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IMPORTANCE OF POWER SERIES BY DINESH VERMA TRANSFORM (DVT)

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ABSTRACT

In Mathematics, a power series in one variable is an infinite series. In this paper, we will find the Dinesh Verma Transform (DVT) of some power series. The purpose of paper is to prove the applicability of Dinesh Verma Transform (DVT) to some infinite power series.

Keywords: Dinesh Verma Transform (DVT), Power series.

1. INTRODUCTION

Dinesh Verma Transform (DVT) is a mathematical tool used to obtain the solutions of differential equations without finding their general solutions [1-3], [8-18].It has applications in nearly all engineering disciplines [19-25]. It also comes out to be very effective tool to find the Dinesh Verma Transform (DVT) of some power series solutions [26-36]. In this paper, We present Dinesh Verma Transform (DVT) approach to find the Dinesh Verma Transform (DVT) of some power series.

2. BASIC DEFINITIONS

2.1 DEFINITION OF DINESH VERMA TRANSFORM (DVT)

Dr. Dinesh Verma introduced a novel transform and named it as **Dinesh Verma transform (DVT).** Let f(t) is a well-defined function of real numbers t ≥ 0. The **Dinesh Verma transform (DVT)** of f(t), denoted by $D\{f(t)\}$, is defined as

$$D\{f(t)\} = p^5 \int_0^\infty e^{-pt} f(t)\,dt = \bar{f}(p)$$

Provided that the integral is convergent, where p may be a real or complex parameter and D is the **Dinesh Verma transform (DVT)** operator.

DINESH VERMA TRANSFORM OF ELEMENTARY FUNCTIONS

According to the definition of **Dinesh Verma transform (DVT)**,

$D\{f(t)\} = p^5 \int_0^\infty e^{-pt} f(t)dt$, then

1. $D\{1\} = p^5 \int_0^\infty e^{-pt}\,dt$

$$= -p^4(e^{-\infty} - e^{-0})$$

$$= -p^4(0-1)$$

$$= p^4$$

Hence $D\{1\} = p^4$

2. $D\{t^n\} = p^5 \int_0^\infty e^{-pt} t^n\,dt$

$$= p^5 \int_0^\infty e^{-z} \left(\frac{z}{p}\right)^n \frac{dz}{p}, z = pt$$

$$= \frac{p^5}{p^{n+1}} \int_0^\infty e^{-z} (z)^n dz$$

Applying the definition of gamma function,

$$D\{y^n\} = \frac{p^5}{p^{n+1}} \Gamma(n+1)$$

$$= \frac{1}{p^{n-4}} n!$$

$$= \frac{n!}{p^{n-4}}$$

Hence,

$$D\{t^n\} = \frac{n!}{p^{n-4}}$$

- $D\{t^n\} = \frac{n!}{p^{n-4}}$, where $n = 0,1,2,..$
- $D\{e^{at}\} = \frac{p^5}{p-a}$,
- $D\{sinat\} = \frac{ap^5}{p^2+a^2}$,
- $D\{cosat\} = \frac{p^6}{p^2+a^2}$,
- $D\{sinhat\} = \frac{ap^5}{p^2-a^2}$,
- $D\{coshat\} = \frac{p^6}{p^2-a^2}$.
- $D\{\delta(t)\} = p^4$

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- The Inverse **Dinesh Verma Transform (DVT)** of some of the functions are given by
- $D^{-1}\{\frac{1}{p^{n-4}}\} = \frac{t^n}{n!}$, where $n = 0,1,2,..$
- $D^{-1}\{\frac{p^5}{p-a}\} = e^{at}$,
- $D^{-1}\{\frac{p^5}{p^2+a^2}\} = \frac{sinat}{a}$,
- $D^{-1}\{\frac{p^6}{p^2+a^2}\} = cosat$,
- $D^{-1}\left\{\frac{p^5}{p^2-a^2}\right\} = \frac{sinhat}{a}$,
- $D^{-1}\left\{\frac{p^6}{p^2-a^2}\right\} = coshat$,
- $D^{-1}\{p^4\} = \delta(t)$

2.3 Power series [4 - 7]:

$$\sum_{n=0}^{\infty} b_n z^n = b_0 + b_1 z + b_2 z^2 + \cdots b_n z^n$$

2.4 Maclaurin series [4, 5, 6,]:

$$y = \sum_{n=0}^{\infty} \frac{y^{(n)}}{n!} z^n = y_0 + \frac{y_0{'}}{1!} z + \frac{y_0{''}}{2!} z^2 + \frac{y_0{'''}}{2!} z^3 \dots \dots \dots$$

