Although various studies are carried out considering various issues related with interfacing of large scale farms. However the work can further be extended to carry out the following studies.

1) Saturation effects should be included in the induction generator and the transformer models.

2) A detailed PWM voltage source converter model with high-frequency switches should be implemented in the DFIG wind power generation system. It might provide more accurate transient responses for grid-connected wind turbines considering overload of power converter with DFIG.

3) Effect of tower shadow, three dimensional wind simulation, and dynamic description of aerodynamic conversion or an improvement of the drive train model should be considered.

4) To develop an integrated design of an offshore wind farm and an interconnection circuit based on a series multi terminal HVDC link with current source inverters (CSI).
BIBLIOGRAPHY


[74] CEA standards (Grid standards) Regulations- 2006.


[76] Indian Wind Grid Code version 1.0, Centre for Wind Energy Technology, PP. 1-54, July 2009.


[103] MERC Order, Case No. 19 of 2012.
## APPENDIX A
### WIND TURBINE AND SQUIRREL CAGE INDUCTION GENERATOR PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total capacity of wind farm</td>
<td>75 MW</td>
</tr>
<tr>
<td>Squirrel cage induction rating</td>
<td>1.6 MVA</td>
</tr>
<tr>
<td>Real power</td>
<td>1.25 MW</td>
</tr>
<tr>
<td>Number of coherent machine</td>
<td>60</td>
</tr>
<tr>
<td>Rated RMS phase voltage</td>
<td>0.398 kV</td>
</tr>
<tr>
<td>Rated RMS phase current</td>
<td>1.355 kA</td>
</tr>
<tr>
<td>Base angular frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Stator resistance</td>
<td>0.004081 [pu]</td>
</tr>
<tr>
<td>First cage resistance</td>
<td>0.0165 [pu]</td>
</tr>
<tr>
<td>Second cage resistance</td>
<td>0.018 [pu]</td>
</tr>
<tr>
<td>Stator unsaturated leakage reactance</td>
<td>0.061 [pu]</td>
</tr>
<tr>
<td>Unsaturated magnetizing reactance</td>
<td>3.434 [pu]</td>
</tr>
<tr>
<td>Rotor unsaturated mutual reactance</td>
<td>0.0374 [pu]</td>
</tr>
<tr>
<td>Second cage unsaturated reactance</td>
<td>0.105 [pu]</td>
</tr>
<tr>
<td>Polar moment of inertia (J = 2 H)</td>
<td>3 [s]</td>
</tr>
<tr>
<td>Mechanical damping</td>
<td>0.008 [pu]</td>
</tr>
<tr>
<td>Power factor at rated load</td>
<td>0.8</td>
</tr>
<tr>
<td>Polar moment of inertia</td>
<td>10 kg.m²</td>
</tr>
<tr>
<td>Air density (ρ)</td>
<td>1.23 kg/m³</td>
</tr>
<tr>
<td>Turbine rotor radius (R)</td>
<td>37.59 m</td>
</tr>
<tr>
<td>Rotor surface area (A)</td>
<td>4439.09 m²</td>
</tr>
<tr>
<td>Base shaft angular speed</td>
<td>1000 rpm</td>
</tr>
<tr>
<td>Machine / turbine Gear ratio</td>
<td>100</td>
</tr>
<tr>
<td>Number of poles</td>
<td>6</td>
</tr>
<tr>
<td>Hub speed with gear box</td>
<td>1.04719</td>
</tr>
<tr>
<td>Rated wind velocity (V)</td>
<td>12 m/sec</td>
</tr>
<tr>
<td>Description</td>
<td>Value</td>
</tr>
<tr>
<td>------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Cut in speed</td>
<td>3 m/s</td>
</tr>
<tr>
<td>Cut out speed</td>
<td>30 m/s</td>
</tr>
</tbody>
</table>
APPENDIX B
WIND TURBINE AND DOUBLE FED INDUCTION GENERATOR PARAMETERS

- Total capacity of wind farm: 0.8 MW
- Double fed induction rating: 1 MVA
- Real power: 0.8 MW
- Number of coherent machine: 1
- Rated RMS phase voltage: 0.398 kV
- Base angular frequency: 50 Hz
- Stator/rotor turn ratio: 0.3
- Angular moment of inertia (J = 2 H): 0.85
- Mechanical damping: 0.0001 [pu]
- Stator resistance: 0.0054 [pu]
- Wound rotor resistance: 0.00607 [pu]
- Magnetizing inductance: 4.5
- Stator leakage inductance: 0.10
- Wound rotor leakage inductance: 0.11
- Air density (ρ): 1.225 kg/m³
- Turbine rotor radius (R): 40 m
- Rotor surface area (A): 5026.54 m²
- Initial speed of machine: 1.1 [pu]
- Hub speed: 1.1
- Rated wind velocity (V): 12 m/sec
- Cut in speed: 3 m/s
- Cut out speed: 30 m/s
APPENDIX C
WIND TURBINE AND SYNCHRONOUS GENERATOR PARAMETERS

