Lecture 10 - Module 2

Today:
- Composing blocks (continued)
- Design procedure
- Design examples

\[ f(c) \rightarrow g(c) \rightarrow \]

\[ f(c) \rightarrow \ \text{mid}_L \rightarrow \ \text{mid}_R \rightarrow g(c) \rightarrow \text{out} \]

\[ \text{Umide}_L = V\text{th}_g \neq \text{Umide}_L = \frac{R\text{th}_g}{R\text{th}_g + R\text{th}_f} \cdot V\text{th}_f + \frac{R\text{th}_f}{R\text{th}_g + R\text{th}_f} \cdot V\text{th}_g \]

in general
except when \( R\text{th}_g = 0 \)

Ideal isolation:

- From perspective of block \( f \) \( \Rightarrow \) see an open-circuit
i.e. \( R\text{th}_g = \infty \)

- From perspective of block \( g \) \( \Rightarrow \) see a voltage source
i.e. \( R\text{th}_f = 0 \)
Example 1: Want this:

\[ \text{Vin} \xrightarrow{R_2 / (R_1 + R_2)} \text{Vin}_{\text{mid}} \xrightarrow{A_V = 10} \text{Vout} \]

Implement:

\[ \text{Vin} \quad \text{R}_1 \quad \text{Vin}_{\text{midL}} \quad \text{Vin}_{\text{midR}} \]

Verify: \( \text{Vin}_{\text{midL}} = \frac{R_2}{R_1 + R_2} \cdot \text{Vin} \)

\( \text{Vin}_{\text{midL}} = \text{Vin}_{\text{midR}} \)

\[ A_V = \frac{\text{Vout}}{\text{Vin}_{\text{midL}}} = 10 \]

Example 2:

\[ \text{Vin} \xrightarrow{\text{Sensor}} \text{Vin}_{\text{mid}} \xrightarrow{-3} \text{Vout} \]

Before the connection:

\( \text{Vin}_{\text{midL}} = \text{Vth}_S \)

When connected:

\( \text{Vin}_{\text{midL}} = \frac{R}{R + R_{\text{thS}}} \cdot \text{Vth}_S \neq \text{Vth}_S \)

Solve:

\[ -3 \cdot \text{Vth}_S = \text{Vout} \]

\[ \text{Vout} = \frac{R_{\text{thS}}}{R + R_{\text{thS}}} \cdot \text{Vin} \]
Design procedure

- **Step 1:** (Specification)
  Concretely (ver)state your goal for the design. (most often from a word spec)

- **Step 2:** (Strategy)
  Describe (often as a block diagram) the strategy to achieve the goal.

  - Often review what you can measure vs. what you wanted to know
  
    - What is the relationship between the two (e.g., touch/no-touch)

- **Step 3:** (Implementation)
  Implement the components within the strategy.

  - Remind yourself of blocks you know that can provide the desired block function

  - Think about how to extend/modify the blocks you know (or get #/1000)

- **Step 4:** (Verification/analysis)
  Does the implementation in step 3 do what is specified in step 1?

  - Check for block-to-block connections
Example design #1: ("Countdown timer")

1. **Step 1:** Build a circuit that, after a button is pressed (5 sec) measures 2 s and will then apply 2 V across the LED. (I assume you can only push the button once)

2. **Step 2:**
   - **Strategy:** Push the button → Turn on timer → Timer → "Time since button pressed" → Apply 2 V to LED
   - **Turn-on circuit:**
     - Timer:
     - 
     - 
     - 

3. **Step 3:**
   - **Implementation:**
     - 

Together:

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- 
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**Formulae:**
- \( I_c = \frac{dV_c}{dt} \)
- \( V_c(t) = \int I_c \cdot t + V_c(0) \)
- \( I_c = \frac{V_t}{C} \)
Step 4: Verify

\[ I_1 = 0 \text{ (o.c. def)} \]
\[ I_2 = -I_s \text{ (curr. source elem. def)} \]
\[ I_1 + I_2 = 0 \text{ (KCL)} \]
\[ 0 + (-I_s) = 0 \times \text{ violation} \]

Revise:

Before the button is pushed: \( S_1 \) is on

\[ V_{time} = 0 \]
\[ I_c = C \frac{dV_{time}}{dt} = 0 \]

When you push the button: \( S_1 \) is off at \( t = t_0 \)

\[ V_{time}(t_0) = 0 \]
\[ V_{time}(t) = \frac{I_s}{C} \cdot (t - t_0) + V_{ref} \]
\[ V_{time}(t_0 + 2s) = V_{ref} \]