TAMPERE UNIVERSITY
DEE-24106 Electric Power System

FREQUENCY CONTROL
Assignment - 3 Report

Name	ID
Md Nurunnabi Emon	281732
Sayad Mohammad Mahadi Hassan	281750

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1. Frequency control of single generator

Answere-1.1.1:

The components of the figures are different because in lecture slide 57 figure 8.6, we have turbine, turbine control, and generator-load with change of frequency. In Frequency control assignment figure 1.2, we have turbine, turbine control, and feedback frequency from the generator.

The main difference between the diagrams is that, the transfer function describing the generator – load is missing from the PSCAD because the generator and load are represented by generator and load models from the PSCAD library.

Answer-1.1.2:

From lecture slide 57,

F1 models Turbine control

$$\frac{K_{sg}}{1+T_{sg}s}$$

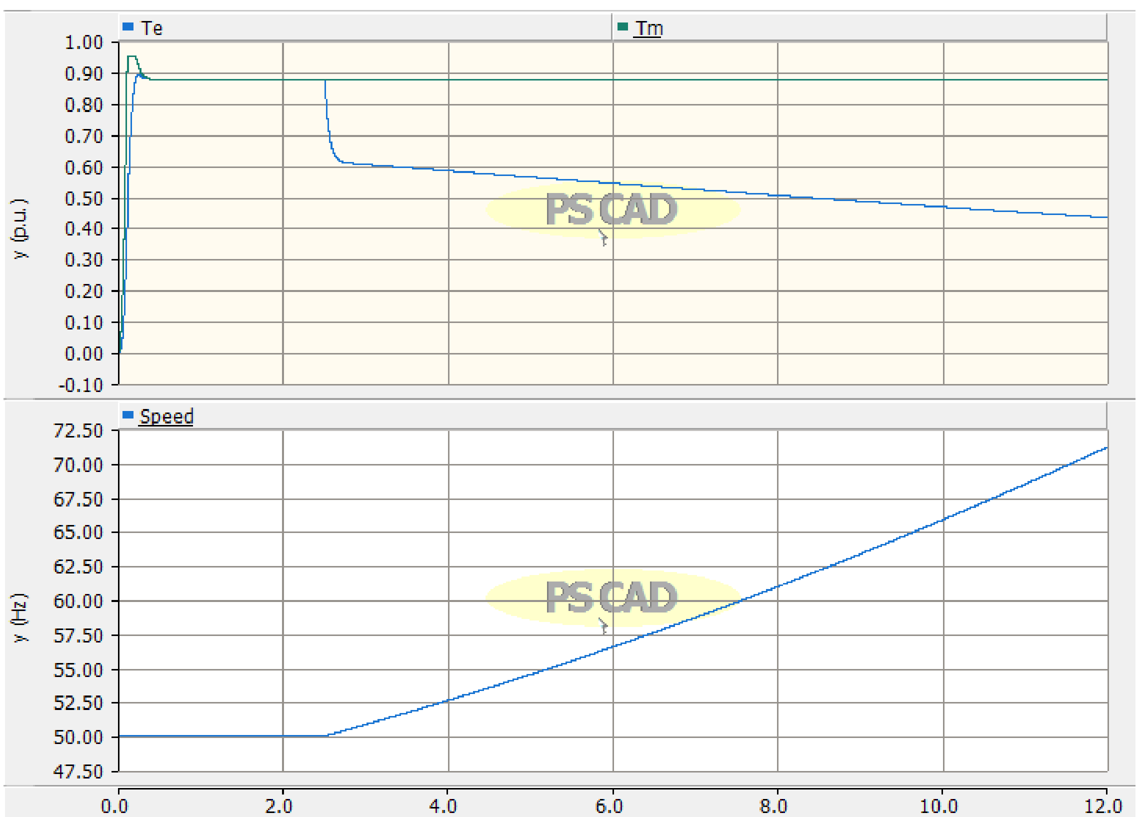
F2 models Turbine

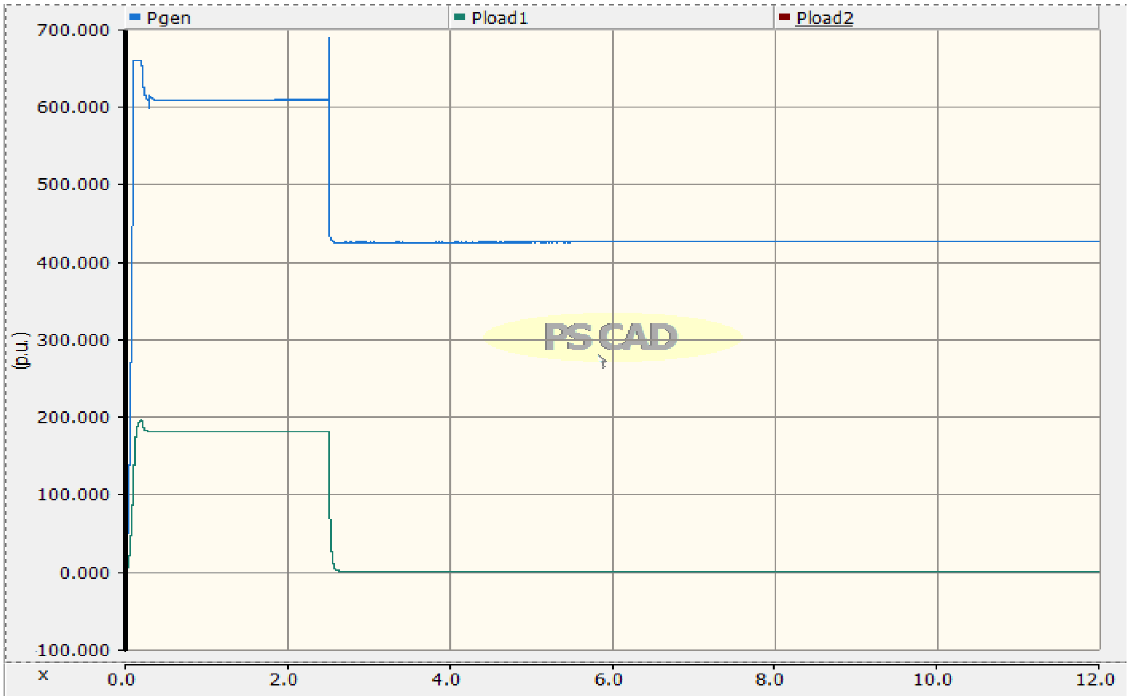
$$\frac{K_t}{1+T_t s}$$

Speed Droop = factor 0.01

Answer-1.2:

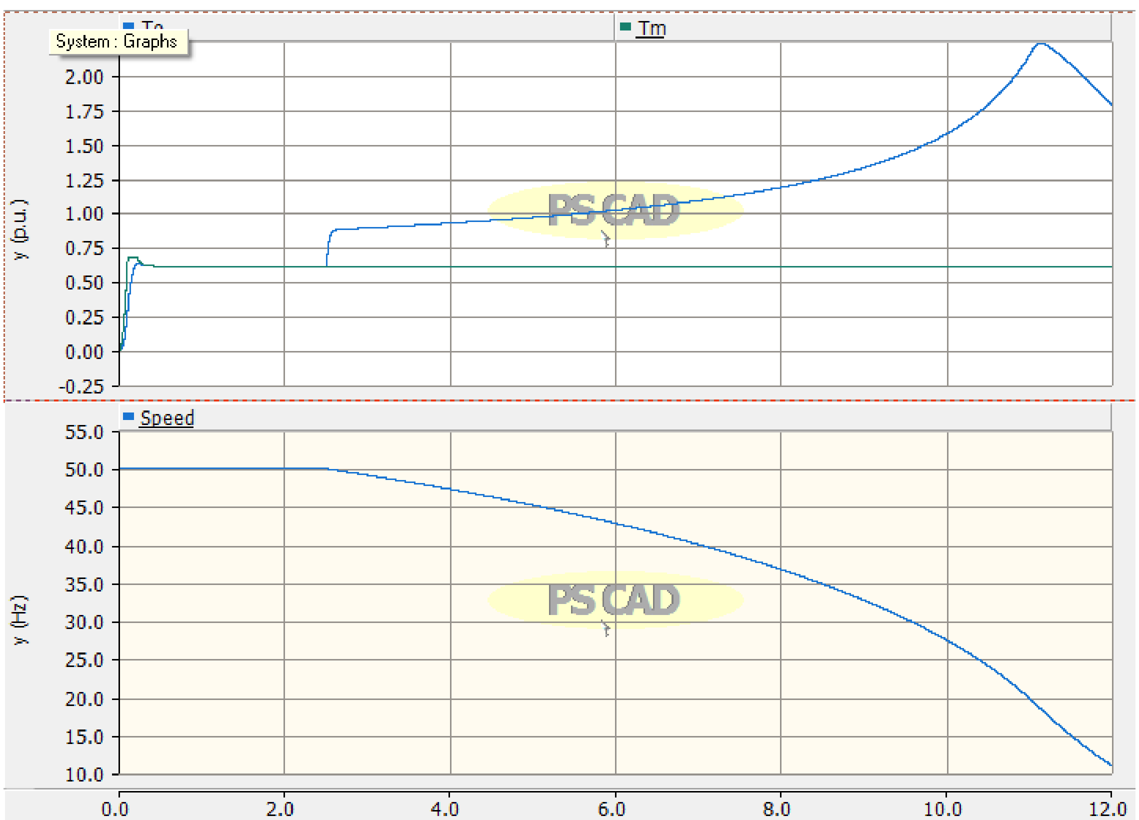
If the frequency were below 45 Hz or above 55 Hz, it will threaten the system security and cause oscillation or even damage the system. The turbine will be damaged if it being run at speed which significantly differs from the nominal speed.

