ECE 105: Introduction to Electrical Engineering

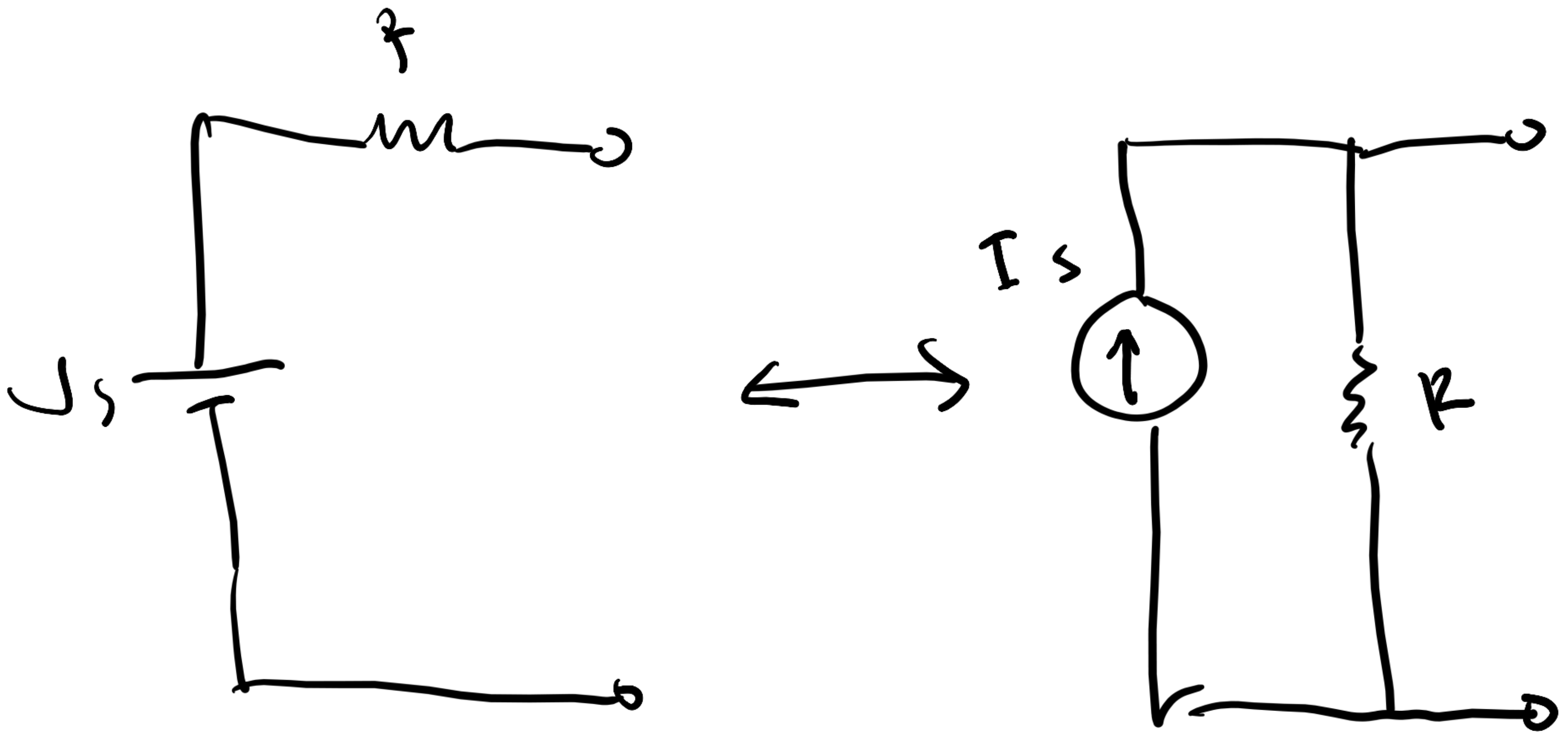
Lecture 7

Circuit Analysis - 3

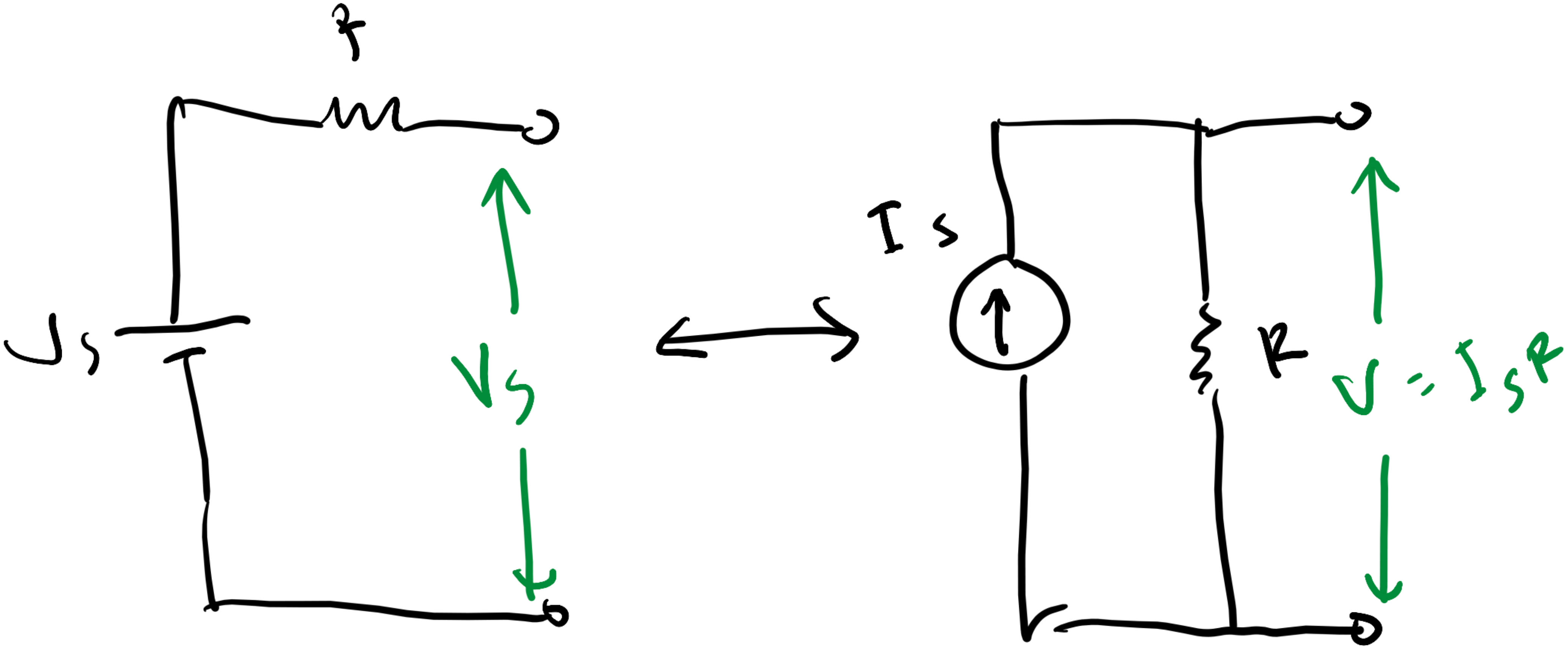
Yasser Khan

Rehan Kapadia

Source transformation – Voltage <> Current

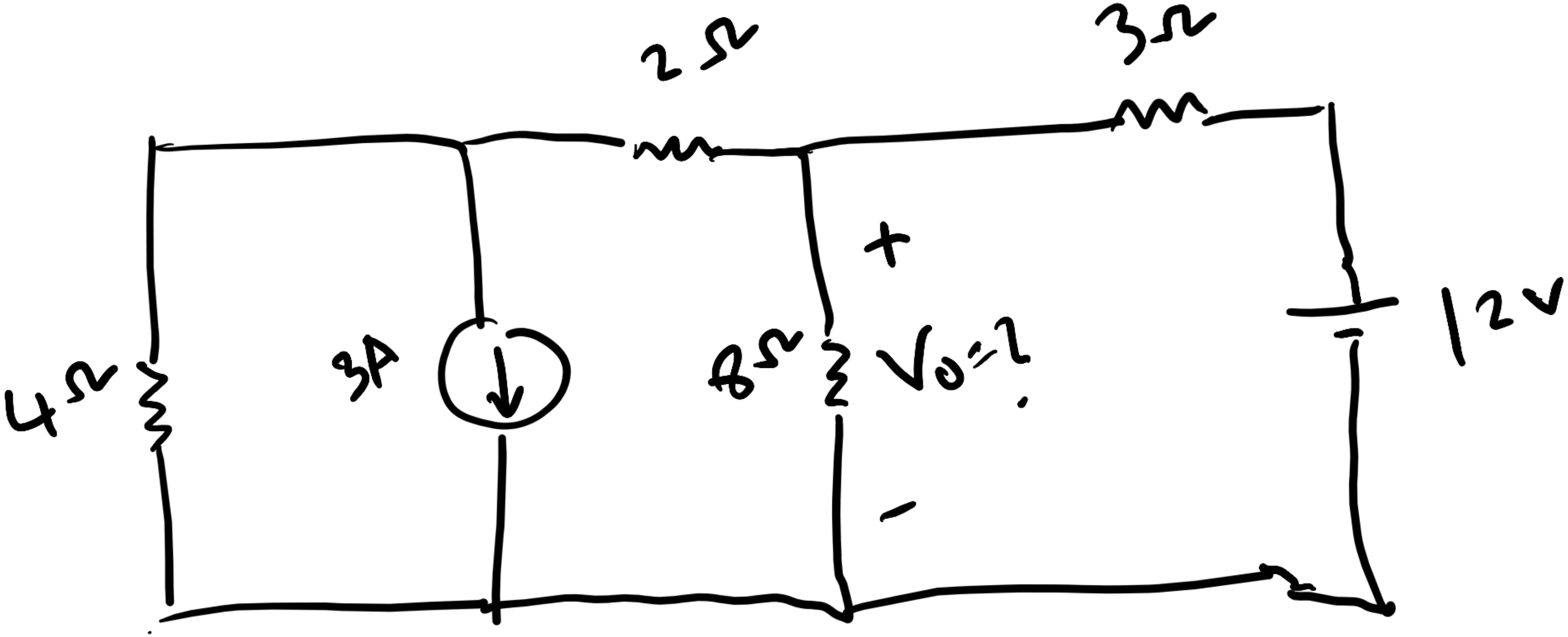


Source transformation – Voltage <> Current

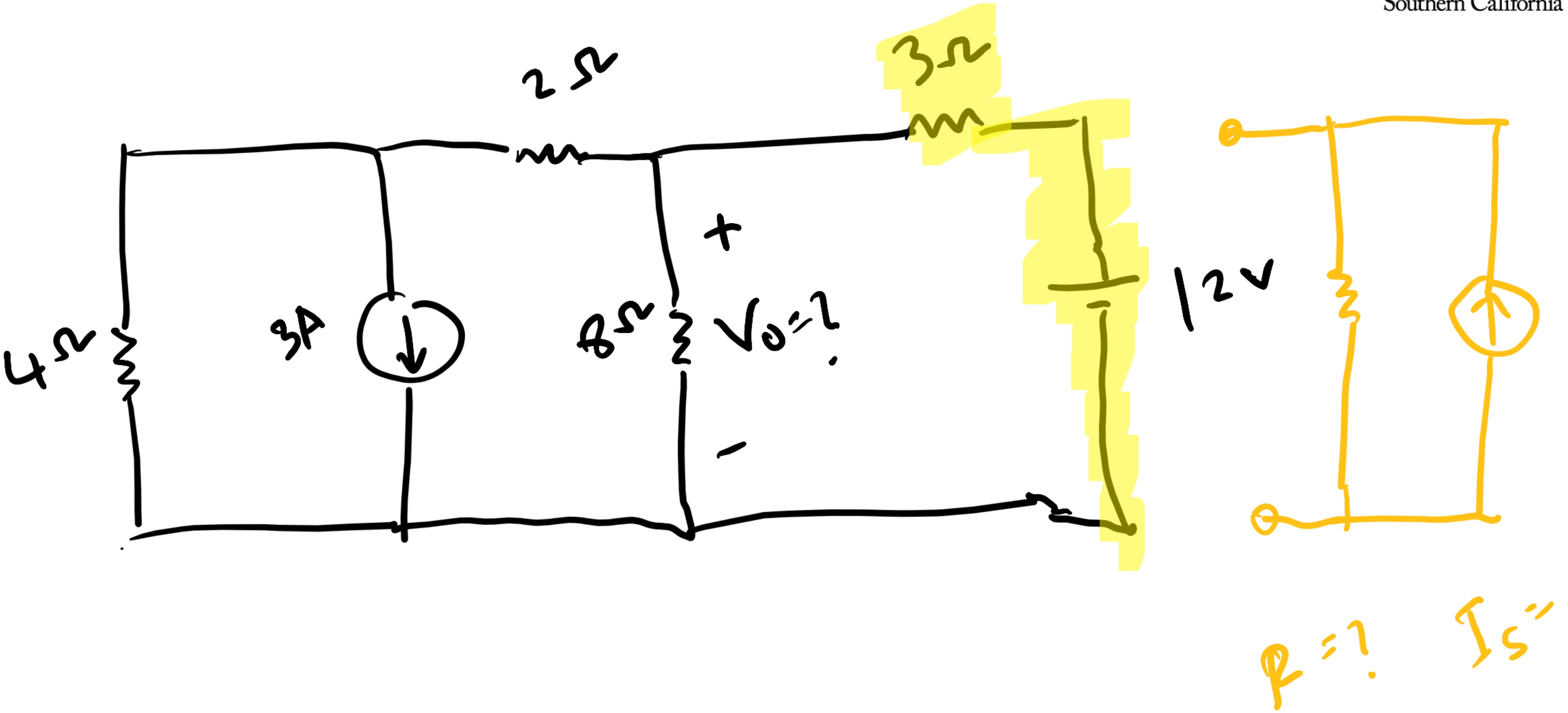


$V_s = I_s R \Rightarrow \quad I_s = \frac{V_s}{R}$

