Induced Voltage Characteristics by Back Iron Effect for Electromagnetic Energy Harvester using Magnetic Fluid

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Introduction

- **Background**
  - Existing Concept of Energy Harvester
    - Constitution of Stationary Induced Coil and Moving Magnet
    - No Magnetic Circuit for Feedback of Magnetic Flux
  - Operation by Large External Vibration
  - Designed Energy Harvester
    - Implementation using Ferrofluid: Possibility for Low Frequency and Small Vibration
    - Adoption of Back Iron Yoke
    - Comparison of Electromotive Force (EMF) Characteristics for Energy Harvester with Air Yoke and Back Iron Yoke

**EMF in Magnetic Circuit**

- **Schematic Diagram**
  - \[ E = \frac{N}{S} \left( \int_{A_t} A_z \ ds - \int_{A_s} A_z \ ds \right) \]
  - \[ E = \frac{l}{S_a} \left( A_{t'} - A_{s'} \right) \]

- **Configuration of Experiment**
  - Shaker and Scope
  - Harvester with Air Yoke
  - Harvester with Back Iron Yoke

- **Ferrofluid**: Fluidity and Magnetic Property
- **Back Iron Yoke Effect**: Decrease Reluctance → Increase Magnetic Flux → Increase EMF

**Experimental Setup**

- **Supplementary Information**
  - Shaker: 0-300 rpm
  - Oscilloscope: GDS-2102A
  - PM: Nd Magnet
  - Enamelled wire: \( \phi = 0.4 \) mm
  - Ferrofluid: Ferrotec®

**Experiment Results**

- **Factors for Ferrofluid Volume and PM Flux**
  - **Variables for Experiment**
  - **Permanent Magnet Arrangement**

- **Instantaneous Values of Induced Electromotive Force**
  - **In Case of Air Yoke**
  - **In Case of Back Iron Yoke**

<table>
<thead>
<tr>
<th>Part</th>
<th>Property</th>
<th>Value</th>
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<tr>
<td>Magnet</td>
<td>Dia. &amp; Thickness</td>
<td>25 mm</td>
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<td>Res. induction</td>
<td>220 mT</td>
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<td>EFH1</td>
<td>Relative Perm.</td>
<td>2.59</td>
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<tr>
<td>Amount</td>
<td>41 ml</td>
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<tr>
<td>Iron core</td>
<td>Type</td>
<td>Steel 45C</td>
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<tr>
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<td>Relative Perm.</td>
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<tr>
<td>Resistance</td>
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<tr>
<td>Inductance</td>
<td>74.3 mH</td>
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- **Comparison of RMS Value of the Electromotive Force according to Ferrofluid Volume and Magnetic Field**
  - **Air Yoke**
  - **Back Iron Yoke**

- **Ferrofluid based Energy Harvester can Apply to the System with the Small and Low Frequency Vibration.**
- **The Energy Harvester with Back Iron Yoke Generates Large EMF due to Abundant Flux Variation.**

**Conclusion**