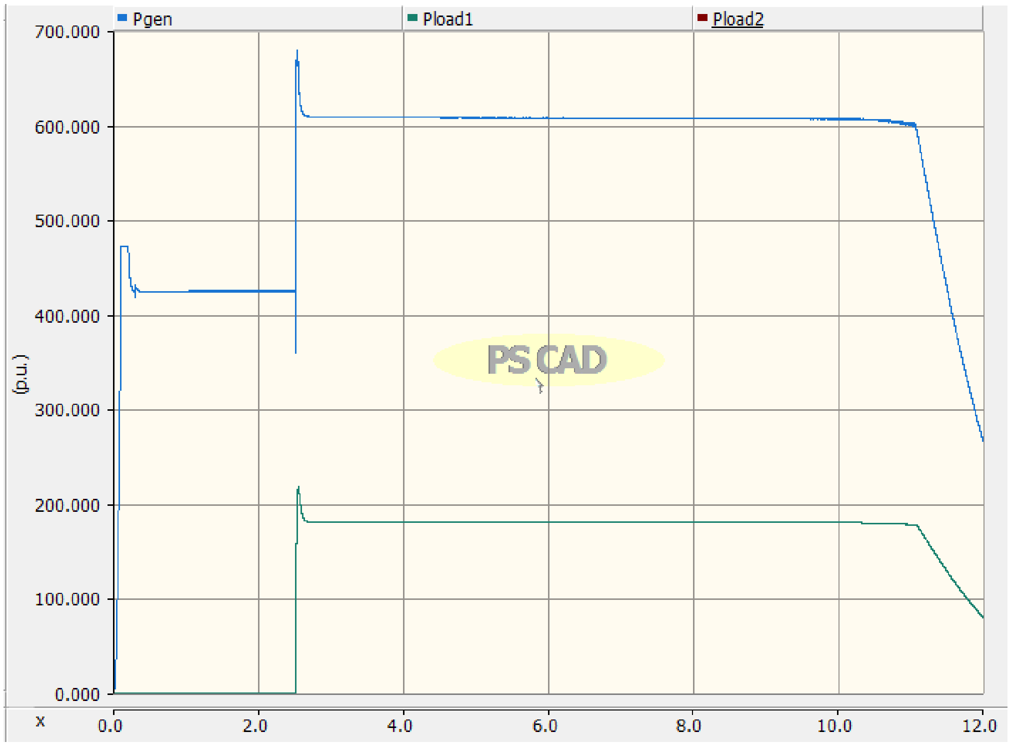




After 2.5s of system operation the load-1 180 MW disconnected, frequency starts to increase. Hence, rotor speed starts to decelerate. Generator is in under loaded condition and frequency will increase beyond the normal operating limit. The system is unstable and protection relay should operate to avoid system collapse so the system will not able to feed the load 2.

