2020 8th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO)
Amity University, Noida, India. June 4-5, 2020

Smart Water Meter using Power Line Communication (PLC) Approach for measurements of Accurate Water Consumption and Billing Process

Abdul Hakeem Khalifa Saleh Al Saidi
Department of Electronics and Communication,
Middle East College,
Muscat, Oman
16F16082@mec.edu.om

Shaik Asif Hussain
Department of Electronics and Communication,
Middle East College,
Muscat, Oman
shussain@mec.edu.om

Shaik Mazhar Hussain
Department of Electronics and Communication,
Middle East College,
Muscat, Oman
mazhar@mec

Ajay Vikram Singh
AIIT
Amity University Uttar Pradesh
Noida, India
avsingh1@amity.ed

Ajay Rana
AIIT, Amity University Uttar Pradesh
Noida, India
ajay_rana@amity.edu

***Abstract*- Data transmission methods have been evolved drastically with the development of internet. Data transmission methods are of two types. One is wired and the other one is wireless networks. Power line communication is considered as one of the tools that is used for power transmission using special type of modems that takes the data with known frequencies. The paper proposes smart water meter that uses flow sensor that collects household water consumption. The proposed system will be set to a threshold limit where the water is cut-off using electronic valve. The collected data will be sent to data center for data analysis through grid power line using PLC modem. The data center further forwards the water billing department for billing purposes through SMS and then it will be sent to user mobile number. The proposed work aims at increasing accuracy of reading and collection process. The benefit of this work is reduced human intervention and measuring tools.**

Keywords – Power Line Communication (PLC), SMS, Smart Water meter, Grid power line

I. INTRODUCTION

Power line communication is considered as one of the existing tools where the data is sent and receive through power lines. Major benefit of using PLC is to get rid of additional cables and costs. Smart meter are used to sense any water leakages and isolates water supply by closing off the solenoid valves. The meter has additional features of getting ON/OFF commands from DIAM control room if the user has not the bills. For opening and closing the water supply, the control room will operate remotely. PLC will used for sending and receiving data through power lines in smart watering system [1]. The Arduino will be used as a central processor that transmits and receives the data and accordingly process it. Several companies in Oman are using PLC technology in order to secure the transmission quality. ABB Oman [2] is using PLC technology to guard the signals and protect the signals from electromagnetic compatibility. Currently, DIAM [3] is supplying water to Oman through pipeline networks. Massive amount of meters were installed in network lines for customers. Due to long distances, the readings were not recorded frequently [4] [5]. From the recent studies, It is clear that no work has been done on smart water meters which can communicate efficiently with the control room frequently and send the readings accurately.

The objectives of the proposed work as listed below

1. Sensing and collecting house hold water consumption using flow sensor
2. Detect water leakage and water usage using local feedback
3. Sending accurate water readings through power grid
4. Monitoring and controlling water remotely
5. Notifying user and billing department by sending SMS.

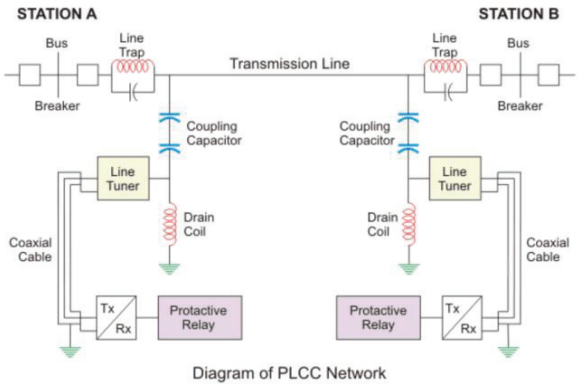

Fig. 1. PLCC network

II. METHDOLOGY

The proposed methodology for the work is V-methodology as most of the work is related to hardware and software. It has divided in to several stages which are listed below

1. **Requirements and specifications of the proposed work** – This phase includes the hardware and software requirements. Hardware components include flow sensor, solenoid valve, Arduino and smart meter. Software part consists of proteus simulation software and sketch IDE
2. **Designing phase** – This phase includes designing of hardware and software system
3. **Functional design** – Functional design includes functioning of each and every component. Once this phase is passed then the next phase includes Testing phase.
4. **Testing phase** – This phase has two sub stages. One is white box and the other one is black box.
5. **Implementation** – This is the final phase of design and implementation. The design is done on PCB board after testing and validation.

