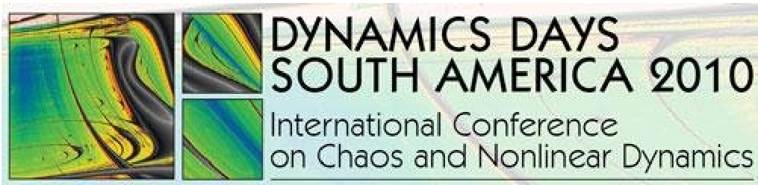

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THE ELECTRONIC BOUNCING BALL CIRCUIT IN A COMMUNICATION SYSTEM

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1-INTRODUCTION

In the literature there are several electronic circuits which can be used to generate chaotic signals for applications in communication systems. Some examples are the Chua´s circuit [1-3], the Lorenz-based chaotic circuit [4], the chaotic Rössler circuits [5] and the particle in a box electronic circuit [6]. In this work, the electronic bouncing ball circuit [7] is applied in a communication system. In this case, the error feedback synchronization [2] between two coupled chaotic systems (transmitter and receiver) is used to implement a security communication system. The scheme proposed was simulated and the results were discussed.

2-PURPOSE

The scheme proposed is based in the chaotic behavior of the bouncing ball electronic circuit of Figure 1. This circuit is described by equation (1).

$$CR_2C_2\frac{d^2V_{BD}}{dt^2} - I_D(-V_{BD} - V_{TD}) = \frac{V_{iD}}{R_i} \qquad (1)$$

The dynamic behavior of the system described by equation (1) depends on the bifurcation parameters frequency w or amplitude A of the signal $V_{TD} = A\sin(wt)$). In this work, the bifurcation parameters ($w = 400\pi\ rad/s\ e\ A = 0.02\ V$) were chosen to a chaotic behavior of the system.

The scheme proposed is illustrated on Figure 2. The transmitter (drive system) is implemented by the circuit of Figure 1. The receiver is composed by the response system, the circuit of Figure 3, and a processing block which could be implemented with electronic components.

The input information is a data stream with three levels m(t). The signal V_{CD} of the transmitter system is sent to the receiver system. The signals V_{TD} and V_{TR} are not in phase. The error feedback synchronization technique [2] is applied to get the generalized synchronization between the transmitter (drive) and receiver (response) systems. The signals V_{BR} and V_{CR} are estimated in the receiver and they are used by the a processing block to recovery de information like $\hat{m}(t)$. The processing block is described by equation (2) and it can be implemented by operational amplifiers.

$$\hat{m}(t) = R_iCR_2C_2\frac{d^2V_{BR}}{dt^2} - R_iI_D(-V_{BR} - V_{TR}) \qquad (2)$$

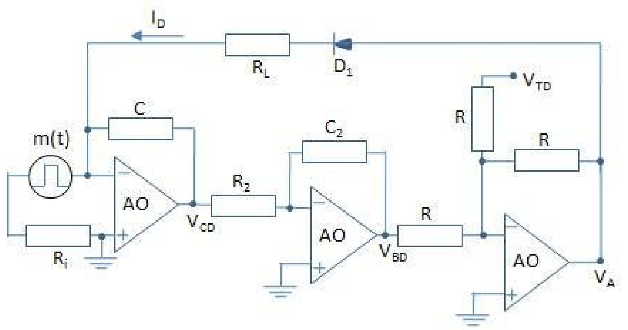

Figure 1. The electronic bouncing ball circuit. AO are operational amplifiers of kind 741. D_1 is a diode 1N4148. Resistors (R= R_2=10kΩ, R_L=510Ω e R_i=1MΩ). Capacitors (C=C_2=0.047uF). Source of information m(t).

