A Novel Simple Reliability Enhancement Switching Topology for Single Phase Buck-Boost Inverter

Snehal Balaji Gatkine
[1]PG Scholar,
[1] Department of Electrical Engineering,
[1]Tulsiramji Gaikwad - Patil College of Engineering and Technology, Nagpur, India

Abstract : **The buck-boost inverter provides boosting and inversion function in a single power processing stage based on the front end buck-boost converter characteristics. The static stabilizer offers a reasonable slow servo controlled as well as other static tap changing facility. The basic topology is with buck-boost transformer with high primary to secondary ratio for voltage correction of 25%. The control voltage is imposed on the primary side of the buck-boost transformer. The voltage regulation of this topology is achieved electronically with the step changes in voltage. This task is accomplished through a feedback and control system implemented. The system uses IGBTs as power switches. Direct AC-AC converter circuit improves the overall system response and fast voltage correction. Number of storage capacitor usage will increase the life of the system. 20 KHz PWM control operation using Microcontroller Atmega16 to achieve time of 1 to 1.5 cycles. Simulation results vividly validate the proposed idea of single phase buck-boost inverter.**

***IndexTerms* - buck-boost inverter , PWM, IGBT Chopper.**

I. INTRODUCTION

The smooth functioning of the majority of electrical and electronic equipment depends on the supply voltage correctness and steadiness. Nowadays, many industries and private users are subjected in long-lasting fluctuations that can be inconvenient or even dangerous.AC voltage stabilizers are used for obtaining a steady AC supply with very close tolerances from fluctuating mains. They find application in a very wide variety of fields. Static Voltage Stabilizer is an IGBT based PWM type buck- boost voltage stabilizer which has tight regulation and fast correction speed which is impossible to obtain conventional methods. In this topology there is no need to convert the AC input to DC and again convert it back to regulated AC output. This simplifies the design, reduces the component count and Improves the efficiency and reliability. The power stage is an IGBT chopper control.

The chopping frequency is around 20 KHz which ensures absolutely silent operation and pure sine wave output (no waveform distortion). The control section is based on micro controller which ensures quick correction of output which is not possible in conventional relay type stabilizer or servo controlled stabilizers. Since the circuit is fully solid state (no mechanical or moving parts) there will not be any wear and tear like the brush tear in servo stabilizer or relay degrading in relay based stabilizer. This is especially useful in places where we need very fast correction speed, constant output voltage, overload current limiting and short circuit protection, soft start, high voltage cut-off and low voltage cut- off, automatic bypass, no wear and tear, long life and maintenance free which is impossible with other conventional relay type or servo control stabilizers.

II. . BRIEF LITERATURE SURVEY

This paper presents A single phase two-quadrant PWM rectifier to power fixed DC voltage at the input of inverter module will be presented in this paper. The proposed PWM rectifier can be operated as a Single phase bridge rectifier to maintain well-regulated and boosted DC-link voltage for Inverter module. The control of this converter is realized using analog type closed loop circuit. A proportional-Integral type controller is designed, and the PWM type switching control signal for IGBT is generated by Op-amp circuitry. In idle case, the proposed PWM rectifier can be arranged to act as a single phase full bridge rectifier [1].

This is an SMPS type voltage stabilizer for mains voltage (AC input and AC output). This is a new switching topology where PWM is made directly in AC-to- AC switching, without any harmonic distortion. In this topology there is no need to convert the AC input to DC and again convert it back to regulated AC output. This simplifies the design, reduces the component count and improves the efficiency and reliability [2].

In this the author analyzed that the Voltage stabilizer provides an output voltage with a specified limit for supplying to load irrespective of wide fluctuation in the input voltage, independent of load power factor and without introducing harmonic distortion. The voltage stabilizer adjusts automatically the voltage variation whether high or low to the proper voltage level necessary for the safe operation of equipment's [3].

This paper proposes the design and implementation of a microcontroller-based single-phase automatic voltage regulator (AVR). The basic building blocks for this design include a PIC 16f 628 microcontroller, a triac, a step-up transformer, a zero crossing circuitry and a load voltage sensing circuitry. This design is based on the principle of phase control of ac voltage using a triac. The trigger pulse for the triac is delayed by the microcontroller to provide the desired regulator terminal voltage. This voltage is always sensed and fed back to the microcontroller via a measuring unit to get a

continuous control system. One of the intensions to develop this AVR is to use it in domestic heating and lighting controls [4].
In this present paper, stress has been laid upon the present scenario of power quality in every grid. With more and more use of nonlinear electrical loads instead of linear loads, we get increased efficiency with reduced power requirements; however this degrades the power quality of whole power system. Power quality is basically determined by the voltage [5].

