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FOPID Controlled Modified Coupled Inductor based SEPIC Converter with Renveble Energy System

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Abstract:

Voltage controlled DC/ DC converters are usually used to feed low power DC drives and batteries. This viewpoint deals with simulation and comparison of coupled inductor based modified single ended primary inductor (SEPIC) converter systems. The aspire of this work is to get better the voltage gain and times response of modified SEPIC converter. Secondary switch with clamped capacitor is added to obtain the soft switching. SEPIC converter simulated and the corresponding results are presented. The presentation of the converter is intentional in terms of output voltage and dynamic characteristics. Design and simulation results are presented to identify a MCI based SEPIC converter system with high power output. The proportional study is obtainable to express the reduction in the ripple in the output voltage. The advantages of the proposed converter are high voltage achieve, reduced switching loss and low electromagnetic interference (EMI). The open loop systems with change in input voltages are simulated. The closed loop systems with proportional integral controller (PIC) and fractional order proportional integral controller (FOPIDC) are simulated and their results are compared. The results of comparison are made to show improvement in time response in terms of settling time and steady state error.

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I. Introduction

A modified coupled inductor based soft switched coupled Single-Ended Primary Converter (SEPIC) is introduced in this paper. A helper switch and a brace capacitor are associated. A coupled inductor and an assistant inductor are used to get swell free information current and accomplish zero-voltage-switching(ZVS) operation of the fundamental and helper switches. Because of high yield pick up adaptability, a modified coupled inductor based SEPIC converters have been generally utilized for applications including power factor change/adjustment [1-6], photo voltaic framework [7-9] and LED lighting [10-12]. The use of modified coupled inductor based SEPIC converter is limited particularly in high voltage applications because of its limited voltage weights on control semiconductor gadgets and low proficiency inferable from hard exchanging operation of the power switches. Voltage multiplier systems can defeat these two principle issues related with the modified coupled inductor based SEPIC converter, subsequently a change in the proficiency can be acquired.

The voltage multiplier system and dynamic control strategy are connected to the customary the modified coupled inductor based SEPIC converter to build the voltage pick up, decrease the voltage worries of the power switches and diode.Soft-switching MCI based SEPIC converter with ripple-free input current is agreed by Hyun.To complete the necessity of high voltage requests in control converter frameworks, an exceptionally effective, basic, single stage bridgeless converter with programmed control enables redress with decreased voltage stresses is exhibited. A most modern bridgeless single-stage AC-DC converter with a planned control Power Factor Correction (PFC) is proposed. The future rectifier depends on the customized coupled inductor based SEPIC topology and it uses a bidirectional switch and two quick diodes[2]with the benefits of high static increase, delicate substitution and an expansion in effectiveness. An improved bridgeless modified coupled inductor based SEPIC converter working in broken conduction mode without current circle is explored in[3] with simultaneous reduction in conduction losses and components.

Bridgeless rectifiers consequent from the conservative modified coupled inductor based SEPIC converter are presented in [4]. Proposed topologies on examination with the established of modified coupled inductor based SEPIC control circuit brought about less conduction misfortunes and an expansion in the change proficiency. In [6] investigational examination of a new modified coupled inductor based SEPIC converter, uses made where three- phase power factor correction circuit employing a single switch with the competence of voltage boosting / bucking and also the converter working at a power factor closer to unity is provided. A modified coupled inductor based SEPIC converter working in discontinuous mode without current loop is premeditated and analyzed in [7] to act as perfect power factor pre-regulators.

Swells introduce in the info current are restricted and thus amazing information current is accomplished by suitably picking the estimations of info inductor and middle capacitor. A novel technique using a modified coupled inductor based SEPIC converter to track the maximum power point of a photo voltaic cell with less hardware requirements and geometric estimation is obtainable in [8] under changeable meteorological surroundings. The adequacy of modified coupled inductor based SEPIC converter based fluffy rationale controller is examined tentatively in [9] to track the greatest power purpose of a photograph voltaic framework under differing load conditions. Constant execution of the framework guarantees ideal utilization of photo voltaic exhibit. Achievement of high efficiency and reduction in voltage stresses by using a single stage modified coupled inductor based SEPIC converter operating in discontinuous conduction mode to constrain the LED lamps for conserving energy is given in [10]. For LED applications a narrative basin- fill modified coupled inductor based SEPIC derived power supply with electrolytic capacitor is specified in [11].

