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AUTOMATED POWER CONTROL AND DISTRIBUTION USING POWER LINE COMMUNICATION

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Abstract

The consumption of electric power is increasing day by day without any control. But it is a fact that power generation is not up to the mark to meet all power demands which necessitates measures like power 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 that helps the suppliers for controlling and distributing the generated power. The proposed system is fully automated and the main components used for the implementation of the system 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

KEYWORDS*:* PLC, Hall Effect, Opto-Triac

INTRODUCTION

To make the optimum utilization of generated power, it is necessary to control its distribution. To avoid complete breakdown of power, a new system is introduced by which power to individual consumers could be controlled. Hence we can avoid the power cut existing in our country. In this system the power consumption is continuously monitored with the help of Hall Effect sensors & breaker system is activated to control the power consumption by a TRIAC arrangement. The available power is effectively distributed according to the demand [3]. PLC (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 major issues faced by any power distribution system are 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.

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. Under circumstances where extra power is required, the power limit could be extended in manual mode. The transmitter section mainly consists of three sub units: power limit input, processor, PLC modem as shown in Fig.1.

Power 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.

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

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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.

PLC module

The PLC 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].

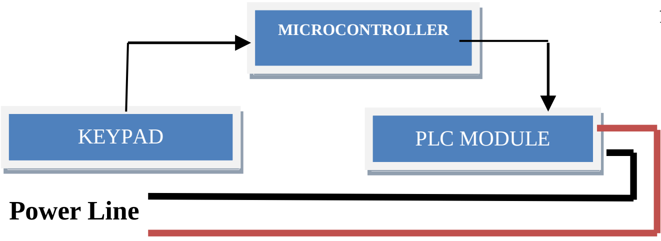

Fig 1. Supplier section

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.

PLC module

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. The entire power flow is shown in fig.3.

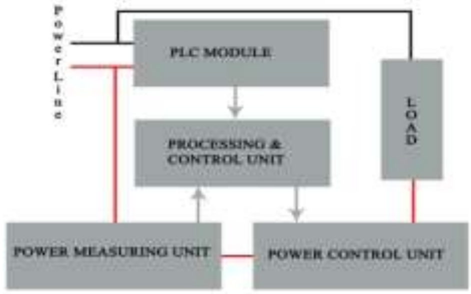

Fig 2. Receiving section

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.

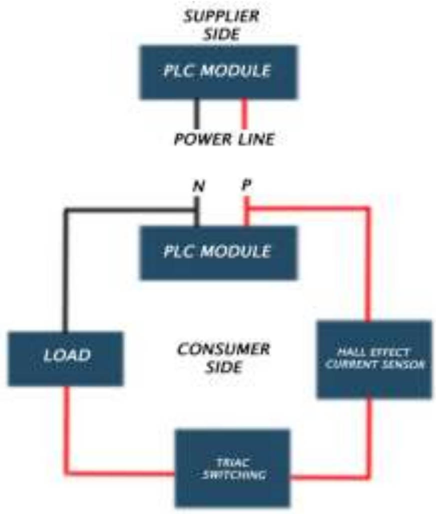

Fig 3. Power flow cycle

Measurement of current

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 [8]. 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.

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About 180mV per ampere is the sensitivity of the prescribed sensor.

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.

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.

$$x_h = 2.5 + 180I \quad (1)$$

$$I = \frac{x - 2.5}{90 \times 10^{-3}} \quad (2)$$

$$I = \frac{X - 500}{18} \quad (3)$$

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.

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) [9].

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 optocoupler MOC 3021 and a TRIAC switching unit BT136 as shown in Fig 4.

