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Applying Many Of The Methods To Synchronization Of Chaoson The Electronic Circuit Chaotic From Type Memductance

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ABSTRACT

The attractor chaotic from the type Chua' attractors, was obtained at study one types of electronic circuit chaotic affiliate for family Chua' circuit, where, the nonlinear part from type memductance, after we succeeded in found the attractor chaotic for circuit, we study many from the methods of synchronization chaos. It was the first method is Pecora and Carroll (PC), but it failed to reach for case complete synchronization, because the ratio of error not equal zero. The same as of result can reach for it, when we applying the method of adaptive-observer, at choose the value of feedback gain c=10. In addition to that, we discussed another method call adaptive feedback synchronization, which Succeed complete synchronization, and the ratio error equal to zero, but exist some noise, which can get rid of it by using the low frequency filter. Also, we suggested new method from the type feedback, which also achieved the complete synchronization, and the noise is disappear clearly, in the method adaptive the complete synchronization achieved after time t=0.05s.

1. Introduction

Divide the mathematical systems to many section, stable and instable , also, linear and nonlinear, for every type from that system has uses in spatial apply fields. Attracted the system which exhibit the chaos, attention many researches, because exist this system in more science fields, as physical[1] chemical[11] biological[12] Fluid science[13] .. Etc. In the physical there is two active fields in search about the chaos, first the nonlinear optics and the other field is quantum optics, the reason return to simplify describe these dynamical systems, in addition to, easy treatment with these systems. But, after 1983 appear another field very important in the physical and engineering it is a study the chaos in the electronic circuits. After success Chua[14] in design the circuit which showing the chaos and that circuit called

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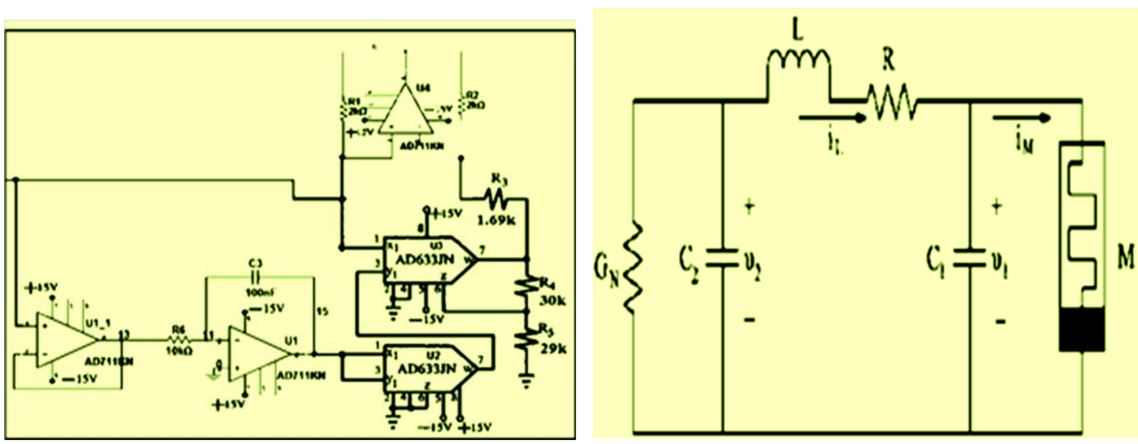
with name Chua's circuit. Matsumoto was succeeded in found the theoretical results for Chua's circuit, and also, can find attractor chaotic which called Chua's attractor. The secret who lead Chua to succeed in design his circuit, is determine the basic elements to appear the chaos, which is three elements, first, three elements to store the energy (two capacity and inductance), two, linear part (resistance), the last, nonlinear part(that know Chua's diode). The reason for failure of previous attempts on Chua is to attempt find electronic circuit obedience to Lorenz or rosler system. Attracted Chua circuit more from researchers because easy applying it, and also, cheap price of component, in addition to very rich in dynamical behavior which show, that Started from the fixed behavior, periodic behavior and chaotic behavior. Many applied fields that using the chaotic electronic circuits, as communication[15] control[16] synchronization[17] Encryption[18].

The chaos synchronization is correlation between two or more chaotic systems, in the method which follows one system to others system, and controls the other. The synchronization is divided to many types according to point of division, So it divide to bidirectional and unidirectional, when looking at to direction signal control. And, the synchronization is divide to complete synchronization[2], lag synchronization[3], phase synchronization[4], projective synchronization[5], adaptive generalized function projective synchronization[6], generalized synchronization[7], hybrid synchronization[8], … Etc, when looking at to the ratio error, where, ($e = X_S - a * X_m$), represent the ratio error, (a) is matrix, X_s, X_m the state vectors for slave and master, when a=1 this case represent complete synchronization, but a = -1 is anti-phase synchronization, a=1 for even and a=-1 for odd this hybrid synchronization, but when, a = $F_1(x)$, $F_2(x)$, …, is adaptive generalized function projective synchronization, spatial case $F_1 = F_2 = \ldots$, is projective synchronization.

