International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-1 Issue-1, April 2012

A Single-Phase AC/AC Converter using Switch Reduction Technique

S. Gunasekaran, H. Abdulrauf, M.A. Harish, S. Premkumar, T.V. Priya, J. Priyadarshini.

Abstract: This paper deals with the design of a single phase six switch AC/AC converter for UPS application. Reduced switch-count topology is used here. This converter is designed for calculating the optimal operating point of the converter based on the design specifications in order to maximize dc bus voltage utilization. It is designed in such a way that output voltage has less THD with unity power factor. This also enhances battery charging applications and also increases the input power. There by the proposed converter has Less THD of input current and output voltage and unity power factor. The strategies have been confirmed by both simulation and experimental results obtained from the converter which used for UPS applications.

Keywords: UPS, AC/AC converter, PWM control, Switch reduction, THD.

I. INTRODUCTION

An uninterruptible power supply also uninterruptable power source (UPS) or battery/flywheel backup is an electrical apparatus that provides emergency power to a load when the input power source fails. A UPS differs from an auxiliary or emergency power system or standby in that it will provide instantaneous or near-instantaneous protection from input power interruptions by means of one or more attached batteries and associated electronic circuitry for low power users, and or by means of diesel generators and flywheels for high power users. The on-battery runtime of most uninterruptible power sources is relatively short 5–15 minutes being typical for smaller unit, but sufficient to allow time to bring an auxiliary power source on line, or to properly shut down the protected equipment.

Revised Manuscript Received on 30 April 2013.
*** Correspondence Author**
Prof. S.Gunasekaren*, Asst. Professor, Department of Electrical and Electronics Department, Sri Krishna College of Technology, Coimbatore, India, E-mail: gunameped@gmail.com
Dr. H. Abdulrauf, Principal, MEA Engineering College, Mallapuram, Kerala, India, E-mail: harauf@yahoo.com
Mr. M.A. Harish, Department of Electrical and Electronics, Sri Krishna college of technology, Coimbatore, India, E-mail: harishbuddy91@gmail.com
Mr. S. Prem kumar, Department of Electrical and Electronics Department, Sri Krishna College of Technology, Coimbatore, India, E-mail: spremkumar@hotmail.com
Ms. T.V. Priya, Department of Electrical and Electronics, Sri Krishna College of Technology, Coimbatore, India, E-mail: t.vishnupriya@gmail.com).
Mr. J. Priyadharshini, Department of Electrical and Electronics, Sri Krishna College of Ttechnology, Coimbatore, India, E-mail: darshu3891@gmail.com

While not limited to protecting any particular type of equipment, a UPS is typically used to protect computers, datacenters, telecommunication equipment or other electrical equipment where an unexpected power disruption could cause injuries, fatalities, serious business disruption or data loss.UPS units range in size from units designed to protect a single computer without a video monitor (around 200 VA rating) to large units powering entire data centers, buildings, or even cities. Conventional UPS topologies can mainly be categorized into three different types: off line, line-interactive and on-line. Amongst different types of UPS systems, on-line configuration (Fig. 1) is known to have the best performance considering power conditioning, reliability and load protection. Great tolerance to input voltage variation and precise regulation of output voltage are the most eminent advantages of this group [1].

