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The Implementation of Sanitary Ware Subsequent Water Simulation Test System

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Abstract

This paper introduces the subsequent water mimetic detection system which uses the C8051 Series MCU as the main control module. The detection module in the system is made of horseshoe ferromagnetic coil which can generate uniform magnetic field. It causes magnetic flux a slight change when several simulations (containing metal ring) are rushing down with the water through the ferromagnetic coil internal. The metabolic magnetic flux signal is processed by detection module, such as peak detection, multi-stage amplification, filtering, voltage comparator and other processing. After these processing, it forms counting pulse signal. The counter controlled by the main control module performs minus counting. The last simulation rushed down with water is detected until the calculator value is 0, then system starts to fetch and display the subsequent water value. The experimental result shows that the system can measure and display water accurately within the permissible error change.

Keywords: *subsequent water; horseshoe magnet; C8051 series MCU*

1. Introduction

With the development of economy and the people living standards' improving, people increase emphasis on sanitary ware, so producing toilet sanitary ware ensured washing ability and relative water-saving is a good method to solve the contradiction between people's health demands and efficient utilization of water resources. Rinse ability as one of the important quality criteria for sanitary ware, it determines the quality of sanitary ware. So it is particularly important to accurately detect the subsequent water [1] of sanitary ware in production process. Subsequent water is the flushing water produced when all simulations washed down by water through outfall of toilet. Its role is that simulations are rushed down with water though connecting pipe via riser pipe in each flushing process and at the same time it achieves sewage pipe self-cleaning, replacing water seal water, without adding water seal water. Subsequent water measurement system of sanitary ware is shown in Figure 1.

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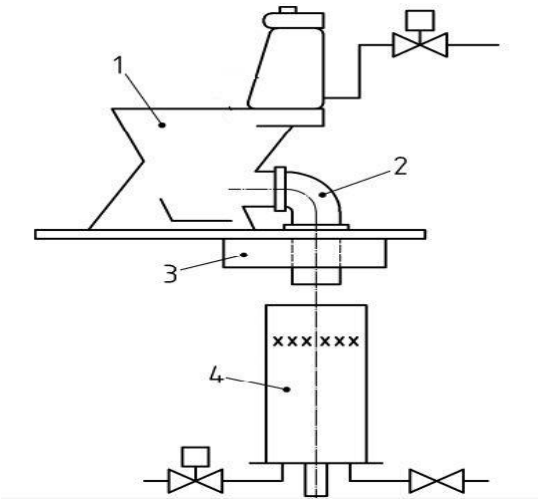

Figure 1. Subsequent Water Measurement System of Sanitary Ware

Among of them, 1-flushing cistern, 2-connecting pipe, 3-riser pipe comprising ferromagnetic coil, 4- water container.

To be able to detect sanitary quality accurately (refer to the industry standard EN977-2012), this paper designs the subsequent water detection system of sanitary ware. The system based on C8051F040 MCU as control core uses metal detection technology to well solve the technical problem of accurate measurement of subsequent water [2].

2. The Design of Mimetic Detection Module

Idea 1: There are four simulations in the toilet, and the system can accurately detect whether each simulation washed down or not when the simulations are rushed by water, then sends a signal to the main control system. When simulations are rushed down completely, the system captures the subsequent water value accurately and displays it in the terminal. Accordingly, the design of the overall block diagram is shown in Figure 2.

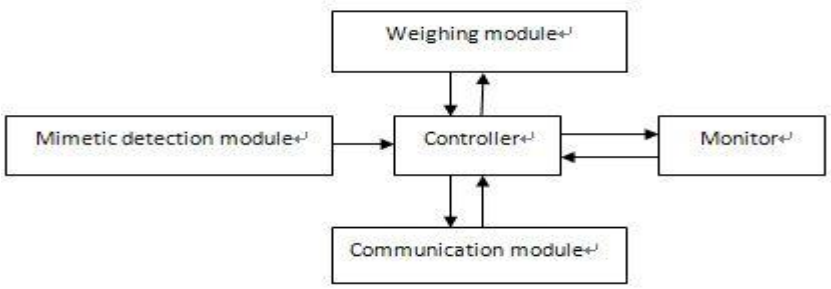

Figure 2. Total Diagram of Design

Simulation detection module is mainly composed of circular ferromagnetic coils. The magnetic flux changes little, when simulation (a metal ring) is down with the water through the coil internal. The master control module judge the simulation whereabouts by checking numerical pulse caused by various magnetic fluxes. In the program design, first assign the counter 4. Then counter minus 1 when the system detects a simulation. It is can determined that the final simulation objects are fallen into water when the counter value is 0. The weighing module begins to read the water level, and display on terminal when water level is stable. However, this thought has a flaw, namely that it cannot be judged whether the simulations are down with water in the situation of single or superposition of multiple at the same time. Due to circular ferromagnetic coils can only produce

