Energy Conservation Through Standby Power Reduction

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Abstract: Standby power is the power used while an electrical device is in its lowest power mode. Several electrical appliances, when put in a stand by mode, considerable amount of electrical energy is wasted. This article furnishes research findings from a wherein, the loss due to standby power was a whopping 175MW or 25% of the total electricity produced worth 613 crores in Delhi alone. Energy conservation has become imperative. Fortunately, Common wealth countries have woken up to the problem and bodies like OECD have adopted corrective actions by benchmarking the 1 Watt as the target for standby consumption. It is estimated that a 75% reduction is possible in new equipments. The savings can be achieved through improvements in hardware such as power supplies, IC Chips and I/O Components. The article suggests that a shift to wideband gap semiconductors such as SiC, Gan and Diamonds are possible candidates for replacing Si to reduce the losses and source for major reduction in the standby power losses to minimum level. Another insight the article reveals is, the idea of using a single chip rather than using multiple chips. Low-Voltage Power Supplies with high efficiency, Decrease the standby power consumption of the other components in the appliance, add a second power supply specifically for the lower power standby mode, Turn the power supply off when the appliance is off.

Key words: Standby Power • Leaking Electricity • Power Supplies • Wide Bandgap Power Semiconductors • High Efficiency Design

INTRODUCTION

The rapid proliferation of electronic devices, which are consuming electricity in the standby mode or when they are switched "off", has created a new category of electricity consumption. There are several names for this category, including "standby use", "minimum use" and "leaking electricity". While "standby use" is technically more accurate, the expression "leaking electricity" is rapidly gaining popularity because it is easy to understand. Leaking electricity is a global phenomenon because the largest "leakers" are internationally-traded appliances, such as televisions, audio equipment and cordless telephones. Researchers in several countries have measured leaking electricity and have reported their results. Many of these appliances are virtually identical in all countries because they are manufactured by only a few, large, multinational companies; as a result, data collected in one country often apply to others. Together, these results give us general understanding of the major contributors of leaking electricity and rough estimates of total leaking electricity in the residential sector. There are nevertheless unique aspects in each country [1].

In this paper, we describe the leaking electricity situation in the Delhi loses power worth Rs. 613 crores to gadgets on standby mode' At a time when power supply is not keeping pace with the demand and between 200 MW and 600 MW of shortage is being experienced in the Capital every day, experts believe that there is an urgent need for consumers to clamp down on power consumption. On how the consumers can contribute to easing Delhi's power crisis, experts insist that people should not keep the gadgets on in the standby mode as a survey has shown that Delhi loses about 175 MW or 25 per cent of electricity produced in Delhi worth Rs 613 crores to gadgets switched off from the remote control. Experts insist energy saved just by switching off the gadgets from the main switch will alone save 175 MW of power in the Capital and other simple energy saving tips can further reduce the power consumption as also the power bills of the consumers [2-4].
As following the chart the use of such gadgets in Delhi is as per a study resulting in loss of about 175 MW or 25 per cent of all electricity generated in the Capital. Noting that the total loss due to gadgets being left on standby use amounts to around Rs 615 crores per annum, the study, as per distribution company sources, points out that consumers generally leave their electronic gadgets in "standby mode". Noting that as against 25 per cent loss in Delhi, the figure is 10 per cent in the United States and 7 per cent in France, the report calls upon consumers to completely "switch off" gadgets when they are not being used so that precious electricity is saved. In addition, we propose a strategy to reduce leaking electricity in future appliances [5-6].

**Modes of Standby Power:** In this paper, [11] we define leaking electricity as the energy consumed by appliances when they are switched off or not performing their principal function Many appliances have three or more different modes of operation, each with a corresponding level of electricity use. It has become increasingly difficult to determine in which mode an appliance is functioning. The following table shows the differences among the four modes used in this report [7-11].

<table>
<thead>
<tr>
<th>Mode</th>
<th>Function</th>
<th>Leaking electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off</td>
<td>No function at all</td>
<td>• Transformer losses&lt;br&gt;• Battery overcharging&lt;br&gt;• Poor design (&quot;internal&quot; on)</td>
</tr>
<tr>
<td>Passive standby</td>
<td>Not performing principal function</td>
<td>• Ready to be switched on&lt;br&gt;• Ready to receive information active standby&lt;br&gt;• Additional function&lt;br&gt;• Support function</td>
</tr>
<tr>
<td>On</td>
<td>Principal function</td>
<td>• Not leaking</td>
</tr>
</tbody>
</table>

There is a passive and an active standby. In the "passive standby" the appliance is waiting to be switched on by a remote control or is waiting to receive information. In "active standby" the appliance is performing some additional or support function. There are cases in which these two standby functions are combined.

A protection system and proper control may resolve the problem.

