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A Novel Multiple-Objective Grid Integrated DG Scheme by Using FFR-CG Controller Based DSTATCOM

K. Ravi Sankar, V. Kamaraju, R. Srinivasa Rao

Abstract*: At present, the power distribution system faces several concerns like sudden-load interruptions and acquires proliferation of quality power due to usage of non-linear loads. The extensive recognition on active compensators is pre-requisite for enhancing the PQ features and sudden-load interruptions in a three-phase 3-wire power distribution system. The integration of renewable energy into distribution as Distributed Generation (DG) furnishes the stable power demand under grid-islanding and grid-interconnection cases. A multiple-objective DSTATCOM is the key choice for enhancing PQ features and maintains stable power demand in a distribution system by utilizing attractive control strategies. The classical control strategies are more adversed with extreme switching losses due to the presence of high-order harmonic frequencies in reference current sequences. This paper explores the novel fundamental frequency based current reference generation scheme for feasible functioning of DSTATCOM with greater efficiency and minimized switching losses. The critical performance of DSTATCOM with novel FFR-CG controller is validated in both PQ compensation and DG-Integration scheme by using Matlab/Simulink platform and simulation results are conferred with comparisons.

Index Terms*: Distributed Generation, Distributed Static Compensator, Fundamental Reference Current Generation Control Scheme, Power Quality Enhancement, Renewable Energy Sources.

I. INTRODUCTION

The growth of global population and utilization of power-electronic devices which consumes the electrical energy and demand of electrical energy has been extended to unpredicted levels. At present scenario, the electrical energy has been diminished due to limited fossil fuels, social, environmental and geographical issues [1], [2]. To fulfill these issues, several attempts have been constituted to meet the energy demand natively through Distributed Generators (DG's) [3]. The incredible establishment of DG scheme provides the greater energy demand, clean energy, sustain the stable real-power exchanging under sudden-load variations with the help of Renewable Energy Sources (RES) [4], [5]. Several renewable sources are Wind-Turbine (WT), Fuel-Cell (FC), Solar-Photovoltaic (SPV) systems, which are directly interfaced to grid system by employing power-conditioner systems.

The usage of massive power-electronic converters for attaining adjustable situations and impacts the power pollution which is strived very hard to maintain Power-Quality (PQ) features [6]. The power distribution system is highly affected from the voltage/current quality due to presence of harmonized switching frequencies coming from the non-linear characterized loads. The other PQ issue includes current harmonics, power-factor correction, reactive-power exchanging, un-balanced loads, etc. In general, these issues in distribution system are not new but, the perception of issues has been recently increased by load-side consumers.

The modern active compensator plays a significant role in power distribution system which involves power-electronic converters to eradicate the PQ issues and flexible power flow to loads [7]-[9]. Various modern active compensators are used to accommodate the PQ features such as clearly highlighted in [10]. Among, the DSTATCOM is integrated as shunt-interfaced device at near to PCC to compensate all current-related PQ issues such as harmonic current distortions, power-factor improvement, reactive-power exchanging, unbalanced-loading, neutral currents, etc [11]. The DSTATCOM administers the respective harmonic current sequences as in-phase compensation principle for generation of switching states with the help of reference current generation through attractive control strategy. It transforms the harmonized, unbalanced, reactive common-coupling area into equivalent balanced-linear resistive system is explored in [12].

Several researchers strive about the design and performance of DSTATCOM, *M. Barghi et al.* [13], explores the comprehensive review of various DSTATCOM configurations for mitigation of PQ issues in three-phase distribution systems. *M. Valappil et al.* [14], proposes a novel three-phase VSI based static compensator to mitigate effects from non-linear loads and unbalanced loading condition in a three-phase 4-wire distribution system with a recognized controller to maintain DC-link voltage as constant. The state of art, design and performance characteristics of various DSTATCOM configurations for PQ enhancement is studied in [15]. The main objective of control strategy is unique functioning and optimum performance of DSTATCOM through generation of reference current components to generate optimal switching pattern to acquire the certain compensation task.

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K. Ravi Sankar, Research Scholar & Associate Professor, Department of Electrical & Electronics Engineering, JNTUCE, Kakinada, India & LIET, Vizianagaram, Andhra Pradesh, India

Dr. V. Kamaraju, Professor, Department of Electrical & Electronics Engineering, Mahaveer Institute of Science and Technology, Bandlaguda, Hyderabad, Telangana, India

Dr. R. Srinivasa Rao, Professor, Department of Electrical & Electronics Engineering, University College of Engineering, JNTUK, Kakinada, Andhra Pradesh, India

The generalized several control strategies are recently reviewed by various literatures such as, Synchronous Reference Frame (SRF) theory, Instantaneous Active-Reactive (IPQ) Power theory, Id-Iq theory, etc. *N. Geddada et al.* [16], explores the new sinusoidal pulse-width modulation based DTSTACOM for non-linear un-balanced load compensation by utilizing the SRF control theory under steady state and dynamic conditions. *S. S. Pawar et al.*, presents the modeling and simulation analysis of DSTATCOM topology for mitigating the current harmonics, un-balanced loading, reactive power compensation, power-factor correction, voltage sag-swell mitigation, etc., by utilizing IPQ theory [17]. The classical control strategies furnishes the reference current sequence, it consists of extreme harmonized frequencies which results the greater dv/dt switch stress, high switching losses, minimizes the over-all DSTATCOM efficiency.

The proposed multi-purpose Distributed Static Compensator (DSTATCOM) reduces the necessity of additional DG-VSI topology and minimizes the over-all compensation costs which increases the power demand capability. The primary task of proposed D-STATCOM is harmonic elimination, reactive power improvement, power-factor correction, unbalanced load, and compensates all current related issues. The secondary task of D-STATCOM is integration of co-generation system into local load as DG-inverter for regulate the sudden load demand, etc.

