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Performance Analysis of L-G and L-l Faults on an Autonomous Microgrid Using MATLAB

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Abstract: The new era of microgrid create an investigation over the renewable energy resources. Microgrid has thrown a great impact over the transient analysis as a major concern. To that case here the major occurs of fault are LG and LL fault were discussed to evaluate the transient stability of a microgrid. Herein, the microgrids are modeled with two distributed generation along with individual converters. Along with the converters droop control strategies were adopted to evaluate the transient stability of microgrid. The performances of microgrid were evaluated in MATLAB.

Key words: Grid connection, microgrid, transient analysis, MATLAB, India

INTRODUCTION

An upcoming usage of renewable energy has invaded in the name of microgrid. Microgrid is defined by the aggregate nature of DG's in addition to that of power electronic devices with their associated loads. The DG's along with controller are being act as micro sources. The most recent use of DG's was solar cells, diesel engine, fuel cells and wind turbine. The DG's are supported to the utility grid through the Static Transfer Switch (STC). The DG's interface with converters is capable to supply the load with utility grid (Lasseter, 2002). The operations of microgrid are categories based on the position of STS. They are mainly operated in two modes, grid connected mode and autonomous mode (Zhao-Xia and Hong-Wei, 2012) while STS is closed its operated in grid connected mode. The major advantages of microgrid are it can operate under fault condition occurs in utility grids which is attain by the autonomous mode of operation, although the power quality were to be maintained (Ashabani and Mohamed 2012).

The uninterrupted power supply is attained by the microgrid with the help of DG's. While any interrupt or fault occurs in utility grid, microgrid switches to islanded mode to ensure the continuous supply of voltage with fewer distortions (Dou and Liu, 2012). This scenario creates complication to the industries in the real time in the power quality parameters like voltage distortions, harmonic content, etc. While switch over to grid connected to islanded mode (Balaguer *et al*., 2011). The stability of microgrid are adopted with the various techniques are investigated with frequent fault conditions. The master-slave and droop techniques were adopted (Xiong and Ouyang, 2011) for the stability of microgrid with triggering fault conditions. In that study two different DG's were adopted to create microgrid. One with diesel based generator another with inverter based DG are accompanied. Generally inverter based DG's were operated under two controller namely current controller and real and reactive power controlling scheme are implemented (Muyeen *et al*., 2014). It is confirmed that the droop control provides the better performance of microgrid under transient stability.

Owing to the utility of main grid, the operating mechanism of microgrid is different and it is necessary to carry out the stability of microgrid (Wessels *et al*., 2011). So, the modeling of microgrid is gives out a great impact towards transient stability. In this study, microgrid are modeled with necessary equation to comprise a dynamic system. The stability of microgrid is investigated with Dynamic Voltage Restores (DVR) (Jain *et al*., 2012). The two different models of Double Feed Induction Motor (DFIG) wind turbine are acted as micro sources. They are made effective protection arrangement with the help of DVR. DVR having the capability of reactive power compensation in along with DG's in order to compensate fault voltage. This helps to provide the uninterrupted power supply to the load demand without producing the additional protection.

The new concerning of transient stability were discussed in (Moreira and Lopes, 2010) by Super Conducting Magnetic Energy Storage (SMES) controller. Wind turbine is opted to create microgrid which is made connected to power system by SMES. This controller was adopted along with artificial neural network with IGBT. It is operated under three major different modes, voltage source inverter with IGBT, sinusoidal based pulse width

