

Supplementary material

Table 1. Bus data of IEEE 14-bus system.

Bus number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Type code	1	2	2	3	3	2	3	2	3	3	3	3	3	3
Voltage (pu)	1.06	1.045	1.01	1.09	1.02	1.07	1.062	1.09	1.056	1.051	1.057	1.055	1.05	1.036
P _{generation} (pu)	2.23	0.4	0	0	0	0	0	0	0	0	0	0	0	0
Q _{generation} (pu)	-0.195	0.369	0.2	0	0	0.24	0	0.182	0	0	0	0	0	0
P _{loading} (pu)	0	0.217	0.942	0.478	0.076	0.112	0	0	0.295	0.09	0.035	0.061	0.135	0.149
Q _{loading} (pu)	0	0.127	0.19	0.039	0.016	0.075	0	0	0.166	0.058	0.018	0.016	0.058	0.05

Table 2. Line data of IEEE 14-bus system.

Line number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
From bus	1	1	2	2	2	3	4	4	4	5	6	6	6	7	7	9	9	10	12	13
To bus	2	5	3	4	5	4	5	7	9	6	11	12	13	8	9	10	11	11	13	14
Line loading limits (MVA)	200	100	100	100	100	50	100	50	50	100	50	20	50	50	50	20	20	20	20	20

Table 3. Cas A studied cases: GOC

Sub-case:	A.1	A.2	A.3	A.4
Disconnected generator bus:	Bus 1	Bus 2	Bus 3	Bus 8

Table 4. Cas B studied cases: LOC

Sub-case:		B.1	B.2	B.3	B.4	B.5	B.6	B.7	B.8	B.9	B.10	B.11	B.12	B.13	B.14	B.15	B.16	B.17	B.18	B.19
Line Outage	From bus	1	1	2	2	2	3	4	4	4	5	6	6	6	7	9	9	10	12	13
	To bus	2	5	3	4	5	4	5	7	9	6	11	12	13	9	10	11	11	13	14

Table 5. Cas C studied cases: Two transformers outage.

Sub-case:		C.1	C.2	C.3
1 st line containing transformer outage	From bus	4	7	4
	To bus	7	4	9
2 nd line containing transformer outage	From bus	4	5	5
	To bus	9	6	6

Table 6. Buses voltages in case A (The values that exceed the constraint limits are highlighted).

Bus no.			1	2	3	4	5	6	7	8	9	10	11	12	13	14
Bus voltage (pu)	Case A.1	before PSO	Disconnect	1.045	1.01	1.09	1.01	1.07	1.06	1.09	1.05	1.05	1.06	1.06	1.05	1.03
		after PSO	Disconnect	1.049	1.04	1.02	1.02	1.06	1.03	1.03	1.03	1.03	1.04	1.04	1.04	1.01
	Case A.2	before PSO	1.06	Disconnected	1.01	0.94	0.93	1.07	1.03	1.09	1.02	1.02	1.04	1.05	1.04	1.01
		after PSO	1.05	Disconnected	1.01	0.94	1.00	1.06	1.01	1.01	1.01	1.01	1.03	1.04	1.03	1.00
	Case A.3	before PSO	1.06	1.045	Disconnected	1.02	1.02	1.07	1.06	1.09	1.06	1.05	1.06	1.06	1.05	1.04
		after PSO	1.03	1	Disconnected	0.99	1.00	1.06	1.01	1.01	1.01	1.01	1.03	1.04	1.03	1.00
	Case A.4	before PSO	1.06	1.045	1.01	1.01	1.02	1.07	1.04	Disconnected	1.04	1.04	1.05	1.05	1.05	1.02
		after PSO	1.06	1.043	1.02	1.01	1.01	1.03	1.02	Disconnected	1.02	1.01	1.01	1.01	1.01	0.99

Table 7. Line loading in case A (The values that exceed the constraint limit are highlighted).

