FLEXIBLE HEART IN SMART GRID

H. Shameema Jafreen[1] and V.S. Sowmiya[2]

[1]*Student, Dept of EEE, Anjalai Ammal – Mahalingam Engineering College,TamilNadu,India.*
[2]*Student, Dept of EEE, Anjalai Ammal – Mahalingam Engineering College,TamilNadu,India.*

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Abstract - *The focus of this paper is to design and construct a flexible highly efficient and reliable transformer (HEART) for power exchange between generation and utilization with an advantage of voltage regulation .The emerging technology of power electronic transformer has been innovated, which realizes voltage transformation, galvanic isolation and power quality enhancements in a single unit. The conventional approach is replaced by the power electronics providing fundamentally different and more complete approach in transformer design. The proposed HEART is capable of meeting the future needs of power electronics centralized systems.The proposed converter can achieve very high voltage conversion ratio with high frequency isolation and bidirectional energy flow, thus it can be used as the interface equipment of high voltage and low voltage dc power grid. With the help of IOT, this HEART can be linked with smart grid and it also can be controlled from remote area.*

Key Words**: Power electronics transformer, Closed loop buck converter buck converter, PWM.**

1. INTRODUCTION

The pseudonyms of flexible HEART are 'Intelligent universal transformer' [IUT],'Solid state transformer' [SST], 'Flexible power electronics transformer' [FPET] [1].

Distribution transformer is the most important and common equipment in power distribution network, which is mainly responsible for voltage transformation, isolation and noise decoupling .The traditional power transformer reliably operates and has high efficiency, but it also has the following short- comings.

- They are proportionately bigger in size.
- Environmental pollution due contaminated transformer oil.
- The unwanted generation of harmonics component will takes place, when the core gets saturated. This results in the phenomenon of excitation inrush current.
- The relaying protection circuits are required.
- The isolation between harmonics current and three phase unbalance is not possible.

These disadvantages are becoming increasingly important as power quality becomes a major concern. In this case power electronic based transformer is a good option for solving the above mentioned issues. The topology of HEART has been developed in such a way that it grasp major attention due to their merits such as high frequency link transformation and flexible regulation of voltage and power.

The HEART can be expanded according to the need of application. As the design of HEART is based on power electronics, it is expandable according to the need of application. This feature justifies the name FLEXIBLE HEART [6].

2. PROPOSED STRUCTURE

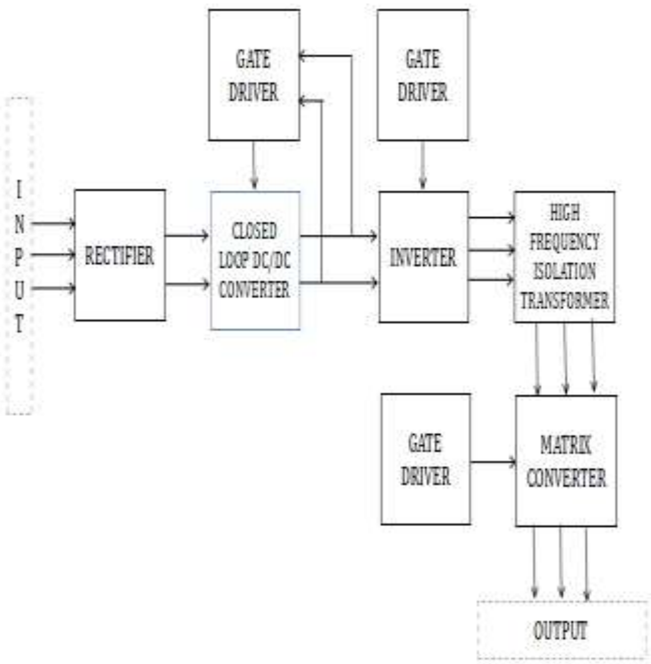


Fig.-1: Block diagram of proposed system

HEART is a new types of device, in which transfer of energy is employed using power electronic devices. It is mainly comprised of power electronic converter and high frequency isolation transformer. Firstly, input rectifier converts power frequency alternating current(ac) to direct current (dc).

