A Novel Research on Improving the Overall Efficiency Among Hard Switching and Soft Switching Circuits using Optimization Techniques

Moinuddin K Syed, K. Raghuveer

***Abstract:** In recent years, Photovoltaic (PV) renewable energies are considered as an essential source of non-polluting and cost-free energy. be that as it may, the execution of the predominant enhance converter is diminished because of hard and smooth exchanging which makes misfortunes while the switches are moved toward becoming ON/OFF. so as to beat those inconveniences, this paper proposed novel investigations for boosting the effectiveness of delicate exchanging enhance converter the use of advancement method. in this, the delicate exchanging raise converter with R-load and RL-stack are propelled the utilization of a Simple Auxiliary Resonant Circuit (SARC) which includes the switch, diode, capacitor, and inductor. This circuit is used to operate the main switch with Zero Voltage Switching (ZVS) and Zero Current Switching (ZCS). In addition, Cat Swarm Optimization (CSO) algorithm is used to improve the performance of PI controller by upgrading the controller gain. The exam and approval of the proposed delicate changing help converter making use of CSO calculation were reenacted in MATLAB Simulink programming. The endeavor results reveal that the sensitive changing assist converter utilising R-stack accomplishes faded variances and replacing misfortunes than utilising RL-stack. also, the outcomes exhibit that the talent of the proposed delicate replacing assist converter is upgraded with the aid of approximately 4.five% utilizing cat swarm optimization (CSO) than the hard switching boost converter.*

***Keywords:** Photovoltaic (PV) cell; Soft switching boost converter; hard switching boot converter; Cat Swarm Optimization (CSO); Simple Auxiliary Resonant Circuit (SARC).*

I. INTRODUCTION

In power system, one of the major challenges is that the daily developing vitality necessity utilizing the customary vitality resources explicitly petroleum products [1]. In this way, the ordinary power age frameworks are ending up additional hard on account of the fuel fatigue, and it's miles expanding an unnatural weather change and exhaustion of the biosphere. therefore, require for inexhaustible power resources alongside wind power and sun control has expanded significantly [2]. From this, sunlight based power helpful asset delivers the yield power from a sun photovoltaic (PV) gadget this is explicitly relies upon the character of associated load, irradiance and the working temperature of PV cells on account of the non-straight I-V and P-V attributes. Along these lines, PV machine has low execution; therefore the power conditioning system (PCS) providing PV power to the load with the high efficiency is necessary [1]. Hence, the dc-dc converter for a PV system is to control the deviation of the maximum power point (MPP) of the solar cell output [3], [4].

Pulse width modulation (PWM) based DC-DC converters are commonly used in various applications due to their ease of control and high-power density [5]. A higher-power density is achieved by increasing the switching frequency. However, switching losses and electromagnetic interference (EMI) increment along the exchanging recurrence [1]. Dynamic methodologies make use of thunderous inductors, capacitors, diodes and assistant dynamic modifications to decrease the converting misfortune inferable from focal impact switches. There are two various types of transfer procedures, for instance, hard changing gadget and sensitive changing strategy. The hard replacing system makes an expansive masking territory amongst voltage and present day of the switch that reasons exchanging misfortunes [6-8]. for the reason that exchanging misfortunes are similar to the changing recurrence; in the end, it can not improve the changing recurrence. which will beat this troubles, delicate exchanging system is applied to lower the exchanging misfortunes for acquiring higher affect thickness. The delicate changing techniques comprise of a zero voltage switching (ZVS) and zero current switching (ZCS) which are turned on or off under the zero voltage or current condition for improving the efficiency [9-11]. Based on these techniques, the efficiency of the PV system is increased by reducing the switching losses.

In this paper, a novel soft switching circuit based on optimization technique is proposed to improve the overall efficiency of the PV system. This article is organized as follows. Section 2 discusses related works. Section 3 presents the proposed methodology. In Section 4, simulation results are discussed and compared with the other existing techniques. Finally, section 5 concludes the paper.

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II. RELATED WORKS

A soft switching boost converter for PV system is proposed that raises the efficiency of the DC-DC converter of PV Power Conditioning System (PCS) [12]. In this, the switching losses are reduced by realizing soft switching approach using resonance. An efficient and low-stress battery charger through a resonant switch converter is proposed to reduce the defects of high voltage and current stresses [13]. The experimental results illustrate that the new battery charger obtained the switching losses are less than the PWM.The existing boost converter reduces the efficiency of PV system due to hard switching which produces switching losses when they are turned on/off. A soft switching boost converter is implemented using a Simple Auxiliary Resonant Circuit (SARC) to improve the execution of PV gadget [1]. The outcomes demonstrated that the exchanging technique decreased the exchanging misfortunes, voltage and contemporary weight. A format and execution assessment of a delicate exchanging converter with HF transformer in lattice connected PV framework is exhibited [14]. The outcomes tried that the proposed structure accomplishes attractive proficiency of PV machine. A delicate exchanging raise converter for improving the execution of the PV contraption the utilization of thunderous components is proposed [15]. in this, the changes complete ZVS and ZCS changing to diminish the exchanging misfortunes. The reenactment results demonstrated that the advanced execution of the proposed converter. An interleaved delicate exchanging increment converter is proposed to development the general execution of sun oriented power period gadget [16]. The proposed topology limits the exchanging misfortunes with the guide of making sense of the thunderous smooth exchanging approach for PV influence molding framework. The reproduction outcomes of the proposed topology approved that the 1.five% of standard productivity is extended to analyze with the interleaved hard exchanging upgrade converter.

