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Simulation Analysis of Grid Tied Inverter for Solar PV Applications

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ABSTRACT: Solar PV based systems are being seen as a major contributor to the present power generation technology. One of the important applications of the solar PV based power generation is to feed the generated power (dc) into grid (ac). The MATLAB modelling of inverter topology reduces total harmonic distortions in line current (grid voltage). A pure sinusoidal line current or waveform with short harmonic filling is the mainly admirable. In the current work, a single phase line commutated inverter topology has been projected and examines which get better the wave shape and hence decreases the total harmonic distortion (THD) of the line current in a grid tie line commutated inverter [1]. The design has successfully been executed. Moreover, the performance of the projected topology is better than the square-wave inverter. This reduces total harmonic distortion THD, losses, switching stress.

KEYWORDS: Grid Tied Inverter, Total Harmonic Distortion, line current.

I.INTRODUCTION

With the rapid development of photovoltaic system installations and increased number of grid connected power systems, it has become essential to build up a well-organized grid interfacing instrumentation suitable for photovoltaic systems. There can be various types of solar system design. But there are two basic design consideration, they are grid-connected (or grid-tied) and off-grid (or stand-alone) . Photovoltaic systems are typically grouped according to their relationship to the utility grid.

A. GRID-TIED SYSTEM

Grid-tied systems are configured so that the power they generate is fed directly into the utility grid. The electricity produced is not stored instead it is delivered directly to the local electric company whenever the system is active [2].

B. OFF-GRID (OR STAND-ALONE) SYSTEM

Off-grid systems are not connected to the public utility grid and are often referred to as “stand-alone” systems. During the day, the electricity generated is used either by powering loads or to charge storage batteries. At night, power is supplied by the energy stored in the batteries. When the sun comes up the next day, the cycle begins again. Off-grid systems are typically found in remote homes, weather stations or radio sites and parks [2].

C. GRID CONNECTED INVERTER

To feed the generated power into grid is the significant application of the solar PV based system. The critical component of this system is inverter, which is accountable for the control of electricity flow between the solar cell (dc source) to grid or loads. Generally pulse width modulation (PWM) technique is used for this application, but have higher switching losses because of gate commutated devices i.e. MOSFET, IGBT etc. the reliability and power handling capability of these devices are quite low in comparison to thyristor [3]. Therefore, a conventional thyristor or power semiconductors devices based ac-to-dc converter is used, with a dc source and an inductor or highly inductive load, operates in the inversion mode with specific condition. The performance of the converter depends upon the switching angle, and impedance angle. Since an SCR is a unidirectional device, the direction of the current through it always remains same. However, due to an RL load, the instantaneous value of voltage may be positive or negative but the average value of output voltage will be only positive for RL load. However, for an active or RLE negative load, the converter may operate in fourth quadrant of voltage-current plane and voltage become negative. The load current may be discontinuous, just continuous (or sinusoidal) or continuous. It depends upon switching angle and impedance angle

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of RL loads. In this paper, the performance of the circuit is simulated using MATLAB/Simulinkto reduce the total harmonic distortion(THD) in the line current and for optimum power transfer to the grid [4]-[5].

II. GRID-TIED SYSTEM CIRCUIT

A full wave centre-tapped controlled converter circuit with RLE load works as inverter mode when the switching angle of each of the converter is greater than 90˚ and RLE negative load (i.e. an RL load with a negative voltage source, E) [6]. When the circuit works in inversion mode, the dc source transfer power to the ac source. Ideally, there should be a lossless inductor but practical inductor are not lossless. Therefore, a series resistance is also incorporated in the circuit. The dc load side has been isolated from the grid via centre-point transformer.

