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Multi-tone RF generation for intermediate-scale trapped-ion control *

Tuesday 28 June 2022 09:00 (22 minutes)

The increasing complexity of trapped-ion experiments requires more powerful classical control systems, in particular to work with many channels in parallel. I will present work on extending our in-house developed control system which is used on multiple setups across several research groups [1-3]. The latest development cycle is focused on the increased requirements of multi-channel, multi-frequency control. This will be described within the context of an experimental setup containing a cryogenic segmented ion trap with two junctions [4] with waveguide arrays used to address individual ions in parallel, with each fed from an independent fibre AOM. Our new platform can synthesize waveforms with up to 4 frequencies directly on the hardware and plays back arbitrary waveforms at 1 Gigasample/s. We have used this to compensate higher-order effects in AOMs when driven with two tones e.g. for a Mølmer-Sørensen gate. In order to ease implementation of complex circuits, we added an interface to Qiskit Pulse, which we modified to include branching behaviour. The API allows us to keep the memory footprint on the low-level hardware low without having to recompile the software running on the control system for every experiment. I will also describe a camera system which achieves low-latency, high-fidelity spatially resolved ion readout.

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[1]: I. Pogorelov, et al., Compact Ion-Trap Quantum Computing Demonstrator, PRX Quantum 2, 020343 (2021)
[2]: V. Negnevitsky, M. Marinelli, et al., Repeated multi-qubit readout and feedback with a mixed-species trapped-ion register, Nature volume 563, pages 527–531 (2018)
[3]: M. Malinowski, et al., Generation of a maximally entangled state using collective optical pumping, arXiv:2107.10374
[4]: Chiara Decaroli, et al., 2021 Quantum Sci. Technol. 6 044001

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