Appendix A

Test Systems

DFIG-based WIPS

Parameters adopted

1. Active power
2. Reactive power
3. DC link voltage
4. DFIG rotor speed

Case system

DFIG-based WIPS consists of a wound rotor type induction generator, and an AC-DC-AC IGBT-based converter is considered.

Technical details

A 120 kV, 60 Hz grid supply is connected to the stator while the rotor is fed through a voltage source converter with a dc-link voltage of 1150V. Six wind turbines of 1.5 MW each created a wind farm of 9 MW, which is desirable real power output. It is also desirable to regulate the reactive power produced by the wind turbine generators to 0 MVar.

A 25 kV distribution system, which exports power to the grid through a 30 km feeder. The wind speed = 15 m/s (fixed), induction generator number of poles = 6, rated speed = 1200 rpm, which is maintained at 1440 rpm (1.2 p.u.) for generating mode.

33 bus

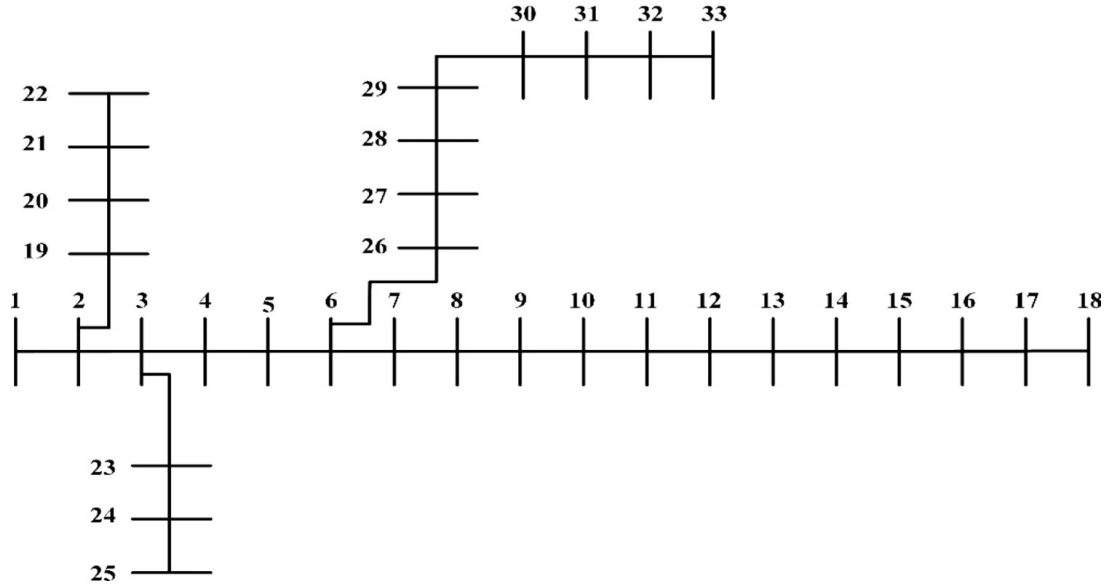

Figure A.1: IEEE 33 bus distribution system.