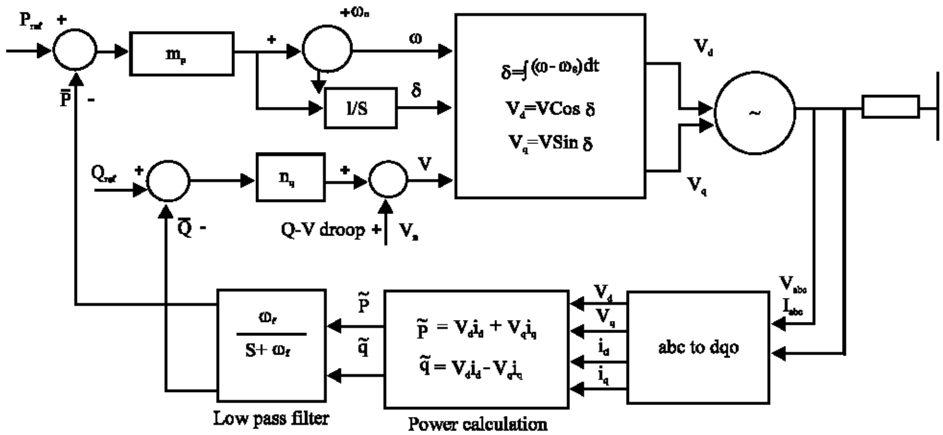

Fig. 1: Droop control block

modulation, PI tuned ANN. Among that PI tuned function gives the better performance and stability improvement of microgrid are obtained. The most common method of approach is carried out (Illindala and Venkataramanan, 2010) by battery storage system.

This battery storage system creates the microgrid and helps in providing uninterrupted power supply at the time of fault conditions. Although, the batteries are not sufficient enough to restrain the fault condition under Batter Energy Storage System (BESS). The dynamic model of microgrid are designed with different operating condition (Kamel, 2014) are investigated in low voltage distribution system. They are also focused with stability along with load shedding among the DG's. Transient stability analysis is necessary while the utility grid is made overloaded. Sudden adding and removing of load create transient instability in the grid system (Ou, 2012). Generally, microgrid performs along with utility grid if there exist of fault under any suspects, microgrid used to satisfy the load at fault condition (Liang *et al.*, 2012).

The controllers are used to control the transient issues in the microgrid in order to perform stable operation. Among the various droop control p-f and q-v droop controller were used to measure the impact over the transient stability shown in Fig. 1.

The P-f and Q-v droop not only used for stability analysis but also performs the additional features of power sharing also among the DG's and helps to maintain the voltage and frequency (Rodriguez *et al.*, 2007; Lopes, 2006). Simulation results show the impact of droop controller techniques in the DG's along with the transient stability under L-G and L-L fault were analyzed in this research.

MATERIALS AND METHODS

Modelling of microgrid: The one line diagram of microgrid were shown in Fig. 2. Microgrid consist of two

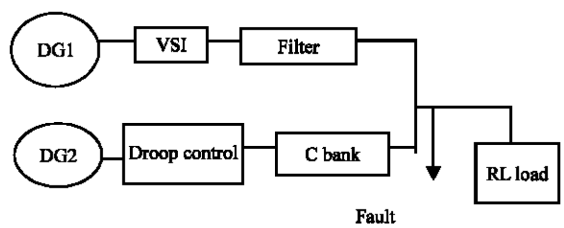

Fig. 2: Modelling of microgrid

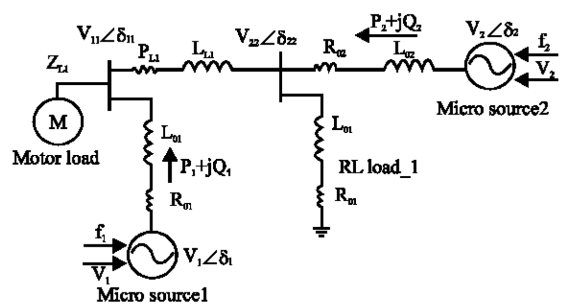

Fig. 3: Equivalent model of microgrid system

DG's of each about comprises of both droop control and inverter based micro sources. Filter which are comprised of Inductance (L) and Capacitance (C) and a common load is connected to the microgrid (Fig. 3):

$$P = \frac{V_1 V_2}{X} \text{Sin}\delta \tag{1}$$

$$Q = \frac{V_1^2}{X} - \frac{V_1 V_2}{X} \text{Cos}\delta \tag{2}$$

The real and reactive power of the transmission lines are given by Eq. 1. Here, the stability of microgrid is made regulated through, the interconnected micro sources.

