Exercise 9

IIR Filter Design

1. Where in the z-plane are the following s-plane poles mapped as a result of bilinear transformation with $c = 0.3$:

- $p_1 = -2 + 3j$
- $p_2 = 2 + 3j$
- $p_3 = 0$
- $p_4 = 8j$
- $p_5 = -18j$
- $p_6 = -8000j$
- $p_7 = -0.3$
- $p_8 = \infty j$

Express $p_1, p_2 \ldots p_8$ as complex exponential.

2. Use pen and paper (and probably a calculator) to design a digital IIR Butterworth filter using bilinear transformation, which meets the following specifications:

$$\omega_p = 0.2\pi$$
$$\omega_s = 0.4\pi$$
$$A_p = 3\text{dB}$$
$$A_s = 20\text{dB}$$

3. Using MATLAB, design an IIR Butterworth, Chebyshev I, Chebyshev II and elliptic filter which meet the following specifications:

$$\omega_p = 0.2\pi$$
$$\omega_s = 0.24\pi$$
$$A_p = 3\text{dB}$$
$$A_s = 20\text{dB}$$

Confirm that the solutions given by MATLAB do meet the specifications.

4. Consider the transfer function:

$$H(z) = \frac{0.3375 + 0.3375z^{-1}}{1 - 0.3249z^{-1}}$$

What is the location of its poles and zeros? What kind of filter is $H(z)$? Using the equations on page 62 of the lecture notes, design a highpass filter with passband edge at $0.7\pi$, assuming that the passband edge of $H(z)$ is located at $0.3\pi$. How about a
highpass filter with passband edge at $0.3\pi$? (Note: Equation 39a, Lecture notes, Part IV, Page 62, which is given below).

\[ Z^{-1} = G(z^{-1}) = -\frac{z^{-1} + \alpha}{1 + \alpha z^{-1}} \]