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Results demonstrate the change in the execution of LED lighting framework with the utilization of proposed topology. Another arrangement with modified coupled inductor based SEPIC executing voltage lift procedures is exhibited and connected to a few DC-DC converters is presented in [12]. Experimental results indicate that the voltage lift DC-DC converter derived from the modified coupled inductor based SEPIC prototype ensures high output voltage transfer gain there by enabling them to be employed for potential applications. To acquire a high step up static gain and drop in upper limit switch voltage, voltage multiplier technique functional to the typical non-isolated DC-DC converter is presented in [13]. By incorporating the multiplier circuit with DC-DC converter the turnaround recuperation current of the diode is limited. For sustainable power source frameworks requiring high voltage exchange picks up a progression of voltage lift split inductor sort help converter is given in [14]. Motivated by the encouraging results shown in [1], the performance evaluation of PI controlled modified coupled inductor based SEPIC converter systems is investigated in this paper. To show the better concert of the closed loop FOPID controlled modified coupled inductor based SEPIC converter system, extensive simulation studies have been carried out with step changes in source voltage

The association of the paper is as per the following: A short presentation is given in segment 1 and the three methods of operation of ZVS converter are introduced in segment 2. Facsimile consequences of open loop and closed loop PI and FOPID proscribed modified coupled inductor based SEPIC converter frameworks are introduced in segments 3. Experimental results are obtainable in section 4. The conclusion drawn from the recreated modified coupled inductor based SEPIC converter framework is given in segment.

Conventional SEPIC structure and PV and Battery based modified coupled inductor(MCI) SEPIC converter system are shown in Fig. 1 (a), Fig. 1 (b). The MCI based SEPIC closed loop PI/FOPID controller system is shown in Fig. 1 (c).

Fig. 1 (a) SEPIC converter system

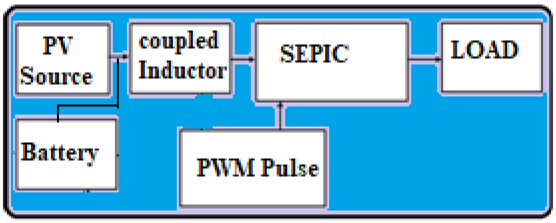

Fig. 1 (b) Coupled inductor based Modified SEPIC converter

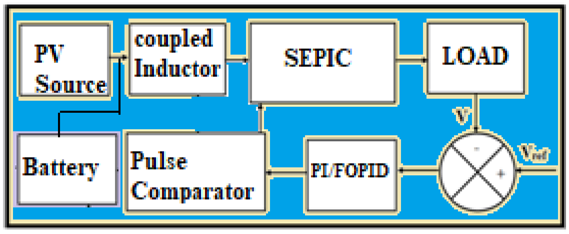

Fig. 1 (c) Closed loop controlled coupled inductor based SEPIC with renveble system

I. Working principle of coupled inductor based SEPIC converter system

Different versions of classical modified coupled inductor based SEPIC converter are highlighted in the literature. Fig. 1.1represents separate inductor version whereas.

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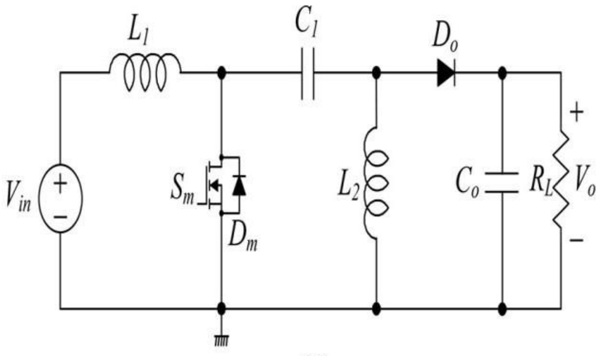


Fig. 1.1 Conventional modified coupled inductor based SEPIC converter

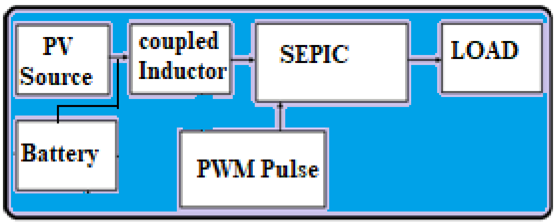


Fig. 1.2 Equivalent circuit of the modified coupled inductor based SEPIC converter

Modes of Operation

The circuit operation is divided into three modes and is explained in detail in this section.

Mode I

In this mode, the switch S_m is turned on. The current throughout the L_c and L_m increases linearly and the energy is stored in them. The current throughout the C_1, L_r and C_o charges the capacitor C_o. While the current reaches zero, the diode

In the converter, L_r resonant inductor, clamp circuit with supplementary switch S_a and compress capacitor are additional to the typical personalized coupled inductor based SEPIC converter which is exposed in Fig. 1.1.

Mode II

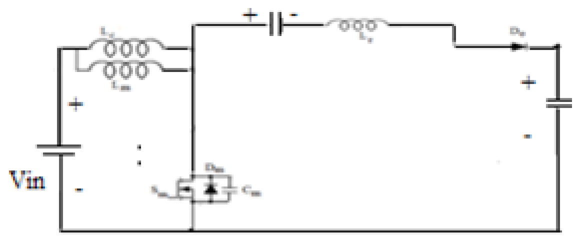


Fig. 2.1 Mode I

The comparable circuit of the customized coupled inductor based SEPIC converter is exposed in Fig. 1.2 in which L_c is designed as magnetic inductor L_m and an idyllic transformer with turns ratio 1: n. The diodes D_a and D_m are implemented for permissive intention that are united across the supplementary switch S_a and the main switch S_m. C_a and C_m represents the interior capacitances and lopsidedly the switches S_a and S_m are operated. Voltage ripple can be disregarded by presumptuous superior standards of the capacitors C_1, C_o and C_c.

