Digital Signal Processing: COSC390

Jordan Hanson

January 1, 2019

Whittier College Department of Physics and Astronomy

Course Introduction

1. *What is digital signal processing?*
2. *COSC330: Computer Logic and Digital Circuit Design*
3. Read the syllabus for a roadmap
4. *This course can be fast.*
5. **Data science project and presentation**
6. Textbook: `http://dspguide.com`
7. Download and install octave:
   `https://www.gnu.org/software/octave`

Lecture format, with modifications

- Theory and examples
- Programming with Octave
- Application
- Study hall
    1. Homework help
    2. Project and presentation development
    3. Special topics lectures

Unit 1.1 Outline

1. Complex numbers 1: Arithmetic and some calculus (continuous and discete)
2. Complex numbers 2: The Fourier series and Fourier transform (continuous and discrete)
3. *Time-permitting*: The Laplace transform (continuous and discrete)

Complex numbers 1

Complex numbers 1: Definition of a complex number

A complex number is an expression for which one term is proportional to $j = \sqrt{-1}$:

$$z = x + jy \tag{1}$$

To call the *complex unit* j is the convention in electrical engineering, and in physics it is often called i.

Example of complex numbers: $(3 + 4j)$, $(x_1 + x_2 j)$. Each number has a *real* part and an *imaginary* part.

Operations to learn:

1. Addition
2. Subtraction
3. Real part Re and Im
4. Multiplication
5. Division
6. Conjugation
7. Magnitude/Norm

Addition follows the pattern of two-dimensional vectors:

$$z_1 = 3 + 4j \tag{2}$$

$$z_2 = -2 + 5j \tag{3}$$

$$z_1 + z_2 = 1 + 9j \tag{4}$$

Subtraction follows the pattern of two-dimensional vectors:

$$z_1 = 3 + 4j \tag{5}$$

$$z_2 = -2 + 5j \tag{6}$$

$$z_1 - z_2 = 5 - 1j \tag{7}$$

Complex numbers 1: Operations

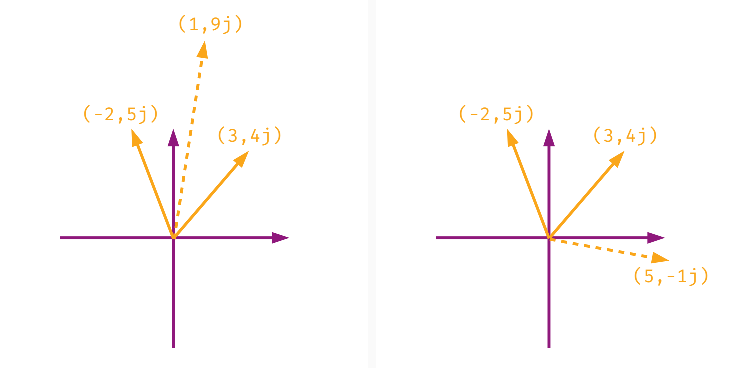

Figure 1: Complex addition and subtraction follows the pattern of two-dimensional vectors.

We also have the Re and Im operations:

$$z_1 = 3 + 4j \tag{8}$$

$$\mathrm{Re}\{z_1\} = 3 \tag{9}$$

$$\mathrm{Im}\{z_2\} = 4 \tag{10}$$

These are known as taking the *real*-part and the *imaginary*-part. The original complex number can be recovered by adding real and imaginary parts together:

$$z_1 = \mathrm{Re}\{z_1\} + j\,\mathrm{Im}\{z_1\} \tag{11}$$

When we add/subtract complex numbers, we combine the real parts and imaginary parts separately.

Add or subtract, then simplify:

1. $z_1 = 7 + 7j$, $z_2 = -6 + 3j$. $z_1 + z_2 =$
2. $z_1 = 2 + 2j$, $z_2 = 3 - 3j$. $z_1 - z_2 =$
3. $z_1 = 2x + 7j$, $z_2 = 2 + 4xj$. $z_1 + z_2 =$

Let $x = -1$ and $y = 1$. *Evaluate the following expressions:*

1. $z_1 = x + yj$, $z_2 = y + xj$. $z_1 + z_2 =$
2. $z_1 = x^2 + y^2 j$, $z_2 = 2y^2 + x^2 j$. $z_1 - z_2 =$

Multiplication: Recall that $j^2 = -1$.

$$z_1 = x_1 + jy_1 \tag{12}$$

$$z_2 = x_2 + jy_2 \tag{13}$$

$$z_1 \times z_2 = x_1x_2 - y_1y_2 + j(x_1y_2 + x_2y_1) \tag{14}$$

The cross-terms are straightforward, but remember the minus sign when multiplying the imaginary parts.

Complex numbers 2

Conclusion

Conclusion

Text