



PLECS

DEMO MODEL

Totem-Pole Bridgeless Boost PFC Converter

Last updated in PLECS 4.4.2

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1 Overview

This demonstration shows a single-phase AC/DC totem-pole bridgeless power factor correction (PFC) boost rectifier circuit.

Note

This model contains model initialization commands that are accessible from:

PLECS Standalone: the menu **Simulation > Simulation Parameters... > Initializations**

PLECS Blockset: right click in the **Simulink model window > Model Properties > Callbacks > InitFcn***

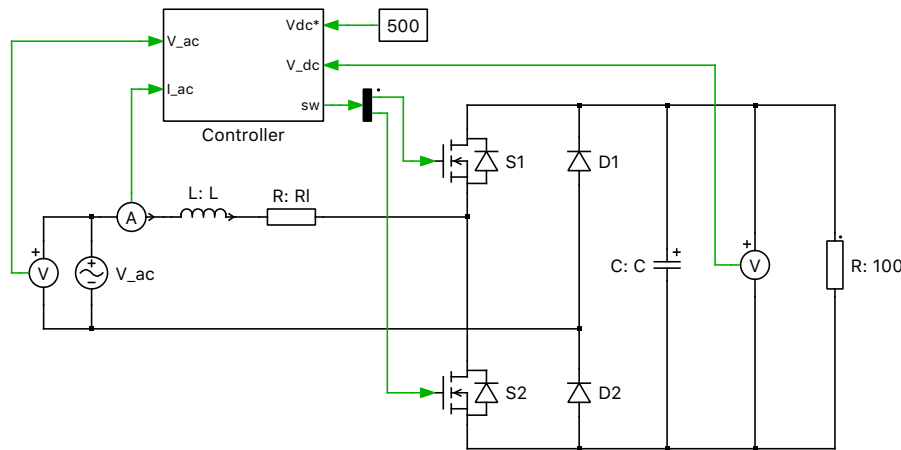


Fig. 1: Totem-Pole Bridgeless Boost PFC Converter

2 Model

2.1 Power circuit

The purpose of AC/DC PFC converters is to provide stable DC voltage output with low THD and high input power factor. Fig. 1 above shows the topology of a totem-pole bridgeless PFC boost rectifier. It is called totem-pole because of the vertical positioning of the two switches, S1 and S2. Line rectification diodes, D1 and D2, are slow recovery diodes here, but they can be replaced with MOSFETs to boost efficiency. The operation of the MOSFET version is the same as below, except that the MOSFET is actively turned on for half cycle line rectification.

2.2 Circuit operation

The circuit operation mode changes at each AC zero crossing.

Fig. 2 illustrates the operation principle of totem-pole bridgeless PFC during the positive half cycle of the AC line voltage. During the positive half cycle, D2 is conducting and connecting the AC source to the output ground. The PWM signal determined by boost duty ratio is driving switch S2; therefore, S2 is the active boost switch. Switch S1 turns on complementary to S2 to reduce the conduction losses and also freewheels the inductor current and transfers the inductor energy to power the output.

The circuit operation during the negative half cycle of the AC line voltage is similar to the positive half cycle, except in this case, D1 is conducting and S1 is the active boost switch. This is illustrated in Fig. 3 below.

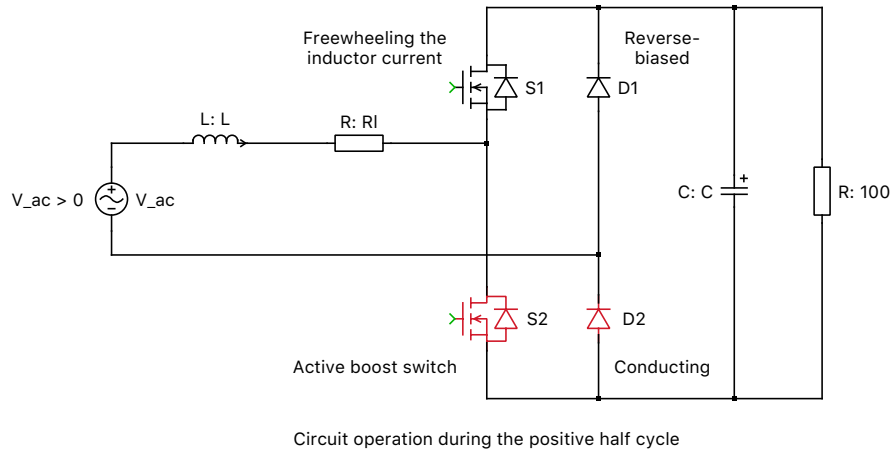


Fig. 2: Active switches for a positive AC current

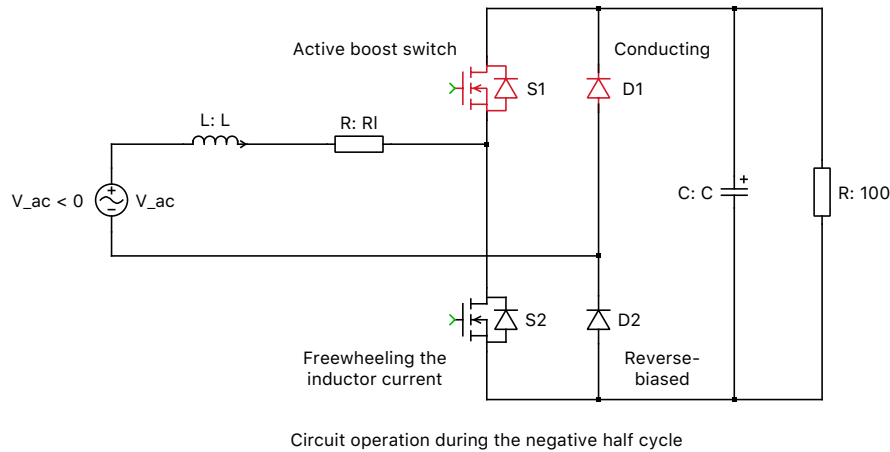


Fig. 3: Active switches for a negative AC current

2.3 Control

As Fig. 4 above depicts, the control scheme is composed of two loops - an outer voltage loop and an inner current loop. The error signal obtained by comparing the measured output voltage (DC) against a voltage setpoint is given to the outer loop proportional-integral (PI) controller for voltage compensation. The voltage loop output is multiplied by the input voltage signal (AC) to generate the current reference. The inner loop proportional-resonant (PR) controller [3] controls the input current to follow the current reference. The resulting value is provided to a modulator for PWM generation.

