$$a_n = \frac{2}{T}\int_0^T i(t)\cos n\omega t \, dt \Rightarrow \frac{2}{N}\sum_{K=1}^{\infty} i\left[\left(K-\frac{1}{2}\right)\frac{N}{T}\right]\cos\left(2n\pi\frac{K-\frac{1}{2}}{N}\right) \quad \text{.............(3)}$$

$$b_n = \frac{2}{T}\int_0^T i(t)\sin n\omega t \, dt \Rightarrow \frac{2}{N}\sum_{K=1}^{\infty} i\left[\left(K-\frac{1}{2}\right)\frac{N}{T}\right]\sin\left(2n\pi\frac{K-\frac{1}{2}}{N}\right) \quad \text{...............(4)}$$

Where N are the constant values with which T (period) is divided into.

EQUIPMENT USED:

1 Signal Generator. Unilab

1 Voltmeter

1 Ammeter

1 Wattmeter. Feedback EW604 or similar

1 Diode to be used as non-linear circuit element

1 Adjustable Resistor

1 Oscilloscope

PROCEDURE:

The circuit was set as shown below.

Please draw your own circuit using the appropriate software package, for instance MS Visio

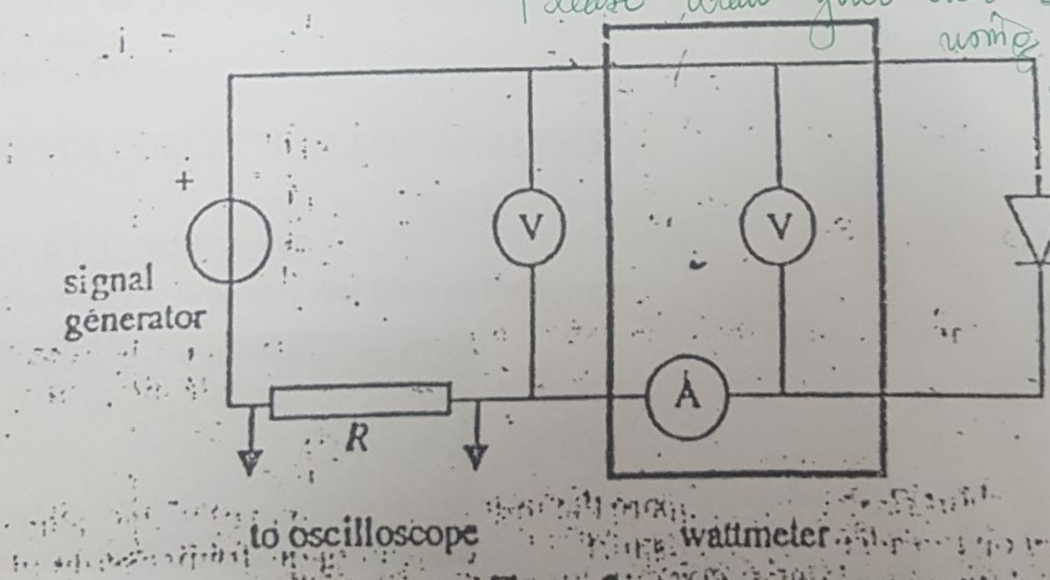


Figure 2

The circuit was switched on and a non-sinusoidal current of convenient size was established by adjusting applied voltage and the resistor. The generator was allowed to generate a sine wave of 586Hz as the equipment could not generate the desired 500Hz. The waveform of the non-sinusoidal current was observed on the oscilloscope. One period of the waveform was set to fill the whole screen. A zero reference was established and a reading as large as possible was obtained from the wattmeter. The value of the resistor was taken note of and remained fixed at the same value.

The voltage and average power were measured using voltmeter and wattmeter respectively and tabulated.

Samples equidistant from one another were picked from one entire period of the waveform. N = 10 was used. The results were for voltage and circulating current were tabulated.

The above steps were repeated for a square wave

Using formulae 2nd , 3rd and 4th the following were determined;

(a) The coefficients of the Fourier series up to the 5th harmonic in two cases, i.e. finding a_0, a_n and b_n. and ϕ_n= arctan($\frac{b_n}{a_n}$) for n=1,2,...,5, a table for the results and a plot on the frequency axis.

