DESIGN AND IMPLEMENTATION OF VARIOUS CONTROLLERS FOR VIENNA RECTIFIER

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ABSTRACT

A regulation on input harmonics and power factor necessitates the use of front end active power correction for all converter applications. Vienna rectifier has become a popular choice for the three phase active power factor correction circuit for all converter applications. The three phase three-level boost type converter is an interesting switch mode topology for the mitigation of power quality problems generated by commonly used nonlinear loads. Vienna rectifier is simulated using MATLAB/SIMULINK. This thesis aim in design, analysis and implementation of Vienna rectifier. The closed loop has been simulated using pi controller.

Key words: Vienna Rectifier, Voltage Controller, Power Controller, Digital to Analog Converter.

I. INTRODUCTION

Vienna Rectifier as was originally developed at the Technical University Vienna. It comprises a semiconductor switch, say, a MOSFET in each phase leg of a 3-Phase diode bridge. By adjusting the width of the pulse that turns ON the MOSFET, corresponding line current is forced to be sinusoidal and in phase with the Voltage. When the MOSFET is turned ON the corresponding phase is connected, via the line inductor, to the center point between the two output capacitors. The phase current rises, through the MOSFET, during that pulse period, charging the capacitor. When the MOSFET is turned off, current tapers through the diode half bridge (upper or lower depending on direction of the current flow).

In Vienna Rectifier configuration, the output capacitor is split in two parts as two equal value capacitors, C1 and C2, connected in series. Across the output capacitors the –Vdc and +Vdc are developed as 3-Phase peak detected outputs. A switch for each phase is connected, such that when “ON”, it connects the line phase to the center node of C1 and C2 through a series inductance. For a short switching period,(assuming 10 microseconds), the capacitors charge linearly. This offsets -Vdc and +Vdc. The offset depends on the corresponding phase voltage and the switch “ON” time duration. The common node of C1 and C2 will have Voltage with triangular wave shape, having three times the mains frequency and its amplitude will be one quarter of the phase voltage. Vienna rectifier has become a popular choice for the three phase active power factor correction circuit for all converter applications. The three phase three-level boost type converter is an interesting switch mode topology for the mitigation of power quality problems generated by commonly used nonlinear loads such as electrical devices and other electronic devices.

II. MODULES OF VIENNA RECTIFIER

2.1 Vienna Rectifier

Many high power equipments derive electrical power from three-phase mains, incorporating an active three-phase PFC front end can contribute significantly in improving overall power factor, reducing line pollution, lowering component stresses and reducing component size(e.g. the filter capacitor). Stationary operational behavior of three-phase/switch/level PWM rectifier was analyzed for asymmetrical loading of the output voltages. Maximum admissible load of the neutral point that is capacitive output voltage center point was calculated.

This topology mentioned known as the VIENNA rectifier and the three-level power structure results in a low blocking voltage stress on the power semiconductors and a small input inductor value and size. Therefore, Vienna is an ideal choice for the implementation of a medium power, unity power factor rectifier that also has a high power density .Three-phase AC to DC diode rectifier with three low-power and low frequency, four quadrant switches, with high power factor was presented . The main features were low cost, small size, high efficiency and simplicity. The high power factor was achieved with three active bidirectional switches rated at a small fraction of the total power, and gated at the line frequency.

2.2 Switch Realiztion Constraints

The ideal SPTT switch can be realized using different combinations of controlled switches and diodes. One of the realizations is the unidirectional topology with reduced count of controlled switches is the Vienna Rectifier.