118-bus

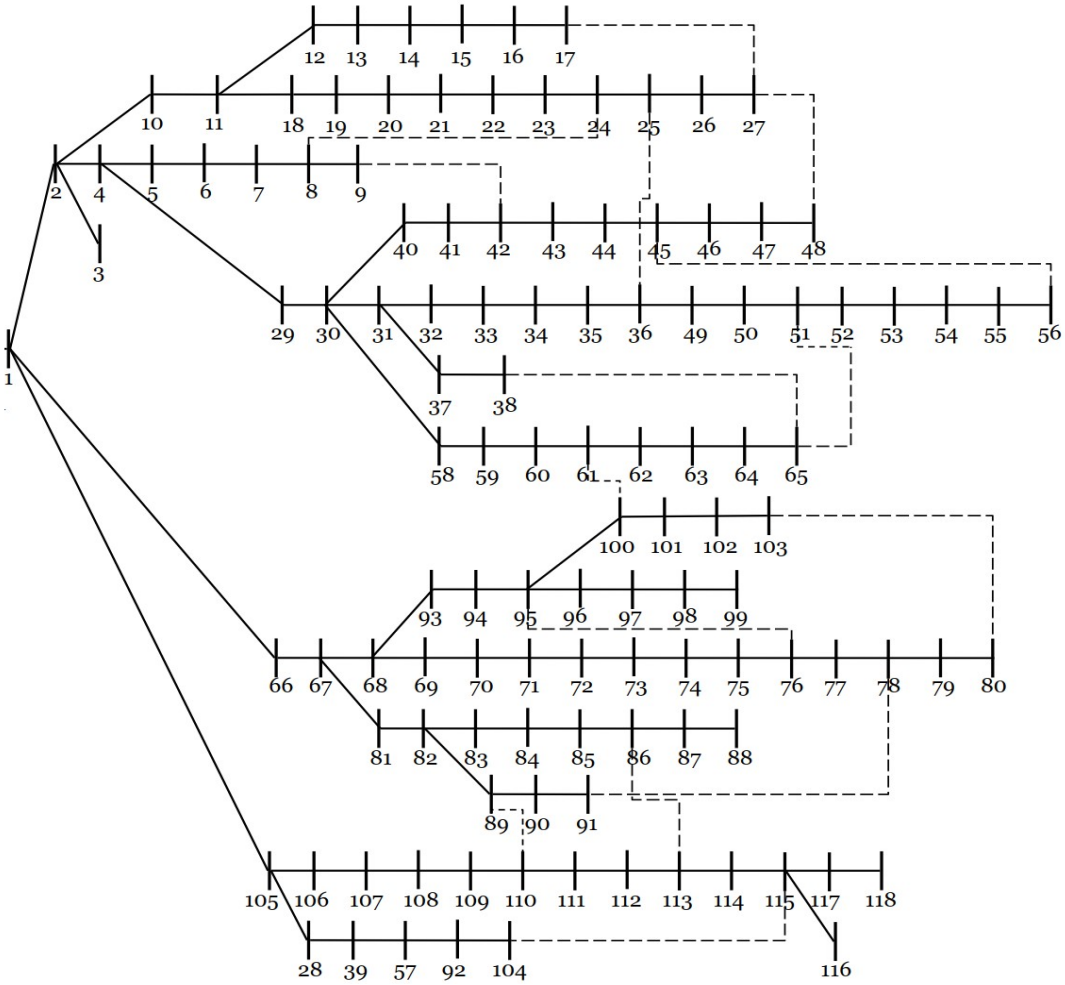

Figure A.2: IEEE 118 bus distribution system.

Appendix B

Reliability Data

Data adapted from [6, 7, 240].

Table B.1: Reliability data adapted for 33 bus

Component	**Reliability data for all loads, feeders, etc.**	
	λ_P(failure per year)	**RT(hr)**
Load@4	0.321	11.04
Load@(5, 7-12, 29, 30, 14, 16, 18-22, 25-28)	0.301	11.44
13, 15	0.314	11.17
17, 23, 24	0.208	1.75
31-33	0.327	10.96
substation	0.1	5
feeder (2, 3, 6)	0.2	3
DG	0.2	12

Table B.2: Load distribution for 33 bus

Bus number (or Load point)	Number of customers	Type of load			
		Mixed	Same type of loads		
2-5	148	Industrial (I)	C	I	R
6-9	10	Commercial (C)	”	”	”
11, 12	132	”	”	”	”
13-15	110	Residential (R)	”	”	”
16	2	”	”	”	”
17-20	118	”	”	”	”
21-26	126	”	”	”	”
27-31	108	”	”	”	”
32, 33	58	”	”	”	”

Table B.3: Reliability data adapted for 118 bus

Component	Reliability data for all loads, feeders, etc.	
	λ_P(failure per year)	RT(hr)
Load	0.208	1.75
substation	0.1	5
feeder	0.2	3
DG	0.2	12

