**Assignment 3:** [**Small**](https://usn.instructure.com/courses/22857/assignments/51599) **Signal Stability**

## [Q1]

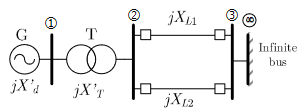


Figure 1: Single Line Diagram of SMIB

## We have;

f = 50 Hz

X’d = 0.20 pu

XT = 0.20 pu

XL1 = 0.15 pu

XL2 = 0.15 pu

p.f = 0.8 lagging

H = 8.45 MJoule/MVA

Pelec = 0.6 p.u

= 1.0 p.u

**Task 1:**

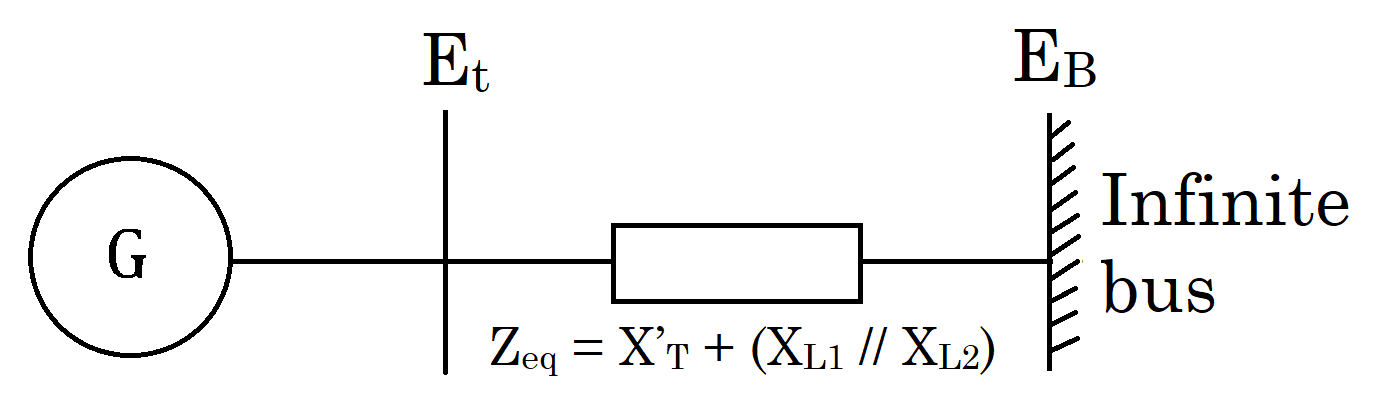


Figure 2: Thevenin Equivalent Circuit

Considering synchronous generator G represented by the classical model

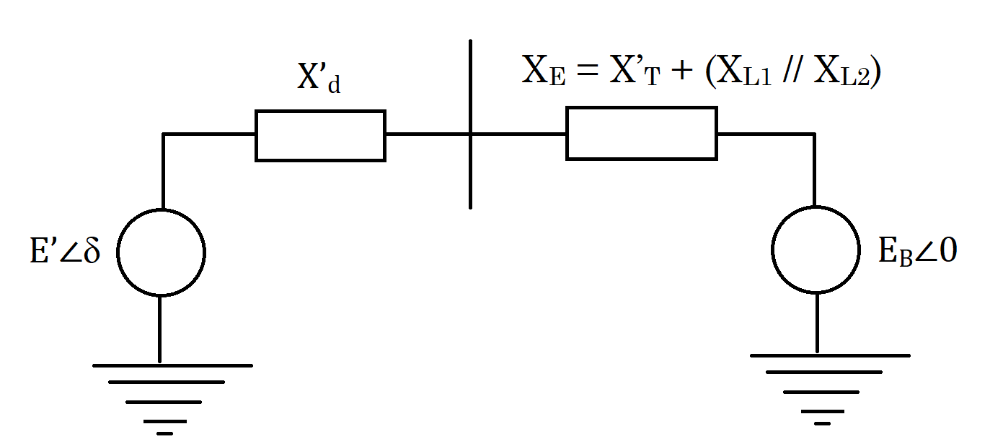


Figure 3: Equivalent Circuit

In the Figure 3, EB is the voltage of the infinite bus and E’ is the voltage of generator, and δ is the angle by which E’ leads EB.

Taking E’ as a reference, we can write,

Also,

And, total reactance is,

Apparent power of the generator is,

Terminal power is same as active power when the resistance of the stator is neglected,

