Real Time Power Grid Monitoring and Management System

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***Abstract* – The use of grid power systems based on the combinations of various electrical networks, information technology, and communication layers called as Smart Grid systems. The technique of smart grid suppressed the problems faced by conventional grid systems such as inefficient energy management, improper control actions, grid faults, human errors, etc. The recent research on smart grid provides the approach for the real-time control and monitoring of grid power systems based on bidirectional communications. However, the smart grid is yet to improve regarding efficiency, energy management, reliability, and cost-effectiveness by considering its real-time implementation. In this paper, we present the real-time design of efficient monitoring and control of grid power system using the GSM.**

Index Terms - demand side management, demand response, Smart Grid, load management, residential load

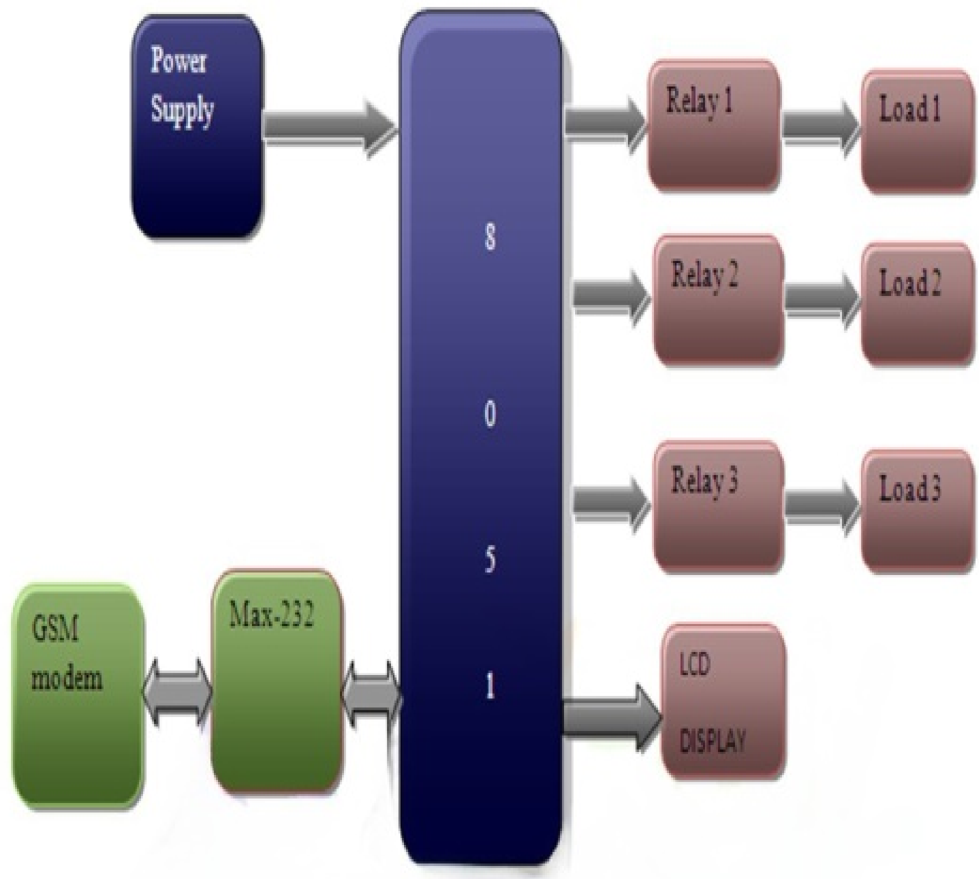
I INTRODUCTION

Electrical energy consumption has increased significantly in the last decades. This is driven by high population increase, economic growth, huge increase in building sector, an increases in the number of electronics and appliances in different end-use sectors (e.g. residential, commercial, industrial,… etc.)

