Effect of Transformer Rating on the Power Quality Problems in 11kv/440v Distribution System

P. PARTHASARADHY[1], S. R. REDDY[1], AMAR BHARATRAO DESHMUKH[2],
K. ATNAKISHORI[1]
[1]EEE Department, GNITC,
Hyderabad,
INDIA

[3]E&TC Department, Anantrao Pawar Collage of Engineering & Research,
Pune,
INDIA

Abstract: - This study explains in detail how the transformer rating affects the proposed distribution system. Also analysis of the suggested distribution system would react when the transformer rating is changed to reduce harmonic interference, this information is essential. The harmonic in the voltage waveform is changed by changing the transformer's rating. The nonlinear and imbalanced load is taken into account in this approach. To reduce harmonics caused by nonlinear and imbalanced loads along with by adjusting the transformer's rating up or down, an SRF-controlled algorithm is suggested. An 11kV/400V distribution system framework, the SRF-controlled DSTATCOM with four-leg VSI is proposed and placed into the system. The proposed DSTATCOM is evaluated for its ability to regulate the voltage at the PCC as the transformer rating rises and falls in nonlinear and imbalanced load conditions. The outcomes of the suggested work are acquired using the MATLAB/SIMULINK program.

Key-Words: - Distribution system, Harmonics, Distribution static compensator (DSTATCOM), PI Controller, nonlinear load, imbalanced load.

Received: May 19, 2024. Revised: October 22, 2024. Accepted: November 17, 2024. Published: December 31, 2024.

1 Introduction

To transmit energy more precisely, industrialized systems have made heavy use of power control devices throughout the last decade [1], [2], [3]. Power standard disturbances like harmonic pollution, imbalanced (unequal) load currents, and reactive power issues are brought on by excessive use of power control devices, which indicate nonlinear loads in a distribution system. The end result is a decrease in efficiency as a whole, a decrease in power factor, an increase in the temperatures of the motors and transformers, the failure of delicate equipment, and more [4], [5]. The source voltage is not uniform because the three loads are not balanced, which is another problem with the quality of the power. The uneven voltage at the source may lead to harmonics in the distribution system that are lower in order of magnitude, and the negative sequence component of the current can reduce torque for electrical system drive machines [6], [7]. Distribution static compensators (DSTATCOM), dynamic voltage restorers (DVRs), and all unified power quality conditioners (UPQCs) are particular apparatuses that can limit these power quality worries. Static compensators are the most ideal choice when other custom power gadgets are not appropriate for balancing out reactive power or controlling harmonic current in the circulation network [8]. The DSTATCOM might work in two modes: one with an inverter and one with a Transformer installed. The transformer model employed by DSTATCOM is a three-leg VSI with several types of transformers, such as a crinkled transformer [9], a T-coordinated transformer [10], a star-delta transformer, and more. The positive and negative current components are stabilized by three- phase VSIs, and the zero current components are eliminated by a transformer. The DSTATCOM inverter models consist of three separate legs of VSI [11], a three-leg VSI with a crinkled phase capacitor [12], [13], and a four-leg VSI [14], [15], [16], [17], [18]. Every one of the models has its advantages and disadvantages. Standard practice calls for a spilt-phase or four- phase VSI inverter to stabilize the neutral current. In this study, by comparing with the results of various transformer and VSI models, the four phases with a crinkled phase capacitor to achieve exact neutrality and supply current normalization. The DC-connect voltage is constrained by the SRF management scheme based on PI controllers. The PI values are controlled using the Ziegler-Nichols method [19], [20], [21]. The distribution model is simplified to 400v in real applications using an 11/400kv three-phase transformer. Under balanced or unbalanced loads, linear or nonlinear, connecting DSTATCOM at the PCC brings reactive and harmonic power down to normal. Considering the impact of the transformer (11/0.4kv) is not done in all circumstances in this previously proposed technique. A distribution transformer with a rating of 11/0.4 kilovolts is usedin this study. Ahead (BUS-1) and behind (BUS-2) of the transformer, we measure and study the reactive power and harmonics change.

This study planned and implemented an 11/0.4kv distribution model of an SRF-regulated DSTATCOM with a divide-part capacitor and a four-phase VSI. To determine how well the proposed DSTATCOM reduces harmonics, settles neutral current, and controls the voltage at the PCC, we test it in a nonlinear and unbalanced load environment. The procured results are assessed with the assistance of the MATLAB/SIMULINK program. The paper's outline is as follows: Section
II provides a comprehensive overview of the system's architecture, Section III details the control approach, Section IV presents the results and discusses them, and Section V concludes with suggestions.

2 System Configuration

Figure 1. Shows the proposed DSTATCOM system's design for a three-phase, four-wire distribution model where the loads are nonlinear and uneven. To reduce the 11kV three-phase supply voltage to 400V, a11kV/400V distribution transformer is used and nonlinear and uneven (imbalanced) loads are connected to the system. At the PCC, the coupled nonlinear and imbalanced burden results in the formation of harmonics. When DSTATCOM is positioned at the PCC, current and voltage harmonics, as well as the uneven waveform at the PCC and in the load voltage, are all eliminated.

