IEEE Access
Multidisciplinary : Rapid Review : Open Access Journal

Received May 23, 2018, accepted June 21, 2018, date of publication July 4, 2018, date of current version July 30, 2018.

Digital Object Identifier 10.1109/ACCESS.2018.2852941

Enhancing Power Quality in Microgrids With a New Online Control Strategy for DSTATCOM Using Reinforcement Learning Algorithm

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This work was supported by the Faculty Development Competitive Research Grant, Nazarbayev University, under Grant 090118FD5318.

ABSTRACT To mitigate the power quality issue in microgrids, a new online reference control strategy for distribution static compensator using the reinforcement learning algorithm is presented. The new controller is supposed to compensate the reactive power, harmonics, and unbalanced load current in a microgrid utilizing voltage and current parameters. Voltage controller is used to adjust the set point of the reactive power reference, whereas the current based controller tries to compensate the unbalanced load current in distributed resource network through the quadrature axis (q-axis) and zero axis (0-axis). The proposed control strategy is applied to an autonomous microgrid with a weak ac-supply (non-stiff source) distribution system under different loads as well as three-phase fault conditions. Different scenarios are studied and simulation results for various conditions are discussed. The performance of the proposed online secondary control strategy is also discussed in detail.

INDEX TERMS DSTATCOM control, microgrid management, online control, power quality enhancement, reactive power control, reinforcement learning.

NOMENCLATURE

Abbreviations:

VSC	Voltage Source Converter
PCC	Power Common Coupling
PI	Proportional–Integral
PWM	Pulse Width Modulation
PLL	Phase-Locked Loop
PQ	Power Quality
RES	Renewable Energy Source
NN	Neural Network
Adaline	Adaptive Linear Element
DSTATCOM	Distribution Static Compensator

Symbols:

γ	Discount Factor
$r(x,u)$	Reward Function
MS_t^n	Mean Absolute Error at State n
ΔV_m	Difference of Voltage at State n and $n-1$
N_s	Number of Samples in Each State
Q_{ref}	Reactive Power Reference of Controller
Δi_q	Difference of Quadrature Axis Current Value at State n and $n-1$
Δi_0	Difference of Zero Axis Current Value at State n and $n-1$
ΔMS_t^n	Difference of Mean Absolute Error at State n and $n-1$

I. INTRODUCTION

Power generation system decentralization requires distributed energy resources to be installed in electric power systems widely. These resources provide flexibility and less dependency to the conventional mono-directional power system. Penetration rate of distributed resource (DR) units are growing very fast in the modern power system network [1]; however, it is becoming gradually clear that disadvantages of DR utilization are quite noticeable as compared to its advantages. DR can potentially initiate technical issues; even though, it has lots of crucial benefits [2]. Complete benefits of DR units are obtained if they are operated in both grid-connected and islanded (autonomous) modes. Therefore, microgrid can be utilized in operation of DRs as a possible solution for both individual and autonomous conditions [3].

On the other hand, with linear and non-linear loads diversity, microgrids are facing significant PQ problems in autonomous mode of operation [4]. Voltage drop, harmonics, voltage sag, and voltage swell are some of them to name a few. To address and overcome these issues, several standards have been developed and enforced on operators and utilities [5]. The mitigation of undesirable PQ issue scan be obtained through precise monitoring and then utilizing proper power electronic devices for compensation. However, this is considered as just one of the possible solutions [6]. In comparison of classical outline network, the Microgird has its own power quality problems because of the network configuration, specific operation features, types of storage and discovery elements considered. Normally, the PQ problems can be categorized in three types: the first one is produced by microsources (i.e., oscillation in output of renewable energy sources); second one is the harmonics that provided by power electronics adopted in microgrid, and finally the third one is the voltage sags produced by growing load reactive power demands. DSTATCOM is one of those devices which can assist to address the PQ challenges in microgrid [7].

Different control techniques have been introduced and discussed for DRs' operation as well as voltage control and unbalanced currents. Reactive power theory [8]; synchronous reference frame theory [9]; modified *p-q* theory [10]; *d-q* axis theory [11], [12]; and, reference currents estimation techniques by maintaining the voltage of dc link are main techniques which have been widely reported in the literature. These techniques are based on complex calculations and generally contain a set of low-pass filters that results in a delay in the computation of reference currents and therefore leads to slow dynamic response of DSTATCOM.

Controlling DSTATCOM by using least mean square-based adaptive linear element is suggested in [7]. Reactive power, harmonics and unbalanced load current compensation of a diesel generator for an isolated system is the main contribution of this method. In order to reach voltage regulation at the dc-bus of a Voltage-Sourced Converter (VSC), positive sequence of load current in the fundamental frequency has been issued via a PI controller. Also, hysteresis-based Pulse Width Modulation (PWM) control strategy is utilized to VSC by controlling source currents to follow the reference currents. Furthermore, Kannan *et al.* [13] suggested a topology for DSTATCOM applications with non-stiff source. This topology enables DSTATCOM to have a reduced dc-link voltage without compromising the compensation capability. Also, the average switching frequency of the DSTATCOM switches is decreased. Asynchronous reference frame theory for three-phase four-wire DSTATCOM includes VSC and a dc link capacitors reported in [14]. Using this strategy, DSTATCOM provides source harmonic reduction, reactive power and neutral current compensation at the PCC.

In [15] a Neural Network (NN) controlled DSTATCOM using a dSPACE processor for voltage regulation or power factor correction is introduced. Load balancing, elimination of harmonic currents and neutral current compensation were taken as the other goals of NN controlled method. Later, a coordinated control strategy with communication in the loop of DR and DSTATCOM in a microgrid was reported by [16]. This strategy is based on the voltage sag and the power flow in the line. Power flow and the voltage at different locations of feeders are communicated for the DSTATCOM to modulate the reactive power compensation. In order to implement this method, it is essential for the communication channel to be accessible.

This study presents a novel online strategy to adjust (reference) tracking of DSTATCOM set point in microgrid by monitoring the PCC voltage and DRs currents. Online control of DSTATCOM with the capability of reactive power, harmonics and unbalanced load compensation is obtained by Reinforcement Learning (RL) algorithm. The proposed control strategy contains two fundamental parts namely; voltage-base and current-base control strategies. The voltage-base strategy adjusts the reactive power reference of DSTATCOM and current-base strategy injects signals through both quadrature axis (*q-axis*) and zero axis (*0-axis*) of VSC current controllers under unbalanced conditions. In the primary control, local voltage and current of DSTATCOM is used to control the voltage and frequency of the system. The secondary reference control is considered as PCC voltage and DRs currents signal to compensate PQ problems in the microgrid. Independency of the secondary from the primary controller is the salient feature of the proposed method. This new strategy is completely suitable for microgrids with regularly changing topology that leads to deteriorate the performance of the designed controller.