Table B.4: Load distribution for 118 bus

Load Group	Bus Number	Number of customers
Residential	3-5, 8, 9, 12, 13, 15-18, 22, 23, 26, 27, 41, 45-50, 54, 55, 58-60, 62-65, 70-72, 76, 78, 80, 87, 88, 90, 91, 93-95, 97-99, 102, 103, 118, 39, 92, 104	100
Industrial	20, 29, 32, 33, 37, 38, 42-44, 52, 56, 61, 66, 69, 73, 74, 77, 81-85, 89, 100, 101, 106-108, 112-114, 116, 117	
Commercial	2, 6, 7, 10, 11, 14, 19, 21, 24, 25, 30, 31, 34-36, 40, 51, 53, 67, 68, 75, 79, 86, 96, 105, 109-111, 115, 28, 57	

Table B.5: Cost per kilo-watt for reliability worth

Type of load	**Interruption duration (minutes)**	**Cost ($/kW)**
Commercial	1	0.38
	20	2.97
	60	8.55
	240	31.32
	480	83.01
Industrial	1	1.63
	20	3.87
	60	9.09
	240	25.16
	480	55.81
Residential	1	0
	20	0.09
	60	0.48
	240	4.91
	480	15.69

Appendix C

DC-link Voltage and Indexes obtained

Table C.1: $index_1$ values obtained

$index_1$	Bus No.	$index_1$	Bus No.
ref bus	1		
0.129×10^{-3}	2	0.104×10^{-3}	18
0.676×10^{-3}	3	0.013×10^{-3}	19
0.696×10^{-3}	4	0.018×10^{-3}	20
0.866×10^{-3}	5	0.013×10^{-3}	21
1.349×10^{-3}	6	0.008×10^{-3}	22
0.678×10^{-3}	7	0.218×10^{-3}	23
0.701×10^{-3}	8	0.261×10^{-3}	24
0.595×10^{-3}	9	0.144×10^{-3}	25
0.592×10^{-3}	10	0.732×10^{-3}	26
0.542×10^{-3}	11	0.737×10^{-3}	27
0.506×10^{-3}	12	0.856×10^{-3}	28
0.481×10^{-3}	13	0.928×10^{-3}	29
0.425×10^{-3}	14	0.867×10^{-3}	30
0.291×10^{-3}	15	0.420×10^{-3}	31
0.233×10^{-3}	16	0.276×10^{-3}	32
0.170×10^{-3}	17	0.066×10^{-3}	33

Table C.2: $index_2$ values obtained

$index_2$	Bus No.	$index_2$	Bus No.
ref bus	1	0.00519×10^{-3}	18
0.00456×10^{-3}	2	0.0028×10^{-3}	19
0.00536×10^{-3}	3	0.00649×10^{-3}	20
0.00349×10^{-3}	4	0.00591×10^{-3}	21
0.00646×10^{-3}	5	0.00118×10^{-3}	22
0.00151×10^{-3}	6	0.00171×10^{-3}	23
0.00287×10^{-3}	7	0.01643×10^{-3}	24
0.00613×10^{-3}	8	0.00394×10^{-3}	25
0.00624×10^{-3}	9	0.00288×10^{-3}	26
0.00543×10^{-3}	10	0.00564×10^{-3}	27
0.00503×10^{-3}	11	0.00376×10^{-3}	28
0.0053×10^{-3}	12	0.00357×10^{-3}	29
0.01644×10^{-3}	13	0.04152×10^{-3}	30
0.00564×10^{-3}	14	0.00736×10^{-3}	31
0.00513×10^{-3}	15	0.00291×10^{-3}	32
0.00259×10^{-3}	16	0.00554×10^{-3}	33
0.00169×10^{-3}	17		

