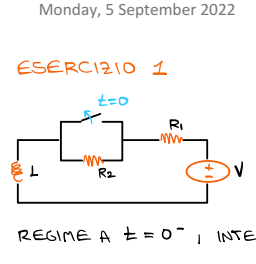
Esercizi TRANS

Monday, 5 September 2022 16:52

ESERCIZIO 1



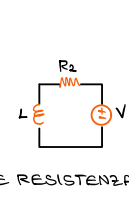
V = 12 V
L = 20 mH
$R_1 = 2\,\Omega$
$R_2 = R_3 = 8\,\Omega$

REGIME A $t = 0^-$, INTERRUTTORE APERTO A $t = 0$

RISOLVIAMO IL TRANSITORIO

INTENSITA' DI CORRENTE

CIRCUITO CHIUSO

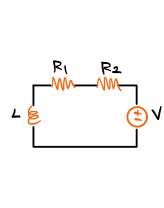


$t < 0 \rightarrow R_2$ CORTOCIRCUITATO

NON PASSA I PER R_1
E' SCELGONO IL PASSAGGIO A MINORE RESISTENZA

$I(0^-) = \frac{V}{R_2} = (12V)/(2\,\Omega) = 6\,A$

CIRCUITO APERTO



$t > 0 \rightarrow R_1, R_2$ IN SERIE

$R_{EQ} = R_1 + R_2 = 10\,\Omega$

$\tau = \frac{L}{R_{EQ}} = 2 \times 10^{-3}\,s$

LA CORRENTE NON VARIA ISTANTANEAMENTE

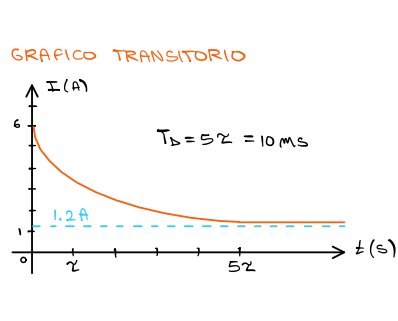
VALORE INIZIALE $I(0^+) = I(0) = I(0^-) = 6\,A$

VALORE A REGIME $I(\infty) = \frac{V}{R_{EQ}} = 1.2\,A$

$I(t) = (I_0 - I_\infty)\,e^{-t/\tau} + I_\infty$

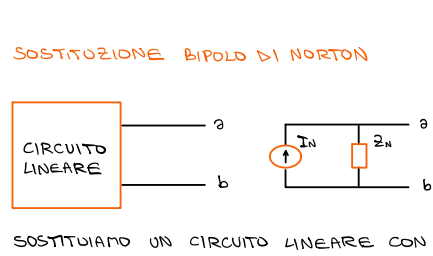
$I(t) = (4.8\,e^{-500t} + 1.2)\,A$

GRAFICO TRANSITORIO



$T_D = 5\tau = 10\,ms$

SOSTITUZIONE BIPOLO DI NORTON



SOSTITUIAMO UN CIRCUITO LINEARE CON UN GENERATORE DI CORRENTE I_N IN PARALLELO AD UNA IMPEDENZA Z_N

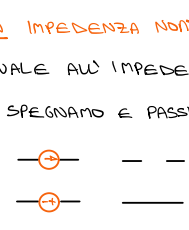
I_N CORRENTE NORTON

UGUALE ALLA CORRENTE DI C.C. TRA a, b
PONIAMO UN RESISTORE $R_{CC} = 0\,\Omega$

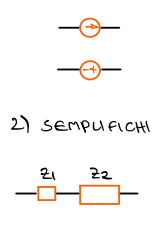
Z_N IMPEDENZA NORTON

UGUALE ALL' IMPEDENZA EQUIVALENTE (Z_{EQ})

1) SPEGNAMO E PASSIVIAMO I GENERATORI INDIPENDENTI



2) SEMPLIFICHIAMO CON SERIE + PARALLELO



$Z_{SERIE} = Z_1 + Z_2$

$Z_{PARALLELO} = \left(\frac{1}{Z_1} + \frac{1}{Z_2}\right)^{-1} = \frac{Z_1 Z_2}{Z_1 + Z_2}$

3) IN PRESENZA DI GENERATORI DIPENDENTI ASSEGNAMO "PROVA" V_P, I_P E RISOLVIAMO

$Z_{EQ} = \frac{V_P}{I_X} = \frac{V_X}{I_P}$

TEOREMA DI NORTON

TEOREMA DI SOSTITUZIONE DELLE RETI

UN INSIEME DI COMPONENTI PUO' ESSERE SOSTITUITO CON UN ALTRO AVENTE LE STESSE RELAZIONI I,V E LO STESSO NUMERO DI MORSETTI

SI ORIGINA DA PRINCIPIO SOVRAPPOSIZIONE EFFETTI (LINEARITA')

NOTA IL CIRCUITO DEVE AMMETTERE UN CONTROLLO IN TENSIONE (TENSIONE FINITA TRA a, b)

DIMOSTRAZIONE CON THEVENIN

$V = V_T - Z_{EQ}\,I$

$V\,Y_{EQ} = I^*$

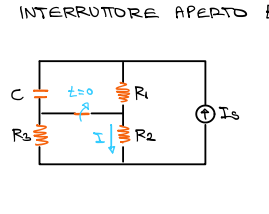
$V_{TH}\,Y_{EQ} = I_{NO}$

$I_{NO} = I^* + I = V\,Y_{EQ} + I = \frac{V}{Z_{EQ}} + I$

ESERCIZIO 2

INTERRUTTORE CHIUSO PER $t < 0$ (REGIME)

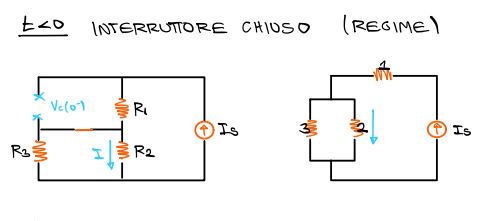
INTERRUTTORE APERTO $t > 0$



$I_S = 2A$
$C = 5\,\mu F$
$R_1 = 4\,\Omega$
$R_2 = 6\,\Omega$
$R_3 = 10\,\Omega$

RISOLUZIONE TRANSITORIO R_2

$t < 0$ INTERRUTTORE CHIUSO (REGIME)



