Comparative Study of PI Controller and PID Controller for Power Quality Improvement

Ms. Ankita A. Yeotikar
PG Student, Electrical and Electronics Engg. Deptt.
PRMCEAM Badnera
Maharashtra, India
ankita.yeotikar@gmail.com

Mr. Swapnil B. Mohod
Asst. Professor, Electrical and Electronics Engg. Deptt.
PRMCEAM Badnera,
Maharashtra, India
swapnilmohod@gmail.com

Abstract— Power factor correction (PFC) is a mandatory functionality of electronic products in the industrial and commercial market in order to mitigate grid harmonics to improve power quality. Since the load characteristics of most PFC applications such as home appliances, battery chargers, switched mode power supplies and other digital products support unidirectional power flow, the general ac - dc boost converter is considered a popular topology. It is one of the low cost, simple methodologies and their performance is well - proven. Maintaining dc - link voltage constantly inside the system in order to feed loads at different power ratings is the main task. Active power filters (APF) is another approach capable of improving grid power quality to control input current with a pure sinusoidal waveform in phase with input voltage. Unlike PFC circuits, the APF is a system in itself which provides compensation of harmonics and reactive power in order to reduce undesirable effects from non-linear loads and uncontrolled passive loads in power systems. The paper introduces a versatile method for mitigating grid power quality using unidirectional ac – dc boost converter.

The additional focus of this paper is to measure the quantity of input current distortions by the unidirectional ac – dc boost converter used for supplying active power to the load and reactive power. By using this method, the amount of reactive power injected due to input current distortion from an individual converter to the grid should be restricted.

This paper presents, control strategy by using dual boost PFC converter. An improved simulation software using MATLAB was developed to study the proposed method to mitigate harmonics in order to improve power quality. Comparative results for power quality improvement by using PI controller and PID controller are observed.

Keywords- *AC-DC boost converter, active power, reactive power compensation (RPC), PI controller, PID controller, total harmonics distortion (THD).*

*****

I.INTRODUCTION

Reactive power has long been considered as an element of electric grid control [3], [9]. It should be properly maintained in order to enhance voltage stability and transmission efficiency in ac power systems. Due to voltage fluctuations and power intermittency caused predominantly by poorly controlled reactive power flow, the end user of electric systems in the world suffers from losses of billions of dollars every year. Although many power electronics based technologies such as flexible alternating current transmission systems [4], [8] and active power filters [2], [5], [6], [7] have emerged to overcome the shortcomings of traditional passive reactive compensation methods, these solutions are limited for improvement of power quality of an entire power system, due to high capital and operating costs, as well as their additional inherent power losses. The purpose of this dissertation is to investigate reactive power capabilities of existing aggregated unidirectional converters and to propose a cost-effective solution for reactive power compensation through control and integration strategies for unidirectional converters in residential distributed power systems [1]. Usually, unidirectional power factor correction converters are utilized in many commercial applications such as laundry machines, air conditioners, and battery chargers as front end circuitry in order to minimize the effects of harmonic distortion and poor power factor caused by their respective nonlinear loads. Since these converters are ubiquitous, they have great potential as reactive power resources in distribution level power systems if they possess reactive power compensation functionality functionalities. However, the distortion of input current as a result of reactive power compensation cannot be avoided due to intrinsic topology limitations of unidirectional converters. These harmonic distortions can be mitigated by employing unidirectional converters soon to be available in residential distributed generation systems. As a result, free reactive power support without additional costs and harmonic pollutions can be obtained through integration of bidirectional and unidirectional converters. Ultimately, residential power systems will possess the ability to act as large reactive power compensators, resulting in more efficient and stable electric power distribution system.

II. SIMULATED MODELS

Figure 1 shows the simulation model for power quality improvement using unidirectional ac – dc boost converter connected in between power grid and linear as well as non linear load. Figure 2 shows the subsystem of simulation model for firing control circuit using PI controller. In simulation model PI controller is replaced by PID controller and comparative results of output using PI controller and PID controller are studied.

In order to validate the effectiveness and performance of the proposed control method for a unidirectional ac-dc boost converter, a bridgeless PFC converter model, a nonlinear load and a linear load are implemented in MATLAB/Simulink. For a comparative evaluation of performances, the three converter operation modes are simulated:1) HCC mode, 2) RPC mode, and 3) combined operations of HCC and RPC.

