International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 6, Issue 6, June 2017, ISSN: 2278 -7798

PERFORMANCE ANALYSIS OF GRID CONNECTED VOLTAGE SOURCE INVERTER

B. Kotaiah, Ms. N. Chaitanya

Abstract: **Over the years, power converters/inverters have found wide applications in grid interfaced systems, including distributed power generation with renewable energy sources. PWM based voltage source inverters are mostly meant for synchronizing the utility grid to the distributed generation system. Following objectives are meant to be achieved for a grid connected PWM inverter in order to meet the growing energy demand: 1. Make the grid stable 2. Control of active and reactive power 3. Power quality improvement (i.e. harmonic elimination) etc. This paper describes a control method for single phase grid connected inverter system. Based on the applied current control strategy the performance of inverter is depends. Here, for current control of the PWM-VSI, proportional integral derivative controller (PID) is employed to enhance the power quality by diminishing current error. This paper describes control of a grid connected inverter system using hysteresis controller, and also hysteresis controller along with PID controller is analyzed for controlling the harmonic content in the current.**

Index Terms**: Grid connected inverter, Renewable energy system, Hysteresis controller, PID controller, Total harmonic distortion (THD).**

1. INTRODUCTION

Due to rapid population growth and global industrialization, the electrical energy demand is growing exponentially. To meet the future energy crisis, DG(Distributed Generation) is one of the viable options because of its environmental friendliness, lower cost and easy availability. To increase the effectiveness of the DG's it must be synchronized with the utility grid[1]. In most of the cases current controlled PWM-VSI is used to match the characteristics of the DG's and requirement of the grid connection,including active and reactive power control through frequency and voltage control and harmonic minimization etc.[2].

To inject high quality power to the utility grid the current control scheme for the grid connected PWM-VSI plays a predominate role. Inspite of the several advantages, the main technical challenge is the synchronizing the DG's with the utility gird according to the grid code requirements.

In most of the cases power electronic converter, especially current controlled PWM-VSI is used for the integration of the DG's with utility grid. The main objectives of the control of grid connected PWM-VSI is: 1) To ensure grid stability. 2) Active and reactive power control. 3) Power quality improvement etc. the power quality largely depends on the inverter controller's performance.

As compared with the open loop voltage PWM converter, the current controlled PWM has several advantages such as fast dynamic response, inherent peak current protection, good dc-link utilization, instantaneous current control etc. PWM (Pulse width modulation) is the most popular control technique for grid connected inverters, among the various PWM techniques.

1.1. MODELLING OF GRID

Normally the function of the source side controller is to track maximum power from the input source and ensure the protection of the input side converter. In the meanwhile, the controller in the grid side converter controls the active and reactive power delivered to the utility grid, control the reactive power exchanged between the DG and the grid, control the DC link voltage, and improve the power quality[3].