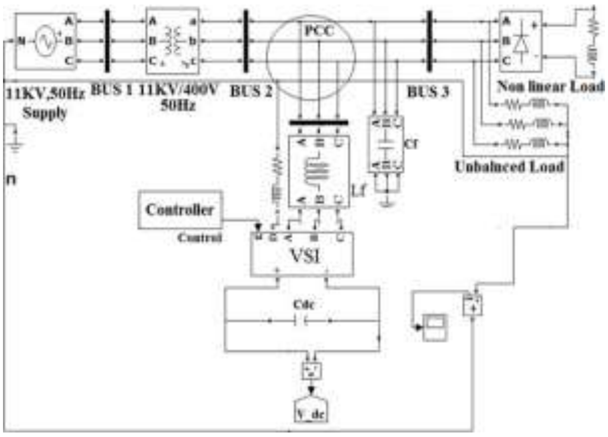


Fig. 1: System Configuration

An inverter with four legs, a DC link capacitor (Cdc), and an interface inductor are used in the DSTATCOM. The filter resistance (rf) is used. The four legs of VSI are made up of 8 IGBT switches. The two IGBT switches are utilized to compensate for neutral current while the other six are utilized to
compensate for harmonics and current wave imbalance. The nonlinear burden contains a three-stage bridge rectifier along with the R-L burden. To effectively compensate for neutral current, the fourth leg is utilized. Three phase loads with different resistance and inductance magnitudes obtained the imbalanced load. Only the source and PCC currents are compensated for the transformer's rating is 1MVA, and the voltage at the PCC remains constant. If the transformer's rating is above 1MVA, along with the source, PCC currents the voltage harmonics also need to be compensated. One major benefit of this architecture is that filters may be removed.

3 Proposed Control Algorithm

Figure 2. Shows the planned SRF-controlled method. In the case of a nonlinear & imbalanced load, the reference control signals for exchange are provided by the control strategy. The DSTATCOM, which is based on VSI, is activated using these control signals to control reactive and harmonic issues conditions.

Active, harmonics, and reactive parts are developed with the nonlinear loads connected in a three-stage system. To account for it, we divide the reactive and harmonic currents according to Clark's equation, which is eq. (1). This change from three-stage load momentary currents to two-stage fixed α-β-0 edges is a piece of the detachment interaction.

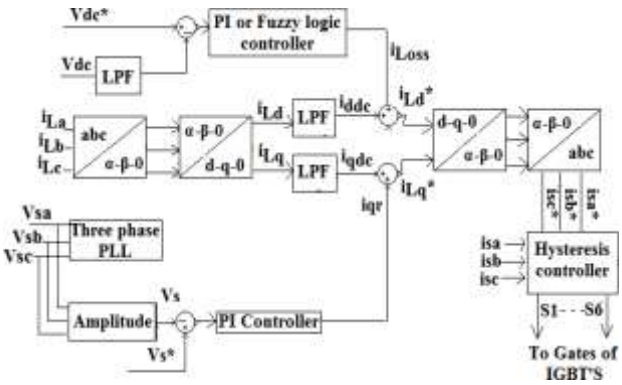


Fig. 2: Block schematic of the proposed control algorithm

$$\begin{bmatrix} i_{L0} \\ i_{L\alpha} \\ i_{L\beta} \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} i_{La} \\ i_{Lb} \\ i_{Lc} \end{bmatrix} \quad (1)$$

By applying the park transformation equation-(2), the components of the stationary α-β--0 current components are converted into this tuning reference frame d-q-0 (d-direct axis, q-quadrature axis).

$$\begin{bmatrix} i_{L0} \\ i_{Ld} \\ i_{Lq} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & \sin\theta \\ 0 & -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} i_{L0} \\ i_{L\alpha} \\ i_{L\beta} \end{bmatrix} \quad (2)$$

In this instance, θ stands for the transformation angle. In order to make the current and voltage synchronization, the sine θ and cos θ are gotten from the voltage supply of a 3-phase PLL block, which is otherwise called a phase-locked circle. The active and reactive loads current are the ones that are derived from the currents of i_{Ld} and i_{Lq}, respectively. A typical current component, as shown in equations
(3) and (4), comprises a typical worth (the dc part) and oscillating part (the ac part).

$$i_{Ld} = i_{ddc} + i_{dac} \quad (3)$$

$$i_{Lq} = i_{qdc} + i_{qac} \quad (4)$$

The normal or DC component of current can be obtained by dividing by iddc and idac. We can divide the wavering or ac part of iLq as iqdc and iqac utilizing idac and intelligence level ac. The portion that is oscillating would be an illustration of a harmonic component. Using a low pass filter, the oscillating current component is eliminated. Finally, by utilizing Conditions (5) and (6), we obtain the active and reactive current components.

$$i_{Ld} = i_{ddc} \quad (5)$$

$$i_{Lq} = i_{qdc} \quad (6)$$

One way to keep the DC connect supply constant and keep track of losses in DSTATCOM is to add the standard reference current from the d-axis point in the d-q frame to the output current of the PI regulator (controller) as a loss current (iLoss). The final reference current is given by equation 7 as

$$i_{Ld}^* = i_{ddc} + i_{loss} \quad (7)$$

In order to regulate the power component and harmonic, the direct axis reference current (iLd*) of the final current component is used.

