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PERFORMANCE IMPROVEMENT OF EXTERNAL INDUCTOR BASED VOLTAGE CONTROLLED DSTATCOM USING FUZZY LOGIC CONTROLLER

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Abstract— This project proposes a new algorithm to generate reference voltage for a distribution static compensator (DSTATCOM) operating in voltage-control mode. The proposed scheme exhibits several advantages compared to traditional voltage-controlled DSTATCOM where the reference voltage is arbitrarily taken. A distribution static compensator (DSTATCOM) is used for load voltage regulation and its performance mainly depends upon the feeder impedance and its nature (resistive, inductive, stiff, non-stiff). This project aims to provide a comprehensive study of design, operation, and flexible control of a DSTATCOM operating in voltage control mode. A detailed analysis of the voltage regulation capability of DSTATCOM under various feeder impedances is presented. Then, a standard design process to work out the value of external inductor is offered. A dynamic reference load voltage generation scheme is also developed which allows DSTATCOM to compensate load reactive power during normal operation, in addition to providing voltage support during disturbances. Simulation results are validating the effectiveness of the proposed scheme using Matlab/Simulink software.

Index Terms— Distribution Static Compensator (DSTATCOM), Current Control, Voltage Control, PowerFactor,PowerQuality,FuzzyLogicController

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I. INTRODUCTION

The fast growth and reputation of power electronics technology lead to wide use of industry loads which posses' power quality (PQ) issues. The power quality is primarily exaggerated due to current harmonics introduced by the nonlinear loads into the distribution network. The PQ issues featured with harmonic distortion, low power factor and phase disproportion produce astonishing turbulence in the function of electrical equipment . Conventionally, static capacitors and passive filters have been employed to enhance PQ in distribution system. Nevertheless, these frequently have issues like fixed compensation, system parameters dependent performance and probable resonance with line reactance . Owing to this the capability to even out the transmission systems and to enhance PQ in distribution systems is showed . Distribution Static synchronous compensator (DSTATCOM) is prevalently acknowledged as a consistent reactive power controller substituting traditional VAR compensators, like

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the thyristor-switched capacitor (TSC) and thyristor controlled reactor (TCR). This device endow with reactive power compensation, active power oscillation damping, flicker attenuation, voltage regulation .DSTATCOM is a component of Flexible AC Transmission Systems (FACTS) family that is associated in shunt with the power system . By controlling the magnitude of the DSTATCOM voltage, the reactive power interactions between the DSTATCOM and the transmission line control the quantity of shunt compensation in the power system . The DSTATCOM is a power electronics device depends on the law of injection or absorption of reactive current at the point of common coupling (PCC) to the power network. The benefit of the DSTATCOM is that the compensating current does not depend on the voltage level of thePCC and thus the compensating current is not minimized as the voltage drops. Thesupplementary motive for choosing a DSTATCOM as an alternative of an SVC are on the wholesuperior operational features, faster performance, lesser size, cost minimization and thecapability to give both active and reactive power, thereby providing flexible voltage control forpower quality enhancement .The load compensation using a DSTATCOM one of the device. The load compensation using a DSTATCOM one of the major considerations is the generation of the reference compensator currents. Power quality problems include high reactive power burden, harmonic currents and load unbalance . Owing to the widely application of power converters in the industry products, power pollution has been serious problem in the distribution system. The power pollution due to large non-linear loads low power factor, low efficiency of power system, voltage distortion and losses in the transmission and distribution lines. In a DSTATCOM, generally, the DC capacitor voltage is regulated using a PI controller when various control algorithms are used for load compensation . However, during load changes, there is considerable variation in DC capacitor voltage which might affect compensation. In this work, a fuzzy logic based supervisory method is proposed to improve transient performance of the DC link. Now a day there has been growing interest in applying fuzzy theory to controller design in many engineering fields. In recent years, fuzzy logic controllers have gained much attention for various applications. The main advantage in use of FLCs is to allow designers to incorporate experimental knowledge in adjustment of controlling parameters. The mamdani type FLCs have been reported for the DSTATCOM but it requires large number of fuzzy sets. In authors have used fuzzy controller for control of power filter . The fuzzy controller has very attractive features over conventional controllers. It is easy to be implemented in a large scale nonlinear dynamic system and not so sensitive to the system models, parameters and operation conditions. In particular human knowledge can be included in control rules with ease . Therefore investigation of fuzzy theory application in power system control grows rapidly. In this paper fuzzy logic controller for distribution Static compensator is implemented.

II. DSTATCOM IN POWER DISTRIBUTION SYSTEM

Fig.1 shows power circuit diagram of the DSTATCOMtopology connected in distribution system. Ls and Rs aresource inductance and resistance, respectively. An externalinductance, L_{ext} is included in series between load andsource points. This inductor helps DSTATCOM to

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achieve loadvoltage regulation capability even in worst grid conditions,i.e., resistive or stiff grid. From IEEE-519 standard, pointof common coupling (PCC) should be the point which isaccessible to both the utility and the customer for directmeasurement . Therefore, the PCC is the point where $L_{ext}$is connected to the source. The DSTATCOM is connected atthe point where load and L_{ext} are connected. The DSTATCOMuses a three-phase four-wire VSI. A passive LC filter isconnected in each phase to filter out high frequency switchingcomponents. Voltages across dc capacitors, V_{dc1} and V_{dc2}, aremaintained at a reference value of V_{dcref}.

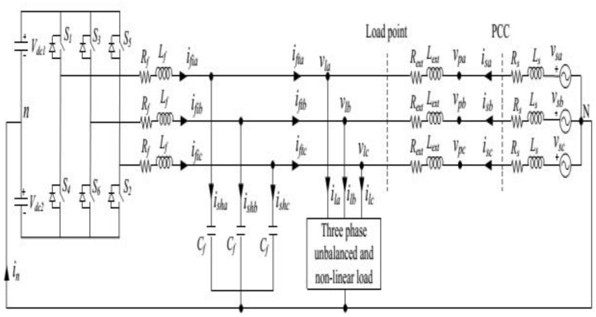

Fig.1. Three phase equivalent circuit of DSTATCOM topology in distribution system

III. EFFECT OF FEEDER IMPEDANCE ON VOLTAGE REGULATION

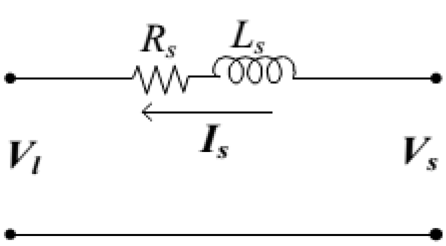

Fig.2. Equivalent source-load model without considering external inductor

To demonstrate the effect of feeder impedance on voltage regulation performance, an equivalent source-load modelwithout considering external inductor is shown in Fig.2. Thecurrent in the circuit is given as

$$\boldsymbol{I}_s = \frac{\boldsymbol{V}_s - \boldsymbol{V}_l}{\boldsymbol{Z}_s} \quad (1)$$

where Vs = Vs∠δ, V l = Vl∠0, Is = Is∠φ, and Zs =Zs∠θs, with Vs, Vl, Is, Zs, δ, φ, and θs are rms source voltage, rms load voltage, rms source current, feeder impedance, loadangle, power factor angle, and feeder impedance angle, respectively. The three phase average load power (Pl) is expressedas

$$P_l = Real\left[3\,\boldsymbol{V}_l \times \boldsymbol{I}_s{}^*\right] \quad (2)$$

