Lattice Semiconductor Corporation

Hall-Effect Magnetic Transducer Interface

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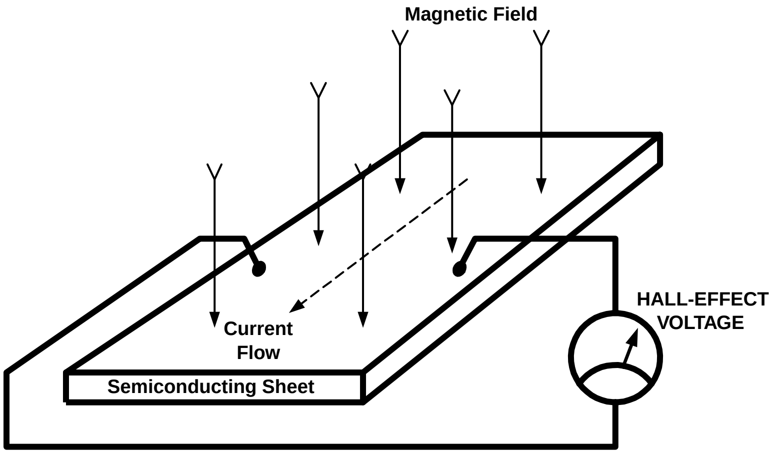
Many applications rely on the ability to sense the polarity and magnitude of a magnetic field. One of the most common technologies used for magnetic field measurement is based on the Hall effect. Hall-effect sensors are most useful for detecting magnetic fields in the range of 0.1 to 10,000 Gauss (10 µTesla to 1 Tesla). Because this range of sensitivities is well matched to applications such as position sensing and electrical current sensing, Hall-effect sensors are used extensively in these areas. Although integrated Hall-effect sensors which include amplifier and signal processing electronics are available from a number of manufacturers, performance, packaging and environmental considerations sometimes require the use of transducer elements with external electronics.

Physically, a Hall-effect transducer is fabricated from a sheet of semiconductor material, which may either be a discrete slab or a layer in an integrated circuit, as shown in Figure 1. When a magnetic field is applied to the transducer, charge carriers (such as electrons) that comprise the current flow are deflected slightly from the path which they would follow in the absence of a magnetic field. This deflection results in a slightly imbalanced distribution of charge carriers in the transducer (from left-to-right in the case of Figure 1). This imbalance results in a small voltage that can be measured across the transducer by connecting a set of electrodes to the appropriate points.