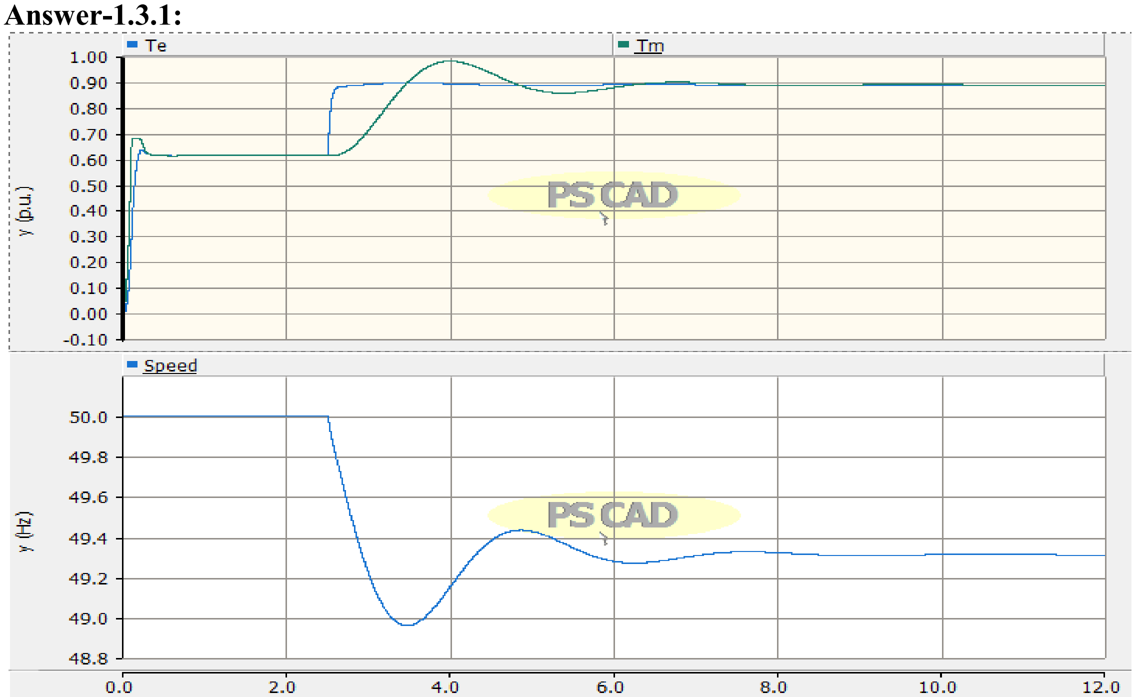
<u>After change the settings of circuit breaker:</u>





The generator tries to increase the frequency due to increase of load. Load change causes change in electrical torque of generators. The unbalance between the torques is the acceleration and deceleration of the generator. At first due to increase in load, frequency will start to decrease. So rotor accelerates to keep the frequency in nominal value. At some point rotor will reach its maximum limit and rotor starts to decelerate, ultimately failure of the system.

Answer-1.3.1:



The steady state frequency of the generator is about = 49.31 Hz

Answer-1.3.2:

Calculate the system frequency change by using total load change and speed droop:

$$\Delta P_t = \Delta P_G = 0.89 - 0.611 = 0.28\ p.u.$$

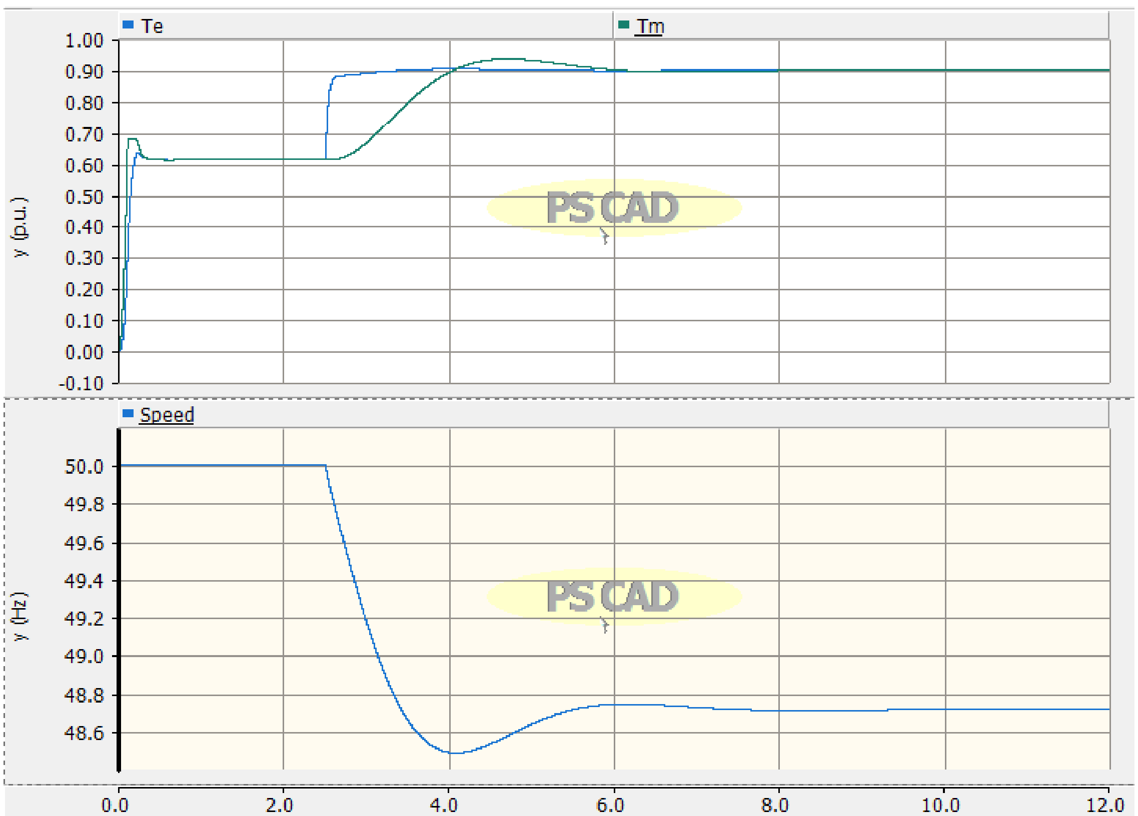
So,

$$\mathrm{R} = -\frac{\Delta \mathrm{f}}{\Delta \mathrm{P}} \quad \Longrightarrow \quad \Delta \mathrm{f} = -0.05 \times 0.28 = -0.014\ \mathrm{p.u.} = -0.70\mathrm{Hz}$$

