A Proposed PID controller based D-STATCOM for enhancing power quality with PR+FB controller

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***Abstract*— This article proposes a PID controller-based custom power device for enhancing Power quality (PQ) with PR and comb filter. This research compares different control strategies for improving the power quality by reducing harmonic content in nonlinear load fed with microgrids. The proposed PID controller tunes the DC-link voltage of DSTATCOM to improve the power factor. A comb filter was used to achieve compensation of harmonics in the grid current which, unlike a PR controller, does not require tuning for separate harmonic compensation. The results of these forms comb filters, such as feed-forward and feedback form, are compared in this study. The D-STATCOM compensates the reactive power and harmonics efficiently. The proposed system is designed in MATLAB/Simulink environments and obtained better results compared to conventional systems.**

***Keywords*— CombFilter, D-STATCOM, Reactive power compensation, Proportional Resonant Controller, Voltage Source Inverter**

I. Introduction

Because of enlargement in the choppy and non-direct burden packages, the electric strength fine has been corrupted within the electricity movement community [1]. The vast utilization of strength hardware apparatus and non-direct loads at PCC creates symphonious flows crumbling the nature of the electric power. Additionally, from the transmission angle, an intense higher symphonious level is affected and reasonable cutoff factors for every consonant and THD mutilation are given employing the global concepts. CPDs are possibly the quality solution for similarly increasing the power first-class in the circulation community.

Thus D-STATCOM has been suggested which is associated in parallel across the heap imparting receptive energy and music to such a quantity that supply flows are adjusted with sinusoidal and near team spirit power issues. Estimation of D-STATCOM includes the age of reference elements or compensation currents for infusing and acknowledging them through suggested VSI and changing approaches to create beats for VSI. The reimbursement execution likewise relies upon the appropriate desire of a calculation for the age of reference elements [2]. A few hypotheses are suggested in the writing for reference current age. All every utilized hypothesis are coordinated base hypothesis, quick balanced parts hypothesis and immediate receptive power hypothesis and changed pq hypothesis. Here in this paper prompt, even part hypothesis is utilized for reference current age. It has no complicated changes and can be utilized for repaying any straight and non-direct loads, symphonious end, power factor improvement and load adjusting. Exchanging strategy is significant in the plan of DSTATCOM. A few exchanging strategies are existing and hysteresis current control is utilized generally due to its effortlessness, great unique reaction, and strength. Nonetheless, it has a variable exchanging recurrence. Subsequently, for the activity of VSI with consistent exchanging recurrence, SPWM is proposed here to switch methodology with full regulators. To alleviate the symphonious flows a few control strategies have been explored [3].

Non-direct regulators, for example, predictive, hysteresis and bum regulators, give highly powerful reactions [6] and are exceptionally hearty to impedance variety, however, the downside is it needs a high inspecting rate for good execution. The symphonious compensator applied in the event of straight regulators is executed either in a fixed reference outline or in a coordinated turning reference outline (dq0). Because of numerous direction changes and balanced parts decay, the application in dqo reference outline is mind-boggling [4] which is not available in the fixed reference outline applications. In the same way, direct current regulator, for example, PI regulator which is notable because of its straightforwardness has deliberately eased blunder and consistent state extent issues in following a sinusoidal sign and has extremely restricted aggravation dismissal capacity.

Consequently, the relative thunderous (PR) regulator worked in fixed reference outline has been viewed as the most encouraging current regulator on account of music concealment capacities with small THD in the current, and following sinusoidal signs. To relieve the music parts, the thunderous regulator for separate sound parts is tuned and associated notwithstanding the regular PR-regulator. Besides, this builds the computational intricacy and reaction time and makes the regulator more minds boggling. Consequently, concurrent numerous symphonious compensation with a brush channel [5] and PR-regulator have been suggested in this article. The remaining article is organized as follows. Section II presents the literature survey, Section III presents the test model, Section IV about the control method, Section V presents results and Section VI concludes.

