

# Performance Analysis of Open Loop and Closed Loop Control of High-Frequency Single Stage Resonant AC / AC Converter

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**Abstract:** In numerous applications, for example, substantial scale LCD board backdrop illumination, road lighting, burrow lighting, and so forth., an air conditioner / dc Light Emitting Diode (LED) driver ought to understand the accompanying three capacities at any rate: control figure adjustment, multichannel consistent ebb and flow yields, and galvanic disconnection. A novel two-arrange multichannel steady flow air conditioning / dc LED driver with a minimal effort and one of the model was proposed is made out of a high-recurrence resounding air conditioning / air conditioning converter and the same number of uninvolved LCL-T thunderous rectifiers as the quantity of the yield channels. To begin with, topology induction of the high-recurrence full air conditioning / air conditioning converter with single stage is introduced, additionally the working rule of it. At that point, the enduring state execution of it is totally dissected, including its info control calculate, voltage increase, add up to consonant twisting of its yield voltage, and its soft switching condition. In order to generate the pulses for MOSFET PWM techniques and PI controller model is also developed to eliminate steady state error. Here both open loop, closed loop and fuzzy control of high frequency single stage resonant AC to AC converter model is developed using MATLAB / SIMULINK software.

**Keywords:** Fuzzy logic control, Open loop and closed control, Resonant converter.

## I. INTRODUCTION

Light-Emitting-Diode (LED) has ended up being continuously standard in our every day for its high brilliant feasibility, long lifetime, et cetera. The segments of high splendid reasonability and life span influence it for engaging in different domain areas [1]-[5]. For the most part, input control for business LED street lights lies in the region of 60 and 240 W [6]; in this way, their drivers must use control figure correction (PFC) frameworks to

finish a capable segment to meet critical symphonious measures, e.g., IEC 61000-3-2 [7]. In view of packaging development and warm organization, interfacing course of action LED strings in parallel has been a run of the mill practice to procure satisfactory luminance.

The present voltage and current sharing limit is poor for in LED strings. Thus, recurring pattern changing framework is required for the driver. Also, galvanic detachment is continually vital for security thought. With everything considered, an aeration and cooling system / LED street lights driver should comprehend the going with three limits at any rate, which are PFC, multichannel consistent recurring pattern yields, and galvanic withdrawal.

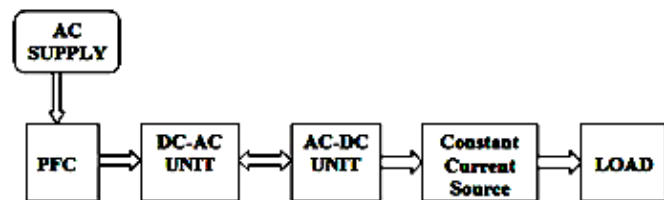


Fig. 1: Traditional Three-Stage Multichannel Constant Current AC / DC LED Driver

Standard three-arrange multichannel reliable back and forth movement ventilating / LED street lights driver is showed up in Fig. 1 [8]. In first, Towering power variable is recognized by the chief correction of power factor arrange, ventilation system input voltage is changed over to steady dc-interface voltage. Dc / dc converter with Front and back end arrange is i charge of giving galvanic partition and changing over the dc-associate voltage into bring down yield dc voltage was arranged as a second stage. The final stage named enduring current source orchestrate makes equal current in LED string. Since galvanic imprisonment is recognized by using dc / dc converter with front and back end arrange with transformer is developed, a dc / aerating and cooling unit (trading framework) and a ventilation system / dc unit (yield rectifier and channel) are consolidated. As needs be, paying little mind to its incredible

execution, this three-orchestrate course of action is entrapped and its adequacy is conveyed down to some degree; also, for the final stage to give different reliable power stage and controller, but costwise increased. In order to avoid above mentioned problems of high frequency single stage resonant AC to AC converter model is preferred.

With a particular true objective to unravel the circuit structure, help capability, and reduce cost, various two-sort out game plans are proposed by consolidating the front-end dc / dc organize and predictable current source mastermind into a minute multichannel unflinching current source arrange, as showed up in Fig. 2.