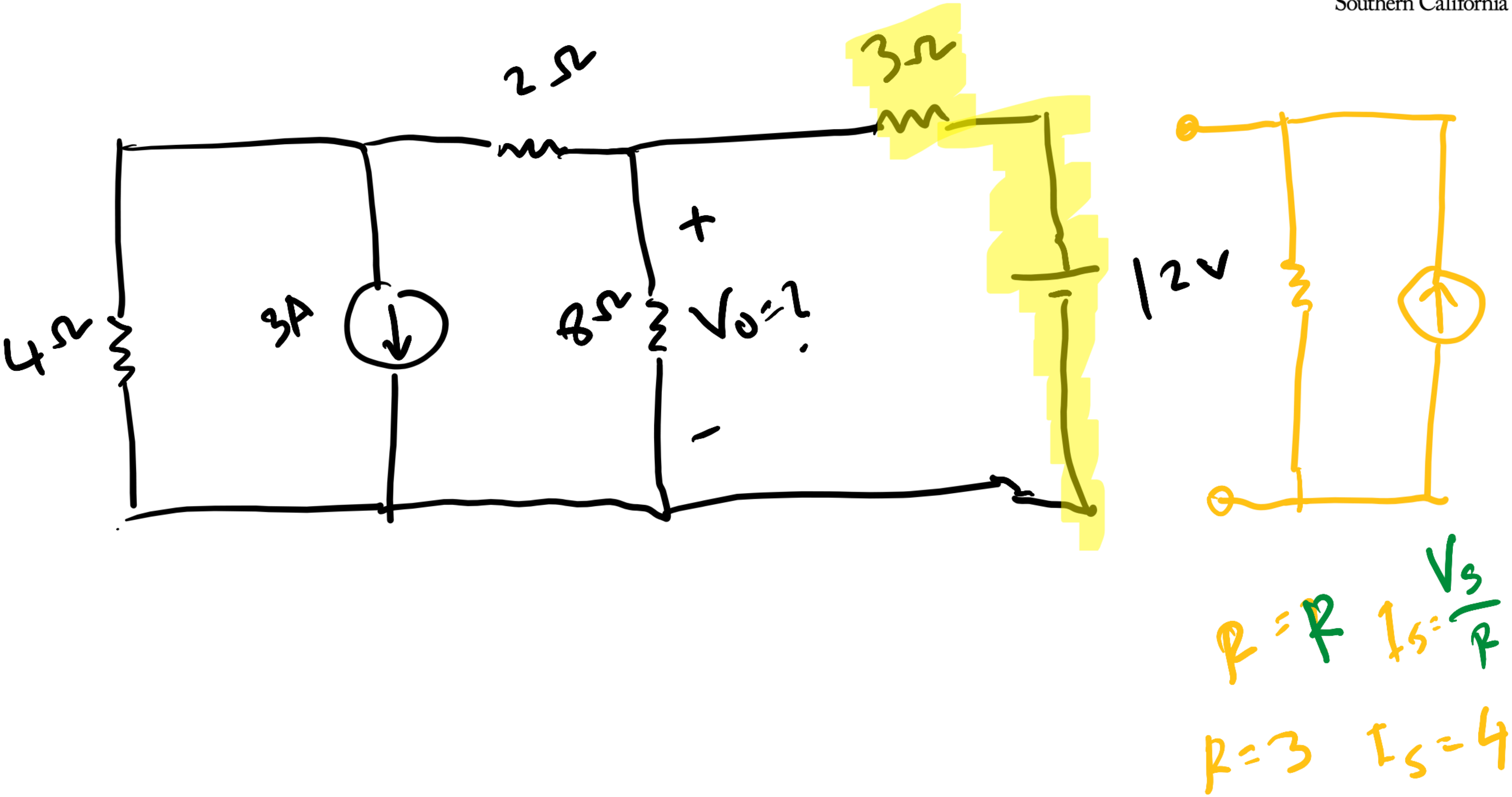
Voltage transformation example



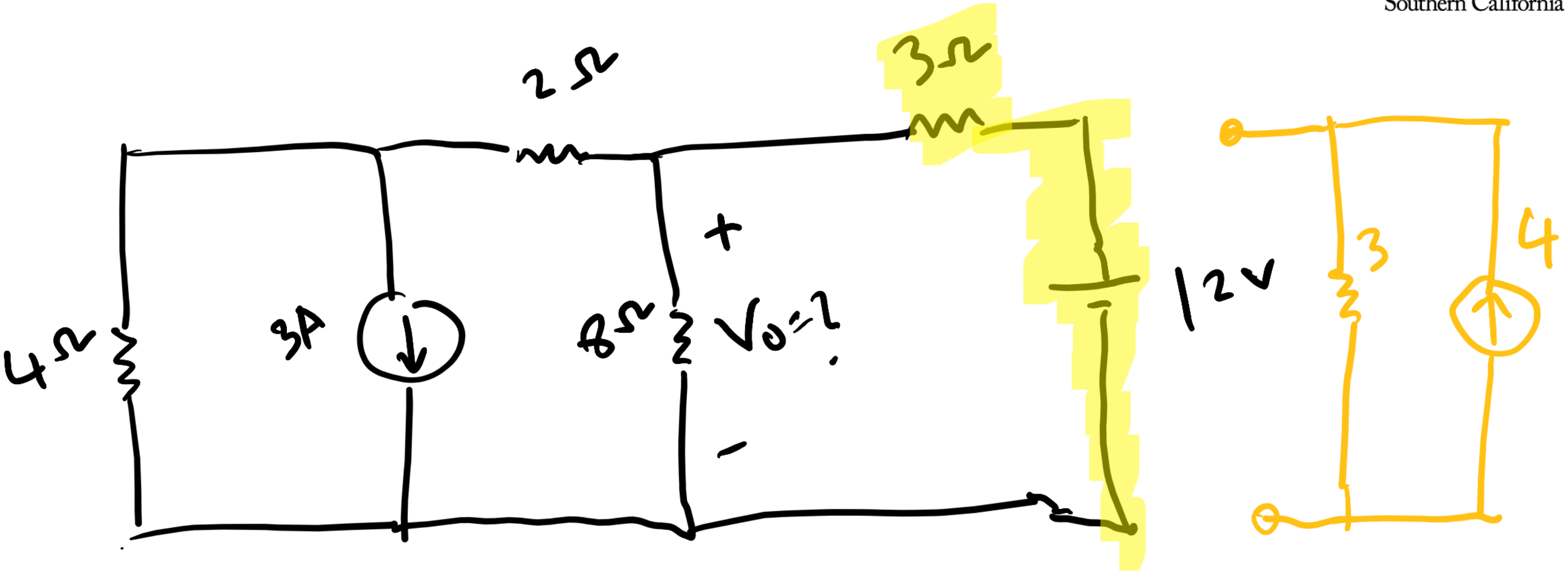
Voltage transformation example



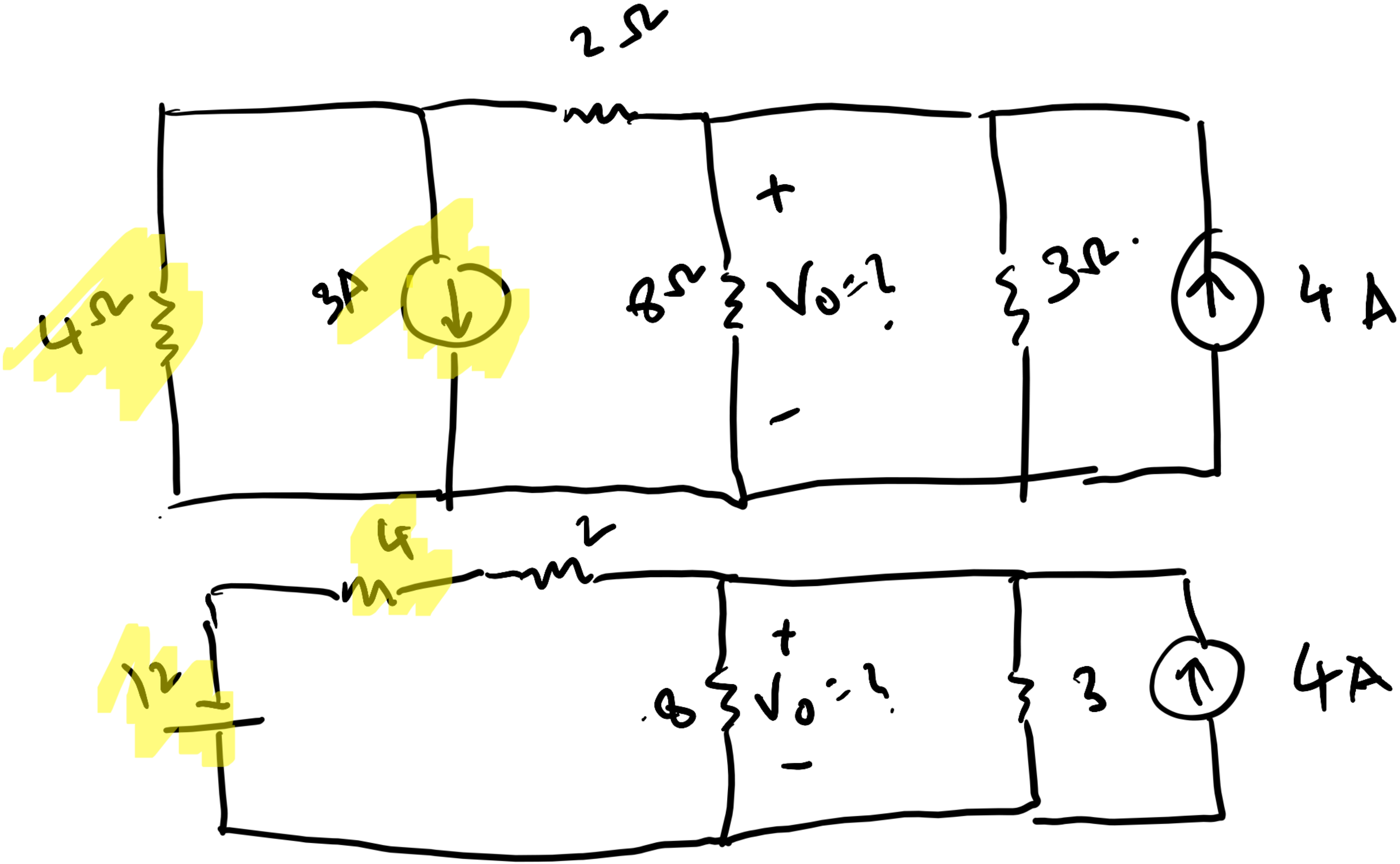
Voltage transformation example



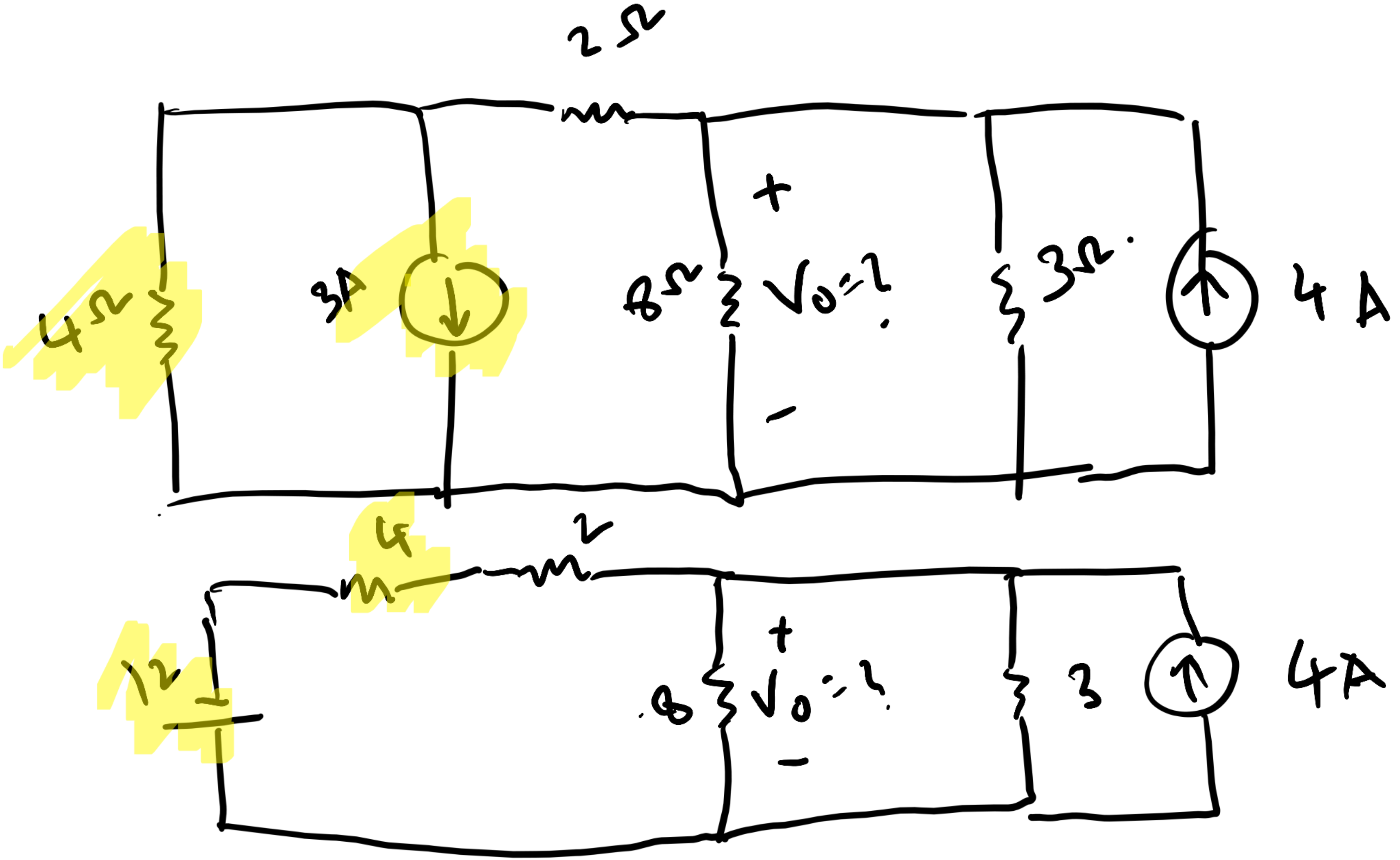
Voltage transformation example



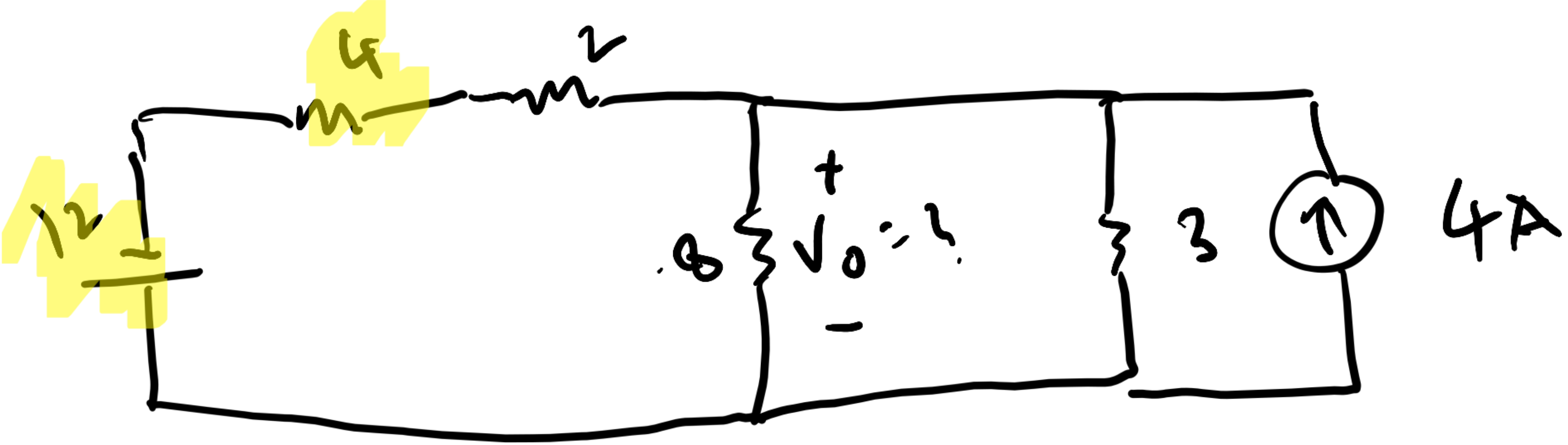
Voltage transformation example

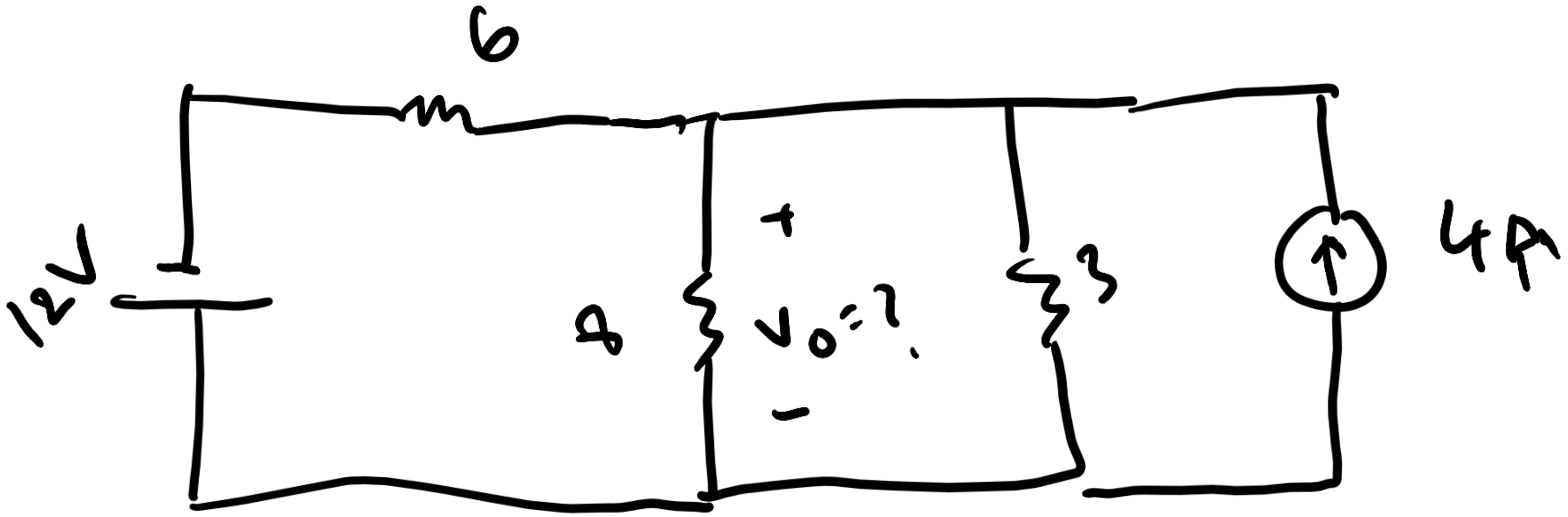


