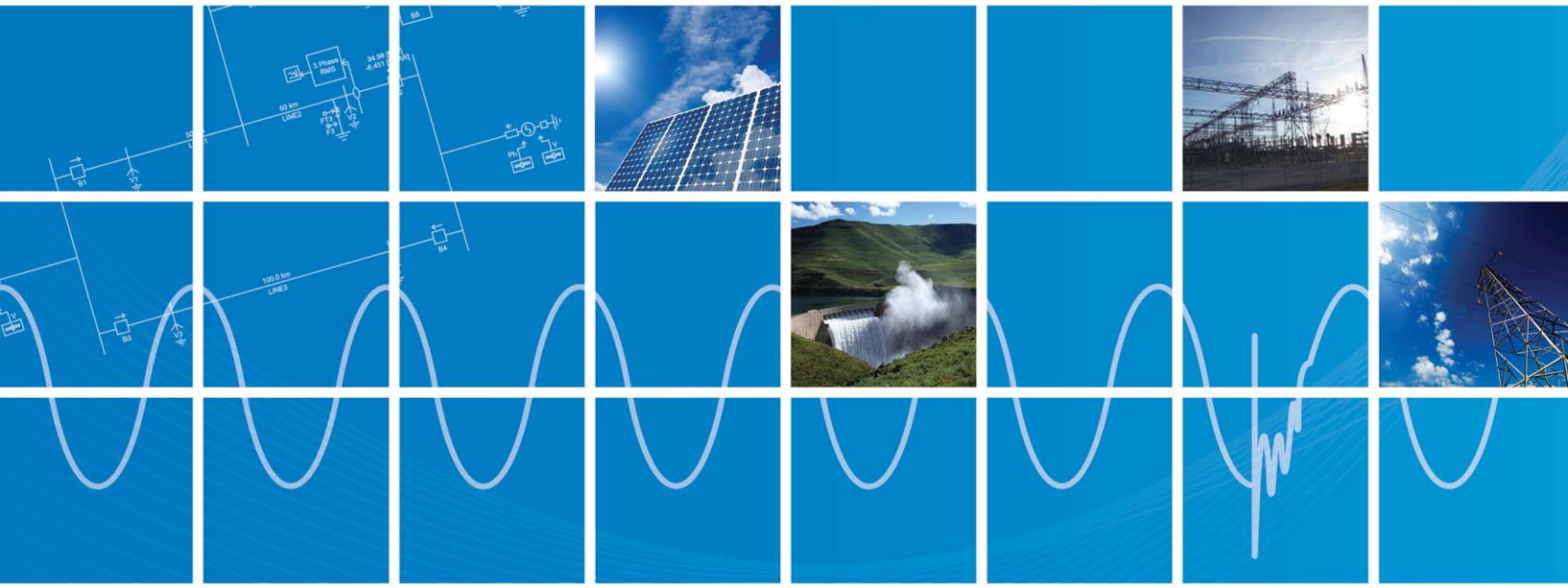
PSCAD™

IEEE 14 Bus System

May 22, 2018
Revision 1



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Contents

1.0 Objective

IEEE bus systems are used by researchers to implement new ideas and concepts. This Technical Note describes the details of the IEEE 14-bus system [1]. The system consists of loads, capacitor banks, transmission lines, and generators as shown in Figure 1.

