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ISLANDING DETECTION TECHNIQUE FOR DISTRIBUTED GENERATION

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Abstract*— Distributed generation plays vital role in the modern power system to meet additional electricity demand. It has also several negative aspects. One of them is islanding. Islanding events may lead to problems like safety hazards for lineman, reduction of equipment's life and disturbance in system. Hence islanding should be detected as soon as possible and give trip signal to targeted DG. In this thesis islanding condition is analyzed for wind based distributed generation system of two 9 MW wind farms each consists of six units of Doubly fed induction generator having capacity of 1.5 MW each. Various Islanding event like symmetrical fault (LLL fault, LLLG fault) and asymmetrical fault (LL fault, LLG fault, LG fault) and non-islanding event like normal, load switching, and DG tripping are analyzed based on sequence components method. All islanding and non-islanding events have simulated on MATLAB/Simulink model.

***Keywords*— Islanding detection ways, Distribution Generation, Negative sequence current, Micro-grid, passive parameter, Renewable energy**

I. INTRODUCTION

Conventional electricity generation and distribution system is done by centralized power plants like thermal plant, hydro plant and nuclear plant. These are very far away from actual users and load which may lead to additional transmission line cost and increase in transmission line losses.

These problems can be avoided by distributed generation system. Distributed generation is a source that is close to the consumer to generate power. Distributed generation source like photovoltaic cell, wind turbine, diesel generator, fuel cell etc. provide additional power connected with distribution network. Since it is connected near to the load it reduces transmission losses and reduce the transmission capacity of line and increase the reliability of power supply of the load.

II. ISLANDING & TECHNIQUES

The definition of islanding According to IEEE std.1547 [5] "A condition in which a Portion of an area EPS (electric power system) is energized Solely by one or more local EPSs through the associated PCCs while that portion of the area EPS is electrically Separated from the rest of the area EPS"

1) Communication based techniques
   a) Power line signalling technique

In this method signal generator transmits signal to receiver connected near to the DG continuously. Under normal operating conditions, DG receives the signal continuously. However, if an islanding occurs, the transmitted signal will cut off due to breaker opening and the signal will not be received by the DG.

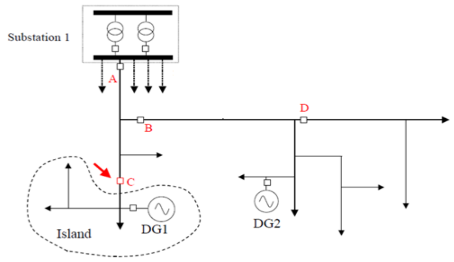


Figure 1. Single line diagram of distribution system

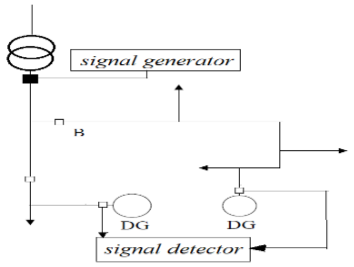


Figure 2. Power line signalling technique

b) Transfer trip technique

In this method Supervisory Control and Data Acquisition (SCADA) system is used to monitor the status of all circuit breaker. When any disconnection is detected transfer trip scheme determines which area is islanded and sends the trip signal to the DG.

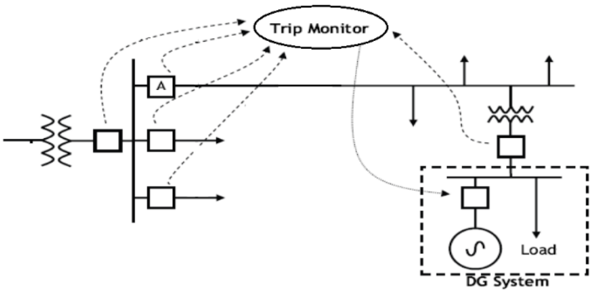


Figure 3. Transfer trip technique

2) Active technique

In this method some small disturbance is injected into system and system becomes unstable if it is islanding otherwise it will settle down and becomes stable again due to inertia of main grid. This method has very small non detection zone. The main drawback of this method is it injects disturbances to the system.