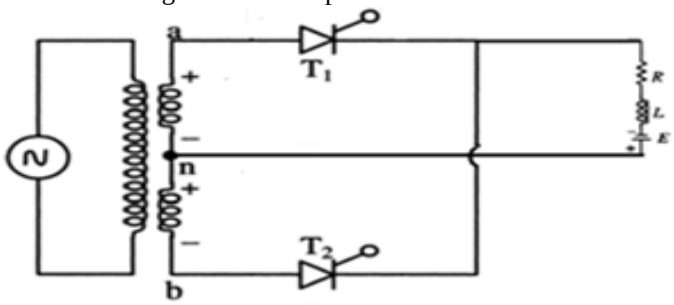

Figure.1 Single phase full wave centre-tapped converter circuit

III. SIMULATION OF CIRCUIT IN MATLAB/SIMULINK

The single phase grid tied inverter has been simulated in simulink package available in MATLAB. The simulink model is shown in the figure. The trigger pulses given from the pulse generator block of simulink library block-set. The pulses to both the thyristors of centre-tapped windings are given at a phase difference of 180degree. Resister is included in series of the inductor to simulate a real inductance. The value of inductor is 42 milihenry. The series resistor is 0.4 ohms. The centre-tapped winding transformer ratio is 230V :: 230V:0V:230V. The simulation work is basically done to study the variation of THD of the line current and average power transferred to the grid with the firing angles.Figure.2 shows Simulink circuit of a grid tied inverter.

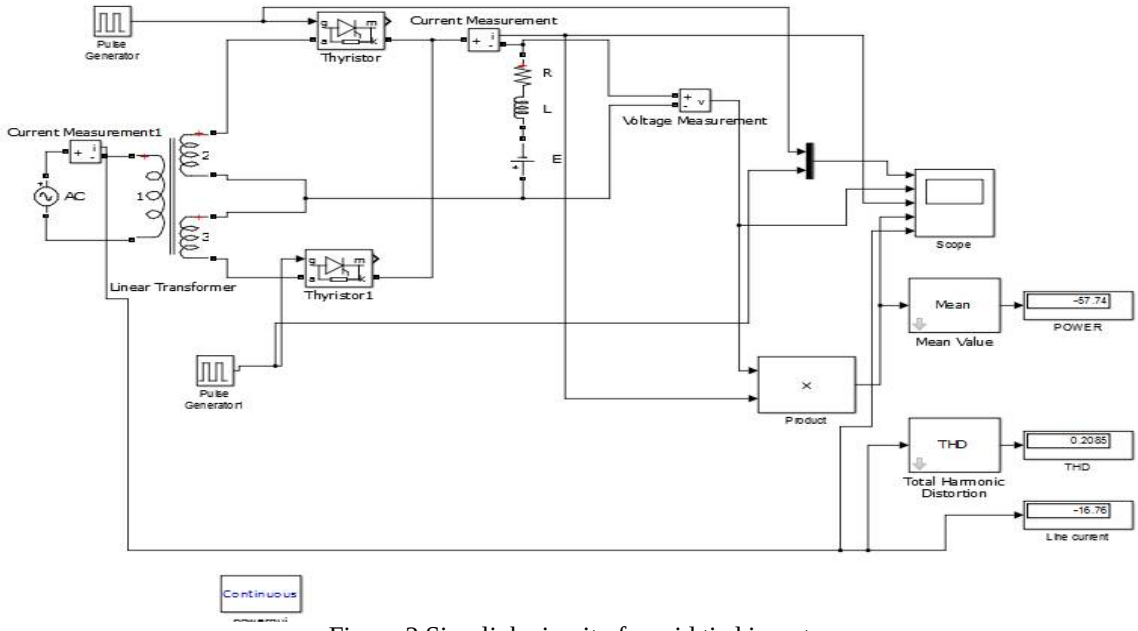

Figure.2 Simulink circuit of a grid tied inverter

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IV. SIMULATION OBSERVATION (HARMONICS AND POWER TRANSFER ANALYSIS)

The effect of variation of dc voltage on the THD and the power transfer is also analyzed. Though a battery has been considered as a dc source for simulation, the result obtained can be utilized when using solar PV panel. Since the dc voltage of a solar PV panel is not constant (vary with insolation, temperature and load), the effect of varying dc voltage on THD and power flow will help in developing a control strategy for operating the system in optimum condition *i.e.* changing the switching angle at different voltage level of PV panel.

