

Ultra-High-Field Safe Magnetic Switch Sensors

NVE's 1.5-volt and 3-volt medical-grade magnetic switch sensors are ideal for harsh electromagnetic environments. These open-drain magnetic switches cannot be damaged in any magnetic field. Medical-grade sensors are available with specified operate and release points ranging from 0.8 to 5 mT (8 to 50 G). These sensors are ideal for medical environments with very large magnetic fields, such as implantable devices, which are often required to be MR Conditional for MRI procedures. This application note documents testing up to 9 T (90 kG), which shows a stable output through the ultra-high-field range.

Unique Construction

NVE's 1.5-volt and 3-volt medical-grade switch sensors use a solid-state, giant magnetoresistance (GMR) material that is uniquely reliable and robust against magnetic saturation and magnetic field shocks. Unlike fragile reed switches, there is no wear, break, or stick mechanism inherent to electromechanical components. And unlike industrial-grade or automotive-grade magnetic switch sensors, NVE's medical-grade switch sensors do not rely on pinned layers, which can be damaged or destroyed by large magnetic fields or high temperatures.

Medical-Grade Switch Sensors for MR Conditional Implantable Devices

NVE's medical-grade switches are graded "MRI Safe" or "MRI Correct" based on their behavior in large magnetic fields. MRI Safe means the sensor can be subjected to unlimited magnetic field strength without being damaged. These switches are suitable for MR Conditional implantable devices. A stronger performance requirement is to be MRI Correct, which stipulates the switch operates correctly in unlimited magnetic fields. MRI Correct switches may be able to operate correctly even within an MRI-magnetic-field environment. The difference between MRI Safe and MRI Correct is illustrated in Figure 1 below:

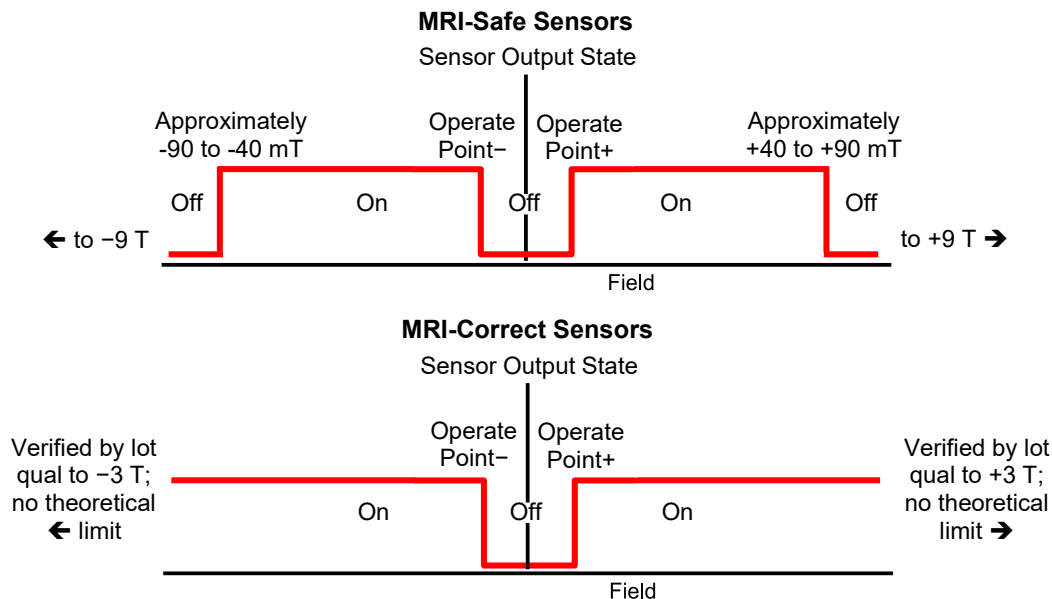


Figure 1. The operating performance differences between MRI-Safe and MRI-Correct switches.

Stable Outputs at Ultra-High Magnetic Fields

MRI Correct operation is verified to 3 T by lot qualification using a high-field, Halbach array magnet. We also verified MRI Correct operation over a field range of -9 T to $+9\text{ T}$ (-90 kG to $+90\text{ kG}$), using a cryogenically-cooled, superconducting electromagnet system. In this experiment, the output voltage was monitored while the applied field was varied. No changes to the output occurred beyond the sensors' designed operation-field points, indicating a stable output (see Figure 2).

