

Fourier Series In Electrocardiograph

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Abstract - Nowadays many people are facing heart related health issues. Here we are going to discuss about the ECG waves. Electrocardiograph represents the P, QRS, T wave that shows our heart beats rate. Definition and theorem of Fourier series is used in Electrocardiograph. The normal and abnormal person P, QRS and T wave had been found by using the Fourier series formula. Some applications of Fourier series are also discussed. Specially, the formation of ECG wave using Fourier series is derived.

Keywords: Fourier series, Trigonometric function, Electrocardiogram

I. INTRODUCTION

The Fourier concept has invaded almost all branches of mathematics. Fourier series are used in the analysis of periodic functions. Many of the phenomena studied in engineering and science are periodic in nature. These periodic functions can be analysed into their constituent components by a process called Fourier analysis [1]. The aim is to find an approximation using trigonometric functions. For non - periodic functions, the Fourier series is replaced by Fourier transform [5]. The history of Electrocardiogram has noted from the article [3] and origination of the machine had been taken from [4]. The half range odd function and half range even function are taken from [6]. Here we are going to find the P, QRS, T value by using the article [2]. In [2] they had developed only R wave. On the base of that we had found for P, QRS and T waves.

II. PRELIMINARIES

Definition 2.1: A function $f(x)$ is said to be periodic with the period p if

$$f(x) = f(x + np), n = 1, 2, \dots [1]$$

Definition 2.2: The Fourier series is a periodic way of rewriting functions as a series of trigonometric functions. The Fourier series of a periodic function $f(x)$ of period $2L$ in the interval $(-L, L)$ is given as

$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty} \left(a_n \cos \frac{n\pi x}{L} + b_n \sin \frac{n\pi x}{L} \right)$$

Where,

$$a_0 = \frac{1}{L} \int_{-L}^L f(x) dx$$

$$a_n = \frac{1}{L} \int_{-L}^L f(x) \cos \left(\frac{n\pi x}{L} \right) dx, n = 1, 2, \dots$$

$$b_n = \frac{1}{L} \int_{-L}^L f(x) \sin \left(\frac{n\pi x}{L} \right) dx, n = 1, 2, \dots [5]$$

Definition 2.3: Let $f(x)$ is an even function. That is, $f(-x) = f(x)$ Then, the Fourier series expansion of $f(x)$ has the cosine terms only and takes the form,



$$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty} a_n \cos\left(\frac{n\pi x}{L}\right)$$

Where,

$$a_0 = \frac{2}{L} \int_0^L f(x) dx$$

$$a_n = \frac{2}{L} \int_0^L f(x) \cos\left(\frac{n\pi x}{L}\right) dx, n = 1, 2, \dots [6]$$

Definition 2.4: Let $f(x)$ is an odd function. That is, $f(-x) = -f(x)$ Then, the Fourier series expansion of $f(x)$ has the sine terms only and takes the form,

$$f(x) = \sum_{n=1}^{\infty} b_n \sin\left(\frac{n\pi x}{L}\right)$$

Where,

$$b_n = \frac{2}{L} \int_0^L f(x) \sin\left(\frac{n\pi x}{L}\right) dx, n = 1, 2, \dots [6]$$

Fourier series: The concept of vectors can directly be extended to signals due to the analogy between signals and vectors. A Fourier series is an expansion of a periodic function of $f(x)$ in terms of an infinite sum of sine and cosines. Fourier series makes use of sine and cosine functions. Since infinite cosine functions and infinite sine functions are mutually orthogonal/exclusive. So, it is possible to represent any function as the sum of infinite sine and cosine functions or a linear combination of sine and cosine functions which is known as Fourier series representation. It is possible to represent a given signal in Fourier series for one period which implies that the Fourier series is applicable for periodic signals only.

Electrocardiogram: When the cardiac impulse passes through the heart, electrical current spread in the tissues surrounding the heart. A small amount of the current spreads to the surface of the body. If electrodes are placed on the skin on opposite sides of the heart, electric potentials generated by these currents are recorded. These recordings are known as ECG. Four patches are placed on the limbs. One is placed on each shoulder or upper arm and one on each leg. These are called limb leads. These are six patches that are placed on the chest wall beginning just to the right of the breast bone. These are called chest leads. These patches are connected to an ECG machine that records the tracing and prints them onto paper.