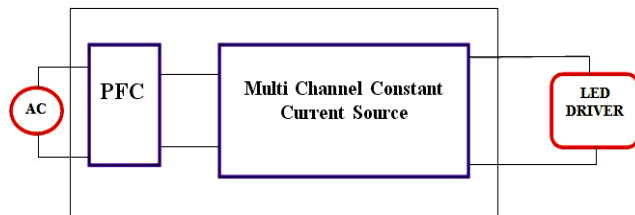


Fig. 2: Two-Stage Multichannel Constant Current AC / DC LED Driver

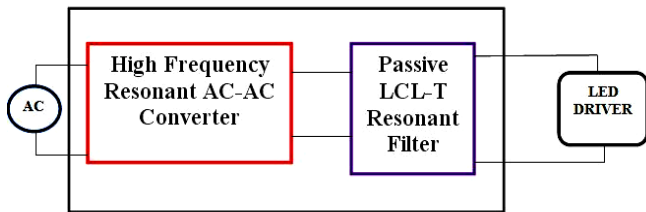


Fig. 3: Proposed Two-Stage Multichannel Constant Current AC / DC LED Driver

The two stage structure is streamlined and the reduced cost is met when differentiated and the game plan in [9]. In any case, remembering the true objective to execute a channels multiples of  $2n$  for reliable current source, and separated  $n$  transformers are necessary. In [10],[11] a multichannel enduring current source and a solitary transformer is developed. The model is additionally enhanced and the charge is additionally diminished. In Fig. 3 normal resonant ac-ac converter with high frequency as well as a new passive LSL-T resonant filter was also developed to reduce unwanted frequency.

Point the uninvolved LCL-T reverberating rectifier analyzed in can achieve predictable yield back and forth movement with no control circuits gave that the plentifulness of its data sinusoidal voltage is figured out how to an unflinching regard and the repeat of it is comparable to the loud repeat of the LCL-T full tank, another two-compose multichannel relentless recurring pattern aerating and cooling / dc LED driver showed up in Fig. 3 is proposed, which is made out of a high-repeat full aerating and cooling/ventilating converter and a similar number of uninvolved LCL-T booming rectifiers as the amount of the LED strings required [12],[13].

In this paper, Chapter 2 explained that high frequency single stage resonant ac / ac converter was topology. Chapter 2 explained that single stage resonant converter operating principle. Simulation results for both open loop and closed loop control especially for fuzzy logic control diagram and results was shown in Chapter 4.

## II. CIRCUIT TOPOLOGY

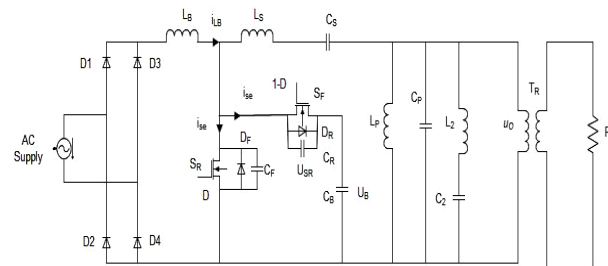


Fig. 4: High Frequency Single-Stage Resonant AC / AC Converter Circuit Topology

A PWM series - parallel LCLC full inverter has lot of merits of outfitting pure sinusoidal voltage with to an awesome degree low total consonant reshaping (THD), fulfilling zero sequence voltage trading of the power electronics switches as well as fundamental circuit model, it is benefit as the high repeat loud dc / aerating and cooling component.

The proposed converter topology is controlled by fusing the lift converter and A PWM series - parallel LCLC full inverter jointly in the going with single stage. As showed up in Fig. 4, the lift converter is made out of a  $L_B$  as lift inductor, a  $S_B$  as a power switch, a  $D_B$  diode, and  $C_B$  as a dc-interface capacitor; the A PWM series-parallel LCLC full inverter is made out of two power switches  $S_R$  and  $S_F$ . Since the voltage get of the A PWM series - parallel LCLC full inverter is centered around  $D = 0.5$ , where  $D$  is the commitment cycle of  $S_R$ , pulse indications of  $S_R$  and  $S_F$  can be exchanged, as showed up in Fig. 4 [14]. From Fig. 4, when  $S_B$  and  $S_F$  are gated turn ON, center point An and center point B are related together; when  $S_B$  and  $S_R$  are gated turn OFF, diode  $D_B$  is constrained to lead, at the same time,  $S_R$  is gated turn ON, in this way, center point An and center B are related together too. Toward the day's end, the voltage between center point An and center B is always zero and they can be particularly shorted, thusly,  $S_B$  and  $S_F$  are parallel-related and one of them can be cleared;  $D_B$  and  $S_R$  are parallel-related also, to be ousted as requirements be. Finally, a singular stage high-regardless, the current through  $S_R$  is bidirectional,  $D_B$  should repeat reverberating cooling / aerating and cooling converter showed up in Fig. 4 is surmised.