$$\mathrm{f} = 50 - 0.70 = 49.3\ \mathrm{Hz}$$

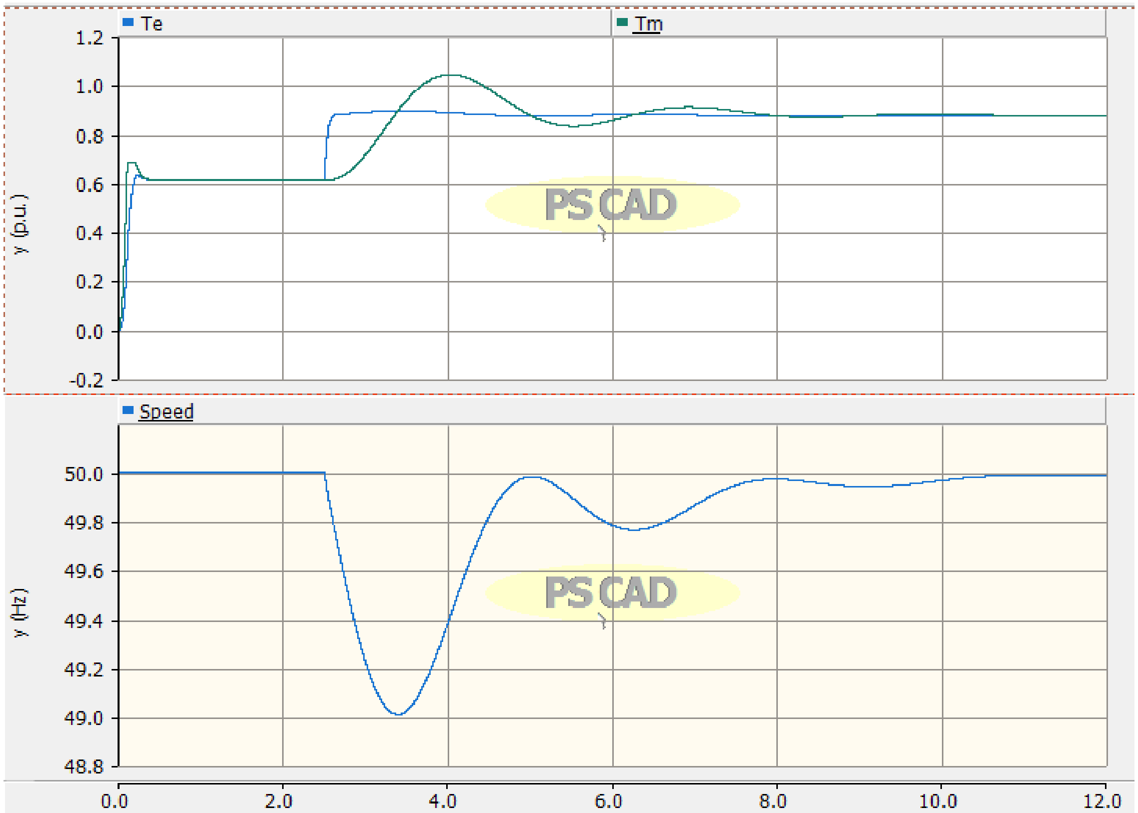
Thus, the simulated and the calculated frequency change are approximately equal.

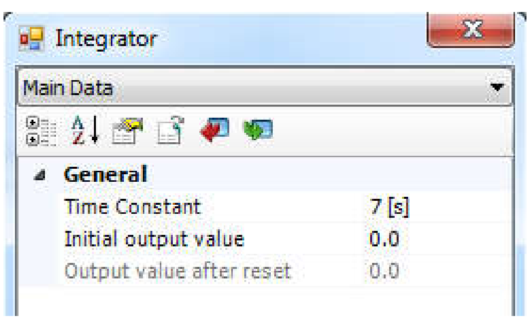
Answer-1.3.3:



According to the simulation figures, the load change is same. The system frequency will