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High Power Density Parallel Resonant Inverter Using Bridgeless Boost Rectifier and Switched Capacitor Cell for Induction Heating

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Abstract:
Objectives:*This papershows a topologyabout voltage fed high frequency parallel load resonant inverter and an auxiliary switched cell for induction heating. The voltage gain is increased and losses are reduced in the system from minimum voltage source.*
Method/Statistical Analysis*: The operation based upon the Bridgeless boost rectifier and PWM technique. Bridgeless converter is used to increase the voltage compare to other conventional bridge rectifier*
Findings: *The Parallel resonant converter proposed here for the process of high frequency conversion without any bridge rectifier, it reduces the relevant losses in conduction power. Power factor correction can be naturally achieved by the inductor based bridgeless boost rectifier. The characteristics are shown in simulation operation.Simulation is done by MATLAB and waveform is obtained in the software.*
Application: *Inductionstove, Waterheater, defrosting, induction cooker.*
Keywords*—High frequency (HF)-pulse width modulation (PWM)-power factor correction (PFC)-induction heating (IH)-switched capacitor (SC)*

I. Introduction:

In power electronics,IH plays a major role in industry and home applications.IH depends on electromagnetic induction , skin effect and principle of heat transfer. The current flows in a conductor reverse the magnetic field produced in a conductor leads to IH. It as high thermal efficiency, low resistance in conductor and high permeability with the help of soft switching and high frequency[1,2,3,4]. Now is getting in to new research and development for high efficiency and reduced cost to obtain power conservation[5,6,7].

In IH applications high efficiency and high power factor are demands to produce power conservations. To improve efficiency with a cost effective, the bridgeless converter is proposed[8,9].It shown in Figure 1.

Bridgeless converter is used to increase the voltage compare to other conventional bridge rectifier. The Ac voltage is converted to boost DC voltage, the additional boost converter is not needed for increase in voltage The switch components are implemented in circuit to produced high switching frequency for IH .In IH parallel resonant inverter is implemented to increase it power and efficiency[12,13] In parallel resonance inverter circuit capacitor charging and discharging period are faster compare to series resonance inverter[14,15].The switched capacitor(SC) is used to increase conduction period of capacitor. The capacitor discharging is providing additional voltage to the circuit.

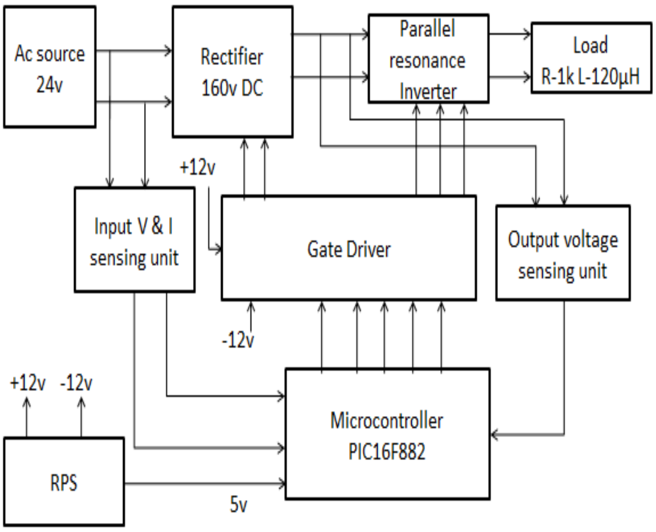

Figure 1. Block Diagram For Proposed System

II. Proposed Converter and operations:

2.1)Circuit Configuration:

The main circuit diagram of proposed circuit in Figure 2. The input AC voltage V_s , and switches Q1 and Q2 comprise the rectifier circuit for voltage boost regulator.D1 and D2 are diode,C1 capacitor parallel to the source.L1 inductor connected between the two switches of bridgeless converter. The BBR converter produced DC output flows to inverter circuit across the Q3 and Q4 switches .It flows to the load resistor R1 and inductor L1,the capacitor C2,C3 are acted as parallel capacitor to the load.Q5 switch connected parallel to the C4 capacitor it creates resonance in capacitor.R1 and L2 are effective resistance and inductor of IH coil.Notation of component shown in Table 1 .

