Design and Implementation of Online Photosensitive Turbid meter

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Abstract. This paper explain a new online Turbidimeter to measure sewage suspended solids based on light scattering principle. This Photosensitive Turbidimeter has the advantages of high accuracy, high stability, low power consumption and so on. It can meets the current national health standards and grassroots laboratory's detecting the turbidity of water samples and satisfies user requirements.

Introduction

Sewage turbidity is one of the most important indicators about whether the sewage reaches the standards [1,2]. It is also an important basis for the assessment of the purification efficiency of water treatment equipments and water treatment technology status. The turbidity values of the sewage indicate the degree of sewage suspended solids and colloidal substances' obstruction of light. Sewage turbidity is not only related to how much sewage suspended solids and colloidal substances is, but also related to their size, shape and reflection of surface light and scattering properties. So, sewage turbidity, sewage suspended solids and colloidal substances have a complex relationship.
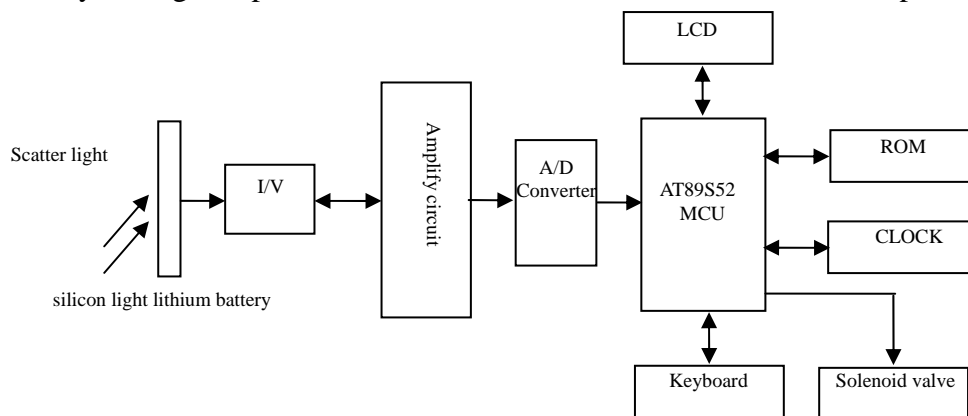

Figure 1 Hardware block diagram

The Principle of Detecting

We get sewage turbidity by testing how much scattered light that has a angle of 90 degrees with incident light silicon photo cell absorbs. This instrument uses a 650nm laser module as the light source to make sure that the measured turbidity value can reflect all the particle's effects of light scattering and transforming all scattered light into electrical energy. The relationship between scattered light and turbidity expressed as（1）

$$I = I_o - I_r \tag{1}$$

Where，I_o is the incident light's intensity，I is the scattered light's intensity，I_r is the transmitted light's intensity. As $I_r = I_0 e^{-KL}$, so we can get（2）

$$I = I_0(1 - e^{-KL}) \tag{2}$$

Where K is the turbidity of the water sampling, L is the optical path of light go though in water

samples. When the turbidity is low and the optical path is short, e^{-KL} approximates $1-KL$. So, we can get（3）.

$$I = I_0 KL \tag{3}$$

Eq.（3）suggests that scattered light and turbidity of the water sample K has the approximate linear relation. So we can think that scattered light intensity is proportional to turbidity.

Hardware design

The hardware system consists of AT89S52 MCU module, clock module, the stable light source current supply module, stable voltage supply module, light source detection and processing module, the A/D conversion module, data storage module, LCD module. As figure 1 shows.

The AT89S52 MCU provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Power-down mode saves the RAM contents. At the same time AT89S52 is compatible with the industry-standard 80C51 instruction set and pinout, which makes the AT89S52 be a powerful micro controller which provides a highly-flexible and cost-effective solution to many embedded control applications.

The turbidity instrument uses silicon light lithium battery to receive the scattering light signal. Then the signal will be amplified. After A/D conversion, the signal will be delivered into MCU for signal processing and then displayed on LCD. Memory unit and keyboard are used to save user's setting parameters and calibration data.

Drive circuit of laser module

The external power supply will cause fluctuations of the light intensity and spectral because of its Instability. So we supply the laser module with constant current power source. As Figure 2 shows, we use the LM317 which is a monolithic integrated circuit to constitute the constant current power supply circuit. When the input is +9V voltage, we get the 22.4 mA current power supply that laser module needed from constant current source circuit.