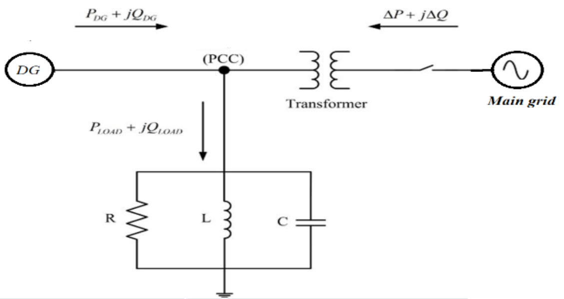
3) Passive technique

a) Under/over Voltage protection:

$$[(\frac{V}{V_{max}})^2-1] \le \frac{\Delta P}{P} \le [(\frac{V}{V_{min}})^2-1]$$

Where V_{max} is maximum allowable voltage

and V_{min} is minimum allowable voltage



Sr no	Techniques	Advantages	Disadvantages
1	Communication based techniques	• Reliable • Do not disturb the system	• Implementation cost is high
2	Active techniques	• Small non- detection zone	• It creates disturbance in the system
3	Passive techniques	• Do not disturb the system • Accurate for large power mismatch	• Large non-detection zones • Nuisance tripping

Table 1. Summary of Islanding Detection Techniques

III. METHODOLOGY OF ISLANDING TECHNIQUES

A. Proposed Negative sequence method

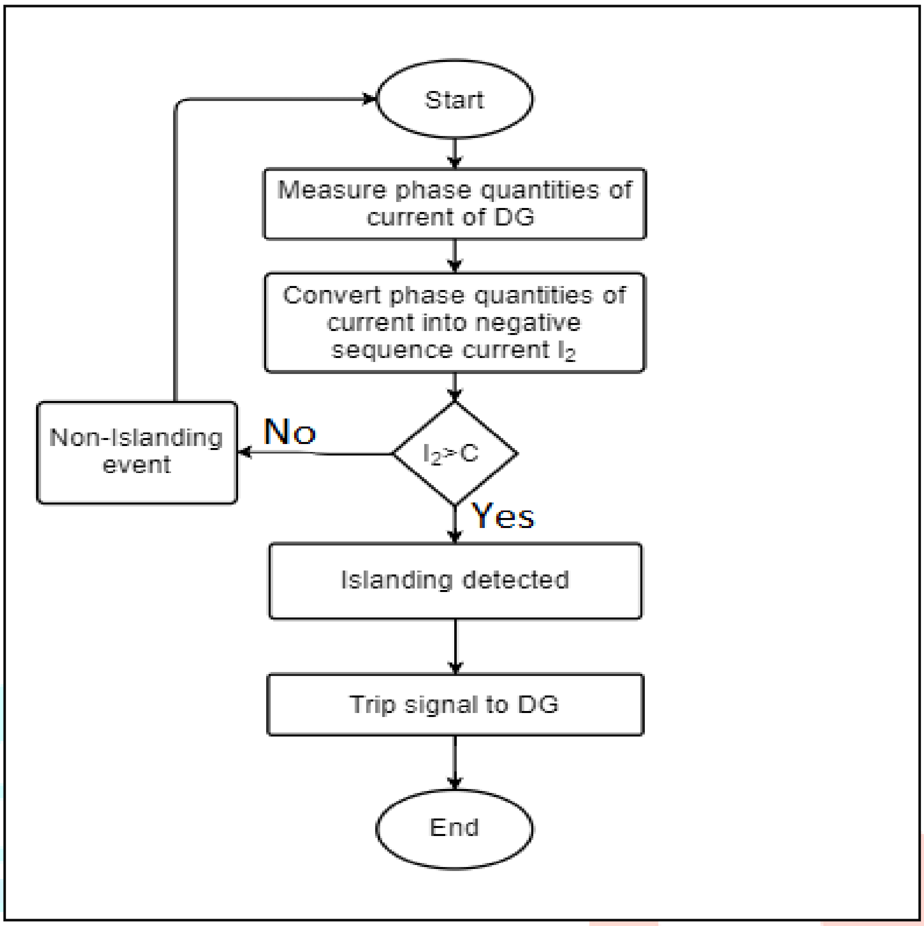


Figure 4. Flowchart for islanding detection.

