Reduction of the Standby Power Consumption of an Automatic Door System

Cheng-Hung Tsai, Ying-Wen Bai, Po-Chen Chen, Roger Jia Rong Jhang and Ming-Bo Lin

***Abstract*—This paper presents a way to reduce the standby power consumption of an automatic door system in the standby state. When an automatic door system is closed does not mean that it is not consuming electric power. Although it is closed, it still consumes 3 to 5 W of so-called standby power consumption when the system is connected to ac power. In this design the automatic door system consumes 50 mW in the standby state. A more effective circuit design for the automatic door system is proposed to reduce the standby power consumption, which would not affect the function quality.**

I. INTRODUCTION

The main function of an automatic door system is opening when a pedestrian is present, holding the door open for several seconds until no pedestrian is in the detection area and then closing the doors. An active infrared sensor (IR sensor) is mounted on the header of each side of the doors for a pedestrian presence detection area. The door opening/closing function uses a DC motor that provides the high efficiency needed to quickly and noiselessly activate the door. Some designs focus on the efficiency of the motor and the mechanical structure utilized to implement each door's motion. The new sensor will more correctly identify the presence of an individual [1]. Unfortunately, the standby power consumption of previous automatic door systems has not been considered. When the doors are closed and no pedestrian is in the detection area, the system still consumes 3 to 5 W of standby power. As the automatic door systems are common facilities in a building, and as large numbers are used, the standby power consumption is an important factor [2]-[3]. In this paper a new design is proposed to decrease the required standby power amount. The standby power is caused by the IR sensor which has to continuously detect the presence of a person. Both the senor and the motor require dc power to operate. However, most buildings only provide ac power. Therefore an automatic door system includes an ac/dc converter to provide dc voltage for operating the system.

II. HARDWARE MODULE OF THE AUTOMATIC DOOR SYSTEM

The standby power consumed by an automatic door system is mainly that needed by the converter. Hence the converter must be switched off to decrease this standby power. The main concept of this design is, if there is no pedestrian present in the detection area, the system should be cut off completely, so it won't consume any power. If a pedestrian is present in the detection area, the ac power source is activated again to open the doors. Fig. 1 shows the block diagram of the automatic door system. This design consists of an IR sensor module, a MCU, a dc supply module and SSRs. The IR sensor module senses whether a pedestrian is present, and the MCU controls whether the main power SSR (MPSSR) should remain either on or off to enable or disable the DC motor. The DC motor rotates either forward or reverse to open or close the doors. The rotation speed variation and the rotation degrees are caused by the MCU control and the driver. The dc supply module is designed to decrease the standby power of the ac/dc converter and to supply the required V_{CC} when the converter is switched off.

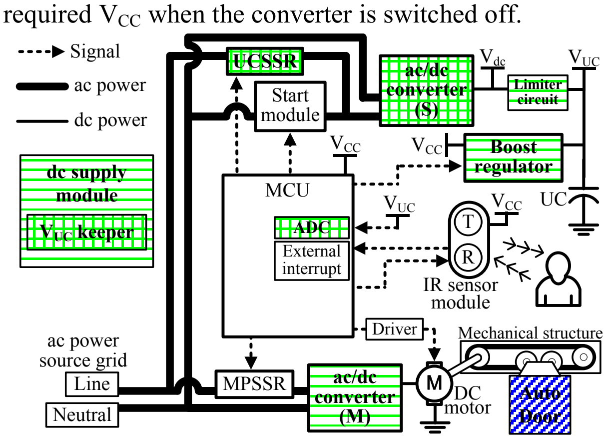

Fig. 1. Block diagram of the automatic door system.

A. *IR sensor module*

The IR sensor module consists of a proximity IR sensor to detect whether a pedestrian is present. The IR sensor module is activated for 20 ms every 0.5 sec by the MCU to reduce the power consumption. The circuit design of the IR sensor module is shown in Fig. 2. The IR sensor module output signal is sent to the MCU external interrupt. If a pedestrian is present, the MCU external interrupt obtains a high level signal. The MCU then enables the ac/dc converter (M) by turning on the MPSSR, that sends dc power to enable the DC motor rotation. The DC motor rotation is designed to drive the mechanical structure to move the doors. Fig. 2 shows the IR sensor module which consumes the standby power of 10 mW. The DC motor rotation power is 100 W when the doors are either opening or closing.

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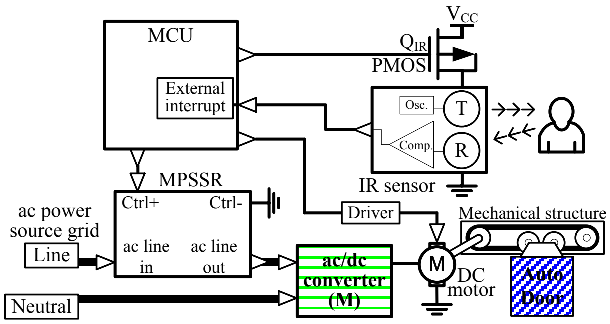

Fig. 2. IR sensor module design.