Since, the voltage regulation are minimized through the droop control (He and Li, 2012). The power sharing among these DG's are made through the droop controller and inverter based controllers.

Control strategies: The controllers are having the tendency of regulating the grid voltage and along with system stability and reliability. The droops are helps to control the real and reactive power through the frequency droop and voltage droop (Majumder *et al*., 2010). The grid voltage and frequency were computed through the droop controls and are given by droop equations:

$$f - f_0 = K_P(P - P_0) \tag{3}$$

$$V - V_0 = K_q(Q - Q_0) \tag{4}$$

Equation 3 and 4 shows the relation between the p-f and q-v then:

$$f = f_0 + K_P(P - P_0) \tag{5}$$

$$V = V_0 + K_q(Q - Q_0) \tag{6}$$

Where:

F, V = Frequency and voltage of microgrid under variable position
F_0 and v_0 = Frequency and voltage under base frequency and voltage of microgrid
P, Q = Real and reactive power of microgrid at variable position of droop
P_0 and Q_0 = Real and reactive power of microgrid at initial condition
K_p and K_d = Droop constant parameter

RESULTS AND DISCUSSION

The microgrid is modelled with two DG's of having rating about 50 Mw. Here, DG's are employed with droop control and controllers. Simulations were carried out by creating various faults in the time period of 0.3 sec. Here, modeling and performance of microgrid were analyzed with RL load under different fault conditions.

LG-fault condition: LG fault is created on 0.3 sec and the following parameters were discussed. Figure 4 shows that the grid voltage is maintained about 1 pu until fault occurs. At 0.3 sec, LG fault is created in phase A and it is made cleared after 0.5 sec.

Figure 5 shows the grid current under fault condition. At initial condition, it maintained to the value about 1 pu at the time of fault occurs 0.3 sec, there creates of transient of peak valve of about 3.0 pu and these settles down after 0.5 sec of time period.

Figure 6 shows the real power delivered to the load. It is kept constant to 1 pu value at beginning before 0.3 sec. At the time of fault happens at 0.3 sec real power dipped to 0.6 pu value after 0.5 sec, it is made cleared and restrained to the original valve of 1 pu.

Figure 7 states the reactive power of microgrid. It started with 0.58 pu at initial condition and it is decreased to 0.74 pu under the fault condition. After the fault it rest to it position to 0.58 pu.

Figure 8 shows that the fault voltage of phase A. It is observed that, it rise to the value of 0.8 pu and it becomes 0 at faulted condition of 0.3-0.5 sec.

Figure 9 shows that the fault current is arisen about 0 from the period of 0-0.3 sec. At the time of fault occurs in 0.3 sec, fault current raises up to 1.0-3.5 pu and it is cleared after 0.5 sec.

L-L fault conditions: The designed microgrid is also evaluated with LL fault condition. Here, LL fault is carried out in phase A and B at the period of 0.3 sec and it is cleared at 0.5 sec.

