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Water Digital Meter Using Mobile Phone: A Case Study Of Ghana Water Company Limited

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Abstract: ***Smart Water meter implies the use of an electronics interface to the Consumption Register module on the Water-meters to capture information such as Consumption, Register Tamper (Tamper-Proof Flag Status), unique ID of meter, etc. The underlying purpose of every information technology is to ease human efforts as far as possible. With the help of the water digital meter, bills are automatically generated for customers and sent to them via SMS or email addresses. Payment of bills is done through mobile money medium and this saves customers time. The smart water supply meter is a device that measures the amount of portable consumed by a domestic user or commercial user, as well as generating bills and delivering it instantly via SMS and E-mail. In recent times, the Ghana Water Company Limited has introduced and implemented an e-billing system which seeks to eliminate the old system of bill distribution at the end of every billing cycle. If this new system is implemented, the meter readers will not be required to physically visit customers premises to take meter readings and send the bills to customers for payment.***

Keywords: Water Digital Meter, Flow rate of water, Mobile Communication, Flow Sensor.

I. INTRODUCTION

In most part of Ghana, analogue water meters are used by Ghana Water Company Ltd to measure consumers water consumption. These water meters are read on a monthly basis by an authorized employee and the consumers bills are computed based on the approved rates. Sometimes the customers premises are not easily accessible and consumption estimates are used to calculate water bills for the customers. Because of water consumption is approximated, the bills are not accurate. This method of manual data collection is also expensive and inefficient. Smart water systems can serve as alternatives to overcome the shortcomings of the manual metering systems.

The water digital meter is a wireless sensor device which can be installed in thousands of households to collect periodic measurements that are reported in real-time. Water metering is the process of measuring water usage. There are two basis of measuring flow, these are volumetric basis and weight basis. The basic relationship for determining the liquid's flow in a pipe is given by the product of the cross-sectional area of the pipe and the average velocity of the flow. The other factors that affect liquid flow rate include the liquid's viscosity, density and the friction of the liquid in contact with the pipe

Flow sensor-based water meter presents a very low cost, reliable, quick water meter system accompanying existing Mobile Phone networks. Monthly water usage can be sent to the Ghana Water company ltd office within few seconds in the form of text message by using the existing Mobile phone network. Such a metering system reduces manpower, with higher accuracy and less power consumption. Water meters generally fall into one of these three categories: simple

mechanical water meters, mechanical water meters with an electronic communication device, and fully electronic water meters. One of the popular water flow measurement techniques is the velocity type in this research a turbine type meter which is a velocity-based meter has been employed. In this meter the entire fluid to be measured enters the flow meter, then passes through a rotor. The flowing fluid impinges on the blades of the turbine and imparts a force that causes the rotation of the rotor. At the steady state, the speed of the rotor is directly proportional to the fluid velocity, and hence to volumetric flow rate. The speed of rotation is monitored in most of the meters by a magnetic pick-up coil which is fitted to the outside of the meter housing. The pick-up coil consists of a permanent magnet with coil windings which are mounted in close proximity to the rotor but external to the fluid channel. As each rotor blade passes the magnetic pick-up coil, it generates a voltage pulse which is a measure of the flow rate, and the total number of pulses gives a measure of the total amount of water. The water digital meter can help to solve the challenges associated with analog meters. The system is made up of two parts; these are the hardware and the software.

The system operates on real time basis with any Internet Service Provider (ISP) because regular update of water consumption by customers are done in the Ghana Water Company Limited office

II. OBJECTIVE

The objectives of this research include:

- ✓ To automatically generate and send water bills to customers through their email addresses and mobile phone as SMS notifications.
- ✓ To make bill payment effective for water consumers by using mobile money e-payment medium.

III. LITERATURE REVIEW

Adequate reviewed of literatures were done to close gaps discovered by previous authors.

REVIEW OF THEORIES AND CONCEPTS

Meter is a device that measures things, but in this research, we do not mean anything different but rather a smart water supply meter. It implies the use of electronic interface to the consumption register module on the water meters to capture information such as consumption, Register Tamper (Tamper-proof Flag status), unique ID of meter.

