PLECS

DEMO MODEL

Buck Converter with Loop Gain Analysis

Last updated in PLECS 4.3.1

1 Overview

This demonstration shows how to obtain the loop gain of a voltage-regulated buck converter with a resistive load. This can be done by performing an AC Sweep Analysis, which inherently first executes a Steady-State Analysis, or alternatively, using Multitone Analysis, which does not execute a Steady-State Analysis.

2 Model

2.1 Electrical model

This schematic shows a simple buck converter using a MOSFET. The circuit is clocked with a fixed frequency of 100 kHz. The output voltage of the converter is regulated to the voltage reference by a proportional integral derivative (PID) controller.

The system is configured with a Loop Gain Meter placed in the feedback path of the voltage regulator. A current source with a Small Signal Perturbation component and Small Signal Response block are placed at the output of the converter to measure the output impedance with closed loop controls.
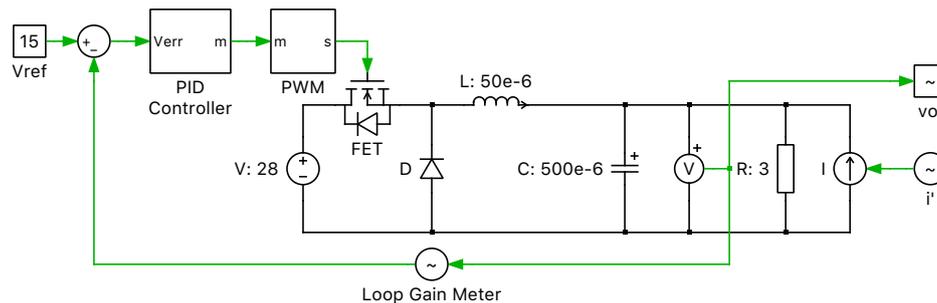

Figure 1: Buck Converter with Loop Gain Analysis

2.2 AC Sweep and Multitone Analysis

The AC Sweep Analysis applies a set of sinusoidal perturbations to the system under study. At each of these user-specified frequencies it then finds the periodic steady-state operating point of the perturbed system, and extracts the system response using Fourier analysis. For detailed information see this tutorial.

The Multitone Analysis is similar to an AC Analysis where the response of the system to a small perturbation signal is analyzed. However, instead of multiple sinusoidal signals of different frequencies, only one multitone signal is applied. The multitone signal is composed of several sinusoidal signals and therefore contains all investigated frequencies at once.

Compared to the AC Sweep Analysis the Multitone Analysis only needs to compute the response to one signal instead of a set of signals for each frequency. One requirement for the Multitone Analysis to work properly is that the value for the initial simulation period parameter must be sufficiently large for the system to have reached steady-state conditions from a transient simulation. Since no information about the system period is needed for the Multitone analysis, this algorithm also works for systems with variable frequency control such as resonant converters.

3 Simulation

For PLECS Standalone and PLECS Blockset the different analysis can be run using the following steps:

- *Standalone:* Choose **Analysis tools...** from the **Simulation** menu, then select an analysis from the list and click **Start analysis**. Clicking **Show results** will display the output of the analysis.
- *Blockset:* Double-click on a PLECS Analysis blocks on the Simulink level. A window opens up that allows to set analysis parameters and to run the analysis by clicking the **Start analysis** button.

While running the analyses, keeping the time domain scope open will provide additional insight into the operation of each analysis tool. However, please note that this will also substantially slow down simulations because of the additional graphics processing so that for maximum speed all scope windows should always be closed. During the execution of the AC Sweep Analysis the scope shows that simulations are executed for each operating point in the set of user defined frequencies, starting from the calculated steady-state operating point. Multitone Analysis shows a longer duration simulation with the superimposed perturbation signal in the time domain. A demonstration of using small-signal
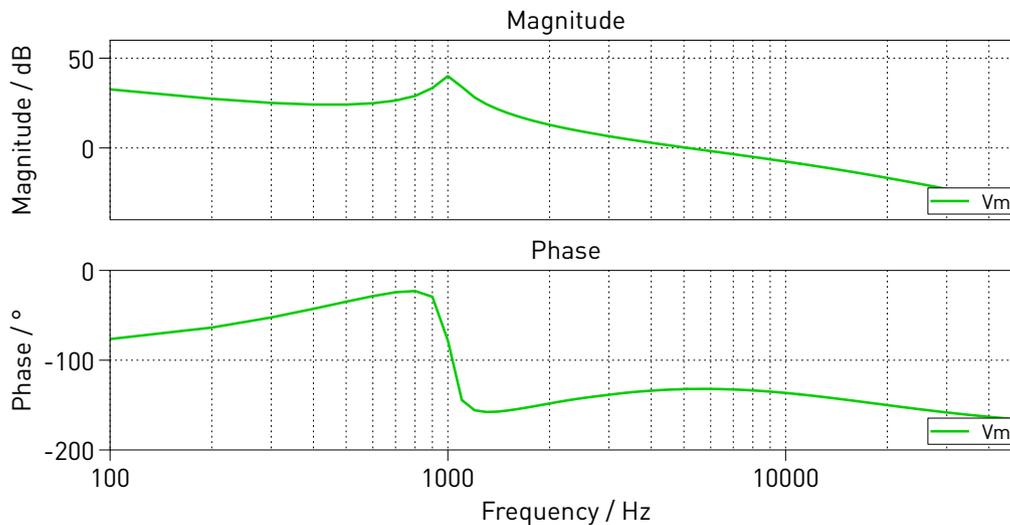

Figure 2: Loop gain of buck converter

analyses to obtain different open-loop transfer functions for an unregulated buck converter is given in the demo model "Buck Converter with Analysis Tools" in the PLECS demo models library.

Revision History:

PLECS 4.3.1   First release

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