Line	From bus		1	1	2	2	2	3	4	4	4	5	6	6	6	7	7	9	9	10	12	13
	To bus		2	5	3	4	5	4	5	7	9	6	11	12	13	8	9	10	11	11	13	14
Line loading $\left(\frac{S_L}{S_{L(max)}}\right)$	Case A.1	before PSO	0.00	0.00	0.23	0.33	0.27	0.22	0.31	0.29	0.19	0.20	0.44	0.49	0.52	0.00	0.29	0.56	0.28	0.90	0.17	0.74
		after PSO	0.00	0.00	0.87	0.83	0.78	0.24	0.28	0.65	0.34	0.43	0.16	0.41	0.38	0.40	0.60	0.35	0.53	0.19	0.09	0.28
	Case A.2	before PSO	0.00	3.19	0.00	0.00	0.00	2.64	2.13	0.75	0.29	0.67	0.35	0.47	0.48	0.80	0.43	0.10	0.23	0.65	0.15	0.59
		after PSO	0.00	0.98	0.00	0.00	0.00	0.38	0.83	0.28	0.17	0.06	0.45	0.50	0.53	0.00	0.28	0.45	0.16	0.90	0.18	0.75
	Case A.3	before PSO	0.38	0.54	0.00	0.52	0.42	0.00	0.44	0.62	0.33	0.45	0.15	0.40	0.38	0.34	0.59	0.37	0.53	0.17	0.08	0.27
		after PSO	0.33	0.31	0.00	0.27	0.17	0.00	0.44	0.28	0.17	0.07	0.44	0.50	0.53	0.00	0.28	0.44	0.16	0.88	0.18	0.74
	Case A.4	before PSO	0.79	0.76	0.74	0.56	0.42	0.50	0.61	0.55	0.32	0.47	0.22	0.43	0.41	0.00	0.55	0.23	0.45	0.34	0.11	0.37
		after PSO	0.65	0.60	0.70	0.46	0.31	0.61	0.63	0.37	0.22	0.18	0.35	0.47	0.48	0.00	0.37	0.20	0.21	0.67	0.15	0.60

Table 8. Buses voltages in case B (The values that exceed the constraint limits are highlighted).

