



International Journal of Engineering, Business and Enterprise Applications (IJEBA)

www.iasir.net

An Autonomous Chaotic Circuit for Wideband Secure Communication

Alpana Pandey¹, R.K. Baghel², R. P. Singh³

^{1,2,3} Department of Electronics & Communication Engineering, Maulana Azad National Institute of Technology, Bhopal Madhya Pradesh, INDIA.

Abstract: In this paper a new autonomous chaotic circuit is proposed to generate a chaotic signal which has wider power spectral density and shows significant power strength over large range of frequencies. The circuit can be used for signal masking application with improved system's security. Circuit is simulated using Orcad-Pspice and realized using simple electronic components.

Keywords: Chaotic circuits, Power spectral density, secure communication.

I. INTRODUCTION

In signal masking application, a chaotic signal is used as pseudorandom noise signal and it is added to the message signal at transmitter to hide the message signal. For this purpose the power spectrum of chaotic signal must be broad, flat and having higher power density than the message signal so that message will be fully buried into the chaotic signal. If such requirement is not fulfilled then system's security is weak and any unintended receiver can recover the masked message signal using high pass filter circuit. Thus it is required to design a chaotic oscillator which could have wide bandwidth and large signal power over wide range of frequencies.

In 2004 G.Alvarez and F. Motoya [1] demonstrated that the cryptosystem given by M.Bautayeb [2] and T.L.Liao [3] are weak and can be broken without knowing its parameter value and even without knowing the transmitter structure. In 2007 G.Alvarez and Shujun Li [4] reported breaking of projective synchronization based chaotic masking cryptosystem proposed by Li and Xu [5] by high pass filtering. The reason of weak security of these systems [2, 3, 5] is that, the spectrum of chaotic signal used for cryptosystem is narrowband, decaying very fast with increasing frequencies as given in Fig.1 [1]. In 2010 J.C.Sprott [6] suggested two chaotic circuits which are simple and robust and oscillate chaotically but the dominant peak of power spectrum appears at low frequency range, approx.10Hz to 1KHz, after that the signal power decays very fast. In 2011 J.C. Sprott [7] presented a new chaotic jerk circuit which has frequency spectrum wide enough up to 10 KHz but the strength is decaying fast with increasing frequencies as shown in Fig.2. In 2012, Jink Pan and Qun Ding [8] modified the Lorenz spectrum by FFT truncation method to get flat spectrum over wide range of frequencies to increase the security and stability of the chaotic masking system but the circuit realization of such scheme is not given. In such case the chaotic signal will be not suitable for the application in the secure communication. Thus in order to increase the security of the chaotic masking system a new chaotic circuit is presented in this paper, which generates a chaotic signal having wide bandwidth and the spectral components have large power over wide range of frequencies. The proposed system can be used for personal secure communication. The circuit simulation is done using ORCAD-PSPICE programs and circuit is designed and implemented with Op-amps and passive components. Section II deals with the mathematical equations governing the operation of the circuit, phase portraits of the simulated and real time implemented system and power spectral density plot of the circuit. Finally in section III conclusion is given.

II. CIRCUIT DESIGN AND IMPLEMENTATION:

The system is defined by jerk equation (1).

$$\ddot{x} + c \dot{x} + b \dot{x} + a x + d x^2 = 0 \quad (1)$$

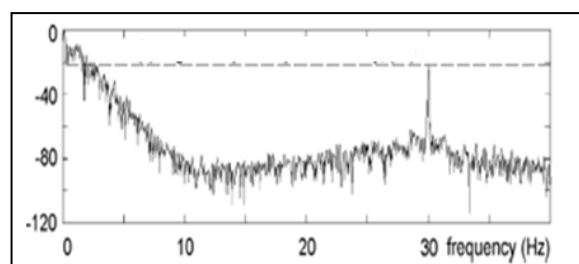


Fig.1 power spectral density of system given in [1].

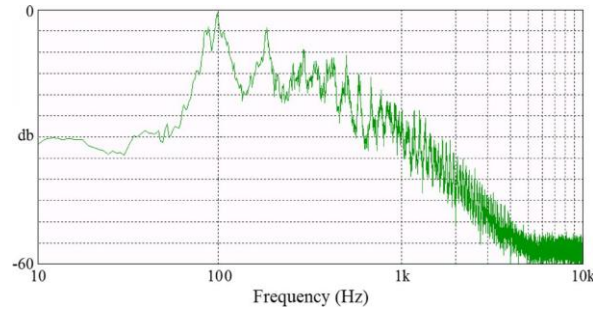


Fig. 2 Frequency spectrum of the output of the chaotic circuit [7].

