REFERENCE LIST

[1] *"IEEE Guide for the Application and Interpretation of Frequency Response Analysis for Oil-Immersed Transformers,"* IEEE Standard C57.149, 2012.

[2] *"Power transformers - Part 18: Measurement of frequency response,"* IEC 60076-18 Edition 1, 2012.

[3] Asif Islam et al. "Detection of Mechanical Deformation in Old Aged Power Transformer Using Cross Correlation Co-Efficient Analysis Method," *Energy Power Eng*. Vol. 3, No. 4, pp. 585-591, Sep. 2011.

[4] Sandeep Kumar et al. "Diagnosis of Power Transformer Through Sweep Frequency Response Analysis and Comparison Methods," presented at the XXXII National Systems Conference, Roorkee, Uttarakhand, December, 2008.

[5] Jitendra kumar and Dr.U.prasadr "Expert System for Sweep Frequency Response Analysis of Transformer Using MATLAB," *Int. J. Sci. Research Publications*, Vol. 2, pp. 674-686, Dec. 2012.

[6] Mohd Fairouz Bin Mohd Yousof, "Frequency Response Analysis for Transformer Winding Condition Monitoring," Ph.D. dissertation, School of Inform. Tec. Elect. Eng., Univ. Queensland, 2015.

[7] Alexander Kraetge et al. "Experiences with the Practical Application of Sweep Frequency Response Analysis (SFRA) on Power Transformers," in *Proc. 16th International Symp. on High Voltage Engineering*, 2009 © SAIEE, Innes House, Johannesburg.

[8] Shivangi Rai and Prof. N.P. Gupta "SFRA, Detect of Winding Deformation in Power Transformer," *IOSR J. Elect. Electron. Eng.*, Vol. 9, pp. 53-57, Nov./Dec. 2014.

[9] Dusan Cakmakov and Emilija Celakoska, "Estimation of Curve Similarity using Turning Functions," Dept. of Mathematics and Informatics, Faculty of Mechanical Eng., Univ. Ss. Cyril and Methodius, Skopje.

[10] "*IEEE Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers*," IEEE Standard C57.104, 2008.

[11] *"Mineral oil-impregnated electrical equipment in service – Guide to the interpretation of dissolved and free gases analysis,"* IEC 60599, Edition 2, 1999.

[12] Rohit Kumar Arora "Different DGA Techniques for Monitoring of Transformers," *Int. J. Electron. Elect. Eng*., Vol. 1, No. 4, pp. 299-303, Dec. 2013.

[13] Michel Duval "Calculation of DGA Limit Values and Sampling Intervals in Transformers in Service" *IEEE Electr. Insul. Mag.,* Vol. 24, No. 5, pp. 7-13, Sep./Oct. 2008.

[14] Ali Naderian Jahromi et al. "An Approach to Power Transformer Asset Management Using Health Index" *IEEE Electr. Insul. Mag.*, Vol. 25, No. 2, pp. 20-34, Mar./Apr. 2009.

[15] Leonidha Londo et al. "Hybrid Dissolved Gas in Oil Analysis Methods," *J. Power Energy Eng.,* Vol. 3, No. 6, pp. 10-19, Jun. 2015.

[16] Ian A.R. Gray "Practical Experience Gained from Dissolved Gas Analysis at an Aluminium Smelter," presented at Doble Eskom Annual International Conference, South Africa, 2010.

[17] "Serveron White Paper: DGA Diagnostic Methods," Serveron Corporation, A BPL Global Company, USA.

[18] N.K.Dhote and Dr. J.B.Helonde "Diagnosis of Power Transformer Faults based on Five Fuzzy Ratio Method," *WSEAS Trans. Power Syst.,* Vol. 7, pp. 114-125, Jul. 2012.

[19] Shubhangi S. Patil and Sushil E. Chaudhari "An Attempt to Investigate the Transformer Failure by using DGA and SFRA Analysis," *IEEE 10th International Conference on the Properties and Applications of Dielectric Materials*, 2012 © IEEE. doi: 10.1109/ICPADM.2012.6318985

APPENDICES

Appendix-A: Sample set of data of a SFRA measurement

No.	Frequency (Hz)	HV open circuit (dB)			HV short circuit (dB)			LV open circuit (dB)		
		R	Y	B	R	Y	B	R	Y	B
1	20	-30.5435	-34.5908	-32.8476	-10.8786	-10.8895	-10.8959	-18.4934	-21.1708	-19.6974
2	21	-30.7727	-34.8649	-33.0859	-10.9019	-10.9139	-10.9161	-18.9897	-21.6494	-20.0757
3	21	-31.0080	-35.1455	-33.3494	-10.9273	-10.9399	-10.9417	-19.3276	-21.9595	-20.3305
4	22	-31.2435	-35.4187	-33.6107	-10.9540	-10.9674	-10.9688	-19.5892	-22.2114	-20.5517
5	23	-31.4764	-35.6831	-33.8678	-10.9801	-10.9937	-10.9951	-19.8043	-22.4341	-20.7566
6	23	-31.7250	-35.9639	-34.1465	-11.0102	-11.0245	-11.0252	-20.0033	-22.6606	-20.9735
7	24	-31.9645	-36.2371	-34.4153	-11.0398	-11.0544	-11.0552	-20.1882	-22.8786	-21.1830
8	25	-32.1985	-36.5020	-34.6777	-11.0706	-11.0857	-11.0862	-20.3548	-23.0871	-21.3865
9	26	-32.4466	-36.7820	-34.9528	-11.1031	-11.1187	-11.1189	-20.5274	-23.3075	-21.6064
10	27	-32.6873	-37.0531	-35.2162	-11.1372	-11.1531	-11.1531	-20.6936	-23.5250	-21.8213
11	28	-32.9344	-37.3257	-35.4897	-11.1716	-11.1881	-11.1878	-20.8610	-23.7475	-22.0420
12	28	-33.1831	-37.6017	-35.7611	-11.2085	-11.2253	-11.2247	-21.0330	-23.9758	-22.2664
13	29	-33.4346	-37.8795	-36.0392	-11.2463	-11.2636	-11.2626	-21.2099	-24.2088	-22.4954
14	30	-33.6801	-38.1450	-36.3040	-11.2848	-11.3024	-11.3011	-21.3845	-24.4370	-22.7180
15	31	-33.9425	-38.4256	-36.5832	-11.3254	-11.3434	-11.3418	-21.5704	-24.6778	-22.9524
16	32	-34.1939	-38.6979	-36.8544	-11.3667	-11.3853	-11.3832	-21.7541	-24.9142	-23.1813
17	33	-34.4492	-38.9695	-37.1234	-11.4085	-11.4278	-11.4253	-21.9423	-25.1532	-23.4119
18	35	-34.7109	-39.2507	-37.4031	-11.4538	-11.4734	-11.4707	-22.1440	-25.4008	-23.6509
19	36	-34.9755	-39.5236	-37.6742	-11.4980	-11.5178	-11.5150	-22.3330	-25.6420	-23.8860
20	37	-35.2147	-39.8038	-37.9545	-11.5456	-11.5657	-11.5628	-22.5416	-25.8905	-24.1249
21	38	-35.4738	-40.0739	-38.2222	-11.5924	-11.6128	-11.6096	-22.7406	-26.1342	-24.3607
22	39	-35.7412	-40.3517	-38.5037	-11.6422	-11.6628	-11.6592	-22.9402	-26.3906	-24.6095
23	41	-36.0117	-40.6348	-38.7737	-11.6916	-11.7128	-11.7087	-23.1611	-26.6461	-24.8516
24	42	-36.2786	-40.9032	-39.0565	-11.7434	-11.7647	-11.7597	-23.3590	-26.9064	-25.1046
25	43	-36.5477	-41.1799	-39.3289	-11.7945	-11.8160	-11.8105	-23.5660	-27.1596	-25.3504
26	45	-36.7980	-41.4721	-39.6013	-11.8477	-11.8697	-11.8640	-23.7929	-27.4202	-25.5967
27	46	-37.0521	-41.7339	-39.8708	-11.8995	-11.9213	-11.9169	-24.0004	-27.6521	-25.8300
28	48	-37.3306	-42.0103	-40.1582	-11.9552	-11.9773	-11.9712	-24.2250	-27.9363	-26.0962
29	49	-37.5955	-42.2712	-40.4335	-12.0095	-12.0318	-12.0251	-24.4256	-28.1956	-26.3537
30	51	-37.8668	-42.5614	-40.7192	-12.0653	-12.0876	-12.0807	-24.6459	-28.4601	-26.6088
31	53	-38.1256	-42.8400	-40.9710	-12.1209	-12.1430	-12.1366	-24.8866	-28.7183	-26.8571
32	54	-38.3945	-43.1235	-41.2542	-12.1776	-12.1999	-12.1938	-25.1013	-28.9634	-27.1066
33	56	-38.6648	-43.4037	-41.5321	-12.2344	-12.2564	-12.2494	-25.3335	-29.2499	-27.3787
34	58	-38.9398	-43.6864	-41.8147	-12.2926	-12.3147	-12.3069	-25.5464	-29.5194	-27.6498
35	60	-39.2112	-43.9649	-42.0898	-12.3492	-12.3715	-12.3637	-25.7766	-29.7803	-27.9082
36	62	-39.4843	-44.2459	-42.3689	-12.4071	-12.4291	-12.4207	-26.0098	-30.0544	-28.1756
37	64	-39.7592	-44.5268	-42.6494	-12.4640	-12.4856	-12.4774	-26.2579	-30.3304	-28.4393
38	66	-40.0243	-44.8042	-42.9258	-12.5210	-12.5427	-12.5348	-26.4995	-30.5771	-28.6887
39	68	-40.3037	-45.0875	-43.2061	-12.5784	-12.6000	-12.5913	-26.7273	-30.8719	-28.9770
40	70	-40.5827	-45.3711	-43.4866	-12.6360	-12.6575	-12.6490	-26.9695	-31.1330	-29.2407
41	72	-40.8576	-45.6507	-43.7700	-12.6915	-12.7126	-12.7041	-27.2146	-31.3997	-29.5041
42	75	-41.1361	-45.9310	-44.0467	-12.7485	-12.7698	-12.7608	-27.4562	-31.6810	-29.7816
43	77	-41.4142	-46.2190	-44.3281	-12.8043	-12.8251	-12.8157	-27.7056	-31.9646	-30.0563
44	80	-41.6951	-46.5052	-44.6214	-12.8607	-12.8813	-12.8722	-27.9581	-32.2333	-30.3265
45	82	-41.9703	-46.7861	-44.8915	-12.9151	-12.9353	-12.9260	-28.2102	-32.5058	-30.5974
46	85	-42.2525	-47.0752	-45.1822	-12.9710	-12.9910	-12.9818	-28.4651	-32.7907	-30.8768
47	88	-42.5310	-47.3579	-45.4634	-13.0246	-13.0444	-13.0354	-28.7145	-33.0680	-31.1521
48	91	-42.8133	-47.6463	-45.7516	-13.0796	-13.0988	-13.0899	-28.9758	-33.3519	-31.4333
49	94	-43.0938	-47.9351	-46.0328	-13.1326	-13.1518	-13.1427	-29.2333	-33.6376	-31.7119
50	97	-43.3751	-48.2236	-46.3230	-13.1864	-13.2054	-13.1962	-29.4964	-33.9158	-31.9917

Appendix-B: Calculated ASLE

Region -1 (20 Hz – 2 kHz)

Item	Grid Substation	TR No.	ASLE (dB)								
			HV open circuit			HV short circuit			LV open circuit		
			R - Y	Y - B	B - R	R - Y	Y - B	B - R	R - Y	Y - B	B - R
1	Badulla	TR03	5.9918	2.7214	3.7002	0.0491	0.0357	0.0138	5.6120	2.8563	3.1992
2	Biyagama	TR03	2.9501	2.7818	0.2178	0.0533	0.0267	0.0799	3.6022	3.4154	0.2144
3	Biyagama	TR04	3.9125	4.0645	0.1903	0.0564	0.0869	0.1433	4.3495	4.3822	0.0450
4	Bolawattha	TR01	3.2165	2.9864	0.2945	0.0107	0.0409	0.0304	3.4434	3.1988	0.2967
5	Bolawattha	TR02	3.2633	2.6929	0.6522	0.0287	0.0167	0.0122	3.4275	2.9719	0.5091
6	Bolawattha	TR03	2.3549	3.7113	1.5405	0.0185	0.0097	0.0089	2.5127	3.8037	1.4069
7	Habarana	TR01	2.0603	3.2568	1.3477	0.0186	0.0629	0.0443	2.2126	3.3945	1.2487
8	Habarana	TR02	4.0879	4.0118	0.2122	0.0119	0.0456	0.0575	4.3776	4.2114	0.2191
9	Hambanthota	TR02	4.0620	3.6081	0.6059	0.0052	0.0794	0.0841	4.0552	4.5058	0.5711
10	Katunayake	TR02	0.8588	5.1333	4.4933	0.0224	0.0418	0.0195	0.9613	4.8145	4.0505
11	Kelaniya	TR01	3.2127	3.3701	0.1804	0.0129	0.0027	0.0130	3.1359	3.3972	0.3203
12	Kiribathkumbura	TR01	2.8422	2.9174	0.1685	0.0215	0.0590	0.0377	2.9524	3.1317	0.1967
13	Kiribathkumbura	TR02	2.7099	2.8575	0.2950	0.0390	0.0213	0.0177	2.9905	3.2178	0.2748
14	Kolonnawa	TR04	3.0675	2.8526	0.3515	0.1856	0.0032	0.1860	3.7442	3.4247	0.3766
15	Kolonnawa	TR05	3.0209	2.9388	0.3682	0.0634	0.1334	0.1967	3.3385	3.0062	0.3960
16	Mahiyangana	TR01	2.0861	5.7212	4.0386	0.0406	0.0101	0.0358	2.2737	5.4267	3.4874
17	Maho	TR02	3.4493	3.1147	0.3913	0.0461	0.0755	0.0294	3.5888	3.4945	0.1121
18	Monaragala	TR01	3.9146	4.5738	0.8487	0.0375	0.0132	0.0243	4.2632	4.8348	0.7333
19	Monaragala	TR02	4.9554	3.5565	1.7819	0.4911	0.4272	0.0726	5.1538	3.7721	1.7043
20	New Valachcheni	TR02	3.4089	3.5054	0.1376	0.0837	0.0113	0.0944	3.8263	3.7880	0.0512
21	Nuwara Eliya	TR01	3.6201	3.3840	0.2983	0.0281	0.0096	0.0197	4.0160	3.8336	0.2521
22	Nuwara Eliya	TR02	3.0554	3.3761	0.4501	0.0380	0.0627	0.0246	3.5175	3.8142	0.3553
23	Nuwara Eliya	TR03	4.4478	3.4700	1.2326	0.0498	0.0253	0.0750	4.6424	3.6428	1.1909
24	Old Anuradhapura	TR01	2.9953	3.0962	0.1600	0.0705	0.0427	0.1119	3.4620	3.4079	0.0800
25	Old Galle	TR01	2.8270	2.5716	0.2721	0.0185	0.0829	0.1004	2.8018	2.7515	0.2063
26	Old Galle	TR02	2.6519	2.6167	0.0708	0.1432	0.0512	0.0926	2.8486	2.7698	0.0959
27	Pannala	TR01	3.1918	2.8508	0.4030	0.0166	0.0282	0.0449	3.4906	3.2420	0.3131
28	Pannala	TR02	3.2692	2.4271	1.0009	0.0079	0.0551	0.0629	3.5422	2.8038	0.8415
29	Pannipitiya	TR03	3.6349	3.5431	0.1421	0.0524	0.0259	0.0779	4.0451	4.0745	0.1457
30	Sapugaskanda	TR01	3.6195	3.6341	0.1229	0.0240	0.0578	0.0816	4.2310	4.3037	0.0824
31	Sapugaskanda	TR03	1.7051	6.8047	5.5144	0.0181	0.0269	0.0091	1.7430	6.2790	4.9687
32	Sri Jayawardanapura	TR01	2.3031	3.3142	1.4913	0.0478	0.0975	0.0527	1.9428	2.9184	1.3586
33	Sri Jayawardanapura	TR02	2.8144	4.2385	2.0384	0.0691	0.1238	0.0550	6.8529	8.2274	2.1567
34	Thulhiriya	TR01	3.2108	3.2749	0.0768	0.0295	0.0398	0.0687	3.4212	3.4060	0.0283
35	Thulhiriya	TR02	3.2205	3.5938	0.4326	0.0178	0.0324	0.0500	3.4050	3.7215	0.3548
36	Trincomalee	TR01	1.9569	4.1554	2.4960	0.0561	0.0096	0.0469	2.1925	4.2154	2.1997
37	Trincomalee	TR02	3.1754	4.3941	1.4621	0.0062	0.0257	0.0318	3.4253	4.5437	1.2934
38	Valachchenei	TR01	2.9241	3.9763	1.2524	0.0781	0.0697	0.0193	3.1896	4.0860	1.0406
39	Valachchenei	TR02	3.0338	3.4401	0.4359	0.0306	0.1110	0.0803	3.3818	3.6051	0.2741
40	Valachchenei	TR03	2.8134	3.1309	0.3283	0.0608	0.0202	0.0408	3.1057	3.3225	0.2331
41	Vaunathiu	TR01	3.2625	4.3094	1.2436	0.0044	0.0396	0.0353	3.7096	4.5440	1.0250
42	Vaunathiu	TR02	3.9401	3.9912	0.1353	0.0217	0.0387	0.0604	4.3365	4.2933	0.0677
43	Veyangoda	TR02	2.6630	3.1809	0.6358	0.0038	0.0461	0.0491	2.8408	3.3521	0.5863
44	Veyangoda	TR03	2.5199	4.5159	2.3332	0.0040	0.0032	0.0043	2.5161	4.1152	1.9898

Region -2 (2 kHz – 20 kHz)

Item	Grid Substation	TR No.	ASLE (dB)								
			HV open circuit			HV short circuit			LV open circuit		
			R - Y	Y - B	B - R	R - Y	Y - B	B - R	R - Y	Y - B	B - R
1	Badulla	TR03	0.4414	0.4418	0.1674	0.3692	0.3645	0.2571	0.4486	0.3238	0.1254
2	Biyagama	TR03	1.7106	1.4594	0.2875	1.8565	1.8009	0.3919	1.6709	1.4636	0.2446
3	Biyagama	TR04	0.7565	0.6655	0.2774	0.9951	0.9000	0.4601	0.8118	0.7966	0.1020
4	Bolawattha	TR01	0.7834	0.9357	0.2158	1.3122	1.4079	0.2600	1.1590	0.7896	0.3904
5	Bolawattha	TR02	0.7894	0.8656	0.2673	1.2926	1.3998	0.2248	1.1984	0.8390	0.3857
6	Bolawattha	TR03	1.6160	1.4521	0.1862	1.7446	1.7218	0.1749	0.7956	0.6305	0.2887
7	Habarana	TR01	0.1626	0.1225	0.1305	0.2674	0.2744	0.1831	0.2595	0.2898	0.0768
8	Habarana	TR02	0.1413	0.2225	0.0965	0.2619	0.2717	0.1537	0.3252	0.2102	0.1170
9	Hambanthota	TR02	0.6352	0.6018	0.1224	0.7804	0.8070	0.1807	0.6555	0.5277	0.1346
10	Katunayake	TR02	0.5315	0.7326	0.2890	1.0454	1.0869	0.2275	0.6951	0.6047	0.2840
11	Kelaniya	TR01	0.9599	0.8597	0.1387	1.1426	1.0958	0.1819	0.3616	0.2733	0.2051
12	Kiribathkumbura	TR01	0.7155	0.8702	0.2276	1.2639	1.4356	0.2900	1.1529	0.8263	0.3558
13	Kiribathkumbura	TR02	0.8366	0.9975	0.2816	1.2905	1.4680	0.2772	1.1823	0.7677	0.4476
14	Kolonnawa	TR04	0.2925	0.4036	0.2797	0.5737	0.2489	0.6141	0.3403	0.5042	0.5498
15	Kolonnawa	TR05	0.3289	0.3903	0.3735	0.4387	0.6021	0.5827	0.4321	0.7849	0.5905
16	Mahiyangana	TR01	0.6228	0.5541	0.2411	0.9263	0.8344	0.1438	0.8978	0.8737	0.1637
17	Maho	TR02	0.8298	0.6112	0.2313	1.0556	0.9556	0.2006	0.6336	0.5550	0.0883
18	Monaragala	TR01	0.7883	0.5546	0.2898	0.9761	0.7620	0.2539	0.7595	0.7813	0.1373
19	Monaragala	TR02	0.7516	0.6019	0.3836	0.9725	0.7791	0.4536	0.7921	0.7443	0.0926
20	New Valachcheni	TR02	0.6790	0.5895	0.3765	1.0913	0.8077	0.4612	0.7300	0.7379	0.1002
21	Nuwara Eliya	TR01	0.3019	0.2855	0.1284	0.4379	0.3461	0.1976	0.2655	0.1697	0.1355
22	Nuwara Eliya	TR02	0.2640	0.3363	0.1331	0.4259	0.5077	0.1554	0.2374	0.1112	0.1860
23	Nuwara Eliya	TR03	0.8995	0.7023	0.2577	1.1746	0.9990	0.3174	0.7237	0.6421	0.0854
24	Old Anuradhapura	TR01	1.2949	0.9995	0.4302	1.6964	1.4346	0.6423	0.6800	0.5565	0.1644
25	Old Galle	TR01	0.2067	0.2363	0.1761	0.3546	0.3824	0.1905	0.2990	0.2966	0.1428
26	Old Galle	TR02	0.4798	0.2957	0.2641	0.3597	0.1250	0.3446	0.1833	0.2434	0.1537
27	Pannala	TR01	0.6176	0.5632	0.1413	0.9960	0.9902	0.1766	0.7563	0.5816	0.2374
28	Pannala	TR02	0.5293	0.5367	0.1003	0.9747	1.0125	0.2172	0.7817	0.5317	0.2793
29	Pannipitiya	TR03	1.2826	1.1038	0.4136	1.8367	1.6748	0.3759	0.9172	0.7746	0.2912
30	Sapugaskanda	TR01	0.6026	0.4932	0.1269	0.6924	0.6763	0.1156	1.1921	1.0776	0.1259
31	Sapugaskanda	TR03	1.1015	1.1593	0.2437	1.3037	1.3758	0.1630	0.6510	0.4118	0.3207
32	Sri Jayawardanapura	TR01	0.8857	0.7179	0.4396	0.9065	0.7488	0.2629	0.2694	0.3361	0.3211
33	Sri Jayawardanapura	TR02	1.0267	0.8375	0.4504	1.0890	0.9061	0.3131	5.0836	5.1142	0.2913
34	Thulhiriya	TR01	0.4280	0.5365	0.1210	0.6440	0.6380	0.2323	0.3825	0.3398	0.0532
35	Thulhiriya	TR02	0.3618	0.4206	0.1011	0.5588	0.5336	0.1960	0.3992	0.3791	0.0626
36	Trincomalee	TR01	0.2010	0.1079	0.1289	0.4121	0.2076	0.2673	0.1881	0.2409	0.1151
37	Trincomalee	TR02	0.1420	0.1711	0.0560	0.2277	0.2358	0.0868	0.2278	0.2001	0.0355
38	Valachchenei	TR01	1.5703	1.2990	0.6874	2.3060	1.9032	0.5543	1.4269	1.2262	0.5303
39	Valachchenei	TR02	1.7188	1.3844	0.6319	2.4383	2.1430	0.5812	1.6564	1.2092	0.6490
40	Valachchenei	TR03	1.4844	1.2661	0.4428	2.2868	2.0879	0.4167	1.6650	1.2406	0.6109
41	Vaunathiu	TR01	0.6276	0.5390	0.1509	0.9172	0.8646	0.1505	0.9168	0.8506	0.1458
42	Vaunathiu	TR02	0.8421	0.7233	0.2905	1.0414	0.9302	0.3286	0.7398	0.7430	0.0945
43	Veyangoda	TR02	1.6830	1.3270	0.4253	1.7631	1.6722	0.4263	0.9477	0.7888	0.2522
44	Veyangoda	TR03	1.6913	1.4844	0.2438	1.7640	1.6905	0.2819	0.7257	0.3979	0.7167

Region -3 (20 kHz – 400 kHz)