Linearinzing it we get,

From the equation of the motion,

Where,

Linearizing the equation of motion and replacing value of we get,

Where, is synchronizing torque coefficient and is given by,

Linearizing equation,

Which results in,

**Task 2:**

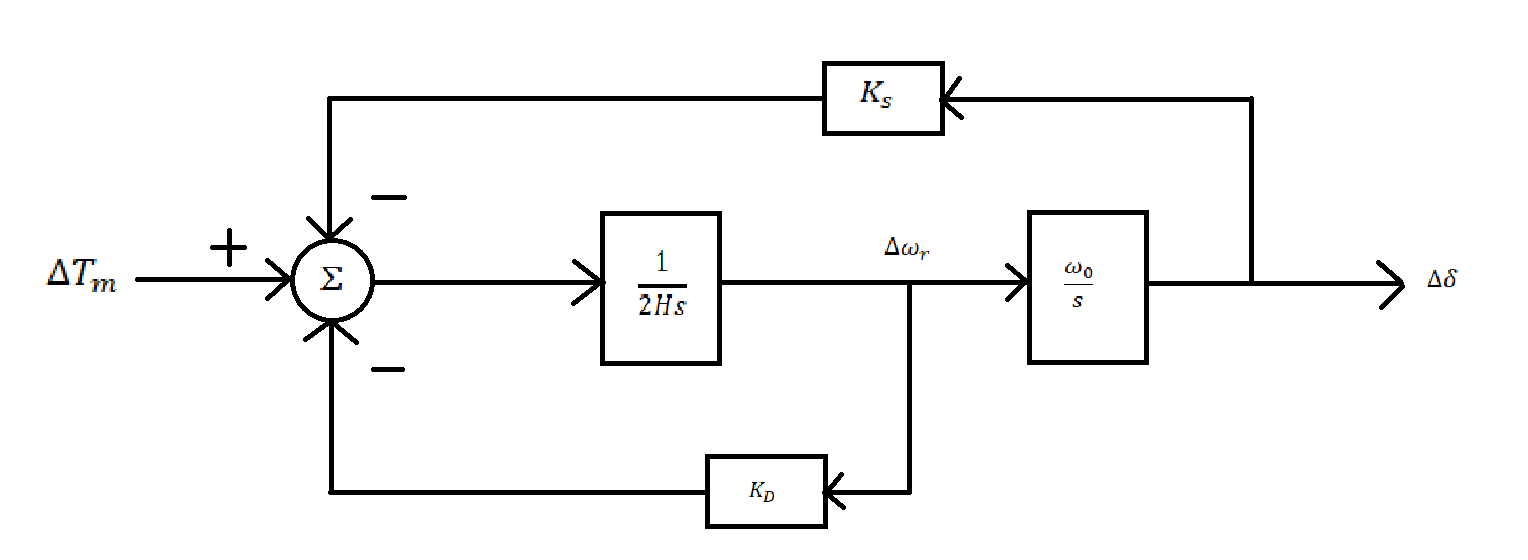


Figure 4: Block Diagram showing the performance of small signal

We have,

And from Figure 4,

We have the characteristic equation,

Where, = Undamped natural frequency in is given by,

And = damping ratio is given by,

Eigenvalues of matrix A is,

**Task 3:**

Given,

We know apparent power as,

And current and reactance are,

We know,

For

i.e

Comparing above equation with

We get,

So, the eigen values are,

Similarly,

For

the eigen values are,

For

The eigenvalues are,

For

The eigenvalues are,

For

The eigenvalues are,

Table 1: Eigen values of different rotational inertia

|  |  |  |
| --- | --- | --- |
| **H [Mjoule/MVA]** | **λ1** | **λ2** |
| 0.845 | j17.693 | - j17.693 |
| 2.1125 | j11.19 | - j11.19 |
| 4.225 | j7.913 | - j7.913 |
| 6.3375 | j6.46 | - j6.46 |
| 8.45 | j5.595 | - j5.595 |

Figure 5. Eigenvalues vs Rotational inertia

**Task 4:**

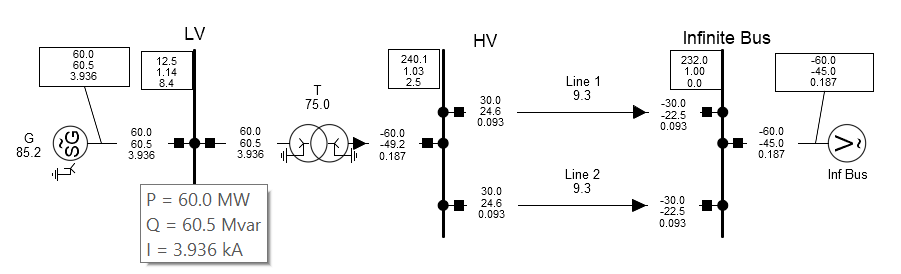


Figure 6: Powerfactory Model of SMIB

**Task 5:**

**(i)**

Table 2: Results from PowerFactory

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Real part (1/s) | Imaginary part (rad/s) | Damped Frequency (Hz) | Damping Ratio |
| Mode 00001 | -0.017751504 | 6.892037899 | 1.0969019 | 0.002575645 |
| Mode 00002 | -0.017751504 | -6.892037899 | 1.0969019 | 0.002575645 |

**(ii)**

From simulation of SMIB in DigSILENT PowerFactory, the A matrix is,

And A matrix from Task 2 calculation is:

There is a different in the A matrix from simulation and calculation because the damping torque coeffiecient is considered zero in Task 3 calculations.

**(iii)**

Table 3: Results comparision PowerFactory and calculations

|  |  |  |
| --- | --- | --- |
| **Eigenvalues** | **Real Part** | **Imaginary Part** |
| **λ1 from calculation** | 0 | 5.595 |
| **λ2 from calculation** | 0 | **-** 5.595 |
| **λ1 from simulation** | -0.018 | 6.892 |
| **λ2 from simulation** | -0.018 | -6.892 |

There is a different in the eigenvalues from simulation and calculation because in the calculations done in Task 3, the real part of the eigenvalues are zero but in the simulations it is not hence the matrix is different in both the cases.

**References**

[1] Prabha Kundra, “Power System Stability and Control”, McGraw-Hill, Inc. 1994

[2] Prof FGL, “Assignment 3: Small signal stability”, 2021