

ELECTRICITY UTILIZATION AND INVOLUNTARY BILLING THROUGH POWER LINE

G Thavasi Raja

Department of Electronics and Communication Engineering,
National Institute of Technology Tiruchirappalli INDIA
(e-mail: thavasi@nitt.edu).

T. D. Sudhakar

Department of Electrical and Electronics engineering,
St. Joseph's college of engineering, ANNA University, Chennai, INDIA
(e-mail: t_d_sudhakar@yahoo.co.in).

Abstract – In every aspect of life, electronics plays a vital role. Though many technological innovations are taking place in this world, existing electricity consumption billing process seems in India to be very obsolete and does not meet the latest technology available. In this paper, the above said process is totally automated and the communication is made possible entirely through the power line. This communication is bi-directional at a faster data rate through long distances. By digitizing, the currently used analog energy meter has been completely transformed to a digital one. Hence it is beneficial to the customers as the system is made very user friendly.

Index Terms--Current Transformer, Microcontroller, MODEM, Voltage Transformer

I. INTRODUCTION

THE advancement of technology is that all the conventional systems need an amendment, which is applicable to electric billing also. In major countries adopts a very conventional method of electricity billing wherein personnel from the electricity board notes down the meter reading from all the buildings in the locality. As the billing is done manually the probabilities of errors and manipulations while observing will be more. Using automation the drawbacks of the present system can be eliminated and the system can be made more efficient. The basic block diagram for automatic billings is shown in the Fig. 1.

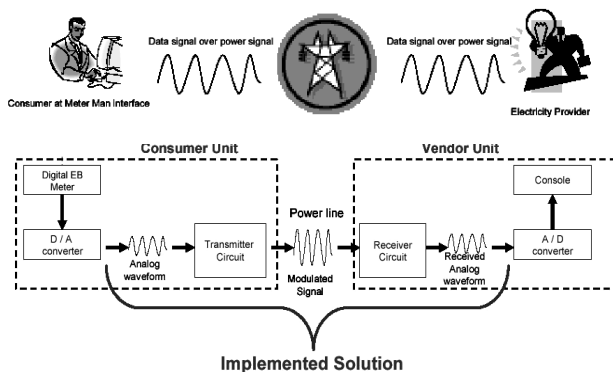


Fig. 1. Basic Design IDEA Block Diagram

The electricity consumption and automatic billing through power line essentially consists of three sections as shown in Fig. 2 and Fig. 3.

- i. Digitizing Energy Meter
- ii. Control System
- iii. Transmission of consumed energy units through power line to EB side

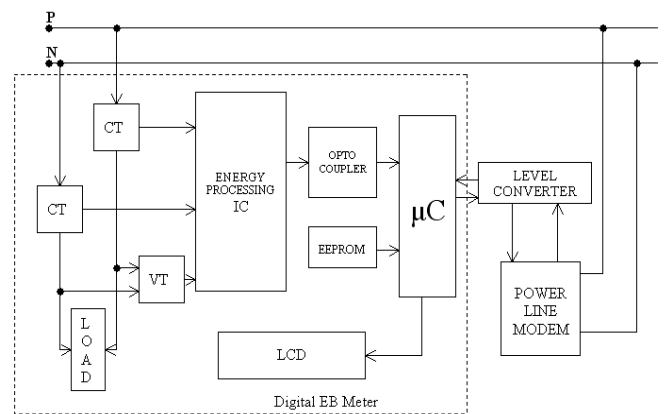


Fig. 2. Customer End

The first section is the energy meter section where the energy consumed by the consumer is calculated digitally. A current transformer (CT) and voltage transformer (VT) of the specified rating are used. The output of the processor IC is a digital pulse, which depends upon, the load used. These pulses are given as the input to the second section through the optocoupler. The second section is the heart of the proposal, which consisting of the micro controller. For every 100 pulse the micro controller receives it increases the number of units consumed by the consumer by 1, which is stored in the EEPROM. This is then displayed in LCD.

