

8-BIT MICROPROCESSOR INTERFACING AND APPLICATIONS

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SENSING PROXIMITY

Inductive proximity sensors are used to sense the nearness of conductive materials. The idea is to put a small inductive coil winding on the inside of a sensor probe like the one shown in Figure 8-16. Observe how the coil forms part of an oscillator circuit. A DC source potential between 5 V and 30 V is applied to the sensor and internally chopped to produce an alternating current which energizes the oscillator circuit. This generates an alternating magnetic field around the coil.

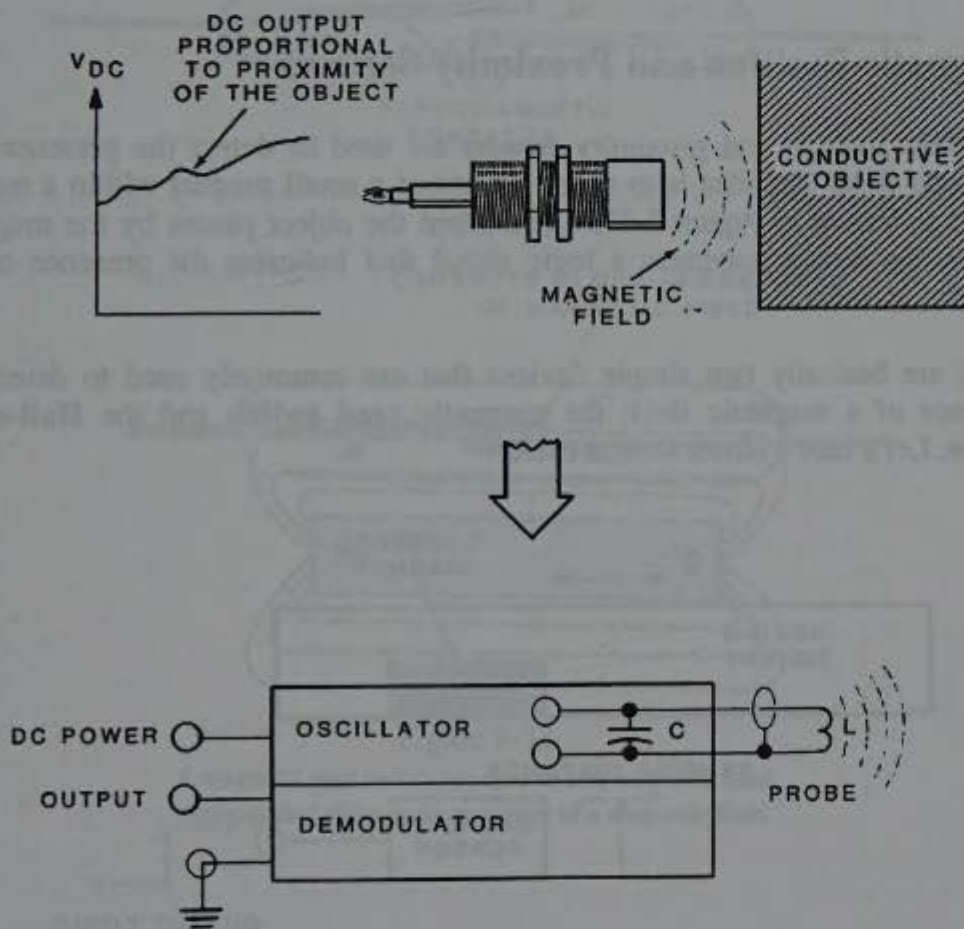


Figure 8-16

A typical commercial inductive proximity sensor.

When a metallic object enters the proximity of the magnetic field, eddy currents are created within the object through electromagnetic induction (Faraday's law). The eddy currents in the object create a magnetic field that opposes the original magnetic field produced by the coil (Lenz's law). As a result, voltages are induced back in the coil that oppose the original oscillating voltage. The net effect is a decrease in voltage across the coil that is proportional to the magnitude of the eddy currents within the metallic object. For this reason, inductive proximity sensors are sometimes called eddy current probes.

The amount of voltage decrease within the probe depends on the gap between the probe and the object, the object resistivity, the magnetic permeability properties of the object, and the oscillating frequency of the probe. However, with a given

metallic object and oscillating frequency, the only variable is the gap between the probe and the object. Consequently, the voltage across the probe coil will change proportionally to the distance between the probe and the object. This change in AC voltage is demodulated and converted to a DC output.

Eddy current probes commonly have a range of an inch or more and a sensitivity of 100 to 200 millivolts per .001 inch of gap. As a result, they can be used to detect the presence of metallic objects as well as measure the distance to those objects. They are particularly useful for measuring vibration.