With assumption of continuous conduction mode (CCM), therein which case the conduction path will flow. To avoid low frequency (lower than the switching frequency) harmonics in line currents, the rectifier phase voltages must be free of low frequency harmonics except for triple harmonics, which may present on the modulation signals to increase the fundamental component without invoking over modulation. Under CCM an important operating constraint can be recognized. If continuous sinusoidal PWM is used, the polarity of the line currents and the polarity of the imposed line to neutral voltage from the switching devices have to be identical. In the past this has been referred to as the pulse polarity consistency rule (PPCR) [8]. Thus on an averaged basis, the line currents have to be in phase with corresponding pole to neutral voltages. Otherwise, low frequency harmonic distortion will occur in both line currents and pole voltages. This requirement is equivalent to the unity power factor at the rectifier poles (*NOT at the source voltages).* On the other hand, under space vector modulation mode the input power factor angle at the rectifier input terminals may lie between (-π/6, π/6[9]. Although this appears to be a drawback, realistic value of input inductors lead to a power factor at the line terminals to be greater than 0.98 for typical cases.

2.3 MOSFET

The metal–oxide–semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) is a type of transistor used for amplifying or switching electronic signals.

Although the MOSFET is a four-terminal device with source (S), gate (G), drain (D), and body (B) terminals ,the body (or substrate) of the MOSFET is often connected to the source terminal, making it a three-terminal device like other field effect transistor. Because these two terminals are normally connected to each other (short-circuited) internally, only three terminals appear in electrical diagrams. The MOSFET is by far the most common transistor in both digital and analog circuits, though the bipolar junction transistor was at one time much more common. The current through the channel

$$i = v/r \qquad (1)$$

Where v is the drain source voltage.

In enhancement mode MOSFETs, a voltage drop across the oxide induces channel between the source and drain contacts *via* the field effect. The term "enhancement mode" refers to the increase of conductivity with increase in oxide field that adds carriers to the channel, also referred to as the *inversion layer*. The channel can contain electrons (called an nMOSFET or nMOS), or holes (called a pMOSFET or pMOS), opposite in type to the substrate, so nMOS is made with a p-type substrate, and pMOS with an n-type substrate . In the less common *depletion mode* MOSFET, detailed later on, the channel consists of carriers in a surface impurity layer of opposite type to the substrate, and conductivity is decreased by application of a field that depletes carriers from this surface layer.

III. MODELLING OF VIENNA RECTIFIER

3.1 Vienna Rectifier Simulation

Using MATLAB the simulation was done and tested for the given specification. There are three stages in Vienna rectifier. Firstly, the single stage was done. Later ,three stages was included.

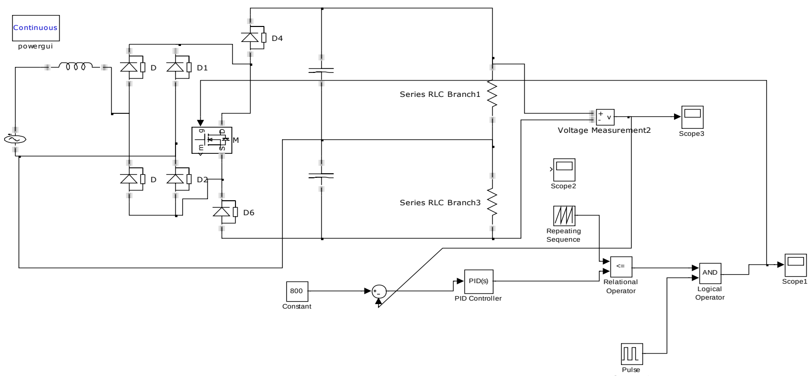

Figure 3.1 Simulation of single stage Vienna rectifier

Here ac voltage is applied and there are six diodes .To track the voltage, the controller is designed. The reference voltage is given as 800v ,so in the output 800v is tracked.

3.2 Simulation for Sinusoidal Change in Input

In this simulation, the same single stage is considered. At the input side, by using of controlled voltage source the change in sinusoidal voltage source is done .Multiply repeating sequence and sinewave source get connected through controlled voltage source.

