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Response of Network Circuits Connected to Exponential Excitation Sources

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Abstract: In science and engineering, network circuit's analysis is a principal course. In this paper, we discuss the application of Mohand Transform for obtaining the Response of electric network circuits with an exponential excitation Source which is generally determined by the application of calculus method or different integral Transforms or convolution method or Matrix method. The response of electric network circuits with an exponential excitation source provides an expression for the current or voltage. This paper presents demonstrated the use of the Mohand Transform for determining the response of electric network circuits with an exponential excitation source.

Keywords: Mohand Transform; Network Circuits; Exponential Excitation Source; Response

I. INTRODUCTION

The electric network circuits are generally analyzed by adopting calculus method or different integral Transforms [1-6] or convolution method [7, 8] or Matrix method [9, 10] and their response depends on the property of elements- inductor L, capacitor C, and resistor R. Such series and parallel network circuits are widely used as a tuning or resonant circuit and are also widely used in oscillatory circuits [7-11]. Mohand Transform has been applied in solving boundary value problems in most of the science and engineering disciplines [12]. This paper presents the application of Mohand Transform for the analysis of network circuits connected to an exponential excitation source and reveals that Mohand Transform is an effective tool for analysis of such network circuits.

II. BASIC DEFINITION

2.1 Mohand Transform

If the function $\hbar(y)$, $y \geq 0$ is having an exponential order and is a piecewise continuous function on any interval, then the Mohand transform [6, 12] of $\hbar(y)$ is given by $M\{\hbar(y)\} = \bar{\hbar}(q) = q^2 \int_0^\infty e^{-qy}\, \hbar(y) dy$.

The Mohand Transform [6, 12] of some of the functions are given by

- $M\{y^n\} = n!/q^{n-1}$, $where n = 0,1,2,..$
- $M\{e^{ay}\} = \frac{q^2}{q-a}$,
- $M\{sinay\} = \frac{aq^2}{q^2+a^2}$,
- $M\{cosay\} = \frac{q^3}{q^2+a^2}$,

2.2 Mohand Transform of Derivatives

The Mohand Transform [6, 12] of some of the Derivatives of $h(y)$ are given by

$M\{h'(y)\} = qM\{h(y)\} - q^2 h(0)$

$or\ M\{\hbar'(y)\} = q\bar{\hbar}(p) - q^2\hbar(0)$

$M\{\hbar''(y)\} = q^2\bar{\hbar}(p) - q^3\hbar(0) - q^2\hbar'(0), and\ so\ on.$

III. MATERIAL AND METHOD

Analysis a series R-L-C network connected to a source of exponential potential

The differential equation for a series R-L-C network connected to an exponential excitation potential source as shown in figure (1) is given by

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$$\mathrm{I}(\mathrm{t})\mathrm{R} + \mathrm{L}\,\dot{\mathrm{I}}(\mathrm{t}) + \frac{\mathrm{Q}(\mathrm{t})}{\mathrm{C}} = ve^{-ut} \qquad \ldots.(1)$$

Differentiating (1) w.r.t. t and simplifying we get,

$$\ddot{\mathrm{I}}(\mathrm{t}) + \frac{\mathrm{R}}{\mathrm{L}}\dot{\mathrm{I}}(\mathrm{t}) + \frac{1}{\mathrm{LC}}\,\mathrm{I}(\mathrm{t}) = \frac{-vu}{\mathrm{L}}e^{-ut} \qquad \ldots.(2)$$

Here, $\mathrm{I}(\mathrm{t})$is the instantaneous current through the series $\mathrm{R} - \mathrm{L} - \mathrm{C}$ network circuit.

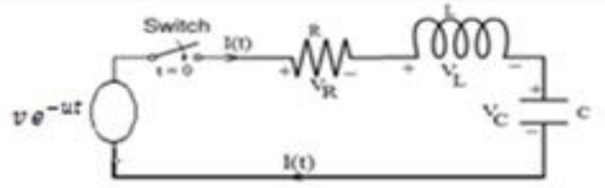

Figure 1:Series R-L-C network connected to an excitation source of exponential potential.

