

9.6 Per-unit and power flow

Name: _____ Class: _____ Date: _____

Total: 24 marks

KEY WORDS power flow

Objective

Solve the two-bus power flow by hand: iterate to the receiving voltage, split the drop into its R and X parts, and size the compensation that restores it.

1 Key knowledge and worked examples

■ The two-bus update

Sending bus $1.0\angle 0^\circ pu$, line $Z = R + jX$, load $S = P + jQ$ at the receiving end. Iterate $V_2 \leftarrow 1.0 - Z \cdot \text{conj}(S/V_2)$ until it settles – the hand-scale Gauss-Seidel step.

■ The voltage-drop approximation

$\Delta V \approx (P \cdot R + Q \cdot X)/|V|$ – with network $X \gg R$, the REACTIVE flow through X dominates the drop, which is why shunt compensation is a voltage tool.

■ Worked example: compensation sweeps the curve

$Z = 0.02 + j0.10 pu$, load $0.8 + j0.4$: uncompensated $|V_2| = 0.937$. Adding $Q_c = 0.2$ at the load bus lifts it to 0.959; $Q_c = 0.4$ (full local Q supply) reaches 0.980 – and line loss falls from 0.0182 to 0.0133 pu because the current falls.

2 Practice

2.1 With $Z = 0.02 + j0.10 pu$ and load $0.8 + j0.4$, compute the approximate drop ΔV and the $P \cdot R$ and $Q \cdot X$ parts separately. [3]

2.2 The converged solution has line current 0.954 pu. Compute the line loss and the sending-end real power. [3]

2.3 For the same system with $Q_c = 0.2$ and $Q_c = 0.4$, compute $|V_2|$ (converged) and the corresponding line losses. [3]

3 Exam-style questions

3.1 A two-bus system: sending bus at 1.0 pu, $Z = 0.05 + j0.15pu$, receiving load $0.5 + j0.25$ pu.

Perform the first TWO Gauss–Seidel iterations from a flat start ($V_2 = 1.0$) and give each result in rectangular form. Iterate to convergence and state $|V_2|$ and its angle. Compute the line current, the real line loss and the sending-end real power, and verify the power balance. [8]

3.2 The system of the worked example ($Z = 0.02 + j0.10pu$, load $0.8 + j0.4$ pu) suffers a 0.937 pu receiving voltage.

Size the shunt compensation Q_c needed to restore $|V_2|$ to about 0.98, showing the sweep you used. Compute the percentage reduction in line loss at that compensation. Explain, from the drop decomposition, why a Q-based fix works better than a P-based one, and what device supplies Q_c in practice. [7]