Table C.3: $index_3$ values obtained

$index_3$	Bus No.	$index_3$	Bus No.
ref bus	1	0.4462	61
0.3824	2	0.4462	62
0.1434	3	0.1912	63
0.8286	4	0.2390	64
0.2470	5	0.1513	65
0.3187	6	0.5976	66
0.2709	7	0.9721	67
0.2151	8	0.7091	68
0.1115	9	0.5577	69
0.4701	10	0.4701	70
0.3824	11	0.1434	71
0.2151	12	0.5816	72
0.2151	13	1.1235	73
0.2071	14	1.3944	74
0.1912	15	0.7729	75
0.0796	16	1.0517	76
0.0637	17	0.94820	77
0.3187	18	1.0916	78
0.7171	19	0.2788	79
0.8764	20	0.2549	80
0.8127	21	0.6533	81
0.3505	22	1.2509	82
0.3426	23	1.0199	83
0.3745	24	0.9641	84
0.2948	25	0.6215	85
0.1593	26	0.3984	86
0.0318	27	0.1992	87
0.3745	28	0.0637	88
0.7410	29	0.7250	89
0.9880	30	0.4462	90
1.1394	31	0.0637	91
1.0836	32	0.2390	92
1.1314	33	0.2310	93
0.8286	34	0.1513	94
0.4860	35	0.7330	95
0.3984	36	0.2549	96
0.9880	37	0.2231	97
0.8844	38	0.1434	98
0.4302	39	0.0557	99
0.2788	40	1.0996	100
0.5498	41	1.0597	101
0.7729	42	0.5737	102
1.2350	43	0.0637	103
0.9322	44	0.0796	104
0.6613	45	0.5498	105
0.1673	46	1.0756	106
0.1274	47	1.1872	107
0.0717	48	1.0677	108
0.2629	49	0.6454	109
0.2470	50	0.3346	110
1.09960	51	0.6932	111
1.3864	52	0.8127	112
1.1872	53	1.2191	113
0.3107	54	0.9163	114
0.5338	55	1.9203	115
0.4701	56	1.0996	116
0.2709	57	0.5418	117
0.2709	58	0.3505	118
0.2310	59		
0.5179	60		

Table C.4: DC-link voltage obtained for corresponding gain values

k_p	k_i	V_{dc}
25	21	1203.6
18	370	1214.2
47	58	1299.1
49	49	1311.9
13	149	1226.7
39	176	1280.8
11	11	1237.9
6	425	1268.1
44	359	1310.6
36	456	1274.6
37	261	1264.8
41	229	1268.7
50	179	1284.6
16	314	1218.2
16	113	1220.9
38	14	1272.5
47	468	1311.1
22	147	1208
22	297	1210.7
12	263	1229.6
30	313	1210.1
33	129	1201.4
18	164	1214.7
33	104	1203.5
16	447	1216.9

k_p	k_i	V_{dc}
22	206	1210.8
36	319	1279.6
5	263	1293.2
40	334	1282.9
49	86	1321.8
28	10	1203.5
24	210	1210.2
40	341	1289.9
46	184	1282.8
23	355	1210.8
49	358	1320.9
41	468	1324.1
20	489	1214.9
3	322	1334.7
14	113	1224.2
21	393	1213.7
36	312	1205.7
16	418	1219.2
8	266	1253.5
17	15	1216.7
24	378	1213.2
32	251	1204.6
42	483	1314.4
28	253	1210.3
40	55	1295.3

k_p	k_i	V_{dc}
27	222	1210.1
3	16	1374.7
7	400	1258.2
30	257	1208.6
5	498	1277.9
13	321	1225.3
38	126	1202.9
48	146	1326.6
28	166	1209.8
8	118	1259
11	346	1232
4	243	1314.8
5	338	1288.7
37	124	1201.1
15	403	1219.9
48	184	1285.8
22	387	1214.3
17	259	1219.5
28	78	1208.8
9	14	1254
33	27	1204.5
22	171	1207.4
11	81	1236.9
14	352	1221.5
12	179	1229.9

k_p	k_i	V_{dc}
10	117	1242.1
39	344	1274.8
34	435	1210.4
2	493	1349.4
4	32	1333.3
31	364	1213
40	105	1283.4
36	377	1283.3
33	278	1209.1
11	182	1234.3
16	225	1219.7
31	458	1210.9
31	446	1210.9
49	308	1291.7
16	307	1218.7
13	404	1225.1
6	366	1271.2
15	230	1220.4
11	112	1236.1
1	121	1486.8
41	309	1276.4
21	361	1213.8
44	342	1300.3
19	11	1211.9
40	358	1299.1