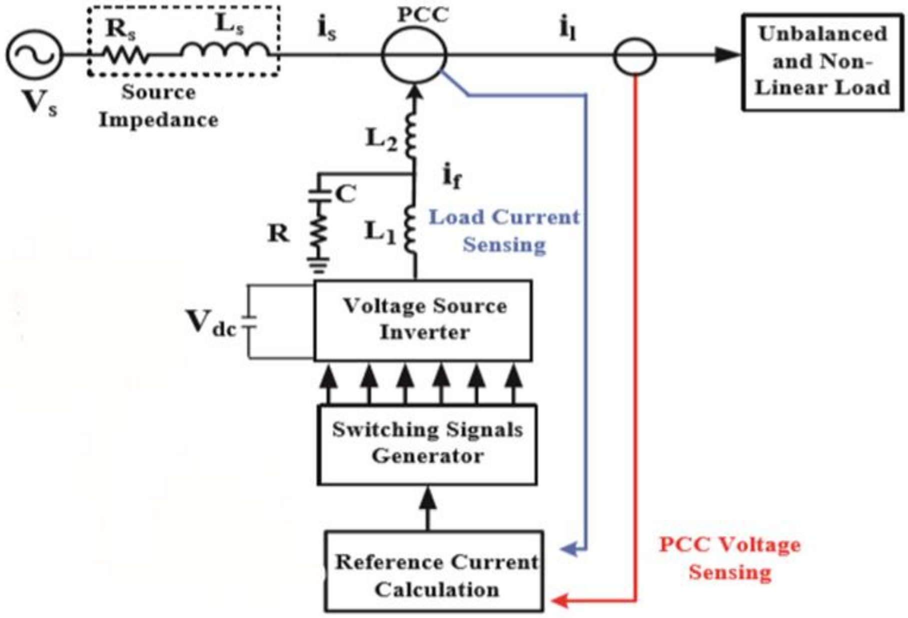

Figure 1: Represents DSTATCOM under implementation

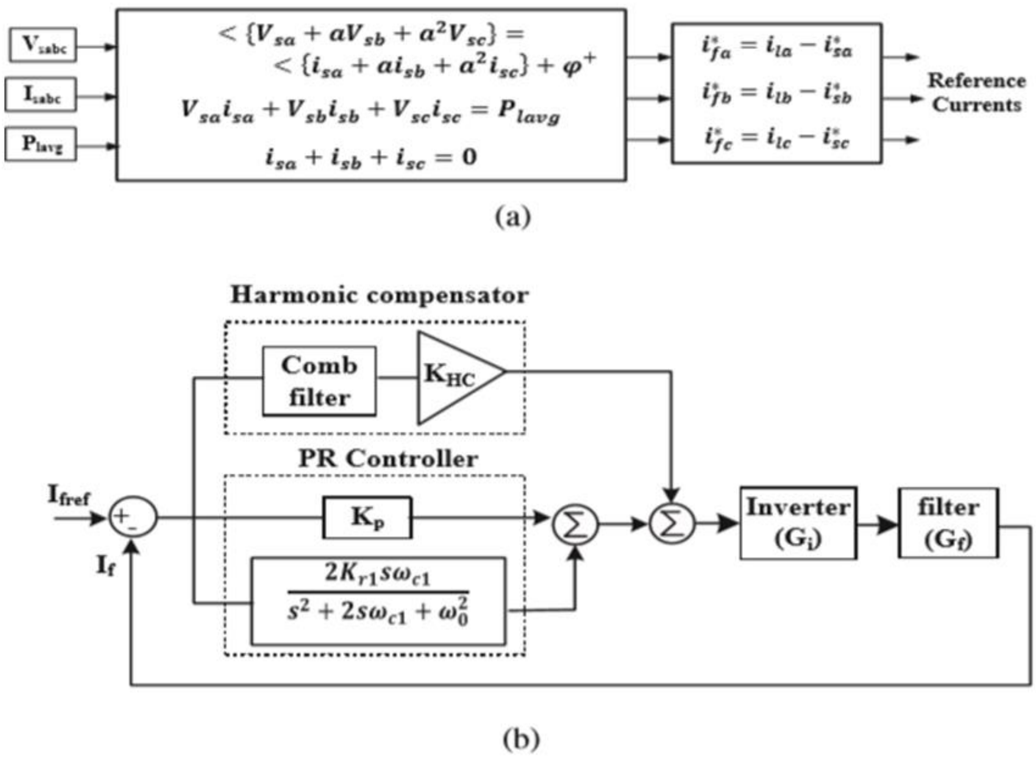

Figure 2: Represents Proposed PR controller with comb filter

II. RELATED WORK

There are major power quality challenges are facing now so we have to enhance the power quality and reduce the losses and improve the Power delivery capacity to the consumers. This research throws light on power quality (PQ) challenges related to the planning of distributed generation systems based on renewable as well as non-renewable sources [5].

