Analog Quantum Simulation of the Dynamics of Open Quantum Systems with Quantum Dots and Microelectronic Circuits

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We introduce a general setup for the analog quantum simulation of the dynamics of open quantum systems based on semiconductor quantum dots electrically connected to an array of quantum *RLC* electronic circuits. The dots are chosen to be in the regime of spin-charge hybridization to enhance their sensitivity to the *RLC* circuits while mitigating the detrimental effects of unwanted noise. In this context, we establish an experimentally realizable map between the hybrid system and a qubit coupled to thermal harmonic environments of arbitrary complexity that enables the analog quantum simulation of open quantum systems. We assess the utility of the simulator by numerically exact emulations that indicate that the experimental setup can faithfully mimic the intended target even in the presence of its natural inherent noise. We further provide a detailed analysis of the physical requirements on the quantum dots and the *RLC* circuits needed to experimentally realize this proposal that indicates that the simulator can be created with existing technology. The approach can exactly capture the effects of highly structured non-Markovian quantum environments typical of photosynthesis and chemical dynamics and it offers clear potential advantages over conventional and even quantum computation. The proposal opens up a general path for effective quantum dynamics simulations based on semiconductor quantum dots.