In this paper, CO-generation based solar PV and Wind Conversion scheme is used as secondary source of grid-connected DG system integrated to PCC level. But the output of these two source are varied with respect to changes in wind flow and light intensity of SPV arrays which affects the output of DG-VSI and affects the DC-link voltage as un-constant, may create un-balanced grid voltages. For regulating, the above-mentioned issues, a novel Fundamental Frequency Based Reference Current Generation (FFR-CG) controller is designed to extract the reference current sequences at fundamental switching frequency with low dv/dt switch stress, low switching loss and maximize the overall compensator efficiency. The performance evaluation of proposed FFR-CG controller is verified under PQ compensation and DG integration scheme by using Computer-Simulation platform, results are conversed with attractive comparisons.

II. PROPOSED MULTI-OBJECTIVE DSTATCOM CONFIGURATION

The DSTATCOM is integrated near to the PCC in a three-phase distribution system as PQ-mode to compensate all current-related issues like eradication of current harmonics, reactive-power exchanging, load-balancing, neutral current elimination and power factor correction, etc. The DSTATCOM is interfaced into three-phase distribution system to drive the balanced non-linear load and sudden interrupted load. It comprises of various elements such as, DC-link capacitor as C_{vdc}, three-phase voltage-source inverter (VSI) as PQ-VSI is designed by MOSFET switches, line-interfacing filter R_{Labc} circuit, sensing elements, reference current generator, gate-pulse switching circuitry, etc. The block diagram of proposed DG-integrated DSTATCOM topology at PCC of three-phase 3-wire distribution system is illustrated in Fig.1.

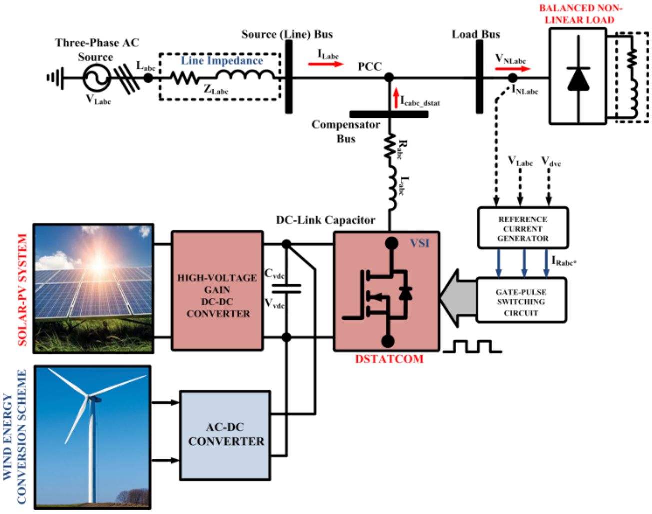

Fig.1 The Block Diagram of Proposed DSTATCOM Topology with DG Integration Scheme

In this scheme grid is supporting the dual non-linear loads, at initial stage load-1 is connected and the other load is connected suddenly at a time of 0.2 sec<t<0.4 sec. Due to this sudden switching of additional load apparatus, the requirement of load current is extracted from the grid which affects the PCC and requirement of load power was increased. During DG-mode, VSI is operated in voltage-controlled mode as DG-VSI to provide active-power to the load. Generally, the DG scheme requires additional source as battery energy storage system (BESS), but it requires additional charge management schemes. Over the BESS, the renewable energy plays a significant role in DG schemes, in that SPV-Wind is the major power producer as CO-generation scheme [11]. The SPV-Wind is the primary source of VSI, commonly which is integrated to DC-link capacitor C_{dc} by utilizing high-voltage gain DC-DC converter. This boost converter transforms the low-level SPV-Wind voltage into high-level required voltage to drive the VSI of STATCOM and sustains DC-link voltage V_{dc} as constant [12]. The appearance of DSTATCOM is typically adopted from active-filtering technique working based on in-phase current injection methodology at PCC level of distribution system. A front-ended line-interfacing second-order filters are pre-requisite for griddling the harmonic components to acquire the active-compensation principle with superior control functions. The significant control strategy provides the optimal switching states to DSTATCOM by sensing the accurate values of load and source parameters by using signal analyzers.

III. PROPOSED FUNDAMENTAL FREQUENCY BASED REFERENCE CURRENT GENERATION (FFR-CG) CONTROL STRATEGY

The proposed FFR-CG control strategy is same as classical SRF theory; a dual conversion process is designed based on correlation between the stationary reference and rotating switching components. The phase sequences of non-linear load currents (i_{NLabc}) is converted into stationary frame as $(I_{NL\alpha\beta})$ by using Clarke's conversion technique.

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These coordinates are again converted into rotating reference frame as (i_{NLdq}) by utilizing angle "θ", as conversion angle which is pretended as $\frac{d\theta}{dt}$ due to non-constant of un-balanced and harmonic components. This dual conversion process is established to attain the decoupled action between the active-reactive sequences converting the three-phase quantities *abc* into two-phase *dq* quantities. The representation of direct axis as d-axis and quadrature as q-axis is positioned based on angle "θ" which is generated by Phase-Locked Loop (PLL). The sensed non-linear load currents (i_{NLabc}) at load-bus is converted into *dq* quantities as (i_{NLdq}), these are attained by arbitration process of $(\alpha\beta)$ coordinates as $(i_{NL\alpha\beta})$, the equations are illustrated in Eqn. (1), Eqn. (2) and Eqn. (3).

$$\begin{bmatrix} i_{NLd} \\ i_{NLq} \end{bmatrix} = \frac{2}{3}\begin{bmatrix} \cos(\theta) & \cos\left(\theta - \frac{2\pi}{3}\right) & \cos\left(\theta + \frac{2\pi}{3}\right) \\ \sin(\theta) & \sin\left(\theta - \frac{2\pi}{3}\right) & \sin\left(\theta + \frac{2\pi}{3}\right) \end{bmatrix}\begin{bmatrix} i_{NLa} \\ i_{NLb} \\ i_{NLc} \end{bmatrix} \quad (1)$$

$$\begin{bmatrix} i_{NL\alpha} \\ i_{NL\beta} \end{bmatrix} = \frac{2}{3}\begin{bmatrix} 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix}\begin{bmatrix} i_{NLa} \\ i_{NLb} \\ i_{NLc} \end{bmatrix} \quad (2)$$

$$\begin{bmatrix} i_{NLd} \\ i_{NLq} \end{bmatrix} = \begin{bmatrix} cos\omega t & sin\omega t \\ -sin\omega t & cos\omega t \end{bmatrix}\begin{bmatrix} i_{NL\alpha} \\ i_{NL\beta} \end{bmatrix} \quad (3)$$

