Efficient Architectures for Internal and External Computer Power Supplies

Dhaval Dalal
Systems Engineering Director, Power Supplies
• Efficiency Drivers
• ATX power requirements overview
  – PFC solution
  – SMPS solution
  – Post regulation
• Notebook adapter power requirements overview
  – PFC solution
  – SMPS solution
  – Single stage option
• Conclusions
Power Efficiency Drivers

• Market forces (small size, weight expectations)
• Competitive pressures
• System level savings (easing of thermal load, improved reliability)
• End customer specifications (e.g. Intel)
• Regulatory requirements (emerging)
- 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

- Power Factor Correction (or Harmonic Reduction)
  - Applicable with IEC 1000-3-2 (Europe, Japan)
  - Some efficiency specifications also require >0.9 PF
### Standby Certification Programs
(External Power Supplies)

<table>
<thead>
<tr>
<th>Code</th>
<th>Region/Country &amp; Timing</th>
<th>No Load Power Consumption</th>
</tr>
</thead>
</table>
| CUC1 | CECP (China) & Energy Star (US)  
From January, 2005 (Tier 1) | = 0.50 W for 0-10 W  
= 0.75 W for 10-250 W |
| CUC2 | CECP and Energy Star  
From July 1, 2006 (Tier 2) | = 0.30 W for 0-10 W  
= 0.50 W for 10-250 W |
| CE1  | Europe (EC Code of Conduct)  
From January 1, 2005 | = 0.30 W for <15 W  
= 0.50 W for 15-50 W  
= 0.75 W for 50-60 W  
= 1.00 W for 60-150 W |
| CE2  | Europe (EC Code of Conduct)  
From January 1, 2007 | = 0.30 W for non-PFC  
= 0.50 W for PFC |
| CA1  | Australia (High Efficiency)  
From April, 2006 | = 0.50 W  
For 0-180 W |
### Active Efficiency Certification Programs

(External Power Supplies)

<table>
<thead>
<tr>
<th>Code</th>
<th>Region/Country &amp; Timing</th>
<th>Active Mode Efficiency</th>
</tr>
</thead>
</table>
| **CUC1**  | CECP (China) & Energy Star (US)  
From January, 2005 (Tier 1)  
Europe (EC Code of Conduct)  
From January 1, 2007 | =0.49*Pno for 0-1 W  
=\[0.09*\ln(Pno)\]+0.49 for 1-49 W  
=0.84 for >49 W |
| **CE2**  | Europe (EC Code of Conduct)  
From January 1, 2005 | =0.70 for 6-10 W  
=0.75 for 10-25 W  
=0.80 for 25-150 W |
| **CE1**  | Europe (EC Code of Conduct)  
From January 1, 2005 | |
| **CUC2**  | CECP and Energy Star (Tier 2)  
From July, 2006 | TBD (More stringent than Tier 1) |
| **CA1**  | Australia (High Efficiency)  
From April, 2006 | =0.48*Pno for 0-1 W  
=\[0.089*\ln(Pno)\]+0.48 for 1-60 W  
=0.84 for >60 W |

- **Note:** Pno is defined as the nameplate output power.
80-plus program

80+ Power Supply Program for Computers

An immediate opportunity to secure energy and peak savings for less than 3 cents per lifetime kWh

New Design Assures Major Reduction in Computer Energy Use

<table>
<thead>
<tr>
<th>Specification</th>
<th>Efficiency Measurements</th>
<th>Maximum heat output in a 250 watt power supply</th>
<th>Typical power supply energy consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003 measured average</td>
<td>65%</td>
<td>71%</td>
<td>69%</td>
</tr>
<tr>
<td>2004 Intel required spec</td>
<td>60%</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td>2004 Intel recommended spec</td>
<td>67%</td>
<td>80%</td>
<td>75%</td>
</tr>
<tr>
<td>80+ power supply</td>
<td>82%</td>
<td>87%</td>
<td>85%</td>
</tr>
</tbody>
</table>

www.80plus.org
• Power Level in the 250-350 W range
• +12/+5/+3.3/-12 V outputs
• Need for standby power (10-15 W)
• Better post regulators for 3.3 V needed
• Improvement in efficiency sought
• More compact solution required
Active vs. Passive PFC