Magnetic Position and Proximity Sensors

Magnetic position and proximity sensors are used to detect the presence of a magnetic field. The idea is to attach or embed a small magnet within a moving object as shown in Figure 8-17. Then, when the object passes by the magnetic sensor, the sensor generates a logic signal that indicates the presence of the object.

There are basically two simple devices that are commonly used to detect the presence of a magnetic field: the magnetic reed switch and the Hall-effect device. Let's take a closer look at each.

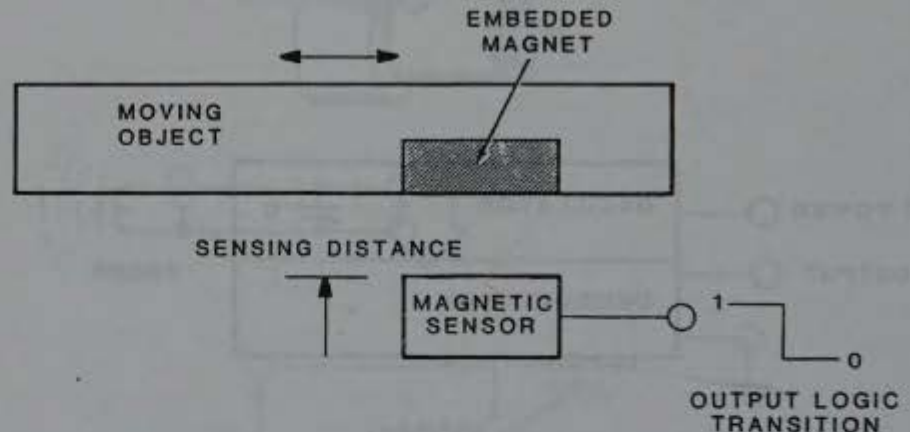


Figure 8-17

A magnetic sensor detects the presence of a small magnet attached or embedded into a moving object.

THE MAGNETIC REED SWITCH

A magnetic reed switch is shown in Figure 8-18. As you can see, the switch consists of two ferromagnetic reed contacts enclosed in a glass tube. The entire device is approximately 1" in length and 1/8" in diameter. When a magnetic field is present, the reed contacts close as shown.

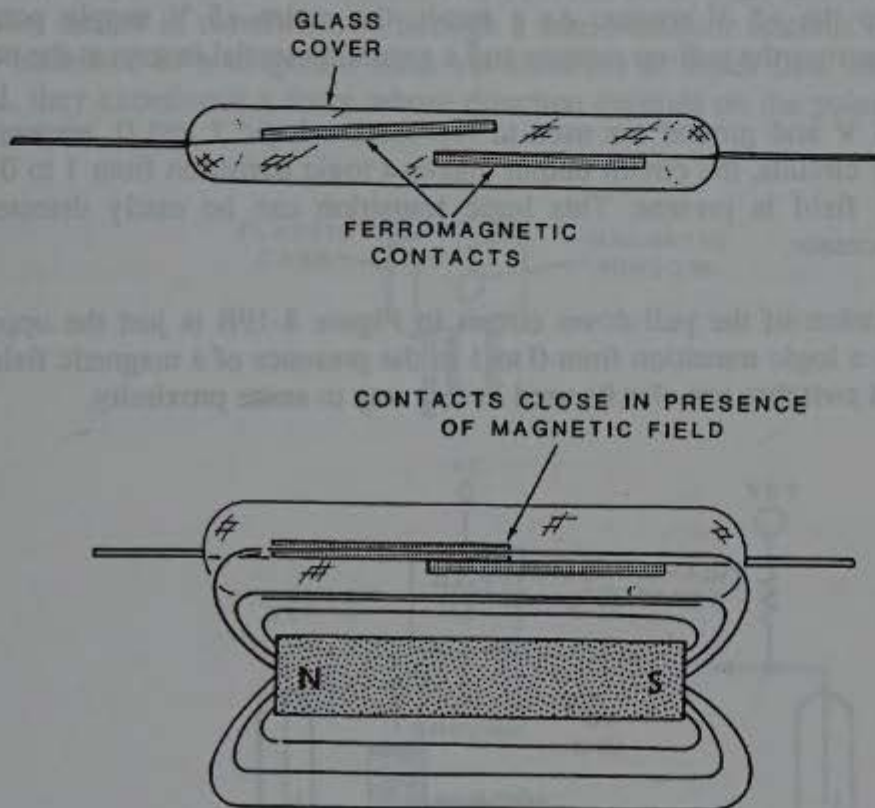


Figure 8-18

A magnetic reed switch consists of two magnetic reed contacts that close in the presence of a magnetic field.

