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Theory of tunable coupling of phase qubits[1] RICARDO A. PINTO, ALEXANDER N. KOROTKOV, University of California, Riverside, MICHAEL R. GELLER, University of Georgia, VITALY S. SHUMEIKO, Chalmers University of Technology, JOHN M. MARTINIS, University of California, Santa Barbara — We theoretically analyze a scheme for tunable coupling of two phase qubits, which has been recently realized experimentally. In this scheme, two inductors create a direct magnetic interaction between the qubits via mutual inductance, and an additional Josephson junction creates an indirect interaction which may be tuned via the bias current of the junction. These two contributions to $\sigma_x\sigma_x$ coupling of qubits have opposite signs and for some value of the bias current cancel each other, thus producing zero coupling. However, a small $\sigma_z\sigma_z$ coupling, which originates due to qubit anharmonicity, gets cancelled at a slightly different bias current, that leads to a small residual coupling. We calculate the residual coupling and the corresponding ON/OFF ratio analytically and numerically. We also discuss a minor modification of the scheme, for which the residual coupling may be zeroed.

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