# Momentary L-G Fault Analysis in 800kW Grid Tied Wind Energy Conversion System

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***Abstract*—** This paper gives the idea about grid connected wind energy conversion system. In this paper work has been done in healthy condition at rated wind speed of 12m/s of 800kW Wind turbine. Moreover the effect of grid fault has been simulated, specifically effect of L-G fault on generator, converter, inverter and grid has been observed and comparing the same with healthy conditions as well as momentary fault analysis. At last comparison has been done with momentary and permanent fault. This simulation work can be performed at various wind speeds and output results have been taken but over here it has been shown at rated wind speed.

***Index Terms*—L-G fault, RPM model, Wind energy conversion system.**

## I. INTRODUCTION

Wind Energy is wild stuff and very tricky to handle. Capturing wind energy is like riding a antelope when we could be using Volkswagen. Wind is free until the government manages to put a tax on it and many people assume that wind energy will therefore be a bargain. If that were so, then we would see windmills everywhere but of course there is no such thing as a free lunch. [4]

There are two primary physical principles by which energy can be extracted from the wind; these are through the creation of either drag or lift force (or through a combination of the two). The difference between drag and lift is illustrated by the difference between using a spinnaker (a large extra sail on racing yatch) sail, which fills like a parachute and pulls a sailing boat with the wind, and a Bermuda rig, the familiar triangular sail which deflects with wind and allows a sailing boat to travel across the wind or slightly into the wind. Drag forces provide the most obvious means of propulsion, these being the forces felt by a person (or object) exposed to the wind. Drag increases with the area facing the wind, dra increases in proportion to the frontal area of an object facir wind.[2] Lift forces are the most efficient means of propulsic but being more subtle than drag forces are not so we understood. [3]

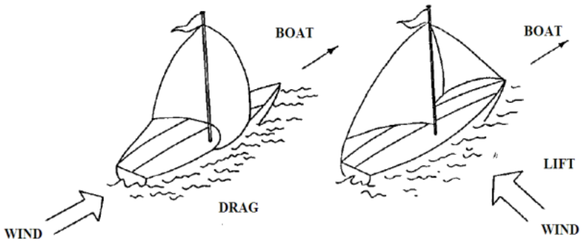



Fig. 1 Lift and Drag forces [3]

As per power and torque equations, values of power and torqu have been calculated. Main three equations are as under:

$$P = \frac{1}{2}\rho ACpV^3$$

$$Tturbine = \frac{1}{2}\rho ACp\frac{V}{\lambda}$$

$$RPM = \frac{(WindSpeed*TSR*60)}{Dia.ofrotor*pi}$$

Where,

P=Power developed by Wind turbine in Watt

T=Torque produced by Wind turbine

Cp=Power co-efficient

ρ=Air density=1.225 kg/$m^3$

A=Area of wind turbine blades in $m^2$

V=Velocity of Wind

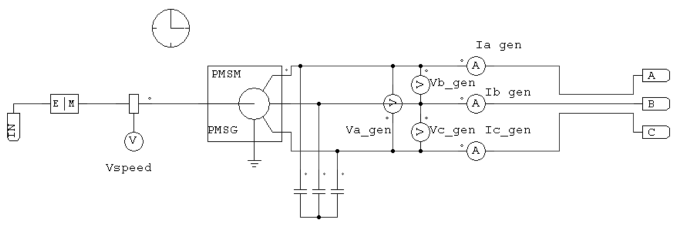
T=Output torque Nm

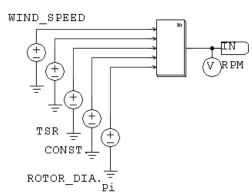
λ = Tip Speed Ratio.

As per torque equation turbine model has been developed.

This paper gives basic idea about simulation work of 800kW wind turbine which is connected via PMSG and with converter & inverter topologies entire system has been simulated at rated speed of 12m/s. then via step up transformer it is connected with grid of 33kV. Now L-G fault create fictitiously at grid side just nearby inverter and the effect of L-G fault on generator, converter and inverter has been observed. Simulation has been done at two different situations. In this work three inverter units are provided but for reduce simulation time (as an equivalent unit) has been simulated in simulation work. This work has been done in PSIM 6.0 ® environment.