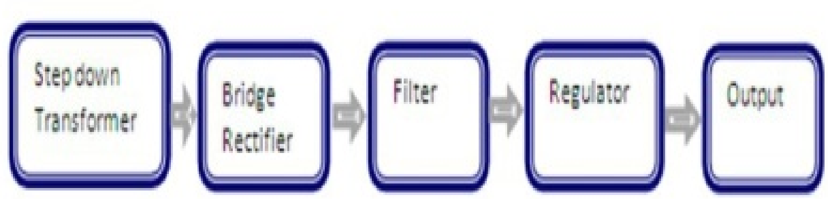
Improve grid reliability and reduce downtime by quickly detecting and responding to power outages and equipment failures. Optimize grid efficiency and reduce costs by monitoring and controlling t flow of electricity to minimize waste and reduce losses. Increase grid resiliency and enhance security by identifying potential cyber threats and physical vulnerabilities in real time

Control algorithms respond to changing conditions to meet operational requirements. They require many input signals and output actions and can be quite complex. Smart meter informs about utility status and communicate in real time the operational between end-user and utility. It also has the ability to communicate with home appliances, record consumption data at different intervals and transfer the measured information to the utilities [4]. Over the last decade, several studies have been reported in the literature regarding the implementation of smart residential energy management systems. Different algorithms have been developed for the residential energy system control and management depending on load types and utility requirements in different regions [5] - [9]. Various home energy management hardware applications are proposed in [10], [11]. Optimal appliance scheduling operation to minimize household energy consumption is presented in [12] - [13] and direct digital control was discussed in [14]. Several schemes of demand response (DR) strategy are proposed in [15] - [20] to coordinate the requirements and needs between energy provider and customer. However, existing home energy management systems are mainly designed to improve the energy efficiency and comfort level within residential building without taking into account the utility status, critical peak hours, and peak pricing. However, none of existing management systems interacts between utility and appliances to reduce energy consumption and implement an efficient monitoring system toward improving energy balance. This paper proposes to develop and implement an effective residential energy management strategy, which can measure, analyze, and control residential loads. The proposed system can also manage consumption energy during off-peak and peak demand times as a step towards energy conservation for the future smart grid, which yields to improve the overall grid efficiency, overall energy consumption and increase reliability of the power grid, especially during the demand responses. The proposed system can also prevent blackouts, reduce CO2 emissions by minimizing energy usage, and minimize social costs from the utility operation in meeting

BLOCK DIAGRAM:



POWER SUPPLY BLOCKDIAGRAM:



Power Station

A power station, also referred to as a power plant and sometimes generating station or generating plant, is an industrial facility for the generation of electric power. Power stations are generally connected to an electrical grid.

Power plants **c**onvert raw energy sources such as coal, nuclear heat, or wind, into usable power in the form of electricity. A thermal power plant, which is one of the most common types, is a plant that creates power by burning fuel to convert it into electricity

Power Grid

An electric grid is a network of synchronized power providers and consumers that are connected by transmission and distribution lines and operated by one or more control centers. When most people talk about the power "grid," they're referring to the transmission system for electricity.

One among the largest power transmission utilities in the world, has developed expertise in its core areas such as power transmission, sub-transmission system, distribution management, load dispatch & communications, in India and abroad

Working

A real-time power grid monitoring and management system working with GSM involves using GSM (Global System for Mobile Communications) technology to remotely monitor and manage the power grid.

Here are the steps involved in setting up such a system:

1. Install sensors and meters: Sensors and meters are installed at various points in the power grid to measure voltage, current, power flow, frequency, and other parameters.
2. Collect and transmit data: The data collected from the sensors and meters is transmitted to a central server via GSM technology. This data can be collected and transmitted in real-time, allowing for immediate analysis and action.
3. Analyze data: The central server analyzes the data collected from the sensors and meters to identify any anomalies or issues that need to be addressed. This analysis can be done using machine learning algorithms or other techniques to detect patterns or abnormalities in the data.
4. Alert operators: If any issues are detected, the system can send alerts to operators via SMS or other forms of communication. These alerts can be customized based on the severity of the issue and the preferences of the operator.
5. Control power grid: Operators can use the system to remotely control various aspects of the power grid, such as adjusting voltage levels, switching on or off power supply to specific areas, and so on. These controls can be implemented through the use of relays, switches, and other equipment. Overall, a real-time power grid monitoring and management system working with GSM can provide power grid operators with greater visibility and control over the system, leading to improved efficiency, reduced downtime, and lower costs.

