Physics Lab

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Introduction to Oscilloscope

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Overview

Here is book of Physics Lab experiment 8, Introduction to Oscilloscope

Experiment Info

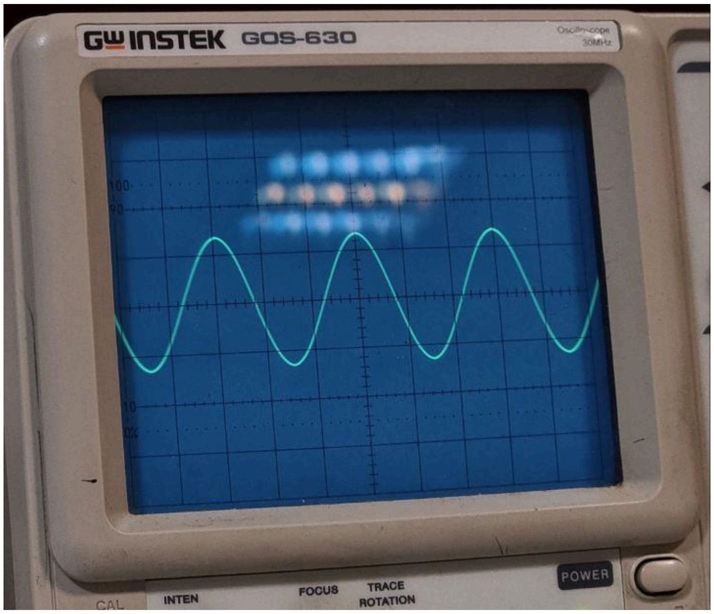
- **Purpose >** Viewing Sine Waves and Measure Frequency and Voltage
- **Necessary Equipment >** AC Power Source, Multimeter, Oscilloscope, Wires and Probes

Relations :

$$\Delta T = \frac{1}{2} \times Scale \times Div_{time} \qquad \Delta V_{p-p} = \frac{1}{2} \times Scale \times Div_{volts}$$

Where :

$$Oscilloscope\ Range\ Scale = 0.2$$



Test Probe via Oscilloscope

Sine Wave Frequency Measurement Table

$Range_{Horizontal}$	$Time/Div$	T	$f_{measured} = \frac{1}{T}$	f_{real}
5	$0.2ms$	$\alpha_1 : 1ms$	$\beta_1 : 1.0000kHz$	$1.1125kHz$
3	$0.2ms$	$\alpha_2 : 0.6ms$	$\beta_2 : 1.6667kHz$	$1.7225kHz$

Calculations of α :

$$\alpha_1 : T = 0.2ms \times 5 = 1ms \qquad \beta_1 : f = \frac{1}{T} \Rightarrow f = 1kHz$$

$$\alpha_2 : T = 0.2ms \times 3 = 0.6ms \qquad \beta_2 : f = \frac{1}{T} \Rightarrow f = 1.6667kHz$$

Oscilloscope Sine Wave Frequency - 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 β_1 : $\varepsilon_{abs_{\beta_1}} = |1112.5Hz - 1000.0Hz| = 112.5Hz$

We get this absolute error for β_2 : $\varepsilon_{abs_{\beta_2}} = |1722.5Hz - 1666.7Hz| = 55.8Hz$

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

We get this absolute error for β_1 : $\varepsilon_{rel_\alpha} = \frac{112.5Hz}{1112.5Hz} \approx 0.10112$

We get this absolute error for β_2 : $\varepsilon_{rel_\alpha} = \frac{55.8Hz}{1722.5Hz} \approx 0.03239$

for systematic formula, We must do several mathematics operations :

1. Consider we have formula $f = \frac{1}{T}$.
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 :

$$Step\ 1: \quad f = \frac{1}{T}$$

for $V_{s_{\beta_1}}$:

$$Step\ 2: \quad ln(f) = ln(1) - ln(T)$$
$$Step\ 2: \quad ln(f) = - ln(T)$$

$$Step\ 3: \quad \frac{df}{f} = - \frac{d(T)}{T}$$

$$Step\ 4: \quad \frac{\Delta f}{f} = - \frac{\Delta(T)}{T}$$

$$Step\ 5: \quad \frac{\Delta f}{f} = \frac{\Delta(T)}{T}$$

$$Step\ 6\sim: \quad \Delta T = 0.2 \times 0.2 \times \frac{1}{2}$$

$$Final: \quad \frac{\Delta f}{f} = \frac{0.02}{1} \Rightarrow \varepsilon_{sys} = 0.02$$

for $V_{s_{\beta_2}}$:

$$Step\ 2: \quad ln(f) = ln(1) - ln(T)$$
$$Step\ 2: \quad ln(f) =- ln(T)$$

$$Step\ 3: \quad \frac{df}{f} =- \frac{d(T)}{T}$$

$$Step\ 4: \quad \frac{\Delta f}{f} =- \frac{\Delta(T)}{T}$$

$$Step\ 5: \quad \frac{\Delta f}{f} = \frac{\Delta(T)}{T}$$

$$Step\ 6\sim: \quad \Delta T = 0.2 \times 0.2 \times \frac{1}{2}$$

$$Final: \quad \frac{\Delta f}{f} = \frac{0.02}{0.6} \Rightarrow \varepsilon_{sys} = 0.0333$$