A ventured forward interleaved high advance up converter is proposed dependent on coordinated transformer voltage doubler for distributed PV framework [17]. The implicit transformer voltage doubler cell is made out of voltage doubler, three transformer windings and two voltage doubler capacitors. likewise, the energetic cinch strategy is connected to reuse the spillage control and harvest ZVS way for every single dynamic switch. By then, the contrary reclamation inconvenience of the diode is relieved by the spillage inductance of the transformer. A delicate exchanging approach principally dependent on the beat width tweaked quadratic converters for a PV and fuel cells structures is provided [18]. in this, a helper circuit is covered to the quadratic converters to increase smooth exchanging and limit the extra misfortunes. The enthusiastic switches inside the converters are moved toward becoming on with ZC-ZVS and flip-off with ZVS. further, it's miles essentially eased the turn around rebuilding issues. The results check that there aren't any additional misfortunes in the structured variant. The execution of an interleaved DC-DC improve converter is examined for PV age gadget [19]. The reenactment outcomes exhibited that the proposed adaptation accomplishes a higher generally speaking execution as far as execution, estimate decrease and unwavering quality.

An interleaved delicate exchanging enhance converter (ISSBC) is proposed for the sun control framework [20]. In such structures, providing individual maximum power point tracking (MPPT) for every one of the PV fashions rises the price. with a purpose to address this issue, particle swarm optimization (PSO) based MPPT calculation offered. A excessive-proficiency DC-DC assist converter which includes one MOSFET transfer and diodes for PV frameworks is displayed [21]. on this, in view of ZVS and ZCS the converter switch is became on/off using diodes which diminish the changing misfortunes. The take a look at outcomes authorised that the proposed lift converter completed a higher productivity contrasted with exceptional converters. A excessive gain and high-effectiveness dc-dc converter using coupled capacitor and inductor is proposed [22]. The reenactment outcomes reveal that the strategy is enhancing the general productiveness of the PV framework utilizing low voltage score transfer. An ISSBC for PV manipulate age framework is produced [23]. This strategy expands the effectiveness of the DC-DC converter of PVPCS, and it lessens the changing misfortunes by actualizing a sensitive complete changing. The controller gadget makes use of PWM to direct the yield depth of interleaved help converter at its best doable esteem and convertor turn-on each the dynamic power switches at 0 voltage to lessen their replacing misfortunes with improving the transformation productivity.

III. RESEARCH METHODOLOGY

In this research, a novel soft switching technique with optimization algorithm is proposed for improving the overall efficiency by reducing the switching losses of the Photovoltaic system. For optimization, Cat Swarm Optimization (CSO) algorithm is used to lessen the switching losses within the switching techniques. also, tough switching method is implemented and its performance is as compared with the proposed technique.A Photovoltaic (PV) cell is a type of p-n junction semiconductor device which converts light energy into electrical energy. In general, PV cell's equivalent circuit is depicted in Fig.1 that included the internal shunt resistance (Rsh) and series resistance (Rs).

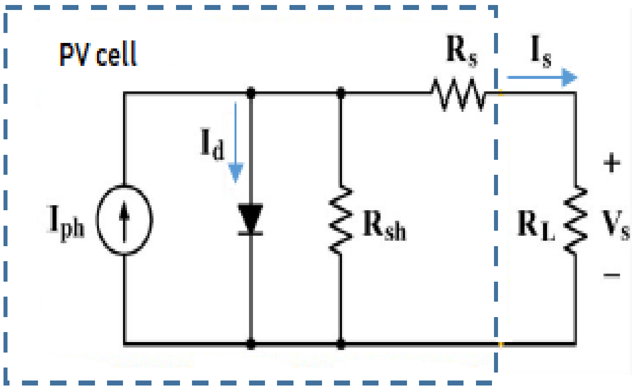

Fig.1 Equivalent circuit of a PV cell.

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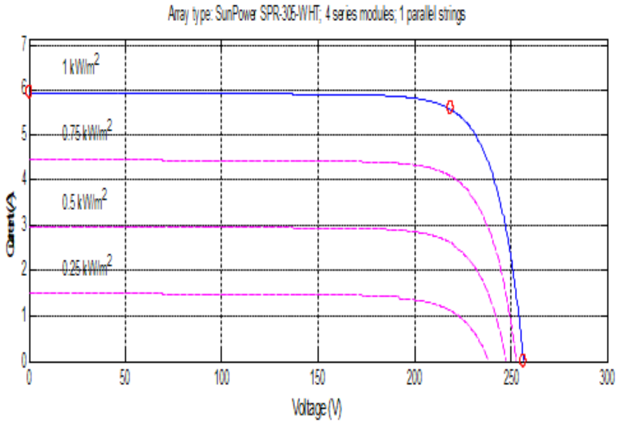

Fig.2 V-I characteristics curves at different irradiance and 25oC

The output V-I characteristics of PV cell demonstrated in Fig.2 which depends on the working temperature of the cell and irradiance. The variety of the open circuit voltage might be especially less even as expanding the irradiance and the short out contemporary has sharp varieties dependent on irradiance. be that as it may, if expanding the running temperature, the vacillations of open-circuit voltage and snappy circuit present day are decreased in a non-straight way [24]. In smooth exchanging raise converter, the helper full circuit is incorporated to the customary raise converter. The helper resounding circuit comprises of one switch, two diodes, one full inductor and one capacitors. The enter of this gadget is the photovoltaic (PV) array. The PV cell supplies 1kW power to this converter. Fig.3 shows the circuit diagram of soft switching boost converter. In this figure, the two switches S1 and S2 are represented as IGBT1 and IGBT2 respectively.

