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DESIGN AND IMPLEMENTATION OF MULTI-TARIFF BILLING SYSTEM

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Abstract- *Bangladesh is a developing country and densely populated. Most of the people especially lived in villages of Bangladesh is not clearly aware of electric billing system especially multi-tariff billing system. They suffer from load shedding, inaccurate billing and billing theft done by utility or supply company because of lacking of consumer's awareness of billing information. The present system of energy metering and billing system of utility or supply company in Bangladesh which is error prone and consumes more time and labor. Manual processing of billing system can cause human error. So to avoid traditional meter reading, save human resources, improve the accuracy and prevent billing theft this paper describes the development of a user-friendly multi-tariff billing system. This system consists of server unit and consumer unit or energy meter. This system provides more accurate meter reading and billing information. In this system, users can observe tariff rate and check their daily, monthly, yearly bill paid to utility company with the help of interfaced keypad. This system may help creating consumer's awareness of abusing electricity and may result in reduced load shedding.*

Keywords: Microcontroller, Serial communication, Current Sensor, Liquid Crystal Display, Interfaced keypad.

1. INTRODUCTION

Multi-tariff billing means variable tariff with respect to time. In multi-tariff billing system, variable tariff rate is imposed on unit of electric energy consumption per hour by a consumer or user. Energy Meter is a device that measures the amount of electrical energy consumed by a residence, business, or an electrically powered device. In the present world, it is a challenge to develop an electric energy meter, the meter reading of which should be more accurate and that can perform many advanced operations for providing fair billing charge and other information to consumer.A Single Phase Intelligent Prepaid Energy Metercollects electricity bills from the consumers prior to its consumption and it is not completely commercial in case of Bangladesh because of lack of complete electrification and load shedding. It is not consumer friendly [1]. An Automated Energy Meter which has capabilities like remote monitoring and controlling of energy meter. It saves huge human labor. The data received from an energy meter has been stored in database serverwhich is located at electricity Board stationthrough SMS gate way for further processingby energy provider. Energy provider sendselectricity bill either by e-mail, SMS or by post to consumer [2]. A prototype microcontroller based single phase digital prepaid energy meter is capable of measuring electric energy consumption according to prepaid card. It can't show variable tariff rate on LCD monitordon't calculate energy consumption according to it [3].A GSM based power meter reading and control systemkeeps track of the meter reading of each day and the reading with the user identification number send it to the user as well as to the electricity department and Electricity billing system associated with electricity department will keep the track of each SMS meter reading and the appropriate bill get generated at the last day of the month and the bill is forwarded to user from the server. So there are no chances of confusion to the user for paying the bill. The GPMC also feature distribution control system which controls the power of the appliances remotely [4]. After all it doesn't introduce multi-tariff billing system and user interfacing option. The power utility can recharge theprepaid card remotely through mobile communication based on customer requests. A prior billing is bound to do away with theproblems of unpaid bills and human error in meter readings, thereby ensuring justified revenue for the utility. But a consumer may suffer in case of emergency load after expiration of prepaid card [5]. So it is evolved to develop a Multi-tariff billing system and familiarize this system with all consumers.This system is designed only for resistive load. This system consists of server and consumer unit. Server unit contains mainly i) microcontroller, ii) LCD monitor and iii) crystal oscillator. This unit is controlled by authority of the utility company. The required data are transmitted from server unit to the residential consumer unit through serial communication. Consumer unit contains several types of main parts. These parts are such as i) load,ii) current sensor,iii) precision

rectifier, iv) microcontroller, v) LCD monitor, and vi) interfacing key pad. Current sensorsense theload current. This current is fed through precision rectifier to microcontroller which performs the analog to digital conversion (ADC).This unit mainly performs the operation of load and bill calculation with the help of received data transmitted by server unit. A consumer can check their daily bill at the end of day and the monthly bill at the end of monthusing keypad. Consumer can also check their yearly bill that was paid by them to utility company.Consumer unit thus performs the user friendly operations.

2. SYSTEM OVERVIEW

The system consists of two microcontrollers- one PIC16F73 and other PIC16F877A. In server unit PIC16F73 microcontroller isconnectedto the LCD monitor and to the consumer unit microcontroller PIC16F877A throughwire. Thismicrocontroller is used for displaying data on LCD monitor and transmitting the data to the consumer unit through serial communication continuously. Figure 1 shows the block diagram of the server unit.