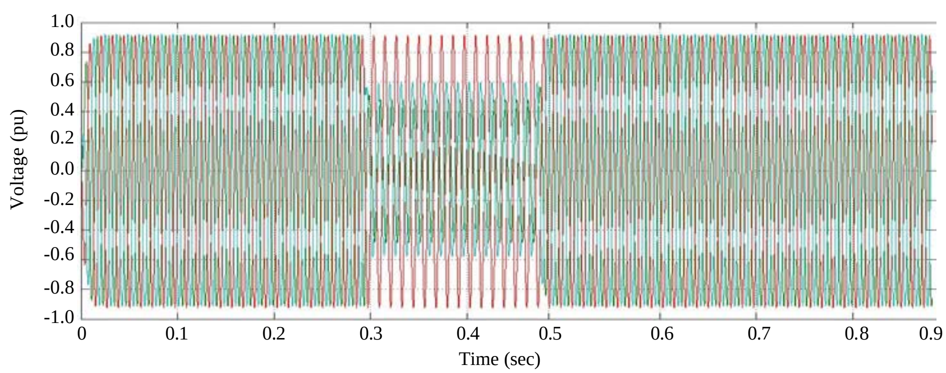

Fig. 4: Grid voltage

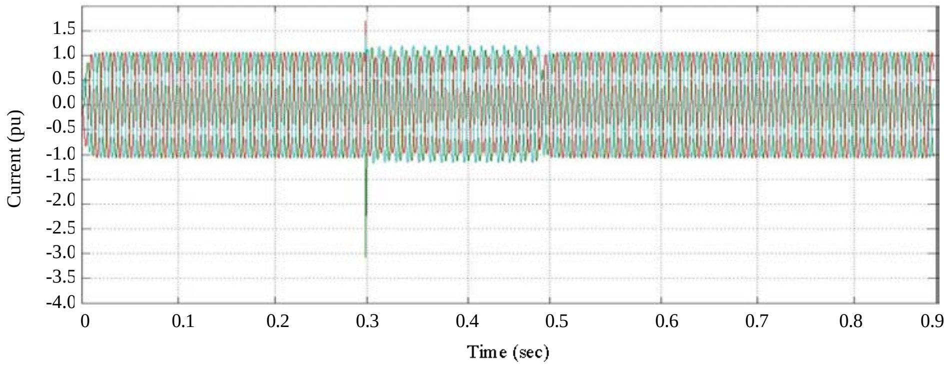

Fig. 5: Grid current under fault condition

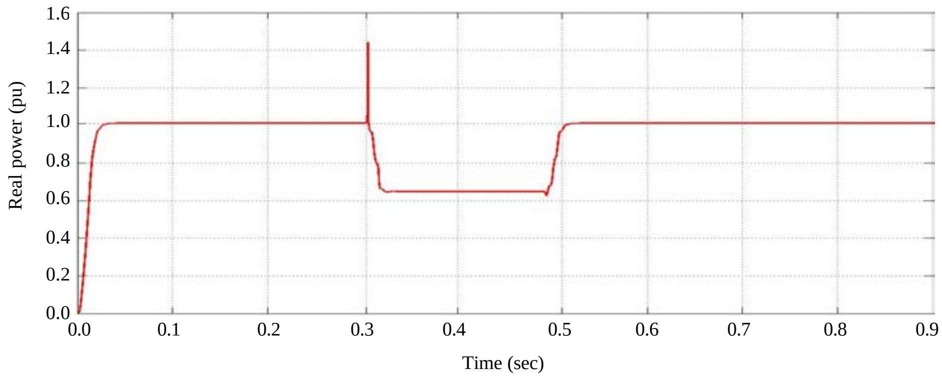

Fig. 6: Real power delivered to the load

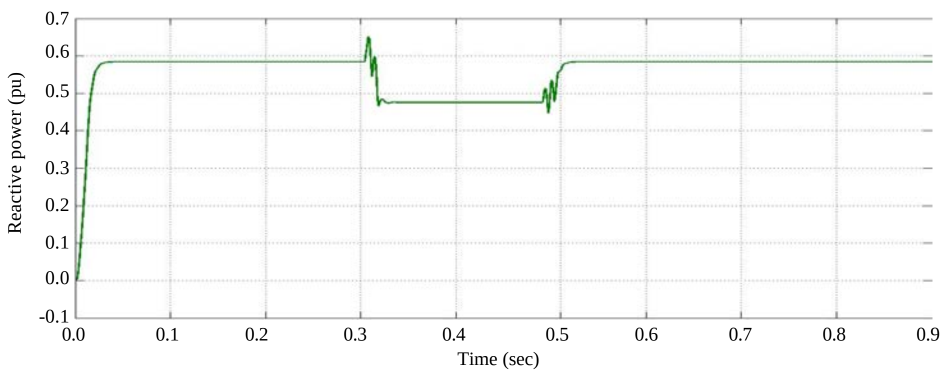

Fig. 7: Reactive power of microgrid

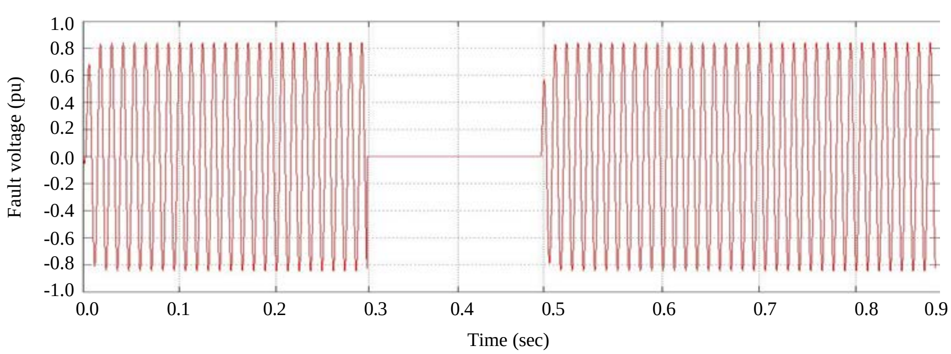

Fig. 8: Fault voltage of phase A

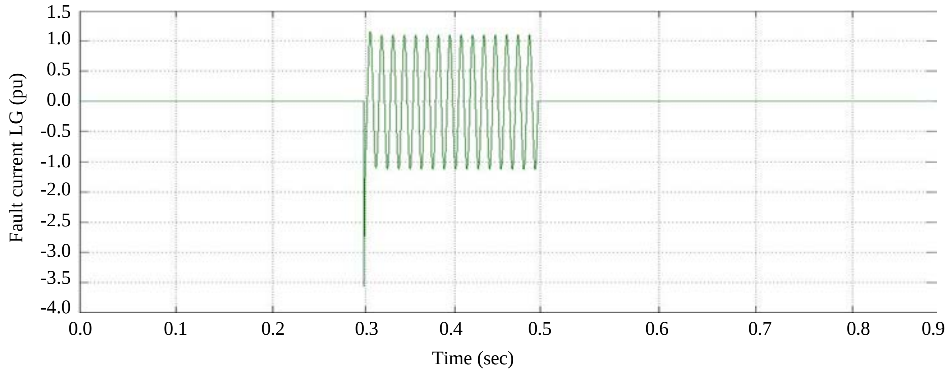

Fig. 9: Fault current

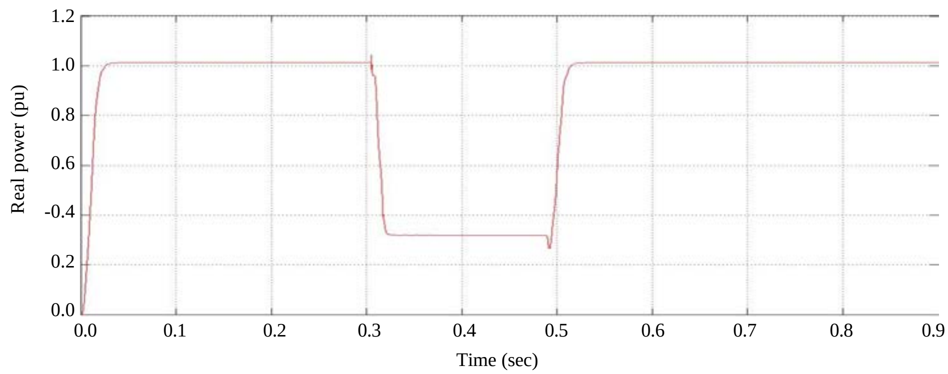

Fig. 10: Real power of microgrid under LL fault condition

