Flexible Smart Meter Capable of Prioritizing load

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Abstract-The generation and transmission capabilities of energy systems are draining everywhere in the world. Load-generation imbalance could be disastrous for power system operation. In order to overcome this imbalance and to meet the rapidly increasing energy demand in developing countries, indiscriminate load shedding is carried out in order to stabilize and ensure the reliable supply to the remaining part of the system. In this paper, an improvement is proposed in the conventional smart meter design to make it capable of monitoring load prioritized electrical circuits for load management in order to avoid complete blackout and to conserve energy irrespective of the Time of Use tariff. The model is simulated and smart meter hardware is developed to test load shedding scheme using proposed prioritization of load circuits.

Key Words- DSM, High priority circuit (HP), Low priority circuit (LP) , Smart Meter (SM), Load prioritization, Load shedding

1 INTRODUCTION

The main elements of a power system are generation, transmission and distribution. Due to low generation of power in Pakistan, uncharacterized load shedding is carried out in order to stabilize and ensure reliable supply to the remaining part of the system. A power system must remain stable for reliable services and should be capable to withstand wide-range of load uncertainty or disturbances. From contingencies perspective, when the system does not require immediate remedial actions, through emergency balancing services load can be controlled. The role of load is obvious, that it can perform very similar action like generators for real power control, and in maintaining balance between Load and Generation. The existing power system is under stress and the attention has shifted to save every watt of power throughout the world. The proposed smart meter is capable of load priority based selective load shedding scheme. There are two output circuits of the proposed smart meter as shown in fig.1. Low priority load circuit and the high priority load circuit. This would enable the system in case of imbalance in supply-demand, power to minimum essential loads can be supplied while disconnecting the low priority load circuit or when any of the load circuit exceeds the predefined limits by utility. The smart meter will trip that over loading circuit, as a result load management and energy conservation will be achieved.

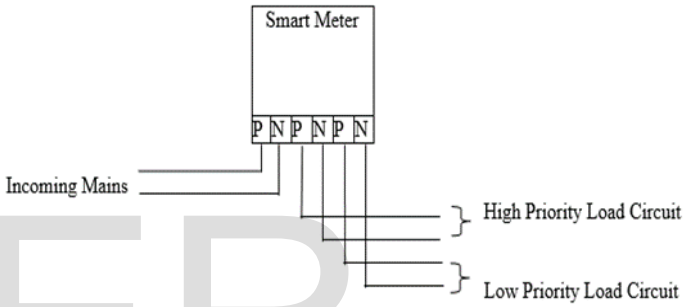

Fig.1. Design of Proposed Smart Meter

2 LITERATURE REVIEW

The introduction of Smart meters to power systems for the demand side management and supportive services to spinning reserve, is appreciated worldwide. With the help of smart meters, consumers are expected to be more involved in their energy consumption and can more easily be added to the energy [1]. In current stressed power systems, load shedding is carried out to overcome the gap between load and generation during frequent frequency drop, whereas, Smart meters could be used to switch off the loads directly [2]. Smart meters are used as the communication gateways for DLC by some companies [3]. Instead of conventional means for spinning reserve in frequency drop, some utilities adopted demand reduction known as UFLS using SM [4]. ZigBee and GSM based smart meters have been developed and hardware model was prepared to verify the results [5]. Two-way communication between domestic loads and energy suppliers is achieved by using Smart meters for price and consumption control [7].

3 DSM THROGH PROPOSED SMART METER

Demand side management is considered as an important tool which could be handy in the improvement of existing ghastly distribution systems to enhance efficiency and power quality for the consumer [2]. If generation capacity is unable to produce

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further supply, the frequency and voltage decay continues and results in blanket load shedding to avoid a catastrophic failure.Smart meters have the capability to directly switch off loads to balance the supply and demand during a supply demand offset [10]. Our proposed scheme with the help of the smart meter shown in fig.2 could be helpful in such condition

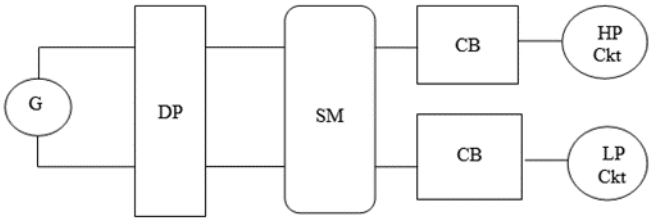

Fig.2. Block Diagram of Proposed Scheme

Where DP is distribution point, Two outputs circuits from smart meter one is high priority (HP) the other is low priority circuit (LP) controlled by circuit breaker (CB). Monthly knowledge based limits will be defined for each load circuit from load-generation history by utility, whenever consumer exceeds the limit SM will trip that circuit and in emergency utility could send trip message to all LP circuits.

