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Review and Analysis of Methods of synchronization for Chaotic Colpitts Oscillators

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Abstract:
The one possible application of the Colpitts generators is chaos-based communications. In this type of communication the problem of mutual synchronization eventually arises. There are lot of work has been done on this topic so review of litereature is present here. Review of results of numerical investigation of synchronization between two identical Colpitts generators is described. The method of linear difference signal has been applied. The corresponding differential equations have been integrated numerically and the synchronization threshold has been found. The measured synchronization error of less than 1% has been determined.

Keywords: Chaotic colpitts, oscillators, Matlab , Linear equations

1. INTRODUCTION

Chaos communications is an application of chaos theory which is aimed to provide security in the transmission of information performed through telecommunications technologies. By secure communications, one has to understand that the contents of the message transmitted are inaccessible to possible eaves droppers .To implement chaos communications using such properties of chaos, two chaotic oscillators are required as a transmitter (or master) and receiver (or slave). At the transmitter, a message is added onto a chaotic signal and then, the message is masked in the chaotic signal. As it carries the information, the chaotic signal is also called chaotic carrier.

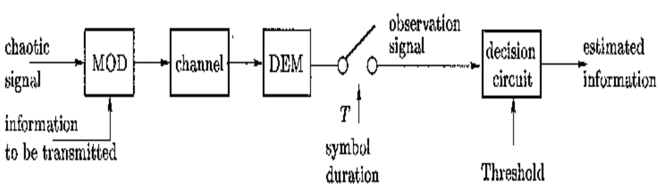

Figure.1. Block diagram of chaos based communication

Chaotic communication signals are spread spectrum signals, which utilize large bandwidth and have low power spectrum density. In traditional communication systems, the analogue sample functions sent through the channel are weight sums of sinusoid waveforms and are linear. However, in chaotic communication systems, the samples are segments of chaotic waveforms and are nonlinear. This nonlinear, unstable and a periodic characteristic of chaoti communication has numerous features that make it attractive for communication use. It has wideband characteristic, it is resistant against multi-path fading and it offers a cheaper solution to traditional spread spectrum systems. In chaotic communications, the digital information to be transmitted is placed directly onto a wide-band chaotic signal.

1.1 CHOATIC SYNCHRONIZATION: In order to recover the information the chaotic generator G1 in the transmitter must be synchronized with the identical chaotic generator G2 in the receiver. There are several methods for synchronizing of chaotic oscillators described as -

1.2 METHOD OF SYNCHRONIZATION

There are several methods of synchronization are used some are

1. Adaptive method
2. Lorenz-based .
3. T-S Fuzzy Modeling
4. Linear differential method

1. Adaptive method

The typical configuration of chaotic synchronization consists of master and slave systems. The master system drives the slave system via a scalar signal transmitted through the coupled channel. In recent years, several adaptive and switching methods have been proposed and sufficient conditions are derived to synchronize the master–slave chaotic systems .

2. Lorenz based method

Simple method to synchronize Lorenz systems with different parameters. One of the Lorenz systems is driven by a variable in the other system. The time series of the driving variable in the drive system and its counterpart in the response system are collected. With the parameters in the response system updated. Based on skills, the correlation coefficient and the standard deviation ratio between the time series of the drive and the response system will gradually approach one, will cause these systems to be synchronized. A potential approach to communications applications is based on chaotic signal masking and recovery [4]-[8]. In signal masking, a noise like masking signal is added at the transmitter to the information-bearing signal $r\,n\,(\,t\,)$, and at the receiver the masking is removed. In our system, the basic idea is to use the received signal to regenerate the masking signal at the receiver and subtract it from the received signal to recover *m(t).* This can be done with the synchronizing receiver circuit,

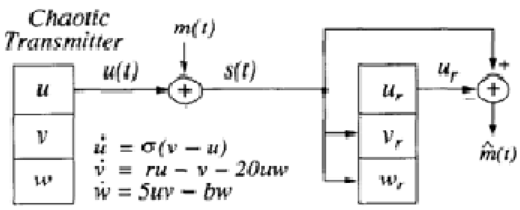

Figure.2. Choatic signal masking system

i.e., is not highly sensitive to perturbations in the drive signal and thus can be done with the masked signal. , consider, for example, a transmitted signal of the form

$s(t) = u(t) + m(t).$

It is assumed that for masking, the power level of *m(t)* is significantly lower than that of *u(t)*.since the ability to synchronize is found experimentally to be robust.