The voltage Sag in the transmission line is reduced by using the Static Synchronous Compensator (STATCOM). STATCOM supplies the reactive power required for the nonlinear loads. STATCOM consists of the voltage source inverter and DC source. The Main AIM of VSC is to compensate for the reactive power the output of the VSC is controlled by the firing angle controller [6]. Using DSTATCOM we can inject the reactive power into the system. By using DSTATCOM at the point of common coupling the voltage is balanced and losses are reduced, then the end users are satisfied [7]. This research on voltage compensation using multilevel DSTATCOM in ATP/EMTP. The distribution static compensator (DSTATCOM) is a device that can compensate voltage sags by injecting reactive power into distribution systems. This paper shows the influence of voltage sags characteristics by the presence of twelve-pulse DSTATCOM [8]. Power quality is a major issue in the electrical and electronics industry and data centers and they are more sensitive to voltage fluctuations. So, by using the DSTATCOM on the distribution side we can enhance the voltage profile and reduce distribution losses. we can reduce the dominant harmonics [9]. The motivation behind this research is to solve the power quality issues in the form of a voltage dip, swell and voltage variations or fluctuations for domestic, commercial and industries. The contributions of these power quality issues are severe in our existing electrical systems nowadays [10].

III. TEST SYSTEM UNDER IMPLEMENTATION

The proposed DSTATCOM for harmonic compensation under the implementation of non-linear loads is depicted in figure.1. It uses the conventional DSTATCOM for compensation of the harmonics, by injecting sufficient compensation currents. The non-linear loads connected to the PCC will produce the harmonics which are degrading the power quality. It is connected in shunt with a grid for compensation of reactive power and harmonics.

IV. PROPOSED PR CONTROLLER WITH COMB FILTER

The reference currents are generated as indicated in figure.2. The generated reference current is sent to the controller as indicated in the figure.2 (b) for generating the required pulses to the DSTATCOM. The PR controllers are the combination of the resonant and proportional term with a high gain transfer function. The comb filter is an additional signal with its delayed version. It is a feed-forward and feedback form that is added to the input signal. The PID controller is recommended for controlling the harmonics as the transient components on the lad side will degrade the DC link voltage. To control this DC link voltage, the required active power is taken from the system.

V. SIMULATION RESULTS AND DISCUSSION

A. *Without compensation filter:*

The simulation results of the proposed system with non-linear load without a compensation filter are presented in this section. Figure 3 represents the grid current and Figures. 4, Figure .5, Figure.6, represent THD waveforms of the grid currents for R, Y, B phases 11.49,12.19,12.83 respectively.

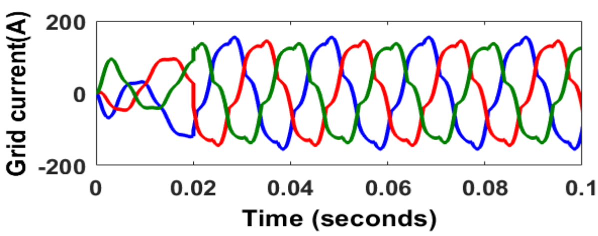

Figure 3: Represents Grid current consist higher order harmonic components without compensation filter