4 IMPLEMENTATION

Proposed scheme of the smart meter is modeled in matlab Simulink as shown in fig.3 where two circuits are emitting from SM one is high priority circuit and other is low priority circuit. RLC Loads are connected to both circuits

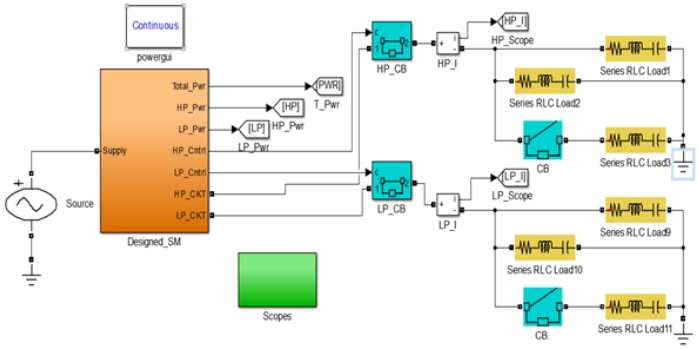

Fig.3. MATLAB Simulink Model of Proposed Scheme

Load profile of LP circuit is shown in Fig.4 , it demonstrations that at time 1.2 second, the load current exceeds its predefined value, the smart meter trips the circuit and current of LP circuit becomes zero. After 0.5 second delay, the smart meter resumes the supply of LP circuit and it runs smooth within limits

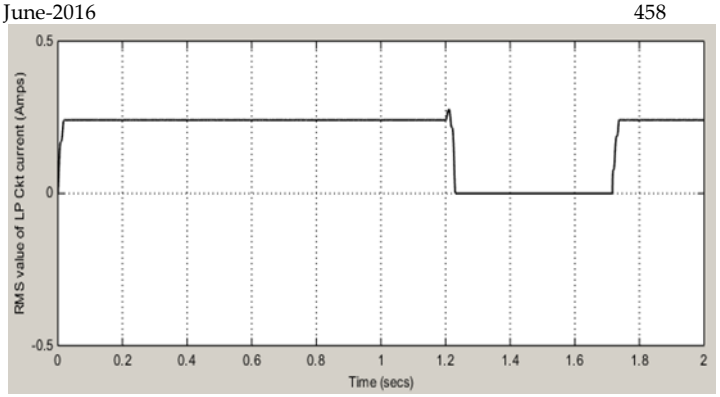

Fig.4. RMS value of LP Circuit Load Current

The following result of LP load circuit shows that when ,at time 1.2 second, the load exceeds than the limit of 35W, the smart meter trips the LP circuit and the load is reduced to zero. After 0.5 second delay, smart meter resumes LP supply as shown under in the Fig.5.

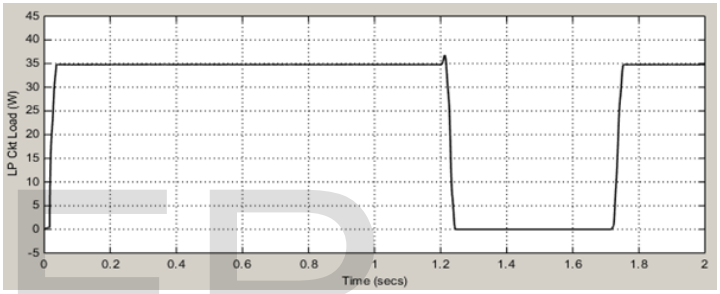

Fig.5.Load Profile of LP Circuit

Fig.6 shows result of HP power scope, that at time 0.5 second, when load exceeds than its 35W limit, the Smart meter will trip the HP circuit, the load become zero and after 0.5 second delay it resumes supply and then run smoothly within the limit

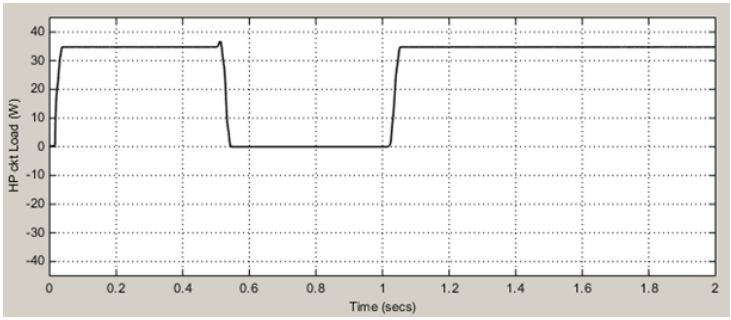

Fig.6. Load Profile of HP Circuit

The total load profile is shown in Fig.7 which shows that at time 0.5 second, when load exceeds the limit, the smart meter will trip the over loading out going circuit and after 0.5 second delay, it will resume the supply of the tripped circuit. At time 1.2 second, when additional load brings to LP circuit, the smart meter trips that circuit and after 0.5 second delay, it resumes the supply