To sum up, the main contribution of this study are, (1) introducing a novel online control strategy based on RL algorithm, and (2) controlling the PCC voltage besides controlling of DRs' current in order to overcome PQ problems. The proposed strategy does not require to access system model, and also it can be simply adopted to different types of distributed resources such as wind turbine, synchronous generator and voltage source converter in microgrid.

To evaluate the strategy, this control algorithm is applied on a test microgrid system under load switching; single and double-phase unbalanced loads, nonlinear loads as well as three-phase fault conditions. The studied microgrid system includes wind turbine, voltage source converter based DR with *dq*-current controller, synchronous generator with a governor, and excitation primary control system. The model is simulated and the results are discussed in detail. Simulation results reveal that the proposed algorithm is able to compensate the voltage drop and mitigate the unbalanced currents of distributed resources.

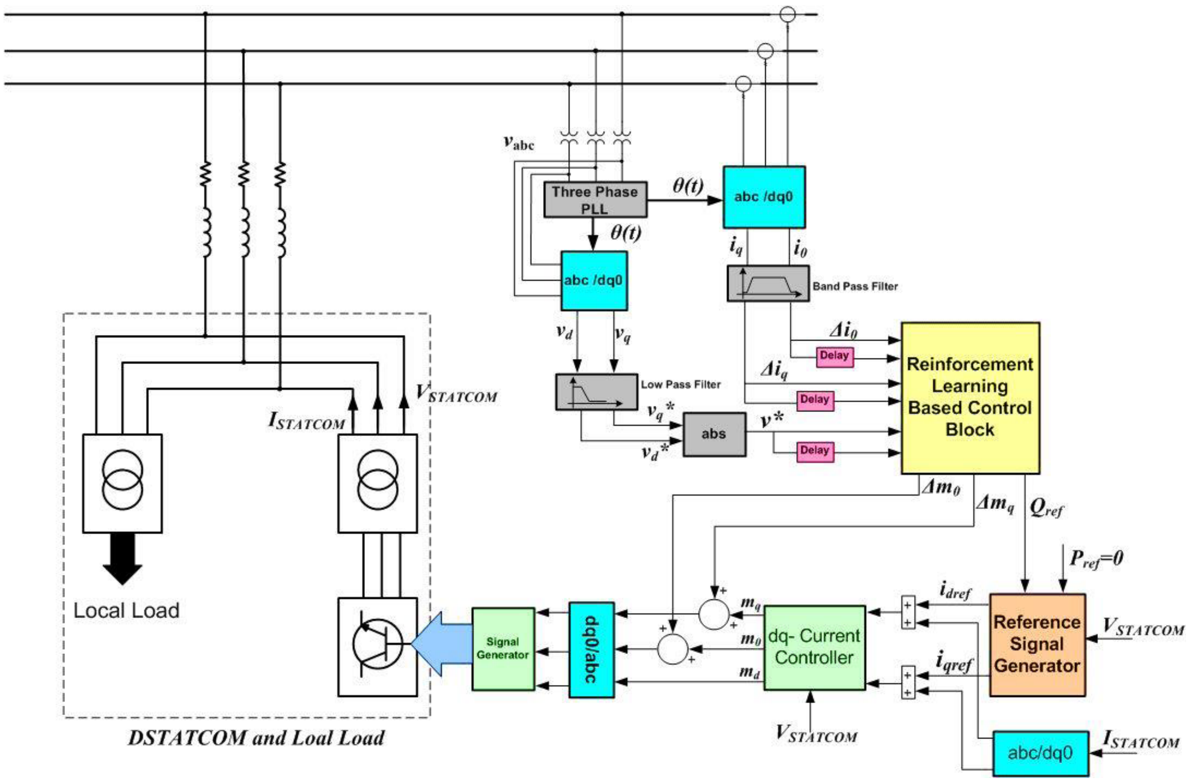

FIGURE 1. Proposed strategy in order to control DSTATCOM in microgrid.

II. PROPOSED CONTROL STRATEGY

The concepts of primary and secondary control are widely employed in the conventional power system [17]. The primary control is local, fast and is designed as a linear controller such as a Proportional Integrative (PI) scheme. The secondary control is a higher level of control and provides set points for the primary controllers in its associated zone. The set points are calculated to optimize some measure of operation, e.g., a flat voltage profile, reactive power generation or real power loss minimization.

In this study, using the RL algorithm, a secondary controller for DSTATCOM is developed. The proposed control strategy is composed of two independent parts. The first is based on voltage control strategy and minimizes the voltage profile of PCC voltage, and the second one is based on current control strategy and optimizes the power quality problems of distributed resources. The block diagram of the control scheme is illustrated in Fig. 1.

A. VOLTAGE-BASE CONTROL STRATEGY

The voltage-base control objective is online modification of the set-point of a STATCOM reactive power reference to obtain a nominal voltage for PCC bus. Fig.1 shows the structure of the proposed controller in islanded mode of operation. PCC voltage (V_{PCC}) is measured and transferred to a *dq*-frame. A three-phase Power Common Coupling (PLL) is used to provide the reference angle for the *abc/dq* block and thus, the *q* component of the PCC voltage is set to zero. In this case, the *d* component of the PCC voltages, v_d, should be regulated to the desired peak value of the PCC voltage (v_{dref}). Afterwards, it is compared with the reference signal and the summation of the error signal square is applied to the designed RL-base controller for regulation. RL controller output would be a reference value for reactive power generation of DSTATCOM (Q_{ref}), which is applied to the reference signal generator of the VSC as depicted in Fig.1.

The set point adjustment is then carried out in each time horizon, T_{Cont}. This horizon influences the behavior of the RL algorithm and its selection is based on the optimal decision and rate of variations of the controlled variables.