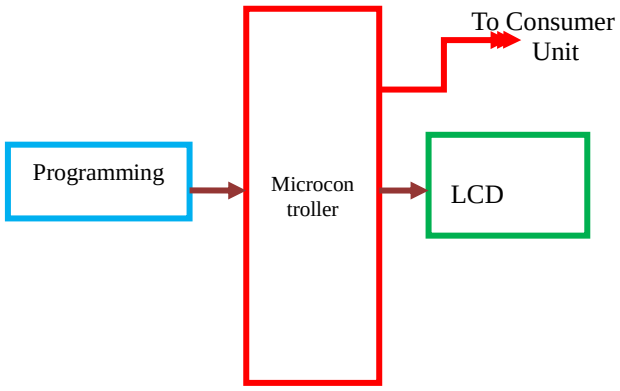

Fig.1: Block diagram of Server Unit

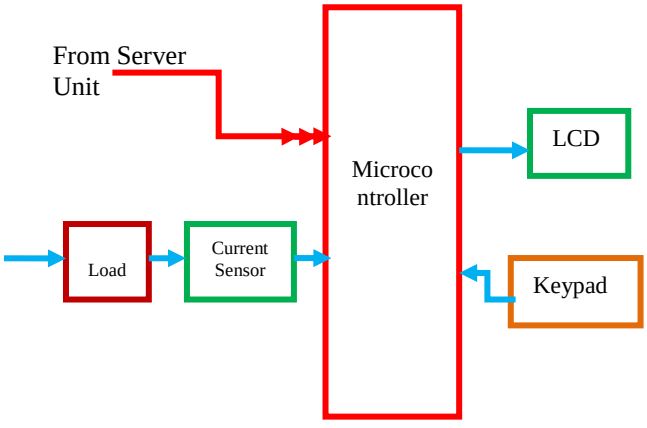

Fig.2: Block diagram of Consumer Unit

On the other hand PIC16F877A microcontroller is connected to shunt current sensor through precision rectifier, to LCD monitor and to interfacing input device such key pad. This microcontroller is usedfor measuring the current and performs analog to digital conversion(ADC) of current and also perform the expected calculations for load and bill according to received data from server unit and saves these data in the EPROM of this microcontroller for further using and analyzing in consumer unit. The performances of the PIC16F877A microcontroller are displayed on the LCD monitor of the consumer unit. User interfacing devise such as a key pad is connected to PIC16F877A microcontroller for checking the daily, monthly or yearly bill that was paid by consumers. Figure 2 shows the block diagram of the consumer unit.

3. SYSTEM DETAILS

3.1 Server Unit

This unit consists of mainly PIC16F877A microcontroller and LCD monitor(LMO44L).

3.1.1 Display Unit

PIC16F73 microcontroller is directly connected to the LCD monitor. In general, programming codes are written as the expectation of the authority of the utility company. Then this programming code is loaded into microcontroller. The authority can change or modified the programming codes at any time according to their demands easily.LCD monitor displays the results of programming of PIC16F73 microcontroller. LCD monitor mainly displays the two results i) time-slot and ii)tariff-rate at the same time. In time-slot portion of the output on the LCD monitor may display sequentially slot: normal, slot: peak, and slot: super peak. In tariff-rate portion of the output on this LCD monitor may display sequentially tariff: 3tk/unit, tariff: 5tk/unit and 10tk/unit respective to sequential output portions of the time-slot.

3.1.2 Serial Communication Unit

This PIC16F73 microcontroller performs serial communication to the consumer unit.Here asynchronous transmission has been used shown in Fig.3.In asynchronous transmission, no clock signal is transmitted. Even when thereceiver and the transmitter use the same frequency, the slightest differencecan stop them running synchronously [6]. Thus microcontroller transmits these data that are shown on the LCD monitor to the consumer unit serially.

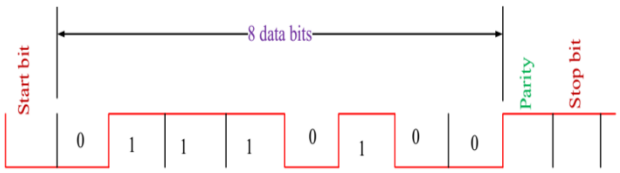

Fig.3: Asynchronous transmission using the UART character.

