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Improvement of simulated nuclear quadrupole resonance signals from explosive detection via a Red-Pitaya board

In Nuclear quadrupole resonance (NQR), the interaction of the nuclear magnetic moments of quadrupolar nuclei (spin greater than 1/2) with the electric field gradient of the surrounding molecular orbitals produces an energy splitting. Because the resonant frequency is very specific to the molecular structure, the NQR can be used to detect explosive materials very accurately and it is extremely useful for detecting modern bombs whose containers made from plastics and wood instead of metals. However, NQR signals are generally very weak so they are difficult to be detected. Recently, Red-Pitaya boards, a Field Programable Gate Array (FPGA) on Single Boards Computers (SBC), has been being utilized in many electronic applications due to their small size and low cost. Since the boards can generate and acquire radio frequency signals, they can be taken as the console of portable bomb detectors. In this work, we study an improvement of the NQR signals of an explosive, ammonium nitrate with a resonant frequency of 423.6 kHz, acquired by using a Red-Pitaya board (model 125.14). To construct the NQR signals, we simulate free induction decay (FID) signals (exponential decay of sinusoidal functions) and add real measured noises from an input port of the Red-Pitaya board. To mimic real situations, the FID amplitude is varied, frequency fluctuations and phase shifts are added. The results show that averaging of signals from repeat measurements can improve the signals in all cases. To distinguish the signals from the noises, a minimal number of measurements is required. This necessary number of repeat measurements increases with frequency fluctuations and phase shifts but decreases when the FID amplitude grows.

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