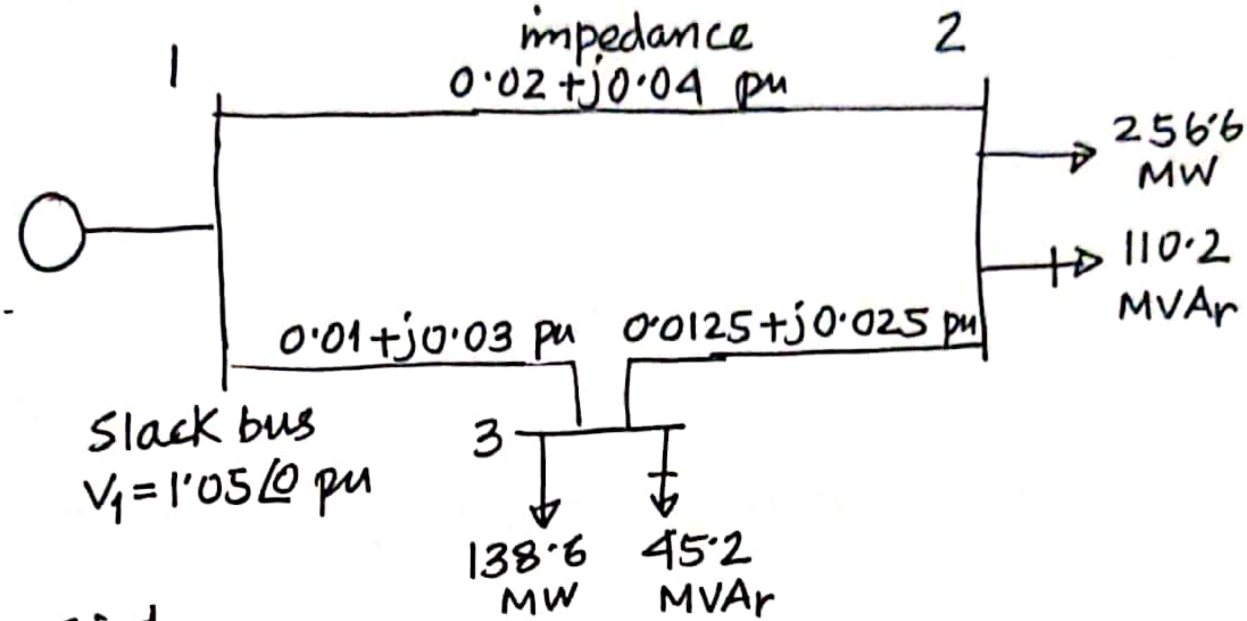
Example 6·7. 100 MVA base



Find

(a) Phasor values of voltage at load bus 2 and 3 (P-Q buses) using Gauss-Seidel method (perform 2 iteration)

(b) Slack bus real and reactive power. ← Find

(c) Determine line flow and line losses. Also construct a power flow diagram.

Solution: (a) Line admittances are

$$y_{12} = y_{21} = \frac{1}{0{\cdot}02+j0{\cdot}04} = 10-j20$$

$$y_{13} = y_{31} = \frac{1}{0{\cdot}01+j0{\cdot}03} = 10-j30$$

$$y_{23} = y_{32} = \frac{1}{0{\cdot}0125+j0{\cdot}025} = 16-j32$$

Y_{Bus} elements.

$$Y_{11} = y_{12}+y_{13} = 20-j50$$

$$Y_{22} = y_{21}+y_{23} = 26-j52$$

$$Y_{33} = y_{31}+y_{32} = 26-j62$$

$$Y_{12} = Y_{21} = -y_{12} = -10+j20$$

$$Y_{13} = Y_{31} = -y_{13} = -10+j30$$

$$Y_{23} = Y_{32} = -y_{23} = -16+j32$$

Bus 2 and 3 are load bus (P-Q bus)

At P-Q buses, the complex power in per-unit (on 100MVA base)

$$S_2^{sch} = -\frac{(P_2+jQ_2)^{sch}}{100} = -\frac{256.6+j110.2}{100} = -2.566-j1.102 \text{ pu}$$

$$S_3^{sch} = -\frac{(P_3+jQ_3)^{sch}}{100} = -\frac{138.6+j45.2}{100} = -1.386-j0.452 \text{ pu}$$

We know, the Gauss-Seidel power flow equation

$$V_i^{K+1} = \frac{1}{Y_{ii}}\left\{\frac{(P_i-jQ_i)^{sch}}{V_i^{*K}} - \sum_{j=1, j\neq i}^{n} Y_{ij} V_j^{K}\right\}$$

