Rethinking Rectification: AC-DC Power Supply in Package

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Rectification of AC mains voltage is almost exclusively implemented with passive diode bridge rectifiers for power applications below 100 W. The diode bridge rectifier is reliable, cost effective and easy to use. But it is also lossy, nonlinear and passive. Thus reducing the power conversion efficiency, while drawing high input peak current with a high harmonic content. Mitigating these non-idealities requires higher order EMI filters and a subsequent power factor correction stage. Advanced active rectifier topologies can mitigate all three non-idealities simultaneously while balancing power conversion efficiency, EMI filter size and power factor. A requirement for achieving increasing power density.

1. Additional Value Required

An active synchronous rectifier must surpass the diode bridge rectifier in terms of added value, as it is impossible to compete directly on price, reliability and ease of implementation.

The rectifier must be thought of as part of the entire power conversion system and not just as an implied necessity.

2. Advanced Rectifier Topologies

Topologies known from high power and high voltage applications, such as multi-level and multi-phase power converters have the potential to add additional value to the overall AC-DC power converters for moderate power levels.

Bridgeless rectification has gained traction in the last decade for power factor correction applications. Wide bandgap devices have made new new topologies viable such as the totem-pole bridgeless rectifier, see Fig. 1 [2].

Multilevel rectifiers implemented using cascaded multi-cell power stages (Fig. 2) [1] or flying capacitor power stages (Fig. 3) [3] have been investigated for higher power levels.

These topologies are usually avoided in practice due to the high circuit and control complexity. They are primarily used for high power and high performance applications where the increased complexity and cost is mitigated by other beneficial performance traits, such as reduced filter requirements.

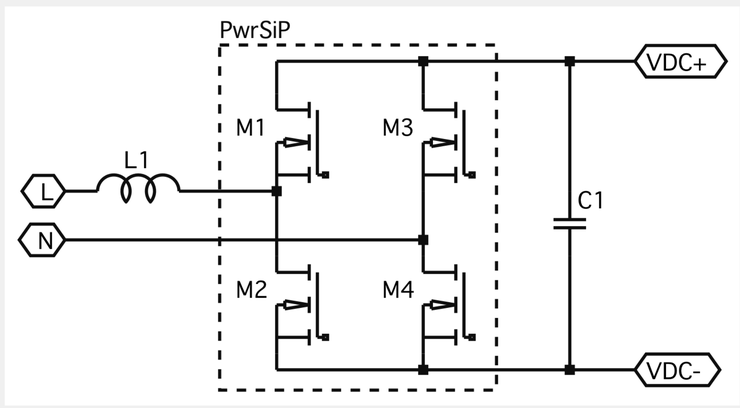

Figure 1. Bridgeless Totem Pole Rectifier

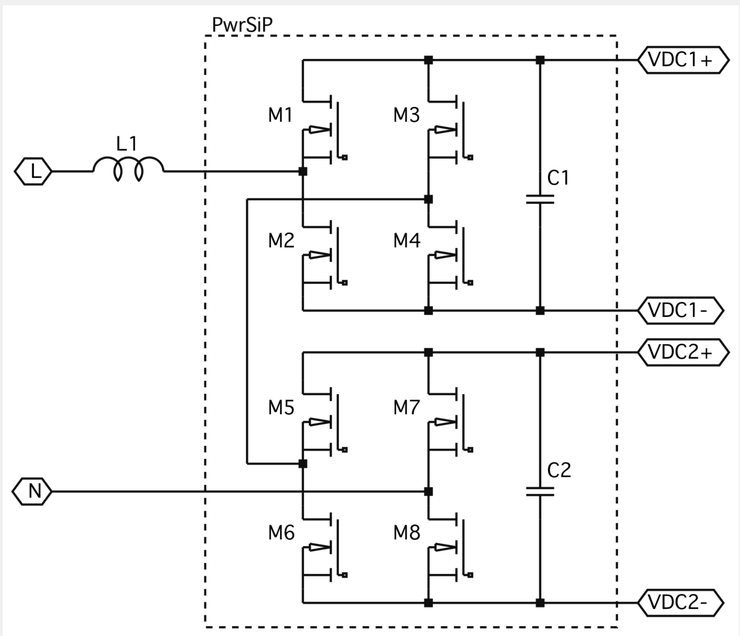

Figure 2. Cascaded Multi-Cell Rectifier

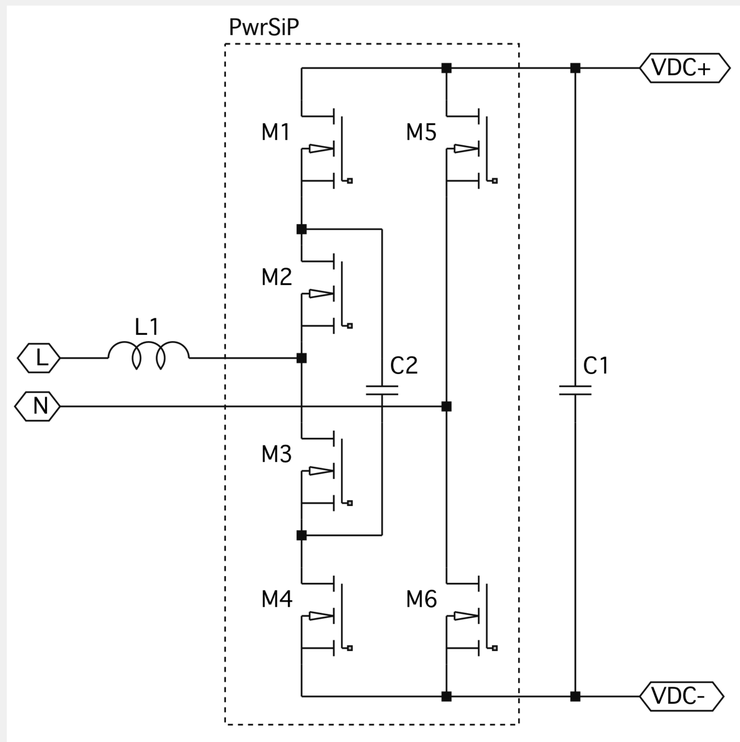

Figure 3. Bridgeless Totem Pole Rectifier with Flying Capacitor

3. Suitable for Integration

Within the field of highly integrated power supplies, such as Power Supply in Package (PSiP), circuit complexity and component count is part of the solution, not the problem.

High power density is achieved by going beyond conventional topologies and solutions limited by the availability of commercial-of-the-shelve components. PSiPs use custom designed integrated circuits, gate drivers, control circuits and power devices. Thus the additional complexity of advanced rectifier topologies are suitable for this type of integration.

4. Additional Value Creation

The advanced rectifier topologies make it possible to implement low loss rectification, with reduced EMI filter requirements and with power factor correction into a single power stage.

Additional benefits could be achieved by combining two or more of the topologies, or by adding other technologies such as multi-phase operation, and active ripple filter.

Coarse voltage transformation and generation of multiple output voltage domains could further reduce requirements of the subsequent power stages. Potentially yielding an overall improvement in efficiency and power density.

5. Rethinking Rectification

Advanced active rectifiers cannot compete with the cost of a diode bridge, but they can add value to the overall AC-DC converter. With the ever increasing regulatory requirements for efficiency and harmonic current emissions, they could however one day be the only suitable solution.

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