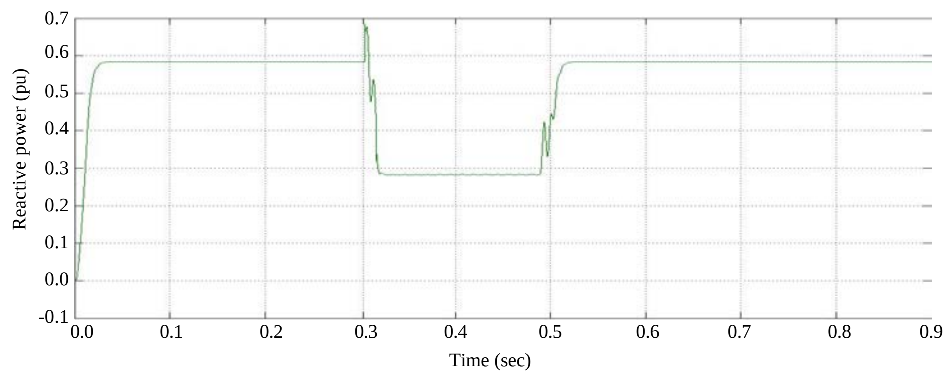

Fig. 11: Reactive power of microgrid under LL fault condition

Figure 10 and 11 shows that the real and reactive power of microgrid under LL fault condition occurs at 0.3-0.5 sec. It is observed that the real power continues from 1 pu until 0.3 sec while the fault is occurred at 0.3 sec, it is reduced to 0.4 pu and it is lasted until the fault cleared at 0.5 sec. Fig 11 states that the reactive power initiated from 0.6 pu and at the time of fault, it is reduced to 0.3 pu. The fault is made cleared after 0.5 sec, it regains back to the initial condition of about 0.6 pu.

Figure 12 and 13 shows the grid voltage and current at LL fault conditions. It is observed that, the grid voltage is maintained near to 0.7 pu and the current is about 0.4 pu. Figure 14 and 15 shows the fault voltage and fault current of the microgrid. At the time of fault period, it is having the value of 0 and at the rest of fault time, it is raising to the value near to 0.8 pu. Figure 15 shows the fault current while it raise to the value of 1.5 pu nearly and it rest to 0 at the rest of period of fault conditions.

