COMPASS HEADING USING MAGNETOMETERS

AN-203

Honeywell's line of magnetoresistive permalloy sensors are sensitive to magnetic fields less than 100 μgauss within a ±2 gauss range. This sensitivity can be compared to the earth's magnetic field which is roughly 0.6 gauss (48 A/m) and results in a measurement resolution of 1 part in 6,000. This applications note will discuss basic principles of compass headings and provide a method for compassing using the Honeywell Smart Digital Magnetometer.

The earth's magnetic field resembles that of a simple bar magnet. This magnetic dipole, Figure 1, has its field lines originating at a point near the south pole and terminating at a point near the north pole. These points are referred to as the magnetic poles. These field lines vary in both strength and direction about the face of the earth. In North America the field lines points downward toward north at an angle roughly 70 degrees into the earth's surface. This angle is called the magnetic angle of inclination (Ø) and is shown in Figure 2. The direction and strength of the earth's magnetic field (He) can be represented by the three axis values Hx, Hy, and Hz. The Hx and Hy information can be used to determine compass headings in reference to the magnetic poles.

Remember that it is the earth's rotational axis that defines the geographic north and south poles that we use for map references. It turns out that there is a discrepancy of ≈11.5 degrees between the geographic poles and the magnetic poles. A value can be applied to the magnetic direction to correct for this called the declination angle. This has been mapped all across the globe [1] and takes into account other factors such as large iron deposits and other natural anomalies. A declination chart of the contiguous United States is shown in Figure 3. A magnetic reading in central California, for example, would indicate 16° to the east when pointing toward true geographic north.

To determine compass headings using a magnetometer, the device must be level to the earth's surface, there should not be any ferrous materials interfering with the earth's field and the declination angle must be known. Various tilt compensation circuits and techniques can be used to normalize a magnetometer reading that is not level. There are also more sophisticated algorithms to account for nearby ferrous materials to correct for their effect on the earth's field.

A compass heading can be determined by using just the Hx and Hy component of the earth's magnetic field, that is, the directions planar with the earth's surface. Hold the magnetometer flat in an open area and note the Hx and Hy magnetic readings. These readings vary as the magnetometer is rotated in a circle as shown in Figure 4. The maximum value of Hx and Hy depend on the strength of the earth's field at that point. The magnetic compass heading can be determined (in degrees) from the magnetometer's x and y readings by using the following set of equations:

$$\text{Direction } (y>0) = 90 - [\arctan(x/y)]*180/\pi$$
$$\text{Direction } (y<0) = 270 - [\arctan(x/y)]*180/\pi$$
$$\text{Direction } (y=0, x<0) = 180.0$$
$$\text{Direction } (y=0, x>0) = 0.0$$

To determine true north heading, add or subtract the appropriate declination angle.

