Univerzitet u Banjoj Luci

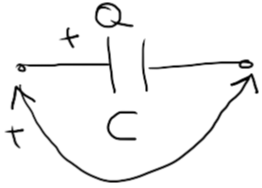
Elektrotehnički fakultet

Osnovi elektrotehnike 1

Električne mreže sa kondenzatorima

Predavanje: 12. blok

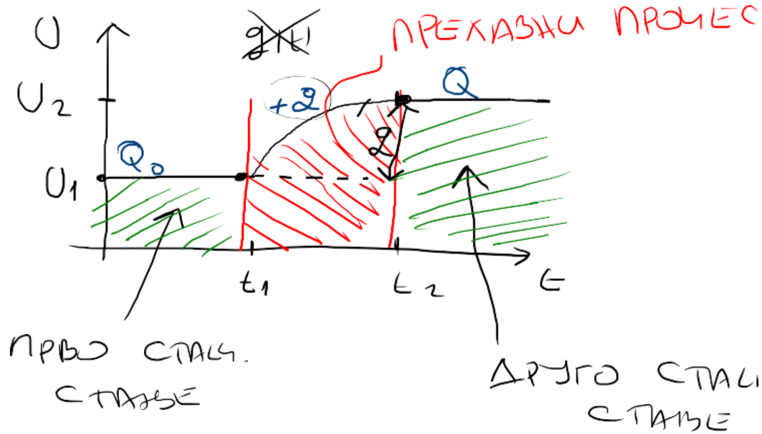
ЕЛЕКТРИЧНЕ МРЕЖЕ СА КОНДЕНЗАТОРИМА



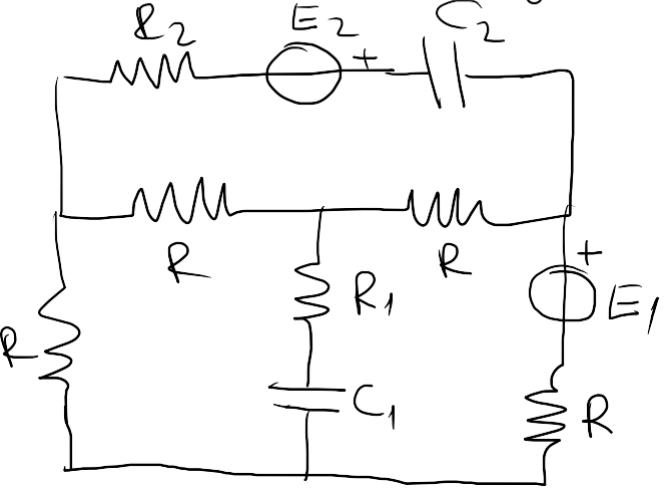
$C = \frac{Q}{U}$

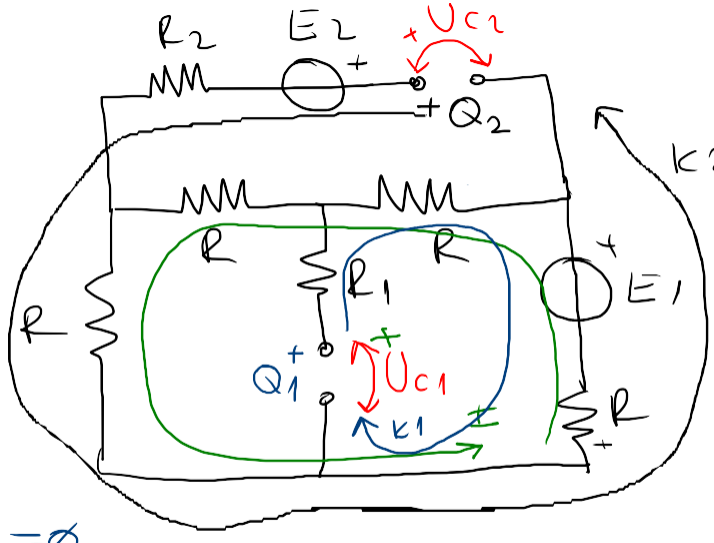
1. садрже R и C али постоје струје бар у неким гранама мреже
2. електростатичке мреже: садрже бар један конд. у свакој грани па им у једној грани која нема струје у стац. стање.

