Demand Side Management Using Direct Load Control for Residential

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Abstract - **Dramatic increase in the number of domestic consumers due to mass electrification will have implications for the national generation, transmission and distribution. The nature of the domestic load coincides with the evening peak which is more expensive to generate. This indicates the need for Demand Side Management (DSM) in residential as a strategy to reduce the impact of domestic peaks on the national electricity load and related costs. This paper describes the software development written in Visual C++ 6.0 to control directly the residential loads through communicating with parallel port. Graphic User Interface (GUI) was designed for the software. Comparison was done between load curve without controller and with controller. The result shows a reduction in energy consumption with the application of DSM controller. Hence, DSM application improves the management of both power and energy consumptions.**

I. INTRODUCTION

DSM encompasses the entire range of activities such as planning, implementation and monitoring that influence the pattern and magnitude of a utility's load. DSM is a method of containing and reducing the overall cost of energy.

By establishing DSM program, residential consumers should aim to conserve all forms of energy by eliminating waste and encouraging the efficient use of energy. The financial benefits of successful demand side management can be quite large. DSM program is a means of reducing operating costs, increasing profits and remaining competitive. In non-profit organisation such as government utilities, hospital and university, DSM can be a way to stretch a very limited budget.

Electric utilities are responsible for the supply of electric power to its consumers in whatever amount they wish to purchase at whatever time they desire. Electric utilities are also responsible to ensure the availability of this power at the most economical cost at acceptable standards and high level of reliability. Utilities had started looking forward to reduce their peak load demands since decades ago in order to decrease the need for future capacity additions and to reduce the high fuel costs of serving these peak demands. Utilities also went to increase off-peak valley-hours load demand to improve the utilization of facilities and thereby reduce the overall cost of electricity. DSM includes the ability of the electric utility to interrupt load so as to reduce demand when needed system reserves and hence cost can be reduced.[1,2,3]

Demand side is part of the energy system that is associated with the final energy users. This part of the system is normally not controlled by the energy supplier. For the power system, the demand side starts beyond the electric meter and consists of energy appliances and surrounding energy related installations. The energy demand is determined by the energy users' need for energy-related services such as light or a specific indoor climate. The Demand-side management methodology states that the purpose of energy efficiency activities is energy conservation.

Electricity is characterised by the fact that its production and consumption act nearly at the same time. As we know, electricity cannot be stored in large quantities. This means that power generation must match demand alteration, whereas demand is affected by climate, economic growth and customers' consumption patterns. These factors make the demand to fluctuate at different time. Utility must invest in the generation plant and equipment to keep enough net peaking capability according to the system maximum demand. If we do not impose any system measures, there will be serious imbalance in power supply and demand. Excessive or insufficient investment will lead to idle asset or create power shortage problems that will be uncomfortable to both suppliers and customers. The system referred to the "Demand Side Management".

This paper describes the software development written in Visual C++ 6.0 to control directly the residential loads through communicating with parallel port. Graphic User Interface (GUI) was designed for the software. Comparison was done between load curve without controller and with controller. The result shows a reduction in energy consumption with the application of DSM controller. This project aimed at developing a DSM program that evaluates the potential and cost savings of applying direct load control schemes in a residential sector.

II. IMPACT OF DSM ON RESIDENTIAL CONSUMERS

Although the domestic sector in Malaysia consumes only 18% of the total electricity delivered, the nature of the domestic load coincides with the evening peak that is more expensive to generate. This indicates the need for Demand Side Management.

It is interested particularly in residential DSM as a strategy to reduce the impact of domestic peaks on the national electricity load and related costs. This is because Tenaga Nasional Berhad (TNB) foresees that the dramatic increase in the number of domestic consumers due to mass electrification will have implications for the generation, transmission and distribution load curves. TNB has thus identified energy efficient lighting program as one of the ways to achieve energy savings in the residential sector.

These demand side management strategies and interventions are more cost-effective than the conventional alternatives such as investment in additional power plant. The fact that inhibits the implementation and use of such strategies and interventions is the high initial cost and the poor especially will face the most difficulty.

By using a systematically approach to setting up a DSM program, it is possible to identify the quantities and specific uses of energy consumed and provide a base for comparison over time.

Doc6Load management and energy conservation are currently being considered and adopted by both governments and public utilities around the world in order to cope with the increasingly common situation of limited capacity additions facing, however, a continuously growing demand.

III. CONTROL STRATEGY

Fig. 1 shows the feedback control strategy [1].