The dual conversion of non-linear load currents on *dq* frame is illutsrated in Eqn. (4),

$$\begin{bmatrix} i_{NLd} \\ i_{NLq} \end{bmatrix} = \begin{bmatrix} \overline{i_{LNd}} + \widetilde{i_{NLd}} \\ \overline{i_{NLq}} + \widetilde{i_{NLq}} \end{bmatrix} \quad (4)$$

From the above-mentioned Eqn. (6) is in *dq* reference frame, the second-order Low-Pass Filter (SO-LPF) is highly recognized for extracting the harmonic elements of $\widetilde{i_{NLd}}$, $\widetilde{i_{NLq}}$ from desired non-linear load currents. The SO-LPF cut-off frequency range is defined based on partly of line fundamental frequency. This SO-LPF minimizes the higher-order switching frequencies and permits the other frequencies into control functions as generation of reference-currents. Since, the main source doesn't supply reactive power to the non-linear load, thus the d-quantities $(\overline{i_{NLq}}\ \widetilde{i_{NLq}})$ are set as zero (0), the respective form is defined in Eqn. (5),

$$\begin{bmatrix} i_{NLd} \\ i_{NLq} \end{bmatrix} = \begin{bmatrix} \overline{i_{NLd}} + \widetilde{i_{NLd}} \\ 0 \end{bmatrix} \quad (5)$$

The active current component (Δ_{iNLd}) is generated by DC-link controller with the help of PI regulator, the mathematical formations as shown in Eqn. 2 and Eqn. 5. The fundamental filtered current $(\widetilde{i_{NLd}})$ are assimilated to furnish the reference current component in *dq*-frame. The attained reference currents are in *dq*-frame can be re-converted into *abc* quantities as (i^*_{Rabc}) is illustrated in Eqn. (6) & Eqn. (7).

$$\begin{bmatrix} i_{NL\alpha} \\ i_{NL\beta} \end{bmatrix} = \begin{bmatrix} cos\omega t & -sin\omega t \\ sin\omega t & cos\omega t \end{bmatrix}\begin{bmatrix} i_{NLd} \\ i_{NLq} \end{bmatrix} \quad (6)$$

$$\begin{bmatrix} i^*_{Ra} \\ i^*_{Rb} \\ i^*_{Rc} \end{bmatrix} = \frac{2}{3}\begin{bmatrix} 1 & 0 \\ -1/2 & \sqrt{3}/2 \\ -1/2 & -\sqrt{3}/2 \end{bmatrix}\begin{bmatrix} i_{NL\alpha} \\ i_{NL\beta} \end{bmatrix} \quad (7)$$

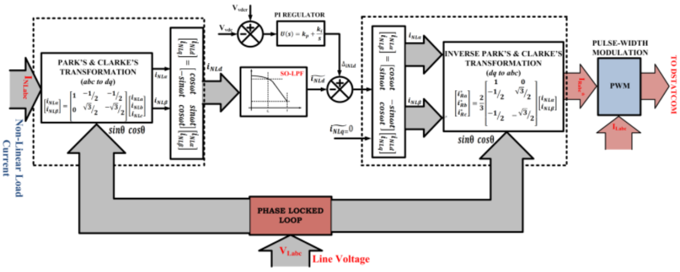

Fig.2 Schematic Diagram of Proposed FFR-CG Control Strategy for DSTATCOM Topology

The schematic diagram of proposed FFR-CG control strategy for DSTATCOM topology is depicted in Fig.2. The reference current (i^*_{Rabc}) coming from FFR-CG control strategy is used to generate the optimal switching states to DSTATCOM by using Hysteresis Current Controller (HCC). The HCC is pre-requisite to generate optimum switching pattern by using pre-defined HCC band limits. These limits treated as boundaries of DSTATCOM injected current which is controlled by upper/lower HCC limits to produce the switching states to respective switches in VSI of DSTATCOM depended by actual and reference current sequences. The switches in VSI's are controlled by reference current, switch is conducted when the actual current is greater than reference current, and other-wise switch is un-conducted. Moreover, the actual current component is swinging continuously in between the HCC bands followed by acquired reference current furnished by FFR-CG control strategy. The Over-all schematic diagram of proposed Co-generation based DG integrated DSTATCOM with FFR-CG controller is depicted in Fig.3.

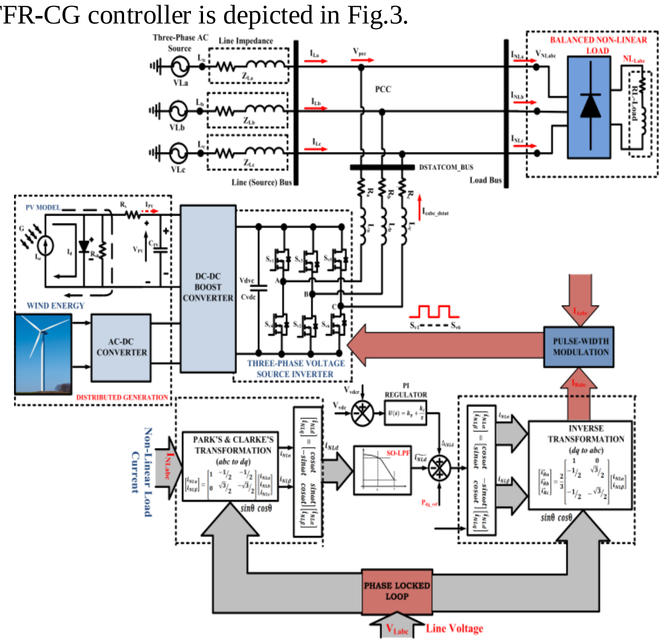

Fig.3 Over-all Schematic Diagram of CO-Generation based DG Integrated DSTATCOM with Proposed FFR-CG Controller

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IV. CO-GENERATION SCHEME

Two or more renewable energy sources are connected to a grid connected system as hybrid or CO-generation electrical power system. In this paper dual SPV-Wind energy sources are used for providing energy to the loads under sudden interruptions coming from additional load with the help of MB-DSTATCOM.