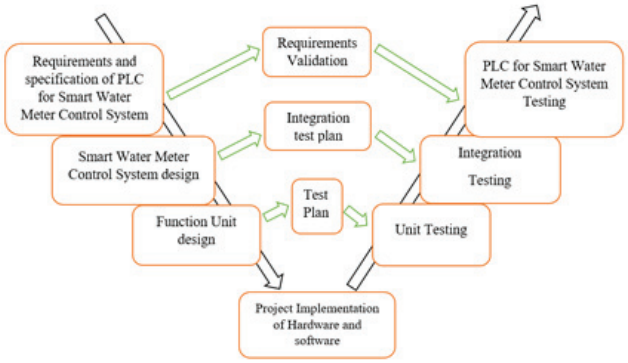

Fig. 2. Methodology

III. LITERATURE REVIEW

Several existing works related to the proposed work have been studied. The literature articles have been well summarized and outcomes have been identified.

Smart Grid Application for a practical Implementation of IP over Narrowband Power Line Communication [1]

The components used in this paper are data connectors, Smart Meter, Actuators, distributor generator for interlinking PLCC with multiple applications. The benefits of this work are PLCC can be used for multiple purposes for other applications. However, Implementation and designing is very difficult to achieve.

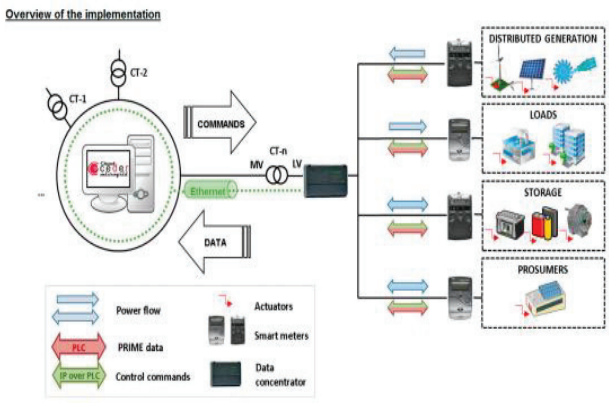

Fig. 3. Smart Grid Communication between the Applications

A. Domestic Water Meter Accuracy [2]

The proposed article is mainly focusing on testing water flow and meter reading. The components used in this paper are valves, pressure generator and water meter. Accurate measurements of meter readings and measurement values. However, this design lacks the implementation as it is just only a survey

Fig. 4. Domestic Water Meter Accuracy

B. Prepaid Smart Water Meter [3]

The objective of this paper is to detect fault in meters and transmitting data to authorized and will be informed accordingly to the consumers. The components used in the paper are PLC modem, CCU, meter unit and display. The major benefit is to detect faults in meters

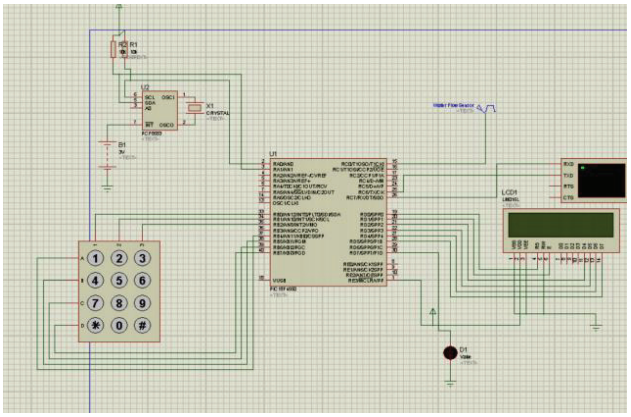

Fig. 5. Schematic Diagram of Prepaid Smart Water Meter

Automatic Meter Reading and Load Management Using PLCC [4]

The proposed article is basically used for leakage detection, sending data to users using mobile applications, displaying water meter reading in LCD and sending data accordingly to water Consumption Company. The

components used in the project are LCD, PLC modem, Raspberry Pi, Microcontroller PIC16F877A. The advantages of proposed work is water consumption will be communicated to the customer, leakage detection in the pipeline, control room will notify to the consumers and authority.

