Maestría en Ingeniería en Automatización de Procesos Industriales

Title

Reconfigurable hardware implementation of PID controllers through memristors

Author

Iván Castillo Bravo

Contributor

Carlos Muñiz Montero

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Iván Castillo-Bravo, Carlos Muñiz-Montero
Master in Industrial Process Automation
{ivan.castillo, carlos.muniz}@uppuebla.edu.mx
Tercer Carril del Ejido Serrano S/N, San Mateo Cuamatla, Juan C. Bonilla, Puebla, México

1. Introduction

The memristor realized by the Hewlett Packard laboratories in 2008 is an important object of study intoday electronics engineering [1]. This work explores the use of meristors to tune the gains of PID controllers. The important concept is that the resistance of a memristor can be tuned by changing its voltage [2]. This way, the use of memristors will allow easily adjust the control system in case of significant changes detected in the plant. Two important issues must be solved: (i) to develop a methodology to easily implement the memristor emulator circuits and (ii) to develop an algorith to detect the changes in the plant and performe the required memristor tuning. It is proposed the use of programmable analogue arrangements (FPAA) to allow and agile and productive experimental development of the memristor-based controller. Besides, the memristor-based PID (M-PID) is compared with respect to conventional and fractiona-order PID controllers.

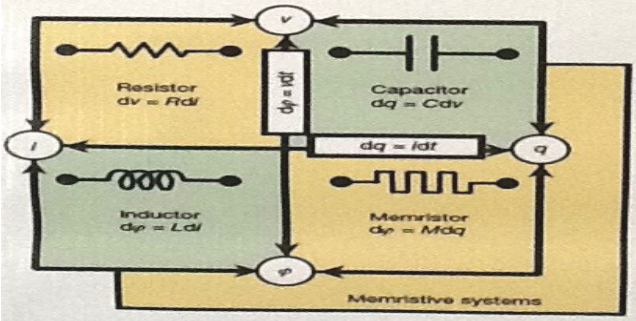

Figure 1. The four fundamental two-terminal circuit elements: resistor, capacitor, inductor and memristor [3].

2. Objectives

2.1. General objective

To design and to implement on reconfigurable hardware tunable PID controllers through arrangements of memristor emulators.

2.2. Specific objectives

- To obtain behavioral models in SIMULINK / MATLAB of PID controllers with tunable gains from memristors emulators to compare their performance with other controllers, such as conventional and fractional order PID controllers.
- To implement the mathematical models in reconfigurable hardware, such as Field Programmable Analog Arrays (FPAA).
- To simulate in SIMULINK / MATLAB an algorithm to tune the proportional, integral and derivative gains of the reconfigurable systems based on memristors.

3. Method

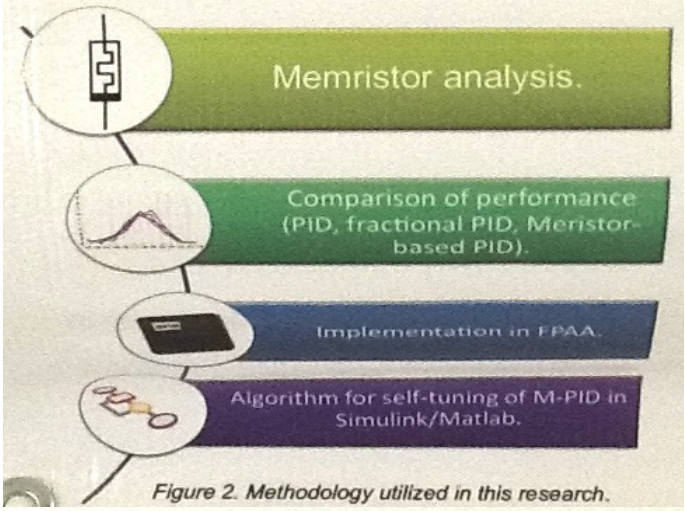

Figure 2. Methodology utilized in this research.

4. System description

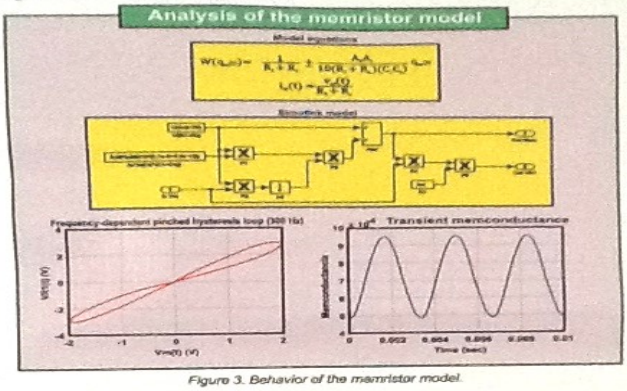

Figure 3. Behavior of the memristor model.

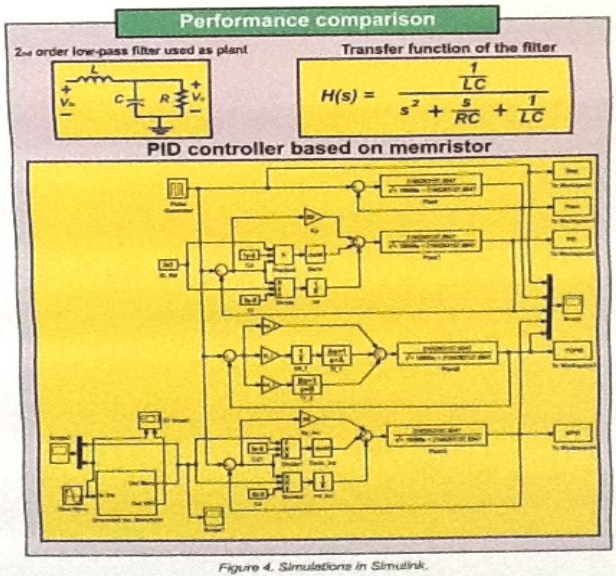

Figure 4. Simulations in Simulink.