System has two equilibrium points (0, 0, 0) and (-8, 0, 0) and the corresponding eigen values are $\lambda_1 = -0.803$, $\lambda_2 = 0.151 + 1.105i$, $\lambda_3 = 0.151 - 1.105i$ and $\lambda_1 = 0.601$, $\lambda_2 = -0.550 + 1.165i$, $\lambda_3 = -0.550 - 1.165i$. Some eigen values have positive real parts which implies chaos [9]. The equation (1) can be implemented electronically as shown in Fig.3. The circuit is designed for four positive real constants a, b, c and d. The values are taken as a = b = 1, c = 0.5 and d = 0.125 and initial conditions is $(x_0, y_0, z_0) = (0.001, 0.01, 0.1)$ Circuit Equation is given as (2).

$$\begin{aligned}\dot{x} &= \frac{1}{C_1 R_1} y \\ \dot{y} &= \frac{1}{C_2 R_2} z \\ \dot{z} &= -\frac{1}{C_3 R_4} x - \frac{1}{C_3 R_5} y - \frac{1}{C_3 R_6} z - \frac{1}{10 C_3 R_3} x^2\end{aligned}\quad (2)$$

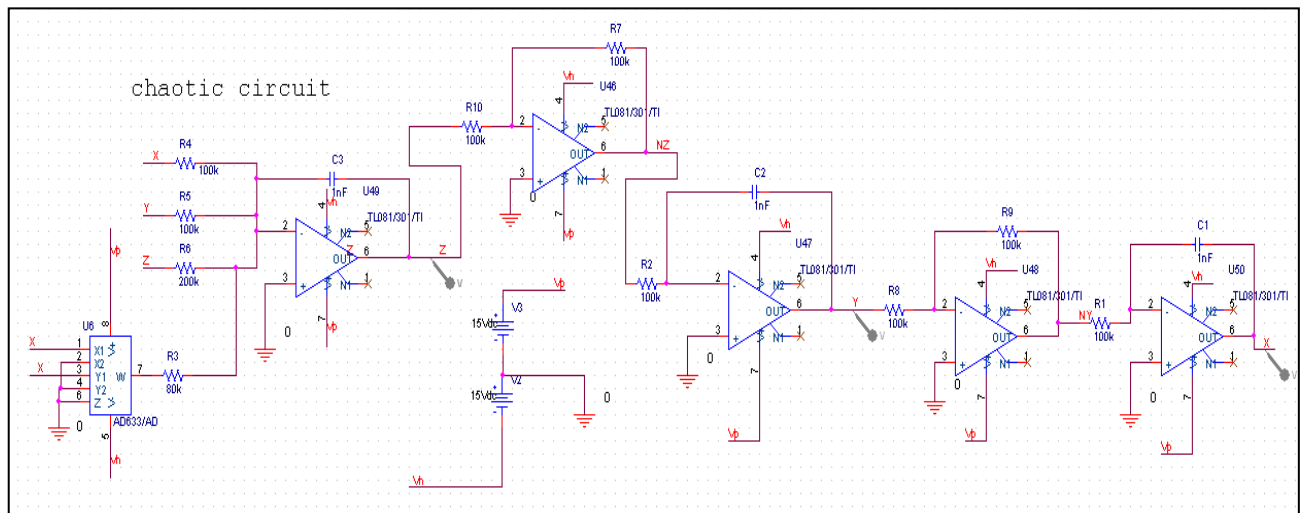


Fig.3 circuit schematic

The component values are calculated by taking suitable value of time constants for the Integrator circuits. Here the value of all three capacitors C_1 , C_2 and C_3 are 1nF and the value of resistors is taken as with $R_1 = R_2 = R_4 = R_5 = R_7 = R_8 = R_9 = R_{10} = 100k$, $R_3 = 80k$ and $R_6 = 200k$. The circuit has three integrators in a feedback loop and a multiplier, Op-amp TL081 and IC AD633/AD is used as a multiplier. The circuit has been fabricated on breadboard. The chaotic attractor can also be seen on the screen of the oscilloscope as shown in Fig.4 as an evidence of chaos. Fig.5 shows the chaotic attractors of the simulated circuit. The circuit displays typical strange chaotic attractor. A chaotic signal has aperiodic nature in time domain and thus exhibits broadband noise like power spectrum. The power density spectrum of chaotic signals is shown in Fig.6. The dominant frequency of oscillation is expected to be $f = 1.105/2\pi RC = 1.75$ KHz which matches with simulation results. The power of the signal no longer concentrated in a small number of frequency components; rather it is distributed over a broad audio range of frequencies as shown in Fig.6.