III. DESIGN OF EXPERIMENTATION

III.I Software Design

The basic building block of this project is as shown below:

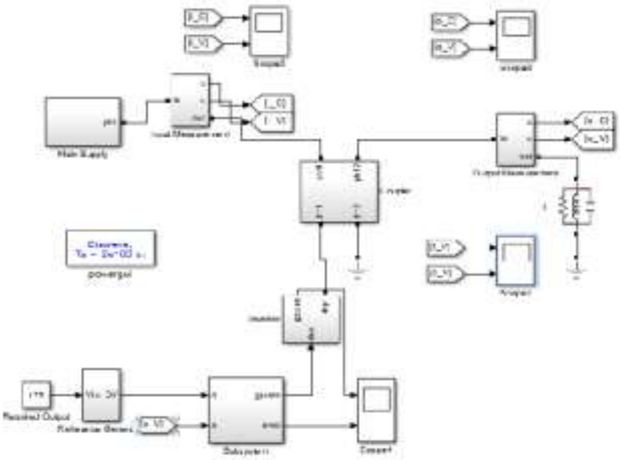

Fig.1 Simulation Diagram of Software Design

As per the simulation diagram shown in figure1, the details of each block with sub diagram are described in detail:

III.I.I Main Supply

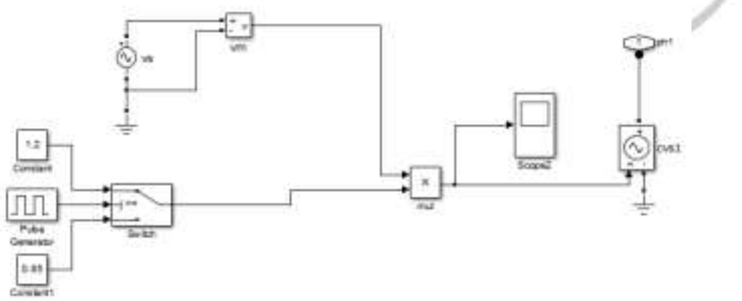

Fig.2 Schematic Diagram of Main Supply

The 230v AC supply is taken from grid. The pulses are increased or decreased by multiplying 1.2 and 0.85 respectively according to the requirement. Then that pulses are get multiplied in the multiplier box. The output can be recorded at Scope 2. The pulses are required to change the input for another reading. The input which are required is ready at controlled voltage source cvs1. We can change input in simulation by changing the value of Vs.

III.I.II Input Measurement

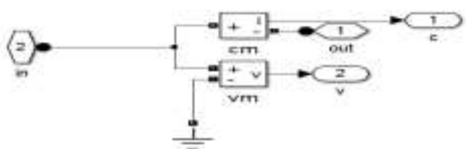

Fig.3 Schematic Diagram of Input Measurement

This block shown in Figure 3, is connected for the measurement of voltage and current. Further, it is connected to scope for input waveform of current as well as voltage.

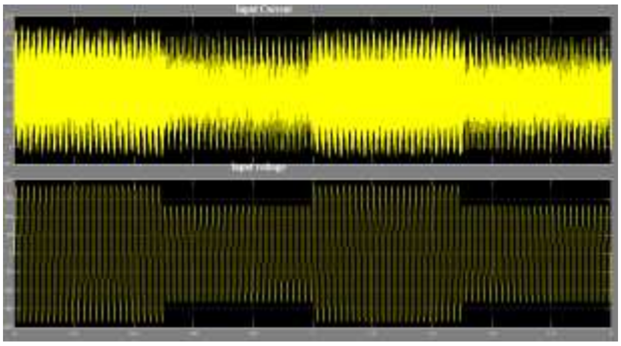

Fig. 4 Input waveform of voltage and current

As shown in Figure 4 input voltage 169V, which is given to the system for measurement .

III.I.III Reference Generator

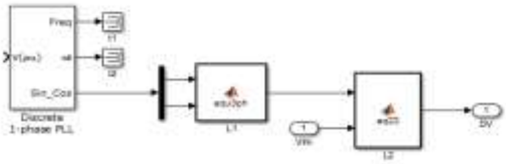

Fig.5 Schematic Diagram of Reference Generator

In this block sinusoidal waveform are generated by providing a simple program.