A. Solar PV System

Harnessing the electric energy from SPV system furnishes the clean energy, extensive nature in present climatic situations, pollution free, long life, greater efficiency characteristics are the key merits of SPV system. The solar PV energy is primary energy source in CO-generation system and it relies on the photo-electric effect to produce the electrical energy [20], [21]. In the dark circumstances of the PV cell is akin of normal diode, when the sun-light energy is higher than the semi-conductor energy gap which provides the cell electrons becomes free and existed current travels through external circuitry. As PV cell have low voltage and more fragile, formed as modules and securing with an enclosed metallic case. Based on the requirement power levels, the PV cells are integrated as series and/or parallel to form as solar PV-array. The mathematical model of the PV cell is extracted by single-diode model as depicted in Fig.4. The outcome of the PV cell resulted based on the physical attraction of the PV cell is relating with the I_{sv}, I_{phv}, R_{sv}, from the irradiation & temperature over the other.

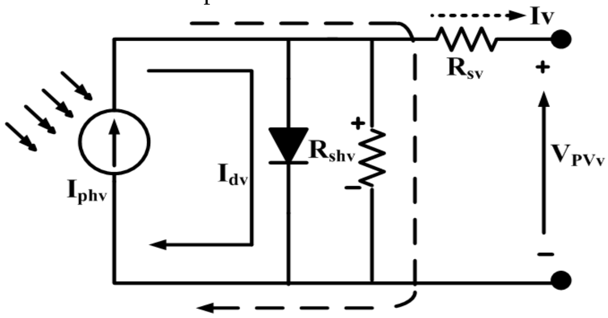


Fig.4 Mathematical model of Solar PV System

$$Iv = I_{phv} - \left(I_{sv}\left[\exp q\,\frac{(V_{PVv}+R_{sv}Iv)}{NKT}\right] - 1\right) - \left[\frac{V_{PVv}+R_{sv}Iv}{R_{shv}}\right] \tag{8}$$

The Eqn.1 illustrates the current equation of PV cell,
Where,
I_{phv} - Photovoltaic current in amps (A)
I_{sv} - Diode's reverse saturation current in amps (A)
q - Electron charge
V_{PVv} - Terminal voltage of the diode in volts (V)
K - Boltzmann's constant value
T - Junction wise temperature
N - Ideality index factor of diode
R_{shv} - Shunt resistance of PV cell in ohms (Ω)
R_{sv} - Series resistance of PV cell in ohms (Ω)

B. Wind Energy System

The Wind-Energy scheme acts as secondary source and it comprises of induction generator [22], [23], due to variable speeds and no need of any additional field excitation circuits. The available wind energy is

$$P_w = \frac{1}{2}\rho A V_w^3 \tag{9}$$

Where, ρ is air-density, A is area of turbine, V_w is wind speed and impossible to extract the kinetic energy of wind, its extraction in terms of fraction of power in wind known as,

$$P_m = C_p P_w \tag{10}$$

$$P_m = C_p \frac{1}{2}\rho A V_w^3 \tag{11}$$

Then $A = \pi R^2$

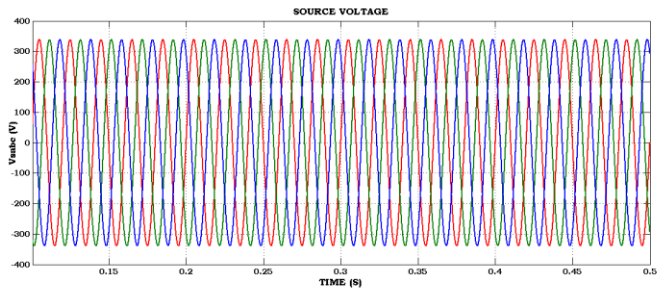
V. MATLAB/SIMULINK RESULTS

The Matlab/Simulink analysis is carried-out based on performance of DSTATCOM in both PQ-mode & DG-mode by using proposed FFR-CG control strategies in a three-phase 3-wire distribution system with the help of computer-simulation tool. Simulation results are carried, the system specifications of proposed FFR-CG based DSTATCOM is illustrated in Table.1.

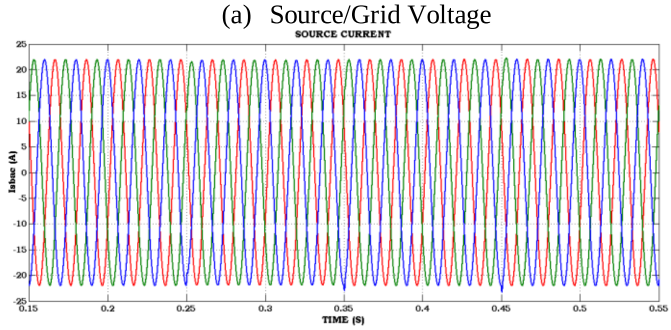
Table 1. System Specifications of FFR-CG based DSTATCOM

S.No	Parameters	Values
1	Source Voltage	415V, 50 Hz
2	Source Impedance	0.1+j0.9Ω
3	Load Impedance	30+j30Ω
4	DC-Link Capacitor	4000µF
5	VSI Filter Units	R-0.1; L-5mH
6	PI Controller Gains	Kp-0.8; Ki-0.5
7	DG Power	Pdg-30KW, Vdg-880V

