Prepaid Metering System for Smart Grid

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***Abstract*-- A smart grid is the evolution of grid from present electrical grid which focuses on reliability and sustainability of supply along with delivering power in an economic manner, thus it is often referred as the future of electrical system. Every home will be fitted with a smart meter which communicates with the grid computer about the status after specific intervals of time. The power consumption status of every home will be updated in the database. A provision to insert recharge card will be provided in smart meter, once card is inserted it will be recharged and the consumer can consume power until balance is left. When balance falls below a preset value alarm is raised and cautioned. Suppose balance is zero than the isolation circuit will cut off the power supply to the home.**

***Keywords*- Smart grid, Smart meter, Recharge card, Isolation circuit.**

I. INTRODUCTION

To cope up the raising electrical demand in an economical manner also with advantage of reliability and sustainability we go for an advanced grid system called smart grid. In addition to this it improves efficiency, load factor and diversity factor, thus it is often referred as the future of electrical system. By interconnecting using grid we increase the capacity of our power system, the excess power of one area is used by another area in need.

The power demand is increasing day by day; we should ensure the supply is always above demand for stable power to all customers. When it comes to smart grid all the problems are rectified. The overall power system efficiency is improved as all the power system networks are inter connected. The advantage of Smart grid is the load factor and diversity factor of the system are improved and the reserve capacity is decreased as the reserve power of one network is feed to another network in need. Thus the surplus serves the network in need along with improved efficiency and reliability of supply.

The storage of Electrical energy is difficult than the production of Electrical energy, this drawback is rectified by the interconnection of power system networks in the form of grid. Grids provide flexibility in Transmission and Distribution of Electric power. This system by the usage of smart grid monitoring system is converted into a real time system, where any failure or fault is communicated to the concerned authorities on time and the fault is rectified.

Due to ever changing demand it is not always possible to erect new power plants as it is a costly affair, where as smart grid technology is economical. Also if we erect new power plants for changing demands we cannot make sure that we will run all the units at full efficiency where as in case of Smart grid technology efficient operation of units is ensured.

The advancement in technology provides various alternative ways of power Transmission and Distribution, one among them is HVDC System (High-Voltage Direct Current). The Transmission by HVDC has several advantages as compared to HVAC (High-Voltage Alternating Current). Flexible Alternating Current Transmission Systems (FACTS) provide an efficient method for reactive power compensation, Voltage compensation, power factor improvement etc. The real time monitoring and control system used is Supervisory Control and Data Acquisition systems (SCADA) which is highly efficient. Also Wide area monitoring systems (WAMS) monitors the grids and keeps track of all the parameters and takes necessary control and corrective action at real time.

To cope up the raising electrical dema

II. PROPOSED SYSTEM

The proposed system will rectify the drawbacks of the present system. The proposed system performs real time monitoring and control. Power theft will be identified and avoided. In addition to this any faults in distribution side will be identified and rectified; also the breakage of conductors due to bad weather condition will be identified and unformed to concerned authorities.

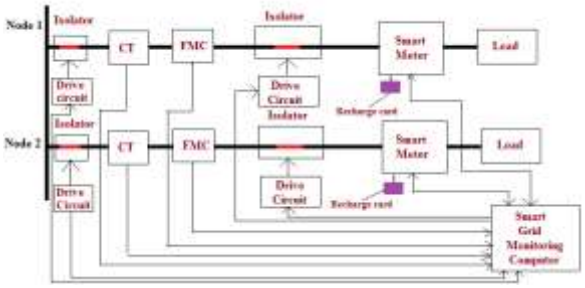

Fig. 1 Block diagram

III HARDWARE DESCRIPTION

A. SMART METER

Smart meter is a meter which is capable of having two way communications and it is a substitute to the meters in use.

Smart meter communicates with the Smart grid monitoring computer in regular intervals of time and updates the status of power consumption, voltage rating, current rating,

frequency and power factor of a particular home in the database in Smart grid monitoring computer.

As the value of current rating per home is known by the smart meter also CT at the distribution transformer of a particular node will know the total current ration of node.

If there is any difference in the reading of CT and the sum of the current ratings mentioned in Smart meter it will be taken as power theft and that particular node will be isolated, the command for isolation will be given by the Smart Grid Monitoring Computer.

