Modeling and Analysis of a Grid-Connected Hybrid Power System with Wind and Solar PV Integration

Electrical Transient Analyzer Program

Load Flow Analysis

Loading Category (1): Design

Generation Category (1): Design

Load Diversity Factor: None

	Swing	V-Control	Load	Total
Number of Buses:	1	4	8	13

	XFMR2	XFMR3	Reactor	Line/Cable/ Busway	Impedance	Tie PD	Total
Number of Branches:	4	0	0	8	0	0	12

Method of Solution:	Newton-Raphson Method
Maximum No. of Iteration:	9999
Precision of Solution:	0.0000010
System Frequency:	50.00 Hz
Unit System:	Metric

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Adjustments

Tolerance	Apply Adjustments	Individual /Global	Percent
Transformer Impedance:	Yes	Individual	
Reactor Impedance:	Yes	Individual	
Overload Heater Resistance:	No		
Transmission Line Length:	No		
Cable / Busway Length:	No		

Temperature Correction	Apply Adjustments	Individual /Global	Degree C
Transmission Line Resistance:	Yes	Individual	
Cable / Busway Resistance:	Yes	Individual	

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Bus Input Data

Bus			Initial Voltage		Load							
					Constant kVA		Constant Z		Constant I		Generic	
ID	kV	Sub-sys	% Mag.	Ang.	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar
Bus1	34.500	1	100.0	0.0								
Bus2	4.160	1	100.0	0.0			0.000	-1.000				
Bus3	0.600	1	100.0	0.0								
Bus4	0.600	1	102.0	0.0								
Bus5	0.600	1	100.0	0.0								
Bus6	0.600	1	100.0	0.0								
Bus7	0.600	1	100.0	0.0								
Bus8	0.600	1	100.0	0.0								
Bus9	0.600	1	100.0	0.0								
Bus10	0.600	1	100.0	0.0								
Bus11	0.600	1	100.0	0.0								
Bus12	0.600	1	100.0	0.0								
Bus14	0.220	1	100.0	0.0								
Total Number of Buses: 13					0.000	0.000	0.000	-1.000	0.000	0.000	0.000	0.000

Generation Bus				Voltage		Generation			Mvar Limits	
ID	kV	Type	Sub-sys	% Mag.	Angle	MW	Mvar	% PF	Max	Min
Bus1	34.500	Swing	1	100.0	0.0					
Bus3	0.600	Voltage Control	1	100.0	0.0	0.230			0.111	0.000
Bus4	0.600	Voltage Control	1	102.0	0.0	0.225			0.100	0.000
Bus5	0.600	Voltage Control	1	100.0	0.0	0.600			0.706	0.000
Bus6	0.600	Voltage Control	1	100.0	0.0	1.200			0.334	-1.078
Bus8	0.600	Mvar/PF Control	1	100.0	0.0	0.225	0.000	100.0		
Bus9	0.600	Mvar/PF Control	1	100.0	0.0	0.225	0.000	100.0		
Bus10	0.600	Mvar/PF Control	1	100.0	0.0	0.225	0.000	100.0		
Bus11	0.600	Mvar/PF Control	1	100.0	0.0	0.225	0.000	100.0		
Bus14	0.220	Mvar/PF Control	1	100.0	0.0	0.018	-0.003	-98.3		
						3.173	-0.375			

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Line/Cable/Busway Input Data

ohms or siemens/1000 m per Conductor (Cable) or per Phase (Line/Busway)

Line/Cable/Busway ID	Library	Size	Length Adj. (m)	% Tol.	#/Phase	T (°C)	R	X	Y
Cable1	0.6NCUN3	400	50.0	0.0	1	75	0.056700	0.074800	
Cable2	0.6NCUN3	400	50.0	0.0	1	75	0.056700	0.074800	
Cable3	0.6NCUN3	400	50.0	0.0	1	75	0.056700	0.074800	
Cable4	0.6NCUN3	400	50.0	0.0	1	75	0.056700	0.074800	
Cable5	0.6NCUN3	95	50.0	0.0	1	75	0.229700	0.077400	
Cable6	0.6NCUN3	95	50.0	0.0	1	75	0.229700	0.077400	
Cable7	0.6NCUN3	400	50.0	0.0	1	75	0.056700	0.074800	
Cable8	0.6NCUN3	400	50.0	0.0	1	75	0.056700	0.074800	

Line / Cable / Busway resistances are listed at the specified temperatures.