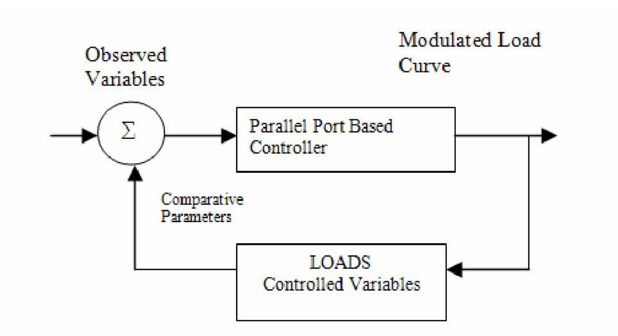

Fig. 1: Feedback Control

The control variables used in the control process are as following:

Observed Variables:
Power (daily target)
Energy (monthly target).
Luminescence (lighting circuits)
Temperature (air conditioning load)

Controlled Variables:
Loads chosen to be controlled can either be lighting, motor, PC, refrigerator and other home appliances. The control action consists of turning them on or off.

Comparative Parameters:
The standard value for luminescence (320 lux) and pre-defined values for temperature (21° C) were considered.

The developed controller consists of a parallel port in the motherboard of a computer, which manages the residential demand of electrical energy, taking into account the equipment, such as light bulb (lighting circuits), lamp box, and AC motor.

IV. PROGRAM FLOW CHART

The program flowchart used to develop the program code written in Visual C++ 6.0 is shown in Fig. 2.

V. EXPERIMENTAL SET-UP

Figure 3 shows the block diagram of the system. The interfacing circuit between the pc and load mainly consists of Opto-coupler, and fuse. Opto-coupler is used to isolate the Alternating Current source and Direct Current source. Figure 4 shows the experimental set-up which was carried out in Makmal Sistem Tenaga, Universiti Teknologi Malaysia.

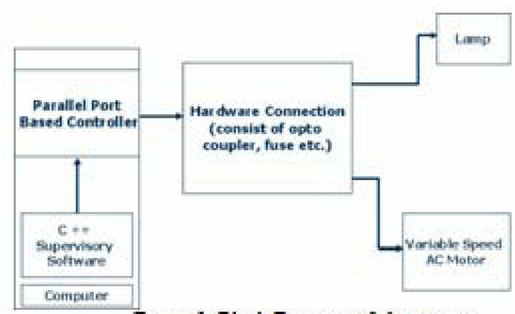

Figure 3: Block Diagram of the system

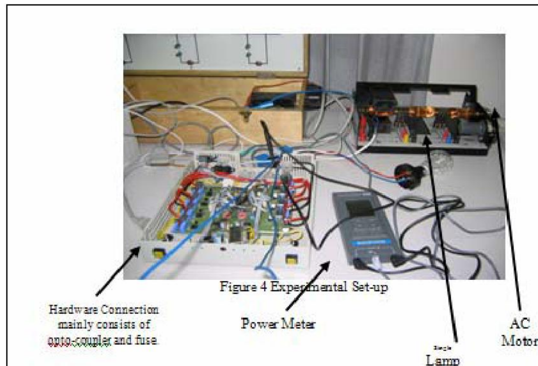

Fig. 4: Experimental set-up

VI. RESULTS AND ANALYSIS

The test was conducted from 9.00am to 5.00pm and the data was taken at every half hour. Table 1 shows the measurement of the data taken during the experiment.

Using power target as 300W, the load curve without controller and load curve with controller were plotted to show the reduction of power and energy consumption. The load curve without controller and load curve with controller were shown in Figure 5. The energy consumption is equivalents to the area below each curve. Therefore, the cost saving can be obtained by the difference of energy consumption between two load curves as shown below. In general the percentage energy saving in every household is 5 to 10 %

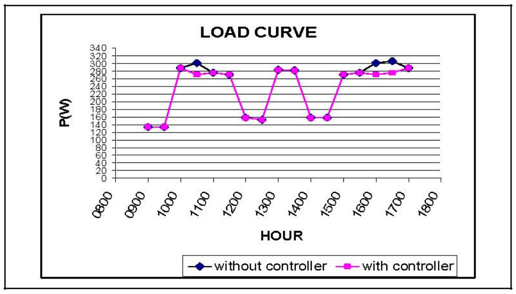

Fig. 5: Load Curve

TABLE 1

MEASUREMENT OF POWER

Data measurement without controller		Data measurement with controller	
HOUR	P(W)	HOUR	P(W)
0900	134.2	0900	134.2
0930	134.2	0930	134.2
1000	288.3	1000	288.3
1030	301.4	1030	271
1100	276	1100	276
1130	271	1130	271
1200	158.4	1200	158.4
1230	153.4	1230	153.4
1300	283.3	1300	283.3
1330	282.3	1330	282.3
1400	158.4	1400	158.4
1430	158.4	1430	158.4
1500	271	1500	271
1530	276	1530	276
1600	301.4	1600	271
1630	306.4	1630	276
1700	288.3	1700	288.3