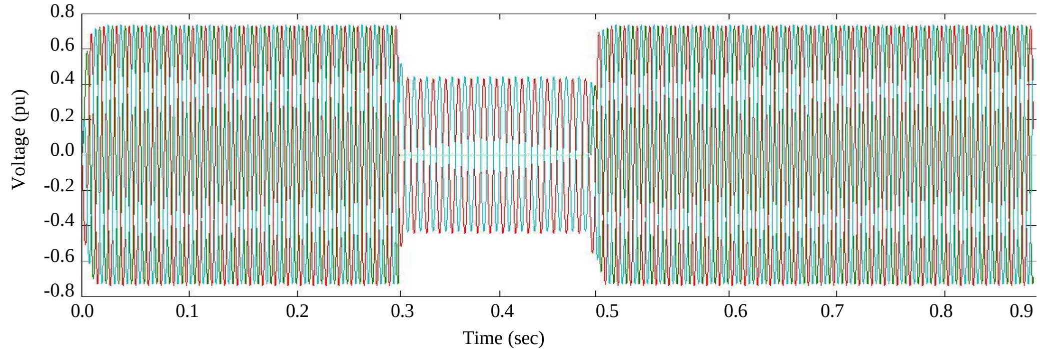

Fig. 12: Grid voltage at LL fault conditions

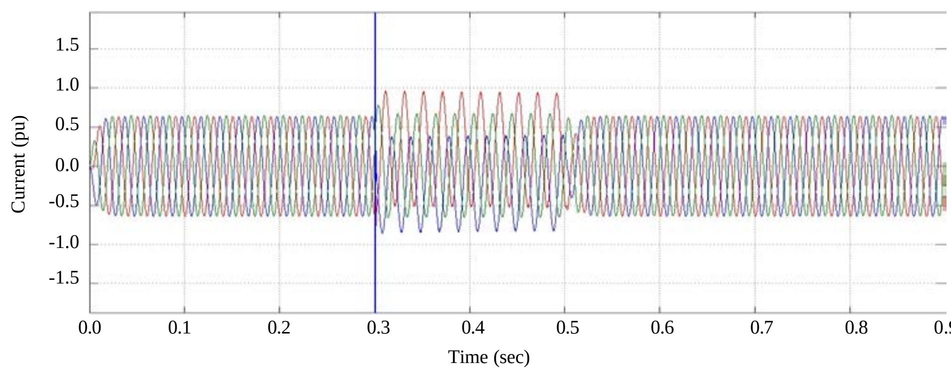

Fig. 13: Grid current at LL fault conditions

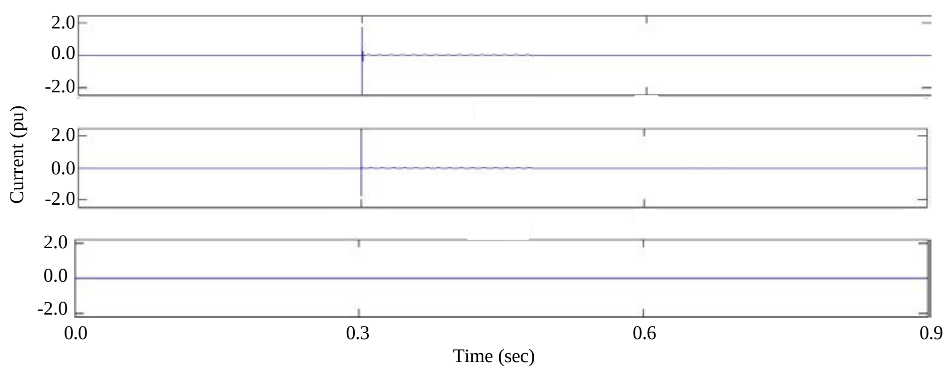

Fig. 14: Fault voltage of the microgrid

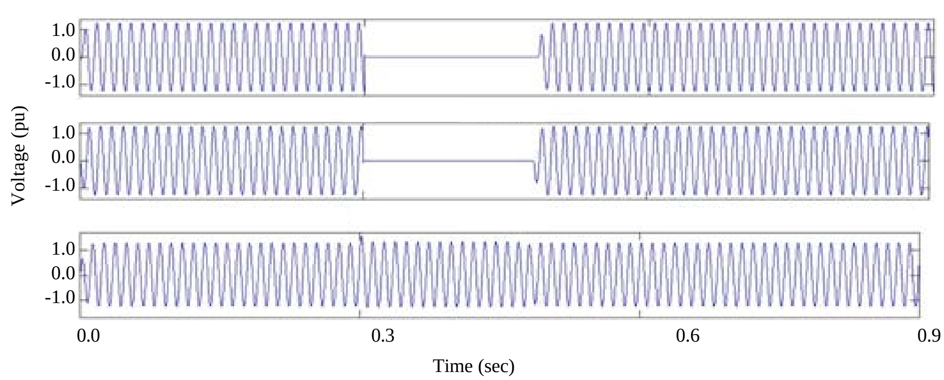

Fig. 15: Fault current of the microgrid

CONCLUSION

This study is investigated the microgrid under the most occurred faulted condition like LG and LL fault and the observation of microgrid under such fault were discussed. In order to improve the system performance controller were adopted. Where the droop control based DG's was adopted along with inverter based DG helps to enrich the system behaviors under different fault conditions. The simulation results are validated that the proposed controller were having the better regulation of microgrid voltage, real power, reactive power and adopted with frequency within acceptable range under autonomous mode.

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