LECTURE 5

MathCAD

With over a million users worldwide, Mathcad is today's standard for technical calculation. In science, engineering, design and economics; in industry, research and education; wherever figures need to be computed, you'll find Mathcad. That's because Mathcad is the complete, integrated environment for performing, documenting and communicating technical calculations. It gives you the tools you need sample data and build models, to document and communicate your analysis. Mathcad is ideal for formulating ideas, exploring problems, evolving solutions and sharing results. Within a Mathcad work-sheet you can perform 'live' numeric or symbolic calculations, add graphics and animations, annotate and format text. When you need to change a variable, Mathcad updates your results, formulae and graphs - instantly. You get instant feedback as you try different approaches, so you can experiment with what-if scenarios, establish limits, test results and make accurate decisions.

Sinusoidal steady-state analysis is greatly facilitated if the currents and voltages are represented as vectors in the complex-number plane known as phasors. Let's us consider phasor in complex plane. First we need to write a complex number. Then, form its presentation as a phasor in MathCAD and draw it using MathCAD plot interface, beside we will draw wave diagram of the steady-state process. Here is an example:

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1. Rectangular form - real part x and imaginary part y = x + jy

z := 2 + j \cdot 5

2. Exponential form z = r \exp(\theta)

|z| = 5.385 \le \text{Magnitude}

\frac{\arg(z)}{\deg} = 68.199 \le \text{Angle (argument)}

\overline{z} = 2 - 5i \le \text{Complex conjugate}
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It is suitable to use Mathcad to get all presentation of complex numbers altogether (all at once - magnitude and phase, imaginary and real pats of complex number)

 $Z(z) := \begin{vmatrix} r \leftarrow |z| \\ \theta \leftarrow \frac{\arg(z)}{\deg} \\ x \leftarrow \operatorname{Re}(z) \\ y \leftarrow \operatorname{Im}(z) \\ c \leftarrow \begin{pmatrix} r & \theta \\ x & y \end{pmatrix} \end{vmatrix}$

The same program can be used for addition, subtraction, division and multiplication of complex numbers

$$Z(2 + i \cdot 3) = \begin{pmatrix} 3.606 & 56.31 \\ 2 & 3 \end{pmatrix}$$

$$z1 := 2 + i \cdot 3 \quad z2 := 5 - i \cdot 4 \quad z3 := -1 + i \cdot 2 \quad Z(z1 + z2 + z3) = \begin{pmatrix} 6.083 & 9.462 \\ 6 & 1 \end{pmatrix}$$

$$Z(z1 - z2) = \begin{pmatrix} 7.616 & 113.199 \\ -3 & 7 \end{pmatrix} \quad Z(z1 \cdot z2) = \begin{pmatrix} 23.087 & 17.65 \\ 22 & 7 \end{pmatrix} \quad Z\begin{pmatrix} z1 \\ z2 \end{pmatrix} = \begin{pmatrix} 0.563 & 94.97 \\ -0.049 & 0.561 \end{pmatrix}$$

Complex plane representation of Phasor -vector

 $a := 0.3 \le$ reduce or enlarge arrow's wings

 $\underline{z} := 1. + i \cdot 1.$





First step can be obtained by selecting Tools/Animation/Record (see picture)

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$$\begin{split} & \underset{x,y}{\text{NL}} := 101 \quad i := 0.. \text{ N } \quad x_{1} := \frac{2}{N} \cdot i - 1 \\ & \underset{x,y}{\text{Z}}(x,y) := x + i \cdot y \quad x_{0} := \frac{1}{N} \cdot (k + 20) \quad j_{y} := i \quad w(x,y) := \ln\left(\frac{1}{z(x,y)}\right) \end{split}$$

Potential function of complex variables

$$\underset{\textbf{W}, j}{\textbf{W}} \coloneqq w \Big(x_i + x_0, x_j \Big) - w \Big(x_i - x_0, x_j \Big)$$



MathCAD is a convenient program for solving transient processes in electric power engineering. A transient process is performed by ordinary differential equations. Let us consider example of using MathCAD for solving differential equation in state-space form



Given

$$\begin{split} i_{L}:L + U_{C} + i_{L}:R = E \\ i_{L} = C \cdot U_{C} \\ A(i_{1}, U_{C}, E) &:= Find(i_{1}, U_{C}) \rightarrow \begin{bmatrix} \frac{-(U_{C} + i_{L}:R - E)}{L} \\ \frac{i_{L}}{C} \end{bmatrix} \\ A(1, 0, 0) \rightarrow \begin{pmatrix} -\frac{R}{L} \\ \frac{1}{L} \end{pmatrix} \quad A(0, 1, 0) \rightarrow \begin{pmatrix} -\frac{1}{L} \\ 0 \end{pmatrix} \quad A(0, 0, E) \rightarrow \begin{pmatrix} E \\ L \\ 0 \end{pmatrix} \quad A := augment(A(1, 0, 0), A(0, 1, 0)) \\ A \rightarrow \begin{pmatrix} -\frac{R}{L} & -\frac{1}{L} \\ \frac{1}{L} & 0 \end{pmatrix} \\ Form State - space Matrix \\ B_{2}:= 1C \quad S_{2}:= 150 \cdot 10^{-6} \quad J_{n}:= 0.05 \\ A_{n}:= \begin{pmatrix} -\frac{R}{L} & -\frac{1}{L} \\ \frac{1}{L} & 0 \end{pmatrix} \quad p := eigenvals(A) \quad g_{2}:= |Im(p_{0})| \quad J_{n}:= \frac{2\pi}{0} \\ t := 0, 0.01 \text{ T. T. } 1C \quad N_{2}:= 50C \quad E(t) := sin(100t) + 0.4 sin(1000t) \\ B(t):= \begin{pmatrix} \frac{E(t)}{L} \\ 0 \end{pmatrix} \quad D(t, x) := A \cdot x + B(t) \\ i := 0 \quad N \quad J_{N}:= (0) \text{ T. } x_{2} := 10 \text{ T. } x_{2}:= rkfixe(x_{0}, x_{1}, x_{2}, N, D) \\ D = to reas extraction to explain the space is the differential equation to the space is the differential equation to the space is the space$$

Returns a matrix of solution values for the differential equation specified by the derivatives in D and having initial conditions x_0 on the interval $[x_1,x_2]$ using a fixed step Runge-Kutta method. Parameter N controls the number of rows in the matrix output.

$$t := x^{(0)} \begin{pmatrix} u_{l_{1}} \\ i_{c_{1}} \end{pmatrix} := \begin{pmatrix} 1 & 0 \\ 0 & c \end{pmatrix} :D \left[\begin{pmatrix} x^{(0)} \\ x^{(0)} \end{pmatrix} : \left[\begin{pmatrix} x^{(0)} \\ x^{(0)} \end{pmatrix} \right] \\ \hline \begin{pmatrix} x^{(0)} \\ x^{(0)} \end{bmatrix} \end{bmatrix}$$

Generator

F

R

R