Mobile Phone is a mobile station which comprises mobile equipment and Subscriber Identity Module (SIM) card. The subscribers receive water consumption and bill notifications on their phones. The subscribers must be within a network coverage to receive such notifications.

REVIEW OF RELATED WORK

Regardt.I. Müller and Marthinus .J. Booysen in their paper titled "A Water Flow Meter For Smart Metering Application", a novel low-cost water flow meter is developed for use in household smart metering solutions. The design is based on an orifice plate, to leverage the Venturi effect, which causes a measurable pressure drop. The meter is tested using representative flow rates, and compared with an existing solution. The results clearly demonstrate that the water flow meter matches the more complex and expensive product, providing a viable solution for household smart metering.

Ms. Candice Marilyn Gallyot, Ms. Gulabi Mandal, Ms. Harshitha S.V., Mr. Hrishikesh Aiyappa B.K. SMART WATER METER USING WIRELESS NETWORKING, Project Reference No.: 40s_Be_0108

The world is facing an environmental crisis unprecedented in human history. This has caused a depletion of fresh water sources. There is an acute shortage of drinking water and unsustainable stress is being imposed on drinking water sources.

In the prevailing political climate, the tariff cannot be linked to the actual cost of water extraction and distribution of water. The tariff is therefore very low. The present water distribution slab system is based on tariff. There is an approximately 40% increase in the tariff as we move to the higher slabs. However, there is no limit on the total volume consumed in the present system. This system has failed because consumers have a high purchasing power. Therefore, there is no perceptible reduction in the volume of water consumed and its wastage.

The Smart Water meter using wireless networking, uses a new slab system based on total volume to be supplied. Limits are set by the Ghana Water Company Limited (G.W.C.L). After reaching a predetermined cap water supply is terminated completely for that month automatically. The consumers are given prior warnings through SMS notification. Any fault or meter tampering can be detected automatically. The distribution valve can be remotely controlled by the water supply Board for reset and close. A database consisting of user details, water consumption details is maintained and updated on a monthly basis on the local server which can be used for billing purposes and hence eliminating the need for third party data collection. In the event of power failure, the smart water meter does not get reset. We used arduino uno which incorporate the higher end technologies like IoT, Wi-Fi, cloud database and web application.

Kiran M. Dhobale, Sangmeshwar P. Gorgile, Pradnya J. Gunjal, Krushna A. Hirve, in their Journal IOT based Smart Water Supply management System,Vol. 6, Issue 1, January 2017

In some water-related field such as pre-flood warning system, irrigation system, electricity powerhouse, and research, water level information is a very important issue. Usually, water level measurement was done manually, however this cannot be effective due to some difficulties like problem to reach the measurement site, human error, etc. Some automatic water level measurement systems have been made using mechanical sensors such as resistive sensor, capacitive sensor, or magnetic sensor, but these sensors have

to do direct contact with water that makes their life span shorter because of corrosion. On the other hand, this system uses ultrasonic sensor that can measure the water level without direct contact with water, which makes its life span longer. According to the World Bank report released in 2014, urban water supply in India is faced with severe challenges including distribution inefficiency leading to higher operational costs with only 20% of the connections being metered, and in most cities about 40% water supply not resulting in any revenue. Hence, the traditional water metering system employed in India needs both infrastructural improvements and a smart flow metering approach. The manual examination of water meters for billing purposes is prone to human error and manipulation. Many of the meters are placed in inaccessible locations. Apartments and commercial complexes use a common water meter and the bill amount is shared equally irrespective of an individual's usage, providing little incentive for residents to conserve water. The water meter readings are manually fed into a computer to provide the bill, a method that is again prone to human error. Smart water systems can serve as alternatives to overcome the shortcomings of manual metering systems. They are wireless sensor networks: water meters installed in thousands of households collect periodic measurements that are reported in real-time over a wireless network to a central database. This system will update water level related notifications to web servers using internet, which means that there is no need to come directly to the measurement site. Water supply management will be done according to water level present in Dam. This system sends the data to the central office using web server for database maintenance. The data base is secured by providing a password protected access. The user will be notified to pay the bill according to the water usage. The incoming water is measured in volumetric rate like litres per minute. The volume of water is measured with a flow sensor interfaced to Arduino.

