

# Analysis of Micro-Grid System during Faults on Transmission Line

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**ABSTRACT:** Micro-grid is formed using synchronous based distributed generation. Operation of system for micro-grid interconnection with utility grid through point of common coupling and autonomous mode of micro-grid are simulated for various fault condition in PSCAD, because fault current have to be analysed before designing protection system for both modes of operation of micro-grid.

**KEYWORDS:** Point of common coupling, Distributed generation, Micro-grid, Single line to ground (SLG), Line to Line (L-L).

## I. INTRODUCTION

In recent years, all eyes in the energy business have been turning to micro-grids, smaller versions of centralized systems that can connect to the main grid or act alone as an island. Researchers are looking to micro-grids for answers to changing consumer demands and a need for increased reliability. Micro-grids offer an efficient energy delivery and supply system, micro-grids are fast multiplying and will clearly play an increasingly important role in the future power supply system. Micro-grids are, in fact, modern, small-scale versions of the centralized electricity system. They use distributed energy, which shortens the distance between power source and load, reducing transmission loss. They use renewable energy sources. A main function of micro-grid is to ensure stable operation during faults and various network disturbances. Provide good solution to supply power in case of an emergency and power shortage during power interruption in the main grid. A number of questions arise when you connect micro-grids to conventional grids. When exactly, in view of the huge number of abnormalities a utility can experience should you island a micro-grid? When the micro-grid is operating separately from the utility, can you provide it with enough coordinated fault protection? Once you create multiple islands, how do you ensure the right selectivity to avoid unnecessary tripping? It has been referred by several nations and research institutes, in Which describes the basic aim of better utilization of the Distributed Generation to satisfy the demand of cluster network of loads at the Load End of the conventional grid. The power can flow in two way route through the common switch known as the Point of Common Coupling (PCC). In [1] describes the feasibility of control strategies to be adopted for the operation of a micro-grid when it becomes isolated. Fault current supply by micro-grid during grid connected mode and autonomous operation will different. After disconnection of main utility grid due to fault condition, current flowing through the lines will be different. Current supplied by the micro-grid source will also change depending on the fault location in the system. So, different fault currents have to analyze to protect the micro-grid. Simulation for the study system with two micro-grid source creating single line to ground fault and line to line fault at transmission lines is presented.

A study system is defined and the corresponding PSCAD/EMTDC based computer simulation model is developed. Section II of the paper introduces the study system. Results of the study and discussion are presented in section III. Future work and conclusion are stated in section IV and V respectively.

## II. SYSTEM UNDER STUDY

System under study [2] is consists of two synchronous based DG interconnected with the main utility grid through the point of common coupling. Directional over current relay used in for the protection of micro-grid and relay coordination is done using particle swarm optimization technique.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

With the breaker  $B_s$  closed utility is operated in parallel with the DG<sub>s</sub>, once circuit breaker  $B_s$  opens, due to any fault or abnormality, DGs are operated in micro-grid. Due to change in configuration of the system fault current flowing through the lines and loads changes. Wind turbine type synchronous base DG is used for micro-grid system. The system and DG parameter are given in appendix [2].

