smart ctrl

control design for power electronics

Digital Control Loop Design

Tutorial –March 2017-

How to Contact:

info@powersmartcontrol.com

www.powersmartcontrol.com

Power Smart Control SL

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1. Introduction

SmartCtrl[1] is a general-purpose controller design software specifically for power electronics application. This tutorial is intended to guide you, step by step, to design the digital control loop of a boost converter and simulate it on PSIM.

2. Digital control design

2.1. Selection of the converter to be controlled

1. Open your *SmartCtrl* Software.
2. To begin the design of a single control loop DC/DC converter press on  or select the corresponding option from *File->New and initial dialog*. In this case, choose a Single loop DC-DC converter, and a voltage mode controlled boost converter.

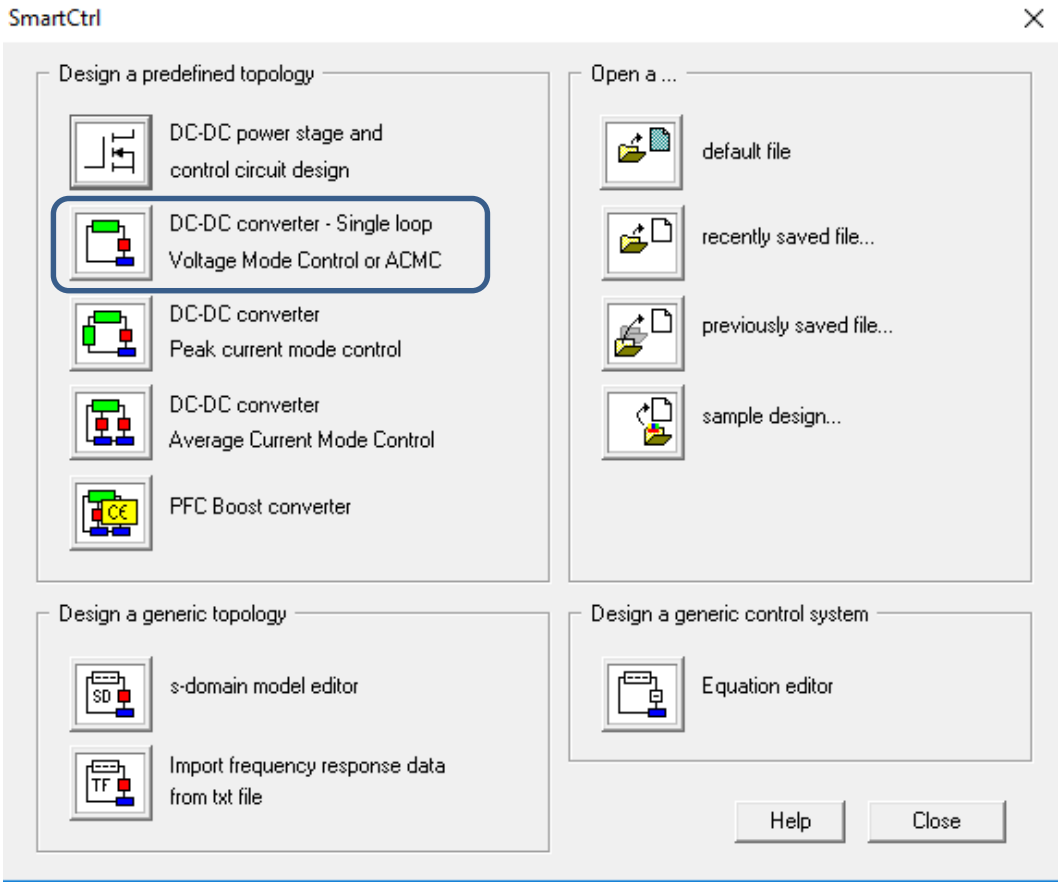

Figure 1. DC_DC Single loop selection

[1] SmartCtrl is copyright ©2009-2017 by Carlos III University of Madrid, GSEP Power Electronics Systems Group, Spain