Item	Grid Substation	TR No.	ASLE (dB)								
			HV open circuit			HV short circuit			LV open circuit		
			R - Y	Y - B	B - R	R - Y	Y - B	B - R	R - Y	Y - B	B - R
1	Badulla	TR03	0.8254	1.4101	1.0628	0.7370	1.5574	1.6153	1.0988	1.0461	0.8795
2	Biyagama	TR03	0.7940	0.9632	1.3423	0.9038	1.1832	1.0686	2.5131	2.5886	1.1225
3	Biyagama	TR04	0.5457	0.3198	0.8015	0.5987	0.3787	0.7448	0.8557	1.0170	1.0659
4	Bolawattha	TR01	1.4850	1.2426	1.6514	1.6221	1.2237	1.6935	0.5940	0.8748	0.6814
5	Bolawattha	TR02	1.6407	1.2490	1.8079	1.6580	1.1831	1.8968	0.6675	0.8704	0.5628
6	Bolawattha	TR03	0.4367	0.5702	0.6050	0.5818	0.6008	0.5897	0.8735	0.6777	0.7051
7	Habarana	TR01	0.4600	0.4743	0.4181	0.5251	0.5555	0.3449	1.4728	1.2537	0.7223
8	Habarana	TR02	0.4599	0.4297	0.5199	0.5752	0.4507	0.3891	1.3460	0.6911	0.9554
9	Hambanthota	TR02	0.5023	0.5212	0.5998	0.5318	0.5324	0.5168	0.9426	0.7755	0.3384
10	Katunayake	TR02	0.2619	0.3503	0.4288	0.2840	0.3622	0.3850	0.9970	1.3347	0.4694
11	Kelaniya	TR01	0.5510	0.7775	0.9203	0.6509	0.9489	0.9186	1.5259	0.8344	0.8534
12	Kiribathkumbura	TR01	1.4319	1.1340	1.8098	1.5220	1.1041	1.8480	0.7152	0.7844	0.4995
13	Kiribathkumbura	TR02	1.3965	1.2328	1.7337	1.4519	1.2469	1.7953	1.2054	0.9865	0.5511
14	Kolonnawa	TR04	0.7898	0.6439	0.5793	1.2359	0.5274	1.2817	5.1964	0.6128	4.9437
15	Kolonnawa	TR05	0.5234	0.4915	0.4176	0.3583	1.2229	1.0178	0.5578	4.4342	4.2336
16	Mahiyangana	TR01	0.4236	0.4216	0.7139	0.4711	0.4367	0.5648	0.8966	0.8006	0.3653
17	Maho	TR02	0.5157	0.5298	0.5232	0.5961	0.6103	0.4567	0.8212	0.9870	0.8823
18	Monaragala	TR01	0.6711	0.2989	0.7544	0.7090	0.4019	0.5968	0.7768	0.7330	0.4721
19	Monaragala	TR02	0.7692	0.3683	1.0604	0.7518	0.4596	0.8519	1.2169	0.6182	1.1686
20	New Valachcheni	TR02	0.7991	0.4282	1.0264	0.8523	0.4934	0.8938	0.7252	0.7505	0.7154
21	Nuwara Eliya	TR01	0.7481	0.4896	0.5681	0.8170	0.7462	0.4369	1.0799	1.0439	0.8826
22	Nuwara Eliya	TR02	0.7023	0.4113	0.5051	0.7944	0.7019	0.3528	1.1851	1.0490	0.9064
23	Nuwara Eliya	TR03	0.4848	0.5637	0.7572	0.4598	0.6176	0.6201	0.9724	0.9568	0.7344
24	Old Anuradhapura	TR01	0.9177	0.5691	1.0105	0.8803	0.7032	1.1015	1.0611	0.9870	1.5175
25	Old Galle	TR01	0.2816	0.4331	0.4652	0.2251	0.3654	0.3866	0.4368	0.5385	0.2999
26	Old Galle	TR02	0.2668	0.3011	0.3527	0.2047	0.2617	0.2889	0.2917	0.3037	0.3061
27	Pannala	TR01	0.3505	0.3451	0.2986	0.3979	0.4059	0.2374	0.5467	0.8253	0.4798
28	Pannala	TR02	0.2993	0.2638	0.4475	0.2478	0.3094	0.4256	0.8946	0.8950	1.3085
29	Pannipitiya	TR03	0.6350	0.7296	1.0026	0.6912	0.8411	0.8078	1.3997	1.1545	1.1765
30	Sapugaskanda	TR01	0.7543	0.6611	0.8009	0.5760	0.4274	0.6621	2.1486	1.9415	0.8876
31	Sapugaskanda	TR03	0.7047	0.6248	0.9448	0.7029	0.6177	0.7379	1.2790	0.9235	0.6866
32	Sri Jayawardanapura	TR01	0.8772	0.8527	0.8256	0.8840	0.8527	0.8374	0.5258	0.7288	0.6470
33	Sri Jayawardanapura	TR02	0.7170	0.8139	0.8950	0.7167	0.8105	0.8901	1.6892	1.7522	0.4803
34	Thulhiriya	TR01	1.0236	0.6015	0.7510	0.8420	0.6633	0.6011	2.2324	1.3209	1.0963
35	Thulhiriya	TR02	0.8573	0.6279	0.7242	0.7166	0.6248	0.5301	2.1952	1.2567	1.2415
36	Trincomalee	TR01	0.5347	0.4348	0.5384	0.6148	0.4395	0.5051	1.6596	0.6007	1.5564
37	Trincomalee	TR02	0.4179	0.4317	0.4591	0.4208	0.4663	0.4530	0.9401	0.6192	0.9565
38	Valachchenei	TR01	2.6943	2.8669	4.4248	2.8208	2.9523	4.4427	1.9698	1.2456	1.2818
39	Valachchenei	TR02	2.3313	3.0199	4.2955	2.5516	3.1965	4.4765	1.8232	1.1747	1.1385
40	Valachchenei	TR03	2.4451	2.9026	4.3223	2.5106	3.0960	4.4038	1.7003	1.1704	1.2161
41	Vaunathiu	TR01	0.4337	0.4027	0.7370	0.4535	0.5048	0.5708	0.7428	1.1074	0.6825
42	Vaunathiu	TR02	0.6445	0.3874	0.9077	0.6798	0.4304	0.7892	0.9429	0.7175	0.6077
43	Veyangoda	TR02	0.9278	0.9533	1.4070	1.0055	1.2038	1.1113	1.1939	0.9214	0.8992
44	Veyangoda	TR03	0.9100	0.8663	1.2667	0.9670	1.1830	1.0884	1.6054	2.2377	1.7507

Region -4 (400 kHz – 2 MHz)

Item	Grid Substation	TR No.	ASLE (dB)								
			HV open circuit			HV short circuit			LV open circuit		
			R - Y	Y - B	B - R	R - Y	Y - B	B - R	R - Y	Y - B	B - R
1	Badulla	TR03	0.7706	1.4386	1.9229	0.8524	1.3264	2.0126	3.4637	4.5424	1.7813
2	Biyagama	TR03	0.9071	0.9644	1.1224	0.8240	0.9726	1.0605	4.1579	2.7352	3.0028
3	Biyagama	TR04	1.2175	1.8484	2.4801	1.2253	1.7014	2.4376	3.2854	3.9997	1.1231
4	Bolawattha	TR01	1.4296	1.8364	2.4841	1.4056	1.7916	2.4286	3.8379	4.3189	2.1505
5	Bolawattha	TR02	1.2838	1.8694	2.0859	1.2636	1.8210	2.0474	4.6677	3.1650	1.9187
6	Bolawattha	TR03	2.3778	3.2268	3.5133	2.3340	3.1469	3.3411	3.2757	1.4444	2.4541
7	Habarana	TR01	1.2868	1.4956	2.6713	1.2845	1.4892	2.6417	4.8984	3.4836	3.1711
8	Habarana	TR02	1.1759	1.5819	2.6006	1.1761	1.5930	2.5856	5.3469	4.8697	3.3982
9	Hambanthota	TR02	1.2129	1.0266	2.1229	0.9381	1.2456	2.0489	2.8262	2.8920	1.3173
10	Katunayake	TR02	0.6647	1.7628	2.2579	0.6849	1.7244	2.2394	3.7378	3.8232	1.8037
11	Kelaniya	TR01	6.0702	6.1653	1.8794	6.1180	6.1870	1.8427	2.7809	1.5657	1.5257
12	Kiribathkumbura	TR01	1.2877	1.7991	2.2352	1.2693	1.7552	2.1971	3.4217	3.8802	1.9466
13	Kiribathkumbura	TR02	1.3467	1.7181	2.2798	1.3206	1.6794	2.2367	4.9382	4.9238	0.9207
14	Kolonnawa	TR04	1.3277	0.7353	1.5549	1.3364	0.7453	1.5269	2.4602	2.1633	2.0459
15	Kolonnawa	TR05	1.2755	1.1456	2.1355	1.2720	1.1625	2.1234	2.5167	3.1476	1.9399
16	Mahiyangana	TR01	1.4835	2.4520	3.5925	1.5892	2.2534	3.5201	3.5865	4.4859	1.6007
17	Maho	TR02	1.2721	2.5203	3.0709	1.2592	2.2855	2.9522	2.5866	4.3107	2.6128
18	Monaragala	TR01	1.3748	1.7313	2.1431	1.3698	1.6178	2.0962	3.6018	4.8683	1.9066
19	Monaragala	TR02	1.7100	1.9083	2.1727	1.8781	1.5834	2.1266	3.4307	4.1523	1.3944
20	New Valachcheni	TR02	1.4959	1.7738	2.3904	1.3842	1.6701	2.3433	3.4727	4.1714	1.1900
21	Nuwara Eliya	TR01	1.1231	0.7027	0.9864	1.1363	0.7227	0.9721	5.3118	3.3611	4.8573
22	Nuwara Eliya	TR02	0.9702	0.7194	0.8839	1.0761	0.7198	0.9316	5.8556	3.3994	4.9825
23	Nuwara Eliya	TR03	1.5377	2.2396	3.3345	1.6285	2.0040	3.2093	4.4972	4.5950	1.5550
24	Old Anuradhapura	TR01	4.5924	1.5037	5.8694	4.6438	1.4451	5.8588	4.9861	2.7091	4.8205
25	Old Galle	TR01	0.3158	0.9746	0.9907	0.3373	0.9691	1.0285	0.9865	0.8691	0.7917
26	Old Galle	TR02	0.4991	0.3158	0.6944	0.5052	0.3665	0.7167	0.7499	0.8936	1.2385
27	Pannala	TR01	7.7741	8.2226	2.5464	7.6857	7.9899	2.5439	1.0643	3.0188	2.5015
28	Pannala	TR02	0.6356	1.8902	2.3306	0.6602	1.8513	2.3045	0.8720	3.7323	2.9928
29	Pannipitiya	TR03	0.9511	1.0213	1.7402	0.9420	0.9986	1.6747	4.8589	2.0440	4.4780
30	Sapugaskanda	TR01	2.4248	1.9014	3.1436	2.4335	1.7894	3.2240	5.8004	3.1182	3.3141
31	Sapugaskanda	TR03	1.8159	2.5876	2.4142	1.7407	2.6515	2.4484	5.0918	1.7565	4.5693
32	Sri Jayawardanapura	TR01	1.6536	2.0490	3.5742	1.6920	2.0557	3.5870	4.5401	9.0490	6.5456
33	Sri Jayawardanapura	TR02	2.1427	2.0174	3.6482	2.1281	2.0174	3.6201	4.5444	5.0565	6.1806
34	Thulhiriya	TR01	0.4549	0.7835	0.9961	0.4591	0.7192	0.9655	4.8660	2.8139	3.1233
35	Thulhiriya	TR02	0.5849	0.4516	0.9808	0.5969	0.4125	0.9384	5.2167	1.7861	4.2353
36	Trincomalee	TR01	1.2805	1.5222	2.6527	1.2873	1.5241	2.6365	4.7916	3.3126	3.4260
37	Trincomalee	TR02	1.4756	1.2547	2.6446	1.4509	1.2104	2.5182	5.3394	3.8979	3.3611
38	Valachchenei	TR01	0.7839	0.6368	1.2968	0.8156	0.6047	1.2946	4.8685	4.9956	1.2619
39	Valachchenei	TR02	0.6670	0.9271	1.1006	0.6793	0.9015	1.1066	4.3883	4.7049	0.5529
40	Valachchenei	TR03	0.3527	0.7189	0.8262	0.4627	0.6945	0.9760	3.8307	4.0675	1.2741
41	Vaunathiu	TR01	0.9152	1.6907	2.2159	0.9973	1.5107	2.1548	3.2588	4.6634	1.7299
42	Vaunathiu	TR02	1.3447	1.9761	2.4904	1.3297	1.8132	2.4149	4.0581	5.0723	1.4455
43	Veyangoda	TR02	0.9643	1.0132	1.1001	0.9267	1.0055	1.0531	4.1055	2.0966	3.1783
44	Veyangoda	TR03	1.0603	1.0528	1.2214	0.9975	1.0542	1.1654	4.5957	2.4748	3.4309

Appendix-C: Calculated CCF values

Region -1 (20 Hz – 2 kHz)

Item	Grid Substation	TR No.	Cross Correlation Coefficient (CCF)								
			HV open circuit			HV short circuit			LV open circuit		
			R - Y	Y - B	B - R	R - Y	Y - B	B - R	R - Y	Y - B	B - R
1	Badulla	TR03	0.8707	0.9666	0.9420	1.0000	1.0000	1.0000	0.8802	0.9433	0.9539
2	Biyagama	TR03	0.9302	0.9371	0.9994	1.0000	1.0000	1.0000	0.8822	0.8886	0.9996
3	Biyagama	TR04	0.9311	0.9256	0.9997	1.0000	1.0000	1.0000	0.8900	0.8901	1.0000
4	Bolawattha	TR01	0.9075	0.9201	0.9989	1.0000	1.0000	1.0000	0.8794	0.8882	0.9990
5	Bolawattha	TR02	0.9053	0.9342	0.9958	1.0000	1.0000	1.0000	0.8848	0.9026	0.9974
6	Bolawattha	TR03	0.9538	0.8897	0.9779	1.0000	1.0000	1.0000	0.9279	0.8836	0.9840
7	Habarana	TR01	0.9661	0.9196	0.9845	1.0000	1.0000	1.0000	0.9458	0.9134	0.9889
8	Habarana	TR02	0.8752	0.8793	0.9995	1.0000	1.0000	1.0000	0.8366	0.8418	0.9995
9	Hambanthota	TR02	0.8908	0.9095	0.9964	1.0000	1.0000	1.0000	0.8570	0.8478	0.9971
10	Katunayake	TR02	0.9950	0.8798	0.9015	1.0000	1.0000	1.0000	0.9892	0.9059	0.9325
11	Kelaniya	TR01	0.9186	0.9105	0.9996	1.0000	1.0000	1.0000	0.8993	0.8900	0.9991
12	Kiribathkumbura	TR01	0.9295	0.9256	0.9997	1.0000	1.0000	1.0000	0.9057	0.8999	0.9996
13	Kiribathkumbura	TR02	0.9322	0.9255	0.9994	1.0000	1.0000	1.0000	0.8986	0.8924	0.9994
14	Kolonnawa	TR04	0.9044	0.9163	0.9983	1.0000	1.0000	1.0000	0.8387	0.8496	0.9988
15	Kolonnawa	TR05	0.9109	0.9137	0.9979	1.0000	1.0000	1.0000	0.8834	0.8962	0.9986
16	Mahiyangana	TR01	0.9768	0.8640	0.9220	1.0000	1.0000	1.0000	0.9579	0.8716	0.9429
17	Maho	TR02	0.9180	0.9328	0.9987	1.0000	1.0000	1.0000	0.8988	0.9012	0.9999
18	Monaragala	TR01	0.9201	0.8980	0.9952	1.0000	1.0000	1.0000	0.8729	0.8660	0.9961
19	Monaragala	TR02	0.8861	0.9322	0.9791	0.9904	0.9905	1.0000	0.8687	0.8881	0.9825
20	New Valachcheni	TR02	0.9327	0.9287	0.9998	1.0000	1.0000	1.0000	0.8990	0.8994	1.0000
21	Nuwara Eliya	TR01	0.8816	0.8946	0.9990	1.0000	1.0000	1.0000	0.8272	0.8304	0.9992
22	Nuwara Eliya	TR02	0.9153	0.8985	0.9975	1.0000	1.0000	1.0000	0.8526	0.8446	0.9987
23	Nuwara Eliya	TR03	0.8612	0.9117	0.9853	1.0000	1.0000	1.0000	0.8373	0.8723	0.9877
24	Old Anuradhapura	TR01	0.9256	0.9207	0.9997	1.0000	1.0000	1.0000	0.8763	0.8772	0.9999
25	Old Galle	TR01	0.9197	0.9334	0.9992	1.0000	1.0000	1.0000	0.9108	0.9151	0.9999
26	Old Galle	TR02	0.9259	0.9279	0.9999	1.0000	1.0000	1.0000	0.9086	0.9122	0.9999
27	Pannala	TR01	0.9067	0.9242	0.9982	1.0000	1.0000	1.0000	0.8716	0.8776	0.9988
28	Pannala	TR02	0.9064	0.9452	0.9896	1.0000	1.0000	1.0000	0.8839	0.9049	0.9933
29	Pannipitiya	TR03	0.9030	0.9055	0.9998	1.0000	1.0000	1.0000	0.8490	0.8450	0.9982
30	Sapugaskanda	TR01	0.9363	0.9366	0.9999	1.0000	1.0000	1.0000	0.8961	0.8945	1.0000
31	Sapugaskanda	TR03	0.9790	0.7128	0.7924	1.0000	1.0000	1.0000	0.9635	0.7576	0.8312
32	Sri Jayawardanapura	TR01	0.9471	0.8853	0.9642	1.0000	1.0000	1.0000	0.9530	0.9113	0.9815
33	Sri Jayawardanapura	TR02	0.9212	0.8316	0.9368	1.0000	1.0000	1.0000	0.6769	0.5516	0.9576
34	Thulhiriya	TR01	0.9301	0.9276	0.9999	1.0000	1.0000	1.0000	0.9067	0.9066	1.0000
35	Thulhiriya	TR02	0.9276	0.9119	0.9985	1.0000	1.0000	1.0000	0.9015	0.8925	0.9991
36	Trincomalee	TR01	0.9683	0.8753	0.9480	1.0000	1.0000	1.0000	0.9438	0.8773	0.9647
37	Trincomalee	TR02	0.9185	0.8515	0.9797	1.0000	1.0000	1.0000	0.8798	0.8344	0.9851
38	Valachchenei	TR01	0.9289	0.8772	0.9857	1.0000	1.0000	1.0000	0.8846	0.8600	0.9904
39	Valachchenei	TR02	0.9258	0.9064	0.9983	1.0000	1.0000	1.0000	0.8853	0.8799	0.9995
40	Valachchenei	TR03	0.9335	0.9189	0.9991	1.0000	1.0000	1.0000	0.8998	0.8938	0.9996
41	Vaunathiu	TR01	0.9443	0.9137	0.9917	1.0000	1.0000	1.0000	0.9002	0.8916	0.9933
42	Vaunathiu	TR02	0.9204	0.9181	0.9997	1.0000	1.0000	1.0000	0.8809	0.8817	1.0000
43	Veyangoda	TR02	0.9420	0.9202	0.9960	1.0000	1.0000	1.0000	0.9156	0.9026	0.9973
44	Veyangoda	TR03	0.9484	0.8547	0.9546	1.0000	1.0000	1.0000	0.9211	0.8814	0.9691

Region -2 (2 kHz – 20 kHz)

Item	Grid Substation	TR No.	Cross Correlation Coefficient (CCF)								
			HV open circuit			HV short circuit			LV open circuit		
			R - Y	Y - B	B - R	R - Y	Y - B	B - R	R - Y	Y - B	B - R
1	Badulla	TR03	0.9992	0.9990	0.9993	0.9973	0.9975	0.9979	0.9991	0.9995	0.9999
2	Biyagama	TR03	0.9056	0.9312	0.9951	0.8728	0.8799	0.9936	0.9549	0.9680	0.9961
3	Biyagama	TR04	0.9823	0.9892	0.9969	0.9633	0.9748	0.9980	0.9894	0.9914	0.9997
4	Bolawattha	TR01	0.9705	0.9618	0.9987	0.9332	0.9237	0.9975	0.9572	0.9767	0.9964
5	Bolawattha	TR02	0.9747	0.9650	0.9983	0.9352	0.9225	0.9975	0.9566	0.9784	0.9953
6	Bolawattha	TR03	0.8998	0.9136	0.9983	0.8752	0.8756	0.9985	0.9807	0.9911	0.9969
7	Habarana	TR01	0.9997	0.9997	0.9998	0.9981	0.9989	0.9991	0.9992	0.9991	0.9999
8	Habarana	TR02	0.9997	0.9994	0.9999	0.9982	0.9985	0.9998	0.9989	0.9995	0.9998
9	Hambanthota	TR02	0.9815	0.9811	0.9995	0.9683	0.9655	0.9993	0.9951	0.9969	0.9997
10	Katunayake	TR02	0.9901	0.9887	0.9993	0.9642	0.9653	0.9986	0.9887	0.9949	0.9980
11	Kelaniya	TR01	0.9634	0.9721	0.9992	0.9409	0.9430	0.9986	0.9961	0.9984	0.9989
12	Kiribathkumbura	TR01	0.9793	0.9698	0.9973	0.9382	0.9264	0.9956	0.9576	0.9791	0.9951
13	Kiribathkumbura	TR02	0.9621	0.9506	0.9974	0.9264	0.9093	0.9953	0.9579	0.9808	0.9944
14	Kolonnawa	TR04	0.9981	0.9970	0.9937	0.9969	0.9977	0.9935	0.9964	0.9885	0.9767
15	Kolonnawa	TR05	0.9989	0.9899	0.9940	0.9936	0.9787	0.9938	0.9935	0.9537	0.9542
16	Mahiyangana	TR01	0.9831	0.9899	0.9981	0.9673	0.9742	0.9988	0.9884	0.9915	0.9997
17	Maho	TR02	0.9755	0.9856	0.9979	0.9536	0.9674	0.9985	0.9895	0.9927	0.9995
18	Monaragala	TR01	0.9788	0.9875	0.9968	0.9617	0.9753	0.9973	0.9896	0.9914	0.9998
19	Monaragala	TR02	0.9797	0.9909	0.9928	0.9619	0.9811	0.9947	0.9896	0.9913	0.9998
20	New Valachcheni	TR02	0.9768	0.9860	0.9942	0.9581	0.9746	0.9963	0.9896	0.9907	0.9998
21	Nuwara Eliya	TR01	0.9964	0.9943	0.9994	0.9942	0.9952	0.9991	0.9976	0.9998	0.9978
22	Nuwara Eliya	TR02	0.9970	0.9948	0.9996	0.9948	0.9932	0.9996	0.9980	1.0000	0.9983
23	Nuwara Eliya	TR03	0.9668	0.9798	0.9962	0.9382	0.9561	0.9971	0.9885	0.9912	0.9998
24	Old Anuradhapura	TR01	0.9403	0.9646	0.9921	0.8883	0.9134	0.9850	0.9919	0.9953	0.9989
25	Old Galle	TR01	0.9993	0.9982	0.9995	0.9975	0.9974	0.9997	0.9968	0.9975	0.9999
26	Old Galle	TR02	0.9976	0.9985	0.9990	0.9980	0.9998	0.9983	0.9997	0.9988	0.9995
27	Pannala	TR01	0.9896	0.9894	0.9996	0.9710	0.9725	0.9994	0.9866	0.9936	0.9981
28	Pannala	TR02	0.9902	0.9890	0.9998	0.9721	0.9713	0.9997	0.9869	0.9945	0.9980
29	Pannipitiya	TR03	0.9359	0.9467	0.9945	0.8799	0.8977	0.9949	0.9842	0.9917	0.9971
30	Sapugaskanda	TR01	0.9897	0.9931	0.9996	0.9820	0.9840	0.9999	0.9871	0.9902	0.9996
31	Sapugaskanda	TR03	0.9595	0.9624	0.9988	0.9380	0.9282	0.9987	0.9873	0.9956	0.9971
32	Sri Jayawardanapura	TR01	0.9904	0.9941	0.9986	0.9783	0.9875	0.9978	0.9990	0.9987	0.9979
33	Sri Jayawardanapura	TR02	0.9831	0.9902	0.9982	0.9609	0.9781	0.9964	0.7532	0.7463	0.9993
34	Thulhiriya	TR01	0.9944	0.9930	0.9995	0.9843	0.9876	0.9994	0.9983	0.9987	1.0000
35	Thulhiriya	TR02	0.9966	0.9955	0.9998	0.9887	0.9916	0.9994	0.9982	0.9985	1.0000
36	Trincomalee	TR01	0.9990	0.9996	0.9998	0.9958	0.9989	0.9987	0.9996	0.9994	0.9998
37	Trincomalee	TR02	0.9998	0.9996	0.9999	0.9983	0.9988	0.9999	0.9994	0.9996	1.0000
38	Valachchenei	TR01	0.9423	0.9661	0.9875	0.8552	0.9042	0.9879	0.9517	0.9690	0.9905
39	Valachchenei	TR02	0.9395	0.9639	0.9911	0.8297	0.8762	0.9896	0.9435	0.9683	0.9887
40	Valachchenei	TR03	0.9547	0.9688	0.9947	0.8658	0.8873	0.9926	0.9420	0.9663	0.9884
41	Vaunathiu	TR01	0.9861	0.9900	0.9993	0.9691	0.9746	0.9994	0.9874	0.9910	0.9996
42	Vaunathiu	TR02	0.9757	0.9836	0.9960	0.9500	0.9626	0.9971	0.9888	0.9906	0.9998
43	Veyangoda	TR02	0.9124	0.9466	0.9918	0.8830	0.8993	0.9894	0.9802	0.9895	0.9966
44	Veyangoda	TR03	0.9136	0.9340	0.9967	0.8835	0.8926	0.9960	0.9853	0.9980	0.9896

