Introduction

Among the various sensing technologies used to detect magnetic fields, the Hall effect is perhaps the most widespread and commonly used. Because it is possible to construct high-quality Hall-effect transducers with the standard integrated circuit processes used in the microelectronics industry, and to integrate ancillary signal-processing circuitry on the same silicon die, usable sensors can be fabricated readily and inexpensively. Hundreds of millions of these devices are produced every year for use in a wide variety of applications. A few places where Hall-effect transducers can be found are:

- ***Automobiles*** – Ignition timing, antilock braking (ABS) systems,
- ***Computers*** – Commutation for brushless fans, disk drive index sensors,
- ***Industrial Controls*** – Speed sensors, end-of-travel sensors, encoders,
- ***Consumer Devices*** – Exercise equipment, cell phones.

Knowledge of the Hall effect itself is quite old, as it was discovered experimentally by Edwin Hall in 1879. The discovery of the effect, incidentally, preceded the discovery of the electron by Thomson in 1897 by nearly 20 years. At the time Hall was performing his experiments, electric current was commonly believed to be a continuous fluid, not a collection of discrete elementary particles.

It is quite remarkable that Hall's experiments allowed him to observe the effect at all, when one considers the instrumentation available at the time and the subtle nature of the experiment, which most likely provided signals of only microvolts. Nevertheless, the Hall effect became reasonably well known early on; the Smithsonian Institute Physical Tables from 1920 include a table describing the magnitude of the Hall effect for a number of substances [Fowle20].

In the 1950s, Hall-effect transducers were commonly used to make laboratory-type magnetic measurement instruments. The availability of semiconductor materials enabled the fabrication of high-quality transducers.

In the 1960s and 1970s, it became possible to build Hall-effect sensors on integrated circuits with on-board signal-processing circuitry. This advance vastly reduced the cost of using these devices, enabling their widespread practical use. One of the first major applications was in computer keyboards, where the new integrated Hall-effect sensors were used to replace mechanical contacts in the key switches. By substituting solid-state sensors for electro-mechanical contacts, the reliability and durability of keyboards were vastly improved.

As it became possible to put more transistors on a given-sized silicon die, the basic transducer could be surrounded with support functions at little additional cost. This allowed Hall-effect sensors with on-board logic for bus interfacing, temperature compensation, and application-specific signal processing. Hall-effect ICs with sophisticated on-chip interface circuitry began appearing in the late 1980s, with new devices still being developed to meet the needs of specialized applications.

While the end-objective of measuring a magnetic field is rare outside of a physics laboratory, magnetic fields make useful intermediaries for sensing other phenomena. Because large magnetic fields are not commonly encountered in nature and can pass through most materials unhindered, they make flexible and vivid indicators when they can be controlled by other phenomena. One simple example of this is in proximity detection, which is the function of sensing if an object is present or absent. The characteristics of the object may make it difficult to directly sense its presence in a given environment. An attached magnet, however, can make it very easy to detect under a variety of conditions. While the ultimate goal is the detection of the object, it is accomplished in this case by the detection of a magnetic field. The most common sensing applications for Hall-effect sensors are proximity, position, speed, and current. Integrated Hall-effect sensors are the preferred choice for a number of reasons:

- ***Small Size*** – Integrated Hall-effect sensors with on-board amplifiers can be obtained in surface-mount IC packages, taking up no more area on a printed circuit board than a discrete transistor. Simple Hall-effect transducers can be obtained in packages that are nearly microscopic. The small size of Hall-effect sensors allows them to physically fit into many places where other magnetic transducers would be too bulky.

- ***Ruggedness*** – Because most Hall-effect sensors are fabricated as monolithic integrated circuits, they are very immune to shock and vibration. In addition, standard IC packaging is highly resistant to moisture and environmental contaminants. Finally, monolithic Hall-effect ICs that operate over the temperature range of –40°C to +150°C are readily available from a number of sources. Hall-effect ICs have been successfully used in hostile environments such as inside automotive transmissions and down the bore-hole in oil-well drilling equipment.

- ***Ease-of-Use*** – While Hall-effect transducers are not even close to being the most sensitive or accurate means of measuring magnetic fields, they are predictable and well-behaved. The output of a Hall-effect transducer is nearly linear over a substantial range of magnetic field and exhibits no significant hysteresis or memory effects. Unlike many types of magnetic sensors, Hall-effect transducers can differentiate north and south fields. Because of their small size, they are effectively "point" sensors, measuring the field at a single point in space. Finally, Hall-effect transducers measure a single spatial component of a field, allowing one to sense the direction of a field as well as its magnitude.

- ***Cost*** – While an instrumentation-grade Hall-effect sensor can cost several hundred dollars, the vast majority of transducers currently produced in the world are sold for less than 50 cents, including signal-processing electronics. Hall-effect sensors are among the most cost-effective magnetic field sensors available today.

For all of the previous reasons, Hall-effect sensors are useful items in the system designer's toolbox. Subsequent chapters of this book will explain how they work, how to interface with them, and how to use them in real-world applications.