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Line Power Control and Distribution using Power Line Communication

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Abstract: **The electric power generation in our country rely primarily on hydro electric generators. The main suppliers of electrical power are government or public sector authorities, but it is a fact that power generation is not up to the mark to meet all power demands which necessitates measures likepower cut,load shedding etc.., to meet the future demand. To avoid complete breakdown of power a new system is introduced by which power to individual consumers could be limited. The main components used are an intelligent embedded system with the most modern AVR controller, a power line communication system and a set of Hall Effect sensors. The core logic behind the project is to monitor the current consumption at peak hours and to activate a breaker when the consumption increases beyond the limit value for that particular consumer. So in this way power consumption could be limited at peak hours and enables the distribution of available power according to the allowed demand**

Index Terms— **PLC, Hall Effect Sensor, Opto-Triac**

I. INTRODUCTION

Since power generation is much lesser than power demand, preventive measures like power cut is often employed. To avoid complete breakdown of power, a new system is introduced by which power to individual consumers could be controlled.The power consumption is continuously monitored & breaker system is activated to control the power consumption.The available power is effectively distributed according to the demand. [3] Power line communication technology is used as the medium of communication between the consumer and the power provider. This in turn simplifies energy monitoring and implements power consumption control. The main components used are AVR controller, a power line communication module and a set of Hall Effect sensors. One of the major issues faced by any power distribution system is the large variations in power consumption over time. i.e. the difference between power demand at the peak and off-peak hours is too high that it has a detrimental effect on power generation systems.

This system that is being introduced enables real time monitoring of power consumption pattern of individual consumers. Also controlling of power at any required time of the day could be established effectively. This in turn eliminates the need of work personnel for energy meter reading. For effective implementation the substation or generating station from where the power is distributed or generated is considered as the transmitting section and the consumers are considered as receivers.

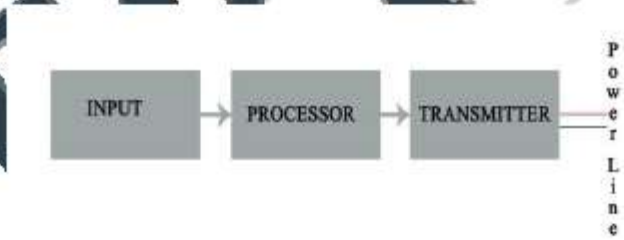

Fig 1. Transmitter Section

I. TRANSMITTER SECTION

The power provider station is considered as the transmitter section. The power limit could be established in automatic as well as manual modes. In the automatic mode the power limit for each consumer is autonomously decided by comparing the available power and power demand. The transmitter section mainly consist of 3 sub units: power limit input, processor, PLC modem as shown in Fig 1.

A. Power limit input

Since the processor automatically calculates the power limit for each consumer from the known values of power, this unit is non-functional in the automatic mode.

A 4x4 matrix keypad is attached to the processor to enter the power limit manually. In case a particular consumer requires an additional power, the address code and power limit for that consumer could be entered in this manner.

B. Processor

In the automatic mode the processor compares the available power and power demand and computes the power limit to each consumer. [4] Whereas in the manual operation the processor just plays the role of an interfacing medium between the keypad and PLC modem.

During energy metering operation, the energy consumed by each costumer is received at the processor unit which further calculates the cost of energy as per tariff and sends it back to the costumer.

C. PLC modem

The PLC (power line communication) modem serves the prime purpose of providing communication between the transmitter and receiver.It has a data transfer rate of 9.6 Kb/s. It transmits the power limit data from transmitter to receiver and also the consumed energy from receiver to transmitter. It also acts as an excellent isolating medium between power line and processor. Prior to transmission, the PLC modem creates 3 replicas of the data to be transmitted which are then transmitted simultaneously for accurate and precise data transmission. [2]

II. RECEIVING SECTION

The receiving module of the power line communication is placed at the consumer premises. It constitutes of a PLC modem, Processing and control unit, Power measuring and control units. The block diagram of the arrangement is as on Fig 2.

A. PLC modem

The data sent from the transmitter section is received by the PLC module at receiver section. [7] Data is transmitted at a rate of 9.6 Kbps which is far more higher compared to the 50Hz of the electric power frequency. Hence the data could be easily distinguished at the receiver section. Data mainly consists of an address code followed by the power corresponding to each address code. Each such code is send as triplets. At the receiving section PLC module compares this address code thrice. If the code is correct for at least twice, then the data is accepted.

Power Measurement Unit

It consist of a Hall Effect current sensor, wave shaping circuit and analog to digital converter. Hall effect current sensor act as a coreless current transformer which measures the total load current and produce a small voltage corresponding to the load current. Wave shaping circuit transforms the output voltage into a rectified DC voltage.ADC obtains the digital value of load current which is further required for power measuring.

a) Current Measurement

Hall Effect current sensor ACS714 is a current sensing element.Hall sensor consists of an electric and magnetic field in orthogonal direction. Associated with this field a 2.5V is present at its output. Whenever load current passes, this field gets affected;consequently the output voltage changes proportionally. Load current passes through a conductor placed nearby the hall sensor. As the distance between this conductor and sensor increases, higher rate of current can be sensed. About 180mV per ampere is the sensitivity of the prescribed sensor.