Region -3 (20 kHz – 400 kHz)

Item	Grid Substation	TR No.	Cross Correlation Coefficient (CCF)								
			HV open circuit			HV short circuit			LV open circuit		
			R - Y	Y - B	B - R	R - Y	Y - B	B - R	R - Y	Y - B	B - R
1	Badulla	TR03	0.9654	0.9313	0.9777	0.9825	0.9220	0.9311	0.9668	0.9672	0.9775
2	Biyagama	TR03	0.9817	0.9760	0.9608	0.9710	0.9654	0.9671	0.8649	0.8493	0.9716
3	Biyagama	TR04	0.9959	0.9989	0.9921	0.9946	0.9979	0.9945	0.9668	0.9765	0.9693
4	Bolawattha	TR01	0.9551	0.9672	0.9250	0.9541	0.9707	0.9269	0.9920	0.9782	0.9897
5	Bolawattha	TR02	0.9284	0.9518	0.9171	0.9432	0.9634	0.9243	0.9910	0.9804	0.9923
6	Bolawattha	TR03	0.9912	0.9952	0.9893	0.9901	0.9950	0.9941	0.9828	0.9826	0.9854
7	Habarana	TR01	0.9951	0.9933	0.9970	0.9938	0.9921	0.9986	0.9447	0.9515	0.9838
8	Habarana	TR02	0.9952	0.9935	0.9965	0.9946	0.9934	0.9987	0.9622	0.9859	0.9816
9	Hambanthota	TR02	0.9939	0.9913	0.9938	0.9918	0.9927	0.9944	0.9771	0.9825	0.9964
10	Katunayake	TR02	0.9989	0.9977	0.9964	0.9987	0.9974	0.9968	0.9713	0.9473	0.9901
11	Kelaniya	TR01	0.9928	0.9921	0.9884	0.9873	0.9867	0.9891	0.9200	0.9651	0.9813
12	Kiribathkumbura	TR01	0.9605	0.9698	0.9261	0.9616	0.9724	0.9292	0.9865	0.9802	0.9937
13	Kiribathkumbura	TR02	0.9570	0.9721	0.9307	0.9596	0.9743	0.9338	0.9675	0.9678	0.9938
14	Kolonnawa	TR04	0.9874	0.9916	0.9925	0.9789	0.9938	0.9733	0.5166	0.9924	0.5434
15	Kolonnawa	TR05	0.9934	0.9931	0.9959	0.9963	0.9776	0.9848	0.9918	0.6452	0.6658
16	Mahiyangana	TR01	0.9951	0.9979	0.9919	0.9945	0.9976	0.9962	0.9627	0.9810	0.9925
17	Maho	TR02	0.9942	0.9923	0.9945	0.9930	0.9913	0.9970	0.9684	0.9727	0.9819
18	Monaragala	TR01	0.9961	0.9983	0.9962	0.9964	0.9972	0.9982	0.9719	0.9878	0.9890
19	Monaragala	TR02	0.9919	0.9988	0.9909	0.9941	0.9963	0.9946	0.9619	0.9893	0.9718
20	New Valachcheni	TR02	0.9921	0.9979	0.9916	0.9931	0.9971	0.9961	0.9738	0.9851	0.9876
21	Nuwara Eliya	TR01	0.9858	0.9927	0.9925	0.9825	0.9874	0.9967	0.9736	0.9689	0.9688
22	Nuwara Eliya	TR02	0.9869	0.9923	0.9936	0.9846	0.9861	0.9977	0.9663	0.9686	0.9654
23	Nuwara Eliya	TR03	0.9933	0.9965	0.9954	0.9948	0.9961	0.9977	0.9608	0.9728	0.9827
24	Old Anuradhapura	TR01	0.9923	0.9945	0.9906	0.9889	0.9926	0.9869	0.9703	0.9732	0.9487
25	Old Galle	TR01	0.9979	0.9964	0.9914	0.9984	0.9972	0.9931	0.9977	0.9974	0.9986
26	Old Galle	TR02	0.9986	0.9972	0.9952	0.9991	0.9977	0.9960	0.9993	0.9989	0.9987
27	Pannala	TR01	0.9983	0.9986	0.9987	0.9981	0.9984	0.9991	0.9888	0.9724	0.9903
28	Pannala	TR02	0.9990	0.9992	0.9987	0.9990	0.9989	0.9987	0.9762	0.9717	0.9620
29	Pannipitiya	TR03	0.9944	0.9875	0.9815	0.9886	0.9881	0.9899	0.9291	0.9478	0.9690
30	Sapugaskanda	TR01	0.9942	0.9945	0.9933	0.9952	0.9977	0.9944	0.8829	0.8982	0.9802
31	Sapugaskanda	TR03	0.9922	0.9937	0.9820	0.9912	0.9928	0.9891	0.9554	0.9715	0.9870
32	Sri Jayawardanapura	TR01	0.9916	0.9845	0.9924	0.9918	0.9842	0.9920	0.9989	0.9979	0.9973
33	Sri Jayawardanapura	TR02	0.9940	0.9863	0.9884	0.9942	0.9864	0.9884	0.9800	0.9782	0.9968
34	Thulhiriya	TR01	0.9838	0.9940	0.9920	0.9914	0.9922	0.9953	0.8793	0.9415	0.9696
35	Thulhiriya	TR02	0.9857	0.9943	0.9948	0.9925	0.9927	0.9973	0.8740	0.9453	0.9552
36	Trincomalee	TR01	0.9937	0.9947	0.9970	0.9924	0.9948	0.9977	0.9458	0.9911	0.9557
37	Trincomalee	TR02	0.9958	0.9950	0.9960	0.9963	0.9948	0.9969	0.9762	0.9901	0.9758
38	Valachchenei	TR01	0.9009	0.9073	0.7575	0.8692	0.8714	0.7077	0.8627	0.9638	0.8970
39	Valachchenei	TR02	0.9174	0.9012	0.7678	0.8882	0.8504	0.7002	0.8805	0.9634	0.9131
40	Valachchenei	TR03	0.9090	0.9071	0.7628	0.8822	0.8611	0.7121	0.8645	0.9610	0.8884
41	Vaunathiu	TR01	0.9944	0.9988	0.9913	0.9943	0.9972	0.9952	0.9740	0.9730	0.9911
42	Vaunathiu	TR02	0.9940	0.9984	0.9939	0.9945	0.9976	0.9968	0.9692	0.9856	0.9897
43	Veyangoda	TR02	0.9796	0.9771	0.9563	0.9675	0.9577	0.9565	0.9495	0.9646	0.9794
44	Veyangoda	TR03	0.9812	0.9774	0.9586	0.9707	0.9491	0.9406	0.9266	0.8781	0.9382

Region -4 (400 kHz – 2 MHz)

Item	Grid Substation	TR No.	Cross Correlation Coefficient								
			HV open circuit			HV short circuit			LV open circuit		
			R - Y	Y - B	B - R	R - Y	Y - B	B - R	R - Y	Y - B	B - R
1	Badulla	TR03	0.9914	0.9583	0.9447	0.9869	0.9623	0.9349	0.9221	0.8722	0.9738
2	Biyagama	TR03	0.9765	0.9841	0.9886	0.9783	0.9838	0.9895	0.7743	0.8456	0.8885
3	Biyagama	TR04	0.9409	0.9550	0.9092	0.9444	0.9628	0.9114	0.8967	0.8477	0.9873
4	Bolawattha	TR01	0.9491	0.9312	0.8723	0.9503	0.9336	0.8764	0.6479	0.5644	0.8673
5	Bolawattha	TR02	0.9543	0.9403	0.8904	0.9556	0.9426	0.8944	0.5291	0.8052	0.8434
6	Bolawattha	TR03	0.8010	0.8583	0.7995	0.8169	0.8673	0.8167	0.8259	0.9651	0.9106
7	Habarana	TR01	0.9770	0.9711	0.9113	0.9764	0.9716	0.9114	0.2850	0.5992	0.7485
8	Habarana	TR02	0.9777	0.9682	0.9110	0.9779	0.9676	0.9106	0.0655	0.1720	0.7782
9	Hambanthota	TR02	0.9927	0.9863	0.9719	0.9866	0.9929	0.9722	0.7891	0.7741	0.9609
10	Katunayake	TR02	0.9936	0.9515	0.9260	0.9932	0.9531	0.9268	0.6892	0.6717	0.9398
11	Kelaniya	TR01	0.4676	0.5993	0.9385	0.4624	0.5934	0.9413	0.7036	0.8471	0.9085
12	Kiribathkumbura	TR01	0.9543	0.9420	0.8847	0.9554	0.9441	0.8881	0.7828	0.7524	0.8703
13	Kiribathkumbura	TR02	0.9607	0.9359	0.8835	0.9618	0.9386	0.8875	0.4604	0.4382	0.9580
14	Kolonnawa	TR04	0.9825	0.9905	0.9764	0.9815	0.9903	0.9760	0.6616	0.8014	0.8241
15	Kolonnawa	TR05	0.9720	0.9809	0.9464	0.9718	0.9806	0.9461	0.6535	0.5956	0.8905
16	Mahiyangana	TR01	0.8946	0.9024	0.7875	0.8982	0.9224	0.7996	0.8911	0.8274	0.9563
17	Maho	TR02	0.9273	0.9217	0.8596	0.9335	0.9364	0.8692	0.9290	0.8262	0.9285
18	Monaragala	TR01	0.9451	0.9626	0.9330	0.9476	0.9701	0.9354	0.8829	0.8003	0.9709
19	Monaragala	TR02	0.9526	0.9582	0.9323	0.9426	0.9611	0.9347	0.8986	0.8278	0.9737
20	New Valachcheni	TR02	0.9439	0.9564	0.9192	0.9474	0.9622	0.9218	0.8948	0.8554	0.9765
21	Nuwara Eliya	TR01	0.9834	0.9937	0.9909	0.9827	0.9933	0.9911	0.2357	0.5735	0.7070
22	Nuwara Eliya	TR02	0.9824	0.9946	0.9912	0.9821	0.9945	0.9923	0.2645	0.6046	0.7049
23	Nuwara Eliya	TR03	0.8936	0.9129	0.8091	0.8996	0.9334	0.8227	0.8496	0.8448	0.9730
24	Old Anuradhapura	TR01	0.8656	0.9887	0.8244	0.8670	0.9890	0.8274	0.2567	0.7477	0.5772
25	Old Galle	TR01	0.9932	0.9590	0.9612	0.9929	0.9515	0.9507	0.9729	0.9785	0.9697
26	Old Galle	TR02	0.9869	0.9925	0.9779	0.9866	0.9922	0.9778	0.9825	0.9670	0.9419
27	Pannala	TR01	0.3652	0.0778	0.8994	0.3658	0.0846	0.9035	0.9057	0.5045	0.6621
28	Pannala	TR02	0.9930	0.9395	0.9115	0.9926	0.9423	0.9136	0.8724	0.5138	0.8106
29	Pannipitiya	TR03	0.9868	0.9947	0.9831	0.9875	0.9947	0.9840	0.3740	0.8420	0.5729
30	Sapugaskanda	TR01	0.8884	0.8985	0.7966	0.8853	0.8976	0.7921	0.4367	0.8118	0.7640
31	Sapugaskanda	TR03	0.8925	0.8593	0.8559	0.9030	0.8484	0.8436	0.6359	0.9307	0.7012
32	Sri Jayawardanapura	TR01	0.9341	0.9734	0.8786	0.9283	0.9717	0.8674	0.5961	0.1365	0.4301
33	Sri Jayawardanapura	TR02	0.8809	0.9449	0.8250	0.8823	0.9447	0.8285	0.7377	0.5786	0.4052
34	Thulhiriya	TR01	0.9974	0.9948	0.9860	0.9973	0.9954	0.9867	0.7185	0.9250	0.8691
35	Thulhiriya	TR02	0.9964	0.9965	0.9865	0.9964	0.9971	0.9877	0.6563	0.9560	0.7349
36	Trincomalee	TR01	0.9737	0.9724	0.9098	0.9734	0.9723	0.9093	0.3906	0.6247	0.7523
37	Trincomalee	TR02	0.9737	0.9804	0.9248	0.9736	0.9800	0.9244	0.2964	0.5074	0.7627
38	Valachchenei	TR01	0.9977	0.9980	0.9975	0.9978	0.9980	0.9976	0.5673	0.5548	0.9342
39	Valachchenei	TR02	0.9945	0.9954	0.9969	0.9947	0.9955	0.9969	0.6004	0.5867	0.9924
40	Valachchenei	TR03	0.9983	0.9989	0.9990	0.9979	0.9989	0.9990	0.6175	0.6647	0.9392
41	Vaunathiu	TR01	0.9562	0.9580	0.9279	0.9577	0.9685	0.9323	0.8971	0.7874	0.9632
42	Vaunathiu	TR02	0.9407	0.9423	0.9034	0.9430	0.9557	0.9095	0.8641	0.7869	0.9773
43	Veyangoda	TR02	0.9752	0.9787	0.9872	0.9763	0.9788	0.9877	0.8153	0.9154	0.9095
44	Veyangoda	TR03	0.9675	0.9798	0.9860	0.9690	0.9790	0.9871	0.8130	0.8830	0.8149

Appendix-D: Calculated distance values correspond to turning functions of SFRA measurement.

Region -1 (20 Hz – 2 kHz)

Item	Grid Substation	TR No.	Distance								
			HV open circuit			HV short circuit			LV open circuit		
			R - Y	Y - B	B - R	R - Y	Y - B	B - R	R - Y	Y - B	B - R
1	Badulla	TR03	8.6E-01	6.3E-01	9.0E-01	5.1E-03	7.3E-03	5.7E-03	9.0E-01	9.4E-01	9.9E-01
2	Biyagama	TR03	1.5E+00	1.5E+00	5.5E-01	7.8E-03	1.5E-02	1.3E-02	2.2E+00	2.3E+00	4.2E-01
3	Biyagama	TR04	1.1E+00	1.0E+00	1.5E-01	5.5E-03	7.6E-03	1.2E-02	1.6E+00	1.6E+00	1.2E-01
4	Bolawattha	TR01	2.2E+00	1.7E+00	1.2E+00	1.6E-02	1.0E-02	1.8E-02	2.5E+00	2.5E+00	9.1E-01
5	Bolawattha	TR02	2.3E+00	2.0E+00	2.0E+00	4.1E-02	1.9E-02	2.7E-02	2.3E+00	2.5E+00	1.9E+00
6	Bolawattha	TR03	1.1E+00	1.4E+00	1.1E+00	1.0E-02	9.1E-03	1.7E-02	1.9E+00	1.5E+00	1.1E+00
7	Habarana	TR01	9.2E-01	1.2E+00	8.0E-01	1.3E-02	9.2E-03	1.7E-02	2.2E+00	1.3E+00	1.7E+00
8	Habarana	TR02	1.4E+00	1.4E+00	3.0E-01	7.7E-03	6.4E-03	9.7E-03	1.9E+00	2.1E+00	1.3E+00
9	Hambanthota	TR02	1.5E+00	1.5E+00	7.3E-01	3.3E-03	7.6E-03	6.9E-03	2.5E+00	2.2E+00	8.2E-01
10	Katunayake	TR02	5.4E-01	1.6E+00	1.7E+00	9.8E-03	1.5E-02	9.8E-03	8.0E-01	1.2E+00	1.2E+00
11	Kelaniya	TR01	1.5E+00	1.6E+00	3.0E-01	5.8E-03	3.4E-03	7.0E-03	2.2E+00	2.2E+00	4.1E-01
12	Kiribathkumbura	TR01	1.6E+00	1.8E+00	8.2E-01	1.6E-02	1.2E-02	8.8E-03	2.5E+00	2.3E+00	6.0E-01
13	Kiribathkumbura	TR02	1.8E+00	1.8E+00	3.8E-01	1.1E-02	1.0E-02	7.6E-03	2.7E+00	2.5E+00	6.5E-01
14	Kolonnawa	TR04	2.3E+00	2.3E+00	5.9E-01	1.7E-02	1.2E-02	2.3E-02	3.5E+00	3.6E+00	3.9E-01
15	Kolonnawa	TR05	2.1E+00	2.1E+00	6.5E-01	6.5E-03	1.0E-02	1.6E-02	2.2E+00	2.4E+00	4.5E-01
16	Mahiyangana	TR01	5.2E-01	9.2E-01	9.5E-01	5.1E-03	4.5E-03	5.2E-03	7.7E-01	8.3E-01	9.0E-01
17	Maho	TR02	1.1E+00	1.1E+00	3.6E-01	4.7E-03	8.1E-03	3.9E-03	2.0E+00	2.8E+00	9.5E-01
18	Monaragala	TR01	1.1E+00	1.2E+00	6.3E-01	4.0E-03	3.8E-03	2.5E-03	1.8E+00	1.6E+00	7.8E-01
19	Monaragala	TR02	1.1E+00	9.9E-01	9.9E-01	1.6E+00	1.6E+00	7.4E-03	2.1E+00	2.4E+00	1.3E+00
20	New Valachcheni	TR02	1.1E+00	1.1E+00	9.8E-02	6.8E-03	1.9E-03	7.6E-03	1.7E+00	1.5E+00	7.9E-01
21	Nuwara Eliya	TR01	2.0E+00	2.1E+00	4.6E-01	1.1E-02	1.1E-02	1.8E-02	3.1E+00	3.1E+00	1.2E+00
22	Nuwara Eliya	TR02	1.8E+00	1.9E+00	6.4E-01	6.8E-03	1.2E-02	9.0E-03	3.9E+00	3.8E+00	5.8E-01
23	Nuwara Eliya	TR03	1.3E+00	1.1E+00	8.4E-01	8.7E-03	8.7E-03	9.8E-03	1.7E+00	1.9E+00	9.9E-01
24	Old Anuradhapura	TR01	1.6E+00	1.6E+00	3.3E-01	1.2E-02	8.3E-03	1.2E-02	3.3E+00	2.9E+00	1.5E+00
25	Old Galle	TR01	2.5E+00	2.4E+00	3.5E-01	3.2E-03	1.0E-02	1.1E-02	3.3E+00	3.3E+00	8.6E-01
26	Old Galle	TR02	2.6E+00	2.6E+00	2.3E-01	1.4E-02	1.2E-02	1.2E-02	3.4E+00	3.3E+00	2.0E-01
27	Pannala	TR01	1.9E+00	1.9E+00	1.1E+00	1.2E-02	1.7E-02	2.3E-02	2.6E+00	2.8E+00	8.2E-01
28	Pannala	TR02	1.7E+00	1.5E+00	9.6E-01	5.8E-03	1.2E-02	1.2E-02	2.2E+00	2.4E+00	1.3E+00
29	Pannipitiya	TR03	1.6E+00	1.6E+00	8.9E-01	6.8E-02	5.0E-02	9.9E-02	2.7E+00	3.6E+00	2.4E+00
30	Sapugaskanda	TR01	9.3E-01	9.4E-01	1.0E-01	1.9E-02	3.5E-02	4.7E-02	1.5E+00	1.5E+00	7.6E-02
31	Sapugaskanda	TR03	1.2E+00	1.6E+00	1.7E+00	1.7E-02	2.6E-02	3.9E-02	1.3E+00	1.7E+00	1.7E+00
32	Sri Jayawardanapura	TR01	2.9E+00	3.8E+00	3.4E+00	2.2E-01	4.9E-01	4.3E-01	2.5E+00	2.0E+00	2.4E+00
33	Sri Jayawardanapura	TR02	2.6E+00	3.3E+00	3.3E+00	1.1E-01	1.1E-01	8.4E-02	4.2E+00	3.0E+00	3.5E+00
34	Thulhiriya	TR01	1.2E+00	1.2E+00	2.7E-01	3.7E-02	4.0E-02	1.1E-02	1.6E+00	1.6E+00	2.5E-01
35	Thulhiriya	TR02	1.2E+00	1.2E+00	3.8E-01	4.1E-03	5.2E-02	5.1E-02	1.7E+00	1.6E+00	4.7E-01
36	Trincomalee	TR01	9.1E-01	1.3E+00	1.2E+00	5.7E-03	3.1E-03	4.5E-03	2.1E+00	1.2E+00	1.8E+00
37	Trincomalee	TR02	1.2E+00	1.4E+00	8.9E-01	2.0E-03	4.9E-03	5.3E-03	1.9E+00	1.7E+00	9.6E-01
38	Valachchenei	TR01	1.5E+00	1.6E+00	1.1E+00	8.0E-03	1.2E-02	5.9E-03	2.3E+00	1.9E+00	1.1E+00
39	Valachchenei	TR02	1.5E+00	1.5E+00	3.8E-01	6.5E-03	1.0E-02	5.5E-03	2.2E+00	2.7E+00	1.6E+00
40	Valachchenei	TR03	1.5E+00	1.5E+00	3.2E-01	1.1E-02	5.4E-03	1.1E-02	2.2E+00	2.1E+00	1.7E-01
41	Vaunathiu	TR01	9.9E-01	1.1E+00	6.9E-01	7.6E-03	5.6E-03	5.9E-03	1.6E+00	1.3E+00	9.4E-01
42	Vaunathiu	TR02	1.1E+00	1.1E+00	1.7E-01	3.9E-03	7.6E-03	9.8E-03	1.7E+00	1.7E+00	6.4E-02
43	Veyangoda	TR02	1.3E+00	1.4E+00	6.3E-01	8.4E-03	1.0E-02	4.8E-03	2.1E+00	2.3E+00	1.5E+00
44	Veyangoda	TR03	1.1E+00	1.4E+00	1.3E+00	8.0E-03	4.3E-03	1.1E-02	1.9E+00	1.4E+00	1.4E+00

Region -2 (2 kHz – 20 kHz)

