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Modified SOGI-based DSTATCOM for Power Quality Enhancement

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ABSTRACT:High distortion in the load current of a weak power system network may happen as a result of the presence of non-linear and dynamic loads. As a result, harmonics may enter the supply system and negatively impact the other connected loads. This project focuses on a solution to power quality issues because the traditional control algorithms do not effectively reduce power quality issues. This suggested topology discusses a second order generalised integrator-based controller that is intended to successfully address PQ problems brought on by a weak grid. With the aid of DSTATCOM, SOGI is intended to extract the load current's fundamental active current magnitude and lessen PQ problems. The zigzag transformer is used to achieve neutral current compensation.

KEYWORDS:Distribution Static Compensator (DSTATCOM), Voltage Source Converter (VSC), Hysteresis Current Controller (HCC)

I. Introduction

Due to the fact that traditional energy production facilities use fossil fuels, which can be scarce and quickly depleted, research is currently being done on renewable electricity generation sources like the sun and wind. Modern control algorithms and advanced power electronics interface circuits [1] are essential for the green integration of REPs. Most of the world's independent REP-producing stations are used, and they could be considered weak grid systems. If a device's short circuit ratio is less than three, it is said to be a vulnerable grid system [2].Numerous additional factors, such as voltage unbalance, harmonics, inter-harmonics, voltage fluctuations, reactive electricity burden, islanding, and compensation issues, also prevail [3].The primary area with regard to the vulnerable grid is the calculation of frequency, section angle, and voltage magnitude. PQ issues with REP technology through wind are numerous. Variable velocity wind generator operation is mentioned in relation to vulnerable distribution networks [4].

Amin and Mohammed have developed an out-of-control rectifier and a digitally controlled inverter for variable speed wind turbines. The self-excited induction generator's control circuitry is used to regulate the flow of active and reactive power through the LC filter that is inserted between the inverter and the grid[5].an overview of the weak network that supports a doubly fed induction generator and a power generation unit. A good way to reduce voltage fluctuations and other PQ issues while increasing wind strength is to use the adaptive voltage control method, which has been used for variable velocity wind turbines in [6].

A primary grid is connected to an adaptive control-vulnerable grid in [7] so that the device can achieve precise phase margin and excessive bandwidth. The use of a unified PQ conditioner is described as a weak grid in [8] non-linear discrete time version with a discrete Hamilton-Jacobi-Issacs premier stabilising controller. This paper demonstrates the damping in the event of islanding and the reduced ability of oscillations inside the vulnerable grid structures as a result of load removal. In order to maximise the performance of the entire converter wind turbines under distorted conditions, Leon and Solsona provided a manipulative approach[9] that specifically addresses the harmonic rejection capability under variations of the grid frequency.

II. PROPOSED SYSTEM

The TPFW machine in this case uses a non-linear load. In this instance, imparting inductors with a three mH cost are used to supply the distortion. At the point of ordinary coupling, the load and the compensator are attached. A chain isolator in section 'c' is used to differentiate the weight while incorporating unbalance in the system. The zig-zag transformer, which is connected to the point of common coupling and contains three single phase transformers, is used to perform neutral current compensation. The neutral cord is brought into small impedance Zsn.Current and voltage signals from voltage and current sensors are fed to DSPACE 1104 to produce gating pulses of DSTATCOM in order to manipulate the compensating currents of the proper magnitude and segment on the point of common coupling to resolve the PQ issues in the proposed system.

