



# CUSTOMER AND COMPANY ORIENTED NOVEL ELECTRICAL AND WATER BILLING SYSTEM THROUGH POWER LINE CARRIER COMMUNICATION

Dr. GopiKrishna Pasam, Dr. Sultan Feisso, Mr. Wondwosen Wubu Mersha  
Dept. of Electrical and Computer Engineering, College of Electrical and Mechanical Engineering  
Addis Ababa Science and Technology University, Addis Ababa, Ethiopia

**Abstract**—Reading of energy and water consumption at the customer premises by the concern company persons is a monotonous and an uneconomical task. In present scenario, most of the companies following that the meter reading people goes to each meter and take the meter reading manually which will later be entered in the billing software for generating billing and payment automation. If the manual meter reading and bill data entry process can be automated then it would reduce the laborious task and financial wastage. The automatic reading of electrical energy and water consumption is possible through our proposed system which will uses the Power Line Carrier Communication (PLCC) for data collecting from the meters, processing the collected data for billing and other decision purposes. In this paper, we have proposed and developed a prototype model to accomplish automatic energy and water reading system, through this proposed system, the service company can record actual energy, water consumption instantaneously and also can apply demand side management concepts to control the unpaid customers, over load utilizing customers. In addition to that the consumer can know any time the actual consumed energy and water billing through SMS and internet portal. This type of system is the modern, which is more economical and most appropriate for all types of customers especially for the remote area customer's perspective.

**Keywords**—Power Line Carrier Communication; Electrical energy meter; water flow meter; Power line carrier module; Arduino micro controllers, GSM modules etc.,

## I. INTRODUCTION

In the recent years, the automation in every field is becoming necessary and having many advantages. But from several years this most advantageous automation is not applied in the field of utility bills (energy, water and Gas) collection. In the present system the service provider for electrical energy, water and gas still uses conventional methods for getting the

consumed readings by individual customer. The meter reader people goes to each meter from local to remote locations and takes the meter reading manually to issue the bills which is prepared by the concern authority companies after submitting the meter data. This type of meter reading is a repetitive, time consuming and an expensive task, also the data can be erroneous by human errors discussed by Tan, H.R et al (2017). Whereas the telecom companies not having this type of old meter reading system, that is why when we observe these telecom companies getting more profits throughout the world as compared to the electricity companies, gas supplying companies and municipalities.

In contrast to the above discussion, a system for automatically collecting and storing utility data and transmitting the stored data from the user premises to a remote location. The system comprises interface means for converting the utility usage data into data signals that can be recorded and a microprocessor for storing the utility information and controlling the transmission of the information from the user premises to the central location by telephone or GSM. Like these automatic meter reading systems were discussed by Verma, S.P, Jovellana, B.D, Gungor, V.C., Zabasta, A., et al (1989, 1998, 2011, 2011).

It is the advantage of power line communication (PLC) that digitalization and networking of existing facilities could be organized at low cost. Because there is no need for any further construction of communication lines, given that home appliances, information devices and other various kinds of control devices therein related are easily digitalized. Moreover, automatic meter reading (AMR) is very attractive to utility companies because not only does it reduce the cost of reading meters, but controls and monitors energy demand, and resolves

consumer problems effectively deliberated by Park, B.S, Melvin, J.W.I, Ferreira, H.C, Bumiller, G (2002, 2008, 2011,2010).

The SOMPLC-PLC83 is a self-contained hardware system on Module (SOM) for Power Line Communication, including the Analog Front End and the digital Modem on one single PCB. It is the ideal plug-in tool for developers willing to easily and quickly evaluate the most popular narrowband power line communication standards. Granted developers bring up the high voltage coupling, the SOM easily plugs into the application with standard communication ports (UART, SPI, I2C, CAN) via a connector header interface [10]. Another type of 130 KHZ range KQ-130F PLC module [11] is used for small prototype applications.

After going through the abundant literature, our proposed system proving as the novel, unique and not discussed the implementation of proposed customer and company oriented novel electrical and water billing system. Literature mentioned in [1] to [18] supports the development of various stages of our proposed system prototype. In this paper, the proposed system and its innovation is discussed in the section II, Methodology with implementation steps are discussed in the section III, followed by the corresponding results in section IV and conclusions in section V.

## II. PROPOSED SYSTEM AND ITS INNOVATION

The proposed meter less, electrical energy and water reading system is shown in Fig. 1. The initiation for this type of proposed system is the present telecom billing system.