III. NORMAL AND ABNORMAL P, QRS, T WAVES

Normal P Wave: The P wave was about 0.3mv and lasted from 160ms to 280ms. The shape of the P wave is almost parabolic. When $t=160$ then the polynomial is,

$$f(x) = a(t - 220)^2 + v$$

$$a(160 - 220)^2 + 0.3 = 0$$

$$f(x) = -8.333 \times 10^{-5}(t - 220)^2 + v$$

$$a_0 = -0.021 + 0.24v$$

$$a_n = \sin\left(\frac{280n\pi}{500}\right) \left[\frac{-0.2991 + v}{n\pi} + \frac{41.665}{n^3\pi^3} \right] + \sin\left(\frac{160n\pi}{500}\right) \left[\frac{-0.2991 + v}{n\pi} + \frac{41.665}{n^3\pi^3} \right] + \cos\left(\frac{280n\pi}{500}\right) \left[\frac{-4.9998}{n\pi} \right] + \cos\left(\frac{160n\pi}{500}\right) \left[\frac{-4.9998}{n\pi} \right]$$

$$b_n = \cos\left(\frac{280n\pi}{500}\right) \left[\frac{0.2991 - v}{n\pi} + \frac{41.665}{n^3\pi^3} \right] + \sin\left(\frac{280n\pi}{500}\right) \left[\frac{-4.9998}{n\pi} \right] + \sin\left(\frac{160n\pi}{500}\right) \left[\frac{-4.9998}{n^2\pi^2} \right] \\ + \cos\left(\frac{160n\pi}{500}\right) \left[\frac{-0.2991 + v}{n\pi} + \frac{41.665}{n^3\pi^3} \right]$$

Substituting a_0, a_n, b_n in $f(x)$ we get,

$$f(x) = \left[\frac{0.021 + 0.24v}{2} \right] + \sum_{n=1}^{\infty} \sin\left(\frac{280n\pi}{500}\right) \left[\frac{-0.2991 + v}{n\pi} + \frac{41.665}{n^3\pi^3} \right] + \sin\left(\frac{160n\pi}{500}\right) \left[\frac{-0.2991 + v}{n\pi} + \frac{41.665}{n^3\pi^3} \right] \\ + \cos\left(\frac{280n\pi}{500}\right) \left[\frac{-4.9998}{n\pi} \right] + \cos\left(\frac{160n\pi}{500}\right) \left[\frac{-4.9998}{n\pi} \right] \cos\left(\frac{n\pi x}{500}\right) \\ + \sum_{n=1}^{\infty} \cos\left(\frac{280n\pi}{500}\right) \left[\frac{0.2991 - v}{n\pi} + \frac{41.665}{n^3\pi^3} \right] + \sin\left(\frac{280n\pi}{500}\right) \left[\frac{-4.9998}{n\pi} \right] + \sin\left(\frac{160n\pi}{500}\right) \left[\frac{-4.9998}{n^2\pi^2} \right] \\ + \cos\left(\frac{160n\pi}{500}\right) \left[\frac{-0.2991 + v}{n\pi} + \frac{41.665}{n^3\pi^3} \right] \sin\left(\frac{n\pi x}{500}\right)$$

Normal QRS wave: The QRS wave was about 0.8mv and lasted from 300ms to 340ms. The shape of the QRS wave is almost parabolic. When $t=300$ then the polynomial is,

$$f(x) = a(t - 320)^4 + v$$

$$a(300 - 320)^4 + 0.8 = 0$$

$$f(x) = -5 \times 10^{-6}(t - 320)^4 + v$$

$$a_0 = -0.0128 + 0.08v$$

$$a_n = \sin\left(\frac{340n\pi}{500}\right) \left[\frac{-0.8 + v}{n\pi} + \frac{6000}{n^3\pi^3} - \frac{7500000}{n^5\pi^5} \right] + \sin\left(\frac{300n\pi}{500}\right) \left[\frac{0.8 - v}{n\pi} + \frac{6000}{n^3\pi^3} + \frac{7500000}{n^5\pi^5} \right] \\ + \cos\left(\frac{340n\pi}{500}\right) \left[\frac{-80}{n^2\pi^2} + \frac{300000}{n^4\pi^4} \right] + \cos\left(\frac{300n\pi}{500}\right) \left[\frac{80}{n^2\pi^2} - \frac{300000}{n^4\pi^4} \right]$$