Secondly, the buck converter is employed for stepping down the voltage which is suitable for distribution purpose. Next, the direct current is converted to high frequency alternating current with the help of inverter. Now, the output of inverter is fed to the matrix converter through high frequency isolation transformer.

The reason for employing high frequency is to reduce volume and weight of the isolation transformer and to improve its efficiency. Finally, the required output can be obtained from matrix converter by varying the firing scheme of control circuit. The matrix converter is designed in such a way that, it can be able to give the output of either ac or dc.

3. AC TO DC CONVERTER

The line commutated ac to dc power converter are the controlled rectifiers used to obtain variable dc output from fixed voltage fixed frequency ac power supply. The phase controlled thyristors are employed in which the delay angle of thyristors is controlled to obtain variable dc output voltage and variable dc output current.

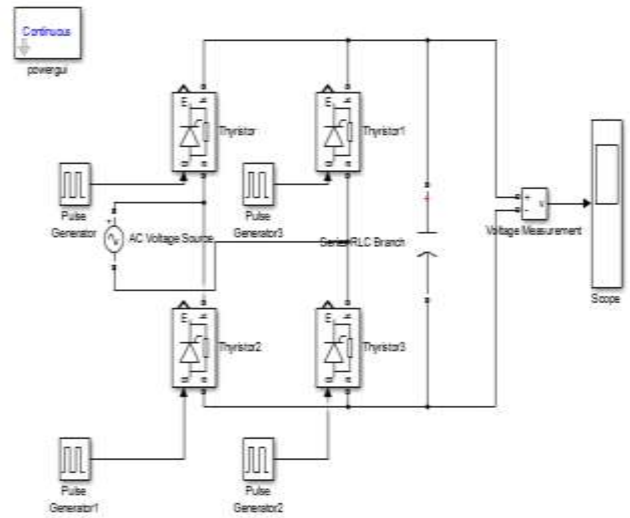


Fig.-2: Configuration of rectifier

3.1 HARDWARE OF AC TO DC CONVERTER

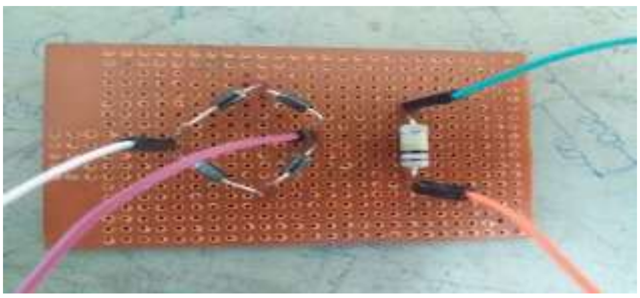


Fig.-3: Hardware of rectifier

4. BUCK CONVERTER

The buck converter is one of the class of switched mode power supply. This is the DC to DC converter that steps down the voltage from the input to the output. The basic configuration of buck converter consists of minimum of two semiconductor devices and one energy storage element either inductor or capacitor. The filters circuits are added to reduce the ripples in the output voltage.

The open loop buck converter has simple design with no feedback. The output voltage is decided by the switching frequency of MOSFET and the duty cycle. When the pulse is high the current flows through the switching device, storage element and thereby completes the circuit through DC input. During the OFF time i.e. when the switch is open the stored energy in the inductor will be free wheeled through capacitor and diode. Thus it is possible to obtain continuous conduction mode operation.

In proposed system buck converter with closed loop control system is incorporated. The important application of closed loop implementation of step down converter is to achieve better voltage regulation and better performance and this is the major advantage of flexible HEART.

The output of buck converter is sensed and given as input to the aurdino. The aurdino will compare this output voltage with the standard reference voltage and generates the PWM output according to the error voltage.

