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SIMULATION OF SOLAR BASED INDUCTION HEATING SYSTEM.

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Abstract— Induction heating system use electricity for the generation of heat, where solar energy is largely available energy for generation of heat. Combining solar energy with induction heat generation technique is the efficient solution for the heat generation application. Resonant converters featuring soft switching are commonly used in domestic induction heating applications due to their high efficiency and high power density. The design and implementation procedure of an improved efficiency and low profile resonant inverter for induction heating applications is presented. By using automotive-grade MOSFET devices, reducing conduction losses against the classical IGBT-based converter. In addition to this, the reduced switching times of MOSFET devices decrease switching losses, further increasing the conversion efficiency. The proposed system presents an effective control scheme incorporated in class E resonance induction heating by using solar energy. Pulse width modulation technology is used for charging the battery from photovoltaic array. The principle of induction cooker is based on heating the metallic pan with circulating eddy currents induced by high frequency AC magnetic field. The coil within the induction cooker and the load (pan / pot) acts as a transformer if the load has an electrically conducting base. If the conducting base is ferromagnetic, then the power is transferred with high efficiency.

Key words**:** Voltage Source Converters, Solar Photovoltaic Arrays, DC-DC Converters, Maximum power point tracking. Current source converter,.

I. INTRODUCTION

One of the most serious problems that we are witness is the increasing cost and scarcity of cooking gas. An alternate method is to use electricity for the purpose. But the extensive upsurge in the price of electricity and the lack of availability of large amount of electricity forces us to think about yet another alternative. On the other hand solar energy is the largely available source which we can use for cooking but this energy is not available 24 hours so it is not possible to use it in the night. So this energy has to be stored in the battery. This stored energy can be use to produce the electricity and further for induction heating.

Induction cooking is the highly efficient technique for the cooking purpose, when it combines with solar system it will provide the future solution for the cooking technology. Although solar based cooking may have high initial cost, but over a long term it is cost effective solution. Induction heating is a well known technique to produce very high temperature such as in melting steel. The technique requires high frequency current supply that enables to induce high frequency eddy current circulating in the target object[1].

The most popular types of electric heating can be classified mainly into two types. First one is resistance heating and second one is induction heating. Resistance heating has the advantages of low cost and easy maintains but, the disadvantage is its low efficiency. Considering induction heating, an inverter topology supplies a high frequency current to an induction coil, producing an alternating magnetic field. If this field is applied to a ferromagnetic pan, it produces eddy currents, and magnetic hysteresis, which heat up the pan. Recently, domestic induction hobs have become increasingly popular owing to their specifications such as quick warming, energy saving and high efficiency.

In general, two methods are used to generate high frequency current namely hard switching and soft switching technique. Hard switching has disadvantage of the higher power frequency in the LC circuit and it produces positive cycle as switching losses in the switching devices. Using power MOSFET can solve this problem [7]. Soft switching or sometime called resonant technique reduce those switching losses. However, it requires devices with low on state power losses. So MOSFET is preferred for switching operation.

II. MODELING OF PV CELL

The photovoltaic system converts sunlight directly to electricity without having any disastrous effect on our environment. The basic segment of PV array is PV cell, which is just a simple p-n junction device. The manifests the equivalent circuit of PV cell. Equivalent circuit has a current source (photocurrent), a diode parallel to it, a resistor in series describing an internal resistance to the flow of current and a shunt resistance which expresses a leakage current. The current supplied to the load can be given as.

$$I = I_{PV} - I_O \left[exp\left(\frac{V+IR_S}{aV_T}\right) - 1\right] - \left(\frac{V+IR_S}{R_P}\right)$$

