Load Management Strategy in Smart Micro Grid

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Abstract

The smart load management, an aspect in smart micro-grids, is prototyped. The load management algorithm classifies the loads as primary, secondary and scheduled ones. A prioritizing algorithm, based on the mentioned classification, manages the loads in such a way that the primary loads are given the highest priority. In a three feeders case study environment, the availability of electrical power and the load requirements, are observed continuously to prevent overloading of feeders and tripping/shedding of loads. This is done by shifting the loads amongst the feeders based on the availability of power. This eliminated consumer irritation and in bigger picture it provides efficient utilization of the available power.

Keywords: Smart Micro Grid, Load Management, Load Shifting, Consumer Choice, Load Scheduling, Proteous Software, Arduino UNO, Arduino Mega.

Introduction

Smart micro grid is the upgradation of the ordinary grid station into smarter one and makes it automatic and decision making with the help of intelligent devices which is not in the case of ordinary grid station. The concept is enforced by an increasing demand of sustained and controlled electrical power. Analyst’s calculations show that energy consumption is increasing every day. According to the UN data, incoming four decades population of our world will be double. Therefore, to meet the energy crisis, better power systems are needed.

The U.S.A department of energy developed the concept of a smart grid. San Diego was the place where the U.S.A installed the first smart grid (San Diego, 2006). The analyst’s observed the effectiveness and technical feasibility of installing smart grid concept or smart grid technologies.

The concept of smart grid passed through evolution. In the start, smart grid technologies were created using simple pieces of equipment, metering, electric control and monitoring system. In 1980s, the automated meters were used to monitor load while in 1990 advanced metering infrastructure was used (Staff, 2006)

American Recovery and Reinvestment Act (ARRA) in the US is one of the biggest projects in the world. America has invested almost $9 million in this project. This concept is also working successfully in Austin.

This project was started in 2003 and its main aim was to replace old meters with smart meters that will work through a wireless mesh network (Betsy Loeff, March 2008). In Colorado, the first smart grid project was completed in 2008. In this project, the smart meter had used as a gateway to the home automation network. This system controls all devices and sockets (Betsy Loeff, March 2008). German Power Company has planted a project named 'MoMa' in Mannheim city. This project is based on broadband power line technique (Ali, 2011). Canada has planted a large smart grid project in Ontario, named Hydro-1. This project is serving almost 1.3 million customers in the area of Ontario. This initiative has won an award from the utility planning network (Leccese F, May 2012) (Galvin R, Yeager K., July 2008) (John, Jeff , November 17, 2009).

Upgradation of current system with the load management strategy in smart micro grid done with the help of software simulation as well as hardware prototype which reduces overloading problem and equally distribute the load among all the feeders. Proposed strategy manages the load according to the load priority, time preferences and availability of power along with the consideration of over voltage, over load, short circuit and under voltage.

The paper is organized as follows: Section II includes Description of Load Management Strategy. Section III includes Software Simulation. Section IV incudes Hardware Simulation. Section V includes Result and Discussion. Section VI includes Concluding Remarks and Section VII includes References.
Description of Load Management strategy

Load managing and load scheduling is the important feature of the smart micro grid. There are many strategies developed for smart grid power utilization but one such study conducted is the load management and load scheduling in smart micro grid is done with the help of Virtual environment Proteous and Hardware Prototype. Strategy illustrate the utilization of power in effective manner by classification of loads in Primary, Secondary and Schedule ones. Description of loads are given below.

**Primary Load**

Primary load is load’s which are necessary for survival of consumer, i.e. Light in night time, Fan during summer, Heater during winter etc.

**Secondary Load**

Secondary load is load’s which are optional by consumer i.e. Television, Oven, etc.

**Schedule Load**

Schedule load are the load which operate on the basis of power availability and time scheduling. These loads consumed much energy as compared to the previous ones and increased the electricity bill. i.e. Electric Iron, Pump motor etc.

A monitoring system is installed which continuously measure the power consumption and send command to perform required operation during running mode. Strategy is implemented on three feeder’s which are at small distance with each other. These feeders are wirelessly controlled by the main feeder. High Priority is set for primary, Secondary load is at less priority then primary and schedule load are at least priority among all loads. Fig.1 Show the Flow chart of proposed strategy in smart micro grid.

![Flow Chart of Load Management Strategy](image1.png)

**Figure 1 Flow Chart of Load Management Strategy**

Software simulation of proposed strategy in smart micro grid is done on the Proteous software and divided into two parts.