4.1 CIRCUIT DIAGRAM

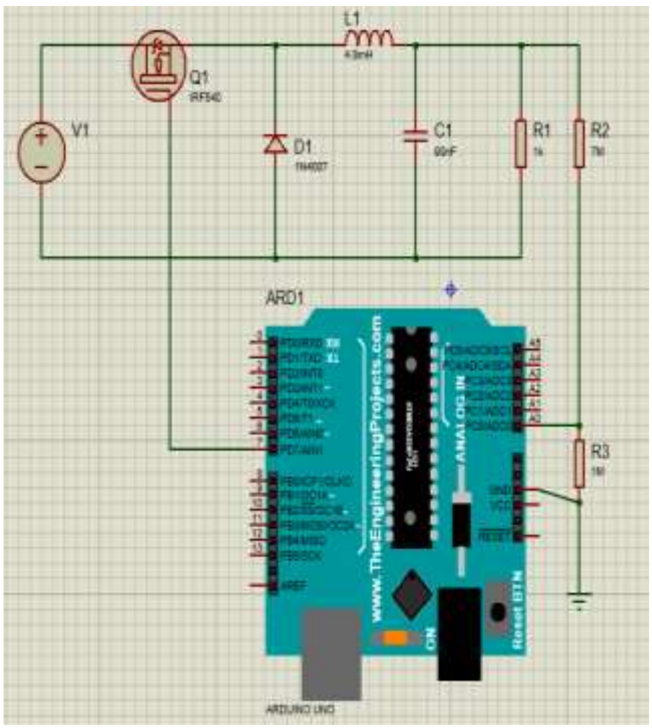


Fig.-4: Configuration of buck converter

4.2 HARDWARE IMPLEMENTATION OF BUCK CONVERTER

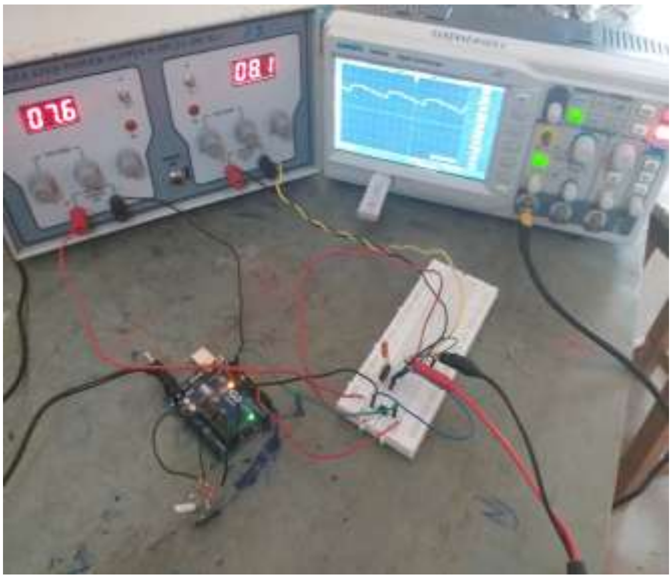


Fig.-5: Hardware of buck converter

5. INVERTER CONFIGURATION

This is the simple and basic configuration of single phase inverter which can convert DC voltage to AC voltage at high efficiency and low cost. The traditional control method is replaced by the use of microcontroller. This makes it simple and cost effective. The microcontroller used in this project is PIC16f877a.The transformation from high voltage DC to sinusoidal AC waveform using pulse width modulation. The conversion of the high DC source to an AC waveform using pulse width modulation. The development of microcontroller technology have made it advantageous in performing the functions that were yearly done by analog electronic components such as analog to digital converter, comparator, pulse generator and also reduces the number of components needed.

The another advantage is the flexibility in design due to capability of flash programing. Advances in microcontroller technology have made it possible to perform functions that were previously done by analog electronic components. With multitasking capability, micro controllers today are able to perform functions like comparator, analog to digital conversion (ADC), setting input/output (I/O), counters/timer, among others replacing dedicated analog components for each specified tasks, greatly reducing number of component in circuit and thus, lowering component production cost. Flexibility in the design has also been introduced by using microcontroller with capability of flash programming/reprogramming of tasks [3].

