Solution of ECE 316 Test 8 S06

1. What are the numerical s-plane finite pole and finite zero locations for Butterworth filters of order N with corner frequencies f_c in Hz or ω_c in radians/second. (For repeated poles or zeros list them multiple times.)

(a) Lowpass, $N = 2$, $\omega_c = 25$

Poles at $25e^{\pm j3\pi/4} = 17.68(-1 \pm j)$ and No Zeros

$$\mathrm{H}_{norm}(s) = \frac{1}{(s - e^{j3\pi/4})(s - e^{-j3\pi/4})} \xrightarrow{s \to s/25} \mathrm{H}(s) = \frac{1}{(s/25 - e^{j3\pi/4})(s/25 - e^{-j3\pi/4})}$$

$$\mathrm{H}(s) = \frac{625}{(s - 25e^{j3\pi/4})(s - 25e^{-j3\pi/4})} \text{ , Poles at } 25e^{\pm j3\pi/4} = 17.68(-1 \pm j)$$

No finite zeros.

(b) Highpass, $N = 2$, $f_c = 5$

Poles at $10\pi/e^{\pm j3\pi/4} = 22.2(1 \pm j)$ and Double Zero at zero.

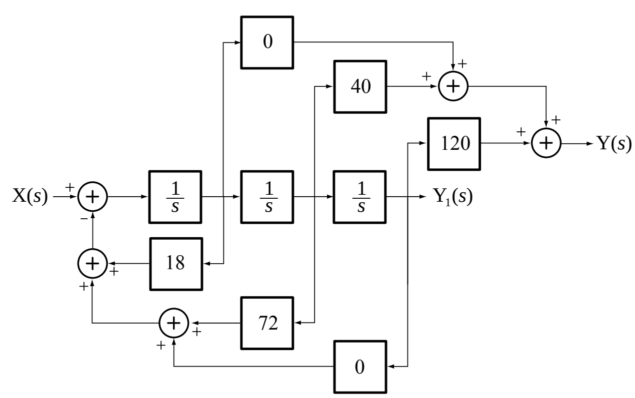
$$\mathrm{H}_{norm}(s) = \frac{1}{(s - e^{j3\pi/4})(s - e^{-j3\pi/4})} \xrightarrow{s \to 10\pi/s} \mathrm{H}(s) = \frac{1}{(10\pi/s - e^{j3\pi/4})(10\pi/s - e^{-j3\pi/4})}$$

$$\mathrm{H}(s) = \frac{s^2/(10\pi)^2}{(1 - se^{j3\pi/4}/10\pi)(1 - se^{-j3\pi/4}/10\pi)} \text{ , Poles at } 10\pi/e^{\pm j3\pi/4} = 22.2(1 \pm j)$$

2. Put numbers in the standard third-order CT system canonical block diagram below for the system whose transfer function is

$$\mathrm{H}(s) = \frac{40(s+3)}{s(s+6)(s+12)} = \frac{40s + 120}{s^3 + 18s^2 + 72s}.$$

(Put a number in each gain block even if it is zero.)



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1. What are the numerical s-plane finite pole and finite zero locations for Butterworth filters of order N with corner frequencies f_c in Hz or ω_c in radians/second. (For repeated poles or zeros list them multiple times.)

(a) Lowpass, $N = 2$, $f_c = 25$ $\quad \omega_c = 2\pi f_c = 50\pi$

Poles at $50\pi e^{\pm j3\pi/4} = 111.07(-1 \pm j)$ and No Zeros

$$\mathrm{H}_{norm}(s) = \frac{1}{(s - e^{j3\pi/4})(s - e^{-j3\pi/4})} \xrightarrow{s \to s/50\pi} \mathrm{H}(s) = \frac{1}{(s/50\pi - e^{j3\pi/4})(s/50\pi - e^{-j3\pi/4})}$$

$$\mathrm{H}(s) = \frac{(50\pi)^2}{(s - 50\pi e^{j3\pi/4})(s - 50\pi e^{-j3\pi/4})} \quad \text{, Poles at } 50\pi e^{\pm j3\pi/4} = 111.07(-1 \pm j)$$

No finite zeros.

(b) Highpass, $N = 2$, $\omega_c = 5$

Poles at $5/e^{\pm j3\pi/4} = 3.53(1 \pm j)$ and Double Zero at zero.

$$\mathrm{H}_{norm}(s) = \frac{1}{(s - e^{j3\pi/4})(s - e^{-j3\pi/4})} \xrightarrow{s \to 5/s} \mathrm{H}(s) = \frac{1}{(5/s - e^{j3\pi/4})(5/s - e^{-j3\pi/4})}$$

$$\mathrm{H}(s) = \frac{s^2/25}{(1 - se^{j3\pi/4}/5)(1 - se^{-j3\pi/4}/5)} \quad \text{, Poles at } 5/e^{\pm j3\pi/4} = 3.53(1 \pm j)$$

2. Put numbers in the standard third-order CT system canonical block diagram below for the system whose transfer function is

$$\mathrm{H}(s) = \frac{20(s+2)}{s(s+5)(s+11)} = \frac{20s + 40}{s^3 + 16s^2 + 55s}.$$

(Put a number in each gain block even if it is zero.)