Applications of Calculus in Electronics & Cammunication Engineering

- What is calculus in Engineering?

Calculus is concerned with two basic operations, differention and integration, and is a tool used by engineers to determine such quantities as rates of change and areas; In fact, calculus is the mathematical 'backbone' for dealing with problems where variables change with time or some other reference variable and a basic understanding of calculus is essential for further study and the development of confidence in solving practical engineering problems.

- Applications of Differential calculus in EC Engineering

In Electronics and Electrical Engineering, we've done lot of simplification by a lot of assumptions to make things less complicated as it tends to be and is possible for us to handle without the use very complicated formulas that is commonly used in UG Physics courses.

⇒ Lumped elements are called as such because they obey the lumped matter discipline. Resistors, wires, capacitors and more are some instances of lumped elements, that we are constantly dealing with lumped elements.

Suppose that we have a capacitor, a resistor and an inductor that are connected in series. Then, we are required to solve the differential equation in terms of charge or even current.

The equations are :

* Capacitor $Q = CV \iff dQ/dt = C \frac{dv}{dt}$
* Linear resistor $V = iR \iff V = R\, dq/dt$
* continuity $\nabla \cdot J = -\partial \rho / \partial t$
* Faraday's $\nabla \times E = -\partial B / \partial t$
* RLC circuits

(The voltage drop across an inductor

$$U_L(t) = L\, d/dx\, I(T)$$

* Robotic movements - By voltage (Differentiator circuit)
* Kirchhoff's voltage Law : $E(t) = L(dI/dt) + IR$
* Maxwell's Equation :

$\Rightarrow \nabla \cdot D = \rho_v$ $\Rightarrow \nabla \cdot B = 0$

$\Rightarrow \nabla \times E = -\frac{\partial B}{\partial t}$ $\Rightarrow \nabla \times H = \partial D/\partial t + J$

* more ...

- Applications of Integral calculus in EC Engineering

*. Integrals are widely used to describe transient processes in electric circuits.

Example: Relationship Between charge and current $\Rightarrow Q = \int_{t_1}^{t_2} I(t)\, dt$

* RC circuit

$$RI(t) + \frac{1}{C}\int_0^t I(s)\,ds = \mathcal{E}$$

* Power and energy

$$E = \int_0^t V(s)\, I(s)\, ds$$

* Energy stored in capacitor

$$E_C = \int_0^Q dW = \int_0^Q \frac{q}{C}\,dq = \frac{Q^2}{2C} = \frac{CV^2}{2}$$

* Faraday's

$$\oint E \cdot dl = \partial \Phi_B / \partial t$$

* LMD

$$\int_{ca} E \cdot dl + \int_{ab} E \cdot dl + \int_{bc} E \cdot dl = 0$$

* Kirchhoff's Voltage rule (KVL)

$$\oint_S J \cdot ds = -\partial q / \partial t$$

* Op Amps

- $v_c(t) = \frac{1}{C}\int_0^t i_c(\tau)\,d\tau$
- $i_L(t) = \frac{1}{L}\int_0^t v_L(\tau)\,d\tau$

* Wireless communication and Signal Processing

It happens that many of the transforms traditionally used in signal processing have natural analogs under the Euler integral, Popularized by Baryshnikov and Ghrist. The properties of these transforms are sensitive to topological (as well as certain geometric) features in the sensor field and allow signal processing to be performed on structured, integer valued data, such as might be gathered from ad hoc networks of inexpensive sensors.

Example:

The analog of the fourier transform computes a measure of width for support for indicator functions. There are some of which are present in traditional transform theory (such as the presence of sidelobes), and some which new (such as the non linearity of the transform when extended to real-valued data). These challenges and some mitigation strategies will be presented as well as a showcase of the transforms and their capabilities.

- Fourier Transform

$$\tilde{\dot{F}}\left[\frac{d}{dt}x(t)\right] \triangleq \int_{t=-\infty}^{t=+\infty} \underbrace{\left[\frac{d}{dt}(x)(t)\right]}_{dv} \underbrace{e^{-i\omega t}}_{u}\, dt$$

$$= e^{-i\omega t}x(t)\Big|_{t=-\infty}^{t=+\infty} - \int_{t=-\infty}^{t=+\infty} x(t)(-i\omega)e^{-i\omega t}\, dt$$

$$= e^{-i\omega\infty}x(\infty) - e^{-i\omega\infty}x(-\infty) - (-i\omega)\int_{t=-\infty}^{t=+\infty} x(t)e^{-i\omega t}\, dt$$

$$= i\omega X(\omega)$$ (Can be done by Digital Integration)

~ THANKYOU ~