be higher when speed droop becomes higher. In our case with 9% speed droop, change is system frequency is higher than that of with 5% speed droop. The higher the values of the speed droop, the lower the response of the generator to changes in load demand.

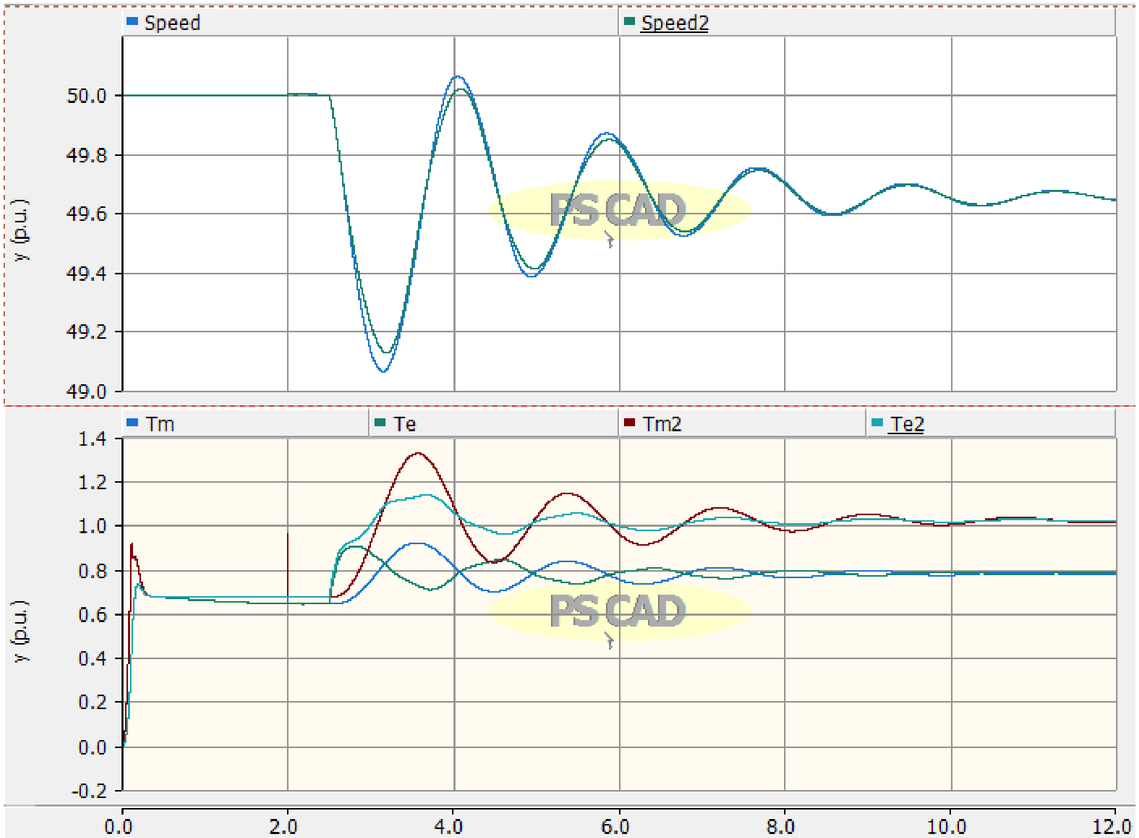
Answer-1.4.1:


Te
Tm
y (p.u.)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
PS CAD
Speed
y (Hz)
50.0
49.8
49.6
49.4
49.2
49.0
48.8
0.0
2.0
4.0
6.0
8.0
10.0
12.0


Integrator
Main Data
General
Time Constant
7 [s]
Initial output value
0.0
Output value after reset
0.0

2. Frequency control of parallel generators

Answer-2.1.1:

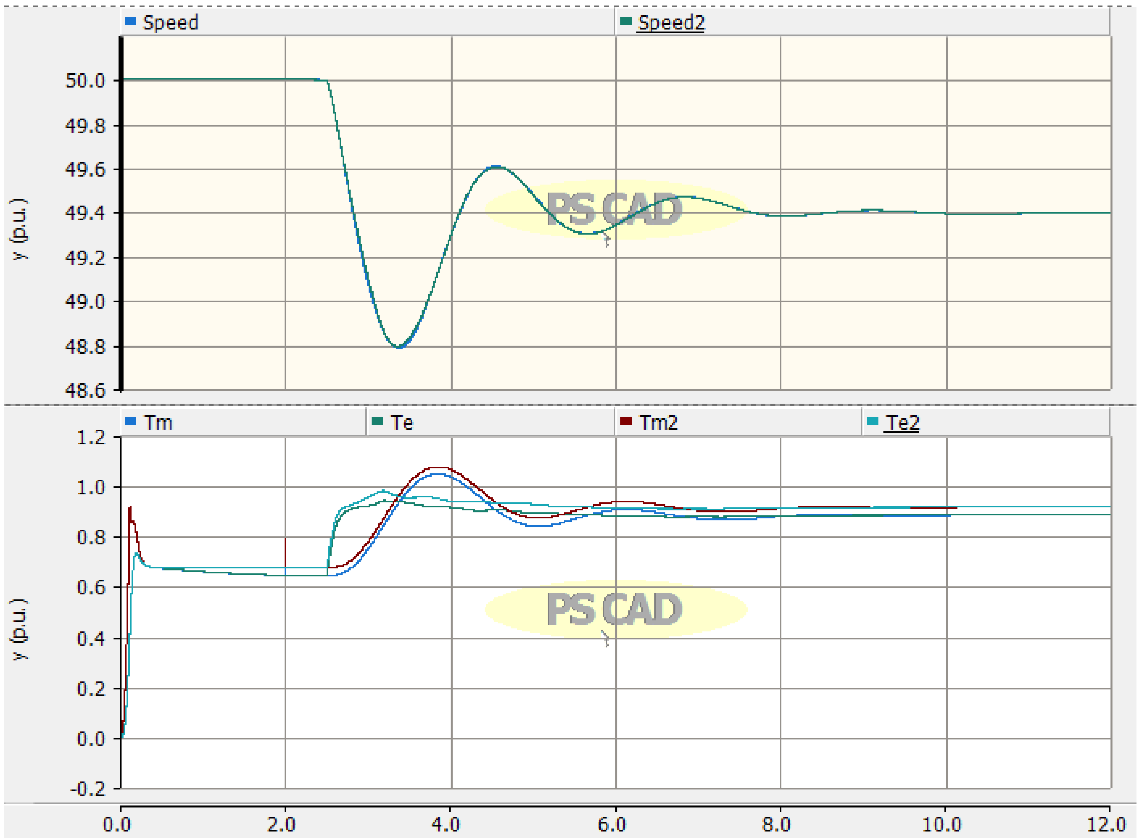


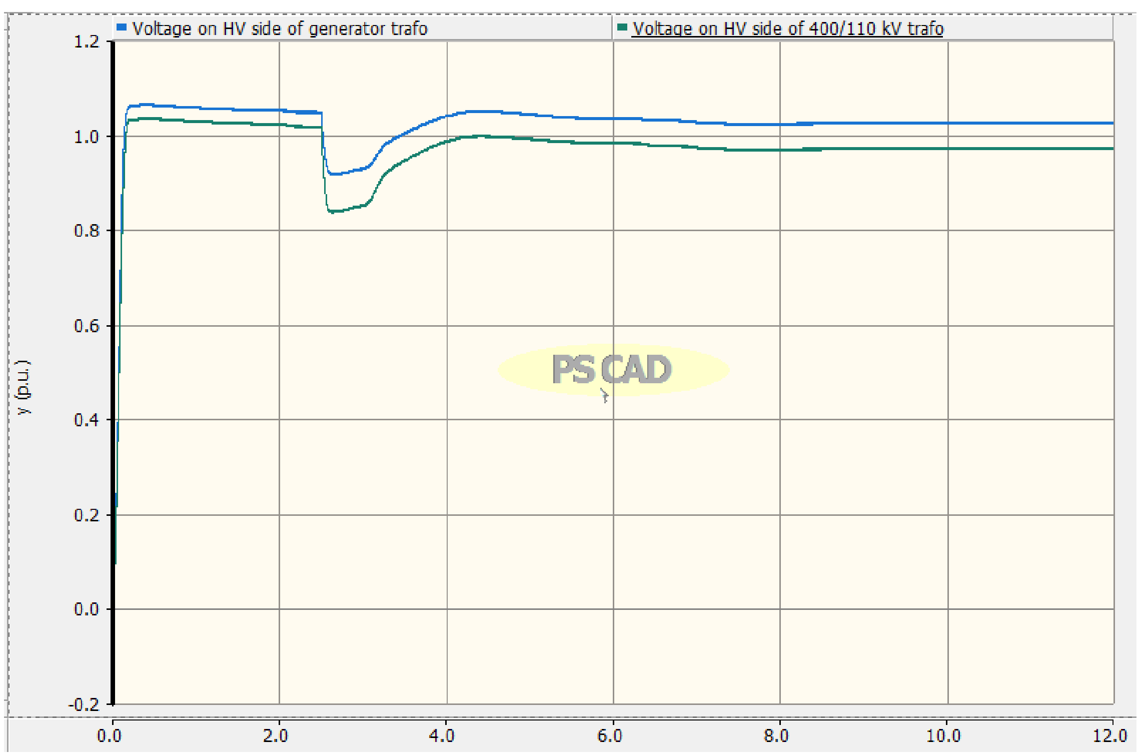
When a generator set is in a paralleled arrangement, the voltage and frequency outputs of the generator sets are forced to exactly the same values when they are connected to the same bus. According to $= \frac{\Delta f}{\Delta P}$, when speed droop is smaller, the power output is stronger.

Generator 2 is taking more loads in an increased load condition due to smaller frequency droop allowance. Due to lower droop allowance, Generator 2 tries to catch up the frequency and hence it accelerates earlier than Generator 1.

Such behavior is dangerous in some cases. This can cause the generator overloaded due to the lower droop setting such as change of load share can cause overload in one of the parallel generator. The chance of overload is high when there is a high change of load in the system.

Answer-2.1.2:





When the speed droop settings are the same, then the change in load will be divided between the generators in proportion to their nominal power ratings.