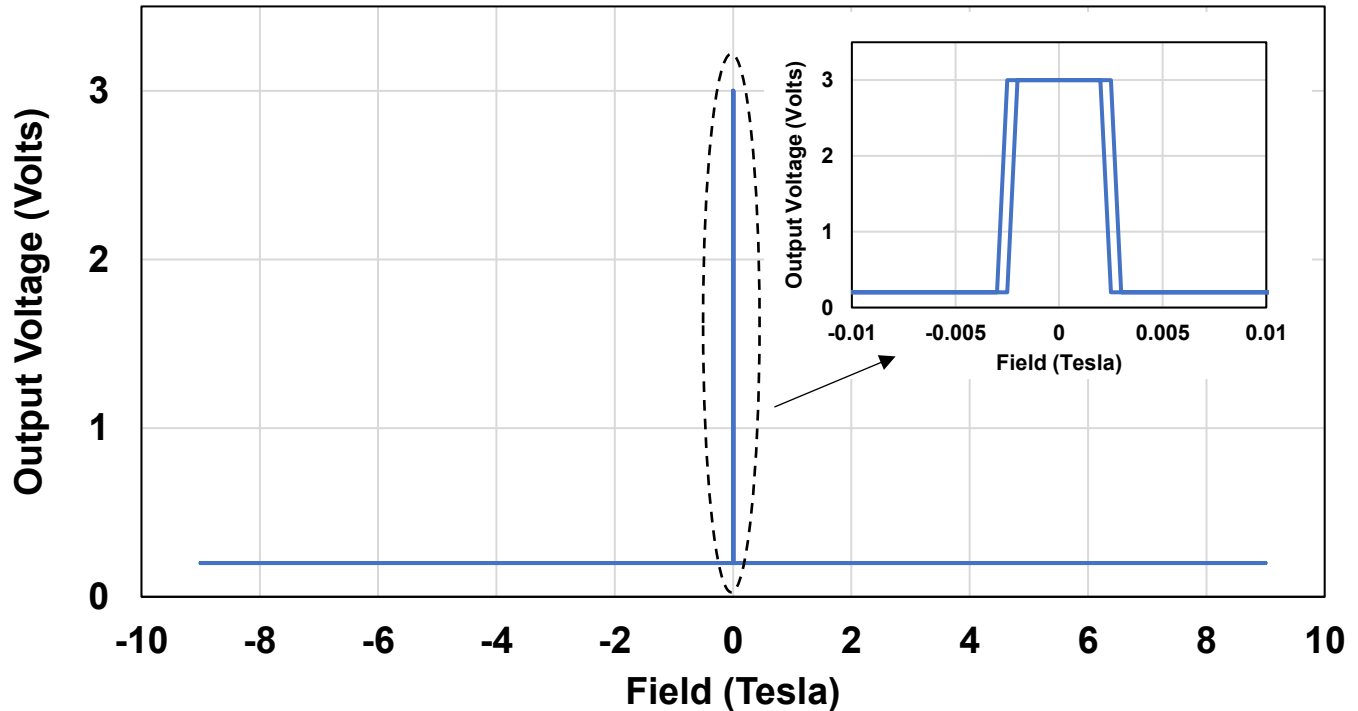


Figure 2: NVE's MRI-Correct, medical-grade switch sensors operate normally in extremely large magnetic fields.

Even when pushed to [frog-levitating](#) magnetic field magnitudes, the switch output did not “double switch” or fail up to the maximum available test field of $\pm 9\text{ T}$. While we didn't use frogs to demonstrate magnetic fields, we did document our latest experiment in a VLOG [here](#).

Giant Magnets to Test Giant Magnetoresistance

The experimental setup for ultra-high-field testing is shown in Figure 3. Sensors were mounted within a liquid-helium-cooled, superconducting electromagnet system. The sensors were maintained at room temperature while the test was performed. This superconducting magnet generates extremely large, uniform magnetic fields at the sample (up to 9 T), considerably larger than those used in typical MRI machines. This testing demonstrates NVE's sensors are safe to use in extreme magnetic field environments.