$V(R_3) = V(R_2)$ PARALLELO
$\Sigma I_i = I_S$ CONSERVAZIONE

$R_3 I_3 = R_2 I_2$ OHM
$I_S = I_2 + I_3$ KIRCHHOFF

$R_3(I_S - I_2) = R_2 I_2$

$I_2(R_2 + R_3) = R_3 I_S$

$I_2(0^-) = \frac{R_3}{R_2 + R_3} I_S = 1.25\,A$

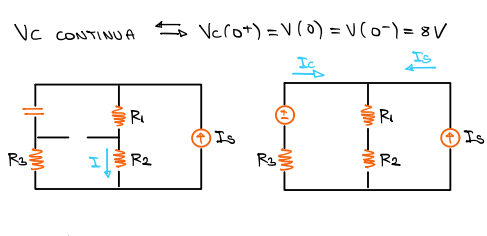
$V_C(0^-) = V(R_1) = I_S R_1 = 8V$

$t > 0$ INTERRUTTORE APERTO

INIZIO TRANSITORIO

VCONDENSATORE E' UNA VARIABILE DI STATO

V_C CONTINUA $\leftrightarrows V_C(0^+) = V(0) = V(0^-) = 8V$



CONSIDERIAMO IL CONDENSATORE COME GENERATORE DI TENSIONE IDEALE

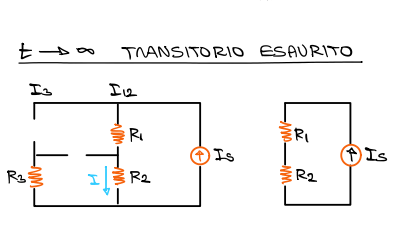
TEOREMA SOVRAPPOSIZIONE

$V(0^+) = (R_1 + R_2 + R_3)\,I_C(0^+) = 8V$

$I_{S,2}(0^+) = I_S \frac{R_3}{R_1 + R_2 + R_3} = 1A$

$I_2(t = 0^+) = I_C + I_{S,2} = 0.4A + 1A = 1.4A$

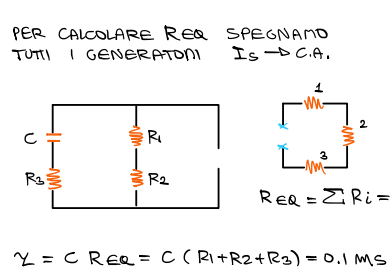
$t \rightarrow \infty$ TRANSITORIO ESAURITO



$I_2(\infty) = I_S = 2A$

COSTANTE DI TEMPO

PER CALCOLARE R_{EQ} SPEGNAMO TUTTI I GENERATORI $I_S \rightarrow$ C.A.

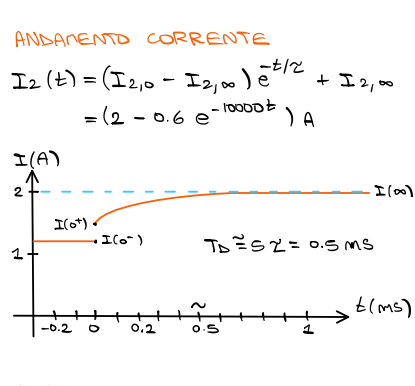


$R_{EQ} = \Sigma R_i = 20\,\Omega$

$\tau = C\,R_{EQ} = C(R_1 + R_2 + R_3) = 0.1\,ms$

ANDAMENTO CORRENTE

$I_2(t) = (I_{2,0} - I_{2,\infty})\,e^{-t/\tau} + I_{2,\infty}$
$= (2 - 0.6\,e^{-10000t})\,A$



$T_D \approx 5\tau = 0.5\,ms$

ENERGIA IMMAGAZZINATA IN CONDENSATORE

PRIMA DEL TRANSITORIO ($t < 0$)

$E = \frac{1}{2} C V^2 = \frac{1}{2} C (V(0^-))^2 = 1.6 \times 10^{-4}\,J$

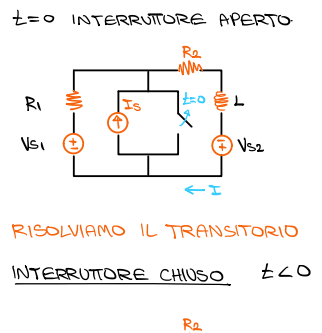
DOPO IL TRANSITORIO ($t \rightarrow \infty$)

$E = \frac{1}{2} C V^2 = \frac{1}{2} C (V(\infty))^2 = 1 \times 10^{-3}\,J$

ESERCIZIO 3

REGIME STAZIONARIO $t < 0$ (INTERRUTTORE CHIUSO)

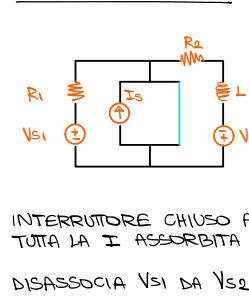
$t = 0$ INTERRUTTORE APERTO



$V_{S1} = 10V$
$V_{S2} = 15V$
$I_S = 5A$
$R_1 = 5\,\Omega$
$R_2 = 3\,\Omega$
$L = 10\,mH$

RISOLVIAMO IL TRANSITORIO

INTERRUTTORE CHIUSO $t < 0$



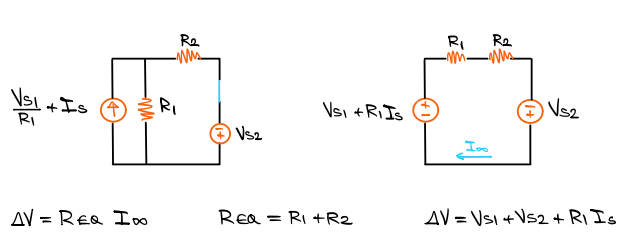
INTERRUTTORE CHIUSO FA SI CHE IL FILO ASSORBA TUTTA LA I ASSORBITA DAI GENERATORI

DISASSOCIA V_{S1} DA V_{S2}

APPLICHIAMO OHM SU $R_2 \rightarrow I(0^-) = \frac{V_{S2}}{R_2} = 5A$

VALORE (DI STATO) INIZIALE

INTERRUTTORE APERTO $t > 0$



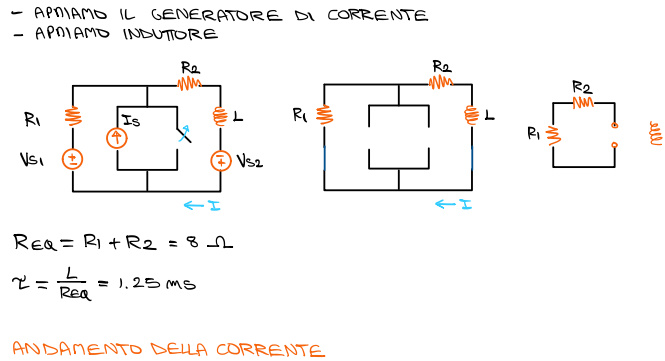
$\Delta V = R_{EQ}\,I_\infty$ $R_{EQ} = R_1 + R_2$ $\Delta V = V_{S1} + V_{S2} + R_1 I_S$