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List of Publications

From Thesis Work

A. SCIE Journals

1. **Sachin Kumar**, R.K. Saket, D.K. Dheer, J.B. Holm-Nielsen, P. Sanjeevikumar, "Reliability Enhancement of Electrical Power System Including Impacts of Renewable Energy Sources: A Comprehensive Review", IET Generation, Transmission & Distribution. Vol. 14, No. 10, pp. 1799–1815 (2020). doi: https://doi.org/10.1049/iet-gtd.2019.1402

2. **Sachin Kumar**, Kumari Sarita, R.K. Saket, Dharmendra Kumar Dheer, R.C. Bansal, Saad Mekhilef, "Reliability Assessment for DFIG-based WECS Considering the Impact of 3-phase Fault and Lightning Impulse Voltage", International Transactions on Electrical Energy Systems, Wiley, pp. 1-19, e12952 (2021). doi: https://doi.org/10.1002/2050-7038.12952

3. **Sachin Kumar**, Kumari Sarita, Akanksha S.S. Vardhan, Rajvikram Elavarasan, R.K. Saket, Narottam Das, "Reliability Assessment of Wind-Solar PV Integrated Distribution System using Electrical Loss Minimization Technique", Energies. Vol. 13, No. 21, pp. 1-30 (2020). doi: https://doi.org/10.3390/en13215631

4. **Sachin Kumar**, R.K. Saket, Dharmendra Kumar, P. Sanjeevikumar, Frede Blaabjerg, "Layout optimization algorithms and reliability assessment of wind farm for microgrid integration: a comprehensive review", IET Renewable Power Generation. Vol. 15, pp. 2063–2084, (2021). doi: https://doi.org/10.1049/rpg2.12060

5. **Sachin Kumar**, Kumari Sarita, R.K. Saket, Dharmendra Kumar Dheer, "Reliability assessment of optimally DG integrated distribution system based on power loss minimization", Electric Power Components and Systems, Taylor & Francis (Manuscript in Press)

Work with Research Team

A. Journals

1. Kumari Sarita, **Sachin Kumar**, R.K. Saket, "Open-Circuit Fault Diagnosis of Multilevel Converter using Entropy Features-based SVM Technique along with Two-Samples based Detection Algorithm", Computers & Electrical Engineering, Elsevier, Vol. 96, Part A, 107481 (2021), doi: https://doi.org/10.1016/j.compeleceng.2021.107481 **(SCIE)**

2. K.S. Anand Kumar, Kumari Sarita, **Sachin Kumar**, R.K. Saket, Akshay Swami, "Machine Learning-based Approach for Prevention of COVID-19 using Steam Vaporiser", GMSARN International Journal **(In Press) (Scopus Indexed)**

3. Kumari Sarita, **Sachin Kumar**, Aanchal Singh S. Vardhan, Rajvikram Madurai Elavarasan, R.K. Saket, G.M. Shafiullah, Eklas Hossain, "Power Enhancement With Grid Stabilization of Renewable Energy-Based Generation System Using UPQC-FLC-EVA Technique". IEEE Access, Vol. 8, pp. 207443-207464 (2020) doi: 10.1109/ACCESS.2020.3038313 **(SCIE)**

4. Lokesh Varshney, Aanchal Singh S. Vardhan, Akanksha Singh S. Vardhan, **Sachin Kumar**, R.K. Saket, Member, P. Sanjeevikumar, "Performance characteristics and reliability assessment of self-excited induction generator for wind power generation", IET Renewable Power Generation (2021), doi: https://doi.org/10.1049/rpg2.12116 **(SCIE)**

5. K.S. Anand Kumar, S.S. Aanchal Vardhan, S.S. Akanksha Vardhan, **Sachin Kumar**, R.K. Saket, R. Rajendran, S. Eslamian, "Microbial Fuel Cells for Soil Based Green Energy Conversion System", International Journal of Hydrology Science and Technology, Vol. 11, No. 4, pp 439-460 (2021) **(Scopus Indexed)**

6. KS Anand Kumar, **Sachin Kumar**, R.K. Saket, R. Rajendran, "Technological Aspects of Microbial Fuel Cells and Soil Based Green Energy Conversion System", GMSARN International Journal. Vol. 13, Issue 4, pp. 159-170 (2019) **(Scopus Indexed)**