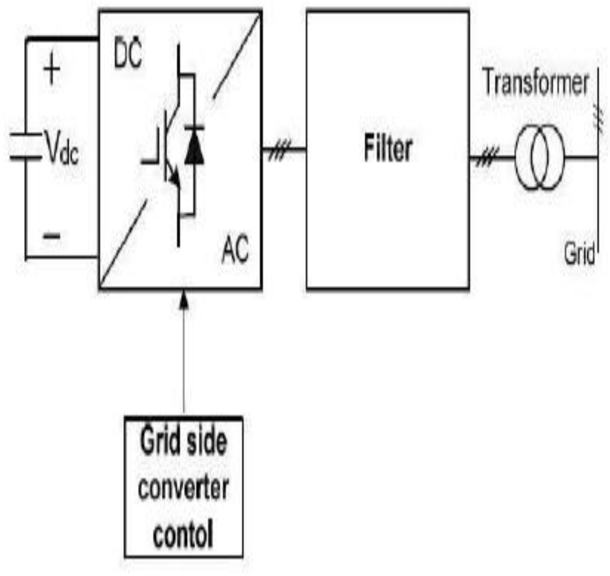

Figure.1.General Structure of the distributed generation (DG) system

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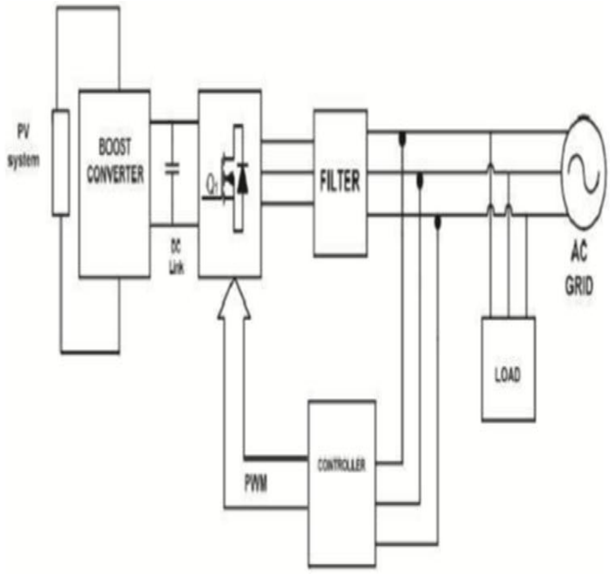

Figure.2.Block diagram of grid connected RE system

As the increase in the number of sources that are natural DC sources, for instance fuel cells and photovoltaic arrays, or whose AC frequency is either not constant or is much higher than the grid frequency. These generators necessarily require a DC/AC converter to be connected to grid [4].

2. NEED FOR THE STUDY

Due to poor power quality, the system will faces the various problems like voltage sag(or dip), very short interruptions, long interruptions, voltage spike, voltage swell, harmonic distortion, voltage fluctuations, noise etc., as a power systems engineer we must ensure that we has to supply uninterrupted rated power to the customers within the specified limits.

3. OBJECTIVES OF THE STUDY

The objective of this paper is to present a conventional controller for a single phase grid connected PWM inverter. The improvement of power quality is achieved by reducing the harmonic content in the output current. Here we use two control schemes for reducing harmonic content in the current, they are:

1.Hysteresis controller.

2.PID controller.

4. CONTROLLER DESIGN

4.1. HYSTERESIS CONTROLLER

Here single phase load is connected to the PWM voltage source inverter. The load current is compared with the reference current and error signal is passed through hysteresis band to generate the firing pulses, which are operated to produce output voltage in such a manner to reduce harmonic content in the current [5]

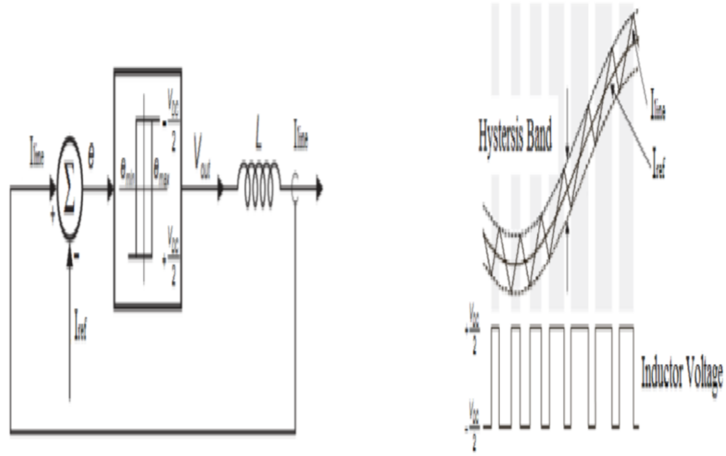

Figure.3. PWM obtained from hysteresis current control

4.2. PID CONTROLLER

PID controller (proportional integral derivative controller) is a feedback controller which drives the plant to be controlled by a weighted sum of the error (difference between the output and desired set point) [6]-[8].

