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DATA ACQUISITION FROM A CHUA'S CHAOTIC SYSTEM

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This paper describes the data acquisition from a chaotic system. As chaotic system we used a Chua circuit, a third-order RLC circuit with four linear elements and only one nonlinear element. Chua's circuit is readily constructed at low cost using standard "off-shelf" electronic elements and exhibits a rich variety of bifurcation and chaos. This circuit is the first physical system, whose theoretical behaviour agrees with both computer simulations and experimental results, for which the presence of chaos has been proven mathematically.

As acquisition board we used a board with an 80C552 microcontroller and we developed the software for the acquisition on C++ Builder. Finally, this pack is used for the study of this chaotic system and in the future for control.

Key words: Chua, chaotic, aquisition, system, microcontroller

1. INTRODUCTION. CHUA'S CIRCUIT.

In the last few years various nonlinear electronic systems which show chaotic behaviour have been constructed and described theoretically. Certain effects blamed on noise are really examples of chaotic behaviour of a completely deterministic nature. One of such circuits is Chua's circuit which is given in figure 1.

It is a third-order RLC circuit with four linear elements (two capacitors, one resistor and one inductor), and has only one nonlinear element; a piecewise linear resistor.

The state equations of Chua's circuit are as (2) where G= 1/R and the three segment piecewise linear VC_1-i characteristic of nonlinear element is de fined by:

$$f(vc1) = m0vc1 + \frac{1}{2}(m1 - m0)\left(|\, vc1 + Bp \,| - |\, vc1 - Bp \,|\right) \qquad (1)$$

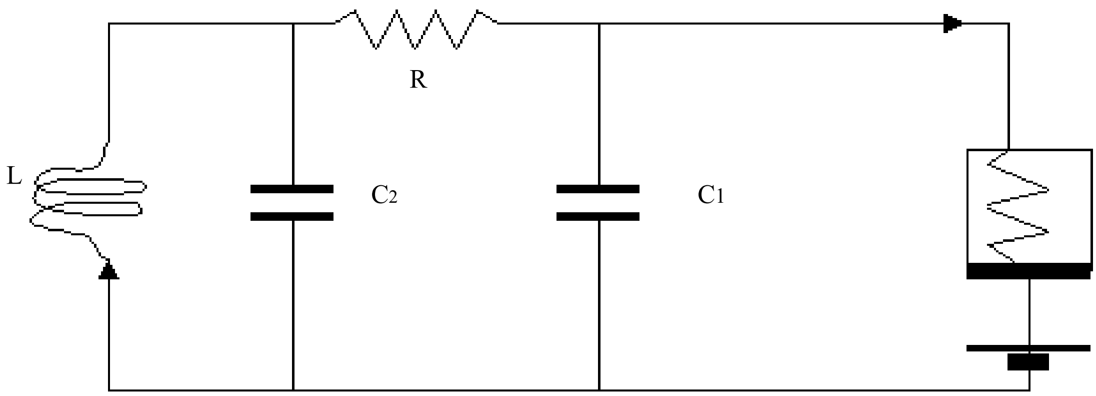


Figure 1. Chua's circuit

$$C1 \frac{dvc\,1}{dt} = G(vc\,2 - vc\,1) - f(vc\,1)$$

$$C2 \frac{dvc\,2}{dt} = G(vc\,1 - vc\,2) + iL \qquad (2)$$

$$L \frac{diL}{dt} = vc\,2$$

(1) is a particular one; the slopes in the inner and outer regions are m_0 and m_1 respectively ; ± B_p denotes the break points. Equations (2) constitute an autonomous dynamical system, meaning that there is no external signal injected into the system ; the system is allowed to evolve through its natural dynamics. When the resistance R, inductance L , and capacitances C_1 and C_2 in Chua's circuit are positive numbers, from an energy-conservation point of view, the nonlinear resistor must be active for the circuit to oscillate, let alone become chaotic. In practical implementations, the active nonlinear resistor responsible for supplying power to the pasive linear elements is in turn powered by a battery [2].

Chua's circuit is readily constructed at low cost using standard 'off-shelf' electronic elements. The circuit is the first physical system, whose theoretical behaviour agrees with both computer stimulations and experimental results, for which the presence of chaos has been proven mathematically.

Just as the classical parallel RLC resonant circuit is the simplest physical system which can model the onset of oscillations in dynamical systems, so Chua's circuit in the simplest paradigm for studying nonperiodic phenomena in nonlinear circuits. Chua's circuit is the simplest possible in the sense that chaos cannot occur in an autonomous circuit (modelled by nonlinear state equations) with fewer than three energy storage elements (capacitors and inductors) and that at last one nonlinear active element is needed even for oscillation to be possible.

