

Digital Signal Processing SS 2024 – Exercise 1

Digital Signal Processing Tutorial

Group 23

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Exercise 1

We have three complex numbers given:

$$c_1 = -5 + 3j \qquad c_2 = \frac{\sqrt{2}}{2} e^{-\frac{3\pi j}{4}} \qquad c_3 = \frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}j$$

a) We do the calculations by hand. First, let's use Euler's formula to simplify c_2 :

$$c_2 = \frac{\sqrt{2}}{2} e^{-\frac{3\pi j}{4}} = \frac{\sqrt{2}}{2} \left(\cos\left(\frac{3\pi}{4}\right) + j \sin\left(\frac{3\pi}{4}\right) \right) = \frac{\sqrt{2}}{2} \left(-\frac{\sqrt{2}}{2} + \frac{\sqrt{2}}{2}j \right) = -\frac{1}{2} + \frac{1}{2}j$$

With this, let us now compute the following numbers:

$$c_4 = c_1 + c_2 = -5 - \frac{1}{2} + 3j + \frac{1}{2}j = -\frac{11}{2} + \frac{7}{2}j$$

$$c_5 = c_1 \cdot c_2 = (-5 + 3j) \cdot \left(-\frac{1}{2} + \frac{1}{2}j \right) = \frac{5}{2} - \frac{5}{2}j - \frac{3}{2}j - \frac{3}{2} = 1 - 4j$$

$$c_6 = |c_3|^2 = \left(\sqrt{\left(\frac{1}{\sqrt{2}}\right)^2 + \left(\frac{1}{\sqrt{2}}\right)^2} \right)^2 = \left(\sqrt{\frac{1}{2} + \frac{1}{2}} \right)^2 = (\sqrt{1})^2 = 1$$

$$c_7 = \arg(c_3) = \operatorname{atan2}\left(\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}\right) = \arctan\left(\frac{\frac{1}{\sqrt{2}}}{\frac{1}{\sqrt{2}}}\right) = \arctan(1) = \frac{\pi}{4}$$

$$c_8 = \frac{c_1}{c_2} = \frac{-5 + 3j}{\frac{-1+1j}{2}} = \frac{-10 + 6j}{-1 + 1j} = \frac{(-1 - 1j)(-10 + 6j)}{(-1 - 1j)(-1 + 1j)} = \frac{10 - 6j + 10j + 6}{1 - 1j + 1j + 1} = 8 - 2j$$

$$c_9 = c_1 \cdot c_1^* = (-5 + 3j)(-5 - 3j) = 25 + 15j - 15j + 9 = 34$$

b) We check the result using MATLAB.

This is the code we use:

```
c1 = -5 + 3j
c2 = sqrt(2)/2 * exp((3j*pi)/4)
c3 = 1/sqrt(2) + 1j/sqrt(2)
```

```
c4 = c1 + c2
```

```
c5 = c1 * c2
```

```

c6 = abs(c3)^2
c7 = angle(c3)
c8 = c1 / c2
c9 = c1 * c1 '

```

These are the results:

```

c1 = -5.0000 + 3.0000 i
c2 = -0.5000 + 0.5000 i
c3 = 0.7071 + 0.7071 i
c4 = -5.5000 + 3.5000 i
c5 = 1.0000 - 4.0000 i
c6 = 1.0000
c7 = 0.7854
c8 = 8.0000 + 2.0000 i
c9 = 34

```

Checks out. (Question: what is the best way to get this output from MATLAB to latex? The way I did it was copying it from the console, but that was rather cumbersome since I needed to remove the blank lines.)

Exercise 2

Exercise 3

Exercise 4