Multi-qubit time-varying quantum channels for NISQ-era superconducting quantum processors

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Time-varying quantum channel (TVQC) models have been proposed in order to consider the time-varying nature of the parameters that define qubit decoherence [1]. Realizations of multi-qubit TVQCs have been assumed to be equal for all the qubits of an error correction block, indicating that the random variables describing the fluctuations of T1 and T2 are qubit-wise fully correlated [1,2]. However, the fluctuations of the decoherence parameters are explained by the incoherent coupling of the qubits with unstable near-resonant two-level-systems (TLS), indicating that such variations are local to each of the qubits of the system [3,4,5]. In this work [6], we perform a correlation analysis of the fluctuations of the relaxation times of multi-qubit quantum processors ibmq_quito, ibmq_belem, ibmq_lima, ibmq_santiago and ibmq_bogota. Our results show that it is reasonable to assume that the fluctuations of the relaxation and dephasing times of superconducting qubits are local to each of the qubits of the system. Thus, we discuss the multi-qubit TVQC when the fluctuations of the decoherence parameters are local to each qubit, which we name as fast time-varying quantum channels (FTVQC). Moreover, we numerically study the performance of quantum error correction codes (QECC) when they operate over FTVQCs. Finally, we propose the ergodic quantum capacity as a lower bound the asymptotically achievable limit for QECCs over these channels.

References

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Figures

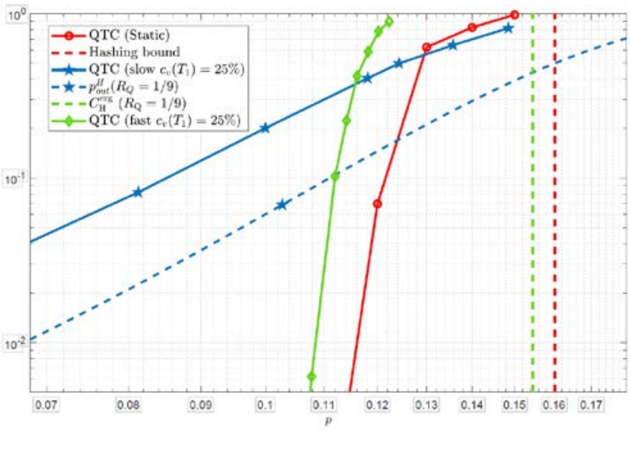

Figure 1: QTC operating over static, Slow TVQC and Fast TVQC.