Where,

I_{PV}-Photocurrent current,

I_O-diode's Reverse saturation current,

V-Voltage across the diode,

α-Ideality factor

V_T-Thermal voltage

R_S-Series resistance

R_P-Shunt resistance

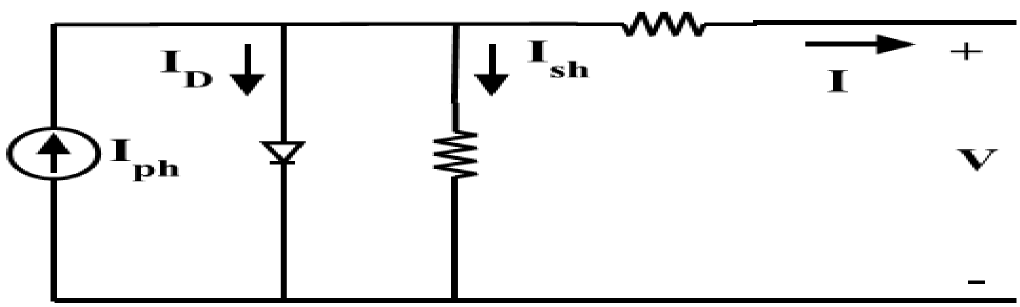

Fig. 1. Equivalent circuit of Single diode modal of a solar cell

PV cell photocurrent, which depends on the radiation and temperature, can be expressed as.

$$I_{PV} = \left(I_{PV\_STC} + K_l\, \Delta T\right)\frac{G}{G_{STC}}$$

Where,

K_l-cell's short circuit current temperature coefficient

G-solar irradiation in W/m2

G_{STC}-nominal solar irradiation in W/m2

I_{PV_STC}-Light generated current under standard test condition

The reverse saturation current varies as a cubic function of temperature, which is represented as

$$I_o = I_{o\_STC}\left(\frac{T_{STC}}{T}\right) exp\left[\frac{qE_g}{aK}\left(\frac{1}{T_{STC}} - \frac{1}{T}\right)\right]$$

Where,

I_{o_STC}-Nominal saturation current

E_g-Energy band gap of semiconductor

T_{STC}-temperature at standard test condition

q-charge of electrons

The reverse saturation current can be further improved as a function of temperature as follows

$$I_o = \frac{I_{SC\_STC} + K_l \Delta T}{exp\left[\left(\frac{V_{OC\_STC} + K_v \Delta T}{aV_T}\right)\right] - 1}$$

Where ,

I_{SC_STC}-short circuit current at standard test condition

V_{OC_STC}-short circuit voltage at standard test condition

K_V-temperature coefficient of open circuit voltage

Efficiency of a PV cell does not depend on the variation in the shunt resistance Rp of the cell but efficiency of a PV cell greatly depends on the variation in series resistance Rs .

As Rp of the cell is inversely proportional to the shunt leakage current to ground so it can be assumed to be very large value for a very small leakage current to ground. As the total power generated by a single PV cell is very low, we used a combination of PV cells to fulfill our desired requirement. This grid of PV cells is knows as PV array. The equations of the PV array can be represented as.

$$I = I_{PV}N_P - I_O N_P\left[exp\left(\frac{V + IR_S\left(\frac{N_S}{N_P}\right)}{aV_T N_S}\right) - 1\right]$$

Where,

N_S-Number of series cells

N_P-Number of parallel cells

The two key parameters which are used to relate the electrical performance are the open-circuit voltage of the cell VOC and short-circuit current of the cell Isc.

The maximum power can be stated as $P_{max} = V_{max} I_{max}$

III. SIMULATION AND RESULT

The simulation results are analyzed at different instances. The I-Y curves of the SPY are furnished in where we can observe the solar irradiance level at $1000 wb/m^2$ and the cell temperature at 50^0 c.