## II. CLOSE LOOP SIMULATION & RESULTS WITH RPM MODEL & WIND TURBINE TORQUE MODEL




WIND TURBINE RPM MODEL

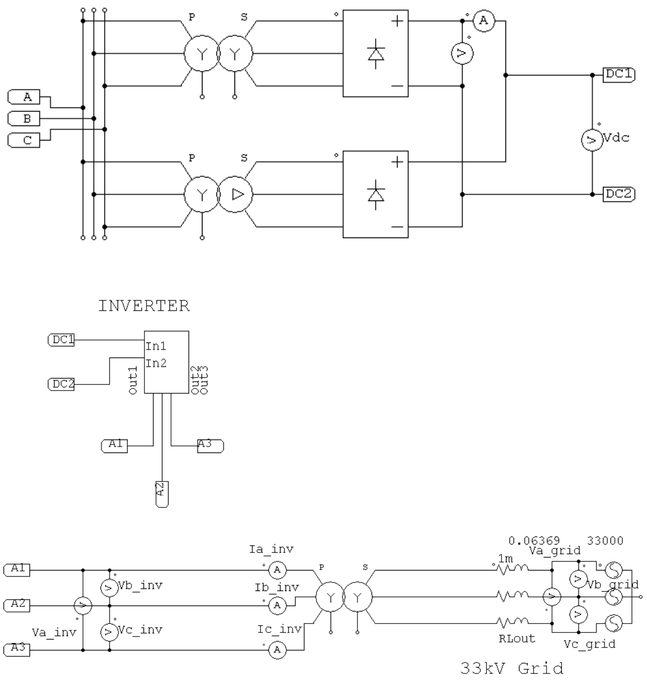



Fig. 2 Close loop simulation with three inverter units in healthy condition

Fig. 2 shows simulation circuit wind energy conversion system connected with grid. This is a close loop simulation. First system has been simulated in healthy condition at rated wind speed as per appendix table i.e. at 12m/s. Then same system can be simulated at L-G fault on grid side. Results shown below gives the response of PMSG based wind energy conversion system connected with grid at each end of conversions.