Substituting V_l and I_s in (2), the load active power is

$$P_l = \frac{3V_l^2}{Z_s}\left[\frac{V_s}{V_l}\cos(\theta_s - \delta) - \cos\theta_s\right] \quad (3)$$

Rearranging (3), expression for δ is computed as follows:

$$\delta = \theta_s - \cos^{-1}\left[\frac{V_l}{V_s}\left(\cos\theta_s + \frac{P_l Z_s}{3V_l^2}\right)\right] \quad (4)$$

For power transfer from source to load with stable operationin an inductive feeder, δ must be positive and less than 90◦.Also, all the terms of the second part of (4), i.e., insidecos−1, are amplitude and will always be positive. Therefore,value of the second part will be between ‘0’ to ‘π/2’ for theentire operation of the load. Consequently, the load angle will ie between θs to (θs - π/2) under any load operation, andtherefore, maximum possible load angle is θs.

The vector expression for source voltage is given as follows:

$$\boldsymbol{V}_s = V_l + I_s Z_s \angle(\theta_s + \phi) \quad (5)$$

A DSTATCOM regulates the load voltage by injectingfundamental reactive current. To demonstrate the DSTATCOMvoltage regulation capability at different supply voltages fordifferent Rs/Xs, vector diagrams using (5) are drawn in Fig.3. To draw diagrams, load voltage V_l is taken as referencephasor having the nominal value OA (1.0 p.u.). With aim of making $V_l = V_s = 1.0$ p.u., locus of Vs will be a semicircle ofradius V_l. Since, the maximum possible load angle is 90◦ inan inductive feeder, Phasor Vs can be anywhere inside curveOACBO. It can be seen that the value of θs + φ must begreater than 90◦ for zero voltage regulation. Additionally, it ispossible only when power factor is leading at the load terminals θs cannot be more than 90◦.Fig.3(a) shows the limiting case when Rs/Xs = 1, i.e., θs= 45◦. From (4), the maximum possible load angle is 45◦.The maximum value of angle, θs + φ, can be 135◦ when φ is90◦. Hence, the limiting source current phasor OE, whichis denoted by Islimit, will lead the load voltage by 90◦.Lines OC and AB show the limiting vectors of Vs and IsZs,respectively with D as the intersection point. Hence, areaunder ACDA shows the operating region of DSTATCOM forvoltage regulation. The point D has a limiting value of Vslimit= Is Zs = 0.706 p.u. Therefore, maximum possible voltageregulation is 29.4%. However, it is impossible to achieve thesetwo limits simultaneously as δ and φ cannot be maximum atthe same time. Again if Zs is low then source current, whichwill be almost inductive, will be enough to be realized by aDSTATCOM.Fig.3(b) considers case when Rs/Xs = √3 i.e., θs =30◦. The area under ACDA shrinks, which shows that withthe increase in Rs/Xs from the limiting value, the voltageregulation capability decreases. In this case the limiting values of Vslimit and Is Zs are found to be 0.866 and 0.5 p.u., respectively. Here, maximum possible voltage regulation is13.4%. However, due to high current requirement, a practicalDSTATCOM can provide very small voltage regulation.Voltage regulation performance curves for more resistivegrid, i.e., θs = 15◦, as shown in Fig.3(c), can be drawnsimilarly. Here, area under ACDA is negligible. For this case,hardly any voltage regulation is possible. Therefore, morethe feeder is resistive in nature, lesser will be the voltageregulation capability.Therefore, it is inferred that the voltage regulation capabilityof DSTATCOM in a distribution system mainly depends uponthe feeder impedance. Due to resistive nature of feeder in adistribution system, DSTATCOM voltage regulation capabilityis limited. Moreover, very high current is required to mitigatesmall voltage disturbances which results in higher rating ofIGBT switches as well as increased losses. One more pointworth to be noted is that, in the resistive feeder, there will besome voltage drop in the line at nominal source voltage whichthe DSTATCOM may not be able compensate to maintain load voltage at 1.0 p.u. even with an ideal VSI.

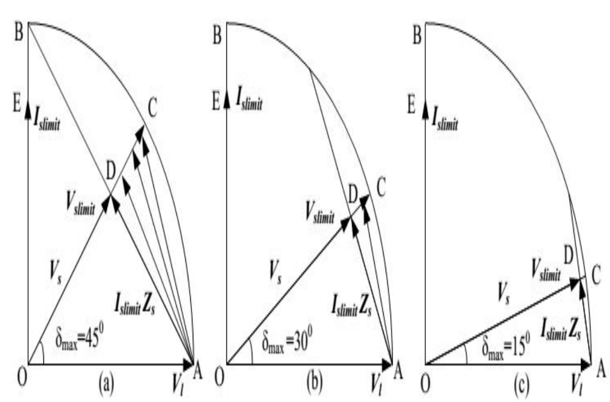

Fig.3. Voltage regulation performance curve of DSTATCOM at different Rs/Xs. (a) For Rs/Xs = 1. (b) For Rs/Xs = √3. (c) For Rs/Xs = 3.73.

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IV. SELECTION OF EXTERNAL INDUCTOR FOR VOLTAGE REGULATION IMPROVEMENT AND RATING REDUCTION

A generalized procedure to selectexternal inductor for improvement in DSTATCOM voltageregulation capability while reducing the current rating of VSI.Fig.4 shows single phase equivalent DSTATCOM circuitdiagram in distribution system. With balanced voltages, sourcecurrent will be

$$I_s = \frac{V_s\angle\delta - V_l\angle 0}{(R_s + R_{ext}) + j(X_s + X_{ext})} = \frac{V_s\angle\delta - V_l\angle 0}{R_{sef} + jX_{sef}} \quad (6)$$

Where $R_{sef} = R_s + R_{ext}$ and $X_{sef} = X_s + X_{ext}$ are effectivefeeder resistance and reactance, respectively. R_{ext} is equivalent series resistance (ESR) of external inductor, and will besmall. With $\theta_{sef} = \tan^{-1}\frac{X_{sef}}{R_{sef}}$ and $Z_{sef} = \sqrt{R_{sef}^2 + X_{sef}^2}$ as effective impedance angle and effective feeder impedance,respectively, the imaginary component of Isis given as

$$I_s^{im} = \frac{V_l \sin\theta_{sef} + V_s \sin(\delta - \theta_{sef})}{Z_{sef}} \quad (7)$$