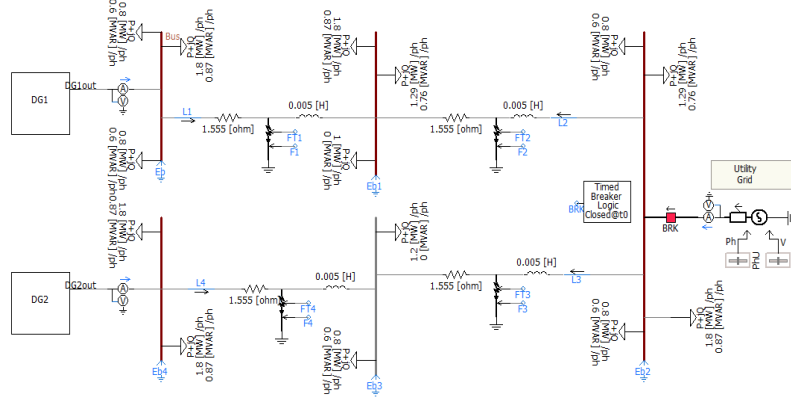


Fig. 2.1. System study in PSCAD with various fault location

System under study is simulated in PSCAD for normal and abnormal operation. Fault is created at various locations in the system as shown in Fig. 2.1 and fault current flowing through the lines is analyzed for grid connected mode and islanded operation of micro-grid. When utility grid is disconnected due to opening of utility breaker during fault condition, fault current supplied by the micro-grid DG will change. So we have to consider this change in fault current during designing protection system.

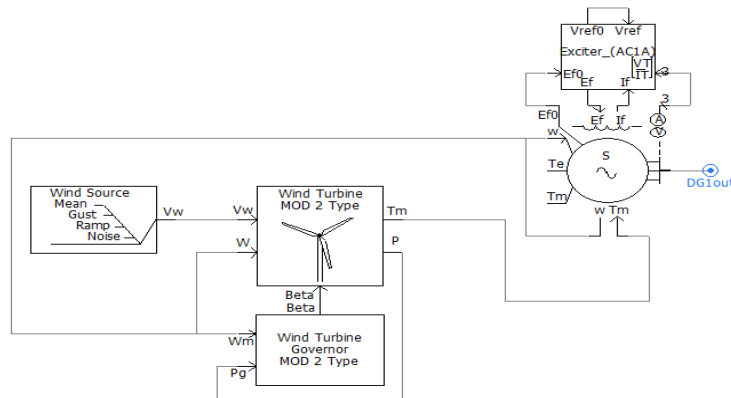


Fig. 2.2. DG with wind turbine used as a micro-source

Distributed generation used as a micro-source, which is driven by wind turbine as shown in fig-2.2. It shows subsystem of the main study system marked as DG1 and DG2. In wind source Guest, ramp and noise wind speed are not considered. Only mean wind speed of 13 m/s is considered. Data used in wind turbine are mentioned in Appendix. Output power from the turbine can be calculated from the following formula.

Turbine output power is given by:

$$P = \frac{1}{2 \times 10^6} * \rho_{air} * A * C_p * V_w^3 * \eta_{GB}$$

Coefficient of power is given by:

$$C_p = \frac{1}{2} * \left( TSR - 5.6 - \frac{\beta^2}{45} \right) * e^{-\frac{TSR}{6}}$$

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Vol. 5, Issue 3, March 2016

Tip speed ratio is given by:

$$TSR = \frac{2.237 * V_w}{W_H}$$

Angular hub speed is given as:

$$W_H = \frac{W}{GR}$$

Where,

W = Rotational speed of the machine (rad/sec)

GR = Gearbox ratio

V<sub>w</sub> = Wind speed

A = Rotor area

η<sub>GB</sub> = Gearbox efficiency

β = Pitch angle (deg)

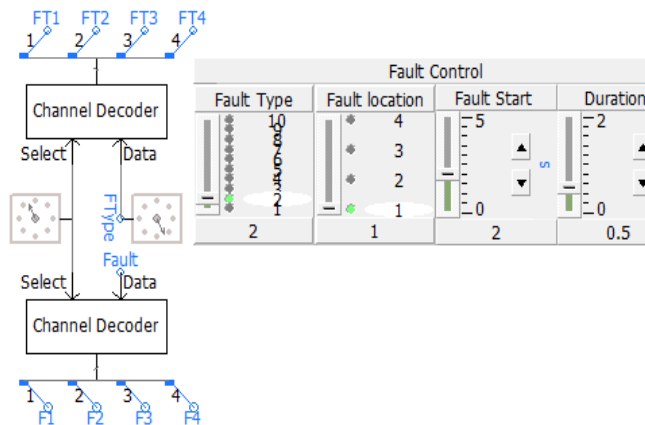


Fig. 2.3. Fault Control

Fig 2.3 shows the fault control logic [6], in which fault type and fault location can be changed from the fault control panel for simulation purpose. We can also adjust fault start and duration of fault from panel. In fault type, at position 1 phase A to ground (A-G) fault occurred. Same as for position 2,3,4,5,6,7,8,9,10 B-G, C-G, AB-G, AC-G, BC-G, ABC-G, AB, AC and no fault respectively will occur.

