QR Hits a Homerun: Landmine-Detection Systems Based on Quadrupole Resonance Technology Show Progress

Peter Turner
GE Security

Caroleen L. Williams
GE Security

Follow this and additional works at: https://commons.lib.jmu.edu/cisr-journal

Part of the Defense and Security Studies Commons, Emergency and Disaster Management Commons, Other Public Affairs, Public Policy and Public Administration Commons, and the Peace and Conflict Studies Commons

Recommended Citation

This Article is brought to you for free and open access by the Center for International Stabilization and Recovery at JMU Scholarly Commons. It has been accepted for inclusion in Journal of Conventional Weapons Destruction by an authorized editor of JMU Scholarly Commons. For more information, please contact dc_admin@jmu.edu.
Landmine-Detection Systems Based on Quadrupole Resonance Technology Show Progress

QR Hits a Home Run:

Landmine-Detection Systems Based on Quadrupole Resonance Technology Show Progress

This study explains how quadrupole resonance technology in mine-detection systems improves with use and drastically reduces false alarms and deminer fatigue.

by Dr. Peter Turner and Caroleen L. Williams (GE Security)

For the past 10 years, Quantum Magnetics, Inc. (a California corporation and wholly owned subsidiary of General Electric Company, hereinafter referred to as GE Security) has been developing landmine detection technology specific to identifying landmines. Although the company also develops other technologies for bomb, drug and concealed-weapons detection, it continues to keep its core objective on course: discovering the explosives used in buried landmines quickly, with few false alarms. By targeting the specific molecules contained in explosives such as ammonium nitrate, PETN, RDX, tetryl, and TNT, the system is relatively easy to detect and discriminate from the surrounding clutter. To detect only the small metal firing pin in an otherwise all-plastic or all-wood mine, however, the metal detector must be set to a very high sensitivity. Consequently, such detectors also find every other piece of metallic clutter littering a battlefield and are unable to distinguish between the two. A technology capable of distinguishing real landmines from clutter would be welcome to deminers, soldiers and citizens alike.

About Quadrupole Resonance

QR systems incorporate MRE technology commonly used as a diagnostic tool in hospitals. Low-intensity radio waves at frequencies in and just above the AM radio band are used to probe certain molecular properties of items adjacent to the detection coil (see Figure 1). The probe emits pulses of low-intensity radio waves at a frequency unique to the target atomic species and its molecular environment. The radio waves momentarily disturb the alignment of the targeted nuclei. As the nuclei relax to their equilibrium condition, they emit their own—albeit resonant—signal to the probe certain molecular properties of items adjacent to the detection coil (see Figure 1). The probe emits pulses of low-intensity radio waves at a frequency unique to the target atomic species and its molecular environment. The radio waves momentarily disturb the alignment of the targeted nuclei. As the nuclei relax to their equilibrium condition, they emit their own—albeit resonant—signal.

Figure 1: A schematic illustration of the QR method of detection. Only specific nuclei within the target compound responds to the initial radio pulses. Graphic courtesy of GE Security.

Technology incorporated within the QR system also responds to the presence of large metal objects, so the QR system can detect both anti-tank and anti-personnel mines, either metal- or plastic-based, with an exceptionally high probability of detection—all while minimizing false alarms. Since QR is chemically specific, the presence of other substances will not adversely affect results. A significant advantage of QR detection is that it is signal-to-noise-rate-limited, not clutter-limited, so QR is the only technology capable of resolving its own false alarms. For example, the longer the probe remains at a site, the greater the signal accumulated at that site, while the random and fluctuating electronic noise that occasionally masks the QR signal is averaged to a consistent and uniform value.

Reducing clutter alarms by even as little as 70 to 80 percent increases the productivity of every deminer and substantially reduces the fatigue factor they suffer when coping with the hundreds of false alarms. Moreover, as the QR detection probe “interrogates” a given area, results are presented as a simple red light/green light display to indicate either the presence—or the absence—of a landmine. QR systems require no special calibration or special maintenance and are ruggedly designed to withstand many hours of uninterrupted use. Importantly, the technology is safe for the user, as it does not ionize radiation, radioactive sources or strong magnetic fields.

Test Results

The Center has already demonstrated the potential of QR technology by successfully scanning anti-tank landmines filled with bombs in Fudalen (Europa), France. The first tests results reportedly proved the first ever QR detection of TNT landmines in the field. Subsequent development programs at the Center have substantially increased TNT sensitivity to the point where it now detects TNT-filled anti-tank landmines and all but the very smallest anti-personnel landmines.