Q_0 – поч. наел.
Q – крајње наел.
q



Мрежа са кондензатора и кондензатора





$$I = \frac{E_1}{4R}$$

$$Q_2 = C_2 U_{C2}$$

$$-U_{C1} + U_{R1} - RI + E_1 - RI = 0$$

$U_{R1} \to 0$

$$U_{C1} = E_1 - 2RI$$

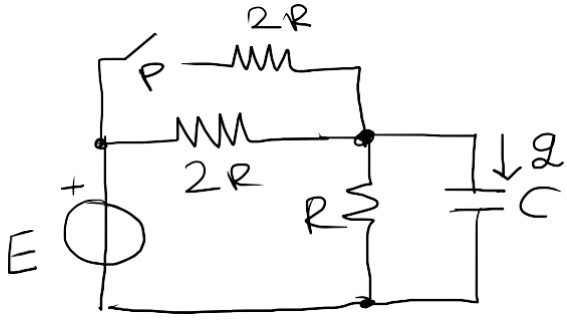
$$U_{C1} = E_1 - 2R\frac{E_1}{4R} = \frac{E_1}{2}$$

$$Q_1 = C_1 U_{C1} = \frac{1}{2} C_1 E_1$$

$$K2: -U_{C2} + E_2 + RI + RI - E_1 = 0$$

$$U_{C2} = E_2 - E_1 + 2R\frac{E_1}{4R}\,2$$

$$\boxed{U_{C2} = E_2 - 0{,}5\,E_1}$$



$$q = Q'' - Q' = C \cdot U'' - C U' = C \cdot (U'' - U')$$

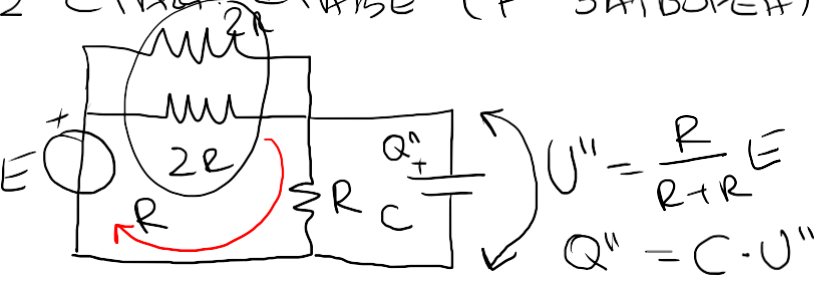
$$\boxed{q = C \cdot \Delta U}$$

1° СТАЦ. СТАНЕ (P ОТВОРЕН)

$$U' = \frac{R}{R+2R} E$$

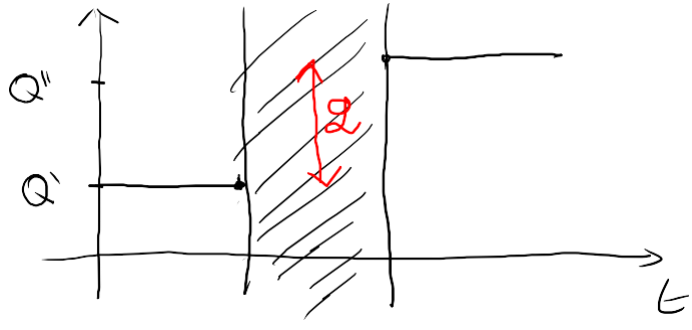
$$Q' = C \cdot U'$$

2° СТАЦ. СТАНЕ (P ЗАТВОРЕН)



$$U'' = \frac{R}{R+R} E$$

$$Q'' = C \cdot U''$$



$$q = Q'' - Q' = C \cdot \frac{RE}{R+R} - C \frac{RE}{3R}$$

$$q = \frac{CE}{2} - \frac{CE}{3}$$

ELEKTROSTATSKE MREŽE

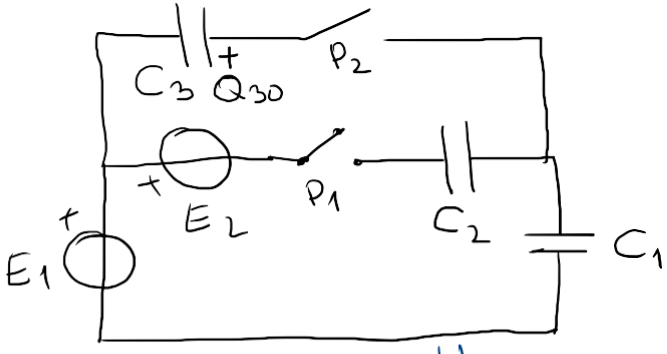
$\Sigma q = \phi$ tj. $\Sigma q_{ul} = \Sigma q_{izl}$ 1. K.Z za elektrostat. mreže

$\Sigma E - \Sigma \frac{Q}{C} = \phi$ 2. K.Z. za elektrostat. mreže i odnosi se na krajnje konture mreže.