IV. MATLAB/SIMULINK implementation

Proposed system as shown in figure 5.4 is implemented on MATLAB/SIMULINK. Sample time is 50e-6 second and at 50 Hz frequency. Wind speed is kept constant at 11m/s. fault breaker is activated during 0.40 to 0.45 seconds. Generator G1 is modeled as constant voltage source since it is connected with main grid having infinite power capacity. Phase quantity of current of DG is converted into negative sequence current by using sequence analyzer tool in Simulink.

Negative sequence current I_2 is measured at DG1 for following possible cases of islanding events.

A) Normal

B) Symmetrical fault (LLL, LLLG)

C) Unsymmetrical fault (LL, LLG, LG)

D) Load switching (8MW, 0.9MVAR)

E) Grid switching

F) Dg2 tripping

Figure 5.9 shows MATLAB implementation of proposed system and figure 5.10 shows subsystem model to measure negative sequence current from phase quantities of DG current by using sequence analyzer tool.

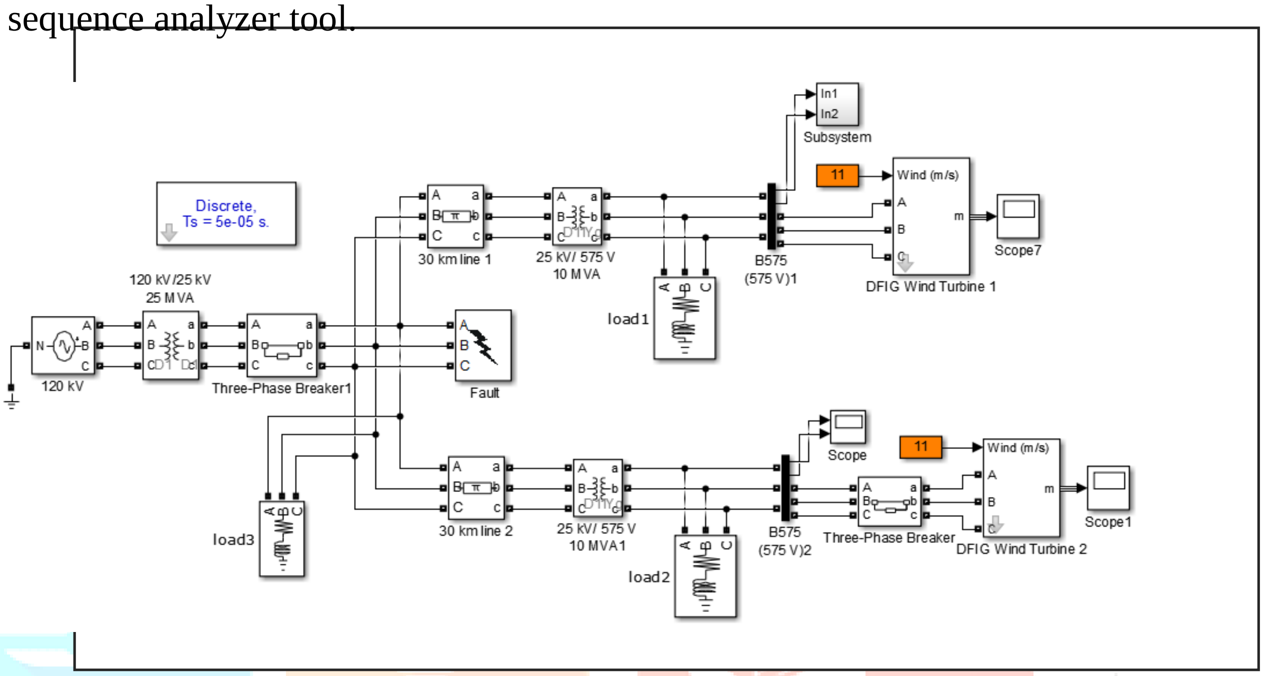


Figure 5 Simulink model of proposed system.