Two Configurations for Detection

Supported by the Office of Naval Research, the Magnetics Center of Excellence is currently working on a man-carried backpack QR/metal detector/ground penetrating radar system for use by the U.S. Marine Corps. Once this work is completed, the handheld detection system will be capable of scanning all varieties of terrain encountered by deminers, either military or civilian.

Figure 2: Backpack-mounted landmine detection system. Graphic by Walter Freeman

A separate project sponsored by the U.S. Army focuses on incorporating QR technology into a vehicle-mounted configuration for use in detecting anti-tank mines in route-clearance operations (see Figure 3). A prototype command sensor, designed to validate or correct alarms produced by other primary sensor technologies, has been tested during night and daytime trials.

Results of these tests demonstrated QR technology was practical during the night with higher radio frequency interference conditions are prevalent—previous QR systems were unable to operate in areas subject to high radio interference. The performance of this latter prototype has been further improved and the system is now undergoing engineering development to reduce the size, weight and power consumption of the detection coil while meeting stringent field-reliability requirements.

Figure 3: Vehicle-mounted landmine-detection system. Graphic by Walter Freeman

QR Technology Today

When work is completed on both the handheld and vehicle-mounted QR systems, today’s false alarm rates are expected to be reduced by 60 to 95 percent. Other important milestones have been met as well. For example, four years ago, the electronics needed to perform the handheld QR measurements occupied two racks of electronics weighing well over 200 pounds and consuming 2 kilowatts of electric power. Today, the handheld detection system can be comfortably carried and uses under 500 watts of electric power. It operates for many hours at a time without recharging—a substantial improvement over earlier models. Moreover, the earlier vehicle-mounted route-clearance prototype required over 1,000 pounds of control electronics and a 500-pound, 10-kilowatt diesel generator to power it. The current prototype weighs less than 200 pounds and is complete with its own portable battery power supply; it is also much more sensitive and can be adapted for use on many different types of vehicles.

Conclusion

Obviously, important progress has been made, but the Center continues to work on a fast track to further improve landmine detection technology as it recognizes the need for safe, reliable landmine-detection systems as soon as possible—for both military and humanitarian uses. It is expected the handheld deminer units will be ready within a year, and it is possible the vehicle-mounted systems will be available soon thereafter. This is goal the Center’s scientists are determined to meet.

References and Endnotes, page 108

Published by JMU Scholarly Common, 2006 | 9.2 [February] 2006 | Journal of mine action | research and development | 951
Geneva Diary: Report From the GICHD, Massifield [from page 82]

Endnotes

2. One square meter is approximately equivalent to 1.2 square yards.

Mine Action Support Group Update, October 2005, MASG Newsletter [from page 85]

Endnotes

Editor’s Note: Some countries and mine action organizations are urging the use of the terms “mine-free,” which while not exposing the terms “mines-safe” or “impact-free.” “Mine-free” contains a condition where all landmines have been cleared, whereas the terms “mines-safe” and “impact-free” refer to the condition in which landmines no longer pose a credible threat to a community or country.

LRC System Allows Remote Disposal, Barthold [from page 89]

Endnotes
1. Patent pending.

How Deminer Position Contributes to Injury, Jetté, Dionne, Maach, Makris, Ceh and Bergeron [from page 93]

Endnotes

2. Rats to the Rescue: Results of the First Tests on a Real Minefield, Verhagen, F. Weetjens, Turner and Williams

3. Note: The editorial staff of the Journal goes to great effort to make sure that what is printed in our magazine is accurate, properly documented and unbiased. However, in Issue 9.1 there were two errors for which we feel we must apologize. In the staff-written profile of Afghanistan (pages 66-67), our writer misinterpreted something that was written in an earlier article by Patrick Fruchet (http://maic.jmu.edu/journal/8.1/features/fruchet/fruchet.100). The editorial staff of the Journal goes to great effort to make sure that what is printed in our magazine is accurate, properly documented and unbiased. However, in Issue 9.1 there were two errors for which we feel we must apologize. In the staff-written profile of Afghanistan (pages 66-67), our writer misinterpreted something that was written in an earlier article by Patrick Fruchet (http://maic.jmu.edu/journal/8.1/features/fruchet/fruchet.100). The editorial staff of the Journal goes to great effort to make sure that what is printed in our magazine is accurate, properly documented and unbiased. However, in Issue 9.1 there were two errors for which we feel we must apologize. In the staff-written profile of Afghanistan (pages 66-67), our writer misinterpreted something that was written in an earlier article by Patrick Fruchet (http://maic.jmu.edu/journal/8.1/features/fruchet/fruchet.100).