MultiCraft

International Journal of Engineering, Science and Technology
Vol. 15, No. 3, 2023, pp. 58-63

INTERNATIONAL JOURNAL OF ENGINEERING, SCIENCE AND TECHNOLOGY

www.ijest1-ng.com
www.ajol.info/index.php/ijest


# Reaction of undamped systematically driven vibrators via Gupta Transform

**Rahul Gupta[1], Rohit Gupta[2*], Yuvraj Singh[3], Inderdeep Singh[4], Dinesh Verma[5]**

*[1]Department of Physics, G.D. Goenka Public School, Jammu, INDIA*
*[2*]Department of Applied Sciences (Physics), Yogananda College of Engineering & Technology, Jammu, J&K, INDIA*
*[3]Department of Electrical Engineering, Yogananda College of Engineering & Technology, Jammu, J&K, INDIA*
*[4]Department of Mechanical Engineering, Yogananda College of Engineering & Technology, Jammu, J&K, INDIA*
*[5]Department of Mathematics, NIILM University, Kaithal, Haryana, INDIA*
**Corresponding Author: guptarohit565@gmail.com, +919797653429*
*ORCID iDs: http:/orcid.org/0000-0002-9893-9141 (Rahul); https://orcid.org/0000-0002-9744-5131 (Rohit); https://orcid.org/0000-0002-9659-2797 (Dinesh)*

**Abstract**

This paper deals with the dictation of the reaction of undamped, systematically driven electrical and mechanical vibrators by the Gupta transform (GT) and tenders an alternate style for the dictation of the reaction of undamped, systematically driven electrical and mechanical vibrators. It reveals that the GT is an effectual method for the dictation of undamped, systematically driven electrical and mechanical vibrators and proves the materiality of the GT for the dictation of reaction of undamped, systematically driven electrical and mechanical vibrators.

*Keywords*: Reaction, Gupta transform (GT), undamped, systematically driven electrical and mechanical vibrators

DOI: http://dx.doi.org/10.4314/ijest.v15i3.6

*Cite this article as*:
Gupta R., Gupta R., Singh Y., Singh I., Verma D. 2023. Reaction of undamped systematically driven vibrators via Gupta transform. *International Journal of Engineering, Science and Technology*, Vol. 15, No. 3, pp. 58-63. doi: 10.4314/ijest.v15i3.6

~~Received: July 25, 2023; Accepted: August 3, 2023; Final acceptance in revised form: August 6, 2023~~

## 1. Introduction

The integral GT has been alleged by the authors Rahul Gupta and Rohit Gupta in recent years (Gupta et al, 2022). This paper deals with the dictation of the reaction of undamped, systematically driven electrical and mechanical vibrators by the Gupta transform (GT). There are a number of styles like the Laplace transform, matrix approach, Rohit transform, Shehu transform, SEE transform, Aboodh transform, Mohand transform, etc. This paper tenders an alternate style for the dictation of the reaction of undamped, systematically driven electrical and mechanical vibrators. It reveals that the GT is an effectual method for the dictation of undamped, systematically driven electrical and mechanical vibrators and proves the materiality of the GT for the dictation of reaction of undamped, systematically driven electrical and mechanical vibrators. The GT (Gupta et al, 2022) is defined for a function of exponential order as follows: Considering functions in the set C defined as:

$$C = \{g(t): \exists\, R, q_1, q_2 > 0, \qquad |g(t)| < Re^{q_i|(t)|}, if\ t\ \in (-1)^i X[0,\infty)\}$$

For a given function in set C, the constant R must be a finite number $q_1$ and $q_2$, may be finite or infinite.

The GT of a function g(t) is defined by the integral equations as

$$\dot{R}\{g(t)\} = G(q) = \frac{1}{q^3}\int_0^\infty e^{-qt}\, g(t)dt,\ t \geq 0\ , q_1 \leq q \leq q_2.$$

The variable q in this transform is used to factor the variable t in the argument of the function g. The key stimulation for appealing GT for the dictation of the reaction of undamped, systematically driven electrical and mechanical vibrators is that the procedure of solving a ruling ordinary differential equation for such issue is clarified to an algebraic problem (Gupta et al, 2022). This procedure of metamorphosing the issues of calculus to algebraic issues is well known as operational calculus. The GT procedure has two chief edges over the calculus procedure:

- **i.** issues entailing differential equations are reckoned up more directly i.e. initial (or boundary) value issues are reckoned up without first ascertaining a common solution.
- **ii.** A Non-homogenous differential equation is reckoned up without first reckoning up the correlating homogeneous differential equation.