Let initial estimate - $V_2^0 = 1.0\angle 0$ and $V_3^0 = 1.0\angle 0$

given - $V_1 = 1.05\angle 0$ (slack bus)

Iteration 1: $K=0$

$i=2$ Bus 2 $\Rightarrow$ $$V_2^1 = \frac{1}{Y_{22}}\left\{\frac{(P_2-jQ_2)^{sch}}{V_2^{*0}} - (Y_{21}V_1 + Y_{23}V_3^0)\right\}$$

$$= \frac{1}{26-j52}\left[\frac{-2.566+j1.102}{1.0\angle -0} - \{(-10+j20)\times 1.05\angle 0 + (-16+j32)\times 1.0\angle 0\}\right]$$

$$= 0.9825-j0.031 = 0.983\angle -1.8071$$

$i=3$ Bus 3 $\Rightarrow$ $$V_3^1 = \frac{1}{Y_{33}}\left\{\frac{(P_3-jQ_3)^{sch}}{V_3^{*0}} - (Y_{31}V_1 + Y_{32}V_2^1)\right\}$$

$$= \frac{1}{26-j62}\left[\frac{-1.386+j0.452}{1.0\angle -0} - \{(-10+j30)\times 1.05\angle 0 + (-16+j32)\times(0.983\angle -1.8071)\}\right]$$

$$= 1.0011-j0.0353 = 1.0017\angle -2.0172$$

Iteration 2: K=1

$$V_2^2 = \frac{1}{Y_{22}}\left\{\frac{(P_2-jQ_2)^{sch}}{V_2^{*1}} - (Y_{21}V_1 + Y_{23}V_3^1)\right\}$$

$$= \frac{1}{26-j52}\left[\frac{-2.566+j1.102}{0.983\angle 1.8071} - \{(-10+j20)\times 1.05\angle 0 + (-16+j32)\times 1.0017\angle -2.0172\}\right]$$

$$= 0.9816 - j0.0520 = 0.983\angle -3.0348$$

$$V_3^2 = \frac{1}{Y_{33}}\left\{\frac{(P_3-jQ_3)^{sch}}{V_3^{*1}} - (Y_{31}V_1 + Y_{32}V_2^2)\right\}$$

$$= \frac{1}{26-j62}\left[\frac{-1.386+j0.452}{1.0017\angle 2.0172} - \{(-10+j30)\times 1.05\angle 0 + (-16+j32)\times 0.983\angle -3.0348\}\right]$$

$$= 1.0008 - j0.0459 = 1.0019\angle -2.6275$$

The approximate values of phasor voltages are

$V_2 = 0.983\angle -3.0348$ pu

$V_3 = 1.0019\angle -2.6275$ pu

Actual after (7) iter..
$V_2 = 0.98183\angle -3.5035$
$V_3 = 1.00125\angle -2.8624$

(b) The complex power at slack bus

$$P_1 - jQ_1 = V_1^*\{Y_{11}V_1 + (Y_{12}V_2 + Y_{13}V_3)\}$$

$$= (1.05\angle 0)\times\{(20-j50)\times 1.05\angle 0 + \{(-10+j20)\times 0.983\angle -3.0348 + (-10+j30)\times 1.0019\angle -2.6275\}$$

$P_1 - jQ_1 = 3.7738 - j1.9556$ pu

Real power, $P_1 = 3.7738$ pu $= 3.7738\times 100 = 377.38$ MW

Reactive Power, $Q_1 = 1.9556$ pu $= 1.9556\times 100 = 195.56$ MVAr

(c) The line currents are—

$$I_{12} = y_{12}(V_1 - V_2) = (10 - j20)(1.05\angle 0 - 0.983\angle -3.0348)$$
$$= 1.7246 - j0.8471$$

$$I_{21} = -I_{12} = -1.7246 + j0.8471$$

$$I_{13} = y_{13}(V_1 - V_3) = (10 - j30)(1.05\angle 0 - 1.0019\angle -2.6275)$$
$$= 1.8694 - j1.0153$$

$$I_{31} = -I_{13} = -1.8694 + j1.0153$$

$$I_{23} = y_{23}(V_2 - V_3) = (16 - j32)(0.983\angle -3.0348 - 1.0019\angle -2.6275)$$
$$= -0.5032 + j0.5174$$

$$I_{32} = -I_{23} = 0.5032 - j0.5174$$

Line flows are

$$S_{12} = V_1 I_{12}^* = 1.05\angle 0 \times (1.7246 + j0.8471) = 1.8108 + j0.8895 \text{ pu}$$
$$= 181.08 \text{ MW} + j88.95 \text{ MVAr}$$

