A reconfigurable and expandable kit to teach electronic circuits based on Operational Amplifiers

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***Abstract* — Teaching and learning Operational Amplifiers (OpAmps) in electronic engineering courses is a requirement, since they are a type of integrated circuit widely used for implementing simple or complex circuits. As a contribution to improve the way this integrated circuit is included in electronic engineering courses' curricula, it was designed and implemented a reconfigurable and expandable kit to teach electronic circuits based on the OpAmp uA741. Able to run in a PC, the kit comprises a software application locally interfaced with a hardware platform. This platform includes a circuit with the OpAmp uA741 able to be reconfigured according to a set of parameters defined by a software application. Besides the reconfiguration capability provided by this kit, it also enables the establishment of automatic connections for measuring or applying signals to a reconfigured circuit, plus the ability to simulate the same or other OpAmp-based circuits. This paper provides an overview about the OpAmp uA741 and about its relevance in engineering education. Features and functionalities provided by the kit is described. At the end, supported by a technical demonstration of the kit in an international conference, some teachers' opinions about their perceptions concerning its adoption in a real educational scenario are presented.**

Keywords - OpAmps, Reconfiguration; Simulation, Engineering education, E-learning.

I. Introduction

In the literature there are several methods to teach electronic engineering, most of them focusing on caching students' motivation to learn [1][2]. Videos demonstrating phenomena, plus free and web accessible interactive simulators, are just some of the learning objects that are being applied in education, with successful and promising results [3]. This is particularly important for teaching electronics, and in particular electronic sensors, since most of them are essentially analog, which requires well-designed educational tools. Although the experience shows that digital processing has advantages towards analog processing, such as more accuracy and versatilely to change the behavior of a circuit, the key point is that the signal processing part of a sensor always requires analogue to digital conversions. It is therefore required a previous processing of the analog signals, even if they are latter converted to the digital domain. Joining this evidence with the required versatility to design electronic circuits, in which concerns the ability to change their behavior without replacing the adopted components, contributed to the appearance of reconfigurable analog devices such as Field-Programmable Analog Arrays (FPAA)[1] and Programmable System-on-Chips (PSoC)[2]. The tendency for their wide adoption in the design of analogue electronic circuits may have important implications in the teaching strategy, as referred in [4]. Although, whatever the adopted device for designing analogue circuits are, internally they provide the use of one or more Operational Amplifiers (OpAmps), indicating that this type of Integrated Circuits (IC) is still one of the most important for the design of electronic circuits. It is therefore important to understand the best way to teach them according to the best educational methods.

Teaching and learning electronics cannot be limited to teacher-centered methods supported by traditional classroom environments. New strategies are being applied to catch students' interest and to incentivize their autonomy to learn electronics, such as the flipped classroom. This strategy is basically a type of blended learning that reverses the traditional learning environment by delivering or providing instructional content outside of the classroom, with good results in electronics engineering [5][6]. The new and advanced learning objects supported by the flipped classroom strategy, which may include distance learning approaches, have been incentivizing the adoption of the Problem Based Learning (PBL) methodology that defends students' autonomy to solve problems with teacher guidance. Recent studies indicate this methodology with active-learning, experiment-based and project-based learning approaches, a success to teach electronics [7][8], being therefore important to teach and learn OpAmps, which are traditionally the first IC considered in every electronic engineering course. OpAmps simplicity and utility to design simple and/or complex electronic circuits, and their adoption in recent electronic devices, such as the indicated FPAAs and PSoC, justifies, as already referred, their relevance in electronic engineering, which means that students should acquire good knowledge of their operation. Their adoption in many electronic devices and circuits, justifies that all electronic engineering courses include the study of these type of IC in their curricula. Understanding how they work and their common applications are therefore fundamental, requiring

[1] A Field-Programmable Analog Array (FPAA) is an integrated device containing configurable analog blocks. (e.g. of a well-known manufacturer: http://www.anadigm.com/fpaa.asp).

[2] Programmable System-on-Chip (PSoC) is a family of microcontroller integrated circuits by Cypress (http://www.cypress.com/products/psoc-creator-integrated-design-environment-ide). These chips include a CPU core and mixed-signal arrays of configurable integrated analog and digital peripherals.