Voltage transformation example

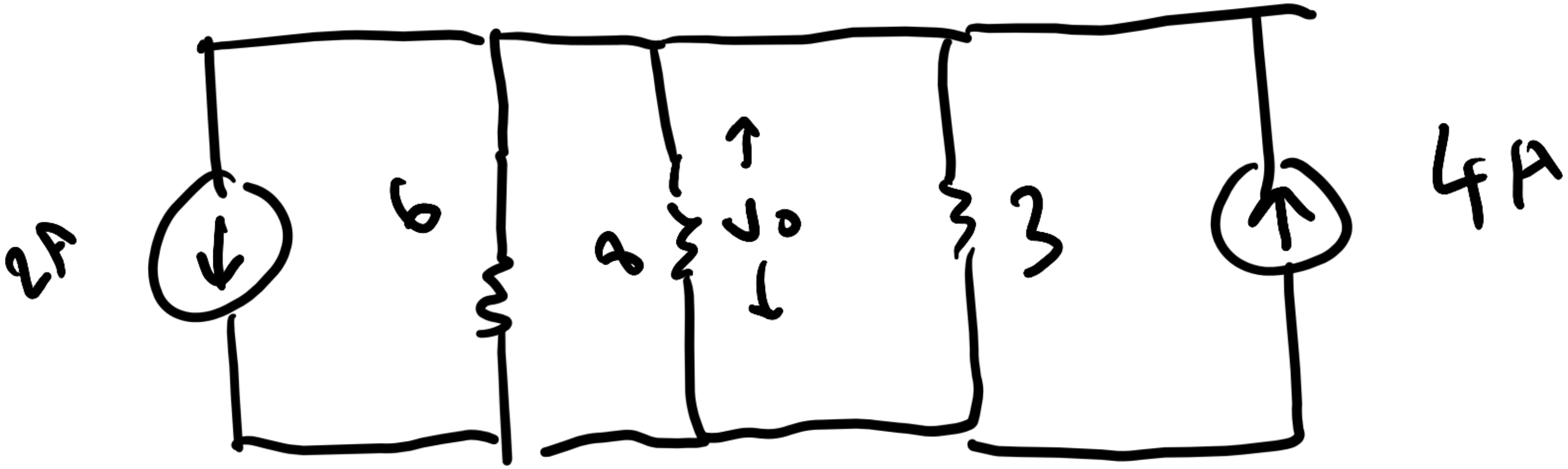


Voltage transformation example

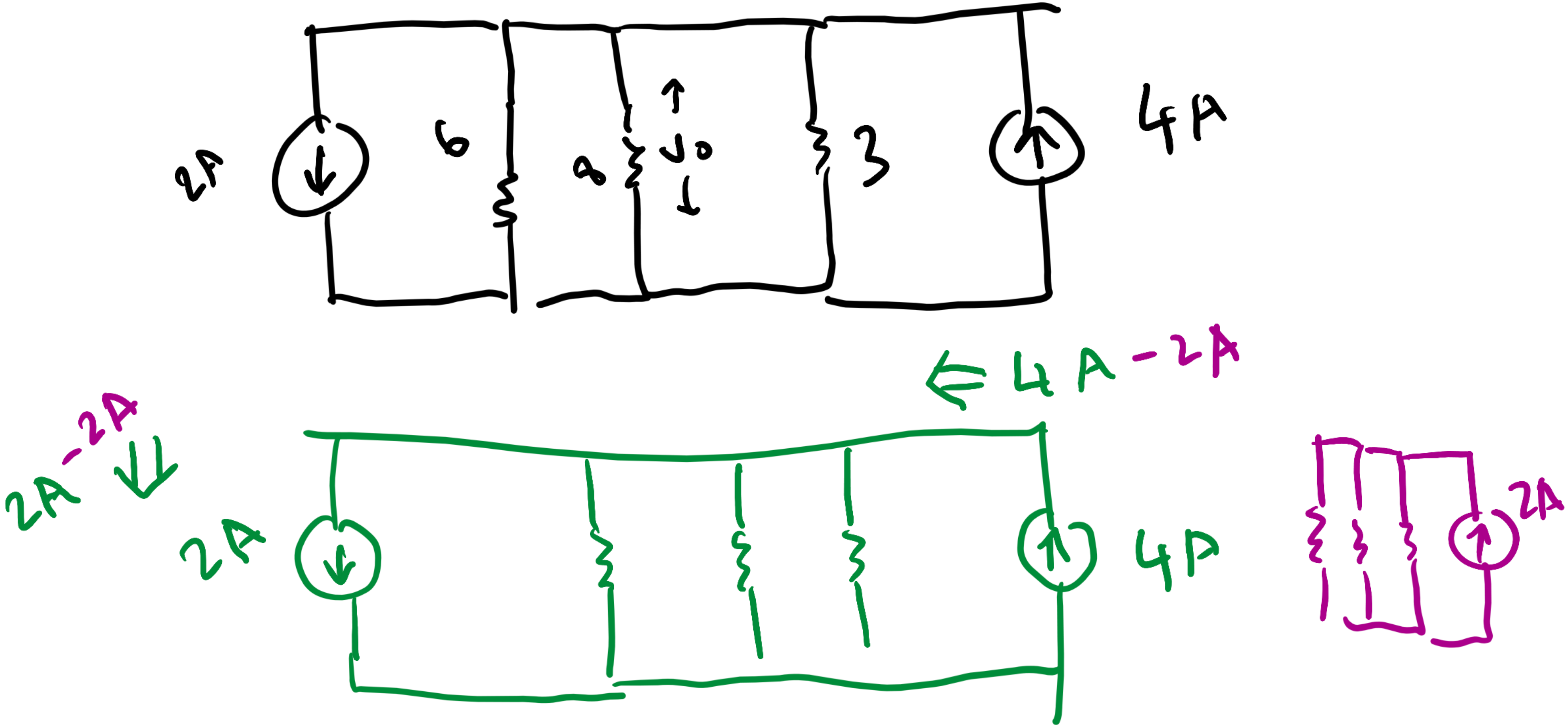




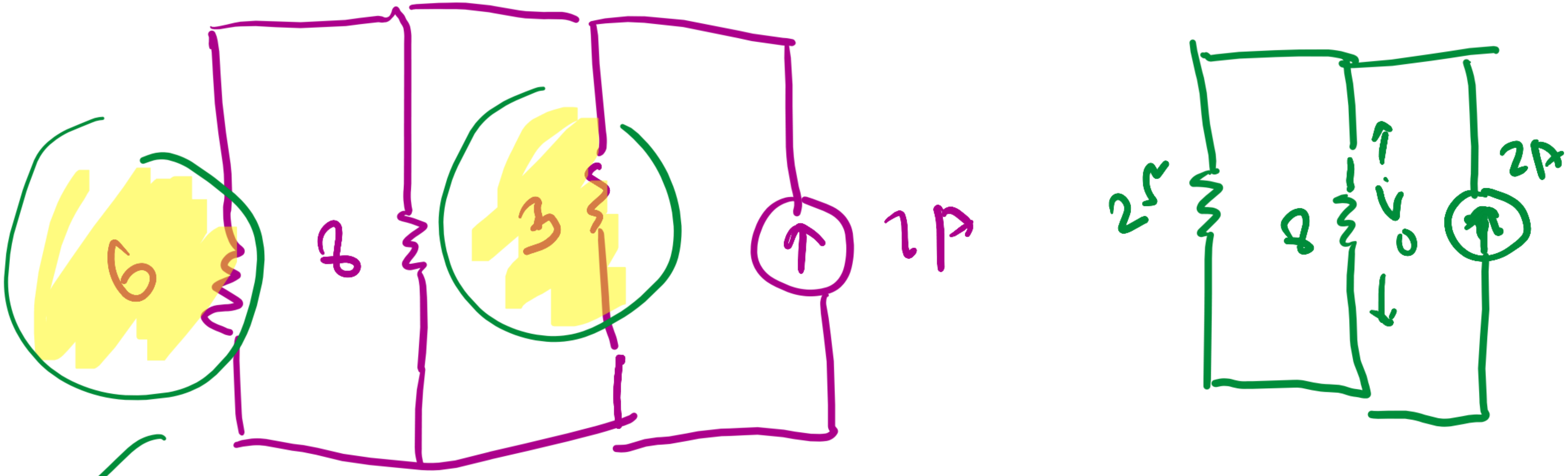
Voltage transformation example



Voltage transformation example

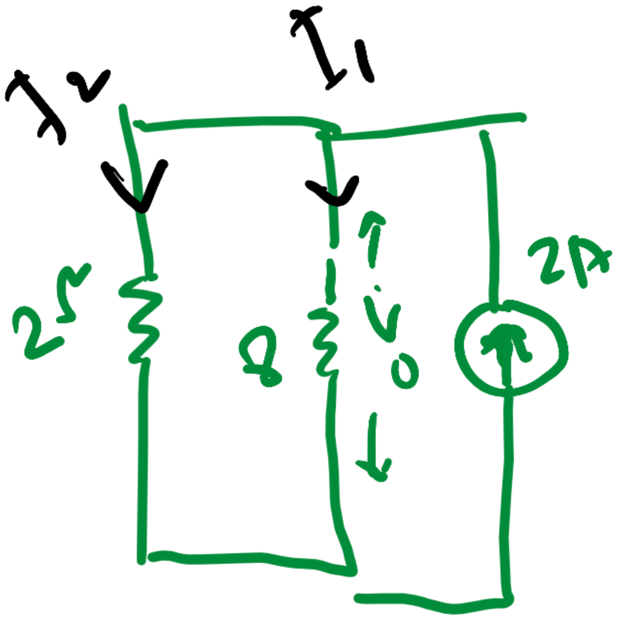


Voltage transformation example



$$\frac{1}{R_{eq}} = \frac{1}{6} + \frac{1}{3} = \frac{9}{18} \Rightarrow R_{eq} = 2$$