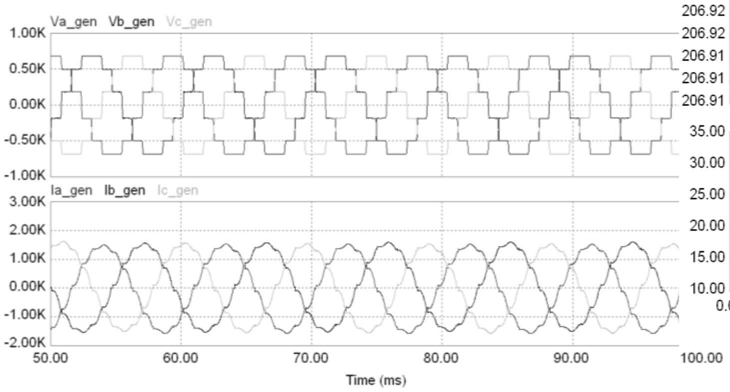



Fig. 3 Input voltage and current

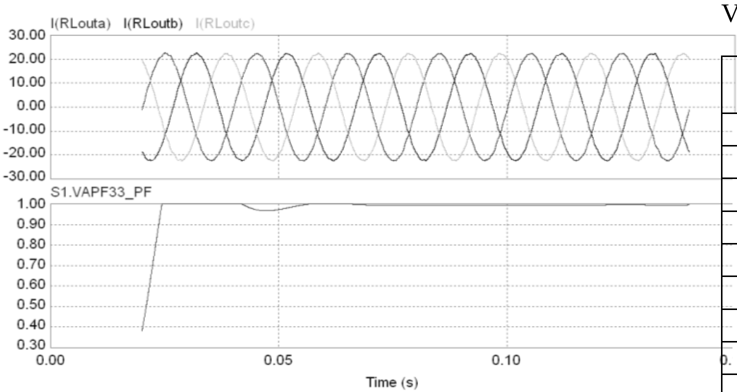



Fig. 4Grid current and Power factor

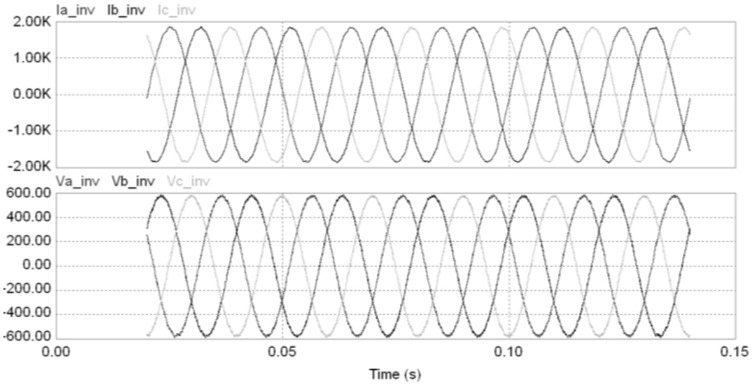



Fig. 5 Inverter output voltage and current

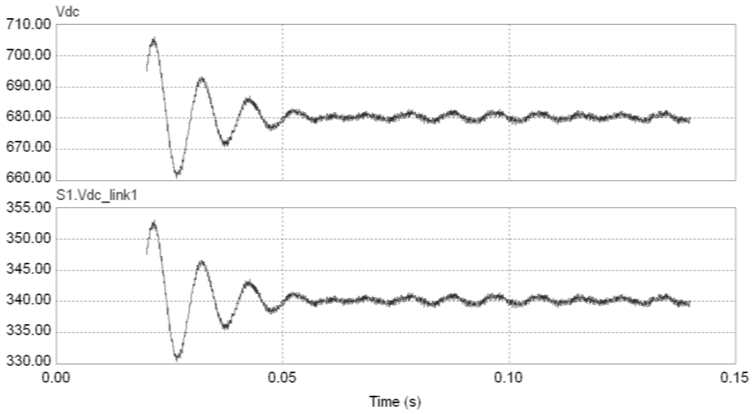



Fig. 6 DC link voltage and DC voltage

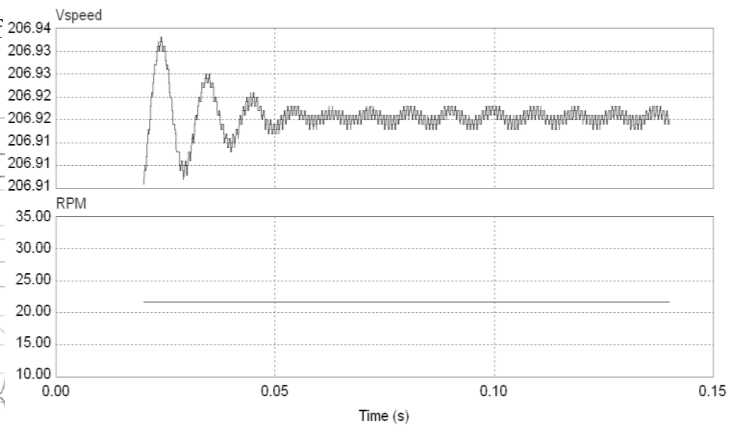



Fig. 7 Generator Speed and turbine RPM

Table 1
Various measured Parameters in RMS in Healthy conditions at rated speed

| Parameters in RMS | Wind Speed 12m/s |
|---|---|
| Ia_gen | 1082.11A |
| Ib_gen | 1071.66A |
| Ic_gen | 1070.65A |
| Va_gen | 499.09V |
| Vb_gen | 497.26V |
| Vc_gen | 494.83V |
| Va_inv | 406.18V |
| Vb_inv | 406.23V |
| Vc_inv | 406.128V |
| Ia_inv | 1302.89A |

| | |
|---|---|
| Ib_inv | 1301.20A |
| Ic_inc | 1300.37A |
| Irlouta . | 15.79A |
| Irloutb | 15.77A |
| Irloutc | 15.76A |
| Vdc | 680.85V |
| Vdc link | 340.32V |

## III. SIMULATION WITH L-G FAULT AND MOMENTARY L-G FAULT (A COMPARISON)

Here only inverter section has been shown rest of all system remains same as previous figure, main aim is on the effect of L-G fault on inverter and grid and comparing the same with momentary fault analysis.

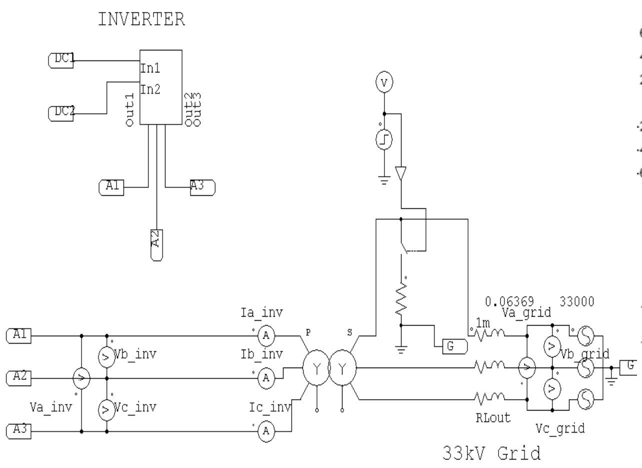



Fig. 8 LG fault in Phase A (Simulation)