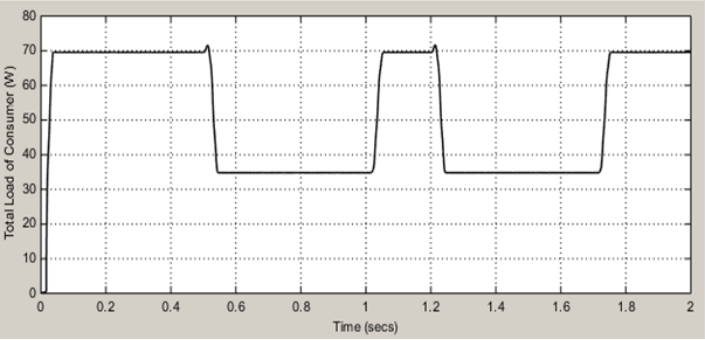

Fig.7. Total Load Profile of HP and LP circuits

5 HARDWARE IMPLEMENTATION

The smart meter is implemented practically, Fig.8 shows its schematic diagram. Major components used in circuit are explained individually.

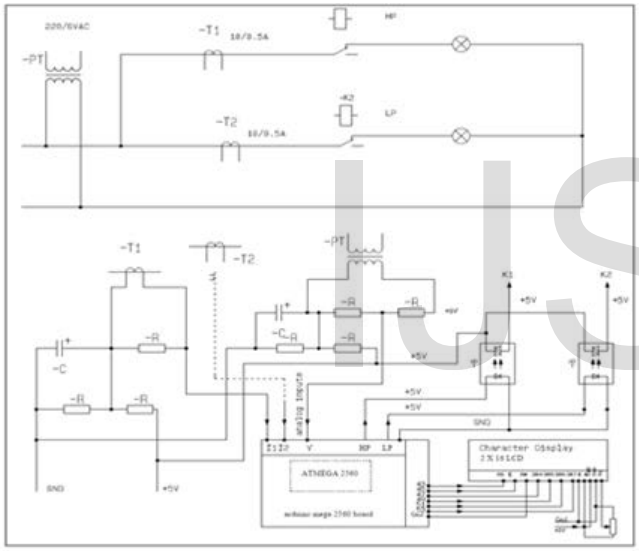

Fig.8. Schematic Diagram of Proposed Smart Meter

5.1 ATMEGA 2560 with Arduino Board

Microcontroller-based Arduino boards, which is designed and manufactured for making digital devices and interactive items, that can control and sense devices in the physical world. Arduino is an open-source platform [9]. A set of analog and digital input output pins, Arduino board have the capability of interfacing with different other boards and applied circuits. Arduino board is very flexible and versatile for the support of microcontroller. For programming the microcontrollers, C++ language is used. Power to Arduino can be given by using power jack USB port, it can also be powered through pin V_{in} by using an external battery or adapter. Shields can be used in Arduino for integrating and utilization of Ethernet, GSM, and RF for communication purpose.

5.2 Relay Board

A two channel relay interface board with LED indicators is used. In which one relay is used for HP circuit tripping and the second relay is used for LP circuit tripping.

5.3 keypad

4 x 4 matrix keypad is used for entering the value of load magnitude limits for both HP and LP circuits for the corresponding month. Microcontroller receives data from keypad in character form and a library in Arduino software is used to convert these characters to integer form for processing.

5.4 Display

An LCD is used to display electronics visuals. We used a 16 pins LCD with operating voltage of 5V DC. The data pins (D0 to D3) of LCD are connected with the microcontroller to display kwh reading and consuming power of each LP &HP circuit.

Hardware Function

Voltage and current signals are level shifted and fed to the Arduino board. The function of this circuit is used to clamp the ac signal with respect to a preset reference DC voltage. The output from the voltage level shifter is given to the analog input of Arduino board at pins A0 and ground. In the same way output of current level shifter is fed to the analog input of Arduino board at pins A1 and ground. When the inputs are given to the Arduino board, the microcontroller on the board will calculate the energy. So level shifter circuits are used to clamp the signal and directly feed the Arduino for calculating the energy of each circuit, and the calculated energy could be transmitted to the server by using any communication means through the shield fixed on the top of Arduino board. The LCD will display the value of consumed energy and running LP and HP loads, and the consumed energy record could be sent to the consumer on request. When the energy consumption is greater than that of predetermined limit for each circuit, then immediately TRIP message will be sent to relay to disconnect that circuit. Hardware for our proposed smart meter is shown in Fig.9.

Fig.9 Final produced hardware of SM

7 CONCLUSION

This research strives to launch a framework for DSM by using the proposed smart meter to avoid the complete blackout. The results show that DSM using smart meter is a viable option. The smart meter will help the utility to reduce the energy loss, load shedding and also help the consumers to understand their load patterns. It involve healthy interaction between both user and utility, which will enhance reliability, consistency and stability in the system. The complete shutdown could be avoided and continuous supply of electricity will be ensured to high priority load by selective load shedding. Graphical user interface provide new techniques to priorities the load according to the demand which open various innovations for end user to concentrate at real problems of blackout.

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