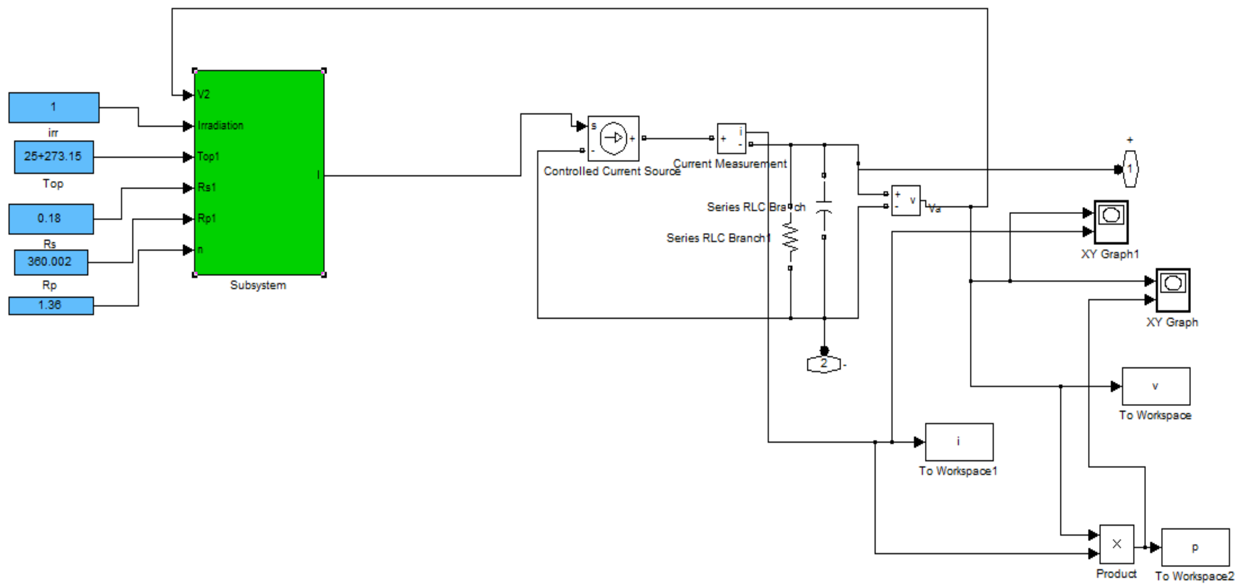

Fig 2.Simulation Model of PV cell at 25^0 c and $1000wb/m^2$

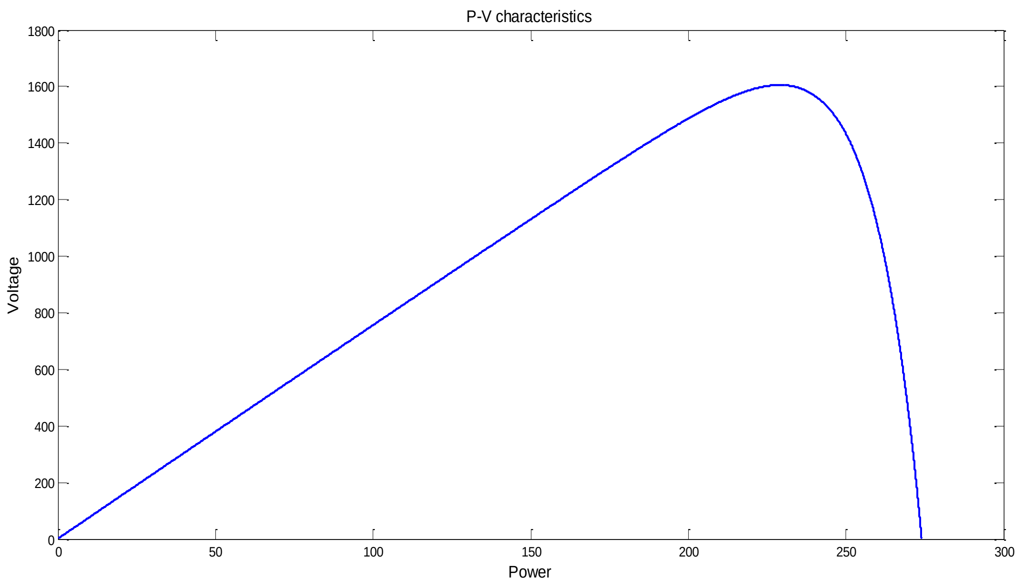

Fig 3. P-V Curve at 25^0 c and $1000wb/m^2$

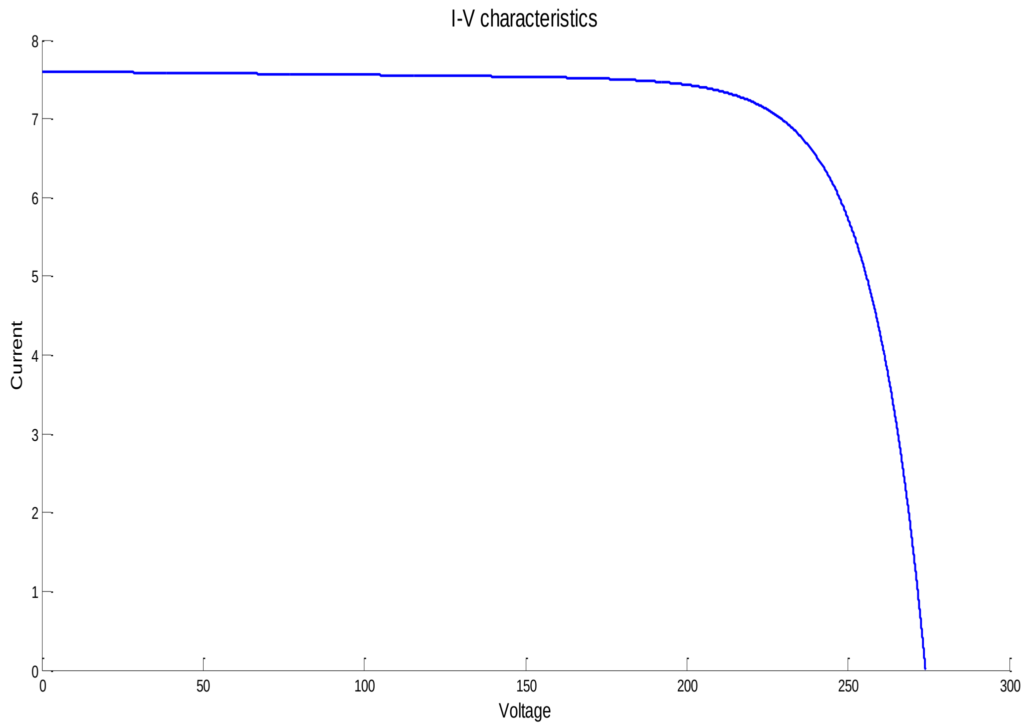

Fig 4. I-V Curve at 25^0 c and $1000wb/m^2$