Item	Grid Substation	TR No.	Distance								
			HV open circuit			HV short circuit			LV open circuit		
			R - Y	Y - B	B - R	R - Y	Y - B	B - R	R - Y	Y - B	B - R
1	Badulla	TR03	5.8E-03	4.8E-03	5.5E-03	1.0E-02	9.9E-03	7.6E-03	5.5E-03	3.6E-03	2.3E-03
2	Biyagama	TR03	5.2E-02	5.0E-02	1.1E-02	4.7E-02	4.4E-02	1.6E-02	2.7E-02	2.4E-02	1.3E-02
3	Biyagama	TR04	2.8E-02	2.6E-02	1.5E-02	3.8E-02	3.2E-02	9.6E-03	1.9E-02	1.8E-02	3.2E-03
4	Bolawattha	TR01	4.6E-02	4.8E-02	7.4E-03	4.7E-02	4.7E-02	9.6E-03	3.5E-02	2.9E-02	1.0E-02
5	Bolawattha	TR02	4.1E-02	4.3E-02	6.3E-03	4.4E-02	4.6E-02	8.0E-03	3.3E-02	2.6E-02	1.1E-02
6	Bolawattha	TR03	9.9E-02	9.8E-02	5.6E-03	4.9E-02	5.0E-02	5.9E-03	2.1E-02	1.5E-02	1.1E-02
7	Habarana	TR01	5.9E-03	6.6E-03	3.7E-03	1.2E-02	7.5E-03	7.0E-03	5.2E-03	4.6E-03	2.6E-03
8	Habarana	TR02	6.4E-03	8.0E-03	2.5E-03	1.1E-02	1.1E-02	2.4E-03	5.2E-03	3.4E-03	2.9E-03
9	Hambanthota	TR02	1.6E-02	1.8E-02	3.2E-03	1.9E-02	2.0E-02	3.6E-03	9.1E-03	7.3E-03	2.3E-03
10	Katunayake	TR02	2.1E-02	2.3E-02	7.9E-03	4.4E-02	4.4E-02	6.8E-03	1.7E-02	1.3E-02	7.1E-03
11	Kelaniya	TR01	2.5E-02	2.2E-02	3.6E-03	2.8E-02	2.7E-02	5.5E-03	8.4E-03	5.4E-03	5.0E-03
12	Kiribathkumbura	TR01	3.7E-02	3.8E-02	9.0E-03	4.7E-02	4.8E-02	1.1E-02	3.3E-02	2.6E-02	1.1E-02
13	Kiribathkumbura	TR02	6.2E-02	6.2E-02	9.0E-03	4.9E-02	5.1E-02	1.2E-02	3.2E-02	2.5E-02	1.1E-02
14	Kolonnawa	TR04	1.1E-02	1.1E-02	1.8E-02	1.2E-02	8.9E-03	1.3E-02	1.5E-02	1.6E-02	1.7E-02
15	Kolonnawa	TR05	7.3E-03	2.1E-02	1.7E-02	1.4E-02	1.8E-02	1.1E-02	1.7E-02	5.1E-02	5.6E-02
16	Mahiyangana	TR01	2.7E-02	2.3E-02	8.5E-03	3.2E-02	2.9E-02	6.5E-03	1.8E-02	1.7E-02	3.5E-03
17	Maho	TR02	3.4E-02	3.0E-02	8.6E-03	3.8E-02	3.3E-02	5.8E-03	1.7E-02	1.5E-02	4.1E-03
18	Monaragala	TR01	3.2E-02	3.0E-02	1.4E-02	4.0E-02	3.4E-02	1.1E-02	1.9E-02	1.8E-02	2.6E-03
19	Monaragala	TR02	2.8E-02	2.4E-02	2.1E-02	3.6E-02	2.7E-02	1.3E-02	1.9E-02	1.7E-02	2.7E-03
20	New Valachcheni	TR02	3.4E-02	3.4E-02	2.1E-02	4.0E-02	3.3E-02	1.2E-02	1.9E-02	1.8E-02	2.8E-03
21	Nuwara Eliya	TR01	9.9E-03	1.4E-02	5.7E-03	1.9E-02	1.6E-02	7.1E-03	8.5E-03	2.9E-03	8.0E-03
22	Nuwara Eliya	TR02	1.2E-02	1.6E-02	5.0E-03	2.0E-02	2.2E-02	4.7E-03	9.6E-03	2.2E-03	8.4E-03
23	Nuwara Eliya	TR03	4.4E-02	4.1E-02	1.2E-02	4.7E-02	4.3E-02	9.5E-03	1.9E-02	1.7E-02	3.0E-03
24	Old Anuradhapura	TR01	3.7E-02	3.2E-02	1.6E-02	3.8E-02	3.5E-02	2.2E-02	1.1E-02	7.7E-03	7.3E-03
25	Old Galle	TR01	6.6E-03	1.1E-02	7.9E-03	2.0E-02	1.8E-02	6.7E-03	1.3E-02	1.3E-02	2.5E-03
26	Old Galle	TR02	1.7E-02	1.2E-02	1.1E-02	1.7E-02	5.4E-03	1.4E-02	6.4E-03	1.0E-02	7.2E-03
27	Pannala	TR01	2.1E-02	2.1E-02	4.5E-03	3.7E-02	3.6E-02	3.7E-03	1.8E-02	1.3E-02	6.8E-03
28	Pannala	TR02	2.0E-02	2.1E-02	2.6E-03	3.6E-02	3.7E-02	4.0E-03	1.8E-02	1.2E-02	7.1E-03
29	Pannipitiya	TR03	6.1E-02	6.0E-02	1.2E-02	4.7E-02	4.3E-02	1.4E-02	1.8E-02	1.2E-02	1.1E-02
30	Sapugaskanda	TR01	1.9E-02	1.6E-02	3.3E-03	2.3E-02	2.2E-02	2.4E-03	1.6E-02	1.4E-02	3.1E-03
31	Sapugaskanda	TR03	3.2E-02	3.2E-02	3.6E-03	3.3E-02	3.5E-02	4.2E-03	1.8E-02	1.2E-02	1.0E-02
32	Sri Jayawardanapura	TR01	2.3E-02	2.1E-02	2.7E-02	5.1E-02	3.7E-02	2.5E-02	7.4E-03	1.1E-02	1.3E-02
33	Sri Jayawardanapura	TR02	2.5E-02	2.2E-02	1.7E-02	3.6E-02	2.7E-02	1.2E-02	1.2E-01	1.2E-01	6.7E-03
34	Thulhiriya	TR01	1.2E-02	1.2E-02	2.2E-03	2.2E-02	1.9E-02	5.1E-03	5.6E-03	5.0E-03	1.4E-03
35	Thulhiriya	TR02	9.7E-03	1.1E-02	2.4E-03	2.1E-02	1.8E-02	6.2E-03	5.9E-03	5.5E-03	1.0E-03
36	Trincomalee	TR01	7.4E-03	5.9E-03	3.2E-03	1.3E-02	7.9E-03	6.5E-03	4.1E-03	3.8E-03	4.3E-03
37	Trincomalee	TR02	3.8E-03	6.1E-03	2.9E-03	1.1E-02	9.3E-03	3.7E-03	3.8E-03	3.1E-03	1.3E-03
38	Valachchenei	TR01	1.1E-01	1.0E-01	2.4E-02	1.1E-01	9.3E-02	3.4E-02	5.5E-02	4.7E-02	2.8E-02
39	Valachchenei	TR02	1.0E-01	9.2E-02	2.2E-02	1.1E-01	9.4E-02	3.4E-02	5.9E-02	4.8E-02	2.8E-02
40	Valachchenei	TR03	8.3E-02	7.8E-02	1.7E-02	1.0E-01	9.5E-02	2.2E-02	6.0E-02	4.9E-02	2.8E-02
41	Vaunathiu	TR01	2.4E-02	2.2E-02	7.2E-03	3.4E-02	3.1E-02	5.6E-03	2.0E-02	1.8E-02	3.8E-03
42	Vaunathiu	TR02	3.4E-02	3.5E-02	1.8E-02	5.0E-02	4.7E-02	1.2E-02	2.0E-02	1.9E-02	2.4E-03
43	Veyangoda	TR02	4.5E-02	4.0E-02	1.5E-02	4.4E-02	4.0E-02	2.1E-02	2.0E-02	1.4E-02	1.2E-02
44	Veyangoda	TR03	4.7E-02	4.4E-02	6.9E-03	4.4E-02	4.0E-02	1.0E-02	1.7E-02	9.1E-03	1.8E-02

Region -3 (20 kHz – 400 kHz)

Item	Grid Substation	TR No.	Distance								
			HV open circuit			HV short circuit			LV open circuit		
			R - Y	Y - B	B - R	R - Y	Y - B	B - R	R - Y	Y - B	B - R
1	Badulla	TR03	4.9E-02	5.8E-02	2.7E-02	4.1E-02	4.9E-02	5.0E-02	1.9E-02	1.9E-02	1.6E-02
2	Biyagama	TR03	1.7E-02	1.3E-02	1.5E-02	2.2E-02	2.0E-02	1.3E-02	4.1E-02	4.2E-02	1.5E-02
3	Biyagama	TR04	1.0E-02	3.7E-03	1.2E-02	9.3E-03	6.1E-03	6.0E-03	2.0E-02	1.5E-02	9.8E-03
4	Bolawattha	TR01	8.6E-03	7.2E-03	8.5E-03	9.2E-03	6.9E-03	8.3E-03	7.1E-03	7.8E-03	7.3E-03
5	Bolawattha	TR02	1.3E-02	1.2E-02	1.0E-02	1.1E-02	1.0E-02	9.3E-03	6.1E-03	7.0E-03	5.4E-03
6	Bolawattha	TR03	1.7E-02	6.1E-03	1.7E-02	1.9E-02	1.3E-02	9.7E-03	8.2E-03	2.0E-02	2.0E-02
7	Habarana	TR01	9.1E-03	8.9E-03	6.8E-03	9.6E-03	9.6E-03	3.6E-03	1.1E-02	1.2E-02	1.5E-02
8	Habarana	TR02	9.7E-03	8.6E-03	7.6E-03	8.6E-03	8.7E-03	2.9E-03	1.1E-02	9.3E-03	1.4E-02
9	Hambanthota	TR02	6.2E-03	6.4E-03	5.2E-03	1.1E-02	1.1E-02	3.8E-03	1.3E-02	1.0E-02	4.8E-03
10	Katunayake	TR02	3.2E-03	4.2E-03	4.2E-03	5.8E-03	8.7E-03	4.6E-03	1.3E-02	2.0E-02	1.1E-02
11	Kelaniya	TR01	8.9E-03	7.2E-03	5.7E-03	1.4E-02	1.1E-02	6.5E-03	2.8E-02	2.2E-02	1.2E-02
12	Kiribathkumbura	TR01	7.6E-03	6.8E-03	8.4E-03	7.6E-03	7.1E-03	1.0E-02	9.2E-03	8.8E-03	7.4E-03
13	Kiribathkumbura	TR02	8.8E-03	7.6E-03	8.9E-03	8.4E-03	8.8E-03	9.6E-03	1.1E-02	1.0E-02	5.0E-03
14	Kolonnawa	TR04	1.4E-02	1.3E-02	1.6E-02	1.4E-02	1.3E-02	1.9E-02	3.1E-02	1.6E-02	2.8E-02
15	Kolonnawa	TR05	1.3E-02	1.3E-02	8.3E-03	1.1E-02	2.3E-02	1.5E-02	7.9E-03	2.6E-02	2.4E-02
16	Mahiyangana	TR01	1.0E-02	5.1E-03	1.0E-02	1.0E-02	7.1E-03	5.6E-03	2.3E-02	1.7E-02	1.1E-02
17	Maho	TR02	1.3E-02	1.3E-02	7.2E-03	1.2E-02	1.4E-02	4.5E-03	2.0E-02	1.4E-02	1.2E-02
18	Monaragala	TR01	1.0E-02	6.8E-03	6.2E-03	9.4E-03	8.1E-03	2.7E-03	2.0E-02	1.1E-02	1.3E-02
19	Monaragala	TR02	1.5E-02	4.1E-03	1.4E-02	1.0E-02	8.1E-03	6.2E-03	1.9E-02	1.1E-02	1.2E-02
20	New Valachcheni	TR02	1.6E-02	5.6E-03	1.3E-02	1.2E-02	8.0E-03	6.3E-03	1.9E-02	1.4E-02	8.9E-03
21	Nuwara Eliya	TR01	2.5E-02	1.4E-02	2.2E-02	1.9E-02	1.6E-02	7.0E-03	2.0E-02	3.1E-02	3.6E-02
22	Nuwara Eliya	TR02	2.8E-02	1.5E-02	2.3E-02	1.8E-02	1.6E-02	5.7E-03	2.2E-02	3.1E-02	3.7E-02
23	Nuwara Eliya	TR03	1.2E-02	8.2E-03	7.3E-03	1.1E-02	8.9E-03	4.4E-03	2.4E-02	1.5E-02	1.4E-02
24	Old Anuradhapura	TR01	1.4E-02	9.2E-03	8.7E-03	1.9E-02	1.1E-02	1.6E-02	2.3E-02	9.8E-03	2.3E-02
25	Old Galle	TR01	4.9E-03	3.6E-03	7.2E-03	3.6E-03	2.9E-03	5.3E-03	1.3E-02	1.1E-02	6.6E-03
26	Old Galle	TR02	1.9E-03	2.7E-03	2.9E-03	1.4E-03	2.3E-03	2.6E-03	2.2E-03	4.8E-03	4.9E-03
27	Pannala	TR01	3.2E-03	3.1E-03	3.4E-03	4.9E-03	7.0E-03	3.0E-03	1.1E-02	1.9E-02	1.1E-02
28	Pannala	TR02	3.0E-03	2.8E-03	2.6E-03	4.5E-03	7.1E-03	4.0E-03	1.1E-02	1.9E-02	1.2E-02
29	Pannipitiya	TR03	1.2E-02	1.1E-02	1.4E-02	2.3E-02	1.7E-02	9.3E-03	3.3E-02	2.7E-02	1.9E-02
30	Sapugaskanda	TR01	7.4E-03	9.3E-03	5.8E-03	9.7E-03	6.9E-03	6.5E-03	2.3E-02	2.2E-02	6.3E-03
31	Sapugaskanda	TR03	1.4E-02	8.2E-03	1.3E-02	1.5E-02	1.4E-02	7.1E-03	2.5E-02	2.2E-02	1.7E-02
32	Sri Jayawardanapura	TR01	2.3E-02	2.8E-02	1.0E-02	2.4E-02	2.9E-02	1.1E-02	3.8E-03	6.0E-03	4.0E-03
33	Sri Jayawardanapura	TR02	1.6E-02	2.2E-02	1.3E-02	1.6E-02	2.2E-02	1.3E-02	9.5E-03	8.6E-03	3.6E-03
34	Thulhiriya	TR01	2.4E-02	1.0E-02	1.7E-02	1.5E-02	1.4E-02	6.1E-03	4.4E-02	3.6E-02	1.7E-02
35	Thulhiriya	TR02	2.3E-02	1.2E-02	1.4E-02	1.4E-02	1.4E-02	4.9E-03	4.6E-02	3.6E-02	2.1E-02
36	Trincomalee	TR01	1.0E-02	6.8E-03	6.7E-03	9.1E-03	7.4E-03	2.9E-03	1.1E-02	9.8E-03	1.5E-02
37	Trincomalee	TR02	9.8E-03	8.1E-03	8.2E-03	8.7E-03	8.3E-03	4.8E-03	1.2E-02	7.1E-03	1.3E-02
38	Valachchenei	TR01	4.6E-02	3.9E-02	5.9E-02	6.2E-02	5.6E-02	6.4E-02	5.6E-02	3.3E-02	4.4E-02
39	Valachchenei	TR02	4.3E-02	4.2E-02	5.7E-02	5.5E-02	5.3E-02	5.9E-02	5.0E-02	2.6E-02	3.9E-02
40	Valachchenei	TR03	4.0E-02	3.9E-02	5.4E-02	5.6E-02	5.0E-02	5.7E-02	7.6E-02	3.3E-02	6.8E-02
41	Vaunathiu	TR01	7.7E-03	4.5E-03	9.0E-03	8.8E-03	7.3E-03	6.2E-03	2.0E-02	1.6E-02	8.7E-03
42	Vaunathiu	TR02	1.4E-02	5.3E-03	1.2E-02	1.1E-02	7.3E-03	6.3E-03	2.1E-02	1.5E-02	1.0E-02
43	Veyangoda	TR02	1.7E-02	1.2E-02	1.6E-02	2.1E-02	2.1E-02	1.6E-02	2.8E-02	2.7E-02	1.4E-02
44	Veyangoda	TR03	1.8E-02	1.3E-02	2.0E-02	2.1E-02	2.8E-02	2.7E-02	3.2E-02	3.5E-02	2.5E-02

Region -4 (400 kHz – 2 MHz)

Item	Grid Substation	TR No.	Distance								
			HV open circuit			HV short circuit			LV open circuit		
			R - Y	Y - B	B - R	R - Y	Y - B	B - R	R - Y	Y - B	B - R
1	Badulla	TR03	3.9E-04	1.1E-03	1.2E-03	3.7E-04	1.1E-03	1.1E-03	3.0E-03	4.2E-03	3.0E-03
2	Biyagama	TR03	5.4E-04	5.8E-04	7.2E-04	5.3E-04	5.5E-04	7.2E-04	2.9E-03	3.5E-03	2.1E-03
3	Biyagama	TR04	1.1E-03	8.7E-04	9.8E-04	1.0E-03	8.3E-04	9.6E-04	3.1E-03	3.6E-03	1.3E-03
4	Bolawattha	TR01	2.8E-03	3.2E-03	3.9E-03	2.7E-03	3.2E-03	3.8E-03	4.0E-03	5.4E-03	4.4E-03
5	Bolawattha	TR02	2.9E-03	3.5E-03	4.0E-03	2.8E-03	3.4E-03	4.0E-03	6.2E-03	4.9E-03	2.7E-03
6	Bolawattha	TR03	1.4E-03	1.5E-03	1.3E-03	1.4E-03	1.4E-03	1.2E-03	3.8E-03	1.5E-03	3.2E-03
7	Habarana	TR01	2.8E-04	3.8E-04	4.8E-04	2.8E-04	3.9E-04	4.7E-04	3.1E-03	3.0E-03	2.2E-03
8	Habarana	TR02	2.9E-04	3.8E-04	4.8E-04	2.8E-04	3.9E-04	4.8E-04	3.9E-03	4.0E-03	2.8E-03
9	Hambanthota	TR02	4.0E-04	5.2E-04	6.8E-04	5.0E-04	3.8E-04	6.8E-04	2.9E-03	2.6E-03	1.2E-03
10	Katunayake	TR02	2.8E-04	5.2E-04	6.8E-04	2.8E-04	5.2E-04	6.9E-04	2.3E-03	3.6E-03	2.6E-03
11	Kelaniya	TR01	9.5E-04	7.1E-04	1.0E-03	9.4E-04	7.0E-04	9.9E-04	2.8E-03	1.8E-03	2.4E-03
12	Kiribathkumbura	TR01	2.8E-03	3.5E-03	4.3E-03	2.7E-03	3.5E-03	4.2E-03	2.8E-03	2.5E-03	2.8E-03
13	Kiribathkumbura	TR02	2.7E-03	3.4E-03	4.2E-03	2.6E-03	3.3E-03	4.2E-03	4.9E-03	5.1E-03	1.6E-03
14	Kolonnawa	TR04	2.4E-04	3.0E-04	3.1E-04	2.5E-04	3.0E-04	3.2E-04	2.3E-03	1.9E-03	2.0E-03
15	Kolonnawa	TR05	2.8E-04	3.8E-04	3.6E-04	2.8E-04	3.8E-04	3.7E-04	1.9E-03	2.8E-03	2.0E-03
16	Mahiyangana	TR01	1.3E-03	1.7E-03	1.9E-03	1.3E-03	1.4E-03	1.7E-03	4.1E-03	7.1E-03	7.2E-03
17	Maho	TR02	1.3E-03	1.4E-03	1.7E-03	1.2E-03	1.2E-03	1.5E-03	4.5E-03	5.3E-03	3.2E-03
18	Monaragala	TR01	1.1E-03	8.1E-04	9.4E-04	1.0E-03	7.6E-04	9.3E-04	4.5E-03	5.0E-03	2.8E-03
19	Monaragala	TR02	9.8E-04	8.9E-04	9.2E-04	1.0E-03	9.0E-04	9.1E-04	3.9E-03	4.8E-03	2.5E-03
20	New Valachcheni	TR02	1.1E-03	8.9E-04	9.3E-04	1.0E-03	8.5E-04	9.2E-04	4.9E-03	4.9E-03	3.0E-03
21	Nuwara Eliya	TR01	3.6E-04	3.4E-04	4.3E-04	3.6E-04	3.4E-04	4.3E-04	2.4E-03	3.4E-03	2.6E-03
22	Nuwara Eliya	TR02	3.5E-04	2.2E-04	3.6E-04	3.5E-04	2.3E-04	3.4E-04	2.2E-03	3.8E-03	3.3E-03
23	Nuwara Eliya	TR03	1.3E-03	1.6E-03	1.8E-03	1.2E-03	1.2E-03	1.6E-03	4.3E-03	3.9E-03	3.2E-03
24	Old Anuradhapura	TR01	1.0E-03	6.9E-04	1.2E-03	1.0E-03	7.0E-04	1.2E-03	3.3E-03	2.4E-03	2.8E-03
25	Old Galle	TR01	2.5E-04	4.1E-04	4.6E-04	3.1E-04	5.3E-04	6.4E-04	7.8E-04	6.9E-04	8.8E-04
26	Old Galle	TR02	2.1E-04	2.5E-04	2.7E-04	2.4E-04	2.9E-04	3.4E-04	1.1E-03	1.1E-03	1.9E-03
27	Pannala	TR01	8.5E-04	1.0E-03	8.2E-04	2.1E-03	2.3E-03	8.3E-04	1.0E-03	2.1E-03	1.5E-03
28	Pannala	TR02	3.4E-04	6.3E-04	8.0E-04	3.5E-04	6.3E-04	8.1E-04	5.8E-04	4.1E-03	3.9E-03
29	Pannipitiya	TR03	6.2E-04	5.1E-04	6.8E-04	6.0E-04	5.1E-04	6.7E-04	3.3E-03	1.8E-03	3.0E-03
30	Sapugaskanda	TR01	1.3E-03	1.0E-03	1.3E-03	1.3E-03	1.0E-03	1.3E-03	5.1E-03	2.3E-03	4.3E-03
31	Sapugaskanda	TR03	1.1E-03	1.2E-03	1.3E-03	9.6E-04	1.4E-03	1.4E-03	2.9E-03	2.2E-03	2.4E-03
32	Sri Jayawardanapura	TR01	7.7E-04	6.1E-04	8.6E-04	7.8E-04	6.2E-04	8.6E-04	4.3E-03	4.8E-03	4.6E-03
33	Sri Jayawardanapura	TR02	1.2E-03	8.4E-04	1.3E-03	1.2E-03	8.4E-04	1.3E-03	3.3E-03	3.0E-03	3.2E-03
34	Thulhiriya	TR01	2.5E-04	4.1E-04	5.7E-04	2.5E-04	3.8E-04	5.6E-04	4.5E-03	2.6E-03	3.5E-03
35	Thulhiriya	TR02	1.4E-04	2.4E-04	3.2E-04	1.4E-04	2.2E-04	3.1E-04	5.0E-03	2.7E-03	4.9E-03
36	Trincomalee	TR01	2.9E-04	3.9E-04	4.8E-04	2.9E-04	4.0E-04	4.8E-04	2.5E-03	2.8E-03	2.4E-03
37	Trincomalee	TR02	3.1E-04	3.4E-04	4.5E-04	3.0E-04	3.5E-04	4.5E-04	2.9E-03	4.0E-03	3.2E-03
38	Valachchenei	TR01	8.1E-04	6.0E-04	6.5E-04	8.1E-04	5.9E-04	6.5E-04	3.4E-03	5.1E-03	4.0E-03
39	Valachchenei	TR02	4.2E-04	7.2E-04	6.5E-04	4.2E-04	7.1E-04	6.4E-04	3.0E-03	3.4E-03	1.1E-03
40	Valachchenei	TR03	6.0E-04	4.7E-04	4.7E-04	6.0E-04	4.7E-04	4.7E-04	4.9E-03	4.3E-03	3.1E-03
41	Vaunathiu	TR01	9.9E-04	9.1E-04	9.9E-04	9.3E-04	8.5E-04	9.4E-04	2.6E-03	4.0E-03	2.4E-03
42	Vaunathiu	TR02	1.1E-03	1.1E-03	1.2E-03	1.1E-03	9.4E-04	1.1E-03	3.5E-03	4.8E-03	3.1E-03
43	Veyangoda	TR02	5.3E-04	5.0E-04	7.2E-04	5.3E-04	4.7E-04	7.1E-04	3.4E-03	3.5E-03	2.7E-03
44	Veyangoda	TR03	5.4E-04	6.9E-04	7.5E-04	5.4E-04	6.7E-04	7.4E-04	4.6E-03	4.7E-03	4.3E-03

Appendix-E: Weights and scores derived for the calculation of each index, for four regions.