The PID controller is mathematically denoted as:

$$Kpe(t) + Ki\int e(t)dt + Kd\ de(t)/dt$$

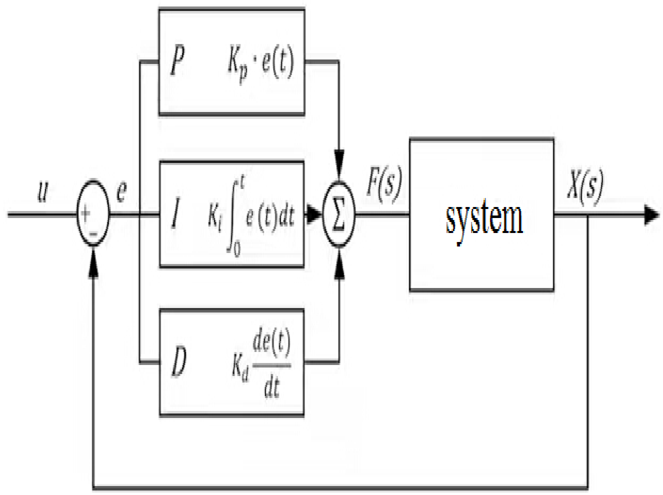

Figure.4. Proportional Integral Derivative controller

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4.3. SYSTEM PARAMETERS FOR GRID CONNECTED SYSTEM

4.3.1. HYSTERESIS CONTROLLER

Smoothening reactor in henry	R in ohms	L in henry	C in farad	Kp	Ki	Max Iref in amp	Max Iload in amp
0.075	0.05	0.075	1e-3	1	0.1	1	10
0.075	0.05	0.075	1e-3	10	0.1	1	10
0.075	0.05	0.075	1e-3	0.1	0.1	1	10
0.075	0.05	0.075	1e-3	10	1	1	10
0.075	0.05	0.075	1e-3	10	10	1	10
0.075	0.05	0.075	1e-3	1	10	1	10
0.01	0.05	0.01	1e-3	1	10	10	200
0.05	0.05	0.01	1e-3	1	10	2	200
0.005	0.05	0.01	1e-3	1	10	20	200
0.0075	0.05	0.01	1e-3	1	10	10	200
0.006	0.05	0.01	1e-3	1	10	12	200
0.0025	0.05	0.01	1e-3	1	10	50	200
0.0025	0.05	0.05	1e-3	1	10	50	15
0.0025	0.05	0.025	1e-3	1	10	50	35
0.0025	0.05	0.02	1e-3	1	10	50	48

Table.1. System parameters for grid connected inverter system using Hysteresis controller

- By changing the values of smoothening reactor we can achieve desire reference current(Iref).
- By changing the values of load inductor we can achieve desire load current(Iload).

When Vgrid>Vsource:

Vgrid=230 V,Vsource=100 V

	Frequency=60 Hz	Frequency=50 Hz
Iref	15.03%	30.86%
Iload	0.01%	28.68%

Table.2. Total harmonic distortion (THD)

When Vgrid<Vsource:

Vgrid=230 V, Vsource=500 V

	Frequency=60 Hz	Frequency=50 Hz
Iref	9.24%	27.52%
Iload	0.01%	28.68%

Table.3. Total harmonic distortion (THD)

4.3.2. PID CONTROLLER

Smoothening reactor in henry	R in ohms	L in henry	C in farads	Kp 1,2	Ki 1,2	Kd 1,2	Max Iref in amps	Max Iload in amps
0.00275	0.05	0.0225	1e-3	1,1	1,1	0,0.2	40	40
0.0275	0.05	0.225	1e-3	1,1	1,1	0,0.2	4	4

Table.4.System parameters for grid connected inverter system using PID controller

When Vgrid>Vsource:

Vgrid=230 V, Vsource=100 V

	Frequency=60 Hz	Frequency=50 Hz
Iref	6%	21.28%
Iload	0%	28.5%

Table.5. Total harmonic distortion (THD)

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When Vgrid<Vsource:

Vgrid=230 V, Vsource=400 V

	Frequency=60 Hz	Frequency=50 Hz
Iref	10.88%	31.18%
Iload	0%	28.5%

Table.6. total harmonic distortion (THD)

5. RESULTS

5.1. ANALYSIS USING HYSTERESIS CONTROLLER

In Fig.5, 6, 7, the grid voltage, reference current and load current are shown for a grid connected PWM inverter when controlled using a hysteresis controller.