It is anticipated that the source will provide the d-q fram reactive current (iqr) and ordinary reactive reference current (iqdc) necessary to regulate the voltage at the PCC. The final reactive reference current is given in equation (8).

$$i_{Lq}^* = i_{qdc} + i_{qr} \quad (8)$$

To obtain the reactive current (iqr), the output PI controller is used. Find the voltage amplitude Vs and the reference voltage Vs* to determine the PI controller input. We take into account the amplitude, Vs, of the PCC voltage here as:

$$Vs = \sqrt{2/3\,(V_{sa}^2 + V_{sb}^2 + V_{sc}^2)} \quad (9)$$

The PI regulator's result is as per the following Equation (10).

$$V_{qr(n)} = V_{qr(n-1)} + K_{pq}(V_{te(n)} - V_{te(n-1)}) + K_{iq}V_{te(n)} \quad (10)$$

The error difference between the amplitude of the terminal voltage and the reference AC system voltage at the nth sampling instant is denoted as Vte(n) = V*s-Vs(n). The typical values of its integral and proportional components are Kpq and Kiq.

The voltage component and part of the reactive load can be controlled with the assistance of the reactive reference current portion (iLq*).

To understand how the α-β-0 frame is made, the contents of iLd* and iLq* which are the reference currents to the active and reactive are converted using inverse Park's equation (11).

$$\begin{bmatrix} i_{s0}^* \\ i_{s\alpha}^* \\ i_{s\beta}^* \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} i_{L0}^* \\ i_{Ld}^* \\ i_{Lq}^* \end{bmatrix} \quad (11)$$

A three-stage reference current (a-b-c) may be generated from the reference signals received from inverse Park's by applying the conditions of reverse Clark's equation (12).

$$\begin{bmatrix} i_{sa}^* \\ i_{sb}^* \\ i_{sc}^* \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 0 & 1 & 0 \\ 0 & -1/2 & \sqrt{3}/2 \\ 0 & -1/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} i_{s0}^* \\ i_{s\alpha}^* \\ i_{s\beta}^* \end{bmatrix} \quad (12)$$

To turn on the switches of the VSI of IGBTs, the getting three-phase reference current (isa*, isb*, isc,*) matches with the genuine filter current at the hysteresis band controller. When contrasted with different regulators, in terms of transporter-based, dab beat, feed-forward, and fast movement, this hysteresis band regulator has various benefits, the most remarkable of which are its simplicity of establishment, further developed dependability, and speedier response time. A significant drawback of the carrier based regulator, as checked with the hysteresis band controller, is the pressure at switching components because of the constantly fluctuating frequency of turn-on & turn off devices.

4 Results & Discussion

With the consideration of nonlinear and imbalanced load in mind, we can see how changing the three- phase transformer rating impacts the proposed distribution system. If the transformer's low power rating is less than 1MVA, its rating will be decreased, and if it's more than 1MVA, its rating will be increased. Harmonics are brought into the proposed distribution framework by the nonlinear and unequal burden. These harmonics are compensated by using VSI-based DSTATCOM with synchronous reference frame control algorithm. Both the source and the PCC make use of the suggested model for imbalance adjustment and harmonic reduction. To have a clearer picture, we keep the simulation time in the range of 0.2 and 0.3 seconds. We used the MATLAB/SIMULINK program to get the findings. For these scenarios, we can see how DSTATCOM performs.

- Transformer with a low power rating without DSTATCOM
- High-power transformer rating without DSTATCOM
- Low-power-rated transformer with DSTATCOM

4.1 Transformer with a Low Power Rating without DSTATCOM

The source voltage waveform as shown in Figure 3(a). Figure 3(b) shows an imbalance in source current (bus 1) and harmonics when a nonlinear and uneven load is applied to the suggested distribution system. Harmonics at the PCC voltage and current waveform (bus-2) are also introduced by the nonlinear and imbalanced burden found in Figure 3(c) and Figure 3(d). This waveform distorts and influences the loads connected to the PCC. Plots depicting the voltage at load are shown in Figure 3 (e), while the plots of the current at load are shown in Figure 3 (f). The result of the PCC phases current in phase-A is illustrated in Figure 3(g).

