Stochastic Resonance in Single-Electron Inverter Improved by Attachment of Input Discretizer

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1. Introduction

The property of noise-enhanced signal transmission through stochastic resonance has been observed in a wide variety of nonlinear systems. In this paper, we propose to improve stochastic resonance of a single-electron (SE) four-junction inverter (FJI) \([1]\) by utilizing an SE input discretizer (ID) \([2]\).

2. Stochastic resonance of a SE ID-FJI

Figure 1 shows the diagram of an SE FJI with an ID (ID-FJI) \([3]\). The discretized charge \(Q_0\) in the ID makes the switching characteristics sharp, which is expected to enhance the signal-detection ability through stochastic resonance. Monte-Carlo simulation was executed with following conditions.

- ID: \(J_0 (1 \text{ aF}, 100 \text{ k}\Omega), \ C = 72 \text{ aF}; \ J_1 & J_4 (1 \text{ aF}, 100 \text{ k}\Omega), \ J_2 & J_3 (2 \text{ aF}, 50 \text{ k}\Omega), \ C_{g1} = C_{g2} = 8 \text{ aF}; \ C_{b1} = C_{b2} = 7 \text{ aF}; \ V_s = 6.7 \text{ mV}, \ C_{out} = 1 \text{ fF}, \ T = 0 \text{ K}, \) no co-tunneling.
- Input-output characteristics of both the solo- and ID-FJI are presented in Fig. 2.

We evaluated the correlation coefficients between the rectangular input signal and output voltage response under Gaussian noise with various standard deviation \(\sigma\) with keeping its mean value \(\mu\) as 0, the results of which are shown in Fig. 3. Strict thresholds of the solo FJI and the ID-FJI, \(\theta_s\), (below which the outputs are strictly unresponsive) \([4]\) are 2.828 mV and 3.389 mV, respectively. With the same normalized input signal \(V_{in}/\theta_s = 0.995\), the peak of correlation coefficient of the ID-FJI (~0.957) is significantly better than that of the solo FJI (~0.627).

3. Conclusion

The ID-FJI with sharper switching achieves better stochastic resonance than the solo FJI.

References