B. CURRENT-BASE CONTROL STRATEGY

The current-base control objective is based on online injecting corrective signals ($[\Delta m_{d,} \Delta m_q]$) into the system through both quadrature axis (*q-axis*) and zero axis (*0-axis*) current controllers of the interface converter; see Fig. 1. This corrective signal injection through the *q-axis* controller modifies frequency deviation under islanded conditions at the PCC. The injected signal through the *zero axis* of controller causes unbalancing in load current, which is provided by DSTATCOM. By this composition, unbalanced current of the generation unit is set to zero.

As demonstrated in Fig. 1, DRs' currents (I_{DRS}) are measured and then active, reactive and zero components are derived. Implementing a band pass filter; the DC values of these *dq0* components are eliminated and the $[\Delta i_d \Delta i_q]$ signals are applied to the proposed control strategy. The output signals of RL controller would be $[\Delta m_d \Delta m_q]$, which are applied to the gating signal generator of the VSC.

III. REINFORCED LEARNING BASED CONTROLLER

A. REINFORCEMENT LEARNING ALGORITHM

Reinforcement learning [18] is considered as one of the most crucial and effective online control strategies. At the beginning, selection is based on the trial-and-error model. However, after pass time horizon, the algorithm is trained to apply suitable control action on different plants indirectly. For each state in this method, a different control action is applied. For instance, if x_t and u_t denote the system state and system control at time t, the state at time $t+1$ is given by [19]:

$$x_{t+1} = f(x_t, u_t), \quad u_t \in U, \ \forall t > 0 \tag{1}$$

For each control action in any intervals, a reward or a punishment is presumed. In other word, if this action improves the system error; a reward will be anticipated for this action; otherwise a punishment will be applied. The selection of reward or punishment is specified by comparison between error in t and $t+1$. Thus, reward selection at time t for each action is given by:

$$R(x_0, u\{t\}) = \sum_{t=0}^{\infty} \gamma^t r(x_t, u_t), \tag{2}$$

where, γ is a value between *0* and *1*, $0 < \gamma < 1$, and $r(x, u) \leq B$. B is the maximum value of the reward and is selected through trial and error.

Using obtained values; a value function is defined. From this function, suitable control signal for the next step will be selected as:

$$V(x) = \max_{u(t)} R(x, u(t)) \tag{3}$$

Utilizing Bellman equation [19], the value function is given by:

$$V(x) = \max_{u \in U} [r(x, u) + \gamma V(f(x, u))] \tag{4}$$

The optimal control policy is expressed as:

$$\left[u^*(x) = \arg\max_{u \in U} [r(x, u) + \gamma V(f(x, u))]\right] \tag{5}$$

According to the mentioned relation for each interval, a reward or punishment function called Q function can be obtained by:

$$Q(x, u) = r(x, u) + \gamma V(f(x, u)) \tag{6}$$

Re-express $V(x)$ in terms of this function is given by:

$$V(x) = \max_{u \in U} Q(x, u), \tag{7}$$

and finally, optimal control policy is obtained by:

$$u^*(x) = \arg\max_{u \in U} Q(x, u) \tag{8}$$

In the proposed secondary controller, for each pair of input/output signal, three different actions can be taken into account. In each state, adaptation unit must select one single action among all three possible actions. Some of the actions are eliminated through the evaluation of their punishment functions; and therefore, a selection process is applied to the other remained actions.

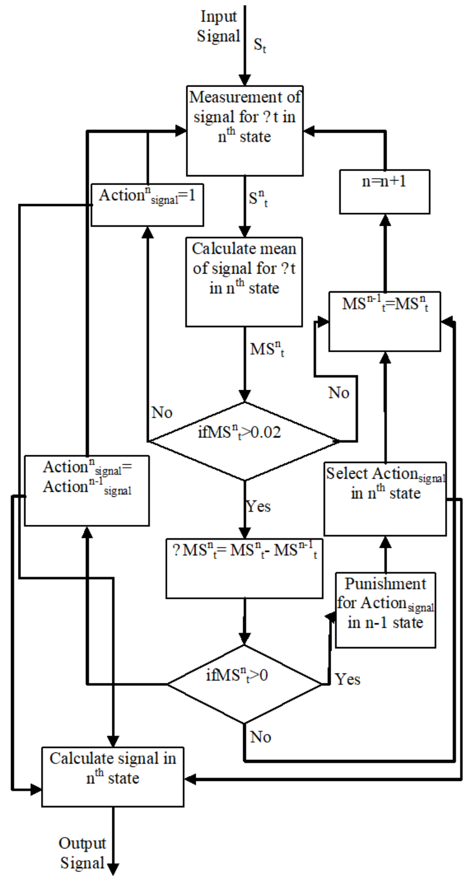

FIGURE 2. Flowchart of the reinforcement learning block algorithm for three pairs input/output.

B. RL METHODOLOGY

The flowchart for the secondary reinforcement learning control block is provided in Fig. 2.Using this flowchart, each pair of $(\Delta i_0, \Delta m_0)$; $(\Delta i_q, \Delta m_q)$; and, $(\Delta v, Q_{ref})$ signals' relation are obtained. Any changes of the input signals cause a change in the outputs. For instance, the voltage deviation Δv over 4ms is measured and the mean absolute error of the PCC voltage is calculated using (9).

$$MS_t^n = \frac{\sum_{m=1}^{N_s} \Delta V_m}{N_s}, \tag{9}$$

where, $(\Delta V_m = [\Delta v_1, \Delta v_2, \ldots, \Delta v_{Ns}]_m$; N_s; and, MS_t^n are number of samples and the mean absolute error at the state n, respectively. If $MS_t^n < 0.02$, value of the output doesn't change in the next state, whereas for $MS_t^n \geq 0.02$, deviation