Bus no.			1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Bus voltage (pu)	Case B.1	before PSO	1.06	1.05	1.01	1.00	0.99	1.07	1.05	1.09	1.05	1.04	1.05	1.06	1.05	1.03	
		after PSO	1.06	0.99	1.03	0.99	1.00	1.06	1.01	1.01	1.01	1.01	1.01	1.03	1.04	1.03	1.00
	Case B.2	before PSO	1.06	1.05	1.01	1.01	1.01	1.07	1.06	1.06	1.09	1.05	1.05	1.06	1.06	1.05	1.03
		after PSO	1.06	1.03	1.01	0.97	0.97	0.98	0.98	0.97	0.98	0.97	0.97	0.97	0.96	0.96	0.95
	Case B.3	before PSO	1.06	1.05	1.01	1.01	1.01	1.07	1.06	1.06	1.09	1.05	1.05	1.06	1.06	1.05	1.03
		after PSO	1.04	1.02	1.01	1.00	1.00	1.06	1.02	1.00	1.02	1.02	1.02	1.04	1.04	1.04	1.01
	Case B.4	before PSO	1.06	1.05	1.01	1.01	1.01	1.07	1.06	1.06	1.09	1.05	1.05	1.05	1.06	1.05	1.03
		after PSO	1.04	1.02	1.02	0.99	0.99	1.02	1.03	1.06	1.02	1.01	1.01	1.01	1.00	1.00	0.99
	Case B.5	before PSO	1.06	1.05	1.01	1.01	1.01	1.07	1.06	1.06	1.09	1.05	1.05	1.06	1.06	1.05	1.03
		after PSO	1.01	1.02	1.02	1.00	1.00	1.06	1.02	1.02	1.02	1.02	1.02	1.04	1.04	1.04	1.01
	Case B.6	before PSO	1.06	1.05	1.01	1.02	1.02	1.07	1.06	1.06	1.09	1.06	1.05	1.06	1.06	1.05	1.04
		after PSO	1.05	1.03	1.03	1.00	1.01	1.06	1.02	1.02	1.02	1.02	1.02	1.04	1.04	1.04	1.01
	Case B.7	before PSO	1.06	1.05	1.01	1.01	1.02	1.07	1.06	1.06	1.09	1.05	1.04	1.05	1.06	1.05	1.03
		after PSO	1.06	1.04	1.02	1.00	1.01	1.03	1.01	1.01	1.01	1.01	1.00	1.01	1.01	1.00	0.98
	Case B.8	before PSO	1.06	1.05	1.01	1.01	1.02	1.07	1.07	1.07	1.09	1.05	1.05	1.06	1.06	1.05	1.03
		after PSO	1.06	1.04	1.02	1.00	1.00	1.01	0.98	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.96
	Case B.9	before PSO	1.06	1.05	1.01	1.02	1.02	1.07	1.06	1.06	1.09	1.05	1.05	1.06	1.06	1.05	1.03
		after PSO	1.06	1.04	1.02	1.00	1.00	1.02	1.01	1.01	1.01	1.00	1.00	1.00	1.00	1.00	0.98
	Case B.10	before PSO	1.06	1.05	1.01	1.02	1.03	1.07	1.07	1.07	1.09	1.07	1.06	1.06	1.05	1.05	1.04
		after PSO	1.06	1.04	0.97	1.00	1.01	1.07	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.00	0.99
	Case B.11	before PSO	1.06	1.05	1.01	1.02	1.02	1.07	1.06	1.06	1.09	1.05	1.04	1.03	1.06	1.05	1.03
		after PSO	1.06	1.04	1.02	1.00	1.01	1.03	1.01	1.01	1.01	1.01	1.00	0.99	1.02	1.01	0.99
	Case B.12	before PSO	1.06	1.05	1.01	1.02	1.02	1.07	1.06	1.06	1.09	1.05	1.05	1.06	1.03	1.04	1.03
		after PSO	1.05	1.02	1.01	1.00	1.00	1.06	1.02	1.02	1.02	1.02	1.02	1.04	1.01	1.03	1.01

Case B.13	before PSO	1.06	1.05	1.01	1.02	1.02	1.07	1.06	1.09	1.05	1.04	1.05	1.03	1.00	1.01
	after PSO	1.04	1.01	1.01	1.00	1.00	1.06	1.01	1.01	1.01	1.01	1.03	1.02	0.97	0.97
Case B.14	before PSO	1.06	1.05	1.01	1.02	1.02	1.07	1.07	1.09	1.03	1.03	1.05	1.05	1.05	1.02
	after PSO	1.04	1.02	1.01	1.00	1.00	1.06	1.02	1.01	1.01	1.03	1.04	1.04	1.03	1.00
Case B.15	before PSO	1.06	1.05	1.01	1.02	1.02	1.07	1.07	1.09	1.06	1.03	1.04	1.06	1.06	1.04
	after PSO	1.05	1.02	1.02	1.00	1.01	1.06	1.03	1.03	1.03	1.02	1.03	1.04	1.04	1.02
Case B.16	before PSO	1.06	1.02	1.01	1.02	1.02	1.07	1.07	1.09	1.06	1.06	1.06	1.05	1.04	1.00
	after PSO	1.06	1.05	1.03	1.01	1.01	1.02	1.03	1.03	1.03	1.02	1.01	1.00	0.98	0.94
Case B.17	before PSO	1.06	1.05	1.01	1.02	1.02	1.07	1.06	1.09	1.05	1.05	1.06	1.06	1.05	1.03
	after PSO	1.06	1.04	1.02	1.00	1.01	1.03	1.02	1.02	1.01	1.01	1.02	1.01	1.01	0.99
Case B.18	before PSO	1.06	1.05	1.01	1.02	1.02	1.07	1.06	1.09	1.06	1.05	1.06	1.06	1.05	1.04
	after PSO	1.05	1.02	1.01	1.00	1.00	1.06	1.02	1.02	1.02	1.02	1.04	1.05	1.03	1.01
Case B.19	before PSO	1.06	1.05	1.01	1.02	1.02	1.07	1.06	1.09	1.05	1.05	1.06	1.06	1.06	1.02
	after PSO	1.04	1.01	1.01	0.99	1.00	1.06	1.01	1.01	1.01	1.01	1.03	1.05	1.05	0.98

Table 9. Line loading in case B (The values that exceed the constraint limit are highlighted).