Equations (2) can be rewritten in the dimensionaless form [1]:

$$\begin{aligned} \overset{*}{x} &= \alpha\left(y - x - f(x)\right) \\ \overset{*}{y} &= x - y + z \\ \overset{*}{z} &= -\beta y \end{aligned} \tag{3}$$

2. DATA ACQUISITION PACK. DESCRIPTION.

For our data acquisition from Chua system we used a board like in figure 2. The board is composed by:

- a source- realised by a LM7805 circuit and can accept a tension voltage level between 9 and 15 Volts ;
- 80C552 microcontroller. The cuartz frecquence is about 11 MHz. The microcontroller can access an external memory until 64 kbytes divided in 2 blocks of 32 kbytes each. The EPROM memory block can be accessed as program memory and as data memory too. A selection circuit permmitt the address alocation for these two zones of memory. We used an EEPROM 24C04 which is addressed on the internal bus I^2C ;
- the connection between PC and board is assured by RS-232 ;
- digital-analogical converter which is realised with AD 7537 and AD712 circuits. We have two independents channel with the possibility of selection between jumpers for tension voltage level;
- keyboard;
- reset and mode buttons;
- buzzer;

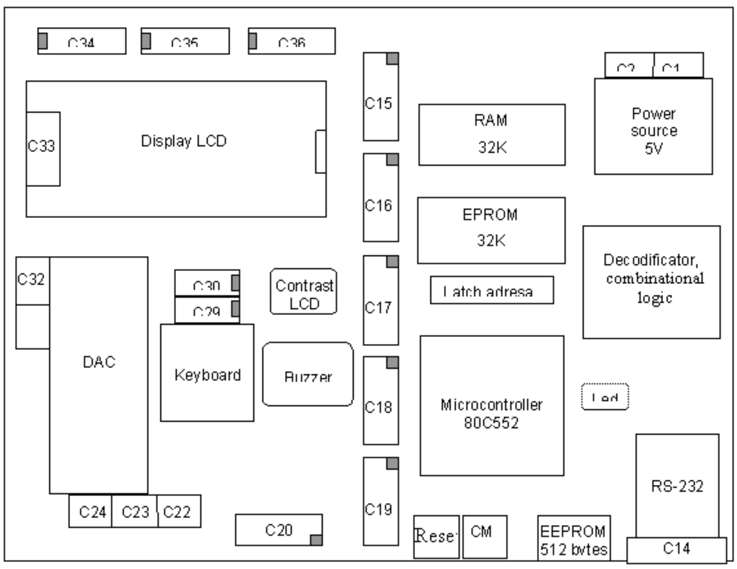
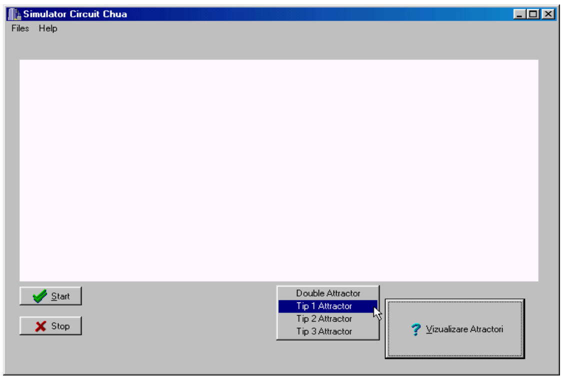


Figure 2. 80C552 Acquisition board

We developed the software for data acquisition in C++ Builder using libraries dedicated for our board. In our application we can view in graphics the evolution of the measured data.



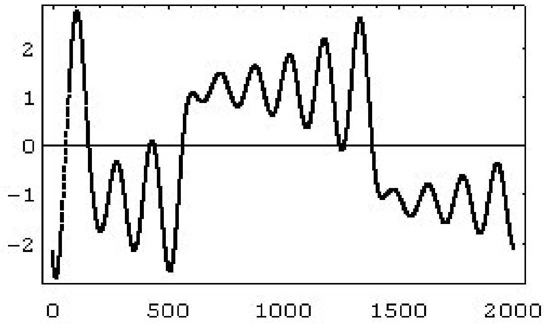


Figure 3. The application window and the results

3. CONCLUSIONS

We realised data acquisition using the presented pack and obtained good results. We choosed C++ Builder because the software package is more friendly if you know C++ programming language and these kind of application are more easy for developing in it.

Problems can appear just in the moment in which you choose a wrong period for aquisition signal from the circuit because you can loose chaotic behaviour but this problem can be solved with detailed board.

In future we will develop the entire application for the control of this Chua's circuit, and for eliminate the chaotic zone from its behaviour.

4. REFERENCES

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