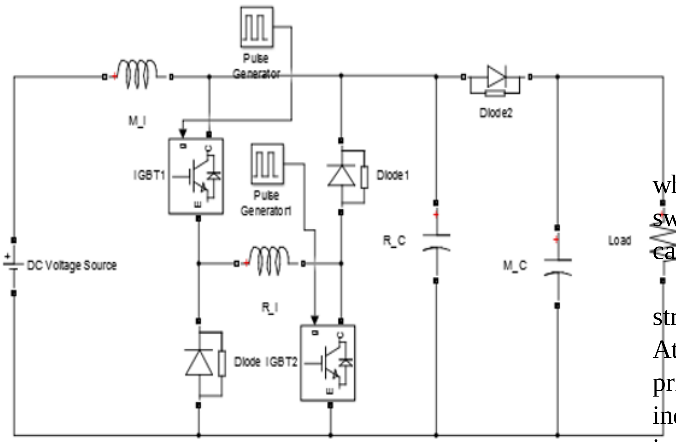

Fig. 3. Circuit diagram of soft-switching boost converter.

In soft switching boost converter, the modern-day can not flow through switches S1 and S2 while the switches are in OFF states and the positioned away power of the fundamental inductor is exchanged to the heap. Fig.four reveal that the hypothetical waveforms of diverse operational modes (Park et al., 2010).

Mode 1 ($t0 \leq t < t1$)

In this mode, the inductor current decreases linearly. Also, the current does not flow to the resonant inductor and capacitor has charged as output voltage at that time. Once two of the switches S1 and S2 have been switched ON, mode 1 is completed. These conditions are given below,

$$v_L(t) = V_s - V_o$$

$$i_L(t) = i_L(t_0) - \frac{V_s - V_o}{L}$$

$$i_{D_o}(t) = i_L(t)$$

$$i_{L_r}(t) = 0$$

$$v_{C_r}(t) = V_o$$

Where, V_s is input voltage, V_o is output voltage, $i_L(t)$ is inductor current, $i_{D_o}(t)$ is output of diode current, $i_{L_r}(t)$ is Resonant inductor current, and $v_{C_r}(t)$ is Resonant capacitor voltage.

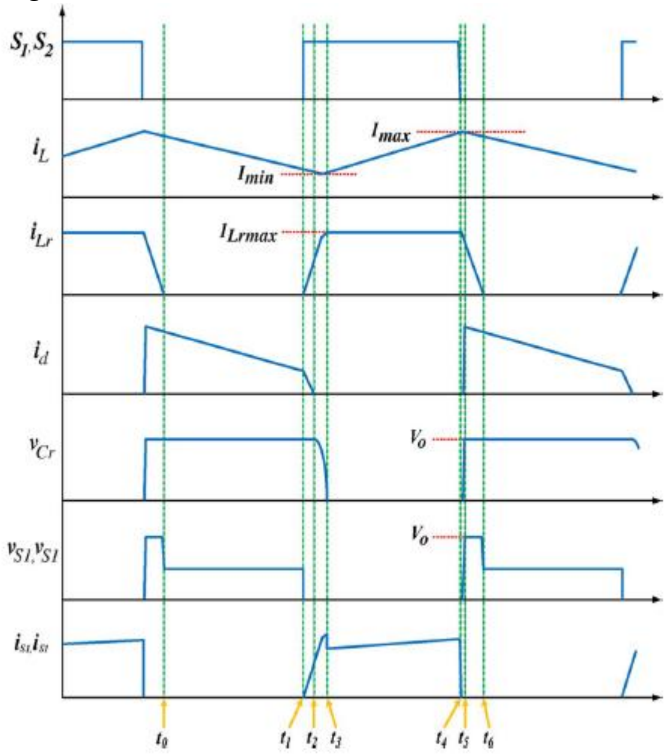

Fig.4 Theoretical waveforms of operational modes [1].

Mode 2 ($t1 \leq t < t2$)

In this mode, the current flows to the resonant inductor when the switches S1 and S2 are turned ON. Also, two of the switches are turned ON under zero-current condition which is called as Zero-Current Switching (ZCS).

moreover, the resounding cutting edge will increment straightly and the heap contemporary consistently diminishes. At t2, the yield diode present day is zero on account of the principle inductor and full inductor forefront have indistinguishable bleeding edge. additionally, the yield diode is turned off, while the full capacitor

voltage is equal to V0.

$$i_{L_r}(t_1) = 0$$

$$v_L(t) = V_o$$

$$i_{L_r}(t) = \frac{V_o}{L_r}t$$

$$i_L(t) = i_L(t_1) - \frac{V_o - V_s}{L}t$$

$$i_L(t_2) = i_{L_r}(t_2),\ i_{D_o}(t_2) = 0$$

Mode 3 ($t2 \leq t < t3$)

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The current flowed to the load through output diode due to the resonant capacitor, furthermore, the full inductor begin a reverberation at t2. the present streaming to the resounding inductor is a mix of the number one inductor cutting-edge and the thunderous capacitor modern-day. The degree of full current is communicated as pursues,

$$i_{L_r}(t) = I_{min} + \frac{V_o}{Z_r}\sin(\omega_r)$$

At the resonant time, the resonant capacitor Cr is discharged from Vo to zero which is gives as,

$$v_{C_r}(t) = V_o cos(\omega_r t)$$

$$v_{C_r}(t_2) = V_o, \quad v_{C_r}(t_3) = 0$$

Resonant frequency and impedance are expressed as follows,

$$\omega_r = \frac{1}{\sqrt{L_r C_r}} \text{ and } Z_r = \sqrt{\frac{L_r}{C_r}}$$

The mode 3 is completed, when the voltage of the resonant capacitor is equal to zero.