$Q = q \pm Q_0$

ΣE => uzima „+" ako je ref. smer za E isti kao i smer orijentacije konture.

$\Sigma \frac{Q}{C}$ => „+" ako se pri obilasku konture ide na kraju kondenzatora za koji je definisano da je „+".



P_1 и P_2 отв $\Rightarrow$ P_1 замк. $\Rightarrow$ замк. и P_2

$Q_{10} = 0$ $\quad Q_{20} = 0$

$$E_1 - E_2 - \frac{q}{C_2} - \frac{q}{C_1} = 0$$

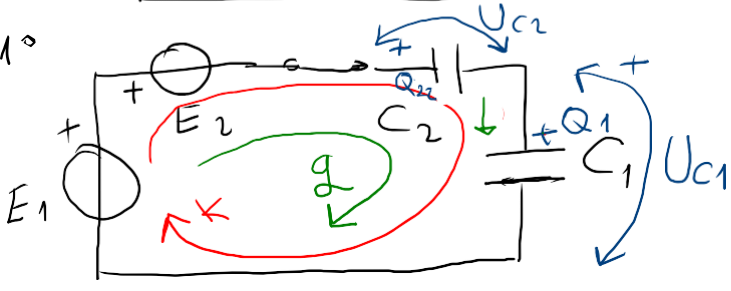
$$E_1 - E_2 = q\left(\frac{1}{C_1} + \frac{1}{C_2}\right) = q\,\frac{C_1 + C_2}{C_1 \cdot C_2}$$

$$q = \frac{C_1 C_2}{C_1 + C_2}\left(E_1 - E_2\right)$$

$$Q_1 = q$$

$$Q_2 = q$$

1°

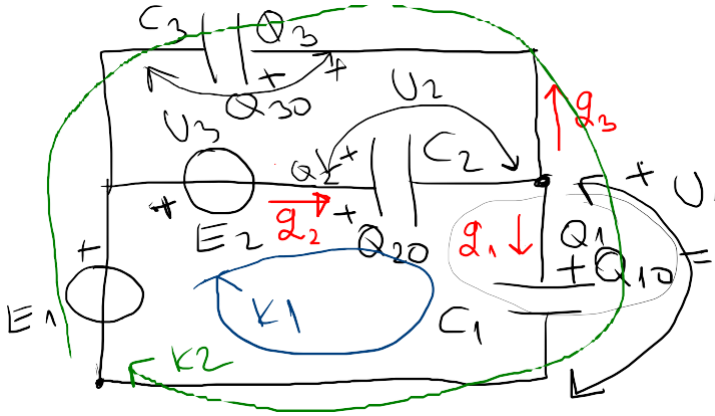


$$\Sigma E - \Sigma \frac{Q}{C} = 0$$

$$\left(E_1 - E_2\right) - \left(\frac{Q_2}{C_2} + \frac{Q_1}{C_1}\right) = 0$$

$Q_1 = Q_{10} + q$ $\quad Q_2 = Q_{20} + q$

$Q_1 = Q_2 = q$



$Q_{10} = Q_{10} = q$

Q_1 из предходна схема

$$U_{C1} = \frac{Q_{10} + q_1}{C_1}$$

$$\sum U = 0$$

$$K1: \; -E_1 + E_2 + U_2 + U_1 = 0$$

$$E_1 - E_2 = U_1 + U_2$$

$$E_1 - E_2 = \frac{Q_1 + q_1}{C_1} + \frac{Q_2 + q_2}{C_2}$$

$$q_2 = q_1 + q_3$$

$$E_1 - E_2 - \left(\frac{Q_2}{C_2} + \frac{Q_1}{C_1} \right) = 0$$

$$E_1 - \left(-\frac{Q_3}{C_3} + \frac{Q_1}{C_1} \right) = 0$$

$$E_1 - E_2 = \frac{Q_{10} + q_1}{C_1} + \frac{Q_{20} + q_2}{C_2}$$

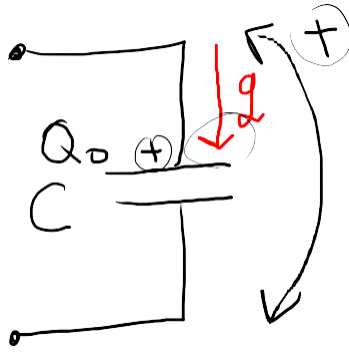
$$E_1 = \frac{Q_{10} + q_1}{C_1} - \frac{Q_{30} + q_3}{C_3}$$