The GT, when applied to a function, metamorphose that function into a novel function by using a procedure that entails integration.

The GT of some basic functions is as follows

- $\dot{R}\{t^n\} = \frac{n!}{q^{n+4}}\ , where\ n = 0,1,2,3 \ldots\ldots\ldots$
- $\dot{R}\{e^{at}\} = \frac{1}{q^3(q-a)}\ ,\ \ q > a$
- $\dot{R}\{sinat\} = \frac{a}{q^3(q^2+a^2)}\ ,\ \ q > 0$
- $\dot{R}\{cosat\} = \frac{1}{q^2(q^2+a^2)}\ ,\ \ q > 0$

$$\dot{R}\{\delta(t-a)\} = \frac{1}{q^4}\ e^{-aq}$$

The GT of some derivatives is given by

$$\dot{R}\{g'(t)\} = \frac{1}{q^3}\int_0^\infty e^{-qt}\, g'(t)dt$$

$$\begin{aligned}\dot{R}\{g'(t)\} &= \frac{1}{q^3}\left\{-g(0) - \int_0^\infty -qe^{-qt}\, g(t)dt\right\}\\ &= \frac{1}{q^3}\left\{-g(0) + q\int_0^\infty e^{-qy}\, g(t)dt\right\}\\ &= \mathrm{q}G(q) - \frac{1}{q^3}g(0)\end{aligned}$$

Now cutting out g(t) by $g'(t)$ and $g'(t)\ by\ g''(t)$, we have

$$\begin{aligned}\dot{R}\{g''(t)\} &= q\dot{R}\{g'(t)\} - \frac{1}{q^3}g'(0)\\ &= \mathrm{q}\left\{\mathrm{q}\dot{R}\{g(t)\} - \frac{1}{q^3}g(0)\right\} - \frac{1}{q^3}g'(0)\\ &= q^2\dot{R}\{g(t)\} - \frac{1}{q^2}g(0) - \frac{1}{q^3}g'(0)\\ &= q^2G(q) - \frac{1}{q^2}g(0) - \frac{1}{q^3}g'(0)\end{aligned}$$

Hence $\dot{R}\{g'(t)\} = q\dot{R}\{g(t)\} - \frac{1}{q^3}g(0)$,

$$\dot{R}\{g''(t)\} = q^2G(q) - \frac{1}{q^2}g(0) - \frac{1}{q^3}g'(0)$$

and so on.

## 2. Methodology

### I. Undamped Mechanical Systematically Driven Vibrator

The systematically driven mechanical vibrator (Gupta et al, 2022 and Gupta et al, 2023) is specified by

$$m\ddot{y}(\mathrm{t}) + \mathrm{b}\dot{y}(\mathrm{t}) + \mathrm{ky}(\mathrm{t}) = \mathrm{F}\cos\omega t \quad (1)$$

For an **Undamped Mechanical Systematically Driven Vibrator**, draining constant (Olivar et al, 2017), b = 0, therefore, (1) transforms to

$$m\ddot{y}(t) + ky(t) = F\cos\omega t$$

Or

$$\ddot{y}(t) + \omega_0{}^2 y(t) = \frac{F}{m}\cos\omega t \tag{2}$$

$$where\ \omega_0 = \sqrt{\frac{k}{m}}$$

Here,

(i) $y(0) = 0.$

(ii) $\dot{y}(0) = 0.$

The GT of (2) furnishes

$$q^2\bar{y}(q) - \frac{1}{q^2}y(0) - \frac{1}{q^3}\dot{y}(0) + \omega_0{}^2\bar{y}(q) = \frac{F}{m}\frac{1}{q^2(q^2+\omega^2)} \tag{3}$$

Here $\bar{y}(q)$ denotes the GT of $y(t)$.

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

$$q^2\bar{y}(q) + \omega_0{}^2\bar{y}(q) = \frac{F}{m}\frac{1}{q^2(q^2+\omega^2)}$$

$$\bar{y}(q) = \frac{F}{m}\frac{1}{q^2(q^2+\omega^2)(q^2+\omega_0{}^2)}$$

$$\bar{y}(q) = \frac{F}{m}\{\frac{1}{q^2(-\omega_0{}^2+\omega^2)(q^2+\omega^2)} + \frac{1}{q^2(-\omega^2+\omega_0{}^2)(q^2+\omega_0{}^2)}\}$$