Figure 1. Inside a Hall-effect Transducer

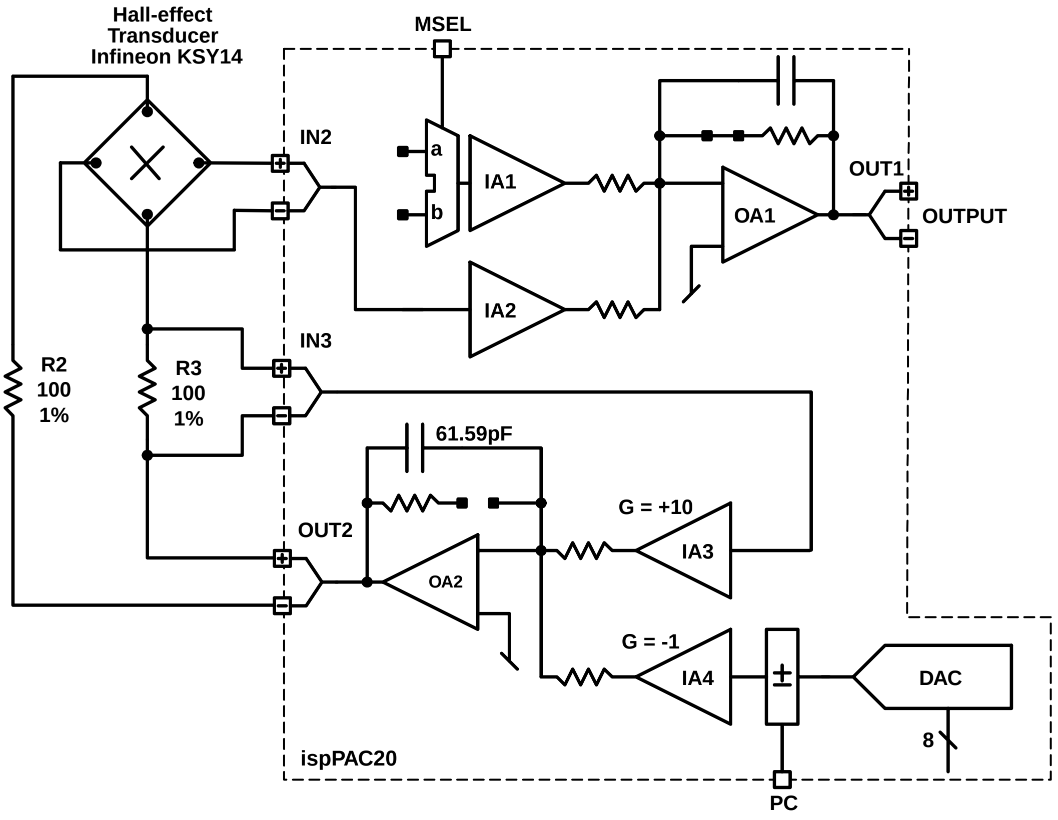


Electrically, a Hall-effect transducer looks much like a resistive Wheatstone bridge, with an output resistance ranging from a few Ohms to a few thousand Ohms. A constant-current excitation is applied to the power supply terminals and a voltage is developed at the output terminals. This output voltage is proportional to the product of the excitation current and the sensed magnetic field. Higher excitation current will result in higher sensitivity to magnetic fields. Constant-current excitation is used with Hall-effect transducers in preference to constant-voltage excitation because it results in less variation in transducer gain over temperature.

The output signal provided by most Hall transducers is very small. Gallium-Arsenide transducers will often provide output signal on the order of 100 µV/Gauss, when operated with excitation currents of a few mA. To give some perspective on the output voltages one can expect from such a device in practice, the earth’s magnetic field is approximately 1/2 Gauss, and the face of a ‘refrigerator’ magnet is typically about 400 gauss. These fields would result in only 50µV and 20mV respectively from a ‘typical’ Hall-effect transducer. For this reason, an amplifier with low input-voltage offsets and a high gain is needed to obtain an output signal of acceptable magnitude.

Figure 2 shows a schematic of a circuit that provides an interface to a Hall-effect transducer, using an ispPAC®20 device. This circuit provides both a programmable constant-current excitation and a 10X high-impedance, low-offset signal amplifier.

Figure 2. ispPAC20 Interface for Hall-effect Transducer



The DAC is used to set the amount of current used to bias the transducer. Since the transducer sensitivity is proportional to bias current, this is a convenient way to set the system gain and to provide calibration. The bias current itself is developed by a feedback loop comprising OA2, R3, IA3 and IA4. The voltage output from the DAC is used to determine the setpoint current. The output of OA2 applies a voltage across the transducer and resistors R2 and R3. By sensing the voltage across R3, IA3 measures the actual current. This information is then fed back to modify OA2's output so that the target current is achieved. By setting the gain of IA3=10, and R3=100Ω, a bias current range of +/-3 mA can be achieved. R4 is in the circuit to maintain symmetry, so that the common-mode output voltage of the Hall transducer is roughly 2.5V, reducing demands on IA2's common-mode rejection capabilities.

IA2 is used to amplify the output of the Hall transducer. Some of the key features the ispPAC differential amplifiers provide are low input voltage offsets (20µV typical) and low input bias currents (3pA typical). These features are helpful in minimizing the measurement error contributed by the front-end amplifier. Although the amplifier shown here is limited to a maximum gain of 10, this is often sufficient to bring the signal up to a level where it may be effectively processed by non-precision circuitry or an Analog-to-Digital converter.

Technical Support Assistance

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