A. Performance of Multi-Objective DSTATCOM by using proposed FFR-CG Control Scheme under PQ-mode (PQ-VSI)



(a) Source/Grid Voltage



(b) Source/PCC Current

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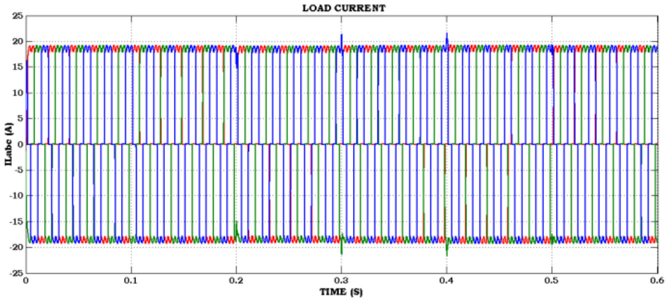
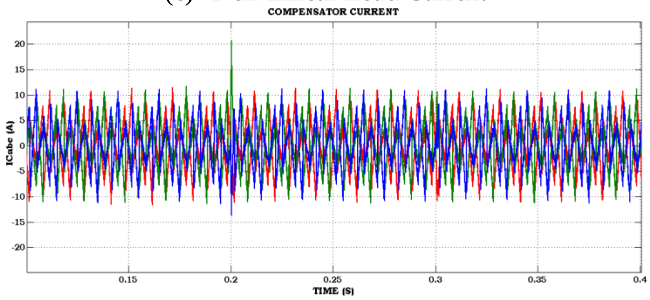
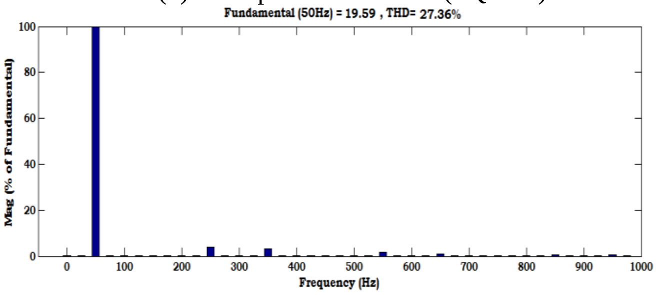


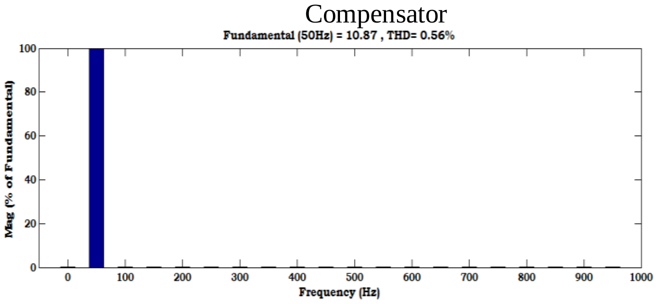
(c) Non-Linear Load Current



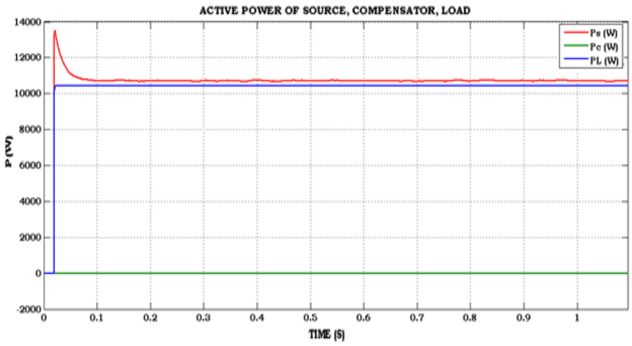
(d) Compensator Current (PQ-VSI)



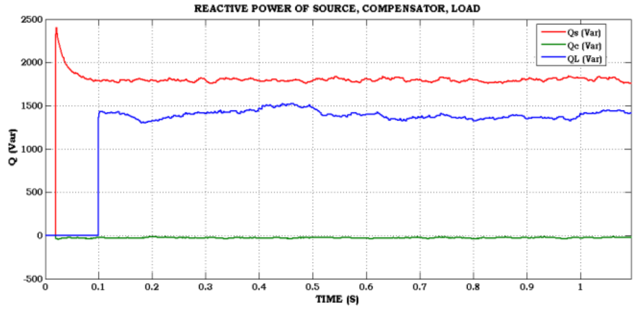
(e) FFT Spectrum of Source Current without Compensator



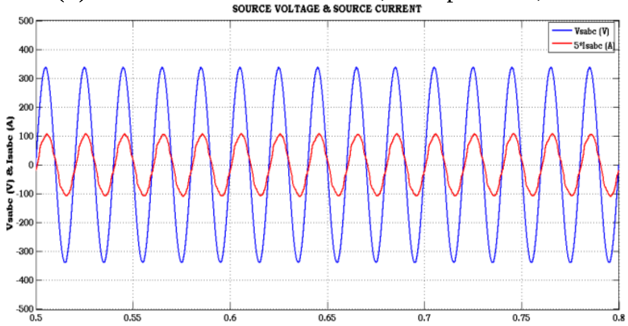
(f) FFT Spectrum of Source Current with Compensator



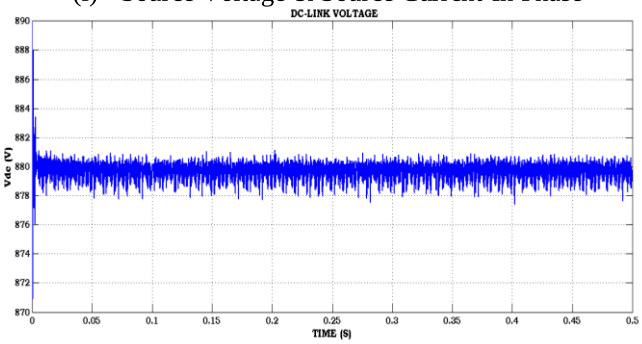
(g) Active Power of Source, Compensator, Load



(h) Reactive Power of Source, Compensator, Load



(i) Source Voltage & Source Current-In Phase



(j) DC-Link Voltage

Fig.5 Simulation Results of Multi-Objective DSTATCOM by using proposed FFR-CG Controller under PQ-mode

The simulation results of Multi-Objective DSTATCOM by using proposed FFR-CG controller under PQ-mode as depicted in Fig.5. In that, (a) Source/Grid Voltage, (b) Source/PCC current, (c) Non-Linear Load Current, (d) Compensator Current (PQ-VSI), (e) FFT Spectrum of Source Current without Compensator, (f) FFT Spectrum of Source Current with Compensator, (g) Active Power of Source, Compensator, Load, (h) Reactive Power of Source, Compensator, Load, (i) Source Voltage & Current-in-phase condition defines the Unity Power-Factor, (j) DC-Link Voltage, respectively. Here, load treated as Non-Linear load considering the Diode-Bridge Rectifier (DBR) driven by three-phase distribution system supplies the 415V, 50Hz. It affects the source current at PCC level and creates series concerns to adjacent loads which are connected near to PCC point. The MB-DSTATCOM operated in PQ-mode for compensating the current harmonics at PCC and acquires fundamental & pure sinusoidal quantities which are in-phase to source voltage represented as unity-power factor (for clear view the value of source current is increased to 5 times). The FFT spectrum of source current without Compensator is 27.36% and with compensator is 3.22%, these are in IEEE limitations.

