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Quantum qubit measurement using a quantum point contact with a quantum Langevin equation approach BING DONG, NORMAN HORING, HONG-LIANG CUI, Department of Physics and Engineering Physics, Stevens Institute of Technology, Hoboken, New Jersey 07030 — Quantum measurement of a solid-state qubit by a mesoscopic detector is of fundamental interest and is still a controversial issue in quantum physics. In this work, we employ the theory of open quantum systems, the quantum Heisenberg- Langevin equation approach, to establish a set of quantum Bloch equations for a two-level system (coupled quantum dots) capacitively coupled to a quantum point contact (QPC) in a fully microscopic way. In our derivation, the operators of the qubit and detector are first determined formally by integration of their Heiserberg equations of motion (EOM), exactly to all orders in the tunnel coupling and qubit-detector coupling constants. Next, under the assumption that the timescale of the decay processes is much slower than that of free evolution, we express the time-dependent operators involved in the integrals of these EOM's approximately in terms of their free evolution. Finally, these EOM's are expanded in the powers of the coupling constants up to second order. The resulting Bloch equations allow us to examine qubit relaxation and decoherence in coupled quantum dots induced by measurement processes at arbitrary bias- voltage and temperature. As an illustration, we present analytical and numerical results for the qubit relaxation and decoherence.

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