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2-Winding Transformer Input Data

Transformer		Rating					Z Variation			% Tap Setting		Adjusted	Phase Shift	
ID	Phase	MVA	Prim. kV	Sec. kV	% Z1	X1/R1	+ 5%	- 5%	% Tol.	Prim.	Sec.	% Z	Type	Angle
T1	3-Phase	20.000	34.500	4.160	8.00	15.50	0	0	0	0	0	8.0000	Dyn	0.000
T2	3-Phase	2.500	0.600	4.160	6.00	7.10	0	0	0	0	0	6.0000	YNd	0.000
T3	3-Phase	2.500	0.600	4.160	6.00	7.10	0	0	0	0	0	6.0000	YNd	0.000
T5	3-Phase	1.000	4.160	0.220	5.00	5.79	0	0	0	0	0	5.0000	Dyn	0.000

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Branch Connections

CKT/Branch		Connected Bus ID		% Impedance, Pos. Seq., 100 MVA Base			
ID	Type	From Bus	To Bus	R	X	Z	Y
T1	2W XFMR	Bus1	Bus2	2.58	39.92	40.00	
T2	2W XFMR	Bus7	Bus2	33.48	237.65	240.00	
T3	2W XFMR	Bus12	Bus2	33.48	237.65	240.00	
T5	2W XFMR	Bus2	Bus14	85.10	492.71	500.00	
Cable1	Cable	Bus6	Bus5	78.75	103.89	130.36	
Cable2	Cable	Bus5	Bus4	78.75	103.89	130.36	
Cable3	Cable	Bus4	Bus3	78.75	103.89	130.36	
Cable4	Cable	Bus3	Bus7	78.75	103.89	130.36	
Cable5	Cable	Bus8	Bus9	319.03	107.50	336.65	
Cable6	Cable	Bus9	Bus10	319.03	107.50	336.65	
Cable7	Cable	Bus10	Bus11	78.75	103.89	130.36	
Cable8	Cable	Bus11	Bus12	78.75	103.89	130.36	

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LOAD FLOW REPORT

Bus		Voltage		Generation		Load		Load Flow					XFMR
ID	kV	% Mag.	Ang.	MW	Mvar	MW	Mvar	ID	MW	Mvar	Amp	%PF	%Tap
* Bus1	34.500	100.000	0.0	-3.001	0.176	0.000	0.000	Bus2	-3.001	0.176	50.3	-99.8	
Bus2	4.160	100.014	0.7	0.000	0.000	0.000	-1.000	Bus1	3.003	-0.140	417.2	-99.9	
								Bus7	-2.105	1.104	329.8	-88.6	
								Bus12	-0.880	0.034	122.2	-99.9	
								Bus14	-0.018	0.003	2.6	-98.3	
Bus3	0.600	98.967	5.6	0.230	0.000	0.000	0.000	Bus4	-1.939	0.911	2082.7	-90.5	
								Bus7	2.168	-0.911	2286.6	-92.2	
Bus4	0.600	99.592	7.2	0.225	0.100	0.000	0.000	Bus5	-1.751	0.962	1930.1	-87.6	
								Bus3	1.976	-0.862	2082.7	-91.7	
Bus5	0.600	100.006	8.6	0.600	0.000	0.000	0.000	Bus6	-1.182	0.920	1441.6	-78.9	
								Bus4	1.782	-0.920	1930.1	-88.9	
* Bus6	0.600	100.000	9.8	1.200	-0.897	0.000	0.000	Bus5	1.200	-0.897	1441.6	-80.1	
Bus7	0.600	98.243	3.8	0.000	0.000	0.000	0.000	Bus3	-2.124	0.969	2286.6	-91.0	
								Bus2	2.124	-0.969	2286.6	-91.0	
Bus8	0.600	103.529	3.2	0.225	0.000	0.000	0.000	Bus9	0.225	0.000	209.1	100.0	
Bus9	0.600	102.836	3.1	0.225	0.000	0.000	0.000	Bus8	-0.223	0.001	209.1	100.0	
								Bus10	0.448	-0.001	419.7	100.0	
Bus10	0.600	101.447	2.8	0.225	0.000	0.000	0.000	Bus9	-0.442	0.003	419.7	100.0	
								Bus11	0.667	-0.003	633.1	100.0	
Bus11	0.600	100.933	2.4	0.225	0.000	0.000	0.000	Bus10	-0.664	0.007	633.1	100.0	
								Bus12	0.889	-0.007	847.6	100.0	
Bus12	0.600	100.251	1.9	0.000	0.000	0.000	0.000	Bus11	-0.883	0.015	847.6	-100.0	
								Bus2	0.883	-0.015	847.6	-100.0	
Bus14	0.220	100.013	0.7	0.018	-0.003	0.000	0.000	Bus2	0.018	-0.003	48.7	-98.3	

* Indicates a voltage regulated bus (voltage controlled or swing type machine connected to it)

# Indicates a bus with a load mismatch of more than 0.1 MVA

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Bus Loading Summary Report

Bus			Directly Connected Load								Total Bus Load			
			Constant kVA		Constant Z		Constant I		Generic					Percent
ID	kV	Rated Amp	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MVA	% PF	Amp	Loading
Bus1	34.500										3.006	99.8	50.3	
Bus2	4.160					-1.000					3.213	93.5	445.8	
Bus3	0.600										2.352	92.2	2286.6	
Bus4	0.600										2.197	89.9	2123.2	
Bus5	0.600										2.006	88.9	1930.1	
Bus6	0.600										1.498	80.1	1441.6	
Bus7	0.600										2.335	91.0	2286.6	
Bus8	0.600										0.225	100.0	209.1	
Bus9	0.600										0.448	100.0	419.7	
Bus10	0.600										0.667	100.0	633.1	
Bus11	0.600										0.889	100.0	847.6	
Bus12	0.600										0.883	100.0	847.6	
Bus14	0.220										0.018	100.0	47.9	