From Fig. 4, clearly  $S_R$  and  $S_F$  are mutual by the correction of power factor unit and high-repeat full dc / aerating and cooling unit, and only a solitary controller is relied upon to control the sufficiency of the high-repeat pure sinusoidal voltage, in this way, the circuit is unraveled as well as price of it is less amount

equally while differentiating and the two-sort out plan showed up in Fig. 4.

### III. PRINCIPLE OF OPERATION OF PROPOSED CONVERTER

Fig. 5 demonstrates the working waveforms of single stage resonant ac / ac converter and its identical circuits for every working mode are exhibited.

Mode 1 [ $t_0 \leq t < t_1$ ]: At  $t_0$ ,  $S_F$  is turned ON with initial null voltage because the inherent diode is compelled to lead in the past mode. Inductor current  $i_{Lb}$  increments directly, all the while, the vitality put away then resounding tank allows freewheels through switch  $S_F$  then continues providing energy to the heap.

Mode 2 [ $t_1 \leq t < t_2$ ]: At  $t_1$ ,  $S_F$  is killed,  $C_F$  is charged, and  $C_R$  is released in the meantime. Since the expansion rate of  $U_{Sf}$  is constrained by  $C_F$  and  $C_R$ ,  $S_F$  is killed at ZVS around and the kill misfortunes of it can be diminished. Once  $U_{Sf}$  increments to  $U_B$  and  $U_{Sf}$  abatements to null position, this operating mode closes.

Mode 3 [ $t_2 \leq t < t_3$ ]: At  $t_2$ ,  $U_{Sr}$  declines to zero and the characteristic diode  $D_R$  is compelled to direct. And this mode,  $L_B$  is released by  $U_{in}-U_B$ , and the vitality put away in it discharges to  $C_B$  and the full tank.

Mode 4 [ $t_3 \leq t < t_4$ ]: At  $t_3$ ,  $S_R$  is gated ON at ZVS on the grounds that  $U_{Sr}$  is clipped to null position by the  $D_R$ . In this operating mode, the proportional circuit is similar to previous mode number 3.

Mode 5 [ $t_4 \leq t < t_5$ ]: At  $t_4$ , inductor current  $i_{Lb}$  declines to zero, all the while, diodes  $D_{R1}$  and  $D_{R2}$  are turn around one-sided. In this mode, the vitality put away in  $C_B$  discharges to the thunderous tank and continues providing energy to the heap.

Mode 6 [ $t_5 \leq t < t_6$ ]: At  $t_5$ ,  $S_R$  is killed. So also, the expansion rate of  $U_{Sr}$  is constrained by  $C_F$  and  $C_R$ ,  $S_R$  is killed at ZVS roughly and its kill misfortunes are lessened.

Mode 7 [ $t_6 \leq t < t_7$ ]: At  $t_6$ ,  $U_{Sf}$  abatements to null and inborn  $D_F$  diode begins to lead, that makes a voltage switching as zero condition for switching ON  $S_F$ . In this mode,  $D_{R1}$  diode and  $D_{R4}$  are compelled to lead, lift inductor  $L_B$  is energized by the air conditioner line voltage  $U_{in}$ .

At  $t_7$ ,  $S_F$  is switched ON at voltage switching as zero condition and converter starts another exchanging cycle [15].

Operational Modes 1–7 carry out in the positive half-cycle of air conditioning line voltage [16].