Voltage transformation example



$$I_1 = \frac{2 \times 2A}{10}$$

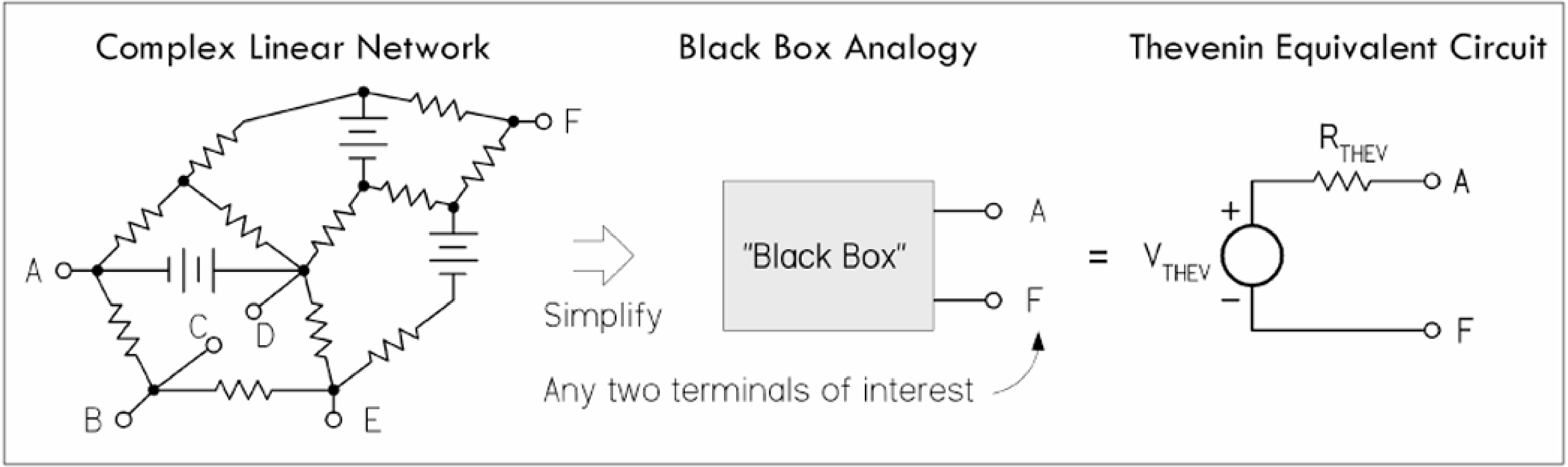
$$= .4A$$

$$V_0 = I_1 \cdot 8\Omega$$

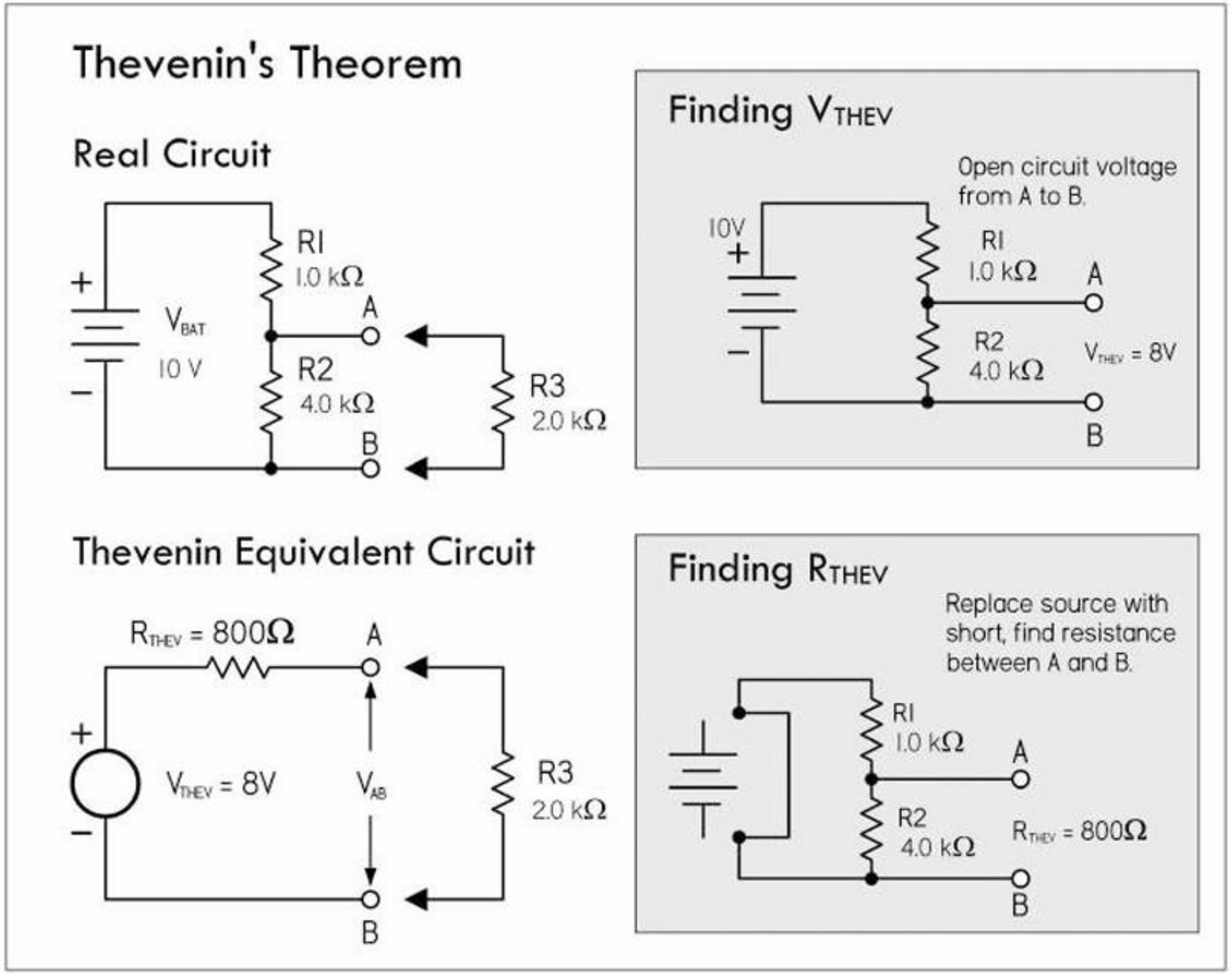
$$= .4A \; 8\Omega$$

$$= 3.2\ V$$

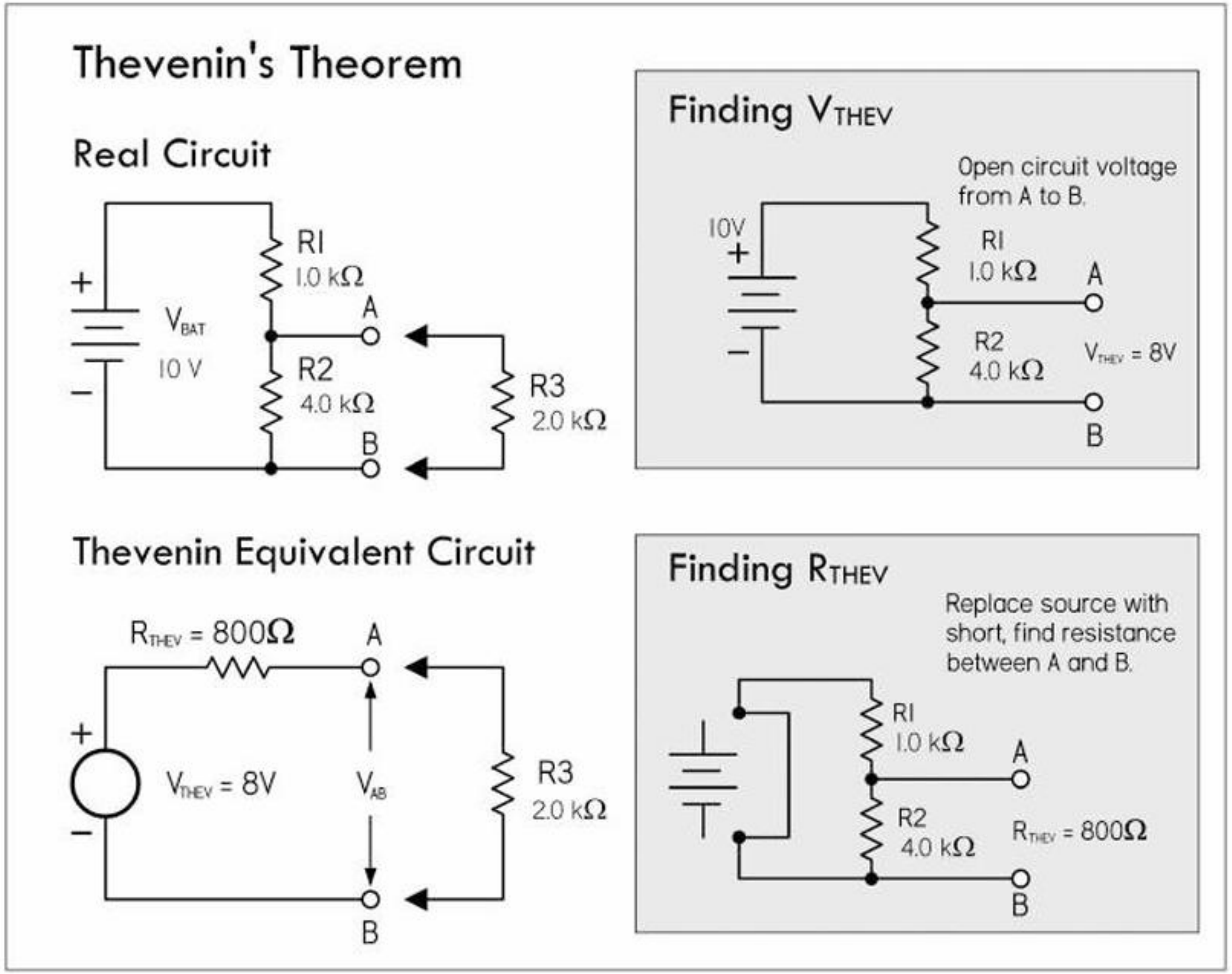
Equivalent circuits

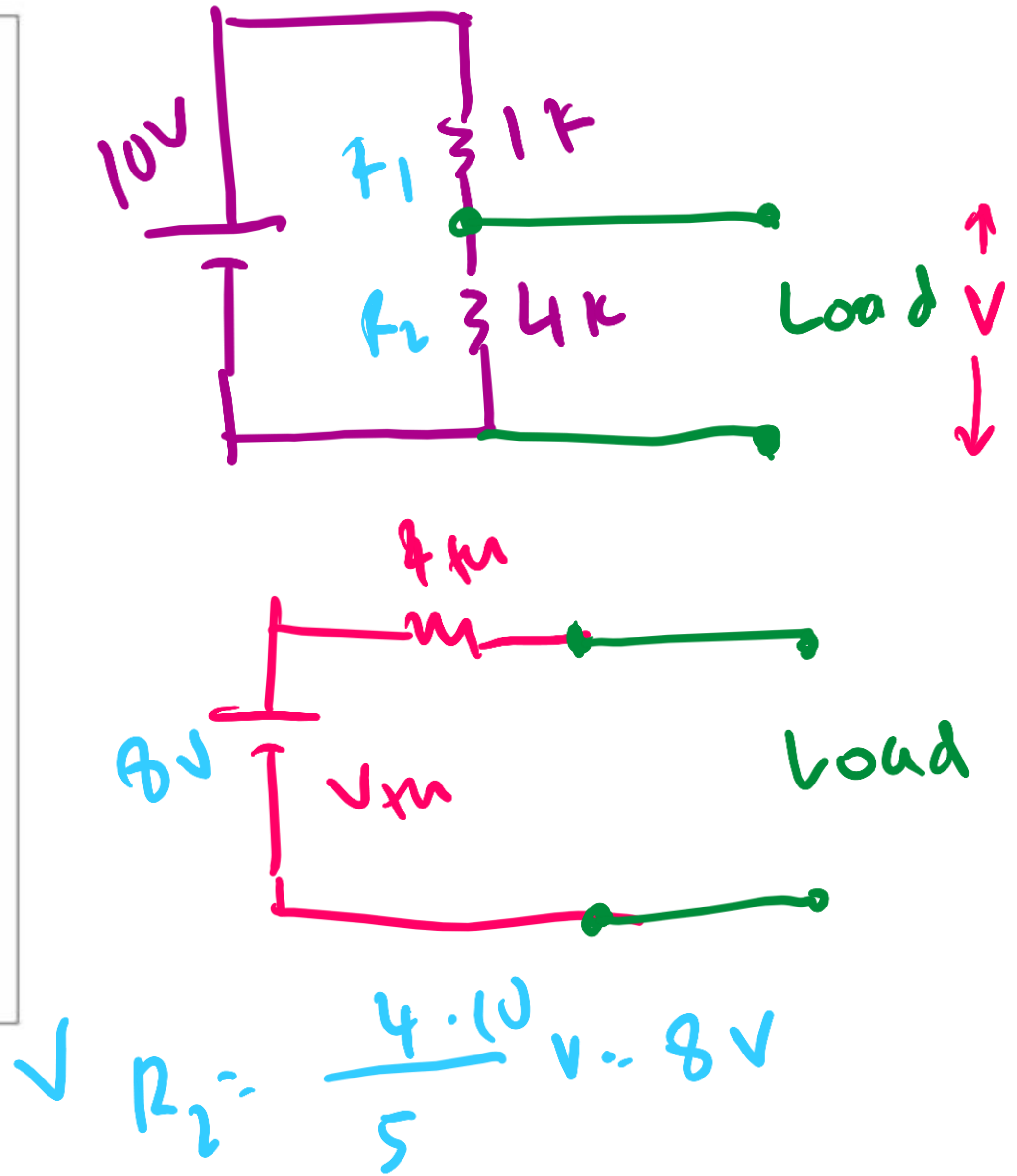


Thevenin’s equivalent circuit

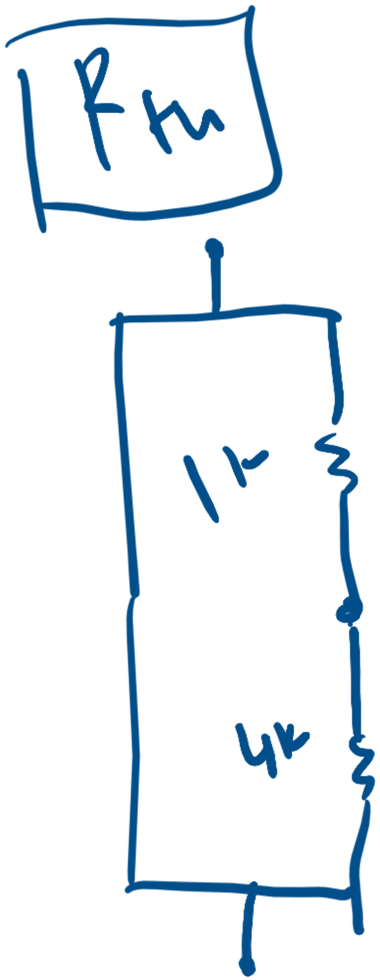


Thevenin's equivalent circuit



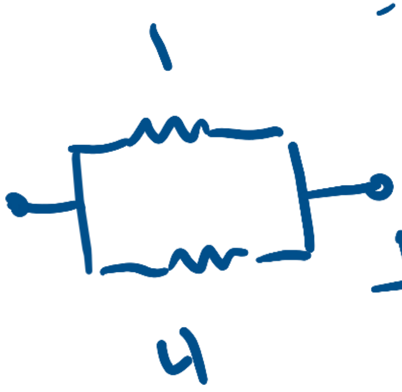


Thevenin's equivalent circuit



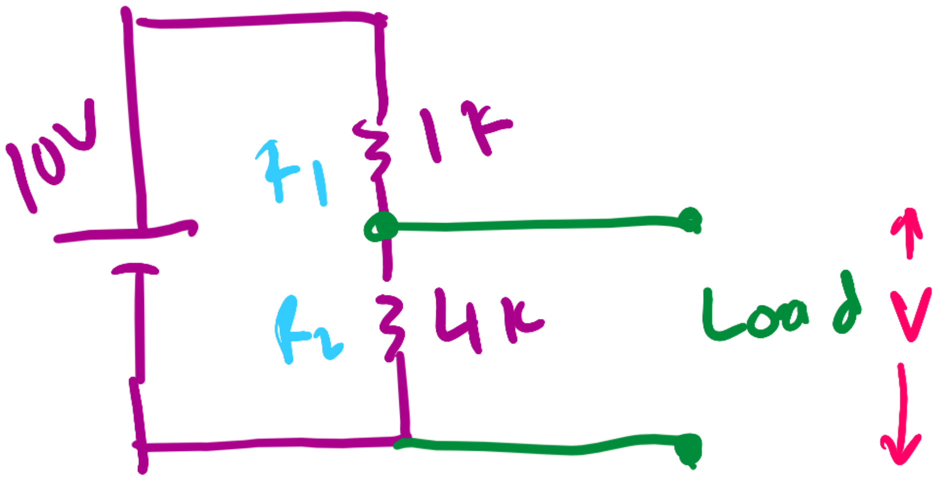
$$\frac{1}{R_{eq}} = \frac{1}{1k} + \frac{1}{4k}$$