From the analysis of the simulink model for grid tied line commutated inverter, the waveforms of thyristor pulse, load voltage, load current, power output and low THD line current is shown in Figure.3 for 12 voltage battery. THD is measured through powergui FFT analysis tool of simulink block and shown in Figure.4.

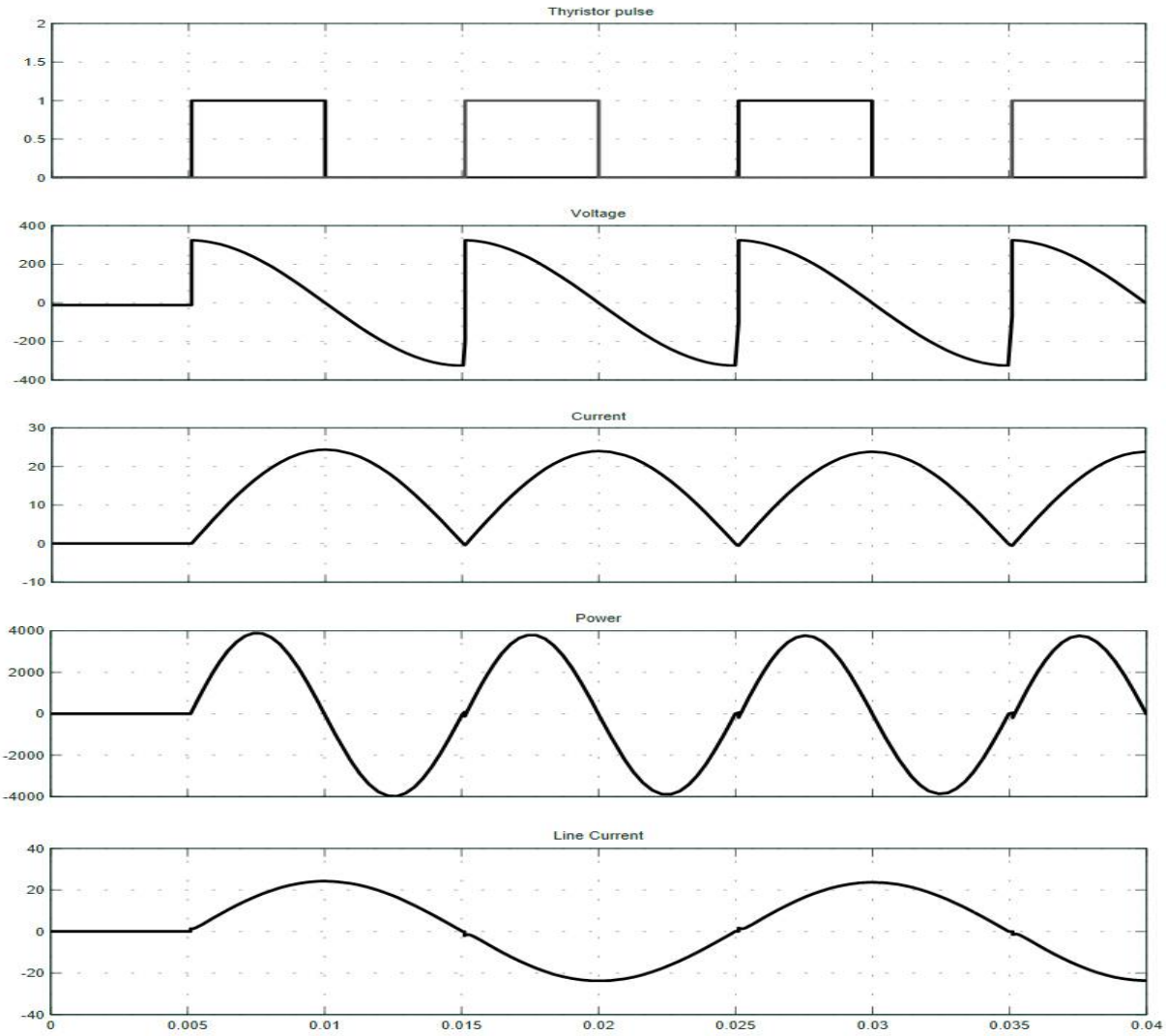

Figure.3Waveform for 92degree E=12 R=0.4Ohm L=0.042Henry

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SI. No.	Firing angle	Power (watts)	Load current (amp)	THD of line current
1.	92	-66.97	23.79	2.023
2.	93	-64.17	23.4	3.003
3.	94	-62.18	23.15	3.627
4.	95	-64.64	22.93	4.204
5.	100	-65.45	21.02	9.134
6.	105	-62.33	18.9	14.93
7.	110	-57.74	16.76	20.85
8.	115	-52.02	14.87	27.12
9.	120	-45.68	12.99	33.7
10.	125	-38.66	11.12	40.93
11.	130	-31.8	9.386	48.68
12.	135	-25.2	7.766	57.26