$$b_n = \cos\left(\frac{340n\pi}{500}\right) \left[\frac{0.8 - v}{n\pi} - \frac{6000}{n^3\pi^3} + \frac{7500000}{n^5\pi^5} \right] + \cos\left(\frac{300n\pi}{500}\right) \left[\frac{-0.8 + v}{n\pi} + \frac{6000}{n^3\pi^3} - \frac{7500000}{n^5\pi^5} \right] \\ + \sin\left(\frac{340n\pi}{500}\right) \left[\frac{-80}{n^2\pi^2} + \frac{300000}{n^4\pi^4} \right] + \sin\left(\frac{300n\pi}{500}\right) \left[\frac{-80}{n^2\pi^2} + \frac{300000}{n^4\pi^4} \right]$$

$$f(x) = \left[\frac{-0.0128 + 0.08v}{2} \right] + \sum_{n=1}^{\infty} \sin\left(\frac{340n\pi}{500}\right) \left[\frac{-0.8 + v}{n\pi} + \frac{6000}{n^3\pi^3} - \frac{7500000}{n^5\pi^5} \right] \\ + \sin\left(\frac{300n\pi}{500}\right) \left[\frac{0.8 - v}{n\pi} + \frac{6000}{n^3\pi^3} + \frac{7500000}{n^5\pi^5} \right] + \cos\left(\frac{340n\pi}{500}\right) \left[\frac{-80}{n^2\pi^2} + \frac{300000}{n^4\pi^4} \right] \\ + \cos\left(\frac{300n\pi}{500}\right) \left[\frac{80}{n^2\pi^2} - \frac{300000}{n^4\pi^4} \right] \cos\left(\frac{n\pi x}{500}\right) + \sum_{n=1}^{\infty} \cos\left(\frac{340n\pi}{500}\right) \left[\frac{0.8 - v}{n\pi} - \frac{6000}{n^3\pi^3} + \frac{7500000}{n^5\pi^5} \right] \\ + \cos\left(\frac{300n\pi}{500}\right) \left[\frac{-0.8 + v}{n\pi} + \frac{6000}{n^3\pi^3} - \frac{7500000}{n^5\pi^5} \right] + \sin\left(\frac{340n\pi}{500}\right) \left[\frac{-80}{n^2\pi^2} + \frac{300000}{n^4\pi^4} \right] \\ + \sin\left(\frac{300n\pi}{500}\right) \left[\frac{-80}{n^2\pi^2} + \frac{300000}{n^4\pi^4} \right] \sin\left(\frac{n\pi x}{500}\right)$$

Normal T wave: The T wave was about 0.3mv and lasted from 400ms to 580ms. The shape of the T wave is almost parabolic. When $t=400$ then the polynomial is,

$$f(x) = a(t - 490)^2 + v$$

$$a(400 - 490)^2 + 0.3 = 0$$

$$f(x) = -3.7037 \times 10^{-5}(t - 490)^2 + v$$

$$a_0 = -0.0351 + 0.30v$$

$$\begin{aligned} a_n = & \sin\left(\frac{580n\pi}{500}\right) \left[\frac{-2429.998 + v}{n\pi} - \frac{899991.1}{n^3\pi^3} - \frac{55555500}{n^5\pi^5} \right] \\ & + \sin\left(\frac{400n\pi}{500}\right) \left[\frac{2429.998 - v}{n\pi} - \frac{899991.1}{n^3\pi^3} + \frac{55555500}{n^5\pi^5} \right] + \cos\left(\frac{580n\pi}{500}\right) \left[\frac{-53999.946}{n^2\pi^2} + \frac{9999990}{n^4\pi^4} \right] \\ & + \cos\left(\frac{400n\pi}{500}\right) \left[\frac{53999.946}{n^2\pi^2} - \frac{9999990}{n^4\pi^4} \right] \end{aligned}$$

$$\begin{aligned} b_n = & \cos\left(\frac{580n\pi}{500}\right) \left[\frac{2429.998 + v}{n\pi} - \frac{899991.1}{n^3\pi^3} - \frac{55555500}{n^5\pi^5} \right] \\ & + \cos\left(\frac{400n\pi}{500}\right) \left[\frac{-2429.998 - v}{n\pi} + \frac{899991.1}{n^3\pi^3} + \frac{55555500}{n^5\pi^5} \right] + \sin\left(\frac{580n\pi}{500}\right) \left[\frac{53999.946}{n^2\pi^2} - \frac{9999990}{n^4\pi^4} \right] \\ & + \sin\left(\frac{400n\pi}{500}\right) \left[\frac{-53999.946}{n^2\pi^2} + \frac{9999990}{n^4\pi^4} \right] \end{aligned}$$