**Active PFC**

- **Input Filter**
- **Rectifier**
- **PFC**

**Passive PFC**

- Inrush Current Limiter (Thermistor)
- PFC Inductor
- Diff Mode Inductor (L2)
- Common Mode Inductor (L3)

+ Bus

+ Bus Return
## Solution Comparison

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Active PFC</th>
<th>Passive PFC</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Complexity</td>
<td>Medium (full power stage needed)</td>
<td>Low (choke, range switch, extra bulk cap)</td>
<td>Reduced complexity for active PFC with newer components</td>
</tr>
<tr>
<td>Input rms current</td>
<td>3.0 A</td>
<td>3.69 A</td>
<td>Higher current leads to larger filter size</td>
</tr>
<tr>
<td>Output voltage range</td>
<td>300-415 V</td>
<td>200-375 V</td>
<td>Impact on SMPS stage operation</td>
</tr>
<tr>
<td>Bulk capacitance</td>
<td>220 uF, 420 V</td>
<td>2x1000 uF, 200 V</td>
<td>Passive value often traded off against Vo range</td>
</tr>
<tr>
<td>Protection features</td>
<td>Incorporated</td>
<td>Not available</td>
<td>Added circuit costs</td>
</tr>
<tr>
<td>Reliability</td>
<td>Foolproof (no range switch)</td>
<td>Potential failure due to range switch</td>
<td></td>
</tr>
<tr>
<td>Efficiency at 115 V</td>
<td>~94 %</td>
<td>~96 %</td>
<td>Active efficiency can improve with better semiconductors</td>
</tr>
</tbody>
</table>
Full Coverage of PFC Solutions

Power Factor Controllers

Variable Frequency
- Critical Conduction
  - With HV Start-up: MC33368
  - Without HV Start-up: MC33260, MC33262

Fixed Frequency
- Discontinuous Mode
  - Without HV Start-up: NCP1601
  - With HV Start-up: NCP1651
- Continuous or Discontinuous
  - Without HV Start-up: NCP1650, NCP1653 (8-pin package)
The NCP1653 is ideal in systems where **cost-effectiveness, reliability and high power factor** are the key parameters. It incorporates all the necessary features to build **compact and rugged PFC stages**.

- Near-Unity Power Factor
- Fixed Frequency (100 kHz), Continuous Conduction Mode
- High Protection Level for a safe and robust PFC stage
  - Soft-Start
  - Over-Current Limitation, Over-Voltage Protection
  - In-rush Currents Detection
  - Feed-back Loop Failure Detection...
- “Universal” 8 pins package (DIP8 and SO8)
- Low Start-up Consumption, Shutdown Mode
- Few external components, ease of implementation
- Follower Boost Capability => flexibility, up-graded efficiency and cost-effectiveness
**Generic Application Schematic**

- **Simple to Implement!**
- **Few External Components!**

Diagram showing a simple power supply circuit with components labeled:
- **Vin**
- **L1**
- **Icoil**
- **D1**
- **Vout**
- **LOAD**
- **Emi Filter**
- **C1**, **C2**, **C3**, **C4**, **C5**
- **NCP1653**
- **Rsense**

The diagram highlights the AC line input, EMI filter, and the implementation of a simple design using a few external components.
When the coil current is small:
The sum (Vramp + VRs) needs a long time to exceed Vref
=> The duty-cycle is large

When the coil current is high (top of the sinusoid):
The sum (Vramp + VRs) needs a shorter time to exceed Vref => The duty-cycle is smaller
Four steps:
1. Dimension the coil inductance, the MOSFET, the diode, the bulk capacitor and the input bridge, as you would do for any PFC stage
2. Select the feedback arrangement
3. Select the input voltage circuitry
4. Dimension the current sense network

Step 1 is “as usual”, Steps 2, 3 and 4 are straightforward
(see table of next slide)