a. ARDUINO

Arduino is a computer hardware and software company, project, and user community that designs and manufactures microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world. These systems provide sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards ("shields") and other circuits.

b. ROTOBOTIX WATER FLOW SENSOR YF-S201

This sensor sits in line with your water line and contains a pinwheel sensor to measure how much liquid has moved through it. There's an integrated magnetic Hall Effect sensor that outputs an electrical pulse with every revolution. The Hall Effect sensor is sealed from the water pipe and allows the sensor to stay safe and dry. The sensor comes with three wires: red (5-24VDC power), black (ground) and yellow (Hall Effect pulse output). By counting the pulses from the output of the sensor, you can easily calculate water flow. Each pulse is approximately 2.25 milliliters. [4] Formula to calculate water flow:

Flow Rate (L/min) = Pulse frequency (Hz) / 7.5.

Flow Rate (Litres/hour) = (Pulse frequency x 60 min)/7.5Q

TEST SETUP AND RESULTS

This section describes the test setup and results. The purpose of the tests was twofold: to calibrate the flow meter against a trusted and accurate off-the-shelf flow meter, and to determine its accuracy and the limits of its use.

IV. METHODOLOGY

The Hardware components used in this project are:

- ✓ Flow Sensor.
- ✓ Solenoid valve.
- ✓ JHD 162A LCD Module.
- ✓ Power Supply.
- ✓ Voltage Regulator.

PRINCIPLES OF OPERATION

FLOW SENSOR

The Water Flow sensor measures the rate of a liquid flowing through it. The YF-S201 water flow sensor consists of a plastic valve body, flow rotor and hall effect sensor. It is usually used at the inlet end to detect the amount of flow. When liquid flows through the sensor, a magnetic rotor will rotate and the rate of rotation will vary with the rate of flow. The hall effect sensor will then output a pulse width signal. Connect it to a microcontroller and control the water flow rate to suit your needs. The following precaution should be considered:

- ✓ A 20 mm rifled pipe is recommended
- ✓ Avoid unit contact with corrosive chemicals
- ✓ The unit must be installed vertically, tilted no more than 5 degrees
- ✓ Liquid temperature should be less than 120 C to avoid damage to unit

Figure 1

SOLENOID VALVE

A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a

solenoid: in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids.

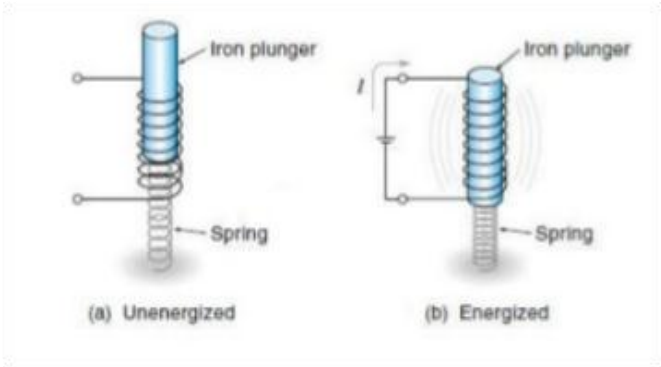

Figure 2

They are found in many application areas. Solenoids offer fast and safe switching, high reliability, long service life, good medium compatibility of the materials used, low control power and compact design. A solenoid valve has two main parts: the solenoid and the valve.