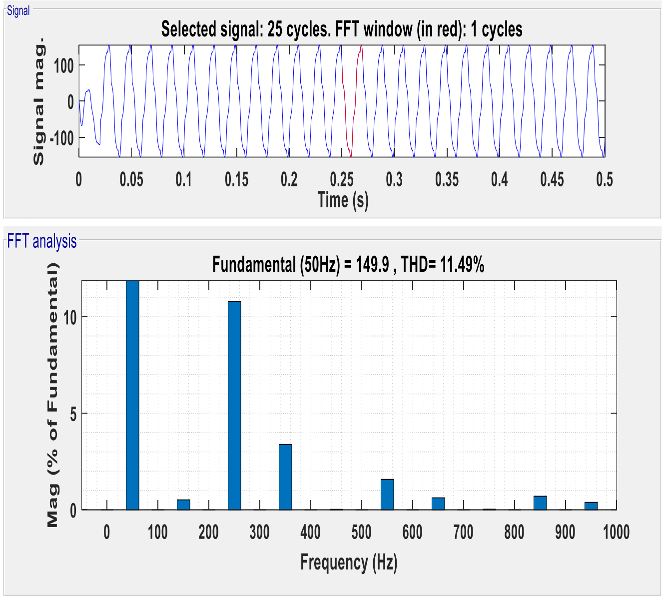

Figure 4: R Phase THD before compensation

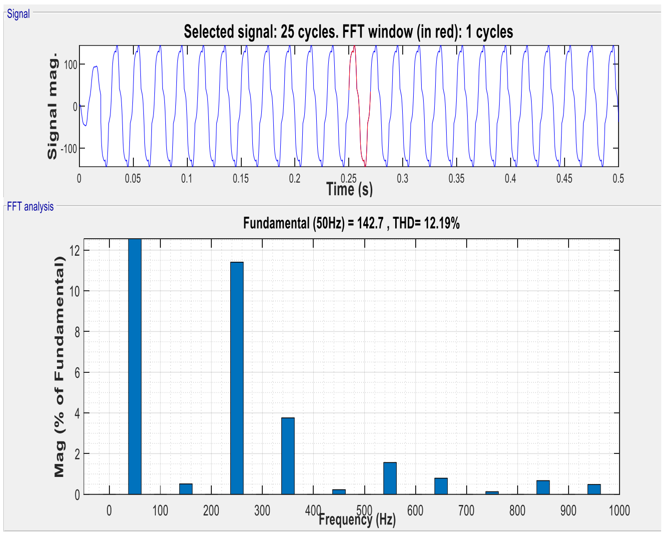

Figure 5: Y Phase THD before compensation

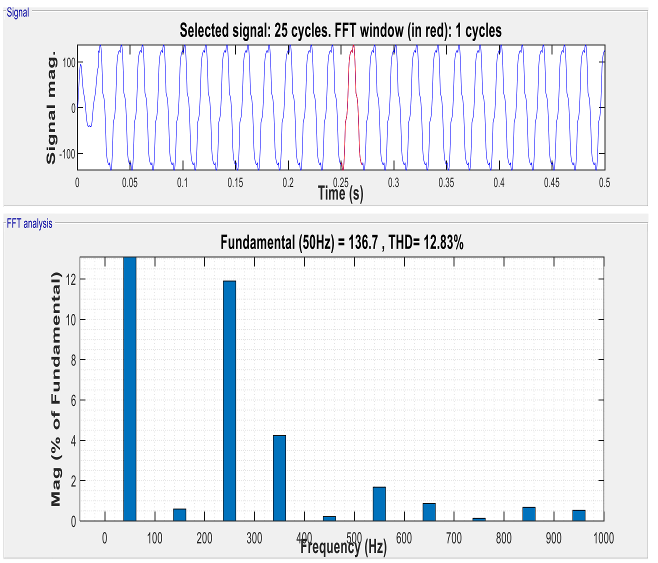

Figure 6: B Phase THD before compensation

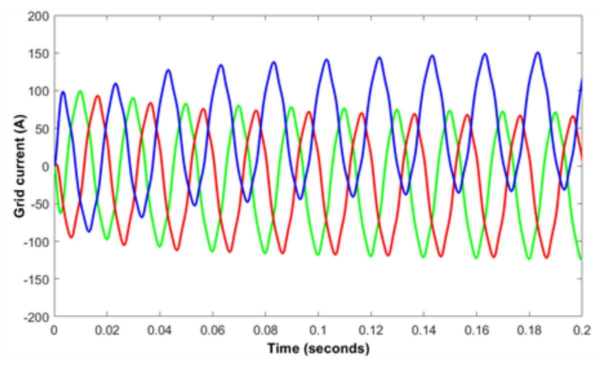

Figure 7: Grid Current after compensation using PR controller

B. With compensation: Using PR controller

The simulation results of the proposed system with non-linear load using a PR controller are presented in this section. Figure 7 represents grid current after compensation and Figure. 8 represents filter current Figure 9, Figure.10, Figure 11 represents THD waveforms of the grid currents for R, Y, B phases 4.03, 4.19, 4.35 respectively.