ISSN: 2321-8169
268 – 271

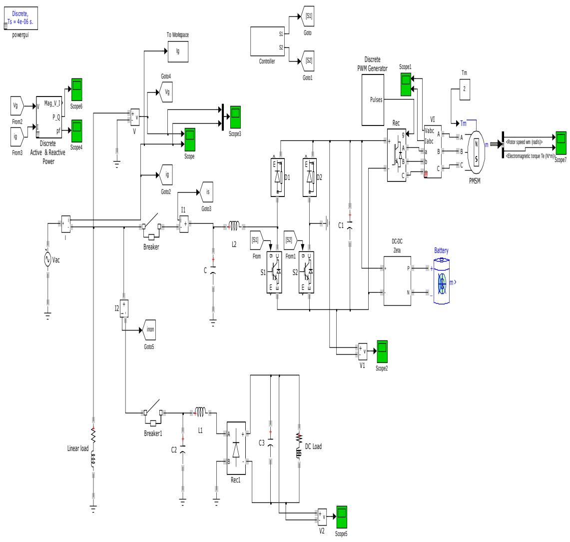

Figure 1.Simulation model for power quality improvement using unidirectional ac –dc boost converter

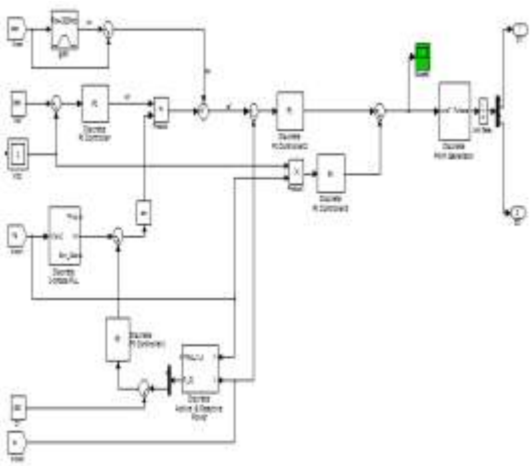

Figure 2. Simulation diagram of subsystem dual boost PI control

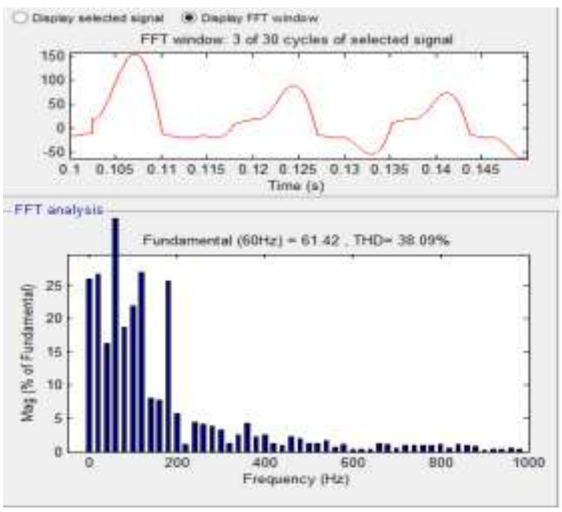

Figure 3. THD without connecting unidirectional ac – dc boost converter

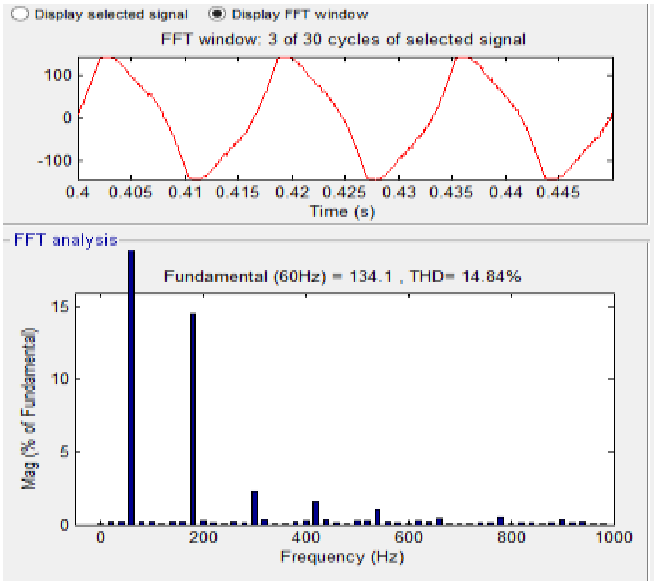

Figure 4. THD when unidirectional ac– dc boost converter connected applying PI controller