Relating the inverse GT, we have

$$y(t) = \frac{F}{m}\{\frac{1}{(-\omega_0{}^2+\omega^2)}\cos\omega t + \frac{1}{(-\omega^2+\omega_0{}^2)}\cos\omega_0 t\}$$

$$y(t) = \frac{F}{m}\{\frac{1}{(\omega^2-\omega_0{}^2)}\cos\omega t - \frac{1}{(\omega^2-\omega_0{}^2)}\cos\omega_0 t\}$$

$$y(t) = \frac{F}{m}\frac{1}{(\omega^2-\omega_0{}^2)}(\cos\omega t - \cos\omega_0 t)$$

$$y(t) = \frac{2F}{m}\frac{1}{(\omega_0{}^2-\omega^2)}\sin\frac{(\omega_0-\omega)t}{2}\sin\frac{(\omega_0+\omega)t}{2} \tag{4}$$

If $\omega > \omega_0$, then (4) is supposed to be the product of two terms: $\frac{2F}{m}\frac{1}{(\omega_0{}^2-\omega^2)}\sin\frac{(\omega_0-\omega)t}{2}$ and $\sin\frac{(\omega_0+\omega)t}{2}$ . Since $\omega$ is nearly more than $\omega_0$, therefore, $|\omega - \omega_0|$ is small, and the angular frequency of the term $\sin\frac{(\omega_0+\omega)t}{2}$ is very high than that of the term $\frac{2F}{m}\frac{1}{(\omega_0{}^2-\omega^2)}\sin\frac{(\omega_0-\omega)t}{2}$. In this case, (4) specifies a vibration of a high frequency whose amplitude is regulated by a vibration of a low frequency as shown in figure 1. Taking F = $10^4$ N, m = $10^2$ Kg, $\omega$ = 9 x $10^2$ rad/sec and $\omega_0$= $10^3$ rad/sec, the graph of equation (4), between y and t is shown in Figure 1.

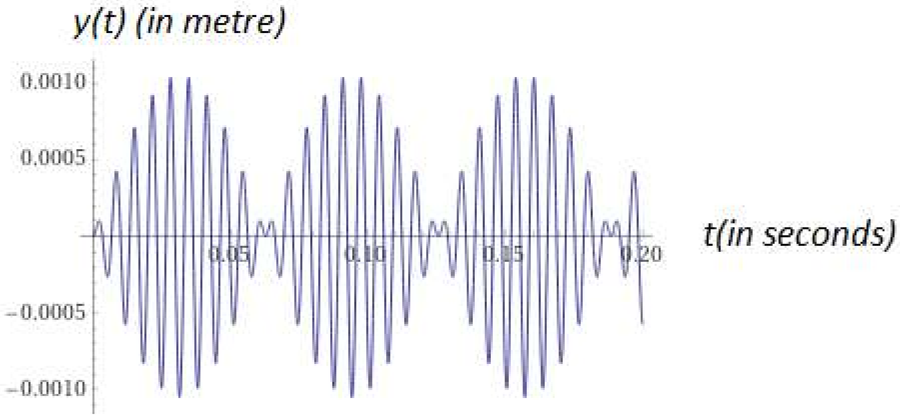


Figure 1

## II. Undamped Electrical Systematically Driven Vibrator

The systematically driven electrical vibrator (Gupta et al, 2022 and Gupta et al, 2023) is specified by

$$L\ddot{q}(t) + R\dot{q}(t) + \frac{1}{C}q(t) = V\cos\omega t$$

$$\text{Or } \ddot{q}(t) + \frac{R}{L}\dot{q}(t) + {\omega_0}^2 q(t) = \frac{V}{L}\cos\omega t \tag{5}$$

For an **Undamped Electrical Systematically Driven Vibrator** (Deshpande et al, 2014), the resistance, R = 0, therefore, equation (5) becomes

$$\ddot{q}(t) + {\omega_0}^2 q(t) = \frac{V}{L}\cos\omega t \tag{6}$$

$where\ \omega_0 = \sqrt{\frac{1}{LC}}\ and\ q(t)$ is the instantaneous charge.

Here (Berman et al, 2018),

(i) $q(0) = 0$.

(ii) $\dot{q}(0) = 0$.

The GT of (6) furnishes

$$p^2\bar{q}(p) - \frac{1}{p^2}q(0) - \frac{1}{p^3}\dot{q}(0) + {\omega_0}^2\bar{q}(p) = \frac{V}{L}\frac{1}{p^2(p^2+\omega^2)} \tag{7}$$

Here $\bar{q}(p)$ denotes the GT of $q(t)$.