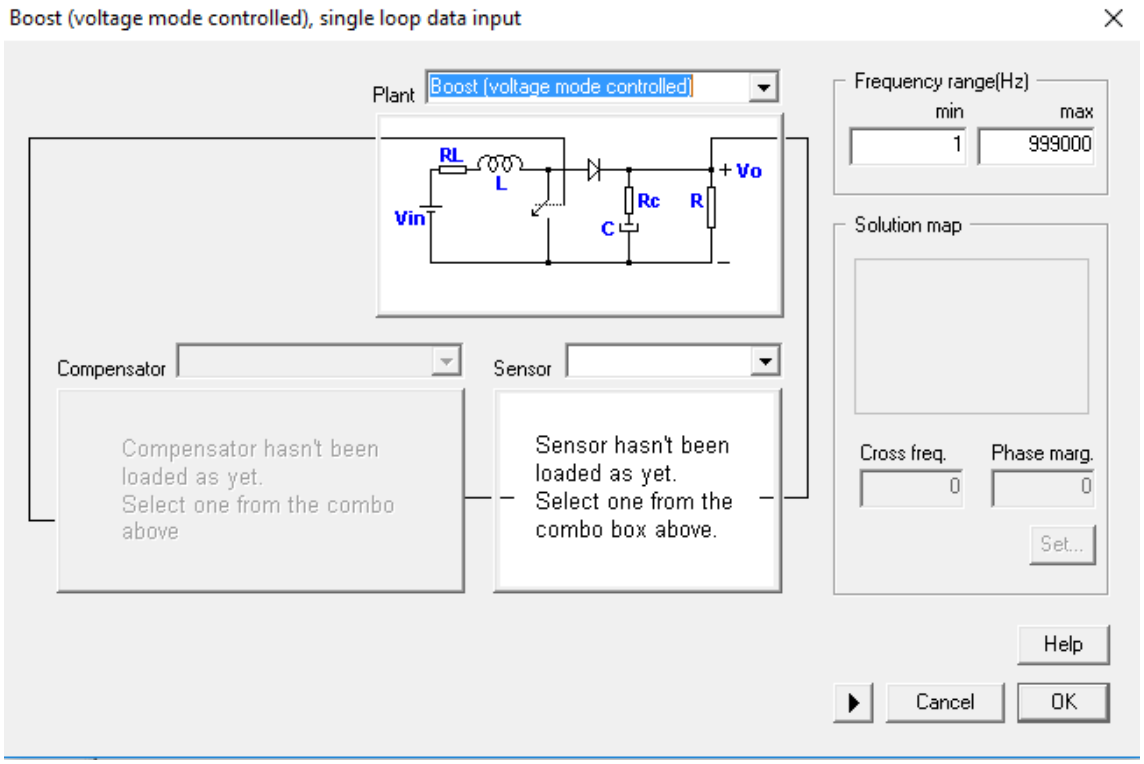

Figure 2. Boost converter selection

3. Introduce the parameters for the plant

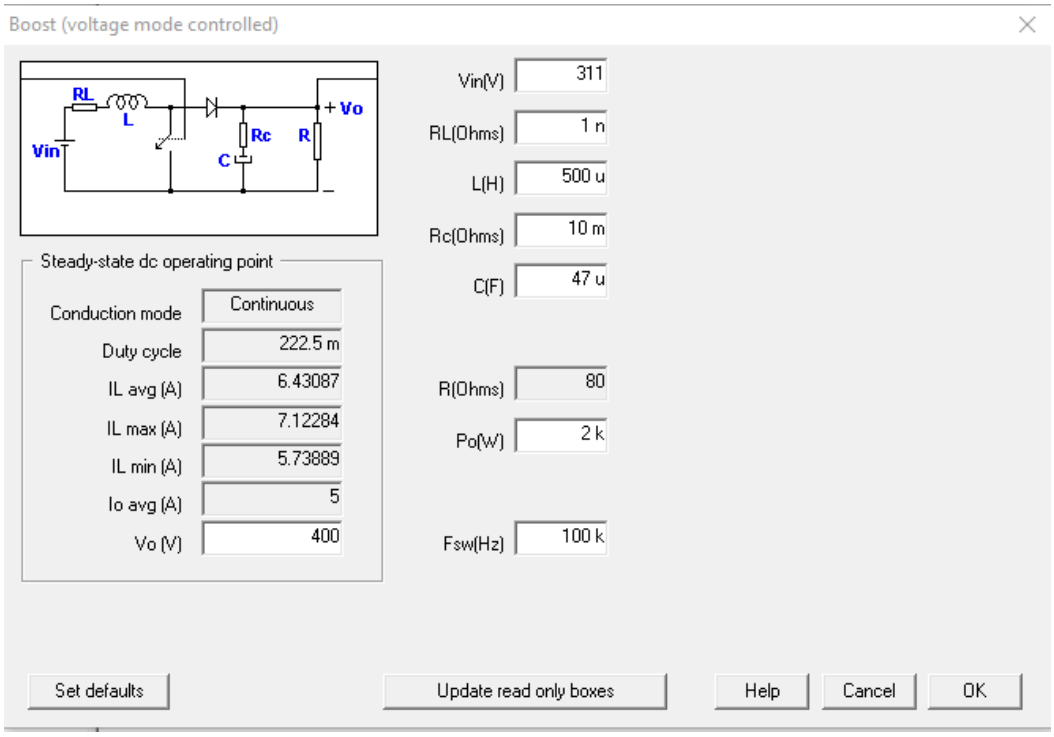

Figure 3. Plant parameters

4. Select the sensor. For a digital controller, only a *Voltage divider* or an *Isolated V. sensor* are allowed.

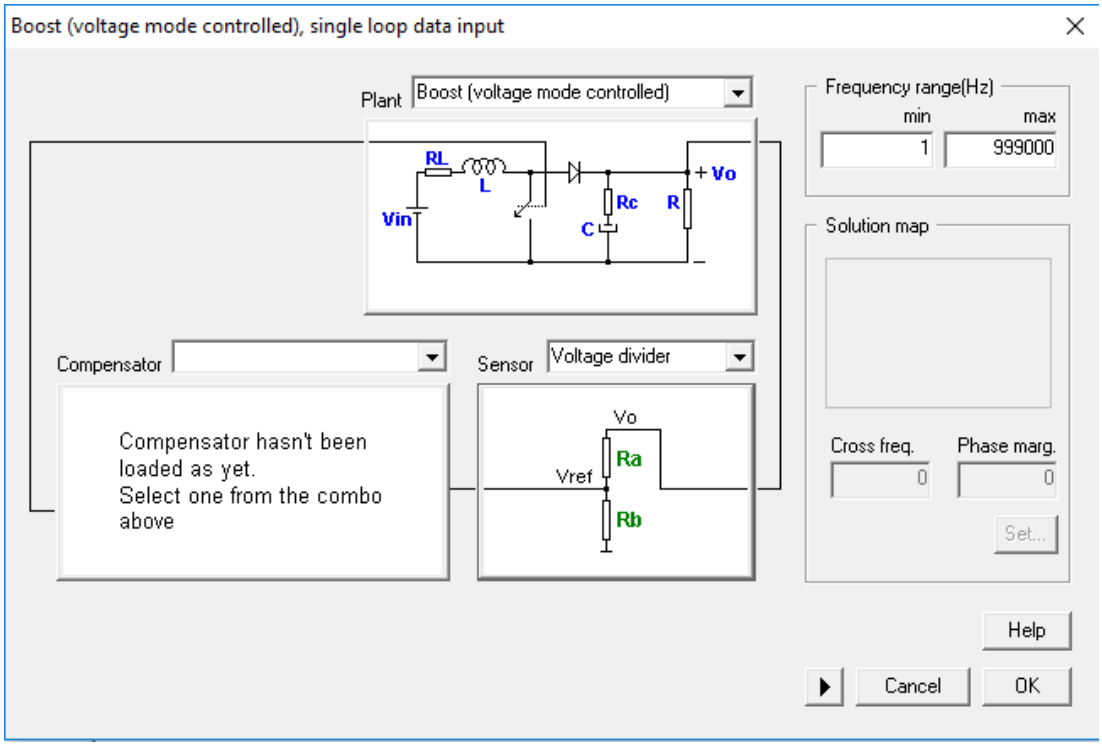

Figure 4. Sensor selection

