Open-loop quantum control of small-size networks for high-order cumulants and cross-correlations sensing

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Quantum control techniques represent one of the most efficient tools to attain high-fidelity quantum operations and a convenient approach for quantum sensing and quantum noise spectroscopy. In this work, we investigate dynamical decoupling while processing an entangling two-qubit gate based on an Ising-xx interaction, each qubit being affected by pure dephasing classical correlated $1/f$-noises. To evaluate the gate error, we used the Magnus expansion introducing generalized filter functions that describe decoupling while processing and allow us to derive an approximate analytic expression as a hierarchy of nested integrals of noise cumulants. The error is separated in contributions of Gaussian and non-Gaussian noise, the corresponding generalized filter functions being calculated up to the fourth order. By exploiting the properties of selected pulse sequences, we show that it is possible to extract the second-order statistics (spectrum and cross-spectrum) and to highlight non-Gaussian features contained in the fourth-order cumulant. We discuss the applicability of these results to state-of-the-art small networks based on solid-state platforms.

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[1] Antonio D'Arrigo, Giulia Piccitto, Giuseppe Falci, Elisabetta Paladino, arXiv:2401.05766