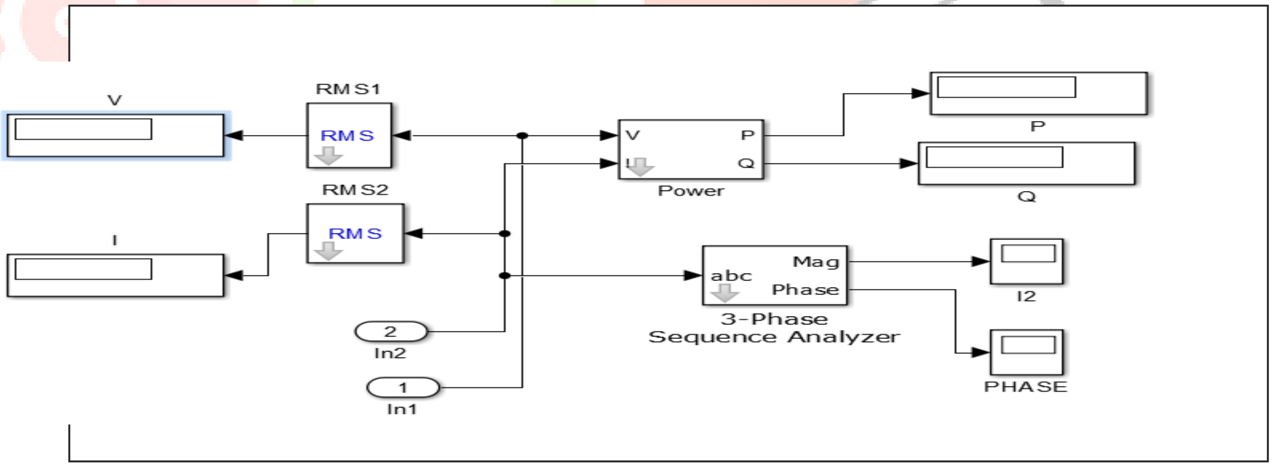


Figure 6 subsystem for I_2 measurement.

V. SIMULATION RESULTS

Figure 5.11 shows result for normal condition. X-axis represents time in second and Y-axis represents negative sequence current I_2 in ampere. at t=0 all breaker are closed so starting peak of I_2 is due to breaker closing at t=0s.

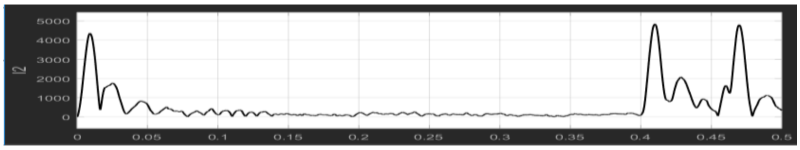


Figure 7 Negative sequence current I_2 for normal condition.

Fig 5.12 and Fig 5.13 shows results for symmetrical fault (LLL, LLLG) at t=0.4 s to t=0.45s

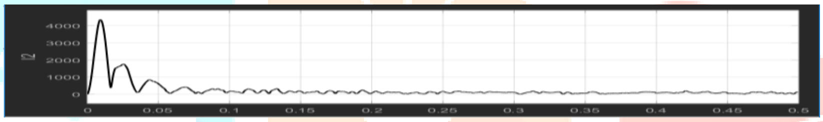


Figure 8 Negative sequence current I_2 for LLLG fault.

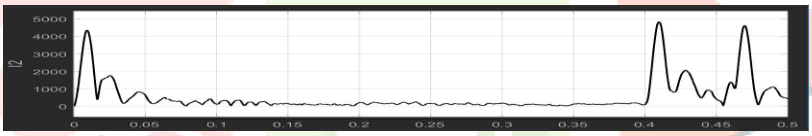


Figure 9 Negative sequence current I_2 for LLL fault.