VII. CONCLUSIONS

The reduction of energy consumption was obtained by the controller action. The controller compares experimental data with the power target and energy target respectively, thus switching the corresponding loads. The load curve of off controller and load curve with controller showed the reduction of energy consumption.

This shows that the controller was able to fulfil the power target by turning off a particular load according to the priority list.

VIII. REFERENCES

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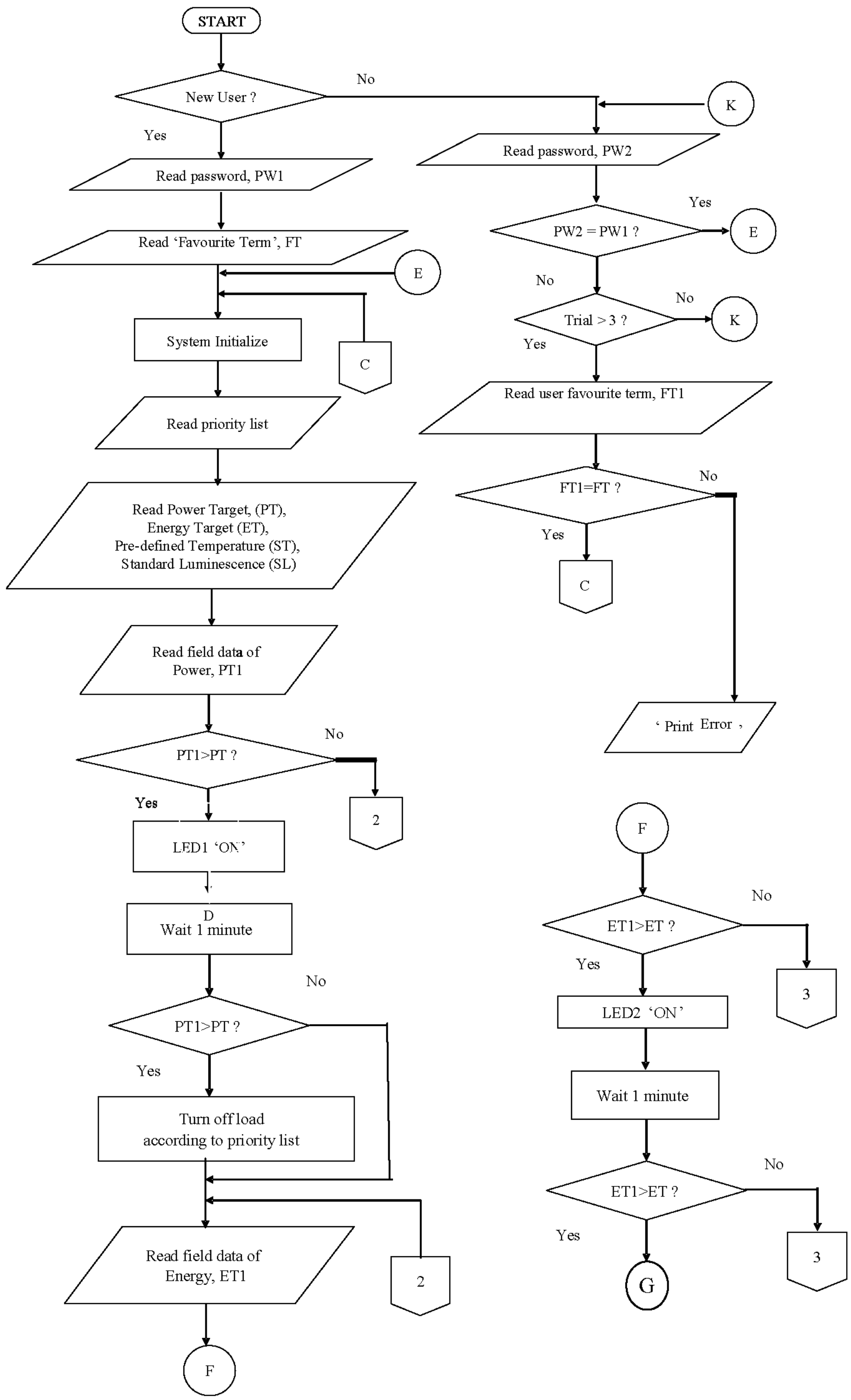

