Семинарно занятие No: 2

Активни интегриращи и диференциращи вериги

Цел на занятието:

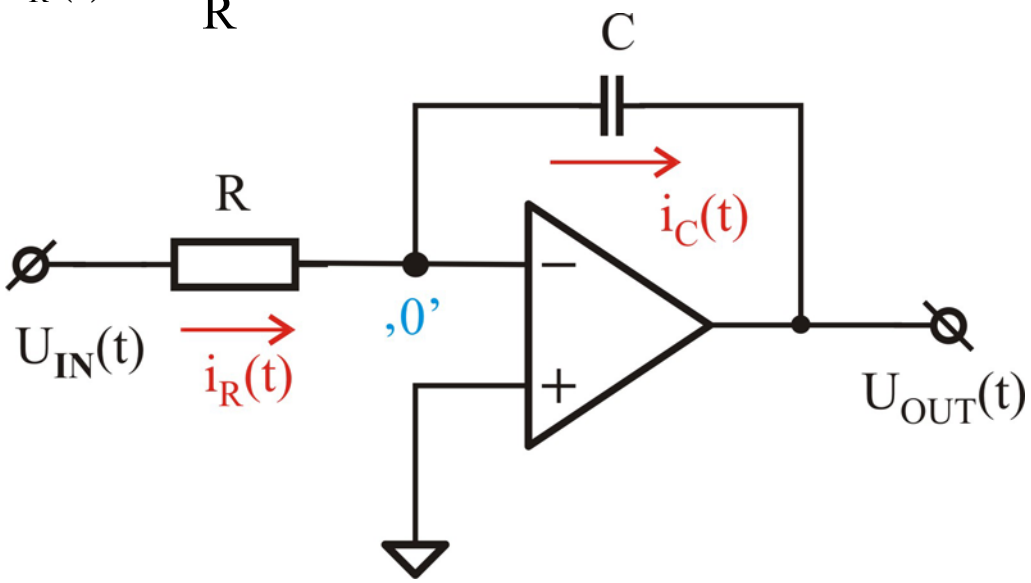
Дефиниране, определяне, математически и логически анализ на преходни процеси в активни линейни интегриращи и диференциращи вериги.

Интегратор с операционен усилвател

$$i_R(t) = \frac{U_{IN}(t)}{R}$$

$$i_R(t) = i_C(t) = i(t)$$

$$dU_C.C = i_C(t).dt$$



$$U_C(t) = \frac{1}{C}.\int i_C(t).dt + U_C(0)$$

$$U_{OUT}(t) = -U_C(t)$$

$$U_{OUT}(t) = -\frac{1}{C}.\int i(t).dt + U_C(0)$$

$$U_{OUT}(t) = -\frac{1}{C}.\int \frac{U_{IN}(t)}{R}.dt + U_C(0)$$

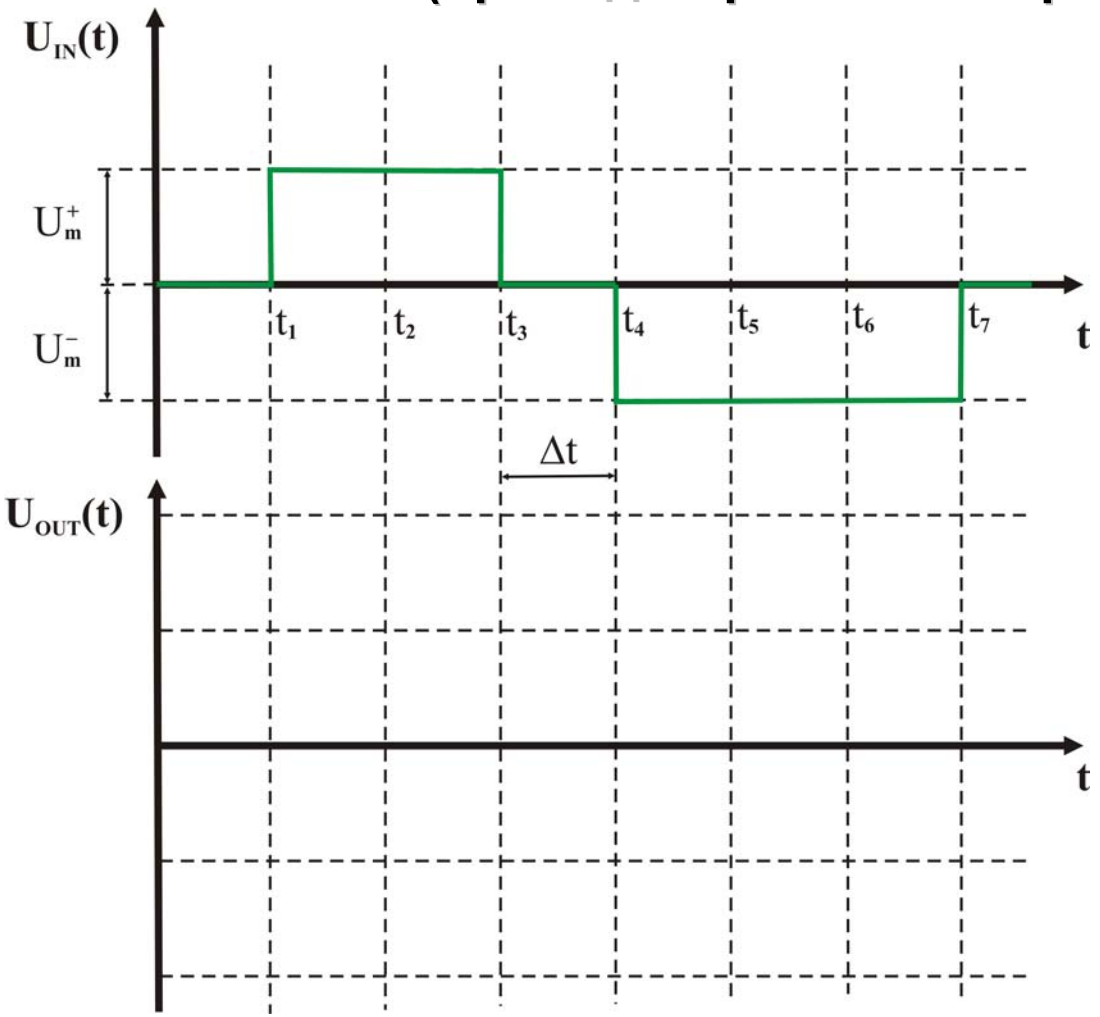
$$U_{OUT}(t) = -\frac{1}{R.C}.\int U_{IN}(t).dt + U_C(0)$$

