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Design and Implementation of Intelligent Energy Monitoring System for Industrial Machines

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Abstract: In the present era, electrical energy required is increasing drastically, we rather than focusing on producing more energy it is required to manage the energy consumption. Country growth in present era is depending on Industries. As to manage the energy that is consumed for many Industrial Machineries it is required to be monitored and balanced, such that an effective and efficient way of consumption of energy can be obtained. So there is necessary to know the details of energy consumed for Machines, when they are in working state and it is also required to control and operate from the remote location, as such the energy consumption can be managed. After understanding the necessity, we proposed an intelligent energy monitoring system using ARM7 to control the Machineries from remote location. This system provides graphical user interface to interact and also display the energy being consumed in graphical form.

Index Terms: Intelligent energy monitoring unit, LPC2148 Microcontroller, Relays, Energy Meter, Zigbee, JAVA frontend application.

I. INTRODUCTION

In earlier era, Machineries are directly connected from external energy utility through distributed energy meter. In that case we don't have any chance to manage and controlling of machine [1]. And also operator doesn't know how much energy consuming in different machineries and which machine can consume high energy compare to other devices. Especially when we use sequence of producing materials one after the other to produce the finished products, there the monitoring of energy is to be maintained such that the efficiency of the energy consumed can be managed. Mostly the industries usually comes across problems with electrical energy bills, as such they use huge machineries to produce the product by considering this necessity to manage the energy efficiently and to reduce the consumption of the energy by the machines, we designed an Intelligent energy monitoring system which monitors and balances the energy that is required. With this proposed system the monitoring and controlling of the machines can be done more effectively and also reduces the electrical bills for the Industrialists and this automatically replicates to the cost of manufacturing and the product rate being produced is also be reduced, [2] [3]. This machine control can collect power consumption data from Machines, and it executes native control based on command signals, which can give to intelligent energy monitoring unit. Here we will arrange a gateway that is a smart meter; it can be providing an interface between a utility and machine operator, [6] [7]. In that gateway collects a Control Response signal from a utility, which is used as an input for our intelligent energy monitoring unit. Here the maintenance engineer can operate intelligent energy monitoring system by wireless communication through zigbee and using ARM 7 processor. In this intelligent energy monitoring system design there are two sections, control section and monitoring section. In control section design, energy meter, opt coupler, relays, ARM7 processor are interconnected. In monitoring section, the user gets the information through wireless communication using zigbee and RS232 interconnection connected to personal computer or any other operating device. The detailed system design is explained in other sections.

II. PROPOSED MODEL OF IEM SYSTEM

In Block diagram of intelligent energy monitoring System is shown in figure 1. The intelligent energy monitoring system can perform mainly in two modes

- IEM Unit Mode
- Monitoring Mode

A. Intelligent energy monitoring unit Mode:

The intelligent energy monitoring unit designed to perform on three modes

- Data Collecting and Processing Mode
- Control mode
- Communication mode

1. Data Collecting and Processing Mode

In this data collecting processing mode power consumption data can be collect from individual machines. This data can be processed based on command signals which can sent by the microcontroller.

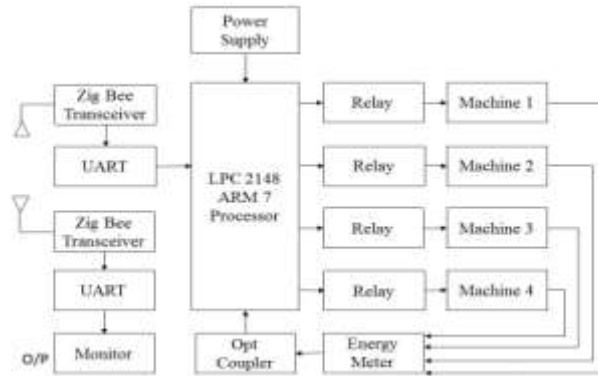


Fig. 1: Block diagram of proposed IEM system

2. *Control Mode*

In this control mode which can be designed as a simple relay circuit, this relay circuit works like a switch. By using this relay circuit we can operate machines as ON/OFF.