In this paper, we working on find the attractor chaotic for one the chaos circuit, following the family Chua circuit, after that we find the chaos synchronization in the method (PC). Also, applying the feedback synchronization and using adaptive synchronization and new method for feedback synchronization tested.

2. The Chaos Circuit

We will choose one circuits which follow Chua circuit, show in the figure (1a), with the nonlinear part from type memductance, show in (1b)[17,18]. this circuit consist two capacity (C_1, C_2), self induction coil L, and two resistance (R, G_N), in addition to nonlinear part (M). To describe this circuit by deferential equations, we will using Kerchhoff's law to obtain on :



b) non-linear part.(memductance) **a) The chaotic electronic circuit**

Figure (1)

$$\frac{d\varphi}{dt} = v_{c1} \tag{2.1}$$

$$\frac{dv_{c1}}{dt} = \frac{1}{C_1}\left(i_{lm} - w(\varphi)\, v_{c1m} \right) \tag{2.2}$$

$$\frac{dv_{c2}}{dt} = -\frac{1}{C_2}\left(i_l + G_N v_{c2} \right) \tag{2.3}$$

$$\frac{di_l}{dt} = \frac{1}{L}\left(v_{c2} - R\ i_l - v_{c1}\right) \tag{2.4}$$

where $w(\varphi)$ represent the function for nonlinear part :

$$w(\varphi) = \frac{dq(\varphi)}{d\varphi} = -\alpha + 3b\ \varphi^2 \tag{2.5}$$

where v_{c1}, v_{c2} represent voltage of first and two capacity, i_l is current the coil, φ magnetic flux, q is charge. To find the chaos, we will solve the equations (1-4) by use the method numerical Runge-Kutta from fourth order, at the parameter h=0.1*10^{-5} , G_N= 0.4*10-4 , b= 4.0 * 10^4, α = 0.5*10^{-4}, R=300 Ω , L=100mH , $c_1 = 20\, nF$ and $c_2 = 31\, nF$. The initial condition i_l= 0.001, φ =0.0 , v_{c1}=0.006 , v_{c2}=0.02. we get on the attractor chaotic in plane (v_{c1}- v_{c2}).

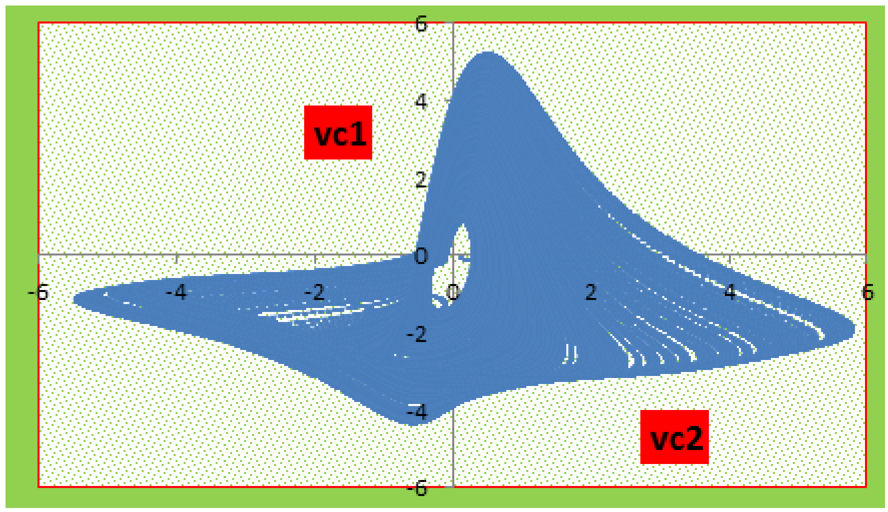


Figure (2) : the attractor chaotic in plane (v_{c1}- v_{c2}).