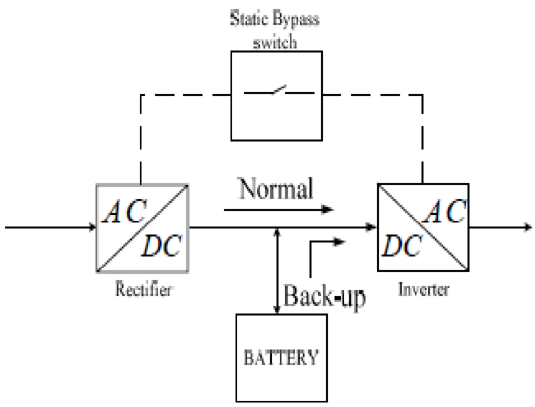

Fig.1Basic Block diagram of on line ups

II. CONTROL TOPOLOGIES

The recent trend in on line UPS system configuration is to reduce the number of switches used. The objective is to reduce the cost of the system and also the harmonic distortions. The converter used also plays a main role in the harmonic profile. There are two types of topologies offered for on-line UPS. The first and early topology consists of a series inductor between the utility mains and the critical load, and bilateral converter in parallel with the critical load, acting as abattery charger under normal condition and an inverter supply backup power from the battery to the load in the event of power outage. This type of UPS is also sometimes referred to as parallel-processing UPS which involves only one power stage [2].

The other approach to switch reduction of on-line UPS systems is based on merging the two stages of power conversion into one. Specifically, the proposed converter in (Fig.2), and in general the AC/AC converters which share one or two legs between the inverter and the rectifier stage use this concept [3].

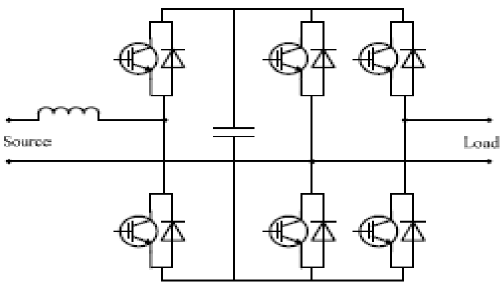

Fig.2 Three leg single phase inverter

III. SINGLE PHASE CONVERTER

In this paper, a single phase converter is designed in which the switches of the converter are shared [4].This is shown in figure 3. Similar to three phase converters there are two operating modes in this converter. They are equal frequency (EF) and different frequency (DF).

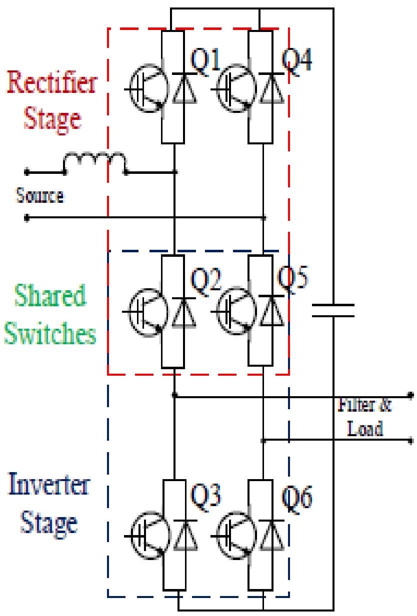

Fig.3 Proposed single phase converter

Equal frequency mode is considered most suitable for UPS systems [5]. This is concluded considering the output voltage THD, switching losses, input power factor,DC bus utilization. To maximize the use of DC utilization as well as regulation of output frequency, techniques is used in this paper. The technique is that to find optimal operating point for normal operation and a battery charging strategy after backup mode is finished for maximum battery charging pace. The proposed topology enjoys the benefits of an ideal single-phase AC/AC converter such as low THD input current, unity power factor, fast dynamic response and the ability to compensate input voltage drop when supplying linear or nonlinear loads.

The fig.3 shows the proposed structure that consists of six semiconductor devices Q1, Q2, Q3, Q4, Q5, and Q6. Q1,Q2,Q4,Q5 act as a rectifier and Q2,Q5,Q3,Q6 act as a inverter and Q2,Q5 is the shared switches. It is shared between inverter and rectifier. Here the single phase input ac voltage is given to rectifier and here it converts the ac supply voltage to dc voltage. And then this dc voltage is given to inverter this again converts the dc voltage to ac voltage. Here we convert the ac through dc link converter. We go for this type of converter to get a unity power factor and low THD values. The number of switches is reduced by 25% compared to common back to back converter.