$$q_2 = q_1 + q_3$$

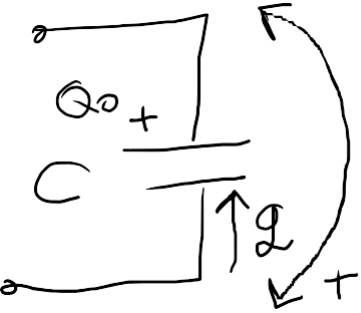
Q_{10} и Q_{20} сме одредили у прошлој схеми

Q_{30} било одређено иницијалним задатком.

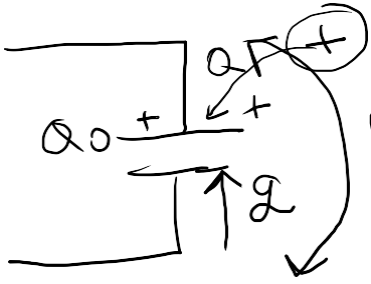
$\Rightarrow$ 3 јед. $\Rightarrow$ q_1, q_2, q_3



$$U = \frac{Q}{C} = \frac{Q_0 + q}{C}$$

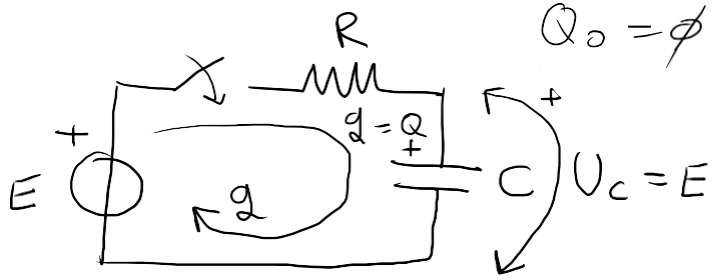


$$U = \frac{Q}{C} = \frac{-Q_0 + q}{C}$$



$$U = \frac{Q}{C} = \frac{Q_0 - q}{C}$$

ПУЊЕЊЕ (ОПТЕРЕЋИВАЊЕ) КОНДЕНЗАТОРА



$Q_0 = 0$

$W = \frac{1}{2} C U^2$

$W_c = \frac{1}{2} C E^2$