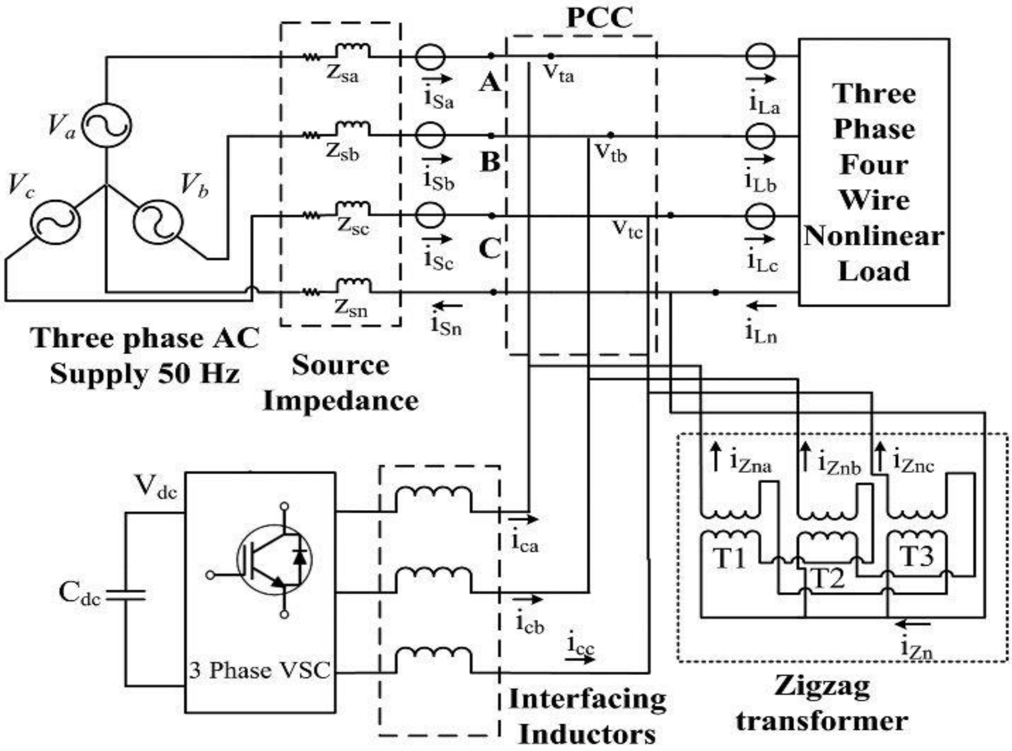

Fig. 1:System configuration of TPFW system incorporating zig-zag transformer

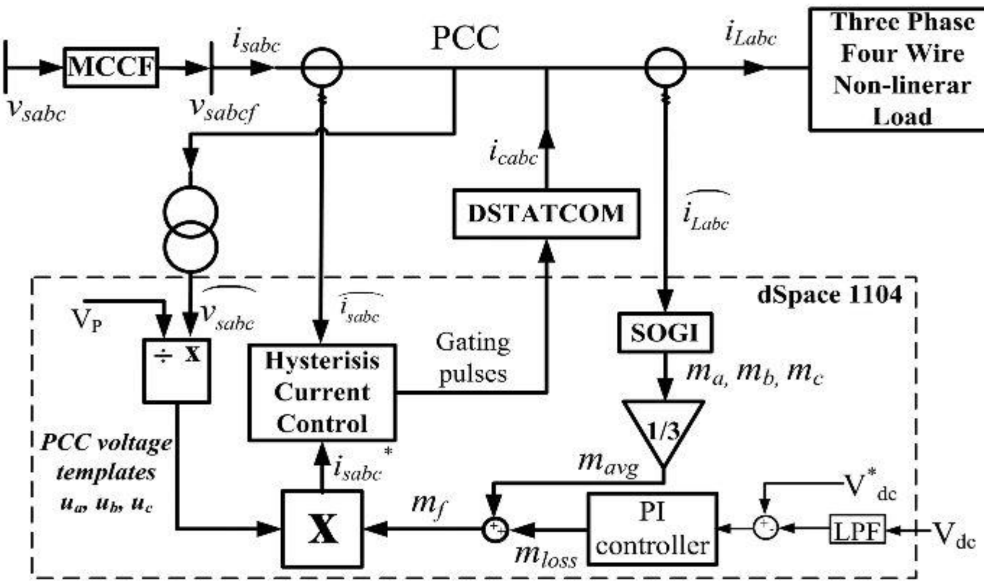

Fig. 2:Control scheme diagram of proposed system

III. DESIGN OF PROPOSED DSTATCOM

1.Reference Current Generation Scheme

Nonlinear loads, both balanced and unbalanced, are connected to the vulnerable grid machine in this TPFW machine. The voltages become more unbalanced and distorted as a result of the creation of a large impedence in three grids, which causes unbalanced and distorted current to waft through percent. Directly using templates from distorted voltages to generate reference currents is not possible for DSTATCOM to function properly. For voltage and contemporary abstraction, the MCCF-SOGI block method is discussed. Here, transformation is performed at the common coupling point,

$$\begin{bmatrix} v_{t\alpha} \\ v_{t\beta} \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} v_{ta} \\ v_{tb} \\ v_{tc} \end{bmatrix} \quad (1)$$