$I_\infty = \frac{V_{S1} + V_{S2} + R_1 I_S}{R_1 + R_2} = 6.25\,A$

COSTANTE DI TEMPO

RESISTENZA AI CAPI DELL' INDUTTORE

- CORTOCIRCUITIAMO I GENERATORI DI TENSIONE
- APRIAMO IL GENERATORE DI CORRENTE
- APRIAMO INDUTTORE



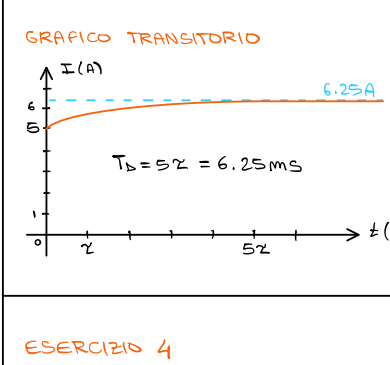
$R_{EQ} = R_1 + R_2 = 8\,\Omega$

$\tau = \frac{L}{R_{EQ}} = 1.25\,ms$

ANDAMENTO DELLA CORRENTE

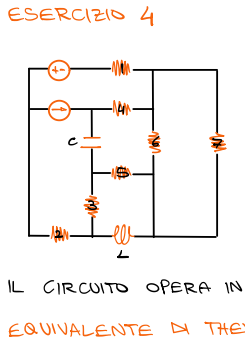
$I(t) = (I_0 - I_\infty)\,e^{-t/\tau} + I_\infty = (-1.25\,e^{-800t} + 6.25)\,A$

GRAFICO TRANSITORIO



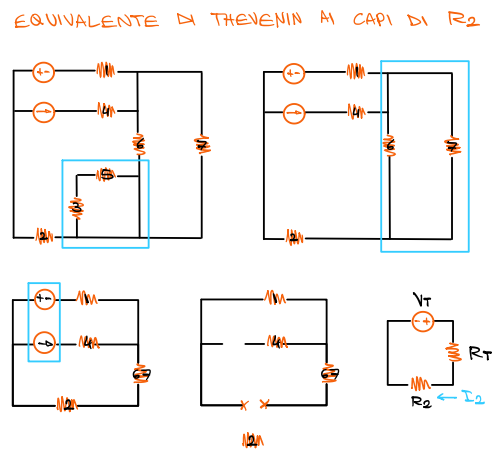
$T_D = 5\tau = 6.25\,ms$

ESERCIZIO 4



IL CIRCUITO OPERA IN REGIME STAZIONARIO

EQUIVALENTE DI THEVENIN AI CAPI DI R_2

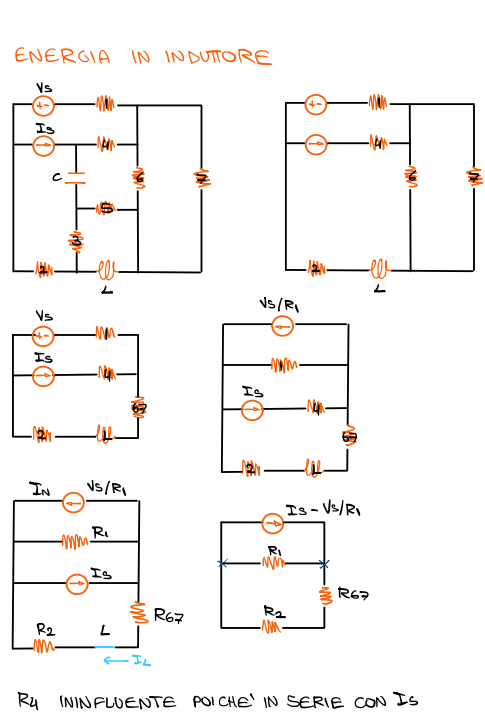


$R_{67} = R_6 // R_7 = \frac{R_6 R_7}{R_6 + R_7}$

$R_T = R_{THEVENIN} = R_1 + R_{67} = 13.632\,\Omega$

$V_T = -V_3 + R_1 I_1 = 6V$

ENERGIA IN INDUTTORE



R_4 ININFLUENTE POICHE' IN SERIE CON I_3

$R_1 // R_{672}$ $R_{672} = R_{67} + R_2$

PARTITORE DI CORRENTE

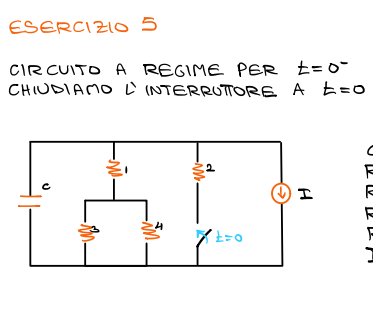
$I_L = I \cdot \frac{R_1}{R_1 + R_{672}} = \left(I_3 - \frac{V_3}{R_1}\right) \cdot \frac{R_1}{R_1 + R_2 + R_{67}} = -0.322\,A$

ENERGIA IMMAGAZZINATA

$E = \frac{1}{2} L I_L^2 = 0.515\,mJ$

ESERCIZIO 5

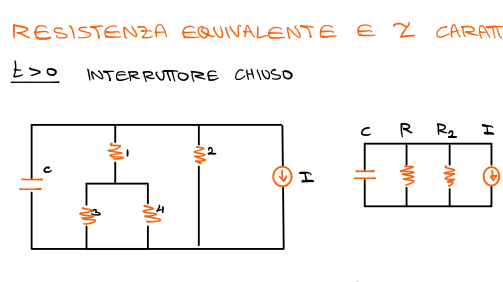
CIRCUITO A REGIME PER $t = 0^-$
CHIUDIAMO L' INTERRUTTORE A $t = 0$



$C = 2\,\mu F$
$R_1 = 3.6\,k\Omega$
$R_2 = 4\,k\Omega$
$R_3 = 6\,k\Omega$
$R_4 = 4\,k\Omega$
$I = 4\,mA$

RESISTENZA EQUIVALENTE E τ CARATTERISTICA

$t > 0$ INTERRUTTORE CHIUSO



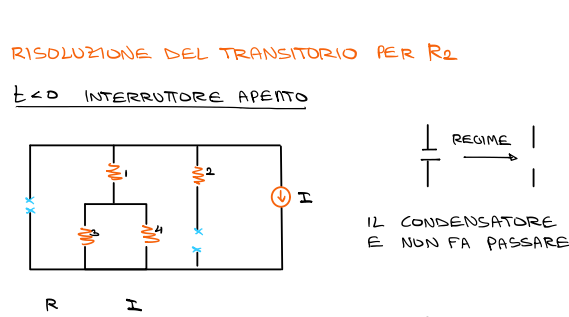
$R = R_1 + R_3 // R_4 = R_1 + \frac{R_3 R_4}{R_3 + R_4} = 6\,k\Omega$

$R_{EQ} = R_2 // R = \frac{R_2 R}{R_2 + R} = 2.4\,k\Omega$

$\tau = R_{EQ} \cdot C = 4.8\,ms$

RISOLUZIONE DEL TRANSITORIO PER R_2

$t < 0$ INTERRUTTORE APERTO



IL CONDENSATORE SI SATURA E NON FA PASSARE I

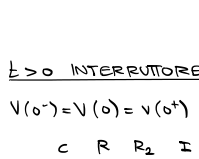
TUTTA LA CORRENTE PASSA PER $R = R_1 + R_3 // R_4$