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Branch Loading Summary Report

CKT / Branch		Busway / Cable & Reactor			Transformer				
		Ampacity	Loading		Capability	Loading (input)		Loading (output)	
ID	Type	(Amp)	Amp	%	(MVA)	MVA	%	MVA	%
Cable5	Cable	266.88	209.13	78.36					
* Cable6	Cable	266.88	419.66	157.25					
T1	Transformer				10.000	3.007	30.1	3.006	30.1
* T2	Transformer				1.500	2.377	158.4	2.335	155.6
T3	Transformer				1.500	0.883	58.9	0.881	58.7
T5	Transformer				1.000	0.019	1.9	0.019	1.9

* Indicates a branch with operating load exceeding the branch capability.

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Branch Losses Summary Report

Branch ID	From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop
	MW	Mvar	MW	Mvar	kW	kvar	From	To	in Vmag
Cable1	-1.182	0.920	1.200	-0.897	17.7	23.3	100.0	100.0	0.01
Cable2	-1.751	0.962	1.782	-0.920	31.7	41.8	99.6	100.0	0.41
Cable3	-1.939	0.911	1.976	-0.862	36.9	48.7	99.0	99.6	0.62
Cable4	2.168	-0.911	-2.124	0.969	44.5	58.7	99.0	98.2	0.72
Cable5	0.225	0.000	-0.223	0.001	1.5	0.5	103.5	102.8	0.69
Cable6	0.448	-0.001	-0.442	0.003	6.1	2.0	102.8	101.4	1.39
Cable7	0.667	-0.003	-0.664	0.007	3.4	4.5	101.4	100.9	0.51
Cable8	0.889	-0.007	-0.883	0.015	6.1	8.1	100.9	100.3	0.68
T1	-3.001	0.176	3.003	-0.140	2.3	36.1	100.0	100.0	0.01
T2	-2.105	1.104	2.124	-0.969	18.9	134.2	100.0	98.2	1.77
T3	-0.880	0.034	0.883	-0.015	2.6	18.4	100.0	100.3	0.24
T5	-0.018	0.003	0.018	-0.003	0.0	0.0	100.0	100.0	0.00
					171.6	376.3			

* This Transmission Line includes Series Capacitor.

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Alert Summary Report

	% Alert Settings
	Critical
Loading	
Bus	0.0
Cable / Busway	0.0
Reactor	0.0
Line	0.0
Transformer	0.0
Panel	0.0
Protective Device	0.0
Generator	0.0
Inverter/Charger	100.0
Bus Voltage	
OverVoltage	105.0
UnderVoltage	95.0
Generator Excitation	
OverExcited (Q Max.)	100.0
UnderExcited (Q Min.)	100.0

Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
PVA1	PV Array	Overload	0.787	Amp	9.392	1193.0	3-Phase
PVA2	PV Array	Overload	0.787	Amp	9.392	1193.0	3-Phase
PVA3	PV Array	Overload	0.787	Amp	8.870	1126.7	3-Phase
PVA4	PV Array	Overload	0.787	Amp	7.983	1014.0	3-Phase
PVA4	PV Array	OverCurrent	0.787	Amp	7.983	1014.0	3-Phase
PVA5	PV Array	Overload	0.787	Amp	9.392	1193.0	3-Phase
PVA6	PV Array	Overload	0.787	Amp	7.983	1014.0	3-Phase
PVA6	PV Array	OverCurrent	0.787	Amp	7.983	1014.0	3-Phase
WTG1	Wind Turbine Generator	Under Excited	0.000	Mvar	0.000	0.0	3-Phase
WTG2	Wind Turbine Generator	Over Excited	0.100	Mvar	0.100	100.0	3-Phase
WTG3	Wind Turbine Generator	Under Excited	0.000	Mvar	0.000	0.0	3-Phase
WTG4	Wind Turbine Generator	Under Excited	0.000	Mvar	-0.372	0.0	3-Phase
WTG5	Wind Turbine Generator	Under Excited	0.000	Mvar	0.000	0.0	3-Phase

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Critical Report

Device ID	Type	Condition	Rating/Limit	Unit	Operating	% Operating	Phase Type
WTG6	Wind Turbine Generator	Under Excited	0.000	Mvar	0.000	0.0	3-Phase
WTG7	Wind Turbine Generator	Under Excited	0.000	Mvar	0.000	0.0	3-Phase
WTG8	Wind Turbine Generator	Under Excited	0.000	Mvar	0.000	0.0	3-Phase

SUMMARY OF TOTAL GENERATION , LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	-3.001	0.176	3.006	99.83 Leading
Source (Non-Swing Buses):	3.173	-0.800	3.272	96.96 Leading
Total Demand:	0.172	-0.624	0.647	26.52 Leading
Total Motor Load:	0.000	0.000	0.000	
Total Static Load:	0.000	-1.000	1.000	0.00 Lagging
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.172	0.376		
System Mismatch:	0.000	0.000		

Number of Iterations: 1