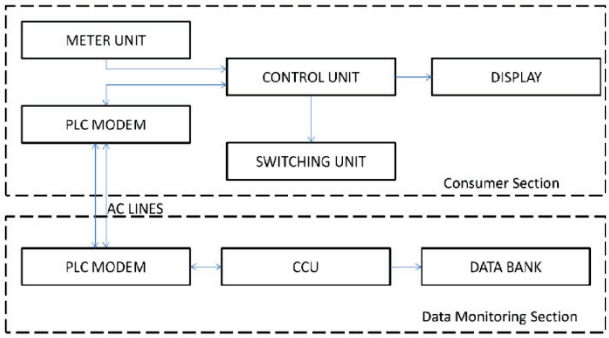

Fig. 6. Block Diagram of PLCC smart Electricity Meter

IV. DESIGN AND IMPLEMENTATION

A. System Block Diagram

Figure 7 shows the system block diagram that represent the main components in the system

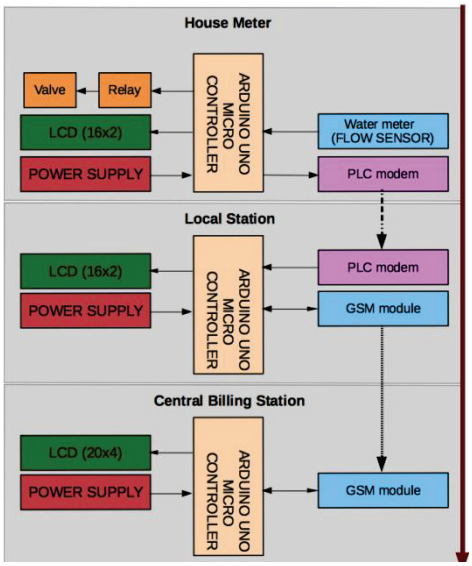

Fig. 7. System Block Diagram

B. Explanation

The below block diagram shows the interfacing components to PIC microcontroller. The block diagram is divided in to three sections. One is house meter, Local station and central billing section. Each section has its own functioning and operation. The complete system uses two methods of operation using PLC and station. PLC modem connects house hold to local station through grid whereas the station connects to the billing. All the three sections are connected with LCD and power supply. The communication happens through GSM module for sending and receiving messages whereas the PLC modem is used for power line communication. Water meter is used to read the values about water consumption and leakage

C. System Flow Chart

Below figure 8 shows the data flow of the proposed work. The water flow check will be done at house water meter section where if the limit is reached then the valve will be off otherwise the process will be continued. Once the valve is OFF then the PLC will send data. Once the data is available at the local collection station, the data will be displayed on the LCD and SMS will be sent to billing station. If the SMS is available then the data is parsed and displayed on LCD and the bill is sent to the user. Figure 9 shows the system process of water consumption to GSM transmission.

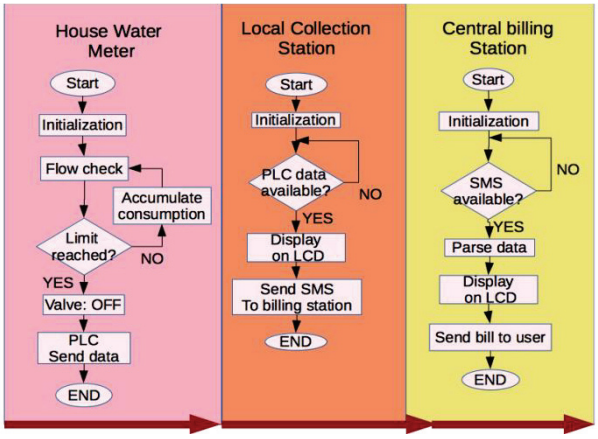

Fig. 8. Flow chart

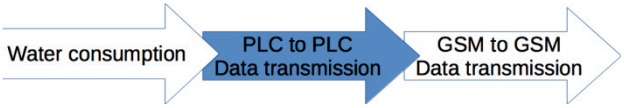

Fig. 9. System process

D. Water Consumption

The system uses flow sensor that calculates the water volume passing through the certain period of time. Number of calculations and equations needs to be considered before calculating the power consumption. First, determining the flow rate then based on the elapse time the consumption can be done. The flow rate calculations can be done using the velocity of water and the flow rate can be calculated by the below equation

$$Water\ consumption\left(\frac{Liter}{hour}\right) = \frac{input\ from\ flow\ sensor(number\ of\ turns)}{pulse\ frequncy} * hour$$

Where,

Pulse frequency (Hz) =7.5 (Flow rate L/min from datasheet)

$$Water\ consumption\left(\frac{Liter}{hour}\right) = \frac{(number\ of\ turns)}{7.5} * 60$$

Power management

Table I below shows the power consumption of the circuit and system.