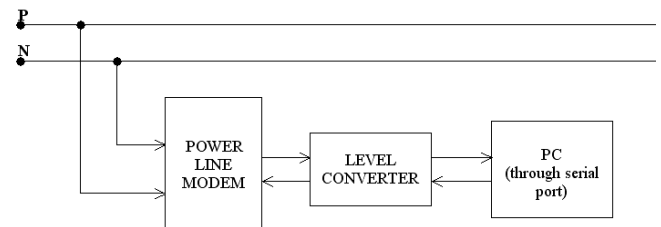


Fig. 3. EB End

The third section is EB end consists of the MODEM which is a transceiver i.e. it can receive as well as transmit data. The modem receives the input from the micro-controller and transmits it to the EB side. These are received by the modem placed in the EB side and sent to the PC. The tariffs are calculated using VB by the PC and

sent to the micro controller through the same pair of MODEM. Hence the number of units consumed and the amount is displayed in the LCD.

II. DESIGN CRITERIA

In this section, the design detail of the four individual module used for digitizing the energy meter and, power line transmission are discussed.

A. Energy Meter Section

The Energy meter section consists of 2 CTs, a VT & an ADE7751 [5]. The 2 CTs are connected to the phase and neutral. A VT and a CT is used to measure the power consumed by the consumer. The ADE7751 is an analog to digital converter, which converts the analog signal from the transformers to digital pulses and feeds it to the microcontroller. The 2 CTs are required but during a fault condition of the CTs the ADE7751 will take the greater value of the two currents.

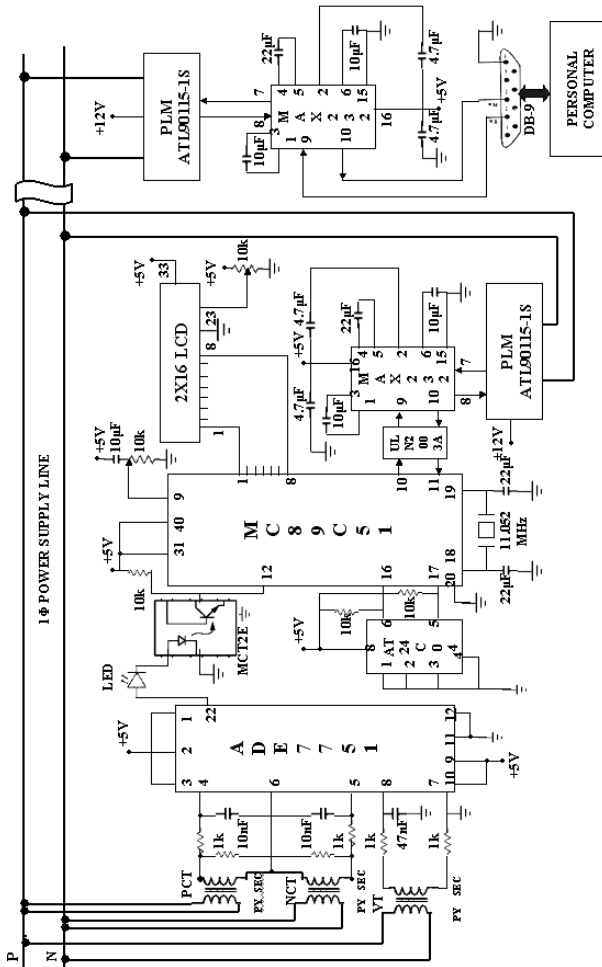


Fig. 4. Method to Implement Power Line MODEM

B. Microcontroller Section

The next is microcontroller section and consists of microcontroller, optocoupler, interface, EEPROM, power line MODEM and LCD. The microcontroller being used is 89C51 [1]. The optocoupler being used is MCT2E. The optocoupler is optically coupled and electrically isolated. This prevents any transients from affecting the microcontroller. The EEPROM is AT24C04 is used to store

the output of the microcontroller permanently. Hence even in the case of a power failure the data is not lost. The interface used is MAX232 [5]. This is used to control the speed of data transfer between MODEM and the microcontroller. The MODEM used here is ATL90115-1 [4]. This is used to transmit the data received from the microcontroller to the EB side and from the EB side to the microcontroller using the existing power lines. It does at a frequency of 115 KHz. As a result of this the external noise is totally reduced. The method used to implement power line MODEM is shown in the Fig. 4.