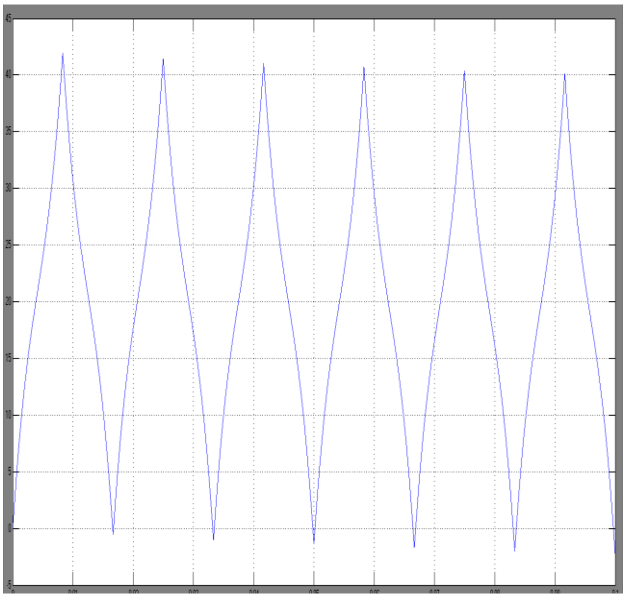

Figure.6.Reference current

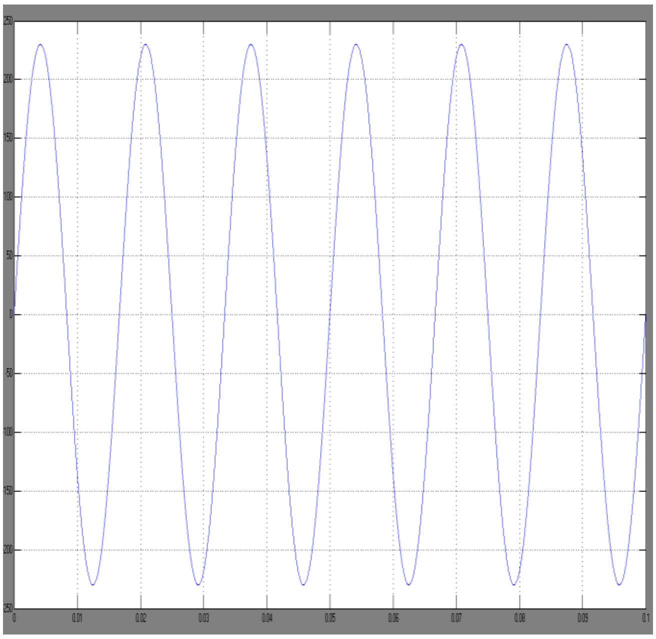

Figure.5.Grid Voltage

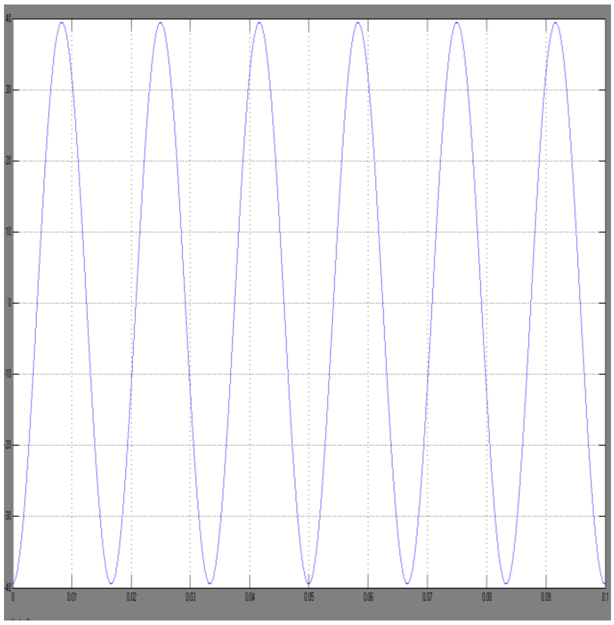

Figure.7.Load current

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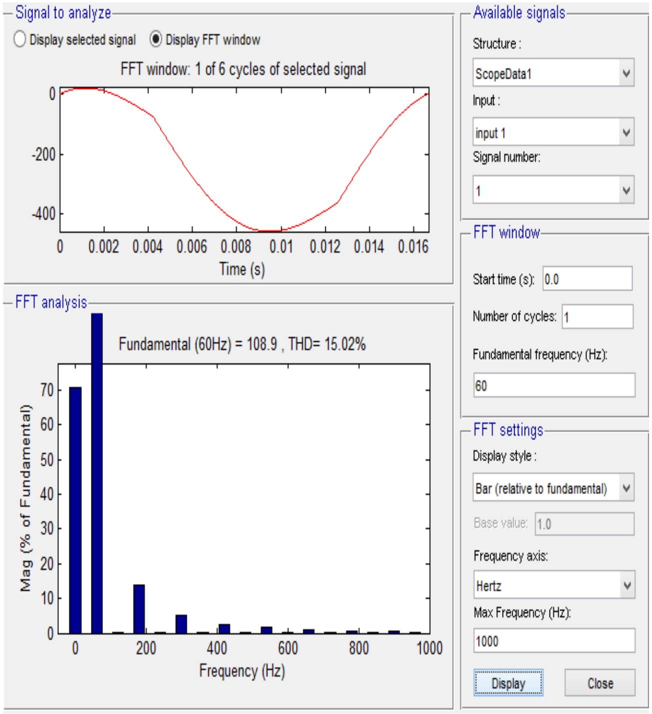

Figure.8. THD for a grid connected inverter using hysteresis controller

By using the hysteresis controller for a grid connected inverter, the output current or the load current contains more harmonic content. From Fig. 8,the THD of the load current is about 15%.

5.2. ANALYSIS USING PID CONTROLLER

In Fig.9, 10, 11, the grid voltage, source current and load current are shown for a grid connected PWM inverter when controlled using a PID controller.

