

STUDENT FEEDBACK FORM-JORDAN THOMAS

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills		
Your work has shown that you researched adequately into the topic and you demonstrated a good understanding of the subject. If you had used other sources such as books, papers, magazines etc, rather than simply relying on the internet would have gained the highest score. The student has clearly shown that he has all-important skills needed to define the essential ideas from sufficient information. The quality of the references needs to be improved.	15	10
2. Knowledge and Understanding Skills		
The report shows good effort and good understanding of the topics covered. Good structure, detail and data presented in clear and appropriate format throughout.	20	20
3. Cognitive and Intellectual Skills		
Your work showed that you can summarise scientific facts into your own words without compromising academic style. There is a coherent flow in the writing and the reader can easily follow the simulations process and the analysis of the results. You have made it interesting to read and have also made attempts at drawing conclusions for the area you studied.	20	12
4. Practical Application Skills		
A good and appropriate application of established methods and techniques. The report clearly demonstrates the student has a clear understanding of studies to date and also shows the student's ability to work as an individual. Good detail provided throughout the report with all aspects being suitably and sufficiently carried out. All tables and figures presented are thoroughly discussed in the assignment. All aspects have been covered in excellent detail.	20	12
5. Transferable Skills for Life and Professional Practice		
Mostly ordered presentation and structure in which relevant concepts are reasonably expressed. Demonstrates the basic skills for employment requiring the exercise of personal responsibility and decision-making, with some areas of minor weakness	25	12

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)

Late Submission Penalties (tick if appropriate)

Up to 1 week late (40% Max)

Over 1 week late (0%)

66%

✓



HND: ELECTRICAL & ELECTRONIC ENGINEERING

Jordan Thomas



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Module Code: M2X0003

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Definition of Fourier series and Fourier transform

Fourier series

The Fourier series was originally introduced by the French mathematician Joseph Fourier who used the series to describe how heat transferred through a metal plate. Now it is widely used for analysis in engineering and physics as a way to expand a periodic function by a series in terms of an infinite amount for sine waves and cosine waves. (Interactive Mathematics, 08. 2017) These periodic functions can be analysed into their harmonics and fundamentals. ✓

The Fourier series is as follows:

$$f(x) = a_0 + \sum_{n=1}^{\infty} [a_n \cos nx + b_n \sin nx]$$

a_0
A₀ — This refers to the fundamental frequency.

a_n, b_n
A_n, B_n — These are the harmonic components of the fundamental frequency. Even harmonics will be an even value as a fundamental frequency and odd harmonics will be an odd value as a fundamental frequency.

