Detection of Nitrogen Substances by Nuclear Quadrupole Resonance in Large Volumes

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Abstract—Nuclear quadrupole resonance (NQR) is one of the prospective methods for the remote detection of nitrogen-based explosives and narcotic substances [1–3]. The advantage of this method is that the nuclear quadrupole resonance spectrum is unique for each chemical compound. The detection of even one line of the spectrum is sufficient for the identification of a substance. However, NQR is characterized by a relatively low signal-to-noise ratio and high influence of outside radiofrequency interference. Therefore, the development of efficient approaches for distant or large-volume NQR detection is a non-trivial issue.

In this work, we describe the design of a sensing system for the NQR detection of nitrogen substances in a large inspection volume. The system consists of a Tecmag Scout NQR console, Tomco pulse amplifier (1 kW), a large distance/volume RF probe (either planar gradiometer or toroidal coil), duplexer and a high-power Q-factor spoiler. We studied the conditions for optimal unilateral detection at distances up to 40 cm as well as for the detection inside a large volume (> 1 m$^3$). It has been shown that a $^{14}$N NQR signal of a small amount (up to 100 g) depending on RF probe configuration and ambient RF noise level) of hexamethylenetetramine (HMT) as the reference nitrogen substance can be detected using both types of RF detectors. Furthermore, a possibility of NQR detection for a partially shielded HMT sample has been also shown. The influence of conducting bodies near an NQR sample for detection performance has been studied as well. We have also demonstrated that this system can be applied to the detection of ammonium nitrate.

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REFERENCES