Modelling and Analysis of Hybrid Water Meter using Arrow Pointer Sensor

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***Abstract*— The arrow-pointer meter is currently widely used. In this paper, a low-cost and high accuracy water meter using arrow sensor is presented. The aim of this paper is to design a low cost water meter using noncontact arrow-sensor to identify the location of arrow pointer on the scale panel of a water meter. To be compatible with the currently used arrow meter, this system involves embedding an electrical circuit into the body of a conventional mechanical water meter. The electrical structure includes signal generator, signal sensors, signal detection circuit, digital encoder, and remote controller, to sense the position of an arrow pointer. An electrical circuit is mounted on PCB to the meter body for reading the arrow scale. A signal generator (SG) outputs a square waveform at a given frequency through the arrow sensor to a detection circuit. When the signal arrives at sensing pads, the detection circuit senses which number on the meter is indicated. The detected result is then binary encoded and transmitted to a server by a wireless communication system using GSM technology. This method can save more power dissipation and is easy to install to the current water pipeline. Also, the cost of the water meter is reduced compared to the digital water meter. For long range communication, GSM technology is used. In GSM the data is transmitted for long range with high efficiency. Moreover, the meter reading can be sent to multiple users at a time and also can be sent to the server.**

Keywords—arrow pointer meter; arrow sensor; sensing pad; water monitoring system.;

I. Introduction (*Heading 1*)

Pricing a natural resource such as water is no easy task. First it is hard to establish how much consumers are willing to pay for it. Generally the decision to have running water and sewerage services is not made by the user but collectively by a group of users (neighborhood) or mandated by the local government. If this is the case then it is not generally correct to speak of access demand given a price. Besides, service disconnection is often not allowed once installed. Second it is hard to determine an opportunity cost for this resource in case of shortages. This is so because the opportunity cost of water depends on several factors such as source of extraction (i.e wells, rivers etc.) the region climate and the resource relative abundance. Finally, water consumption may involve hard – to - measure externalities. An excessively low consumption may endanger population health contributing to the spread of infectious and parasitic diseases like cholera and diarrhea. On the other hand, a high level of consumption can cause a drop in the level of water reservoirs hampering service continuity in hot seasons.

TABLE I. Comparisons of Various Types of Water Meters

Functions \ Kinds	Conventional Mechanism	Electronic Meter	Hybrid Meter
Performance	Uniform	Multifunction, dependent software	Multifunction, dependent software
Battery	No	Need	No
Communication interface	No	Yes	Yes
Data analyze	No	Yes	Yes
Water monitoring system	No	Yes	Yes
Power dissipation	Zero	Large	Little (supply when reading)
Compatible to the current system	Yes	No	Yes
Cost	Low	High	Median
Remote auto reading	No	Yes	Yes

This paper proposes a hybrid electrical/mechanical metering system designed for low cost implementation and reduced power consumption. Our motive is to embed the electrical circuit to the mechanical water meter for an arrow point sensing. The size and function of the device is compatible with the existing water meters, thereby facilitating easy installation on the current water pipeline. The Conventional water meter employed a mechanism structure in which the water flow drives gears that move an arrow pointer on a scale panel[1]. Figure 1 shows a typical water meter used in Taiwan that includes four coarse numbers and four fine arrow scales. When the water flow is recorded using the simple mechanical structure, the meter does not require electrical power. However, recording the flow of water using a mechanical device requires that values be recorded manually. Recently, the electronic water meter is presented to record digital data using electrical counters. The electronic meter can monitor the current metering value remotely [1]–[5]. Unfortunately, such meters draw power constantly, thereby wasting electricity. In addition, avoiding temporal power interruptions requires that batteries be embedded in the body of the meter. Electrical meters are incompatible with many existing water systems, which have prevented more widespread adoption. The proposed device works like a conventional gear meter; however, power is supplied to the electrical circuit of the meter only when the remote server sends a request for a metered value, after which power is automatically suspended. Hence the power dissipation is very slight.