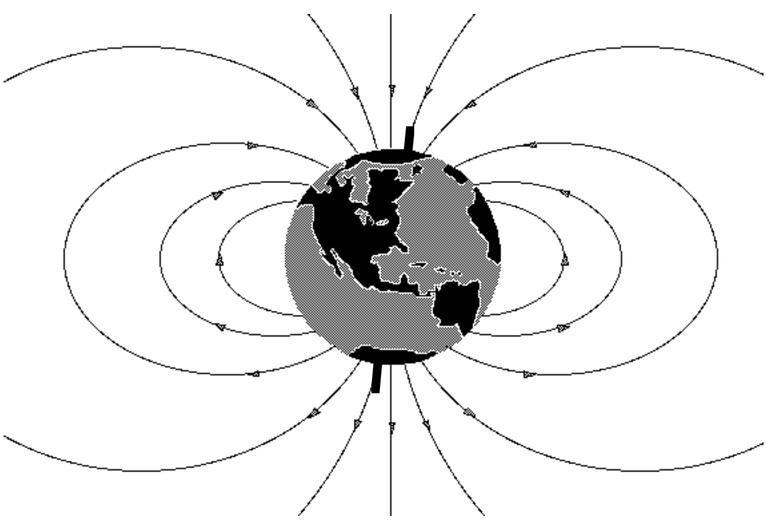

Figure 1 - Earth's Magnetic Field

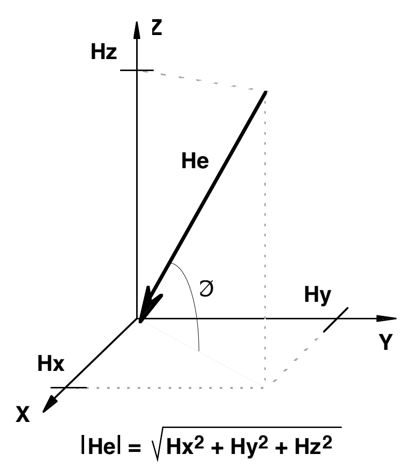

Figure 2 - Earth's Field (He) in 3 Axis

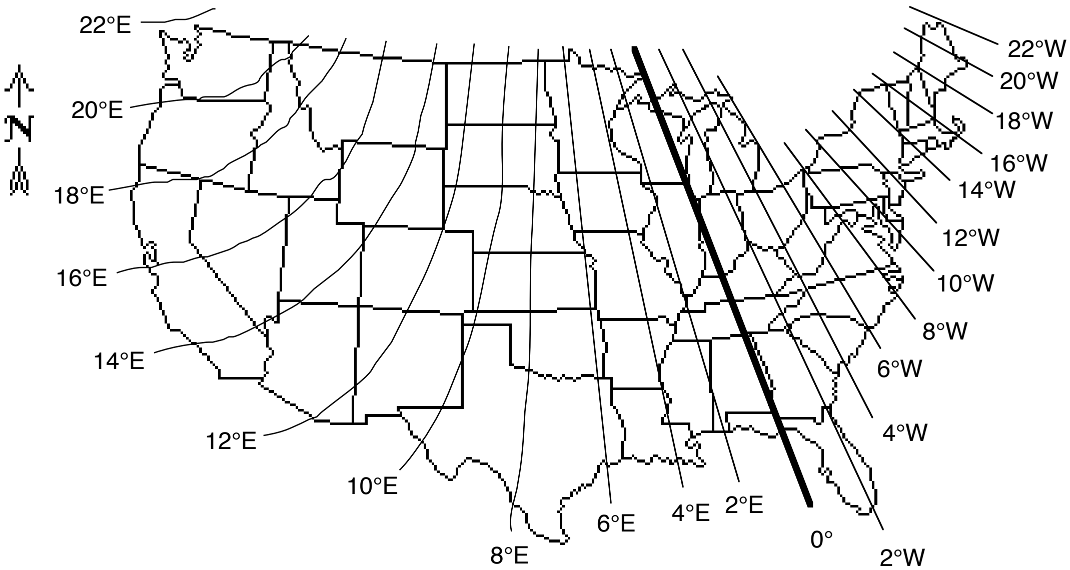

Figure 3 - Declination (or isogonic) chart of the United States

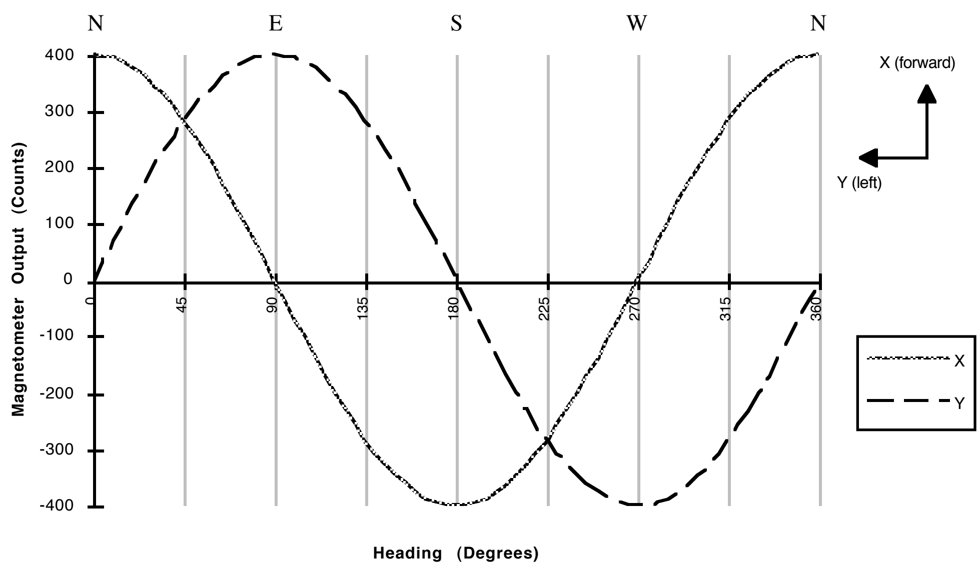

Figure 4 - Hx and Hy Magnetometer Readings for Different Compass Headings

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Magnetic Flux Density
10,000 gauss (G) = 1 tesla (T)

Magnetic Field
1 oersted (Oe) = 79.58 amperes/meter (A/m)
100,000 gamma = 1 Oe = 79.58 A/m

Note: In air 1 G = 1 Oe

[1] National Geophysical Data Center, NOAA Code E/GC1, 325 Broadway, Boulder, CO 80303-3328, U.S.A. (303) 497-6478