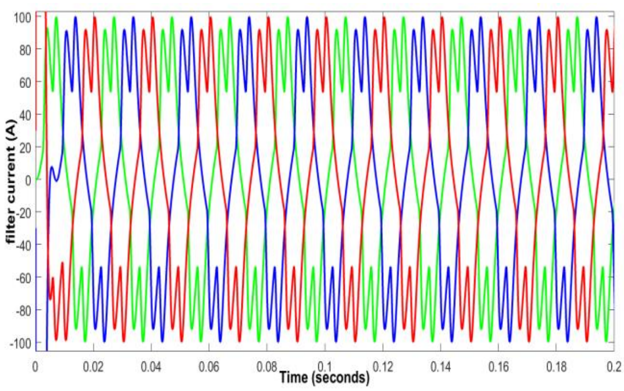

Figure 8: Filter current

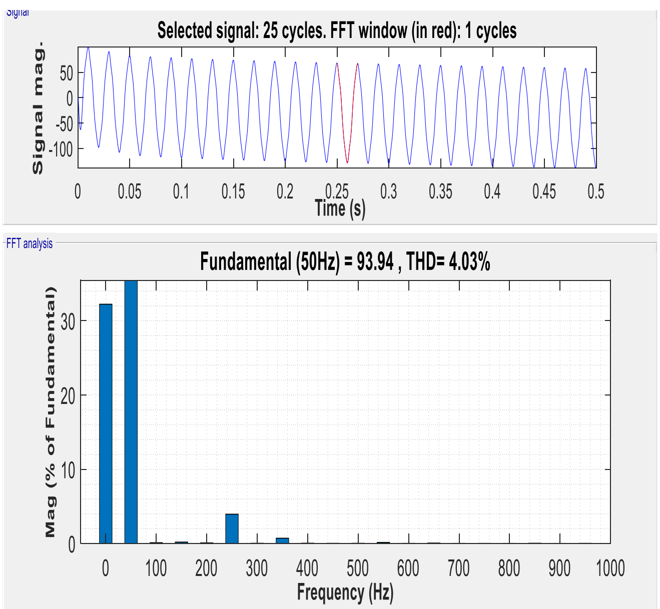

Figure 9: R Phase THD after compensation

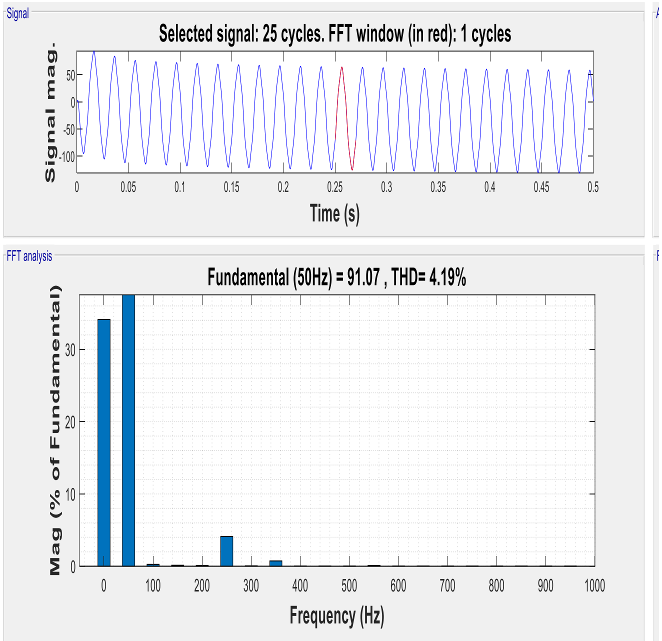

Figure 10: Y Phase THD after compensation

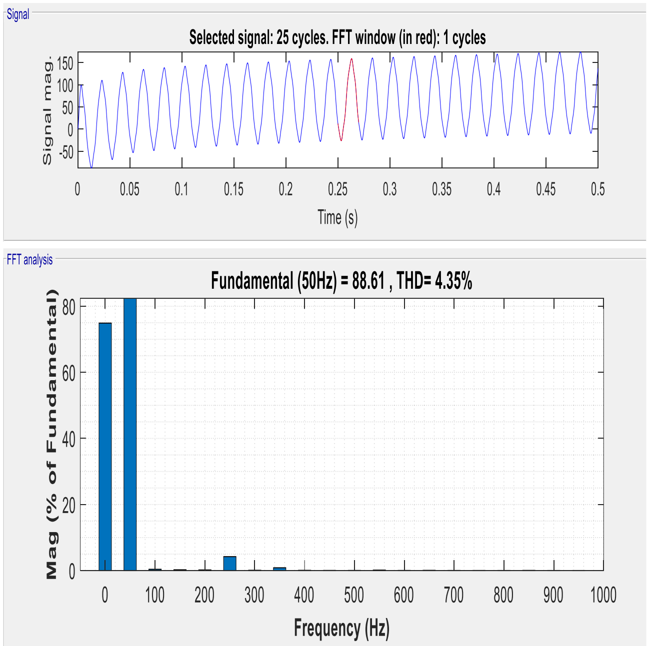

Figure 11: B Phase THD after compensation

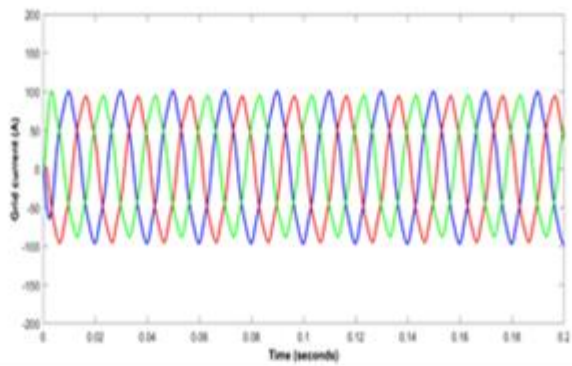

Figure 12: Grid Current after compensation using PR +FF controller

C. ***PR+FF controller***

The simulation results of the proposed system with non-linear load with compensation filter are presented in this section. Figure 12 represents grid current after compensation and Figure. 13 filter current, Figure .14, Figure.15, Figure .16 represents THD waveforms of the grid currents for R, Y, and B phases 4.22, 4.44, 4.65 respectively.

