IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Computer aided power system analysis

Example of GSLF

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GSLF algorithm

N - Bus
m - machine }
1 → slack bus
2, ---- m → PV buses
m+1, m+2, --- N → PQ buses

1. Take Flat start
2. Take iteration count $j = 1$
3. For $i = 2, \dots m$ we do
   i) Calculate $Q_i^{(j)}$

If $Q_i^{min} \le Q_i^{(j)} \le Q_i^{max}$
Then we only calculate the bus voltage angle, keeping $V_i^{(j)} = V_i^{sp}$

If either $Q_i > Q_i^{max}$ or $Q_i < Q_i^{min}$, then we calculate both $V_i^{(j)}$ and $\theta_i^{(j)}$

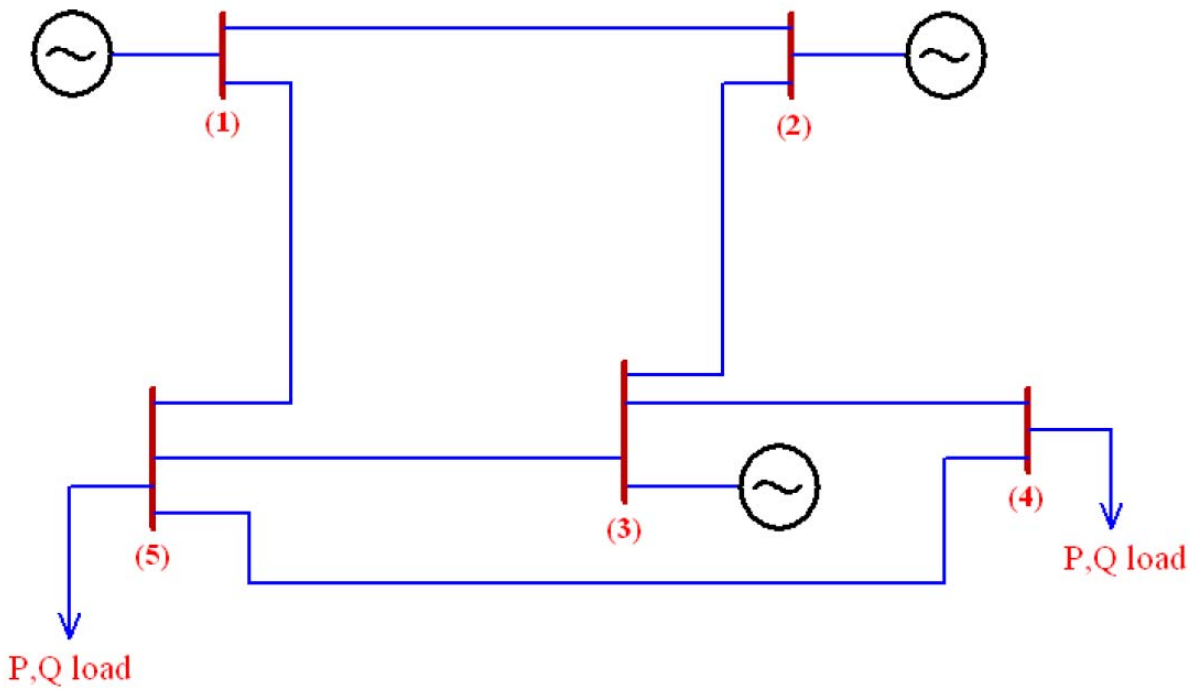
4. For $i = m+1, \ldots N$ we calculate both $V_i^{(j)}$ and $\delta_i^{(j)}$

5. $e_i = \left| \bar{V}_i^{(j)} - V_i^{(j-1)} \right| \quad \forall\ i = 2, 3, \ldots N$

6. Calculate $e_{max} = \max(e_1, e_2, \ldots e_N)$

7 If converged, stop. Else $j = j+1$ and go to step 3.

Example 5-bus system



Bus data for 5 bus system

Bus no.	Type	$\|V\|$ (p.u)	θ (deg)	P_G (MW)	Q_G (MVAR)	P_L (MW)	Q_L (MVAR)	Q_{MIN} (MVAR)	Q_{MAX} (MVAR)	G_{sh} (p.u)	B_{sh} (p.u)
1	1	1	0	0	0	0	0	0	0	0	0
2	2	1	0	50	0	0	0	-500	500	0	0
3	2	1	0	100	0	0	0	-500	500	0	0
4	3	1	0	0	0	115	60	-500	500	0	0
5	3	1	0	0	0	85	40	-500	500	0	0
Base MVA = 100											

Line data for 5 bus system

Branch no.	From bus	To bus	R (p.u)	X (p.u)	B/2 (p.u)	Tx. Tap
1	1	2	0.042	0.168	0.041	0
2	1	5	0.031	0.126	0.031	0
3	2	3	0.031	0.126	0.031	0
4	3	4	0.031	0.126	0.031	0
5	3	5	0.053	0.210	0.051	0
6	4	5	0.063	0.252	0.061	0