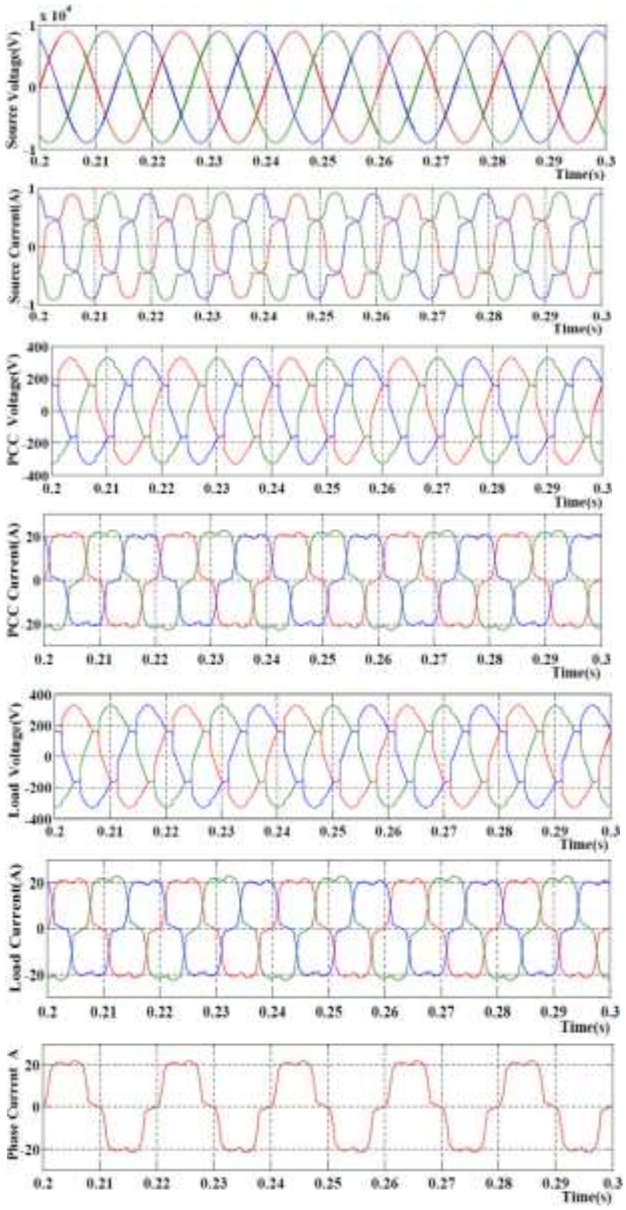


Fig. 3: (a) The source voltage; (b) the source current at PCC (Bus-2) waveform; (c) the voltage waveform at PCC (Bus-2); (d) the current waveform at the PCC (bus-2); (e) the load voltage waveform; (f) the load current waveform; and (g) the source voltage waveform. Shows that the phase current waveform of phase –A, When nonlinear and imbalanced loads are present at the PCC, The

concerned waveforms are when D-STATCOM is absent.

4.2 High-Power Transformer Rating without DSTATCOM

As depicted in Figure 4(b), nonlinear and unbalanced loads connected to the proposed distribution system are responsible for the imbalance and harmonics in the source current (Bus-1).

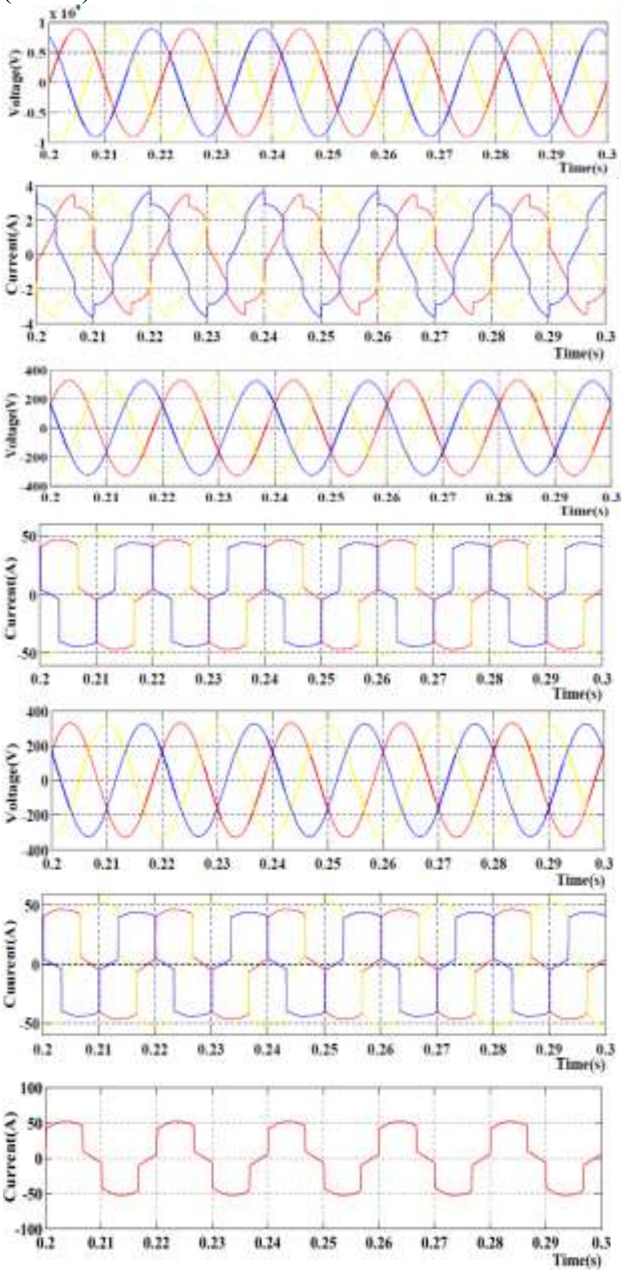


Fig. 4: a) The voltage waveform at the source; (b) The source current-voltage waveform at the PCC (Bus-2); (c) The voltage waveform at the PCC; and (d) The PCC current waveform (bus 2), (e). The basic shape of the load voltage waveform, is shown by (f). Waveform of the load current (g). Unbalanced nonlinear load on a per-phase PCC current waveform, without DSTATCOM

As the transformer's rating rises, harmonics are eliminated from the source, PCC, and load voltage waveforms as shown in the Figure 4(a), Figure 4 (c) and Figure 4 (e). In any case, the imbalanced and nonlinear burden causes harmonics into the source, PCC, and load current (bus 2) waveforms, as observed in Figure 4(b), Figure 4(d) and Figure 4(f). The loads connected to the PCC are affected by the harmonic current. Figure 4(g) displays the waveform of the per-phase PCC current.