3. METHODOLOGY

3.1 Dinesh Verma Transform (DVT) of Geometric Series later than the expanding to power series appearance [4 - 7]:

$$\frac{1}{1-z} = \sum_{n=0}^{\infty} z^n = f(z)$$

$$D\{f(z)\} = D\left\{\sum_{n=0}^{\infty} z^n\right\}$$

$$= p^5 \int_0^\infty e^{-pz} \sum_{n=0}^{\infty} z^n \, dz$$

$$= \sum_{n=0}^{\infty} p^5 \int_0^\infty e^{-pz} z^n \, dz$$

$$= \sum_{n=0}^{\infty} D\{z^n\}$$

$$= \sum_{n=0}^{\infty} \frac{n!}{p^{n-4}}$$

Hence,

$$\mathbf{D\{f(z)\}} = \sum_{n=0}^{\infty} \frac{\mathbf{n!}}{\mathbf{p^{n-4}}}$$

3.2 Dinesh Verma Transform (DVT) of the Power series expansion of e^z later than the expanding to power series appearance [4 - 7]:

$$e^z = \sum_{n=0}^{\infty} \frac{z^n}{n!} = f(z)$$

$$D\{f(z)\} = D\left\{\sum_{n=0}^{\infty} \frac{z^n}{n!}\right\}$$

$$= p^5 \int_0^\infty e^{-pz} \left\{\sum_{n=0}^{\infty} \frac{z^n}{n!}\right\} dz$$

$$= \sum_{n=0}^{\infty} p^5 \int_0^\infty e^{-pz} \frac{z^n}{n!} dz$$

$$= \sum_{n=0}^{\infty} \frac{1}{n!} \left[p^5 \int_0^\infty e^{-pz} z^n \, dz\right]$$

$$= \sum_{n=0}^{\infty} \frac{1}{n!} D\{z^n\} = \sum_{n=0}^{\infty} \frac{1}{n!} \cdot \frac{n!}{p^{n-4}}$$

Hence, $\mathbf{A\{f(z)\}} = \sum_{n=0}^{\infty} \frac{\mathbf{1}}{\mathbf{p^{n-4}}}$

3.3 Dinesh Verma Transform (DVT) of the Power series expansion of $\log(1+z)$ later than the expanding to power series appearance [4 - 7]:

$$\log(1+z) = \sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n} z^n = f(z)$$

$$D\{f(z)\} = D\left\{\sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n} z^n\right\}$$

$$= p^5 \int_0^\infty e^{-pz} \left\{\sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n} z^n\right\} dz$$

$$= \sum_{n=1}^{\infty} p^5 \int_0^\infty e^{-pz} \frac{(-1)^{n+1}}{n} z^n \, dz$$

$$= \sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n} \left[p^5 \int_0^\infty e^{-pz} z^n \, dz\right]$$

$$= \sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n} D\{z^n\}$$

$$= \sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n} \frac{n!}{p^{n-4}}$$

$$= \sum_{n=1}^{\infty} (-1)^{n+1} \frac{(n-1)!}{p^{n-4}}$$

Hence ,

$$\mathbf{A\{f(z)\}} = \sum_{n=1}^{\infty} (-\mathbf{1})^{n+1} \frac{(\mathbf{n}-\mathbf{1})!}{\mathbf{p^{n-4}}}$$

3.4 Dinesh Verma Transform (DVT) of the Power series expansion of $\log(1+z)$ later than the expanding to power series appearance [4 - 7]:

$$\log(1+z) = \sum_{n=1}^{\infty} \frac{(-1)^{2n-1}}{n} z^n = f(z)$$

$$D\{f(z)\} = D\left\{\sum_{n=1}^{\infty} \frac{(-1)^{2n-1}}{n} z^n\right\}$$

$$= p^5 \int_0^\infty e^{-pz} \left\{\sum_{n=1}^{\infty} \frac{(-1)^{2n-1}}{n} z^n\right\} dz$$

$$= \sum_{n=1}^{\infty} p^5 \int_0^\infty e^{-pz} \frac{(-1)^{2n-1}}{n} z^n \, dz$$

$$= \sum_{n=1}^{\infty} \frac{(-1)^{2n-1}}{n} p^5 \int_0^\infty e^{-pz} z^n \, dz$$

