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**Lab 10: Fourier Series Matlab Answer Sheet**

1. What happens to the overall signal when harmonics are added?

* The signal appears to shrink a little but by the time more harmonics are added it also begins to form a bit of a shape instead of just a scratch signal.

1. Observe each plot, listen to the associated sound and explain the relationship you notice between plot and corresponding sound.

* They sound similar but different in the amount of buzzing. After adding the third it is not as noticeable. But after adding multiple harmonics the signal sounds quite different from the original all because the buzzing from the overlap.

1. Write a brief description of how CODE 2 implements the Fourier series described by Equation (1).

* It asks for how many terms to use in the approximation and it is given by the user. This is used as well as a few equations to get a better approximation the more terms used since it runs through the loop more times and gets close to an exact number (however it can never be exact).

1. Using the command hold on, plot the graph produced by CODE 1 and CODE 2 on the same picture. Consider the number of terms N\_TERMS = 7. Insert a legend on your plot describing the two signals: name the ideal square wave f(x) and the approximation f’(x).



1. Run the code that results from B.2 for N\_TERMS = 10,20 and 30 without closing the Figure each time you run. This way you will have multiple plots on Figure 1. Include the plot on your report and answer the following question: considering the ideal square wave f(x) as a reference, where in the signal wave do the approximations of f(x) have the greatest error/oscillation?

* They all have biggest error on the rising and falling edges no matter the number of approximations.



Approximation with 10 Terms



Approximation with 20 Terms



Approximation with 30 Terms

1. The Gibbs phenomenon is an overshoot (or "ringing") of the Fourier series. Defining the overshoot as the difference in amplitude between the highest point of the approximation and the reference function, record the overshoot values in Table 1 associated with each of the following number of terms. What is the relationship between the overshoot and the number of terms in the series?

Table 1 – Overshoot for different number of terms of the FS.

|  |  |
| --- | --- |
| Number of terms | Overshoot |
| 7 | 0.0856 |
| 20 | 0.0895 |
| 30 | 0.0834 |
| 50 | 0.0824 |

* The relationship between them all is almost the exact same. This shows that no matter the number of approximations, there will always be this error on the rising and falling edge.

1. Run CODE 2 multiple times (for N\_TERMS = 7,20,30,50 and 100.) and, using the command tic toc, record in Table 2 the time MATLAB takes to perform the approximation of f(x). Notice that you can uncomment % tic and % toc to perform the required task.

Table 2 – Computational time for different number of terms of the FS.

|  |  |
| --- | --- |
| Number of terms | Computational time |
| 7 | 0.039652 s |
| 20 | 0.090180 s |
| 30 | 0.126992 s |
| 50 | 0.201497 s |
| 100 | 0.0382748 s |

1. From the previous problems it could be noticed that, the higher number of terms of the series is, more precise the approximation will be; however, the computational time cost increases. In practice, we must find a balance between precision and computational cost when using Fourier series. What determines this balance?

* What determines this balance is how close we can get to exact approximations, without taking too long to find that figure. So finding how exact the increase in between each number of terms is crucial. I assume this is why the partial sums play such a big role in Fourier series.

1. CODE 2 implements the approximation of a square wave using Fourier series. Modify this code so that it will produce the approximation of a triangular wave (more specifically, a sawtooth wave) similar to the one shown in Figure 1. In your report, include, on the same figure, plots of the approximated sawtooth function considering N\_TERMS = 10,20 and 30.



Approximation with 10 Terms



Approximation with 20 Terms



Approximation with 30 Terms

F.1.) What did you enjoy about this lab?

* + I liked how well the plots show what is happening with the approximations. I also liked the sound part of part A

F.2.) What didn’t go well in this lab?

* + It took me a moment to remember how to plot the sawtooth function.

F.3.) How would you improve the lab experiment for future classes?

* + I am still confused on how this sawtooth function works. Maybe explain just a little bit in the lab procedure.