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Mitigation of Harmonics of Single-Phase Inverter Using Passive Filter

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***Abstract*— In electrical power system power quality is a major issue that's why we always focus on PQ. This paper presents mitigation of harmonics of single phase inverter by using passive filters. Under normal situation, a three-phase inverter generates high-order harmonics, which can generally be filtered by low pass filter, while Single Phase inverter generates not only high-order harmonics but also low-order harmonics even in normal situation, which is hard to be eliminated. In this research work, a Passive filter is designed in order to diminish the harmonics generated at the output of single phase inverter to improve the performance of device toward it is connected. The results have been obtained with and without installation of filters and finally observed that after installation of filters the harmonics of current are reduce and power factor is improved.**

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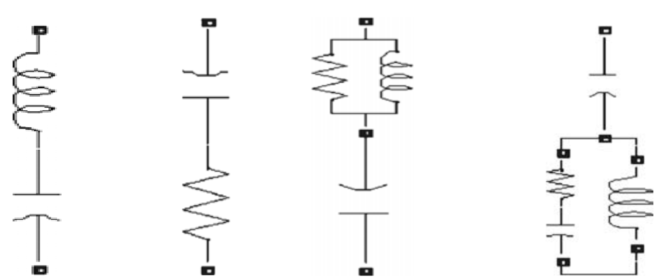
***Index Terms*— passive filter, harmonics distortion, current distortion, power factor.**

I. INTRODUCTION

Due to latest development of fast switching solid state devices, power electronic technology is expanding in the areas of residential, commercial, industrial, aerospace, electric vehicles, motor drives and power system utilities [1-3].

DC-AC converters also known as inverters can generate voltage with any required magnitude, frequency and phase angle. Nowadays, inverters widely used in solar systems, wind power plants, high voltage dc transmission systems (HVDC),flexible ac transmission systems (FACTS), active filters, [1-3]. Inverters provide lower consumption of energy, better system efficiency and improved the quality of product [2-3]. The efficiency of inverters is increased day by day due to switch mode action of semiconductor devices, but on other hand switching action of semiconductor devices generate harmonics which will lead the power quality issues in electrical systems. The power quality issues particularly harmonics in electrical energy system have become a major challenge for engineers to maintain the sinusoidal waveform for inverters. Now day by day power quality issues are growing up because of the widespread use of nonlinear loads.The use of power electronics and nonlinear loads, power networks facing high levels of unwanted harmonic distortion and they create additional losses, decreased equipment life span, protection of systems ,low power factor, hindrance in control system, communications and low efficiency. Also these loads inject the harmonic current into electrical networks that leads to various problems such as overloading of neutral conductors, power correcting equipment and transformers, failure of control system & unpredictable behavior of protection & relay connected in system etc. Nonlinear loads create harmonics in electrical power system that's why power quality of a system is decreased. so various techniques are used to eliminate the harmonics from the system. The active and passive filters are utilized to improve power factor and mitigate the harmonic currents. Active filters are extremely elastic, but they make system complicated and costlier.[1-4] Passive filters are preferable choice being simple, reliable and cost effective contributing in improvement of power factor and harmonic currents filtering. They also decrease harmonic voltages in installations where the supply voltage is troubled. Various techniques have been planned for conniving the passive filters. The aim is to reduce the harmonic impedance at particular frequencies and to exploit the fundamental frequency impedance of the filter for minimizing losses[5-6]. The types of harmonic filter are given in Fig. 1.



(a)Single tuned First order (b) Second order (c)Third order High pas (d) High pas High pass

Fig. 1: Passive Harmonic Filters

II. LITERATURE REVIEW

Mitigation of Harmonics are done by different methods or techniques by using filters. Active and passive filter are used to mitigate the harmonics. Passive filter are widely used because of better stability and withstand large current and also improve the power quality , THD and gives us pure sine wave. Where active filter require external power supply and also require dc power supply for operation[4-7]. That's why we use LC passive filter to mitigate the harmonics of single phase inverter. Some authors apply these techniques in different ways like using simulink software and some authors apply these technique in three phase system. But now we are design a prototype model of mitigation of harmonics of single inverter using passive filter[11-14].

