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Investigation of Dependent Rikitake System to Initiation Point

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ABSTRACT

In this paper we investigate depending of the Rikitake system to initiation point, and monitor changing behavior of this system. We will have 4 initiation points in Cartesian system. We at 4 positions, will monitor behavior of this system, while holding constant other values, and after per position, will draw operation of system on axes of x, y, z and 3-D plot. We want to know, what is the effect of initiation point on Rikitake system? Numerical simulations to illustrate the effect of initiation point are presented, and at the end conclusions and comparing the states together are obtained.

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1. INTRODUCTION

At the first, I want to explain, the physics rules behind of Rikitake system for more and better understanding behavior of Rikitake system. The Rikitake system is a mathematical model that obtained from a simple mechanical system that it used by Rikitake (Denis de Carvalho Braga et al., 2010) to study the reversals of the Earth's magnetic field.

This system made from two magnetic disks (D_1,D_2) and two shafts and two coils (L_1, L_2) see Figure1.This system run by an external power supply on two brushes (terminals) for a moment (for start after starting the system power supply will disconnect) and the system will be run. There is a G for both conducting disks (D_1,D_2) Both disks rotate in the same sense, one with an angular velocity of ω1 around the axis of rotation A1and the other with angular velocity ω2 around the axis of rotation A2. And there is too two I_1 and I_2 that these made from L_1 and L_2 the coils the cross connect to D_2 and D_1 the currents in coils cause a magnetic field that it is opposite the magnetic field of disks (D_1, D_2) The opposition was so continued until the currents in two loops L_1 and L_2 be reverse this reversal in currents means that the magnetic field (emf) of earth be reversal. This procedure happens for magnetic field of the earth but without control and any prediction this procedure called chaos. Chaos Is very sensitive to initiation point. This system under particular initial conditions this process becomes chaotic. (Ahmad Harb, Nabil Ayoub, 2013).

Many works have described the dynamics of Rikitake system. Historically E. C. Bullard has described the magnetic field of the earth, and too described the behavior of earth's magnetic field and its simulations. He then in 1955 the similar behavior between a set of homogeneous dynamos and terrestrial magnetism and described the stability of a homopolar dynamo (Liu Xiao-Jun, et.al, 1999), analyzed the dynamics of the Rikitake system to describe the reversals of the Earth's magnetic field. They concluded that the chaotic behavior of the system can be used for simulation the geomagnetic field reversal.. The Rikitake chaotic attractor was studied by several authors (T. McMillen, 1999) and (Mohammad Javidi,et al., 2013) has studied the shape and dynamics of the Rikitake attractor. (J. Llibre .et al., 2009) used the Poincare compactification to study the dynamics of the Rikitake system at infinity. Chien- Chih Chen et al. have studied the stochastic resonance in the periodically forced Rikitake dynamo.(Chien- Chih Chen et al., 2007) In the past years, many scientists are working on control the chaotic behaviors. Harb and Harb have designed a nonlinear controller to control the chaotic behavior in the phase-locked loop by means of nonlinear control (Harb and Harb, 2007). Ahmad Harb have designed a controller to control the unstable chaotic oscillations by means of back stepping method (Ahmad Harb, Bassam Harb, 2004). The modern nonlinear theory for bifurcation has been discussed and chaos theory was used to investigated dynamics of the Rikitake system and an equation was found that was the same as the mathematical model of the Lorenz system(Ahmad Harb, Nabil Ayoub, 2013)The synchronization for chaotic of Rikitake system was studied by several authors. (Mohamad Ali khan, 2012) and (Carlos Aguilar-Ibañez, 2010) and (U.E. Vincent, 2011), (Yousof Gholipour and Mahmood moula, 2014) Investigated stability of Rikitake system with changing the resistance wires of system.

In this paper we suppose that the all situations and values are constant, and we change initiation point $E(x_0,y_0,z_0)$, and compare states of system in different points.