4.3 Low Power Rating Transformer with DSTATCOM

The SRF-controlled DSTATCOM injects the necessary reactive power to compensate for harmonics in the source and PCC currents, as well as imbalances in the waveform when connected to the PCC. The source voltage waveform as shown in Figure 5(a). A PI controller controls the voltage at the DC interface. The given waveforms of the PCC current and the corrected source are depicted in Figure 5(b) and Figure 5(d). The voltage waveform at PCC is illustrated in Figure 5(c). Figure 5(e) and Figure 5(f) show the waveforms of the load voltage and current, respectively. In Figure 5(g) per phase load current waveform, and (h).per phase PCC current waveform Figure 5(i) the DC-link voltage (i.e. Vdc=Vdc1+Vdc2) waveform.

4.4 Total Harmonic Distortion Analysis

This section discusses the PCC and source current wave patterns with and without DSTATCOM, as well as the overall harmonic distortion of these components.

4.4.1 Low Power Rating Transformer without DSTATCOM

Figure 6(a) shows that there is a harmonic distortion of 16.48% at the PCC (BUS-2). There is a source current harmonic distortion of 15.80% at bus-1, as seen in Figure 6(b). PCC voltage waveforms exhibit harmonics due to the low power rating transformer. Figure 6(c) Shows that there is a 17.15% harmonic distortion at the PCC voltage waveform.

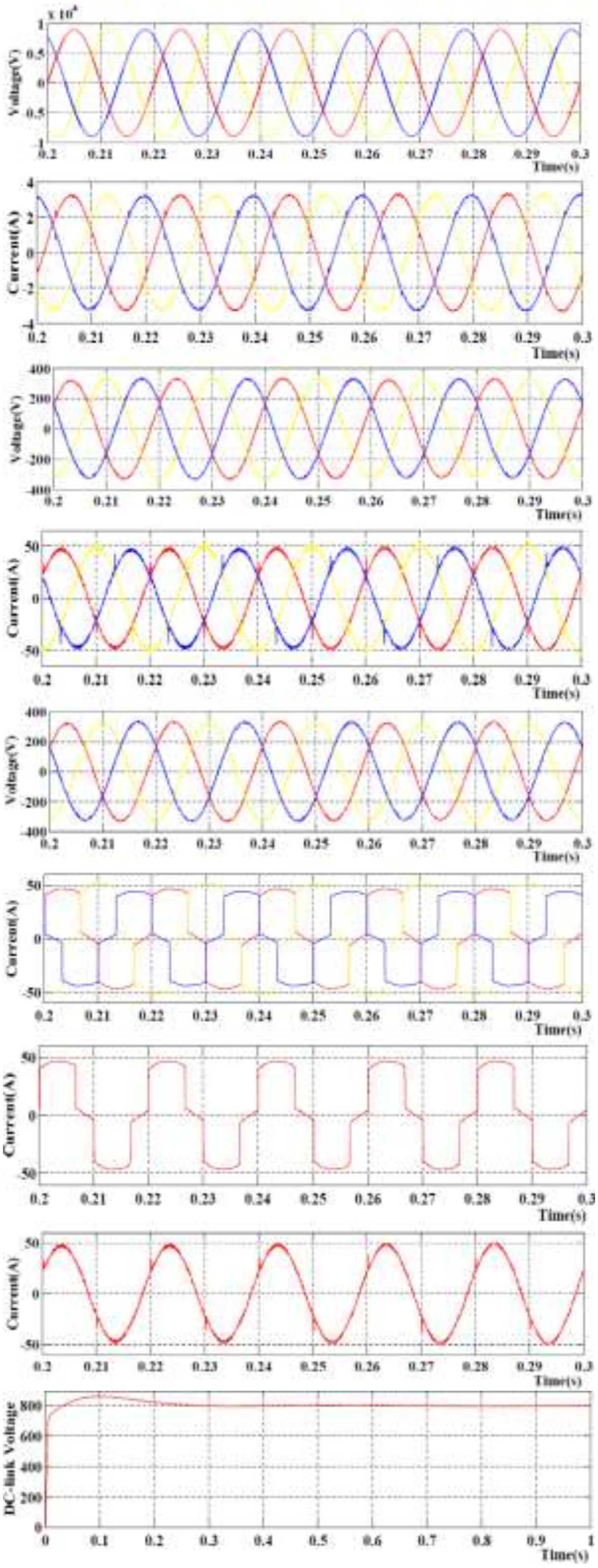


Fig. 5: (a) The origin voltage waveform; (b) The origin current waveform. (c) Bus 2 voltage waveform at PCC; (d) Bus 2 current waveform at PCC; (e) Load voltage waveform; (f) Load current waveform; (g) Load voltage waveform of phase-A representation of the load current in a waveform, (h)referred to as the current waveform at the PCC, and (i)the DC bus voltage form (Vdc) of the DC-link using DSTATCOM control