III. SINGLE PHASE PARALLEL INVERTER

The basic circuit diagram of a single phase parallel inverter is shown in Fig 2. The capacitor employed for its commutation. It includes two thyristors T1 and T2 an output transformer, an inductor (L) and a commutating capacitor (C).The turns ratio of transformers assumed to be unity from each primary half to secondary winding. The output voltage and output current are indicated as V_o and I_o respectively in the given circuit.. The inductor (L) is used to make the source current constant at I_o positive directions for voltages and currents are marked in fig no1.(Indicate Io and Vo on Figure)

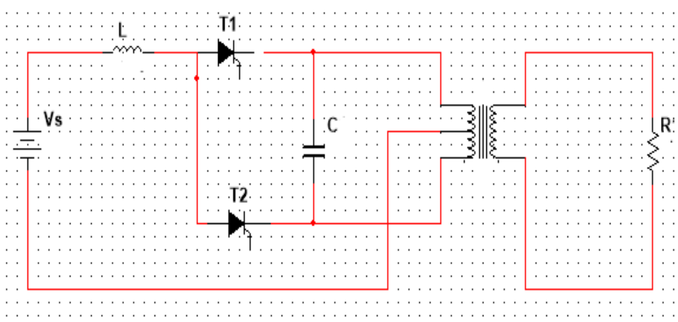


Fig.2.Single phase capacitor commutated parallel inverter circuit with center tapped transformer diagram

The proposed topology of inverter is operated in two modes:
Mode I: In this mode, thyristor T1is forward conducting mode and a current is flowing in the upper half of primary winding. The magnetic flux is established by this current linked with both halves of primary winding that result in to induce emf in upper and lower halves of the primary. Hence, voltage appeared across primary winding becomes 2Vs, which energizes the commutating capacitor C to a voltage of 2Vs with upper plate positive as shown in Fig.2.ThyristorT2 is forward biased through T1 by the capacitor voltage 2Vs. Hence, a constant current Io flows through Vs, L,T1 and upper half of primary winding [7-9].

Mode II: At switching time t = 0, turn on thyristor T2 occurs at application of triggering pulse to its gate. Meanwhile, capacitor voltage 2Vs establishes as a reverse bias across T1, which turned off it. In the, lower half of primary winding, Vs and L as shown in fig, the current Io starts to flow through T2. During this time, capacitive voltage 2Vs is appeared across the transformer primary and a capacitor current–ic is developed. Before the turn on of T2 i.e at t = 0-, mmf in upper section primary winding becomes IoN1 and vanishes in the lower portion of the primary winding i.e. becomes zero. After turn on of T2 at t = 0+, mmf slinked with both upper and lower halves would not vary suddenly. Thus, at t = 0+,-ic = Io such that mmf in the lower half remained zero and mmf in the upper half portion becomes equal to mmf at t = 0-.After t = 0, capacitor C de energizes and current ic is such that it supplies the load current io and balance the primary and secondary ampere turns of the transformer. Capacitive current flows continuously till capacitor becomes energized from +2Vs, to -2Vs at time t = t1. The voltage across load also varies from Vs at t = 0 to –Vs at t = t1.[10-12]

IV. HARMONIC ANALYSIS OF SINGLE PHASE PARALLEL INVERTER

Fig. 3 shows the experimental setup of parallel inverter. The harmonics of this inverter with and without passive filter is analyzed with the help of power quality analyzer. The waveform of output voltage for inverter is nonsinusoidal shown in Fig. 4. The harmonic spectrum of output voltage is also shown in Fig.5 which only contains odd harmonics due to half symmetry in output voltage waveform. The dc offset is also absent due to this half symmetry. The total harmonic distortion (THD) is 39.3% preset in the waveform of output voltage [13-14].