=> Ease of implementation
| 2 - Feedback arrangement | $R_{fb1} + R_{fb2} + R_{fb3}$ | $\frac{V_{out} - 4V}{200 \mu A}$ | $R_{fb1} = 680 \kappa \Omega$  
$R_{fb2} = 680 \kappa \Omega$  
$R_{fb3} = 560 \kappa \Omega$ |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C_{fb1}</td>
<td>$C_{fb1} = 1, nF$</td>
<td>$C_{fb1} = 1, nF$</td>
<td></td>
</tr>
<tr>
<td>C_{2}</td>
<td>$C_{2} = 100, nF$</td>
<td>$C_{2} = 100, nF$</td>
<td></td>
</tr>
</tbody>
</table>
| 3 - Input voltage sensing | $R_{in} = \left(\frac{2 \cdot \sqrt{2 \cdot \frac{V_{acLL}}{\pi}}}{15\, \mu A}\right) - 4V$ | $R_{in} = 4.7\, M\Omega$  
$R_{in} = 470\, k\Omega$ |
| R_{in1} and R_{in2}     | (R_{in} = R_{in1} + R_{in2}) | Choose: $R_{in1} \approx 10 \cdot R_{in2}$ |                                 |
| C_{in1}                 | $1\, nF$                    | $C_{in1} = 1\, nF$              |                                 |
| C_{in2}                 | $C_{in2} = 20\, mF / R_{in2}$ | $C_{in2} = 33\, nF / 63\, V$    |                                 |
| 4 - Current sense network | $R_{sense}$ | Choose $R_{sense}$ so that its dissipation keeps reasonable (as a rule of the thumb, select $R_{sense}$ so that $p_{R_{sense}}$ is less $0.5\% \cdot (P_{out\, max})$) | $R_{sense} = 0.1\, \Omega / 3\, W$ |
| R_{c1}                  | $R_{c1} = \frac{R_{sense} \cdot (I_{coil\, max})}{200\, \mu A}$ | $R_{c1} = 2.85\, k\Omega$      |                                 |
| R_{c2}                  | $R_{c2} = k \cdot \frac{n^2 \cdot R_{sense} \cdot (R_{in1} + R_{in2}) \cdot V_{acLL}}{R_{sense} \cdot (P_{out\, max}) \cdot V_{out\, LL}}$ | $R_{c2} = 56\, k\Omega$      |                                 |
| $R_{c2}$                | $C_{c2} \approx 20\, \mu F / R_{c2}$ | $C_{c2} = 330\, pF$              |                                 |
Pout = 300 W, universal mains (90 Vac <-> 265 Vac)
Waveforms @ full load and 110 Vac

- Ac line current (10 A / div)
- Bulk Voltage (100 V / div)
  (375 V mean)
- Rectified ac line voltage
  (100 V / div)
- NCP1653 pin5 Voltage
  (5 V / div)

PF = 0.998 , THD = 4 %
Waveforms @ full load and 220 Vac

- Ac line current (5 A / div)
- Bulk Voltage (100 V / div) (386 V mean)
- Rectified ac line voltage (100 V / div)
- NCP1653 pin5 Voltage (5 V / div)

PF = 0.991, THD = 7 %
At full load, the efficiency is around 93 % @ 110 Vac and 95 % @ 220 Vac. The efficiency keeps high from Pmax to Pmax/5 (over 90 % @ 110 Vac and 91 % @ 220 Vac)
The THD keeps low over a large power range.
• The NCP1653 keeps regulating in the 300 W application by entering a low frequency burst mode.

• The power losses @ 250 Vac, are: 200 mW (Burst mode frequency: around 0.3 Hz).
Converter Specifications

- \( \text{Vin} = 300\text{-}425 \text{ V} \) (with PFC front-end but allowing for single cycle dropout)
- \( \text{Vo1} = 12 \text{ V} \) (\( \pm 10\% \)), 15 A; \( \text{Vo2} = 5 \text{ V} \) (\( \pm 10\% \)), 15 A; \( \text{Vo3} = 3.3 \text{ V} \) (\( \pm 10\% \)), 13.6 A
- \( \text{Pomax} = 310 \text{ W} \)
- \( \text{Fsw} = 250 \text{ kHz} \)
Advantage of the Active Clamp

