AZD082 - How capacitive sensing can reduce standby power in household appliances to well below 50mW

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1. Introduction

The consumer electrical appliances that are found in virtually every household, such as microwaves, personal computers and television sets, consume a significant amount of power when left in standby mode or even when switched off. Strict regulations are being set in place to limit this standby power, which is said to have exceeded 20 GW in the residential sector of industrialized countries. Standby power consumption has become one of the largest individual electrical end uses of the residential sector, averaging at 10% (60W per home) [1] of the average power usage of households.

This article will show how to reducestandby power to well below 50 mW, while at the same minimizing cost/complexity and extending the product’s expected life. Special attention is given to capacitive proximity sensing, which allows the designer to add a substantial amount of intelligence – waking up and enabling the electronic device only when required and permitting a visual indication to the user of what is required to access the specific features of the device.

2. The culprits

The term ‘off’ has become an increasingly relative one as far as electronic appliances are concerned and can refer to the many lower power modes of modern electronic devices. The most popular low-power modes currently in use include standby, sleep, standby active and soft off mode. For the purposes of this article,all non-active modes in which the device is not performing its primary function will be referred to as standby mode.

Almost any product with an external power supply, LED or display that runs continuously, a remote control, a battery-charging functionality or any type of monitoring functionality will draw power continuously. Table 1.1 provides a condensed overview of some of the most common household appliances, together with their typical standby power consumption.

Table 1.1 Typical household appliance standby power consumption [2]

Appliance	Typical standby power consumption	Contribution to total household standby power consumption
Major appliances	1.4W	13%
Televisions	3.6W	7%
Set top boxes	12.1W	4%
Other home entertainment	3.9W	20%
Computers and peripherals	5.2W	30%
Telephones and other office equipment	3.6W	8%
Monitoring and continuous appliances (alarm systems etc.)	1.1W	10%
Other products	0.4W	5%
External power supplies	1W	N/A (distributed across the device range)

3. Addressing standby power consumption

There are in essence three broad strategies available to reduce the standby power in household electrical appliances:

1. **Social education**. Educating the public on what to look for when purchasing an electronic appliance, as well as encouraging users to unplug devices not in use.
2. **Technological innovation.** This involves the implementation of innovative technology to improve the efficiency of power supplies, thereby minimizing the power consumed in relation to the functions being used.
3. **Intelligent device behavior and interaction.** This deals with the intelligent activation of low-power modes through user monitoring.

Social education has its practical limits. Even technological innovation has its practical limits in terms of cost and what is possible given the energy required to keep circuit blocks active.

The third strategy is where the author believes room exists for dramatic improvement in terms of intelligently choosing to disable certain functionality based on whether the user is present or not. In the following section, a few general, yet powerful, suggestions and examples are given of user detection and the successive enabling/disabling of electronic circuits.

4. Intelligent low-power modes with capacitive proximity sensing

Traditionally, low-power modes are activated after a certain fixed delay, this time being dependent on the device. However, in many appliances this often limits the usefulness of and features presentable to the user. For example, it is highly desirable to display the current status or time on many appliances, such as ovens, microwaves and DVD players, but only to do so when the user is in proximity of the appliance in order to conserve energy.

Intelligent low-power modes with capacitive proximity sensing are implementable due to the extremely low power consumption (in the order of 3-10 uA) [3] of the sensors that are available in the market today, as well as the low implementation cost. Figure 1.1 illustrates the capacitive proximity sensing principle in which a low-cost PCB copper pour acts as a sense pad to detect the presence of the user. Detection distances of up to 10 cm are easily obtainable, while up to 30 cm and more can be obtained with special attention to the electrode design.

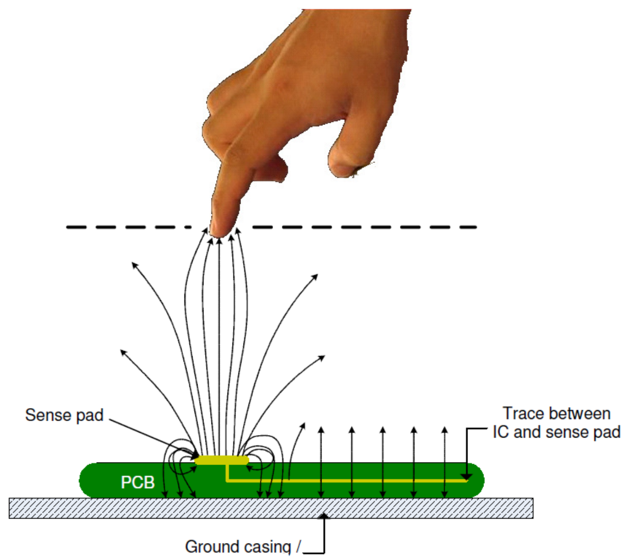

Figure 1.1 Capacitive proximity sensing with a sense pad on an inexpensive PCB.