Since many years the electricity companies and municipalities have been using conventional energy meters and water meters respectively, whereas telecom companies are generating reliable customer mobile billing without using of meters. This type of telecom billing system has more convenient to the customer to know their usage bill at any time and giving more profits to the telecom companies throughout world. Using our innovative proposed system, we can incorporate and implement such type of customer and company oriented electrical and water billing system through power line communication without using of telecommunication networks.

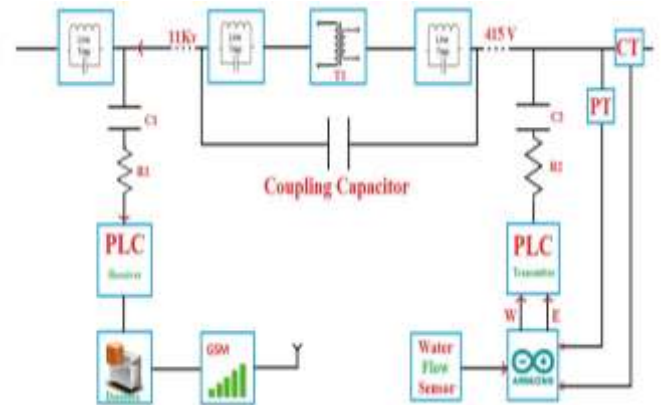


Fig. 1. Proposed meter less electrical energy and water reading system

The proposed system will consists of two own measuring systems (Electrical energy and Water), one Power Line Communication (PLC) transmission system at customer location and PLC receiver system, RS 232 cable, proposed database computer with GSM modem at company location. Our own meter-less electrical energy measuring system at customer location will be used to measure current using current transformer and voltage using potential transformer, these two signals are given to the Arduino microcontroller to measure electrical energy, which will be fed to the PLC transmission system.

Our own meter-less water flow measuring system at customer location will be used to measure flow of water using water flow sensor, which gives water flow signal to the Arduino to measure water flow from the municipality water pipe, this amount of usage of water information will be fed to the PLC transmission system. Power Line Communication system uses the SOMPLC-PLC83 as shown in Fig.2, it is a self-contained hardware system on module (SOM) for power line communication, including the analog front end and the digital modem on one single PCB. The SOMPLC used as the instantaneous PLC transmission system for the measured energy and water at the customer location and similar PLC receiving system will be used to receive the data from the different customers and this data is fed to database system through RS232 cable.

In addition to this type of automatic novel energy and water recording system, the proposed system at company location will have GSM module connected to the company database system. Using this, the company system will respond to customer billing queries by means of free SMS and also it will

send an alert message of usage of electrical energy and water. When company database system is connected to internet, the usage of electricity and water information will be obtained by the customer and company personnel.



Fig. 2: SOMPLC-F28PLC83System on Module for Power Line Communication

Our innovative proposed energy and water billing system gives more profits to electricity companies and municipality by avoiding old measuring methods which are having several disadvantages such as tampering, wrong feeding of energy and water readings by manual readers. Our proposed system enhances skilled job seekers towards utilizing of modern technology for the development of nation. In this way the proposed system will be an innovative by incorporating telecommunication type billing system for the electrical energy and water billing system.

The Advantages of proposed system are:

- ❖ Avoid Manual errors
- ❖ Very useful for Remote locations
- ❖ We can provide communication and internet for remote locations where no GSM signal but power available.
- ❖ No separate wires required for communication, so no additional costs pertaining to cables and related infrastructure
- ❖ Same technology we can use for communication between houses
- ❖ Secure data encryption
- ❖ Very importantly Load management facility is possible
- ❖ Theft of power information will be identified
- ❖ Reliable billing, graphs, energy consumption analysis, exact losses calculation.
- ❖ On-line monitoring of usage of energy and water is possible.
- ❖ Single system for all types of meters.

- ❖ Transformer over loading problems will be solved.

### III. METHODOLOGY

The proposed system as shown in Fig. 1, consists of hardware implementation setup at customer location and company location.

#### A. Development of proposed prototype at customer location

*Stage-1:* Development of meter less electrical energy measurement using Current Transformer (CT), Potential Transformer (PT) and Arduino.

*Stage-2:* Development of meter less water flow measurement using water flow sensor YF S201 as shown in Fig. 3 [10] and Arduino.

*Stage-3:* Development of Power Line Communication (PLC) transmitter system at customer location using KQ-130F power line carrier data transceiver module as shown in Fig. 4, it integrates the KQ-330F module and Arduino microcontroller circuit without other coupled components, directly connected to the 220V AC for power line communication to transfer the measured electrical energy and water flow readings through Arduino microcontroller.