2. MODELING AND ANALYSIS

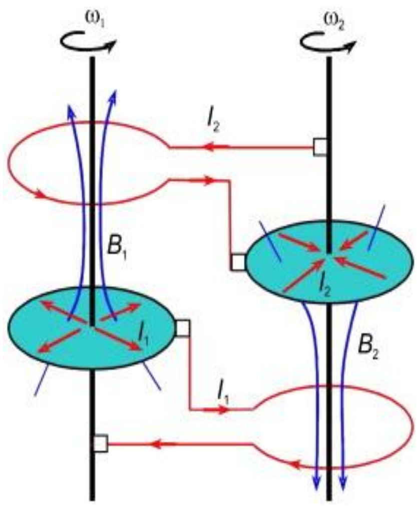

Figure 1. The Rikitake dynamo is composed of two disk dynamos coupled to one another.

The mathematical model of system is as follows:

$$\begin{cases} x' = -ux + zy \\ y' = -uy + (z-a)x \\ z' = 1 - x\ y \end{cases} \tag{1}$$

Where $(x, y, z) \in R^3$ are the state variables and a, u > 0 parameters are positive. Note that the mathematical model of Rikitake system is a quadratic system in R^3. The choice value of the parameters a and u reflects a physical meaning in the Rikitake model.

It is well known that system (1) has two equilibrium points $E_+ = (x_0, y_0, z_0)$; $E_- = (-x_0, -y_0, z_0)$ In order to study the stability of $E_\pm$, it is only sufficient to study the stability of the equilibrium point E_+.

$$\begin{cases} X=\sqrt{\dfrac{a+\sqrt{a^2+4u^2}}{2u}} \\ Y=\sqrt{\dfrac{2u}{a+\sqrt{a^2+4u^2}}} \\ Z=\dfrac{a+\sqrt{a^2+4u^2}}{2u} \end{cases} \tag{2}$$

Where:

$$a = R\sqrt{\frac{LC}{GM}} \quad u = (\omega_1 - \omega_2)\sqrt{\frac{CM}{GL}} \tag{3}$$

3. SIMULATION RESULT AT 4 POINTS

In this section we will investigate dependent Rikitake system to initiation point. While all the situations and values are constant and suppose chaos situation for Rikitake system (Yousof Gholipour and Mahood Moula, 2014). When a=3 and u=1.2, change initiation point $E(x_0,y_0,z_0)$ and observe amount of dependent and change of Rikitake system.

We consider 4 positions:

1- $E_+(x_0,y_0,z_0)=(1,1,1)$
2- $E_+(x_0,y_0,z_0)=(0.5,0.5,0.5)$
3- $E_+(x_0,y_0,z_0)=(3,2,1)$
4- $E_-(x_0,y_0,z_0)=(-1,-2,-3)$

Now display the numerical solution of Rikitake system. For all positions the situations and values are constant, and set u=1.2, a=3 and steps h=0.01. We plot the system behavior for four positions around X, Y, Z axes and 3-D plot.

1. $E_+(x_0,y_0,z_0)=(1,1,1)$

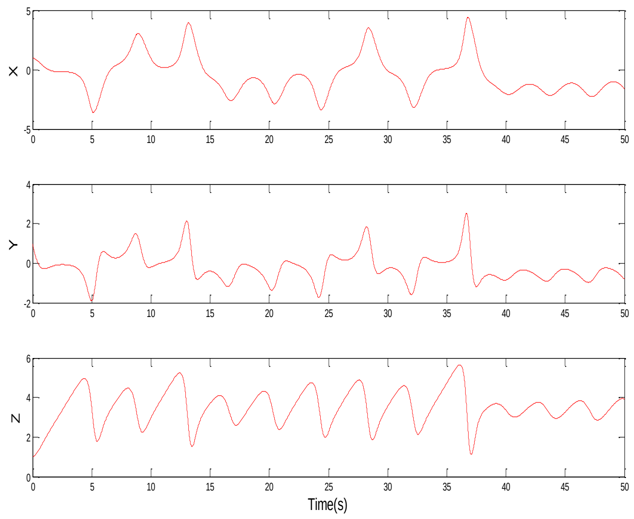

Figure 2. Rikitake System Behavior for E = (1, 1, 1)