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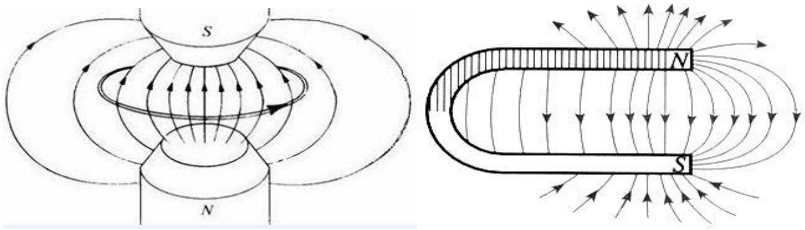
non-uniform magnetic field, so falling's simulation objects cannot be judged accurately through the change of the magnetic flux leading to a big error to the measurement of subsequent water. The distribution of magnetic induction line of circular magnet is shown in Figure 3 (a).

Idea 2: Replace circular coils with u-shaped coil in simulation detection module. Seen electromagnetic theory knowledge: closed loop has magnetic flux change when closed conductor has a movement in magnetic field cutting magnetic induction line. Flux is defined that there is an area of S and a plane perpendicular to the direction of the magnetic field in magnetic field with magnetic induction B. The product of magnetic flux density B and the area S calls the magnetic flux through this plane Φ [3].Formula: $\Phi = BS$. The formula shows that the size of the magnetic flux variation is proportional to the size of conductor cutting the magnetic induction line. The magnetic induction line distribution of horseshoe magnet is shown in Figure 3 (b).



(a) (b)

Figure 3 (a) Magnetic Induction Line Distribution of Round Magnet (b) Magnetic Induction Line Distribution of Horseshoe Magnet

The magnetic flux of coil has a slightly change when a simulation (containing metal ring) is down with the water through the coil of ferromagnetic. As there are four simulations, it is assumed that the simulation object whereabouts has the following several ways: 1) A single simulation down with water at one time. 2) One time at least two overlapping simulations in level at the same time. 3) Three mimetic overlap falling in level at the same time. 4) Four mimetic overlap falling in level at the same time. As the horseshoe ferromagnetic coils generate uniform magnetic field, the magnetic flux changes is directly proportional to the area that the metal ring cutting magnetic induction line. Now it can be analyzed as following:

①As the simulation is down in single, magnetic flux in ferromagnetic coil caused by each simulation through ferromagnetic coils is same. It will produce corresponding count pulse accurately after the series of the processing circuit. Then the main control module begins to count the simulations.

②When there are two simulations falling in overlap level at the same time, the magnetic flux variation is akin to a single mimetic whereabouts twice.

③So the flux change of situation 3 and 4 is three times and four times to a single mimetic down respectively.

Through calculating the flux variation, we can accurately determine the final time of simulation object washed away by water which provides preconditions for measuring subsequent water accurately. The flow chart of system testing is shown in Figure 4. Weighing module is made up of weighing sensor, it can relatively accurate weigh the subsequent water [4]. The main control module based on C8051F040 is mainly for signal acquisition and data processing. The man-machine interface consisted of C8051F040 and touch screen, mainly completes the data's display. This design adopts the second idea to complete simulation test after comprehensive comparison of the first and the second idea.