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$$= \sum_{n=1}^{\infty} \frac{(-1)^{2n-1}}{n} D\{z^n\}$$

$$= \sum_{n=1}^{\infty} \frac{(-1)^{2n-1}}{n} \frac{n!}{p^{n-4}}$$

$$= \sum_{n=1}^{\infty} (-1)^{2n-1} \frac{(n-1)!}{p^{n-4}}$$

Hence ,

$$\mathbf{D\{f(z)\}} = \sum_{n=1}^{\infty} (-1)^{2n-1} \frac{(n-1)!}{p^{n-4}}$$

3.5 Dinesh Verma Transform (DVT) of the Power series expansion of $\log\frac{(1+z)}{(1-z)}$ later than the expanding to power series appearance [4 - 7]:

$$\log\frac{(1+z)}{(1-z)} = \sum_{n=1}^{\infty} \frac{2}{2n-1} z^{2n-1} = f(z)$$

$$D\{f(z)\} = D\left\{\sum_{n=1}^{\infty} \frac{2}{2n-1} z^{2n-1}\right\}$$

$$= p^5 \int_0^{\infty} e^{-pz} \left\{\sum_{n=1}^{\infty} \frac{2}{2n-1} z^{2n-1}\right\} dz$$

$$= \sum_{n=1}^{\infty} p^5 \int_0^{\infty} e^{-pz} \frac{2}{2n-1} z^{2n-1} dz$$

$$= \sum_{n=1}^{\infty} \frac{2}{2n-1} \left[p^5 \int_0^{\infty} e^{-pz} z^{2n-1} dz\right]$$

$$= \sum_{n=1}^{\infty} \frac{2}{2n-1} D\{z^{2n-1}\}$$

$$= \sum_{n=1}^{\infty} \frac{2}{2n-1} \frac{(2n-1)!}{p^{2n-1-4}}$$

$$= \sum_{n=1}^{\infty} \frac{2(2n-2)!}{p^{2n-5}}$$

Hence,

$$\mathbf{D\{f(z)\}} = \sum_{n=1}^{\infty} \frac{4(n-1)!}{p^{2n-5}}$$

3.6 Dinesh Verma Transform (DVT) of the Power series expansion of Cosx later than the expanding to power series appearance [4 - 7]:

$$\cos x = \sum_{n=0}^{\infty} \frac{(-1)^n}{2n!} z^{2n} = f(z)$$

$$D\{f(z)\} = D\left\{\sum_{n=0}^{\infty} \frac{(-1)^n}{2n!} z^{2n}\right\}$$

$$= p^5 \int_0^{\infty} e^{-pz} \left\{\sum_{n=0}^{\infty} \frac{(-1)^n}{2n!} z^{2n}\right\} dz$$

$$= \sum_{n=0}^{\infty} p^5 \int_0^{\infty} e^{-pz} \frac{(-1)^n}{2n!} z^{2n} dz$$

$$= \sum_{n=0}^{\infty} \frac{(-1)^n}{2n!} \left[p^5 \int_0^{\infty} e^{-pz} z^{2n} dz\right]$$

let $2n = u$

$$= \sum_{n=0}^{\infty} \frac{(-1)^n}{2n!} D\{z^u\}$$

$$= \sum_{n=0}^{\infty} \frac{(-1)^n}{2n!} \frac{u!}{p^{u-4}}$$

$$= \sum_{n=0}^{\infty} \frac{(-1)^n}{2n!} \frac{2n!}{p^{2n-4}}$$

Hence, $\mathbf{D\{f(t)\}} = \frac{(-1)^n}{p^{2n-4}}$

3.7 Dinesh Verma Transform (DVT) of the Power series expansion of Sinx later than the expanding to power series appearance[4 - 7]:

$$\text{Sinx} = \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)!} z^{2n+1} = f(z)$$

$$D\{f(z)\} = D\left\{\sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)!} z^{2n+1}\right\}$$

$$= p^5 \int_0^{\infty} e^{-pz} \left\{\sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)!} z^{2n+1}\right\} dz$$

$$= \sum_{n=0}^{\infty} p^5 \int_0^{\infty} e^{-pz} \frac{(-1)^n}{(2n+1)!} z^{2n+1} dz$$

$$= \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)!} \left[p^5 \int_0^{\infty} e^{-pz} z^{2n+1} dz\right]$$

$$= \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)!} D\{z^{2n+1}\}$$

$$= \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)!} \frac{(2n+1)!}{p^{2n+1-4}}$$

