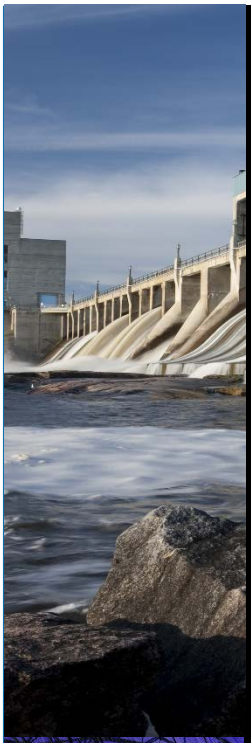

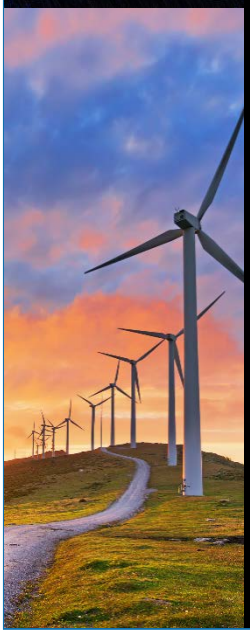

Two Area Power System

RTDS Technologies

Contents

1. CASE INFORMATION

Case Name	Two Area Power System
Location	RSCAD\Example Cases\Benchmark Systems
Revision Date	01 – November, 2022
Created by	Arunprasanth Sakthivel
Target	PB5, NovaCor
Minimum Hardware	1 x NovaCor Chassis with at least 1 enabled core 1 x PB5 based rack with at least 2 PB5 cards
Keywords	Generator, Exciter, Governor, Fault, Transmission line
Purpose	To provide an RSCAD model of the two area power system for rotor angle stability studies

2. INTRODUCTION

The two area power system is a test system proposed by Dr. P. Kundur for rotor angle stability studies [1]. Figure 1 shows the one-line diagram of the test system.

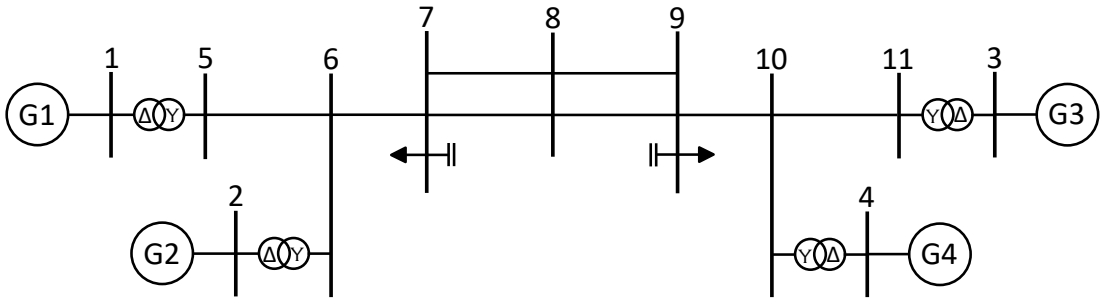

Figure 1 : One-Line Diagram of Two Area Power System

The data pertaining to the system are given in Section 3. The power flow results from RSCAD® and PSS®E are compared in Section 4 to show that a close match can be achieved. Section 5 lists references related to the data and models used in the system.

3. SYSTEM MODELLING

The power flow data of the system are taken from [1]. It must be noted that the line data provided in [1] is not compensated for long line effects [2]. Therefore, the line data is directly used in the RSCAD simulation. In addition, the line data used in PSSE is also not compensated for long line effects as lines in the system are not too long.

Table 1 Bus Data

BUS	Type	V (pu)	P_G (MW)	Q_G (MVAr)	Q_{SH} (MVAr)	P_L (MW)	Q_L (MVAr)
1	P-V	1.03 ∠ 20.2°	700	185	-	-	-
2	P-V	1.01 ∠ 10.5°	700	235	-	-	-
3	SLACK	1.03 ∠ -6.8°	719	176	-	-	-
4	P-V	1.01 ∠ -17.0°	700	202	-	-	-
7	P-Q	-	-	-	200	967	100
9	P-Q	-	-	-	350	1767	100

Table 2 Branch Data (100 MVA Base)

From BUS	To BUS	R (pu)	X (pu)	B (pu)
5	6	0.0025	0.025	0.04375
6	7	0.0010	0.010	0.01750
7	8	0.0110	0.110	0.19250
7	8	0.0110	0.110	0.19250
8	9	0.0110	0.110	0.19250
8	9	0.0110	0.110	0.19250
9	10	0.0010	0.010	0.01750
10	11	0.0025	0.025	0.04375

Table 3 Transformer Data (900 MVA Base)

From BUS	To BUS	R (pu)	X (pu)	Tap Ratio[1]
1	5	0.0	0.15	1.0
2	6	0.0	0.15	1.0
3	11	0.0	0.15	1.0
4	10	0.0	0.15	1.0

The dynamic data for generator is taken from [1]. The 'IEEE Type ESAC4A' excitation system is used for voltage regulation and the 'TGOV' thermal governor is used for frequency regulation of all four generators. In addition, the 'STAB1' power system stabilizer is used to improve the rotor angle stability.