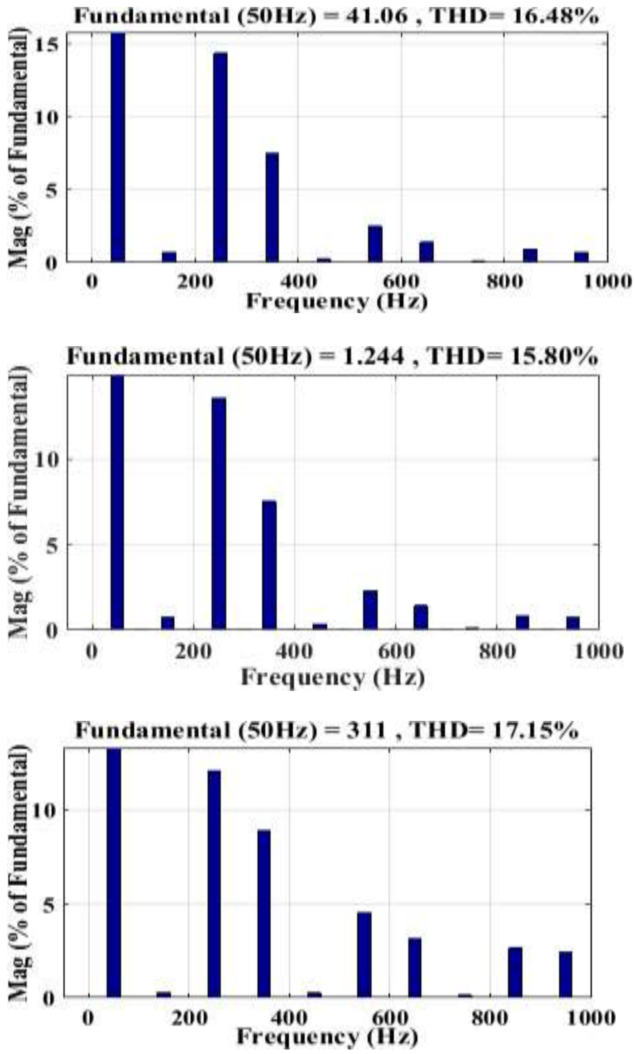
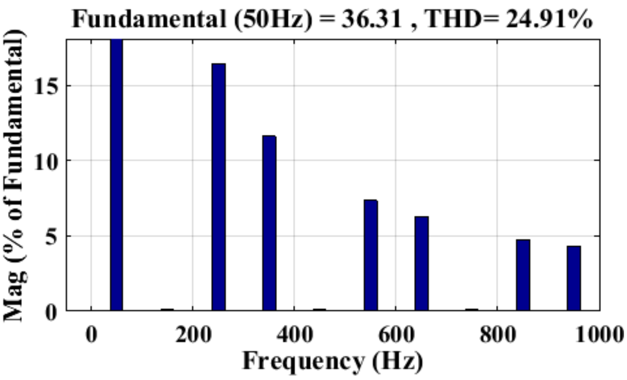


Fig. 6 (a): Shows the source current THD (BUS-1), Figure 6(b) shows the current total harmonic distortion (THD) at bus-2 (PCCs). Figure 6 (c). The voltage at the PCC is THD when a transformer with a low power rating and no DSTATCOM is used

4.4.2 High-power Transformer Rating without DSTATCOM

When the transformer's power rating is greater than 1 MVA, harmonics do not appear in the voltage waveform; however, they do appear in the source and PCC current waves as a result of nonlinear and imbalanced loads. Figure 7(a) shows that the PCC (bus 2) has a current harmonic distortion of 24.91%. You can see that the source current harmonic distortion at bus-1 is 11.63% in Figure 7(b).

