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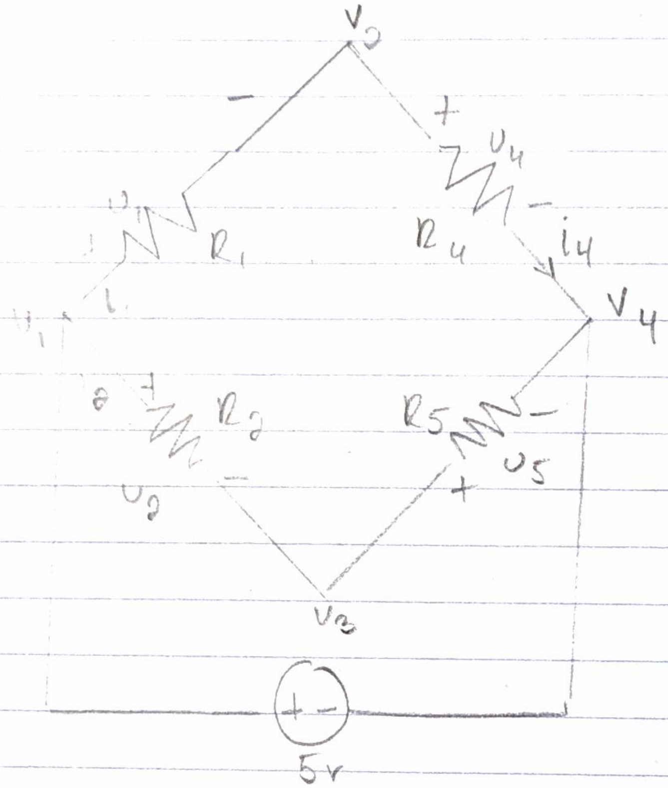
10-23-17
EE16A

EE 16A Homework # 8

3 Wheatstone Bridge

3A



2 voltage dividers

$$U_4 = \frac{R_1}{R_1+R_4}(V_1 - V_4)$$

$$U_5 = \frac{R_5}{R_2+R_5}(V_1 - V_4)$$

A Thevnin voltage is the difference between the two voltages

$$U_4 - U_5 = (V_1 - V_4) \cdot \frac{R_1(R_2+R_5) + R_5(R_1+R_4)}{(R_1+R_4)(R_2+R_5)}$$

C $R_{th} = (R_1 \| R_4) + (R_2 \| R_5)$

$$= \frac{R_1+R_4}{R_1R_4} + \frac{R_2+R_5}{R_2R_5} = \frac{(R_1+R_4)(R_2R_5) + (R_2+R_5)(R_1R_4)}{R_1R_4R_2R_5}$$

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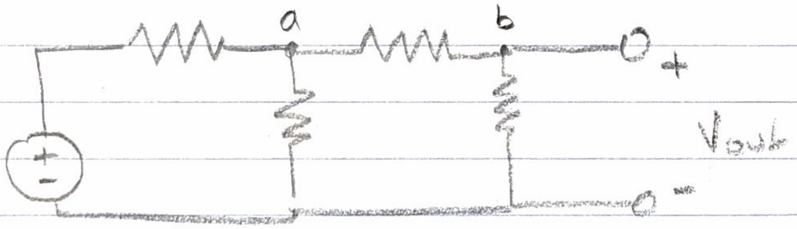
B No, the Thevinin voltage V_{th} in part A and the bridge voltage aren't equal. This is a result of the serial capacitors which does not let us directly determine the results of the bridge, so it is not possible to determine if the resistors and voltages are equal.