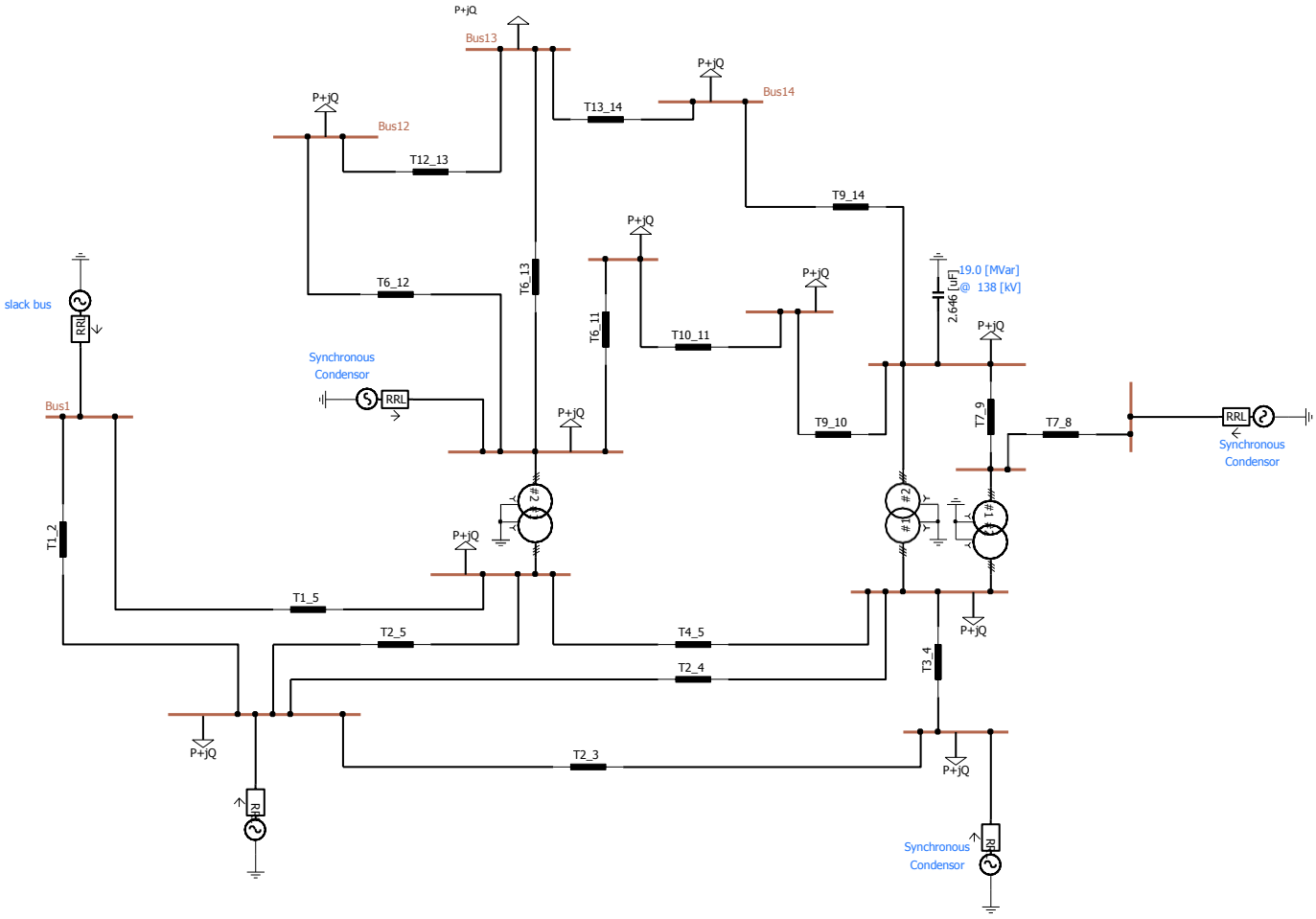

Figure 1 - PSCAD Model of the IEEE 14-bus system

Each machine (generator) is represented as a voltage source where its source impedance is set arbitrarily as 10 Ohms. Table 1 summarizes the characteristics of each source, with a base of 100 [MVA] for per unitizing.

Table 1 - Terminal conditions of IEEE 14-bus system

Bus	V kV]	δ [deg]	P [pu]	Q [pu]
1	146.28	0.0000	2.3239	-0.1655
2	144.21	-4.9826	0.4000	0.4356
3	139.38	-12.7250	0.0000	0.2508
6	147.66	-14.2209	0.0000	0.1273
8	150.42	-13.3596	0.0000	0.1762

Transmission lines are modelled using the Bergeron model. Table 2 summarizes the transmission line parameters.

Table 2 - Transmission line characteristics of IEEE 14-bus system

Line		R [pu/m]	X [pu/m]	B [pu/m]
From Bus	To Bus			
1	2	1.94E-07	5.92E-07	5.28E-07
1	5	5.40E-07	2.23E-06	4.92E-07
2	3	4.70E-07	1.98E-06	4.38E-07
2	4	5.81E-07	1.76E-06	3.40E-07
2	5	5.70E-07	1.74E-06	3.46E-07
3	4	6.70E-07	1.71E-06	1.28E-07
4	5	1.34E-07	4.21E-07	1.00E-09
6	11	9.50E-07	1.99E-06	1.00E-09
6	12	1.23E-06	2.56E-06	1.00E-09
6	13	6.62E-07	1.30E-06	1.00E-09
7	8	1.00E-09	1.76E-06	1.00E-09
7	9	1.00E-09	1.10E-06	1.00E-09
9	10	3.18E-07	8.45E-07	1.00E-09
9	14	1.27E-06	2.70E-06	1.00E-09
10	11	8.21E-07	1.92E-06	1.00E-09
12	13	2.21E-06	2.00E-06	1.00E-09
13	14	1.71E-06	3.48E-06	1.00E-09

Loads are modelled as a constant PQ load with parameters as shown in Table 3.