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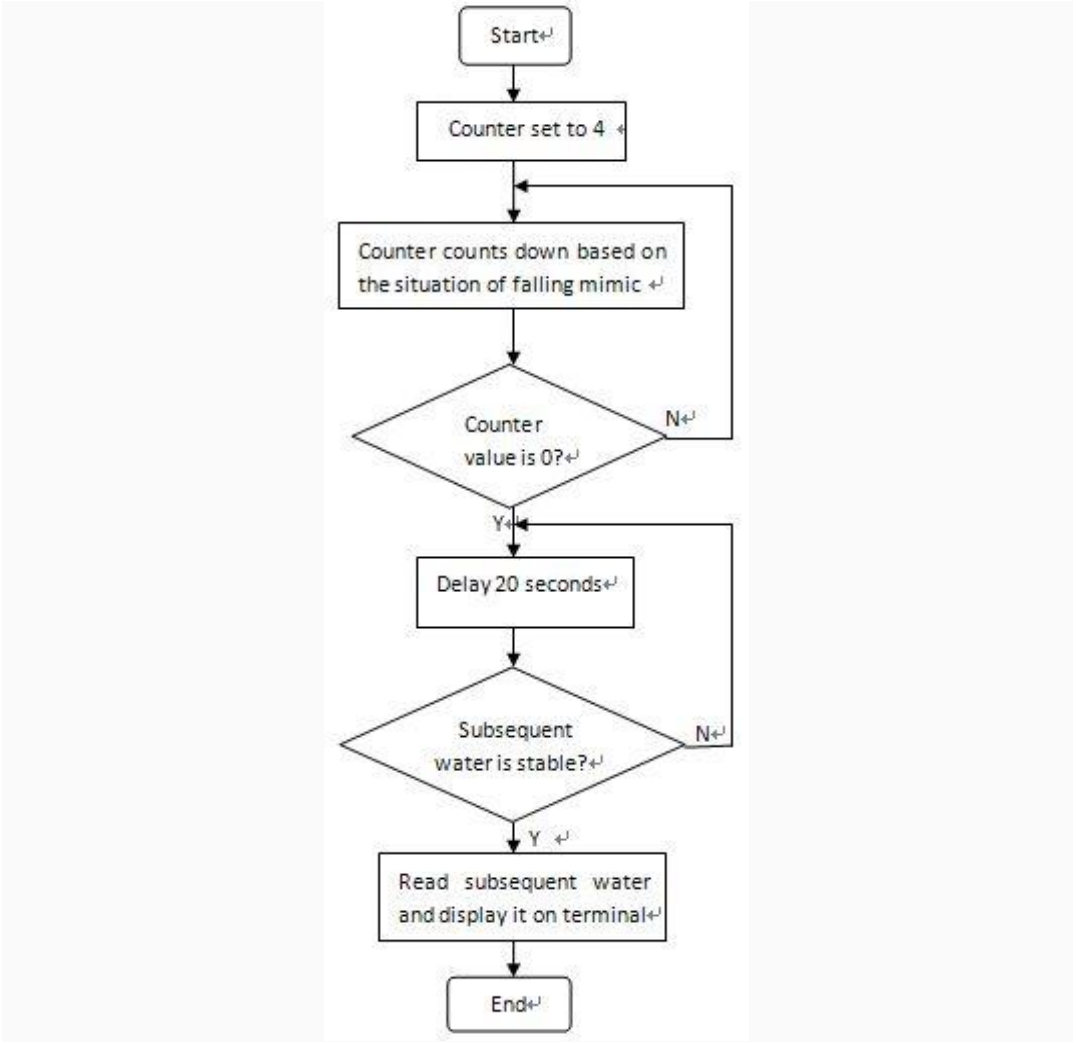

Figure 4. Flow Chart of Simulation Test

3. Design of Simulation Detection Module

The core of this design is to detect the time of last simulation objects (containing metal ring) rushed down by water and accurately measure the corresponding follow-up amount of water. Therefore, the design module block diagram for this part is as follows:

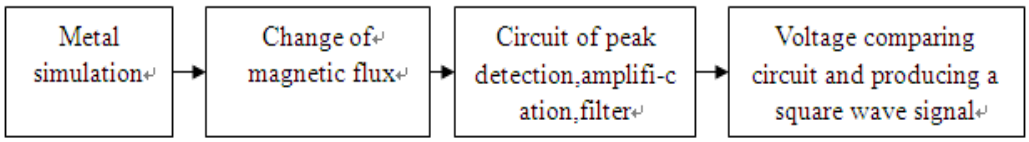

Figure 5. Module Block Diagram of Simulation Detection

1) The selection of Simulation Objects:

Simulation should use standard specimen which is made up of artificial casing (tubular), and insert an stainless steel metal detector ring (diameter of wire is 1.6 mm, quality is 1.6 g) with an internal diameter of 14 mm or an silver ring with internal diameter of 10 mm (wire diameter is 2.0 mm), and pour into 37ml of water in it, the upper be fasten with linen line [5]. Each specimen is strapped into three Chambers and each test uses four, which is equivalently to the amount of shit of a man. Standard specimen can be

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used multiple times and has a good mimetic effect; the specimen can truly evaluate the degree of flushing smooth for supporting system [6]. Shape is shown in Figure 6.

