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Fundamental limits of energy dissipation in computation GRAHAM BOECHLER, JEAN WHITNEY, CRAIG LENT, ALEXEI ORLOV, GREG SNIDER, University of Notre Dame — The limiting factor for microprocessor development in recent years has been heat generation, which has led to a debate regarding the limits of energy dissipation required for computation. Landauer argued that energy is unavoidably lost only when data is erased—the so-called Landauer Principle. Quasi-adiabatic computation is a proposed solution which relies on recycling the energy used during computation. This has been challenged recently by the assertion that recovering the energy is impossible due to a fundamental minimum energy of kTln(2) that must be lost during the charging and discharging of an RC circuit. We experimentally measured the power dissipated in an RC circuit in the time and frequency domains. In both cases, we measure an energy dissipation less than kTln(2) in the resistor while many times kT is delivered to the capacitor. Our experiments demonstrate that there is no fundamental lower limit to the energy that must be dissipated in charging and discharging a capacitor, even for energy losses well below kT. This therefore provides experimental support for the Landauer Principle: there is no fundamental lower limit for energy dissipation required for computation.

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