Where,Vta ,Vtb ,Vtc are the three phase PCC voltages Vtα ,Vtβ are the transformed voltages. The transformed voltages can be further be expanded as,

$$v_{t\alpha\beta}^{h} = v_{t\alpha\beta}^{h+} + v_{t\alpha\beta}^{h-} + v_{t\alpha\beta}^{h0} \quad (2)$$

To extract fundamental positive component of PCC voltages, MCCF tuned to the fundamental positive frequency, that is 50Hz which is operated on transformed Vtαβ,

$$\begin{bmatrix} v_{taf}^{+} \\ v_{tbf}^{+} \\ v_{tcf}^{+} \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & 0 \\ -\frac{1}{2} & \frac{\sqrt{3}}{2} \\ -\frac{1}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} v_{t\alpha}^{+} \\ v_{t\beta}^{+} \\ v_{to} \end{bmatrix} \quad (3)$$

In turn, the fundamentally important modern components were extracted using a SOGI block. The recommended approach uses a sophisticated fusion of MCCF and SOGI filters to remove voltage and modern.The wonderful collection aspect of grid voltage is extracted using an MCCF from the polluted grid, and a SOGI block is intended to produce reference compensating alerts for PQ reduction.

A MCCF is made up of a number of CCFs, each of which may be used to extract a specific harmonic signal from a distorted signal. This is how the's' domain transfer function is written:

$$\text{CCFs} = \frac{\omega_r}{s - jk\omega_o + \omega_o} \quad (4)$$

When ω=ωo the CCF has zero phase shift unity gain type of response while at ω=ωr bandwidth and the gain of the filter are ideal. So ωr is chosen equal to ωo. The merits of CCF over moving average filter is the capability to discriminate between positive and negative sequence component of exact harmonic. The fundamental frequency ωo is 314 rad/s and the bandwidth of the filter can be given as 314rad/s.

As an MCCF filter has no phase lag in the system, it is chosen to compute the positive sequence components of grid voltage. Each phase's active components for three-phase load currents are designed with the aid of a SOGI block.The effective active component current magnitude for phase 'a' is given by,

$$m_a = \sqrt{i_{Lap}^2 + i_{Laq}^2} \quad (5)$$

$$m_{avg} = \frac{m_a + m_b + m_c}{3} \quad (6)$$

The PCC voltage templates (u_a, u_b, u_c) are designed as,

$$u_a = \frac{v_{taf}}{v_p},\ \ u_b = \frac{v_{tbf}}{v_p},\ \ u_c = \frac{v_{tcf}}{v_p} \quad (7)$$

IV. SIMULATION RESULTS

Table 1 System parameters

Parameters	Values
Programmable AC source	3-phase , 415Vrms(ph-ph)
Source Impedence	Zs=0.14+j0.6 Ω
DC link capacitor	CDc=2200 µ F
Reference dc link voltage	VDc=1100v
Filter inductor	Lf=5mHand 2.5mH in neutral
DC pi controller gains	Kpd=0.6 and Kid=0.039
AC PI controller gains	Kpa=0.08 and Kia=0.8

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The simulation model, which consists of a source, load, DSTATCOM, and control block, is shown in Figure 3. The nonlinear load is a diode bridge rectifier, while the linear load is a series combination of resistance and inductance for each phase. When a non-linear load is connected, the source current becomes distorted and the harmonics in the load current rise. With the help of the controller, harmonics are lessened while high efficiency is kept. The simulation's results are shown below.

