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Mechanically Persistent Oscillator Supplied With Ramp Signal

Rohit Gupta[1*]

[1]Yogananda College of Engineering and Technology, Jammu Gurha Brahmana Patoli Akhnoor Road, Jammu (J&K), 181205, India

*Corresponding Author: Rohit Gupta

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ABSTRACT: This paper submits a new tactic known as the integral Rohit transform (RT) for uncovering the response of a mechanically persistent oscillator supplied with a ramp signal. It let outs that RT is an operative tool for uncovering the response of a mechanically persistent oscillator supplied with a ramp signal.

Keywords: RT, mechanically persistent oscillator, Ramp Signal

1. INTRODUCTION

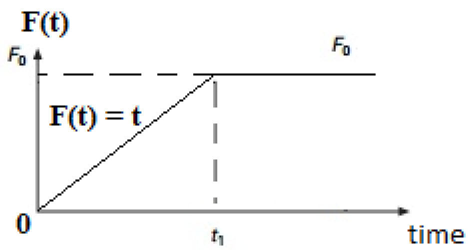

Figure: Ramp Function

The ramp signal (shown in the figure above) is explicated as:

$F(t) = t \; for \; 0 < t < t_1$

$= F_o \; for \; t \geq t_1.$

The author Rohit Gupta has proffered the integral RT in recent years [1, 2].

The RT is explicated as $R\{g(t)\} = G(q) = q^3 \int_0^\infty e^{-qt} g(t)dt$. Here t ≥ 0 and the integral is merging.

A unit step function [3] is explicated as $U(t-a) = 0 \; for \; t < a \; and \; 1 \; for \; t \geq a$.

The RT of a unit step function is stated as

$$R\{U(t-c)\} = q^3 \int_0^\infty e^{-qt} U(t-c)dt$$

$$R\{U(t-c)\} = q^3 \int_c^\infty e^{-qt} dt$$

$$R\{U(t-c)\} = q^2 e^{-qc}$$

*Corresponding author: guptarohit565@gmail.com

Shifting property of RT:
If $R\{g(t)\} = G(q),\ then\ R[g(t-c)U(t-c) = e^{-qc}G(q).$
Proof:

$$R[g(t-c)U(t-c) = q^3\int_0^\infty e^{-qt}\, g(t-c)U(t-c)dt$$

$$R[g(t-c)U(t-c) = q^3\int_c^\infty e^{-qt}\, g(t-c)dt$$

$$R[g(t-c)U(t-c) = q^3\int_0^\infty e^{-q(v+c)}\, g(v)dv, \quad where\ v = t-c$$

$$R[g(t-c)U(t-c) = e^{-q(c)}\, q^3\int_0^\infty e^{-q(v)}\, g(v)dv$$

$$R[g(t-c)U(t-c) = e^{-q(c)}\, q^3\int_0^\infty e^{-q(t)}\, g(t)dt$$

$$R[g(t-c)U(t-c) = e^{-q(c)}G(q)$$

The RT of some basic functions is stated as

- $R\{t^n\} = \frac{n!}{q^{n-2}}$, $where\ n\ is\ 0, 1, 2 \ldots$
- $R\{sinct\} = \frac{c\,q^3}{q^2+c^2}$,
- $R\{cosct\} = \frac{q^4}{q^2+c^2}$,

The RT of some derivatives is explicated as
$R\{g'(t)\} = qR\{g(t)\} - q^3g(0),$
$R\{g''(t)\} = q^2R\{g(t)\} - q^4g(0) - q^3g'(0)$, and so on.

2. METHODOLOHY

A mechanically persistent oscillator [4, 5] supplied with ramp signal is specified by the following equation:
$m\ddot{y}(t) + ky(t) = F(t)$

Or

$$\ddot{y}(t) + \omega_0{}^2y(t) = \frac{F(t)}{m} \quad \ldots.(1)$$

$where\ \omega_0 = \sqrt{\frac{k}{m}}$, $F(t)$ is a ramp signal, y (0) = 0 and $\dot{y}(0) = 0$.

The RT of (1) provides

$$q^2\bar{y}(q) - q^4y(0) - q^3\dot{y}(0) + \omega_0{}^2\bar{y}(q) = \frac{1}{m}q^3\int_0^\infty e^{-qt}\,F(t)\,dt$$

$$\Rightarrow q^2\bar{y}(q) - q^4y(0) - q^3\dot{y}(0) + \omega_0{}^2\bar{y}(q) = \frac{1}{m}q^3\int_0^{t_1} e^{-qt}\,t\,dt + \frac{F_o}{m}q^3\int_{t_1}^\infty e^{-qt}\,dt$$

Here $\bar{y}(q)$ denotes the RT of $y(t)$.
Put $y(0) = 0$ and $\dot{y}(0) = 0$ [3], we get

$$q^2\bar{y}(q) + \omega_0{}^2\bar{y}(q) = \frac{1}{m}q^3\int_0^{t_1} e^{-qt}\,t\,dt + \frac{F_o}{m}q^3\int_{t_1}^\infty e^{-qt}\,dt$$

$$\Rightarrow q^2\bar{y}(q) + \omega_0{}^2\bar{y}(q) = -\frac{1}{m}q^2[t_1e^{-qt_1}] + \frac{1}{m}q^2\int_0^{t_1} e^{-qt}\,dt - q^2\frac{F_o}{m}[e^{-qt_1}]\}$$