Mode 4 (t3 ≤ t < t4)

Mode 4 starts, when the voltage of the resonant capacitor is equal to zero after the resonant period in interval 3. In this interval, the freewheeling diodes of D1 and D2 are turned on, and the current of the resonant inductor is the maximum value. In this mode, the main inductor voltage is equal to the input voltage and the current storing energy increases linearly.

$$v_L(t) = V_s$$

$$i_L(t) = I_{min} + \frac{V_s}{L} t$$

Where, I_{min} is minimum current of the main inductor.

Mode 5 (t4 ≤ t < t5)

In Mode 5, all of the switches are turned OFF under the zero voltage condition by the resonant capacitor. The initial conditions of the resonant inductor current and resonant capacitor voltage of this mode are as follows,

$$i_{L_r}(t_4) = I_{L_r,max}$$

$$v_{C_r}(t_4) = 0$$

Where, $I_{L_r,max}$ is maximum resonant current of the main inductor.

The resonant capacitor Cr is charged to the output voltage by two of the inductor currents, when all of the switches are in OFF.

$$i_{L_r}(t) = I_{max} - (I_{max} + I_{L_r,max})cos(\omega_r t)$$

$$v_{C_r}(t) = Z_r(I_{max} + I_{L_r,max})sin(\omega_r t)$$

$$v_{C_r}(t_5) = V_o$$

Where, I_{max} is maximum current of the main inductor.

Mode 6 (t5 ≤ t < t6)

Mode 6 starts when the resonant capacitor is equal to the output voltage and the output diode is turned ON under the zero voltage condition. In this, two of the inductor currents are linearly decreased and the energy of the resonant inductor is fully transferred to the load. Finally, the interval 6 is completed.

$$i_L(t) = I_{max} - \frac{V_o - V_s}{L_r} t$$

$$i_{L_r}(t) = i_{L_r}(t_6) - \frac{V_o}{L_r} t$$

$$i_{L_r}(t_6) = 0$$

Soft Switching Boost converter

Soft switching boost converter is an auxiliary resonant circuit together with the traditional boost converter circuit. The auxiliary resonant circuit comprises an inductor, a capacitor, a switch and a diode. Zero voltage switching (ZVS) and zero current switching (ZCS) reduced the coincided area of present day and voltage for the length of exchanging which thusly limits the exchanging misfortunes at better frequencies. The enter to the smooth exchanging upgrade converter is outfitted from the PV framework. In ZVS, the switch is turned on while the voltage all through the full capacitor is zero. In zero present day exchanging, the turn is killed while the advanced through the resounding inductor is zero. From this, it is sensible that, the covered place is lesser while in contrast with extreme exchanging which thusly decreases the exchanging misfortune. the use of assistant full circuit normally decreases the electromagnetic interference (EMI).

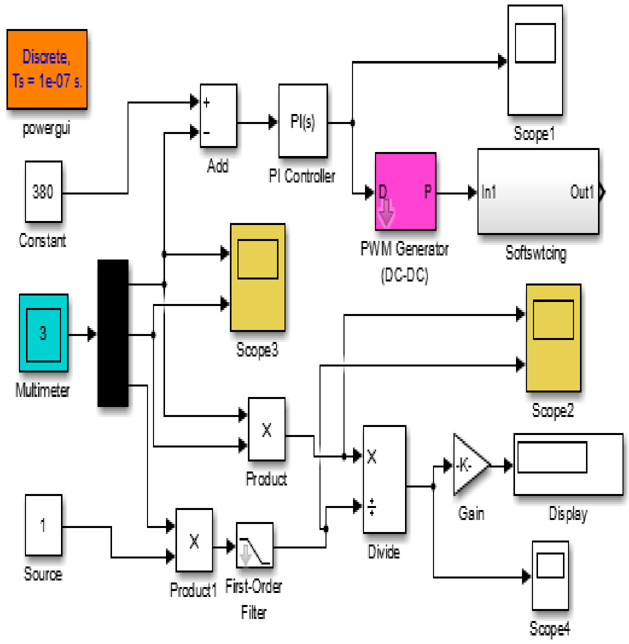

Fig.7 Circuit diagram of control technique

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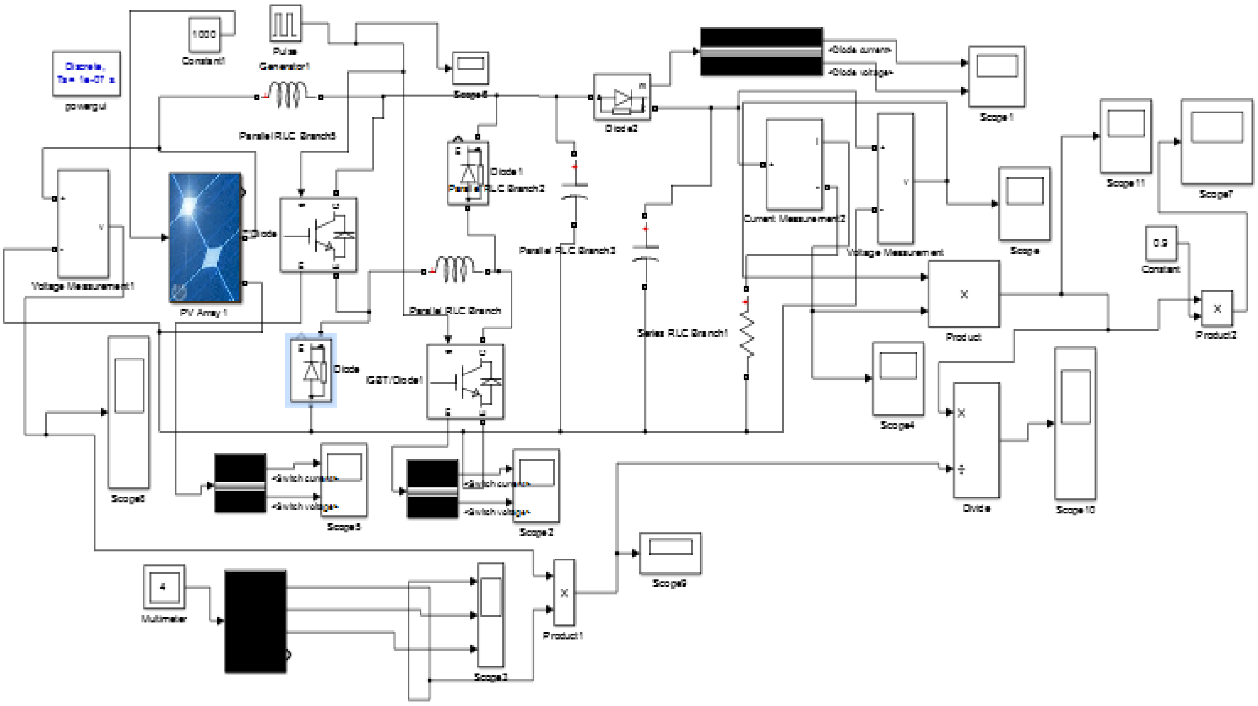

