Regenerative Boost Converter

Introduction

In this Paper I describe a possible solution for a bidirectional regenerative boost converter. To evaluate the function of such a converter a simulation model was made. The simulation model includes the power stage and the current and voltage controller.

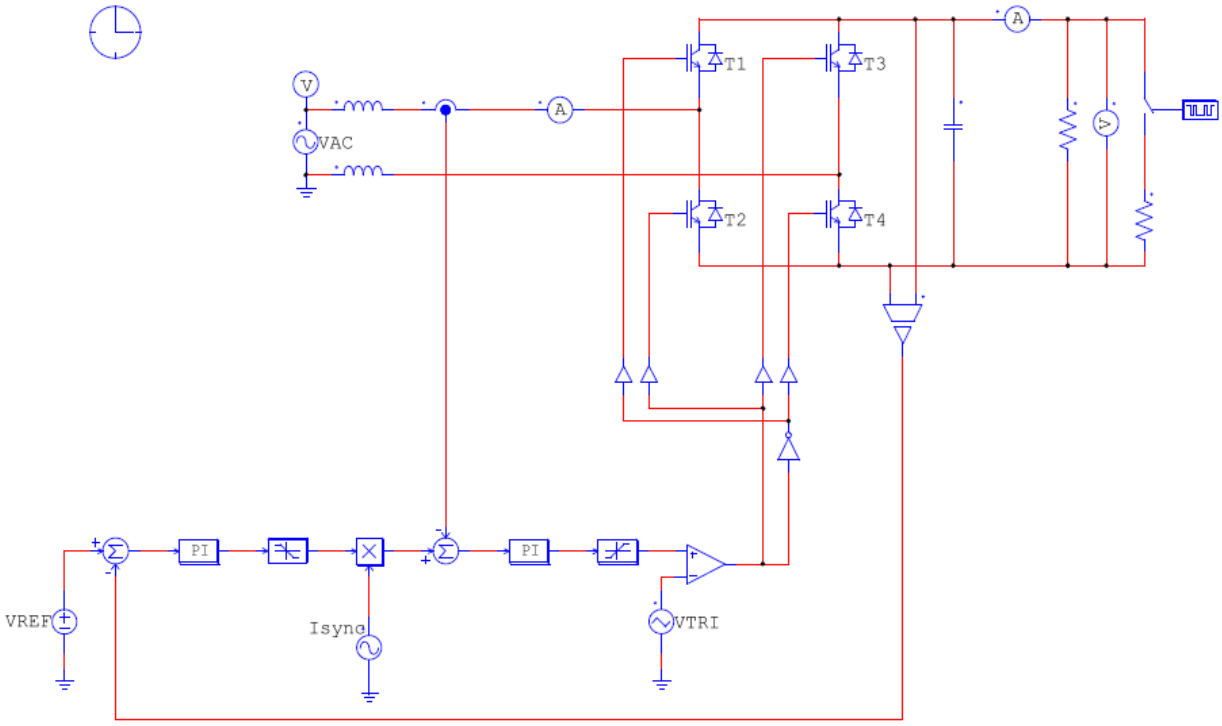
The simulation was made with the PSIM Demo Version 6.1. Due to the Demo version with its restriction according to max. possible nodes, the simulation was made only for a single phase converter. The principle for the single phase converter is the same as for a 3-phase converter. The second restriction to to the limited simulation points of the demo verson was a low switching frequency of 4kHz.

There are several principle for a bidirectional converter:

- Matrix converter
- Two-stage DPEC inverter
- Two-stage DPEC inverter with RB IGBT (reverse blocking IGBT)
- Bidirectional Voltage source inverter (bidirectional VSI)

From the above topologies only the VSI inverter is able to boost the bus voltage.

Simulation Circuit



The simulation circuit shows the principle of the bidirectional VSI. The input stage consist of two half bridge IGBT with internal fast freewheeling diodes. On the input side are the two boost inductions (each 2mH). The value of the DC-BUS capacitor is 5000uF. The controller consist of a voltage controller (PI) and a current controller (PI).

