EFFICIENCY IMPROVEMENT IN FULL BRIDGE SERIES RESONANT INVERTER USING AVC COMPARED WITH PWM CONTROL TECHNIQUE UNDER VARYING LOAD CONDITION

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Article History: Received: 12.12.2022 **Revised:** 29.01.2023 **Accepted:** 15.03.2023

Abstract

Aim: This paper uses Pulse Width Modulation (PWM) and Asymmetrical Voltage Cancellation (AVC) control to demonstrate two effective methods for controlling the efficiency output of a full bridge series resonant inverter (FBSRI). A modest signal analysis is used to derive the complete closed loop control model. Simulation findings confirm the performance of the suggested control.

Materials and Methods: A constant DC source powered recommended frameworks are implemented with various control techniques to obtain 7 samples per group and a G power of 0.80 is implemented to analyse the efficiency.

Results: The proposed converter, as per the results,with a significant value 0.563 ($p > 0.05$, statistically insignificant) does have a greater efficiency of 87.86% for the selected data than the traditional analysis, which has a lesser efficiency of 84.76%.

Conclusion: The simulation results show that efficiency can be controlled across a broad range by using AVC compared with PWM control technique.

Keywords: Full Bridge Series Resonant Inverter, Pulse Width Modulation, Novel Asymmetrical Voltage Cancellation control, DC Source, Power Electronics, MATLAB.

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1. Introduction

Asymmetrical voltage cancellation (AVC) control technique is proposed. The phased look loop (PLL) is used to track the switching frequency. The complete closed loop control model is obtained using a small signal analysis (Gaur et al.). The demand for energy in the United States is rapidly increasing (Douglas et al.). Rising electricity consumption and the substitution of fossil fuels necessitate the usage of renewable power. Full Bridge Series Resonant Inverter Various types of converters are utilised in different applications (Khalilpour).

The asymmetrical voltage-cancellation is used for controlling the output power. With the low quality factor loads, a fixed frequency control might lead to non-zero-voltage-switching (NON-ZVS) operation(Chakrabarty and Adda). The proposed control strategy ensures the ZVS operation for switching loss reduction by varying the switching frequency slightly higher than the resonant frequency.Bidirectional power transfer converters can also be employed as power sources for multi-output control circuits. Control type soft switching circuits are rare and far between today (Mochizuki and Ollapally). The typical topologies include phase shifting full-bridge converters, asymmetrical half-bridge converters (Hammock et al.), push-pull converters, and LLC series resonant converters, among others. The usage of resonant converters has gotten a lot of attention in recent times (Lee et al.) . Several resonant converter DC source topologies were built and verified (Varma et al.), and they can all be put together as a single building block known as a resonant inverter When contrasted to typical hard-switched PWM converters (Frenck et al.), resonant converters offer lower switching losses and switching strains, allowing them to operate at higher frequencies(Lu et al.). The main applications of Full Bridge Series Resonant Inverter are Power Control in Dual Half-Bridge (Peet et al.), Flexibility in the power control of ultrasonic transducers can be enhanced using AVC (Jittakort et al.). Based on the proposed boost converter, around 2096 articles are published by Google scholar and 392 articles are published in IEEE Xplore. Under the Zero Voltage Switching (ZVS) condition, an LCL resonant push-pull structure was proposed (Werner et al.). Large current or voltage stresses on switching elements, as well as higher conduction loss, are hard to manage in resonant converters (Fouquet).

Our institution is passionate about high quality evidence based research and has excelled in various domains (Vickram et al.; Bharathiraja et al.; Kale et al.; Sumathy et al.; Thanigaivel et al.; Ram et al.; Jothi et al.; Anupong et al.; Yaashikaa et al.; Palanisamy et al.). In addition, this research examines the ideal switching control mechanism and output current for a high-frequency working environment in order to improve inverter efficiency even more. In such circumstances, and with fixed transistor losses, the inverter's overall output would be increased.

2. Materials and Methods

The research was performed in the Power Systems Simulation lab in the Department of Electrical and Electronics and Engineering at Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences. Based on past research, the sample size was determined. This study does not require ethical approval because no human or animal samples were used. The sample size is calculated using two algorithms in the G Power software. Based on this, each group will have 7 samples (Jittakort et al.), for a total of 14 samples. (g power setting parameters: statistical test-difference between two independent means, α=0.05, power=0.80, effect size d=0.5) mean Mean AVC 87.8657, and PWM 84.7614 , Standard Deviation (SD)-3.56720. Matlab R2019a software tool kit is used to build the circuit and to simulate.