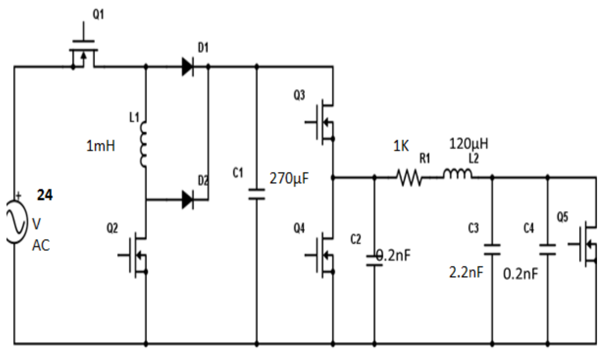

Figure2 . Circuit Diagram For High Power Density Parallel Resonant Inverter Bridgeless Boost Rectifier And Switched Capacitor Cell For Induction Heating

Table 1. Parameters Of Circuit

BLOCK	INDICATION	DESCRIPTION
BRIDGELESS RECTIFIER	Q1(IRF260)	SWITCH1
	Q2(IRF260)	SWITCH2
	D1(SCHOTTKY20/200)	DIODE1
	D2(SCHOTTKY20/200)	DIODE2
	L1(1mH)	INDUCTOR1
	C1(270µF)	CAPACITOR1
INVERTER	Q3(IRF260)	SWITCH3
	Q4(IRF260)	SWITCH4
	Q5(IRF260)	SWITCHED CAPACITOR
	C2(0.2nF)	CAPACITOR2
	C3(2.2nF)	CAPACITOR3

	C4(0.2nF)	CAPACITOR4
	R1(1K)	RESISTOR1
	L2(120µH)	INDUCTOR2

2.2) Modes Of Operation:

In bridgeless converter and parallel inverter obtained two modes of operation, the charging and discharging of capacitor and inductor play a major role in operation. It contain two modes of operation.

MODE 1:

In this mode the rectifier and inverter are conducted in positive cycle.Q1 is ON, Q2 is OFF in a rectifier , the current flows through the Q1,D1.L1 is charging in a mode,mode circuit diagram shown in Figure 3 .In inverter side Q3 and switched capacitor Q5 is ON. The current flows to R1,L2 ,the other capacitor C3,C4,C2 is charging condition.

$$V_S = j\omega C_r \int I_1\, dt \qquad - (1)$$

$$V_0 = j\omega C_r \int (I_1 - I_2)dt - j\omega C_i \int I_2 dt \qquad - (2)$$

Where,

$C_r = C_1 + C_2$, total rectifier side capacitor

$C_i = C_3 + C_4$, total inverter side capacitor

V_S =source voltage

V_0 =load voltage across R0, L2

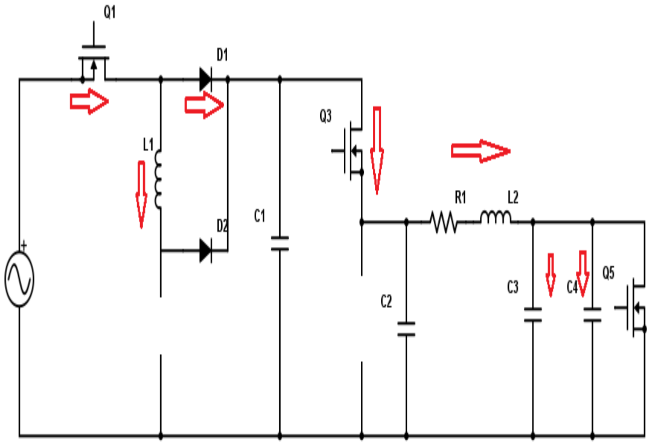

Figure3. Mode of Transition During Positive Polarity Cycle

MODE 2

The negative half cycle, the Q2 is ON ,the current flows to D2 from inductor L1 and it flows to capacitor. The capacitor C1 is discharging ,Q2 is turned ON all the capacitor in a inverter starts discharging, flows to R1and L2.The continuous flows obtained in load.mode circuit diagram shown in Figure 4 .

$$V_0 = (C_3 + C_4) \int I_3\, dt \qquad - (3)$$

Where,

C_4 =switched capacitor

V_0 = load voltage across R0, L2

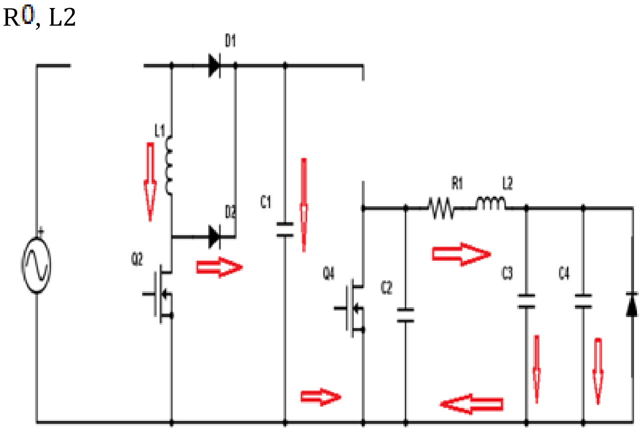

Figure4. Mode of Transition During Negative Polarity Cycle

III. Simulation Parameter

A) Design parameter:

V_s is the input ac supply is given as 24 volts to the bridgeless rectifier. The switching frequency of the inverter is given as the reciprocal of total time period given to the pulses is 20 kHz .The resonant frequency has determined the maximum output voltage and current has produced under resonating conditions. The power is obtained with switching of converter. The bridgeless rectifier output voltage is 150v.

$$P_{SW}=\frac{1}{2} V I (t_{ON}+ t_{OFF}) \qquad - (4)$$

The switches used for the proposed inverter are the MOSFET switches which are relatively low in cost and also suitable for high power applications. The dc blocking capacitor is used as a filter which is used to reduce the harmonics distortions. The dc voltage is applied to the inverter switch Q3 and Q4,the parallel inverter load voltage of 150v ac obtained and load current of 0.1A .The power is obtained in load is 5.5 watts for 24input voltage. The power factor is obtained 0.84.

The open-loop circuit is as shown in Figure5 . By using PWM the system frequency can be adjusted close to the resonant frequency. The maximum output power produced is 5.5 watts. The AC input voltage waveform is shown in the Figure 5b, input voltage waveform of the inverter is shown in Figure 5a, the switching pulse for the switches Q1,Q2 are shown in Figure 5e,output voltage of the inverter is as shown in Figure 5c,

B) Simulation Model:

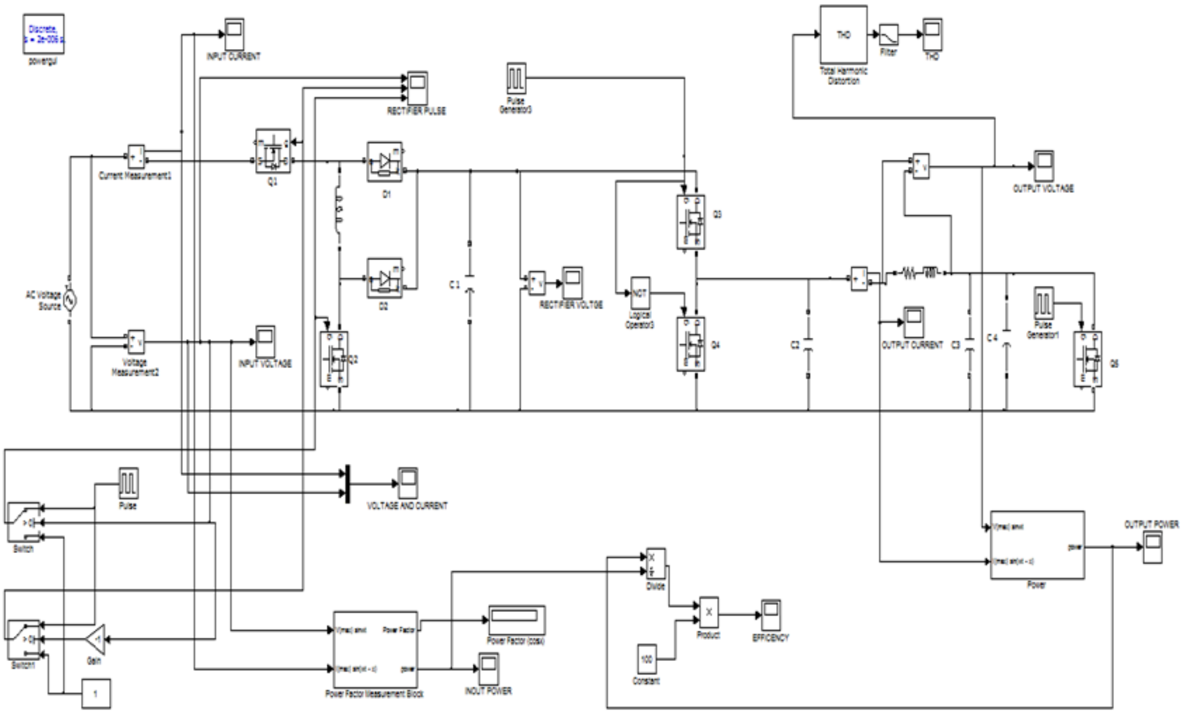

Figure 5. Matlab Simulation Mode

Output current of the inverter is as shown in the Figure5d , output power of the inverter is as shown in fig. The input voltage of the rectifier is a single phase AC voltage source which is given as 24 volts The Input voltage of the inverter is fed from the output of the rectifier and it is given as 160 volts. The output voltage of the inverter is obtained as160 volts for the open loop system. The output current of the inverter is obtained as 0.1 amps for the open loop. The MOSFET switches are fixed according to the pulse pattern generated using pulse density modulation for the switches Q1 ,Q2 as shown .The output power of the inverter is obtained as 5.5 watts for the open loop system.

The pulse are generated using pulse generated using PWM techniques. The pulse width 80% is given with period of 2.5ms. Inverter output voltage is obtained across the load of resistor and inductor R1,L2. The load are the induction coil or induction load.The pwm technique produce the high switching frequency of 20 KHZ .Parallel resonance inverter is controlled by three switch Q3,Q4,Q5.Q5 is a switch used for capacitor C4 to discharge flow to resonant converter. The power is obtained 5.5 wats in output.The total 0.84 value. Compare to series resonance inverter ,power factor is more in parallel resonance inverter.

PFC operation based on PWM scheme is helps to achieve, capacitor should be small enough to frequency parameter is greater than the utility frequency it results produce low distortion in current.In figure 5f is the output load power.The frequency distortions shown as THD figure 5g.Efficecncy is shown in based on power in figure 5h.