Fig.4 Actual circuit in operation.

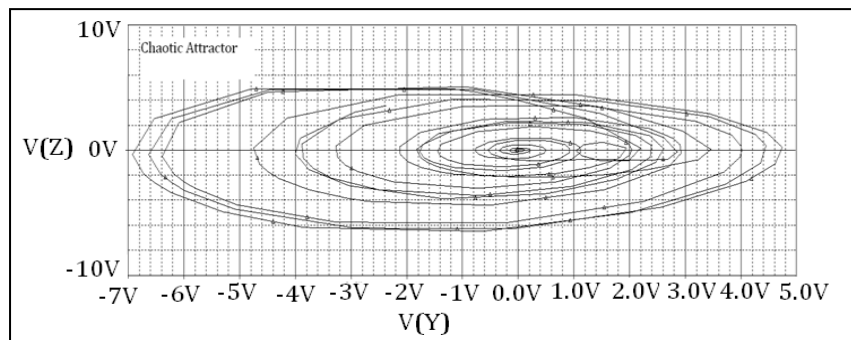


Fig.5 Pspice simulation result of chaotic Attractor.

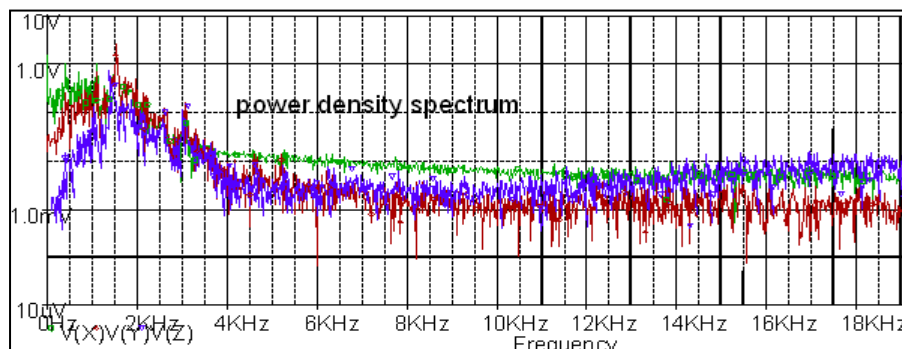


Fig6. Power density spectrum of chaotic signal

III. CONCLUSION:

A new chaotic circuit is designed and implemented to generate a chaotic signal which has wider power spectral density and exhibits significant power strength over large frequencies. The circuit can be used as chaotic generator in signal masking applications to improve the security of the cryptosystem.

IV. REFERENCES

- [1] G. Álvarez, F. Montoya, M. Romera, and G. Pastor, " Breaking Two Secure Communication Systems Based on Chaotic Masking", " IEEE Trans. Circuits Syst. II, Exp.Briefs, vol. 51, no. 10, Oct. 2004 pp 505-506.
- [2] M. Boutayeb, M. Darouach, and H. Rafaralahy, "Generalized state-space Observers for chaotic synchronization and secure communication," IEEE Trans. Circuits Syst. I, vol. 49, Mar. 2002, pp. 345–

349.

[3] T. L. Liao and N. S. Huang, "An observer based approach for chaotic Synchronization with application to secure communications," IEEE Trans. Circuits Syst. I, vol. 46, Sept. 1999, pp. 1144–1150.

[4] G. Álvarez, Shujun Li and F. Montoya, "Breaking projective chaos synchronization secure communication using filtering and generalized synchronization," Elsevier, 2007.

[5] Z. Li, D. Xu, "A secure communication scheme using projective chaos Synchronization", Chaos Solitons and Fractals 22 (2) (2004) 477–481.

[6] Jessica R. Piper, J.C.Sprott, "Simple Autonomous Chaotic Circuits", IEEE Trans. Circuits Syst. II, Exp.Briefs, Vol. 57, No. 9, September 2010, pp730-734.

[7] J.C.Sprott, "A new chaotic jerk circuit", IEEE Transactions on Circuits and Systems-II: Express Briefs, Vol.58, April 2011, pp.240-243.

[8] Jing pan, Qun Ding, Baoxiang Du, "A new improved scheme of chaotic masking secure communication based on Lorenz system", International Journal of Bifurcation and Chaos, Vol. 22, No. 5 (2012)

[9] Kathleen T. Alligood, Tim D Sauer, James A. Yorke, CHAOS An introduction to Dynamical System. Springer Publications 1997.