Detecting the presence of a user enables the design engineer to easily add and implement various features, while at the same time requiring lower standby power, as illustrated in Figure 1.2.

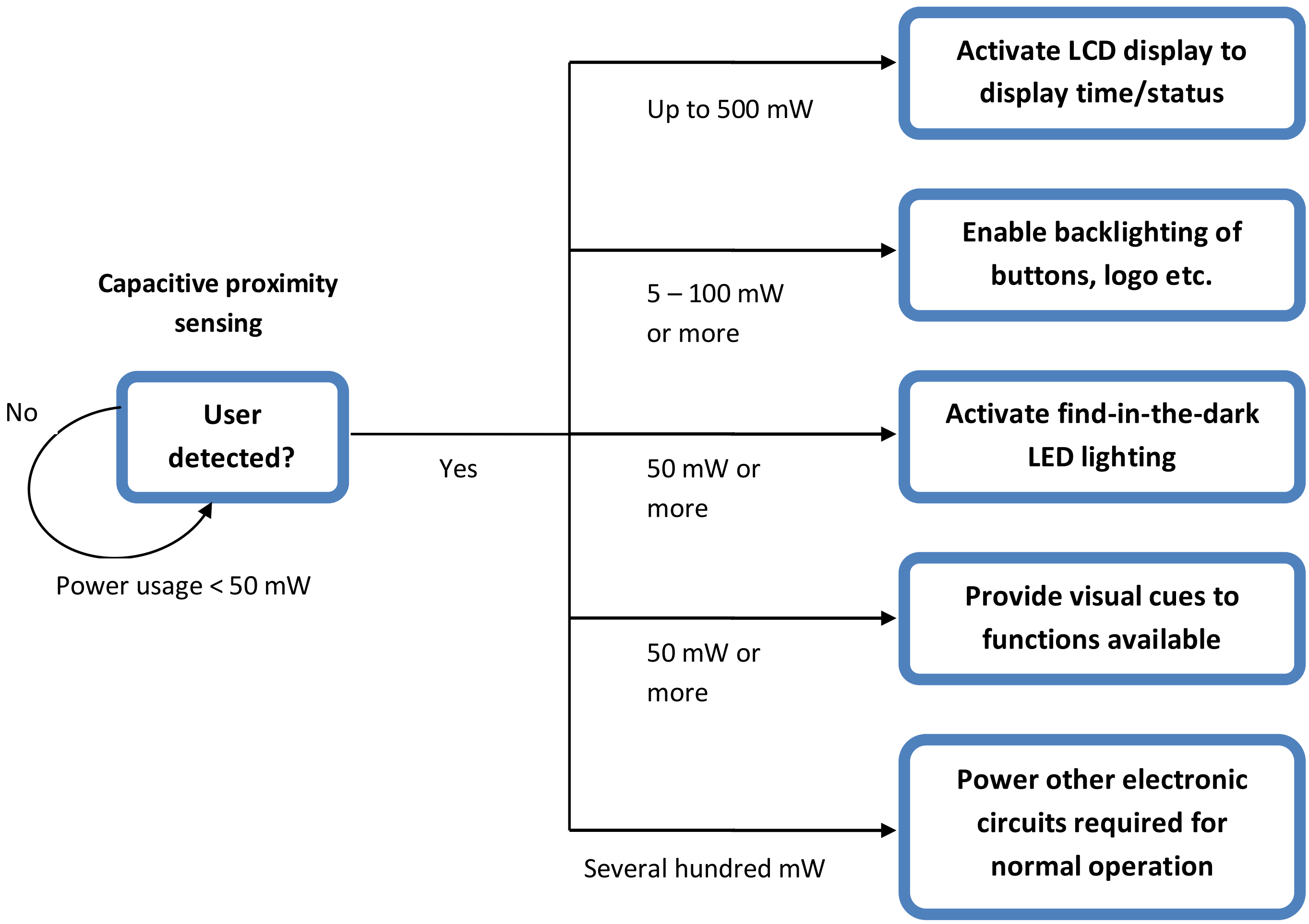

Figure 1.2 Intelligent power saving by enabling various functionality only when needed.

Again, the designer has several options to consider in relation to the manner in which the proximity detection information is used to activate the low-power modes. Capacitive proximity sensing ICs are available with direct outputs as well as I2C-compatible data interfaces [4], which easily allow them to either directly disable parts of the electronic circuit or to be connected to a microcontroller if available. Another option to consider is that modern SMPS controllers have standby and disable input pins that can be connected to the capacitive proximity sensing device. Practical implementation methods are illustrated in the section that follows.