5. Introduce the parameters for the sensor

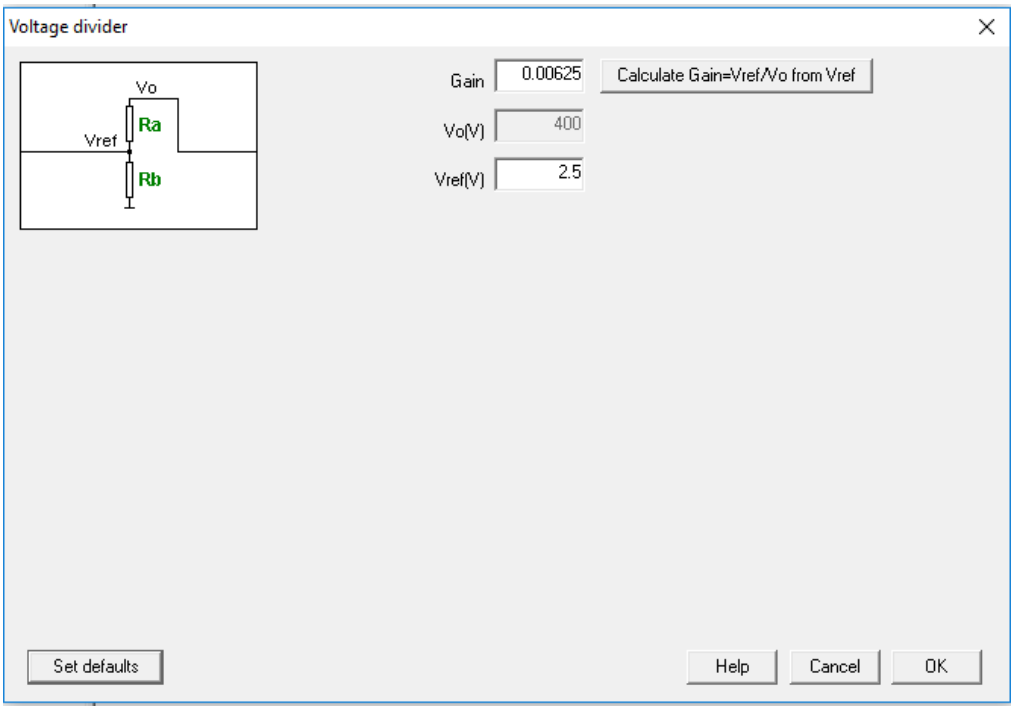

Figure 5. Sensor parameters

2.2. Implementation of a digital controller

1. Now select one of the available digital compensators (PI or PID).

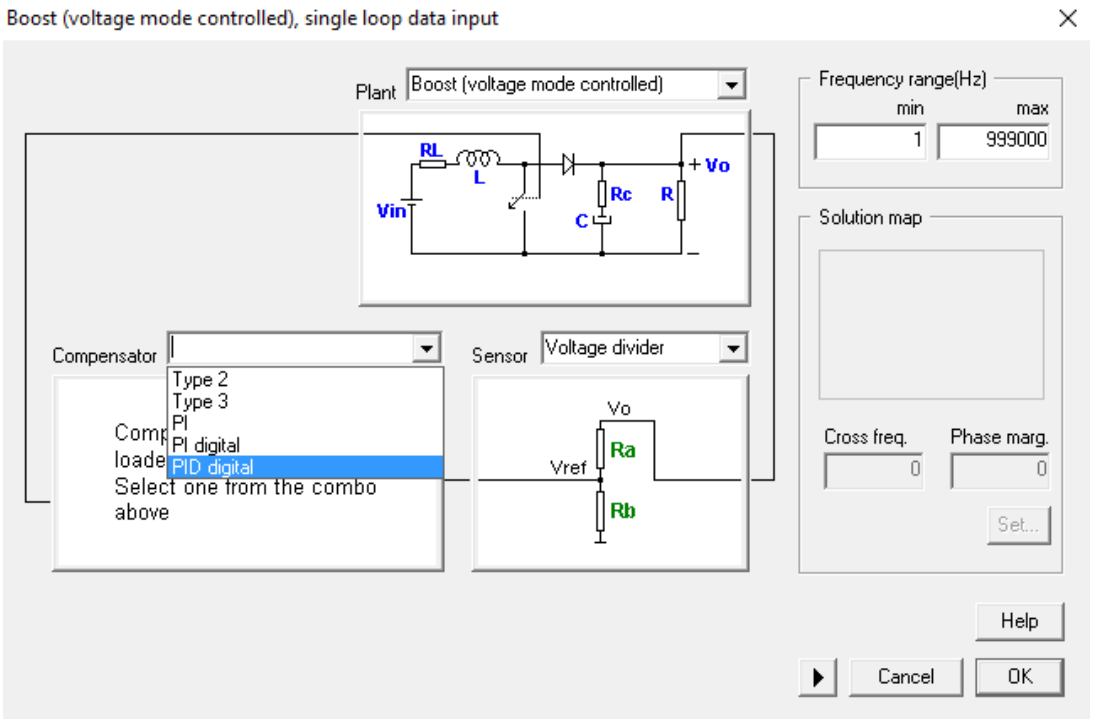

Figure 6. Digital compensator selection

2. Select the desired parameters for the compensator (explained in the help files).