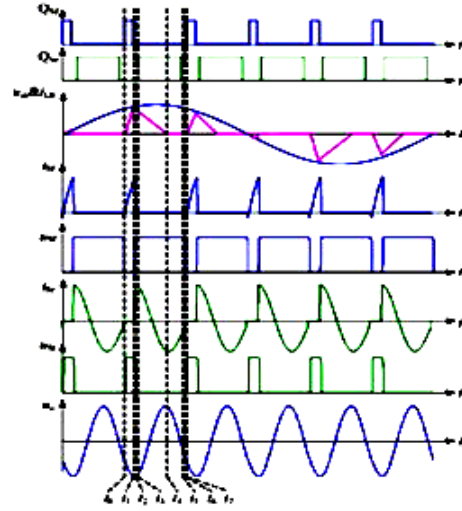


Fig. 5: Operational Waveforms of the Presented Single-Stage High Frequency Resonant AC / AC Converter

### IV. SIMULATION RESULTS OF OPEN LOOP AND CLOSED LOOP CONTROL OF HIGH-FREQUENCY SINGLE STAGE RESONANT AC / AC CONVERTER

#### A. Open Loop Single Stage Resonant AC / AC Converter

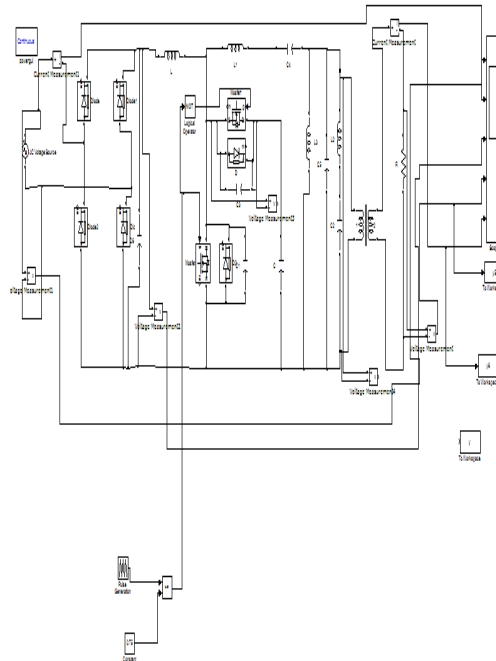


Fig. 6: Simulation Diagram of Open Loop Resonant AC - AC Converter

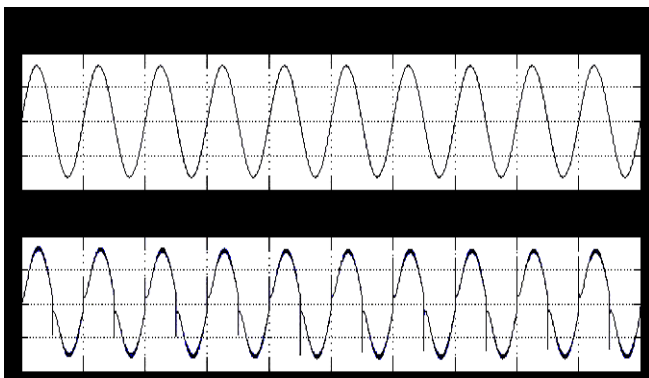


Fig. 7: Simulation Response of Input Voltage and Input Current

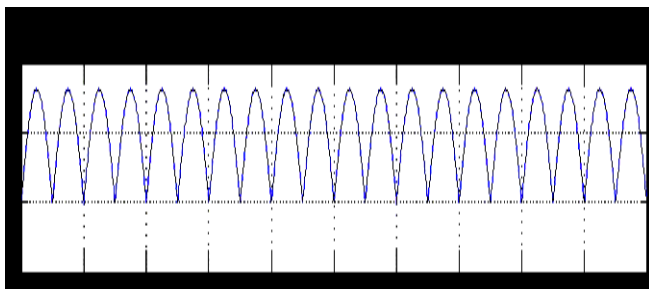


Fig. 8: Simulation Response of DC Link Voltage

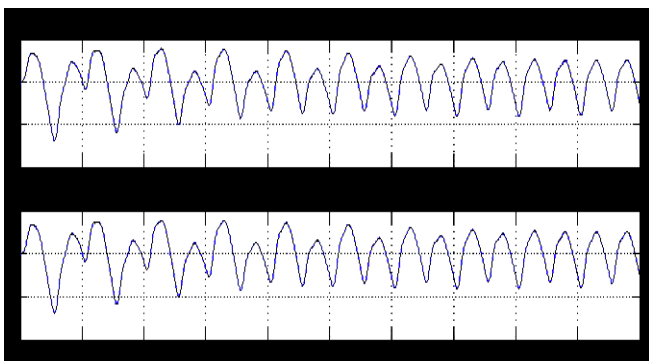


Fig. 9: Simulation Response of Output Voltage and Output Current

Fig. 6 shows simulation diagram of open loop high frequency single stage resonant AC-AC converter. Fig. 7 shows simulation response of source voltage and current waveforms results are takes as 0 to 0.3 seconds. Fig. 8 shows pure dc link voltage as which is given to input of the resonant inverter. Fig. 9 shows the output voltage and output current waveform. Since we have used open loop system, the distortions are more.