P. Parthasaradhy, S. R. Reddy,
Amar Bharatrao Deshmukh, K. Atnakishori



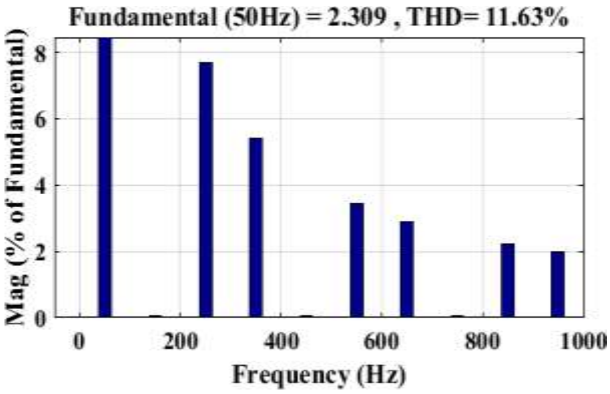
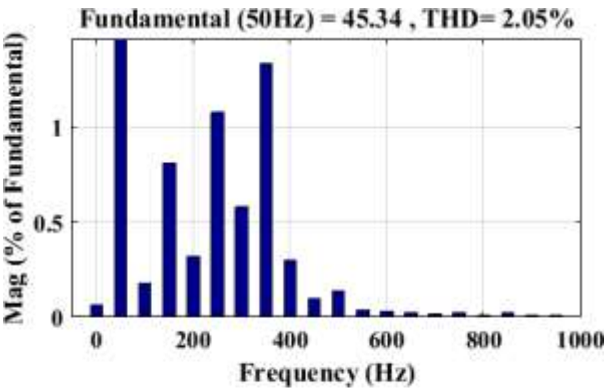
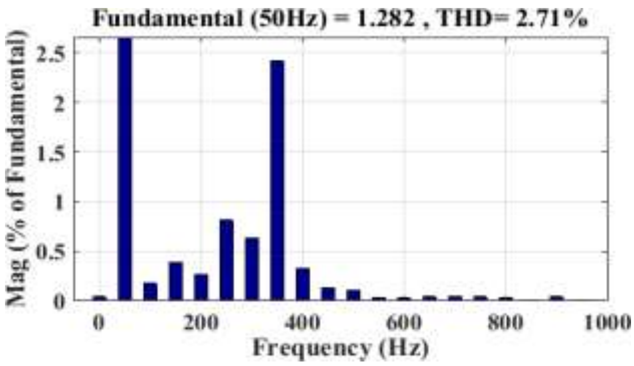


Fig. 7: (a) & Figure 7(b) presents the current total harmonic distortion (THD) at the bus-2 (PCC). When a transformer with a very high VA rating is used, the source current THD that is referred to as BUS-1 current.

4.4.3 Low Power Rating Transformer with DSTATCOM

Connecting the DSTATCOM to the suggested system reduces harmonic distortion in the following ways: the current harmonic distortion at PCC (BUS-2) is 2.05%. Figure 8(a). Figure 8(b) shows that the total harmonics of the source current are decreased to 2.71%. As shown in Figure 8(c), the fraction of voltage harmonics at the PCC has decreased to 2.57%.





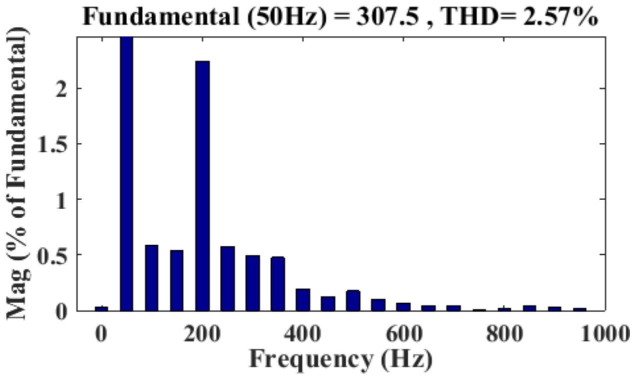


Fig. 8: (a). Current total harmonic distortion at Bus-1. Figure 8(b) and Figure 8(c) show the current total harmonic distortion (THD) at the point of common coupling (PCC) and the voltage THD at the same location, respectively, as measured by the low power rating transformer DSTATCOM

5 Conclusion

The synchronous reference frame control procedure is utilized to investigate and develop a four leg VSI based DSTATCOM for the 11kV/400V nonlinear & imbalanced distribution framework for load. The introduction of voltage and current harmonics into the system when limiting the transformer rating to less than 1 MVA. Only current harmonics, not voltage ones, are present when the transformer's power rating exceeds 1 MVA. Using SRF-controlled DSTATCOM under nonlinear and imbalanced load, the voltage and current harmonics are compensated. We look at total harmonic distortion with and without DSTATCOM, as well as with and without high power ratings. By using the MATLAB/SIMULINK program, the simulation results are confirmed.

References:

[1] B. Bose, "Global energy scenario and impact of power electronics in 21st. century," *IEEE Trans. Ind. Electron.*, vol. 60, no. 7, pp. 2638-2651, July 2013.

https://doi.org/10.1109/TIE.2012.2203771.

[2] Hive S, Chatterjee K, Fernandes BG. VAR compensation and elimination harmonics in three-phase four-wire system based on unified constant frequency integration control. In: *IEEE 11th international conference on harmonics and quality of power*; 2004, Lake Placid, NY, USA. pp. 647–51. http://dx.doi.org/10.1109/ICHQP.2004.1409429.

[3] George M, Basu KP. Modelling and control of three-phase shunt active power filter. *Am J Appl Sci* 2008; 5(5):1064–70. http://dx.doi.org/10.3844/ajassp.2008.1064.1070.

[4] G.-Myoung Lee, Dong-Choon Lee, Jul-ki Seok, ''Control of series Active power filters compensating for source voltage Unbalance and current harmonics'', *IEEE Transactions on Industrial Electronics*, vol.51.no.1.pp.132-139, February 2004. http://dx.doi.org/10.1109/TIE.2003.822040.

[5] Singh B, Chandra A, Al-Haddad K. Reactive power compensation and load balancing in electric power distribution systems. *Int J Electr Power Energy System* 1998; 20:375–81.Aug. https://doi.org/10.1016/S0142-0615(98)00008-8.

