An educational kit to teach and learn Operational Amplifiers

Ricardo J. Costa, Paulo Portela, Gustavo R. Alves
ISEP/CIETI/LABORIS
rjc@isep.ipp.pt; portela.paulo@gmail.com; gca@isep.ipp.pt

***Abstract* – Operational Amplifiers (OpAmps) are widely used for implementing simple and complex electronic circuits in electronic engineering. As a contribution to improve the way this IC is included in electronic engineering courses' curricula, this paper presents a prototype of an educational kit comprising a simulation tool and a reconfigurable hardware platform with the OpAmp uA741. It enables the simulation and experimentation of several electronic circuits constructed with the OpAmp uA741.**

Keywords- OpAmps, Reconfiguration, Simulation, Engineering education, Electronic kit.

I. Introduction

OpAmps' simplicity and utility to design simple and complex electronic circuits justify that all electronics engineering degrees include the study of this type of Integrated Circuit (IC) in their curricula. Understanding how they work and their common applications are therefore fundamental. According to engineering educators, the laboratory work is fundamental [1][2], which requires the adoption of real laboratories to experiment OpAmps-based circuits. Despite the available laboratories for electronics (some of them remotely accessed, such as the VISIR, whose adoption has originated many studies [3][4]) they don't exclusively focus on OpAmps. Additionally, the available kits are traditionally manually reconfigured, not giving the required flexibility a computer-based solution would provide, and they don't have any dedicated simulation tool. Due to this evidences, a solution based on a common laboratory is the usual option but, most of the times the circuits; i) must be simulated, using commercial software (some requiring licenses) and; ii) are setup in breadboards, which can be very time consuming and may cause some difficulties to students, due to badly applied connections, noises that may appear, among others. While in some situations setting up a circuit and expose students to those difficulties are part of the learning outcomes, in many situations the main outcome focus on the behavior of the circuit itself, based on the redefinition of some components and parameters.

Therefore, this paper presents a demo of a reconfigurable and expansible electronic kit able to be reconfigured with different electronic circuits based on a single uA741 OpAmp. Currently the kit is locally accessed and reconfigured through a computer. It includes a tool to simulate some basic and typical circuits with the OpAmp, and enable an automatic implementation of those circuits using real hardware, as in a traditional laboratory.

After this introduction, section II presents the kit, section III describes the components attached to the kit used in this demo, and section IV concludes the paper.

II. Developed kit

The developed kit allows the simulation, setup and experimentation of electronic circuits based on the OpAmp uA741. It is supported by a local architecture comprising a hardware platform accessed through a software application. As represented in the diagram of figure 1 and in the picture of figure 2, the kit comprises a reconfigurable hardware platform interfaced with a common PC through a serial connection, and it may have external instruments connected to it. The PC runs the software application to reconfigure the platform and to simulate some circuits.

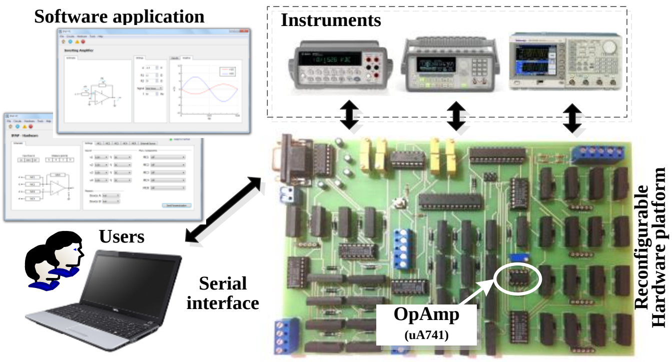

Figure 1: Overall architecture of the electronic kit.

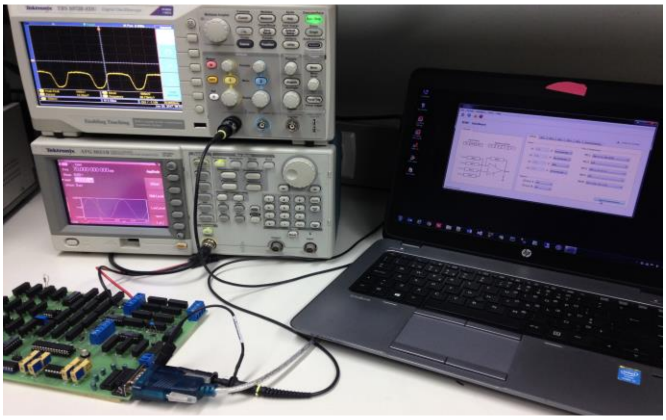

Figure 2: Picture exemplifying the electronic kit using two external instruments (oscilloscope and function generator).

The platform includes an OpAmp uA741 that implements the main circuit illustrated in figure 3 able to be reconfigured to design the circuits to experiment (e.g. inverter, non-inverter differential, integrator, etc.). To enable its expandability, the platform provides a set of connecting points to connect external components (e.g. resistors, capacitors, other ICs, etc.) included in the denominated Module of Components (MC). These are attached to specific branches of the main circuit, which means that the complexity of a reconfigured circuit may be more or less complex according to the selected components. To measure or apply some electrical signals in different points of the circuit, the platform may use commercial instruments (e.g. oscilloscope, multimeter, function generator, etc.).