$$\begin{aligned} f(x) = & \left[\frac{-0.0351 + 0.36v}{2} \right] + \sum_{n=1}^{\infty} \sin\left(\frac{580n\pi}{500}\right) \left[\frac{-2429.998 + v}{n\pi} - \frac{899991.1}{n^3\pi^3} - \frac{55555500}{n^5\pi^5} \right] \\ & + \sin\left(\frac{400n\pi}{500}\right) \left[\frac{2429.998 - v}{n\pi} - \frac{899991.1}{n^3\pi^3} + \frac{55555500}{n^5\pi^5} \right] + \cos\left(\frac{580n\pi}{500}\right) \left[\frac{-53999.946}{n^2\pi^2} + \frac{9999990}{n^4\pi^4} \right] \\ & + \cos\left(\frac{400n\pi}{500}\right) \left[\frac{53999.946}{n^2\pi^2} - \frac{9999990}{n^4\pi^4} \right] \cos\left(\frac{n\pi x}{500}\right) \\ & + \sum_{n=1}^{\infty} \cos\left(\frac{580n\pi}{500}\right) \left[\frac{2429.998 + v}{n\pi} - \frac{899991.1}{n^3\pi^3} - \frac{55555500}{n^5\pi^5} \right] \\ & + \cos\left(\frac{400n\pi}{500}\right) \left[\frac{-2429.998 - v}{n\pi} + \frac{899991.1}{n^3\pi^3} + \frac{55555500}{n^5\pi^5} \right] + \sin\left(\frac{580n\pi}{500}\right) \left[\frac{53999.946}{n^2\pi^2} - \frac{9999990}{n^4\pi^4} \right] \\ & + \sin\left(\frac{400n\pi}{500}\right) \left[\frac{-53999.946}{n^2\pi^2} + \frac{9999990}{n^4\pi^4} \right] \sin\left(\frac{n\pi x}{500}\right) \end{aligned}$$

Abnormal P Wave: Let us assume P wave was about 0.5mv and lasted from 200ms to 320ms. The shape of the P wave is almost parabolic. When t=200 then the polynomial is,

$$f(x) = a(t - 260)^2 + v$$

$$a(200 - 260)^2 + 0.5 = 0$$

$$f(x) = -1.3888 \times 10^{-4}(t - 260)^2 + v$$

$$a_0 = -0.0399 + 0.24v$$

$$\begin{aligned} a_n = & \sin\left(\frac{320n\pi}{500}\right) \left[\frac{-0.4999 + v}{n\pi} + \frac{69.44}{n^3\pi^3} \right] + \sin\left(\frac{200n\pi}{500}\right) \left[\frac{-0.4999 + v}{n\pi} + \frac{69.44}{n^3\pi^3} \right] + \cos\left(\frac{320n\pi}{500}\right) \left[\frac{-8.3328}{n\pi} \right] \\ & + \cos\left(\frac{200n\pi}{500}\right) \left[\frac{-8.3328}{n\pi} \right] \end{aligned}$$

$$\begin{aligned} b_n = & \cos\left(\frac{320n\pi}{500}\right) \left[\frac{0.4999 - v}{n\pi} + \frac{69.44}{n^3\pi^3} \right] + \sin\left(\frac{320n\pi}{500}\right) \left[\frac{-8.3328}{n\pi} \right] + \sin\left(\frac{200n\pi}{500}\right) \left[\frac{-8.3328}{n^2\pi^2} \right] \\ & + \cos\left(\frac{200n\pi}{500}\right) \left[\frac{-0.4999 + v}{n\pi} + \frac{69.44}{n^3\pi^3} \right] \end{aligned}$$

$$f(x) = \left[\frac{0.0399 + 0.24}{2} \right] + \sum_{n=1}^{\infty} \sin\left(\frac{320n\pi}{500}\right) \left[\frac{-0.4999 + v}{n\pi} + \frac{69.44}{n^3\pi^3} \right] + \sin\left(\frac{200n\pi}{500}\right) \left[\frac{-0.4999 + v}{n\pi} + \frac{69.44}{n^3\pi^3} \right] \\ + \cos\left(\frac{320n\pi}{500}\right) \left[\frac{-8.3328}{n\pi} \right] + \cos\left(\frac{200n\pi}{500}\right) \left[\frac{-8.3328}{n\pi} \right] \cos\left(\frac{n\pi x}{500}\right) \\ + \cos\left(\frac{320n\pi}{500}\right) \left[\frac{0.4999 - v}{n\pi} + \frac{69.44}{n^3\pi^3} \right] + \sin\left(\frac{320n\pi}{500}\right) \left[\frac{-8.3328}{n\pi} \right] + \sin\left(\frac{200n\pi}{500}\right) \left[\frac{-8.3328}{n^2\pi^2} \right] \\ + \cos\left(\frac{200n\pi}{500}\right) \left[\frac{-0.4999 + v}{n\pi} + \frac{69.44}{n^3\pi^3} \right] \sin\left(\frac{n\pi x}{500}\right)$$