Fig. 2: Project Flow chart

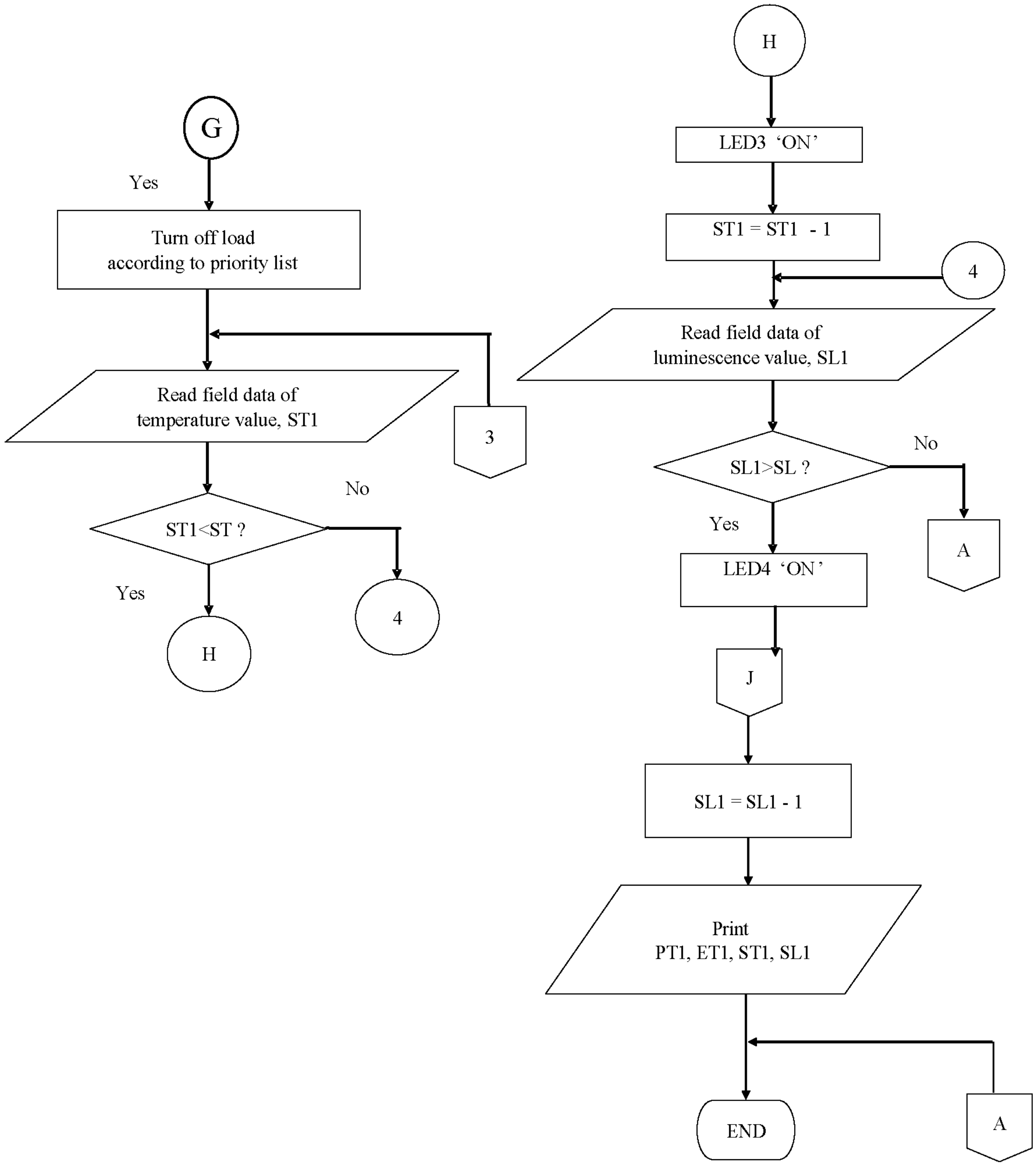

Fig. 1: Project flow chart (cont..)