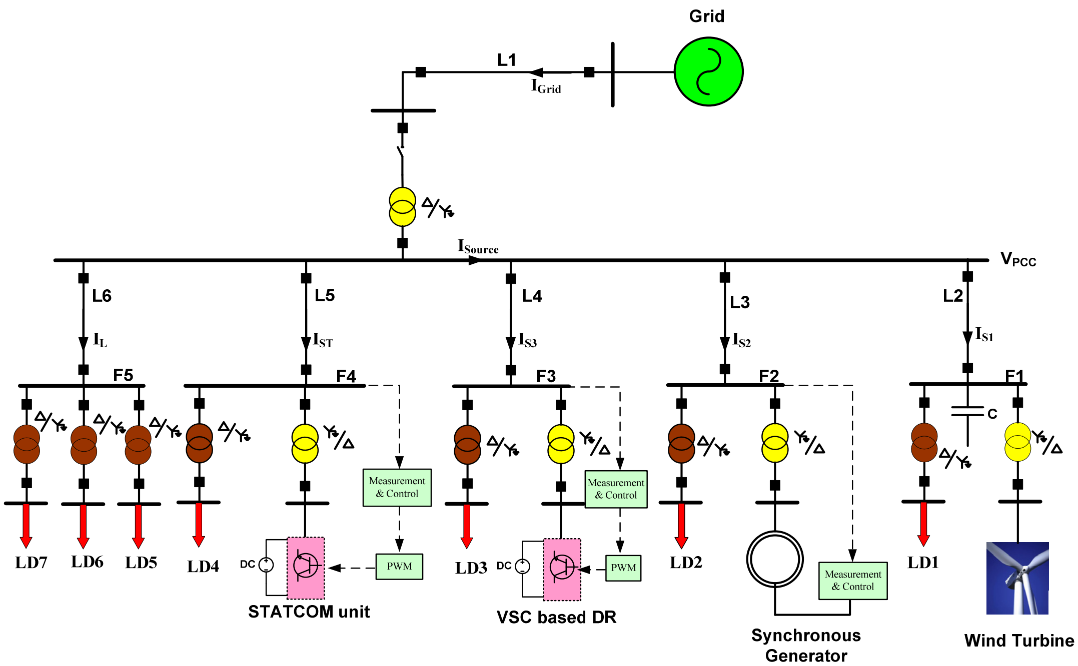

FIGURE 3. Single line diagram of simulated microgrid system.

TABLE 1. Parameters of loads, transformers and distributed resources of the studied microgrid.

Feeder	Line Imp. (%)	DR Max. Power	Transformers	Load Rate P+*j*Q (pu)	Leakage Impedance
Feeder 1	Z_{L2}=3.1+j6.4	P_{WT}=150 kVA	T_{G1}=250 kVA T_{L1}=100 kVA	LD1=0.75+*j*0.44 Q_C=*j*1.5	(0.06 + 0.1)
Feeder 2	Z_{L3}=2.2+j4.1	P_{SG}=100 kVA	T_{G2}=160 kVA T_{L2}=100 kVA	LD2=0.5+*j*0.25	(0.08 +0.2)
Feeder 3	Z_{L4}=2.1+j3.8	P_{VSC}=80 kVA	T_{G2}=100 kVA T_{L3}=100 kVA	LD3=0.6+*j*0.38	(0.1 +0.40)
Feeder 4	Z_{L5}=2.3+j5.2	$Q_{STATCOM}$=50 kVAr	T_{G4}=100 kVA T_{L4}=100 kVA	LD4=0.2+*j*0.1	(0.1 +0.40)
Feeder 5	Z_{L6}=4.5+j7.9	------	T_{L5}=50 kVA T_{L6}=75 kVA T_{L7}=50 kVA	LD5=0.4 LD6=0.4+*j*0.3 LD7=0.2	(0.15 +0.6)

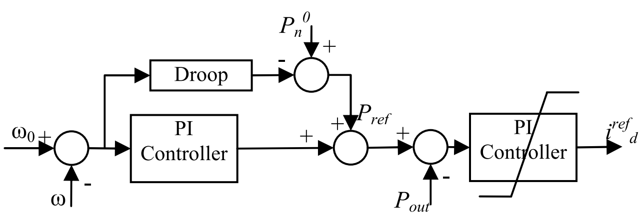

FIGURE 4. Controller of VSC-based distributed generation for active power compensation.

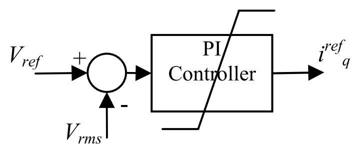

FIGURE 5. Controller of VSC-based distributed generation for reactive power compensation.

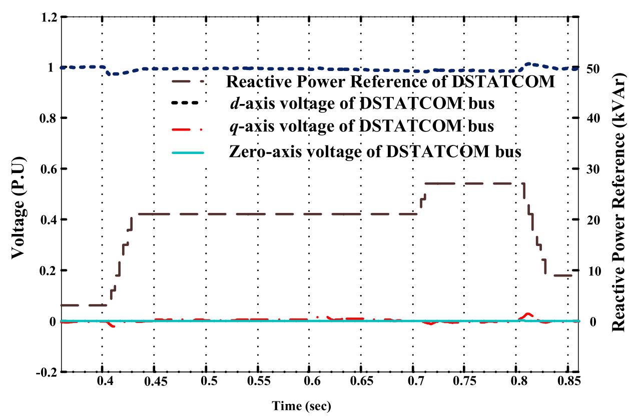

FIGURE 6. System response to *scenario 1*, (a) Power production of DRs, (b) Reference power of DSTATCOM and *dq0* voltage of PCC.

of $MS(\Delta MS_t^m)$ is given as;

$$\Delta MS_t^n = MS_t^n - MS_t^{n-1}, \tag{10}$$

where, MS_t^n and MS_t^{n-1} are the mean absolute error at state n and n-1, respectively.

For $\Delta MS_t^m > 0$, it is obvious that action of the pervious state impairs the voltage error. In this case, punishment is considered for the pervious state action and new action is selected for $n+1$ state. However, if $MS_t^m \leq 0$, it shows that the pervious state action improves the voltage error. Thus, reward is given for this action and it is selected as the next state action. For each of three input/output signals $[(\Delta i_0, \Delta m_0)$; $(\Delta i_q, \Delta m_q)$; and,$(\Delta v, Q_{ref}]$ the same procedure is applied independently as described in Fig. 2. Limits of the output

