# LCL Filter Design for PWM Rectifiers

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## 1. INTRODUCTION

PWM-rectifiers are gaining popularity in AC-drives due to their benefits of low line current distortion, unity power factor, controllable reactive power, bi-directional power flow, controllable DC-link voltage, insensitivity to line voltage variations, active filtering capability, motor power increase and transformer and cable cost reduction. Another emerging application area among motor control for active rectifiers is distributed generation such as wind turbines, combined heat and power (CHP), solar energy, fuel cells and micro-turbines. An active rectifier consists of typically a three phase inverter for PWM and an LC- or LCL-filter for energy coupling and switching frequency harmonics reduction. In particular the LCL-version has gained popularity due to smaller size despite the potential stability problems in control. Many papers on this topic have already been published but most of the papers deal mainly with control issues and general design guidelines. Such guidelines include small capacitor values in order to minimize reactive power and tolerable filter current ripple. The detailed design optimisation of the LCL-filter itself, although very important for performance, size and cost, has not received much attention in the literature.

In this paper the multiple requirements of an LCL-filter are addressed and formulated analytically into a design optimisation algorithm. The results are illustrated with simulations.

## 2. LCL-FILTER

There are multiple requirements for LCL-filters (Figure 1):
1) to decouple energy between grid voltage and voltage source inverter
2) to filter differential mode inverter switching noise from mains
3) to filter common mode inverter switching noise from mains
4) to have low losses and compact size.

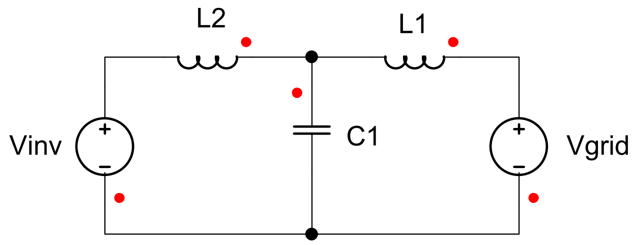


Figure 1. LCL - filter

In our research we are investigating and simulating the following characteristics of the filter:

- Energy decoupling
- Differential mode filtering
- Filter resonance and damping
- Common mode filtering
- Loss, size, cost-optimisation

We will then perform an optimisation analysis for the design of the LCL-filter, concentrating on the best L1/L2-ratio in relation to the actual cost. A comparison will be done between different configurations.

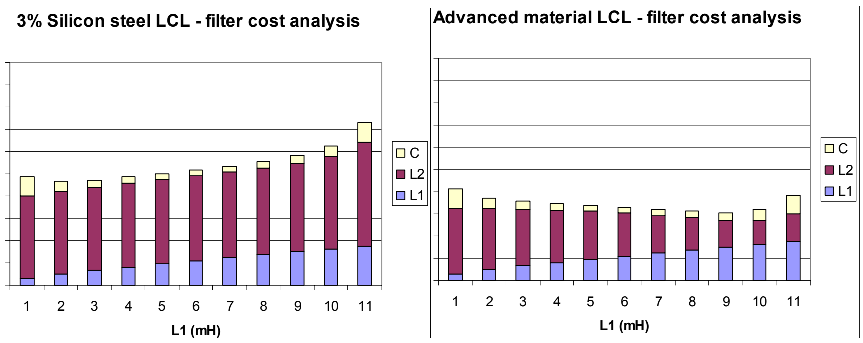

Figure 2: Filter material costs versus L1 (L1 + L2 = 12mH)

For the cost-optimised LCL-solution we will then perform various simulations in regard to the actual operation.

## 3 PLANNED CONCLUSION

In this paper various aspects of LCL-filter design will be discussed. In particularly cost-performance design optimisation of magnetic components (chokes) will be addressed and analysed. With various simulations we will investigate the effects of different components, values, magnetic materials and configurations with the goal to find a cost-effective solution with reasonable filtering performance.