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Calibration of a type 2 controller applied to a buck converter: a multi-objective analysis

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Abstract

Control lops are nowadays everywhere, from tiny devices to robust industrial applications. However, even when only few parameters are being dealt, manually fine-tuning has been shown to be a meticulous task for achieving designers' desired performance. Fine-tuning a controller parameters is an arduous job that requests expertise of the domain. On the other hand, metaheuristics have been barely applied for accomplishing this task. In particular, due to different behaviors that a control loop can have, a multi-objective analysis shows up as essential. In this work, we apply a Multi-Objective Variable Neighborhood Search based algorithm for assisting the design of a Buck Converter, integrating the optimization process with an evaluation mechanism integrated with a circuit simulation software. The obtained Pareto Front presented various response behaviors, optimizing different desired characteristics. We suggest that the proposed framework is a promising tool for assisting decision makers to design more efficient and dynamic systems.

Keywords: Automatic circuit design, Optimal Design, Non-dominated control models, Metaheuristics, MOVNS

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1 Introduction

Although they generate very good results, classical control methods are often not simple to apply to more complex plants or to cascade control systems where one controller's parameters directly or indirectly influence the action of the other controller [9]. Watt Regulators was a historic and pioneer project for controlling the speed of steam engines. In the following years ON-OFF controllers had been widely used and, with the advent of the electronics, PID control systems are replacing those previous ones, obtaining better control results. Until nowadays, a huge percentage of industrial process are controlled with PID based strategies.

One of the great difficulties in controlling systems/processes is the calibration of the controller, namely controller designing. This design ensures that it will act on the plant in order to obtain a desired response [1].

One of the areas where closed-loop control can be applied is in power electronics where inverters require a feedback control to make the correct switching of MOSFETS or transistors. In particular, this paper deals with the control of switched sources with cascade voltage and current, calibrating the parameters using a metaheuristic based procedure. Other works from the literature proposed the calibration of PID controllers using heuristic based tools [8,11,3]. Furthermore, inspired by pioneers [10], we introduce a multi-objective analysis in the controller designing process. In this sense, we consider the use of sets of non-dominated solutions, according to well-known metrics, for assisting the decision making process.

In this paper, a case of study is dealt in order to calibrate two control loops in cascade of a Buck Controller. In particular, a Type II controller is considered, which is, basically, a Proportional+Integral (PI) with the addition of one more pole in its transfer function (addition of one more capacitor in the electronic circuit).

2 Buck converter and controller

2.1 Voltage Step-Down Converter

From the various topologies of DC-DC converters, a very robust voltage step-down converter and simple assembly is called a step-down or buck. This type of converter lowers a continuous input voltage to a continuous one, but of lesser intensity [6].

The output voltage (V_o), when not considering the semiconductors and