B. FUSE MONITORING CIRCUIT

Power supply circuit is used in the hardware prototype to supply power for the IC and the Relays. Transformer primary is feed with 230V AC the output of secondary is 12V AC, by using DB107 IC(bridge rectifier) Ac is converted into DC further by 7812 IC stable 12V DC output is obtained similarly by using 7805 IC 5V DC output is obtained. For filtering ripples from the output of the rectifier IC we use capacitor of 470 µf /25 V.

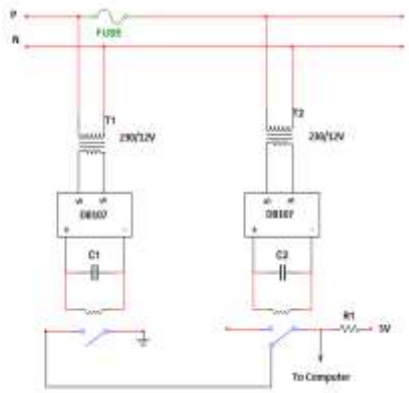

Fig.2

FUSE MONITORING CIRCUIT

C. ANALOG TO DIGITAL CONVERTER CIRCUIT

An analog-to-digital converter converts analog input value into equivalent digital output value. It is abbreviated as ADC.

The IC's used in this conversion process are ADC0809, 555 Timer, 74HC240 and 74HC245. For interfacing circuit consists of two buffers IC's 74HC244.

For the C program feed in the S,art grid monitoring computer to understand the values are converted into digital.

D. POWER THEFT BOARD

Power theft detection board in the hardware prototype is designed for two consumers.

As the value of current rating per home is known by the smart meter also CT at the distribution transformer of a particular node will know the total current ration of node.

If there is any difference in the reading of CT and the sum of the current ratings mentioned in Smart meter it will be taken as power theft and that particular node will be isolated, the command for isolation will be given by the Smart Grid Monitoring Computer.

The terminals of power theft detection board to be connected are,

a) I_T is the total current measured by CT.

b) $I_T(L)$ is given to load from voltage transducer board.

c) The input of Drive circuit of consumer 1 is Iso ckt(1) .

d) The input of Drive circuit of consumer 2 is Iso ckt(2) .

If value of I_T is greater than the sum of Iso ckt(1) and Iso ckt(2) then it is identified as power theft.

E. RELAY AND ISOLATION DRIVE CIRCUIT

The relay circuit is used for isolation that is switching on and off the supply. It is controlled by the Smart Grid Monitoring Computer. Main components of isolation circuit is listed below

- Transistor
- Resistors (2.2 KΩ, 330 Ω)
- Attractive Relay
- Lamp, LED
- Diode, Capacitor (10 µf)

The relay energisation and de-energisation command is issued by the Smart Grid Monitoring Computer. A transistor is placed in the relay drive circuit for switching. An input voltage of sufficient magnitude will turn on the transistor and bring it to saturation state. The diode is a freewheeling element to prevent the induced voltage to drive the transistor.

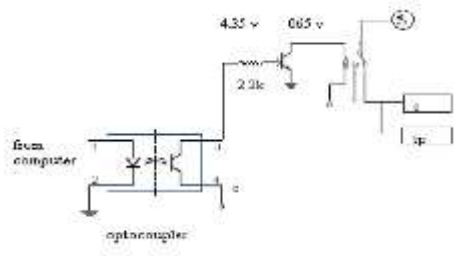

Fig. 3 Relay driver circuit

F. WORKING OF DRIVE CIRCUIT

The input for the drive circuit is given by the Smart Grid monitoring Computer. The input of drive circuit is in binary that is 1or 0.

If the drive circuit receives signal 1 from the Smart Grid monitoring Computer then the drive circuit will isolate the load that is relay will be de-energised.

This isolation happens if the balance is very low and the Smart meter is not yet recharged and also during power theft as an external third party has tried to consume power from the node in which that particular consumer is connected.

When the Smart Grid Monitoring computer sensed any fault the relay is used to isolate the 230V power supply to the load, there by unauthorized usage is avoided.

The relay has one more added advantage when some unfavourable condition is found the relay isolates the faulty portion there by protects the healthy circuit in load side.