Fig.5 Soft switching boost converter using R-load

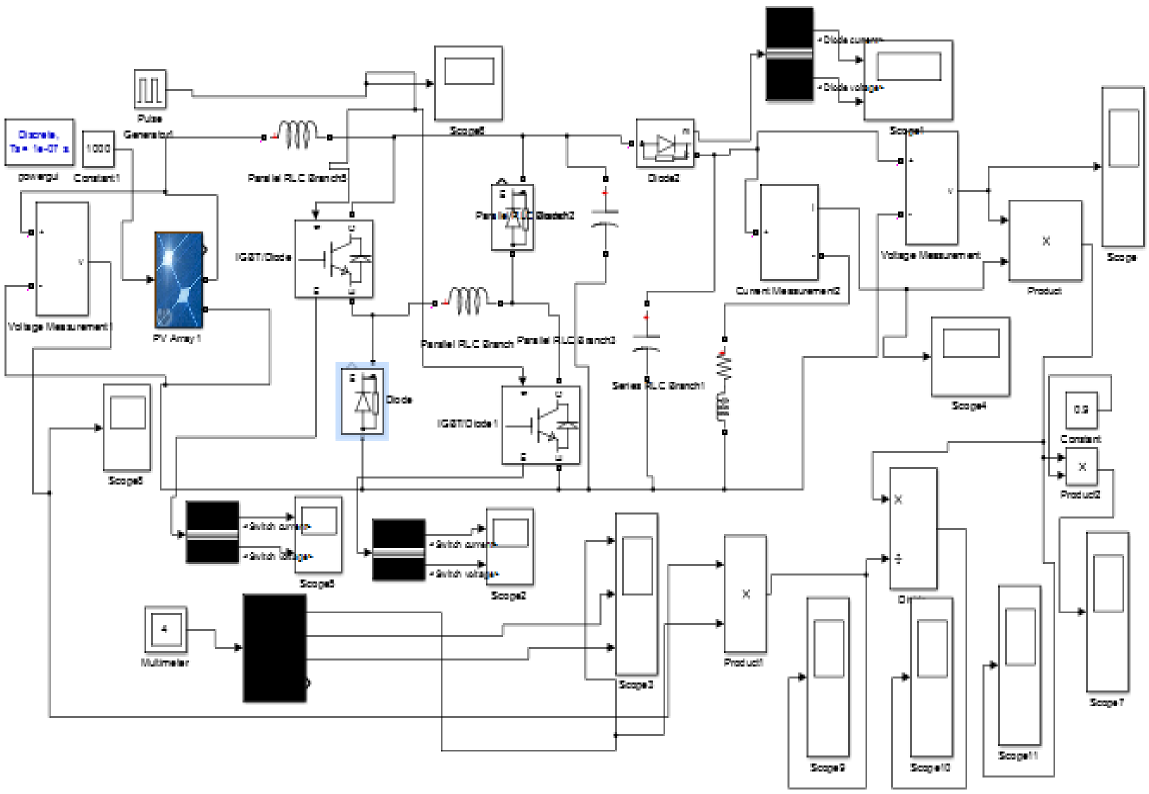

Fig.6 Soft switching boost converter using R-load.

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Hard Switching Boost converter

Boost converter is a DC-DC converter whose output voltage is greater than the input voltage. In PV fed system, this acts as a maximum power point tracker. It consists of a switch, a diode, a capacitor and an inductor. In this, the MOSFET exchange utilized and capacitor is normally acquainted in yield feature with decrease the swells. The enter to the enhance converter is encouraged from PV gadget. The exchanging misfortunes are high in troublesome exchanging converter in light of the fact that there is covering of voltage and current amid exchanging. As power is the made of present day and voltage exchanging misfortune is additional in intense exchanging. there is a surprising breaking of present day through the device that closes in Electromagnetic impedance in troublesome exchanging converters.

Cat Swarm Optimization (CSO) Algorithm

In this, to improve the performance of PI controller by optimizing the controller gain Cat Swarm Optimization (CSO) is used. Also, it reduces the switching losses and improves the soft switching boost converter performance using R-load ad RL-load. CSO is one of the metaheuristic calculations which work dependent on the swarm understanding advancement [25-27]. CSO is produced dependent on the conduct of pussycats and determined that tom cats invest maximum severe electricity at resting and watching their circumstance. they're persistently conscious and flow progressively. at the factor when the presence of prey is outstanding, they hobby it fast spending the gigantic degree of power. CSO calculation is persuaded by using those tom cats standards of behavior which includes looking for and following mode.