IV. EQUAL FREQUENCY MODE OF OPERATION

In this mode input and output frequency are considered equal. If the references are in-phase, for optimal switching modulation, the offset is determined by (1) in which M_1 and M_2 could be either rectifier or inverter modulation indices and could be increased up to one [6]. If the references are phase-shifted, the condition (2) should be met and no offset should be added.

If $M_1>M_2$ = $\begin{cases} offset1 = 0 \\ offset2 = M_2 - M_1 \end{cases}$ (1)

$$M_1 \sin(\omega t + \theta) + 1 - M_1 \geq M_2 \sin \omega t + M_2 - 1 \quad (2)$$

V. DIFFERENT FREQUENCY MODE OF OPERATION

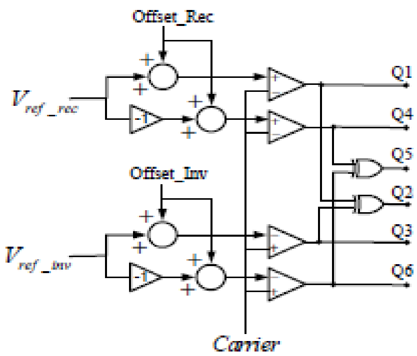

Fig.4 Block diagram of signal generation unit

The fig.4 shows the modulating signal of the proposed converter. This circuit uses logical XOR gates. The modulating signal is obtained from the negative values by either shifting up or down with appropriate operating mode (DF or EF).This generates the modulating signal of the upper and lower switches. The frequency and amplitude various independently in different frequency mode by splitting the modulation index between them. Adding offsets of 0.5and -0.5 to rectifier and inverter references and restricting their amplitudes to less than half, gives the proper modulating signals.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

VI. CONTROL CIRCUIT

The modulation signals of the inverter and rectifier are produced independently. Therefore all existing methods can be applied for controlling the DC bus voltage in single phase rectifiers. The method used here is single phase P-Q theory, which is developed from the convectional P-Q theory [7]. The block diagram is represented in fig.5. The main advantages for using this theory are that reduced THD, unity power factor and dynamic response. First by using (3), and imaginary component of the feedback variable is created which lags the real signal by 90^o

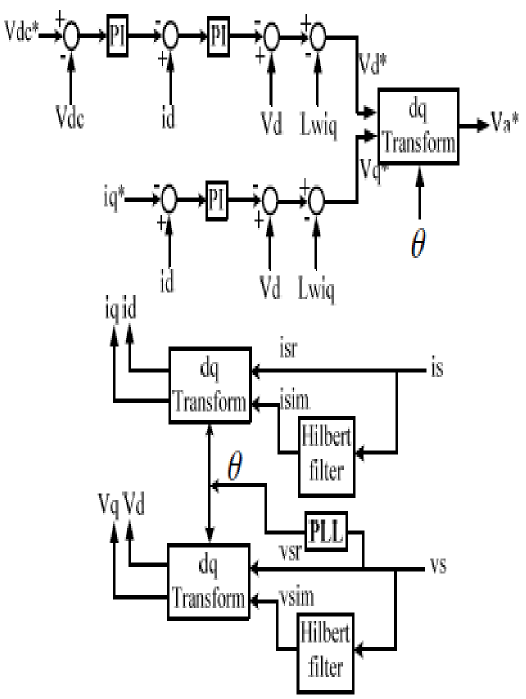

Fig.5 Block diagram of the control circuit

$$\begin{cases} S_{SIm} = S_{Sm} \sin\left(\omega t + \phi - \frac{\Pi}{2}\right) \\ S_{SR} = S_{SM} \sin(\omega t + \phi) \end{cases} \quad (3)$$

Using these two signals and (4), the feedback variable will be transformed to d-q plane; reference values of V_d^* and V_q^* are obtained by indirectly controlling injected active/reactive power to the system with the aim of controlling dc bus voltage.

$$\begin{bmatrix} S_d \\ S_d \end{bmatrix} = \begin{bmatrix} \sin\theta & -\cos\theta \\ \cos\theta & \sin\theta \end{bmatrix} \begin{bmatrix} S_{SR} \\ S_{SIm} \end{bmatrix} \quad (4)$$

The main disadvantages in EF operating mode of operation is that frequency dependency between rectifier and inverter stages. This dependency will disable the system from regulating output frequency in normal operation, which is an important criterion for on-line operating UPS. SO choice less DF operating mode is chosen. The only disadvantage in DF operating mode is that Dc bus is utilized less and there by switching losses occur. To avoid this a operating point for the converter is designed and this can be used for battery charging applications.

