Compact DC/AC Power Inverter

Design Day - Fall 2014

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● Introduction to Power Inverters
● Motivation and Goals
● Design Specifications
  ○ *Little Box Challenge*
  ○ Chosen Parameters
● Final Design
  ○ Self Assessment
● Future Suggestions
● Demonstration and Questions
Introduction to Power Inverters

- Convert DC to AC
  - Power devices
  - Supplement grid

- Variety of sizes & applications
  - Solar, portable power, etc.

- Design constraints:
  - Size, efficiency, power density

http://en.wikipedia.org/wiki/Power_inverter
Motivation and Goals

- Opportunities from Industry

- What could a new design mean?
  - Better stand alone systems
  - Greater efficiencies
  - Solar power generation
Motivation and Goals (cont.)

- Falling panel prices, stagnant inverter prices
- Easy to find room for tissue box sized device
- Modified sine waves are “sloppy”

Motivation and Goals (cont.)

- New technologies provide more design choices
  - Silicon Carbide
  - Gallium Nitride

- Inexpensive, open-source availability
  - Free Libraries
  - Extensive Support

Chosen MOSFET

http://www.cree.com/power/littleboxchallenge

http://arduino.cc/en/Trademark/CommunityLogo
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement (Nominal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Load</td>
<td>2 kVA</td>
</tr>
<tr>
<td>Power Density</td>
<td>&gt; 50 W/in³</td>
</tr>
<tr>
<td>Volume</td>
<td>&lt; 40 in³</td>
</tr>
<tr>
<td>Voltage Input</td>
<td>450 V DC</td>
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<tr>
<td>Voltage Output</td>
<td>240 V RMS AC</td>
</tr>
<tr>
<td>Frequency Output</td>
<td>60 Hz</td>
</tr>
<tr>
<td>Maximum Outer Temperature</td>
<td>&lt; 60 °C</td>
</tr>
<tr>
<td>Electromagnetic Compliance</td>
<td>FCC Part 15 B</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement (Nominal)</th>
</tr>
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<tbody>
<tr>
<td>Maximum Load</td>
<td>1 kVA</td>
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<tr>
<td>Power Density</td>
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<tr>
<td>Volume</td>
<td>&lt; 40 in3</td>
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<tr>
<td>Voltage Input</td>
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<tr>
<td>Voltage Output</td>
<td>120 V RMS AC</td>
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<tr>
<td>Frequency Output</td>
<td>60 Hz</td>
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<tr>
<td>Maximum Outer Temperature</td>
<td>&lt; 60 °C</td>
</tr>
<tr>
<td>Electromagnetic Compliance</td>
<td>FCC Part 15 B</td>
</tr>
</tbody>
</table>
DC-DC Conversion
Pulse Width Modulation
Final Design (cont.)

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H Bridge
Final Printed Circuit Board Layout
3” x 3.3”

- Board Size
- Trace widths
- Vias
Initial Enclosure Layout

- Two of Four MOSFETS
- One of Two Gate Drivers
- Arduino
- Capacitor Bank
- Inductor
- PCB Cutout
- Central and Reverse Portions not Shown

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Inductor Enclosure

Final Layout
<table>
<thead>
<tr>
<th>Item</th>
<th>Price</th>
<th>Quantity</th>
<th>Total</th>
<th>Description</th>
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<tbody>
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<td>4</td>
<td>$287.96</td>
<td>Silicon Carbide MOSFETs</td>
</tr>
<tr>
<td>FAN7382</td>
<td>$3.75</td>
<td>2</td>
<td>$7.50</td>
<td>600 Volt Gate Driver</td>
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<tr>
<td>DC-DC Converters</td>
<td>$2.02</td>
<td>2</td>
<td>$4.04</td>
<td>Supply Rail for Micro Controller</td>
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<tr>
<td>LM2940</td>
<td>$1.65</td>
<td>1</td>
<td>$1.65</td>
<td>5V Regulator</td>
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<tr>
<td>Enclosure</td>
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<tr>
<td>ATMega328</td>
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<tr>
<td>PCB</td>
<td>$0.00</td>
<td>1</td>
<td>$0.00</td>
<td>Printed Circuit Board from ECE Shop</td>
</tr>
</tbody>
</table>

**TOTAL:** $330.47
Future Suggestions - Heat Design

- Better materials
  - Heat sinks
  - Plating

- Milled Enclosure
  - PCB Guides
  - Dissipation fins
Future Suggestions - Printed Circuit Board

- Contain H Bridge, filter, processor, and DC/DC converter on same PCB

- Use surface mount over DIP components
  - Smaller, contain multiple parts

- Port placement
  - Transistor closer to edge
Future Suggestions - Filtering

- Current filter designed for smaller loads (~ 400W)
- 1 capacitor over capacitor bank
  - High voltage
- Increase inductor wire diameter
- Isolation transformer
● Education
  ○ The process
  ○ Technical integration

● Self Assessment
  ○ Shortcomings
  ○ Successes

● Thank you
Now, time for a video demonstration...
Questions?