• Non-monotonic nature of the Vds plot offers a MAJOR benefit for wide Vin applications
  – Vds varies <50 V over Vin range vs. 250 V for 1-sw forward
1. Select turns ratio and max D
2. Select switching frequency
3. Transformer design (core and windings)
   - Gapping the core is helpful in this design
4. Select power semiconductors
   - Choice of diodes or FETs on secondary
5. Clamp circuit design
   - Trade off between reverse saturation and higher Vds ripple
6. Output filter design (similar to forward)
• Higher turns ratio (N) requires higher $D_{\text{max}}$
• Trade-off with high $V_{\text{ds}}$ stress
• Higher N reduces primary current and secondary voltage
• In this example, select 0.60 $D_{\text{max}}$
• Choose 0.55 for more $V_{\text{ds}}$ margin
Results at nominal line

SMPS Efficiency (Vin = 400V)

Efficiency (%) vs. Iout2 (A)

- lout1 = 3A
- lout1 = 9A
- lout1 = 15A
Switching waveforms
### Active Clamp vs. 1-sw Forward (1:1 reset)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>1-Sw Forward</th>
<th>Active Clamp</th>
<th>Active Clamp Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dmax</td>
<td>0.5 (0.46)</td>
<td>0.65 (0.6)</td>
<td>Higher D leads to several advantages</td>
</tr>
<tr>
<td>Vds/rating</td>
<td>850/900 V</td>
<td>656/800 V</td>
<td>Limits switch voltage, no leakage spike effects</td>
</tr>
<tr>
<td>Np/Nreset</td>
<td>115/115</td>
<td>150/None</td>
<td>No reset winding</td>
</tr>
<tr>
<td>Iprim (rms/pk)</td>
<td>1.78/2.81 A</td>
<td>1.56/2.15 A</td>
<td>Lower currents</td>
</tr>
<tr>
<td>Additional needs</td>
<td>Reset wndg</td>
<td>Clamp switch</td>
<td>⇒Low current</td>
</tr>
<tr>
<td></td>
<td>Reset diode</td>
<td>Drive ckt</td>
<td>⇒Floating drive req’d</td>
</tr>
<tr>
<td></td>
<td>Snubbers</td>
<td>Clamp cap</td>
<td>⇒Low value (nF), HV</td>
</tr>
<tr>
<td>Inductor</td>
<td>2.08 uH</td>
<td>1.6 uH</td>
<td>23% reduction in Inductor for same freq.</td>
</tr>
<tr>
<td>Sec. peak V</td>
<td>18.5 V</td>
<td>14.2 V</td>
<td>More margin for 24 V</td>
</tr>
<tr>
<td>Transformer</td>
<td>1-Q operation</td>
<td>2-Q operation</td>
<td>Better core utilization</td>
</tr>
</tbody>
</table>
3.3 V Post Regulation

**Mag-amp regulation**
- Traditional solution
- Works at low freq.
- No synchronous rectification – low eff.

**Switching regulation**
- Emerging solution
- Can go to high freq.
- Synchronous rectifier leads to >2% gain in efficiency
- More integration feasible
Features

• Undervoltage Lockout
• Thermal Shutdown for Over-Temperature Protection
• PWM Operation Synchronized to the Converter Frequency
• High Gate Drive Capability (Source 0.5 A - Sink 0.75 A)
• Bootstrap for N-MOSFET High-Side Drive
• Over-Laps Management for Soft Switching (3 out of 4 are smooth switching)
• High Efficiency Post-Regulation
• Ideal for Frequencies up to 400 kHz

Typical Applications

• Off-line Switch Mode Power Supplies
• Power DC-DC Converters
NCP4330 Based Solution

NCP4330 CCM Waveforms

1. 5 V secondary after the 5 V rectifier (from the 300 W ATX supply).
2. Input to the 3.3 V output inductor.
3. Lower gate drive.

NCP4330 DCM Waveforms

1. 5 V secondary after the 5 V rectifier (from the 300 W ATX supply).
2. Input to the 3.3 V output inductor.
3. Upper gate drive.
4. Lower gate drive.
Description
The NCP101X series integrates a fixed-frequency (65-100-130kHz) current-mode controller and a 700V voltage MOSFET (11Ω and 23Ω). Housed in a PDIP7 package, the NCP101X offers everything needed to build a rugged and low-cost power supply, including soft-start, frequency jittering, skip mode, short-circuit protection, skip-cycle, a maximum peak current setpoint and a Dynamic Self-Supply (no need for an auxiliary winding).