With the addition of external impedance, the effective feederimpedance becomes predominantly inductive. Hence, $Z_{sef} \approx X_{sef}$. Therefore, approximated I_s^{im} will be

$$I_s^{im} = \frac{V_l \sin\theta_{sef} + V_s \sin(\delta - \theta_{sef})}{X_{sef}} \quad (8)$$

DSTATCOM Power rating (S_{vsi}) is given as follows [21]:

$$S_{vsi} = \sqrt{3}\,\frac{V_{dc}}{\sqrt{2}}\,I_{vsi} \quad (9)$$

Where I_{vsi} is the rms phase current rating of the VSI and V_{dc} is the voltage maintained at the dc capacitors. The DSTATCOMaims to inject harmonic and reactive current component ofload currents. Suppose I_{lim} is the maximum rms reactive and harmonic current rating of the load, then the value ofcompensator current used for voltage regulation (same as I_{sim})is obtained by subtracting I_{lim} from I_{vsi} and given as follows:

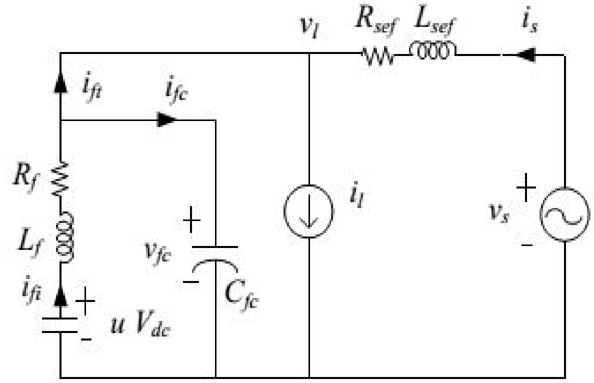

Fig.4. Single phase equivalent circuit of DSTATCOM topology with externalinductor in distribution system

$$I = I_{vsi} - I_l^{im} = \frac{\sqrt{2}S_{vsi}}{\sqrt{3}V_{dc}} - I_l^{im} \quad (10)$$

Comparing (8) and (10) while using value of δ from (4), following expression is obtained:

$$X_{sef} = \frac{V_l \sin\theta_{sef} - V_s \sin\left[\cos^{-1}\left[\frac{V_l}{V_s}\left(\cos\theta_{sef} + \frac{P_l X_{sef}}{3V_l^2}\right)\right]\right]}{\frac{\sqrt{2}S_{vsi}}{\sqrt{3}V_{dc}} - I_l^{im}} \quad (11)$$

V. DESIGN EXAMPLE OF EXTERNAL INDUCTOR

Here, it is assumed that the considered DSTATCOM protects load from voltage sag of 60%. Hence, source voltage Vs = 0.6 p.u. is considered as worst case voltage disturbances.During voltage disturbances, the loads should remain operational while improving the DSTATCOM capability to mitigatethe sag. Therefore, the load voltage during voltage sag is maintained at 0.9 p.u.,

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which is sufficient for satisfactory operationof the load. In the present case, maximum required value of I_{iml} is 10 A. With the system parameters given in Table I,the effective reactance after solving (11) is found to be 2.2 Ω(L_{sef} = 7 mH). Hence, value of external inductance, Lext, will be 6.7 mH. This external inductor is selected while satisfyingthe constraints such as maximum load power demand, ratingof DSTATCOM, and amount of sag to be mitigated. In this design example, for base voltage and base power rating of 400V and 10 kVA, respectively, the value of external inductance is 0.13 p.u.

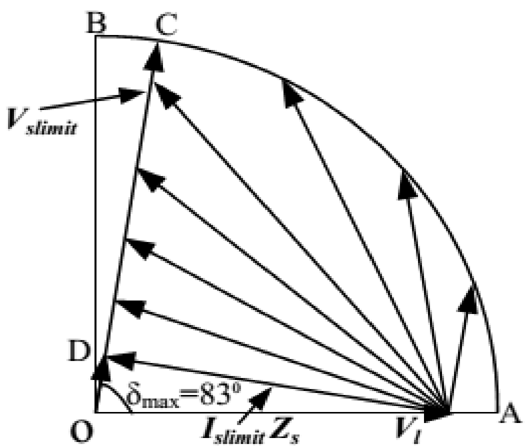

Fig.5. Voltage regulation performance of DSTATCOM with externalinductance.

Moreover, with total inductance of 7 mH (external and actual grid inductance), the total impedance will be 0.137p. u. The short circuit capacity of the line will be 1/0.13 = 7.7p.u. Which is sufficient for the satisfactory operation of thesystem? Additionally, a designer always has flexibility to findsuitable value of Lext if the constraints are modified or circuitconditions are changed. Moreover, conventional DSTATCOMoperated for achieving voltage regulation uses large feederinductances.With the external inductance while neglecting its ESR,Rs/X_{sef} will be 0.13 i.e., θ_{sef} = 83◦. Voltage regulationperformance curves of the DSTATCOM in this case are shownin Fig.3.5, where the area under ACDA covers the majorityof the stable operating range OABO. Hence, introduction ofexternal inductor greatly improves the DSTATCOM voltageregulation capability. Additionally, due to increased effectivefeeder impedance the current requirement for sag mitigationalso reduces. Moreover, if ESR of the external inductor isincluded, then the equivalent feeder impedance angle changesslightly (i.e., from 83 degree to 80.45 degree), and hasnegligible effect on the expression obtained in (11) as wellas the voltage regulation capability of the DSTATCOM.

VI. FLEXIBLE CONTROL STRATEGY

A flexible control strategy to improvethe performance of DSTATCOM in presence of the external inductor Lext. Firstly, a dynamic reference load voltage basedon the coordinated control of the load fundamental current,PCC voltage, and voltage across the external inductor iscomputed. Then, a proportional integral (PI) controller is usedto control the load angle which helps in regulating the dcbus voltage at a reference value. Finally, three phase referenceload voltages are generated. The block diagram of the control strategy is shown in Fig.6.

A. Derivation of Dynamic Reference Voltage Magnitude (V_l^*)

In conventional VCM operation of DSTATCOM, the reference load voltage is maintained at a constant value of 1.0p.u. [10]–[12]. Source currents cannot be controlled in thisreference generation scheme. Therefore, power factor willnot be unity and source exchanges reactive power with thesystem even at nominal supply. To overcome this limitation,a

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flexible control strategy is developed to generate referenceload voltage. This scheme allows DSTATCOM to set differentreference voltages during various operating conditions. Thescheme is described in the following.