*Disconnected line is assigned by black cell.

Line	From bus		1	1	2	2	2	3	4	4	4	5	6	6	6	7	7	9	9	10	12	13
	To bus		2	5	3	4	5	4	5	7	9	6	11	12	13	8	9	10	11	11	13	14
Line loading $\frac{S_L}{S_{L(max)}}$	Case B.1	before PSO		2.64	0.49	0.26	0.52	1.07	1.50	0.58	0.29	0.50	0.23	0.43	0.42	0.45	0.51	0.21	0.40	0.38	0.11	0.41
		after PSO		0.82	0.60	0.25	0.09	0.81	0.82	0.22	0.14	0.09	0.50	0.52	0.56	0.00	0.22	0.58	0.18	0.89	0.20	0.84
	Case B.2	before PSO	1.21		0.87	0.83	0.78	0.24	0.28	0.65	0.34	0.43	0.16	0.41	0.38	0.94	0.56	0.35	0.53	0.19	0.09	0.28
		after PSO	0.81		0.43	0.67	0.65	0.48	0.18	0.62	0.37	0.48	0.12	0.39	0.36	0.00	0.61	0.44	0.85	0.09	0.07	0.02
	Case B.3	before PSO	0.75	0.96		0.90	0.69	2.11	1.06	0.59	0.30	0.48	0.20	0.42	0.40	0.39	0.54	0.27	0.45	0.29	0.10	0.35
		after PSO	0.53	0.57		0.47	0.35	0.40	0.53	0.45	0.27	0.30	0.28	0.45	0.44	0.00	0.45	0.08	0.32	0.48	0.13	0.48
	Case B.4	before PSO	0.72	0.92	0.90		0.67	0.18	1.00	0.60	0.36	0.48	0.20	0.42	0.42	0.54	0.26	0.45	0.29	0.10	0.36	0.35
		after PSO	0.72	0.92	0.82		0.75	0.32	0.39	0.63	0.33	0.44	0.15	0.40	0.37	0.38	0.59	0.35	0.52	0.19	0.09	0.28
	Case B.5	before PSO	0.70	0.92	0.82	0.75		0.32	0.94	0.64	0.33	0.43	0.16	0.41	0.38	0.38	0.59	0.35	0.52	0.19	0.09	0.28
		after PSO	0.56	0.63	0.42	0.47		0.18	0.33	0.43	0.25	0.21	0.30	0.46	0.46	0.00	0.43	0.11	0.29	0.54	0.13	0.52
	Case B.6	before PSO	0.82	0.70	0.98	0.45	0.33		0.51	0.61	0.32	0.45	0.15	0.45	0.38	0.33	0.58	0.35	0.52	0.18	0.09	0.28
		after PSO	0.66	0.65	0.61	0.49	0.39		0.47	0.58	0.34	0.50	0.15	0.40	0.37	0.00	0.58	0.37	0.53	0.17	0.08	0.27
	Case B.7	before PSO	0.89	0.57	0.98	0.89	0.17	0.17		0.42	0.21	0.62	0.35	0.46	0.47	0.41	0.41	0.41	0.32	0.67	0.14	0.59
		after PSO	0.71	0.51	0.63	0.75	0.22	0.25		0.43	0.26	0.62	0.29	0.45	0.45	0.00	0.43	0.31	0.35	0.53	0.12	0.49
	Case B.8	before PSO	0.79	0.76	0.72	0.54	0.43	0.50	0.51		0.62	0.59	0.31	0.45	0.46	0.27	0.27	0.41	0.37	0.60	0.13	0.54
		after PSO	0.65	0.67	0.52	0.49	0.41	0.30	0.39		0.67	0.65	0.32	0.46	0.46	0.00	0.00	0.27	0.28	0.60	0.14	0.55
	Case B.9	before PSO	0.79	0.76	0.73	0.56	0.42	0.49	0.59	0.81		0.51	0.22	0.43	0.41	0.37	0.78	0.28	0.42	0.36	0.11	0.39
		after PSO	0.65	0.67	0.53	0.51	0.40	0.29	0.46	0.81		0.57	0.22	0.43	0.41	0.00	0.80	0.25	0.42	0.35	0.11	0.39