(a) Weights and scores derived for ASLEI

Region -1 (20 Hz – 2 kHz)

Test Connection	Phases	ASLE Value	Score (S_i)	Weight	
				$W1_i$	$W2_j$
HV open	R-Y	< 2.4000	4	1	3
		2.4000 - 1.8500	3		
		1.8500 - 1.3000	2		
		1.3000 >	1		
	Y-B	< 3.2000	4	1	
		3.2000 - 2.4500	3		
		2.4500 - 1.7000	2		
		1.7000 >	1		
	B-R	< 3.5000	4	3	
		3.5000 - 2.8500	3		
		2.8500 - 2.2000	2		
		2.2000 >	1		
HV short	R-Y	< 3.5000	4	1	1
		3.5000 - 2.3850	3		
		2.3850 - 1.2700	2		
		1.2700 >	1		
	Y-B	< 3.0000	4	1	
		3.0000 - 2.3000	3		
		2.3000 - 1.6000	2		
		1.6000 >	1		
	B-R	< 3.5000	4	3	
		3.5000 - 2.8500	3		
		2.8500 - 2.2000	2		
		2.2000 >	1		
LV open	R-Y	< 4.3000	4	1	2
		4.3000 - 3.8650	3		
		3.8650 - 3.4300	2		
		3.4300 >	1		
	Y-B	< 4.8000	4	1	
		4.8000 - 4.3000	3		
		4.3000 - 3.8000	2		
		3.8000 >	1		
	B-R	< 3.2000	4	3	
		3.2000 - 1.8500	3		
		1.8500 - 0.5000	2		
		0.5000 >	1		

Region -2 (2 kHz – 20 kHz)

Test Connection	Phases	ASLE Value	Score (S_i)	Weight	
				$W1_i$	$W2_j$
HV open	R-Y	< 1.5000	4	1	3
		1.5000 - 1.1250	3		
		1.1250 - 0.7500	2		
		0.7500 >	1		
	Y-B	< 1.3000	4	1	
		1.3000 - 1.0000	3		
		1.0000 - 0.7000	2		
		0.7000 >	1		
	B-R	< 0.4400	4	2	
		0.4400 - 0.3500	3		
		0.3500 - 0.2600	2		
		0.2600 >	1		
HV short	R-Y	< 1.8000	4	1	2
		1.8000 - 1.3900	3		
		1.3900 - 0.9800	2		
		0.9800 >	1		
	Y-B	< 1.7000	4	1	
		1.7000 - 1.2800	3		
		1.2800 - 0.8600	2		
		0.8600	1		
	B-R	< 0.4500	4	2	
		0.4500 - 0.3500	3		
		0.3500 - 0.2500	2		
		0.2500 >	1		
LV open	R-Y	< 1.4000	4	1	2
		1.4000 - 1.0650	3		
		1.0650 - 0.7300	2		
		0.7300 >	1		
	Y-B	< 1.1000	4	1	
		1.1000 - 0.8500	3		
		0.8500 - 0.6000	2		
		0.6000 >	1		
	B-R	< 0.5000	4	2	
		0.5000 - 0.3500	3		
		0.3500 - 0.2000	2		
		0.2000 >	1		

Region -3 (20 kHz – 400 kHz)

Test Connection	Phases	ASLE Value	Score (S_i)	Weight	
				$W1_i$	$W2_j$
HV open	R-Y	< 1.4000	4	1	3
		1.4000 - 1.0600	3		
		1.0600 - 0.7200	2		
		0.7200 >	1		
	Y-B	< 1.2000	4	1	
		1.2000 - 0.8850	3		
		0.8850 - 0.5700	2		
		0.5700 >	1		
	B-R	< 1.7000	4	1	
		1.7000 - 1.2500	3		
		1.2500 - 0.8000	2		
		0.8000 >	1		
HV short	R-Y	< 1.6000	4	1	2
		1.6000 - 1.1500	3		
		1.1500 - 0.7000	2		
		0.7000 >	1		
	Y-B	< 1.2500	4	1	
		1.2500 - 0.9350	3		
		0.9350 - 0.6200	2		
		0.6200 >	1		
	B-R	< 1.8000	4	1	
		1.8000 - 1.3000	3		
		1.3000 - 0.8000	2		
		0.8000 >	1		
LV open	R-Y	< 2.0000	4	1	2
		2.0000 - 1.5000	3		
		1.5000 - 1.0000	2		
		1.0000 >	1		
	Y-B	< 1.3000	4	1	
		1.3000 - 1.1400	3		
		1.1400 - 0.9800	2		
		0.9800 >	1		
	B-R	< 1.3000	4	1	
		1.3000 - 1.0900	3		
		1.0900 - 0.8800	2		
		0.8800 >	1		

Region -4 (400 kHz – 2 MHz)

Test Connection	Phases	ASLE Value	Score (S_i)	Weight	
				$W1_i$	$W2_j$
HV open	R-Y	< 2.4000	4	1	3
		2.4000 - 1.8500	3		
		1.8500 - 1.3000	2		
		1.3000 >	1		
	Y-B	3.2000	4	1	
		3.2000 - 2.4500	3		
		2.4500 - 1.7000	2		
		1.7000 >	1		
	B-R	< 3.5000	4	1	
		3.5000 - 2.8500	3		
		2.8500 - 2.2000	2		
		2.2000 >	1		
HV short	R-Y	< 3.5000	4	1	2
		3.5000 - 2.3850	3		
		2.3850 - 1.2700	2		
		1.2700 >	1		
	Y-B	< 3.0000	4	1	
		3.0000 - 2.3000	3		
		2.3000 - 1.6000	2		
		1.6000 >	1		
	B-R	< 3.5000	4	1	
		3.5000 - 2.8500	3		
		2.8500 - 2.2000	2		
		2.2000 >	1		
LV open	R-Y	5.3000	4	1	2
		5.3000 - 4.6500	3		
		4.6500 - 4.0000	2		
		4.0000 >	1		
	Y-B	< 4.8000	4	1	
		4.8000 - 4.2500	3		
		4.2500 - 3.7000	2		
		3.7000 >	1		
	B-R	< 4.8000	4	1	
		4.8000 - 3.4000	3		
		3.4000 - 2.0000	2		
		2.0000 >	1		

(b) Weights and scores derived for CCFI

Region -1 (20 Hz – 2 kHz)

Test Connection	Phases	CCF Value	Score (S_i)	Weight	
				$W1_i$	$W2_j$
HV open	R-Y	< 0.9200	1	1	3
		0.9200 - 0.9100	2		
		0.9100 - 0.9000	3		
		0.9000 >	4		
	Y-B	< 0.9100	1	1	
		0.9100 - 0.8850	2		
		0.8850 - 0.8600	3		
		0.8600 >	4		
	B-R	< 0.9900	1	3	
		0.9900 - 0.9700	2		
		0.9700 - 0.9500	3		
		0.9500 >	4		
HV short	R-Y	< 1.0000	1	1	1
		1.0000 - 0.9995	2		
		0.9995 - 0.9990	3		
		0.9990 >	4		
	Y-B	< 1.0000	1	1	
		1.0000 - 0.9995	2		
		0.9995 - 0.9990	3		
		0.9990 >	4		
	B-R	< 1.0000	1	3	
		1.0000 - 0.9995	2		
		0.9995 - 0.9990	3		
		0.9990 >	4		
LV open	R-Y	< 0.8900	1	1	2
		0.8900 - 0.8700	2		
		0.8700 - 0.8500	3		
		0.8500 >	4		
	Y-B	< 0.8900	1	1	
		0.8900 - 0.8650	2		
		0.8650 - 0.8400	3		
		0.8400 >	4		
	B-R	< 0.9980	1	3	
		0.9980 - 0.9740	2		
		0.9740 - 0.9500	3		
		0.9500 >	4		

Region -2 (2 kHz – 20 kHz)

Test Connection	Phases	CCF Value	Score (S_i)	Weight	
				$W1_i$	$W2_j$
HV open	R-Y	< 0.9800	1	1	3
		0.9800 - 0.9600	2		
		0.9600 - 0.9400	3		
		0.9400 >	4		
	Y-B	< 0.9800	1	1	
		0.9800 - 0.9650	2		
		0.9650 - 0.9500	3		
		0.9500 >	4		
	B-R	< 0.9980	1	2	
		0.9980 - 0.9960	2		
		0.9960 - 0.9940	3		
		0.9940 >	4		
HV short	R-Y	< 0.9600	1	1	2
		0.9600 - 0.9200	2		
		0.9200 - 0.8800	3		
		0.8800 >	4		
	Y-B	< 0.9700	1	1	
		0.9700 - 0.9300	2		
		0.9300 - 0.8900	3		
		0.8900	4		
	B-R	< 0.9980	1	2	
		0.9980 - 0.9955	2		
		0.9955 - 0.9930	3		
		0.9930 >	4		
LV open	R-Y	< 0.9890	1	1	2
		0.9890 - 0.9730	2		
		0.9730 - 0.9570	3		
		0.9570 >	4		
	Y-B	< 0.9920	1	1	
		0.9920 - 0.9845	2		
		0.9845 - 0.9770	3		
		0.9770 >	4		
	B-R	< 0.9990	1	2	
		0.9990 - 0.9945	2		
		0.9945 - 0.9900	3		
		0.9900 >	4		

Region -3 (20 kHz – 400 kHz)

Test Connection	Phases	CCF Value	Score (S_i)	Weight	
				$W1_i$	$W2_j$
HV open	R-Y	< 0.9930	1	1	3
		0.9930 - 0.9765	2		
		0.9765 - 0.9600	3		
		0.9600 >	4		
	Y-B	< 0.9930	1	1	
		0.9930 - 0.9765	2		
		0.9765 - 0.9600	3		
		0.9600 >	4		
	B-R	< 0.9920	1	1	
		0.9920 - 0.9560	2		
		0.9560 - 0.9200	3		
		0.9200 >	4		
HV short	R-Y	< 0.9920	1	1	2
		0.9920 - 0.9760	2		
		0.9760 - 0.9600	3		
		0.9600 >	4		
	Y-B	< 0.9920	1	1	
		0.9920 - 0.9760	2		
		0.9760 - 0.9600	3		
		0.9600 >	4		
	B-R	< 0.9940	1	1	
		0.9940 - 0.9620	2		
		0.9620 - 0.9300	3		
		0.9300 >	4		
LV open	R-Y	< 0.9680	1	1	2
		0.9680 - 0.9240	2		
		0.9240 - 0.8800	3		
		0.8800 >	4		
	Y-B	< 0.9730	1	1	
		0.9730 - 0.9590	2		
		0.9590 - 0.9450	3		
		0.9450 >	4		
	B-R	< 0.9820	1	1	
		0.9820 - 0.9610	2		
		0.9610 - 0.9400	3		
		0.9400 >	4		

Region -4 (400 kHz – 2 MHz)

Test Connection	Phases	CCF Value	Score (S_i)	Weight	
				$W1_i$	$W2_j$
HV open	R-Y	< 0.9600	1	1	3
		0.9600 - 0.9200	2		
		0.9200 - 0.8800	3		
		0.8800 >	4		
	Y-B	< 0.9600	1	1	
		0.9600 - 0.9100	2		
		0.9100 - 0.8600	3		
		0.8600 >	4		
	B-R	< 0.9200	1	1	
		0.9200 - 0.8600	2		
		0.8600 - 0.8000	3		
		0.8000	4		
HV short	R-Y	< 0.9600	1	1	2
		0.9600 - 0.9200	2		
		0.9200 - 0.8800	3		
		0.8800 >	4		
	Y-B	< 0.9630	1	1	
		0.9630 - 0.9315	2		
		0.9315 - 0.9000	3		
		0.9000 >	4		
	B-R	< 0.9200	1	1	
		0.9200 - 0.8700	2		
		0.8700 - 0.8200	3		
		0.8200 >	4		
LV open	R-Y	< 0.7000	1	1	2
		0.7000 - 0.5000	2		
		0.5000 - 0.3000	3		
		0.3000 >	4		
	Y-B	< 0.8000	1	1	
		0.8000 - 0.6550	2		
		0.6550 - 0.5100	3		
		0.5100 >	4		
	B-R	< 0.8900	1	1	
		0.8900 - 0.7750	2		
		0.7750 - 0.6600	3		
		0.6600 >	4		

(c) Weights and scores derived for DisTF

Region -1 (20 Hz – 2 kHz)

Test Connection	Phases	DisTF	Score *(Si)*	Weight	
				$W1_i$	$W2_j$
HV open	R-Y	< 2.6000	4	1	3
		2.6000 - 2.0000	3		
		2.0000 - 1.4500	2		
		1.4500 >	1		
	Y-B	< 2.6000	4	1	
		2.6000 - 2.0000	3		
		2.0000 - 1.5000	2		
		1.5000 >	1		
	B-R	< 1.6000	4	3	
		1.6000 - 1.1500	3		
		1.1500 - 0.7000	2		
		0.7000 >	1		
HV short	R-Y	< 0.1000	4	1	1
		0.1000 - 0.0500	3		
		0.0500 - 0.0080	2		
		0.0080 >	1		
	Y-B	< 0.1000	4	1	
		0.1000 - 0.0550	3		
		0.0550 - 0.0100	2		
		0.0100 >	1		
	B-R	< 0.0800	4	3	
		0.0800 - 0.0450	3		
		0.0450 - 0.0100	2		
		0.0100 >	1		
LV open	R-Y	< 3.2600	4	1	2
		3.2600 - 2.7300	3		
		2.7300 - 2.2000	2		
		2.2000 >	1		
	Y-B	< 3.0000	4	1	
		3.0000 - 2.5000	3		
		2.5000 - 2.0000	2		
		2.0000 >	1		
	B-R	< 2.3000	4	3	
		2.3000 - 1.6500	3		
		1.6500 - 1.0000	2		
		1.0000 >	1		

Region -2 (2 kHz – 20 kHz)

Test Connection	Phases	DisTF	Score (Si)	Weight	
				$W1_i$	$W2_j$
HV open	R-Y	< 0.0600	4	1	3
		0.0600 - 0.0400	3		
		0.0400 - 0.0200	2		
		0.0200 >	1		
	Y-B	< 0.0600	4	1	
		0.0600 - 0.0400	3		
		0.0400 - 0.0200	2		
		0.0200 >	1		
	B-R	< 0.0206	4	2	
		0.0206 - 0.0150	3		
		0.0150 - 0.0090	2		
		0.0090 >	1		
HV short	R-Y	< 0.0500	4	1	2
		0.0500 - 0.0400	3		
		0.0400 - 0.0300	2		
		0.0300 >	1		
	Y-B	< 0.0501	4	1	
		0.0501 - 0.0400	3		
		0.0400 - 0.0300	2		
		0.0300 >	1		
	B-R	< 0.0200	4	2	
		0.0200 - 0.0150	3		
		0.0150 - 0.0095	2		
		0.0095 >	1		
LV open	R-Y	< 0.0400	4	1	2
		0.0400 - 0.0290	3		
		0.0290 - 0.0180	2		
		0.0180 >	1		
	Y-B	< 0.0500	4	1	
		0.0500 - 0.0200	3		
		0.0200 - 0.0140	2		
		0.0140 >	1		
	B-R	< 0.0270	4	2	
		0.0270 - 0.0170	3		
		0.0170 - 0.0070	2		
		0.0070 >	1		

Region -3 (20 kHz – 400 kHz)

Test Connection	Phases	DisTF	Score (Si)	Weight	
				$W1_i$	$W2_j$
HV open	R-Y	< 0.0250	4	1	3
		0.0250 - 0.0175	3		
		0.0175 - 0.0100	2		
		0.0100 >	1		
	Y-B	< 0.0200	4	1	
		0.0200 - 0.0145	3		
		0.0145 - 0.0090	2		
		0.0090 >	1		
	B-R	< 0.0220	4	1	
		0.0220 - 0.0155	3		
		0.0155 - 0.0090	2		
		0.0090 >	1		
HV short	R-Y	< 0.0240	4	1	2
		0.0240 - 0.0170	3		
		0.0170 - 0.0100	2		
		0.0100 >	1		
	Y-B	< 0.0300	4	1	
		0.0300 - 0.0200	3		
		0.0200 - 0.0100	2		
		0.0100 >	1		
	B-R	< 0.0270	4	1	
		0.0270 - 0.0165	3		
		0.0165 - 0.0060	2		
		0.0060 >	1		
LV open	R-Y	< 0.0400	4	1	2
		0.0400 - 0.0300	3		
		0.0300 - 0.0200	2		
		0.0200 >	1		
	Y-B	< 0.0330	4	1	
		0.0330 - 0.0250	3		
		0.0250 - 0.0170	2		
		0.0170 >	1		
	B-R	< 0.0360	4	1	
		0.0360 - 0.0245	3		
		0.0245 - 0.0130	2		
		0.0130 >	1		

Region -4 (400 kHz – 2 MHz)

Test Connection	Phases	DisTF	Score (Si)	Weight	
				$W1_i$	$W2_j$
HV open	R-Y	< 0.0015	4	1	3
		0.0015 - 0.0012	3		
		0.0012 - 0.0008	2		
		0.0008 >	1		
	Y-B	< 0.0016	4	1	
		0.0016 - 0.0012	3		
		0.0012 - 0.0007	2		
		0.0007 >	1		
	B-R	< 0.0020	4	1	
		0.0020 - 0.0014	3		
		0.0014 - 0.0009	2		
		0.0009 >	1		
HV short	R-Y	< 0.0008	4	1	2
		0.0008 - 0.0014	3		
		0.0014 - 0.0020	2		
		0.0020 >	1		
	Y-B	< 0.0023	4	1	
		0.0023 - 0.0015	3		
		0.0015 - 0.0007	2		
		0.0007 >	1		
	B-R	< 0.0017	4	1	
		0.0017 - 0.0012	3		
		0.0012 - 0.0008	2		
		0.0008 >	1		
LV open	R-Y	< 0.0050	4	1	2
		0.0050 - 0.0040	3		
		0.0040 - 0.0030	2		
		0.0030 >	1		
	Y-B	< 0.0050	4	1	
		0.0050 - 0.0043	3		
		0.0043 - 0.0035	2		
		0.0035 >	1		
	B-R	< 0.0040	4	1	
		0.0040 - 0.0035	3		
		0.0035 - 0.0030	2		
		0.0030 >	1		

Appendix-F: Calculated values for ASLEI, CCFI and DisTF for four regions

(a) Values calculated for ASLEI for four regions

Item	Grid Substation	TR No.	Range 1	Range 2	Range 3	Range 4
1	Badulla	TR03	3.0000	1.1429	2.4762	1.1905
2	Biyagama	TR03	1.5667	3.1429	2.8571	1.1905
3	Biyagama	TR04	1.9333	2.0357	1.3333	1.5714
4	Bolawattha	TR01	1.5667	2.0714	2.8095	2.0000
5	Bolawattha	TR02	1.7000	2.1429	3.0476	1.4286
6	Bolawattha	TR03	1.7667	2.2857	1.1429	2.8095
7	Habarana	TR01	1.7000	1.0000	1.2857	1.6190
8	Habarana	TR02	1.8667	1.0000	1.1905	1.9048
9	Hambanthota	TR02	2.0667	1.0000	1.0000	1.0000
10	Katunayake	TR02	3.0000	1.6786	1.2857	1.5714
11	Kelaniya	TR01	1.6000	1.5000	1.7619	2.4286
12	Kiribathkumbura	TR01	1.5000	1.9643	2.8095	1.4762
13	Kiribathkumbura	TR02	1.5000	2.2857	2.9048	2.1905
14	Kolonnawa	TR04	1.5667	2.0714	2.1429	1.3333
15	Kolonnawa	TR05	1.5000	2.3571	1.8571	1.0952
16	Mahiyangana	TR01	3.2000	1.2143	1.0000	2.5238
17	Maho	TR02	1.5667	1.2500	1.1905	2.1429
18	Monaragala	TR01	2.1333	1.6071	1.0952	1.7619
19	Monaragala	TR02	2.0000	2.1071	1.7619	1.4762
20	New Valachcheni	TR02	1.6667	2.0714	1.4762	1.8095
21	Nuwara Eliya	TR01	1.8000	1.0000	1.6190	1.5714
22	Nuwara Eliya	TR02	1.7333	1.0000	1.4762	1.5714
23	Nuwara Eliya	TR03	2.0000	1.5714	1.0000	2.2381
24	Old Anuradhapura	TR01	1.5667	2.4643	2.0476	2.9048
25	Old Galle	TR01	1.5000	1.0000	1.0000	1.0000
26	Old Galle	TR02	1.5000	1.3571	1.0000	1.0000
27	Pannala	TR01	1.5667	1.3571	1.0000	2.7619
28	Pannala	TR02	1.6667	1.2857	1.2857	1.6667
29	Pannipitiya	TR03	1.8000	2.7857	1.9524	1.3810
30	Sapugaskanda	TR01	1.8667	1.2857	2.0952	2.7143
31	Sapugaskanda	TR03	3.1000	1.6786	1.4762	2.3333
32	Sri Jayawardanapura	TR01	1.7000	1.9286	1.7143	2.8571
33	Sri Jayawardanapura	TR02	2.4000	2.7143	2.0476	3.0000
34	Thulhiriya	TR01	1.6000	1.0000	2.2381	1.2857
35	Thulhiriya	TR02	1.6000	1.0000	2.1429	1.3810
36	Trincomalee	TR01	2.2667	1.1429	1.4762	1.7143
37	Trincomalee	TR02	1.9333	1.0000	1.0952	1.9524
38	Valachchenei	TR01	1.8667	3.8929	3.7143	1.4762
39	Valachchenei	TR02	1.6000	4.0000	3.7143	1.2857
40	Valachchenei	TR03	1.5000	3.6429	3.7143	1.0952
41	Vaunathiu	TR01	2.0000	1.2857	1.0952	1.3333
42	Vaunathiu	TR02	1.8667	1.8571	1.1429	2.0952
43	Veyangoda	TR02	1.7000	2.9286	2.2857	1.1905
44	Veyangoda	TR03	2.3667	2.5000	2.7143	1.2857

(b) Values calculated for CCFI for four regions

Item	Grid Substation	TR No.	Range 1	Range 2	Range 3	Range 4
1	Badulla	TR03	2.8333	1.1429	2.7143	1.2381
2	Biyagama	TR03	1.3000	3.3571	2.7143	1.0952
3	Biyagama	TR04	1.2333	1.4286	1.1905	1.7143
4	Bolawattha	TR01	1.5000	2.1786	2.7619	2.0952
5	Bolawattha	TR02	1.6333	2.1786	3.0476	1.9048
6	Bolawattha	TR03	1.8333	2.3571	1.3810	3.1429
7	Habarana	TR01	1.6667	1.0000	1.2857	1.9048
8	Habarana	TR02	2.0000	1.0000	1.1905	1.9048
9	Hambanthota	TR02	2.0333	1.0714	1.2381	1.0952
10	Katunayake	TR02	2.8667	1.2857	1.1905	1.4286
11	Kelaniya	TR01	1.3333	1.5000	2.0952	2.4286
12	Kiribathkumbura	TR01	1.1667	2.2143	2.5238	1.9048
13	Kiribathkumbura	TR02	1.1667	2.6071	2.8571	1.9524
14	Kolonnawa	TR04	1.7000	2.4286	2.0476	1.1905
15	Kolonnawa	TR05	1.3333	2.5714	1.7619	1.2857
16	Mahiyangana	TR01	2.9333	1.1429	1.2381	2.6667
17	Maho	TR02	1.2667	1.4643	1.4286	1.9524
18	Monaragala	TR01	1.6000	1.5357	1.0000	1.2381
19	Monaragala	TR02	2.3000	2.1071	1.4762	1.4762
20	New Valachcheni	TR02	1.1667	1.8214	1.2857	1.6190
21	Nuwara Eliya	TR01	1.9667	1.1429	1.6667	1.6667
22	Nuwara Eliya	TR02	1.6333	1.1429	1.7619	1.6667
23	Nuwara Eliya	TR03	2.2333	1.8571	1.1905	2.1905
24	Old Anuradhapura	TR01	1.3000	2.9286	1.6667	2.8571
25	Old Galle	TR01	1.2667	1.0000	1.2381	1.2381
26	Old Galle	TR02	1.1667	1.0000	1.0000	1.0000
27	Pannala	TR01	1.5000	1.2143	1.0952	3.1429
28	Pannala	TR02	1.9333	1.2143	1.1905	1.7619
29	Pannipitiya	TR03	1.8000	3.0000	1.9524	1.4762
30	Sapugaskanda	TR01	1.1667	1.1429	1.5714	3.1429
31	Sapugaskanda	TR03	3.1667	1.8571	1.6667	2.9524
32	Sri Jayawardanapura	TR01	2.0667	1.2857	1.5714	2.2381
33	Sri Jayawardanapura	TR02	3.1667	1.5714	1.4762	2.6667
34	Thulhiriya	TR01	1.1667	1.0000	2.0476	1.0952
35	Thulhiriya	TR02	1.1667	1.0000	1.8095	1.2857
36	Trincomalee	TR01	2.7333	1.0000	1.2857	1.8095
37	Trincomalee	TR02	2.3333	1.0000	1.0952	1.7619
38	Valachchenei	TR01	2.0667	3.4643	3.8095	1.2857
39	Valachchenei	TR02	1.4000	3.8929	3.7143	1.2857
40	Valachchenei	TR03	1.1667	3.4643	3.8095	1.1905
41	Vaunathiu	TR01	1.3667	1.1429	1.2381	1.4762
42	Vaunathiu	TR02	1.3000	1.9643	1.0000	1.8095
43	Veyangoda	TR02	1.3667	3.2857	2.3810	1.0000
44	Veyangoda	TR03	2.5333	2.7857	2.7619	1.0952