$$= \frac{5}{1.4}$$

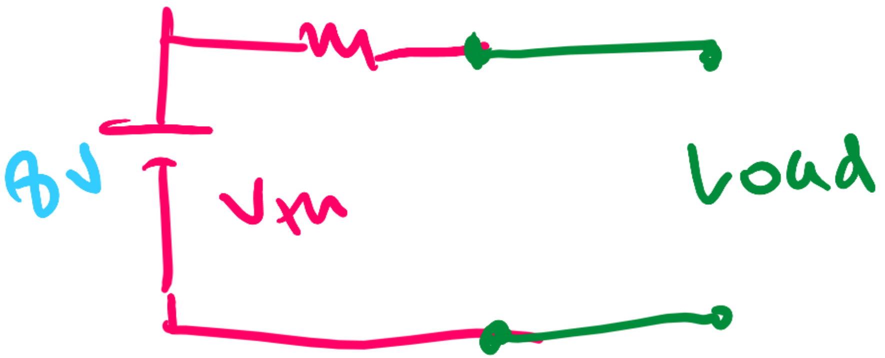


$$\frac{1}{R_{eq}} = \frac{5}{4}$$

$$R_{eq} = 800\,\Omega$$

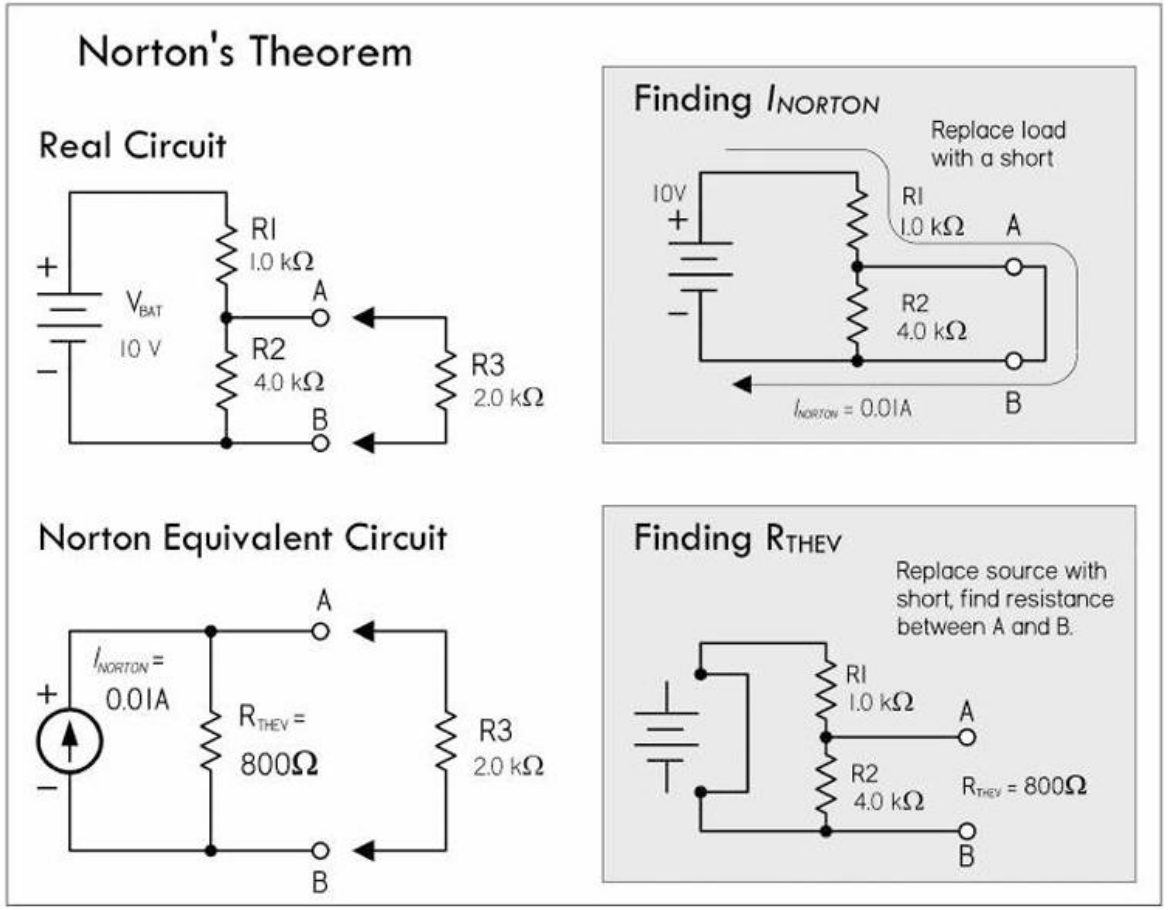


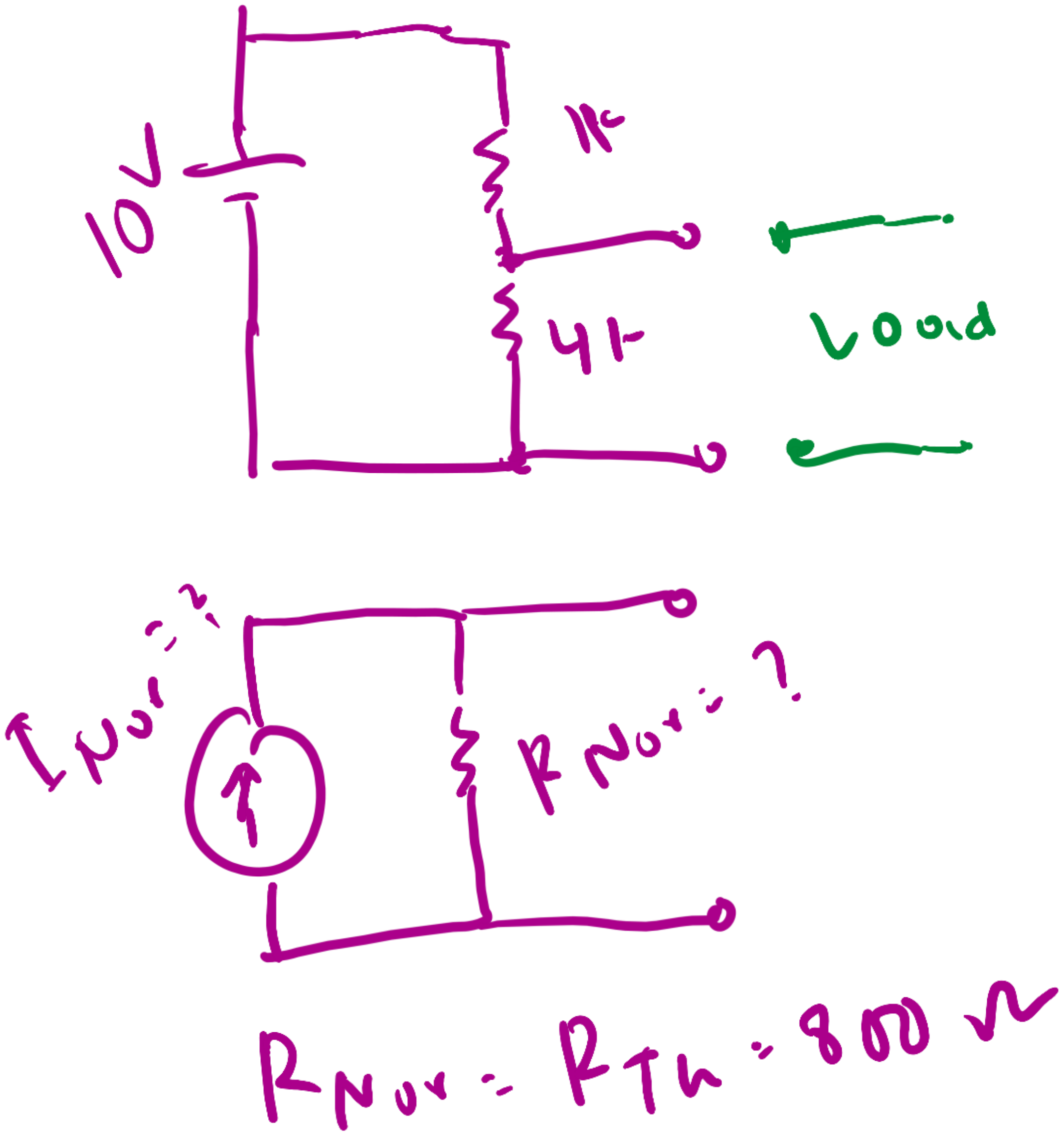
$R_{th} = 800\,\Omega$



$$\checkmark\ R_2 = \frac{4 \cdot 10}{5}\,V = 8V$$

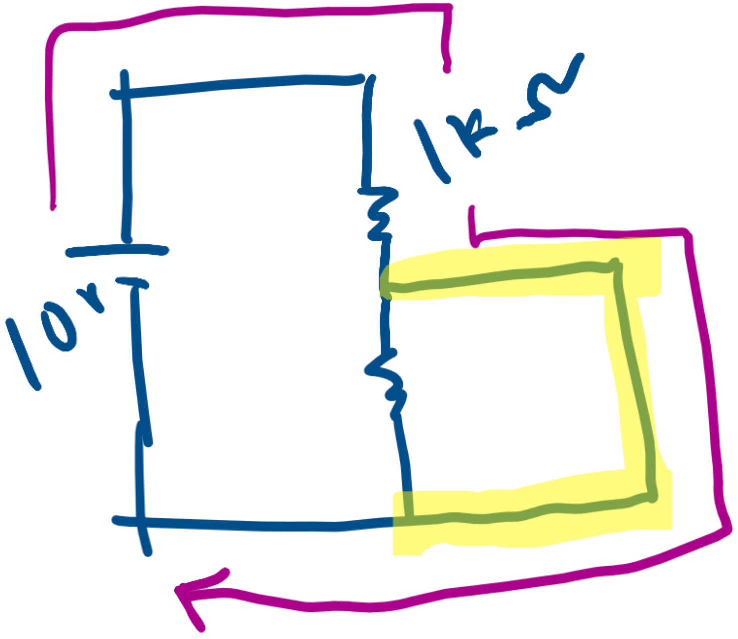
Norton's equivalent circuit

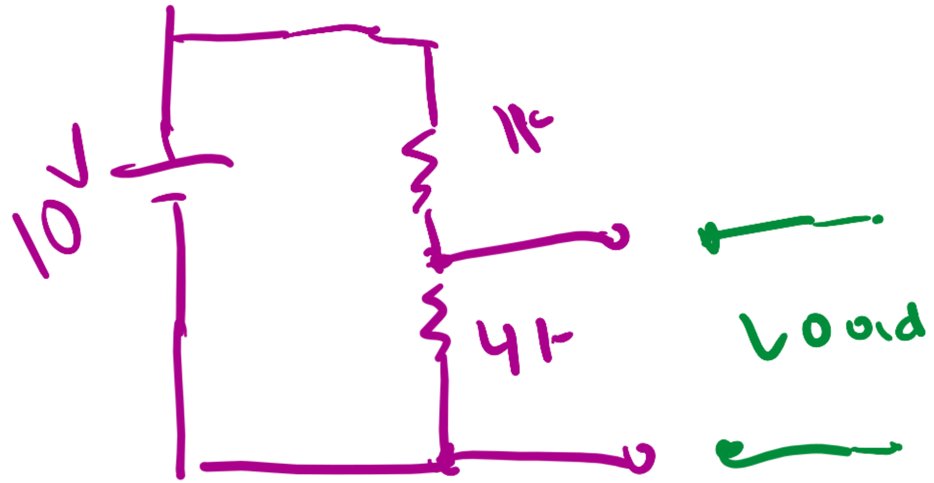




Norton's equivalent circuit

Replace load with a **short.**



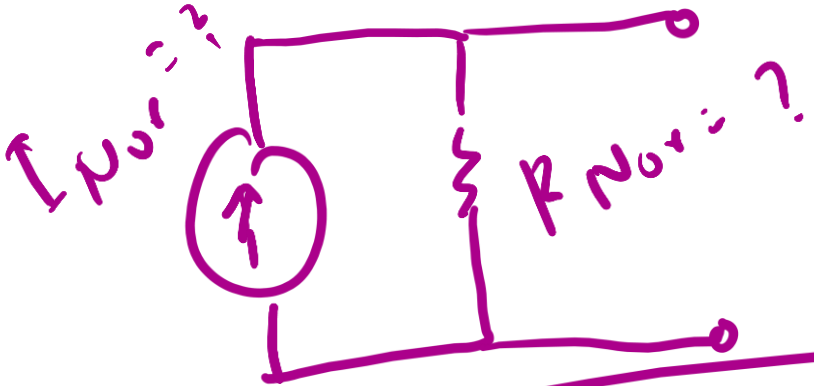


$V = IR$

$I = \frac{V}{R} = \frac{10V}{1K}$

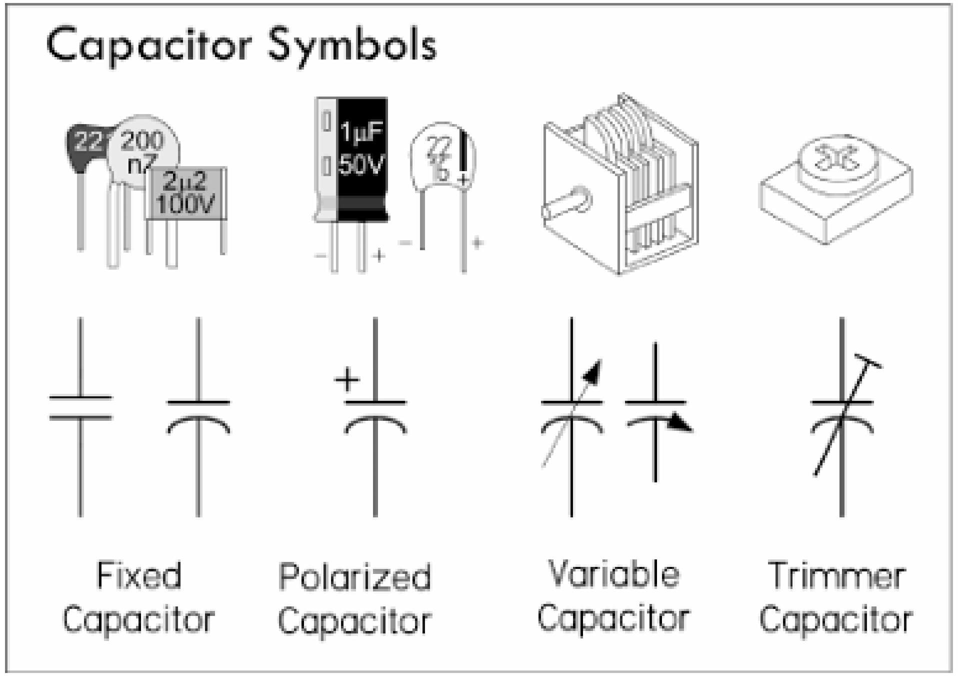
$= .01A$

$I_{Nor} = .01A$

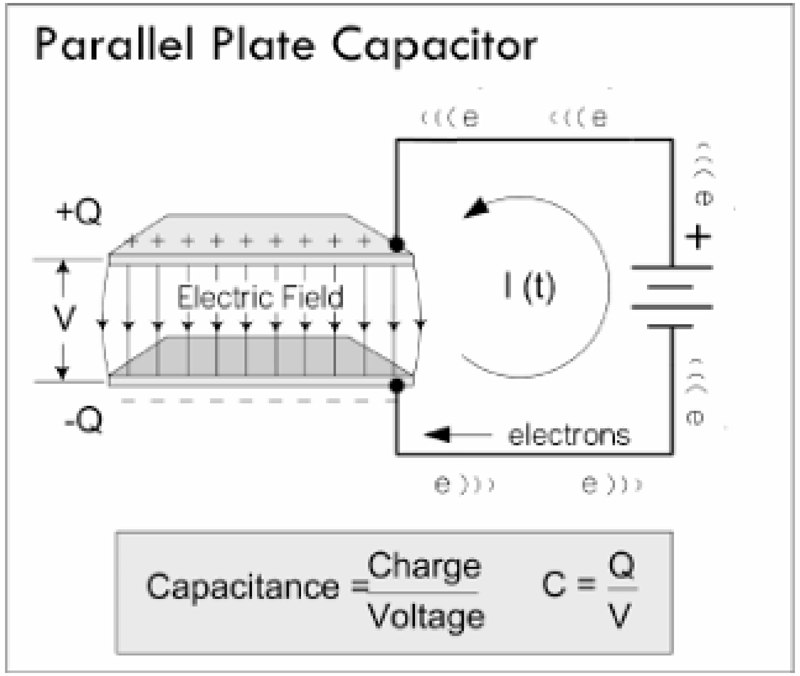


$R_{Nor} = R_{Th} = 800\Omega$

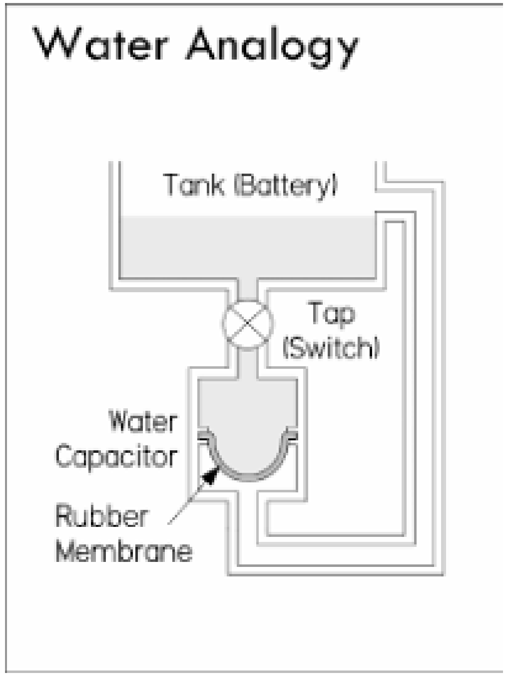
Capacitors



Capacitor Symbols
Fixed Capacitor
Polarized Capacitor
Variable Capacitor
Trimmer Capacitor

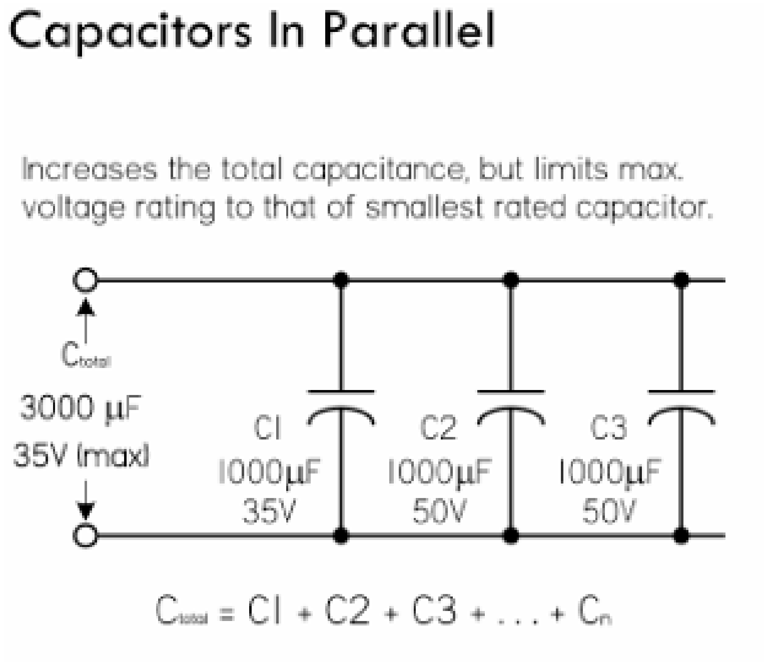


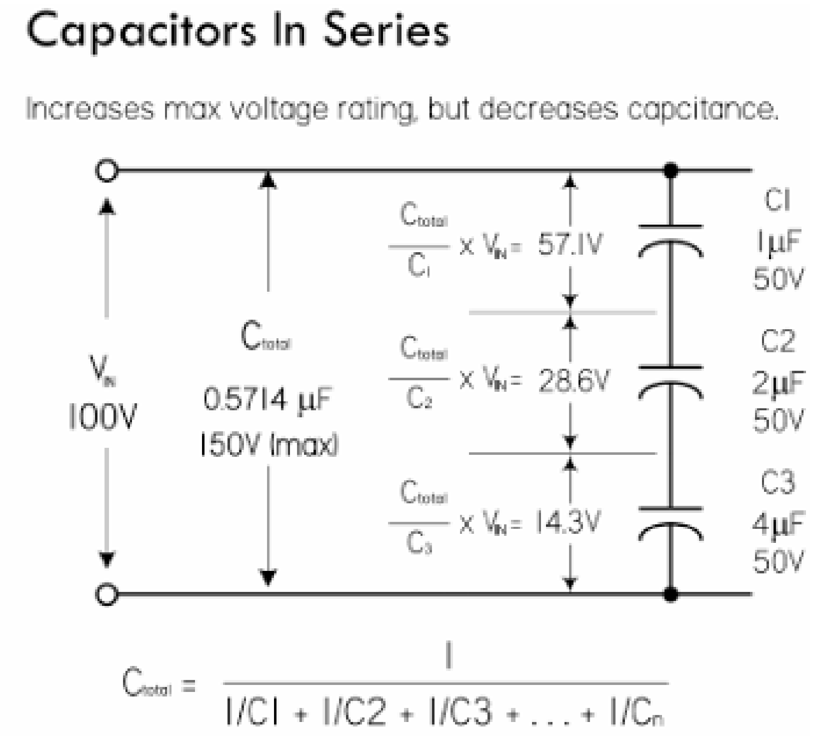
Parallel Plate Capacitor
+Q
-Q
V
Electric Field
I (t)
electrons
Capacitance = Charge / Voltage
C = Q / V