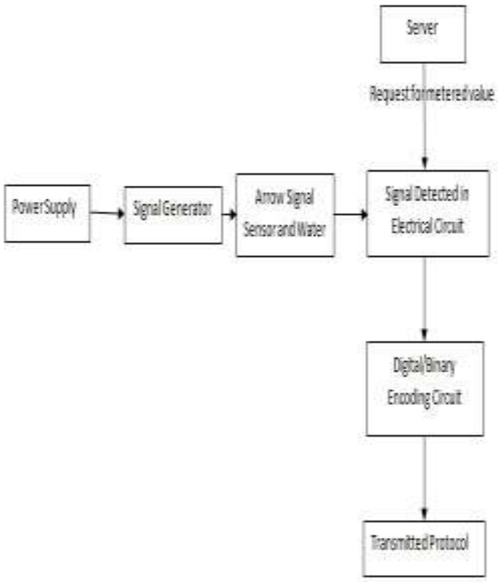

Fig. 1. Arrow Pointer Sensor Design Architecture.

II. PROPOSED ARROW SENSOR FOR WATER METER

The location of arrow pointer on the scale panel of a water meter is determined to design a non contact arrow sensor. A small, inexpensive recognition system is embedded into the body of the water meter to accomplish this. Arrow sensor is designed and can be easily embedded and varied according to analog to digital conversion. The motive is to embed the electrical circuit to the mechanical water meter for an arrow point sensing. The size and function of the device is compatible with the existing water meters, thereby facilitating easy installation on the current water pipeline. The proposed device works like a conventional gear meter; however, power is supplied to the electrical circuit of the meter only when the remote server sends a request for a metered value, after which power is automatically suspended. Hence the power dissipation is very slight. Compared with the current electrical meter, this method can save more power dissipation and is easy to install to the current water pipeline. Also, this kind of meter can keep a simple and low-cost like a conventional gear meter.The conventional method used an optical image recognition approach to identify the arrow position and to read the metering value [7], [8]. The implementation cost becomes high, which is not appreciated for the current metering system.. Figure 1 shows the structure of proposed recognition system for an arrow meter. A signal generator (SG) outputs a square waveform at a given frequency through the arrow sensor to a detection circuit. When the signal arrives at sensing pads, the detection circuit senses which number on the meter is indicated. The detected result is then binary encoded and transmitted to a server by a wireless communication system.

Fig. 2. A typical residential water meter

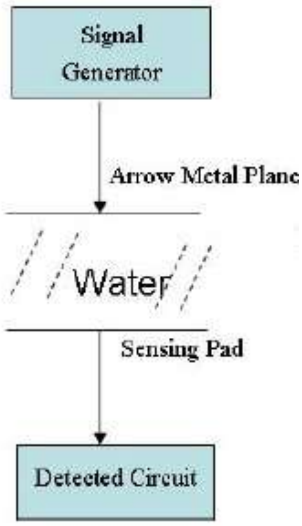

Fig. 3. Structure of Proposed recognition system

A. *Originality Design*

For arrow point sensing, one designs a sensing pad on the location of each digital number. A capacitor is generated between sensing pad and metal arrow. Based on capacitive signal transfer theory, the high-frequency signal can be through the metal arrow pointer to sensing pads. Figure 2 shows the physical structure of the arrow sensor with on PCB (Printed Circuit Broad). To detect the numbers 0 to 9, we added copper foil into a PCB underneath the position of each number to act as a sensing pad for the signal detection.

Current-sense resistors, which come in a variety of shapes and sizes, are used to measure current in many automotive, power control, and industrial systems. When using very low value resistors (a few milliohms or less), the resistance of the solder becomes a substantial portion of the sense element resistance and adds significantly to the measurement error. High-accuracy applications often use 4-terminal resistors and Kelvin sensing to reduce this error, but these special-purpose resistors can be expensive. In addition, the size and design of the resistor pads play a crucial role in determining the sense accuracy when measuring large currents. This article describes an alternative approach that enables high-accuracy Kelvin sensing using a standard, low-cost, 2-pad sense resistor with a 4-pad layout. Figure 4 shows the test board used to characterize the errors caused by five different layouts.

Fig. 4. Sense resistor layout test PCB.

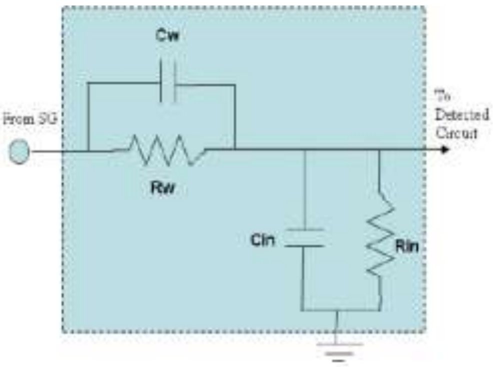

Fig. 5. Equivalent circuit for arrow sensor

To achieve maximum sensitivity, the sensing pad is laid out in the form of an inverted triangle. Each sensing pad is connected to the detection circuit. The signal generator produced a square waveform through a metal axis to the metal arrow, where the arrow pointer was made of stainless steel. If the arrow pointer touched the sensing pad, the copper foil would eventually be worn away.