III.I.IV Subsystem

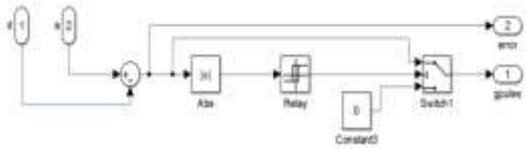

Fig.6 Subsystem

In this block PI controller are used for a generation of pulses. Those pulses are given to the inverter circuit for triggering of IGBT. As shown in main simulation Fig. no 5.1 the output of subsystem is given to the scope for the observation of error and gate pulses of inverter. Waveforms are as shown below in Figure 7.

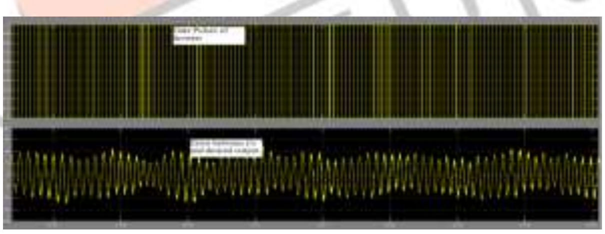

Fig. 7 Waveform of Error and Gate pulses

III.I.V Inverter

In this block IGBT inverter are used to convert DC into AC and again it is converted to AC using inverter.

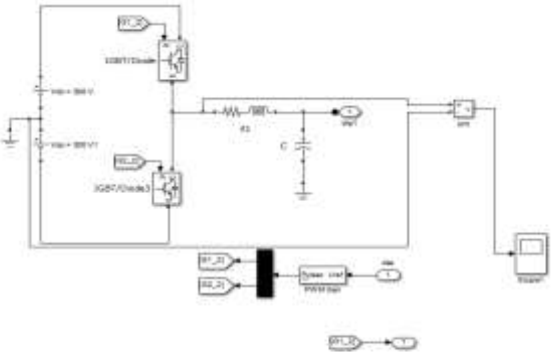

Fig 7.Inverter

III.I.VI Coupler

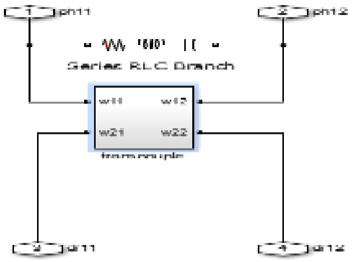

Fig 8 Coupler

Here in Figure 8, two signals are present one is directly from Grid and another is output of inverter. In this block phase shift and magnitude of two signals is checked. If it is out of phase it was harmful to circuit. Therefore, both signals are started from zero firing angles. According to the feedback network constant output is obtain by adding or subtracting signal. For adding or subtracting transformer is used which is present in block of trans couple. Its schematic diagram is as shown below

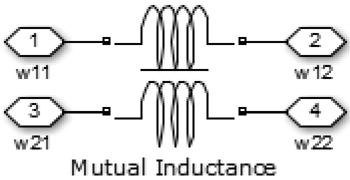

Fig.9 Schematic Diagram of Transformer

III.I.VII Output Measurement

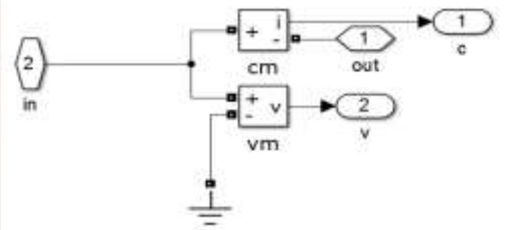

Fig.10 Output Measurement

In this block constant output is obtained , which is 174V as is desired one. In this block only scopes are connected for the measurement of output voltage and current. Waveform of output voltage and current are as shown below :

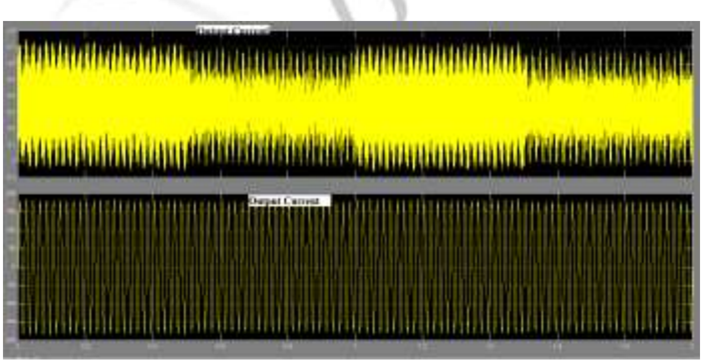

Fig.11 Waveform of Output Current & Voltage

From the above Figure 11 of waveform it is observed that the output voltage is constant though there is variation in input as shown in figure above.

