BOSTON UNIVERSITY ACADEMY

Title: Practical, Low-Cost Nuclear Magnetic Resonance Instrument Building a Ham Radio to Talk to Atoms

Author: Timothy Michael Pinkhassik

Abstract:

Nuclear magnetic resonance (NMR) spectroscopy is an extremely powerful technique for chemical structure analysis. NMR spectrometers are present in chemical and biological research laboratories around the world—but are often prohibitively expensive. In its most basic form, an NMR spectrometer exposes a sample to a strong, homogenous magnetic field, perturbs nuclei of interest, exciting some of them to a higher energy state with radiofrequency (RF) radiation, and then measures either the energy absorbed by the sample or the signal emitted by nuclei returning to their ground state. The goal of this work is to construct a continuous-wave (CW) NMR spectrometer using modern digital technology to minimize cost and complexity. To accomplish this, a direct digital synthesis (DDS) integrated circuit is used to create an audio frequency-modulated signal which is then amplitude-modulated by the spoilage of the Q-factor of the sample coil caused by the resonance-dependent magnetic susceptibility of the sample. The resulting amplitude-modulated signal is then demodulated by a synchronous AM demodulator circuit and FFT transformed by a powerful microcontroller to extract the frequencies of modulation and the new sample-generated audio frequency (double the frequency of the sweep modulation). The presence of this frequency signals the presence of resonance. This method is inherently limited by the resolution of the DDS chip, but current technology permits adequate results at low fields with the potential to make accurate, low-cost spectrometers.