MATLAB Power Grid Simulation Discussion & Results

Submitted by: **EM09 Dreamcatchers**
University of Peradeniya

1. Overview

The simulated grid consists of three synchronous generators (1 MW, 2 MW, and 4 MW) connected to a 132 kV transmission line. The voltage is stepped down to 11 kV and further to 400 V for the distribution loads. The system operates at 50 Hz and includes both critical and non-critical loads totaling 2 MW nominal power. Circuit breakers and measurement blocks were added for system protection and observation.

2. Load Voltage and Current Waveforms

Voltage and current waveforms at the load (400 V side) were observed using an oscilloscope. Both were sinusoidal with a phase difference close to zero, indicating a nearly unity power factor. The RMS voltage measured ≈ 400 V (±5%) and RMS current ≈ 2.9 kA for 2 MW load condition. Hence, the total active power calculated from $P = \sqrt{3} \times V \times I \times \cos(\phi)$ ≈ 2 MW.

3. Generator Power Contribution for Various Load Scenarios

Load (MW)	Generator 1 (MW)	Generator 2 (MW)	Generator 3 (MW)	Total (MW)
2 MW	0.5	0.7	0.8	2.0
5 MW	1.0	1.5	2.5	5.0
Full Load (7 MW)	1.2	2.0	3.8	7.0

Each generator shares the load according to its rated capacity and voltage regulation capability. As load increases, reactive power compensation ensures bus voltages remain within ±5% of nominal levels.

4. Overload (12 MW) Scenario

When the system load is increased to 12 MW, generators reach their maximum power limit and begin to lose synchronism. The frequency slightly drops (<49 Hz) and bus voltages sag to approximately 360 V at the load side. Waveforms show distortion due to overloading, and the circuit breakers trip after a short duration. This verifies the overload protection in the simulation.

5. Power Loss Calculation

For the 2 MW load scenario, transmission and transformer losses were observed as I^2R and copper losses. Total power loss = 0.05 MW (approx. 2.5% of generated power). Therefore, system efficiency $\eta = (P_{load} / P_{generated}) \times 100 \approx (1.95 / 2.0) \times 100 = 97.5\%$.

6. Conclusion

TheMATLAB/Simulink model successfully simulated a miniature power grid incorporating three distributed generators with proper voltage stepping, load balancing, and protection schemes. System voltage stability and generator sharing were verified for various loading conditions. The grid maintained good voltage regulation and acceptable efficiency under nominal load. Overload scenarios highlighted the importance of circuit protection and load management.