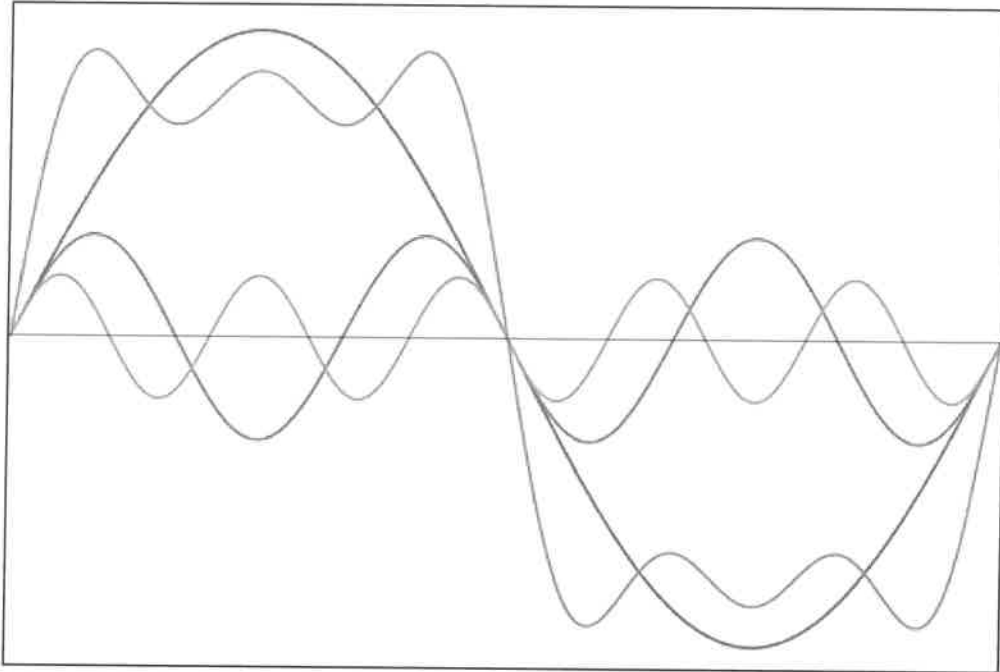
Fourier transform

The Fourier transform is used to breakdown a function or signal displayed as a waveform into a sum of sinusoidal base functions. The transform shows that any waveform can be re-written. (The Fourier Transform.com, 2010). This tool shows us how to reverse the waveform into its sinusoidal components and is therefore an extremely important tool for scientists and engineers due to the amount of applications. The Fourier transform is an extension of the Fourier series idea but applies to non-periodic function. (The Fourier Transform.com, 2010). ✓

Importance of the Fourier transform

It is an important mathematical tool because it can allow the user to view a signal in a different domain. Within this many challenging problems can become very simple to analyse as the transfer of a signal is able to frequencies and proportions that make up the signal. Some practical examples of how important the transform is are: The technology and consumer products associated with digital processing rest on the mathematical base of Fourier analysis. (A.G.Marshall and F.R.Verdun) Also it is impossible to describe the function of an X-ray diffraction machine without using the vocabulary and concepts of Fourier analysis. (Useful Tips and Tricks for Technology, Finance and Life, January 23rd, 2015) ✓

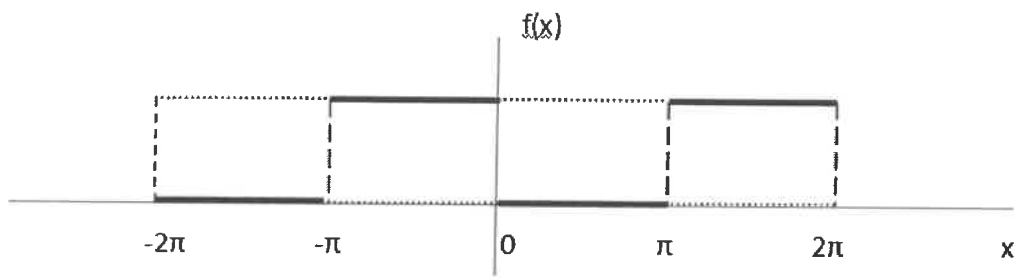
Square sign wave



(Electrical Engineering , May 2012) ✓

The image above shows how a square wave is formed. When more than one sine wave gets combined they form a complex wave. The blue line is the fundamental; it has a high amplitude and a low frequency. The purple line is the 3rd harmonic it has a lower amplitude but a higher frequency. The brown line is the 5th harmonic which has the smallest amplitude but the highest frequency (There are no even harmonics in a square wave). The green line is the result of adding these. The wave is not quite square but it is clear to see the difference made with more harmonics. With an infinite amount of harmonics a perfect square wave would be created. ✓

Fourier trigonometric series representation (task 3)



- Where $f(x) = \begin{cases} 1, & -\pi < x < 0 \\ 0, & 0 < x < \pi \end{cases}$
- $f(x) = a_0 + \sum_{n=1}^{\infty} [a_n \cos nx + b_n \sin nx]$

