Novel CCD Magnetic Field Sensors*

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A new class of magnetic field sensors has been demonstrated. These devices are based upon charge-coupled device (CCD) technology, and appear to have significant performance advantages over conventional Hall cells. We have seen a sensitivity improvement of at least one order of magnitude, and a reduction in offsets of approximately one order of magnitude. Hence, the sensitivity-to-offset ratio, a key figure of merit, is about two orders of magnitude higher for the new sensors. We believe that this new technology will enable us to develop the first low-cost, sub-gauss semiconductor magnetic field sensors.

Although the new class of sensors uses the same Hall effect as do conventional sensors, the increased sensitivity is achieved as a result of the ability of the CCD to move charge through a magnetic field much faster than can do be done in conventional Hall cells. This higher speed directly increases the Lorentz force on the charge, thereby increasing the Hall voltage. Furthermore, the new sensors can develop the full Hall voltage because the CCD technology in which they are implemented allows the charge to be recirculated. This feature is in contrast to conventional Hall cells, in which the charge exits the devices before it can move laterally the distance necessary to support the full hall voltage.

Lower offsets and drift are a result of two factors. First, unlike a Hall cell, the sense points are not effectively taps on a divider across the excitation voltage (tap position errors typically cause offsets of ~ 100 gauss). Second, gain is controlled by average carrier velocity, which is determined by gate length and clock frequency. This is average carrier velocity, which is determined by gate length and clock frequency. This is in contrast to a conventional Hall cell, where gain is proportional to the mobility, which has a temperature dependence of $T^{3/2}$.

The performance of the new CCD magnetic sensors opens up new applications that were beyond the reach of conventional Hall cells. We have received considerable interest from customers in the areas of automotive control, non-contact current sensing, power meters, and compasses (for direction finding).

This presentation will cover the principles of operation of the sensors, test results, and describe the CMOS/CCD process used in implement them.

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*patent pending