Thus, a noncontact arrow sensor is proposed based on capacitive signal sensing [9]. The structure in Figure 5 acts like a capacitor between the sensing pad and the metal arrow. In practical applications, the water meter is filled to water. The water between the two parallel pieces of metal provides the medium of the capacitor.

PIC16F877A microcontroller is used to implement hybrid water. Here long life battery is used to draw power when needed thus can reduce the power consumption. Fig 6 shows equivalent circuit diagram of hybrid water meter using PIC microcontroller with GSM. Here crystal oscillator is used to produce the signal. The TTL level produced in the PIC is stored in GSM by using MAX232. And thus it is stored in PC at 12V.

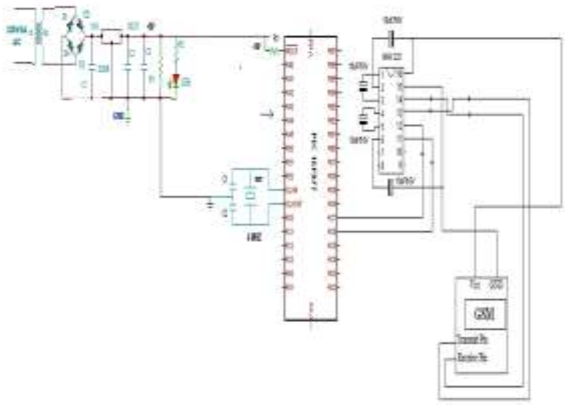

Fig. 6. Equivalent Circuit Diagram of Hybrid Water Meter using PIC with GSM

B. Block Diagram

1) Transmitting Section

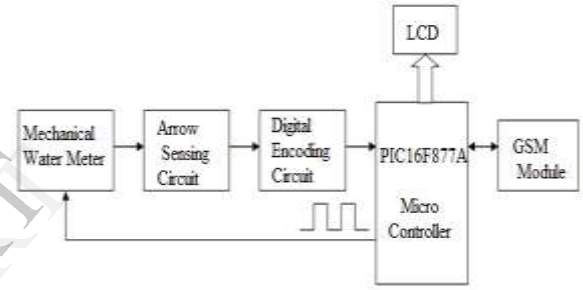

Fig. 7. Block Diagram of Transmitting Section

2) Receiving Section

Fig. 8. Block Diagram of Receiving Section

Figure 7 shows the block diagram of transmitting section where the water flow is sensed by arrow sensing circuit and then it is digitally encoded. Using PIC microcontroller the encoded value will be displayed on LCD and transmitted using GSM.

At the receiver section the digitally encoded value gets stored in the PC using GSM module. The figure 8 shows the block diagram of receiving section. Here by using a microcontroller the values get stored in PC.

III. SIMULATION RESULTS

The ISIS schematic capture window of arrow pointer based water meter reading system is shown in figure 9 using PROTEUS software. Initially the port is configured to determine the I/O pin. Four pins are used as the input switches which determine the digital reading of water meter. These input pins are connected to a PIC16F877A microcontroller. An LCD display is also connected to the microcontroller where the values get displayed. Ten outputs are used which denotes the digital value of water meter reading, connected to the microcontroller. A transmitting switch is also used as the input. The whole is then connected to the PWD server where the values get stored.

A virtual terminal is shown in figure 10.While running the simulation both LCD as well as serial initialization takes place. It is displayed on the LCD as 'METER READING' on transmitting section and on receiving section it is displayed as 'PWD SERVER, METER VALUE'.