### III. SIMULATION RESULTS IN PSCAD

Fault current is analysed for the Single line to ground (SLG) fault and line to line (L-L) fault at F1 and F3 location in the system. Fault is created at 2 second for the duration of 0.5 second. Utility breaker is open first for any type of abnormality after 0.1 second. During that 0.1 second after fault creation utility and DGs both will supply fault current. When utility is disconnected at 2.1 second then fault current supplied by micro-grid DG is changes. Current flowing through the lines also changes. If the fault is no longer exists after 2.5 second, then utility breaker again closed within 0.1 second.

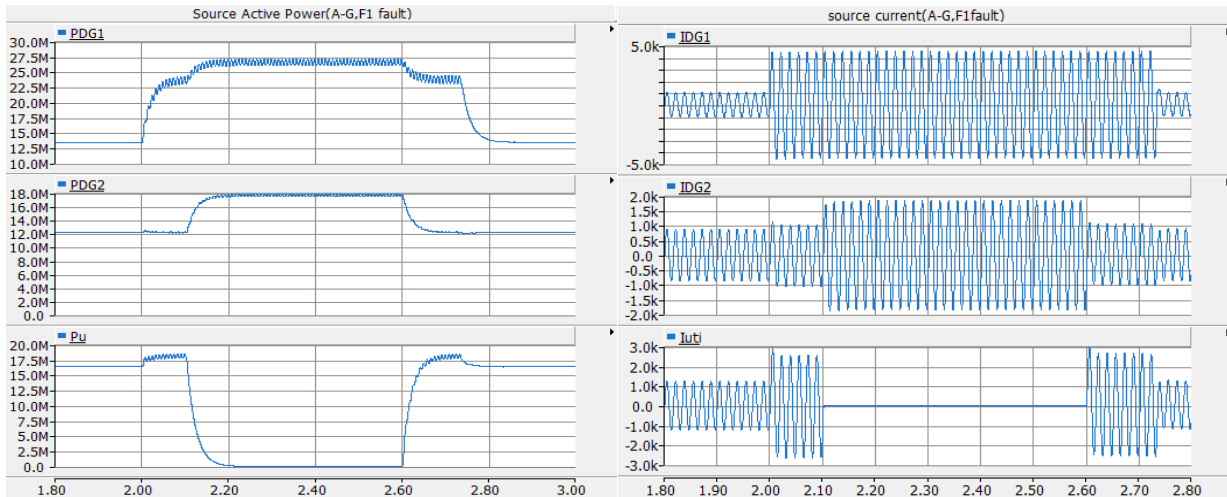


Fig. 3.1. Source active power during A-G fault at F1 location Fig. 3.2. Source Current during A-G fault at F1 location

When phase A to Ground (A-G) fault is created at F1 location in the system at 2 second, Active power supplied by the utility source and micro-grid for the phase A is analysed. Fault current is analysed for both mode of operation. At 2 second power supplied by the DG-1 in increased to 13MW to 24MW and after 2.1 sec when utility power becomes zero then power supplied by DG-1 in increased to 27.5MW as shown in fig-3.1. Change in fault current supplied by the DG-1 is very less during transition from grid connected mode to autonomous mode when fault at F1 location or near to the DG-1 as shown in fig-3.2.