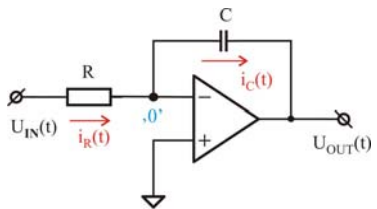
За $\mathbf{U_{INP}(t) = \{const\}}$ за рамките на времето за интегриране от $\mathbf{t_1}$ до $\mathbf{t_2}$ и нулеви първоначални условия $\mathbf{U_C(0) = 0}$

$$U_{OUT}(t) = -\frac{1}{R.C}.\int_{t_1}^{t_2} U_{IN}(t).dt + U_C(0) = -\frac{U_{IN}.(t_2 - t_1)}{R.C}$$

Интегратор с операционен усилвател

(времедиаграма на напреженията)



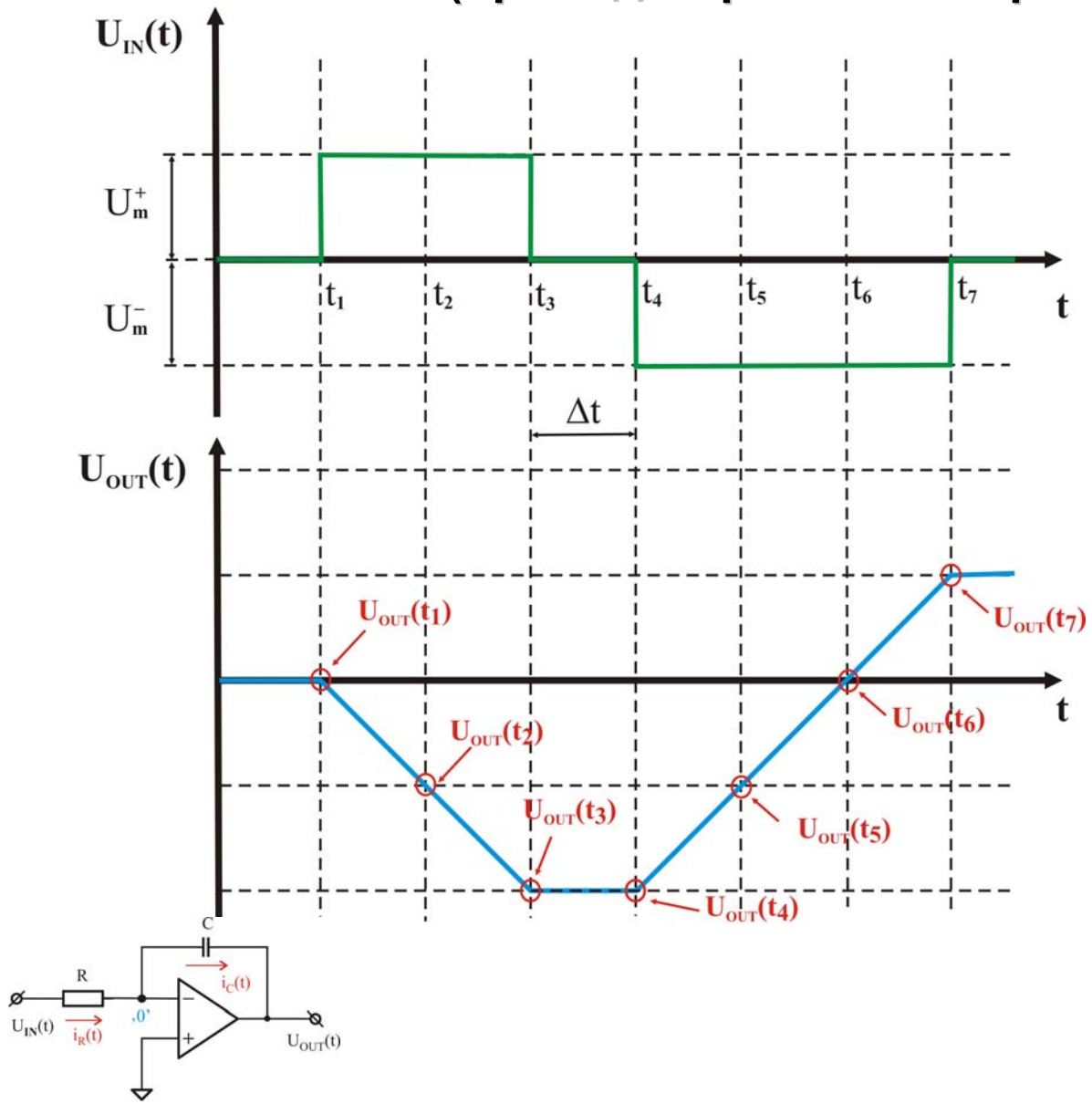


$$\begin{cases} U_C(0) = 0 \\ \left|U_m^+\right| = \left|U_m^-\right| = U_m = \text{const} \\ t_n - t_{n-1} = \Delta t = \text{const} \end{cases}$$

$$\begin{cases} U_{OUT}(0) = ... \\ U_{OUT}(t_1) = ... \\ U_{OUT}(t_2) = ... \\ U_{OUT}(t_3) = ... \\ U_{OUT}(t_4) = ... \\ U_{OUT}(t_5) = ... \end{cases}$$