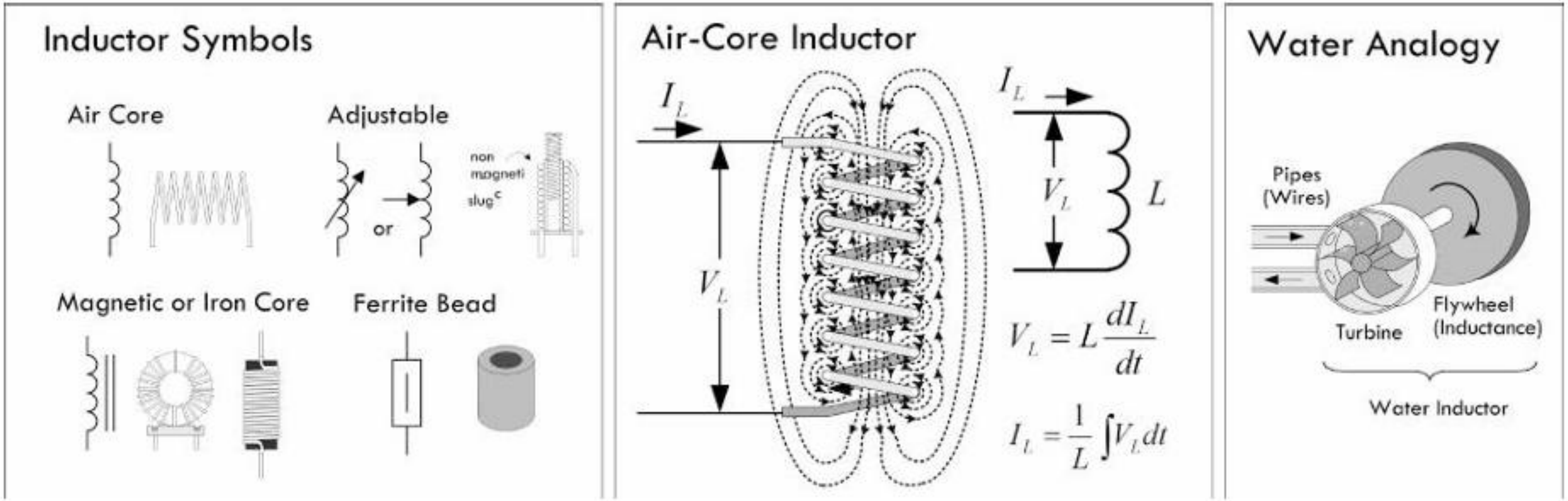
Water Analogy
Tank (Battery)
Tap (Switch)
Water Capacitor
Rubber Membrane

Capacitors


Capacitors In Parallel
Increases the total capacitance, but limits max. voltage rating to that of smallest rated capacitor.
Ctotal
3000 µF
35V (max)
C1
1000µF
35V
C2
1000µF
50V
C3
1000µF
50V
Ctotal = C1 + C2 + C3 + . . . + Cn


Capacitors In Series
Increases max voltage rating, but decreases capcitance.
VIN
100V
Ctotal
0.5714 µF
150V (max)
Ctotal / C1 x VIN = 57.1V
Ctotal / C2 x VIN = 28.6V
Ctotal / C3 x VIN = 14.3V
C1
1µF
50V
C2
2µF
50V
C3
4µF
50V
Ctotal = 1 / (1/C1 + 1/C2 + 1/C3 + . . . + 1/Cn)

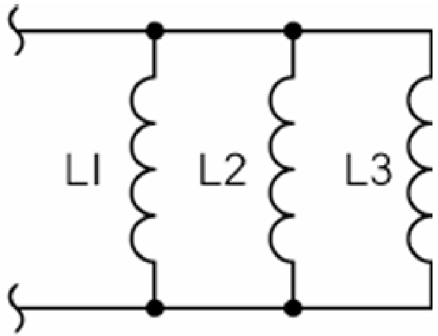
Inductors



Inductor Symbols
Air Core
Adjustable
or
non magnetic slug
Magnetic or Iron Core
Ferrite Bead
Air-Core Inductor
I_L
V_L
L
$V_L = L\frac{dI_L}{dt}$
$I_L = \frac{1}{L}\int V_L dt$
Water Analogy
Pipes (Wires)
Turbine
Flywheel (Inductance)
Water Inductor

Inductors

Inductors in Series



Inductors in parallel

$$L_{eq} = L_1 + L_2 + L_3$$

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$$

Touchpad – Network 2 in the demo board

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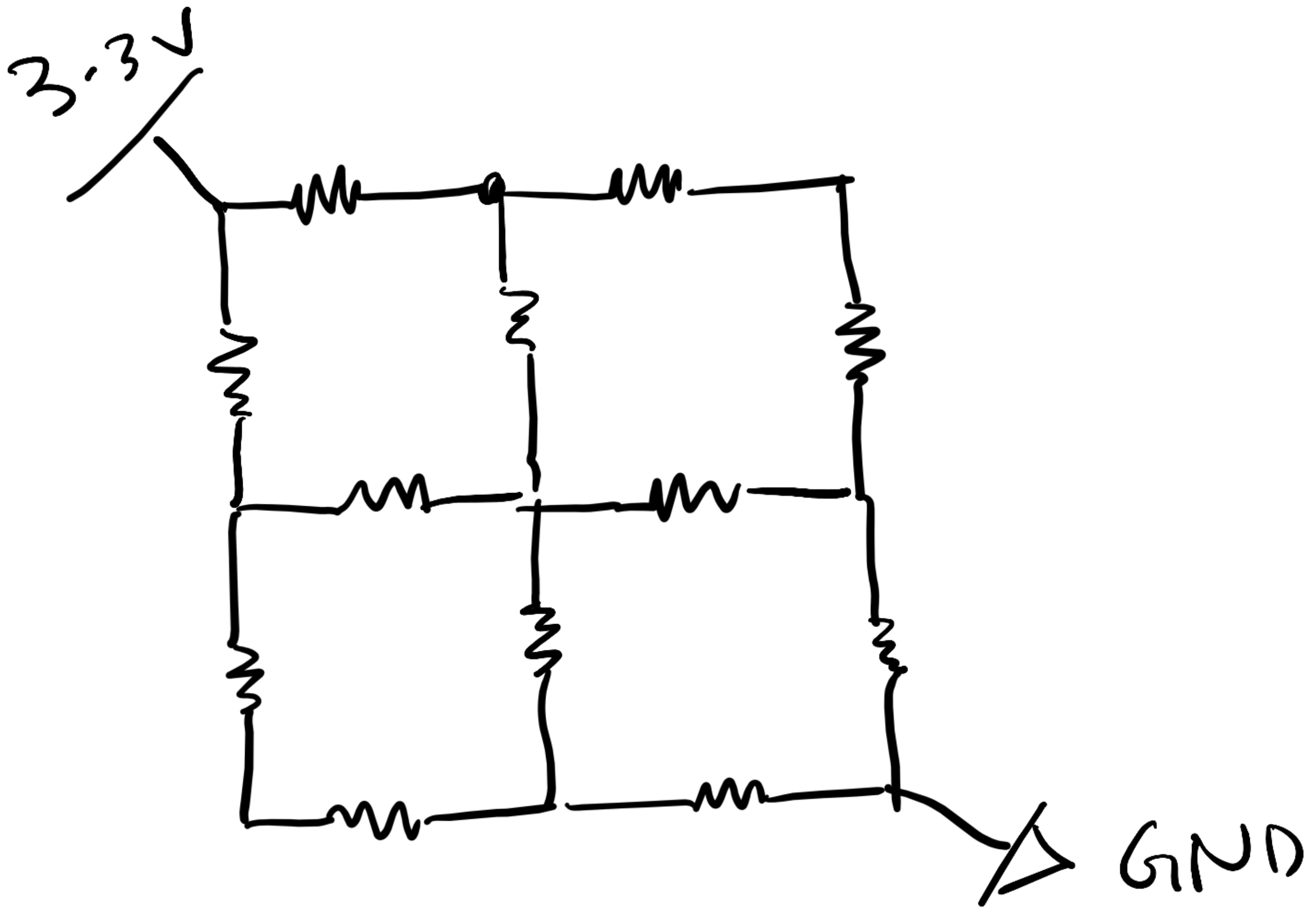

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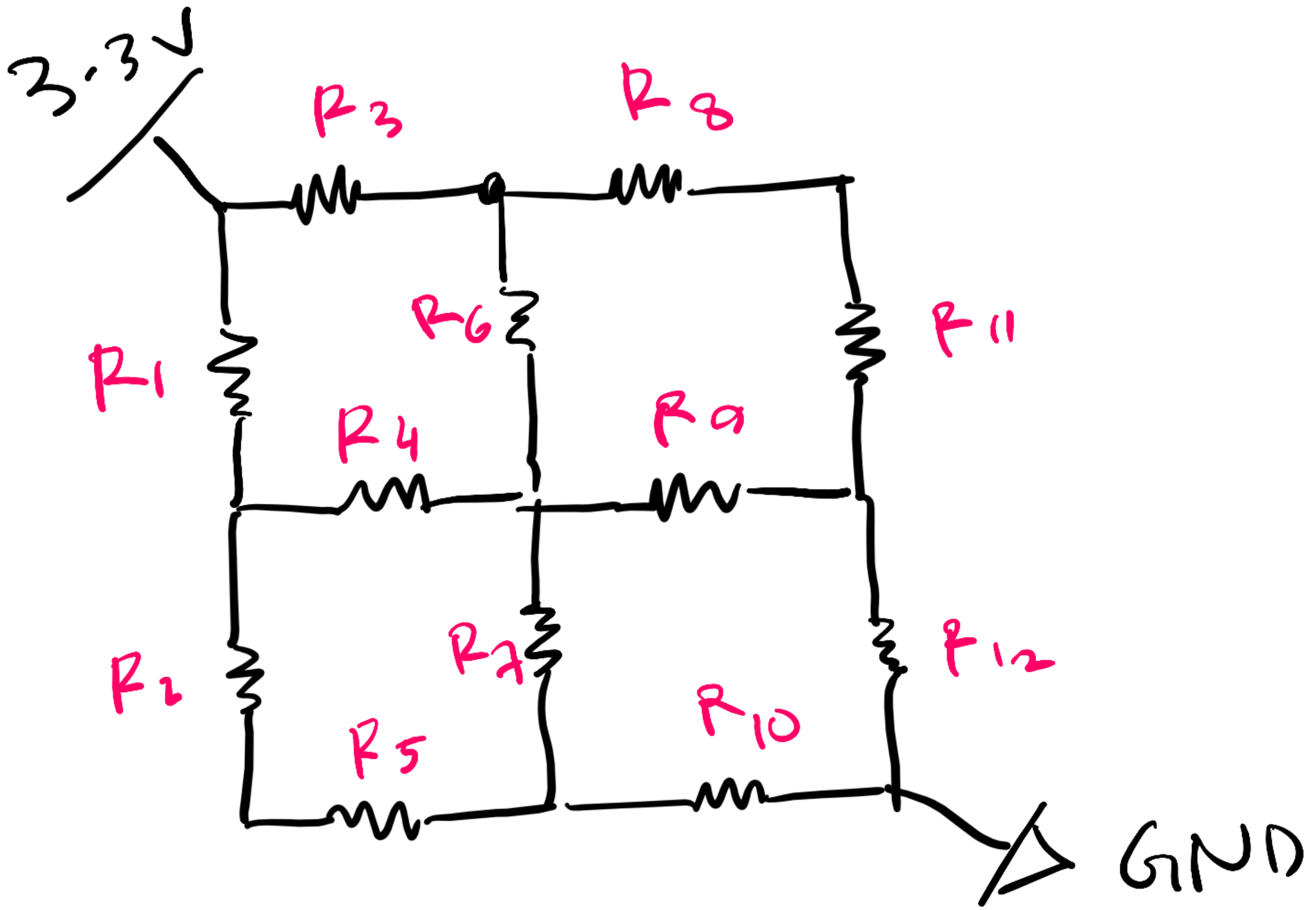

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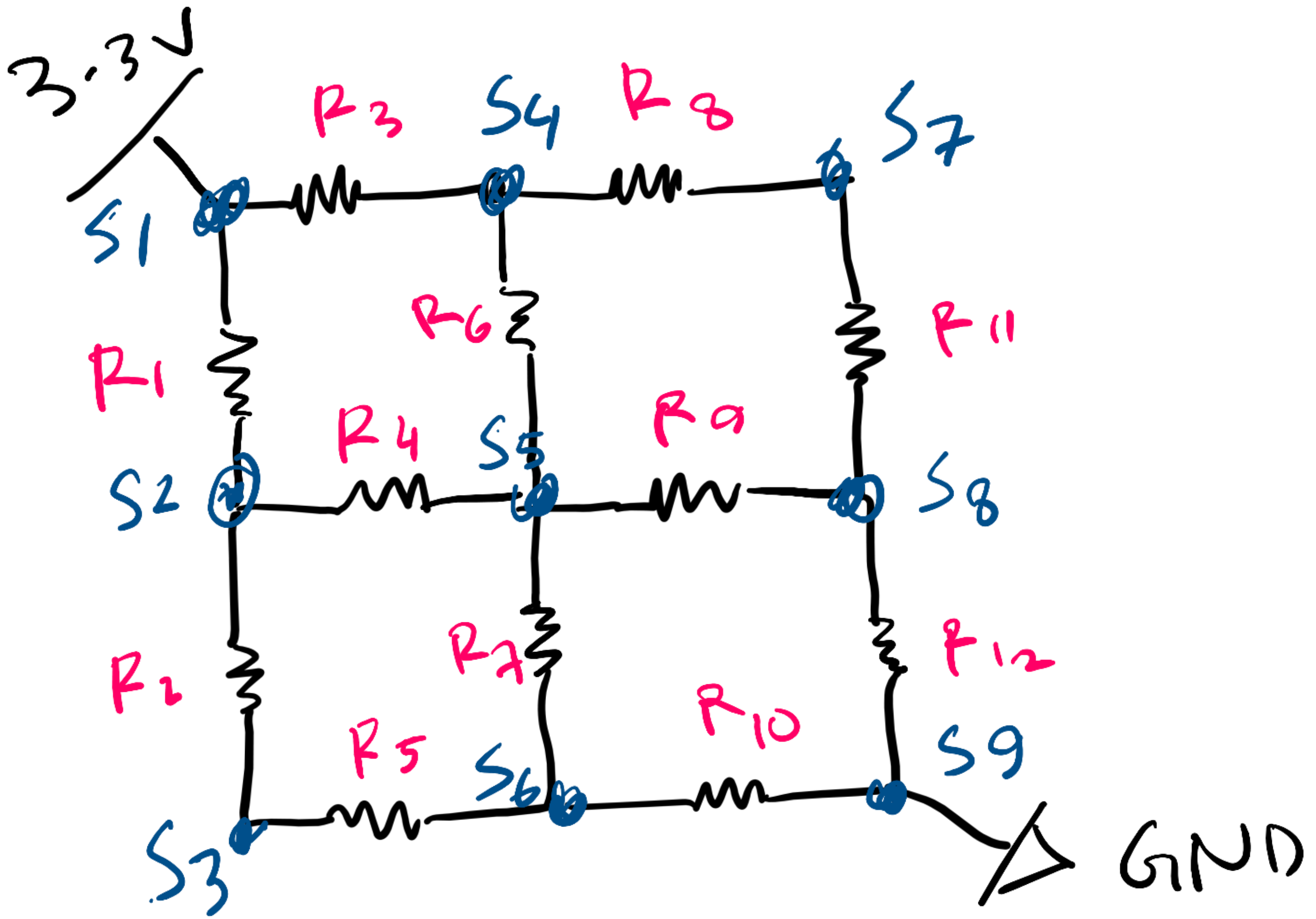

