CROCUS Technology
Blossoming FUTURE

Position Sensing

Distance -vs- Field Strength

Relevant Crocus Devices

The concepts and examples in this application note are applicable to all of the following Crocus devices:

CTSR200 Series

Introduction

In our App-Note-101 we discussed the effects of distance on the field strength and how we could benefit from this phenomenon in the current-sensing application. As it is covered by Biot–Savart law, the magnetic field strength is inversely proportional to the distance from the current carrying conductor. In this application-note we will be using the same concept in the position-sensing application.

Dipoles and Magnetic Field Vector

A permanent magnet, such as a bar magnet, owes its magnetism to the intrinsic magnetic dipole moment of the electron. The two ends of a bar magnet are referred to as poles, and may be labeled "north" and "south" (Figure 1). In terms of the Earth's magnetic field, these are respectively "north-seeking" and "south-seeking" poles, which are if the magnet were freely suspended in the Earth's magnetic field, the north-seeking pole would point towards the north and the south-seeking pole would point towards the south. The dipole-moment of the bar magnet points from its magnetic south to its magnetic north pole.

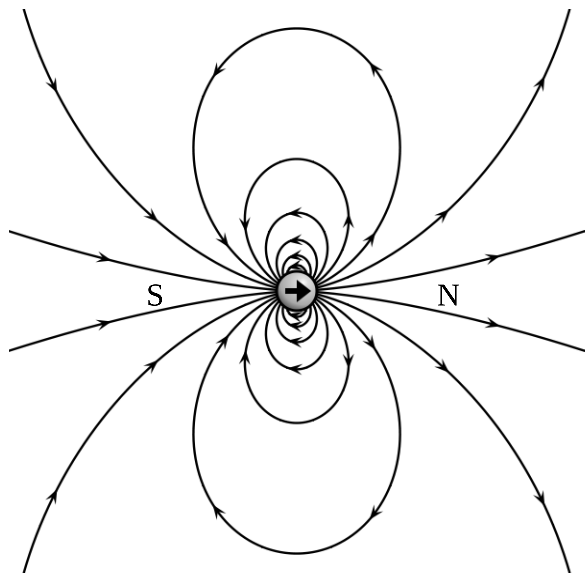


Figure 1

The far-field strength, B, of a dipole magnetic field is given by:

$$B(m,r,\lambda) = \frac{\mu_0 m}{4\pi r^3}\sqrt{1+3\sin^2\lambda}$$

Where:

B is the strength of the field, measured in Teslas.

r is the distance from the center, measured in meters.

λ is the magnetic latitude (equal to 90° − θ) where θ is the magnetic colatitude, measured in radians or degrees from the dipole axis.

m is the dipole moment (VADM=virtual axial dipole moment), measured in ampere square-meters ($A \cdot m^2$), which equals joules per tesla.

μ_0 is the permeability of free space, measured in Henries per meter.

To simplify the problem, we only consider position measurements on the line passing through the core of the dipole. In this case the square root term equals to 1, thus:

$$B(m,r) = \frac{\mu_0 m}{4\pi r^3}$$

We can see, now the strength of the field is following a relation of $\frac{1}{r^3}$ with the distance r.

Implementation

Having the magnetic field strength in relation of

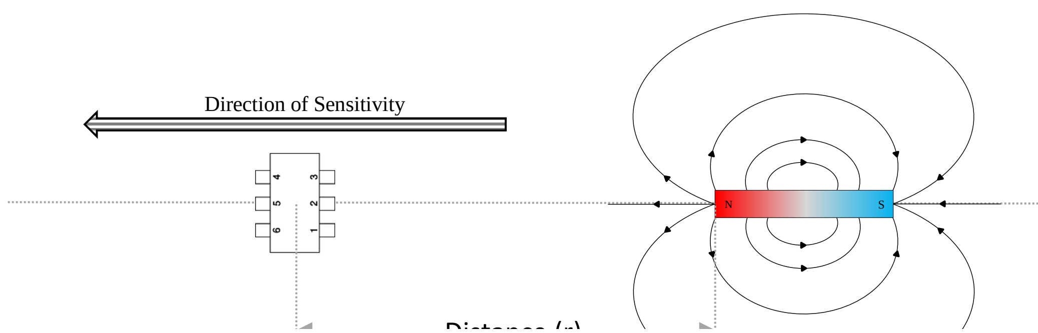
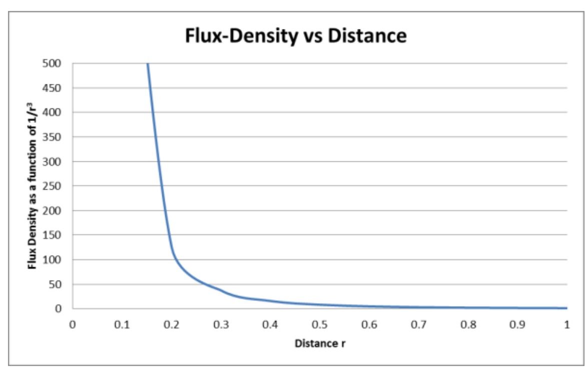


Figure 2

$\frac{1}{r^3}$ with the distance r (while maintaining position on the line passing through the core of the dipole), we can have a fixed magnet in line with a magnetic sensor and map the distance between the two to the strength of the field measured by the sensor. Undoubtedly, the dipole and the sensor need to have the correct orientation with respect to each other to maintain the position on the line passing thro
the direction of sensitivity of the sensor also needs to be parallel to the line passing through the core of the dipole. This sample setup is depicted in Figure 2.

Having these boundaries and changing the distance between the magnet and the sensor will result in a magnetic field strength following a curve according to Figure 3.



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Summary

This application note shows the correlation of the magnetic field strength and the distance of the sensor from the magnet.

In order to successfully measure the distance from the source, one has to take into account several factors such as physical aspect of the setup as well as range of the distance to be measured.

Due to equation complexity, the most important factor in this application is to maintain the alignment between the sensor's direction of sensitivity in line with the dipole-moment which passes straight through the core of the magnet.