Hence, $\mathbf{D\{f(t)\}} = \sum_{n=0}^{\infty} \frac{(-1)^n}{p^{2n-3}}$

3.8 Dinesh Verma Transform (DVT) of the Power series expansion of Coshx later than the expanding to power series appearance[4 - 7]:

$$\text{Coshx} = \sum_{n=0}^{\infty} \frac{1}{2n!} z^{2n} = f(z)$$

$$D\{f(z)\} = D\left\{\sum_{n=0}^{\infty} \frac{1}{2n!} z^{2n}\right\}$$

$$= p^5 \int_0^{\infty} e^{-pz} \left\{\sum_{n=0}^{\infty} \frac{1}{2n!} z^{2n}\right\} dz$$

$$= \sum_{n=0}^{\infty} p^5 \int_0^{\infty} e^{-pz} \frac{1}{2n!} z^{2n} dz$$

$$= \sum_{n=0}^{\infty} \frac{1}{2n!} \left[p^5 \int_0^{\infty} e^{-pz} z^{2n} dz\right]$$

let $2n = u$

$$= \sum_{n=0}^{\infty} \frac{1}{2n!} D\{z^u\}$$

$$= \sum_{n=0}^{\infty} \frac{1}{2n!} \frac{u!}{p^{u-4}}$$

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$$= \sum_{n=0}^{\infty} \frac{1}{2n!} \frac{2n!}{p^{2n-4}}$$

Hence, $D\{f(t)\} = \sum_{n=0}^{\infty} \frac{1}{p^{2n-4}}$

3.9 Dinesh Verma Transform (DVT) of the Power series expansion of Sinx later than the expanding to power series appearance [4 - 7]:

$$\text{Sinhx} = \sum_{n=0}^{\infty} \frac{1}{(2n+1)!} z^{2n+1} = f(z)$$

$$D\{f(z)\} = D\left\{\sum_{n=0}^{\infty} \frac{1}{(2n+1)!} z^{2n+1}\right\}$$

$$= p^5 \int_0^{\infty} e^{-pz} \left\{\sum_{n=0}^{\infty} \frac{1}{(2n+1)!} z^{2n+1}\right\} dz$$

$$= \sum_{n=0}^{\infty} p^5 \int_0^{\infty} e^{-pz} \frac{1}{(2n+1)!} z^{2n+1} dz$$

$$= \sum_{n=0}^{\infty} \frac{1}{(2n+1)!} p^5 \int_0^{\infty} e^{-pz} z^{2n+1} dz$$

$$D\{f(z)\} = \sum_{n=0}^{\infty} \frac{1}{(2n+1)!} D\{z^{2n+1}\}$$

$$= \sum_{n=0}^{\infty} \frac{1}{(2n+1)!} \frac{(2n+1)!}{p^{2n-3}}$$

Hence, $D\{f(t)\} = \sum_{n=0}^{\infty} \frac{1}{p^{2n-3}}$

3.10 If f(z) is a power series expansion at thepoint b, where b is any constant, b ∈ R, Its Taylor'sseries expansion

$$f(z) = \sum_{n=0}^{\infty} b_n (z-b)^n$$

[4 - 7]:

Then, The **Dinesh Verma Transform (DVT)** of f(z) is given in the form of power series as

$$D\{f(z)\} = D\left[\sum_{n=0}^{\infty} b_n (z-b)^n\right]$$

$$= p^5 \int_0^{\infty} e^{-pz} \left\{\sum_{n=0}^{\infty} b_n (z-b)^n\right\} dz$$

$$= p^5 \sum_{n=0}^{\infty} b_n \int_0^{\infty} e^{-pz} \{(z-b)^n\} dz$$

$$= p^5 \sum_{n=0}^{\infty} b_n \int_0^{\infty} e^{-p(b+u)} \{(u)^n\} dz$$

$$= p^5 \sum_{n=0}^{\infty} b_n e^{-pb} \int_0^{\infty} e^{-up} \{(u)^n\} dz$$

$$= \sum_{n=0}^{\infty} b_n e^{-pb} \left[p^5 \int_0^{\infty} e^{-up} \{(u)^n\} dz\right]$$

$$= \sum_{n=0}^{\infty} b_n e^{-pb} D(u)^n$$

$$D\left[\sum_{n=0}^{\infty} b_n (z-b)^n\right] = \sum_{n=0}^{\infty} b_n e^{-pb} \frac{n!}{p^{n-4}}$$