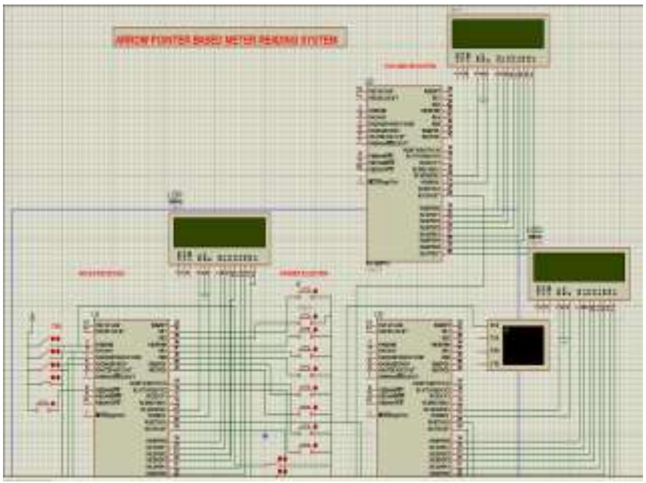

Fig. 9. ISIS Schematic Capture Window 1

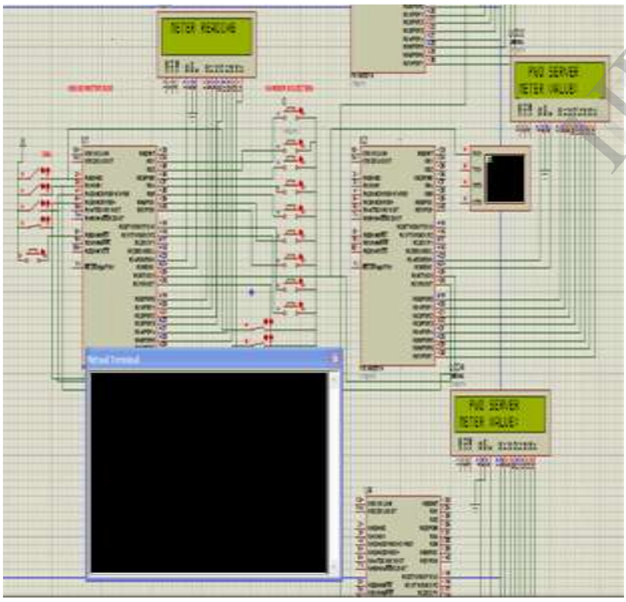

Fig. 10. ISIS Schematic Capture Window 2

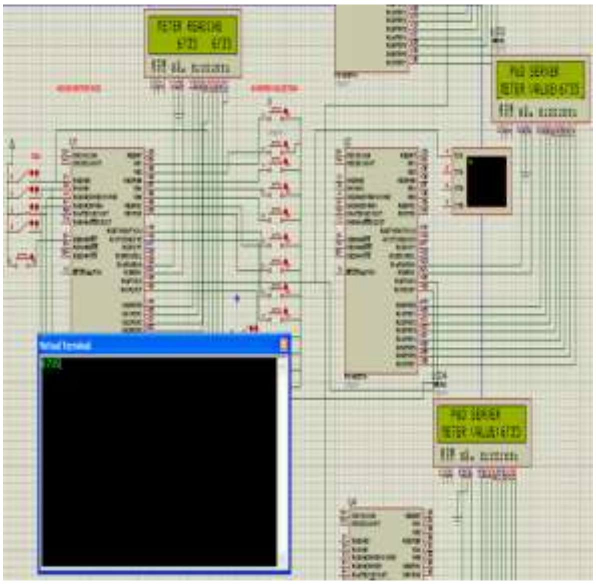

Fig. 11. ISIS Schematic Capture Window 3

The final output is shown in figure 11. As the values are entered by pressing any one of the four switches, these values get displayed on the LCD display. Each switch can transmit any one of the digital value from 0-9 as the rate of the water flow. If the transmitting switch is pressed the values that are displayed on the LCD will get displayed and get stored in the PWD server. The transmission can be viewed by using a virtual terminal

IV. CONCLUSION

This paper presents a low-cost and high-accuracy hybrid water meter using arrow pointer sensor. An electrical circuit is mounted on Printed Circuit Board (PCB) and only one low-cost PIC16F877A is used in the meter body for reading the arrow scale. Also the water meter reading can be communicated to different users and to the server, indicating the current flow of the water by using the GSM module. When the water flow is recorded using the simple mechanical structure, the meter does not require electrical power. However, recording the flow of water using a mechanical device requires that values be recorded manually. The electronic water meter is presented to record digital data using electrical counters. The electronic meter can monitor the current metering value remotely. Unfortunately, such meters draw power constantly, thereby wasting electricity. In addition, avoiding temporal power interruptions requires that batteries be embedded in the body of the meter. On comparing both the mechanical and electrical system, this hybrid water meter has the advantages of low-cost embedded digital meter mounted on the body of conventional mechanical water meter and low power consumption, where power supply is required only for reading the meter. The hybrid meter is fully compatible to the existing mechanism meter, thus facilitating easy installation. With these advantages, the proposed sensor would be appreciated for real time applications

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