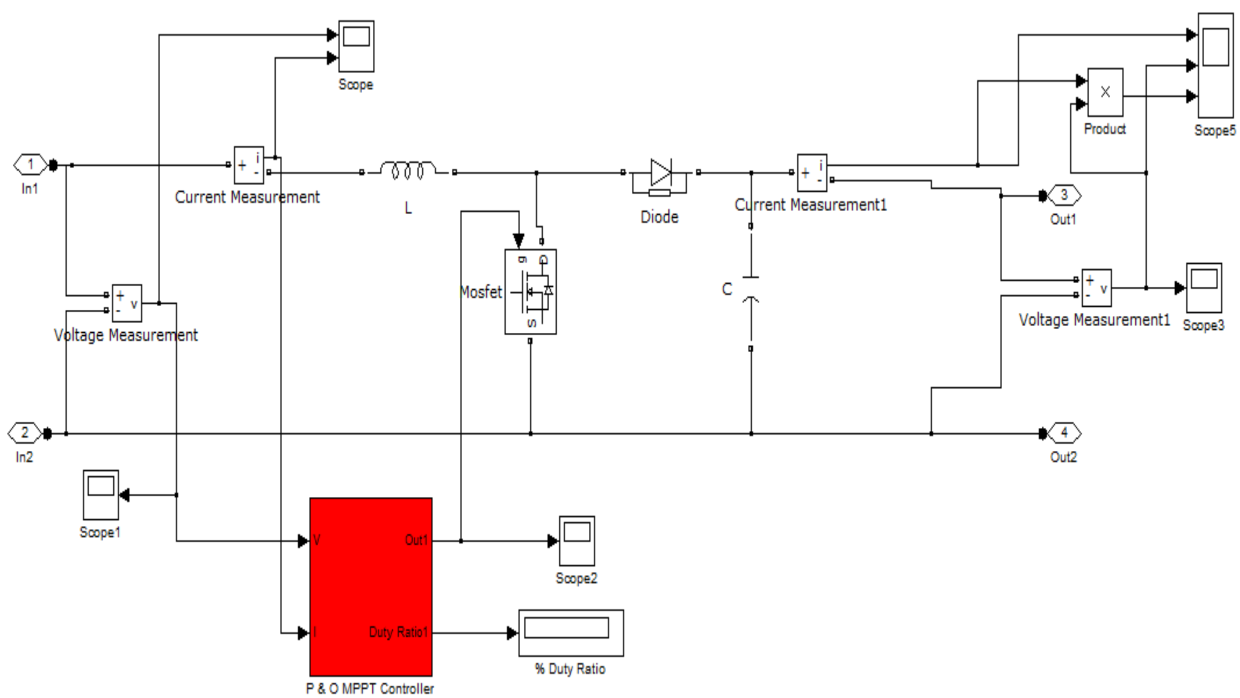

Fig 5. Simulation Model PV cell with Boost DC-DC converter

A.Open Loop Push Pull DC-DC Converter Output Voltage and Current in MATLAB

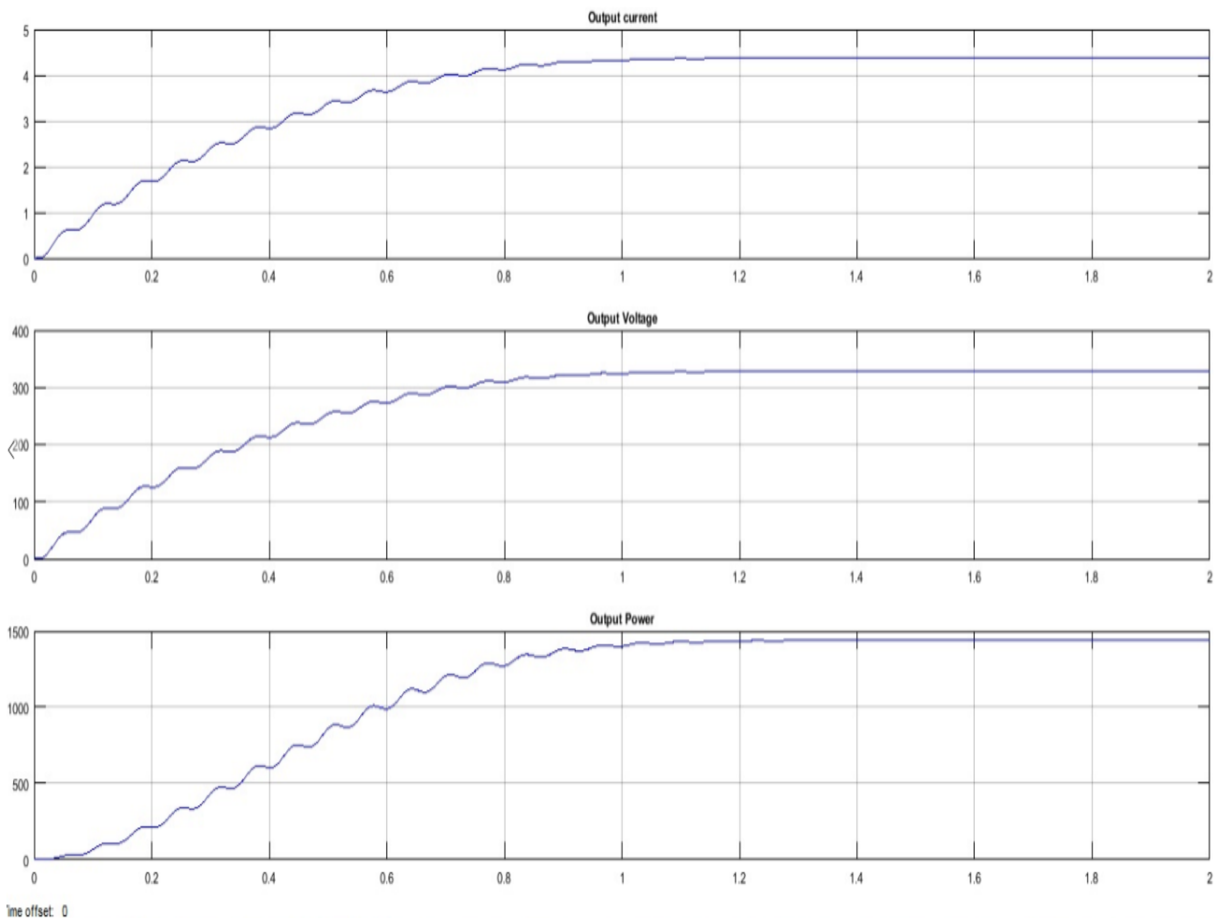