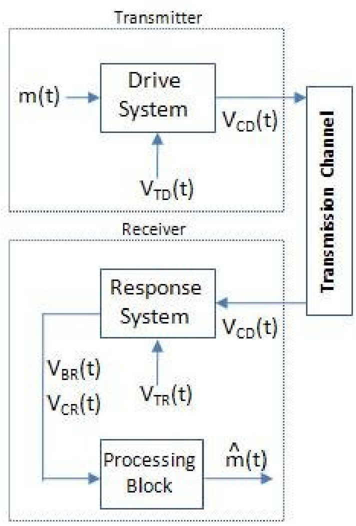

Figure 2. Chaotic communication system

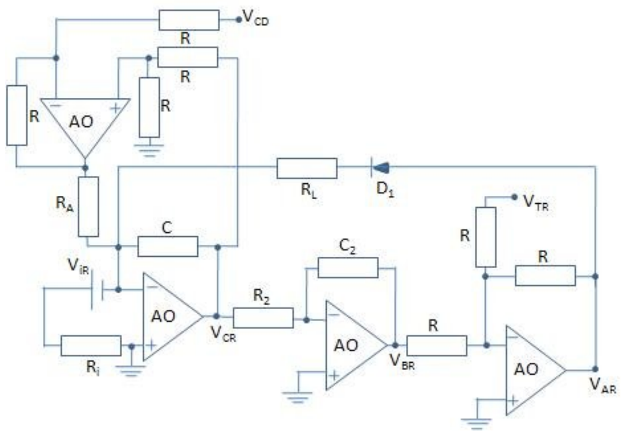

Figure 3. Electronic circuit of response system. AO are operational amplifiers of kind 741. D_1 is a diode 1N4148. Resistors (R= R_2=10kΩ, R_L=510Ω, R_i=1MΩ and R_A=4.53 kΩ). Capacitors (C=C_2=0.047uF). Source V_{iR}=1.5V.

3-METHODS, SIMULATION AND RESULTS

The system of Figure 2 was simulated using a computational numerical method. A data stream with three levels m(t) of Figure 4 was used like the input information. The signal V_{CD} of the transmitter was sent to the receiver. After the chaotic synchronization between drive and response systems, the signals V_{BR} e V_{CR} are estimated in the receiver. These signals were used to recover the binary input information $\hat{m}(t)$. The signals generated in computational simulations are illustrated on Figure 4.

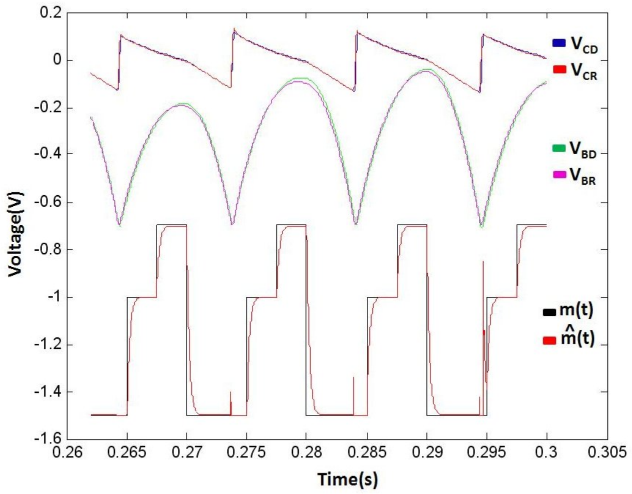

Figure 4. Simulations of the communication system proposed.

4-DISCUSSION

The results of simulations exhibited on Figure 4 show the full synchronization between drive and response system. The full synchronization can be matched through the element R_A of the response system as shown on Figure 3. In this case, the signals V_{CD} and V_{CR} are identical. The same occurs with V_{BD} and V_{BR}. A security communication system can be implemented with this scheme proposed. The signal sent by the transmitter could be V_{CD} or V_{BD}. The better choice would be a chaotic signal without correlation with the information signal.

5-CONCLUSION

The results of simulations show the application of the bouncing ball electronic system in a communication system. The scheme proposed could be used in security communication systems.

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