A simple cost-efficient magneto alert sensor (MALSE) against static magnetic fields

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Introduction:

While MR is a diagnostic imaging tool which saves lives, magnetic forces of fringe magnetic field components of MR systems on ferromagnetic components can impose a severe occupational health and safety hazard. With the advent of ultrahigh field MR Systems – including passively shielded magnet versions – this risk - commonly known as missile effect /1/ - is pronounced. Numerous accidents have been reported ranging from mechanical damage to patient death. These casualties are probably most widely known through television documentaries and printed media but still present the tip of the iceberg of safety violations (/2/ /3/ /4/). Various policies have been implemented around the world to safeguard healthcare workers, volunteers and patients with the ultimate goal of avoiding unforeseen disasters and injuries**.** These measures involve safety initiatives and awareness campaigns spearheaded by the ISMRM's safety committee and include safety training, occupational health instructions, safety guidelines and implementation of warning signs. These safety procedures are commonly supplemented by commercially available metal detectors positioned at the entrance of the MR scanner room. The costs of metal detectors are significant. Also, frequent encounters occur that metal detectors are not properly used due to overwhelming work load and lack of discipline. For all these reasons, we propose a simple and cost-efficient magneto alert sensor (MALSE) which provides alerts in the presence of static magnetic fields and which can be used in various configurations. Its clinical efficacy is examined at 1.5 T and 7.0 T.

Method:

Reed contacts are known to react on low static magnetic fields. The activation threshold depends in the individual design and is in the range of 0.5 mT. We propose a simple but efficient setup consisting of three orthogonal reed contacts in parallel which are connected in series with a (e.g. lithium) battery and an acoustical (buzzer) or optical (LED) signal source (Figure 1). Such a device is affordable and can be easily miniaturized (Figure 3). It can be attached to all ferromagnetic parts which should not enter the MR system room. The device does not consume battery power if not activated and therefore its lifetime is only limited by the usual idle battery lifetime (up to 10 years for lithium batteries). It can be integrated into the warning symbols which are attached to ferromagnetic parts in the vicinity of MR systems. The use of piezo signal generators is preferred because of their small dimensions and slim geometry. Piezo devices also come with the benefit of being suitable for ultrahigh magnetic fields.

Results:

For proof of concept a prototype made of standard electronic components was realized (Figure 3). It was tested in the fringe field of a passively shielded whole body 7.0 T MR magnet (Siemens Magnetom, Erlangen, Germany and Magnex Scientific Inc., Oxford, UK) and in the magnetic environment of an actively shielded clinical 1.5 T whole body MR system (Siemens Magnetom Avanto, Erlangen, Germany) as shown in Figure 4 and 5. The magneto alert sensor device showed its reliable functionality and applicability in many cases in a routine clinical environment. The acoustic alert was powerful enough to warn clinical staff and patients. The simple warning device could help to ensure that ferromagnetic parts are kept outside of a fringe magnetic field of 1 mT or less.

Discussion and Conclusions:

The proposed cost-efficient warning device against static magnetic fields was found to support safety procedures for guarding against ferrometallic projectiles- even at ultrahigh magnetic field strengths – which has practical, patient comfort, economic and safety implications. The clinical efficacy of the magneto alert device has been shown for 1.5 T and 7.0 T MR systems. Its superior simplicity and robustness has been demonstrated by eliminating the frequently-encountered risk of carrying equipment and parts which are not in full compliance with MR-safety guidelines into the operator or scanner room. Admittedly, it does not take rocket science to build this magneto alert device which renders it suitable for mass production. In conclusion, we believe that hazardous situations induced by parts which should not enter the vicinity of a MR-system can be avoided by simply mounting the proposed magneto alert sensor to these parts. We anticipate an extension of this work to evolve towards a warning device which provides alerts for dB/dt levels which exceed the thresholds defined by the IEC and other regulatory/governmental bodies.

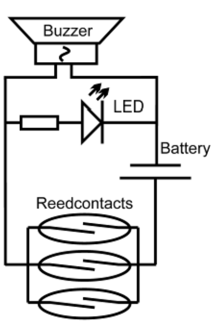

Figure 1: The principal circuit contains three main components: A battery, reed contacts and a signal unit. The circuit does not consume any power and the battery life time is only limited by self-discharge.

Figure 2: Conventional warning symbols used in a MR-environment. The magneto alert device can be easily combined with these symbols because of its possible miniaturization.

Figure 3: A magneto alert prototype device made from standard electronic components is shown. Of course, even more miniaturized versions are possible, in particular when using a reduced buzzer size. Please note that this prototype included only two reed contacts.

Figure 4 + 5: The practical operation of the prototype device is shown. The magneto alert is activated at the 0.5 mT line of a 1.5 T system (top) and just outside the RF cabin door of a 7 T system (right).

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