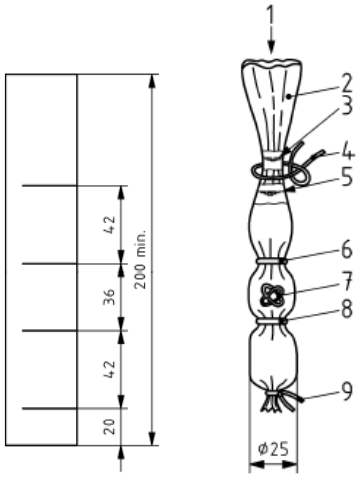

Figure 6. Standard Size and Shape of Specimens

Where 1-inject simulation 37ml water, 2-artificial casing, 3-water level after banding ,4- linen wire, 5-water level before banding, 6-o-ring, 7-metal detecting ring, 8-o-ring, 9-linen wire.

2) The Metal Detector Circuit:

The core of this design: There is uniform magnetic field produced by horseshoe ferromagnetic in the round pipe which simulations fall through. The placement of horseshoe ferromagnetic is that the two coils' U-shaped mouth be put in level relatively and embedded inside the riser porcelain body in relatively level. The winding method of ferromagnetic coil is that ferromagnetic coil is single layer winded with the 0.5 diameter copper enameled wire [7]. So there will be small changes in the magnetic flux due to the metal ring for cutting the magnetic induction line when analog through ferromagnetic coils. Because the area that the metal ring's cutting the magnetic induction line in each case is different, it produces different magnetic flux variation. Using peak detection circuit to detect magnetic flux changes value, then amplifier flux through multistage amplifier circuit, and finally remove interference information through the filter circuit and converts the flux variation to square wave signal through the voltage comparison circuit [8]. Square wave signal pulse signal is converted to pulse signal by the subsequent processing circuits. Master control module judges the simulation of objects falling according to the pulse signal's magnitude, then the counter counts reduction, it is proved that simulation has been thoroughly flushed when counter reduces to 0, finally weigh the follow-up to the amount of water by weighing module [9]. The principle diagram of metal detector circuit is as follows:

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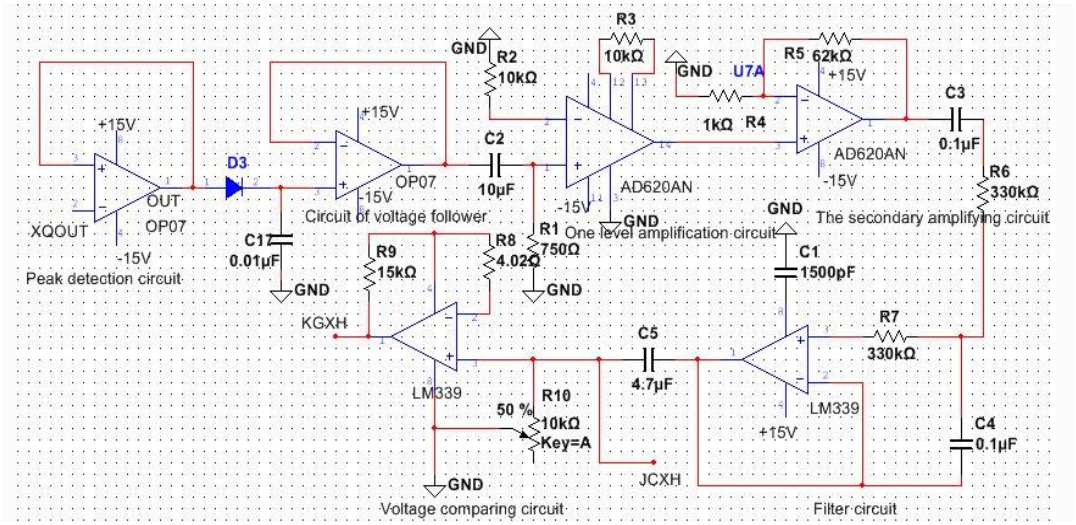

Figure 7. Circuit Principle Diagram of Metal Detector

In order to measure the flux change precisely, this circuit makes an elaborate screening of all kinds of amplifier. Among of them, the peak detection circuit and voltage following circuit are made up of OP07 amplifier, OP07 has a very low input offset voltage, so it doesn't need the extra zero in many applications, and it has low input offset current and high open-loop gain. As a result, it is especially suitable for high gain measurement equipment and enlarging the weak signal of the transducer. Multistage amplifier circuit consists of AD620AN amplifier, AD620AN has some characteristics, for example, high common mode rejection ratio, broad Amplification bands, small noise coefficient, the of low power consumption. Filter circuit and voltage comparison circuit composed of LM339, which has wide working voltage, small current consumption, low input offset voltage, wide range of common-mode input voltage and the output can be compatible with TTL, MOS and CMOS advantages [10].