Интегратор с операционен усилвател

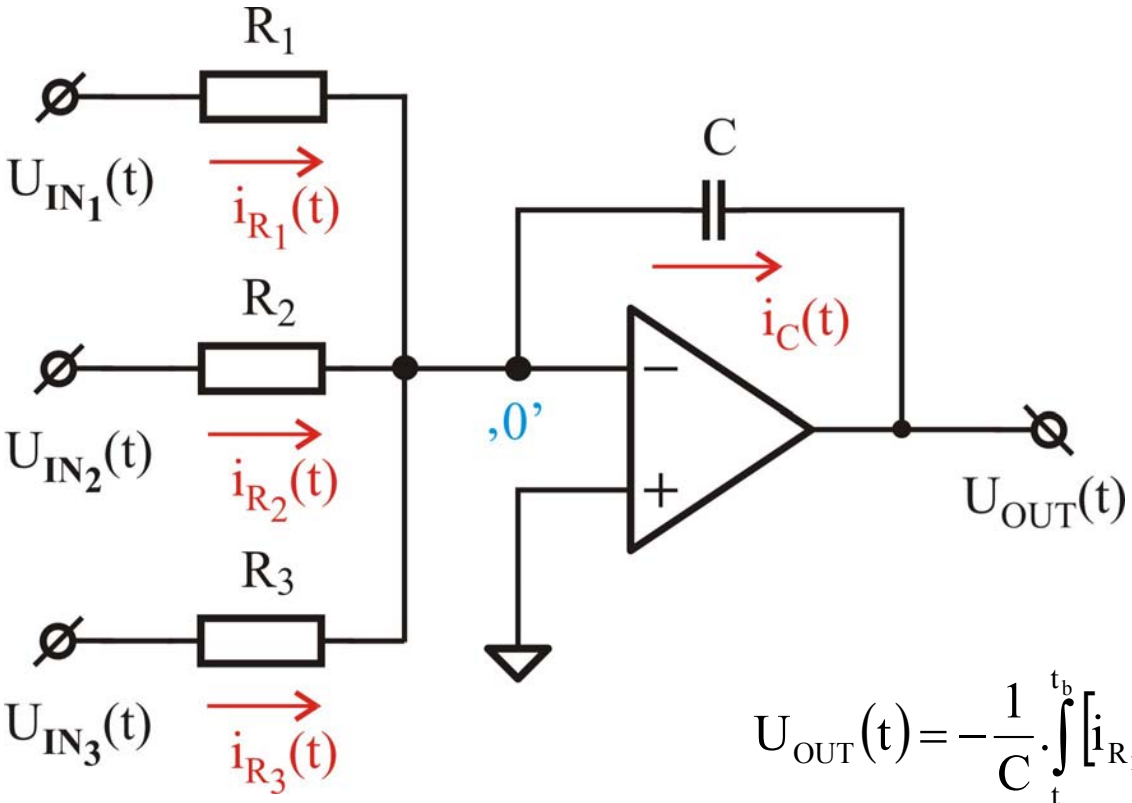
(времедиаграма на напреженията)



$$\begin{cases} U_C(0) = 0 \\ \left|U_m^+\right| = \left|U_m^-\right| = U_m = \text{const} \\ t_n - t_{n-1} = \Delta t = \text{const} \end{cases}$$

$$\begin{cases} U_{OUT}(0) = 0 \\ U_{OUT}(t_1) = 0 \\ U_{OUT}(t_2) = -\dfrac{U_m.\Delta t}{R.C} \\ U_{OUT}(t_3) = -\dfrac{2.U_m.\Delta t}{R.C} \\ U_{OUT}(t_4) = U_{OUT}(t_3) \\ U_{OUT}(t_5) = \ldots\ldots\ldots \end{cases}$$

Интегратор сумматор



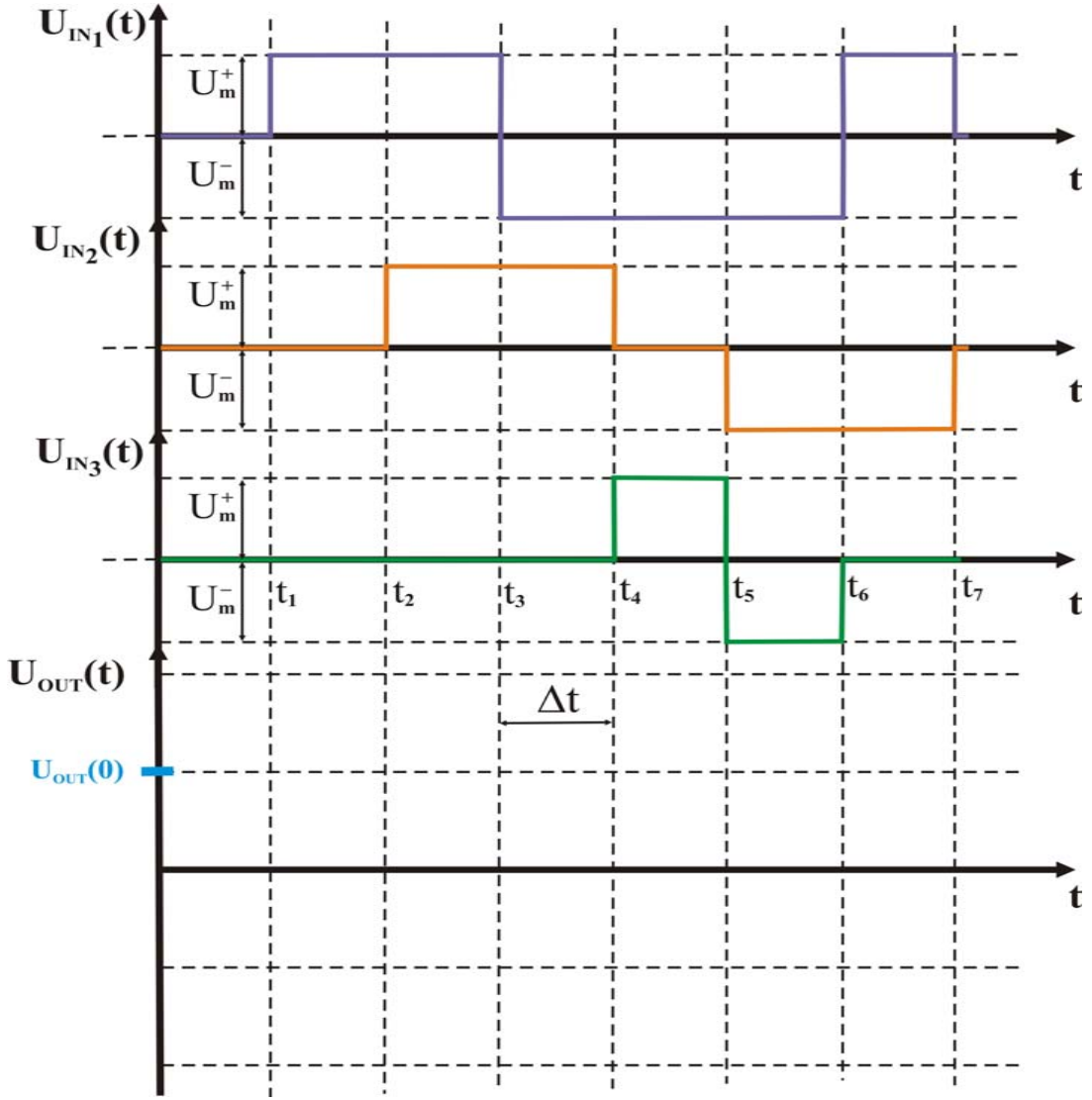
$$i_C(t) = i_{R_1}(t) + i_{R_2}(t) + i_{R_3}(t)$$