$V(0^-) = -R\,I = -24V$

NOTIAMO CHE $I_2(0^-) = 0$ POICHE' CIRCUITO APERTO

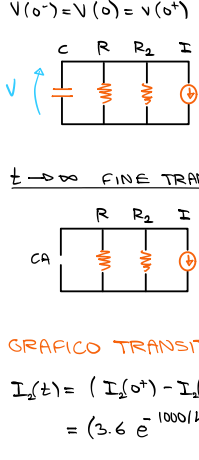
$t > 0$ INTERRUTTORE CHIUSO

$V(0^-) = V(0) = V(0^+)$ POICHE' VARIABILE DI STATO



$I_2(0^+) = -\frac{V_C(0^+)}{R_2} = 6\,mA$

$t \rightarrow \infty$ FINE TRANSITORIO

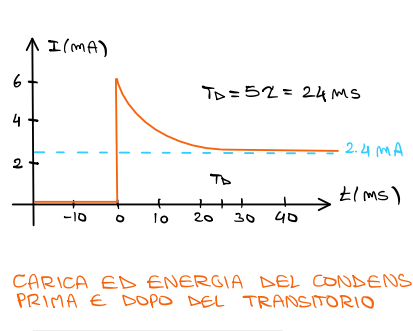


$I_2(\infty) = I \cdot \frac{R}{R + R_2} = 2.4\,mA$

$V(\infty) = I \cdot (R // R_2) = 5.6\,V$

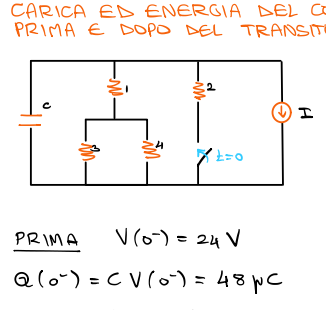
GRAFICO TRANSITORIO

$I_2(t) = (I_2(0^+) - I_2(\infty))\,e^{-t/\tau} + I_2(\infty)$
$= (3.6\,e^{-1000/4.8\,t} + 2.4)\,mA$ $t > 0$



$T_D = 5\tau = 24\,ms$

CARICA ED ENERGIA DEL CONDENSATORE PRIMA E DOPO DEL TRANSITORIO

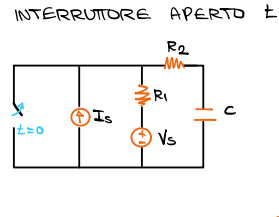


PRIMA $V(0^-) = 24\,V$
$Q(0^-) = C\,V(0^-) = 48\,\mu C$
$E(0^-) = \frac{1}{2} C V(0^-)^2 = 0.6\,mJ$

DOPO $V(\infty) = 5.6\,V$
$Q(\infty) = C\,V(\infty) = 19.2\,\mu C$
$E(\infty) = \frac{1}{2} C V(\infty)^2 = 50\,\mu J$

ESERCIZIO 6

REGIME PER $t = 0^-$
INTERRUTTORE APERTO $t = 0$



$V_S = 13V$
$I_S = 4A$
$C = 20\,\mu F$
$R_1 = 7\,\Omega$
$R_2 = 10\,\Omega$

COME SI RISOLVE UN TRANSITORIO?

1) INDIVIDUARE LA CONDIZIONE INIZIALE (TENSIONI E CORRENTI A 0^-)

2) ANALISI DI REGIME ($t \rightarrow \infty$)

SOSTITUIAMO CC INDUTTORI, CA CONDENSATORI

RISOLVIAMO IL CIRCUITO PER SOSTITUZIONE O SOVRAPPOSIZIONE

3) $t = 0^-, 0, 0^+$ IMPONIAMO LA CONSERVAZIONE DELLE VARIABILI DI STATO, CONTINUITA'

LE CORRENTI IN L, LE TENSIONI IN C SONO CONTINUE

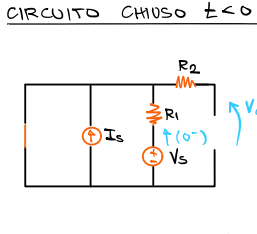
4) INDIVIDUIAMO LA COSTANTE DI TEMPO

RC $\rightarrow \tau = R_{EQ}\,C$ RL $\rightarrow \tau = L/R_{EQ}$

R_{EQ} SI OTTIENE SPEGNENDO I GENERATORI

RISOLUZIONE TRANSITORIO

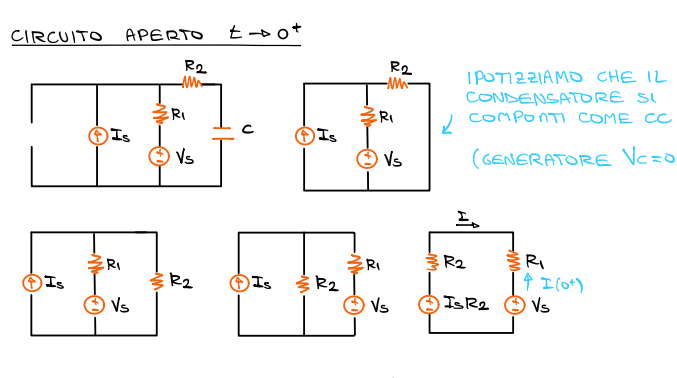
CIRCUITO CHIUSO $t < 0$ (REGIME)



$I(0^-) = \frac{V_S}{R_1} = 1.857\,A$

$V_C(0^-) = 0\,V$

CIRCUITO APERTO $t \rightarrow 0^+$



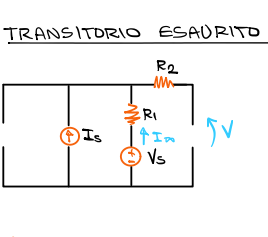
IPOTIZZIAMO CHE IL CONDENSATORE SI COMPORTI COME CC (GENERATORE Vc=0)

KIRCHHOFF $IR_2 + IR_1 + I_S R_2 - V_S = 0$

$I(R_1 + R_2) = V_S - I_S \cdot R_2$

$I(0^+) = \frac{V_S - I_S \cdot R_2}{R_1 + R_2} = -1.588\,A$

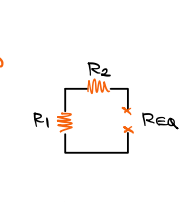
TRANSITORIO ESAURITO $t \rightarrow \infty$



$I_\infty = -I = -4A$

$V_\infty = V_S + R_1 I_S = 41V$

COSTANTE DI TEMPO



$R_{EQ} = R_1 + R_2 = 17\,\Omega$

$\tau = R_{EQ}\,C = 0.34\,ms$

ANDAMENTO DELLA CORRENTE

$$I(t) = \begin{cases} 1.857\,A & t < 0 \\ (I_0 - I_\infty)\,e^{-t/\tau} + I_\infty & t > 0 \end{cases}$$

$$I(t) = \begin{cases} 1.857\,A & t < 0 \\ (2.412\,e^{-\frac{t}{3.4 \times 10^{-4}}} - 4)\,A & t > 0 \end{cases}$$

RICAVA CARICA ED ENERGIA DEL CONDENSATORE AL TEMPO $t = 0.5\,ms$

QUANDO FINISCE IL TRANSITORIO?