3. the method Pecora and Carroll synchronization

The method Carroll and Pecora represent simple method to achieve synchronization, where sent one the state vector from master system to slave system, we choose v_{c2} can sent from master to slave, as explain in the equations following :

$$\frac{d\varphi m}{dt} = v_{c1m} \tag{3.1}$$

$$\frac{dv_{c1m}}{dt} = \frac{1}{C_1}\left(i_{lm} - w(\varphi m)\, v_{c1m} \right) \tag{3.2}$$

$$\frac{dv_{c2m}}{dt} = -\frac{1}{C_2}\left(i_{lm} + G_N v_{c2m} \right) \tag{3.3}$$

$$\frac{di_{lm}}{dt} = \frac{1}{L}\left(v_{c2m} - R\ i_{lm} - v_{c1m}\right) \tag{3.4}$$

Where $w(\varphi m)$ represent the function for nonlinear part :

$$w(\varphi m) = \frac{dq(\varphi)}{d\varphi} = -\alpha + 3b\ \varphi m^2 \tag{3.5}$$

$$\frac{d\varphi s}{dt} = v_{c1s} \tag{3.6}$$

$$\frac{dv_{c1s}}{dt} = \frac{1}{C_1}\left(i_{ls} - w(\varphi s)\, v_{c1s} \right) \tag{3.7}$$

$$\frac{dv_{c2s}}{dt} = -\frac{1}{C_2}\left(i_{ls} + G_N v_{c2m} \right) \tag{3.8}$$

$$\frac{di_{ls}}{dt} = \frac{1}{L}\left(v_{c2s} - R\, i_{ls} - v_{c1s} \right) \tag{3.9}$$

Where $w(\varphi s)$ represent the function for nonlinear part :

$$w(\varphi s) = \frac{dq(\varphi)}{d\varphi} = -\alpha + 3b\, \varphi s^2 \tag{3.10}$$

$$e_1 = v_{c1s} - v_{c1m} \quad , \quad e_2 = v_{c2s} - v_{c2m} \quad , \quad e_3 = i_{c1s} - i_{c1m} \, , \quad e_4 = \varphi_s - \varphi_m$$

Where m refer to master system, s refer to slave system, we note in (8.3) exist v_{c2m} for achieve (pc). The figures (3) represent the results this method, which appear not to happen the complete synchronization because the error ratio not equal to zero, but continue oscillation act wave with small amplitude. Also, note in planes (v_{c1s}- v_{c1m}) , (v_{c2s}- v_{c2m}) and (i_{ls}- i_{lm}) despite of smooth line But the two waves are not equal to each other. The parameters this method the same as parameters chaotic circuit, and the initial condition to the slave system is i_{ls}= 0.001, φs =0.0 , v_{c1s}=0.005 , v_{c2s}=0.015.