(b) The R.M.S. value of the truncated Fourier series of 4.5(a) (10 terms using the formula;

$$I^2{}_{RMS} = \frac{1}{2}\sum_{n=0}^{5} I^2{}_n = \frac{a_0}{4} + \frac{1}{2}\sum_{n=1}^{5}(a_n{}^2 + b_n{}^2)$$

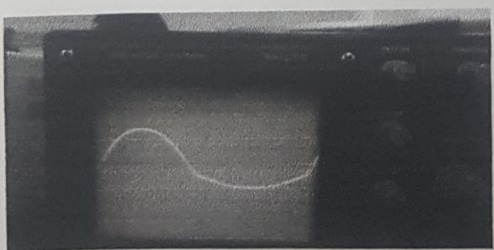
(c) The average power consumed by the non-linear device was estimated by computing the sum of the powers contained in the DC component plus the first five harmonics using the formula ;

(d) P_{av}=VI_{RMS}

DATA COLLECTION AND ANALYSIS:

PART 1 : SINE WAVE

Figure 1: The Generated Sine Wave on Oscilloscope



The noted resistance was found to be 10KΩ = 10000Ω.

Table 1: Voltage vs power

VOLTAGE (V)	POWER (W)
2.7019	0.125

For the power:

A Range = 0.05 V Range = 5

Deflection = 0.5

Power = Deflection × A Range × V Range = 0.5 × 0.05 × 5 = 0.125W

Table 2 Determination Of Fourier Coefficients

K	K (K - ½) T/N	i(K -½) T/N
1	5×10^{-3}	5×10^{-7}
2	5×10^{-3}	5×10^{-7}
3	-2×10^{-3}	3×10^{-7}
4	-2.4×10^{-3}	-2×10^{-7}
5	-3.2×10^{-3}	-2.4×10^{-7}
6	-3.2×10^{-3}	-3.2×10^{-7}
7	-3.4×10^{-3}	-3.4×10^{-7}
8	-3.2×10^{-3}	-3.2×10^{-7}
9	-2×10^{-3}	-2×10^{-7}

Voltage scale is 2 per division. The resistance is 10KΩ = 10000Ω.

PART 2 : SQUARE WAVE

The noted resistance was found to be 10KΩ = 10000Ω.

Table 3: Voltage vs power

VOLTAGE (V)	POWER (W)
3.720	0.2

For the power:

A Range = 0.05   V Range = 0.5

Deflection = 0.8

Power = Deflection × A Range × V Range = 0.8 × 0.5 × 0.5 = 0.2W

Table 4 Determination Of Fourier Coefficients

K	K (K - ½) T/N	i(K -½) T/N
1	4×10^{-3}	4×10^{-7}
2	4×10^{-3}	4×10^{-7}
3	4×10^{-3}	4×10^{-7}
4	4×10^{-3}	4×10^{-7}
5	4×10^{-3}	4×10^{-7}
6	-5×10^{-3}	-5×10^{-7}
7	-5×10^{-3}	-5×10^{-7}
8	-5×10^{-3}	-5×10^{-7}
9	-5×10^{-3}	-5×10^{-7}

DATA ANALYSIS

1. Sample calculation for Table 1.

- Determining $v[(k-\frac{1}{2})(\frac{T}{N})]$:

$$v[(k-\tfrac{1}{2})(\tfrac{T}{N})] = \text{sensitivity} \times \text{No of divisions.}$$

$$= 2.0\ \text{Amp/div} \times 1.6\ \text{div}$$

$$= \underline{\underline{3.2\ \text{Aplitude voltage}}}.$$

- Determining $i[(k-\frac{1}{2})(\frac{T}{N})]$:

$$I = \frac{V}{R} = \frac{3.2}{7k\Omega} = 0.000457A$$

$$= 4.57 \times 10^{-4} A.$$

- Determining a_0:

$$a_0 = \frac{2}{N} \sum_{k=1}^{\infty} i[(k-\tfrac{1}{2})\tfrac{N}{T}]$$

$$a_0 = \tfrac{2}{10}[0.000457 + 0.000571 + 0.0004 + 0.000571 + 0.000229 - 0.000348 - 0.000371 - 0.000343 - 0.000514]$$

$$= 0.0000286A$$

Type your data analysis for continuity and consistence of your report.

$$\therefore\ \underline{\underline{a_0 = 2.86 \times 10^{-5} A}}.$$

Sample Calculation for Table 2.

