

ECE 351 - SECTION 52

LAB 8

Fourier Series Approximation of a Square Wave

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1 Introduction

Using python, the Fourier series of a square wave is found and then plotted for a number of N values.

2 Equations

$$w = \frac{2\pi}{T}$$

$$a_k = 0$$

$$b_k = 2\left[\frac{1-\cos(\pi k)}{\pi k}\right]$$

$$a_0 = 0$$

$$x(t) = \sum_{n=1}^{\infty} \left[\frac{2(1-\cos(\pi k))\sin(kwt)}{\pi k} \right]$$

3 Methodology

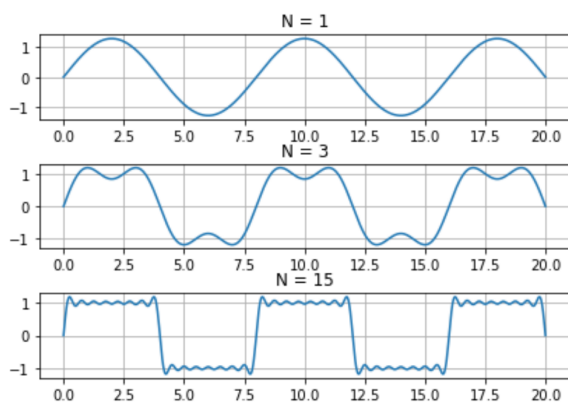
First, the equations found in the prelab are inputted into python. In python, multiple n values are inputted into the equations and the outputs are printed. Next, the Fourier series function is plotted for $N = 1, 3, 15, 50, 150, 1500$, with $T = 8s$.

4 Results

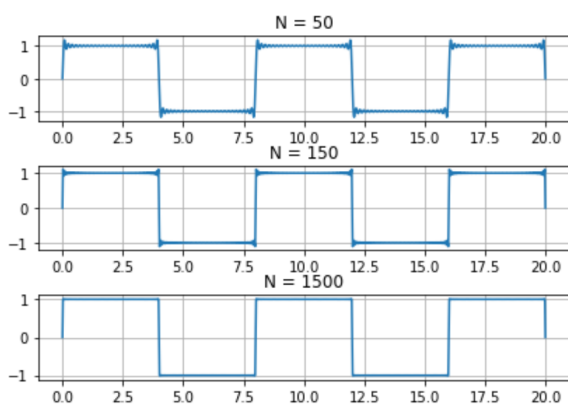
Task 1 Outputs:

```
k=1
1.2732395447351628
0
k=2
0.0
0
k=3
0.4244131815783876
0
```

Plot Set 1:



Plot Set 2:



5 Questions

1. Is $x(t)$ an even or odd function? Explain

$x(t)$ is an even function because $x(-t) = x(t)$, which is defined as an even function.

2. Based on results from Task 1, what do you expect a_1, a_2, \dots, a_n to be?

All values of a_n will be equal to 0. This is because for odd function, $a_n = 0$ for all values.

3. How does the approximation of the square wave change as the value of N increases? In what way does the Fourier series struggle to approximate the square wave

As the value of N increases, the approximation of the square wave gets more accurate. The Fourier series struggles to approximate the square wave at low N values, where the wave turns out inaccurate.

4. What is occurring mathematically in the Fourier series summation as the value of N increases?

As N increases, the number of times the Fourier series is added increases, which leads to greater accuracy of the Fourier series.

6 Conclusion

In this lab, python was used to generate plots of the Fourier series approximation of a square wave. In the plots, it is shown that as the N value increases, the accuracy of the approximation increases, to the point where, at $N = 1500$, the Fourier series looked identical to the square wave function.