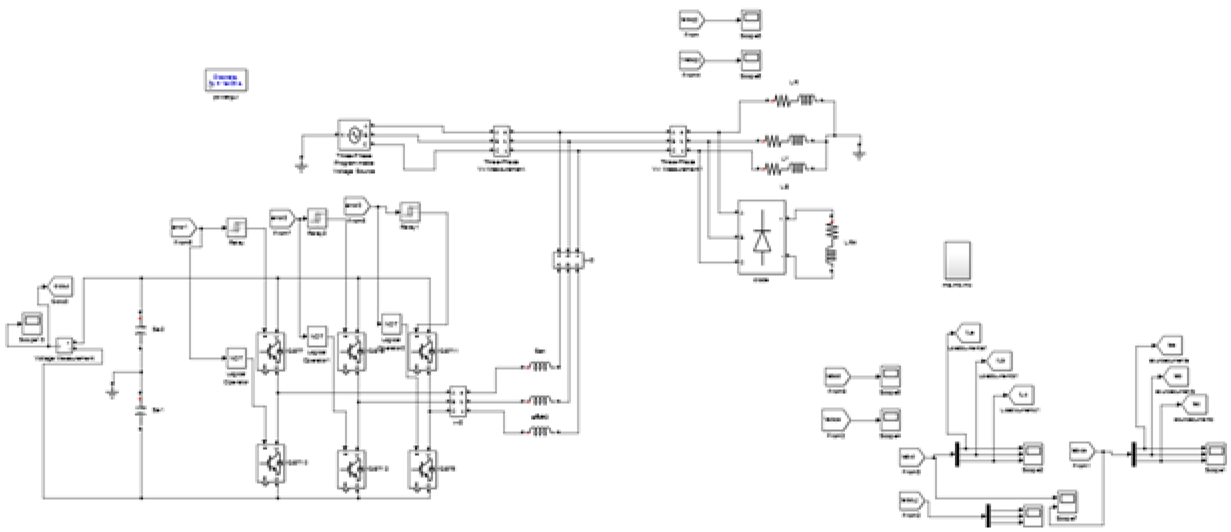

Figure 3Simulation diagram of proposed system

The magnitudes of the phase 'a' fundamental active current (ma), phase 'b' fundamental active current (mb), and phase 'c' fundamental active current (mc) are shown in Figure 4.

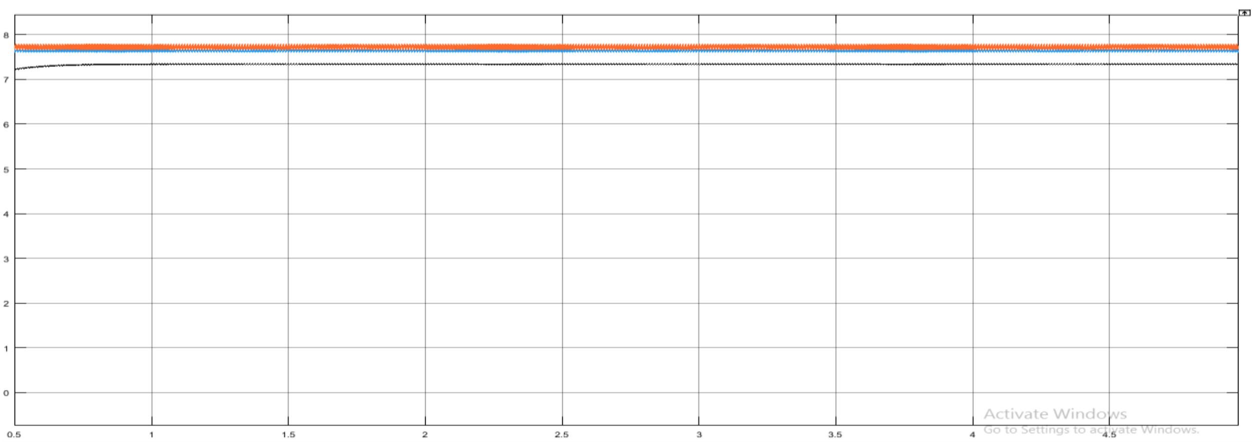

Figure 4Active component of load current for three phases

After connecting a non-linear load, the source current in the previous Figure 4 is distorted. Here, it is almost rated valu for current value. Because of impedance changes, a non-linear load does not consume a sinusoidal current. Consequently, that source current will also be deformed.