3.2 Consumer Unit

Consumer unit or energy meter mainly consists of load, current sensor, PIC16F877A microcontroller, LCD monitorsand keypad. This unit is a user friendly unit. Because users are able to check their daily, monthly and yearly bill that was paid by them to the utility company using keypad.

3.2.1Current Sensor

In consumer unit shunt resistor current sensor has been used for current sensing. Current shunt resistors are low resistance precision resistors used to measure AC or DC electrical currents by the voltage drop those currents create across the resistance.The current passing through the current sensor is fed to precision rectifier.

3.2.2Precision Rectifier

A normal diode rectifier can't rectify voltage less than 0.6 V. So a precision rectifier has been used to rectify the signal of very smallamplitude, say 0.1 V.

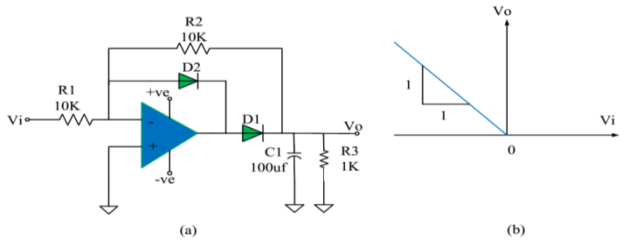

Fig.4: (a) An improved version of the precision half-wave rectifierand (b) The transfer characteristic for R_1=R_2[7].

3.2.3 Receiverand Display Unit

This unit consists of PIC16F877A microcontroller and aLCD monitor. This microcontroller converts the current sensed by the current sensor from analog signal to digital signal(ADC).It performs the calculations mentioned above with the combinations of received signal from the server unit. This microcontroller also sends the data to display time-slot, tariff-rate, consuming load and bill on the LCD monitor.

3.2.4 Keypad Interfacing

A 4×3 keypad is interfaced to this microcontroller as input device which is used to check daily, monthly bill that to be paid and yearly bill that was paid to supply company.

Fig.5: Keypad interfaced with microcontroller

3.3 Circuit Diagram

The circuit diagram of the system is drawn by using Microsoft Office 2010 Visio. The circuit diagram ofserver unit shown in Fig.6. Microcontroller is fed by regulated 5 V to keep it in operation. Here, the output port, RC6 has been used for serial transmission with consumer unit or energy meter. RB3, RB4, RB5, RB6 ports are used to send data to LCD monitor for displaying time-slot and tariff-rate. These data are transmitted to energy meter simultaneously. In consumer unit, supply power is fed to load. Then load current is sensed by shunt resistor current sensor. Figure 7 shows the circuit diagram of consumer unit. The output signal of current sensor is rectified by precision rectifier. This rectified signal is to PIC16F877A microcontroller through input port, RA0. This microcontroller performs analog to digital conversion of this rectified signal. Microcontroller performs mathematical operation for load, bill and other required calculation with the combination of received data transmitted by server unit. A keypad is connected to this microcontroller through RD0, RD1, RD2, RD3, RD4, RD5, RD6 output ports. Keypad is used to check daily bill that to be paid, monthly, yearly bill that was paid by consumer to utility company and further analysis. Figure 8 shows the combination of server and consumer unit or energy meter through serial communication.

