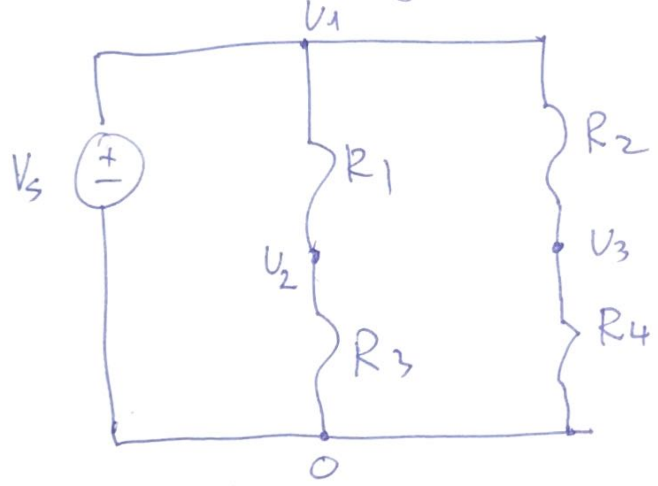
(l1) EE16A

Lecture 4 – Module 2

* An interesting circuit – continued
* 2D touchscreen
* A faster circuit analysis

Note 14

An interesting circuit



$U_2 = ?$ $\quad U_3 = ?$

$$U_2 - 0 = \frac{R_3}{R_1 + R_3} \cdot (U_1 - 0) \quad (U_1 - 0 \to V_s)$$

$$U_2 = \frac{R_3}{R_1 + R_3} \cdot V_s$$

$$U_3 = \frac{R_4}{R_2 + R_4} \cdot V_s$$

Let's have: $R_3 = k R_1$ & $R_4 = k R_2$

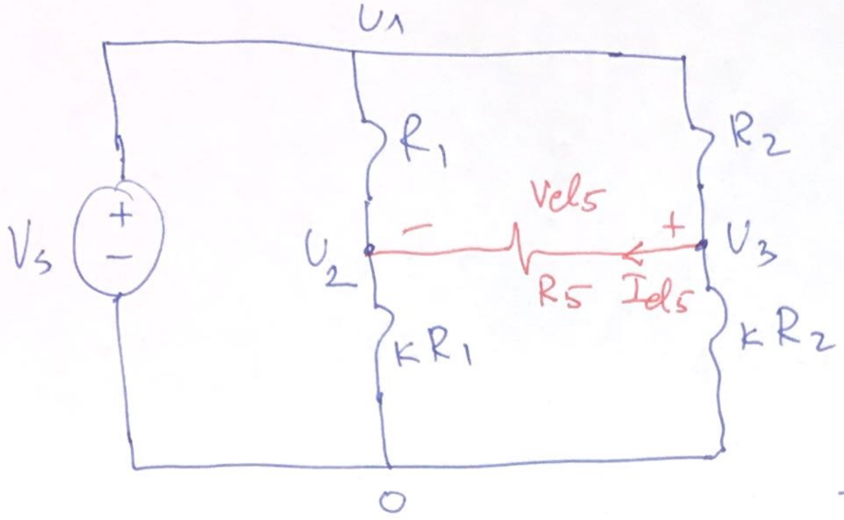
$$U_2 = \frac{k \cdot R_1}{R_1 + k R_1} V_s = \frac{k}{1+k} V_s$$

$$U_3 = \frac{k \cdot R_2}{R_2 + k R_2} V_s = \frac{k}{1+k} V_s$$

$\Rightarrow U_2 = U_3$

(2)

Let's add a resistor:



$V_{el5} = U_3 - U_2$ (voltage def)

$V_{el5} = R_5 \cdot I_{el5}$ (elem. I-V def)

Bold assumption:

$V_{el5} = 0$

If $V_{el5} = 0 \Rightarrow I_{el5} = \frac{V_{el5} \to 0}{R_5} = 0$

solved previously for $I_{el5} = 0 \Rightarrow U_2 = U_3 = \frac{k}{1+k} V_s$

$\Rightarrow V_{el5} = 0$ b.c $V_{el5} = U_3 - U_2 = \frac{k}{1+k} V_s - \frac{k}{1+k} V_s$

$= 0$

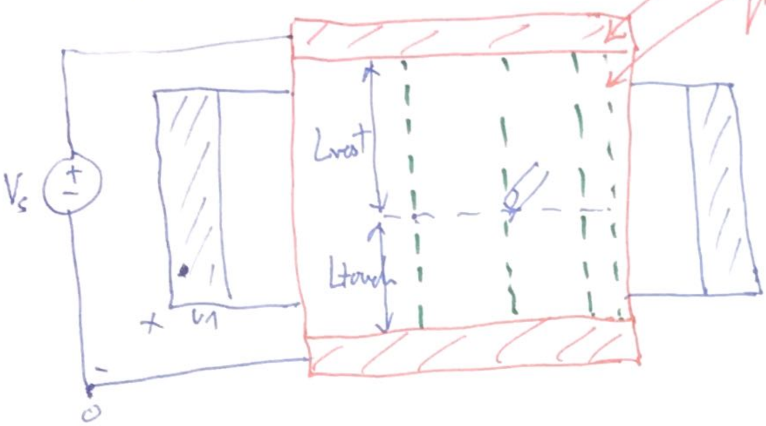
(L3)

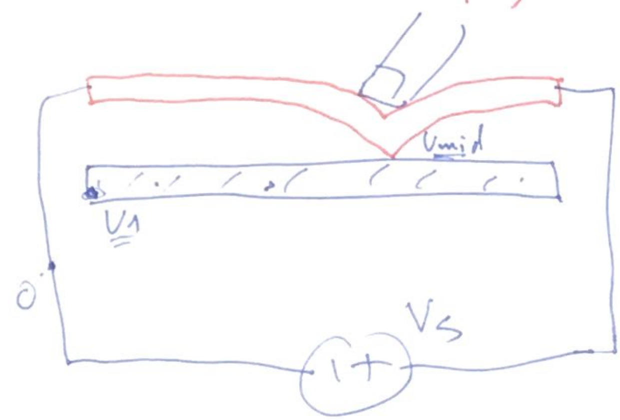
2D Touchscreen:

Top view:

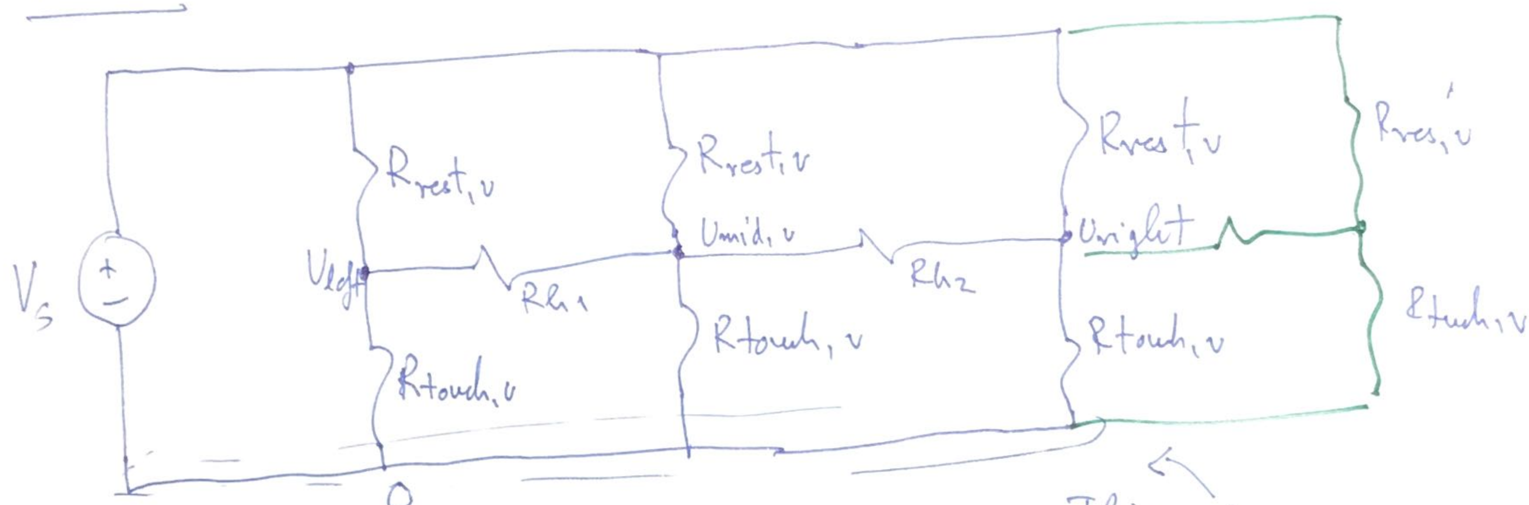
good conductor (low ρ) – model as wires

poor conductor (high ρ) – model as R's





Model:



This is our "interesting" circuit b/c all resistor's are proportional in all vertical branches.

$$U_{mid,v} = \frac{R_{touch,v}}{R_{rest,v} + R_{touch,v}} \cdot V_s$$

$$= \frac{\rho \cdot \frac{L_{touch,v}}{A}}{\rho \cdot \frac{L_{rest,v}}{A} + \rho \cdot \frac{L_{touch,v}}{A}} \cdot V_s$$