III.I.VIII Powergui

The Powergui block is necessary for simulation of any Simulink model containing Simulink Power Systems blocks. It is used to store the equivalent Simulink circuit that represents the state-space equations of the Model.[6] The Powergui block allows you to choose one of the following methods to solve your circuit:

- Continuous method, which uses a variable step Simulink solver.

- Discretization of the electrical system for a solution at fixed time steps.
- Phasor solution method

III.II Hardware Design

The main connection diagram of this project is as shown below:

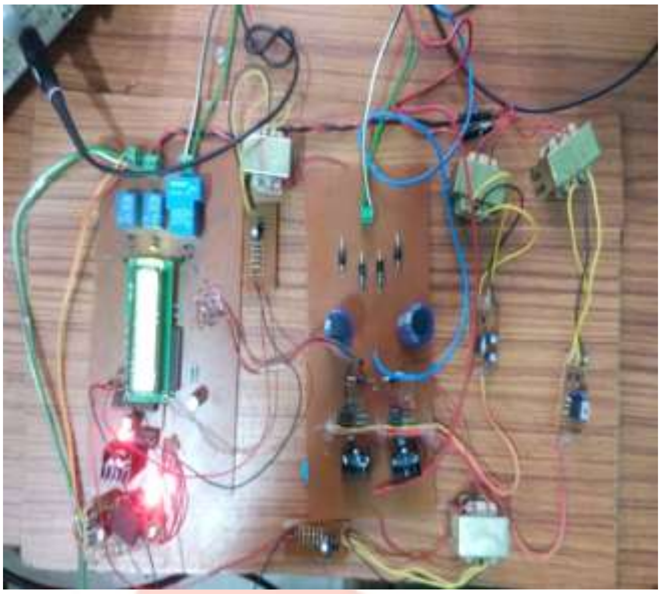

Fig .12 Schematic model of Hardware

The above figure shows the schematic diagram of Hardware Model. The various components used in the above model is as Adapter, different types of microcontroller, LCD, relays, voltage regulator, Heat Sink, diode rectifier, snubber circuit, transformer , Isolators and drive circuit etc.

IV. SPECIFICATIONS OF COMPONENTS USED

Table.1 Specifications of Components Used

Serial. .No.	Component	Rating
1	Adapter	12V, 1Amp, DC
2	ATMEGA8 Microcontroller	4.5 to 5.5V , 32 Pin
3	7805 Regulator	5V, 1A
4	7812 Regulator	12V, 1A
5	Transformer	12v, 500mA
6	Relay	5V, 12C, SPDT

V. DESIGN CRITERIA

V.I Diode Bridge Rectifier

Input line voltage = $230V_{ac}$

Output DC voltage = $300\ V_{dc}$

Load current = 2 Amp.

V_m = $\sqrt{2}$ x 230 = 325 V

V_{dc} = $2\ V_m/\pi$ =2 x 396 /π

= 210 (without filter)

Diode :-

V_R (max) > V_m

> 396 Volts

I_f (max) > I_0

> 2.2 A

I surge > I_p

> 34.15 A

selected diode are D_1 to D_4 = 1N5408

Table . 2 Specifications of Diode

1.	Maximum Average Forward Rectified Current (I_{av})	3 A
2.	Maximum Recurrent Peak Reverse Voltage (V_{rm})	400 V
3.	Maximum DC Blocking Voltage (V_{dc})	400 V

V.II IGBT

While selecting IGBT

V_{ds} > 0.707 x V_{dc} [let m_a=1 (max)]

> 0.707 x 300

> 212 volts

V_{gs} > 12 volts

I_d > I_L max

> 2 Amps

Switching time should be as small as possible selected IGBT is FGA15N120.

1.	Drain-Source Voltage	1200 V
2.	Gate-Source Voltage	+20V/-20V
3.	Continuous Drain Current	15 A
4.	Turn-Off Delay Time	110 ns
5.	Fall Time	58 ns

Table .3 Specifications of IGBT

V.III Isolator and Drive Circuit

Selected isolator is 4N35 which has got IRED and phototransistor internally.

The maximum forward current for LED = 20_m A

Peak output voltage of ATMEGA8 will be = 5 v

Let maximum current for LED to be selected as 0 $_m$ A

R = V_i / I_f

= 5 / 20 A

= 250 Ω

Selected R = 270 Ω ¼ w

With this value ,

I_f (max) = 5 / 270Ω

= 18.5 $_m$ A

Which is acceptable value for 4N35

Selected Resistors are = 270 Ω ¼ w each.