The switch S_m is twisted off and the switch S_a is twisted on. The power in the inductor L_c is transferred to the capacitor C_c.

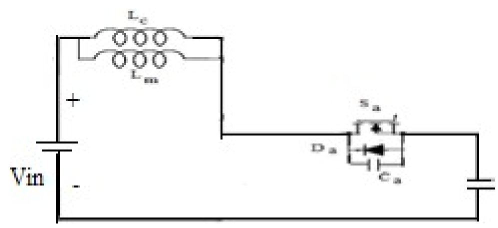


Fig. 2.2 Mode II

Mode III

In this mode, both the switches are twisted off. The energy stored in the capacitor C_o drives current throughout the load. The voltage across C_o decreases exponentially.

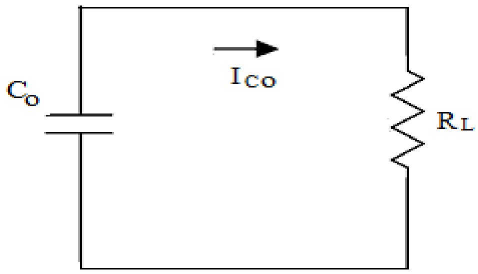


Fig. 2.3 Mode III

II. SIMULATION RESULTS

1. PV and battery based modified SEPIC converter

The circuit diagram of modified SEPIC converter with source disturbance is shown in the Fig. 3.1 (a). The output of PV is boosted using a modified SEPIC converter. The solar output voltage is shown in Fig. 3.1 (b). The output voltage of SEPIC converter with R-load is shown in the Fig. 3.1 (c).The output current waveform are shown in Fig. 3.1 (d).The output voltage is 96V. The output Power is shown in the Fig. 3.1 (e) and its value is 85W. The current is 0.9A. The parameters used for simulation study is listed in Table 3.

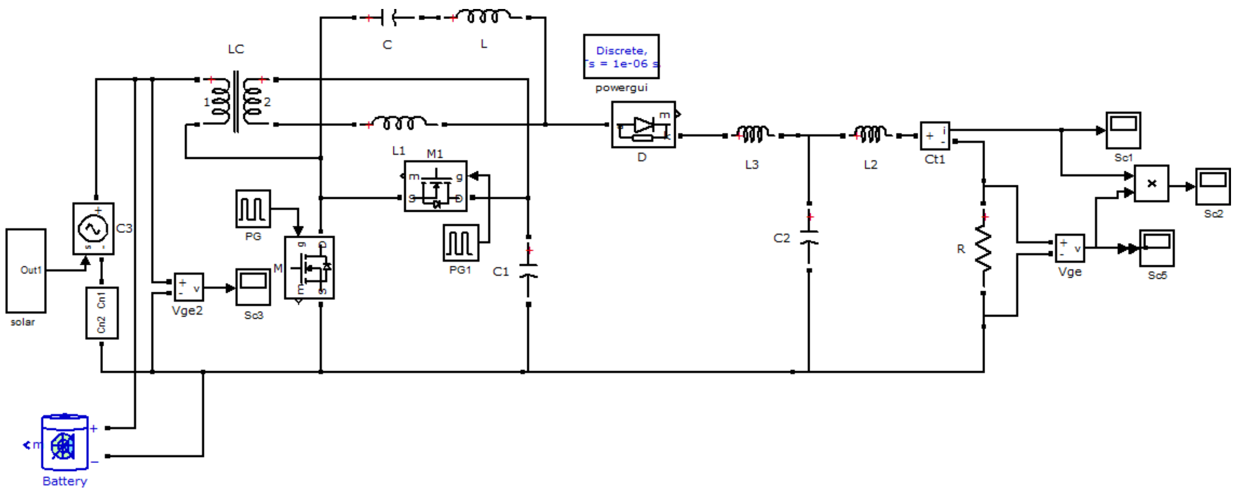


Fig. 3.1 (a) Circuit diagram of PV and Battery based Modified SEPIC converter with Open loop source disturbance