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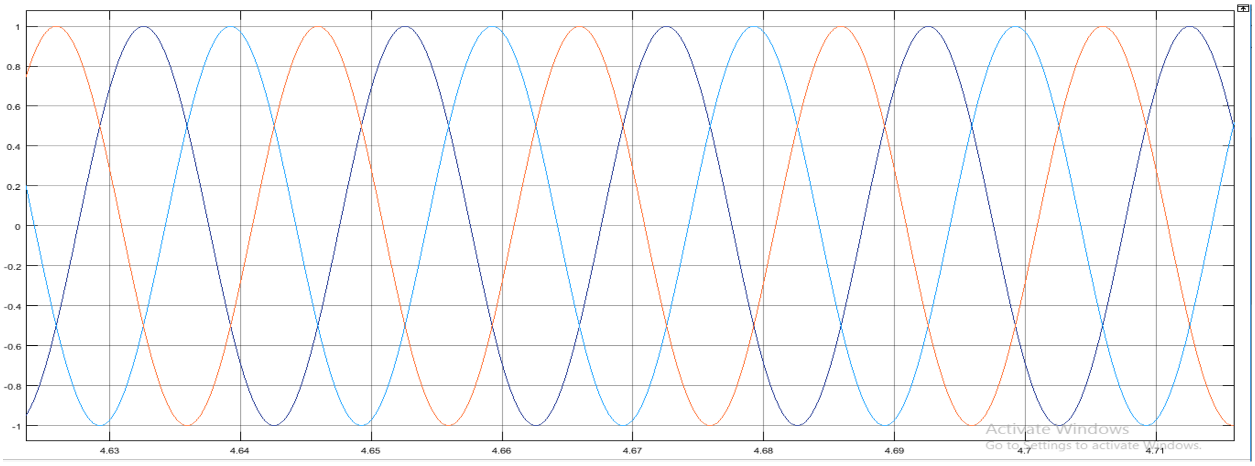


Figure 5Three phase PCC voltage templates (ua, ub, uc)

Figure 5 displays PCC voltage templates (ua, ub, uc) which is equal in magnitude and phase and figure 6 is the actual source current without compensation

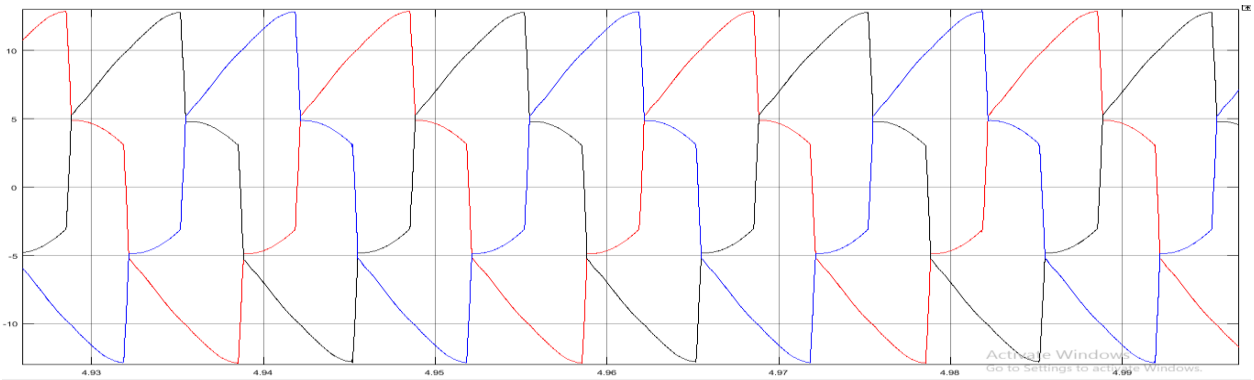
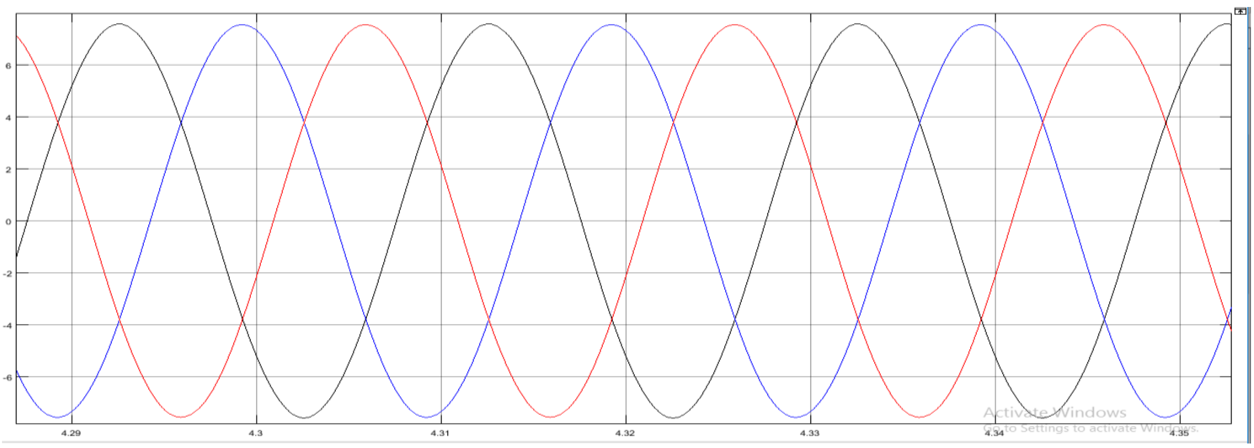