D $I = \frac{V}{R}$ $$\frac{\dfrac{(V_1 - V_4)(R_1)(R_2+R_5) + (R_5)(R_1+R_4)}{(R_1+R_4)(R_2+R_5)}}{\dfrac{2(R_1+R_4)(R_2R_5) + (R_2+R_5)(R_1R_4)}{R_1R_4R_2R_5}}$$

4 DAC $V_{out} = V_s \sum_{n=0}^{N} \frac{1}{2^n} \cdot b_n$

A

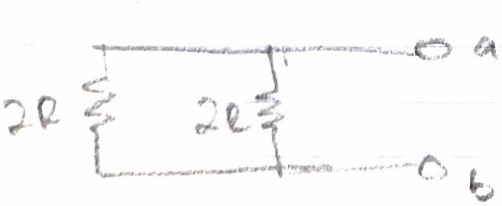


At point A $V = VR_{sum} = \frac{1}{2}R$ (parallel resistors)

Voltage $= \frac{1}{2}V_s$ correspondingly as I remains constant

Yes $V_{out} = \frac{1}{4}V_s$ (Parallel Resistors)

B

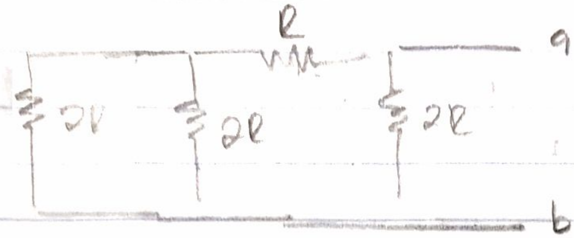


$R_{eq} = \frac{1}{2} 2R = R$ (Parallel Resistors)

$\frac{1}{2R} + \frac{1}{2R} = \frac{2}{2R} = R$ ✓

PG 3

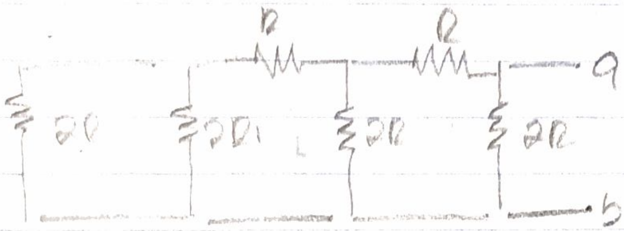
II



$$R_{eq} = \frac{1}{\frac{1}{2R} + \frac{1}{R} + \frac{1}{2R} + \frac{1}{2R}}$$

$$R_{eq} = \frac{1}{\frac{1+2+1+1}{2R}} = \frac{2}{5}R$$

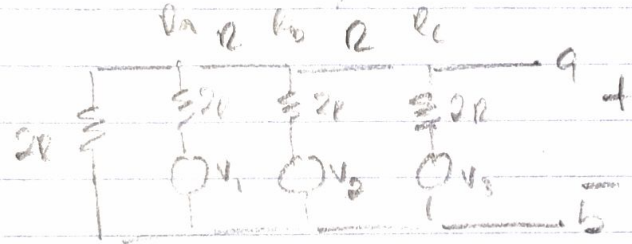
II



$$R_{eq} = \frac{1}{2\cdot\frac{1}{R} + 4\cdot\frac{1}{2R}} =$$

$$\frac{4}{2R} + \frac{4}{2R} = \frac{8}{2R} = \boxed{\frac{1}{4R}}$$

C



$$V_{out} = V_1 \frac{1}{2}(2R) + V_2 \left(\frac{1}{2}\left(\frac{1}{\frac{1}{2R} + \frac{1}{R} + \frac{1}{2R}}\right)\right)$$

$$= V_1 R + V_2 \left(\frac{1}{\frac{2+2+1}{2R}}\right) = \left(\frac{1}{\frac{5}{2}}\right) = \frac{1}{2}\cdot\frac{2}{5}R$$

$$= V_1 R + V_2 \frac{1}{5R} + V_3 \left(\frac{1}{2}\,\frac{1}{\frac{1}{5R} + \frac{1}{R} + \frac{1}{2R}}\right)$$

$$= V_1 R + V_2 \frac{1}{5}R + V_3 \frac{1}{2}\left(\frac{1}{\frac{2}{10R} + \frac{10}{10R} + \frac{5}{10R}}\right) =$$