- Simulation of feeder
- Simulation of grid

The data of every feeder sent to main feeder and main feeder respond according to the logics which we are done in programming. The arduino software is used as programming platform. Each feeder has three types of loads classified as:

- Primary Load
- Secondary Load
- Schedule Load

**Feeders Simulation**

![Feeders Simulation](image2.png)

**Figure 2 Feeders Simulation**
In feeder's simulation 220V supply is connected with loads parallel to each other and each load is controlled by switch. A current sensor is connected in series with load to measure current of feeders. Input of the sensor is current while output is analogue signal from 0 to 5V and its value is in between 0-1023 according to load current. when load is on current is draw from load which is sense by current sensor. Output pin of current sensor is connected with arduino where logical programming calibrates the sensor for exact value of current. After calculation of current, power is obtained by multiplying the current with voltage. On feeder side three parameters voltage, current, and power is displayed at Liquid Crystal Display (LCD). Fig.2 shows feeders simulation.

Grid Simulation

![Figure 3 Grid Simulation](image)

Loads of each feeder managed according to availability of power by grid. Running wattage of each feeder are displayed at Grid side using LCD. Fig.3 shows the simulation of grid.

Complete Simulation

Complete simulation consists of both feeders and grid simulation combined. Fig.4 shows the complete simulation.

Hardware Simulation

Hardware implementation of proposed strategy is done in following steps:

Implementation of Grid Transformer

Shell type transformers are used to limit the output to 250 VA because decision is taken at low level. Actually, these transformer takes 220V at input and provide 220V at output with power rating of 250 VA each. Fig.5 shows grid transformer implementation.

![Figure 5 Implementation of Grid Transformer](image)

Implementation of Grid Control Circuitry

Grid circuitry consist of arduino mega,20x4 LCD, HC-11 wireless module etc. Control circuitry operate the relays as per signal of main controller and shift the loads among feeders. Data of each feeder is displayed on liquid crystal display. Fig.6 shows Grid control circuitry implementation.

![Figure 6 Implementation of Grid Control Circuitry](image)

Implementation of Feeder Control Circuitry

Feeder control circuitry consists of different relays and Integrated Circuits (IC). It has five electromagnetic relays which is used to switched load's as per requirement. Each feeder contains one relay for primary, one for secondary and three for schedule load. To operate these relays an IC uln2803 consists of transistor having eight outputs is used. Fig.7 shows feeder control circuitry implementation.

![Figure 7 Implementation of Feeder Control Circuitry](image)
Load Management Strategy in Smart Micro Grid

Implementation of Load Unit

Load unit consists of three types of loads for each feeder. Switches are used to operate loads manually. Fig. 8 shows the implementation of load unit.

Implementation of Complete Hardware

Complete hardware consists of plug, transformers, current sensors, load unit, step-down transformer, liquid crystal display, Arduino Uno, Arduino Mega, relays, etc. Plug provides the main supply from the socket. Transformers are used to limit the power requirement. Current sensors ACS712 are used to measure current for each feeder. A 220/12V step-down transformer and voltage regulator 7805 is used to turn on the LCD and Arduino after rectification through a bridge rectifier. All these components are combined at a single board. Fig. 9 shows complete hardware implementation.

Result and Discussion

Proposed strategy is performed practically on the hardware prototype and different results obtained which are shown below:

Load management strategy among feeders without schedule load

Case 01

When one feeder will be overloaded, it will check the availability of power on the nearest feeder. If power is available, it will shift secondary load on that feeder; otherwise, it will move to the next case. Fig. 10 shows hardware result of case 01 and Fig. 11 shows real-time Arduino plotter result of case 01.

Case 02

When one feeder will be overloaded and power is not available with the nearest feeder, it will check the power availability next to the nearest feeder. If power is available, it will shift secondary load on that feeder; otherwise, it will move to the next case. Fig. 12 shows hardware result of case 02 and Fig. 13 shows the real-time Arduino plotter result of case 02.
Cases for Schedule Load

Case 01

During time of schedule load if capacity available on feeders then schedule load will be on in normal condition. Fig.16 shows hardware result of schedule load case 01 and Fig.17 shows real time arduino plotter result of schedule load case 01.

Case 02

If feeders are overloaded due to schedule load, then trip the secondary loads first then check if capacity is still not available due to primary load, then trip schedule loads as well because primary loads are at higher priority. Fig.18 shows hardware result of schedule load case 02 and Fig.19 shows real time arduino plotter result of schedule load case 02.
Proposed and implemented strategy deals with the load shifting from one feeder to another feeder at the time of overloading and tripping the load at time of power shortage which increase the demand of project, by National Transmission and Dispatch Company (NTDC), Water and Power Development Authority (WAPDA), and power distribution companies. Project cost effective and efficient and can be implemented at any area of Pakistan as well as in other countries.

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