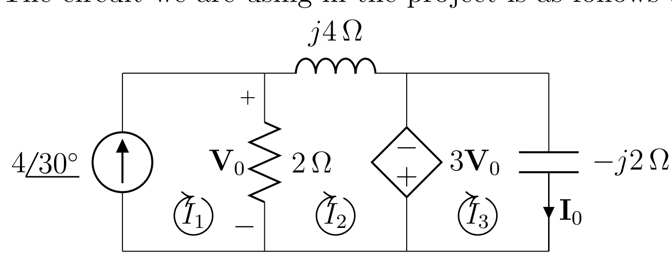
Chapter 2

PART - I : Circuit Analysis

2.1 Mesh Analysis

The circuit we are using in the project is as follows :



Let us assume the currents in the three mesh as I_1, I_2 and I_3 as shown in the figure.

By using the Kirchhoff's Voltage Rule. [1, 4],
we have the mesh equations as follows :

$$I_1 = 4\angle 30^\circ \tag{2.1}$$
$$(I_1 - I_2)(2) = V_\circ \tag{2.2}$$
$$(I_2 - I_1)(2) + I_2(j4) - 3V_\circ = 0 \tag{2.3}$$
$$I_3 = I_\circ \tag{2.4}$$
$$3V_\circ + I_3(-j2) = 0 \tag{2.5}$$

2.1.1 Mesh Equations

Now by rearranging the mesh equations, we have

$$I_1 = 4\angle 30^\circ \tag{2.6}$$
$$I_1(2) - I_2(2) - V_\circ = 0 \tag{2.7}$$
$$-I_1(2) + I_2(2 + j4) - 3V_\circ = 0 \tag{2.8}$$
$$I_3 - I_\circ = 0 \tag{2.9}$$
$$3V_\circ - I_3(j2) = 0 \tag{2.10}$$

2.1.2 Matrix Representation

The matrix representation . [5] of rearranged mesh equations is as follows :

$$\begin{bmatrix} 0 & 0 & 1 & 0 & 0 \\ -1 & 0 & 2 & -2 & 0 \\ -3 & 0 & -2 & (2+j4) & 0 \\ 0 & -1 & 0 & 0 & 1 \\ 3 & 0 & 0 & 0 & -j2 \end{bmatrix} \times \begin{bmatrix} V_\circ \\ I_\circ \\ I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 4\angle 30^\circ \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \tag{2.11}$$

2.1.3 Condition Number of Matrix

THe condition number of the matrix in the above equation, matrix is :

$$A = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 \\ -1 & 0 & 2 & -2 & 0 \\ -3 & 0 & -2 & (2+j4) & 0 \\ 0 & -1 & 0 & 0 & 1 \\ 3 & 0 & 0 & 0 & -j2 \end{bmatrix} \tag{2.12}$$

Now finding the Euclidean norm . [6] of the Matrix A

$$\|A\| = \sqrt{\sum_n Re(a_{ij}^2)}$$

By solving to find norm,

$$\|A\| = \sqrt{1^2 + 3^2 + 3^2 + (-1)^2 + 1^2 + 2^2 + (-2)^2 + (-2)^2 + 2^2 + 1^2}$$
$$\|A\| = 6.2422$$

Now sovling the inverse of the matrix A

$$A^{-1} = \begin{bmatrix} 0.4 + j0.8 & -0.4 - j0.3 & -0.2 + j0.1 & 0 & 0 \\ 1.2 - j0.6 & -0.45 + j0.6 & 0.15 + j0.3 & -1 & j0.5 \\ 1 & 0 & 0 & 0 & 0 \\ 0.8 - j0.4 & -0.3 + j0.15 & 00.1 - j0.05 & 0 & 0 \\ 1.2 - j0.6 & -0.45 + j0.6 & 0.15 + j0.3 & 0 & j0.5 \end{bmatrix} \tag{2.13}$$

By solving to find Euclidean norm of the Matrix A^{-1},

$\|A^{-1}\| = \sqrt{(0.4)^2 + (1.2)^2 + (0.8)^2 + (1.2)^2 + (0.4)^2 + (0.45)^2}$

contd. $\overline{+(0.3)^2 + (0.45)^2 + (0.2)^2 + (0.15)^2 + (0.1)^2 + 1^2}$

$$\|A^{-1}\| = 2.8906$$

The condition number of a matrix A is given as

$$Cond(A) = \|A\| \times \|A^{-1}\|$$

$$Cond(A) = 6.2422 \times 2.8906 \quad = \quad 18.0439$$

2.2 Solving Mesh Equations Using LAPACK

We used the LAPACK library subroutines to solve the system of linear equation, which we represented in the matrix form. The subroutine *CGESV* solves the system of linear equations of the form $A \times X = B$. This subroutine used the LU decomposition.