Applications
- Auxiliary Power Supply
- Stand-by Power Supply
- AC/DC Adapter
- Off-line Battery Charger

Features
- Current-Mode control
- Skip-cycle capability
- High-voltage start-up current source
- Dynamic Self-Supply (DSS)
- Internal Short–Circuit Protection independent of aux. voltage by permanently monitoring the feedback line
- Reduced optocoupler consumption
- Frequency jittering

Benefits
- Good audio-susceptibility
- Inherent pulse-by-pulse control
- Provides improved efficiency at light loads
- No acoustic noise
- Clean a loss less start-up sequence
- No Auxiliary winding
- Reliable short circuit protection, immediately reducing the output power
- Further improvement of stand-by behaviour
- Reduced EMI signatur

Ordering Information
NCP101XAP06, NCP101XAP10, NCP101XAP13: PDIP7 = 50/Tube

More Information Online: www.onsemi.com/NCP1010
- Datasheet: NCP1010/D
- Application note: ANXXX
- Limited Demoboards for large opportunities to come.
**Description**
The NCP112 incorporates all the monitoring functions required in a multi-output power supply. It can monitor 3 outputs and communicate their status to a system controller with programmable delays to prevent spurious operation. Functionally and pin-compatible to other supervisory ICs, the NCP112 provides improved performance.

**Features**
- Overvoltage and undervoltage protection for 12 V, 5 V and 3.3 V outputs
- Additional uncommitted OV protection input
- Programmable UV blanking during powerup
- Fault o/p with enhanced (20 mA) sink current
- Programmable on/off delay time
- Programmable power good delay time

**Benefits**
- Minimizes external components
- Extra flexibility
- Accommodates any startup characteristics
- Guarantees shutdown under fault conditions
- Allows system specific flexibility

**Applications**
- Desktop ATX Power

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**NCP112 Supervisory**

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**Device Detail - Standby**

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**Applications**
- Desktop ATX Power
• 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
Complete System Results

- THD at high line – 9 % (meets IEC1000-3-2)
- Input power at Vin=115 Vac and Standby load =0.5 W is <1.0 W
High Power Adapter Requirements

• Increasing power levels for mainstream applications

• Need for low standby power consumption
  – 1 W (2004) => 0.5 W (2005)

• Addition of PFC requirements for > 75 W

• Output voltages from 15 to 24 V

• Need for high efficiency (>85%), small size, low cost
Typical Application Circuit

Few external components → Reduces overall power supply cost and size
• The instantaneous inductor current varies from zero to the reference voltage. There is no dead time.

• The average inductor current follows the same wave-shape as the input voltage, so there is no distortion or phase shift.

• **CRM suffers from large switching frequency variations:**
  – power factor degradation in light load conditions.
  – high switching losses unless a large and expensive coil is implemented.
  – Last but not least:
    • difficulty to filter the EMI
    • risk of generating interference that disturb the systems powered by the PFC stage (tuner, screens).
• Why not to associate fixed frequency and Discontinuous Conduction Mode?

• If furthermore, the circuit can enter CRM without PF degradation while in heavy load, there is no RMS current increase due the dead-time presence.

• **Couldn’t it be the ideal option for low to medium power applications?**
If \((\text{ton} \times \text{dcycle})\) is made constant:

\[ \Rightarrow \text{the input current is proportional to } V_{\text{in}} \]

\[ \Rightarrow \text{the input current is sinusoidal.} \]
Conditions: \( f_{sw} = 100 \text{ kHz}, \) \( P_{in} = 150 \text{ W}, \) \( V_{ac} = 230 \text{ V}, \) \( L = 200 \mu\text{H} \)
NCP1601: It works

Conditions: Pout = 130 W, Vac = 90 V, PF = 0.998, THD = 4%
The NCP1601 yields high PF ratios and effectively limits the Total Harmonic Distortion over a large ac line and load range.
According to the coil and the oscillator frequency you select, the NCP1601 can:

- Mostly operate in Critical Conduction Mode and use the oscillator as a frequency clamp.
- Mostly operate in fixed frequency mode and only run in CRM at high load and low line.
- Permanently operate in fixed frequency mode.

In all cases, the circuit provides near-unity power factor.