5. The Experimental Results and Discussions

Connect the water tank level and attach each part of the attachment and pipeline. Then turn on the power, create a new project, and then click the Start button, put down simulation, weigh a certain weight of water into the pipe until the water calm, click the Done button, and then record the data on the touch screen, repeats 20 times to obtain test data. The data is shown in Table 1.

Table 1. Test Results

Detection times	Actual weight (Kg)	Measuring weight (Kg)	Relative error (%)
1	0.5	0.52	4%
2	0.5	0.46	-8%
3	0.5	0.51	2%
4	0.5	0.53	6%
5	0.5	0.47	-6%
6	0.5	0.51	2%
7	0.5	0.48	-4%
8	0.5	0.51	-2%
9	0.5	0.48	-4%
10	0.5	0.48	-4%
11	0.5	0.46	-8%
12	0.5	0.52	4%

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13	0.5	0.51	2%
14	0.5	0.43	-6%
15	0.5	0.51	2%
16	0.5	0.47	-6%
17	0.5	0.53	6%
18	0.5	0.48	-4%
19	0.5	0.53	6%
20	0.5	0.54	8%

According to the measurement results, the relative error of 20 measurements range from -8% to 8%, that is to say, the measurement accuracy rate reaches 92% meeting the expectations. Of course, there are still some measurement errors, summarized the reasons for these errors, taking the following main points into account:①The analytical relationship is assumed based on theoretically ideal conditions, such as the whereabouts of simulations, the distance between the two analog also produce small effects on the magnetic field. ②Due to subsequent water containing minerals, the different frequencies of coil will cause water to have an effect on the magnetic field. ③Induced signal extracting from weighing system mixing a lot of interference signal has inevitably some impact on measurement results.

6. Conclusions

The sanitary water detection system discussed this paper can measure subsequent water accurately under the EN977-2012 standards. It makes a significant contribution to ensuring consumers' legitimate rights and maintaining the industry norms. However, there are still some problems in the detection accuracy, such as capability of anti-jamming, the device stability, and so on. The research of these key technical issues will increase the added value of water detection system which will provide effective protection on the production of a more water-saving sanitary ware and can produce good social and economic benefits.

References

[1] Z. Jiangwei and L. Baiqing, "Chinese sanitary ceramics export barriers analysis", vol. 5, **(2011)**, pp. 9-11.
[2] H. Mengke, X. Shengran and Z. Haomin, "Subsequent Water Testing in Toilet Capability Test System Based on Configuration Software king View6.51", Industrial Control Computer. vol. 20, no. 5, **(2007)**, pp. 36-38.
[3] F. Mengli, C. Yuping, S. Chunrong, "The Development and Comparison of Several Electromagnetic Nondestructive Detected Technologies", Journal of Sichuan Ordnance, vol. vol. 33, no. 2, **(2012)**, pp. 107-110.
[4] W. Bo, W. Weiming, "Six liters of water system," toilet water modeling structure and the relationship between research", Ceramics, vol. 1, **(1998)**, pp.45-47.
[5] D. Ke, Q. Yuxia, Y. Zhangyi, "Magnetoelectric Speed Sensor to Detect Ultra-Low Frequency Vibrations", TELKOMNIKA Indonesian Journal of Electrical Engineering, vol. 11, no. 5, **(2013)**, pp. 2502-2507.
[6] M. Jian, "Study on Key Technique of Electromagnetic Detection for Metal", Tianjin: Tianjin University Electrical Automation Engineering, vol. 11 no. 6, pp. 2503-2508.
[7] Wang xian' an, Wang Xianyu. Design of a Kind of Pocket Electronic Balance. Light Industry Machinery. vol. 25, no. 2, **(2007)**, pp. 110-112.
[8] L. Ling, Y. Baoshan and L. Yede, "The design of electronic cashier scale based on C8051F350 computer", Shandong University of Technology (Natural Science). (2009), vol. 23, no. 3, pp. 81-84.
[9] L. Xu, H. Gu, C. Li, A. Shi and Jie Shen, **"**System design of water quality monitoring robot with automatic navigation and self-test capability", International Journal of Control and Automation, vol. 5, no. 6, **(2013)**, pp. 67-82.
[10] J.K. Park, J.S. Lee, M. G. Kin, "Construction of console application for automated GPS data processing", International Journal of Control and Automation, vol. 1, no. 6, **(2013)**, pp. 247-254.

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