$U_c = E$

Према закону одржања рада и енергије

$A_g = \Delta Q \int_A^P \vec{E}_{STE} \, d\vec{l}$

E

$A_g = Q \cdot E = C E^2$

$A_g = A_j^\circ + W_c$

$A_j^\circ = A_g - W_c = \frac{1}{2} C E^2$

~~$A_j^\circ = R I^2 \quad I = \frac{E}{R}$~~

$* \; Q_0 \neq 0 \Rightarrow W_{c0}$

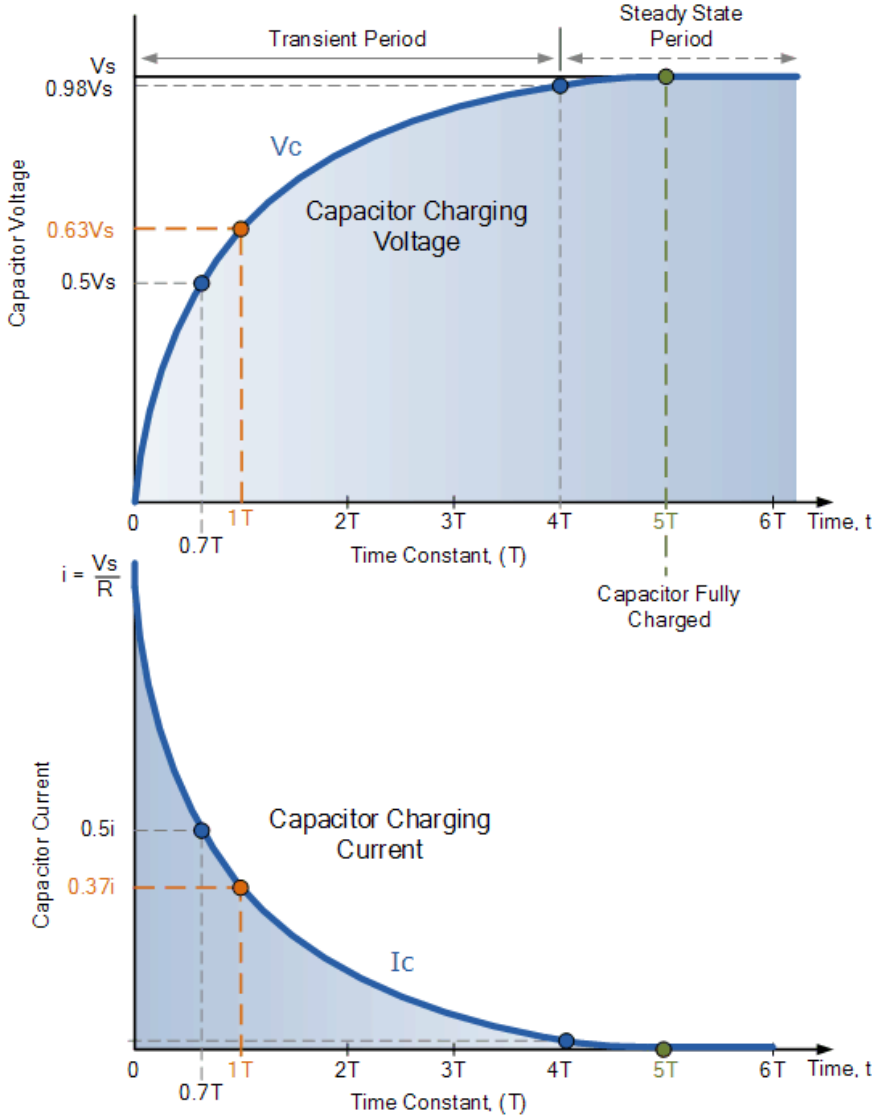
$A_g = A_j^\circ + \Delta W_c$

$\Delta W_c = W_c^{NSS} - W_S^{SSS} = W_c^{POSLE} - W_c^{PRIJE}$

$A_g = A_j^\circ + W_c'' - W_c'$

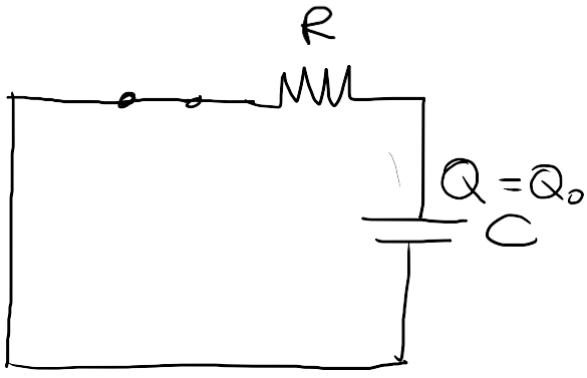