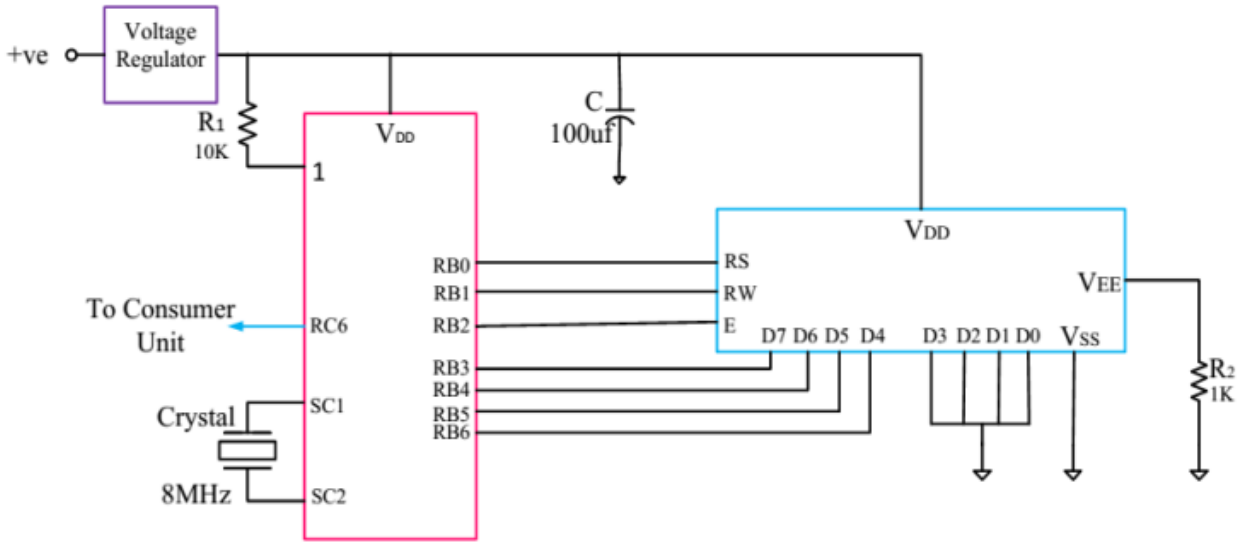

Fig.6: Circuit diagram of server unit.

