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Time domain simulator for KID arrays and their associated readout systems

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We have developed a model for calculating the linear and non-linear behaviour of Kinetic Inductance Detectors (KIDs) in the time domain. Crucially, the simulator works in 'real time', producing the time-sequence data that would be measured in an experiment. In other words, the value of every independent variable is specified at an instant in time, and then the value of every dependent variable is calculated at the same instant in time. It is not necessary to capture a long time sequence and then to analyse it as a single block of data, say through an FFT. It is straightforward to simulate large arrays and to include all aspects of readout tone generation and analysis: waveform synthesis, digitisation, up and down conversion, I-Q mixers, filters. The method is able to calculate the response to slowly time varying signals, as are found at submillimetre and far-infrared wavelengths, and fast transient signals, as are found at optical and x-ray wavelengths. We used the time-domain simulator to study the transient response, small-signal response, and pulsed response of single KIDs and their readout systems. It is straightforward to track the I and Q outputs as a function of time as independent parameters are varied. We have modelled large arrays, concentrating on effects such as phase delays in transmission lines, and cross talk between different pixels caused by overlapping resonances and sideband generation. The method is able to reproduce a wide range of complex phenomena seen experimentally. In the paper, we will review the theoretical background to the method, and describe a range of illustrative simulations.

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