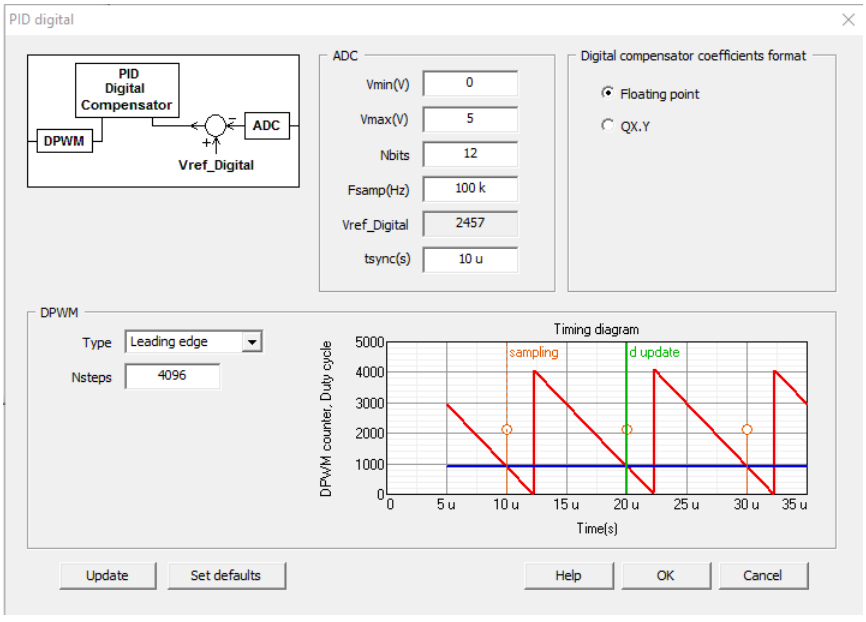

Figure 7. Digital compensator parameters

3. Click on the shadowed *Solution map* and select the desired design point (Phase margin and Cross frequency). The areas that will generate an stable system are in white, and an aditional orange doted line appears that divides them in two. The white zone above the dotted line marks the points where no double 180º crossing occurs.