*B. Closed Loop Resonant AC-AC Converter without Using Fuzzy Logic*

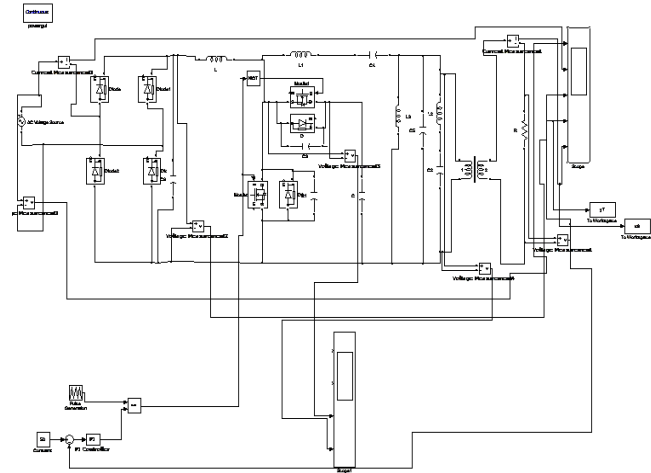


Fig. 10: Simulation Diagram of Closed Loop Resonant AC-AC Converter

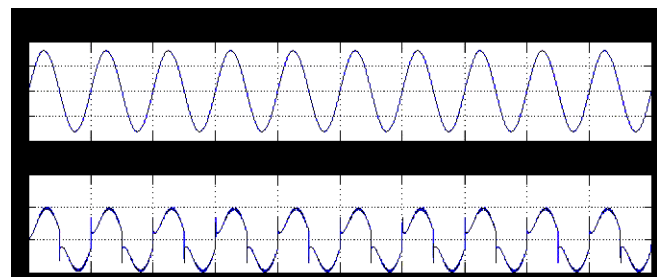


Fig. 11: Simulation Response of Input Voltage and Input Current

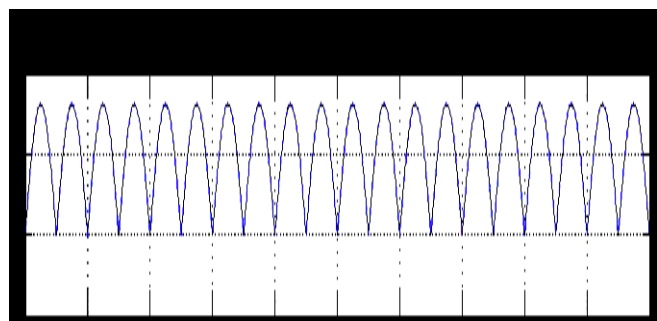


Fig. 12: Simulation Response of DC Link Voltage

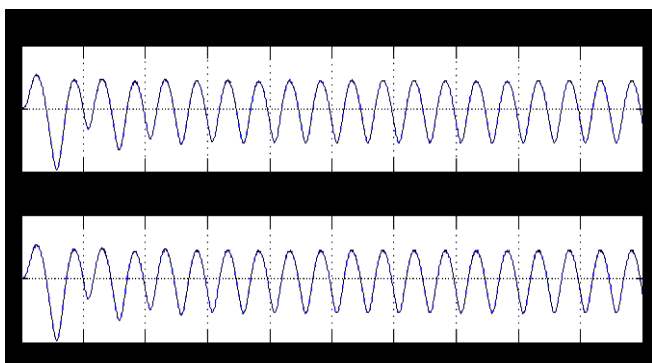


Fig. 13: Simulation Response of Output Voltage and Output Current

Fig. 10 represents that simulation diagram of closed loop high frequency single stage resonant AC-AC converter. Fig. 11 shows the source voltage and source current waveform. Compare to open loop input current performance was good. In closed loop PI controller is used as a feedback. Here the  $K_p$  value is 0.01 and integral gain is 0.5 [17],[18]. Fig. 12 represents dc link voltage and waveforms maintain constant dc. Fig. 13 represents output voltage and currents waveforms for proposed converter. Compare to open loop control the oscillations in waveforms are reduced. In closed loop system the distortions are less compared to open loop system.

