VINNITSA NATIONAL AGRARIAN UNIVERSITY

Department of General Engineering Sciences and Labour Safety

CALCULATION OF TRANSIENTS IN ELECTRICAL CIRCUITS BY OPERATOR METHOD

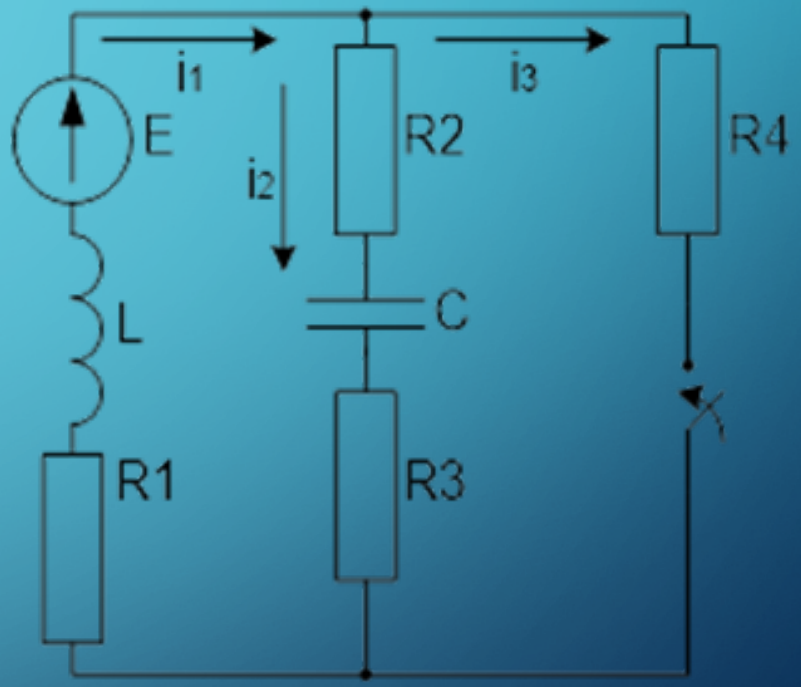
by Associate Professor V. Hraniak

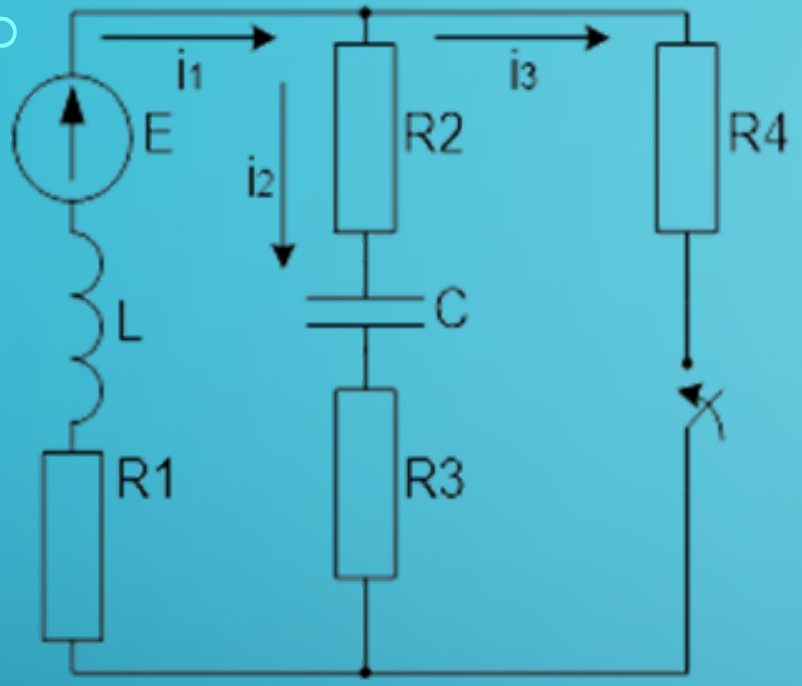
EXAMPLE 1 OF CALCULATING THE TRANSIENT BY OPERATOR METHOD