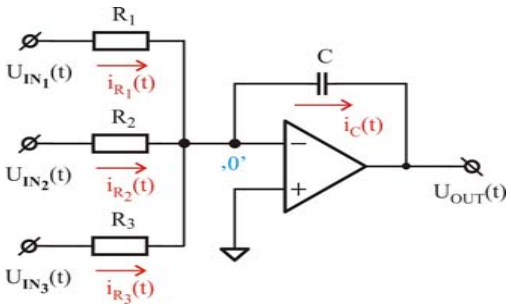
$$dU_C.C = i_C(t).dt$$

$$U_{OUT}(t) = -U_C(t)$$

$$U_{OUT}(t) = -\frac{1}{C}.\int_{t_a}^{t_b}\left[i_{R_1}(t) + i_{R_2}(t) + i_{R_3}(t)\right].dt + U_C(0)$$

$$U_{OUT}(t) = -\frac{1}{C}.\int_{t_a}^{t_b}\left(\frac{U_{IN_1}(t)}{R_1} + \frac{U_{IN_2}(t)}{R_2} + \frac{U_{IN_3}(t)}{R_3}\right).dt + U_C(0)$$





Интегратор суматор

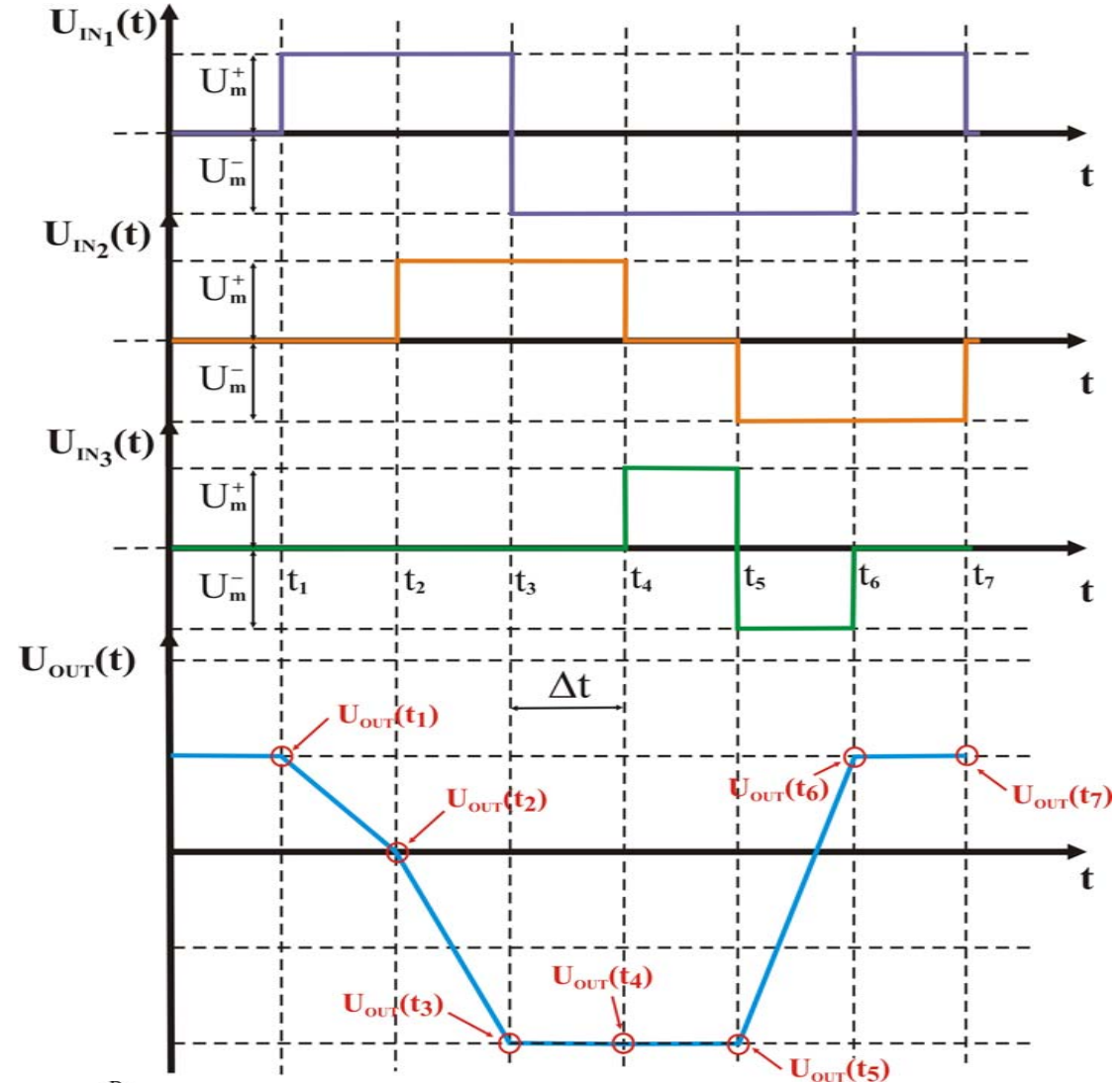
(времедиаграма на напреженията)