$W_c'' = \frac{C E^2}{2}$

$A_j \neq \frac{1}{2} C E^2$



$$V_C = V_S\left(1 - e^{(-t/RC)}\right)$$

ПРАЦЭСЫ ЗАРАДКІ (РАЗРАДКІ) КОНДЭНСАТАРА

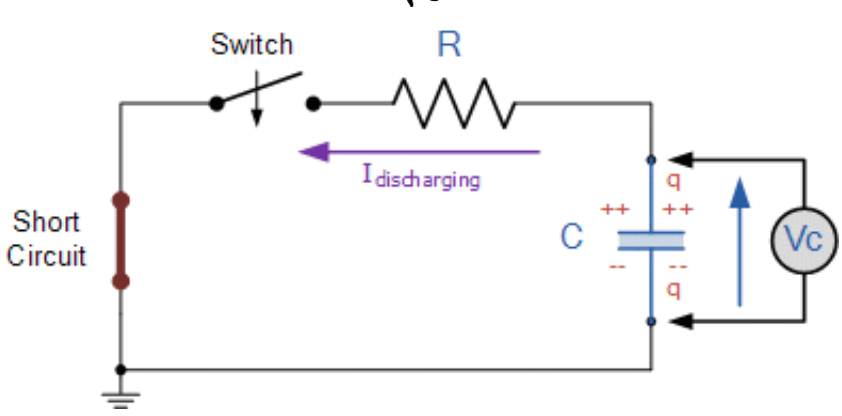


$$A_g = A_j + \Delta W_c = A_j + (W_c'' - W_c') = A_j - W_c'$$

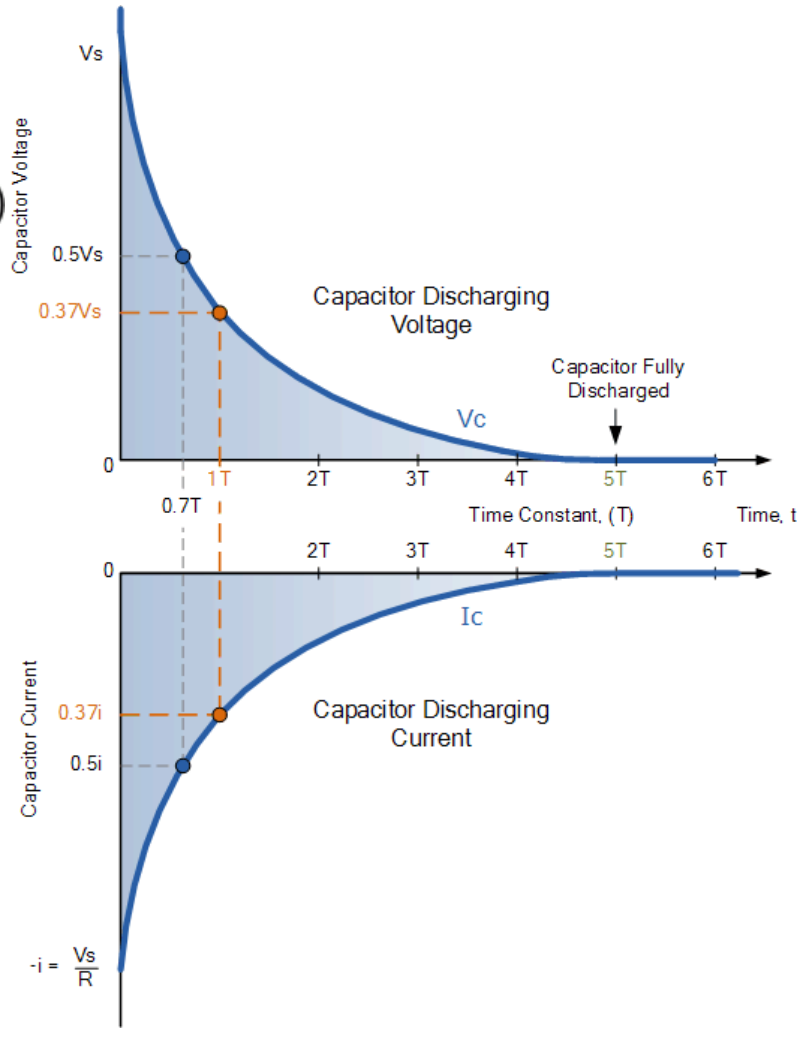
$$W_c' = A_j$$

$$W_c' = \frac{C(U')^2}{2}$$

ПРАНЦЬЕЦЬЕ (РАСТЕРЕКЦВАЦЬЕ) КОНДЕНЗАТОРА

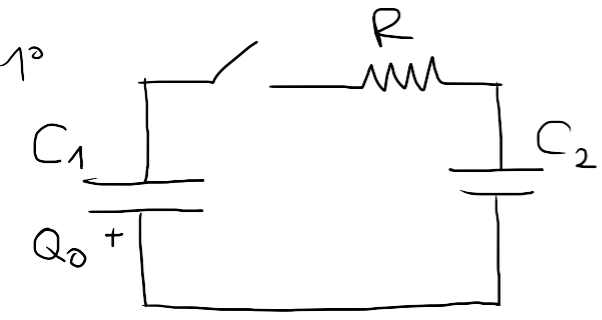


$$V_C = V_S \times e^{-t/RC}$$



ПРАЗНЕЕЊЕ КОНДЕНЗАТОРА (КОЛО СА ДВА КОНДЕНЗАТОРА)