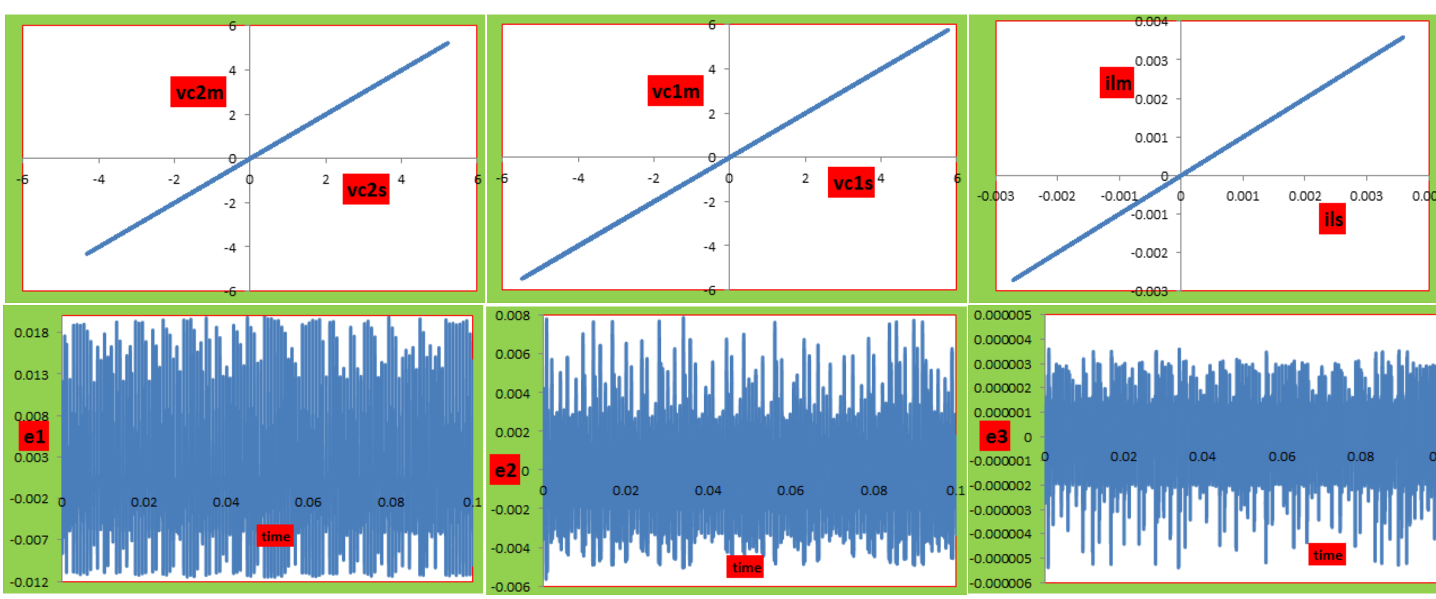


Figure (3) : plot the state vectors and the error ratios.

4. the adaptive – observe synchronization

After failure the method (PC) synchronization, we used adaptive – observe synchronization, which depend on addition the term feedback to the slave system (c* e), where c is feedback gain. This method apply at c=10, and choose the same as parameters and initial condition in the method (PC), but also failure this method because the error ratio not converge to zero, and the complete synchronization does not achieve. This mean cannot establish communication system, and it must procedure some correction. To achieve this method we will add the term (c^*e_2) to the equation (8.3):

$$\frac{d\varphi m}{dt} = v_{c1m} \tag{4.1}$$

$$\frac{dv_{c1m}}{dt} = \frac{1}{C_1}\left(i_{lm} - w(\varphi m)\, v_{c1m} \right) \tag{4.2}$$

$$\frac{dv_{c2m}}{dt} = -\frac{1}{C_2}\left(i_{lm} + G_N v_{c2m} \right) \tag{4.3}$$

$$\frac{di_{lm}}{dt} = \frac{1}{L}\left(v_{c2m} - R\ i_{lm} - v_{c1m} \right) \tag{4.4}$$

Where $w(\varphi m)$ represent the function for nonlinear part :

$$w(\varphi m) = \frac{dq(\varphi)}{d\varphi} = -\alpha + 3b\,\varphi m^2 \tag{4.5}$$

$$\frac{d\varphi s}{dt} = v_{c1s} \tag{4.6}$$

$$\frac{dv_{c1s}}{dt} = \frac{1}{C_1}\left(i_{ls} - w(\varphi s)\, v_{c1s} \right) \tag{4.7}$$

$$\frac{dv_{c2s}}{dt} = -\frac{1}{C_2}\left(i_{ls} + G_N v_{c2m} \right) + c^* e_2 \tag{4.8}$$

$$\frac{di_{ls}}{dt} = \frac{1}{L}\left(v_{c2s} - R\ i_{ls} - v_{c1s} \right) \tag{4.9}$$

Where $w(\varphi s)$ represent the function for nonlinear part :

$$w(\varphi s) = \frac{dq(\varphi)}{d\varphi} = -\alpha + 3b\,\varphi s^2 \tag{4.10}$$

The equations (1-4) & (5-9) solved by numerical method Runge – Kutta, and get on the results in figure (4), which consist plot planes (v_{c1s}- v_{c1m}) , (v_{c2s}- v_{c2m}) and (i_{ls}- i_{lm}), in addition to plot the error ratios. The figure (4) explain case not getting the complete synchronization.

