Reducing the Standby Power Consumption of a Home Audio System

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***Abstract*—Even though a home audio system is turned off, it still consumes from 1 to 6 W when it is plugged into an ac socket. In this design the home audio system consumes 10 mW when it is turned off and yet plugged in. A more effective circuit design for a home audio system is proposed to reduce the standby power consumption, which would not affect the system's quality. This power consumption in the standby state is lower than that of others and not only simple to set up but also inexpensive.**

I. Introduction

A home audio system is a popular home appliance. The system generally consists of three parts: sound sources (radio/CD/MP3/USB audio player), amplifiers and speakers. The sound sources provide an electrical signal to the amplifiers. The signal is amplified by the amplifiers to drive the speakers which convert the electrical signal back into sound. There is at least one research group which developed a home audio network system in a smart home environment that provides suitable music for different rooms [1]. Better performance audio amplifiers are proposed for cost and power efficiency. These amplifiers need dc voltage to operate by means of a linear regulator. The linear regulator band which provides very low output noise and ripple is very helpful in reproducing high volume sound. But the linear regulator's efficiency is low. There are three states of our proposed home audio system defined in this paper: the cut-off state, the standby state and the power-on state. The cut-off state is when that the audio is unplugged from its ac power source and does not consume any electricity. In the standby state the audio is connected to an ac power source, but the audio is not turned on. In the power-on state the audio is activated, and when pushing the play button, sound is reproduced. Though the audio system in the standby state is not performing its main function of acoustics, it is often performing some internal functions like sensing remote signals and coordinating with the built-in microcontroller while awaiting user commands. These internal functions require power to operate, and the power consumption used by the audio while in the standby state is referenced to as "standby power" in this paper. "Standby power" first originated because these internal functions require not only a specific low dc voltage to operate but also continuous power supplied by the linear regulator which cannot be switched off, and that means that the power is not completely cut off when the audio system is in the standby state. The audio system consumes from 1 to 6 W or even more, which is many times more than the power actually used for the internal functions. The standby power of a home audio system draws power 24 hours a day. This amount is typically small, but it really adds up and still represents an important issue. Many electric appliances have standby power consumption amounting to around 10% of a household's total power. Therefore much research has been done into reducing standby power consumption both in appliances and in equipment by way of home energy management systems which both monitor and control the devices and are based on complex architecture. As the home audio system is a common appliance, huge numbers of them are used. Thus their standby power consumption is an important factor which cannot be ignored. In this paper a design is presented to reduce the standby power consumption of the home audio system [2] [3].

The organization of this paper is as follows. Section II describes the circuit designs for the reduction of the standby power consumption. Section III shows the measurement of the power consumption of the design to verify the total power saved, and a comparison with and without this design. Section V is both a conclusion and a summary.

II. Circuit Design Of The Ultra-Low Standby Power Home Audio System

In general the home audio system is plugged into an ac power source. The standby power consumed by the audio is mainly that needed by the linear regulator. The regulator consists of a line frequency step-down transformer, a bridge diode, series-pass element and a feedback control which together accommodate the regulated secondary voltage, as depicted in Fig. 1.

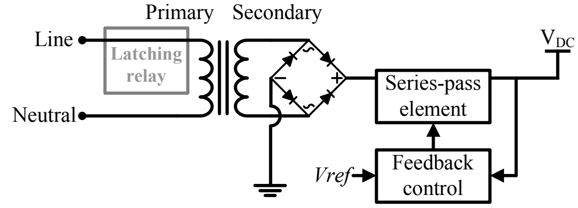

Fig. 1. Block diagram of the linear regulator.

The primary side wirings of the linear regulator always cause power consumption. In order to reduce this standby power the regulator must be turned off. The main concept of our design is that if the audio is turned off, it should be completely cut off so it won't use any unnecessary power. All ac power can be cut off completely by means of a latching relay, as shown in Fig. 1. When the power button is not pressed, it is not being used and thus the ac source power should be completely cut off by the latching relay, thus reducing the standby power to zero. If one wants to use the audio, the first action is to press the power button. The ac power source is connected, and the audio is in a power-on state. If the power on button is pressed again to turn the audio system off, the linear regulator is cut off from the ac power, as if the audio were unplugged. Many home audio systems include a remote controller for the convenience of the user; the power button is on both the audio and the remote controller. The block diagram of the ultra-low standby power home audio system described here is shown in Fig. 2.