$T_D \cong 5\tau = 1.7\,ms$

TRANSITORIO NON FINITO

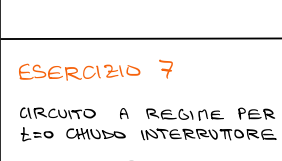
$V(0.5\,ms) = (V_0 - V_\infty)\,e^{-t/\tau} + V_\infty =$
$= 41(1 - e^{-t/\tau})\,V$
$= 31.58\,V$

$Q(t) = V(t)\,C = 632\,\mu C$

$E(t) = \frac{1}{2} C\,V(t)^2 = 9.97\,mJ$

ESERCIZIO 7

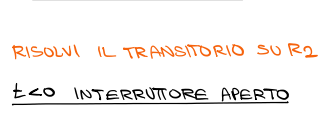
CIRCUITO A REGIME PER $t < 0$ (0^-)
$t = 0$ CHIUDO INTERRUTTORE



$V_1 = 12V$
$V_2 = 20V$
$L = 2H$
$R_1 = 4\,\Omega$
$R_2 = 4\,\Omega$

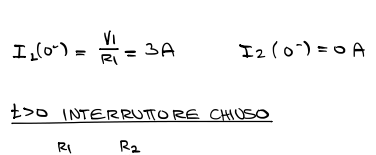
RISOLVI IL TRANSITORIO SU R_2

$t < 0$ INTERRUTTORE APERTO



$I_1(0^-) = \frac{V_1}{R_1} = 3A$ $I_2(0^-) = 0\,A$

$t > 0$ INTERRUTTORE CHIUSO



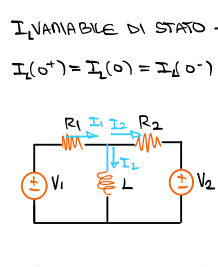
CORTOCIRCUITIAMO V_1, V_2 PER CALCOLARE R_{EQ}

$R_{EQ} = R_1 // R_2 = \frac{R_1 R_2}{R_1 + R_2} = 2\,\Omega$

$\tau = \frac{L}{R_{EQ}} = 1\,ms$

I_L VARIABILE DI STATO $\rightarrow$ I CONTINUA

$I_L(0^+) = I_L(0) = I_L(0^-) = 3A$

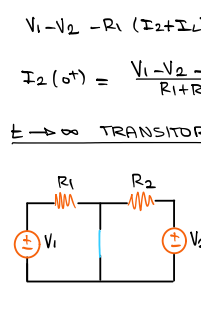


KIRCHHOFF
$I_1 = I_2 + I_L$
$V_1 - R_1 I_1 - R_2 I_2 - V_2 = 0$

$V_1 - V_2 - R_1(I_2 + I_L) - R_2 I_2 = 0$

$I_2(0^+) = \frac{V_1 - V_2 - I_L(0^+) \cdot R_1}{R_1 + R_2} = -2.5\,A$

$t \rightarrow \infty$ TRANSITORIO ESAURITO



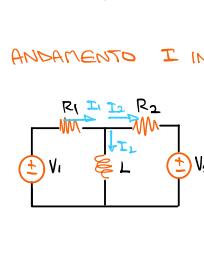
INDUTTORE CORTOCIRCUITA

$I_2(\infty) = -\frac{V_2}{R_2} = -5\,A$

FORMA ANALITICA

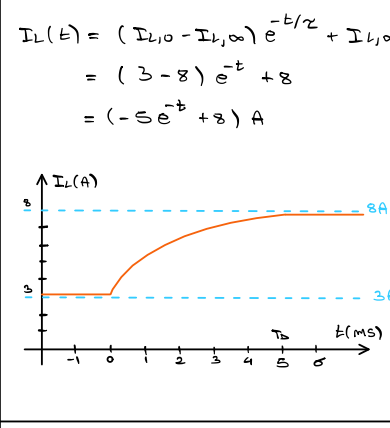
$I_2(t) = (I_{2,0} - I_{2,\infty})\,e^{-t/\tau} + I_{2,\infty}$
$= (-2.5 + 5)\,e^{-t} - 5$
$= (2.5\,e^{-t} - 5)\,A$

ANDAMENTO I INDUTTANZA + GRAFICO



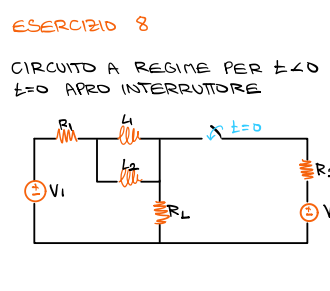
$I_1 = I_2 + I_L$
$I_L(\infty) = I_1(\infty) - I_2(\infty) = 8A$
$I_L(0^+) = I_L(0^-) = 3A$

$I_L(t) = (I_{L,0} - I_{L,\infty})\,e^{-t/\tau} + I_{L,\infty}$
$= (3 - 8)\,e^{-t} + 8$
$= (-5\,e^{-t} + 8)\,A$



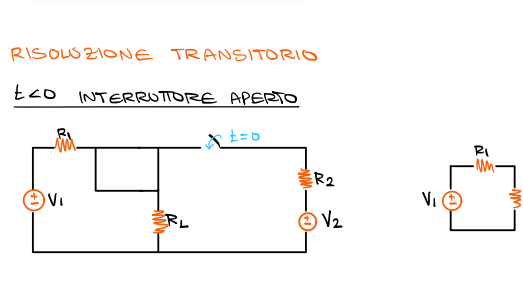
ESERCIZIO 8

CIRCUITO A REGIME PER $t < 0$
$t = 0$ APRO INTERRUTTORE



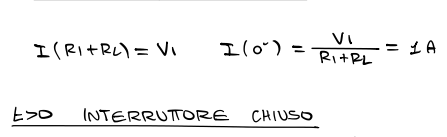
RISOLUZIONE TRANSITORIO

$t < 0$ INTERRUTTORE APERTO



$I(R_1 + R_L) = V_1$ $I(0^-) = \frac{V_1}{R_1 + R_L} = 1A$

$t > 0$ INTERRUTTORE CHIUSO



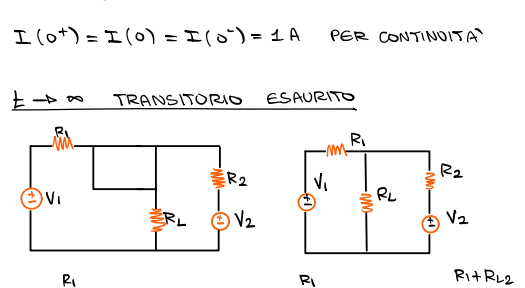
$L_{EQ} = \frac{L_1 L_2}{L_1 + L_2} = 2\,H$

