PI And PR Controller for Grid Connected Voltage Source Inverter

Mukta Rajendra Ghive[1], Jawadekar U A[2]

[1]*Student, Department of Electrical Engineering, Sant Gadge Baba Amravati University, Amravati, India.*

[2]*Assistant Professor, Shree Sant Gajanan Maharaj College of Engineering, Shegaon, Maharashtra, India.*

Corresponding Author: muktaghive@gmail.com

Abstract: - Over-the year, power converters have found wide application in grid-interfaced systems, including distributed power generation systems with a renewable energy source. In a distributed energy system like a solar hydro or any diesel generation where the output of the system is DC and is expected to be converted in an AC, an inverter is used. There are various mode to have a controlled output of the inverter. We will study the three-phase voltage source inverter control scheme. The different control methods used are PI controller and PR controller. The main advantage of the PI controller is that there will be no remaining control error after the set point change or a process disturbance. In a PI control the stationary reference frame is used to transfer feedback quantities, where the decoupling of components requirements increases the complication, a new proportional reason and control strategy is employed, in which of second order very high gain ideally infinite gain is introduced at a fundamental frequency. The main advantage of the PR controller is to be reduced DC steady state error to a zero by forcing the ideally infinite gain at the resonating frequency. We will compare the PI and PR controllers and simulation in MATLAB.

Key Words: —*PI controller; PR controller; alpha beta reference frame; reference tracking.*

I. INTRODUCTION

In the last few years, the demand of electricity has increased tremendously and fossil fuels being depleted due to the same so it becomes mandatory to interconnect renewable energy sources with the help of wind turbines, photo voltaic etc. Hence, it is general expectations to increase the electricity generation with the help of renewable energy sources.

The use of RES is getting increased and it can be justified from the table below. Initially the generation of electricity with RES was up to 5% only but now from last few years it has been increased to 17%-25%. In year 2019-20the use of solar energy has increase drastically from last few decades. Microgrid concept has recently adopted to connect the renewable energy sources more effectively in the system and to cope up with the power quality issues. Microgrid can operate in both grid-connected mode and isolated mode basically microgrid is a combination of RES and loads. All renewable energy sources are parallel provided to an AC common bus via inverters or AC to AC converter.

Manuscript revised June 01, 2021; accepted June 02, 2021.
Date of publication June 03, 2021.
This paper available online at www.ijprse.com
ISSN (Online): 2582-7898

The common bus is then provided to the utility or grid and voltage source inverter is the most important functional element of an AC microgrid system the various renewable energy sources within microgrid system can perform independently or interconnected to a common DC link, which supplies constant input to the voltage source inverter.

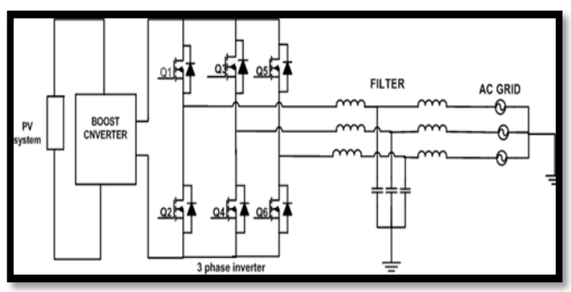

Fig.1. Power circuit of grid connected 3-phase inverter

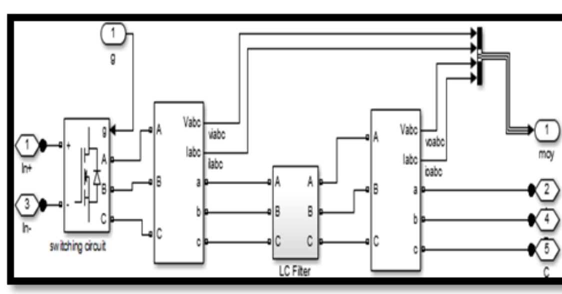

Fig.2. MATLAB simulation of Grid connected 3-phase inverter

A. PI Controller

A PI controller is by far the most common type of controller. The ideal PI controller implements the control law

$$u_t = K_c(t) + \frac{1}{T_i}\int_0^{t1} e(\tau)d\tau + u_0$$

Where the gain Kc and the integral time Ti are adjustable parameters, u0 is less important due to the integral. The main advantage of the PI controller is that there will be no remaining control error after a set point change or a process disturbance. A disadvantage is that there is a tendency for oscillations. PI control is used when no steady-state error is desired and there is no reason to use derivative action. Measurement noise is often a reason for not using derivative action. PI control is suitable for noisy processes, integrating processes and processes resembling first- order systems. The most typical application is flow control. PI control might also be preferable for processes with large time delays

The transfer function of a simple PI controller can be given as

$$TF = K_P + \frac{K_I}{s}$$

Where, KP, KI are the proportional and integral gain terms.

