Enabling Efficient Solutions for Power Supplies

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Regulatory Challenges

Standby Power Reduction
- 25% of total energy consumption is in low power/sleep/standby mode
- Concerted effort by CECP, Energy Star, IEA and other international agencies to limit standby power

Active Mode Efficiency Improvement
- 75% of total energy consumption is in active mode
- Changing efficiency from 60% to 75% can result in 15% energy savings
- Next focus area for agencies

Judicious combination of the above two strategies to achieve optimum energy savings (optimized for the usage profile of the application)
Semiconductor Industry Response

Standby Power Reduction
- Semiconductor solutions available to facilitate low power mode
- Cost impact on end systems has been negligible
- As power levels go up, more innovation required to meet the challenge

Active Mode Efficiency
- Improving efficiency requires component level improvements AND topology changes
- Semiconductors to play a key role in facilitating the transition
Where are the **losses** occurring? (with prevalent topology)

- Capacitive losses: \( \frac{1}{2} C \cdot V^2 \cdot f_{sw} \)
- Biasing network
- Controller current
- Gate charge: \( Q_g \cdot f_{sw} \)
- Start-up network

**Active Mode:**
- Rectifier conduction
- Transformer core and copper losses
- FET conduction losses
- Resistor dissipative loss
- Snubber losses
What is **standby** power...?

- The power drawn from the mains when an external power supply is left connected to the line without load ➔ battery chargers, AC/DC wall adapters etc.
- The power drawn when a system goes into sleep-mode while still having some intelligent activity is sleep mode ➔ TV sets (LED on, µP waiting for remote), Notebook Adaptors

**EC recommendations:**

<table>
<thead>
<tr>
<th>Rated Input Power</th>
<th>No-load power consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phase 1 1.1.2001</td>
</tr>
<tr>
<td>&gt; 0.3 W and &lt; 15 W</td>
<td>1.0 W</td>
</tr>
<tr>
<td>≥ 15 W and &lt; 50 W</td>
<td>1.0 W</td>
</tr>
<tr>
<td>≥ 50 W and &lt; 75 W</td>
<td>1.0 W</td>
</tr>
</tbody>
</table>

**Energy Star recommendations:** 0.5 W for <10 W, 0.75 W for >10 W

- **High level of integration has allowed <200 mW standby consumption for 150 W systems – easy to design**
A 84 mW@230 VAC standby power at no-load was measured!
Industry has developed low standby solutions for SMPS
Addition of PFC stage poses new challenges
Benefits of Power Factor Correction

- RMS current for non-PFC circuits is 70% higher compared to PFC circuits:
  - this causes stress on the wiring
  - limits usable power from an electrical outlet
  - sometimes this trips circuit breakers
  - higher RMS current raises the cost of generation / distribution

- In Europe and other parts in the world (not yet US), governments mandate clean, low distortion currents…
- Regulations are derivatives of the IEC 1000-3-2 or the EN61000-3-2 (EC)
- 4 classes: A (all eq. except:) B (portable tools), C (lighting) and D (PC, monitors, TVs)

  PF correction is mandatory for Pin > 75W!!
Emerging techniques to meet the standby power challenge with PFC

Shut-down your PFC in standby-mode and pass the 100 mW barrier...
Power Supply Roadmaps - Topologies

Higher power applications are technology leaders
– Spillover to lower power as technology matures

External power supplies are market impact leaders
– Can drive innovation through customer perception

- **FLYBACK REG**
  - 1-Switch, 1-Diode
  - 1-Xfmr

- **FLYBACK CTRL**
  - 1-Switch, 1-Diode
  - 1-Xfmr

- **1SW FORWARD**
  - 1-Switch, 2-Diode
  - 1-Xfmr, 1-Inductor

- **ACTIVE CLAMP**
  - 2-Switch, 2-Diode
  - 1-Xfmr, 1-Inductor

- **HALF BRIDGE**
  - 2-Switch, 2-Diode
  - 1-Xfmr, 1-Inductor

- **FULL BRIDGE**
  - 4-Switch, 2-Diode
  - 1-Xfmr, 1-Inductor

- **FULL BRIDGE PHASE SHIFTED**
  - 4-Switch, 2-Diode
  - 1-Xfmr, 1-Inductor

**NOTEBOOK ADAPTERS**

**ADAPTERS**

**ATX POWER SUPPLIES**

- 10W
- 100W
- 500W
## Increasing Efficiencies

Breakdown of the efficiency challenge and ON Semiconductor response

250 W Output Desktop Power Supply

<table>
<thead>
<tr>
<th></th>
<th>TODAY</th>
<th>MID 2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Loss Break Down</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOSFETs</td>
<td>25W</td>
<td>12W</td>
<td>7.5W</td>
</tr>
<tr>
<td>Rectifiers</td>
<td>37W</td>
<td>28W</td>
<td>12W</td>
</tr>
<tr>
<td>Passives</td>
<td>30W</td>
<td>28W</td>
<td>16.5W</td>
</tr>
<tr>
<td>Misc</td>
<td>20W</td>
<td>15W</td>
<td>8W</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>112W</td>
<td>83W</td>
<td>44W</td>
</tr>
</tbody>
</table>

1 Switch Forward using today’s MOSFETs & Rectifiers

1 Switch Forward using **improved components**

**New Topology** using **improved components**
Improving PFC Efficiency

- CCM for higher power, CRM/DCM for lower power
- Topology improvements drive component changes

- Better $\text{trr}$ for CCM
- Lower VF for CRM/DCM
- Vo $\propto$ Vin
  - Smaller FET and L
  - Lower PFC losses
  - Wider Vin for SMPS
- Control maximum power
- Lower $R_{ds-on}$
- Lower $T_{on}$ losses (CCM)
Improving SMPS Efficiency

- Topology Upgrade (Flyback -> Forward -> Bridge)
- Soft-switching extends range (QR, Active clamp etc)
- Component level improvements (FET, sync rec etc)
Benefits of Higher Efficiency to the End User

- To control heat build-up designers need...

- Reduced power losses save the consumer money

- Governmental power loss regulations being implemented

Lower cost, weight, noise and bulk to the end product

We pay for power that is turned into heat!

Energy saved = fewer power plants = less pollution

USA Energy Star

Energy Conservation Certification

Money Isn't All You're Saving
ON Semi’s Support for Efficient Power

- ON Semiconductor is committed to improving the energy efficiency in power supplies.
- Has played a leadership role in delivering cost effective standby power solutions.
- Improved efficiency solutions allow ON Semiconductor to:
  - Differentiate itself from competition.
  - Demonstrate innovative semiconductor solutions to help advance the state-of-the-art.
  - Be seen as a market leader.
- ON welcomes more stringent future specifications:
  - Sets the challenge for innovation.
  - Helps drive technology curve (akin to Moore’s Law).
ON Semi’s Market Success

- Recognized world-wide as innovative power supply solution provider
- Market Leader in controllers for external adapters
  - Revolutionary product-line – NCP12XX series
  - Leading customers: Delta, Astec, Lite-On, Bestec
- Significant success in China Consumer Power market through industry leading standby solutions
  - 2 Consecutive years of CECP awards
  - Leading customers such as TCL, Haier, Foxlink
- Global customers include:
  - Philips, Motorola, Vestel, Beko, Hipro, Celetron
ON Semiconductor®

Thank You!

Questions?