5.1 CIRCUIT DIAGRAM

The following shows the overall block diagram of inverter circuit.

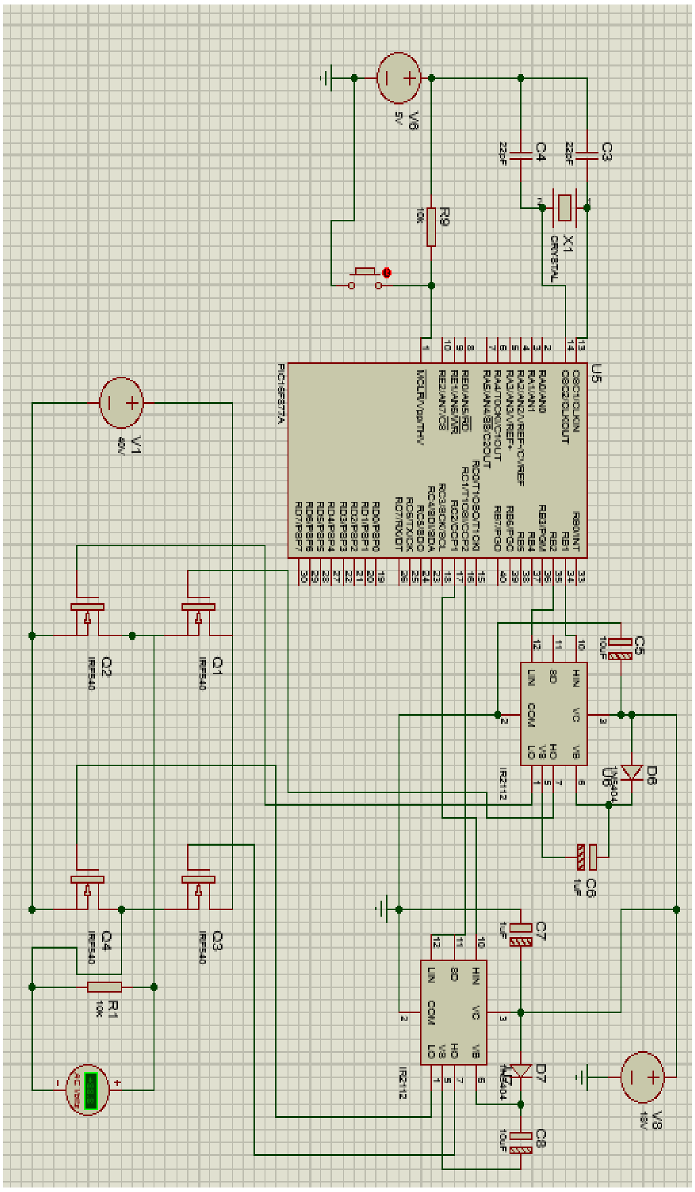


Fig.-6: Configuration of inverter

6. MATRIX CONVERTER

The converter which performs single stage of convertion from AC to AC is known as matrix converter. In other words fixed AC voltage to variable AC voltage and frequency without a large storage element[3]. This is also termed as universal converter where AC-AC, AC-DC, DC-AC convertion topologies can be achieved[1].The lack of DC links ensures it has a compact design. In addition to this, it uses bidirectional switches which make it achievable to have a controllable power factor input.

This converter makes the HEART more advantageous because of its capacity to regenerates the energy back to the utility and controllable input current displacement factor. It has the ability to reduce the need of energy storing elements used in both rectifier and inverter system.

The three major methods for the control of matrix converter are as follows.

- Pulse width modulation
- Space vector modulation
- Venturi-analysis of transfer function

This paper focuses on the pulse width modulation technique for the control of matrix converter.

The matrix converter consists of two fully controlled bridge circuit, where each bridge has 4 MOSFET, and each bridge is connected in opposite direction (back to back).