	Case B.10	before PSO	0.81	0.74	0.75	0.61	0.38	0.42	1.01	1.02	0.66		0.48	0.30	0.25	0.33	1.15	1.60	1.36	1.30	0.15	0.72
		after PSO	0.65	0.58	0.70	0.46	0.28	0.59	0.77	0.56	0.33		0.16	0.41	0.34	0.00	0.55	0.35	0.50	0.21	0.87	0.29
Case B.11	before PSO	0.79	0.75	0.73	0.56	0.41	0.48	0.48	0.66	0.65	0.37		0.41	0.42	0.40	0.64	0.73	0.38	0.19	0.11	0.43	
	after PSO	0.66	0.66	0.53	0.51	0.39	0.28	0.54	0.63	0.37	0.45		0.43	0.42	0.00	0.63	0.74	0.38	0.19	0.11	0.42	
Case B.12	before PSO	0.79	0.75	0.73	0.56	0.41	0.48	0.63	0.61	0.32	0.45	0.17		0.53	0.36	0.58	0.31	0.56	0.23	0.32	0.23	
	after PSO	0.65	0.58	0.39	0.39	0.28	0.17	0.48	0.47	0.27	0.30	0.16		0.59	0.00	0.47	0.01	0.40	0.19	0.32	0.39	
Case B.13	before PSO	0.80	0.75	0.74	0.56	0.41	0.48	0.65	0.63	0.34	0.43	0.23	1.03		0.40	0.63	0.21	0.90	0.37	0.68	0.13	
	after PSO	0.62	0.56	0.39	0.39	0.27	0.18	0.48	0.51	0.30	0.26	0.36	0.97		0.00	0.51	0.16	0.76	0.68	0.82	0.98	
Case B.14	before PSO	0.79	0.76	0.73	0.56	0.42	0.48	0.61	0.58	0.31	0.49	0.30	0.39	0.35		0.30	0.52	0.61	0.54	0.07	0.19	
	after PSO	0.66	0.66	0.54	0.51	0.40	0.28	0.50	0.54	0.32	0.55	0.31	0.37	0.32		0.00	0.54	0.70	0.55	0.05	0.12	
Case B.15	before PSO	0.79	0.76	0.73	0.56	0.42	0.48	0.61	0.58	0.31	0.49	0.30	0.39	0.35	0.30	0.52		0.61	0.54	0.07	0.19	
	after PSO	0.65	0.60	0.70	0.46	0.31	0.61	0.65	0.41	0.24	0.17	0.30	0.48	0.50	0.00	0.41		0.21	0.55	0.16	0.64	
Case B.16	before PSO	0.79	0.76	0.73	0.56	0.42	0.48	0.60	0.56	0.29	0.51	0.09	0.52	0.56	0.30	0.51	0.54		0.12	0.20	0.82	
	after PSO	0.58	0.62	0.43	0.48	0.39	0.25	0.43	0.53	0.31	0.56	0.03	0.52	0.56	0.00	0.52	0.67		0.14	0.20	0.82	
Case B.17	before PSO	0.79	0.75	0.73	0.56	0.41	0.48	0.65	0.63	0.34	0.43	0.08	0.42	0.41	0.38	0.61	0.54	0.44		0.10	0.36	
	after PSO	0.65	0.66	0.54	0.51	0.39	0.28	0.53	0.61	0.36	0.48	0.08	0.42	0.40	0.00	0.60	0.54	0.47		0.01	0.03	
Case B.18	before PSO	0.79	0.76	0.73	0.56	0.42	0.42	0.48	0.63	0.32	0.46	0.17	0.32	0.41	0.35	0.57	0.13	0.52	0.21		0.28	
	after PSO	0.66	0.66	0.54	0.51	0.40	0.28	0.52	0.58	0.35	0.49	0.15	0.32	0.40	0.00	0.58	0.37	0.54	0.17		0.26	
Case B.19	before PSO	0.80	0.75	0.74	0.56	0.41	0.48	0.65	0.63	0.34	0.43	0.22	0.35	0.29	0.38	0.62	0.26	0.81	0.34	0.03		
	after PSO	0.65	0.66	0.54	0.51	0.39	0.28	0.53	0.62	0.37	0.47	0.20	0.35	0.29	0.00	0.61	0.27	0.81	0.31	0.03		