$R_{EQ} = R_1 + R_L // R_2 = R_1 + \frac{R_L R_2}{R_2 + R_L} = 4.5\,\Omega$

$\tau = \frac{L_{EQ}}{R_{EQ}} = 0.444\,s$

$I(0^+) = I(0) = I(0^-) = 1A$ PER CONTINUITA'

$t \rightarrow \infty$ TRANSITORIO ESAURITO



$R_{L2} = R_L // R_2 = \frac{R_L R_2}{R_L + R_2} = 1.5\,\Omega$

$V_T = I_2 R_{L2} = \frac{V_2}{R_2} \frac{R_L R_2}{R_L + R_2} = \frac{V_2 R_L}{R_L + R_2} = 6V$

$V_1 - V_T = I(\infty) \cdot R_{EQ}$

$I(\infty) = \frac{V_1 - V_T}{R_{EQ}} = \frac{V_1 - V_T}{R_1 + R_{L2}} = 0$

ANDAMENTO DELLA CORRENTE

$I(t) = (I_0 - I_\infty)\,e^{-t/\tau} + I_\infty$
$= (1 - 0)\,e^{-t/\tau}$
$= e^{-t/0.44}$ A

MASSIMO TRASFERIMENTO POTENZA

CIRCUITO A REGIME $t = 0^-$

(R_1 E' RINTERNA PER V_1)

CONDIZIONE DI MAX TRASFERIMENTO SU UN CARICO RESISTIVO

$R_{CARICO} = R_{INTERNA} \rightarrow P_{MAX}$

$P_{MAX}(R_2) = \left(\frac{V}{2}\right)^2 / R_L = 3W$

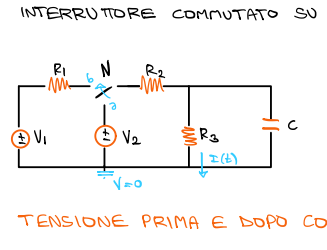
ENERGIA ASSORBITA

$E(R_L)_{[0,2]} = P_{MAX}(R_L)\,\Delta t$

$E(L)_{[0,2]} = \int_0^2 P(t)\,dt = \int_0^2 R\,I^2(t)\,dt$
$= 3 \int_0^2 (e^{-5t/4})^2\,dt$
$= 3\left(\frac{2}{5}\right)(1 - e^{-5}) \cong \frac{2}{3} \sim 0.666$

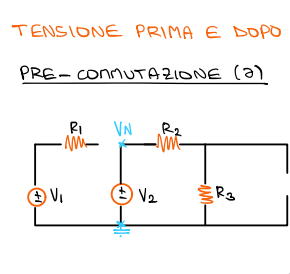
ESERCIZIO 9

CIRCUITO A REGIME PER $t = 0^-$ (INTERRUTTORE SU a)
INTERRUTTORE COMMUTATO SU B ($t = 0$)



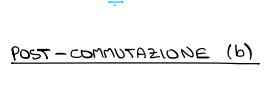
TENSIONE PRIMA E DOPO COMMUTAZIONE (REGIME)

PRE-COMMUTAZIONE (a)



$V_N = V_2 = 12V$

POST-COMMUTAZIONE (b) (FINE TRANSITORIO)



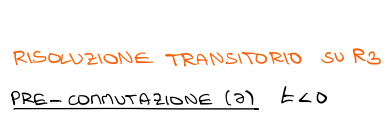
$V_1 = I(R_1 + R_2 + R_3)$ GLOBALE

$V_N = V(R_1) = I R_1$ OHM LOCALE

$V_N = \frac{R_1}{R_1 + R_2 + R_3} V_1 = 14.4V$

RISOLUZIONE TRANSITORIO SU R_3

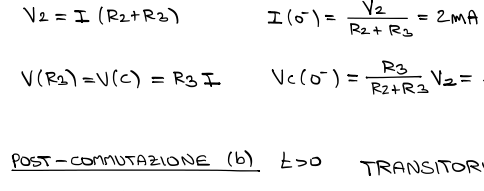
PRE-COMMUTAZIONE (a) $t < 0$



$V_2 = I(R_2 + R_3)$ $I(0^-) = \frac{V_2}{R_2 + R_3} = 2\,mA$

$V(R_3) = V(C) = R_3 I$ $V_C(0^-) = \frac{R_3}{R_2 + R_3} V_2 = 4V$

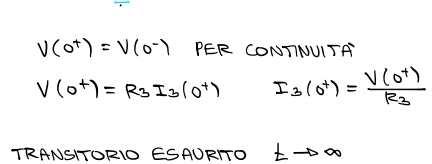
POST-COMMUTAZIONE (b) $t > 0$ TRANSITORIO



$V(0^+) = V(0^-)$ PER CONTINUITA'

$V(0^+) = R_3 I_3(0^+)$ $I_3(0^+) = \frac{V(0^+)}{R_3} = 2\,mA$

TRANSITORIO ESAURITO $t \rightarrow \infty$

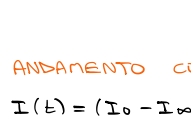


$V_1 = I(R_1 + R_2 + R_3) \rightarrow I = I_3(\infty) = \frac{V_1}{R_1 + R_2 + R_3} = 2.4\,mA$

$V_C(\infty) = V_3(\infty) = R_3 I = \frac{R_1}{R_1 + R_2 + R_3} V_1 = 4.8V$

COSTANTE DI TEMPO τ

SI OTTIENE SPEGNENDO TUTTI I GENERATORI



$R_{EQ} = (R_1 + R_2) // R_3 = \frac{(R_1 + R_2) \cdot R_3}{R_1 + R_2 + R_3} = 1.6\,k\Omega$

$\tau = R_{EQ}\,C = 8\,ms$

ANDAMENTO CORRENTE I_3

$I(t) = (I_0 - I_\infty)\,e^{-t/\tau} + I_\infty$
$= (2 - 2.4)\,e^{-125t} + 2.4$
$= (-0.4\,e^{-125t} + 2.4)\,mA$

ENERGIA ASSORBITA DAL RESISTORE R_3

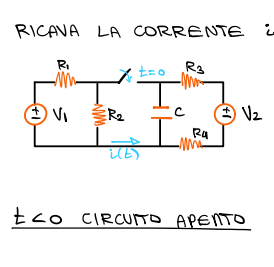
$E = \int V \cdot I\,dt = \int R_3\,I^2(t)\,dt$

$= R_3 \int_0^{5\,ms} (-0.4\,e^{-125t} + 2.4)^2\,dt = \dots \cong 44\,\mu J$

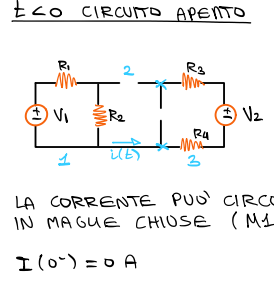
ESERCIZIO 10

INTERRUTTORE APERTO $t < 0$
CHIUSO PER $t = 0$

RICAVA LA CORRENTE $i(t)$



$t < 0$ CIRCUITO APERTO (REGIME)