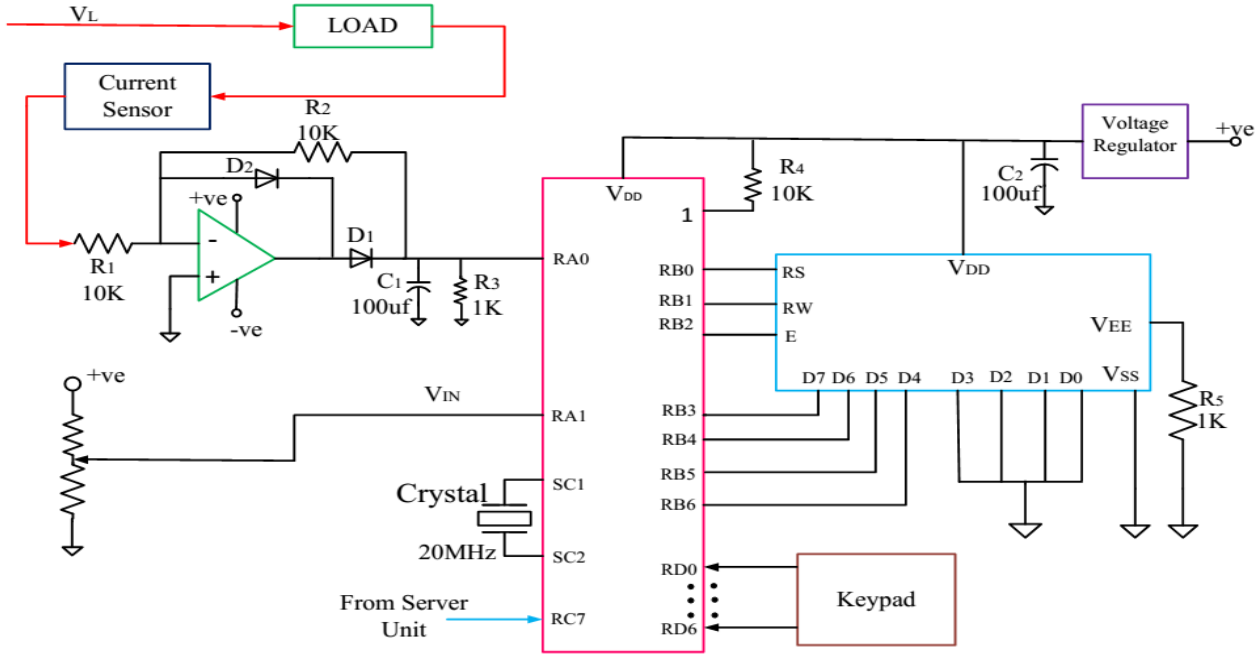

Fig.7: The circuit diagram of consumer unit

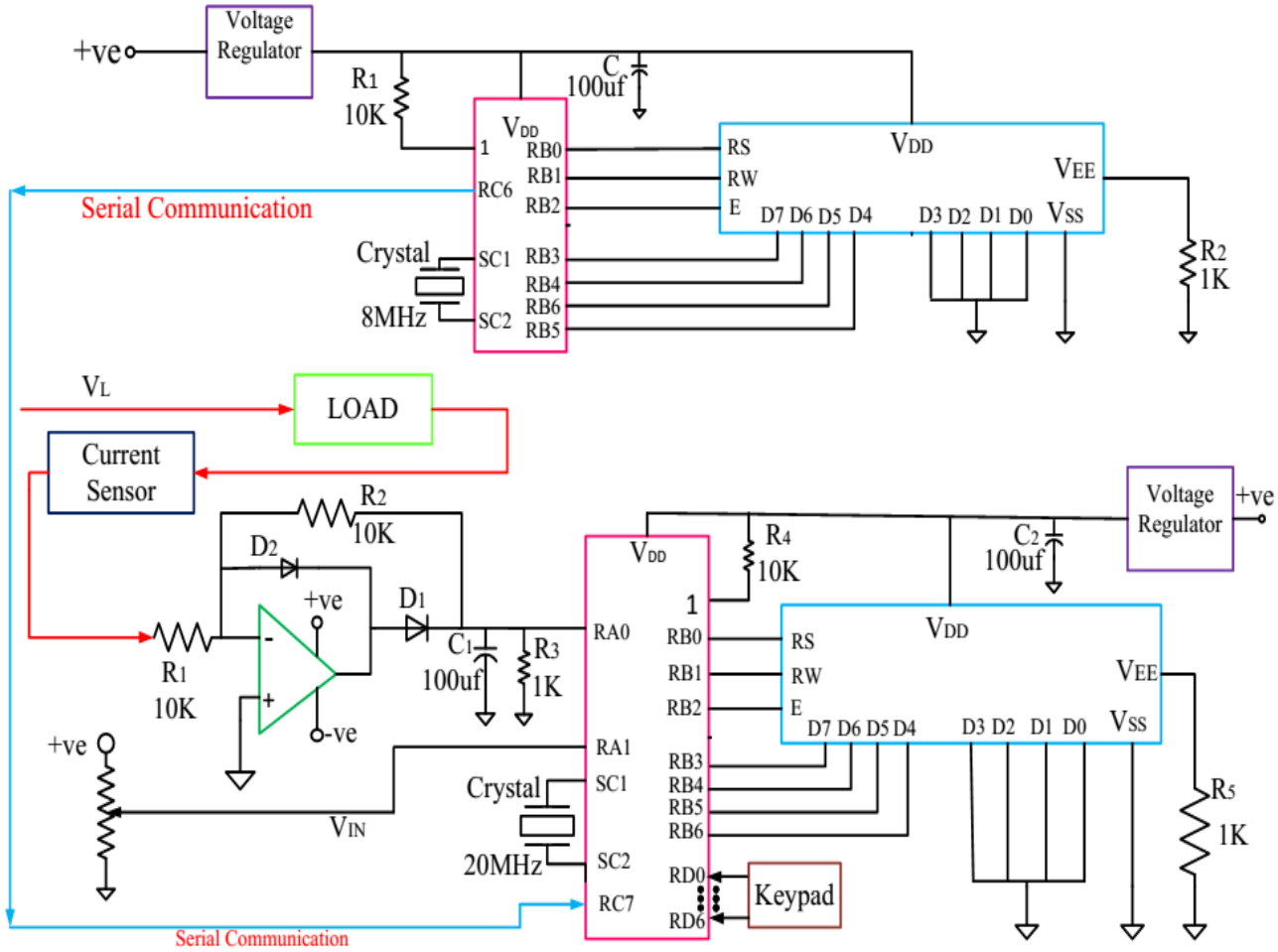

Fig.8: The circuit diagram of complete system

4. SYSTEM FLOW CHART

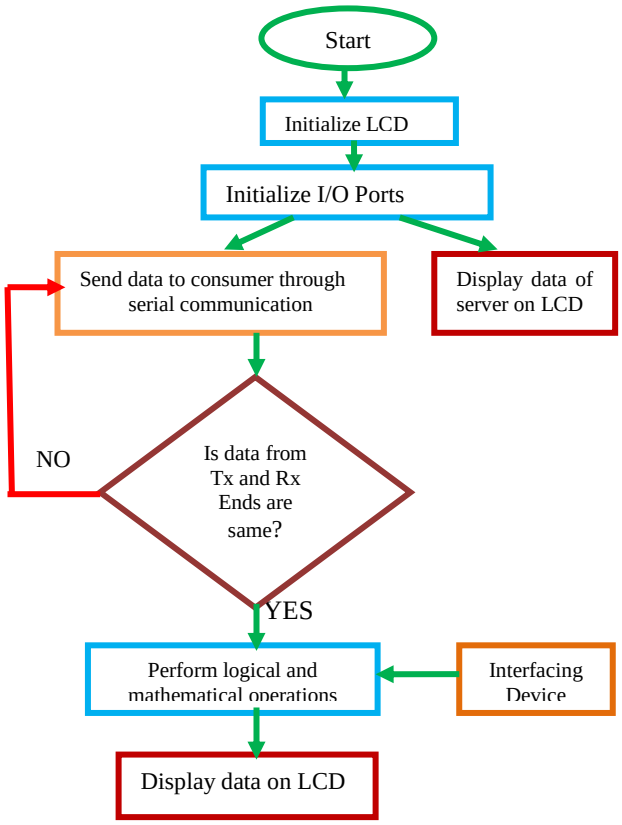

Fig.9: Flowchart of the system

The flowchart of the system is shown in Fig.9. The system is started by initializing the LCD and input/output ports of the microcontroller. The required data of server unit are displayed on LCD and sent to consumer unit through serial communication. The receiver of consumer unit then checks whether the data from the transmitting and receiving end are same. If the data is not same, the data is sent again. If the data is same, then the received data at remote end is displayed on the LCD.

5. CIRCUIT IMPLEMENTATION

The implemented circuits are shown in Fig.10, 11 and 12. Figure 10 shows the server unit which consists of PIC16F73, LCD monitor, crystal oscillator, capacitor, variable resistor and push buttons. Here, variable resistor is used for contrasting LCD monitor.LCD monitor displays the data that are to be transmitted to receiver or consumer unit. Figure 11 shows the consumer unit which is consists of loads, shunt resistor current sensor, precision rectifier, dual power supply, PIC16F877A microcontroller, LCD monitor and interfaced keypad. Here, LCD monitor displays the expected data of consumer unit or energy meter. The interfaced keypad is used to check bill and further analysis. Figure 12 shows the implemented complete system. The complete system is a combination of two main units performing serial communication between them, power supply, transformer and switch box. The total implementation cost of this system is 2500 BDT.