Put $q(0) = 0$ and $\dot{q}(0) = 0$, we have

$$p^2\bar{q}(p) + {\omega_0}^2\bar{q}(p) = \frac{V}{L}\frac{1}{p^2(p^2+\omega^2)}$$

$$\bar{q}(p) = \frac{V}{L}\frac{1}{p^2(p^2+\omega^2)(p^2+{\omega_0}^2)}$$

$$\bar{q}(p) = \frac{V}{L}\left\{\frac{1}{p^2(-{\omega_0}^2+\omega^2)(p^2+\omega^2)} + \frac{1}{p^2(-\omega^2+{\omega_0}^2)(p^2+{\omega_0}^2)}\right\}$$

Relating the inverse GT, we have

$$q(t) = \frac{V}{L}\left\{\frac{1}{(-{\omega_0}^2+\omega^2)}\cos\omega t + \frac{1}{(-\omega^2+{\omega_0}^2)}\cos\omega_0 t\right\}$$

$$q(t) = \frac{V}{L}\left\{\frac{1}{(\omega^2-{\omega_0}^2)}\cos\omega t - \frac{1}{(\omega^2-{\omega_0}^2)}\cos\omega_0 t\right\}$$

$$q(t) = \frac{V}{L}\frac{1}{(\omega^2-{\omega_0}^2)}(\cos\omega t - \cos\omega_0 t)$$

$$q(t) = \frac{2V}{L}\frac{1}{({\omega_0}^2-\omega^2)}\sin\frac{(\omega_0-\omega)t}{2}\sin\frac{(\omega_0+\omega)t}{2} \tag{8}$$

If $\omega$ is nearly more than $\omega_0$, then (8) is supposed to be the product of two terms: $\frac{2V}{L}\frac{1}{(\omega_0{}^2-\omega^2)}\sin\frac{(\omega_0-\omega)t}{2}$ and $\sin\frac{(\omega_0+\omega)t}{2}$ . Since $\omega$ is nearly more than $\omega_0$, therefore, therefore, $|\omega - \omega_0|$ is small and the angular frequency of the term $\sin\frac{(\omega_0+\omega)t}{2}$ is much higher than that of the term $\frac{2V}{L}\frac{1}{(\omega_0{}^2-\omega^2)}\sin\frac{(\omega_0-\omega)t}{2}$. In this case, (8) specifies a vibration of a high frequency whose amplitude is regulated by a vibration of a low frequency as shown in figure 2. Taking V = 3 x $10^2$ volt, L= $10^{-1}$ H, $\omega$ = 9 x $10^2$ rad/sec and $\omega_0$= $10^3$ rad/sec, the graph of equation (8), between q and t is shown in Figure 2.