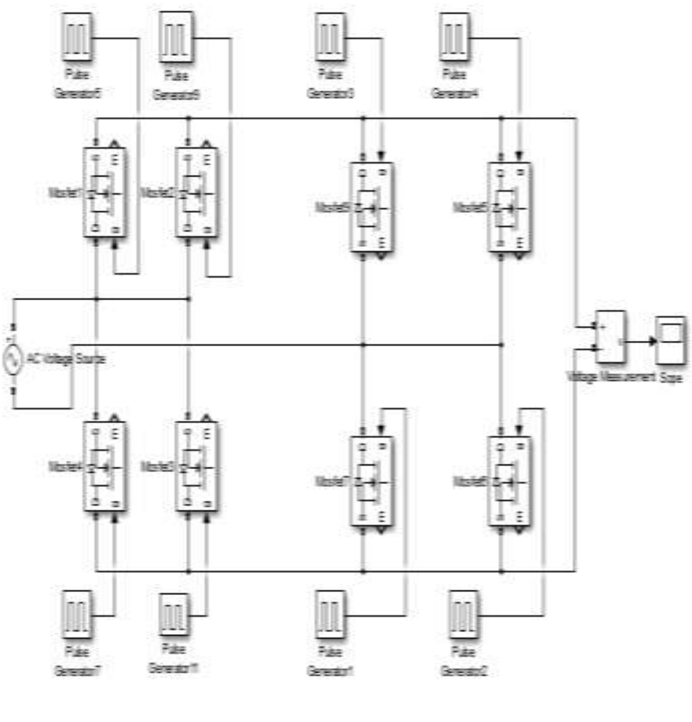


Fig.-7: Configuration of matrix converter

During positive half cycle of the input voltage, positive converter is turned ON and it supplies the load current. During negative half cycle of the input, negative converter is turned ON and it supplies load current. If both converters are turned ON, it will lead to short circuit at the input.

By varying the switching period of MOSFET, the time periods of both positive and negative half cycles are changed and hence the frequency.

7. SIMULATION MODEL AND RESULT:

In order to predict the performance of HEART, the proposed design was simulated in steady state condition. The simulation is done for a input of 12kV and it is step down to 6kV which is output of HEART.