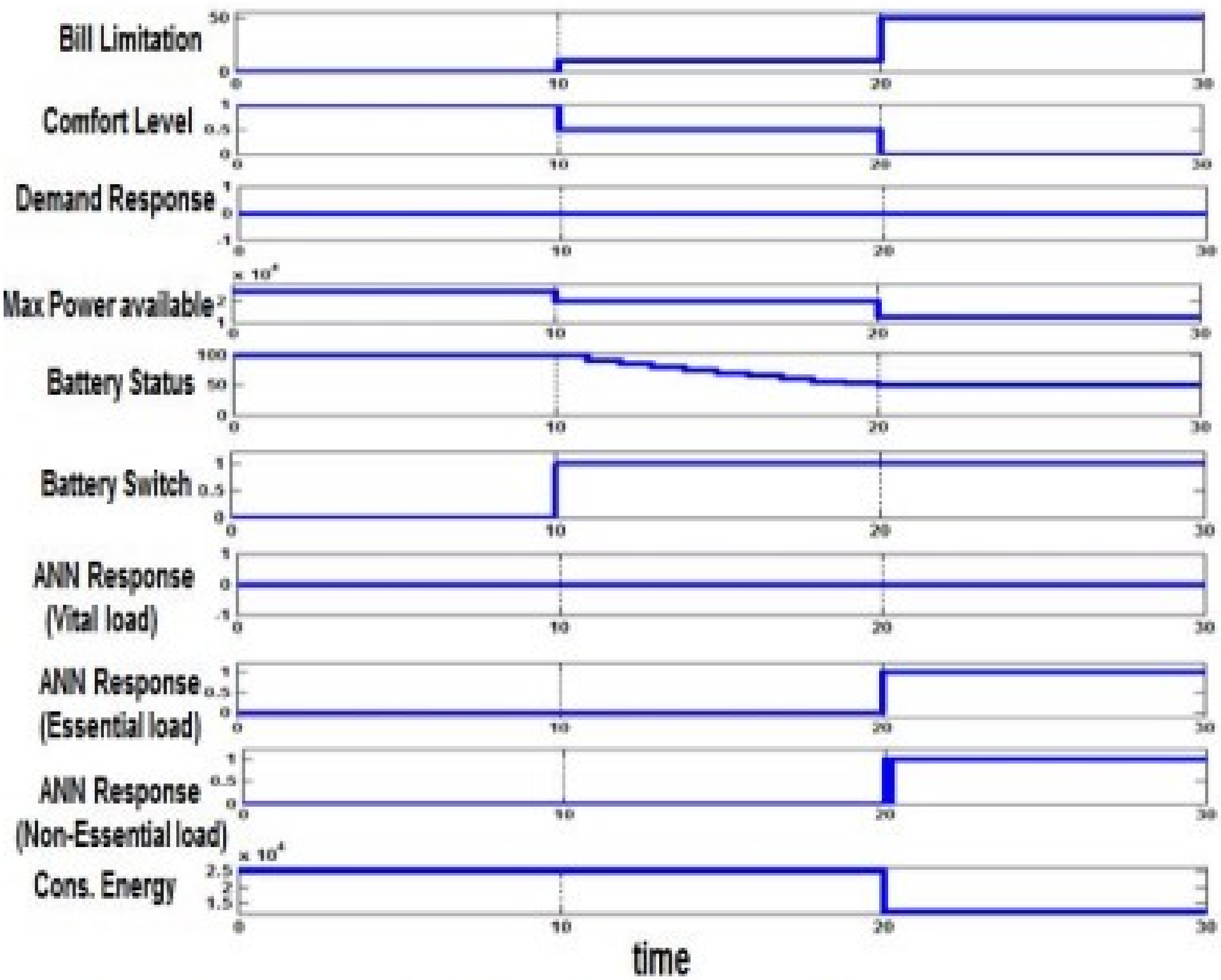


Fig.3. Simulation results of ANN response in different energy saving scenarios

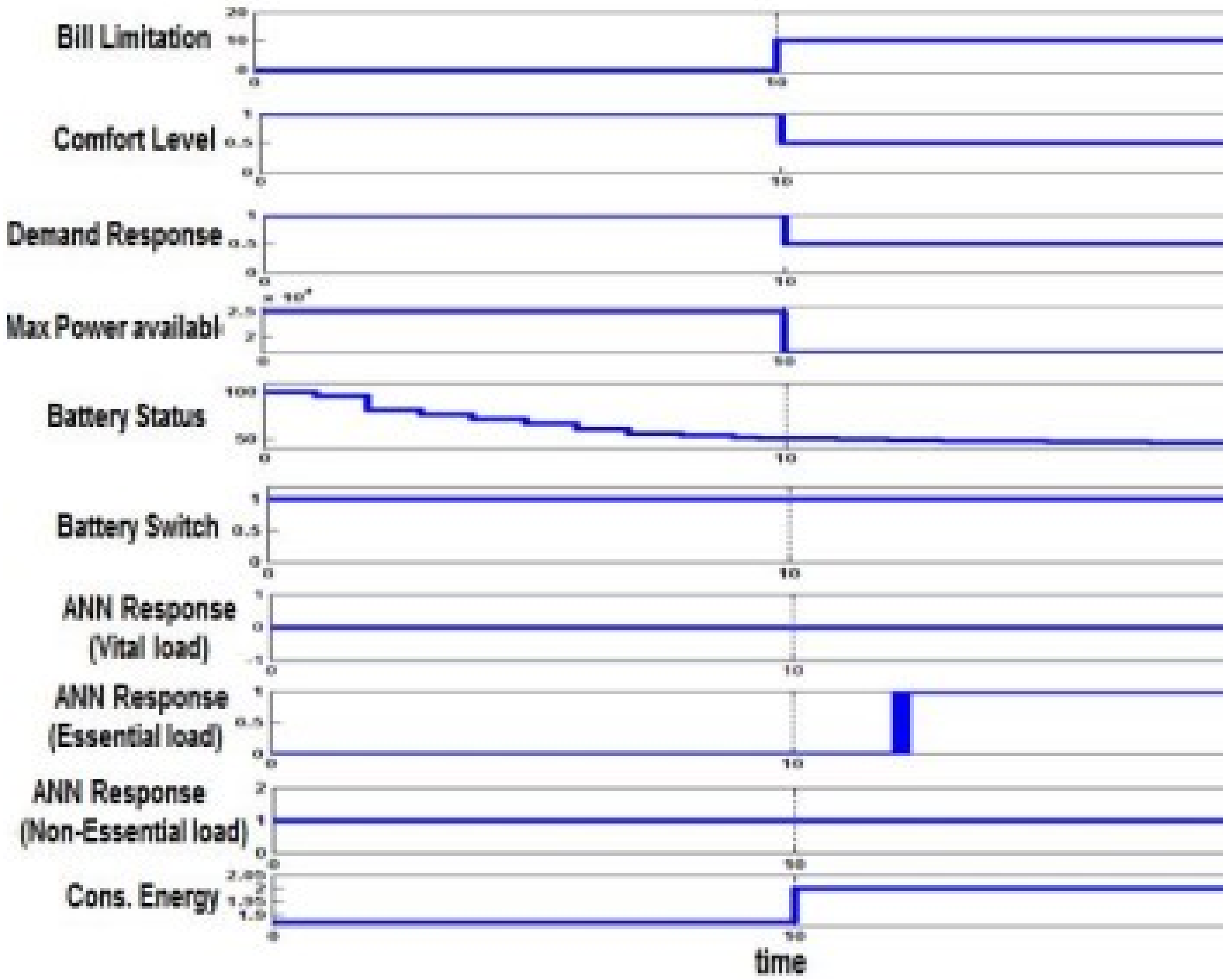


Fig. 4. Simulation results of ANN response in demand response sce

In this process the proposed online algorithm allows to manage energy consumption during the day time based on the status of battery storage from the PV system using external controlled load switches. The proposed algorithm of energy saving strategy for residential loads will be implemented in a closed-loop form, which is more dynamic, effective, simple, robust and easy to implement. The proposed robust energy saving strategy aims to save around 33-40% of our daily energy consumption

A. Demand Response (DR) strategy

Demand response (DR) is defined as "changes in electric usage by demand-side resources that allows for lower electricity consumption when the system is under stress [25]. In the demand response (DR) case, the input data to the management controller is set based on: loads importance (vital, essential, and non-essential), measured energy consumption of each load, and the status (checking) of smart meter commands from utility (utility events). Utilities plan to do the DR event in a centralized manner by sending commands to the proposed energy management system through smart meter carrying the required percentage of DR to manage loads in the residential buildings. The strategy of load management is defined based on the percentage of demand response, load priority and consumer's preference, comfort level, electricity bill limitation, and battery status