**Measurements of Stand by Power:** The chart given in [1] is obtained from the article Hindu and is used for the discussion. Data are from a variety of sources. Standby losses can be described analytically as follows:

\[ W_{sb} = P_{sb} \times t_{sb} \times n \]

- \( W_{sb} \) : Standby losses in terms of watt-hours per day or year
- \( P_{sb} \) : Effective output consumed, watt
- \( t_{sb} \) : Time in the standby mode
- \( n \) : Number of households.

**Field Measurements:** Even though many different appliances have standby losses, only a few appliances account for most of the residential standby losses [8-12]. The measurements show the range in standby losses in addition to the potential for energy savings as the stock turns over. For clarity of presentation, we present only selected data rather than all of our measurements. Most of the appliances measured were manufactured in the last two years. However, we have also included a few measurements of older units to illustrate the trends in standby losses and the potential for energy savings.

**Technical Options to Reduce Leaking Electricity:** Most of the sensors, displays and memories need much less than one Watt. Unfortunately, the power supplies are inefficient and consume many times more power. [13-15] We believe that it is now technically practical to reduce standby losses to less than one Watt. One or more of the following technologies could be employed to achieve the 1-Watt goal:

- Energize only the components needed for the standby services.
- Improve the efficiency of the low-voltage transformer.
- Move the power switch to the high-voltage side.
- By using latest semiconductors as wide band gap.
At least one company has developed more efficient low-voltage transformers. They easily achieved the 1-Watt ceiling for the three appliances measured with a new, switching power supply. The switchers cost only a little more than the popular linear power supplies and will soon be competitive in almost all situations.

Moving the switch to the high-voltage side is a simple measure, but can only be applied in some situations [14-18]. The advantage is that the appliance is "off" but the disadvantage is that it can't perform any services.

Recent developmental advances have allowed silicon (Si) semiconductor technology to approach the theoretical limits of the Si material; however, power device requirements for many applications are at a point that the present Si-based power devices cannot handle. The requirements include higher blocking voltages, switching frequencies, efficiency and reliability. To overcome these limitations, new semiconductor materials for power device applications are needed. This report compares wide-band gap semiconductors with respect to their promise and applicability for power applications and predicts the future of power device semiconductor materials.

Together, these technologies could reduce leaking electricity by over 75% with little increase in first cost and probably life cycle savings to the consumers. Some technical problems certainly exists --such as radio interference by switching power supplies -- but non appear insurmountable.

**Low-Voltage Power Supplies:** Low-voltage power supplies are the most ubiquitous component contributing to standby losses because they must be active for an appliance to perform standby functions. They are also, perhaps, the most readily improved. Whenever current flows through a conventional low-voltage power supply -- i.e. whenever the appliance is on or uses power for standby functions -- as many as 3 watts are wasted. If the on/off switch is on the low-voltage side of the power supply, these losses also occur when the appliance is performing no function at all.

**Improve the Efficiency of Conversion to Lower Voltages:**

The two main types of power supplies used today are linear power supplies and the more efficient electronic "switching" power supplies. Currently, linear power supplies are used in many low-power appliances, such as answering machines and battery chargers. Changing from linear to switching power supplies in such appliances would not only reduce standby losses, but would also improve efficiency when the appliance is on. For situations in which a switching power supply cannot be used, linear power supply efficiencies can be improved by using more metal and more and thinner laminations in the core of the transformer (Rainer, Greenberg & Meier 1996).

**Decrease the Standby Power Consumption of the Other Components in the Appliance:** Because the standby power consumption of the low-voltage power supply is proportional to the amount of power it supplies at any given moment, decreasing the power it provides to the other standby components decreases its own standby losses as well.

**Add a Second Power Supply Specifically for the Lower Power Standby Mode:** Low-power, power supplies waste proportionally less power than higher-power ones. Using a secondary power supply is already common practice in systems drawing more than 50 watts, such as personal computers, monitors and televisions. With newer switching power supplies consuming only two or three hundred milliwatts, this option may now be cost-effective for lower power appliances as well.

**Turn the Power Supply off When the Appliance Is off:** A simple way to do this is to design the appliance so that the power switch is on the high-voltage side of the power supply. Other possibilities include designing a smart power supply that can sense when the appliance has been turned off, or offering an optional standby mode by using a power supply with a three-way on-ready-off switch. If an appliance needs just a few milliwatts of power in standby mode, rechargeable batteries can be used to provide power to components that need it. As photovoltaic and energy storage technologies improve, it may even become cost-effective to keep components or batteries charged with small photovoltaic cells. Implementing the other efficiency measures described above could save several times this amount.

