A Peak-Shift Control Method for Charging and Discharging of the Battery in an Ultrabook

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***Abstract*—As the electricity rates during peak hours are higher, this paper proposes a method for an ultrabook to automatically shift the charging period to an off-peak period. In addition this design sets an upper limit for the battery which thus protects the battery and avoids its remaining in a state of continued high voltage. We use a low-power embedded controller (EC) as the main control part together with RTC ICs. The sensing value of the EC and the presetting of parameters are used to control the conversion of the AC/DC module. Our user interface design allows the user to set the peak/off-peak period and the upper limit of the battery. The design also controls dynamically both the charging current and the charging voltage, in accordance with the temperature of the battery. In this way our design extends the life of the battery.**

I. INTRODUCTION

Summer, the annual peak period of power consumption, causes the electricity bill to go up. Our concept of the peak shift is to let an ultrabook shift the charging period to an off-peak period not only to reduce the bill but also to help reduce the demand for electricity at peak periods [1].

There is a rechargeable battery in an ultrabook system which is activated if the system operates without an AC power source. The controller automatically switches the hardware circuit to the battery mode. If the system is plugged into an AC power source, the controller automatically switches it to the AC mode [2].

In addition to an automatic shift of the charging period to an electricity off-peak period, this design has a second focus which is to lengthen the life of the rechargeable battery. The number of times that a lithium battery charges and discharges is limited. If the battery discharges deeply each time, this discharge reduces its life. For example: a battery of 3 cells, at a full voltage of 12.1V discharging to less than 9.3V, can enter the protected mode against discharging deeply, that is, lower than 9.3V [3].

The design allows the user to set the battery's full capacity upper limit, to avoid its remaining in a state of high voltage. The design further extends the life-span of a rechargeable battery by using the integration of software and hardware modules to prevent it from discharging deeply. When the electricity peak period begins in the summer, this design makes use of the ultrabook with the aim of reducing the use of peak electricity energy, and thus reduces the electricity bill and extends the life of the battery [3].

II. SOFTWARE DESIGN

This design includes two modules in the ultrabook system: the hardware module and the software module. The hardware module lets the EC control switch the AC/DC circuit and when necessary adds the RTC IC to provide daily accurate schedule control. The block diagram of this is shown in Fig. 1.

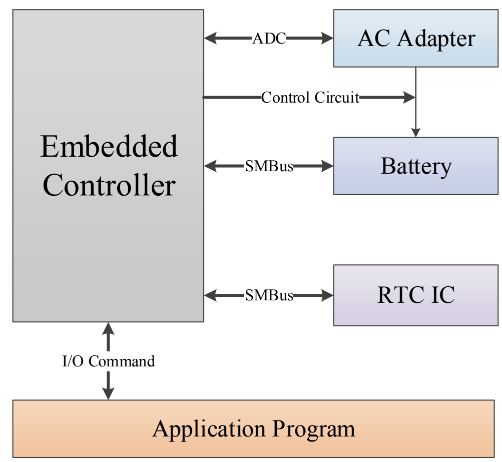

Fig. 1. System architecture of the EC and application program.

For the software module we have designed an application program which allows the user to set both the peak/off-peak period and the upper limit of the battery charge. The flowchart of the peak-shift control method is shown in Fig. 2.

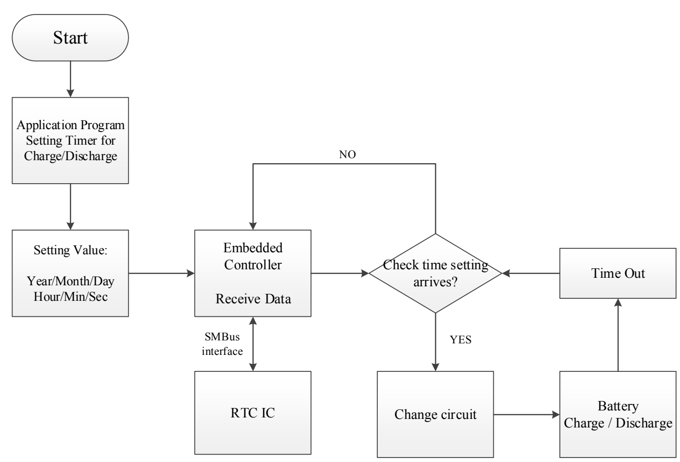

Fig. 2. Flowchart of the peak-shift control method.

That EC can daily be adjusted accurately from the peak/off-peak through the RTC IC. The peak-shift control method automatically controls, based on the AC/DC circuit, the set parameters of the rechargeable battery and the peak/off-peak period of the system. The application program has been designed with Visual C ++, which lets a user's interface control the rechargeable battery to charge/discharge automatically according to different operating settings and schedules.