Incoming data

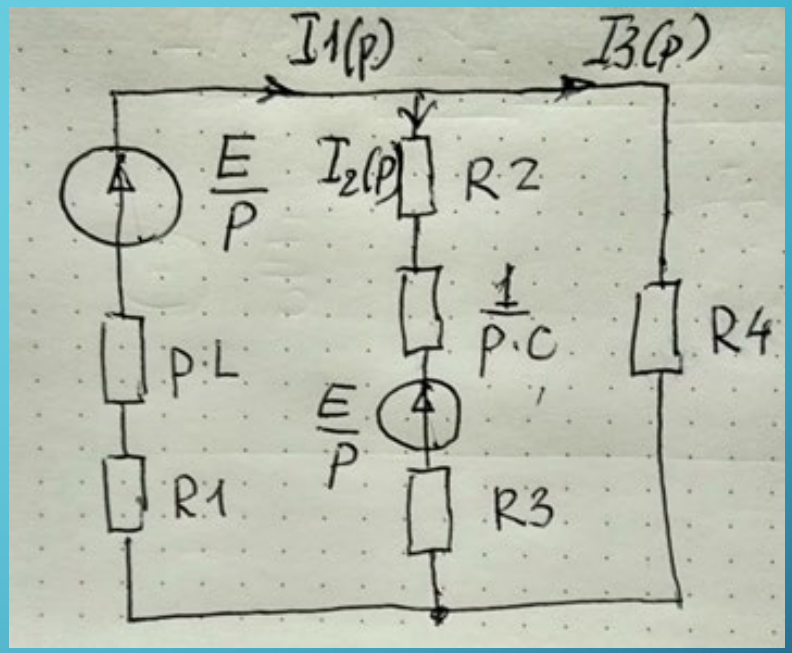
$L := 1 \cdot 10^{-3}$ $C := 10^{-5}$ $R1 := 12$ $R2 := 12$

$E := 200$ $R4 := 10$ $R3 := 10$





substitution scheme



System of equations in operator form

$$I11 - I2 - I3 = 0$$

$$I11 \cdot R1 + I11 \cdot p \cdot L + I2 \cdot R2 + I2 \cdot R3 + I2 \cdot \frac{1}{p \cdot C} = 0$$

$$I3 \cdot R4 - I2 \cdot R2 - I2 \cdot R3 - I2 \cdot \frac{1}{p \cdot C} = \frac{E}{p}$$

Solution of the system of equations

$$I1(p) = 12500 \cdot \frac{(11 \cdot p + 50000)}{\left(22000 \cdot p + 68750000 + p^2\right) \cdot p}$$

$$I2(p) = \frac{-25}{4} \cdot \frac{(12000 + p)}{\left(22000 \cdot p + 68750000 + p^2\right)}$$

$$I3(p) = \frac{25}{4} \cdot \frac{\left(34000 \cdot p + 100000000 + p^2\right)}{\left(22000 \cdot p + 68750000 + p^2\right) \cdot p}$$