Abnormal QRS wave: Let us assume that QRS wave was about 0.10mv and lasted from 350ms to 390ms. The shape of the QRS wave is almost parabolic. When $t=350$ then the polynomial is,

$$f(x) = a(t - 370)^4 + v$$

$$a(350 - 370)^4 + 0.10 = 0$$

$$f(x) = -6.25 \times 10^{-7}(t - 370)^4 + v$$

$$a_0 = -1.6 \times 10^{-3} + 0.08v$$

$$a_n = \sin\left(\frac{390n\pi}{500}\right) \left[\frac{-0.1 + v}{n\pi} + \frac{750}{n^3\pi^3} - \frac{137500}{n^5\pi^5} \right] + \sin\left(\frac{350n\pi}{500}\right) \left[\frac{0.1 - v}{n\pi} + \frac{750}{n^3\pi^3} + \frac{937500}{n^5\pi^5} \right] \\ + \cos\left(\frac{390n\pi}{500}\right) \left[\frac{-10}{n^2\pi^2} + \frac{37500}{n^4\pi^4} \right] + \cos\left(\frac{350n\pi}{500}\right) \left[\frac{10}{n^2\pi^2} - \frac{37500}{n^4\pi^4} \right]$$

$$b_n = \cos\left(\frac{390n\pi}{500}\right) \left[\frac{0.1 - v}{n\pi} - \frac{750}{n^3\pi^3} + \frac{937500}{n^5\pi^5} \right] + \cos\left(\frac{350n\pi}{500}\right) \left[\frac{-0.1 + v}{n\pi} + \frac{750}{n^3\pi^3} - \frac{937500}{n^5\pi^5} \right] \\ + \sin\left(\frac{390n\pi}{500}\right) \left[\frac{-10}{n^2\pi^2} + \frac{37500}{n^4\pi^4} \right] + \sin\left(\frac{350n\pi}{500}\right) \left[\frac{-10}{n^2\pi^2} + \frac{37500}{n^4\pi^4} \right]$$

$$f(x) = \left[\frac{1.6 \times 10^{-3} + 0.08v}{2} \right] + \sum_{n=1}^{\infty} \sin\left(\frac{390n\pi}{500}\right) \left[\frac{-0.1 + v}{n\pi} + \frac{750}{n^3\pi^3} - \frac{137500}{n^5\pi^5} \right] \\ + \sin\left(\frac{350n\pi}{500}\right) \left[\frac{0.1 - v}{n\pi} + \frac{750}{n^3\pi^3} + \frac{937500}{n^5\pi^5} \right] + \cos\left(\frac{390n\pi}{500}\right) \left[\frac{-10}{n^2\pi^2} + \frac{37500}{n^4\pi^4} \right] \\ + \cos\left(\frac{350n\pi}{500}\right) \left[\frac{10}{n^2\pi^2} - \frac{37500}{n^4\pi^4} \right] \cos\left(\frac{n\pi x}{500}\right) + \sum_{n=1}^{\infty} \cos\left(\frac{390n\pi}{500}\right) \left[\frac{0.1 - v}{n\pi} - \frac{750}{n^3\pi^3} + \frac{937500}{n^5\pi^5} \right] \\ + \cos\left(\frac{350n\pi}{500}\right) \left[\frac{-0.1 + v}{n\pi} + \frac{750}{n^3\pi^3} - \frac{937500}{n^5\pi^5} \right] + \sin\left(\frac{390n\pi}{500}\right) \left[\frac{-10}{n^2\pi^2} + \frac{37500}{n^4\pi^4} \right] \\ + \sin\left(\frac{350n\pi}{500}\right) \left[\frac{-10}{n^2\pi^2} + \frac{37500}{n^4\pi^4} \right] \sin\left(\frac{n\pi x}{500}\right)$$