Fig 8. Output Voltage and Current of Push Pull DC-DC converter

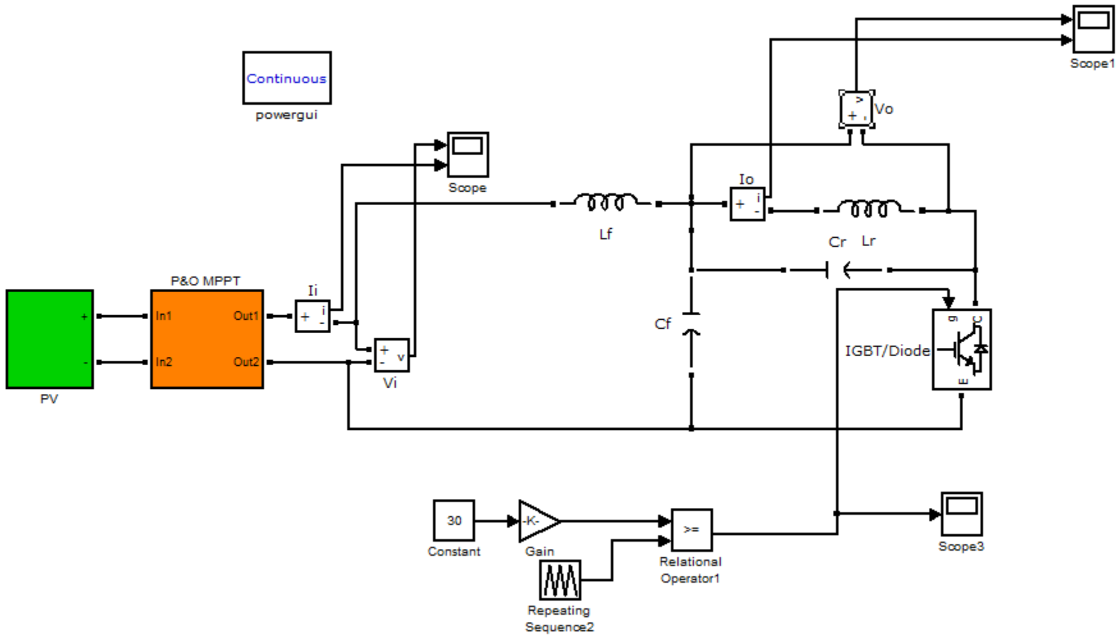

Fig 9 simulation of pv with resonant inverter

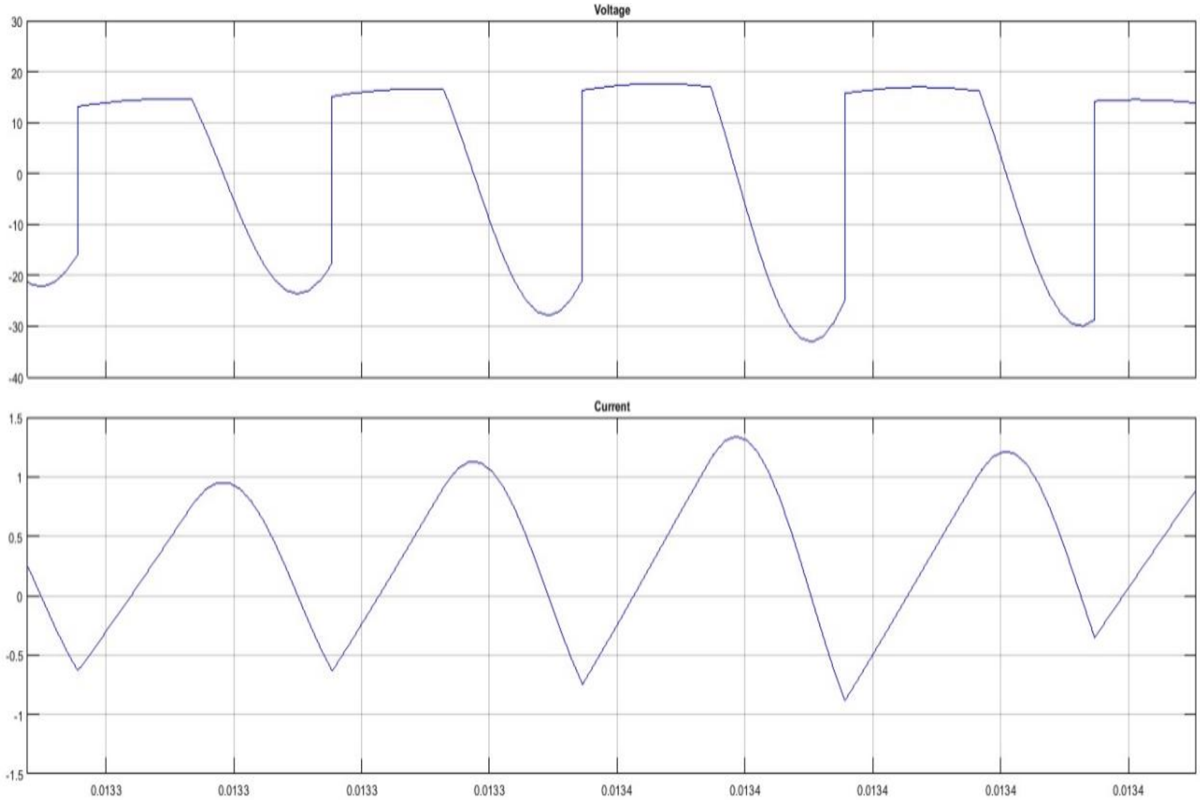

Fig 9 output of resonant inverter

IV. CONCLUSION

By literature review and simulation we can conclude about various control strategy of induction heating also different high frequency inverter for the heating purpose and give the results of PV with boost converter with maximum power point tracking and also the simulation of Class E resonant inverter. The proposed system can be extended to higher power rating and used for commercial heating applications such as water heating for industrial purpose, for food cooking in hotels as well as in households.

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