JHD162A LCD MODULE (16×2)

Alphanumeric displays are used in a wide range of applications, including palmtop computers, word processors, photocopiers, point of sale terminals, medical instruments, cellular phones, etc. The 16x2 intelligent alphanumeric dot matrix displays is capable of displaying 224 different characters and symbols. Serial LCD firmware allows serial control of the display. This option provides much easier connection and use of the LCD module. The firmware enables microcontrollers (and microcontroller-based systems such as the PICAXE) to visually output user instructions or readings onto an LCD module. All LCD commands are transmitted serially via a single microcontroller pin

The function of each pin of the JHD162A LCD module is given below.

- ✓ Pin1 (GND): Ground pin of the LCD module.
- ✓ Pin2 (VCC): +5V power supply is given to this pin
- ✓ Pin3 (VEE): Contrast adjustment pin. This is done by connecting the ends of a 10K potentiometer to +5V and ground and then connecting the slider pin to the VEE pin. The voltage at the VEE pin defines the contrast. The normal setting is between 0.4 and 0.9V.
- ✓ Pin4 (RS): Register select pin. The JHD162A has two registers namely command register and data register. Logic HIGH at RS pin selects data register and logic LOW at RS pin will select command register. If we make the RS pin HIGH and put a data on the data lines (DB0 to DB7) it will be recognized as a data. If we make the RS pin LOW and put a data on the data lines, then it will be taken as a command.
- ✓ Pin5(R/W): Read/Write modes. This pin is used for selecting between read and write modes. Logic HIGH at this pin activates read mode and logic LOW at this pin activates write mode.
- ✓ Pin6 (E): This pin is meant for enabling the LCD module. A HIGH to LOW signal at this pin will enable the module.
- ✓ Pin7 (DB0) to Pin14 (DB7): These are data pins. The commands and data are put on these pins. Pin15 (LED+): Anode of the back-light LED. When operated on 5V, a 560-ohm resistor should be connected in series to this pin.
- ✓ Pin16 (LED-): Cathode of the back-light LED.

FEATURES

The JHD162A has 16 pins and can be operated in 4-bit mode or 8-bit mode. Here we are using the LCD module in 4-bit mode.

- ✓ If interface data is 4 bit long: Data transfer are made through 4 bus lines DB4 to DB7 (while the rest of 4 bus lines from DB0 to DB3 are not used). Data transfer with MPU are completed when 4-bit data are transferred in twice.
- ✓ If interface data is 8 bit long: Data transfer is made through all of 8 bus lines from DB0 to DB7.
- ✓ 192 kinds of alphabets, numerals, symbols and special characters can be displayed by built-in character generator (ROM) and other preferred characters can be displayed by RAM.
- ✓ Low power consumption.
- ✓ Compact and light weight design which can be easily assembled in devices.

POWER SUPPLY

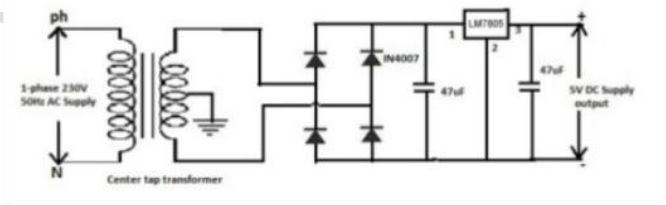

Figure 3

Every electrical and electronic device that we use in our day-to-day life will require a power supply. In general, we use an AC supply of 230V 50Hz, but this power has to be changed into the required form with required values or voltage range for providing power supply to different types of devices. There are various types of power electronic converters such as step-down converter, step-up converter, voltage stabilizer, AC to DC converter, DC to DC converter, DC to AC converter, and so on. For example, consider the microcontrollers that are used frequently for developing many embedded systems'-based projects and kits These microcontrollers require a 5V DC supply, so the AC 230V needs to be converted into 5V DC using the step-down converter in their power supply circuit.

VOLTAGE REGULATOR IC

In this circuit, we are using 7805 VOLTAGE REGULATORS. The voltage regulator IC maintains the output voltage at a constant value. Regulators are designed to supply required voltage without fluctuations. Capacitors of suitable values can be connected at input and output pins depending upon the respective voltage levels which are used

to eliminate the ripples and make the output stable. After regulation we get a 5V DC voltage at the output of 7805 IC which is needed to give supply to the controller.