3. T-S fuzzy modeling

A fuzzy controller or model uses fuzzy rules, which are linguistic if-then statements involving fuzzy sets, fuzzy logic, and fuzzy inference. Fuzzy rules play a key role in representing expert control/modeling knowledge and experience and in linking the input variables of fuzzy controllers/models to output variable (or variables). Two major types of fuzzy rules exist, namely, Mamdani fuzzy rules and Takagi-Sugeno (TS, for short) fuzzy rules.

4. .Linear differential method.

This method employs the feedback in the form of linear difference between the output of the transmitter $u1(t)$ and the output of the receiver $u2(t)$. The difference Signal $k\Delta u=k(u1-u2)$ when applied with a certain weight $k>kth$ to an appropriate input of the receiver synchronizes the latter to the transmitter [13,14].

2 .CHOATIC OSCILLATION

The circuit diagram of the Colpitts oscillator is shown in Fig. 1. The resonance loop consists of three inertial elements: inductor L, also two capacitors C1 and C2. The quality of the tank can be controlled by means of the series resistor R. The oscillator has a common-base configuration with a voltage source V0 in the collector loop and a current source I0 in the emitter one.

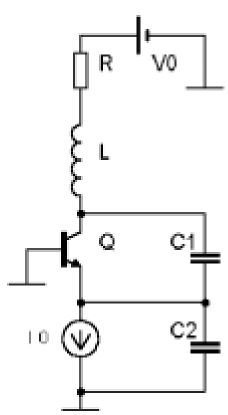

Figure.3. The Colpitts oscillator

The fundamental frequency of the oscillator can be Estimate as.

$$f^* = \frac{1}{2\pi}\sqrt{\frac{C_1 + C_2}{LC_1C_2}} \quad (1)$$

Transistor Q plays the role of both, the active amplifying device and the nonlinear element. Thus, the oscillator is a 3rd order nonlinear dynamical system with a potential possibility to exhibit chaotic oscillations. Dynamics of the oscillator is given by the following set of differential equations:

$$\begin{aligned} C_1\frac{dU_{C1}}{dt} &= I_L - I_K, \\ L\frac{dI_L}{dt} &= V_0 - RI_L - U_{C1} - U_{C2}, \\ C_2\frac{dU_{C2}}{dt} &= I_L - I_K + I_E(U_{C2}) - I_0. \end{aligned} \quad (2)$$

The collector current *IK* is proportional to the emitter current: *IK*=α*IE*. The nonlinear current-voltage characteristic of the emitter-base (EB) junction can be approximated by two linear segments:

$$I_E(U_{C2}) = \begin{cases} \frac{-U_{C2} - U^*}{r}, & U_{C2} < -U^*, \\ 0, & U_{C2} \geq -U^*. \end{cases} \quad (3)$$

Here r is the small signal ON resistance of the EB junction and U^* is the break-point voltage ($U^* \approx 0.7$V).Assuming for simplicity that the forward current gain $\alpha \approx 1$, that is
$IK \approx IE$ and introducing the following
dimensionless variables and parameters

$$\begin{aligned} &x = \frac{U_{C1}}{U^*};\quad y = \frac{\rho I_L}{U^*};\quad z = \frac{U_{C2}}{U^*};\quad \theta = \frac{t}{\tau};\quad \dot{u} \equiv \frac{du}{d\theta}; \\ &\tau = \sqrt{LC_1};\quad \rho = \sqrt{\frac{L}{C_1}};\quad \varepsilon = \frac{C_2}{C_1}; \\ &a = \frac{\rho}{r};\quad b = \frac{R}{\rho};\quad c = \frac{V_0}{U^*};\quad d = \frac{\rho I_0}{U^*}. \end{aligned} \quad (4)$$

we come to the set of differential equations convenient for numerical integration

$$\begin{aligned} \dot{x} &= y - F(z), \\ \dot{y} &= c - x - by - z, \\ \varepsilon\dot{z} &= y - d. \end{aligned} \quad (5)$$

Here

$$F(z) = \begin{cases} -a(z+1), & z < -1, \\ 0, & z > -1. \end{cases} \quad (6)$$

or certain sets of the circuit parameters, i.e. the coefficients in Eq. (1) the system exhibits chaotic
oscillations (Fig. 2).