Pulse Width Modulation

PWM works by pulsating DC current, and varying the amount of time that each pulse stays 'on' to control the amount of current that flows to a device such as an LED. PWM signals are typically square waves, like the one in the illustration below. A PWM signal (square wave) with a 50% duty cycle . Create a ratio that places the length of the cycle activity in the numerator and the length of the overall cycle in the denominator. Divide the numbers. Multiply the result by 100 percent. This yields the pulse width of the duty cycle(Manias).

Asymmetrical Voltage Cancellation

The asymmetrical voltage-cancellation (AVC) control is described as a generalization of the conventional phase-shift and asymmetrical duty-cycle control techniques. The proposed control technique is applied to a full-bridge series resonant inverter, with five different resultant operation modes.

A pair of inductors and a capacitor makes up LLC resonant converters, which are series-parallel resonant converters. Certain converters could achieve voltage control over a wide range and ZVS across the entire load range. While the LLC resonant converter operates at zero voltage, PWM

switching produces additional harmonics, as identified in the articles . The decrease as a result.
Fig. 1 and Fig. 2 show the SLRI's functional circuit. As the SLRI source, a continuous DC source was chosen. The switches in the circuit are commutated to produce a square wave output . It acts as a buffer between the outcome and the profit. DC source The rectifier network receives the AC output, which is subsequently controlled by a capacitor.
A SRI with AVC control approach is presented in this work. Two control loops are used in the proposed control strategy: a frequency control loop and a power control loop. The first is used to monitor the resonance frequency during the heating cycle in order to accomplish ZVS operation, and the second is used to modify the switch duty cycle if the load parameter changes(Smil).

Statistical Analysis

Statistical study of FBSRI is done with SPSS software. The independent variable is the duty ratio of PWM and AVC production, whereas the dependent variable is efficiency. To determine their maximal efficiency, all procedures are subjected to two independent group analysis tests.

3. Results

Fig.1 and Fig. 2. show the generalised structure of a complete bridge inverter operated by PWM and AVC methods. Fig.3 and Fig. 4. demonstrate the output and output power acquired from the existing system and the proposed study. The PWM and AVC control schemes' switching cycles are depicted in sections 5 .
Table 1. Simulation results of Existing and Proposed methods . It shows that 7 samples taken for the calculation of mean values and by using AVC controller and PWM controller .
The existing model had a standard deviation of 84.76 percent and a standard error of 1.3482 with 7 samples, but the proposed method had a standard deviation of 87.86 percent and a standard error of 1.6009 with 7 samples (Table 2). The significance value is 0.563, which is lower. The equivalent load power is estimated based on duty cycle fluctuations. Significance value is observed as 0.563 ($p>0.05$) which is considered to be statistically insignificant.
A T-test comparison of output power and suggested systems is shown in Table 2. The load resistance has been changed from 100 ohm to 700 ohm. Table 3 shows an Independent Samples test that compares the load power of the planned and current systems.
Figure 5 compares the efficiency of two groups for gaining maximum power in the existing study versus the suggested study. The proposed system may produce more consistent results.