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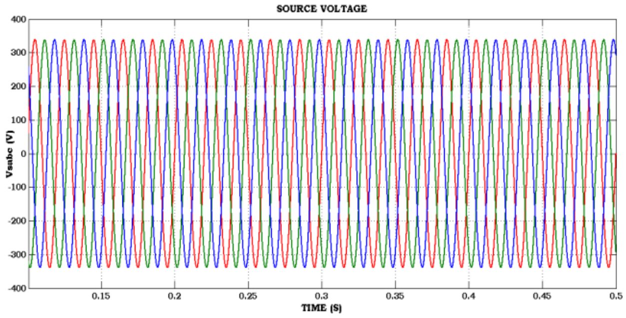
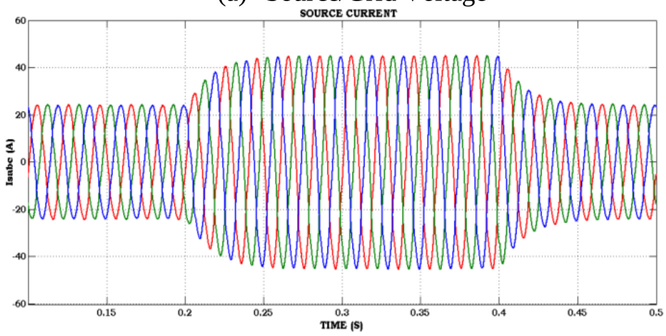
The DC-link voltage is maintained as constant with a value of 880V, the active power of source (Ps) is maintained as 11KW, Load active power (P_L) is 10.4KW, and compensator (P_C) is 0KW because of operated in PQ-mode. The reactive power of source (Qs) is maintained as 1.81KVar, Load active power (Q_L) is 1.4KVar, and compensator (Q_C) is 0KVar because of operated in PQ-mode.

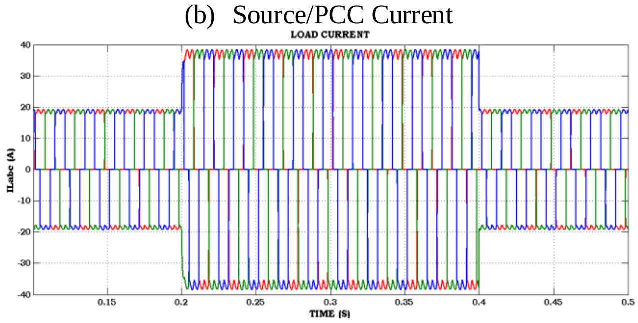
B. Performance of Multi-Objective DSTATCOM by using proposed FFR-CG Control Scheme under Sudden-Load Interruptions without DG Integration



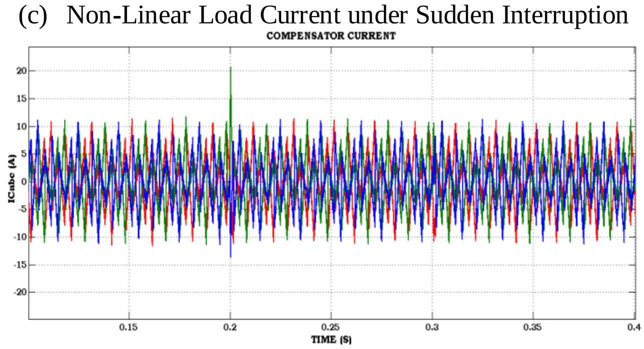
(a) Source/Grid Voltage



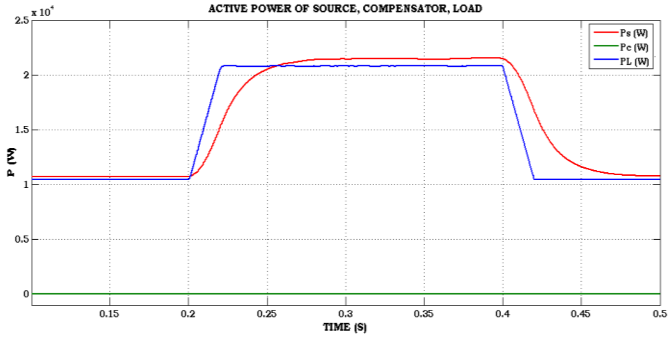
(b) Source/PCC Current



(c) Non-Linear Load Current under Sudden Interruption



(d) Compensator Current without DG

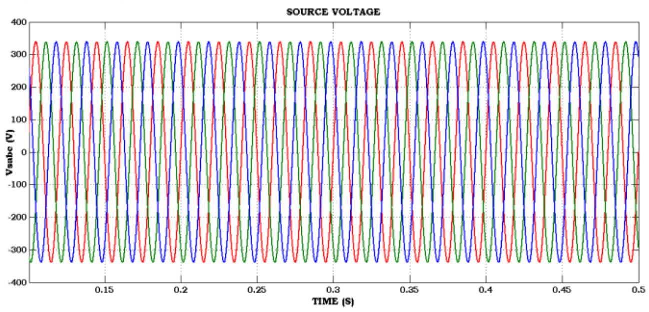


(e) Active Power of Source, Compensator, Load

Fig.6 Simulation Results of Multi-Objective DSTATCOM by using proposed FFR-CG Controller under Sudden-Load Interruptions without DG