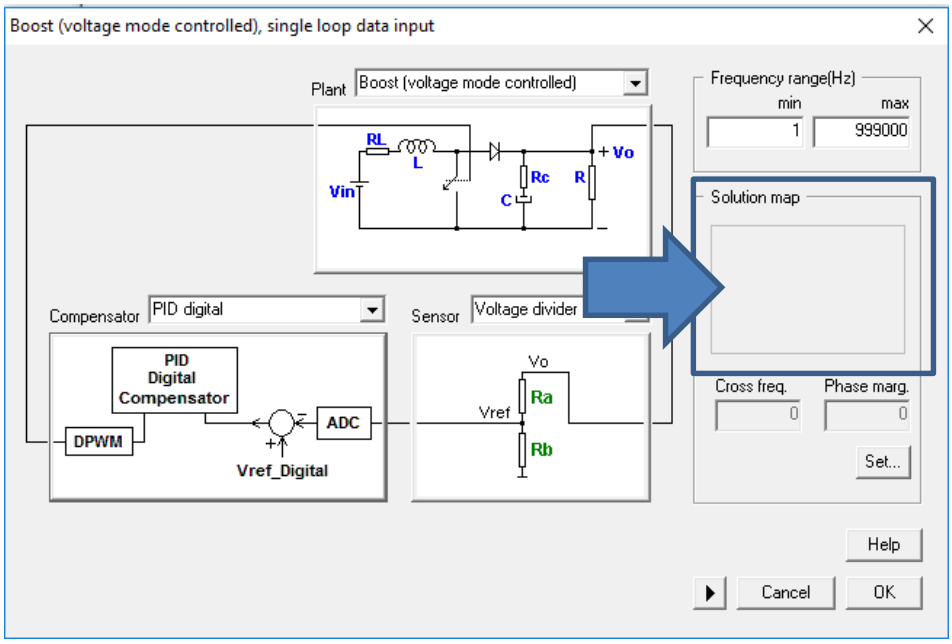

Figure 8. Solution map selection

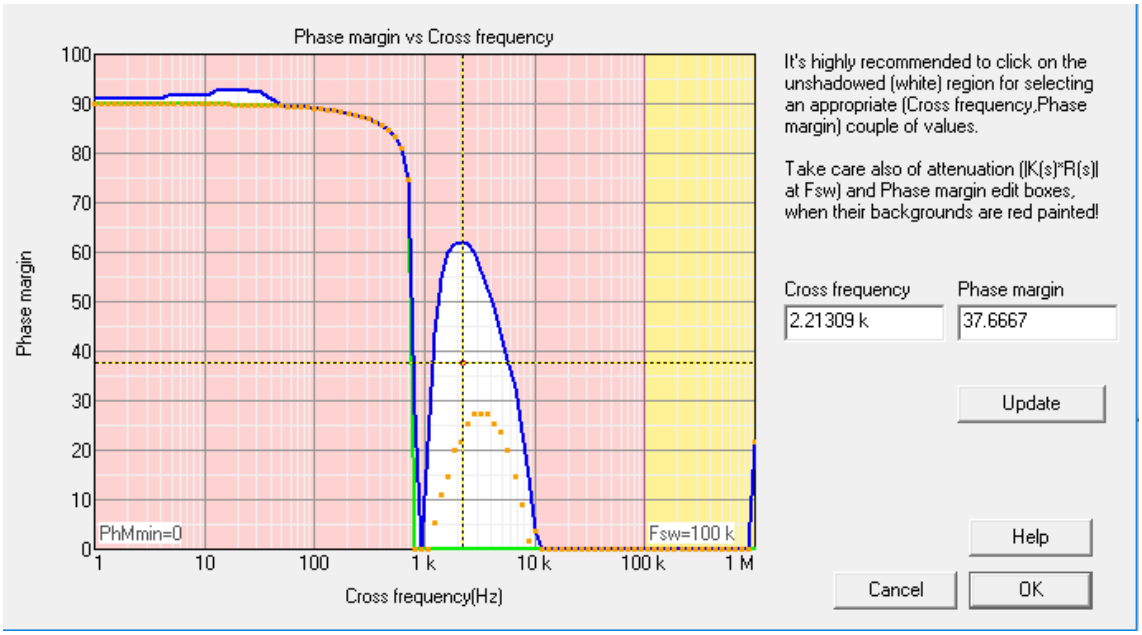

Figure 9. Selection of the design point

4. Press ok and you will be able to see a preview of the converter waveforms, along with the Bode and Nyquist Plots.

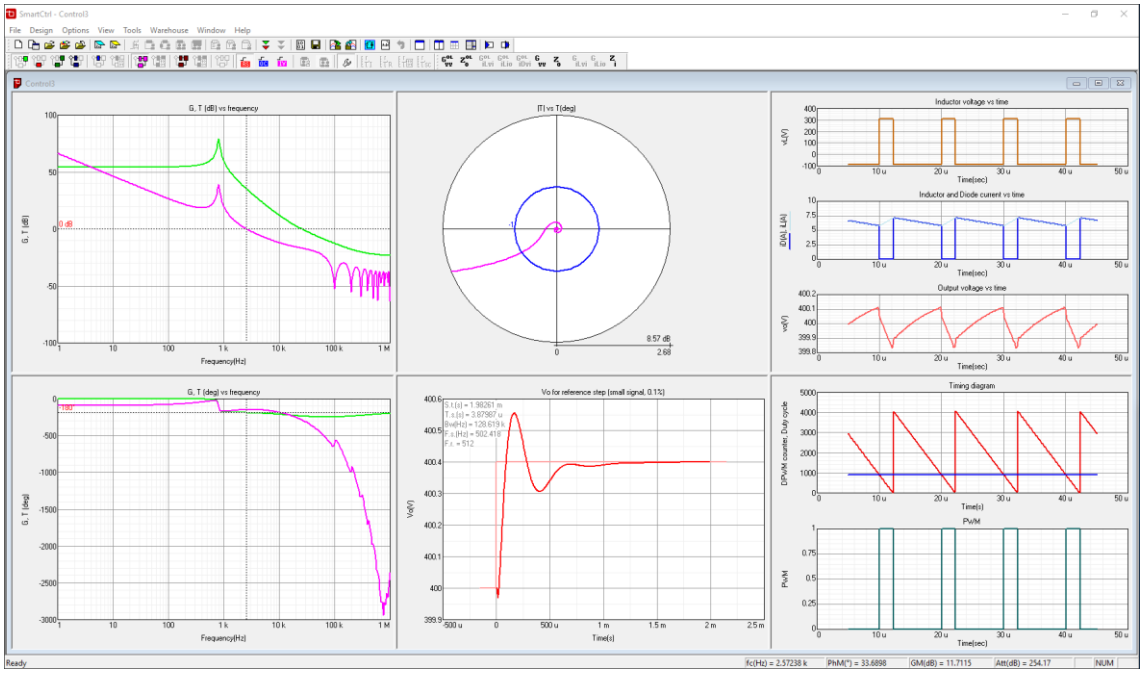

Figure 10. Waveforms preview and Bode and Nyquist plots.

3. Design validation

To validate your design through simulation you can easily export it to PSIM.