VII. SIMULATION OF THE PROPOSED CIRCUIT

The proposed converter circuit is simulated using MATLAB 7.8. This is represented in fig.6. In this simulation, the value of DC bus voltage is decreased so as by increasing the modulation index. This will reduce the maximum output power of inverter since the value of the input power is decreased. Therefore the limitation is justified here, i.e. the output voltage THD is reduced and also the switching losses.

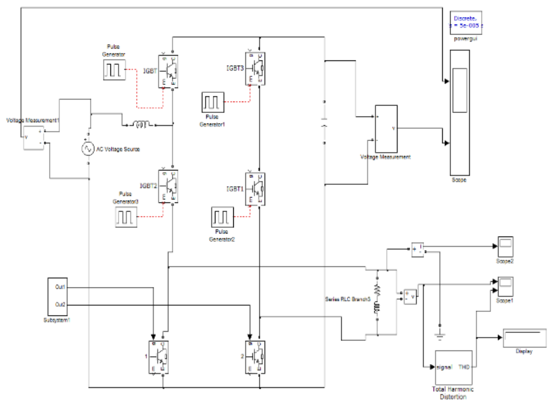

Fig.6 Simulated matlab model of proposed single phase converter

The output waveforms of the simulated circuit are shown in fig.7, fig.8 & fig.9. If the conventional method were used, the level of dc bus voltage would be 450 V for this converter. But this value is 350v for the novel method. This means that the dc bus voltage level is reduced by 22.2%.

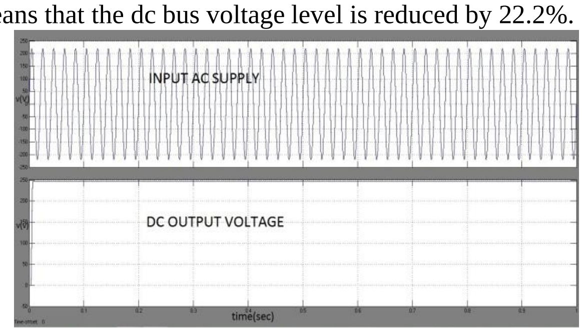

Fig.7 Input ac supply and converted dc output voltage

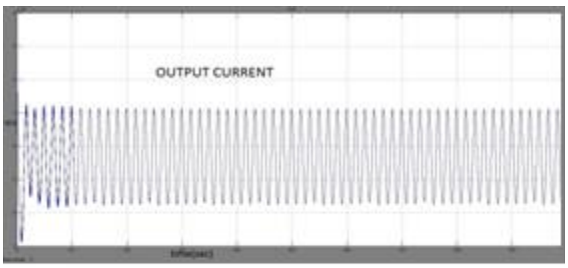

Fig.8output current from the inverter

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

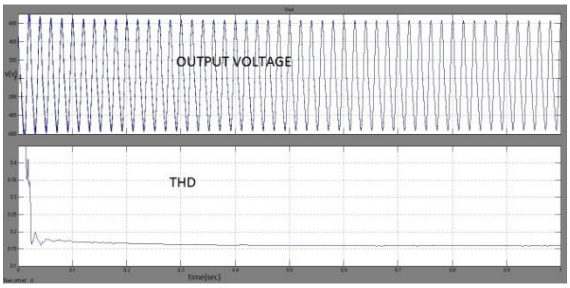

Fig.9 output voltage and THD

VIII. CONCLUSION

Overall, the proposed converter and the suggested operating point along with the proposed strategy for the battery charging enjoys several advantages over its three-phase counterpart such as being suitable for low power/voltage applications, enhanced bus utilization, reduced switching loss, improved output voltage THD, expedited battery charging rate, etc. The proposed converter is simulated and results verify that this technique gives us less THD, unity power factor and reduced switching losses.