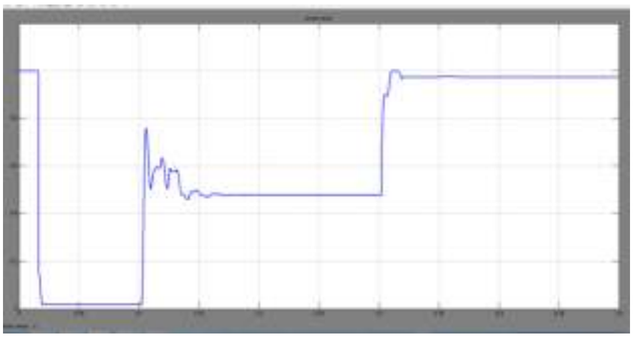

Figure 5. Improved power factor nearer to unity using PI control technique

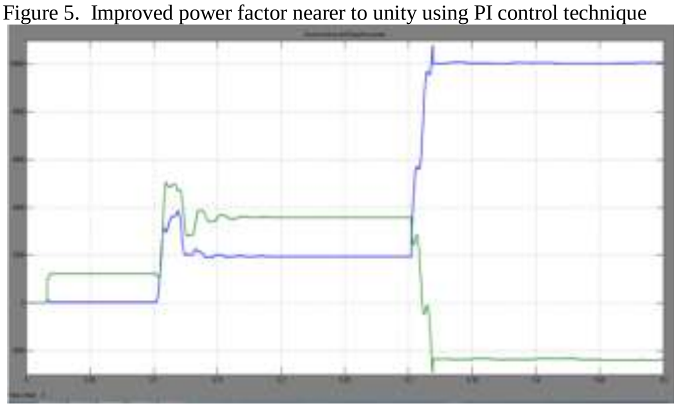

Figure 6. Active power and reactive power when PI control is applied.

Figure 4 shows the simulation results in HCC mode when a single-phase rectifier with a nonlinear load is connected to the unidirectional ac-dc boost converter at the PCC applying PI control technique. Comparing results in figure 3 and 4 it is observed that THD is reduced from 38.09% to 14.84% .

The PFC operation begins with a 200 V dc-bus voltage reference. However, the grid THD increases as it becomes polluted with the harmonic current from the nonlinear load, resulting in 38.09% THD and 0.789 PF. At 0.3s, the operation mode of the converter is changed from PFC to HCC. It can be observed that the grid current is a nearly sinusoidal waveform with 14.84% THD and 0.976 PF as a result of cancelling the harmonic current at the load side. Figure 5 shows the simulation results in RPC mode when a permanent magnet synchronous motor connected to the unidirectional ac-dc boost converter at the PCC is used as linear load with a poor PF of 0.8. It can be observed that the power factor of the grid is improved from 0.8 to 0.976 when the converter generates 500 Var in RPC mode. However, the THD of the grid current increases due to inherent distortions of reactive power current in unidirectional ac-dc boost converters. The amount of reactive power used for compensation should be limited to maintain low THD of the grid current. Figure 5 shows the simulation results for combined operations of HCC and RPC when the two emulated loads used in previous simulations are connected at the PCC. When HCC and RPC begin simultaneously, the resulting grid power quality improves to a PF of 0.976 and 14.84% THD practically.

While comparing the simulation results by applying firing control technique using PI controller and PID controller it is observed that since results obtained by applying PI control is more accurate to improve the power quality compared to PID control. Hence, it can be stated that PI controller if the most efficient control system as compared to PID.

This means that the grid power quality is enhanced by using PI control technique from the results of the proposed control method. If more converters are available at the PCC and the total amount of RPC can be larger with smaller assignments of RPC of individual converters, the grid current will be more sinusoidal and in phase with the grid voltage.