3. *Communication mode*

A communication mode will provide the communication path between the intelligent energy monitoring unit and machine controllers. In this mode, the intelligent energy monitoring unit sends command signals to all machine controllers and receives response command signals from machine controllers. In this intelligent energy monitoring unit demonstration, we will use a laptop with ZigBee-enabled communication.

B. Monitoring Module:

In this monitoring module, the workflow of the mode is based on a Java front-end application. By using this Java front-end application, we develop monitoring and control functionalities. Here, a laptop which includes a control Response algorithm that can serve the main role in the intelligent energy monitoring system. It has control functionalities for selected machines by the command signals. Here, it can collect electrical consumption data from all machine controllers. Here, industrial owner machine priority, performance settings, interface to retrieve machine status and review their energy consumption, all of these operations can be made by here only. In graphical user interface, it can be designed by a Java front-end application. In this front-end application, we can provide two panels. One is a sender panel and another one is a receiver panel. In the sender panel, total number of units, individual power consumption data in Watts, and ON/OFF buttons for each and every machine will be displayed.

III. HARDWARE DESIGN OF INTELLIGENT ENERGY MONITORING SYSTEM:

Intelligent energy monitoring systems have several components with an ARM processor, they are ZigBee module, smart meter, energy supply, machine controllers, and LCD display. The intelligent energy monitoring system comprises an intelligent energy monitoring unit that delivers monitoring and control functionalities to the industrial owner. *Machine controllers* collect power consumption data from particular machines and implement a native controller based on command signals from the intelligent energy monitoring system. A gateway, such as a smart meter, can be used to deliver an interface between a utility and the database for the electrical consumption. It is also maintained through the internet [8], [9]. So, by using the intelligent energy monitoring system, the industrial owner will be able to manage and control machines directly, and he will know how much energy consumption is in each machine and which machine can consume high energy compared to other machines.

A. Industrial Section:

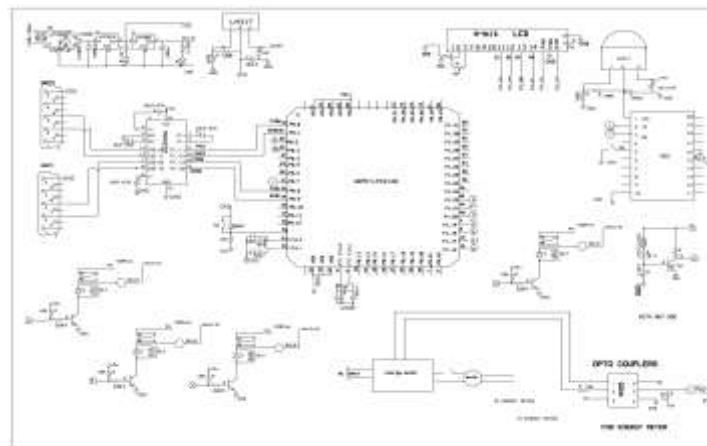


Fig. 2: Prototype Schematic diagram of IEM unit

In the section the design of the mode is specified with ARM processor, Zigbee, Relays, energy meter, LCD display and other respective components are used. The schematic design of the section and respective circuit connections is specified below,

B. Monitoring Section:

In this section design of mode specified with Zig Bee, MAX232, UART and Personal Computer. The schematic design of the monitoring section and respective circuit connections is specified below.

