DEVELOPMENT OF DEMAND RESPONSE CONTROL INTERFACE TO MAXIMISE ENERGY UTILISATION

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Bachelor in Electrical Engineering

June 2013
“I hereby declare that I have read through this report entitled “Development of Demand Response Control Interface to Maximize Energy Utilization” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Power Electronics & Drive)”

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DEVELOPMENT OF DEMAND RESPONSE CONTROL INTERFACE TO MAXIMISE ENERGY UTILISATION

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor in Electrical Engineering (Power Electronics & Drive)

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MAY 2013
I declare that this report entitled “Development of Demand Response Control Interface to Maximize Energy Utilization” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date   : ....................................................
To my beloved mother and father
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ABSTRACT

The development of ‘Energy Demand Response Control Interface’ for domestic purpose is able to control the energy usage to its optimum level that been set by the user. This project is to study the power usage among the domestic users and about the way controlling the over usage of power. When the power demand level exceeds the normal value, the system will automatically dispatch the energy by switch the power usage at residential and industry sectors to be stable and normal. Therefore, this project designs a low cost device that able to manipulate the household electrical appliances in order to prevent overload. This device can identify the usage type and help prevent energy wastage especially for domestic user. This project is differs from the normal power meter where it only able to measure and provide the power input and usage level whereas this device able to measure the normal domestic load level and presents in the LCD panel that been attached. Other than that, the device also owns the capability of controlling the power usage of the residential load by itself where when the power usage exceeds the maximum level, the system will automatically control and switch off or change the other less important load section to match with the safe level of usage. This device is easy to be fixed or installed to the power distribution box at home and helps to reduce the household expenses for the energy usage.
ABSTRAK

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CHAPTER 1

INTRODUCTION

1.1 Research Motivation

TNB customers are supplied with generated power from hydroelectric and thermal plants. This network system is made up of transmission lines, substations and distribution lines. Through this reliable system, TNB supplies electricity to customers consistently and continuously, as well as ensuring a balance between demand and supply at all times.

![Figure 1.1: Typical daily weekday system load profile [1]](image)

Based on the Figure 1.1, it can be seen that the customers electricity demand change according to time. Therefore, this project research is mainly to help TNB to control the demand of electricity so that demand graph will be equal and the peak demand is minimize as...
shown in Figure 1.2. If the customers demand continues as shown in Figure 1.1, it will cause high cost of demand and the generator can only be used for short period.

![Figure 1.2: Ideal TNB electricity generation demand](image)

1.2 Problem Statement

There are other similar devices as the proposed demand response controller that available globally for example; Efergy e2 Whole House Energy Monitor which is the energy meters and smart home devices that help homeowners take control of their energy use with price of $138.05 [2]. The main problem with the devices is its expensive price tags. On the other hand, the devices also only able to certain task such as either measuring or partially control the usage. For some other devices, it continuously needs human monitoring due to its manual interfaces and controls. When use such manually controlled devices, the residential users need to be keeping on monitor the device and control the power distribution time-to-time on peak usage criteria. This helps the power generation or the suppliers to maintain their healthy power generation level but it become inconvenient to the users. Other than that users also need to manually turn off and on the power usage section to reduce the maximum power usage level. This situation will cause unwanted trouble and burden to the domestic users whom are mainly everyday workers.
1.3 Project Objective

The main objectives of this project are:

- To design a low cost device that able to manipulate the domestic household electric appliances in order to reduce peak level demand.
- To develop a device that will operate automatically with the assist of microcontroller to help the customer plan the power usage without any manual calibration or interfaces.

1.4 Project Scope

- To design and develop a device that will reduce energy consumption level of household electrical appliances automatically, hence helps to reduce energy consumption.
- To control the energy usage to its optimum level according to the energy demand that been set by the user.
- To control the demand level automatically by sensing the trigger point of overload condition and off the related load.
CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Reference and understanding is gained from various sources such as books, journals, Internet and previous projects. These materials are used as the main source for the entire project. In this part, many journals were referred and analysed but only few selected journals which are essential for my research based on the objective of the project are reviewed.

2.2 Research on Demand Side Load Management of Smart Grids using Intelligent Trading/Metering/Billing System

This paper presents an intelligent trading/metering/billing system (ITMBS) developed in Nanyang Technological University of Singapore that had been applied in Demand Side Load Management (DLSM) of smart grids (SGs) and smart distribution systems (SDs)[3]. The ITMBS gives detail of energy usage and the real time cost. It also allows the user to control demand through setting the operating time of the household appliances based on real time price to change their consumptions and cut costs. Besides that, users enable to control the program by themselves at the center of micro-grid to change the air condition setting by changing ON or OFF which are based on cost and weather condition. The proposed systems consist of several steps include using smart meter for measuring water,
gas and electric usage, power line communication (PLC) used to transfer data from smart meter to local server, control unit (DCUs) used to give the real time price information. Centre and local database stores and manage the billing details and also user details. This project mainly present about the demand management using DCU on smart grid.

2.3 Research on an Electronic Meter for Measuring the Saving in Electrical Power.

This paper presents an electronic meter to measure electrical energy by using simple and hold method [4]. This method produces two type signal where one for peak value of line voltage (Vm) and second for instantaneous value of line current, Vm,i.e,Im cos F where F for phase angle measured between Vm and Im. Multiplication of both signals over predetermined period gives the energy usage value. Voltage of frequency converter (VFC) are used for digitize the electrical energy signal. This project use simple equipments for electrical energy measurement. This project gives good result under different loading conditions and with a power factor ranging from low to high value.