3 Simulation

Run the simulation to view output voltage, input current and scaled input voltage waveforms. Fig. 5 above shows that the input voltage (in red) and the input current (in green) are almost in phase. At steady state, the ripple in the output voltage and the THD of the input current can be measured using the "Cursors" button at the top of the Scope.

From the drop-down menu of the Cursors button select "Delta", "Min", "Max" and "THD". Manually set the Delta value to the inverse of line frequency ($1/F$). The data table then displays the value for the minimum, maximum, and the THD of the signal between the cursors. The resulting output voltage ripple is 8.1 % and the THD of the input current is 5.4 %. The distortion power factor associated with the

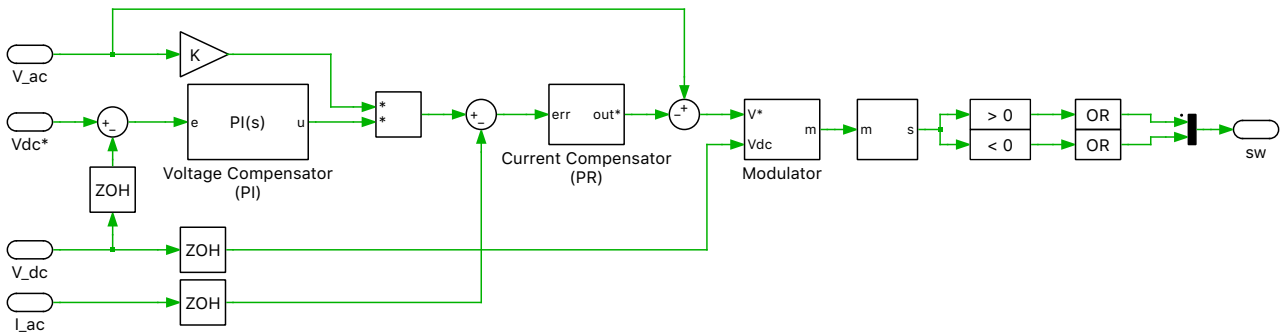


Fig. 4: Totem-Pole Bridgeless Boost PFC Converter Controls

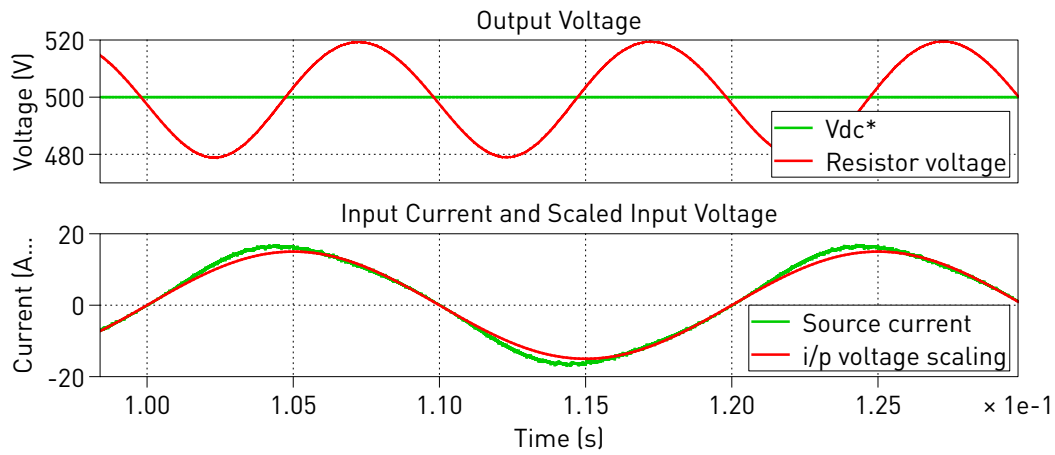


Fig. 5: Totem-Pole Bridgeless Boost PFC Converter Simulation

input current is 0.9985. The harmonic order of these waveforms can also be viewed using the “Fourier spectrum” button at the top of the Scope.

4 Bibliography

- [1] L. Huber, Y. Jang and M. M. Jovanovic, *Performance Evaluation of Bridgeless PFC Boost Rectifiers*, IEEE Transactions on Power Electronics, vol. 23, no. 3, pp. 1381-1390, May 2008.
- [2] L. Zhou, Y. Wu, *99% Efficiency True-Bridgeless Totem-Pole PFC Based on GaN HEMTs*, Click to access online: Transphorm webpage¹.
- [3] R. Teodorescu, F. Blaabjerg, *Proportional-Resonant Controllers. A New Breed of Controllers Suitable for Grid-Connected Voltage-Source Converters*, Journal of Electrical Engineering.

¹ https://www.transphormusa.com/sites/default/files/transphorm/news/Totem-pole%20paper_0.pdf

Revision History:

| | |
|-------------|--------------------------------|
| PLECS 4.3.1 | First release |
| PLECS 4.4.2 | Update PI controller component |

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