[6] Sabha Raj Arya, Bhim Singh, Ram Niwas, Ambrish Chandra, and Kamal Al-Haddad. "Power Quality Enhancement Using DSTAT- COM in Distributed Power Generation System," *IEEE Tran. Ind. App.* Nov 2016, VOL.52 (6):5203-52122. https://doi.org/10.1109/PEDES.2014.7042038.

[7] B. Singh, P. Jayaprakash, D. Kothari, A. Chandra, and K. Al Had-dad, "Comprehensive study of DSTATCOM configurations," *IEEE Trans. On Ind. Informatics*, vol. 10, no. 2, pp. 854–870, May 2014. http://dx.doi.org/10.1109/TII.2014.2308437.

[8] AredesM, Hafner J,Heuman K. Three phase four-wire shunt active filter control strategies. *IEEE Trans Power Electron Mar.* 1997; 12(2):311–8. https://doi.org/10.1109/63.558748.

[9] B. Singh, P. Jayaprakash, T. R. Somayajulu, and D. Kothari, "Reduced rating VSC with a zig-zag transformer for current compensation in a three-phase four-wire distribution system," *IEEE Trans. on Power Del.*,vol. 24, no. 1, pp. 249–259, Jan. 2009. https://doi.org/10.1109/TPWRD.2008.2005398

[10] B. Singh, P. Jayaprakash, and D. Kothari, "A T-connected transformer and three-leg VSC based DSTATCOM for power quality improvement," *IEEE Trans. on Power Electron.*, vol. 23, no. 6, pp. 2710–2718, Nov.2008. https://doi.org/10.1109/TPEL.2008.2004273.

[11] B. Singh, S. Arya, C. Jain, and S. Goel, "Implementation of four-leg distribution static compensator," *IET Generation Transmission Distribution*, vol. 8, no. 6, pp. 1127–1139, Jun. 2014. http://dx.doi.org/10.1049/iet-gtd.2013.0582.

[12] Mahesh K. Mishra, A. Ghosh, A. Joshi, and H. Suryawanshi, "A novel method of load compensation under unbalanced and distorted voltages,"*IEEE Trans. on Power Del.*, vol. 22, no. 1, pp. 288–295, Jan. 2007. http://dx.doi.org/10.1109/TPWRD.2006.881579.

[13] S. Karanki, N. Geddada, Mahesh K. Mishra, and B. Kumar, "A DSTATCOM topology with reduced dc-link voltage rating for load compensation with non-stiff source," *IEEE Trans. on Power Electron.*,vol. 27, no. 3, pp. 1201–1211, Mar. 2012. http://dx.doi.org/10.1109/TPEL.2011.2163946.

[14] S. R. Reddy, P. V. Prasad and G. N. Srinivas, "Power Quality Enhancement Using Particle Swarm Optimization Based Shunt Active Power Filter," *International Journal of Mathematical Models and Methods In Applied Sciences*, Vol.16, PP.134-139, 2022. https://doi.org/10.46300/9101.2022.16.22.

[15] Bhattacharya, C. Chakraborty, and S. Bhattacharya, "Parallel connected shunt hybrid active power filters operating at different switching frequencies for improved performance," *IEEE Trans. on Ind. Electron.*, vol. 59, no. 11, pp. 4007–4019, Nov. 2012. http://dx.doi.org/10.1109/TIE.2011.2173893.

[16] Ghosh and A. Joshi, "A new approach to load balancing and power factor correction in power distribution system," *IEEE Trans. on Power Del.*, vol. 15, no. 1, pp. 417–422, Jan. 2000. https://doi.org/10.1109/61.891535.

[17] D. M. Brod and D. Novotny, "Current control of VSI-PWM inverters," *IEEE Trans. on Ind. Appl.*, vol. IA-21, no. 3, pp. 562–570, May 1985.

https://doi.org/10.1109/TIA.1985.349711.

[18] U. Rao, Mahesh K. Mishra, and A. Ghosh, “Control strategies for load compensation using instantaneous symmetrical component theory under different supply voltages,” *IEEE Trans. on Power Del.*, vol. 23, no. 4, pp. 2310–2317, 2008. https://doi.org/10.1109/TPWRD.2008.923053.

[19] Mahesh K. Mishra., A. Ghosh, and A. Joshi, “A new STATCOM topology to compensate loads containing AC and DC components,” in Power Engineering Society Winter Meeting, 23 – 27, January, 2000, Singapore. *IEEE*, vol. 4, 2000, pp. 2636–2641. http://dx.doi.org/10.1109/PESW.2000.847298.

[20] Ghosh and G. Ledwich, Power Quality Enhancement Using Custom Power Devices, ser. Kluwer international series in engineering and computer science. *Springer* US, 2002.313. ISBN: 9781461511533.

[21] S. R. Reddy, P. V. Prasad and G. N. Srinivas, “Performance Comparison of DSTATCOM with PI and PSO-PI Controller under Nonlinear Load Condition,” *Power Research-A Journal of CPRI*, Vol.16 (2), PP.115-124, 2020. https://doi.org/10.33686/pwj.v16i2.153673.

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

No funding was received for conducting this study.

Conflict of Interest

The authors have no conflicts of interest to declare