How to Contact:

✉️ info@powersmartcontrol.com
✉️ www.powersmartcontrol.com

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1. Introduction

SmartCtrl\(^1\) is a CAD software specifically designed to aid in the design of the control loop used in power electronics applications. With this aim, SmartCtrl provides many predefined topologies, compensators and control types which allow an easy and straightforward way of designing the control loop.

This tutorial is intended to guide you, step by step, along the design of a peak-current mode control of a DC/DC converter using the pre-defined topologies of the SmartCtrl Software.

The peak current mode control (PCMC) was proposed in the 80's by Bob Mammano, and it became fashionable with the appearance of UC1842 device [1]. It is based on controlling the output voltage of the DC/DC converter through the control of the inductance maximum peak current.

2. Brief operating principle explanation of the Peak Current Mode Control

Figure 1 shows the circuit of a buck converter with peak current mode control. When the switching period starts, the transistor is switched on and the voltage drop across the inductance is positive; therefore, its current will increase accordingly. This current is compared to the control current (I\text{c}) provided by the voltage loop regulator, and when the inductance current reaches I\text{c} the transistor is switched off, and so the inductance current slope becomes negative.

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The main drawback of this control technique is its noise susceptibility, which may cause a premature reset of the latch and consequently, the appearance of subharmonic oscillations that may lead to instabilities [1]. Instability due to subharmonic oscillations appears only in continuous conduction mode when duty cycles are above 50%, as demonstrated in [1]; and it can be eliminated by adding an artificial ramp to the sensed current waveform (see Figure 2)).
3. Let's design a Peak Current Mode Control with SmartCtrl.

Within the pre-defined control strategies provided by SmartCtrl, you can find the Peak Current Mode Control. This control strategy can be applied to any of the pre-defined DC/DC converters included in SmartCtrl: Buck, Boost, Buck-Boost, Flyback and Forward. Along this tutorial, the peak current mode control is going to be applied to a buck converter. Let's start a step by step configuration of this system.

To access the configuration window of the Peak Current Mode Control, there are three possible paths:

1. Click on the remarked icon and then on the DC/DC converter – Peak Current mode control button.

   ![Figure 3 Start a peak current mode control. Option 1.](image)

2. Click on the Design drop-down menu, DC/DC converters, Peak Current Mode Control.
3. Click on the peak current mode control icon.

Regardless the starting option, the configuration process is exactly the same and it is explained along the following paragraphs.

Step 1: Select one of the pre-defined DC/DC converters.
In this example, the selected DC/DC converter is a Buck converter which parameterization window is shown in Figure 7.

**Figure 7** Buck converter parameterization window.

**Step 2:** After that, the value of the resistive current sensor must be defined.

**Figure 8** Resistive current sensor.
Step 3: Then, define the modulator parameters.

From top to bottom, the modulator input signals are as follows:

- **Vramp** is the characteristic compensation slope used with this type of control technique. This compensation slope is added to the inductance current in order to ensure the system stability when duty cycles are above 50%.
- **Vsensed** is the equivalent voltage of the sensed inductance current.
- **Vc** is the sensed regulator output voltage

Regarding the modulator design criteria, they are defined below:

- **Sn** The inductance charge slope.
- **Sf** The inductance discharge slope.
- **Se** The slope of the compensation ramp, it is computed as function of Sn and Sf.
- **Att** Is the attenuation applied to the regulator output voltage
Step 4: Once the modulator has been defined, the voltage sensor must be selected amongst the available pre-defined voltage sensors. In this example, a voltage divider has been selected.

Figure 10 Voltage sensor selection and parameterization.
Step 5: In order to complete the configuration of the controlled system, the last regulator type must be selected from the corresponding dropdown list.

Figure 11 Regulator selection and parameterization.
Step 6: Finally, the designer will be asked to select the phase margin and the crossover frequency of the open loop. As usual, SmartCtrl provides the solutions map in order to ease the selection of these parameters. Click OK to validate the selection, and right afterwards the graphic panels will show the Bode plots, Nyquist, transient response and steady state waveforms of the DC/DC converter with a peak current mode control, as shown in Figure 13.

Figure 12 Cross frequency and phase margin.
At any time, the user can change the parameterization of the system and the results will be updated accordingly. To change the parameterization, just click on one of the remarked icons shown in Figure 13.

4. Bibliography
