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Constructing Two-Qubit Gates for Exchange-Based Quantum Computing DANIEL ZEUCH, Dept. of Physics, University of Konstanz, Dept. of Physics and NHMFL, Florida State University, ROBERT CIPRI, N.E. BONESTEEL, Dept. of Physics and NHMFL, Florida State University — Exchange pulses are local unitary operations obtained by turning on and off the isotropic exchange interaction between pairs of spin-1/2 particles, for example electron spins in quantum dots. We present a procedure for analytically constructing sequences of exchange pulses for carrying out leakage free two-qubit gates on logical three-spin qubits. At each stage of our construction we reduce the problem to that of finding a sequence of rotations for an effective two-level system. The resulting pulse sequences are 39 pulses long, longer than the original 19-pulse sequence of DiVincenzo et al. [1] and the more recent 18-pulse sequence of Fong and Wandzura [2], both of which were obtained numerically. Like the latter sequence, our sequences work regardless of the total spin of the six spins used to encode two qubits. After introducing our method, we prove that any leakage-free sequence of exchange pulses must act on at least five of the six spins to produce an entangling two-qubit gate.

[1] D.P. DiVincenzo et al., Nature **408**, 339 (2000).
[2] B.H. Fong & S.M. Wandzura, Quantum Info. Comput., **11**, 1003 (2011).

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