1. Press *File –> Export –> To PSIM –> Schematic (Ctrl+Shift+S).*

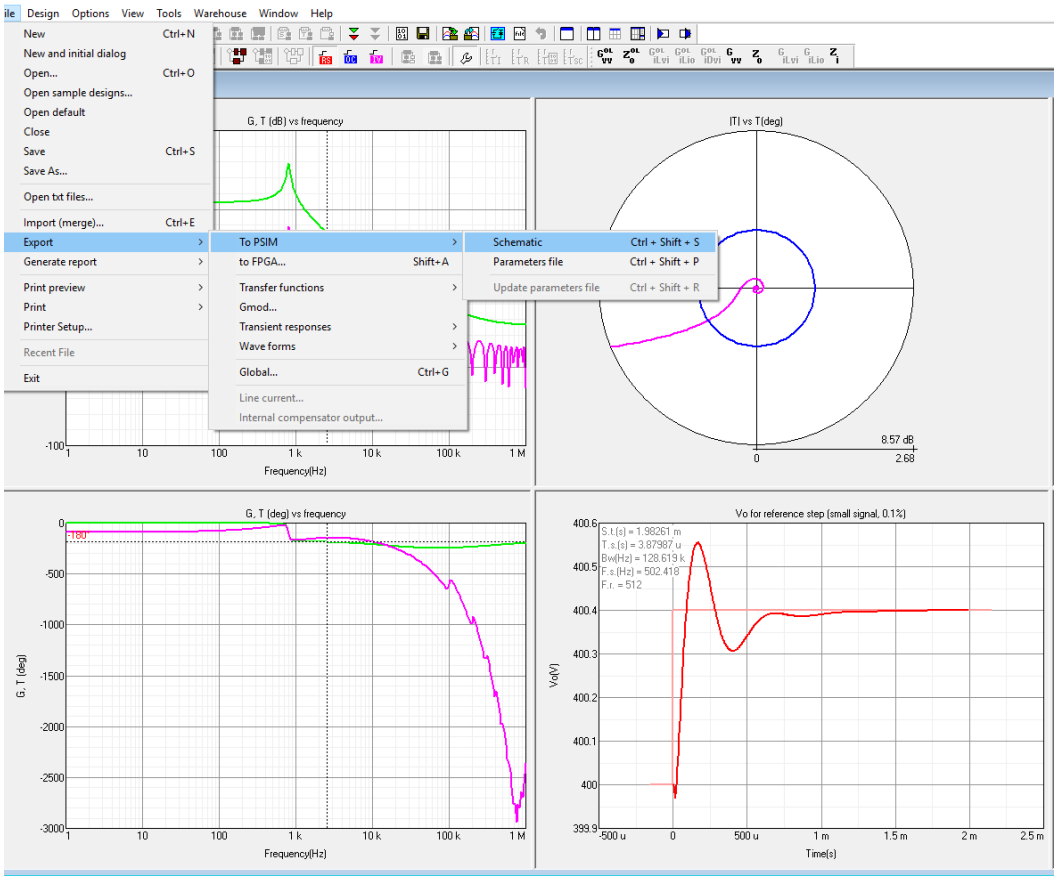

Figure 11. Export selection.

2. Select the PSIM file to where you want to export the design and choose the options shown in the image below.

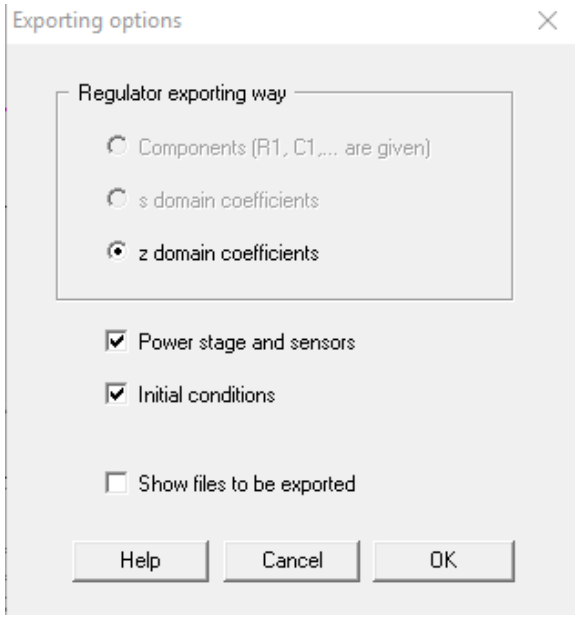

Figure 12. Export options

3. Press Ok and the whole design will be opened in PSIM, ready to be simulated.

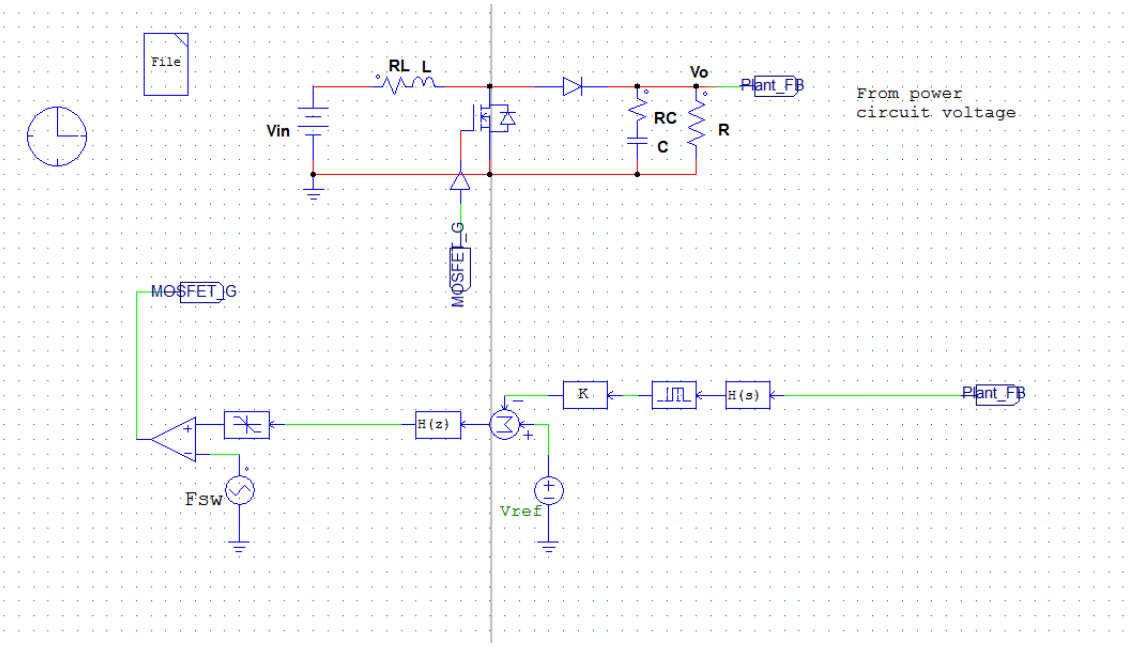

Figure 13. PSIM Schematic

4. If desired, you can check the Time-domain response given by SmartCtrl, with an AC sweep performed in PSIM. To do so, you should add a perturbation, an AC probe, and an AC sweep block, as shown in the image below.