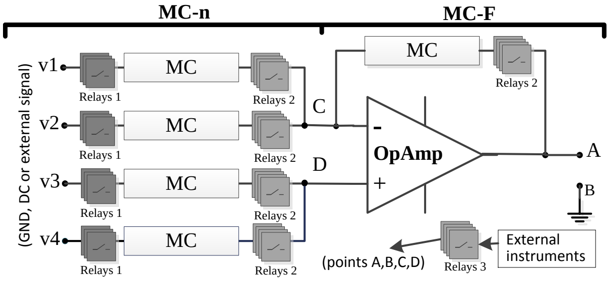

Figure 3: Schematic of the reconfigurable main circuit.

The reconfiguration and the measurement of signals are managed by the software application installed in the PC, which controls the relays provided in the different branches of the main circuit (relays 1, 2 and 3). This software also enables simulating and experimenting some (or all) the simulated circuits (figure 4). It is up to a teacher/technician to prepare the kit to conduct the experiments and the simulations.

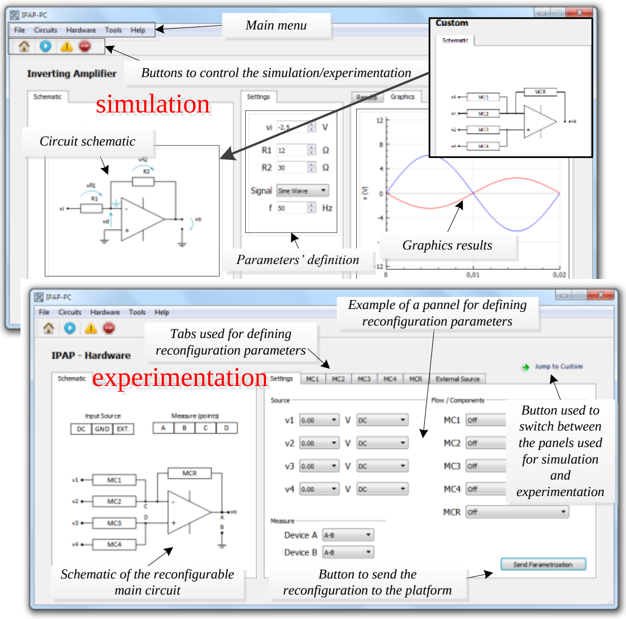

Figure 4: Interfaces for simulating and experimenting circuits.

III. Prepared Circuit for Demonstrations

To demonstrate the kit, it was attached a set of components illustrated in figure 5, plus some external instruments, namely a function generator in v1 and v4, a fixed DC voltage in v2 and a two channel oscilloscope (channel 1 is connected in v1 and channel 2 can be connected to points A, C or D with the ground in point B). Using the software application, users can simulate and experiment different circuits according to the definitions made in the platform.

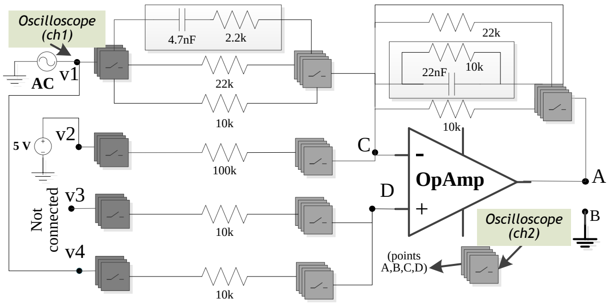

Figure 5: Circuit provided for demonstrating the kit.

IV. Conclusions

OpAmps are probably the most known IC in electronic engineering. The simplicity they provide to design electronic circuits (amplifiers, filters, limiters, etc.) justifies their inclusion in electronic engineering course curricula. Therefore, this kit allows user to simulate and experiment some electric circuits based on the OpAmp uA741. Currently the kit gives some advantages to easy and fast the implementation of electronic circuits without the use of a traditional breadboard, components and wires. However, future versions should be improved, since some minor errors exists and there are some limitations concerning the available circuits to simulate. Additionally, its remote access should also be considered in future versions, in order to facilitate its adoption as a resource for distance learning degrees.

References

[1] Norrie S. Edward, “The role of laboratory work in engineering education: student and staff perceptions,” *IJEEE - Int. J. Electr. Eng. Educ.*, vol. 39, no. 1, pp. 11–19, Jan. 2002.

[2] Lyle D. Feisel and Albert J. Rosa, “The Role of the Laboratory in Undergraduate Engineering Education,” *J. Eng. Educ.*, vol. 94, pp. 121–130, Jan. 2005.

[3] A.V. Fidalgo et al., “Using remote labs to serve different teacher’s needs A case study with VISIR and RemotElectLab,” in *9th International Conference on Remote Engineering and Virtual Instrumentation (REV’2012), Bilbao, Spain 4-6 July*, 2012, pp. 1–6.

[4] Javier Garcia-Zubia et al., “Empirical Analysis of the Use of the VISIR Remote Lab in Teaching Analog Electronics,” *IEEE Transactions on Education*, vol. PP, no. 99, pp. 1–8, 04-Oct-2016.