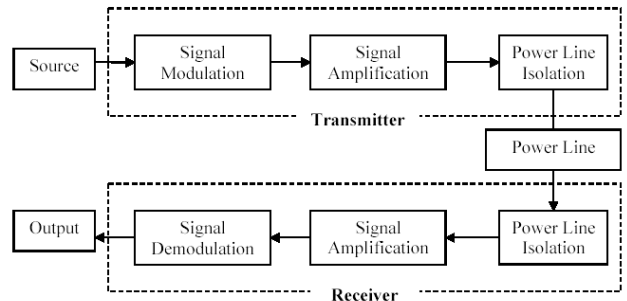


Fig. 5. Circuit Diagram

C. EB Section

The last is EB section consists of MODEM [4], interface and a PC. The PC is fed with all the slabs for the calculation of bills for the number of units consumed. Once the PC receives the number of units consumed by the consumer it calculates the bill using the slabs fed in it. It then sends this to the microcontroller through the same pair of MODEMS. Then the units consumed and the corresponding cost is displayed in the LCD. The complete circuit diagram of customer end and EB end system setup is given in the Fig. 5 and the power supply system model for microcontroller and other ICs are given in the Fig. 6. The ADE7751 will compare the 2 CTs value and if their difference is greater than 12.5% then it will indicate a fault condition that is the power is dropped at some point before neutral.

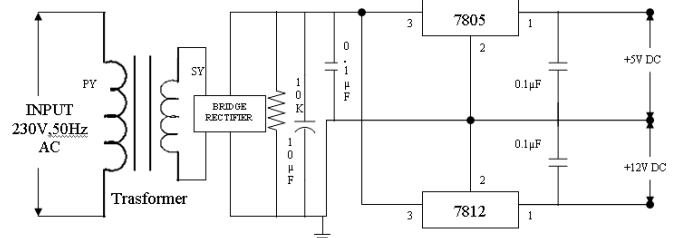


Fig. 6. Power Supply Unit

D. Power Line Interface

One of the most important parts of the power line transmitter and receiver is the Power Line Interface. Because the circuit has to connect to the 230V 50 Hz power line, without careful isolation, the rest of the circuit will be burnt easily. The ideal isolation circuit should completely block the 50Hz signal, and pass the information signal. By placing this isolation circuit between the power line and the rest of the circuit, ensure that the 230V power signal will not affect the transmitter and receiver circuit, and also, the

information signal can be sent and received from the power line. The response curve for the isolation circuit done through simulation is shown in the Fig. 7.

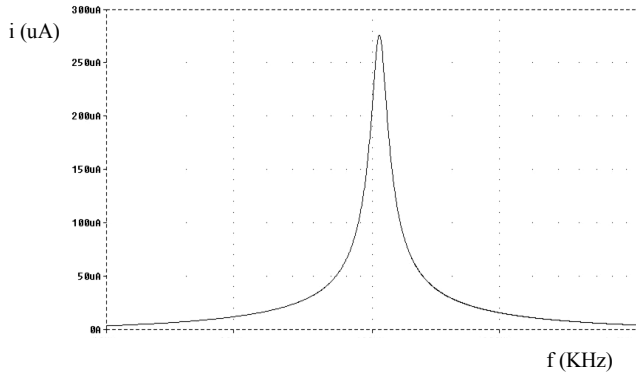


Fig. 7. Response Curve for Isolation Circuit

III. IMPLEMENTATION PROBLEMS

One of the major problem implementation problem faced is the uniformity of transformer winding. The windings on the two CT transformers used were supposed to be uniform for the metering IC ADE7751 to produce an efficient output. But due to manufacturing defect they were different and hence the output of ADE7751 deviated largely from the correct one. The discovered problem was overcome by adding two presets; one each for the two CTs and thus the output of the metering IC was rectified and found to produce the correct needed number of pulses as output. At first to make interface established between systems with PC through USB port, but found it to be complicated and not much effective. Then it is solved by replacing USB port with the serial port (DB-9) connector.