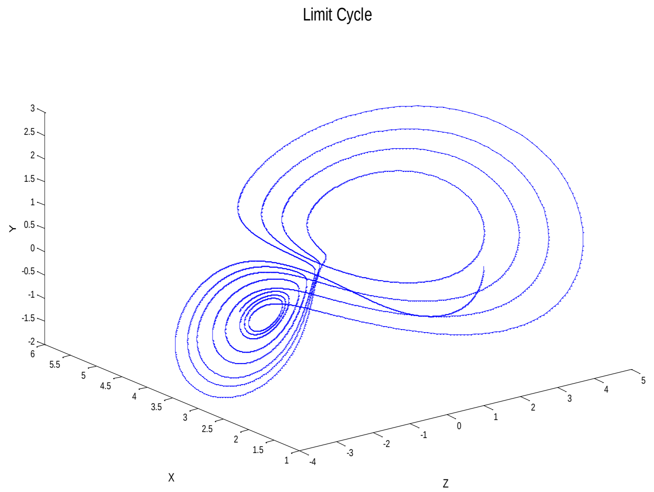

Figure 3. The Limit Cycle. Amount of Stability System When E = (1,1,1)

2. $E_{+}(x_0,y_0,z_0)=(0.5,0.5,0.5)$

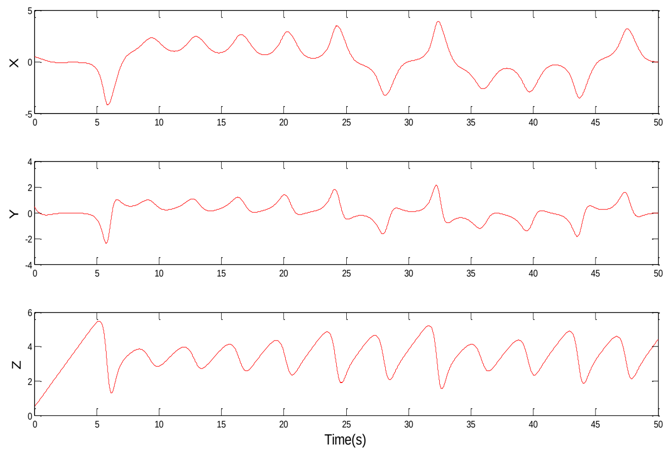

Figure 4. Rikitake System Behavior for E = (0.5,0.5,0.5)

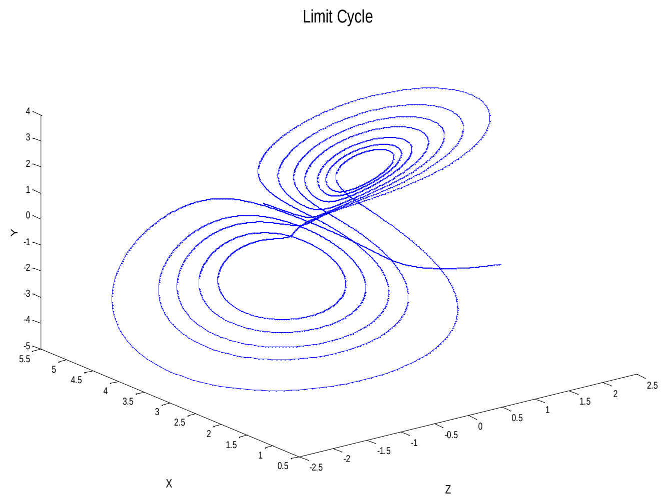

Figure 5. The Limit Cycle Amount of Stability System When E = (0.5,0.5,0.5)

3. $E_{+}(x_0,y_0,z_0)=(3,2,1)$

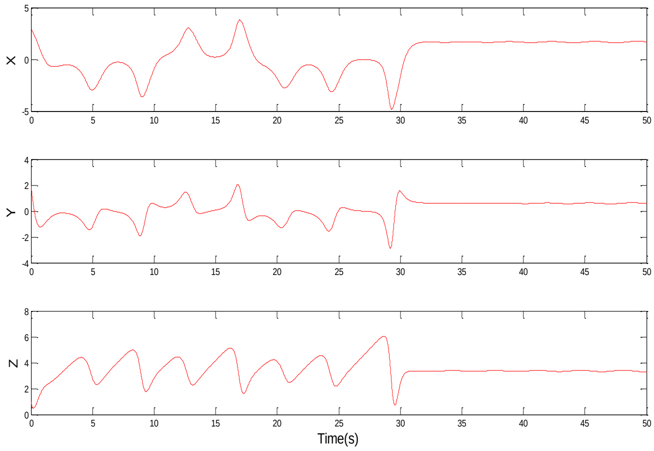

Figure 6. Rikitake System Behavior for E = (3,2,1)