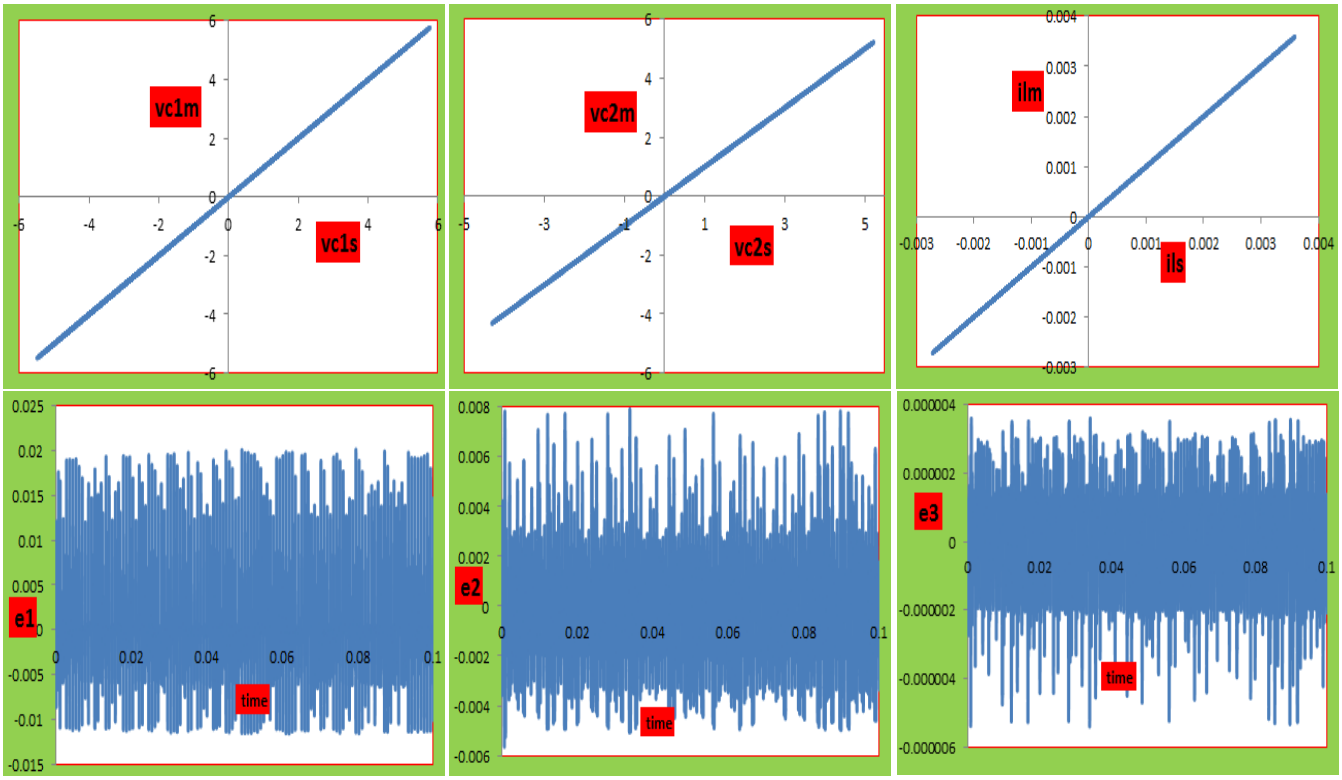


Figure (4) : the method adaptive – observe synchronization at c=10.

5.the adaptive synchronization

Failure the previous two methods, lead to use the adaptive synchronization, to achieve the complete synchronization, so that, we will work following :

$$\frac{d\varphi m}{dt} = v_{c1m} \tag{5.1}$$

$$\frac{dv_{c1m}}{dt} = \frac{1}{C_1}\left(i_{lm} - w(\varphi m)\, v_{c1m} \right) \tag{5.2}$$

$$\frac{dv_{c2m}}{dt} = -\frac{1}{C_2}\left(i_{lm} + G_N v_{c2m} \right) \tag{5.3}$$

$$\frac{di_{lm}}{dt} = \frac{1}{L}\left(v_{c2m} - R\ i_{lm} - v_{c1m}\right) \tag{5.4}$$

Where $w(\varphi m)$ represent the function for nonlinear part :

$$w(\varphi \mathrm{m}) = \frac{dq(\varphi)}{d\varphi} = -\alpha + 3b\ \varphi \mathrm{m}^2 \tag{5.5}$$

$$\frac{d\varphi s}{dt} = v_{c1s} + u_4 \tag{5.6}$$

$$\frac{dv_{c1s}}{dt} = \frac{1}{C_1}\left(i_{ls} - w(\varphi s)\, v_{c1s} \right) + u_1 \quad (5.7)$$

$$\frac{dv_{c2s}}{dt} = -\frac{1}{C_2}\left(i_{ls} + G_N v_{c2s} \right) + u_2 \quad (5.8)$$

$$\frac{di_{ls}}{dt} = \frac{1}{L}\left(v_{c2s} - R\, i_{ls} - v_{c1s} \right) + u_3 \quad (5.9)$$