$$\Rightarrow q^2\bar{y}(q) + \omega_0{}^2\bar{y}(q) = -\frac{1}{m}q^2[t_1e^{-qt_1}] - \frac{1}{m}q[e^{-qt_1} - 1] - q^2\frac{F_o}{m}[e^{-qt_1}]\}$$

$$\Rightarrow q^2\bar{y}(q) + \omega_0{}^2\bar{y}(q) = -\frac{1}{m}\{q^2t_1e^{-qt_1} - qe^{-qt_1} + q - q^2F_oe^{-qt_1}\}$$

$$\Rightarrow q^2\bar{y}(q) + \omega_0{}^2\bar{y}(q) = \frac{1}{m}\{q^2F_oe^{-qt_1} + qe^{-qt_1} - q - q^2t_1e^{-qt_1}\}$$

$$\Rightarrow \bar{y}(q) = \frac{1}{m}\left\{\frac{q^2}{(q^2+\omega_0^{\,2})}F_o e^{-qt_1} + \frac{q}{(q^2+\omega_0^{\,2})}e^{-qt_1} - \frac{q}{(q^2+\omega_0^{\,2})} - \frac{q^2 t_1 e^{-qt_1}}{(q^2+\omega_0^{\,2})}\right\}$$

$$\Rightarrow \bar{y}(q) = \frac{1}{m}\left\{\frac{q^4}{q^2(q^2+\omega_0^{\,2})}F_o e^{-qt_1} + \frac{q^3}{q^2(q^2+\omega_0^{\,2})}e^{-qt_1} - \frac{q^3}{q^2(q^2+\omega_0^{\,2})} - \frac{q^4}{q^2(q^2+\omega_0^{\,2})}t_1 e^{-qt_1}\right\}$$

$$\Rightarrow \bar{y}(q) = \frac{1}{m}\left\{\frac{q^2}{(\omega_0^{\,2})}F_o e^{-qt_1} - \frac{q^4}{(\omega_0^{\,2})(q^2+\omega_0^{\,2})}F_o e^{-qt_1} + \frac{q}{(\omega_0^{\,2})}e^{-qt_1} - \frac{q^3}{(\omega_0^{\,2})(q^2+\omega_0^{\,2})}e^{-qt_1} - \frac{q}{(\omega_0^{\,2})} + \frac{q^3}{(\omega_0^{\,2})(q^2+\omega_0^{\,2})} - \frac{q^2}{(\omega_0^{\,2})}t_1 e^{-qt_1} + \frac{q^4}{(\omega_0^{\,2})(q^2+\omega_0^{\,2})}t_1 e^{-qt_1}\right\}$$

Applying inverse RT, we get

$$y(t) = \frac{1}{m}\left\{\frac{F_o}{(\omega_0^{\,2})}U(t-t_1) - \frac{F_o\cos\omega_0(t-t_1)}{(\omega_0^{\,2})}U(t-t_1) + \frac{(t-t_1)}{(\omega_0^{\,2})}U(t-t_1) - \frac{\sin\omega_0(t-t_1)}{\omega_0(\omega_0^{\,2})}U(t-t_1) - \frac{(t)}{(\omega_0^{\,2})} + \frac{\sin\omega_0(t)}{\omega_0(\omega_0^{\,2})} - \frac{t_1}{(\omega_0^{\,2})}U(t-t_1) + \frac{t_1\cos\omega_0(t-t_1)}{(\omega_0^{\,2})}U(t-t_1)\right\}$$

$$\Rightarrow y(t) = \frac{1}{m(\omega_0^{\,2})}\left\{F_o U(t-t_1) - F_o\cos\omega_0(t-t_1)\,U(t-t_1) + (t-t_1)U(t-t_1) - \frac{\sin\omega_0(t-t_1)}{\omega_0}U(t-t_1) - t + \frac{\sin\omega_0(t)}{\omega_0} - t_1 U(t-t_1) + t_1\cos\omega_0(t-t_1)\,U(t-t_1)\right\}$$

$$\Rightarrow y(t) = \frac{1}{k}\left\{F_o U(t-t_1) - F_o\cos\omega_0(t-t_1)\,U(t-t_1) + (t-t_1)U(t-t_1) - \frac{\sin\omega_0(t-t_1)}{\omega_0}U(t-t_1) - t + \frac{\sin\omega_0(t)}{\omega_0} - t_1 U(t-t_1) + t_1\cos\omega_0(t-t_1)\,U(t-t_1)\right\}$$

For t < t_1,

$$y(t) = \frac{1}{k}\left[-t + \frac{\sin\omega_0 t}{\omega_0}\right]$$

Or

$$y(t) = \frac{1}{k}\left[\frac{\sin\omega_0 t}{\omega_0} - t\right]$$

For t > t_1,

$$y(t) = \frac{1}{k}\left\{F_o - F_o\cos\omega_0(t-t_1) - \frac{\sin\omega_0(t-t_1)}{\omega_0} + \frac{\sin\omega_0(t)}{\omega_0} - 2t_1 + t_1\cos\omega_0(t-t_1)\right\}$$

Or

$$y(t) = \frac{1}{k}\left\{ F_o[1 - \cos\omega_0(t - t_1)] - \frac{1}{\omega_0}[\sin\omega_0(t - t_1) - \sin\omega_0(t)] - t_1[2 - t_1\cos\omega_0(t - t_1)]\right\}$$

3. CONCLUSION

This paper has typified the RT for uncovering the response of a mechanically persistent oscillator supplied with a ramp signal. A new tactic has been fruitfully drawn on for uncovering the response of a *mechanically* persistent oscillator supplied with a ramp signal.

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CONFLICTS OF INTEREST

The author declares no conflict of interest

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