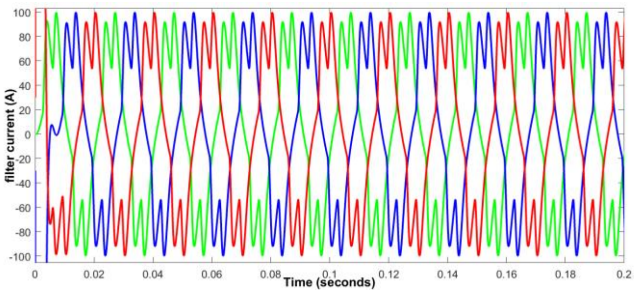

Figure 13: Represents Filter current

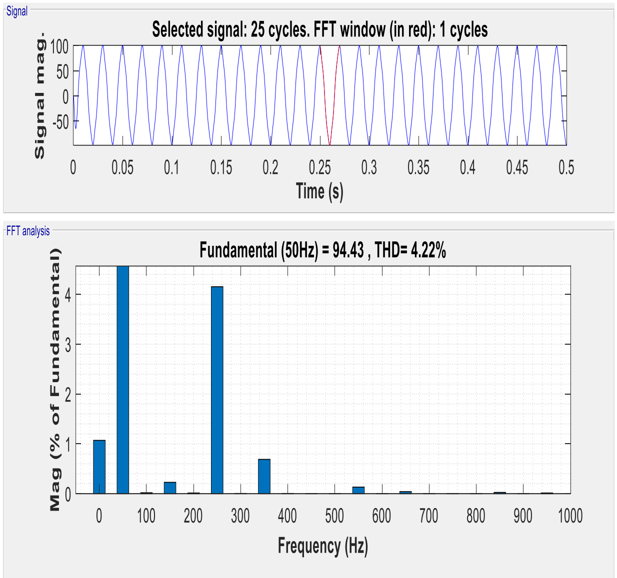

Figure 14: R Phase THD after compensation

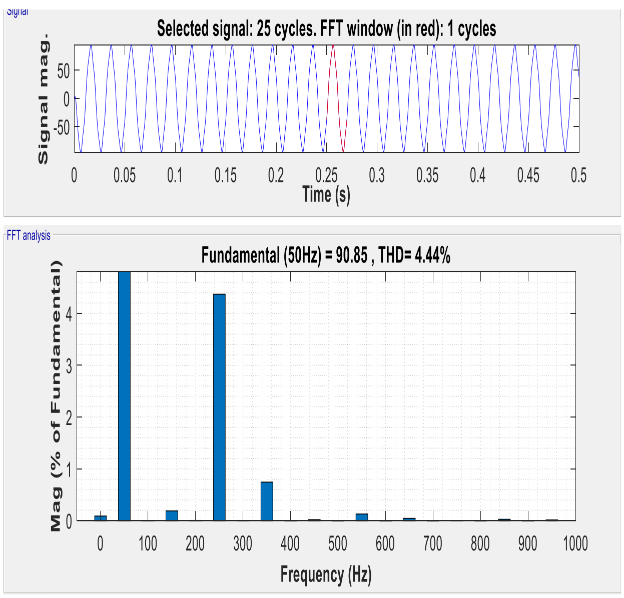

Figure 15: Y Phase THD after compensation

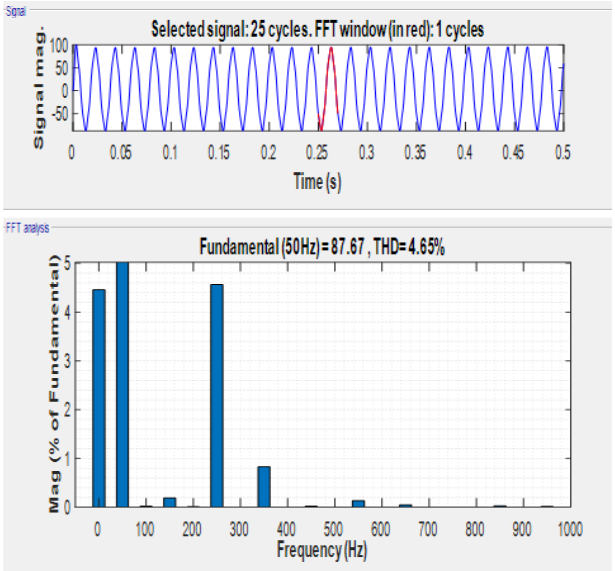

Figure 16: B Phase THD after compensation

D. ***PR+FB controller***

The simulation results of the proposed system with non-linear load with compensation filter are presented in this section. Figure 17 represents grid current, Figure 18 represents Filter current after compensation and Figure. 19, Figure 20, Figure 21, represents THD waveforms of the grid currents for R, Y, B phases 4.03,4.19,4.35 respectively.

