Fourier Series Coefficient from Simulink

ECE 4513

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Abstract:
Fourier series is a concept initiated by Jean Fourier for its application to heat flow and tides. In signals and system it allows us to decompose a periodic signal into infinite sum of a sinusoid. As a engineer it allows us to understand a periodic signal as the sum of various frequencies.

Introduction:
This lab was an introduction to MATLAB/Simulink and how to generate a periodic waveform whose values are stated in a separate PDF. For this lab a sinusoid is added to a constant C voltage, then inputted into a dead zone discontinuity block. This output is then feed into a spectrum analyzer and analyzed for the lab. The dead zone discontinuity block will have a SDZ of -3.5 and a EDZ OF 3.5. The parameters of the lab were as followed A=9,T = 1.6 mSec,and C= -2.

Our first task was to use the parameters given to make a the signal that will analyze.The next task was to obtain the magnitude of the polar Xn Fourier Series components using Simulink. The components for n=0 to 5 were found. Next we obtained the polar Xn coefficients by manual calculation for 0-5. Task 3 was to calculate the magnitude of the complex Fourier Series components | Dk | for k = 0-5. The final task was to calculate the percentage of total normalized average power %Pav for the summated Xn for the sets n=0-2,n=0-3,n=0-4, and n = 0-5 using Parseval's Theorem.

Discussion:
The first step was to create the signal needed to analyze using the parameters given to us in a separate pdf. In order to do this the file given was used and the values were changed, the amplitude was changed to 9 and the constant that was added to the sinusoidal was changed to -2. Next the deadzone start and stop were changed to -3.5 and 3.5 respectively The final step was to change the settings on the spectrum analyzer. The following settings were changed the span was changed to 15e3,CF changed to 7500,window length to 1050. This gave a RBW of 648.96 which is the resolution of the readings we record..

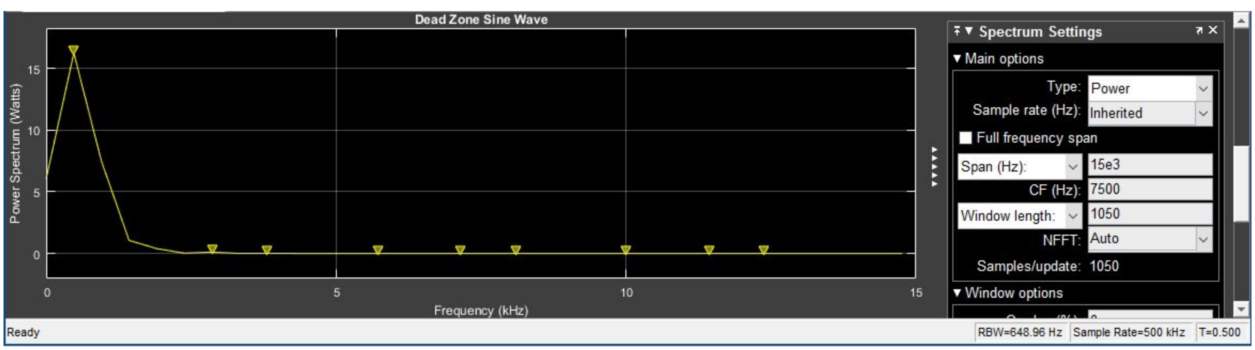

Figure 1: The diagram above shows the spectrum output of the signal created. The settings on the right are the ones changed to better fit our analysis.

The scope of the signal we created before and after inputting it into the deadzone will be posted in the appendix. The next task was to obtain the magnitude of the polar Xn for n=0,1,2,3,4,5. In order to achieve this the units from the spectrum analyzer were changed from dbm to watts. The resulting values are found in figure 2 below.

n	Xn	Est(From Simulink)	|Dk| = A/(pi*(1-N^2))	Xn Calculated
0	6.055	2.46069096	2.858849091	5.717698182
1	13.58	2.605762844	2.25	4.5
2	2.836	1.190798052	0.952949697	1.905899394
3	0.38	0.4358898944	0.3573561364	0.7147122727
4	0.061	0.174642492	0.1905899394	0.3811798788
5	0.023	0.1072380529	0.1191187121	0.2382374242
%Pav	**Pav**			
14.85%	151.2985105			
15.10%				
15.14%				
15.16%				

Figure 2: The calculated Xn and simulink Xn are shown as well as %Pav,Pav, and both calculated and estimated Dk.