TABLE 1. Comparison of results when firing control techniques are PI control and PID control

Sr. No.	Control mode	Results obtained applying PI control technique	Results obtained applying PID control technique
1	Distortion factor V_g, I_g	Distortion factor disappear	Minimum distortion is present
2	PFC	0.976	0.85
3	THD	14.84%	19.31%
4	HCC+ RPC	P = 10 kW , Q= 2 kVAR	P = 2kW, Q = 2.5 kVAR

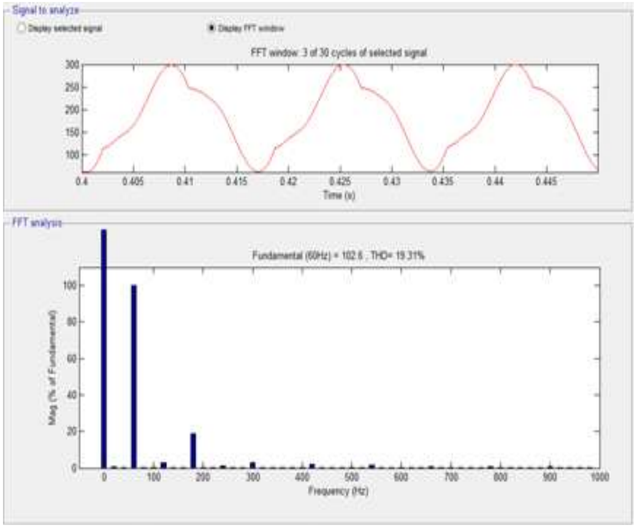

Figure 7. THD when unidirectional ac– dc boost converter connected applying PID controller

III.CONCLUSION

Since unidirectional ac-dc boost converters are already ubiquitously connected with ac power systems, existing unidirectional ac-dc boost converters possess the ability to improve substantially the stability of ac power systems by maximizing functionalities of aggregated unidirectional ac-dc boost converters. A versatile control methods for the unidirectional ac-dc boost converter with PI controller gives better output to enhance grid power quality through the combination of HCC and RPC, which can be a more economical solution for future smart grid applications. The effectiveness of the proposed control method was validated through simulation showing improved power factor and total harmonic distortion of the grid. At the same time, it should be noted that due to the inherent limitations of the unidirectional ac-dc boost converter, the grid current will be distorted unintentionally when operating in RPC mode where the THD of capacitive current is worse than that of the inductive current due to extended cusp distortions. Hence, the amount of reactive power injected from an individual converter to the grid should be restricted. Although, combined operation of these aggregated converters, each restricted in RPC, can meet the reactive power demand while still effectively compensating for generated harmonics.

REFERENCES

[1] Park and park, “Versatile control of unidirectional ac–dc boost converters for power quality mitigation,” IEEE Trans. Power Electron., vol. 30, no. 9, Sept. 2015.

[2] B. Singh, K. Al-Haddad, and A. Chandra, “A review of active filters for power quality improvement,” IEEE Trans. Ind. Electron., vol. 46, no. 5, pp. 960–971, Oct. 1999.

[3] J. Dixon, L. Moran, J. Rodriguez, and R. Domke, “Reactive power compensation technologies: State-ofthe-art review,” Proc. IEEE, vol. 93, no. 12, pp. 1244– 1264, Dec. 2005.

[4] L. Gyugyi, “Power electronics in electric utilities: Static VAR compensators,” Proc. IEEE, vol. 76, no. 4, pp. 483– 494, Apr. 1988.

[5] M. El-Habrouk, M. K. Darwish, and P. Mehta, “Active power filters: A review,” Proc. Inst. Elect. Eng.—Electr. Power Appl., vol. 147, no. 5, pp. 403–413, Sep. 2000.

[6] M. M. Jovanovicand, Y. Jang,"State-of-the-art, single - phase, active power factor - correction techniques for high - power applications—An overview," IEEE Trans. Ind. Electron., vol. 52, no. 3, pp. 701–708, Jun. 2005.

[7] P. Acuna, L. Moran, M. Rivera, J. Dixon, and J. Rodriguez, "Improved active power filter performance for renewable power generation systems," IEEE Trans. Power Electron., vol. 29, no. 2, pp. 687–694, Feb. 2014.

[8] P. S. Sensarma, K. R. Padiyar, and V. Ramanarayanan, "Analysis and performance evaluation of a distribution STATCOM for compensating voltage fluctuations," IEEE Trans. Power Del., vol. 16, no. 2, pp. 259–264, Apr. 2001.

[9] R. Majumder, "Reactive power compensation in singlephase operation of microgrid," IEEE Trans. Ind. Electron., vol. 60, no. 4, pp. 1403–1416, Apr. 2013.