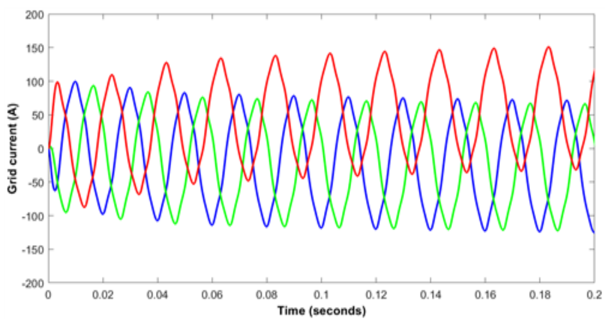

Figure 17: Grid Current after compensation using PR+FB controller

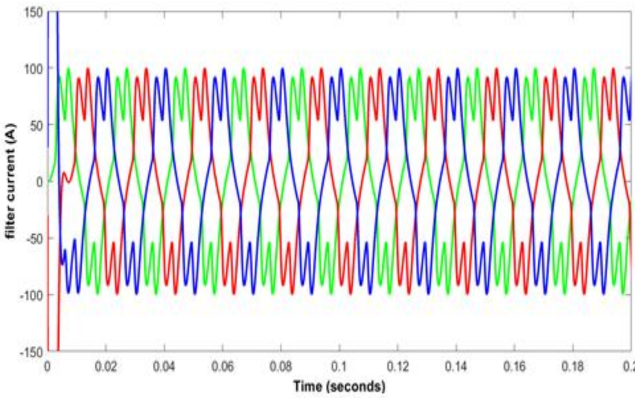

Figure 18: Filter Current

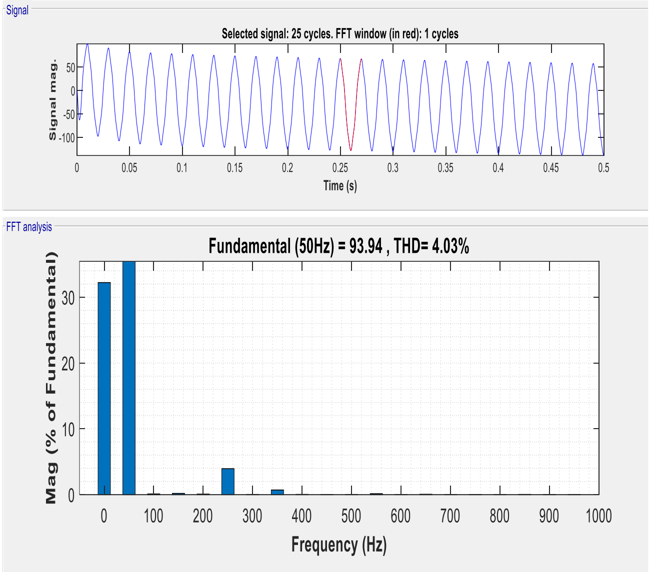

Figure 19: R Phase THD after compensation

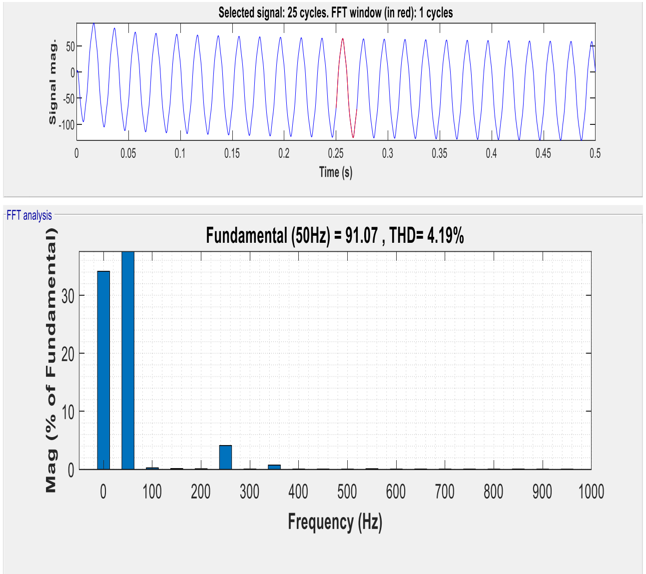

Figure 20: Y Phase THD after compensation

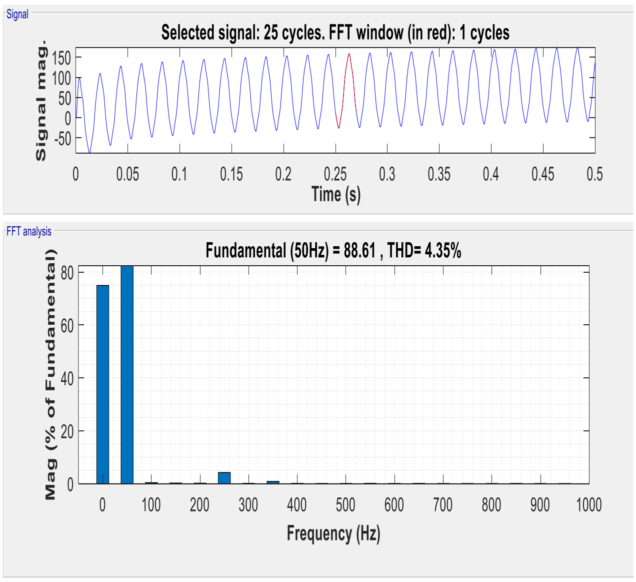

Figure 21: B Phase THD after compensation

VI. Proposed Extension with PID Controller

The simulation results of the proposed system with non-linear load with PID controller are presented in this section where the harmonic distortion is decreased to 4.03 as mentioned in figure 30. In conventional systems like without compensation, we get THD 11.89% which means we get heavily distorted waveform and after adding DSTATCOM with PR controller for the grid-connected