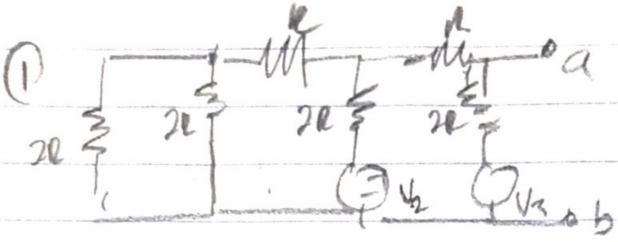
$$V_1 R + V_2 \frac{1}{5}R + V_3 \frac{1}{2}\frac{10R}{17} = \frac{5}{17}R$$

$$= V_1 R + V_2 \frac{1}{5}R + V_3 \frac{5}{17}R$$

D $V_{out} = \boxed{\frac{1}{5}\text{ Volts}}$

PG 4

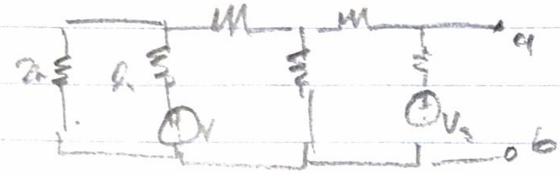
(E) ①



$th_{eq} = \frac{1}{8}R$

$V_{eq} = \frac{V_1}{8}$

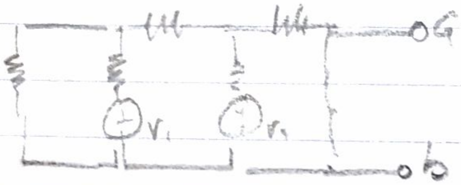
②



$th_{eq} = \frac{1}{4}R$

$V_{eq} \; \frac{V_2}{4}$

③



$th_{eq} = \frac{1}{2}R$

$V_{eq} = \frac{V_3}{2}$

(F) The voltage across the speaker is less because the speaker acting like a resistor, lowers the voltage. This is essentially adding another resistor, but it is not in parallel so it does not lower the resistance; it increases the resistance overall lowering the voltage of the system so it is lower than what we computed in part D.

5 Maximum Horsepower: $V = IR$ $\quad P = V \cdot I$

A The power delivered by the voltage source is

$R_{eq} = R_s$ (serial resistor) $\quad \frac{P}{V} = I$

$V_{out} = V_s \cdot (R_s + R_{motor}) I \quad V = \frac{P}{V} \cdot R \quad P = \frac{V^2}{R}$

$\boxed{P = \frac{V_s^{\,2}}{(R_s)^2}}$ ← power delivered to resistor (R_{motor})

PG 5

(5)

B $P_{motor} = I \cdot V$ $V = IR$ $I = \frac{V}{R}$

$P_{motor} = \frac{V^2}{R} =$ wher $R_{eq} = R_s + R_{motor}$

$= \frac{V_s^2}{(R_s + R_{motor})}$

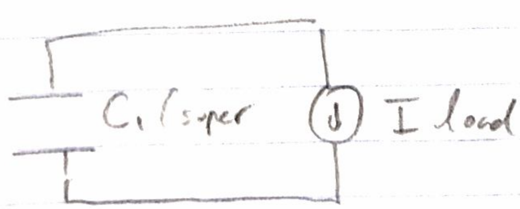
C $\frac{dP}{dR} = \frac{-V^2}{R^2} = \frac{-V_s^2}{(R_s + R_{motor})^2} = 0$ when $-V_s^2 = 0$

D $P = \frac{V^2}{R} \rightarrow \frac{V_s^2}{R_s}$ (in order to maximize power to the motor, we need to minimize the resistance at R_s, as $R_s \downarrow$ $P\uparrow$ as they have an inverse relationship

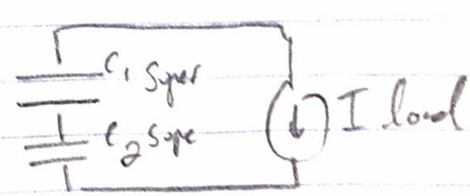
(as close to zero but not zero)