1) Normal Operation: It is defined as the condition whenload voltage lies between 0.9 to 1.1 p.u. In this case, theproposed flexible control strategy controls load voltages suchthat the source currents are balanced sinusoidal and VSI doesnot exchange any reactive power with the source. Hence, thesource supplies only fundamental positive sequence currentcomponent to support the average loads power and VSI losses.Reference source currents (i^*_{sj} where j = a, b, c are threephases), computed using instantaneous symmetrical component theory [22], are given as

$$i^*_{sj} = \frac{v^+_{pj1}}{\Delta^+_1}(P_l + P_{loss}) \quad (12)$$

Where $\Delta^+_1 = \sum_{j=a,b,c}(v^+_{pj1})^2$. The voltages v^+_{pa1}, v^+_{pb1} and v^+_{pc1} are fundamental positive sequence components of PCCvoltages. Average load power (Pl) and VSI losses (P_{loss}) are calculated using moving average filter (MAF) as follows:

$$P_l = \frac{1}{T}\int_{t_1-T}^{t_1}(v_{la}i_{la} + v_{lb}i_{lb} + v_{lc}i_{lc})\,dt \quad (13)$$

$$P_{loss} = \frac{1}{T}\int_{t_1-T}^{t_1}(v_{la}i_{fta} + v_{lb}i_{ftb} + v_{lc}i_{ftc})\,dt \quad (14)$$

The reference source currents must be in phase with therespective phase fundamental positive sequence PCC voltagesfor achieving UPF at the PCC. Instantaneous PCC voltage And reference source current in phase-a can be defined as follows:

$$v^+_{pa1} = \sqrt{2}V^+_{pa1}\sin(\omega t - \varphi^+_{pa1}),\ i^*_{sa} = \sqrt{2}I^*_{sa}\sin(\omega t - \varphi^+_{pa1}) \quad (15)$$

Where$V^+_{pa1}$and ϕ^+_{pa1} are rms voltage and angle of fundamentalpositive sequence voltage in phase-*a*, respectively. $I^*_{sa}$is therms reference source current obtained from (12). With externalimpedance, the expected load voltage is given as follows:

$$\boldsymbol{V_{la} = V^+_{pa1} - I^*_{sa}\,Z_{ext}} \quad (16)$$

From (15) and (16), the load voltage magnitude will be

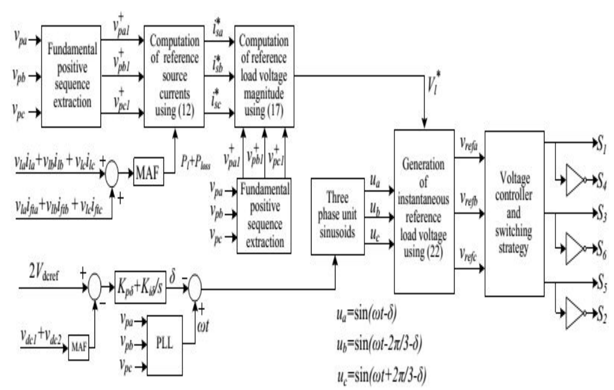

Fig.6. Block diagram of proposed flexible control strategy.

$$V_{la} = \sqrt{\left[\left(V^+_{pa1}\cos\varphi^+_{pa1} - I^*_{sa}\,Z_{ext}\cos\left(\theta_{ext} - \varphi^+_{pa1}\right)\right)^2 + \left(V^+_{pa1}\sin\varphi^+_{pa1} - I^*_{sa}\,Z_{ext}\sin\left(\theta_{ext} - \varphi^+_{pa1}\right)\right)^2\right]} \quad (17)$$

With UPF at the PCC, the voltage across the externalinductor will lead the PCC voltage by 90◦. Neglecting ESRof external inductor, it can be observed that the voltage acrossexternal inductor improves the load voltage compared to thePCC voltage. This highlights another advantage of externalinductor where it helps in improving the load voltage. As longas V_{la} lies between 0.9 to 1.1 p.u., same voltage is used asreference terminal voltage (V^*_l), i.e.,

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$$\text{if } V_{la} \in [0.9 - 1.1 \text{ p.u.}], \text{ then } V_l^* = V_{la} \quad (18)$$

2) Operation during Sag: Voltage sag is considered whenvalue of (17) is less than 0.9 p.u. To keep filter currentminimum, the reference voltage is set to 0.9 p.u. Therefore,

$$V_l^* = 0.9 \text{ p.u} \quad (19)$$

3) Operation during Swell: A voltage swell is consideredwhen any of the PCC phase voltage exceeds 1.1 p.u. In thiscase, reference load voltage (V_l^*) is set to 1.1 p.u. which resultsin minimum current injection. Therefore,

$$V_l^* = 1.1 \text{ p.u} \quad (20)$$

B. Computation of Load Angle (δ)

Average real power at the PCC (P_{pcc}) is sum of averageload power (Pl) and VSI losses (P_{loss}). The real power P_{pcc} is taken from the source depending upon the angle betweensource and load voltages, i.e., load angle δ. If DSTATCOMdc bus capacitor voltage is regulated to a reference value, thenin steady state condition P_{loss} is a constant value and forms fraction of P_{pcc}. Consequently, δ is also a constant value.The dc link voltage is regulated by generating a suitablevalue of δ. The average voltage across dc capacitors (V_{dc1} +V_{dc2}) is compared with a reference voltage and error is passedthrough a PI controller. Output of PI controller, δ, is given as

$$\delta = K_{p\delta}\, e_{vdc} + K_{i\delta} \int e_{vdc}\, dt \quad (21)$$

Where $v_{dc} = 2\ V_{dcref} - (V_{dc1} + V_{dc2})$ is the voltage error.$K_{p\delta}$ and $K_{i\delta}$ are proportional and integral gains, respectively.

C. Generation of Instantaneous Reference Voltage

Selecting suitable reference load voltage magnitude andcomputing load angle δ from (21), the three phase balancedsinusoidal reference load voltages are given as follows:

$$v_{refa} = \sqrt{2}\, V_l^* \sin(\omega t - \delta)$$
$$v_{refb} = \sqrt{2}\, V_l^* \sin(\omega t - 2\pi/3 - \delta)$$
$$v_{refc} = \sqrt{2}\, V_l^* \sin(\omega t + 2\pi/3 - \delta) \quad (22)$$

These voltages are realized by the VSI using a predictivevoltage controller .

VII. DESIGN OF A FUZZY CONTROLLER

The difficulty regarding the PI controller gain is the fine tuning of the controller so as to achieve the optimal operation of the task. The major drawback of the PI controller is faced when the process is nonlinear and also when the system is having oscillations. Considering all these facts, a fuzzy logic controller was implemented. A fuzzy controller can work in linear as well as in nonlinear design parameters. FL requires some numerical parameters in order to operate such as what is considered significant error and significant rate-of-change-of error, but exact values of these numbers are usually not critical unless very responsive performance is required in which case empirical tuning would determine them.

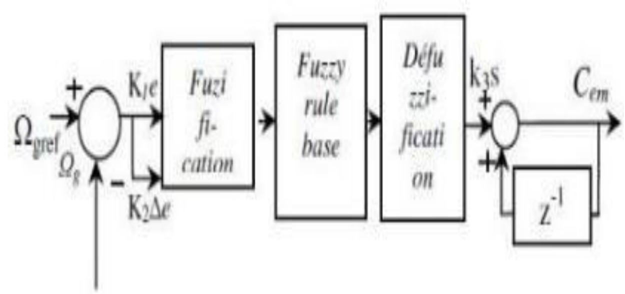


Fig.7 Fuzzy Logic Controller

FL requires some numerical parameters in order to operate such as what is considered significant error and significant rate-of-change-of-error, but exact values of these numbers are usually not critical unless very responsive performance is required in which case empirical tuning would determine them. For example, a simple temperature control system could use a single temperature feedback sensor whose data is subtracted from the command signal to compute "error" and then time-differentiated to yield the error slope or rate-of change-of-error, hereafter called "error-dot".