It follows that the strength of integral action increases with decreasing integral time Ti. The figure shows that the steady state error disappears when integral action is used. The tendency for oscillation also increases with decreasing Ti.

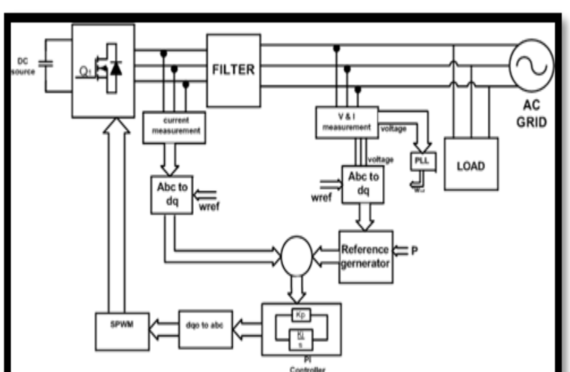

Fig.3. PI Controller Block Diagram

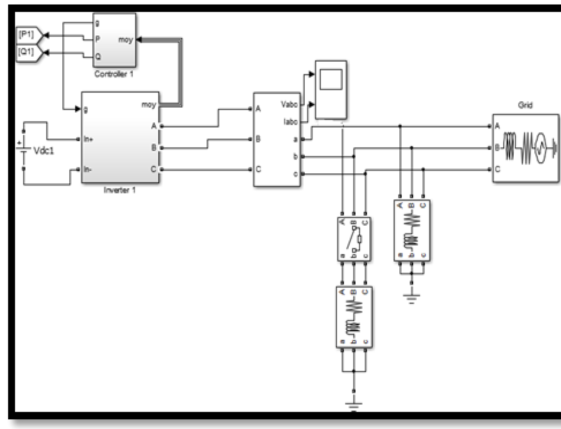

Fig.4. MATLAB simulation of PI controller

B. PR Controller

PR controller is used to compensate the errors of PI controller. In PR control method, the three phase to two-phase transformation is not applied directly. Using the PR controllers, the converter reference tracking performance can be enhanced and previously known shortcomings associated with conventional PI controllers can be alleviated. These short-comings include steady. Using PI control, however, leads to steady-state current error (both in phase and magnitude) when tracking sinusoidal input, and hence a poor harmonic compensation performance is expected.

Instead, the equivalent stationary PR controller can be used as the inner current controller, as shown in Fig.4. Compared to a stationary PI controller, the only computational requirement imposed by the PR controller is an extra integrator for implementing a second-order system, but with a modern low-cost 16-bit fixed-point DSP, this increase in computation can generally be ignored.