Where $w(\varphi m)$ represent the function for nonlinear part :

$$w(\varphi s) = \frac{dq(\varphi)}{d\varphi} = -\alpha + 3b\, \varphi s^2 \quad (5.10)$$

$$e_1 = v_{c1s} - v_{c1m} \;,\; e_2 = v_{c2s} - v_{c2m} \;,\; e_3 = i_{c1s} - i_{c1m} \;,\; e_4 = \varphi_s - \varphi_m$$

$$\dot{e_1} = \frac{1}{C_1}\left(i_{ls} - w(\varphi s)\, v_{c1s} \right) - \frac{1}{C_1}\left(i_{lm} - w(\varphi m)\, v_{c1m} \right) + u_1$$

$$\dot{e_1} = \frac{1}{C_1}\left(e_3 - w(\varphi s)\, v_{c1s} + \frac{1}{C_1} w(\varphi s)\, v_{c1s} \right) + u_1$$

$$\dot{e_2} = -\frac{1}{C_2}\left(i_{ls} + G_N v_{c2s} \right) + \frac{1}{C_2}\left(i_{lm} + G_N v_{c2m} \right) + u_2 = -\frac{1}{C_2}\left(e_3 + G_N e_2 \right) + u_2$$

$$\dot{e_3} = \frac{1}{L}\left(v_{c2s} - R\, i_{ls} - v_{c1s} \right) - \frac{1}{L}\left(v_{c2m} - R\, i_{lm} - v_{c1m} \right) + u_3 = \frac{1}{L}\left(e_2 - e_1 - R * e_3 \right)$$

$$\dot{e_4} = v_{c1s} - v_{c1m} + u_4 = e_1 + u_4$$

$$U_1 = \frac{1}{C_1}\left(-e_3 + w(\varphi s)\, v_{c1s} - \frac{1}{C_1} w(\varphi s)\, v_{c1s} \right) - e_1 \quad (5.11)$$

$$U_2 = \frac{1}{C_2}\left(e_3 + G_N e_2 \right) - e_3 \quad (5.12)$$

$$U_3 = \frac{1}{L}\left(e_2 - e_1 - R * e_3 \right) - e_3 \quad (5.13)$$

$$U_4 = e_1 - e_4 \quad (5.14)$$

Where u_1, u_2, u_3, u_4 are terms of control, we solve the equations (1-4) &(6-9) in addition to (11-14) by Runge – Kutta, and we obtain on the figures(5), where planes (v_{c1s}- v_{c1m}) , (v_{c2s}- v_{c2m}) , (i_{ls}- i_{lm}) and (φ_s- φ_m) indicate to correspond between master and slave signals, as well as, the error ratios converge to zero, that mean, the complete synchronization is happened, and success this method. We applied the same parameters and initial conditions in the method (PC). There are in the error ratios (e_1, e_2, e_3, e_4) some perturbation with very small amplitude, can eliminate by use low frequency filter, in order to obtain on the massage without any change.

