Application Bulletin AB-7

GMR in Isolation

The giant magnetoresistive (GMR) effect has provided NVE with a new technology that offers many advantages over the traditional methods for isolation such as the optocoupler or capacitive barrier. In awarding the 2007 Nobel Prize in Physics for GMR the Nobel Committee said, “GMR can be considered one of the first real applications of the promising field of nanotechnology.”

GMR offers two significant advantages over competitive methods of isolation. First, the giant change in resistance of GMR provides a larger signal. Second, and perhaps more important, the technology is compatible with integrated circuit technology, allowing monolithic GMR devices to be included as part of the chip package. This results in smaller, faster, and more precise devices such as IsoLoop® isolators and sensors.

GMR is a large change in electrical resistance observed devices commonly referred to as a spin valves, shown in Figure 1. The electrical resistivity of GMR materials depends on the relative magnetic alignment of the ferromagnetic pinned and free layers separated by a non-magnetic conducting spacer. Electrons scatter more frequently when their quantum spin differs from the magnetic orientation of the layer through which they are traveling, as in Figure 2. Thus GMR is a type of spintronics, harnessing the spin of electrons rather than their charge. If the magnetic moments of the ferromagnetic layers are aligned, as in Figure 3, electron scattering is minimized and resistance is lowest. If the magnetic moments of the ferromagnetic layers are in opposing directions (anti-aligned), electron scattering is a maximum and resistance is highest.

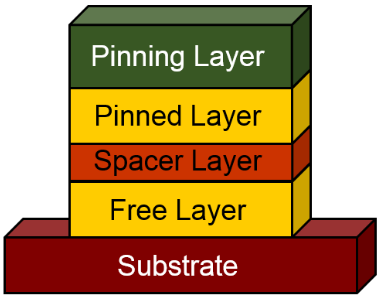

Fig. 1. Spin Valve

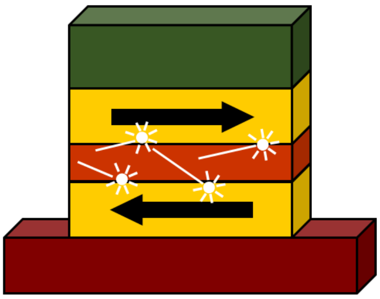

Fig. 2. High resistance, anti-aligned magnetic moments

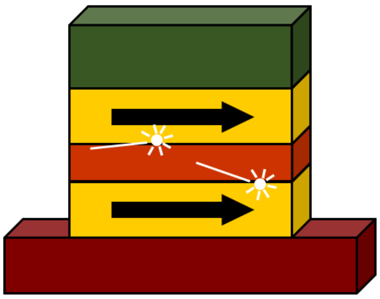

Fig. 3. Low resistance, aligned magnetic moments

A typical spin valve resistance curve is shown in Figure 4:

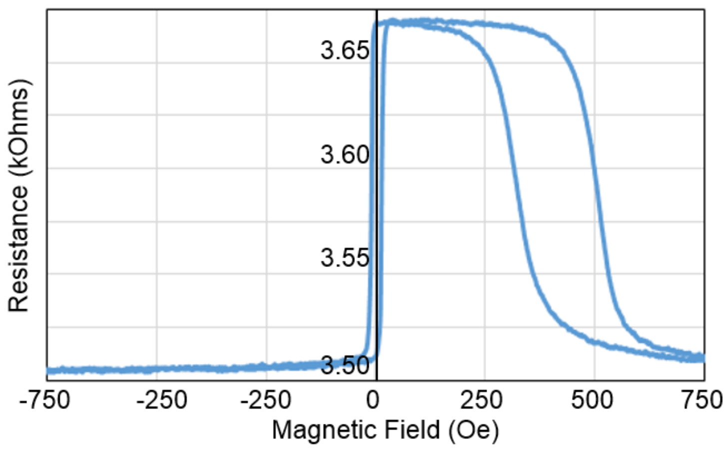

Figure 4. Spin Valve Hysteresis Loop

The free layer reverses direction in magnetic fields of approximately 20 Oe, while the pinned layer remains magnetic fixed due to its exchange bias to the antiferromagnetic pinning layer. At fields of approximately 300 Oe, the pinned layer begins changing direction, and at fields of 750 Oe the resistance returns to the aligned value. NVE's digital IsoLoop isolators operate in fields where the pinned layer remains fixed, so the resistance of the spin valves is a bistable high or low value.

A general equation for the resistance of a spin valve is given in equation 1, where R_o is the minimum resistance and ΔR is the total resistance change:

$$R = R_o + \Delta R \sin^2\left(\frac{\theta}{2}\right) \qquad (1)$$

A convenient parameter defining the amount of spin valve signal is the magnetoresistance, where $MR = \Delta R/R_o$.

NVE's passive input IsoLoop isolators use a linear GMR material that varies in resistance following equation 1, unlike the digital GMR materials shown in Fig. 4. More information for NVE's passive input isolators can be found in Application Bulletin AB-20.

The heart of IsoLoop Isolators is a Wheatstone bridge constructed of GMR resistor elements shown in Figure 5:

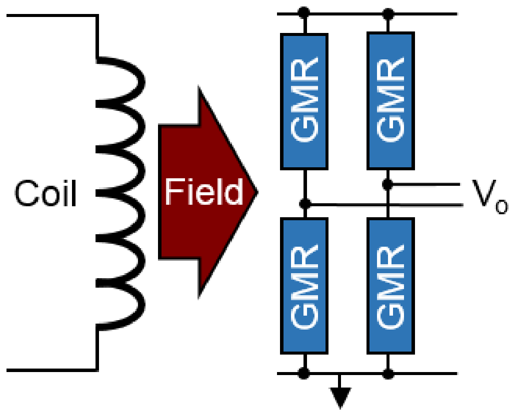

Figure 5. GMR Wheatstone Bridge

The directional current in the coil driven from the input side of the isolator creates a magnetic field that switches the GMR in the bridge. This gives the corresponding directional output V_o that drives the isolator's output. The coil, GMR, and support integrated circuitry are integrated on a single chip. Advantages of this approach include small packages, high speed, and low power.

Based on this patented spintronic process, IsoLoop isolators are the most advanced and versatile devices of their type. Advantages include:

- Small packages: up to two channels in an MSOP-8 and four channels in a QSOP-16
- High data rates: up to 150 Mbps
- Very low Pulse Width Distortion: to 300 ps
- Very low propagation delay skew: 4 ns (device-to-device); 2 ns channel-to-channel
- Wide temperature range: −40ºC to +125 ºC with no derating

Devices include isolated one, two, four, and five-channel configurations; passive or digital inputs; CMOS or open-drain outputs; isolated RS-485 (including Profibus compliant); isolated RS-422; and isolated CAN. Devices are available in standard MSOP, QSOP, SOIC, and PDIP packages and are VDE and UL approved.

For more information, contact your local NVE distributor or visit www.nve.com or www.IsoLoop.com.

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