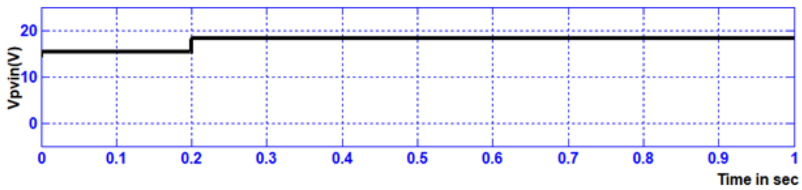


Fig. 3.1 (b) Voltage across PV

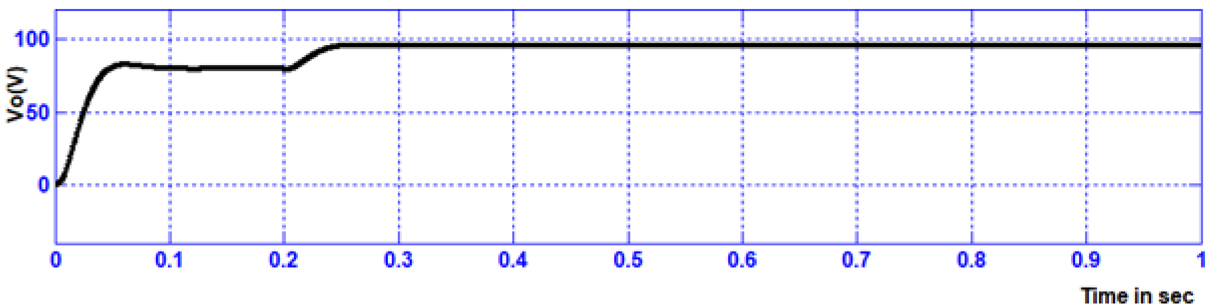


Fig. 3.1 (c) Voltage across R-load

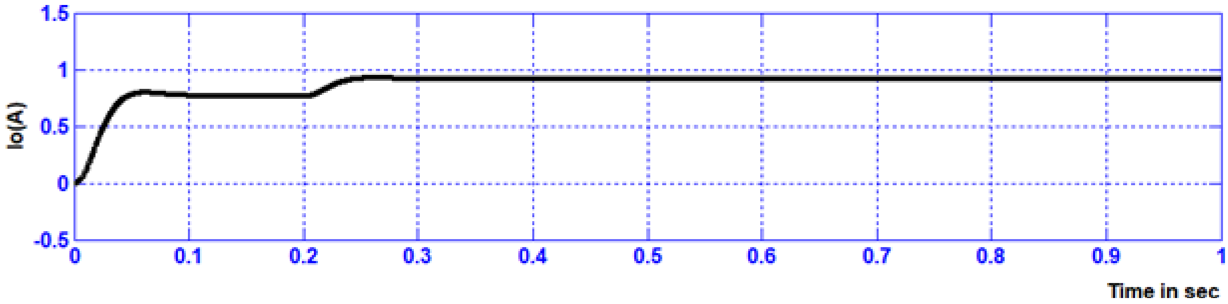


Fig. 3.1 (d) Current through R-load

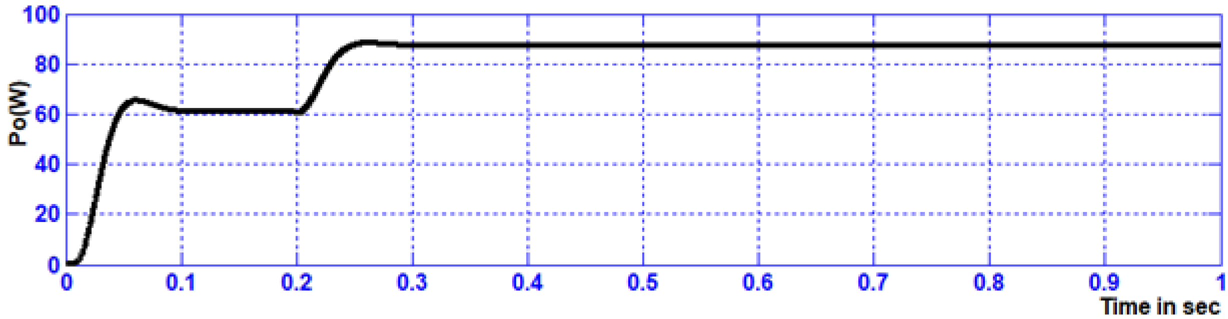
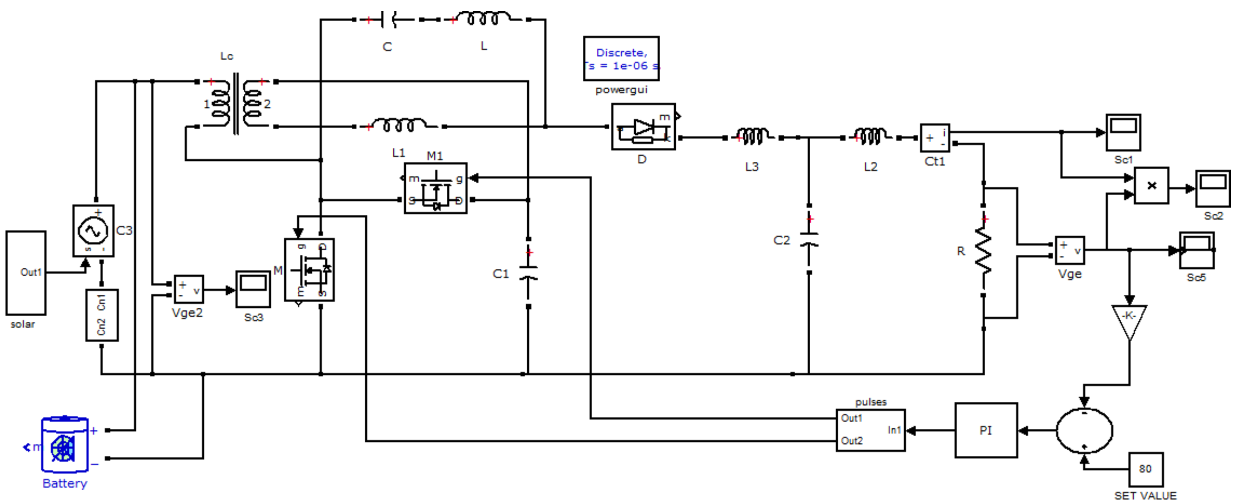