The protection features it incorporates, ensures a reliable and rugged operation.

Housed in a DIP8 or SO8, it requires few external components and eases the PFC implementation.
**Features**

- Current-Mode control
- Skip-cycle capability
- Soft skip mode (NCP1230A only)
- Go To Standby for PFC stage or main PSU
- High-voltage start-up current source
- Internal Ramp Compensation
- Frequency jittering
- Internal Short–Circuit Protection independent of aux. voltage by permanently monitoring the feedback line

**Benefits**

- Good audio-susceptibility
- Inherent pulse-by-pulse control
- Provides improved efficiency at light loads
- No acoustic noise
- Disable the front end PFC or main PSU during standby
- Reduces the no load total power consumption
- Clean a loss less start-up sequence
- Reliable short circuit protection, immediately reducing the output power
- Saves components
- Suitable for continuous mode FB with DC >50%
- Reduced EMI signature
- Rugged Power Supply

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**NCP1230 – Low-standby High Performance Controller**
How to reduce the standby power?

Skipping un-wanted switching cycles: The *skip* mode…

- excellent no-load standby power
- reduces switching losses
- improves low load efficiency
- cheap implementation!
Observing the loop to detect the standby

- **Fb is ok**
- **Drv**
- **FB**
- **PFC running**
- **Standby is entered**
- **Standby is left**
- **PFC is down**
- **25% of max Ip**
- **GTS armed**
- **GTS reset**
- **No delay**
- **Skip activity**
- **Delay 125ms**
- **Vcc**

**No delay**
Advantages

- Reduce the average input power drawn from the line (standby power)
- No acoustic noise
- A low cost magnetic component can be used
- Under fault conditions, reduces the stress on the power components
Skip Cycle Operation

Current is softly increased

Reduces further the acoustical noise!
Final standby power measurements

No-Load Standby Power

P_load 500 mW

Standby power @ no-load = 145 mW
Pactive mode = 794 mW @ 230 vac
Advantages

- Elimination of **one** power processing stage
- Requires a **single** switch, **single** magnetic, **single** rectifier & **single** cap.
- Ideal for mid-high output voltage systems (12-150 V)

Beware

- Low frequency output ripple can be high
### Component Comparisons

<table>
<thead>
<tr>
<th>Component</th>
<th>2-stage converter (with critical mode PFC)</th>
<th>1-stage converter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input peak current</td>
<td>~3.5 A for 90 W</td>
<td>~3.5 A for 90 W</td>
</tr>
<tr>
<td>PFC MOSFET</td>
<td>500 V</td>
<td>800 V</td>
</tr>
<tr>
<td>Inductor</td>
<td>600 uH</td>
<td>600 uH (need secondary windings)</td>
</tr>
<tr>
<td>PFC Rectifier</td>
<td>600 V, ultrafast (4 A)</td>
<td>Not needed</td>
</tr>
<tr>
<td>PFC capacitor</td>
<td>100 uF, 450 V</td>
<td>Not needed</td>
</tr>
<tr>
<td>SMPS transformer</td>
<td>Not needed</td>
<td>Not needed</td>
</tr>
<tr>
<td>SMPS Switch</td>
<td>600 V or higher</td>
<td>Not needed</td>
</tr>
<tr>
<td>Output capacitor</td>
<td>X uF</td>
<td>4X uF</td>
</tr>
</tbody>
</table>
• Output ripple is dominated by 120 Hz signal
  – Inversely proportional to output capacitance value
Results - Input Current Waveforms

Vin = 115 V

- Easily meet the high-line requirements for IEC1000-3-2

Vin = 230 V

- THD can be improved with better snubbers or higher inductance (trade-off with losses)
• Regulation meets the typical specifications
  – Output line regulation: 20 mV
  – Output load regulation: 20 mV
• No Load power (at 230 V input) = 465 mW
  – Meets all stringent existing requirements
• Full load efficiency at 90 V input = 85.90 %
  – Compares favorably with optimized 2-stage designs
  – Meets the CECP and EPA requirements
Conclusions

• Efficiency improvements are key to achieving regulatory and market requirements for NB adapters and DT power supplies

• This seminar showed the means to achieve these cost effectively

• Stay tuned for more exciting computing power solutions from ON Semiconductor