Fig 5.14, 5.15, and 5.16 shows results for unsymmetrical fault (LL, LLG, LG) at t=0.4 s to t=0.45s.

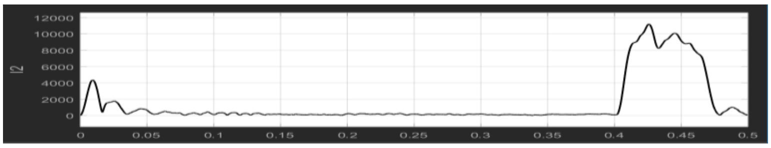


Figure 10 Negative sequence current I_2 for LL fault

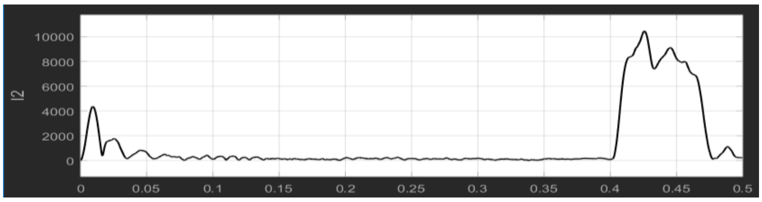


Figure 11 Negative sequence current I_2 for LLG fault.

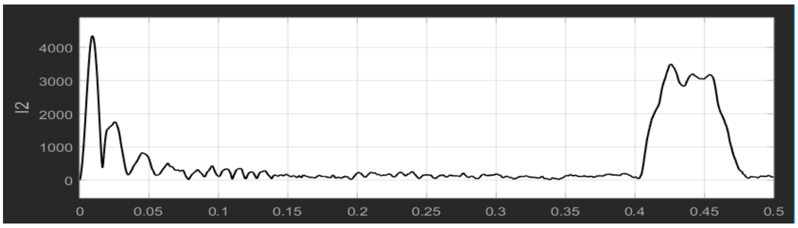


Figure 12 Negative sequence current I_2 for LG fault.

Figure 5.17, 5.18 and 5.19 shows results for grid switching, load switching and DG2 tripping at t=0.4 s to t=0.45 sec

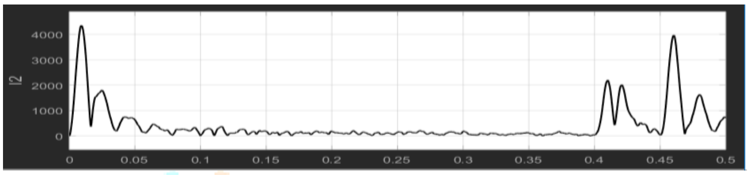


Figure 13 Negative sequence current I_2 for grid switching.

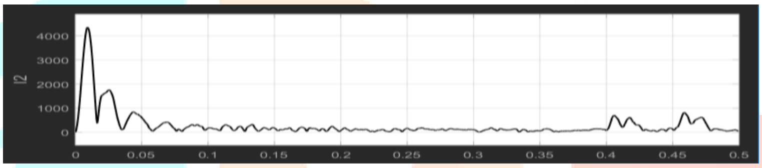


Figure 14 Negative sequence current I_2 for load switching.

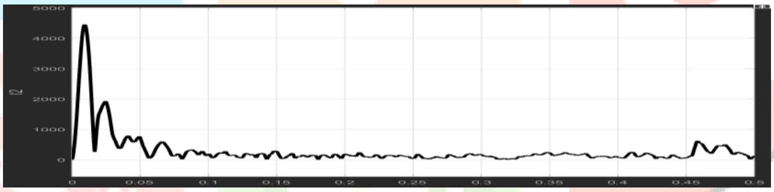


Figure 15 Negative sequence current I_2 for DG2 tripping.