The initial conditions are:

(i) At t = 0, I (0) = 0….. (3)

(ii) Since at t = 0, I (0) = 0, therefore, equation (1) gives$\dot{\mathrm{I}}(0) = \frac{v}{\mathrm{L}}$ …… (4)

Taking Mohand transformation of equation (2), we get

$$q^2\bar{I}(\mathrm{q}) - q^3 I(0) - q^2\dot{\mathrm{I}}(0) + \frac{\mathrm{R}}{\mathrm{L}}\{q\bar{I}(\mathrm{q}) - q^2 I(0)\} + \frac{1}{\mathrm{LC}}\bar{I}(\mathrm{q}) = \frac{-vuq^2}{\mathrm{L}(q+u)} \qquad \ldots (5)$$

Applying conditions: $I(0) = 0$ and $\dot{\mathrm{I}}(0) = \frac{v}{\mathrm{L}}$ and simplifying (5), we get

$$\bar{\mathrm{I}}(\mathrm{q}) = \frac{\mathrm{v}}{\mathrm{L}}\frac{q^3}{(q+u)(q^2 + \frac{\mathrm{R}}{\mathrm{L}}q + \frac{1}{\mathrm{LC}})} \qquad \ldots..(6),$$

$$where\ 2\delta = \frac{\mathrm{R}}{\mathrm{L}}\ and\ \omega = \sqrt{\frac{1}{\mathrm{LC}}}$$

$$or\ \bar{\mathrm{I}}(\mathrm{q}) = \frac{\mathrm{v}}{\mathrm{L}}\frac{q^3}{(q+u)(q^2 + 2\,\delta\,q + \omega^2)}$$

$$or\ \bar{\mathrm{I}}(\mathrm{q}) = \frac{\mathrm{v}}{\mathrm{L}}\frac{q^3}{(q+u)(q+\beta_1)(q+\beta_2)} \qquad \ldots.(7)$$

$$where\ \omega' = \sqrt{\delta^2 - \omega^2}, \delta + \omega' = \beta_1\ and\ \delta - \omega' = \beta_{2,}\ \ \beta_1 - \beta_2 = 2\omega'.$$

$$or\ \bar{\mathrm{I}}(\mathrm{q}) = \frac{\mathrm{v}}{\mathrm{L}}\left\{\frac{-uq^2}{(q+u)(-u+\beta_1)(-u+\beta_2)} + \frac{-\beta_1 q^2}{(-\beta_1+u)(q+\beta_1)(-\beta_1+\beta_2)} + \frac{-\beta_2 q^2}{(-\beta_2+u)(-\beta_2+\beta_1)(q+\beta_2)}\right\} \ldots\ldots (8)$$

Applying inverse Mohand transform, we get

$$I(\mathrm{t}) = \frac{\mathrm{v}}{\mathrm{L}}\left\{\frac{-ue^{-ut}}{(-u+\beta_1)(-u+\beta_2)} + \frac{-\beta_1 e^{-\beta_1 t}}{(-\beta_1+u)(-\beta_1+\beta_2)} + \frac{-\beta_2 e^{-\beta_2 t}}{(-\beta_2+u)(-\beta_2+\beta_1)}\right\}$$

$$or\ I(\mathrm{t}) = \frac{\mathrm{v}}{\mathrm{L}}\left\{\frac{[\delta - \omega']e^{-\delta t}e^{\omega' t}}{2\omega'[\delta - \omega' - u]} - \frac{\mathrm{u}e^{-\mathrm{u}t}}{[\delta + \omega' - u][\delta - \omega' - u]} - \frac{[\delta + \omega']e^{-\delta t}e^{-\omega' t}}{2\omega'[\delta + \omega' - u]}\right\} \qquad \ldots (9)$$

This equation (9) is an expression for the current through a series R-L-C network circuit connected to an exponential excitation source at any instant.

When t increases indefinitely, $e^{-\delta t}$ tends to zero, so

$$I(\mathrm{t}) = \frac{\mathrm{v}}{\mathrm{L}}\frac{-\mathrm{u}e^{-\mathrm{u}t}}{[\delta + \omega' - u][\delta - \omega' - u]}$$

$$or\ I(\mathrm{t}) = \frac{\mathrm{v}}{\mathrm{L}}\frac{\mathrm{u}e^{-\mathrm{u}t}}{[u^2 - \omega^2 - 2\,\omega']}$$

Analysis of a parallel R-L-C network connected to an exponential excitation current source

The differential equation for a parallel $\mathrm{R} - \mathrm{L} - \mathrm{C}$ network circuit connected to an exponential excitation current source as shown in figure (2) is given by

$$\frac{\mathrm{V}(\mathrm{t})}{\mathrm{R}} + \frac{1}{\mathrm{L}}\int \mathrm{V}(\mathrm{t})\mathrm{dt} + \mathrm{C}\,\dot{\mathrm{V}}(\mathrm{t}) = \mathrm{I_o}e^{-ut} \qquad \ldots..(10)$$

