Eastern Macedonia and Thrace Institute of Technology

Dept. of Electrical Engineering

Abstract:

Study of a non-linear Circuit (Chaos Realised)

by

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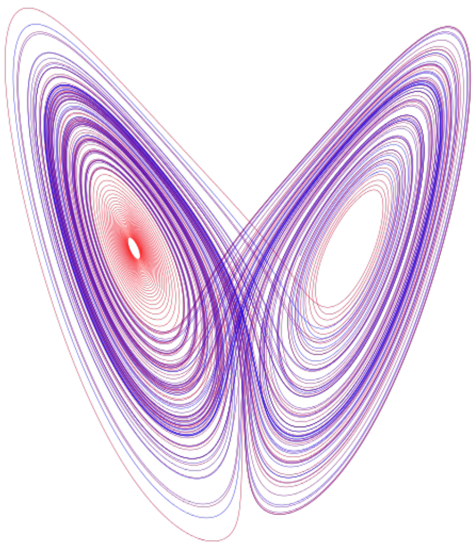

Thesis presented for the degree of Bachelor of Science in Electrical Engineering at the Macedonia and Thrace Institute of Technology

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KAVALA 2014

Abstract

In this paper, the astonishing reality of chaos is probed and examined in a variety of ways. The brief history of the discovery of Chaos, the unsettling realisation that despite the fact that chaotic phenomena have been a part of the cosmos since its very formation as we've only recently discovered them, are given in order to stimulate the critical thinking faculties. The nonlinear and chaotic worlds are mesmerising when one illustrates them by means of graphs and plots or when one ponders and contemplates their actual meaning and application to the real world. The undeniable beauty of the Lorenz Attractor is a fine example, and with just a hint of imagination one can see the wings of a butterfly unravel from this chaotic attractor. Far from just of artistic value, chaos theory is thought to hold the key to solving a plethora of problems, from economic depressions, stock market crashes to security in communications to weather forecasting.

An attempt to define chaotic behaviour takes place, followed by evidence of the impact chaos has on our lives in the form of pictures, equations and thoughts. However, chaos is indeed surrounding us. The trajectory of a fly's movement is a chaotic phenomenon, as is the weather and the stock market. The illusive thing that leads to an inexplicable behaviour of the physical world seems to have great minds under its spell; from the time of the great physicist Sir Isaac Newton and Pierre-Simon Laplace to the era of Albert Einstein and Neil's Bohr, a mental hunt to identify it has been taking place. After all, chaos might very well be one of the reasons that life as we know it exists: from the impact it has on the shapes and colours of biological things like trees, leaves, animals to the shapes that inanimate matter forms, such as that of the ripples and waves that sand produces, to the formation of human life itself, chaos is all around.

The chaos theory describes the behaviour of certain dynamical systems. A dynamic system is one whose state changes with time; a chaotic one is a dynamical system which is described by a high sensitivity to initial conditions, such that an infinitesimally small variation in them can lead to a completely different outcome. Whilst endless complexity is a by-product of the chaotic regime, chaos itself need not arise from or be governed by complex rules. As is the case with Chua's circuit, the very circuit examined here, simple rules naturally give rise to chaos; order and chaos, it seems, emerge on their own so long as feedback is part of the system. Chaotic systems are examined and are being analysed; in particular, Chua's Circuit which has had a great impact on facilitating our studies of chaotic behaviour and is proven paramount to our understanding it.

Chaos does indeed play an important role in our lives as it describes phenomena that anyone is familiar with and everyone encounters each day. Once every few decades an invention changes the landscape of some aspects of our life. Industrial revolutions improved our everyday lives, whilst medical revolutions expanded our lifespans. The 20th century's most vital discoveries are believed to be the Chaos, Quantum and Relativity theories and yet not much interest was attributed to Chaos theory until Lorentz realised that earth's very weather behaves as a chaotic system.

An experiment was designed for this thesis and information was drawn from its analysis via 'Auguri', a programme designed for chaotic analysis. Through various methods, the chaotic behaviour of Chua's Circuit was studied and confirmed. Step by step, each new statistics of the voltage time series performed by the Auguri computer programme indicated that Chua's circuit does produce chaos.

The significance of this lies partly in the simplicity of the circuit examined, and party on the applications of said confirmed chaotic behaviour. Chaos can be used for, and is actually one of the best options for communications encryption due to its inherent complex properties such as its noise-like dynamics its complex behaviour, and its spread spectrum. These properties can be used to encode data, preventing prying eyes from viewing what is being transmitted. By its very nature values produced by a chaotic phenomenon are immeasurably difficult to reproduce as any chaotic attractor contains as infinite number of unstable, periodic orbits. It is this sheer difficulty that holds the key to a better encryption system. However unpredictable, chaos does remain a deterministic phenomenon, and in practice, devices that use chaotic behaviour for cryptography end up using synchronisation of chaos or control of chaos to decode the data on the other end. In order to achieve this, two chaotic oscillators are required as a transmitter and a receiver. The data to be obfuscated are masked in the chaotic signal produced by the transmitter. The chaotic signal, or chaotic carrier is transmitted to the other end. The original data can be retrieved, for example, by a subtraction of the synchronised receiver's signal from the chaotic carrier.

The end users are definitely attracted to safer methods of communication and are more likely to purchase a more secure device, but the effect is immensely hindered by an overpriced product. To this end, Chua's circuit is ideal, for the simpler a circuit is, the cheaper it becomes. Chua's circuit is extremely simple, and yet, in all its simplicity it does qualify as a chaotic circuit as it meets all three conditions.

Keywords: Nonlinear Circuit, Chaotic Behaviour, Chaos, Chua's Circuit, Chaotic Cryptography, Synchronisation, Secure Communications.