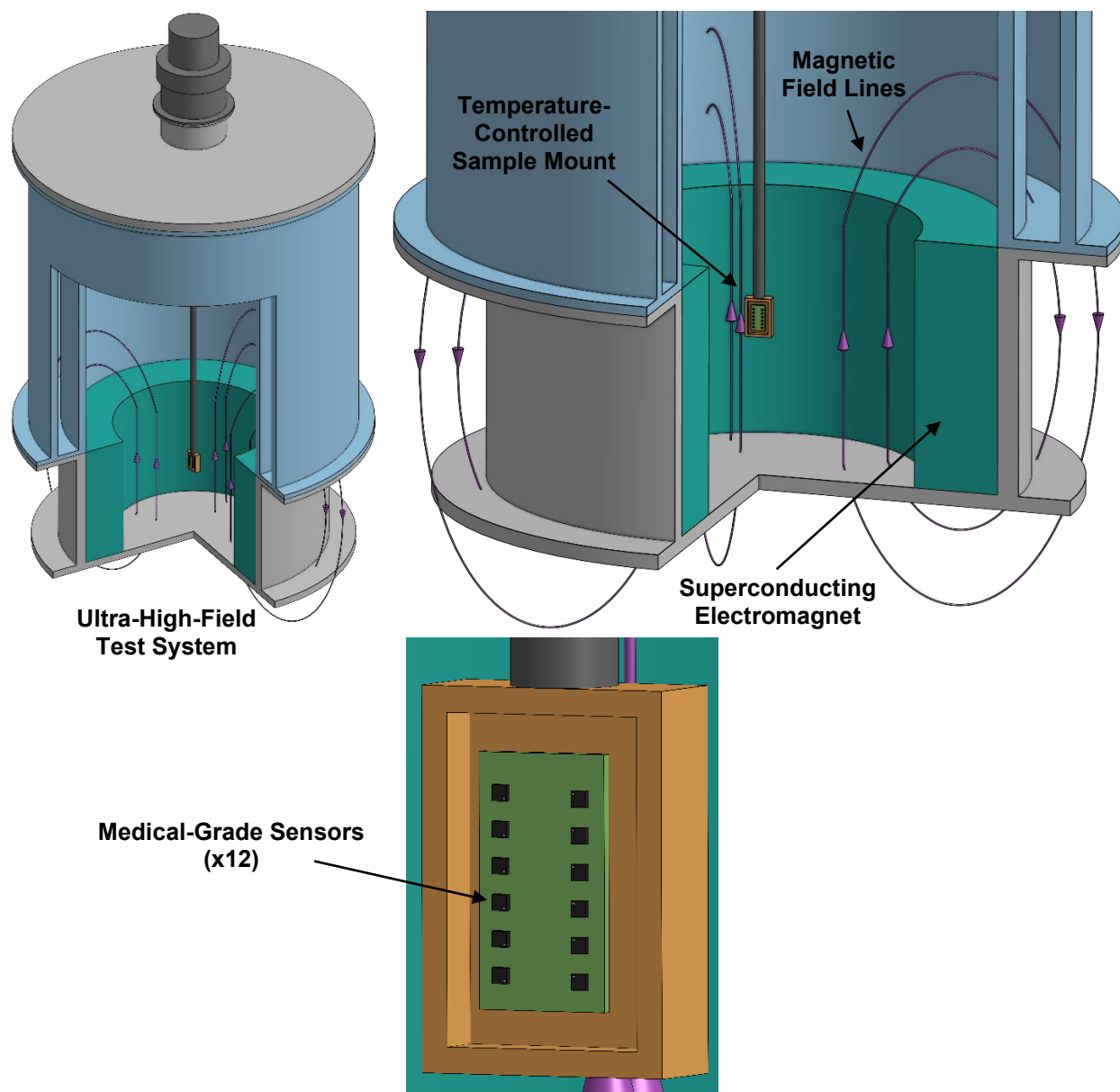


Figure 3: Experimental setup for the ultra-high-field sensor performance testing.

NVE Engineers are Happy to Help

We will respond to your questions within 24 hours by email. No matter where you are in the world, we have representatives to support you, and we look forward to helping with your next great design.

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