Table.1 Power transfer and THD of line current with different switching angle combinations. The battery voltage is 12V R=0.4Ohm L=0.042Henry

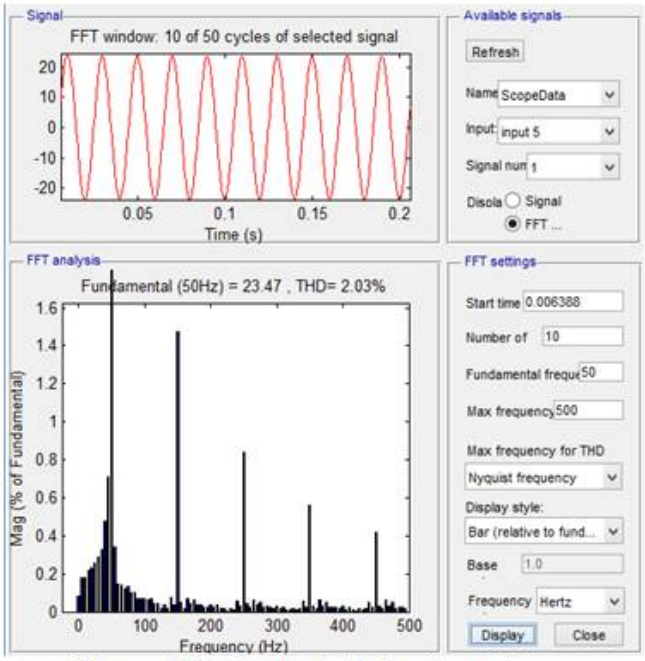

Figure.4 FFT Analysis of Line Current

Variation of THD and power with switching angle for single phase inverter is shown in **Table.1** for 12voltage battery.

SI. No.	Firing angle	Power (watt)	Load current (amp)	THD of line current
1.	92	-75.51	31.48	11.56
2.	93	-153.8	28.9	8.076
3.	94	-215.9	26.43	4.155
4.	95	-247.6	23.96	1.603
5.	100	-228.6	22.33	5.603
6.	105	-201	20.04	11.58
7.	110	-175.8	17.85	17.43
8.	115	-150.6	15.88	23.66
9.	120	-126.9	13.93	30.15
10.	125	-104.1	11.98	37.23
11.	130	-83.43	10.17	44.76
12.	135	-64.9	8.472	53.03

Table.2 Power transfer and THD of line current with different switching angle combinations. The battery voltage is 24V R=0.4Ohm L=0.042Henry