This project develops to gather information related with electrical energy usage using Bluetooth energy meter [5]. They proposed two methods to retrieving the details from meter that are Automatic Meter Reading (AMR), where it transfer stored household energy usage information in certain period of time to a ‘wirelessly’ connected reader such as personal computer (PC) whereas another method is Automatic pulling mechanism (APM) which is used to poll each Bluetooth reader to communicate with PC to get the meter reading of household appliances. The microchip micro-Controller used as connector to interface with Bluetooth blueEz meter from CSR and Analog device. The Bluetooth-Enabled Energy Meter also used in other applications such as use PDA as a Reader, Data Collection via Fixed-line Telephone Network and also by using GSM Modem. This devise really helps to safe cost and time as compared to the conventional method of getting the meter reading.
2.5 Research on an Implementation and Evaluation of the Apparatus for Intelligent Energy Management to Apply to the Smart Grid at Home.

Smart grid system based on Advance Metering Infrastructure (AMI) is used to record and control the energy usage by using demand response technique [6]. This paper analyzed the impact of energy saving based on the change of price and its verification through lighting control system. This smart controller operates as a smart lighting controller at homes where it is installed with lighting devices. The demonstration system is consists of three smart controllers connected lighting devices as an electric appliance which does not support the smart grid capability and is operated with the AMI. The device also communicated with PC, network module and smart controller that interface with electrical equipment. Smart controller is placed between illumination and plug, illumination power to get the detail of energy usage cost from PC that performs as AMI. If the energy unit cost high, it will cut off the power and return to normal after certain time. The function of smart controller is based on smart grid concepts where the more the load increases, the more the price of electricity rise in smart grid. This research propose TOP condition consist of Low, Medium, and High state. When the price is in the "Low" state, a user can choose any one of illuminations, in case of the "Medium" state, the incandescent lamp will be turned off whereas when the price is in the "High" state, the user only makes use of the fluorescent tube.

2.6 Conclusion

As a conclusion, journal reviews that have been done give more understanding regarding the project. This gives guidance on how to design the system and what type of upgrading can be made to make my project better than previous project. Besides that, journals help to do research on components that are required to develop an electrical ‘Energy Demand Response Control Interface’ for domestic usage which has many similarities with the project that had been developed. This project is mainly differs from the usual or normal power meter where it only able to measure and provide the power input and usage level. This device also able to measure the normal domestic load level and presents in on the LCD panel that been attached. Other than that, the device owns the capability of controlling the power usage of the residential by itself.
CHAPTER 3

METHODOLOGY

3.1 Project Methodology

This part explained about the methods used in conducting the project in more efficient and systematic way. Figure 3.1 shows the flow chart of the methodology.

![Flow chart of the methodology](image)

Figure 3.1: Flow chart of the methodology
In order to achieve the objective of the project, the first step need to consider is a comprehensive reading and literature review on ITMBS system, an electronic meter, Bluetooth energy meter and microcontroller. Next, the most important step need to be considered is the hardware and software familiarization. Hardware that is used in this project includes current sensor and microcontroller whereas the MPLAP software is used for the microcontroller programming. After that, the process is continues with designing and developing the demand response controller using current sensor, PIC, relay, liquid crystal display, and push button. Simulation is done for the system by using Proteus. Once the hardware and software development was done, the software was programmed into the Microcontroller and integrated into the hardware. The system was troubleshoot to detect any problem and once the rectification is done, system will be integrated again and observation continues. Then, analysis is done to obtain all the results and data related in developing the demand response controller. At last, the final report was prepared.

3.2 Divide the Work Packages (Phase)

Phase 1: Project analysis

- Gather information regarding the project by reviewing journals, books, previous projects, and also website. This information is very useful to complete the project proposal.

Phase 2: Software development

- By using computer simulation software (Proteus), the control interface hardware to detect the overload energy is designed.

Phase 3: Hardware analysis

- Research and study about the components that are going to be used in developing demand response system.

Phase 4: Hardware development

- To test the hardware and software that is being developed and troubleshoots the system if any problems occur.
3.3 Project Development

The Figure 3.2 and Figure 3.3 show about process involved in developing the ‘Energy Demand Response Control Interface’ for domestic usage.

First of all, in normal residential connection, the main supply from TNB line is connected to distribution box (DB) which distributes electricity directly to the loads. But in this project, the normal connection is upgraded by fixing current transformer at the middle of connection between TNB line and distribution box. This is to ensure that the current and frequency input in the range 0-50A and 50/60Hz and measures output dc voltage in the range 0-5V to PIC.

There are two main inputs in PIC that is, keypad and push button which are used to set the total household power usage measured in kilowatt (kW). Push button that we are using has 3 options. First option is do nothing meaning that the customer do not care if overload occur as they still need the electricity. Second option is off the circuit for certain period such as, example from 6pm to 10pm the circuit is off by press the button. This option is based on TNB request to save household energy usage. And the third choice is off partially meaning that off either one load for certain period.

Therefore, whenever the load generated exceed the normal value or demand increased, LCD will display the kW value and set the trigger point. Then, PIC will sense the trigger point and alarm circuit is activated to create sound signal. This signal in turn triggers either load 1 or load 2 or load 3 to be in off mode. This is done by using relay which will deactivate the load using timer until the kW value returns to normal again. For example, let said even though after one hour the timer running, but the load still not reduces, therefore it will change automatically from load 1 to load 2 or load 3 for another one hour until the kW value returns normal and also it will continuously communicate with PIC the change in circuit automatically.