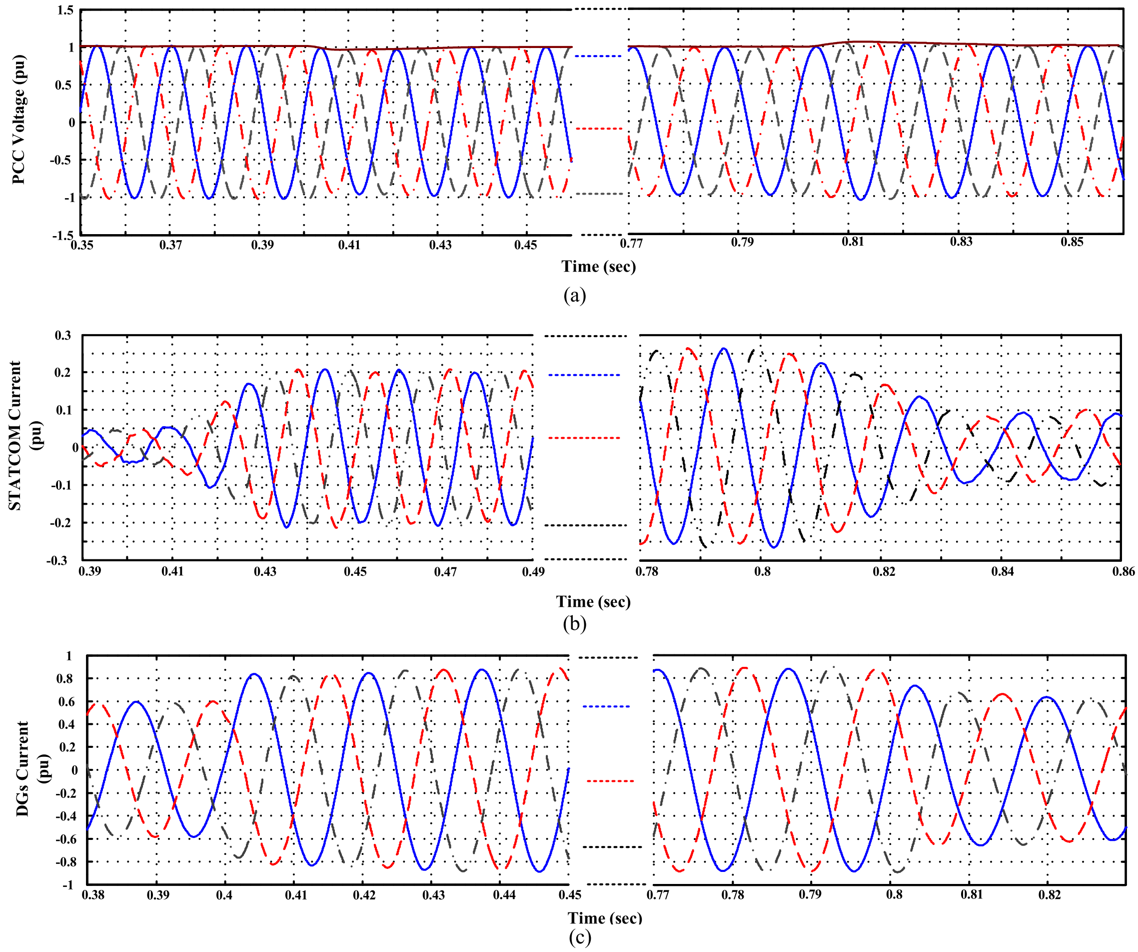

FIGURE 7. System response for *scenario 1*, (a) PCC voltage, (b) STATCOM current, (c) DGs current (I_{DGs}).

signals are considered to prevent of set points increasing from nominal value.

IV. SYSTEM DESCRIPTION

A. SYSTEM TOPOLOGY

Single line diagram of the microgrid system to investigate the proposed algorithm operational behavior is shown in Fig. 3. It consists of radial distribution system which is connected to the utility grid through a 13.8kV line. The distribution system consists of five feeders, three DR units, a DSTATCOM unit feeder, and set of linear and non-linear loads.

The 500 kVA substation transformer is configured in delta at the high voltage side and grounded Wye at the low voltage side. The system includes three DR units, i.e. DR_1 (150 kVA), DR_2 (100 kVA) and DR_3 (80 kVA) on the feeders F_1, F_2 and F_3, respectively. DR_1 is a wind turbine with a self-excited asynchronous generator.

DR_2 is a synchronous generator with excitation and governor control system, and DR_3 is a voltage source converter-based distributed generation system controlled by active/reactive control strategy system. A DSTATCOM unit (50 kVA) is connected to F_4 in order to improve the PCC voltage and power quality problem.

The linear loads of LD_1 to LD_4 are supplied through the radial feeders of F_1 to F_4. Loads LD_1 to LD_4 are composed of linear RL branches. LD_5 to LD_7 are supplied through feeder 5, where, LD_5 and LD_6 are linear RL branches and LD_7 is a three-phase full controlled rectifier load. F_1 consists of three-phase capacitor bank which is used as excitation system of the asynchronous generator. The electrical parameters of system, including impedance of lines, transformer parameters and configuration, and rated loads of feeders are given in Fig. 3 and Table 1, respectively.

B. ACTIVE/REACTIVE POWER MANAGEMENT

After islanding from the main grid, frequency of the microgrid is defined by operation points of distributed resources. To restore the system frequency, the synchronous generator is equipped with governor and excitation systems.

Also, the active power generation of the VSC-based DR unit is specified based on a frequency-drop characteristic and a frequency restoration algorithm. Figure 4 shows a generic active power management block for VSC-based on DR unit in microgrid. The local frequency which is estimated by a PLL is the input parameter of the controller block. The controller output is then output of the block is the reference