Seeking mode

Seeking model is utilized to build the circumstance of the feline this is resting, gazing at and looking for the home position to transport to. The system of hunting down mode comprises four significant measurements.Seeking Memory Pool (SMP) is describe the seeking memory size for each cat that specifies the points hunted by the cat. Counts of Dimension to Change (CDC) is important metric in seeking mode which defines the number of dimension is altered. Seeking Range of the selected Dimension (SRD) is defined as the dimension which is selected to mutate, the difference between the updated and old values within the range. Self-Position Considering (SPC) decides whether the cat is standing in the point will be one of the cats to move. The following five steps describes the process of seeking mode.

Create n copies of the current position of cati, where n=SMP. If the value of SPC is true, (n=SMP-1) then retain the present position as one of the candidates.

For each copy, randomly add or minus SRD percent of current values and substitute the previous ones based on CDC.

Estimate the fitness values (F) of each cat point.

If all F values are not precisely equal, compute the selecting probability (Pm) of each cat point by below equation, else set all the Pm of each cat point is 1.

$$P_m = \frac{|F_m - F_b|}{F_{max} - F_{min}}, where\ 0 < m < n$$

F_b is the best solution, F_{max} is the maximum fitness value in the cats, F_{min} is the minimum fitness value in the cats.

Randomly select the point to move to from the cat points, and switch the position of cati.

Tracing or Chasing mode

The tracing or chasing mode is the next process for displaying the situation of the feline in pursuing some goals. whilst a tom cat goes into following or pursuing mode, it moves depending on its personal speeds for each measurement. The way closer to following mode is portrayed as pursues,

Update the velocities for every dimension based on following equation,

$$v_{i,j} = v_{i,j} + r_1 * c_1 * (x_{best,j} - x_{i,j}), \qquad where\ j = 1,2, \dots, M$$

Where, $x_{best,j}$ is the position of the cat who has the best fitness value, r_1 is the random value in the range of [0, 1], $x_{i,j}$ is the position of cati, c_1 is the constant.

Verify if the velocities are in the range of the largest velocity, and the new velocity is over-range, set it is equal to the limit.

Update the position of cati based on below equation,

$$x_{i,j} = x_{i,j} + v_{i,j}$$

CSO Process

CSO algorithm is obtained by combing two modes such as seeking mode and tracing mode using mixer ratio (MR). MR is a small value to guarantee that the cats spend most of the in seeking. The CSO process is defined as following steps,

Create N cats in the process.

Randomly sprinkle the cats into M-dimensional solution space and randomly pick values which are within the maximum range

Calculate the fitness value of each cat by employing the positions of cats into the fitness function.

Move the cats along with their flags, if cati is in seeking mode, employ the cat to the seeking and observing mode, else apply the chasing mode.

Re-select number of cats and set them into chasing mode based on MR. then set the other cats into seeking mode.

Verify the termination condition; if satisfied, terminate the program and else repeat Step3 to Step5.

Algorithm 1: Cat Swarm Optimization (CSO)
Input: Initialize the cat population and SPC
While (the condition is not satisfied or) **do**
Calculate the fitness function values for all cats and sort them

IV. RESULTS AND DISCUSSIONS

In the proposed research, resistive R-load and RL load essentially based two styles of delicate exchanging support converters are progressed. in this, smooth exchanging upgrade converters the utilization of R-stack procured the solid condition by utilizing taking less time. also, R-stack gives the yield present day and voltage with less vacillations and exchanging misfortunes. inside the RL-stack, delicate exchanging support converters the utilization of RL-stack achieved the strong circumstance outcomes through taking additional time. additionally, RL-stack accomplishes the yield present day and voltage has additional changes and exchanging misfortunes. along these lines, the R-stack based delicate exchanging upgrade converter offers additional proficiency. in this, the outcomes are given for R-stack principally based delicate exchanging improve converter .