6 Super Capacitors

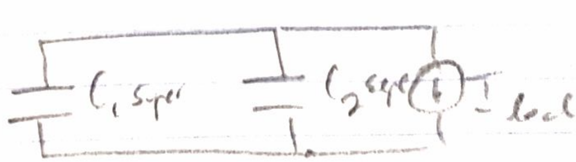
A



single



stacked



PG 6

B I $Q_{sc} = C_{sc} V_s \Rightarrow V_s = \frac{Q_{sc}}{C_{sc}}$

$$\frac{dv}{dt} = \frac{1}{C_{sc}} \cdot \frac{dQ_{sc}}{dt} = \frac{-I_{load}}{C_{sc}}$$

$$dv = -\frac{I_{load}}{C_{sc}} dt$$

$$V = \int_{t_0}^{t} dv = \int_{t^0}^{t} -\frac{I_{load}}{C_{sc}} dt = \frac{-I_{load} t}{C_{sc}} +$$

$$= \boxed{\frac{I_{load} t}{C_{sc}} - \frac{I_{load} t_0}{C_{sc}} + V(t_0)}$$

II $C_{eq} = \frac{C_{sc}^2}{2C_{sc}}$ $\quad Q_{sc} = C_{eq} V_s$

$$V = \frac{Q_{sc}}{C_{eq}} \Rightarrow \frac{dv}{dt} = -\frac{I_{load}}{C_{eq}} \Rightarrow dV = -\frac{I_{load}}{C_{eq}} dt$$

$$V(t) = \int dv + V(0) = -\frac{I_{load}}{C_{eq}} dt + V(0)$$

$$V_2(t) = \boxed{-2 \frac{C_{eq} I_{load}}{C_{eq}^2} t + V(0)} \quad V(0) = V_{init}$$

III $C_{eq} = 2C_{sc}$

$$V_3(t) = \boxed{\frac{-I_{load}}{2C_{sc}} t + V(0)}$$

PG 7

C I $V_1(t) = V_{init} - \frac{I_{load}}{C_{sc}} \Delta t = V_{min} \rightarrow V_{init} - V_{min} = \frac{I_{load}}{C_{sc}} t$

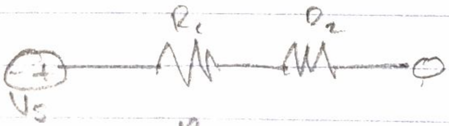
$t = \frac{C_{sc}}{I_{load}} (V_{init} - V_{min})$

II $V_2(t)$ - $t = \frac{C_{sc}}{2 I_{load}} (V_{init} - V_{min})$

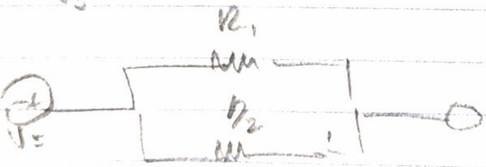
III $V_3(t)$ $t = \frac{2 C_{sc}}{I_{load}} (V_{init} - V_{min})$

D 2 super capacitors stacked in parallel has a longer life and is more efficient.

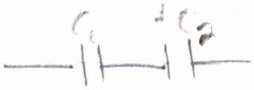
7 Write all the basic ways for series and parallel resistors and capacitors and calculate the equivalent resistance & capacitance.



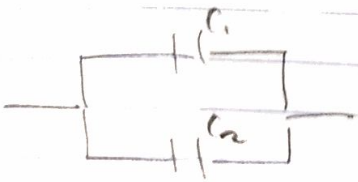
$= R_{eq} = \boxed{R_1 + R_2}$



$= R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \boxed{\frac{R_1 R_2}{R_1 + R_2}}$



$= C_{eq} = \boxed{C_1 + C_2}$



$= C_{eq} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2}} = \boxed{\frac{C_1 C_2}{C_1 + C_2}}$

PG 8

8. I worked on this homework assignment alone