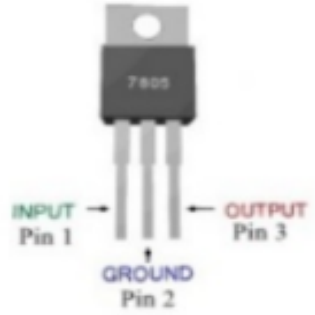

Figure 4

The LM7805, like most other regulators, is a three-pin IC.

- ✓ Pin1 (Input Pin): The Input pin is the pin that accepts the incoming DC voltage, which the voltage regulator will eventually regulate down to 5 volts.
- ✓ Pin2 (Ground): Ground pin establishes the ground for the regulator.
- ✓ Pin3 (Output Pin): The Output pin is the regulated 5 volts DC.

The maximum value for input to the voltage regulator is 35V. It can provide a constant steady voltage flow of 5V for higher voltage input till the threshold limit of 35V. If the voltage is near to 7.5V then it does not produce any heat and hence no need for heat sink. If the voltage input is more, then excess electricity is liberated as heat from 7805.If adequate heat sinking is provided, they can deliver over 1A output current.

Circuit Diagram of Regulator IC7805: Normally we get fixed output by connecting the voltage regulator at the output of the filtered DC see in above diagram. It can also be used in circuits to get a low DC voltage from a high DC voltage for example we use 7805 to get 5v from 12v. There are two types of voltage regulators. 1. Fixed voltage regulators 78xx, 79xx. 2. Variable voltage regulators.

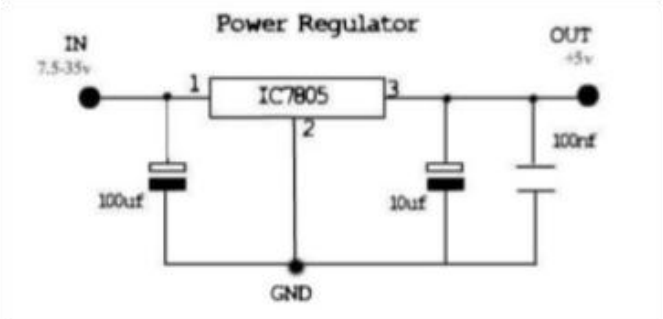

Figure 5

In fixed voltage regulators there are two classifications which include:

- ✓ Positive voltage regulators
- ✓ Negative voltage regulators

APPLICATIONS

- ✓ Load Regulation.
- ✓ Ripple Rejection.
- ✓ Fixed Output Regulator.
- ✓ Constant Current Regulator.
- ✓ Switching Regulator.

THE APPROACH

Water meters are used to measure the volume of water used by residential and commercial buildings that are supplied with water by a public water supply system. Thus, by using this we can keep monitoring on the usage of water by different consumers. Hardware used in the project:

- ✓ Flow Sensor.
- ✓ Solenoid valve.
- ✓ JHD162A LCD Module.
- ✓ Power Supply.
- ✓ Voltage Regulator.

How does the system work?