II.SIMULATION RESULTS

The performance of the proposed algorithm is demonstrated by simulation studies for a residential energy management model based on Mat lab/Simulink. The model has been simulated with two scenarios: general operation of the proposed energy management system and demand response events. The proposed algorithm has the ability to monitor, analyze, and control residential loads during peak demand. Figs. (3-4) shows the simulation results for different energy saving scenarios and Demand Response scenarios. In energy

saving case, the feed-forward neural network concerns to observe estimated available power, comfort level, battery status, and energy consumption of each electric load. A two- hidden layer feed-forward artificial neural network, trained using the back-propagation algorithm, is used in this investigation. The outputs of the ANN algorithm "Zero" is assigned to "no action from proposed system", while the output "One" is assigned to "disconnect action to load". It is noticed that when the resident adjusts the bill limitation to zero, comfort level becomes high, battery status is full, the action from the proposed algorithm to battery switch is zero, and the residential loads are at "no action". If the resident adjusts the bill limitation to (10%), the comfort level becomes medium, battery status is full, the action from the proposed algorithm to battery switch is one, and the system manages smartly between the utility energy consumption and energy from residential renewable system without effecting energy consumption. However if the resident adjusts the bill limitation to (50%), the comfort level is low, battery status is (50%), the action from the proposed algorithm to battery switch is one, the actions to the essential and non-essential electrical loads are one, while the actions to vital loads are zero as shown in Fig. 3. it proves that the response of the ANN aims to save energy consumption while considering residential households preferences and comfort level.

In the demand response (DR) scenario, the ANN observes: the changes in the DR from utility (DR=1), battery energy used. The ANN response to the residential loads 0, 1, 1, will correspond to vital, a part of essential, and non-essential electrical loads, which will help avoiding residential blackouts. When the proposed system has no action the ANN output will be "Zero" and will turn to "One" when disconnected the load. The proposed system observes the changes in the DR from utility (DR=1), then the action from the proposed algorithm to battery switch is one. If the resident adjusts the bill limitation to (50%), the comfort level becomes high, the battery status is (100%), the action from the

Disconnect unnecessary loads through controllable load switches as shown in Fig. 6 (b). The ANN algorithm aims to save energy consumption while considering residential household's preferences and comfort level. The measured current and voltage of Television load for different power readings are shown in Figs. 7(a) and 7 (b), respectively. Where energy management system keeps connected necessary loads to achieve the best tracking performance while considering residential customer preferences and comfort level.

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Proposed algorithm to battery switch is one, also the action to electrical loads are zero. However, if the bill limitation is adjusted to (10%), the comfort level is medium, battery status reaches to (50%), the action from the proposed algorithm to essential is one, and it is managing smartly non-essential loads till battery status reaches to (50%). Then, the action becomes one, while action to vital loads becomes zero but it will change smartly to manage between energy from vital loads and available energy, which will help avoiding residential blackouts as shown in Fig. 4.

III.EXPERIMENTAL VALIDATION

Actual case study for a residential villa in Qatar, the area of the villa is 180 m2 consumes from 6000 to 9500 kWh/month. The experimental setup is shown in Fig. 5. The proposed system measured current, voltages, frequency, active power, reactive power, and apparent power for different appliance loads as shown in Figs. (6-7). Then our experimental algorithm is performed on DSPACE DS1103, The control algorithm is built within Simulink environment combined with the Real-Time Interface (RTI) platform provided by ds PACE to configure and generate the control switching signals. It is implemented by the main processor of the DS-1103 board using the discrete solver at fs = 100 kHz to verify the performance of the proposed energy management scheme. The AC and Television are considered here as examples of residential loads, and utility is selected as source of local power to evaluate the proposed energy management system. The input data sets the split-system air conditioner load as a non-essential load, and Television as essential electrical load. The measured current and voltage of the split- system air conditioner load have been presented in Fig. 6 (a), Fig. 6 (b). It shows on one screen active power (W), apparent power (VA), and reactive power (VAR) of air conditioner load with time scale 240 Sec (4 minutes). The response of the ANN for energy saving scenario with comfort level is low, battery status is (50%), and the action from controller star

IV.CONCLUSION

This paper proposes a reliable algorithm to achieve accurate management to the power building loads, improve the overall grid efficiency, and increase reliability of power grids through a significant and reliable indicator for monitoring, analyzing and reporting energy consumption for the utility through smart meters. It is shown that the proposed strategy can reduce peak electricity demand, reduce electricity consumption, and mitigate electrical system emergencies. The proposed algorithm utilizes only the analysis of current and voltage waveforms. The proposed residential energy management strategy has low computational cost to manage energy consumption in the residential sector. Experimental results and real time implementation have been provided to validate the simulation res

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