G. INTERFACING CARD

74LS244 IC is the interfacing IC, it is used to transfer 8 bit data into serial of 4 bit data's. The input side of the digital data is denoted by A1 to A8 similarly B0 to B8 is the output digital data. The printer port is used for data transfer, the output data B0 to B3 is transferred to PC printer port first by making G1 low and G2 high and then the output data B4 to B7 is transferred next by making G1 high and G2 low.

H. PARALLEL PRINTER PORT

The Parallel Printer Port is present in the Smart Grid Monitoring Computer, it 5 digital inputs accessed and also has 12 digital outputs which are accessed using 3 consecutive 8-bit ports.

- 8 output pins are accessed using the data port.
- The Input pins (one inverted) are accessed by the STATUS Port.
- The 4 output pins (three inverted) accessed using the CONTROL port
- The remaining 8 pins are connected to ground.

The parallel printer port is a specially designed port attached. The data commands from the Smart Grid computer flows through the Printer port cable.

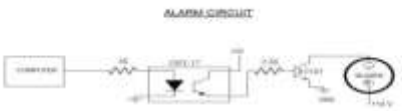

Fig.4 Alarm Circuit

I. ALARM CIRCUIT

CNY-17 is an opto coupler IC used in the hardware prototype. The alarm indicates the status of the meter. When the recharged balance falls below the pre set value alarm is raised and the signal is given from the smart grid monitoring computer. Also if the Recharge card is invalid the alarm blows and when theft load is connected alarm blows.

J. RECHARGE UNIT

The provision for inserting Recharge card requires a 10 pin connector. Where pin 5 to 9 indicate the 6 digit validity code. The pin 2 and 3 is used to interface card. Pin 1 and 10 are connected to ground potential and at pin 5 we connect 5V supply.

The recharge cards are manufactured for different amounts so that the customer can use it as per their convenience.

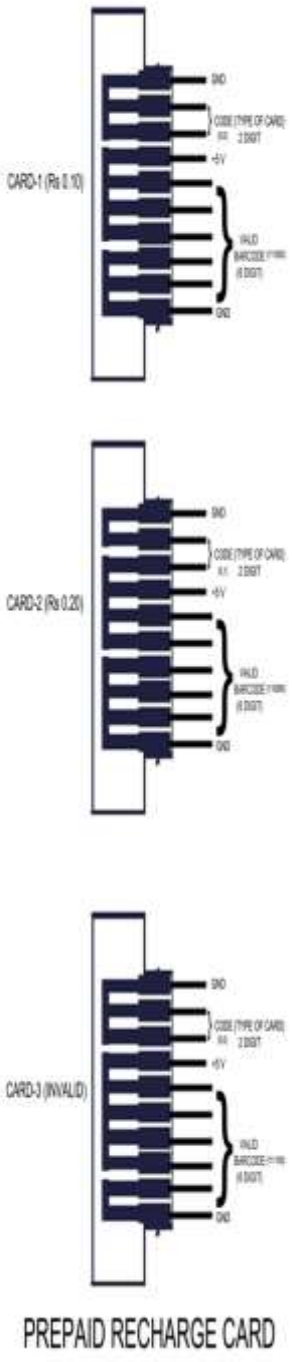

Fig 5 Recharge unit

IV. RESULTS AND DISCUSSION

1) The Voltage level of the distribution side is constantly monitored when there is any fall in voltage level due to excessive loading the system can identify this and change the tap settings of the distribution transformer to maintain the voltage level.

2) FMC constantly provides the status of the fuse. If power at home fails even when there is supply is on the distribution transformer it is automatically communicated to the smart grid computer, as it may be due to breakage of conductors in over head lines due to unfavourable weather (storm and rain

3) The current transformer present in the distribution side measures the total current consumed by all homes in a particular node. Similarly the smart meter measures the current consumption of every home thus if there is any difference between the total current and the sum of current consumption from each home it will be taken as power theft.

4) The node where power theft occurs is identified and only in that particular node supply is cut off.

5) By using smart meter we have an advantage of two way communication between the load and supply side.

6) The smart meter updates the data base of the smart grid computer about the power consumption status, voltage rating current rating, power factor and frequency.

7) The smart meter also updates the recharged amount, current balance and last recharged date and time.

8) The above mentioned technology is better than the present technology in use, in future this may make our life simpler and also save time.