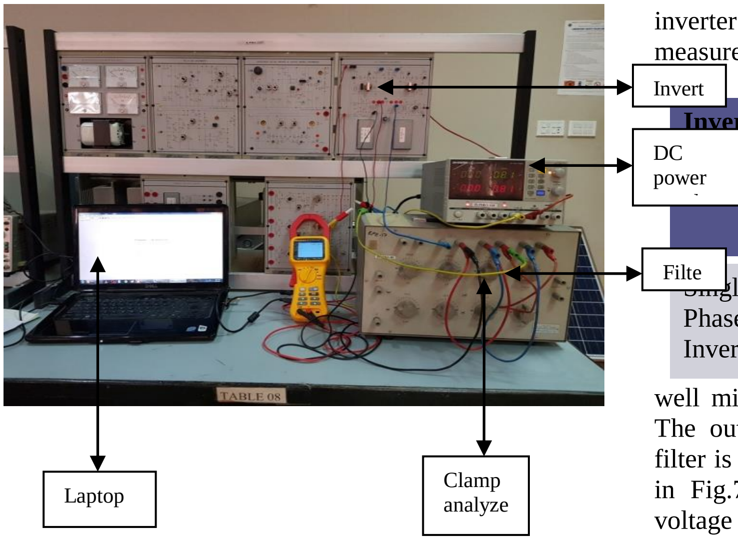


Fig. 3 Experimental setup of single phase parallel inverter

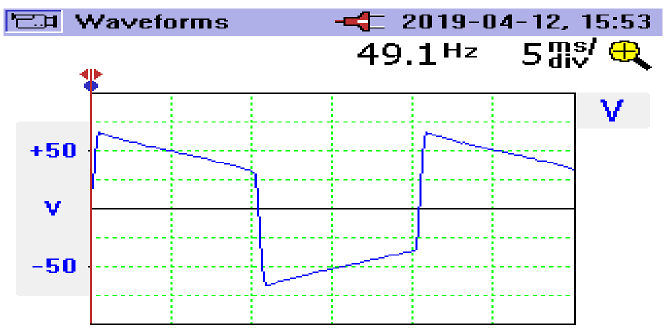


Fig.4.Output voltage waveform of Parallel inverter without passive filter

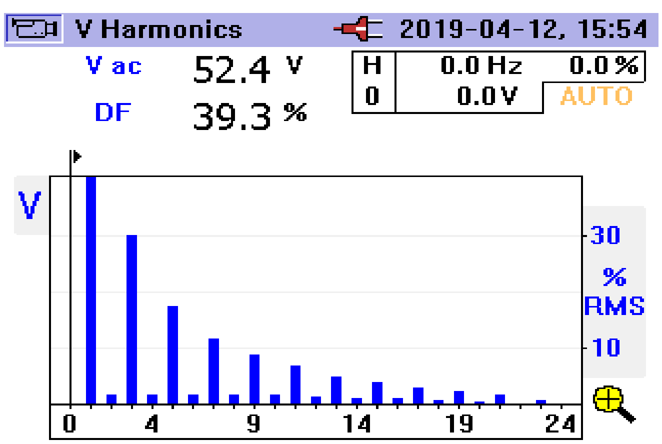


Fig. 5. Harmonic spectrum of output voltage of Parallel inverter without passive filter.

The behavior of single phase parallel inverter is also analyzed by connecting the passive filer at the output of inverter. The results of this inverter with passive filter is also measured with power quality analyzer. The passive filter is

Inverters	% THD (without filter)	% THD (with filter)
Single Phase Inverter	39.3 %	4.6 %

well mitigated the distortion in the output voltage of filter. The output voltage waveform of an inverter with passive filter is shown in Fig. 6 and the harmonic spectrum is shown in Fig.7. The total harmonic distortion (THD) in output voltage is 4.6 % only after filtration which is within the limit of IEEE standards.

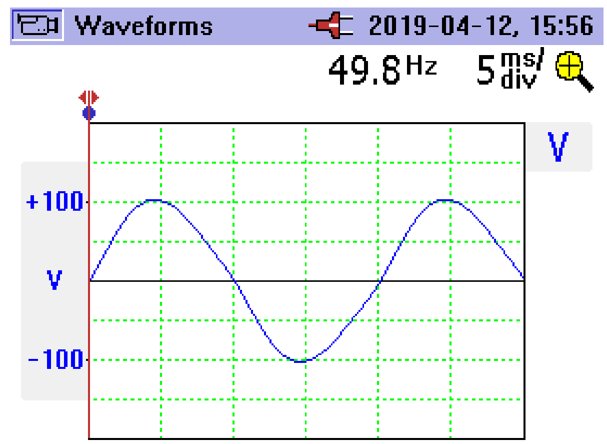


Fig. 6. Output voltage waveform of Parallel inverter with passive filter

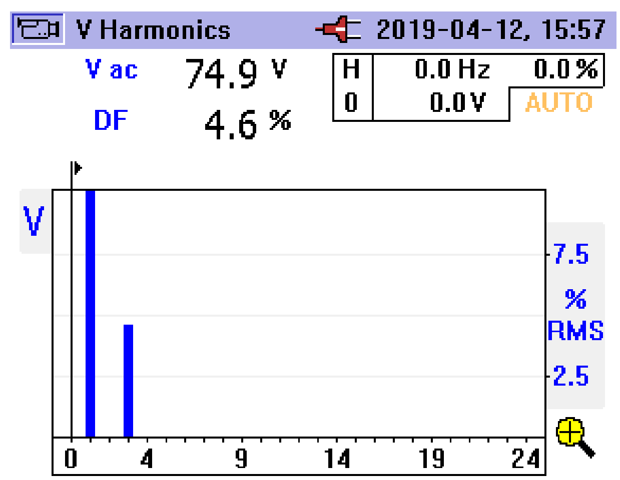


Fig. 7. Harmonic spectrum of Parallel inverter with passive filter.