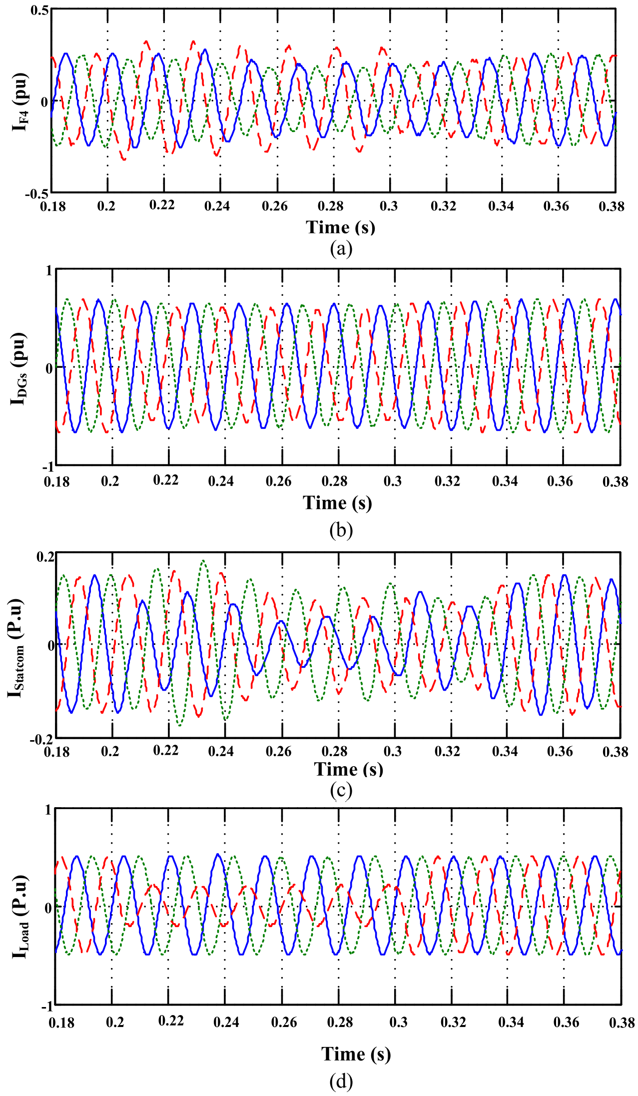

FIGURE 8. System response for *scenario 2*, (a) Feeder 4 current, (b) DR current, (c) STATCOM current, (d) Load current.

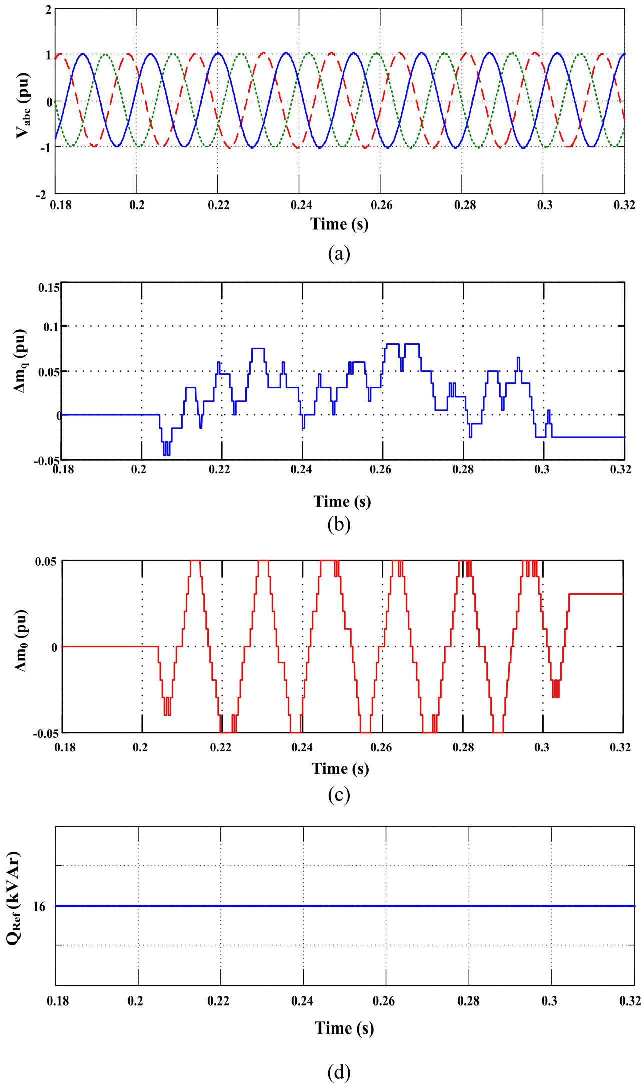

FIGURE 9. System response to *scenario 2*, (a) The PCC voltage, (b) *q* axis injected current, (c) zero axis injected current, (d) DSTATCOM reactive power reference.

current for the d-axis inner current controller of VSC-DR unit, corresponding to the active power reference of the unit.

In order to control the reactive power of VSC-based DR unit, voltage-base control strategy is applied; see Fig. 5. Reactive power of the DR unit is controlled to regulate the voltage of DRs' buses at a pre-specified level (normally 1 pu).

V. SIMULATION STUDY AND RESULTS DISCUSSION

To examine and evaluate the proposed control strategy performance, different case studies were exercised. All these studies were conducted for autonomous operation.

Moreover, in grid-connected condition, the proposed method has the same performance of the autonomous mode. In islanding operation, the microgrid is a weak ac-supply distribution system and the frequency control is one of the main issues. To examine both strategies in autonomous mode, three-phase load variation, unbalanced load including single phase and double-phase changes, three-phase fault event, and nonlinear load switching are emulated.

A. SCENARIO 1: LOAD CHANGES IN AUTONOMOUS MODE

The proposed strategy was examined through feeder 5 load changes. In steady state condition, the load of F_1 is 0.75, LD_2 is $0.4 + j0.25$, LD_3 is $0.4 + j0.16$, LD_4 is 0.2 and the load of F_5 is scheduled for $0.4 + j0.12$, all in per unit. From entire demand, $2.15 + j0.53$ system load, 0.75, 0.6 and 0.8puare supplied by the wind turbine, VSC-based DR and synchronous DR. The system reactive power requirement is distributed among DR units, DSTATCOM and capacitor bank. A $0.2 + j0.1$ pu load in F_5 is increased at $t = 0.4s$ and at $t = 0.8s$. This load is disconnected from F_5. Immediately after load disconnected, production of VSC-based and synchronous DR changes. Fig.6 depicts response of the system to this scenario.

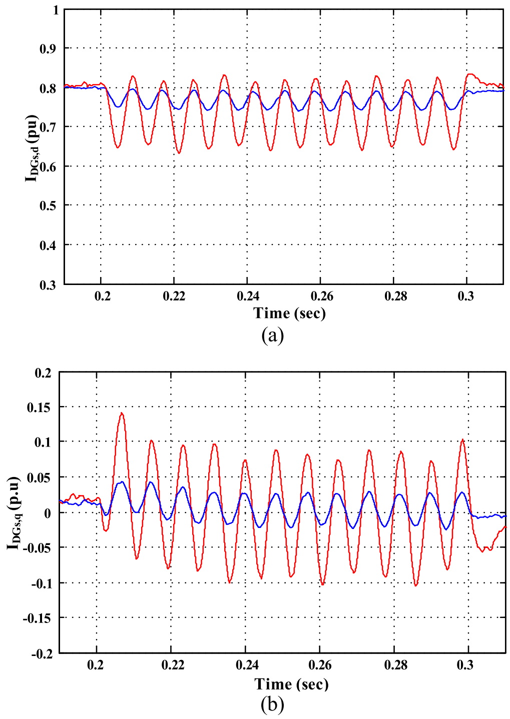

FIGURE 10. System response to *scenario 2*, (a) *d* axis current of DRs, (b) *q* axis current of DRs.