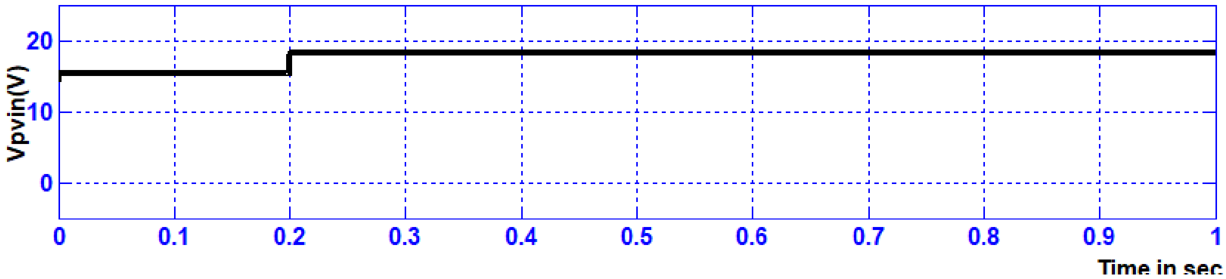
Fig. 3.1 (e) Output power

II. Modified coupled inductor based SEPIC converter closed loop system with PI controller

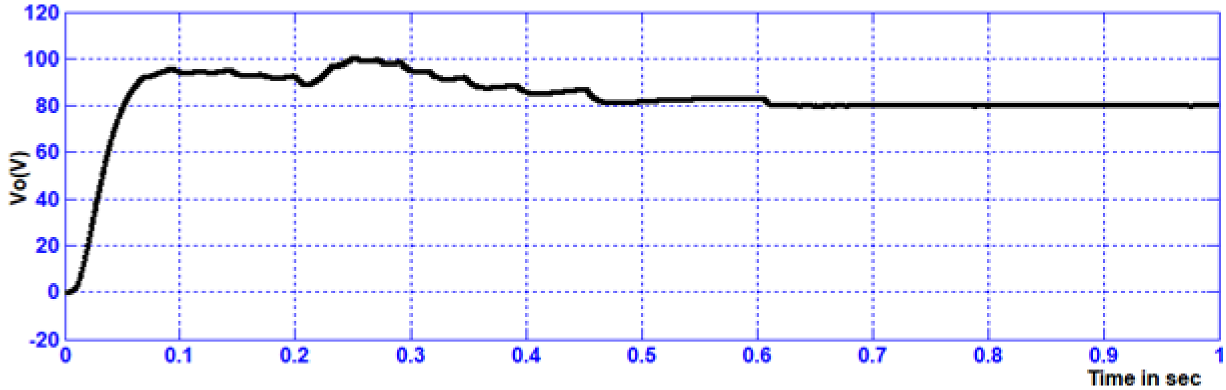
The closed loop system with PI controller is shown in Fig. 3.2 (a). The output voltage is sensed and it is compared with the reference voltage. Then it is applied to a comparator through the PI controller. The comparator compares the time based voltage with error and generates proper pulses to regulate the output voltage. The output voltage of the solar system and closed loop SEPIC converter output voltage is shown in Fig. 3.2 (b) and Fig. 3.2 (c). The voltage gets increased to settled 80V at 0.6 seconds and the corresponding output current and power waveforms are shown in Fig. 3.2 (d) and Fig. 3.2 (e).



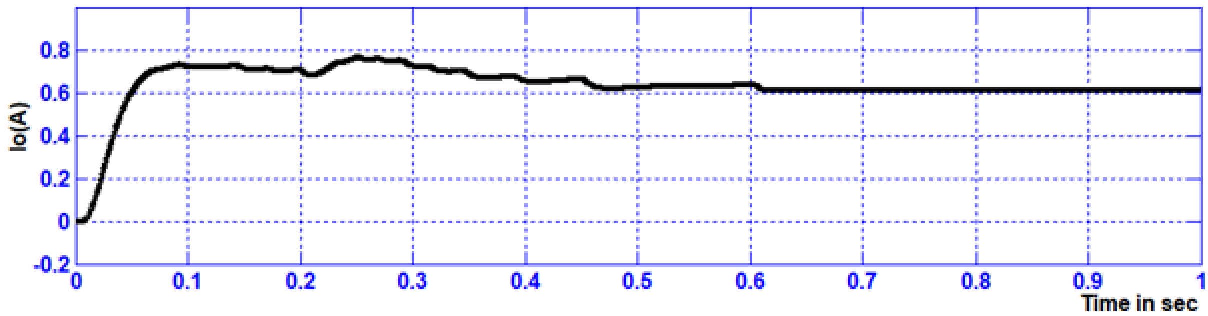
3.2 (a) Circuit diagram of PV and Battery based Modified SEPIC converter with closed loop PI controller