4. Discussions

A standard method's efficiency is reviewed and compared to the new method's efficiency. The proposed method is more flexible when compared to the current method.
The efficiency was enhanced in zero-voltage switching (ZVS) full-bridge series resonant inverters with asymmetrical voltage-cancellation (AVC) control for different load quality factors (Musabeyoglu) . The optimum AVC control allows the all switches to be turned on with zero voltage with the minimum switching frequency (Razali) , The synthesized converter allows supplying two inductive loads up to their rated values simultaneously and independently with only one converter, saving two transistors compared with the fullbridge alternative solution (Kularatna).The inverter output power is controlled using the asymmetrical voltage-cancellation (AVC) method and together with a phase-locked loop control, the switching frequency of the inverter is automatically adjusted to maintain a lagging phase angle under load-parameter variations (Eltamaly and Abdelaziz). SRCs have been subjected to a variety of control techniques such as Average current control (Schwarz 1975), frequency control (Robson 1982), diode conduction angle control (King, j. King, and Stuart 1983), ideal path regulation tracking the resonant tank's energy level (Oruganti and Lee 1985). Half-bridge SRC topologies were the focus of these approaches. Full-bridge SRCs have been subjected to phase-shift modulation (Nathan and Ramanarayanan, n.d.; Y. Lu et al. 2005; Yan Lu, Eric Cheng, and Ho 2008; Ye, Jain, and Sen 2007; Tsai 1989). For half and full-bridge SRCs, various steady-state models with rigorous mathematical evaluation were established (King and Stuart 1981; King, j. King, and Stuart 1982; Ayachit 2011; Lee, q. Lee, and Siri 1986).
The SRC appears to have the disadvantage of sharing the input power among the resonant impedance and the load, resulting in a DC gain of less than one (Steigerwald 1987). When there is no load or merely a modest load, controlling the DC output can be difficult. A FBSRI's characteristic and suggested control system are described in depth. From light load to full load, full-bridge inverter switching devices operate in the ZVS zone. The proposed control technique is tested with a single load and can be scaled up to numerous loads in the future.

5. Conclusion

The proposed converter, as per the results, does have a greater efficiency of 87.86% for the selected data than the traditional analysis, which has a lesser efficiency of 84.76%. Based on independent T test analysis the significance value is obtained as 0.563 ($p>0.05$) which is considered to be statistically insignificant.

Declaration

Conflicts of Interest

No conflict of interest in this manuscript.

Author Contributions

Author MT was involved in Data collection, data analysis, and manuscript writing . Author SJR is involved in data validation and review of manuscripts.

Acknowledgments

The authors would like to express their gratitude towards Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences (Formerly known as Saveetha University) for providing the necessary infrastructure to carry out this work successfully.

Funding: We thank the following organizations for providing financial support that enabled us to complete the study.

1. Tech grader, chennai
2. Saveetha University
3. Saveetha Institute of Medical And Technical Sciences
4. Saveetha School of Engineering

6. Reference

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Tables and Figures

Table 1. Simulation results of Existing and Proposed method

Load resistance (ohm)	Efficiency (%)	
	AVC controller	PWM controller
100	93.55	90.62
200	91.62	88.37
300	88.06	86.92
400	87.59	85.06
500	85.2l0	82.83
600	84.93	81.00
700	84.11	78.53

Table 2. Efficiency calculation of using seven samples selected for each group.

Group Statistics

	GROUP NAME	N	Mean	Standard Deviation	Standard Error Mean
Efficiency	AVC controller	7	87.8657	3.56720	1.34827
	PWM controller	7	84.7614	4.25838	1.60952

Table 3. The independent sample test revealed a substantial variation in duty ratio and load power among the suggested two stages and the standard single stage. Significance value is observed as 0.563 (p>0.05) which is considered to be statistically insignificant.

Independent Sample Test										
Levene's Test for Equality of Variances				T-test for Equality of Means						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Differences	95% Confidence Interval of the Difference	
									Lower	Upper
Efficiency	Equal Variances assumed	.354	.563	1.479	12	.165	3.10429	2.09961	-1.47038	7.67895
	Equal Variances not assumed			1.479	11.642	.166	3.10429	2.09961	-1.48602	7.69459