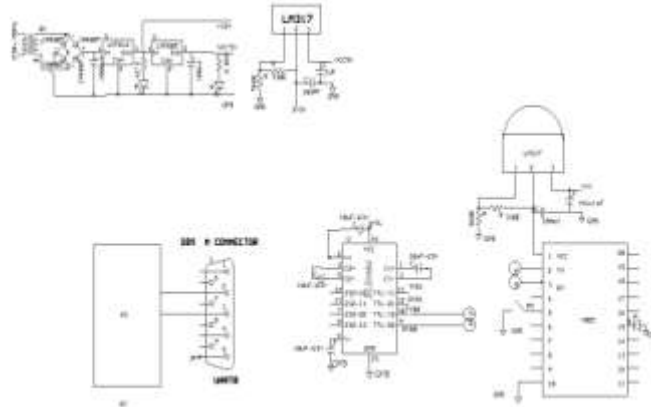


Fig. 3: Schematic diagram of MS unit

C. ARM7 Microcontroller:

In our research, we are using LPC2148 microcontroller that is nothing but an ARM 7 microcontroller why because this LPC2148 can consume low power, which it works at on board voltage regulator 3.3 voltage with up to 800mA current and single power supply 6v AC or DC required to this microcontroller. LPC2148 microcontroller has power supply LED and power supply filtering capacitor and it is 16/32 bit ARMTDMI-STM with 512k bytes program flash, USB 2.0, 42k bytes RAM, two UARTS, 5V tolerant input output, RTC, 10 bit ADC, one DAC and it has two channel RS232 interface and drivers. Principally Lpc2148 has 45 universally useful info yield pins are accessible. Force sparing modes incorporate sit without moving and shut down, and it has up to nine edge or level touchy outside intrude on pins accessible. Processor wakeup from shut down mode through outer interfere, USB Broun out discover (BOD) or ongoing clock (RTC). In framework of application programming, ISP/IAP through on chip genuine screen programming, and high velocity following of direction execution. So this LPC2148 microcontroller is enough to do this research. In intelligent energy monitoring system, we need enough this microcontroller to do our research work. Here we wrote code in keil software and embedded in to ARM 7 microcontroller and we connected different general purpose input output pins for control each and every machine, LCD display and zigbee commands.

D. Power Supply:

In this proposed system, we obliged working voltage for ARM controller board is 12v. Subsequently the 12v D.C. power supply is required for the ARM board. This directed 12v is produced by venturing down the voltage from 230v to 18v now the step brought down a.c voltage is continuously amended by the Bridge Rectifier utilizing 1n4007 diodes. The redressed a.c voltage is currently sifted utilizing a "C" channel. Presently the corrected, sifted D.C. voltage is nourished to the Voltage Regulator. This voltage controller gives/permits us to have a Regulated consistent Voltage which is of +12v. The controlled voltage is again separated utilizing an electrolytic capacitor 100μf. Presently the yield from this segment is bolstered to microcontroller board to supply working voltage

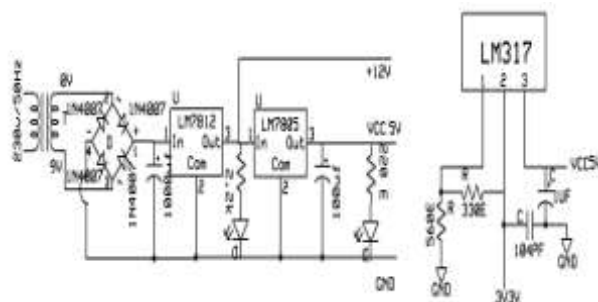


Fig. 4: schematic design of power supply for LPC2148

E. Relays:

In this intelligent energy monitoring unit we are using four current transformers for four machine machines. Here these four current transformers are connecting to relays, these relays are act as a switch between microcontroller and machines.

In intelligent energy monitoring system we are using energy meter for calculating power consumption data i.e. how many units can be consumed in these four machines. So for that four machines are connecting from energy meter. Here we are arranging one more relay to energy meter and this relay is also will connect to microcontroller. So in our research work, we are using five relays.

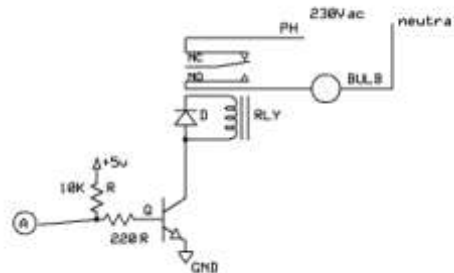


Fig. 5: Design of Relay with machine

F. Energy Meter:

Here from external power utility will connect to main input power supply for energy meter. It works as a gateway between external power supply and industrial machines. In intelligent energy monitoring system energy meter plays a main role, why because here entire four current transformers with four machines are directly connected to energy meter. It can be calculate individual power consumption. Energy meter can be connect to opt coupler, this opt coupler will works as data transmitter from energy meter to micro controller. Here individual energy consumption data can be sent to opt coupler. This opt coupler will connect to GPIO pin. Finally individual power consumption data can be sent from energy meter to opt coupler. This opt coupler will sent a data to microcontroller. But this power consumption data is in analog format, so we want to convert this analog data to digital data.