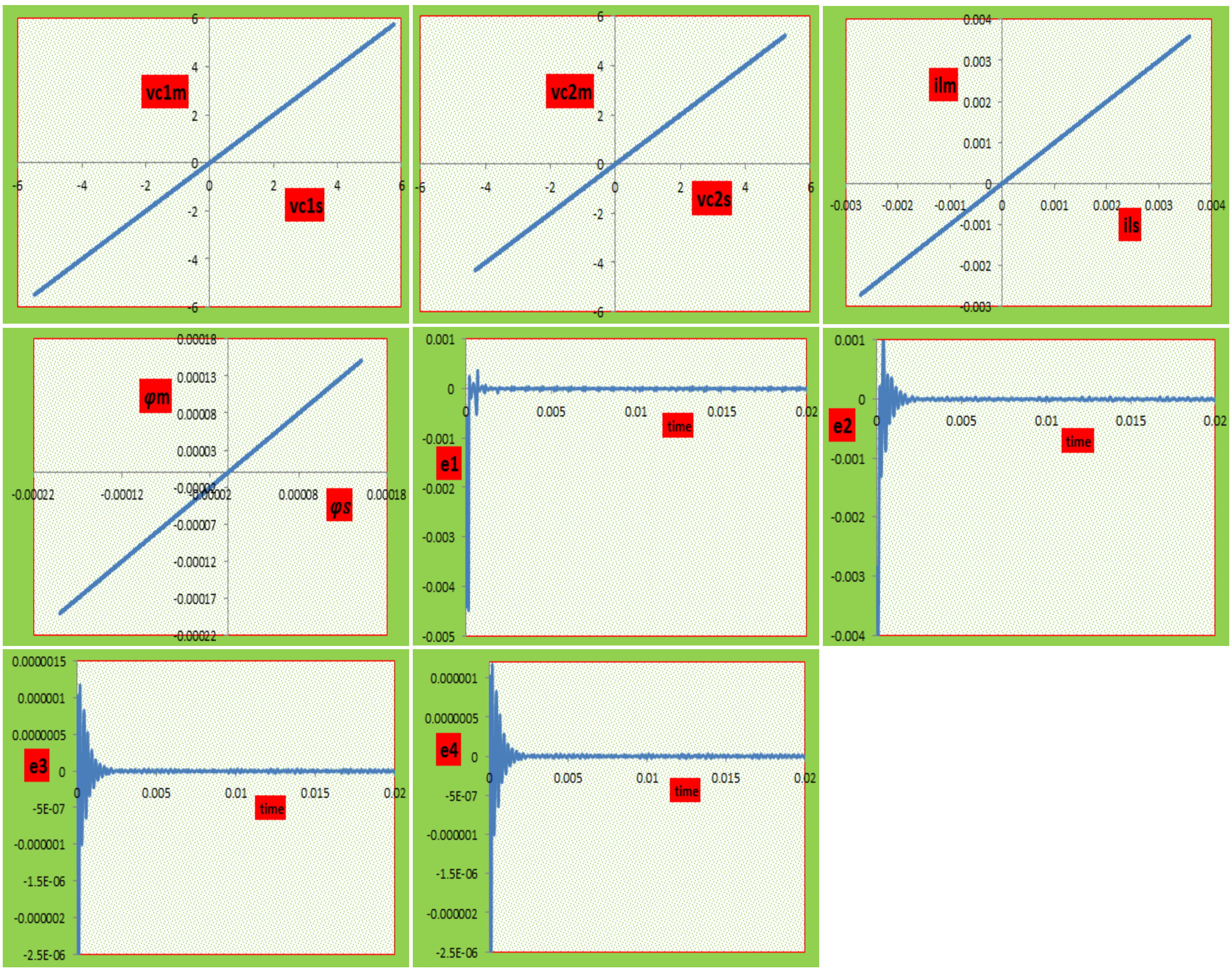


Figure (5) : the method adaptive synchronization .

6.the modification synchronization

Despite of success the adaptive synchronization, but we try to eliminate the perturbation in the error without filter, therefore, we suggest modification in the method feedback, by add (u_1, u_4) to the slave system :

$$\frac{d\varphi m}{dt} = v_{c1m} \quad (6.1)$$

$$\frac{dv_{c1m}}{dt} = \frac{1}{C_1}\left(i_{lm} - w(\varphi m)\, v_{c1m} \right) \quad (6.2)$$

$$\frac{dv_{c2m}}{dt} = -\frac{1}{C_2}\left(i_{lm} + G_N v_{c2m} \right) \quad (6.3)$$

$$\frac{di_{lm}}{dt} = \frac{1}{L}\left(v_{c2m} - R\; i_{lm} - v_{c1m}\right) \quad (6.4)$$

Where $w(\varphi m)$ represent the function for nonlinear part :

$$w(\varphi\mathrm{m}) = \frac{dq(\varphi)}{d\varphi} = -\alpha + 3b\,\varphi\mathrm{m}^2 \quad (6.5)$$

$$\frac{d\varphi\mathrm{s}}{dt} = v_{c1s} \quad (6.6)$$

$$\frac{dv_{c1s}}{dt} = \frac{1}{C_1}\left(i_{ls} - w(\varphi s)\, v_{c1s} \right) + u_4 \quad (6.7)$$

$$\frac{dv_{c2s}}{dt} = -\frac{1}{C_2}\left(i_{ls} + G_N v_{c2m} \right) \qquad + u_1 \quad (6.7)$$

$$\frac{di_{ls}}{dt} = \frac{1}{L}\left(v_{c2s} - R\; i_{ls} - v_{c1s}\right) \quad (6.9)$$

Where $w(\varphi m)$ represent the function for nonlinear part :

$$w(\varphi\mathrm{s}) = \frac{dq(\varphi)}{d\varphi} = -\alpha + 3b\,\varphi\mathrm{s}^2 \quad (6.10)$$

$$U_1 = \frac{1}{C_1}\left(-e_3 + w(\varphi s)\, v_{c1s} - \frac{1}{C_1}\, w(\varphi s)\, v_{c1s}\right) - e_1 \quad (6.11)$$

$$U_4 = e_1 - e_4 \quad (6.12)$$

In this method, we sent v_{c2m} from master to slave system, and add part of control, the parameters and initial conditions the same as in the method (PC). The results this method explain in figures (6), we note achieve the complete synchronization at t=0.01s, and the error ratios equal to zero, without any perturbation. This mean, we can sent message from master to slave system without loss.