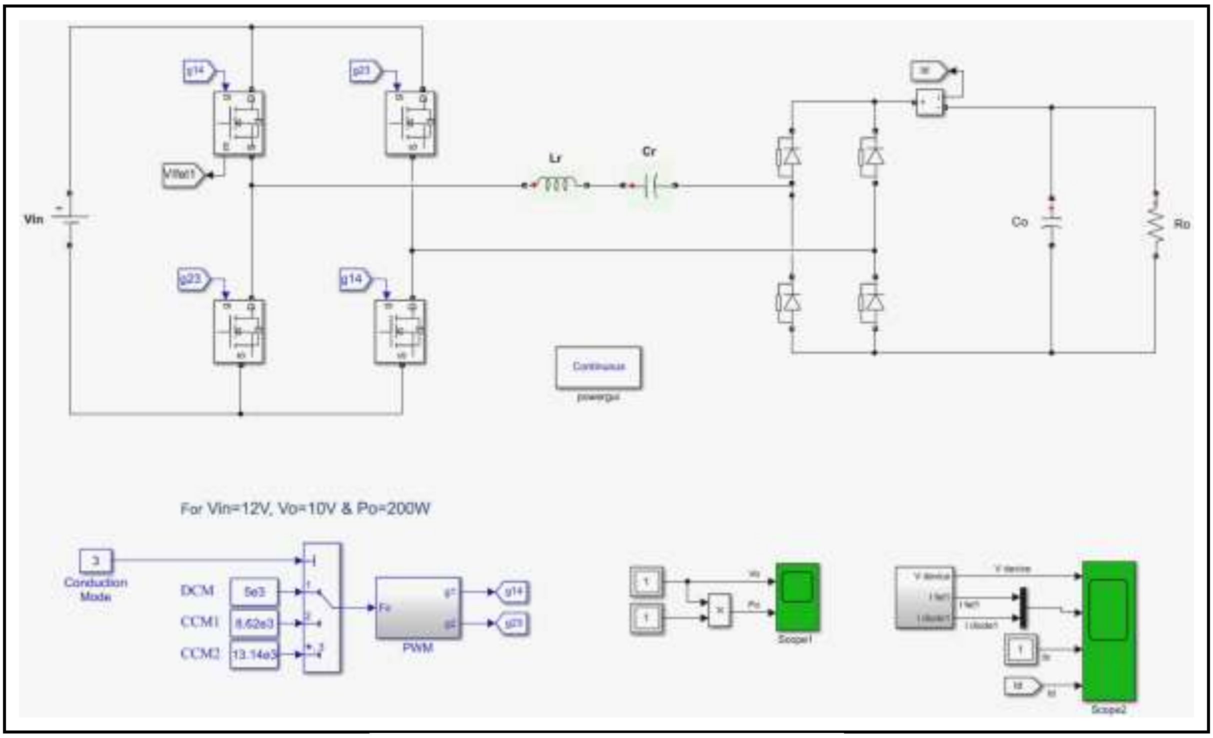

Fig. 1. Simulink structure of existing system

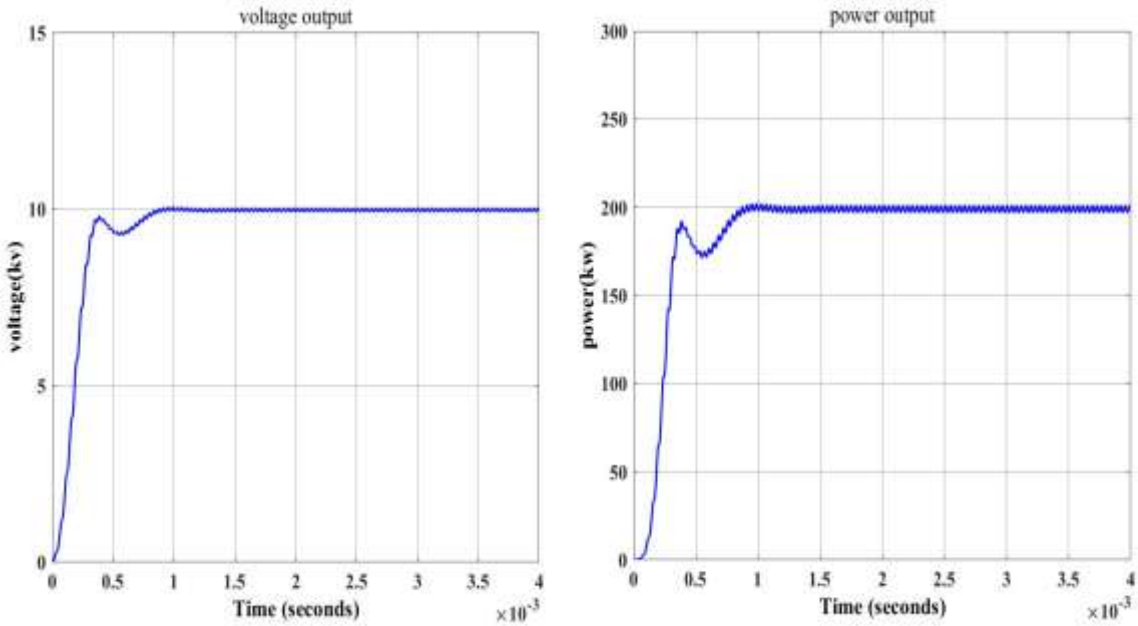

Fig. 2. Output voltage and power gained from existing system

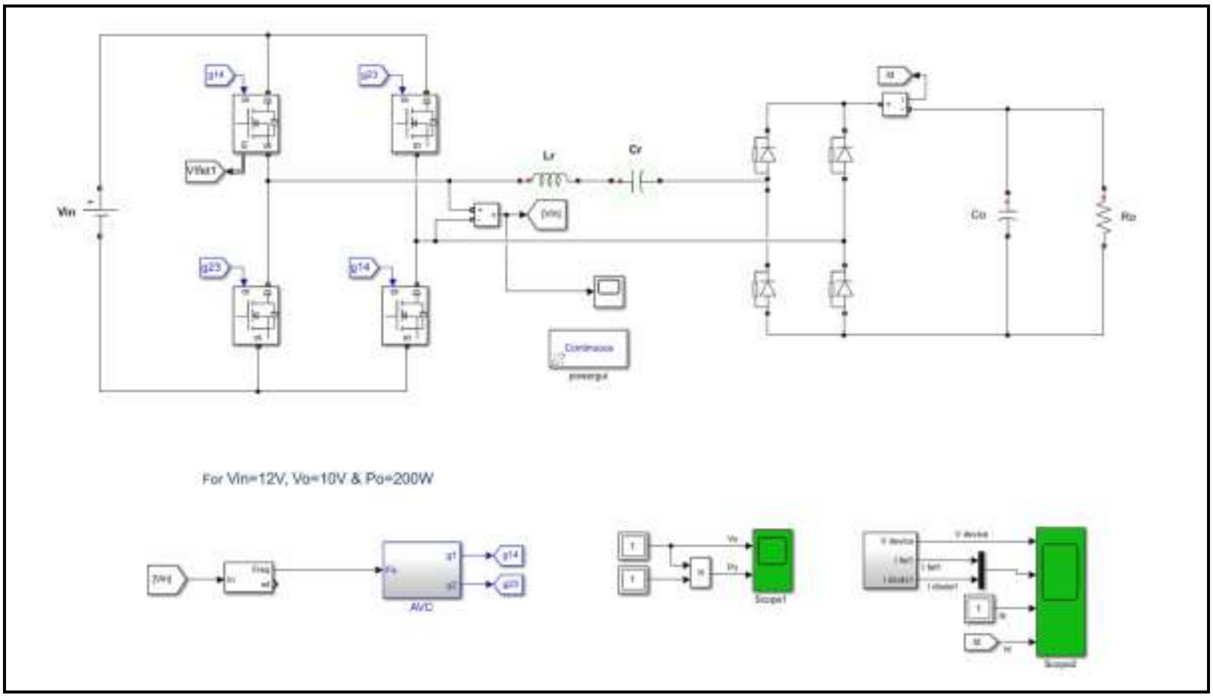