The reed switch by itself does not generate a signal in the presence of a magnetic field — it must be connected as part of a pull-up or pull-down resistor circuit like those shown in Figure 8-19. Look at the pull-up resistor circuit in Figure 8-19A. When no magnetic field is present, the switch is open and no current flows from ground. Consequently, no voltage is dropped by the pull-up resistor and the full +5 V supply potential is seen at the circuit output. However, when a magnetic field is present the switch closes and conducts electron current from ground to the +5 V source. As a result, the entire +5 V supply potential is dropped across the pull-up resistor and a ground potential is seen at the output.

Since +5 V and ground are used to represent a logic 1 and 0, respectively in computer circuits, the circuit output makes a logic transition from 1 to 0 when a magnetic field is present. This logic transition can be easily detected by a microprocessor.

The operation of the pull-down circuit in Figure 8-19B is just the opposite. It generates a logic transition from 0 to 1 in the presence of a magnetic field. Magnetic reed switches can also be used in this way to sense proximity.

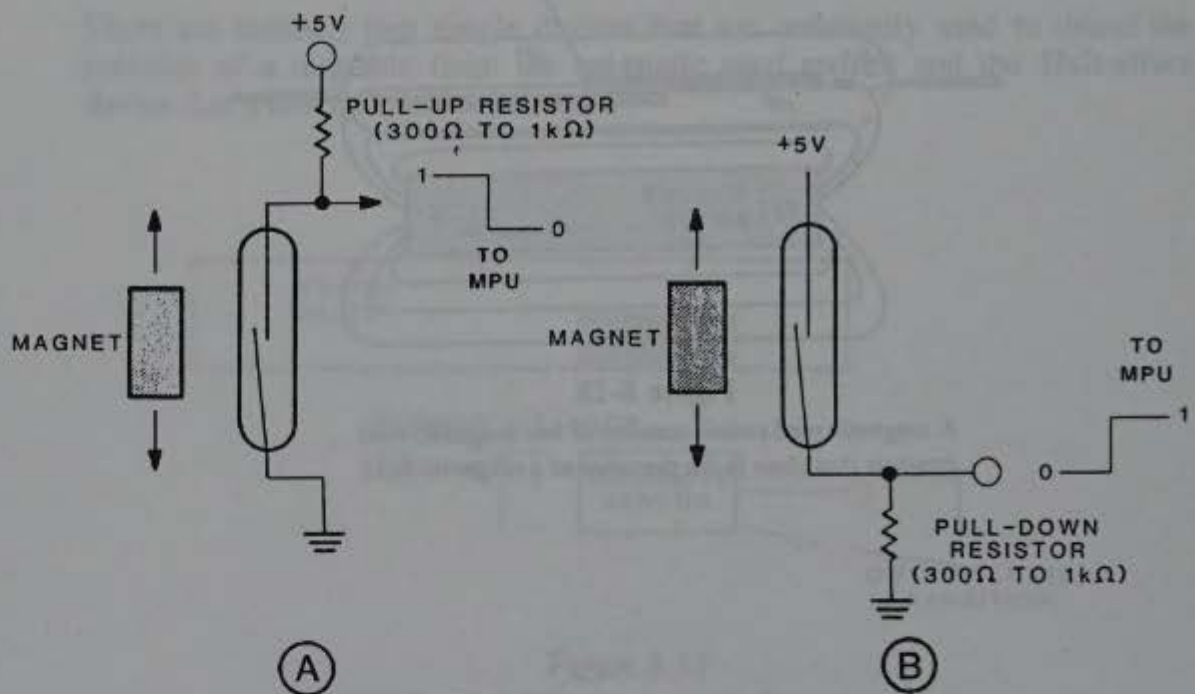


Figure 8-19

A. A magnetic reed switch must be connected as part of a pull-up resistor, or
B. Connected as part of a pull-down resistor circuit.

HALL-EFFECT DEVICES

A Hall-effect device, shown in Figure 8-20, is a solid-state device that looks like a small-signal transistor. Since it is solid-state, it is more reliable and rugged than the glass-type magnetic reed switch.

As its name implies, the Hall-effect device operates on a "Hall-effect" principle. Hall-effect occurs as current flows through a semiconductor material that is under the influence of a magnetic field. As electrons or holes flow through the material, they experience a force whose direction depends on the polarity of the magnetic field.

