Characterizing the Frequency Dependence of the Permeability in various DC Fields

In the first part of this lab, we determined the field dependence of the complex susceptibility of the ferrite core at a fixed frequency. In this section, we will measure the frequency dependent susceptibility at fixed DC fields using a slightly different technique. The measurement setup (Fig. 4) for this experiment is simpler than the previous measurement in that there is only one modulation coil. The coil wound on the toroid is once again connected in series to a resistor R. The value of R is chosen to be much larger than the impedance of the coil \( R \parallel \omega L \) over the 1kHz – 100 kHz range of the measurement (\( R = 500 \, \Omega \) and \( L \sim 10 \, \mu\text{H} \)). This will allow us to assume that the current
through the coil is constant as the frequency is varied. The AC excitation is provided by the internal oscillator of the SR830 lock-in amplifier. The internal oscillator also serves as the reference to the lock-in. Since the current through the coil is dominated by $R$, we can neglect any phase variation due to the changing coil impedance during the frequency sweep.

In this experiment we will be measuring the complex inductance $L = L' + iL''$ of the coil as a function of frequency for various fixed values of $H_0$. The inductance can then be related to the complex permeability of the core. The voltage across the coil $V_{\text{lock-in}}$ will be measured at different frequencies in the range of $1\text{kHz} - 100\ \text{kHz}$. The inductance $L$ can be found from

\begin{equation}
V_{\text{lock-in}} = V_{AC} \frac{Z_L}{R_i + Z_L}
\end{equation}

where $V_{AC}$ is the voltage on the output of the function generator, $V_{\text{lock-in}}$ is the voltage across the coil (input to the lock-in) and $Z_L = i\omega L$ is the impedance of the inductor. Once again, the data acquisition for this portion of the experiment is fully automated.