REFERENCES

1. A. Fatemi1, M. Azizi, M. Shahparasti, M. Mohamadian, A. Yazdian" A Novel Single-Phase Six-Switch AC/AC Converter for UPS Applications" in 2011 2nd Power Electronics, Drive Systems and Technologies Conference.
2. Chia-Chou Yehand MadhavD.Manjrekar,"A Reconfigurable Uninterruptible Power Supply System for Multiple Power Quality Applications" in IEEE transactions on power electronics, vol. 22, No. 4, July 2007.
3. Congwei Liu, BinWu, Fellow, Navid R. Zargari,Dewei (David) Xu, and Jiacheng Wang," A Novel Three-Phase Three-Leg AC/AC ConverterUsing Nine IGBTs" in IEEE transactions on power electronics, vol. 24, no. 5, May 2009.
4. Gui-Jia Su and TetuhikoOhno" A New Topology for Single Phase UPS Systems" in 1997 IEEE
5. Congwei Liu, Bin Wu, NavidZargariand David Xu"A Novel Nine-Switch PWM Rectifier-Inverter Topology For Three-Phase UPS Applications" in 2000 IEEE
6. FengGao, Lei Zhang, Ding Li, Poh Chiang Loh, ,Yi Tang, and HouleiGao, Member, IEEE" Optimal Pulsewidth Modulation ofNine-Switch Converter" in IEEE transactions on power electronics, vol. 25, no. 9, September 2010".
7. M. Tarafdar. Haque" Single-phase PQ theory" in 2002 IEEE

AUTHOR'S INFORMATION

S.Gunasekaren received the Bachelors Degree in Electrical and Electronics Engineering in 2005.He completed his Masters degree in power electronics and drives in the year 2007.He is currently a PhD candidate in the faculty of Electrical and Electronics Engineering, Anna University of Coimbatore. His current research interests include power electronics, simulation and control techniques, AC and DC drives and VLSI.

Dr.H. Abdul Rauf is currently the Principal of MEA Engineering College, Mallapuram, Kerala, India. Being an eminent professor of Anna University, there are many students doing their research under his guidance in various fields. Some of main areas of research are Control system, power electronics, Mobile computing and Computer Networks.

M.A.Harish is currently doing his U.G in Electrical and Electronics Engineering, Sri Krishna College of Technology, Coimbatore. He has attended workshops on "open source software uses DSP applications "and has presented conference on A Single-Phase Six-Switch AC/AC Converter for UPS Applications. His areas of interests are power systems and implementation of embedded system on the same. Currently working on power optimization

S.Prem Kumar is currently doing his Under Graduate in Electrical and Electronics Engineering, Sri Krishna College of Technology, Coimbatore . He has attended workshops on "open source software uses in DSP applications", "virtual instrumentation", "Recent trends in embedded system" and has presented a conference on A Single-Phase Six-Switch AC/AC Converter For UPS Applications. His areas of interests are optimal power flow control and applications of soft computing techniques in power systems.

T.V.Priya is currently doing her under graduate in Electrical and Electronics, Sri Krishna college of technology, Coimbatore. She has attended workshop on "virtual instrumentation", has presented a conference on A Single-Phase Six-Switch AC/AC Converter for UPS Applications. Her areas of interests are power systems and applications of soft computing techniques in power systems.

J.Priyadharshini is currently doing her under graduate in Electrical and Electronics, Sri Krishna college of technology, Coimbatore. She has attended workshops on "open source software uses in DSP applications", has presented a conference on A Single-Phase Six-Switch AC/AC Converter For UPS Applications. Her areas of interests are power electronics and applications of soft computing techniques in power systems.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)