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RESPONSE OF NETWORK CIRCUITS CONNECTED TO IMPULSIVE POTENTIAL SOURCE VIA NEW INTEGRAL TRANSFORM: GUPTA TRANSFORM

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ABSTRACT

The impulsive response of electric network circuits is generally analyzed by adopting different integral transforms or approaches or methods. The paper inquires the impulsive response of network circuits by new integral transform: Gupta Transform and proves the applicability of Gupta Transform to obtain the impulsive response of network circuits.

Keywords: Gupta Transform, Impulsive Response, Network Circuits.

I. INTRODUCTION

The Gupta Transform has been applied in solving initial value problems in most of the science and engineering disciplines. The Gupta Transform was composed recently by the authors: Rahul Gupta and Rohit Gupta and they applied it to analyze initial value problems in science and engineering disciplines [1, 2]. This transform is not widely known since it is composed recently. The electrical circuits are usually analyzed by adopting different integral transforms [3], [4], [5], [6] or methods [7]-, [8], [9], [10]. In this paper, we present a new integral transform called Gupta Transform to analyze the impulsive response of network circuits and reveals that it can also be obtained easily by the application of Gupta Transform.

II. GUPTA TRANSFORM

Let g(y) is a continuous function on any interval for y ≥ 0. The Gupta Transform [1, 2] of g(y) is defined as $\dot{R}\{g(y)\} = \frac{1}{q^3}\int_0^\infty e^{-qy}\, g(y)dy = G(q)$, provided that the integral is convergent, where q may be a real or complex parameter and $\dot{R}$ is the Gupta Transform operator.

The Gupta Transform of elementary functions are given in [1, 2]

The inverse Gupta Transform of the function G(r) is denoted by $\dot{R}^{-1}$\{G (r)\} or g (y).

If we write $\dot{R}\{g(y)\} = G(r)$, then $\dot{R}^{-1}\{G(r)\} = g(y)$, where $\dot{R}^{-1}$ is called the inverse Gupta Transform operator.

The Inverse Gupta Transform of elementary functions are given in [1, 2].
The Gupta Transform of some derivatives [1, 2] of g(y) are

$$\dot{R}\{g'(y)\} = q\dot{R}\{g(y)\} - \frac{1}{q^3}g(0),$$

$$\dot{R}\{g''(y)\} = q^2\dot{R}\{g(y)\} - \frac{1}{q^2}g(0) - \frac{1}{q^3}g'(0)$$

III. MATERIAL AND METHODS

SERIES R-L NETWORK CIRCUIT WITH IMPULSIVE POTENTIAL SOURCE

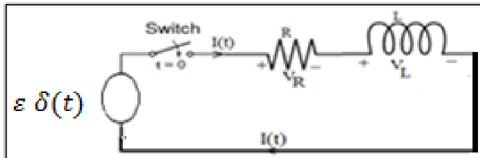

Figure1 : SERIES R-L NETWORK CIRCUIT WITH IMPULSIVE POTENTIAL SOURCE

The series R-L network circuit with impulsive potential source [4], [5], [11] is analyzed by the following differential equation

$L\dot{I}(t) + R\,I(t) = \varepsilon\,\delta(t)$, $\quad \dot{} \equiv \frac{d}{dt}$

Or

$\dot{I}(t) + \frac{R}{L}I(t) = \frac{\varepsilon}{L}\,\delta(t)$ .... (1)

ε is the strength of delta potential in volt

And I (0) = 0.
The Gupta transform of equation (1) gives

$qG(q) - \frac{1}{q^3}I(0) + \frac{R}{L}G(q) = \frac{\varepsilon}{Lq^4}$.... (2)

Put $I(0) = 0$, equation (2) on simplifying gives

$G(q) = \frac{\varepsilon}{Lq^4(q+\frac{R}{L})}$

$G(q) = \frac{\varepsilon}{Rq^4} - \frac{\varepsilon}{Rq^3(q+\frac{R}{L})}$ .... (3)

Taking inverse Gupta Transform, it has been obtained

$I(t) = \frac{\varepsilon}{R}[1 - e^{-\frac{R}{L}t}]$...... (4)

This equation yields the instantaneous current through the series R-L network circuit with an impulsive potential source.

SERIES R-L-C NETWORK CIRCUIT WITH IMPULSIVE POTENTIAL SOURCE

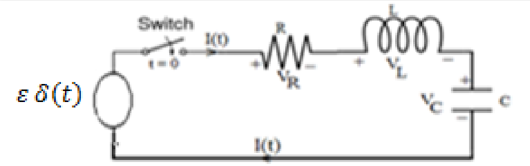

Figure2 : SERIES R-L-C NETWORK CIRCUIT WITH IMPULSIVE POTENTIAL SOURCE

The series R-L-C network circuit impulsive potential source [4, 5, 10] is analyzed by the following differential equation

$$\dot{Q}(t)R + L\,\ddot{Q}(t) + \frac{Q(t)}{C} = \varepsilon\,\delta(t)$$

Or

$\ddot{Q}(t) + \frac{R}{L}\dot{Q}(t) + \frac{1}{LC}Q(t) = \frac{\varepsilon}{L}\delta(t)$.... (5)

Here, $Q(t)$ is the instantaneous charge and Q (0) = 0

and $\dot{Q}(0) = 0$.