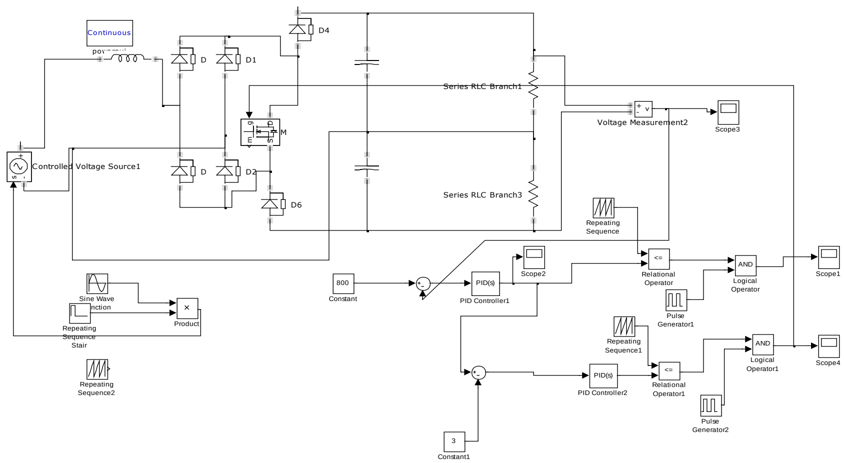

Figure 3.2 Simulation for step change in input.

Here MOSFT act as a switch. In every phase the two switches will conduct. By using voltage measurement in matlab the voltage is measured. The Vienna rectifier consists of three phases.

3.3 Simulation for Step Change in Load

In this simulation is done by either changing the resistance value or resistance is added and voltage value is noted. This simulation is done for single stage.

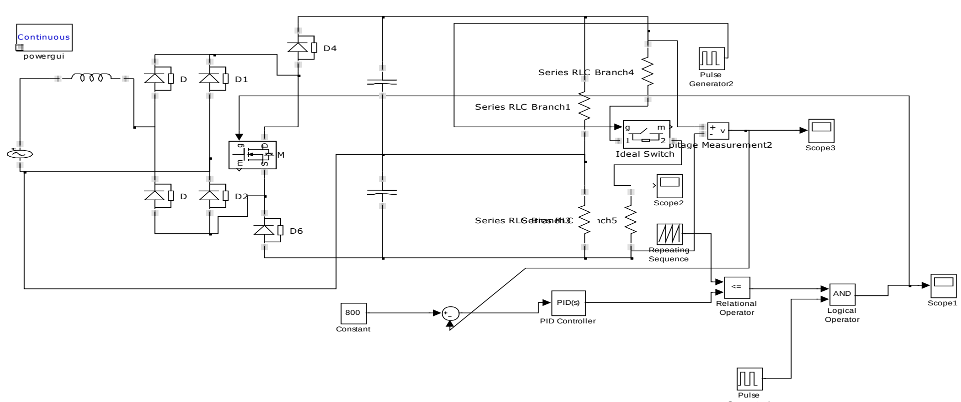

Figure 3.3 Simulation for Step Change In Load

3.4 Simulation for Three Stage Vienna Rectifier

In this stage three phases are considered. Each phase consists of individual switch and diodes. Here PI controller is designed and the switching function takes place.

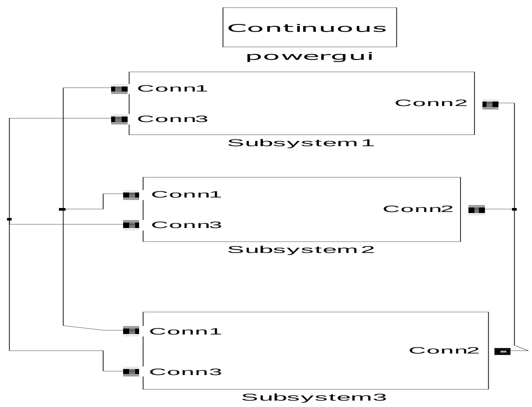

Figure 3.4 Subsystem for Vienna rectifier

Subsystem is created for every phase. I controller is designed for each phase. There are three subsystems in which they are interconnected.