A small correction: For the line connected between buses 3 and 4; R = 0.024 p.u., X = 0.136 p.u. and B/2 = 0.082 p.u

GSLF results in 5 bus system without any generator Q limit for iterations 1-3

Bus no.	Iteration = 1			Iteration = 2			Iteration = 3		
	Q_{cal} (p.u)	$\|V\|$ (p.u)	θ (deg)	Q_{cal} (p.u)	$\|V\|$ (p.u)	θ (deg)	Q_{cal} (p.u)	$\|V\|$ (p.u)	θ (deg)
1	-	1.0	0	-	1.0	0	-	1.0	0
2	-0.0720	1.0	2.0533	-0.0663	1.0	4.1038	-0.2022	1.0	3.7091
3	-0.0932	1.0	3.5968	0.2937	1.0	2.6494	0.5142	1.0	1.6234
4	-	0.9394	-3.2379	-	0.9167	-5.0548	-	0.9101	-6.0776
5	-	0.957	-2.5257	-	0.9482	-3.2562	-	0.946	-3.797
	error = 0.081708			error = 0.037148			error = 0.017906		

GSLF results in 5 bus system without any generator Q limit for iterations 4-6

Bus no.	Iteration = 4			Iteration = 5			Iteration = 6		
	Q_{cal} (p.u)	$\|V\|$ (p.u)	θ (deg)	Q_{cal} (p.u)	$\|V\|$ (p.u)	θ (deg)	Q_{cal} (p.u)	$\|V\|$ (p.u)	θ (deg)
1	-	1.0	0	-	1.0	0	-	1.0	0
2	-0.2129	1.0	3.1318	-0.2071	1.0	2.6927	-0.2013	1.0	2.3782
3	0.5926	1.0	0.8641	0.6263	1.0	0.3228	0.6461	1.0	-0.0546
4	-	0.9082	-6.7844	-	0.9074	-7.266	-	0.9069	-7.5985
5	-	0.9452	-4.1735	-	0.9448	-4.435	-	0.9446	-4.6163
	error = 0.013252			error = 0.0094475			error = 0.0065856		

Final Results of the 5 bus system with GSLF (threshold = 1.0e-12)

Bus no.	Without generator Q limit			
	$\|V\|$ (p.u)	θ (deg)	P_{inj} (p.u)	Q_{inj} (p.u)
1	1.0	0	0.56743	0.26505
2	1.0	1.65757	0.5	-0.18519
3	1.0	-0.91206	1.0	0.68875
4	0.90594	-8.35088	-1.15	-0.6
5	0.94397	-5.02735	-0.85	-0.4
	Total iteration = 69			

GSLF results in 5 bus system with generator Q limit on bus 3 (Q_{max} = 50 MVAR) for iterations 1-3

Bus no.	Iteration = 1			Iteration = 2			Iteration = 3		
	Q_{cal} (p.u)	$\|V\|$ (p.u)	θ (deg)	Q_{cal} (p.u)	$\|V\|$ (p.u)	θ (deg)	Q_{cal} (p.u)	$\|V\|$ (p.u)	θ (deg)
1	-	1.0	0	-	1.0	0	-	1.0	0
2	-0.0720	1.0	2.0533	-0.0663	1.0	4.1038	-0.2022	1.0	3.7091
3	-0.0932	1.0	3.5968	0.2937	1.0	2.6494	0.5142	0.9955	1.6318
4	-	0.9394	-3.2379	-	0.9167	-5.0548	-	0.9071	-6.0918
5	-	0.957	-2.5257	-	0.9482	-3.2562	-	0.944	-3.8036
	error = 0.081708			error = 0.037148			error = 0.019063		

Final Results of the 5 bus system with GSLF with generator Q limit

Bus no.	Without generator Q limit				With generator Q limit			
	$\|V\|$ (p.u)	θ (deg)	P_{inj} (p.u)	Q_{inj} (p.u)	$\|V\|$ (p.u)	θ (deg)	P_{inj} (p.u)	Q_{inj} (p.u)
1	1.0	0	0.56743	0.26505	1.0	0	0.56979	0.33935
2	1.0	1.65757	0.5	-0.18519	1.0	1.69679	0.5	-0.04769
3	1.0	-0.91206	1.0	0.68875	0.9825	-0.63991	1.0	0.5
4	0.90594	-8.35088	-1.15	-0.6	0.88918	-8.35906	-1.15	-0.6
5	0.94397	-5.02735	-0.85	-0.4	0.93445	-4.98675	-0.85	-0.4
	Total iteration = 69				Total iteration = 66			