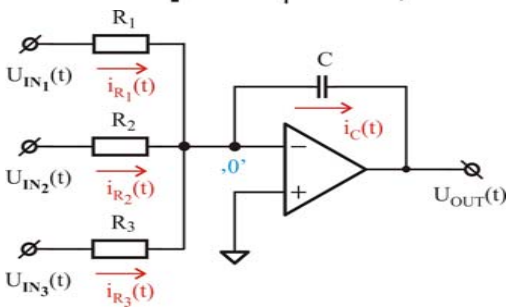
$$\begin{cases} U_C(0) = \text{const} \\ \left|U_m^+\right| = \left|U_m^-\right| = U_m = \text{const} \\ t_n - t_{n-1} = \Delta t = \text{const} \end{cases}$$

$$\begin{cases} U_{OUT}(0) \neq 0 = \text{const} \\ U_{OUT}(t_1) = ... \\ U_{OUT}(t_2) = ... \\ U_{OUT}(t_3) = ... \\ U_{OUT}(t_4) = ... \\ U_{OUT}(t_5) = ... \end{cases}$$

Интегратор суматор

(времедиаграма на напреженията)

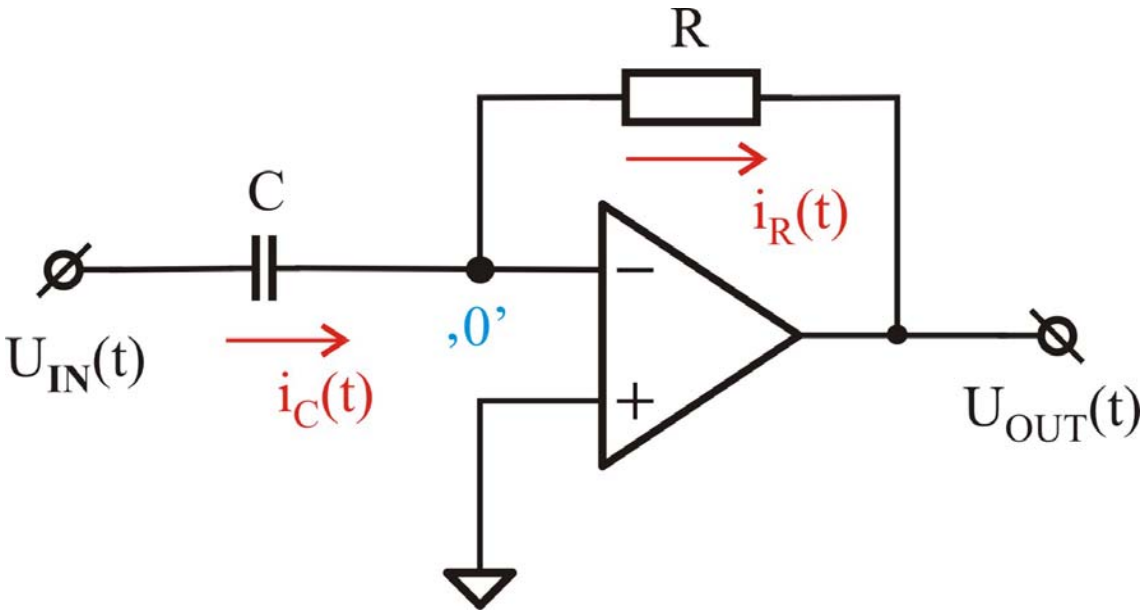




$$\begin{cases} U_C(0) = \text{const} \\ \left|U_m^+\right| = \left|U_m^-\right| = U_m = \text{const} \\ t_n - t_{n-1} = \Delta t = \text{const} \end{cases}$$

$$\begin{cases} U_{OUT}(0) \neq 0 = \text{const} \\ U_{OUT}(t_1) = U_{OUT}(0) \\ U_{OUT}(t_2) = -\dfrac{U_m.\Delta t}{R.C} \\ U_{OUT}(t_3) = U_{OUT}(t_2) - \dfrac{2.U_m.\Delta t}{R.C} \\ U_{OUT}(t_4) = U_{OUT}(t_3) \\ U_{OUT}(t_5) = \ldots\ldots\ldots \end{cases}$$

Диференциатор с операционен усилвател



$$u_C(t) = U_{IN}(t)$$

$$i_C(t) = C.\frac{du_C(t)}{dt}$$

$$i_R(t) = i_C(t) = i(t)$$

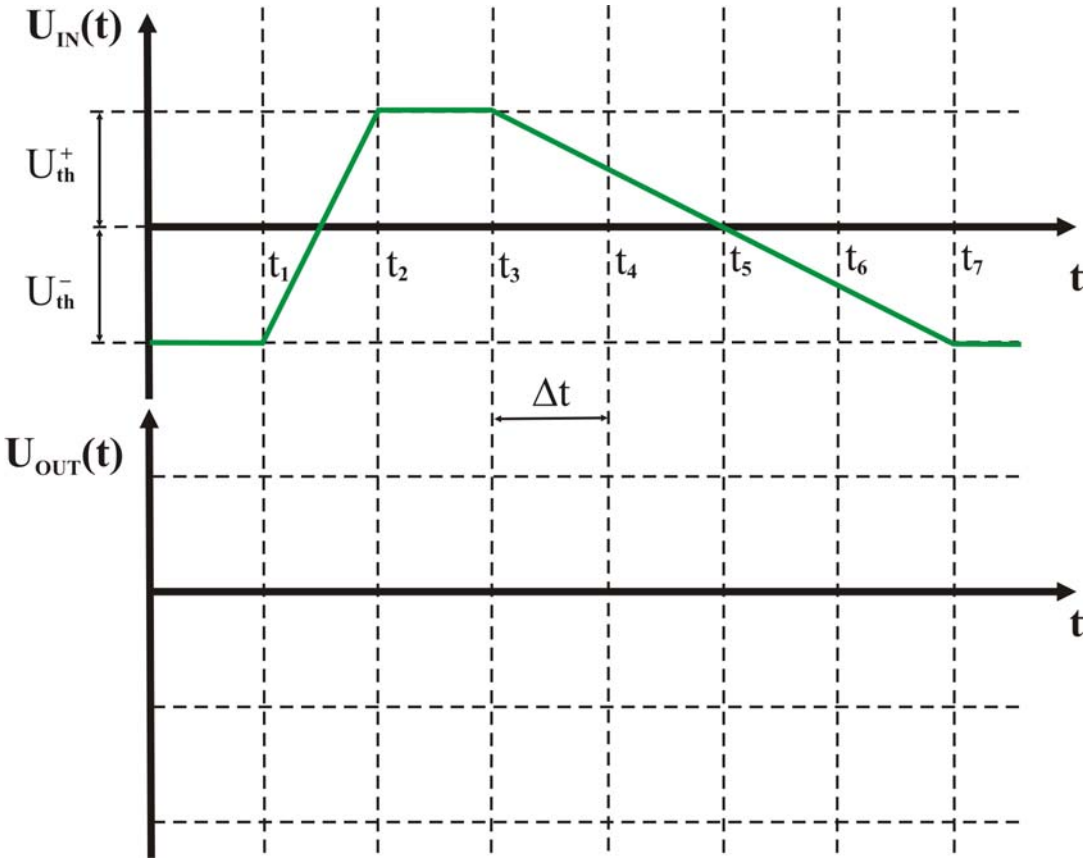
$$U_{OUT}(t) = -R.i_R(t) \Rightarrow U_{OUT}(t) = -i_C(t).R$$