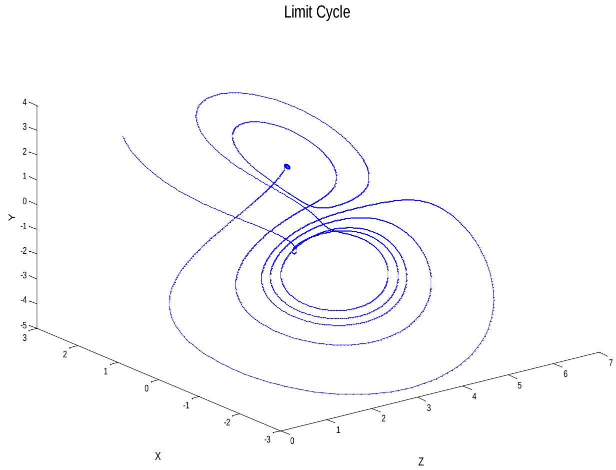

Figure 7. The Limit Cycle Amount of Stability System When E = (3,2,1)

4. $E_{-}(x_0,y_0,z_0)=(-1,-2,-3)$

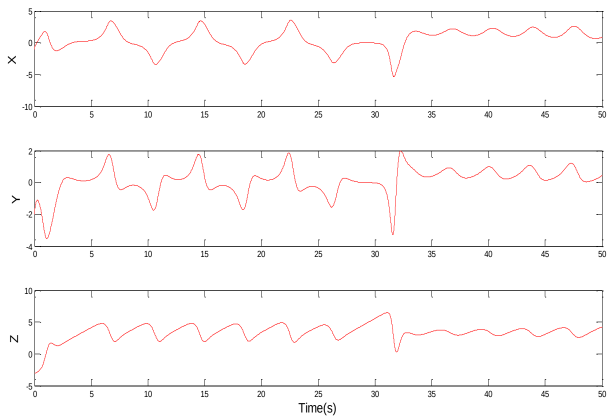

Figure 8. Rikitake System Behavior for E = (-1,-2,-3)

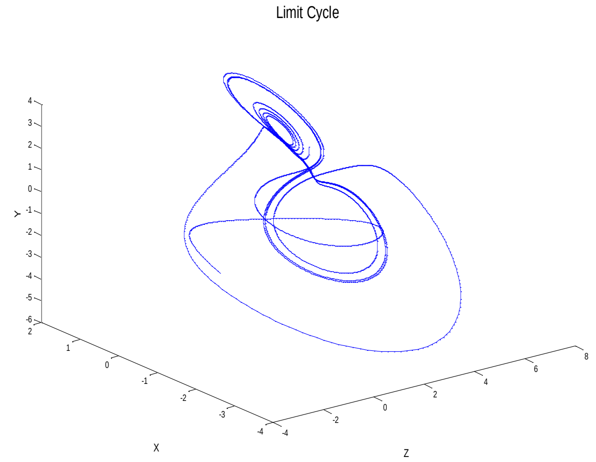

Figure 9. The Limit Cycle Amount of Stability System When E = (-1,-2,-3)

In the numerical simulations we see that the initial point has effect on behavior of system, the effect of initial point on this system is too deep, and all behavior of the system changed when initial point changed.

4. CONCLUSION

In this paper we, Investigated of dependent Rikitake system to initiation point. Firstly, discussed the physics rules behind Rikitake system and, last works about this system, after that presented the Rikitake model and at the behavior of system at four positions, investigated amount of dependent system to initiation point, and plotted axes x, y, z and 3-D plot, while all the situations and values was constant and suppose chaos situation for Rikitake system and a=3, u=1.2. We concluded from numerical simulations that, the Rikitake system is sharply dependent to initiation point. By note that, the studies showed that this system has intrinsic chaotic behavior, change in initiation point, will change behavior of system. Because of this Intrinsic properties we should adjust a & u (Equation 3) of this system carefully for have a system with fix behavior.