IV. INTERFERENCE REDUCTION

Since power lines are designed to send power, they are not optimized as transmission medium for data. Power lines typically have high amounts of noise, which causes signal distortion. This signal distortion increases the bit error rate (BER). The BER is defined as the ratio of incorrect bits demodulated by the receiver to the number of total bits received. Furthermore, power line signals are also subject to high amounts of attenuation. These factors are the primary reasons because power lines have not been adopted for mainstream data delivery. To overcome these shortcomings of the power line, various advanced modulation methods available to decrease the BER. The current prototype uses FSK to modulate the message signal. All existing modulation techniques have deteriorated performance under the presence of interference, but there exist techniques that have slightly better performance than FSK in noise. A technique called BPSK (Binary Phase Shift Keying) has better performance than FSK under noise. BPSK uses two phase differences in the modulated signal to distinguish between a 0 and 1.

V. TESTING AND SIMULATION RESULTS

To test the system required loads to be applied at the customer end. The loads needed to be different to show corresponding difference in the consumed power. The number of pulses produced at the output of ADE7751 is

proportional to the power consumed by the load attached at the customer end. Practically, in the EB system, 25000 pulses are considered as one unit, i.e. the power consumed by a 1000 watts load for one hour is equal to one unit.

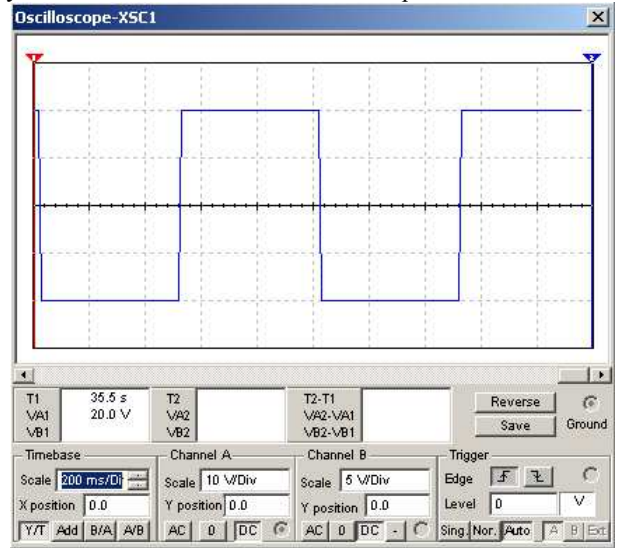


Fig. 8. Output Pulses at pin CF in ADE7751 when a 15 W LOAD is connected.

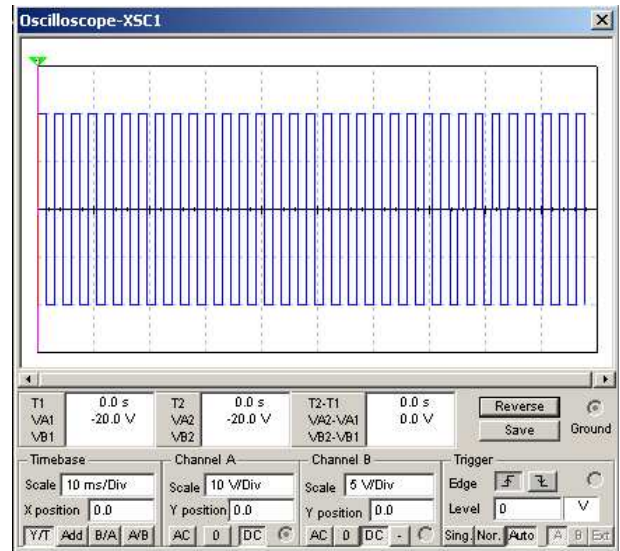


Fig. 9. Output Pulses at pin CF in ADE7751 when a 100 W LOAD is connected.