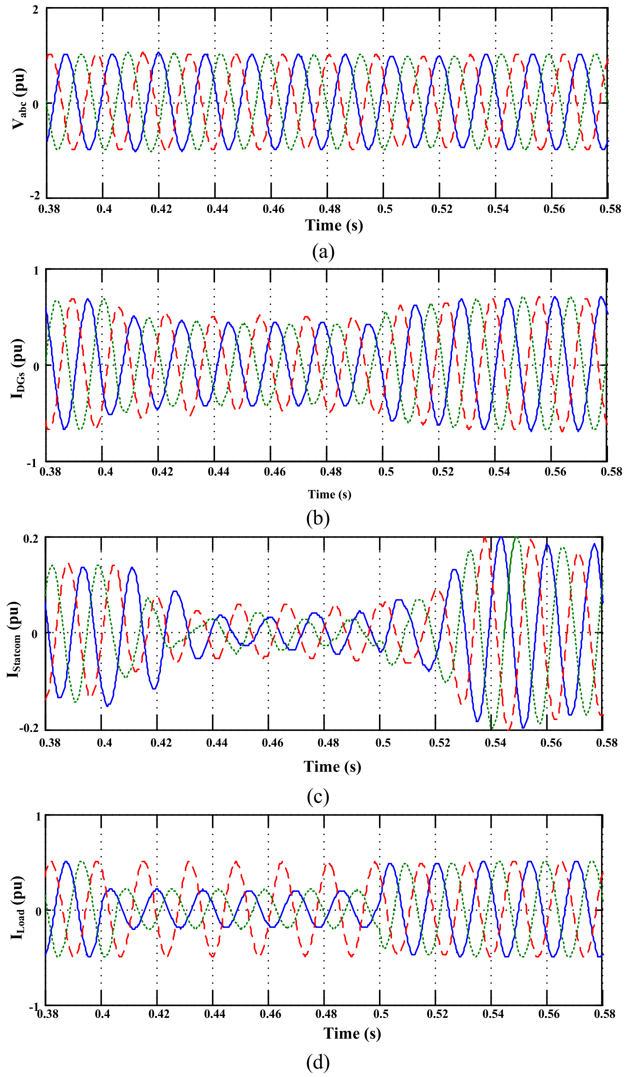

FIGURE 11. System response to *scenario 2*, (a) Feeder 4 current, (b) DRs current, (c) STATCOM current, (d) Load current.

Figures 6(a) and (b) show the active power production of DR units and reactive power reference variation of DSTATCOM with *dq0* PCC voltage, respectively. It is obvious from Fig. 6(b) that the voltage-base RL control strategy will change the reference value of DSTATCOM reactive power.

Figures 7(a), (b) and (c) illustrate the voltage of the PCC, DSTATCOM and DRs current before and after load variation, respectively. It is clear that the proposed strategy has controlled voltage of the PCC after load variation by increasing the reactive power generation of DSTATCOM.

B. SCENARIO 2: UNBALANCED LOAD CONDITION

Unbalanced load condition in autonomous mode operation is quite undesirable for distributed generation units. To examine the performance of the proposed algorithm, two unbalanced conditions are presented in this scenario. It is assumed that before switching, the microgrid was operating in steady state condition (*scenario 1*) and the load of F_5 is divided into two equal $0.2 + j0.06$ pu loads.

To emulate the unbalanced conditions, supplied load on phase *a* in one of the F_5 feeders is disconnected at $t = 0.2s$ and then reconnected at $t = 0.3s$.

Figures 8 and 9 show the disconnection and connection of load in feeder F_5 in a period of $0.1s$. Other feeders (feeder 4) DRs, DSTATCOM and loads current are depicted in Figures 8(a) through 8(d), respectively. It can be easily observed that even if the load currents (I_{Load}) become unbalanced, the source currents still remain in balanced condition when the proposed control strategy is applied. Figure 9(a) shows the PCC voltage. Δm_q and Δm_0 are illustrated in Figures 9(b) and 9(c), respectively, whereas unbalanced currents of DRs are compensated using these signal variations. Figure 9(d) shows the reference value for DSTATCOM.

The *d* and *q* axes' current of DRs without Δm_q and Δm_0 are shown in Fig. 10. Figure 10 clearly shows that the amplitude variation and signal deviation of *d* and *q*-axes' currents are reduced significantly using the proposed control strategy.

For further analysis, another scenario was emulated. At $t = 0.4s$, load is disconnected from phases *a* and *b* in one of the F_5 loads and reconnected at $t = 0.5s$. For the time period of $t = 0.4s$ to $t = 0.5s$, dynamic behavior of the Feeder 4, DRs, DSTATCOM and loads currents are presented in Figures 11(a) through 11(d), respectively. It could be readily concluded that DSTATCOM system is able to balance distributed resources currents using the proposed control strategy under this new imposed condition.