### C. Simulation Response of Closed Loop System with Fuzzy Logic

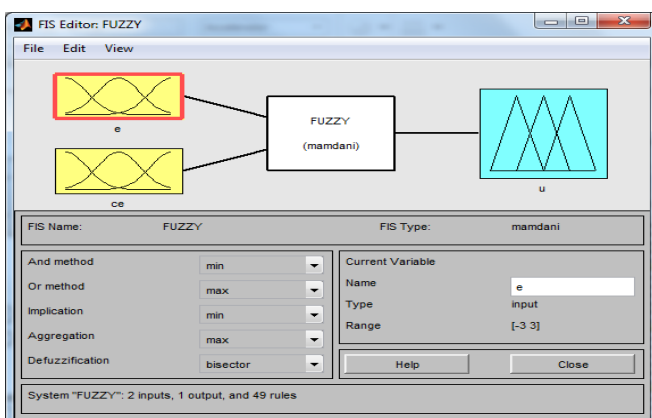


Fig. 14: Fuzzy Sets and Output States

Same resonant AC / AC converter is implemented in FL also. Eliminate PI controlled and introduce fuzzy logic controller. Select input membership function error and change in error and select output as carrier value for PWM signal. Input and output membership function of the fuzzy logic is represented in Fig. 14 and form 49 rules and visualize in Fig. 15.