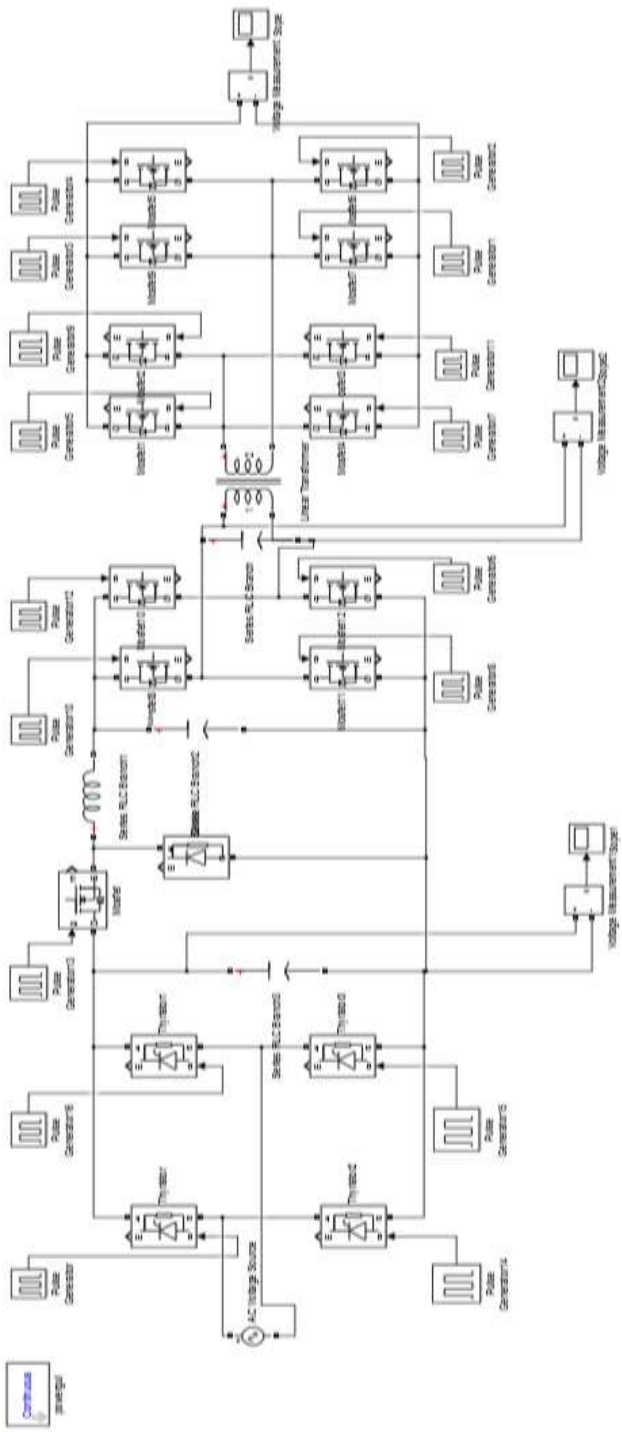


Fig.-8: Proposed structure of HEART

The output of rectifier, buck converter, inverter and matrix converter units are shown in following figures.