A_0 $\rightarrow a_0$

$$a_0 = \frac{1}{2\pi} \int_{-\pi}^{\pi} f(x) dx$$

$$a_0 = \frac{1}{2\pi} \int_{-\pi}^0 f(x) dx + \frac{1}{2\pi} \int_0^{\pi} f(x) dx$$

$$a_0 = \frac{1}{2\pi} \int_{-\pi}^0 1 dx + \frac{1}{2\pi} \int_0^{\pi} 0 dx$$

$$a_0 = \frac{1}{2\pi} [x]_{-\pi}^0$$

$$a_0 = \frac{1}{2\pi} [\pi]$$

$$a_0 = \frac{1}{2}$$

A_n $\rightarrow a_n$

$$a_n = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \cos nx dx$$

$$a_n = \frac{1}{\pi} \int_{-\pi}^0 1 \cos nx dx + \frac{1}{\pi} \int_0^{\pi} 0 \cos nx dx$$

$$a_n = \frac{1}{\pi} \left(\left[\frac{\sin nx}{n} \right]_{-\pi}^0 \right)$$

$$a_n = \frac{1}{n\pi} ([\sin nx]_{-\pi}^0)$$

$$a_n = \frac{1}{n\pi} [\sin n0 - \sin(-n\pi)]$$

$$a_n = \frac{1}{n\pi} [0 + \sin(n\pi)]$$

$$a_n = \frac{1}{n\pi} [0 + 0]$$

$$a_n = 0$$

B_n $\rightarrow$ ~~D_n~~

$$b_n = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \sin nx \, dx$$

$$b_n = \frac{1}{\pi} \int_{-\pi}^0 f(x) \sin nx \, dx + \frac{1}{\pi} \int_0^{\pi} f(x) \sin nx \, dx$$

$$b_n = \frac{1}{\pi} \int_{-\pi}^0 1 \sin nx \, dx + \frac{1}{\pi} \int_0^{\pi} 0 \sin nx \, dx$$

$$b_n = \frac{1}{\pi} \left[\frac{-\cos nx}{n} \right]_{-\pi}^0$$

$$b_n = \frac{-1}{n\pi} [\cos nx]_{-\pi}^0$$

$$b_n = \frac{-1}{n\pi} [\cos 0 + \cos \pi]$$

$$b_n = \frac{-1}{n\pi} [1 + 1]$$

$$b_n = \frac{-2}{n\pi} \text{ when } n \text{ is odd}$$

$$b_n = 0 \text{ when } n \text{ is even}$$

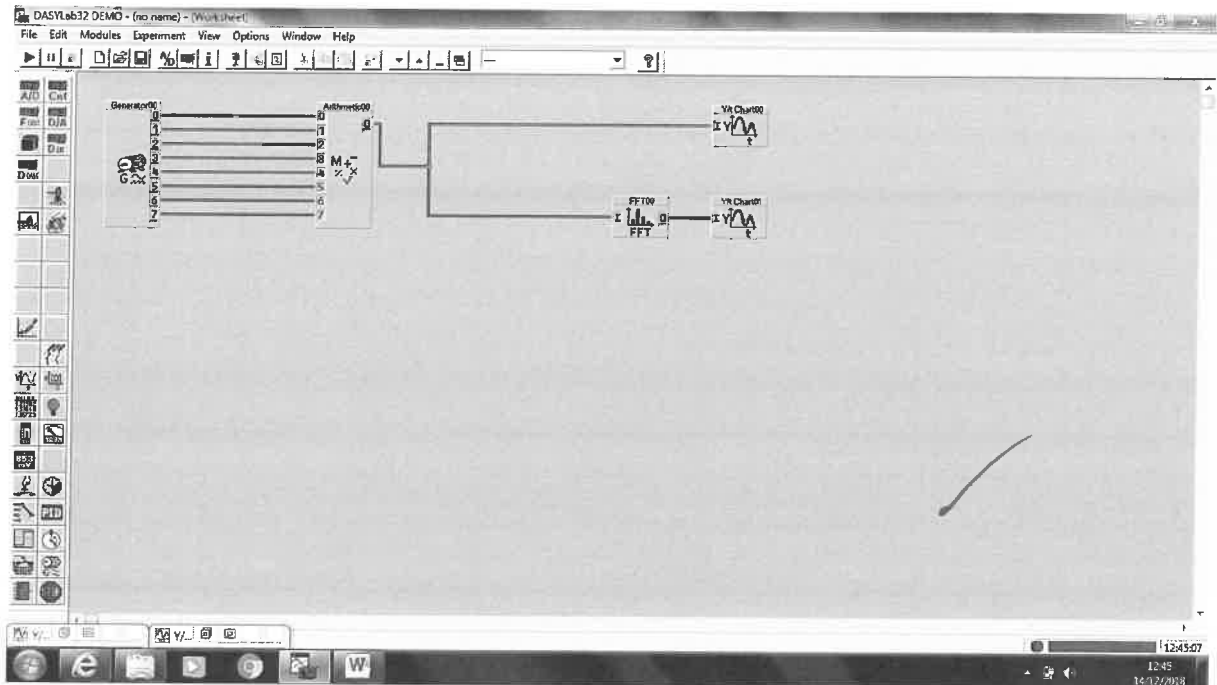
Therefore the Fourier series representation for the first 7 harmonics is,