(c) Values calculated for DisTFI

Item	Grid Substation	TR No.	Range 1	Range 2	Range 3	Range 4
1	Badulla	TR03	1.3000	1.0000	3.3333	1.6667
2	Biyagama	TR03	1.3667	2.5714	2.5714	1.0000
3	Biyagama	TR04	1.1000	2.0714	1.3333	2.0952
4	Bolawattha	TR01	2.2000	2.2857	1.0952	3.9048
5	Bolawattha	TR02	2.9000	2.1429	1.6190	3.6190
6	Bolawattha	TR03	1.6333	2.2143	2.0000	2.3810
7	Habarana	TR01	1.8333	1.0000	1.0952	1.0952
8	Habarana	TR02	1.2667	1.0000	1.0952	1.1905
9	Hambanthota	TR02	1.5333	1.0000	1.1905	1.0000
10	Katunayake	TR02	2.2667	1.6429	1.0952	1.0952
11	Kelaniya	TR01	1.3333	1.2143	1.4762	1.8095
12	Kiribathkumbura	TR01	1.7000	2.0714	1.0952	3.1429
13	Kiribathkumbura	TR02	1.4000	2.7857	1.0952	3.6190
14	Kolonnawa	TR04	1.9667	1.9286	2.3333	1.0000
15	Kolonnawa	TR05	1.6667	2.3214	1.9524	1.0000
16	Mahiyangana	TR01	1.3000	1.4286	1.5714	3.4286
17	Maho	TR02	1.1333	1.4286	1.5714	3.0000
18	Monaragala	TR01	1.0000	1.8571	1.2381	2.2857
19	Monaragala	TR02	1.7667	2.2143	1.4762	2.1905
20	New Valachcheni	TR02	1.0000	2.1429	1.4762	2.3810
21	Nuwara Eliya	TR01	2.1000	1.1429	2.7619	1.0000
22	Nuwara Eliya	TR02	1.6333	1.1429	3.0000	1.1905
23	Nuwara Eliya	TR03	1.3333	2.0714	1.4286	2.8095
24	Old Anuradhapura	TR01	1.8000	2.3571	1.8571	1.7619
25	Old Galle	TR01	1.9333	1.0000	1.0000	1.0000
26	Old Galle	TR02	2.0667	1.5000	1.0000	1.0000
27	Pannala	TR01	1.8667	1.3571	1.0952	1.9524
28	Pannala	TR02	1.9667	1.5000	1.0952	1.3810
29	Pannipitiya	TR03	2.8333	2.4286	2.2857	1.0952
30	Sapugaskanda	TR01	1.2667	1.0714	1.4286	2.7143
31	Sapugaskanda	TR03	2.5667	1.5714	1.8571	2.1429
32	Sri Jayawardanapura	TR01	3.6667	2.7143	2.3333	1.9048
33	Sri Jayawardanapura	TR02	3.9000	2.2857	2.0952	2.3333
34	Thulhiriya	TR01	1.1667	1.0000	2.6667	1.2857
35	Thulhiriya	TR02	1.2333	1.0000	2.4286	1.4762
36	Trincomalee	TR01	2.0000	1.0000	1.0952	1.0000
37	Trincomalee	TR02	1.3000	1.0000	1.0000	1.1905
38	Valachchenei	TR01	1.8333	3.9286	3.9048	2.0952
39	Valachchenei	TR02	1.6000	3.9286	3.9048	1.2381
40	Valachchenei	TR03	1.4000	3.7143	3.9048	1.4762
41	Vaunathiu	TR01	1.0000	1.5000	1.0952	2.0000
42	Vaunathiu	TR02	1.0000	2.2857	1.5714	2.2857
43	Veyangoda	TR02	1.3333	2.7500	2.4286	1.1905
44	Veyangoda	TR03	1.9000	2.0714	3.0476	1.6667

Appendix-G: The SFRAI values for the four regions

Item	Grid Substation	TR No.	Range 1	Range 2	Range 3	Range 4
1	Badulla	TR03	2.6333	1.1190	2.7381	1.2937
2	Biyagama	TR03	1.4000	3.1548	2.7381	1.1111
3	Biyagama	TR04	1.4444	1.7381	1.2619	1.7302
4	Bolawattha	TR01	1.6389	2.1607	2.5000	2.3651
5	Bolawattha	TR02	1.8667	2.1607	2.8095	2.0317
6	Bolawattha	TR03	1.7778	2.3095	1.4048	2.9048
7	Habarana	TR01	1.7056	1.0000	1.2540	1.6746
8	Habarana	TR02	1.8333	1.0000	1.1746	1.7857
9	Hambanthota	TR02	1.9611	1.0357	1.1508	1.0476
10	Katunayake	TR02	2.8111	1.4762	1.2063	1.4206
11	Kelaniya	TR01	1.4222	1.4524	1.8810	2.3254
12	Kiribathkumbura	TR01	1.3667	2.1071	2.3810	1.9683
13	Kiribathkumbura	TR02	1.3167	2.5298	2.5794	2.3095
14	Kolonnawa	TR04	1.7000	2.2262	2.1270	1.2063
15	Kolonnawa	TR05	1.4444	2.4583	1.8254	1.1746
16	Mahiyangana	TR01	2.7500	1.2143	1.2143	2.7460
17	Maho	TR02	1.3444	1.3869	1.3730	2.1905
18	Monaragala	TR01	1.6778	1.6131	1.0714	1.5873
19	Monaragala	TR02	2.1111	2.1250	1.5714	1.5952
20	New Valachcheni	TR02	1.3056	1.9583	1.3810	1.8095
21	Nuwara Eliya	TR01	1.9333	1.0952	1.8333	1.5238
22	Nuwara Eliya	TR02	1.6667	1.0952	1.8730	1.5556
23	Nuwara Eliya	TR03	2.0056	1.7976	1.1667	2.3095
24	Old Anuradhapura	TR01	1.4722	2.6786	1.8254	2.6905
25	Old Galle	TR01	1.4556	1.0000	1.1190	1.1190
26	Old Galle	TR02	1.4278	1.2024	1.0000	1.0000
27	Pannala	TR01	1.5833	1.2857	1.0635	2.8175
28	Pannala	TR02	1.8500	1.2857	1.2063	1.6667
29	Pannipitiya	TR03	1.9722	2.8333	2.0079	1.3810
30	Sapugaskanda	TR01	1.4167	1.1786	1.7222	2.9286
31	Sapugaskanda	TR03	3.0444	1.7500	1.6349	2.6111
32	Sri Jayawardanapura	TR01	2.2111	1.7381	1.7460	2.3889
33	Sri Jayawardanapura	TR02	3.0333	2.0714	1.7698	2.7222
34	Thulhiriya	TR01	1.3111	1.0000	2.2143	1.1905
35	Thulhiriya	TR02	1.3222	1.0000	2.0238	1.3492
36	Trincomalee	TR01	2.4556	1.0476	1.3175	1.6429
37	Trincomalee	TR02	2.0278	1.0000	1.0794	1.7302
38	Valachchenei	TR01	1.9611	3.6845	3.7937	1.4841
39	Valachchenei	TR02	1.5000	3.9345	3.7460	1.2778
40	Valachchenei	TR03	1.3167	3.5655	3.7937	1.2063
41	Vaunathiu	TR01	1.5167	1.2500	1.1667	1.5159
42	Vaunathiu	TR02	1.4389	1.9821	1.1429	1.9841
43	Veyangoda	TR02	1.4722	3.0774	2.3571	1.0952
44	Veyangoda	TR03	2.3722	2.5714	2.7937	1.2540

Appendix-H: A sample test report of dissolved gas concentration measurement

MORGAN SCHAFFER
Transformers - The Inside View

Transformer Fault Gas Analysis

Results

Sample

Equipment ID:	DC TR03	Serial Number:	99.4.0009
Apparatus Type:	TRN	Sampling Point:	BOTTOM
Designation:	Galle TR03	Syringe ID:	6736
Sampled By:	Charaka	Date Sampled:	2015/03/18
Oil Temperature:	50 ℃	Tank Pressure:	1 psig
Comment:	Oil type: ASTM 3612		

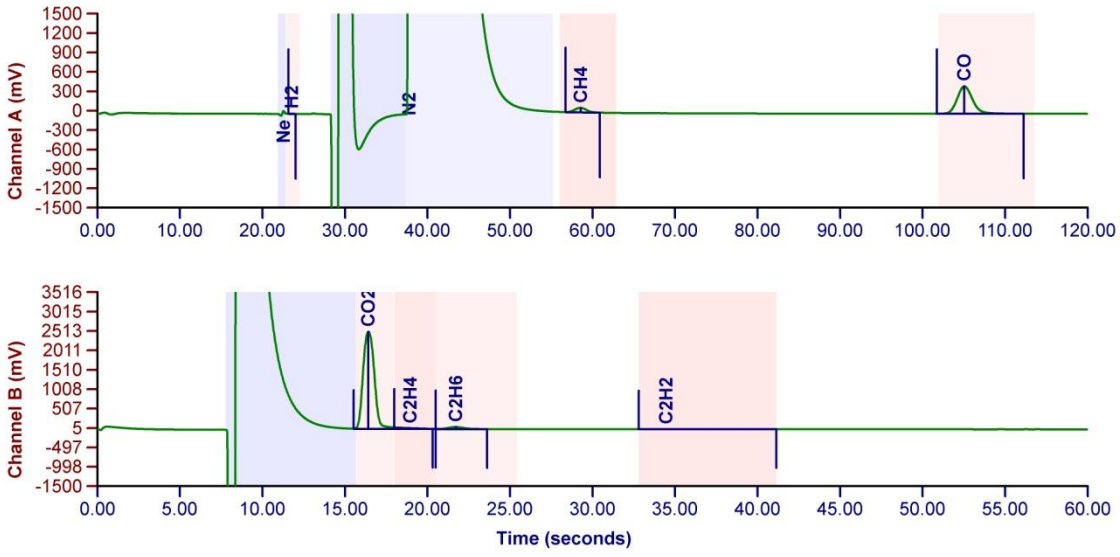
Analysis Identification

Method File:	20150320 Daily Method.prm
Calgas File:	20150320112043 Calibration.prs
Air File:	20150320112543 Air.prs
Oil File:	20150320125435 Oil.prs
Calgas O2N2 File:	20150320112043 Calibration.prs
Air O2N2 File:	20150320112543 Air.prs
Oil O2N2 File:	
Analyzed By:	Charaka
Date Acquired:	2015/03/20
Instrument ID:	11009003
Version:	PPMreport 3.2.0

Measurement Results

H2 (Hydrogen)	**23** ppm
CH4 (Methane)	**57** ppm
CO (Carbon Monoxide)	**158** ppm
CO2 (Carbon Dioxide)	**1565** ppm
C2H4 (Ethylene)	**0** ppm
C2H6 (Ethane)	**102** ppm
C2H2 (Acetylene)	**0** ppm
O2 (Oxygen)	**-** ppm
N2 (Nitrogen)	**-** ppm
TDG:	**-** %
TDCG:	**0.03** %
THCG (O2N2):	**-** %
THCG (Pressure):	**0.17** %

Graphs



Appendix-I: Concentration levels of dissolved gases and the different diagnoses based on the concentration

Item	Grid Substation	TR No.	H_2	CH_4	CO	CO_2	C_2H_4	C_2H_6	C_2H_2	Diagnosis				
										Key Gas Analysis		Dornenburg's Ratio Analysis	Roger's Ratio Analysis	Duval's Triangle Analysis
1	Ambalangoda	TR01	12	127	235	1932	13	308	0	Condition 1	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
2	Ambalangoda	TR02	17	127	308	2334	7	283	0	Condition 2	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
3	Ampara	TR01	18	89	508	3072	31	173	0	Condition 2	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault 300 ˚C – 700 ˚C
4	Ampara	TR02	0	0	48	364	0	2	0	Condition 1				
5	Ampara	TR03	22	48	173	725	4	104	0	Condition 1	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	
6	Badulla	TR01	36	19	74	1350	0	49	0	Condition 1	Not Available	Not Available	Not Available	
7	Badulla	TR02	22	6	167	1239	0	13	0	Condition 1				
8	Badulla	TR03	37	8	231	992	0	4	0	Condition 1				
9	Balangoda	TR01	82	5	125	804	2	0	0	Condition 1				
10	Balangoda	TR03	31	0	92	396	0	0	0	Condition 1				
11	Beliaththa	TR01	41	6	735	1926	1	0	0	Condition 2	Overheated cellulose			
12	Beliaththa	TR02	43	7	583	1818	5	0	0	Condition 1	Overheated cellulose			
13	Biyagama	TR01-R	36	47	95	1456	15	229	0	Condition 1	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	
14	Biyagama	TR01-Y	47	50	104	1461	19	246	2	Condition 2	Not Available	Thermal Decomposition	Not Available	Thermal fault 300 ˚C – 700 ˚C
15	Biyagama	TR01-B	37	159	15	546	418	59	4	Condition 2	Overheated oil	Thermal Decomposition	Thermal fault > 700 ˚C	Thermal fault > 700 ˚C
16	Biyagama	TR02-R	77	39	75	1246	35	176	5	Condition 2	Not Available	Not Available	Not Available	Discharge of low energy
17	Biyagama	TR02-Y	44	44	78	1608	18	224	2	Condition 2	Not Available	Thermal Decomposition	Not Available	
18	Biyagama	TR02-B	40	37	93	676	18	200	0	Condition 1	Not Available	Not Available	Normal	
19	Biyagama	TR03	23	57	158	1565	0	102	0	Condition 1	Not Available	Not Available	Not Available	Partial discharge of low energy
20	Biyagama	TR04	26	9	103	507	2	5	0	Condition 1				
21	Bolawattha	TR01	107	115	707	6387	31	127	0	Condition 2	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault 300 ˚C – 700 ˚C
22	Bolawattha	TR02	99	75	529	5397	25	73	0	Condition 2	Not Available	Not Available	Normal	Thermal fault 300 ˚C – 700 ˚C
23	Bolawattha	TR03	17	101	171	2350	5	274	0	Condition 1	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
24	Dehiwala	TR02	30	51	261	2183	3	72	0	Condition 1	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
25	Embilipitiya	TR01	22	76	273	1437	5	182	0	Condition 1	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
26	Embilipitiya	TR02	15	79	254	1562	5	201	0	Condition 1	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
27	Habarana	TR01	51	5	71	533	2	0	0	Condition 1				
28	Habarana	TR02	1162	38	125	1237	3	0	0	Condition 2	Corona in oil	Not Available	Not Available	
29	Hambanthota	TR01	0	64	599	2149	6	110	0	Condition 2	Not Available	Not Available	Not Available	Thermal fault < 300 ˚C
30	Hambanthota	TR02	30	2	302	792	0	0	0	Condition 1				
31	Horana	TR01	12	21	2055	10498	0	4	0	Condition 3	Overheated cellulose			
32	Horana	TR02	11	22	2282	11406	0	4	0	Condition 3	Overheated cellulose			
33	Horana	TR03	34	21	163	728	4	26	0	Condition 1				
34	Katunayake	TR02	10	132	412	2988	14	245	0	Condition 2	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
35	Kelanitissa	TR01	29	0	266	11	37	4	0	Condition 1				
36	Kelanitissa	TR02	24	52	201	25	44	31	0	Condition 1	Not Available	Not Available	Thermal fault 300 ˚C – 700 ˚C	Thermal fault 300 ˚C – 700 ˚C
37	Kelaniya	TR01	35	190	736	4921	110	271	1	Condition 2	Not Available	Thermal Decomposition	Thermal fault 150 ˚C – 300 ˚C	Thermal fault 300 ˚C – 700 ˚C
38	Kiribathkumbura	TR01	64	154	921	7294	36	184	0	Condition 2	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
39	Kiribathkumbura	TR02	70	195	1103	7232	42	242	0	Condition 3	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
40	Kiribathkumbura	TR03	9	124	148	2188	9	360	0	Condition 2	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
41	Kolonnawa	TR01	0	77	139	2919	5	172	0	Condition 2	Not Available	Not Available	Not Available	Thermal fault < 300 ˚C
42	Kolonnawa	TR02	0	98	130	2939	7	215	0	Condition 2	Not Available	Not Available	Not Available	Thermal fault < 300 ˚C
43	Kolonnawa	TR03	0	119	134	2797	18	269	0	Condition 2	Not Available	Not Available	Not Available	Thermal fault < 300 ˚C
44	Kolonnawa	TR04	11	119	72	3362	27	244	0	Condition 2	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
45	Kolonnawa	TR05	12	127	235	1932	13	308	0	Condition 1	Not Available	Not Available	Not Available	Thermal fault < 300 ˚C

Item	Grid Substation	TR No.	H_2	CH_4	CO	CO_2	C_2H_4	C_2H_6	C_2H_2	Diagnosis				
										Key Gas Analysis		Dornenburg's Ratio Analysis	Roger's Ratio Analysis	Duval's Triangle Analysis
46	Kosgama	TR02	12	93	86	2180	5	114	0	Condition 1	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
47	Kotugoda	TR01-R	89	54	77	713	11	184	0	Condition 1	Not Available	Not Available	Normal	Thermal fault < 300 ˚C
48	Kotugoda	TR01-Y	73	43	79	715	13	188	0	Condition 1	Not Available	Not Available	Normal	
49	Kotugoda	TR01-B	84	472	118	932	458	311	2	Condition 3	Not Available	Thermal Decomposition	Thermal fault 300 ˚C – 700 ˚C	Thermal fault 300 ˚C – 700 ˚C
50	Kotugoda	TR02-R	64	65	112	1412	30	231	0	Condition 1	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault 300 ˚C – 700 ˚C
51	Kotugoda	TR02-Y	67	61	122	1195	27	212	0	Condition 1	Not Available	Not Available	Normal	Thermal fault 300 ˚C – 700 ˚C
52	Kotugoda	TR02-B	52	66	130	1431	18	273	0	Condition 1	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault 300 ˚C – 700 ˚C
53	Kotugoda	TR03	0	73	311	2774	5	126	0	Condition 2	Not Available	Not Available	Not Available	Thermal fault < 300 ˚C
54	Kotugoda	TR04	0	45	476	2996	4	62	0	Condition 1	Not Available	Not Available	Not Available	
55	Kurunegala	TR01	28	104	274	3208	6	289	0	Condition 2	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
56	Kurunegala	TR02	32	112	267	3804	7	339	0	Condition 2	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
57	Kurunegala	TR03	31	33	118	684	5	42	0	Condition 1	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	
58	Mahiyangana	TR01	27	3	93	416	2	10	1	Condition 1				
59	Mahiyangana	TR02	30	0	341	1163	0	0	0	Condition 1				
60	Maho	TR02	43	7	71	474	2	10	1	Condition 1				
61	Matara	TR01	110	43	146	1185	5	18	2	Condition 1	Not Available	Not Available	Not Available	
62	Matara	TR02	20	74	289	2046	12	68	2	Condition 1	Not Available	Thermal Decomposition	Not Available	Thermal fault < 300 ˚C
63	Matara	TR03	34	0	92	554	0	0	0	Condition 1				
64	Mathugama	TR01	17	166	245	1713	133	569	0	Condition 3	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault 300 ˚C – 700 ˚C
65	Mathugama	TR02	29	132	370	717	10	197	0	Condition 2	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
66	Mathugama	TR03	36	35	1056	403	5	7	0	Condition 2	Overheated cellulose			
67	Monaragala	TR01	14	0	92	284	5	20	0	Condition 1				
68	Monaragala	TR02	0	0	110	592	2	0	0	Condition 1				
69	New Anuradhapura	TR01-R	40	12	942	4742	6	0	0	Condition 3	Overheated cellulose			
70	New Anuradhapura	TR01-Y	58	12	1002	3823	13	0	0	Condition 2	Overheated cellulose			
71	New Anuradhapura	TR01-B	47	12	761	1245	8	7	0	Condition 2	Overheated cellulose			
72	New Anuradhapura	TR02-R	26	11	929	3920	6	0	0	Condition 2	Overheated cellulose			
73	New Anuradhapura	TR02-Y	36	10	566	2650	15	4	25	Condition 2	Not Available	Arcing (High intensity PD)	Discharge of high energy	Discharge of high energy
74	New Anuradhapura	TR02-B	45	11	953	3313	14	0	0	Condition 2	Overheated cellulose			
75	New Valachcheni	TR01	45	59	166	600	9	96	0	Condition 1	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
76	New Valachcheni	TR02	11	3	109	348	0	0	0	Condition 1				
77	Nuwara Eliya	TR01	0	40	303	842	5	70	0	Condition 1	Not Available	Not Available	Not Available	
78	Nuwara Eliya	TR02	0	26	42	386	3	58	0	Condition 1	Not Available	Not Available	Not Available	
79	Nuwara Eliya	TR03	39	3	130	265	0	0	0	Condition 1				
80	Old Anuradhapura	TR01	9	1	120	2077	3	0	0	Condition 1				
81	Old Anuradhapura	TR02	12	14	772	6052	5	3	0	Condition 2	Overheated cellulose			
82	Old Anuradhapura	TR03	9	6	547	5571	3	0	4	Condition 1	Overheated cellulose	Arcing (High intensity PD)	Not Available	Discharge of high energy
83	Old Galle	TR01	29	26	775	6503	70	19	47	Condition 3	Not Available	Not Available	Discharge of high energy	Discharge of high energy
84	Old Galle	TR02	47	58	669	4302	211	58	7	Condition 3	Not Available	Thermal Decomposition	Thermal fault > 700 ˚C	Thermal fault > 700 ˚C
85	Panadura	TR01	16	137	97	2279	10	377	0	Condition 2	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
86	Panadura	TR02	11	118	79	1553	7	336	1	Condition 1	Not Available	Thermal Decomposition	Not Available	Thermal fault < 300 ˚C
87	Panadura	TR03	43	0	155	1191	4	19	0	Condition 1				
88	Pannala	TR01	70	144	302	5667	279	361	8	Condition 3	Not Available	Thermal Decomposition	Thermal fault 150 ˚C – 300 ˚C	Thermal fault > 700 ˚C
89	Pannala	TR02	8	110	214	2236	7	275	0	Condition 1	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
90	Pannipitiya	TS01-R	0	44	83	1209	0	98	0	Condition 1	Not Available	Not Available	Not Available	