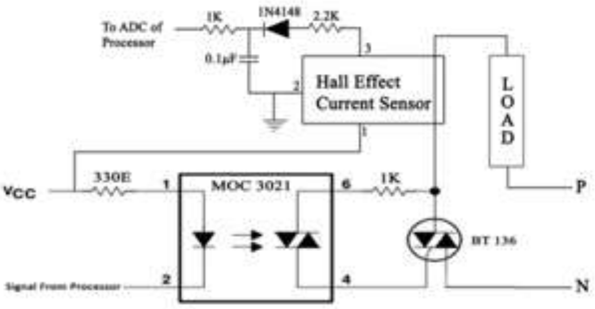

Fig 4.Power control unit

Optocoupler

MOC3021 is an optocoupler that transfers electrical signals between two isolated circuits by using light. Opto-isolators prevent high voltages from affecting the system that receives the signal. Commercially available opto-isolators withstand input-to-output voltages up to 10 kV and voltage transients with speeds up to 10 kV/μs.An opto-isolator contains a source (emitter) of light, almost always a near infrared light-emitting diode (LED), that converts electrical input signal into light, a closed optical channel (also called dielectrical channel), and a photo sensor, which detects incoming light and either generates electric energy directly, or modulates electric current flowing from an external power supply. opto-isolator can transfer light signal but not electrical signal . The sensor could be a photo resistor, photodiode, phototransistor, a silicon-controlled rectifier (SCR) or a photodiac. MOC3021 contains an LED with a photodiac.

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 program flow chart is as shown Fig 5.

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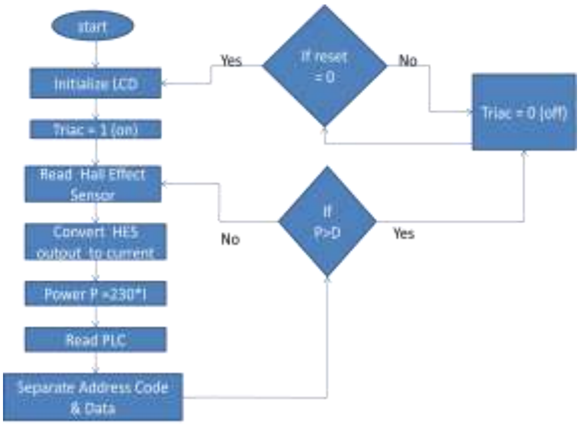

Fig 5.Program Flow chart

AUTOMATIC ENERGY METERING

One of the greatest advantages of this device is that no extra personnel are required for energy meter reading. [10] 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.

FUTURE ADVANCEMENTS

Incorporation of certain modifications can enable this device to be used as a complete power monitoring and control device. For instance, if this is to be installed on electric poles from where service mains are connected to consumers, it could be used to prevent power theft. [1] The difference between the incoming and outgoing currents at the poles is an indication that power theft has occurred. If each electric pole is provided with a specific address code in a manner quite similar to that of consumers, the generating station / substation (where the transmitter is installed) could instantaneously be informed about the theft and also the pole/point at which it has occurred [6].

Advanced customer management systems like e-billing can easily implemented with the installation of this device. Apart from displaying the energy cost directly to the consumer it could also be informed through the internet and a provision to pay these bills online could be established as well.

EXPERIMENTAL RESULT

Since it is necessary to establish the functionality of this device, an experimental setup was carried out as follows:

The receiving section was installed at two domestic power consumers. A far end location common to both consumers was chosen as the transmitting section from where the power is to be controlled. The power to be limited is entered manually at this section which contains the address code and power data for each consumer. On receiving this data the processor at both consumers accepts those corresponding to their address code and sets the power limit by displaying it on the LCD screen. Once the limit had been administered successfully the power switching unit tripped the power supply off as the consumption exceeded the limit. The consumer then has to adjust the load so as to confine within the limit and reset the device so that he can resume the power utilization.

	Address code	Connected load (W)	Power limit (%)	Cut-off power (W)
Consumer 1	0	4200	70	2940
Consumer 2	1	3800	70	2660

Table 1. Power control data

CONCLUSION

Here we have discussed the automated control and distribution of electric power according to its generation. Today we are facing power cut due to the uncontrolled consumption of power. This system proposes the automation of power control using a microcontroller based system. The system has basically a power measuring section and a controlling section. Whenever the consumer consumes a power greater than the allotted power then a breaker system will get activated and trips the supply, hence the power to each of the

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consumer is controlled .Continuous monitoring of current is made possible through a set of hall effect sensors. The information from supplier's side is transmitted to receiver section through the power line communication system. In the proposed system along with the power control, automatic energy metering is also made possible. Hence the supplier can see how much energy is consumed by each of the consumer. The data transmissions between the transmitter and receiver are made possible through the power line cables. The system proposes equal sharing of generated power and completely avoids the power cut.

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