3.5 Simulation for Three Stage Vienna Rectifier

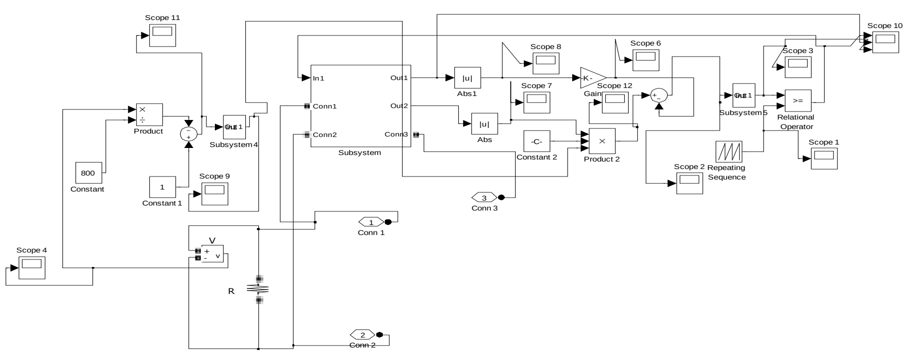

Figure 3.5 Simulation for three stage Vienna rectifier

PI controller values- Kp=.02,ki=2,proportional gain=100

PI controller values- Kp=5,ki=5000,proportional gain=100

3.6 Simulation for Inner System of Vienna Rectifier

In this simulation, voltage is measured by using voltage measurement. By this way, control flow takes place.

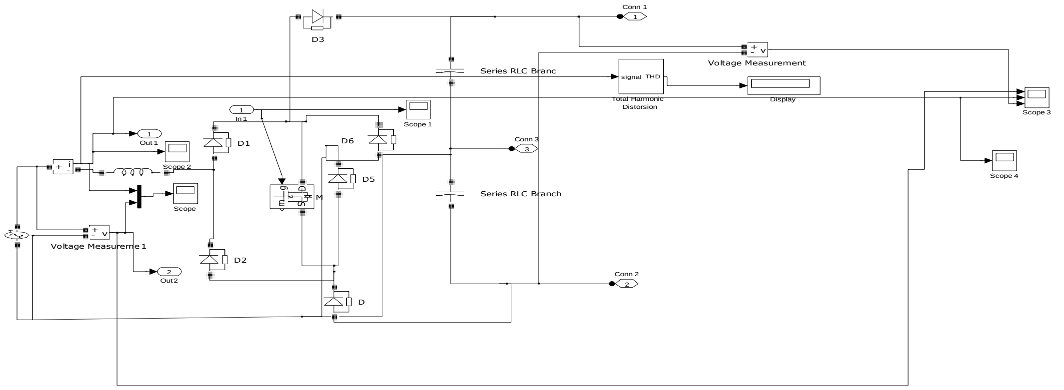

Figure 3.6 Simulation for inner system of vienna rectifier

IV. SIMULATION RESULTS

4.1 Single Stage

RESPONSE

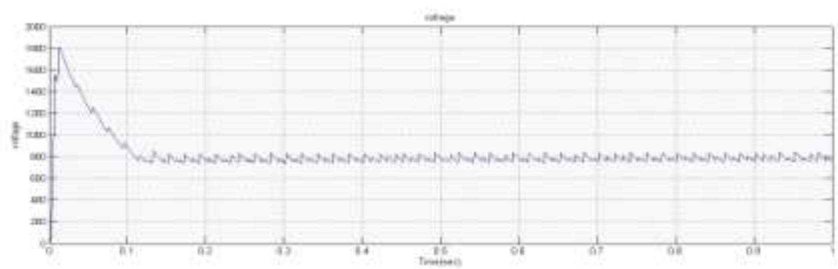

Figure 4.1 Single stage of vienna rectifier for voltage.