The simulation results of Multi-Objective DSTATCOM by using proposed FFR-CG controller under Sudden-Load Interruptions without DG as depicted in Fig.6. In that, (a) Source/Grid Voltage, (b) Source/PCC current, (c) Non-Linear Load Current under Sudden Interruptions, (d) Compensator Current without DG, (e) Active Power of Source, Compensator, Load, respectively. In normal, condition the source voltage is maintained as 415V, 50 Hz supply with a source/PCC current of 20A. During sudden-load interruptions in load current at 0.2 sec<t<0.4sec, the current is suddenly increased to 39.5A. The requirement of additional load demand is supported by utility source only; in this way the adjacent loads connected at PCC are affected. In this way, the compensator never supported and acts as PQ-mode with a constant current value of 10A. In this condition, the PQ-VSI is inadequate to supply the pre-requisite of additional energy to acquire the load active power. During normal situation (before 0.2 sec), the active power of source (P_s) is maintained constant with a value of 11KW, Load active power (P_L) is 10.4KW, and compensator (P_C) is 0KW because of operated in PQ-mode. In sudden-load situation between 0.2 sec<t<0.4 sec, the active power of source (P_s) is increased with a value of 20.1KW, Load active power (P_L) is 20.1KW, and compensator (P_C) is 0KW, it requires extra active-power to support the load in sudden interruptions.

C. Performance of Multi-Objective DSTATCOM by using proposed FFR-CG Control Scheme under Sudden-Load Interruptions with DG Integration (DG-VSI)



(a) Source/Grid Voltage

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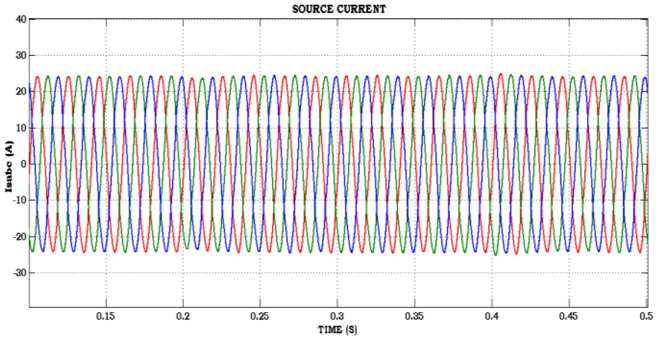
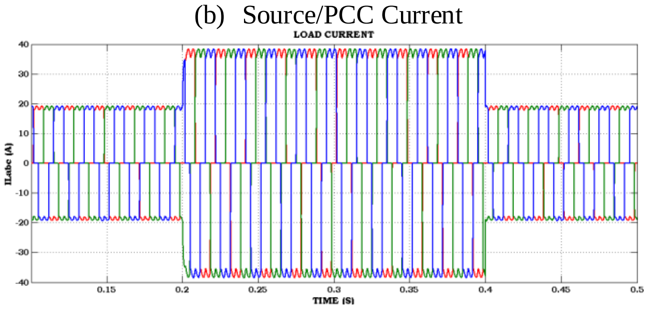
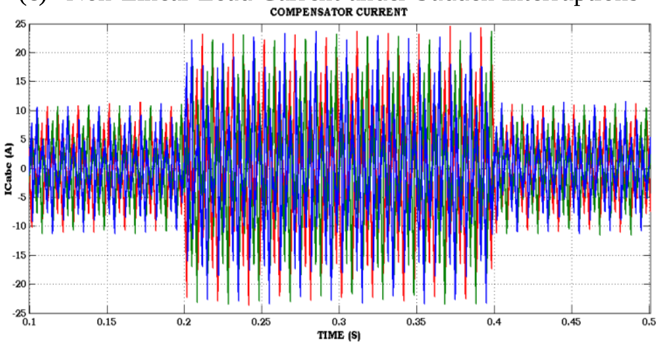


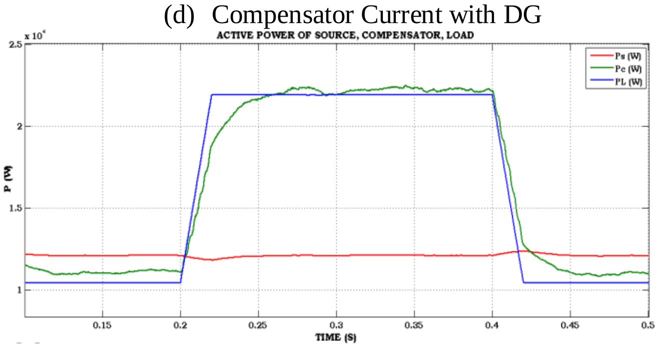
(b) Source/PCC Current



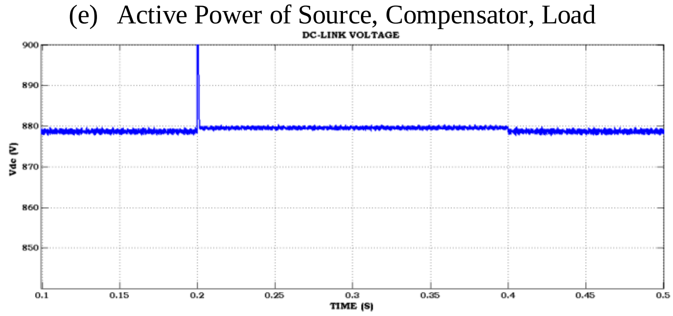
(c) Non-Linear Load Current under Sudden Interruptions



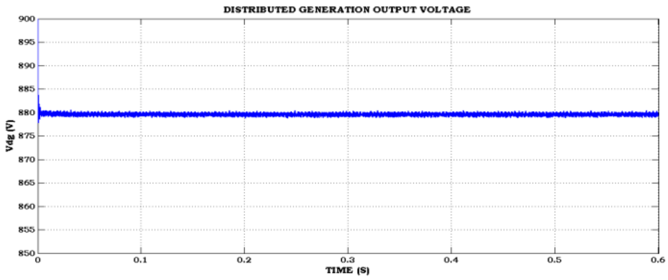
(d) Compensator Current with DG



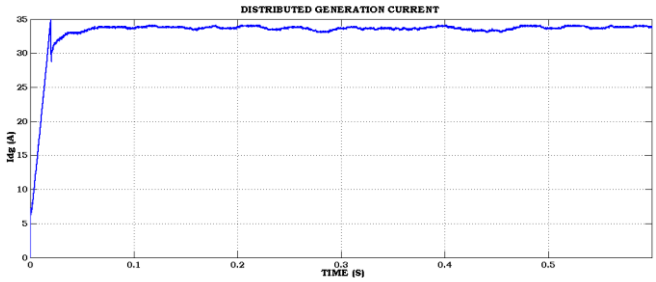
(e) Active Power of Source, Compensator, Load