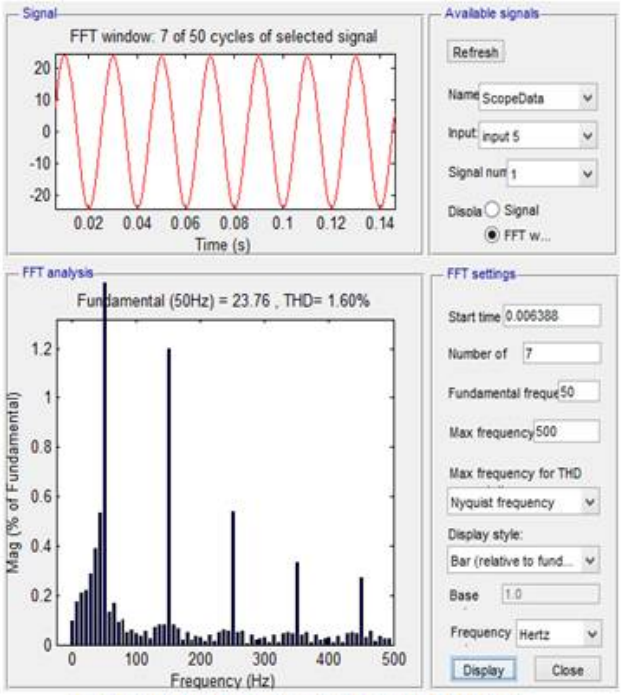

Figure.5 FFT Analysis of Line Current

Variation of THD and power with switching angle for single phase inverter is shown in **Table.2** for 24voltage battery.

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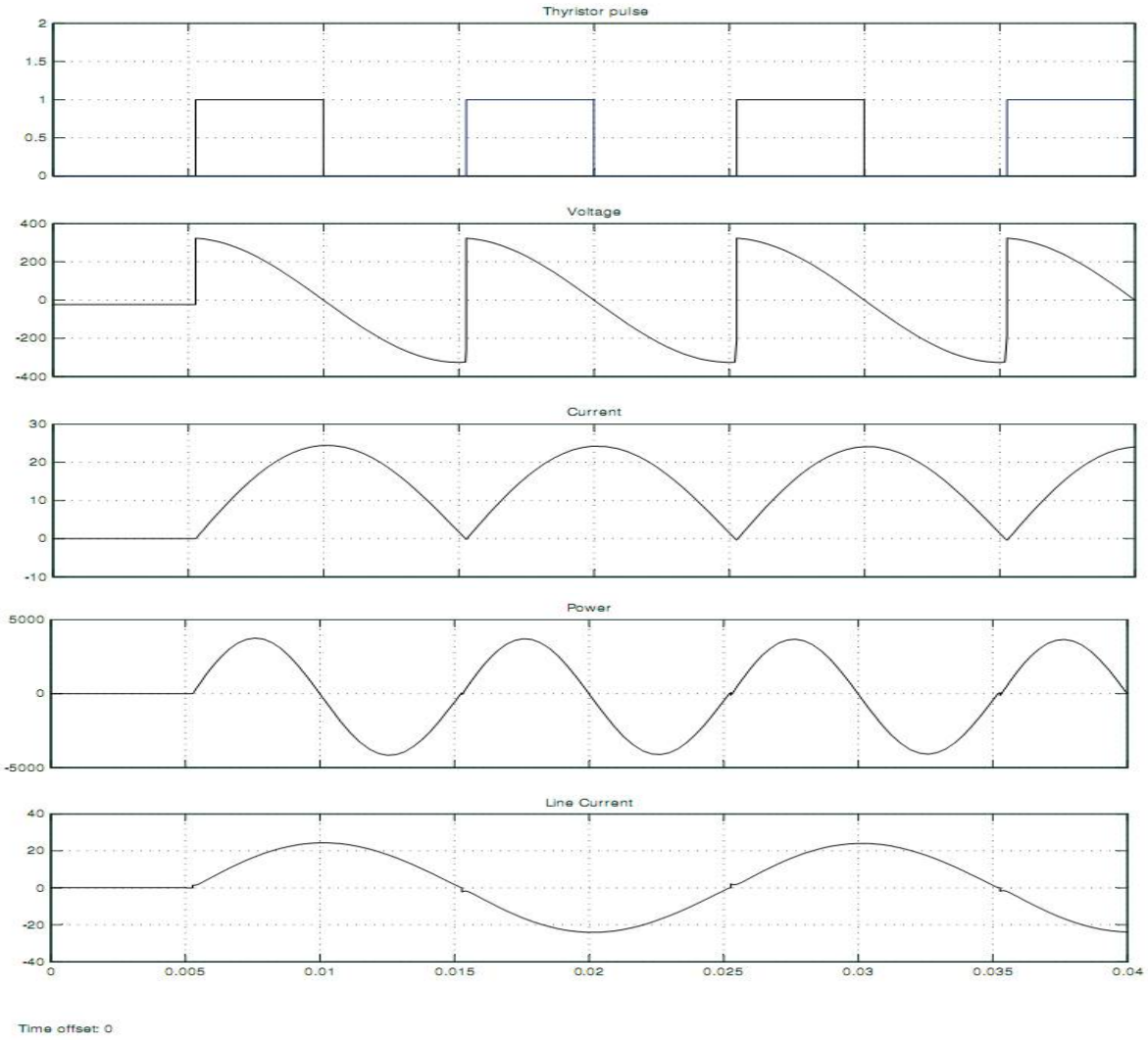