The figure 4.1 shows the result of simulation of vienna rectifier in single stage.Reference value is given as 800 ,by making feedback reference to the voltage the control action takes place.The main purpose of controller is whatever value given in the reference same value is going to settle and will be the output.

4.2 Simulation For Vienna Rectifier

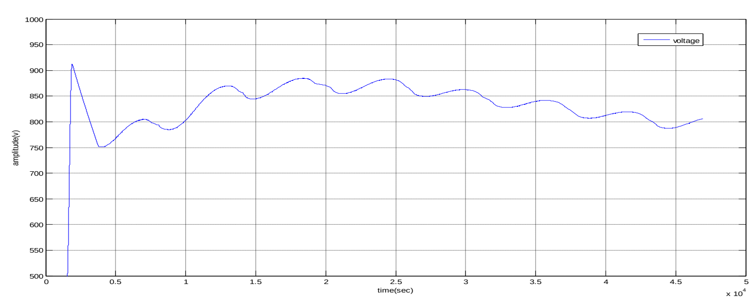

Figure 4.2 Simulation for vienna rectifier

In this simulation,voltage controller is designed.

4.3 Simulation For Three Phase Rectifier(Inner Block)

In this simulation,input and output voltages are analysed.The controller which is designed for voltage of any one phase which will be the input for next two phases.The ac voltage is given as 230 v (peak voltage is 325)

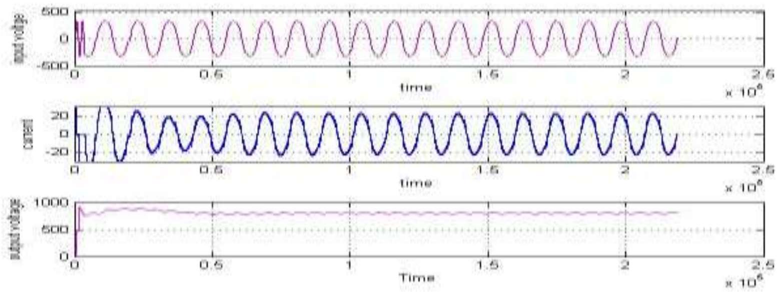

Figure 4.3 Simulation for three phase rectifier

4.4 Simulation Forthree Phase Rectifier(Outer Block)

In this part,simultion is crried out for three phase vienna rectifier

Figure 4.4 Simulation For Three Phase Rectifier

V. CONCLUSION OF THE SIMULATION RESULT

In this operation of Vienna rectifier was developed and the modeling was done. Control strategy is applied to design controller for this rectifier. Using anfis for the same system fuzzy controller was designed error and trained values are manipulated.

VI. SUGGESSIONS FOR FUTURE WORK

In future work, along with the overall hardware testing simulation of Vienna rectifier and simulation also to do in neuro fuzzy. The monitored data are sent serially to a pc for logging data continuously. Finally, it is implemented with the hardware DSPPIC3022.

REFERENCES

1. Hao Chen, Nicholas David, and Dionysios C. Aliprantis," Analysis of Permanent- Magnet Synchronous Generator With Vienna Rectifier for Wind Energy Conversion System" , IEEE Transaction on Sustainable Energy, vol.4, no.1, pp. 154–163,Jan. 2013.

2. Lijun Hang, Ming Zhang, Leon M. Tolbert and Zhengyu Lu,," Feed forward Compensation Method for High-Power-Density Three-Phase Vienna PFC Converter" , IEEE Transaction on Industrial Electronics, vo60, no.4, pp. 1512–1519, Apr. 2013.
3. R. K. Mudi and **N.** R Pal, **"**A Robust Self-Tuning Scheme for PI- and PD Type Fuzzy Controllers", IEEE Tram. On Fuzzy System**,** Vol. 7**,** No. **1,** pp. 2-16, Febpp.18-31**,** 1976.24-32, 1996.pp.79-86, Jm~aty1 997.NO. 1**,** pp. 5-11, January 2004**.**nlary 1999.214