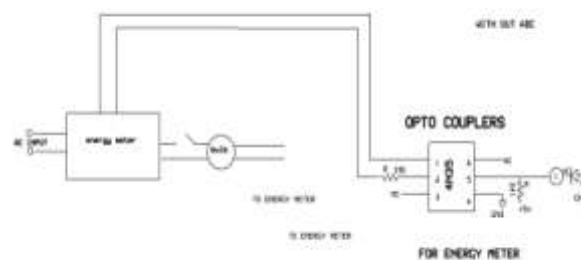


Fig. 6: Schematic Design of Energy meter

G. Zigbee:

In intelligent energy monitoring system we are using two zigbee modes for communication purpose. One zigbee can be arranged to microcontroller and another zigbee can be arranged to personal computer board (PCB). By using USB to Serial communication data bus the data can be transfer to personal computer. When industrial owner sends commands from personal computer, these command signals are through personal computer board zigbee to another zigbee which is attached with microcontroller .Suppose industrial owner can be send a command from graphical user interface in personal computer ON and OFF buttons, machines can be activated based on commands. In intelligent energy monitoring system can provide machine status updated in every five seconds, this data can be shown to industrial owner in every five seconds in graphical user interface receiver panel. So this entire data can be transfer through zigbee.

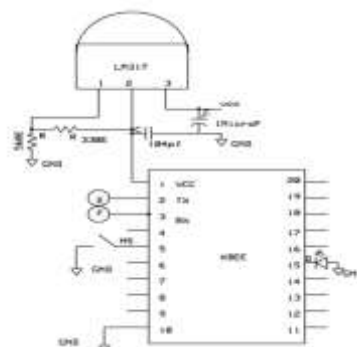


Fig. 7: Circuit design of Zigbee mode connected

H. Java frontend application:

Intelligent energy monitoring systems have a graphical user interface for user interaction. So for that we developed java frontend application for industrial owner. Here industrial owner will be operating from personal computer. In java frontend application we can provide two panels, i.e. sender and receiver panel.

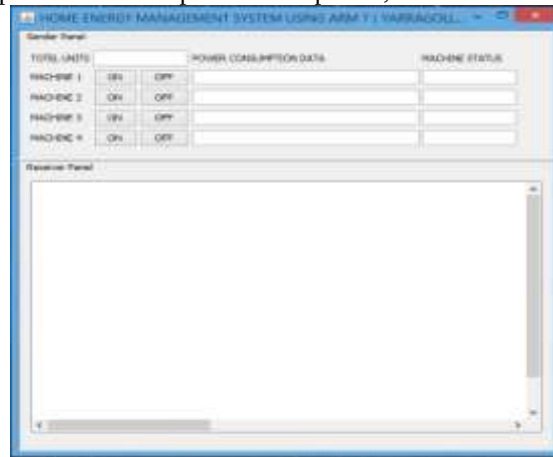


Fig. 8: Front End Graphical Interface of IEM System

In sender panel we provided total power consumption data in units and each and every machine of power consumption data individually. This power consumption data will be updated every five seconds. Here we designed two buttons for the purpose of power ON and OFF to each machine. Machine status also we displayed that when machine is currently ON in frontend application shows machine is ON or when machine is currently OFF then in frontend application shows that machine is OFF. Here when industrial owner click ON button in frontend application then the conformation message will shows to industrial owner like “want you On this machine” and YES or NO buttons, here industrial owner will decide once again. In receiver panel will act as like a hyper terminal i.e. the power consumption data can be display line by line of four machines and total number units can be consumed based on Watts KW. It can also to be update every five seconds, but previous data will not erase. It can be act as a data base i.e. Here we will see the previous data by day to day power consumption data. In above graph shows that daily status and power consumption data in watts, those watts will converts as units that total number of units will also displayed. Here daily status of the each and every machine that can be displayed ADC value of each and every machine in watts. Suppose in Day1 machine 1 can consumed 78 watts power, that power consumption data can be convert to units like one unit formula as shown below.