b) Wave shaping section

Since the load current is AC, the output voltage obtained from the hall sensor is an AC voltage. The processing section could accept only DC inputs. Inorder to tackle this situation the wave shaping circuit is introduced. Basically it is a half wave rectifier which converts AC into rippled DC. The rectified output is again filtered to obtain almost pure DC.

c) Conversion of the voltage to digital data (ADC)

The analogue voltage corresponding to the load current is fed to the analogue to digital converter in the processing unit. The processor ATMEGA 16 has a 10 bit inbuilt ADC which is used for the conversion purpose.

$$x_h = 2.5 + 180I$$

$$I = \frac{x - 2.5}{90 \times 10^{-3}}$$

$$I = \frac{X - 500}{18}$$

Where x is the voltage to the processor, X is the output of ADC, x_h is the hall effect sensor output and I is the load current.

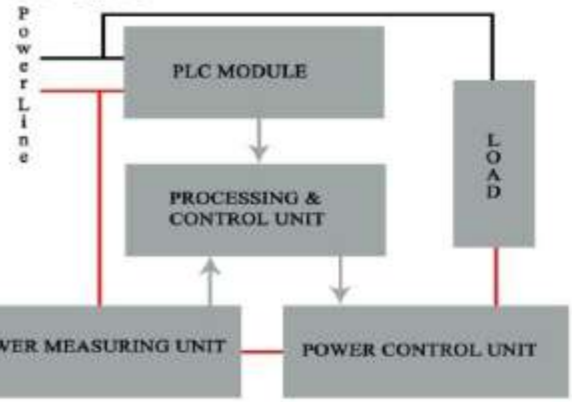

Fig 2. Receiving Section

Processing unit

The entire control of the system lies within the processing and control unit section. ATMEGA16 is an AVR microcontroller used in this unit. This requires a 5V DC supply and 16 MHz clock in order to attain a high speed of 16 MIPS (million instructions per second).

The data from the PLC contains address and data codes for all consumers of a locality but the processor accepts only that data which corresponds to the address code of that particular consumer. The consumed power is then calculated by taking the products of the load current, supply voltage and assumed power factor.

The power limit, current power consumption and cost of utilised energy are actively visualised on a 16x2 LCD display

(HD44780).

Fig 3.Power line flow cycle

d)Power control unit

After comparing the data from the hall sensor with the power limit, the processor will send a signal to the power control unit. Power control unit mainly consists of an opto coupler MOC 3021 and a TRIAC switching unit BT136 as shown in Fig 4.

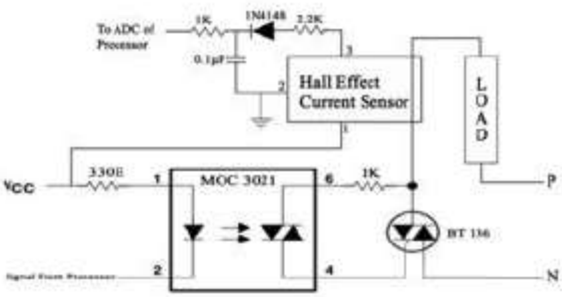

Fig 4.Power handling unit

E. Power switching device

Triac (BT136) is the switching element in the system by means of which power to the consumers are controlled.A *Triac* can be triggered into conduction by both positive and negative voltages applied to its Anode and with both positive and negative trigger pulses applied to its Gate terminal making it a two-quadrant switching Gate controlled device. A Triac behaves just like two conventional thyristors connected together in inverse parallel (back-to-back) with respect to each other and because of this arrangement the two thyristors share a common Gate terminal all within a single three-terminal package. It consists of three terminals namely MT_1, for *Main Terminal 1* and MT_2 for *Main Terminal 2* with the Gate terminal G. The entire power flow cycle is as shown Fig 3.

III. Energy metering

One of the greatest advantages of this device is that no extra personnel are required for energy meter reading. The processor continuously monitors the consumed power of each customer. It also automatically integrates the power consumption for each second and stores in memory. At the event of meter reading, a signal is send from the transmitter to receiver. Once it is received the processor replies back with the energy stored in memory. The processor at the transmitting station calculates the cost for this energy using the present tariff and sends it back to the consumer where it is displayed on the LCD screen.

This enables the tariff to be flexible corresponding to the variation in energy usage over time. i.e, the cost of energy at peak hours could be made higher than off-peak hours which urge the consumers to use lesser energy at the peak hours thereby bridging the wide gap between peak and off-peak energy consumptions. This in turn would reduce the overburden on generating stations and remarkably reduce the shortage of power.

CONCLUSION

In this paper we have discussed the control of power consumption according to it's generation .Today we are facing power cut due to the uncontrolled consumption of power.This paper proposes the automation of power control of individual consumers based on a microcontroller based system.This paper has basically a controlling section and a breaking section.Whenever the consumer consumes a power greater than the allotted power then a breaker system will get activated and hence trips the supply .Continous monitoring of current is made possible through a set of hall effect sensors.In the proposed system along with the power control energy metering is also made possible .Hence the supplier can see how much energy is consumed by each of the consumer.The data communication between the transmitter and the receiver is through power line communication .Through this automatic line power control we can solve the existing power shortage as well as the power cut.

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