Abnormal T wave: Let us assume T wave was about 0.4mv and lasted from 420ms to 600ms. The shape of the T wave is almost parabolic. When $t=420$ then the polynomial is,

$$f(x) = a(t - 510)^2 + v$$

$$a(420 - 510)^2 + 0.4 = 0$$

$$f(x) = -4.9382 \times 10^{-5}(t - 510)^2 + v$$

$$a_0 = -0.0351 + 0.30v$$

$$a_n = \sin\left(\frac{600n\pi}{500}\right) \left[\frac{-3239.995 - v}{n\pi} - \frac{1199982.6}{n^3\pi^3} - \frac{74073000}{n^5\pi^5} \right] \\ + \sin\left(\frac{420n\pi}{500}\right) \left[\frac{3239.995 + v}{n\pi} - \frac{1199982.6}{n^3\pi^3} + \frac{74073000}{n^5\pi^5} \right] \\ + \cos\left(\frac{600n\pi}{500}\right) \left[\frac{-71998.956}{n^2\pi^2} + \frac{74073000}{n^4\pi^4} \right] + \cos\left(\frac{420n\pi}{500}\right) \left[\frac{71998.956}{n^2\pi^2} - \frac{74073000}{n^4\pi^4} \right]$$

$$b_n = \cos\left(\frac{600n\pi}{500}\right) \left[\frac{3239.995 + v}{n\pi} - \frac{1199982.6}{n^3\pi^3} - \frac{74073000}{n^5\pi^5} \right] \\ + \cos\left(\frac{420n\pi}{500}\right) \left[\frac{-3239.995 - v}{n\pi} + \frac{1199982.6}{n^3\pi^3} + \frac{74073000}{n^5\pi^5} \right] \\ + \sin\left(\frac{600n\pi}{500}\right) \left[\frac{71998.956}{n^2\pi^2} - \frac{74073000}{n^4\pi^4} \right] + \sin\left(\frac{420n\pi}{500}\right) \left[\frac{-71998.956}{n^2\pi^2} + \frac{74073000}{n^4\pi^4} \right]$$

$$f(x) = \left[\frac{1.6 \times 10^{-3} + 0.08v}{2} \right] + \sum_{n=1}^{\infty} \sin\left(\frac{600n\pi}{500}\right) \left[\frac{-3239.995 - v}{n\pi} - \frac{1199982.6}{n^3\pi^3} - \frac{74073000}{n^5\pi^5} \right] \\ + \sin\left(\frac{420n\pi}{500}\right) \left[\frac{3239.995 + v}{n\pi} - \frac{1199982.6}{n^3\pi^3} + \frac{74073000}{n^5\pi^5} \right] \\ + \cos\left(\frac{600n\pi}{500}\right) \left[\frac{-71998.956}{n^2\pi^2} + \frac{74073000}{n^4\pi^4} \right] + \cos\left(\frac{420n\pi}{500}\right) \left[\frac{71998.956}{n^2\pi^2} - \frac{74073000}{n^4\pi^4} \right] \cos\left(\frac{n\pi x}{500}\right) \\ + \sum_{n=1}^{\infty} \cos\left(\frac{600n\pi}{500}\right) \left[\frac{3239.995 + v}{n\pi} - \frac{1199982.6}{n^3\pi^3} - \frac{74073000}{n^5\pi^5} \right] \\ + \cos\left(\frac{420n\pi}{500}\right) \left[\frac{-3239.995 - v}{n\pi} + \frac{1199982.6}{n^3\pi^3} + \frac{74073000}{n^5\pi^5} \right] \\ + \sin\left(\frac{600n\pi}{500}\right) \left[\frac{71998.956}{n^2\pi^2} - \frac{74073000}{n^4\pi^4} \right] + \sin\left(\frac{420n\pi}{500}\right) \left[\frac{-71998.956}{n^2\pi^2} + \frac{74073000}{n^4\pi^4} \right] \sin\left(\frac{n\pi x}{500}\right)$$

IV. CONCLUSION

This study represents a comprehensive overview of deriving ECG values using Fourier series expansion. The Fourier series expansion of this derived function is formed after finding the mean value term (a_0), the first coefficient term (a_n) and second coefficient term (b_n). By assigning values for time and amplitude in Fourier series which have been already formed, the electrocardiograph is found. The results show that normal limits of most ECG parameters vary, with age and sex and strongly suggest that diagnostic ECG criteria should be age and sex-specific from the ECG report, time and amplitude of various waves are interpreted. Out of this project work, the real application of Fourier series in ECG is exactly derived and ECG wave P, QRS and T are shown.

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