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SPIN DEPENDENT TUNNELING SENSORS

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In order to obtain significantly higher sensitivities to magnetic fields, a new type of magnetoresistive material is being adapted to use in magnetic field sensors. This material exhibits a phenomenon called **Spin Dependent Tunneling (SDT)** which results in a significant change in effective resistance due to a change in the applied field. The resistance *vs.* field effects are similar to the usual GMR spin valve effect, but larger. Sensors have been constructed from SDT material for use in low field applications which presently require fluxgate magnetometers. As with other NVE GMR sensors they are very small (SOIC-8 package), require little power, and are easily combined with other electronics.

Wheatstone bridge sensors can be made from SDT materials. Because of the insulating layer, high resistances can be obtained in very small areas. These SDT sensors can be operated in a hysteretic or linear mode depending on the sensing application. With no current passed through the integrated biasing straps, the output has an open shape with considerable hysteresis. This mode is useful for on-off, or digital, applications in which one wants a large signal change to occur at fields above a certain level, say ± 1 Oe. This type of output is shown as the dotted line in figure 1. The switching threshold for this curve can be adjusted by changing the length of the flux concentrators. With approximately 40 mA of current through the integrated biasing coil, the output becomes linear, with a slightly lower slope, but much less hysteresis. This mode is ideal for sensing very small changes in magnetic field. Sensor output using this mode of operation is shown as the solid line in figure 1.

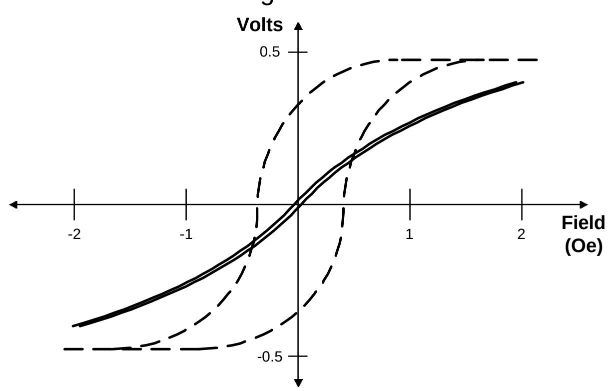

Figure 1. Bridge sensor output for a 12 kW bridge using 10 V bridge excitation. The dotted line is with no field biasing current while the solid line is with 40 mA biasing current.

Table I shows the preliminary operating parameters of Wheatstone bridge **STD** sensors. A useful feature of sensors made with SDT material is the ability to fabricate a very wide range of resistance values using the same footprint. The 5 to 50 kΩ specifications above are towards the lower end of the resistance range. If a particular application requires a higher resistance value, resistances as high as 10 MΩ sensor are relatively easy and economical to fabricate.

Table I. Preliminary operating parameters of STD sensors. *(These sensors are still under development.)*

Sensor Type:	Wheatstone Bridge
Linear Field Range:	+/- 0.5 Oe
Output vs. Field polarity:	Bipolar
Voltage sensitivity:	~10 to 100 mV/V/Oe
High frequency noise floor:	~10 to 100 nOe/√Hz
Noise at 1 Hz:	~1 to 10 µOe/√Hz
Saturation Field	+/- 1.0 Oe
Bridge Resistance:	5 to 50 kΩ
Maximum bridge power:	2 to 20 mW
Flux Concentration:	10 x
Die Size:	1.65 x 2.14 mm
Operating temperature range:	-40 ^{0}C to +185 ^{0}C
Maximum operating voltage:	15V

Notes for using the SDT sensor chips

Excitation voltage (<= 10 V) should be applied to pins 8 and 2. The polarity is not critical. Bridge output is taken from pins 1 and 7.

The orthogonal coil (**OC**) is an integrated planar winding through which current may be passed to reduce hysteresis and increase linearity. *The sensor will function without any current through this coil*, and will still be very useful for distinguishing +1 Oe from –1 Oe. Stable low field (1 mOe) sensing is not possible without an orthogonal bias. The existing design can only tolerate **20mA** through this coil and this is sufficient. However, 40 mA may be required to fully eliminate hysteresis.

Current passing through the parallel coil (**PC**) (another integrated planar winding) generates a field parallel to the sensitive axis of the sensor. It can be used to run the sensor in an active feedback mode, to apply a constant field bias to the sensor, or to generate a pulsed or oscillating field. 10 mA of current produces an effective field offset of 0.7 Oe on the sensor output.

SDT Example Parameters