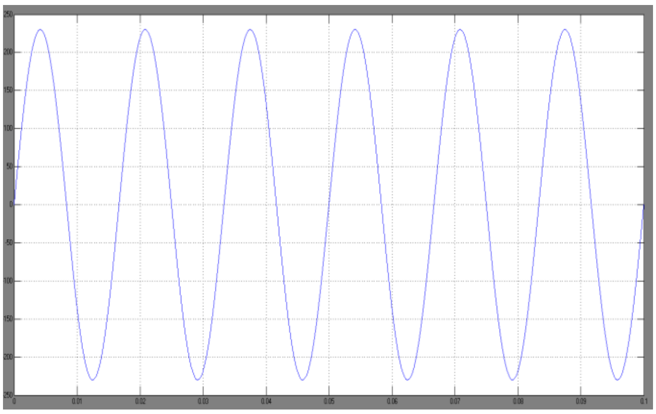

Figure.9. Grid Voltage

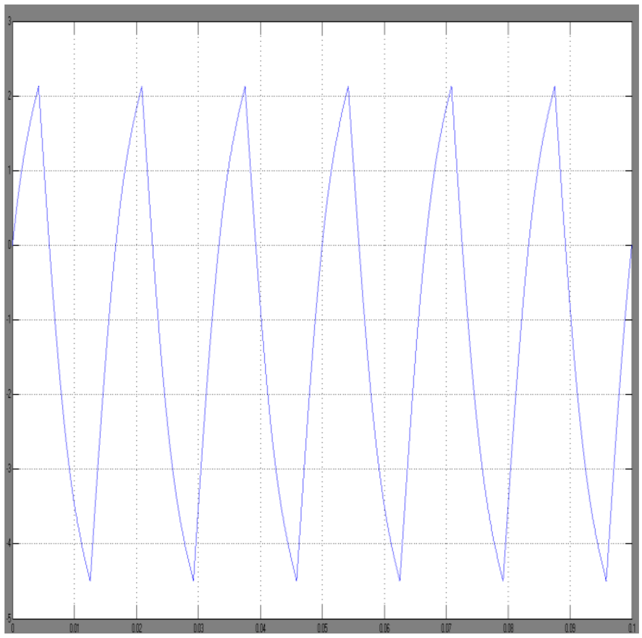

Figure.10. Reference Current

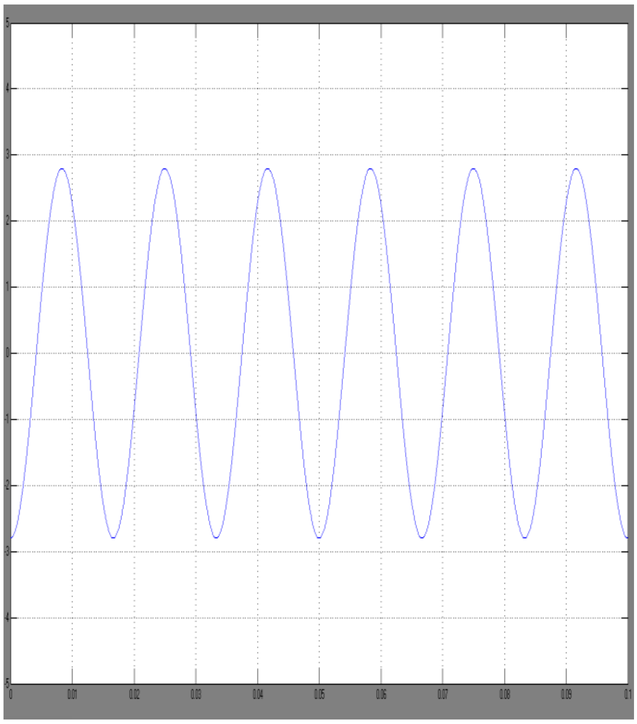

Figure.11. Load Current

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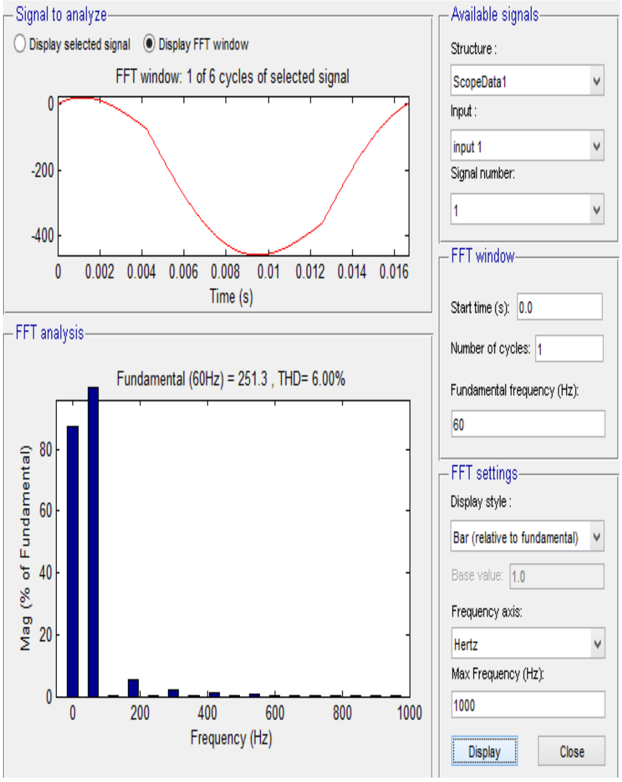

Figure.12. THD for grid connected inverter using PID controller

By using the PID controller for a grid connected inverter, the output current or the load current contains less harmonic content when compared with hysteresis controller. From Fig.12, it can be seen that the THD value is about only 6%. It can be observed that the PID controller has resulted in better control of current as the harmonics have reduced.

6. CONCLUSION

Through simulation the performance of a grid connected voltage source inverter is analyzed through PID and hysteresis current control techniques. To understand the physical behavior of the system the tuning parameters of the PID controller is determined. The performance of the grid connected inverter is observed in improving the power quality by reducing the harmonic content in the current by using the hysteresis controller resulting the THD=15% and by using the PID controller resulting the THD=6%. Therefore PID controller is best suited in order to reduce the harmonics in the current.

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