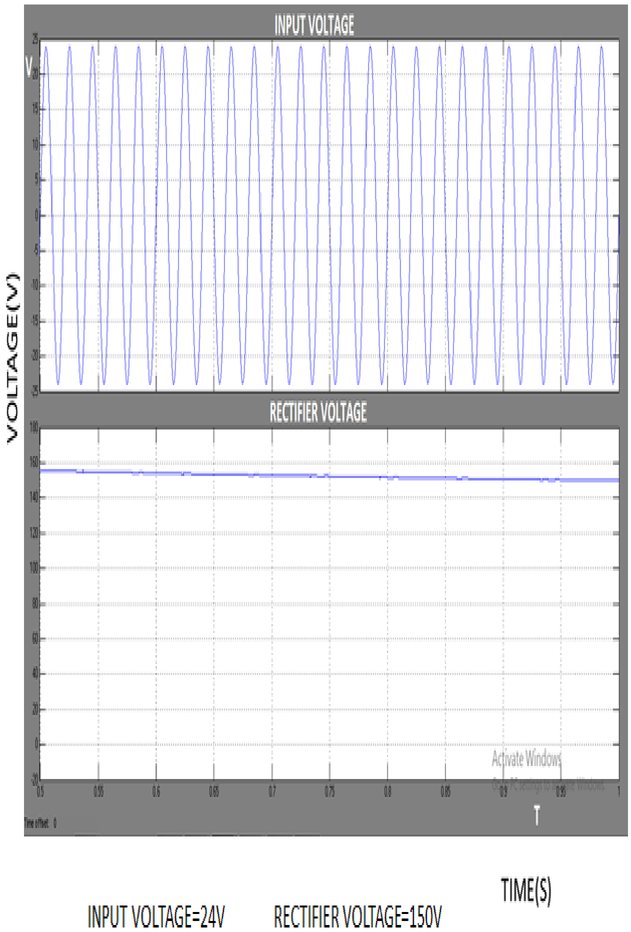

Figure5a. Input Source Voltage And Rectifier Voltage

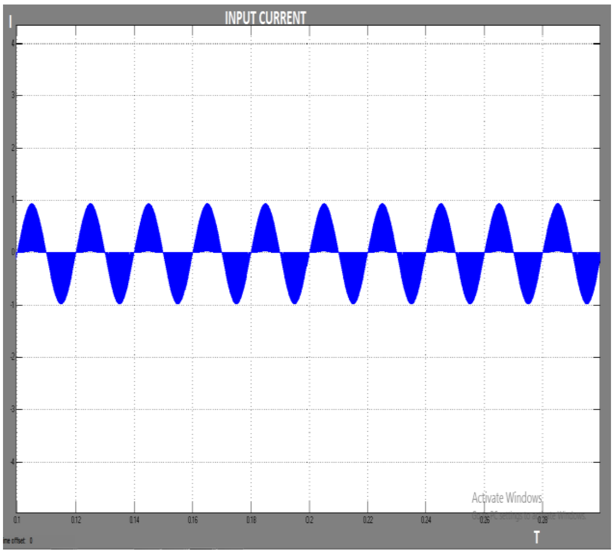

Figure 5b. Input Current From Source To Bridgeless Rectifier

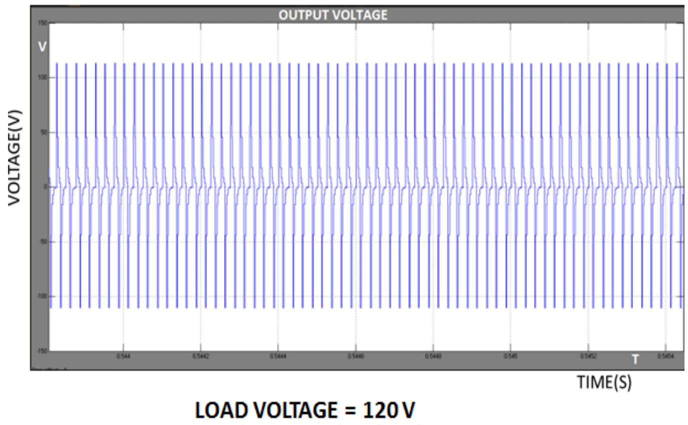

Figure 5c.load voltage

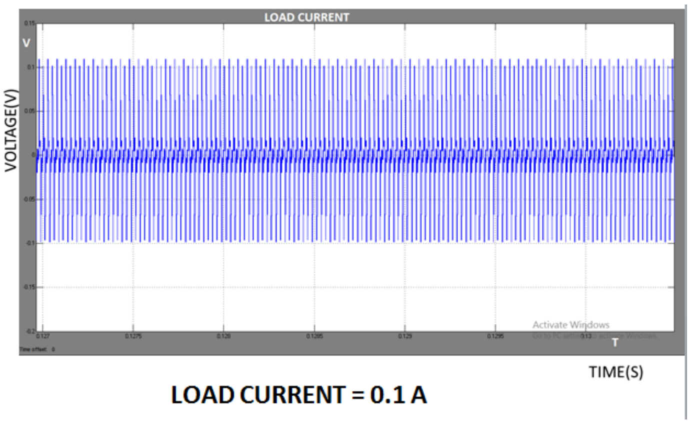

Figure 5d. Load Current

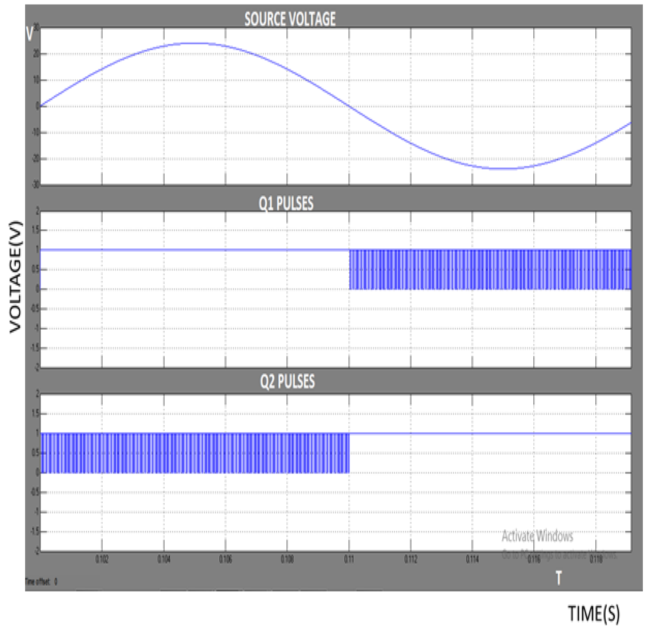

Figure 5e. Switching Pulses Of Switch Q1,Q2 By PWM Generator

In a switching frequency the two switches are turned on different period,Q1 switch is turned on in the same time Q2 turned on in a fast switching state. The pulse width of 80% is given to circuit. The same thing Q3 and Q5 turned on to flow the current to the load R1,L2. The capacitor are charges in a first mode of operation and discharge in a second mode of operation. The power is produced in resonant inverter and it compare with input power it produce the 88% of efficiency. Parallel resonance inverter fast discharging and charging time compare to serious resonance inverter.