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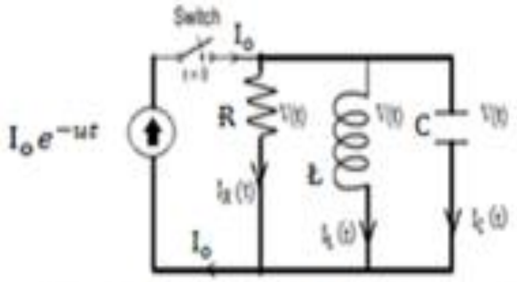

Figure 2: Parallel R-L-C network connected to an exponential excitation current source

Differentiate (10) w.r.t. t and simplifying, we get,

$\ddot{V}(t) + \frac{1}{RC}\dot{V}(t) + \frac{1}{LC}V(t) = \frac{-I_o u}{C} e^{-ut}$ …. (11)

The initial conditions are:

(i) At t = 0, $V(0) = 0$.

(ii) Since at t = 0, $V(0) = 0$, therefore, (11) gives $\dot{V}(0) = \frac{I_o}{C}$.

Taking Mohand transformation of (11), we get

$q^2\bar{V}(q) - q^3V(0) - q^2\dot{V}(0) + \frac{1}{RC}\{q\bar{V}(q) - q^2V(0)\} + \frac{1}{LC}\bar{V}(q) = \frac{-I_o uq^2}{C(q+u)}$……. (12)

Applying conditions: $V(0) = 0$ and $\dot{V}(0) = \frac{I_o}{C}$ and simplifying (12), we get

$\bar{V}(q) = \frac{I_o}{C}\left[\frac{q}{(q+u)(q^2 + 2aq + \omega^2)}\right]$, where $2a = \frac{1}{RC}$ and $\omega = \sqrt{\frac{1}{LC}}$

$$or\ \bar{V}(q) = \frac{I_o}{C}\left[\frac{q^3}{(q+u)(q^2 + 2aq + \omega^2)}\right]$$

$$or\ \bar{V}(q) = \frac{I_o}{C}\left[\frac{q^3}{(q+u)(q+a_1)(q+a_2)}\right]$$

where $a + \omega' = a_1$ and $a - \omega' = a_2$, $\omega' = \sqrt{a^2 - \omega^2}$, $a_1 - a_2 = 2\omega'$.

$$or\ \bar{V}(q) = \frac{I_o}{C}\left\{\frac{-uq^2}{(q+u)(-u+a_1)(-u+a_2)} + \frac{-a_1q^2}{(-a_1+u)(q+a_1)(-a_1+a_2)} + \frac{-a_2q^2}{(-a_2+u)(-a_2+a_1)(q+a_2)}\right\}$$

Applying inverse Mohand transform, we get

$$V(t) = \frac{I_o}{C}\left\{\frac{-ue^{-ut}}{(-u+\beta_1)(-u+\beta_2)} + \frac{-\beta_1 e^{-\beta_1 t}}{(-\beta_1+u)(-\beta_1+\beta_2)} + \frac{-\beta_2 e^{-\beta_2 t}}{(-\beta_2+u)(-\beta_2+\beta_1)}\right\}$$

$$or\ V(t) = \frac{I_o}{C}\left\{\frac{[\delta - \omega']e^{-\delta t}e^{\omega' t}}{2\omega'[\delta - \omega' - u]} - \frac{ue^{-ut}}{[\delta + \omega' - u][+\delta - \omega' - u]} - \frac{[\delta + \omega']e^{-\delta t}e^{-\omega' t}}{2\omega'[\delta + \omega' - u]}\right\} \ldots (13)$$

This equation (13) is an expression for the potential across a parallel R-L-C network connected to an exponential excitation current source at any instant.

When t increases indefinitely, $e^{-\delta t}$ tends to zero, so

$$V(t) = \frac{I_o}{C}\frac{-ue^{-ut}}{[\delta + \omega' - u][\delta - \omega' - u]}$$

$$or\ V(t) = \frac{I_o}{C}\frac{ue^{-ut}}{[u^2 - \omega^2 - 2\omega']}$$

IV. RESULT AND CONCLUSION

In this paper, we have successfully obtained the response of network circuits connected to exponential excitation source. This paper exemplified the application of Mohand Transform for obtaining the response of network circuits connected to exponential excitation source. This paper brought up the Mohand Transform as a simple and effective technique for analyzing the network circuits connected to exponential excitation source.

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