CHAOS CONTROL IN TRANSMISSION LINES COUPLED TO NONLINEAR CIRCUITS

Dr. Ioana Triandaf

Naval Research Laboratory
Code 6792
Washington, DC 20375
Email: ioana.triandaf@nrl.navy.mil

Abstract - **In a transmission line oscillator a linear wave travels along a piece of cable, and interacts with terminating electrical components. We present a simple model of a two-conductor transmission lines, connected to a transistor. Loss of signal integrity may manifest itself as chaotic behavior. In a real circuit, such chaotic signals, could be transmitted into the primary circuitry and disrupt or possibly damage the device. A chaos control method is presented that achieves chaos suppression by small perturbations of the resistance at one of the boundaries of the transmission line.**

Index Terms— Chaos, transmission line, Telegrapher's equation, chaos control.

1. INTRODUCTION

The effect of the transmission line on the signal integrity is a critical aspect of high-speed digital system performance. Interconnections between electronic devices may behave as transmission lines and one would like to reduce signal losses and distortions in order to ensure the correct operation of electronic circuits.

In what follows we give an exampled of signal distortion due to chaotic behavior, which occurs when the transmission line is coupled with a transistor. We show how this chaotic behavior can be controlled.

2. THE NONLINEAR DYNAMICAL SYSTEM

It is known [1] that the voltage $v = v(x, t)$ and the current $i = i(x, t)$ along a two-conductor transmission line are modelled by the Telegrapher's equations:

$$\partial v/\partial x = -L\partial i/\partial t, \;\; \partial i/\partial x = -C\partial v/\partial t \;, 0 < x < 1, t \geq 0 \quad (1)$$

where L and C are the inductance and the capacitance per unit line length, respectively. For our system we impose intial conditions and the following boundary conditions [2]:

$$v(0, t) = 0, \qquad v(1, t) = \alpha i(1, t) - \beta i^3(1, t) \qquad t \geq 0 \qquad (2)$$

where α and β are parameters. These boundary conditions correspond to having a transistor attached to the far end of the transmission line. A source is attached at the near end. We vary α and keep $\beta = 1$. As α varies periodic patterns of the solution change into complex patterns which become chaotic. In Fig.1a) we show the chaotic solution of Eq. (1), at a fixed spatial point, and note that chaos is pervasive for $0 < x < 1$.

This spatial chaotic solution can be controlled using a boundary control method [4]. Boundary control of chaos is done by applying perturbations in the parameter α at $x = 1$. Using a Poincare map approach, the parameter perturbations are applied when the solution at the boundary reaches a maximum. These perturbations are calculated proportional to the distance to the desired state which is multiplied by a gain factor derived by a local linearization of the solution about the orbit to be stabilized [3]. As a result of applying the boundary control, a high-period orbit is obtained. The periodic solution at a fixed spatial point is shown in Fig.1b). The stabilization performed at the boundary achieves control over the entire spatial domain since for hyperbolic equations the solution remains constant along characteristic curves emerging from the boundary.

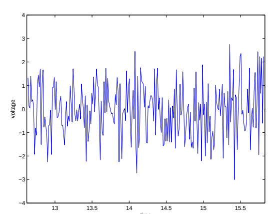

Fig. 1 a) Chaotic voltage as a function of time sampled at $x = 0.8$

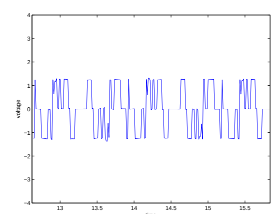

Fig.1 b) Controlled voltage as a function of time sampled at $x = 0.8$

3. REFERENCES

1. Clayton R. Paul, "Analysis of Multiconductor Transmission Lines", IEEE Press, Wiley, 2007.
2. Goong Chen et al. "Chaotic Vibrations of the One-Dimensional Wave Equation Due to a Self-Excitation Boundary Condition, Part I", Trans. of the American Mathematical Society, Vol. 350, Number 11, Nov 1998, pages 4265-4311.
3. Edward Ott, Celso Grebogi and James A. Yorke, "Controlling chaos", Phys. Rev. Lett. 64, 1196 (1990).
4. Ioana Triandaf, Ira B. Schwartz,"Karhunen-Loeve mode control of chaos in a reaction-diffusion process", Phys. Rev. E 56, 204 (1997).

The author gratefully acknowledges the support of the Office of Naval Research.