$$\text{Unit} = W \times H \div 1000$$

Here w = Energy consumption unit (watt)

H = time (hours)

The energy E in kilowatt-hour (kWh) per day equal to the power pin watts (w) times’ number of usage hours per day is divided by 1000 watts per kilowatt. Like this intelligent energy monitoring system can be display units. In this way intelligent energy monitoring system can be shown to industrial owner in graphical way also. When we see in above graph Day1, Day2, Day3, Day4, Day5, Day6 of power consumption data in watts and each and every day how much unit’s consumption data also displayed. Now industrial owner will clearly know how much power can consume daily and which machine can consume high power compare to other machines.

IV. RESULTS

Programming Commands for analog to digital conversion:

A part of code for analog to digital conversion. These are the commands are using for ADC conversion in intelligent energy monitoring system.

```
AD0CR=0X002E0402;
AD0CR|=0x01000000;
MACHINE1=ADC_DAT0();
d[1]=MACHINE1;
lcdcmd(0x8D);
convert0(MACHINE1);
```

Programming Commands for machines ON/OFF:

A part of code for machine ON and OFF conditions are using in intelligent energy monitoring system.

```
if(rec_flg==1)
{
    rec_flg=0;
    i=0;
```

```
if(!strcmp(a,"L1ON*"))    //machine 1 on
{
IOSET0|=machine1;
}
if(!strcmp(a,"L1OFF*"))  //machine 1 off
{
IOCLR0|=machine1;
}
}
```

Result of Control Section in IEM System:

This is the intelligent energy monitoring system hardware design kit. If we observe here we are using five current transformers, first transformer is using for main power supply and remaining four transformers is using for relays to display individual power consumption data.



Fig. 9: Prototype of Control Section in IEM system

This individual power consumption data can be display based on energy meter. By using ARM 7 we programmed to display ADC value for four machines of power consumption data and to control four machines for ON and OFF. Power consumption data can be displayed in Watts. Here we control four machines and will display four machine of power consumption data.

Result of Monitoring Section in IEM System:

This is the personal computer board (PCB), if we see the above figure we arrange a zigbee with MAX 232 and battery for power supply. By using serial communication cable and will attached to USB to serial converter cable. So finally by using personal computer board data can be transferred to personal computer.



Fig. 10: Prototype of MS in IEM System

Results in Graphical user interface application:

This is a final result of intelligent energy monitoring system. If we observe here each every machine of power consumption data can be displayed in current consumption data column. Machine status is nothing but which machine is ON and which machine is OFF currently. Total units is also displaying here in the sender panel. In receiver panel we are providing a graphical format of power consumption data in previous six days.

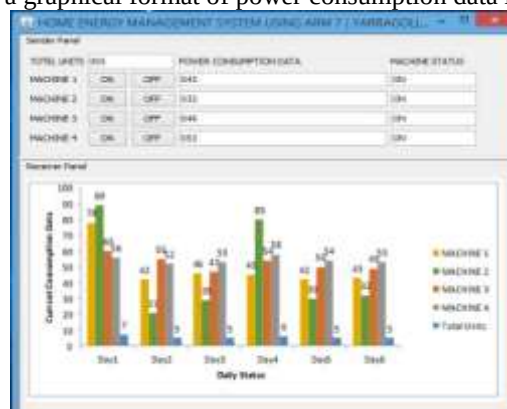


Fig. 11: Graphical Interface with respective results

V. CONCLUSION

In the proposed system, the controlling and monitoring of the machines' is performed from remote location with graphical user interface as a front end panel. The schematic design of the circuits for the prototype of the system is considered to design for four different machines. This system provides the information of the electrical energy being consumed and provides the energy accessibility for the operator to know about the maintenance issues of the machines. This measured electrical estimation provides the analytical analysis to manage the industry and also reduce the machines of maintenance on organization. This system can be utilized in various applications and can reduce the consumption of energy. We believe in reduction in consumption of power rather than concentrating on production of energy by spoiling the natural resources, this research implementation is done by considering this concept as motive.

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