The roots of the signifier

Given

$$22000 \cdot p + 68750000 + p^2 = 0$$

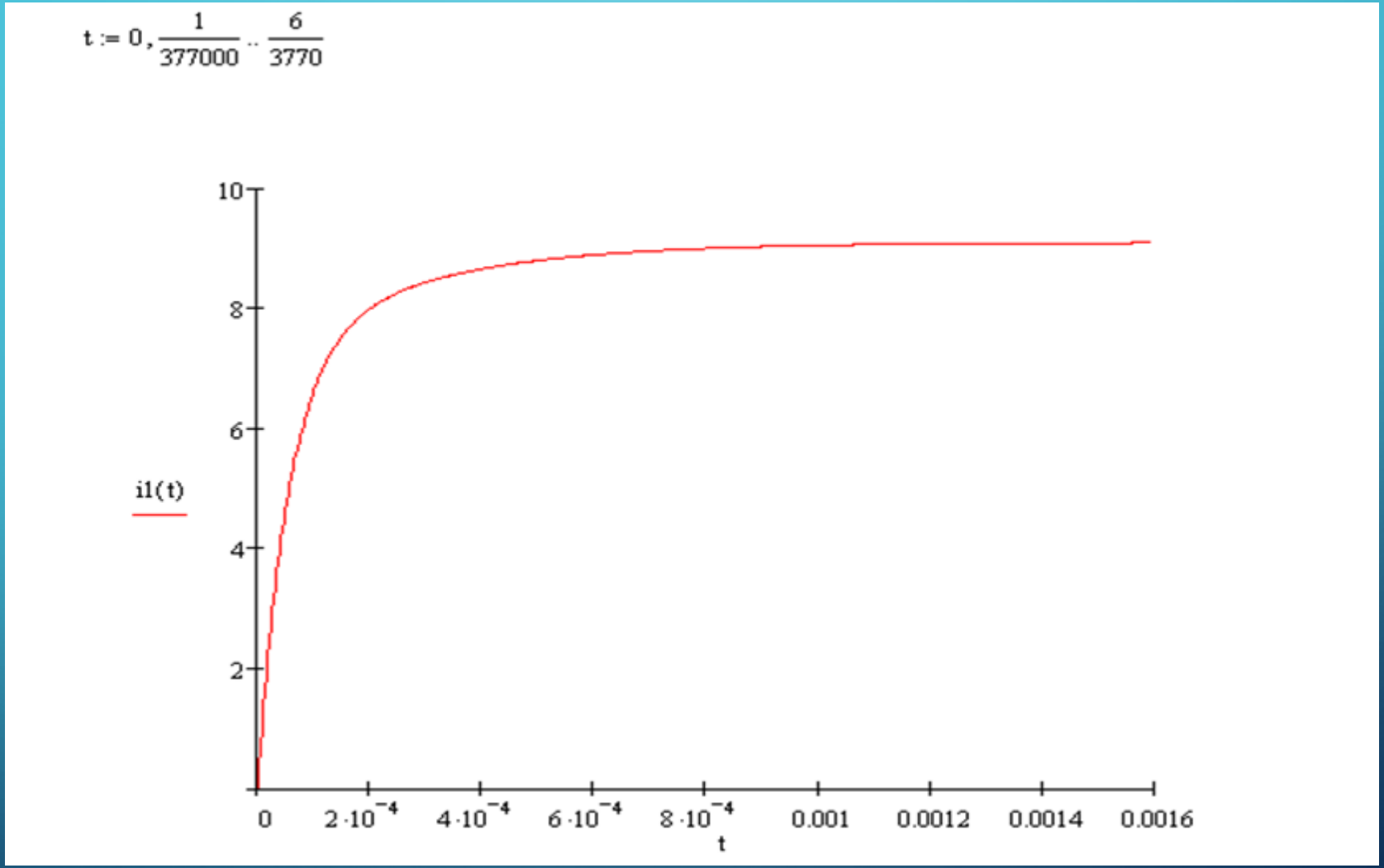
$$\text{Find}(p)\ \text{float},4 \rightarrow \begin{pmatrix} -3770. & -1.823 \cdot 10^4 \end{pmatrix}$$

Finding original features

$$i1(t) := I(p)\ \text{invlaplace},p \rightarrow \frac{100}{11} - \frac{100}{11} \cdot \exp(-11000 \cdot t) \cdot \cosh\left(500 \cdot 209^{\frac{1}{2}} \cdot t\right) + \frac{75}{209} \cdot \exp(-11000 \cdot t) \cdot 209^{\frac{1}{2}} \cdot \sinh\left(500 \cdot 209^{\frac{1}{2}} \cdot t\right)$$

$$i1(t)\ \text{float},4 \rightarrow 9.091 - 9.091 \cdot \exp\left(-1.100 \cdot 10^4 \cdot t\right) \cdot \cosh(7230. \cdot t) + 5.190 \cdot \exp\left(-1.100 \cdot 10^4 \cdot t\right) \cdot \sinh(7230. \cdot t)$$