$$U_{OUT}(t) = -R.C.\frac{dU_{IN}(t)}{dt}$$

!!! За физическите ограничения спрямо допустимите стойности на $\mathbf{U_{OUT}(t)}$ - следва физическо ограничение спрямо максимално допустимата скорост на нарастване на $\mathbf{U_{IN}}$, която генерира стойността на $\mathbf{i_C(t)}$.

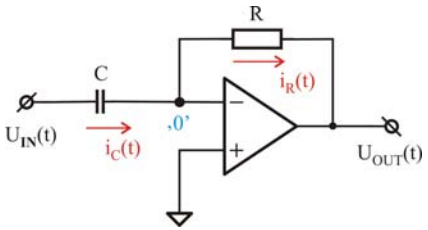
Диференциатор с операционен усилвател

(времедиаграма на напреженията)



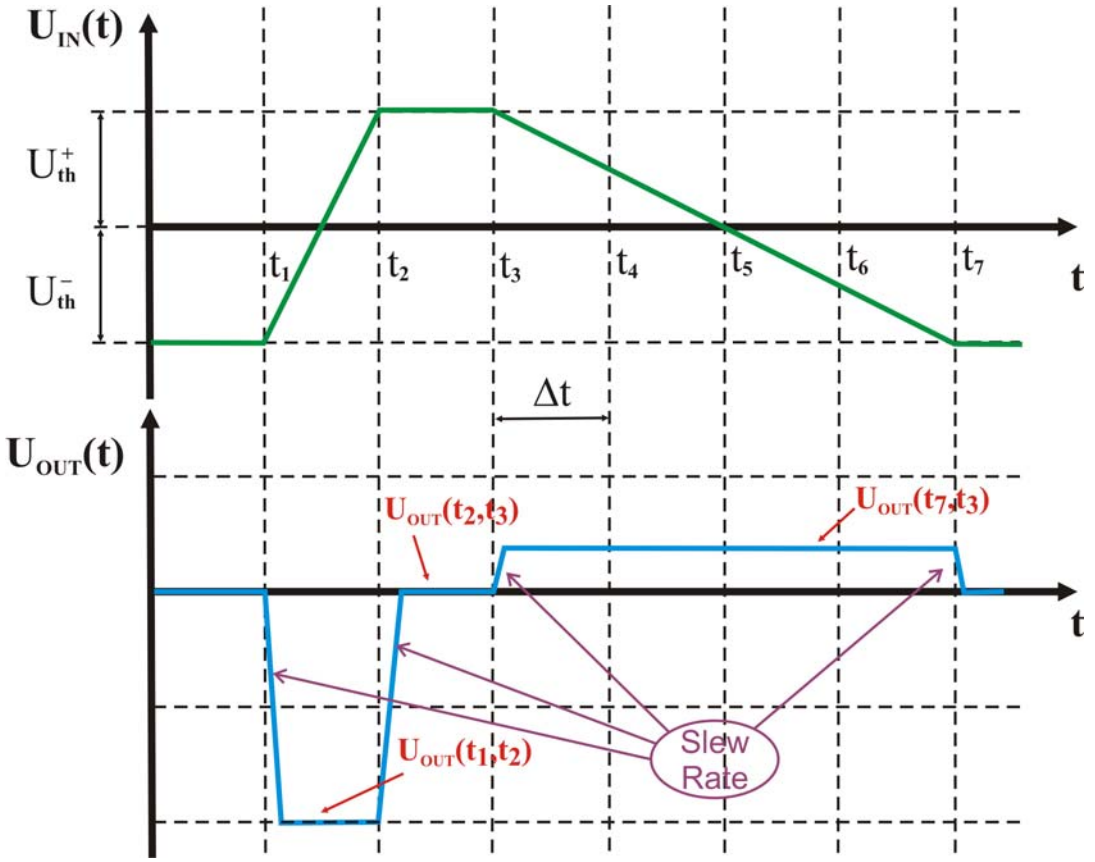
$$\begin{cases} U_C(0) = \text{const} \\ \left|U_{th}^{+}\right| = \left|U_{th}^{-}\right| = U_{th} = \text{const} \\ t_n - t_{n-1} = \Delta t = \text{const} \end{cases}$$

$$\begin{cases} U_{OUT}(t_1, t_2) = ... \\ U_{OUT}(t_2, t_3) = ... \\ U_{OUT}(t_3, t_7) = ... \end{cases}$$



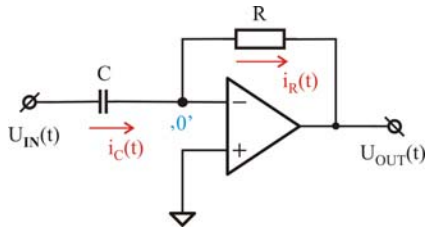
Диференциатор с операционен усилвател

(времедиаграма на напреженията)



