Physics Lab

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Transformer

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Overview

Here is book of Physics Lab experiment 7, Analyzing Transformer

Experiment Info

- **Purpose >** Studying transformer functionality
- **Necessary Equipment >** Several Coils with Different Rounds, U-Shape Metal Core, I-Shape Metal Core, AC Voltage Source, Resistor, Multimeter, Wires

Relations : $$\frac{N_s}{N_p} = \frac{V_s}{V_p} = \frac{I_p}{I_s} \quad \Rightarrow \quad V_s = V_p \frac{N_s}{N_p}$$

Where :

N_p : First coil rounds

N_s : Second coil rounds

V_p : First voltage

V_s : Second voltage

I_p : First Current

I_s : Second Current

Analyzing Transformer

Steps

1. First we picked two transformers with a difference of more than 200 rounds.
2. Then we set frequency of function generator on $50Hz$ with a sine wave shape also we set the multimeter button on AC mode.
3. For creating additive frequency, We connect the coil with lower rounds to the function generator and for creating ablative frequency, We connect the coil with higher rounds to the function generator.
4. After assembling the circuit, If shown voltage is lower than $3V$, We must set it to higher voltage by changing AMPL.
5. Then we filled out related tables with different coils

Analyzing Transformers Tables

N_p	N_s	V_P	$V_{s-measured}$	$V_{s-real} = V_p \frac{N_s}{N_p}$
300	600	$3.87V$	$7.23V$	$\alpha: 7.7400V$
700	1200	$4.78V$	$7.53V$	$\beta: 8.1943V$

N_p	N_s	V_P	V_s	$V_s = V_p \frac{N_s}{N_p}$
600	300	$4.75V$	$2.17V$	$\gamma: 2.3750V$
1200	700	$4.89V$	$2.57V$	$\delta: 2.8525V$

Calculations of α, β, γ and δ :

$$\alpha: 3.87V \times \frac{600}{200} = 7.7400V$$

$$\beta: 4.78V \times \frac{1200}{700} \approx 8.1943V$$

$$\gamma: 4.75V \times \frac{300}{600} = 2.3750V$$

$$\delta: 4.89V \times \frac{700}{1200} \approx 2.8525V$$

Analyzing Transformers - Error Calculations

Error calculations are divided into 3 categories, absolute, relative and systematic errors and my personal task is to calculate errors of **first experiment** :

from absolute formula : $Absolute\ Error\ = |real\ value\ -\ measured\ value|$

We get this absolute error for α : $\varepsilon_{abs_\alpha} = |7.7400V\ -\ 7.23V| = 0.51V$

We get this absolute error for β : $\varepsilon_{abs_\beta} = |8.1943V\ -\ 7.53V| = 0.6643V$

We get this absolute error for γ : $\varepsilon_{abs_\gamma} = |2.3750V\ -\ 2.17V| = 0.205V$

We get this absolute error for δ : $\varepsilon_{abs_\delta} = |2.8525V\ -\ 2.57V| = 0.2825V$

from relative formula : $Relative\ Error\ = \frac{|real\ value - measured\ value|}{real\ value}$

We get this absolute error for α : $\varepsilon_{rel_\alpha} = \frac{0.51V}{7.7400V} \approx 0.06589$

We get this absolute error for α : $\varepsilon_{rel_\alpha} = \frac{0.6643V}{8.1943V} \approx 0.08107$

We get this absolute error for α : $\varepsilon_{rel_\alpha} = \frac{0.205V}{2.3750V} \approx 0.08632$

We get this absolute error for α : $\varepsilon_{rel_\alpha} = \frac{0.2825V}{2.8525V} \approx 0.09904$

for systematic formula, We must do several mathematics operations :

1. Consider we have formula $V_s = V_p \frac{N_s}{N_p}$.
2. Take the ln from both sides.
3. Take the differential from both sides.
4. Convert differentials to delta (Δ).
5. Convert every $-$ to $+$.
6. accuracy of **Analog Device** is equal to the lowest shown range on the device.
7. Error of **Analog Device** is equal to the lowest shown range on device multiplied by 0.5.

8. accuracy of **Digital Device** is equal to 10^{-x} where x is float level on the screen.
9. Error of **Digital Device** is equal to 10^{-x} where x is float level on the screen.