when $n=1$

$$a_n = \frac{2}{N}\sum_{k=1}^{\infty} i\left[(k-\tfrac{1}{2})\frac{N}{T}\right]\cos\left(2n\pi\frac{(k-\frac{1}{2})}{N}\right)$$

$$= \frac{2}{10}\left[0.000457\left(\cos\frac{\pi}{10}\right) + 0.000571\left(\cos\frac{3\pi}{10}\right) + 0.0004\left(\cos\left(\frac{5\pi}{10}\right)\right) + 0.0000571\left(\cos\frac{7\pi}{10}\right) + 0.000229\cos\left(\frac{9\pi}{10}\right)\right.$$

$$+ 0.000343\left(\cos\left(\frac{11\pi}{10}\right)\right) - 0.000371\left(\cos\left(\frac{13\pi}{10}\right)\right) -$$

$$\left. 0.000343\left(\cos\frac{15\pi}{10}\right) - 0.000514\left(\cos\frac{17\pi}{10}\right)\right]$$

$$= 0.000152A$$

$$a_n = 0.000152A = \underline{1.52\times10^{-4}A}.$$

$$b_n = \frac{2}{N}\sum_{k=1}^{\infty} i\left[(k-\tfrac{1}{2})\frac{N}{T}\right]\sin\left(2\pi n\left(\frac{k-\frac{1}{2}}{N}\right)\right)$$

$$= \frac{2}{10}\left[0.000457\sin\left(\frac{\pi}{10}\right) + 0.000571\sin\left(\frac{3\pi}{10}\right) + 0.0004\sin\left(\frac{5\pi}{10}\right)\right.$$

$$+ 0.0000571\left(\sin\frac{7\pi}{10}\right) + 0.000229\left(\sin\frac{9\pi}{10}\right) - 0.000343\left(\sin\frac{11\pi}{10}\right)$$

$$\left. - 0.00037\sin\left(\frac{13\pi}{10}\right) - 0.000343\sin\left(\frac{15\pi}{10}\right) - 0.000514\sin\left(\frac{17\pi}{10}\right)\right]$$

$$= \frac{2}{10}\left[0.0000258 + 0.0000939 + 0.00011 + 0.0000219 - 0.0000113 - 0.0000207 - 0.0000264 - 0.0000282 - 0.0000478\right]$$

$$= 0.000456A$$

$$b_n = 0.000456A = \underline{4.56\times10^{-4}A}.$$

Determination of Angle.

$$\phi_n = \text{Arctan}\left(\frac{b_n}{a_n}\right)$$

$$= \tan^{-1}\left(\frac{4.56 \times 10^{-4}}{1.52 \times 10^{-4}}\right)$$

$$= 71.57^\circ.$$

$$\phi_n = 71.57^\circ$$

Calculation for RMS value of Fourier series:

$$I^2_{RMS} = \frac{1}{2}\sum_{n=0}^{5} I^2{}_n = \frac{a_0}{4} + \frac{1}{2}\sum_{n=1}^{5}(a_n^2 + b_n^2)$$

$$= \frac{a_0}{4} + \frac{1}{2}\left[a_1^2 + b_1^2 + a_2^2 + b_2^2 + a_3^2 + b_3^2 + a_4^2 + b_4^2 + a_5^2 + b_5^2\right]$$

$$= \frac{(2.86 \times 10^{-5})^2}{4} + \frac{1}{2}\left[0.0286^2 + 0.152^2 + 0.456^2 + 0.0603^2 + 0.112^2 + (-0.0891)^2 + 0.022^2 + 0.0727^2 + 0.0311^2 + 0.0286^2\right]$$

$$= 0.0000001559\,A.$$

$$I^2_{RMS} = 1.559 \times 10^{-7}\,A.$$

Calculation for Average power.

