Part 1B Experimental Engineering

Integrated Coursework **Extended Exercise**

Windowing

Introduction

The DFT algorithm, like the Fourier transform, is designed to operate on a continuous signal (i.e., continuous in time). As it is not possible to measure a signal for all time, the continuous signal is synthesised from that measured during a finite time period (period T). This will usually produce a discontinuity in the signal when an attempt is made to match up the first and last sampled points – see figures below.

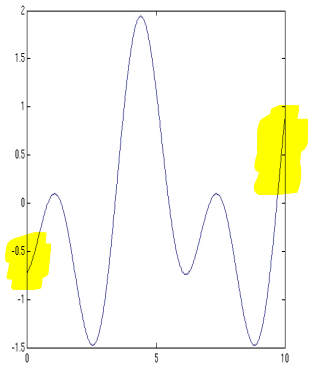

Figure 1: Sampled wave

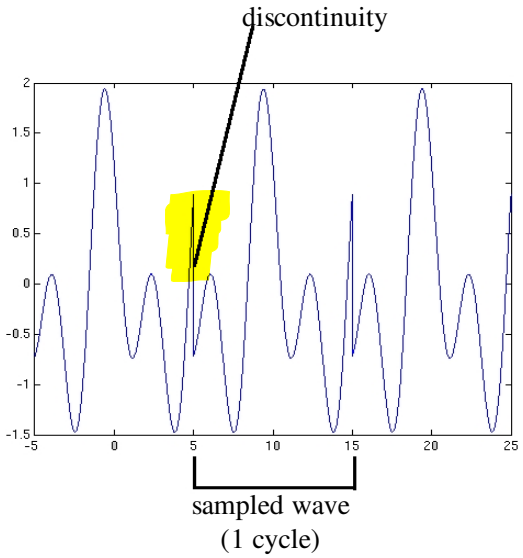

Figure 2: Repeated wave used in the Fourier transform/DFT

This causes a problem, as the Fourier transform treats the discontinuity as part of the original function, leading to spurious results (termed spectral leakage). This can be mitigated by the use of windowing. A window functions multiplies the time-domain signal to reduce or remove this discontinuity. This is demonstrated in the diagrams below using a Hamming window – this is a particular type of window function, of which there are many.

While the use of a window function can be beneficial, it can also have drawbacks. In this extended exercise, you are asked to investigate these effects further.

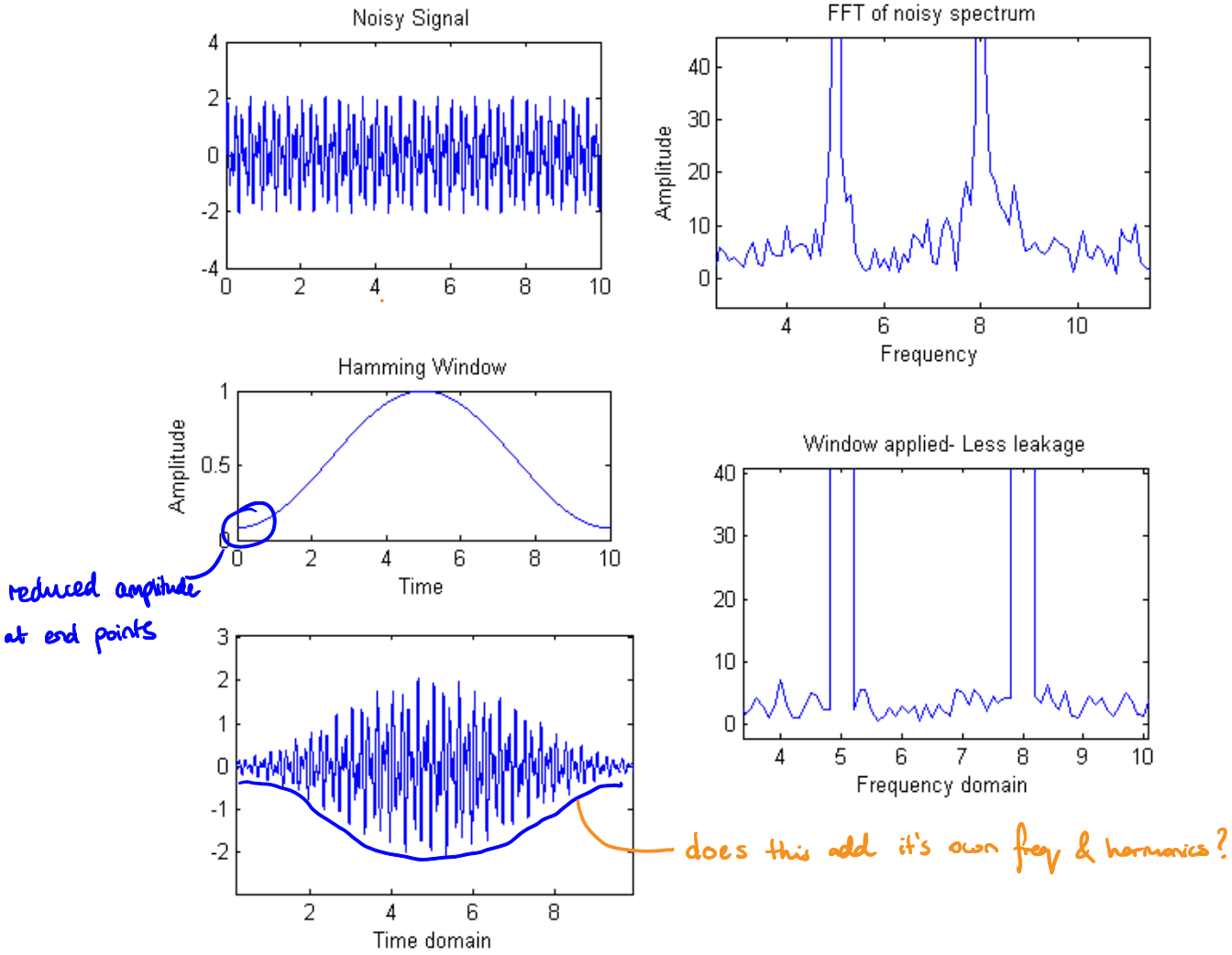

Figure 3: The effects on the Fourier transform of multiplying the time-domain signal by a window function

Aims and Objectives

1. Understand the purpose of windowing, when it might be needed, and what factors should be taken into account.
2. Research various different types of window functions and investigate their properties.
3. Comment on how the signal properties affect the choice of window. What type of window function would you use for the data collected in the short lab, and why? What type of window would you use for actual earthquake data? *(Hint: remember a real earthquake has quite a sharp increase in amplitude at the beginning. Some earthquake data is available in the integrated coursework online resources.)*

Then attempt one (or both) of the following tasks:

- Design and conduct an experiment to test the effects of various types of windowing function. Using generated data (e.g. a sum of sine waves) gives a signal with a known frequency content, so you know what the desired results are, and can compare each window function with these.
- Investigate and test the effects of window overlapping. What are the optimum amounts of overlap required for various signals and window functions?