1°



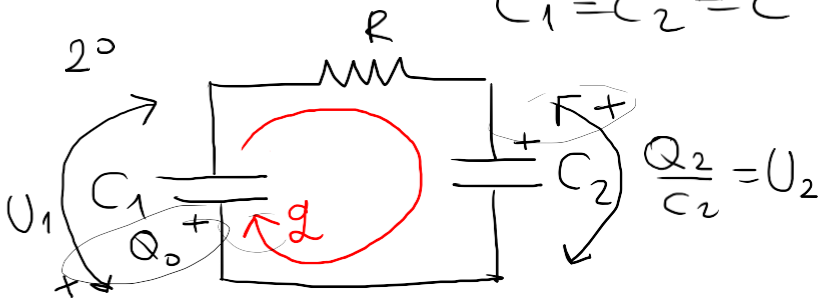
$$W_{C1}' = \frac{Q_0^2}{2C_1}$$

$$W_{C2}' = 0$$

$$W_C' = W_{C1}' + W_{C2}' = \frac{Q_0^2}{2C_1}$$

2°

$$C_1 = C_2 = C$$



$$\frac{Q_2}{C_2} = U_2$$

$$U_2 = \frac{Q_2}{C_2}$$

$$U_1 = \frac{Q_1}{C_1}$$

$$\Sigma E - \Sigma \frac{Q}{C} = 0$$

$$\frac{Q_2}{C_2} + \frac{Q_1}{C_1} = 0$$

$$Q_1 = Q_0 + q$$

$$Q_2 = q$$

$$\frac{Q_0 + q}{C_1} + \frac{q}{C_2} = 0$$

$$q = -\frac{C_2}{C_1 + C_2} Q_0$$

$$C_1 = C_2 \Rightarrow q = -\frac{Q_0}{2}$$

$$\Rightarrow Q_1 = \frac{Q_0}{2} \qquad Q_2 = -\frac{Q_0}{2}$$

$$W_{C1}'' = \frac{Q_1^2}{2C_1} \qquad W_{C2}'' = \frac{Q_2^2}{2C_2}$$

$$W_{C1}'' = W_{C2}'' = \frac{Q_0^2}{8C}$$

$$W_C'' = W_{C1}'' + W_{C2}'' = \frac{Q_0^2}{4C}$$

$$\Delta g = \Delta j + \Delta W_c$$

$$\Delta j + \left(\frac{Q_0^2}{4C} - \frac{Q_0^2}{2C} \right)$$

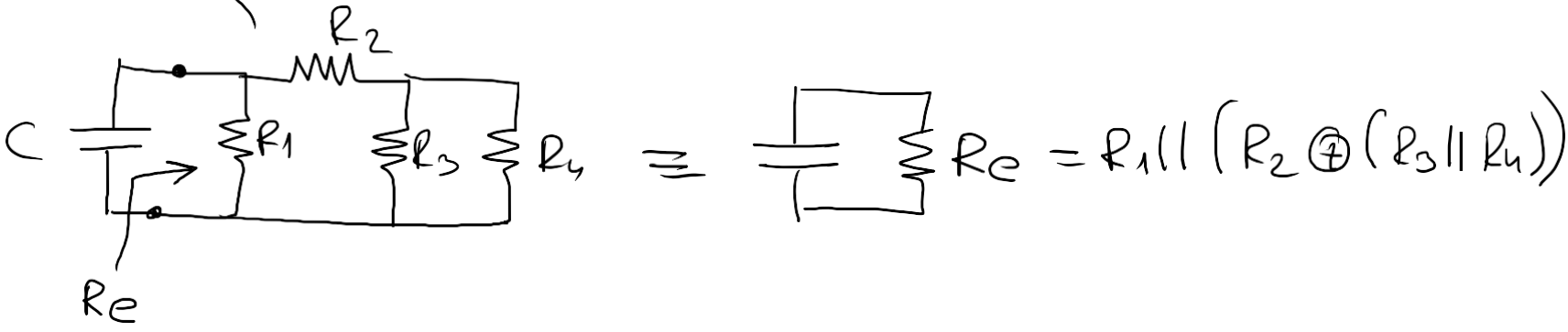
$$\Delta j = -\left(\frac{Q_0^2}{4C} - \frac{Q_0^2}{2C} \right) = \frac{Q_0^2}{4C}$$

ВРЕМЕНСКА КОНСТАНТА ПУЊЕЊА И ПРАЖЊЕЊА КОНДЕНЗАТОРА

$1/e \simeq 36{,}8\ \%$ почетне вредности

$63{,}2\ \%$ крајње вредности

$\tau = R_e \cdot C$

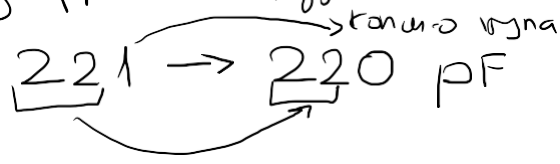


$5 \div 6\,\tau$

$\tau\ [s]$

ОЗНАЧАВАЊЕ ВРИЈЕДНОСТИ КАПАЦИТИВНОСТИ КОНДЕНЗАТОРА

- Ако се капацитивност изражава у pF комбинацијом 3 цифре: прва цифра показује колико нула има иза друге и треће цифре