nonlinear load we get THD 4.19% and again we can use PR+ comb filter we get 4.03%. In the case of our proposed PID with existing, we obtained 4.03% THD.

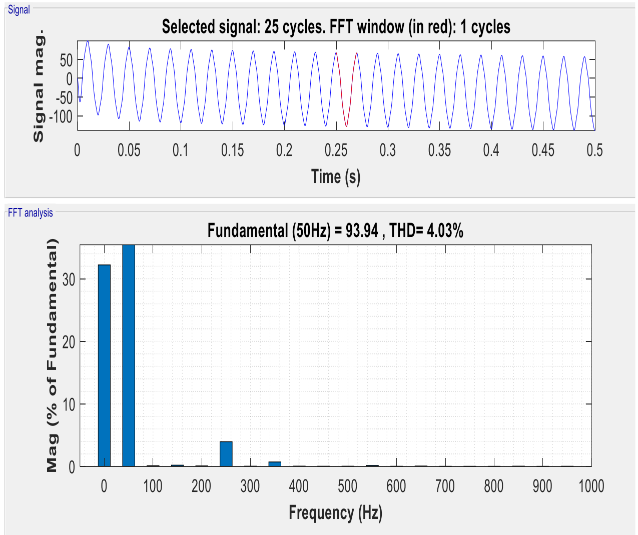

Figure 22 : Proposed PID Controller we will achieve 4.03% of THD

VII. Conclusion

In this project, we propose PID controller-based DSTATCOM for enhancing power quality in Microgrid fed nonlinear systems. Due to nonlinear loads, current related PQ issues will rise due to the system will be affected. For compensating line current harmonics and reactive power in this proposed system we are using PID with a PR+ comb filter. The proposed system is designed in MATLAB/SIMULINK toolbox and obtained results are proven to be compared to the conventional system proposed system reduces the THD as per IEEE standards.

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