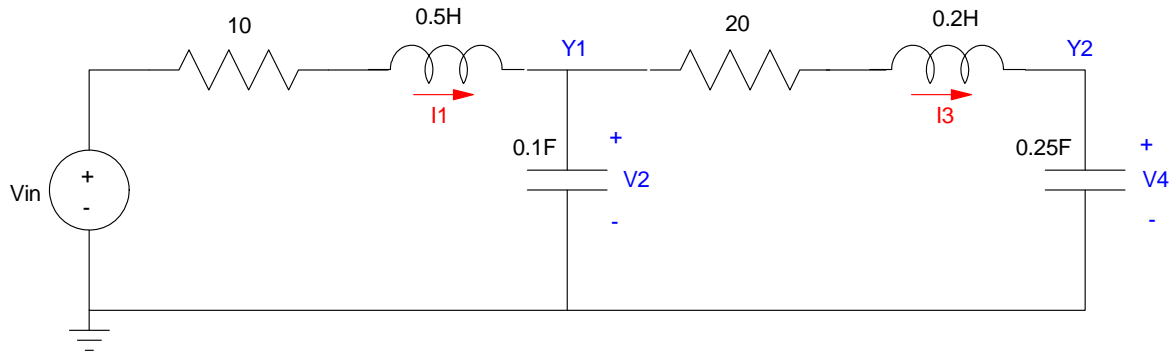


# Homework #5: ECE 461/661

State-Space, Canonical Forms, Transfer Functions for Electrical Circuits, Heat Equation. Due Monday, October 1, 2018

## Transfer Functions for Electrical Circuits

### Problem 1 & 2:



Problem 1 & 2

### Problem 1: Assume the output is $Y1$ .

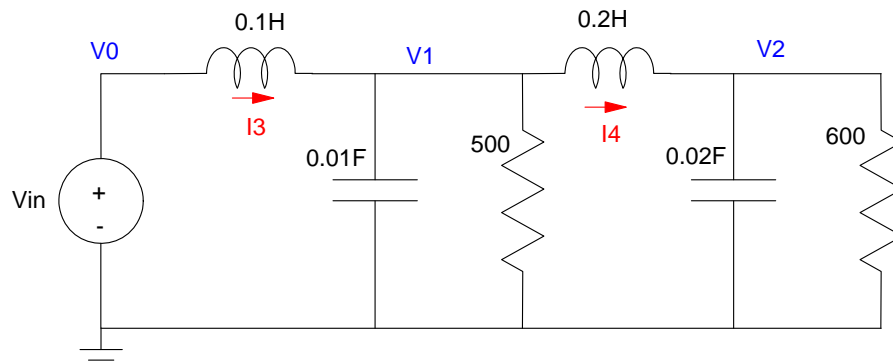
- Write the  $N$  coupled differential equations which describe this circuit (i.e. write the dynamics in terms of  $I_L$  and  $V_C$ )
- Express these differential equations in state-space form with the state variables being  $\{I1, V2, I3, V4\}$
- Find the transfer function from  $V_{in}$  to  $Y1$
- Plot the step response

### Problem 2: Assume the output is $Y2$ .

- Find the transfer function from  $V_{in}$  to  $Y2$
- What changes in the state-space equations when you change the output?
- What changes in the transfer function when you change the output? (do the poles change? do the zeros change?)

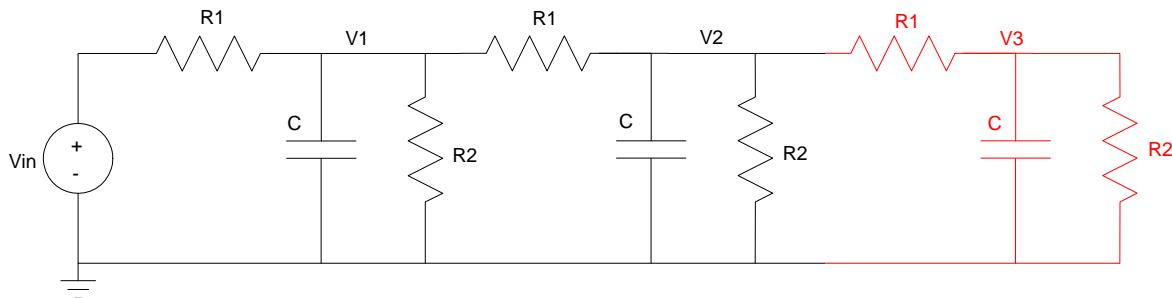
### Problem 3:

- Write the  $N$  coupled differential equations which describe this circuit (i.e. write the dynamics in terms of  $I_L$  and  $V_C$ )
- Express these differential equations in state-space form with the state variables being  $\{I1, I2, I3, V4\}$
- Find the transfer function from  $V_{in}$  to  $V2$
- Plot the step response



Problem #3

**Problem 4: 3-Stage RC Filter**



Problem 4:  $C = 0.01F$ ,  $R1 = 10 \text{ Ohms}$ ,  $R2 = 100 \text{ Ohms}$

- Write the  $N$  coupled differential equations which describe this circuit (i.e. write the dynamics in terms of  $V1, V2, V3$ )
- Express these differential equations in state-space form with the state variables being  $\{V1, V2, V3\}$
- Find the transfer function from  $Vin$  to  $V3$
- Plot the step response

**Problem 5: 10-Stage RC Filter.** Add seven more stages to the previous problem (copy the section in red seven more times).

- Express these differential equations in state-space form with the state variables being  $\{V1, \dots, V10\}$
- Find the transfer function from  $Vin$  to  $V10$
- Plot the step response