Fig. 3. Simulink structure of the suggested method

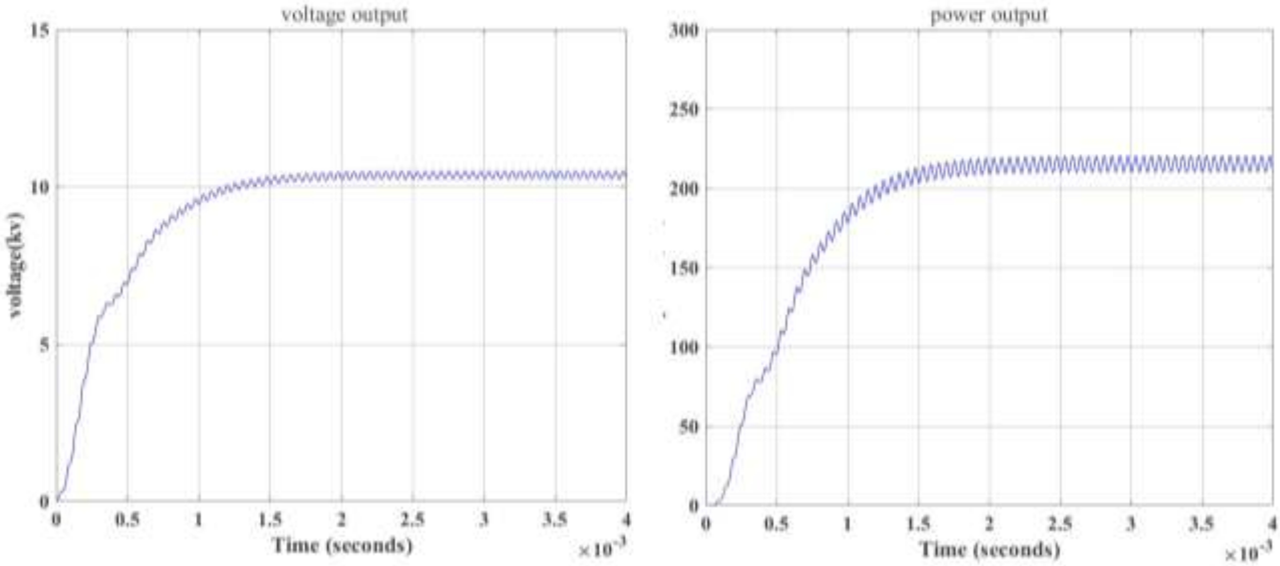

Fig. 4.Output voltage and power gained from proposed system

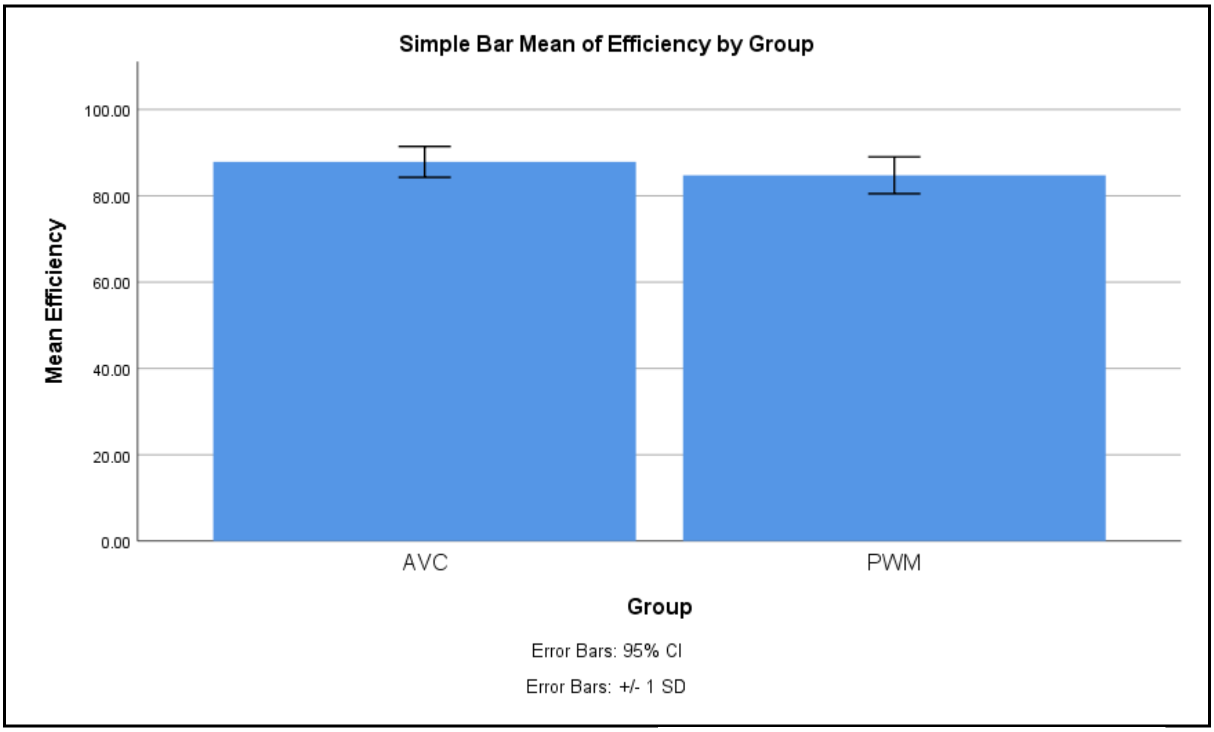

Fig. 5. Comparison of AVC and PWM controllers in terms of mean power and change in duty ratio is presented. X-axis represents AVC controller versus PWM controller; Y-axis represents average power gained from two different groups ± 1 SD.