2.2.1 Programming in C++

Ihe input to the program is given as the data in the text file. The progam reads the data through the text file through looping and assigns it to various variables.
The various arguments for the *CGESV* sub routine are identified and initialized. Then the subroutine *CGESV* is called and the output is displayed using iostream subroutines.

The detailed C++ program can be found in the APPENDIX (Part1.cpp).

2.2.2 Outputs from C++ Program

The output we have obtained after solving the system of linear equations using LAPACK subroutine in C++ are

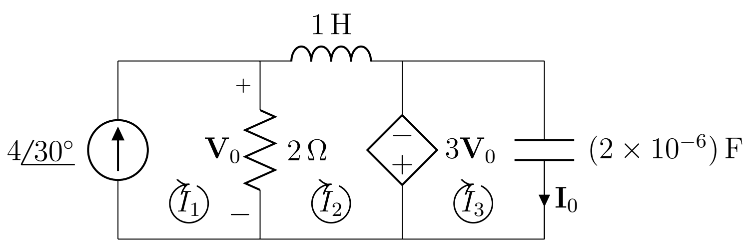
$$V_\circ = -0.2160 + 3.5680i5$$
$$I_\circ = 5.3520 + 0.3240i$$
$$I_1 = 13.4600 + 2.0000i$$
$$I_2 = 3.5680 + 0.2160i$$
$$I_3 = 5.3520 + 0.3240i$$

Chapter 3

PART - II : Circuit Analysis

3.1 Mesh Analysis

The circuit analysis is done for the below circuit. Where the inductor value is taken as 1 H and the capacitance value is taken as the 2×10^{-6} F.



Let us assume the currents in the three mesh as I_1, I_2 and I_3 as shown in the figure.

Computing the values of impedance of inductor. [7] and capacitor. [8] are as follows :

$$X_L = j\omega L = j\omega \quad \text{as} \quad L = 1H \tag{3.1}$$
$$X_C = 1/j\omega C = 1/j\omega(2 \times 10^{-6}) \quad \text{as} \quad C = 2 \times 10^{-6}F \tag{3.2}$$

By using the Kirchhoff's Voltage Rule. [1], we have the mesh equations as follows :

$$I_1 = 4\underline{/30^\circ} \tag{3.3}$$
$$(I_1 - I_2)(2) = V_\circ \tag{3.4}$$
$$(I_2 - I_1)(2) + I_2(j\omega) - 3V_\circ = 0 \tag{3.5}$$
$$I_3 = I_\circ \tag{3.6}$$
$$3V_\circ + I_3(\frac{1}{j\omega(2 \times 10^{-6})}) = 0 \tag{3.7}$$

3.1.1 Mesh Equations

Now by rearranging the mesh equations, we have

$$I_1 = 4\underline{/30^\circ} \tag{3.8}$$
$$I_1(2) - I_2(2) - V_\circ = 0 \tag{3.9}$$
$$-I_1(2) + I_2(2 + j\omega) - 3V_\circ = 0 \tag{3.10}$$
$$I_3 - I_\circ = 0 \tag{3.11}$$
$$3V_\circ - I_3(j\frac{1}{\omega(2 \times 10^{-6})}) = 0 \tag{3.12}$$

3.1.2 Matrix Representation

The matrix representation of rearranged mesh equations is as follows :

$$\begin{bmatrix} 0 & 0 & 1 & 0 & 0 \\ -1 & 0 & 2 & -2 & 0 \\ -3 & 0 & -2 & (2 + j\omega) & 0 \\ 0 & -1 & 0 & 0 & 1 \\ 3 & 0 & 0 & 0 & \frac{-j}{\omega(2\times 10^{-6})} \end{bmatrix} \times \begin{bmatrix} V_\circ \\ I_\circ \\ I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 4\underline{/30^\circ} \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \tag{3.13}$$

3.2 Solving Mesh Equations Using LAPACK

We used the LAPACK library subroutines to solve the system of linear equation, which we represented in the matrix form. The subroutine *CGESV* solves the system of linear equations of the form $A \times X = B$. This subroutine used the LU decomposition.

3.2.1 Programming in C++

The value of frequency and the output file name are given as the command line inputs.
The various arguments for the *CGESV* sub routine are identified and initialized. Then the subroutine *CGESV* is called and the output is displayed using iostream subroutines.

The detailed C++ program can be found in the Appendix ("Part2.cpp").