$$f(x) = \frac{1}{2} + \frac{-2}{\pi} \sin x + 0 \sin 2x + \frac{-2}{3\pi} \sin 3x + 0 \sin 4x + \frac{-2}{5\pi} \sin 5x + 0 \sin 6x + \frac{-2}{7\pi} \sin 7x$$

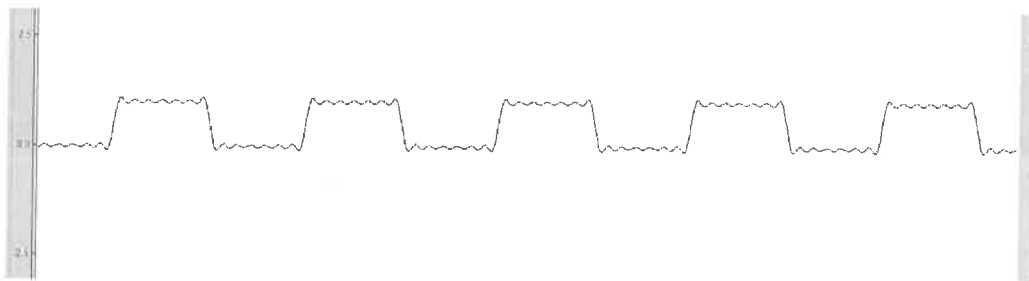


Verification and Fast Fourier Transform (FFT)

I have used dasy lab software in order to find and display the transform of square wave. I will describe each screen shot as required below:

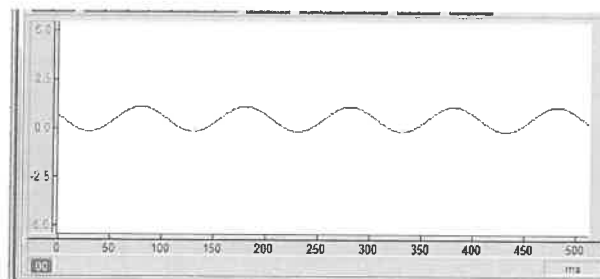


This is the design page which is used to create the sign waves. For this example I used 7 harmonics which are displayed as the green lines between the generator and the arithmetic tool. The output then goes into a Fast Fourier Transfer (FFT) tool and a graph for analysis.

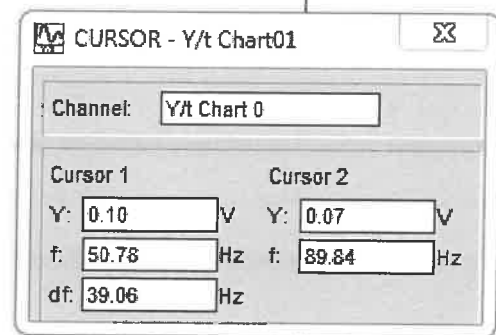


The above is the waveform I created using the software. This is the result of 7 harmonics and the wave is beginning to take a square shape.