LA CORRENTE PUO' CIRCOLARE SOLO IN MAGLIE CHIUSE (M1)

$I(0^-) = 0\,A$

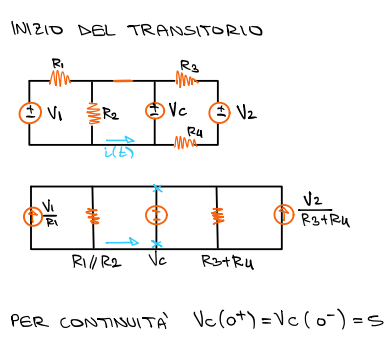
TENSIONE AI CAPI DEL CONDENSATORE

$V_C = -I R_3 + V_2 - I R_4$

$V(0^-) = V_2 = 5V$

$t > 0$ CIRCUITO CHIUSO

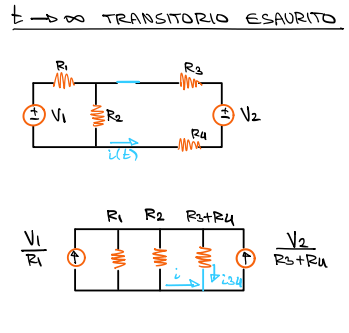
INIZIO DEL TRANSITORIO



PER CONTINUITA' $V_C(0^+) = V_C(0^-) = 5A$

$I(0^+) = \frac{V_C(0^+)}{R_1 // R_2} - \frac{V_1}{R_1} = -0.5A$

$t \rightarrow \infty$ TRANSITORIO ESAURITO



PARTITORE DI CORRENTE $R_1 // R_2$, $R_3 + R_4$

$R_{34} = R_3 + R_4$

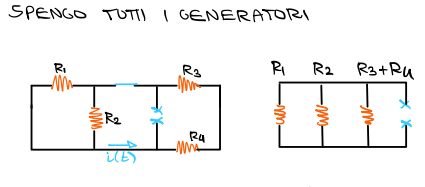
$R_{12} = \frac{R_1 R_2}{R_1 + R_2}$

$I_{34} = \left(\frac{V_1}{R_1} + \frac{V_2}{R_3 + R_4}\right) \cdot \frac{R_{12}}{R_{12} + R_{34}} = 8/7\,A$

$I(\infty) = I_S - I_{34} = \frac{V_2}{R_3 + R_4} - I_{34} = 0.143\,A$

RESISTENZA EQUIVALENTE

SPENGO TUTTI I GENERATORI

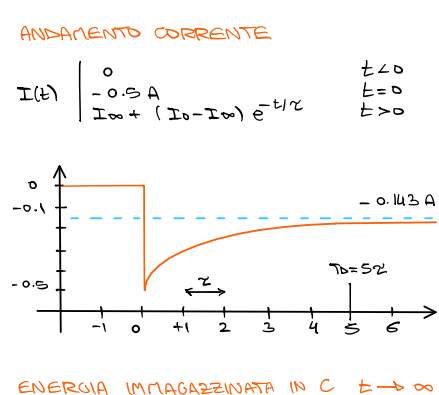


$R_{EQ} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3 + R_4}\right)^{-1} = 1.43\,\Omega$

COSTANTE DI TEMPO $\tau = R_{EQ} C = 1\,ms$

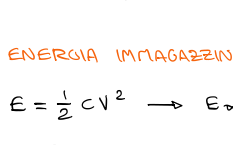
ANDAMENTO CORRENTE

$$I(t) \begin{cases} 0 & t < 0 \\ -0.5\,A & t = 0 \\ I_\infty + (I_0 - I_\infty)\,e^{-t/\tau} & t > 0 \end{cases}$$



ENERGIA IMMAGAZZINATA IN C $t \rightarrow \infty$

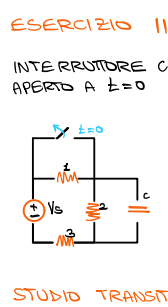
$E = \frac{1}{2} C V^2 \rightarrow E_\infty = \frac{1}{2} C V_\infty^2 = 11.4\,mJ$



$V_C(\infty) = V_2 - (R_4 + R_3) I_\infty$

ESERCIZIO 11

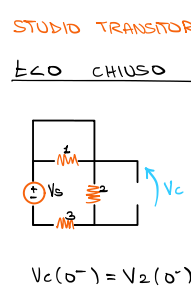
INTERRUTTORE CHIUSO $t < 0$
APERTO A $t = 0$



$V_S = 2V$
$R_1 = 2\,k\Omega$
$R_2 = 4\,k\Omega$
$R_3 = 2\,k\Omega$
$C = 0.5\,\mu F$

STUDIO TRANSITORIO

$t < 0$ CHIUSO REGIME



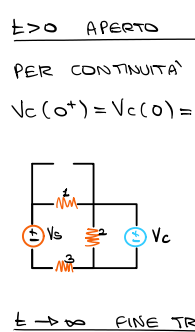
$V_S = I(R_2 + R_3)$

$I(0^-) = \frac{V_S}{R_2 + R_3} = 3.333 \times 10^{-4}\,A$

$V_C(0^-) = V_2(0^-) = R_2 I = \frac{R_2}{R_2 + R_3} V_S = 1.333\,V$

$t > 0$ APERTO TRANSITORIO

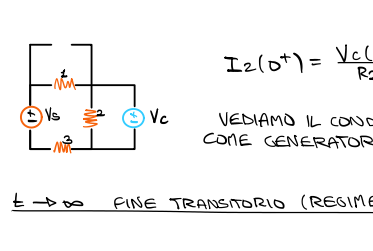
PER CONTINUITA' V. DI STATO:
$V_C(0^+) = V_C(0) = V_C(0^-) = 1.333\,V$



$I_2(0^+) = \frac{V_C(0^+)}{R_2}$

VEDIAMO IL CONDENSATORE COME GENERATORE DI TENSIONE

$t \rightarrow \infty$ FINE TRANSITORIO (REGIME)



$R_{EQ} = R_1 + R_2 + R_3$

$I(\infty) = \frac{V_S}{R_1 + R_2 + R_3} = 2.5 \times 10^{-4}\,A$

$V_C(\infty) = V_2(\infty) = R_2\,I(\infty) = \frac{R_2}{R_1 + R_2 + R_3} V_S = 1V$

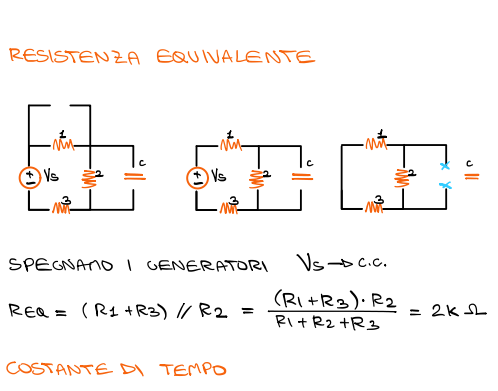
VARIABILE DI STATO

$V_C(t)$ E' UNA VDS $I = C\dot{V}$

SEMPRE CONTINUA $\forall t \in \mathbb{R}$

V NON PUO' VARIARE BRUSCAMENTE PERCHE' RICHIEDEREBBE P INFINITA

RESISTENZA EQUIVALENTE



SPEGNAMO I GENERATORI $V_S \rightarrow$ C.C.