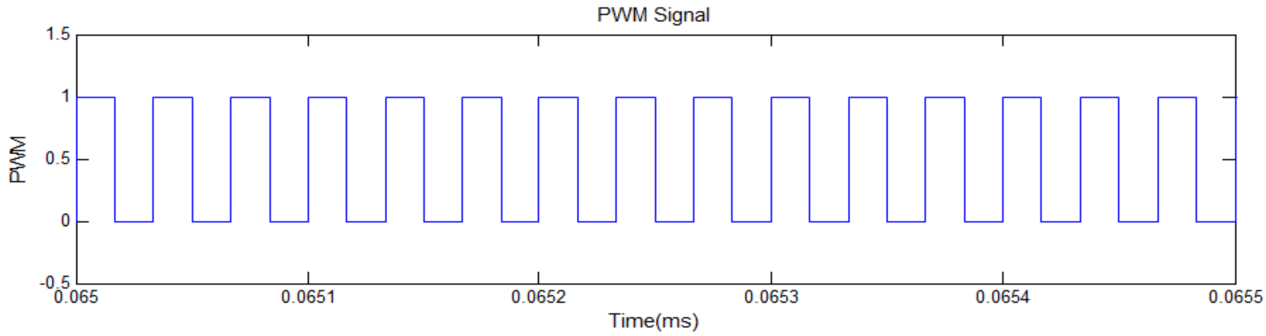

Fig.8 pulse width modulation (PWM) gate signal of the main switch

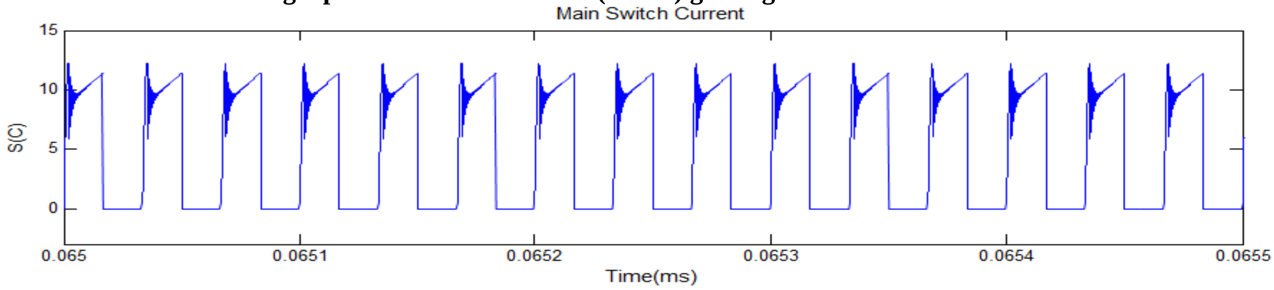

Fig.9 Current of the main switch

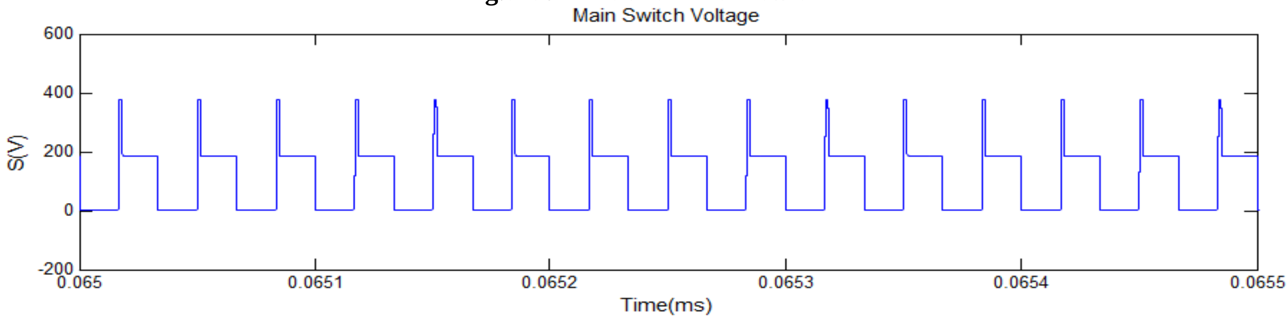

Fig.10 Voltage of the main switch

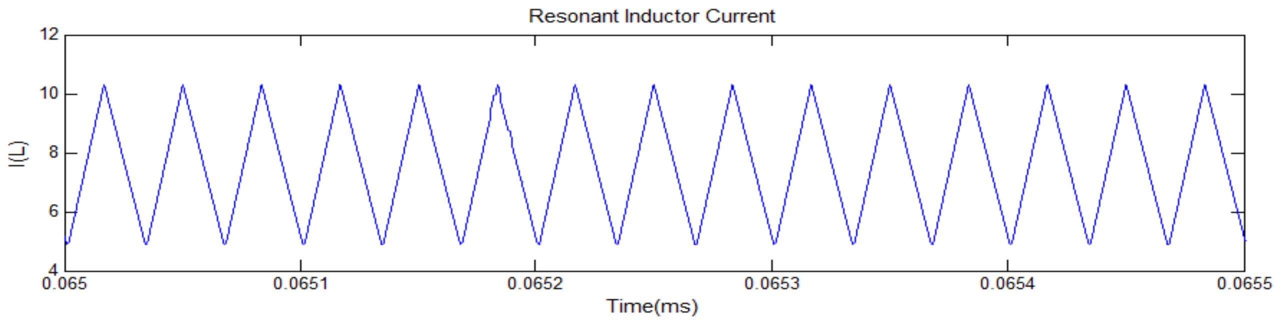

Fig.11 Resonant inductor current of the converter

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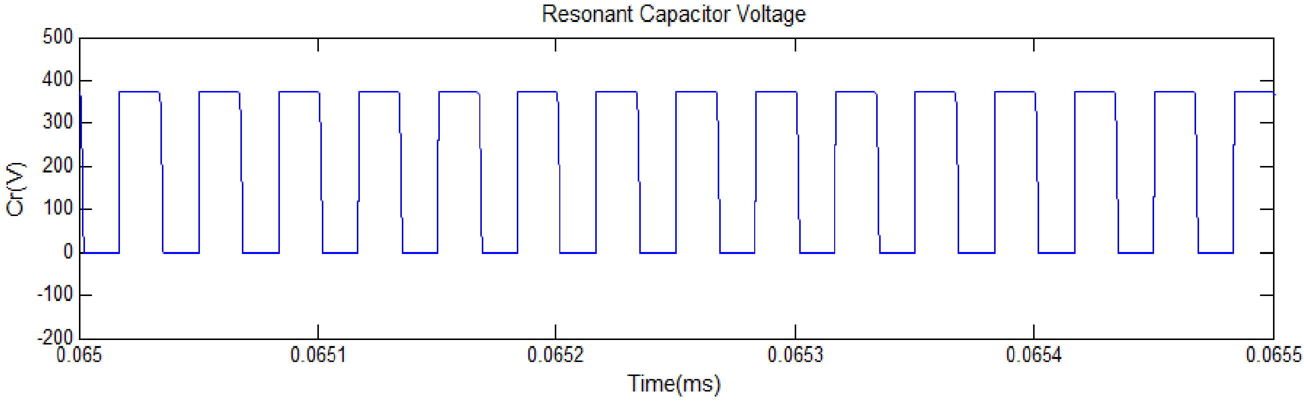