5. Results

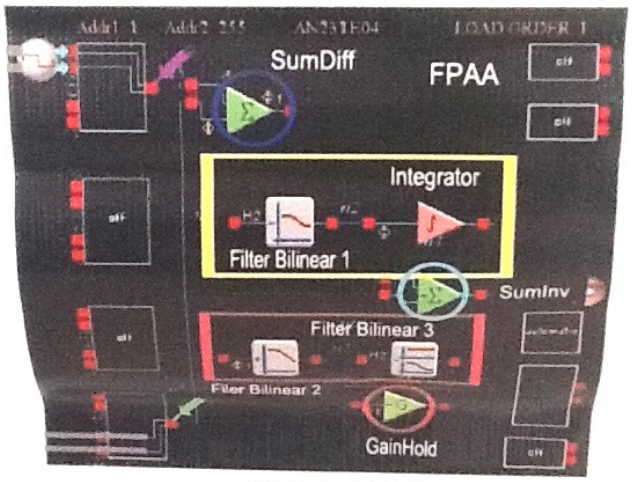

Figure 5. Implementation in FPAA.

Table 1. Data comparison.

	PID	FOPID	PID
$t_{d\,(msec)}$	17	8.7	18
$t_{r\,(msec)}$	103	47	107
$t_{p\,(msec)}$	124	53	129
$M_{p\,(\%)}$	1.59	12.32	1.61
$t_{s\,(msec)}$	587	217	564

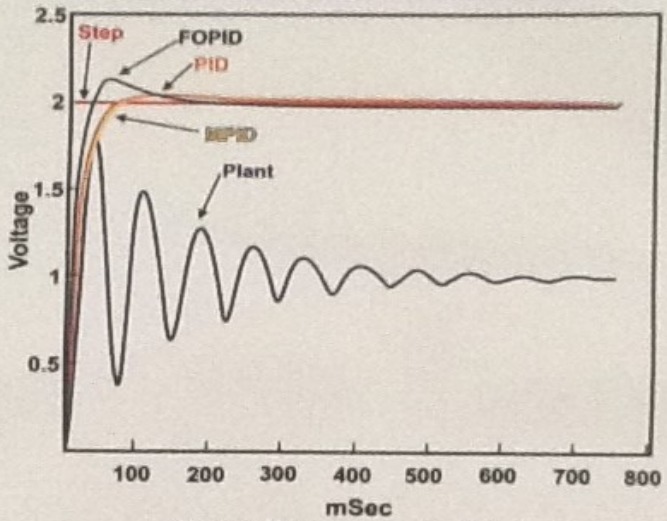

Figure 6. Step response (Simulink).

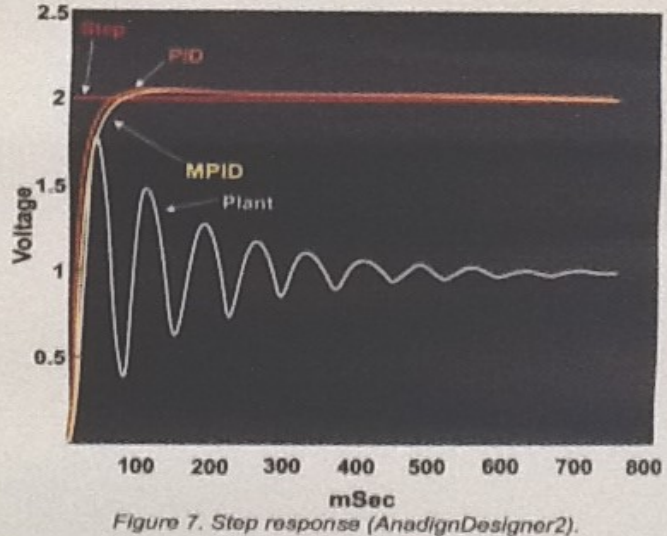

Figure 7. Step response (AnadigmDesigner2).

6. Conclusion

Novel alternatives for analog implementation in FPAA of integer and fractional order PIDs and memristor-based PIDs were introduced. The proposed realizations can be easily fulfilled using commercially available FPAAs, allowing to easily change the design without having to change hardware. Besides, the proposed implementation of memristors can be used in other applications, such as memristor-based oscillators.

Thesis Progress

- Objective 1: 100%
- Objective 2: 80%.

Acknowledgements

To CONACYT for scholarship.

Bibliography

[1] L. Chua, "Memristor-the missing circuit element," *IEEE Transactions on circuit theory*, vol. 18, no. 5, pp. 507-519, 1971.

[2] C. Sanchez-Lopez, F. Morales-Lopez, and M. Carrasco-Aguilar, "High-level simulation of a pid controller based on memristor," in New *Circuits and Systems Conference (NEW-CAS), 2016 14th IEEE International*. IEEE, 2016, pp. 1-4.

[3] D. B. Strukov, G. S. Snider, D. R. Stewart, and R. S. Williams, "The missing memristor found," *Nature*, vol. 453, no. 7191, pp. 80-83, 2008.

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