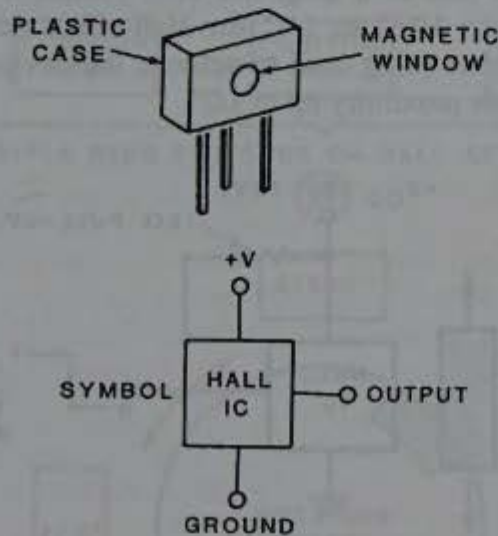


Figure 8-20

A Hall-effect device is a solid-state magnetic switch that looks like a small signal transistor.

The basic idea is that a Hall-effect device produces a Hall voltage that is proportional to the strength of an external magnetic field, and whose polarity is a function of the magnetic field polarity.

Hall-effect devices are used in the same way as magnetic reed switches for proximity sensing. A typical circuit connection is shown in Figure 8-21. Observe that a 1 k Ω pull-up resistor is inserted between the V_{cc} supply lead and the output lead of the device. Most Hall-effect devices are designed to operate on a V_{cc} potential anywhere between +5 V and +16 V. The third device lead is connected to ground. The output of this circuit will change state from a logic 0 to a logic 1 when the device is activated by the presence of a magnetic field of suitable strength.

You should be aware that a Hall-effect device requires a stronger magnetic field than a reed switch. Consequently, the proximity sensing distance of a Hall-effect device is less than that of a magnetic reed switch. Typical sensing distances range from less than 1/16" to 1/4" for Hall-effect devices, depending on the strength of the magnet being used to activate the device. Reed switches, on the other hand, can sense proximity up to 1/2".

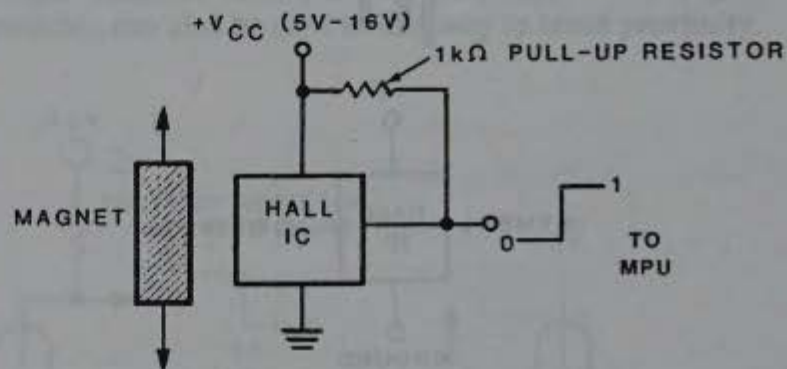


Figure 8-21

A typical circuit connection for a Hall-effect device.

SENSING POSITION

Both linear and angular position can be measured using multiple magnetic reed switches, or Hall-effect devices as shown in Figure 8-22. In Figure 8-22A, a magnet is embedded into the bottom of a moving object such as a machine tool table. As the table moves laterally, the magnet passes over several separate reed switches or Hall-effect devices. Each sensor is located at a precise position, say every 1/2", so that the position of the table can be determined from the sequential activation of the sensors. Of course, the linear position resolution depends on the number and spacing of the magnetic sensors. Also, the sensors must be located close enough to the table to be within their given sensing range.

In Figure 8-22B, several magnetic reed switches or Hall-effect devices are positioned around a rotating shaft to measure angular position. In this application, a small permanent magnet is embedded into the shaft. As the shaft rotates, its angular position is determined by the sequential activation of the sensors. Again, the position resolution depends on the number of sensors that are used. If six sensors are used, the angular position of the shaft in Figure 8-22B could be resolved to 60° rather than 90° .