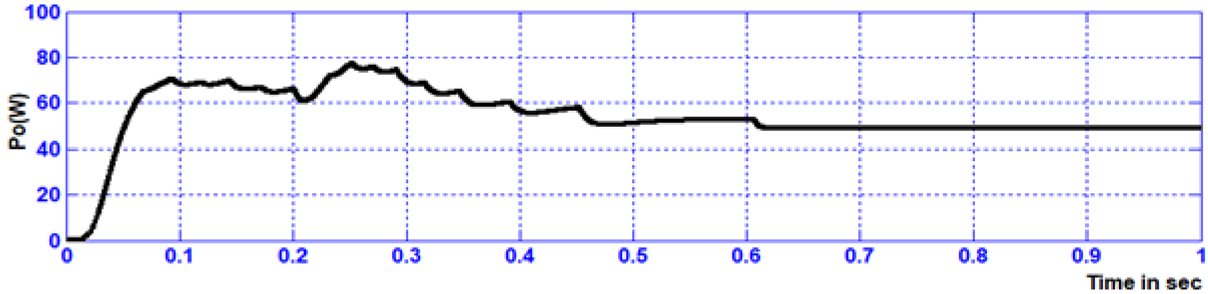
3.2 (b) Voltage across PV



3.2 (c) Voltage across R-load



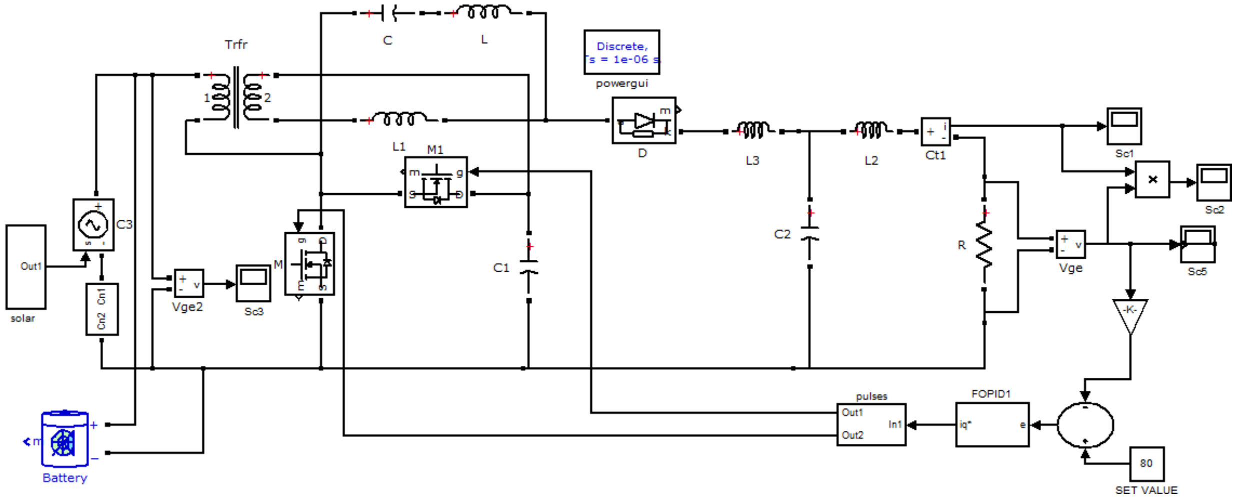
3.2 (d) Current through R-load



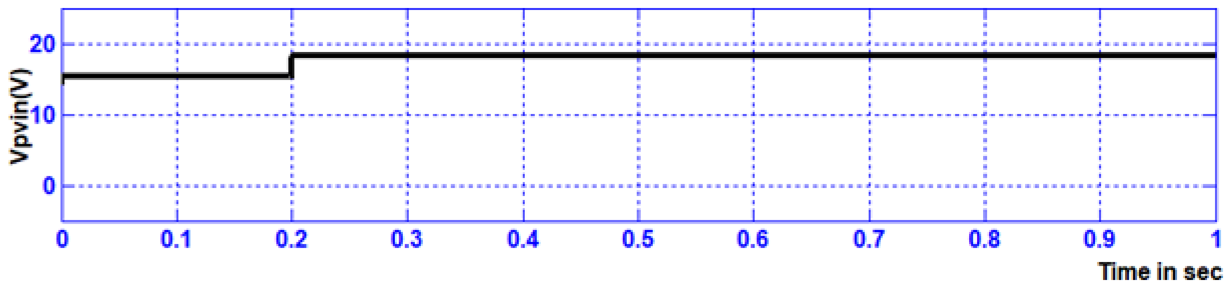
(e) Output power

III.Coupled inductor based SEPIC converter closed loop system using FOPID controller