Login

User Name:

Password:

Fig. 10. Login Form

For testing purpose of the system, 100 pulses (ON & OFF pulses) to be considered as one unit and made the design. So to choose bulbs of different watts (15W, 25W, 40W and 100W) to act as loads at customer end to show difference in the consumed power and hence the difference in the number of pulses at the output of ADE7751 are shown in the Fig 8 and Fig 9.

Fig. 11. Transaction Form.

The implementation of the device, named Meter Man, began with the design of a transmitter and receiver circuit. The circuit would need to be able to receive data, modulate it, and then interface with the power line. The FSK modulating type power line MODEM chip with power amplifier had used for the design. The receiver was also built using a FSK demodulating chip and power amplifiers to interface with the circuit. The final step was to build filters that would allow us to retrieve the original message. Although the design had encountered several problems on the way and finally design had made successfully, simulated, and implemented the transmitter and receiver circuits. It is also researched several ways to improve the system. By changing the modulation technique to BPSK can reduce interference. By changing the modulation technique to QPSK the data rate can be made double and reduced interference. The system would therefore function better with a QPSK chip. To further increase the data rate, OFDM could be employed to get the maximum utilization of the power line. To make the system user friendly would need a graphical user interface. The GUI could be programmed in Microsoft Visual C++ or Java to communicate with the low level instructions in the PowerPC micro-controller to give a user-friendly interface for both the transmitter and receiver.

Here visual basic graphical user interface software 6.0 for receiving the digital EB meter reading data transmitted through power line using power line MODEM and the same data is received through the power line MODEM that is connected to serial port of the port of the personal

computer placed in EB station. After that the calculated amount in rupees proportional to EB meter power data and the amount will be transmitted to the consumer's home through power line and displayed in the LCD display placed in digital EB meter. The real end system model output is displayed in the Fig. 10. and Fig. 11. The Fig. 10. shows the application main login window of the PC in the substation in that user name and password of the particular substation has to be entered. After that it will automatically opens second window shown in the Fig. 11. In that the Customer ID, Name and Category are selected. The corresponding power reading for the particular user will be displayed in the screen and also displays amount proportional to the power consumption. The whole system is checked for single user model only. For more users it can be extend by using the same idea.

VI. CONCLUSIONS AND FUTURE IMPROVEMENTS

The interesting feature about the device is that it communicates solely through the power lines. This is an implementation of data transmission through power lines. A successful implementation of this type of technology would open the door to new data services that could also be provided through the power lines. The system is entirely designed to work on single phase, but this can be further extended to work on 3 phase also. Transmission distance for the designed power line modem is up to 300m, can be improved by upgrading the power line modem. For higher loads exact design of current transformers will provide efficient output. By cryptography the communications can be made much secured.

VII. REFERENCES

- [1] Muhammad Ali Mazidi, and Janice Gillispie Mazidi, "The 8051 Microcontroller and Embedded Systems", Pearson Education, 2000.
- [2] William Stallings, "Wireless Communication and Networks", Pearson Education, 2002.
- [3] John Sheriff, "John Sheriff Teaches Visual Basic 6.0", Prentice Hall of India, 2002.
- [4] www.archnetco.com
- [5] www.alldatasheets.com
- [6] www.epanorama.com

VIII. BIOGRAPHIES

Thavasi Raja G was born in Virudhunagar district in India, on June 16, 1981. He has completed M.E in communication systems with distinction from Thiagarajar college of Engg, Anna University, Tamil Nadu, India. He is currently working as a lecturer at National Institute of Technology (NIT) Tiruchirappalli, Tamil Nadu, India. His area of interest includes signal processing, wireless communication and FPGA application for wireless.



Sudhakar T D was born at Chennai in INDIA, on June 14, 1980. His undergraduate and graduate studies are from Madras and Anna University. He is currently doing his PhD in the field of Power System Restoration. His research interest is in the field of Service Restoration in distribution networks by incorporating optimization techniques.