Figure 2 constant current source circuit

Signal sampling circuit

This circuit that shown in figure 3 converts the +9V DC voltage input power into +5V voltage output stabilization power for the MAX186 module, the preamplifier circuit and the LCD module all need +5V voltage.

Software Design

The software adopts the modular design. The software module consists of a main module and 4 sub-modules consist of key processing module, LCD display module, A/D sampling and data processing module and communication module. The main program flow chart is shown in figure 4. Sub-modules work in the interrupt mode and connect with each other by global variables.
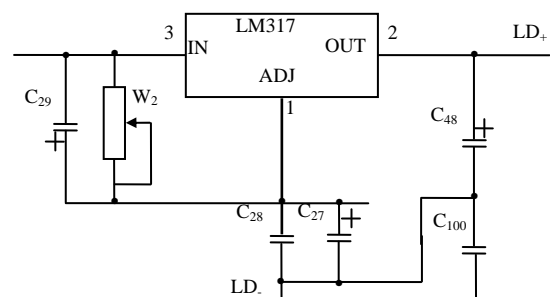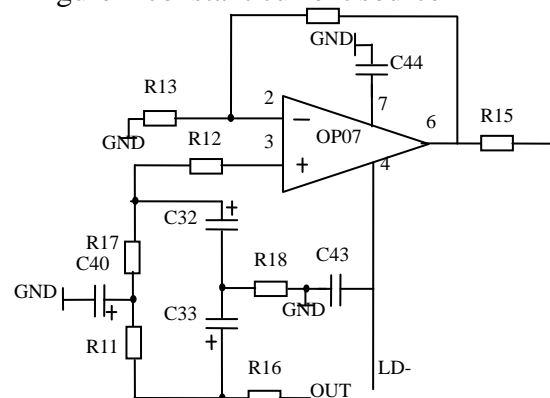

Figure 3 Signal sampling and regulator circuit

Analysis of Results

We test this instrument by using Formazin as internationally accepted turbidity standard solution. The measuring range of the instrument is 0～1000NTU. Its accuracy is 0.001. We obtain the voltage signals of scattered light and transmitted light as chart 1 shows from testing the standard Formazin of 100, 200, 400, 600, 800, 1000 NTU.

Chart 1 Measuring and contrast

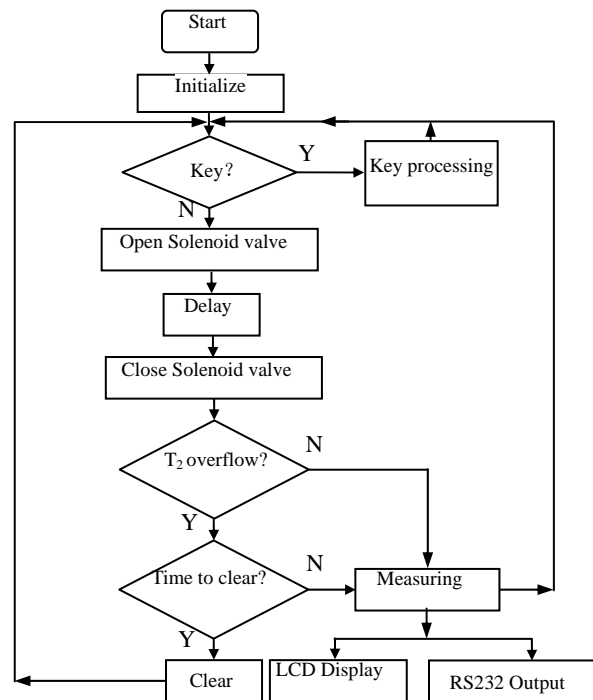| Formazin /NTU	Measured turbidity values/NTU	90° Scattered light signal I_S/V	Transmitted light signal I_T/V	90° Scattered light signal / Transmitted light signal
100	97.1	0.2789	0.2936	0.9173
200	198.8	0.8074	0.1378	5.4937
400	399.7	1.3368	0.0792	15.1685
600	598.6	1.9153	0.0639	26.5726
800	798.2	2.3042	0.0597	37.7355
1000	997.3	2.7825	0.0564	48.3547

Figure 4 Main program flowcharts

Summary

We can draw the conclusion through the measured data compared with standard solution from above: the on-line turbidity meter has the advantages of high precision, good working stability, repeated measurements and so on. At the same time the hardware and software parts of turbidity adopt the modular design, so we can optimize the design and save the cost.

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