Total capacity of wind farm : 75 MW
Synchronous generator rating : 2 MVA
Real power : 1.67 MW
Number of coherent machine : 45
Rated RMS phase voltage : 0.398 kV
Rated RMS phase current : 1.45 kA
Inertia constant : 6.3 [s]
Mechanical friction & windage : 0.02 [pu]
Iron loss resistance : 30 [pu]
Neutral series resistance : 20 [pu]
Smoothing time constant : 0.02 [s]
D: Unsaturated reactance [Xd] : 0.4 [pu]
D: Unsaturated transient reactance [Xd’] : 0.3 [pu]
D: Unsaturated sub-transient reactance [Xd”] : 0.22 [pu]
Q: Unsaturated reactance [Xq] : 0.51 [pu]
Q: Unsaturated transient reactance [Xq’] : 0.228 [pu]
Q: Unsaturated sub-transient reactance [Xq”] : 0.29 [pu]
Air density (ρ) : 1.225 kg/m$^3$
Turbine rotor radius (R) : 46.20 m
Rotor surface area (A) : 6705.54 m$^2$
Base shaft angular speed : 3.14 rad/sec
Number of poles : 200
Hub speed with no gear box : 3.14 rad/sec
Rated wind velocity (V) : 12 m/sec
Cut in speed : 3 m/s
Cut out speed : 30 m/s
# APPENDIX D

## GRID AND TRANSMISSION LINE PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid base MVA</td>
<td>200 [MVA]</td>
</tr>
<tr>
<td>Base voltage</td>
<td>220 kV</td>
</tr>
<tr>
<td>Base frequency</td>
<td>50 [Hz]</td>
</tr>
<tr>
<td>Transformer</td>
<td>200 MVA, 220 kV/ 132 kV</td>
</tr>
<tr>
<td>Length of transmission line</td>
<td>57.5 km</td>
</tr>
<tr>
<td>Transmission line resistance</td>
<td>0.0695 Ω/km</td>
</tr>
<tr>
<td>i.e. 0.0695Ω/Km * 57.5 Km</td>
<td>4 Ω</td>
</tr>
<tr>
<td>Transmission line reactance</td>
<td>0.0014 Ω/km</td>
</tr>
<tr>
<td>i.e. 0.0014 Ω/Km * 57.5 Km</td>
<td>0.082 Ω</td>
</tr>
</tbody>
</table>
APPENDIX E
STATCOM PARAMETERS

Active power (P) : 15.19 MW
Reactive power (Q) : 150.40 MVAR
Apparent power (S) : 151.91 MVA
DC link voltage (V_{dc}) : 114.12 kV
V_{CMAX} : 125.53 kV
DC link capacitance (C_{dc}) : 302 µF
GTO voltage rating (V_{dc}) : 114.12 kV
GTO current rating (I_{dc}) : 1.12 kA
Forward voltage drop : 42.55 V
Forward break over voltage : 163.18 kV
Reverse withstand voltage : 163.18 kV
## APPENDIX F

### LOAD PARAMETERS

<table>
<thead>
<tr>
<th>Load Type</th>
<th>Power Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load 1: Active</td>
<td>33 MW</td>
</tr>
<tr>
<td>Load 1: Reactive</td>
<td>20 MVAR</td>
</tr>
<tr>
<td>Load 2: Active</td>
<td>140 MW</td>
</tr>
<tr>
<td>Load 2: Reactive</td>
<td>70.32 MVAR</td>
</tr>
<tr>
<td>Linear Load</td>
<td>173 MW</td>
</tr>
<tr>
<td>Nonlinear Load</td>
<td>154.77 MW</td>
</tr>
<tr>
<td>Commercial Load</td>
<td>168.92 MW</td>
</tr>
<tr>
<td>Industrial Load</td>
<td>169.25 MW</td>
</tr>
</tbody>
</table>
PUBLICATIONS ON THESIS WORK


22


**PUBLICATIONS IN PROCESS**