3.11 If f(z) is a power series expansion at the point 0, where 0, Its Power series expansion is [5, 6, 7,]:

$$f(z) = \sum_{n=0}^{\infty} b_n (z)^n$$

Then, The **Dinesh Verma Transform (DVT)** of f(z) is given in the form of power series as

$$D\{f(z)\} = D\left[\sum_{n=0}^{\infty} b_n (z)^n\right]$$

$$= p^5 \int_0^{\infty} e^{-pz} \left\{\sum_{n=0}^{\infty} b_n (z)^n\right\} dz$$

$$= p^5 \sum_{n=0}^{\infty} b_n \int_0^{\infty} e^{-pz} \{(z)^n\} dz$$

$$= \sum_{n=0}^{\infty} b_n p^5 \int_0^{\infty} e^{-pz} \{(z)^n\} dz$$

$$= \sum_{n=0}^{\infty} b_n D(z)^n$$

$$A\left[\sum_{n=0}^{\infty} b_n (z)^n\right] = \sum_{n=0}^{\infty} b_n \frac{n!}{p^{n-4}}$$

3.12 Dinesh Verma Transform (DVT) of the Power series expansion of e^{t^2} later than the expanding to power series appearance [5, 6, 7,]:

$$f(z) = e^{t^2} = \sum_{n=0}^{\infty} \frac{z^{2n}}{n!}$$

$$A[f(z)] = p^5 \int_0^{\infty} e^{-pz} \left\{\sum_{n=0}^{\infty} \frac{z^{2n}}{n!}\right\} dz$$

$$= p^5 \sum_{n=0}^{\infty} \frac{1}{n!} \int_0^{\infty} e^{-pz} \{(z)^{2n}\} dz$$

$$= \sum_{n=0}^{\infty} \frac{1}{n!} \left[p^5 \int_0^{\infty} e^{-pz} \{(z)^{2n}\} dz\right]$$

$$= \sum_{n=0}^{\infty} \frac{1}{n!} D(z)^{2n}$$

$$D\left[\sum_{n=0}^{\infty} \frac{z^{2n}}{n!}\right] = \sum_{n=0}^{\infty} \frac{1}{n!} \frac{2n!}{p^{2n-4}}$$

3.13 Dinesh Verma Transform (DVT) of Convergence Series [4, 5, 6,]:

$$1 + \frac{c+z}{1!} + \frac{(c+2z)^2}{2!} + \frac{(c+3z)^3}{3!} + \cdots$$

$$= \sum_{n=0}^{\infty} \frac{(c+nz)^n}{n!} = f(z)$$

So, $D\{f(z)\} = D\left\{\sum_{n=0}^{\infty} \frac{(c+nz)^n}{n!}\right\}$

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$$p^5 \int_0^\infty e^{-pz} \left\{ \sum_{n=0}^\infty \frac{(c+nz)^n}{n!} \right\} dz \quad ,$$

let $c + nz = t$

$$= \sum_{n=0}^\infty p^5 \int_0^\infty e^{-pz} \frac{(c+nz)^n}{n!} dz$$

$$= \sum_{n=0}^\infty p^5 \int_0^\infty e^{-p\left(\frac{t-c}{n}\right)} \frac{t^n}{n!} \frac{dt}{n}$$

$$= \sum_{n=0}^\infty p^5 e^{\frac{pc}{n}} \int_0^\infty e^{-p\left(\frac{t}{n}\right)} \frac{t^n}{n!} \frac{dt}{n} \quad , \quad \text{let } \frac{t}{n} = u$$

$$= \sum_{n=0}^\infty p^5 e^{\frac{pc}{n}} \int_0^\infty e^{-pu} \frac{n^n u^n}{n!} \frac{ndu}{n}$$

$$= \sum_{n=0}^\infty e^{\frac{pc}{n}} \frac{n^n}{n!} p^5 \int_0^\infty e^{-pu} u^n du$$

$$= \sum_{n=0}^\infty e^{\frac{pc}{n}} \frac{n^n}{n!} D(u^n)$$

Hence,

$$A\left\{ \sum_{n=0}^\infty \frac{(c+nz)^n}{n!} \right\} = \sum_{n=0}^\infty e^{\frac{pc}{n}} \frac{n^n}{p^{n-4}}$$

CONCLUSION:

In this paper, we have found the Dinesh Verma Transformation of some power series and it comes out to be very foremost tool to find the Dinesh Verma Transform (DVT) of power series.

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