$U_{mid,v} = U_{left} = U_{right}$

$I_{R_{h1}} = 0$, $I_{R_{h2}} = 0$

⇓

voltage div to solve for $U_{mid,v}$

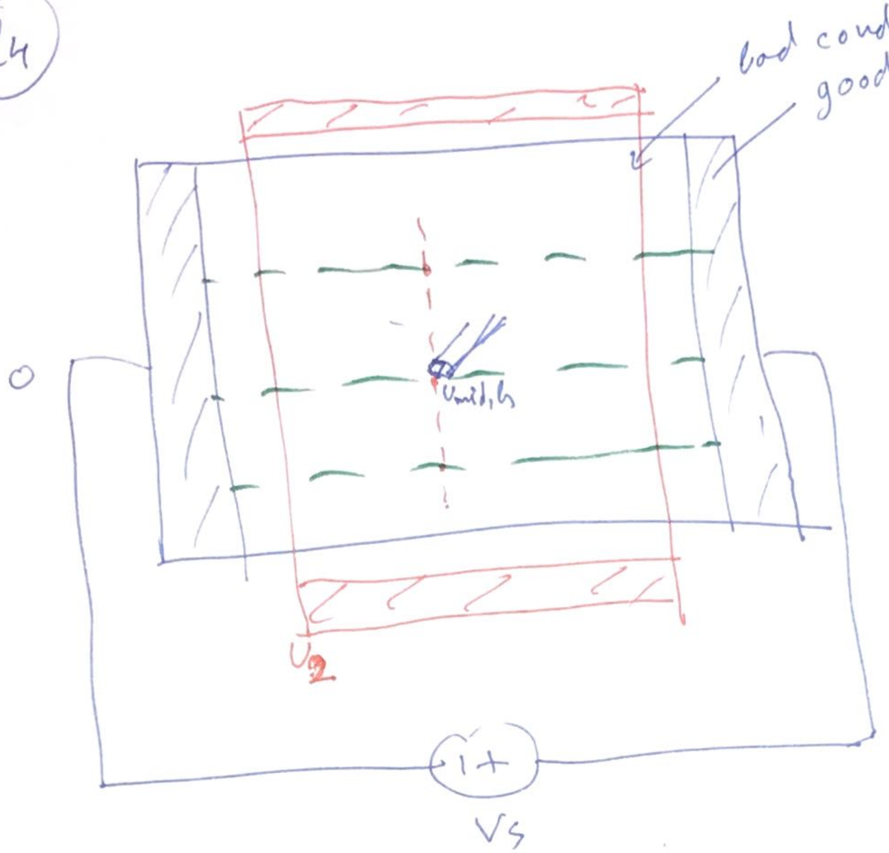
$L_{rest,v} + L_{touch,v} = L_v$

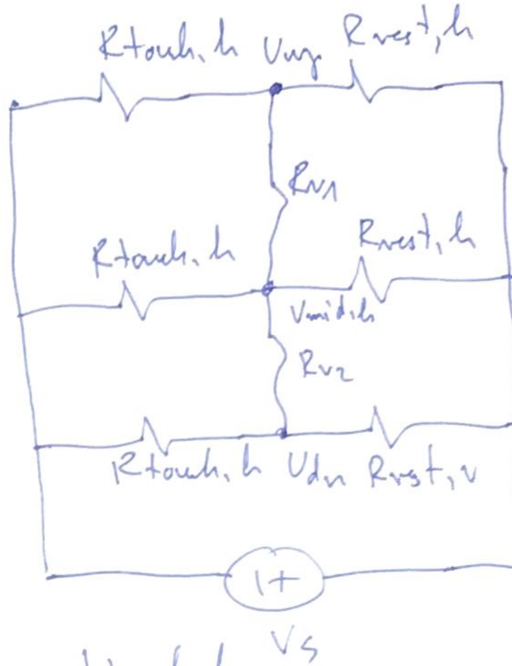
$$\boxed{U_{mid,v} = \frac{L_{touch,v}}{L_v} \cdot V_s}$$

vertical finger position info

$U_1 = U_{mid,v}$

(4)



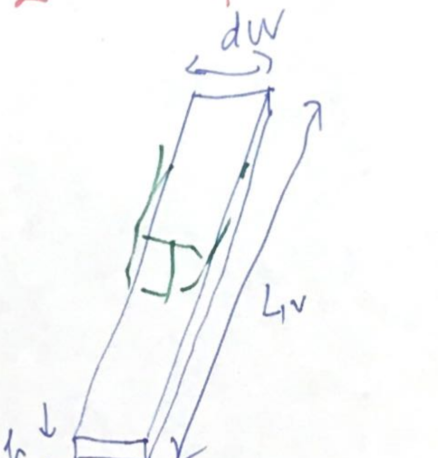


$$R_{touch,h} \rightarrow \rho \cdot \frac{L_{touch,h}}{A}$$

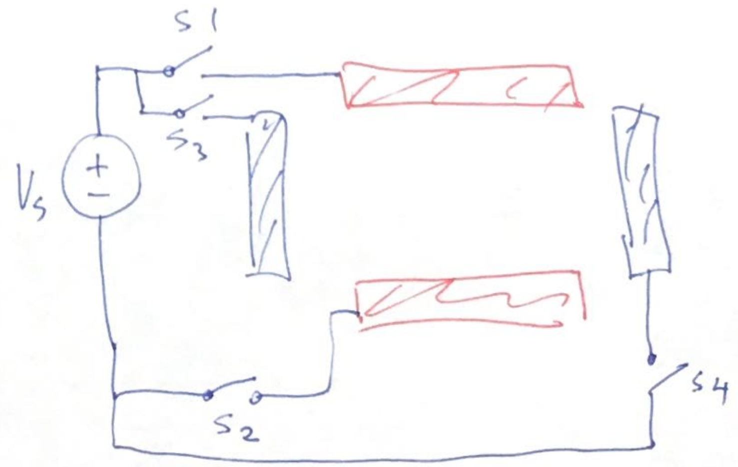
$$U_{up} = U_{dn} = U_{mid,h} = \frac{R_{touch,h}}{R_{touch,h} + R_{rest,h}} \cdot V_s$$

