Pulse Detection with a Multi-state System

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Abstract

Complex systems are diverse in nature and their modelling is system dependent. Many complex systems are naturally modelled as multi-state systems with their operation being defined by dynamics between states with various feedback paths defining the options for state transitions, e.g. [1]. Cooperative behaviour, as found in self organizing systems, e.g. the decision making model [2], is based on modelling interactions between a collection of entities where local outcomes are dependent on connected state levels.

A prototypical multi-state system is defined by the differential equation

$$\frac{dx(t)}{dt} = \sin[2\pi x(t)]$$

which comprises, as illustrated in Figure 1, of a sequence of stable states interleaved by meta-stable states. Such a multi-state system can be approximated by the use of a quantizer as illustrated in Figure 1. This paper examines the potential such a multi-state system has for pulse detection. When half the quantization level is greater than three times the rms output noise level the multi-state system acts as an integrator for a pulse input but acts as a broadband amplifier for the input noise. A result of this is that there is effective signal integration without the droop inherent in practical integrators; the effective time constant is infinite [3]. For pulse detection, it is shown the performance can approach that of a matched filter detector for the case of white noise. The structure enables sub-threshold detection of a pulse train and automatic counting of distinct pulses in a pulse train.

Indicative results are shown in Figure 2 for the normalized case, consistent with the small signal gain of unity and a bandwidth of 1Hz , and a randomly timed impulse pulse train.

References