5. Practical implementation methods using popular SMPS controllers

A few practical and generic examples of how to implement low standby power household appliances are provided, together with rough estimates of the improvement that can be expected in this regard. In each case a capacitive proximity sensor from Azoteq is used to detect the presence of the user.

5.1 Secondary side display and LED lighting enable/disable

LCD displays and LED lighting are always active on household appliances when the device is plugged in, and often unnecessarily so. When the user's presence is not detected it is advantageous to disable these energy consumers. Figure 5.1 illustrates this concept where a typical LCD display is enabled/disabled by the microcontroller,based on data received from the capacitive proximity sensor. A microcontroller is used in conjunction with an IQS232 single-channel capacitive touch and proximity sensor from Azoteq.

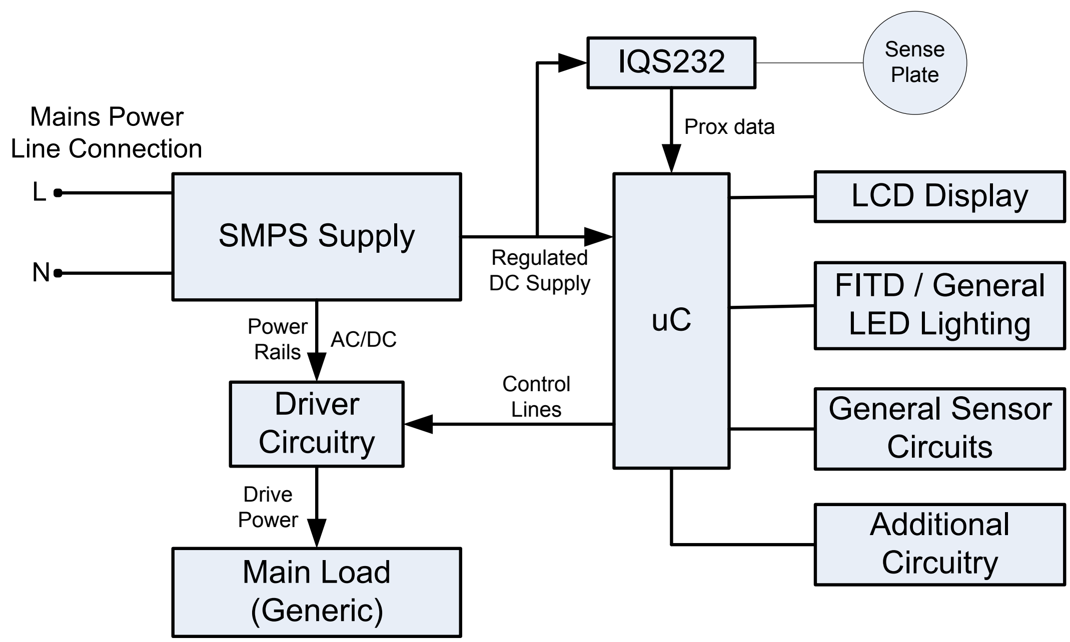

Figure 5.1 Secondary side display and LED lighting enable/disable with capacitive proximity sensing.

Standby power saving includes:

- The LCD can be switched off completely: up to 500 mW power savings if a small LCD color display is used.
- The LED backlighting and find-in-the-dark lighting can be disabled: the power savings possible can range from a single 5 mW LED to several LEDs totaling 100 mW or more.
- If an interrupt input pin of the microcontroller is connected to the direct output pin of the IQS232, the microcontroller can be halted during periods of user absence, adding another potential 50 mW power saving.
- The power consumption of the IQS232 is negligible, averaging 4 uA in its lowest power states.

A total standby power saving of well over 600 mW is possible. Considering that the typical SMPS supply powers the devices with an optimistic efficiency of 70% (note that this is typically not at full load, when the supplies are most efficient), it is clear that the power consumption will far exceed the typical requirement of 300 mW stipulated by most regulatory agencies (Energy Star V2.0).

It is clear that even with a power supply that is 100% efficient, the need to intelligently disable functionality without detrimentally affecting the functionality of the appliance is critical.

5.2 Disable the SMPS controller

As stated previously, many modern SMPS controllers have disable or power-saving logic input pins that, when activated, lower the standby power to virtually zero. This is often a better alternative to disabling the supply as a whole when either limited intelligence exists on the secondary side or when a cost-effective supply with poor efficiency is used. In this example, the TopSwitch constant voltage SMPS controller from Power Integrations is used together with the IQS232 single-channel capacitive touch and proximity sensor from Azoteq.