Item	Grid Substation	TR No.	H_2	CH_4	CO	CO_2	C_2H_4	C_2H_6	C_2H_2	Diagnosis			
										Key Gas Analysis		Dornenburg's Ratio Analysis	Roger's Ratio Analysis	Duval's Triangle Analysis
91	Pannipitiya	TS01-Y	0	44	84	1244	0	102	0	Condition 1	Not Available	Not Available	Not Available	
92	Pannipitiya	TS01-B	0	42	86	1280	0	99	0	Condition 1	Not Available	Not Available	Not Available	
93	Pannipitiya	TS01-R	0	45	87	1277	0	102	0	Condition 1	Not Available	Not Available	Not Available	
94	Pannipitiya	TS01-Y	0	45	93	1382	0	97	0	Condition 1	Not Available	Not Available	Not Available	
95	Pannipitiya	TS01-B	0	47	98	1391	0	109	0	Condition 1	Not Available	Not Available	Not Available	
96	Pannipitiya	TR01	32	0	449	1682	0	0	0	Condition 1	Overheated cellulose			
97	Pannipitiya	TR02	0	6	101	2252	144	22	13	Condition 2	Overheated oil	Not Available	Not Available	Thermal fault > 700 ˚C
98	Pannipitiya	TR03	11	0	80	1147	0	0	0	Condition 1				
99	Polonnaruwa	TR01	16	2	75	224	0	3	0	Condition 1				
100	Rathnapura	TR01	11	0	0	657	0	0	0	Condition 1				
101	Rathnapura	TR02	18	6	612	2546	0	0	0	Condition 1	Overheated cellulose			
102	Rathmalana	TR01	30	112	95	1765	11	337	0	Condition 1	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
103	Rathmalana	TR02	32	76	444	6682	19	168	0	Condition 3	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault 300 ˚C – 700 ˚C
104	Rathmalana	TR03	0	0	103	2433	2	0	0	Condition 1				
105	Sapugaskanda	TR01	0	0	84	389	0	0	0	Condition 1				
106	Sapugaskanda	TR02	13	8	545	3909	0	2	0	Condition 1	Overheated cellulose			
107	Sapugaskanda	TR03	14	130	165	3001	7	359	0	Condition 2	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	Thermal fault < 300 ˚C
108	Sapugaskanda	TR04	261	65	458	3238	4	9	0	Condition 2	Not Available	Not Available	Normal	Thermal fault < 300 ˚C
109	Seethawaka	TR01	0	0	78	2039	1	0	0	Condition 1				
110	Seethawaka	TR02	9	12	96	1932	57	12	0	Condition 1	Not Available	Not Available	Thermal fault > 700 ˚C	Thermal fault > 700 ˚C
111	Seethawaka	TR03	29	19	88	419	2	50	0	Condition 1	Not Available	Not Available	Normal	
112	Sri Jayawardanapura	TR01	23	3	522	2066	0	0	0	Condition 1	Overheated cellulose			
113	Sri Jayawardanapura	TR02	43	3	411	1280	0	2	0	Condition 1	Overheated cellulose			
114	Thulhiriya	TR01	68	27	479	6455	11	27	0	Condition 1	Not Available			
115	Thulhiriya	TR02	30	6	455	7868	4	3	0	Condition 1	Overheated cellulose			
116	Thulhiriya	TR03	25	128	12	491	346	47	4	Condition 2	Overheated oil	Thermal Decomposition	Thermal fault > 700 ˚C	Thermal fault > 700 ˚C
117	Trincomalee	TR01	14	3	636	4170	27	0	0	Condition 2	Overheated cellulose			
118	Trincomalee	TR02	40	11	1188	6008	0	0	0	Condition 2	Overheated cellulose			
119	Valachchenei	TR01	28	20	416	1837	4	5	13	Condition 2	Not Available	Arcing (High intensity PD)	Not Available	Discharge of low energy
120	Valachchenei	TR02	23	8	371	2890	4	0	17	Condition 2	Not Available	Arcing (High intensity PD)	Not Available	Discharge of low energy
121	Valachchenei	TR03	18	10	631	4995	8	0	7	Condition 2	Overheated cellulose	Arcing (High intensity PD)	Not Available	Discharge of high energy
122	Vaunathiu	TR01	24	4	70	250	2	10	0	Condition 1				
123	Vaunathiu	TR02	17	8	60	278	3	13	0	Condition 1				
124	Vauniya	TR01	32	2	359	1217	0	0	3	Condition 1	Overheated cellulose	Not Available	Not Available	Discharge of low energy
125	Vauniya	TR02	0	37	477	2555	6	61	3	Condition 1	Not Available	Not Available	Not Available	Discharge of low energy
126	Veyangoda	TR01	26	28	140	588	4	37	0	Condition 1	Not Available	Not Available	Thermal fault 150 ˚C – 300 ˚C	
127	Veyangoda	TR02	89	556	257	3068	583	271	0	Condition 3	Not Available	Not Available	Thermal fault 300 ˚C – 700 ˚C	Thermal fault > 700 ˚C
128	Veyangoda	TR03	0	255	14	416	377	139	0	Condition 3	Not Available	Not Available	Not Available	Thermal fault > 700 ˚C
129	Veyangoda	IBT01	13	6	656	3187	0	6	0	Condition 1	Overheated cellulose			
130	Veyangoda	IBT02	11	3	752	4400	0	0	0	Condition 2	Overheated cellulose			

Appendix-J: DGAI and categorization of transformers

Item	Grid Substation	TR No.	DGAI	Condition Level
1	Ambalangoda	TR01	2.17	POOR
2	Ambalangoda	TR02	2.17	POOR
3	Ampara	TR01	1.83	POOR
4	Ampara	TR02	1.00	GOOD
5	Ampara	TR03	1.33	ACCEPTABLE
6	Badulla	TR01	1.00	GOOD
7	Badulla	TR02	1.00	GOOD
8	Badulla	TR03	1.00	GOOD
9	Balangoda	TR01	1.00	GOOD
10	Balangoda	TR03	1.00	GOOD
11	Beliaththa	TR01	1.11	GOOD
12	Beliaththa	TR02	1.06	GOOD
13	Biyagama	TR01-R	1.83	POOR
14	Biyagama	TR01-Y	1.83	POOR
15	Biyagama	TR01-B	2.44	POOR
16	Biyagama	TR02-R	1.78	ACCEPTABLE
17	Biyagama	TR02-Y	1.83	POOR
18	Biyagama	TR02-B	1.67	ACCEPTABLE
19	Biyagama	TR03	1.33	ACCEPTABLE
20	Biyagama	TR04	1.00	GOOD
21	Bolawattha	TR01	2.11	POOR
22	Bolawattha	TR02	1.44	ACCEPTABLE
23	Bolawattha	TR03	2.00	POOR
24	Dehiwala	TR02	1.17	GOOD
25	Embilipitiya	TR01	1.83	POOR
26	Embilipitiya	TR02	1.83	POOR
27	Habarana	TR01	1.00	GOOD
28	Habarana	TR02	1.56	ACCEPTABLE
29	Hambanthota	TR01	1.39	ACCEPTABLE
30	Hambanthota	TR02	1.00	GOOD
31	Horana	TR01	1.56	ACCEPTABLE
32	Horana	TR02	1.56	ACCEPTABLE
33	Horana	TR03	1.00	GOOD
34	Katunayake	TR02	2.28	POOR
35	Kelanitissa	TR01	1.00	GOOD
36	Kelanitissa	TR02	1.00	GOOD
37	Kelaniya	TR01	2.78	POOR
38	Kiribathkumbura	TR01	2.44	POOR
39	Kiribathkumbura	TR02	2.67	POOR
40	Kiribathkumbura	TR03	2.00	POOR
41	Kolonnawa	TR01	1.72	ACCEPTABLE
42	Kolonnawa	TR02	1.89	POOR
43	Kolonnawa	TR03	2.06	POOR
44	Kolonnawa	TR04	2.11	POOR
45	Kolonnawa	TR05	2.00	POOR

Item	Grid Substation	TR No.	DGAI	Condition Level
46	Kosgama	TR02	1.50	ACCEPTABLE
47	Kotugoda	TR01-R	1.67	ACCEPTABLE
48	Kotugoda	TR01-Y	1.67	ACCEPTABLE
49	Kotugoda	TR01-B	3.33	VERY POOR
50	Kotugoda	TR02-R	1.83	POOR
51	Kotugoda	TR02-Y	1.67	ACCEPTABLE
52	Kotugoda	TR02-B	1.83	POOR
53	Kotugoda	TR03	1.56	ACCEPTABLE
54	Kotugoda	TR04	1.11	GOOD
55	Kurunegala	TR01	2.11	POOR
56	Kurunegala	TR02	2.11	POOR
57	Kurunegala	TR03	1.00	GOOD
58	Mahiyangana	TR01	1.00	GOOD
59	Mahiyangana	TR02	1.00	GOOD
60	Maho	TR02	1.00	GOOD
61	Matara	TR01	1.11	GOOD
62	Matara	TR02	1.17	GOOD
63	Matara	TR03	1.00	GOOD
64	Mathugama	TR01	2.67	POOR
65	Mathugama	TR02	2.06	POOR
66	Mathugama	TR03	1.17	GOOD
67	Monaragala	TR01	1.00	GOOD
68	Monaragala	TR02	1.00	GOOD
69	New Anuradhapura	TR01-R	1.33	ACCEPTABLE
70	New Anuradhapura	TR01-Y	1.28	ACCEPTABLE
71	New Anuradhapura	TR01-B	1.11	GOOD
72	New Anuradhapura	TR02-R	1.28	ACCEPTABLE
73	New Anuradhapura	TR02-Y	1.94	POOR
74	New Anuradhapura	TR02-B	1.28	ACCEPTABLE
75	New Valachcheni	TR01	1.33	ACCEPTABLE
76	New Valachcheni	TR02	1.00	GOOD
77	Nuwara Eliya	TR01	1.17	GOOD
78	Nuwara Eliya	TR02	1.00	GOOD
79	Nuwara Eliya	TR03	1.00	GOOD
80	Old Anuradhapura	TR01	1.00	GOOD
81	Old Anuradhapura	TR02	1.33	ACCEPTABLE
82	Old Anuradhapura	TR03	1.56	ACCEPTABLE
83	Old Galle	TR01	2.89	POOR
84	Old Galle	TR02	2.33	POOR
85	Panadura	TR01	2.17	POOR
86	Panadura	TR02	2.00	POOR
87	Panadura	TR03	1.00	GOOD
88	Pannala	TR01	3.78	VERY POOR
89	Pannala	TR02	2.00	POOR
90	Pannipitiya	TS01-R	1.33	ACCEPTABLE

Item	Grid Substation	TR No.	DGAI	Condition Level
91	Pannipitiya	TS01-Y	1.33	ACCEPTABLE
92	Pannipitiya	TS01-B	1.33	ACCEPTABLE
93	Pannipitiya	TS01-R	1.33	ACCEPTABLE
94	Pannipitiya	TS01-Y	1.33	ACCEPTABLE
95	Pannipitiya	TS01-B	1.33	ACCEPTABLE
96	Pannipitiya	TR01	1.06	GOOD
97	Pannipitiya	TR02	2.06	POOR
98	Pannipitiya	TR03	1.00	GOOD
99	Polonnaruwa	TR01	1.00	GOOD
100	Rathnapura	TR01	1.00	GOOD
101	Rathnapura	TR02	1.11	GOOD
102	Rathmalana	TR01	2.00	POOR
103	Rathmalana	TR02	1.94	POOR
104	Rathmalana	TR03	1.00	GOOD
105	Sapugaskanda	TR01	1.00	GOOD
106	Sapugaskanda	TR02	1.17	GOOD
107	Sapugaskanda	TR03	2.28	POOR
108	Sapugaskanda	TR04	1.39	ACCEPTABLE
109	Seethawaka	TR01	1.00	GOOD
110	Seethawaka	TR02	1.17	GOOD
111	Seethawaka	TR03	1.00	GOOD
112	Sri Jayawardanapura	TR01	1.06	GOOD
113	Sri Jayawardanapura	TR02	1.06	GOOD
114	Thulhiriya	TR01	1.28	ACCEPTABLE
115	Thulhiriya	TR02	1.33	ACCEPTABLE
116	Thulhiriya	TR03	2.44	POOR
117	Trincomalee	TR01	1.22	ACCEPTABLE
118	Trincomalee	TR02	1.44	ACCEPTABLE
119	Valachchenei	TR01	1.61	ACCEPTABLE
120	Valachchenei	TR02	1.94	POOR
121	Valachchenei	TR03	1.50	ACCEPTABLE
122	Vaunathiu	TR01	1.00	GOOD
123	Vaunathiu	TR02	1.00	GOOD
124	Vauniya	TR01	1.06	GOOD
125	Vauniya	TR02	1.11	GOOD
126	Veyangoda	TR01	1.00	GOOD
127	Veyangoda	TR02	3.44	VERY POOR
128	Veyangoda	TR03	2.83	POOR
129	Veyangoda	IBT01	1.17	GOOD
130	Veyangoda	IBT02	1.28	ACCEPTABLE

Appendix-K: MATLAB coding of the computing tool

(a) MATLAB coding for the AssessCon.m file

```
function varargout = AssessCon(varargin)
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @AssessCon_OpeningFcn, ...
                   'gui_OutputFcn',  @AssessCon_OutputFcn, ...
                   'gui_LayoutFcn',  [] , ...
                   'gui_Callback',   []);
if nargin && ischar(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT


% --- Executes just before AssessCon is made visible.
function AssessCon_OpeningFcn(hObject, eventdata, handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   command line arguments to AssessCon (see VARARGIN)

% Choose default command line output for AssessCon
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);
set(handles.edit1,'String','Select Data File');
set(handles.edit2,'String','');
set(handles.edit3,'String','');
set(handles.edit4,'String','');
set(handles.edit5,'String','');
set(handles.edit6,'String','');
set(handles.edit7,'String','');
set(handles.edit8,'String','');
set(handles.text11,'String','');
set(handles.text12,'String','');
set(handles.text13,'String','');
set(handles.text14,'String','');
set(handles.text15,'String','');
set(handles.text16,'String','');
set(handles.text22,'String','');
set(handles.text23,'String','');
set(handles.text24,'String','');
set(handles.text25,'String','');
set(handles.text26,'String','');
set(handles.text27,'String','');
% UIWAIT makes AssessCon wait for user response (see UIRESUME)
% uiwait(handles.figure1);


% --- Outputs from this function are returned to the command line.
function varargout = AssessCon_OutputFcn(hObject, eventdata, handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;


% --- Executes on button press in pushbutton1.
function pushbutton1_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
```

```
[filename filepath] = uigetfile();
path = [filepath filename];
set(handles.edit1,'String',path);


function edit1_Callback(hObject, eventdata, handles)
% hObject    handle to edit1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit1 as text
%        str2double(get(hObject,'String')) returns contents of edit1 as a double



% --- Executes during object creation, after setting all properties.
function edit1_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit1 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end


% --- Executes on button press in pushbutton2.
function pushbutton2_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
filepath = get(handles.edit1,'String');
data(1) = str2double(get(handles.edit2,'String'));
data(2) = str2double(get(handles.edit3,'String'));
data(3) = str2double(get(handles.edit4,'String'));
data(4) = str2double(get(handles.edit5,'String'));
data(5) = str2double(get(handles.edit6,'String'));
data(6) = str2double(get(handles.edit7,'String'));
data(7) = str2double(get(handles.edit8,'String'));
[SFRAI_1 SFRAI_2 SFRAI_3 SFRAI_4 DGAI] = Main(filepath,data);

SFRAI_1_L = [1.7 2.1 2.55];
SFRAI_2_L = [1.75 2.1 3.6];
SFRAI_3_L = [1.45 2.2 3.5];
SFRAI_4_L = [1.55 2.0 3.0];

if(SFRAI_1<=SFRAI_1_L(1))   SFRAI_code(1) = 1;  set(handles.text22,'String','GOOD');
%set(handles.text11,'String',' Annually Regular Checkups');
elseif((SFRAI_1<=SFRAI_1_L(2)) && (SFRAI_1>SFRAI_1_L(1)))   SFRAI_code(1) = 2;
set(handles.text22,'String','ACCEPTABLE'); %set(handles.text11,'String','Annually Regular
Checkups');
elseif((SFRAI_1<=SFRAI_1_L(3)) && (SFRAI_1>SFRAI_1_L(2)))   SFRAI_code(1) = 3;
set(handles.text22,'String','POOR'); set(handles.text11,'String','Possible Core deformations,
open circuits or shorted turns OR Residual Magnetism');
else SFRAI_code(1) = 4; set(handles.text22,'String','VERY POOR');
set(handles.text11,'String','Severe Core Defect, Possible open circuits or shorted turns OR
Residual Magnetism');
end

if(SFRAI_2<=SFRAI_2_L(1))   SFRAI_code(2) = 1;  set(handles.text23,'String','GOOD');
%set(handles.text12,'String',' Annually Regular Checkups');
elseif((SFRAI_2<=SFRAI_2_L(2)) && (SFRAI_2>SFRAI_2_L(1)))   SFRAI_code(2) = 2;
set(handles.text23,'String','ACCEPTABLE'); %set(handles.text12,'String','Annually Regular
Checkups');
elseif((SFRAI_2<=SFRAI_2_L(3)) && (SFRAI_2>SFRAI_2_L(2)))   SFRAI_code(2) = 3;
set(handles.text23,'String','POOR'); set(handles.text12,'String','Possible bulk winding movement
between windings and clamping structure');
else SFRAI_code(2) = 4; set(handles.text23,'String','VERY POOR');
set(handles.text12,'String','Severe bulk winding movement');
end

if(SFRAI_3<=SFRAI_3_L(1))   SFRAI_code(3) = 1;  set(handles.text24,'String','GOOD');
%set(handles.text13,'String',' Annually Regular Checkups');
elseif((SFRAI_3<=SFRAI_3_L(2)) && (SFRAI_3>SFRAI_3_L(1)))   SFRAI_code(3) = 2;
set(handles.text24,'String','ACCEPTABLE'); %set(handles.text13,'String','Annually Regular
Checkups');
elseif((SFRAI_3<=SFRAI_3_L(3)) && (SFRAI_3>SFRAI_3_L(2)))   SFRAI_code(3) = 3;
set(handles.text24,'String','POOR'); set(handles.text13,'String','Possible deformation/damages in
main or tap windings');
```

```
else SFRAI_code(3) = 4; set(handles.text24,'String','VERY POOR');
set(handles.text13,'String','Severe deformation/damages in main or tap windings');
end

if(SFRAI_4<=SFRAI_4_L(1))   SFRAI_code(4) = 1;  set(handles.text25,'String','GOOD');
%set(handles.text14,'String',' Annually Regular Checkups');
elseif((SFRAI_4<=SFRAI_4_L(2)) && (SFRAI_4>SFRAI_4_L(1)))   SFRAI_code(4) = 2;
set(handles.text25,'String','ACCEPTABLE'); %set(handles.text14,'String','Annually Regular
Checkups');
elseif((SFRAI_4<=SFRAI_4_L(3)) && (SFRAI_4>SFRAI_4_L(2)))   SFRAI_code(4) = 3;
set(handles.text25,'String','POOR'); set(handles.text14,'String','Possible movement in main or
tap windings/leads, Ground impedance variation');
else SFRAI_code(4) = 4; set(handles.text25,'String','VERY POOR');
set(handles.text14,'String','Movement in main or tap windings/leads, Ground impedance
variations');
end


DGAI_L = [1.2 1.8 3];

if ( DGAI < DGAI_L(1) ) DGAI_code = 1; set(handles.text26,'String','GOOD');
%set(handles.text15,'String','DGAI Decription 1');
elseif ( (DGAI < DGAI_L(2)) && (DGAI >= DGAI_L(1)) )  DGAI_code = 2;
set(handles.text26,'String','ACCEPTABLE'); %set(handles.text15,'String','DGAI Decription 2');
elseif ( (DGAI < DGAI_L(3)) && (DGAI >= DGAI_L(2)) )  DGAI_code = 3;
set(handles.text26,'String','POOR'); %set(handles.text15,'String','DGAI Decription 3');
else    DGAI_code = 4; set(handles.text26,'String','VERY POOR');
%set(handles.text15,'String','DGAI Decription 4');
end
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%calculating CI

SFRA_CI = (1 * SFRAI_1 + 4 * SFRAI_2 + 3 * SFRAI_3 + 2 * SFRAI_4)/10;
SFRA_CI_L = [ 1.75 2.05 3.0 ];
if ( SFRA_CI < SFRA_CI_L(1) ) SFRA_CI_code = 1;
elseif ( (SFRA_CI < SFRA_CI_L(2)) && (SFRA_CI >= SFRA_CI_L(1)) ) SFRA_CI_code = 2;
elseif ( (SFRA_CI < SFRA_CI_L(3)) && (SFRA_CI >= SFRA_CI_L(2)) ) SFRA_CI_code = 3;
else   SFRA_CI_code = 4;
end

% disp('Condition Index Description')
if ( (SFRAI_code(1) <= 2) && (SFRAI_code(2) <= 2) && (SFRAI_code(3) <= 2) && (SFRAI_code(4) <= 2)
&& (SFRA_CI_code == 1) && (DGAI_code == 1)) CI_code = 1; set(handles.text27,'String','GOOD');
set(handles.text16,'String','Good for normal operation');
elseif ( (SFRA_CI_code == 1) && (DGAI_code == 1)) CI_code = 2;
set(handles.text27,'String','ACCEPTABLE'); set(handles.text16,'String','Good for normal operation
with regular monitoring');
elseif ( (SFRAI_code(1) <= 2) && (SFRAI_code(2) <= 2) && (SFRAI_code(3) <= 2) && (SFRAI_code(4)
<= 2) && (SFRA_CI_code == 1) && (DGAI_code == 2)) CI_code = 1;
set(handles.text27,'String','GOOD'); set(handles.text16,'String','Good for normal operation');
elseif ( (SFRA_CI_code == 1) && (DGAI_code == 2)) CI_code = 2;
set(handles.text27,'String','ACCEPTABLE'); set(handles.text16,'String','Good for normal operation
with regular monitoring');
elseif ( (SFRA_CI_code == 1) && (DGAI_code == 3)) CI_code = 2;
set(handles.text27,'String','ACCEPTABLE'); set(handles.text16,'String','Need regular
monitoring');
elseif ( (SFRA_CI_code == 1) && (DGAI_code == 4)) CI_code = 3;
set(handles.text27,'String','POOR'); set(handles.text16,'String','Need closely monitor the
condition');
elseif ( (SFRA_CI_code == 2) && (DGAI_code == 1)) CI_code = 2;
set(handles.text27,'String','ACCEPTABLE'); set(handles.text16,'String','Need regular
monitoring');
elseif ( (SFRA_CI_code == 2) && (DGAI_code == 2)) CI_code = 2;
set(handles.text27,'String','ACCEPTABLE'); set(handles.text16,'String','Need regular
monitoring');
elseif ( (SFRA_CI_code == 2) && (DGAI_code == 3)) CI_code = 2;
set(handles.text27,'String','ACCEPTABLE'); set(handles.text16,'String','Need regular
monitoring');
elseif ( (SFRA_CI_code == 2) && (DGAI_code == 4)) CI_code = 3;
set(handles.text27,'String','POOR'); set(handles.text16,'String','Need closely monitor the
condition');
elseif ( (SFRA_CI_code == 3) && (DGAI_code == 1)) CI_code = 2;
set(handles.text27,'String','ACCEPTABLE'); set(handles.text16,'String','Need regular
Monitoring');
elseif ( (SFRA_CI_code == 3) && (DGAI_code == 2)) CI_code = 3;
set(handles.text27,'String','POOR'); set(handles.text16,'String','Need closely monitor the
condition');
elseif ( (SFRAI_code(1) <= 3) && (SFRAI_code(2) <= 3) && (SFRAI_code(3) <= 3) && (SFRAI_code(4)
<= 3) && (SFRA_CI_code == 3) && (DGAI_code == 3)) CI_code = 3;
set(handles.text27,'String','POOR'); set(handles.text16,'String','Need closely monitor the
condition');
```

```
elseif ( (SFRA_CI_code == 3) && (DGAI_code == 3)) CI_code = 4; set(handles.text27,'String','VERY
POOR'); set(handles.text16,'String','Need extra attention and consideration for replacements');
elseif ( (SFRAI_code(1) <= 3) && (SFRAI_code(2) <= 3) && (SFRAI_code(3) <= 3) && (SFRAI_code(4)
<= 3) && (SFRA_CI_code == 3) && (DGAI_code == 4)) CI_code = 3;
set(handles.text27,'String','POOR'); set(handles.text16,'String','Need closely monitor the
condition');
elseif ( (SFRA_CI_code == 3) && (DGAI_code == 4)) CI_code = 4; set(handles.text27,'String','VERY
POOR'); set(handles.text16,'String','Need extra attention and consideration for replacements');
elseif ( (SFRA_CI_code == 4) && (DGAI_code == 1)) CI_code = 3;
set(handles.text27,'String','POOR'); set(handles.text16,'String','Need closely monitor the
condition');
elseif ( (SFRA_CI_code == 4) && (DGAI_code == 2)) CI_code = 3;
set(handles.text27,'String','POOR'); set(handles.text16,'String','Need closely monitor the
condition');
elseif ( (SFRA_CI_code == 4) && (DGAI_code == 3)) CI_code = 4; set(handles.text27,'String','VERY
POOR'); set(handles.text16,'String','Need extra attention and consideration for replacements');
elseif ( (SFRA_CI_code == 4) && (DGAI_code == 4)) CI_code = 4; set(handles.text27,'String','VERY
POOR'); set(handles.text16,'String','Need extra attention and consideration for replacements');
%else   set(handles.text27,'String','VERY POOR');   set(handles.text16,'String','Extra attention
and consideration for replacements');
end



function edit2_Callback(hObject, eventdata, handles)
% hObject    handle to edit2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit2 as text
%        str2double(get(hObject,'String')) returns contents of edit2 as a double


% --- Executes during object creation, after setting all properties.
function edit2_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function edit3_Callback(hObject, eventdata, handles)
% hObject    handle to edit3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit3 as text
%        str2double(get(hObject,'String')) returns contents of edit3 as a double

% --- Executes during object creation, after setting all properties.
function edit3_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function edit4_Callback(hObject, eventdata, handles)
% hObject    handle to edit4 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit4 as text
%        str2double(get(hObject,'String')) returns contents of edit4 as a double


% --- Executes during object creation, after setting all properties.
function edit4_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit4 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
```

```
% handles    empty - handles not created until after all CreateFcns called


% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end

function edit5_Callback(hObject, eventdata, handles)
% hObject    handle to edit5 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% Hints: get(hObject,'String') returns contents of edit5 as text
%        str2double(get(hObject,'String')) returns contents of edit5 as a double


% --- Executes during object creation, after setting all properties.
function edit5_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit5 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function edit6_Callback(hObject, eventdata, handles)
% hObject    handle to edit6 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit6 as text
%        str2double(get(hObject,'String')) returns contents of edit6 as a double


% --- Executes during object creation, after setting all properties.
function edit6_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit6 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end

function edit7_Callback(hObject, eventdata, handles)
% hObject    handle to edit7 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit7 as text
%        str2double(get(hObject,'String')) returns contents of edit7 as a double


% --- Executes during object creation, after setting all properties.
function edit7_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit7 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function edit8_Callback(hObject, eventdata, handles)
% hObject    handle to edit8 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit8 as text
%        str2double(get(hObject,'String')) returns contents of edit8 as a double
```

```
% --- Executes during object creation, after setting all properties.
function edit8_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit8 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end

function update_waitbar(handles,value)

h=handles.waitbar_axes;set(h,'Visible','On');

axes(h);cla;h=patch([0,value,value,0],[0,0,1,1],'b');

axis([0,1,0,1]);axis off;drawnow;
```