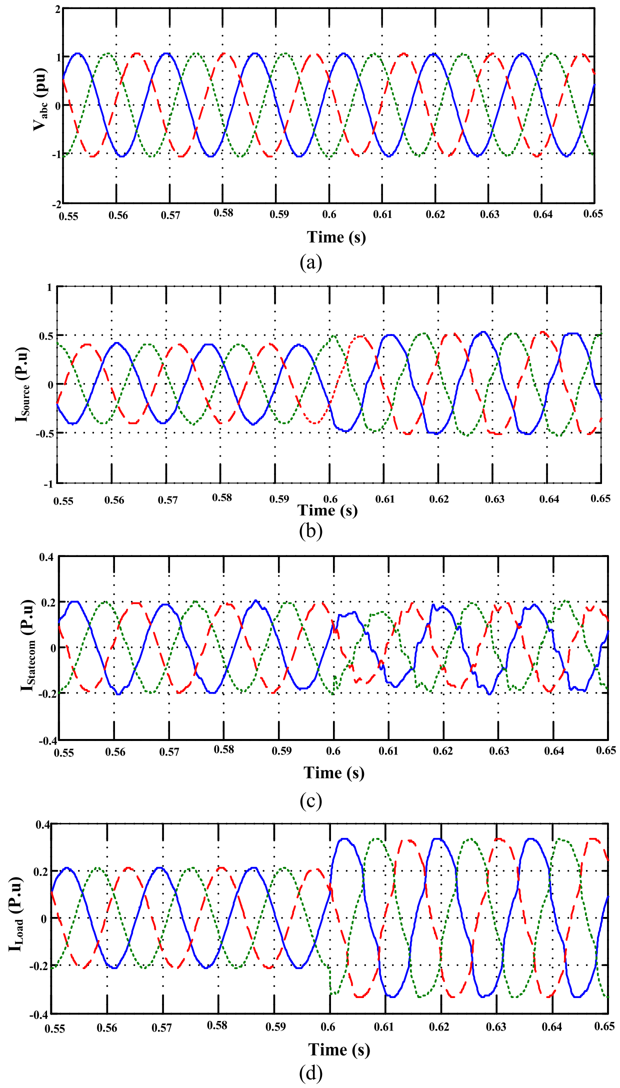

FIGURE 12. **System response to *scenario 3*, (a) Feeder 4 current, (b) DRs current, (c) STATCOM current, (d) Load current.**

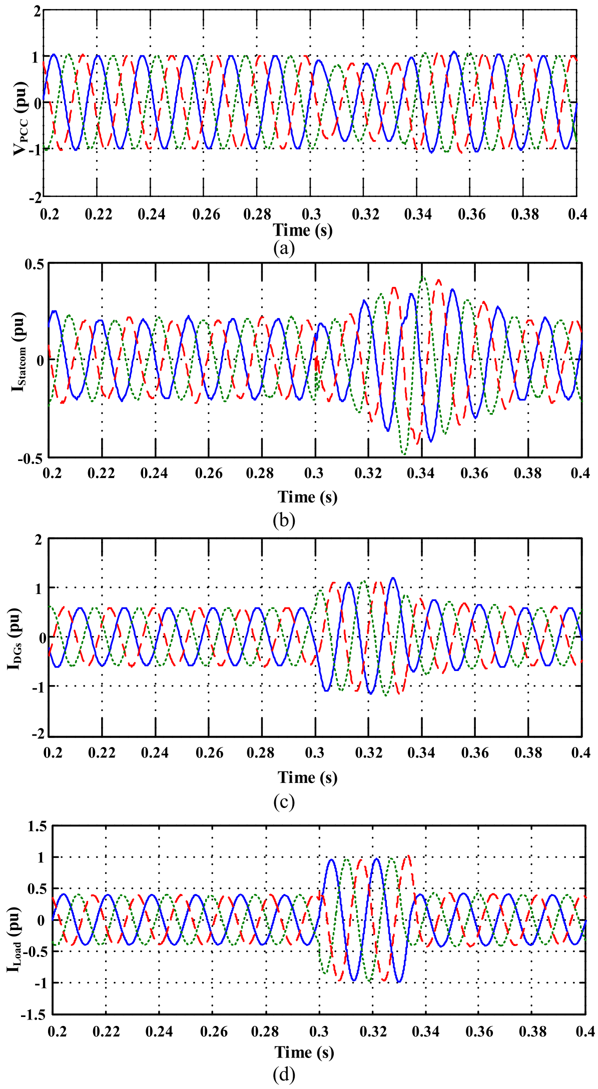

FIGURE 13. **System response for *scenario 2*, (a) Feeder 4 current, (b) DGs current, (c) STATCOM current, (d) Load current.**

C. SCENARIO 3: NON-LINEAR LOAD SWITCHING

Non-linear load switching condition is simulated and the results are illustrated in Fig. 12. Figure 12 shows performance of the microgrid with DSTATCOM under nonlinear loading conditions. Before switching, system loading condition was the same as *Scenario 1*. At $t = 0.6s$, a15kW (0.15pu) load was connected to F_5.Simulation results in Fig. 12 reveal that using the proposed algorithm, load harmonic distortions mitigation provided by DSTATCOM and the proposed strategy is able to balance distributed resources currents in nonlinear load switching condition.

D. SCENARIO 4: THREE-PHASE FAULT CONDITION

As the last part of study, three-phase fault condition is simulated. The system behavior due to a fault at $t = 0.3s$ in autonomous operation of the microgrid is shown in Fig.13. Pre-faulting, demand is similar to what discussed in *Scenario 1*. Figure 13(a) shows the PCC voltage before and after fault. It can be observed that the PCC voltage is dropped initially. Figure 13(b) shows the STATCOM current, the current of I_{DRs}. Fault currents (load current) are shown in Figures 13(c) and 13(d), respectively.

This section examined the dynamic behavior of a multi-DR microgrid system with DSTATCOM, under linear and nonlinear load switching, unbalanced load and three phase fault conditions. The voltage-base control strategy adjusts the reactive power output of DSTATCOM based on the PCC voltage of the microgrid. However, the current-base strategy is used to compensate the unbalanced currents of DRs. The simulation results of tested microgrid under all of the conditions validated the performance and robustness of the proposed control strategy.

VI. CONCLUSION

A novel online strategy for reactive power control of DSTATCOM using secondary control concept using the reinforcement learning algorithm in microgrid was introduced and discussed in this study. The main goal was to compensate the reactive power, harmonics and unbalanced load current. The proposed online reference control strategy was based on the voltage and current profile adjustment. The voltage controller acts through the monitoring of the PCC voltage magnitude and set point adjustment of reactive power reference of DSTATCOM, whereas the current-base controller injects the signals through quadrature axis (*q-axis*) and zero axis (*0-axis*) of VSC current controllers to compensate the unbalanced load current of DRs. The voltage-base strategy controls the voltage drop at the PCC, though, the current-base strategy controls the unbalanced current of distributed resources.

Various linear and nonlinear load switching, unbalanced load and fault conditions in a microgrid were simulated to evaluate the proposed technique capabilities. In load switching conditions, when the voltage of PCC exceeded desirable value, the voltage-base controller could improve the PCC voltage by variation of DSTATCOM reactive power generation reference. However, under unbalanced current conditions, the current-base control strategy mitigated unbalanced condition using the reference signal injection through *q* and *zero* axes of the PWM. The simulation results for different scenarios confirmed the performance of the proposed online secondary control strategy.

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