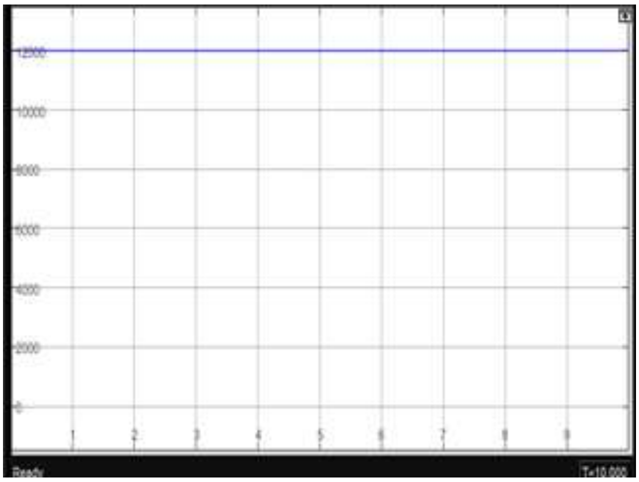


Fig.-9: Output voltage of rectifier

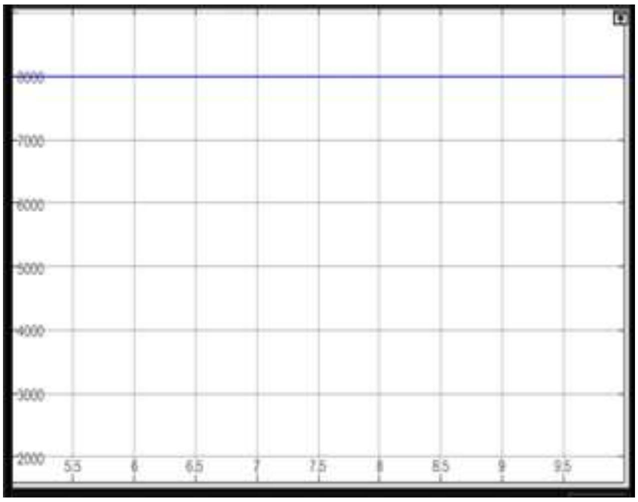


Fig.-10: Output voltage of buck converter

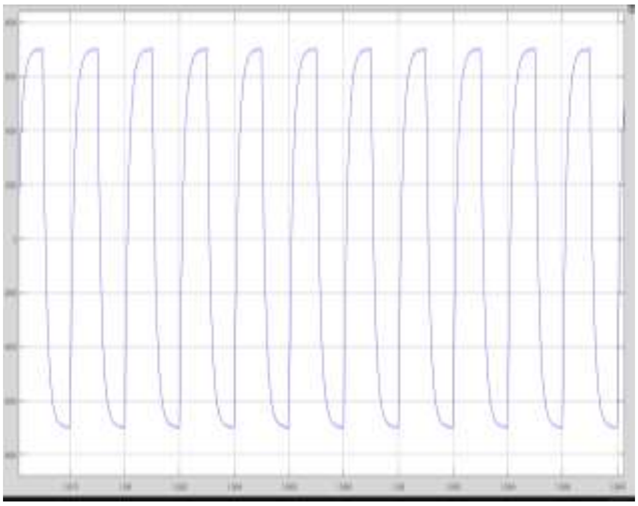
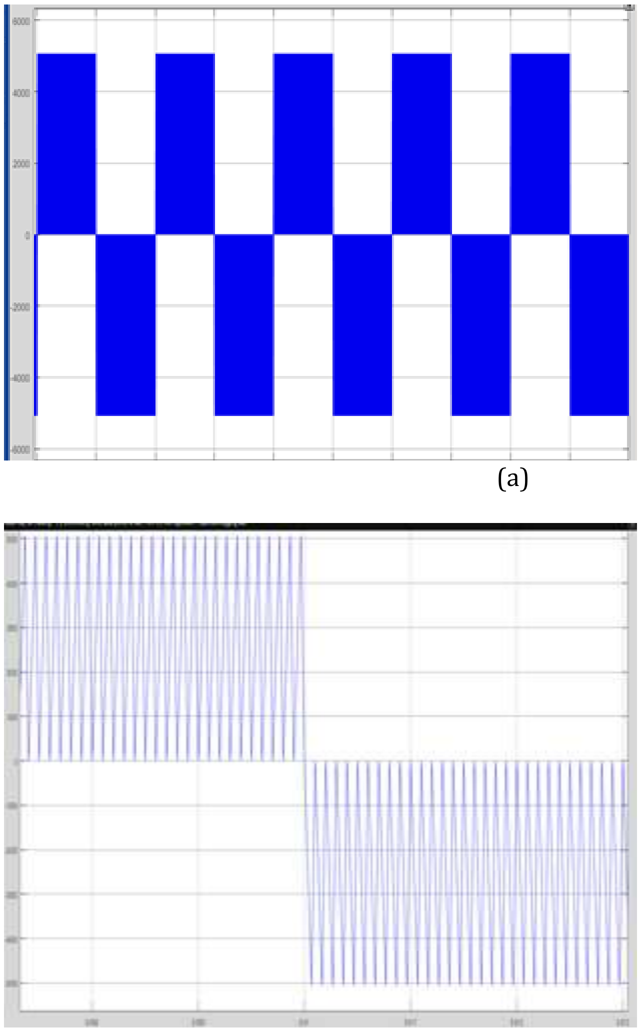


Fig.-11: Output voltage of Inverter



(a)

(b)

Fig.-12: Output voltage of matrix converter

Table-1

S.No	Parameters	Value
1	Input AC supply voltage	12Kv
2	Input supply frequency	50Hz
3	Output DC voltage of rectifier	12kV
4	Switching frequency of buck converter	2kHz
5	Output voltage of buck converter	8kV
4	Output AC voltage of inverter	7kV
5	Output frequency of inverter	5kHz
6	Output voltage of matrix converter	6kV
7	Output frequency of matrix converter	50Hz

8. HARDWARE CONFIGURATION:

Fig.-13: Hardware configuration of proposed structure

9. CONCLUSION:

The design and construction of HEART and its control methods are focused on this paper. The main advantage of this paper is, even though the load fluctuation occurs the HEART can maintain a constant output voltage i.e., voltage regulation. The matrix converter which is used in the secondary part, eliminates the effect of harmonics additionally improving the efficiency. A prototype of 12kV/6kV is simulated in MATLAB/SIMULINK and the simulation result shows that the proposed system can step down the voltage in a efficient manner.

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