7. Sanjay Kumar, K.S. Anand Kumar, **Sachin Kumar**, O.P. Bharti, Lokesh Varshney, R.K. Saket, D.N. Vishwakarma, "Probabilistic Evaluation and Design Aspects for Reliability Enhancement of Induction Motor", International Journal of Reliability & Safety. Vol. 13, No. 4, pp. 267-290 (2019) **(Scopus Indexed)**

8. M.S. Ghayad, N.M. Badra, M.A. Attia, A.Y. Abdelaziz, Sanjay Kumar, **Sachin Kumar**, R.K. Saket, "Gravitational Search and Sine Cosine Algorithms to Enhance the VSC-HVDC System Performance Under Different Disturbances," IEEE Xplore, pp. 1-7, (2019), doi: 10.1109/i-PACT44901.2019.8960216 **(Scopus Indexed)**

B. Book Chapters

1. **Sachin Kumar**, Aanchal Singh S. Vardhan, Akanksha Singh S. Vardhan, R.K. Saket, D.P. Kothari, S. Eslamian, "Hydropower and Floods", Taylor & Francis **(In Press)**

2. Mohamed Hamdy, Mahmoud A. Attia, Almoataz Y. Abdelaziz, **Sachin Kumar**, Kumari Sarita, R.K. Saket, "Performance enhancement of STATCOM integrated Wind Farm for harmonics mitigation using optimization techniques", Springer Lecture Notes in Networks and Systems 154, ICT Analysis and Applications, Proceedings of ICT4SD Goa India, Vol. 2, pp 507-516 (2020) doi: https://doi.org/10.1007/978-981-15-8354-4

3. Kumari Sarita, **Sachin Kumar**, R.K. Saket, "Fault Detection of Smart Grid Equipment Using Machine Learning and Data Analytics", Springer Lecture Notes in Electrical Engineering 693, Proceedings of International Conference on Emerging Trends for Smart Grid Automation and Industry 4.0, Jharkhand, India (2020), doi: 10.1007/978-981-15-7675-1

4. Mahmoud A. Attia, Mohamed Mokhtar, Almoataz Y. Abdelaziz, Suchetan Sasis, **Sachin Kumar**, R.K. Saket, "Optimal Controller Design for Automatic Generation Control Under Renewable Energy Disturbance", Springer Lecture Notes in Electrical Engineering 693, Proceedings of International Conference on Emerging Trends for Smart Grid Automation and Industry 4.0, Jharkhand, India (2020), doi: 10.1007/978-981-15-7675-1

C. Conferences

1. Mohamed Hamdy, Mahmoud A. Attia, Almoataz Y. Abdelaziz, **Sachin Kumar**, Kumari Sarita, R. K. Saket, "Performance enhancement of STATCOM integrated Wind Farm for harmonics mitigation using optimization techniques", ICT Analysis and Applications, Proceedings of ICT4SD Goa India (2020)

2. Kumari Sarita, **Sachin Kumar**, R.K. Saket, "Fault Detection of Smart Grid Equipment Using Machine Learning and Data Analytics", International Conference on Emerging Trends for Smart Grid Automation and Industry 4.0, BIT-Mesra, Ranchi, Jharkhand, India (2019)

3. Mahmoud A. Attia, Mohamed Mokhtar, Almoataz Y. Abdelaziz, Suchetan Sasis, **Sachin Kumar**, R.K. Saket, "Optimal controller design for Automatic Generation Control under Renewable Energy disturbance", International Conference on Emerging Trends for Smart Grid Automation and Industry 4.0, BIT-Mesra, Ranchi, Jharkhand, India (2019)

4. M.S. Ghayad, N.M. Badra, M.A. Attia, A.Y. Abdelaziz, Sanjay Kumar, **Sachin Kumar**, R.K. Saket, "Gravitational Search and Sine Cosine Algorithms to Enhance the VSC-HVDC System Performance Under Different Disturbances," 2019 Innovations in Power and Advanced Computing Technologies (i-PACT) Vellore, India (2019)