VIII. MATLAB/SIMULATION RESULTS

Case I Conventional D-STATCOM

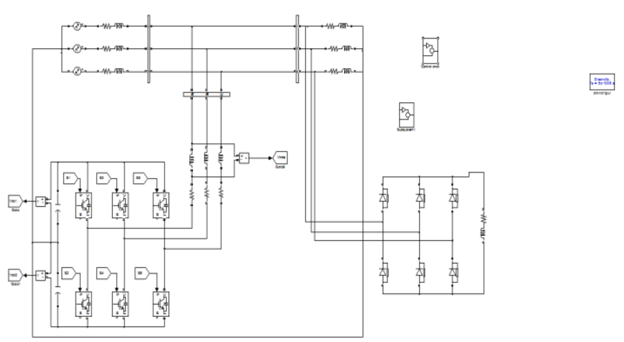
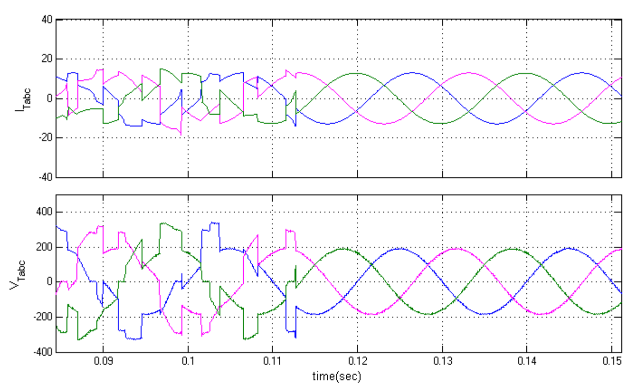
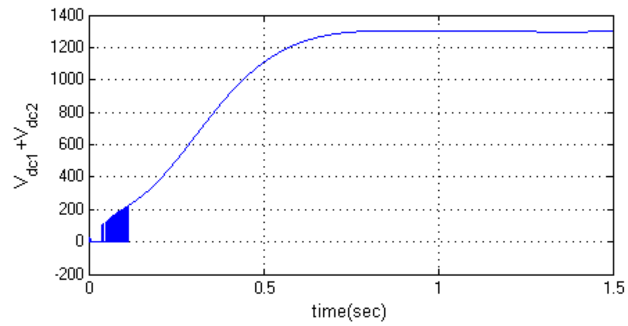


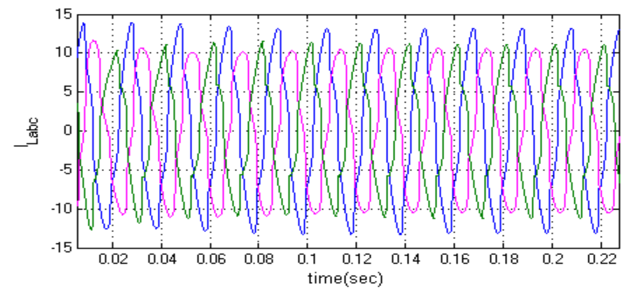
Fig.8. MATLAB/SIMULINK circuit for conventional D-STATCOM



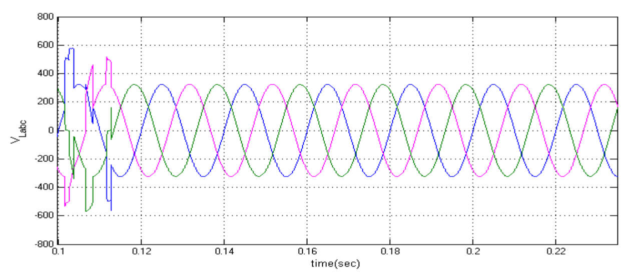
(a) Simulation waveform of IabcT,VabcT



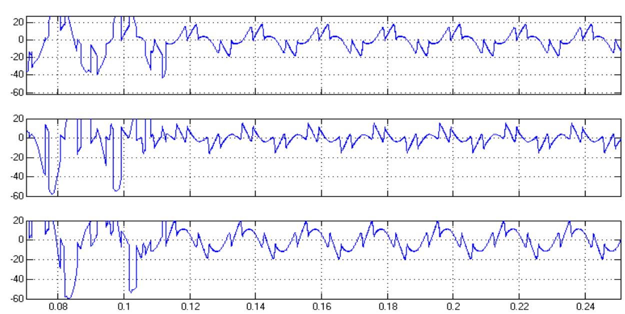
(b) Simulation waveform of Vdc1+vdc2



(c) Simulation waveform of load current Iabcl



(d) Simulation waveform of load voltage VabcL



(e) Simulation waveforms of Filter currents

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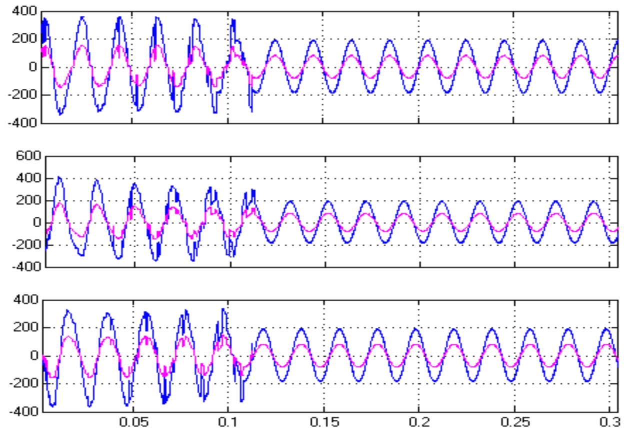
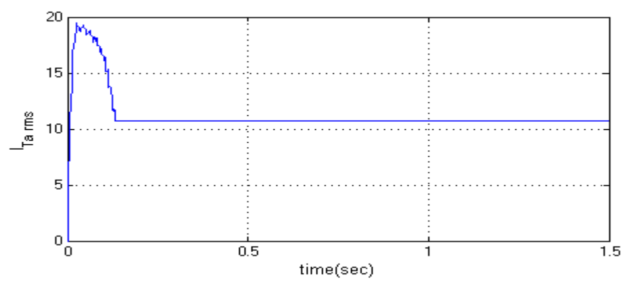
Fig.9. Voltage regulation performance of conventional DSTATCOM with resistive feeder