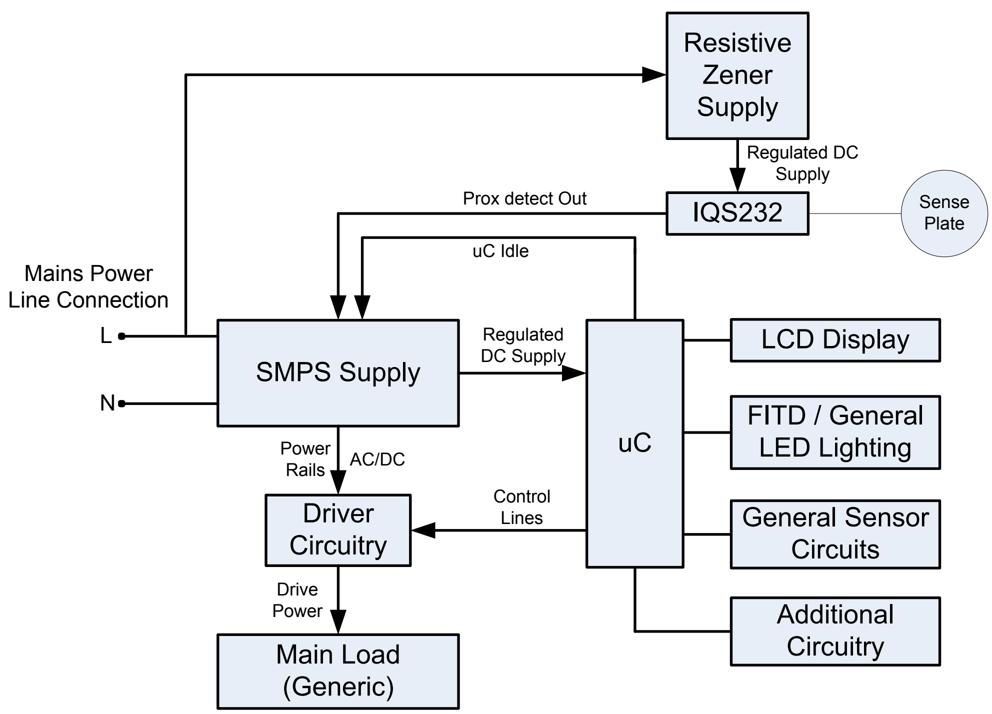

Figure 5.2 Illustrating standby power saving by disabling the SMPS controller IC.

Standby power saving includes:

- The potential standby power saving of the SMPS alone (with no secondary side power consumption), which can range from 100 mW to over 1 W, depending on the SMPS controller used. With the TOP265EG used in this example, the standby power saving averages 180 mW at 110 V and 100 mW at 220 V.

- The IQS232 being powered through a simple resistive network from the primary bus voltage. Considering the power consumption in one of its low-power states, the estimated power consumption becomes 3.1 mW at 110 V and 6.2 mW at 220 V.

Even if an inefficient SMPS is used, or in the case of constant current SMPS supplies where the standby current is necessarily high, extremely low standby power figures at low cost are possible by intelligently detecting the user's presence with a capacitive proximity sensor.

6. Conclusion

Standby power consumption in households is being targeted by governments and regulatory agencies worldwide as a substantial and unnecessary power loss. A considerable amount of pressure is being placed on electronic design engineers of household appliances to meet the requirements of regulatory agencies and governments, while at the same time keeping production costs to a minimum.

In this paper, cost-effective methods for improving the standby power consumption of typical household appliances by means of capacitive proximity sensing were discussed. A considerable number of options for improving the standby power become available simply by knowing when the user is within proximity of the appliance, as has been illustrated clearly.

Additional benefits of capacitive sensing include visual indication of the subsequent expected user interaction when the device is being approached, as well as informative display options at the appropriate times when the user is present.

In a follow-up article Azoteq will show how a SMPS controller IC has been integrated into their latest range of capacitive proximity and touch sensing devices in order to provide significant power and cost savings.

7. Biography

Gerrit de Villiers completed his Bachelors in ElectronicEngineering at the University of Pretoria and continued his studies with a Master's degree in Engineering, specializing in optical sensors for nuclear environments. He then managed several turnkey products for Keystone, with a focus on consumer products. In 2011 he joined Azoteq as an application engineer and now develops intelligent SMPS supplies incorporating capacitive touch sensing for the consumer market.

8. References

[1] Meier, A.,*Standby: where are we now?* Proceedings of the ECEEE 2005 Summer Study, Mandelieu, pp. 847-854

[2] A report for the Equipment Energy Efficiency (E3), Standby Power – Current status, October 2006, Report number 2006/10

[3] IQS232 Datasheet. Available at www.azoteq.com

[4] www.azoteq.com