Comparison results without and with filter
Table no 1

V. CONCLUSION

In this paper, the harmonics of single phase parallel inverter is mitigated by using LC passive filter. It is clear from the obtained results that after employing LC passive filter the total harmonic distortion in the output voltage are reduced from 39.3% to 4.6 %.

VI. ACKNOWLEDGMENT

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REFRENCES

[1] Bose, Bimal K. "Global energy scenario and impact of power electronics in 21st century." *IEEE Transactions on Industrial Electronics* 60, no. 7 (2013): 2638-2651.

[2] Mahar, M.A., Abro, M.R. and Larik, A.S., 2009. Simulation analysis of cascade controller for DC-DC bank converter. Mehran University Research Journal of Engineering and Technology, 28(3), pp.349-356.

[3] Larik, A., Mahar, M.A. and Shaikh, A.R., 2011. Performance analysis of phase controlled unidirectional and bidirectional ac voltage controllers. Mehran University Res. J. Eng. & Tech, 30(1), pp.151-158.

[4] Bruno Pires de Campos , Luiz A.R. de Sousa , Paulo F. Ribeiro : Mitigation of harmonic distortion with passive filters, IEEE Fellow Member Federal University ofItajubá, UNIFEI Itajubá, Brazil, *2016 17th International Conference on*.IEEE, 2016

[5] Dehbonei, H., Lo Borle, and C. V. Nayar. "A review and a proposal for optimal harmonic mitigation in single-phase pulse width modulation." *Power Electronics and Drive Systems, 2001.Proceedings., 2001 4th IEEE International Conference on*. Vol. 1.IEEE, 2001.

[6] Mahar, M.A., Uqaili, M.A. and Larik, A.S., 2011. Harmonic analysis of ac-dc topologies and their impacts on power systems. Mehran University Research Journal of Engineering & Technology, 30(1), pp.173-178.

[7] D.Maheswaran, N.Rajasekar, Ashok Kumar " design of passive filters for reducing harmonic distortion and correcting power factor in two pulse rectifier systems using optimization" journal of theoretical and applied information technology, 30th april 2014. vol. 62 no.3.

[8] P.MathanMohani, G.Amuthan "Comparative Evaluation of Various Single Phase Harmonic Filters for Non-Linear Load" IEEE - International Conference On Advances In Engineering, Science And Management (ICAES M -2012) March 30, 31, 2012.

[9] Cortés, Patricio, Gabriel Ortiz, Juan I. Yuz, José Rodríguez, Sergio Vazquez, and Leopoldo G. Franquelo. "Model predictive control of an inverter with output LC filter for UPS applications." *IEEE Transactions on Industrial Electronics*56, no. 6 (2009): 1875-1883.

[10].Dinesh Kumar, FiruzZare "Analysis of Harmonic Mitigations using HybridPassive Filters" 16th International Power Electronics and Motion Control Conference and Exposition Antalya, Turkey 21-24 Sept 2014.

[11] SahanaC B , "Study on Mitigation of Harmonics by Using Passive Filter and Active Filter",International Journal of Innovative Research in Computer and Communication Engineering*An ISO 3297: 2007 Certified Organization Vol.3, Special Issue 5, May 2015.*

[12] H. AKAGI, "Modern active filters and traditional passive filters" BULLETIN OF THE POLISH ACADEMY OF SCIENCES TECHNICAL SCIENCES Vol. 54, No. 3, 2006.

[13] "PWM Harmonic Signature-Based Islanding Detection for a Single-Phase Inverter With PWM Frequency Hopping" KalhanaColombage, *Student Member, IEEE*, Jiabin Wang, *Senior Member, IEEE*, Chris Gould, *Member, IEEE*, and Chaohui Liu, *Student Member, IEEE,* IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 53, NO. 1, JANUARY/FEBRUARY 2017.

[14] Mohammad Amin Chitsazan , Andrzej M Trzynadlowski "Harmonic Mitigation in InterphasePower Controller Using Passive Filter-Based Phase Shifting Transformer" Energy Conversion Congress and Exposition (ECCE), 2016 IEEE