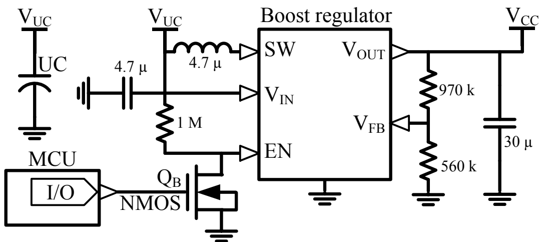

Fig. 3. Boost regulator circuit design.

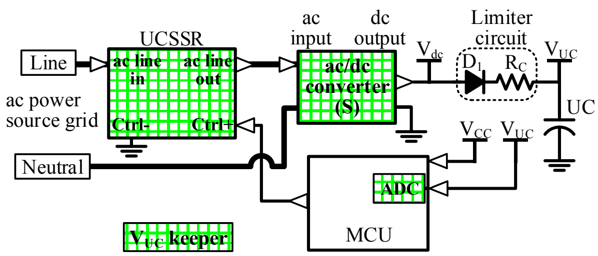

Fig. 4. V_{UC} keeper and limiter circuit.

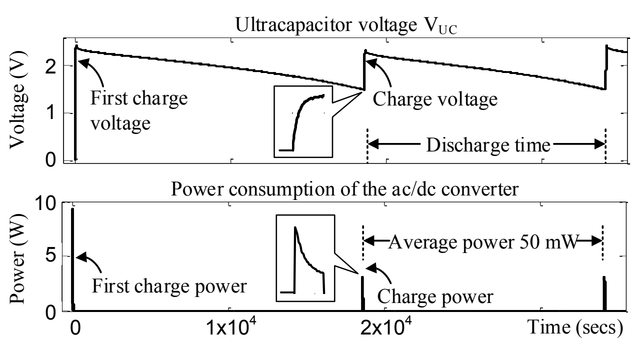

Fig. 5. V_{UC} and power consumption during charge and discharge.

B. dc supply module

The dc supply module provides the V_{CC} for the IR sensor module and dc voltage for the DC motor. The MCU controls both the V_{UC} keeper and the boost regulator which keeps the V_{UC} at the predefined voltage level and boosts the V_{CC} at the fixed level as operation voltage.

1. Boost regulator

Fig. 3 shows the boost regulator circuit. The boost regulator boosts low voltage to support the IR sensor module operation. The UC supports the boost regulator's input voltage (V_{UC}) as a power source. The input voltage V_{UC} can be kept at a sufficient value that outputs V_{CC}=3.3 V. The values of V_{UCmin} and V_{UCmax} are determined by the method [2].

2. V_{UC} keeper and limiter circuit

The inefficiency of the converter (S) is the main reason for having standby power. To overcome this problem we have included the V_{UC} keeper and the limiter circuit which are shown in Fig. 4. The dc output of the ac/dc converter (S) V_{dc} is the power source that provides the UC with a sufficient charge when its voltage V_{UC} is below a predefined value of V_{UCmin}. The limiter circuit is used to avoid any high charge current. The UC charge SSR (UCSSR) is a switch of the ac/dc converter (S) which is controlled by the MCU. The MCU detects the value generated by the ADC to judge when to charge and when to stop charging the UC.

III. MEASUREMENT OF THE POWER CONSUMPTION

Fig. 5 shows the measurement of the V_{CC} and V_{UC} waveform in standby state, with respect to both charge and discharge times. The power consumption of the discharge part is 0 W and that of the charge part is more than 3 W. The charge and discharge of the UC form a cycle whose time is $T_{cycle}= T_{charge}+ T_{discharge}$.

We denote the average power in T_{cycle} as Pw_{ave} and

$$Pw_{ave} = \frac{\sum Pw_{charge} \times \Delta t + \sum Pw_{discharge} \times \Delta t}{T_{charge} + T_{discharge}}, \ \sum Pw_{discharge} = 0 \quad (1)$$

and Δt=0.3 sec, thus $Pw_{ave} = \sum Pw_{charge} \times \Delta t / T_{cycle} = 0.05$ W. (2)

IV. CONCLUSIONS

Although the standby power of an automatic door system is not great, it affects the electricity bill in the long run. This design applies the MCU and the UC control circuit to reduce the standby power to 50 mW, which is also much less than that of other automatic door system. Our design, which is appropriate for automatic sliding, revolving, folding and swing door systems, is both easy to set up, inexpensive, has similar functions, and in the long run, saves more power.

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