The Arduino flow meter works on the principle of the Hall Effect. According to which, a voltage difference is induced in a conductor transverse to the electric current and the magnetic field perpendicular to it. Here, the Hall Effect is utilized in the flow meter using a small fan/propeller shaped rotor which is placed in the path of the liquid flowing. The liquid pushes against the fins of the rotor, causing it to rotate. The shaft of the rotor is connected to a Hall Effect sensor. It is an arrangement of a current flowing coil and a magnet connected to the shaft of the rotor, thus a voltage/pulse is induced as this rotor rotates. In this flow meter, for every liter of liquid passing through it per minute, it outputs about 4.5 pulses. This is due to the changing magnetic field caused by the magnet attached to the rotor shaft as seen in the picture below. We measure the number of pulses using an Arduino and then calculate the flow rate in liters per hour (L/hr) using a simple conversion formula. Connecting the Arduino to the Flow Rate Sensor The connections required for this flow rate sensor with respect to the Arduino is very minimal. There are only three wires coming from the flow rate sensor: the 5V Vcc (Red wire), the GND (Black wire) and the signal/pulse (Usually yellow) line. Connect the Vcc and GND of the flow meter to the Arduino˝s Vcc and GND. The pulse line of the flow rate sensor is connected to the Arduino˝s digital pin 2.Connecting Arduino with MOBILE PHONE Here are two ways of connecting MOBILE PHONE module to arduino. In any case, the communication between Arduino and MOBILE PHONE module is serial. So we are supposed to use serial pins of Arduino (Rx and Tx). So if you are going with this method, you may connect the Tx pin of MOBILE PHONE module to Rx pin of Arduino and Rx pin of MOBILE PHONE module to Tx pin of Arduino. MOBILE PHONE Tx–>ArduinoRxandMOBILE PHONE Rx–>ArduinoTx. Now connect the ground pin of arduino to ground pin of Mobile Phone module. Now you can load different programs to communicate with Mobile Phone module and make it work. To send an SMS, we should set our MOBILE PHONE module to Text mode first. This is achieved by sending an AT Command “AT+CMGF=1”We send this command by writing this to SoftwareSerial port. To achieve this we use the mySerial.println() function. MySerial.println writes data to software serial port (the Tx pin of our Software Serial –that is pin 10) and this will be captured by MOBILE PHONE module

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(through its Rx pin). After setting the MOBILE PHONE module to Text mode, we should the the mobile number to which we shall send the SMS. This is achieved with AT command "AT+CMGS=\"+91xxxxxxxxxx\"\r" –where you may replace all x with the mobile number. In next step, we should send the actual content of SMS. The end of SMS content is identified with CTRL+Z symbol. The ASCII value of this CTRL+Z is 26. So we send a char(26) to MOBILE PHONE module using the line mySerial.Println((char)26); Each and every AT command may be followed by 1 second delay. We must give some time for MOBILE PHONE module to respond properly. Once these commands are send to MOBILE PHONE module, you shall receive an SMS in the set mobile number.

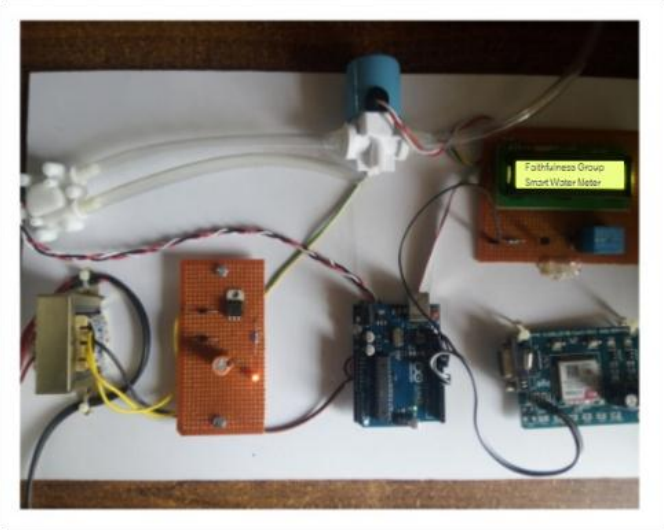

Figure 6

V. CONCLUSION

In conclusion, we designed and implemented water digital meter which measures the amount of water consumed by customers and remotely shut down the water supply to consumers whenever they fail to pay their water bills. The device is efficient and the Ghana Water Company Limited staff need not to physically visit customers premises to take meter readings and distribute bills to their respective customers. Accuracy of water consumed is guaranteed and exact bills are automatically generated.

VI. RECOMMENDATION

Based on the numerous benefits mentioned above, we therefore recommend the Ghana Water Company Limited to implement the water digital meter.

If the system is not implemented, the company will keep spending huge amount of money to pay staff to visit customers premises to read meters and distribute waters bills. Estimated bills will still be computed for customers whose premises are inaccessible.

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