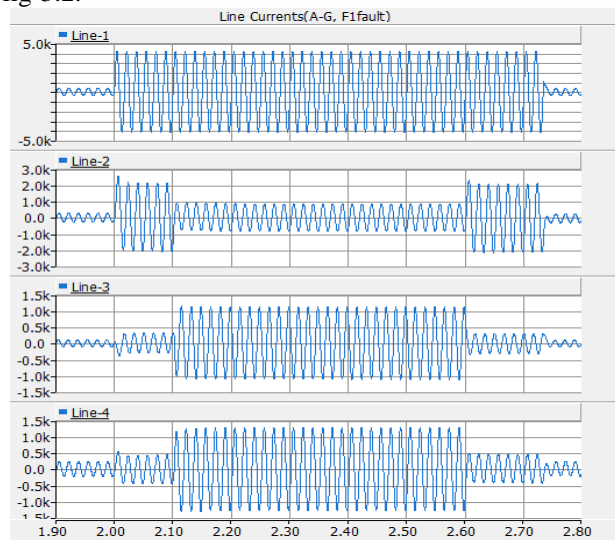


Fig. 3.3. Line Current during A-G fault at F1 location

Fault current is increased after transition of micro-grid from grid connected mode to autonomous mode of operation. Current flowing through the line-1, line-2, line-3, and line-4 at this mode of operation are 4kA, 1kA, 1.2kA and 1.3kA respectively as shown in fig-3.3.

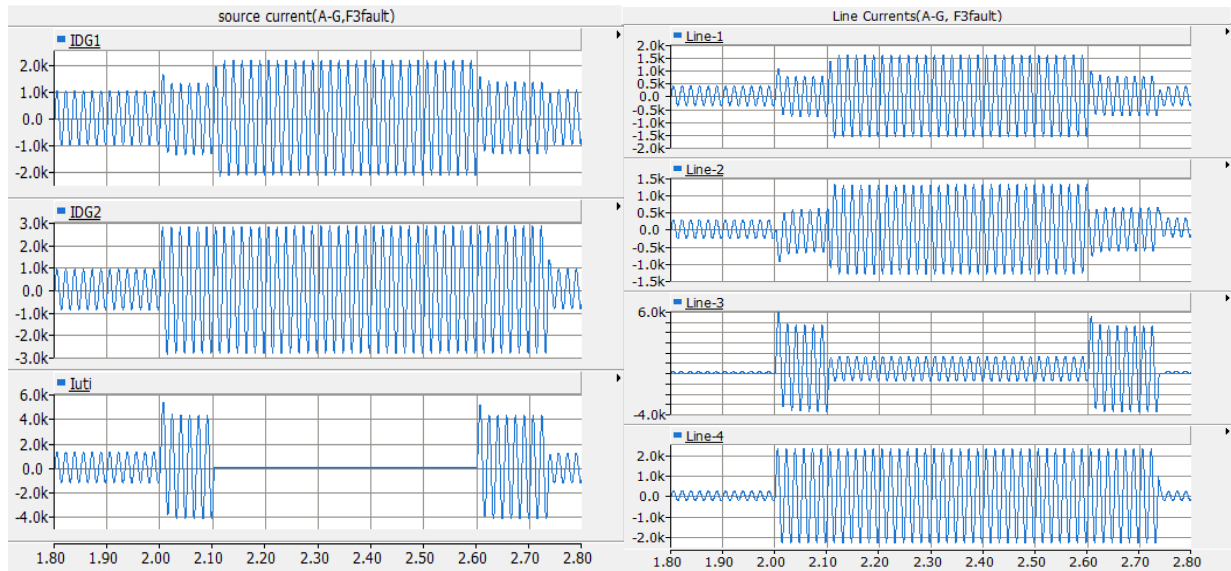


Fig. 3.5.Source Current during A-G fault at F3 location Fig. 3.6. Line Current during A-G fault at F3 location

Same as fault current supplied by the source and line current is also analysed, when phase A to Ground fault is created at F3 location for the both mode of operation. Change in fault current supplied by the DG-2 is very less during transition from grid connected mode to autonomous mode when fault at F3 location or near to the DG-2 as shown in fig-3.5.