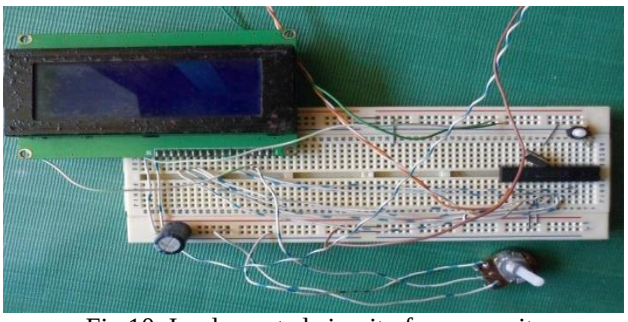

Fig.10: Implemented circuit of server unit

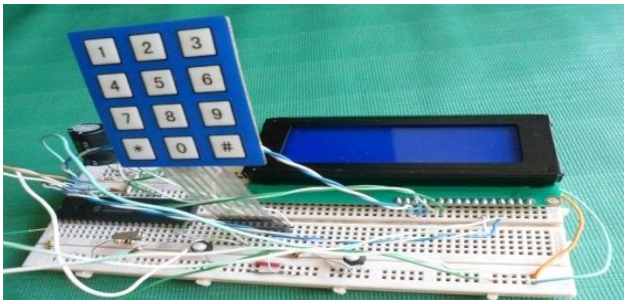

Fig.11: Implemented circuit of consumer unit

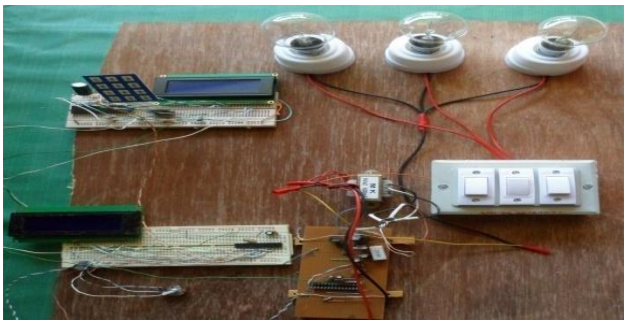

Fig.12: Implemented circuit of complete system

Server unit displaystime-slot and tariff–rateand transmits these data to consumer unit.Figure 13 shows SLOT: PEAK and TARRIF: 10TK/UNIT. Consumer unit or energy meter displays i) SLOT: PEAK and ii) TARIFF: 5TK/UNIT simultaneously with server unit display, iii) Day-7, iv) LOAD: 100W, v) BILL: 7.30TK shown in Fig.14. Interfacing keypad is used to check bill and further analysis. Figure 15 shows that an individual day can be selected to check the bill that to be paid to utility company using keypad. Figure 16 shows the total bill of an individual day that to be paid to utility company. Figure 17 shows the total bill of an individual month that to be paid to utility company at the end of the month.

Fig.13:Output showing server unit data

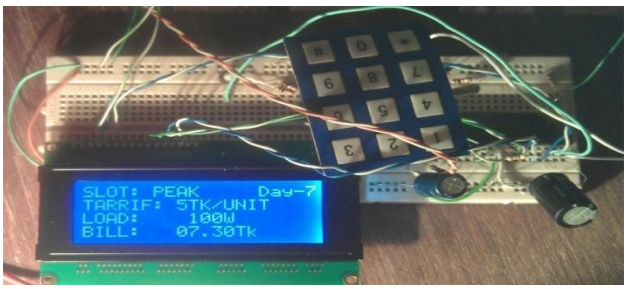

Fig.14: output showing consumer unit data

Fig.15: Output showing day selection using keypad

Fig.16: Output showing bill of the individual day using keypad

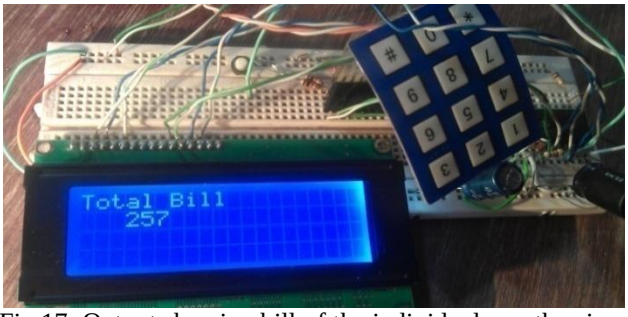

Fig.17: Output showing bill of the individual month using keypad

6. LIMITATIONS

1. Serial communication may be interrupted with the breakdown of wire by any kind of faults.
2. The system is not capable of measuring phase angle in case of capacitive and inductive load. So watt reading of this meter may be error prone in case of this load.
3. Only, Simplex transmission technique has been used here.Other techniques may be used also.

7. FUTURE WORKS

1. Implementation of wireless communication betweenserver unit and consumer unit.
2. To design this system for capacitive and inductive load also.
3. USB port can be connected tothe consumer unit formonitoring data byPC.
4. External memory device can be interfacedwithconsumer unit microcontroller for further analysis.
5. The data of output of both server and consumer unit canbe sent to mobile phone by using GSM module orBluetooth module for further analysis.

8. CONCLUSION

This paper represents a multi-tariff billing system. This paper mainly focuses on consumer unit portion or energy meter.Consumer unit responses to the data transmitted by server unitsimultaneously.The data of server unit can be controlled by authority of utility company. Energy meter of this paper is capable to perform advanced operations and displays various advancedfeatures such as i) slot, ii) day, iii) tariff-rate, iv) load and v) bill.A user or a consumer can check their daily, monthly and yearly bill that to be paid to utility company with the help of interfaced keypad. These data can be used for further analysis. Thus, this consumer unit portion or energy meter performs user friendly operations. This system is cost effective. It may prevents billing theft by authority. This system may help creating consumer's awareness of abusing electricity and may result in reduced load shedding largely.

9. REFERENCES

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