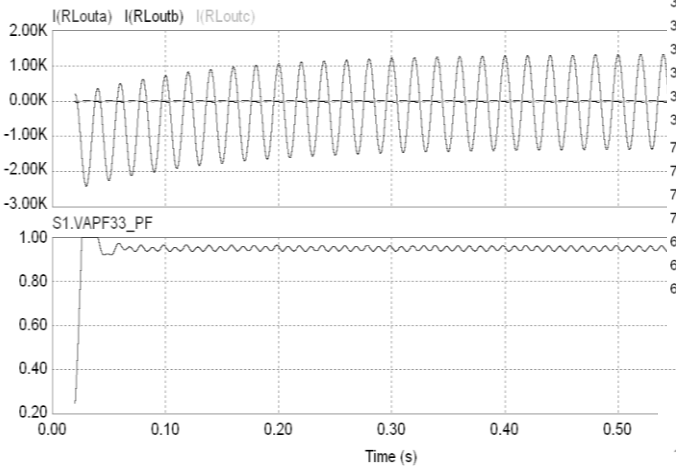



Fig. 9 Grid current and Power factor (L-G fault in Ph. A)

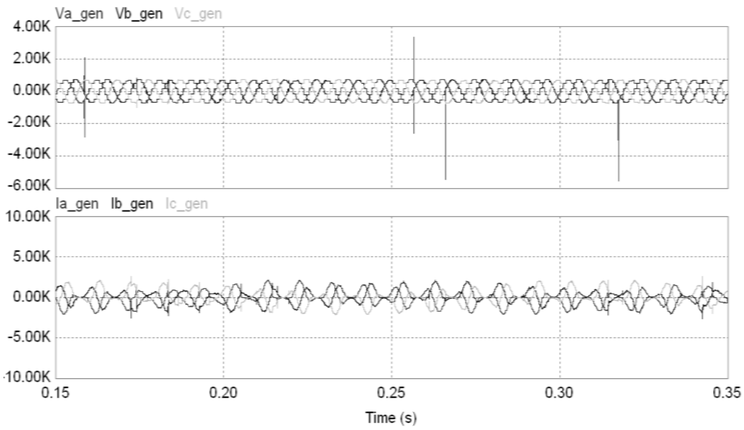



Fig. 10 Generated voltages and currents

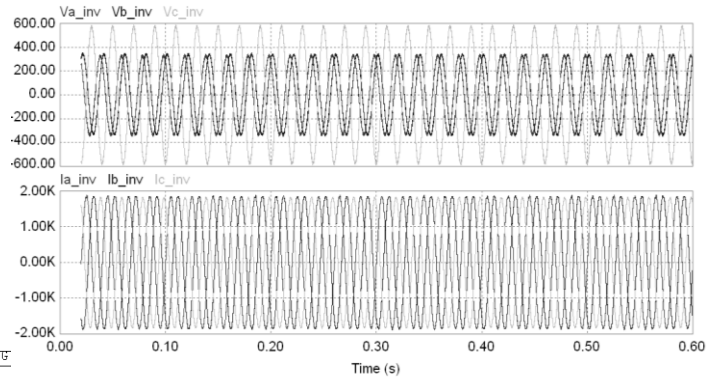



Fig. 11 Inverter output voltage and current

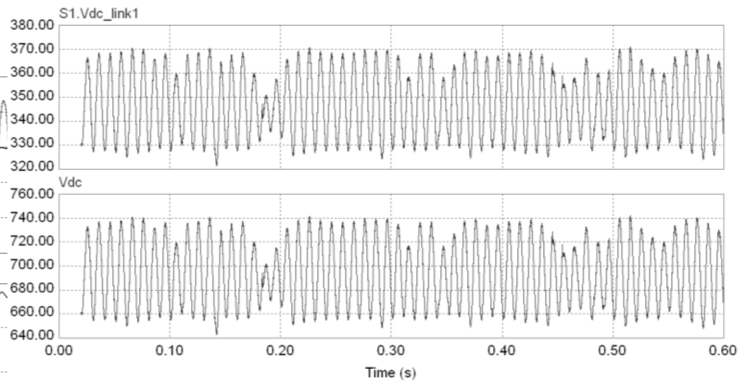



Fig. 12 DC voltage after twelve pulse converter and DC link voltage

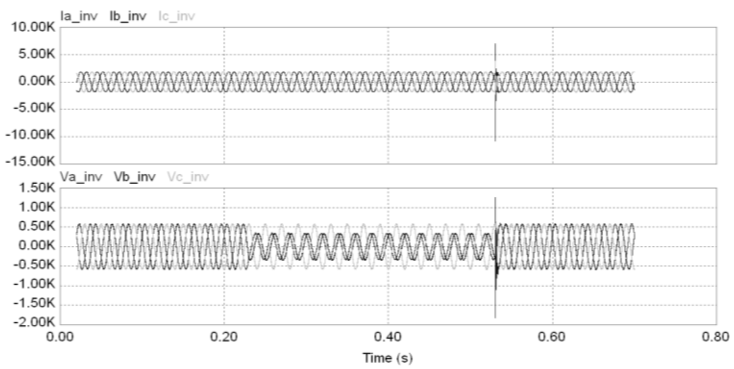



Fig. 13 Effect of LVRT feature in Momentary L-G fault

## IV. CONCLUSION

In healthy system speed of wind turbine is within limit moreover this can be simulated at any wind speed between cut in and cut out wind speed of wind turbine and all the parameters can be achieved. When LG fault occurred at that time if there is permanent fault there is a reduction power factor from unity to 0.8 and voltage after inverter end also reduced in that phase and next to that phase also.. Moreover the results of momentary L-G fault prove the effect of momentary and permanent fault. This feature is known as LVRT i.e. Low Voltage Ride Through.

Table 2
Various measured Parameters in RMS during L-G fault occurs in WECS

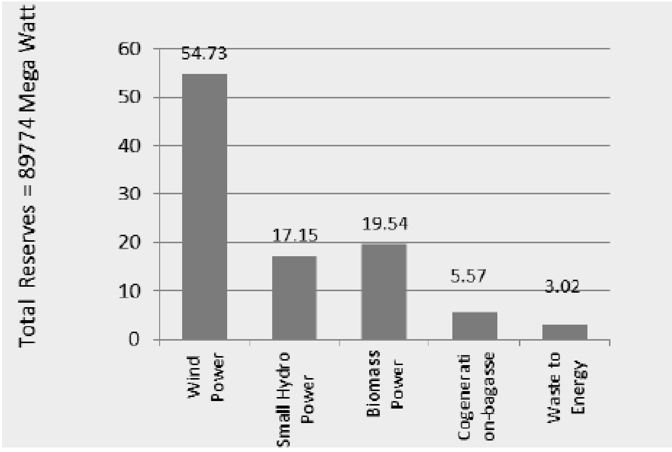
| Parameters in RMS (Simulation time 0.6) | Wind Speed 12m/s **L-G fault in Ph-A** |
|---|---|
| Ia_gen | **860.7A** |
| Ib_gen | **840.57A** |
| Ic_gen | **897.60A** |
| Va_gen | 523.38V |