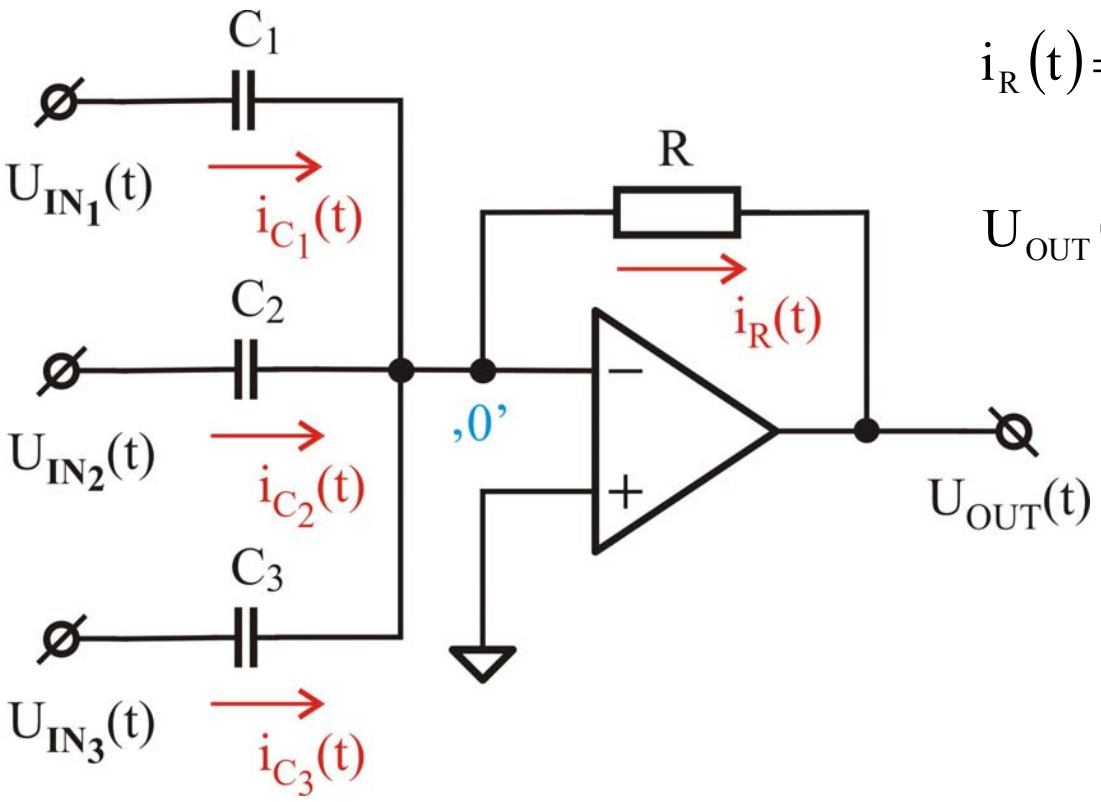
$$\begin{cases} U_C(0) = \text{const} \\ \left|U_{th}^{+}\right| = \left|U_{th}^{-}\right| = U_{th} = \text{const} \\ t_n - t_{n-1} = \Delta t = \text{const} \end{cases}$$

$$\begin{aligned} & U_{OUT}(t_1, t_2) = \\ & = -R.C.\frac{\left[U_{IN}(t_2) - U_{IN}(t_1)\right]}{\left[t_2 - t_1\right]} = \\ & = -R.C.\frac{2.U_{th}}{\Delta t} \\ & U_{OUT}(t_2, t_3) = 0 \\ & U_{OUT}(t_3, t_7) = \\ & = -R.C.\frac{\left[U_{IN}(t_7) - U_{IN}(t_3)\right]}{\left[t_7 - t_3\right]} = \\ & = -R.C.\frac{2.U_{th}}{4.\Delta t} \end{aligned}$$



!!! $SR = \max\left(\left|\frac{dU_{OUT}(t)}{dt}\right|\right)$

Идея за деференциатор суматор



$$i_R(t) = i_{C_1}(t) + i_{C_2}(t) + i_{C_3}(t)$$

$$U_{OUT}(t) = R.\left[i_{C_1}(t) + i_{C_2}(t) + i_{C_3}(t)\right]$$

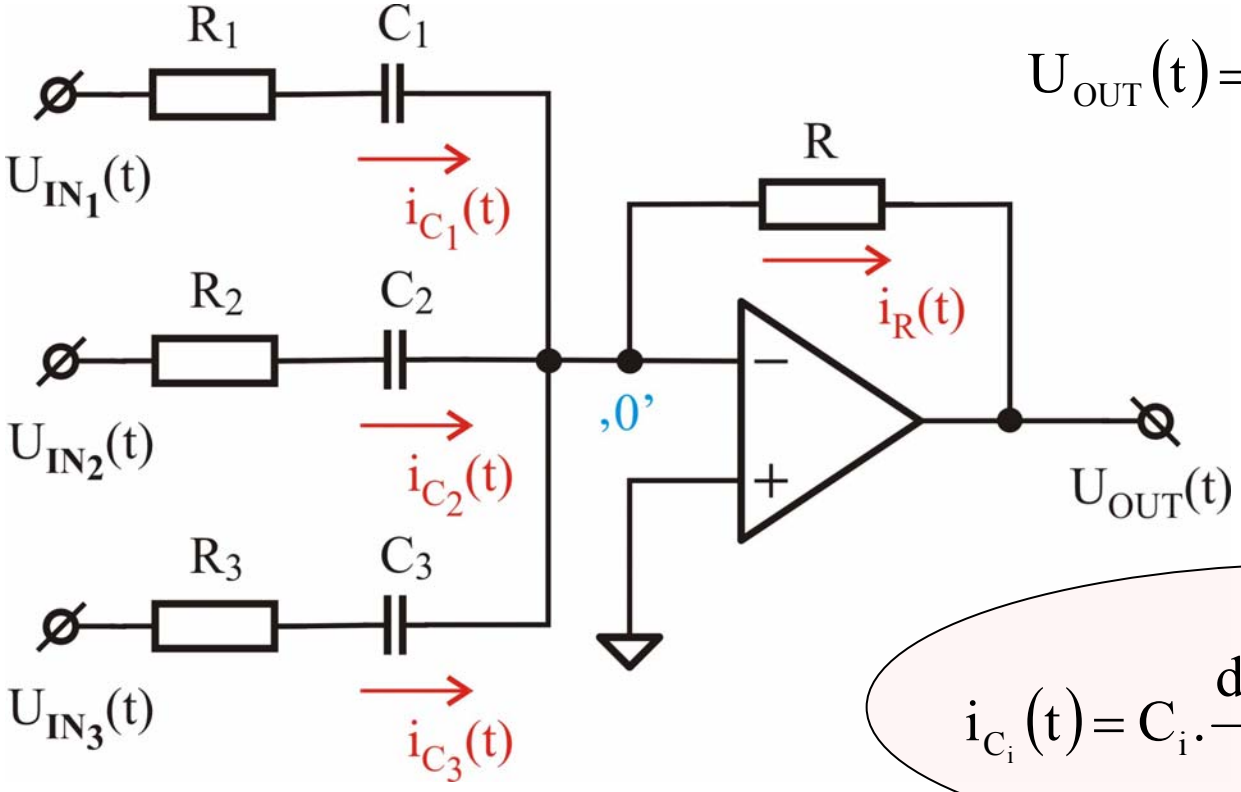
!!!!

