A New Method for Digitally Producing Waveforms and Its Use in Digital Ion Trap Mass Spectrometry - POSTER ABSTRACT

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Novel Aspect: We present a new method for digitally producing waveforms.

Introduction

A prototype digital waveform synthesizer has been developed that permits near megahertz frequency stepping with up to 48 bit step resolution. The novel aspect of this synthesizer is that it only switches the frequency at the end of the cycle of the waveform. The advances presented here provide a great deal of flexibility for precisely producing and switching arbitrary waveforms. Our synthesizer is being developed to produce the waveforms needed to operate a digital ion trap mass spectrometer. The expectations and limitations of this technology as applied to ion trap mass spectrometry will be presented and discussed.

Methods

Direct Digital synthesis (DDS) is a technique for producing frequency and phase tunable waveform output with high resolution and extremely fast hopping speed. Unfortunately, it is limited in its use as a method for producing arbitrary waveforms because the frequency can switch anywhere during the period of the waveform output. Our synthesizer uses a proprietary method for producing high resolution frequency and phase tunable output that only switches at the end of the waveform cycle with fast hopping speed. This permits its use as an agile and extremely accurate frequency adjustable clock that can be used in arbitrary waveform production. We have used this technique to produce digital ion trap waveforms.

Preliminary results

Our prototype waveform synthesizer switches frequencies only at the precise end of the waveform cycle. We have used it to produce waveforms for the ring and end cap electrodes. It is capable of locking the ring frequency to integer multiples of the end cap waveforms to permit resonant ejection. Mass spectral data have only been gathered in the low mass range (< 1000 amu) with gas phase analytes, so far. Our waveform generation system has been used with a PolarisQ ion trap and chamber. The voltage of the applied waveforms was limited by the power constraints of our high voltage pulser to 250 V0-p. Mass resolution using mass

selected instability was roughly 250 at 502 amu. This value correlates well with simulations. Resonant ejection experiments in this range yield a resolution of approximately 1000 to 2000. The maximum waveform jitter has been measured to be approximately 200 ps. Mass spectral resolution in this range is limited by pseudo-potential well depth. It is not limited by the waveform synthesizer. As we move toward higher mass, resolution will get much better because we will be able to apply higher voltages and the temporal resolution of our waveform (T/?T) will increase as well. Our plan is to incorporate this waveform generation hardware with our ultra high mass inlet (also presented here at this conference) to perform mass spectrometry into the gigadalton range. We also point out that the results observed here are continually being improved as we work out the kinks in the system. Already plans are being laid to create the next generation of these electronics that should improve the maximum waveform jitter by a factor of two or better.

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