Table 4 Generator Data-1

GEN	Base (MVA)	Xa (pu)	Xd (pu)	Xd' (pu)	Xd" (pu)	Xq (pu)	Xq' (pu)	Xq" (pu)
1	900	0.2	1.8	0.3	0.25	1.7	0.55	0.25
2	900	0.2	1.8	0.3	0.25	1.7	0.55	0.25
3	900	0.2	1.8	0.3	0.25	1.7	0.55	0.25
4	900	0.2	1.8	0.3	0.25	1.7	0.55	0.25

Table 5 Generator Data-2

GEN	Base (MVA)	Ra (pu)	Tdo' (s)	Tdo" (s)	Tqo' (s)	Tqo" (s)	H (s)	D(pu/pu)
1	900	0.0025	8.0	0.03	0.4	0.05	6.5	0.0
2	900	0.0025	8.0	0.03	0.4	0.05	6.5	0.0
3	900	0.0025	8.0	0.03	0.4	0.05	6.175	0.0
4	900	0.0025	8.0	0.03	0.4	0.05	6.175	0.0

[1] Tap ratio is modelled to the from bus side of transformer

Table 6 Exciter Data (IEEE Type ESAC4A)

GEN	Tr (s)	Tb (s)	Tc (s)	Ka (pu)	Ta (s)	Kc (pu)	Vrmax (pu)	Vrmin (pu)	Vimax (pu)	Vimin (pu)
1	0.0	0.0	0.0	100.0	0.02	0.0	7.0	-7.0	0.5	-0.5
2	0.0	0.0	0.0	100.0	0.02	0.0	7.0	-7.0	0.5	-0.5
3	0.0	0.0	0.0	100.0	0.02	0.0	7.0	-7.0	0.5	-0.5
4	0.0	0.0	0.0	100.0	0.02	0.0	7.0	-7.0	0.5	-0.5

Table 7 Governor Data (TGOV1)

GEN	R (pu)	T1 (s)	Vmax (pu)	Vmin (pu)	T2 (s)	T3 (s)	Dt (pu)
1	0.05	0.05	10.00	-10.00	2.1	7.0	0.0
2	0.05	0.05	10.00	-10.00	2.1	7.0	0.0
3	0.05	0.05	10.00	-10.00	2.1	7.0	0.0
4	0.05	0.05	10.00	-10.00	2.1	7.0	0.0

Table 8 PSS Data (STAB1)

GEN	K/T (pu/s)	T (s)	T1/T3	T3 (s)	T2/T4	T2 (s)	HLIM (pu)
1	3.0	2.0	2.0	0.04	2.0	0.04	0.1
2	3.0	2.0	2.0	0.04	2.0	0.04	0.1
3	3.0	2.0	2.0	0.04	2.0	0.04	0.1
4	3.0	2.0	2.0	0.04	2.0	0.04	0.1

NOTE: The transmission lines in RSCAD case have been configured to read data from the tlines file located in the case folder. If required, tline data input files (.tli) of all transmission lines can be found inside the 'Tline Files' folder.

4. LOADFLOW RESULTS

The loadflow results obtained using the embedded loadflow program in RSCAD is compared against the PSS/E loadflow results in Table 9 and Table 10. The comparison of dynamic simulation results for transient disturbances are presented in [3].

Table 9 Load Flow Results of Generator Buses

BUS	|V| (pu)		∠V (deg)[2]		PG (MW)		QG (MVAr)	
	RTDS	PSS/E	RTDS	PSS/E	RTDS	PSS/E	RTDS	PSS/E
1	1.03	1.03	-3.0320	27.0698	700.000	700.000	184.850	185.002
2	1.01	1.01	-12.7940	17.3055	700.000	700.000	234.177	234.578
3	1.03	1.03	-30.0000	0.0000	718.930	719.083	175.714	175.993
4	1.01	1.01	-40.1854	-10.1917	700.000	700.000	201.427	202.038

Table 10 Load Flow Results of Load Buses

BUS	|V| (pu)		∠V (deg)	
	RTDS	PSS/E	RTDS	PSS/E
5	1.0065	1.0065	20.5062	20.6078
6	0.9782	0.9781	10.4242	10.5233
7	0.9611	0.9610	2.0167	2.1143
8	0.9496	0.9486	-11.7989	-11.7551
9	0.9716	0.9714	-25.3420	-25.3519
10	0.9836	0.9835	-16.9300	-16.9369
11	1.0083	1.0083	-6.6253	-6.6270

[2] The 30 degree difference in voltage angle is due to the Y-Δ step-up transformers at the generator buses in RSCAD.

5. REFERENCES

[1] P.S. Kundur, Power System Stability and Control, New York, McGraw−Hill, 1983.

[2] J.J. Grainger and W.D. Stevenson, Power System Analysis, New York, McGraw-Hill, 1994.

[3] S. Arunprasanth, H. Meiklejohn, and R. Wierckx, "Benchmarking Standard Power Test Systems for Real-Time Simulation Studies", CIGRE Sessions-2018.