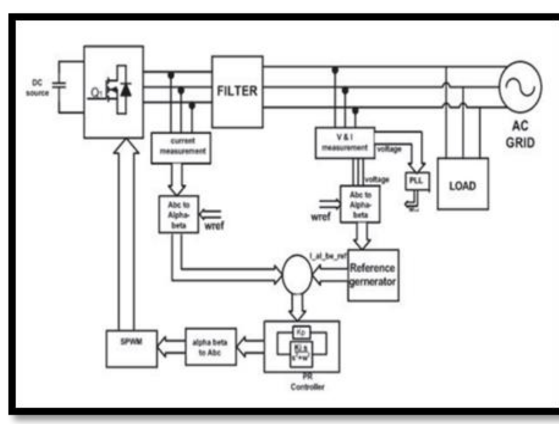

Fig.5. Block Diagram of PR controller

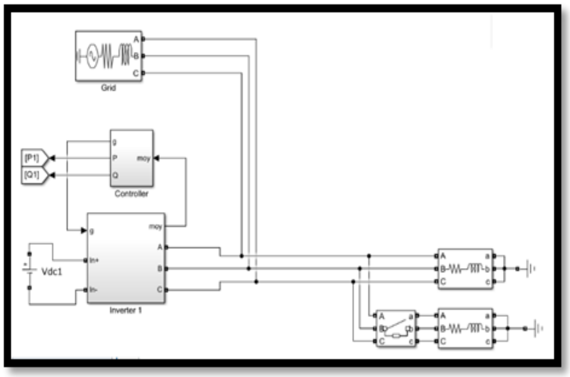

Fig.6. MATLAB simulation of PR controller

II. Simulation Results And Discussion

Three phase voltage source inverter is connected to grid then controlled by PI controller and then by PR controller. Simulation is performed by various load condition. DC supply is given to inverter as a distributed generation source.to reduce the harmonics the LC filter is used. The Quasi-shape inverter output is converted into sinusoidal wave. Then the output is given to grid-connected load. In these simulation by the time taken by the PR controller to reach steady state is less than PI controller.