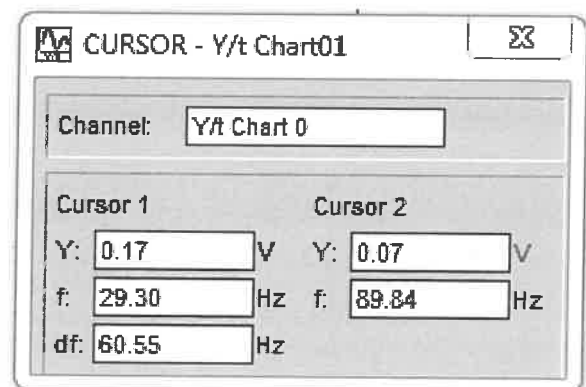
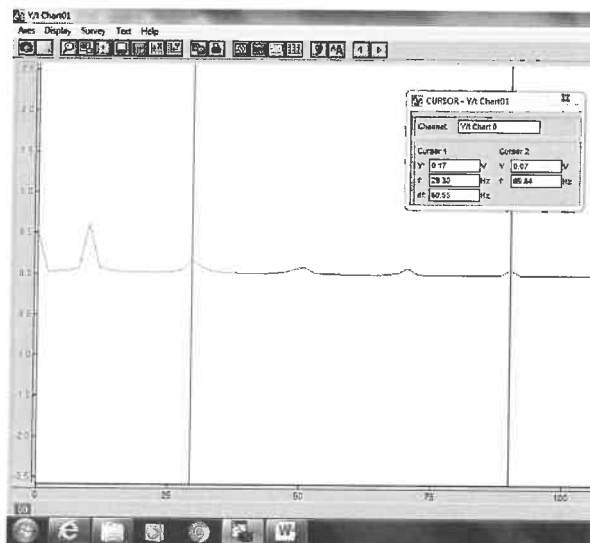
In comparison the waveform below only has 3 harmonics and it is clear to see the difference in the wave shape.



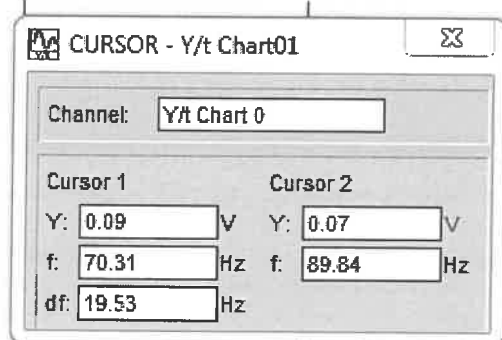
I then used the Fast Fourier Transfer tool to find the transform of my wave and analyse below.



Above shows the chart with the cursor at 2 different frequencies, 50.78 Hz and 89.84 Hz. 50.78 Hz has an amplitude of 0.10. 89.84 Hz has an amplitude of 0.07. These are both very close to my calculations below.



This chart has the cursor on the first odd harmonic at 29.30 Hz with amplitude of 0.17. This again is very close to the figure I calculated below.



For this example the cursor is on the odd harmonic for 70.31 Hz with the amplitude of 0.09.

The results from my calculations for the odd harmonics are as follows:

The first harmonic has a frequency of 10.

The second harmonic has a frequency of 30 and amplitude of $0.212 (2 \div (3\pi))$

The third harmonic has a frequency of 50 and amplitude of $0.127 (2 \div (5\pi))$
The forth harmonic has a frequency of 70 and amplitude of $0.090 (2 \div (7\pi))$
The fifth harmonic has a frequency of 90 and amplitude of $0.070 (2 \div (9\pi))$
The sixth harmonic has a frequency of 110 and amplitude of $0.057 (2 \div (11\pi))$
Finally the seventh harmonic has a frequency of 130 Hz and amplitude of $0.0489 (2 \div (13\pi))$

Summary

I feel the results generated through the software are very similar to the results I've calculated which prove the accuracy. The simulation is a good tool to break down complex waveforms and help analyse them. For the first part I could have added more harmonics to try and create a more perfect square wave.



Reference page

Bibliography

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