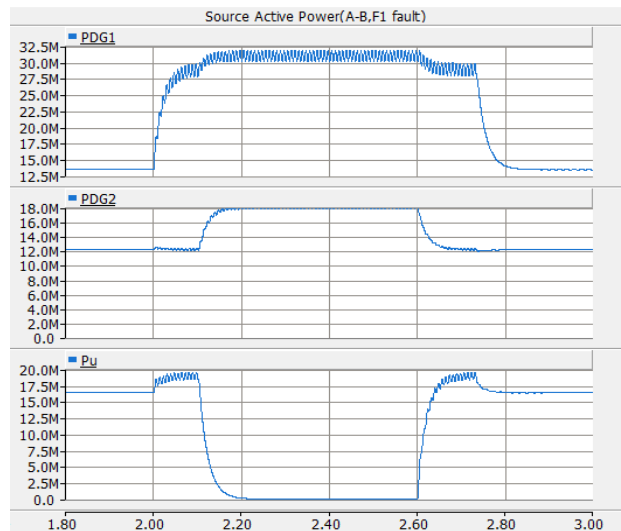


Fig. 3.7.Source active power during AB fault at F1 location

When Phase A to Phase B (L-L) fault is created at F1 location in the system at 2 second, Active power supplied by the utility source and micro-grid for the phase A is analysed. Fault current is analysed for both mode of operation. At 2 second power supplied by the DG-1 in increased to 13MW to 23MW and after 2.1 sec when utility power becomes zero then power supplied by DG-1 in increased to 31MW as shown in fig-3.7.

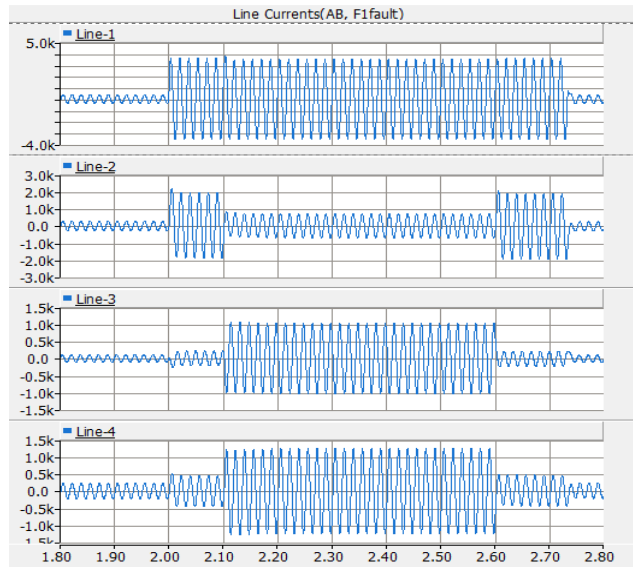


Fig. 3.9. Line Current during AB fault at F1 location

Fault current is increased after transition of micro-grid from grid connected mode to autonomous mode of operation. Current flowing through the line-1, line-2, line-3, and line-4 at this mode of operation are 3.9kA, 0.8kA, 1kA and 1.2kA respectively as shown in fig-3.9.