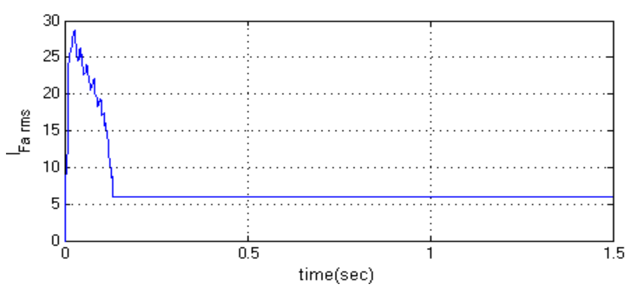
Case-II: Proposed D-STATCOM



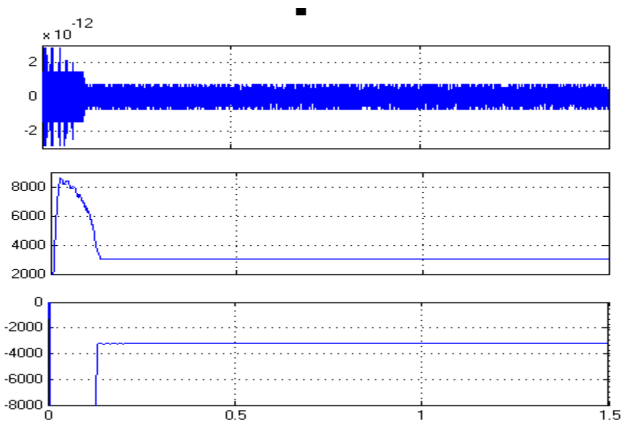
(a) Simulation waveforms of D-STATCOM IabcT, VabcT



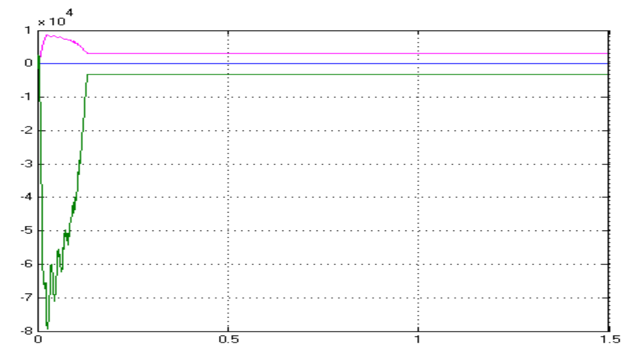
(b) Simulation waveforms of D-STATCOM IabcT RMS



(c) Simulation waveform of D-STATCOM RMS 1 filter current



(d) Simulation Waveform of D-STATCOM PQ values Reactive power



(e) Simulation waveforms of D-STATCOM filter current, load current , load voltage

Fig.10. Proposed D-STATCOM outputs

Case III : Proposed D-STATCOM on Sag condition

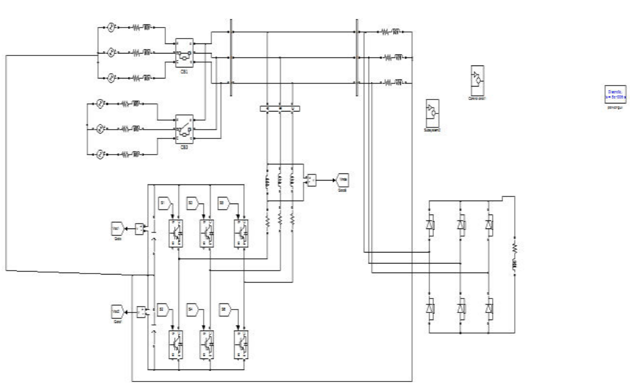


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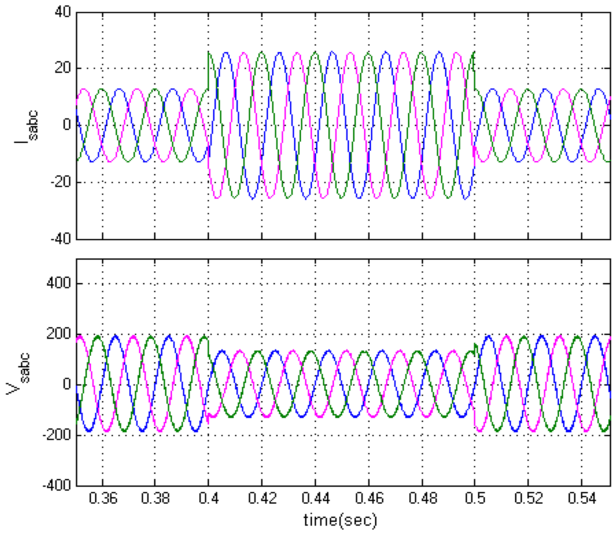
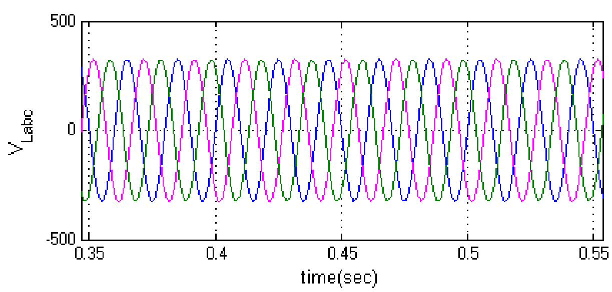
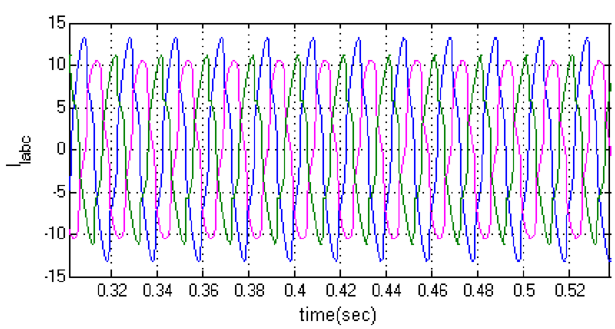
Fig.11. MATLAB/SIMULINK circuit for proposed Statcom on Sag condition



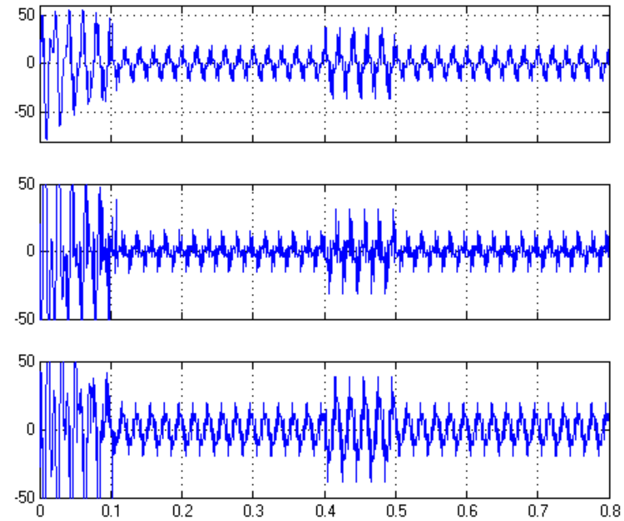
(a) Simulation waveform for Proposed D-statcom of IabcT, voltage sag VabcT