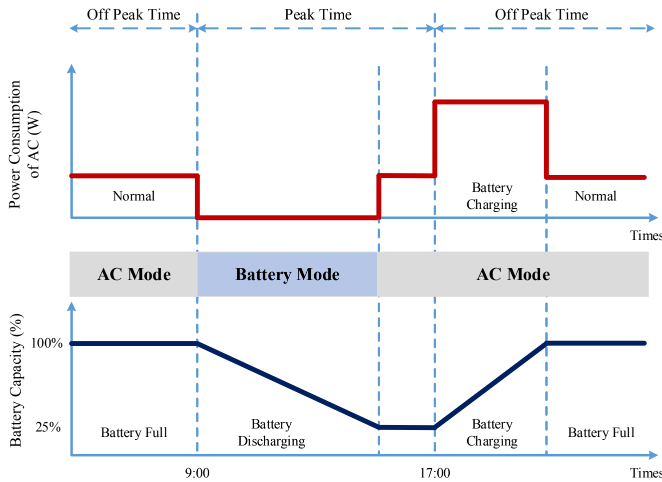

Fig. 3. Power consumption of the peak-shift control method.

Fig. 3 shows the operation parameter settings for the peak-shift control method. The off-peak time is 17:00-09:00 and the peak time is 09:00-17:00; the upper limit of the battery capacity is 100%, and the battery capacity when it is beginning to be charged is 25%. These settings are our default values. Different settings may be set for different ultrabooks.

Table I shows the different temperatures with respect to different charging conditions. If the temperature of the battery is raised, the design reduces the battery charge voltage, so the battery will not be in a state of high voltage. The setting also includes different settings of the charging current with respect to different temperatures.

TABLE I
BATTERY CHARGING VOLTAGES AND CHARGING CURRENTS AT DIFFERENT TEMPERATURES

Battery temperature	Charging voltage	Charging current
0°C - 10°C	12.6V	0.45A
10°C - 20°C	12.6V	2.25A
20°C - 45°C	12.6V	3.0A
45°C - 55°C	12.0V	2.25A

III. RESULTS OF THE EXPERIMENT

For this experiment we have on ten different occasions we have measured the power consumption of an ultrabook system within 24 hours. The average results of the peak/off-peak period are shown in Fig. 4. After entering a peak period the EC switches the hardware circuit to the battery mode in order to use the battery energy during the peak period. But when the battery has been discharged to a capacity of 25% the EC protects the battery from a deep discharge by switching to the AC mode to provide a power source for the operation. The rechargeable battery cannot be charged until the off-peak period.

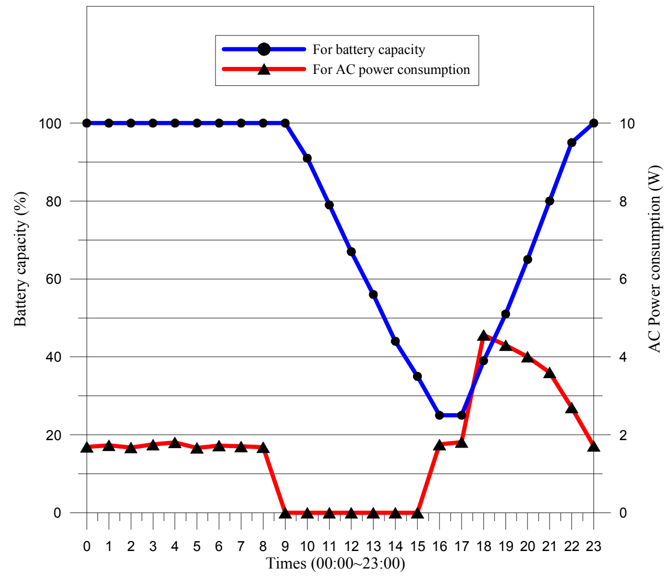

Fig. 4. Power consumption measurements of the peak-shift control method.

Table II compares our method with the previous method. Our design is useful for the rechargeable battery and for the reduction of the electricity bill with an ultrabook.

TABLE II
A COMPARISON OF THE PREVIOUS METHOD AND OUR METHOD

	Previous method	Our method
Dynamic control of battery charge	No	Yes
Protection of the battery (Prevention of high voltage/high current when charging)	No	Yes
Reduced use of peak electricity energy	No	Yes
Reduced electricity bill	No	Yes

IV. CONCLUSION

This design uses the peak-shift control method to reduce both the use of peak electricity energy by ultrabook systems and the electricity bill, especially during the peak periods of electricity demand in the summer. In addition to dynamically controlling both the charging voltage and the charging current, our design sets up different conditions for different temperatures, thus protecting the battery from states of extremely high current and high voltage which may shorten the life of a rechargeable battery. Our method prevents the battery from discharging deeply, which could result in a shutting down of the ultrabook system.

REFERENCE

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