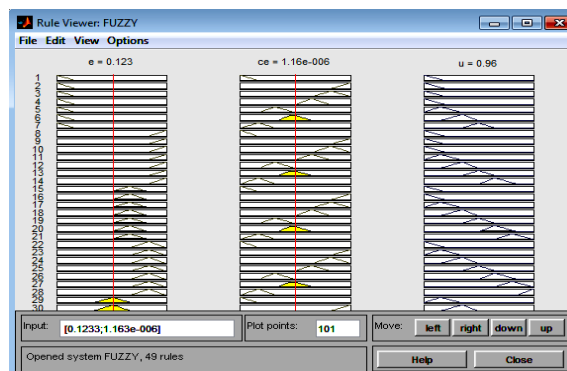


Fig. 15: Fuzzy Rule Base Viewer

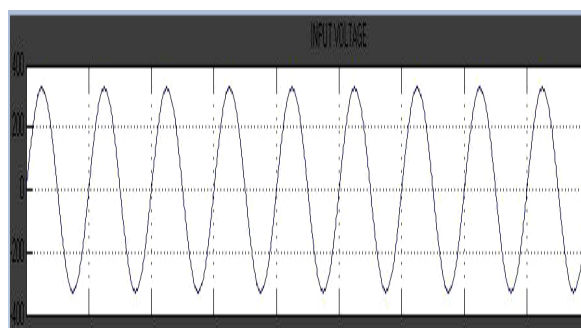


Fig. 16: Simulation Response of Input Voltage

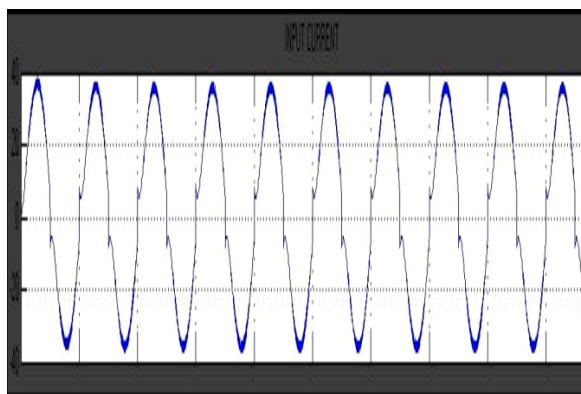


Fig. 17: Simulation Response of Input Current

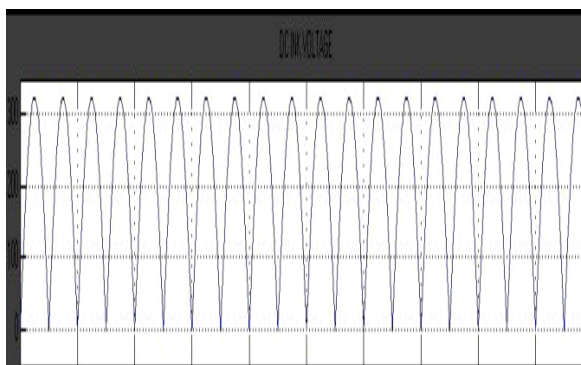


Fig. 18: Simulation Response of DC Link Voltage

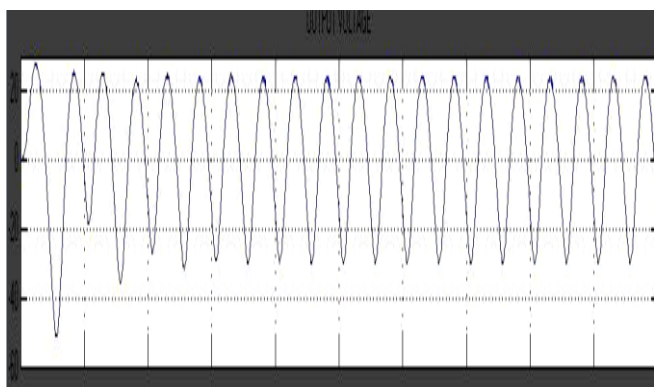


Fig. 19: Simulation Response of Output Voltage

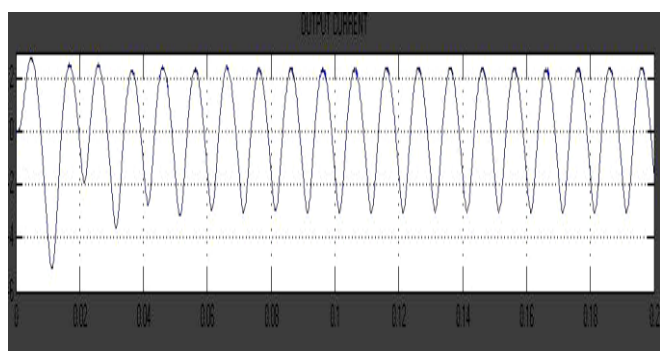


Fig. 20: Simulation Response of Output Current

After implementing fuzzy logic in this paper input voltage, input current, dc link voltage having less distortions compare to open loop and closed loop control which is represented Fig. 16 - Fig. 18. Similarly output voltage and outcurrent waveforms are also less harmonics which is represents in Fig. 19 and Fig. 20.

TABLE I: COMPARISON RESULTS OF OPEN LOOP AND CLOSED LOOP SYSTEM

Sl. no	Parameters	Rise Time (tr)		Peak Time (tp)		Peak Over Shoot (mp)	
		OL	CL	OL	CL	OL	CL
1	Load Voltage	158.	25	48.	68.	329.	188.
		857	1.7	146	837	500	118
		2	80	7	0	1	1
2	Load Current	158.	25	4.8	1.3	329.	188.
		857	1.7	147	767	500	118
		2	80			1	1
		8					

Load voltage and load current waveforms time domain specifications which found in MATLAB and shows in Table I. Experimentally closed loop control of proposed resonant single stage converter shows in Fig. 21.

D. Hardware Results



Fig. 21: Experimental Setup for Single Stage AC-AC Converter

IV. CONCLUSION

In this paper A solitary stage high-recurrence full air conditioning / air conditioning power electronic converter has been proposed for a two-organize multichannel consistent momentum air conditioning and LED driver with high - recurrence pure sinusoidal voltage transport. So initially open loop and closed loop control of resonant converter was discussed and its performance was analysed. For closed loop control in order to generate the pulses for MOSFET PWM techniques and PI controller model is also developed to eliminate steady state error. After that one of the intelligent technique fuzzy logic also implemented for their accurate results. In future same converter neuro model will developed and compare results to existing techniques.

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