(b) Simulation waveform for Proposed D-statcom of vabcL



(c) Simulation waveform for Proposed D-statcom of IabcL



(d) Simulation waveform for Proposed D-statcomfor Field currents

Fig.12. Proposed DSTATCOM on Sag condition

Case IV: Proposed D Statcom on Swell condition

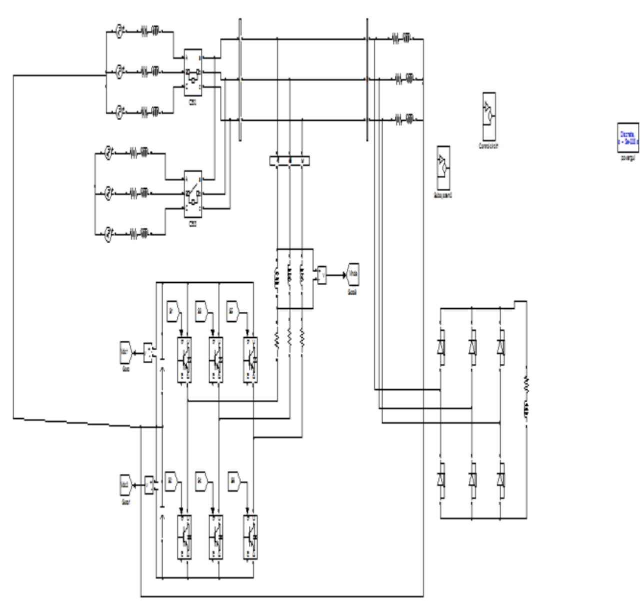


Fig.13. MATLAB/SIMULINK circuit for proposed D Statcom on Swell condition

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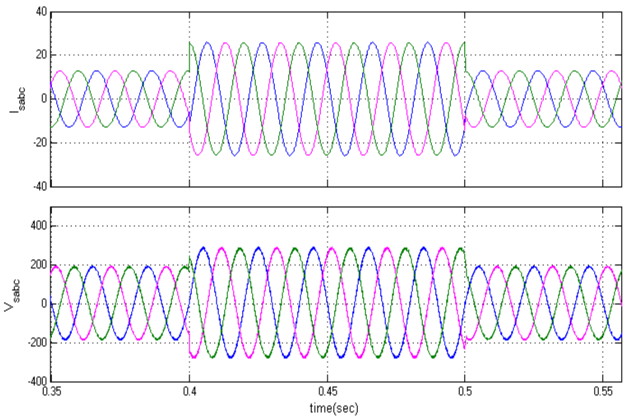
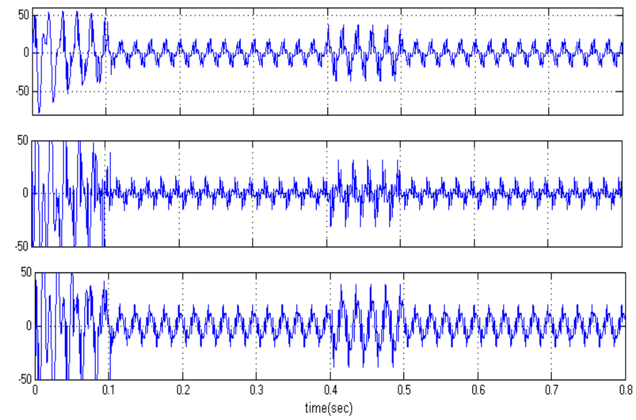
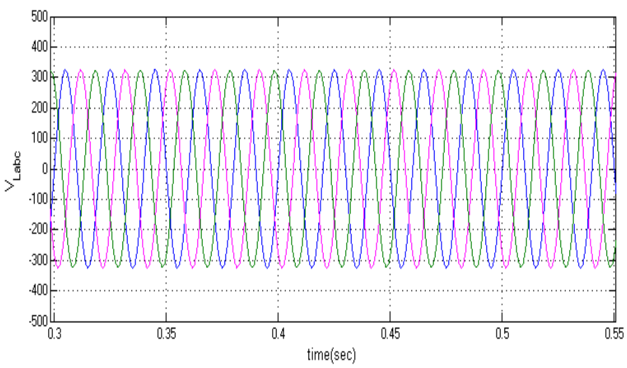


(a) Simulation waveform for Proposed D-statcom of IabcT, voltage swell VabcT

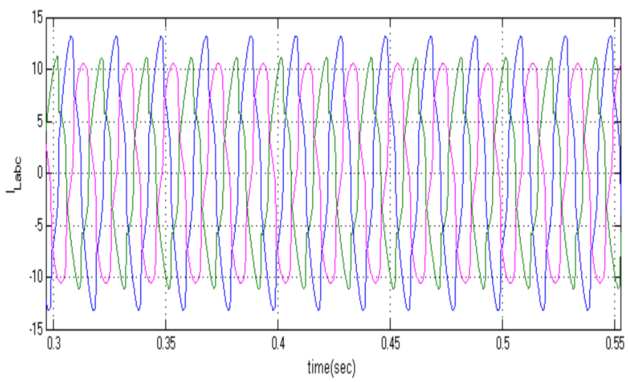


(d) Simulation waveform for Proposed D-statcomfor Field currents

Fig.14. Simulation results (a) During normal operation (case 2). (b) During voltage sag (case 3). (c) During voltage swell (case 4).