TABLE I. POWER CONSUMPTION

Local Water Meter	
Item	Consumption
Flow sensor	15-20mA at 5V DC
valve	285mA at 12V DC
LCD	160 mA at 5V DC

Arduino	45 mA at 5V DC
PLC	≤11mA at 5 DC transmitting, receiving ≤300mA at 5 DC
Power required	1A@5V power supply + 1A@12V power supply
Collection Station	
Item	Consumption
LCD	160 mA at 5V DC
Arduino	45 mA at 5V DC
PLC	≤11mA at 5 DC transmitting, receiving ≤300mA at 5 DC
GSM	Max.2A at 5V DC
Power required	2.5A@5V power supply
Central Billing Station	
Item	Consumption
LCD	160 mA at 5V DC
Arduino	45 mA at 5V DC
GSM	Max.2A at 5V DC
Power required	2.5A@5V power supply

E. System Validation

Table II below shows the validation results for the mentioned objectives.

TABLE II. SYSTEM VALIDATION

Objectives	Validation	Validated/ not validated
using flow sensor collecting and registering household accumulative water consumption	Flow sensor converts the flow rate to water consumption	Validated
Local display feedback is used to detect and notify water leakage and water consumption.	LCD displays the water reading. Hence the consumer can monitor if the switch is being ON.	Validated
Powerline grid lines to transmit water usage to power supplier.	PLC codes and decodes the data and transmits via power line	Validated
Remotely controlling water supply	The data will be recorded centrally	Validated
Using SMS to notify billing and water consumption	Customer notification is done using SMS	Validated

F. Tabulating test results

The results below in table III tabulated are for all the items that were tested.

TABLE III. TESTING RESULTS

Item tested	Description	Result
Flow sensor	Senses and detects water flow	P
Valve	To ON/OFF as per threshold value set	P
Power line communication to Power line communication (PLC)	Package of one PLC is sent to the second PLC to decode	P
PLC to Global systems for mobile communications (GSM)	Package of PLC is opened and set in GSM format	P
Global systems for mobile communications (GSM) to GSM	GSM created and parsed at the other end of the loop	P

Where 'P' indicates PASS.

ACKNOWLEDGMENT

The research work was supported by Middle East College, Muscat in providing the lab facilities and also creating an academic environment to achieve the desired results. We are also thankful to all the esteemed professors in the department who moderated the manuscript at each step. We are immensely grateful to Dr Asif Hussain shaik to define new research findings related to the work proposed.

REFERENCES

[1] M. S. Yousuf and M. El-Shafei, "Power Line Communications: An Overview - Part I," in 2007 Innovations in Information Technologies (IIT), Dubai, 2007.

[2] "Oman," ABB LLC, [Online]. Available: https://www.omanmade.com/businesses/abb-l-l-c/. [Accessed 04 02 2020].

[3] "DIAM OMAN," [Online]. Available: https://www.diam.om/. [Accessed 04 02 2020].

[4] Z. Mingyue, "Measurements and Channel Characteristics of LV Power Line Communications Networks in China," in 2006 IEEE International Symposium on Power Line Communications and Its Applications, Orlando, FL, USA, 2006.

[5] G. Wei-chun, L. Huan-huan, Z. Hong-hao, G. Qiang, Z. Gui-ping, M. Yi-ling and F. Li-na, "Research on communication technology of power monitoring system based on medium voltage power line carrier and low power wide area network," in 2017 IEEE Conference on Energy Internet and Energy System Integration (EI2), Beijing, China, 2018.

[6] N. A. I. D. l. V. D. A. T. F. I. a. A. A. Uribe-Pérez, "Smart grid applications for a practical implementation of IP over narrowband power line communications," Energies, vol. 10, no. 1782, 2017.

[7] K. &. H. Du Plessis, "Domestic water meter accuracy," WATER AND SOCIETY , 2015.

[8] Fatma Al Shuhaimi; Manju Jose; Ajay Vikram Singh, "Software Defined Network as Solution to Overcome Security Challenges in IoT", 2016 5th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO) at AUUP, NOIDA, India, September 07-09, Year: 2016 Pages: 491 - 496, DOI: 10.1109/ICRITO.2016.7785005

[9] J. S. ,. F. v. S. a. Q. Z. Xiaowei Wang, "Implementing the Prepaid Smart Meter System for Irrigated Groundwater Production in Northern China: Status and Problem," Water, 2017.

[10] M. V. Aleyas, N. Antony, S. T, S. K. M and V. Balakrishnan, "Automatic Meter Reading and Load Management Using Power Line Carrier Communication," International Journal of Advanced Research in Electrical,Electronics and Instrumentation Engineering, vol. 3, no. 5, p. 18, 2017.