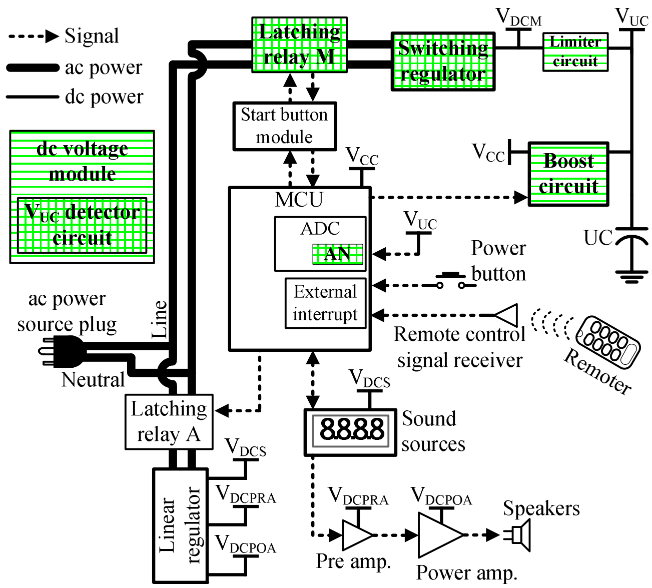

Fig. 2. Block diagram of this design.

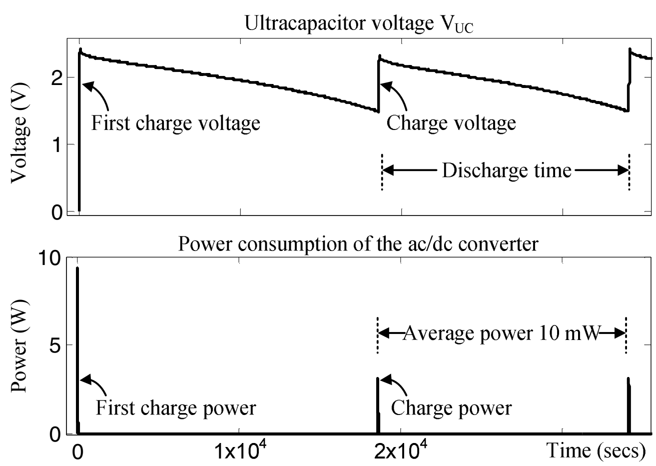

Fig. 3. V_{UC} and power consumption during charge and discharge.

The output voltages of the low ripple linear regulator are denoted as V_{DCS}, V_{DCPRA} and V_{DCPOA} that provide the audio system operation to reproduce sound. The output voltage of the efficiency switching regulator is denoted as V_{DCM} which supports both the MCU and the dc voltage module operation which are used to reduce the standby power. The V_{DCM} is the ultracapacitor (UC) charge source, the UC voltage is the V_{UC} which is the input of the boost circuit, and the output voltage of the boost circuit is the V_{CC}. The V_{CC} is the required operation voltage that supports the MCU and the operation of other modules. When the V_{UC} detector circuit detects that the V_{UC} is below a predefined value of V_{UCmin}, the V_{DCM} provides the UC with a sufficient charge. The start button module is designed to charge the dc voltage module when the audio is initialized. The remote control signal receiver detects the remoter signal. The operations of the audio, such as amplifiers and speakers, do not warrant a detailed description in this paper because those components would utilize a more mature technology circuit design.

III. Measuring The Power Consumption Of This Design

In this design the standby power of the linear regulator used in Fig. 1 is 1 W; the V_{UC} and the ac power consumption with respect to charge and discharge times are shown in Fig. 3.

The power consumption of the discharge time is 0 W. The charge and discharge of the UC are a cycle whose time in the standby state is more than 8 hrs. The percentage of improvement is 99.99 %.

$$T_{cycle} = T_{charge} + T_{discharge}\,. \tag{1}$$

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

$$Pw_{ave} = \frac{\sum Pw_{charge} + \sum Pw_{discharge}}{T_{charge} + T_{discharge}},\ \sum Pw_{discharge} = 0 \tag{2}$$

thus $Pw_{ave} = \sum Pw_{charge} / T_{cycle} = 0.01$ W. (3)

TABLE I
Comparison Of Power Consumption Of This Design

Type	Standby state power	Power on state power
With this design	0.01 W	6 W
Without this design	1 W	6 W

IV. Conclusion

Although the standby power of a home audio system is not great, it affects the electricity bill in the long run. This paper proposes a new circuit design which reduces the standby power substantially. Moreover, the power consumption is much less than that of any other home audio system with a linear regulator. This new design only consumes 10 mW and is both easy to set up and inexpensive. In the long run our design saves more power whilst the performance of the audio remains unchanged.

Reference

[1] Taewan Kim, Sang Hoon Hong, and Yunmo Chung, "A Hardware Framework for Smart Speaker Control of Home Audio Network," *IEEE Trans. Consumer Electron.*, vol.54, no.4, pp.2506-2510, Nov. 2010.

[2] Ying-Wen Bai, and Yi-Te Ku, "Automatic room light intensity detection and control using a microprocessor and light sensors," *IEEE Trans. Consumer Electron.*, vol.54, no.3, pp.1173-1176, August 2008.

[3] Cheng-Hung Tsai, Ying-Wen Bai, Chun-An Chu and Ming-Bo Lin, "Design and Implementation of a Socket with Zero Standby Power using a Photovoltaic Array," *IEEE Trans. Consumer Electron.*, vol. 56, no. 4, pp. 2686-2693, Nov. 2010.