Figure.6Waveform for 95degree E=24 R=0.4Ohm L=0.042Henry

From the analysis of the simulink model for grid tied line commutated inverter, the waveforms of thyristor pulse, load voltage, load current, power output and low THD line current is shown in Figure.6 for 24 voltage battery. THD is measured through powergui FFT analysis tool of simulink block and shown in Figure.5.

V. RESULT

For the MATLAB/simulink model of grid tied inverter, the variation of THD and power with different dc voltage source and firing angle are studied and it is observed that the lower THD and better power transfer for battery voltage 24V and resistor R=0.4Ohm, inductor L=0.042Henry and firing angle 95 degree. The power is -247.6 watt and THD is 1.6% (low).

VI. CONCLUSION

Centre tapped converter circuit which works as inverter for single phase grid tied system has successfully been implemented in simulation. A thorough study has been made to obtain optimal performance with battery as dc source and can be extended for solar PV modules. With reduced THD, it will to be a better re-placement for square wave inverter in various distributed system connected to the grid.

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REFERENCES

[1] J. Kumar, B. Das and A. Pramod, "Selective Harmonic Elimination Technique for a Multilevel Inverter," Pro-ceedings of Fifteenth National Power Systems Confer-ence (NPSC), Bombay, December 2008, pp. 608-613.
[2] A. Myrzlk and M. A. Johanna, "Novel Inverter Topolo-gies for Single-Phase Stand-Alone or Grid Connected Photo-Voltaic Systems," 4th IEEE International Confe-rence on Power Electronics and Drive Systems, Denpas-sar, October 2001, pp. 103-108.
[3] M.S. Jamil Asghar, Power Electronics, New Delhi; Prentice hall of India (2004).
[4] A. Sarwar, M. S. J. Asghar, Imdadullah and S. K. Moin Ahmed, "Development of Solar PV Based Grid Con-nected Inverters," Proceedings of International Confe-rence on Electrical Energy System & Power Electronics,Chennai, April 2009, pp. 1172-1177.
[5] Adil Sarwar, "Microcontroller Based Novel Dc-to-Ac Grid Connected Inverter Topology", ACEEE Int. J. on Electrical and Power Engineering, Vol. 02, No. 03, Nov 2011.
[6] J. Iwaszkiewicz and B. J. Perz, "Multilevel Convertors for Distributed Power Generation Systems with DC Voltage Sources," International Conference on Renewable Ener-gies and Power Quality, Saragossa, 2005.