#### B. Development of Proposed Prototype at Company Location

*Stage-1:* Implementation of PLC transmitter signal bypass at 11KV/415 V distribution transformers using line trap modules and 11KV rated coupling capacitor.

*Stage-2:* Development of Power Line Communication (PLC) receiver system at company location using SOMPLC-PLC83 for power line communication of receiving of measured electrical energy and water flow readings from customer location

*Stage-3:* Establishment of PLC receiver system connection with company database server for instantaneous storing of customer electrical energy and water consumption. Using this data an instantaneous and an automatic billing will be available for pursue of company personnel to generate monthly bill.

*Stage-4:* In order to establish customer oriented billing system, we propose implementation of an innovative idea that is establishment of two channel GSM modem (One for Electrical energy and another one for water) and connecting it with company server through RS232 cable, so that whenever a customer send free enquiring SMS to the respective company GSM modem it will reply with instantaneous usage details of electrical energy or water along with the due billing amount to be paid.



Fig.3. Arduino Compatible Water Flow Sensor (YF S201)



Fig.4. KQ-130F power line carrier data transceiver module

#### IV. RESULTS AND DISCUSSIONS

The circuit diagram as show in Fig. 5 is used to develop the prototype model for the implementation of the proposed test system. It consists of two circuits, one is related to the company location and other is related to the customer location.

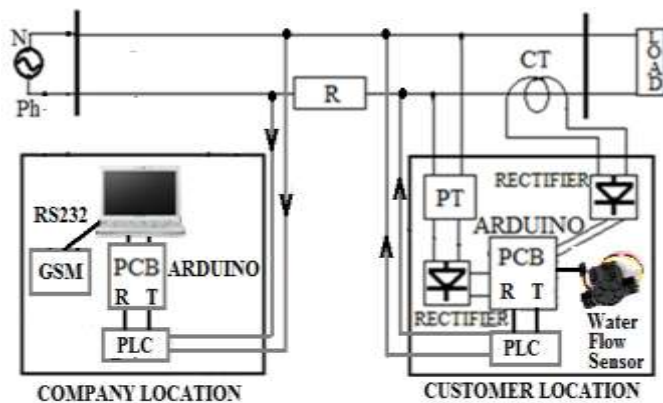


Fig.5. Implementation circuit diagram of proposed system

The circuit at customer location is having potential transformer to sense voltage, current transformer to sense current, the arduino is programmed to calculate phase angle so that the total electrical energy consumed by the customer will be measured by Arduino. Similarly the Arduino will measure water consumed by the customer through water flow

measurement sensor. The electrical energy and water measurement signals from thr Arduino are fed to the KQ-130F power line carrier (PLC) data transceiver module, this module supports the Arduino interfacing up to 9600 bits pe second. Some more significant specifications of KQ-130F PLC module are mentioned in the Table I.

The circuit at comapny location is having an another PLC which will acts as a receiver to get electrical energy and water signals from the cutomer location. Through the PLC the Arduino will process and stores the timely data signals into the computer database. Further the computer is connected to the GSM module through RS 232 cable, when ever customer wants to know the billing information, customer can send a SMS, so that the system will respond back monthly wise consumption billing. In that way customer can take appropriate decision to control his consumption levels by avavoiding unnecessary usage power and water, so this proposed system is more convenient to the customers and service companies.

Using the PLC modules we can distinguish the electrical energy and water signals and also the each customer by providing customer identification in the first 8 bitsand in the next 8 bits for energy and water consumption readings.

Table I: Specifications KQ-130F PLC module

Parameter	Value
Insulation resistance	500V $\geq$ 500M $\Omega$
Power supply	DC +5V
Working frequency	120-135KHZ
Interface baud rate	9600bps
Actual baud rate	100bps
Receiver sensitivity:	$\leq$ 1mV
Bandwidth	$\leq$ 10 KHZ



Fig.6. Intial stage of development



Fig.7. Finally imlemented prototype model



Fig.8. Customer location power transferring through PLC



Fig.9. Company location power reading from sending end through PLC

Using the circuit diagram as shown in Fig.5, we have successfully tested the transferring of the signals from the customer location circuit and getting of corresponding signals at the company location, this result can clearly observed in the Fig. 8 and Fig. 9. The photo snaps of such implemented results are shown in Fig. 6 to Fig. 9.