$$P_{av} = VI_{RMS}.$$

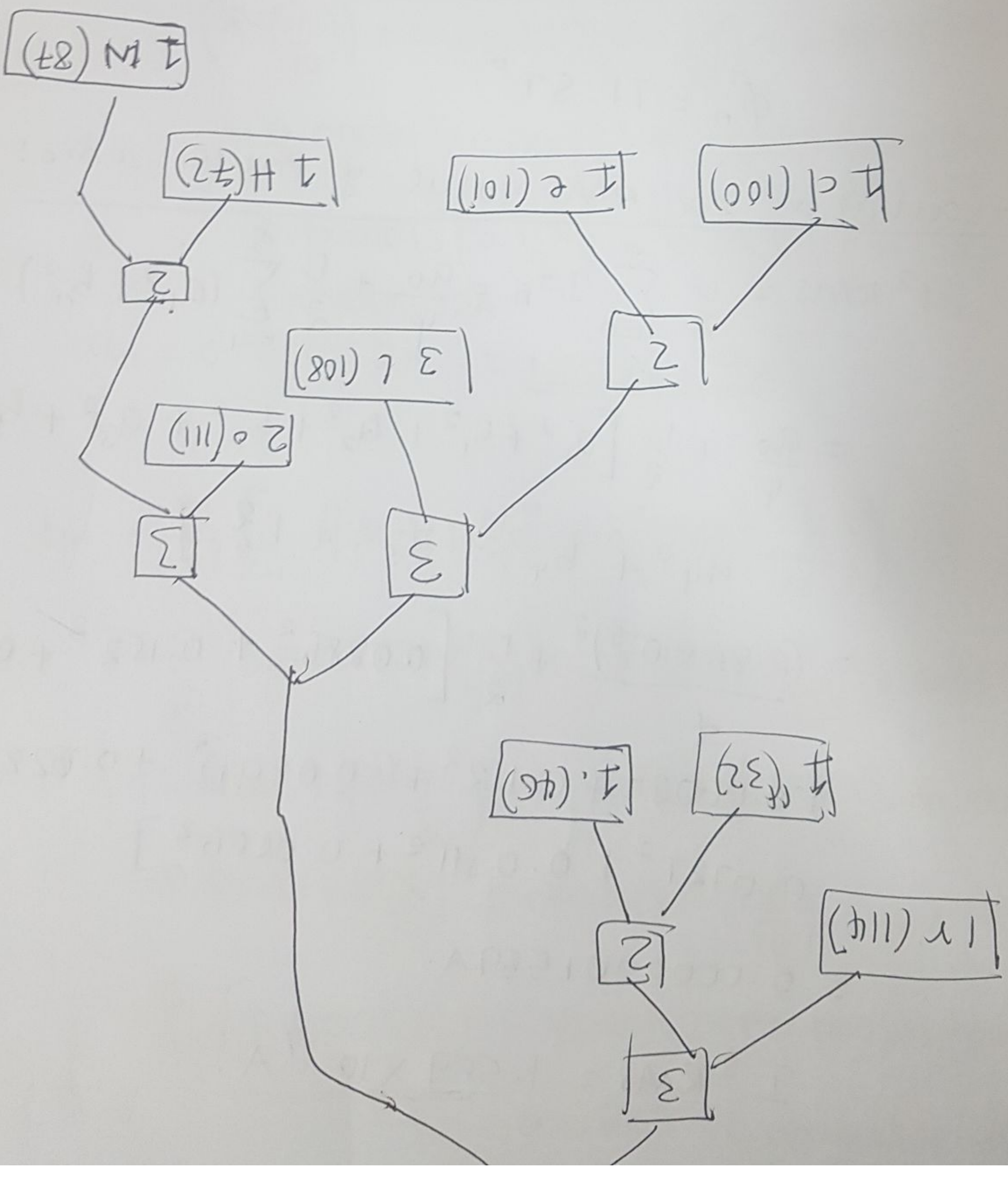
$= 0.6 \left[\sqrt{(0.559 \times 10^{-7})} \right]$

$= 0.0002392$

10

$= 0.2369 mW.$

$= \underline{\underline{2.369 \times 10^{-1} mW}}.$



DISCUSSION:

The experiment began with a few complications that included inaccurate instrument measures and defective equipment which were solved with replacements, which stalled progress but not to an excessive measure.

The harmonics were uncovered, the values found with the formula provided. There was a clear symmetrical pattern emerging when one is to observe the table displaying the a_n and b_n values with the a_n = 0.0286mA at n=0 while b_n = 0.0286mA in the final readings supporting the fact that a wave can be broken down into odd and even components, hence the amplitude/frequency and phase/frequency waveforms drawn out. However, the average power measured compared to the one calculated are different, leading one to assume that incorrect measurements were taken or human error mismatched collected information during calculation. This can be backed up by the fact that the obtained rectified sine wave was not similar to that proposed by theory with a 0V voltage when the sine wave is in its negative half cycle. The slight 'hump' observed gave rise to the negative values obtained in table 1, signifying the presence of backward leakage current which in the working world of technology could cause problems to devices such as transistors and diodes.

CONCLUSION:

The Fourier coefficients of the non sinusoidal periodic current were obtained successfully and the current could therefore be expressed as follows

Endeavour to write a concise conclusion yet informative, by way of answering the main objectives.

REFERENCES:

1 Kuo Franklin F., Network Analysis and Synthesis, 3rd Ed., 1986, J. Wiley (SE).

2 Wadhwa C.L., Network Analysis and Synthesis, 2nd Ed., 2006, New Age International (P) Ltd. Publishers.

Use IEEE referencing standard.