VI. MATHEMATICAL MODELING

proposed system on which islanding event is investigated. It consists of two wind-based DG source. Each DG source consist of 6 units (DFIG-doubly fed induction generator) and each unit can generate 1.5MW. Both DG source is connected to main grid through distribution transformer and 30KM PI transmission line. Load L1 and load L2 are connected near DG source side [10][13].

5.3.1 Equipment's rating

Generator parameter

Rated short-circuit MVA =1000 MVA,

f=50 Hz,

Rated kV =120 KV

Distributed Generations (DGs) parameter

Rated MW capacity = 6*1.5 = 9 MW

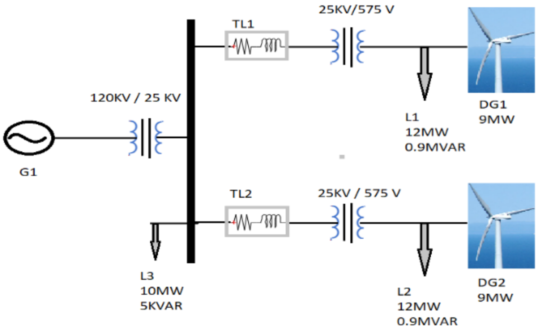


Figure 16 Single line diagram of proposed system

(wind farm consists of six wind turbines of 1.5MW
capacity of each (Doubly Fed Induction Generator))
Rated voltage = 575 V

Transformer T1 parameter
Rated MVA = 25 MVA,
f = 50 Hz,
Rated kV = 120/25,
R1 = 0.00375 Pu, X1= 0.1 Pu, Rm= 500 Pu, Xm= 500 Pu.

Transformer T2 and T3 parameter:
Rated MVA = 10 MVA,
f = 50 Hz
Rated kV = 575 V/ 25 kV
R1 = 0.00375 Pu, X1= 0.1 Pu, Rm= 500 Pu, Xm= 500 Pu

Distribution lines (DL): DL-1 and DL-2 parameter:
PI-Section, 30 km each,
Rated kV = 25 KV,
Rated MVA = 20 MVA,
R1 = 0.1153 ohms/km, R0 = 0.413 ohms/km,
L1 = H/km, L0 = 3.32e-3 H/km,
C1 = 11.33e-009 F/km, C0 = 5.01e-009 F/km,

Load parameter
L1, L2 = 12 MW, 0.9 MVAR

L3 = 10 MW, 5 Kvar

5.3.2 per unit value calculation

Transformer PU reactance

X_{t1}= 2×0.1j = 0.2j (25MVA base)

Now $Z_{base}=\frac{V_b}{I_b}$

$$=\frac{V_b\times V_b}{(VI)_b}$$

From above equation Z_{base} α $\frac{1}{(VI)_b}$ [for same base voltage]

So X_{t1} for 10 MVA base is given by

X_{t1}= 0.2j×$\frac{10}{25}$

= 0.08j

X_{t2} = 2*0.1j = 0.2j (10MVA base)

X_{t3} = 2*0.1j = 0.2j (10MVA base)

Transmission line

R = 0.1153 ohm/Km

L = 1.05 mH/Km

L = 30km

Z = R + J(2×Π×F×l)

= 0.1153 + J 0.3297

= 10.479 ∠70.72 ohm

Now

$Z_{base} = \frac{V_b}{I_b}$

$= \frac{V_b \times V_b}{(VI)_b}$

$= \frac{25KV \times 25KV}{20MVA}$

= 31.25 ohm

$Z_{pu} \;\; = \frac{Z_{actual}}{Z_b}$

= 0.3353 ∠70.72 pu (20MVA base)

Now Z_{pu} for 10 MVA base is given by

Z_{pu} = 0.3353 ∠70.72 $\times \frac{10}{20}$

= 0.1677 ∠70.72

Load impedance $Z_l = 0.02755\angle 4.289\ ohm$

$Z_{base} = \frac{V_b}{I_b}$

$= \frac{V_b \times V_b}{(VI)_b}$

$= \frac{575V \times 575V}{12.033MVA}$

= 0.02747 ohm

$Z_{pu} \;\; = \frac{Z_l}{Z_{base}}$

= 1 ∠4.289 (12.033 MVA base)

