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Non-Intrusive Appliance Load Monitoring System Using Zigbee Protocol

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***Abstract*— the paper discusses about the technology of non-intrusive appliance load monitoring. In this method we try to reduce the power consumption as much as possible by monitoring various loads. The level of the power consumption is set to a threshold level above which power consumption of the system is forbidden. This helps in keeping the power consumption of a non-intrusive system to an optimum level. Zigbee protocol is used as communication protocol to monitor the different ratings such as current, voltage of the system. The receiver side of the zigbee is connected to a PC in which user interface is used as VB(visual basic). The relays are used as switches for the loads that control the switching of the loads.**

***Index Terms*— maximum demand, zigbee, power consumption**

I. INTRODUCTION

The NIALM(Non-Intrusive Appliance Load Monitoring System) has caught a lot of attention because of its energy efficiency. In the days where carbon foot printing is a major problem therefore limiting the consumption of the power is very important. In recent analysis it is stated that power consumption of the United States is over 200 billion kWh. This produces the need of a smart system which can control the power consumption. This system manages to control the loads efficiently based on their maximum demand. The industries have the maximum amount of power consumption that causes major power shortage problems. The problem of load shedding is also a major problem caused by the industrial power consumption. Therefore energy conservation has become a crucial factor in developing globalisation. Therefore this paper emphasises on controlling the maximum demand. Maximum demand is set according to the power consumption of the system. By setting this maximum we can design the system with thus as threshold power consumption limit. The features of maximum demand controller are given as:

- Better Utilization of available Power
- Avoid Penalty, Disconnection
- Improved Load Factor
- True RMS measurement
- Auto scaling from kVA to MVA
- Predictive control method adopted
- to optimize demand control
- Field programmable CT & PT ratios
- Demand profile generation for
- setting realistic demand targets
- Records 5 peak demands with date & time
- Time of the day (TOD) facility
- Integration time selectable : 15/30 minutes
- RS485 communication interface to PC (optional)
- 3 Control outputs for better control

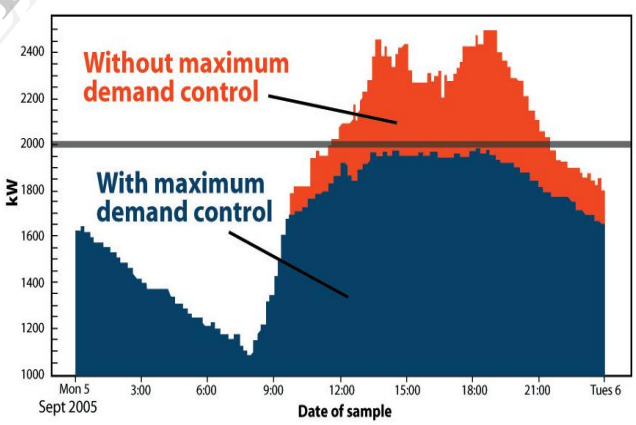

Fig 1.Graph showing maximum demand control

From the above graph we can see that when maximum demand is not set then the power consumption can exceed the limit of power consumption. This causes penalties sometimes by the electric companies. Some spikes can appear when maximum demand is not set.

When maximum demand is set then the power consumption is normalized. The spikes appearing are cut off because of this method. But the demand charges can be lowered in following conditions:

- The energy consumption rate has fluctuations or power peaks during the billing period.
- Some significant loads can be temporarily shed at peak demand times.
- The time to shed and restore loads is known.

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Thus by controlling maximum demand we get two major benefits:

- Released electrical system capacity
- Reduced operating costs.

II. ACQUISITION OF LOAD RATINGS

A. *Voltage and current ratings*

A potential transformer is used for acquisition of voltage ratings of the load in this system. A potential transformer is connected in parallel to all the loads which then calculated the total load voltage. The output of the potential is given to controller through a bridge rectifier which converts ac to dc.

For the calculation of the current ratings a current transformer is used. It is connected in series of the loads and calculates the total current flowing through the loads. For current transformer we have to use precision rectifier for converting ac to dc because the output of current transformer is in mV. The diodes have the threshold voltage of 0.7 volts thus bridge rectifier cannot be used in current transformer.

B. *Evaluation of the load profile*

After calculating the current and power ratings calculate the power consumption by the formula:

P = VI

The load factor is also calculated by the following formula:

$$LF = [E/@ \text{ x } 24 \text{ hr/day x } N)] \text{ x } 100\%$$

Where: LF = load factor (%)

E = energy use (kWh)

D = maximum demand (kW)

N = number of days in billing period

C. *Operations on load*

After the evaluation of the load we have to set the priorities for the loads. It is important to know that which loads can be controlled and which loads are important for the operation of process of manufacturing. Some of the controllable loads are given as follows:

- Storage water heating
- Slab heating
- Storage room heating
- Ventilation air heating
- Space heating
- Air conditioners
- Industrial vehicle battery
- Air compressors
- Process grinders
- Dehumidification kilns
- Refrigeration motors
- Electric process furnaces
- Pumps

The loads then are given the priority after deciding is they are controllable. The loads which are most important are given the highest priority so that they are last ones to be switched off. Here are some points to be considered for setting the priority to the load:

- Which loads can be shed?
- Which loads are off first?
- How long can each load be off?
- Which loads can be operated at reduced power/speed?
- Which loads cannot be shed no matter what the demand?