Трябва да има ограничителни елементи за породените взаймни токове генерирани от входните напрежения през капацитивните структури.

Коригиран деференциатор суматор

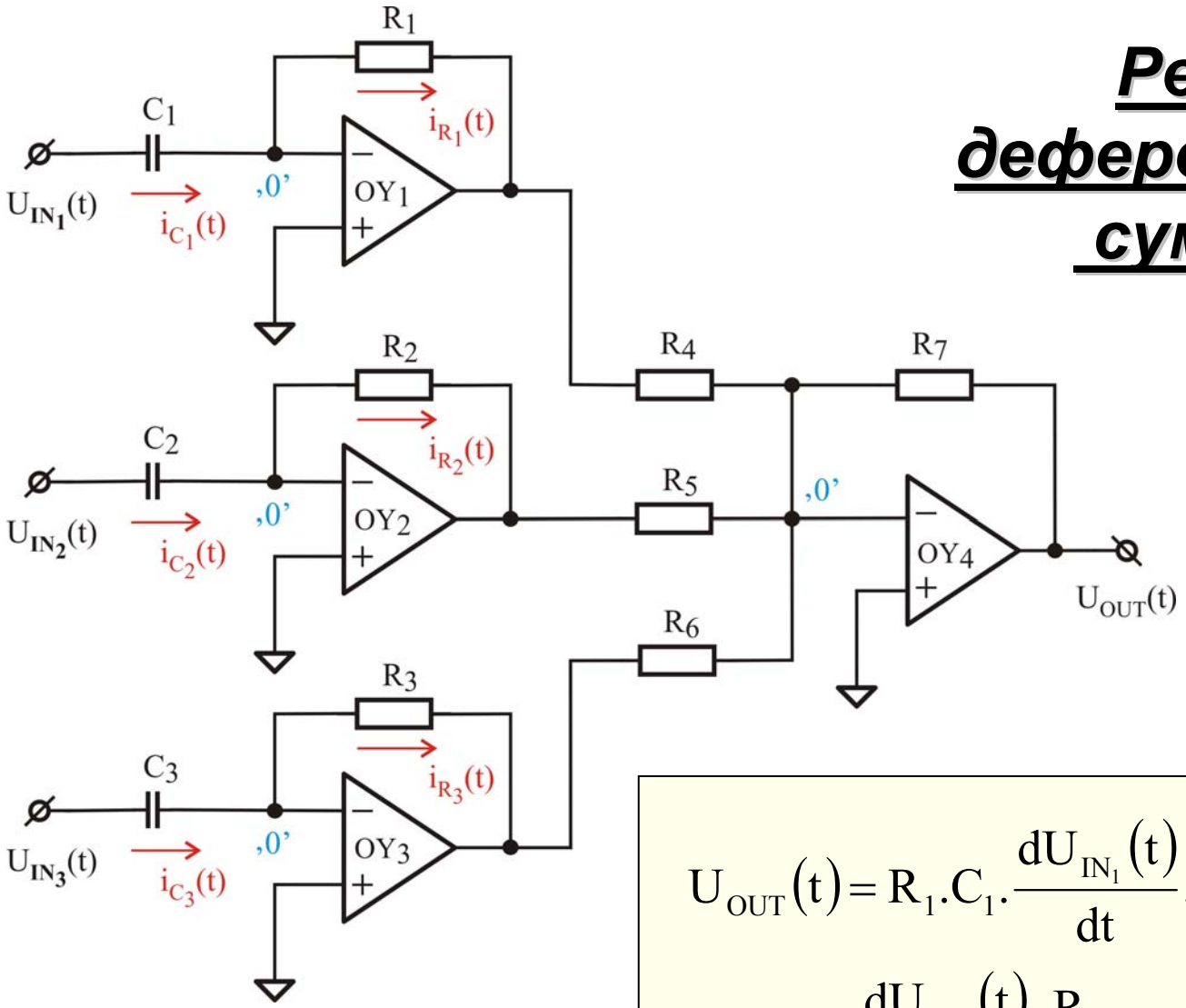
$$i_R(t) = i_{C_1}(t) + i_{C_2}(t) + i_{C_3}(t)$$

$$U_{OUT}(t) = R.\left[i_{C_1}(t) + i_{C_2}(t) + i_{C_3}(t)\right]$$



$$i_{C_i}(t) = C_i \cdot \frac{d\left[U_{IN_i}(t) - R_i . i_{C_i}(t)\right]}{dt}$$

Реален диференциатор суматор



$$U_{OUT}(t) = R_1.C_1.\frac{dU_{IN_1}(t)}{dt}.\frac{R_7}{R_4} +$$

$$+ R_2.C_2.\frac{dU_{IN_2}(t)}{dt}.\frac{R_7}{R_5} + R_3.C_3.\frac{dU_{IN_3}(t)}{dt}.\frac{R_7}{R_6}$$