LANDMINE DETECTION SYSTEM WITH NMR GRADIOMETER

V. Cattin*, C. Bruschini[1], A. Guiga, J.M. Ittel, , J.M. Léger, J.C. Vidal
LETI (CEA - Technologie Avancées) DSYS CSME, CEA/G
17 Avenue des Martyrs, 38054 Grenoble Cédex 9 – France
[1]EPFL – LAMI & VUB-ETRO-IRIS, EPFL-LAMI
CH-1015 Lausanne – Swizerland

During the last 5-10 years, landmine problems became increasingly urgent. Since detection and clearance are very often carried out using manual methods, new systems are being studied to provide safer and more powerful detection and localisation functions. In this context, we have implemented a mine detection system based on high resolution scalar magnetic sensors.

Passive magnetic sensors detect the presence of ferromagnetic material. They measure both the remanent magnetization and the magnetization induced by the earth magnetic field in such materials. Most land mines contain enough metal to be detected by this method even if their metallic pieces are often very small (<1g). We propose to use a Leti NMR scalar magnetic sensor (Abragam-Overhauser effect). Such a sensor measures the module of the ambient field, or the projection of the magnetic response of the mine on the earth field direction. Its main advantages compared to other magnetic sensors are higher resolution ($pT/Hz^{1/2}$), especially in the DC band, its robustness and insensitivity to movements. The high-resolution demonstration system we set up consists of a vertical gradiometer composed of two NMR sensors. The first sensor is moved along a profile at about 10 cm from the ground and measures the magnetic mine effect. The other is about 1.5 m above the ground and is used as a reference to measure the ambient electromagnetic noise perturbations, both industrial and geological, which may screen the target response. This gradiometer concept ensures a large noise reduction, from about 1000 pT_{pp} down to less than 10 pT_{pp}. The distance between the two sensors has to be matched to the depth of investigation and the sensitivity.

This system was tested to measure magnetic effects of several common AP landmines provided by the EPFL. We have first verified that the geological environment and the industrial magnetic perturbations are efficiently reduced by the gradiometer. We then performed static measurements and the obtained magnetic effects range between 50 pT up to 7.5 nT for the smaller and larger metallic components of the different mines. By moving the gradiometer above the targets, we obtain a profile which characterises the magnetic signature of the target. In the future, such a system could be used either to build a reliable magnetic effect database of mines, or to design a new handheld or vehicle-integrated detection device. In the next step, signal processing can be used to extract specific parameters of each target like distance, size or magnetic moment.