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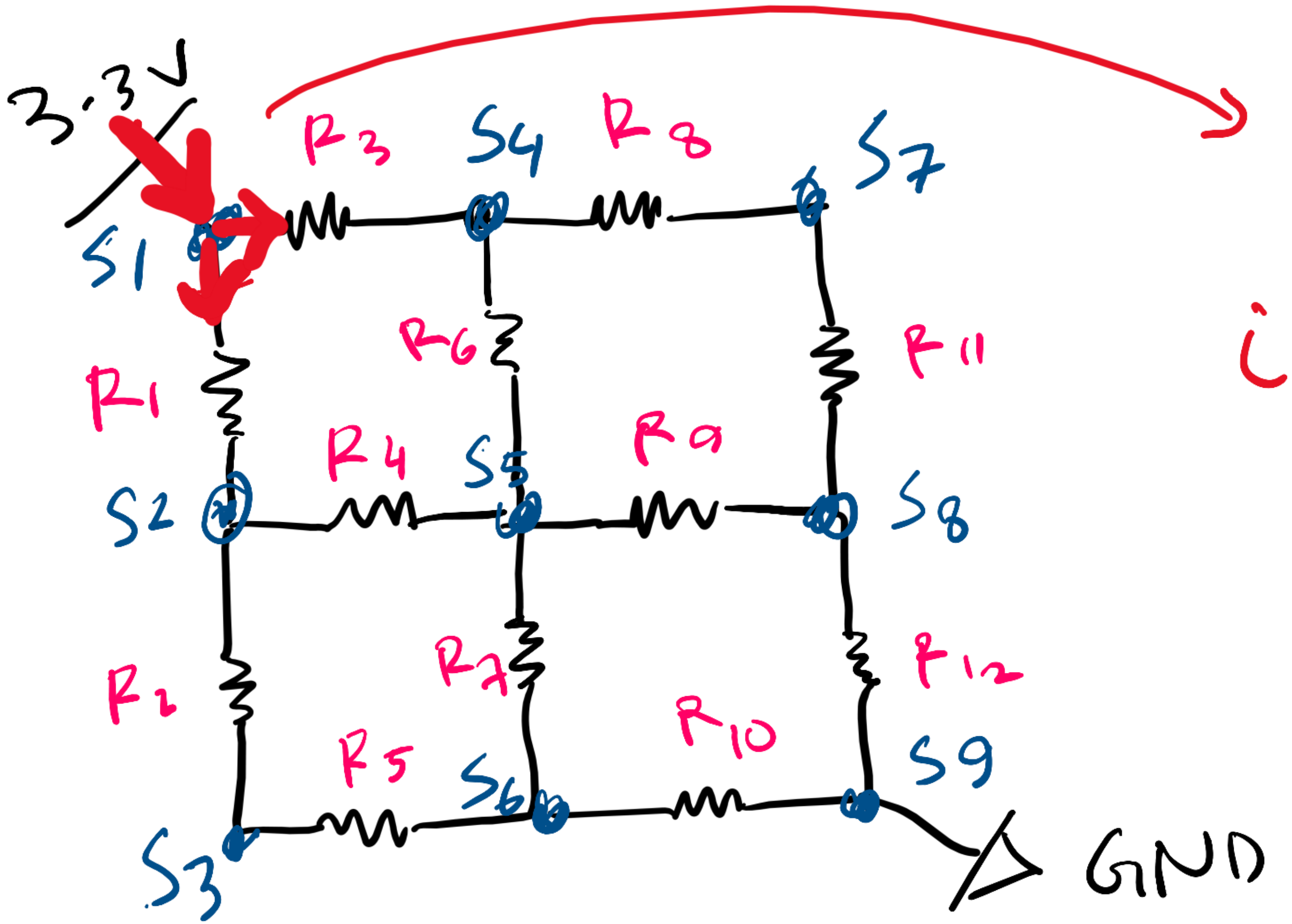


$$i_{tot} = i_{R_1} + i_{R_3}$$

$$i_1 = i_2 + i_4$$

$$i_3 = i_6 + i_8$$

$$\vdots$$

$$i_{10} + i_{12} = i_{tot}$$

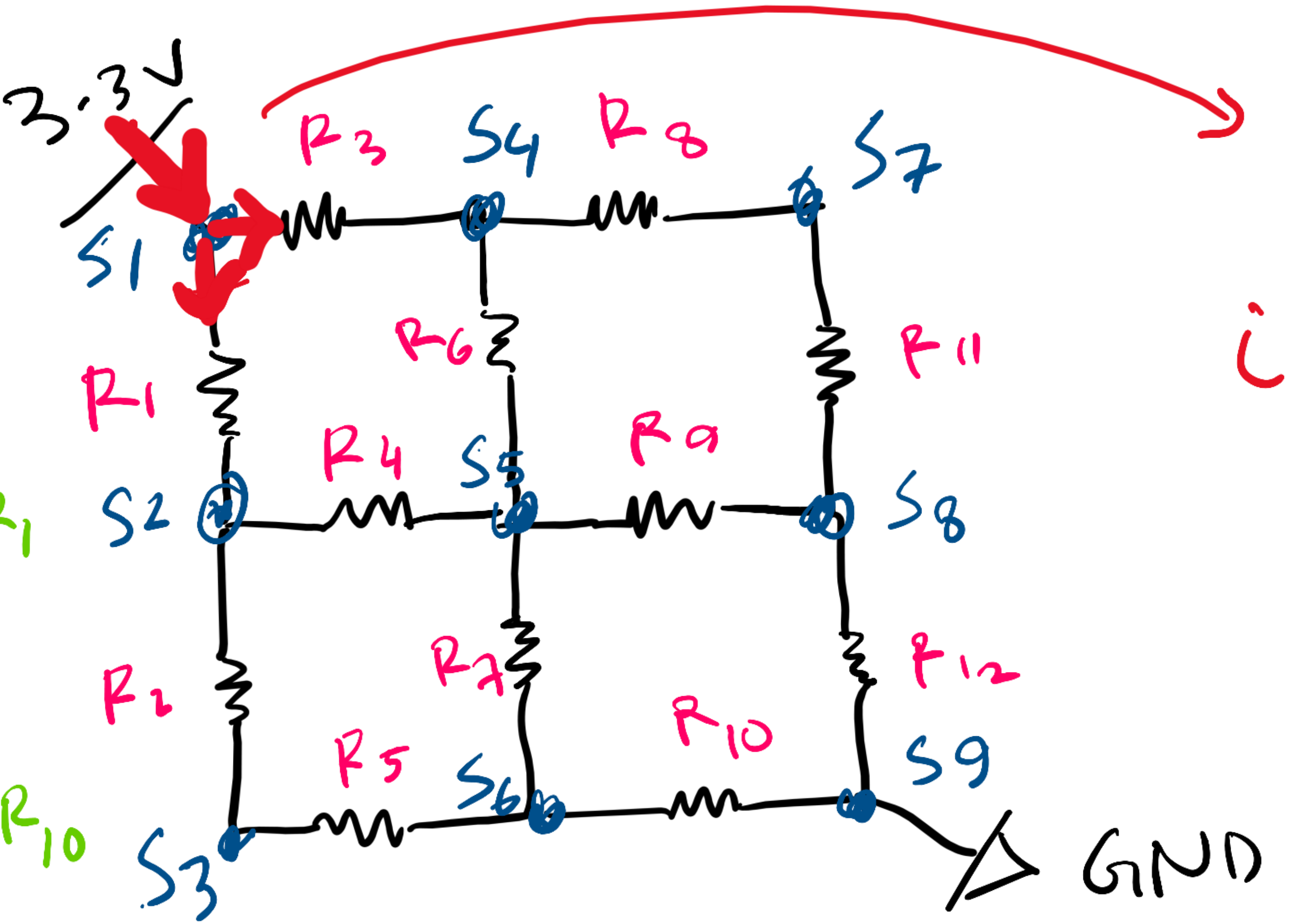
Touchpad – Network 2 in the demo board

$V = IR$

$S_1 - S_2 = i_1 R_1$

⋮

$S_6 - S_9 = i_{10} R_{10}$



$i_{tot} = i_{R_1} + i_{R_3}$

$i_1 = i_2 + i_4$

$i_3 = i_6 + i_8$

⋮

$i_{10} + i_{12} = i_{tot}$

Touchpad – Network 2 in the demo board

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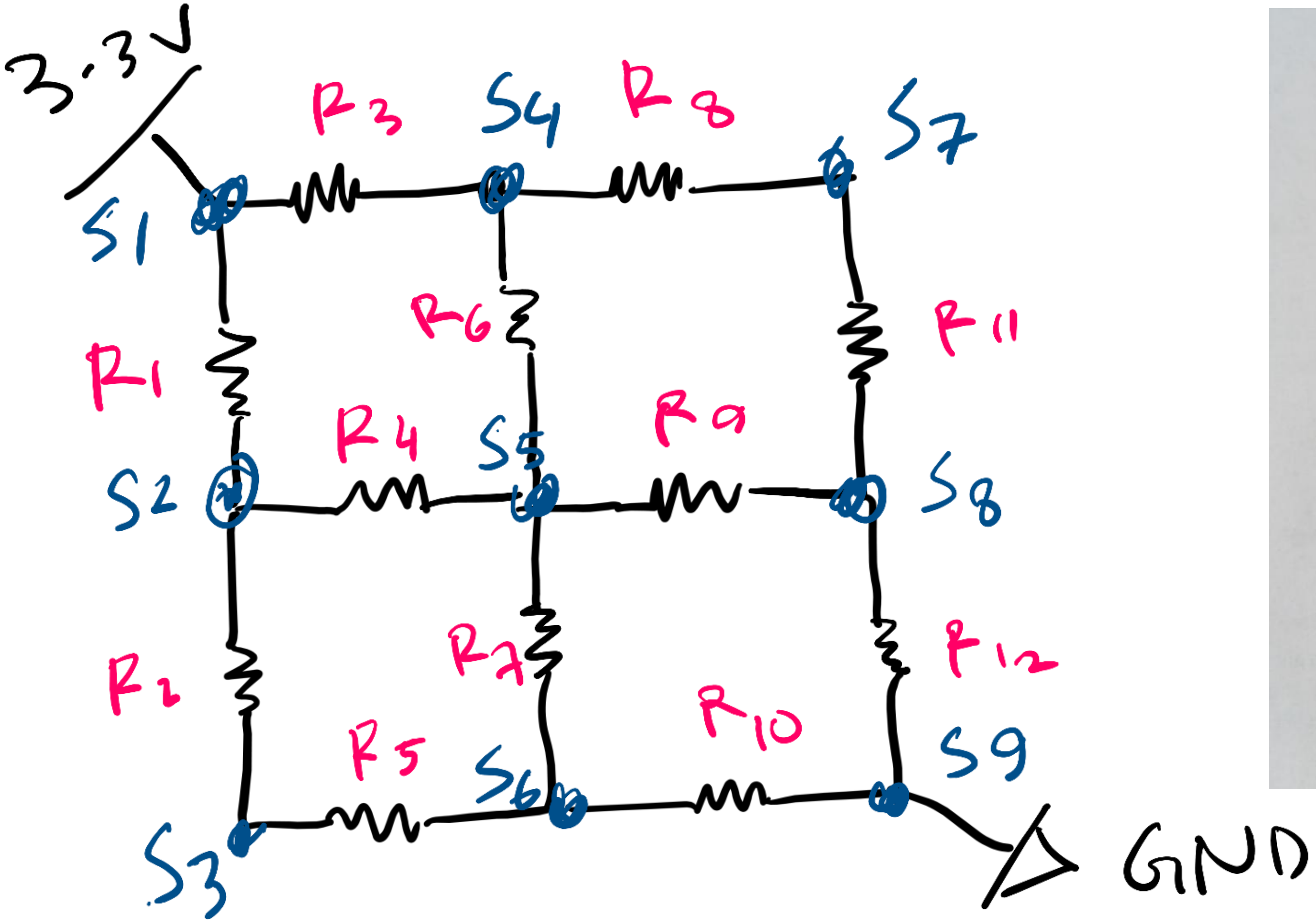