Fig.12 Resonant capacitor voltage of the converter

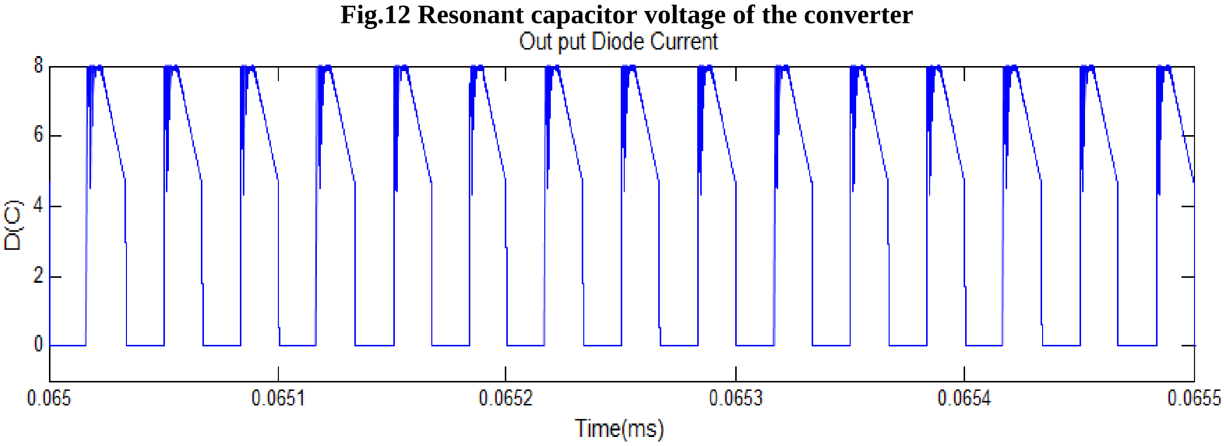


Fig.13 Output diode current of the soft switching boost converter

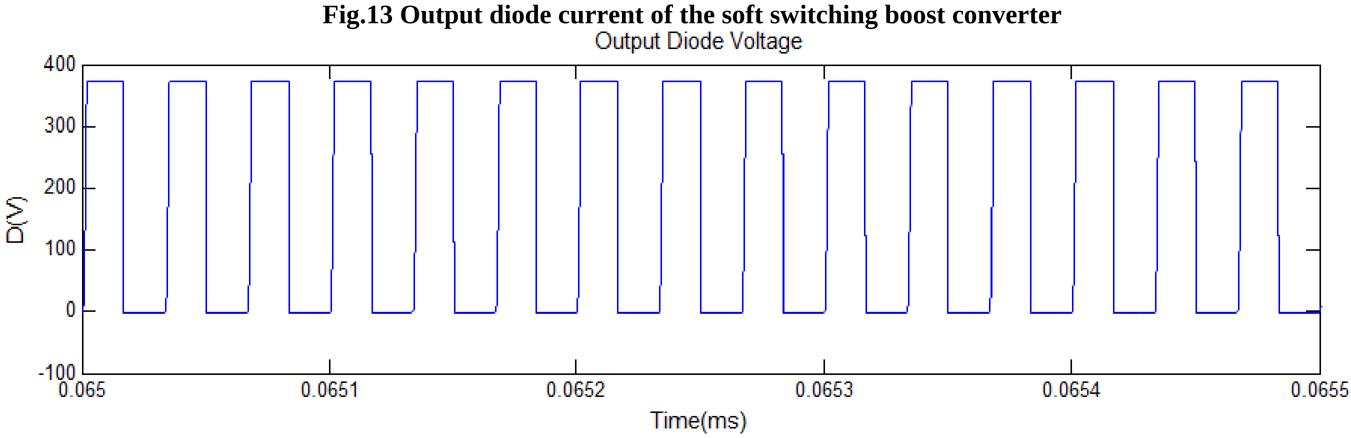
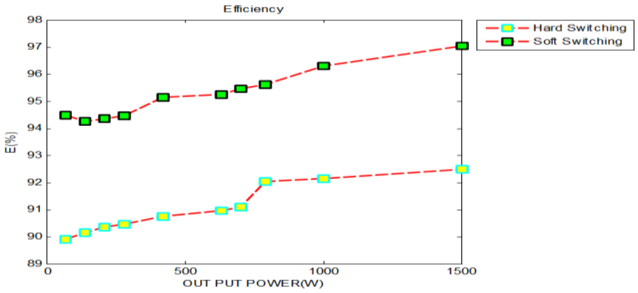


Fig.14 Output diode current of the soft switching boost converter

Fig.15 demonstrates that the efficiency of the proposed soft exchanging and tough replacing lift converters. From this, the greatest effectiveness of the proposed sensitive changing and difficult changing raise converters are ninety seven% and ninety two.5% separately. This checked the skillability of proposed sensitive replacing is stepped forward via round four. 5% using cat swarm optimization (CSO) than the hard switching boost converter.



V. CONCLUSION

on this paper, a particular research for boosting the execution of delicate exchanging help converter has been proposed the utilization of feline swarm enhancement set of tenets. The delicate exchanging raise converter with R-load and RL-stack are propelled the utilization of a Simple Auxiliary Resonant Circuit (SARC). This circuit is used to operate the main switch with Zero Voltage Switching (ZVS) and Zero Current Switching (ZCS). Also, the performance is enhanced by optimizing the PI controller gain using CSO algorithm. The results demonstrate that the soft switching boost converter using R-load attained reduced fluctuations and switching losses than using RL-load. Furthermore, the efficiency of the proposed soft switching boost converter is enhanced by about 4.5% using cat swarm optimization (CSO) than the hard switching boost converter.

The preferred spelling of the word "acknowledgment" in America is without an "e" after the "g." Avoid the stilted

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