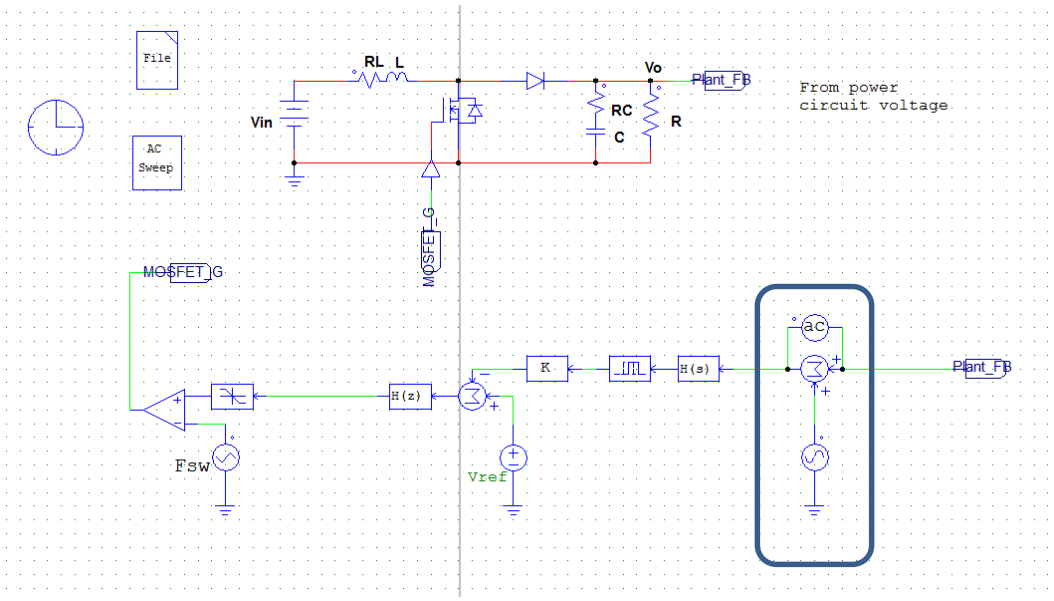

Figure 14. PSIM Schematic ACsweep

5. Once performed, save the data to a .txt file for future use. In order to compare both theoretical and simulated responses, you should also export the SmartCtrl output data to a .txt file, so both can be plotted at the same time.

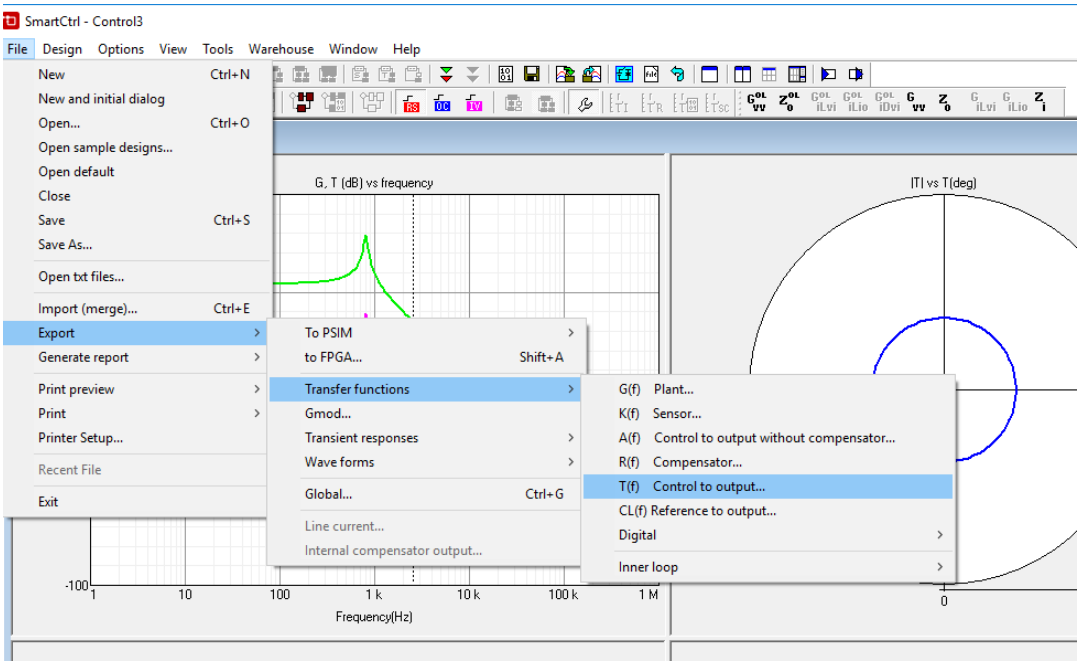

Figure 15. Transfer function export options

6. Select the desired export options

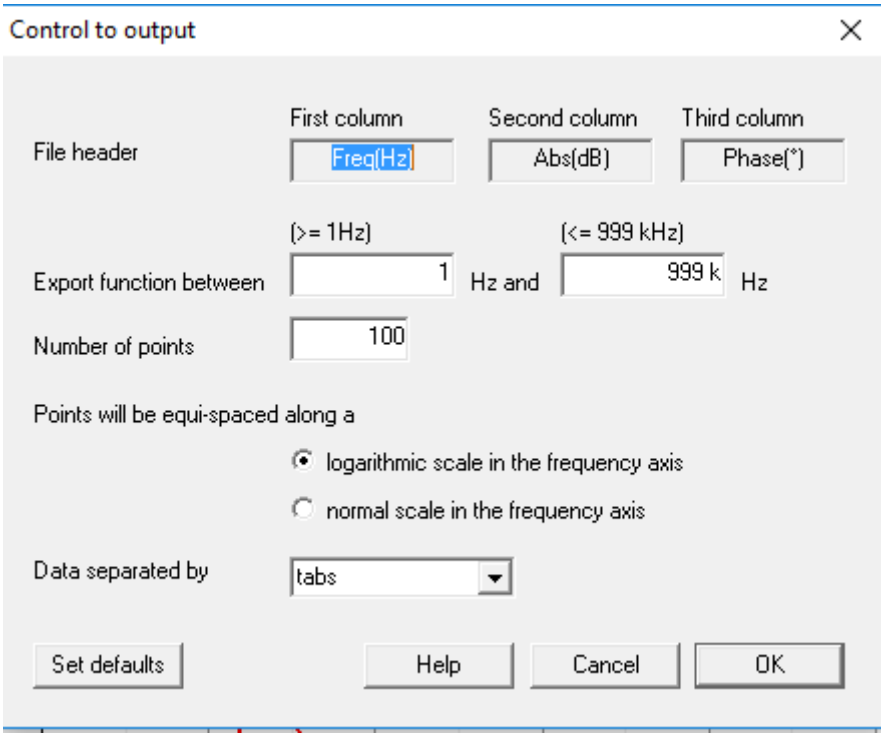

Figure 16. Export parameters

7. One option to compare them is to merge both in *SimView* (PSIM simulation viewer). If you want the *SmartCtrl* exported file to be opened with the correct format, you should change the default column names to: "Frequency amp(*name*) phase(*name*)", with a tabulation between each one. Remember it is case sensitive.