Graph construction



EXAMPLE 2 OF CALCULATING THE TRANSIENT BY OPERATOR METHOD

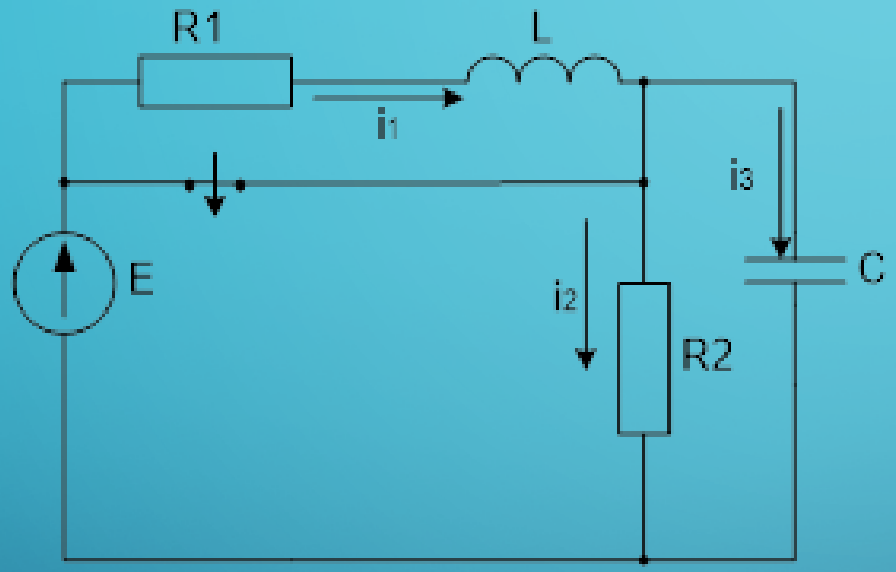
$E := 300$

$R1 := 20$

$R2 := 10$

$L := 1 \cdot 10^{-3}$

$C := 10 \cdot 10^{-6}$



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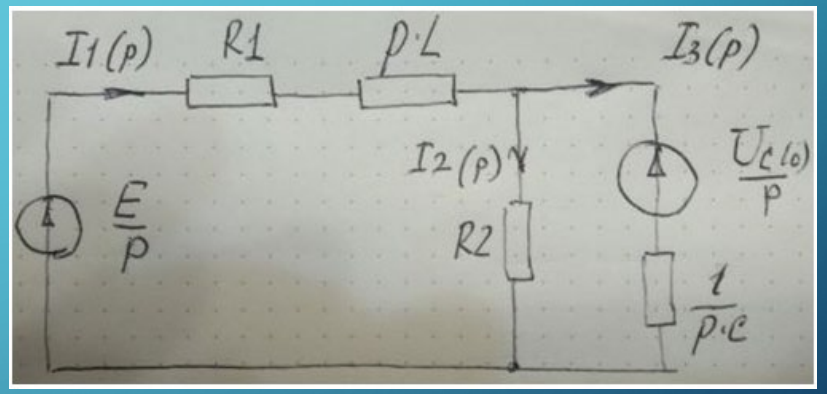