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REFERENCES

[1] Ahmad Harb, Bassam Harb, 2004. Chaos control of third-order phase-locked loops using backstepping nonlinear controller.Chaos, Solitons & Fractals, 20(4).
[2] Ahmad Harb, Nabil Ayoub, 2013. Nonlinear Control of Chaotic Rikitake Two-Disk Dynamo, International Journal of Nonlinear Science, Vol.15, No.1, pp.45-50.
[3] Carlos Aguilar-Ibañez, Rafael Martinez-Guerra, Ricardo Aguilar-López, Juan L. Mata-Machuca, 2010. Synchronization and parameter estimations of an uncertain Rikitake system, Physics Letters A 374, 3625–3628.
[4] C.-C. Chen, C.-Y. Tseng, 2007. A study of stochastic resonance in the periodically forced Rikitake dynamo. Terr. Atmos.Ocean. Sci., 18(4):671-680.
[5] Denis de Carvalho Braga, Fabio Scalco Dias and Luis Fernando Mello. 2010. on the stability of the equilibria of the Rikitake system. Physics Letters, 374: 4316-4320.
[6] Gholipour, Yousof, and Mahmood Mola. "Investigation stability of Rikitake system." Journal of Control Engineering and Technology 4, no. 1 (2014).
[7] Gholipour, Yousof, Amin Ramezani, and Mahmood Mola. "Illustrate the Butterfly Effect on the Chaos Rikitake system." Bulletin of Electrical Engineering and Informatics 3, no. 4 (2014): 273-276.
[8] Mehriz, Iran, and Iran Dariun. "Illustrate the effect of value of P, I, D in a PID controller for a four Tank process.
[9] Gholipour, Y., Mola, M. Stabilization Of Chaos Rikitake System By Use Of Fuzzy Controller. Science International-Lahore 27 (1), 115-119. (2015).
[10] Gholipour, Y., Chavooshi Zade, M.; "Replacement Unstable Transmission Zeros For A Non Minimum Phase Quadruple-Tank Process". Science International-Lahore 27 (2)1097-1100, 2015 (2015).
[11] Gholipour, Yousof, Esmail Mirabdollahi Shams, and Iran Mehriz. "Introduction new combination of zero-order hold and first-order hold".

[12] Gholipour, Yousof, Esmail Mirabdollahi Shams, and Iran Mehriz. "Introduction new combination of zero-order hold and first-order hold." International Electrical Engineering Journal (IEEJ); Vol. 5 (2014) No.2, pp. 1269-1272.
[13] Gholipour, Y. Zare, A., Chavooshi Zade, M. "Illustrate the effect of value of P, I, D in a PID controller for a four Tank process"; International Electrical Engineering Journal (IEEJ); Vol. 5 (2014) No.5, pp. 1420-1424.
[14] J. Llibre, M. Messias, 2009. Global dynamics of the Rikitake system.Physica D, 238:241-252.
[15] Liu Xiao-jun, Li Xian-feng, Chang Ying-xiang, Zhang Jian-gang, 2008. *Chaos and Chaos Synchronism of the Rikitake Two-Disk Dynamo*.Fourth International Conference on Natural Computation, IEEE computer Society,DOI10.1109/ICNC.2008.706:613-617.
[16] Mohammad Javidi, Nemat Nyamorad, 2013. Numerical Chaotic Behavior of the Fractional Rikitake System, World Journal of Modelling and Simulation, Vol. 9, No. 2, pp. 120-129.
[17] Mohammad Ali Khan, Different, 2012. Synchronization Schemes for chaotic Rikitake Systems, Journal of Advanced Computer Science and Technology, 1 (3), 167-175.
[18] T. McMillen, 1999. The shape and dynamics of the Rikitake attractor. The Nonlinear Jour., vol.1:1-10.
[19] U.E. Vincent, R. Guo, 2011. Finite-time synchronization for a class of chaotic and hyperchaotic systems via adaptive feedback controller, Physics Letters A 375, 2322–2326.