Now we can calculate systematic error using main formula :

$$Step\ 1: \quad V_s = V_p \frac{N_s}{N_p}$$

for V_{s_α} :

$$Step\ 2: \quad ln(V_s) = ln(N_s) + ln(V_p) - ln(N_p)$$

$$Step\ 3: \quad \frac{dV_s}{V_s} = \frac{dN_s}{N_s} + \frac{dV_p}{V_p} - \frac{dN_p}{N_p}$$

$$Step\ 4: \quad \frac{\Delta V_s}{V_s} = \frac{\Delta N_s}{N_s} + \frac{\Delta V_p}{V_p} - \frac{\Delta N_p}{N_p}$$

$$Step\ 5: \quad \frac{\Delta V_s}{V_s} = \frac{\Delta N_s}{N_s} + \frac{\Delta V_p}{V_p} + \frac{\Delta N_p}{N_p}$$

$$Step\ 6\sim: \quad \Delta N_p = \Delta N_s = 0 \quad , \quad \Delta V_p = 10^{-2}$$

$$Final: \quad \frac{\Delta V_s}{V_s} = \frac{0}{600} + \frac{10^{-2}V}{3.87V} + \frac{0}{300} \approx 0.00258$$

$$\Rightarrow \varepsilon_{sys_\alpha} = 0.00258$$

for V_{s_β} :

$$Step\ 2: \quad ln(V_s) = ln(N_s) + ln(V_p) - ln(N_p)$$

$$Step\ 3: \quad \frac{dV_s}{V_s} = \frac{dN_s}{N_s} + \frac{dV_p}{V_p} - \frac{dN_p}{N_p}$$

$$Step\ 4: \quad \frac{\Delta V_s}{V_s} = \frac{\Delta N_s}{N_s} + \frac{\Delta V_p}{V_p} - \frac{\Delta N_p}{N_p}$$

$$Step\ 5: \quad \frac{\Delta V_s}{V_s} = \frac{\Delta N_s}{N_s} + \frac{\Delta V_p}{V_p} + \frac{\Delta N_p}{N_p}$$

$$Step\ 6\sim: \quad \Delta N_p = \Delta N_s = 0 \ , \ \Delta V_p = 10^{-2}$$

$$Final: \quad \frac{\Delta V_s}{V_s} = \frac{0}{1200} + \frac{10^{-2}V}{4.78V} + \frac{0}{700} \approx 0.00209$$

$$\Rightarrow \varepsilon_{sys_\beta} = 0.00209$$

for V_{s_γ} :

$$Step\ 2: \quad ln(V_s) = ln(N_s) + ln(V_p) - ln(N_p)$$

$$Step\ 3: \quad \frac{dV_s}{V_s} = \frac{dN_s}{N_s} + \frac{dV_p}{V_p} - \frac{dN_p}{N_p}$$

$$Step\ 4: \quad \frac{\Delta V_s}{V_s} = \frac{\Delta N_s}{N_s} + \frac{\Delta V_p}{V_p} - \frac{\Delta N_p}{N_p}$$

$$Step\ 5: \quad \frac{\Delta V_s}{V_s} = \frac{\Delta N_s}{N_s} + \frac{\Delta V_p}{V_p} + \frac{\Delta N_p}{N_p}$$

$$Step\ 6\sim: \quad \Delta N_p = \Delta N_s = 0 \ , \ \Delta V_p = 10^{-2}$$

$$Final: \quad \frac{\Delta V_s}{V_s} = \frac{0}{300} + \frac{10^{-2}V}{4.75V} + \frac{0}{600} \approx 0.00211$$

$$\Rightarrow \varepsilon_{sys_\gamma} = 0.00211$$

for V_{s_δ} :

$$Step\ 2: \quad ln(V_s) = ln(N_s) + ln(V_p) - ln(N_p)$$

$$Step\ 3: \quad \frac{dV_s}{V_s} = \frac{dN_s}{N_s} + \frac{dV_p}{V_p} - \frac{dN_p}{N_p}$$

$$Step\ 4: \quad \frac{\Delta V_s}{V_s} = \frac{\Delta N_s}{N_s} + \frac{\Delta V_p}{V_p} - \frac{\Delta N_p}{N_p}$$

$$Step\ 5: \quad \frac{\Delta V_s}{V_s} = \frac{\Delta N_s}{N_s} + \frac{\Delta V_p}{V_p} + \frac{\Delta N_p}{N_p}$$

$$Step\ 6\sim: \quad \Delta N_p = \Delta N_s = 0 \ \ , \ \ \Delta V_p = 10^{-2}$$

$$Final: \quad \frac{\Delta V_s}{V_s} = \frac{0}{700} + \frac{10^{-2}V}{4.89V} + \frac{0}{1200} \approx 0.00204$$

$$\Rightarrow \varepsilon_{sys_\delta} = 0.00204$$