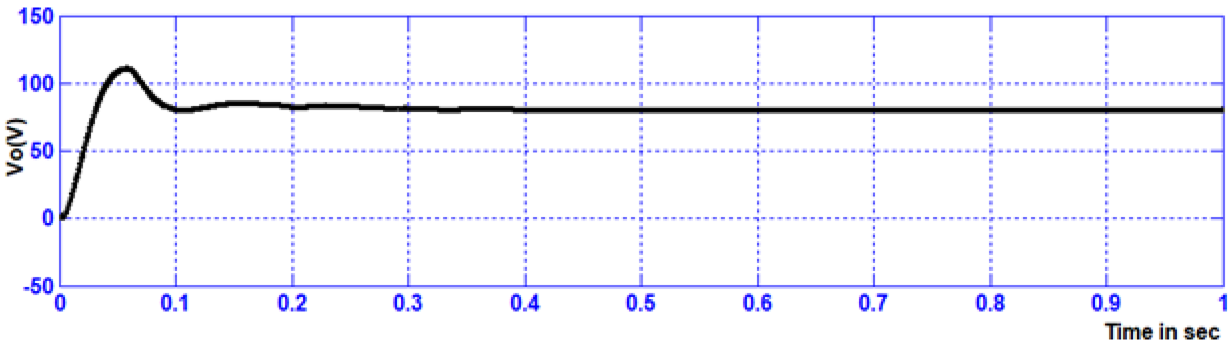
The closed loop system with FOPID is shown in Fig. 3.3 (a). The PI controller is replaced by FOPID controller. The inputs to FOPID are given to pulse generator. The input voltage is shown in Fig. 3.3 (b). The output voltage with FOPID is shown in Fig. 3.3 (c). The output power and current waveforms are shown in Fig. 3.3(d) and 3.3(e). The output power is 80 watts and current is 0.6A. It can be seen that the rise time, peak time and settling time are very much reduced by using FOPID. The summary of time domain parameters is given in Table II.



(a) Circuit diagram of PV and Battery based Modified SEPIC converter with closed loop FOPID controller



3.3 (b) Voltage across PV



3.3 (c) Voltage across R-load

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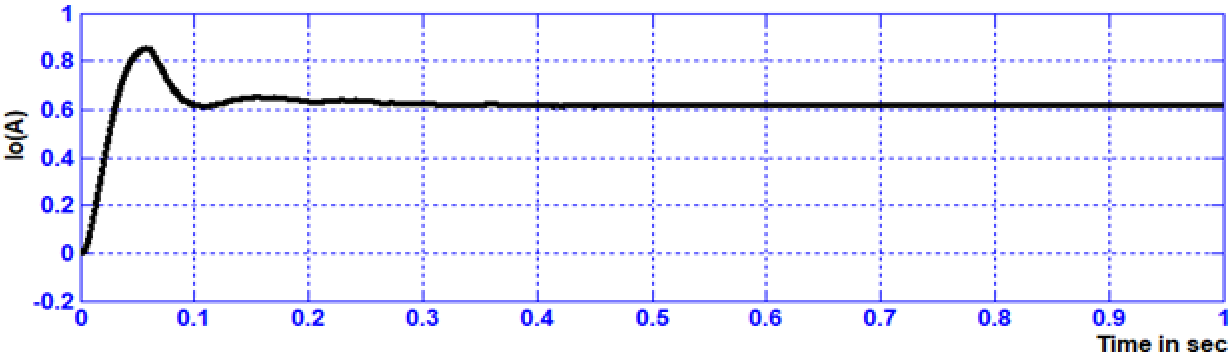
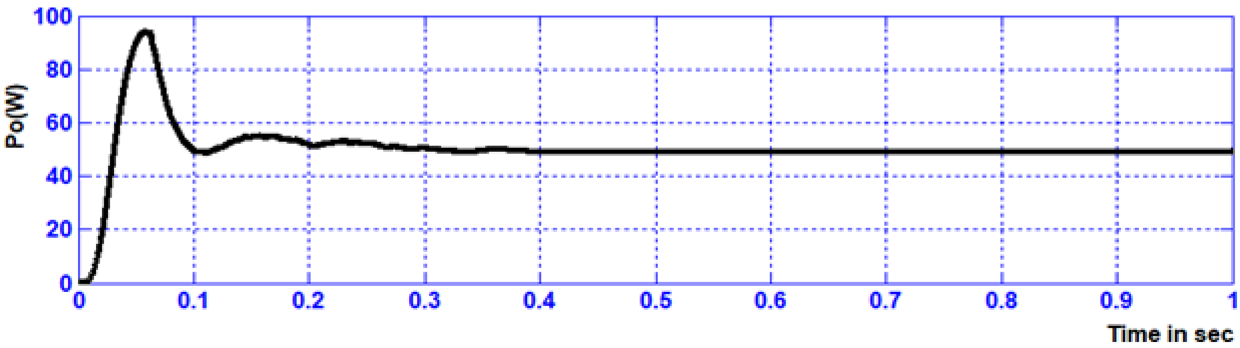
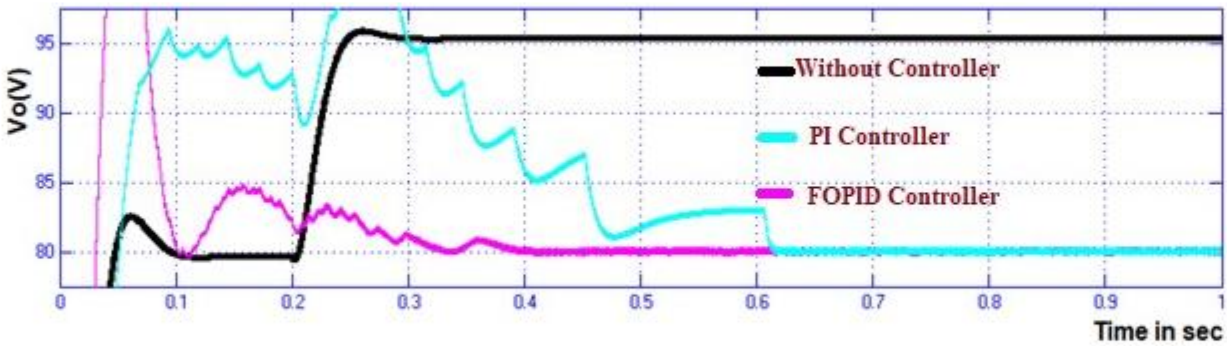