$$S_{21} = V_2 I_{21}^* = 0.983\angle -3.0348 \times (-1.7246 - j0.8471)$$
$$= -1.737 - j0.7418 \text{ pu} = -173.7 \text{ MW} - j74.18 \text{ MVAr}$$

$$S_{13} = V_1 I_{13}^* = 1.05\angle 0 \, (1.8694 + j1.0153) = 1.9629 + j1.1606 \text{ pu}$$
$$= 196.29 \text{ MW} + 116.06 \text{ MVAr}$$

$$S_{31} = V_3 I_{31}^* = 1.0019\angle -2.6275 \times (-1.8694 - j1.0153)$$
$$= -1.9176 - 0.9303 \text{ pu} = 191.76 \text{ MW} - 93.03 \text{ MVAr}$$

$$S_{23} = V_2 I_{23}^* = 0.983\angle -3.0348 \times (-0.5023 - j0.5174)$$
$$= -0.52 - j0.4817 \text{ pu} = -52 \text{ MW} - j48.17 \text{ MVAr}$$

$$S_{32} = V_3 I_{32}^* = 1.0019\angle -2.6275 \times (0.5023 + j0.5174)$$
$$= 0.5265 + j0.4948 \text{ pu} = 52.65 \text{ MW} + j49.48 \text{ MVAr}$$

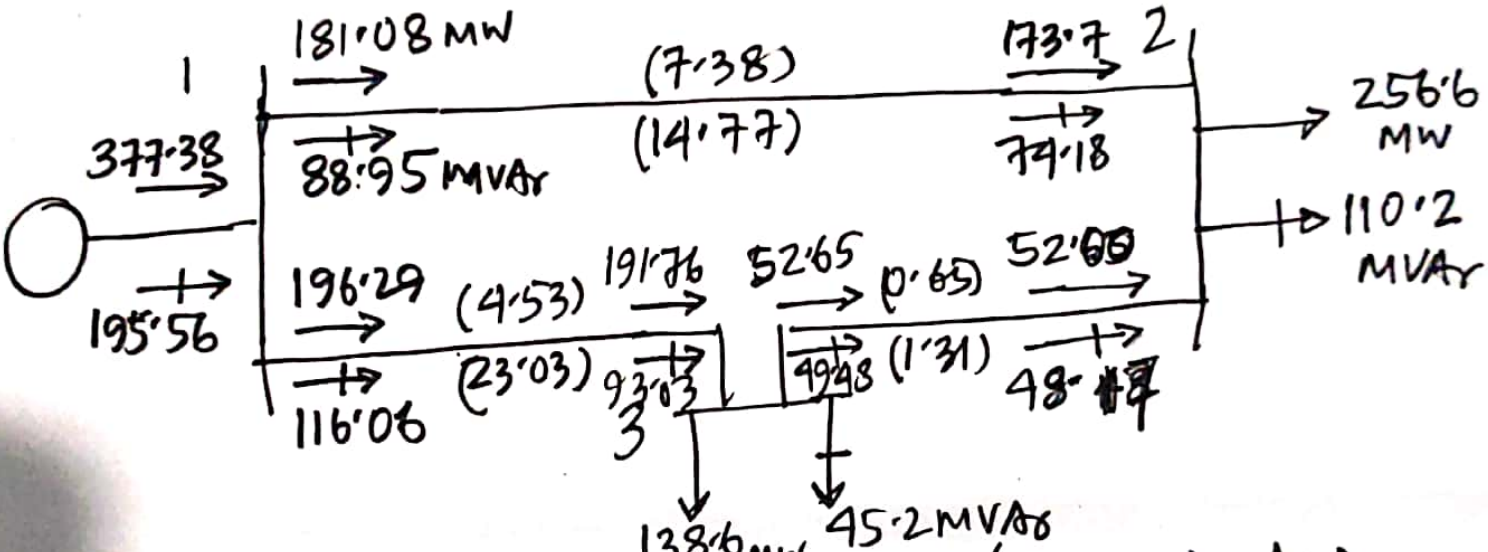
Line losses are

$$S_{L,12} = S_{12} + S_{21} = 181.08\,MW + j88.95\,MVAr - 173.7\,MW - j74.18\,MVAr$$

$$= 7.38\,MW + j14.77\,MVAr$$

$$S_{L,13} = S_{13} + S_{31} = 4.53\,MW + j23.03\,MVAr$$

$$S_{L,23} = S_{23} + S_{32} = 0.65\,MW + j1.31\,MVAr$$



Power Flow diagram (Approximate)