**Wide Band Gap Semiconductors Discussion:** The emergence of silicon carbide- (SiC) based power semiconductor switches with their superior features compared with silicon (Si) based switches has resulted in substantial improvements in the performance of power electronics converter systems. These systems with SiC power devices are more compact, lighter and more efficient.
However, power device requirements for many applications are at a point that the present Si-based power devices cannot handle. The requirements include higher blocking voltages, switching frequencies, efficiency and reliability. To overcome these limitations, new semiconductor materials for power device applications are needed. For this, wide band gap semiconductors like silicon carbide (SiC), gallium nitride (GaN) and diamond with their superior electrical properties are likely candidates to replace Si in the near future.

Most present commercial power electronic devices (diodes, thyristors, IGBTs, MOSFETs, etc.) are silicon-based. The performance of these systems is approaching the theoretical limits of the Si fundamental material properties. The emergence of new power electronic devices based on wide bandgap (WBG) semiconductor materials will likely result in substantial improvements in the performance of power electronics converter systems in terms of higher blocking voltages, efficiency and reliability as well as reduced thermal requirements. Graph shows resistance of the drift region for each material at different breakdown voltages.

### Table 1: Physical characteristics of Si and main wide bandgap semiconductors

<table>
<thead>
<tr>
<th>Property</th>
<th>Si</th>
<th>GaN</th>
<th>4H SiC</th>
<th>4H SiC</th>
<th>GaN</th>
<th>Diamond</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandgap, E&lt;sub&gt;g&lt;/sub&gt; (eV)</td>
<td>1.12</td>
<td>1.43</td>
<td>3.03</td>
<td>3.26</td>
<td>3.45</td>
<td>5.45</td>
</tr>
<tr>
<td>Dielectric constant, ε&lt;sub&gt;r&lt;/sub&gt;</td>
<td>11.9</td>
<td>13.1</td>
<td>9.66</td>
<td>10.1</td>
<td>9</td>
<td>5.5</td>
</tr>
<tr>
<td>Electron Breakdown Field, F&lt;sub&gt;B&lt;/sub&gt; (kV/cm)</td>
<td>300</td>
<td>400</td>
<td>2000</td>
<td>2200</td>
<td>2000</td>
<td>10000</td>
</tr>
<tr>
<td>Electron Mobility, μ&lt;sub&gt;e&lt;/sub&gt; (cm&lt;sup&gt;2&lt;/sup&gt;/V·s)</td>
<td>1900</td>
<td>800</td>
<td>500</td>
<td>1000</td>
<td>1200</td>
<td>2200</td>
</tr>
<tr>
<td>Hole Mobility, μ&lt;sub&gt;h&lt;/sub&gt; (cm&lt;sup&gt;2&lt;/sup&gt;/V·s)</td>
<td>600</td>
<td>100</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>850</td>
</tr>
<tr>
<td>Hall Mobility, μ&lt;sub&gt;h&lt;/sub&gt; (cm&lt;sup&gt;2&lt;/sup&gt;/V·s)</td>
<td>1.5</td>
<td>0.46</td>
<td>4.9</td>
<td>4.9</td>
<td>1.3</td>
<td>2.2</td>
</tr>
<tr>
<td>Saturation Electron Drift Velocity, v&lt;sub&gt;dsat&lt;/sub&gt; (cm/s)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2.2</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Conclusions and Future Directions

### Reasons for an International Effort to Reduce Standby Losses

Reducing standby losses in appliances is suitable for international action because the market for these goods is international. At the same time, a coordinated effort would bring much greater benefits than would individual efforts by a few countries. The savings would be both economic, in reduced consumer costs of operating the appliances and environmental, in the form of reduced carbon dioxide (CO<sub>2</sub>) emissions. Global action to reduce standby losses could reduce global CO<sub>2</sub> emissions by about three times as much, or 27 megatons per year (Webber 1998).

A coordinated international effort can also transform the entire global appliance market. All manufacturers of final products and components will shift to low-loss components and designs. In this way, countries not directly participating in this plan will benefit because low-loss devices will become the standard rather than the exception. The poorer countries will therefore also enjoy operating savings and reduced CO<sub>2</sub> emissions. Finally, the global appliance market is evolving rapidly and life cycles of electronic appliances are short. This means that new specifications can be incorporated into new designs and be marketed within a few years.

### CONCLUSION

This paper presents evidence that it is technically feasible to reduce standby losses in domestic appliances to less than one watt. Innovative manufacturers for many products, including televisions and audio equipment, are already meeting, or are close to meeting, the 1-watt target without any sacrifice in services or increase in the purchase price. The costs of key low-loss technologies are rapidly falling, so that the incremental cost to meet a 1-watt target is also falling. So the manufacturers have to meet target with using wide band gap semiconductor materials as core part in their power supplies at standby state or to provide secondary power supplies using wide band gap semiconductors. If all appliances were replaced by units meeting the 1-watt target, aggregate standby losses would fall at least 75%. So that from the article seen huge crores have been saved.

### REFERENCES

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