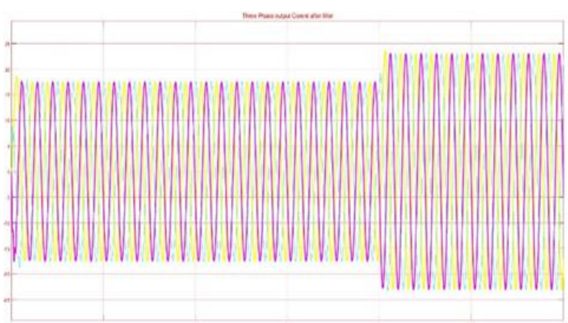

Fig.7. 3-Phase inverter

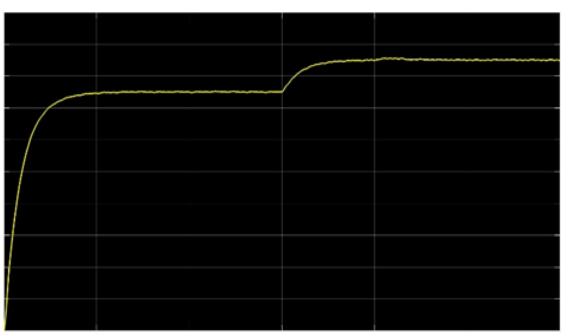

Fig.8. Active power supply by inverter using PI controller

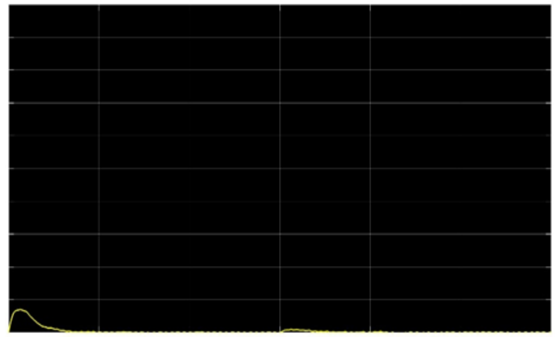

Fig.9. Reactive power supply by inverter using PI controller

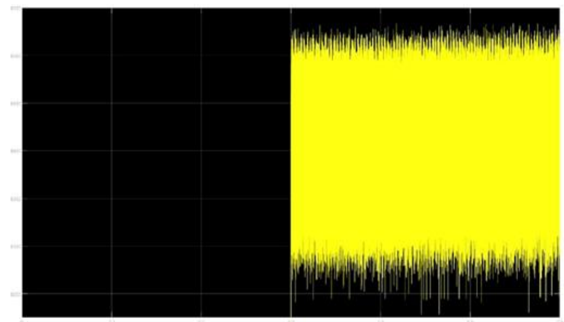

Fig.10. PR controller

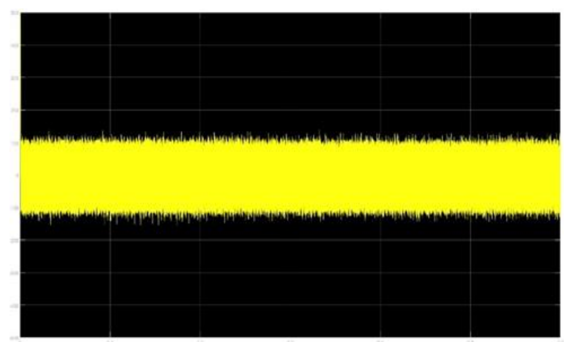

Fig.11. PR controller

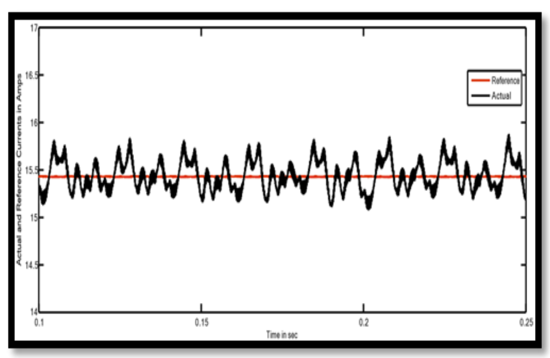

Fig.12. Actual Tracking reference quantity with for PI controller

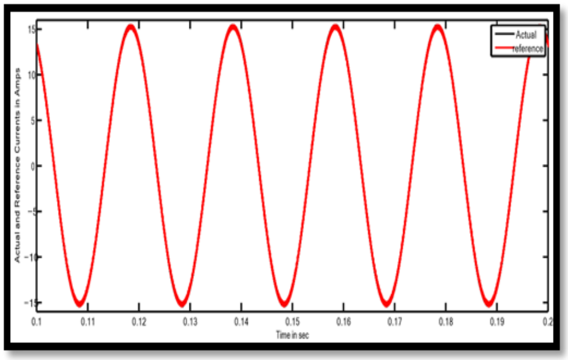

Fig.13. Actual Tracking reference quantity with for PR controller.

The fig.12. And fig.13. Gives the reference tracking of both PI & PR controller. The simulation results tracking is improved with the help of PR controller.

III. Conclusion

In this report, the main attempt made for showing the comparison of performance of PI and PR controllers. This report proposes the detail analysis of the various basic control strategies for voltage source inverter and also gives the study of Photovoltaic grid interconnected system. In this report, model of filter is derived in dqo reference frame and hence shown that the problem of three phase decoupling in dqo reference frame. All the sub-models are individually modelled and implemented.

The shortcomings of PI controller as more settling time, inadequate reference tracking system and complicated implementation are overcame in PR controller. Both the PI and PR controller are implemented for grid connected voltage source inverter and for droop controlled parallel inverters. Hence PI and PR controller are compared and it can be concluded that PR controller has a good performance that PI controller, but it requires an extra integrator than PI controller.

References

[1]. X. Yaan, W. Meek, H. Stemmler, and J. Allmeling", Stationary frame generalized integrater for current control of active power filter with zero steady state error for current harmonic of concern under unbalanced and distorted opearating condition", Industry Application, IEEE Transaction on, vol38, no.2, pp.532, Mar2002.

[2]. R. Teodorescu, F. Blaabjerg, M. lissere, and P. Log", Proportional Resonant controllers and filter for grid connected voltage e- source converters", Electric Power Application, IEE Proceedings, vol. 153, no. 5, pp.750-762, September 2006.

[3]. R. Teodorescu, F. Blaabjerg, M. lissere, and A. Del'Aquila", A stable three phase LCL filter based active rectifier without damping ", vol.3, pp. 1552-1557 vol.3, oct 2003.

[4]. D. N. Zmood and D. G. Holmes", Stationary frame current regulation of PWM inverter with zero steady state error ", IEEE Trans. Power electron, vol. 18, No.3 pp. 814-822, May 2003.

[5]. J. Vasquez, J. Guerrero, M. Savaghebi, J. Eloy-Garcia, and R. Teodorescu, "Modeling, analysis, and design of stationary-reference-frame droop-controlled parallel three-phase voltage source inverters," Industrial Electronics, IEEE Transactions on, vol. 60, no. 4, pp. 1271–1280, April 2013.

[6]. N. Pogaku, M. Prodanovic, and T. Green, "Modeling, analysis and testing of autonomous operation of an inverter-based microgrid," Power Electronics, IEEE Transactions on, vol. 22, no. 2, pp. 613–625, March 2007.

[7]. A. Nachiappan, K. Sundararajan, and V. Malarselvam, "Current controlled voltage source inverter using hysteresis controller and pi controller," pp. 1–6, Jan 2012.

[8]. H. Cha, T.-K. Vu, and J.-E. Kim, "Design and control of proportional-resonant controller based photovoltaic power conditioning system," pp. 2198–2205, Sept 2009.