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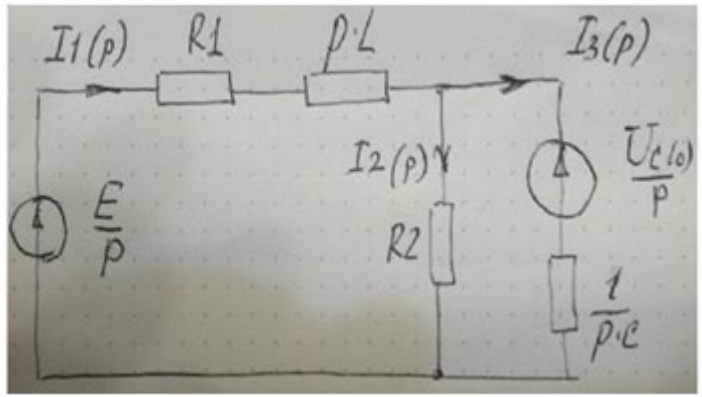

Given

$$I1 - I2 - I3 = 0$$

$$I1 \cdot (R1 + p \cdot L) + I2 \cdot R2 = \frac{E}{p}$$

$$I2 \cdot R2 - I3 \cdot \frac{1}{p \cdot C} = \frac{E}{p}$$

$$\text{Find}(I1, I2, I3) \rightarrow \begin{pmatrix} \dfrac{3000000000}{p^3 + 30000 \cdot p^2 + 300000000 \cdot p} \\ \dfrac{30 \cdot p^2 + 600000 \cdot p + 3000000000}{p^3 + 30000 \cdot p^2 + 300000000 \cdot p} \\ -\dfrac{30 \cdot p + 600000}{p^2 + 30000 \cdot p + 300000000} \end{pmatrix}$$

Given

$$p^3 + 30000 \cdot p^2 + 300000000 \cdot p = 0$$

$$\text{Find}(p)\ \text{float}, 4 \rightarrow (-15000.0 + 8660.0i \quad -15000.0 - 8660.0i \quad 0$$

$$I1(p) := \frac{3000000000}{p^3 + 30000 \cdot p^2 + 300000000 \cdot p}$$

$$I2(p) := \frac{30 \cdot p^2 + 600000 \cdot p + 3000000000}{p^3 + 30000 \cdot p^2 + 300000000 \cdot p}$$

$$i1(t) := I1(p) \left| \begin{array}{l} \text{invlaplace}, p \\ \text{float}, 3 \end{array} \right. \rightarrow -10.0 \cdot e^{-15000.0 \cdot t} \cdot \cos(8660.0 \cdot t) + -17.3 \cdot e^{-15000.0 \cdot t} \cdot \sin(8660.0 \cdot t) + 10.0$$

$$i2(t) := I2(p) \left| \begin{array}{l} \text{invlaplace}, p \\ \text{float}, 3 \end{array} \right. \rightarrow 20.0 \cdot e^{-15000.0 \cdot t} \cdot \cos(8660.0 \cdot t) + 10.0$$

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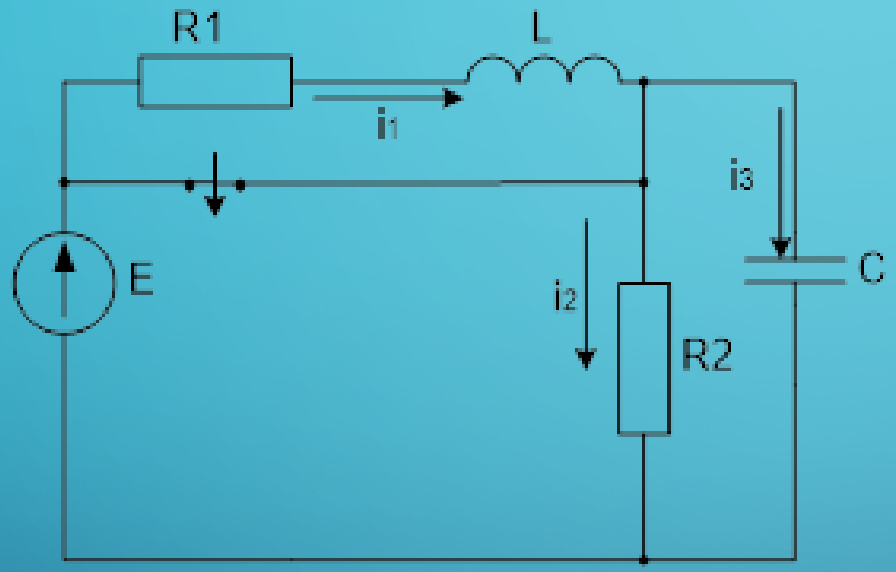

