

1 The Fluxgate Magnetometer

Chapter 13: Understanding the Fluxgate Magnetometer

Notes

- Teachspin Fluxgate Magnetometer Module:
 - Fluxgate Sensor:
 - Double Solenoid: Two electrically separate wires are wound and stored in a tube for the fluxgate sensor to fit in. This is so we can have up to two independently added magnetic fields.
 - * Solenoid pitch = 2.54 mm, and the expected magnetic field inside the Solenoid is given by

$$B_{\text{ext}} = 2\mu_0 ni$$

where i is the current through a solenoid, 2 accounts for the doubled layer, and the turn density is

$$n = 1 \text{ turn} / (0.00254 \text{ m}) = 394 \text{ m}^{-1}$$

From this, the magnitude of the external magnetic field given a current i is

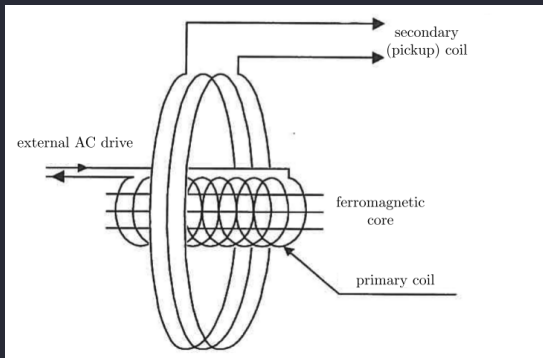
$$\frac{B_{\text{ext}}}{i} = 2 \cdot (4\pi 10^{-7} \text{ Tm/A}) 394 \text{ m} = 990 \mu\text{T/A}$$

- Modeling Output: Calibrating the Solenoid
 - * For simple models the $2f$ -component of the field is linear $A = SB_{\text{ext}}$, but we are actually measuring the magnitude of the spectral component

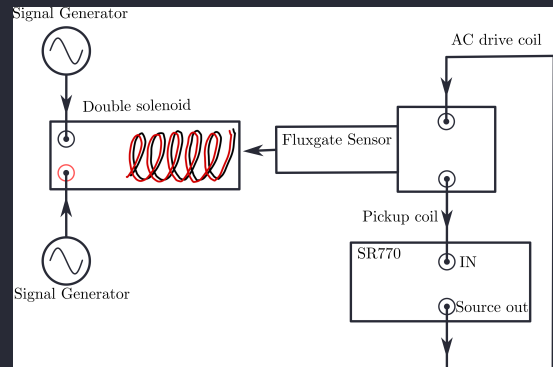
$$M = S|B_{\text{ext}}|$$

- * The geometry of the vector components require us to take a phaser sum which gives us the square magnitude of the measured field

$$M^s = S^2 \left[\left(B_{\text{ext}} + \frac{A_{\text{para}}}{S} \right)^2 + \left(\frac{A_{\text{perp}}}{S} \right)^2 \right] = S^2 [(B_{\text{ext}} + a)^2 + b^2]$$



(a) Fluxgate Magnetometer sensor components



(b) Fluxgate sensor and double solenoid setup

Figure 1.1: (a) Fluxgate Magnetometer sensor components and (b) Fluxgate sensor and double solenoid setup

Experimental Setup

- SR770 Config:
 - FREQ: SPAN 3.125 kHz for observation, 12.2 Hz for measurement; Center Freq. 2 kHz (second harmonic)
 - MEASure: PSD, Flattop Window
 - Average: 16, Exponential
 - SOURCE OUT: 1 kHz 1 V

Procedure

- 770: 1 kHz 1 V Sine SOURCE OUT → Power Audio Amp. module and adjust gain to 6 V (monitor output with splitter to scope)
- Power Audio Amp. output → Fluxgate Primary (AC drive) coil
- Secondary (pick-up) coil → SR770 input
- Place the Fluxgate sensor in the double solenoid pointing straight down
- Measure second harmonic $2f$ component of the frequency spectrum
- Add 2.5 V DC current (from 33500 B) to Solenoid A and measure the changes in the $2f$ component
 - NOTE: Use 50 Ohm Terminator so the measured output voltage is exactly the displayed voltage due to the internal 50 Ohm impedance of the 33500B
- 770 config change: FREQ SPAN 12.2 Hz
- Solenoid A: Replace DC current with AC ($f_A = 5$ Hz 1 V Sine wave from 33500B) and find the $2f \pm f_A$ components
- Solenoid B: Add a second AC drive ($f_B = 2.5$ Hz 0.5 V Sine wave from second 33500 B) and measure the four side band frequencies $2f \pm f_A, 2f \pm f_B$

Observations