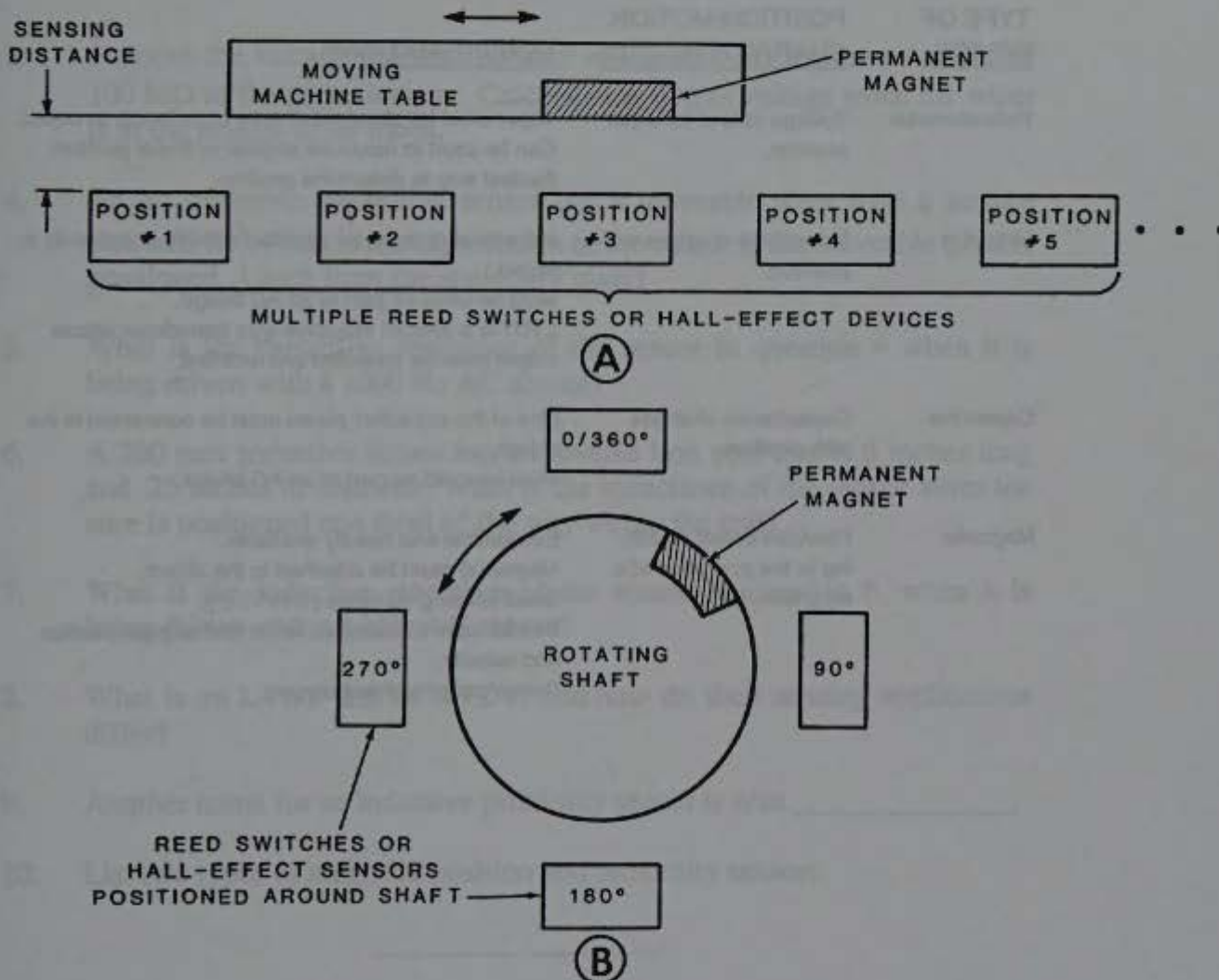


Figure 8-22

- A. Measuring linear position, and
 B. Measuring angular position,
 both using magnetic sensors.

The position and proximity sensors discussed in this section are summarized in Table 8-3.

Table 8-3
Position/proximity sensor comparisons

<u>TYPE OF DEVICE</u>	<u>ELECTRICAL VS. POSITION/MOTION CHARACTERISTICS</u>	<u>CONSIDERATIONS</u>
Potentiometer	Voltage output for wiper position.	Wiper must be attached directly or indirectly to object. Can be used to measure angular or linear position. Easiest way to determine position.
Inductive	Inductance changes with position.	Inductor core must be attached directly or indirectly to object. Must be used as part of an AC bridge. LVDT is a special inductive type transducer whose output must be detected and rectified.
Capacitive	Capacitance changes with position.	One of the capacitor plates must be connected to the object. Must be used as part of an AC bridge.
Magnetic	Provides on/off switching in the presence of a magnetic field.	Economical and readily available. Magnet(s) must be attached to the object. Small sensing distance (1/16"-1/2"). Can be used to measure linear and angular position and velocity. Doesn't require direct contact.