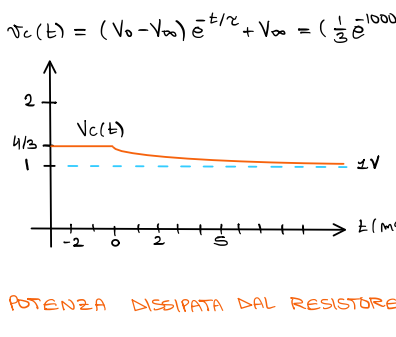
$R_{EQ} = (R_1 + R_3) // R_2 = \frac{(R_1 + R_3) \cdot R_2}{R_1 + R_2 + R_3} = 2\,k\Omega$

COSTANTE DI TEMPO

$\tau = R_{EQ}\,C = 1\,ms$

ANDAMENTO TENSIONE

$V_C(t) = (V_0 - V_\infty)\,e^{-t/\tau} + V_\infty = \left(\frac{1}{3} e^{-1000t} + 1\right)\,V$



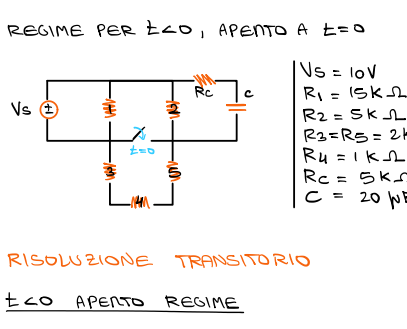
POTENZA DISSIPATA DAL RESISTORE R_2

$P_{R2}(t) = I_2(t) \cdot V_2(t) = \frac{V_C(t)^2}{R_2} = \frac{1}{R_2}\left(\frac{1}{3} e^{-1000t} + 1\right)^2\,mW$

$P_{R2}(\infty) = \frac{V_C(\infty)^2}{R_2} = \frac{(1V)^2}{4000\,\Omega} = 0.25\,mW$

ESERCIZIO 12

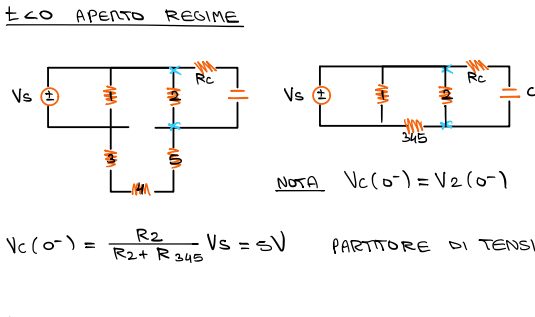
REGIME PER $t < 0$, APERTO A $t = 0$



$V_S = 10V$
$R_1 = 15\,k\Omega$
$R_2 = 5\,k\Omega$
$R_3 = R_5 = 2\,k\Omega$
$R_4 = 1\,k\Omega$
$R_C = 5\,k\Omega$
$C = 20\,\mu F$

RISOLUZIONE TRANSITORIO

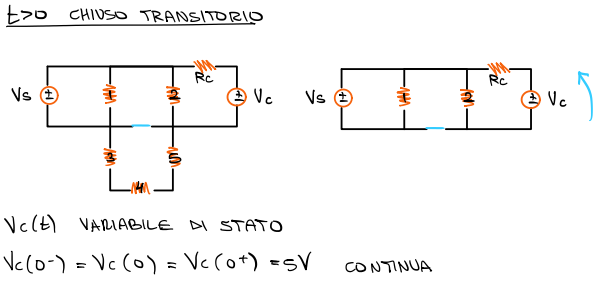
$t < 0$ APERTO REGIME



NOTA $V_C(0^-) = V_2(0^-)$

$V_C(0^-) = \frac{R_2}{R_2 + R_{345}} V_S = 5V$ PARTITORE DI TENSIONE

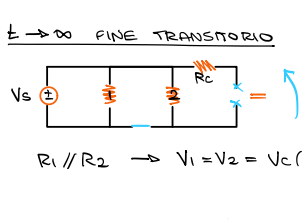
$t > 0$ CHIUSO TRANSITORIO



$V_C(t)$ VARIABILE DI STATO

$V_C(0^-) = V_C(0) = V_C(0^+) = 5V$ CONTINUA

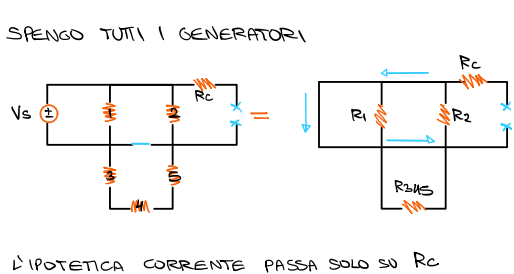
$t \rightarrow \infty$ FINE TRANSITORIO



$R_1 // R_2 \rightarrow V_1 = V_2 = V_C(\infty) = V_S = 10V$

RESISTENZA EQUIVALENTE

SPENGO TUTTI I GENERATORI



L'IPOTETICA CORRENTE PASSA SOLO SU R_C

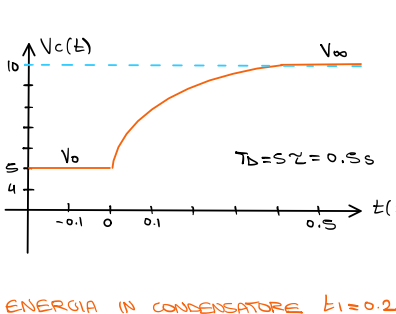
$R_{EQ} = R_C$ LE ALTRE SONO CORTOCIRCUITATE

COSTANTE DI TEMPO

$\tau = C\,R_{EQ} = 0.1\,s$

ANDAMENTO TENSIONE

$V_C(t) = (V_0 - V_\infty)\,e^{-t/\tau} + V_\infty$
$= (5 - 10)\,e^{-10t} + 10$
$= (-5\,e^{-10t} + 10)\,V$



$T_D = 5\tau = 0.5\,s$

ENERGIA IN CONDENSATORE $t_1 = 0.2$ $t_2 = 2$

$E(0.2) = \frac{1}{2} C\,V(0.2)^2 = 0.87\,mJ$

$E(2) \sim E(\infty) = \frac{1}{2} C\,V(\infty)^2 = 1\,mJ$

POTENZA ASSORBITA DA R_C $t = 0.1\,s$

$P(0.1) = I(0.1)\,V(0.1) = R_C\,I(0.1)^2 = 0.7\,mW$

$I(t) = C \frac{\partial V(t)}{\partial t} = 50\,e^{-10t}$

$I(R_C) = I(C)$