#### V. CONCLUSIONS

After going through the abundant literature, our proposed system proving as the novel, unique and not discussed the implementation of proposed customer and company oriented novel electrical and water billing system. The implementation of our innovative proposed energy and water billing system gives more profits to electricity companies and municipality by avoiding old measuring methods which are having several disadvantages such as tampering, wrong feeding of energy and

water readings by manual readers. In addition to that demand side management techniques can be implemented such as when customer not paid money within the stipulated time, the company automatically disconnect power to the customer and similarly if any customer uses more power than the allotted limit those customers can be disconnected automatically, in that way the power engineers can maintain and enhances secure operation of power system. Our proposed system enhances skilled job seekers towards utilizing of modern technology for the development of nation. In this way the proposed system will be an innovative by incorporating telecommunication type billing system into the electrical energy and water billing system.

#### VI. REFERENCES

- [1] Tan, H.R., Lee, C.H. and Mok, V.H., 2007, December. Automatic power meter reading system using GSM network. In The 8th International power engineering conference (IPEC 2007) (pp. 465-469).
- [2] Verma, S.P. and Lin, K.S., Net Labs Inc, 1989. System for automatically reading utility meters from a remote location. U.S. Patent 4,833,618.
- [3] Jovellana, B.D., Jovellana and Bartolome D., 1998. Automatic utility meter monitor. U.S. Patent 5,767,790.
- [4] Gungor, V.C., Sahin, D., Kocak, T., Ergut, S., Buccella, C., Cecati, C. and Hancke, G.P., 2011. Smart grid technologies: Communication technologies and standards. *IEEE transactions on Industrial informatics*, 7(4), pp.529-539.
- [5] Zabasta, A., Kunicina, N., Chaiko, Y. and Ribickis, L., 2011, April. Automatic wireless meters reading for water distribution network in Talsi city. In EUROCON-International Conference on Computer as a Tool (EUROCON), 2011 IEEE (pp. 1-4). IEEE.
- [6] Park, B.S., Hyun, D.H. and Cho, S.K., 2002, October. Implementation of AMR system using power line communication. In Transmission and Distribution Conference and Exhibition 2002: Asia Pacific. *IEEE/PES (Vol. 1, pp. 18-21)*. IEEE.
- [7] Melvin, J.W.I. and Mollenkopf, J.D., Current Technologies LLC, 2008. Power line communication system with automated meter reading. U.S. Patent 7,436,321.
- [8] Ferreira, H.C., Lampe, L., Newbury, J. and Swart, T.G. eds., 2011. Power line communications: theory and applications for narrowband and broadband communications over power lines. John Wiley & Sons.



- [9] Bumiller, G., Lampe, L. and Hrasnica, H., 2010. Power line communication networks for large-scale control and automation systems. *IEEE Communications Magazine*, 48(4).
- [10] <http://www.ti.com/general/docs/lit/getliterature.tsp?baseLiteratureNumber=spruhr4&fileType=pdf>
- [11] <https://www.electroschematics.com/12145/working-with-water-flow-sensors-arduino/>
- [12] <https://hacktronics.co.in/ethernet-modules/kq-130f-power-line-carrier-data-transceiver-module>
- [13] Primicanta, A.H., Nayan, M.Y. and Awan, M., 2009, November. Hybrid automatic meter reading system. In *Computer Technology and Development, 2009. ICCTD'09. International Conference on* (Vol. 2, pp. 264-267). IEEE.
- [14] Son, Y.S., Pulkkinen, T., Moon, K.D. and Kim, C., 2010. Home energy management system based on power line communication. *IEEE Transactions on Consumer Electronics*, 56(3).
- [15] Pukale, R.S., Bavache, S.V., Kashid, S.N., Sabale, A.P., Patil, P.P. and Shinde, P.H., 2017, March. Automatic meter reading of electricity by using power line communication. In *Innovations in Green Energy and Healthcare Technologies (IGEHT), 2017 International Conference on* (pp. 1-5). IEEE.
- [16] Barker, S., Irwin, D. and Shenoy, P., 2017. Pervasive energy monitoring and control through low-bandwidth power line communication. *IEEE Internet of Things Journal*, 4(5), pp.1349-1359.
- [17] Sharma, K. and Saini, L.M., 2017. Power-line communications for smart grid: Progress, challenges, opportunities and status. *Renewable and Sustainable Energy Reviews*, 67, pp.704-751.
- [18] Mathews, J.A., Varghese, J., Raju, J., Daley, L. and AO, B., 2017. Intelligent energy meter with power theft detection.