The Gupta transform of (5) gives

$q^2G(q) - \frac{1}{q^2}Q(0) - \frac{1}{q^3}Q'(0) + \frac{R}{L}\{qG(q) - \frac{1}{q^3}Q(0)\} + \frac{1}{LC}G(q) = \frac{\varepsilon}{Lq^4}$

Put Q (0) = 0 and $\dot{Q}(0) = 0$, we get

$$q^2G(q) + \frac{R}{L}qG(q) + \frac{1}{LC}G(q) = \frac{\varepsilon}{Lq^4}$$

$$G(q) = \frac{\varepsilon}{Lq^4}\,\frac{1}{(q^2 + \frac{R}{L}q + \frac{1}{LC})}$$

Or

$G(q) = \frac{\varepsilon}{Lq^4}\,\frac{b}{(q+b_1)(q+b_2)}$ .... (6),

Here $\frac{R}{2L} + \sqrt{(\frac{R}{2L})^2 - \frac{1}{LC}} = b_1$,

$$\frac{R}{2L} - \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}} = b_2,$$

such that $b_1 - b_2 = 2\sqrt{(\frac{R}{2L})^2 - \frac{1}{LC}}$ and $b_1 b_2 = \frac{1}{LC}$.

Therefore,

$$G(q) = \frac{\varepsilon}{L}\left\{\frac{1}{b_1 b_2 q^4} + \frac{1}{b_1(b_1-b_2)q^3(q+b_1)} - \frac{1}{b_2(b_1-b_2)q^3(q+b_2)}\right\}$$
... (7)

Taking inverse Gupta Transform, we get

$$Q(t) = \frac{\varepsilon}{L}\left\{\frac{1}{b_1 b_2} + \frac{e^{-b_1 t}}{b_1(b_1-b_2)} - \frac{e^{-b_2 t}}{b_2(b_1-b_2)}\right\} \text{.... (8)}$$

or

$$I(t) = \dot{Q}(t) = \frac{\varepsilon}{L}\left\{\frac{-e^{-b_1 t}}{(b_1-b_2)} + \frac{e^{-b_2 t}}{(b_1-b_2)}\right\}$$

or

$$I(t) = \frac{\varepsilon}{L}\left\{\frac{e^{-b_2 t}}{(b_1-b_2)} - \frac{e^{-b_1 t}}{(b_1-b_2)}\right\} \text{.... (9)}$$

This equation yields the instantaneous current through the series R-L-C network circuit with an impulsive potential source.

SERIES RC NETWORK CIRCUIT WITH IMPULSIVE POTENTIAL SOURCE

The series R-C network circuit with impulsive potential source [4, 5] is analyzed by the following differential equation

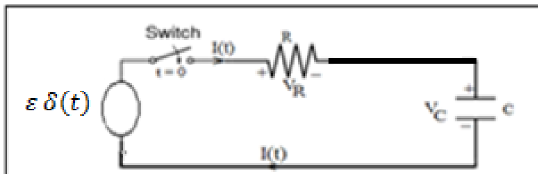

Figure3: SERIES R-C NETWORK CIRCUIT WITH IMPULSIVE POTENTIAL SOURCE

$$\dot{Q}(t)R + \frac{Q(t)}{C} = \varepsilon\,\delta(t)$$

Or

$$\dot{Q}(t) + \frac{1}{RC}Q(t) = \frac{\varepsilon}{R}\delta(t) \text{.... (10)}$$

Here, $Q(t)$ is the instantaneous charge and Q (0) = 0.

The Gupta transform of (10) gives

$$qG(q) - \frac{1}{q^3}Q(0) + \frac{1}{RC}G(q) = \frac{\varepsilon}{Rq^4}$$

Put Q (0) = 0 we get

$$qG(q) + \frac{1}{RC}G(q) = \frac{\varepsilon}{Rq^4}$$

$$G(q) = \frac{\varepsilon}{Rq^4\left(q+\frac{1}{RC}\right)}$$

OR

$$G(q) = \frac{\varepsilon C}{q^4} - \frac{C\,\varepsilon}{q^3\left(q+\frac{1}{RC}\right)} \text{....... (11)}$$

Taking inverse Gupta Transform, it has been obtained

$$Q(t) = \varepsilon C\left[1 - e^{-\frac{1}{RC}t}\right]$$

Or

$$I(t) = \dot{Q}(t) = \frac{\varepsilon}{R}\left[e^{-\frac{1}{RC}t}\right] \text{..... (12)}$$

This equation yields the instantaneous charge through the series R-C network circuit with an impulsive potential source.

IV. CONCLUSION

In this paper, we have obtained successfully the impulsive response of network circuits by Gupta Transform. It is finished that the Gupta Transform is accomplished in obtaining the impulsive response of the electrical network circuits. The results obtained are the same as obtained with other methods or approaches.

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