Example taken from the book:
Grainger and Stevenson: Power System Analysis

Chapter 9 - Power Flow Solutions

Example 9.2. Figure 9.2 shows the one-line diagram of a simple power system. Generators are connected at buses ① and ④ while loads are indicated at all four buses. Base values for the transmission system are 100 MVA, 230 kV. The *line data* of Table 9.2 give per-unit series impedances and line-charging susceptances for the nominal-π equivalents of the four lines identified by the buses at which they terminate. The *bus data* in Table 9.3 list values for P, Q, and V at each bus. The Q values of load are calculated from the corresponding P values assuming a power factor of 0.85. The net scheduled values, $P_{i,\text{sch}}$ and $Q_{i,\text{sch}}$, are negative at the load buses ② and ③. Generated Q_{gi} is not specified where voltage magnitude is constant. In the voltage column the values for the load buses are flat-start estimates. The slack bus voltage magnitude $|V_1|$ and angle δ_1, and also magnitude $|V_4|$ at bus ④, are to be kept constant at the values listed. A power-flow study is to be made by the Gauss-Seidel method. Assuming that the iterative calculations start at bus ②, find the value of V_2 for the first iteration.

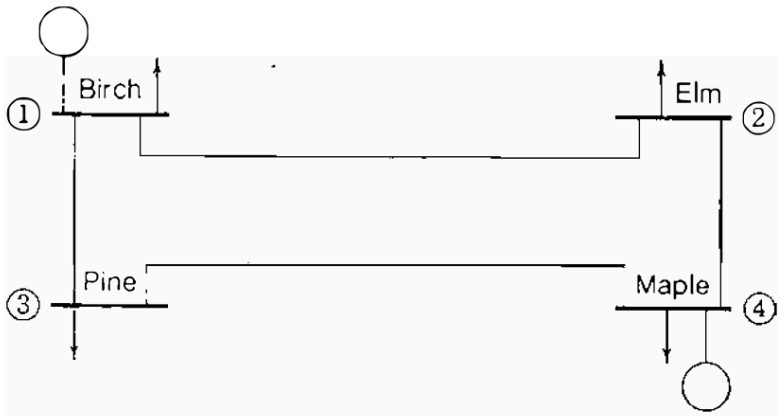

FIGURE 9.2
One-line diagram for Example 9.2 showing the bus names and numbers.

TABLE 9.2
Line data for Example 9.2†

Line, bus to bus	Series Z		Series $Y = Z^{-1}$		Shunt Y	
	R per unit	X per unit	G per unit	B per unit	Total charging Mvar‡	$Y/2$ per unit
1–2	0.01008	0.05040	3.815629	−19.078144	10.25	0.05125
1–3	0.00744	0.03720	5.169561	−25.847809	7.75	0.03875
2–4	0.00744	0.03720	5.169561	−25.847809	7.75	0.03875
3–4	0.01272	0.06360	3.023705	−15.118528	12.75	0.06375

†Base 100MVA, 230 kV.
‡At 230 kV.

TABLE 9.3
Bus data for Example 9.2

Bus	Generation		Load			
	P, MW	Q, Mvar	P, MW	Q, Mvar†	V, per unit	Remarks
1	—	—	50	30.99	$1.00\angle 0°$	Slack bus
2	0	0	170	105.35	$1.00\angle 0°$	Load bus (inductive)
3	0	0	200	123.94	$1.00\angle 0°$	Load bus (inductive)
4	318	—	80	49.58	$1.02\angle 0°$	Voltage controlled

†The Q values of load are calculated from the corresponding P values assuming a power factor of 0.85.

Solution

Bus information									Line flow			
Bus no.	Name	Volts (p.u.)	Angle (deg.)	Generation (MW)	Generation (Mvar)	Load (MW)	Load (Mvar)	Bus type	To Bus	Name	Line flow (MW)	Line flow (Mvar)
1	Birch	1.000	0.	186.81	114.50	50.00	30.99	SL	2	Elm	38.69	22.30
									3	Pine	98.12	61.21
2	Elm	0.982	−0.976	0.	0.	170.00	105.35	PQ	1	Birch	−38.46	−31.24
									4	Maple	−131.54	−74.11
3	Pine	0.969	−1.872	0.	0.	200.00	123.94	PQ	1	Birch	−97.09	−63.57
									4	Maple	−102.91	−60.37
4	Maple	1.020	1.523	318.00	181.43	80.00	49.58	PV	2	Elm	133.25	74.92
									3	Pine	104.75	56.93
		Area totals		504.81	295.93	500.00	309.86					

FIGURE 9.4
Newton-Raphson power-flow solution for the system of Example 9.5. Base is 230 kV and 100 MVA. Tables 9.2 and 9.3 show the line data and bus data, respectively.