

## IMPROVEMENT OF THE SIGNAL-TO-NOISE RATIO WITH STOCHASTIC RESONANCE IN A BISTABLE CIRCUIT

G. V. Savino\*, A. M. Ormachea and M. A. Donzelli

Laboratorio de Técnicas Digitales, Dto. de Ingeniería Eléctrica.  
Facultad de Ciencias Exactas y Tecnología, Univ. Nac. de Tucumán.  
Avenida Independencia 1800 (4000), Tucumán, Argentina.  
e-mail:gsavino@herrera.unt.edu.ar

**Keyword** : noise, stochastic resonance, bistable.

### Abstract

The output signal-to-noise ratio (SNRo) of real linear systems, such as amplifiers, is always lower than the input signal-to-noise ratio (SNRi), and filtering is not possible if the signal and noise share the same frequency band. We demonstrate that a sinusoidal wave can be printed in the Schmitt-Trigger (ST) circuit transitions with an SNRo better than SNRi by tuning the ST input threshold for each noise power. Curiously, this is true only when the signal is "noisy" with an SNRi less than 8, as compared with the case for "clean" signals (SNRi>8) where the print process diminishes the SNR. An input signal with an SNR as low as 1.8 can be printed with a SNRo=7, that is, about 4 times better. These results may be attributed to the stochastic resonance phenomenon. We also show that any noise added at the input will always impair both the input and the output SNR.

### 1. Introduction

Electrical random noise originating from different sources are always present and impair signal quality, which is measured as the signal-to-noise ratio (SNR). The SNR at the output (SNRo) of any linear electronic device is lower than SNR at the input (SNRi), because all electronic devices add their own noise. If the signal and noise share the same frequency band the SNR cannot be improved by filtering. The situation is worse when the signal power and noise power are similar and the signal is immersed or embedded in the noise. In these conditions the signal becomes undetectable.

Since the demonstration of the stochastic resonance phenomenon (SR) (Benzi *et al.*, 1985), different researchers have shown that SNRo can be improved by adding extra noise at the input (Moss, 1982). Indeed, the SNRo of bistable and excitable devices such as the circuit (ST) (Fauve and Heslot, 1983; Gammaitoni *et al.*, 1989), the FitzHugh-Nagumo neuron (Longtin, 1993), or potential wells (Zhou and Moss, 1990) excited by a subthreshold sinusoidal input initially increases when input noise is added. However, increasing input noise past the value at which maximum SNRo is obtained leads to diminishing SNRo. A plot of SNRo vs noise power results in the characteristic stochastic resonance curve. In practice, one obtains the maximum SNRo (SNRo<sub>max</sub>) by adjusting the input noise back and

forth, we can interpret this maneuver as a tuning one. But until now to our best knowledge this SNRo<sub>max</sub> has not been related or compared with the SNR at the input.

In this paper we show that in the bistable Schmitt-Trigger (ST), SNRo<sub>max</sub> can be obtained by adjusting the hysteresis or threshold for a constant input power noise and signal amplitude, that is, for a constant SNRi. Since the SNRi remains constant, it compares with the SNRo<sub>max</sub> to determine if SNRi is > or < SNRo<sub>max</sub>. This is very useful for deciding whether to apply in a given system signal processing such as described above, which implies a printing of the signal in the ST transitions. We also show that any noise added at the input will always impair both the input and the output SNR in spite of SR phenomenon.

### 2. Methods

Transitions between the +1,-1 stable states of a numerically simulated ST device are induced by the input  $V_i = \text{noise} + \text{signal}$  (fig. 1).

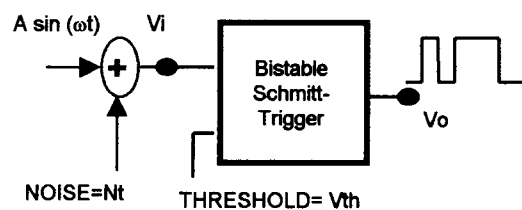


Fig. 1. The electronic ST circuit.

\* Correspondence should be addressed to G. Savino