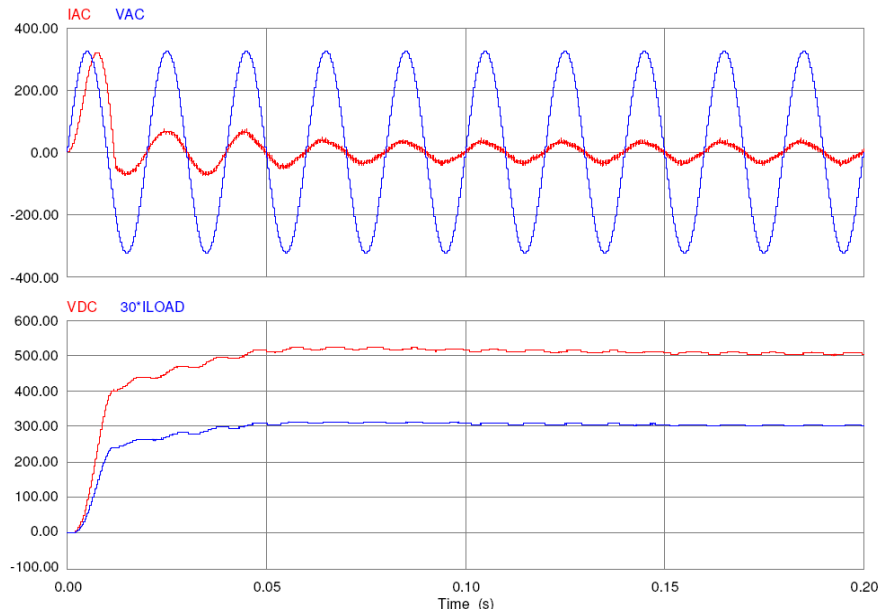
In the step up mode the transistor T2 and T4 with the freewheeling diodes from T1 and T3 are used. The bidirectional VSI is working in the boost mode only when the output voltage is higher then the input peak voltage ($VDC > VAC_{peak}$). Due to this restriction the inrush current on power on is only limited by the boost induction.

In the regenerative mode the bidirectional VSI is working as a buck converter($VDC > VAC_{peak}$). In this mode all four switches are used. To feed back the energy to the main the current controller (which is synchronized to the main voltage) phase must be shifted by 180°.

In this simulation the input current is controlled to 50A. The load current was 10A and the DC-BUS voltage was controlled to 500V.

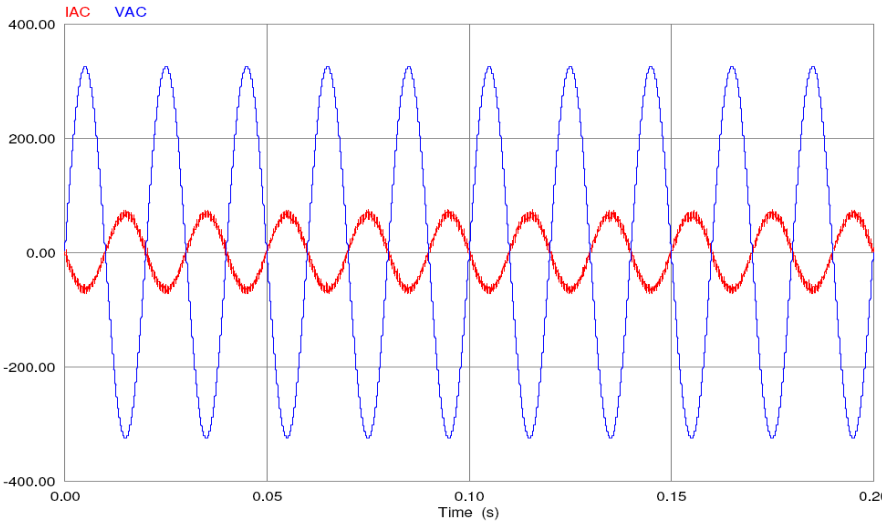
Simulation Results

Boost Mode:



At the beginning ($VDC<VAC_{peak}$) the input bridge is working as a normal passive rectifier. The inrush current is limited to 300A only by the boost induction. After aprox. 20ms the boost controller starts to boost the bus voltage to 500V, the input current is purely sinusoidal. With the VSI a high power factor with very low THD is achieved.

Regenerative Mode:



In the regenerative mode the input current changes its phase by 180°. The output current is purly sinusoidal.

Summary:

The performance of the VSI is excellent because it is fully controlled. One disadvantage is the size of the input boost inductions. The boost inductions must be very large because each converter leg switches the dc-link voltage. One should also consider to replace the electrolytic capacitor by film types whitch are better suited for high frequency switching noise.