RUTGERS

School of Engineering
Department of Electrical and Computer Engineering

332:494 – Smart Grid – Spring 2021
Project Guidelines
Project Due: 05/11/2021

General Guidelines and schedule for course project:

The course project accounts for 30% of the final grade.

The project should be simulation-based. It offers an opportunity to focus on a specific subject or technology that are of interest. The course project includes running a system simulation accompanied by a written report.

1. The project may be done individually or in teams of two students.
2. Project may be selected from the provided list or proposed by the students. A minimum of 7 bus system needs to be selected by a team of two and a minimum of 5 bus system for individual projects.
3. All material should be submitted electronically by uploading it into the assignment folder or under the personal Sakai Dropbox.
4. Students may propose their own ideas for this project.
5. All code files should be uploaded in addition to the report.

Written report guidelines:

Use the IEEE conference paper template for the report writeup:
https://www.ieee.org/conferences/publishing/templates.html
The report needs to be at a minimum 3 pages long and maximum 6 pages.

The report should include the following analysis and information:
1. Title of the report and student(s) name(s) and RUID(s).
2. Introduction: a brief overview of the role of power flow analysis and its use for contingency analysis or other applications.
3. Case study/Problem formulation: This section is where details of the related work are explained. This section can include multiple subsections based on the topic discussed. Problem formulation, model development, objectives, etc. For the selected system, detail the admittance matrix, given powers and voltages and the method used to solve it:
    a) Use Gauss-Seidal (GS) method to find a good initial solution
    b) Implement Newton-Raphson (NR) method, using the solution from the GS as an initial guess.

c) Find all powers (real and reactive) flowing through the lines, the node voltages and the line currents.
d) Choose one bus for contingency analysis. Assuming this bus is failing and taken out of use, repeat the analysis for the new topology: find all powers (real and reactive) flowing through the remaining lines, the node voltages and the line currents under the new topology.

4. Detailed solution & discussion: mathematical representation of the solution and power flow diagram, where relevant. Discussion on the simulation results: what are the conditions for the line currents ampacity in order for the system to operate given the assumed failure?
5. Conclusions: A brief discussion of the case analyzed, and the results obtained. Include insight into your specific problem.
6. Appendix: detailed code

List of suggested projects:

For ONE of the following projects develop an appropriate on-line diagram. Write a report and a general Matlab M-code or PowerWorld Model.

For ANY of these projects perform the following:
1) Compute the pu one-line model.
2) Compute all bus voltages using Gauss–Seidel method on Matlab
3) Use The GS solution as an initial solution, and compute all bus voltages using Newtown–Raphson method on Matlab
3) Compute all power values including power flow on each line (in/out), line losses and generated power. Compute all node voltages and line currents.
4) Contingency analysis: assume one of the busses has a fault thus we need to simulate the same system **without** this line. How does it change the power flow over the lines? Compute all power values including power flow on each line (in/out), line losses and generated power. Is there any significant change in one (or more) of the lines?

Project Option 2.1

The one-line diagram of a power grid is depicted in figure 1. The details for the grid are given in the figure. Assume a base power of 100MVA and base voltage of 13.2 kV. Assume the input reactance of the local power grid is 10% based on the transformer T_1. The input resistance of the PV sources is 7% based on their rating and input reactance of other sources is 7% base on their ratings.
The system data:
Transformer T_1: 20 MVA, 33 /13.2 kV, 10% reactance
Transformer T_2: 20 MVA, 13.2 / 3.3 kV, 12% reactance
Transformer T_3: 5 MVA, 3.3 / 460 V, 6.5% reactance
Transformer T_4, T_5, and T_6: 2 MVA, 3.3 / 460 V, 6.5% reactance

Transformer T_7: 5 MVA, 3.3 / 460 V, 6% reactance
Transmission line impedance is given in Table 2

Table 2: Transmission Line Data for project 2.1

Line	Resistance (Ω)	Series Reactance (Ω)
8–9	.05	0.5
9–10	0.04	0.4
9–11	0.04	0.51
11–12	0.04	0.5
11–13	0.01	0.12
13–14	0.03	0.32
14–15	0.04	0.45

The local loads (bus 16, bus 17 and bus 18) and bus 8 are set at 1 MVA at 0.85 power factor lagging.