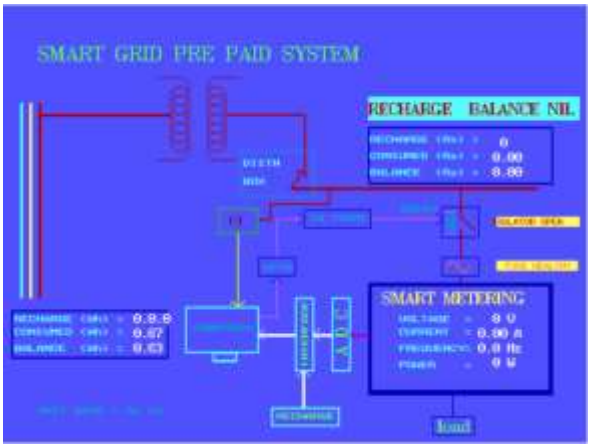

Fig 6 Recharge Balance NIL case

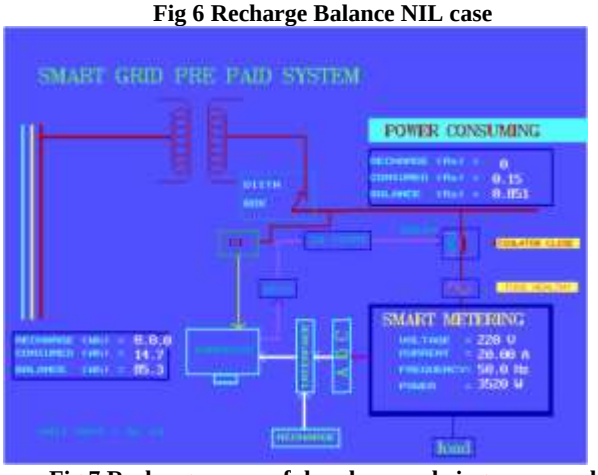

Fig 7 Recharge successful and power being consumed

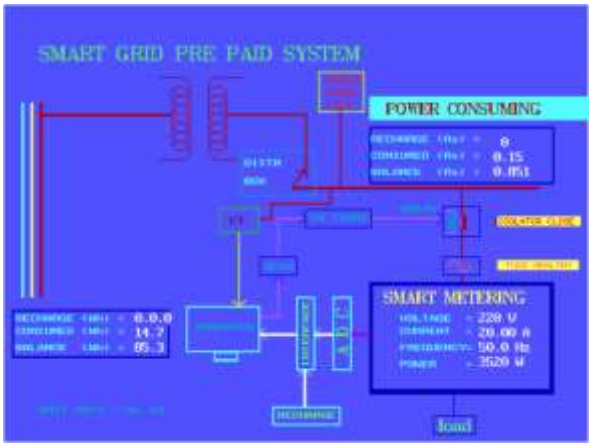

Fig 8 Theft load connected

V. CONCLUSION AND FUTURE SCOPE

A. CONCLUSION

Since the system is under constant monitoring any voltage control can be done in real time, thus the reliability of power delivery is ensured.

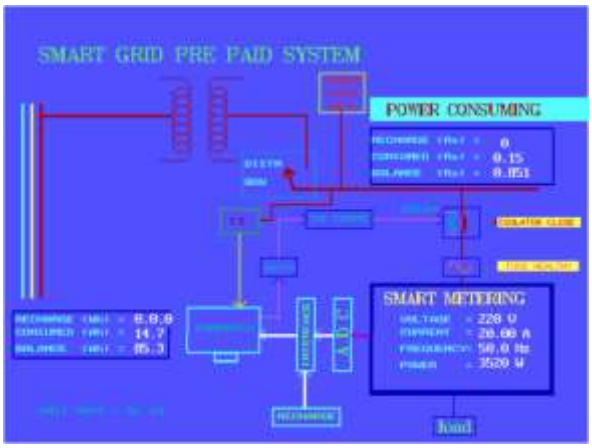

Fig 9 Theft load node disconnected

B. FUTURE SCOPE

Fuse monitoring circuit provides the status of fuse; healthy fuse and power supply failure are indicated in fuse monitoring circuit. All the data are updated every now and then in the smart grid computer, by using smart meter two way communication is enabled, thus power theft when identified can be avoided by turning off supply only for that particular node.

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