The task in 2 and 3 are to manual calculate the Xn coefficient and the magnitude of complex Fourier Series components |Dk| both for n = 0,1,2,3,4,5. In order to do this the equations below are used.

$$|D_k| = \frac{A}{(pi * (1 - N^2))} \qquad X_n = 2|D_k|$$

Figure 3:Shows equations used for task 2 and 3

The equation (Xn/2)^(.5) is used to find the estimated value of Dk based on the computer simulation.The final task was to calculate the percentage of total normalized average power. The equations used for this is shown below.

$$\boxed{\frac{1}{T}\int_{-T/2}^{T/2} |s(t)|^2\, dt = |X_0|^2 + \sum_{n=1}^{\infty} X_n^2 / 2}$$

Figure 5: The equation above is used to find Pav which is needed to find %Pav

$$\boxed{\% P_{AV} = \frac{|D_0|^2 + 2\sum_{k=1}^{N} |D_k|^2}{P_{AV}} \times 100}$$

Figure 6: The equation above is used to find %Pav

The final values of each task are shown in figure 2.

Conclusions:

For this lab the creation of the wave was properly created and shown in the appendix figure 8. The SDZ and EDZ was found by using the equation -.5(A+C) and .5(A+C) respectively. One error that could have occurred during this lab was calculating Xn and |Dk|, using the equation from the PPT could have changed based on the equation used. An example of this is in order to find Xn the integral of the signal times e^(a), this would have created a very large equation that could be affected by incorrect evaluation.Another error that could have occured in this lab is finding the deltaF. For this lab we used the simulation value of 648 Hz, this would changed the number of samples and the Fs of the lab.

Appendix:

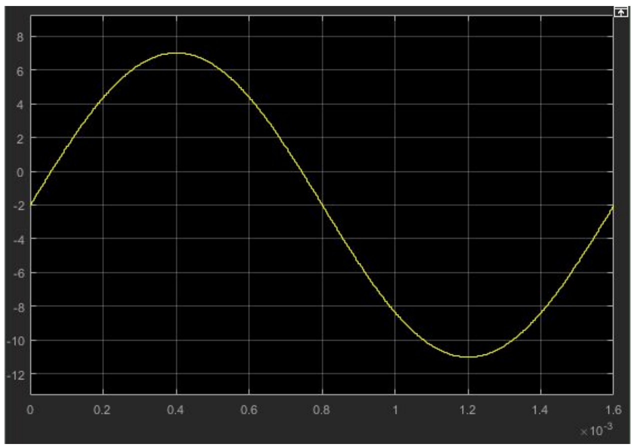

Figure 7: Signal above is a sine wave with A=9 added with a constant -2.

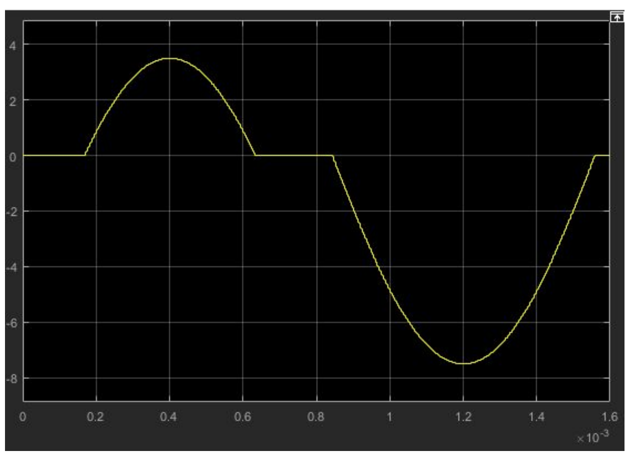

Figure 8: Signal above is the output of the deadzone block with SDZ of -3.5 and EDZ of 3.5.

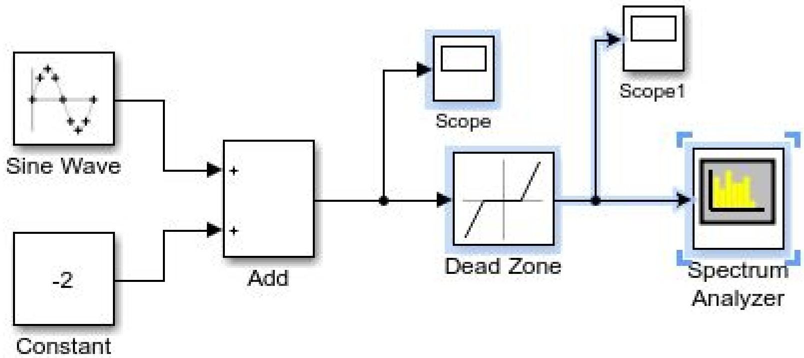

Figure 9: Shows the block diagram of the lab. Scope is the signal shown in figure 7 and scope1 is the signal shown in figure 8. The constant value of -2 is used for the constant block.