Now Z_{pu} for 10MVA base is given by

$$Z_{pu} = 1\ \angle 4.289 \times \frac{10}{12.033}$$

$$= 0.833\angle 4.289 \text{ (10MVA base)}$$

DGs reactance = 1.1j pu (10MVA base)

5.3.3 Fault current calculation

Figure 5.5 shows the reactance diagram of proposed system. symmetrical fault (LLL) occurs at point F as shown in figure. Fault current contribution by DG 1 is calculated by using super position theorem.

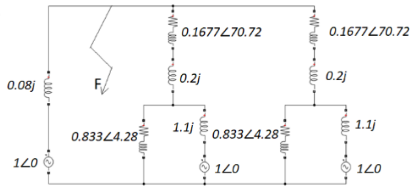


Figure 17 Reactance diagram of proposed system

As shown in figure 5.5 here total three voltage source are connected so considering only one voltage source at a time i.e.G1(main grid) and short circuited remaining two voltage source fault current contribution by G1 source can be calculated. Modified circuit diagram is illustrated in figure 5.6

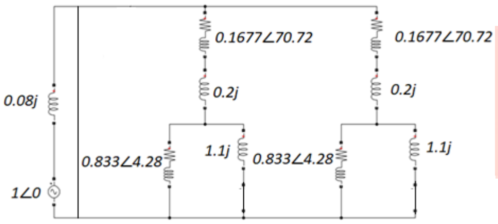


Figure 18 Fault current contribution by main grid

Fault current contribution by main grid

$$I_1 = \frac{1}{0.08j} = 12.5\angle - 90$$

Now considering Only DG1 and short circuiting remaining two fault current contribution by DG1 is calculated

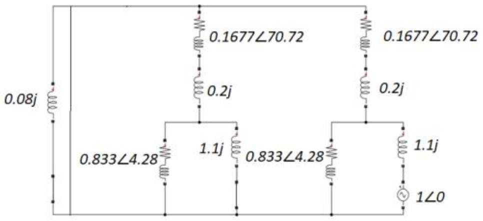


Figure 19 fault current contribution by DG1

Further simplified network is shown in figure 5.8

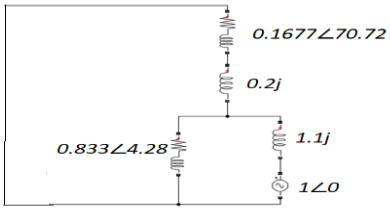


Figure 20 simplified network

Fault current contribution by DG1

$$Z_{equ} = [\{(0.1677\angle 70.72 + 0.2j)\ II\ 0.833\angle 4.289\} + 1.1j]$$

$$= 1.3755\angle 83.59$$

$$I_{DG1} = \frac{1}{Z_{equ}}$$

$$= 0.73\angle - 83.59 \text{ pu}$$

$$I_{DG1} = \frac{I_{DG}*0.833\angle 4.289}{0.833\angle 4.289 + 0.2j + 0.1677\angle 70.72}$$

$$I_{DG} = 0.8628\angle - 62.49 \text{ PU}$$

$$I_{base} = \frac{10MVA}{\sqrt{3} * 575V}$$

$$= 10.041 \text{ KA}$$

$$I_{DG1} = I_{base} * I_{DG}$$

$$= 8.66 \text{ KA}$$

Total fault current $I_f = I_1 + I_{DG1} + I_{DG2}$

$$= 12.5\angle - 90 + 0.73\angle - 83.59 + 0.73\angle - 83.59$$

$$= 13.95\angle\text{-}89 \text{ pu}$$

$$I_{base} = \frac{10MVA}{\sqrt{3}*25kV}$$

$$= 230.94 \text{ A}$$

$$I_F = I_{base} * I_f$$

$$= 3221.61 \text{ A}$$

VII. CONCLUSION

VIII. References

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