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A SIMPLE FRACTIONAL CHAOTIC OSCILLATOR FOR EDUCATIONAL PURPOSES

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Abstract. A simple fractional order chaotic oscillator suitable for pedagogical purposes is proposed. The oscillator circuit is a generalization of an integer order chaotic oscillator previously reported in the literature, known as the "Vilnius oscillator". The fractional order model is derived from its parent model by replacing the ordinary capacitors by fractional order ones. Numerical simulations obtained for the generalized circuit demonstrate the presence of chaos, as verified by the positivity of the largest Lyapunov exponent associated with the data series. An adjustment of the parameters of the integer order circuit is needed in order to generate chaos in the fractional order circuit. Hence, the chaotic ranges of the different circuit parameters are characterized for the proposed model. In particular, the amplifier's gain must be raised in order to compensate for the reduction in circuit order.
Keywords. Fractional order circuits, Chaotic oscillators, Vilnius oscillator, Educational circuits.

1 Introduction

Nonlinear systems can exhibit a multitude of complex phenomena depending on their structures and control parameter values. One such phenomenon is chaos, which has attracted a lot of research efforts in the past few decades. The interest in such behavior can be broadly subdivided into two categories: analysis and synthesis. The first category focuses on deriving the conditions for chaos generation in a particular system, whereas in the second category the focus is on designing systems that are intended to generate chaos. While numerical simulations can be very helpful in studying such complex phenomena, experimental verification using simple circuits is undoubtedly most welcome, especially by students who are intending to delve into this challenging field of research. A simple circuit capable of chaos generation, Fig. 1, has recently been proposed for educational purposes [1], and became known as "Vilnius oscillator". It is well known that in order for chaos to appear in an integer order nonlinear autonomous continuous-time system, the order of the system must be at least 3. The presence of three energy storage elements in