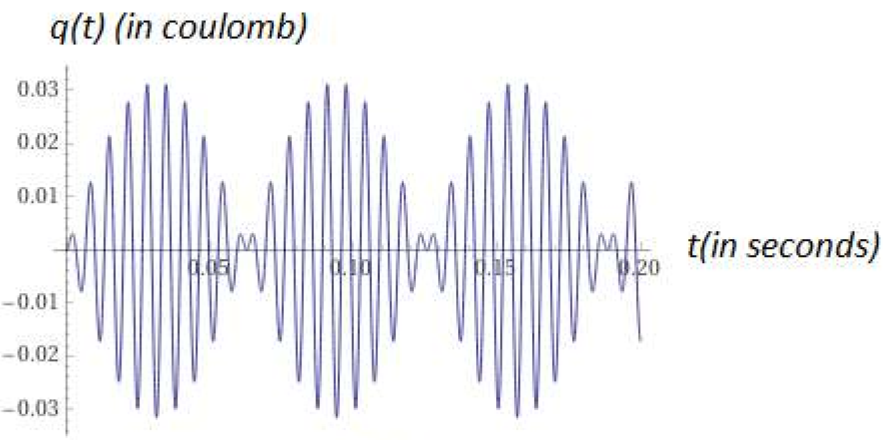

Figure 2

## 3. Discussion

The reaction of undamped, systematically driven electrical and mechanical vibrators has been fortuitously dictated by the integral GT. This paper has tendered an alternate style for the dictation of the reaction of undamped, systematically driven electrical and mechanical vibrators In an undamped, systematically driven mechanical vibrator, if $\omega$ is nearly more than $\omega_0$, then $|\omega - \omega_0|$ is small and the angular frequency of the term $\sin\frac{(\omega_0+\omega)t}{2}$ is much higher than that of the term $\frac{2F}{m}\frac{1}{(\omega_0{}^2-\omega^2)}\sin\frac{(\omega_0-\omega)t}{2}$. In this case, the reaction of mechanical oscillator specifies a vibration of a high frequency and whose amplitude is regulated by a vibration of a low frequency as shown in figure 1. In an undamped, systematically driven electrical vibrator, if $\omega$ is nearly more than $\omega_0$, then $|\omega - \omega_0|$ is small and the angular frequency of the term $\sin\frac{(\omega_0+\omega)t}{2}$ is much higher than that of the term $\frac{2V}{L}\frac{1}{(\omega_0{}^2-\omega^2)}\sin\frac{(\omega_0-\omega)t}{2}$. In this case, the reaction of electrical oscillator specifies a vibration of a high frequency whose amplitude is regulated by a vibration of a low frequency as shown in figure 2.

## 4. Conclusions

The paper exemplified the GT for dictating the reaction of undamped, systematically driven electrical and mechanical vibrators. It reveals that the GT is an effectual method for the dictation of undamped, systematically driven electrical and mechanical vibrators and proves the materiality of the GT for the dictation of reaction of undamped, systematically driven electrical and mechanical vibrators.

## References

Berman M., & Cederbaum L. S., 2018. Fractional driven-damped oscillator and its general closed form exact solution, *Physica A: Statistical Mechanics and its Applications*, Vol. 505(C), pp. 744-762.

Deshpande A.S., 2014. 'Transient analysis of R-L-C series circuit to step voltage by engineering method, *International Journal of Computational and Applied Mathematics*, Vol. 9, No. 2, pp. 63-70.

Gupta R., Pandita N., Gupta R., 2022. Solving one-dimensional heat and wave equations via gupta integral transform, *2022 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS),* Erode, India, pp. 921-925, doi: 10.1109/ICSCDS53736.2022.9760823.

Gupta R., Gupta R., Talwar L., Anamika and Verma D., 2022. Analysis of RLC network connected to steady stimulating source via gupta transform, *2022 International Conference on Automation, Computing and Renewable Systems (ICACRS),* Pudukkottai, India, pp. 9-12, doi: 10.1109/ICACRS55517.2022.10029269.

Gupta R., Singh I., Sharma A., 2022. Response of an undamped forced oscillator via rohit transform. *International Journal of Emerging Trends in Engineering and Research*, Vol. 10, No. 8, pp. 396-400.

Gupta R., Gupta R, 2023. Response of undamped oscillators exposed to rectangular pulse force, *International Journal of Scientific Research in Physics and Applied Sciences*, Vol. 11, No. 2, pp. 10-14.

Olivar-Romero F and Rosas-Ortiz O 2017 Journal of Physics: Conference Series 839 012010.

**Biographical notes**

**Mr. Rahul Gupta** pursued M.Sc. in Physics from University of Jammu in the year 2014. He was formerly a Lecturer in the department of Applied Sciences (Physics) in the Yogananda College of Engineering and Technology, Jammu. He is now Lecturer in the department of Physics in the G.D. Goenka Public School, Jammu. He has taught UG Classes for well over 6 years. He has published more than 45 research papers in reputed journals. He has published 3 books for Engineering and Graduation level.

**Mr. Rohit Gupta** pursued M.Sc. in Physics from University of Jammu in the year 2012. He is a Lecturer in the department of Applied Sciences (Physics) in the Yogananda College of Engineering and Technology, Jammu. He has been teaching UG Classes for well over 10 years. He has published more than 70 research papers in reputed journals. His main research work focuses on application of mathematical tools in Science and Engineering problems. He has published four books for Engineering and Graduation level.

**Er. Yuvraj Singh** is an Assistant Professor in the Department of Electrical Engg., Yogananda College of Engineering and Technology, Jammu, India. He has pursued M. Tech. from Beant College of Engg. And Tech. in the year 2015. He has been teaching UG Classes for well over 6 years.

**Er. Inderdeep Singh** is an assistant Professor in the Department of Mechanical Engg., Yogananda College of Engineering and Technology, Jammu, India. . He has pursued M. Tech. from Maharishi Markendeshwar University in the year 2012. He has been teaching UG Classes for well over 8 years.

**Dr. (Prof.) Dinesh Verma** is a Professor in the Department of Mathematics in the NIILM University, Kaithal Haryana, India. He has done Ph.D. at M.J.P. Rohilkhand University, Bareilly (U.P.) in 2004. He has been teaching UG Classes for well over two decades. He has to his credit six books for Engineering and Graduation level. He has to his credit 90 research Papers. He has membership with ISTE and ISCA.