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Quantum logic gates by Walsh modulation HARRISON BALL[1], DAVID HAYES[2], MICHAEL J. BIERCUK[3], ARC Centre for Engineered Quantum Systems, School of Physics, The University of Sydney, NSW 2006 Australia —
We study a new class of error suppressing protocols for nontrivial quantum logic gates robust against band-limited stochastic noise to high order. Our underlying mathematical framework is to generate an amplitude modulated control field via synthesis of Walsh functions (an orthonormal set of basis functions well-known in signal processing) resulting in a composite pulse sequence parameterized in the amplitudes of the Walsh spectral components. In this work we show how one Walsh amplitude may be constrained to generate a target Bloch rotation while the remainder may be fine-tuned to optimize the decoupling power of the sequence. We use the filter function formalism to quantify the decoupling power and to derive a decoupling condition which enables us to prescribe an optimization procedure, searching over Walsh spectral weights. With these insights we characterize the robustness of a generalized family of rotary spin echo sequences against both dephasing noise and relaxation noise coaxial with control. We further derive a family of nontrivial, bounded, amplitude modulated gates decoupled to first order against dephasing noise, and describe a method to discover similar families of higher order protocols intrinsically compatible with control hardware and digital control circuitry.

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