Sine Wave Voltage Measurement Table

$Range_{Horizontal}$	$Volt/Div$	V_{p-p}	$V_{E-measured} = \frac{V_{p-p}}{2\sqrt{2}}$	V_{E-real}
4	$0.5V$	$\alpha_1 : 2V$	$\beta_1 : 0.7071V$	$0.87V$
2.6	$5V$	$\alpha_2 : 0.6ms$	$\beta_2 : 4.5962V$	$4.75V$

Calculations of α :

$$\alpha_1 : V_{p-p} = 0.5V \times 4 = 2V$$

$$\alpha_2 : V_{p-p} = 5V \times 2.6 = 13V$$

$$\beta_1 : V_E = \frac{V_{p-p}}{2\sqrt{2}} \Rightarrow V_E = 0.7071V$$

$$\beta_2 : V_E = \frac{V_{p-p}}{2\sqrt{2}} \Rightarrow V_E = 4.5962V$$

Oscilloscope Sine Wave Voltage - 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 β_1 : $\varepsilon_{abs_{\beta_1}} = |0.87V\ -\ 0.7071V| = 0.1629V$

We get this absolute error for β_2 : $\varepsilon_{abs_{\beta_2}} = |4.75V\ -\ 4.5962V| = 0.1538V$

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

We get this absolute error for β_1 : $\varepsilon_{rel_{\alpha}} = \frac{0.1629V}{0.87V} \approx 0.1872$

We get this absolute error for β_2 : $\varepsilon_{rel_{\alpha}} = \frac{0.1538V}{4.75V} \approx 0.03238$

for systematic formula, We must do several mathematics operations :

10. Consider we have formula $V_E = \frac{V_{p-p}}{2\sqrt{2}}$.
11. Take the ln from both sides.
12. Take the differential from both sides.
13. Convert differentials to delta (Δ).
14. Convert every $-$ to $+$.
15. accuracy of **Analog Device** is equal to the lowest shown range on the device.
16. Error of **Analog Device** is equal to the lowest shown range on device multiplied by 0.5.
17. accuracy of **Digital Device** is equal to 10^{-x} where x is float level on the screen.
18. 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 :

$Step\ 1$: $V_E = \frac{V_{p-p}}{2\sqrt{2}}$

for $V_{s_{\beta_1}}$:

$$Step\ 2: \quad ln(V_E) = ln(V_{p-p}) - ln(2\sqrt{2})$$

$$Step\ 3: \quad \frac{dV_E}{V_E} = \frac{d(V_{p-p})}{V_{p-p}}$$

$$Step\ 4: \quad \frac{\Delta V_E}{V_E} = \frac{\Delta(V_{p-p})}{V_{p-p}}$$

$$Step\ 5: \quad \frac{\Delta V_E}{V_E} = \frac{\Delta(V_{p-p})}{V_{p-p}}$$

$$Step\ 6\sim: \quad \Delta(V_{p-p}) = 0.2 \times 0.5 \times \frac{1}{2}$$

$$Final: \quad \frac{\Delta f}{f} = \frac{0.05}{1} \Rightarrow \varepsilon_{sys} = 0.05$$

for $V_{s_{\beta_2}}$:

$$Step\ 2: \quad ln(V_E) = ln(V_{p-p}) - ln(2\sqrt{2})$$

$$Step\ 3: \quad \frac{dV_E}{V_E} = \frac{d(V_{p-p})}{V_{p-p}}$$

$$Step\ 4: \quad \frac{\Delta V_E}{V_E} = \frac{\Delta(V_{p-p})}{V_{p-p}}$$

$$Step\ 5: \quad \frac{\Delta V_E}{V_E} = \frac{\Delta(V_{p-p})}{V_{p-p}}$$

$$Step\ 6\sim: \quad \Delta(V_{p-p}) = 0.2 \times 5 \times \frac{1}{2}$$

$$Final: \quad \frac{\Delta f}{f} = \frac{0.5}{1} \Rightarrow \varepsilon_{sys} = 0.5$$