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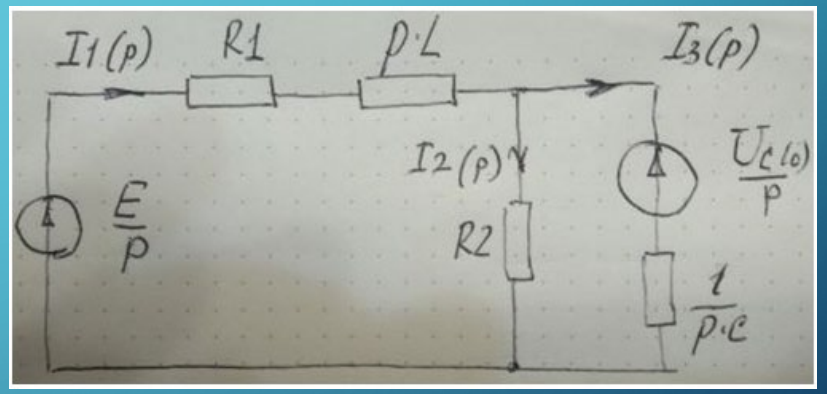

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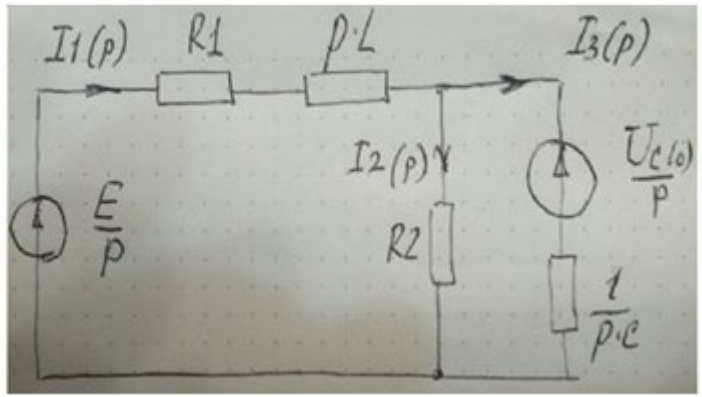

Given

$$I1 - I2 - I3 = 0$$

$$I1 \cdot (R1 + p \cdot L) + I2 \cdot R2 = \frac{E}{p}$$

$$I2 \cdot R2 - I3 \cdot \frac{1}{p \cdot C} = \frac{E}{p}$$

$$\text{Find}(I1, I2, I3) \rightarrow \begin{pmatrix} \dfrac{3000000000}{p^3 + 30000 \cdot p^2 + 300000000 \cdot p} \\ \dfrac{30 \cdot p^2 + 600000 \cdot p + 3000000000}{p^3 + 30000 \cdot p^2 + 300000000 \cdot p} \\ -\dfrac{30 \cdot p + 600000}{p^2 + 30000 \cdot p + 300000000} \end{pmatrix}$$

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$$i1(t) := I1(p) \left| \begin{array}{l} \text{invlaplace}, p \\ \text{float}, 3 \end{array} \right. \rightarrow -10.0 \cdot e^{-15000.0 \cdot t} \cdot \cos(8660.0 \cdot t) + -17.3 \cdot e^{-15000.0 \cdot t} \cdot \sin(8660.0 \cdot t) + 10.0$$

$$i2(t) := I2(p) \left| \begin{array}{l} \text{invlaplace}, p \\ \text{float}, 3 \end{array} \right. \rightarrow 20.0 \cdot e^{-15000.0 \cdot t} \cdot \cos(8660.0 \cdot t) + 10.0$$