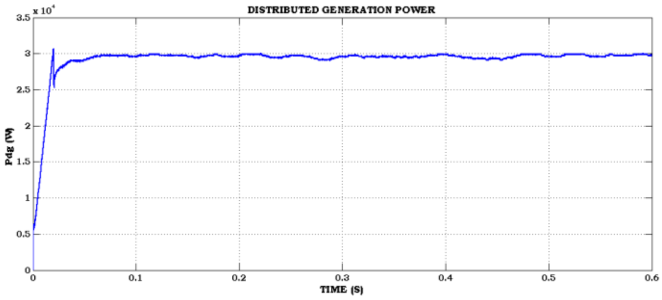
(f) DC-Link Voltage



(g) DG Voltage



(h) DG Current



(i) DG Power

Fig.7 Simulation Results of Multi-Objective DSTATCOM by using proposed FFR-CG Controller under Sudden-Load Interruptions with DG Integration

The simulation results of Multi-Objective DSTATCOM by using proposed FFR-CG controller under Sudden-Load Interruptions with DG as depicted in Fig.7. In that, (a) Source/Grid Voltage, (b) Source/PCC current, (c) Non-Linear Load Current under Sudden Interruptions, (d) Compensator Current without DG, (e) Active Power of Source, Compensator, Load, (f) DC-Link Voltage, (g) DG Voltage, (h) DG Current, (i) DG Power, respectively. During sudden-load interruptions in between 0.2sec<t<0.4sec load currents are suddenly increased to 39.5A due to additional load is connected. Due to this additional load change, the pre-requisite of extra energy is supplied by DG-VSI compensator which un-affects the other loads integrated near to PCC implies the continuity of supply. In these sudden-load changes, the MB-DSTATCOM acts as DG-mode and supports required energy to load provided by CO-generation Scheme based PV+Wind energy system to attain rated active power to the load. The additional 20A current is injected by DG-VSI by utilizing PV+Wind source to maintain load current as 40A and other adjacent loads are un-affected. During sudden interruptions between 0.2sec<t<0.4sec the source active power (P_s) is increased with a value 10.81 KW, the load active power (P_L) is maintained as constant with a value 20.

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21 KW supported DG scheme, the DG-VSI of active power (P_c) is 20.21KW supported by DG-VSI functioning by DG controller. The solar PV+Wind Energy Co-generation scheme is operated with power-conditioning system which generates the high-level voltage nearly 880V, which is integrated at common DC-link point and the DG current is nearly 33.5A and the DG power is nearly 30KW to achieve the load when entire grid was interconnected and/or islanding mode.

Table 2. THD Comparisons under Classical SRF/IPQ Control Strategies over Proposed FFR-CG based DSTATCOM for PQ Enhancement

Parameter (THD %)	Classical SRF Control Theory[18]	Classical IPQ Control Theory[19]	Proposed FFR-CG Control Theory
Line Current	1.98%	1.14%	0.56%
Load Current	27.36%	27.36%	27.40%
Compensation Current	407.95%	330.86%	0.39%

The THD comparisons under classical SRF/IPQ control strategies over proposed FFR-CG based DSTATCOM for PQ enhancement in a three-phase 3-wire distribution system is illustrated in Table.2. The proposed FFR-CG control strategy provides the best compensation characteristics over the classical SRF/IPQ controllers. Mainly, the THD of line current attains very accurate value and the THD of compensator injected/reference current has very reduced value over the classical SRF/IPQ theories, both the values are complying with IEEE-standard limits. The graphical view of THD comparisons is shown in Fig.8, the proposed FFR-CG has good compensation characteristics and it is best suited for any compensator to control the dynamics in power distribution system.

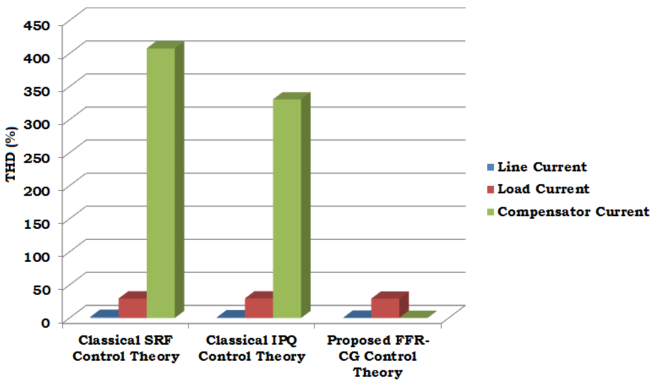

Fig.8. Graphical View for Comparisons of THD vs Various Control Strategies under Different Parameters

VI. CONCLUSION

The proposed FFR-CG control objective furnishes the optimum switching signals to MB-DSTATCOM operated in both PQ-VSI mode for PQ enhancement and DG-VSI mode for active-power control by using Co-Generation based PV+Wind System. The proposed MB-DSTATCOM doesn't requires any additional control functions and VSI modules for active power control which implies the compensation characteristics at reduced cost. The proposed FFR-CG control strategy is used for generation of optimal switching pattern to VSI of DSTATCOM in a three-phase 3-wire distribution system over the classical SRF/IPQ controllers. The switching states acquired from fundamental reference current generator provides the favourable merits such as low switch dv/dt stress, low switching losses, greater efficiency, low THD in reference currents, etc. A result shows the proposed MB-DSTATCOM as PQ-VSI and DG-VSI modes with the help of Computer Simulation tool. The FFT spectrum of source current in various control functions is well within IEEE standards. An functioning of MB-DSTATCOM is very attractive for both PQ compensation and DG-integration to regulate the various concerns in both grid-integration scheme and grid-islanding scheme.

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