Frequency	amp(Plant)	phase(Plant)
1	66.2348	-89.8695
1.14975	65.0227	-89.85
1.32191	63.8107	-89.8275
1.51987	62.5987	-89.8017
1.74746	61.3867	-89.772
2.00913	60.1747	-89.7378
2.30999	58.9627	-89.6986
2.6559	57.7507	-89.6535
3.05361	56.5387	-89.6016
3.51087	55.3268	-89.5419
4.03661	54.1148	-89.4733
4.64107	52.9029	-89.3944
5.33605	51.6911	-89.3038
6.1351	50.4793	-89.1995
7.0538	49.2676	-89.0796
8.11008	48.056	-88.9418
9.32453	46.8445	-88.7834
10.7208	45.6333	-88.6012

Figure 17. Exported file example

8. You can also see them both in SmartCtrl by means of the *Import(Merge)* button in the File menu:

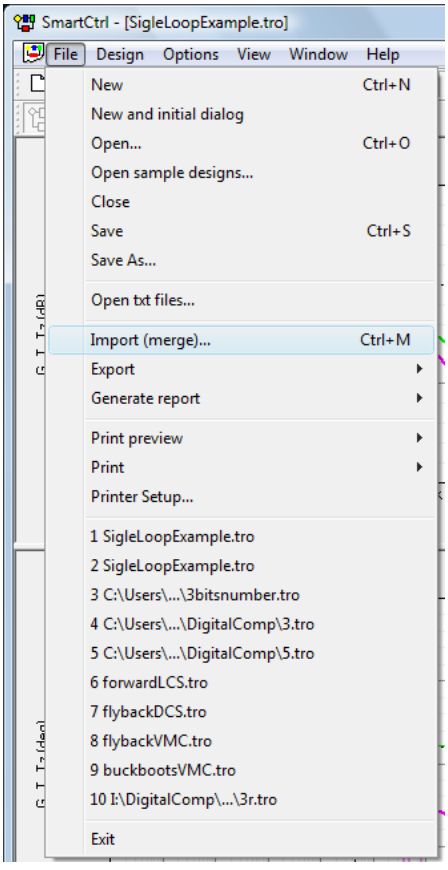

Figure 18. Merge menu

9. Then click on *Add*, select the desired transfer function to be imported and search for the .txt file in your computer.

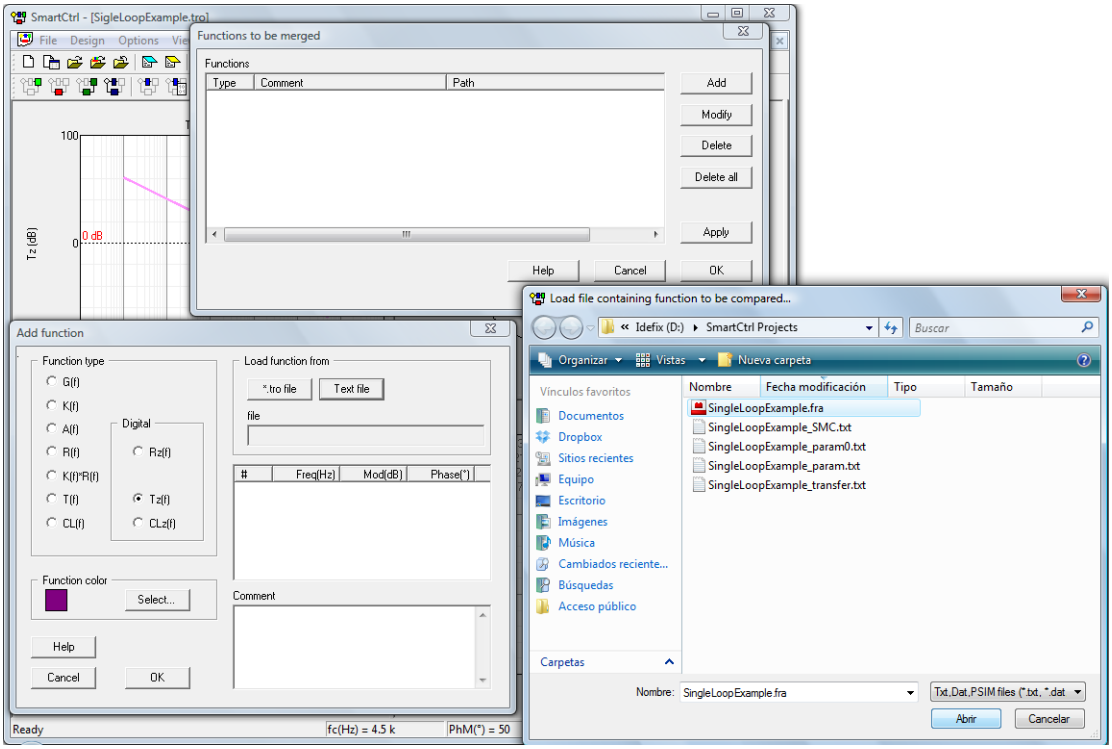

Figure 19. Merge steps