Achieving High Efficiency And High Power Density On A 12V 100A Offline Power Supply

Joe Mancuso
Transistor Devices, Inc.
“2U Power Supply”
Design Objectives

• Low Cost
• Fit in a 1U or 2U high standard 19” equipment rack 16” deep.
• Fit four across in standard 19” equipment rack.
• Supply 1200W continuous.
Power Supply Sub-assemblies

MOLDED FRONT PANEL

AC/DC SUB-ASSEMBLY

DC/DC SUB-ASSEMBLY

Energy Solutions for the Next Generation
PFC Sub-assembly

• Conventional Boost Topology.
• CCM Control IC.
• Single IGBT.
• Single Soft Recovery Boost Diode.
• Micro-controller for start-up, fault reporting and sequencing.
PFC Block Diagram

EMI FILTER AND MAINS RECTIFIERS

AC INPUT: 90VAC to 270VAC

CCM CONTROL IC

MICRO CONTROLLER

L

CR

380VDC

Energy Solutions for the Next Generation
PFC Sub-assembly

- Energy Storage Capacitors
- Boost Inductor
- EMI Filter Surge Protection Inrush Limit
- Control Circuits
- Boost Diode and IGBT heatsink
- Off-Line Bias Supply
- Input Diode Heatsink
PFC Performance Data

- Input Voltage: 90VAC to 270VAC
- Output Voltage: 380VDC
- Output Wattage: 1310W
- Efficiency: 93% @ 120VAC input, 97% @ 240VAC input
- Power Factor: .99
- THD: <5% (complies with IEC/EN61000-3-2)
Energy Solutions for the Next Generation

PFC Input Current

Tek Stop

5 Aug 2004
09:32:53

Ch4 10.0 A Ω
28.40 %
FFT of Input Current Waveform

Delta: 33.2 dB  
@: -10.4 dB  
Delta: 120 Hz  
@: 180 Hz

Energy Solutions for the Next Generation


**DC/DC Converter**

- ZVT H-Bridge
- Current Doubler
- Output Synchronous Rectifiers
- Isolating MOSFETs
DC/DC Sub-assembly

- ZVT MOSFET HEATSINK
- OUTPUT INDUCTOR
- OUTPUT MOSFET HEATSINK
- ZVT CONTROL DAUGHTER CARD
- POWER TRANSFORMER
- OUTPUT CONTROL DAUGHTER CARD
- ISOLATING MOSFET

Energy Solutions for the Next Generation
DC/DC Performance Data

- Input Voltage: 315DC to 420VDC
- Output Voltage: 10VDC to 13.5VDC
- Output Wattage: 1200W
- Efficiency: 92% @ 380VDC
ZVT PWM Drive Waveforms

DRIVE A

DRIVE B

DRIVE C

DRIVE D

RESULTING PWM

Energy Solutions for the Next Generation
QB OFF to ON Transition, 100A Load
QB OFF to ON Transition, 22A Load

DRAIN VOLTAGE

GATE VOLTAGE

6 Aug 2004
15:10:16
Energy Solutions for the Next Generation
QB OFF to ON Transition, 10A Load

DRAIN VOLTAGE

GATE VOLTAGE
QD OFF to ON Transition, 10A Load

DRAIN VOLTAGE

GATE VOLTAGE

6 Aug 2004
15:13:05

Energy Solutions for the Next Generation

TDI
Transistor Devices
QD OFF to ON Transition, 100A Load

DRAIN VOLTAGE

GATE VOLTAGE

6 Aug 2004
15:38:45

Energy Solutions for the Next Generation
# Schottky Diode vs. MOSFET Power Dissipation

<table>
<thead>
<tr>
<th></th>
<th>Schottky Diode</th>
<th>MOSFET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part Type.</td>
<td>100V, 60A</td>
<td>100V, 75A</td>
</tr>
<tr>
<td>Forward Drop @ 100°C, 12.5A</td>
<td>.60V</td>
<td></td>
</tr>
<tr>
<td>RDS,ON @ 100°C</td>
<td></td>
<td>.012 Ohms</td>
</tr>
<tr>
<td>Power Dissipated</td>
<td>7.50W</td>
<td>1.88W</td>
</tr>
</tbody>
</table>

**Energy Solutions for the Next Generation**

*TDI Transistor Devices*
Current Doubler and MOSFET Synchronous Rectifiers

Energy Solutions for the Next Generation
QE Drain and Gate Waveforms

DRAIN VOLTAGE

GATE VOLTAGE
QE Turn Off Transition

DRAIN VOLTAGE

GATE VOLTAGE

Energy Solutions for the Next Generation
QE Turn ON Transition

DRAIN VOLTAGE

GATE VOLTAGE

Energy Solutions for the Next Generation
Isolating MOSFET Criteria

- Low forward voltage drop.
- Stay conducting (channel enhanced) during an output short circuit.
- Not influence the output bus during a hot swap.
- Turn off rapidly in the event of an internal voltage failure (i.e. shorted output capacitor or MOSFET rectifier) and not influence the output bus.
- Not influence the output bus during a light load to full load transient.
Isolating MOSFET Circuit

SYNCHRONOUS RECTIFIERS

ISOLATING FET CONTROL

12V @ 100A
Output Bus Disturbance

- Output Bus
- Simulated Fault

Energy Solutions for the Next Generation
Efficiency Graph

12V @ 100A Power Supply Efficiency

Load Current (Amps)

Efficiency (%)

- 120VAC Efficiency
- 240VAC Efficiency
Design Summary

• Enclosure design permits greatest amount of space for the internal power electronics.

• Cooling fan delivers sufficient airflow with high static pressure.

• Sub-assemblies are parts count optimized.

• High efficiency conversion topologies (CCM PFC Boost, ZVT H-Bridge, current doubled synchronous MOSFET rectifiers, isolating MOSFETS) used to realize design.
Thank you

Transistor Devices, Inc.
Hackettstown N.J.