(b) MATLAB coding for the Main.m file

```
function [SFRAI_1 SFRAI_2 SFRAI_3 SFRAI_4 DGAI] = Main(filepath,data)

Data_xls = xlsread(filepath);
r_1_LB = 20;    %region 1 lower bound
r_1_UB = 1999;    %region 1 upper bound
r_2_LB = 2000;    %region 2 lower bound
r_2_UB = 20000;    %region 2 upper bound
r_3_LB = 20000;    %region 3 lower bound
r_3_UB = 400000;    %region 3 upper bound
r_4_LB = 400000;    %region 4 lower bound
r_4_UB = 2000000;    %region 4 upper bound

%Divide in to regions
Region1=Data_xls(Data_xls(:,1)>=r_1_LB & Data_xls(:,1)<r_1_UB,:);
Region2=Data_xls(Data_xls(:,1)>=r_2_LB & Data_xls(:,1)<r_2_UB,:);
Region3=Data_xls(Data_xls(:,1)>=r_3_LB & Data_xls(:,1)<r_3_UB,:);
Region4=Data_xls(Data_xls(:,1)>=r_4_LB & Data_xls(:,1)<=r_4_UB,:);

[N1, ~] = size(Region1);
[N2, ~] = size(Region2);
[N3, ~] = size(Region3);
[N4, ~] = size(Region4);

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Calculatin CCFI
%R-Y  -> R-B  ->  Y-B
CCF_L_R1 = [[0.9200 0.9100 0.9000],
[0.9900 0.9700 0.9500],
[0.9100 0.8850 0.8600],
[1.0000 0.9995 0.9990],
[1.0000 0.9995 0.9990],
[1.0000 0.9995 0.9990],
[0.8900 0.8700 0.8500],
[0.9980 0.9740 0.9500],
[0.8900 0.8650 0.8400]];

CCF_L_R2 = [[0.9800 0.9600 0.9400],
[0.9980 0.9960 0.9940],
[0.9800 0.9650 0.9500],
[0.9600 0.9200 0.8800],
[0.9980 0.9955 0.9930],
[0.9700 0.9300 0.8900],
[0.9890 0.9730 0.9570],
[0.9990 0.9945 0.9900],
[0.9920 0.9845 0.9770]];

CCF_L_R3 = [[0.9930 0.9765 0.9600],
[0.9920 0.9560 0.9200],
[0.9930 0.9765 0.9600],
[0.9920 0.9760 0.9600],
[0.9940 0.9620 0.9300],
[0.9920 0.9760 0.9600],
[0.9680 0.9240 0.8800],
[0.9820 0.9610 0.9400],
[0.9730 0.9590 0.9450]];

CCF_L_R4 = [[0.9600 0.9200 0.8800],
[0.9200 0.8600 0.8000],
[0.9600 0.9100 0.8600],
[0.9600 0.9200 0.8800],
[0.9200 0.8700 0.8200],
[0.9630 0.9315 0.9000],
[0.7000 0.5000 0.3000],
[0.8900 0.7750 0.6600],
[0.8000 0.6550 0.5100]];


W11 = [1 3 1];
W12 = [1 2 1];
W13 = [1 1 1];
W14 = [1 1 1];
W2 = [3 1 2 3 2 2 3 2 2 3 2 2];

%R-Y  -> R-B  ->  Y-B
n = 1;
for i=0:4:8
    for j=3:5
        for k=3:5
            if(j<k)
```

```
                CoMat = cov(Region1(:,j+i),Region1(:,k+i))*(N1-1);
                CCF1(n) = (CoMat(1,2)/sqrt(CoMat(1,1)*CoMat(2,2)));
                if (CCF1(n) >= CCF_L_R1(n,1)),S1(n)=1;elseif(CCF1(n) < CCF_L_R1(n,1) && CCF1(n)
>= CCF_L_R1(n,2)),S1(n)=2;elseif(CCF1(n) < CCF_L_R1(n,2) && CCF1(n) >=
CCF_L_R1(n,3)),S1(n)=3;else S1(n)=4;end
                n = n + 1;
            end
        end
    end
end

n = 1;
for i=0:4:8
    for j=3:5
        for k=3:5
            if(j<k)
                CoMat = cov(Region2(:,j+i),Region2(:,k+i))*(N2-1);
                CCF2(n) = (CoMat(1,2)/sqrt(CoMat(1,1)*CoMat(2,2)));
                if (CCF2(n) >= CCF_L_R2(n,1)),S2(n)=1;elseif(CCF2(n) < CCF_L_R2(n,1) && CCF2(n)
>= CCF_L_R2(n,2)),S2(n)=2;elseif(CCF2(n) < CCF_L_R2(n,2) && CCF2(n) >=
CCF_L_R2(n,3)),S2(n)=3;else S2(n)=4;end
                n = n + 1;
            end
        end
    end
end

n = 1;
for i=0:4:8
    for j=3:5
        for k=3:5
            if(j<k)
                CoMat = cov(Region3(:,j+i),Region3(:,k+i))*(N3-1);
                CCF3(n) = (CoMat(1,2)/sqrt(CoMat(1,1)*CoMat(2,2)));
                if (CCF3(n) >= CCF_L_R3(n,1)),S3(n)=1;elseif(CCF3(n) < CCF_L_R3(n,1) && CCF3(n)
>= CCF_L_R3(n,2)),S3(n)=2;elseif(CCF3(n) < CCF_L_R3(n,2) && CCF3(n) >=
CCF_L_R3(n,3)),S3(n)=3;else S3(n)=4;end
                n = n + 1;
            end
        end
    end
end

n = 1;
for i=0:4:8
    for j=3:5
        for k=3:5
            if(j<k)
                CoMat = cov(Region4(:,j+i),Region4(:,k+i))*(N4-1);
                CCF4(n) = (CoMat(1,2)/sqrt(CoMat(1,1)*CoMat(2,2)));
                if (CCF4(n) >= CCF_L_R4(n,1)),S4(n)=1;elseif(CCF4(n) < CCF_L_R4(n,1) && CCF4(n)
>= CCF_L_R4(n,2)),S4(n)=2;elseif(CCF4(n) < CCF_L_R4(n,2) && CCF4(n) >=
CCF_L_R4(n,3)),S4(n)=3;else S4(n)=4;end
                n = n + 1;
            end
        end
    end
end

CCFI_1 =
(W2(1)*sum(S1(1:3).*W11)+W2(2)*sum(S1(4:6).*W11)+W2(3)*sum(S1(7:9).*W11))/(sum(W2(1:3)*sum(W11)))
;
CCFI_2 =
(W2(4)*sum(S2(1:3).*W12)+W2(5)*sum(S2(4:6).*W12)+W2(6)*sum(S2(7:9).*W12))/(sum(W2(4:6)*sum(W12)))
;
CCFI_3 =
(W2(7)*sum(S3(1:3).*W13)+W2(8)*sum(S3(4:6).*W13)+W2(9)*sum(S3(7:9).*W13))/(sum(W2(7:9)*sum(W13)))
;
CCFI_4 =
(W2(10)*sum(S4(1:3).*W14)+W2(11)*sum(S4(4:6).*W14)+W2(12)*sum(S4(7:9).*W14))/(sum(W2(10:12)*sum(W
14)));

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Calculatin DBI
%R-Y  -> R-B  ->  Y-B

DB_L_R1 = [[2.4000 1.8500 1.3000],
[3.5000 2.8500 2.2000],
[3.2000 2.4500 1.7000],
[3.5000 2.3850 1.2700],
[3.5000 2.8500 2.2000],
[3.0000 2.3000 1.6000],
```

```
[4.3000 3.8650 3.4300],
[3.2000 1.8500 0.5000],
[4.8000 4.3000 3.8000]];

DB_L_R2 = [[1.5000 1.1250 0.7500],
[0.4400 0.3500 0.2600],
[1.3000 1.0000 0.7000],
[1.8000 1.3900 0.9800],
[0.4500 0.3500 0.2500],
[1.7000 1.2800 0.8600],
[1.4000 1.0650 0.7300],
[0.5000 0.3500 0.2000],
[1.1000 0.8500 0.6000]];

DB_L_R3 = [[1.4000 1.0600 0.7200],
[1.7000 1.2500 0.8000],
[1.2000 0.8850 0.5700],
[1.6000 1.1500 0.7000],
[1.8000 1.3000 0.8000],
[1.2500 0.9350 0.6200],
[2.0000 1.5000 1.0000],
[1.3000 1.0900 0.8800],
[1.3000 1.1400 0.9800]];

DB_L_R4 = [[2.4000 1.8500 1.3000],
[3.5000 2.8500 2.2000],
[3.2000 2.4500 1.7000],
[3.5000 2.3850 1.2700],
[3.5000 2.8500 2.2000],
[3.0000 2.3000 1.6000],
[5.3000 4.6500 4.0000],
[4.8000 3.4000 2.0000],
[4.8000 4.2500 3.7000]];

W11 = [1 3 1];
W12 = [1 2 1];
W13 = [1 1 1];
W14 = [1 1 1];
W2 = [3 1 2 3 2 2 3 2 2 3 2 2];

%R-Y  -> R-B  ->  Y-B
n = 1;
for i=0:4:8
    for j=3:5
        for k=3:5
            if(j<k)
                DB1(n) = sum(abs(Region1(:,j+i)-Region1(:,k+i)))/N1;
                if (DB1(n) >= DB_L_R1(n,1)),S1(n)=4;elseif(DB1(n) < DB_L_R1(n,1) && DB1(n) >=
DB_L_R1(n,2)),S1(n)=3;elseif(DB1(n) < DB_L_R1(n,2) && DB1(n) >= DB_L_R1(n,3)),S1(n)=2;else
S1(n)=1;end
                n = n + 1;
            end
        end
    end
end

n = 1;
for i=0:4:8
    for j=3:5
        for k=3:5
            if(j<k)
                DB2(n) = sum(abs(Region2(:,j+i)-Region2(:,k+i)))/N2;
                if (DB2(n) >= DB_L_R2(n,1)),S2(n)=4;elseif(DB2(n) < DB_L_R2(n,1) && DB2(n) >=
DB_L_R2(n,2)),S2(n)=3;elseif(DB2(n) < DB_L_R2(n,2) && DB2(n) >= DB_L_R2(n,3)),S2(n)=2;else
S2(n)=1;end
                n = n + 1;
            end
        end
    end
end

n = 1;
for i=0:4:8
    for j=3:5
        for k=3:5
            if(j<k)
                DB3(n) = sum(abs(Region3(:,j+i)-Region3(:,k+i)))/N3;
                if (DB3(n) >= DB_L_R3(n,1)),S3(n)=4;elseif(DB3(n) < DB_L_R3(n,1) && DB3(n) >=
DB_L_R3(n,2)),S3(n)=3;elseif(DB3(n) < DB_L_R3(n,2) && DB3(n) >= DB_L_R3(n,3)),S3(n)=2;else
S3(n)=1;end
                n = n + 1;
            end
```

```
        end
    end
end

n = 1;
for i=0:4:8
    for j=3:5
        for k=3:5
            if(j<k)
                DB4(n) = sum(abs(Region4(:,j+i)-Region4(:,k+i)))/N4;
                if (DB4(n) >= DB_L_R4(n,1)),S4(n)=4;elseif(DB4(n) < DB_L_R4(n,1) && DB4(n) >=
DB_L_R4(n,2)),S4(n)=3;elseif(DB4(n) < DB_L_R4(n,2) && DB4(n) >= DB_L_R4(n,3)),S4(n)=2;else
S4(n)=1;end
                n = n + 1;
            end
        end
    end
end

DBI_1 =
(W2(1)*sum(S1(1:3).*W11)+W2(2)*sum(S1(4:6).*W11)+W2(3)*sum(S1(7:9).*W11))/(sum(W2(1:3)*sum(W11)))
;
DBI_2 =
(W2(4)*sum(S2(1:3).*W12)+W2(5)*sum(S2(4:6).*W12)+W2(5)*sum(S2(7:9).*W12))/(sum(W2(4:6)*sum(W12)))
;
DBI_3 =
(W2(7)*sum(S3(1:3).*W13)+W2(5)*sum(S3(4:6).*W13)+W2(5)*sum(S3(7:9).*W13))/(sum(W2(7:9)*sum(W13)))
;
DBI_4 =
(W2(10)*sum(S4(1:3).*W14)+W2(11)*sum(S4(4:6).*W14)+W2(12)*sum(S4(7:9).*W14))/(sum(W2(10:12)*sum(W
14)));

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%Calculatin DISI
%R-Y  -> R-B  ->  Y-B

DIS_L_R1 = [[2.6000 2.0000 1.4500],
[1.6000 1.1500 0.7000],
[2.6000 2.0000 1.5000],
[0.1000 0.0500 0.0080],
[0.0800 0.0450 0.0100],
[0.1000 0.0550 0.0100],
[3.2600 2.7300 2.2000],
[2.3000 1.6500 1.0000],
[3.0000 2.5000 2.0000]];

DIS_L_R2 = [[0.0600 0.0400 0.0200],
[0.0206 0.0150 0.0090],
[0.0600 0.0400 0.0200],
[0.0500 0.0400 0.0300],
[0.0200 0.0150 0.0095],
[0.0501 0.0400 0.0300],
[0.0400 0.0290 0.0180],
[0.0270 0.0170 0.0070],
[0.0500 0.0200 0.0140]];

DIS_L_R3 = [[0.0250 0.0175 0.0100],
[0.0220 0.0155 0.0090],
[0.0200 0.0145 0.0090],
[0.0240 0.0170 0.0100],
[0.0270 0.0165 0.0060],
[0.0300 0.0200 0.0100],
[0.0400 0.0300 0.0200],
[0.0360 0.0245 0.0130],
[0.0330 0.0250 0.0170]];

DIS_L_R4 = [[0.0015 0.0012 0.0008],
[0.0020 0.0014 0.0009],
[0.0016 0.0012 0.0007],
[0.0008 0.0014 0.0020],
[0.0017 0.0012 0.0008],
[0.0023 0.0015 0.0007],
[0.0050 0.0040 0.0030],
[0.0040 0.0035 0.0030],
[0.0050 0.0043 0.0035]];


W11 = [1 3 1];
W12 = [1 2 1];
W13 = [1 1 1];
W14 = [1 1 1];
W2 = [3 1 2 3 2 2 3 2 2 3 2 2];
```

```
%R-Y  -> R-B  ->  Y-B
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%calculating DIS
%-----------------------------------------Region1 - DIS-----------------------------------------
theta = 0;
ps = 0;
p = 0;
Sv = 0;
Sh = 0;
for i=3:5:7:9:11:13
    for x=1:(N1-1)
        Sv = Region1(x+1,i) - Region1(x,i);
        Sh = Region1(x+1,1) - Region1(x,1);
        theta(x,i) = atan(Sv/Sh);
    end
    theta(N1,i) = atan(Region1(N1,i)/Region1(N1,1));
end

for i=3:5:7:9:11:13
    p(1,i) = theta(1,i);
    ps(1,i) = p(1,i);
    for x=2:N1
        p(x,i) = theta(x,i) - theta(x-1,i);
        ps(x,i) = p(x,i) + ps(x-1,i);
    end
end

n = 1;
for i=0:4:8
    for j=3:5
        for k=3:5
            if(j<k)
                DIS1(n) =sqrt( sum( ( ps(:,j+i) - ( ps(:,k+i) )).^2 ) );
                if (DIS1(n) >= DIS_L_R1(n,1)),S1(n)=4;elseif(DIS1(n) < DIS_L_R1(n,1) && DIS1(n)
>= DIS_L_R1(n,2)),S1(n)=3;elseif(DIS1(n) < DIS_L_R1(n,2) && DIS1(n) >=
DIS_L_R1(n,3)),S1(n)=2;else S1(n)=1;end
                n = n + 1;
            end
        end
    end
end

%-----------------------------------------Region2 - DIS-----------------------------------------

theta = 0;
ps = 0;
p = 0;
Sv = 0;
Sh = 0;
for i=3:5:7:9:11:13
    for x=1:(N2-1)
        Sv = Region2(x+1,i) - Region2(x,i);
        Sh = Region2(x+1,1) - Region2(x,1);
        theta(x,i) = atan(Sv/Sh);
    end
    theta(N2,i) = atan(Region2(N2,i)/Region2(N2,1));
end

for i=3:5:7:9:11:13
    p(1,i) = theta(1,i);
    ps(1,i) = p(1,i);
    for x=2:N2
        p(x,i) = theta(x,i) - theta(x-1,i);
        ps(x,i) = p(x,i) + ps(x-1,i);
    end
end

n = 1;
for i=0:4:8
    for j=3:5
        for k=3:5
            if(j<k)
                DIS2(n) =sqrt( sum( ( ps(:,j+i) - ( ps(:,k+i) )).^2 ) );
                if (DIS2(n) >= DIS_L_R2(n,1)),S2(n)=4;elseif(DIS2(n) < DIS_L_R2(n,1) && DIS2(n)
>= DIS_L_R2(n,2)),S2(n)=3;elseif(DIS2(n) < DIS_L_R2(n,2) && DIS2(n) >=
DIS_L_R2(n,3)),S2(n)=2;else S2(n)=1;end
                n = n + 1;
            end
        end
    end
end
```

```
%-----------------------------------------Region3 - DIS-----------------------------------------
theta = 0;
ps = 0;
p = 0;
Sv = 0;
Sh = 0;
for i=3:5:7:9:11:13
    for x=1:(N3-1)
        Sv = Region3(x+1,i) - Region3(x,i);
        Sh = Region3(x+1,1) - Region3(x,1);
        theta(x,i) = atan(Sv/Sh);
    end
    theta(N3,i) = atan(Region3(N3,i)/Region3(N3,1));
end

for i=3:5:7:9:11:13
    p(1,i) = theta(1,i);
    ps(1,i) = p(1,i);
    for x=2:N3
        p(x,i) = theta(x,i) - theta(x-1,i);
        ps(x,i) = p(x,i) + ps(x-1,i);
    end
end

n = 1;
for i=0:4:8
    for j=3:5
        for k=3:5
            if(j<k)
                DIS3(n) =sqrt( sum( ( ps(:,j+i) - ( ps(:,k+i) )).^2 ) );
                if (DIS3(n) >= DIS_L_R3(n,1)),S3(n)=4;elseif(DIS3(n) < DIS_L_R3(n,1) && DIS3(n)
>= DIS_L_R3(n,2)),S3(n)=3;elseif(DIS3(n) < DIS_L_R3(n,2) && DIS3(n) >=
DIS_L_R3(n,3)),S3(n)=2;else S3(n)=1;end
                n = n + 1;
            end
        end
    end
end

%-----------------------------------------Region4 - DIS-----------------------------------------
theta = 0;
ps = 0;
p = 0;
Sv = 0;
Sh = 0;
for i=3:5:7:9:11:13
    for x=1:(N4-1)
        Sv = Region4(x+1,i) - Region4(x,i);
        Sh = Region4(x+1,1) - Region4(x,1);
        theta(x,i) = atan(Sv/Sh);
    end
    theta(N4,i) = atan(Region4(N4,i)/Region4(N4,1));
end

for i=3:5:7:9:11:13
    p(1,i) = theta(1,i);
    ps(1,i) = p(1,i);
    for x=2:N4
        p(x,i) = theta(x,i) - theta(x-1,i);
        ps(x,i) = p(x,i) + ps(x-1,i);
    end
end

n = 1;
for i=0:4:8
    for j=3:5
        for k=3:5
            if(j<k)
                DIS4(n) =sqrt( sum( ( ps(:,j+i) - ( ps(:,k+i) )).^2 ) );
                if (DIS4(n) >= DIS_L_R4(n,1)),S4(n)=4;elseif(DIS4(n) < DIS_L_R4(n,1) && DIS4(n)
>= DIS_L_R4(n,2)),S4(n)=3;elseif(DIS4(n) < DIS_L_R4(n,2) && DIS4(n) >=
DIS_L_R4(n,3)),S4(n)=2;else S4(n)=1;end
                n = n + 1;
            end
        end
    end
end

DISI_1 =
(W2(1)*sum(S1(1:3).*W11)+W2(2)*sum(S1(4:6).*W11)+W2(3)*sum(S1(7:9).*W11))/(sum(W2(1:3)*sum(W11)))
;
```

```
DISI_2 =
(W2(4)*sum(S2(1:3).*W12)+W2(5)*sum(S2(4:6).*W12)+W2(6)*sum(S2(7:9).*W12))/(sum(W2(4:6)*sum(W12)))
;
DISI_3 =
(W2(7)*sum(S3(1:3).*W13)+W2(8)*sum(S3(4:6).*W13)+W2(9)*sum(S3(7:9).*W13))/(sum(W2(7:9)*sum(W13)))
;
DISI_4 =
(W2(10)*sum(S4(1:3).*W14)+W2(11)*sum(S4(4:6).*W14)+W2(12)*sum(S4(7:9).*W14))/(sum(W2(10:12)*sum(W
14)));


SFRAI_1 = (CCFI_1 * 2 + DBI_1 * 1+ DISI_1 * 1 )/4;
SFRAI_2 = (CCFI_2 * 2 + DBI_2 * 1+ DISI_2 * 1 )/4;
SFRAI_3 = (CCFI_3 * 2 + DBI_3 * 1+ DISI_3 * 1 )/4;
SFRAI_4 = (CCFI_4 * 2 + DBI_4 * 1+ DISI_4 * 1 )/4;


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%calculating DGAI
W = [2 3 3 3 5 1 1];

level(:,1) = [100 200 300 500 700];
level(:,2)   = [75  125 200 400 600];
level(:,3)   = [65  80  120 180 220];
level(:,4)   = [50  80  100 150 200];
level(:,5)   = [3   7   15  25  35 ];
level(:,6)   = [350 700 900 1100 1400];
level(:,7)   = [2500 3000 4000 5000 7000];

for i =1:7
    if ((data(i)) <=  level(1,i)) s(i) = 1;
    elseif (((data(i)) <=  level(2,i)) && ((data(i)) >  level(1,i))) s(i) = 2;
    elseif (((data(i)) <=  level(3,i)) && ((data(i)) >  level(2,i))) s(i) = 3;
    elseif (((data(i)) <=  level(4,i)) && ((data(i)) >  level(3,i))) s(i) = 4;
    elseif (((data(i)) <=  level(5,i)) && ((data(i)) >  level(4,i))) s(i) = 5;
    else s(i) = 6;
    end
end

DGAI = sum(s.*W) / sum(W);

end
```