Table 3 - Load characteristics of IEEE 14-bus system

Bus	P [pu]	Q [pu]
2	0.217	0.127
3	0.942	0.190
4	0.478	-0.039
5	0.076	0.016
6	0.112	0.075
9	0.295	0.166
10	0.090	0.058
11	0.035	0.018
12	0.061	0.016
13	0.135	0.058
14	0.149	0.050

2.0 Validation

The PSCAD model was validated against the PSS/E power flow values from [1]. Table 4 depicts the line and source power flow comparison.

Table 4 - Source and line power comparison of IEEE 14-bus system

Bus		PSS/E		PSCAD	
		P [pu]	Q [pu]	P [pu]	Q [pu]
1		2.324	-0.165	2.3230	-0.1548
2		0.400	0.436	0.3995	0.4493
3		0.000	0.251	0.0007	0.2613
6		0.000	0.127	0.0020	0.1498
8		0.000	0.176	-0.0011	0.1896
From Bus	**To Bus**				
1	2	1.569	-0.204	1.5690	-0.2005
1	5	0.755	0.039	0.7543	0.0450
2	3	0.709	-0.016	0.7096	-0.0164
2	4	0.561	-0.030	0.5606	-0.0209
2	5	0.406	0.012	0.4043	0.0165
3	4	0.237	-0.048	0.2354	-0.0540
4	5	0.612	-0.158	0.6130	-0.1750
6	11	0.074	0.034	0.0747	0.0384
6	12	0.078	0.025	0.0781	0.0253
6	13	0.177	0.072	0.1782	0.0740
7	8	0.000	0.176	0.0011	0.1844
7	9	0.281	0.050	0.2793	-0.0539
9	10	0.052	0.042	0.0511	0.0380
9	14	0.093	0.034	0.0878	0.0217
10	11	0.038	0.016	0.0390	0.0200
12	13	0.016	0.008	0.0166	0.0080
13	14	0.056	0.017	0.0568	0.0188

3.0 Set-up Instructions

Dependencies

This example is compatible with PSCAD v4.5.3 and beyond. The files

required to run the tutorial are as follows:

- New_IEEE_14_CT.pscx

4.0 Future updates to the system model

- Replace the voltage sources with detailed machine models for dynamic analysis.
- Update short circuit levels of each source to represent specific system strengths.

5.0 Technical References

[1] Illinois Center for a Smarter Electric Grid. (2013). [Online]. Available FTP: http://publish.illinois.edu/smartergrid/

[2] http://sas.ieee.ca/pesias/seminar_slides/IEEE_PES-IAS_Chapter_24_01_13.pdf

Appendix 1

The line resistances and reactances are provided in [1] for each line segment of the test system. The following table lists the approximate line length of each segment, based on typical line data (as listed in Table A-2).

Table A-1- Approximate line lengths based on typical line reactance values as shown in Table A-2

From Bus	To Bus	Total Reactance (Ω)	Approximate length of the line based on typical line reactance values (km)
1	2	1.13E+01	2.25E+01
1	5	4.25E+01	8.49E+01
2	3	3.77E+01	7.54E+01
2	4	3.35E+01	6.70E+01
2	5	3.31E+01	6.63E+01
3	4	3.26E+01	6.51E+01
4	5	8.02E+00	1.60E+01
6	11	3.79E+01	7.58E+01
6	12	4.88E+01	9.75E+01
6	13	2.48E+01	4.95E+01
7	8	3.35E+01	6.70E+01
7	9	2.09E+01	4.19E+01
9	10	1.61E+01	3.22E+01
9	14	5.14E+01	1.03E+02
10	11	3.66E+01	7.31E+01
12	13	3.81E+01	7.62E+01
13	14	6.63E+01	1.33E+02

Table A-2- Typical line reactance values

Voltage (kV)	R(Ω/km)	X(Ω/km)
72	0.41	0.5
138	0.14	0.5
230 (single)	0.09	0.5
230 (bundled)	0.04	0.4
345 (bundled)	0.03	0.3
500 (bundled)	0.02	0.3

DOCUMENT TRACKING

Rev.	Description	Date
0	Initial	30/Dec/2014
1	Update to new brand guidelines	22/May/2018