Impact of the Statistical Properties of Random Telegraph Noises Generated by Stochastic Magnetic Tunnel Junctions on Probabilistic Computing Performance

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Probabilistic computers (p-computers) with probabilistic bits are expected to address some computationally hard problems for conventional deterministic computers, and stochastic magnetic tunnel junctions (s-MTJs) show promise as the crucial constituent of the p-bits [1,2]. Here, we study the computational accuracy as a function of the statistical properties of random telegraph noise (RTN) from s-MTJs [3-8].

We investigate the computing results based on the Ising model in terms of the difference in the appearance frequency of the lowest energy (E) states (correct solutions) compared to the higher E states (incorrect ones) in the statistics. We simulate the NAND-gate operation [9] (3-bits), full adder operation (5-bits) using experimentally obtained RTN of s-MTJs [8] with various statistical properties (amplitude, distribution, etc.). We also test software-generated continuous random numbers as an extreme case. The interaction between bits is implemented by sending a signal given by $-I_0\partial E/\partial x_i$ to the ith bit, where I_0 corresponds to the inverse temperature and x_i is the binary state of the ith bit. It takes longer to get the solution distribution for too high I_0, whereas the contrast becomes small for the too low I_0, giving upper and lower bounds of I_0. We observe that various kinds of RTNs can be used in p-computers by only tuning I_0 even if they have a binary-like distribution [Fig. 1]. We also discuss the factors determining the contrast, providing a guideline to design the s-MTJs and operate the p-computer.

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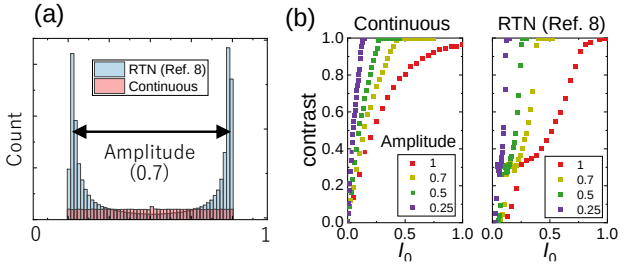

Fig. 1 (a) Histogram of the random telegraph noise (RTN) and binary/continuous random number. (b) I_0* for each amplitude of RTN and binary/ continuous random numbers.