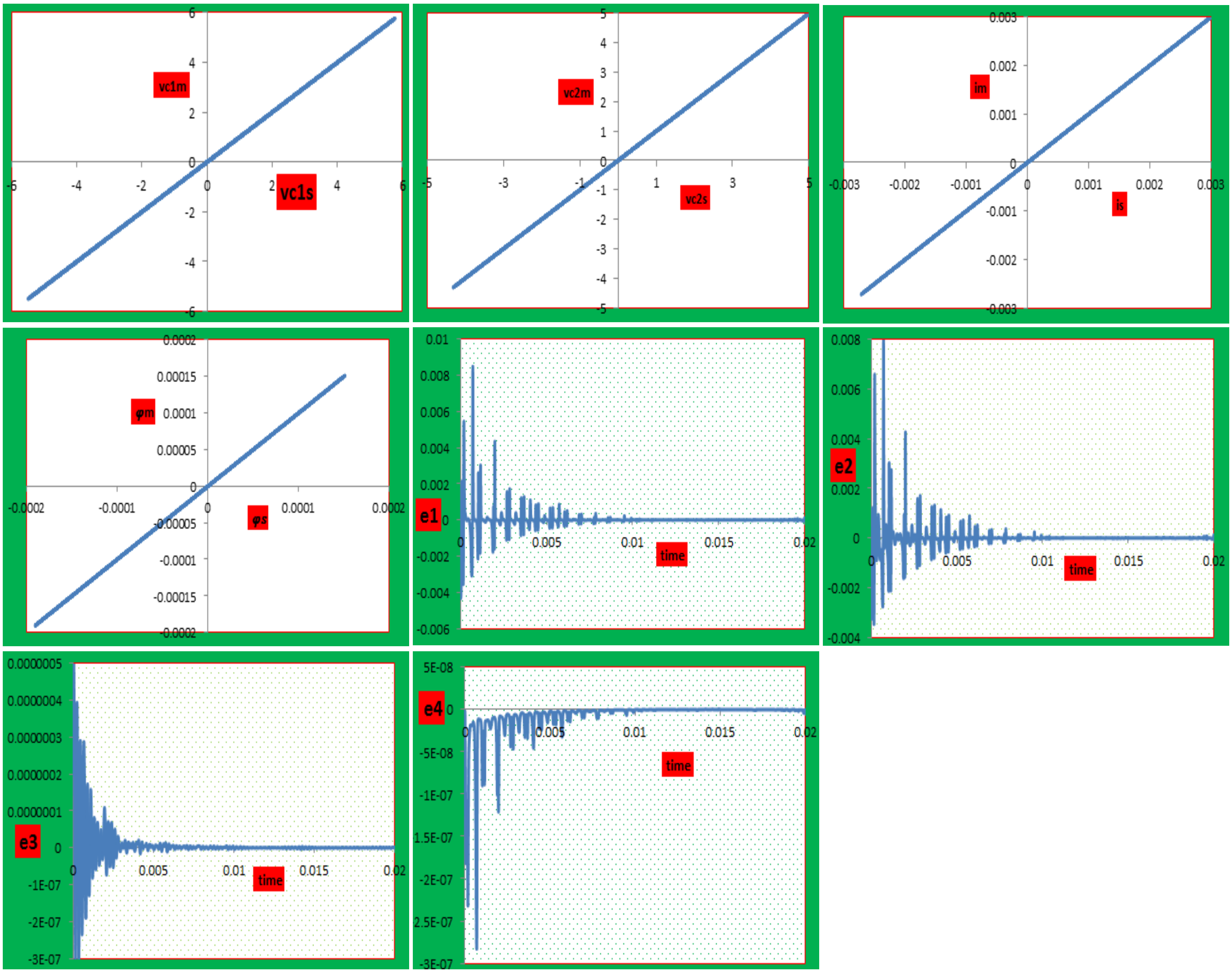


Figure (6) : the method modification feedback synchronization .

Conclusion : the circuit which studied is from type Chua' circuits with part nonlinear from type memductance, this circuit consider very rich in varied dynamical behavior , starting from fixed behavior, periodic behavior and chaotic behavior. The attractor chaotic very useful in experimental application, because guarantee secret information significantly, and not possibility arrive for it from the attackers. Apply many methods for synchronization, because failure some the methods, of which, method PC, feedback at feedback gain c= 10, where, the error ratio not equal zero or converge to zero, so, we adopted on another method, as adaptive synchronization which achieved great success in synchronization, and it showed results large difference about the previous two methods, where the error ratios equal zero after small time less from 0.05s. but we note exist noise in it, can eliminate by addition low frequency filter. In addition, in this paper we discuss new method from type feedback, which achieve the complete synchronization after time t= 0.02s, with hidden the noise. The last two methods very useful in communication from type mask, and this principle goal to achieve synchronization.

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