Efficiency= (output power/input power)×100 - (5)

Performance of the device is depends on the THD factor, if the THD value is high the non pure sinusoidal waves obtained. whenever THD is reduced pure sinusoidal is obtained. In parallel resonant inverter THD is good, it obtained the value of 0.9.comparison table shown in Table2 .

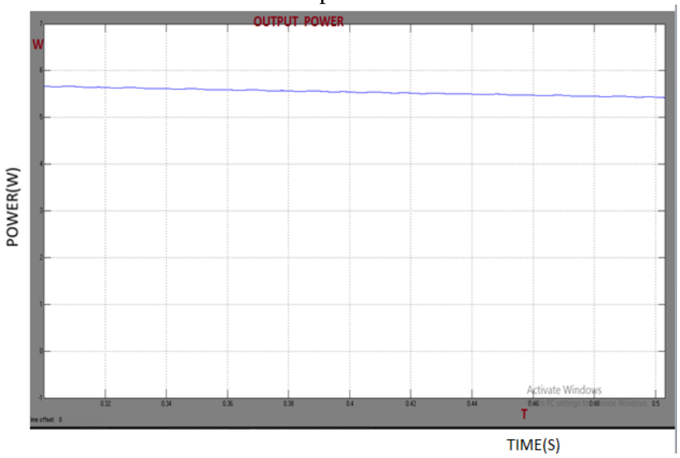

Figure 5f. Output Load Power

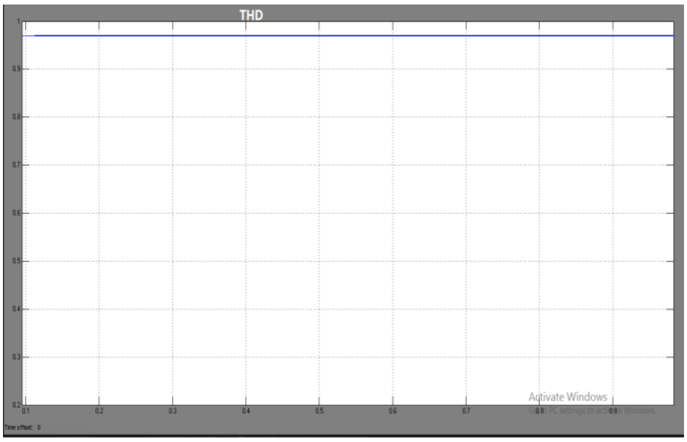

Figure 5g. THD For The Circuit

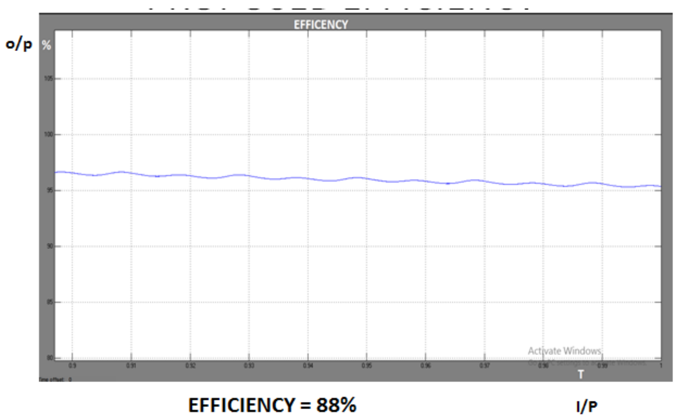

Figure5h Efficiency

Table2. Comparison Table

PARAMETER	EXISTING SYSTEM	PPROPOSED SYSTEM
INPUT VOLTAGE	24 AC	24AC
LOAD VOLTAGE	12 AC	120V AC
RECTIFIER OUTPUT VOLTAGE	22V DC	150V DC
LOAD CURRENT	0.01 A	0.1 A
INPUT POWER	0.62W	5.4W
LOAD POWER	0.42 W	4.8 W
POWER FACTOR	0.34	0.84
EFFICIENCY	68 %	88%
THD	2.4	0.9

IV. Conclusion

In this paper effectiveness of proposed bridgeless boost converter with voltage boost implemented for IH appliances. The output power is boosts up with switched capacitor. The closer values are achieved in PFC and THD with PWM technique. The performance characteristics of proposed HF inverter circuit is better than previous inverter. Parallel resonance inverter is give higher efficiency than serious resonance inverter. The lifted voltage and switched technique obtained the 88% power efficiency. In future work, IGBT as implemented in higher power applications to improve the THD and efficiency performance.

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