Closed-Loop Control for High Frequency Variable Inductor System

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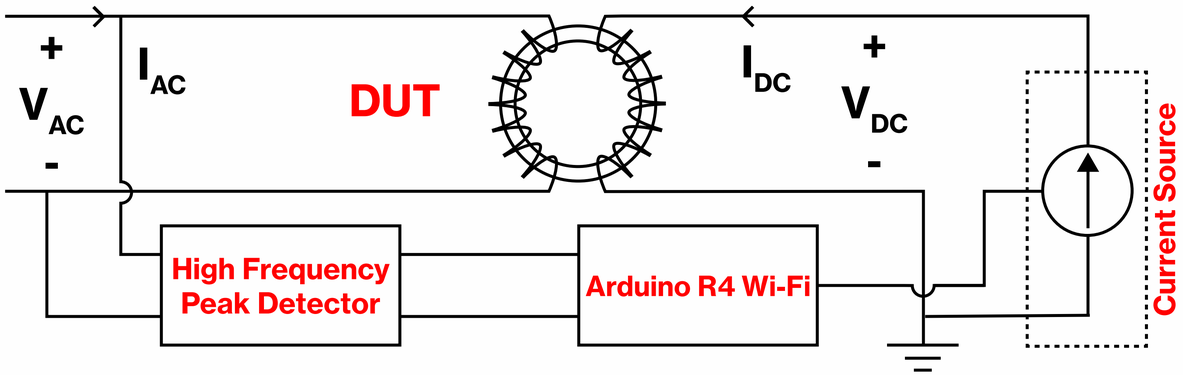
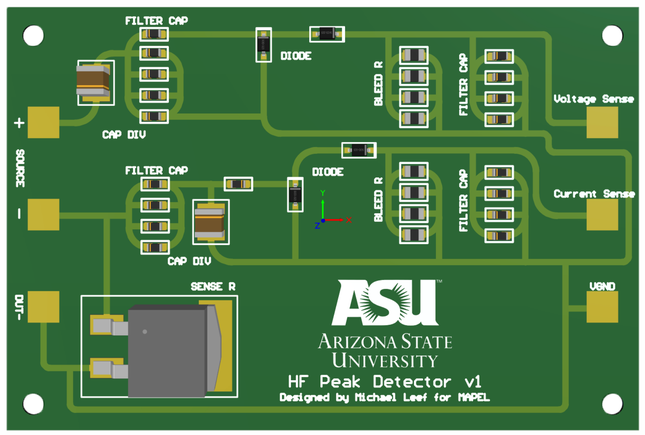
Abstract

Designing variable passive devices comes with a set of challenges regarding parasitic effects. By saturating magnetic materials, the permeability can be modulated to achieve dynamic control of inductance based on AC inputs. However, measuring voltages and currents at the AC input risks the fidelity of the signal yet is necessary to induce a DC flux for a specific inductance value. This project aims to develop a sensing apparatus for a compatible embedded system and design a closed-loop feedback mechanism to regulate the inductance of the magnetic material. This is critical for applications such as power amplifier testing in plasma environments.

Apparatus

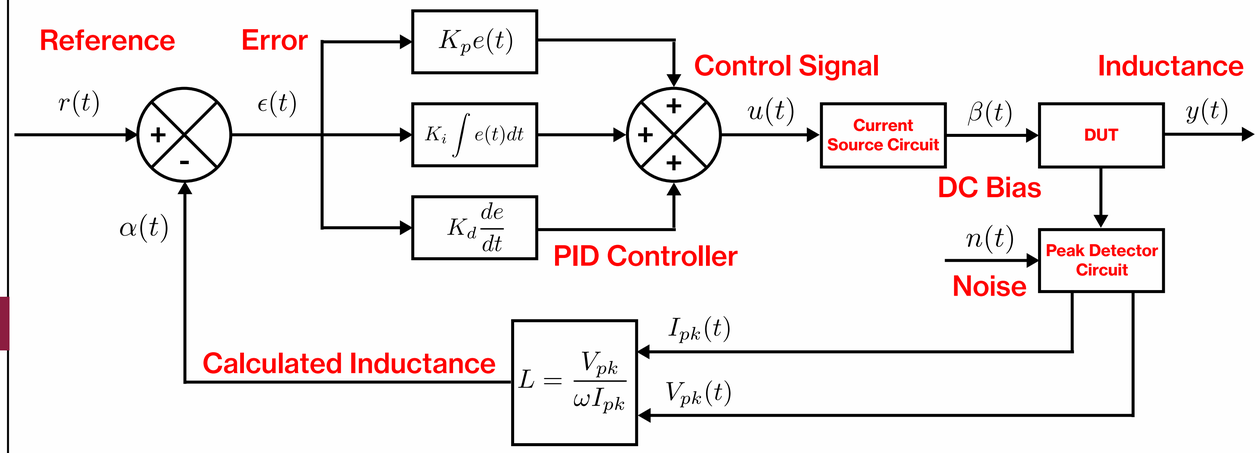




High Frequency Peak Detector

- Detects high frequency voltages and currents for the DUT.
  - Max. Input: 480 V_{PP}~3 A
  - Max. Output: 4.1 V_{DC}
- 6 µs maximum propagation delay
- A_V(13.56 MHz) ≈ - 30 dB

Control Architecture



Next Steps

- Sweep the sinusoidal input between 0-480 VPP and determine a functional model for the voltage and current signals into the Arduino ADC.
  - Test for continuity, heat dissipation, and parasitic impedances in the board.
- Tune the PID controller to optimize its dynamic response to changes in the magnetic core's inductance.
  - Aim for a dynamic propagation delay of <100 µs.
- Design the control architecture for a 2x2 variable inductor matrix using the I2C protocol with a single controller and multiple peripherals.

Acknowledgments

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