Figure 6Three phase load current

Figure 6 displays the actual load current which is highly distorted and nonlinear due to the presence of nonlinear load. These nonlinear load current makes the distortion in the PCC voltages and disrupt other loads which is connected in the PCC.



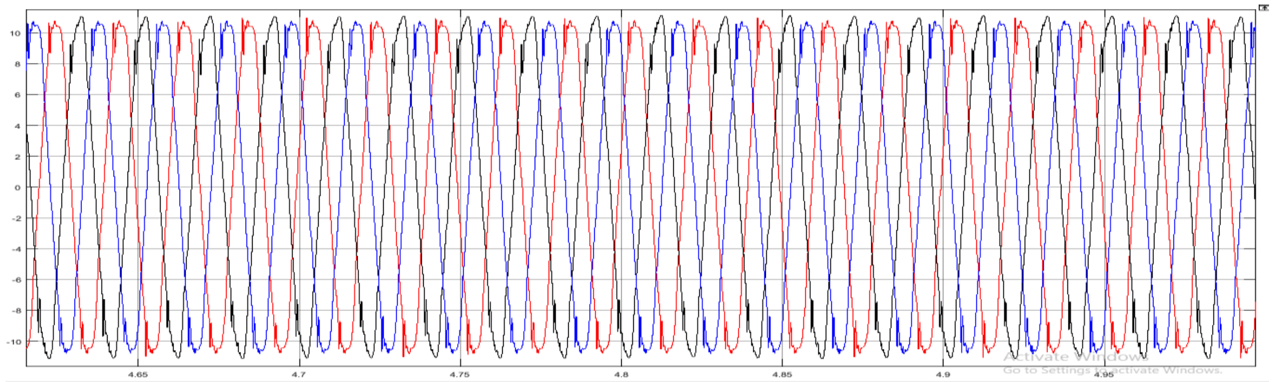


Figure 7Three phase reference source current and compensated Source current

Figure 7 shows the effectiveness of proposedcontrol in creating reference source current to compensate the load at PCC and make the source current to be Sinusoidal and linear