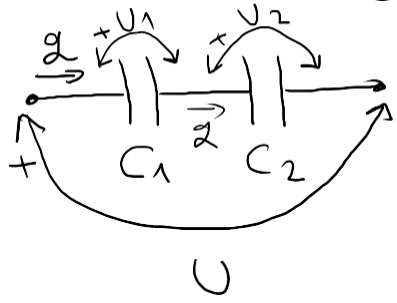
470 → 47 pF

563 → 56000 pF = 56 nF

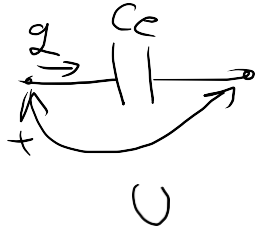
- Ако се капацитивност означава тачком иза које иде број онда је капацитивност изражена у MF.

.0047 → 0,0047 MF = 4,7 nF

СЕРИЈСКА ВЕЗА КОНДЕНЗАТОРА



$\equiv$

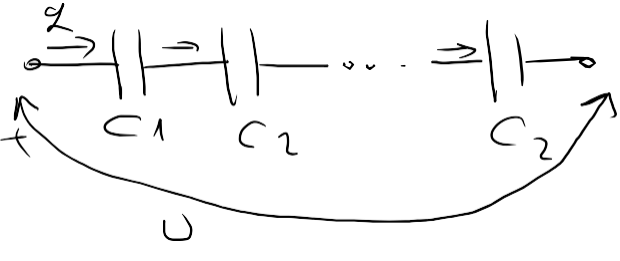


$$U = \frac{q}{C_e}$$

$$U = \frac{q}{C_1} + \frac{q}{C_2} = q\left(\frac{1}{C_1} + \frac{1}{C_2}\right)$$

$$U = q\,\frac{C_1 + C_2}{C_1 \cdot C_2}$$

$$C_e = \frac{C_1 C_2}{C_1 + C_2}$$



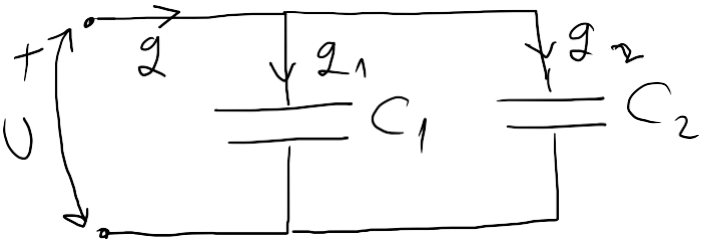
$$U = \frac{q}{C_1} + \frac{q}{C_2} + \dots + \frac{q}{C_n}$$

$$U = q\left(\frac{1}{C_1} + \frac{1}{C_2} + \dots + \frac{1}{C_n}\right)$$

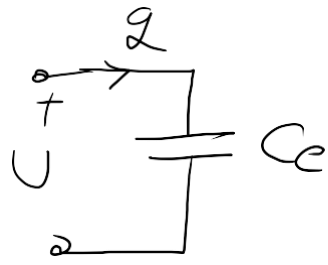
$$U = \frac{q}{C_e} = q\,\frac{1}{C_e}$$

$$\frac{1}{C_e} = \frac{1}{C_1} + \frac{1}{C_2} + \dots + \frac{1}{C_n}$$

ПАРАЛЕЛНА ВЕЗА КОНДЕНЗАТОРА



$$\equiv$$



$$q = q_1 + q_2$$

$$U = \frac{q_1}{C_1} = \frac{q_2}{C_2}$$

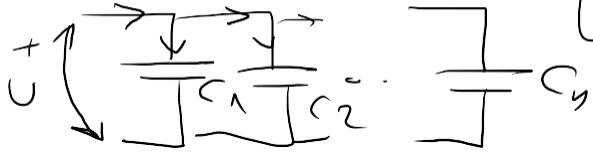
$$q = C_1 U + C_2 U$$

$$q = U(C_1 + C_2)$$

$$U = \frac{q}{C_1 + C_2}$$

$$U = \frac{q}{C_e}$$

$$\Rightarrow \boxed{C_e = C_1 + C_2}$$



$$\boxed{C_e = C_1 + C_2 + \ldots + C_n}$$