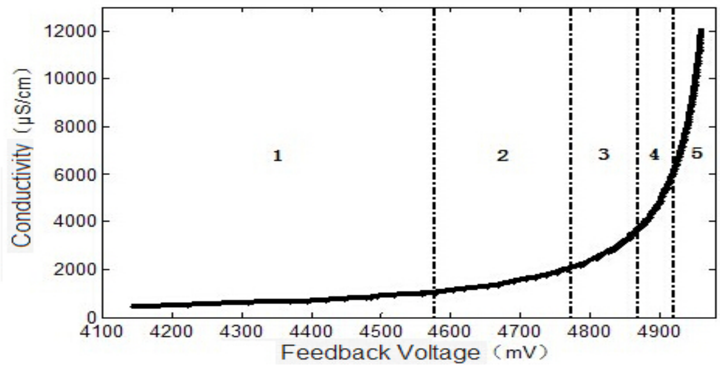


**Fig.3.** The conductivity and feedback voltage relationship diagram.

To meet the demand for conductivity measurement, the value of the feedback voltage is divided into five segments piecewise linear fitting, the fitting result as Equation (5) below. The linear regression coefficients $R^2$ were 0.97 or more, fitting better. Where $x$ is the feedback voltage(mV), $f(x)_{25°C}$ is the conductivity values obtained by after the model processing(μS/cm).

$$\left.\begin{array}{lll} f(x)_{25°C} = 1.817x - 7266 & 4360 \le x < 4570 & R^2 = 0.9843 \\ f(x)_{25°C} = 5.115x - 2.241e+004 & 4570 \le x < 4770 & R^2 = 0.9735 \\ f(x)_{25°C} = 18.76x - 8.766e+004 & 4770 \le x < 4870 & R^2 = 0.9774 \\ f(x)_{25°C} = 54.11x - 2.602e+005 & 4870 \le x < 4920 & R^2 = 0.9836 \\ f(x)_{25°C} = 162.2x - 7.926e+005 & 4920 \le x < 4970 & R^2 = 0.975 \end{array}\right\} \quad (1)$$

### 3.2 Validation of Linear Fitting Model

In order to verify the accuracy of the model, we conducted a verification test of piecewise linear fitting model. This experiment simulated the 97 group conductivity calibration solution conductivity value at 25 ° C, as much as possible so that it is evenly distributed within the measurement range of 0.7 mS / cm-11.7mS / cm s. Piecewise linear model of the system processing simulation data get measured values and simulation data for comparison. Simulation results of the validation are shown in Fig4.

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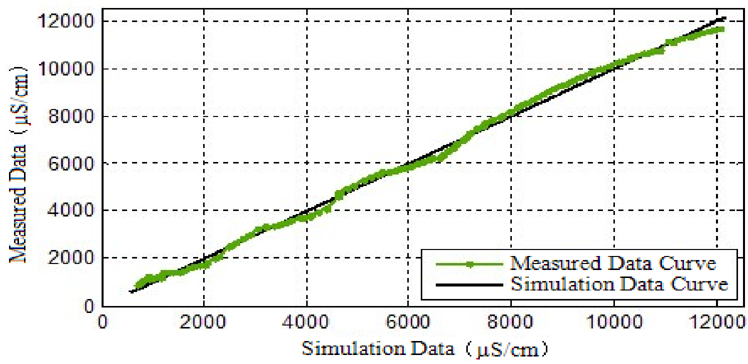


**Fig.4.** Simulation verification results of the linear model.

Figure analysis shows that the measured data curve obtained by the piecewise linear model provide a better fit to the simulation data, linear fitting coefficient R of measured data is 0.9876, higher measurement accuracy. Meanwhile, in order to verify the accuracy of the measured data, we focused on the measurement data and the simulation data in accordance with equation (2) for the relative error calculation. The average relative error of each segment is less than 4.0%, calculated results show that the higher the conductivity measurement accuracy.

$$\delta = \frac{\left| Y_M - Y_S \right|}{Y_S} \times 100\% \quad (2),$$

In the formula, $\delta$ is the relative error of the measurement, $Y_M$ is the measured conductivity value, $Y_S$ is the conductivity value of the simulation.

## 4 Summary

Developed a milk conductivity detection equipment, it mainly has collected milk conductivity, display information, keyboard and other functions. It has changed the traditional milk conductivity monitoring mode, for the prevention of mastitis and other diseases provide effective technical means, and to improve the intelligence level of the milk conductivity measurements, to achieve a milk conductivity monitoring automation management.

For the system, we conducted simulation experiments and analysis. For the relationship between electrical conductivity and the feedback voltage, we conducted simulation experiments. By comparison, we choose piecewise linear fitting model, fitting coefficient is higher, fitting better, the relative error is low.

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