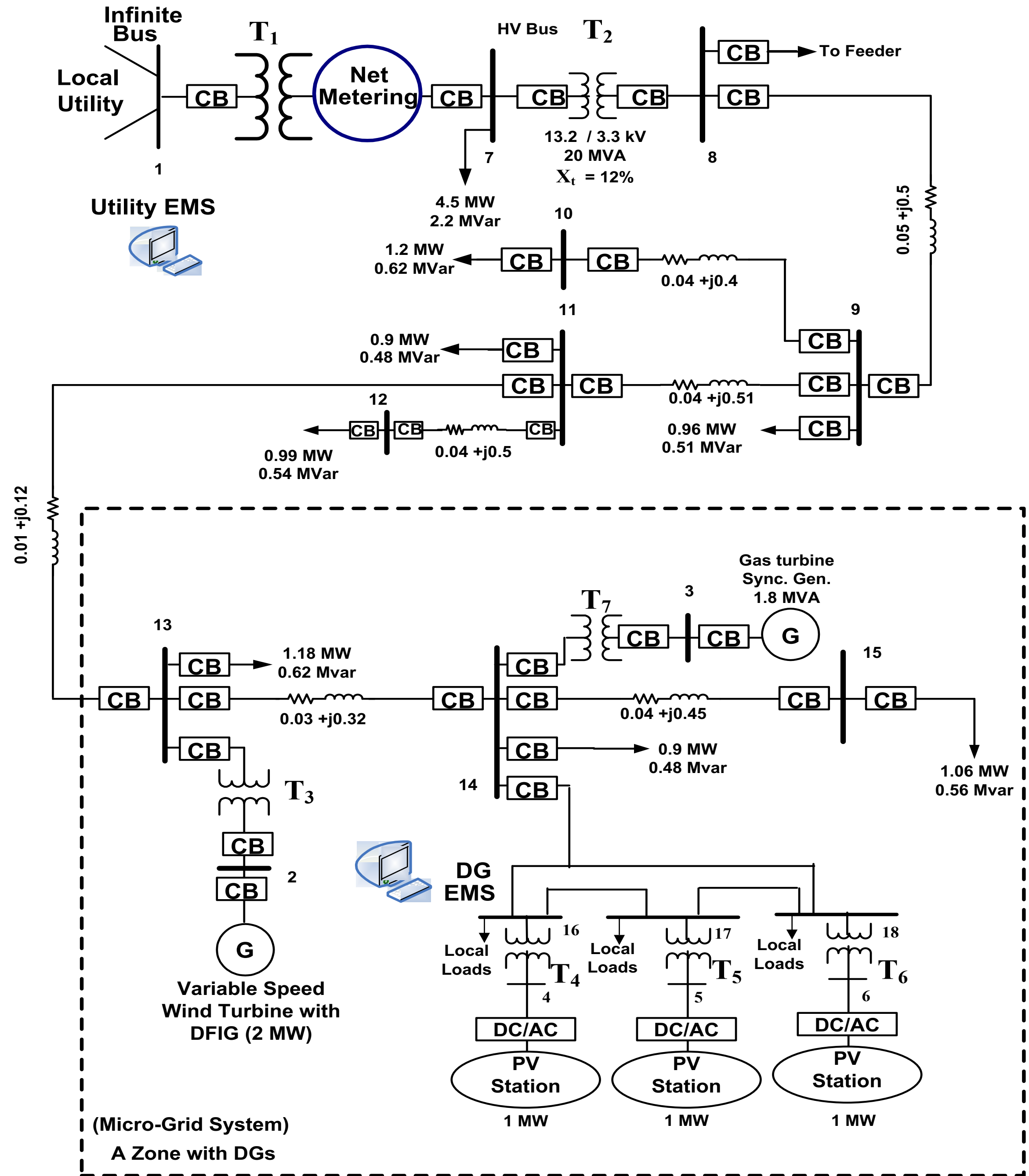


Figure 1: System for projects 2.1

Project Option 2.2

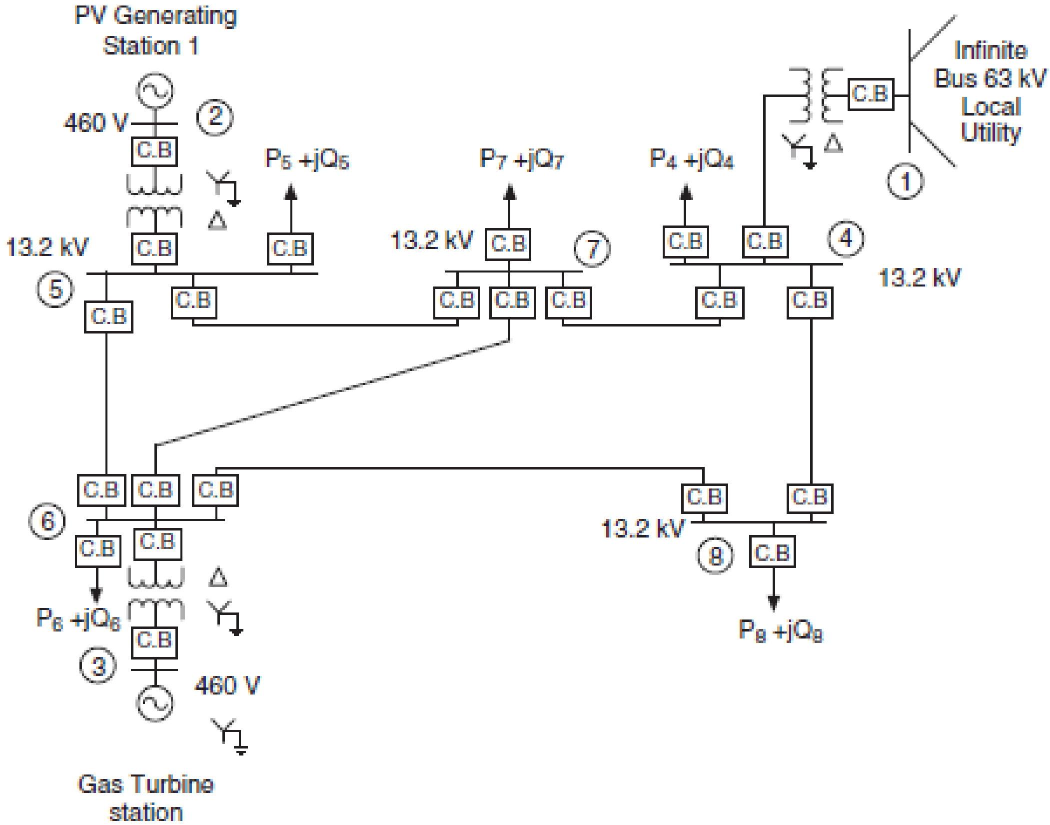


Figure 2: System for projects 2.2

PV generating station #1: 2MVA; internal impedance 50%

Gas turbine: 1MVA; internal impedance 4%

Transformers: 460V/13.2kV (Y/D) ; 10% internal reactance; 10MVA rated power (all three phase)

Power grid transformer: 20MVA; 63kV/13.2KV; 7% reactance

B4 load: 1.5MW; pf=0.85 lag

B5 load: 5.5MW; pf=0.9 lag;

B6 load: 4MW; pf=0.95 lag;

B7 load: 5MW; pf=0.95 lag;

B8 load: 1MW; pf=0.9 lag;

Transmission Line Data for project 2.2

Resistance: 0.0685 ohm/mile; reactance: 0.4 ohm/mile; half line charging admittance: $11\text{x}10^{-6}$ siemens/mile

Line 4-7: 5 miles

Line 4-8: 1 miles

Line 5-6: 3 miles

Line 5-7: 2 miles

Line 6-7: 2 miles

Line 6-8: 4 miles

Project Option 2.3

For the single-line diagram in Figure 4 convert all positive-sequence impedance, load, and voltage data to per unit using the given system base quantities.
Run the power flow program and obtain the bus, line, and transformer input/output voltages