$$\boxed{U_{mid,h} = \frac{L_{touch,h}}{L_h} \cdot V_s}$$

$$U_2 = U_{mid,h}$$



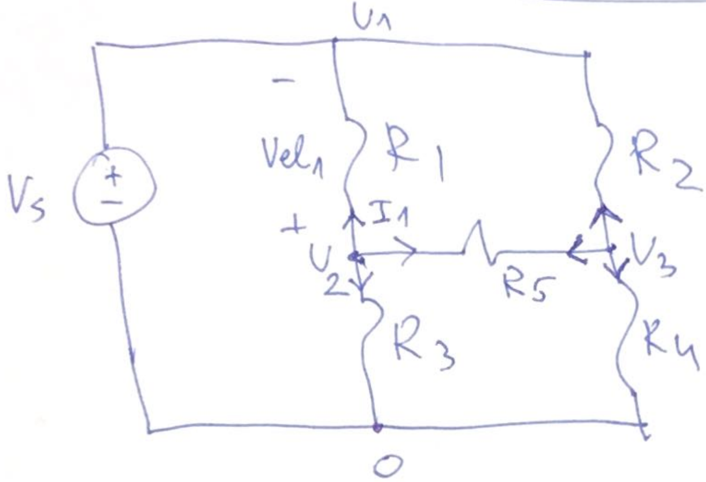
$$dA = dW \cdot h$$



Step 1: S1, S2 on, S3, S4 off

Step 2: S1, S2 off, S3, S4 on

Faster circuit analysis:



step 1: Label the nodes (unknowns & ref node)

step 2: Write the equations for nodes that have voltage source between them.

$$U_1 - 0 = V_S \Rightarrow \boxed{U_1 = V_S}$$

step 3: Write KCLs & IR element combo including any possible current sources

For node 2: $I_1 = \frac{U_2 - U_1}{R_1} = \frac{Vel_1}{R_1}$ (elem. def) — $U_2 - U_1 = Vel_1$ (voltage def)

Magic:

Apply to U_2: $\frac{U_2 - U_1}{R_1} + \frac{U_2 - 0}{R_3} + \frac{U_2 - U_3}{R_5} = 0$ ($U_1 \to V_S$)

Apply to U_3: $\frac{U_3 - U_1}{R_2} + \frac{U_3 - U_2}{R_5} + \frac{U_3 - 0}{R_4} = 0$ ($U_1 \to V_S$)

From U_2: $U_2\left(\frac{1}{R_1} + \frac{1}{R_3} + \frac{1}{R_5}\right) - \frac{1}{R_5} \cdot U_3 = \frac{V_S}{R_1}$

From U_3: $U_2\left(-\frac{1}{R_5}\right) + U_3\left(\frac{1}{R_2} + \frac{1}{R_5} + \frac{1}{R_4}\right) = \frac{V_S}{R_2}$

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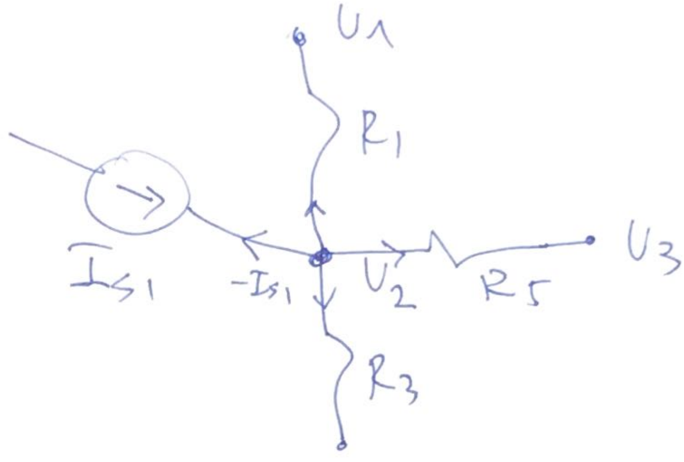

From U_2:

$$\frac{U_2 - U_1}{R_1} + \frac{U_2 - U_3}{R_5} + \frac{U_2 - 0}{R_3} - I_{s1} = 0$$

"Nodal" analysis