High signal-to-noise ratio gain by adding noise: stochastic resonance and possible applications

R. Mingesz, P. Makra and Z. Gingl
Dept. of Experimental Physics, University of Szeged, H-6720 Szeged, Hungary

In some systems, the addition of noise may improve signal transfer—this phenomenon is often called stochastic resonance (SR). The quality and readability of a signal is usually measured by the signal-to-noise ratio (SNR) and the improvement of signal quality during transfer can be characterised by the ratio of output SNR and input SNR, which is sometimes called SNR gain. For potential practical applications high SNR gains (much larger than 1) are essential, but in the field of SR it is still an open question whether high SNR gains are really achievable or rather the dubious SNR definitions lead to it. There are many possible ways to investigate signal improvement, including the use of information theoretic quantities. SNR gains above unity were found in many systems; however, these results were obtained only for special input signals and under quite strict conditions, like close-to-threshold signal amplitude and small duty cycle, etc. In our current work we apply a cross-correlation based method of signal-noise separation, which is backward compatible with the classical SNR definition, but can be applied to any kind of input signal. Using measurements and simulations based on the most common double well SR system we have found that gains greater than unity are achievable under rather relaxed conditions and much wider range of input signals, including irregular and random signals as well. We also address some possible benefits concerning real-world applications.

1. L. B. Kiss, "Possible breakthrough: signicant improvement of signal-to-noise ratio by stochastic resonance," in Chaotic, Fractal and Nonlinear Signal Processing, R. Katz, ed., 375, pp. 382- 396, 1996.
2. Z. Gingl, P. Makra, and R. Vajtai, "High signal-to-noise ratio gain by stochastic resonance in a double well," Fluctuation and Noise Letters 1, pp. L181-L188, 2001.
3. P. Hänggi, M. E. Inchiosa, D. Fogliatti, and A. R. Bulsara, "Nonlinear stochastic resonance: The saga of anomalous output-input gain," Physical Review E 62, pp. 6155-6163, 2000.