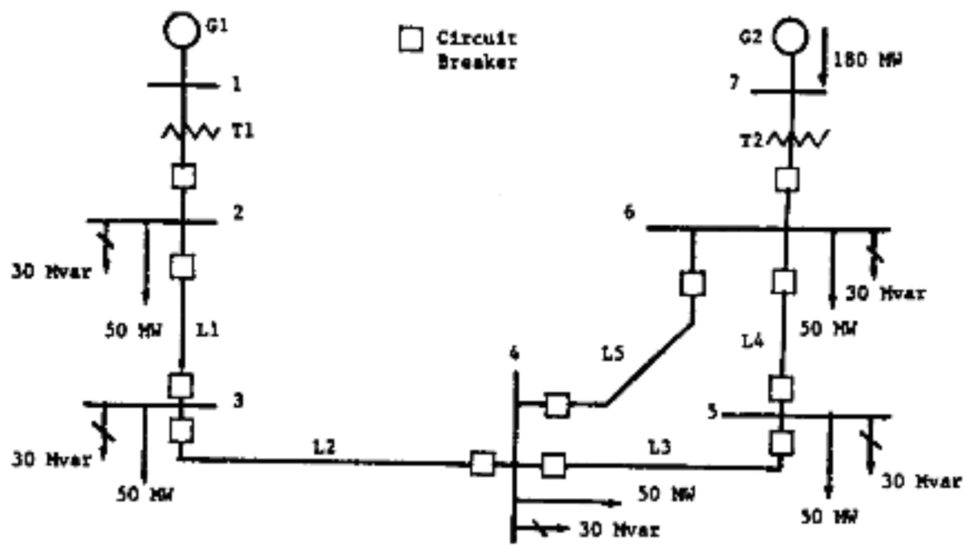


Figure 4 (a): System for project 2.3

Generator Ratings
G1: 100 MVA, 13.8 kV, x" = 0.12, per unit
G2: 200 MVA, 15.0 kV, x" = 0.12, per unit
The generator neutrals are solidly grounded
Transformer Ratings
T1: 100 MVA, 13.8 kVΔ/230 kVY, x=0.1 per unit
T2: 200 MVA, 15 kVΔ/230 kVY, x=0.1 per unit
The transformer neutrals are solidly grounded
Transmission Line Ratings
All Lines: 230 kV, z_1 =0.08 + j0.5 Ω/km,
y_1 = j3.3 E-6 S/km,
Maximum MVA = 400
Line Lengths: L_1 = 15 km, L_2 assigned by the instructor (20 to 50 km), L_3 = 40 km, L_4 = 15 km, L_5 = 50 km.

Power Flow Data
Bus 1 : Swing bus, V_1 = 13.8 kV, δ_1 = 0°
Bus 2,3,4,5,6 : Load buses
Bus 7 : Constant voltage magnitude bus, V_7 = 15 kV,
P_{G7} = 180 MW, - 87 Mvar < Q_{G7} < + 87 Mvar
System Base Quantities
S_{base} = 100 MVA (three-phase)
V_{base} = 13.8 kV (line-to-line) in the zone of G1

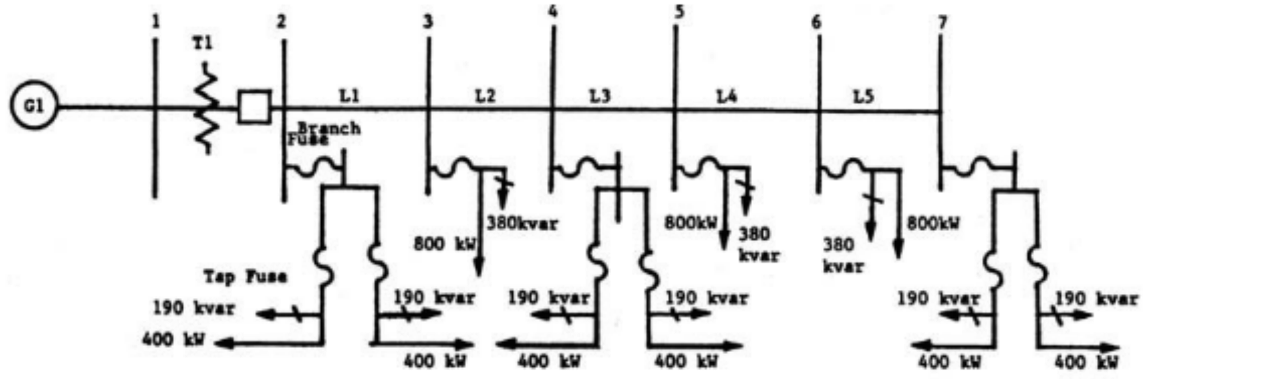
(Comment: for L2 please choose a value between 20km to 50 km)

Figure 4: System for project 2.3

Project Option 2.4

For the single-line diagram in Figure 5 convert all positive-sequence impedance, load, and voltage data to per unit using the given system base quantities.

Run the power flow program and obtain the bus, line, and transformer input/output voltages



<u>Generator Ratings</u>
G1 (infinite bus): 50 MVA, 345 kV, x" = 0.15 per unit
The generator neutrals are solidly grounded
<u>Transformer Ratings</u>
T1: 5 MVA, 345 kVΔ/13.8 kVY, x = 0.1 per unit
The transformer neutrals are solidly grounded
<u>Transmission Line Ratings</u>
All Lines: 13.8 kV, $z_1 = 0.19 + j0.38$ Ω/km,
$y_1 = j4.0$ E-6 S/km,
Maximum MVA = 5
Line Lengths: $L_1 = 2$ km, L_2 assigned by the instructor (1 to 5 km), $L_3 = L_4 = L_5 = 2$ km.

<u>Power Flow Data</u>
Bus 1 : Swing bus, $V_1 = 345$ kV, $\delta_1 = 0°$
Bus 2,3,4,5,6,7 : Load buses
<u>System Base Quantities</u>
S_{base} = 10 MVA (three-phase)
V_{base} = 13.8 kV (line-to-line) in the zone of the lines

(Comment: for L2 please choose a value between 1km to 5km)

Figure 5: System for project 2.4

Project Option 2.5

Propose/choose a power network example with at least 7 buses (either an IEEE test bus, or other examples from the course textbooks). Provide the system details (i.e. generating sources, transformers, loads, etc.). Develop the per unit model for the systems. Run the power flow program and obtain the bus, line, and transformer input/output voltages