4N35 requires supply voltage = 12 V_{dc}

So we design power supply for the rating 100 $_m$ A.

Using transformer of 12- 0 secondary voltage.

V_m (sec) = √2 x 12 = 17 V

Selected ripple voltage V_{rpp} = 0.5 V

For same voltage, at any input range of AC supply we used a regulator IC as 7812.

Selected Opto Coupler is 4N35 which has

Using transformer of 12- 0 secondary voltage.

V_m (sec) = √2 x 12 = 17 V got IRED and phototransistor internally.

The maximum forward current for LED = 20 $_m$ A

Peak output voltage of ATMEGA8 will be = 5 v

Let maximum current for LED to be selected as 20 $_m$ A

R = V_i / I_f

= 5 / 20 $_m$ A

= 250 Ω

Select R = 270 Ω ¼ w

with this value

I_f (max) = 5 / 270Ω

= 18.5 $_m$ A

Which is acceptable value for 4N35

Selected Resistors are = 270 Ω ¼ w each.

4N35 requires supply voltage = 12 V_{dc}
So we design power supply for the rating 100 $_m$A.

Selected ripple voltage $V_{r\,pp}$ = 0.5 V
For same voltage, at any input range of AC supply we used a regulator IC as 7812
Hence V_{dc} = 12 V

Table.4 Spécifications of Isolator and Drive Circuits

1.	Collector emitter breakdown voltage	70 V
2.	Collector current	100 mA
3.	Forward current	20 mA
4.	Reverse voltage	6 V

VI. SOFTWARE REQUIRED

- MATLAB SIMULINK,
- ATMEL STUDIO 6.0,
- PCB ARTIST,
- SINAPROG

VI. RESULT

The ultimate aim of this project is obtain constant output voltage even there is increase or decrease in input voltage. This can observed by combine view of input and output voltage which is as below:

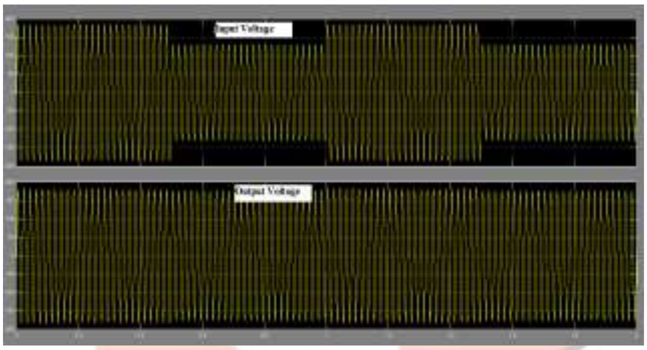

Fig.13 Waveform of Input and Output Voltage

Table.5 Result of Simulation and Hardware Model

Serial No	Input to System	Simulation Output	Hardware Output	Difference
1	180	175	174	1
2	178	175	175	0
3	169	175	173	2
4	154	175	174	1

From the above results we can say that, simulation model gives more accurate results than the hardware model. There is a slight difference between both the outputs which is negligible.

VII. CONCLUSION

A single phase buck-boost inverter has been proposed in the paper. The topology is simple, symmetrical and easy to control. The other desirable features include good efficiency due to optimal number of device switching's and reduced switching issues. The proposed inverter has a number of attractive features, such as covering the low and variable input voltage, low switching losses, boosting and inversion functions, few voltage and current sensors, and finally resulting in a low cost solutions.

REFERENCES

[1] Pratik J. Munjani1, Nitin H. Adroja2, Vinod J. Rupapara3 Modelling of PWM Rectifier for Static Automatic Voltage Regulator, International Journal of Advance Engineering and Research Development (IJAERD) ETCEE-2014 Issue, March 2014, e-ISSN: 2348 - 4470 , print-ISSN:2348-6406
[2] Matrin Electronic Devices & Instruments" AC –AC PWM mode Static voltage Stabilizer using IGBT and DSP".
[3] AUTOMATIC VOLTAGE STABLIZER" prepared by Electrical Division MSME-Development Institute Ministry of MSME Government of India 34, Industrial Estate Nunhai , Agra- 282001
[4] Nang Kaythi Hlaing "Microcontroller-Based Single-Phase Automatic Voltage Regulator" 978-1-4244-5539-3/10/$26.00 ©2010 IEE
[5] S .Gupta "POWER QUALITY IMPROVEMENT USING PWM VOLTAGE REGULATOR" IJMIE Volume 2, Issue 5 ISSN : 2249-0558