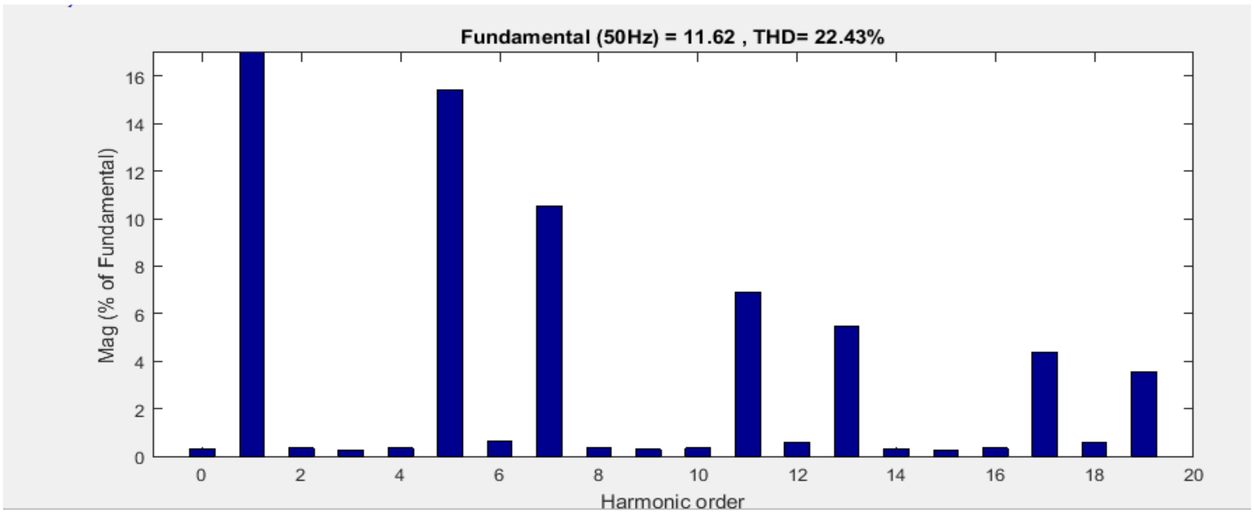


Figure 8 THD for source current before compensation

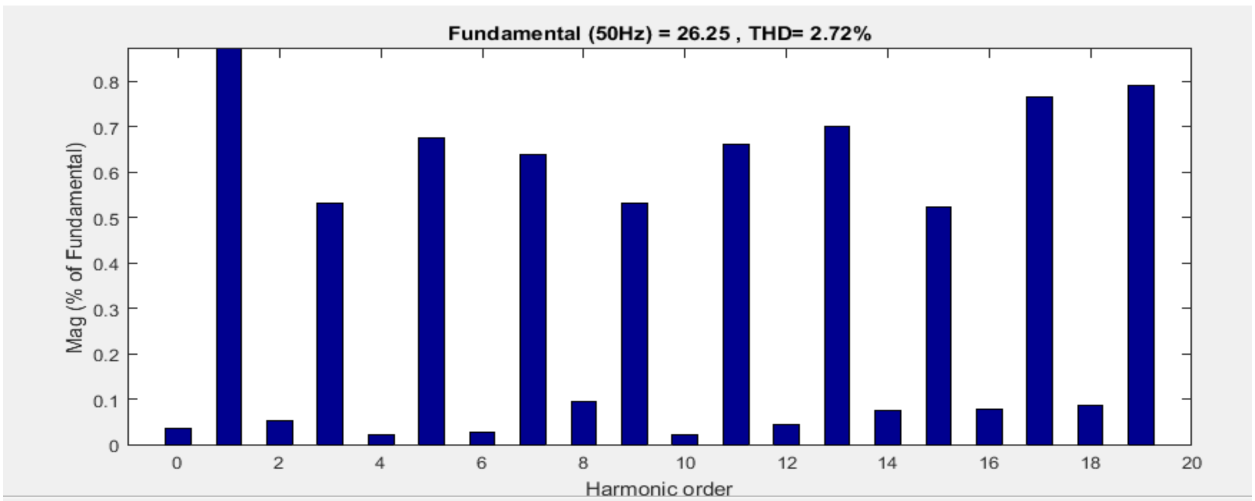


Figure 9THD for source current before compensation

Figure 8 and 9 shows the effectiveness ofproposed system in alleviating power quality issues and compensating loads, load balancing done by the proposed controller.

V. CONCLUSION

This paper suggests a straightforward but efficient control method to reduce PQ issues in TPFW weak grid systems. In order to compensate for load, this project uses a SOGI-based controller. The active current magnitude and positive sequence component of PCC voltage are intended to be extracted by the proposed SOGI controller. A new control algorithm has been designed and tested for load balancing, power factor correction, and neutral current compensation in the supply side and provides fast and efficient control in a weak grid environment without introducing phase delay due to SOGI's filtering action. This is because conventional algorithms are unable to achieve the desired compensation under polluted grid conditions. MATLAB simulation has been used to show how the controller functions.

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