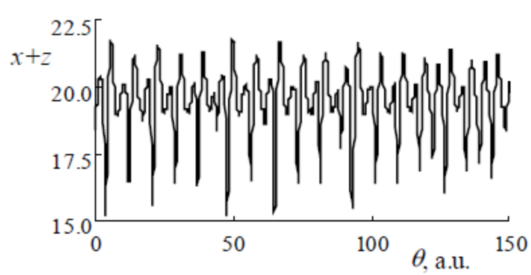

Figure .4. Typical waveform of chaotic oscillations
from Eq. (5): collector voltage $U\text{k}=U\text{C}1+U\text{C}2 \sim x+z$.
$\varepsilon=1$, $a=30$, $b=0.8$, $c=20$, $d=0.6$.

2.1 SYNCHRONIZATION OF IDENTICAL OSCILLATION

Let us consider two identical Colpitts generators, G1 and G2 with the transistor collectors coupled via
linear resistor Rk (Fig. 3).

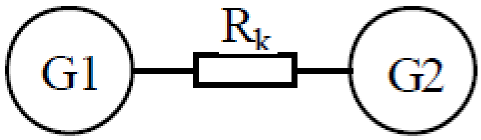

Figure. 5. Coupled generators.

Introducing the coupling coefficient $k=\rho/R$k the overall system can be described by the set of six differential equations:

$$(7)\quad \begin{aligned} \dot{x}_1 &= y_1 - F(z_1) + k(x_2 + z_2 - x_1 - z_1), \\ \dot{y}_1 &= c - x_1 - by_1 - z_1, \\ \varepsilon\dot{z}_1 &= y_1 - d + k(x_2 + z_2 - x_1 - z_1), \\ \dot{x}_2 &= y_2 - F(z_2) + k(x_1 + z_1 - x_2 - z_2), \\ \dot{y}_2 &= c - x_2 - by_2 - z_2, \\ \varepsilon\dot{z}_2 &= y_2 - d + k(x_1 + z_1 - x_2 - z_2). \end{aligned}$$

Though the two generators G1 and G2 are fully identical ones, the oscillations $x1(t)$ and $x2(t)$, also $y1$and $y2$, as well as $z1$ and $z2$ do not coincide with each other until the systems are not coupled (k=0) or the coupling coefficient is insufficient ($k<kth$). The synchronization threshold estimated numerically is $kth \approx 0.5$ (coupled collectors). Unsynchronized oscillators are illustrated in Fig. 4 (t<150). Different behavior of identical dynamical systems is caused by different initial conditions of the generators. When the generators are coupled to each other (t=150) and the coupling is strong enough ($k>kth$) the oscillators " forget" their own initial conditions and after a short transient (t=150…160) they synchronize to each other: ($x1+z1$) ⇒ ($x2+z2$). Meanwhile, the difference signal ($x1+z1$)−($x2+z2$) tends to zero (bottom trace in Fig. 4). We note, however, that each of the in dividual signals ($x1+z1$) and ($x2+z2$) remain chaotic as evident from the top trace in Fig. 4 at t>150.

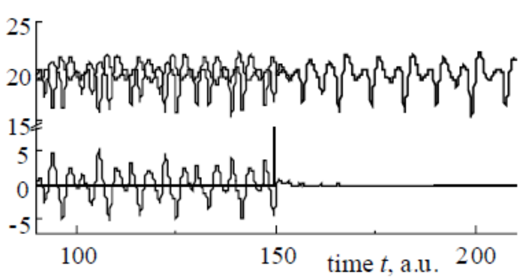

Figure.6. Collector voltages from Eq. (7), $x1+z1$ and $x2+z2$ (top), and the difference signal ($x1+z1$)−($x2+z2$)(bottom). k=0 at t<150 and k=0.8 at t>150.

The threshold value of the coupling coefficient $kth \approx 0.14$.

3. PROPOSED WORK

First We have to investigate numerically synchronization between two coupled chaotic Colpitts oscillators by linear difference method which has been described above. It gives better results (in the sense of the *SQ*). We will also improve SQ of chaotic colpitts oscillator for frequency in the range of Megahertz or Gigahertz by modifying coupling coefficient and parameter variations for chaotic oscillator .

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