3.3 (d) Current through R-load



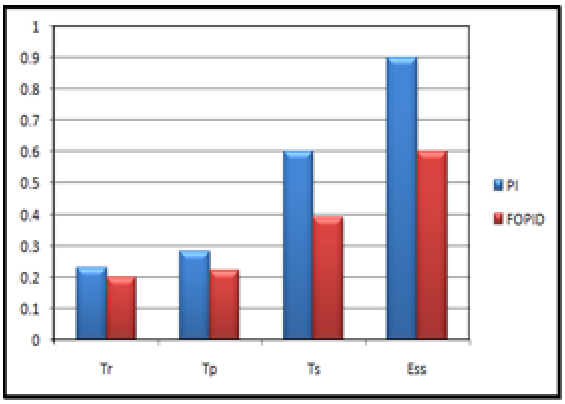
3.3 (e) Output Power



3.3 (f) comparison of output voltage regulation of without controller, with PI & FOPID controller

Table-1
Comparison of time domain parameters
(Vref =80V)

Controller	Tr	Tp	Ts	Ess
PI	0.23	0.28	0.60	0.9
FOPID	0.20	0.22	0.39	0.6



(g) Bar chart of PI and FOPID controlled system with Vref=80V

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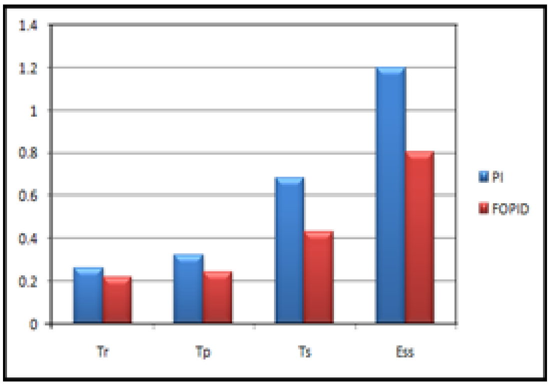
Table-2
Comparison of time domain parameters
(Vref =85V)

Controller	Tr	Tp	Ts	Ess
PI	**0.26**	**0.32**	**0.68**	**1.2**
FOPID	**0.22**	**0.24**	**0.43**	**0.8**



(h) Bar chart of PI and FOPID controlled system with Vref=85V

TABLE 3 COMPONENTS USED FOR SIMULATION CIRCUIT

S.No	Name	Rating
1	C	10uF
2	C1	8uF
3	C2	100uF
4	L	2mH
5	L1	35uH
6	L2	5uH
7	MOSFET (IR840)	600V,8A
8	L3	4.5mH
9	Ro	200Ω
10	DIODE	1N4007
11	PV	12V
12	BATTERY	12V
13	Lc	0.1mH
14	PI	Kp=0.18,Ki=0.9
15	FOPID	Kp=0.5,Ki=0.7,Kd=0.9,Kf=0.2

III. Conclusion

Modified coupled inductor based SEPIC converter closed loop systems are designed, modeled and simulated in open loop and closed loop using MATLAB and the results are presented. The simulation results indicate that the modified coupled inductor based SEPIC converter system produces output voltage regulation of 80V with help of PI and FOPID controller. The consequences of closed loop structure point to that the response with FOPID is superior to that of PI controlled system. The settling time is as low as 0.39 seconds and steady state error in output voltage is 0.6V by employing FOPID. Rise time(tr), Peak time(tp) and settling time(ts) response characteristics compared with different reference voltage discussed an above table1, 2.The proposed system has advantages like increased output power, reduced ripple and low switching losses. Closed loop simulation of coupled inductor based SEPIC converter system using SMC can be done in future work and results will be compared with FOPID controlled modified SEPIC- converter system. The Hardware of modified coupled inductor based SEPIC converter system can be done using Ardunio - processor to increase the switching frequency. The contribution of the present work is to improve dynamic response of modified coupled inductor based SEPIC converter system using FOPID.

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