| Vb_gen | 522.23V |
| Vc_gen | 508.13V |
| Va_inv | **234.41V** |
| Vb_inv | **238.13V** |
| Vc_inv | 406.18V |
| Ia_inv | 1307.95A |
| Ib_inv | 1316.79A |
| Ic_inc | 1289.03A |
| Irlouta . | **1024.85A** |
| Irloutb | 15.95A |
| Irloutc | 15.67A |
| Vdc | 694V |
| Vdc link | 347V |

## APPENDIX 1
RESULTS OF WIND SPEED, MECH. POWER & TORQUE OF 800KW WIND TURBINE

| Wind Speed (m/s) | Cp* | Power (Watt) | Torque (N.m) |
|---|---|---|---|
| 5 | 0,46 | 77410,8125 | 619,2865 |
| 6 | 0,48 | 139581,792 | 775,4544 |
| 7 | 0,49 | 226268,4393 | 923,54465 |
| 8 | 0,49 | 337753,472 | 1055,4796 |
| 9 | 0,49 | 480902,8928 | 1187,41455 |
| 10 | 0,48 | 646212 | 1292,424 |
| 11 | 0,42 | 752594,6505 | 1243,9581 |
| **12** | **0,34** | **790963,488** | **1098,5604** |
| 13 | 0,27 | 798596,8673 | 945,08505 |
| 14 | 0,22 | 812719,292 | 829,3054 |
| 15 | 0,18 | 817862,0625 | 726,9885 |
| 16 | 0,15 | 827151,36 | 646,212 |
| 17 | 0,12 | 793709,889 | 549,2802 |
| 18 | 0,1 | 785147,58 | 484,659 |
| 19 | 0,09 | 831069,0203 | 460,42605 |
| 20 | 0,08 | 861616 | 430,808 |
| 21 | 0,06 | 748071,1665 | 339,2613 |
| 22 | 0,06 | 860108,172 | 355,4166 |
| 23 | 0,05 | 819006,3963 | 309,64325 |
| 24 | 0,04 | 744436,224 | 258,4848 |
| 25 | 0,04 | 841421,875 | 269,255 |

*Power Coefficient

## APPENDIX 2
PRESENT WIND POWER STATUS IN INDIA [13]

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