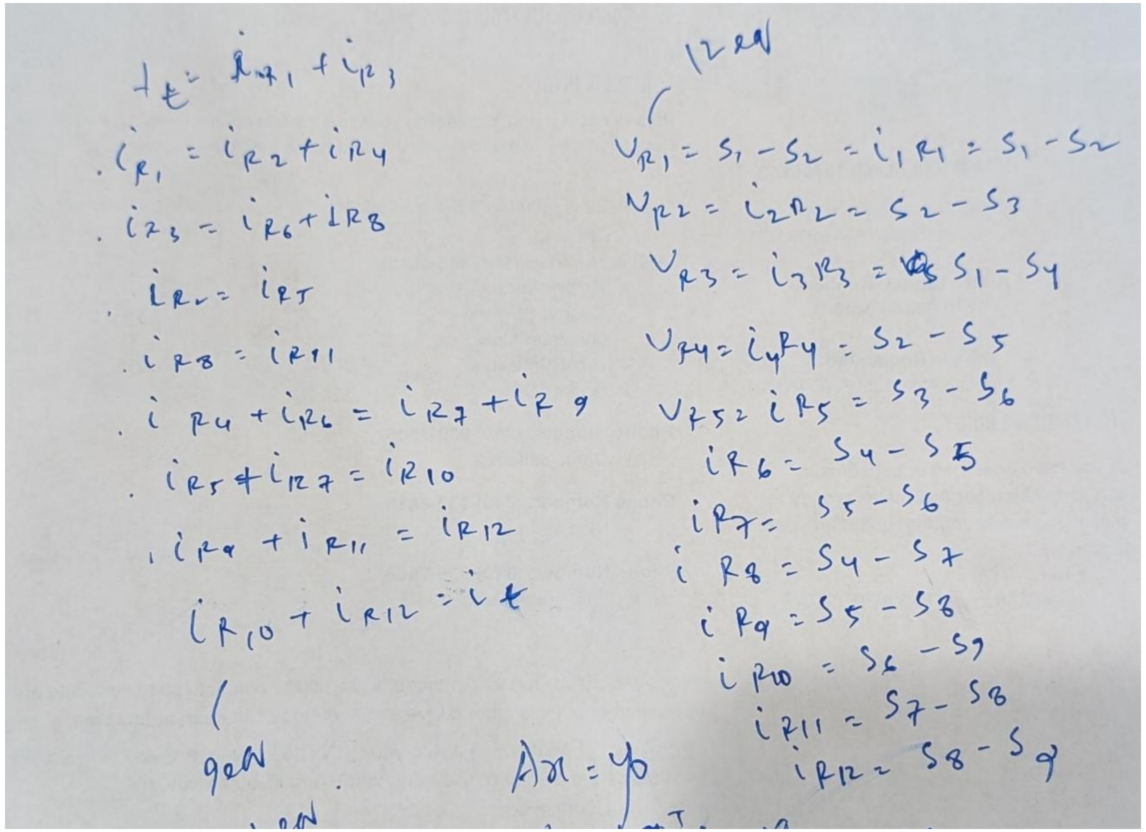

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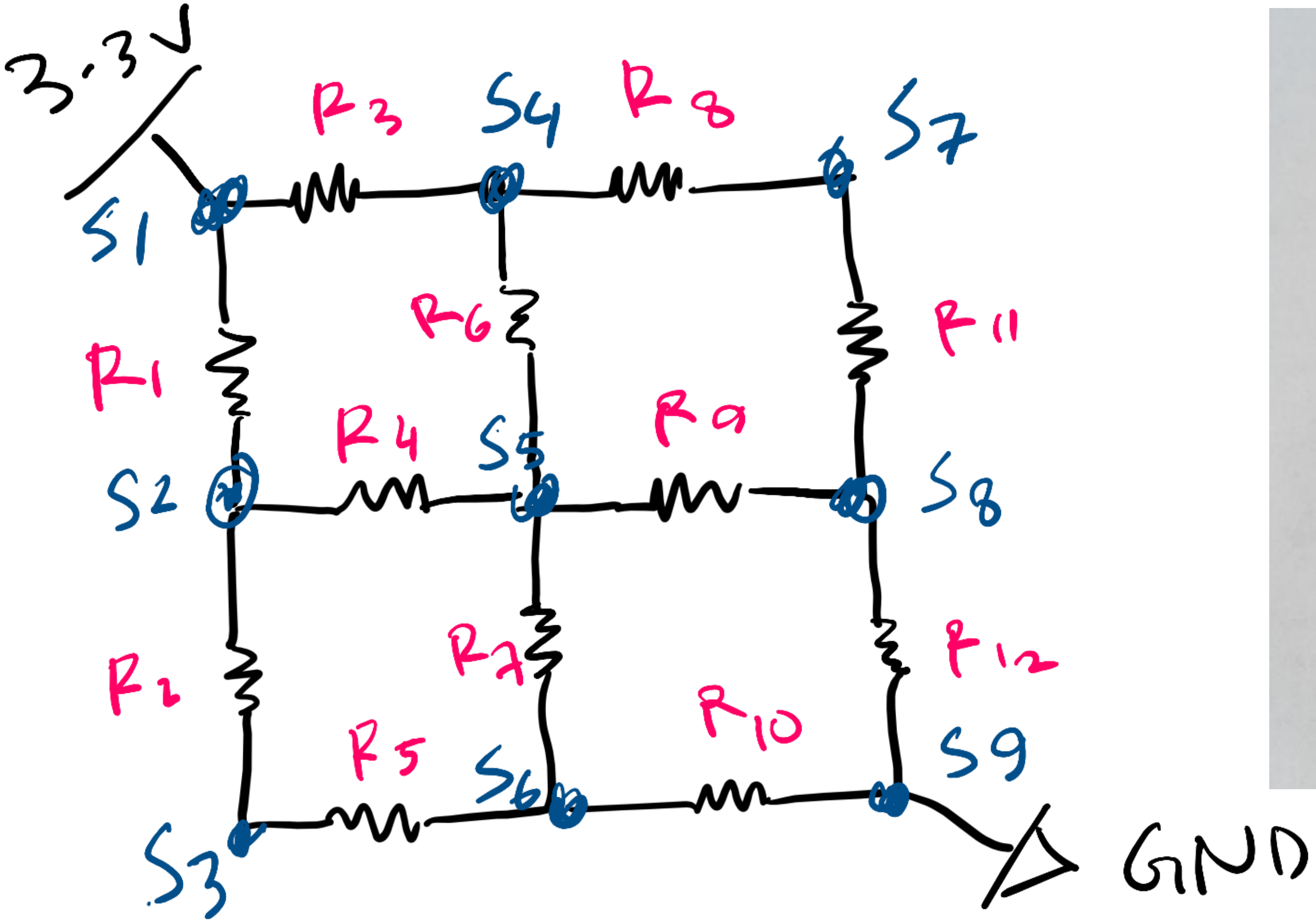

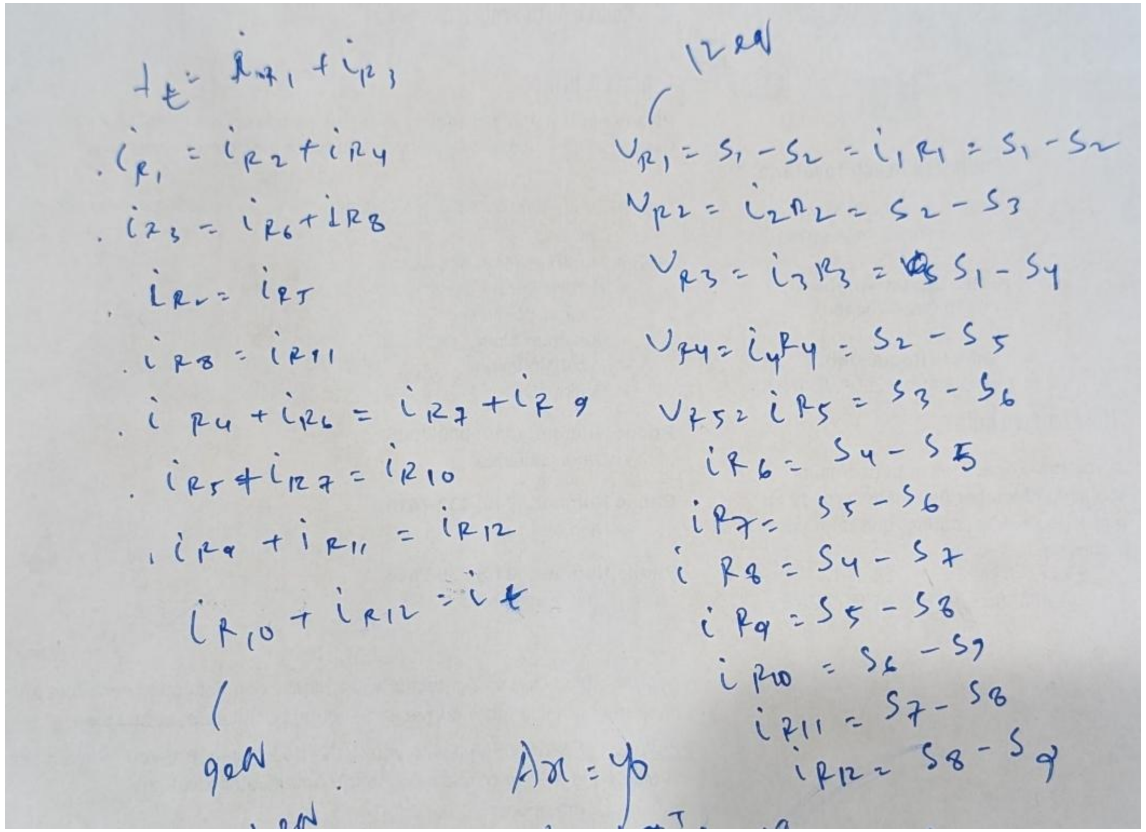

Touchpad – Network 2 in the demo board

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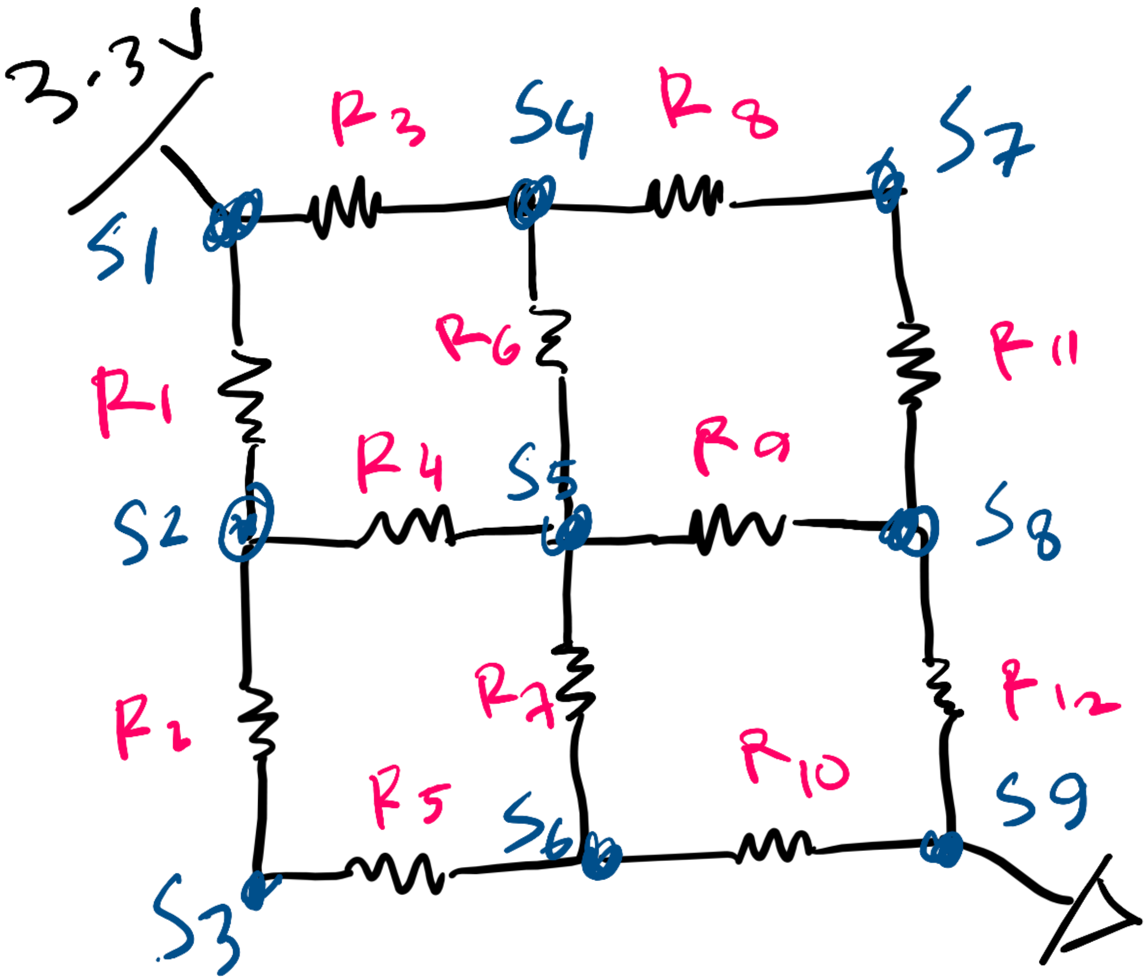
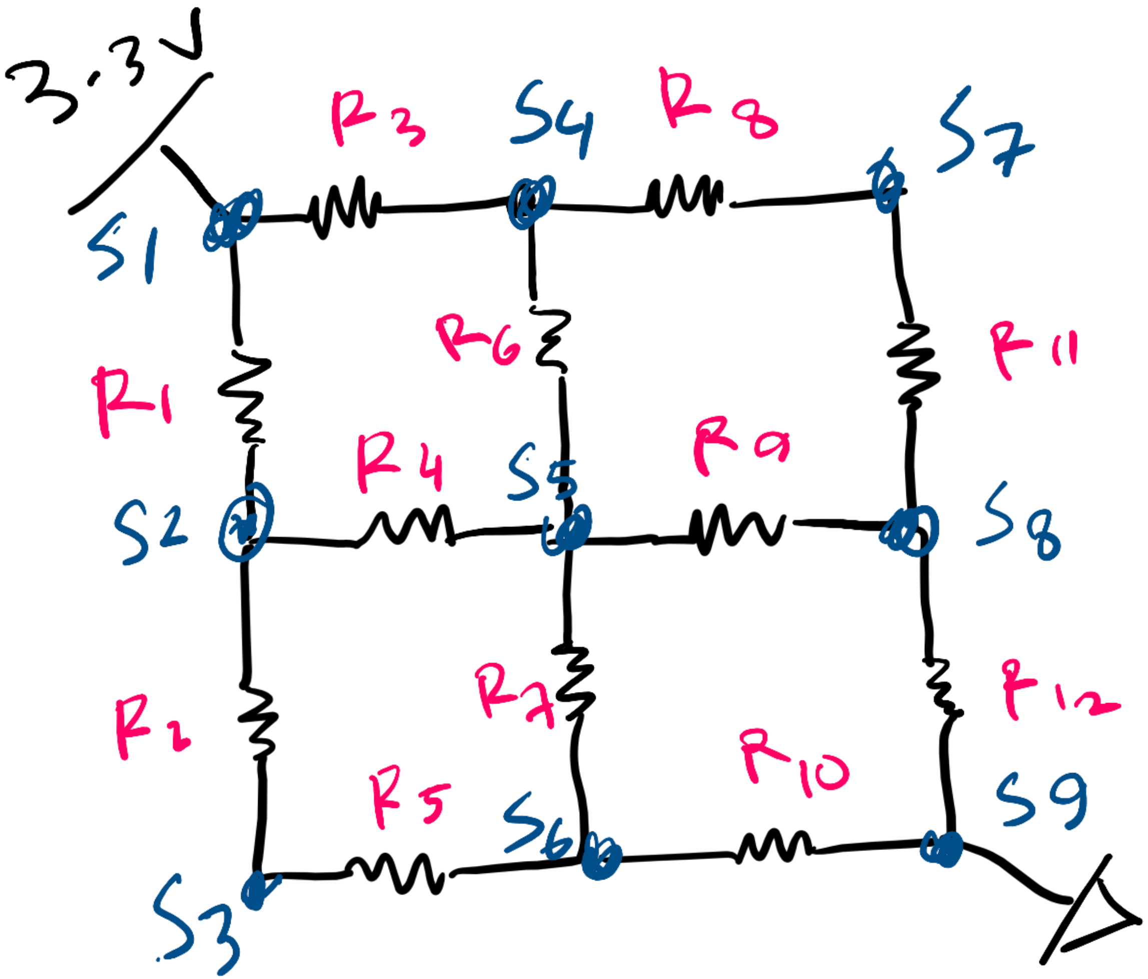


1. $it = i1 + i3$
2. $i1 = i2 + i4$
3. $i3 = i6 + i8$
4. $i2 = i5$
5. $i8 = i11$
6. $i4 + i6 = i7 + i9$
7. $i5 + i7 = i10$
8. $i9 + i11 = i12$
9. $i10 + i12 = it$
10. $i1 \cdot r1 = s1 - s2$
11. $i2 \cdot r2 = s2 - s3$
12. $i3 \cdot r3 = s1 - s4$
13. $i4 \cdot r4 = s2 - s5$
14. $i5 \cdot r5 = s3 - s6$
15. $i6 \cdot r6 = s4 - s5$
16. $i7 \cdot r7 = s5 - s6$
17. $i8 \cdot r8 = s4 - s7$
18. $i9 \cdot r9 = s5 - s8$
19. $i10 \cdot r10 = s6 - s9$
20. $i11 \cdot r11 = s7 - s8$
21. $i12 \cdot r12 = s8 - s9$

With the conditions:

- $r1 = r2 = r3 = r4 = r5 = r6 = r7 = r8 = r9 = r10 = r11 = r12 = 100$
- $s1 = 3.3$
- $s9 = 0$

Touchpad – Network 2 in the demo board



The solution to the system of equations is as follows:

- $i1 = 0.011$
- $i2 = 0.0055$
- $i3 = 0.011$
- $i4 = 0.0055$
- $i5 = 0.0055$
- $i6 = 0.0055$
- $i7 = 0.0055$
- $i8 = 0.0055$
- $i9 = 0.0055$
- $i10 = 0.011$
- $i11 = 0.0055$
- $i12 = 0.011$
- $it = 0.022$

The intermediate variables are:

- $s2 = 2.2$
- $s3 = 1.65$
- $s4 = 2.2$
- $s5 = 1.65$
- $s6 = 1.1$
- $s7 = 1.65$
- $s8 = 1.1$