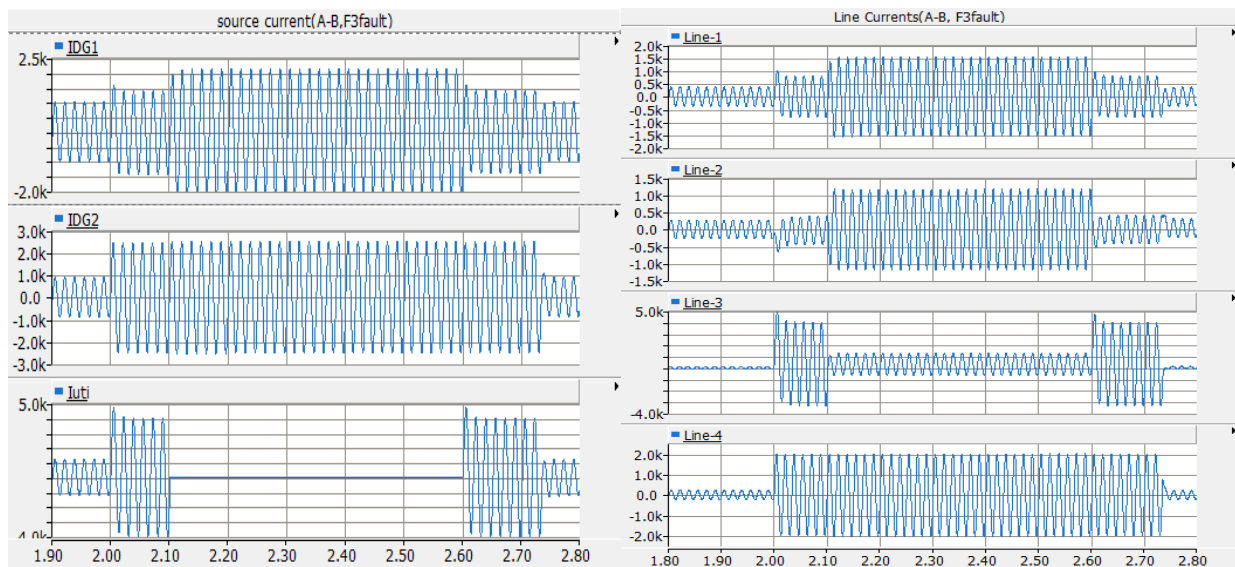


Fig. 3.11. Source Current during AB fault at F3 location Fig. 3.12. Line Current during AB fault at F3 location.

Same as fault current supplied by the source and line current is also analysed, when phase A to phase B fault is created at F3 location for the both mode of operation. So relay setting for this different fault current also have to consider during designing protection system.

Fault current is decreased for autonomous mode of operation only for line-2 when fault at F1 location as shown in fig-3.3, fig-3.9 and for line-3 when fault at F3 location as shown in fig-3.6, fig-3.12. This is due to reduction of contribution of fault current from main utility grid system. So it is also taken into account during design of protection system.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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## IV. FUTUREWORK

As there is need of new protection techniques to protect the micro-grid, protection system has to design such that it will protect the micro-grid for both modes of operation. Relay setting has to be modified for different fault current when utility grid is connected and not connected. Protection system with directional element can be used for double end fed system.

## V. CONCLUSION

Micro-grid operation for various fault condition is analysed. Current flows through the line and power supplied by the micro-grid are changes when system configuration changes due to disconnection of utility grid. So different relay setting will require for autonomous mode and grid connected mode, if we wants to design protection system.

## VI. APPENDIX

DG1 and DG2 Specification			
$S_{base}$	5 MVA	$V_{base}$	13.8 kV
$R_a$	0.0052 (p.u)	H	2.9 (sec)
$X_d$	2.86 (p.u)	$X_q$	2 (p.u)
$X_d'$	0.7 (p.u)	$X_q'$	0.85 (p.u)
$X_d''$	0.22 (p.u)	$X_q''$	0.2 (p.u)
$T_{do}'$	3.4 (sec)	$T_{do}''$	0.01 (sec)
$X_p$	0.098 (p.u)	$T_{do}'''$	0.05 (sec)
Line Parameter			
$R_{line1} = R_{line2} = R_{line3} = R_{line4}$		1.155 (ohm)	
$L_{line1} = L_{line2} = L_{line3} = L_{line4}$		0.005 (H)	
Source parameter			
$S_{base}$	100 MVA	$V_{source}$	13.8 kV
$X_{source}$	0.42 (ohm)	$f_{source}$	60 Hz
Turbine parameter			
$\omega$	376.9 rad/s	Gear Ratio	90.5
Radius	31.5 m	Rotor Area	3177 m <sup>2</sup>
Air density ( $\rho$ )	1.225 kg/m <sup>3</sup>	$V_w$	13 m/sec

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