III. WORKING

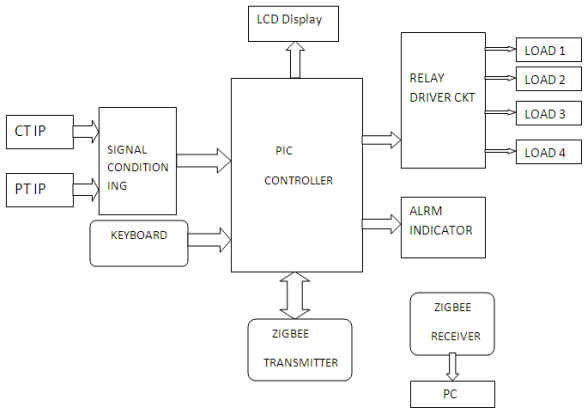

Fig 1. Block diagram

A. *Block diagram*

The main operation of our project is switching of the loads. Hence we have used relays for the switching of the loads. CT and PT are used to take input from the loads. In signal conditioning we use bridge rectifier for PT and precision rectifier for CT. LCD is used to display the following values:

- Load voltage
- Load current
- Set threshold value
- Total power consumption

In the monitoring side zigbee module is used for monitoring with visual basic as GUI. Zigbee used is of the range 100 meters. The zigbee pro can also be used which has a range up to 1000 meters.

B. *Switching of loads*

The main operation of the project is the switching part. The switching of the loads is done when the power consumption exceeds the threshold value. The system is given a certain delay after it checks the load ratings. There are two conditions that can happen:

- If the power consumption is below the threshold value then it does nothing and continues the operation
- If the power consumption is above the threshold value then it switches off the load with least priority. If further the power consumption is above the threshold then again turn off the load with least priority. Continue this operation until the power consumption is below set value.

In the switching of loads the load with high priorities should always be on. Therefore while setting the maximum power consumption this factor should be taken into

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consideration and threshold value should not be set to low so that the operation must be interrupted.

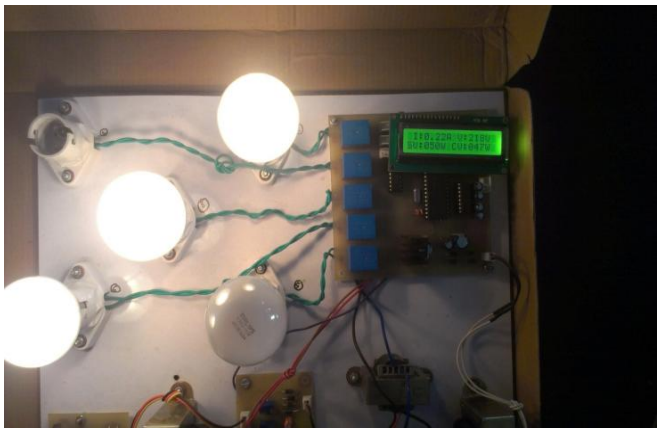

Fig 2. Swtiching off of the least priority load

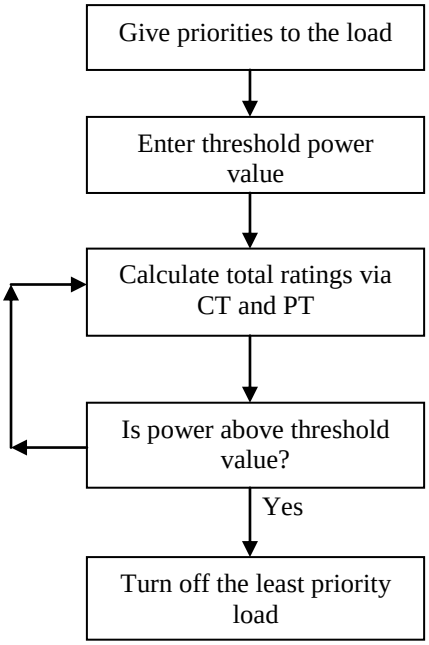

Fig 3. Flowchart of the operation

C. *Monitoring*

The part of the monitoring involves the visual basic side of the operation. The zigbee module is used for the transmission of the diff ratings of the load. Visual basic is used to monitor all the load ratings like load voltage, load current, load power, set power.

The visual basic GUI is controlled by zigbee. If the input set value is to be changed then it can be changed from VB. The setting is sent to the system. The LCD then changes the settings of its display and displays a new value. Then again new values of the load ratings can be seen on the GUI of the VB.

The zigbee module used has range of about 100 meters so it can monitor the system within 100 meter radius. Thus, in monitoring we can monitor and control all the load ratings. If the setting is to be changed it can be changed through VB also.

IV. CONCLUSION

Maximum demand controller monitors the demand of the plant and compares it to a set maximum value. Non-essential loads can be switched off automatically when the actual demand exceeds the set point. The demand charge reflects the peak rate at which electrical energy is consumed and is higher when there is more electrical equipment running. Electric utilities must have sufficient capacity to serve the instantaneous demand of all customers at any time; therefore, electricity charges are based on maximum plus the total electrical energy consumed.

V. FUTURE SCOPE

If we introduce 3g into this system then any we can access the data of the load ratings from anywhere. By using internet connectivity we can store the data of load ratings. If a person has internet connection then he can monitor the ratings from anywhere with internet.

This system can also be used as event recording. The various power fluctuations can be recorded.

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