15kW Bi-directional Vienna PFC

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1. Demo board Introduction
2. Modified Vienna Topology Comparison
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15kW 3L T-Type Converter PFC

Main specs
- Pout = 15kW @ Vin = 380Vac & Vout = 800V
- PF > 0.98 @ 20% load
- THD < 5% @ 20% load > 97% @ 20% load
- CCM decoupling current control loop
- Active & Reactive power control
- Grid Connection capability
- Switching frequency = 70kHz
- I_ripple = 2.5A
- VDC_ripple = 10Vpp

Key products
- STM32G474 (32 bit Microcontroller)
- SCTW40N120G2V (70mΩ 1200V SiC MOSFET)
- SCTW35N65G2V (55mΩ 650V SiC MOSFET)
- STGAP2S (Galvanic Isolated Gate Driver)
- STPS1L30A, STPS2H100A, STTH1L06A, STPS1150A, STPS2L60A (SiC, Schottky and Ultrafast diodes)
- STS6NF20V (N-channel 20 V, STripFET II Power MOSFET)
- TSV911IDT, TSV912IDT, TSV914IDT (wide-bandwidth rail to rail Op-Amps)
- STLM20W87F (Analog temperature sensor)
- LD29080DT50R, LD29080S33R (LDOs)
- VIPer26K (High Voltage Converter)
Industrial On-board Charger System Concept

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage</td>
<td>$L_x - L_y \rightarrow 400 , V_{AC}$, $L_x - N \rightarrow 230 , V_{AC}$</td>
</tr>
<tr>
<td>DC Link Voltage</td>
<td>400..1000 V</td>
</tr>
<tr>
<td>Nominal Power</td>
<td>11..22 kW</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>200..500 $V_{DC}$ for 400 $V_{DC}$ Batteries, 500..900 $V_{DC}$ for 800 $V_{DC}$ Batteries</td>
</tr>
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</table>
**Modified Vienna Rectifier Topology Comparison**

**Mod. Vienna Type 1**
- All 650V rated devices → lower cost
- 2 devices in the main current path (D1&D2) → lower efficiency

**Mod. Vienna Type 2**
- 1 device in the main current path (D2) → Higher efficiency
- Need 1200V diodes (D2), typically SiC. → Higher cost
Vienna rectifier Type 1

Vienna rectifier Type 2

<table>
<thead>
<tr>
<th>Topology Comparison</th>
<th>Efficiency Comparison @ $P_{\text{out}} = 20$ kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mod. Vienna Type 1</td>
<td>Mod. Vienna Type 2</td>
</tr>
<tr>
<td>D1</td>
<td>STBR6012W</td>
</tr>
<tr>
<td>T1</td>
<td>STGW40H65DFB-4, STW88N65M5-4, SCTW90N65G2V-4</td>
</tr>
<tr>
<td>D2</td>
<td>STPSC40065C</td>
</tr>
<tr>
<td></td>
<td>STPSC40H12C</td>
</tr>
</tbody>
</table>

Simulated efficiency @ $T_j = 125^\circ\text{C}$, considering only semiconductor losses.
Modified Vienna Rectifier Topology Comparison

Modified Vienna Type 1

+ All 650V rated devices  → lower cost
- 2 devices in the main current path (D1&D2)  → lower efficiency

Modified Vienna Type 2

+ 1 devices in the main current path (D2)  → Higher efficiency
- Need 1200V diodes (D2), typically SiC.  → Higher cost
Bidirectional PFC - system architecture
Bidirectional Control

Grid to Battery

Outer Loop

Voltage Controller

Id Controller

Iq Controller

"Decoupling" Inner Loop

Battery to Grid

Outer Loop

Power Controller

Power Measure

"Decoupling" Inner Loop

CONVERTER

Space Vector MODULATOR

PLL

CONVERTER

Grid to Battery

Battery to Grid
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Thank you