Table 10. Buses voltages in case C (The values that exceed the constraint limits are highlighted).

Bus no.			1	2	3	4	5	6	7	8	9	10	11	12	13	14
Bus voltage (pu)	Case C.1	before PSO	1.06	1.05	1.01	1.01	1.01	1.07	1.06	1.09	1.03	1.03	1.04	1.05	1.04	1.02
		after PSO	1.01	1.02	1.02	1.00	1.00	1.00	1.00	1.00	1.06	1.03	1.02	1.02	1.01	1.01
	Case C.2	before PSO	1.06	1.05	1.01	1.00	1.02	1.07	1.07	1.09	1.06	1.05	1.05	1.00	1.05	1.04
		after PSO	1.06	1.04	0.97	1.00	1.02	1.00	0.97	0.97	0.97	0.96	0.97	0.98	0.97	0.95
	Case C.3	before PSO	1.06	1.05	1.01	1.02	1.03	1.07	1.06	1.09	1.07	1.06	1.06	1.05	1.05	1.04
		after PSO	1.06	1.04	0.97	1.00	1.02	1.01	1.00	1.00	0.99	0.99	1.00	1.00	0.99	0.97

Table 11. Line loading in case C (The values that exceed the constraint limit are highlighted).

Line	From bus		1	1	2	2	2	3	4	4	4	5	6	6	6	7	7	9	9	10	12	13
	To bus		2	5	3	4	5	4	5	7	9	6	11	12	13	8	9	10	11	11	13	14
Line loading $\left(\frac{S_L}{S_{L(max)}}\right)$	Case C.1	Before PSO	0.79	0.80	0.72	0.52	0.47	0.53	0.26	Disconnected	Disconnected	0.93	0.73	0.58	0.66	0.42	0.41	1.03	0.63	1.62	0.26	1.19
		after PSO	0.60	0.54	0.39	0.32	0.32	0.28	0.28	Disconnected	Disconnected	0.51	0.17	0.41	0.38	0.90	0.88	0.43	0.53	0.26	0.09	0.31
	Case C.2	Before PSO	0.82	0.74	0.77	0.62	0.38	0.47	1.00	Disconnected	1.89	Disconnected	0.52	0.33	0.28	0.25	0.25	1.71	1.38	1.38	0.17	0.78
		after PSO	0.60	0.53	0.68	0.42	0.25	0.65	0.69	Disconnected	0.63	Disconnected	0.36	0.47	0.48	0.00	0.00	0.39	0.29	0.69	0.15	0.61
	Case C.3	Before PSO	0.82	0.74	0.76	0.62	0.37	0.43	1.01	1.85	Disconnected	Disconnected	0.26	0.32	0.26	0.35	1.81	1.68	1.36	1.30	0.15	0.72
		After PSO	0.63	0.56	0.69	0.45	0.27	0.62	0.73	0.76	Disconnected	Disconnected	0.24	0.43	0.42	0.00	0.77	0.28	0.40	0.41	0.11	0.42

Power Systems Test Case Archive, available at: http://www.ee.washington.edu/research/pstca/pf14/pg_tca14bus.htm.