(b) Simulation waveform for Proposed D-statcom of vabcL



(c) Simulation waveform for Proposed D-statcom of IabcL

Case V : System without DSTATCOM

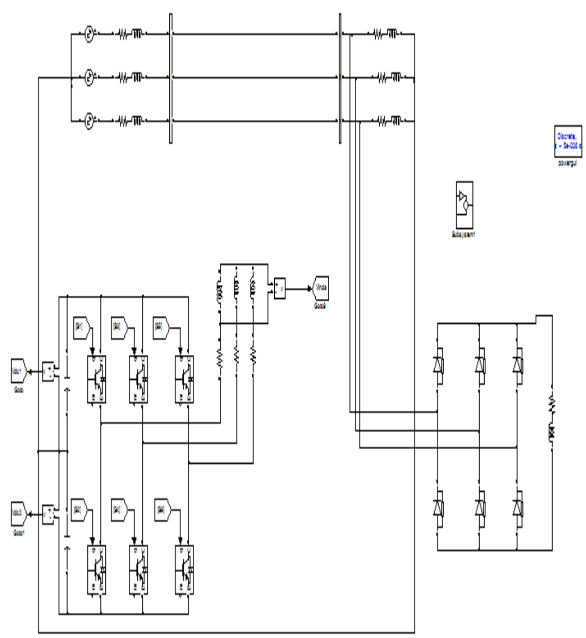


Fig.15. MATLAB/SIMULINK circuit without D-STATCOM

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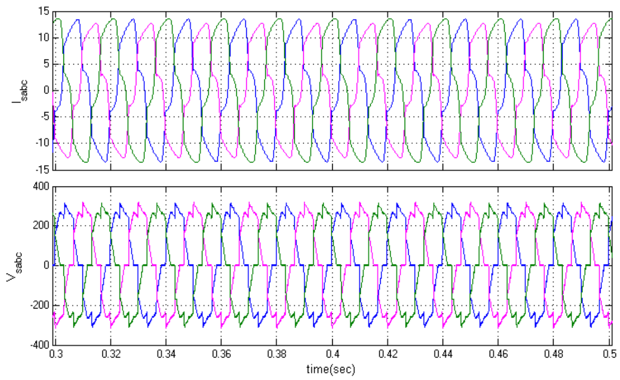
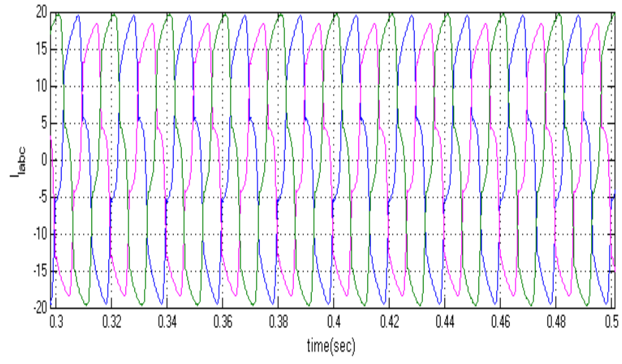


(a) Simulation waveform for IabcT, VabcT without D-STATCOM



(b) Simulation waveform for IabcL without STATCOM

Fig.16. Simulation waveforms without DSTATCOM

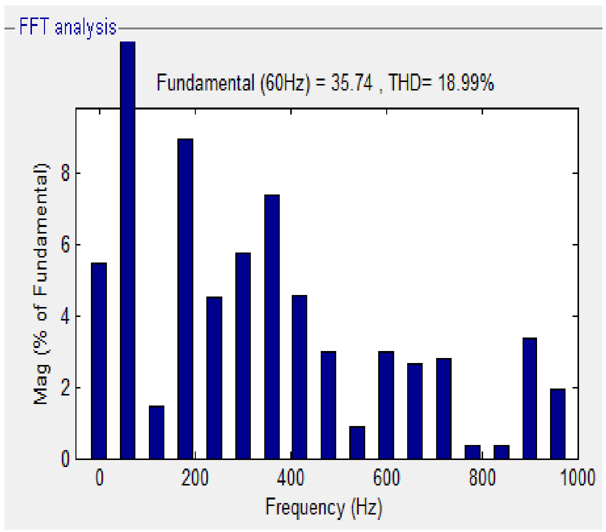


Fig.17. THD of proposed DSTATCOM

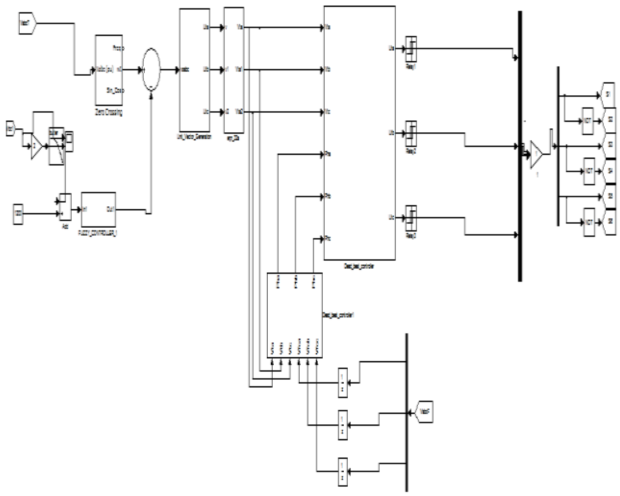


Fig.18. MATLAB/SIMULINK control circuit for D-STATCOM with fuzzy logic controller

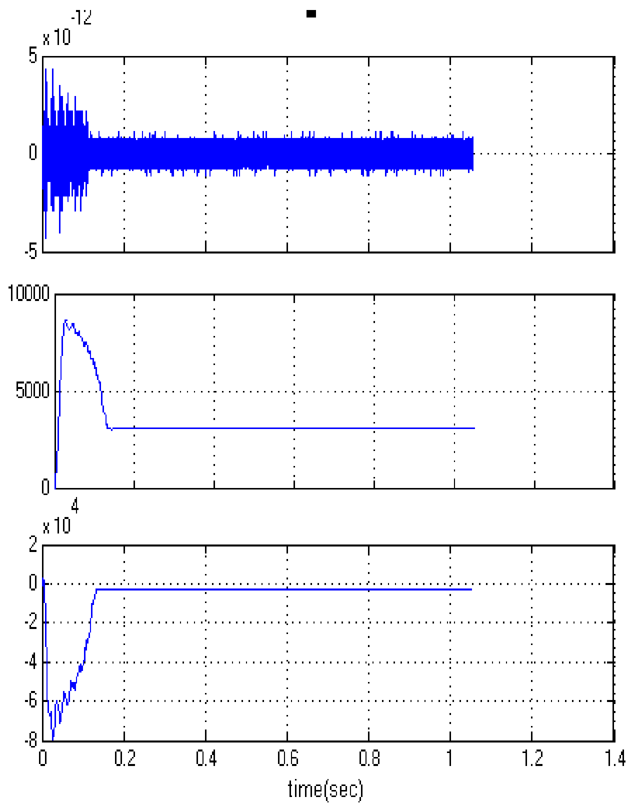


Fig.19. Simulation waveform of Reactive power components of DSTATCOM with fuzzy controller

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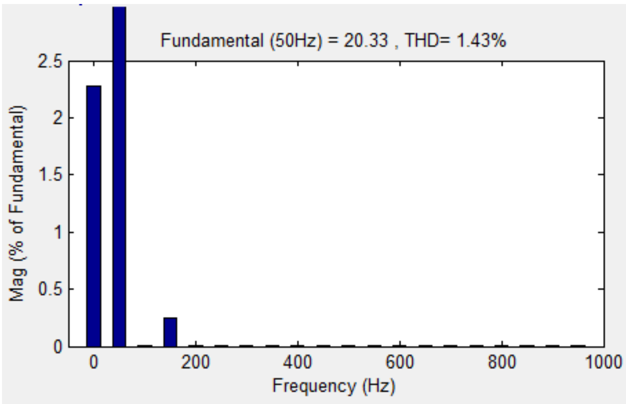

Fig.20. THD of DSTATCOM with fuzzy logic controller

IX. CONCLUSION

In this paper, to protect the load from voltage disturbances under stiff source a new fuzzy based control algorithm for multifunctional DSTATCOM has been proposed. This has been achieved by placing an external series inductance of suitable value between the source and the load. In addition, instantaneous reference voltage is controlled in such a way that the source currents are indirectly controlled, and the advantages of CCM operation are achieved while operating in VCM for a permissible range of source voltage. The proposed algorithm and multifunctional DSTATCOM are able tomitigate voltage- and current-related PQ issues, and the THD analysis revealed that the fuzzy logic controller is good.

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